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IN THE CIRCUIT COURT OF THE FIRST CIRCUIT

STATE OF HAWAII

IN RE:
HAWAII STATE ASBESTOS CASES

This Document Applies To:

CABATBAT, ARTURO
CASSANI, VINCENT J.
FELICIANO, JOSEPH
RIVEIRA, PATRICK (D)
VILLIATORA, MELCHIRO (D)
YATSU, HENRY

CIVIL NO. 09-1-ACM-002 (EEH)
(Toxic Tort / Asbestos Personal Injury)

PLAINTIFFS' OMNIBUS MEMORANDUM IN OPPOSITION TO MOTIONS FOR SUMMARY JUDGMENT FILED BY DEFENDANTS REGARDING THE DUTY TO WARN; DECLARATION OF COUNSEL; EXHIBITS A-LL; CERTIFICATE OF SERVICE

CIVIL NOS.
08-1-2033-10 (EEH)
09-1-0234-01 (EEH)
08-1-1957-09 (EEH)
08-1-2559-12 (EEH)
09-1-0209-01 (EEH)
09-1-0374-02 (EEH)

Hearing Date: September 17, 2009
Hearing Time: 9:00 a.m.
Judge: Honorable Eden E. Hifo

TRIAL: October 5, 2009
JUDGE: Hon. Eden Elizabeth Hifo

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PLAINTIFFS' OMNIBUS MEMORANDUM IN OPPOSITION
TO MOTIONS FOR SUMMARY JUDGMENT FILED BY DEFENDANTS
REGARDING THE DUTY TO WARN

I. PREFACE

Defendants ask this court to hold that as a matter of law, equipment manufacturers had no duty to warn end users about a hazard that was certain to occur during the routine repair and maintenance of their products. Defendants argue that they are entitled to such a ruling based on the recent decisions of two appellate courts in Washington and California.

These cases are not Hawaii law. They are directly contrary to Hawaii's express public policy of providing the "the maximum possible protection that the law can muster against dangerous defects in products." *Stewart v. Budget Rent A Car Corp.*, 52 Haw. 71 (1970). Moreover, contrary to Defendants' arguments, Plaintiffs are not asking the court to impose an "ersatz duty 'to warn of the hazards of another manufacturer's products.'" *Simonetta v. Viad Corporation,* 197 P.3d 127, 139 (Wash. 2008) (Dissent of Justice Stephens). Plaintiffs merely contend that the equipment manufacturers had a legal responsibility to warn about the hazards which were necessarily associated with the intended use, repair, and maintenance of their *own* products on Navy and merchant marine vessels. This duty to warn is not based on any novel or unusual legal theory. On the contrary, it is consistent with both well-settled Hawaii law, and Defendant's actual practice.

Defendants cannot deny that they had a legal duty to provide Pearl Harbor shipyard workers and ship personnel with: 1) adequate instructions for the safe operation and repair of their turbines, pumps, valves, and other marine equipment; and 2) warnings about the dangers that were inherent in the foreseeable use of their products on Navy vessels. *See Acoba v. General Tire, Inc.*, 92 Hawai'i 1, 15 (1999); Restatement (Second) of Torts §§ 388, 402A. Indeed, Defendant manufacturers issued technical manuals with detailed instructions on repair and maintenance, and workers relied on these manuals for the information that they needed in order to work safely with each manufacturer's equipment.

As the exhibits hereto will show, moreover, these technical manuals routinely warned service personnel to take precautions against hazardous substances that Defendants did not supply or manufacture, such as carbon tetrachloride, benzine, sulfamic acid, tri-sodium phosphate, trichlorethylene, and Freon. Contrary to their protestations, Defendants regularly

gave workers instructions about how to work safely with other manufacturers' hazardous products where they knew workers would be exposed to those substances during the regular maintenance and repair of Defendants' own equipment.

As the exhibits hereto will also show, Defendants knew that workers would necessarily be exposed to toxic asbestos dust during the regular maintenance and repair of Defendants' marine equipment. Defendants knew their equipment required asbestos insulation, packing, and/or gaskets to function properly on Navy and merchant marine ships. Indeed, equipment manufacturers routinely specified and supplied asbestos gaskets and packing with their equipment, and many manufacturers specified and supplied asbestos insulation as well. Defendants knew that during routine maintenance, ship personnel and shipyard workers would have to strip and replace asbestos insulation, packing, and/or gaskets from their equipment, exposing all the workers in the surrounding area to aspirable asbestos. Defendants' technical manuals often instructed workers how to strip and replace asbestos gaskets and packing, and at times told workers how to apply and remove insulation as well.

Under these circumstances, Defendant manufacturers had a responsibility to inform themselves about the hazards of the asbestos products that they knew would be used on their marine equipment, and they had a duty convey that information to the workers who serviced that equipment. It is perfectly fair and logical to hold that Defendants should have warned workers to take precautions against potentially deadly asbestos exposure, just as they warned workers to protect themselves against carbon tetrachloride, caustic soda, sulfamic acid, and other toxic substances that Defendants knew would be used on their equipment during routine maintenance and repairs.

Accordingly, Defendant equipment manufacturers had a duty to warn about the dangers of asbestos exposure, which were inherent in the repair, maintenance, and use of their equipment on U.S. Navy vessels. Defendants' motions must be denied in on the merits.

II. LEGAL ANALYSIS.

A. *Simonetta*, *Braaten* and *Taylor* are Not Hawaii Law On Duty To Warn.

As the Washington Supreme Court stated in *Simonetta*, the duty to warn "is a question of law that generally depends on mixed considerations of logic, common sense, justice, policy, and precedent." *Simonetta*, 197 P.3d at 131. Thus, in determining whether there is a

duty to warn under Hawaii law, the court must first be guided by our state's precedent and express public policy of providing the "the maximum possible protection that the law can muster against dangerous defects in products." *Stewart*, 52 Haw. at 74. Essentially, the court must determine "whether . . . such a relation exists between the parties that the community will impose a legal obligation upon one for the benefit of the other." *Wagatsuma v. Patch*, 10 Haw. App. 547, 569 (1994) (internal citation omitted).

In *Simonetta*, *Braaten*, and *Taylor*, the courts of Washington and California determined that in their communities, manufacturers had no legal obligation to instruct workers on how to protect themselves from toxic asbestos dust as they operated and maintained the defendants' equipment, even when those manufacturers had every reason to know that workers would be exposed to potentially deadly asbestos fibers each time they worked on the defendants' products. Thus, the Washington and California courts declined to recognize a duty to warn about asbestos even where: 1) the manufacturers knew that their equipment required asbestos insulation, gaskets, and packing in order to function as intended; 2) the manufacturers routinely supplied or specified asbestos insulation, gaskets, and/or packing with their equipment; and 3) the manufacturers knew that the ship personnel and shipyard workers would *necessarily* be exposed to potentially deadly asbestos during routine maintenance and repair. *Simonetta v. Viad Corporation*, 197 P.3d 127 (Wash. 2008) (holding that an equipment manufacturer had no duty to warn of the hazards of asbestos insulation); *Braaten v. Saberhagen Holdings*, 198 P.3d 493 (Wash. 2008) (holding that equipment manufacturers whose products were supplied with asbestos packing and gaskets had no duty to warn about replacement packing and gaskets, although they had a duty to warn of the original packing and gaskets); *Taylor v. Elliott Turbomachinery Co., Inc.*, 171 Cal. App. 4th 564 (2009) (adopting the holding of *Simonetta* and *Braaten*).

These cases are not Hawaii law, and are directly contrary to Hawaii public policy. Rather than providing the plaintiffs in those cases with maximum possible protection under the law, the Washington and California courts made a policy decision to shield defendant manufacturers from liability based on an imagined fear that "over-extending the level of responsibility could potentially lead to commercial as well as legal nightmares." *Taylor*,

171 Cal. App. 4th at 576.[1] However, this is not the policy of our state. As the *Simonetta* dissenters concluded, "to hold that [an equipment manufacturer] had no duty to warn of a serious hazard it knew or should have known was involved in the use of its product ignores logic, common sense, and justice." *Simonetta*, 197 P.3d at 139 (Dissent of Justice Stephens, joined by Justices Sanders and Chambers)

As Justice Debra Stephens of the Washington Supreme Court explained in her dissent in *Simonetta*, the rule adopted by the *Simonetta* majority is contrary to the basic policy goal of providing consumers with maximum protection against dangerous products:

> The paramount policy goal of strict liability is to place the cost of protecting product users on those in a better position to offer that protection. . . . Joseph Simonetta had an expectation that he would be warned of potential dangers associated with Viad's evaporator, and Viad was in a superior position to offer warnings about the dangers involved in the use of its product. I would hold that Simonetta established a prima facie case of negligence and strict liability against Viad and that his claims should proceed to trial.

Simonetta, 197 P.3d at 143 (Dissent of Justice Stephens)

Moreover, as Justice Stephens also noted, the policy arguments for shielding the equipment defendants from liability are fundamentally flawed:

> The majority appears to accept Viad's plea that if this court acknowledges a duty to warn here, the result will be unchecked liability for manufacturers who fail to warn about other products that may be used in conjunction with their own. For example, Viad asserts that were this court to hold that it had a duty to warn about the evaporator's use with asbestos insulation, then orange juice producers must warn about the dangers of mixing their product with vodka. The fallacy here is in disregarding the importance . . . of the manufacturer's knowledge of how its product will be used. Viad owes a duty to warn not because asbestos insulation *might happen to be used* in conjunction with its evaporator, but because such insulation was known to be necessary for the evaporator to function. Recognizing a duty in this instance will not broaden the duty of manufacturers to anticipate and warn of every conceivable use of their products. Instead, it is consistent with settled negligence law that imposes a duty to warn of 'the hazards involved in reasonably foreseeable uses of the product.'

Id. at 141 (emphasis in original)

[1] Plaintiffs also note that Judge Robert Dondero, the California judge who authored the *Taylor* decision, appears to have a predisposition against warnings to protect the public against dangerous products. In May 2006, Judge Dondero struck down an effort by California Attorney General Bill Lockyer to require tuna producers to warn consumers about the hazards of mercury in canned fish. Judge Dondero adopted the tuna companies' argument that the California warning was preempted by a less stringent FDA advisory. *People v. Tri-Union Seafoods*, 2006 WL 1544384 (Cal. Super. Ct. May 11, 2006), *appeal docketed*, No. A116792 (Cal. Ct. App. 1st Dist. Feb. 20, 2007). Judge Dondero's industry-friendly preemption analysis was specifically rejected by the Third Circuit in *Fellner v. Tri-Union Seafoods*, 539 F.3d 237 (3d Cir. 2007), and is entirely inconsistent with the U.S. Supreme Court's recent decision in *Wyeth v. Levine*.

Thus, there is no reason for this court to adopt *Simonetta, Braaten,* and *Taylor* as Hawaii law. The decisions in these cases do not serve the "public interest in human health and safety" that forms the underlying basis of product liability law in our state. *Stewart*, 52 Haw. at 74. On the contrary, to adopt such a rule here would leave injured plaintiffs without recourse for the injuries they sustained when they were exposed to asbestos while working on Defendants' equipment.

B. Under Hawaii Law, Defendants Had a Duty to Make Their Equipment Safe for Use by Giving Workers Adequate Warnings of the Inherent Danger of Asbestos Exposure

It is well-settled that under Hawaii law, a manufacturer owes a duty to warn users about all non-obvious dangers that are inherent in the foreseeable use of the product. A product may be considered defective "even if flawlessly made, if the use of the product in a manner that is intended or reasonably foreseeable . . . involves a substantial danger that would not be readily recognized by the ordinary user of the product and the manufacturer fails to give adequate warnings of that danger." *Masaki v. General Motors Corp.*, 71 Haw. 1, 22 n.10 (1989).

As our Supreme Court explained in *Ontai v. Straub Clinic & Hosp.*, 66 Haw. 237, 248 (1983),

> A duty to warn actually consists of two duties: One is to give adequate instructions for safe use; and the other is to give a warning as to dangers inherent in improper use.

Ontai, 66 Haw. at 248.

The *Ontai* Court made it clear that in order to make its product safe for use, a manufacturer has a duty to give users all the instructions that they reasonably need to ensure that the product can be used without injury. This includes warnings about all hazards that are inherent in the anticipated uses of the product, including foreseeable misuse.

Thus, the Court in *Ontai* held that General Electric was liable for the injuries sustained by a Straub patient who fell off a GE X-ray table when the footrest gave way, because GE had not adequately instructed the Straub technicians who operated GE's equipment how to safely install the footrest and had failed to warn the technicians about the dangers inherent in improper installation. The Court further explained that even if the plaintiff's injuries were partly caused by the negligence of the Straub technicians, "General Electric should not be allowed to

escape liability if the risk to which Ontai was exposed was unreasonable and foreseeable by G.E." *Id.*

Likewise, in *Masaki v. General Motors Corp.*, 71 Haw. 1 (1989), the Court held that GM could be liable for the injuries sustained by an auto mechanic who was crushed by a GM vehicle, in part because GM had failed to provide a warning system to alert mechanics of the dangers of exiting the vehicle without latching the gear shift in park. The *Masaki* Court upheld the following jury instruction as a correct statement of Hawaii law:

> The third test is that the product is defective in design even if faultlessly made, if the use of the product in a manner that is intended or reasonably foreseeable including reasonably foreseeable misuses, involves a substantial danger that would not be readily recognized by the ordinary user of the product and the manufacturer fails to give adequate warnings of the danger.

Masaki., 71 Haw. at 22 n.10 (1989).

Here, Defendants equipment was intended to be installed on marine vessels with asbestos gaskets and/or packing already inside, and then covered with asbestos insulation which was necessary for the equipment to function. Defendants knew that their equipment would be insulated with asbestos, and they specified and supplied asbestos gaskets and packing. This use of asbestos in Defendants' products was not merely a foreseeable use, but an intended use.

Once installed on the ship, Defendants were well-aware that their equipment would undergo periodic maintenance and repairs. Defendants also knew or should have known that when their equipment was repaired or overhauled, the operators and maintenance workers would have to strip and replace the asbestos insulation, gaskets and/or packing, and would necessarily be exposed to potentially deadly asbestos dust in the process. Thus, the reasonably foreseeable repair and maintenance of defendants' equipment involved a substantial danger that would not be readily recognized by the ordinary workers who were servicing Defendants' products.

Under the Hawaii law set forth in *Ontai* and *Masaki*, therefore, Defendant equipment manufacturers had a duty to: 1) provide Plaintiffs with adequate instructions for the safe operation and repair of their equipment, including instructions to take precautions while working with asbestos components; and 2) warn Plaintiffs about the inherent danger of exposure to asbestos fibers each time workers ripped out asbestos insulation, packing, and gaskets from Defendants' equipment during routine maintenance.

While Defendants' equipment might have been faultlessly made, it was not reasonably safe for its intended use, because Defendants failed to warn the Pearl Harbor workers that they would be exposed to toxic asbestos dust virtually every time the equipment was overhauled or repaired. Thus, under well-settled Hawaii product liability law, the absence of warnings or instructions about the hazards of asbestos rendered the Defendant's products defective.

C. Defendants' Arguments About the "Products of Others" Are Fundamentally Misplaced

Despite the Hawaii law and public policy cited above, Defendants argue that they had no legal duty to instruct Pearl Harbor workers to take precautions against asbestos exposure while working on Defendants' equipment, because "a manufacturer has no duty to warn about another manufacturer's product." [*See, e.g,* Defendant Warren Pumps' Motion for Summary Judgment at 13]. However, this argument is fundamentally misplaced. The hazards of asbestos exposure were inherent in the normal use of the Defendants' *own* products on U.S. Navy vessels. Under Hawaii law, Defendants had a corresponding responsibility to warn of those hazards. As the dissenting Justices of the Washington Supreme Court explained in *Simonetta,* Defendants' "extended discussion of the ersatz duty 'to warn of the hazards of another manufacturer's product,'" merely "obscures the issue and introduces confusion into otherwise settled product liability law." *Simonetta,* 197 P.3d at 139 (Dissent of Justice Stephens).

1. Defendants Had a Duty To Warn About the Inherent Danger of Asbestos Exposure When Their *Own* Products Were Used as Intended

First, Plaintiffs are not asking the court to impose an "ersatz duty 'to warn of the hazards of another manufacturer's product.'" *Simonetta,* 197 P.3d at 139 (Dissent of Justice Stephens). On the contrary, Plaintiffs merely ask the court to recognize Defendants' well-established duty to provide adequate instructions for the safe use of their *own* equipment, including warnings about the dangers of asbestos exposure that was certain to occur during routine repair and maintenance. As the *Simonetta* dissenters correctly noted, "recognition of [the] duty in this case follows from the application of **settled legal principles** to this new set of facts." *Id.* (bold emphasis added here and throughout)

As the dissenting justices explained in *Simonetta*, the duty to warn here is quite straightforward:

> Here, the use of Viad Corporation's evaporator required insulation, which in the 1950s in navy distilling units, was asbestos-containing insulation. Routine maintenance of the evaporator exposed users to aspirable asbestos. Thus the simple answer to the question of whether Viad owed Joseph Simonetta a duty in this case is yes.

Id. at 138.

Thus, Viad had a duty to warn about asbestos insulation and gaskets under a negligence theory, because Viad knew that the equipment could not function without the use of asbestos:

> The focus under § 388 is on dangers involved in the *use* of a product. **Simply put, the duty to warn contemplates that a product will *actually be used*. The hazard of exposure to aspirable asbestos was integral to the ability to use Viad's evaporator**, given that the unit could not function without insulation and service of the unit required periodic removal and replacement of the necessary insulation. Viad's argument, accepted by the majority, imagines that we are dealing with a perfect platonic form of an evaporator rather than the functional product. Once a manufacturer releases a product for use, its duty of reasonable care under negligence law includes "a duty to warn of hazards involved in the use of a product which are or should be known to the manufacturer."

Id. at 140 (italics in original).

Justice Stephens explained that Viad also owed a duty to warn about asbestos under a theory of strict liability, because the evaporator was not reasonably safe for use without a warning about the *inherent* danger of asbestos exposure during routine maintenance:

> Whether the evaporator functioned as designed is not the issue, of course, as a product may be unreasonably dangerous in the absence of adequate warnings notwithstanding that it is not itself "defective." . . . **[T]he focus of the inquiry under §402A is on the warnings required to make the evaporator reasonably safe, including what a reasonable user would expect to be told about the dangers inherent in the use of the evaporator.** This inquiry does not allow for the artificial segregation of the evaporator from the asbestos insulation that Simonetta necessarily encountered in order to use the product. Viad does not suggest that Simonetta's maintenance of the evaporator was not a foreseeable use. Thus the question is simply whether the risk of exposure to aspirable asbestos during required maintenance of the evaporator is a risk inherent in the *use* of the product. Based on the record in this case, the Court of Appeals properly concluded that it was. I would affirm that conclusion and recognize a duty here.

Id. at 140 (italics in original).

Finally, Justice Stephens addressed the majority's contention that Viad did not have a duty to warn about the dangers of asbestos used on its equipment, because it had not actually supplied the asbestos insulation, gaskets, and packing in use at the time of plaintiff's

exposure. Justice Stephens explained that the majority had improperly "redefin[ed] the product at issue." She explained that:

> This entire discussion of the chain of distribution, which is the core of the majority's negligence analysis, is unnecessary. The product at issue is Viad's evaporator, not the insulation. . . . When the evaporator is properly the focus of the inquiry, the majority's arguments regarding the chain of distribution have little relevance. It is undisputed that the evaporator was in Viad's chain of distribution.

Id. at 141.

Justice Stephens further explained that:

> Rather than addressing the facts of this case according to the standard for strict liability under 402A, the majority again shifts focus to the wrong product, suggesting that the Court of Appeals' decision holds Viad strictly liable for defects in asbestos products made by another. But Viad's duty under §402A, as under a negligence theory, is to warn of hazards associated with the use *of its own product*, the evaporator.

Id. at 142 (emphasis in original).

Thus, numerous courts have held that equipment manufacturers have a duty to warn of dangers of asbestos insulation, gaskets, and packing, even where the asbestos was manufactured or supplied by another. *See, e.g., Sether v. Agco Corp.*, 2008 WL 1701172 (S.D. Ill. 2008) ("To the extent GE seems to argue that it owed no duty to warn, the Court does not agree. According to GE, it manufactured marine steam turbines without any thermal insulation material on them and shipped the turbines with only a coat of paint on the surface of the metal, so that any thermal insulation material would have been supplied and installed by the shipbuilders at the shipyard. **It is well settled, of course, that a manufacturer of a product has a duty to provide those warnings or instructions that are necessary to make its product safe for its intended use**."); *Chicano v. General Electric*, 2004 U.S. Lexis 20330 (E.D. Penn 2004)("There is at least a genuine issue of material fact as to whether GE could be expected to foresee that the asbestos-containing material would be used to insulate its turbines. Therefore, GE's duty to warn may not be limited because it knew of the danger from asbestos-containing insulation, which it neither manufactured nor assembled with its turbine."); *Lindquist v. Buffalo Pumps*, 2006 R.I. Super LEXIS 168 (2006)("The Court finds that this case contains triable issues of fact in relation to Buffalo's duty to warn of the dangers posed by the asbestos gaskets and packing used in its pumps."); *Berkowitz v. A.C. & S. Inc.*, 288 A.D. 2d 148, 733 N.Y.S. 2d 410

(2001)("Nor does it necessarily appear that Worthington had no duty to warn concerning the dangers of asbestos that it neither manufactured nor installed in its pumps.")

Likewise, in *Tellez-Cordova v. Campbell*, 129 Cal. App. 4th 577, 28 Cal. Rptr. 3d 744 (2004), a tool manufacturer had a duty to warn end users that using its high power tools to grind discs, belts and wheels can cause pulmonary fibrosis lung disease from the metallic dust grinding off the discs, bolts and wheels, i.e., dust from products which the tool company did not sell. The court explained that the defendant in that case had a duty to warn about the metallic dust, because "it was not happenstance that the tools were used in conjunction with other products, but . . . use with the specified wheels, discs, and grinders was the inevitable use." *Tellez-Cordova*, 129 Cal. App. 4th at 584. Thus, the court explained, "respondents are not asked to warn of defects in a final product over which they had no control, but of defects which occur when their products are used as intended--indeed, under the allegations of the complaint, as they must be used." *Id.* at 583.

This is also analogous to the non-asbestos case of *Ilosky v. Michelin Tire Corp.*, 172 W.Va. 435, 307 S.E.2d 603 (1983). In this case, Michelin sold a non-defective radial tire. However, it failed to warn about the foreseeable use of its non-defective tires when used in conjunction with another product. In that case, using radial tires on the front axle and conventional tires on the rear axle creates the danger of over steering. This jury instruction was approved by the court:

> The seller of a product has a duty to:
>
> 1. Warn that the product, even if harmless or safe in itself, is, when mixed or used in conjunction with another product, dangerous or potentially dangerous to users, where it is reasonably foreseeable that uninformed users may mix the products.

Ilosky, 307 S.E.2d at 610 n. 6

2. There Is No Logical Reason that Defendants' Duty to Warn Should Be Limited to the Original Asbestos that Was First Placed on Their Equipment

Second, Defendants argue that under *Braaten* and *Taylor*, an equipment manufacturer has no duty to warn workers about the hazards of asbestos exposure unless Plaintiffs can prove that they were exposed to the original "asbestos that was first placed on the

[equipment] by [the manufacturer] or by the U.S. Navy." [*See, e.g.* Defendant William Powell's Motion for Summary Judgment at 5.]

However, this limitation on the duty to warn is simply illogical. There is no reason to hold that the manufacturer had a duty to warn workers about the hazards of asbestos exposure from the original insulation, packing, and gaskets used on its equipment, but no duty to warn about identical replacement components. As the *Braaten* dissenters correctly pointed out, Defendants' argument "disassociates the manufacturers from the replacement packing and gaskets necessary to the use of their products simply because they did not manufacture the replacement parts. . . . [T]his is a false disassociation under both negligence and strict liability." *Braaten*, 198 P.3d at 505.

Under Defendants' proposed rule, at the time the equipment was shipped, the manufacturer *would* have been under a legal duty to warn workers about the hazards in the original asbestos insulation, gaskets, and packing, and instruct the workers to take appropriate safety precautions when stripping and replacing those original asbestos components. However, this legal obligation would have somehow evaporated after the first time the equipment was repaired. There is no logical reason that defendant's duty to warn should be limited in this fashion.

On the contrary, the defendant's duty to warn is premised upon the fact that defendants knew that the original asbestos insulation, gaskets, and packing would regularly be stripped from their equipment and replaced with identical asbestos components during routine maintenance and repair, and that workers would be exposed to asbestos in the process. Thus, in order make their equipment safe for use, Defendants had a duty to warn workers to take precautions against asbestos *each* time their equipment was repaired or maintained. This duty did not disappear after the equipment was repaired or overhauled for the first time.

3. ***Both*** **the Equipment Manufacturers and the Asbestos Manufacturers Had a Duty to Warn about Asbestos**

Finally, the equipment manufacturers implicitly argue that only the asbestos manufacturers had a duty to warn about asbestos. Defendants argue that they cannot be held legally responsible for Plaintiffs' asbestos disease, because they contend that the true cause of Plaintiffs' injuries was the "release of asbestos from products manufactured by others," and that Defendants' equipment did not in any way cause or create the risk of harm. Thus, in the view of

the equipment manufacturers, they have no legal responsibility for the foreseeable injuries that Plaintiffs sustained when they were exposed to asbestos while working on Defendants' equipment. However, this argument is both factually and legally flawed.

In fact, Defendants' products did contribute the risk of harm here. Plaintiffs were not exposed to asbestos merely because asbestos insulation, gaskets, and packing happened to be present on U.S. Navy vessels. Rather, those asbestos products had to be installed on Defendants' valves, pumps, and turbines to allow them to function in the marine environment. Some of Plaintiffs' heaviest asbestos exposures occurred during the repair and maintenance of Defendants' equipment, when ship personnel and shipyard workers had to rip out asbestos insulation, gaskets, and packing from Defendants' valves, pumps and turbines in order to service them. Defendants' products could not be used on U.S. Navy vessels without these asbestos components, and Plaintiffs could not work on the equipment without releasing dangerous asbestos fibers into the air. Thus, in a very real sense, the equipment manufacturers' products were also responsible for Plaintiffs' exposure.

Moreover, the law clearly recognizes that an injury may have multiple causes, and there may be multiple parties who are legally responsible. As the Hawaii Supreme Court held in *Ontai*, "even though Piscusa may have been negligent in attaching the footrest to the X-ray table, his negligence in and of itself would not necessarily exempt G.E. from liability for Ontai's injuries. This court has held that a third party's negligence is not a defense unless such negligence is the sole proximate cause of the plaintiff's injuries." *Ontai*, 66 Haw. at 248-249. Here, as the *Simonetta* dissenters correctly noted, "[t]here may be multiple proximate causes of an injury, so the fact that the asbestos manufacturers' failure to warn also caused Simonetta's injury has no bearing on whether Viad owed a duty." *Simonetta*, 197 P.3d at 142 (Dissent of Justice Stephens).

Finally, it is well-settled that the manufacturer's duty to warn is non-delegable. A manufacturer has a duty to give warnings in such a manner that is calculated to reach the ultimate end-users of its products. *See Johnson v. Raybestos-Manhattan,* 69 Haw. 287, 288 (1987); *Johnson v. Raybestos-Manhattan,* 829 F.2d 907 (9th Cir. 1987) (Hawaii law). Thus, "[w]hile it is certainly true that the asbestos manufacturers also could have warned about the dangers of their insulation, this does not negate Defendants' duty." *Simonetta*, 197 P.3d at 143 (Dissent of Justice Stephens).

D. Defendants' Case Law Is Not On Point

The principal Hawaii case on the duty to warn cited here is *Acoba v. General Tire, Inc*., 92 Hawai'i 1 (1999). In that case, the plaintiff had personally received every possible warning he could on how to work with multi-rim assemblies. As explained by the Hawaii Supreme Court, "Shimabuku testified by deposition that he told [plaintiff] Romero not to use the worn lock ring and to wait for a replacement. Shimabuku located a replacement and radioed Romero. He again told Romero not to use the old lock ring and that the replacement would be delivered to him." *Acoba*, 92 Hawai'i at 5.

As the *Acoba* Court explained, the manufacturer had met its duty to warn.

> The undisputed facts show that [Firestone] carried its burden of producing evidence of the absence of breach [of duty]. In its motion for summary judgment, Firestone submitted a copy of its **52-page safety and service manual** sent to Ken's Tire [plaintiff's employer] in 1987. The manual contained specific information in instructing and warning tire service people to discard deteriorated, rusty, cracked or distorted rim components. It warns that use of "bent flanges . . . may lead to explosive separation during inflation." It also cautions that "assembling damaged parts is extremely dangerous . . ." The manual also provides pictures and examples of different types of damage, rusted, cracked, eroded, . . . rims and **specifically warns of the risk of failing to use proper safety equipmen**t. It also states prominently on its cover that federal OSHA regulations "require all employers to make sure their employees who service wheels/rims understand the safety information contained in this manual. . . ."
>
> Firestone further met its burden through its submission of deposition testimonies of Edward Shimabuku, a Ken's Tire supervisor and Blake Higashi, a former general manager of Ken's Tire, stating that Ken's Tire had received the Firestone manual and that instructional charts were mounted on the repair shop's walls. Higashi also testified that Ken's Tire regularly held safety meetings for its employees during which Romero and other employees were instructed about proper safety and maintenance procedures for use of multi-piece tire rims.

Acoba, 92 Hawai'i at 15-16. Thus, it defies explanation how the plaintiff could have been better warned about the danger of multi-piece tire rims. If the plaintiff is warned, then the duty to warn has been discharged. *See Tabieros v. Clark Equipment Co*., 85 Hawai'i 336, 371 (1997) ("Clark could not be liable to the plaintiffs in this case by virtue of having failed to warn Tabieros of a danger of which he was already aware"). In contrast, the evidence is undisputed that Plaintiffs and their co-workers at Pearl Harbor were never warned of the dangers of asbestos.

Defendants could try to seize upon the fact that the *Acoba* Court found that "under the circumstances of this case," the inner tube manufacturer or tire manufacturer did not have to warn about the defective multi-piece tire rims. *Acoba*, 92 Hawai'i at 18. However, the

circumstances of *Acoba* were very different from the circumstances here. Unlike Plaintiffs here, the *Acoba* plaintiff was thoroughly warned. Moreover, there was no evidence in *Acoba* that the dangers of using an old, rusty multi-rim assembly were inherent to the use of the inner tube and tires manufactured by the defendants. On the contrary, there was no indication that the plaintiff's decision to use an old, defective multi-piece rim assembly was even reasonably foreseeable to the tire and inner tube manufacturer. The accident in *Acoba* happened in 1992 and "the rim assembly consisted of two components, a Firestone type RHT5 . . . rim base manufactured in 1952 and a Firestone type RIT lock ring manufactured in 1940." *Id.* at 5. It is hard to fathom how an inner tube manufacturer selling a product in 1990 would know its product would be put on a defective multi-piece rim that was manufactured 40 and 50 years earlier.

This is in contrast to marine equipment which Defendants knew had to be insulated with asbestos. In this case, Defendants specified and sold asbestos gaskets, packing and/or insulation with their equipment. This factually distinguishes the *Acoba* case. Moreover, Defendants grossly over-read the holding in *Acoba*. In fact, the Hawaii Supreme Court reaffirmed that:

> In this jurisdiction, a manufacturer has a two-fold duty to provide (1) adequate instructions for safe use of the product; and (2) warnings as to the dangers inherent in improper use of the product.

Acoba, 92 Hawai'i at 15. Foreseeable end-users such as the Shop 38 machinists, were not given adequate instructions by the manufacturer for the safe use of marine equipment nor were they warned as to the dangers inherent in the foreseeable use of Defendants' products.

Powell v. Standard Brands, 166 Cal. App. 3d 357, 212 Cal. Rptr. 395 (1985), is likewise completely distinguishable. *Powell* held one paint thinner manufacturer did not have a duty to warn regarding injuries caused by another paint thinner manufacturer. This is the same as holding that Ingersoll-Rand has no duty to warn regarding injuries caused solely by Goulds pumps. *Powell* merely rejected market share liability under *Sindell v. Abbott*, 26 Cal. 3d 588 (1980). (*Powell*, 212 Cal. Rptr. at n2 & 398-399).

Finally, Defendants cite *In re Deep Vein Thrombosis*, 356 F. Supp. 2d 1055 (N.D. Cal. 2005), which is similarly inapplicable. In *Deep Vein Thrombosis*, Boeing sold its aircraft to several airlines with no installed seating, and the airlines selected an allegedly defective seat design from a different manufacturer. The plaintiffs there argued that Boeing had a duty to: 1)

warn its airline customers about the hazards of unsafe seat design; 2) identify manufacturers of unsafe seats; 3) recommend a safer alternative seating design; and 4) identify the manufacturers that made the safer seats. *Deep Vein Thrombosis*, 356 F. Supp. 2d at 1067. Under those circumstances, the court held that Boeing was not required to advise its customers about "potentially defective additional pieces of equipment that the purchaser *may or may not* use to complement the product bought from the manufacturer." *Deep Vein Thrombosis*, 356 F. Supp. 2d at 1068 (emphasis added). The court likewise found that Boeing had no legal duty to warn airline passengers that the airline "*may or may not* have supplemented the manufacturer's completed product with an allegedly defective piece of equipment," since there was no indication that Boeing had any reason to know "(1) what seat manufacturer Delta chose and (2) whether the seats actually installed are somehow defective." *Id.* (emphasis added). [2]

This is very different from the situation here. Plaintiffs do not ask the court to hold that Defendants have a duty to become experts in every product that *might* be used in conjunction with their own equipment. Nor do Plaintiffs ask that Defendants to conduct a post-sale inspection of their equipment to ensure that their customers do not ultimately choose to supplement their purchase with some other product that might prove defective. Rather, Plaintiffs argue that under the facts here, Defendants had a duty to warn workers who operated and repaired their equipment to take precautions against exposure to asbestos - a toxic substance that Defendants knew would *necessarily* be used with their equipment, and which Defendants themselves specified and supplied to their customers.

III. THE FACTUAL RECORD

Finally, Defendants' duty to warn about asbestos must be analyzed in light of the actual facts of this case. Attached as Exhibits A - LL is a selection of historical documents produced by Defendants in discovery or obtained by Plaintiffs in government archives. These documents clearly indicate that Defendants knew that shipyard personnel and Navy seamen would regularly be exposed to asbestos while repairing and maintaining their equipment. The

[2] The court also questioned the good faith of the plaintiffs' claims, noting that plaintiffs' counsel had previously represented to the Judicial Board on Multi-District Litigation that "if the plane manufacturer [Boeing] did not manufacture or install the seat, we have stipulated to summary judgment in those cases." *Id.* at 1063-64. The court also noted that "in their complaints, plaintiffs assert that the airlines, as well as the 'airline industry generally, had actual knowledge of the risk to passengers of contracting DVT during lengthy flights.' . . . . In trying to impose liability on Boeing, however, plaintiffs characterize the airlines and the airline industry as uninformed and unsophisticated about the risk of DVT." *Id.* at 1068.

documents also show that while Defendants failed to warn workers about asbestos, they routinely instructed workers how to safely work with hazardous substances that Defendants did not supply or manufacture where they knew workers were likely to be exposed to those substances during the regular maintenance and repair of their equipment.

The factual record shows that Defendants knew that their equipment would contain asbestos insulation, gaskets, and/or packing, because the equipment required these asbestos components in order to function as intended on U.S. Navy vessels. This is evidenced by the fact that Defendants actually specified and/or supplied asbestos for use with their equipment. In most cases, defendants shipped their equipment with asbestos packing and gaskets already in place, and they frequently supplied replacement packing and gaskets as a spare part. Defendants also routinely specified the use of asbestos gaskets and packing in their technical manuals, parts lists, and drawings. Certain defendants also supplied asbestos insulation to their commercial and Navy customers; provided insulation drawings that called for asbestos insulation; and included directions about insulation in their manuals.

The factual record also shows that Defendants knew that the asbestos on their equipment would have be stripped and replaced during routine repair and maintenance. In fact, Defendants' equipment manuals frequently instructed operators and maintenance personnel how to remove and replace asbestos gaskets and packing, and at times also specifically noted the need to remove or apply insulation and lagging. They simply failed to warn workers to take precautions against asbestos exposure while doing so.

Finally, the factual record shows that equipment manufacturers routinely warned workers about other toxic substances that Defendants neither manufactured nor supplied, such as carbon tetrachloride, caustic soda, sulfamic acid, and benzene. Thus, there is nothing far-fetched about the idea that Defendants had a duty to warn about asbestos that was supplied by other manufacturers. On the contrary, such warnings were standard practice in the industry.

A. Aurora Pumps

Exhibits A and B make it clear that Aurora Pumps knew and intended that the workers maintaining their pumps would be exposed to asbestos. Exhibit A is an excerpt from an Aurora Pumps Technical Manual for Fire, Flushing and Emergency Bilge Pumps supplied to the

U.S. Navy. Exhibit B is a 1965 Aurora Pumps Bulletin for Type GB pumps supplied to commercial customers.

The Aurora manual attached as Exhibit A contains extensive information about asbestos packing and gaskets. On page 1-3 of the manual, Aurora instructs maintenance personnel that the packing box of the pump should be filled with "braided asbestos impregnated with a sealing ingredient and graphite which serves as a lubricant." [Exhibit A at WAL-4020] On page 4-1, Aurora makes it clear that Aurora provided the original asbestos packing, stating that: "Pumps leaving our plant are packed and lubricated ready for use." [Exhibit A at WAL-4024] Aurora Pump Drawing 2HCS-207 also indicates that Aurora supplied extra sets of Garlock asbestos packing as a replacement part, which are included in the list of "Onboard Repair Parts" as "Extra Spares." [Exhibit A at p. WAL-4032, 4033]

On page 4-1 of the manual, Aurora gives extensive, detailed instructions for the removal and replacement of this asbestos packing, but does not include any type of asbestos warning:

> [W]hen a pump is to be repacked, the following procedure must be followed. The packing used is long fibre asbestos, square braided, and well impregnated with oils and graphite, and should be similar to Garlock #234. (Mll-P-17577 Type 1-1103).
> When repacking the pump, refer Figure 5-3, proceed as follows: (1) Remove all packing from the stuffing box. Clean the stuffing box and shaft thoroughly so that it is free from dirt, oil or grease. (2) Cut off ring of 3/8 square packing slightly larger than the size of the shaft on which it is to be used. (Make butt joints, not lap joints, with each ring). Then force the ring to the base of the stuffing box. Be sure the joint is butted and not overlapped. Tamp the ring so that it forms a perfect fit around the shaft. Install each ring separately with butt joints staggered around the shaft and tamp each ring so that it is formed to the stuffing box. After 2 rings have been installed, insert the lantern ring. Completely fill the stuffing box by installing 4 more rings of packing, then draw up the gland sufficiently to set the packing. (3) Release the packing gland nuts until they can be turned with the fingers.

[Exhibit A at WAL-4024]

Exhibit A also indicates that Aurora provided asbestos gaskets with its pumps. Asbestos gaskets are listed in the Lists of Materials on Aurora Drawings 2FCS-218, and 2FCS-217. [Exhibit A at WAL-4035 - 4037]. Asbestos gaskets are also included in the "List of Materials II: Quantities for One Unit" among the "Online Repair Parts" listed in Aurora Pump Drawing 2HCS-207. [Exhibit A at WAL-4033].

The Aurora Pumps Bulletin attached as Exhibit B makes it clear that Aurora also routinely supplied asbestos packing to its commercial customers, stating that "[w]hen requested, GB pumps are supplied with packing rings." [Exhibit B at A0021]. Aurora specified that this

packing would be asbestos, and made it clear that the pumps were actually designed to use asbestos:

> The stuffing box is designed for die-molded graphited packing. Long strands of interwoven asbestos form the backbone of the general service type packing.

Id.

B. Buffalo Pumps

Exhibits C through E demonstrate that Buffalo Pumps knew and intended that workers maintaining their equipment would be exposed to asbestos. Exhibit C is a compilation of Buffalo Pumps insulation drawings prepared for the U.S. Navy, and produced to Plaintiffs in the Tucker case. Exhibit D is a 1968 Equipment Manual for Buffalo Pumps distiller pumps on DE-1052 class vessels. Exhibit E is an excerpt from a Centrifugal Pump Application Manual, published by Buffalo Pumps in 1959 for general use by engineers.

In the insulation drawings attached as Exhibit C, Buffalo Pumps gave detailed instructions about the use of asbestos insulation and lagging on its feed pumps, drain pumps, and booster pumps on U.S. Navy vessels during the 1930s and 40s. For example, BPI-Tucker 000091 specifies that feed water drain booster pumps on cruisers should be insulated with 85% magnesia, to be applied approximately 1/2” thick around the suction and 1 1/2" thick around the pump casing, except the parts exposed for disassembly. BPI-Tucker 000092 though 000094 include similar instructions for feed pumps on destroyers. While BPI-Tucker 000098 through 000105 make it clear that the asbestos insulation itself was provided by the shipyard, Buffalo Pumps specified the use and application of the insulation, and Buffalo Pumps was clearly well-aware that its pumps on Navy vessels would be insulated with asbestos.

The excerpts from the Buffalo distiller pump manual attached as Exhibit D also makes it clear that Buffalo actually supplied its pumps to the Navy with asbestos packing and gaskets, and gave workers detailed instructions on how to remove and replace those asbestos components. Exhibit D indicates that Buffalo supplied the pump with asbestos packing installed:

> The pump casing contains an inboard and outboard stuffing box. The outboard stuffing box contains five rings of graphite asbestos packing conforming to Military Specification MIL-P-17303 . The inboard stuffing box has six rings of packing.

[Exhibit D at BPI-07.08-Hawaii 000032]

Exhibit D further indicates that Buffalo was well-aware that this asbestos packing would periodically need to be removed and replaced. Buffalo gave workers detailed instructions

on how to work with the asbestos packing, even including a "CAUTION" that they should not use bulk packing or cut packing on the shaft. However, Buffalo did not warn workers to protect their own health against the toxic properties of asbestos:

> Packing. (See figure 2-6-2) . Excessive leakage at the stuffing boxes that cannot be eliminated by taking up on nuts (13B) will require repacking the pump.
> . . . .
> 2. Remove all old packing from the stuffing box using care not to damage the shaft sleeves . Remove seal cage halves (14A).
> CAUTION: Always completely repack the pump with new packing (66) . Do not use bulk packing or cut packing on the shaft.
> . . . . .
> 4. Use five rings of pre-cut packing for the outboard stuffing box and six rings for the inboard stuffing
> 5. Install one ring of packing (3/8 inch square per Military Specification MIL-P-17303), graphite asbestos on shaft . "Walk" packing onto shaft by separating ends along shaft. Never attempt to pull ends apart.

[Exhibit D at BPI-07.08-Hawaii 000042.]

Exhibit D likewise demonstrates that Buffalo supplied its pumps with asbestos gaskets, as indicated on the Pump List of Materials included in the manual at BPI-07.08-Hawaii 000047. Buffalo also instructed workers on the removal and replacement of these gaskets as follows, but again neglected to include a safety warning about asbestos:

> Gaskets . Renew gaskets after each disassembly if inspection shows gaskets to be cracked or damaged . Gasket seating surfaces should be thoroughly cleaned and inspected for damage . Coat both sides of the gaskets with graphite and oil before replacing the gaskets.

[Exhibit D at BPI-07.08-Hawaii 000050.]

Finally, the excerpts of a Centrifugal Pump Application Manual attached as Exhibit E make it clear that Buffalo Pumps knew and intended that asbestos would be used in its pumps even outside the Navy context. Buffalo's Manual made it clear that "conventional packing" for centrifugal pumps at that time consisted of "rows of asbestos containing various lubricants." [Exhibit E at Manual-000093.] Moreover, Buffalo gave detailed information about ten different types of asbestos packing that it recommended for use with its pumps in various applications, including three types of blue asbestos packing. [Exhibit E at Manual-000094].

C. Cleaver Brooks / Aqua-Chem

Exhibits F through J demonstrate that Cleaver-Brooks/Aqua-Chem routinely warned workers to take safety precautions against hazardous substances that were supplied and manufactured by others, where the workers would be exposed to those substances during routine

maintenance of Cleaver-Brooks products. These exhibits also demonstrate that Cleaver-Brooks / Aqua-Chem instructed maintenance workers to install, inspect, and replace insulation and other asbestos components on their distillers and boilers, but did not warn about the hazards of asbestos.

Exhibit F is an excerpt from a 1959 Aqua-Chem manual for a Flash-Type Distilling Unit on cargo vessels. In this manual, Aqua-Chem instructed maintenance workers that the distiller's heat transfer tubes could be cleaned either manually or with a weak acid solution. Aqua-Chem explained that acid cleaning was effective, but warned that "special equipment is required, and great care should be exercised when working with acid to prevent injury to personnel." Aqua-Chem went on to provide detailed, specific instructions about the safety precautions that workers should take to avoid dangerous acid exposure while servicing Aqua-Chem's distillers:

> Acid Cleaning safety Precautions
> 1. All personnel working with or near acid should wear protective clothing consisting of face shield or goggles, rubber gloves, and rubber apron. Care should be taken to avoid inhalation of acid fumes.
> 2. Acid should always be added to water - water added to acid may cause dangerous spattering.·
> 3. Acid spilled on the person or other object should be promptly washed with large quantities of fresh water.

[Exhibit F at Manual-000392]

Cleaver-Brooks provided an even more detailed warning about the hazards of acid in its 1961 manual for Flash-Type Distilling Units, excerpts of which are attached as Exhibit G. In the 1961 manual, Cleaver-Brooks again warned all workers in the area to wear protective clothing and avoid inhaling acid fumes. In addition, Cleaver-Brooks advised workers who inhaled the fumes to seek medical attention immediately, thereby underscoring the seriousness of the danger and giving workers additional information about how to protect themselves against the hazards of acid exposure:

> Acid Cleaning Safety Precautions
> 1. All personnel working with or near acid should wear protective clothing consisting of face shield or goggles; rubber gloves, and rubber apron.
> 2. Acid should always be added to water – water added to acid may rouse dangerous spattering.
> 3. Any person who inhales acid fumes should be withdrawn from the contaminated. area immediately and taken to fresh air. If exposure was' of any consequence, secure a physician. Place exposed person on his back with feet slightly elevated until physician arrives.
> 4. Acid spilled on e person or other object should be promptly washed with large quantities of fresh water. Affected skin areas should then be washed with lime water or covered with a lime paste. Resulting burns should be treated by physician as soon as possible.

[Exhibit G at Manual-000514]

Cleaver-Brooks' 1961 manual also advised maintenance workers to insulate the distiller's air ejector steam line as protection against wet steam in the evaporator. [Exhibit G at Manual-000527] Here, however, Cleaver-Brooks failed to warn workers to use any protective clothing or take any safety precautions when applying asbestos insulation to the distiller.

Aqua-Chem again provided extensive warnings about acid but failed to warn about asbestos in its 1974 manual for a Marine Flash Distilling Plant, excerpts of which are attached as Exhibit H. The 1974 manual instructed workers to avoid dusting powdered acids, to ensure that the area was well-ventilated, to use a variety of safety equipment, and even to put up warning signs in the area to alert other workers of the danger. Indeed, Aqua-Chem even included a special Technical Bulletin on the hazards of acid as an insert to the manual:

> SAFETY PRECAUTIONS
> A. Always add to acid to water, slowly and carefully to avoid spattering. Never add water to concentrated acid
> B. Avoid "dusting" of powdered acids
> C. Insure that all gases generated during cleaning operation are vented to weather
>
> SAFETY EQUIPMENT
> A. Safety clothing - foul weather gear is desirable In its absence, wool clothing is recommended
> B. Safety goggles
> C. Safety hats
> D. Rubber footwear. If boots are used trouser legs should be outside the boot tops
> E. Signs: "DANGER – ACID" and "NO SMOKING"

[Exhibit H at Manual-000591, 595]

Again, however, Aqua-Chem failed to provide any such warning about the hazards of asbestos insulation, although it clearly instructed that "all heated surfaces must be adequately insulated to prevent injury to personnel." [Exhibit H at Manual-000563] Aqua-Chem did not inform workers that they should protect themselves against asbestos exposure when they were instructed to "insulate ejector steam lines" and inspect the evaporator shell for "insulation discoloration" in order to check for leaks. [Exhibit H at Manual-000567, 609].

Likewise, in its 1965 manual for a Model C-B land-based boiler, excerpts of which are attached as Exhibit I, Cleaver-Brooks properly warned workers to take safety precautions when using caustic soda or soda ash to boil out a new boiler unit:

> When dissolving chemicals, the chemical should be added to the water. NEVER ADD WATER TO THE CHEMICALS! . . . .The heat created and resultant boiling when chemical is added to the water must be kept under control to prevent excessive turbulence and possible injury to personnel. For that reason, only small amounts of chemical should be added at any one time.
>
> CAUTION!

> Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals.

[Exhibit I at MPS_52494, 52531]

.

However, Cleaver-Brooks failed to provide any such warning when instructing workers to apply asbestos rope and asbestos cement to the rear door of the boiler's furnace. [Exhibit I at MPS_52537.]

Ten years later, in its 1975 manual for CB Packaged Boilers, excerpts of which are attached as Exhibit J, Cleaver-Brooks again provided an appropriate warning for caustic soda, and soda ash:

> CAUTION!
> Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals. Do not permit the dry material or concentrated solution to come into contact with skin or clothing.

[Exhibit J at Manual-000721]

Again, however, Cleaver Brooks failed to provide any type of safety warning when instructing workers to apply asbestos cement, asbestos millboard, and asbestos rope to the boiler furnace. [Exhibit J at Manual-000778 through 780]

D. <u>Crane Co.</u>

Exhibits K through O demonstrate that Crane Co knew and intended that workers maintaining Crane valves would be exposed to asbestos insulation, packing, and gaskets. As these exhibits show, Crane routinely supplied a variety of asbestos products for use with its valves, both to the U.S. Navy and to commercial customers, including its own proprietary brand of Cranite asbestos gaskets and packing.

Exhibit K is a selection of pages from Crane Co. Catalog No. 53 for Valves, Fitting, and Pipes, dated 1952. This catalog demonstrates that Crane Co was well-aware that its valves were routinely insulated with asbestos. Indeed, Crane offered its commercial customers numerous lines of Johns-Manville asbestos insulating materials, including 85% magnesia; Asbestocel; asbestos millboard, asbestos blocks, and asbestos insulating cement. [Exhibit K at 000201 – 202]. Crane was likewise aware that its valves would contain asbestos gaskets and packing. In fact, Crane offered its own proprietary brand of "Cranite" asbestos sheet packing and gaskets, which it advertised as "An Asbestos Composition manufactured solely for Crane."

[Exhibit K at 000204]. Thus, Crane cannot deny that it knew very well that the workers who serviced its valves would be exposed to asbestos.

Crane Co. also specified and supplied asbestos gaskets and packing directly to the U.S. Navy, as demonstrated in Exhibit L. Exhibit L is a compilation of Crane Co drawings for valves on U.S. Navy DD-692 class destroyers and DE-339 class destroyer escorts. The List of Materials in the upper right hand corner of each drawing specifies that the valves will contain asbestos packing. [Exhibit L at WAL-3856 – 3867]. Each List of Materials also identifies the gaskets used on the valves as "Cranite," Crane Co's proprietary brand of asbestos material. *Id.*

In addition, as reflected in Exhibit M, Crane supplied gaskets and packing to the U.S. Navy as spare parts for the overhaul of its valves. Exhibit M is a Crane invoice dated September 26, 1973, for "Parts for Overhaul of Crane Co. Valves for SSBN622 Overhaul, US Navy Contract." According to the invoice, Crane supplied 153 sets of packing and 147 sets of gaskets for use by Navy maintenance personnel in the overhaul of Crane valves on the SSBN-662. [Exhibit M at CRIMDEBN00010931 – 10933].

Crane Co also published manuals and service bulletins that gave maintenance workers detailed instructions about how to work safely with their valves, including gaskets and packing. Exhibit N is a selection of pages from a Crane publication entitled "Piping Pointers for Industrial Maintenance Men." Crane explained to workers that it had issued this pamphlet because "not only is Crane the world's largest source of dependable valves and fittings for every service, but also the source of the most reliable data regarding their use." [Exhibit N at Manual-000810]. Thus, Crane's "Piping Pointers" included an entire page of safety instructions about the hazards involved in the repair and maintenance of Crane valves, including hazards that might arise from products manufactured by others:

> 1. Before breaking into a line, shut it off and drain. Failure to do so may result in a shower of water, but it might have been acid or steam.
> . . . .
> 5. Always use chain blocks, cable slings, rope falls, or rope slings when raising or lowering a piece of heavy piping. Make sure hoists are strong enough and that hitches won't slip.
> . . . .
> 10.Keep your bench clean of 'odds and ends.' Wipe up oil spots on the floor to avoid slipping. Use safety goggles on chisel or grinding work.

[Exhibit N at Manual-000808].

Crane's "Piping Pointers" also included detailed instructions about the removal and replacement of packing and gaskets, and specifically noted that the gaskets were often asbestos. [Exhibit N at Manual-000805, 806] Here, however, Crane neglected to include any safety warning about the hazards of asbestos. *Id.*

Finally, Exhibit O is an Instruction Manual for the Installation, Operation, and Maintenance of various Crane valves. The manual contains detailed instructions for the removal and replacement of the stuffing box packing. Crane cautioned workers to take extreme care to avoid damage to the stuffing box bore, but neglected to warn them to avoid inhaling asbestos dust:

> The following procedure should be used to replace packing in assembled valves whether or not installed in the system. . . . -
> I. Remove nuts from packing gland bolting.
> 2. Raise packing gland and gland flange to allow access to stuffing box.
> 3. Remove the old packing using a suitable packing removal tool.
> CAUTION: Extreme care shall be taken to prevent damage to surfaces of the stem and stuffing box bore.
> 4. Clean the stem, stuffing box, and packing gland.
> 5. Inspect surfaces of the stem and stuffing box for damage such as nicks and scratches which may cause an inadequate packing seal. Damaged parts shall be repaired or replaced.
> 6. Lubricate packing gland studs.
> 7. Install new packing into stuffing box. One packing ring shall be installed at a time. . . .

[Exhibit O at CRIMDEBN0018732]

E. <u>Foster Wheeler</u>

Exhibit P demonstrates that Foster Wheeler was well-aware that the routine maintenance of its equipment on U.S. Navy vessels would expose workers to asbestos insulation. Exhibit P is an excerpt of a manual of Instructions for Foster Wheeler Marin Steam Generators on Fletcher Class destroyers. Indeed, Foster Wheeler specifically instructed workers that the care and maintenance of the boiler's economizer included "Applying Insulation," because "[t]he casing of the economizers should be maintained gas tight and well-insulated." [Exhibit P at Manual-001149, 1187].

The List of Reference Drawings also makes it clear that Foster Wheeler provided numerous insulation drawings with its boiler, including a "List of Field Bolts, Gaskets, and Insulating Material," several drawings for "Insulated Panels," and a drawing for "Insulation Pads." [Exhibit P at pp. Manual-001154, 1155]. Plaintiffs do not have the particular drawings referenced. However, the BuShips Insulation Plan for boiler steam drums on DD-445 class

vessels, attached as Exhibit W, makes it clear that the insulating material on the boilers would have included amosite felt and asbestos cloth. [Exhibit Q at Fletcher Class 0976, 0977].

F. General Electric

Like Cleaver-Brooks and Aqua-Chem, General Electric also provided warnings about the products of other manufacturers that were used in conjunction with its own equipment. Exhibit R is an excerpt from a GE Manual for Ship Service Generator Set on DD-692 class vessels. In this manual, GE provided extensive warnings about the hazards of benzene, gasoline, and carbon tetrachloride that were used to clean the generator windings, although GE did not manufacture or supply these solvents:

> BENZINE OR GASOLINE: Either benzine or gasoline is very inflammable,and their vapors mixed with the proper percentage of air are quite explosive. If this type of solvent is used, there should be good ventilation, and every care taken to avoid fire risk. Care should also be taken to see that the workers' clothes do not become saturated with the solvent. Clothing which does become saturated with the solvent should be removed before the worker leaves the job.
>
> CARBON TETRACHLORIDE: Carbon tetrachloride is noninflammable and nonexplosive. This solvent is much more corrosive in its action than either benzine or gasoline. . . . Because of its toxic effect, adequate ventilation must be provided. . . . . Its use is preferable where fire risk is high.
>
> MIXTURE: A mixture of 50 percent carbon tetrachloride and 50 percent benzine, or 60 percent tetrachloride and 40 percent gasoline, is noninflammable; but the vapors mixed with the proper amount of air are explosive. There should be fair ventilation so that tile explosive fumes will not - accumulate. There is no particular danger from spilling these mixtures on the clothing. This solvent may therefore be used where there is fire risk, but only where the ventilation is sufficient to prevent the accumulation of an explosive mixture of fumes.

[Exhibit R at Manual-000870]

By contrast, GE did not provide any warnings about the hazards of asbestos when instructing workers to remove the turbine lagging in order to disassemble the generator's turbine. [Exhibit R at Manual-000852].

G. General Motors

Exhibits S through W demonstrate that General Motors routinely warned workers about the hazards of carbon tetrachloride and other solvents used to clean its marine engines and heat exchangers, although GM neither manufactured nor supplied the solvents. However, these exhibits also make clear that GM did not warn about the hazards of asbestos, even when instructing workers to remove and replace asbestos gaskets and packing.

Exhibit S is an excerpt from a GM manual for the Care and Operation of Model 3-268A Cleveland Diesel engines on U.S. Navy vessels. GM's Cleveland Diesel division

instructed workers to take special safety precautions against the toxic effects of carbon tetrachloride used to maintain the engine's oil coolers and Bendix drive. GM warned that the carbon tetrachloride should only be used in a well-ventilated area, and noted that the toxic effects of the chemical were cumulative:

> During the cleaning operation, the cooler should be handled carefully to avoid injuring the tubes. The cleaning should be done in a room with adequate ventilation, or in the open air, on account of the toxic qualities of carbon tetrachloride (Pyrene fire extinguisher fluid), which is used as the cleaning fluid. Frequent wetting of the skin with this fluid should be avoided because the toxic effects are cumulative. Immersion of the hands in this fluid should also be avoided.

[Exhibit S at CY-Manuals-000077]

> Clean the screw shaft and the meshing pinion with carbon tetrachloride (Pyrene fire extinguisher fluid). A cautionary note on the use of this cleaning fluid appears in Section 2 in the chapter entitled, "Lubricating Oil System."

[Exhibit S at CY-Manuals-000102]

GM's Harrison Radiator Division offered a similar warning about the hazards of carbon tetrachloride and trichlorethylene fumes in its 1945 Heat Exchanger Service Manual, NAVSHIPS 345-0231, attached as Exhibit R:

> (3) Caution. Carbon tetrachloride and trichlorethylene give off toxic vapors and, when employed for cleaning purposes must be used in the open air on deck or in a well ventilated room.

[Exhibit T at CY-Manuals-001137]

Harrison Radiator expanded on this warning in its 1957 Service Bulletin to commercial customers, attached as Exhibit U. Harrison advised workers to use carbon tetrachloride, trichlorethylene, or varnalese to clean its oil coolers, but warned:

> CAUTION: If solvents are used, care must be taken to utilize them in accordance with their manufacturer's instructions. It is essential to provide suitable and adequate ventilation as a protection against toxic effects. Fire protection in accordance with local laws must also be provided.

[Exhibit U at DDC000011383]

An identical warning also appeared in Harrison's 1967 Heat Exchanger Service Manual, excerpts of which are attached as Exhibit V. [Exhibit V at DDC000011400 - 11401]

Finally, in the Service Manual for In-line Series 71 engines, excerpts of which are attached as Exhibit W, GM's Detroit Diesel division gave workers an even stronger warning about the hazardous chemicals that were frequently used to maintain GM engines:

> 5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron. Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

[Exhibit W at GM_MERRION006549].

GM also specifically warned workers to take precautions when using cleaning solutions to clean the engine's turbocharger:

> **CAUTION:** Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes.

[Exhibit W at GM_MERRION006964].

By contrast, GM did not suggest even the most minimal safety precautions when instructing workers to install twenty to thirty feet of asbestos packing into the turbocharger:

> 22. Install the asbestos packing in the nozzle ring grooves.
> a. Use all of the packing (20 feet).
> b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

[Exhibit W at GM_MERRION006981].

> 22. Install the asbestos packing in the nozzle ring grooves.
> a. Use all of the packing (30 feet).
> b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

[Exhibit W at GM_MERRION006986].

H. IMO/De Laval

Exhibits X, Y, and Z demonstrate that De Laval Steam Turbine Company also knew that the workers maintaining its equipment would be exposed to asbestos. These exhibits show that De Laval specified and/or supplied the asbestos-containing insulation, gaskets and packing used with its pumps and turbines, and gave specific instructions about how to work with those asbestos components.

Exhibit X is an excerpt from a De Laval manual for Lube Oil Pumps on the BB-57 and BB-59. The manual makes it clear that De Laval is aware that the turbine would be

insulated according to Navy specifications, and that the insulation would need to be disturbed in the course of regular use:

> Insulation (All Classes)
> The steam chest and turbine casing are insulated and lagged according to Navy requirements. The insulation and lagging are sectionalized so that the steam strainer and the turbine cover can be removed and replaced without the necessity for renewing the insulation.

[Exhibit X at Manual-001301]

Indeed, the manual indicates De Laval supplied its own insulation drawings, listed as Factory No. G-7449, G-7456, and G-7463. [Exhibit X at Manual-001261, 1262] The manual also states that "[t]he nozzle valve and the governing valve were packed at the factory with asbestos Packing conforming to Navy Specification 33P26, type B." [Exhibit X at Manual-001297].

Moreover, De Laval instructed workers on a number of maintenance procedures that required them to disturb this asbestos insulation and packing. For example, De Laval gave workers the following instructing for disassembling the steam nozzle valve and steam chest governing valve:

> To remove the valve elements, it is necessary first to detach the steam chest from the main casing which involves (1) breaking the steam inlet and steam chest drain connections, (2) detaching the line pressure gage, (3) removing the steam chest lagging and insulation, and (4) disconnecting the governor linkage at the valve operating spindle
>
> Directions for taking out the valve parts follow:
> Remove the steam chest lagging and insulation.

[Exhibit X at Manual-001294, 1297.]

Likewise, when disassembling the gear unit, De Laval instructed workers to pull off the turbine lagging. And while De Laval told workers that it was not necessary to disturb the cover plate insulation, it did not give workers any indication that this procedure could expose them to hazardous asbestos dust:

> Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.
> . . . . .
> Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.
> Remove the turbine shaft packing.

[Exhibit X at Manual-001291]

De Laval gave similar instructions in its manuals for Main Feed Booster Pumps on DD-445 and DD-692 class vessels, excerpts of which are attached as Exhibits Y. Both manuals again instructed workers to pull off turbine lagging and remove packing when disassembling the gear unit:

> Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.
> . . . . .
> Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.
> Remove the turbine shaft packing.

[Exhibit Y at BPI-07.08-Hawaii 011493; BPI-07.08-Hawaii 003749]

Both manuals in Exhibit Y also make it clear that De Laval provided the pumps with asbestos packing, again noting that"[t]he nozzle valve and the governing valve were packed at the factory with asbestos Packing conforming to Navy Specification 33P26, type B." [Exhibit Y at BPI-07.08-Hawaii 011500; BPI-07.08-Hawaii 003758].

Moreover, De Laval was well aware that the turbines would be insulated with asbestos, as indicated by the De Laval Insulation Drawing for Fuel Oil Booster and Transfer Pumps attached as Exhibit Z. This drawing, which bears De Laval Plan No. 8575, gives detailed instructions for the application of almost 40 pounds of asbestos cloth, amosite asbestos felt, and 85% magnesia to the turbines of De Laval Pumps on CL-55 class U.S. Navy vessels. [Exhibit Z at 4].

I. Leslie

Exhibit AA, BB, and JJ demonstrate that like De Laval, Leslie Controls was well aware that the workers maintaining its equipment would be exposed to asbestos insulation and packing. Throughout Exhibits AA, BB, and JJ, Leslie gave numerous instructions about how its valves and surrounding piping should be insulated, and specifically called for the use of asbestos packing. In Exhibit JJ, Leslie expressly indicated that the pipes should be covered with 85% magnesia asbestos insulation. Exhibit KK also shows that Leslie instructed workers to take precautions against the hazards of toxic solvents, even though Leslie never warned about the hazards of asbestos.

Exhibit AA is a set of Instructions for Leslie Pressure Reducing Valves and other Navy equipment from the U.S.S. Kidd. Exhibit BB is an excerpt from a Technical Manual for Leslie valves and regulators on U.S. Navy vessels AE-21 and 22. Exhibit JJ is a Leslie

handbook of Engineering, Operating, and Maintenance Data for Leslie controls, strainers and whistles, identified as Catalog Series 5300. Exhibit KK is a Leslie Technical Manual for Air Priority Valves on U.S. Navy vessels, dated January 1974.

In Exhibit AA, Leslie instructed the workers installing its pressure reducing valves to "[i]nsulate all pipe before and after reducing valve to minimize condensation." [Exhibit AA at Manual-000959] Leslie similarly instructed workers installing its Leslie-Tyfon whistle that "Piping should be well insulated and where exposed should be double insulated." *Id.* at Manual-000978. Leslie also supplied drawings that showed where external insulation was to be applied. [Exhibit AA at Manual-000983]. Moreover, Leslie included "insulation" as one of the numbered items on its Leslie-Tyfon steam whistle Parts List, indicating that Leslie may have actually supplied the insulation. *Id.* at Manual-000981.

In the manual attached as Exhibit BB, Leslie likewise told workers to "[i]nsulate all pipe before and after reducing valve to minimize condensation." [Exhibit BB at Manual-001007]. Leslie also instructed workers on the removal and replacement of asbestos packing, as follows:

> 14. Packing Renewal. Remove old Packing Set (11) and clean stuffing box thoroughly. With lower stem (5) in place, repack in following order and with openings in packing alternated.
> a. 1-Braided Asbestos Ring
> b. 1-Metallic Ring
> e. 1-Lubricator Sleeve
> d. l-Metallic Ring
> e. sufficient soft (plastic) Rings to fill box leaving space for (f) Ring.
> f .1-Metallic Ring

[Exhibit BB at Manual-000996]

The Leslie handbook of Engineering, Operating, and Maintenance Data attached as Exhibit JJ contains numerous similar instructions regarding insulation. Leslie again told workers to "insulate all pipe before and after reducing valve," to "insulate all steam lines to minimize condensation losses" on pump pressure regulators, and to ensure that the piping to Leslie-Tyfon whistles was "well insulated and where exposed to outside conditions, doubly insulated." [Exhibit JJ at ManualBIW-000565, 683, 761.] Leslie also advised users that its temperature and pressure regulators for heaters and heat exchangers were available with extension neck casings and special bulb casings "that permit full exterior insulation of the tank or oven." *Id.* at ManualBIW-000704, 709.]

Exhibit JJ also makes it clear that Leslie was entirely aware that this exterior insulation would contain asbestos, and even supplied asbestos insulation. In Leslie's reference tables of "Engineering Data for Steam Flow through Pipes," Leslie expressly indicated that steam pipes should be covered with "2-in. thick 85% magnesia insulation." *Id.* at ManualBIW-000784. Likewise, the Part List for the Leslie-Tyfon steam whistle included "Insulation – Asbestos" with a Leslie part number. *Id*. at ManualBIW-000770. Nevertheless, Leslie entirely failed to tell workers how to protect themselves against the asbestos dust that would be generated when they applied and removed this insulation.

By contrast, in the manual attached as Exhibit KK, Leslie did instruct workers to take precautions against breathing toxic solvent vapors while cleaning valve parts:

> WARNING
> Flammable and toxic solvents should be used only in a well-ventilated area; avoid breathing solvent vapors. Keep flame and others sources of ignition away from solvent or solvent vapors.

[Exhibit KK at ManualBIW-000850]

J. <u>Warren Pumps</u>

The series of Warren Pumps purchase orders and invoices attached as Exhibit CC leaves no doubt that Warren Pumps not only knew that its pumps would be insulated with asbestos, but actually supplied the original asbestos insulation at times. An invoice for Warren feed pumps supplied to the U.S. Navy Yard makes it clear that "[s]uitable steam cylinder, cylinder head and valve insulation of 85% magnesia and planished steel lagging shall be furnished by the Vendor," while [l]iquid cylinder insulation and lagging will be provided by the Shipbuilder as required." [Exhibit CC at WP 0144844]. Other invoices specify that the steam cylinders of Warren's pumps were "to be insulated with a suitable thickness of 85% magnesia insulation." [Exhibit CC at WP 0144815, 816, 818, 819, 822, 823, 825-827]. Thus, Warren clearly knew that its pumps on Navy vessels would require the use of asbestos.

Moreover, Warren routinely instructed workers how to safely use other manufacturers' products where those products were necessary for the installation and maintenance of Warren's own equipment. In the Warren Pumps manual attached as Exhibit DD, for example, Warren Pumps warned workers to ensure that they had adequate ventilation when

using cleaners or solvents to clean Warren's oil coolers, although Warren neither manufactured nor supplied those solvents:

> To clean inside of plate, immerse the core in a suitable cleaner or solvent.
> (CAUTION: This operation should be done in the open air or with adequate ventilation.)

[Exhibit DD at HI-EM-00212]

Likewise, in the Warren drawing attached as Exhibit EE, Warren gives the following instructions for working with another manufacturer's adhesive::

> Screws PC No. 11 are fastened to shafts PC No. 8 & 9 with adhesive Ren RP-1250 Paste & Hardener, Mfr by Ren Plastics, Inc. . . . Denatured alcohol should be used for cleaning the parts prior to use of adhesive & for cleaning off excessive adhesive after assembly. "Ren" hand cleaner is suitable for removing adhesive from hands.

[Exhibit EE at Note 16]

K. Westinghouse

Exhibit FF is an excerpt from a Westinghouse manual for Lubricating Oil and Fuel Oil Pumps on the USS Kidd. Exhibit GG is an excerpt from a Westinghouse manual for Forced Draft Blowers on the USS Kidd. Like Warren Pumps, Westinghouse also warned workers to take appropriate safety precautions to avoid inhaling toxic fumes from cleaners and solvents supplied by other manufacturers. Both manuals contain substantially the same warning:

> To clean the inside of the plate, immerse the core in a suitable cleaner or solvent. (CAUTION: This operation should be done in the open air or with adequate ventilation.)

[Exhibit FF at Manual-001081; Exhibit GG at Manual-001126.]

In addition, the insulation drawings attached as Exhibit HH demonstrate that Westinghouse also knew that the turbines on its equipment required asbestos insulation. Exhibit HH is a Westinghouse insulation drawing for turbo-generator sets on AO-143 class Navy vessels. In this drawing, Westinghouse clearly specified several types of asbestos insulation in the List of Materials for its turbine, including "Thermal Block," "Asbestos Felt," and "Asbestos Cloth." [Exhibit HH at CHPL-22]. Westinghouse also gave detailed instructions for the application of the insulation. In some places, Westinghouse noted that workers should apply "portable insulation for access to strainer." [Exhibit HH at CHPL-21]. In other places, Westinghouse instructed workers to "recess insulation for steam seal manifold piping," or for "gland pipe" or "guide studs." *Id.* Westinghouse also instructed workers to "insulate piping to steam seal manifold." However, Westinghouse did not warn workers that this operation should

only be done with adequate ventilation, nor did they instruct workers to use respiratory protection or take any other precautions against the hazards of asbestos exposure.

L. William Powell

Like the other equipment defendants, William Powell knew that its valves would require asbestos insulation, gaskets, and packing. Exhibit LL is a William Powell Valves Catalog dated 1975. The catalog makes it clear that William Powell sold its valves with asbestos gaskets and packing already installed. William Powell advertised that the body, bonnet, and cap of its valves were "regularly supplied with a bonded, compressed asbestos gasket." [Exhibit LL at ManualBIW-000184.] William Powell also advertised that "valves used for temperatures over 500°F can be supplied with asbestos packing." *Id.* The catalog also makes it clear that William Powell was well-aware that its high-temperature valves would be insulated, as it advertised that the body of its Powell pressure seal valves was streamlined to "simplif[y] application and reduce[] cost of insulation." *Id.* at ManualBIW-000130].

M. Yarway

Finally, the Foster Wheeler manual attached as Exhibit V includes a Yarnall-Waring Co. drawing with detailed instructions for the insulation of the Yarway Remote Pressure Differential Indicator installed on Foster Wheeler Boilers. [Exhibit V at Manual-001248, Figure 52.] Yarway instructed workers to apply "INSULATION 1" THICK ON 1/2" PIPES" and "INSULATION 1" THICK ON 3/4" PIPES," but warned "DO NOT INSULATE" the indicator's head chambers. *Id.* Yarway also directed workers to install a warning plate on the indicator that stated: "SECURE ALL SUPERHEATER BURNERS WHEN POINTER IS IN RED ZONE." *Id.* However, Yarway did not include any type of asbestos warning or caution.

IV. CONCLUSION

Under these facts, Defendants had a duty to make their equipment safe for use by warning workers to take precautions against asbestos exposure. Based on the foregoing reasons and authorities, Plaintiffs respectfully request this Honorable Court to deny Defendants' motions for summary judgment.

DATED: Honolulu, Hawaii, _____.

_____

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IN THE CIRCUIT COURT OF THE FIRST CIRCUIT

STATE OF HAWAII

IN RE: HAWAII STATE ASBESTOS CASES	CIVIL NO. 09-1-ACM-2 (EEH) (Toxic Tort / Asbestos Personal Injury)
This Document Applies To:	**DECLARATION OF COUNSEL**
	CIVIL NO(S).:
CABATBAT, ARTURO	08-1-2033-10 (EEH)
CASSANI, VINCENT J.	09-1-0234-01 (EEH)
FELICIANO, JOSEPH	08-1-1957-09 (EEH)
RIVEIRA, PATRICK (D)	08-1-2559-12 (EEH)
VILLIATORA, MELCHIRO (D)	09-1-0209-01 (EEH)
YATSU, HENRY	09-1-0374-02 (EEH)

DECLARATION OF COUNSEL

I, ILANA K. WAXMAN, hereby declare pursuant to Circuit Rule 7(g), Rules of the Circuit Court of the State of Hawaii, as follows:

1. I have personal knowledge of the following facts, and I am competent to testify as follows.

2. I am one of the attorneys for Plaintiffs herein and make this declaration upon personal knowledge unless otherwise indicated.

3. Attached hereto and marked as Exhibit A is an excerpt from a true and correct copy of an Aurora Pumps Technical Manual for Fire, Flushing and Emergency Bilge Pumps supplied to the U.S. Navy (WAL-4014 to 4090). The original manual was found at the National Archives by William A. Lowell, as stated in paragraph 7v of the Lowell Declaration which is attached as an exhibit to the Plaintiffs Opposition to Defendants Motion for Summary Judgment in the Agena case.

4. Attached hereto and marked as Exhibit B is a true and correct copy of a 1965 Aurora Pumps Bulletin for Type GB pumps, which was produced by Defendant Aurora Pumps in the Hawaii litigation (A0017 to 28).

5. Attached hereto and marked as Exhibit C is a true and correct copy of Buffalo Pumps insulation drawings prepared for the U.S. Navy, and produced to Plaintiffs by Defendant Buffalo Pumps in the Tucker case (Tucker 000091 to 105).

6. Attached hereto and marked as Exhibit D is an excerpt from a true and correct copy of a 1968 Equipment Manual for Buffalo Pumps distiller pumps on DE-1052 class vessels, produced to Plaintiffs by Defendant Buffalo Pumps in the Hawaii litigation (BPI-07.08-Hawaii 000001 to 55).

7. Attached hereto and marked as Exhibit E is an excerpt from a true and correct copy of an original 1959 Centrifugal Pump Application Manual published by Buffalo Pumps (MANUAL-000001 to 279). The complete original volume is in Plaintiffs' possession, and a true and correct copy was previously produced to Defendants.

8. Attached hereto and marked as Exhibit F is an excerpt from a true and correct copy of a 1959 Aqua-Chem manual for a Flash-Type Distilling Unit on cargo vessels. Plaintiffs obtained this manual from the collection of William A. Lowell, and produced the complete manual to Defendants in the Hawaii litigation (Manual-000359 to 467). This manual is prima facie authentic based on its distinctive characteristics including Aqua-Chem company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

9. Attached hereto and marked as Exhibit G is an excerpt from a true and correct copy of a 1961 Cleaver-Brooks manual for Flash-Type Distilling Units. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000468 to 546). This manual is prima facie authentic based on its distinctive characteristics including Cleaver-Brooks and Aqua-Chem company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

10. Attached hereto and marked as Exhibit H is an excerpt from a true and correct copy of a 1974 Aqua-Chem manual for a Marine Flash Distilling Plant. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000547 to 690). This manual is prima facie authentic based on its distinctive characteristics including Aqua-Chem company logos and other trademarks, as well as the manual's internal consistency and

professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

11. Attached hereto and marked as Exhibit I is an excerpt from a true and correct copy of 1965 manual for a Model C-B Boiler (MPS_0052465 to 52565). The complete manual was produced by Defendant Cleaver Brooks in the Hawaii litigation.

12. Attached hereto and marked as Exhibit J is an excerpt from a true and correct copy of a 1975 manual for CB Packaged Boilers. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000691 to 794). This manual is prima facie authentic based on its distinctive characteristics including Cleaver-Brooks company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the boiler manual attached as Exhibit I. *See* Haw. R. Evid. 901(b)(3).

13. Attached hereto and marked as Exhibit K is a true and correct copy of a selection of pages from Crane Co. Catalog No. 53 for Valves, Fitting, and Pipes, dated 1952 (000161 to 210). These pages were used an exhibit to the January 9, 2007 deposition of Crane representative Anthony Pantaleoni, who conceded the authenticity of the catalog. The relevant portions of Mr. Pantaleoni's deposition transcript are attached hereto as Exhibit II. [Exhibit II at 52:9 – 52:20].

14. Attached hereto and marked as Exhibit L is a true and correct copy of a compilation of Crane Co drawings for valves on U.S. Navy DD-692 class destroyers and DE-339 class destroyer escorts (WAL-3856 to 3867). The original drawings were found at the National Archives by William A. Lowell, as stated in paragraph 7r of the Lowell Declaration attached as an exhibit to the Plaintiffs Opposition Memorandum in Agena.

15. Attached hereto and marked as Exhibit M is a true and correct copy of a Exhibit M is a Crane invoice dated September 26, 1973, for "Parts for Overhaul of Crane Co. Valves for SSBN622 Overhaul, US Navy Contract" (CRIMDEBN00010931 to 10933). This document was produced by Defendant Crane Co from the Crane document repository in Freehold, New Jersey, and has a Crane Co. bate number.

16. Attached hereto and marked as Exhibit N selected pages from a Crane publication entitled "Piping Pointers for Industrial Maintenance Men" (Manual-000795 to 811).

I personally photocopied these pages from the original publication, which I found in the Trade Literature Collection in the National Museum of American History Library at the Smithsonian Institution in Washington, D.C.

17. Attached hereto and marked as Exhibit O is a true and correct copy of an Instruction Manual for the Installation, Operation, and Maintenance of various Crane valves (CRIMDEBN00018721 to 18735). This document was produced by Defendant Crane Co from the Crane document repository in Freehold, New Jersey, and has a Crane Co. bate number.

18. Attached hereto and marked as Exhibit P is an excerpt of a true and correct copy of a book of Instructions for Foster Wheeler Marin Steam Generators on Fletcher Class destroyers (Manual-001147 to 1254). This manual is prima facie authentic based on its distinctive characteristics including Foster Wheeler company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

19. Attached hereto and marked as Exhibit Q is a true and correct copy of a BuShips insulation drawing for the Insulation and Lagging of a Boiler Steam Drum on DD-445 class vessels (FletcherClass-0975 to 976). Plaintiffs obtained this drawing from the collection of William A. Lowell.

20. Attached hereto and marked as Exhibit R is an excerpt from a true and correct copy of a GE Manual for Ship Service Generator Set on DD-692 class vessels (Manual-000812 to 954). This manual is prima facie authentic based on its distinctive characteristics including General Electric company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

21. Attached hereto and marked as Exhibit S is an excerpt from a true and correct copy of a GM manual for the Care and Operation of Model 3-268A Cleveland Diesel engines on U.S. Navy vessels (CYManuals-000043 to 195). Plaintiffs obtained a true and correct copy of the complete manual from the library of U.S.S. Cassin Young (DD-793) ship museum in Boston, MA.

22. Attached hereto and marked as Exhibit T is an excerpt from a true and correct copy of a 1945 Harrison Radiator Heat Exchanger Service Manual, NAVSHIPS 345-

0231 (CYManuals-001096 to 1143). Plaintiffs obtained a true and correct copy of the complete manual from the library of U.S.S. Cassin Young (DD-793) ship museum in Boston, MA.

23. Attached hereto and marked as Exhibit U is a true and correct copy of a 1957 Harrison Radiator Service Bulletin (DDC000011381 to 11384). This Bulletin was produced by Defendant General Motors in the Hawaii litigation.

24. Attached hereto and marked as Exhibit V is an excerpt from a true and correct copy of a 1967 Harrison Radiator Heat Exchanger Service Manual (DDC000011385 to 11420). The complete manual was produced by Defendant General Motors in the Hawaii litigation.

25. Attached hereto and marked as Exhibit W is an excerpt from a true and correct copy of a 1983 Detroit Diesel Service Manual for In-line Series 71 engines (GM MERRION006533 to 7542). The complete manual was produced by Defendant General Motors in the Hawaii litigation.

26. Attached hereto and marked as Exhibit X is an excerpt from a true and correct copy of a De Laval manual for Lube Oil Pumps on the BB-57 and BB-59 (Manual-1255 to 1334). This manual is prima facie authentic based on its distinctive characteristics including De Laval Steam Turbine company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the De Laval manuals attached as Exhibit Y. *See* Haw. R. Evid. 901(b)(3).

27. Attached hereto and marked as Exhibit Y is an excerpt from a true and correct copy of the De Laval manuals for Main Feed Booster Pumps on DD-445 and DD-692 class vessels (BPI-07.08-Hawaii 011468 to 11526; BPI-07.08-Hawaii 003724 to 3772). The complete manuals, which also applied to Buffalo main feed pumps on the same vessels, were produced by Defendant Buffalo Pumps in the Hawaii litigation.

28. Attached hereto and marked as Exhibit Z is a true and correct copy of De Laval Plan No. G-8575. Defendant IMO Industries produced the complete drawing to Plaintiffs in the Hawaii litigation.

29. Attached hereto and marked as Exhibit AA is a true and correct copy of a set of Instructions for Leslie Pressure Reducing Valves and other Navy equipment from the

U.S.S. Kidd (Manual-000955 to 984). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

30. Attached hereto and marked as Exhibit BB is a true and correct copy of a Technical Manual for Leslie valves and regulators on U.S. Navy vessels AE-21 and 22 (Manual-000985 to 1062). This manual is prima facie authentic based on its distinctive characteristics including Leslie company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the Leslie manual attached as Exhibit AA. *See* Haw. R. Evid. 901(b)(3).

31. Attached hereto and marked as Exhibit CC is a true and correct copy of a series of Warren Pumps purchase orders and invoices, which were produced by Defendant Warren Pumps in the Hawaii litigation (WP 0144815 to 144844)..

32. Attached hereto and marked as Exhibit DD is an excerpt from a true and correct copy of a Warren Pumps manual for Main Condenser Circulating Pumps on DD-692 vessels (HI-EM-00191 to 231). The complete manual was produced by Defendant Warren Pumps in the Hawaii litigation.

33. Attached hereto and marked as Exhibit EE is a true and correct copy of Warren Pumps Drawing No. A-1459, which was produced by Defendant Warren Pumps in the Hawaii litigation (HI-AN-00267).

34. Attached hereto and marked as Exhibit FF is a true and correct copy of a Westinghouse manual for Lubricating Oil and Fuel Oil Pumps on the USS Kidd (Manual-001063 to 1114). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

35. Attached hereto and marked as Exhibit GG is a true and correct copy of a Westinghouse manual for Forced Draft Blowers on the USS Kidd (Manual-001115 to 1146). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

36. Attached hereto and marked as Exhibit HH is a true and correct copy of Westinghouse insulation drawing I-JH-2183 (CHPL-22 to 23). This drawing was produced by Defendant Westinghouse in the Hawaii litigation, among the documents related to the USS Chipola (AO-63).

37. Attached hereto and marked as Exhibit II is a true and correct copy of a selected portion of the transcript of the Deposition of Anthony Pantaleoni taken by Plaintiffs on January 9, 2007.

38. Attached hereto and marked as Exhibit JJ is a true and correct copy of selected portions from a Leslie handbook of Engineering, Operating, and Maintenance Data for Leslie controls, strainers and whistles, identified as Catalog Series 5300 (ManualBIW-000518-535, 565-568, 682-686, 698-710, 753-784). Plaintiffs obtained this manual from a library of technical manuals at Bath Iron Works shipyard in Bath, Maine.

39. Attached hereto and marked as Exhibit KK is a true and correct copy of a Leslie Technical Manual for Air Priority Valves on U.S. Navy vessels, dated January 1974 (ManualBIW-000840 – 856). Plaintiffs obtained this manual from a library of technical manuals at Bath Iron Works shipyard in Bath, Maine.

40. Attached hereto and marked as Exhibit LL is a true and correct copy of a selected portion of a William Powell Valve Catalog dated 1975 (ManualBIW-000001 – 12, 129-133, 179-185). Plaintiffs obtained this catalog from a library of technical manuals at Bath Iron Works shipyard in Bath, Maine.

I, Ilana K. Waxman, do declare under penalty of perjury that the foregoing is true and correct.

DATED: Honolulu, Hawaii, _____.

_____
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IN THE CIRCUIT COURT OF THE FIRST CIRCUIT

STATE OF HAWAII

IN RE:
HAWAII STATE ASBESTOS CASES

This Document Applies To:

CABATBAT, ARTURO
CASSANI, VINCENT J.
FELICIANO, JOSEPH
RIVEIRA, PATRICK (D)
VILLIATORA, MELCHIRO (D)
YATSU, HENRY

CIVIL NO. 09-1-ACM-002 (EEH)
(Toxic Tort / Asbestos Personal Injury)

PLAINTIFFS' OMNIBUS MEMORANDUM IN OPPOSITION TO MOTIONS FOR SUMMARY JUDGMENT FILED BY DEFENDANTS REGARDING THE DUTY TO WARN; DECLARATION OF COUNSEL; EXHIBITS A-LL; CERTIFICATE OF SERVICE

CIVIL NOS.
08-1-2033-10 (EEH)
09-1-0234-01 (EEH)
08-1-1957-09 (EEH)
08-1-2559-12 (EEH)
09-1-0209-01 (EEH)
09-1-0374-02 (EEH)

Hearing Date: September 17, 2009
Hearing Time: 9:00 a.m.
Judge: Honorable Eden E. Hifo

TRIAL: October 5, 2009
JUDGE: Hon. Eden Elizabeth Hifo

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PLAINTIFFS' OMNIBUS MEMORANDUM IN OPPOSITION
TO MOTIONS FOR SUMMARY JUDGMENT FILED BY DEFENDANTS
REGARDING THE DUTY TO WARN

I. PREFACE

Defendants ask this court to hold that as a matter of law, equipment manufacturers had no duty to warn end users about a hazard that was certain to occur during the routine repair and maintenance of their products. Defendants argue that they are entitled to such a ruling based on the recent decisions of two appellate courts in Washington and California.

These cases are not Hawaii law. They are directly contrary to Hawaii's express public policy of providing the "the maximum possible protection that the law can muster against dangerous defects in products." *Stewart v. Budget Rent A Car Corp.*, 52 Haw. 71 (1970). Moreover, contrary to Defendants' arguments, Plaintiffs are not asking the court to impose an "ersatz duty 'to warn of the hazards of another manufacturer's products.'" *Simonetta v. Viad Corporation*, 197 P.3d 127, 139 (Wash. 2008) (Dissent of Justice Stephens). Plaintiffs merely contend that the equipment manufacturers had a legal responsibility to warn about the hazards which were necessarily associated with the intended use, repair, and maintenance of their *own* products on Navy and merchant marine vessels. This duty to warn is not based on any novel or unusual legal theory. On the contrary, it is consistent with both well-settled Hawaii law, and Defendant's actual practice.

Defendants cannot deny that they had a legal duty to provide Pearl Harbor shipyard workers and ship personnel with: 1) adequate instructions for the safe operation and repair of their turbines, pumps, valves, and other marine equipment; and 2) warnings about the dangers that were inherent in the foreseeable use of their products on Navy vessels. *See Acoba v. General Tire, Inc.*, 92 Hawai'i 1, 15 (1999); Restatement (Second) of Torts §§ 388, 402A. Indeed, Defendant manufacturers issued technical manuals with detailed instructions on repair and maintenance, and workers relied on these manuals for the information that they needed in order to work safely with each manufacturer's equipment.

As the exhibits hereto will show, moreover, these technical manuals routinely warned service personnel to take precautions against hazardous substances that Defendants did not supply or manufacture, such as carbon tetrachloride, benzine, sulfamic acid, tri-sodium phosphate, trichlorethylene, and Freon. Contrary to their protestations, Defendants regularly

gave workers instructions about how to work safely with other manufacturers' hazardous products where they knew workers would be exposed to those substances during the regular maintenance and repair of Defendants' own equipment.

As the exhibits hereto will also show, Defendants knew that workers would necessarily be exposed to toxic asbestos dust during the regular maintenance and repair of Defendants' marine equipment. Defendants knew their equipment required asbestos insulation, packing, and/or gaskets to function properly on Navy and merchant marine ships. Indeed, equipment manufacturers routinely specified and supplied asbestos gaskets and packing with their equipment, and many manufacturers specified and supplied asbestos insulation as well. Defendants knew that during routine maintenance, ship personnel and shipyard workers would have to strip and replace asbestos insulation, packing, and/or gaskets from their equipment, exposing all the workers in the surrounding area to aspirable asbestos. Defendants' technical manuals often instructed workers how to strip and replace asbestos gaskets and packing, and at times told workers how to apply and remove insulation as well.

Under these circumstances, Defendant manufacturers had a responsibility to inform themselves about the hazards of the asbestos products that they knew would be used on their marine equipment, and they had a duty convey that information to the workers who serviced that equipment. It is perfectly fair and logical to hold that Defendants should have warned workers to take precautions against potentially deadly asbestos exposure, just as they warned workers to protect themselves against carbon tetrachloride, caustic soda, sulfamic acid, and other toxic substances that Defendants knew would be used on their equipment during routine maintenance and repairs.

Accordingly, Defendant equipment manufacturers had a duty to warn about the dangers of asbestos exposure, which were inherent in the repair, maintenance, and use of their equipment on U.S. Navy vessels. Defendants' motions must be denied in on the merits.

II. LEGAL ANALYSIS.

A. *Simonetta, Braaten* and *Taylor* are Not Hawaii Law On Duty To Warn.

As the Washington Supreme Court stated in *Simonetta*, the duty to warn "is a question of law that generally depends on mixed considerations of logic, common sense, justice,

policy, and precedent." *Simonetta*, 197 P.3d at 131. Thus, in determining whether there is a duty to warn under Hawaii law, the court must first be guided by our state's precedent and express public policy of providing the "the maximum possible protection that the law can muster against dangerous defects in products." *Stewart*, 52 Haw. at 74. Essentially, the court must determine "whether . . . such a relation exists between the parties that the community will impose a legal obligation upon one for the benefit of the other." *Wagatsuma v. Patch*, 10 Haw. App. 547, 569 (1994) (internal citation omitted).

In *Simonetta, Braaten,* and *Taylor*, the courts of Washington and California determined that in their communities, manufacturers had no legal obligation to instruct workers on how to protect themselves from toxic asbestos dust as they operated and maintained the defendants' equipment, even when those manufacturers had every reason to know that workers would be exposed to potentially deadly asbestos fibers each time they worked on the defendants' products. Thus, the Washington and California courts declined to recognize a duty to warn about asbestos even where: 1) the manufacturers knew that their equipment required asbestos insulation, gaskets, and packing in order to function as intended; 2) the manufacturers routinely supplied or specified asbestos insulation, gaskets, and/or packing with their equipment; and 3) the manufacturers knew that the ship personnel and shipyard workers would *necessarily* be exposed to potentially deadly asbestos during routine maintenance and repair. *Simonetta v. Viad Corporation,* 197 P.3d 127 (Wash. 2008) (holding that an equipment manufacturer had no duty to warn of the hazards of asbestos insulation); *Braaten v. Saberhagen Holdings*, 198 P.3d 493 (Wash. 2008) (holding that equipment manufacturers whose products were supplied with asbestos packing and gaskets had no duty to warn about replacement packing and gaskets, although they had a duty to warn of the original packing and gaskets); *Taylor v. Elliott Turbomachinery Co., Inc.*, 171 Cal. App. 4th 564 (2009) (adopting the holding of *Simonetta* and *Braaten*).

These cases are not Hawaii law, and are directly contrary to Hawaii public policy. Rather than providing the plaintiffs in those cases with maximum possible protection under the law, the Washington and California courts made a policy decision to shield defendant manufacturers from liability based on an imagined fear that "over-extending the level of responsibility could potentially lead to commercial as well as legal nightmares." *Taylor*,

171 Cal. App. 4th at 576.[1] However, this is not the policy of our state. As the *Simonetto* dissenters concluded, "to hold that [an equipment manufacturer] had no duty to warn of a serious hazard it knew or should have known was involved in the use of its product ignores logic, common sense, and justice." *Simoneffo*, 197 P.3d at 139 (Dissent of Justice Stephens, joined by Justices Sanders and Chambers)

As Justice Debra Stephens of the Washington Supreme Court explained in her dissent in *Simonetto*, the rule adopted by the *Simonetto* majority is contrary to the basic policy goal of providing consumers with maximum protection against dangerous products:

> The paramount policy goal of strict liability is to place the cost of protecting product users on those in a better position to offer that protection. . . . Joseph Simonetta had an expectation that he would be warned of potential dangers associated with Vlad's evaporator, and Vlad was in a superior position to offer warnings about the dangers involved in the use of its product. I would hold that Simonetta established a prima facie case of negligence and strict liability against Vlad and that his claims should proceed to trial.

Simoneffo, 197 P.3d at 143 (Dissent of Justice Stephens)

Moreover, as Justice Stephens also noted, the policy arguments for shielding the equipment defendants from liability are fundamentally flawed:

> The majority appears to accept Vlad's plea that if this court acknowledges a duty to warn here, the result will be unchecked liability for manufacturers who fail to warn about other products that may be used in conjunction with their own. For example, Vlad asserts that were this court to hold that it had a duty to warn about the evaporator's use with asbestos insulation, then orange juice producers must warn about the dangers of mixing their product with vodka. The fallacy here is in disregarding the importance . . . of the manufacturer's knowledge of how its product will be used. Vlad owes a duty to warn not because asbestos insulation *might happen to be used* in conjunction with its evaporator, but because such insulation was known to be necessary for the evaporator to function. Recognizing a duty in this instance will not broaden the duty of manufacturers to anticipate and warn of every conceivable use of their products. Instead, it is consistent with settled negligence law that imposes a duty to warn of 'the hazards involved in reasonably foreseeable uses of the product.'

Id. at 141 (emphasis in original)

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[1] Plaintiffs also note that Judge Robert Dondero, the California judge who authored the *Taylor* decision, appears to have a predisposition against warnings to protect the public against dangerous products. In May 2006, Judge Dondero struck down an effort by California Attorney General Bill Lockyer to require tuna producers to warn consumers about the hazards of mercury in canned fish. Judge Dondero adopted the tuna companies' argument that the California warning was preempted by a less stringent FDA advisory. *People v. Tri-Union Seafoods*, 2006 WL 1544384 (Cal. Super. Ct. May 11, 2006), appeal docketed, No. A116792 (Cal. Ct. App. 1st Dist. Feb. 20, 2007). Judge Dondero's industry-friendly preemption analysis was specifically rejected by the Third Circuit in *Fellner v. Tri-Union Seafoods*, 539 F.3d 237 (3d Cir. 2007), and is entirely inconsistent with the U.S. Supreme Court's recent decision in *Wyeth v. Levine*.

Thus, there is no reason for this court to adopt *Simonena*, *Braaten*, and *Taylor* as Hawaii law. The decisions in these cases do not serve the "public interest in human health and safety" that forms the underlying basis of product liability law in our state. *Stewart*, 52 Haw. at 74. On the contrary, to adopt such a rule here would leave injured plaintiffs without recourse for the injuries they sustained when they were exposed to asbestos while working on Defendants' equipment.

B. Under Hawaii Law, Defendants Had a Duty to Make Their Equipment Safe for Use by Giving Workers Adequate Warnings of the Inherent Danger of Asbestos Exposure

It is well-settled that under Hawaii law, a manufacturer owes a duty to warn users about all non-obvious dangers that are inherent in the foreseeable use of the product. A product may be considered defective "even if flawlessly made, if the use of the product in a manner that is intended or reasonably foreseeable . . . involves a substantial danger that would not be readily recognized by the ordinary user of the product and the manufacturer fails to give adequate warnings of that danger." *Masaki* v. *General Motors Corp.*, 71 Haw. 1, 22 n.10 (1989).

As our Supreme Court explained in *Ontai* v. *Straub Clinic & Hosp.*, 66 Haw. 237, 248 (1983),

> A duty to warn actually consists of two duties: One is to give adequate instructions for safe use; and the other is to give a warning as to dangers inherent in improper use.

Ontai, 66 Haw. at 248.

The *Ontai* Court made it clear that in order to make its product safe for use, a manufacturer has a duty to give users all the instructions that they reasonably need to ensure that the product can be used without injury. This includes warnings about all hazards that are inherent in the anticipated uses of the product, including foreseeable misuse.

Thus, the Court in *Ontai* held that General Electric was liable for the injuries sustained by a Straub patient who fell off a GE X-ray table when the footrest gave way, because GE had not adequately instructed the Straub technicians who operated GE's equipment how to safely install the footrest and had failed to warn the technicians about the dangers inherent in improper installation. The Court further explained that even if the plaintiff's injuries were partly caused by the negligence of the Straub technicians, "General Electric should not be allowed to

escape liability if the risk to whicb Ontai was exposed was unreasonable and foreseeable by G.E." *Id.*

Likewise, in *Masaki v. General Motors Corp.*, 71 Haw. 1 (1989), the Court held that GM could be liable for the injuries sustained by an auto mechanic who was crushed by a GM vehicle, in part because GM had failed to provide a warning system to alert mechanics of the dangers of exiting the vehicle without latcbing the gear shift in park. The *Masaki* Court upheld the following jury instruction as a correct statement of Hawaii law:

> The third test is that the product is defective in design even if faultlessly made, if the use of the product in a manner that is intended or reasonably foreseeable including reasonably foreseeable misuses, involves a substantial danger that would not be readily recognized by the ordinary user of the product and the manufacturer fails to give adequate warnings of the danger.

Masaki, 71 Haw. at 22 n.10 (1989).

Here, Defendants equipment was intended to be installed on marine vessels with asbestos gaskets and/or packing already inside, and then covered with asbestos insulation which was necessary for the equipment to function. Defendants knew that their equipment would be insulated with asbestos, and they specified and supplied asbestos gaskets and packing. This use of asbestos in Defendants' products was not merely a foreseeable use, but an intended use.

Once installed on the ship, Defendants were well-aware that their equipment would undergo periodic maintenance and repairs. Defendants also knew or should have known that wben their equipment was repaired or overhauled, the operators and maintenance workers would have to strip and replace the asbestos insulation, gaskets and/or packing, and would necessarily be exposed to potentially deadly asbestos dust in the process. Thus, the reasonably foreseeable repair and maintenance of defendants' equipment involved a substantial danger that would not be readily recognized by the ordinary workers who were servicing Defendants' products.

Under the Hawaii law set forth in *Ontai* and *Masaki*, therefore, Defendant equipment manufacturers had a duty to: 1) provide Plaintiffs with adequate instructions for the safe operation and repair of their equipment, including instructions to take precautions while working with asbestos components; and 2) warn Plaintiffs about the inherent danger of exposure to asbestos fibers each time workers ripped out asbestos insulation, packing, and gaskets from Defendants' equipment during routine maintenance.

While Defendants' equipment might have been faultlessly made, it was not reasonably safe for its intended use, because Defendants failed to warn the Pearl Harbor workers that they would be exposed to toxic asbestos dust virtually every time the equipment was overhauled or repaired. Thus, under well-settled Hawaii product liability law, the absence of warnings or instructions about the hazards of asbestos rendered the Defendant's products defective.

C. Defendants' Arguments About the "Products of Others" Are Fundamentally Misplaced

Despite the Hawaii law and public policy cited above, Defendants argue that they had no legal duty to instruct Pearl Harbor workers to take precautions against asbestos exposure while working on Defendants' equipment, because "a manufacturer bas no duty 10 warn about another manufacturer's product." [*See, e.g,* Defendant Warren Pumps' Motion for Summary Judgment at 13]. However, this argument is fundamentally misplaced. The hazards of asbestos exposure were inherent in the normal use of the Defendants' *own* products on U.S. Navy vessels. Under Hawaii law, Defendants had a corresponding responsibility to warn of those bazards. As the dissenting Justices of the Washington Supreme Court explained in *Simonetta*, Defendants' "extended discussion of the ersatz duty 'to warn of the hazards of another manufacturer's product,'" merely "obscures the issue and introduces confusion into otherwise settled product liability law." *Simonetta*, 197 P.3d at 139 (Dissent of Justice Stephens).

1. Defendants Had a Duty To Warn About the Inherent Danger of Asbestos Exposure When Tbeir *Own* Products Were Used as Intended

First, Plaintiffs are not asking the court to impose an "ersatz duty 'to warn of the hazards of another manufacturer's product.'" *Simonetta*, 197 P.3d at 139 (Dissent of Justice Stephens). On the contrary, Plaintiffs merely ask the court to recognize Defendants' well-established duty to provide adequate instructions for the safe use of their *own* equipment, including warnings about the dangers of asbestos exposure that was certain to occur during routine repair and maintenance. As the *Simonetta* dissenters correctly noted, "recognition of [the] duty in this case follows from the application of settled legal principles to this new set of facts." *Id.* (bold emphasis added here and throughout)

As the dissenting justices explained in *Simonetta*, the duty to warn here is quite straightforward:

> Here, the use of Viad Corporation's evaporator required insulation, which in the 1950s in navy distilling units, was asbestos-containing insulation. Routine maintenance of the evaporator exposed users to aspirable asbestos. Thus the simple answer to the question of whether Viad owed Joseph Simonetta a duty in this case is yes.

Id. at 138.

Thus, Viad had a duty to warn about asbestos insulation and gaskets under a negligence theory, because Viad knew that the equipment could not function without the use of asbestos:

> The focus under § 388 is on dangers involved in the *use* of a product. Simply put, the duty to warn contemplates that a product will *actually be used*. The hazard of exposure to aspirable asbestos was integral to the ability to use Viad's evaporator, given that the unit could not function without insulation and service of the unit required periodic removal and replacement of the necessary insulation. Viad's argument, accepted by the majority, imagines that we are dealing with a perfect platonic form of an evaporator rather than the functional product. Once a manufacturer releases a product for use, its duty of reasonable care under negligence law includes "a duty to warn of hazards involved in the use of a product which are or should be known to the manufacturer."

Id. at 140 (italics in original).

Justice Stephens explained that Viad also owed a duty to warn about asbestos under a theory of strict liability, because the evaporator was not reasonably safe for use without a warning about the *inherent* danger of asbestos exposure during routine maintenance:

> Whether the evaporator functioned as designed is not the issue, of course, as a product may be unreasonably dangerous in the absence of adequate warnings notwithstanding that it is not itself "defective." . . . [T]he focus of the inquiry under §402A is on the warnings required to make the evaporator reasonably safe, including what a reasonable user would expect to be told about the dangers inherent in the use of the evaporator. This inquiry does not allow for the artificial segregation of the evaporator from the asbestos insulation that Simonetta necessarily encountered in order to use the product. Viad does not suggest that Simonetta's maintenance of the evaporator was not a foreseeable use. Thus the question is simply whether the *risk* of exposure to aspirable asbestos during required maintenance of the evaporator is a risk inherent in the *use* of the product. Based on the record in this case, the Court of Appeals properly concluded that it was. I would affirm that conclusion and recognize a duty here.

Id. at 140 (italics in original).

Finally, Justice Stephens addressed the majority's contention that Viad did not have a duty to warn about the dangers of asbestos used on its equipment, because it had not actually supplied the asbestos insulation, gaskets, and packing in use at the time of plaintiff's

exposure. Justice Stephens explained that the majority had improperly "redefin[ed] the product at issue." She explained that:

> This entire discussion of the chain of distribution, which is the core of the majority's negligence analysis, is unnecessary. The product at issue is Viad's evaporator, not the insulation. . . . When the evaporator is properly the focus of the inquiry, the majority's arguments regarding the chain of distribution have little relevance. It is undisputed that the evaporator was in Viad's chain of distribution.

Id. at 141.

Justice Stephens further explained that:

> Rather than addressing the facts of this case according to the standard for strict liability under 402A, the majority again shifts focus to the wrong product, suggesting that the Court of Appeals' decision holds Viad strictly liable for defects in asbestos products made by another. But Viad's duty under §402A, as under a negligence theory, is to warn of hazards associated with the use *of its own product*, the evaporator.

Id. at 142 (emphasis in original).

Thus, numerous courts have held that equipment manufacturers have a duty to warn of dangers of asbestos insulation, gaskets, and packing, even where the asbestos was manufactured or supplied by another. *See, e.g., Serher v. Agco Corp.*, 2008 WL 1701172 (S.D. Ill. 2008) ("To the extent GE seems to argue that it owed no duty to warn, the Court does not agree. According to GE, it manufactured marine steam turbines without any thermal insulation material on them and shipped the turbines with only a coat of paint on the surface of the metal, so that any thermal insulation material would have been supplied and installed by the shipbuilders at the shipyard. It is well settled, of course, that a manufacturer of a product has a duty to provide those warnings or instructions that are necessary to make its product safe for its intended use."); *Chicano v. General Electric*, 2004 U.S. Lexis 20330 (E.D. Penn 2004)("There is at least a genuine issue of material fact as to whether GE could be expected to foresee that the asbestos-containing material would be used to insulate its turbines. Therefore, GE's duty to warn may not be limited because it knew of the danger from asbestos-containing insulation, which it neither manufactured nor assembled with its turbine."); *Lindquist v. Buffolo Pumps*, 2006 R.I. Super LEXIS 168 (2006)("The Court finds that this case contains triable issues of fact in relation to Buffalo's duty to warn of the dangers posed by the asbestos gaskets and packing used in its pumps."); *Berkowitz v. A.C. & S. Inc.*, 288 A.D. 2d 148, 733 N.Y.S. 2d 410 (2001)("Nor does it

necessarily appear that Worthington had no duty to warn concerning the dangers of asbestos that it neither manufactured nor installed in its pumps.")

Likewise, in *Tellez-Cordova* v. *Compbell*, 129 Cal. App. 4th 577, 28 Cal. Rptr. 3d 744 (2004), a tool manufacturer had a duty to warn end users that using its high power tools to grind discs, belts and wheels can cause pulmonary fibrosis lung disease from the metallic dust grinding off the discs, bolts and wbeels, i.e., dust from products which the tool company did not sell. The court explained that the defendant in thai case had a duty to warn about the metallic dust, because "it was not happenstance that the tools were used in conjunction with other products, but . . . use with the specified wheels, discs, and grinders was the inevitable use." *Tellez-Cordova*, 129 Cal. App. 4th at 584. Thus, the court explained, "respondents are not asked to warn of dcfects in a final product over which they had no control, but of defects which occur when their products are used as intended--indeed, under the allegations of the complaint, as they must be used." *Id.* at 583.

This is also analogous to the non-asbestos case of *Ilosky* v. *Michelin Tire Corp.*, 172 W.Va. 435, 307 S.E.2d 603 (1983). In this case, Michelin sold a non-defective radial tire. However, it failed to warn about the foreseeable use of its non-defective tires when used in conjunction with another product. In that case, using radial tires on the front axle and conventional iires on the rear axle creates the danger of over steering. This jury instruction was approved by the court:

> The settei of a produci has a duty to:
>
> t. Warn thai the pioduci, even if harmtess or safe in itself, is, wheo mixed oi used in conjunction with another pioduct, dangerous oi potentially dangerous to users, where it is reasonably foreseeable thai uninformed users may mix the products.

Ilosky, 307 S.E.2d at 610 n. 6

2. <u>There Is No Logical Reason that Defendants' Duty to Warn Should Be Limited to the Original Asbestos tbat Was First Placed on Their Equipment</u>

Second, Defendants argue that under *Braaten* and *Taylor*, an equipment manufacturer has no duty to warn workers about the hazards of asbestos exposure unless Plaintiffs can prove that they were exposed to the original "asbestos that was first placed on the

[equipmeot[by [the manufacturer[or by the U.S. Navy." [*See, e.g.* Defendant William Powell's Motion foı Summary Judgment at 5.[

However, this limitation on the duty to warn is simply illogical. There is no reason to hold that the manufacturer had a duty to warn workers about the hazards of asbestos exposure from the original insulation, packing, and gaskeıs used on its equipment, but no duty to warn about identical replacemeni components. As the *Braaıen* dissenters correctly pointed out, Defenılants' argument "disassociates the manufacturers from the replacement packing and gaskeıs necessary to the use of their products simply because they did not manufacture the replacement parts. . . . [T]his is a false disassociation under both negligence and strict liability." *Braaten*, 198 P.3d at 505.

Under Defeodants' proposed rule, at the time the equipment was shipped, the manufacturer *wauld* have been under a legal duty to warn workers about the hazards in the original asbestos insulatioo, gaskets, and packing, and instruct the workers to take appropriate safety precautions when stripping and replacing those original asbestos componeots. However, this legal obligatioo would have somehow evaporated after the first time the equipment was repaired. There is no logical reason that defeodant's duty ıo warn should be limited in this fashioo.

On the contrary, the defendant's duty to warn is premised upon the faci that defeodants knew that the original asbestos insulatioo, gaskets, and packing would regularly be stripped from their equipment and replaced with identical asbestos compooents during routine maintenance and repair, and that workers would be exposed to asbestos in the process. Thus, in order make their equipmeot safe for use, Defendants had a duty to warn workers to take precautions against asbestos *each* time their equipment was repaired or maintained. This duty did not disappear afier the equipment was repaired or overhauled for the first time.

3. *Both* the Equipment Manufacturers and the Asbestos Manufacturers Had a Duty to Warn ahout Asbestos

Finally, the equipment manufacturers implicitly argue that only the asbestos manufacturers had a duty to warn about asbestos. Defendants argue that they cannot be held legally responsible for Plaintiffs' asbest*o*s disease, because they conteod that the true cause of Plaintiffs' injuries was the "release of asbestos from products manufactured by others," and that

Defendants' equipment did not in any way cause or create the risk of harm. Thus, in the view of the equipment manufacturers, they have no legal responsibility for the foreseeable injuries that Plaintiffs sustained when they were exposed to asbestos while working on Defendants' equipment. However, this argument is both factually and legally flawed.

In fact, Defendants' products did contribute the risk of harm here. Plaintiffs were not exposed to asbestos merely because asbestos insulation, gaskets, and packing happened to be present on U.S. Navy vessels. Rather, those asbestos products had to be installed on Defendants' valves, pumps, and turbines to allow them to function in the marine environment. Some of Plaintiffs' heaviest asbestos exposures occurred during the repair and maintenance of Defendants' equipment, when ship personnel and shipyard workers had to rip out asbestos insulation, gaskets, and packing from Defendants' valves, pumps and turbines in order to service them. Defendants' products could not be used on U.S. Navy vessels without these asbestos components, and Plaintiffs could not work on the equipment without releasing dangerous asbestos fibers into the air. Thus, in a very real sense, the equipment manufacturers' products were also responsible for Plaintiffs' exposure.

Moreover, the law clearly recognizes that an injury may have multiple causes, and there may be multiple parties who are legally responsible. As the Hawaii Supreme Court held in *Ontai*, "even though Piscusa may have been negligent in attaching the footrest to the X-ray table, his negligence in and of itself would not necessarily exempt G.E. from liability for Ontai's injuries. This court has held that a third party's negligence is not a defense unless such negligence is the sole proximate cause of the plaintiff's injuries." *Ontai*, 66 Haw. at 248-249. Here, as the *Simanema* dissenters correctly noted, "[t]here may be multiple proximate causes of an injury, so the fact that the asbestos manufacturers' failure to warn also caused Simonetta's injury has no bearing on whether Viad owed a duty." *Simanema*, 197 P.3d at 142 (Dissent of Justice Stephens).

Finally, it is well-settled that the manufacturer's duty to warn is non-delegable. A manufacturer has a duty to give warnings in such a manner that is calculated to reach the ultimate end-users of its products. *See Johnson* v. *Raybestos-Manhattan*, 69 Haw. 287, 288 (1987); *Johnson* v. *Raybestos-Manhattan*, 829 F.2d 907 (9th Cir. 1987) (Hawaii law). Thus, "[w]hile it is certainly true that the asbestos manufacturers also could have warned about the dangers of their

insulation, this does not negate Defendants' duty." *Simonetto*, 197 P.3d at 143 (Dissent of Justice Stephens).

D. Defendants' Case Law Is Not On Point

The principal Hawaii case on the duty to warn cited here is *Acobo v. General Tire, Inc.*, 92 Hawai'i 1 (1999). In that case, the plaintiff had personally received every possible warning be could on how to work with multi-rim assemblies. As explained by the Hawaii Supreme Court, "Sbimabuku testified by deposition that he told [plaintiff] Romero not to use the worn lock ring and to wait for a replacement. Shimabuku located a replacement and radioed Romero. He again told Romero not to use the old lock ring and that the replacement would be delivered to bim." *Acobo*, 92 Hawai'i at 5.

As the *Acobo* Court explained, the manufacturer had met its duty to warn.

> The undisputed facts sbow that [Firestone] carried its burden of producing evideoce of the absence of breach [of duty]. In its motion for summary judgment, Firestooe submined a copy of its 52-page safety and service manuat sent to Ken's Tire [ptainuff's employer] in 1987. The manuat contaioed specific information in instructing and warning tire service people to discard deteriotated, rusty, cracked or distorted iim components. It warns that use of "bent flanges . . . may tead to explosive separation duiing inflatioo." ft also cautions that "assembting damaged parts is extremety dangerous . . ." Thc manuat atso provides pictures and examptes of different types of damage, rusted, cracked, croded, . . . rims and specifically warns of the risk of fatting to use proper safety equipment. ft also states ptominentty on its cover that federal OSHA regutations "require att employers to make sure their employees who service wheels/rims understaod the safety informaiion contained in this manuat. . . ."
>
> Firestone further met its burden through its submission of deposition testimonies of Edward Shimabuku, a Ken's Tiic supervisor aod Btake Higasbi, a former generat manager of Kco's Tire, stating that Ken's Tire bad received the Firestone manuat and that instructional charts were mounted on the repair shop's watts. Higashi also testified that Ken's Tire regutarty hetd safety meetiogs for its employees during which Romero and other emptoyces were instructed about proper safety and maintenance procedures for use of multi-piece tire rims.

Acobo, 92 Hawai'i at 15-16. Thus, it defies explanation how the plaintiff could have been better warned about the danger of multi-piece tire rims. If the plaintiff is warned, then the duty to warn has been discharged. *See Tobieros v. Cfork Equipment Co.*, 85 Hawai'i 336, 371 (1997) ("Clark could not be liable to the plaintiffs in this case by virtue of having failed to warn Tabieros of a danger of which he was already aware"). In contrast, the evidence is undisputed that Plaintiffs and their co-workers at Pearl Harbor were never warned of the dangers of asbestos.

Defendants could try to seize upon the fact that the *Acobo* Court found that "under the circumstances of this case," the inner tube manufacturer or tire manufacturer did not have to warn about the defective multi-piece tire rims. *Acobo*, 92 Hawai'i at 18. However, the circumstances of *Acobo* were very different from the circumstances here. Unlike Plaintiffs here, the *Acobo* plaintiff was thoroughly warned. Moreover, there was no evidence in *Acobo* that the dangers of using an old, rusty multi-rim assembly were inherent to the use of the inner tube and tires manufactured by the defendants. On the contrary, there was no indication that the plaintiff's decision to use an old, defective multi-piece rim assembly was even reasonably foreseeable to the tire and inner tube manufacturer. The accident in *Acobo* happened in 1992 and "the rim assembly consisted of two components, a Firestone type RHT5 . . . rim base manufactured in 1952 and a Firestone type RIT lock ring manufactured in 1940." *Id.* at 5. It is hard to fathom how an inner tube manufacturer selling a product in 1990 would know its product would be put on a defective multi-piece rim that was manufactured 40 and 50 years earlier.

This is in contrast to marine equipment which Defendants knew had to be insulated with asbestos. In this case, Defendants specified and sold asbestos gaskets, packing and/or insulation with their equipment. This factually distinguishes the *Acobo* case. Moreover, Defendants grossly over-read the holding in *Acobo*. In fact, the Hawaii Supreme Court reaffirmed that:

> In this jurisdiction, a manufacturer has a two-fold duty to provide (1) adequate instructions for safe use of the product; and (2) warnings as to the dangers inherent in improper use of the product.

Acobo, 92 Hawai'i at 15. Foreseeable end-users such as the Sbop 38 machinists, were not given adequate instructions by the manufacturer for the safe use of marine equipment nor were they warned as to the dangers inherent in the foreseeable use of Defendants' products.

Powell v. *Standard Bronds*, 166 Cal. App. 3d 357, 212 Cal. Rptr. 395 (1985), is likewise completely distinguishable. *Powell* held one paint thinner manufacturer did not have a duty to warn regarding injuries caused by another paint thinner manufacturer. This is the same as holding that Ingersoll-Rand has no duty to warn regarding injuries caused solely by Goulds pumps. *Powell* merely rejected market share liability under *Sindell* v. *Abbott*, 26 Cal. 3d 588 (1980). (*Powell*, 212 Cal. Rptr. at n2 & 398-399).

Finally, Defendants cite *In re Deep Vein Thrombosis*, 356 F. Supp. 2d 1055 (N.D. Cal. 2005), which is similarly inapplicable. In *Deep Vein Thrombosis*, Boeing sold its aircraft to several airlines with no installed seating, and the airlines selected an allegedly defective seat design from a different manufacturer. The plaintiffs there argued that Boeing had a duty to: 1) warn its airline customers about the hazards of unsafe seat design; 2) identify manufacturers of unsafe seats; 3) recommend a safer alternative seating design; and 4) identify the manufacturers that made the safer seats. *Deep Vein Thrombosis*, 356 F. Supp. 2d at 1067. Under those circumstances, the court held that Boeing was not required to advise its customers about "potentially defective additional pieces of equipment that the purchaser *may or may not* use to complement the product bought from the manufacturer." *Deep Vein Thrombosis*, 356 F. Supp. 2d at 1068 (emphasis added). The court likewise found that Boeing had no legal duty to warn airline passengers that the airline "*may or may not* have supplemented the manufacturer's completed product with an allegedly defective piece of equipment," since there was no indication that Boeing had any reason to know "(1) what seat manufacturer Delta chose and (2) whether the seats actually installed are somehow defective." *Id.* (emphasis added). [2]

This is very different from the situation here. Plaintiffs do not ask the court to hold that Defendants have a duty to become experts in every product that *might* be used in conjunction with their own equipment. Nor do Plaintiffs ask that Defendants to conduct a post-sale inspection of their equipment to ensure that their customers do not ultimately choose to supplement their purchase with some other product that might prove defective. Rather, Plaintiffs argue that under the facts here, Defendants had a duty to warn workers who operated and repaired their equipment to take precautions against exposure to ashestos - a toxic substance that Defendants knew would *necessarily* be used with their equipment, and which Defendants themselves specified and supplied to their customers.

[2] The court also questioned the good faith of the plaintiffs' claims, noting that plaintiffs' counsel had previously represented to the Judicial Board on Multi-District Litigation that "if the plane manufacturer [Boeing] did not manufacture or install the seat, we have stipulated to summary judgment in those cases." *Id.* at 1063-64. The court also noted that "in their complaints, plaintiffs assert that the airlines, as well as the 'airline industry generally, had actual knowledge of the risk to passengers of contracting DVT during lengthy flights.' . . . . In trying to impose liability on Boeing, however, plaintiffs characterize the airlines and the airline industry as uninformed and unsophisticated about the risk of DVT." *Id.* at 1068.

III. THE FACTUAL RECORD

Finally, Defendants' duty to warn about asbestos must be analyzed in light of the actual facts of this case. Attached as Exhibits A - LL is a selection of historical documents produced by Defendants in discovery or obtained by Plaintiffs in government arcbives. These documents clearly indicate that Defendants knew that shipyard personnel and Navy seamen would regularly be exposed to asbestos while repairing and maintaining their equipment. The documents also show that while Defendants failed to warn workers about asbestos, they routinely instructed workers how to safely work with hazardous substances that Defendants did not supply or manufacture where they knew workers were likely to be exposed to those substances during the regular maintenance and repair of their equipment.

The factual record shows that Defendants knew that their equipment would contain asbestos insulation, gaskets, and/or packing, because the equipment required these asbestos components in order to function as intended on U.S. Navy vessels. This is evidenced by the fact that Defendants actually specified and/or supplied asbestos for use with their equipment. In most cases, defendants shipped their equipment with asbestos packing and gaskets already in place, and they frequently supplied replacement packing and gaskets as a spare part. Defendants also routinely specified the use of asbestos gaskets and packing in their technical manuals, parts lists, and drawings. Certain defendants also supplied asbestos insulation to their commercial and Navy customers; provided insulation drawings that called for asbestos insulation; and included directions about insulation in their manuals.

The factual record also shows that Defendants knew that the asbestos on their equipment would bave be stripped and replaced during routine repair and maintenance. In fact, Defendants' equipment manuals frequently instructed operators and maintenance personnel how to remove and replace asbestos gaskets and packing, and at times also specifically noted the need to remove or apply insulation and lagging. They simply failed to warn workers to take precautions against asbestos exposure while doing so.

Finally, the factual record shows that equipment manufacturers routinely warned workers about other tnxic substances that Defendants neither manufactured nor supplied, such as carbon tetrachloride, caustic soda, sulfamic acid, and benzene. Thus, there is nothing far-fetched

about the idea that Defendants had a duty to warn about asbestos that was supplied by other manufacturers. On the contrary, such warnings were standard practice in the industry.

A. Aurora Pumps

Exhibits A and B make it clear that Aurora Pumps knew and intended that the workers maintaining their pumps would be exposed to asbestos. Exhibit A is an excerpt from an Aurora Pumps Technical Manual for Fire, Flushing and Emergency Bilge Pumps supplied to the U.S. Navy. Exhibit B is a 1965 Aurora Pumps Bulletin for Type GB pumps supplied to commercial customers.

The Aurora manual attached as Exhibit A contains extensive information about asbestos packing and gaskets. On page 1-3 of the manual, Aurora instructs maintenance personnel that the packing box of the pump should be filled with "braided asbestos impregnated with a sealing ingredient and graphite which serves as a lubricant." [Exhibit A at WAL-4020] On page 4-1, Aurora makes it clear that Aurora provided the original asbestos packing, stating that: "Pumps leaving our plant are packed and lubricated ready for use." [Exhibit A at WAL-4024] Aurora Pump Drawing 2HCS-207 also indicates that Aurora supplied extra sets of Garlock asbestos packing as a replacement part, which are included in the list of "Onboard Repair Parts" as "Extra Spares." [Exhibit A at p. WAL-4032, 4033[

On page 4-1 of the manual, Aurora gives extensive, detailed instructions for the removal and replacement of this asbestos packing, but does not include any type of asbestos warning:

> [W]heo a pump is to be repacked, the fottowing procedure must be followed. The packing used is long fibre asbestos, square braided, and wett impregnated with oits and graphite, and should be similar to Gartock #234. (Mtt-P-17577 Type 1-1103).
> Wben repacking the pump, refer Figure 5-3, proceed as follows: (1) Remove att packing from the stuffing box. Ctean the stuffing box and shaft thoroughly so that it is free from dirt, oil or grease. (2) Cut off riog of 3/8 square packing stightty targer than the size of the shaft on which it is to be used. (Make bun joints, not tap joints, with each ring). Then force the ring to thc base of the stuffing box. Be sure the joint is butted and oot overtapped. Tamp the ring so that it forms a perfect fit around the shaft. Instatt each ring separately with butt joints staggered around thc shaft and tamp eacb ring so that it is formed to the stuffing box. After 2 rings have been instatted, insert the tantern ring. Comptetety fitt the stuffing box by installing 4 more riogs of packing, then draw up the gland sufficieotly to set the packing. (3) Retease the packing gland nuts unitt they can be turned with the fingers.

[Exhibit A at WAL-4024]

Exhibit A also indicates that Aurora provided asbestos gaskets with its pumps. Asbestos gaskets are listed in the Lists of Materials on Aurora Drawings 2FCS-218, and 2FCS-217. [Exhibit A at WAL-4035 - 4037]. Asbestos gaskets are also included in the "List of Materials II: Quantities for One Unit" among the "Online Repair Parts" listed in Aurora Pump Drawing 2HCS-207. [Exhibit A at WAL-4033].

The Aurora Pumps Bulletin attached as Exhibit B makes it clear that Aurora also routinely supplied asbestos packing to its commercial customers, stating that "[w]hen requested, GB pumps are supplied with packing rings." [Exhibit B at A0021[. Aurora specified that this packing would be asbestos, and made it clear that the pumps were actually designed to use asbestos:

> The stuffing box is designed for die-molded graphited packing. Long strands of interwoven asbestos form the backbone of the general service type packing.

Id.

B. Buffalo Pumps

Exhibits C through E demonstrate that Buffalo Pumps knew and intended that workers maintaining their equipment would be exposed to asbestos. Exhibit C is a compilation of Buffalo Pumps insulation drawings prepared for the U.S. Navy, and produced to Plaintiffs in the Tucker case. Exhibit D is a 1968 Equipment Manual for Buffalo Pumps distiller pumps on DE-1052 class vessels. Exhibit E is an excerpt from a Centrifugal Pump Application Manual, published by Buffalo Pumps in 1959 for general use by engineers.

In the insulation drawings attached as Exhibit C, Buffalo Pumps gave detailed instructions about the use of asbestos insulation and lagging on its feed pumps, drain pumps, and booster pumps on U.S. Navy vessels during the 1930s and 40s. For example, BPI-Tucker 000091 specifies that feed water drain booster pumps on cruisers should be insulated with 85% magnesia, to be applied approximately 1/2" thick around the suction and 1 1/2" thick around the pump casing, except the parts exposed for disassembly. BPI-Tucker 000092 though 000094 include similar instructions for feed pumps on destroyers. While BPI-Tucker 000098 through 000105 make it clear that the asbestos insulation itself was provided by the shipyard, Buffalo Pumps specified the use and application of the insulation, and Buffalo Pumps was clearly well-aware that its pumps on Navy vessels would be insulated with asbestos.

The excerpts from the Buffalo distiller pump manual attached as Exhibit D also makes it clear that Buffalo actually supplied its pumps to the Navy with asbestos packing and gaskets, and gave workers detailed instructions on how to remove and replace those asbestos components. Exhibit D indicates that Buffalo supplied the pump with asbestos packing installed:

> The pump caslog contains an foboard aod outboard stuffing box. The outboard stufflog box contains flve tings of graphite asbestos packing conforming to Mitliary Specifkation MIL-P-t7303 . The inboard stuffing box has six rings of packing.

[Exhibit D at BPI-07.08-Hawaii 000032]

Exhibit D further indicates that Buffalo was well-aware that this asbestos packing would periodically need to be removed and replaced. Buffalo gave workers detailed instructions on how to work with the asbestos packing, even including a "CAUTlON" that they should not use bulk packing or cut packing on the shaft. However, Buffalo did not warn workers to protect their own health against the toxic properties of asbestos:

> Packing. (See flgue 2-6-2) . Excessive teakage at the stuffing boxes that cannot be elimlnated by taking up on nuts (t3B) will require repacking the pump.
>
> . . . .
>
> 2. Remove alt otd packing ftom the stuffing box using cate oot to damage the shaft steeves . Remove seat cage hatves (t4A).
>
> CAUTtON: Always compteteiy repack the pump wlth new packing (66) . Do not use butk packing ot cut packing on the shaft.
>
> . . . . .
>
> 4. Use flve tings of pre-cut packiog for the outboard stuffing box and six tings for the inboard stufflog
>
> 5. Instatt one ring of packing (3/8 inch square per Milliary Specifkation MIL-P-t7303), graphite asbestos on shaft . "Walk" packing onto shaft by Separsting ends atong shaft. Never attempt to pult eods apart.

[Exhibit D at BPI-07.08-Hawaii 000042.]

Exhibit D likewise demonstrates that Buffalo supplied its pumps with asbestos gaskets, as indicated on the Pump List of Materials included in the manual at BPI-07.08-Hawaii 000047. Buffalo also instructed workers on the removal and replacement of these gaskets as follows, but again neglected to include a safety warning about asbestos:

> Gaskets . Renew gaskets aftet each disassembly if inspection shows gaskets to be cracked or damaged . Gasket seating surfaces should be thoroughly cleaned and inspected for damage . Coat both sides of the gaskets with graphite and oil before replacing the gaskets.

[Exhibit D at BPI-07.08-Hawaii 000050.]

Finally, the excerpts of a Centrifugal Pump Application Manual attached as Exhibit E make it clear that Buffalo Pumps knew and intended that asbestos would be used in its

pumps even outside the Navy context. Buffalo's Manual made it clear that "conventional packing" for centrifugal pumps at that time consisted of "rows of asbestos containing various lubricants." [Exhibit E at Manual-000093.] Moreover, Buffalo gave detailed information about ten different types of asbestos packing that it recommended for use with its pumps in various applications, including three types of blue asbestos packing. [Exhibit E at Manual-000094].

C. Cleaver Brooks / Aqua-Chem

Exhibits F through J demonstrate that Cleaver-Brooks/Aqua-Chem routinely warned workers to take safety precautions against hazardous substances that were supplied and manufactured by others, where the workers would be exposed to those substances during routine maintenance of Cleaver-Brooks products. These exhibits also demonstrate that Cleaver-Brooks / Aqua-Chem instructed maintenance workers to install, inspect, and replace insulation and other asbestos components on their distillers and boilers, but did not warn about the hazards of asbestos.

Exhibit F is an excerpt from a 1959 Aqua-Chem manual for a Flash-Type Distilling Unit on cargo vessels. In this manual, Aqua-Chem instructed maintenance workers that the distiller's heat transfer tubes could be cleaned either manually or with a weak acid solution. Aqua-Chem explained that acid cleaning was effective, but warned that "special equipment is required, and great care should be exercised when working with acid to prevent injury to personnel." Aqua-Chem went on to provide detailed, specific instructions about the safety precautions that workers should take to avoid dangerous acid exposure while servicing Aqua-Chem's distillers:

> Acid Cleaning safety Precautions
> 1. All personnel working with or near acid should wear protective clothing consisting of face shield or goggles, rubber gloves, and rubber apron. Care should be taken to avoid inhalation of acid fumes.
> 2. Acid should always be added to water - water added to acid may cause dangerous spattering.
> 3. Acid spilled on the person or other object should be promptly washed with large quantities of fresh water.

]Exhibit F at Manual-000392]

Cleaver-Brooks provided an even more detailed warning about the hazards of acid in its 1961 manual for Flash-Type Distilling Units, excerpts of which are attached as Exhibit G. In the 1961 manual, Cleaver-Brooks again warned all workers in the area to wear protective clothing and avoid inhaling acid fumes. In addition, Cleaver-Brooks advised workers who

inhaled the fumes to seek medical attention immediately, thereby underscoring the seriousness of the danger and giving workers additional information about how to protect themselves against the hazards of acid exposure:

> Acid Cleaning Safety Precautions
> 1. All personnel working with or near acid should wear protective clothing consisting of face shield or goggles; rubber gloves, and rubber apron.
> 2. Acid should always be added to water – water added to acid may rouse dangerous spattering.
> 3. Any person who inhales acid fumes should be withdrawn from the contaminated. area immediately and taken to fresh air. If exposure was' of any consequence, secure a physician. Place exposed person on his back with feet slightly elevated until physician arrives.
> 4. Acid spilled on e person or other object should be promptly washed with large quantities of fresh water. Affected skin areas should then be washed with lime water or covered with a lime paste. Resulting burns should be treated by physician as soon as possible.

[Exhibit G at Manual-000514]

Cleaver-Brooks' 1961 manual also advised maintenance workers to insulate the distiller's air ejector steam line as protection against wet steam in the evaporator. [Exhibit G at Manual-000527] Here, however, Cleaver-Brooks failed to warn workers to use any protective clothing or take any safety precautions when applying asbestos insulation to the distiller.

Aqua-Chem again provided extensive warnings about acid but failed to warn about asbestos in its 1974 manual for a Marine Flash Distilling Plant, excerpts of which are attached as Exhibit H. The 1974 manual instructed workers to avoid dusting powdered acids, to ensure that the area was well-ventilated, to use a variety of safety equipment, and even to put up warning signs in the area to alert other workers of the danger. Indeed, Aqua-Chem even included a special Technical Bulletin on the hazards of acid as an insert to the manual:

> SAFETY PRECAUTIONS
> A. Always add to acid to water, slowly and carefully to avoid spattering. Never add water to concentrated acid
> B. Avoid "dusting" of powdered acids
> C. Insure that all gases generated during cleaning operation are vented to weather
>
> SAFETY EQUIPMENT
> A. Safety clothing - foul weather gear is desirable In its absence, wool clothing is recommended
> B. Safety goggles
> C. Safety hats
> D. Rubber footwear. If boots are used trouser legs should be outside the boot tops
> E. Signs: "DANGER – ACID" and "NO SMOKING"

[Exhibit H at Manual-000591, 595[

Again, however, Aqua-Chem failed to provide any such warning about the hazards of asbestos insulation, although it clearly instructed that "all heated surfaces must be adequately insulated to prevent injury to personnel." [Exhibit H at Manual-000563] Aqua-Chem

did not inform workers that they should protect themselves against asbestos exposure when they were instructed to "insulate ejector steam lines" and inspect the evaporator shell for "insulation discoloration" in order to check for leaks. [Exhibit H at Manual-000567, 609].

Likewise, in its 1965 manual for a Model C-B land-based boiler, excerpts of which are attached as Exhibit I, Cleaver-Brooks properly warned workers to take safety precautions when using caustic soda or soda ash to boil out a new boiler unit:

> When dissolving chemicals, the chemical should be added to the water. NEVER ADD WATER TO THE CHEMICALS! . . . .The heat created and resultant boiling when chemical is added to the water must be kept under control to prevent excessive turbulence and possible injury to personnel. For that reason, only small amounts of chemical should be added at any one time.
>
> CAUTION!
> Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals.

[Exhibit I at MPS_52494, 52531]

However, Cleaver-Brooks failed to provide any such warning when instructing workers to apply asbestos rope and asbestos cement to the rear door of the boiler's furnace. [Exhibit I at MPS_52537.]

Ten years later, in its 1975 manual for CB Packaged Boilers, excerpts of which are attached as Exhibit J, Cleaver-Brooks again provided an appropriate warning for caustic soda, and soda ash:

> CAUTION!
> Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals. Do not permit the dry material or concentrated solution to come into contact with skin or clothing.

[Exhibit J at Manual-000721]

Again, however, Cleaver Brooks failed to provide any type of safety warning when instructing workers to apply asbestos cement, asbestos millboard, and asbestos rope to the boiler furnace.]Exhibit J at Manual-000778 through 780]

D. Crane Co.

Exhibits K through O demonstrate that Crane Co knew and intended that workers maintaining Crane valves would be exposed to asbestos insulation, packing, and gaskets. As these exhibits show, Crane routinely supplied a variety of asbestos products for use with its

valves, both to the U.S. Navy and to commercial customers, including its own proprietary brand of Cranite asbestos gaskets and packing.

Exhibit K is a selection of pages from Crane Co. Catalog No. 53 for Valves, Fitting, and Pipes, dated 1952. This catalog demonstrates that Crane Co was well-aware that its valves were routinely insulated with asbestos. Indeed, Crane offered its commercial customers numerous lines of Johns-Manville asbestos insulating materials, including 85% magnesia; Asbestocel; asbestos millboard, asbestos blocks, and asbestos insulating cement. [Exhibit K at 000201 – 202]. Crane was likewise aware that its valves would contain asbestos gaskets and packing. In fact, Crane offered its own proprietary brand of "Cranite" asbestos sheet packing and gaskets, which it advertised as "An Asbestos Composition manufactured solely for Crane." [Exhibit K at 000204]. Thus, Crane cannot deny that it knew very well that the workers who serviced its valves would be exposed to asbestos.

Crane Co. also specified and supplied asbestos gaskets and packing directly to the U.S. Navy, as demonstrated in Exhibit L. Exhibit L is a compilation of Crane Co drawings for valves on U.S. Navy DD-692 class destroyers and DE-339 class destroyer escorts. The List of Materials in the upper right hand corner of each drawing specifies that the valves will contain asbestos packing. [Exhibit L at WAL-3856 – 3867]. Each List of Materials also identifies the gaskets used on the valves as "Cranite," Crane Co's proprietary brand of asbestos material. *Id.*

In addition, as reflected in Exhibit M, Crane supplied gaskets and packing to the U.S. Navy as spare parts for the overhaul of its valves. Exhibit M is a Crane invoice dated September 26, 1973, for "Parts for Overhaul of Crane Co. Valves for SSBN622 Overhaul, US Navy Contract." According to the invoice, Crane supplied 153 sets of packing and 147 sets of gaskets for use by Navy maintenance personnel in the overhaul of Crane valves on the SSBN-662. [Exhibit M at CRIMDEBN00010931 – 10933].

Crane Co also published manuals and service bulletins that gave maintenance workers detailed instructions about how to work safely with their valves, including gaskets and packing. Exhibit N is a selection of pages from a Crane publication entitled "Piping Pointers for Industrial Maintenance Men." Crane explained to workers that it had issued this pamphlet because "not only is Crane the world's largest source of dependable valves and fittings for every service, but also the source of the most reliable data regarding their use."]Exhibit N at Manual-

000810]. Thus, Crane's "Piping Pointers" included an entire page of safety instructions about the hazards involved in the repair and maintenance of Crane valves, including hazards that might arise from products manufactured by others:

> 1. Before breaking into a line, shut it off and drain. Failure to do so may result in a shower of water, but it might have been acid or steam.
> . . . .
> 5. Always use chain blocks, cable slings, rope falls, or rope slings when raising or lowering a piece of heavy piping. Make sure hoists are strong enough and that hitches won't slip.
> . . . .
> 10.Keep your bench clean of 'odds and ends.' Wipe up oil spots on the floor to avoid slipping. Use safety goggles on chisel or grinding work.

[Exhibit N at Manual-000808].

Crane's "Piping Pointers" also included detailed instructions about the removal and replacement of packing and gaskets, and specifically noted that the gaskets were often asbestos. [Exhibit N at Manual-000805, 806[Here, however, Crane neglected to include any safety warning about the hazards of asbestos. *Id.*

Finally, Exhibit O is an Instruction Manual for the Installation, Operation, and Maintenance of various Crane valves. The manual contains detailed instructions for the removal and replacement of the stuffing box packing. Crane cautioned workers to take extreme care to avoid damage to the stuffing box bore, but neglected to warn them to avoid inhaling asbestos dust:

> The following procedure should be used to replace packing in assembled valves whether or not installed in the system. . . . -
> 1. Remove nuts from packing gland bolting.
> 2. Raise packing gland and gland flange to allow access to stuffing box.
> 3. Remove the old packing using a suitable packing removal tool.
> CAUTION: Extreme care shall be taken to prevent damage to surfaces of the stem and stuffing box bore.
> 4. Clean the stem, stuffing box, and packing gland.
> 5. Inspect surfaces of the stem and stuffing box for damage such as nicks and scratches which may cause an inadequate packing seal. Damaged parts shall be repaired or replaced.
> 6. Lubricate packing gland studs.
> 7. Install new packing into stuffing box. One packing ring shall be installed at a time. . . .

[Exhibit O at CRIMDEBN0018732]

E. Foster Wheeler

Exhibit P demonstrates that Foster Wheeler was well-aware that the routine maintenance of its equipment on U.S. Navy vessels would expose workers to asbestos insulation.

Exhibit P is an excerpt of a manual of Instructions for Foster Wheeler Marin Steam Generators on Fletcher Class destroyers. Indeed, Foster Wheeler specifically instructed workers that the care and maintenance of the boiler's economizer included "Applying Insulation," because "[t]he casing of the economizers should be maintained gas tight and well-insulated." [Exhibit P at Manual-001149, 1187].

The List of Reference Drawings also makes it clear that Foster Wheeler provided numerous insulation drawings with its boiler, including a "List of Field Bolts, Gaskets, and Insulating Material," several drawings for "Insulated Panels," and a drawing for "Insulation Pads." [Exhibit P at pp. Manual-001154, 1155]. Plaintiffs do not have the particular drawings referenced. However, the BuShips Insulation Plan for boiler steam drums on DD-445 class vessels, attached as Exhibit W, makes it clear that the insulating material on the boilers would have included amosite felt and asbestos cloth. [Exhibit Q at Fletcher Class 0976, 0977].

F. General Electric

Like Cleaver-Brooks and Aqua-Chem, General Electric also provided warnings about the products of other manufacturers that were used in conjunction with its own equipment. Exhibit R is an excerpt from a GE Manual for Ship Service Generator Set on DD-692 class vessels. In this manual, GE provided extensive warnings about the hazards of benzene, gasoline, and carbon tetrachloride that were used to clean the generator windings, although GE did not manufacture or supply these solvents:

> BENZINE OR GASOLINE: Either benzine or gasoline is very inflammable,and their vapors mixed with the proper percentage of air are quite explosive. If this type of solvent is used, there should be good ventilation, and every care taken to avoid fire risk. Care should also be taken to see that the workers' clothes do not become saturated with the solvent. Clothing which does become saturated with the solvent should be removed before the worker leaves the job.
>
> CARBON TETRACHLORIDE: Carbon tetrachloride is noninflammable and nonexplosive. This solvent is much more corrosive in its action than either benzine or gasoline. . . . Because of its toxic effect, adequate ventilation must be provided. . . . . Its use is preferable where fire risk is high.
>
> MIXTURE: A mixture of 50 percent carbon tetrachloride and 50 percent benzine, or 60 percent tetrachloride and 40 percent gasoline, is noninflammable; but the vapors mixed with the proper amount of air are explosive. There should be fair ventilation so that the explosive fumes will not accumulate. There is no particular danger from spilling these mixtures on the clothing. This solvent may therefore be used where there is fire risk, but only where the ventilation is sufficient to prevent the accumulation of an explosive mixture of fumes.

[Exhibit R at Manual-000870]

By contrast, GE did not provide any warnings about the hazards of asbestos when instructing workers to remove the turbine lagging in order to disassemble the generator's turbine. [Exhibit R at Manual-000852].

G. General Motors

Exhibits S through W demonstrate that General Motors routinely warned workers about the hazards of carbon tetrachloride and other solvents used to clean its marine engines and heat exchangers, although GM neither manufactured nor supplied the solvents. However, these exhibits also make clear that GM did not warn about the hazards of asbestos, even when instructing workers to remove and replace asbestos gaskets and packing.

Exhibit S is an excerpt from a GM manual for the Care and Operation of Model 3-268A Cleveland Diesel engines on U.S. Navy vessels. GM's Cleveland Diesel division instructed workers to take special safety precautions against the toxic effects of carbon tetrachloride used to maintain the engine's oil coolers and Bendix drive. GM warned that the carbon tetrachloride should only be used in a well-ventilated area, and noted that the toxic effects of the chemical were cumulative:

> During the cleaning operation, the cooler should be handled carefully to avoid injuring the tubes. The cleaning should be done in a room with adequate ventilation, or in the open air, on account of the toxic qualities of carbon tetrachloride (Pyrene fire extinguisher fluid), which is used as the cleaning fluid. Frequent wetting of the skin with this fluid should be avoided because the toxic effects are cumulative. Immersion of the hands in this fluid should also be avoided.

[Exhibit S at CY-Manuals-000077]

> Clean the screw shaft and the meshing pinion with carbon tetrachloride (Pyrene fire extinguisher fluid). A cautionary note on the use of this cleaning fluid appears in Section 2 in the chapter entitled, "Lubricating Oil System."

[Exhibit S at CY-Manuals-000102]

GM's Harrison Radiator Division offered a similar warning about the hazards of carbon tetrachloride and trichloroethylene fumes in its 1945 Heat Exchanger Service Manual, NAVSHIPS 345-0231, attached as Exhibit R:

> (3) Caution. Carbon tetrachloride and trichlorethylene give off toxic vapors and, when employed for cleaning purposes must be used in the open air on deck or in a well ventilated room.

[Exhibit T at CY-Manuals-001137]

Harrison Radiator expanded on this warning in its 1957 Service Bulletin to commercial customers, attached as Exhibit U. Harrison advised workers to use carbon tetrachloride, trichlorethylene, or varnalese to clean its oil coolers, but warned:

> CAUTION: If solvents are used, care must be taken to utilize them in accordance with their manufacturer's instructions. It is essential to provide suitable and adequate ventilation as a protection against toxic effects. Fire protection in accordance with local laws must also be provided.

[Exhibit U at DDC000011383]

An identical warning also appeared in Harrison's 1967 Heat Exchanger Service Manual, excerpts of which are attached as Exhibit V. [Exhibit V at DDC000011400 - 11401]

Finally, in the Service Manual for In-line Series 71 engines, excerpts of which are attached as Exhibit W, GM's Detroit Diesel division gave workers an even stronger warning about the hazardous chemicals that were frequently used to maintain GM engines:

> 5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron. Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

[Exhibit W at GM_MERRION006549].

GM also specifically warned workers to take precautions when using cleaning solutions to clean the engine's turbocharger:

> CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes.

[Exhibit W at GM_MERRION006964].

By contrast, GM did not suggest even the most minimal safety precautions when instructing workers to install twenty to thirty feet of asbestos packing into the turbocharger:

> 22. Install the asbestos packing in the nozzle ring grooves.
> a. Use all of the packing (20 feet).
> b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

[Exhibit W at GM_MERRION006981].

> 22. Install the asbestos packing in the nozzle ring grooves.
> a. Use all of the packing (30 feet).

b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

[Exhibit W at GM_MERRION006986].

H. IMO/De Laval

Exhibits X, Y, and Z demonstrate that De Laval Steam Turbine Company also knew that the workers maintaining its equipment would be exposed to asbestos. These exhibits show that De Laval specified and/or supplied the asbestos-containing insulation, gaskets and packing used with its pumps and turbines, and gave specific instructions about how to work with those asbestos components.

Exhibit X is an excerpt from a De Laval manual for Lube Oil Pumps on the BB-57 and BB-59. The manual makes it clear that De Laval is aware that the turbine would be insulated according to Navy specifications, and that the insulation would need to be disturbed in the course of regular use:

Insulation (All Classes)
The steam chest and turbine casing are insulated and lagged according to Navy requirements. The insulation and lagging are sectionalized so that the steam strainer and the turbine cover can be removed and replaced without the necessity for renewing the insulation.

[Exhibit X at Manual-001301]

Indeed, the manual indicates De Laval supplied its own insulation drawings, listed as Factory No. G-7449, G-7456, and G-7463. [Exhibit X at Manual-001261, 1262] The manual also states that "[t]he nozzle valve and the governing valve were packed at the factory with asbestos Packing conforming to Navy Specification 33P26, Type B." [Exhibit X at Manual-001297[.

Moreover, De Laval instructed workers on a number of maintenance procedures that required them to disturb this asbestos insulation and packing. For example, De Laval gave workers the following instructing for disassembling the steam nozzle valve and steam chest governing valve:

To remove the valve elements, it is necessary first to detach the steam chest from the main casing which involves (1) breaking the steam inlet and steam chest drain connections, (2) detaching the line pressure gage, (3) removing the steam chest lagging and insulation, and (4) disconnecting the governor linkage at the valve operating spindle

Directions for taking out the valve parts follow:
Remove the steam chest lagging and insulation.

[Exhibit X at Manual-001294, 1297.]

Likewise, when disassembling the gear unit, De Laval instructed workers to pull off the turbine lagging. And while De Laval told workers that it was not necessary to disturb the cover plate insulation, it did not give workers any indication that this procedure could expose them to hazardous asbestos dust:

> Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.
> . . . . .
> Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.
> Remove the turbine shaft packing.

[Exhibit X at Manual-001291]

De Laval gave similar instructions in its manuals for Main Feed Booster Pumps on DD-445 and DD-692 class vessels, excerpts of which are attached as Exhibits Y. Both manuals again instructed workers to pull off turbine lagging and remove packing when disassembling the gear unit:

> Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.
> . . . . .
> Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.
> Remove the turbine shaft packing.

[Exhibit Y at BPI-07.08-Hawaii 011493; BPI-07.08-Hawaii 003749[

Both manuals in Exhibit Y also make it clear that De Laval provided the pumps with asbestos packing, again noting that"[t]be nozzle valve and the governing valve were packed at the factory with asbestos Packing conforming to Navy Specification 33P26, type B." [Exhibit Y at BPI-07.08-Hawaii 011500; BPI-07.08-Hawaii 003758[.

Moreover, De Laval was well aware that the turbines would be insulated with asbestos, as indicated by the De Laval Insulation Drawing for Fuel Oil Booster and Transfer Pumps attached as Exhibit Z. This drawing, which bears De Laval Plan No. 8575, gives detailed instructions for the application of almost 40 pounds nf asbestos cloth, amosite asbestos felt, and 85% magnesia to the turbines of De Laval Pumps on CL-55 class U.S. Navy vessels. [Exhibit Z at 4[.

I. Leslie

Exhibit AA, BB, and JJ demonstrate that like De Laval, Leslie Controls was well aware that the workers maintaining its equipment would be exposed to asbestos insulation and packing. Throughout Exhibits AA, BB, and JJ, Leslie gave numerous instructions about how its valves and surrounding piping should be insulated, and specifically called for the use of asbestos packing. In Exhibit JJ, Leslie expressly indicated that the pipes should be covered with 85% magnesia asbestos insulation. Exhibit KK also shows that Leslie instructed workers to take precautions against the hazards of toxic solvents, even though Leslie never warned about the hazards of asbestos.

Exhibit AA is a set of Instructions for Leslie Pressure Reducing Valves and other Navy equipment from the U.S.S. Kidd. Exhibit BB is an excerpt from a Technical Manual for Leslie valves and regulators on U.S. Navy vessels AE-21 and 22. Exhibit JJ is a Leslie handbook of Engineering, Operating, and Maintenance Data for Leslie controls, strainers and whistles, identified as Catalog Series 5300. Exhibit KK is a Leslie Technical Manual for Air Priority Valves on U.S. Navy vessels, dated January 1974.

In Exhibit AA, Leslie instructed the workers installing its pressure reducing valves to "[i[nsulate all pipe before and after reducing valve to minimize condensation." [Exhibit AA at Manual-000959[Leslie similarly instructed workers installing its Leslie-Tyfon whistle that "Piping should be well insulated and where exposed should be double insulated." *Id.* at Manual-000978. Leslie also supplied drawings that showed where external insulation was to be applied. [Exhibit AA at Manual-000983[. Moreover, Leslie included "insulation" as one of the numbered items on its Leslie-Tyfon steam whistle Parts List, indicating that Leslie may have actually supplied the insulation. *Id.* at Manual-000981.

In the manual attached as Exhibit BB, Leslie likewise told workers to "[i[nsulate all pipe before and after reducing valve to minimize condensation." [Exhibit BB at Manual-001007]. Leslie also instructed workers on the removal and replacement of asbestos packing, as follows:

> t4. Packing Reoewal. Remove otd Packing Set (t t) and ctean stuffing boX thotoughty. With tower stem (5) in ptace, repack in fottowing otder and with openings in packing atternated.
> a. t-Btaided Asbestos Ring
> b. t-Metaltic Ring
> e. t-Lubticatot Steeve
> d. t-Metattic Ring

e. sufficient soft (plastic) Rings to fill box leaving space for (f) Ring.
f. 1-Metallic Ring

[Exhibit BB at Manual-000996]

The Leslie handbook of Engineering, Operating, and Maintenance Data attached as Exhibit JJ contains numerous similar instructions regarding insulation. Leslie again told workers to "insulate all pipe before and after reducing valve," to "insulate all steam lines to minimize condensation losses" on pump pressure regulators, and to ensure that the piping to Leslie-Tyfon whistles was "well insulated and where exposed to outside conditions, doubly insulated." [Exhibit JJ at ManualBIW-000565, 683, 761.] Leslie also advised users that its temperature and pressure regulators for heaters and heat exchangers were available with extension neck casings and special bulb casings "that permit full exterior insulation of the tank or oven." *Id.* at ManualBIW-000704, 709.]

Exhibit JJ also makes it clear that Leslie was entirely aware that this exterior insulation would contain asbestos, and even supplied asbestos insulation. In Leslie's reference tables of "Engineering Data for Steam Flow through Pipes," Leslie expressly indicated that steam pipes should be covered with "2-in. thick 85% magnesia insulation." *Id.* at ManualBIW-000784. Likewise, the Part List for the Leslie-Tyfon steam whistle included "Insulation – Asbestos" with a Leslie part number. *Id.* at ManualBIW-000770. Nevertheless, Leslie entirely failed to tell workers how to protect themselves against the asbestos dust that would be generated when they applied and removed this insulation.

By contrast, in the manual attached as Exhibit KK, Leslie did instruct workers to take precautions against breathing toxic solvent vapors while cleaning valve parts:

WARNING
Flammable and toxic solvents should be used only in a well-ventilated area; avoid breathing solvent vapors. Keep flame and others sources of ignition away from solvent or solvent vapors.

[Exhibit KK at ManualBIW-000850]

J. Warren Pumps

The series of Warren Pumps purchase orders and invoices attached as Exhibit CC leaves no doubt that Warren Pumps not only knew that its pumps would be insulated with asbestos, but actually supplied the original asbestos insulation at times. An invoice for Warren

feed pumps supplied to the U.S. Navy Yard makes it clear that "[s]uitable steam cylinder, cylinder head and valve insulation of 85% magnesia and planished steel lagging shall be furnished by the Vendor," while [l]iquid cylinder insulation and lagging will be provided by the Shipbuilder as required." [Exhibit CC at WP 0144844]. Other invoices specify that the steam cylinders of Warren's pumps were "to be insulated with a suitable thickness of 85% magnesia insulation." [Exhibit CC at WP 0144815, 816, 818, 819, 822, 823, 825-827]. Thus, Warren clearly knew that its pumps on Navy vessels would require the use of asbestos.

Moreover, Warren routinely instructed workers how to safely use other manufacturers' products where those products were necessary for the installation and maintenance of Warren's own equipment. In the Warren Pumps manual attached as Exhibit DD, for example, Warren Pumps warned workers to ensure that they had adequate ventilation when using cleaners or solvents to clean Warren's oil coolers, although Warren neither manufactured nor supplied those solvents:

> To clean inside of plate, immerse the core in a suitable cleaner or solvent. (CAUTION: This operation should be done in the open air or with adequate ventilation.)

[Exhibit DD at HI-EM-00212]

Likewise, in the Warren drawing attached as Exhibit EE, Warren gives the following instructions for working with another manufacturer's adhesive::

> Screws PC No. 11 are fastened to shafts PC No. 8 & 9 with adhesive Ren RP-1250 Paste & Hardener, Mfr by Ren Plastics, Inc. . . . Denatured alcohol should be used for cleaning the parts prior to use of adhesive & for cleaning off excessive adhesive after assembly. "Ren" hand cleaner is suitable for removing adhesive from hands.

[Exhibit EE at Note 16]

K. Westinghouse

Exhibit FF is an excerpt from a Westinghouse manual for Lubricating Oil and Fuel Oil Pumps on the USS Kidd. Exhibit GG is an excerpt from a Westinghouse manual for Forced Draft Blowers on the USS Kidd. Like Warren Pumps, Westinghouse also warned workers to take appropriate safety precautions to avoid inhaling toxic fumes from cleaners and solvents supplied by other manufacturers. Both manuals contain substantially the same warning:

> To clean the inside of the plate, immerse the core in a suitable cleaner or solvent. (CAUTION: This operation should be done in the open air or with adequate ventilation.)

[Exhibit FF at Manual-001081; Exhibit GG at Manual-001126.]

In addition, the insulation drawings attached as Exhibit HH demonstrate that Westinghouse also knew that the turbines on its equipment required asbestos insulation. Exhibit HH is a Westinghouse insulation drawing for turbo-generator sets on AO-143 class Navy vessels. In this drawing, Westingbouse clearly specified several types of asbestos insulation in the List of Materials for its turbine, including "Thermal Block," "Asbestos Felt," and "Asbestos Cloth." [Exhibit HH at CHPL-22]. Westinghouse also gave detailed instructions for the application of the insulation. In some places, Westinghouse noted that workers should apply "portable insulation for access to strainer." [Exhibit HH at CHPL-21]. In other places, Westinghouse instructed workers to "recess insulation for steam seal manifold piping," or for "gland pipe" or "guide studs." *Id.* Westinghouse also instructed workers to "insulate piping to steam seal manifold." However, Westinghouse did not warn workers that this operation should only be done with adequate ventilation, nor did they instruct workers to use respiratory protection or take any other precautions against the hazards of asbestos exposure.

L. William Powell

Like the other equipment defendants, William Powell knew that its valves would require asbestos insulation, gaskets, and packing. Exhibit LL is a William Powell Valves Catalog dated 1975. The catalog makes it clear that William Powell sold its valves with asbestos gaskets and packing already installed. William Powell advertised that the body, bonnet, and cap of its valves were "regularly supplied with a bonded, compressed asbestos gasket." [Exhibit LL at ManualBIW-000184.] William Powell also advertised that "valves used for temperatures over 500°F can be supplied with asbestos packing." *Id.* The catalog also makes it clear that William Powell was well-aware that its high-temperature valves would be insulated, as it advertised that the body of its Powell pressure seal valves was streamlined to "simplif[y] application and reduce[] cost of insulation." *Id.* at ManualBIW-000130].

M. Yarway

Finally, the Foster Wheeler manual attached as Exhibit V includes a Yarnall-Waring Co. drawing with detailed instructions for the insulation of the Yarway Remote Pressure Differential Indicator installed on Foster Wheeler Boilers. [Exhibit V at Manual-001248, Figure 52.] Yarway instructed workers to apply "INSULATION 1" THICK ON 1/2" PIPES" and "INSULATION 1" THICK ON 3/4" PIPES," but warned "DO NOT INSULATE" the indicator's

head chambers. *Id.* Yarway also directed workers to install a warning plate on the indicator that stated: "SECURE ALL SUPERHEATER BURNERS WHEN POINTER IS IN RED ZONE." *Id.* However, Yarway did not include any type of asbestos warning or caution.

IV. CONCLUSION

Under these facts, Defendants had a duty to make their equipment safe for use by warning workers to take precautions against asbestos exposure. Based on the foregoing reasons and authorities, Plaintiffs respectfully request this Honorable Court to deny Defendants' motions for summary judgment.

DATED: Honolulu, Hawaii, SEP 08 2009.

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IN THE CIRCUIT COURT OF THE FIRST CIRCUIT

STATE OF HAWAII

IN RE: HAWAII STATE ASBESTOS CASES	CIVIL NO. 09-1-ACM-2 (EEH) (Toxic Tort / Asbestos Personal Injury)
This Document Applies To:	DECLARATION OF COUNSEL
	CIVIL NO(S).:
CABATBAT, ARTURO CASSANI, VINCENT J. FELICIANO, JOSEPH RIVEIRA, PATRICK (D) VILLIATORA, MELCHIRO (D) YATSU, HENRY	08-1-2033-10 (EEH) 09-1-0234-01 (EEH) 08-1-1957-09 (EEH) 08-1-2559-12 (EEH) 09-1-0209-01 (EEH) 09-1-0374-02 (EEH)

DECLARATION OF COUNSEL

I, ILANA K. WAXMAN, hereby declare pursuant to Circuit Rule 7(g), Rules of the Circuit Court of the State of Hawaii, as follows:

1. I have personal knowledge of the following facts, and I am competent to testify as follows.

2. I am one of the attorneys for Plaintiffs herein and make this declaration upon personal knowledge unless otherwise indicated.

3. Attached hereto and marked as Exhibit A is an excerpt from a true and correct copy of an Aurora Pumps Technical Manual for Fire, Flushing and Emergency Bilge Pumps supplied to the U.S. Navy (WAL-4014 to 4090). The original manual was found at the National Archives by William A. Lowell, as stated in paragraph 7v of the Lowell Declaration which is attached as an exhibit to the Plaintiffs Opposition to Defendants Motion for Summary Judgment in the Agena case.

4. Attached hereto and marked as Exhibit B is a true and correct copy of a 1965 Aurora Pumps Bulletin for Type GB pumps, which was produced by Defendant Aurora Pumps in the Hawaii litigation (A0017 to 28).

5. Attached hereto and marked as Exhibit C is a true and correct copy of Buffalo Pumps insulation drawings prepared for the U.S. Navy, and produced to Plaintiffs by Defendant Buffalo Pumps in the Tucker case (Tucker 000091 to 105).

6. Attached hereto and marked as Exhibit D is an excerpt from a true and correct copy of a 1968 Equipment Manual for Buffalo Pumps distiller pumps on DE-1052 class vessels, produced to Plaintiffs by Defendant Buffalo Pumps in the Hawaii litigation (BPI-07.08-Hawaii 000001 to 55).

7. Attached hereto and marked as Exhibit E is an excerpt from a true and correct copy of an original 1959 Centrifugal Pump Application Manual published by Buffalo Pumps (MANUAL-000001 to 279). The complete original volume is in Plaintiffs' possession, and a true and correct copy was previously produced to Defendants.

8. Attached hereto and marked as Exhibit F is an excerpt from a true and correct copy of a 1959 Aqua-Chem manual for a Flash-Type Distilling Unit on cargo vessels. Plaintiffs obtained this manual from the collection of William A. Lowell, and produced the complete manual to Defendants in the Hawaii litigation (Manual-000359 to 467). This manual is prima facie authentic based on its distinctive characteristics including Aqua-Chem company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

9. Attached hereto and marked as Exhibit G is an excerpt from a true and correct copy of a 1961 Cleaver-Brooks manual for Flash-Type Distilling Units. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000468 to 546). This manual is prima facie authentic based on its distinctive characteristics including Cleaver-Brooks and Aqua-Chem company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

10. Attached hereto and marked as Exhibit H is an excerpt from a true and correct copy of a 1974 Aqua-Chem manual for a Marine Flash Distilling Plant. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000547 to 690). This manual is prima facie authentic based on its distinctive characteristics including Aqua-

Chem company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link* v. *Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

11. Attached hereto and marked as Exhibit 1 is an excerpt from a true and correct copy of 1965 manual for a Model C-B Boiler (MPS_0052465 to 52565). The complete manual was produced by Defendant Cleaver Brooks in the Hawaii litigation.

12. Attacbed herein and marked as Exhibit 1 is an excerpt from a true and correct copy of a 1975 manual for CB Packaged Boilers. Plaintiffs have produced the complete manual to Defendants in the Hawaii litigation (Manual-000691 to 794). This manual is prima facie authentic based on its distinctive characteristics including Cleaver-Brooks company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link* v. *Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the boiler manual attached as Exhibit 1. *See* Haw. R. Evid. 901(b)(3).

13. Attacbed heretn and marked as Exhibit K is a true and correct copy of a selection of pages from Crane Co. Catalog No. 53 for Valves, Fitting, and Pipes, dated 1952 (000161 to 210). These pages were used an exhibit to the January 9, 2007 deposition of Crane representative Anthony Pantaleoni, who conceded the authenticity of the catalog. The relevant portions of Mr. Pantaleoni's deposition transcript are attacbed bereto as Exhibit II. [Exhibit II at 52:9 – 52:20].

14. Attached hereto and marked as Exhibit L is a true and correct copy of a compilation of Crane Co drawings for valves on U.S. Navy DD-692 class destroyers and DE-339 class destroyer escorts (WAL-3856 to 3867). The original drawings were found at the National Arcbives by William A. Lowell, as stated in paragraph 7r of the Lowell Declaration attacbed as an exhibit to the Plaintiffs Opposition Memorandum in Agena.

15. Attacbed bereto and marked as Exhibit M is a true and correct copy of a Exhibit M is a Crane invoice dated September 26, 1973, for "Parts for Overbaul of Crane Co. Valves for SSBN622 Overhaul, US Navy Contract" (CRIMDEBN00010931 to 10933). This document was produced by Defendant Crane Co from the Crane document repository in Freehold, New Jersey, and has a Crane Co. bate number.

16. Attacbed hereto and marked as Exhibit N selected pages from a Crane publication entitled "Piping Pointers for Industrial Maintenance Men" (Manual-000795 10 811). I personally photocopied these pages from the original publication, which I found in the Trade Literature Collection in the National Museum of American History Library at the Smithsonian Insiitution in Washington, D.C.

17. Attached hereto and marked as Exhibit O is a true and correct copy of an Instruction Manual for the Installation, Operation, and Mainuenance of various Crane valves (CRIMDEBN00018721 to 18735). This document was produced by Defendani Crane Co from the Crane document repository in Freebold, New Jersey, and has a Crane Co. bate number.

18. Attached hereto and marked as Exhibit P is an excerpt of a true and correct copy of a book of Instructions for Foster Wheeler Marin Steam Generators on Fletcher Class destroycrs (Manual-001147 to 1254). This manual is prima facie authentic based on its distinctive cbaracteristics including Foster Wheeler company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

19. Attacbed hereto and marked as Exhibit Q is a true and correct copy of a BuShips insulation drawing for the Insulation and Lagging of a Boiler Steam Drum on DD-445 class vessels (FletcherClass-0975 to 976). Plaintiffs obtained this drawing from the collection of William A. Lowell.

20. Attached hereto and marked as Exhibit R is an excerpt from a true and correct copy of a GE Manual for Ship Service Generator Set on DD-692 class vessels (Manual-000812 to 954). This manual is prima facie authentic based on its distinctive characteristics including General Electric company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4).

21. Attached hereto and marked as Exhibit S is an excerpt from a true and correct copy of a GM manual for the Care and Operation of Model 3-268A Cleveland Diesel engines on U.S. Navy vessels (CYManuals-000043 to 195). Plaintiffs obtained a true and correct copy of the complete manual from the library of U.S.S. Cassin Young (DD-793) ship museum in Boston, MA.

22. Attached hereto and marked as Exhibit T is an excerpt from a true and correct copy of a 1945 Harrison Radiator Heat Exchanger Service Manual, NAVSHIPS 345-0231 (CYManuals-001096 to 1143). Plaintiffs obtained a true and correct copy of the complete manual from the library of U.S.S. Cassin Young (DD-793) ship museum in Boston, MA.

23. Attached hereto and marked as Exhibit U is a true and correct copy of a 1957 Harrison Radiator Service Bulletin (DDC000011381 to 11384). This Bulletin was produced by Defendant General Motors in the Hawaii litigation.

24. Attached hereto and marked as Exhibit V is an excerpt from a true and correct copy of a 1967 Harrison Radiator Heat Exchanger Service Manual (DDC000011385 to 11420). The complete manual was produced by Defendant General Motors in the Hawaii litigation.

25. Attached hereto and marked as Exhibit W is an excerpt from a true and correct copy of a 1983 Detroit Diesel Service Manual for In-line Series 71 engines (GM MERRION006533 to 7542). The complete manual was produced by Defendant General Motors in the Hawaii litigation.

26. Attached hereto and marked as Exhibit X is an excerpt from a true and correct copy of a De Laval manual for Lube Oil Pumps on the BB-57 and BB-59 (Manual-1255 to 1334). This manual is prima facie authentic based on its distinctive characteristics including De Laval Steam Turbine company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link v. Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the De Laval manuals attached as Exhibit Y. *See* Haw. R. Evid. 901(b)(3).

27. Attached bereto and marked as Exhibit Y is an excerpt from a true and correct copy of the De Laval manuals for Main Feed Booster Pumps on DD-445 and DD-692 class vessels (BPI-07.08-Hawaii 011468 to 11526; BPI-07.08-Hawaii 003724 to 3772). The complete manuals, which also applicd to Buffalo main feed pumps on the same vessels, were produced by Defendant Buffalo Pumps in the Hawaii litigation.

28. Attached hereto and marked as Exhibit Z is a true and correct copy of De Laval Plan No. G-8575. Defendant IMO Industries produced the complete drawing to Plaintiffs in the Hawaii litigation.

29. Attached hereto and marked as Exhibit AA is a true and correct copy of a set of Instructions for Leslie Pressure Reducing Valves and other Navy equipment from the U.S.S. Kidd (Manual-000955 to 984). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

30. Attached hereto and marked as Exhibit BB is a true and correct copy of a Technical Manual for Leslie valves and regulators on U.S. Navy vessels AE-21 and 22 (Manual-000985 to 1062). This manual is prima facie authentic based on its distinctive characteristics including Leslie company logos and other trademarks, as well as the manual's internal consistency and professional appearance. *See Link* v. *Mercedes-Benz*, 788 F.3d 918, 928 (3d Cir. 1986); Haw. R. Evid. 901(b)(4). The manual may also be authenticated by comparison with the Leslie manual attached as Exhibit AA. *See* Haw. R. Evid. 901(b)(3).

31. Attached hereto and marked as Exhibit CC is a true and correct copy of a series of Warren Pumps purchase orders and invoices, which were produced by Defendant Warren Pumps in the Hawaii litigation (WP 0144815 to 144844)..

32. Attached hereto and marked as Exhibit DD is an excerpt from a true and correct copy of a Warren Pumps manual for Main Condenser Circulating Pumps on DD-692 vessels (Hl-EM-00191 to 231). The complete manual was produced by Defendant Warren Pumps in the Hawaii litigation.

33. Attached hereto and marked as Exhibit EE is a true and correct copy of Warren Pumps Drawing No. A-1459, which was produced by Defendant Warren Pumps in the Hawaii litigation (Hl-AN-00267).

34. Attached hereto and marked as Exhibit FF is a true and correct copy of a Westinghouse manual for Lubricating Oil and Fuel Oil Pumps on the USS Kidd (Manual-001063 to 1114). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

35. Attached hereto and marked as Exhibit GG is a true and correct copy of a Westinghouse manual for Forced Draft Blowers on the USS Kidd (Manual-001115 to 1146). Plaintiffs found the original manual at the library of U.S.S. Kidd (DD-661) ship museum in Baton Rouge, Louisiana.

36. Attached hereto and marked as Exhibit HH is a true and correct copy of Westinghouse insulation drawing l-JH-2183 (CHPL-22 to 23). This drawing was produced by Defendant Westinghouse in the Hawaii litigation, among the documents related to the USS Chipola (AO-63).

37. Attached hereto and marked as Exhibit II is a true and correct copy of a selected portion of the transcript of the Deposition of Anthony Pantaleoni taken by Plaintiffs on January 9, 2007.

38. Attached hereto and marked as Exhibit JJ is a true and correct copy of selected portions from a Leslie handbook of Engineering, Operating, and Maintenance Data for Leslie controls, strainers and whistles, identified as Catalog Series 5300 (ManualBIW-000518-535, 565-568, 682-686, 698-710, 753-784). Plaintiffs obtained this manual from a library of technical manuals at Bath Iron Works shipyard in Bath, Maine.

39. Attached hereto and marked as Exhibit KK is a true and correct copy of a Leslie Technical Manual for Air Priority Valves on U.S. Navy vessels, dated January 1974 (ManualBIW-000840 – 856). Plaintiffs obtained this manual from a library of technical manuals at Bath Iron Works shipyard in Bath, Maine.

40. Attached hereto and marked as Exhibit LL is a true and correct copy of a selected portion of a William Powell Valve Catalog dated 1975 (ManualBIW-000001 – 12, 129-133, 179-185). Plaintiffs obtained this catalog from a library of lechnical manuals at Bath Iron Works shipyard in Bath, Maine.

I, Ilana K. Waxman, do declare under penalty of perjury that the foregoing is true and correct.

DATED: Honolulu, Hawaii, SEP 08 2009.

ILANA K. WAXMAN

EXHIBIT A

REPRODUCED AT THE NATIONAL ARCHIVES

TECHNICAL MANUAL

FIRE, FLUSHING AND EMERGENCY BILGE PUMP

AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
AURORA, ILLINOIS

BUREAU OF SHIPS · NAVY DEPARTMENT · MARCH 1961

EXHIBIT "A"

APPROVAL AND PROCUREMENT RECORD PAGE

BASIC APPROVAL DATA: BUSHIPS APPROVAL FOR NAVSHIPS 311-3111P

TITLE: Fill, flushing and emergency oil fuel pump

Chief, Bureau of Ships ltr. to IPB Nobs 84319 Ser. 619P-111 dated 31 January 1951

CONTRACT OR P.O. NO.	DATE	VESSELS APPLICABLE	QUANTITY OF MANUALS	BUILDING YARD
Nobs -84319 Item 1S	11/13/50	10-159	13	

REMARKS:

CERTIFICATION: Date 1 March 1951

It is hereby certified that the manual Navships 311-3111 provided under P.O. No. Nobs-84319 has been approved by BuShips approval shown above.

WORTH PUMP DIVISION

181 NEW YORK AIR BRAKE COMPANY

WORTHINGTON, CALIFORNIA

J.D. Martner

Manufacturer's Signature

REPRODUCED AT THE NATIONAL ARCHIVES

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SECTION I - GENERAL INFORMATION

I-1 GENERAL DATA

Type	OK
Size Discharge	1
Size Suction	6
Capacity, G.P.M.	750
Total Head P.S.I.	115
Suction Head, ft.	1
Liquid Pumped	See Data
Specific Gravity	1.076
Suction Temp, °F	31
R.P.M.	3510
Efficiency, %	83
B.H.P.	68
Nat. B.H.P. at gas Condition	15
Actual Shut-off Total Head, ft.	344
Weight of Pump & Piping, lbs.	150
Lower Casing, lbs	156
Upper Casing, lbs.	56
Rotating Element, lbs.	11
Impeller, Lbs.	11
Make of Motor	Reliance
Rated H.P. of Motor	75
Weight of Motor, lbs.	650
Make of Controller	Collet-Ramsey
Weight of Controller, Lbs.	90
Make of Coupling	Falk
Size	1F
Weight of Coupling, lbs.	18
Base (Fig. 07)	Acme
Weight	111
Minimum Priming Pump, Size	3B-511
Priming Pump, Lbs.	31
Priming Pump, Mfg. Of	Moyno Engr.
Priming Pump Motor, H.P.	1
Priming Pump Motor, Lbs.	112
Priming Pump Motor, Mfg. Of	Continental

I-2 INTRODUCTION

The Aurora Type OK Pump is a single stage, double suction, volute type centrifugal pump consisting of a casing, rotating element, and bearings. The pump is driven through a flexible coupling by an electric motor.

Liquid travels into the pump suction, divides to flow into volute sides of the impeller thus eliminating axial thrust. By centrifugal action the velocity of the liquid is increased by the impeller vane velocity being converted into useful pressure by the volute and discharge nozzle.

The rotating element is supported by radial ball bearings, grease lubricated, and locked to the shaft. The bearings are mounted in dust tight housings which are held in the saddle at the lower casing and clamped into position by the bearing caps.

Mounted on the base between the pump and motor is a priming pump and motor. This unit must be primed for the initial start-up and each subsequent start-up. The base is constructed so that it forms a reservoir for the priming liquid. The exact mounting details may be found on Figure S-1 Page S-1ff.

SECTION I - GENERAL INFORMATION

1-3 DETAILED DESCRIPTION

The principle features of the WK pump are illustrated and identified by piece numbers in figures 1-3 which is the pump assembly drawing and in figures 1-4 which is the Pump Detail Drawing. The exploded view pump is shown in figure 1-2.

CASING

The casing consists of the Lower Half (2) and the Upper Half (8) and is horizontally split at the shaft centerline. The two halves are doweled to maintain original alignment and bolted together in four main places. The casing is supported by feet cast integrally with the volute section and bearing housing. Serridge ribs (2) are bolted to the Lower Half Casing (24) to clamp the Ball Bearing Cartridges (11) in position. Pegals (1b) are placed in the serridge ribs to prevent rotation and position the cartridges. The Upper Half (8) has a supporting bracket for the casing relief vent line at the top.

ROTATING ELEMENT

The rotating element consists of an impeller (1) which is keyed to the Shaft (6) and held in position by two thrust Sleeves (3) and (15) which are threaded so as to tighten with rotation in the correct way and are also locked to the shaft by two Setscrews (16) positioned at 90° and spotted in the shaft so that if setscrew rotation is encountered the shaft sleeves will not loosen.

The inboard ball bearing (1) is positioned by a shoulder at snap ring on the shaft and held by a Locknut (39), which is prevented from loosening by a lock Washer (50). The bearing is held in the cartridge with spare allowed for axial Movement. The cartridge is enclosed by the Cap (25) and Water Slinger (51) so that grease and dirt are prevented from entering and grease is prevented from escaping.

The outboard ball bearing (4a) is positioned at the inboard bearing with the exception that the snap ring between the position of the bearing in the cartridge.

The bearings are grease lubricated by snaps of the grease rope (3) with excess drained through openings in the bottom of the cap see Pipe Plug (18).

PACKING BOX

The Packing (21) is a braided asbestos impregnated with a sealing lubricant graphite which serves as a lubricant.

To further aid the lubrication, liquid is taken from the casing through the Water Seal Line (51) and delivered to the Lantern Ring (11).

The flow of liquid into the casing is shared by the packing and the Packing Box Gushion (29).

The Gland (11) is split to permit easy removal for replacing the packing, and is held concentric by the Gland Clamp (25). Studs Bolts (26) are held in the casing by Pins (3d) with the lower terminated in the gland by a Washer (3b) and nut (18).

COUPLING

The Lois "Sureflex" coupling is keyed to the pump shaft and prime mover shaft. This coupling consists of two hubs, a grid member which connects the two hubs, two covers with neoprene seals against the hub with a gasket to hold to form a compartment for lubricant. The hubs are furnished with setscrews to position the coupling hubs to the shafts.

BASE

A base is furnished by the pump manufacturer, see figure 1-2.

The base is of structural steel members with pads welded to the members for supporting the pump, driver, and ground piping pump and motor. The sump and driver are held to the pads by studs and nuts, and are positioned by heavy dowel pins.

SECTION 2 - OPERATING INSTRUCTIONS

2-1 STARTING

1. Make certain that the pump bearings and the flexible coupling are properly lubricated.
2. Open the pump suction valve.
3. Open recirculating valves in the pump recirculating line and valves in the pressure gauges.
4. Read the Centrifugal Instructions before starting the unit since the priming pump must start and pulse the pump before water will be delivered.
5. Start the unit. Jog the pump to check rotation with the rotation arrow. If rotation is wrong, change lead on motor (3 phase motor).
6. Slowly open slide the pump discharge valve until proper pump discharge pressure is obtained after the pump has been primed by the priming pump.
7. If pump is provided with packing rings a slight leakage of liquid type should be maintained.

2-2 SECURING

1. Close the pump discharge valve.
2. Stop the pump.
3. Close the pump suction valve.

2-3 SAFETY PRECAUTIONS - 500 GPM FIRE PUMP (MOTOR DRIVEN)

1. Do not step down in vicinity of rotating parts.
2. Do not attempt to start pump while motor is on.
3. In case of excess vibration or unusual noise, shut down the pump.
4. Do not use water on motor fire. (Use CO_2).
5. Open and tag the circuit breaker to prevent accidental starting of the motor while inspecting or painting on unit.

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SECTION 3 - INITIAL INSTALLATION

Upon receipt of material, check it over to make sure that nothing has been damaged in transit, or that nothing is missing. Care should always be taken to see that the unit is not damaged as it is a piece of precision machinery.

3-1 ALIGNMENT OF UNIT

The base supporting the pump and driver is to be placed on leveling shocks so original alignment can be readjusted. To check this alignment the following procedure should be followed:

1. Remove bolts and nuts from coupling cover and separate coupling covers.
2. Remove guidemembers.
3. Use a straightedge and wedge or feeler gauges to check as below.
4. Check at 4 points on the coupling at approximately 90 degree intervals.
5. The misalignment shall not exceed .010 inches.

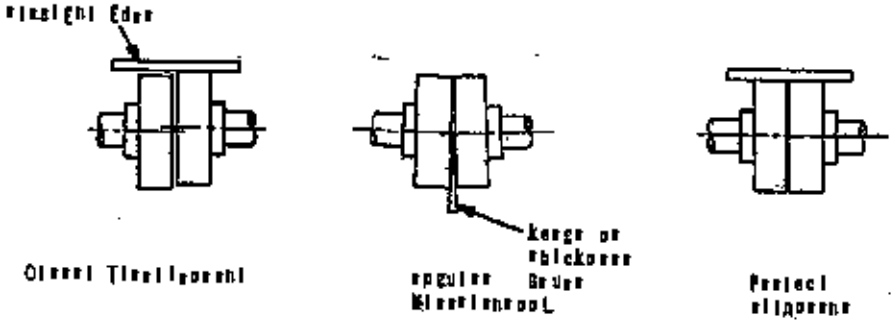


FIGURE 3-1 ALIGNMENT PROCEDURE

When pumps or prime movers are to be heated in operation, the units should be checked after the parts have reached operating temperatures.

3-2 SUCTION PIPING

Correct and incorrect methods of connecting suction line to pump.

Connect side lines. Place mill line on rollwalls. Do not force pipe into place with flange bolts for this may cause mill out of alignment. Piping should be supported independently of pump so as not to put strain on pump casing. After the piping has been installed, alignment should be checked again and if necessary, correction made. When piping is subject to temperature changes it should be arranged so expansion and contraction does not place a strain on the pump casing.

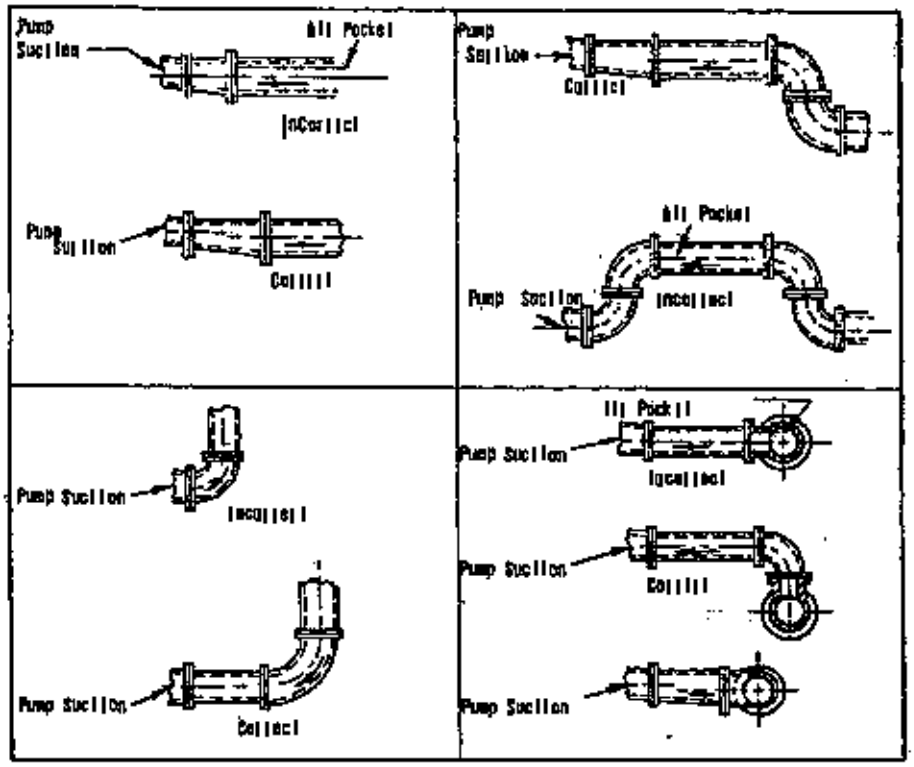
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3-2 SUCTION PIPING (CON'T.)

Care should be taken with new cast iron lines to see that no foreign materials such as chips, rags, etc. are in the piping as this debris will be drawn into the pump and cause damage and trouble.

Check the alignment after the piping has been completed.

FIGURE 3-2 METHOD OF CONNECTING SUCTION PIPING



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SECTION 4 - MAINTENANCE

4-1 BEARING LUBRICATION

It would be impossible to self-anaheses the importance of proper lubrication of ball bearings in pumps. Recommended ball bearing grease to be used is "LUBRITE" M-1M issued by Mil-G-18709 specifications. It is impossible to state how often ball bearings should be treated or flushed, however the following tip or following until certain operating conditions.

(a) Add grease to bearings every 500 hours of running time if pump is in dry location or every 3000 hours if pump is in damp location.
(b) In case the pump is run less than 5000 or 3000 hours a year, grease should be added twice 6 months to a year.
(c) When adding grease remove Pipe Plug (18) again on Sectional Assembly drawing and operate the grease gun until grease is forced out. When grease flows out of it is added, the bearing is sufficiently filled.
(d) The specifications amount of grease into the cartridges are 1.25 oz. for the outboard and 1.5 for the inboard.

IMPORTANT: Heating of bearings frequently often too much grease instead of an insufficient and fill-up inspection to determine the trouble should be made before going to added.

At the end of three months of service, housings should be opened and cleaned with kerosene and new clean grease supplied. Great care should be exercised to keep housing clean and only clean grease should be used for lubricating bearings. Under no circumstances should grease gun which has been used be used. Foreign solids or liquids entering housing can temporarily ruin the bearings in a short time. It is important to get clean instruments and cloths that cleaning housing and greasing bearings.

4-2 TO PACK PACKING BOX

Pump leaking out stem are gated and lubricated freely for use. However, when a pump is to be repaired, the following procedure must be followed. The packing used is long fibre asbestos, square braided, and well impregnated with oils and graphite, and should be similar to Garlock 1134. (Mil-P-1557 Type I-1103).

When repacking the pump, refer figure 5-3, started as follows: (1) Remove the packing from the stuffing box. Clean the packing box and inner sleeve enough so that it is free from dirt, oil or grease. (2) Cut off ring of 3/8 fourth packing slightly larger than the area of the path on which it is to be used. (Wire cutters, not box cutter, with each ring). Then take the ring to the back of the stuffing box. Be sure the joint is staged and not overlapped. Take the ring so that it takes a perfect fit around the shaft. Install with ring separately with each joints staggered around the shaft and ramp each ring so that it is forced to the stuffing box. After 6 rings have been inserted, insert the lantern ring. Repeating this operation by inserting 4 more rings of packing. Then dirt up the gland nuts with fingers so as the packing. (3) Insert the packing gland nuts after that can be turned with the fingers. After the pump is operated adjust the packing gland to permit continuous dripping to lubricate the packing and to keep the parts cool.

4-3 PERIODIC INSPECTION

(a) While unit is in storage it will be necessary to rotate the pump by hand five or three times a month to prevent grease in ball bearings from settling and allowing moisture to come in contact with the unprotected surfaces of these parts. Also give caution to this Coupling between this and coupling is used.

(b) Grease for ball use when put into operation the grease in ball openings should be checked once before put again to see that it does not get too low. This also applied to the lubricant in the left hand of different mounting. Refer to maintenance section of the dispatcher parts for the proper removal and replacing of the grease.

(c) The packing should be checked once per month to see that it has not dried out.

(d) Before leaving the factory, greased surfaces of various materials are treated with a thin layer of protective preservative against to protect them during extended periods of storage.

4-4 TO DISASSEMBLE PUMP (REFER TO FIGURE 5-(, 5-3 AND 5-4).

1. Disconnect the priming piping between the valve (115) and priming pump and remove the priming relief (115) from the Upper Shell Half (8) by removing Nuts (117). Remove Valve (116).

2. Tighten down on Setscrew (59) to block casing flange apart.

3. Place a slot wedge under the seam on the Upper Casing (8) and lift up with a hoist.

4. Place Casing Gaskets (28) in order as they step out. If allowed to dry last will shrink and cannot be used again.

5. Remove Nuts (18) on Centerline Cage (1) on both ends of pump and remove.

6. Loosen Nuts (19) on Swing Bolts (19). Swing bolts can then be swung back at Flange (7). Remove Clamp Halves.

7. Complete rotating element can be lifted out for inspection.

8. Remove Casing Sealing Rings (27) but match mark them with the impeller if they are to be used again.

4-5 TO DISASSEMBLE ROTATING ELEMENT

1. To remove Ball Bearing (1), loosen Capscrews (17(and take off Bearing Cap (15) thereby Exp). Bend up prong of (ockut Washer (59) and unscrew lockout (19). Lock-out washer can then be removed. Apply a puller to the end of the shaft (6) and the inside face of Bearing Centerline (41), being careful not to apply it to the Rotor Slinger (51). Pull the Bearing Centerline (41) and Ball Bearing (1) together off the shaft. The Ball Bearing can then be removed from the housing.

2. Remove ot Ball Bearing (13) in (duplicate(in back of Ball Bearing (1) except that the Bearing Cap (Outboard End) is (18).

3. Remove Water Slinger Retainers (52) and pull off Water Slingers (91(.

4. Slide off Lantern Rings (17) and Packing Box Bushings (19).

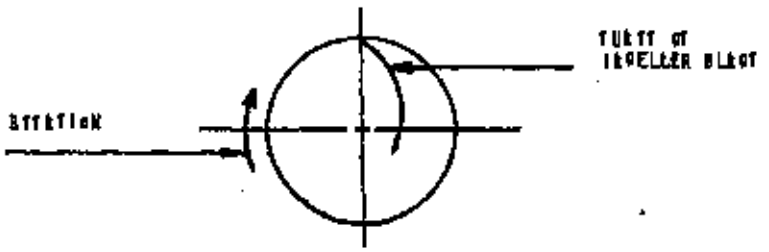
5. Before steps are taken to remove the Impeller (11), match mark the impeller with the ends of the Shaft so that in reassembling it will go back in the same position.

6. Remove Retainers (16) in Shell Sleeve No. 1 (9). Put a pipe wrench on the largest diameter of the Shell Sleeve and turn in same direction as Impeller ordinarily rotates. Impeller (11) can be slid off the shaft. To remove Shaft Sleeve No. 1 (18) follow the procedure at (9) except to turn it in the opposite direction from the Impeller rotation.

4-6 TO REASSEMBLE ROTATING ELEMENT

1. Check condition of Impeller Key (17) and if necessary replace with a new piece.

2. Slide on Impeller (11) on shaft making sure the ends of its pieces is as was shown.



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4-5

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SECTION 4 - MAINTENANCE (CON'T.)

4-6 TO REASSEMBLE ROTATING ELEMENT (CON'T.)

3. Cover on shaft sleeve (9) and (16) making sure to get the correct sleeve on the correct side, as one has left hand threads and the other has right hand threads. Do not tighten shaft sleeves until ready to center the impeller.

4. Slide Packing Set Bushings (19) on gear shaft sleeve. Lantern Ring can be set slipped into place over shaft sleeve.

5. Put Seal Rings (51) in position and place Casing Wearing Ring (21) on the impeller.

6. Slide Water Slingers (31) on the Shaft, but do not tighten.

7. Insert Ball Bearings (1) and (11) in their respective Bearing Cartridge, (11) and Instrall on the shaft until the Ball Bearing is against the shoulder of the shaft. (On the alternate bearing construction it is necessary to slide on the bearing Cartridge (11), put Retaining Ring (53) on the Shaft, and then install Ball Bearing.) Put lockout Washers (50) in position next to the Ball Bearings and screw on locknuts (19). When locknuts are tight make sure the peen of the locknut Washer is bent into the slot of the locknut.

8. Replace the Bearing Caps (11) and (15) in their proper Cartridges and fasten in by means of Capscrews (32).

4-7 TO REASSEMBLE PUMP (REFER TO FIG. 5-1, 5-3 AND 5-4).

1. Place rotating element in the lower Casing Half (21). Make sure the grooves in the Casing Wearing Rings (11) fit properly on the tongue in the lower Casing.

2. The Ball Bearing Cartridges (44) and oil in place with the lee dowel pin holes in vertical upright position. Set Cartridge Caps (1) in place with Dowel Pins (10) in holes of Ball Bearing Cartridge. Put on the four Nuts (18) and tighten down the Cartridge Caps.

3. While holding Shaft (6) so it will not turn, adjust shaft Sleeves (9) and (16) until Impeller (11) is centered with Casing Wearing Rings (22). When the Impeller is properly centered tighten the Shaft Sleeves. Replace setscrews after setting shaft.

4. Place Water Slingers (51) in position in the Ball Bearing Cartridge setting sure to leave proper running clearance. Tighten down slipper by means of Setscrews (11).

5. Slide Parting Bar Bushings (19) into position. Pack pump at placing Packing (11) in the packing bar with the Upper Casing Half (5) slit. Alternate the splits in the packing rings. Place annular rings in front of the Lantern Rings (17) so that when the Upper Casing Half is dropped on, the Lantern Ring will line up with the water inlet.

6. Before replacing Upper Casing half (5), make sure Vent (70) are in place and using bolts (15) are on the Vent. Put Gasket (28) on the lower Casing flange and lower the Upper Casing Half (5) in place. Set down lightly, making sure the Casing Wearing Rings (12) and Packing Bar Bushings (19) fit in place. Have Upper Shaft pack and turn slightly and let drop in place. Make sure the Gasket Halves come together, otherwise the Casing Wearing Rings and Packing Bar Bushings can be bent when the two halves are pulled tight.

7. Bring Swing Bolts into place and tighten Nuts (19).

8. Place Nuts (18) on studs (19) and tighten down evenly.

9. Replace the Priming Valve (111) and Water Vent Nuts (112) on Studs (111). Reconnect priming piping between Valve (115) and priming pump.

10. Be sure pump Purge Valve (117) is back in operation.

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4-8 FAULTY OPERATION

In obtaining a pump, that which may seem to be serious flaws, may arise, and close and careful inspection will usually reveal the fault to be some minor oversight and investigation of the following typical conditions should be made:

1. If no water is being delivered:
   (a) Pump may not be primed.
   (b) Speed may be too low.
   (c) Discharge head is too high.
   (d) Suction lift too high, check with gauges.
   (e) Impeller is completely plugged up.
   (f) The impeller may be rotating in wrong direction.

2. If not enough water is being delivered:
   (a) Air leaks may exist in the section of the packing case.
   (b) Speed may be too low.
   (c) Discharge head may be higher than anticipated.
   (d) Section lift may be too high.
   (e) Impeller may be partially plugged up.
   (f) Wearing rings may be worn.
   (g) Impeller may be damaged.
   (h) Packing may be defective.

3. If not enough pressure:
   (a) Speed may be too low.
   (b) There may be air in water.
   (c) Wearing rings worn.
   (d) Impeller damaged.
   (e) Casing packing ineffective.
   (f) Impeller diameter too small.

4. If pump works for awhile then loses prime:
   (a) There may be a leak in the suction line.
   (b) Water seal may be clogged.
   (c) Suction lift too great.
   (d) Air or gas may be in the liquid.

5. The pump may take too much horsepower:
   (a) The speed is too high.
   (b) The head is different than for which the pump was selected.
   (c) The liquid may be heavier than water, in this case viscosity and specific gravity should be checked.
   (d) Mechanical defects exist such as bent shaft.
   (e) Rubbing element may be binding, because packing boxes may be too tight, wearing rings may be worn, or casing packing may be defective.

If the speed is too low on a unit direct connected to electric motors, investigation should be made to determine whether motor is across the line and whether it is receiving full voltage.

[illegible] Wrenches etc.

Also see [illegible] be in sense to shaft [illegible] be made.

For alternates of above data see applicable out[illegible]

SECTION 4 - MAINTENANCE
(CON'T.)

4-9 ADJUSTMENT AND TESTS

After the unit has been refitted or after any disassembly of the unit for overhaul the following adjustments and tests should be made.

1. Check alignment of coupling as shown in Figure 3-1.
2. Check all piping to see that there is no strain or distortion imposed upon the casing by the piping as fitted in Section 3, Figure 3-2.
3. Check the motor electrical connections to see that the correct rotation and start will occur when the motor is started.
4. Check the glands to be sure they are not pulled up so tight they will cause the pumping to bind and run hot when the pump is put into operation. Try Section 1, To Pack Packing Box, for correct adjustment.
5. Check the ball bearings to see that the correct amount of grease is in the bearing housings. Refer to Section 1, "Bearing Lubrication" for type and amount.
6. Check the coupling to see that the proper amount of grease is in the cover. Refer to Section 1, "Maintenance" paragraph 1-4.

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SECTION 4

4-6 COUPLINGS

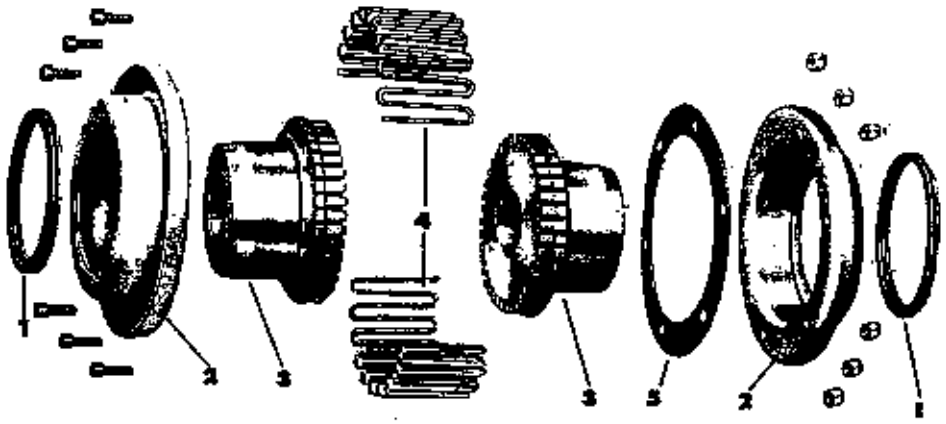
INSTRUCTIONS

FOR

INSTALLATION AND MAINTENANCE

PARTS

PARTS OF TYPE F COUPLINGS



1. Assembled Seals
2. Cases Halves
3. Hubs
4. Coildembers
5. Gaskets

When ordering these Parts be sure to give the coupling size stamped on cases and coupling hub.

INSTALLING

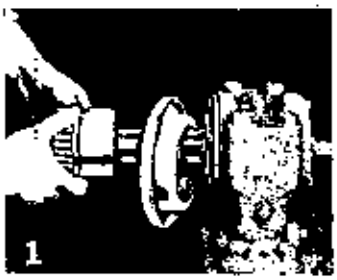
Fork Couplings are shipped with all deals disassembled. Before installing, clean all deals thoroughly. Make sure that all gasket and dirt is removed from seals, goldmembers, hubs, etc.

Find correct shaft dp spacing bores at each hub. Complete instructions for installing the coupling are given on Page 4-F No special tools are required. Wrenches are furnished for Allen-head screws.

Align the gap has been set and the shafts lined up the foundation bolts should be tightened in their permanent positions, and a final check for alignment should be made.

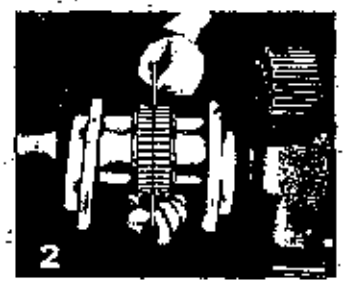
For dimensions of shaft bore recommended setting.

REPRODUCED AT THE NATIONAL ARCHIVES



PUTTING COVERS AND HUB ON SHAFTS

Place covers on shafts before pressing or shrinking on the hubs. Press or shrink hubs on their respective shafts so that the face of each hub is flush with the end of each shaft.



CHECKING GAP AND ANGULAR ALIGNMENT

Whenever possible set machines so that Normal Gap is used.

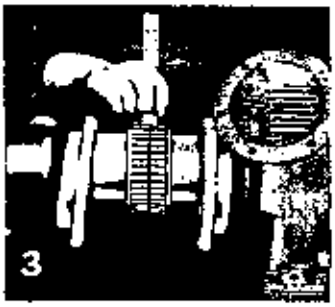
Line up shafts by using a spacer block and feelers in the gap between, the coupling faces checking at quarter points "P" apart.

GAP

Max.	3/16
Normal	1/8
Min.	1/4

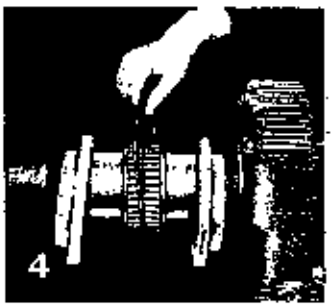
THE NORMAL GAP should be maintained wherever possible. The maximum gap must not be exceeded and a minimum gap must be maintained to prevent the faces of the two hubs from striking.

Sleeve bearing motors have a certain amount of end play. Before setting the motor, push both shafts back to the limit of end clearance with coupling faces as far apart as they will go and make sure that this gap does not exceed the maximum limit for the coupling. Next, push both shafts together as far as they will go and check the minimum distance between the coupling faces.



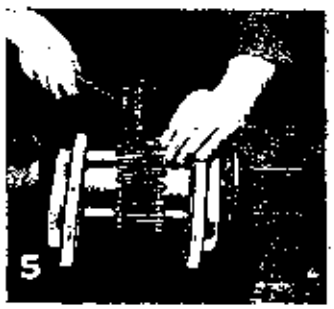
CHECKING PARALLEL ALIGNMENT

Line up the shafts by using a straight edge over the top of the hubs. Repeat the same procedure at another point on the hubs 90° away. Final check-up should be made after the foundation bolts are fastened.



INSERTING GASKETS

After the coupling is aligned, insert the gaskets, letting it hang on either hub away from the teeth. Care should be taken not to injure the gasket. Next force as much grease as possible down into the gap between coupling faces.



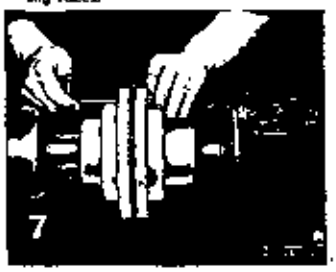
INSERTING GRIDMEMBER

Insert the grid in the grooves. This operation requires no special tools. Sizes 3 to 11 have single layer gridmember pressed aluminum.



PACKING GREASE OVER GRID AND TEETH

Pack the spaces between and around the grid with as much lubricant as possible. Fill coupling to absolute limit — this is essential to proper functioning. Scrape or wipe off excess lubricant flush with top of gridmember; clean inside of cover.



PUTTING ON COVER

Draw the cover up and fasten in place with bolts provided. Wrenches are furnished where Allen-head cap screws are used. Use nail or small screw driver under seal ring for venting during assembly of cover. Add lubricant with grease gun. Make sure that Neoprene Seals are squarely seated on hubs and not pinched under cover.

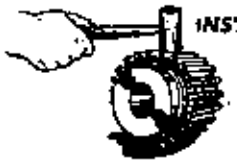


LUBRICATE AT LEAST ONCE EVERY 6 MONTHS

Alemite flush type grease fittings provide a convenient method of lubricating to ensure an ample supply of grease at all times. Use nail or small screw driver under seal ring for venting. See page I–8 for recommended lubricants.

REPRODUCED AT THE NATIONAL ARCHIVES

METHOD OF INSTALLATION AND REMOVAL OF GRIDMEMBER



INSTALLATION — Grid member ends are of unequal radius therefore it is necessary to spread the grid member slightly so that it will pass over the coupling teeth at its outside diameter. To accomplish this with a minimum amount of spreading, the grid member section key is started in either end and the rings lined up so that only part way into the slots. When all of the rings have partially started in their respective grooves, the grid member may then be slid all of the way down into place without further difficulty.

NOTE: Grid member is to be kept centered in slots around entire circumference

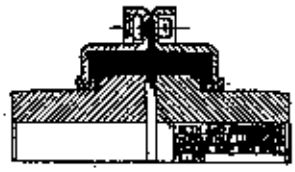


REMOVAL — To remove a grid member from Falk Steelflex Coupling requires no special tools and is easily accomplished by following the proper procedure. A small rod or screw driver that will conveniently fit into the open loop with the grid member is all that is required in the way of tools. Begin at the open end of the grid member section and insert the rod or screw driver into the loop end. Using the keyway adjacent to each loop as a fulcrum, pry the grid member out radially in each grooved slot. Proceed alternately from side to side lifting the grid member about half way out until the end of the grid member is reached and by following the same procedure once again the grid member will clear the teeth.

HOW TO FILL FALK STEELFLEX COUPLING WITH GREASE



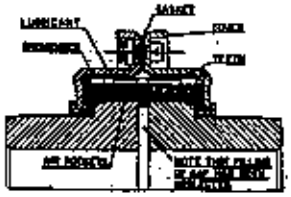
View showing coupling properly filled with grease. All pockets have been practically removed by careful packing, and gap between hubs has been entirely filled.



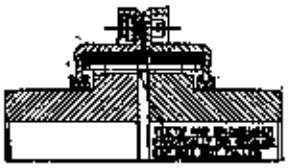
Grease in the gap acts as a reservoir when coupling is rotating and fills the empty spaces between the teeth and grid when thrown outward by centrifugal force.

WHAT HAPPENS WHEN COUPLING IS IMPROPERLY FILLED WITH GREASE

View showing coupling improperly filled with grease. Notice air pockets and empty spaces between hubs.



Centrifugal force, caused by rotation of coupling, throws grease outward. Notice how lubricant has been removed from rubbing surfaces, thus causing excess wear.

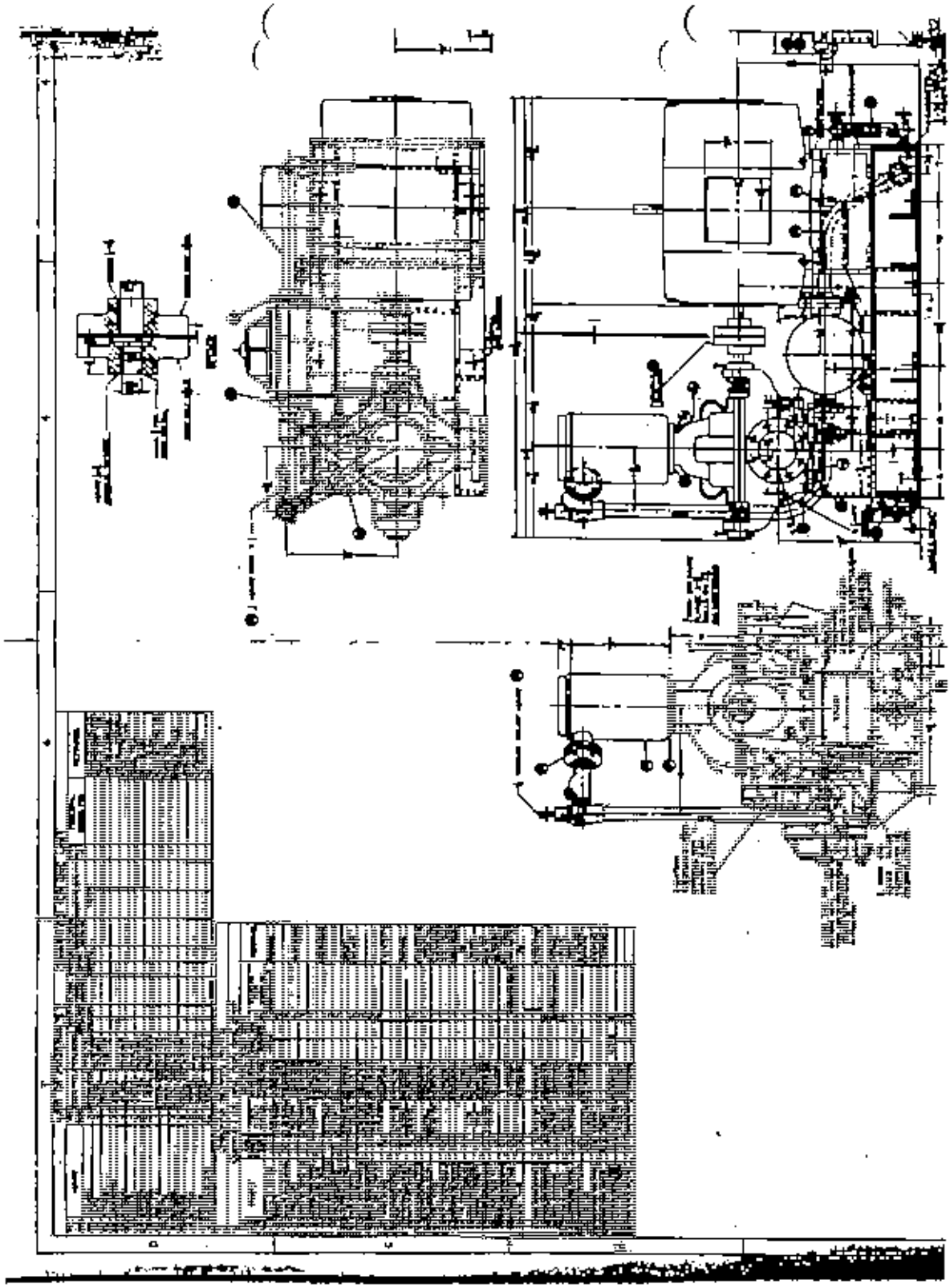


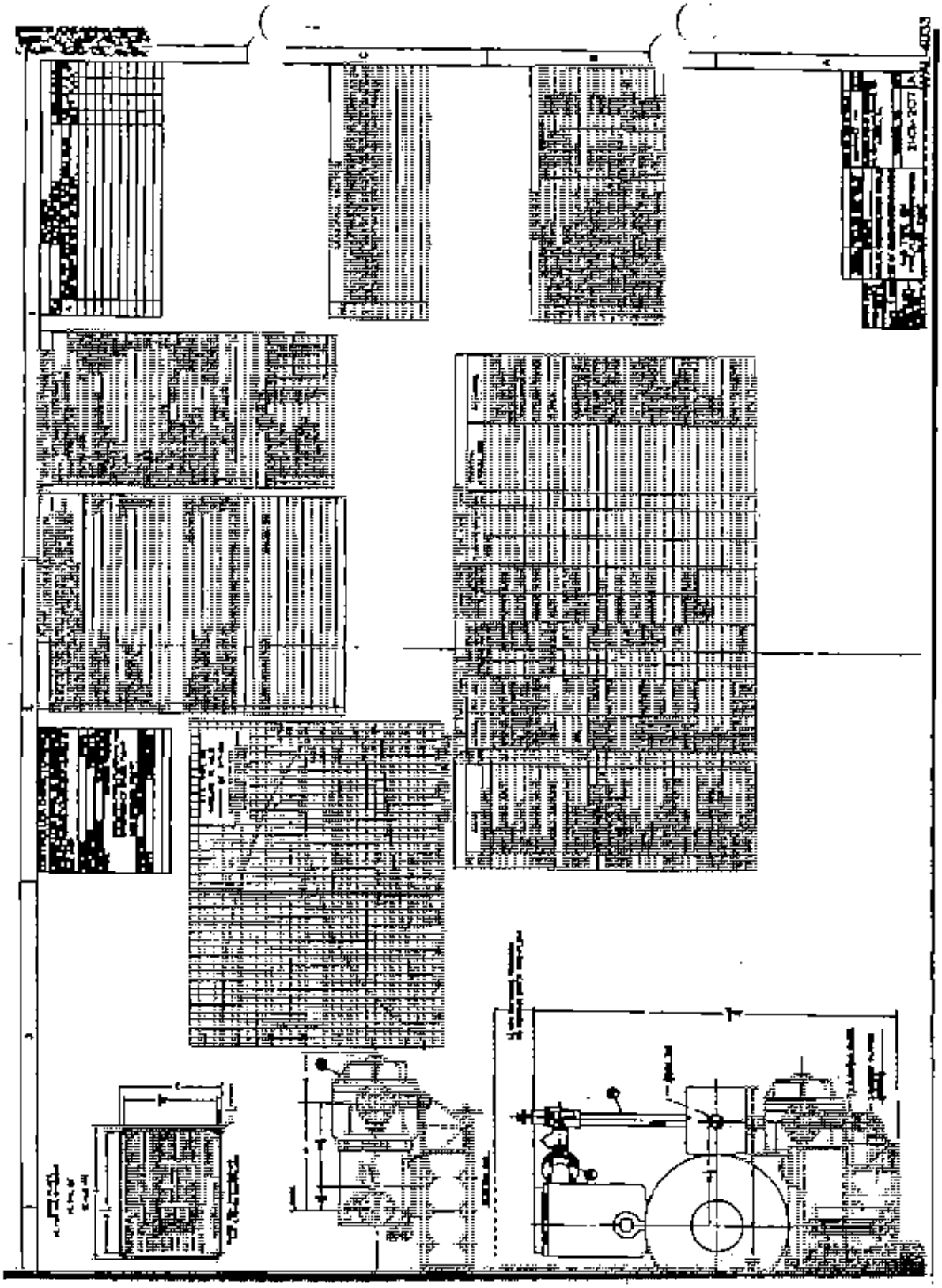
USN TYPE ALEMITE FITTING

The flow type fitting used on Falk Steelflex Couplings sizes 3F to 18F is a standard fitting by Alemite Co., Bridgeport to prevent grease leakage under centrifugal force. On the 190F the button head fitting is used.

RECOMMENDED LUBRICANTS

FED. VV-G-632 TYPE A GR. 2 OR MIL-G-2108





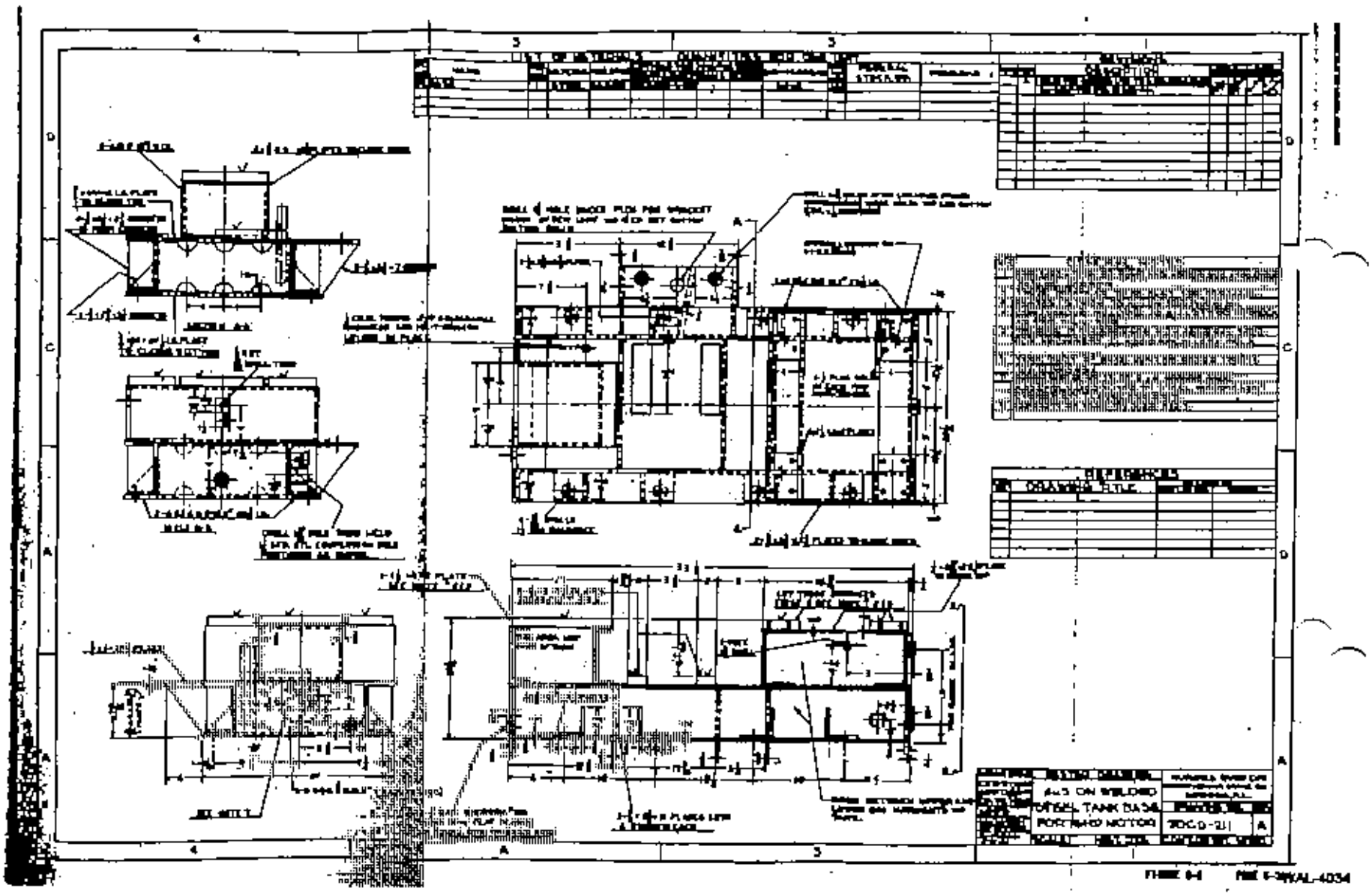
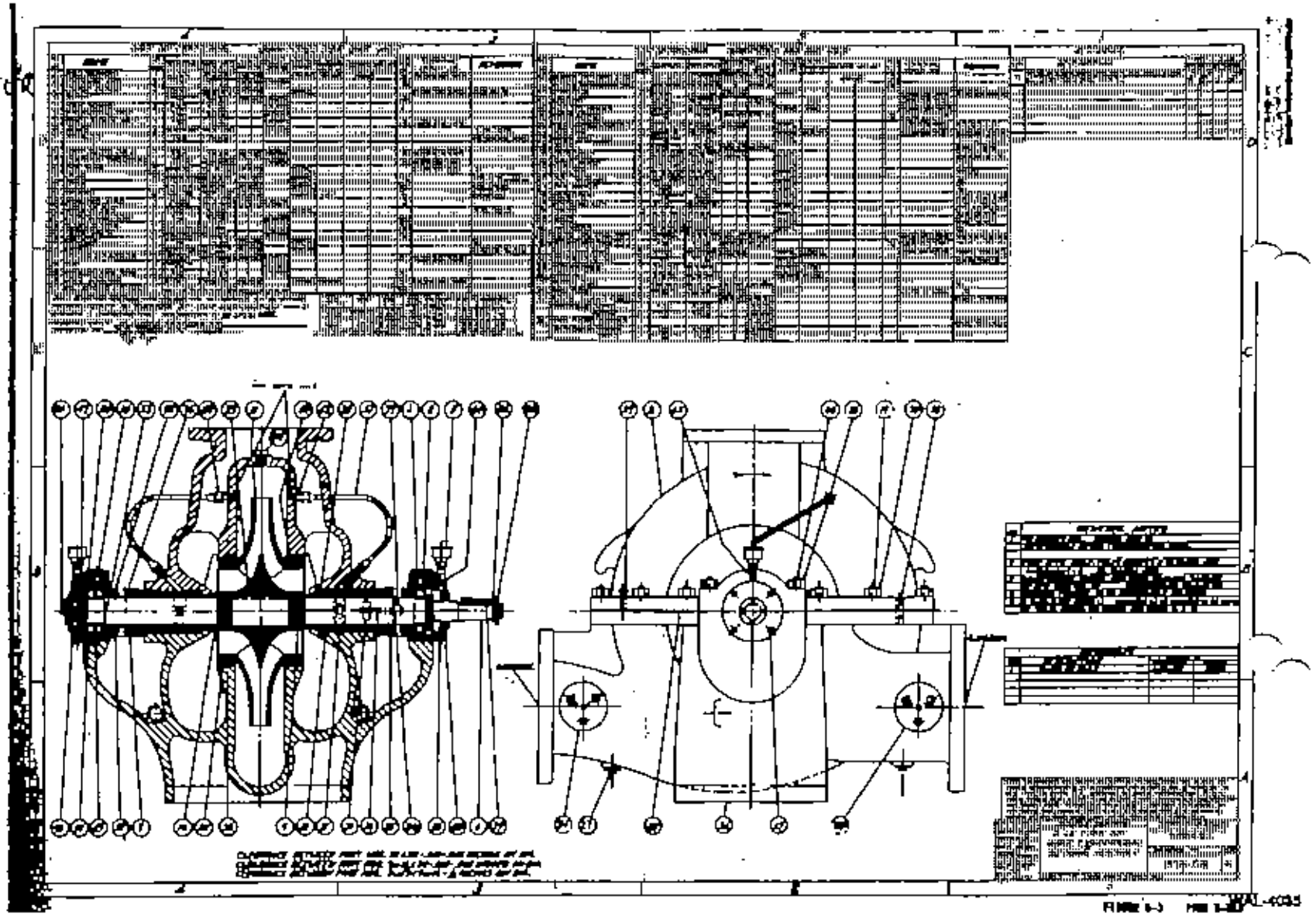
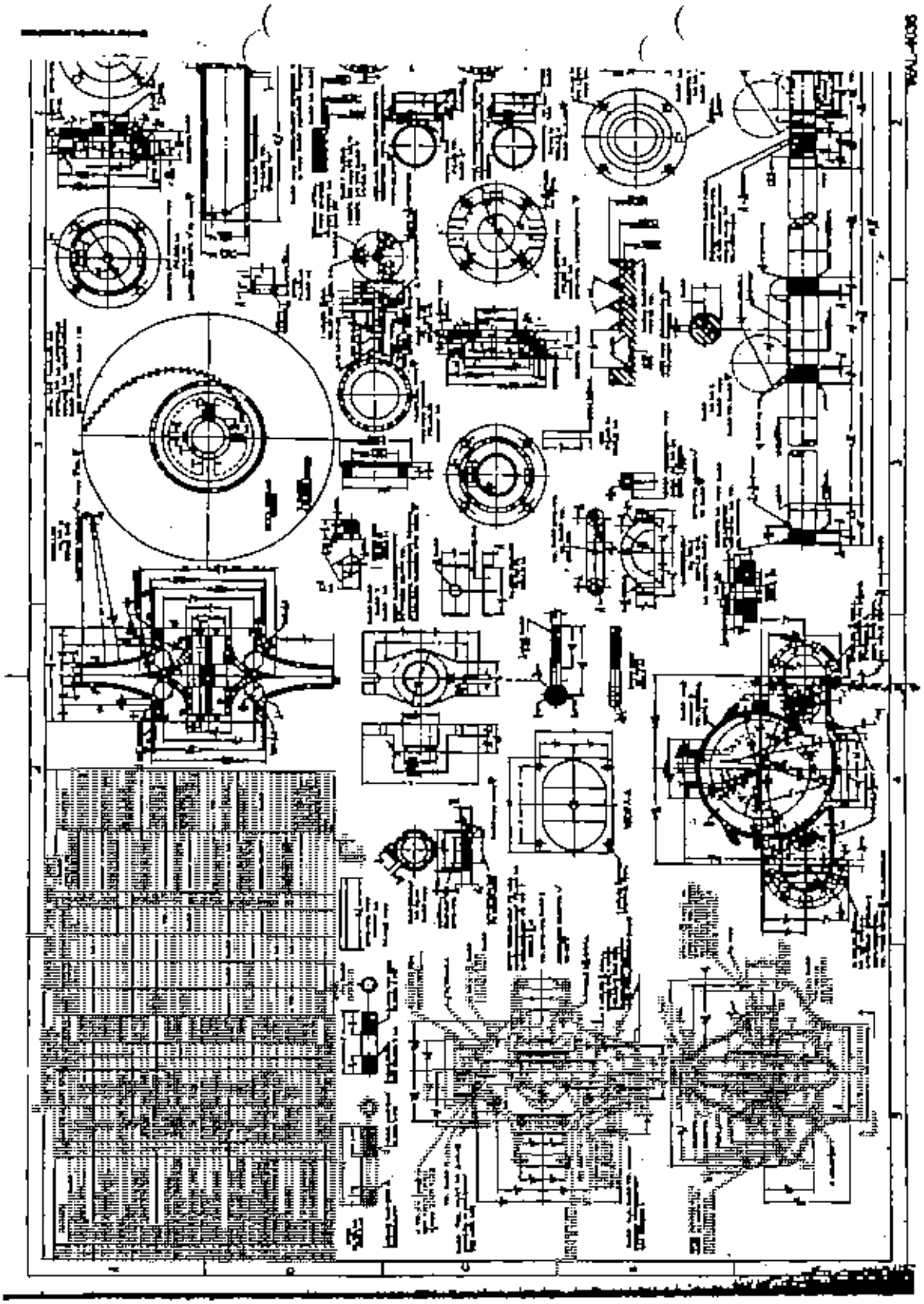


FIGURE 6-1 FIRE F-30(AL-4034

SEAL SUCTION VICTOR

PACKING
BY
GARLOCK





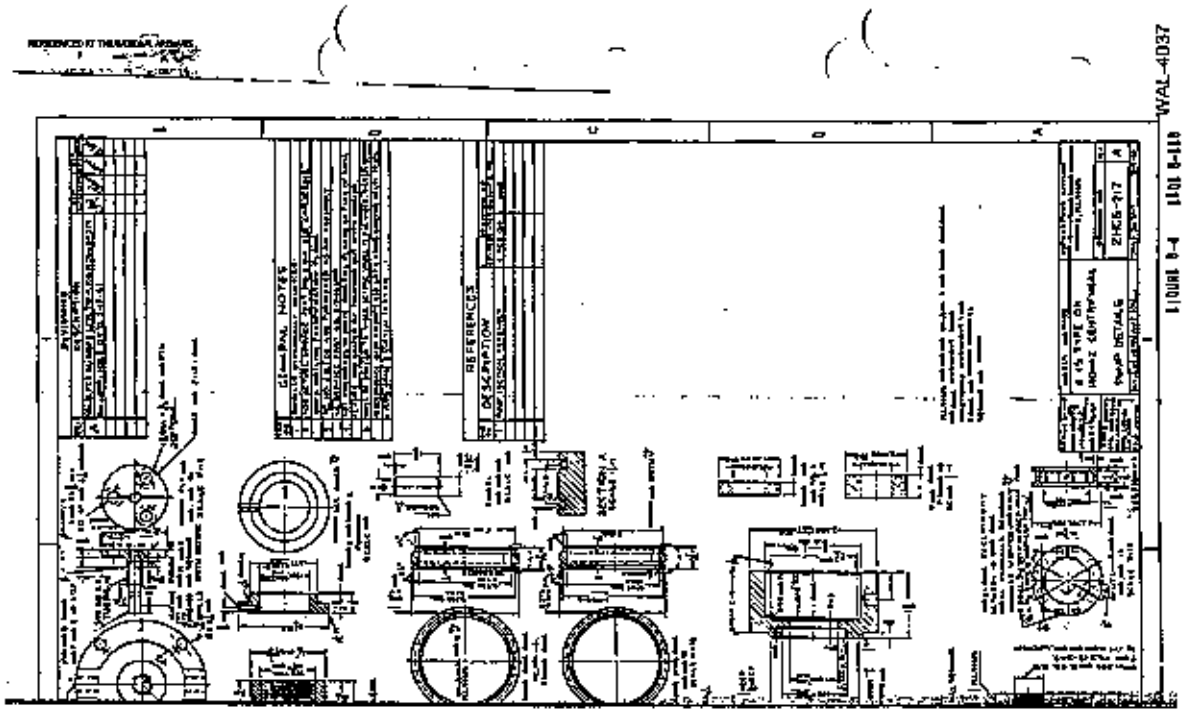
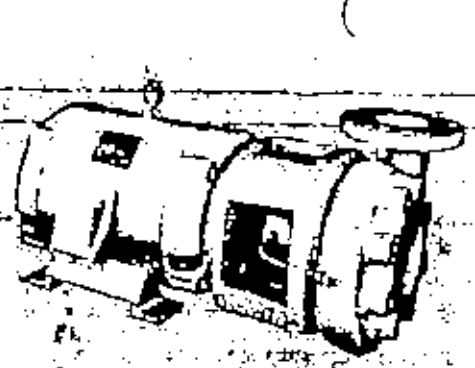
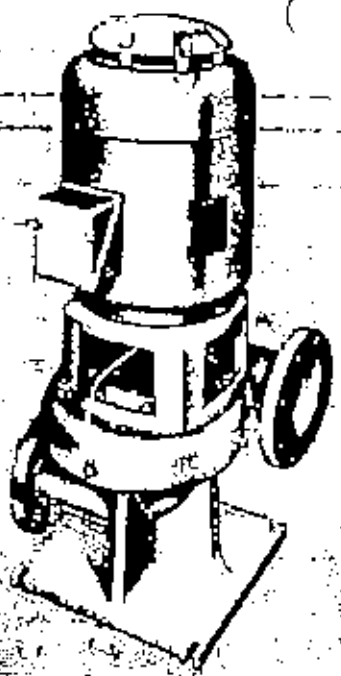


EXHIBIT B

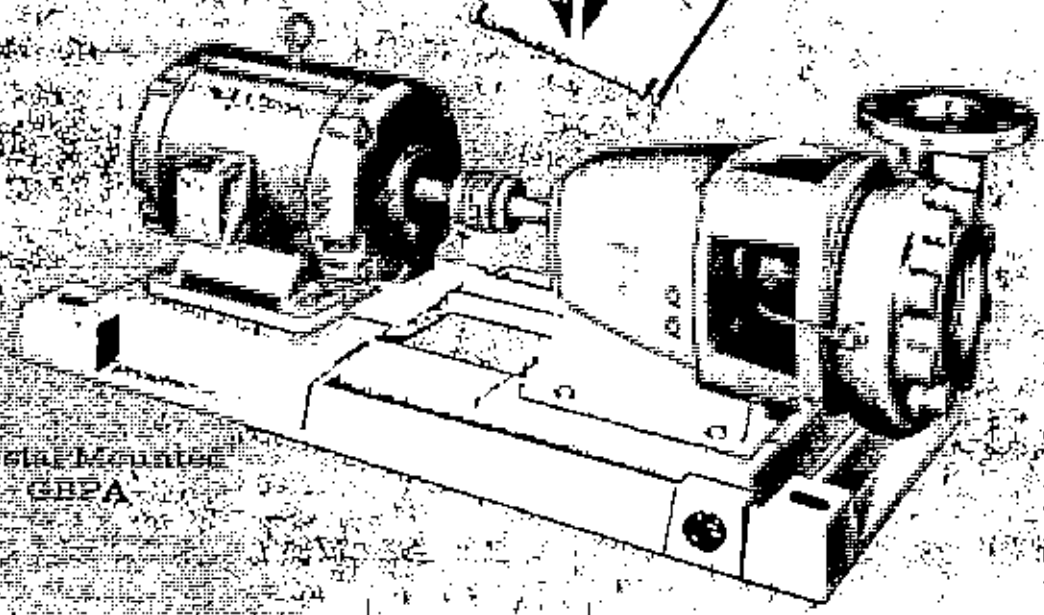
BULLETIN
330B
GB



Close-Coupled
GBHA



Vertical GBVA



Pedestal Mounted
GBPA

A.I.A. FILE NO. 30-C-3

AURORA
END SUCTION
CENTRIFUGAL

Capacities to 1600 G.P.M. Heads to 350 Ft. temperatures to 300° F.

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL CORPORATION
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

EXHIBIT "B"

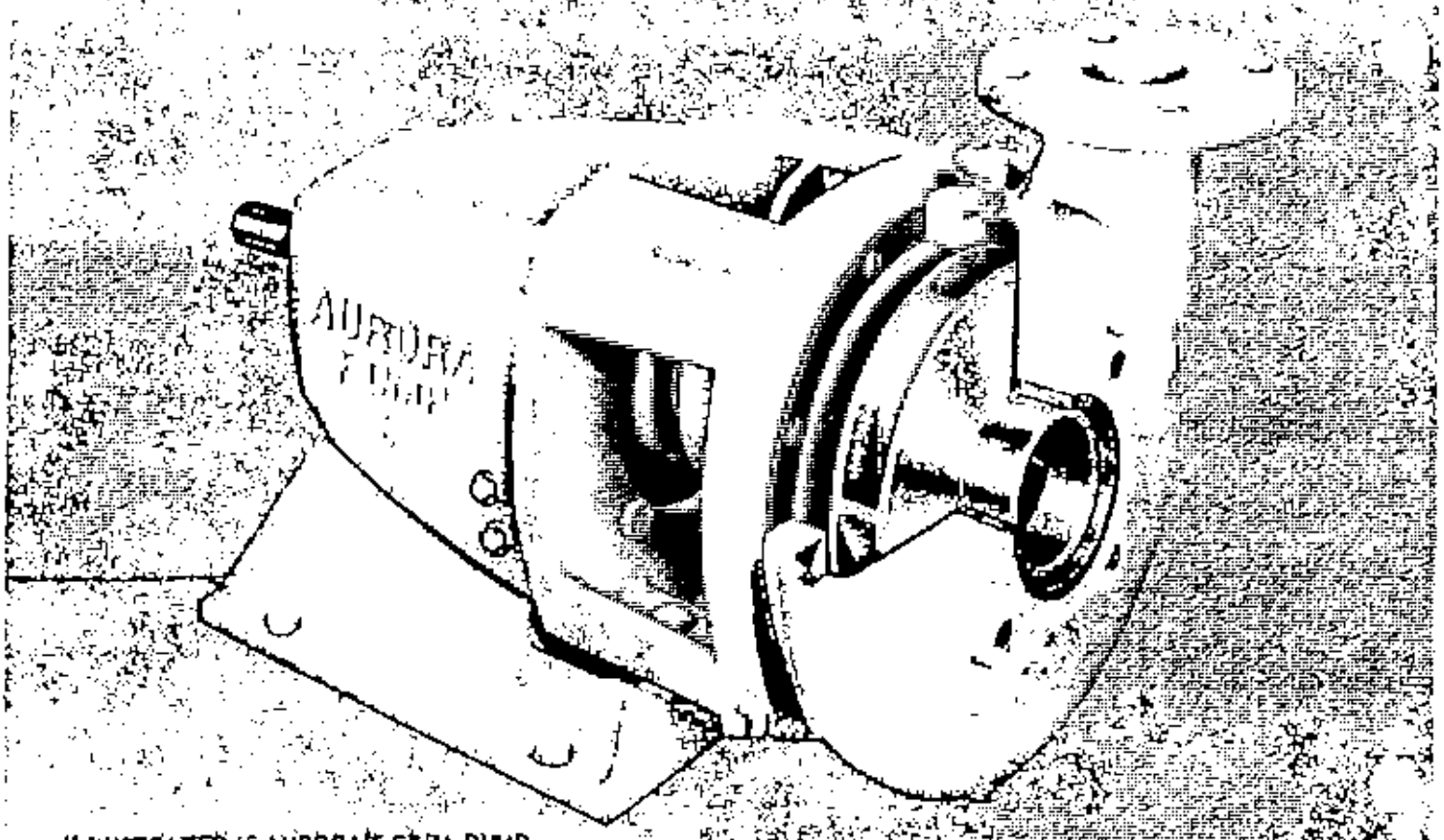
Copyright 1965 Aurora Pump Division/The New York Air Brake Company

INTRODUCTION

[illegible] is much more involved than it was just five years ago. The variety of liquids being handled has increased along with temperatures and pressures. The cost of engineering and manufacturing have risen considerably. The need for economy and interchangeability in design has come into greater prominence. The variety of today's installations demands quiet, smooth-running pumps with long life. [illegible] performance has become essential.

Aurora Pump offers the Power Frame mounted GB pumps as the best solution to your pumping problems. With this new design we offer:

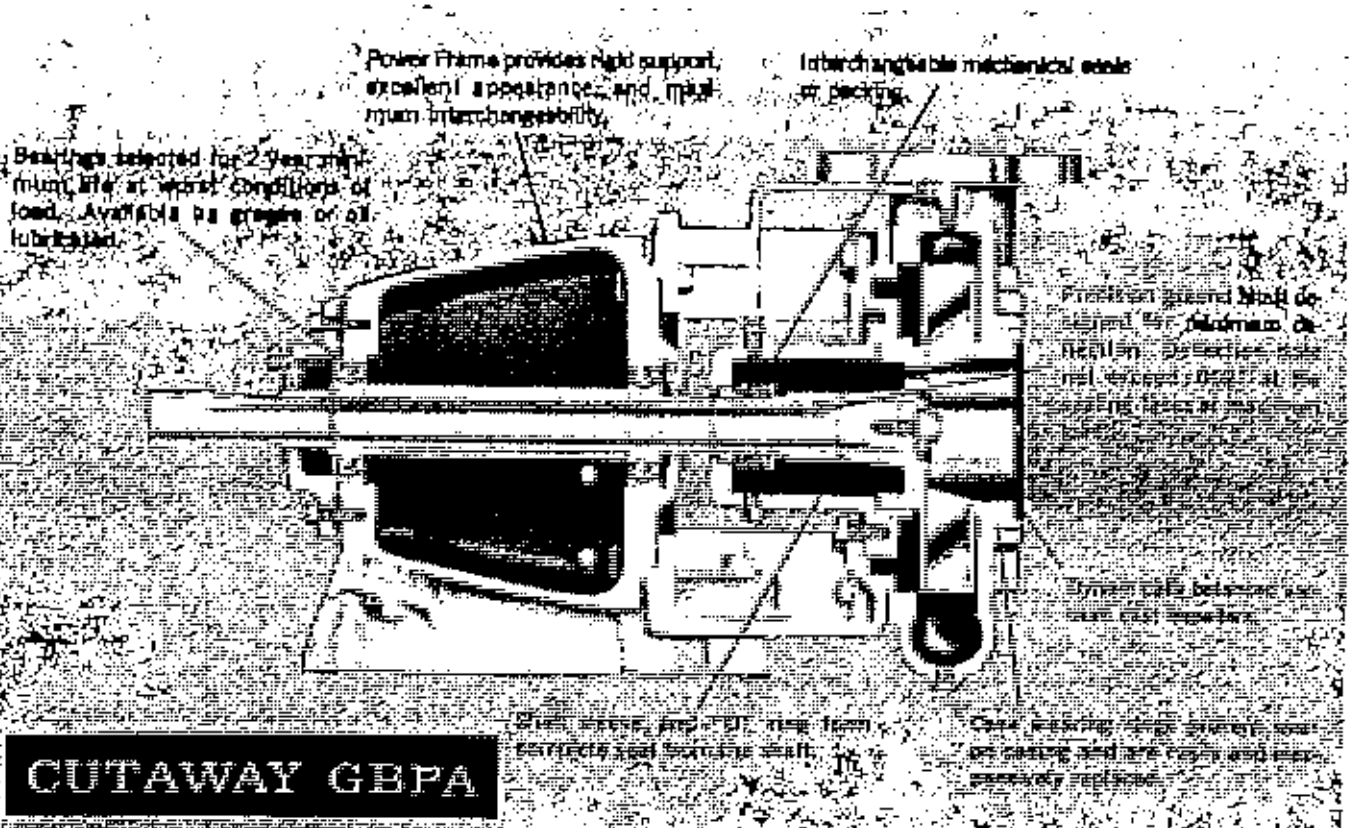
- Maximum interchangeability for greater economy
- Quiet, smooth-running design for longer life
- Compact design for easy installation and maintenance
- Reliable operation



ILLUSTRATED IS AURORA'S GBPA PUMP. THE CASING HAS BEEN PARTIALLY CUT AWAY TO REVEAL THE IMPELLER.

A0018

CUTAWAY AND DESIGN DETAILS



CUTAWAY GBPA

QUICK REFERENCE

TYPE GB PUMPS

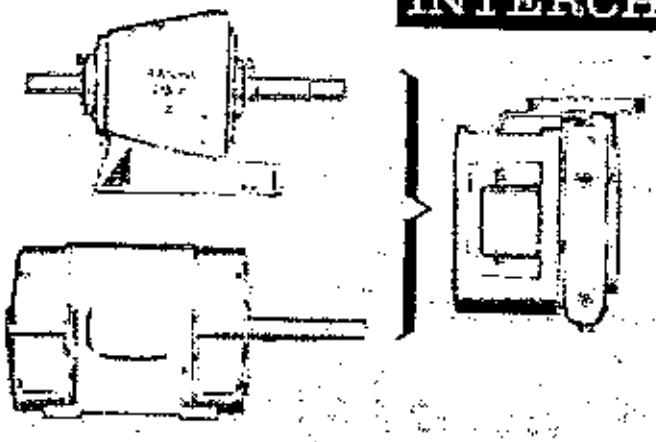
FEATURE SELECTOR

STANDARD	OPTIONAL
Bronze shaft sleeve (bronze-fitted and all-bronze pumps)	Stainless steel shaft sleeve (bronze-fitted and all-bronze pumps)
Stainless steel shaft sleeve (all iron and stainless steel pumps)	Impeller wearing rings
Casing wearing rings	Semi-open impellers (GBPA Power Frame only)
Mechanical seal (No. 1, see page 5)	Packing (No. 2, optional at no additional cost, see page 5)
Regreaseable ball bearings (GBPA Power Frame only)	Packing with lantern ring (No. 5)
Discharge position (No. 1, see page 10 and 11)	Packing with water jacket (No. 4)
	Mechanical seal with water jacket (No. 5)
	Special mechanical seals available upon request
	Double row thrust ball bearings (GBPA Power Frame only)
	Special alloy shafts
	Hardened shaft sleeves
	Oil lubricated ball bearings (GBPA Power Frame only)
	Discharge position (No. 2 and 4, optional at no additional cost, see pages 10 and 11)

A0019

INTERCHANGEABILITY AND DESIGN

INTERCHANGEABILITY



GB pumps offer the greatest degree of interchangeability

- All pumps adapt to 3 Power Frames
- Discharge is available in 3 positions
- Five stuffing box options available for every pump size, with more available on request

An important GB interchangeability feature is shown. The complete liquid end (casing, impeller, insert, and bracket) of any size GB pump is fully interchangeable between standard close coupled motors and the Aurora Power Frame of comparable size. Remove the liquid end from the motor and assemble it on the Power Frame. The shaft extension and mounting face dimensions are identical. This means less spare part inventory and speedy delivery on replacement parts.

DESIGN DETAILS

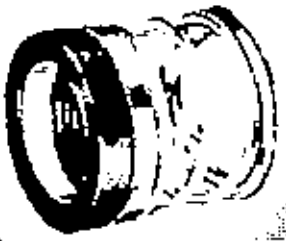
LISTED BELOW ARE FACTS COVERING THE GENERAL DESIGN OF THE STUFFING BOX, SHAFTS AND BEARINGS USED IN AURORA POWER FRAMES 1, 2, AND 3.

			POWER FRAME 1	POWER FRAME 2	POWER FRAME 3
STUFFING BOX	PACKING	STUFFING BOX BORE DIAMETER	2"	2-3/8"	2-3/8"
		STUFFING BOX DEPTH	2-1/8"	2-1/8"	2-1/8"
		OUTSIDE DIAMETER OF SLEEVE FOR PACKING	1-1/2"	1-7/8"	1-7/8"
		NUMBER OF PACKING RINGS (OPTIONS 2 AND 4)	8	8	8
		TOTAL NUMBER OF PACKING RINGS WITH LANTERN RING (OPTION 3)	6	6	6
		NUMBER OF RINGS IN FRONT OF LANTERN RING	2	2	2
		PACKING SIZE	1/4" x 1/4"	1/4" x 1/4"	1/4" x 1/4"
	MECH SEAL	DIAMETER OF MECHANICAL SEAL SEAT	1-3/4"	2-1/8"	2-1/8"
		LENGTH OF MECHANICAL SEAL	1-1/2"	1-9/16"	1-9/16"
		OUTSIDE DIAMETER OF SLEEVE FOR MECH. SEAL	1-1/8"	1-1/2"	1-1/2"
SHAFT		DIAMETER AT IMPELLER	7/8"	1-1/16"	1-1/4"
		DIAMETER AT SHAFT SLEEVE	1"	1-3/8"	1-3/8"
		DIAMETER BETWEEN BEARINGS (MAX. SHAFT DIA.)	1-3/8"	1-15/16"	2-3/16"
		DIAMETER AT COUPLING END	7/8"	1-1/4"	1-5/8"
		MAXIMUM DEFLECTION AT SEALING FACE	.002"	.002"	.002"
BALL BEARINGS		BALL BEARING (INBOARD RADIAL BEARING)	206K	308K	310K
		BALL BEARING (OUTBOARD THRUST BEARING)	206KG	308KG	310KG
		BEARING CENTERS	7-21/32"	8-25/32"	9-25/32"
		*MINIMUM BEARING LIFE UNDER WORST CONDITIONS OF LOAD	2 YEARS	2 YEARS	2 YEARS

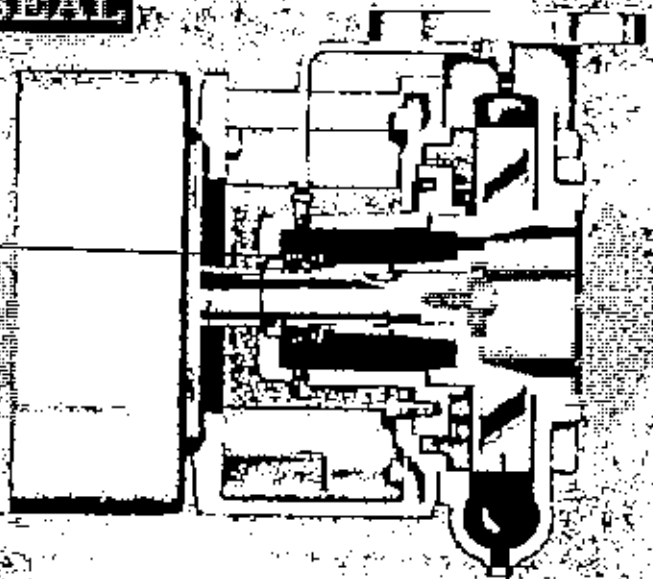
* AVERAGE BEARING LIFE IS 5 TIMES MINIMUM LIFE.

DESIGN DETAILS

CUTAWAY OF GBHA WITH MECHANICAL SEAL

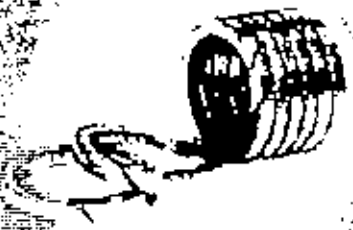


MECHANICAL SEAL



The mechanical seal used in GB pumps is selected to provide an extremely wide service range. Quality in design and materials gives reliability and long life.

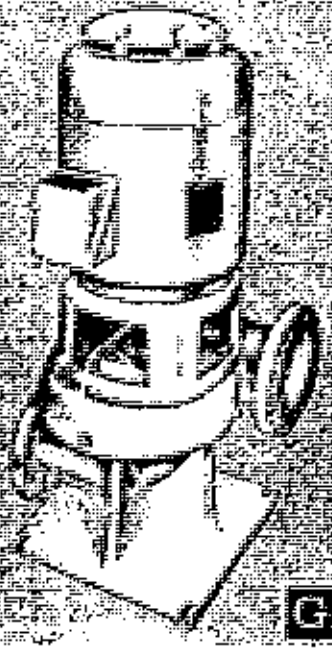
The sealing box is designed for die-molded graphoil packing. Long strands of interwoven sheets form the packing gland on GB pumps and can be completely renewed in only minutes of the pump.



PACKED



ENCLOSED IMPELLER



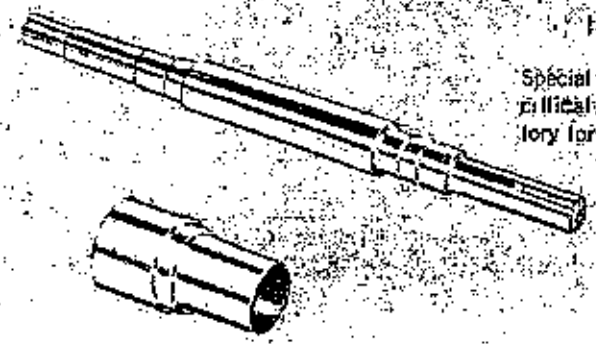
GOVERNED GEVA

For applications where heat input is a problem, specify GEVA pump. The heated jacket and pump gaze on the cast iron GBHA pump, convert the unit to a vertical pump.

GEVA

OPTIONAL EQUIPMENT

will handle the majority of application requirements. To meet the requirements of special applications Aurora Pump has assembled a number of optional features which are available at additional cost. For requirements not handled by the features shown below please refer to the factory.



Special alloy shafts are available for critical services. Refer to the factory for recommendations.



Hardened shaft sleeves to retard wear and scoring are available for pumps with packing.



Semi-open impellers are used for applications where solids appear in the liquid. The blades are self-wiping on the casing. Semi-open impellers are available on GRPA pumps only.

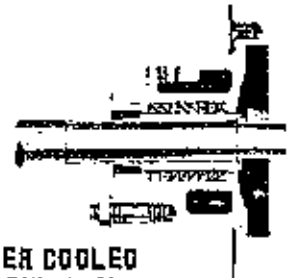
Impeller wearing rings are available where required. Wearing rings prevent wear to the impeller and are easily and inexpensively replaced.



PACKING [2]



PACKING WITH LANTERN RING [3]



WATER COOLED PACKING [4]

Die-molded, graphite-impregnated packing rings are used in

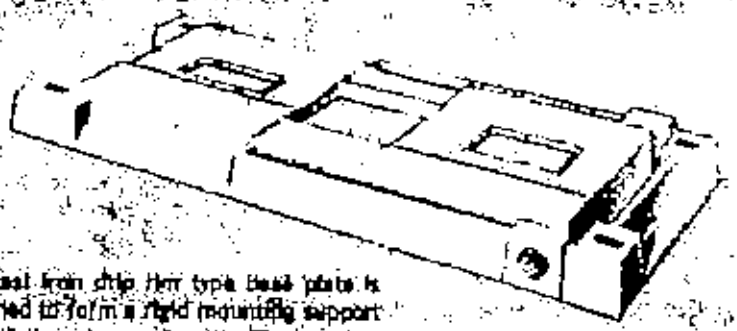
Packing is used on applications where liquids contain abrasives.

is provided with a tapped opening for lubricating the stuffing box. Lubrication is accomplished by either greasing directly into the lantern ring cavity through a grease fitting or by connecting a by-pass line between the pump discharge and the lantern ring. In the stuffing box bore is surrounded by a water jacket with "In" and "Out" tapped openings for connecting coolant water. See limitations chart for recommendations.

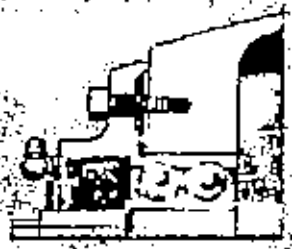
OPTIONAL EQUIPMENT



A formed steel coupling guard rigidly bolted to the base plate is available.



The cast iron drip rim type base plate is designed to form a rigid mounting support for both the pump and motor. The base has machined mounting pads for the pump and motor and an integral drip rim for condensation and stuffing box leakage.



Double row ball bearings are available for severe applications — 2 H.P. and larger units.



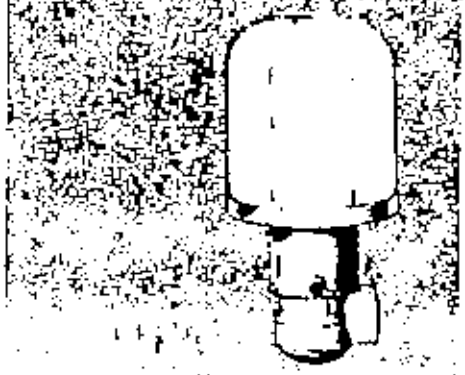
A steel base plate is also available for mounting GBPA pumps.



WATER COOLED MECHARICAL SEAL (S)



SPECIAL MECHARICAL SEALS (S)



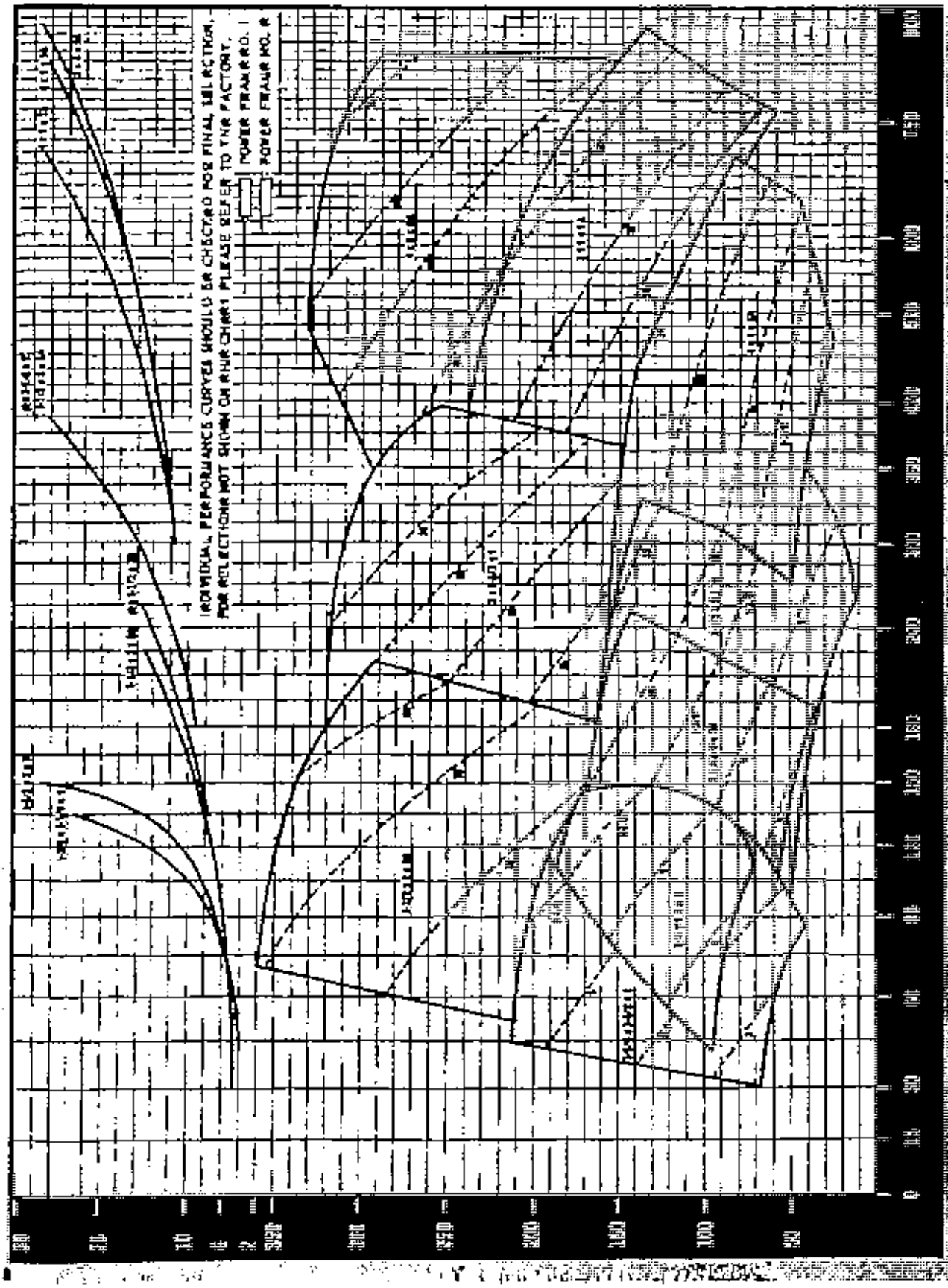
GBPA pumps are available with an oiler to provide constant lubrication to the bearings. The GBPA pump is easily field converted from grease to oil by replacing the pipe plug on the side of the Power Frame with the oiler and the two grease fittings with vent tubes. A0023

uses the same seal as the STANDARD MECHANICAL SEAL. A water jacket assembly is built into the insert. "In" and "Out" tapped openings are provided for connecting coolant water. See limitations chart for temperature recommendations.

to meet the most demanding liquid handling requirements are available upon request from the factory.

SELECTION CHART

3500 R.P.M.

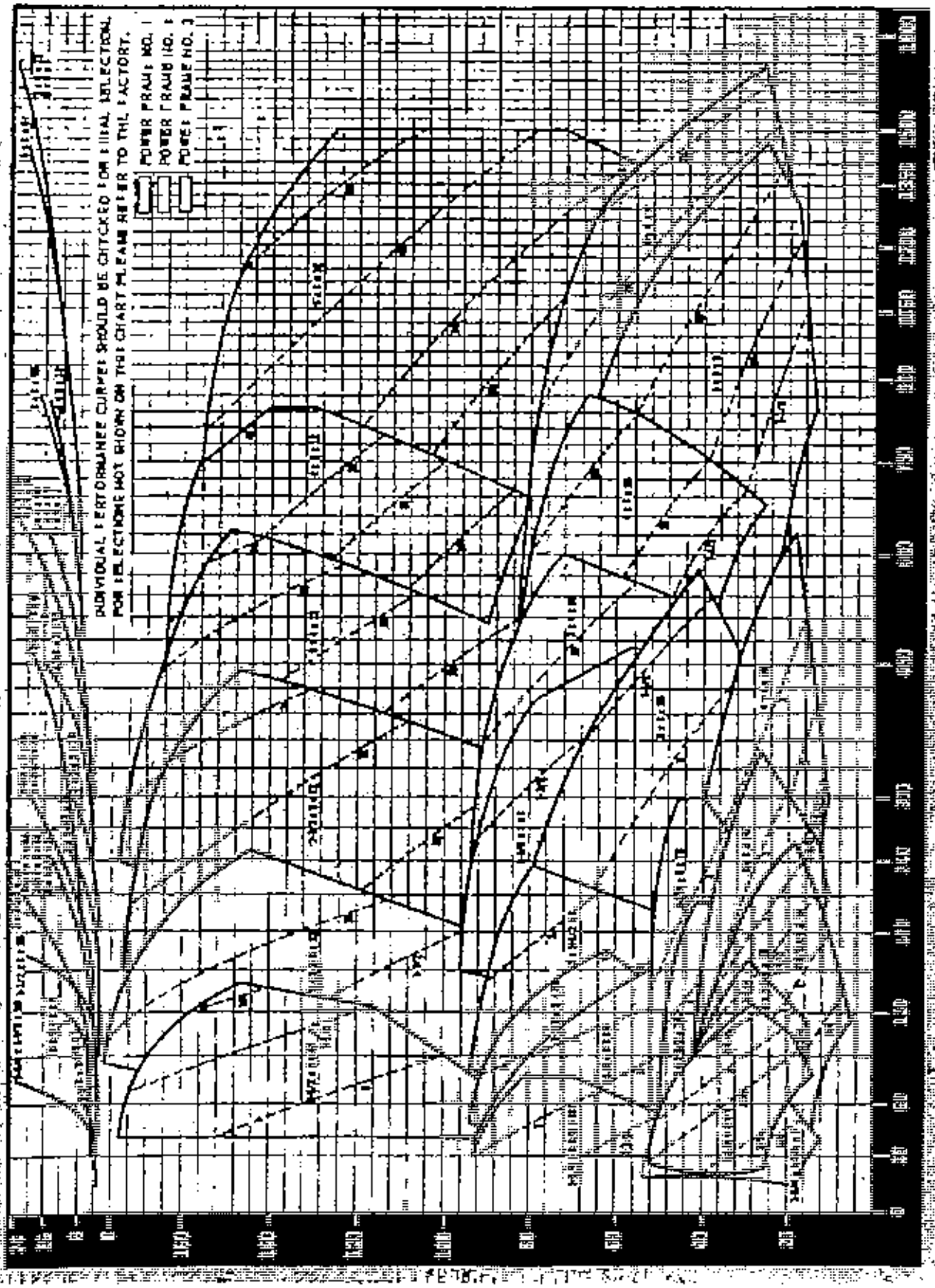


A0024

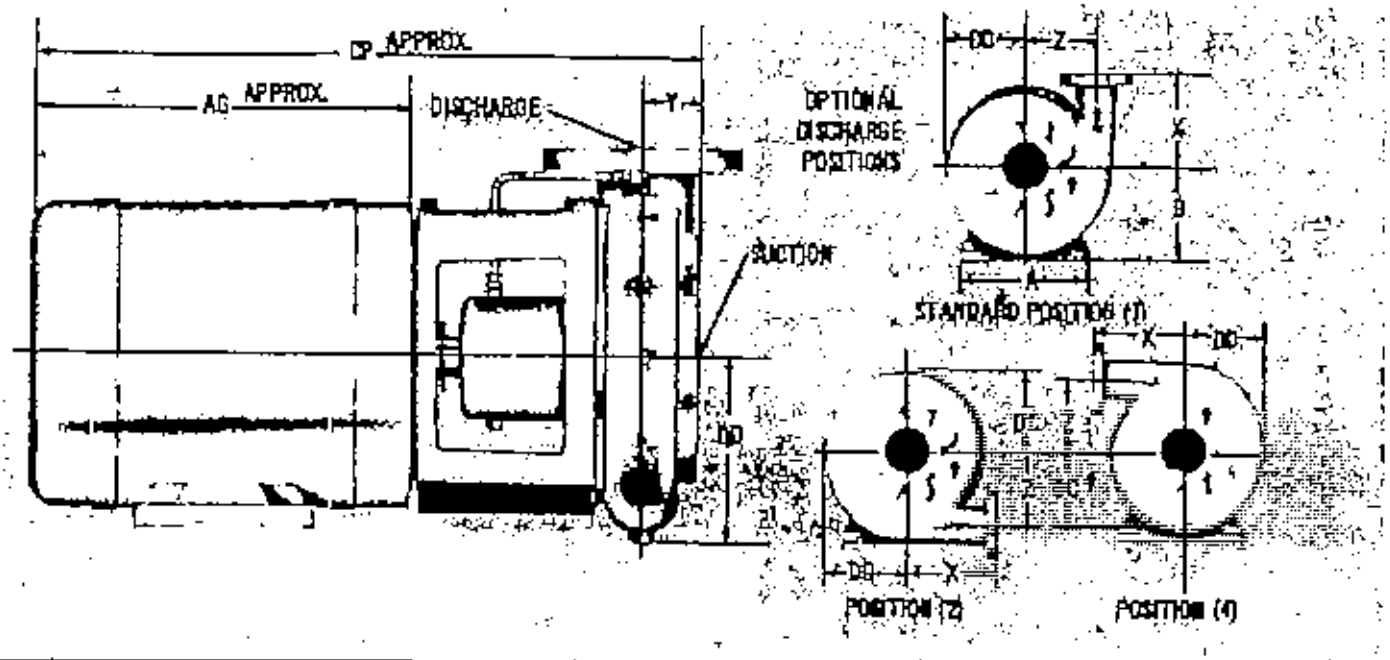
AURORA Always PUMPS

SELECTION CHART

1750 R.P.M.



DIMENSION CHART



GBHA PUMPS WITH THREADED CONNECTIONS								
PUMP SIZE DISCH.	SUCT.	CASE PORTS	PUMP WEIGHT IN LBS.	X	Y	Z	DC	DD
1-1 9	1-1 2	7	73	5-1 4	2-7 16	4-2 14	4-15 16	5-3 14
1-1 4	1-1 2	9	89	6-5 8	2-9 16	5-3 8	6-3 16	6-3 8
1-1 2	1	7	80	5-3 8	2-1 2	4-5 16	5-1 8	5-2 8
1-1 2	1	9	96	6-3 4	2-5 8	5-1 2	6-5 16	6-9 16
1-1 1	2	17	142	1-1 4	7-3 4	7-1 16	3	8-1 4

GBHA PUMPS WITH ALL STD. 125 LBS. FLANGED CONNECTIONS								
2	1-1 2	7	86	5-5 8	1-7 8	4-9 16	5-3 8	5-13 16
2	1-1 2	9	108	7	1-7 8	5-11 16	6-1 2	8-7 8
2	2-1 2	12	163	8	1-7 8	7-5 16	8-3 16	8-1 2
2-1 1	3	7	97	5-7 8	3	4-13 16	5-13 16	4-1 4
2-1 2	3	9	111	7-1 4	3	5-15 16	6-3 4	7-1 4
2-1 3	3	12	172	8-1 4	2	7-3 8	8-3 9	8-3 4
3	4	9	121	7-1 2	2-5 8	4-1 8	4-7 9	7-7 16
3	4	12	185	8-1 2	2-1 9	7-9 16	8-7 16	8-15 16
4	4	7	119	6-1 2	2-3 8	5-1 2	6-7 16	7-5 16
4	5	9A	142	7-1 4	3-1 9	5-5 4	6-11 16	7-2 8
4	5	9B	142	7-3 4	2-5 8	6-5 4	8-1 16	8-11 16
4	5	12	196	8-3 4	2-5 9	2-15 16	8-7 8	9-9 16
5	6	9	192	4	2-3 4	7	8	9
5	4	12	224	9	2-7 8	8-5 16	9-1 4	10-1 8
6	4	9	196	8-1 4	2-3 4	7	8	9
5	4	12	249	9-1 4	3-1 8	8-11 16	9-11 16	10-13 16

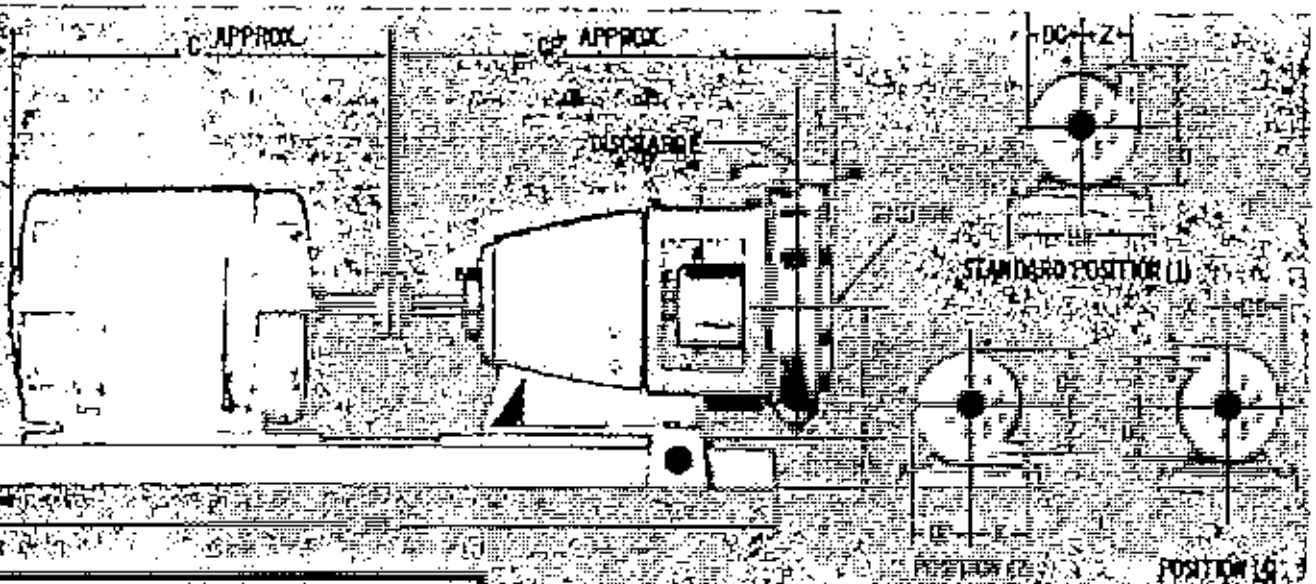
FRAME	HORSEPOWER 3600 RPM	HORSEPOWER 1750 RPM	MOTOR WEIGHT (APPROX.)	A	D	AG	CP
143T	1-1/2	1	30	8-7/8	5-1/2	9	21
145T	2-3	1-1/2-2	40	8-7/8	5-1/2	10	22
182T	5	3	59	10-3/8	4 1/2	11	22
184T	7-1/2	5	77	10-3/8	4-1/2	12	24
213T	10	7-1/2	104	12-7/16	5-1/4	14	26
215T	15	10	120	12-7/16	5-1/4	15	29
254T	20	15	172	13-7/8	6-1/4	18	32
256T	25	20	199	13-7/8	6-1/4	19	32
284T	30	25	257	15-7/8	7	19	33
286T	40	30	306	15-7/8	7	21	35
324S	50	40	350	17-5/8	9	22	36
326T	60	50	385	17-5/8	8	23	32
364T	75	60	560	19-3/4	9	22	37

GBHA AND GBPA

NOTES:
1. ALL DIMENSIONS ARE APPROXIMATE.
2. NOT FOR CONSTRUCTION PURPOSES UNLESS CERTIFIED.
3. ALL HORSEPOWER RATINGS SHOWN ARE FOR OPEN DRIPPROOF ONLY.
4. CONTINUOUS SEA WATER CAPACITIES AND PRESSURE AS LOCATION AND CONDITIONS VARY WITH EACH INSTALLATION.
5. UNDER DISCHARGE POSITION, CASING DIMENSIONS WHICH DIFFER DIMENSION "CP" MAY BE OBTAINED BY ADDING FIVE INCHES.
6. ADD SHAFT AND WATER WEIGHT FOR NET WEIGHT. ADD BASE FOR GBPA WEIGHT.

A0028

AURORA always PUMPS DIMENSION CHART



GBPA PUMPS WITH THREADED CONNECTIONS

PUMP SIZE DISCH.	SUCTION	CASE BORE	PUMP WEIGHT IN LBS.	X	Y	Z
1-1/4	1-1/2	7	73	5-1/4	2-7/16	4-3/16
1-1/4	1-1/2	9	89	6-5/8	1-9/16	5-3/8
1-1/2	2	7	80	5-3/8	2-5/32	4-5/16
1-1/2	2	9	96	6-3/4	2-5/8	5-1/2
1-1/2	2	12	142	8-3/4	2-3/32	7-1/16

GBPA PUMPS WITH 125 LBS. FLANGED CONNECTIONS

2	2-1/2	7	86	5-3/8	1-7/8	4-9/16
2	2-1/2	9	108	7	1-7/8	5-1/16
2	2-1/2	12	163	9	1-7/8	7-3/16
2-1/2	7	7	97	5-1/8	2	4-13/16
2-1/2	1	9	117	7-1/4	2	5-15/16
2-1/2	2	12	172	8-1/4	2	7-3/8
5	4	9	121	7-1/2	1-1/8	4-1/8
5	4	12	185	8-1/2	2-1/8	7-9/16
4	4	7	119	6-1/2	2-3/8	5-1/2
4	5	9A	142	7-1/4	1-1/8	5-3/4
4	5	9B	142	7-3/4	2-5/8	6-5/8
4	5	12	196	8-3/4	2-5/8	7-15/16
5	5	9	192	8	2-3/4	7
5	6	12	224	9	2-7/8	8-5/16
6	6	9	196	8-1/4	2-3/4	7
6	4	12	249	9-7/4	3-1/8	8-11/16

BASE NUMBER	BASE WEIGHT IN LBS.	HA	HB	HH
5	85	14-3/4	37-1/4	2-1/6
3	105	18	43-3/8	2-1/2
4	140	18-7/4	47-1/2	2-1/5
5	190	24	55	2-1/2

NOTE: PROPER POWER FRAME SELECTION CAN BE MADE FROM THE SELECTION CHARTS SHOWN ON PAGES 9 AND 9.

WHEN TWO "D" DIMENSIONS ARE INDICATED, ALWAYS USE THE LARGER FIGURE.

POWER FRAME			WEIGHT IN LBS.			D		
						36	37	38
NEMA FRAME	3600 RPM	1800 RPM	WEIGHT IN LBS.			BASE NUMBER		
56		1/2-1/2-3/4	50	13		2		
143T	1-1/2	1	30	11		2		
145T	2-3	1-1/2 - 2	35	12		2	5	
182T	5	3	45	13		2	5	
184T	7-1/2	5	50	14		2	5	2
2117	10	7-1/2	105	16		2	5	5
2157	15	10	125	19		2	3	3
254T	20	15	200	21			4	4
256T	25	20	225	25			4	4
284T		25	295	24			4	5
284TS	30		285	22			4	
286T		30	325	25			4	5
286TS	40		325	24			4	
324T		40	400	26				5
324TS	50		400	25			5	
326TS	60	50	450	26			2	5
364TS	75	60	325	27			5	5

A0027

LIMITATIONS - CHART

TYPE GB PUMPS

STANDARD CONSTRUCTION

NOTE: MAXIMUM DISCHARGE PRESSURE SHOULD BE DETERMINED BY ADDING SUCTION PRESSURE TO HEAD DEVELOPED BY PUMP.		MAXIMUM DISCHARGE PRESSURE IN LBS. (SEE NOTE)	MAXIMUM SUCTION PRESSURE IN LBS.	MAXIMUM HYDROSTATIC TEST PRESSURE IN LBS.
PUMP SERIES	ALL 7" BORE AND 1" - 1-1/2" DISCHARGE 9" BORE PUMPS	160	75	240
	2" DISCHARGE AND LARGER 9" BORE PUMPS	140	75	210
	ALL 12" BORE PUMPS	100	75	150

NOTE: ALL TEMPERATURE LIMITATIONS GIVEN ARE FOR WATER.		CLOSE COUPLED PUMPS	PEDESTAL MOUNTED PUMPS
MAX. TEMP.	STANDARD MECHANICAL SEAL	212°F.	225°F.
	MECHANICAL SEAL WITH WATER JACKET	250°F.	300°F.
	STANDARD PACKING	230°F.	250°F.
	PACKING WITH LANTERN RING	230°F.	250°F.
	PACKING WITH WATER JACKET	250°F.	300°F.

ENGINEERS SPECIFICATIONS

[illegible] CHART, PLEASE REFER TO [illegible]

[illegible]

1. Standard packing
2. Packing with lantern ring
3. Packing with water jacket

FLEXIBLE COUPLED PUMPS (GBPA)

[illegible] HP, [illegible] phase, [illegible] cycle, [illegible] volts, [illegible] RPM (drip proof) (totally enclosed (explosion proof) motor [illegible]

CLOSE COUPLED PUMPS (GBHA) (GBVA)

Each pump is to be close coupled to a standard NEMA [illegible] HP, [illegible] phase, [illegible] cycle, [illegible] volt, [illegible] RPM (drip proof) (totally enclosed (explosion proof) motor [illegible]

AURORA PUMPS

AURORA PUMP A UNIT OF GENERAL SIGNAL CORPORATION
800 AIRPORT ROAD • NORTH AURORA, ILLINOIS • 60542
FACTORY BRANCH SALES OFFICES: LITHONIA (ATLANTA), GEORGIA
AURORA (CHICAGO), ILLINOIS HACKENSACK, NEW JERSEY
CLEVELAND, OHIO DALLAS, TEXAS MILWAUKEE, WISCONSIN
CANADIAN PLANT: REXDALE (TORONTO), ONTARIO
Local Distributor is listed in the yellow pages of your phone book.
Export Department: Aurora, Illinois Cable Address "SIGNAIRT"
The Trade-mark AURORA is registered in U.S. Patent Office.
Copyright 1968, Aurora Pump, a Unit of General Signal Corporation

EXHIBIT C

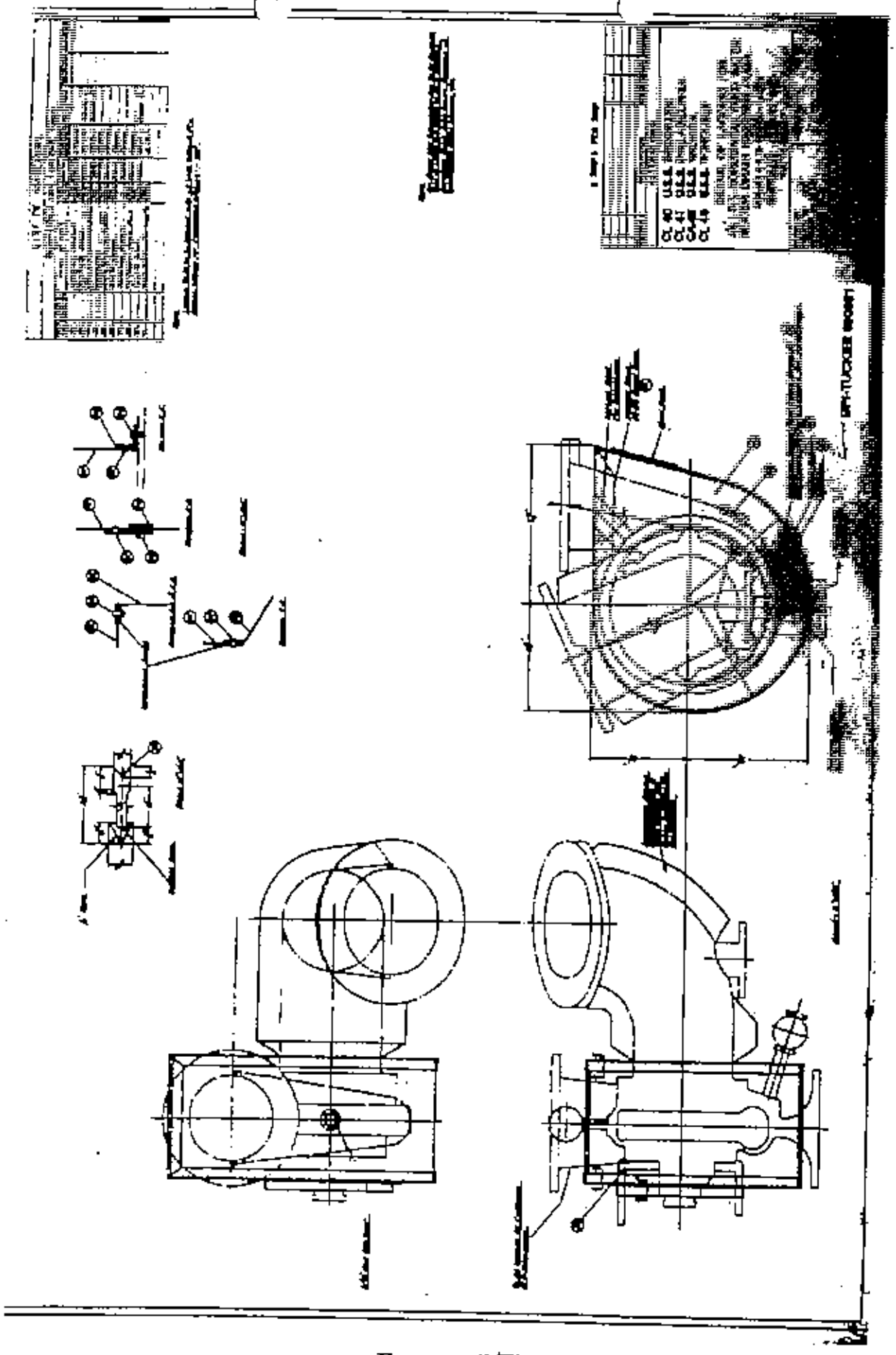
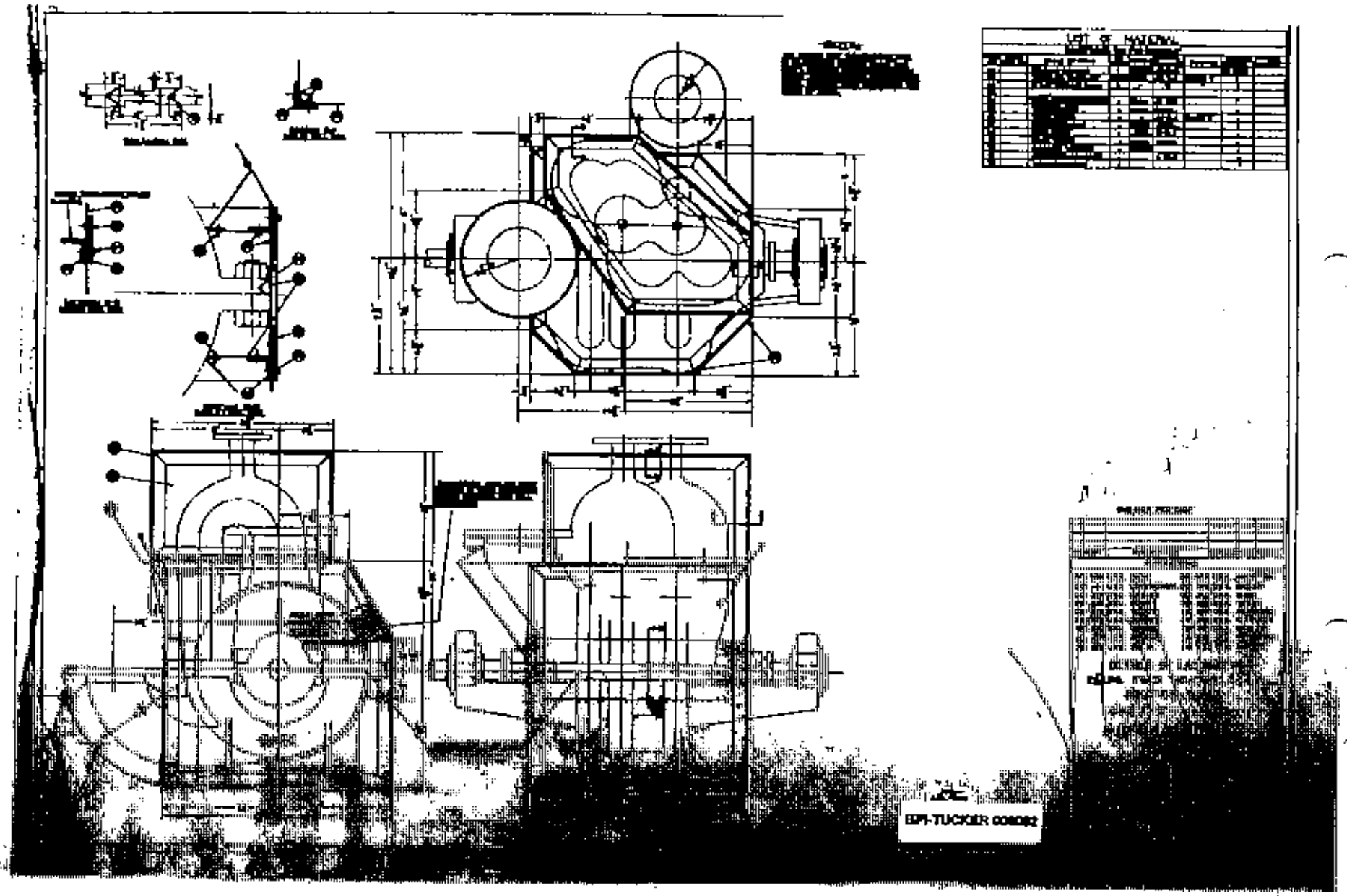
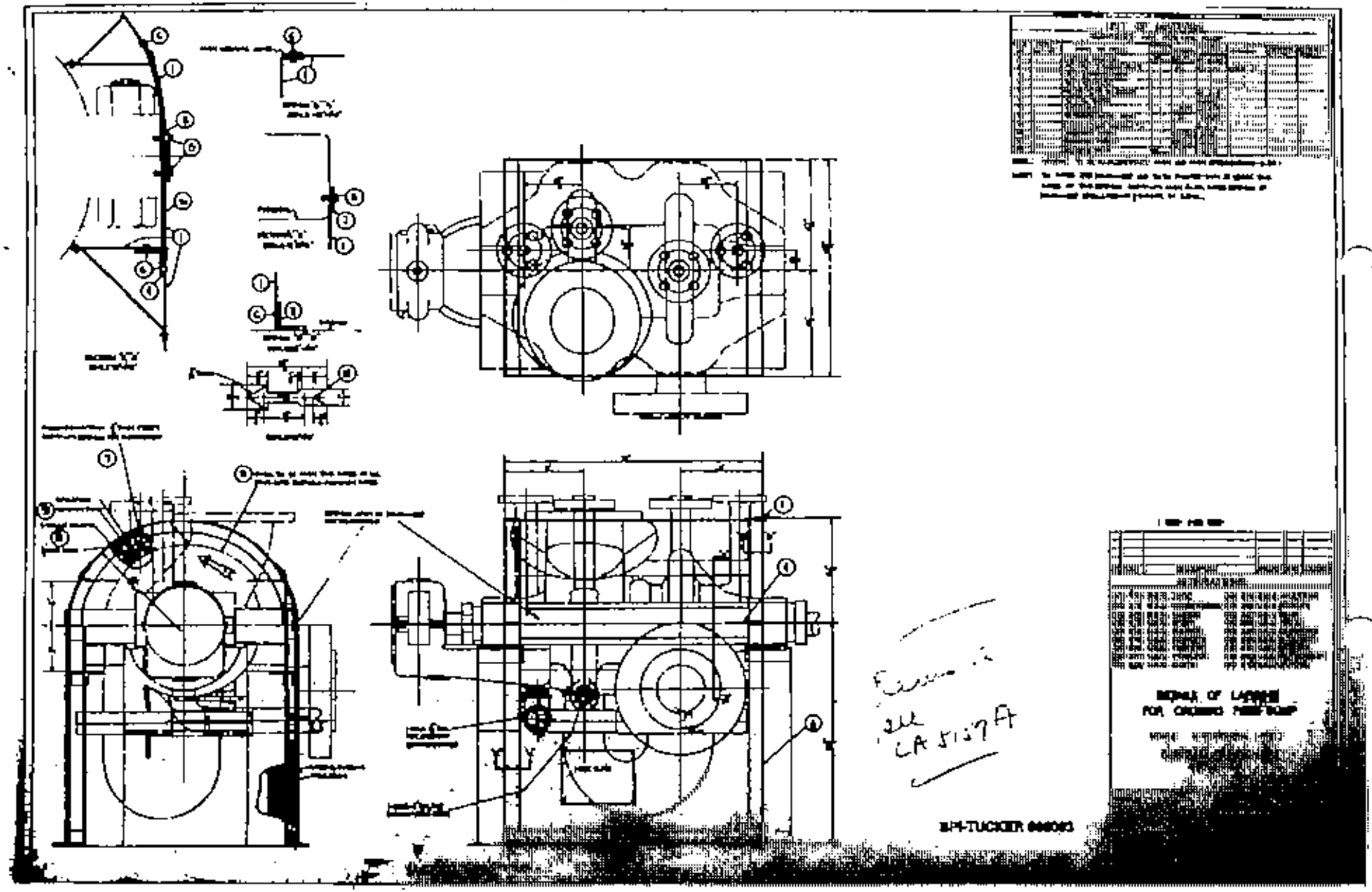
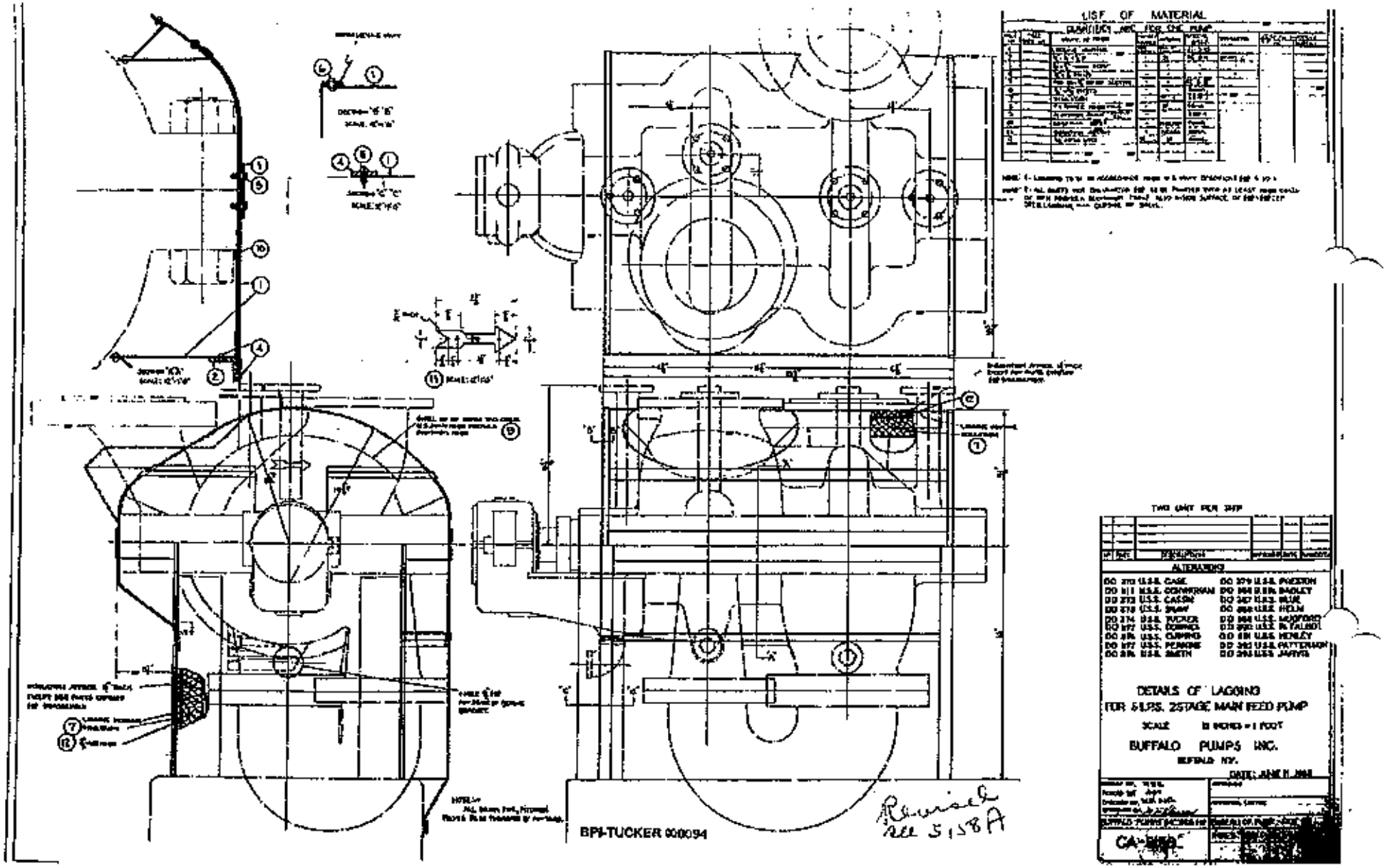
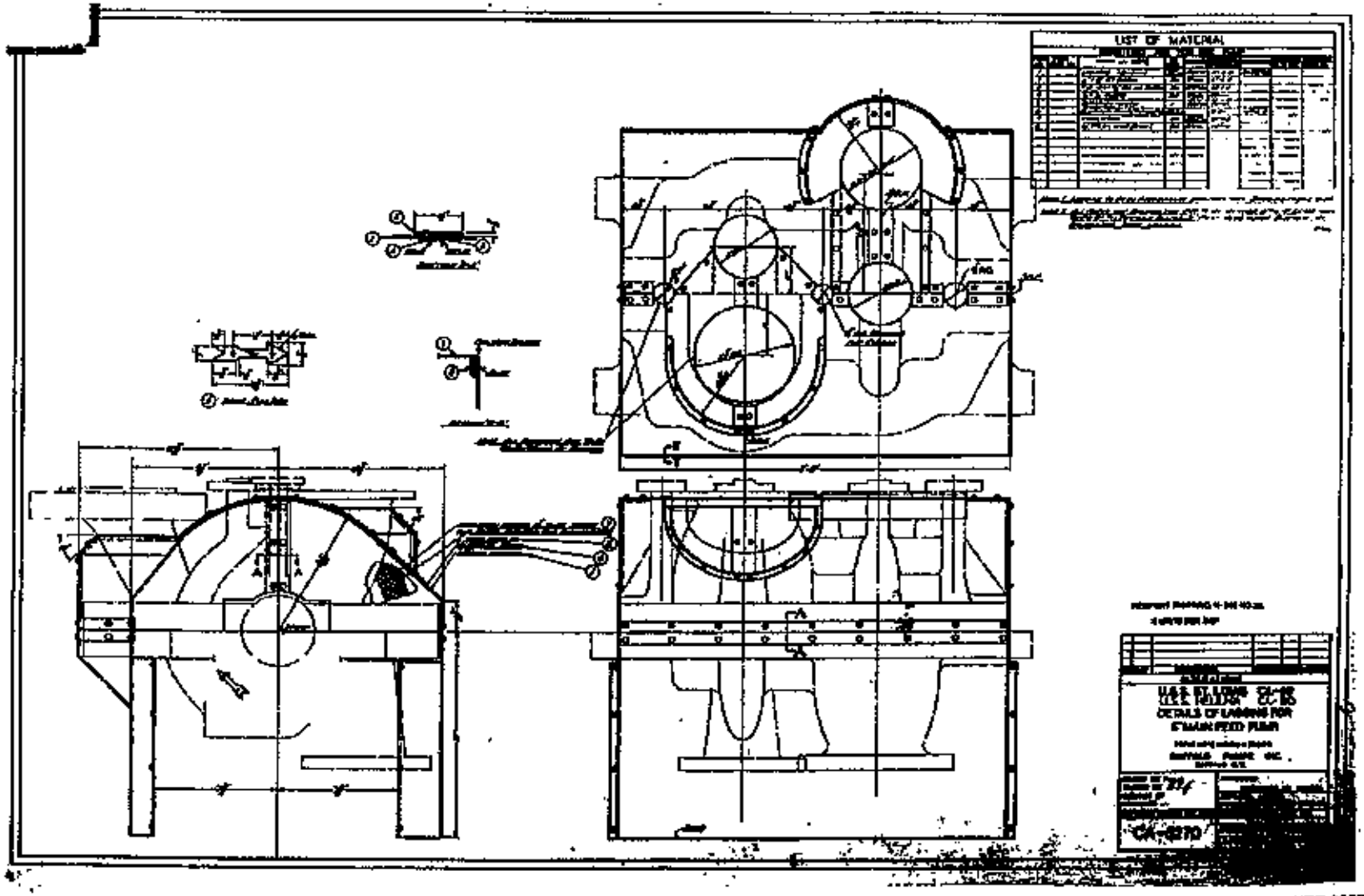


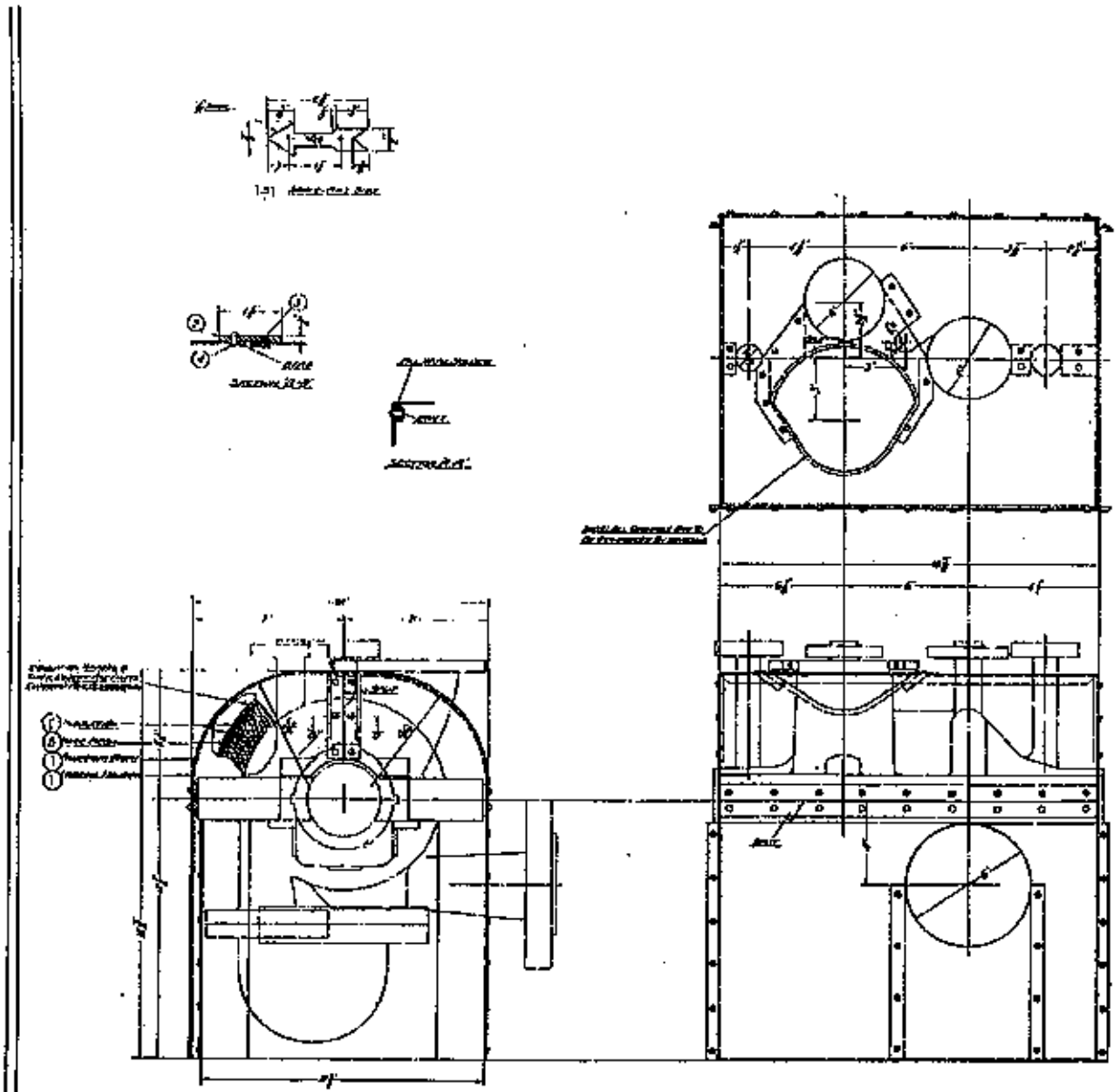
EXHIBIT "C"






LIST OF MATERIAL
DETAILS OF LAGGING
FOR 5 1/2 STAGE MAIN FEED PUMP
SCALE 12 INCHES = 1 FOOT
BUFFALO PUMPS INC.
BUFFALO NY.
BPI-TUCKER 000094
Revised
Rec 5-18-A


LIST OF MATERIAL



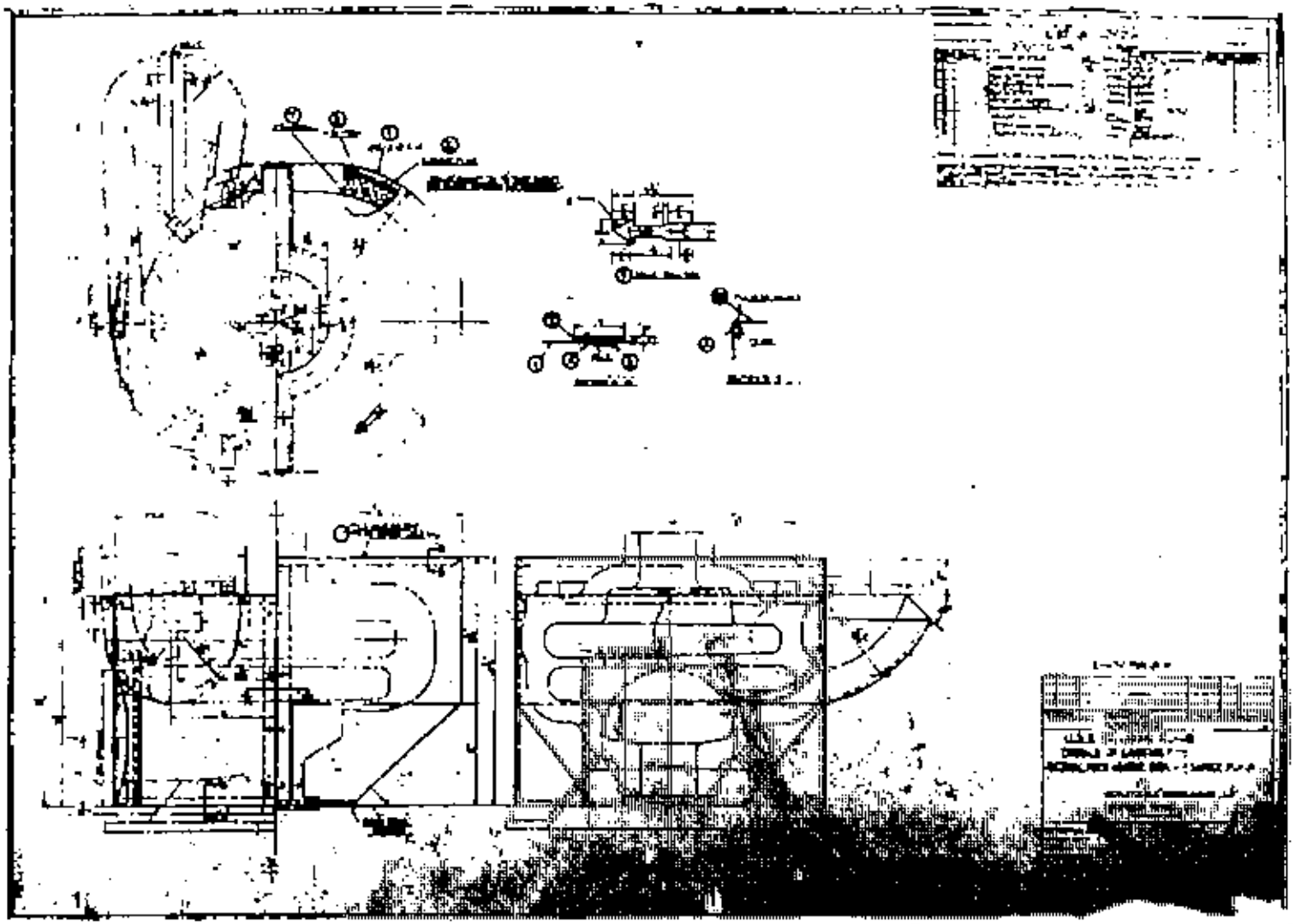
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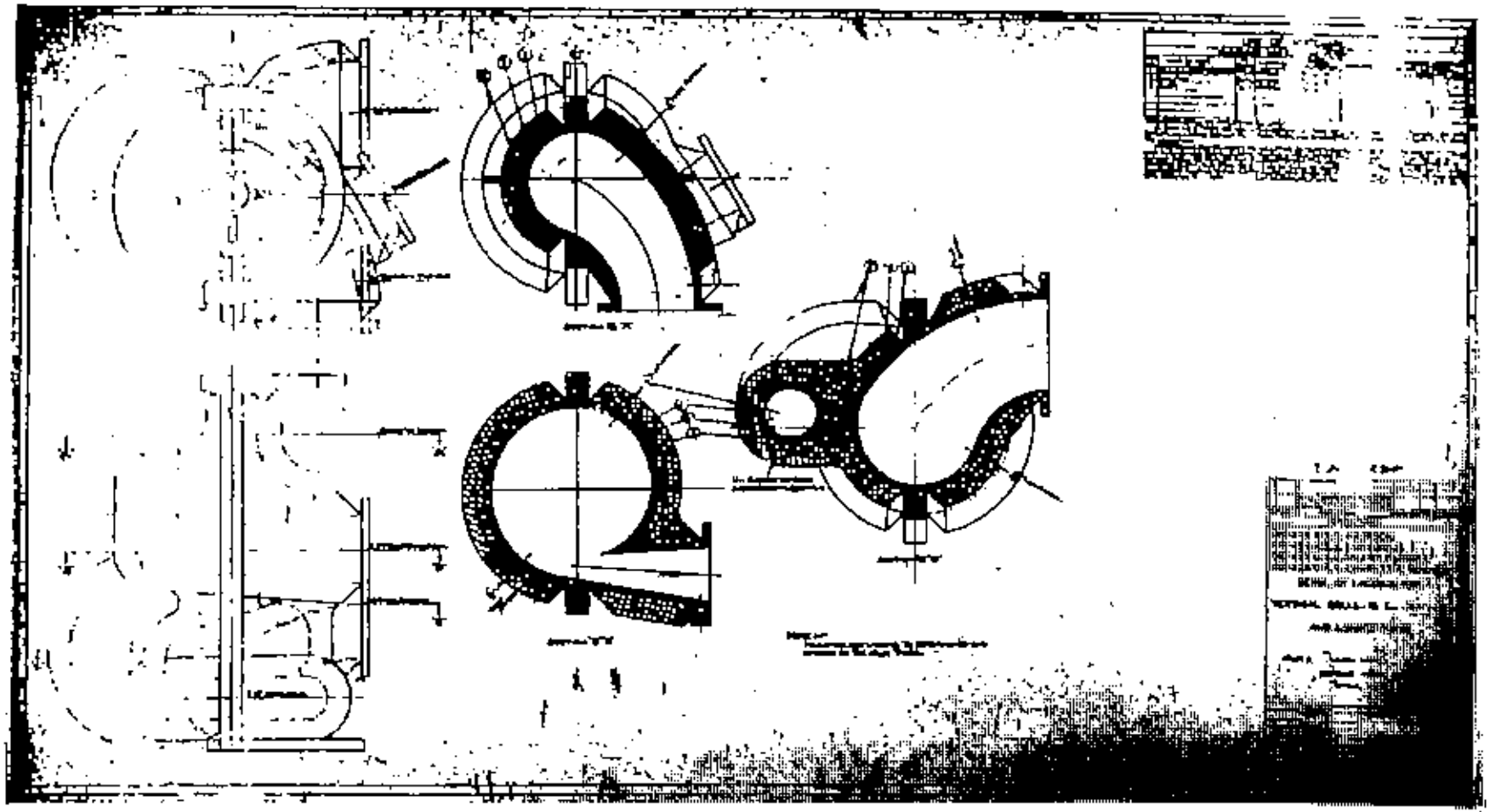
USS ST LOUIS CL-49
USS HELENA CL-50
DETAILS OF LAGGING
FOR CRUISING FEED PUMP

BUFFALO PUMPS INC.

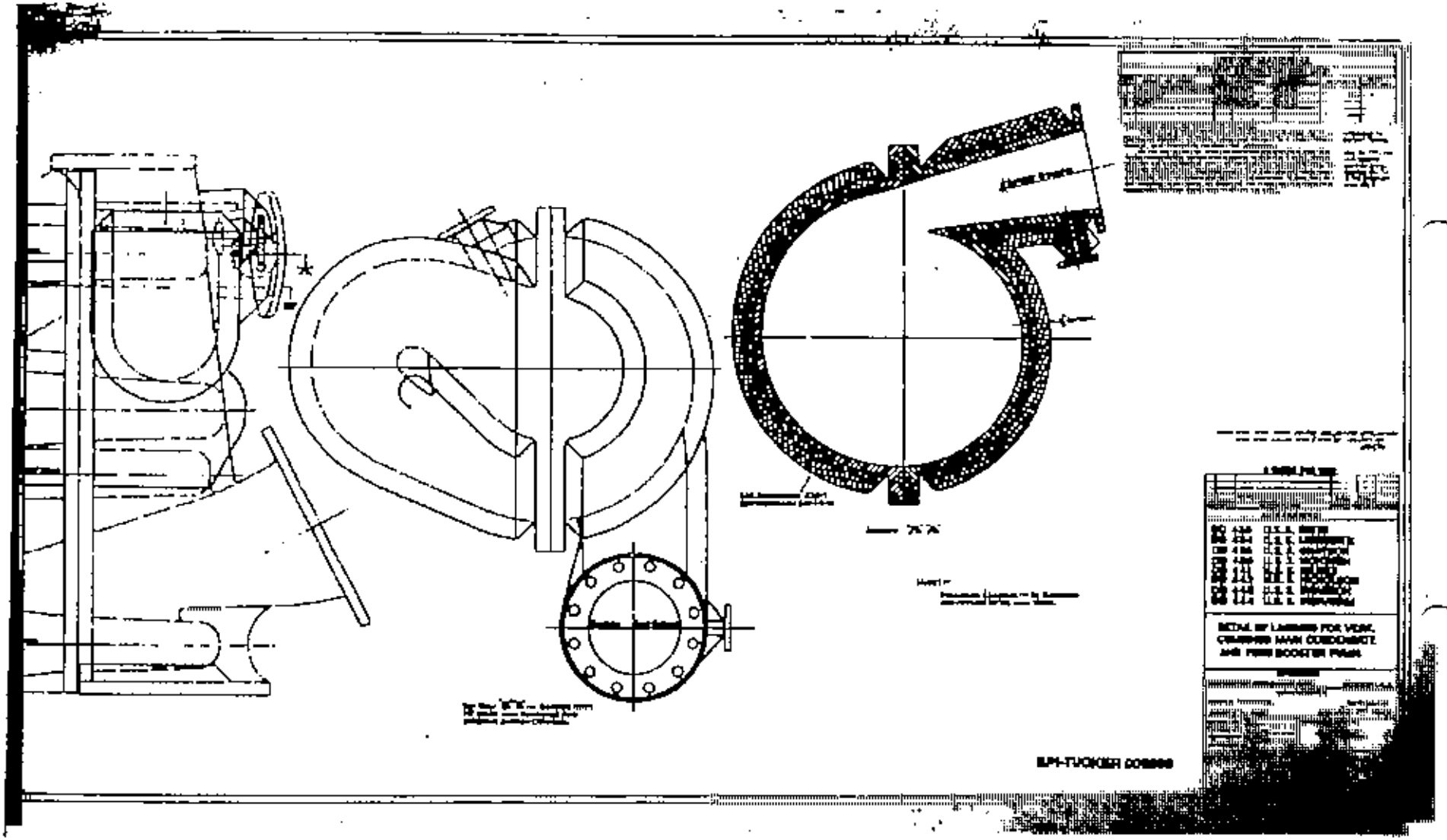
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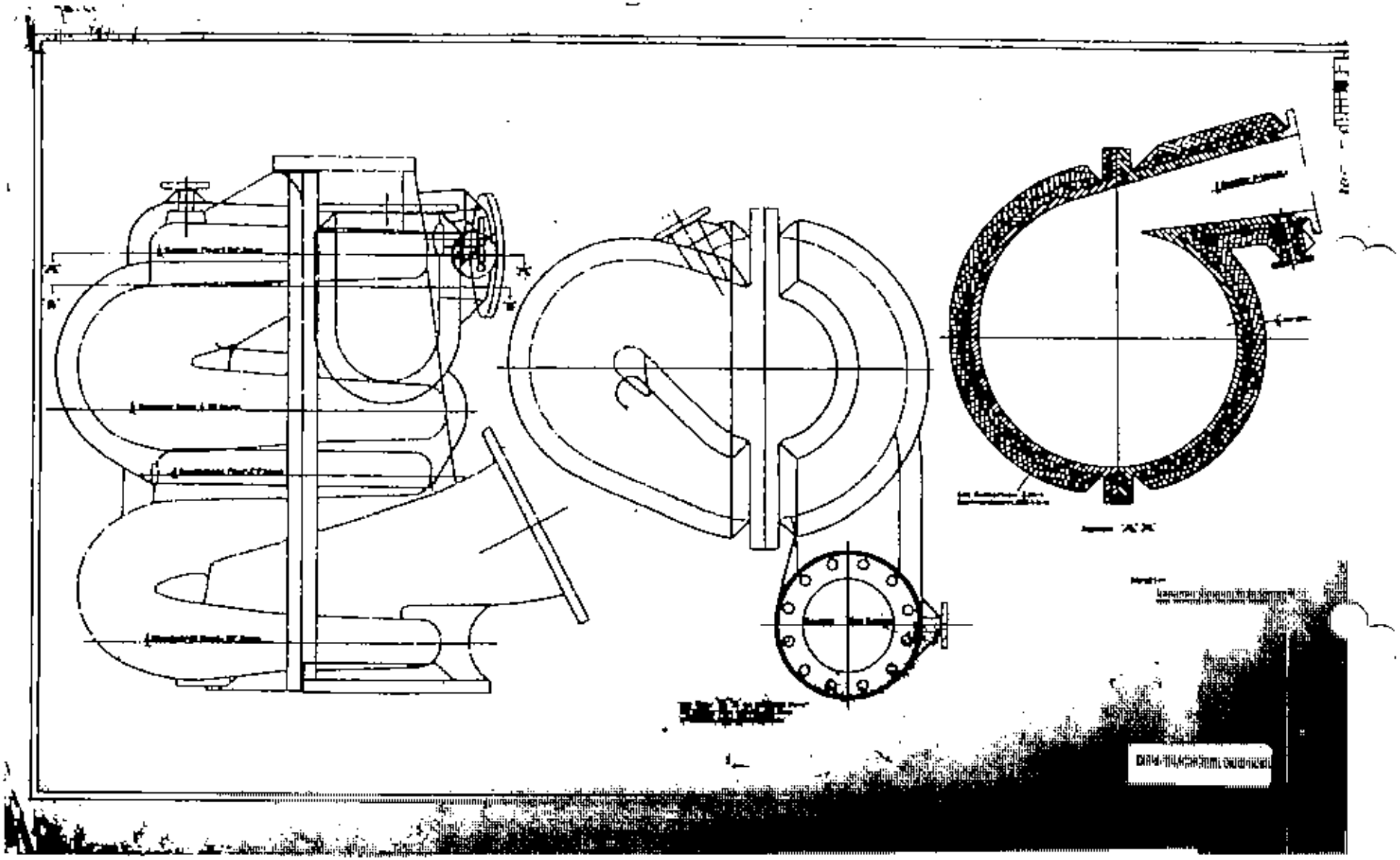
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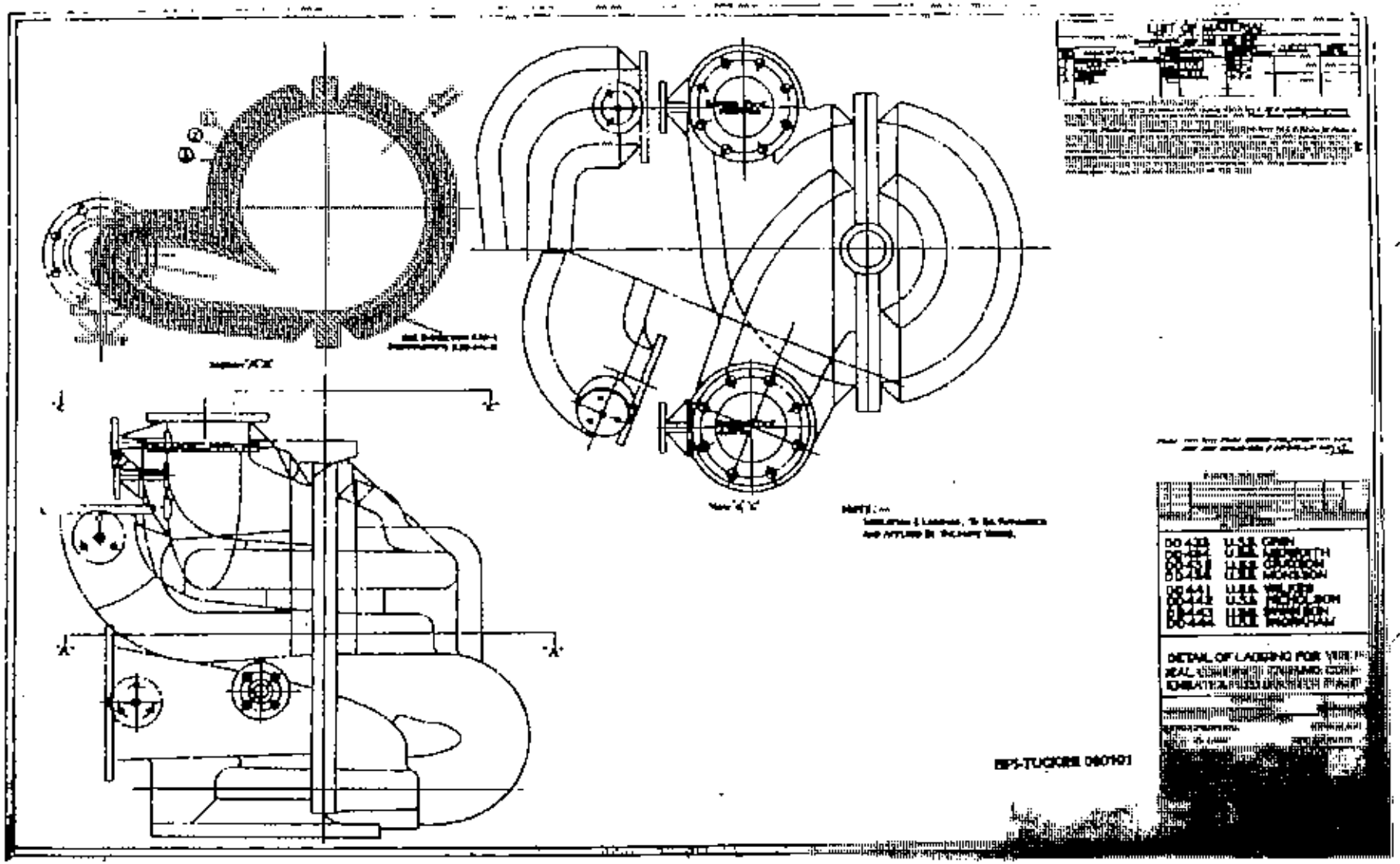


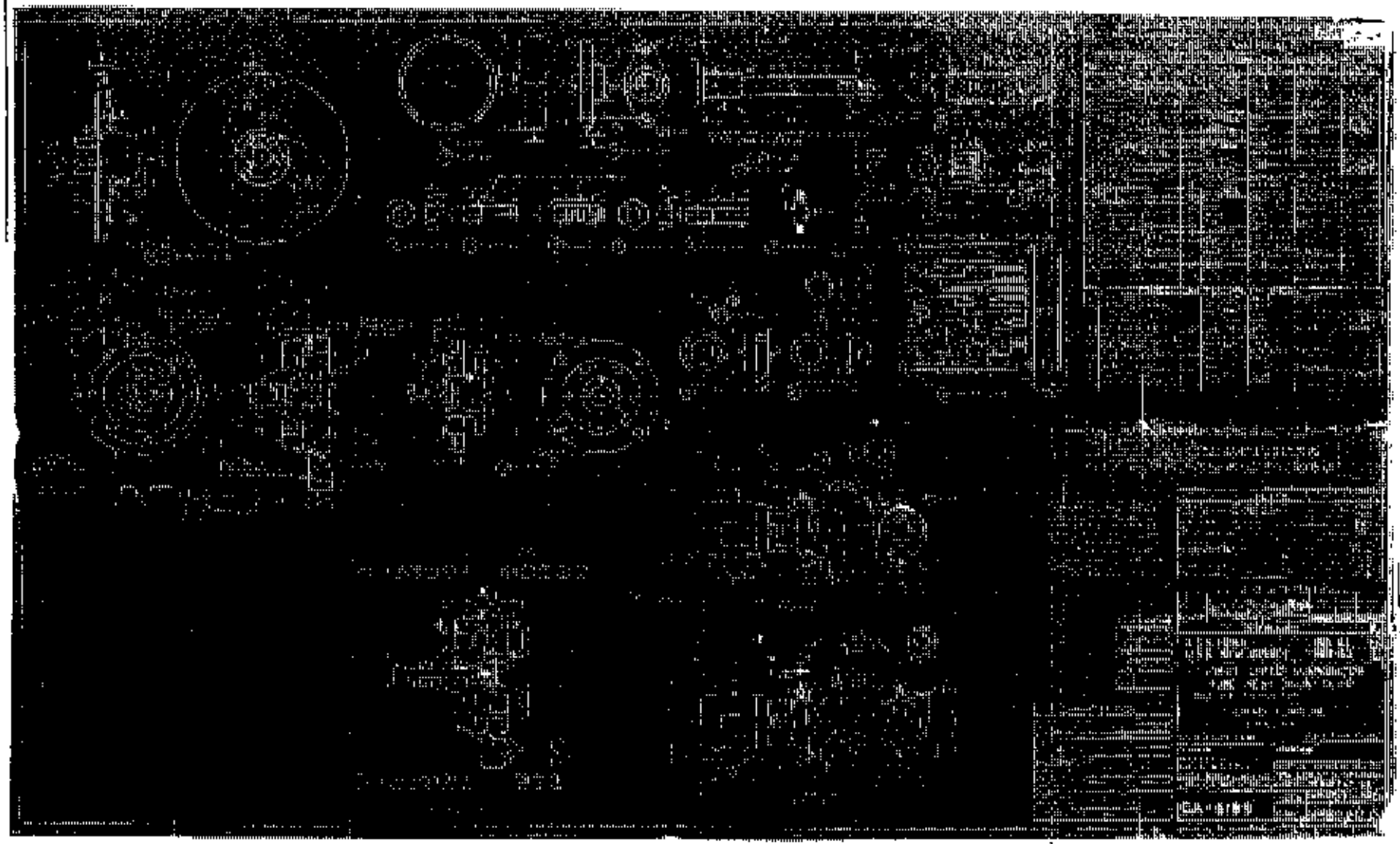


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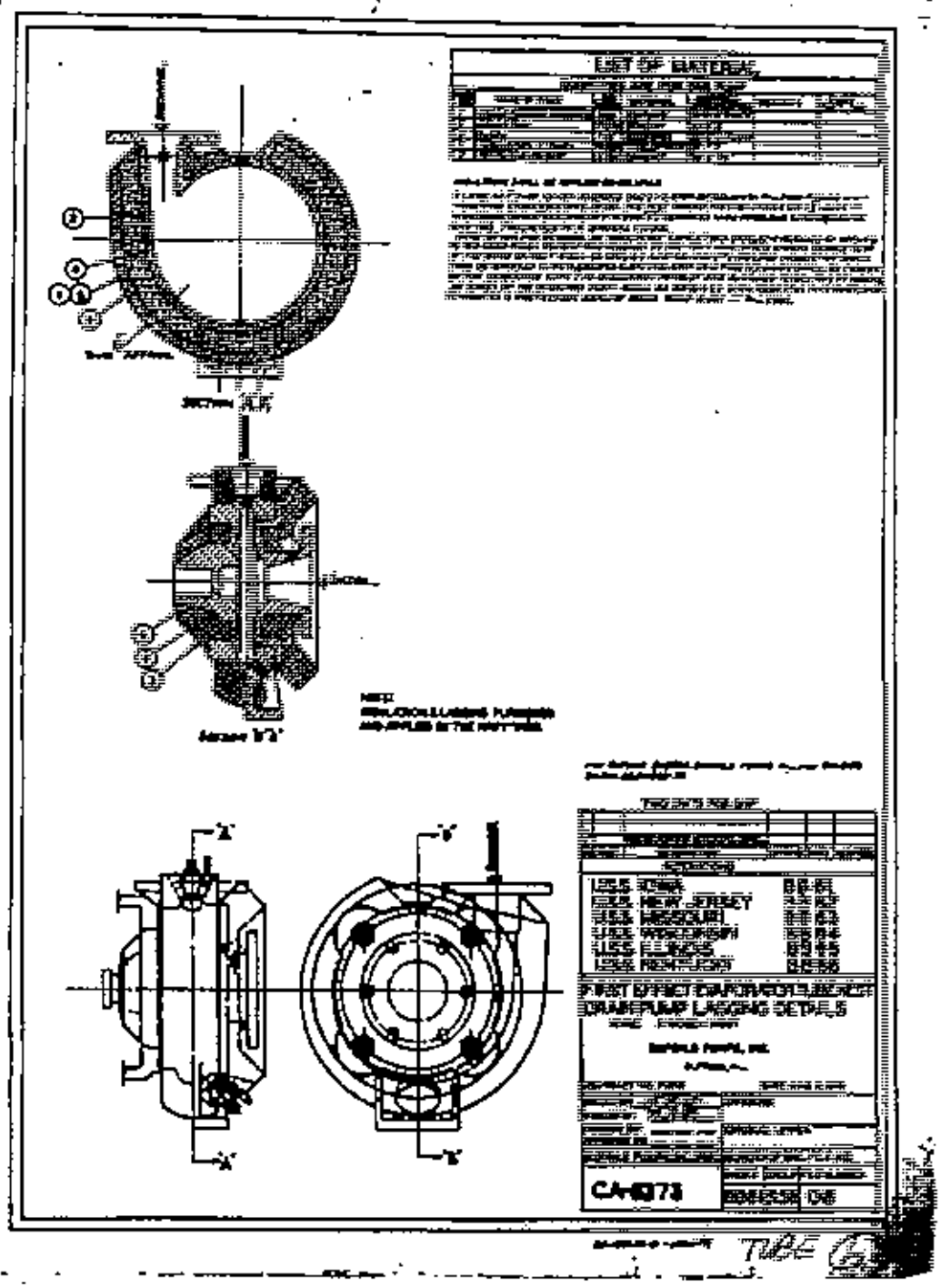


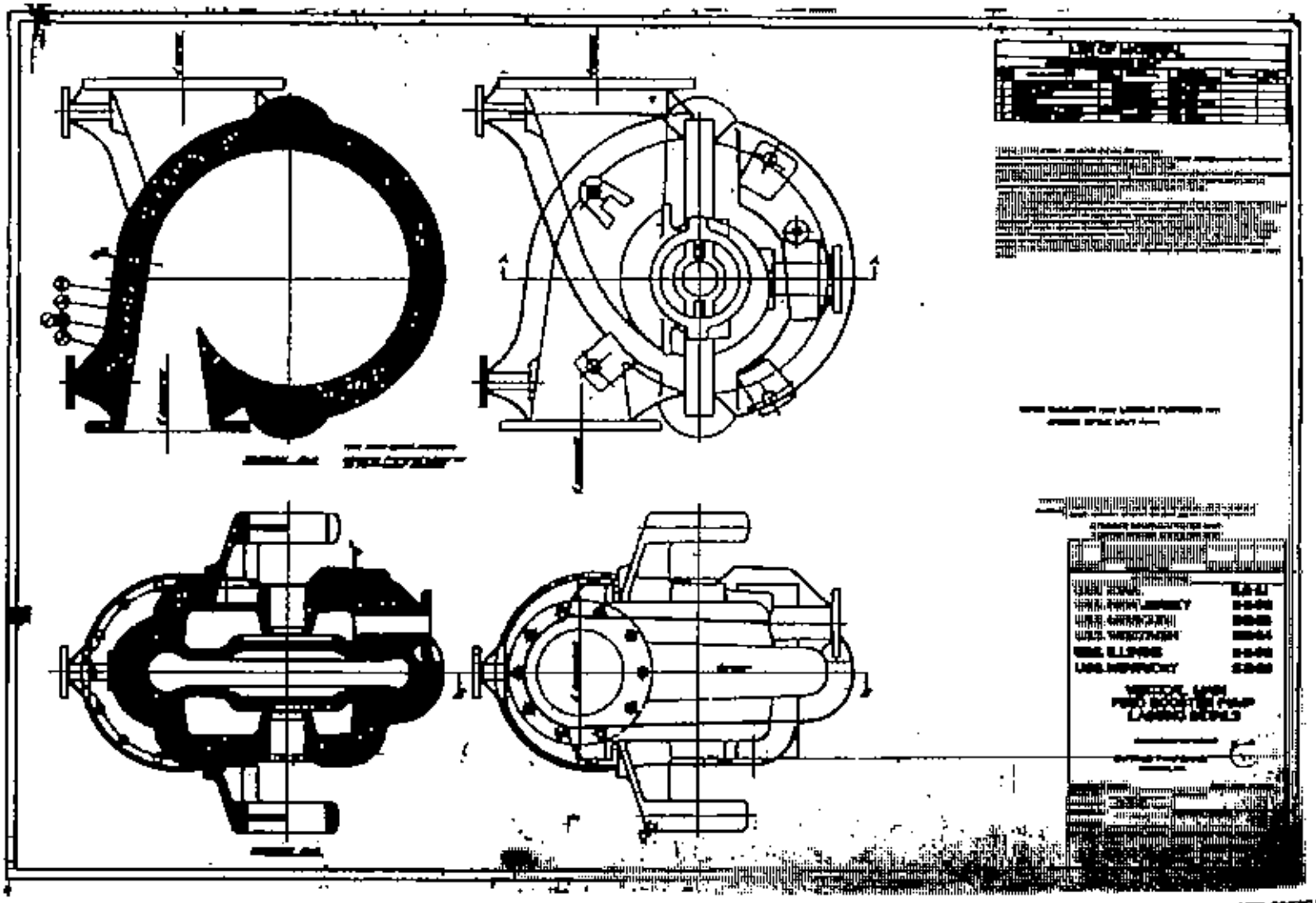


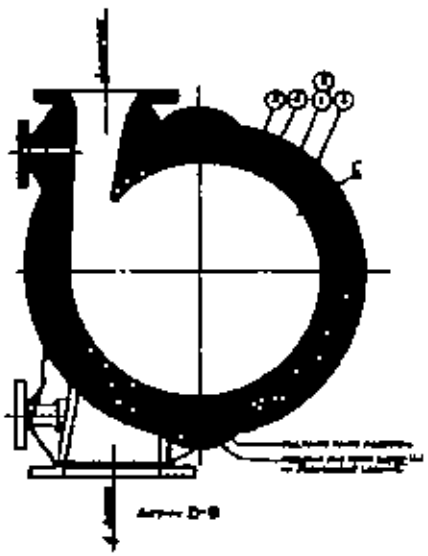


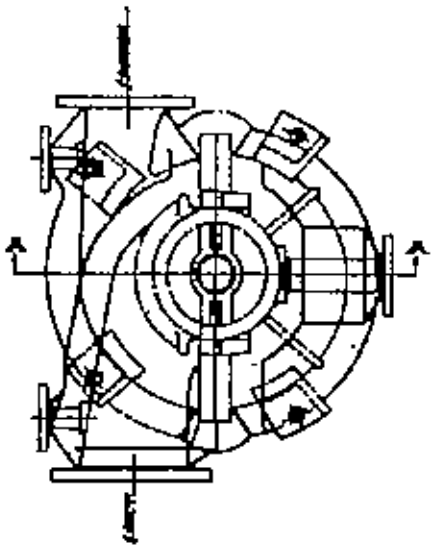


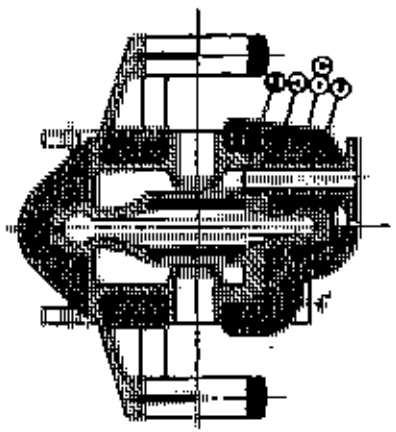
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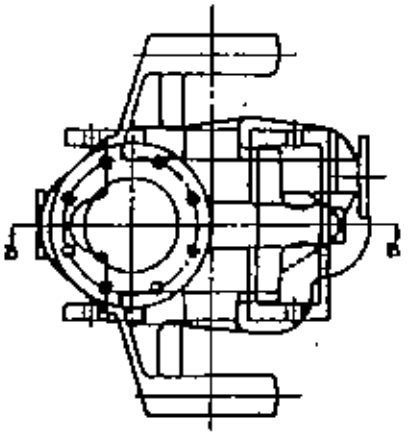

LIST OF MATERIAL
CA-6373











DPI-TUCKER 009105

EXHIBIT D

UNCLASSIFIED

NAVSHIPS 0947-117-1010

TYPE I

EQUIPMENT MANUAL

for

DISTILLER DISTILLATE PUMP
DISTILLER SEA WATER
HEATER DRAIN PUMP

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND

UNCLASSIFIED

EXHIBIT "D"

570

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NAVSHIPS 0947-117-1010

TYPE I

EQUIPMENT MANUAL

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DISTILLER DISTILLATE PUMP

DISTILLER SEA WATER HEATER DRAIN PUMP

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND

UNCLASSIFIED

1 November 1968

BPI-07.08-Hawaii 000002

APPROVAL AND PROCUREMENT RECORD PAGE

APPROVAL DATA FOR: NAVSHIPS 0947-117-1010
Technical Manual: DISTILLER DISTILLATE PUMP AND DISTILLER SEA WATER HEATER DRAIN PUMP
APPROVAL AUTHORITY: Approved by Todd Shipyards Corp. (Seattle Division) (G & C) letter DE-1052 Class/S58 (2-6207-N), dated March 5, 1968

CONTRACT OR PURCHASE ORDER	SHIPS APPLICABLE	QUANTITY OF MANUALS	QUANTITY OF EQUIPMENT	BUILDING YARD
DES-2016	DE-1052, DE-1053, DE-1054, DE-1062, DE-1064, DE-1068, DE-1070	74	14	Todd Shipyards Corp., Seattle, Washington

REMARKS:

CERTIFICATION: DATE 1 November 1968

It is hereby certified that NAVSHIPS 0847-117-1010 to be provided under Purchase Order DES-2016 has been approved by the approval data shown above.

B.W. Ellis, Vice President Engineering
Buffalo Forge Company, Pump Division
North Tonawanda, New York

Federal Code No. 83130

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APPROVAL DATA FOR: NAVSHIPS 0947-117-1010
Technical Manual: DISTILLER DISTILLATE PUMP AND DISTILLER SEA WATER HEATER DRAIN PUMP
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CONTRACT OR PURCHASE ORDER	SHIPS APPLICABLE	QUANTITY OF MANUALS	QUANTITY OF EQUIPMENT	BUILDING YARD
DES-2016	DE-1052, DE-1053, DE-1054, DE-1062, DE-1064, DE-1066, DE-1070	74	14	Todd Shipyards Corp., Seattle, Washington
DEL-4262	DE-1066, DE-1058, DE-1060, DE-1067, DE-1071, DE-1074, DE-1076	28	14	Todd Shipyards Corp., San Pedro, California

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APPROVAL DATA FOR: NAVSHIPS 0947-117-1010
Technical Manual: DISTILLER DISTILLATE PUMP AND DISTILLER SEA WATER HEATER DRAIN PUMP
APPROVAL AUTHORITY: Approved by Todd Shipyards Corp. (Seattle Division) (G & C) letter DE-1052 Class/S58 (2-6207-N), dated March 5, 1968

CONTRACT OR PURCHASE ORDER	SHIPS APPLICABLE	QUANTITY OF MANUALS	QUANTITY OF EQUIPMENT	BUILDING YARD
DES-2016	DE-1052, DE-1053, DE-1054, DE-1062, DE-1084, DE-1088, DE-1070	74	14	Todd Shipyards Corp., Seattle, Washington
DEL-4262	DE-1055, DE-1058, DE-1080, DE-1067, DE-1071, DE-1074, DE-1075	28	14	Todd Shipyards Corp., San Pedro, California
NDE2-24513	DE-1057, DE-1083, DE-1065, DE-1069, DE-1073	23	10	Lockheed Shipbuilding & Construction Co.; Seattle, Washington

REMARKS:

CERTIFICATION: DATE 1 November 1968

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APPROVAL DATA FOR: NAVSHIPS 0947-117-1010
Technical Manual: DISTILLER DISTILLATE PUMP AND DISTILLER SEA WATER HEATER DRAIN PUMP
APPROVAL AUTHORITY: Approved by Todd Shipyards Corp. (Seattle Division) (G & C) lettsr DE-1052 Class/S56 (2-6207-N), dated March 5, 1668

CONTRACT OR PURCHASE ORDER	SHIPS APPLICABLE	QUANTITY OF MANUALS	QUANTITY OF EQUIPMENT	BUILDING YARD
DES-2016	DE-1052, DE-1053, DE-1054, DE-1062, DE-1064, DE-1066, DE-1070	74	14	Todd Shipyards Corp., Seattle, Washington
DEL-4262	DE-1055, DE-1056, DE-1060, DE-1067, DE-1071, DE-1074, DE-1076	28	14	Todd Shipyards Corp., San Pedro, California
NDE2-24513	DE-1057, DE-1063, DE-1065, DE-1069, DE-1073	23	10	Lockheed Shipbuilding & Construction Co., Seattle, Washington
DE505	DE-1056, DE-1059, DE-1061, DE-1066, DE-1072, DE-1075, DE-1077	32	14	Avondals Shipyards Inc., New Orleans, Louisiana

REMARKS:

CERTIFICATION: DATE 1 November 1968

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LIST OF EFFECTIVE PAGES

Page Number	Change In Effect
Title	Original
APR	Original
iii	Original
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1-i thru 1-iii	Original
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1-1-1 thru 1-1-3	Original
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1-6-1/2	Original
1-6-3/4	Original
1-6-5/6	Original
1-6-7/8	Original
Motor and Controller Instructions	Original
2-i thru 2-iii	Original
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2-6-3/4	Original
2-6-5/6	Original
2-6-7/8	Original
2-6-9/10	Original
Falk Coupling Bulletin	Original
Motor and Controller Instructions	Original
User Activity Comment Sheet	Original

BPI-07.08-Hawaii 000007

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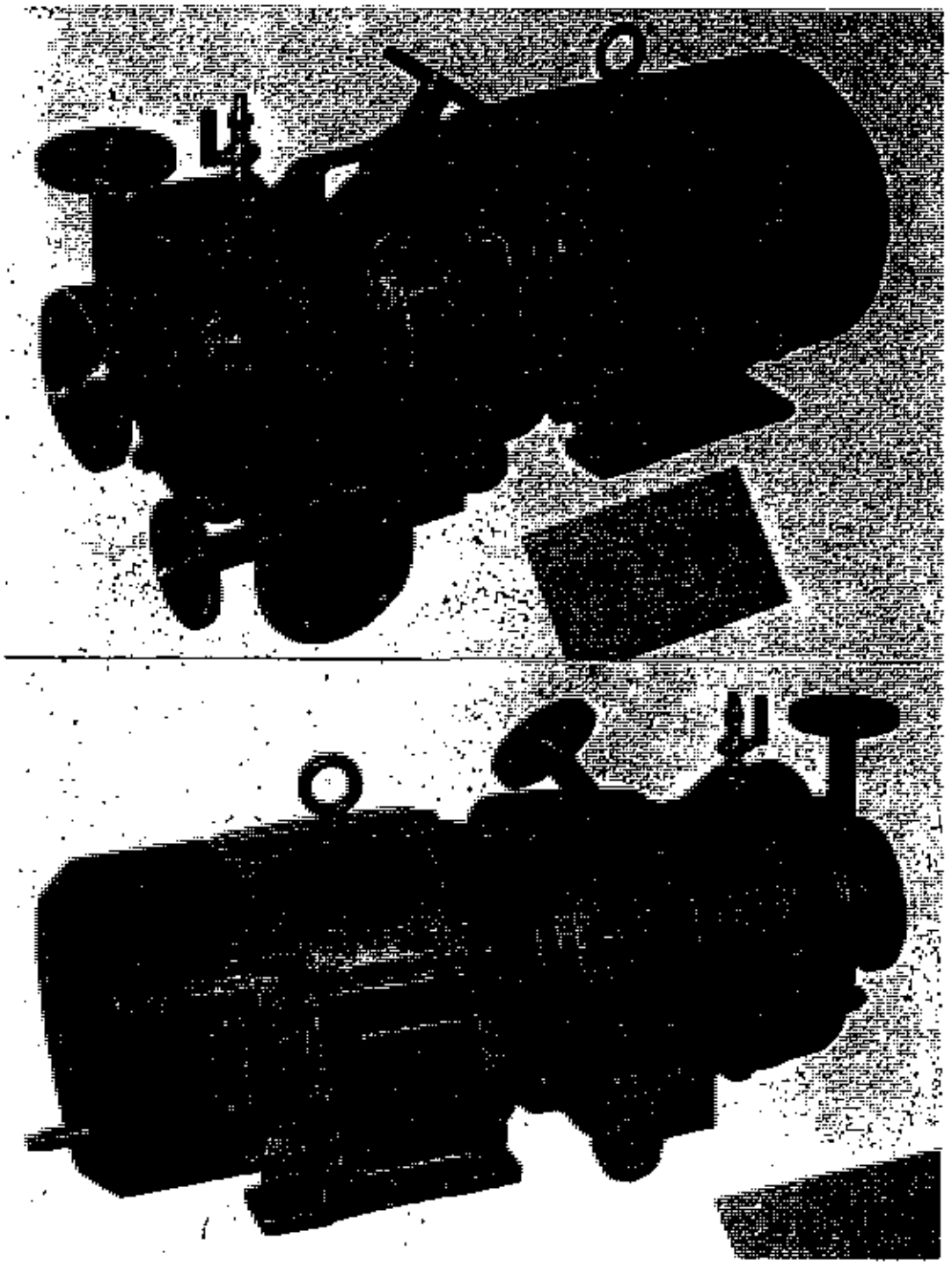


Figure 1-1-1. Photograph of Assembled Distiller Distillate Pump

CHAPTER 1 - DISTILLER DISTILLATE PUMP

SECTION 1

GENERAL INFORMATION

1-1-1. General Data.

PUMP

Type	Close Coupled
Mounting	Horizontal
Military Specification	MIL-P-18472C (Dec. 17, 1962)
Pump Class	1 x 1-1/4 Type 2N
Navy Contract	Ncbs 4782 and 4783
No. of Units Per Ship	2
Class	D-1
Capacity, GPM	10
Total Head, Ft.	95
Liquid Handled	Distilled Water
Specific Gravity	1.0
RPM	3500
BHP at Rating	1.09
Efficiency	22%
NPSH, Feet	2
Suction Pressure Hg. Abs.	3.15 Inches
Liquid Temperature	104°F
Maximum BHP at any condition	2.2

MOTOR*

HP	3
RPM (Synchronous)	3600
Volts/Phase/Cycles	440/3/60
Frame	184CN
Enclosure	Totally Enclosed
Mounting	Horizontal
Duty	Continuous
Ambient Temperature	50°C
Service	Navy A
Bearings	Ball
Insulation	Class B
Class	Squirrel Cage Induction
Full Load Amps	3.25
Specification	MIL-M-17060B

CALCULATED WEIGHTS

Pump (Dry)	75 Lbs
Pump (Operating)	78 Lbs
Motor	103 Lbs
Controller	18.5 Lbs
Total One Unit (Dry)	177 Lbs
Total One Unit (Operating)	180 Lbs

OVERALL DIMENSIONS OF ASSEMBLED UNIT

Length	24-1/2"
Width	12-5/8"
Height	13"

*Refer to Electrical Equipment Sections for complete specifications on the motor.

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REFERENCE DRAWINGS

DWG. NO.	TITLE
CA11345	Outline Elevation and Certification Data
CA11455	Sectional and List of Material
86761	Motor Plan
86761-4	Motor Certification Data Sheet
C6962H144	Controller Master Plan
A6962CD3115	Controller C. D. Sheet

CLEARANCES

Part	Clearance - Inches Radial	Axial
Impeller (4) to Side Plate (12)	-----	1/16
Impeller (4) to Casing (3)	-----	3/32
Impeller (4) to Side Plate Wearing Ring (9) and Casing Wearing Ring (10)	0.006 to 0.006	-----
Throat Bushing (25) to Impeller (4)	0.014 to 0.023	-----
Throat Bushing (25) to Casing (3)	0.015 to 0.023	-----
Lantern Ring (7) to Casing (3)	0.015 to 0.023	-----
Lantern Ring (7) to Sleeve (2)	0.031 to 0.039	-----
Gland (13) to Sleeve (2)	0.031 to 0.039	-----
Gland (13) to Casing (3)	0.015 to 0.023	-----

1-1-2. Introduction.

This equipment manual covers the description, operation, and maintenance of the horizontal motor driven 1 x 1-1/4 2N Distiller Distillate Pump manufactured by Buffalo Forge Co., Pump Division, North Tonawanda, New York.

The pump is a single end suction, one stage, centrifugal unit mounted in a horizontal position with the discharge on the side of the casing. The pump rotating elements are secured to the shaft of the driving unit and the pump casing is secured to the motor end bell through a motor bracket.

1-1-3. Detailed Description (See figure 1-6-2).

Casing. Casing (3) is a gun metal casting bolted between side plate (12) and motor bracket (22). Accurate alignment is assured by stepped fits with both side plate and motor bracket. The casing forms the volute section of the pump. It contains the discharge opening, a stuffing box, a drain plug (34) located at the lowest part of the pump, a vent cock (28) at the top of the casing to release air entrained in the casing, a flanged gauge connection (39) and a flanged connection (47) for seal water for the compression packing contained in the stuffing box. A replaceable wearing ring (10) is fitted in the casing to provide close running clearance with impeller (4), thus eliminating casing wear and minimizing leakage from the discharge volute.

Side Plate. Side plate (12) is a gun metal casting bolted to casing (3). The side plate contains the suction opening and a flanged vent connection (40). A replaceable side plate wearing ring (9) eliminates wear on the side plate and reduces leakage from the discharge volute to the suction side of the pump.

Motor Bracket. A motor bracket (22) of cast gun metal serves as a mounting piece between the pump casing and the motor end bell and extends the pump length to provide access to pump stuffing box. The motor bracket contains drain fittings which may be used to remove leakage from the stuffing box.

Impeller. The impeller (4) is a single suction, enclosed type impeller of gun metal. It is secured to the shaft with impeller nut (6) and prevented from rotating on shaft by a leather key (5).

Stuffing Box. A stuffing box formed by the casing houses throat bushing (25), five rings of packing (33) and lantern ring (7). A split gland (13) held in place with studs (14) and nuts (30) compresses packing to reduce leakage. Seal water to cool, lubricate, and seal the stuffing box is required from a separate seal water supply.

Shaft. The pump shaft is an extended portion of the driving motor shaft. Shaft sleeve (2) protects the shaft from wear and corrosion in the gland area.

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Lubrication. The pump stuffing box is lubricated by clean water from a separate seal water supply. No other pump lubrication is required. Refer to the electrical section for instructions regarding the electric motor.

1-1-4. Principles of Operation.

A centrifugal pump depends on centrifugal force for its operation. This force is generated by the high speed rotation of the impeller. A series of radial curved vanes are cast on the face of the impeller, with a suitable means of entry for the liquid at the center or eye of the impeller. When a positive supply of the liquid being pumped is initially introduced at the impeller eye, the high speed rotation of the impeller throws the liquid outward giving a high velocity head (pressure due to speed). The pressure head of the liquid at this stage is relatively low as compared with that at discharge, and most of the energy of the liquid is due to its speed. Upon leaving the curved vanes of the impeller, the liquid enters the casing where the curved volute passage leads the liquid to the discharge piping. In the volute the energy imparted from the liquid's speed is gradually changed to a static pressure head by reducing the speed of the liquid as it passes through the volute.

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SECTION 2

INSTALLATION

1-2-1. General.

Pump and motor have been crated and bolted to a skid prior to shipment. Inspect for damage which may have occurred during storage or shipment.

Gland (13), lantern ring (7), and packing rings (33) are wired to the stuffing box or packed in a separate container inside the shipping crate. Pack the stuffing box per instructions in Section 4, paragraph 1-4-4.

1-2-2. Mounting (See figure 1-6-1).

The unit must be installed with shaft in a true horizontal position and flanges in a true vertical or horizontal position. Use metal shims between the foundation and mounting feet to level the unit if necessary. Tighten alternate foundation bolts gradually and evenly around unit. If necessary, minor adjustments in position can be made by shimming under the motor or motor bracket mounting feet.

1-2-3. Alignment.

The complete unit was accurately aligned before shipment. However, alignment should be checked after the unit has been installed and again after piping is connected and the unit bolted in place. To check alignment, rotate motor shaft by hand. If rotor turns easily without scraping or binding, unit is in alignment and no adjustments are necessary. It may be necessary to remove the packing to check alignment. If rotor binds or scraping noises are heard, attempt to bring the unit into alignment by loosening the mounting bolts and inserting shims under the mounting feet. Try combinations of shim thicknesses and locations to bring unit into correct alignment. If this fails refer to Section 4.

1-2-4. Piping.

All piping should be supported independently near the pump so that no strain will be transmitted to the pump when the flange bolts are tightened. Expansion and contraction stresses from hot liquids must be considered to avoid warping. If the piping is the wrong length, or does not match the pump flanges properly, do not force the connection. The unit can be sprung out of alignment by faulty piping. This unit requires piping for suction, discharge, vent, and stuffing box seal water from an external supply of liquid. A connection is also required at the motor bracket to remove stuffing box leakage. A gage connection is provided on the discharge nozzle.

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SECTION 3

OPERATING INSTRUCTIONS

1-3-1. Safety Precautions.

WARNING: This pump is driven by an electric motor using 440 volts. All safety precautions listed in BuShips Manual, Chapter 60 and in the U.S. Navy Safety Precautions must be strictly observed.

Before starting this unit check:

1. Pump priming. Insure that pump is completely filled with liquid.
2. Shaft freedom.
3. Cleanliness of passages in piping system and pump.
4. Packing glands - Nuts should be finger tight to allow ample leakage.

If the unit is being started for the first time after installation or overhaul, check the following in addition to steps one through four above.

1. Alignment. Shaft must rotate without binding or scraping of any kind.
2. Direction of rotation must agree with arrow on the casing or side plate.
3. All connections for leaks.

1-3-2. Starting.

CAUTION: Do not run this pump dry. To do so may cause damage to the pump rotating elements.

1. Open suction valve if closed.
2. Open vent valve and see that pump is primed.
3. Check seal water line to insure a flow of liquid to stuffing box.
4. Start motor.
5. Open discharge valve slowly when discharge pressure is reached.

1-3-3. Running.

1. Tighten gland nuts (30) slowly and evenly to reduce stuffing box leakage to about one drop per second. If stuffing box heats up increase leakage.

2. Inspect unit periodically during operation for proper stuffing box leakage. Check temperature and pressure against the figures listed under General Data in Section 1 and investigate and correct any variation from normal. Investigate and correct any unusual noise or vibration.

1-3-4. Securing.

1. Close pump discharge valve.
2. Stop motor.
3. Close pump suction and seal water valves, if required. If possible leave these valves open at all times.

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SECTION 4

MAINTENANCE

CAUTION: Before performing any maintenance on this unit, isolate pump from system by closing and tagging or locking all valves closed. Tag or lock all switches to motor and controller in the open position. All safety precautions listed in the BuShips Manual, Chapter 60, and in the U.S. Navy Safety Precautions should be observed.

1-4-1. Tests and Inspection (See Figure 1-6-2).

Daily

1. Turn idle pump shaft by hand.
2. Check pump and piping for leaks. Check stuffing box leakage rate (about one drop per second).
3. Check pumping conditions.

Weekly

1. Run pump under power and check for unusual noises or vibration.
2. Check operation of valves in system.

Annually

1. Open pump casing. Inspect and clean or replace parts.
2. Check clearances between impeller hubs and casing and side plate wearing rings. When clearance has increased to double the initial value, the original clearance, as shown on page 1-1-1, should be restored by replacing the effected parts.
3. Check shaft sleeve (2), packing (13), impeller (4), and shaft (1) for wear, damage or deterioration.

1-4-2. Trouble Shooting.

Table 1-4-1 lists most of the troubles that may be encountered during pump operation with probable causes and remedies. For mechanical troubles it is necessary to disassemble the pump and inspect for damaged or worn parts. Where disassembly is applicable, the necessity for replacement of parts can be determined by visual inspection and measurement of clearances. If the actual clearance does not agree with the recommended clearance shown in paragraph 1-1-1 or figure 1-6-2, and pump efficiency is reduced, the parts should be replaced. Broken, scored, galled or otherwise badly damaged parts should be replaced. Refer to paragraphs 1-4-3 and 1-4-4 respectively for disassembly and maintenance.

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Table 1-4-1. Trouble Shooting

Trouble	Cause	Remedy
Noisy Installation	Noise caused by other equipment	Investigate source of noise.
	Incomplete priming	Fill pump and suction line completely.
	Suction lift too high	Check level in supply tank.
	Speed too high	Check the driver for high speed. Refer to the applicable trouble shooting tables.
	Foreign material in pump	Disassemble pump or piping and remove obstruction.
	Loose parts in pump or piping system	Inspect unit, tighten loose bolts, repair or replace damaged or broken parts.
Pump overloads driver	Speed too high	Check the driver for high speed. Refer to the applicable trouble shooting tables.
	Pumping too much liquid	Increase discharge head by adjusting valve in discharge line.
	Mechanical defects: Bent shaft Rotating element binds Wearing rings worn	Inspect and repair as necessary.
	Packing gland too tight	Release gland pressure slightly.
Pump loses prime after starting	Incomplete priming	Vent pump casing and fill completely with liquid.
	Air leaks in suction piping	Inspect suction piping, gaskets and flanges, replace faulty gaskets and piping.
	Suction lift too high	Check pump and suction piping for obstructions. Check the level in the supply tank.
	Air or gases in liquid	Insure that casing vent line is open. Inspect suction piping, gaskets and flanges for leaks. Replace faulty parts.
	Impeller partially clogged	Disassemble pump casing and remove obstruction.
	Defective casing gasket	Replace.
	Lantern ring plugged	Clean. Seal water must be free of foreign matter.
Pump discharge pressure low	Air leaks in suction piping	Inspect suction piping, gaskets and flanges. Replace faulty gaskets and piping.
	Suction lift too high	Inspect pump and suction piping for obstructions. Check the level in the supply tank.
	Wrong direction of rotation	See that pump shaft runs in direction of arrow on casing.

Table 1-4-1. Trouble Shooting (Cont.)

Trouble	Cause	Remedy
Pump discharge pressure low (cont.)	Speed too low	Check driver for low speed. Refer to applicable trouble shooting tables.
	Air in liquid	Check piping for leaks. Repair.
	Impeller partially clogged	Disassemble casing and remove obstruction.
	Mechanical defects: Wearing rings worn Impeller damaged	Inspect pump parts and clearances. Repair or replace parts or renew clearance.
	Delivering excess capacity	Increase discharge head by discharge valve adjustment.
Low capacity	Air leaks in piping or stuffing box	Inspect piping for leaks. Repair or replace piping. Check for adequate supply of seal water.
	Discharge head higher than expected	Check suction valve at pump. Insure all suction valves are fully open.
	Suction lift too high	Inspect pump and suction piping. Open all valves completely. Remove any obstructions.
	Wrong direction of rotation	See that pump shaft turns in direction of arrow on pump casing and driver stand.
	Obstruction in pump or piping	Inspect piping and pump. Remove any obstructions.
	Speed too low	Check speed of driver and refer to the applicable trouble shooting tables.
	Mechanical defects: Wearing rings worn Impeller damaged	Inspect pump parts and clearances. Repair or replace parts or renew clearances.
Pump does not deliver liquid	Pump not primed	Fill pump and suction line completely.
	Discharge head too high	Open all valves in discharge line completely.
	Insufficient submergence or excessive suction lift	Check liquid level in supply tank.
	Impeller Clogged	Inspect impeller and remove obstruction.
	Obstructions in piping or pump	Inspect all piping and remove any obstructions.
	Speed too low or pump not running	Check driver. Refer to applicable trouble shooting section.
	Pump not vented	Open casing vent valve and vent line.
Stuffing box overheats	Insufficient leakage or packing too tight	Release gland pressure slightly. Make sure there is adequate supply of seal water.
	Packing incorrectly installed or wrong packing used	Inspect packing. Repack if necessary.

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Table 1-4-1. Trouble Shooting (Cont.)

Trouble	Cause	Remedy
Excessive vibration	Pump misaligned	Inspect alignment. Correct as necessary.
	Impeller unbalanced	Inspect impellers for damage or obstruction. Repair damage or remove obstruction.
	Broken or loose bolts	Inspect foundation bolts. Replace or tighten bolts.
Pump will not start	Impeller locked	Inspect casing and impellers. Remove any obstructions.
	Packing too tight	Adjust gland for proper lubrication of packing and sleeve.
	Pump driver not started	Start driver.

1-4-3. Disassembly (See figure 1-6-2).

1. Isolate pump and motor from system and disconnect all piping. Open vent valve and remove plug (34). Drain all liquid from pump and then replace plug (34).

2. Remove nuts and bolts from mounting foot on casing (3). Remove nuts (17) from studs (15) and carefully remove side plate (12) with gasket (32).

3. Remove impeller nut (6), impeller nut washer (29) and pull impeller (4) from shaft with a standard aboard ship puller. Insure that pull is evenly applied and parallel to shaft to avoid damage to shaft and impeller. Remove feather key (5).

4. Loosen gland nuts (30). Disassemble casing (3) from motor bracket (22) by removing four nuts (17) from studs (16). Pull casing (3) away from the motor.

5. Remove two nuts (30) from studs (14) and remove gland (13). Unpack stuffing box by removing packing (33), lantern ring (7), and throat bushing (25). Gland (13) may be separated into halves by removing nuts (19) and bolts (18).

6. Motor bracket (22) may be unbolted from motor end bell by removing nuts (24) from studs (23).

7. If necessary, remove casing and side plate wearing rings (10, 9) by drilling holes in rings 180° apart and parallel to shaft. Split rings with a chisel and remove rings in two pieces.

8. Remove shaft sleeve (2) and water deflector (20) in one operation by loosening set screw (21) and pulling parts off shaft with a standard aboard ship puller with necessary extensions.

1-4-4. Maintenance and Repair (See figure 1-6-2).

Packing: Excessive leakage from the stuffing box that cannot be reduced by adjusting packing gland nuts (30) indicates a need for repacking the unit. Do not attempt to partially repack pump. Remove all old packing rings (33) and replace with new packing. Examine shaft sleeve for wear. If badly worn or scored it must be refinished in a lathe or replaced with new sleeve. Sleeve can be progressively refinished until it is 3/32" undersize before it must be replaced (see paragraphs 1-4-3, 1-4-5). Sleeve should have a highly finished surface to reduce packing wear.

NOTE: Packing may be replaced without disassembly of pump. Gland (13) is split and can be removed from the shaft by removing nuts (19) and bolts (18). Do not install the packing unless the casing is properly installed on the shaft.

1. Clean stuffing box and shaft sleeve (2) to remove all oil, grease and dirt.

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2. Cut five rings of packing (33) separately with ends cut square to produce accurate butt joints when installed. Do not cut packing on shaft. Packing supplied with the onboard repair parts are pre-cut. Select five rings of 1/4" square plastic metallic packing per MIL-P-17303, Symbol 1433.

3. Install one ring of packing. "Walk" packing onto shaft by separating ends along shaft. Never attempt to pull ends apart. Force packing ring snug against throat bushing (25). Be sure packing joint is butted and not overlapped and tamp ring to provide a tight fit around the shaft. Repeat operation for second ring.

4. Slide lantern ring (7) into stuffing box. Be sure lantern ring will be under seal water opening when gland is tightened.

5. Insert remaining three rings of packing (33) separately, tamping each ring to the stuffing box; stagger the joint locations around the shaft.

6. Replace gland (13) and gland nuts (30). Tighten nuts (30) evenly and hard, until packing is compressed. Loosen nuts (30) to allow considerable leakage during first eight hours of operation. Then adjust to reduce leakage to about one drop per second. If stuffing box heats up, increase leakage.

Wearing Rings: If wear has increased the clearance between wearing rings and impeller to double the initial value (see paragraph 1-1-1) and pump performance is affected, the wearing rings should be replaced.

1. Remove casing and side plate wearing rings (10, 9) (see paragraph 1-4-3). Clean ring seats. If impeller (4) is scored or pitted, turn impeller in a lathe just enough to renew finish and concentricity. Undersize casing and side plate wearing rings, furnished as onboard repair parts, should be used and machined to mate with the impeller diameters with the correct clearance.

2. See paragraph 1-1-5 for installation of wearing rings.

Alignment: Check alignment every 1400 hours of operation. (See Section 3).

1-4-5. Reassembly.

Clean all parts thoroughly before assembly.

1. Replace wearing rings as follows:

   A. Machine impeller hubs to renew finish and concentricity. Bore casing and side plate wearing rings (10, 9) (furnished undersize as spares) to produce the correct clearances with impeller (see paragraph 1-1-1 and Figure 1-5-2 for clearances).

   B. Coat the wearing ring bores in the casing and side plate with white lead and tap each wearing ring into bore until it is squarely seated at the bottom of the bore.

2. If removed, replace motor bracket (22) on motor end bell with nuts (24) on studs (23).

3. Replace water deflector (20), coat shaft with white lead and tap or press shaft sleeve (2) onto shaft (1). Be sure sleeve is fully mounted on shaft. Assemble water deflector (20) on shaft sleeve and tighten set screw (21) into hole in sleeve. Install throat bushing (25) in casing (3).

4. Replace casing (3) on motor bracket (22) with nuts (17) on studs (16). Install feather key (5) on shaft.

5. Tap impeller (4) onto shaft (1) and lock impeller in place with lockwasher (29) and impeller nut washer (6).

6. Check impeller runout with a dial indicator. Maximum allowable radial runout is 0.002" total indicator reading.

7. If casing gasket (32) is damaged or deteriorated, replace it. Coat both sides of the gasket with a graphite-oil mixture.

8. Replace side plate (12) using nuts (17) on studs (16).

9. Install pump and motor on foundation and connect all piping.

10. Check alignment (see Section 2) then repack pump per paragraph 1-4-4.

11. Start the unit and check for leaks.

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SECTION 5

PARTS IDENTIFICATION

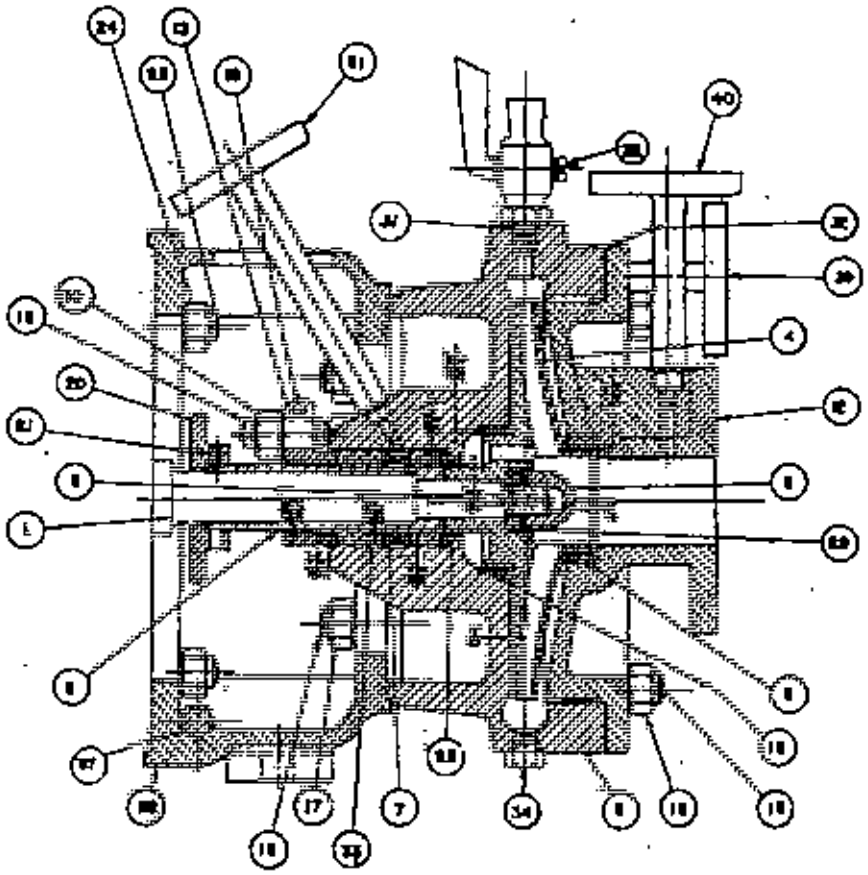
1-5-1. Parts List.

When ordering parts for pumps, refer to figure 1-6-2 for the pump sectional drawing and to figure 1-6-3 for the list of materials. Refer to the Ships Allowance List and NAVSHIPS forms 4786 and 4786A for a listing of onboard repair parts. Include the nameplate data, piece number, service part number and Federal Stock Number (as available) in each order to the manufacturer.

1-5-2. Special Tools.

No special tools are required.

BPI-07.08-Hawaii 000022



SCALE: NONE

	1 × 1½ CLASS 2 H SECTIONAL LIST OF MATERIAL & DETAILS	BUFFALO FORGE, INC. BUFFALO N.Y.
		CA11455

Figure 4-4-1

Pump Sectional Drawing
From Contractor's Drawing No. CA11455

Buffalo Forge Company
Pump Division
North Tonawanda, New York

4-4-1/1

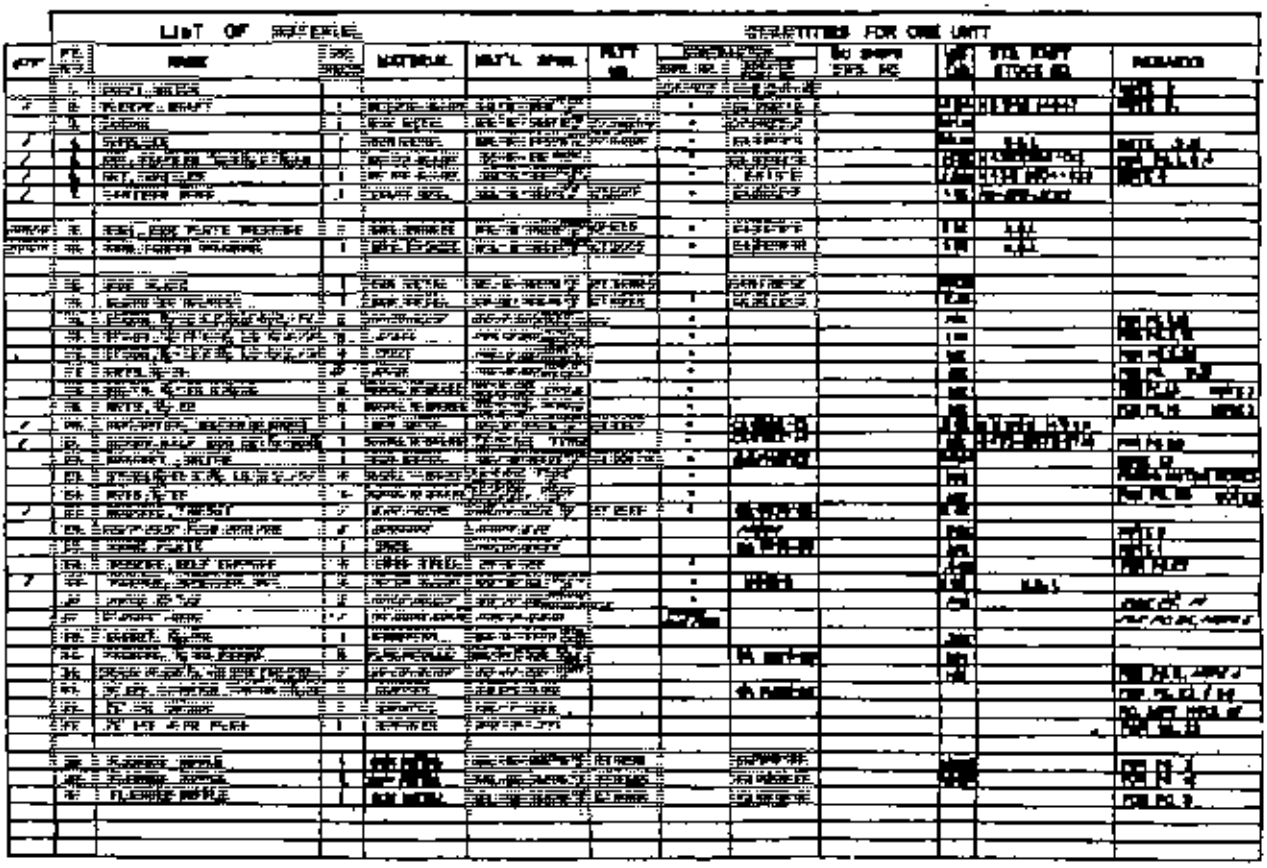


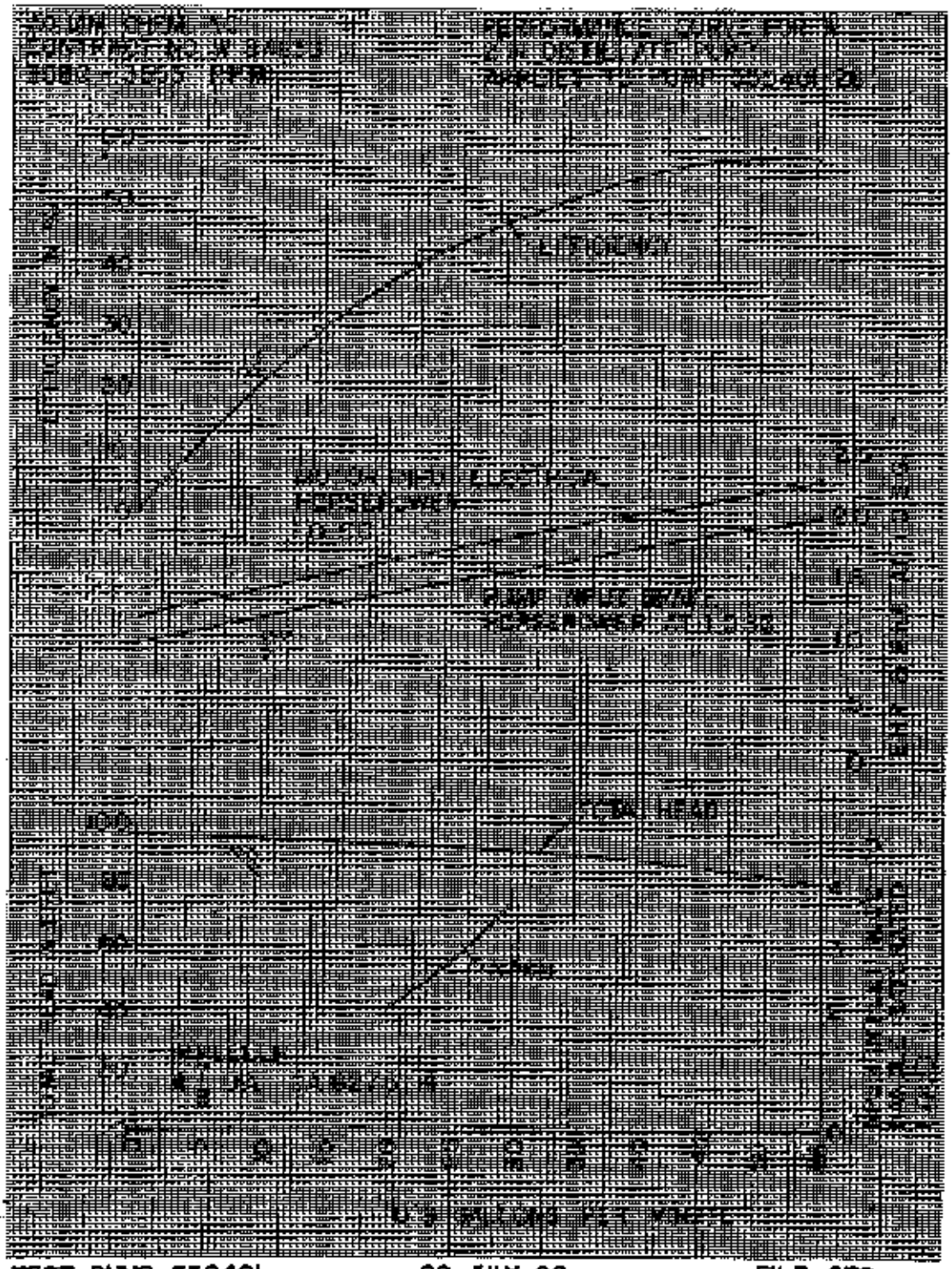
Figure 1-6-1

Pump List of Material
From Contractor's Drawing No. CA11405

Buffalo Forge Company
Pump Division
North Tonawanda, New York

1-6-1/6

N-1847



TEST PUMP 550401 20 JULY 66 FILE 870
ITEM 2

Buffalo Forge Company
Pump Division
North Tonawanda, New York

Figure 1-6-4

Pump Performance Characteristics Curve

1-6-7/8

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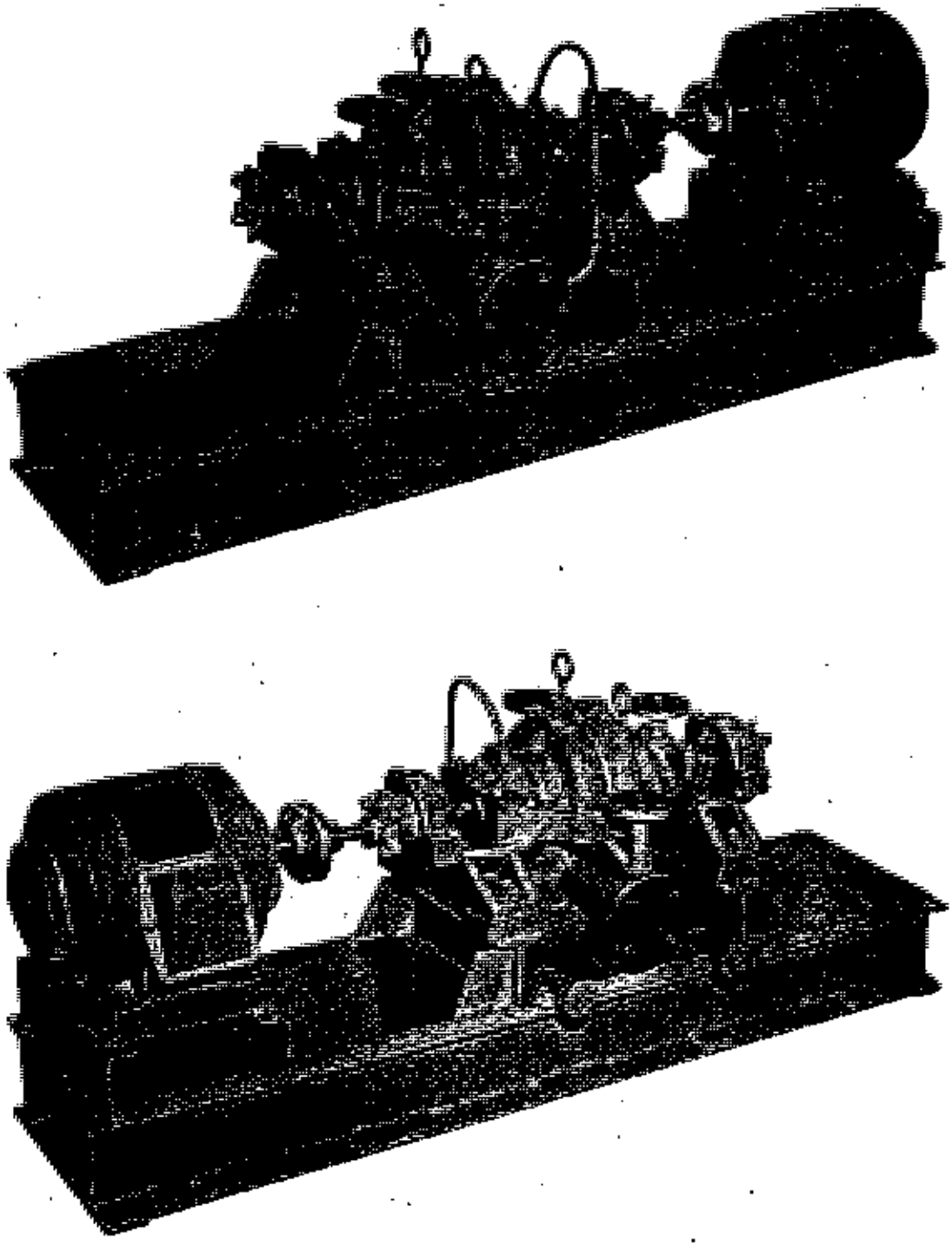


Figure 3-1-1. Photograph of Assembled Distiller Sea Water Heater Drain Pump

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CHAPTER 2 - DISTILLER SEA WATER HEATER DRAIN PUMP

SECTION 1

GENERAL INFORMATION

2-1-1. General Data.

PUMP

Type	Flexibly Coupled, Split Case Centrifugal, 2 Stage
Mounting	Horizontal, multi-stage
Classification	D-1
Military Specification	MIL-P-18472C (17 Dec. 1962)
Pump Class	1-1/4 x 1-1/2 Class RR
Navy Contract	Nobs 4763 and 4783
No. of Units Per Ship	2
Capacity, GPM	9
Total Head, PSI	80
Liquid Handled	Water
Specific Gravity	0.97
Temperature	188°F
Suction Pressure, PSIA	11.0
Submergence, FT.	6
RPM	3600
BHP at Rating	1.86
Efficiency, %	15
Max. BHP at any Condition	5

MOTOR*

HP	5
RPM (Synchronous)	3600
Volts/Phase/Cycles	440/3/60
Frame	184NZ
Enclosure	Dripproof
Mounting	Horizontal
Duty	Continuous
Ambient Temperature	50°
Service	Navy A
Design	B
Bearings	Ball
Insulation	Class B
Classification	Squirrel Cage Induction
Speed Class	Constant
End Bracket Design	Standard
Military Specification	MIL-M-17060B

CALCULATED WEIGHTS

Pump with Base (Dry)	644 Lbs.
Pump with Base (Operating)	650 Lbs.
Motor	95 Lbs.
Controller	19.5 Lbs.
Total Weight (Dry)	739 Lbs.
Total Weight (Operating)	745 Lbs.

*Refer to Electrical Sections for complete specifications.

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OVERALL DIMENSIONS OF ASSEMBLED UNIT

Length (Side Elevation)	4'-10"
Width (Front Elevation)	18-5/8"
Height	28-3/8" Includes Removal Clearance

REFERENCE DRAWINGS

DWG. NO.	TITLE
CA11340	Outline and Certification Data
CA11341	Sectional and List of Material
87240	Reliance Motor Drawing
87240-1	Reliance Certification Data Sheet
C8862H144	Controller Master Drawing
A6882CD3176	Controller Certification Data Sheet

CLEARANCES

Part	Clearances - Inches Radial	Axial
Deflector (18) and Shaft (7)	0.008 to 0.009	-----
Deflector (18) and Inboard Cover Bearing (25)	0.023 to 0.038	-----
Gland (12A) to Deflector (18A) or (18B)	0.015 to 0.017	-----
Impeller (3) or (3A) to Casing Wearing Rings (9)	0.0045 to 0.0070	3/32
Spacer Sleeve (21A) and Interstage Diaphragm Bushing (20)	0.0047 to 0.0055	-----
Throat Bushing (11) or (11A) and Shaft Sleeve (8) or (8A)	0.013 to 0.015	-----
Seal Cage (14A) and Shaft Sleeve (8A)	0.023 to 0.028	-----
Shaft Sleeve (8) and Bearing Housing (38)	0.028 to 0.008	1/16
Bearing Housing (38) and Shaft Sleeve (8) Inside Housing (38)	0.028 to 0.032	-----

2-1-2. Introduction.

This equipment manual contains description, installation, operating, and maintenance instructions with a list of materials for the 1-1/4 x 1-1/2 Class RR, Distiller Sea Water Heater Drain Pump manufactured by Buffalo Forge Company, Pump Division, North Tonawanda, New York.

The unit is a horizontally mounted, two stage centrifugal pump coupled to a driving motor by a flexible coupling. The motor and pump are mounted on a structural steel subbase.

2-1-3. Detailed Description (See figure 2-B-2).

Casing. The casing is a gun metal casting split horizontally into two halves for access to internal parts without breaking suction and discharge piping connections. Casing halves (2, 2A) are accurately positioned with taper pins and bolted together. The suction and discharge openings are located in the bottom casing half (2A). Flanged nipples are provided on the suction nozzle for vent and gauge connections. A flanged nipple on the discharge nozzle serves as a gauge connection. A flanged nipple extends from the first stage stuffing box for an external seal water supply. Unions lead from the casing cavities under the stuffing boxes to permit piping away seal water leakage. A casing cover (2B) is provided on the bottom of the stationary half casing. It covers the internal cross over passage from the first stage to the second stage.

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Casing wearing rings are provided on the inlet side of the impellers. The wearing rings are of the labyrinth type and serve to minimize fluid leakage from the discharge volute to the suction. An interstage diaphragm (19) and diaphragm bushing (20) are provided between the impellers and are a close running fit with spacer sleeve (21A) to minimize leakage between pump stages. The wearing rings, diaphragm bushing and spacer sleeve eliminate casing wear and are easily replaceable to maintain close running clearances.

Subbase. The subbase (1) forms the rigid mounting platform necessary to maintain alignment between pump and motor. It is constructed of welded structural steel channels.

Impellers. The impellers (3) and (3A) are gun metal castings and are keyed to shaft (7) with a feather key (17B). Hydraulic balance (balancing of thrusts created by hydraulic pressures) is achieved by mounting the impellers back to back. Spacer sleeve (21A) prevents wear on the impellers where they pass through the casing between the two pump stages.

Shaft. The shaft (7) is machined from a steel forging. It is protected from wear and corrosion by shaft sleeves (8), (8A), in stuffing box and pressure areas. The shaft is carefully finished and balanced.

Bearings. Ball bearings (27) and (26) support the shaft and are located in inboard and outboard bearing housings. Bearing (27) serves as a guide bearing while bearing (26) serves as a guide and thrust bearing. Each bearing consists of two angular contact ball bearings mounted back to back in a dust resistant housing. The bearing housings (38) are rabbeted to the stationary casing half (2A) for proper bearing location and are grease lubricated by grease contained in the bearing housing. A grease fitting is provided to replenish grease. NOTE: See Table 2-4-1.

Stuffing Boxes. The pump casing contains an inboard and outboard stuffing box. The outboard stuffing box contains five rings of graphite asbestos packing conforming to Military Specification MIL-P-17303. The inboard stuffing box has six rings of packing. Throat bushing (11) forms the bottom of the outboard first stage stuffing box. Throat bushing (11A) with an integral seal cage forms the bottom of the inboard, second stage, stuffing box. Seal cage (14A) is provided in the outboard stuffing box. Glands (12A), cored to provide a smothering chamber, close the stuffing boxes and compress the packing to limit leakage. An external supply of clean liquid must be connected to flanged nipple (155). This liquid enters the stuffing box at seal cage (14A) and serves to seal the stuffing box and cool and lubricate the packing. Seal water for the inboard stuffing box is provided by the liquid pumped which enters at throat bushing (11A). The bushing acts to reduce the pressure on the high pressure stuffing box to about suction pressure. Leakage is piped back to the pump suction.

Casing Wearing Rings. The pump casing is fitted with replaceable casing wearing rings (9) located on the suction side of the impellers. The wearing rings are gun metal castings and are located and prevented from rotating by a tongue and groove fit, with a projection that mates with a slot in the casing.

Coupling. The driving shaft is connected to the pump shaft by an all metal flexible coupling (68). The driven hub is bored for a taper fit, mounted on the pump shaft (7) and secured with a feather key (17A) and locknut (f46). The driving hub is pressed onto the straight motor shaft and located by key (17). A spring type grid-member connects the hubs. The hubs are housed inside a coupling cover. The coupling is lubricated by grease contained inside the coupling cover.

Lubrication. Lubricating of pump bearings, packing and coupling is as follows: Ball bearings (26) and (27) are lubricated with grease contained in a reservoir in the bearing housing. The flexible coupling is grease lubricated from grease contained in the coupling cover. Packing (66) is lubricated by seal water. Spacer sleeve (21A) is lubricated by the liquid pumped. NOTE: See Table 2-4-1.

2-1-4. Principles of Operation.

A centrifugal pump depends on centrifugal force for its operation. This force is generated by the high speed rotation of the impeller. A series of radial curved vanes are cast on the face of the impeller with a suitable means of entry for the liquid at the center or eye of the impeller. When a positive supply of the liquid being pumped is introduced at the impeller eye, the high speed rotation of the impeller throws the liquid outward, giving a high velocity head (pressure due to speed). The pressure head of the liquid at this point is relatively low as compared with that at discharge, and most of the energy of the liquid is due to its speed. Upon leaving the curved vanes of the impeller, the liquid enters the casing where the curved volute passage leads the liquid to the suction of the next stage. In this stage the same process takes place with the liquid finally led to the discharge piping. In the volutes, the energy imparted from the liquid's speed is gradually changed to a static pressure head by reducing the speed of the liquid as it passes through the volutes.

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SECTION 2

INSTALLATION

2-2-1. General (See figure 2-6-2).

The pump with driving motor and subbase has been crated and bolted to a wood skid prior to shipment. Inspect unit for damage which may have occurred in transit or during storage.

Glands (12A) and seat cage (14A) are either wired to stuffing box or packed in a separate container inside the crate with packing (66). See paragraph 2-4-5 for the packing procedure.

Bearings (26) and (27) have been lubricated with grease conforming to Military Specification MIL-G-18709. Wash out bearing housing assembly with solvent and relubricate (see paragraph 2-4-1). Insure proper lubricant level and good condition of grease in coupling before operating. Check alignment after installation and re-align unit if necessary (see paragraph 2-2-3).

2-2-2. Installation.

See figure 2-6-1 for bolting diagram and flanged connections to pump. Refer to motor section for electrical connections.

Make suction, discharge, packing leakage drains, seal water, vent and gauge connections to pump after unit is installed. The gauge connection on the suction nozzle has a flange blankoff. Keep all lines free of dirt, scale, waste, tools and other foreign matter. Support all piping independently so that piping weight and stresses from expansion will not spring unit out of alignment. If piping is of wrong length, correct it before connecting to pump

2-2-3. Alignment.

The unit must be properly aligned to prevent shaft and bearing wear. Check alignment after installation or disassembly and re-align if necessary. With the coupling cover halves removed and the coupling hubs separated, proceed as follows:

1. Insure that foundation is level. Use shims under the foundation bolts to accurately level the subbase (1) if necessary.

2. Position motor on subbase and line up with pump as closely as possible using measuring instruments and a level.

3. Check that the driving and driven hubs run true with their respective shafts on both face and circumference of machined flange. If run out exceeds 0.002 inches, the hub is not correctly seated on the shaft. A high key or rough spot may prevent the coupling from seating properly, or the pump shaft taper and straight motor shaft may not mate properly. Correct any excess run out before proceeding.

4. Position motor and pump with shafts separated 1/8 inch at all points around coupling hub. Correct any misalignment by shifting motor to produce the correct gap.

5. Check angular alignment with thickness or feeler gauge. Insert the gauge between vertical faces of driving hub and driven hub at four points 90° apart around hubs. The gap should be equal within 0.002 inches for best alignment. However, if the gap is within 0.002 to 0.005 inches and the unit operates without vibration or noise, the unit may be considered satisfactorily aligned. If the gap is out of alignment by 0.005 inches or more, or if the unit vibrates, or noise occurs during operation, the unit must be realigned until the gap is equal at all four points measured within 0.002 inches. Alignment can be corrected by shimming under the motor.

6. Check the parallel alignment using a short straightedge at four points 90° apart across the O.D. of the coupling hubs (see figure 2-6-5). Determine any offset with a feeler gauge under the straightedge. Correct any misalignment in the horizontal plane by shifting motor; correct vertical misalignment by shimming either motor or pump depending on which is lower. The unit can be considered out of parallel alignment if a 0.005 inch feeler (or greater) can be inserted under the straightedge. If the feeler is between 0.002 to 0.005 inches and the unit is operating without vibration or noise, the alignment can be considered satisfactory. For the best alignment, the feeler gauge reading should be 0.002 inches or less.

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NOTE: Repeat steps 4, 5 and 6 each time unit is shimmed or shifted until unit is properly aligned.

7. Insert gasket between hubs and hang it on either hub. Use care not to damage gasket. Next force as much lubricant as possible into the gap and gridmember grooves. Insert gridmember. Gridmember grooves are truly radial and it is necessary to spread the gridmember slightly so that it will pass over the coupling tooth at its outside diameter. To accomplish this with a minimum amount of spreading, start the gridmember at either end and tap the rungs only part way into the grooves. After all the rungs are partially in their respective grooves, tap the gridmember all the way into place.

8. Pack the spaces between and around the gridmember with as much lubricant as possible. Scrape or wipe excess lubricant off flush with top of gridmember. Lightly oil hubs to facilitate the sliding of covers into the hubs.

9. Mount covers so that lubrication fittings are 180° apart. Insert a thin screw driver under the seal ring for venting purposes and then tighten the cover bolts. Check seals for proper seating and align cover to prevent cover wobble. The unit should be given a short run to check alignment.

10. Lubricate the coupling once every 1400 hours of operation (see paragraph 2-4-1 (m) lubrication instructions).

11. If it becomes necessary to realign the pump and motor, so that the original dowels between the pump or motor and the subbase are no longer in alignment, drill and ream new dowel holes and install new dowels. Be sure that all hold down bolts are drawn up tightly while drilling and reaming dowel holes.

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SECTION 3

OPERATING INSTRUCTIONS

2-3-1. Safety Precautions.

The following safety precautions and operating checks should be made before starting this unit.

1. This equipment is used on 440 volts. All safety precautions set forth in the Bureau of Ships Manual Chapter 60 should be observed.

2. Be sure the pump is free of all foreign material and that working parts are free to rotate without binding.

3. Rotate the shaft manually to insure that it will rotate freely without binding or noise or grinding of any kind.

4. Do not tighten pump packing glands more than finger tight. Allow excessive leakage until unit is operating properly.

5. Inspect lubricant to pump and motor bearings and in flexible coupling. Refer to applicable lubrication sections for procedures and lubricants.

6. Avoid water hammer by properly venting pump and piping.

If the unit is being started for the first time after installation or overhaul, the following safety precautions and operating checks shall be made in addition to steps one through six above.

1. Alignment (refer to paragraph 2-2-3).

2. Direction of rotation. The correct direction of rotation is indicated by an arrow on the pump casing.

3. Cleanliness of water passages in piping and pump. This check should be made after piping and pump have been thoroughly flushed to make sure they are free of all foreign material. Be certain all discs used to blank off piping are removed.

2-3-2. Starting.

1. Follow all safety precautions listed in paragraph 2-3-1.

2. Open suction valve.

3. Open vent cocks on top casing half. Fill pump completely with water. Close vent cocks when pump is completely primed. The vent line should remain open during pump operation.

CAUTION: Do not run this pump dry. Pump will be damaged if the casing is not filled with liquid while pump is running.

4. See that gland nuts are finger tight only and that liquid is flowing to the seal water connection on the outboard pump stuffing box.

5. Start motor.

6. Open discharge valve when gauge shows operating discharge pressure.

2-3-3. Running.

1. Tighten gland nuts slowly and evenly to reduce leakage to approximately one drop per second. If stuffing box heats up increase leakage.

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2. Inspect unit periodically during operation for proper lubrication of stuffing box and bearings. Check temperature and pressure for any variation from the conditions listed in paragraph 2-1-1 and for any unusual noise or vibration. Investigate and correct any troubles found. Refer in paragraph 2-4-2 for trouble shooting procedures.

2-3-4. Securing.

1. Close pump discharge valve.

2. Stop motor.

3. Close pump suction, vent and seal water valves if required. Otherwise leave these valves open.

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SECTION 4

MAINTENANCE

Table 2-4-1. Lubrication

Item	Lubricant	Frequency
Coupling (68)	Grease conforming to Military Specification MIL-G-18709	Every 1400 hours of operation and after each disassembly.
Packing (66) in first stage stuffing box	Seal water from a separate seal water line	Continuously during operation.
Packing (65) in second stage stuffing box	Liquid pumped	Continuously during operation.
Bearings (26) and (27)	Grease conforming to Military Specification MIL-G-18709	Every 1400 hours of operation. Do not fill reservoir more than 1/3 to 1/2 full.
Spacer Sleeve (21A)	Liquid pumped	Self lubricating.

2-4-1. Lubrication (See figure 2-6-2).

Ball Bearings (26) and (27). Inboard and outboard bearings are lubricated by a grease reservoir in the bearing housing. Grease may be added to the housing through grease fittings (82B).

CAUTION: Do not over-lubricate the ball bearings. Too much grease will cause overheating and may cause damage. Fill the bearing housing 1/3 to 1/2 full of grease.

Coupling (68). The flexible coupling should be lubricated through the grease fittings contained in each coupling cover. Lubricate every 1400 hours of operation or at least every 12 months. Vent the coupling seal when adding grease. Refer to separate coupling instructions in Section 6, Drawings.

2-4-2. Trouble Shooting.

Table 2-4-2 lists most of the troubles that may be encountered during pump operation with their probable causes and remedies. For mechanical troubles it is necessary to disassemble the pump and inspect for damaged or worn parts. Where disassembly is applicable, the necessity for replacement of parts can be determined by visual inspection and measurement of clearances. If the actual clearance does not agree with the recommended clearance shown in paragraph 2-1-1 or figure 2-6-2, and pump efficiency is reduced, the parts should be replaced. Broken, scored, galled or otherwise badly damaged parts should be replaced. Refer to paragraphs 2-4-4 and 2-4-5 respectively for disassembly and maintenance.

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Table 2-4-2. Trouble Shooting

Trouble	Cause	Remedy
Noisy installation	Noise caused by other equipment	Investigate source of noise.
	Incomplete priming	Fill pump and suction line completely.
	Suction lift too high	Check level in supply tank.
	Speed too high	Check the driver for high speed. Refer to the applicable trouble shooting tables.
	Foreign material in pump	Disassemble pump or piping and remove obstructions.
	Loose parts	Inspect unit, tighten loose bolts, repair or replace damaged or broken parts.
Pump overloads driver	Speed too high	Check the driver for high speed. Refer to the applicable trouble shooting tables.
	Wrong direction of rotation	See that pump shaft turns in direction of arrow on casing.
	Packing too tight	Release gland pressure slightly.
	Mechanical defects: Bent shaft Rotating element binds Wearing rings worn	Inspect and repair as necessary.
	Head lower than rating (pumping too much liquid)	Adjust head by means of a valve in the discharge line.
Pump loses prime after starting	Incomplete priming	Vent pump casing and fill completely with liquid.
	Air leaks in suction piping	Inspect suction piping, gaskets and flanges, replace faulty gaskets and piping.
	Suction lift too high	Check pump and suction piping for obstructions. Check the level in the supply tank.
	Air or gases in liquid	Insure that casing vent line is open. Inspect suction piping, gaskets and flanges for leaks. Replace faulty parts.
	Impeller partially clogged	Disassemble pump casing and remove obstruction.
	Defective casing gasket	Replace.
	Insufficient submergence	Check liquid level in supply tank.
Pump discharge pressure low	Air leaks in suction piping	Inspect suction piping, gaskets and flanges. Replace faulty gaskets and piping.
	Suction lift too high	Inspect pump and suction piping for obstructions. Check the level in the supply tank.

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Table 2-4-2. Trouble Shooting (Cont.)

Trouble	Cause	Remedy
Pump discharge pressure low (cont.)	Wrong direction of rotation	See that pump shaft turns in direction of arrow on casing.
	Speed too low	Check driver for low speed. Refer to applicable trouble shooting tables.
	Air in liquid	Check piping for leaks. Repair.
	Impeller partially clogged	Disassemble casing and remove obstruction.
	Mechanical Defects: Wearing rings worn Impeller damaged	Inspect pump parts and clearances. Repair or replace parts or renew clearances.
	Delivering excess capacity	Increase discharge head by discharge valve adjustment.
Low Capacity	Air leaks in piping or stuffing boxes	Inspect piping for leaks. Repair or replace piping. Check for adequate supply of seal water.
	Discharge head higher than expected	Check suction valve at pump. Insure all suction valves are fully open.
	Suction lift too high or insufficient submergence	Inspect pump and suction piping. Open all valves completely. Remove any obstructions.
	Wrong direction of rotation	See that pump shaft turns in direction of arrow on pump casing and driver stand.
	Obstruction in pump or piping	Inspect piping and pump. Remove any obstructions.
	Speed too low	Check speed of driver and refer to the applicable trouble shooting tables.
	Mechanical defects: Wearing rings worn Impeller damaged	Inspect pump parts and clearances. Repair or replace parts or renew clearances.
Pump does not deliver liquid	Pump not primed	Fill pump and suction line completely.
	Discharge head too high	Open all valves in discharge line completely.
	Insufficient submergence or suction lift too high	Check liquid level in supply tank.
	Impeller clogged	Inspect impeller and remove obstruction.
	Obstructions in piping	Inspect all piping and remove any obstructions.
	Speed too low or pump not running	Check driver. Refer to applicable trouble shooting section.
	Pump not vented	Open casing vent valve.

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Table 2-4-2. Trouble Shooting (Cont.)

Trouble	Cause	Remedy
Stuffing box overheats	Insufficient leakage or packing too tight	Release gland pressure slightly.
	Packing incorrectly installed or wrong packing used	Inspect packing. Repack if necessary.
	Improper installation of seal cage and packing	Check to see that seal cage and packing are installed in proper sequence (See figure 2-6-2).
Excessive vibration	Pump misaligned	Inspect alignment. Realign if necessary.
	Impeller unbalanced	Inspect impeller for damage or obstruction. Repair damage or remove obstruction.
	Broken or loose bolts	Inspect driver stand and foundation bolts. Replace or tighten bolts.
Bearings overheat	Ball bearing overlubricated	Inspect grease level. Remove excess grease.
	Bearings not lubricated (bearing scored or discolored)	Inspect bearing and casing water passages. Remove dirt or obstructions. Lubricate per instructions.
Pump will not start	Impellers jacked	Inspect casing and impellers. Remove any obstructions.
	Packing too tight	Adjust gland for proper lubrication of packing and sleeve.
	Pump driver not started	Start driver.

2-4-3. Inspection, Tests and Adjustments (See figure 2-6-2).

Inspection

Daily

1. Turn idle pump shaft by hand.

2. Check pump and piping for leaks. Check leakage at stuffing box. Stuffing box leakage should be about one drop per second.

3. Check pumping conditions for variation from normal.

Weekly

1. Run pump under power and check for unusual noise or vibration.

2. Check operation of all valves in the system.

Annually

1. Open pump casing and inspect, clean or replace parts.

2. Check wearing ring clearances. Renew if necessary.

3. Check sleeves, packing, impeller, bearings, shaft and coupling for wear, damage or deterioration.

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Adjustments and Tests.

Packing Gland. Adjust gland (12A) by means of nuts (13B) to give an operating leakage of one drop per second. If stuffing box heats up increase leakage.

Ball Bearings (26) and (27). Check bearings for overheating. Inspect grease level and add or remove grease if necessary (refer to paragraph 2-4-1). Do not over-lubricate. Bearing will overheat if too much grease is used.

Coupling (68). Inspect coupling by removing machine screws and nuts from cover halves. Pull cover halves back away from hubs and check that gridmember is fully covered with grease. If necessary, pack the spaces between and around the gridmember with as much lubricant as possible. Scrape excess grease off flush with top of gridmember. Replace cover halves and fasten with machine screws and nuts. Vent the coupling seals and add grease through the grease fitting in each cover. (Refer to instructions contained in the coupling bulletin contained in Section 6, Drawings).

Rotor. Before installing assembled rotor, check coupling hub, shaft and impeller for runout. Maximum run-out for any part is 0.002 inch, total indicator reading.

Pressure Test. After complete reassembly, start the unit. Carefully inspect the unit for leaks and correct as required.

2-4-4. Disassembly (See figure 2-6-4).

CAUTION: Before performing any disassembly, isolate the pump from the system by closing and tagging or locking all valves closed. Tag or lock all switches to motor and controller in the open position. All safety precautions listed in the BuShips Manual Chapter 60 and in the U.S. Navy Safety Precautions should be observed.

1. Open vent cocks (67). Remove drain plug (200) in the casing cross over cover (2B) and drain liquid out of pump. Remove tube fitting (78) at the second stage stuffing box. Replace the drain plug.

2. Disconnect suction, discharge, vent, packing leakage drains and seal water connections if necessary, otherwise leave all piping connected.

3. Remove nuts and bolts from flexible coupling (68) cover halves. Slide seal rings and covers away from the hubs. Clean grease from gridmember and remove the gridmember by inserting a screwdriver into the loop ends and prying the gridmember up in even gradual stages. Proceed alternately from side to side lifting the gridmember about half way out until the end of the gridmember is reached. Refer to separate coupling instructions in the Drawing Section 6 for complete details.

4. Remove bearing caps (23) from inboard and outboard bearing housings (32) by taking nuts (109) off studs (107B).

5. Remove nuts (13B) from studs (13) and slide both glands (12A) back along shaft (7). The glands are split and may be taken off the shaft by removing nuts (257) and bolts (256).

6. Drive out taper pins (144). Remove nuts (109) from studs in the stationary casing half. Remove top casing half (2) using auxiliaries on lifting eyebolts (258). The rotor assembly may now be lifted from the casing for complete disassembly. It may be necessary to tighten forcing bolts (108) to break the joint between the casing halves. Remove gasket (55) if necessary.

7. Support the rotor horizontally between wooden blocks and proceed with disassembly.

Flexible Coupling.

1. Remove locking nut (146) from shaft (7). Remove the driven hub using a small aboard ship puller. Slide gasket, cover and seal ring off shaft. Remove feather key (17). Remove driving hub in a similar manner and take key (17A) off shaft. Examine the coupling seal rings for damage and discard if necessary.

Bearings (26) and (27).

1. Loosen setscrew (18C) and slide flinger (18) off shaft. Remove grease fittings (32B) and pipe plugs (74) from bearing covers (25) and (24) and bearing housings (32). Drain as much lubricant as possible from housing and then remove inboard and outboard bearing covers (24) and (25) by taking outr (109A) off studs (107D).

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Remove grease from bearing housings. If damaged, remove gaskets (65C) and (65D).

2. Bend tang of lockwashers (28) from slot in bearing lock nut (29). Remove lock nuts and washers from shaft.

3. Clean shaft thoroughly and coat with white lead. Remove bearing housing (98) and two ball bearings from each end using an aboard ship puller. Attach bearing puller to bearing housing and adjust to give a straight uniform pull parallel to the shaft. Tighten the puller jacking screw evenly until all parts are off the shaft. Remove shims (173).

CAUTION: Do not hammer on the bearings.

Impellers and Sleeves.

1. Use an aboard ship puller and pull deflectors (18A) and (18B) off the shaft. If not removed in halves, slide gland (12A) off the shaft. Remove packing rings (86), seal cage halves (14A), throat bushings (11) and (11A), and casing wearing rings (9).

2. Note the location and direction of impellers (3) and (3A) on the shaft so that they can be reinstalled correctly. Place the rotor in an arbor press with the impeller evenly supported on the press bed. Be sure the shaft is at right angles with the press bed by checking squares if necessary. Press on shaft (7) and remove shaft sleeve (8A), key protecting ring (48) and impeller (3). Reverse the rotor in the press bed and press on shaft (7) while supporting impeller (3A) to remove shaft sleeve (8), key protecting ring (48) and impeller (3A). Remove interstage diaphragm (19), interstage diaphragm bushing (20) and spacer sleeve (21A).

CAUTION: Use extreme care when pressing parts off in the arbor press. If parts do not move with a reasonable pressure, remove the rotor and machine off sleeves (8) and (8A) in a lathe, then remove the impellers in an arbor press.

3. Remove feather key (17B). Inspect and replace if necessary.

Casing (Stationary half).

1. The stationary casing half (2A) may be removed after all piping is disconnected and pins (144A) driven out, by taking nuts (109C) off studs (107F) and screws (260) out of the subbase.

2. Cover (2B) may be removed by taking nuts (109) off studs (107C).

2-4-5. Maintenance and Repair.

Alignment. Alignment should be checked every 1400 hours of operation and after installation or overhaul. Refer to paragraph 2-2-3 for alignment procedures.

Packing. (See figure 2-6-2). Excessive leakage at the stuffing boxes that cannot be eliminated by taking up on nuts (13B) will require repacking the pump.

1. Remove nuts from gland eyebolts (13) and slide gland (12A) back on shaft or remove in halves if necessary. Pump disassembly is not required for packing replacement.

2. Remove all old packing from the stuffing box using care not to damage the shaft sleeves. Remove seal cage halves (14A).

CAUTION: Always completely repack the pump with new packing (86). Do not use bulk packing or rut packing on the shaft.

3. Inspect shaft sleeves for score marks or damage that would allow leakage. If sleeve is scored or damaged, repair (paragraph 2-4-5) or replace (see paragraph 2-4-6). Clean shaft sleeves and stuffing box of all oil, dirt or grease before installing new packing.

4. Use five rings of pre-cut packing for the outboard stuffing box and six rings for the inboard stuffing box.

5. Install one ring of packing (3/8 inch square per Military Specification MIL-P-17303), graphite asbestos on shaft. "Walk" packing onto shaft by separating ends along shaft. Never attempt to pull ends apart.

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taper pins (144) and nuts (109) on studs (107), (107A), being sure that forcing bolts (108) are backed off.

4. Repack the stuffing box (see paragraph 2-4-5). Spin the rotor assembly to insure freedom of rotation.

5. Replace tube fitting (78). Reconnect the piping if disconnected and start the unit. Inspect carefully for leaks and correct any that are found.

6. Align the coupling (68) and complete assembly of the coupling. Alignment instructions are listed in paragraph 2-2-3. Refer to Sections 2 and 3 for Installation and Operation Instructions.

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SECTION 5

PARTS IDENTIFICATION

2-5-1. Parts List.

When ordering parts for pumps, refer to figure 2-6-2 for the pump sectional drawing and to figure 2-6-3 for the list of materials. Refer to the Ships Allowance List and NAVSHIPS forms 4786 and 4786A for a listing of onboard repair parts. Include the nameplate data, piece number, service part number, and Federal Stock Number (as available) in each order to the manufacturer.

2-5-2. Special Tools.

No special tools are required.

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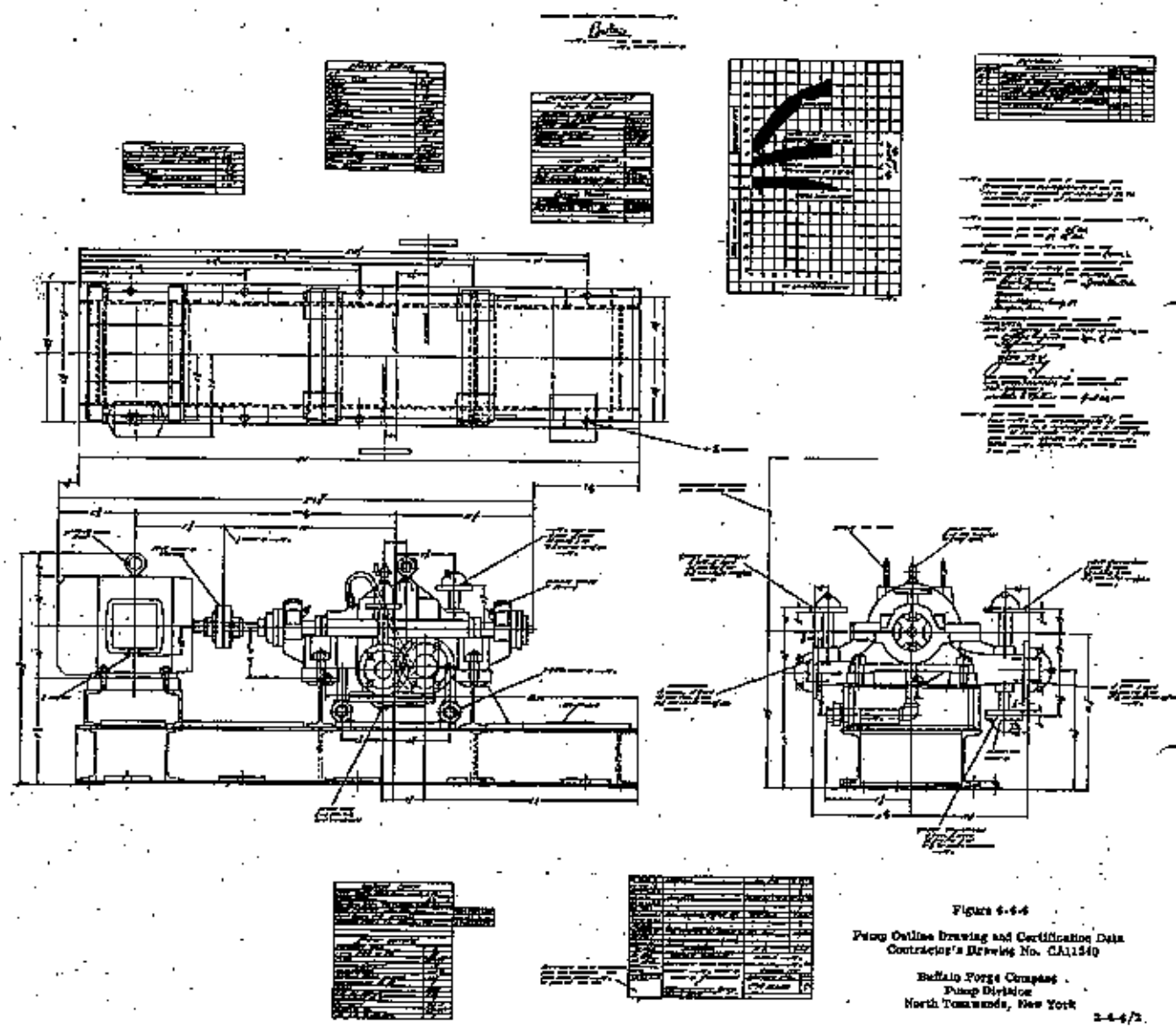


Figure 6-6-6

Pump Outline Drawing and Certification Data
Contractor's Drawing No. CA11540

Buffalo Forge Company
Pump Division
North Tonawanda, New York

2-6-6/2

FIG 1

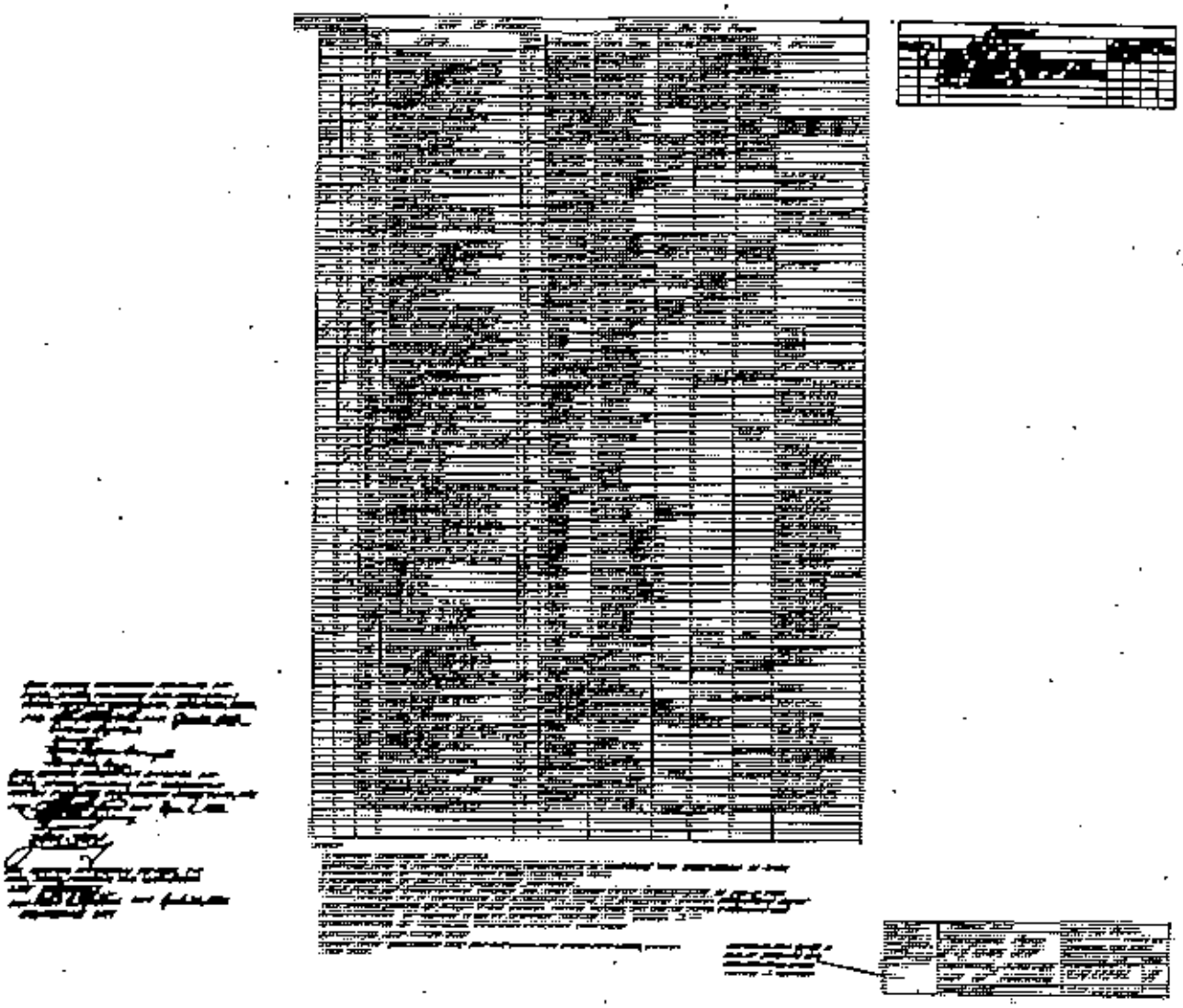


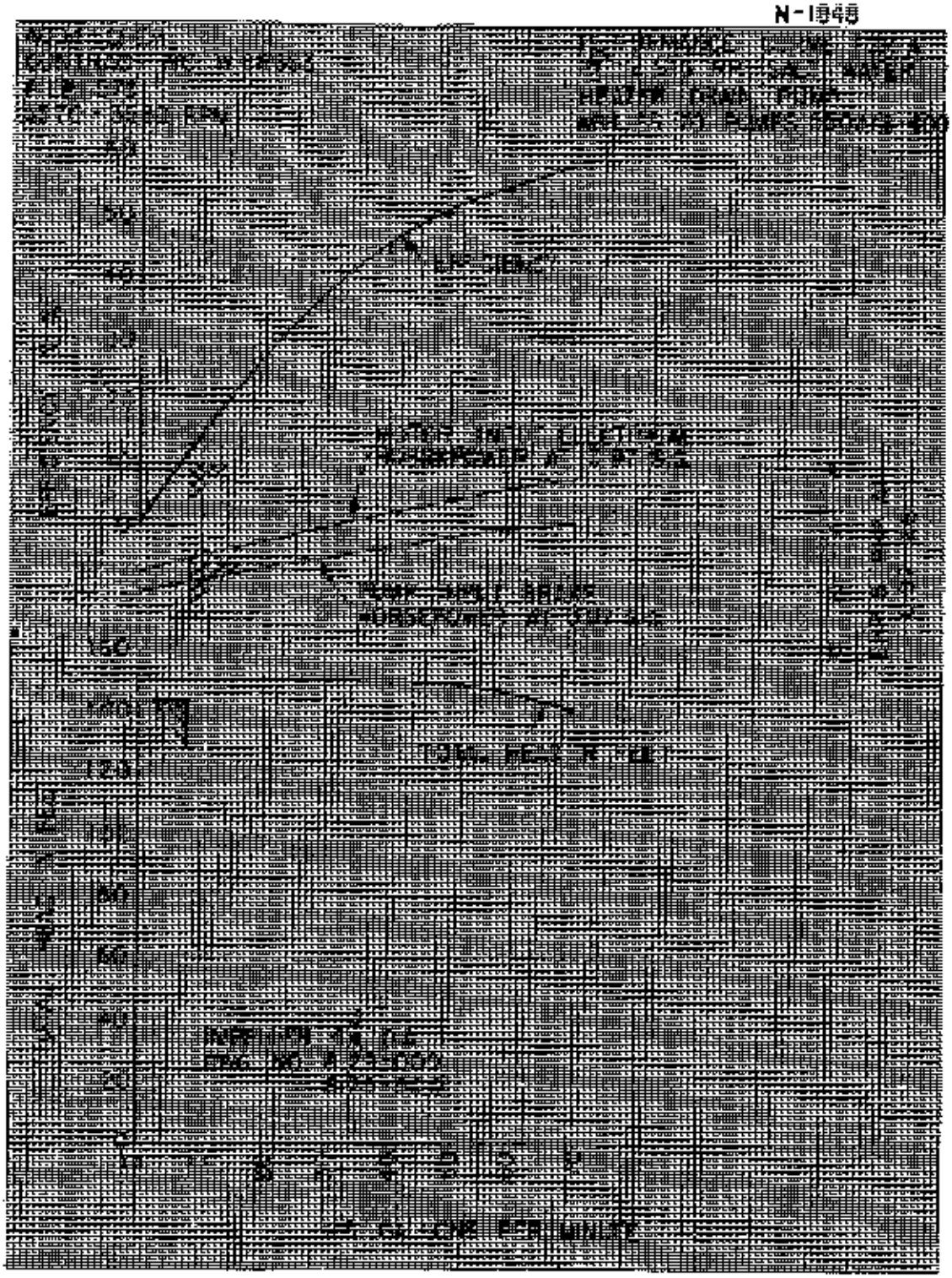
Figure 3-5-3

Pump List of Materials
From Contractor's Drawing No. CA1134J

Buffalo Forge Company
Pump Division
North Tonawanda, New York

3-5-1/6

N-1948



TEST PUMP 550376 11 APR. 67 FILE 570
KLH

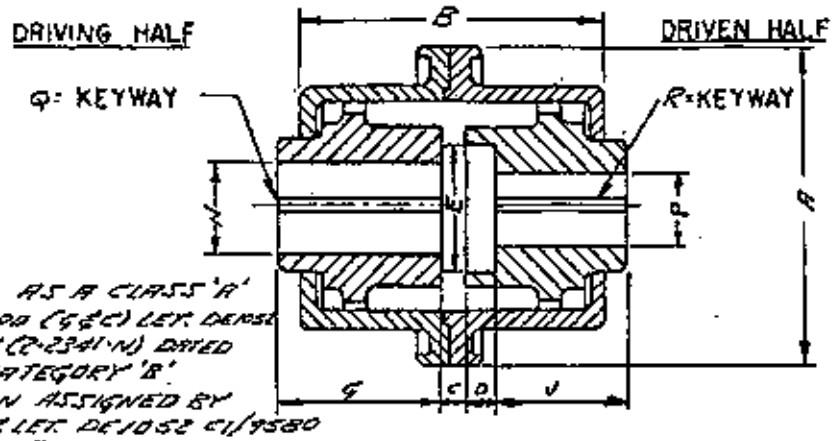
Buffalo Forge Company
Pump Division
North Tonawanda, New York

Figure 2-6-4

Pump Performance Characteristics Curve

2-6-7/8

8957-20
Rev B



APPROVED AS A CLASS 'A' DWG. BY TODD (Y&EC) LET. DENSE C1/5568/5681 (P-2341-N) DATED 3 FEB. 1961. CATEGORY 'B' CLASSIFICATION ASSIGNED BY SUPSHIP N.Y. LET. DE1052 C1/9580 SER. 280-9967 DATED DEC. 6, 1965

ITEM NO.	SIZE COUP.	A	B	C	D	E		G		J				N	P		Q	R		
File 570	3F	$3\frac{3}{4}$	$3\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$1\frac{1}{8}$		$1\frac{3}{8}$		$1\frac{1}{8}$				.8760 .8755	.6890 .6885		$\frac{3}{16}$ x $\frac{3}{32}$	$\frac{3}{16}$ KNS		
															Ø					
File 618	4F	$4\frac{1}{8}$	$4\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$1\frac{1}{8}$		$2\frac{1}{8}$		$1\frac{5}{8}$				1.1260 1.1255	.6890 .6885		1" x .1864	3" KNS		

NOTE - REFER TO PURCHASE ORDER FOR APPLICABLE FILE NO. BEFORE PROCEEDING.

FALK COUPLINGS

					RMS	
A	WAS 9/16 BORE	Heller	Rec		NTS	
B	APPROVAL OF MOTOR	Heller	Rec		S-A-GE	

Figure 2-6-5

Coupling Drawing
From Contractor's Drawing No. 8957-20

Buffalo Forge Company
Pump Division
North Tonawanda, New York

2-6-9/10

5. Force the packing snug against throat bushing (11) or (11A) being sure the joint is butted and not overlapped. Tap the ring to provide a tight fit around the shaft. Install additional rings with the butt joints staggered around the shaft and tamp each ring to form it to the stuffing box. Install six rings of packing in the inboard stuffing box. Install three packing rings, seal cage (14A) and two additional rings of packing in the outboard stuffing box. After installing the packing and seal cage, replace gland (12A) and tighten nuts (13B) hard to compress the packing. Loosen the nuts to allow considerable leakage during the first eight hours of operation then adjust the nuts to give an operating leakage of about one drop per second. If the stuffing box heats up increase the leakage.

Wearing Rings (9). Wearing ring clearances must be renewed by installing new casing wearing rings (9) when clearances become twice the initial value of 0.0045 to 0.0070 inches radially. Clearance should be restored as follows:

1. Machine the wearing surfaces of the impeller just enough to renew the finish and insure concentricity.

2. Machine the new casing wearing ring, which is furnished undersize, to match the impeller dimensions with the required clearance.

3. If necessary, replace spacer sleeve (21A) with an oversize sleeve and machine the new sleeve to match the inner diameter of interstage diaphragm bushing (20), cleaned up to renew finish and concentricity, with a clearance of 0.0047 to 0.0055 inches.

Gaskets. Renew gaskets after each disassembly if inspection shows gaskets to be cracked or damaged. Gasket sealing surfaces should be thoroughly cleaned and inspected for damage. Coat both sides of the gaskets with graphite and oil before replacing the gaskets.

Impellers (3) and (3A). Impeller repair will be limited to restoring correct balance. For all other repairs, replace the impeller.

1. To determine if an impeller is out of balance, mount the impeller on an arbor and support the arbor between two level, parallel knife edges. Note the position at which the impeller comes to rest. If impeller is out of balance, it will turn and come to rest with the same heavy side down in several successive tests. Mark the heavy side.

2. To restore balance, grind metal from shroud. Remove the exact amount of metal necessary to restore balance. Remove metal from the impeller shroud that was on the bottom when balanced. Blend grinding into existing shrouds.

3. Have the impeller dynamically balanced as soon as possible.

Shaft (7). Shaft repair will be limited to straightening a slightly bent shaft. If shaft is badly bent replace it.

1. To straighten a slightly bent shaft proceed as follows:

2. Mount shaft between centers.

3. Determine runout with a dial indicator.

4. Use a bar to straighten the shaft. Attempt to spring it into concentricity. Shaft must be concentric within 0.002 inch, total indicator reading.

Shaft Sleeves. Repair of damaged shaft sleeves will be limited to removing burrs and light scoring. Shaft sleeve can be machined 3/32 inch undersize in a lathe or smoothed with crocus cloth. Replace sleeve to repair any other damage.

Bearings (26) and (27). Repair of ball bearings will not be attempted. Replace all damaged ball bearings.

2-4-6. Reassembly (See figure 4-6-2).

1. Insure that all parts are clean and free from burrs.

2. Reassemble in the reverse order of disassembly using the following assembly instructions.

Casing Wearing Rings (9). Casing wearing rings must be machined to obtain the desired clearance with the impellers (see paragraph 2-4-5).

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Packing (66). Do not install packing until the top casing half has been replaced. Refer to paragraph 2-4-5 for instructions.

Rotor Assembly.

1. Inspect leather keys for damage and distortion. Replace any damaged keys. When the use of an arbor press is specified make sure that the pressure is steadily and evenly applied, that parts are not cocked and that parts seat evenly and properly. Apply a thin coating of white lead to shaft surface on which a part is being pressed.

2. Install key (17B) on shaft (7). Install first stage impeller (3) on the shaft using an arbor press to position the impeller on the shaft hub. Press key protecting ring (49) and sleeve (8A) on the shaft.

3. Position spacer sleeve (21A), on impeller hub (3). Assemble interstage diaphragm bushing (20) into interstage diaphragm (12) using an arbor press if necessary. Make sure the flange fits into the recess in the diaphragm. Slide the diaphragm with bushing over spacer sleeve (21A).

4. Check the clearance between the sleeve (21A) and bushing (20). It should be 0.0045 to 0.0055 inches. Machine parts as necessary to obtain this clearance.

5. Press second stage impeller (3A), key protecting ring (49) and shaft sleeve (8) on the inboard part of shaft (7). Adjust the location of the impellers by pressing on the shaft sleeves until they are centralized in the same location they were in prior to disassembly.

6. Slide throat bushings (11) and (11A) on the shaft. Press deflectors (18A) and (18B) on the shaft.

7. Slide casing wearing rings (9) onto the shaft. Lubricate the inner race of the ball bearings and shaft (7). Install the bearings in bearing housing (38) and press the bearings and housings on the shaft. Bearings (26) should be located in the outboard housing. Bearings (27) should be located in the inboard housing. Press on the bearing inner races only. Do not hammer on the bearings. Install lockwasher (28) and locknuts (29). Bend the tang of the lockwasher into the locknut.

8. Slide bearing cover (25) and deflector (12) on the shaft. Install coupling cover and hub on shaft (7) with feather key (17A). Lock in place with locknut (146).

9. Check the assembled rotor assembly for runout in accordance with paragraph 2-4-5. Maximum allowable runout is 0.002 inches total indicator reading.

10. Install driven half coupling cover and hub on the motor shaft with leather key (17).

11. Be sure that all parts are located properly before installing the rotor in the stationary casing half.

Casing (Stationary half).

1. If removed, replace casing half (2A) on subbase (1) and install taper pins (144A) and nuts (109C) on studs (107F). Attach pipe support (201) to the subbase with screws (260).

1. If removed install cover (2B) on casing half (2A) with gasket (65J) and tighten nuts (109) on studs (107C).

3. Position blank-off flange (264) on the suction gauge nozzle with gasket (265) and tighten nuts (109) onto bolts (265).

Rotor Installation.

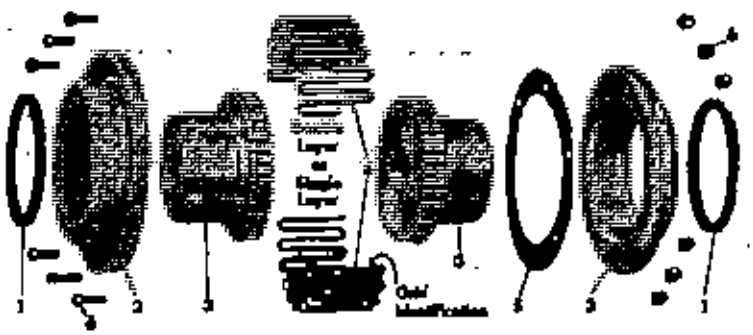
1. Lower the rotor assembly into the stationary half casing and insure correct positioning of all components. Turn bearing housings (38), casing wearing rings (9), throat bushings (11) and (11A) and interstage diaphragm (12) so that the shoulders and pins on these parts mate with the holes and slots in the stationary half casing. It may be necessary to make an axial adjustment of the impellers by shimming between bearing (26) and flinger (18A) with shims (177).

2. Install bearing caps (23) using nuts (109) on studs (107B). Install bearing covers (24) and (25) with gaskets (65C) and (65D) using nuts (109A) on studs (107D). Install grease fittings (32B) and fill the bearing housing 1/3 to 1/2 full of grease. Replace pipe plugs (74). Position deflector (18) next to bearing cover (24) and lock in place with setscrew (18C).

3. Install gasket (65) (see instructions in paragraph 2-4-5) and removeable half casing (2). Replace

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TYPE F STEELFLEX COUPLINGS



1. Seal Ring
2. Half Cover
3. Hub (Specify bore and keyway)
4. Grid
   INNER layer painted aluminum, stamped "IN"
   OUTER layer painted bronze, stamped "OUT"
5. Gasket
6. Cap Screws and Nuts

When ordering spare parts, specify hub bores and keyways and grid coupling size as stamped on coupling cover and hub.

INSTALLATION — For best results, assemble standard couplings with minimum misalignment and with "normal gap." Heat shaft interference fit hubs in an oven or by oil. Apply flame heat evenly to large hubs, but DO NOT apply flame directly on the grid grooves area. Also, DO NOT heat hubs over 275° F.

LIMITED END FLOAT — Consult Factory for coupling modifications when limited end float is required to protect motor sleeve bearings or other equipment.

GRID — DO NOT APPLY LOAD UNLESS complete grid is installed correctly. The number of segments and layers is listed in Table 1. Color coding is explained on Page 2 under "INSERT GRID." Grid Identification is stamped at the end of the section as shown above.



Installation — Grid rings are truly radial, therefore it is necessary to extend the grid slightly so that it will pass over the coupling teeth at the outside diameter. To accomplish this with a minimum amount of spreading, start the grid at either end and tap the rings only part way into the grooves. After all of the rings are partially in their respective grooves, tap the grid all the way into place. When installing a two-layer grid, center the sections of the outer ("OUT") layer over the free ends of the inner ("IN") layer, see A above, and extend all free ends in the same direction, see A and B above.



Removal — A round rod or screw driver that will conveniently fit into the open loop ends of the grid is all that is required in the way of tools. Begin at the open end of the grid section and insert the rod or screw driver into the loop ends. Use the teeth adjacent to each loop as a fulcrum and pry the grid out radially in even, gradual steps. Proceed alternately from side to side lifting the grid sheet half way out until the end of the grid is reached. By following the same procedure once again, the grid will clear the teeth.

LUBRICATION SPECIFICATIONS — Refer to Manual 408-110 for recommended lubricants. The following specifications apply to lubricants for Falk couplings that are lubricated normally and operate within ambient temperatures of 0° to 150° F. For temperatures beyond this range, consult the Factory.

Dropping Point — 300° F. or higher.

Consistency — NLGI No. 2 with worked penetration value in the range of 280 to 300.

Separation and Resistance — Low oil separation rate and high resistance to separation from centrifuging.

Liquid Constituent — Possess good lubricating properties . . . equivalent to a high quality, well refined, petroleum oil.

Inactive — Must not corrode steel or cause swelling or deterioration of neoprene.

Clean — Free from foreign inclusions.

MAINTENANCE — Adequate lubrication is essential for proper operation of the coupling. Lubricate at least once every twelve months. Lubricate oftener when the coupling is exposed to excessive moisture, extreme temperatures or rapid reversing or shock loads.

DISCONNECTING — To disconnect, check coupling, all bolts, remove cap screws, move covers back and remove grid as shown at the left.

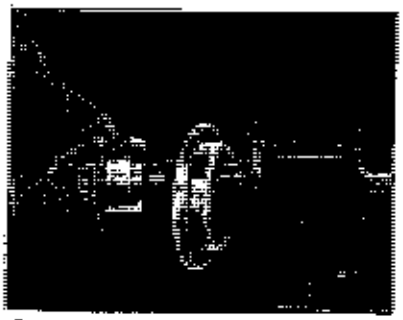
TABLE 1 INSTALLATION DATA*

Coupling Size	Max Speed rpm	Approx Lubricant Fill cu in	Gap (See Page 2) Min	Gap (See Page 2) Nom	Gap (See Page 2) Max	Grid No. of Layers	Grid Color of Inner Layer	Coupling Size
3						1	—	3
4						1	1	4
5						1	1	5
6						1	—	6
7						1	1	7
8						1	1	8
9						1	—	9
10						1	1	10
11						1	1	11
12						1	—	12
14						1	1	14
16						1	1	16
18						1	1	18
20						2	1	20

* Refer to Factory for maximum bore and retaining information.

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INSTALLATION OF TYPE F STEELFLEX COUPLINGS



1 MOUNT COVER, SEAL RING AND HUB ON SHAFT

Place cover with seal ring on shaft before mounting hub. Mount hubs on their respective shafts so that the hub faces is flush with the end of the shaft. Tighten set screws when furnished.

COUPLING GAP

Maintain the normal coupling gap shown on Page 1 whenever possible, and to insure optimum performance, do not exceed the minimum and maximum gaps. Consult the Factory if limited axial float is required.

Provide for shaft end play in the coupling gap when sleeve bearing units are used. After mounting the coupling hubs, position the free unit so that the coupling gap will be within the minimum and maximum limits when both shafts are in their extended or retracted positions. After the gap has been set and the shafts aligned, tighten the unit foundation bolts and recheck alignment.



2 PARALLEL ALIGNMENT

For best results, set coupling for normal gap as described to the left and in Step 3. Align shafts so that a straight edge will rest squarely on both hubs as shown above and also at a position 90° away.



3 GAP AND ANGULAR ALIGNMENT

Align the shafts by placing a spacer block whose thickness equals the required gap between the hub faces, as shown, and at a position 90° away. Check with feelers. Fasten foundation bolts and re-check alignment and gap.



4 INSERT GASKET AND LUBRICATE

After coupling is aligned, carefully insert the gasket between hubs and hang it on either hub. Do not damage gasket. Next force as much lubricant as possible into the gap and grid grooves. Refer to Page 1 for lubrication specifications.



5 INSERT GRID

Insert grid as instructed on Page 1. Coupling Sizes 3 thru 11 have a single layer grid which is painted aluminum. Sizes 12 thru 190 have a two layer grid; the inner layer is painted aluminum and stamped "IN"; the outer layer is painted bronze and stamped "OUT."



6 PACK WITH LUBRICANT

Pack the spaces between and around the grid with as much lubricant as possible. Scrape or wipe excess lubricant off flush with top of grid. Lightly oil seal rings to facilitate the sliding of covers onto the hubs.



7 ASSEMBLE COVERS

Assemble covers so that lubrication fittings or NPT holes are 180° apart and align covers to prevent wobble. Tighten cover bolts and shank seals for proper sealing. Insert a smooth, thin screw driver under the seal for venting while intersecting couplings with permanent fittings.



8 LUBRICATE EVERY 12 MONTHS

Use Alemite gun nozzle 2727 for couplings with permanent lube fittings (A above). For others (B above), remove all lube plugs and insert your lube fitting. Lubricate until grease flows through the vent or other opening. Then INSTALL ALL LUBE PLUGS.

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EXHIBIT E

CENTRIFUGAL PUMP APPLICATION MANUAL

An Engineer's Handbook

Covering the general use of Centrifugal Pumps, the types adapted to most various needs, their operation, trouble correction, and general data including standards of the Hydraulic Institute.



Edited by
BRUCE R. ELLIS

Second Edition, 1959

PRICE $5.00

Published by
BUFFALO PUMPS
Division of Buffalo Forge Company
Buffalo, New York

EXHIBIT "E"

MANUAL-000002

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SECTION 26—CONVENTIONAL PACKING

Every pump is provided with a stuffing box to prevent exit of the liquid pumped or to prevent entry of air into the pump. This topic will consider only conventional compression packing consisting of rows of asbestos containing various lubricants.

If no abrasive materials are in the liquid being pumped and there is a possible head on the suction, no seal cage (lantern ring) is required and the box is packed with the required number of rings of a suitable packing.

If a pump operates with less than about 5 p.s.i. gauge on the suction and the liquid being handled is clear, a seal cage should be used in the stuffing box with liquid fed to the seal cage from the pressure side of the pump or from an external source.

If a pump handles a liquid containing abrasive material, a seal cage should be used with clear liquid fed to that seal cage from an external source.

Each row of packing must be carefully cut and bottomed into the stuffing box. Butt ends of adjacent rows of packing must be staggered. Gland should be adjusted finger tight and then pulled up to restrict leakage to a slow drip.

Any complex packing problem should be referred to a reputable packing manufacturer, but a general guide is given in Packing Recommendations, Page 94.

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PACKING RECOMMENDATIONS

Type	*Service*
White braided asbestos with high flash point lubricant and graphite impregnation in each strand.	General Service and water, 180° F. max., 1,000 FPM rubbing speed max.
Dry graphitized plastic packing with white metal particles and special long fibre white asbestos.	Water, maximum 550° F. Ammonia. Mild chemicals. Brine. General Service with rubbing speed over 1,000 FPM.
Dry graphitized plastic packing with white metal particles, synthetic oil proof binder and special long fibre white asbestos.	Organics and light distillates. Maximum 550° F.
Dry plastic packing, Mica lubricated, special long fibre white asbestos.	Food products, fruit juices and eatable products where non-toxic packing is required. Use stainless steel shaft or sleeve.
Dry graphitized plastic packing of special long fibre white asbestos.	Crystalline liquors, also liquids with solid matter in suspension, also caustic alkali. Max. 750° F.
Aircraft blue asbestos lubricated with graphited manganizing lubricant.	Acetic acid, aqua regia, carbolic acid (Phenol), chlorsulphonic acid, hydrochloric acid, mixed acids, nitric acid, oxalic acid, phosphoric acid, sulphuric acid. Max. 300° F.
Ribbons of soft annealed aluminum spirally wrapped and lubricated with oil and graphite over a core of pure dry asbestos roving.	Hot oil, 550° F. to 1,000° F., also heat transfer liquids over 350° F. Min. 500 Brinell under packing.
Teflon suspensoid outside lubricated blue asbestos.	For mild acids. Temperatures −100° to +600° F.
Teflon suspensoid all lubricated white asbestos.	Aqueous solutions with solids in suspension and solvents. Temperatures −100° F. to +600° F.
Teflon suspensoid all lubricated blue asbestos.	Caustic alkali solutions from −100° F. to +600° F., also inorganic acids except fluorides and except high concentrations of oleum.
Pure multifilament braided Teflon strands. No lubricant except the liquid pumped.	All liquids except chlorine-trifluoride and fluorine-trifluoride under special conditions. Temperatures −100° F. to +400° F. Max. rubbing speed 1,000 FPM.

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EXHIBIT F

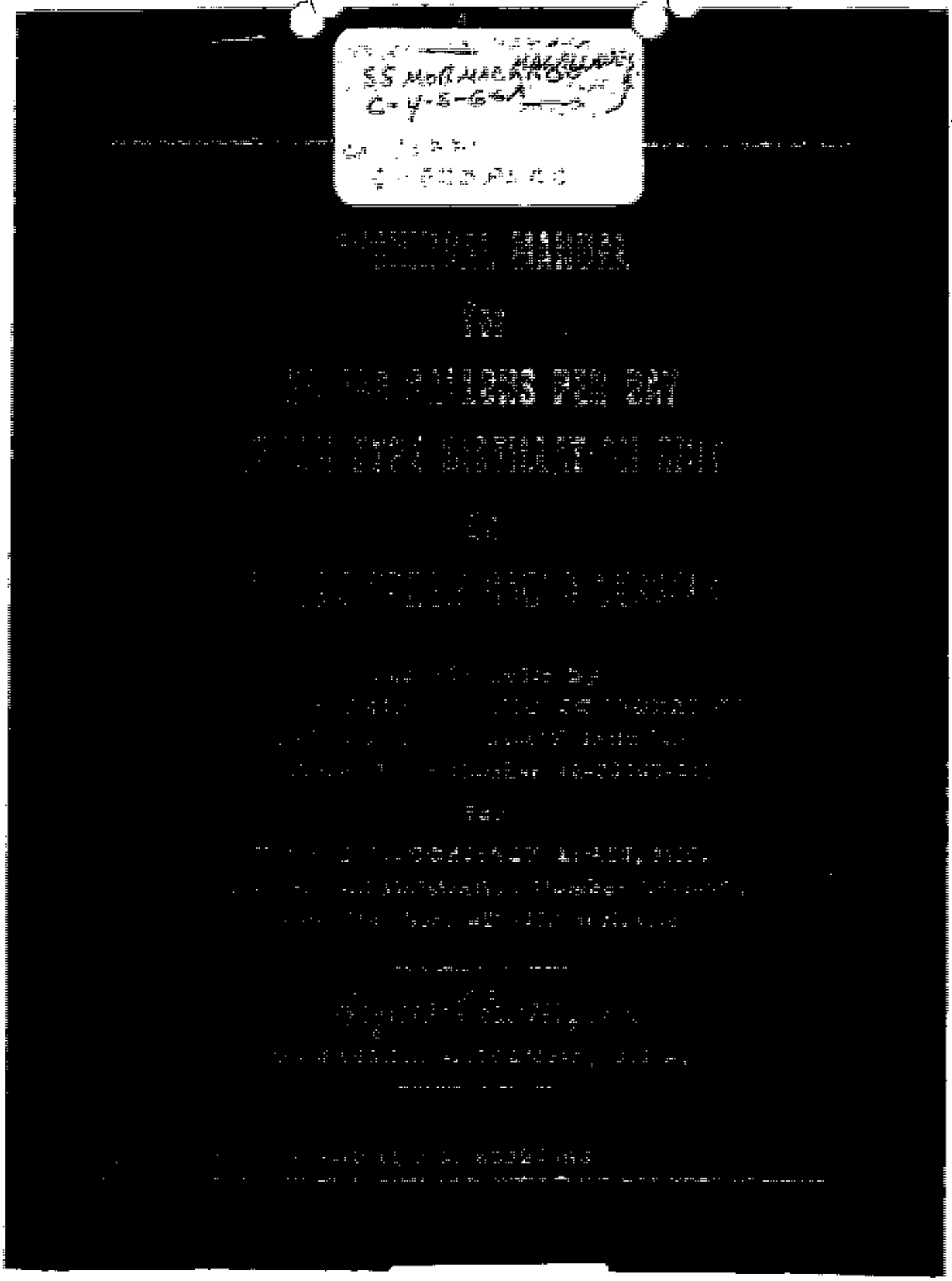


EXHIBIT "F"

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Hull GF 9-30/35
482 ALGENIB
483 VEGA
484 LYNX
485 RIGEL
486 ALTAIR
487 ATRIA

TECHNICAL MANUAL

for

20,000 GALLONS PER DAY FLASH TYPE DISTILLATION UNIT

on

SINGLE SCREW CARGO VESSELS

Vessels built by
INGALLS SHIPBUILDING CORPORATION
Hull Numbers: 482-487 Inclusive
Purchase Order Number 12-03102-011

for

MOORE McCORMACK LINES, INC.
Maritime Administration Number C4-S-60a
Hull Numbers 482-487 Inclusive

C19-2227

Aqua-Chem, Inc.
WAUKESHA, WISCONSIN, U.S.A.

Aqua-Chem, Inc. MANUAL NO. 80221-63

IF FOUND PLEASE RETURN TO
AQUA-CHEM, INC.
WAUKESHA, WISCONSIN 53186
SERVICE DEPT. FILE

F O R E W O R h

This Technical Manual is furnished to provids guidance on operation and general maiutsnancs of the Aqua-Chem Flash Evaporator.

A background of information relating evaporator design and principles of operation is also provided so that operating personnel can more easily hecome acquainted with the Distilling process.

This manual should he placed in the hands of the personnel responsihle for operation and maintenance of the distilling plant. All sections of the hook should he carefully read before commencing operation of the equipment.

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Bulletins on Components Manufactured by Companies Other Than Aqua-Chem, Inc.

Acid Cleaning Pump	Allis-Chalmers
Timer	Eagle Signal
Temperature Switch	Detroit Controls
Steam Trap	Clark Mfg. Co.
Water Meter	Buffalo Meter
3-Way Solenoid Valve	Ruggles-Klingemann
Air Ejector	Graham Mfg. Co.

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GENERAL DATA

Type of Unit: Flash

Model: S830FL2S

Capacity, G.P.D.: 20,000

Once Thru: Design: Yes

Brine Recirculation: No

Shipbuilder: Ingalls Shipbuilding Corporation

Customer: Moore McCormack Lines, Inc.

Purchase Order Number: 12-03102-011

No. of Manuals Required: 25

Date Forwarded:

Number of Units in Order: 6

Dry Weight of Unit: 11,600 (including pump)

Overall - Length: 8' - 6¼"

Overall - Height: 9' - 4"

Overall - Width: 7' - 3"

Pumps Furnished By:		Pump Make & Type
Feed:	Ingalls	Allis Chalmers
Distillate:	Ingalls	Allis Chalmers
Brine:	Ingalls	Allis Chalmers

Heater Discharge: None

Performance Data Chart:

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GENERAL INFORMATION

Application of the Equipment

The Aqua-Chem Flash Type Distilling Unit is a steam operated, low pressure, two-stage feed water distiller designed to produce potable fresh water suitable for general use.

Capacity

The flash evaporator is essentially a constant capacity unit provided that a constant amount of heating steam is supplied to the unit feed water heater. Rated capacity output is based upon a scaled heater tube condition occurring after three months or more of operation. The slightly higher clean tube capacity decreased very gradually as scale builds up in the heater tubes, thereby producing a rise in heater shell pressure. The rate of scale formation is greatly reduced by maintaining a relatively low terminal feed water temperature at the heater discharge and by the fact that no boiling occurs on heat transfer surfaces anywhere within the unit. Eventually, however, an increase in heater shell pressure (due to the gradual accumulation of scale) interferes with the flow of heater supply steam to the extent that the tubes must be chemically or mechanically cleaned to restore operating efficiency and distillate output.

Normally, the flow of heating steam to the feed water heater of a flash distiller is held constant by an orifice plate of critical flow nozzle design installed in the heating steam supply line. As long as the pressure upstream from the orifice plate is held, a constant amount of steam will pass through the critical flow notzle and condense in the heater shell until such time as the heater shell pressure rises to 11 psia (7-1/2" mercury gauge) due to a scaled tube condition. At this point rated capacity is reached and a further rise in heater shell pressure results in a drop off from rated capacity.

When operating on the alternate steam supply, regulation of feed water temperature is accomplished solely by adjustment of a globe valve in the feed water line between the feed water heater discharge and the inlet to the first stage flash chamber. By manual adjustment of feed water flow with the feed water globe valve, feed water temperature is kept at the correct level, since the amount of steam flowing to the heater shell under vacuum is held constant by the critical flow nozzle in the orifice plate which is flanged into the alternate steam line.

The unit is equipped to operate on heating steam. Operation requires adjustment of the feed water temperature control valve and also a valve in the heating steam line. Adjustment of both valves is necessary to establish rated capacity distillate output at the required terminal feed water temperature. The extent to which the heating steam line is

opened determines how much heat is introduced into the unit at the heater. The correct setting of the steam valve is the setting which produces rated capacity distillate output when the feed water valve is adjusted to hold the correct feed water temperature.

Within limits and under certain conditions, other settings of the heating steam control valve are also permissible, though not necessarily advisable.

When the heater tubes are badly scaled, and as a result rated capacity is unobtainable with the steam valve wide open, operation of the unit may be continued temporarily, if less than rated capacity output is satisfactory and conditions are such that shutdown for chemical or mechanical cleaning is highly undesirable. Eventually, however, the rise in heater shell pressure, due to less efficient heat transfer through scaled tubes, will interfere with the flow of steam into the heater shell to the extent that the unit will cease to function properly.

Generally, it is not recommended that the unit be operated at other than rated capacity distillate output if this can be avoided. Attempts should not be made to push output in order to conserve steam when full distillate production is not needed. Pumping problems, unstable operation, or even impure distillate may possibly result if such attempts are made. Flash evaporator components are designed with a particular capacity in mind in order that the unit would have the advantage of being able to operate continuously at a relatively constant output for a number of months.

Rated capacity distillate output is also based upon an incoming sea water feed temperature of 85°F. The unit actually operates more efficiently when using colder sea water provided the terminal feed water temperature at the feed water heater discharge is maintained at the correct level (See Flow Diagram). Increased efficiency is due to the fact that the colder sea water passing through the stage condenser tube bundles substantially increases evaporator vacuum and this in turn results in increased production of flash steam as the sea water flashes down to lower temperatures. When running in cold seas (lower temperatures than 85°F.) better than rated capacity can be expected if all other factors of operation are optimum. There is a limitation on the amount of water which can pass through the heater and exit at 170°F. Should operation indicate that the 170° F. temperature is not being obtained, the hand valve should be adjusted to cut back on the flow of water. Relationship of the hand valve and the auto steam valve is such that any adjustment of the hand valve will correspondingly cause a variance in the steam valve opening.

Unit Design and Distilling Cycle

The shell of the evaporator encloses condenser stages in which heated sea water feed at the bottom of each stage is converted to

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steam by flash evaporation under vacuum. The resulting flash steam is then condensed as fresh water on the tubes of an interoal stage condeoser tube bundle located in the upper portion of each stage and is collected in distillete trooghs. The condeneiog action aids in maintaining the vacuum io the stages produced by a two-stage steam jet ejector. High pressure steam, used in the ejectors, is coodensed on the tubes of an air ejector after-condenser moonted externally on the evaporator. Noncondensibles drawn from the evaporator by the air ejectors are vented to atmosphere from the after-condenser.

The unit is designed to continuously recycle the heat of the flash stam which is condensed to distillate inside the evaporator. The heat is transferred to feed water inside the stage condenser tubes from the steam condensed on the outside of the tubes. Ihe heat of hot distillate and air ejector motive steam is alse utilized in the heating of evaporator feed water, although the main fonctions of tbe distiIlate cooler and the air ejector after-condenser ere the cooling of distillate and the condensing of ejector steam. The major source of heat, however, is the low pressure steam which is condensed in the feed water heeter to raise the temperature of sea wster in the heater tubes to the required first stage iolet temperature. The largest increaee io feed water temperature occurs in tbe stage condensers

The fuoctioo of the heater is to provide e temperature difference between tbe water to be flashed at tbe bottom of the stages and the water in the stage condeoser tubes. The difference in temperatue between tbe two liquids makes possible the transfer of heat from flesh steam to colder sea water serving temporerily as condenser cooling water. The temperature difference, therefore, also makes possible tbe condensation of flash steam to distillete. Heating steam condensate is removed progressively as it accumulates. The heater drain pump maintains a constent head of this condensate thus assuring the maintenance of vacuum withio the heater shell.

High pressure steem used in the operation of the air ejector, is, after use, piped to an after-condeoser and condensed. The condeosate dependent on its purity is then discharged to storaga or waste.

Sea Water Flow

See weter is pumped into the unit by the distiller feed pump aod eoters at the distillate cooler. It is piped in succession through the tubes of the cooler, the evaporator condensers, the air ejector after-condeoser, and the feed water heater, picking up heat in each component. Tbe hot eea water from the heater then enters the first stage of the evaporator.

On entering the first stage of the evaporator the hot feed water passes through spray pipes. Thsse spray pipes are so desigoed to cause the water, as it is sprayed dowowards, to form a thio circular 'curtain' of water.

The effectiveness of evaporation in a vacoum is greatly increased by the rapid release of steam from this thin 'curtain' of water. The rising steam passes through monel mesh type demistere (steam separatars) which contribute greatly to distillate purity by removing entrained salt laden moisture. After passing through the demisters, the steam is drawn into tho stage condensing area where condensation of distillate takes place on the tubes oe the condenser section tube bundle.

That portion of the sea water which does oot flash to steam in the first atage passes into the overflow doct and is carried to the second stoge by way of a sea water loopseal which extends below the evaporator and serves to prevent ao equalizing of the pressure difference betweeo stages while at the same time permitting flow from one stage to another.

Greater vacuum prevails io each succeeding stage (due to the lower temperature of the sea water in the condeoser tube bundle of that stage). This enables the action occurring in the first stoge to ba repeated in each successive stage but at a lower pressore and temperature. The brine leaves the last stage by a large duct in the floor of the chamber.

Distillate Flow

Distillate condensed on the first stage tube bundle is carried through an external distillate loopseal line to the second stage condenser section. On entering the second stage condeoser, a portion of the first stage distillate reflashes to steam and is recondensed along with the second stege steam thereby transferriug additiooal heat to the sea water in the condenser tubes.

This is repeated for each succeseive stage. Returning first stage distillate back into the evaporator at the second stage also serves to equalize dietillate temperatures and enable full distillate production to be withdrawn from a single evaporator outlet. The combined distillate production is removed from the last stage and is pumped through the shell of the distillate cooler by the distillate pump

Cooled distillate is piped through a three-way solenoid trip valve and a distillate meter. The solenoid valve serves to prevent cootamination of fresh water lines and tanks by switching unit production to hilge if impre distillate is produced. Operation of the solenoid valve is cootrolled by the salinity iodicating equipment. This eqoipmeot meaeures distillate and comdensate purity at salinity cells located downstream from each component tube bundle.

The distillate meter indicates the total amount of acceptable distillate produced by the unit as well as the rate of production.

Explanation of Flashing

Flashing is boiling produced by a pressure reduction instead of a temperature elevation. Flash evaporation as a method of steam production, unlike the customary procedure of heating water until it boils, produces steam by reducing the pressure in the evaporator with a vacuum pump or air ejector. The reduction in pressure results in a corresponding reduction in the temperature at which boiling will take place. The lower the pressure, the lower the boiling point.

Flashing begins as sea water enters the first stage of the evaporator at 170° F. Duration of flashing from a given portion of sea water is brief. The water temperature is rapidly reduced to the boiling temperature of the chamber. When this occurs, flashing ceases. However, with the noncondensibles removed, the distillate condensers convert flash vapor to distillate as rapidly as it is produced.

The Degree of Vacuum in the Stages

The degree of vacuum in each stage can be considered as a measurement of the sub-atmospheric pressure exerted by the saturated steam in the stage. The degree of vacuum in the second stage is greater than in the first stage because colder steam exerting less pressure is produced in the second stage. Considered from another standpoint, greater vacuum is produced in the final stage because the colder sea water in the condenser tubes of this stage permits the condensing to be carried on at a lower temperature and, therefore, a correspondingly lower pressure. During operation it may be noted that the colder the sea water entering the condenser tubes, the greater will be the degree of vacuum produced in the stages.

Chlorination

It is recommended that the distillate produced by the unit be chlorinated to prevent bacterial contamination which may possibly occur in pipes or storage tanks which are not part of the distilling unit. Chlorinating the water before it enters the distribution system will prevent such contamination and ensure that no harmful organisms survive at the points of consumption.

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In the eveot that faulty or aboormal operating conditions result io heated feed water eotering the first stage of tbe evaporator at a temperature below 165° F., chlorinatioo of distillate is esseotial to eosure destruction of barmful organisms that may be present io contaminated sea water or harbor water and which are normally destroyed by a higher feed water temperature.

Boiler Feed Water Treatmeot

Since condeosate and distillate are generally found to bave a sligbtly acid pH value, a means of iocreasiog their pH sbould be provided before either of these liquids are osed as boiler feed water in order to preveot barmful corrosion to boiler tubes, tube sbeets, aod shells. Qualified persoooel sbould be consulted to determine tbe feed water treatmeot program best suited to conditions.

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INSTALLATION

General

Install the unit in accordance with practices generally followed in the installation of heavy machinery. In moving the unit into its permanent location, care should be taken to avoid unnecessary stress. Damage to welded, flanged, or screwed connections may seriously impair the ability of the unit to achieve and maintain the high degree of vacuum essential for proper operation. Large diameter lifting eyes are welded to the top of the evaporator to facilitate lifting and moving the unit. Sling with caution using wooden blocks or canvas padding to avoid damage to components. Any piping which may be damaged by the lifting cables should be removed before hoisting.

When installing the unit in its permanent location, adequate working area should be preserved on all sides particularly adjacent to the front water boxes to allow for removal of condenser tube bundles. Refer to General Assembly and Installation Drawing for details of clearance distances around unit required for withdrawal and replacement of faulty tubes.

The unit should be properly leveled by the placement of shims under the evaporator support leg mounting flanges. Leveling will prevent the distortion or flexing of the unit when anchor bolts are tightened down to the mounting structure.

Piping

Piping necessary for unit operation is indicated on the Flow Diagram. Piping to be furnished by the customer is drawn in light broken lines. Piping furnished by Aqua-Chem is indicated by solid lines. Details of Aqua-Chem piping are shown on the Piping Assembly Drawing in the Parts Identification Section of the Manual. Additional piping information is contained on the Desuperheater Piping Assembly Drawing.

All customer furnished lines are to be constructed as straight and as short as possible using a minimum of fittings. Sizes of all pipe lines are indicated on the Flow Diagram.

Hydrotest After Installation, Maintenance, or Repair

Prior to the initial start-up, the unit should be hydtostatically tested at a maximum pressure of 10 psig in order to locate any leaks

in piping or fittings that may have been accidentally caused during shipment or installation.

NOTE: If this unit is equipped with a safety head mounted on the evaporator shell, the rupture disc should be removed and replaced by a circular plate temporarily for the test.

Testing is also recommended after mechanical cleaning and whenever piping or fittings are altered or replaced. The importance of this test cannot be over-emphasized since even a small amount of air leakage into the portion of the unit maintained under vacuum may impair operating efficiency. In addition, such leakage may be difficult to locate when the unit is in operation.

If possible, fresh water should be used for the test to prevent feed water from reaching condensing surfaces and distillate lines.

NOTE: If sea water is used, great care should be exercised to prevent contamination of fresh water lines and storage facilities. Make certain that distillate and condensate to storage lines are secured before hydrotesting.

If possible, the temperature of the water pumped into the unit for the test should not be lower than the surrounding air temperature. Otherwise, the formation of condensate on the outside of the unit may make the location of any leaks difficult to ascertain. In any case, a source of compressed air will be required to blow away water splashed on the unit in the process of venting the shell side of the several component assemblies.

WARNING: Filling should be accomplished gradually with the evaporator shell vented in order to prevent a dangerous pressure build-up within the unit. Remove 1/4" NPT plug on top of each stage prior to starting test.

A suggested method of conducting the hydrostatic test is to fill the shell and tube side of all components and interconnecting piping by operation of feed pump. To allow the filling operation to take place gradually the brine pump should also be placed in operation, but with the brine pump discharge valve partially throttled. If brine discharge is not sufficiently throttled, the water level in the evaporator will not rise above the stage overflow ducts as will be noted by inspection of the observation windows. On the other hand, if the brine discharge is throttled too

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far, the evaporator pressure gauge will indicate a pressure build-up beyond the maximum 10 psig. If this latter condition occurs, the brine discharge may be opened wider and, if necessary, the filling line momentarily closed or throttled at the inlet to the unit.

NOTE: Evaporator relief valve opens at 15 psig, if the unit is so equipped.

Installation of Salinity Equipment

Installation and wiring of salinity equipment should be accomplished in accordance with the manufacturer's instructions. The salinity cells should be located downstream from each of the unit tube bundles at the locations shown on the Flow Diagram. The distillate solenoid transfer valve should be wired into the salinity equipment in a manner to produce immediately the dumping action in the valve when the salinity cell indicates saline water. This occurs before the dump valve is contacted by impure distillate. A two lead conduit connection is located on the solenoid cover box for wiring to the salinity equipment.

Distillate 3-Way Solenoid Seating Check

A check as to whether valve seating is being maintained should be made when relatching valve. Correct seating is indicated when in raising the latch to the distillate delivery port position a solid stop is reached which yields to further pressure and permits latch engagement. Valve seating is altered by adjusting valve stem in stem connection a portion of a turn. Closing force may be adjusted by increasing or decreasing spring tension. Tripping action of valve should be checked after any adjustment.

Pump Installation

Wiring of pump motors and motor controls into the customer's electrical system should be accomplished in accordance with the instructions of the motor control manufacturer. If the unit is equipped with the following pumps, (Distillate, Brine, and Condensate) and if they are not already mounted on the unit proper, but are to be installed by the customer, the ensuing notes should be borne in mind.

CHAPTER II - INSTALLATION

Io the event of a relocation of any pump, these notes will also be applicable io order that faulty pump operatioo might be prevented.

1. Provide for each pump the minimum sobmergence specified by the pump manufacturer. Install the pump far enough below the unit outlet connectioo to provide this sobmergence.

2. Avoid any unoecessary restrictioos in pump suction line such as elbows, valves and other fittings which tend to iocrease the friction losses occurring in the line.

3. Keep the soction lioe size as large as the ooit outlet connection all the way to the pump suctioo inlet. If pump suctioo inlet connection is of smaller size, reduce suction line to re-qoired size ooly at the pomp inlet.

4. Locate pump so as to avoid horizontal runs in the soctioo lioe io order to redoce friction losses and prevent vapor bubbles from collectiog and impairing suction.

5. Run soction line to pump inlet withoot droppiog the Iioe lower thao the pump inlet connectioo. The existeoce of aoy low points io the line will increase frictioo losses and the likelihood of pockets which may resolt in loss of suction and consequent failure of the pump to deliver.

6. Install suction line carefully to ensure that it is free from leaks aod airtight to preveot loss of suction.

7. Provide seal water lioe to pump packing to pre-veot air leakage into pump. Refer to Flow Dia-gram in Operating Instructions for recommended seal water piping arraogements.

A cooscientious adhereoce to these pump iostallation instructions and the use of correctly sized pumps rated by the pump manufacturer for operation uoder the vacoum suction and other service conditions exietiog in the distilling onit components greatly reduces the likeli-hood of faulty pump operations.

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Air Ejector Steao Lioe

Customer's steam plping to the air ejector steam inlet should he sopported so that oo strains are imposed oo the ejectors. The supply pipiog should be carefully arranged so that it contaios oo pockets where water can collect.

To eosure satisfactory operation and pmveot undue wear of nozzles and diffusers, it is important tbst steam as dry as possible is supplied to the ejectors. If the steam line is insulated, this will help prevoot condeosation from taking place before the steam reaches the ejectors. All low points of the supply piping should be trapped for cootiooous drainage of condeosatioo. Also, a drain should be instslled close to the ejector steam iolet for use before start-op.

If the normal steam supply ie very wet, it is advisable to install a pipe line separator close to the ejector steam inlet. This separator should be drained by a steam trap or other means.

In order tbst the minimum ejector steam sopply preesure can be determined accurately, piping for steam inlet pressure gauge should be connected close to the ejector steam inlet as shown on the Flow Diagram. Normal (mio.) steam supply presoure is indicated on the Flow Diagram.

Desuperheater Water

The globe valve cuntrols the amount of heater steam condensate iojected into the steam lioe through the desuperheater spray oozzle. The nozzle changes the condeosate into a fine, uniformly atomized, 80 degree angle, solid cone spray which is converted to steam thereby acquiriog latoot heat and reducing the steam line temperature. The strainer prevents solids from reaching and clogging the spray nozzle.

The desuperheater iocreases unit economy and distillate outpet by permitting steam eotering the heater to readily condeose on the heater tubes. If soperheated steam (at a higher temperature than that corresponding to its pressure) is permitted to eoter the heatsr, heat transfer to feedwater is less efficieot. Tubes first cootacted under such a coodition merely serve to reduce the steam to its saturation temperature. With desuperheated steam, however, condeosatioo occurs oo all of the tubes.

CHAPTER II - INSTALLATION

Mounting and Alignment of Evaporator Pumps

For evaporators, supplied with pumps loose, for customer installation, the following instroctioos should bs oarefully noted.

Shaft elignment is the most important oonsideration in e pump end driver installation. Pump-driver combinations are aligned at the factory, but baseplates can be sprung in shipment or distorted by unequal tightening of foundation bolts, so even they must be checked before they are put io service.

The ooupling is usually checked for tmo oonditions; displaoement of pomp end driver shafts and angulAr misalignment.

Displacement of shafts can be determined by laying a scale or straight edge aoross the rim of both ooupling halves at four positione ninoty degrees apart. Displecement of one half relstive to the other must not exceed .005 in. et any position.

Angular misaligoment is determined by using the same straight edge aoross the rim of both ooupling halves et four points. The rims should then be parallel with the straight edge and with each other at all points.

In most cases aligoment oan be obtained by adjustment of the proper shims uoder the pump or driver. When alignment is reached, tighton the foundation for grouting. After the grout has been poored and allowod to set for 48 hours tighten the foundation bolts evonly and securely. Secure final oonpliog eligoment by shimming until ell coupling conditioos are satisfied.

Pumps on hot eervioe must havo final coupling alignment made with the unit at its operating temperature.

NOTE

The above instructions are also imporseot for evaporators suppliod with the pumps pre-instelled.

Sioce misalignmeot may possibly occur due to rough shipment of the eveporator plant, the pumps shonld be inspected after installation of the evaporator on its fonndation aod before operation begins.

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Feed Water Pressure

Installatioo of the sea water feed line from the feed pump or maio sea water feed lioe should be accomplished io a manner to ensure a oonfluctuating sea water pressure to the distilliog unit. If the sea water feed main pressure surges or fluctuates due to demands of other services supplied with sea water feed, a sea water pressore regulator should he installed upstream from tho sea water inlet to the distillate cooler. Maximum and mioimum feed water supply pressures are given to the Flow Diagram. A stabilized feed pressure will reduce the oumber of reqoired temperature control adjustments thereby permitting more stabilized operation of the unit.

OPERATING INSTRUCTIONS

Safety Precautions

When operating in contaminated waters, the health of personnel may be endangered unless the following instructions are rigidly adhered to:

1. Do not transfer evaporator distilled water to drinking water tanks if the chloride content exceeds 0.065 e.p.m. (0.25 grain of sea salt per gallon). If the method of operation is not such as to ensure that no momentary flow of water can contain more than 0.065 e.p.m. of chloride (0.25 grain of sea salt per gallon), the temperature of the feed water discharge from the salt water heater must be maintained at not less than 165° F.

2. When operating in fresh or brackish contaminated water, the temperature of the feed water discharge from the feed water heater must be maintained at not less than 165° F. at all times. In such waters the density of the feed water may be so low that a low salt content of the distillate will not indicate freedom from priming and carry-over. A chloride content of less than 0.065 e.p.m. (0.25 grain of sea salt per gallon) will not, under such conditions, indicate that the distillate is free from contamination.

3. Do not attempt to operate the distilling plant until the operating principles and instructions contained in this manual are thoroughly understood and the distilling cycle including the flow of sea water feed, distillate, brine, condensate, steam, and noncondensibles can be quickly traced on the Flow Diagram, as well as through the piping and components of the unit itself.

Preliminary Procedures

1. It is recommended that all valves requiring operation be tagged or painted with their corresponding V-number as shown on the Flow Diagram. This will enable the operator to more easily familiarise himself with the unit.

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2. Conduct a careful unit surfaee inspection for loosened, broken, or damaged components, controls, fittings, and piping. Loose or broken conneetions on portions of the unit operated nnder vacunm (shell side of evaporator and feed water heater) mill result in faulty air ejector operation, poor vaconm, and reduced distillate prodnction. Bad connections in suction piping of unit pnmps will result in faulty pump operation necessitating sbutdown to prevent flooding.

3. Determine that tbe distilling plant service requirements (steam, electrical power, and sea water feed) can be supplied to the unit in the required amounts and/or pressures and temperatures prior to start-up times. Refer to Service Requirements in General Data seetion.

4. Review Technical Mannal for distilling plant pumps for pump operating procednres and adjustment of pump packing glands. Generally new packing has to be run in. It is advisable to permit pump stuffing boxes to leak moderately in the beginning to allow for expansinn and proper seating. After the packing has been run in, reduce leakage of gland seal water to a trickle by tigbtening gland. Packing that is ton tigbt will canse undoe friction and wear ont prematorely.

5. Inspect the following strainers and cleon if required:

   a. Distiller feed pump snetion strainer
   b. Air ejeetor steam strainer
   c. Desuperheater water strainer

6. Check salinity indicating system to determine that it is installed and wired in accordance witb Technical Manual and Wiring Diagram.

   a. Determine that all salinity cells have been installed in distillate and condensate piping at connections downstream from each tube bundle in unit pipino. Cell locations are shown on Flow Diagram.

   b. Determine that distillate solenoid transfer valve is wired into salinity system, and that valve is set to divert initially produced distillate to waste and not locked in raised lever position whicb delivers distillate to fresb water system or storage tanks.

c. Check position of valves in condensate piping downstream from air ejector after-condenser and feed water heater. The arrangement should divert to waste condensed ejector motive steam and heater supply steam until the unit is in full operation and the salinity equipment indicates condensate is acceptable for transfer to condensate system.

d. Turn on power to salinity indicating equipment.

7. Close all vent cocks, drain cocks, and drain plug connections on water boxes of unit heat exchangers (distillate cooler, stage condensers, after-condenser and feed water heater).

8. Check to see that both 1/4" NPT brooze vent plugs are tightly screwed into stage vent connections on top of evaporator.

9. Open pressure gauge shut-off cocks.

10. Open gauge glass shut-off valves. Make certain that glass drain cocks are closed.

11. Close evaporator drain connections.

12. Check the looped after-condenser shell vent to atmosphere to determine that it is unobstructed.

Starting Procedure

1. Close the following valves:

A. Feed water inlet (V-11)
B. Brine pump discharge (V-19)
C. Heating steam and alternate steam supply valves
D. Ejector steam system valves:

I. Supply control (V-43)
II. First and second stage shut-off (V-48 & 49)
III. First and second stage stand-by ejector shut-off valves (V-50 & 51)
IV. Standby ejector shut-off (V-53)
V. Shut-off (V-52)

E. Drain regulator by-pass (V-33)
F. Desuperheating water control (V-36)

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G. Distillate System Valves:

I. Pump discharge control (V-75)
II. Sample (V-76)
III. Solenoid trip (V-78), set valve to deliver to waste port.
IV. Meter by-pass (V-80), set to by-pass meter.

2. Open the following valves:

A. Brine pump seal water (V-71)
B. Distillate pump seal water (V-70)
C. Feed water temperature control (V-10) about 1/3 open

3. Fill the evaporator with feed water as follows:

A. Start feed pump, after making sure it is first primed, open feed pump discharge valve (V-1).

B. When feed water is visible from last stage observation window start brine pump and open discharge valve (V-19). Adjustment of valve (V-19) in relationship with valve (V-10) should be made to prevent flooding of the evaporator.

Note: Brine pump cavitation will normally be checked by throttling valve (V-19) to increase suction head.

C. Feed water level in the evaporators may be an inch or two above the spray pipe base or weir base. The water level should not be allowed to cover the spray pipe caps. Observe this from observation window.

4. Draw a vacuum within the evaporator with the steam air ejectors as follows:

A. Be sure vent connection in after-condenser is free from obstruction and open to atmosphere.

B. Open the following valves for use of the air-ejectors not on standby.

I. Ejector steam supply control (V-43)
II. First stage ejector steam shut-off (V-48)
III. Ejector shut-off (V-52)
IV. Second stage ejector steam shut-off (V-49)

C. For use of the standby air ejectors.

I. Open valves:

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I. First stage steam shut-off (V-50)
II. Second stage steam shut-off (V-51)
III. Ejector shut-off (V-53)

5. Observe pressure gauge P-2 on evaporator stage No. 2 to determine the vacuum which should be in the region of 27 - 28" Hg occurring at about 30 minutes.

6. When above vacuum has been achieved, place the feed water heater in operation as follows:

A. Using the saturated heating steam

1. Open steam supply valve

NOTE: Valves in the alternate steam line and the desuperheating control should remain closed when operating with the saturated heating steam.

2. Observe gauge glass on heater hotwell for an accumulation of condensate.

NOTE: 1. Condensate level will be controlled by the drain regulator.

2. If drain regulator fails and flooding occurs, the condensate level may be controlled by opening the by-pass valve (V-33).

B. Using alternate steam

1. Open steam supply valve

NOTE: Valves in heating steam line should remain closed when operating with the alternate heating steam.

2. The critical flow nozzle will pass a constant amount of steam if a five pound pressure is maintained upstream of the nozzle. Observe pressure on gauge P-6.

3. Open desuperheater control valve (V-36) and adjust to maintain an inlet temperature 5 to 10°F. higher than the heater shell temperature.

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7. Adjustment of feed water temperature control valve (V-10) is important at this stage irrespective of the soorce of beating steam.

   A. Throttle down on Valve (V-10) at initial start-up to quickly bring temperature of feed np to 170°F. As temperatnre reachts this point, and begins to riss above it opeo up on valve (V-10) gradually to maintain this temperature.

   E. When nsing either source of heating steam, distillate capacity is controlled by the evaporator feed water iolet control valve (V-10).

      NOTE: Oo any adjostment of Valve (V-10) inspect water level in evaporator throngh observation windows. If level of water rises excessively open brine pomp discharge valve (V-19) proportiooally.

8. Prepare for dietillate prvduction as follows:

   A. Distillate will start to form as feed water temperature approaches 170°F.

   B. Observe distillate pump suction lioe gauge glass for evidence of distillate.

   C. Check to see that 3-way solenoid valve is set for delivery to waste port.

   D. Start distillate to pump wben distillate is visible on sight glass and open valve (V-75) and tbrottle if necessary to maintain a level near the bottom of the glass. A dry glass ie preferable to a wst glass which might wean floodiog of condenser tnbe bundles.

      NOTE: The evaporator is equipped with a sight glass on Stage 2 and a flooding indicator on Stage 1. The level of distillate should never be permitted to wholly cover the glasses. If a level is not visible (that is: below the glase) this should not cause any concern.

   E. Permit distillate to discharge to waste for several hours to thoroughly flusb out evaporator interoals and distillate lioes.

   F. Test distillate purity of water at each cell at the followiog locatioos:

(a) Distillate Stage 1 to 2 (C-1)
(b) Distillate io Stage 2 to Distillate Cooler (C-2)
(c) Condsnsate After-condenser (C-3)
(d) Coodensate feed water beater (C-4)
(e) Distillate out distillate coolsr (C-5)

When distillate purity is less than 1/4 GPG on cell located on distillate line from cooler raise lever on 3-way solenoid valve to engage latcb, thereby switcbing distillate flow from waste to fresh water tank or reserve feed system whicbever is desirable.

NOTE: A temperature control switch and timer is eqnipped on fead water line to first stage evaporator, tbis will permit collection of distillate only if water tsmperature remains above 168° F. for 15 minutes. If temperature falls below 165° F. distillate will be discharged to waste. The use of the device assures tbe destruction of bacteria which does not occur at temperatures somewbat below 165° F. Tbis is especially true when distilliog contaminated barbor or shore water. Sioce most harbor or shore waters are less saline than sea water, detection of carry-over of water droplets by salinity apparatus will be much less effective and subsaquently will not register the transport of bacteria laden water droplets to tbe distillata lines. At sea tbe danger of storage of bacteria laden water will oot normally be present. This is due to the fact that shonld aoy carry-over of bacteria laden water occur they will also contain salt particles, and will be immediately detected by the salinity apparatus and cause tbe distillate to be discharged to waste. The temperature switch is electrically connected to the 3-way solenoid valve and if temperature falls below 165° F. a sigoal is sent to the three-way valve which will immediately dump distillate to waste. Collection will only begin again when feed water temperature remains above 168° F. for a minimum of 15 minutes.

G. Turo distillate by-pass valve (V-80) to direct flow through meter.

H. Inspect purity of feed water heater condeosate and if readiog below 1/4 GPG switch condensate discbarge to sbip condansate system.

I. Inspect purity of after-condenser condensate if reading below 1/4 GPG switch condensate to ship's condensate system.

Operating Procedure

Once started, operation of the unit is essentially automatic. However, the following steps, as required, should be accomplisbed to ensure the most efficient operation.

1. Maintain feed water heater feed water outlet temperature at 170°F. Adjustment of feed water inlet valve (V-10) will normally control the temperature.

2. Keep the condensate level in the feed water heater below the top of the gauge glass on the condensate well; keep distillate level below top of the gauge glass on distillate pump suction piping.

3. Make frequent inspection of evaporator observation windows. Watch for a rise in feed water level which may be caused by an insufficient brine discharge rate. Check for a closed or throttled valve or malfunctioning brine pump. Air leakage into suction piping will impair or prevent entirely the operation of unit pumps, causing a consequent rise in brine, condensate or distillate levels.

4. Note feed water heater shell pressure and temperatore each day after operation has been stabilized. Heater vacuum will eventually decrease from approximately 14 to 7 inches of mercury as the beater tubes go from clean to scaled condition. A corresponding increase in heater shell temperature will aleo occur until at a certain point descaling of heater tubes will be required to prevent distillate production from falling below rated output.

5. Flow Diagram, figures for vapor and feed water temperature and vapor pressures, plus the conditions of heating steam are based on the feed water temperature of 85°F. Should temperature be other than this, which is usually the case, reference should be made to Performance Data Chart, contained in this chapter, for approximate guide to operating figures. The chart illustrates:

    1. Vapor temperature directly related to inlet feed water temperature.

    2. Peed water rate for different temperatures ss an approximate percentage of the rated flow for feed water at 85°F.

Procedure for Securing

1. Close valvea to cut off steam to feed water heater.

2. Close valves tu shut off steam to air ejectors.

3. Close desuperheater control valve (V-36), if operating with alternate steam.

4. Set distillate meter by-pass valve (V-8D) to by-pass meter.

5. Stop distillate pump.

6. Stop feed pomp and close feed water inlet line upstream from distillate cooler (V-1).

7. Stop brine pump and close brine pump discharge valve (V-19).

8. Close brine (V-71) and distillate (V-7D) seal water valves.

9. If shutdown is for prolonged period, the eotire unit shonld he drained and veoted.

Operating Records

It is reeommended thnt complete operating reeords he kept hy operatiog personnel as an aid io determioing faulty or improper operation. The followiog data should he tabulated aftor each start-up, before each shutdown, and once during each watch:

1. Date and Time Started.
2. Date and Time Shutdown
3. Total Hours of Operation
4. Total Hours Since Last Descaling Operation
5. Rate of Distillate Output (GPH)
6. The following pressores:

Feed water in stage 1	P-1
Stage 2	P-2
Brine Pump Discharge	P-3
Distillate Pomp Discharge	P-4
Ejector Steam Supply	P-5
Heating Steam Supply	P-6
Feed Water In Distillate Cooler	P-7

7. The following temperatures:

Feed Water In Distillate Cooler	T-1
Feed Water In After Condenser	T-2
Feed Water Out Feed Water Heater	T-3
Stage 1 Evaporator	T-4
Stage 2 Evaporator	T-5
Distillate Out Distillate Cooler	T-6
Feed Weter Heater	T-7
Steam In Feed Water Heater	T-8

MAINTENANCE

Scale Formation

The rate at which scale forms on the internals of an evaporator is greatly reduced in this low pressure flash distilling unit. Scaling tends to occur principally on the inside of the tubes of the feed water heater, after-condenser, stage condenser and distillate cooler.

Descaling or cleaning operations should be put into effect when the distillate production begins to fall below the desired output. The frequency of descaling is, of course, dependent on the time the unit is in operation and conditions under which it has been working. It is well to note that scale if it is permitted to increase excessively will prevent correct heat transfer and consequently efficient operation of the distilling unit.

Indications of Scale Formation

1. Temperature of feed water leaving feed water heater begins to fall below the operating level.
2. The desired distillate production can no longer be maintained with the feed water temperature control valve wide open.
3. Vacuum in heater begins to decrease towards atmospheric pressure.

Scale formation will occur relatively faster in the feed water heater and due to this the overall efficiency of the unit is affected. Should scaling cause distillate to fall below that production rate designed for fouled tube condition, then this is ample indication to commence descaling operations.

Efficient operation may continue for 3 to 6 months before descaling becomes necessary.

Methods of Scale Removal

Fouled tubes may be cleaned mechanically or chemically.

Mechanical Cleaning
(For Straight Tubes Only)

Cleaning may be accomplished mechanically as follows:

1. Remove mater boxes of components to be claaned.
2. Chip seale from outer surfaces of tube sheets.
3. Insert an air or eleetrically driven tube eleaner into the tubes. A drill type tube eleaner with a mater lubricated carbida tip ie reeommended. Refer to Asaambly Drawings for details of tubes.
4. Flush thoronghly mith a hose to remove all loosened seale.
5. Replace water boxes.

Chemical Claaninq

Cleaning of haat transfer tubes may be accomplished chemically by cirenlating a dilnta acid snlntion through the tnbes of the scaled compnnents. The weak ncid solution will effectively remove the seale deposits withnut seriously attacking the tube walls.

However, special equipment is required, and great cara should be exercised when working mith acid to prevent injury to personnel or eontamination of fresh water lines nnd storage facilities.

Acid Cleaning Safety Freeantions

1. All personnal morking with nr near aeid shauld wear protactiva clothing eonsisting of face shield or goggles, rnbber gloves, and rubber apron. Care ahould be takan to avoid inhalatinn of acid fumes.
2. Acid shonld always be added to water - water nddad to acid may cauae dangerous spattering.
3. Acid spilled on the person or other objeet should be promptly washed with large quantities of fresh water.

Quaotities and Kinds of Acid for Cleaning Flash Evaporators

Acid Alternatives

(a) Commercial Muriatic Acid (20^{0} Baume HCl, 31% HCL by weight)

(b) Sulfamic Acid Powder (Federal Stock No. G6850-637-6142 Scala Removing Compouod)

Choioe of Cleaning Compoond

Commercial muriatic acid, in liquid form, is the cheapsst and most effective acid to use, but it is more difficult to handle and store than sulfamic acid, which comes in powder form. The fumes given off by the hydrochloric (muriatic) acid sre considerably more objectionable than those given off by solfamic, aod the glass carboys are more difficult to handle thao the cardboard contaioers of sulfamic. Moreover, federal stock sulfamic acid cootaios an indicator agent which turns color when the acid bas been neutralized by reacting with scale.

Quantity

The quaotity or total amount of acid raquired for one complete descaling operation will be infloenced to a great sxtent by the type and thickness of scale coating the beat transfsr surfaces. Tabulated data below shows amounts of acid for average scale cooditions. Acid charges at any one time while circulating should oot exceed by very much a solotioo strength of 5% to 6%. Add ooe-half of initisl charge eacb time pH of solutioo rises above pH 3 until pH remains constant and numerically less than pH 3 aod tubes are clean.

AVAILABLE ACIDS FOR CHEMICAL CLEANING

Type of Acid	Supplied	Amount of Acid Required per Cleaning	Initial Acid/Water Ratio At One Time
Hydrochloric as Commercial Muriatic (20° BE HCl 31% by weight)	As liquid in carboys	3.6 lbs. for each Gallon of Water in Cleaning Circuit	1/16 Gal. per Gal. of Water in Cleaning Circuit
Sulfamic Acid Fed. Stock No. G6850-637-6142 HSO_3NH_2	As powder in Polyethylene lined containers	2.7 lbs. for each Gallon of Water in Cleaning Circuit	1/2 lb. per Gal. of Water in Cleaning Circuit

Approx. Solution Strength should be 5% to 6%

CHEMICAL CLEANING DATA

Evaporator Capacity	20,000 G.P.D.
Number of Stages	2
Mixing Tank Size	100 Gallons
* Amount of Water in Circuit #1	135 Gallons
* Amount of Water in Circuit #2	102 Gallons
Amount of Water in Tank	50 Gallons
Amount of Acid: (Initial Charge)	
Muriatic Acid	
Per Circuit #1	8.5 Gallons
For Circuit #2	6.3 Gallons
Sulfamic Acid	
For Circuit #1	68 lbs.
For Circuit #2	51 lbs.
Approximate quantity of Acid to Clean Evaporator:	
Muriatic Acid	86 Gallons
Sulfamic Acid	640 lbs.

* Including Tank Capacity

Neutralization

Flush cleaning cycle with fresh sea water for 15 minutes. If unit is not to be placed back in operation after cleaning and flushing, any traces of acid which may still be present should be neutralized with soda ash (Na_2CO_3) added to the fresh sea water circulating through the cleaning cycle in a ratio of 8-1/2 pounds of soda ash per 100 gallons of water. Follow with fresh sea water to flush out.

Preparation of Components for Cleaning

1. Drain water from system so that acid piping or hose may be connected.

2. Make sure that gasketed joints in unit piping which will form part of the cleaning cycle are tight.

3. Inspect tubes of components to be cleared by removing a piping connection, and log their condition.

4. Remove all zinc anodes from water boxes of components to be cleaned and replace empty anode retainers in water boxes.

5. Connect bottom of acid tank to acid pump suction with 1" suction line.

6. Establish a cleaning circuit for feed water heater and after-condenser, proceed as follows: Refer to Circuit No. 2.

    a. Connect acid pump discharge to last pass zinc pencil connection on inlet-outlet water box of feed water heater.

    b. Remove feed water duct located between first stage condenser outlet and after-condenser inlet.

    c. Connect acid return and vent line to after-condenser inlet and extend acid return line down into acid tank 4" to 6".

d. Provide a means for disposing of spent acid solution. A tee may be located in the acid return line and a second line containing a valve may be connected and used to carry the spent acid to a suitable source for disposal or a drain line and valve may be installed in the bottom of the acid tank.

e. Remove brass immersion well of low temperature switch (if unit is so equipped) from feed water piping between heater and evaporator and plug this connection. Also remove piping and plug pressure gauge connection for gauge in this line.

f. Arrange acid tank and return line to allow for easy venting through looped return line of gases formed when acid solution contacts the scale deposits in the tubes. Specifically, keep the return line open and unobstructed when the acid pump is circulating the cleaning solution. A minimum 1-1/2" line will handle the large volume of gases sometimes liberated when cleaning solution contacts scale deposits.

CAUTION: The gases generated by this reaction consist of carbon dioxide and some hydrogen. A positive means must be used to ensure venting of these gases to the weather. Allow no open flames in the vicinity of the cleaning operation.

g. Tightly close feed water temperature control valve to keep solution out of evaporator.

h. Place near the mixing tank the amount of dry sulfamic acid or gallons of muriatic acid required. Refer to Page 4 - 4 for quantities of acid required.

Cleaning Procedure

1. Fill the mixing tank about 1/2 full of fresh or clean sea water.

2. Open acid Valve (V-A) and (V-B) and start the acid pump and circulate the water through the heat exchangers in the cleaning cycle. Add water until the tank is 1/2 full. Check for and correct any leaking connections. A drop in level in the tank after the system is full will indicate a leak in the system. Any leak must be repaired before proceeding.

3. While the water is circulating, slowly pour acid powder or liquid muriatic acid into the mixing tank through a hole in the tank lid in the proportion shown on Page 4 - 4.

   NOTE: If federal stock sulfamic acid powder is used, it will impart a red color to the solution and as the scale is dissolved the color will change from red to orange or yellow. When the solution turns to yellow color, add 1/2 of initial charge each time the solution turns yellow. If muriatic acid is used, pH test papers will be required to enable easy determination of solution pH. Add 1/2 the initial charge of muriatic acid each time the solution pH becomes numerically higher (less acidic) than pH 3 until the solution pH remains constant and numerically less than 3.

4. When the solution color or pH indicates that the solution is no longer being neutralized by the scale deposits and all gas generation ceases for half an hour, the system components should be clean.

5. Flush system by draining acid solution to waste while adding sea water or fresh water to mixing tank at rate equal to the capacity of the acid pump.

   CAUTION: Do not dump acid to bilge!

6. Neutralize the system by circulating soda ash in a 1% solution (8-1/2 pounds per 100 gallons of water) made by adding soda ash in the same manner as acid powder. Follow with fresh water or clean sea water flushing.

7. Drain circuit and stow all special fittings and pipe.

8. Replace all piping removed for the chemical cleaning operation.

9. Replace zincs and restore system to normal service.

10. Log and describe any leaks which develop after acid cleaning.

11. Replace any leaking gaskets.

12. Replace distilling plant back in operation as soon as possible after neutralizing the acid residue in the system.

13. Procedure for cleaning the distillate cooler and stage condensers is essentially the same as system given above. The following differences should be noted:

    a. The cleaning circuit is established by connecting the 1" acid pump discharge line to the distillate cooler feed water inlet with an adapter; by removing the feed water duct located between the first stage condenser outlet and the after-condenser inlet; and by using the same return line to acid tank arrangement as used for the feed water heater and after-condenser cleaning circuit, except that the return line is connected to the first stage condenser outlet.

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b. Zinc anodes are removed from anode retainers on stage condenser and distillate cooler water boxes.

EXHIBIT G

MOOREMAC PRIDE
MOOREMAC BAY
SOW-1866-J-59

Technical Manual
for
10,000 GALLON PER DAY
PLASTIC TYPE DISTILLING UNIT
MODEL SWSPL2

Sea-Water Special Products, Inc.
WILLIAMSBURG, VIRGINIA

RESTRICTED - PROPRIETARY MATERIAL P.O. 21041-68

EXHIBIT "G"

IF FOUND PLEASE RETURN TO

AQUA-CHEM, INC.

WAUKESHA, WISCONSIN 53186

SERVICE DEPT. FILE

Technical Manual

for

10,000 GALLON PER DAY FLASH TYPE DISTILLING UNIT CLEAVER-BROOKS MODEL S415FL2

BF. 9/24/76

SUN HULL

617 MARCUS PRIDE

618 RAY

619 LAKE

620 COVE

621 SCAN

622 TRADE

TODD

74 CAPE

75 GLEN

SUN SHIPBUILDING AND DRY DOCK COMPANY

Purchase Order G-15606
Hull Numbers 617 and 618 } 50-13601-59

Purchase Order G-20888
Hull Numbers 619, 620, 621 } 50-26521-59.

Purchase Order G-37962
Hull Number 622 } 46343

TODD SHIPYARDS CORPORATION

Purchase Order M-20048
Hull Number 74 } 18659-59.

Purchase Order M-20049
Hull Number 75

Cleaver-Brooks Special Products, Inc.

WAUKESHA, WISCONSIN

CLEAVER-BROOKS MAHUAL NO. 15661-60 FEBRUARY 1961

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45343 (only)

APPROVAL AND PROCUREMENT RECORD

BASIC APPROVAL FOR:

Title: Technical Manual — 10,000 Gallon Per Day Capacity Flash Type Distilling Unit, Model S415FL2 Cleaver-Brooks Special Products, Inc.

Approved By: Sun Shipbuilding and Dry Dock Company letter of D. Mylrea dated 20 June 1960.

Contract Or Order	Date	Vessels Applicable	Quantity Of Manuals	Building Yard
G-15606	8-5-58	Sun Hulls 617 and 618	21	Sun Shipbuilding and Dry Dock Company Chester, Pennsylvania
G-20883	5-4-59	Sun Hulls 619, 620 and 621		Sun Shipbuilding and Dry Dock Company Chester, Pennsylvania
M-20048	9-9-58	Todd Hull 74	12	Todd Shipyards Corporation San Pedro, California
M-20049	9-9-58	Todd Hull 75		Todd Shipyards Corporation San Pedro, California
G-37962	1-12-61	Sun Hull 622	2	Sun Shipbuilding and Dry Dock Company Chester, Pennsylvania

REMARKS:

CERTIFICATION: Date: February, 1961

It is hereby certified that the manual, Cleaver-Brooks No. 18651-60, provided under the above listed orders, has been approved by the authority of basic approval data also shown above.

Wallace R. Semrau

Cleaver-Brooks Special Products, Inc.

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General Data

OVERALL DIMENSIONS

Length	8'-5-1/4"
Width	7'-2"
Height	8'-6-1/4"

UNIT DRY WEIGHT

Model S4I5FL2 (as furnished)	10,500 pounds

SERVICE REQUIREMENTS

Sea Water Feed	146 gallons per minute (at rated condition — 85 degrees F sea water temperature) 45 psig minimum, 75 psig maximum pressure
Steam	
To Air Ejectors	210 pounds per hour at 180 psig, 380 degrees F
To Feedwater Heater (Alternate Supply)	2130 pounds per hour at 5 psig, 228 degrees F (Sat.)
	OR
(Normal Supply)	2150 pounds per hour at 11 psig, 204 degrees F
Electrical	
For Feed Pump and Motor	By Shipbuilder
For Brine Pump and Motor	5 HP
For Distillate Pump and Motor	1 HP
For Heater Drain Pump and Motor	1-1/2 HP

SALIENT DESIGN CHARACTERISTICS

a. Two-stage low pressure sea water evaporation and condensation.

b. Internal distillate condensers.

c. Overflow duct feedwater level control within the stages.

d. Demister mesh steam separators.

e. Evaporator evacuation by two-stage steam jet air ejector. Standby ejector.

f. External air ejector after-condenser, distillate cooler and low pressure feedwater heater.

g. Reduced scale formation because of low temperature flash evaporation under vacuum and elimination of boiling on heat transfer surfaces.

h. Distillate and condensate solenoid transfer valves salinity controller actuated.

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HEAT BALANCE (85 Degrees F Feedwater, Basis H = 0 @ 32 Degrees F.)

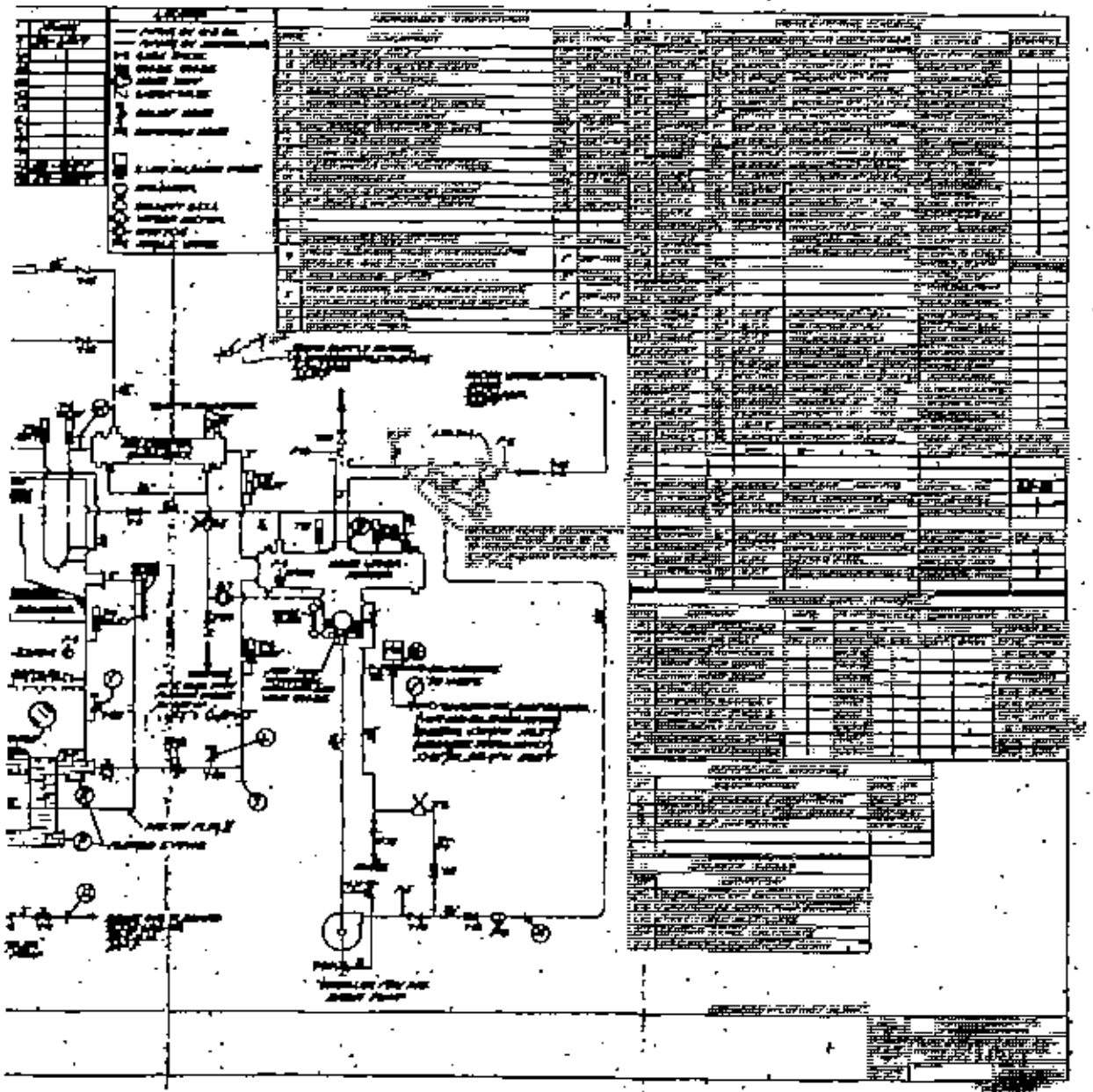
	BTU/Hr. Input	BTU/Hr. Output
Feedwater	3,680,000	
Heating Steam	2,463,000	
Ejector Steam	251,000	
Brine Overboard		5,752,000
Distillate		219,000
Condensate		392,000
Radiation and Venting		31,000
	6,394,000	6,394,000

SERIAL NUMBERS

This manual applicable to distilling units with the following serial numbers only:

SP-59-2143
SP-59-2144
SP-59-2145
SP-59-2146
SP-60-2351
SP-60-2352
SP-60-2353

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SECTION SEVEN Maintenance

FORMATION OF SCALE

The rate at which scale forming elements precipitate from sea water to reduce operating efficiency and distillate output by fouling heat transfer tubes is greatly reduced in a low pressure flash distilling unit.

Low temperature boiling achieved through flash evaporation in a vacuum succeeds in retarding the formation of insoluble compounds which tend to coat the heating surfaces of all evaporators. Moreover, the formation of scale in the evaporator flash chambers is of no consequence since neither the condensation of steam nor the heating of feedwater takes place at the bottom of the stages where flashing occurs.

Periodically, however, after three to six months of operation the tube side of the feedwater and after-condenser, and possibly the tube side of the distillate condensers and distillate cooler will require cleaning to remove deposits from the inside of the tubes in order to restore maximum operating efficiency. The frequency of required shutdown for descaling operations will depend on a number of factors such as the temperature and composition of the feedwater and extent to which the operating instructions are followed. Terminal feedwater temperatures above 175 degrees F and such practices as the recirculation of brine in order to raise the incoming feedwater temperature tend to increase the rate of scaling.

Rated distillate output is based upon a fouled condition in the feedwater heater tubes. Output with clean tubes is somewhat higher. Output decreases gradually at a rate depending on operating conditions and operating procedures. As a result, it may be possible to operate the unit continuously for as long as six months, or more, without shutdown for descaling.

Indications of Scale Formation — The tubes of the feedwater heater will require descaling more frequently than other tube bundles. When operating on alternate 5 psig heating steam, descaling should be accomplished whenever the heating of feedwater to 170 degrees F produces a consistent shell temperature as high as 198 degrees F. Decreased heater vacuum (numerically less than 7-1/2 inches of mercury vacuum (11 psia) on Pressure Gauge P-61 will also indicate the need for descaling operations, when using the alternate steam supply, provided the reduction in heater vacuum is not due to other cause such as faulty venting, high steam supply pressure, or terminal feedwater temperature above 170 degrees F.

The above indications are also applicable when operating the heater on the normal turbine bleed steam. Descaling should be accomplished when the consistent heater shell vacuum has decreased to 11 psia.

Scale in the tubes of the after-condenser will be indicated by the emission of a large amount of steam from the after-condenser vent to atmosphere due to the inability of the after-condenser tube bundle to condense all of the air ejector motive steam.

Heavy scale deposits in the tubes of the forward distillate condensers will result in a substantial decrease in distillate output and also a decrease in the feedwater temperature rise across the condensers, at any given inlet temperature.

Scale in the tubes of the distillate cooler will be evidenced by the inability of the cooler to produce a temperature drop of at least 20 degrees F in the effluent distillate. The low sea water temperatures in the tubes of the cooler permit this heat exchanger to be operated for long periods without descaling.

Positive determination of scaling can be best obtained by actual inspection of tubes and tube sheets after removal of heat exchanger water box anode retainers, piping connections, or entire water box. The inlet-outlet water box of the feedwater heater is provided with a removable inspection cover.

Warning: Do not remove any connections until unit has been secured and drained.

METHODS OF SCALE REMOVAL

Fouled tubes may be cleaned mechanically or chemically.

Mechanical Cleaning — Cleaning may be accomplished mechanically as follows:

1. Remove front and rear water boxes of components to be cleaned.

2. Chip scale from outer surfaces of front and rear tube sheets.

3. Insert an air or electrically driven tube cleaner into the tubes. A drill type tube cleaner with a water

lubricated carbide tip is recommended. Tube dimensions are as follows:

Feedwater Heater — 3/4 inch O.D. x .049 inch wall x 72 inches long.

Distillate Cooler — 5/8 inch O.D. x .049 inch wall x 30 inches long.

After-condenser — 5/8 inch O.D. x .049 inch wall x 38 inches long.

Distillate Condensers — 5/8 inch O.D. x .049 inch wall x 72 inches long.

4. Flush thoroughly with a hose to remove all loosened scale.

5. Replace water boxes.

Chemical Cleaning — Cleaning of heat transfer tubes may be accomplished chemically by circulating a dilute acid solution through the tubes of the sealed components. The weak acid solution will effectively remove the scale deposits without seriously attacking the tube walls.

However, great care should be exercised when working with acid to prevent injury to personnel or contamination of fresh water lines and storage facilities.

Acid Cleaning Safety Precautions

1. All personnel working with or near acid should wear protective clothing consisting of face shield or goggles, rubber gloves, and rubber apron.

2. Acid should always be added to water — water added to acid may cause dangerous spattering.

3. Any person who inhales acid fumes should be withdrawn from the contaminated area immediately and taken to fresh air. If exposure was of any consequence, secure a physician. Place exposed person on his back with feet slightly elevated until physician arrives.

4. Acid spilled on the person or other object should be promptly washed with large quantities of fresh water. Affected skin areas should then be washed with lime water or covered with a lime paste. Resulting burns should be treated by physician as soon as possible.

Quantities and Kinds of Acid for Cleaning Flash Evaporators

Acid Alternatives

a. Commercial Muriatic Acid (20 degrees Baume HCl, 31 per cent HCl by weight)

b. Sulfamic Acid Powder (Federal Stock No. G6850-637-6142 Scale Removing Compound)

Choice of Cleaning Compound — Commercial muriatic acid, in liquid form, is the cheapest and most effective acid to use, but it is more difficult to handle and store than sulfamic acid, which comes in powder form. The fumes given off by the hydrochloric (muriatic) acid are considerably more objectionable than those given off by sulfamic, and the glass carboys are more difficult to handle than the cardboard containers of sulfamic. Moreover, federal stock sulfamic acid contains an indicator agent which turns color when the acid has been neutralized by reacting with scale.

If the acid cleaning is to be done by experienced personnel, hydrochloric acid is probably the better choice, but if done by relatively inexperienced personnel, the use of sulfamic is worth the additional cost involved.

Quantity — To be determined by volume of cleaning circuit (distillate cooler and distillate condensers plus lines to and from mixing tank, or air ejector after-condenser and salt water heater plus lines to and from mixing tank). Volume of circuit determined when pumping sea water from mixing tank into cleaning circuit. For initial slug:

a. 1/16 gallon of HCl for each gallon of sea water circulating in cleaning cycle, OR

b. 1/2 pound of sulfamic acid powder for each gallon of sea water circulating in cleaning cycle

Add one-half of initial charge each time pH of solution rises above pH 3 until pH remains constant and numerically less than pH 3 and tubes are clean.

Neutralization — Flush cleaning cycle with fresh sea water for 15 minutes. If unit is not to be placed back in operation after cleaning and flushing, any traces of acid which may still be present should be neutralized with soda ash (Na_2CO_3) added to the fresh sea water circulating through the cleaning cycle in a ratio of 8-1/2 pounds of soda ash per 100 gallons of water. Follow with fresh sea water flushing.

Required Cleaning Equipment

a. Acid pump, corrosion-resistant construction, 10 to 20 gpm capacity against a static head of 20 feet

b. Mixing tank, 100 gallon capacity, rubber lined

c. Discharge line, acid pump to acid inlet, 1 inch size rubber hose or nonferrous piping

d. Suction line, acid tank to acid pump, 1 inch size rubber hose or nonferrous piping

e. Acid return and vent line, acid outlet to acid tank, 3 inch size rubber hose or nonferrous piping

f. Acid Valves (V-A) and (V-B) shown on Acid Cleaning Diagrams.

Preparation of Components for Cleaning

1. Drain water from system so that acid piping or hose may be connected.

2. Make sure that gasketed joints in unit piping which will form part of the cleaning cycle are tight.

3. Inspect tubes of components to be cleaned by removing a piping connection, and log their condition.

4. Remove all zinc anodes from water boxes of components to be cleaned and replace empty anode retainers in water boxes.

5. Connect bottom of acid tank to acid pump suction with 1 inch suction line.

6. To establish a cleaning circuit for feedwater heater and after-condenser, proceed as follows:

a. Connect acid pump discharge to Connection "X" in heater feedwater outlet piping.

b. Blank off outlet from 1st stage condenser with blank-off plate provided for this purpose.

c. Connect 3 inch acid return and vent line to Connection "W" and extend return line down into acid tank 4 inches to 6 inches.

d. Provide a means for disposing of spent acid solution. A tee may be located in the acid return line and a second line containing a valve may be connected and used to carry the spent acid to a suitable source for disposal, or a drain line and valve may be installed in the bottom of the acid tank.

e. Remove 1/2 inch relief valve from feedwater piping between heater and evaporator and plug this connection. Also remove piping and plug pressure gauge connection for Gauge (P-2) in this line.

f. Arrange acid tank and return line to allow for easy venting through looped return line of gases formed when acid solution contacts the scale deposits in the tubes. Specifically, keep the return line open and unobstructed when the acid pump is circulating the cleaning solution. A minimum 3 inch line will handle the large volume of gases sometimes liberated when cleaning solution contacts scale deposits.

Caution: The gases generated by this reaction consist of carbon dioxide and some hydrogen. A positive means must be used to ensure venting of these gases to the weather. Allow no open flames in the vicinity of the cleaning operation.

g. Tightly close Feedwater Control Valve (V-1) to keep solution out of evaporator.

h. Place near the mixing tank the amount of dry sulfamic acid or gallons of muriatic acid required. To estimate the amount of sulfamic acid required in pounds, multiply the number of gallons of liquid volume in the cleaning circuit by 2.7. An accurate determination of this liquid volume can be made by measuring the quantity of water initially required to fill the system. A record of the volume obtained should be made for future reference.

Cleaning Procedure

1. Fill the mixing tank with 1/2 full of fresh or clean sea water.

2. Open Acid Valves (V-A) and (V-B) and start the acid pump and circulate the water through the heat exchangers in the cleaning cycle. Add water until the tank is 1/2 full. Check for and correct any leaking connections. A drop in level in the tank after the system is full will indicate a leak in the system. Any leak must be repaired before proceeding.

7. While the water is circulating, slowly pour acid powder or liquid muriatic acid into the mixing tank through a hole in the tank lid in the proportion of 1/2 pound of sulfamic acid powder or 1/16 gallon of muriatic acid for each gallon of water in the system.

Note: If federal stock sulfamic acid powder is used, it will impart a red color to the solution and as the scale is dissolved the color will change from red to orange or yellow. When the solution turns to yellow color, add 1/2 of initial acid charge. Continue adding 1/2 of initial charge each time the solution turns yellow. If muriatic acid is used, pH test papers will be required to enable easy determination of solution pH. Add 1/2 the initial charge of muriatic acid each time the solution pH becomes numerically higher (less acidic) than pH 3 until the solution pH remains constant and numerically less than 3.

4. When the solution color or pH indicates that the solution is no longer being neutralized by the scale deposits and all gas generation ceases for half an hour, the system components should be clean.

5. Flush system by draining acid solution to waste while adding sea water or fresh water to mixing tank at rate equal to the capacity of the acid pump.

Caution: Do not dump acid to bilge!

6. Neutralize the system by circulating soda ash in a 1 per cent solution (8-1/2 pounds per 100 gallons

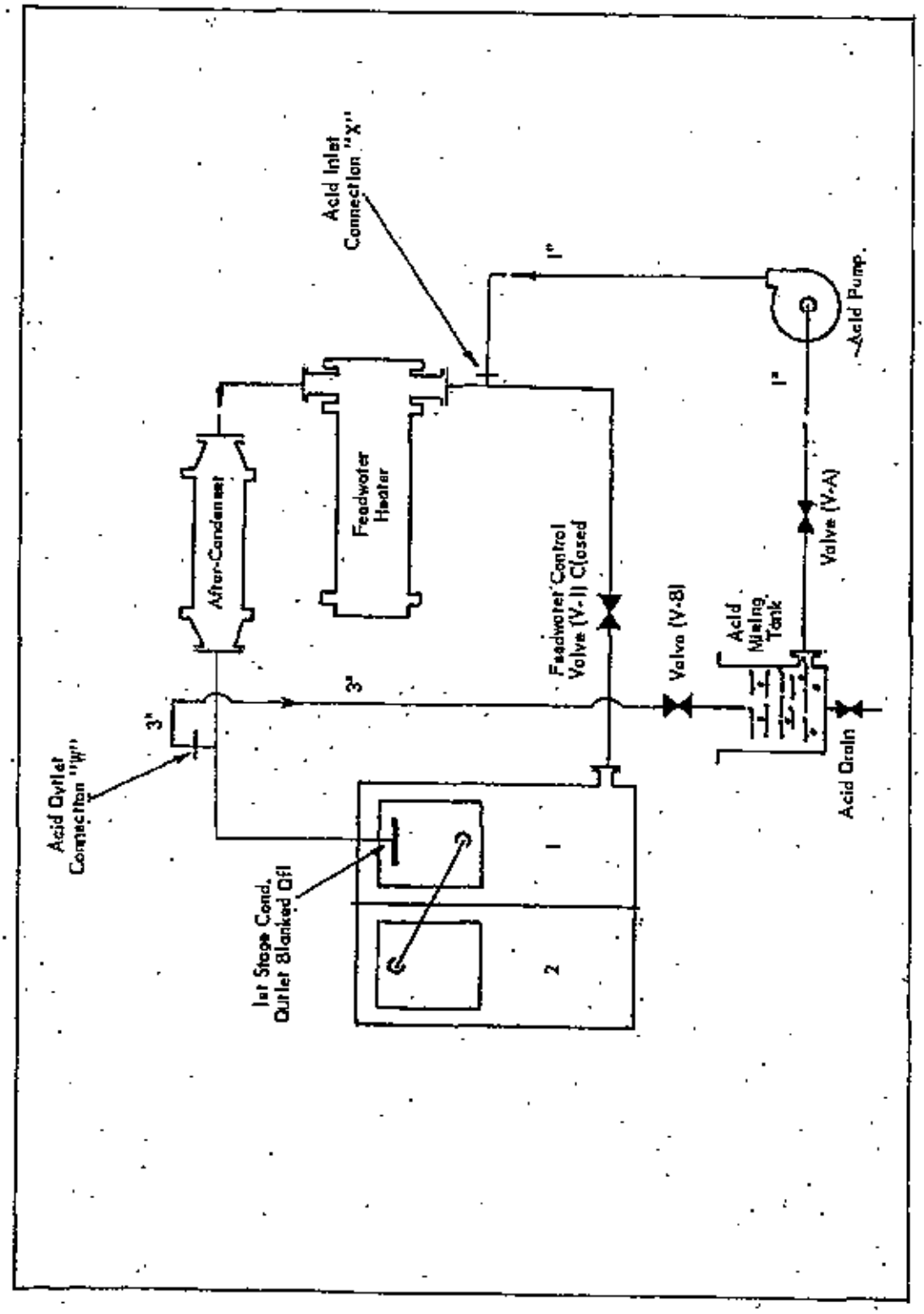


Figure 7-1 – Feedwater Heater and After-Condenser Cleaning Circuit

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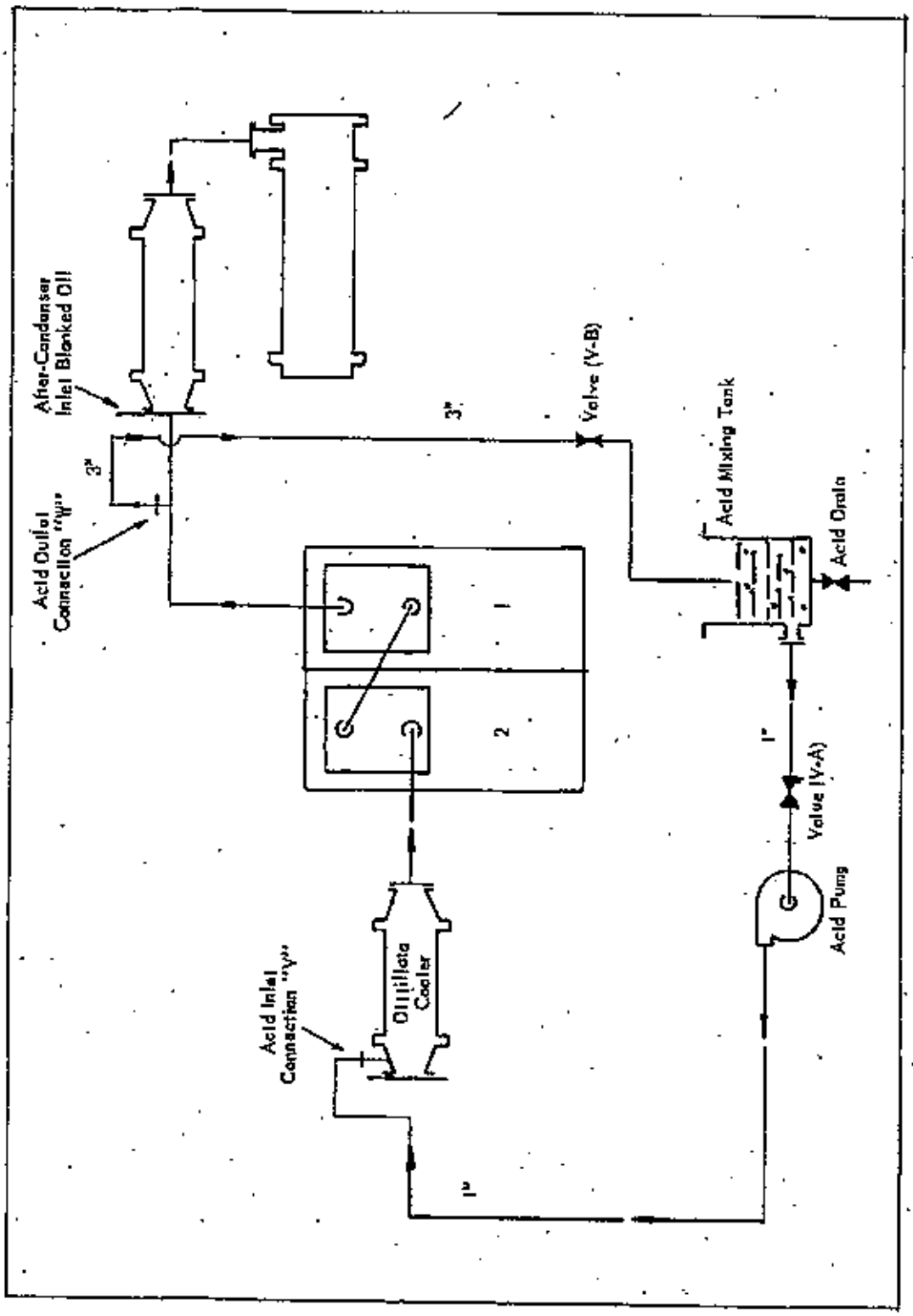


Figure 7-2 — Distillate Cooler and Stage Condenser Cleaning Circuit

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of water) made by adding soda ash in the same manner as acid powder. Follow with fresh water or clean sea water flushing.

7. Drain circuit and stow all special fittings and pipe.

8. Replace zincs and restore system to normal service.

9. Replace all fittings removed for the chemical cleaning operation.

10. Log and describe any leaks which develop after acid cleaning.

11. Replace any leaking gaskets.

12. Place distilling plant back in operation as soon as possible after neutralizing the acid residue in the system.

13. Procedure for cleaning the distillate cooler and stage condensers is essentially the same as system given above. The following differences should be noted:

a. The cleaning circuit is established by connecting the 1 inch acid pump discharge line to the distillate cooler feedwater inlet at Connection "V" and by using the same return line to acid tank arrangement as used for the feedwater heater and after-condenser cleaning circuit except that the feedwater inlet to the after-condenser is blanked off instead of the 1st stage condenser outlet.

b. Zinc anodes are removed from anode retainers on stage condenser and distillate cooler water boxes.

IMPURE DISTILLATE – CAUSES AND REMEDIES

If salinity equipment indicates that the conductivity of distillate exceeds the allowable maximum, it can be assumed that raw water is getting into the distillate somewhere within the system. It may be possible that solids are carrying over with the flash vapors a result of excess foaming in the evaporator. Foaming is usually caused by the presence of organic matter in the feed supply. The condition is removed by continued operation when this results in an improvement in the quality of the feedwater. It, however, prolonged operation is required where the organic content of the feed supply is high (such as in contaminated harbors), it may be necessary to feed a foam suppressing compound into the feedwater line upstream from the distilling unit inlet. A number of substances, such as Dow Corning "Antifoam B", are commercially available for this purpose.

Usually, however, impure distillate will be caused by leakage of sea water from the tube side of the distillate condensers or distillate cooler.

Leaks may be caused by:

a. Tube failure which may result from corrosion or cutting during mechanical cleaning.

b. Clearance between tube and tube sheet. This may result from an under-rolled tube. If clearance exists, sea water in the water box will tend to flow along the outer surface of the tube, past the tube sheet, and into the shell side or condensing area of the component.

The first step in tracing a leak is to determine the component in which it is occurring. The existence of distillate salinity cells downstream from each stage condenser and the distillate cooler provides an easy means of determining the approximate location of a leaky tube.

When a high conductivity reading is indicated at only one cell location, the leak will be found in the tube bundle of the component upstream from this cell. When high conductivity readings are obtained at several cells, the leak will most likely be located in the component upstream from the first cell in the series of those giving unacceptable readings.

The leak in the suspect component can be located by removing water boxes from both ends and hydrostatically testing the shell space surrounding the tube at a maximum pressure of 10 psig. (In the case of either distillate condenser, the entire evaporator must be filled with water.) If the leak is due to a cut or corroded tube, water will emerge from the end of the faulty tube. If the leak is due to an under-rolled tube, water will emerge from the space between the tube and the tube sheet.

Faulty tubes may be sealed with plastic tube plugs or may be removed and replaced by the following method:

1. Remove both water boxes from the leaking component.

2. Insert a tube cutting tool into one end of the faulty tube.

3. Rotate the tool to cut away tube wall, eliminating most of the tube's support at the tube sheet.

4. Repeat at the opposite end.

5. Insert a knock-out tool against the shoulder created by the cutting tool.

6. Knock the tool with a rubber or wooden mallet to force the tube through the tube sheets.

7. Insert new tube.

8. Expand the tube at both tube sheets. The expander may be operated with an air motor, electric drill, or open end wrench. Expansion should be to only 1/8 inch of the inner tube sheet face. [Distillate cooler, distillate condensers and after-condenser tube sheets are 3/4 inch thick. Salt water heater tube sheets are 1 inch.]

9. Bell inlet end of tube and grind off flush with the outer tube sheet face.

10. Apply water test, as when locating leaks, to be certain new tube is tight before replacing water boxes.

IMPROPER FUNCTIONING OF AIR EJECTORS

Faulty ejector performance will cause incomplete removable of noncondensible gases, with subsequent decrease of vacuum. This condition may be brought about by steam pressure at the ejector nozzle being below a minimum pressure for which their nozzles were designed, 180 psig.

The steam nozzles may be plugged with chips or foreign matter which can be removed by running a wire or proper size reamer through the opening of the steam nozzles.

Although these nozzles are protected by a steam strainer which should be blown out frequently, particles of foreign matter, pipe scale, etc., will occasionally get through the strainer, particularly when the system is new, and will plug up steam nozzles thereby causing a reduction in the amount of steam flow, to the setting up of irregular lines of flow, thus reducing the amount of kinetic energy available at the discharge end of these nozzles. One procedure that is particularly desirable to follow in order to ensure a minimum amount of trouble with ejector nozzles plugging, is to blow out the steam piping as close to the ejector as possible when first starting up a new system, and subsequently after the system has run for three or four days.

Worn nozzles on the air ejectors are sometimes encountered after the unit has been in operation for several years or more, although ordinarily a properly designed ejector nozzle should last a number of years.

A steam leak may develop around the nozzle thread where it is screwed into the suction chamber. If the nozzle and nozzle plate are removed, a greyish or unnatural discoloration at the point where the nozzle joins the nozzle plate will indicate that high pressure steam has been leaking through to the suction chamber and acting as an additional load on the ejector.

The air ejector after-condenser should also be considered when faulty performance occurs. A clogged or partially closed after-condenser vent line or the accumulation of scale deposits in the tubes of the condenser may result in a back pressure on the ejectors which will impair their efficient functioning.

USING AIR EJECTOR TEST ORIFICE

The first stage of the ejector is provided with a capped test orifice which may be used to determine if the ejector is operating properly. To use the test orifice, proceed as follows:

1. Blank-off the ejector suction so that no extraneous loads are introduced to the ejector.

2. Remove pipe cap covering the air test orifice so that orifice is exposed to dry atmospheric air.

3. Check to make sure that ejector discharge is clear and unrestricted to prevent excessive back pressure at the ejector.

4. Attach pressure measurement gauge to first stage ejector at tapped 1/4 inch connection on body opposite test orifice.

5. Apply proper motive steam pressure to ejector steam chests.

6. Read suction pressure on pressure measurement gauge after ejector has reached lowest stable absolute pressure. This pressure should correspond very closely to the absolute pressure stamped on the cap if the ejector is working properly.

7. Shut down motive steam supply.

8. Replace cap on air orifice.

9. Remove blank-off on first stage suction.

Should the ejector fail to pull down to this vacuum, the following suggestions should be investigated:

1. Check to be sure proper motive steam pressure is being supplied to ejector and that the motive steam has proper steam temperature, 380 degrees F, since the ejector is designed for superheated steam.

2. Be sure all ejector connections are secure so that no air leakage occurs at any connection.

3. Investigate back pressure at ejector exhaust to make sure it is not excessive and above designed back pressure of 1 psi.

4. Inspect pressure instrument gauge to be sure gauge is reading properly and that no air leakage is occurring in the evaporator gauge lines or gauge connections.

5. Remove steam nozzle and observe if steam leakage is occurring between steam chest and steam nozzle connection.

6. Inspect steam nozzle to see that it is not plugged with foreign matter.

7. Inspect diffusers for erosion and/or corrosion.

Should ejector operate properly under test orifice conditions but fail under operating conditions, the ejector is probably being overloaded by air leaks in the evaporator or piping. (These can be found by hydrostatic test of all lines and components.)

SOLENOID TRANSFER VALVE

Adjustment and Maintenance – Closing force may be adjusted by increasing or decreasing the spring tension. Care should be taken to check valve operation by tripping after any change.

A check as to whether valve seating is being maintained should be made when relatching valve, and is indicated by the feel as of coming up solid, but a further lifting on lever "yields" on the tripping spring to allow latch to engage. Valve seating is altered by adjusting valve stem in stem connection a portion of a turn.

Valve is automatic in its duty cycle and requires only the maintenance given any automatic device. It should have periodic surface inspection and test. Pins and stem connection should be oiled.

THERMOMETERS

Method of Re-uniting Separated Mercury Columns – If the mercury column of a glass thermometer becomes separated due to a jar or shock during shipment or while in service, it can be re-united very easily by heating the thermometer bulb to a temperature somewhat higher than the maximum point on the range. The separable socket should be removed before heating the thermometer.

The heating should be done carefully, while watching the mercury column rise into the expansion chamber at the top of the glass tube.

As soon as the mercury has filled approximately half of the expansion chamber, heating should be stopped. The column should now be re-united. If not, repeat the operation until the column is entirely re-united.

DO NOT OVERHEAT the thermometer to a point where the expansion chamber will be completely filled, since the glass tube is liable to break.

Installation of Thermometers Into Separable Sockets When the thermometer is equipped with a separable socket, the socket is first removed from the thermometer and installed in its final location.

The bulb chamber, at the end of the thermometer stem, is coated with a mixture of graphite and glycerine. This mixture will act as a heat conductive medium between the inside walls of the socket and the outside walls of the bulb chamber thus increasing the response of the thermometer.

This coating should not be removed.

If a thermometer is to be installed in a socket in which the heat conducting medium was not provided, this should be applied before inserting the stem into the socket.

For heat conducting medium use a mixture of glycerine and powdered graphite. For temperatures up to 300 degrees F, a coating of vaseline or any heavy lubricant may be substituted.

ZINC PENCILS

Periodic replacement of galvanic corrosion inhibiting zinc pencils located on component water boxes is required. It is recommended that zincs be inspected on a monthly basis.

Zincs consist of five or ten individual zinc anode elements of discs held by a narrow corrosion resistant shaft which is screwed into the 1 inch retaining plug. Elements are 1 inch in diameter by 7/16 inch thick. They should be replaced when more than 1/2 eaten away. Individual elements may be ordered by Cleaver-Brooks Part Number 889-3. Retaining plugs on stage condenser and feedwater heater water boxes each hold five elements. Distillate cooler and after-condenser plugs each have ten elements.

CONDENSATE STEAM TRAP

The steam trap located in the after-condenser condensate outlet piping upstream from the salt water water heater condensate well enables air ejector motive steam condensed in the after-condenser to flow into the heater condensate well without loss of

vacuum in the heater. It also serves to prevent ejector steam from being drawn into heater condensate pump suction line.

The union connection outlet on the steam trap makes it possible to renew the valve and seat of the trap without removing it fully from the line or dismantling the trap. After breaking the union outlet, the seat can be removed with a screw driver and the needle point valve with a special wrench. The new valve is then inserted, followed by the seat, and the union again assembled.

The air cock located on top of the float housing should be loosened slightly to permit air collecting in the housing to vent to atmosphere. If the cock is tightened, the trap will not operate properly.

FEED REGULATOR

No maintenance of the feedwater heater feed regulator is required as long as condensate level is visible in the condensate well level gauge. If the valve fails to automatically maintain a constant level in the water gauge, the unit should be shutdown and the regulator disassembled to determine the cause.

Drain Regulator Overhauling Instructions – Refer to Drawing No. 822-169 in Parts Identification Section.

1. With distilling unit shutdown and heater steam supply closed, open a connection in heater drain pump suction piping in order to thoroughly drain heater condensate well.

2. Remove regulator valve mounting bolts and nuts. Remove regulator valve from drain pump discharge piping. Remove Trunion Pin (7) which will permit removal of Float (4) and Trunion Assembly (6).

3. Loosen Stem Lockout (12). Remove Stem Connection (11), Lockwasher (13), and Locknut (12).

4. Unscrew Jack Flange (17).

5. To remove Sleeve (16) from valve body, use socket wrench made from 1-1/2 inch heavy steel pipe about 8 inches long with slots cut just opposite each other on one end 1 inch deep and 13/16 inch wide. These slots will engage yoke lugs on bottom of valve sleeve. Turn socket wrench to left with pipe wrench to remove valve sleeve. The valve sleeve will drop down and out of the lock flange opening.

6. Reassembly is accomplished simply by reversing these procedures.

7. Before installing valve on condensate well, set valve and float as follows:

a. Place valve on bench so that the male flange of valve is in vertical position, permitting valve flange to rest on bench.

b. Elevate Float (4) 7/16 inch.

c. With stem locknut loose, turn Stem (14) with a screw driver until stem protrudes 5/8 inch from bottom of Sleeve (16).

d. Hold stem with screw driver and tighten Locknut (12).

8. Install new flange gasket and remount valve body.

Caution: Note direction of arrow, indicating flow, on valve body.

9. Be sure valve body has not been reversed or regulator will act as a drain valve instead of a feed valve.

DISTILLATE METER

The inlet line and all fittings should be cleaned and flushed before the meter is placed in the line. Fittings should not be overtightened. Tighten only enough to ensure sealing of joints.

Accuracy Test – Easiest means of testing accuracy of meter is to pass a measured amount of water through the meter and check against the meter register reading. If the meter is found to be inaccurate, it is recommended that it be prepared for storage in the following manner, if it is not to be repaired immediately. Insert a cork or plug into one end of the meter. Run water into the opposite end of the meter. When the meter is full of water, plug the open end, and let it stand in either an inverted or upright position until dismantled. This will allow the foreign material accumulated around parts of the meter to remain soft, which in turn will allow easier dismantling and cleaning.

Leaks – If leakage appears at the base of the register box, remove the register box, teach under the register with a 5/8 inch open end wrench and tighten the stuffing box nut 1/8 turn at a time, until the leak is stopped. Do not tighten this nut any more than necessary, as this would interfere with operation of the meter.

Interfering Meter Life – The meter can be damaged by running an air at excessive speed, when not filled with water. This can be prevented by opening the potable distillate line slowly when the distiller is being placed on the line.

The meter will be damaged if frozen. Protect it against frost, if possible.

Do not use paint or joint compound on female threads of pipe joints ahead of the meter, as it is liable to wash into the meter and clog the working parts.

EVAPORATOR INTERIOR

There are no moving parts in the evaporator. Actual components are described in Section 2 and shown on the Evaporator Assembly Drawing in Section 8. Scale deposits which reduce distillate output are those which form on the inside of the condenser tubes. These are removed by routine mechanical or chemical cleaning procedures described earlier in this section. Consequently, maintenance to the evaporator interior and component parts, which are reached by removal of the manhole cover, will seldom be required.

As long as the unit produces pure distillate at rated capacity or can be restored to this condition by the prescribed maintenance and descaling procedures, removal of the manhole cover for inspection of the interior of the stages is not required.

However, if the unit cannot be restored to rated capacity operation after fouled heat transfer tubes have been cleaned, and provided the air ejectors and pumps are operating properly, the evaporator interior should be inspected to determine if one or more of the following conditions may exist:

a. The holes in flash plates, through which the feedwater passes prior to flashing to steam, may be clogged or encrusted.

b. The horizontal splash baffles, which prevent the feedwater from letting upward in the stage, may be covered with scale to the extent that the passage of steam up to the demisters is impeded.

c. The demister mesh separators may be fouled or scaled to the extent that flash steam is impeded in its passage to the condenser at the top of the stage.

These conditions may be eliminated chemically by flooding the entire evaporator interior with a dilute acid solution and allowing the solution to remain in the evaporator until all of the scale deposits have been dissolved. An alternative to this procedure which will use less acid is the immersion in the cleaning solution of individual components after they have been removed from the evaporator interior. It is recommended that parts be removed, cleaned and replaced in one stage at a time to prevent mixing of parts. This applies particularly to the perforated flash plates which have different sized feedwater orifices in each stage.

All parts may be easily unbolted, removed and replaced after the manhole cover is unbolted. Splash baffle channels are taken out first. Next, the perforated flash plates, themselves, are removed. This allows sufficient working area to permit entrance of maintenance personnel into the stage. Bolts holding the demister mesh in position can then be unbolted to permit removal of the two sections of mesh in each stage.

TROUBLE SHOOTING GUIDE

Symptom	Cause	Remedy
1. Impure Distillate	1. Leak in stage condenser or distillate cooler tube bundle	a. Test distillate salinity at each cell to determine faulty tube bundle. Hydrotest component shell with water boxes removed to determine faulty tube. See instructions for repairing leaks.
	2. Feedwater level too high in evaporator stages	a. Inspect stage observation windows; increase brine overboard flow, and decrease feedwater flow with Valve [V-1], if necessary.
		b. Check for clogged or throttled brine pump suction or discharge line.

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Symptom	Cause	Remedy
1. Impure Distillate (Cont'd)		b. Refer to pump manufacturer's literature for faulty pump operation.
		d. Adjust feedwater flow with Valve (V-1) to maintain feedwater temperature to first stage evaporator at 170 degrees F.
		e. Adjust turbine bleed steam control valve to produce rated capacity distillate output.
	3. Distillate pure but salinity equipment malfunctioning	a. Refer to salinity equipment manufacturer's Technical Manual for faulty operation of salinity controller.
		b. Test distillate chemically to determine if pure.
	4. Distillate transfer valve not diverting impure distillate to waste	a. Check valve seating of 3-way distillate transfer valve.
	5. Insufficient feedwater flow	a. Operate with maximum feedwater flow consistent with 170 degrees F feedwater temperature and rated capacity distillate output.
		b. Clean feedwater strainer.
	6. Foaming in evaporator	a. Continue operating until condition is removed by improved feed supply source.
		b. Check feed pump suction intake for high organic content or other unusual substances in supply source.
		c. Obtain and use anti-foam compound.
2. Impure Condensate	1. Leak in air ejector after-condenser or salt water heater tube bundle	a. Test condensate salinity at each cell to determine faulty tube bundle. Hydrotest component shell with water boxes removed to determine faulty tube. See instructions for repairing leaks.
	2. Impure elector steam supply	a. Check steam supply for cause.
	3. Impure salt water heater steam supply	a. Check steam supply for cause.
3. Irregular or Surging Feedwater Flow	1. Dirty feed pump suction strainer	a. Examine strainer and clean if required.
	2. Clogged or scaled feed pump suction and discharge lines	a. Open lines and examine when unit is shutdown. Clean lines if required.

Symptom	Cause	Remedy
3. Irregular or Surging Feedwater Flow (Cont'd)	3. Faulty feed pump operation	a. See pump manufacturer's instructions.
	d. Clogged or corroded feedwater valve	a. Clean and inspect Valve (V-11.
4. Low Distillate Output	1. Salt water heater, air ejector after-condenser, and/or stage condenser tubes fouled	a. Mechanically or chemically clean fouled tubes.
	2. Poor vacuum in evaporator and/or salt water heater	a. Refer to Causes and Remedies under Symptom 5.
	3. Stage condensers flooding	a. Refer to manufacturer's instructions for causes of faulty distillate pump operation.
		b. Check for closed or throttled valve in distillate pump discharge piping.
		c. Check for loose connection in distillate pump suction piping.
	4. Feedwater temperature below 170 degrees F	a. Adjust to 170 degrees F with Valve (V-1).
	5. Steam pressure to critical flow nozzle in heater alternate steam supply line less than 5 psig	a. Adjust to 5 psig at Gauge (P-11).
	6. Salt water heater steam supply superheated	a. Adjust Valve (V-12) to prevent heater steam supply temperature at Thermometer (T-11) from exceeding heater shell temperature (T-12) by more than 10 degrees F.
	7. Unit at rated capacity but distillate meter improperly registering	a. Check meter accuracy.
		b. Determine that distillate is not by-passing meter at solenoid dump valve or meter by-pass valve.
	8. Condensed distillate leaking back into feedwater due to leak in distillate collection trough	a. Shut down unit, unbolt manhole covers, orifice assemblies, and mesh demisters. Inspect distillate troughs for leaks after filling troughs with fresh water.
	a. Steam Control Valve (V-21) insufficiently opened when operating on turbine bleed steam	a. Open up on Valve (V-21) and readjust Valve (V-1) for 170 degrees F feedwater temperature.
5. Poor Vacuum in Evaporator and/or Feedwater Heater	1. Clogged air ejector steam strainer	a. Remove and clean strainer screen when unit is shutdown.

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Symptom	Cause	Remedy
5. Poor Vacuum in Evaporator and/or Feedwater Heater (Cont'd)	2. Steam pressure to ejectors less than 180 psig	a. Increase steam pressure at Gauge (P-9) to 180 psig minimum.
	3. Wet steam reaching ejectors	a. Drain ejector steam line.
		b. Insulate ejector steam line.
		c. Increase ejector supply steam temperature to 380 degrees F.
	4. Ejector nozzles or diffusers scaled, worn, or clogged with foreign matter.	a. Shut down unit, disassemble ejectors, clean, inspect, and replace worn parts.
	5. Clogged or closed air ejector after-condenser vent to atmosphere creating back pressure on ejectors	a. Inspect after-condenser shell vent.
	6. Fouled tubes in stage condensers and salt water heater acting, in increase evaporator and heater shell pressure	a. Mechanically or chemically clean fouled tubes.
	7. Air leaking into unit	a. Check piping and instrument connections.
		b. Hydrostatic test entire unit for leaks.
		c. Check for flow of pump seal water which prevents air leakage around pump shafts.
	8. Condensate rising in salt water heater	a. Refer to pump manufacturer's instructions for faulty heater drain pump operation.
		b. Faulty drain regulator. Overhaul regulator when unit is secured.
		c. Clogged or closed drain pump discharge line. Check line and valves.
	9. Steam pressure to critical flow nozzle in alternate heater steam supply line more than 5 psig	a. Reduce to 5 psig at Pressure Gauge (P-11).
	10. Improperly adjusted Vent Valves (V-5) and (V-4)	a. Adjust salt water heater vent valve to obtain closest possible approach between the temperature of the steam in the heater shell and the temperature of feedwater emerging from the heater; adjust stage one evaporator vent valve to obtain closest possible approach between the stage one shell temperature and the sea water temperature at the outlet from the stage one distillate condenser.

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Symptom	Cause	Remedy
5. Poor Vacuum in Evaporator and/or Feedwater Heater (Cont'd)	2. Steam pressure to ejectors less than 180 psig	a. Increase steam pressure at Gauge (P-9) to 180 psig minimum.
	3. Wet steam reaching ejectors	a. Drain ejector steam line.
		b. Insulate ejector steam line.
		c. Increase ejector supply steam temperature to 380 degrees F.
	4. Ejector nozzles or diffusers scaled, worn, or clogged with foreign matter.	a. Shut down unit, disassemble ejectors, clean, inspect, and replace worn parts.
	5. Clogged or closed air ejector after-condenser vent to atmosphere creating back pressure on ejectors	a. Inspect after-condenser shell vent.
	6. Fouled tubes in stage condensers and salt water heater acting to increase evaporator and heater shell pressure	a. Mechanically or chemically clean fouled tubes.
	7. Air leaking into unit	a. Check piping and instrument connections.
		b. Hydrostatic test entire unit for leaks.
		c. Check for flow of pump seal water which prevents air leakage around pump shafts.
	8. Condensate rising in salt water heater	a. Refer to pump manufacturer's instructions for faulty heater drain pump operation.
		b. Faulty drain regulator. Overhaul regulator when unit is secured.
		c. Clogged or closed drain pump discharge line. Check line and valves.
	9. Steam pressure to critical flow nozzle in alternate heater steam supply line more than 5 psig	a. Reduce to 5 psig at Pressure Gauge (P-11).
	10. Improperly adjusted Vent Valves (V-5) and (V-4)	a. Adjust salt water heater vent valve to obtain closest possible approach between the temperature of the steam in the heater shell and the temperature of feedwater emerging from the heater; adjust stage one evaporator vent valve to obtain closest possible approach between the stage one shell temperature and the sea water temperature at the outlet from the stage one distillate condenser.

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EXHIBIT H

TECHNICAL MANUAL



EXHIBIT "H"

MARAD NO. 279-859-1-300

Technical Manual

for

Parts No. 31-8-35 Acrylic

MARINE FLASH DISTILLING PLANT

Built for Bath Iron Works Hulls 366,367,368,369

Bath Iron Works Purchase Order No. 366-223-A

MARAD Hull Nos. 279, 280, 281 & 295

by

aqua-chem, Inc.

WATER TECHNOLOGIES DIVISION
WAUKESHA, WISCONSIN U.S.A.

FOR

STATES STEAMSHIP COMPANY

M.A. DESIGN C7-S-95a RO/RO VESSELS

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C18-8864-8
Printed in U.S.A.

Manual-000548

Technical Manual

for

MARINE FLASH DISTILLING PLANT

by



WATER TECHNOLOGIES DIVISION
WAUKESHA, WISCONSIN U.S.A.

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Manual No. 11557-74

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Printed in U.S.A.

FOREWORD

This Technical Manual is furnished to provide guidance on the installation, operation, and general maintenance of the Aqua-Chem Flash Evaporator.

A background of information relating to evaporator design and principles of operation is also provided so that operating personnel can more eaeily become acquainted with the Distilling process.

This manual should be placed in the hands of the personnel responsible for operation and maintenance of the distilling plant. All sections of the book should be carefully read before commencing operation of the equipment.

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Typist/Date

Manager Publications/Date

SPECIFIC DATA PAGE

11557

WATER TECHNOLOGIES DIVISION

aqua-chem, inc.

TYPE: Two-Stage, Marine Flash Distilling Plant

MODEL: S668 FL2

OPTIONAL EQUIPMENT SUPPLIED:
Mared Book Number 279-558-1-300 Mared Hull Numbers 279, 280, 281, and 295

CUSTOMER: Bath Iron Works
ULTIMATE USER: States Steamship Company
INSTALLED AT/ON: Bath Iron Works Hull's 366, 367, 368, and 369

CUSTOMER ORDER NUMBER: 368-223-A
GOVERNMENT CONTRACT NUMBER: N/A
QUANTITY OF EQUIPMENT: 8 (2 per ship)
QUANTITY OF TECHNICAL MANUALS: 18
EQUIPMENT DATA:

- SPECIFICATION: Aqua-Chem, Inc., Bid No. M-8248 dated 5-14-73

- WEIGHTS & DIMENSIONS:

Dry	7,094 pounds	Length	8'3"
Operating	8,800 pounds	Width	8'0"
Flooded	12,475 pounds	Height	7'8"

- SERVICE (UTILITY) REQUIREMENTS:
  Ejector-230#/hr @ 135 PSIG, 358°F, Heating-Bleed 4040#/hr @ 12.25 PSIA, 210°F., Auxiliary 3780#/hr @ 35 PSIG, 281°F.
  Steam/Condensate
  Electrical: Motor - 440/3/60; Instrument - 110/1/60
  Feed: 115,900#/hr (232 GPM) @ 85°F., 30-35 PSIG
  Blowdown: 110,350#/hr (221 GPM) @ 118°F., 25 PSIG
  Product: 5550#/hr @ 90°F., 15 PSIG (11.2 GPM)
  Compressed (Instrument) Air: 60 PSIG

- SERIAL NUMBER:

AQUA-CHEM JOB NO. W-1423 MANUAL NO. 11557-74

WATER TECHNOLOGIES DIVISION
P. O. BOX 421
MILWAUKEE, WISCONSIN 53201

STANDARD SERVICE POLICY

TECHNICAL BULLETIN
750-1011

WATER TECHNOLOGIES DIVISION

aqua-chem, inc.

1. Aqua-Chem offers to supply the services of a qualified representative to advise and assist purchaser in start up, training, and servicing of Aqua-Chem equipment.

   Purchase order required prior to dispatching service representative.

2. Service Rates

   A. Domestic (within the continental limits of the United States) $ per calendar day or part thereof for each service representative.

   B. Foreign (all areas outside the continental limits of the United States including Hawaii and Alaska) $ per calendar day or part thereof for each service representative.

   C. Overtime

   Normal working time is 8 hours per day Monday through Friday except observed holidays. Time worked by each representative in excess of 8 hours per day Monday through Friday and all time worked on Saturday and Sunday will be charged for at the rate of $ per hour.

   D. Service period charges commence when the service representative leaves his base location in the United States (or his last job assignment) and end upon return to his base location.

   E. Rates quoted are firm for 90 days.

3. Unless otherwise stipulated, The Purchaser shall also pay for:

   A. The actual cost incurred by Aqua-Chem for all transportation and travel expenses of the service representative and for first class accommodations and living expenses from the time of leaving his base location until he returns.

   B. The time and expense of the service representative in securing passports, innoculations and making other required documentation in preparation for travel.

   C. All entry and exit fees, local income or other taxes, telephone and cable, and all other expenses incurred in connection with the work.

4. Unless otherwise stipulated herein, The Purchaser shall furnish at its own expense, and assume full responsibility for all labor and labor supervision and shall make available all equipment, materials and usual installation and hand tools necessary for the work.

5. Aqua-Chem shall not be liable for loss or damage due to delays in furnishing the services or in the work resulting from any cause beyond Aqua-Chem's reasonable control, including, but not limited to, compliance with any governmental regulations, orders or instructions, acts of God, acts or omissions of the Purchaser, acts of civil or military authority, fires, strikes, war, riot, or delays in transportation. Aqua-Chem shall not in any event be held liable for special, indirect or consequential damages; and no allowance will be made for repairs or alterations without its written consent or approval.

Signed _____

Date _____

Telephone: (414) - 962-0100 Telex: 26679 Cable: AQUA TWX: 910-262-3421

aqua-chem, inc.

WATER TECHNOLOGIES DIVISION
P. O. BOX 421
MILWAUKEE, WISCONSIN 53201

PARTS ORDERING INSTRUCTIONS

FOR BETTER SERVICE AND FASTER HANDLING, PLEASE BE SURE TO SHOW THE SERIAL NUMBER OF YOUR UNIT ON ALL PARTS ORDERS AND CORRESPONDENCE.

TECHNICAL BULLETIN
750-1012

WATER TECHNOLOGIES DIVISION

aqua-chem, inc.

FURNISH COMPLETE INFORMATION WHEN ORDERING PARTS

When ordering parts for your unit, be sure to include on your order the unit serial number. Your order should state the Aqua-Chem part number and the name and description of the part required. Also state the quantity desired; and specify method of shipment. Indicate date material is required. If parts are required for accessory equipment, such as electric motors, pump, etc., which may not be shown in the parts reference material, be sure to give the complete name plate data from the accessory for which the parts are required. The serial number of such accessory is essential.

RETURNING PARTS FOR REPAIR

When parts must be returned for repair or replacement at the factory, contact the Parts Department in Milwaukee stating the reasons for return and await permission and directions prior to returning the material. A Purchase Order authorizing repairs and giving complete details must be provided.

Prior to returning any item for repair, remove fittings or accessories from the component, properly drain and clean parts to comply with shipping regulations. Include inside of the package a packing slip identifying the parts, your purchase order number, and your company name.

HOW TO ORDER PARTS

Order parts by letter, wire or telephone from Aqua-Chem, Inc. Water Technologies Division, attn. Parts Department at:

Telephone: 414-962-0100
Telex: 26679
Cable: AQUA
TWX: 910-262-3421

WATER TECHNOLOGIES DIVISION
P. O. BOX 421
MILWAUKEE, WISCONSIN 53201

FINAL POSITIONING

GENERAL

Install the distilling plant in accordance with practices generally followed in the installation of heavy machinery. In moving the unit into its permanent position, care should be taken to avoid excessive stressing. Injury to flanged, screwed or welded connections may impair the ability of the unit to produce the high degree of vacuum essential for proper operation.

Lifting eyes are located at each corner at the top of the evaporator support frame to facilitate moving the unit.

The plant should be properly leveled by use of shims or leveling blocks placed under the frame as required. Leveling will prevent distortion or flexing of the unit when it is secured to the mounting structure.

Allow for adequate working room on all sides of the plant. Refer to General Assembly drawing for clearance required in front of the plant for tube bundle removal.

All heated surfaces must be adequately insulated to prevent injury.

PIPING

All piping connections to the distilling plant must be as true as possible to avoid stresses at the flanges.

This especially applies to steam lines. All piping should be independently supported and allowances made for thermal expansion, where applicable.

A. High Pressure Steam Line -- Piping to air ejectors should be supported so that no strains are imposed on the air ejectors. The steam supply piping should be carefully arranged so that it contains no pockets where water can collect.

   In order to ensure satisfactory operation and to prevent undue wear of the norrie and diffuser, it is important that steam as dry as possible be supplied to the air ejectors. All low points of the steem supply line should be trapped for continuous drainage of condensstion.

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B. Low Pressure Steam Line -- See Desuperheater & Flow Nozzle Drawing. The low pressure steam line orifice plate must be installed with the rounded edge of its critical flow orifice on the downstream side of the steam flow. The plate must be flanged into the line at least 18 inches upstream from the desuperheater spray nozzle. Steam piping must be well supported and insulated, with provisions made for thermal expansion.

C. Pumps -- Piping should fit perfectly and should be supported independently from the pump to avoid any stresses on the pump flanges. It is advisable to increase the size of both suction and discharge pipes at the pump nozzles to decrease friction losses. The piping should be arranged with as few bends as possible, and the bends should have a long radius whenever possible. Expansion and contraction of piping reaction stresses must be considered in all piping.

NOTE: Thoroughly flush out all piping before bolting to pump flanges.

D. Rupture Disc -- Pipe discharge of rupture disc to an area where no injuries will occur if disc fails.

E. Control Valve -- Install condensate control valve so that it is at least 10 feet below the bottom of the feedwater heater hotwell.

ELECTRICAL WIRING

Refer to Wiring Diagram. Only qualified electricians should hook up pump motors, salinity indicating system, etc. Observe all safety precautions:

SALINITY INDICATING EQUIPMENT

Check salinity indicating system to see that it is installed and wired in accordance with manufacturer's instructions and Wiring Diagram. Cell connections should be tightened under pressure to prevent leakage.

The salinity indicating system is comprised of the following components:

Salinity Indicator Control Panel
Four (4) Salinity Cells
External Alarm (audible and visual)
Feedwater Low Temperature Cut-Out Switch
Timer (automatic reset)
3-Way Solenoid Dump Valve, V-10

The system controls the distribution of distillate to storage or to waste, depending upon two conditions; salinity of the distillate, and the terminal temperature of the feedwater out of the feedwater heater into the evaporator. Briefly, the system works as follows. In normal operation with salinity of distillate less than 0.25 grain of salt per gallon (0.25 GPG) and feedwater terminal temperatura at 170°F, the solenoid of the 3-way dump valve V-10 is energized. This directs the flow of distillate through the 4-way cock valve and water meter to storage.

When a high distillate salinity condition occurs, the last salinity cell in the distillate discharge line relays the high salinity (high conductivity) reading to the salinity controller (in panel). The controller breaks the circuit to the timer which raleases the timer clutcb, opening the DPDT switch, thus breaking the oircuit to V-10, causing it to divert distillate to waste.

When salinity returns to acceptable limits of 0.25 GPG or lower, depending upon set point in controller, the dump valve terminals in the panel are automatically energized. Tbe timer clutch engages and the timer motor runs until its set point is reached. At the end of the pre-set time period, the DPDT switch closes, stopping the timar motor, closing the circuit to 3-way dump valve V-10. The valve then must be manually reset to deliver distillate to storage.

NOTE: The timer can be adjusted from 1.1 to 27.5 minutes, however, the U.S. Public Bealth Service requires a minimum dumping time of 15 minutes to tboroughly clean out the distillate system.

When a low feedwater terminal temperature condition occurs (below 168°F.), the low temperature cut-out switch is pulled open, breaking the circuit to the timer and consequently opening the circuit to V-10 diverting distillate to waste. When the feedwater terminal temperature rises above 168°F, the low temparature cut-out switch is pulled in, closing the circuit to the timer clutch and motor. The timer completes its cycle as described above to devert distillate to storage.

FUNCTIDNAL TESTS DF SALINITY SYSTEM

With the salinity system energized, test the system for high salinity operation as follows:

1. Set the salinity controller dial to the 0.25 GPG point.
2. Remove last salinity cell in distillate disobarge line (C-6) and immerse it in a cup of sea water. The controller dial sbould register impure distillate and V-10 sbould switch to the distillate to waste position.

3. With the distiller in normal operation and making acceptable distillate and with the feedwater terminal temperature at 170°F, slowly lower the terminal temperature to 164°F (either throttle heating steam control valve, or increase feedwater flow rate). Carefully adjust the temperature set screw on the temperature switch until it opens. Raise temperature to 170°F, and determine that the temperature switch closes, actuating the timer motor. Repeat this procedure several times to make sure the system de-energizes at 164°F, and resets at 170°F.

HYDROTESTING PROCEDURES

Although the plant was factory hydrotested, prior to initial start-up the distilling plant should be hydrotested again in order to locate any leaks that may have been accidentally caused during shipment or installation. Hydrotesting is also recommended after major internal repairs are made.

CAUTION! DO NOT EXCEED TEST PRESSURE SHOWN ON RESPECTIVE ASSEMBLY DRAWINGS.

A. Evaporator Shell

There are several ways to hydrotest an evaporator shell. Following is a procedure that uses feedwater as the test water and utilizes the feed pump and feedwater control valve, V-2.

1. De-energize salinity indicating system.
2. Tightly close distillate and brine pump discharge valves.
3. Tightly close steam supply valves to air ejectors.
4. Disconnect air ejector discharge line at after condenser. Install a suitable blank-off plate at end of line.
5. Remove shell rupture disc and blank off connection at shell with a suitable metal plate.
6. Unbolt and remove orifice plate in vent line from feedwater heater to evaporator stage 1. Make-up and install a suitable blank-off plate in its place.
7. Remove both vent plugs from top of shell. Install a pressure gauge/bleed valve assembly, in 1st stage vent connection, as shown in the illustration, "Hydrotest Gauge and Bleed Valve Setup."

8. Start feed pump and throttle feedwater control valve to control flow rate. Slowly fill shell until test water emerges from both the open vent connection and the bleed valve, then close feedwater control valve and stop feed pump.

9. Re-install vent plug and close bleed valve.

10. Restart feed pump and adjust feedwater control valve to increasa pressure to design test pressure. If test pressure is exceeded, open bleed valve and throttle feedwater control to relieve pressure. When test pressure is reached, tightly close feedwater control and stop feed pump.

11. Hold test pressure for an hour. Carefully inspect entire exterior of shell and all pipes and flanges for leaks. Also check for insulation discoloration, which indicates a leak. Observe pressure gauges for a drop in pressure, which indicatee a leak.

12. Drain test water from shell (brine pump may be used).

    a. Remove pressure gauge/bleed valve assembly and reinstall vent plug.

    b. Remove blank-off plate from end of air ejector discharge line; rebolt line to after-condenser.

    c. Remove blank-off plate in feedwater heater vent line; reinstall orifice plate.

    d. Replace rupture disc.

    NOTE: TEST WATER WILL REMAIN STANDING IN THE DISTILLATE COLLECTION TROUGHS. TO CHECK FOR LEAKS FROM BELOW, REMOVE BOTH OBSERVATION WINDOWS.

13. Start distillate pump to remove rest of test water.

14. Make necessary rapairs.

B. Feedwater Heater and After-Condenser

The feedwater heater section and the after-condenser section are tested separately.

To hydrotest feedwater heater and low pressure heating steam line, proceed as follows:

1. Close steam line shut-off valve(s).

2. Close condensate discharge valves and desuperheater water valve.

3. Unbolt and remove orifice plate in vent line from feedwater heater to evaporator. Make up and install a suitable blank-off plate in its place.

4. Make up and install a pressure gauge/bleed valve assembly at the highest point in the heating steam line.

5. Remove the shell side thermometer well and connect a suitable fresh water fill line. The fresh water fill line, or hose, must contain a shut-off valve.

6. Open bleed valve for venting off air and fill heater with test water. When test water emerges from bleed valve, shut off fill water and close bleed valve.

7. Watch pressure gauge and resume filling. When test pressure is reached, shut off fill water.

8. Hold pressure for an hour. Inspect heater shell, piping and flanges for leaks. Observe pressure gauge for any pressure drop.

   NOTE: Open shut off valve in after-condenser condensate drain line. If test water drains out of valve, it is an indication that there is an under-rolled tube(s) in the intermediate tubesheet. As it is not possible to determine which tube(s) is under-rolled, all of the tubes at the intermediate tubesheet will have to be re-rolled.

9. Drain test water from heater shell.

   a. Remove test presseure gauge/bleed valve assembly.

   b. Remove all blank-off plates and fill line. Re-install relief valve, orifice plate and thermometer.

10. Make all necessary repairs.

To hydrotest after-condenser section of feedwater heater, proceed as follows:

1. Close shut-off valve in condensate outlet line.

2. Plug or cap condensate vent line to atmosphere.

3. Oisconnect air ejector discharge line at shell. Install a suitable blank-off plate at shell connection.

4. Install a test pressure gauge/bleed valve assembly into shell vent to atmosphere.

5. Connect a suitable fresh water fill line, or hose, at V-20.

6. Open bleed valve for venting off air and slowly fill after-condenser with test water. When test water emerges from bleed valve, shut off fill water and close bleed valve.

7. Watch pressure gauge and resume filliog. When test pressure is reached, sbut off fill water.

8. Hold pressure for an hour. Iospect after-condeoser shell, piping aod flanges for leaks. Observe pressure gauge for any pressure drop.

NOTE: If test water appears in sump of feedwater heater, it is an indication that there is an under-rolled tube(s) in the intermediate tubesheet.

9. Remove fill line and drain after-condenser.

   a. Remove test pressure gauge/bleed valve assembly.

   b. Open vent lioe to atmosphere.

   c. Reconnect air ejector discharge lioe to shell.

10. Make all necessary repairs.

C. Evaporator Coodenser Tube Leakage

To verify suspected tube leakage in evaporator coodenser tube hundle proceed as follows:

1. Remove condeoser waterbox, exposing the coodenser tubesheet and tube ends. Re-iostall the bolts in the tubesheet flanges to tightly secure the tube bundle in the shell.

2. Proceed to fill shell with test water as indicated in above. Test pressure from 10 to 15 PSIG is sufficient. In any case, do not exceed shell side test pressure.

3. Check all tube eods for leaks.

Water leaking from the joint between the tubesheet and the tube indicates a loose tube, and re-rolling of the tube will be required. Water leaking from the inside of the tube indicatea a damaged or ruptured tube. Replacement of single tubes in a U-tube bundle is not always possible, depending upon the location of the damaged tube. Leaking tubes csn be sealed off with standard tube plugs. The maximum number of tubes per pass that can be plugged without seriously affecting evaporator performance is 10%. If it is necessary to plug more than 10% of the tubes in any one pass, it is recommended that tbe entire bundle be retubed. See Tube Repair or Replacement Instructions Insert.

D. Feedwater Heater and After-Condenser and Distillate Cooler Tube Leakage

To verify suspected tube leakage in feedwater heater/after condenser tube bundle, proceed as follows:

1. Remove both covers to expose the tube ends.
2. Proceed to fill shell with test water as indicated above. Do not exceed 10 PSIG.
3. Check all tube ends for leaks.
4. Proceed as under Evaporator Condenser Tube Leaksge.

PREVENTATIVE MAINTENANCE

General

The only mechanical moving parts in the distilling plant are the pumps and motors, distillate solenoid valve, water meter, and the temperature switch/timer mechanism; therefore, preventative maintenance of the major components of the plant, i.e., evaporator shell, and feedwater heater after-condenser will consist of controlling the build-up of scale in the heat transfer tubes of thos components. This is accomplished by chemical cleaning of the tubes, as required.

Scale formation will occur more rapidly in the heat transfer surfaces of the feedwater heater due to the elevated temperatures in that component. Scaling in the flash chambers of the evaporator is of little importance since scale build-up will not affect evaporator capacity, and the scale that does form will flake off end be carried out by the brine overboard flow. However, after a long period of time, it is possible that excessive scaling may occur in ths flash chamber spray pipes and on the demisters. As indicated in ths Corrective Maintenance Section, spray pipes are descaled mechanically after they have been removed from the flash chamber. Demisters can be chemically cleaned in a bath of diluted acid cleaning solution; however, it is strongly recommended that demisters be replaced rather than cleaned.

Inspection and Preventative Maintenance Jobs

A. Air Ejectors - Faulty air ejector operation, which means incomplete removal of non-condensible gases, will be indicated by a decrease in vacuum in the evaporator and feedwater heater (providing the heat transfer tubes in those components ars clean). The most important preventative maintenance to be performed is to maintain a steady supply of dry steam at, or slightly above, design pressurs, to the air ejectors and to insure that no air leaks occur in the evaporator vent line to the ejectors.

   If a condensate drain valve is installed in the steam line to the ejectors, at time of start-up, the drain should be opened to blow off any accumulated condensate and then left slightly cracked open during operation. If a steam trap is installed in the line, it will remove condensate automatically.

   The after condenser should also be considered when faulty performance occurs. A clogged or partially obstructed air ejector condenser vent line, or the accumulation of scale deposits in the tubes of the after-condenssr may result in a back pressure on the ejectnrs whiok will impair their efficient functioning.

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Refer to manufacturer's instructions in the Appendix, for instructions pertaining to testing air ejectors.

B. Appendix Material - All personnel concerned should study each piece of appendix literature to be aware of any precautionary measures and maintenance instructions.

C. Relief Valve - Periodioally test relief valve to be sure it is operational

D. Rupture Disc - Replace rupture disc yearly to prevent premature failure.

ACID CLEANING

Scaled tubes may be cleaned chemically or mechanically. Acid cleaning is the recommended procedure.

A. Indications of Scale Formation - The frequency of descaling operations will depend on temperature and composition of feedwater and how closely operating instructions are followed, therefore, a definite time schedule cannot be tabulated.

Due to the fact that variations in feedwater temperature and evaporator operating conditions will cause a definite change in the evaporator heat balance, thus affecting temperature and pressure readings, it is not advisable for the operator to determine scale formation by analysis of temperature and pressure readings alone. Positive determination of the extent of scale formation is best determined by physical inspection of tubes and tubesheets. This is done most efficiently by removing the covers from the feedwater heater waterboxes and extracting a scale sample. The above can be done during normal shutdown periods and will only require a few minntes of the operator's time. The tubes should be cleaned when scale accumulation reaches approximately 1/64" thickness.

NOTE: The evaporator can be operated in a scaled condition if a shutdown for acid cleaning cannot ba made immediately due to water demand.

This procedure will give a good indication of the amount of scale in the feedwater heater and after-condenser but only an approximation of the amount of scale in the stage condenser tube bundle. However, if the feeówater heater tube bundle requires cleaning, it can be assumed that the stage condenser tubes also require cleaning.

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NOTE: The evaporator must be acid cleaned yearly regardless of the amount of scale at that time.

Excessive scale accumulation will result in elevated temperatures and reduction of distillate production. Continuing to operate the evaporator for extended periods of time with heavily scaled tubes will contribut to difficulty in acid cleaning and possible damage to the tubes. It is therefore recommended that the evaporator be descaled when positive determination of excessive scale build-up has been made.

B. Reasons for Acid Cleaniog - During the operation of a seawater distilling plant, scale always forms on the heating surfaces of the evaporator, and in the tubes of the feedwater heater when using untreated seaweter feed. This scale is usuelly 80 to 90 percent calcium carbonate. The remainder, generally, is a mixture of calcium sulphate, magnesium hydroxide, metal oxides, silica and miscellaneous deposits. When seawater feed is treated, other deposits such as phosphate sludges, may predominate. If fresh feedwater is used, silicates or calcium sulphate may be present. The rate of build-up and composition of the deposits depend on such factors as operating temperatures, brine density and flow rates.

The distilling plant must be shut down to perform acid cleaning. Clean, fresh water should be used if at all possible.

IMPORTANT!

AC-2 Powdered Acid* or sulfamic acid ere the only chemical reagents that can be used safely in the closed acid cleaning circuit of this distilling plant. Aqua-Chem, Inc., will not be responsible for damage to components of the plant if any other chemical is used in the closed circuit.

If AC-2 or sulfamic acid will not adequately clean the heat transfer tubes, consult Aqua-Chem Service Department or qualified shypyard personnel.

SAFETY PRECAUTIONS

A. Always add acid to water, slowly and carefully, to avoid spattering. Never add water to concentrated acid.

*AC-2 Powdered Acid by Aqua-Chem, is especislly compounded for use on Aqua-Chem distilling plants.

SAFETY PRECAUTIONS

A. Always add acid to water, slowly and carefully to avoid spattering. Never add water to concentrated acid.

B. Avoid "dusting" of powdered acids.

C. Insure that all gases generated during cleaning operation are vented to weather.

SAFETY EQUIPMENT

A. Safety clothing - foul weather gear is desirable. In its absence, wool clothing is recommended.

B. Safety goggles.

C. Safety hats.

D. Rubber footwear. If boots are used, trouser legs should be outside the boot tops.

E. Signs: "DANGER - ACID" and "NO SMOKING."

ACID CLEANING CIRCOITS

There are two closed acid cleaning circuits for this plant; one througb the tubeside of the evaporator stage condensers, and feedwater heater/after-condenser, the second circuit through the feedwater heater/after-condenser only. Refer to Flow Diagram drawing.

Determine approximate quantity of acid required from the following formula:

TYPE OF ACID	SUPPLIBD	AMOUNT OF ACID REQ'D PER CLEANING	INITIAL ACID/WATER RATIO CHARGE
AC-2 or Sulfamic	As powder in polyethylene lined containers	180 lbs. for the feedwater heater/after-condenser circuit - 120 lbs. for the stage condenser circuit	10 lbs.

PREPARATION OF COMPONENTS FOR CLEANING

1. Shutdown unit as under Chapter 3 - Operation.

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2. Make sure that the gasketed joints in the unit piping which will form a part of the cleaning cycle are tight.

3. Establish the cleaning circuit desired as follows:

   A. Evaporator stage condenser and feedwater heater and after-condenser tube bundles:

      1. Connect an acid resistant hose from acid outlet line at valve V-27 (Acid Discharge) to the acid connection at valve V-28 (Acid Discharge, Condenser Inlet).

      2. Connect an acid resistant hose from outlet at valve V-30 (Acid Return) to the acid return connection at valve V-26 (Acid Pot Return)

   8. Feedwater heater and after-condenser tube bundle only:

      1. Connect an acid resistant hose from acid outlet line at valve V-27 (Acid Discharge) to the acid connection at valve V-29 (Acid Discharge, Heater Inlet).

      2. Connect an acid resistant hose from outlet at valve V-30 (Acid Return) to the acid return connection at valve V-26 (Acid Pot Return).

4. Provide a means of disposing of the spent acid thru valve V-24 (Acid Pot Drain)

5. Remove vent plugs from top of evaporator stage to allow for the venting of released gases formed when the acid solution contacts the scale deposits.

   CADTIDN: The gases generated by this reaction consist of carbon dioxide and some hydrogen. A positive means must be used to ensure venting of these gases to the weather. Allow no open flames in the vicinity of the cleaning operation.

6. Place near the acid pot the required amount of dry AC-2 or sulfamic acid.

7. Close <u>all</u> valves in the system.

<u>CLEANING PRDCEDURE</u>

A. Evaporator Stage Condenser and Feedwater Heater and After-Condenser Tube Bundles.

1. Open valve V-2 (Peedwater Control) one-quarter open. Open valve V-1 (Peedwater Shut-off) and fill evaporator with seawater to a level about 2" above floor in evaporator second stage.

2. Tightly close valves V-2 (Peedwater Control) and V-1 (Peedwater Shut-off).

3. Open valve V-7 (Brine Pump, Glaod Water, Auxiliary). Check close valve V-4 (Brine Overboard Control).

4. Start brine pump and open valve V-27 (Acid Oischarge)

5. Open valves V-28 (Acid, Condenser Inlet), V-30 (Acid Retnrn), V-26 (Acid Pot Return) and V-25 (Acid Pot Outlet).

6. After tbe water has circulated, stop brine pump and close valves V-25 (Acid Pot Outlet) and V-26 (Acid Pot Return).

7. Open valve V-24 (Acid Pot Orain) and drain pot until it is one-half full.

8. Remove flanged cover from top of pot.

9. Add initial charge of 10 lbs. of AC-2 or Sulfamic acid and stir thoroughly.

NOTE: If federal stock sulfamic acid powder is used, it will impart a red color to the solution and, ss the scale is dissolved, the color will change from red to orange or yellow. If AC-2 is used, pH test papers will be required to enable easy determination of solution pH.

10. Secure acid pot cover flange securely.

11. Open valves V-26 (Acid Pot Return) and V-25 (Acid Pot Outlet), start brine pump and circulate acid solution for 10 minutes.

12. Check the pH of the acid solution after the time interval. Add another charge of AC-2 or sulfamic each time the solution pH becomes numerically higher (less acidic) than pH 3 until the solution pH remains constant and numerially less than 3. To do this proceed as under steps 6 through 11. Oo not sllow pH to fall below 2.

13. When the solution color or pH indicates that the solution is no longer being neutralized by the scale deposits and all gas generation ceases for half an hour, the system components should be clean.

14. Flush system by draining acid solution to waste while adding seawater from the feedwater source.

CAUTION: Do not dump acid to bilge!

NOTE: At this point the tube surfaces should be inspected. If they are still scaled, repeat acid cleaning. The acid may become ineffective due to high clacium concentrations. This will give a low pH reading, but the acid will be unable to dissolve more scale.

15. Neutralize the system by circulating 5 pounds of soda ash in the same manner as acid powder. Follow with fresh water or clean seawater flusbing.

16. Drain circuit and stow all special fittings and pipe.

17. Log and describe any leaks which develop after acid cleaoing.

18. Replace any leaking gaskets.

19. Place distilling plant back in operation as sooo as possible after neutralizing the acid residue in the system.

B. Feedwater Heater/After-Condenser Tube Hundle.

1. Proceed as under "A" steps 1 through 4.

2. Opeo valves V-29, V-30, V-26, and V-25

3. Proceed as under "A" steps 6 through 19.

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ACID CLEANING GUIDE FOR FLASH-SPRAY FILM & VAPOR COMPRESSION EVAPORATORS

TECHNICAL BULLETIN

750-1009

WATER TECHNOLOGIES DIVISION

aqua-chem, inc.

SAFETY PRECAUTIONS

Introduction

Scaled heat transfer tubes are cleaned chemically by circulating a diluted acid solution through, or on the tubes. Unless directed by a higher authority, the following procedures will apply. ~~Hydrochloric (Muriatic) or~~ Sulfamic acid are the only chemical reagents recommended or discussed in this text. Acid cleaning will cause a slight, but acceptable, solution of some metal parts and will also have a slight affect on gasket materials. This low level acid attack should not reduce evaporator tube life significantly, provided that chemical cleaning is used only when necessary and in the recommended manner.

Acid cleaning should not be considered as a cure-all for all evaporator problems or as a substitute for all other evaporator maintenance. Do not neglect feedwater treatment, and cold shock technique (if applicable), with the expectation that heavy evaporator scale can be removed solely by acid cleaning.

Reasons for Acid Cleaning

During the operation of a seawater distilling plant, scale always forms on the heating surfaces of the evaporator, to some extent in the suber of the heat exchangers, and in the tubes of the feedwater heater when using untreated seawater feed. This scale is usually 80 to 90% caldum carbonate. The remainder, generally, is a mixture of calcium sulphate, magnesium hydroxide, metal oxides, silica and miscellaneous deposits. When seawater feed is treated, other deposits such as phosphate sludges, may predominate. If fresh feedwater is used, silicates or calcium sulphate may be present. The rate of build up and composition of the deposits depend on such factors as operating temperatures, brine density and flow rates. Feed treatment and cold shocking reduce the build up of scale, but do not prevent or remove deposits entirely. Indications of scale formation are the following:

1. Consistently rising temperatures in the evaporator stages (decrease in vacuum).
2. Requiring heating steam pressure above the designed set point to the feedwater heater, or heating tube bundle, to produce the specified temperature at the feedwater heater outlet.

Safety Precautions

1. Always add acid to water, slowly and carefully to avoid spattering. Never add water to a concentrated acid.
2. Provide all means possible to avoid spillage of liquid acid.
3. Avoid "dusting" of powered acids.
4. Insure that all gases generated during cleaning operation are vented to weather.

Safety Equipment

1. Safety clothing — Foul weather gear is desirable. In its absence, wool clothing is recommended.
2. Safety goggles.
3. Safety Hats.
4. Rubber footwear. If boots are used, trouser legs should be outside the boot tops.
5. Signs: "DANGER ACID" and "NO SMOKING."

While the chemicals used in acid cleaning are not unusually hazardous, they are dangerous in the sense that most chemicals are dangerous. Careless handling can result in injury to personnel and equipment. In general, all of the chemicals involved in cleaning operation are harmful to the eyes and skin. Personal contact with the chemicals should be avoided at all times. Wherever possible, the chemicals, particularly the acid should be handled by mechanical means rather than manually. Protective clothing should be worn at all times during cleaning as a precaution against accidental spillage or leakage.

The following paragraphs discuss the properties of the several chemicals of concern and first aid treatment to be applied.

~~Hydrochloric Acid~~

A. Properties. This material is irritating to the eyes, nose, respiratory tract, and skin. It reacts with metals to evolve hydrogen gas which is a fire and explosion hazard. In concentrated vapor form, it neutralizes the alkali of the tissues and can cause death from edema or spasm of the larynx and inflammation of the upper respiratory system.

Concentration in the order of 1,500 ppm to 2,000 ppm in the atmosphere are lethal for human beings during the exposure of only a few minutes. The maximum concentration that can be tolerated for an exposure of 1 hour is in a range of 50 to 100 ppm. Fortunately, concentrations of this order cannot be attained except by spilling large quantities of acid in small, closed (unventilated) compartments. Contact with concentrated solutions of HCL can cause small burns or ulcers on the hands. When HCL is swallowed, its first effect is pain at the point of contact with the mouth or throat. Other symptoms are pains in the stomach, difficulty in swallowing, nausea, and vomiting, feeble pulse, diarrhea, and collapse.

B. Fire Hazards. The hydrogen liberated when hydrochloric acid contacts certain metals such as iron and zinc is a light, colorless and odorless gas. It is not poisonous, but it can cause suffocation by replacing the oxygen in the air which sustains life. Hydrogen air mixtures containing from 4 to 74 percent of hydrogen are explosive. Since hydrogen is lighter than air, it will collect in overhead pockets and build up to explosive concentrations. Fires resulting from hydrogen explosions can be extinguished with water.

C. Treatment and Antidotes. In case of contact with acid, flush skin immediately with plenty of water and remove all affected clothing. If the eyes are affected, flush them thoroughly with warm water, and report to the sick bay immediately thereafter. If acid has been swallowed, drink a teaspoonful or more of magnesia, chalk whiting, or small pieces of soap softened in water, several glasses of milk, or several egg whites in milk, under doctor's directions. In the event of severe exposure to acid vapors or in case of spillage in a small, unventilated compartment, remove the patient immediately to fresh air. If possible, give oxygen, or if necessary, artificial respiration. Transfer the patient to the sick bay as soon as possible.

D. Storage and Handling. Whenever HCL acid is used, ventilation to the outside atmosphere should be provided. The acid should be stored in a cool, ventilated place away from fire prone areas, oxidizing agents, direct sunlight, heavy traffic, and severe mechanical shock. Containers should be kept closed and plainly labelled. Flushing water and neutralizers, such as soda ash or slaked lime should be available for immediate use in case of spillage and a drain should be available in the storage area to facilitate flushing.

Sulfamic Acid

No extra precautions are necessary in storing or handling dry sulfamic acid, however, since the acid dust will irritate the nose, eyes, and skin, careless handling which may result in its dispersion should be avoided. Sodium carbonate (soda ash) is also irritating to the eyes, oral, and nasal passages. Dusting of this material should be avoided as far as possible. Use of goggles is advised.

A. Properties. This material is mildly corrosive to metals and somewhat irritating to the skin. It is considerably less objectionable in both respects than dilute hydrochloric acid. There is no fire hazard involved in its use.

B. Treatment. If contacts of the dry powder or solution thereof occurs with the skin or clothing, flush off thoroughly with plenty of water. If the powder or solution gets into the eyes, wash out immediately and repeatedly with cool, fresh water and if any irritation develops, obtain medical attention. Use of the safety equipment will materially assist in avoiding any hazards presented in handling this material. Always add acid to water, slowly and carefully to avoid spattering. Never add water to concentrated acid.

Insure that all gases generated during the cleaning cycle (carbon dioxide) are vented to weather.

A-C 2 Powdered Acid

The properties and treatment are the same as for sulfamic acid.

Selection of Acid

For reasons indicated in Safety Precautions, sulfamic acid is <u>much</u> preferable, ~~to hydrochloric acid. In addition to its other undesirable characteristics, the use of hydrochloric acid requires the use of a special acid resistant pump, tank, and auxiliary piping~~. Order of preference is recommended as follows:

1. AC-2 Powered Acid*
2. Federal Stock Sulfamic
3. ~~Hydrochloric (Muriatic)~~

The strength of acid solutions is indicated by the pH value (see Figure 1). There are two methods to determine the pH value.

1. By use of pH papers, which when subjected to a solution will turn color and indicate pH value.
2. By use of a color indicator incorporated in the acid, such as in Federal Stock Sulfamic.

pH paper can be purchased from pharmaceutical supply houses, drug stores, or obtained from the ship's sick bay. For acid cleaning, a pH paper with a scale from 1 to 7 is recommended.

* AC-2 Powered Acid by Aqua-Chem is specially formulated for use on Aqua-Chem Distilling Units.

How does oH paoer work? An examination of the following pH chart will helo the operator become more familiar with the subject. Tht colors on thit chart are for illustration ourposes only; each manufacturer will haue its own coloring scheme.

As can be seen from tha chart, a oH of 7.0 is naither acidic or alkaline and is therefore neutrat. As the numerical valuec decrease, the acid concentration increases. Below a oH of 1.0, an acid is referred ro as a concentrated solution. For acid cleaning ourposes a maximum tri oH 2.0 will be sufficient to dissolua scale normally found in evaporators. When the acid concentration reaches a pH of 4.0 to 4.5, tha solution does not contain enough acid to dissolve scale, so an additional charge of acid will be required to tower the oH to 2.0 to continua acid cleaning.

Faderal Stock Sulfamic Acid

When one pound of this acid powder is dissolued in one gallon of water, the solution will turn a light red color, indicating sufficient acid concentration to dissolve scale. If tha solution is heated to approximately 120 – 140°F., the color will change to a deep red. As the solution is circulated through the evaporator components and comes in contact with scale deposits, a chemical reaction takes place between the scale and acid which dissolves the scale and reduces the concentration of the acid. The by-product of the chemical reaction is the liberation of carbon dioxide gas which is vented to atmosphara at some point in the cleaning circuit.

As the acid is circulated and the chemical reaction takes olace, scale ic dissolved, consuming acid in the orocess, and the solution will gradually change in color to orange or yellow, indicating that about 85% of the initial charge has been dissiciated. At this time a recharge of sulfamic acid will be required to increase the acid strength and change the color back to red.

Periodic recharging will be required until the acid solution remains red for 1/2 to 3/4 of an hour after the last acid charge. When this color condition occurs, the operator can be assured that all soluble scale in the cleaning circuit has been dissolved since the acid strength is no tenger being dissipated by contact with scale.

The acid should now be completely drained from she olant and the entire cleaning circuit flushed with large quantides of fresh seawater.

CAUTION: Do not dump spent acid solutioo to bilge.

A-C 2 Powdered Acid

There are uarious ways to determinc acid concentration tuch as exact volumetric mixing, chemical filtration and electronic lab equiomant, all of which require quatified personnet.

There is also another inexpensive, accurate and fairly easy way to determina acid concentration. This is with the use of pH papers. For those personnet who are familiar with the use of pH paoer, tha following exolanation will be a refrether course. For thosa personnel not acquainted with thls method, the following will be a guide.

oH is an abbreulation tor "power of the hydrogen ion." oH paoer is a chemically treated strio of ribbon-like paoer which is tensitive to acid or alkaline solutions. When a oiece of chic paoer is dioped into an acid or alkaline solution, it thanget color. The colot change has a definite relationshio to the acidity or alkalinity of the solution being tested. In thit exolanation, we are prmarily concerned with acid solutions, so no further referencet will be made to alkaline solutions.

In general, the procedures for uting oH papers are at follows:

Prepare the evaoorator for acid cleaning. After water it being circulated in the cleaning circuit, add tha initial dose of acid to the acid pot. Shortly after the solution hat circulated, draw off a small samole of tha solution and dio a olece of oH paoer into it. It is onlu necessary to molsten the paper. The paper will now change color. Comoare the color of the paper to the colot comparator chart tuoolied with the paoer. If the pH ualue ir numerically greater than 2.0 (3.0, 4.0, etc.) add mere acid into the cleaning circuit and make the same test again.

When the oH reaches 2.0, continue to circulara the tolution. As the acid contacts tha scale in the evaoorator tubes, the acid will be consumed as the chemical reaction takes place. After aoproximately 15 minutes, take another samole and oerform the same test. If the oH of the solution is 4.0 or higher, add another charge of acid until a oH of 2.0 is once again established. Repeat this procedure untit the acid solution holdt at gH 2.0 lor 1/2 to 3/4 of an hour after the last acid charge. When thit condition occurs, it can be assumed that all scale in tha cleaning circuit has been dissolved and no additional acid is required.

Drain the cleaning circuit and flush the entire system with large quantities of fresh seawater.

NOTE: Do oot dump the abid solution to the bilge.

Remove a drain olug from the fast or hottest pact of the feedwater through tha evaporator waterbox and usually insoect the tubes and tube sheets for scale depotits.

~~Hydrochloric (Muriatic) Acid~~

~~This acid should only be used it A-C 2 or sulfamic acid is not available, and then only by qualified personnel experienced in its use. It ic essential that the operator understand the potential danger involved in the use of this acid. If proper safety precautions are followed, injury to personnel or equipment can be avoided and acid cleaning of the evaporator can be accomplished in a minimum of down time.~~

Prepare the evaporator and component equipment for acid cleaning. After cleaning system has been assembled, filled with water, and recirculation has begun, proceed as follows:

1. Add acid to the acid tank or pot.

   CAUTION: Always add acid to water – never add water to a concentrated acid.

2. Check the acid concentration with pH papers as outlined in the instructions of sulfamic acid cleaning.

   NOTE: Maximum acid concentration should not be appreciably less than pH 2.0.

3. Circulate solution to dissolve scale.

   CAUTION: All gases generated during the cleaning cycle must be vented to weather. No cooking allowed.

4. Make periodic checks of the acid concentration with pH papers as described above.

5. When all scale has been dissolved and gas generation has ceased, drain the plant acid flush completely with large quantities of fresh seawater. The best way to flush out the plant is to put it back into normal operation.

	pH Value	Strength	pH of Household Items	pH of Industrial Chemicals	Logarithmic Value to Pure Water
	0			Sulfuric Acid 4.9% (1.0 N)	10,000,000
	1.0	Very strong		Hydrochloric Acid 0.37% (0.01 N)	1,000,000
	2.0		Lemon Juice		100,000
INCREASING ACIDITY	2.6	Will dissolve average scale			
	3.0		Orange Juice	Acetic Acid 0.67 (0.1 N1	10,000
	4.0	Fairly strong	Beer		1,000
	4.5	Too weak to dissolve scale			
	5.0		American Cheese		100
	6.0	Mild	Milk		10
NEUTRAL	7.0	Neutral	Distilled Water at 77°F. (25°C)		1
	8.0	Mild	Egg White		10
	9.0		Borax		100
INCREASING ALKALINITY	10.0	Fairly strong	Milk of Magnesia		1,000
	11.0			Ammonia 1.7% (0.5 N)	10,000
	12.0			Caustic Soda 0.4% (0.1 N)	100,000
	13.0	Very strong			1,000,000
	14.0			Caustic Soda 4.0% (1.0 N)	10,000,000

043-8074 REV. 3/71
Printed in U.S.A.



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CORRECTIVE MAINTENANCE

IMPURE DISTILLATE OR CONDENSATE

A. Salinity Equipment Malfunction - For operational testing procedures pertaining to the salinity system, refer to Chapter 1. For corrective maintenance procedures pertaining to the salinity system, refer to manufacturer's instructions in Appendix.

B. Foaming - When operating the distilling plant in contaminated waters, it is possible that contaminants can carry over with the flashed vapors and contaminate the distillate in the condensing stage when there is an excess amount of foaming in the evaporator. However, foaming, which is caused by a high concentration of organic substances in the feedwater is usually self-corrective and should not be a major problem. If foaming persists, an anti-foam compound can be injected into the inlet feedwater line or if possible, temporarily shut the distilling plant down until the feedwater improves.

The only other way raw seawater can get into the distillate or condensate is from faulty heat transfer tubes in the evaporator condenser, or in the feedwatar heater. It can only happen if a tube(s) is ruptured (from corrosion or being cut), or from an under-rolled tube end in a tubesheet. Due to the large number of tubes in a bundle, approximately 10 percent of tha tubes per pass can be plugged up to stop seawater from flowing through them before tube replacement action is taken. Under-rolled tube ends can usually be re-rolled to stop the leak. See Tube Repair or Replacement Instructions.

TRACING LEAKS

The first step in tracing a leak is to determioe the tube bundle in which it is occurring. The existence of salinity cells downstream from the distillate and condensate condensers provides a ready means of determining the approximate location of a leaky tuba. When a high conductivity reading is indicated at only one cell location, the leak will be found in the tube bundle upstream from this cell. When high conductivity readings are obtained at several cells, the leak will most likely be located in the tube bundle upstream of the first cell in the series of those giving unacceptable readings.

The leak in the suspected tube bundle can be located by removing its waterbox or cover and hydrostatically testing the shell space

surrounding the tubes. If the leak is due to a cut or corroded tube, water will emerge from the end of the faulty tube. If the leak is due to an under-rolled tube, water will emerge from the joint between the tube and the tubesheet.

EVAPORATOR TUBE BUNDLE REMOVAL

Due to the heavy weight and bulk of the evaporator tube bundles, heavy duty hoisting and supporting equipment is required. See following illustration. The lifting fixture is not supplied, therefore, it must be locally fabricated. There are two important points to remember when removing or installing a heavy tube bundle:

1. The bundle must be pulled out, or pushed in, perfectly straight and level from the evaporator shell.

2. When clear of the evaporator shell, the bundle should always be supported vertically at the tube support plates, not around the tubes themselves.

CAUTION! Before attempting to remove a tube bundle, all internals must be vented and the unit completely drained and cooled. Remote line valves should be locked shut.

Before removing tube bundle, remove inter-stage vent orifice "O" ring grommet and "O" ring grommet at air ejector suction line. See Evaporator Assembly drawing.

Remove the tube bundle as indicated and place the assembly in an area with access room to the front and rear. Be sure the tube bundle is well supported.

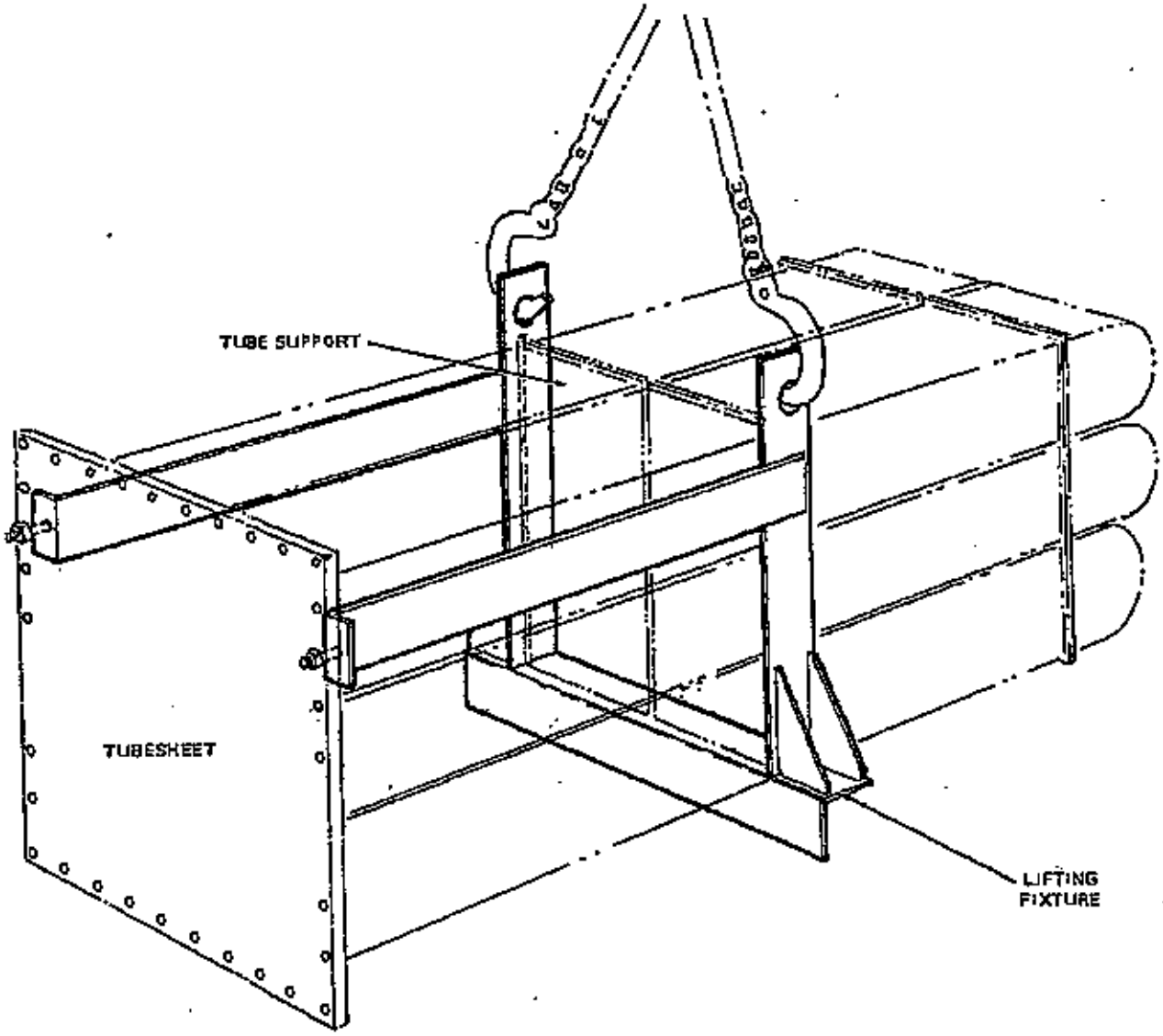
EVAPORATOR TUBE BUNDLE REPLACEMENT

The tube bundle must be slid in perfectly straight and level with the shell and must be well supported. Great care must be exercised when replacing the tube bundle to prevent damage.

Be sure to place new and unused "O" ring grommets in their proper places as noted on the evaporator assembly drawing.

EVAPORATOR INTERIOR

There are no moving parts inside the evaporator shell. Scale deposits which reduce distillate output are those which form inside the condenser tubes. This condition is rectified by chemical cleaning



TUBE BUNDLE REMOVAL

procedures.

As long as the plant produces pure distillate at rated capacity, or can be restored to thie condition by the prescribed maintenance and descaling procedures, removal of manhole covers for inspection of the interior of the stages is not required.

However, if tbe unit cannot be restored to rated output after fouled heat transfer tubes have been cleaned, and provided the air ejectors and pumps are operating properly, the evaporator interior should be inspected to determine if either the demieters or the orifice of the spray pipes, or both, have accumulated excessive scale build-up.

DEMISTER REPLACEMENT AND INSTALLATION

In order to make pure distillate, it is important that the demister pads be installed carefully. There must be no gaps along tbe sides of the demisters, nr between the demisters and the sbell wall, or adjacent demisters. If there are gaps, vapor will shoot directly up through the gap, carrying salt entrained feedwater with it, past the demisters, contaminating the distillate.

A visual inspection must be made after replacement installation to make sure that there are no gaps. Demisters were designed to be installed with a "squeeze" on all sides to ensure a tight fit. The side walls surrounding the demisters must be square and must be braced to hold their dimensions, so that they won't flex and open up a gap.

NOTE: Removal of demisters ie not a routine maintenance procedure, therefore, they sbould not be removed unlese absolutely neceesary. The supporting rods must first be removed before the demisters can be removed, and tbey must be replaced after demister installation.

EVAPORATOR OR HEAT EXCHANGER TUBE REPAIR OR REPLACEMENT STRAIGHT & U-TUBE

INSTRUCTION SHEET

750-1501

WATER TECHNOLOGIES DIVISION

aqua-chem, inc

GENERAL

Faulty tubes may be sealed with tube plugs or they may be replaced. Single tube replacement is not recommended. Leaks at the rolled tube-sheet joints can be repaired by simply re-rolling the tube. If tubes are ruptured, they can be plugged or replaced.

The following correctly sized special tools are required in order to repair or replace tubes:

- Tube Expander and Mandrel
- Tube Drill
- Tube Cutter
- Knock-out Tool
- Belling (Flaring) Tool
- Tube Pilot

REPAIR

Re-rolling Tubes to Seal Tube Sheet Joint

Leaks at tube sheet joints, due to under-rolling, can usually be corrected by carefully re-expanding the tube ends.

Tube expanding, also called tube rolling, is the cold working of a tube end to form a pressure tight joint between the tube and its seat (tube sheet). The thinning of the tube end causes stresses in the tube end and its seat. These stresses determine the holding power of the joint. The holding power is determined by the specific pressure that the equipment must withstand. Tubes and tube sheets of different metals, thicknesses and diameters require specific degrees of expanding to develop maximum joint strength. In any case, over-rolling may cause flaking of the tube, which would probably fail in service.

Controlled rolling (torque rolling) will eliminate under or over-rolling. This requires the use of a special portable motor that senses torque and stops rotation of the expander when a pre-set torque, or tightness of the tube, has been reached.

Plugging or Replacing Ruptured Tube

Ruptured tubes may be sealed with tube plugs or they can be replaced.

NOTE: Replacing just a few tubes in a large tube bundle is not recommended, nor is some cases possible; i.e., inner most tubes of a "U" tube bundle. Instead, plug up 10 to 15 percent of faulty tubes per pass, then consider re-tubing the entire tube bundle.

U-TUBE REPLACEMENT

1. Remove evaporator tube bundle.

   NOTE: Due to the heavy weight and bulk of the evaporator tube bundle, heavy duty hoisting and support equipment, e.g., overhead crane, chain falls, slings, etc., will be required.

2. Place the tube bundle assembly in an area with access room in front and rear. Be sure that the tube bundle is rigidly supported.

TUBE REMOVAL

Remove tubes as follows:

1. For belled tubes, insert tube cutter and rotate tool to cut the tube end flush with the tube sheet face.

   NOTE: If the tube to be replaced is an inner tube, the tubes surrounding this tube shall also have to be removed to provide access to the faulty tube.

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2. Insert tube drill into end of tube and rotate tool to cut away the tube wall for about three quarters of the depth of the tube sheet, eliminating most of the tube sheet support. Extreme care must be taken to avoid damaging tube sheet holes.

   NOTE: Most smaller tubes can be removed with only the use of a knock-out tool. Try that procedure before using a tube drill.

3. Insert knock-out tool against shoulder created by the drill. Rap tool with a ball peen hammer to force tube out of tube sheet(s).

4. When free of the tube sheet(s), pull the tube out from the opposite end.

TUBE REPLACEMENT

Replace tubes as follows:

1. Select new tube of correct length and remove all rust and foreign matter from both inside and outside of the tube end. Tube ends must be clean for the full depth of the tube sheet.

2. Insert tube into tube sheet, using the tube pilot (bullet) as a guide. Tube ends should project 1/16" maximum beyond outer face of tube sheet.

3. Firmly hold tube in place and expand both ends into tube sheet. Expander may be operated with an air driven motor, electric drill, or a hand wrench. Expand to only within 1/8" of the inner face of the tube sheet.

   Limits of Expansion:

   (1) Steel tubes - 8 to 16% of tube wall thickness.

   (2) All other tubes - 8 to 12% of tube wall thickness.

   Examples: .049 wall at 12% = Maximum expansion of .012"
   .049 wall at 16% = Maximum expansion of .014"

4. For inlet tubes, insert belling tool into tube end and rap with a ball peen hammer to bell end flush with tube sheet face.

5. Grind off both ends of tubes flush with tube sheet face.

6. Hydrotest tube bundle.

STRAIGHT TUBE REPLACEMENT

The same procedures apply to replacing straight tubes as replacing U-tubes except that there are two (2) tubesheets and each straight tube is readily accessible.

CARE AND LUBRICATION OF TUBE EXPANDER

Thoroughly clean all parts of expander. Make sure that rolls and mandrel are free and in good condition.

Lubricate expander rolls with a pressure resistant lubricant.

After rolling each tube, dip expander rolls in a solvent of light oil. Inspect the rolls and mandrel. Replace any chipped rolls or mandrel.

After the job is complete, thoroughly clean all parts and tools and store them in a manner that will prevent rusting.

If maintenance personnel are not familiar with tube repair or replacement, it is recommended that the tube bundle be returned to Aqua-Chem, Inc., for repair, or if that is not practical, contact Aqua-Chem Service Department or one of its field representatives.

INSTRUCTION SHEET

750-1502

DEMISTER (VAPOR SEPARATOR) REPLACEMENT & INSTALLATION

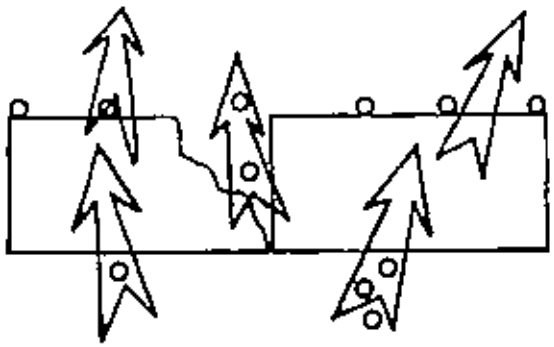
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NOTE: REMOVAL OF DEMISTERS IS NOT A RDUTINE MAINTENANCE PRDCEDURE, THEREPDRE, THEY SHDULD NOT BE REMOVED UNLESS ABSDLUTELY NECESSARV.

In order to make pure distillate, it is important that the demister be installed carefully. There should be no gaps along the sides of the demisters, or between the demisters and the shell wall, or adjacent demisters. If there are gaps, vapor will shoot directly up through the gap, carrying entrained feedwater with it, past the demisters, contaminating the distillate.

A visual inspection must be made after replacement installation to make sure that there are no gaps. Demisters were designed to be installed with a "squeeze" on all sides to ensure a tight fit, without gaps. The side walls surrounding the demisters must be square and must be braced to hold their dimensions, so that they won't flex and open up a gap. When demisters are slid into place, care must be taken so that they are not distorted. If top of the demister "hangs up", the following can happen:



With a casual inspection from below, the demisters would appear to be all right. However, the V-shaped gap between the two demisters would permit considerable carry-over of entrained feedwater. Only careful installation can prevent this from happening. In cases where a demister must be slid past metal spacer rods or bars, or especially when it must be slid past another demister, a sheet metal "shoe horn" should be made to permit the demister to be moved into position without distorting its shape.

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TROUBLE SHOOTING GUIDE

A trouble shooting guide is only a guide and should not be interpreted to be the only procedure to be followed. Familiarity with the distilling plant operation, gained through experience, is the best guide an operator or maintenance technician can have. Because there is no way of predicting what troubles will occur, or in what order, the following sequences of causes and remedies are not necessarily in their correct order. Further, local conditions may result in other causes and remedies. In any case, perform the easiest, most obvious steps first.

SYMPTOM	REMEDIES
SYMPTOM 1 - IMPURE DISTILLATE	
1. Poor plant heat balance.	a. Check all flow rates, temperatures, pressures, steam supplies and feedwater heater terminal temperature per Flow Diagram.
	b. Check air ejector operation. See Symptom 3.
2. Foaming in evaporator stages caused by high organic content in feedwater.	a. Continue operating until condition is corrected by improved feed supply source.
	b. Inject anti-foam compound into feedwater line.
	c. Temporarily shut down plant.
3. Brine flooding evaporator stages.	a. Fully open brine pump discharge. Throttle feedwater control valve temporarily, but do not allow terminal temperature to exceed 170°F. for very long.
	b. When shut down, inspect the following: (1) Internal brine strainer. (2) Brine pump impeller, discharge and suction lines.
	c. Trouble shoot brine pump and/or motor.

4.	Distillate pure but salinity indicating equipment malfunctioning.	a. Test the distillate chemically to determins purity. b. Refer to Salinity Equipment Manual.
5.	Distillate solenoid valve not diverting impure distillate to waste.	a. Trouble shoot valve per manufacturer's instructions.
6.	Thermal switch and/or timer malfunction.	a. Trouble shoot per manufacturer's instructions. b. See testing procedures, Chapter 2.
7.	Demisters improperly installed allowing carryover.	a. Shut down plant. When cool, remove cover and thoroughly inspect demisters in both stages for gaps or holes in mesh. Replace or correct. NOTE: If the plant has been producing good distillate, this procedure is not necessary unless heavy scaling of demisters is suspected.
8.	Leaks in evaporator stage condenser allowing seawater to mix with distillate.	a. Check distillate salinity cells to dstermine faulty bundle(s). Shut down plant, remove watsr box to expose tube ends and hydrotest tube bundle. Plug or replace faulty tubes.

SYMPTOM 2 - LOW DISTILLATE OUTPUT

1.	Poor plant heat balance.	a. See Cause No. 1, Symptom 1.
2.	Pure distillate dumped to waste.	a. See Causes 4, 5, and 6, Symptom 1
3.	Scaled evaporator and/or feedwater heater tubes.	a. Chemically clean tubes.
4.	Condensed distillate leaking back into feed-	a. Shut down unit, remove manhole covers and remove demisters.

	water due to leak in distillate collection troughs.	Inspect distillate troughs for leaks after filling troughs with fresh water. Repair leaks.
5.	Poor vacuum.	a. See Symptom 4.
6.	Heating steam pressure too low.	a. Adjust minimum setting as indicated on Flow Diagram.
7.	Feedwater heater steam supply superheated when operating in port.	a. Increase desuperheater flow rate.
8.	Seawater feed temperature of first stage below 170°F.	a. See Cause 1, Symptom 6.
8.	Faulty distillate pump or motor.	a. Trouble shoot pump and/or motor.

SYMPTOM 3 - IMPURE CONDENSATE

1.	Poor plant heat balance.	a. See Cause No. 1, Symptom 1.
2.	Contaminated steam supply to feedwater heater and air ejectors.	a. Test steam source.
3.	Condensate pure but salinity indicating equipment malfunctioning.	a. Chemically test condensate. b. Refer to Salinity Equipment Manual.
4.	Leaks in feedwater heater and/or after-condenser tubes allowing seawater to mix with condensate.	a. Shut down plant, remove waterboxes to expose tube ends and hydrotest tube bundle. Plug or replace tubes. NOTE: Impure condensate may continue to contaminate steam supply for some time after fault has been corrected.

SYMPTOM 4 - POOR VACUUM

1.	Poor plant heat balance.	a. See Cause No. 1, Symptom 1.

2.	Wet or low pressure steam supply to Air Ejectors.	a. Drain ejector steam line.
		b. Temporarily increase steam pressure and temperature above normal.
		c. Insulate ejector steam line.
3.	After-condenser vents to atmosphere clogged.	a. Clean out vent lines.
4.	Air leaks in lines to evaporator and/or feedwater heater.	a. Check tightness of flanged connections.
5.	Air leaks in vent line to air ejectors.	a. Check tightness of flanged connections. Inspect line for cracks.
6.	Air leaks in evaporator or feedwater heater.	a. Shut plant down and hydrotest each component, repair leaks.
7.	Clogged air ejector steam strainers.	a. Shut plant down, remove and blow out strainers. Inspect nozzle at same time.
8.	Scaled tubes in evaporator and/or feedwater heater causing an increase in pressure (lose of vacuum) and poor condensing action.	a. Chemically clean tubes.
9.	Ejector nozzles or diffuser scaled, worn or clogged with foreign matter.	a. Shut down plant, disassemble ejectors, clean and replace worn parts per manufacturer's instructions.

SYMPTOM 5 - SURGING FLOWS

1.	Pump cavitation.	a. Throttle pump discharge control valve and vent pump. Readjust control valve.
		b. Check for air leakage in pump suction line.
2.	Faulty pump/or motor operation.	a. See Pump Manual.

3.	Clogged feedwater pump suction strainer.	a. Clean strainer.
4.	Clogged or corroded pump suction or discharge control valve.	a. Clean or replace faulty valve.
5.	Pump impeller clogged with scale or debris.	a. Disassemble and inspect pump.
6.	Clogged or corroded feedwater valves.	a. Clean or replace faulty valves.

SYMPTOM 6 - HIGH OR LOW BRINE LEVEL

1.	Poor plant heat balance.	a. See Cause No. 1, Symptom 1.
2.	Clogged brine discharge strainer in evaporator.	a. Shut down plant, clean strainer.
3.	Obstruction in brine overboard line.	a. Oetermine wbere pressure drop is occurring and remedy.

SYMPTOM 7 - HIGH OR LOW DISTILLATE LEVEL

1.	See Causes and Remedies, Symptom 6, that apply to distillate pump.	
2.	Maladjusted distillate pump discharge.	a. Readjust to obtain correct distillate flow per Flow Oiagram.

SYMPTOM 8 - HIGH OR LOW CONDENSATE LEVEL

1.	Orain regulator malfunction.	a. By-pass and control level manually. b. When shut down, repair or replace valve.

SYMPTOM 9 - INCORRECT FEEDWATER HEATER TERMINAL TEMPERATURE

1.	Feedwater control valve not operating correctly.	a. Readjust temperature pilot for 17D°F.

2.	Poor plant heat balance.	a. See Cause No. 1, Symptom 1.
3.	Poor venting of feedwater heater.	a. See Cause No. 4.
4.	Scaled feedwater heater tubes.	a. Chemically clean tubes.
5.	Flooding of feedwater beater shell.	a. See Symptom 8.
6.	Heating steam pressure incorrect.	a. Adjust to correct pressure.
7.	Steam supply superheated when operating "in port".	a. Readjust desuperheater control valve to hold temperature at T-8 from 5 to 10 degrees higher than T-9.

SPARE PARTS LIST

ITEM NO.	DESCRIPTION	AQUA-CHEM PART NO.	QUANTITY
15	Gasket, In/Out Waterbox	32 - 9943	1
16	Gasket, Return Waterbox, Syn. Rubber per MIL-R-21252	32 - 9947	1
17	Gasket for Victualic Size 2.5 IPS Style 77 Coupling	N.P.N.	1
18	Spares for Sentinel Relief Valve, V-27 (940-8193) Spring	N.P.N.	1
19	Valve Disc	N.P.N.	1
20	Spares for Air Ejector (934-A-7755) 1st Stage Nozzle Figure 540	N.P.N.	1
21	1st Stage, Gasket, Steam Cheat (Iron)	N.P.N.	1
22	1st Stage, Gasket, Nozzle (Ankorite)	N.P.N.	1
23	1st Stage, Gasket, Diffuser (Iron)	N.P.N.	1
24	2nd Stage Nozzle Figure 555	N.P.N.	1
25	2nd Stage, Gasket, Steam Chest (Iron)	N.P.N.	1
26	2nd Stage, Gasket, Nozzle (Ankorite)	N.P.N.	1
27	2Dd Stage, Gasket, Diffuser (Iron)	N.P.N.	1
28	Spares for Distillate Pump (699-D-7774) Shaft Sleeve, Monel	76 - 7511	1

SPARE PARTS LIST

ITEM NO.	DESCRIPTION	AQUA-CHEM PART NO.	QUANTITY
29	Impeller	192 - 7555	1
30	Wear Ring, Impeller	66 - 7946	1
31	Wear Ring, Casing	66 - 7945	1
32	Set Screws, Monel, Self Lock	860 - 7544	2
33	Spares for Brine Pump (699-D-7773) Impeller, Monel 10" O.D.	192 - 7520	1
34	"O" Ring Gasket for Mechanical Seal	853 - 7782	2
35	Shaft Sleeve, Monel	76 - 7565	1
36	Throat Bushing, Bronze	10 - 7514	1
37	Impeller Key, Monel	142 - 7505	1
38	Gasket, Cover	32 - 8206	1
39	Gasket, Shaft Sleeve	853 - 7592	1
40	Wear Ring, Impeller	66 - 7651	2
41	Wear Rings, Case	66 - 7636	1
42	Wear Ring, Suction Cover	66 - 7640	1
43	Spares for Chemical Treat. Pump Piston, 5/8 Diameter	007 - 4	1

SPARE PARTS LIST

ITEM NO.	DESCRIPTION	AQUA-CHEM PART NO.	QUANTITY
44	Packing, 5/8 Bore	012 - 4	Set
45	Valve Ass'y, Discharge Check	002 -D	1
46	Valve Ass'y Suction Check	002 - 5	1
47	Solenoid Coil for Dump Valve 948-A-7668	N.P.N.	1

LIST OF DRAWINGS

General Assembly	641-D-7986
Bill of Material	600-A-9338
Flow Diagram	627-D-8464
Symbols	389-B-7792
Valve Schedule	613-B-8268
Pressure Gauge and Thermometer Schedule	613-B-8263
Wiring Diagram	627-D-8463
Evaporator Assembly	633-E-7992
Feedwater Heater Assembly	649-D-7565
Piping Assembly	696-D-8237
Pressure Gauge Panel Assembly	508-D-7831
Acid Pot	732-C-7590
Desuperheater and Flow Nozzle	507-B-9251
Tube Bundle Assembly	534-E-8708
Observation Window Assembly	550-B-7537
Sight Glass Assembly	31-B-35

EXHIBIT I

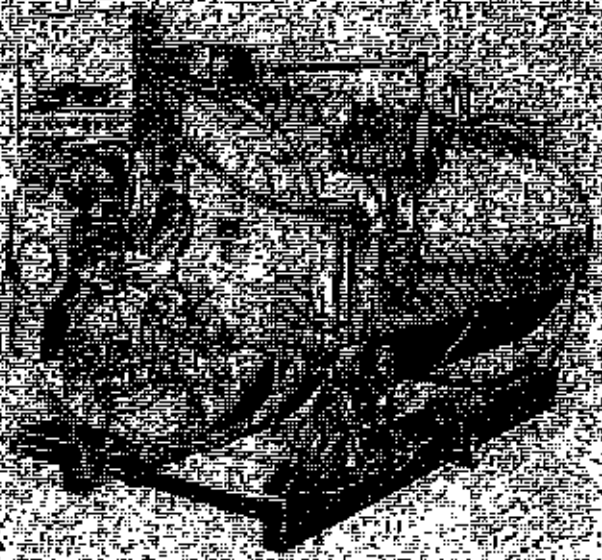
OPERATING MANUAL

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PARTS LIST

Fuel: Light Oil, Gas, or Combination

Model CB Boiler



50 thru 100 HP

Cleaver-Brooks

MILWAUKEE, WIS.

Manual Part No. 7[illegible]

EXHIBIT "I"

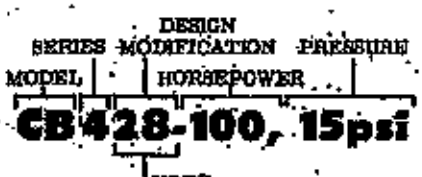
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MODEL NUMBER DESIGNATION

The boiler Model Number Designation consists of the letters "CB" indicating the MODEL, a three digit series number indicating type of fuel and electrical and mechanical design modifications, followed by a dash and a number indicating the rated boiler horsepower. Boiler design pressure completes the designation.

For Example:

A Model "CB" boiler built for operation with either Commercial Standard Number 3 Oil, or Gas, rated at 100 hp, and designed for 15 psi would have the following Model Number Designation.



NOTE
THIS MANUAL COVERS ALL STANDARD DESIGN MODIFICATIONS INDICATED BY ANY CHANGE IN THESE TWO DIGITS.

Cleaver-Brooks Fuel Designations

Series	Fuel	Series	Fuel
100	No. 2 Oil	600	No. 3 Oil
200	No. 2 Oil or Gas	700	Gas
300	No. 5 Oil or Gas	800	No. 4 Oil
400	No. 3 Oil or Gas	900	No. 4 Oil or Gas
500	No. 5 Oil		

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OPERATING MANUAL
and
PARTS LIST

Fuel: Light Oil, Gas, or Combination

Model CB Boiler

50 thru 100 HP

Replacement Price $5.00

Direct Orders for Replacement Manuals to

Cleaver Brooks

SERVICE DEPARTMENT
P. O. BOX 429
MILWAUKEE, WIS. 53201
U.S.A.

Manual Part No. 750-65

LITHO U.S.A.

8/65

MPS_0052467

Cleaver-Brooks

MODEL CB BOILER

700 SERIES FUEL: GAS ONLY 50-200 HP

HANG THIS CARD NEAR BURNER

GENERAL PREPARATIONS FOR STARTING

1. Fill steam boiler to about 2½ inches from bottom of gauge. Fill hot water boilers.
2. Close all fuel cocks.
3. The high limit control is adjusted to shut down burner at the desired high temperature or pressure. This value must never exceed the safety valve pressure setting.
4. Set modulating pressure (or temperature) control at operating value.
5. Set selector switch at "Manual" and turn manual flame control potentiometer to "Closed."

SPECIFIC INSTRUCTIONS

1. Close all oil valves and gas cocks and set selector switch, if furnished, to "Gas."
2. Gas supply pressure should be 11 inches of water measured at pilot line takeoff point (at 50-60 hp boilers, 5 inches for 70-80 hp, 6 inches for 100-750 hp when firing at maximum rate and 9 inches for 700 hp boilers.
3. Turn knurled wheel to programming control to "0."
4. Close all electric entrance switches.
5. Open pilot shutoff cock; and leave main cock closed.
6. Remove scanner (see connector plate. Turn burner switch to "On;" open pilot gas cock on burner train. The pilot flame can be observed through scanner opening.
7. Turn adjustment screw on regulator, if furnished, all the way in. Turn adjustment screw back out until a workable pilot is established.
8. Oil pilot pressure is normally controlled by a fixed orifice. No adjustment is necessary.
9. Turn burner switch to "Off."

STARTING THE BURNER

1. Open main gas cock and turn burner switch to "On." Burner will light. Check combustion with CO_2 readings and check gas consumption to obtain proper efficiency and rated horsepower.
2. Set selector switch to "Automatic." Burner will operate on full modulation principle.

TO SHUT DOWN BURNER

Turn burner switch to "Off."

COMBUSTION AIR AND FUEL ADJUSTMENT

Cams and linkages have been adjusted under load conditions at the factory to give correct burner operation at all loads. CAUTION: Do not change any of these adjustments unless thoroughly familiar with detailed instructions as given in the Operating Manual.

LIMIT SHUTDOWN

Investigate the cause of any unusual shutdown. Check fuel supply and clean lens of scanner. Actuate reset button on programming control to restore operation. If burner still fails to light, check ignition components.

SHUTDOWN FOR EXTENDED PERIOD

Fill boiler with treated water; close all valves and open all service switches. Swing boiler head open and close manual ventilating through boiler tubes.

—DO—

1. Study operating manual thoroughly before attempting to operate this boiler.
2. Keep gauge glass, if used, and all gauges clean and well lighted.
3. Check the operation of low water controls at least once a week under actual operating conditions by draining water from boiler. Burner should shut down when water reaches safe level.
4. Check flame failure control weekly by removing scanner. In two seconds burner should shut down.
5. Clean electrodes periodically.
6. Stop all, wisps of steam leaks promptly to avoid damage.
7. Keep boiler and boiler room clean to lessen fire and accident hazards.

—DON'T—

1. Don't start burner unless water level is within normal range.
2. Don't continue operation with unsafe ignition.
3. Don't use feedwater not approved by boiler water specialists.
4. Don't change settings of pop valve.

CAUTION: Never tamper, or in any way circumvent the action of the low water cutoff control. To operate without this safety control is exceedingly dangerous. Never attempt to change any adjustments on the programming control.

Notice DATE OF INSTALLATION

These brief operating instructions assume that the boiler has been properly conditioned for operation. Before calling for service consult your operating manual, then, check the fuel supply, electric supply fuses, etc. If difficulty cannot be corrected call your nearest Cleaver-Brooks representative or the Service Division, P.O. Box 208, Milwaukee, Wisconsin 53201, Phone 962-0800.

Printed in U.S.A. CB-757

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Cleaver-Brooks

MILWAUKEE, WISCONSIN 53201

Cable Address CLEBRO

TO: Boiler Owners, Operating or Maintenance Personnel

This Operating Manual presents information which will help the persons concerned to properly operate and care for the unit.

Study its contents carefully. The unit will provide good service and continued operation if correct operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principle of operation of the unit and its components is thoroughly understood.

Any "automatic" features included in the design of the unit do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of his boiler.

Cleaver-Brooks self-contained boilers are designed and engineered to give long life and excellent service on the job. Certain electrical and mechanical safety devices are employed to make the boiler automatic, or semi-automatic in operation, and these devices require systematic or periodic maintenance.

Because of state or local codes, there are a variety of electrical controls and safety devices which vary considerably from boiler to boiler. To describe the operation of a typical boiler of this type, this manual contains a section on sequence of operations which is designed to show the operator how a basic boiler operates. Detailed questions regarding the actual wiring of the individual boiler can be obtained by referring to the wiring diagram and sequence of operations chart found in the panel of your boiler.

Operating and safety controls will normally function for long periods of time. We have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunction of controls leads to uneconomical operation and boiler damage, and in most cases can be traced directly to carelessness and deficiencies in testing and maintenance.

Most cases of major boiler damage are the result of operation with low water.

We cannot emphasize too strongly the need for complete testing and maintenance procedure.

It is recommended that cross connecting piping to Low Water devices be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the Low Water devices. Similarly, any float bowls of Low Water devices should be inspected frequently to check for the presence of foreign substances that would impede the float ball movement.

The water side condition of boiler pressure vessel is of extreme importance. Water side surfaces should be inspected frequently to check for the presence of any mud, sludge, scale, or corrosion.

It is customary to engage the services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices.

Very truly yours,

CLEAVER-BROOKS COMPANY

ORIGINATOR AND LARGEST PRODUCER OF PACKAGED BOILERS.

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CHAPTER 4

STARTING PROCEDURES

A. GENERAL PROCEDURE
B. PRELIMINARY STARTING PROCEDURES FOR HOT WATER BOILERS
C. PRELIMINARY STARTING PROCEDURES FOR STEAM BOILERS
D. PRELIMINARY STARTING PROCEDURES FOR SERIES 200 (COMBINATION LIGHT OIL OR GAS) BOILERS
E. PRELIMINARY STARTING PROCEDURES FOR BURNING LIGHT OIL (SERIES 100)
F. NORMAL STARTING PROCEDURES FOR OIL
G. PRELIMINARY STARTING PROCEDURES FOR BURNING GAS (SERIES 700)
H. NORMAL STARTING PROCEDURES FOR GAS

A. GENERAL PROCEDURE

Since this manual covers both hot water and steam boilers, to be fired with either light oil, gas, or a combination burner designed for firing with either fuel, it will be necessary to:

(1) Follow directions specifically applying to either hot water or steam and —

(2) Follow directions applying to combination burners (if boiler is Series 200) and —

(3) Follow directions specifically applying to the fuel that is to be burned, either light oil or gas.

It is recommended that these starting instructions be read through completely until they are thoroughly understood, BEFORE ATTEMPTING TO OPERATE THE BOILER, rather than performing each operation as it is read for the first time.

CAUTION

Do not relight the pilot or attempt to start the main burner, either oil or gas, if combustion chamber (furnace) is hot and/or if gas, oil vapor, or combustion gases are present in the furnace or flue-passages of the boiler.

The burner and control system is designed to provide a safety "pre-purge" period of 45 seconds blower operation prior to establishing of ignition spark and pilot flame. Do not attempt to alter the system in any way which might circumvent this safety feature.

B. PRELIMINARY STARTING PROCEDURES FOR HOT WATER BOILERS

CAUTION

Prior to firing of boiler, make certain that discharge piping from Hot Water Relief Valves and/or discharge piping from all drain valves is piped to a SAFE point of discharge, so that emission of hot water or steam cannot possibly cause injury to personnel or property.

NOTE

Refer to suggestions on Fuel Oil Treatment in Chapter F, Section A, of this manual.

Verify supply of fuel and proper voltage; that is, check for blown fuses or fusetrons, open circuit-breakers, dropped-out overloads, etc. Check resets on Blower Motor Starter and on Lockout Switch; reset if necessary. The number "0" should be showing in the Combustion Control Window of the Timer Motor in the Flame Safeguard and Programming Control.

Initial Boil-Out of New Unit:

Internal capacity of the five sizes of Model CB Boiler covered by this manual is as follows:

Boiler Model and Size	Water--Gallons		Water--Weight	
	Normal	Flooded	Normal	Flooded
CB50	375	440	3125	3665
CB60	350	420	2920	3500
CB70	550	650	4625	5420
CB80	535	630	4450	5250
CB100	610	715	5085	5960

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Recommended procedure for boiling out new units prior to initial firing is as follows:

(1) Soda ash and caustic soda are the suggested chemicals for the cleansing of boilers. The quantities will vary according to conditions but an amount from 3 to 5 pounds of each chemical per 1000 pounds of water will generally suffice.

(2) When dissolving chemicals, the chemical should be added to the water. NEVER ADD WATER TO THE CHEMICALS! A small amount of water should be placed in the bottom of the container in which the chemicals are to be dissolved. Then small amounts of chemical are GRADUALLY added, with careful stirring, until such time as the chemicals have been completely dissolved. The heat created and resultant boiling when chemical is added to the water must be kept under control to prevent excessive turbulence and possible injury to personnel. For that reason, only small amounts of chemical should be added at any one time.

CAUTION

Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals.

(3) The solution prepared according to directions above should be poured into the boiler and then filled, preferably to a top opening where overflow can take place.

(4) CAUTION: It is MANDATORY that Water Relief Valves (or Steam Safety Valves, in the case of steam boilers) be removed from the upper portion of the boiler before adding boil-out solution, so that none of the cleaning solution (or the grease which it may carry) will be carried into the devices.

(5) It is, of course, necessary to close valves leading to and from the piping to prevent the cleaning solution from getting into the system.

(6) An overflow pipe should be screwed into one of the top boiler openings and connected to a convenient drain.

(7) The boiler should then be fired intermittently at a low rate, sufficient to hold solution just at the boiling point. The boil-out operation should be carried out for several hours and then the boiler should be permitted to stand overnight.

(8) The following day, after making certain the unit is properly cooled, drain the boiler of the cleaning solution.

(9) Then, hand-hole and man-hole plates are to be removed and internal surfaces are to be rinsed or flushed clean and free of deposits, using a high-pressure water hose.

After boil-out procedure given above (which may be omitted in the case of units previously used or known to be internally clean), have been completed, consideration must be given to the possibility of contaminating materials entering the boiler from the system. Refer to Chapter 7 of this manual and follow procedures given there regarding feedwater treatment.

Air Removal from the Boiler:

All Cleaver-Brooks hot water boiler outlet connections include a dip tube which extends 3 to 8 inches into the boiler. This dip tube does not allow any air (which may be trapped at the top of the shell) to enter into the system.

Any oxygen or air which is released in the boiler will collect or be trapped at the top of the boiler shell.

The air vent tapping on the top center line of the boiler should be piped into the expansion or compression tank. Any air which is trapped at the top of the boiler will find its way out of the boiler through this tapping.

Maximum Boiler Water Temperature:

Boilers constructed in accordance with Section IV, Low Pressure Heating Boilers, of the ASME Boiler and Pressure Vessel Code can be operated with water temperatures up to 250 degrees F.

Boilers for operation over 250 degrees F must be constructed in accordance with Section I, Power Boilers, of the ASME Boiler and Pressure Vessel Code.

Minimum Boiler Water Temperature:

The minimum recommended boiler water temperature is 170 degrees F. When water temperatures lower than 170 degrees F are used, the combustion gases are reduced in temperature to a point where the water vapor condenses. The next result is that corrosion occurs in the fireside of the boiler and breaching.

This condensation problem is more severe on a unit which operates intermittently and which is greatly oversized for the actual load. This is not a matter which can be controlled by boiler design, since an efficient boiler extracts all the possible heat from the combustion gases. However, this problem can be minimized by maintaining boiler water temperatures above 170 degrees F.

Rapid Replacement of Boiler Water:

The system layout and controls should be arranged and operated so as to positively prevent the possibility of introducing large quantities of cold water into a hot boiler or system or -- conversely -- introduction of large quantities of hot water into a cold boiler or system. If either of these conditions occur, it could cause "shock" or severe, possibly

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CHAPTER 7
MAINTENANCE

A. GENERAL MAINTENANCE
B. REFRACTORY MAINTENANCE
C. BURNER MAINTENANCE
D. ELECTRODE MAINTENANCE
E. MAINTENANCE OF LOW WATER CUTOFF AND WATER LEVEL CONTROLS
F. OPERATING LIMIT PRESSURE CONTROL (STEAM)
G. OPERATING LIMIT TEMPERATURE CONTROL (HOT WATER)
H. ATOMIZING AIR PROVING SWITCH
I. COMBUSTION AIR PROVING SWITCH
J. LIGHT OIL PUMP
K. CLUTCH ASSEMBLY
L. BACK PRESSURE ORIFICE
M. OIL VALVES
N. OIL STRAINERS
O. MOTOR STARTERS
P. MAINTENANCE OF BELTS
Q. SAFETY VALVES
R. EXTENDED BOILER LAY-UP
S. MAINTENANCE OF AIR PUMP LUBRICATING SYSTEM
T. MAINTENANCE OF CASELESS FAN
U. FUSETRON REPLACEMENT CHART

A. GENERAL MAINTENANCE

The operator should, at all times, watch for steam, water, and fuel connection leaks; repairing them as soon as they are noticed. Periodically check the tightness of adjusting screws, locknuts, sheave setscrews, valve packings, etc., maintaining when necessary.

Fuel Oil Treatment:

Conditions and quality of fuel oil being supplied to the burner may vary to the extent and degree that use of fuel oil additives may be indicated to assist in control of burning and handling characteristics.

Feedwater Treatment:

Requirements for feedwater treatment vary considerably and depend upon the pressure or temperature at which the boiler is operated, the raw water source, etc. It is strongly recommended that feedwater treatment be used, because it is a means of prolonging boiler life. A water consultant or reliable water treating company should be contacted and their recommendations followed rigidly.

Cleaning of Piping:

All new boiler piping as well as steam and water piping systems connected to the boiler, contain oil, grease and foreign matter. These impurities must be removed to prevent damage to boiler heating surfaces. On steam systems, the condensate may be wasted until tests show the elimination of undesirable impurities. It is emphasized that condensate should not be wasted if the boiler is operated with untreated water.

On hot water systems, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult water treatment companies for recommendations, cleaning compounds and application procedures.

Cleaning the Pressure Vessel:

The boiler (pressure vessel) and steam and return lines or hot water piping, to effect, represent a closed system. Although the steam and return (condensate) lines or the hot water piping (system) may have been cleaned, per paragraph "Cleaning of Piping," it is possible that:

(a) Cleaning has been inadequate---

(b) Partial or total old system involved---

(c) Conditions prevent adequate cleaning of piping.

Therefore, the pressure vessel will receive an accumulation of foreign material from the system. Since heat is transferred to the boiler water at its point of contact with the furnace, tube sheet and tube metal, it is normal for sludge, mud, scale, settlings and sediment to the water to accumulate on the

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waterside of these metal parts. Such deposits, if present, will not only shorten life of the pressure vessel and interfere with efficient boiler operation as well as functioning of control or safety devices, but they could quite possibly be the cause of unnecessary and expensive rework, repairs and downtime.

Since actual water-side inspection will reveal true internal conditions, we recommend such internal inspection on a periodic basis as a check against conditions indicated by chemical analysis of the boiler water. The frequency of the periodic inspection will depend solely upon internal conditions found. Therefore it will be necessary to flush out any accumulated deposits by periodic partial draining. The frequency of such partial draining, as well as quantity of water resolved at that time, will depend primarily upon the innate condition and properties of the water being used. Any water lost from the boiler through partial draining must be replaced and the raw makeup water must be treated in the same manner as the original fill of water.

The conditions to which the unit will be subjected should be considered and cleaning of the water-side of the pressure vessel should be provided either during the course of the initial start-up or very shortly thereafter.

Your water consultant, or water treating company will be able to recommend a cleaning or boil-out procedure. In the event such service is unavailable or as yet unselected, the following information may be of assistance:

Initial Boil-Out of New Unit:

Internal capacity of the five sizes of Model CB Boiler covered by this manual is as follows:

Boiler Model and Size	Water — Gallons		Water -- Weight	
	Normal	Flooded	Normal	Flooded
CB50	375	440	3125	3658
CB60	360	420	3020	3500
CB70	650	650	4625	5420
CB80	535	630	4460	5250
CB100	610	715	5085	5960

Recommended procedure for boiling out new units prior to initial firing is as follows:

(1) Soda ash and caustic soda are the suggested chemicals for the cleansing of boilers. The quantities will vary according to conditions but an amount from 3 to 5 pounds of each chemical per 1000 pounds of water will generally suffice.

(2) When dissolving chemicals, the chemical should be added to the water. NEVER ADD WATER TO THE CHEMICALS! A small amount of water should be placed in the bottom of the container in which the chemicals are to be dissolved. Then small amounts of chemical are GRADUALLY added, with careful stirring, until such time as the chemicals have been completely dissolved. The heat created and resultant boiling when chemical is added to the water must be kept under control to prevent excessive turbulence and possible injury to personnel. For that reason, only small amounts of chemical should be added at any one time.

CAUTION

Use of a suitable face mask or safety goggles and protective garments is strongly recommended while handling or mixing caustic chemicals.

(3) The solution prepared according to directions above should be poured into the boiler and then filled, preferably to a top opening where overflow can take place.

(4) CAUTION: It is MANDATORY that Water Relief Valves (or Steam Safety Valves, in the case of steam boilers) be removed from the upper portion of the boiler before adding boil-out solution, so that none of the cleaning solution (or the grease which it may carry) will be carried into the devices.

(5) It is, of course, necessary to close valves leading in and from the piping to prevent the cleaning solution from getting into the system.

(6) An overflow pipe should be screwed into one of the top boiler openings and conducted to a convenient drain.

(7) The boiler should then be fired intermittently at a low rate, sufficient to hold solution just at the boiling point. The boil-out operation should be carried out for several hours and then the boiler should be permitted to stand overnight.

(8) The following day, after making certain the unit is properly cooled, drain the boiler of the cleaning solution.

(9) Then, hand-hole and man-hole plates are to be removed and internal surfaces are to be rinsed or flushed clean and free of deposits, using a high-pressure water hose.

After boil-out procedure given above (which may be omitted in the case of units previously used or known to be internally clean), has been completed, consideration must be given to the possibility of contaminating materials entering the boiler from the system. Refer to Chapter 4 of this manual and follow procedures given there regarding feedwater treatment.

Washing Out the Boiler (Steam):

No later than three months after initially placing the boiler in operation, and starting service, and there-

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after as conditions warrant, the boiler should be drained, hand-hole covers removed, and the interior water-side surfaces should be inspected for corrosion, pitting or formations of deposits. Upon completion of inspection, the boiler interior should be flushed out with a high-pressure hose, as required. If deposits are not fully removed by such flushing, this may require immediate consultation with your water consultant or feedwater treatment company and, in extreme cases, it may be necessary to resort to acid cleaning. Should acid cleaning be required, professional advice is recommended. Such inspection will indicate the effectiveness of the feedwater treatment. The relative degree of effectiveness of treatment, water conditions and amount of fresh make-up water required all are factors to be considered in establishing frequency of future boiler wash-out periods. At later wash-outs, the condition of the water-side surfaces will indicate the effectiveness of the water treating program as well as the suitability of the intervals between wash-outs. Feedwater consultant or water treatment company service should include periodic inspection and re-analysis.

Washing Out the Boiler (Hot Water):

In theory, a hot water system and boiler that have been initially cleaned, filled with raw water and that water treated and with no make-up water added, will require no further cleaning or treatment. Since the system (new or old) might allow for the entrance of air and because there may be unnoticed or undetected leakage, the possibility must be considered that such introduction of raw water or air may lead to pitting, corrosion, or the formation of sludge, sediment, scale, etc., on the water-side of pressure vessel metal parts.

If the operator is completely certain that the system is tight, then annual inspection of water-side of the pressure vessel may be sufficient.

If, on the other hand, there is any entry of air or any appreciable addition of raw make-up water to the system, the unit should be inspected (water-side) no later than three months after initially placing the boiler in operation and starting service and periodically thereafter or indicated by conditions observed at times of inspection.

At the time of such inspections, the boiler should be drained, its hand-hole covers removed, and the interior water-side surfaces should be inspected for corrosion, pitting or formation of deposits. Upon completion of inspection, the boiler interior should be flushed out with a high-pressure hose as required.

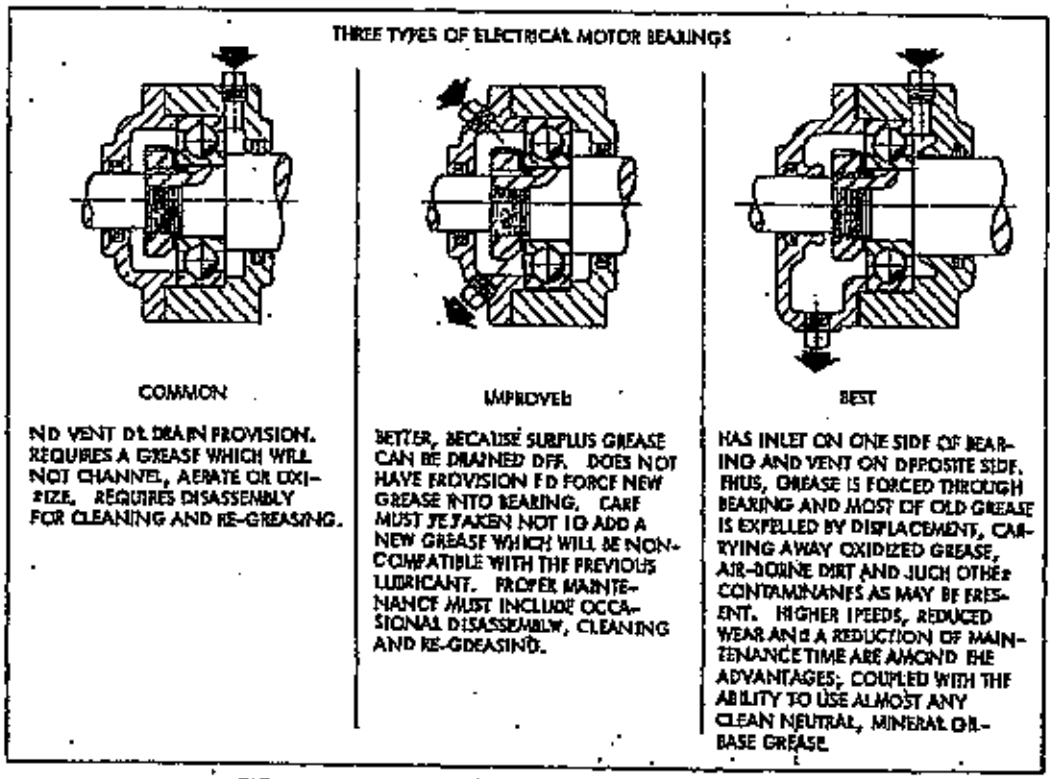


FIGURE 7-1. METHODS OF MOTOR BEARING LUBRICATION

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If deposits are not fully removed by such flushing, this may require immediate consultation with your water consultant or feedwater treatment company and, in extreme cases, it may be necessary to resort to acid cleaning. Should acid cleaning be required, professional advice is recommended. Such inspection will indicate the effectiveness of the feedwater treatment. The relative degree of effectiveness of treatment, water conditions, and amount of fresh make-up water required all are factors to be considered in establishing frequency of future boiler wash-out periods. At later wash-outs, the condition of the water-side surfaces will indicate the effectiveness of the water treating program as well as the suitability of the intervals between wash-outs. Feedwater consultant or water treatment company service should include periodic inspection and re-analysis.

There is a tendency for operators to mistakenly assume that a system is without leakage because of the difficulty of detecting the actual quantity of makeup added to the system during operation. Since the admission of raw make-up water definitely requires treatment in the same manner as water used for complete filling, a water meter capable of accurately recording low rates of flowage is recommended for installation in the make-up line to the system or boiler as a checkpoint for guidance of the operator in determining any leakage or the quantities requirements for additional treatment.

Flame Safeguard and Programming Control:

Maintenance of this control is covered in the last page of Bulletin CB-1 which may be found in the rear of this manual.

Cleaning the Fire Tubes:

Inspect the fire side of the tubes the first time the boiler is washed out and clean if necessary. Accuracy of burner adjustments will dictate need for subsequent cleaning. Refer to Chapter 5 for instructions on Secondary Air Adjustment.

Tube cleaning is accomplished by opening front and rear doors. Before opening front head, be sure to remove Clamp Ring around burner back plate. Tubes may be brushed from either end. All loose soot and accumulations should be removed. Coat the head gaskets with graphite and oil before closing the doors.

Lubrication of Blower Motor:

Manufacturers of electric motors vary widely in their specifications as to the lubrication and care of motor bearings. For maintenance of the make and manufacture of blower motor installed on your unit, follow recommendations of the motor manufacturer.

Recommended Lubricants:

All bearings require a special type of lubricant. An ordinary cup grease should NOT be used. Acceptable greases for normal service and for bearing temperatures between 20 and 200 degrees F should be similar or equal to one of the following types, which are listed for guidance only:

MANUFACTURER	TYPE DESIGNATION
Texas Oil Co.	Regal Starlak No. 2
Standard Oil Co.	Stanchar Grease No. 2
Shell Oil Co.	Retinax A
Esso-Standard Oil	Andok Lubricant B
Socony Mobil Oil Co.	BRB No. 1
Sinclair Refining	Dorolube Grade 1

For abnormal conditions, including high temperature, low temperature, high speed applications, wet or dusty conditions, etc., various special lubricants may be required. For information, consult your lubricant supplier.

B. REFRACTORY MAINTENANCE

The areas in which refractory is installed are as follows:

Front Inner Door Insulation

Dry Oven Insulation

Furnace Liner Refractory

Rear Door Refractory

(1) Front Inner Door Insulation:

Unless complete replacement is required, this insulation or V-Block Mix may be cut out in the affected areas and new material applied by troweling method.

To replace V-Block Mix refractory in Front Inner Door, mix the V-Block Mix with water to a troweling consistency, making certain that the mixing is completely uniform, with no portion either wetter or dryer than the other.

Inspect the cup-headed insulation pins for correct number, spacing and condition.

Apply V-Block Mix, beginning at bottom of door, to a thickness equal to the shrouded portion. Using a trowel, apply V-Block Mix horizontally back and forth across the door, in layers, until the required thickness is reached.

Allow to air-dry as long as possible. If immediate use of boiler is required, slowly and intermittently fire boiler, if possible.

(2) Dry Oven Insulation:

On this series of boilers, the burner housing and Dry Oven are essentially one assembly. Normally the Dry Oven requires little or no maintenance since it is backed up or covered by the front portion of the furnace liner. Should the Dry Oven refractory require maintenance, this is a V-Block Mix and only requires refilling or patching to original contours.

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It is necessary to make certain that the V-Hook bits is uniformly mixed.

(2) Furnace Liner Refractory

(a) Maintenance

A wash coating of Firebrick No. 1, diluted with water to the consistency of cream, applied from time to time, will prolong the life of the Furnace Liner refractory. Recoating intervals will vary with operating loads, and are best determined by the operator when the heads are open for tube cleaning. Firebrick No. 1 is a ready-to-use, air-setting material.

To maintain liners, fuse all joints or cracks, using Firebrick No. 1, applied with a trowel or fingertips. This should be done as soon as cracks are detected. Should segments of liners become burned out or broken, replace with material of the same kind.

Broken or burned out Furnace Liner refractories should be removed as soon as they are detected, so that they will not fuse to the bottom of the Furnace and obstruct the flame.

(b) Removals

Refer to figure 7-8, showing furnace liner in plain furnace (low pressure boilers) and figure 7-9, showing furnace liner in corrugated furnace (power boilers).

The proper refractory should be ordered and on hand prior to removal of existing Furnace Liner refractory. Make certain that parts received will form a circle to conform to Furnace inside diameter.

Furnace Liner refractory may be installed from either front or rear of the boiler, but in either case, one connection is hotMill Furnace Liner refractory at the seal of the Dry Oven.

Existing liner should be removed and Furnace steel (inside diameter of Furnace covered by liner) must be thoroughly cleaned of all refractory cement or other foreign material to insure new liner seating firmly to Furnace Steel.

After cleaning steel, Furnace metal should be inspected for soundness.

Note, from figures 7-8 and 7-9, that procedure for replacement of furnace liner is essentially the same for either plain or corrugated furnaces, as all boilers covered by this manual.

Furnace Liner refractories are to fit tightly against inside diameter of Furnace.

It is recommended that Furnace Liner refractory be fitted dry, notch-marked, removed, and then re-installed with proper refractory cement. If the fit is too loose, and a fill piece is required, such fill piece must, at time of final installation, be at the bottom of the Furnace.

It is possible that in removal of existing Furnace Liner refractories, you will note a metal ring or some pieces of eight inch welded to the inside diameter of the Furnace at a point beyond the seal of

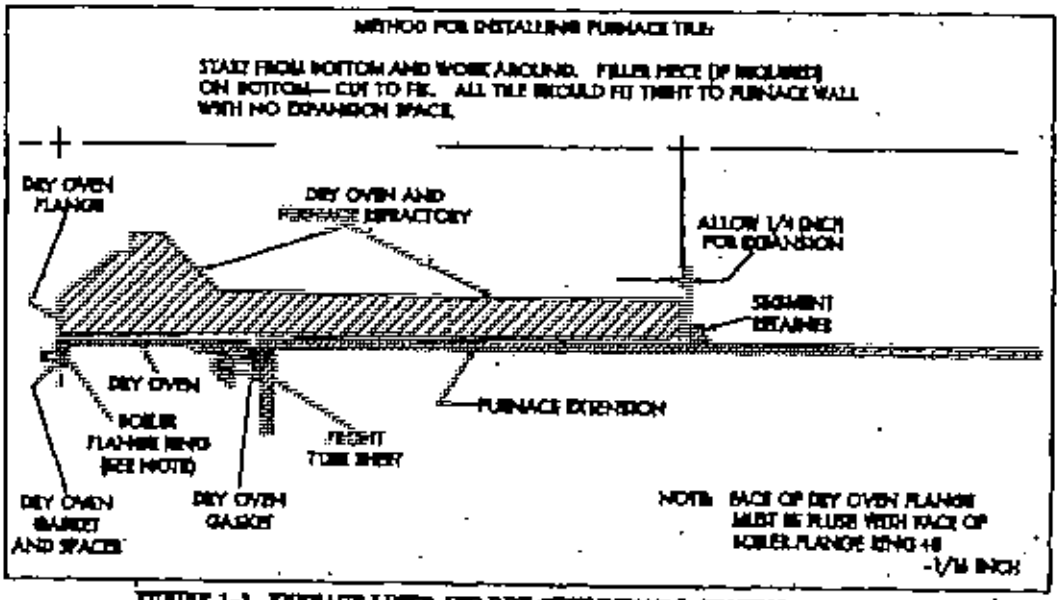


FIGURE 7-8. FURNACE LINER AND DRY OVEN DETAILS, SHOWING PLAIN TYPE FURNACE USED ON LOW PRESSURE BOILER

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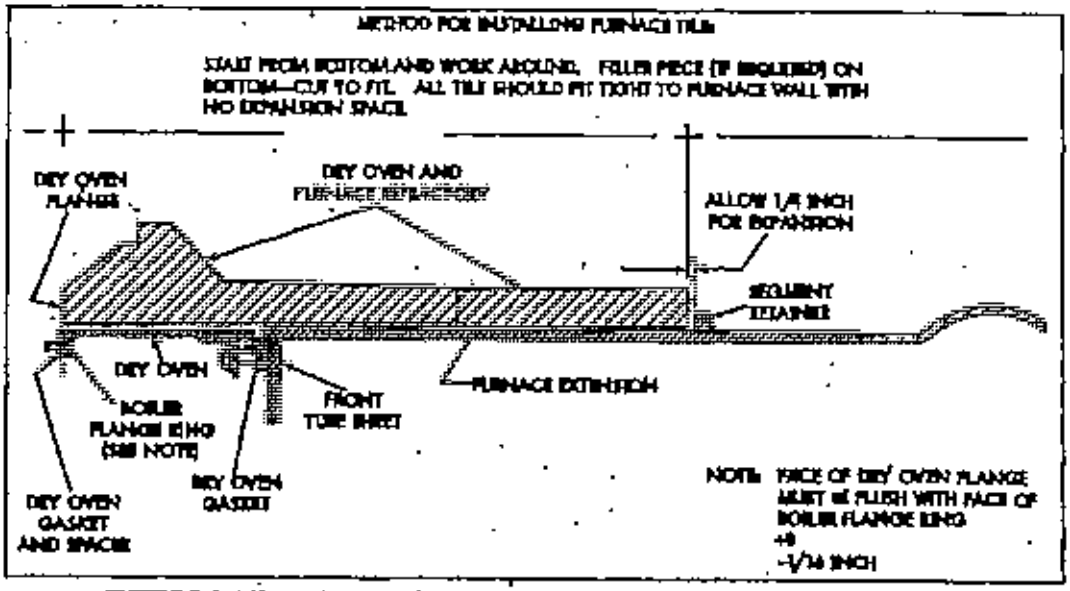


FIGURE 7-3. FURNACE LINER AND DRY OVEN DETAIL, SHOWING CONSOLIDATED-TYPE FURNACE USED ON HIGH PRESSURE ("POWER") BOILER.

the Furnace Liner refractories. Such rings or angles, if found, were originally installed to prevent shifting of Furnace Liner refractories during shipment of the boiler once the boiler is installed, they serve no further purpose and may be removed. If the metal ring or pieces of angle iron not removed at the time of replacing the Furnace Liner, it is essential that a 1/8 inch space be left between the rear of the Furnace Liner refractory and the rear surface of the metal ring or shipping bracket, as shown in Figure 7-1 and 7-3. Failure to allow space for lengthwise expansion will cause undue cracking and deterioration of the refractory tiles.

After completion of installation of Furnace Liner refractories, wash-coat the entire liner with Fire-brex No. 2, diluted with water to the consistency of cream, with particular attention to the filling of any cracks in the Furnace Liner refractory joints.

(d). Rear Door Refractory:

(a) Maintenance

The Rear Door on a Clarkey-Brooks boiler performs four main functions. These are:

1. It retains the heat.

2. It directs the combustion gases through the "Four-Pass" Clarkey-Brooks design.

3. It prevents leakage of combustion gases.

4. It provides access for inspection, cleaning, etc.

Essentially, the Rear Door is a steel shell lined with insulation material and suitable refractory; it also positions a horizontal baffle tile.

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble. This may be an indication of other conditions, such as:

1. Leaky gaskets.

2. Improper seal.

3. Door retaining bolts tightened insufficiently or unevenly.

4. The air line running from the front of the boiler head to the sight tube may have become blocked.

Therefore, before acting on the assumption that the refractory requires re-working, it is best to check these points:

1. Check to make certain the air line from boiler head to sight tube is clear; if not, blow it clear with an air hose.

2. Check condition of Teipole Gasket on rear flange of boiler body.

3. Check condition of asbestos yoke protecting Teipole Gasket.

4. Check horizontal baffle tile for large cracks, breaks, chipped corners, etc.

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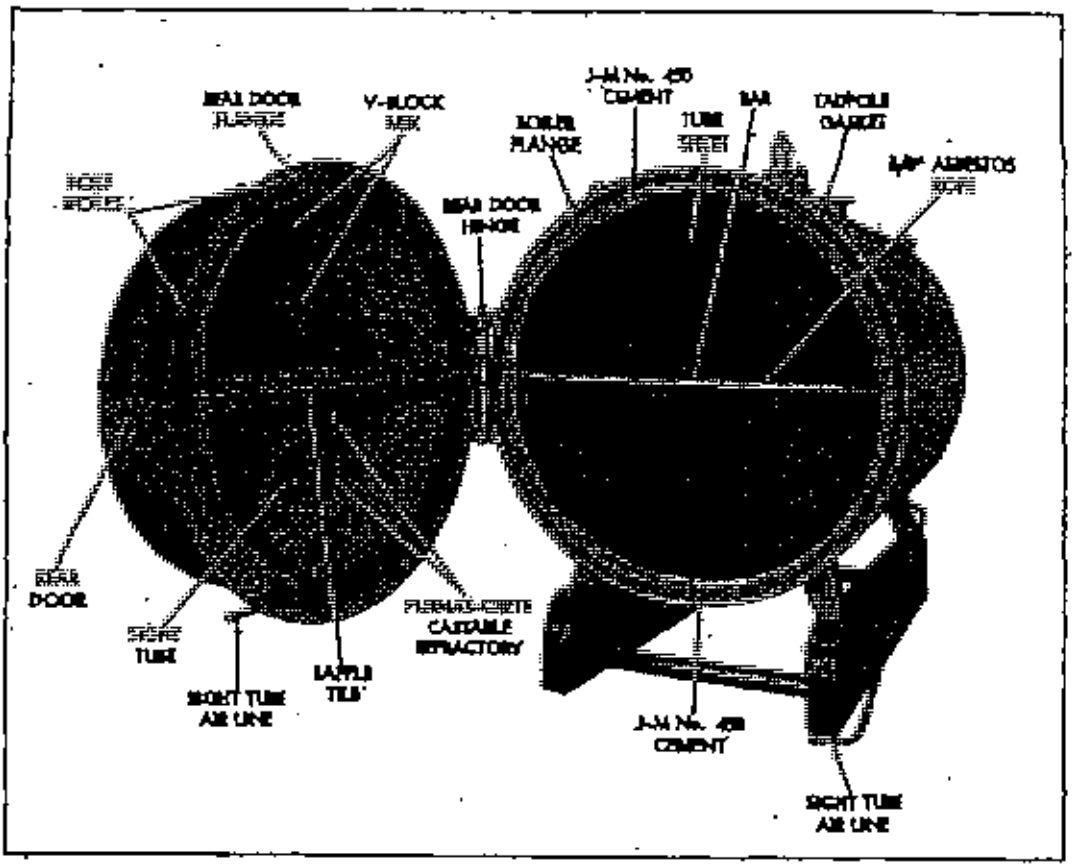


FIGURE 7-4. REAR DOOR OPEN

8. Check for cracks in castable refractory at ends of baffle tile.

9. Check for uneven or insufficient tightening of bolts holding rear door to sliding flange on boiler.

If the above points are checked and found to be satisfactory, proceed to examine the refractory of possible indications of trouble.

It is normal for refractories exposed to hot gases to develop thin ("hair-line") cracks; this by no means indicates improper design or workmanship. Since all refractory materials expand and contract to some degree with changes in temperature, they should be expected to show minor cracks due to contraction when examined at low temperatures. Cracks up to approximately 1/8" across may be expected to close at high temperatures.

(1) Minor Repairs:

After opening the door, clean off the flange surface of the door with a scraper or wire brush and clean the surface of the refractory carefully, with a fiber brush, to avoid damaging the surface. Clean the mating surfaces of the baffle tile and the boiler shell, removing all dried-out sealing material. Inspect for large cracks in the castable refractory. If cracks are present, they are most apt to occur in the area around the sight hole in the lower section of the door. If there are cracks of "hair-line" thickness, they need not be repaired since they will close due to the expansion of the refractories when the boiler is fired.

If there are cracks that are relatively large (1/8 to 1/4 inches in width), they should be filled with a plastic type cement such as Firebrick No. 1. Any gap that may show between the castable refractory and the baffle tile should be filled in a similar fashion.

If the baffle tiles show signs of deterioration at the corners or joints, the spaces between them should be filled with either Firebrick No. 1 or Hi-Lo Set cement.

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[2] Rear Door Closing and Sealing:

When the Rear Door has been opened for repairs, the condition of the sealing gasket should be noted. If this has become hard and brittle, it should be replaced with a new gasket. If the gasket has been replaced recently and remains in satisfactory condition, it should be sealed with a mixture of oil and graphite. If there is any doubt as to the condition, replacement is recommended. Make certain that all retaining rivets are in place in the gasket.

The flange of the door should be clean, smooth and free of old lumps of thermoset cement. Before closing the door, a new piece of 1/8" asbestos rope should be placed under the bar welded to the tube sheet.

The rope is held in place with Refrasil cement or other high-temperature adhesive.

Apply an asbestos pulp seal (Johns-Manville) No. 600 cement mixed with water) around entire door circumference, placing asbestos pulp just within the inside diameter of the Refrasil Gasket, as shown in figure 7-6. The tip of the baffle tile should be filled with the same mixture. On closing the door, this pulp will squeeze out and protect the Refrasil Gasket and the asbestos rope along the horizontal center line of the tube-sheet, forming a seal between the refractory surface and tube sheet.

Should it be necessary to completely replace the refractory in the Rear Door, the Cleaver-Brooks Representative or Service Department should be contacted for instructions as to procedure as well as for a list of the necessary materials.

C. BURNER MAINTENANCE

Efficient operation of oil burning equipment depends upon keeping the nozzle assembly clean. Although the nozzle is purged free of oil after every shutdown, it should be removed from the burner at regular intervals, disassembled, and thoroughly cleaned.

If, at any time, the burner flame appears "stringy," or "lazy," it is possible that the nozzle assembly has become partially clogged. Any blockage or clogging within the nozzle tube or nozzle assembly will cause the reading on the Nozzle Air Pressure Gauge to increase above its normal value.

To disassemble main burner nozzle assembly, unlatch and withdraw the burner gun. Insert nozzle body into the vise or hanger attached to the front head of the boiler. Use spanner wrench furnished with boiler to unscrew the tip (figures 1-8 and 7-6) and carefully remove the swirler and swirler sealing spring, taking care not to drop or damage them (figure 7-6).

Perform the necessary cleaning with a solvent, such as kerosene thinner. Do not use wire or sharp metallic objects for cleaning as they are apt to scratch or deform the orifice as well as the precision-ground surfaces of the swirler and tip, making the nozzle unfit for further use. Instead, use a pointed piece of soft wood.

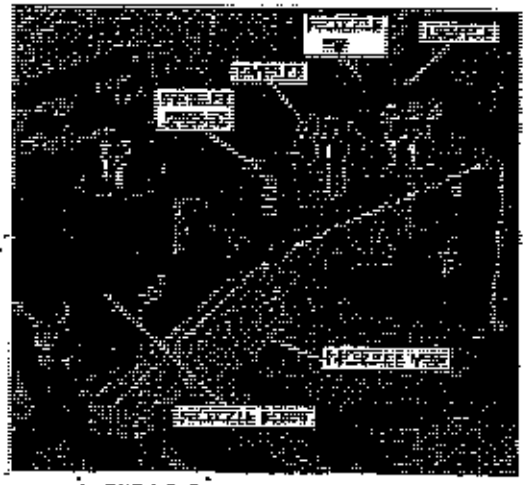


FIGURE 7-6. DISASSEMBLY OF MAIN BURNER NOZZLE

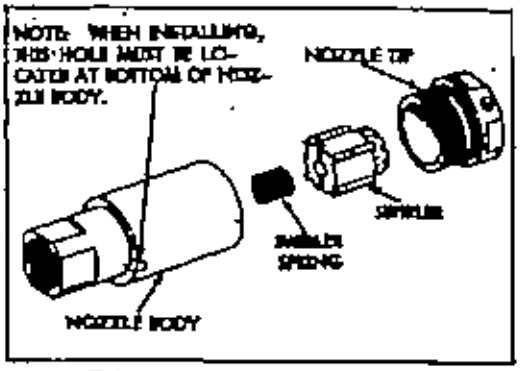


FIGURE 7-6. EXPLODED VIEW OF BURNER NOZZLE

In reassembling the nozzle tip, the body and tip must be screwed tightly together so as to insure proper atomization of oil. Make certain that the swirler sealing spring is in the nozzle and that it is holding the swirler tightly against the tip.

D. ELECTRODE MAINTENANCE

Consult figure 8-11 in Chapter 8 for correct electrode setting dimensions. Check dimensions at electrode as presently set and adjust if necessary. Inspect the tip of electrode for signs of pitting or carbonization deposits. Clean carbon in an electrical carbonizer. It is necessary to keep the insulating portion of the electrode wiped clean (although deposits of carbon are not normally encountered here).

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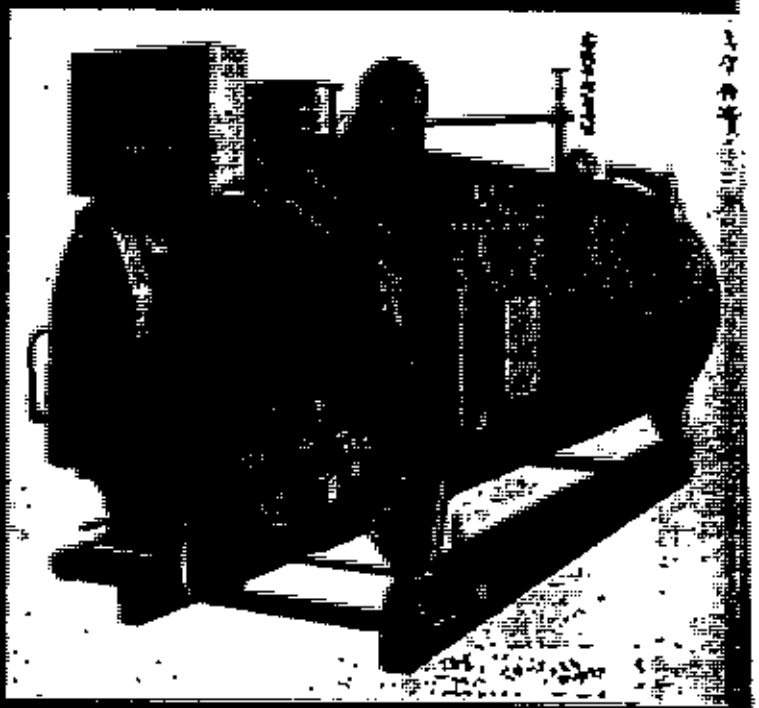
EXHIBIT J

CLEAVER-BROOKS MODEL CB PACKAGED BOILERS

Operation, Service and Parts Manual

125 Thru 350 HP

FUEL: LIGHT OIL,
HEAVY OIL,
GAS OR COMBINATION



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DIRECT PURCHASE ORDERS FOR REPLACEMENT MANUALS TO:

Cleaver-Brooks®
DIVISION OF AQUA-CHEM, INC.
PARTS DEPARTMENT
P.O. Box 429
MILWAUKEE, WISC. 53201

Manual Part No. 750-81

CE-6360 REV. 7/78
Printed in U.S.A.

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[illegible] and operating conditions which the boiler will be subjected to should be considered and cleaning of the waterside of the pressure vessel should be provided during the course of initial start-up.

The pressure vessel and the steam and return lines or hot water piping represent, in effect, a closed system. Although the steam and return (condensate) lines or the hot water piping system may have been previously cleaned it is possible that:

1) Cleaning has been inadequate.
2) Partial or total old system is involved.
3) Conditions may prevent adequate cleaning of piping.

The pressure vessel waterside should be inspected on a periodic basis. This will reveal true internal conditions and serve as a check against conditions indicated by chemical analysis of the boiler water. Inspection should be made three months after initial starting and at regular 6, 9 or 12 month intervals thereafter. The frequency of further periodic inspections will depend upon the internal conditions found.

If any unwanted conditions are observed water consultant or water treating company should be contacted for recommendations.

Any sludge, mud or sediment found will have to be flushed out. The effectiveness of the blowdown practiced on steam boilers will be verified and scheduling or frequency of blowdown may have to be revised. The need for periodic draining or washout will also be indicated.

Any oil or grease present on the heating surfaces should be removed promptly by a boil-out with an alkaline detergent solution.

NOTE: Temperature of initial fill of water for hydrostatic tests, boil-out, or for normal operation should be as stated in the ASME Boiler Code.

F. BOIL-OUT OF A NEW UNIT

The internal surfaces of a newly installed boiler may have oil, grease or other protective coatings used in manufacturing. Such coatings must be removed since they [illegible] the heat transfer rate and could cause overheating of a tube. Before boiling out procedures may begin, the burner should be ready for firing. The operator must be familiar with the procedure outlined under burner operation.

Your water consultant or water treating company will be able to recommend a cleaning or boil-out procedure. In the event such advice is unavailable or is not considered, the following information may be of assistance.

Suggested procedure for boiling out new units prior to initial firing is as follows:

1. Tri-sodium phosphate and caustic soda are the suggested chemicals for cleaning of boilers. The quantities will vary according to conditions but an amount of one pound of each chemical per 50 gallons of water is suggested. See chart below for boiler water capacity.

Boiler Model and Size	Water—Gallons		Water—Weight	
	Normal	Flooded	Normal	Flooded
CB125	690	928	5760	7670
CB150	870	1115	7260	9295
CB175S	—	1095	—	9095
CB200	1095	1335	9035	11130
CB250	1290	1665	10690	13885
CB300	1550	2020	13040	16840
CB350	1856	2410	15485	20090

2. When dissolving chemicals, the following procedure is suggested. Warm water should be put into a suitable container. Slowly introduce the dry chemical into the water stirring at all times until the chemical is completely dissolved. Add the chemical slowly and in small amounts to prevent excessive heat and turbulence.

CAUTION

Use of a suitable face mask, goggles, rubber gloves, and protective garments is strongly recommended when handling or mixing caustic chemicals. Do not permit the dry material or the concentrated solution to come in contact with skin or clothing.

3. An over flow pipe should be attached to one of the top boiler openings and routed to a safe point of discharge. A relief or safety valve tapping is usually used.

4. Water relief valves and steam safety valves must be removed before adding the boil-out solution so that neither it nor the grease which it may carry will contaminate these valves. Use care in removing and re-installing valves.

Refer to Section M in Chapter I for valve installation instructions.

5. All valves in the piping leading to or from the system must be closed to prevent the cleaning solution from getting into the system.

6. Fill pressure vessel with cold water until top of tubes are covered. Add the cleaning solution and then fill to the top. The temperature of the water used to initially fill should be at ambient temperature.

7. The boiler should then be fired slowly and at a low rate sufficient to hold a steady boil at the boiling point. Boil for [illegible]

five hours. Do not produce steam pressure.

8. Allow a small amount of fresh water to enter boiler to create a slight overflow that will carry off surface impurities.
9. Continue boil and overflow until water clears. Shut burner down.
10. Let boiler cool to 120°F or less, then drain using caution that the water is discharged with safety.
11. Remove hand hole plates and wash the waterside surfaces thoroughly using a high pressure water stream.
12. Inspect surfaces and if not clean repeat the boil out.
13. After closing openings and reinstalling safety or relief valves fill boiler and fire until water is heated to at least 180° F to drive off any dissolved gases which might otherwise corrode the metal.

The above procedure may be omitted in the case of a unit previously used or known to be internally clean, however, consideration must be given to the possibility of contaminating materials entering the boiler from the system.

On a steam system, the condensate should be wasted until tests show the elimination of undesirable impurities. During the period that condensate is wasted, attention must be given to the treatment of the raw water used as make-up so that an accumulation of unwanted materials or corrosion does not occur. Follow the advice of your water treating company.

On a hot water system, chemical cleaning is generally necessary and the entire system should be drained after treatment. Consult water treatment companies for recommendations, cleaning compounds and application procedure.

G. WASHING OUT

A. STEAM BOILER

No later than 3 months after initially placing the boiler into operation and starting service, and thereafter as conditions warrant, the pressure vessel should be drained after being properly cooled to near ambient temperature, handhole covers removed and internal waterside surfaces inspected for corrosion, pitting, or formation of deposits.

B. HOT WATER BOILER

In theory, a hot water system and boiler that has been initially cleaned, filled with raw water [and that water treated] and with no make-up water added will require no further cleaning or treatment. However, since the system [new or old] may allow entrance of air and unnoticed or undetected leakage of water, introductions of raw water make-up or air may lead to pitting, corrosion and formation of sludge, sediment, scale, etc., on the pressure vessel waterside.

If the operator is absolutely certain that the system is tight, then an annual waterside inspection may be sufficient.

If there is any doubt then the pressure vessel waterside should be inspected no later than 6 months after initially placing the boiler in operation and periodically thereafter as indicated by conditions observed during inspections.

FLUSHING OF PRESSURE VESSEL INTERIOR

Upon completion of inspection, the pressure vessel interior should be flushed out as required with high pressure hose. If deposits are not fully removed by flushing this may require immediate consultation with your water consultant or feed water treatment company, and in extreme cases, it may be necessary to resort to acid cleaning. Professional advice is recommended if acid cleaning is required.

These inspections will indicate the effectiveness of the feedwater treatment. The effectiveness of treatment, the water conditions, and the amount of fresh water make-up required are all factors to be considered in establishing frequency of future pressure vessel washout periods. The feedwater consultant or water treatment company service should include periodic pressure vessel inspection and water re-analysis.

H. BLOWDOWN—STEAM BOILER

Boiler water blowdown is the removal of some of the concentrated water from the pressure vessel and its replacement with feedwater so that a lowering of the concentration in the boiler water occurs.

Solids are brought in by the feedwater even though this water is treated prior to use through external processes that are designed to remove unwanted substances which contribute to scale and deposit formations. However, none of these are in themselves capable of removing all substances and regardless of their high efficiency, a small amount of encrusting solids will be present in the boiler water.

Solids become less soluble in the high temperature of the boiler water and tend to crystalize and concentrate on heating surfaces. Internal chemical treatment is, therefore, required to prevent the solids from forming harmful scale and sludge.

Scale has a low heat transfer value and acts as an insulation barrier. This retards heat transfer which not only results in lower operating efficiency and consequently higher fuel consumption, but more importantly can cause overheating of boiler metal. This can result in tube failures or other pressure vessel metal damage causing boiler down-

however, the life of the pump is dependent upon a sufficient supply of clean cool lubricating oil. The oil level in the air-oil tank must be observed closely. Lack of oil will damage the pump making replacement necessary. Disassembly or field repairs to the pump are not recommended.

Lubricating Oil

Lubricating oil must be visible in the gauge glass at all times. There is no specific level required as long as oil is visible. Do not operate if oil is not visible.

Oil with proper viscosity must be used. SAE20 detergent is recommended although SAE10 detergent is also permissible. Name brands known to perform satisfactorily include Havoline (Texaco), Mobil Oil (Mobil), Shell X100 and Permalube (Amerikom).

Oil is normally added by removing the filler cap plug in the top of the tank (figure 7-6) and adding sufficient oil to raise the level to the midpoint of the sight glass. This cannot be done while the boiler is in operation. If absolutely necessary to add oil during operation, remove the air cleaner and slowly add clean oil into this opening.

The oil and its containers should be clean. Although there is a strainer in the lube oil line its purpose is to remove any unwanted materials rather than to act as a filter for unclean oil.

Air Cleaner

Never operate the air pump without the air cleaner in place. The cleaner itself must be periodically checked and its element flushed and cleaned. The correct level of oil must be maintained in the cleaner.

Air-Oil Tank

The air-oil tank contains steel wool used as filtering medium to separate the lube oil from the compressed air. A typical tank is shown in figure 7-6. The wool is packed into two compartments and containing approximately five ounces. The wool should be replaced periodically whenever inspection reveals the need. Careful packing is necessary to assure even density. Do not overly compress the wool and be sure it is fluffed out to fill all available space. Improper packing can cause high oil consumption. Use wool of proper density — refer to parts list in Chapter 8.

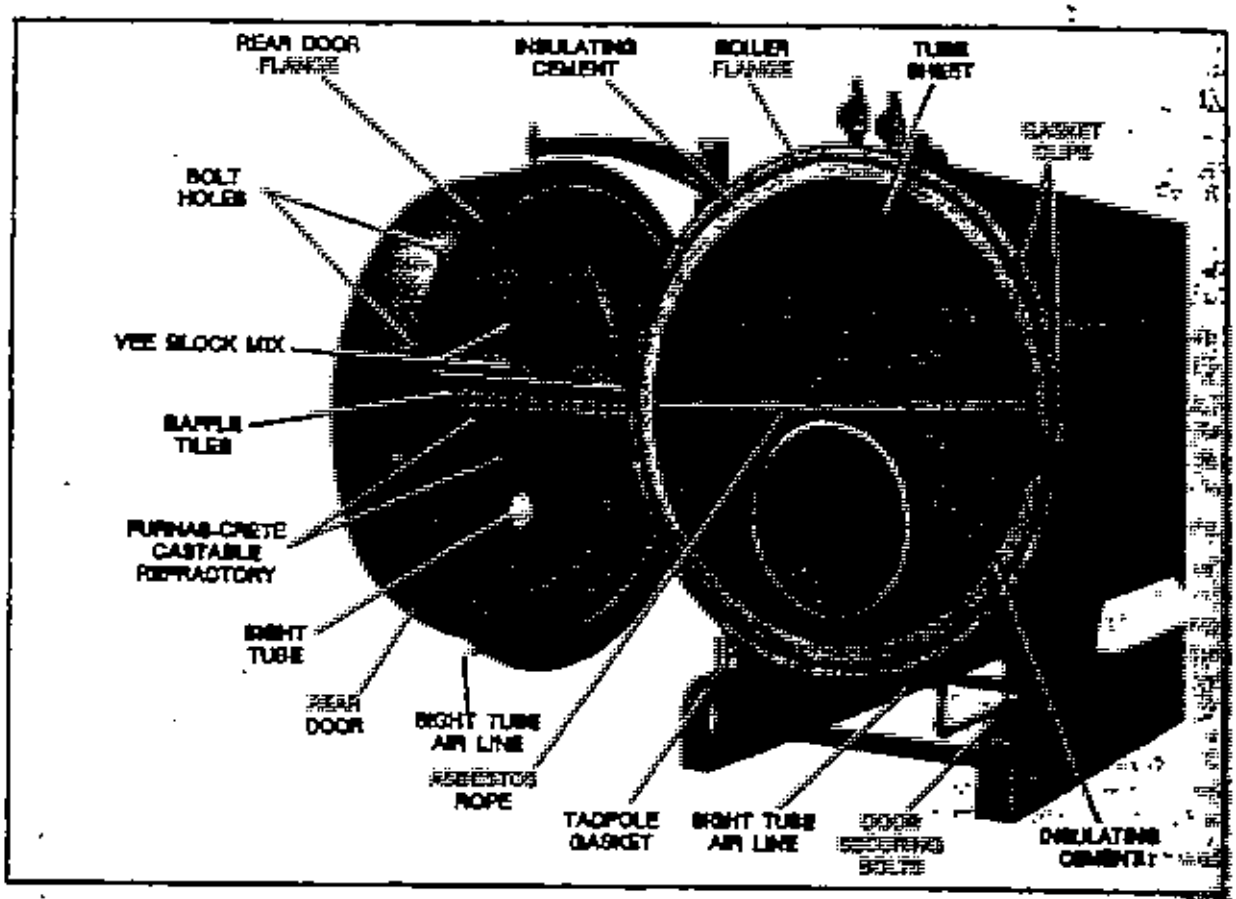


FIGURE 7-6. REAR DOOR OPEN

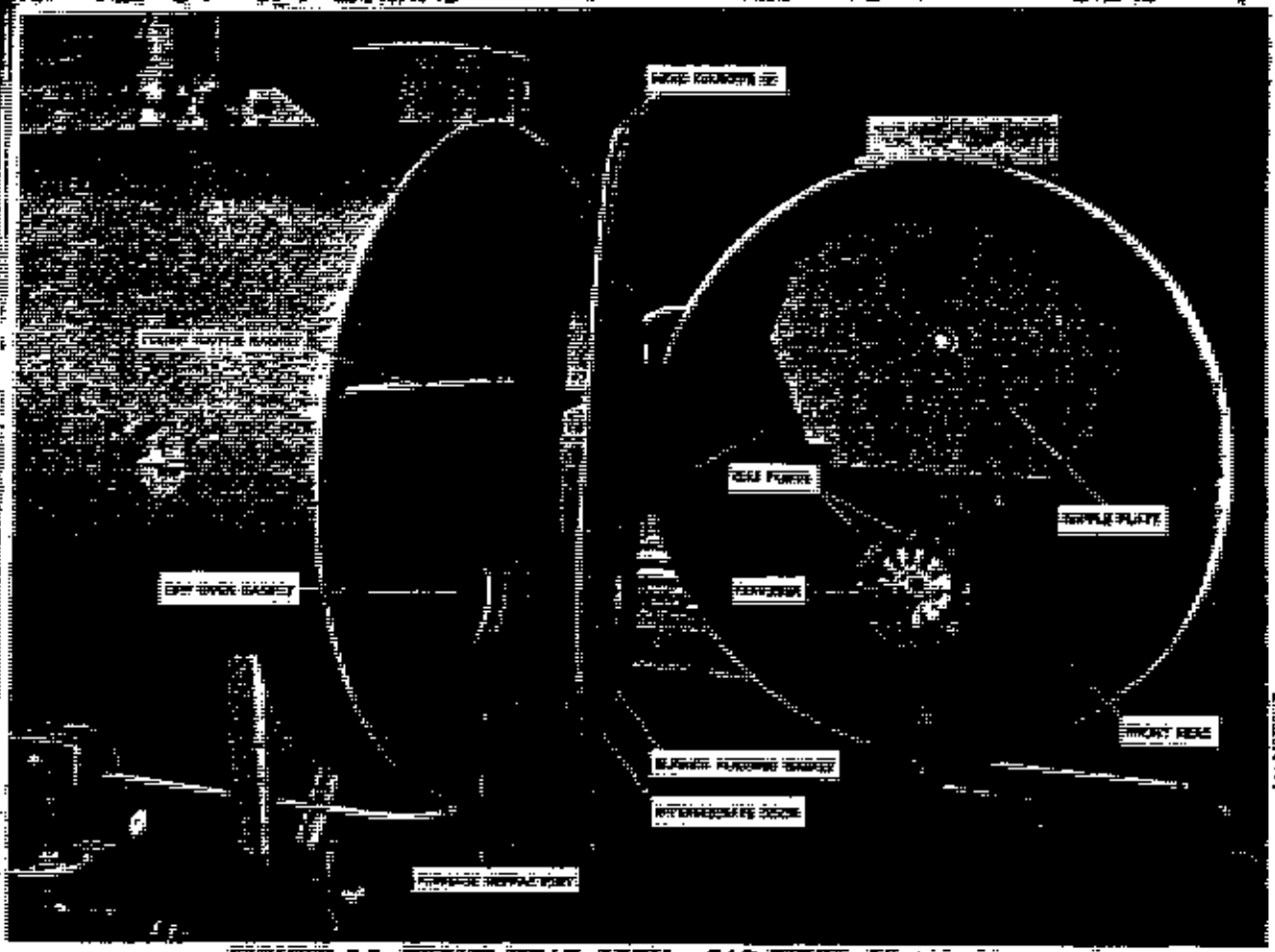


FIGURE 7-7. FRONT HEAD OPEN - GAS FIRED CB 125-150-200

Should sludge accumulate in the tank, drain it and flush with a suitable solvent.

Lube Oil Cooling Coil

The fins on the tubing must be kept clean and free of any dust or dirt that would impede air flow and cause overheating. Use an air hose to blow away debris. Internal cleaning of the tubes is seldom required if a good quality lube oil is used.

Lube Oil Strainer

The lube oil strainer screen must be removed and cleaned at regular intervals. It is advisable to remove this screen each month and clean thoroughly by immersing in solvent and blowing dry with compressed air. To remove, loosen cover cap screw being careful not to lose the copper gasket. Tap strainer cover gently to loosen. Check cover gasket. Slip pliers into the cross on the cap of the strainer and twist counterclockwise to remove gasket. Re-assemble strainer in reverse order.

General

Keep the motor and other components free from dust and dirt to prevent overheating and damage. Motor lubrication should follow manufacturers' recommendations.

F. REFRACTORY

The Cleaver-Brooks boiler is shipped with completely installed refractory. This consists of the rear head (figure 7-6), the inner door and the furnace liner (figure 7-7). Normal maintenance requires little time and expense and prolongs the operating life of the refractory. Preventive maintenance through periodic inspection will keep the operator informed of the condition of the refractory and will guard against unexpected and unwanted down time and major repairs.

Frequent wash-coating of refractory surfaces is recommended. High temperature bonding air-dry type mortar diluted with water to the consistency of light cream is used for this purpose. Re-coating intervals will vary with operating loads and are best determined by the operator when the heads are opened for inspection.

Furnace Liner

Maintenance consists of occasional wash-coating of

the entire liner. Face all joints or cracks by applying high temperature bonding mortar with a trowel or fingertips. This should be done as soon as cracks are detected.

Should segments of the liner become burned out or broken replace the entire refractory. Any refractory that may break out should be removed as soon as detected so that it will not fuse to the bottom of the furnace and obstruct the burner flame.

If replacement is necessary refer to Chapter 8 and order proper replacement materials. Remove existing refractory and thoroughly clean that portion of the furnace covered by the liner to remove all old refractory cement or other foreign material to insure new liner seating firmly to the steel. Inspect furnace metal for soundness. There may be metal clips welded in the furnace at the extreme end of the liner. These were installed to prevent shifting during original shipment and serve no purpose beyond that. They are tack welded in place and can be removed when installing the new liner. If not removed make sure that liner has clearance between this clip and the end of the refractory to allow for expansion in this direction.

Depending upon the design pressure of the boiler, the furnace may be of the corrugated type. Although it is not necessary to fill in the depressions, for convenience of installation some or all of the corrugation valleys may be filled with insulating cement. The liner tile should be fitted tightly against the crown of the corrugations.

Liner Installation - CB125-150-200

These sizes of boilers have a furnace extension or a dry oven as shown in figure 7-8. The throat tile should be installed flush with the front of this oven and should fit tightly against its sides. The two rows of furnace tile should be fitted tightly against the furnace wall. It is not necessary to allow for expansion.

It is recommended that the tile be dry fitted, match marked, removed and then reinstalled with the proper amount of refractory cement. Thin joints are desirable. Generally it will be necessary to shave a portion from one or more tile to obtain a fit. If a fill piece is required, cut it to fit and install this piece at the bottom of the furnace.

It is important to have a good seal between the burner housing and the throat tile. Liberally coat the sealing area with a pulp consisting of asbestos

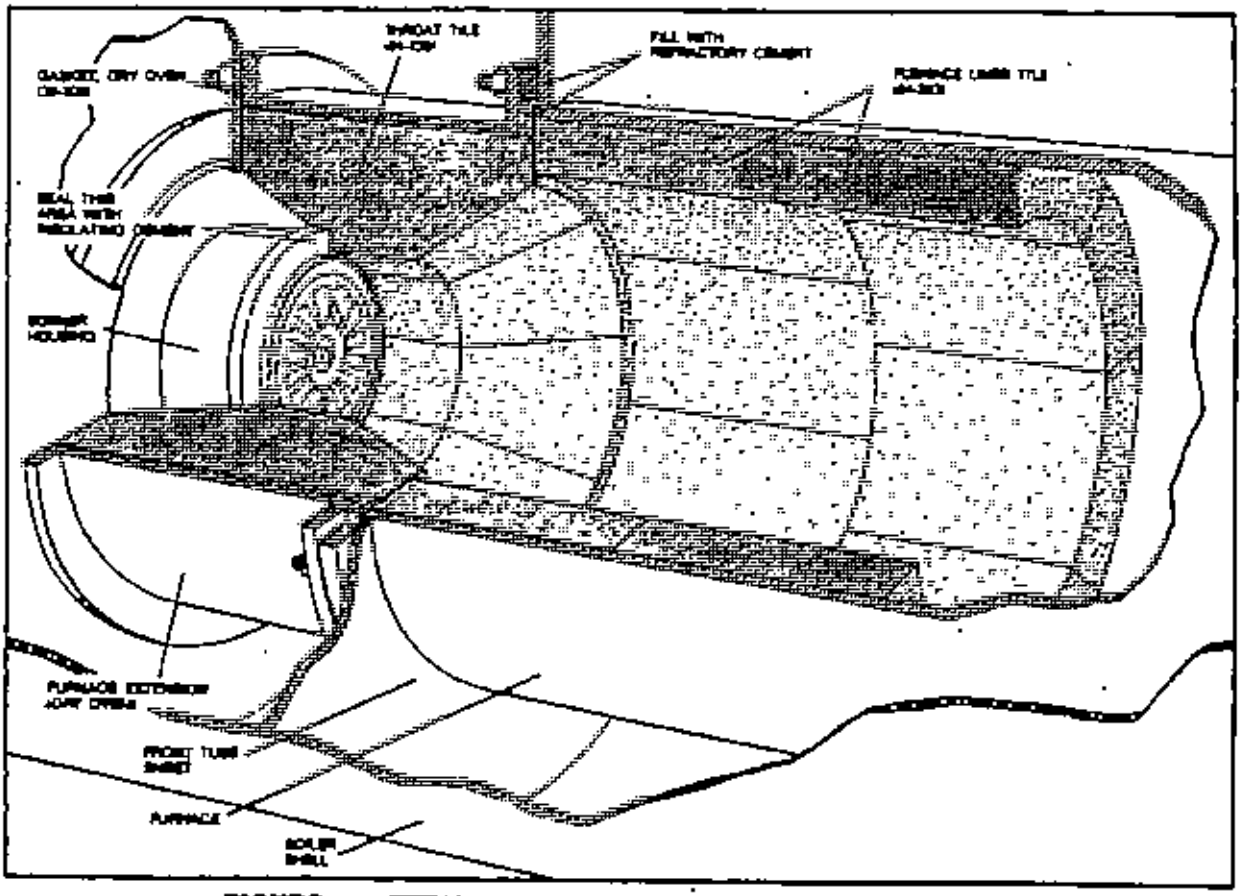


FIGURE 7-8. FURNACE LINER REFRACTORY - 125-150-200 HP

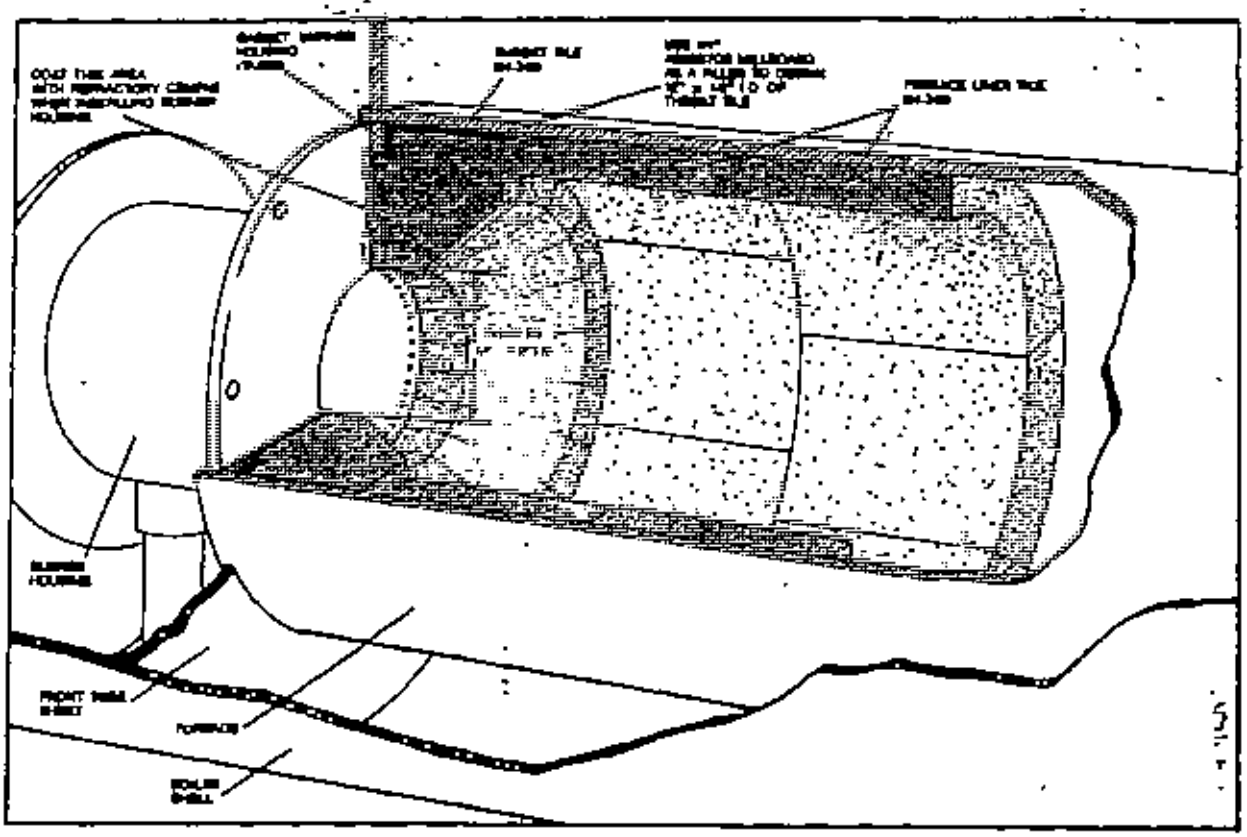


FIGURE 7-9. FURNACE LINER REFRACTORY - 250-300-350 HP

cement or equivalent mixed with water prior to swinging the burner housing into place.

Liner Installation - CB250-300-350

The furnace lining for these size boilers is shown in figure 7-9. The throat tile must be installed to maintain an approximate 12 inch inside diameter and be centered in the furnace. Since the thickness of the furnace metal varies with the boiler design pressure, a shim of appropriate thickness must be used to compensate for this variance. A layer or two of asbestos millboard or a bed of refractory material may be used to center the ring. The inner rows of liner tile can be fitted tightly against the furnace since the inside diameter of these is not an objective.

It is recommended that the tile be dry fitted, match marked, removed and then reinstalled with the proper amount of refractory cement. Thin joints are desirable. Generally it will be necessary to shave a portion from one or more tile to obtain a fit. If a fill piece is required, cut it to fit and install this piece at the bottom of the furnace.

It is important to have a good seal between the burner housing and the front face of the liner. When installing the housing, liberally coat this surface with refractory cement.

Allow refractory to air dry as long as possible. If immediate use of boiler is required fire at low rate and intermittently if possible.

For detailed information request Bulletin C10-588f.

Rear Door

The rear door is a steel shell containing horizontal baffle tiles and lined with insulating material and castable refractory (see figure 7-6).

Burned or discolored paint on the outer surface of the door does not necessarily indicate refractory trouble, but may be an indication of other conditions such as:

(a) Leaking gaskets.

(b) Improper seal.

(c) Door retaining bolts insufficiently, or unevenly tightened.

(d) The air line to the rear sight tube may be blocked or loose.

(e) Repainted with other than heat resistant paint.

Therefore, before assuming that refractory requires re-working:

(a) Check condition of tadpole gasket.

(b) Check condition of insulating cement protecting the tadpole gasket.

(c) Check the horizontal baffle tile for large cracks, breaks, chipped corners, etc.

(d) Check for cracks in castable refractory at ends of baffle tile.

(e) Check tightness of door bolts.

(f) See that air line to sight tube is clear and connections are tight. If necessary, blow clear with an air hose.

It is normal for refractories exposed to hot gases to develop thin "hairline" cracks. This by no means indicates improper design or workmanship. Since refractory materials expand and contract to some degree with changes in temperature they should be expected to show minor cracks due to contraction when examined at low temperature. Cracks up to approximately 1/8" across may be expected to close at high temperature. If there are any cracks that are relatively large (1/8" to 1/4" in width) clean them and fill with high temperature bonding mortar. Any gap that may show between the castable refractory and the baffle tile should be filled in a similar fashion.

After opening the rear door, clean off the flange surface of the door with a scraper or wire brush. Clean the surface of the refractory carefully with a fiber brush to avoid damaging the surface. Clean the mating surfaces of the baffle tile and the boiler shell. Remove all dried out sealing material. Wash-coat the lower half of the rear door refractory prior to closing.

The upper half of the door contains a lightweight insulating material similar to that used in the inner door. A thin wash-coat mixture applied gently with a brush is helpful in moistening a hard surface.

If the baffle tile or the refractory requires replacement contact your local Cleaver-Brooks representative or write to the Cleaver-Brooks Service Department for a copy of bulletin C10-4101 covering major repair or replacement of rear door refractory.

Front Inner Door

The front inner door is lined with a lightweight castable insulation material. Thin "hairline" cracks may develop after a period of time, however, these will generally tend to close due to expansion when the boiler is fired.

A thin wash-coat mixture applied gently with a brush is helpful in maintaining a hard surface.

Minor repairs can be accomplished by enlarging or cutting out effected areas, making certain that they are clean and then patching as required. Should the entire installation require replacement, remove existing material and clean to bare metal. Inspect the retaining pins and replace if necessary. Reinforcing wire suitably attached may also be used. The recommended insulation is known as Vee Block Mix and is available in 50 lb. bags (CB Part Number 872-162).

Mix the material with water to a troweling consistency. Mixing should be completely uniform with no portion either wetter or drier than another. Trowel this mixture into any areas that are being patched. If replacing complete insulation begin at bottom of door and apply the mixture to a thickness equal to the protecting shroud. With a trowel apply horizontally back and forth across the door in layers until the required thickness is reached.

Allow to air-dry as long as possible. If immediate use of boiler is required, fire as slowly as possible to avoid rapid drying of the material.

Q. DOOR CLOSING AND SEALING

Whenever the front or rear door is opened for inspection, the head gaskets should be checked for hardening and brittleness. Doubtful gaskets should be replaced. Coat the gasket with an oil and graphite mixture before closing the door. Make certain that all gasket retaining rivets are in place. The flange of the door should be clean and free of any hardened cement, scale, etc.

Check the condition of the asbestos rope used as a baffle seal. Replace if necessary. If the rope is in good condition, liberally coat it with an insulating pulp prior to closing. Make sure that the rope is properly positioned.

If it is necessary to replace the rope, wire brush the tube sheet area to remove all old sealing material. Place a new piece of 1-1/2" diameter asbestos rope (853-924) on the lip of the baffle tile. Hold it in place with furnace cement or an adhesive.

NOTE: Earlier models had several steel bar segments tack welded across the tube sheet to serve as a gasket retainer for 5/8" diameter rope. It is suggested that these bars be removed and 1-1/2" diameter rope used.

Generously apply a seal, consisting of a pulp mixture of insulating cement and water, around the entire rear door circumference. Place the pulp around the inside diameter of the head gasket as shown in figure 7-9. Also coat the tube sheet area adjacent to the baffle tile.

When the door is closed, the pulp will compress to protect the tadpole gasket and to form a seal between the refractory surface and the tube sheet.

The insulating pulp seal is not needed or used on the front head. Make sure that gaskets are in position when closing.

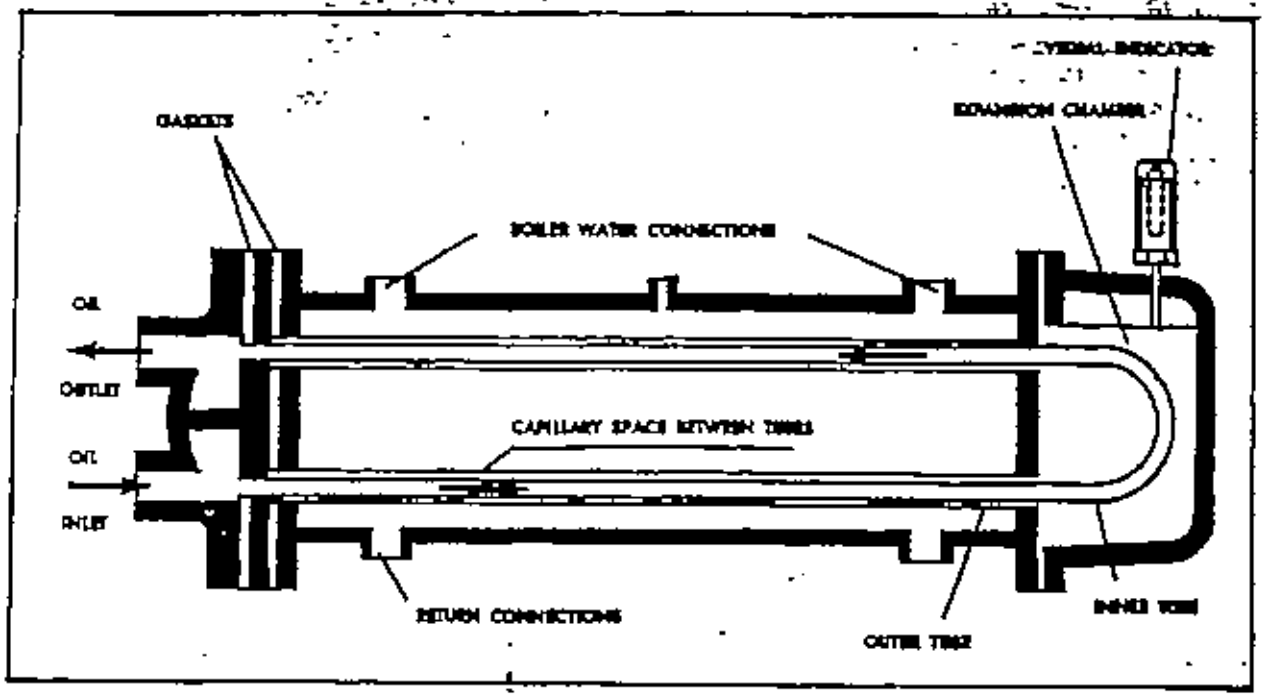


FIGURE 7-10. CIRCUIT LAYOUT OF HOT WATER OIL HEATER (ALSTROM)

When closing the door, bolts should be run in snug and tightened evenly to avoid cocking door and damaging gasket. Start tightening at top center and alternate between top center bolt and bottom center bolt until both are drawn up-tight. Do not overtighten. Continue tightening sequence along top and bottom, tightening bolts alternately until door is secured and gas tight. After boiler is back in operation re-tighten the bolts to compensate for any expansion.

NOTE: Proper sealing of doors is essential to avoid leakage of combustion gases and loss of heat and operating efficiency.

R. LUBRICATION

Electric Motors

Manufacturers of electric motors vary in their specifications for lubrication and care of motor bearings and their recommendations should be followed.

Ball bearing equipped motors are pre-lubricated. The length of time a bearing can run without having grease added will depend upon many factors. The rating of the motor, type of motor enclosure, duty, atmospheric conditions, humidity, and ambient temperatures are but a few of the factors involved.

Complete renewal of grease can, when necessary, be accomplished by forcing out the old grease with the new. Thoroughly wipe those portions of the housing around the filler and drain plugs (above and below bearings). Remove the drain plug (bottom) and free the drain hole of any hardened grease which may have accumulated. With the motor not running, add new grease through the filler hole until clear grease starts to come out of the drain hole. Before replacing the drain plug run the motor for 10 to 20 minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

The lubricant used should be clean and equal to one of the good commercial grades of grease locally available. Some lubricants that are distributed nationally are:

Gulf Oil	—Precision Grease No. 2
Humble Oil	—Andok B
Texaco	—Multifak No. 2
Phillips	—1 B + BB No. 2
Fiske Bros.	—Ball Bearing Lubricant
Standard/Mobil	—Mobilux No. 2

Control Linkage

Apply a non-gumming [illegible] lubricant, such as [illegible] to all pivot points and moving parts. Work lubricant in well and wipe [illegible] Repeat application at required intervals to maintain freedom of motion of parts.

Solenoid valves and [illegible] require no lubrication.

EXHIBIT K

EXHIBIT
6

CRANE

VALVES
FITTINGS
PIPE
FABRICATED PIPING

NUMBER 53

FOUNDED BY R. T. CRANE 1855

CRANE CO.

836 S. MICHIGAN AVENUE, CHICAGO 5, ILLINOIS

6

GUIDE

EXHIBIT "K"

LOS ANGELES CITY SCHOOLS
APPRENTICE
EDUCATION
Park Trades
CURRICULUM DIVISION

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VALVES
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PIPE
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During this period ot narinaal emergency, wo reservr thr right to make changes to materials withour notice, wherevrr ruch rhanges do oot, in our opioioo, affect thr normal serviceability of thr produrt or our rrcommrnded pressure-temperaturr ratings.

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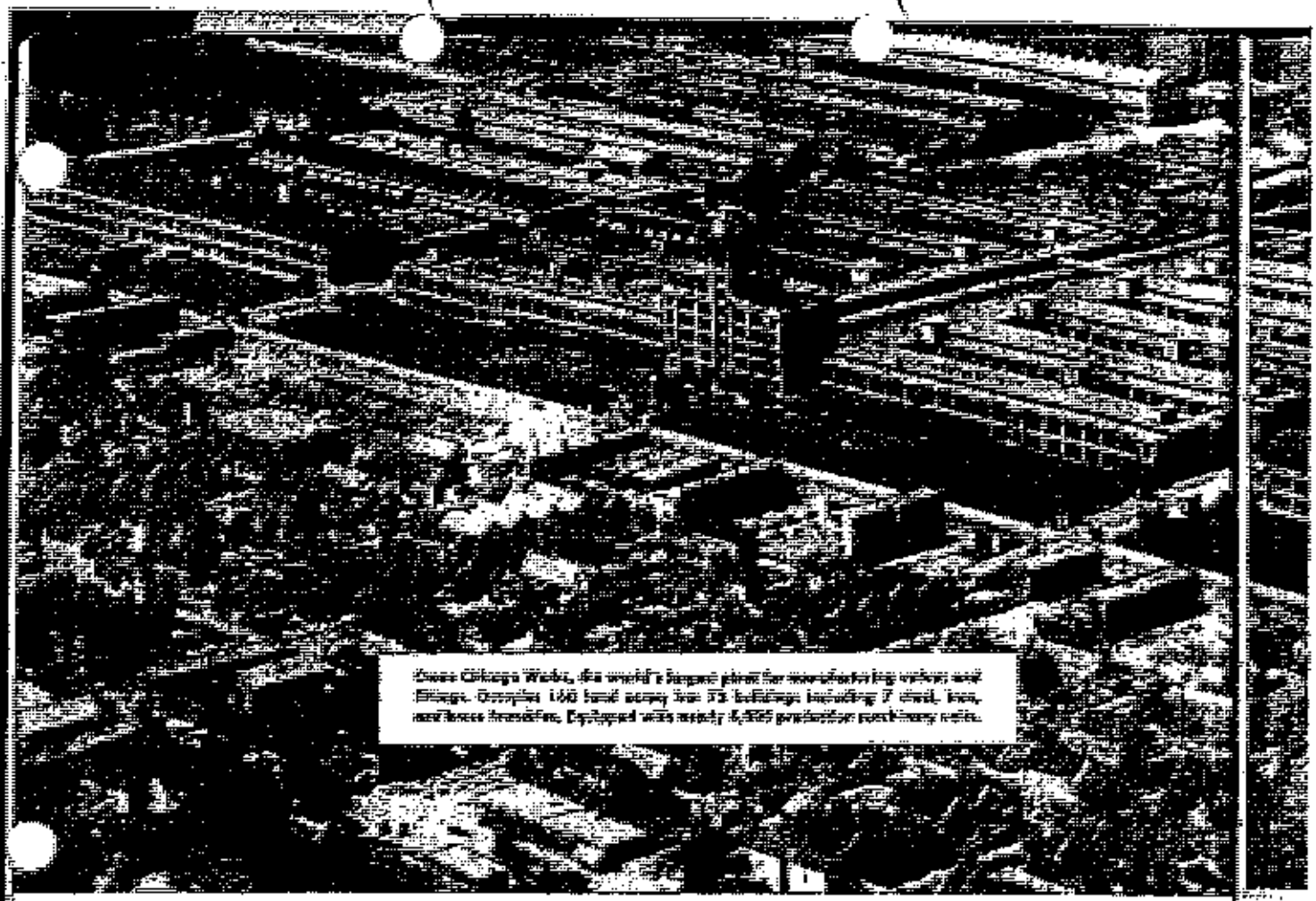
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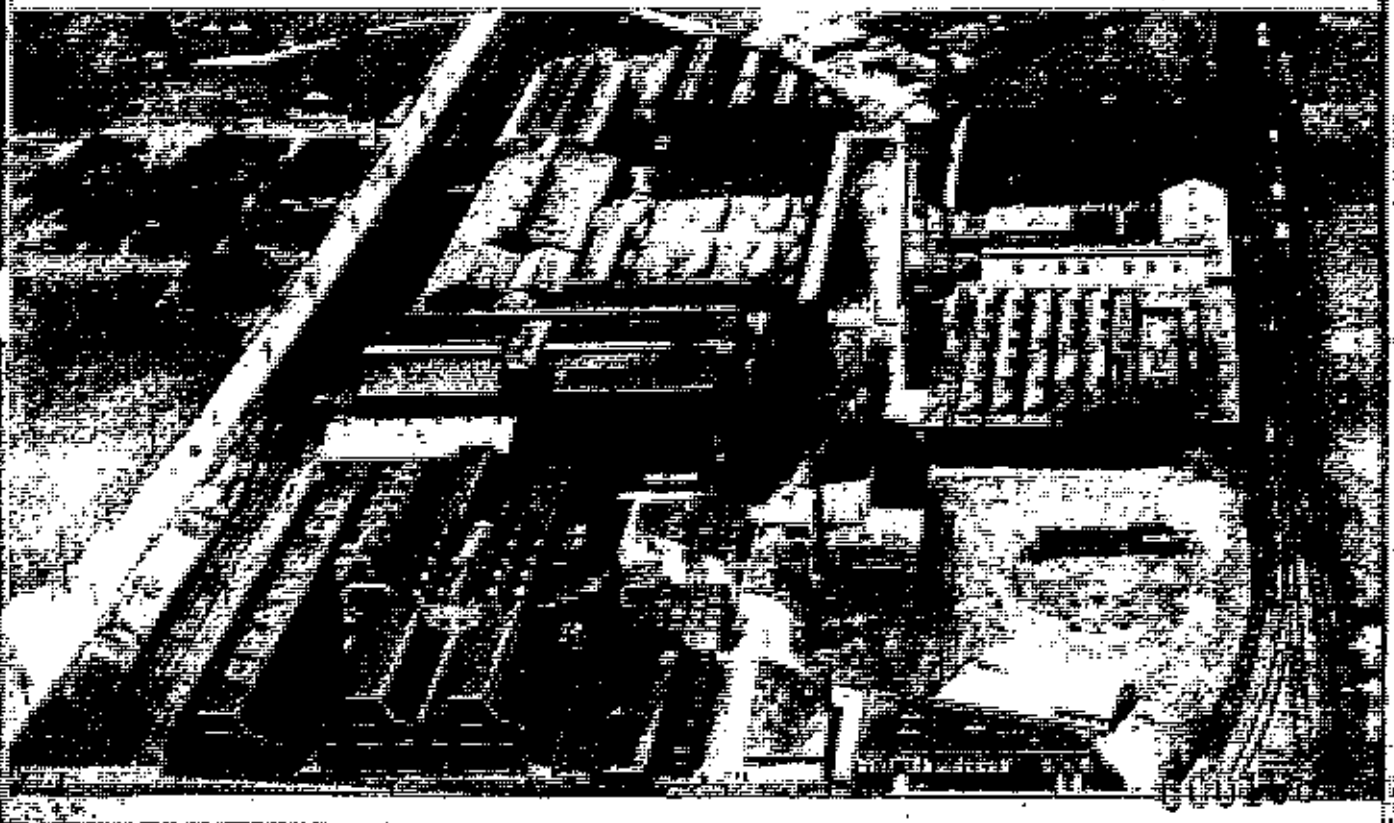
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Glasgow—94-100 Clyde Ferry St., Anderston

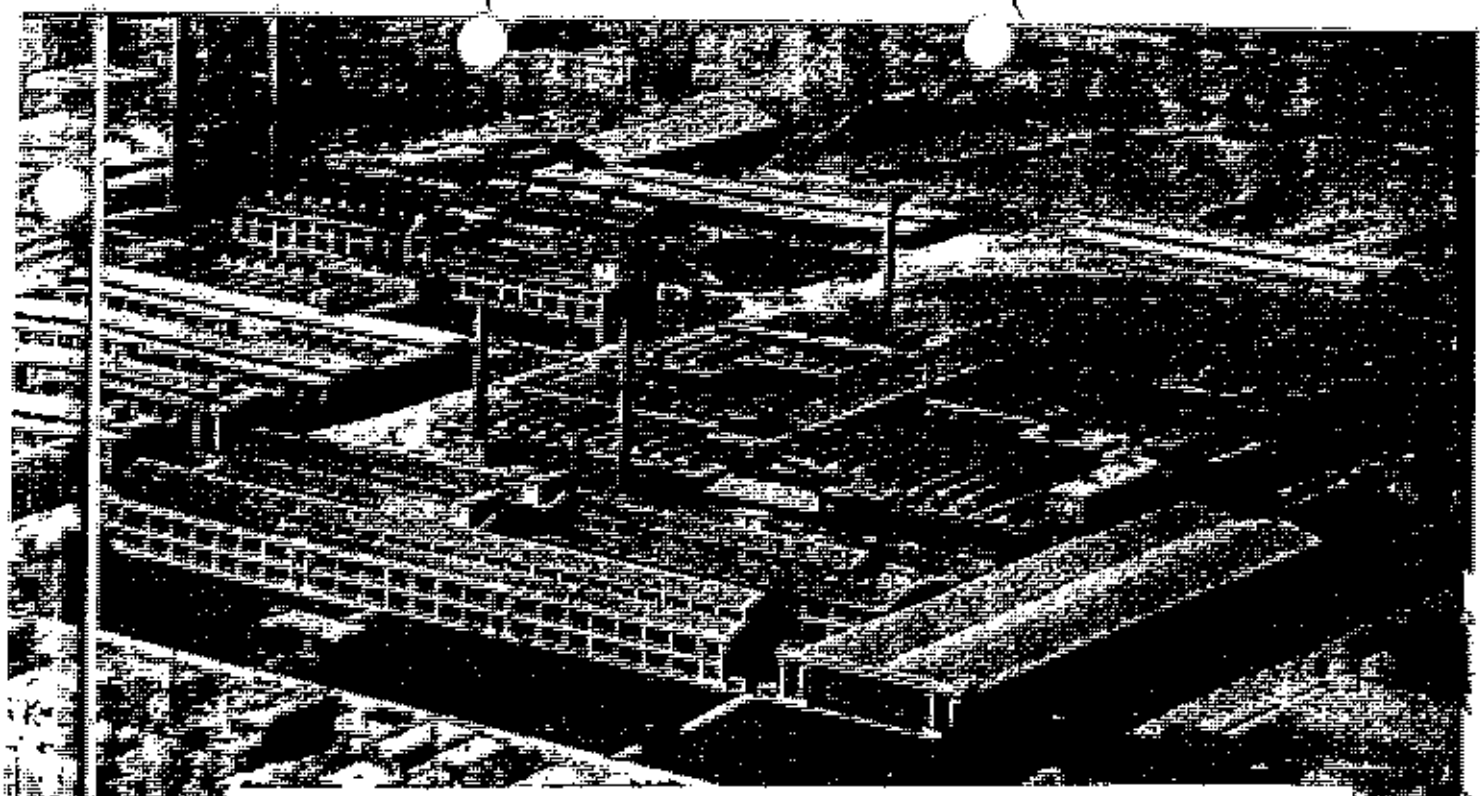
000165



Ewen Chicago Works, the world's largest plant for manufacturing rubber and fibers. Occupies 160 land acres has 73 buildings including 7 steel, iron, and brick foundries. Equipped with nearly 4,500 production machinery units.

Ewen foundries and factories at Chattanooga, Tenn.





The Plants Behind the Products You Choose from this Catalog

Most products listed in this Catalog are made in the great Crane Chicago Works pictured above. Perhaps you know Crane Chicago Works is the world's largest factory of its kind. Here is a completely integrated operation for the production of valves, fittings, and piping specialties—from raw materials to ready-to-use equipment—in all kinds and types in general use today. More than 30,000 individual piping items are made at Crane Chicago Works. Part of the facilities of the Crane Chattanooga Plant are also used to make some of these products.

To you, a piping user, Crane Co.'s mighty production capacity is important. For whether you use much or little equipment, the factory is where your supply begins.

Where Quality Sets the Pace for Mass Production

More important to you is that Crane mass production is quality-maintained production. For example, an ordinary pipe fitting made by Crane is produced with the same scientific care as a Crane alloy steel valve.

Quality first for bigger value to the customer has been the policy of Crane Co. from its humble beginning in 1855. Intensified constantly through the years for almost a century, that policy alone could justify the ever-growing customer confidence in Crane Quality Products.

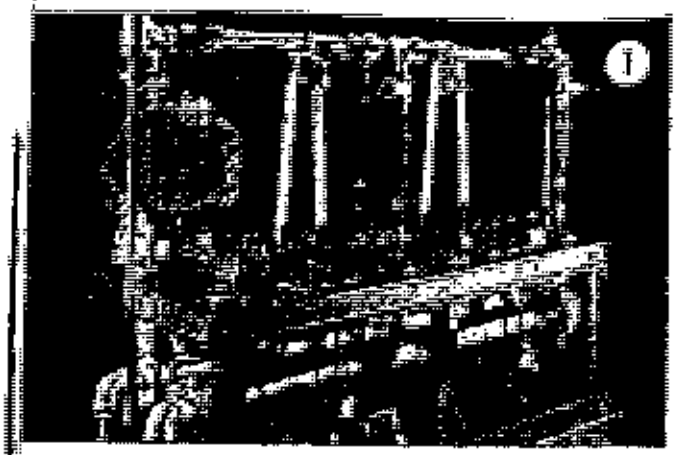
Quality—the Foundation of Crane Co.'s Leadership

With each passing year, the foundation for Crane Quality grows firmer and broader. In control of raw materials, in product design, engineering, manufacturing, and testing techniques, Crane Co. is ever adding to its vast experience.

Not in years alone, but by outstanding achievement, can the leadership of Crane be measured best. Nowhere else in the industry are new piping products born in such an elaborate background as Crane Engineering Laboratories. Nowhere are there better and more complete facilities than those which Crane Co. has for efficient product engineering and manufacturing.

How you are assured of consistently high quality and value in Crane products—how these products are made available where you need them—and how Crane Co. meets the responsibilities of world leadership in supplying piping equipment needs, is evident in the following pages.

Engineering and Development



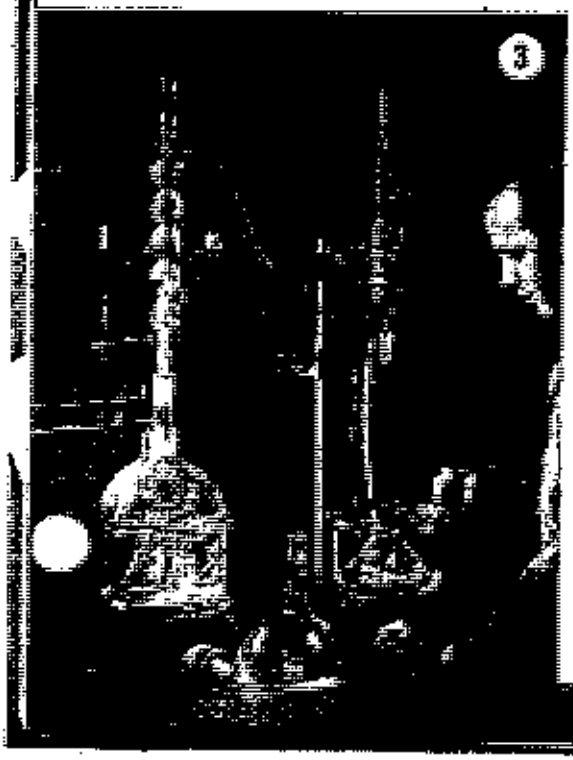


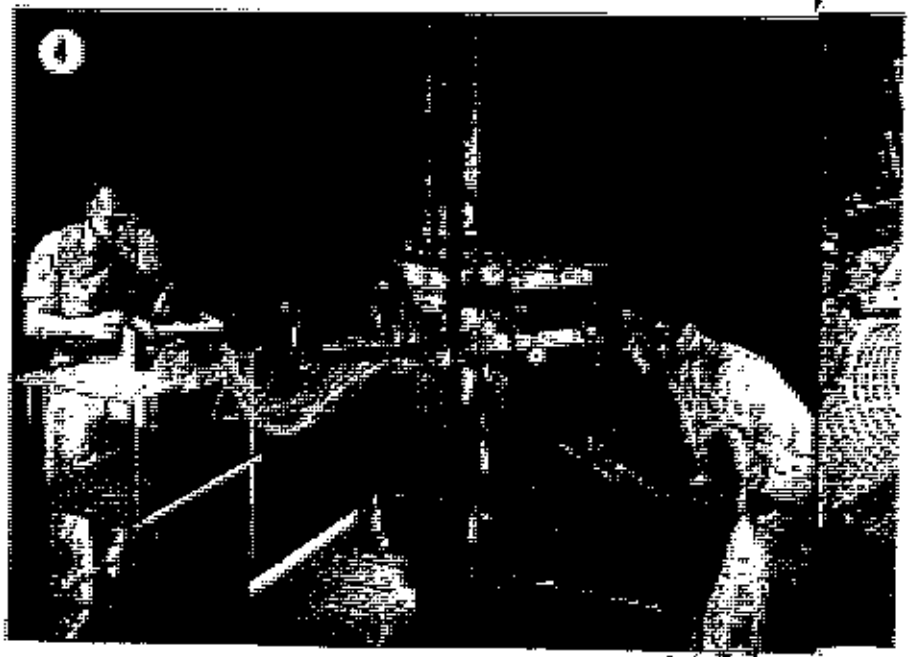
1 **Brass Valve Studies**—How good is a brass valve? This multiple testing machine, simulating actual service conditions, gives Crane Engineers the facts. It helps evaluate not only the relative merits of valve constructions, but also to determine durability and service life of materials in steam and contamplete combination. It is invaluable in study and development of thread profiles, clearances, alternative materials, etc. Such testing enables the constant improvement of performance and dependability.

2 **Creep Research**—The study of elevated tensile properties of metals was started by Crane in 1908, and since 1924, Crane has designed and built its own tensile creep testing equipment. Photo shows battery of individually controlled test furnaces operating in constant-temperature room. They permit direct telescopic creep measurement throughout test runs lasting thousands of hours, and up to the point of rupture. The vast data accumulated by Crane Engineers on elevated temperature properties of metals, has accurately guided Crane in supplying valves and fittings for the ever higher temperatures and pressures demanded by industry.

3 **Double-Check for Facts on Corrosion**—Crane doesn't depend on either laboratory findings or field tests alone for facts on corrosion. One complements the other, with Crane tests guiding field research for most effective results, and often eliminating excessive cost and great hazard to the customer.

4 **Stress Analysis**—Theoretical calculations, alone, of high load stresses on piping equipment may be good, but not good enough for Crane Engineering Laboratories. Photo shows typical simulated service test of 1500-Pound Crane Pressure-Seal line joint, giving accurate measurement of actual strains, deflections and movement on every part of the design.





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Foundry, Forge, and Fabrication

1 ***Steel Melting Facilities***—Four large and many small electric furnaces with capacities ranging from 1000 to 20,000 pounds, having an average melting rate of 24,000 pounds of steel per hour, put Crane among the largest steel foundries in industry. For melting alloy steels, irons, and brass mixtures, Crane operates 101 furnace units of the most modern and efficient design.

2 ***Acres of Casting Capacity***—Ready to convert each furnace melt into piping materials, Crane molding and casting equipment is of the finest type in any foundry. Molding, pouring and shakeout operations are mechanized to the highest degree, utilizing modern roller, belt, or overhead conveyor systems for continuous movement of castings and equipment on the large Crane foundry floors. High efficiency here is a strong factor in the high quality of Crane products.

3 ***Pipe Bending and Fabrication***—This picture tells the story of Crane Co.'s ability to produce almost any shape or size of pipe bend. With special tools and techniques, and highly skilled men, four Crane pipe shops find no specification too difficult to meet. They also produce headers and other units, incorporating valves, handling all operations such as bending, lapping, flanging, welding, etc.,—and can produce pipe coils in all sizes and shapes.

4 ***Big and Modern Forge Shop***—Nearly 45,000 square feet of space is used for steel forging at Crane Chicago Works. This shop is lined with rows of forges ranging from 600 pounds to 22,000 pounds hammer weight, to efficiently produce valve parts, fittings, and flanges. Equipment includes shears to cut billets from cold steel up to 4-in. thick in one bite. Gas-fired furnaces, heat-treating ovens, and acetylene cut-off machines complete this shop.









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Machining and Assembling



1 *Machining Small Parts*—The Crane system of progressive manufacture reaches a high degree of efficiency with precise control of quality in the machining departments. Operations on various valve parts such as discs, stems, and glands, are accurately performed by the machine operators, each with unusual skill in his work.

2 *Facing Discs by Continuous Welding*—One of the outstanding examples of efficient production engineering on Crane steel valves is this disc-facing operation. Here Stellite is being deposited on a disc for a Crane Pressure-Seal valve.

3 *Fast and Accurate Machining*—Here, vertical turret lathes known for great speed and accuracy, are turning the flanges on Crane cast steel valve bodies. Hundreds of the finest machines, many designed by Crane engineers for special needs, occupy thousands of square feet in the great Chicago Works. They insure the high quality of Crane valves and fittings and produce them in ample quantity for every need.

4 *Assembling Crane Valves a Smooth Operation*—The care given to Crane castings and forgings and the meticulous standards for machining all valve parts are reflected in the smoothness of assembly operations. In one department, 150 machines regularly handle steel valves 4 in. and larger. Brass valve assembly lines, using the progressive method, can handle as many as 20 different sizes and types at one time. Photo shows Crane diaphragm valves in process in a typical assembly department for small iron valves.







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TESTING

Inspection and Testing

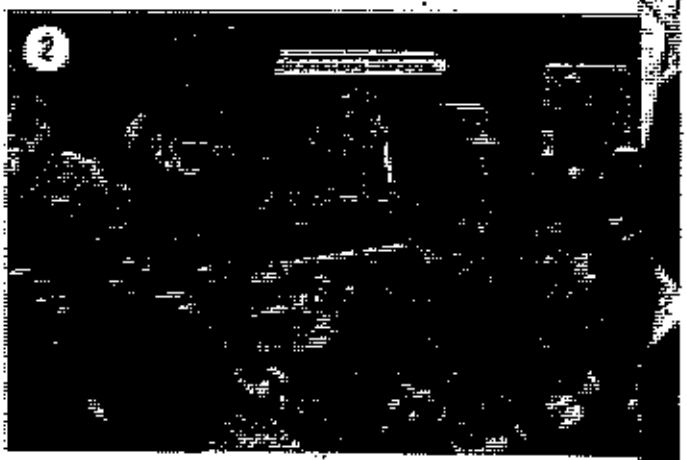
1 *Large Steel Valves Get "O.K." for Service*—Here, Crane Steel gate valves get final check to insure customer satisfaction in the service for which they are intended. Hydrostatic pressure tests are made on shell and seat at prescribed pressures for each class of valve. In addition, valve seats are tested for tightness at 100 pounds, air-under-water. Crane takes great pride in its elaborate system for checking and testing the quality of all valves and fittings.

2 *Fittings Must Measure Up*—Like valves, Crane fittings must measure up to close limits in every way. All types of fittings—steel, iron, and brass—are systematically inspected with precise instruments and gauges. Wall thickness, alignment, threading, drilling, etc., are examined at each stage in process and again before shipping to the customer or being placed in the stock room.

3 *Check Valves Get Rigid Test*—Because check valves depend entirely on gravity or backflow pressure for right seating, Crane engineers devised a highly critical test to assure seat tightness. Check valves are also given hydrostatic pressure tests on shell and seat, for which the 10-inch, 125-pound iron swing check in the photo is being prepared.

4 *Pressure Testing Small Valves*—All steel and iron valves, which are produced in great quantity, are tested at a rapid rate by Crane-developed methods like this. Note the high visibility gauges. As many as 4000 valves in 80 different sizes and types can be tested daily in these departments.



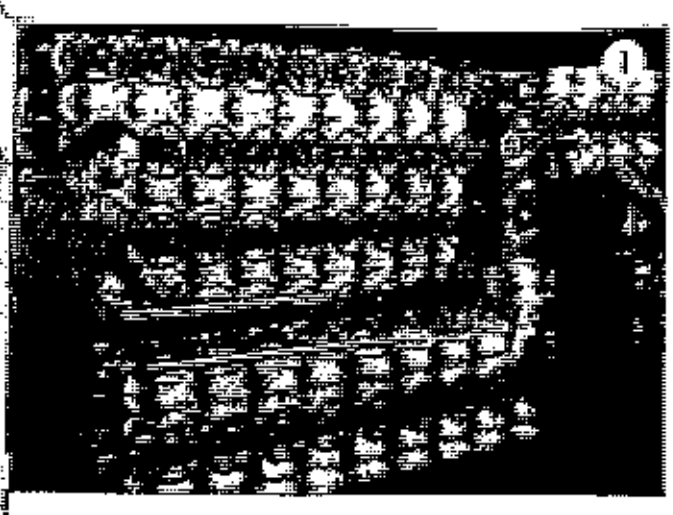


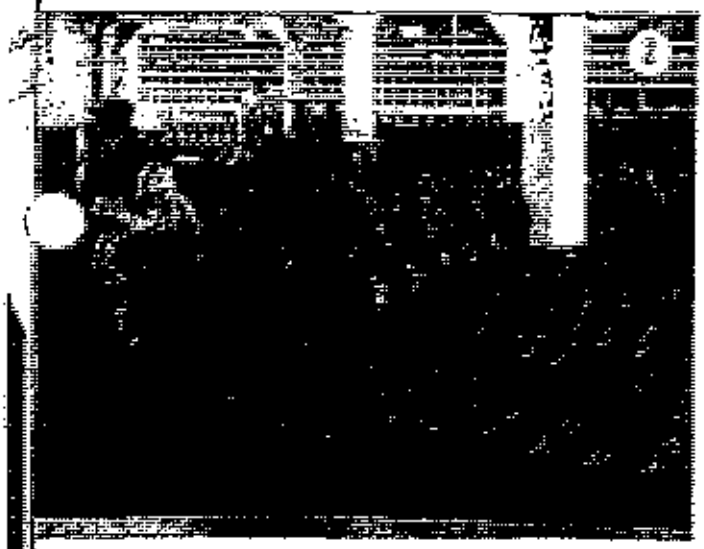




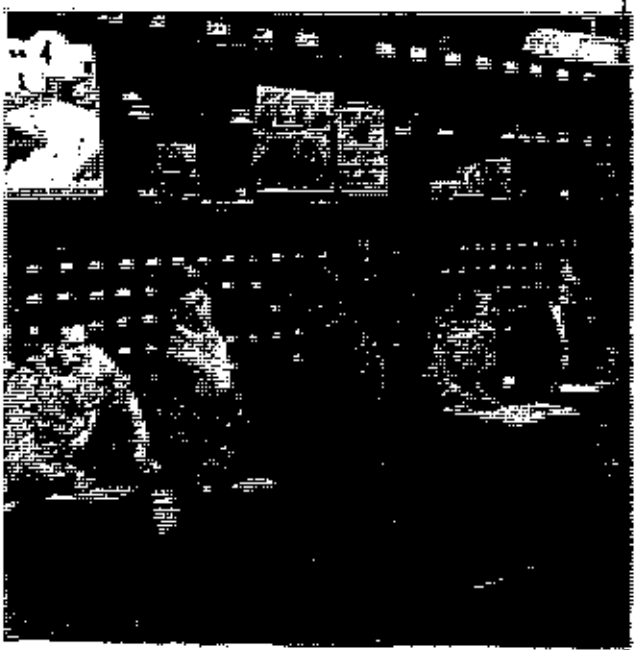
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Warehousing and Distribution









1 *In Storage at Chicago Works*—Here's just a "peek" view of the larger valve stocks normally maintained at the factory, ready for shipment to Crane Branches, Crane Wholesalers, or direct to customers. Shipments from the factory are accelerated by the skillfully planned flow of stock to packing and shipping departments, and highly efficient order-filling methods. 26 freight cars can be loaded from the main shipping platform at one time.

2 *Branch Stock Matched to Local Needs*—More than 140 Crane Branches across the country carry a sufficient supply of staple items to permit filling many orders from stock. Branches in large industrial centers naturally carry larger stocks, as shown in this photo. Crane Wholesalers in these areas, as well as nearby Crane Branches, have access to such supplies for needs that can't await factory shipment.

3 *No Delay at Deliveries at Crane Branches*—Shipping-platforms are usually the busiest places at Crane Branches. As fast as shipments from the factory are received and checked in, stocks move out to local customers. Crane Branches are located for convenient railroad service and rapid truck delivery.

4 *Daily "Over the Counter" Service*—All Crane Branches are equipped to give counter service on staple items throughout each business day. These departments, with close knowledge of stock on hand, also handle your telephone "will call" orders with speed and efficiency.

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Alphabetical Index

All items shown in this catalog are cross-indexed alphabetically. References under broad classifications are covered by page numbers showing the entire range of products. For example, under the very general heading of "Brass Valves", group page numbers are shown for each of the various types, but under the specific heading of "Angle Valves, Brass", etc., will be found a detailed listing of the many available types. Similarly, under "Fittings", will be found group page numbers, the detailed references being made under specific listings such as, "Elbows", "Tees", "Crosses", "Unions", etc.

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A colored paper insert near the center of the book is the key to an easy-to-use Sectional Index. Regular valve and fitting catalog users will find this feature unusually convenient.

000194

Johns-Manville Insulating Materials



Asbestocel
For Temperatures Up to 700° F.



85% Magnesia
For Temperatures Up to 600° F.



Wool Felt
For Hot and Cold Water Service Lines up to 225° F.



Zero
To Prevent Cold Water Pipes from Freezing

Pre-Shrunk Asbestocel

Johns-Manville Pre-Shrunk Asbestocel is a cellular type of insulation, made of alternate layers of plain and corrugated asbestos felts. Used on pipe lines carrying low pressure steam and hot water.

This material will not absorb moisture while in stock or during handling and consequently expand. Pre-Shrunk Asbestocel is made of specially-treated, moisture-resistant asbestos paper which prevents "breathing" and thus removes the cause of objectionable shrinkage cracks. It is also fabricated with an improved type of corrugation which affords greater strength and a more uniform appearance.

Pre-Shrunk Asbestocel is made in sections three feet long for pipe sizes of ½ to 12-inch inclusive and 4-ply thicknesses (¼-inch per ply) or thicknesses of four plies to the inch are available. The following finishes are furnished: regular canvas covered, asbestos paper covered high-speed finish, and glazed white high-speed finish.

Zero Pipe Insulation

Zero Pipe Insulation is designed for insulating cold water pipes that are exposed to moderate (ordinary) rather than extremely low temperatures, or where the time that the surrounding atmosphere would be below the freezing point is of short duration.

It is constructed of layers of hair felt surrounded by several layers of wool felt, with a layer of saturated wool felt inside the hair felt to keep the hair from direct contact with the pipe. Hair felt greatly retards the flow of heat from the water in the pipes to the cooler surrounding air and is protected by a wool felt jacket and an inner layer of saturated felt.

For outdoor lines, for extremely low temperatures, or for temperatures below the freezing point that are of long duration Zero Pipe Insulation with a separate jacket is recommended.

Zero Pipe Insulation is furnished in 3-foot lengths, split for ready application, covered with canvas and equipped with metal bands. Made for pipe sizes from ½ to 8-inch, and in nine thicknesses, approximately ½ inches.

85% Magnesia

Johns-Manville 85% Magnesia insulation combines the high insulating qualities of basic carbonate of magnesia and asbestos, affording a light weight and efficient insulation. It contains a maximum number of dead-air cells which increases its natural resistance to heat transmission and reduces its weight.

Johns-Manville 85% Magnesia Pipe Insulation is moulded in 3-foot lengths in Standard, 1¼-inch, 2-inch, Double Standard, 2½-inch, and 3-inch thicknesses (double layer), to fit standard pipe sizes from ½ to 12-inch.

For smaller pipe, 85% Magnesia Pipe Insulation is furnished in sectional form, packed in crates or cartons with canvas jacket and metal bands. For larger pipe sizes it is supplied in segmental form, without canvas or bands.

Pre-Shrunk Wool Felt

Johns-Manville Pre-Shrunk Wool Felt Pipe Insulation is an effective and economical material for hot water lines and for use on moderately cold water lines where humidity conditions are not severe.

Like Pre-Shrunk Asbestocel, Johns-Manville Pre-Shrunk Wool Felt is made of moisture-resisting felts which prevent the objectionable absorption of moisture in storage, thus minimizing drying shrinkage and pulling apart at the joints after application.

The sheets of wool felt of which this material is composed are indented, which reduces the conductivity of the finished material approximately 25 per cent as compared with ordinary wool felt. It is also up to 25 per cent lighter in weight.

This wool felt has a dual-service felt liner which is waterproof, making it perfectly suited to cold water lines. Since the liner will withstand temperatures as high as 225° F., the material is equally satisfactory for hot water lines.

Available in sections 3-feet long, in thicknesses of ½-inch, ¾-inch, and 1-inch for pipe sizes from ½ to 12-inch. It is available with a canvas finish or with an integral, weather-proof jacket.

Prices and additional information on application

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Johns-Manville Insulating Materials

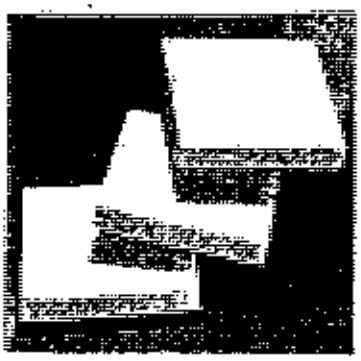
Asbestos Sheet Millboard



Asbestos Sheet Millboard is recommended for general uses requiring sheet or board for protection against fire, heat, acid fumes, etc. It is frequently used as a fireproof lining for floors, partitions, ceilings, elevator shafts, ranges, stoves, grates, etc.

Millboard can be cut with shears to any size desired and fastened with nails or screws. Standard sheet size is 42 x 48 inches; cut pieces can also be furnished. Thicknesses of 1/8 to 1/4-inch are available.

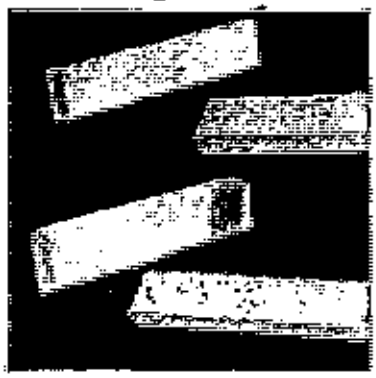
Asbestocel Blocks



An economical insulation for temperatures up to 300° F. Ideal for boilers, warm air ducts, etc.

The blocks are made of built-up asbestos felt layers, alternately plain and corrugated. Available in widths from 6 to 30-inch and in lengths from 36 to 96-inch. Coarse Blocks are furnished in thicknesses of 1 to 8 plies with four plies per inch of thickness. Fine Blocks are furnished in thicknesses of 1 to 16 plies with six or eight plies per inch of thickness.

85% Magnesia Blocks



These blocks are used to insulate flat, curved, or irregular surfaces where temperatures do not exceed 600° F. They are widely used where high insulating value and light weight are needed, and where surfaces are so irregular that an easily cut insulation is required for proper fitting.

Regularly furnished flat or curved in 3 and 6-inch widths, in 18 and 36-inch lengths, and up to 4 inches thick. Flat blocks are available in 9 and 12-inch widths also.

Finishing and Insulating Cements

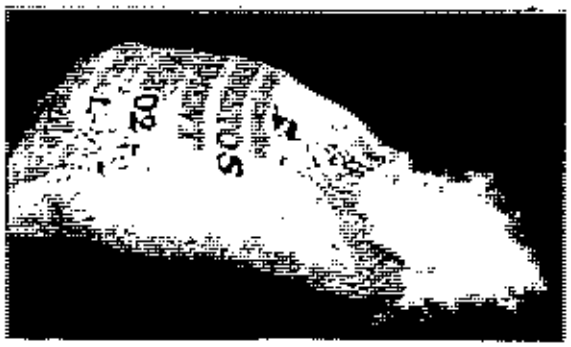
Johns-Manville cements are unexcelled for insulation of irregular surfaces such as on valves, flanges, pipe fittings, etc., or as a surface finish over block or sheet insulations in order to seal joints and to provide a smooth, durable finish.

Finishing cements include two types: The No. 302 is made of asbestos fiber and suitable binding materials. It produces a hard, durable surface which will not crack, break, or peel off.

The No. 371 is a general utility short-fiber asbestos finishing cement, ideal for finishing insulation on heating boilers and pipe fittings.

Insulating cements also include two types: The 85% Magnesia which features a high insulating value and which, except for its powdered form, is similar to the 85% Magnesia Blocks described above.

The No. 450 is a high grade, mineral wool cement with superior insulating properties. Provides high covering capacity and excellent adhesion to either hot or cold surfaces. It is usually applied in thicknesses equal to block insulation where conditions prevent the use of the latter.



Temperature Limits and Covering Capacities of Cements

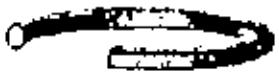
Type of Cement		Max. Temp. Deg. F.	Covering Capacity Applied and Dried 1-inch thick. Sq. Ft. per 100 lbs.	Sq. Ft. per Bag	Approx. pounds of water to mix 100 pounds cement.	Weight per Bag Pounds
Finishing	No. 301	—	25	25	175	150
	No. 302	—	15	10½ or 15	185	80 or 100
Insulating	85% Magnesia	600	50	30	450	60
	No. 450	1400	85	25	350	60

Prices and additional information on application

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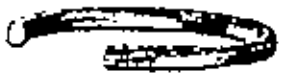
000202

Rings for Ring Joints



Oval Ring
Types A and B

Prices on application



Octagonal Ring
Types A and B

Crane Oval and Octagonal Rings, illustrated above, are available in two grades of material suitable for use in 150, 300, 400, 600, 900, 1500, and 2500-Pound ring joints.

The shape of the ring regularly furnished for various sizes and pressure classes of joints is indicated in the table at the right.

Ordering: Orders for rings should specify the Ring Number and whether Type A or Type B is wanted. When the Type is not specified, Type A Rings will regularly be supplied in the shape shown in the table at the right.

Type A Rings are made of Soft Steel (90 Brinell maximum hardness), either oval or octagonal, as shown in the table at the right; they are recommended for use with Carbon Steel, No. 4 Carbon-Molybdenum Steel, or No. 3 Nickel Steel products.

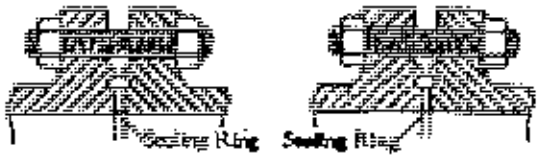
Type B Rings made of 5% Chrome with ½% Molybdenum (130 Brinell maximum hardness), are recommended for corrosive services, as in oil refinery work, and for use with No. 7 Chrome-Molybdenum Steel products. They have the same shape as Type A Rings, being distinguished by a square bead on the outer periphery.

Dimensions of Rings and Ring Joints . . pages 470 and 471
Flanged Joint assembly and maintenance . . . . . page 830

Shape of Ring Regularly Furnished For Various Size Ring Joints

Pressure Class	Oval Rings	Octagonal Rings
150-Pound	All sizes	. . .
300-Pound 400-Pound 600-Pound	18" and smaller	20 and 24"
900-Pound	13" and smaller	14" and larger
1500-Pound	7" and smaller	8" and larger
2500-Pound	3" and smaller	3½" and larger

Corrosion Sealing Rings



For unusually corrosive fluids, *Corrosion Sealing Rings*, illustrated above, are recommended for protection of rings. Prices on application.

Gaskets

For Brass and Bronze Flanged Joints



Full Face Gaskets are furnished without bolt holes unless otherwise ordered; an extra charge is made for punching bolt holes.

Size of Joint Inches	150-Pound MSS Standard Full Face Gaskets List Prices, Each ⅛-inch Cloth Inserted Rubber	⅛-inch "CC" Rubber	⅛-inch Cranite	Inside and Outside Diameters Inches	300-Pound MSS Standard Full Face Gaskets List Prices, Each ⅛-inch "CC" Rubber	⅛-inch Cranite	Inside and Outside Diameters Inches
1	.15	.18	.10	1 × 2½	.29	.22	1 × 2⅝
1¼	.21	.26	.15	1¼ × 2⅞	.29	.26	1¼ × 3⅛
1½	.11	.26	.22	1½ × 3	.38	.34	1½ × 3½
2	.27	.38	.31	2 × 4	.48	.38	2 × 4½
2½	.34	.43	.44	2½ × 5	.58	.53	2½ × 5½
3	.43	.61	.59	3 × 5½	.69	.61	3 × 6⅛
3½	.44	.69	.61	3½ × 6½			
4	.52	.77	.66	4 × 7			
5	.62	1.06	.77	5 × 8			
6	.69	1.28	.81	6 × 9			
8	.96	1.50	1.30	8 × 11½			
10	1.38	2.04	1.70	10 × 14			

Important: Full face gaskets should always be used for brass or bronze flanged joints. Metallic gaskets are not recommended.

When brass or bronze flanged material is bolted to iron or steel material which normally has a raised face, the raised face should be removed to provide a full face bearing for the gasket. Brass or bronze flanged material should not be bolted to Crane-lap flanged pipe joints.

Cranite Gaskets: When installing Cranite Gaskets, they should be coated with Crane Thread Lubricant in order to facilitate making tight joints; see page 464. Cranite Gaskets are satisfactory for use in oil lines where asbestos gaskets are permitted.

39

Sheet Packings . . . page 473 *For Gaskets for Iron and Steel Flanged Joints, see pages 474 to 476.*

000203

Cranite Sheet Packing

CRANITE——*the highest grade sheet packing obtainable.*

Cranite Packing has been approved by the Underwriters' Laboratories, Inc., for use on Underwriters' lists.

The name "CRANITE" is registered in the United States Patent Office.



The list price of Cranite Sheet Packing, for widths and thicknesses regularly furnished, is $1.60 per pound.

The 1/16-inch thickness averages .82 pound to the square foot.

An Asbestos Composition manufactured solely for Crane

Cranite Sheet Packing: Cranite Sheet Packing is made of an asbestos composition, using only selected long fiber asbestos, cross laminated to provide unusual tensile strength. It offers a very uniform and high resistance to compression, is exceptionally strong and rugged, and will not deteriorate with age.

This packing is unhesitatingly recommended for a multitude of services, such as steam, water, oil, dry air, acids, ammonia, alkali, gases, etc., and for temperatures up to 750° F.

Because of the great number of services for which Cranite Sheet Packing can be used, its unusually high quality, and its ability to withstand deterioration, users will find it economical to purchase the packing in quantities and to carry it in stock.

For best results, gaskets cut from Cranite Sheet Packing should be coated with Crane Thread Lubricant when being installed. See page 464 for Crane Thread Lubricants.

Sizes: Cranite Sheet Packing is regularly furnished 1/16-inch thick in sheets 36 or 48 inches square. Other thicknesses from 1/64 to 3/16-inch, or other sizes up to 110 inches square can be made to order; prices and additional data on request.

"CC" Rubber Sheet Packing

The list price of "CC" Rubber Sheet Packing, for widths and thicknesses regularly furnished, is $1.95 per pound.



Average weights per square yard:
1/32-inch thick... 5¼ pounds
1/16-inch thick... 8 pounds
1/8-inch thick...16½ pounds

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Manufactured Solely for Crane

"CC" Rubber Sheet Packing, manufactured solely for Crane, is especially well adapted for high or low pressure service on saturated steam, hot and cold water, air, gases, etc.

"CC" Rubber Sheet Packing is regularly furnished in rolls 36 inches wide and in thicknesses of 1/16-inch 3/32-inch, or 1/8-inch; each of these rolls weighs approximately 100 pounds.

Other widths, up to 72 inches, are available on special order; prices and data furnished on request.

000204

Gaskets

For Cast Iron Flanged Joints



Ring Gaskets cover the face of the flange to the inside edge of the bolts, and will always be furnished unless otherwise ordered.



Full Face Gaskets are furnished without bolt holes unless otherwise ordered; an extra charge is made for punching bolt holes.

Flanged Joint		Ring Gaskets						Full Face Gaskets					
		List Prices, Each				Diameter, in Inches		List Prices, Each				Diameter, in Inches	
Pressure Class	Size	1/16-inch Cloth Inserted Rubber	1/16-inch "CC" Rubber	4-ounce Canvas	1/16-inch Cranite	Inside	Outside	1/16-inch Cloth Inserted Rubber	1/16-inch "CC" Rubber	4-ounce Canvas	1/64-inch Cranite	Inside	Outside
	Inches												
	10	.63	1.05	.37	....	10	13 5/8	1.30	1.05	.81	....	10	16
	12	.86	1.36	.52	....	11	16 3/8	1.70	1.55	1.05	....	11	19
	14	1.05	1.60	.62	....	14	18	1.90	2.90	1.20	....	14	11
For 25-Pound Cast Iron Flanged Joints	16	1.10	2.05	.71	....	16	10 3/4	1.45	3.65	1.45	....	16	23 1/2
	18	1.30	1.35	.77	....	18	11	1.75	4.10	1.65	....	18	15
	20	1.50	1.55	.90	....	10	24 1/8	1.95	4.50	1.75	....	10	27 1/4
	24	1.10	3.00	1.15	....	14	18 3/4	3.75	5.40	2.30	....	24	32
	30	3.10	4.50	1.90	....	30	135 1/8	5.60	9.10	3.40	....	30	38 3/4
	36	4.30	7.00	1.60	....	36	41 7/8	7.50	13.90	4.55	....	36	46
	42	5.15	8.25	3.10	....	41	48 1/2	....	16.55	5.55	....	42	53
	48	....	0.55	4.10	....	48	55	....	19.15	7.15	....	48	59 1/2
	1	.07	.09	.06	.08	1	1 5/8	.15	.18	.13	.18	1	4 1/4
	1 1/4	.10	.13	.09	.09	1 1/4	3	.21	.26	.18	.19	1 1/2	4 5/8
	1 1/2	.10	.13	.09	.11	1 1/2	3 3/8	.11	.16	.18	.12	1 1/2	5
	2	.10	.18	.09	.14	2	4 1/8	.27	.35	.11	.31	2	6
	2 1/2	.13	.12	.10	.17	2 1/2	4 7/8	.34	.43	.17	.44	2 1/2	7
	3	.18	.16	.13	.20	3	5 3/8	.41	.51	.31	.49	3	7 1/2
	3 1/2	.11	.36	.15	.29	3 1/2	6 1/8	.44	.69	.33	.61	3 1/2	8 1/2
	4	.14	.40	.16	.31	4	5 7/8	.51	.77	.35	.66	4	9
	5	.18	.51	.19	.36	5	7 3/4	.61	1.05	.41	.72	5	10
For 125-Pound Cast Iron Flanged Joints	6	.34	.60	.11	.41	6	8 3/4	.69	1.25	.44	.81	6	11
	8	.44	.77	.27	.56	8	11	.96	1.50	.59	1.20	8	13 1/2
	10	.62	1.05	.37	.75	10	13 3/8	1.30	1.05	.81	1.70	10	16
	12	.86	1.36	.51	1.15	11	16 1/8	1.70	2.55	1.05	1.30	11	19
	14	1.05	1.60	.62	1.10	14	17 3/4	1.90	1.85	1.20	1.60	14	11
	16	1.10	1.05	.71	1.40	16	10 3/4	1.45	3.65	1.50	3.10	16	23 1/4
	18	1.25	1.35	.77	1.10	18	11 5/8	1.95	4.10	1.65	3.10	18	15
	20	1.50	1.55	.90	1.45	20	13 3/4	1.95	4.80	1.75	3.50	20	17 1/2
	24	2.05	2.95	1.25	2.50	24	18 1/2	3.75	5.40	2.30	4.35	24	32
	30	3.10	4.50	1.85	....	30	34 3/4	5.60	9.10	3.40	....	30	38 3/4
	36	4.30	6.95	1.60	....	36	41 1/4	7.50	13.90	4.55	....	36	46
	42	5.15	8.15	3.10	....	42	48	....	16.55	5.55	....	42	53
	48	....	4.05	4.05	....	48	54 1/2	....	19.20	7.16	....	48	59 1/2
	1 1/2	....	.18	....	.14	1 1/2	3 3/4						
	2	....	.20	....	.15	2	4 3/8						
	2 1/2	....	.16	....	.19	2 1/2	5 1/4						
	3	....	.33	....	.26	3	5 7/8						
	3 1/2	....	.30	....	.30	3 1/2	6 1/2						
	4	....	.34	....	.36	4	7 1/8						
For 250-Pound Cast Iron Flanged Joints	5	....	.53	....	.47	5	8 1/2						
	6	....	.64	....	.61	6	9 7/8						
	8	....	.92	....	.81	8	12 1/2						
	10	....	1.10	....	1.05	10	14 1/4						
	12	....	1.55	....	1.25	11	16 1/8						
	14	....	1.15	....	1.10	13 1/4	19 1/8						
	16	....	1.55	....	1.40	15 1/4	21 1/2						
	18	....	1.95	....	1.60	17	23 1/2						
	20	....	3.10	....	1.05	19	25 3/4						
	24	....	4.10	....	3.95	13	30 1/2						

Canvas Gaskets: Canvas Gaskets are furnished pre-coated. They should be coated with Crane Thread Lubricant or with red lead and oil when installed.

Cranite Gaskets: When Cranite Gaskets are installed, they should be coated with Crane Thread Lubricant to facilitate making tight joints. Cranite Gaskets are satisfactory for use in oil lines where asbestos gaskets are permitted.

Other materials: Other commercial sheet packing gaskets are made to order; prices on application.

Thread lubricant . . . . . page 464
Gaskets for brass flanged joints . page 471
Sheet packings . . . . . page 472

800-Pound Hydraulic Cast Iron Joints: Gaskets for 800-Pound Hydraulic Cast Iron Flanged Joints are the same as for 900-Pound Steel Flanged Joints; use the list prices and dimensions shown on page 475.

000205

Gaskets

For Steel Flanged Joints

Cranite Gaskets: Cranite Gaskets are recommended for steam, water, air, gas, and many other similar services, including all lines on which asbestos gaskets are permitted. Their use is limited to a maximum of 750° F. When being installed, they should be coated with Crane Thread Lubricant to facilitate the making of tight joints; see page 404.

Corrugated Metallic Gaskets: Corrugated Metallic Gaskets (Copper or Soft Iron) can be furnished when ordered; prices and dimensions on application. They should have a large inside diameter to assure a high unit compressive load; this requirement is mandatory in the case of piping materials used at the higher pressures and temperatures for which they are recommended. The gaskets should be coated with Crane High Temperature Thread Compound when being installed; see page 404.



Ring Gaskets extend to the inside edge of the bolts



Corrugated Metallic Gasket

800-Pound Hydraulic Cast Iron Joints: 800-Pound Hydraulic Cast Iron Flanged Joints use the same gaskets as the 800-Pound Steel; see list prices and dimensions in the table below.

Ring Gaskets—1/16-Inch Thick Cranite

Size of Joint Inches	150-Pound List Price Each	150-Pound I.D. × O.D. Inches	300-Pound List Price Each	300-Pound I.D. × O.D. Inches	400-Pound List Price Each	400-Pound I.D. × O.D. Inches	600-Pound List Price Each	600-Pound I.D. × O.D. Inches	900-Pound List Price Each	900-Pound I.D. × O.D. Inches	1500-Pound List Price Each	1500-Pound I.D. × O.D. Inches
½	.06	½ × 1⅞	.08	½ × 1⅛	....	.....	.08	½ × 1⅛	....	.....	.08	½ × 1½
¾	.07	¾ × 1¼	.08	¾ × 1⅝	....	.....	.08	¾ × 1⅝	....	.....	.09	11/16 × 1¾
1	.08	1 × 2⅜	.09	1 × 1⅞	....	.....	.09	1 × 2⅛	....	.....	.11	½ × 1⅞
1¼	.09	1 1/16 1	.11	1⅛ × 1½	....	.....	.11	1⅛ × 1¾	....	.....	.11	1⅛ × 1½
1½	.11	1½ × 1⅞	.14	1½ × 3¼	....	.....	.14	1½ × 1¾	....	.....	.15	1⅜ × 5⅛
1	.14	1 × 4⅛	.15	1 × 4⅜	....	.....	.15	1 × 4⅜	....	.....	.27	1⅜ × 5⅝
1½	.17	1½ × 4⅛	.19	1½ × 5⅛	....	.....	.19	1½ × 5⅛	....	.....	.16	1½ × 6½
1	.10	1 × 5⅛	.16	1 × 5⅛	....	.....	.16	1 × 5⅛	.16	1⅜ × 6⅝	.40	2¾ × 6½
1½	.19	1½ × 6⅜	.30	1½ × 6½	....	.....	.29	5½ × 6⅜	....	.....	....	.....
4	.11	4 × 6½	.16	4 × 7⅛	.34	4 × 7	.44	4 × 7⅛	.54	1⅜ × 8½	.58	1¾ × 8¼
5	.36	5 × 7¾	.47	5 × 8½	.15	5 × 8⅜	.66	5 × 9½	.71	4¾ × 9½	.81	4⅜ 10
6	.41	6 × 8¾	.61	6 × 9½	.59	6 × 9¾	.69	6 × 10½	1.00	5¾ × 11⅜	1.00	5⅜ × 11⅛
8	.56	8 × 11	.81	8 × 12½	.78	8 × 11	1.00	7¼ × 11⅝	1.40	7½ × 14½	5.40	7 × 11⅞
10	.75	10 × 13¾	1.05	10 × 14¼	1.00	10 × 14⅛	1.65	9⅜ × 15¾	1.10	9⅜ × 17½	1.15	8¾ × 11⅛
11	1.15	11 × 16¼	1.25	11 × 16½	1.25	11 × 16½	1.00	11¾ × 18	1.60	11½ × 19¾	5.05	10⅜ × 20½
14	1.15	11½ × 17¾	2.10	13½ × 19½	1.05	13¾ × 19	1.25	11⅛ × 19⅜	1.70	12¼ × 20½	3.80	11¾ × 11½
16	1.75	15¼ × 19¾	1.30	15½ × 11½	2.35	15 × 11⅛	1.90	14¼ × 11¾	1.10	14 × 11⅝	....	.....
18	1.55	17¼ × 11⅜	5.60	17 × 21½	1.55	17 × 25⅜	3.20	16¼ × 14⅜	1.75	15¾ × 25⅛	....	.....
20	1.80	10¼ × 23⅞	1.05	19 × 25¼	1.05	18⅛ × 15½	3.80	18⅛ × 26½	4.40	17½ × 27½	....	.....
24	1.05	23¼ × 18¼	3.95	23 × 10½	4.00	11⅜ × 10¼	4.75	21 × 11⅛	6.40	11 × 33	....	.....

Large Male and Female Gaskets—1/16-Inch Thick Cranite

Size of Joint Inches	300-Pound List Price Each	300-Pound I.D. × O.D. Inches	400-Pound List Price Each	400-Pound I.D. × O.D. Inches	600-Pound List Price Each	600-Pound I.D. × O.D. Inches	900-Pound List Price Each	900-Pound I.D. × O.D. Inches	1500-Pound List Price Each	1500-Pound I.D. × O.D. Inches
½	.04	½ × 1⅞	....	.....	.04	½ × 1⅞	....	.....	.04	½ × 1⅛
¾	.05	¾ × 1 11/16	....	.....	.05	¾ × 1 11/16	....	.....	.05	11/16 × 1 11/16
1	.05	1 × 1	....	.....	.05	1 × 1	....	.....	.06	⅞ × 2
1¼	.06	1¼ × 1½	....	.....	.06	1¼ × 1½	....	.....	.07	1¼ × 1½
1½	.07	1½ × 1⅞	....	.....	.07	1½ × 2⅛	....	.....	.08	1⅜ × 1⅞
2	.11	1 × 3⅛	....	.....	.11	1 × 3⅛	....	.....	.11	1⅞ × 3⅛
2½	.11	2½ × 4 1/16	....	.....	.11	2½ × 4⅛	....	.....	.11	1¼ × 4 1/16
1	.11	1 × 5	....	.....	.15	1 × 5	.15	1¼ × 5	.16	1¾ × 5
3½	.16	3½ × 5½	....	.....	.16	1¼ × 5½	....	.....	....	.....
4	.14	4 × 6 2/16	.24	4 × 6 2/16	.24	4 × 6 2/16	.15	1⅛ × 6 2/16	.27	2⅜ × 6 2/16
5	.19	5 × 7 5/16	.19	5 × 7 5/16	.10	5 × 7 5/16	.11	1¾ × 7 5/16	.36	4⅜ × 7 5/16
6	.36	6 × 8½	.30	6 × 8½	.56	6 × 8½	.10	5¾ × 8½	.44	5⅜ × 8½
8	.47	8 × 10⅝	.47	8 × 10⅝	.50	1½ × 10⅝	.66	7½ × 10⅝	.61	7 × 10⅝
10	.61	10 × 11¼	.61	10 × 11¾	.66	4¾ × 11¾	.71	4⅛ × 11¼	.88	8⅛ × 11¾
12	.81	11 × 15	.81	12 × 15	.88	11¾ × 15	1.00	11⅛ × 15	1.15	10⅜ × 15
11	.88	12½ × 16¼	.81	13½ × 16½	.97	11⅞ × 16¼	1.15	11¼ × 16½	1.15	11⅜ × 16¼
16	1.05	15¼ × 18½	1.15	15 × 18½	1.20	14¾ × 18½	1.40	14 × 18½	....	.....
18	1.35	17 × 11	1.55	17 × 11	1.55	16½ × 11	1.95	15¼ × 11	....	.....
20	1.45	19 × 11	1.50	18⅞ × 23	1.80	18¼ × 21	1.20	17½ × 11	....	.....
24	1.35	13 × 27½	1.50	11⅝ × 17½	1.85	11 × 27½	3.10	11 × 27½	....	.....

Sheet packings page 411 *Large tongue and groove gaskets page 476*

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Gaskets for All Large Tongue and Groove Flanged Joints

Cranite Gaskets are not recommended for temperatures higher than 750° F. They are satisfactory for use in oil lines where asbestos gaskets are permitted. Corrugated Metallic Gaskets (Copper or Soft Iron) are available; prices on application.

Coating Cranite Gaskets with Crane Thread Lubricant and Corrugated Metallic Gaskets with Crane High Temperature Thread Compound, before installing, will facilitate making tight joints.

Cranite Gaskets are not recommended for use in small male and female or small tongue and groove joints. Cranite offers uniform and high resistance to compression but the gasket contact area in such joints is so narrow, crushing the gasket is possible.

List Prices and Dimensions of Gaskets

For 250-Pound Hydraulic and 300-Pound W.O.G. Cast Iron, and 250, 600, 900, 1500, and 1900-Pound Steel Large Tongue and Groove Flanged Joints

Size of Joint	1/16-Inch Cranite		Size of Joint	1/8-Inch Cranite	
	List Price	Inside and Outside Diameters		List Price	Inside and Outside Diameters
Inches	Each	Inches	Inches	Each	Inches
⅜	.03	1 ×1⅜	8	.13	6⅝ ×7⅝
½	.03	1⅝ ×1 21/32	6	.14	1¼ ×8½
1	.03	1⅝ ×1	8	.28	9¾ ×10½
1¼	.04	1⅝ ×1⅝	10	.34	11¾ ×12¾
1½	.04	1⅝ ×2⅞	12	.42	13⅝ ×15
2	.05	2⅜ ×3⅛	16	.44	14¾ ×17½
2½	.06	3⅛ ×4⅛	16	.61	16¾ ×14½
3	.09	4⅛ ×5	18	.89	19¾ ×21
3½	.14	4⅛ ×5⅛	28	.88	11 ×23
4	.11	5⅛ ×6⅛	14	1.05	15¼ ×27½

Thread lubricant and compound . . . page 484
Sheet packings . . . . . page 471

Ring Gaskets For Unions or Union Fittings

When ordering ring gaskets, specify the gasket material and the size and kind of union or union fitting.



For ring gaskets for Tongue and Groove Flange Unions, see page 416.

List Prices and Dimensions of Ring Gaskets

Size of Union or Union Fitting	For 150-Pound Malleable Iron Screwed Unions and Union Fittings *Circulating Boiler Fittings			For 125-Pound Cast Iron Flange Unions	
	Rubber	Cranite	Inside and Outside Diameters	1/16-Inch Cloth Inserted Rubber	Inside and Outside Diameters
Inches	Price per 100	Price per 100	Inches	Price Each	Inches
⅛	.66	1.00	⅜ ×⅝	....	....
¼	.66	1.25	½ ×⅞	....	....
⅜	1.05	1.80	⅝ ×1	.11	1⅛ ×1⅜
½	1.30	1.80	25/32 ×1 11/32	.11	1⅛ ×1⅜
¾	1.60	2.25	1 1/32 ×1 15/32	.28	1⅝ ×1⅞
1	1.95	2.70	1 5/16 ×2 3/32	.13	1 17/32 ×1⅞
1¼	1.60	2.25	1 5/8 ×2 7/16	.14	1 13/16 ×2⅜
1½	2.20	4.50	1 29/32 ×2 11/16	.13	2⅛ ×2⅞
2	2.20	1.98	2⅛ ×3 1/32	.18	2⅝ ×3⅜
2½	4.20	7.60	2⅝ ×3⅞	.17	3⅛ ×4⅛
3	6.40	7.60	3⅛ ×4⅝	.17	3⅝ ×4⅞
3½	....	....	....	.19	4 ×5⅛
4	....	....	....	.20	4½ ×5⅝
5	....	....	....	.30	5⅝ ×7
6	....	....	....	.36	6⅝ ×8½
8	....	....	....	.88	8⅝ ×10⅝

*Circulating Boiler Fittings (No. 586 and No. 596) use the gaskets shown for the ¼-inch size.

Galvanized Steel Flanged Fittings and Flanges

Extra List Prices for Galvanizing

Size	150-Pound Cast Steel Fittings and Forged Steel Flanges						300-Pound Cast Steel Fittings and Forged Steel Flanges					
	Elbows	Elbows	Crosses	Flanges			Elbows	Elbows	Crosses	Flanges		
	No. 525 D No. 527 D No. 545 D	No. 550 D No. 551 D	No. 557 D No. 559 D	No. 556 Screwed		No. 554 No. 554½ No. 558½ No. 868	No. 401 D No. 403 D No. 421 D	No. 425½ D No. 427 D	No. 433 D No. 438 D	No. 281 E Screwed		No. 280 E No. 281 E No. 286 E No. 287 E
	Reducers No. 547 D No. 548 D	Tees No. 551 D No. 554 D	Laterals No. 561 D No. 563 D	No. 564 Slip-On Welding			Reducers No. 423 D No. 425½ D	Tees No. 407 D No. 411 D	Laterals No. 417 D No. 416 D	No. 184 E Slip-On Welding		
Inches	Extra Each	Extra Each	Extra Each	Extra Each	O.D. In.	Extra Each	Extra Each	Extra Each	Extra Each	Extra Each	O.D. In.	Extra Each
⅛	3.60	5.28	7.08	.90	⅝	1.38	4.40	6.80	8.70	1.20	47/64	1.88
¼	1.30	4.28	7.08	.90	47/64	1.30	4.48	6.80	8.70	1.20	1	1.88
⅜	4.80	1.20	7.08	.90	1	1.30	4.40	6.80	8.70	1.20	01	1.88
½	3.80	5.28	9.00	1.00	6	1.58	4.48	6.84	8.70	1.80	01	2.28
¾	3.68	5.40	7.38	1.00	7	1.64	4.60	6.78	8.60	1.40	7/8	1.38
1	4.00	6.68	8.00	1.30	7 1/16	1.80	5.08	7.68	14.08	1.78	6/4	1.58
1½	6.78	7.08	9.40	1.80	4/4	1.20	6.00	9.08	13.08	1.98	4	1.88
2	6.38	8.08	10.38	1.80	9	1.64	6.80	10.80	13.80	1.48	10	1.60
2½	7.60	18.38	14.08	2.08	10	2.00	6.78	13.08	17.88	2.38	11	4.38
3	8.70	13.00	17.60	1.40	11	4.68	11.80	16.80	22.08	1.80	11⅝	1.08
3½	11.60	19.80	16.80	3.60	11⅝	5.28	15.80	24.80	42.38	6.08	11	7.60
19	11.80	32.00	43.80	3.68	19	6.20	26.80	39.00	52.80	7.60	17/8	11.20
11	38.60	48.00	61.80	7.38	19	11.08	37.80	58.60	78.08	14.80	20⅛	16.80
14	43.88	55.88	87.80	10.68	2⅛	15.80	54.80	81.80	108.60	18.48	23	22.08
16	58.00	87.00	116.00	11.88	18⅝	23.00	72.58	109.00	145.80	23.80	11⅝	32.50

Cast Steel Flanged Fittings . . . pages 347 to 376
Forged Steel Flanges . . . pages 377 to 388

000207

One Source of Supply

Exacting users of materials for piping installations will recognize the advantages of purchasing the fabricated piping from a manufacturer who also produces a complete line of valves, fittings, bolts, gaskets, and accessories.

One responsibility: When the task of furnishing all of the material rests with Crane, there is but one responsibility—one uniform standard of materials, workmanship, and service. Whether the joints used are threaded, flanged, or beveled for welding, the same standards and gauging systems are used uniformly on all of the products.

This assures the user that the component parts of the piping system will fit accurately, provide reliability and safety, and will be easily installed, with a minimum of erection and of maintenance costs.

Simplicity of ordering: An order for the complete piping job is handled as an integral unit; there is not the division of responsibility regarding the dimensions and related details of the various items that occurs when the component parts of a piping system are ordered from several sources of supply.

Time saving: There is a saving in time and expense when orders and detailed drawings are prepared for only one source of supply. The delays caused by shipments from several sources are eliminated.

Ease of maintenance: When repairs or replacement are necessary because of the demands of service, they are effected easily when all of the original material was secured from one source of supply.

Advantages of Crane Shop Fabrication

Accuracy: A piping system, when placed in service, should develop the predetermined results and fulfill all of the expectations of a proper design. This should be accomplished expeditiously and at a minimum of final erected cost consistent with the use of good materials and workmanship. Obviously, this purpose will be defeated unless each piece, large or small, of both simple and complex piping systems, receives the attention necessary to assure accuracy and a high quality of workmanship. Crane shop fabrication accomplishes this desirable end.

Proficiency: In the Crane fabricating shops the mechanics are employed solely on the production of fabricated piping. Such continuity of practice means that they do not lose their proficiency, particularly desirable for welding and other complex operations.

Safety: Safety is a prime requisite of every piping installation. Crane shop fabrication assures purchasers that every necessary precaution has been employed to eliminate hidden hazards of piping.

A weld may appear excellent on the exterior, yet under the surface it may contain gas pockets or have faulty penetration. A threaded flange joint gives no indication in its external appearance, of improper threading. These are but two of the many hidden hazards of piping.

Shop appliances: Shop fabrication requires the use of special machinery, clamps, jigs, and other convenient appliances which are impractical for field service. This equipment permits the alignment and squaring-up of all flanged faces or ends of piping, also accuracy of dimensions and angles—all within the closest practical limits. Such characteristics assure the final fitting of every piece into position without alteration or improper strain, resulting in increased safety and a saving of time and labor.

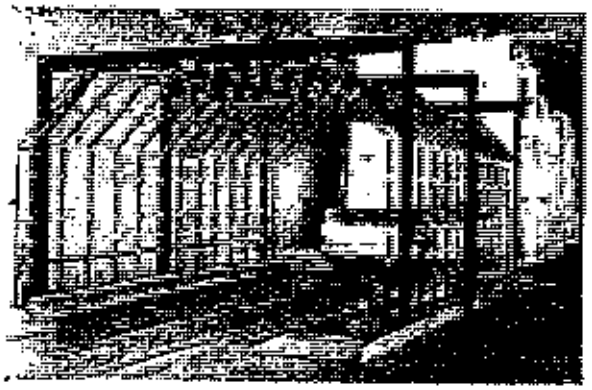
Stress relieving, annealing, or heat treating, when necessary, are readily performed in the shop. All of these advantages are almost impossible of accomplishment in the field.

Working conditions: Working conditions, almost invariably, are better in the shop than in the field. The shop has facilities for handling heavy or bulky pieces, therefore each mechanic is working at all times in a comfortable position and is not concerned about his safety.

Testing: Crane shop fabrication assures dependability because the product is tested and proved sound before shipment. Piping which is fabricated in the field usually must be installed in its final position before it can be tested, and, in the event of failure, the removal for replacement or repair proves expensive and causes delay.

Simplified assembly: The erecting force in the field should only be called upon to assemble a piping system. It should neither be expected to design and fabricate piping, nor to manufacture economically, under adverse field conditions, a product comparable with that of the modern fabricating shop.

Unit fabrication: For further information on unit fabrication, see pages 514 and 515.



Heat treating furnace with spray equipment for quick quenching of product.

000208

Scope of Crane Shop Facilities

Crane can advantageously supply piping for any industry.

Shops at strategic points: Many shops are maintained for supplying the piping needs of industry. A goodly number of the Crane branch houses are equipped for the simpler jobs—the larger branch houses for more elaborate jobs—and fabricating shops embracing the full line of pipe fabrication are located at strategic centers throughout the country.

All types of joints: Any type of joint can be furnished—screwed, flanged, welded, or special. The selection of any type of joint presents a basic engineering or mechanical problem. Crane makes its recommendations accordingly—having an all-inclusive line, it can exercise a degree of impartiality conducive to best serving the interests of the purchaser.

Large stocks: Large stocks of the various kinds of pipe, flanges, valves, fittings, and accessories are carried at all fabricating shops and branches.

Crane is prepared for the job, whether it calls for a single piece of pipe cut to length, or the complete piping equipment of an industry.

Metallurgical and Engineering Control

Laboratories: In the year 1888, Crane established a chemical laboratory with full control over the raw materials used in its products. Constantly expanded, this service has grown into complete research, metallurgical, and testing laboratories. Long a dominant factor in the development of Crane products, all of the accumulated data held by these departments—the applied experience of Crane engineers and research men—are utilized in the production of Crane Fabricated Piping.

Engineering: All fabrication of piping in the Crane shops is under a system of constant procedure control. A thorough gauging system is employed in all operations.

Trained engineers are responsible at all times for the design, superintendence during manufacture, and constant checking of the product.

The services outlined eliminate guesswork in the production of Crane Fabricated Piping.



Studying design through photoelasticity in Crane Research Laboratory.



Constant checking and gauging of Crane Fabricated Piping assures perfect alignment.

Estimating and Ordering

Estimates: A reliable estimate of the cost of any piping system will be furnished promptly upon receipt of an inquiry accompanied by blueprints and specifications.

No matter how complex the layout or how involved the specification, a complete and accurate quotation is assured.

Orders: Crane has specialized for many years in the handling of orders for fabricated piping. Men, well trained and experienced in this work, enter the shop orders direct from complete blueprints, detail sketches, or bills of material, constantly checking all dimensions and details.

Submit inquiries to the nearest Crane representative.

000209

Crane Shop Fabricating Facilities

Equipment

The Crane shops are fully equipped with machinery and facilities for the various operations required in the production of a complete line of fabricated piping.

Much of the shop equipment is special—designed and built to develop the manufacturing technique necessary for the fabrication of piping of uniform accuracy and quality of workmanship.

Many forms of special jigs and appliances are employed constantly to supplement the effectiveness of the machines and other facilities.

Pipe Bending

In Crane shops, the art of bending pipe has been developed to a high degree—pipe bends of many sizes and shapes are in constant production.

Pipe bends have a wide range of usefulness. No two general piping installations are alike, hence pipe bends are especially adapted to solve the many problems of space requirements. The proper proportions of a pipe bend usually are essentially a matter of bending pipe to the dimensions necessary to fit into the available space.

To meet these needs of industry, Crane pipe bending facilities are available; shops are equipped to fabricate pipe Bends from a large range of sizes, weights, and kinds of pipe. See pages 502 to 504.

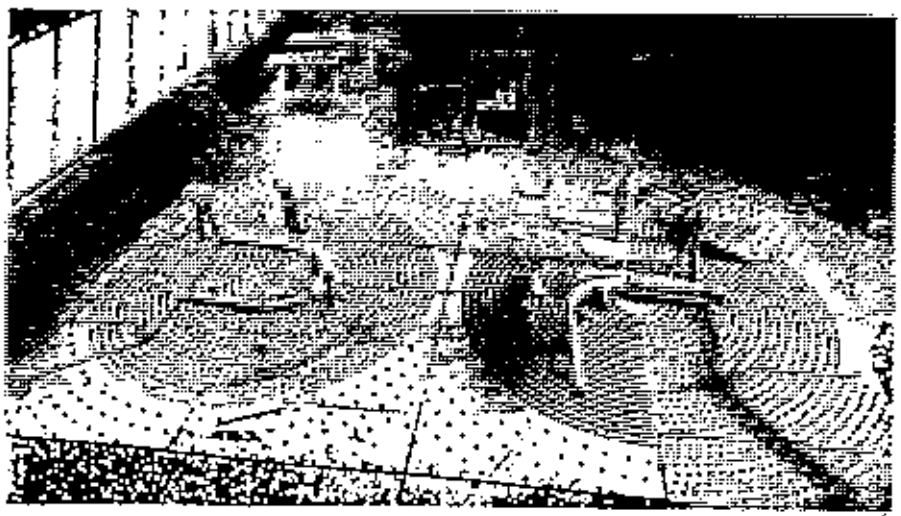
Flanging

Crane shop facilities include equipment for producing the many types of flanged joints in current use. These can be furnished not only in their regular forms but also in the various modifications and special adaptations required. Precision gauges govern every operation, assuring the utmost accuracy. For details, see pages 505 to 509.

Finishing

Special finishing machines enable Crane shops to furnish fabricated piping with a variety of finishes —regular and special. See pages 510 and 511.

Cutting, beveling, threading, soaking-on screwed flanges, facing all types of flanges, machining Crane-lap joints, and various other operations for finishing the ends of Crane Fabricated Piping are performed on these machines with precision and a close adherence to accurate gauging standards.



Pipe bending plant in a Crane Pipe Fabricating Shop.

Welding

Crane pioneered in the welding of fabricated piping. For more than forty years, welding has been used in the fabrication of Crane headers and other products. Untiring research and experiment in the shops and laboratories during this long period are responsible for the constant refinement in the technique of Crane welding.

Crane welders use all modern methods of welding with equal facility and are subjected periodically to qualification tests.

Crane Fabricated Piping includes an almost infinite variety of shop-welded product. For detailed information on welding, see pages 512 to 517.

Swedging

Swedging facilities are available for all sizes of pipe. The facilities include furnaces for heating, powerful forging hammers, and dies to assure accurate fabrication.

Cutting and Threading Pipe

Crane shops are equipped to cut and thread pipe for all commercial services; regular and special threads can be furnished. Accurate threading to gauge, so characteristic of Crane screwed products, is similarly found in pipe cut and threaded in Crane shops.

Testing

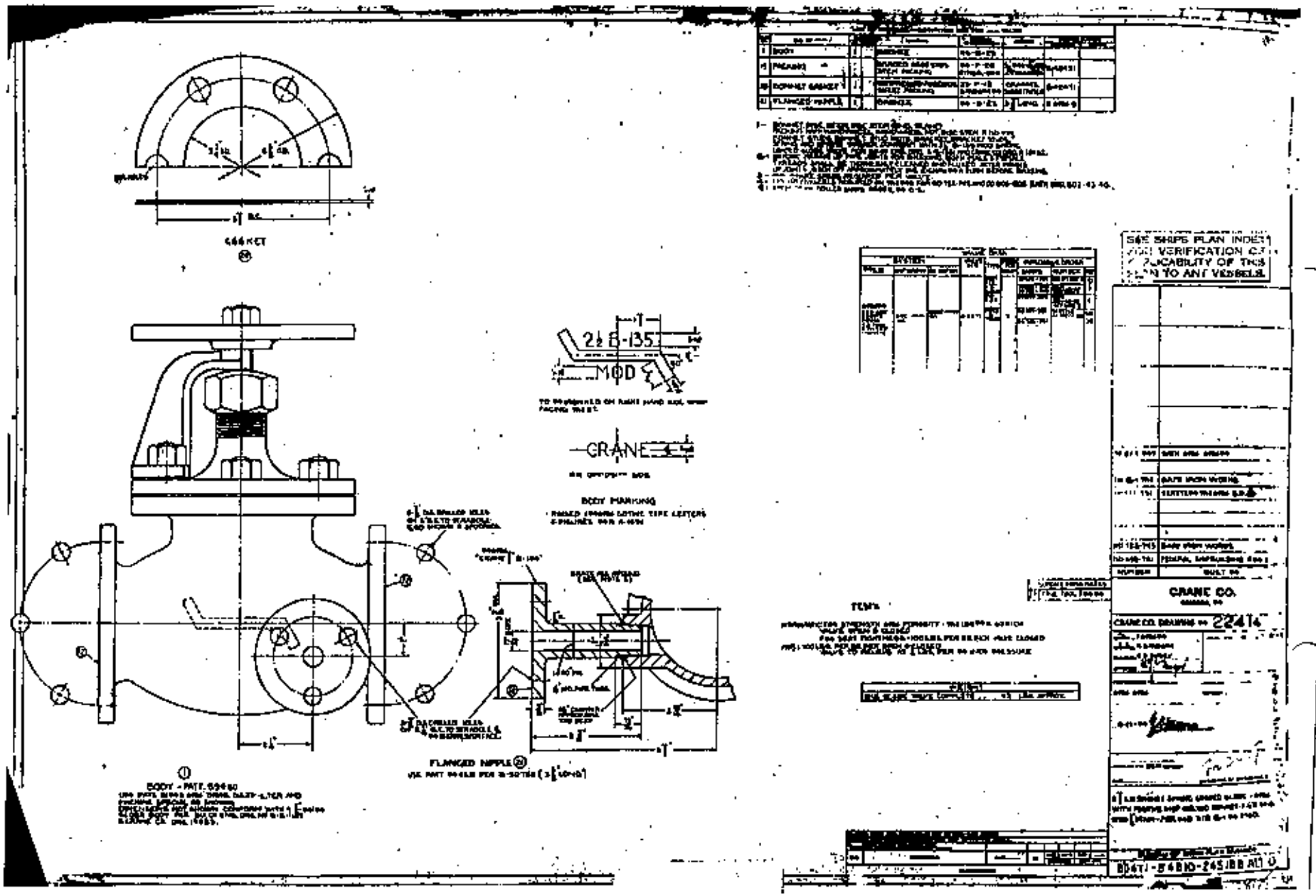
Crane shop facilities include equipment for testing fabricated piping as specified in the various codes, or in accordance with the provisions of a specification. The usual hydrostatic tests are supplemented by air-under-water and other special tests if required.

Cleaning Fabricated Piping

All fabricated piping is regularly cleaned internally by a mechanically driven rotary cleaning tool, or with a wire brush, or blown out with compressed air to remove loose foreign material resulting from fabrication. When specified on orders, special cleaning by pickling or sand-blasting, or both, will be performed at an extra charge.

000210

EXHIBIT L


2½ B-135
MOD
CRANE
BODY MARKING
FLANGED NIPPLE
BODY - PATT. 62660
CRANE CO.
CRANE CO. DRAWING NO. 22414
SEE SHIPS PLAN INDEX
FOR VERIFICATION OF
APPLICABILITY OF THIS
PLAN TO ANY VESSEL

WAL-3856

1	BODY	[illegible]	[illegible]	[illegible]		
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[illegible]	BONNET GASKET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

SEE SHIPS PLAN INDEX FOR VERIFICATION OF APPLICABILITY OF THIS PLAN TO ANY VESSELS

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[illegible]	BATH IRON WORKS
[illegible]	BETTLE[illegible]
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[illegible]	FEDERAL [illegible]
NUMBER	BUILT BY

TESTS

[illegible]

WEIGHT

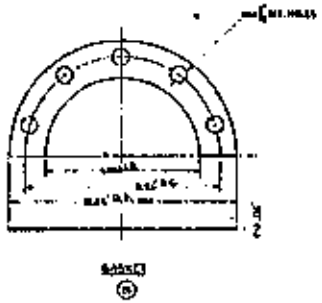
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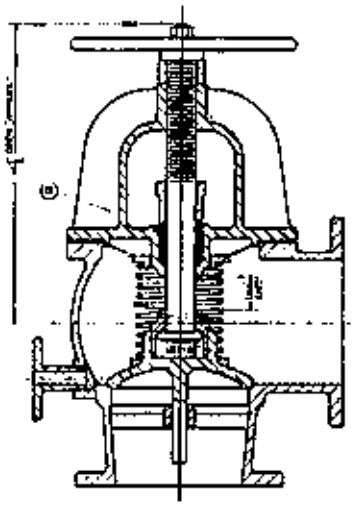
CRANE CO.

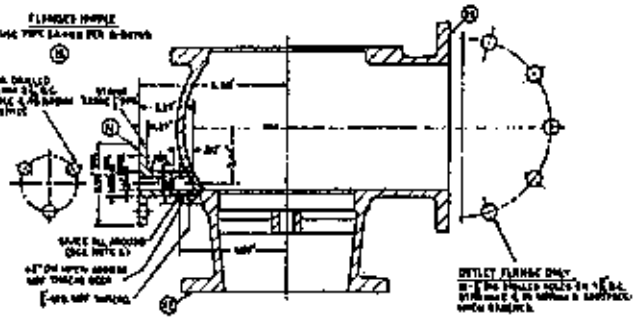
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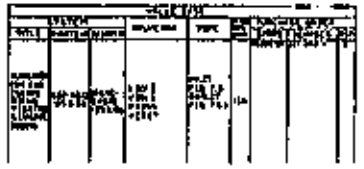
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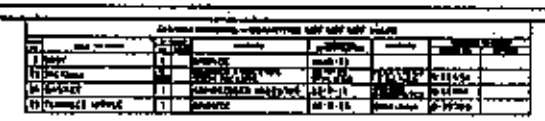


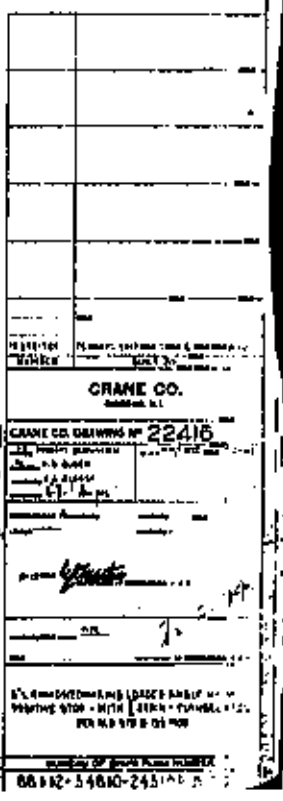




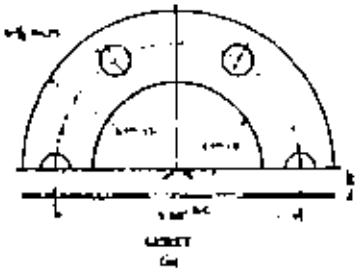


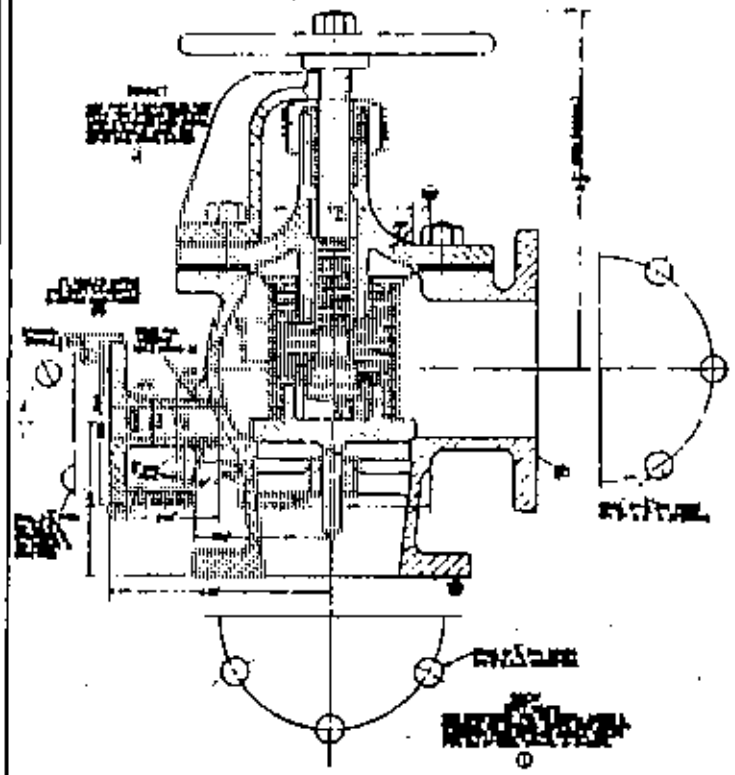


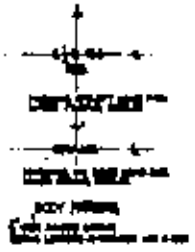




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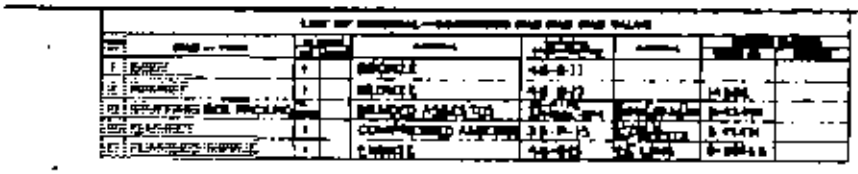


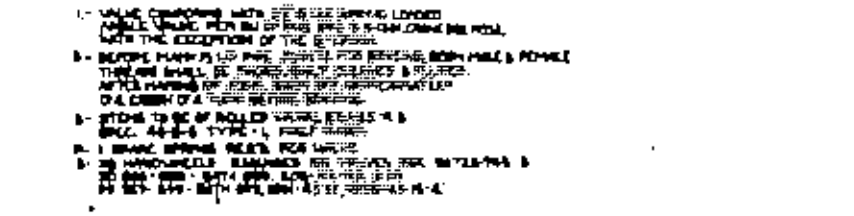


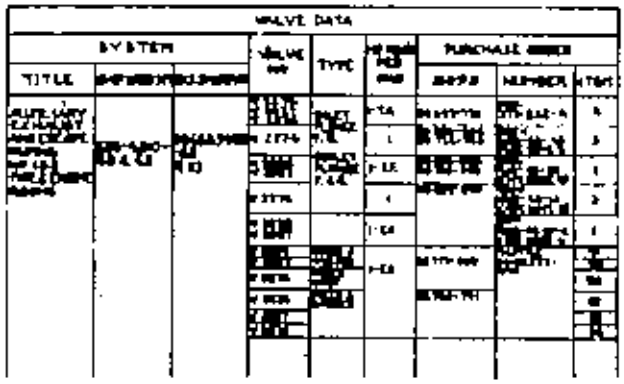


SEE SHIPS PLAN BOOK FOR VERIFICATION OF APPLICABILITY OF THIS PLAN TO ANY VESSEL

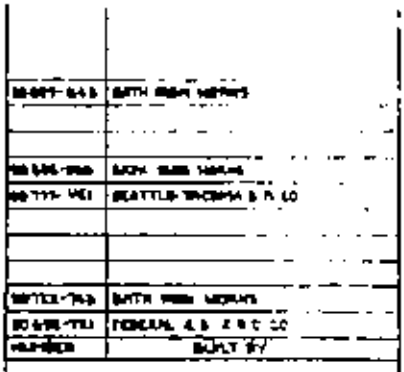
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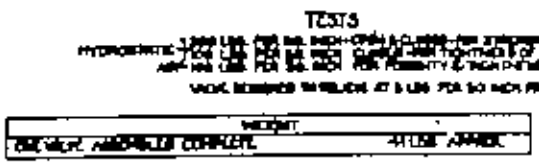




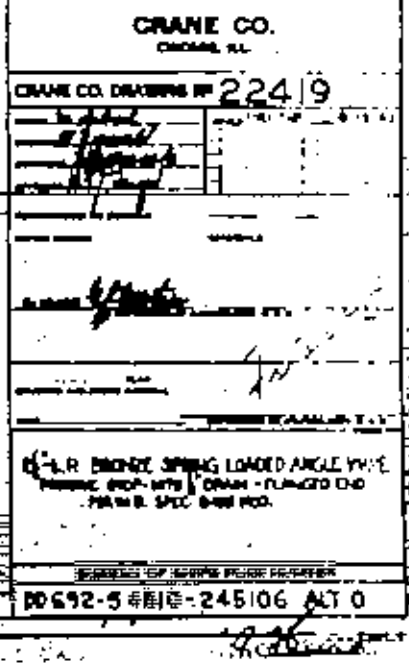


SEE SHIPS PLAN INDEX FOR VERIFICATION OF APPLICABILITY OF THIS PLAN TO ANY VESSEL(S).



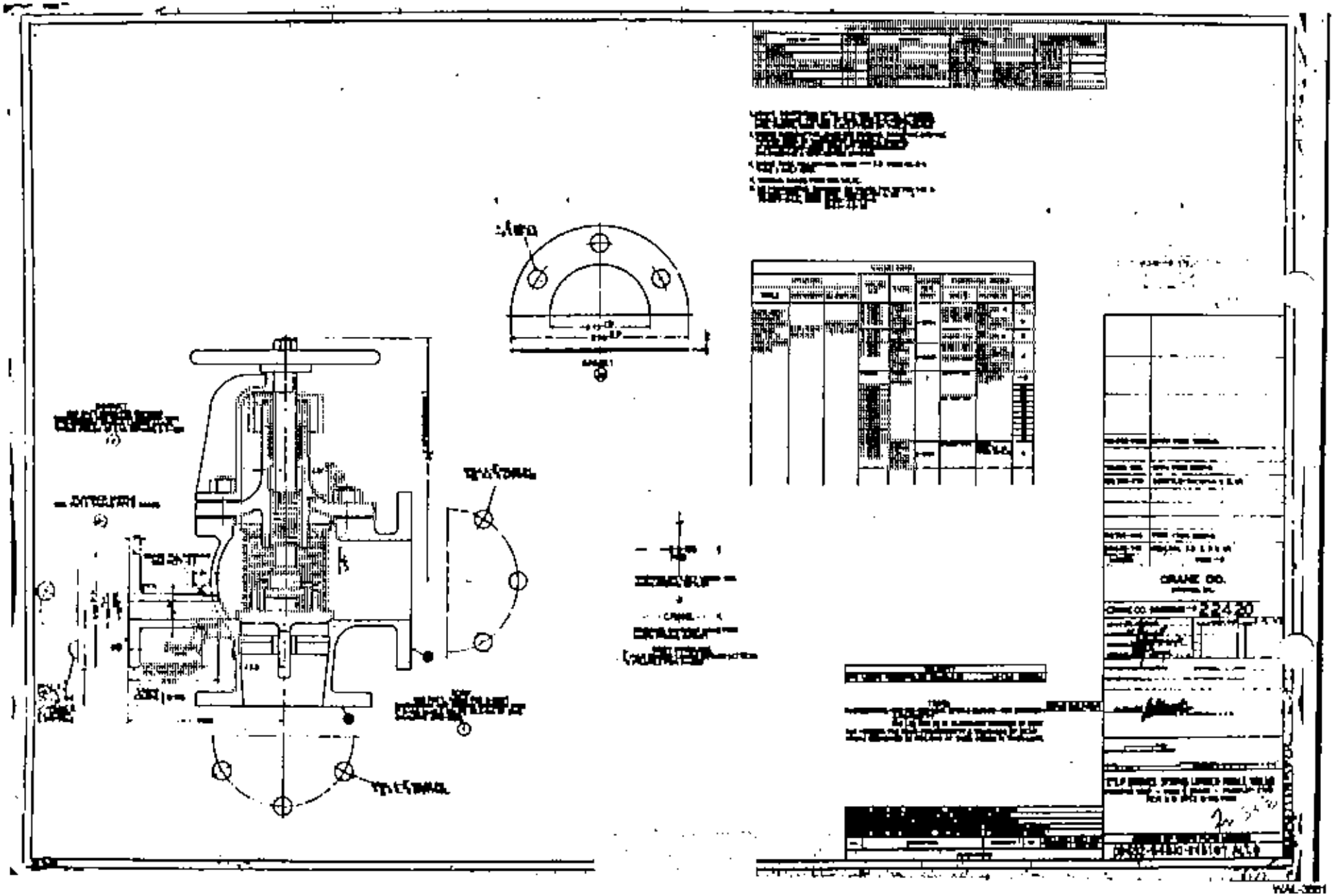


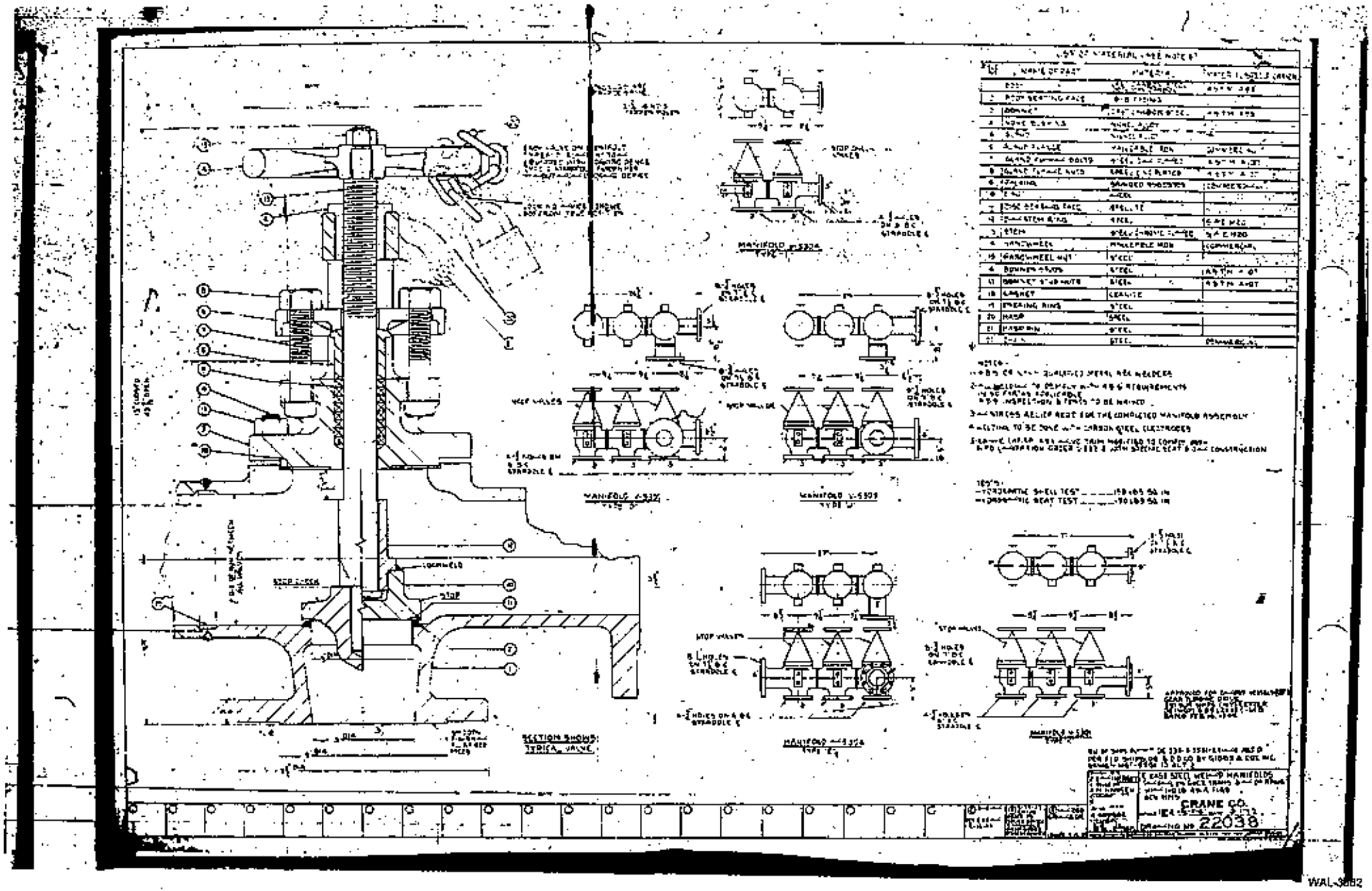




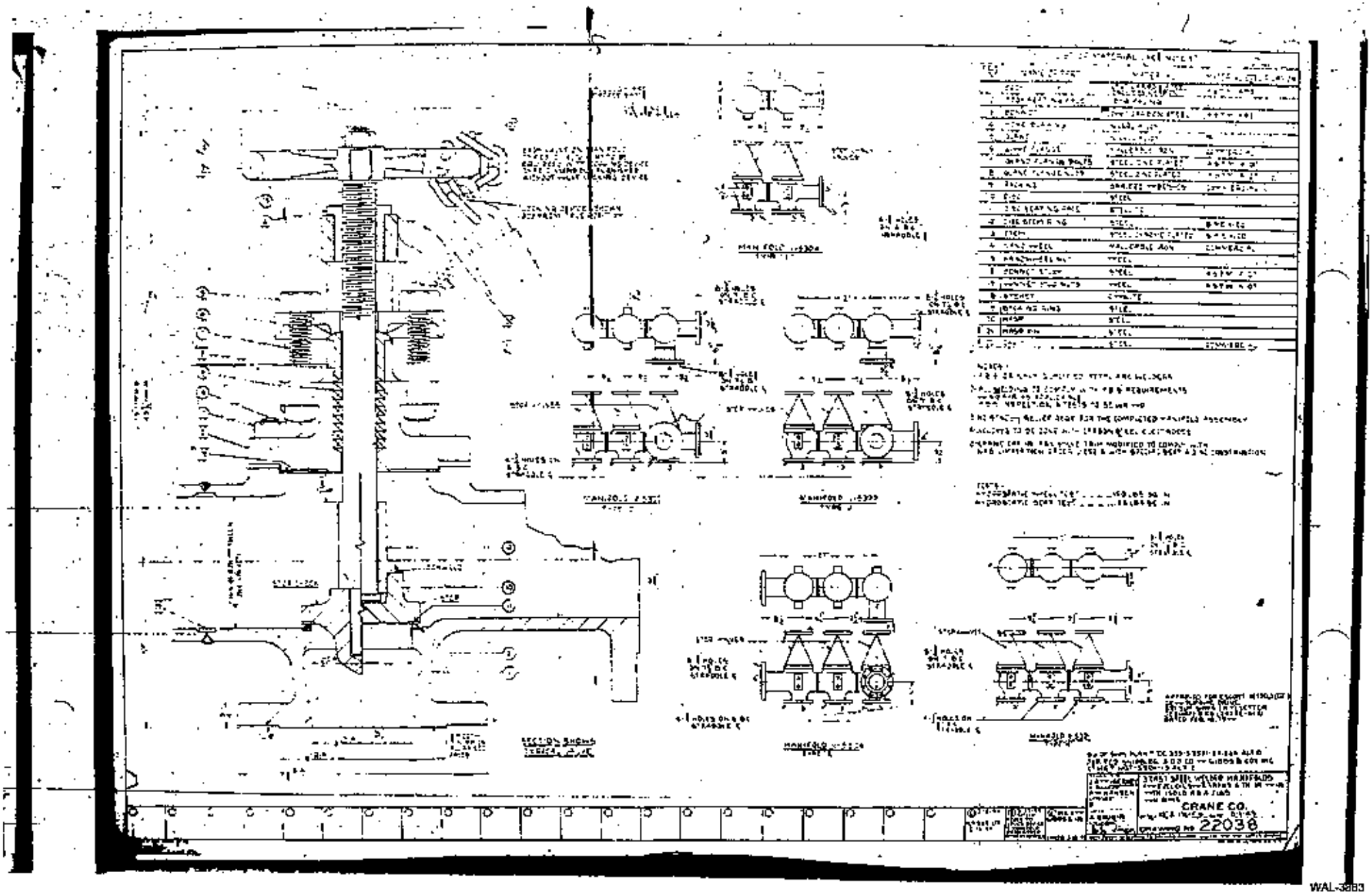




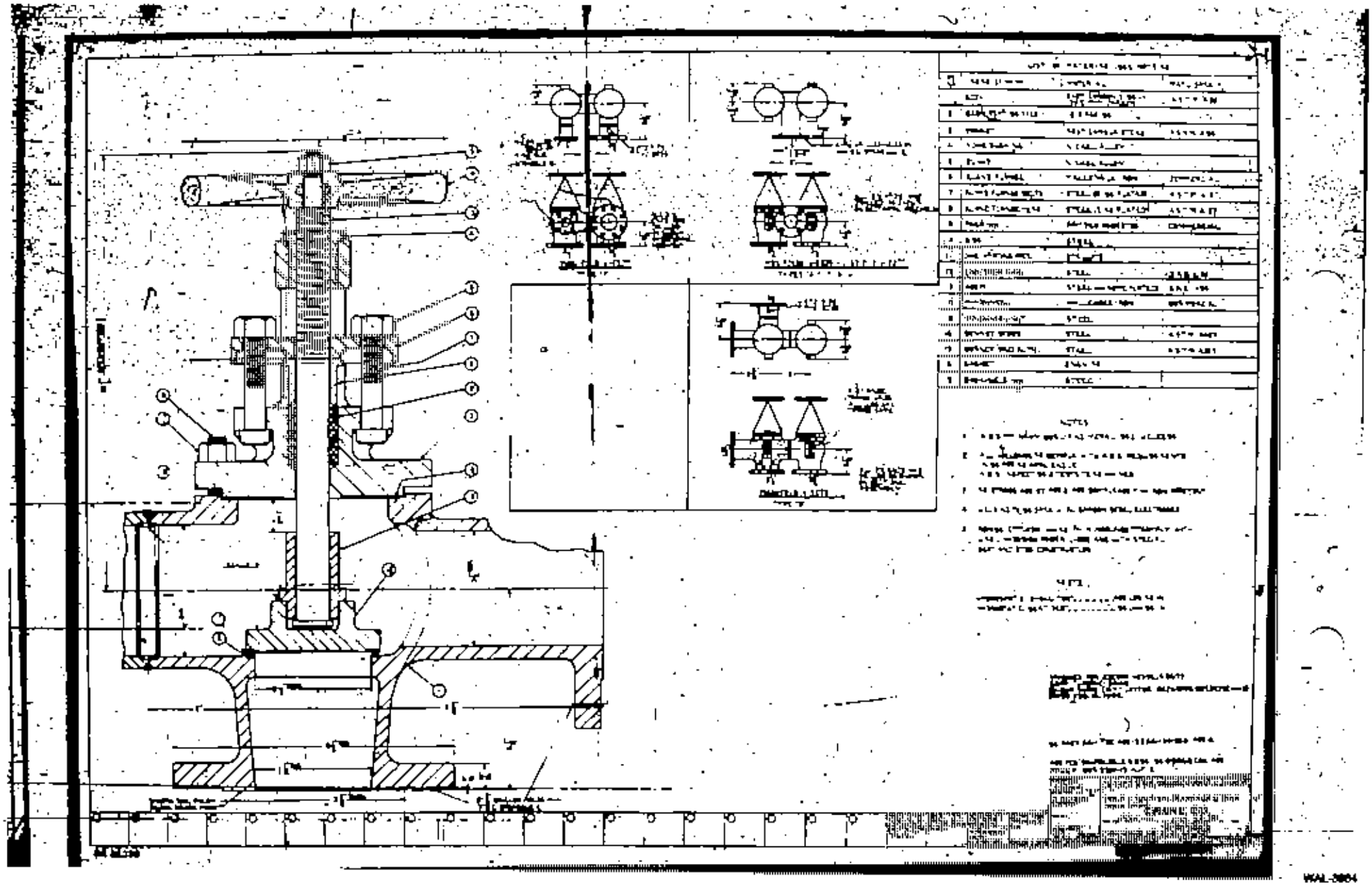


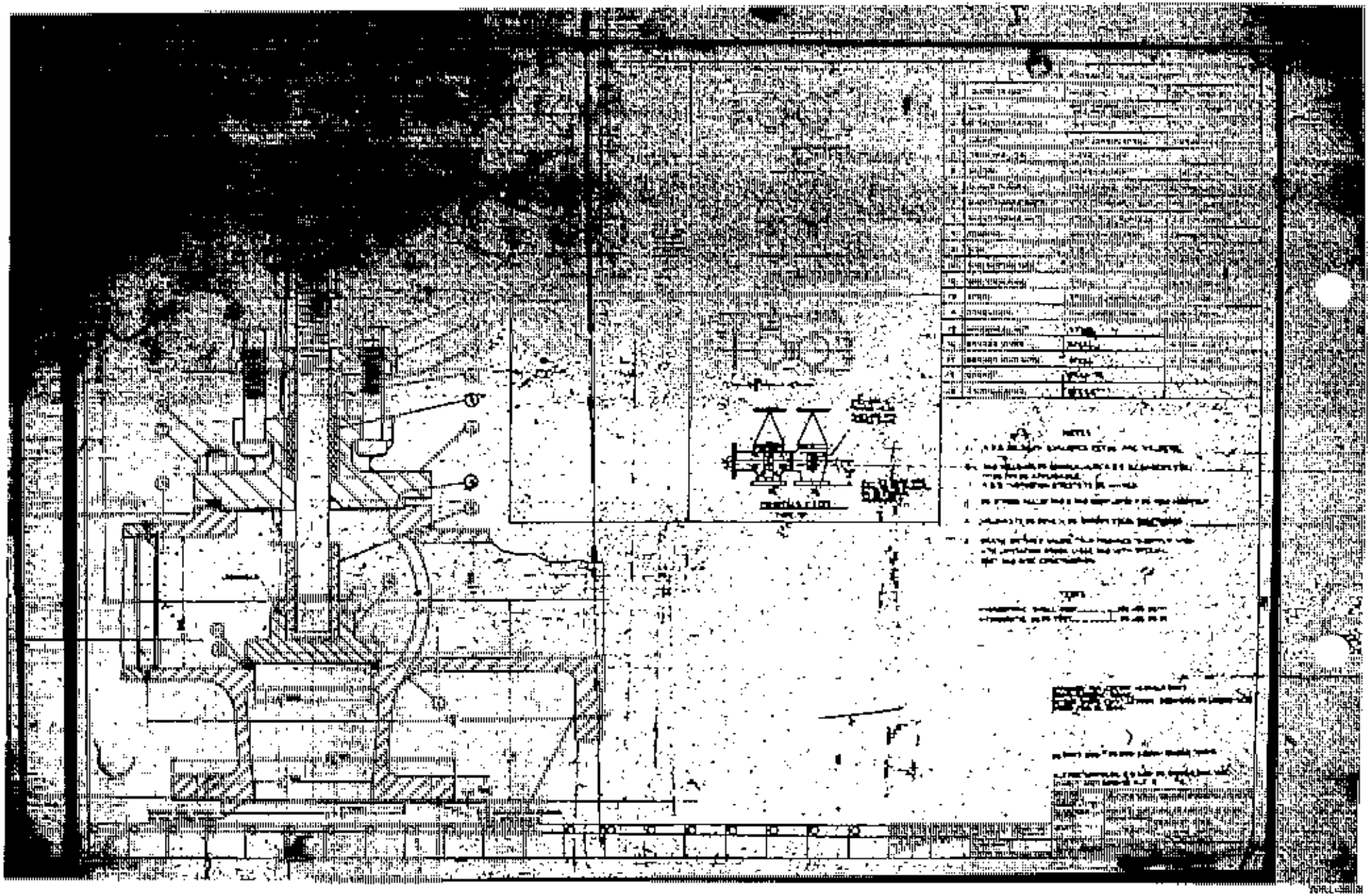


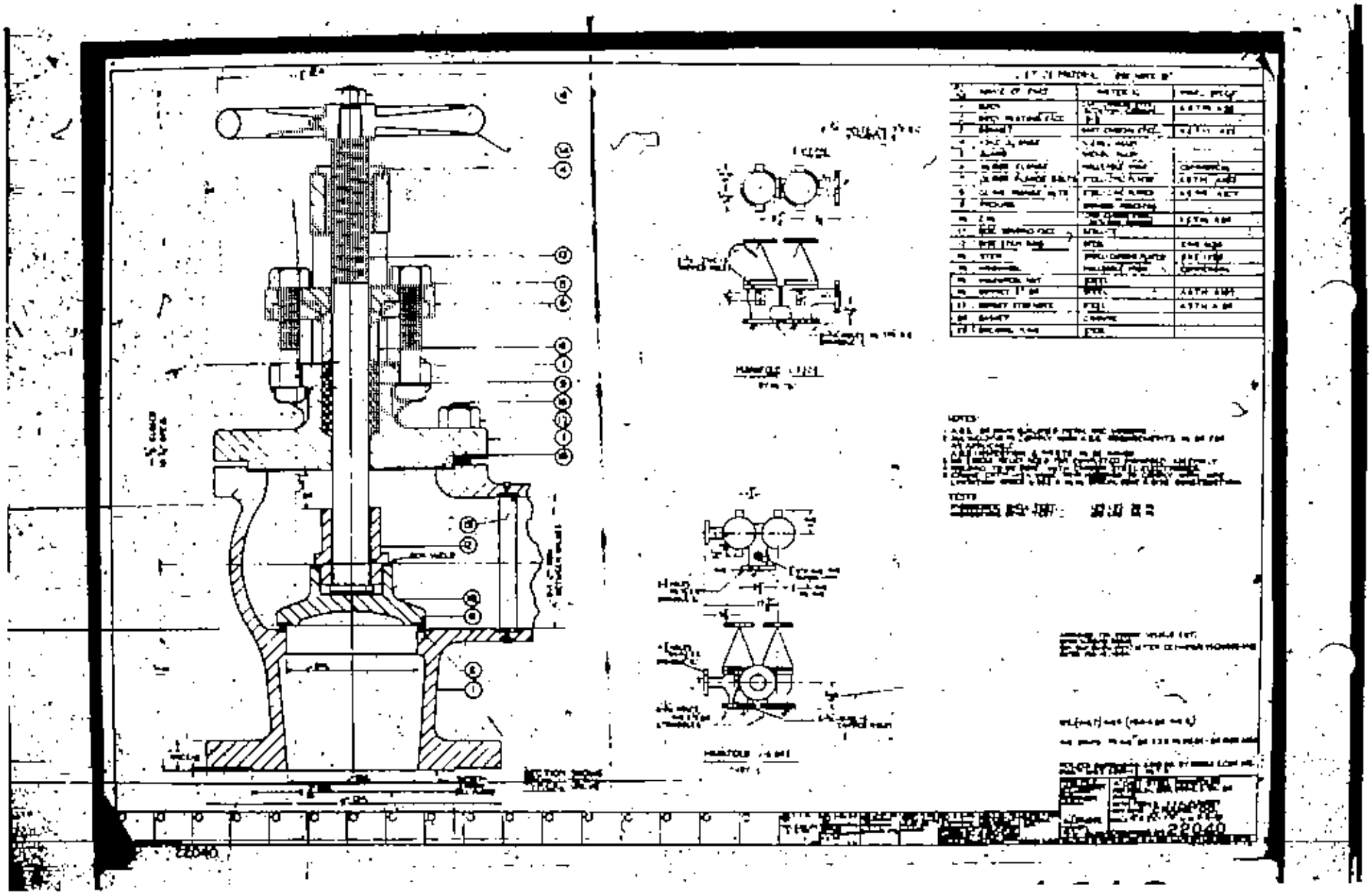
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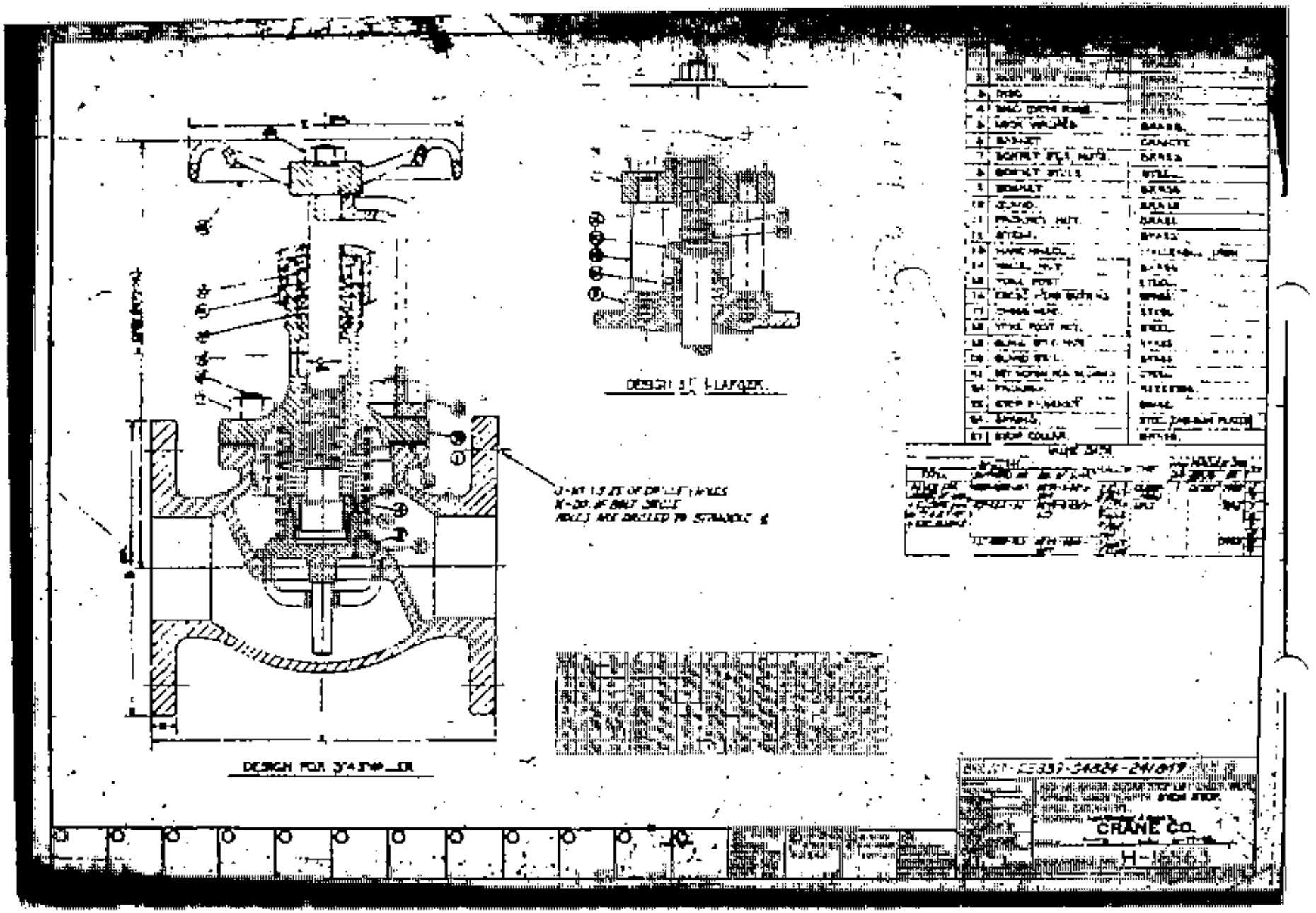


EXHIBIT M

Billing Dept.

TELEPHONE: 523-2900 (AREA CODE 312)

CRANE

CRANE CO. • 5100 SOUTH NEWDIE AVENUE • CHICAGO, ILLINOIS 60652

Crane Supply Co.
1209 Admiral St.
Richmond, Va. 23220
Attn: Mr. Deck Payne

QUOTATION NO. Q-86958

September 26, 1973

Crane # 6-106
P.O. 886356 thru 886361
11-16-73

SUBJECT: YOUR ORDER 4570-5160

GENTLEMEN:

THANK YOU FOR YOUR ORDER DATED AUGUST 8, 1973

WE ARE PLEASED TO QUOTE OUR INTERPRETATION OF YOUR REQUIREMENTS AS FOLLOWS:

ITEM NO.	QUANTITY	SIZE	DESCRIPTION	PRICE EA. NET	XXXXX TOTAL
			PARTS FOR OVERHAUL OF CRANE CO. VALVES FOR SSBN622 OVERHAUL, U.S. NAVY CONTRACT N00024-73-C-0222.		
			FOR 3/4" Globe needle valve, Crane #88 APL/CID 882070698.		
1	1-		Disc	Later	
2	1-		Stem	Later	
3	3-sets		Packing 3/16" sq.	Later	
			NOTE: Above items pending clarification per H. Keluzny's phone conversation of 9/24/73.		
			FOR 2" Globe valve, Crane dwg. 29851, Fig. #3852-U APL/CID 882052612		
4	3- sets		Packing 1/4" sq. P/N A-3474 (9 pcs/set) #11	$4.15/set	$12.45
5	3-		Gasket 3-1/8" I.D. P/N LC-10406 #10	$.60/EA.	$1.80
			For 3/4" globe valve Crane dwg. #29851, Fig. #3652-U APL/CID 882052398		
6	90-sets		Packing 1/4" sq. A-3472 (8 per set) #11	$2.75/set	$247.50
7-	90		Gaskets P/N LC-10397 #10	$.25/EA.	$22.50

-continued-

☐ We are proceeding with your order. If however, price and/or delivery is not satisfactory please notify us immediately to avoid cancellation charges.

☐ We are holding your order pending your approval of this quotation. Upon receipt of your approval we will release for manufacture.

☐ We appreciate the opportunity of quoting and we shall look forward to receipt of your orders.

Very truly yours,
CRANE CO.

PRICING POLICY: The PRODUCTS QUOTED HEREIN ARE FIRM FOR ACCEPTANCE WITHIN 45 DAYS FROM THE DATE OF QUOTATION WITH SHIPMENT TO BE MADE WITHIN 12 MONTHS FROM THE ACCEPTANCE DATE. THE PROVISIONS PRINTED ON THE REVERSE SIDE OF THIS SHEET ARE A PART OF THIS QUOTATION AND NO OTHER TERMS, CONDITIONS, OR OBLIGATIONS WILL GOVERN UNLESS SPECIFICALLY ACCEPTED BY CRANE CO. IN WRITING.

FORM 5888 REV. 4/68

BILLING DEPARTMENT COPY

CRIMDEBN00010931

EXHIBIT "M"

TELEPHONE: 523-2900 (AREA CODE 312)

CRANE

CRANE CO. • 4100 SOUTH KEDZIE AVENUE • CHICAGO, ILLINOIS 60632

QUOTATION NO. Q-86958

SUBJECT:

GENTLEMEN:

THANK YOU FOR YOUR

WE ARE PLEASED TO QUOTE OUR INTERPRETATION OF YOUR REQUIREMENTS AS FOLLOWS:

ITEM NO.	QUANTITY	SIZE	DESCRIPTION	PRICE EA. NET	XXXXX TOTAL
			For 1/2" Globe valve, Crane #3652-XW NAVCOM dwg. 845-1889502, APL/CID 882052278		
8	1-		Disc P/N D-26703	$1.75/EA.	$12.25
9-	7-		Stem P/N D-23669	$4.90/EA.	$34.30
10	42 sets		Packing 3/16" sq. P/N A-3470 (6 per set)	$1.60/SET	$67.20
11	42		Gaskets LC-10408	$.45/EA.	$18.90
			For 1/2" Angle valve, Crane dwg. 29962, Fig. #3653-U APL/CID 882002477.		
12	9-sets		Packing 3/16" Sq. P/N A-3470 (6 per set) #13	$1.60/SET	$14.40
13	9-		Gaskets LC-11371 #9	$.60/EA.	$5.40
			For 1-1/2" Gate valve, Crane dwg. K-1394-A Fig. #3611-U APL/CID 882043338.		
24	3/sets		Packing 1/4" Sq. P/N A-3473 (8 per set) #12	$3.20/SET	$9.60
15	3-		Gaskets 2-5/8" I.D. LC-L1391	$.80/EA.	$2.40
			For 2-1/2" Globe stop check valve, Crane dwg. #H-26622.		
16-	1-		Bonnet Pc. #2	$347.50	$347.50
17	1-		Body Seat ring Pc. #4	$292.90	$292.90

-continued-

☐ We are proceeding with your order. If however, price and/or delivery is not satisfactory please notify us immediately to avoid cancellation charges.

☐ We are holding your order pending your approval of this quotation. Upon receipt of your approval we will release for manufacture.

☐ We appreciate the opportunity of quoting and we shall look forward to receipt of your order.

Very truly yours,
CRANE CO.

PRICING POLICY: THE PRODUCTS QUOTED HEREIN ARE FIRM FOR ACCEPTANCE WITHIN 45 DAYS FROM THE DATE OF QUOTATION WITH SHIPMENT TO BE MADE WITHIN 12 MONTHS FROM THE ACCEPTANCE DATE. THE PROVISIONS PRINTED ON THE REVERSE SIDE OF THIS SHEET ARE A PART OF THIS QUOTATION AND NO OTHER TERMS, CONDITIONS, OR GUARANTEES WILL GOVERN UNLESS SPECIFICALLY ACCEPTED BY CRANE CO. IN WRITING.

FORM 5803 REV. 4/69

BILLING DEPARTMENT COPY

CRIMDEBN0001D932

TELEPHONE 523-2900 (AREA CODE 312)

CRANE

CRANE CO. • 4100 SOUTH KEDZIE AVENUE • CHICAGO, ILLINOIS 60632

QUOTATION No. Q-86958

SUBJECT:

GENTLEMEN:

THANK YOU FOR YOUR

WE ARE PLEASED TO QUOTE OUR INTERPRETATION OF YOUR REQUIREMENTS AS FOLLOWS:

ITEM NO.	QUANTITY	SIZE	DESCRIPTION		PRICE EA. NET	AMOUNT
						TOTAL
18	3-		Disc	Pc. #5	$ 27.85 ✓	$83.55
19	1-		Disc holder	Pc. #6	$269.85 ✓	$269.85
20	1-		Disc Retaining plate	Pc. #7	$108.00 ✓	$108.00
21	1-		Stem	Pc. #8	$406.25 ✓	$406.25
22	3-		Seal rings	Pc. #9	$49.80 ✓	$149.40
23	1-		Liner	Pc. #10	$394.80 ✓	$394.80
24	1-		Gland	Pc. #14	$193.15 ✓	$193.15
25	1-		Yoke bushing	Pc. #17	$157.25 ✓	$157.25
26	3-sets		Packing 9 rings per set	Pc. #12	$7.65 ✓	$22.95
					GRAND TOTAL....	$2,874.30
			TERMS: Net 30 days			Sales Service co
			In The event you have any questions certaining to this proposal, please contact Mr. H. H. Kalm.			Advise Delivery

☒ We are proceeding with your order. If however, price and/or delivery is not satisfactory please notify us immediately to avoid cancellation charges.

☐ We are holding your order pending your approval of this quotation. Upon receipt of your approval we will release for manufacture.

☐ We appreciate the opportunity of quoting and we shall look forward to receipt of your order.

Very truly yours,
CRANE CO.

J. J. Petrokse, Supervisor
Special Project Department NL #1

JJP:EHK:db

PRICING POLICY: THE PRODUCTS QUOTED HEREIN ARE FIRM FOR ACCEPTANCE WITHIN 45 DAYS FROM THE DATE OF QUOTATION WITH SHIPMENT TO BE MADE WITHIN 12 MONTHS FROM THE ACCEPTANCE DATE. THE PROVISIONS PRINTED ON THE REVERSE SIDE OF THIS SHEET ARE A PART OF THIS QUOTATION AND NO OTHER TERMS, CONDITIONS, OR OBLIGATIONS WILL GOVERN UNLESS SPECIFICALLY ACCEPTED BY CRANE CO. IN WRITING.

FORM 5859 REV. 4/68

BILLING DEPARTMENT COPY

CRIMDEBN00010933

EXHIBIT N

Piping Pointers



Prepared by CRANE CO., ***World's Leading Maker of Valves and Fittings***

PIPING POINTERS FOR INDUSTRIAL MAINTENANCE MEN

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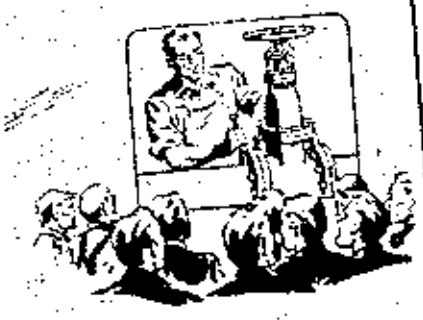
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A Glimpse into the World's Largest Valve and Fitting Plant ..... Page 30

The "Piping Pointers" Film

Prepared in response to numerous requests, the sound film edition of "Piping Pointers" is in most part based on the contents of this manual. However, in view of the advisability of limiting the film's showing time to 10 minutes, it does not include all the subject matter contained in the following pages. It is recommended, therefore, that this manual be retained for continued study of the additional and more complete information it contains. A careful review of its pages promises a profitable investment of time for every piping man.

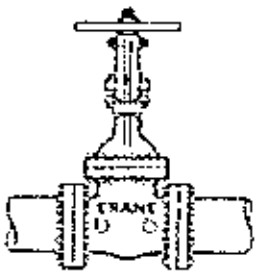
The "Piping Pointers" film is available for showing in any plant, trade school, or industrial training center. It is a 16 mm. sound film. Applications for showings can be made through the Crane branch in any industrial area.



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A01356—100M—12-43
PRINTED IN U.S.A.

C696.065
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FOREWORD

In every industrial plant where piping is used, safe and serviceable maintenance of valves and fittings is indispensable. The purpose of "Piping Pointers" is to make available to industrial maintenance men the practical information which Crane, the world's largest manufacturer of valves and fittings, has developed in its more than 89 years' experience.

★

CRANE CO.

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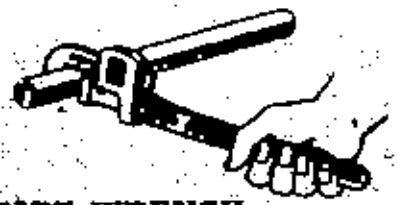
NATION-WIDE SERVICE TO INDUSTRY THROUGH BRANCHES AND WHOLESALERS EVERYWHERE

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HINTS ON HANDLING VALVES, FITTINGS AND PIPE

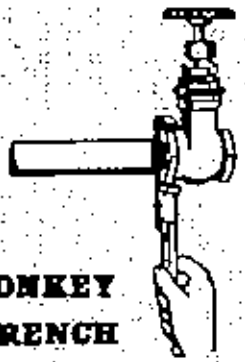
Good handling of piping materials begins with knowing the tools that are used on them. Let's start with wrenches—they're most important, but when used improperly, they can do a lot of damage. The types of wrenches you will be working with are, pipe, monkey, strap, end, and pipe tongs, with the first two being your constant companions.

Before we go any further, let's learn this simple rule regarding the use of wrenches on every job: (1) Choose the right type, (2) Choose the right size. Why this rule is so important, you will see in the following paragraphs.



PIPE WRENCH

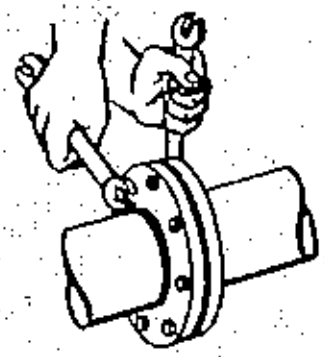
Note how the pipe wrench works. The harder you pull, the tighter it squeezes. It was designed for use on pipe and screwed end fittings only. On parallel-sided objects, its efficiency is not up to that of a monkey wrench and, in addition, its squeezing action can do great damage. Many inexperienced piping men have learned to their sorrow, that using a pipe wrench on a valve may cripple or even crush its body.



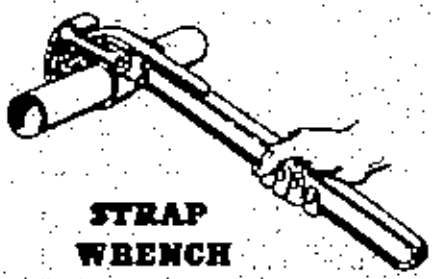
MONKEY WRENCH

For hexagonal end valves and fittings, a monkey wrench with its smooth, square jaws is always your best bet. Not only does it fit better on the parts to be turned, but it doesn't have the crushing effect of a pipe wrench. You hardly need be told that a monkey wrench can't be used on pipe or other round parts because its jaws have no means of gripping such shapes.

OPEN END WRENCHES

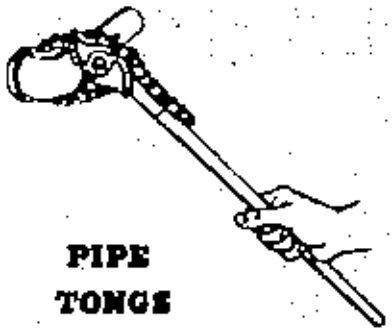


For pulling up flange bolts, etc., you will find your open end wrenches most suitable and fastest to work with. However, use the right size if you wish to avoid bruised knuckles due to slippage of the wrench, and to prevent wearing the bolt heads round.



STRAP WRENCH

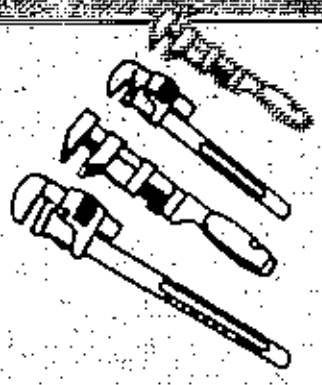
The strap wrench is used mainly when working with plated or polished finish materials in order not to mar the surfaces. Also, it often comes in handy in tight places where you can't get in with a pipe wrench.



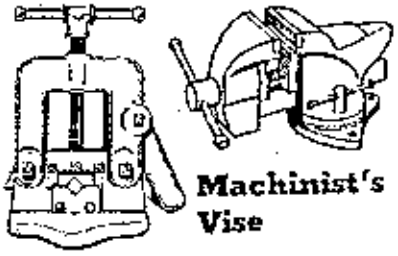
PIPE TONGS

Pipe tongs are wrenches of the chain strap and lever type. They are made for handling pipe from ¼-inch size up, but are generally used for larger sizes, 6 inches and above.

ALWAYS USE THE RIGHT SIZE WRENCH



A wrench that's too small makes it hard to pull up a joint. But there's more danger in picking one that's too large. It gives you more leverage than needed, and, unknowingly, you may pull up a joint so tight as to crack a fitting, twist a valve out of shape, or ram the pipe clear into the seats. But, you will soon get the "feel" of wrenches and know what size is best for the job to be done.

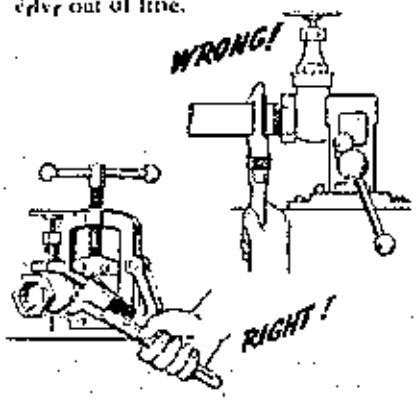


Machinist's Vise

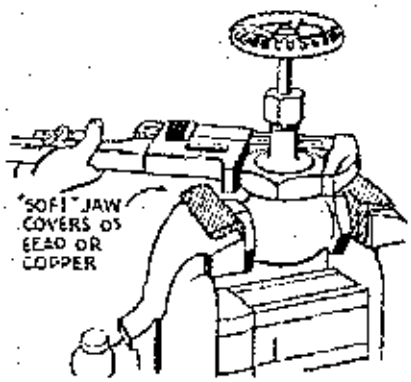
Pipe Vise

Your next most frequently used tool will be the vise, and there are several cautions regarding its use that are worth noting. The two common types are shown above. The pipe vise is used for pipe only. The machinist's vise has square jaws only, or a combination of square and gripper jaws, making it suitable for pipe as well as other work.

The screw action of a vise exerts a powerful force on the jaws. That's why experienced piping men never put a valve or fitting in the vise when making up a joint on the bench. There's too much danger of squeezing the part so much as to distort it, or of putting the working parts of a valve out of line.



The correct procedure, shown here, is to put the pipe in the vise and to turn the valve or fitting. Note also, that the right place to put your wrench is on the pipe end of the valve or fitting. This gives you more direct leverage on the joint, and in the case of valves, prevents the possibility of twisting the unsupported valve body or hurting its working parts.



Copper or Lead Covers on Vise Jaws

When using a machinist's vise to hold a valve for any repair work, put it in with the jaws to the valve ends—not to the sides of the valve body. This is a precaution against damaging the valve body. When working on valves, or any valve part, always use "soft jaws" (copper or lead covers over the jaws) to prevent damage to finished surfaces.

Look Out for Dirt in Pipe Lines

Dirt, sand, rust, scale, metal chips and burrs—any foreign matter is a menace to valves or other equipment in a pipe line. Sooner or later, it causes cutting and damaging of valve seats, with leakage resulting.

Valves and fittings should be stored where not exposed to foreign matter, weather, or harm in other ways—such as falling or being hit by other objects. The covers usually put on valve ends at the factory should not be removed until the valve is ready for use. Storing piping materials with the best protection possible will pay dividends after installation.

A "Blow-out" Before Using May Prevent Breakdowns Later

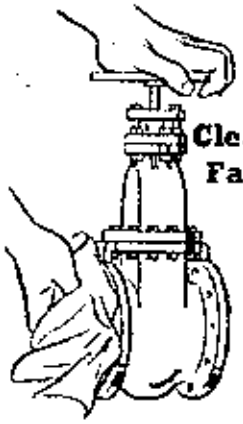


It's easy for sand, dirt, and scale to accumulate in pipe stored in a yard or shed. Never use pipe before blowing it out with compressed air or swabbing it out thoroughly.

When a new pipe line is installed, it's a good idea to flush it out completely with water to remove any loose scale or foreign matter.

Dirt in the threads can also get into lines when the joint is made up. Often it causes tearing of the metal when screwing up a connection; it increases friction and interferes with making a tight joint. The safest practice is to brush or wipe the threads of all pipe, valves, and fittings before you start to make a joint.

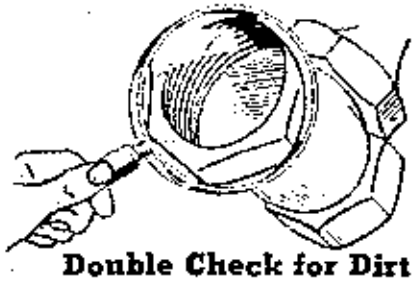
When pipe is threaded "on the job," particularly if a rotary type cutter is used, the ends should be filed or reamed to remove burrs before threading. Loose burrs in pipe lines may damage valve seats; those that hang on can cause obstruction to flow.



Clean Flange Faces Make Better Joints

The faces of flanged end equipment should be cleaned thoroughly before installing. Manufacturers usually coat them with a heavy oil or grease to prevent rusting. A solvent will easily remove this coating.

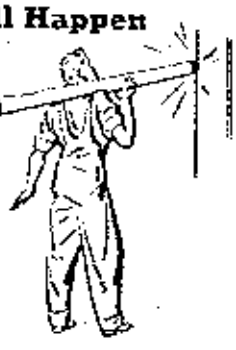
Special precaution should be taken against dirt on gaskets. They should be carefully wiped before using. Hard dirt particles in flanged joints can prevent proper seating of gaskets or cut into the machined flange faces deeply enough to cause leaks.



Double Check for Dirt in Valves and Fittings

No matter how much care you've taken in storing valves and fittings, it's wise to give each one a careful looking over for dirt in the threads and body just before putting them in a line. If you have convenient facilities for blowing them out, do it. Never fail to take this precaution when using old materials.

Accidents Will Happen

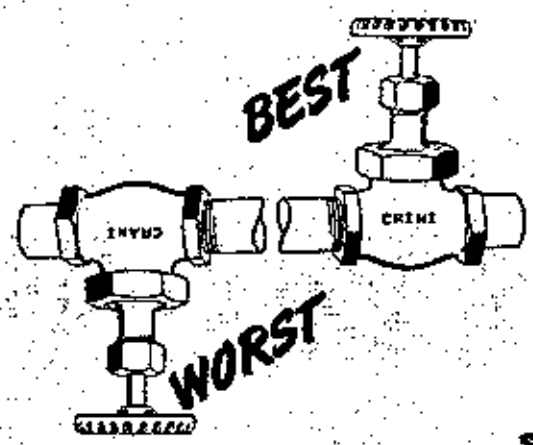


Despite the care you give pipe on the job, occasionally a threaded end will get bruised in handling. When this happens, don't take a chance with a joint. If the end is badly damaged, cut it off and re-thread. More than likely, it will be repairable by running a die over the threads to clean up and straighten them. But don't fail to do this. Bruised female threads in pipes, valves, and fittings can usually be repaired by running a tap into the threads.

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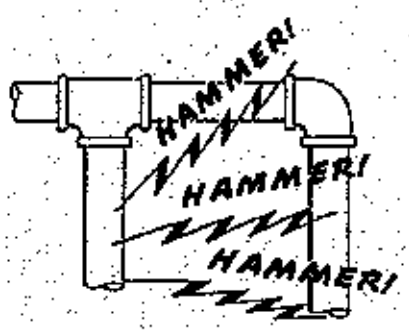
GOOD PIPING SERVICE BEGINS WITH GOOD INSTALLATION

You can't expect a valve, for example, to work at its best and stay on the job if it's put in wrong or installed in the wrong place. It is the responsibility of maintenance men to handle piping equipment with an eye to good performance, convenient operation, safe and durable service. A few cautions regarding the installation of piping for longer life and better service are given below.



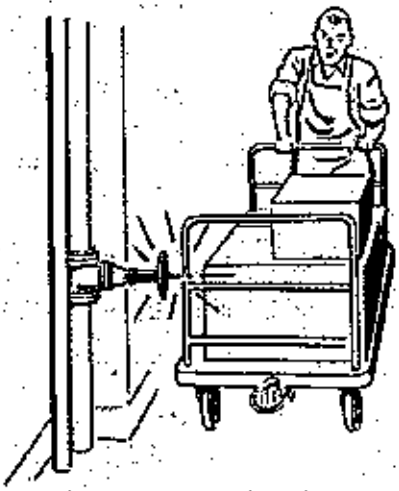
VALVES WORK BEST WHEN STANDING UP

Unless it is impossible, always install valves with stem pointing straight up. Any position from straight-up to horizontal is satisfactory, but a compromise. When stem points downward, the bonnet acts as a trap for sediment which may cut and damage the stem threads.



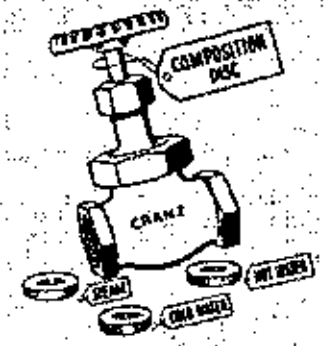
STEAM TRAPS WILL STOP THIS

Hammering in steam lines may be a signal that condensate is interfering with the flow of steam. This powerful force can pull piping from its anchors and cause erosion of valve seats by its high velocity. You can't stop formation of condensate, but you can provide for its drainage by installing traps of suitable capacity.



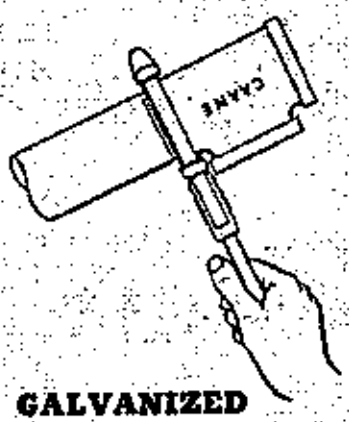
VALVES CAN'T BE ABUSED

and operate efficiently. Don't expose them to damaging blows. A bent stem not only cripples a valve but may cause a shutdown and result in costly repair.



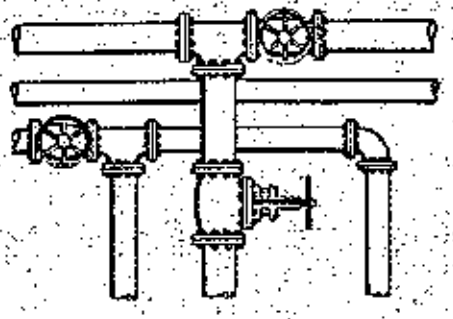
USING THE RIGHT DISC?

You can't beat composition and fibre valves for all-around work and quick disc repair. But you can save much disc-changing time by using the right quality disc for each service. A few extra disc holders with proper discs save more time when changing services. You just slip them on the stem.



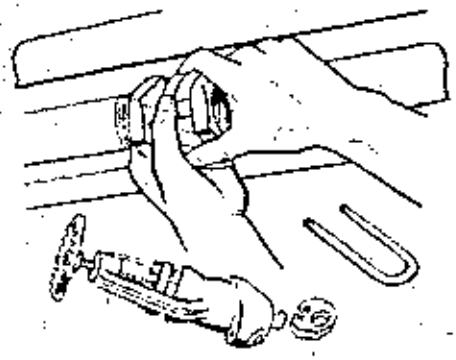
GALVANIZED MATERIALS NEED EXTRA CARE IN HANDLING

Their coating is put on for extra protection against corrosion. But, to be effective, it must be continuous. Rough handling when pulling up joints may injure the surfacing. Use the pipe wrench carefully.



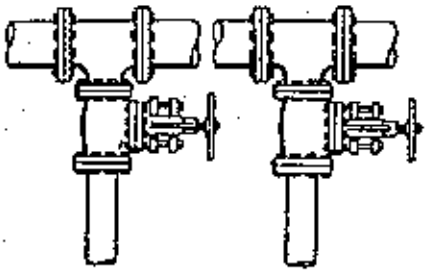
VALVES— BUT WHAT FOR?

All valves should be identified to show what lines they control. In addition, shopmen should be thoroughly instructed on valve use so that in emergencies, valves can be quickly operated.



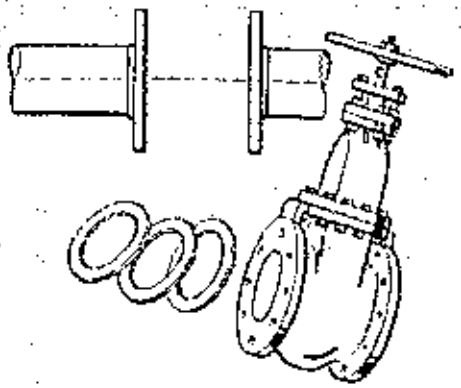
WORKING IN CLOSE QUARTERS?

When you're putting a line into cramped space, it sometimes helps a lot to remove the bonnet assembly from valves. This gives you more clearance and protects the stems from possible damage.



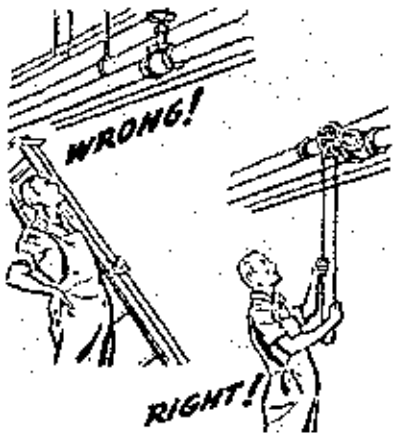
WHERE TO PUT SHUT-OFF VALVES

A standard practice of putting in branch line shut-off valves up close to the main line is safer. In an emergency, there's no time for looking for valves. These valves should be fully identified and shop foremen instructed on their use.



IS THE GASKET RIGHT?

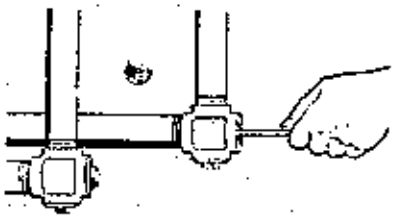
It makes a big difference what kind of gaskets you use in flanged joints. What's good for one service may not last in another. For durable, leak-proof joints, be sure the gaskets are right for every job!



SHUT IT OFF—*But How?*

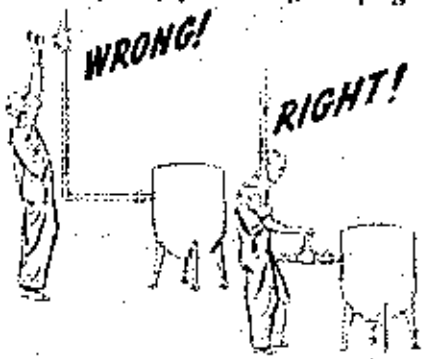
Valves should be placed for convenient operation. There is danger to life and equipment any time a ladder must be used in a busy plant.

When "hard-to-get-at" valves must be frequently operated, it's best to relocate them for safety's sake, or equip them with a chain wheel, extension stem, or remote control device.



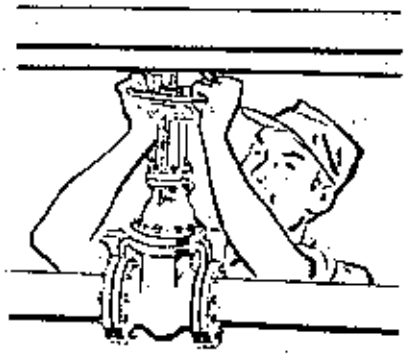
CROSSES MAKE CLEANING EASY

In lines where sediment is present, and in viscous fluid lines, there may be frequent clogging at the turns. By using crosses instead of elbows at turns, rodding out of lines is easily done by simply removing the plugs.



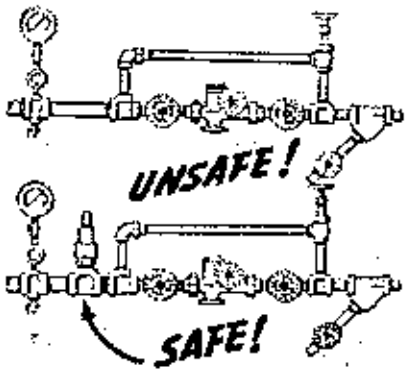
Place Operating Valves for Convenient Use

You can't expect a shipworker to open a valve fully, close it tight, or regulate it properly if he can't do it conveniently and safely. Better care of valves is encouraged when they are installed so they can be operated without difficulty or danger.

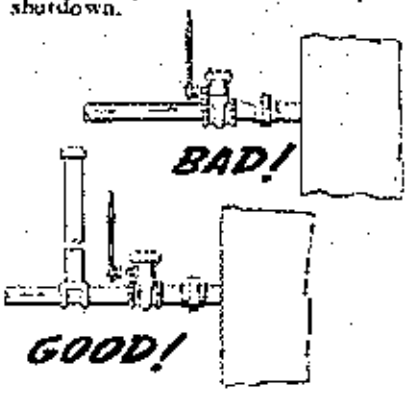


OPEN—*but not enough!*

Quick wearing of valve seats is often due to valves that can't be fully opened. Rising-stem valves must have plenty of clearance or non-rising-stem patterns should be used instead.



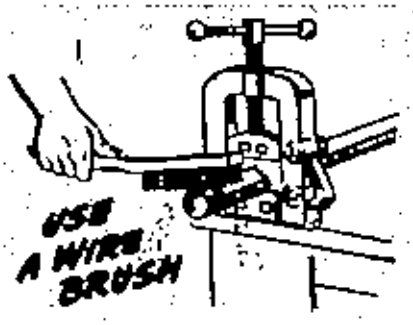
A relief valve makes this a safe hook-up. Should the pressure regulator fail, the relief valve, set at proper pressure limits, will prevent damage to processing equipment. The by-pass, installed with a plug disc valve for throttling, permits servicing of pressure regulator without complete shutdown.



Water hammer can do serious damage to piping. When quick-opening valves are used in liquid lines, they may cause water hammer in varying degrees unless proper protective measures are provided.

An adequate cushioning chamber should be installed ahead of quick-opening valves. An assembly of a tee, a length of pipe, and a pipe cap will serve this purpose efficiently and is easily put into any line.

HOW TO MAKE UP A SCREWED JOINT

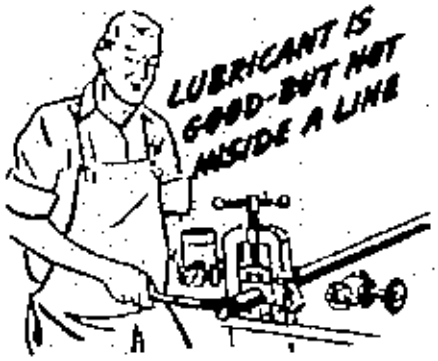


The most common method of joining pipe is the screwed connection. All of us know that it consists merely of threaded male and female ends screwed together. Yet, the perfection that has been attained in standardizing the threading of piping materials is actually amazing. Pick up a valve made in Chicago, a fitting from Los Angeles, and join them to a pipe from Pittsburgh threaded with tools from Cincinnati. There's no question they will fit—perfectly!

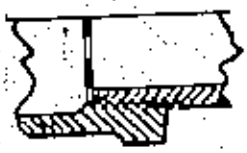
This outstanding example of standardization practice began with the establishment of American Pipe Threads Standards. They rigidly guide the entire piping industry and are responsible today for the simplicity of making up a screwed joint.

The chart below shows the relation of male and female parts in a properly made-up joint. Their make-up is controlled by standard dimensions for the pitch and depth of threads, number to the inch, length, etc. Strict adherence to these dimensions when threading pipe, is the secret of good screwed connections. For this, well-kept threading tools are necessary.

To get a good metal-to-metal joint, the first thing we do is wipe both male and female threads clean. Dirt can make a good fit impossible. Wire brushing is recommended, especially if threaded pipe has been exposed to weather. Running a tap or die over the threads will usually straighten any that may be damaged.



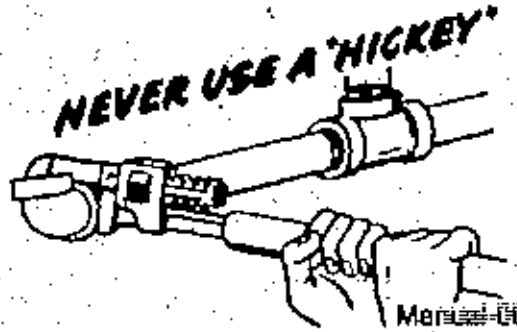
A bit of good thread lubricant or "pipe dope," as it is frequently called, on the male threads only, comes next. Lubricant is used not as a cement to seal the joint, but to reduce friction when pulling up. It must not be expected to compensate for poor workmanship. Putting lubricant on the male threads only, prevents any excess from squeezing into the pipe and causing harm to valve seats or other mechanism.



We start the joint by hand, and "feeling" that thread engagement is right, turn it up as far as it will go. If the threading job was up to standard, and the threads free of dirt, we have an almost tight joint now. A few turns with the wrench is all that's needed.

But let's not make the mistake of "leaning on the joint" with an oversize wrench. We must always remember the danger of crippling a fitting or running the pipe clear into the valve seats with too much pull.

No attempt should be made to run all the male threads into the joint. The end of the die always leaves a few imperfect and unusable threads. And never should it be necessary to use a "hickey" (extension handle) on a wrench to make a joint tight. Like an over-size wrench, it gives enough leverage to cripple a valve or stretch or crack a fitting. The only safe place for a "hickey" is on stubborn joints when taking down lines.



American Standard Pipe Threads



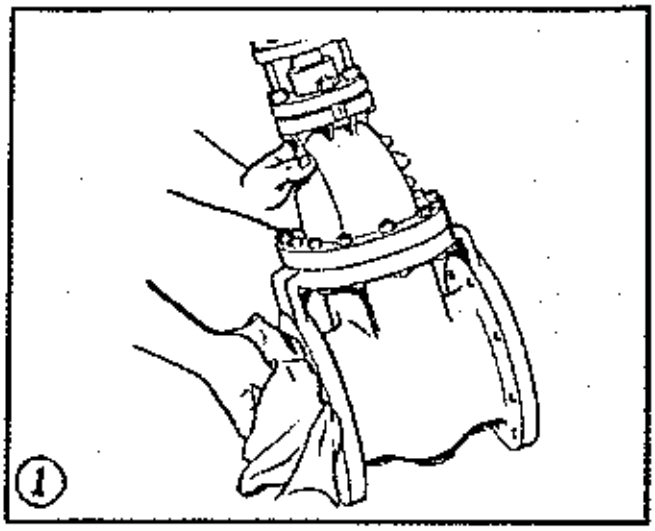
Dimensions in inches

Nominal Pipe Size	L Length of Effective Thread	E Normal Entering into Hand between Male and Female Thread	Number of Threads Per Inch
⅛	0.2638	0.180	27
¼	0.4018	0.200	18
⅜	0.4078	0.240	18
½	0.5577	0.320	14
¾	0.5457	0.339	14
1	0.6828	0.400	11½
1¼	0.7068	0.420	11½
1½	0.7235	0.420	11½
2	0.7365	0.436	11½
2½	1.1375	0.682	8
3	1.2000	0.766	8
3½	1.3500	0.821	8
4	1.3000	0.844	8

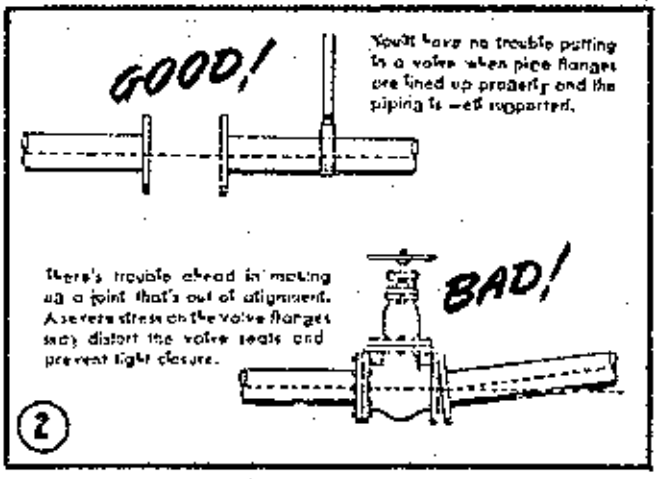
Mercer-000002

HOW TO MAKE UP A FLANGED JOINT

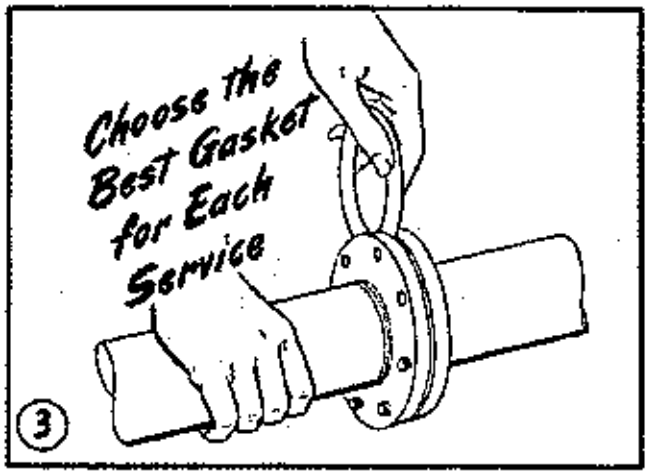
In our discussion of end connections, we saw the common methods of attaching flanges to pipe. Now, let's go through the process of joining this pipe to a flanged end valve, for example. A flanged joint is the result of bolting the two flanges together, with a gasket between their machined faces.



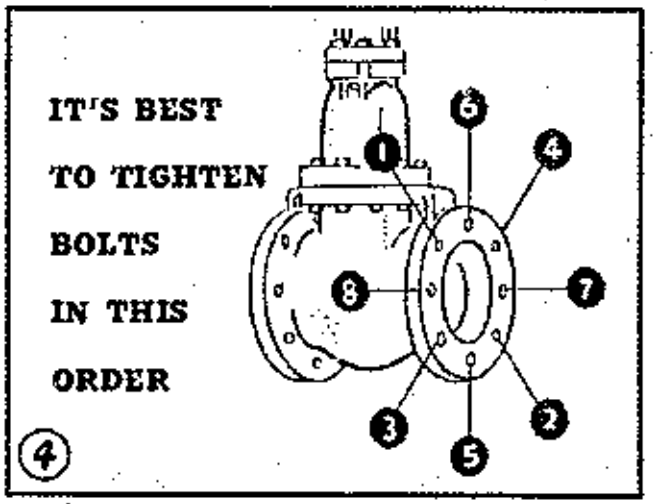
We remember that step No. 1 in making any joint is to clean all parts. So, with a solvent-soaked rag we thoroughly remove the rust-preventing grease put on flanges at the factory. We clean off all dirt and grit particles that might cause trouble in the joint. Next, we wipe off the gasket just to be sure there's nothing to keep it from seating properly.



The pipe is in place, all properly supported. We know that a valve can't be expected to hold up an unsupported length of pipe without causing a great strain. The pipe flanges have been accurately aligned to receive the valve—by checking with a spirit level, both horizontally along the pipe and vertically across flange faces—and are now ready to be bolted tight.



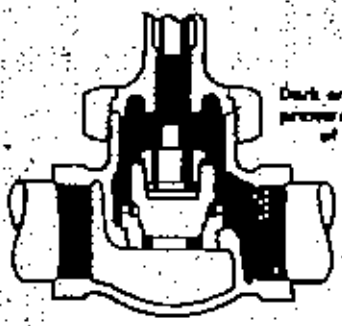
With the valve securely held in position, we slip in half of the bolts through the flanges at the bottom. They will hold the gasket in place. But before inserting the gasket, we coat its faces with a little graphite and oil or other recommended lubricant. This will make for easier removal when the joint must be opened. Then, we slip in the bolts, all the way round, apply a little thread lubricant to each and turn up the nuts by hand as far as they'll go.

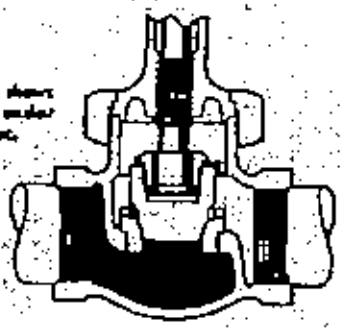


Now, we start pulling up with a wrench—not in rotation, but by the cross-over method to load the bolts evenly and eliminate any concentrated stress on the flanges. Here and there we keep going until the joint is uniformly tight. Then to the other end to repeat the whole operation.

HOW TO INSTALL A GLOBE VALVE

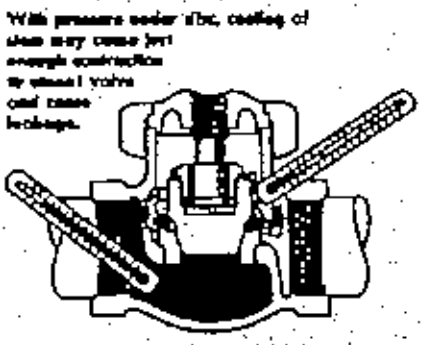
The question of which is the better way to install a globe valve—with pressure above or below the disc—has had much discussion over the years. Sound reasons have been advanced for each preference. But, with the improvements made in trim materials, the method of globe valve installation appears to be of less significance. Nevertheless, there are still logical reasons for using one or the other, depending on service conditions. The following examples will help you decide which method to use:



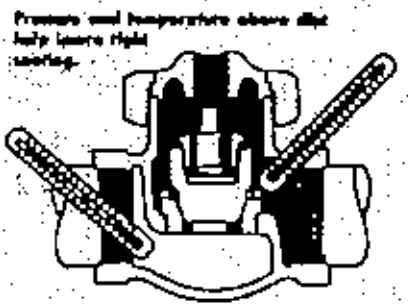


Suppose the disc of a globe valve in a boiler feed line which you know should have continuous flow, somehow became detached from the stem. Pressure from above the disc might cause it to seat and check the flow, if not shut it off completely. There's a case where pressure from below the disc is advisable.

Now, suppose the disc of a globe valve being used to regulate flow of steam to a steam-driven pump became detached from the stem. Pressure from below the disc might push the valve wide open and cause the pump to run wild. Here, pressure from above the disc would be safer.



Consider another case of temperature service with pressure under the disc. When the flow is shut off, the upper part of the valve is likely to cool. Cooling of the stem may cause sufficient contraction to unseat the valve just enough to cause leakage. The resulting extremely high velocity of flow may cause severe erosion of the disc and seat. And leakage of steam to empty kettles, for example, may cause severe damage. Here, too, pressure from above the disc would obviously be better.



Experience has shown that valves in hot services, steam or otherwise, operate more efficiently when their mechanism is exposed to constant temperatures. This again indicates a preference for pressure above the disc.

What's the Answer?

Summarizing these applications, the general rule seems to be that unless pressure under the disc is definitely required, a globe valve will give more satisfactory service when installed with pressure above the disc. Follow same rule for angle valves.

General Cautions on Installing Gate, Globe, Angle and Check Valves

Flow through angle valves is similar to flow through globe valves. Principles outlined at left, also apply to angle valve installations.

★

While most valves can be installed with stem at any angle, best position is with stem pointing straight up. When stem points downward, the bonnet acts as pocket for scale and other foreign matter in the line. Such matter may interfere with valve operation by cutting and eventually destroying inside stem threads.

★

In liquid lines subject to freezing temperatures, upside down position for valves is bad because liquid trapped in bonnet may freeze and rupture it. Even when installed upright, valves in such lines should have drain plugs in the body as protection against freeze-ups.

★

Recommended position for double disc gate valves is with stem upright. Spreader mechanism in disc has been known to fail in any other position. When valve must be installed with stem in horizontal position, a wedge disc valve is to be preferred.

★

For severe throttling services, plug-type disc globe and angle valves are best. Gate valves are never recommended for throttling.

★

Special caution is advised to install all check valves so that disc opens with flow.

★

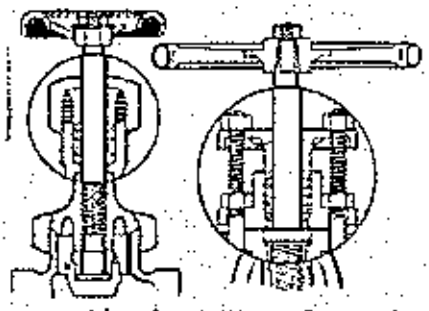
To insure closing of disc when back-flow occurs, position of check valves is fine must permit closure of disc by gravity.

WHAT TO DO WHEN VALVES LEAK

Stopping Stuffing Box Leaks

In every gate, globe, and angle valve, the stuffing box is an important part. It holds the packing which seals the bonnet against leaks around the stem. Leaks at this point are called stuffing box leaks. Pressure on packing is applied by a packing nut or gland flange, depending on valve design, which hits on a gland in the stuffing box.

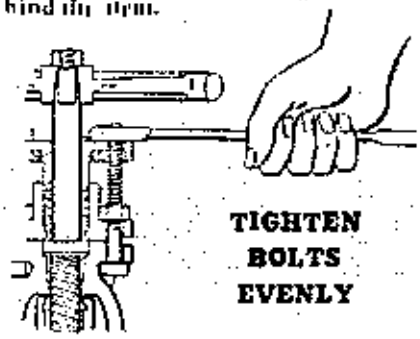
Packing wears in direct relation to service conditions. It loses life with age, but wear is mainly due to rising and turning motion of valve stem, combined with deteriorating effects of service conditions. In average service,



valves, packing lasts a long time and needs little attention. A few drops of oil on the stem, now and then, help to reduce wear.

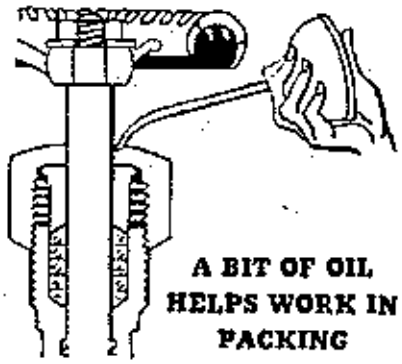
When New Valves Leak

Occasionally a stuffing box leak develops soon after a valve is installed. Unless the packing is unsuited for the service, the leak can usually be stopped by merely pulling down on the packing nut. On gland flange type stuffing boxes, we must be careful in tightening bolts evenly as cocking the gland will bind the stem.



TIGHTEN BOLTS EVENLY

When leaks show up on a valve in service for some time, repacking of the stuffing box may be necessary. The procedure is simple, and can sometimes be done without removing the valve from the line. All Crane valves, for example, have a machined collar on the stem and a machined seating surface in the bonnet that backs seating the valve when it is wide open. This feature permits repacking under pressure, provided that pressure is not too high.



A BIT OF OIL HELPS WORK IN PACKING

To repack, we first loosen all stuffing box parts to permit ease access. With a packing hook—usually a material bit with bent end—take out all old packing and then clean up inside of stuffing box. Be sure to remove all particles adhering to the stem, or abrasions on it, we polish the stem with any fine emery cloth.

After wiping all parts, inside and out the box, we insert some of the new packing. Most manufacturers use a split-ring type packing in new valves. If the same type is used for replacement, after pulling in a few rings, ramp is well into place using the packing gland as a tamping tool. Then add to the packing to fill the box. Take care to stagger the ring splits so they are not all in line. Upon re-assembling the parts, a few turns of the handwheel and a few drops of oil will help work in the packing to the stem.

FACTS ABOUT GASKETS



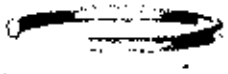
Flat Ring Gasket

To make flanged joints pressure tight, gaskets are usually installed between the flanges. They come in three general types: (1) ring gaskets which cover the face of the flange to the inside of bolt holes; (2) full-face gaskets; bolts are inserted through them; (3) a metal ring of elliptical section which fits into machined grooves in matching flange faces. This type gasket is used only in very high pressure-temperature services.



Flat Full-Face Gasket

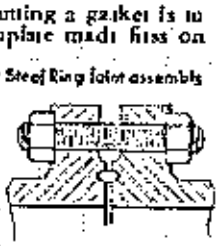
Gaskets are made in various materials: rubber, asbestos composition, and soft metals. For low pressures and cold services, rubber gaskets are generally used. For cold service at higher pressures, and for services up to 750 deg. F., asbestos compositions are frequently used. Metallic gaskets, although suited for most services, are mainly used in steel piping.



Ring for Ring Joint, oval or octagon cross-section

Gaskets are regularly available in standard sizes. However, many plants having need for numerous gaskets of rubber and asbestos, find it economical to buy these materials in sheet form and cut gaskets as required.

Good practice in cutting a gasket is to trace it from a template made first on heavy paper. This assures close and accurate fit. Consult manufacturers' recommendations for using various materials, also for treatment suggested before inserting gaskets in joints.



Steel Ring Joint assembly

"THE MORE YOU MAKE, THE BETTER YOU CAN MAKE IT"

That's an old axiom—proved over and over again—in the automobile industry, in aviation, electronics, in making machine tools or what have you. It's a natural process that as you keep making more and more of anything, you keep learning how to make it better.

So it is in valves and fittings. Crane quality is the kind of quality that is achieved in the world's largest and most completely equipped plant producing such materials. And Crane has the added advantage of almost 90 years' experience in manufacturing quality products.

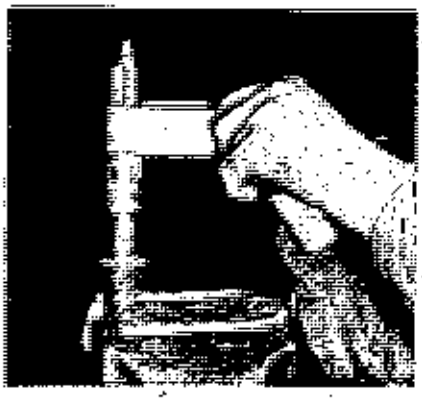
HOW TO REPAIR THE SEATS IN LEAKY GATE VALVES

When you definitely know that a valve leaks at the seats, don't delay to examining it to find out why. Neglected leaks will damage seating surfaces beyond repair. In new installations, leakage may be due to dirt or pipe scale. Immediate inspection and cleaning, or repairing if needed, may prevent serious damage.

To illustrate the procedure of making repairs, a solid wedge disc valve is used. The general method, however, applies to other types of gate valves which are repairable. The job is not an easy one, but it can be done in the following manner.



Illus. 1



Illus. 2



Illus. 3

After removing the bonnet, clean and examine the disc and body thoroughly. (*Illus. 1*) Carefully determine the extent of damage to body rings and disc. If corrosion has caused excessive pitting or eating away of metal, as in case of gouged rifts in body, it may be impractical to attempt repairs.

A complete checkup and servicing of all parts of the valve is recommended. Remove the stem from bonnet and examine it for scoring and pitting where the packing bears. As a rule, light polishing with fine emery cloth is all that's needed to put the stem in good condition. (*Illus. 2*) Use "soft" jaws if you put stem in vise.

Next, remove all the old packing and clean out the stuffing box. (*Illus. 3*) At the same time, clean inside of valve bonnet and other parts to remove all dirt, scale, corrosion, etc., to keep them from getting into valve seats.

It doesn't pay to salvage an old gasket. Remove it completely and replace with one of proper quality and size. (*Illus. 4*) After cleaning and examining all parts, if you see that the valve can be repaired by removing cuts from the disc and body seat faces, or by replacement of body parts, proceed as follows:

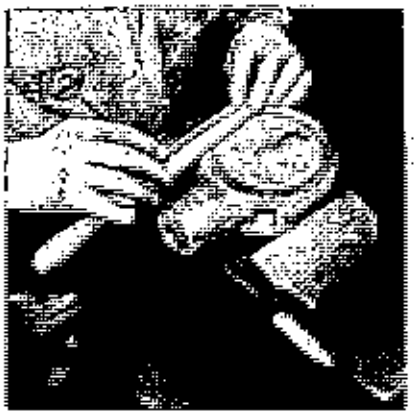
Set the disc in a vise with the face leveled. (*Illus. 5*) Wrap a piece of fine emery cloth around a flat tool and rub or "lap" the entire bearing surface (*both sides of disc*) to a smooth, even finish. Remove as little metal as possible.

The usual cuts and scratches found on body rings can also be repaired by "lapping." Use an emery block small enough to permit convenient rubbing of the rings all around. (*Illus. 6*) Work carefully and watch closely; avoid removal of too much metal to prevent disc seating too low. When seating surfaces (*disc and body rings*) seem to be properly "lapped-in," coat faces of disc with Prussian blue and drop it in the body to check the "bearing." When a good continuous contact is obtained the valve will be tight—and it ready for reassembly. When assembling, first insert stem in bonnet, install new packing, assemble other parts; attach disc to stem and place assembly in body. Raise the disc to prevent contact with the seats so that the bonnet can be properly seated on the body before tightening the joint.

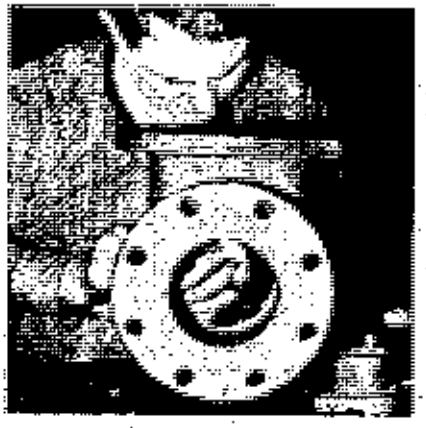
Good practice suggests testing the repaired valve before putting it back in the line. This is for assurance that repairs have been properly made.



Illus. 4



Illus. 5



Illus. 6

When seat rings in gate valves must be replaced, they can be removed and replaced best with a power lathe. Check up body with rings vertical to the arbor and use a strong steel bar across the ring lugs to unscrew them. Removal by hand can be done with a diamond point chisel, being careful not to hurt the threads. The new rings must be "socked home" tight. A big wrench on a steel bar across the lugs will help, when rings must be put in by hand. Always be sure to coat the threads with a good lubricant before putting them in. "Lap-in" the rings (*Illus. 6*) for a perfect fit to disc.

Manual-000806

HOW TO REGRIND OR RENEW DISC AND SEAT IN GLOBE VALVES

Repairs on globe and angle valves can frequently be made without removing them from the line. This feature should encourage immediate repair when leakage occurs, to prevent serious damage.

To illustrate the general procedure, a plug type disc valve is used. But the method applies to other globe and angle valves, except those with composition disc. The simple procedure for renewing composition discs is shown below.

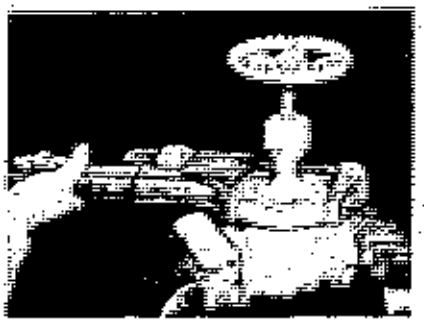


Fig. 1

Working at a bench, of course, is most convenient. Set the valve firmly in the vise, straight up. (*Illus. 1*) Use "soft" jaws to prevent damage to body. It's best not to use a pipe wrench on the bonnet or union ring. A monkey wrench won't damage these parts. While parts are disassembled, examine and clean them thoroughly. And it's also a good idea to renew the packing in the stuffing box at this time. The same method suggested for gate valves applies here.



Fig. 2

Remove stem from bonnet—plate disc in vise and unscrew disc stem ring. (*Illus. 2*)



Fig. 3

Next, lift out stem, insert a slug or coin inside of disc. (*Illus. 3*) Replace stem and tighten disc stem ring. The slug takes up "play" between disc and stem. In some valves, a pin is inserted in hole provided to lock disc on stem. Now you're almost ready to grind.

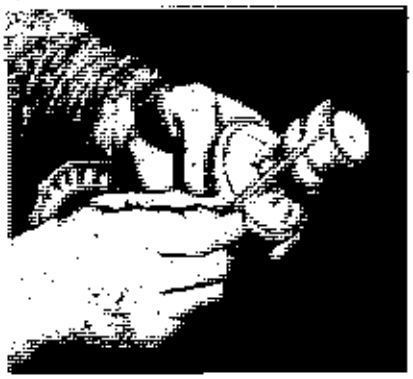


Fig. 4

Apply an emery base grinding compound to both disc and seat. A little compound will go a long way—too much is wasteful and likely to remove too much metal. (*Illus. 4*)

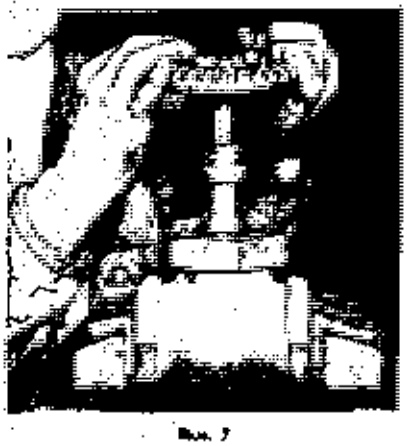


Fig. 5

Place bonnet and body together, giving bonnet or bonnet ring two or three turns by hand to provide a guide for the stem. (*Illus. 5*) With hand hold on rotate the handwheel readily until all pitting is removed and a continuous, smooth bearing on the seating surfaces is obtained. Don't grind more than is needed.



Fig. 6

When grinding is completed, wipe the disc, seat and body clean of all compound and dirt. (*Illus. 6*) Before reassembling valve, be sure to remove slug from disc or give it free swivel action on stem.



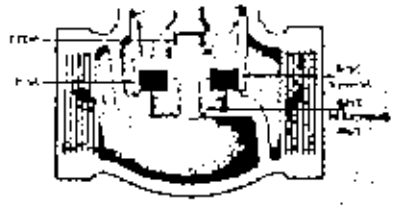
Fig. 7

When seat rings must be removed, it is desirable to use a tool specially designed for this purpose. (*Illus. 7*) Doing so will prevent damage to the valve body.

HOW TO RENEW DISC IN COMPOSITION DISC VALVES

This procedure is simple and takes little time. And while it may vary slightly for some valves, it is typical in principle.

Replacing a composition disc as soon as a seat leak is discovered, will add much to the valve's life. Here's how it's done:



Turn the stem to partly open position, unscrew the bonnet bolts, and lift out the bonnet assembly. Slip off disc holder. Remove disc retaining nut on under side of holder, and replace disc.

Where frequent disc changing is necessary, it is recommended that a few extra disc holders and discs be kept on hand. This saves time—it's also convenient when valves are changed in other service. Composition disc valves are ideal "all-purpose" valves, and discs are available for steam, hot and cold water, air, oil, gas, gasoline. This feature simplifies maintenance and parts stocks problems.

Manual-000807

PLANNING THE JOB WITH PRECISION



Being a good pipe-fitter also means being a good job planner. Maintenance work, especially if urgent, frequently requires shutting down equipment in production departments. Obviously, holding interruption of production to a minimum is all-important. The piping man's job must be planned and performed with greatest efficiency.

There are many things we can do—and are expected to do—to help ourselves and our job. Following are a few suggestions—a sort of check-list we can use to advantage on every job.

1. Find out exactly what is wrong or what is to be done, and estimate the time required to do it.



2. Arrange with department head for the best time to do the job and to shut down any equipment if necessary, based on your estimate of time required.

3. Make a list of all the materials and tools required.

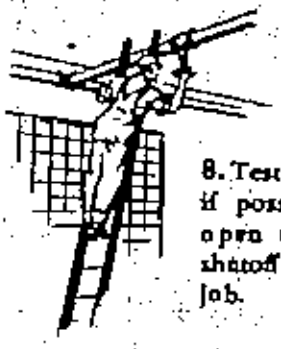


4. Determine how much of the work is to be done in your shop, and what must be done on the job. Careful planning here of all fabrication and assembly work that can be done at your work bench will save time and effort, and reduce any plant shut-down time.

5. See if you can do any work such as installing pipe supports, before shutting down the department.

6. Know exactly how you will proceed once you start on the job.

7. When the job is completed, check up on all details to be sure they have been properly carried out.



8. Test the work if possible. Re-open any lines shutoff to do the job.

9. Be a good housekeeper. Return all materials and tools to their respective places. You will need them again.



10. Making good on the job is largely a matter of learning good shop practices and making them a habit. No book and no course of instruction can give you all the piping pointers there are. But, making the best use of help available, such as this "Piping Pointers" Manual—studying it and keeping it handy for reference—plus your own resourcefulness and ingenuity, will surely lead to success in your work.

PLAYING SAFE ON THE JOB

Our job will be as safe as we make it. Each plant has its own safety rules designed to meet specific working conditions. However, there are certain general rules which piping men, if they are to be safe workers, will always observe. A few are given here.

1. Before breaking into a line, shut it off and drain. Failure to do this may result in a shower of water, but it might have been acid or steam.

2. Always work from above a floor when possible.

3. When loosening a flanged joint, start with the bolts farthest from you. In case of drip or spray, it won't be likely to leak on you.

4. Look out for hot lines. Just touching hot temperature piping may mean a bad burn, and the shock may cause dropping of tools, leading to other accidents.

5. Always use chain blocks, cable slings, rope falls, or rope slings when raising or lowering a piece of heavy piping. Make sure hoists are strong enough and that hitches won't slip.

6. Never leave a job without blanking off an open line. Someone may unknowingly turn it on and do damage. Best practice is to chain and lock shut-off valves and to hang signs on lines that are being repaired.

7. Tightening flange bolts with the line under pressure is not good practice. It may cause excessive strain resulting in rupture.

8. Always see that overhead piping is well supported with approved hangers—not makeshifts. Safest policy is to use hangers every ten feet. Heavy valves may need additional support.

9. Always put valves where workers can operate them easily without reaching or using ladders. Where that can't be done, install chain wheels or other means of remote control.

10. Keep your bench clean of "odds and ends." Wipe up all spots on the floor to avoid slipping. Use safety goggles on chisel or grinding work.

IT'S THE INGENUITY THAT COUNTS

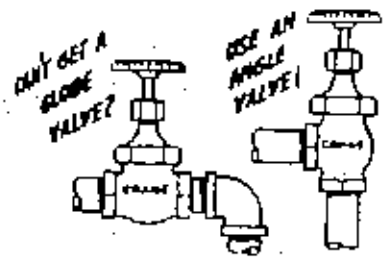


Who knows better than maintenance men how essential piping is to every industry—whether in making steel or chemicals, food or fabrics. And who knows better that when a pipe line is shut down, it may mean production is slowed down—often completely stopped.

In an emergency—a breakdown—a rush installation—when badly needed parts aren't available—that's when a piping man's knowledge of his job counts most. Being able to do something—the best thing for the moment—ingenuity—that's what it takes!

A few examples of piping ingenuity follow. But they're just a start toward what can be done when the need arises. Let's keep them in mind—learn others—work out more ourselves. They'll come in handy when we least expect it.

EXAMPLES OF PIPING INGENUITY



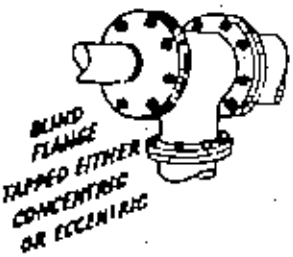
WHEN YOU'RE SHORT A GLOBE VALVE

When a globe valve isn't available for the place it's wanted, perhaps an angle valve will serve as well, and at the same time eliminate two joints and an elbow. Such installations are generally satisfactory because usually there is a turn in the line close to where the valve is to be located.



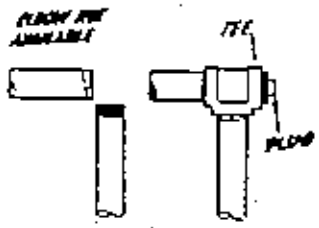
EMERGENCY WELDED JOINTS WITH SCREWED FITTINGS

Before socket-weld fittings were made, it was common practice to use screwed fittings and seal-weld seams around the threads. While this is not considered best practice now, in an emergency when socket-weld fittings are not on hand, seal-welding with screwed fittings will enable completion of a job.



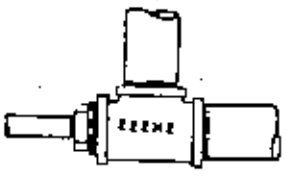
AN IMPROVISED SCREWED REDUCING FLANGE

A blind flange can be tapped—either concentric or eccentric as needed—to make a reducing flange. This is practical as long as the tapped opening is not too large in pipe size to prevent sufficient thread length for a safe joint. Another way is to use a bushing in a straight flange.



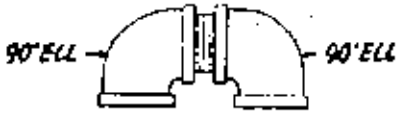
A TEE FOR AN ELBOW

Use tees or crosses with plugs to make 90 deg. turns in a line when you haven't elbows to complete a rush job. Either will work satisfactorily. In lines requiring frequent cleaning, tees or crosses as turns make rodding out easier by simply removing the plugs.



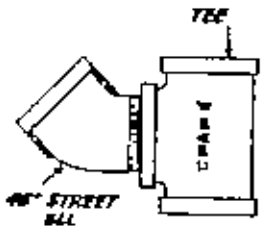
BUSHINGS TO THE RESCUE

When you can't get the exact fitting you want, use the nearest size that's available, straight or reducing, and bring it down to size with a bushing.



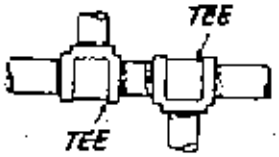
WHAT—NO RETURN BEND?

Discovering that you haven't the return bend that is needed for an emergency in installation shouldn't stump a good piping man. His ingenuity will suggest joining two ells and a nipple to make the good substitute shown above.



AN EMERGENCY Y-BRANCH

When you're on a rush job and find yourself short of a Y-branch fitting, think of this substitute. A tee and a 45-degree street ell, joined as shown above, will serve the same purpose.



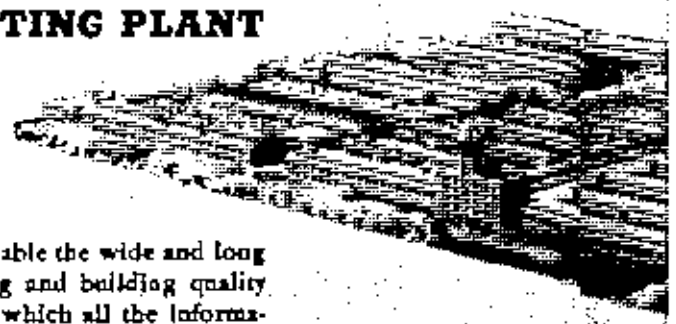
TWO TEES MAKE A "CROSS"

Suppose, in an emergency, you needed a cross of a given type and size which wasn't in stock. Don't give up. You may have two tees with which to make an offset cross. True, it may not look as well as a cross fitting and makes extra joints, but it serves the purpose and may save much valuable production time.

Manual-000808



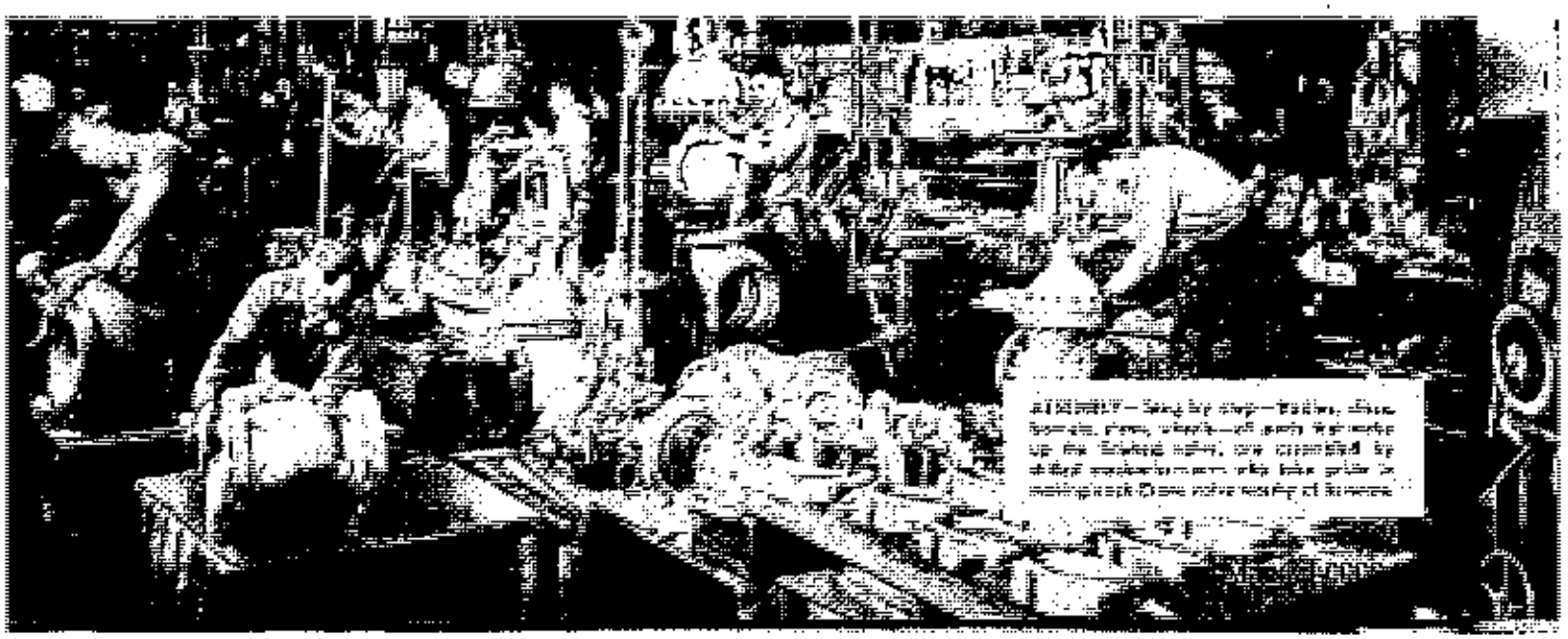
A GLIMPSE OF CRANE CHICAGO WORKS...
THE WORLD'S LARGEST VALVE AND FITTING PLANT

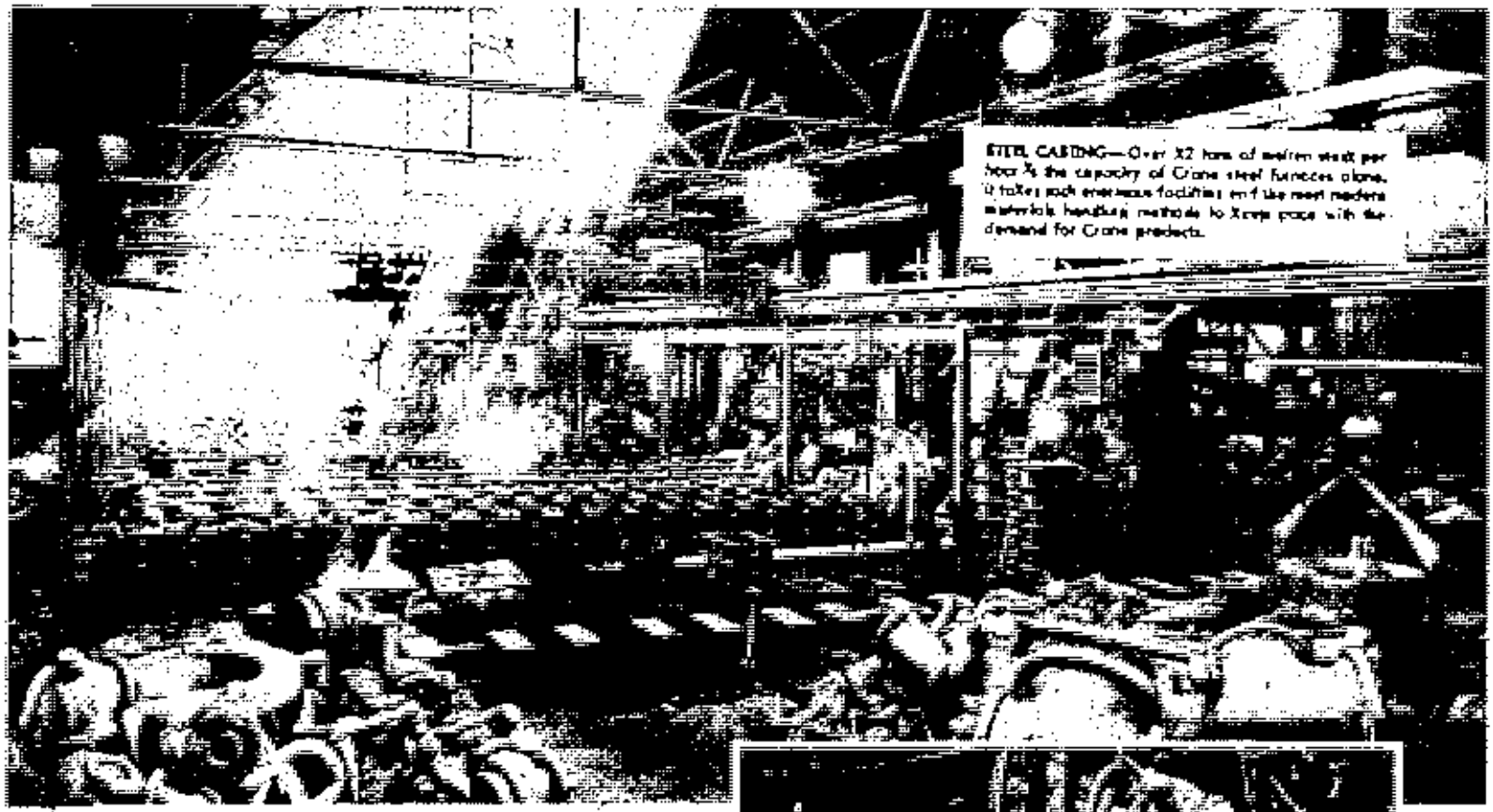


Industrial America was still in its infancy when Crane Co. was established in 1855. As industry forged ahead with the development of new steam power applications and process piping methods, Crane anticipated their flow control needs with constantly improving valves and fittings. As piping pressures and temperatures climbed, Crane produced the equipment to handle them safely.

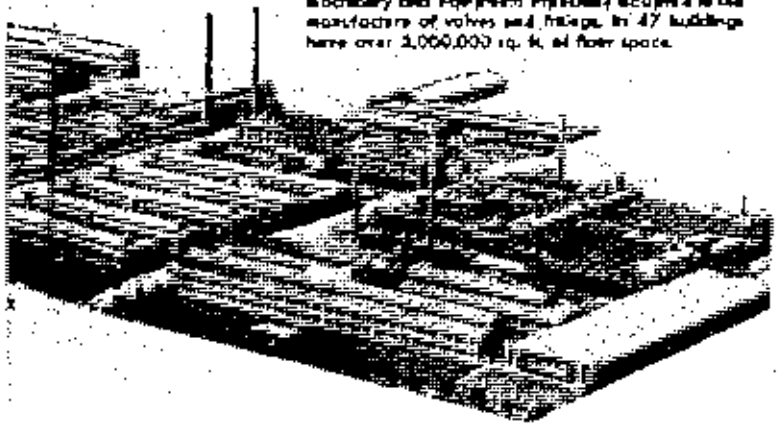
Today, not only is Crane the world's largest source of dependable valves and fittings for every service, but also the source of the most reliable data regarding their use. Thus, it was only natural that Crane should publish this "Piping Pointers" manual. For, nowhere else is there available the wide and long experience in designing and building quality valves and fittings, on which all the information in this manual is based.

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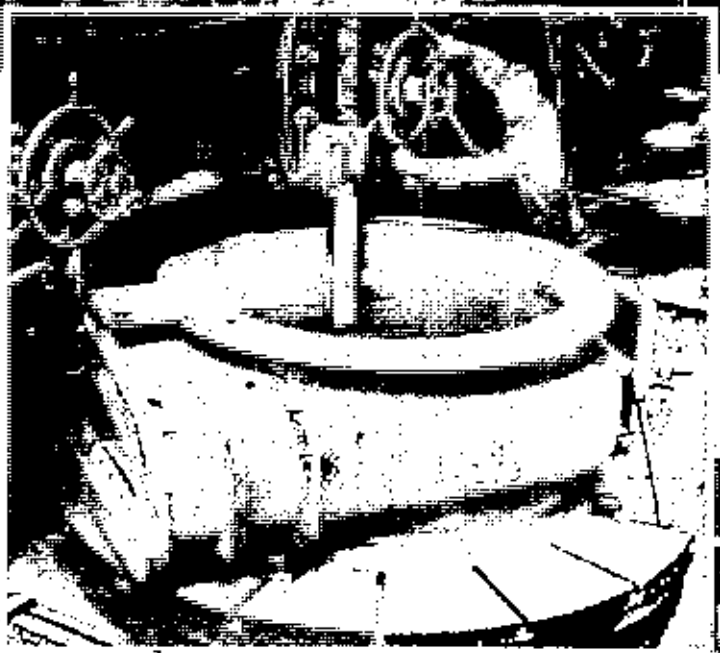


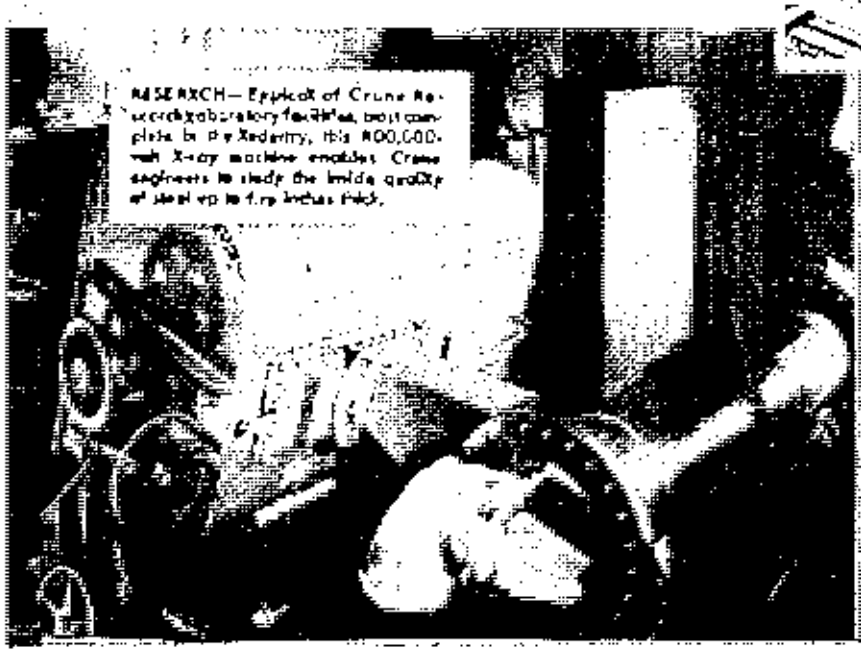


STEEL CASTING—Over 32 tons of molten steel per hour is the capacity of Crane steel furnaces alone. It takes such enormous facilities and the most modern materials handling methods to keep pace with the demand for Crane products.

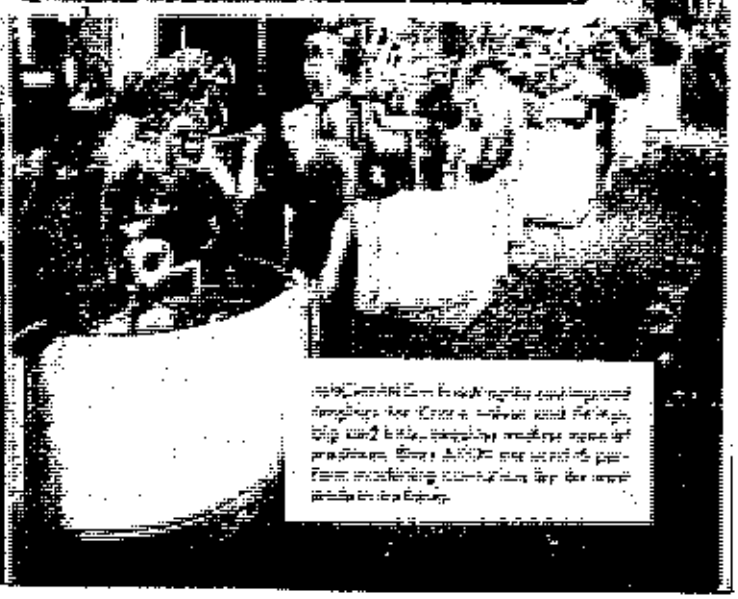


CRANE CHICAGO WORKS—A mighty array of machinery and equipment especially adapted to the manufacture of valves and fittings. In 47 buildings here over 3,000,000 sq. ft. of floor space.





RESEARCH—Epitome of Crane Research laboratory facilities, best equipped in the Industry, this 400,000-volt X-ray machine enables Crane engineers to study the inside quality of steel up to 4½ inches thick.



MANUFACTURING—Latest tools and improved processes for Crane valves and fittings, like this 2-ton capacity machine made of aluminum, three A.C.F. and several of your Crane manufacturing operations for the most profitable in the Group.

EXHIBIT O

INSTRUCTION MANUAL
FOR
INSTALLATION, OPERATION & MAINTENANCE
OF CRANE
BOLTED BONNET/CAP GATE, GLOBE
AND SWING CHECK VALVES

1

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EXHIBIT "O"

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INSTRUCTION MANUAL

FOR

INSTALLATION, OPERATION AND MAINTENANCE

OF

CRANE BOLTED BONNET/CAP GATE, GLOBE & SWING CHECK VALVES

I. INTRODUCTION

These instructions are furnished for use in installation, operation and maintenance of cast steel bolted bonnet/cap gate, globe and swing check valves. These valves are designed and manufactured in conformance with the requirements of Specification ANSI B16.34.

II. RECEIVING INSPECTION

A. Upon receipt of the valves at the destination, the valves should be examined thoroughly for signs of mishandling or damage during shipment.

B. The valves should be stored, if necessary, in a sheltered area to protect them from weather, dirt and foreign material. The valves should not be uncrated, or removed from their protective covering, or exposed to the atmosphere except in a clean area just prior to installation. Refer to Recommendations for the Storage of Valves.

C. The valve identification is stamped on metal plates attached to a yoke arm or cap of each valve.

VALVES • FITTINGS • PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

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III. HANDLING AND PREPARATION FOR INSTALLATION

A. Lift the valve using slings around the body under the bbonet flange and rotate the boooet end to the upright position. End protectors should not be removed until the valve is in proper position for inserting into the line.

B. Remove end closures protecting the port ends and rlean the weld end preperation/flange gasket surface with a solvent such as Acetone in preparation for welding or bolting in plare.

IV. INSTALLATION

A. The valve identification is stamped on metal plates attached to a yoke arm or top of each valve.

B. The valve should be blocked or slung into position with apparatus that will safely support the valve weight.

C. Weld or bolt the valve into the piping system in desired position in arrordance with applicable rodes and requirements.

D. Valve is now ready for service and system tests.

V. OPERATION

Gate and globe valves are opened by turning the handwheel counterclorkwise; clockwise to rlose.

Swing check valvee are opened and closed by line pressure or back pressure.

VI. TECHNICAL DATA

A. INSTALLATION ADJUSTMENT AND TEST OF CRANE GATE, GLOBB AND SWING CHECK VALVES.

1. Installation

Before installing the valve check to assure that valve being installed is specified for location, examine lines for foreign matter and clean them thoroughly. Make sure no foreign material is in the ports of of the valve. Locate the valve in place and weld or bolt.

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VI. TECHNICAL DATA - Contd.

A. INSTALLATION ADJUSTMENT AND TEST OF CRANE GATE, GLOBE AND SWING CHECK VALVE.

2. Adjustment and Test

After installation, operate gate and globe valves from full closed to full open position, and back to full closed position. Check all joints for leaks. In the event of leakage, repair as required, and repeat the above.

B. LUBRICATION AND MAINTENANCE OF CRANE GATE AND GLOBE VALVES.

1. Lubrication

Valves need no internal lubrication. Lubrication may be required, however, for the valve stem threads and for the operator (if valve is equipped with an operator). Grease fittings are provided for periodic lubrication at selected location.

2. Maintenance

Gate and globe valves should be operated through approximately 80% of travel at intervals of approximately one month depending on convenience. If not operated at intervals of one month or less, it is recommended that regular inspection of the stuffing box should be made to verify tightness. In adjusting the stuffing box, great care should be taken that the packing is not tighter than necessary to control leakage and that the eyebolt nuts are adjusted equally. Uneven adjustment can cause damage to the stem and operating failure. If leakage is detected and cannot be stopped by tightening the gland eyebolt nuts, the leakage may be attributed to one or more of the following reasons:

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VI. TECHNICAL DATA - Contd.

B. LUBRICATION AND MAINTENANCE OF CRANE GATE AND GLOBE VALVES.

2. Maintenance - Contd.

1. Incorrect packing used; replace with proper packing.

2. Packing may have become hard; replace with new packing.

3. Stem may be scored or deeply scratched; stem must be replaced.

4. Packing may not have been properly installed; packing ring splits should be staggered so that the splits are not positioned one over the other.

5. Stuffing box gland may be binding against either the stem or the stuffing box, due to uneven bolt pull-up. Stuffing box parts should be repositioned to assure even compression of the packing.

C. REPAIR OF GATE VALVES

1. Valve Disassembly:

Have replacement gasket available, unwedge the disc.

Remove bonnet bolting and carefully lift bonnet assembly with disc from body.

Caution: Side of disc should be match marked to side of body for reassembly in original position. Be careful to prevent disc from sliding off end of stem prematurely.

2. Procedure for lapping disc:

Apply Grade 80 or 120 emery cloth to flat surface. Lay disc face on abrasive and use oscillating motion for lapping until face is polished. In extreme cases, first use a soft grade of carborundum stone.

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VI. TECHNICAL DATA - Coord.

C. REPAIR OF GATE VALVES - Coord.

3. Procedure for lapping body seat ring:

Apply Grade 80 or 120 emery cloth to a convenient size block. Hand lap by applying abrasive to face of body seat ring, use oscillating motion all around until face is polished. In extreme cases, first use a coir grade of carborundum stone. After lapping, clean body seat and disc to remove residue from the abrasives. Apply Prussian Blue to faces of disc and insert into seat, tap lightly to record seat bearing. If bearing periphery does not record a complete circle on disc face, repeat lapping operation to remove high spots until a complete circle is obtained.

4. Procedure for making up bonnet joint:

Before reassembly of bonnet to body, inspect bonnet flange and body-bonnet flange gasket surfaces for damage and/or any foreign material that will obstruct a good sealing surface. Such matter must be removed with a emery cloth (Grade 80 or 120). Clean off all residue from gasket and gasket surface before reassembly.

5. Reassembly:

Apply high temperature thread lubricant to gasket (on noncritical service application only), sportface surfaces and bonnet bolting. Place gasket on body. During bonnet assembly raise stem to full open position. Insert bonnet with disc to body in proper position. Tighten bonnet bolting alternately (crossover method) with even pressure, up to a bolt stress of 30,000 Lbs./In^2. Should there be any leakage at bonnet joint after valve is put into service, tighten nuts up to a maximum of 45,000 Lbs./In.^{2} bolt stress.

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VI. TECHNICAL DATA - Contd.

D. REPAIR OF GLOBE VALVES

1. Valve Disassembly:

Have replacement gasket available.

Remove bonnet bolting and carefully lift bonnet assembly with disc from body.

2. Procedure for lapping disc and body seat ring:

Apply a small amount of valve grinding compound all around the seat bearing surface then place disc into port and lap with alternate rotary motion. Lift disc at intervals and turn 180° and continue lapping. Remove compound occasionally in lapping, clean body seat and disc to remove compound residue.

Apply Prussian Blue to disc and insert into seat. Applying normal pressure to disc, rotate 5° (approx.) to record seat bearing. If bearing periphery does not record a complete circle on disc face, repeat operation to remove high spots until a complete circle is obtained.

3. Procedure for making up bonnet joint:

Before reassembly of bonnet to body inspect bonnet flange and gasket surfaces for damage and/or any foreign material that will obstruct a good sealing surface. Such matter must be removed with emery cloth (Grade 8D or 12D). Clean off all residue from gasket and gasket surface before reassembly.

4. Reassembly:

Place gasket on body. Apply high temperature thread lubricant to gasket, (on nonciritical service applications only), body studs and spotface surfaces.

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VI. TECHNICAL DATA - Contd.

D. REPAIR OF GLOBE VALVES - Contd.

4. Reassembly: - Contd.

On bonnet assembly, raise stem to full open position. To stall bonnet to body in proper position. Tighten bonnet stud nuts alternately (crossover method) with even pressure, up to a bolt stress of 30,000 lbs./In.^{2}. Should there be leakage at bonnet joint after valve is put into service, tighten nuts up to a maximum of 45,000 Lbs./In.^{2} bolt stress.

E. REPAIR OF SWING CHECK VALVES

1. Valve disassembly:

Have replacement gasket available.

Remove cap bolting and carefully lift cap from body. Do not damage gasket seating surface.

Remove external hexagon plugs. Hold disc-hinge subassembly in place and remove hinge pin. The subassembly can not be removed from the body. For disassembly of the disc-hinge assembly, remove the disc nut locking pin, disc nut and washer.

2. Procedure for lapping disc and body seat ring:

For lapping disc and body seat ring, apply Grade 80 or 120 emery cloth to a flat plate. lay the abrasive side of the place on seat face and use rotary motion for lapping until face is polished. If the disc face is damaged such that grinding is required, a minimum of stock should be removed.

After lapping, clean body seat ring and disc to remove residue from the abrasives. Apply light film of Prussian Blue to face of disc and reassembly to body. Appply pressure on disc and cap lightly with a rawhide mallet to record bearing.

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VI. TECHNICAL DATA - Contd.

E. REPAIR OF SWING CHECK VALVES - Contd.

2. Procedure for lapping disc and body seat ring: - Contd.

If the bearing does not record a complete circle on disc and body ring faces, repeat lapping operation to remove high spots until a complete circle is obtained. (The hinge assembly must be free on the disc, with no binding, when the disc face is flat on the seat ring face.)

3. Procedure for making up rep joint:

Before reassembly of cover flange to body, inspect flange gasket surfaces for damage and any foreign material that will obstruct a good sealing surface. Such matter must be removed with emery cloth (Grade 80 or 120). Clean off all residue from gasket and gasket surface before reassembly.

4. Reassembly:

Assemble disc-hinge subassembly in reverse order from disassembly by placing the hinge onto the disc hub. Install washer and disc nut taking care to realign hole in disc for locking pin.

Carefully position subassembly disc face onto body-seat and align hinge pin hole with body plug holes and install hinge pin.

Install hexagon body plugs.

Place gasket into body. Apply high temperature thread lubricant to gasket, (on noncritical service applications only), body studs and sportface surfaces. Insert cap to body with flow arrow leading in proper direction.

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VI. TECHNICAL DATA - Contd.

E. REPAIR OF SWING CHECK VALVES - Contd.

4. Reassembly: - Contd.

Tighten cap stud nuts alternately (crossover method) with even pressure, up to a bolt stress of 30,000 Lbs./In.^{2}. Should there be leakage at the top joint or body plugs after valve is put in service, tighten nuts up to a maximum of 45,000 Lbs./In.^{2}. bolt stress.

VII. PROCEDURE FOR REPLACING SPLIT RING PACKING IN VALVE STUFFING BOX

The following procedure should be used to replace packing in assembled valves whether or not installed in the system. During the packing replacement, the valve should be isolated and depressurized.

1. Remove nuts from packing gland bolting.
2. Raise packing gland and gland flange to allow access to stuffing box.
3. Remove the old packing using a suitable packing removal tool.

CAUTION: Extreme care shall be taken to prevent damage to surfaces of the stem and stuffing box bore.

4. Clean the stem, stuffing box, and packing gland.
5. Inspect surfaces of the stem and stuffing box for damage such as nicks and scratches which may cause an inadequate packing seal. Damaged parts shall be repaired or replaced.
6. Lubricate packing gland studs.
7. Install new packing into stuffing box. One packing ring shall be installed at a time, as follows:

(a) Carefully install the ring on the stem, opening the split rings with a twisting motion.

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VII. PROCEDURE FOR REPLACING SPLIT RING PACKING IN VALVE STUFFING BOX - Contd.

(b) Position on stem locating thr split approximately 120 degtees from the split of the pteviously installed tfng.

(c) Ptess ting ioto tbe stoffiog box with cate to ptevent tuttfng tbs packing on edges of the stwffing box, and rarefully tamp ting in place.

(d) Comptess the tfng usiog patking gland, flaoge and outs, tighteniog with teasonable totque fot gland boltfog.

Note: A split collat extensfoo of xoft metal, ot hatd wood, sbould be used with the patking gland, until tbe riog stack fs high enough to be testhed by the gland, to ensure comptession of tha lower tings.

(e) The mioimum numbet of packing tinga to be iostalled shall be fo sctordance with deafgn requitements. If the specified mioimum numbet of tings caonot be iostalled, it sbould be astertained that the tings have been installed and comptessed properly.

(f) Installation of additional patking ting may be oetessary to ensure that suffitient tleatsnce exists between the gland tollar and the bonnet to permit future patking adjustment.

Note: The maximum oumbet of parkiog tings installed shall permit the glaod to be tetsioed within the stuffiog box bore.

Batk off patkiog gland etud outs and tetighten with totque of apptoximotely one half of that used to otfginelly comptess patking.

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VII. PROCEDURE FOR REPLACING SPLIT RING PACKING IN VALVE STUFFING BOX - Contd.

(i) (Contd.) If possible, pressurize the valve and packing for several minutes, then depressurize. Valve shall not be back-seated at this time.

Cycle Valve several times.

Adjust torque if required for tightness.

If valve is to be stored, loosen the packing gland until it just contacts the packing with no loading or bolting.

Tag the valve to indicate that the gland has been loosened.

VIII. RECOMMENDATIONS FOR THE STORAGE OF VALVES

1. The storage area should be reasonably level, well drained, and have a paved surface, and be protected by a roof and sheltered from rain, dust, dirt and the elements.
2. Packing should be removed from the stuffing box if the valve is to be stored for six (6) months. Valve stuffing box should be repacked before valve is installed. It is highly recommended that only new material be used when repacking.
3. If storage is less than six (6) months, the stem should be repositioned periodically (by turning the handwheel) to differing locations to minimize galvanic corrosion. (Once a month may be adequate.)
4. If storage is greater than six (6) months, desiccant bags should be placed inside the valve to prevent internal corrosion.
5. Ends should be adequately sealed off to prevent entrance of moisture or foreign material, and protected to prevent damage to weld ends or gasket surfaces.

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VIii. RECOMMENDATIONS FOR THE STORAGE OF VALVES - Cootd.

6. Valves should be skidded and tovered with heavy gauge polyethyiene, or other suitable matetial, secured to the base of the skid with nailed batteos, however, do not seal all sides sinte air tirtuistion is netessary.

7. Crsoe Co. is anxious to assist in assuting that equipment is stored, installed, used and maintained in the best prsetical wanoer. inasmuth as tbe material fs not io our possession, you tan houever uoderatand that Crane Co. tannot accept any responsibility for the storage of material.

IX. RECOMMENDED SPARE PARTS:

Opoo eompietioo of instaliatioo and teating of the piping and valve system, it is recommended tbat one (1) bonnet/cap gasket and one (1) set of stuffing box patking be stotked as spares for eath vaive. When ordering spares, referente valve size, cataiog number, assembly drswing number and piece oumbers ehown oo the bill of materials in the assembiy drawing section of this manual.

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EXHIBIT P

INSTRUCTIONS

FOR THE

FOSTER WHEELER MARINE STEAM GENERATORS

INSTALLED IN

USS GUEST DD472

USS FIDDLER DD479

USS CHARRETTE DD581

USS KONNER DD582

USS HALL DD583



*** NAVSHIPS ***

NAVSHIPS 0951-000-5010

DEPARTMENT OF THE NAVY

BUREAU OF SHIPS

FOW-53

I N S T R U C T I O N S

FOR THE

FOSTER WHEELER MARINE STEAM GENERATORS

INSTALLED IN:

U. S. S.	OUEST	DD-472
U. S. S.	BENNETT	DD-473
U. S. S.	CHARRETTE	DD-581
U. S. S.	CONNER	DD-582
U. S. S.	HALL	DD-583

U. S. NAVY CONTRACT Nos 77418 and NDs 471-A

F.W.S. - 514-53, 578-645, and 1241-60

FOSTER WHEELER CORPORATION

NEW YORK

FWB-514 Revised 8/5/59

Manual-001148

MARINE STEAM GENERATOR - INSTRUCTIONS

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MARINE STEAM GENERATOR - INSTRUCTIONS

INTRODUCTION

This Instruction Book has been prepared primarily for the use of ths operators of the Foster-Wheeler separately-fired superheater marine steam generators as inetalled in DD-472, 473, 581, 582, 583 Dsstroyers. It contains information concerning the construction, operation and maintsnance that is peculiar to thess genarators.

The operating procedure to be followed is that which is given in ths Bureau of Ships Manual - Chapter 51 "Boilers" (NAVSHIPS 250-000-51) iasued by tbe U. S. Navy Department, Bureau of Ships

As a matter of conveniance to the fireroom operator, the Instruction Book contains a brief, mora easily remembered outlins of those portions of tha above manual which are pertinent to everyday operation.

MARINE STEAM GENERATOR - INSTRUCTIONS

Section 1

APPLICABLE REFERENCE DRAWINGS

Foster Wheeler Corporation Drawings

Bureau of Ships Type "B" Plan Number	Manufacturer's Plan Number		Title
DD445-S5101-101	NY-400-540	--	General Arrgt.-Sectional Elevation.
DD445-S5101-102	NY-400-541	-	General Arrgt.-Sectional Side Elevation
DD445-S5101-103	NY-400-542	-	General Arrgt.-Plan Sect.
DD445-S5101-104	NY-400-543	-	General Arrgt.-Plan View
DD445-S5101-125	NY-400-544	-	Arrgt. of External Conns. (Elev.)
DD445-S5101-124	NY-400-545	-	Arrgt. of External Conns. (Plan)
DD445-S5103-144	NY-400-546	-	Arrgt. of Valves & Fittings
DD445-S5103-101	NY-400-547	-	Details of External Conns.
DD445-S5101-105	NY-400-548	-	Assembly of Drums
DD445-S5103-103	NY-400-549	-	Arrgt. of Saddles
DD445-S5103-104	NY-400-550	-	Details of Saddles
DD445-S5101-123	NY-400-551	-	Outline of Boiler
DD445-S5101-106	NY-400-554	-	Details of Steam Drum
DD445-S5102-115	NY-400-555	-	Structural Conns. to Steam Drum
DD445-S5102-116	NY-400-556	-	Steam Drum Protection Plates
DD445-S5103-105	NY-400-557	-	Assembly of Internal Fittings & Baffles
DD445-S5103-106	NY-400-558	-	Details of Internal Baffles
DD445-S5103-107	NY-400-559	-	Details of Internal Fittings
DD445-S5103-108	NY-400-560	-	Details of Internal Fittings
DD445-S5102-208	NY-400-561	-	Details of S.H. Header Protection Plates
DD445-S5101-107	NY-400-562	-	Details of Water Drum
DD445-S5102-113	NY-400-563	-	Structural Conns. to Water Drum
DD445-S5101-108	NY-400-564	-	Details of Water Header
DD445-S5101-119	NY-400-565	-	Pressure Part Details, Water Header
DD445-S5102-117	NY-400-566	-	Structural Conns. to Water Header
DD445-S5102-118	NY-400-567	-	Protection Pls. for Water Header
DD445-S5101-109	NY-400-569	-	Arrgt. of Boilers & Downcomer Tubes
DD445-S5101-110	NY-400-570	-	Details of Boiler Tubes
DD445-S5101-134	NY-400-571	-	Boiler Tool Details
DD445-S5101-129	NY-400-572	-	Details & Assemblies of Tools
DD445-S5101-130	NY-400-573	-	Tube Expander Details
DD445-S5101-131	NY-400-574	-	list of Tools & Spares #1
DD445-S5101-132	NY-400-575	-	List of Tools & Spares #2
DD445-S5101-127	NY-400-576	-	Arrgt. S.H. Tubes
DD445-S5101-128	NY-400-577	-	Details of S.H. Tubes
DD445-S5102-204	NY-400-578	-	Details of Rear Superheater Supports
DD445-S5101-121	NY-400-579	-	S.H. Pressure Part Details
DD445-S5101-122	NY-400-580	-	S.H. Pressure Part Details
DD445-S5101-133	NY-400-581	-	S.H. Tool Details
DD445-S5102-114	NY-400-582	-	Arrgt. & Details of S.H. Header Ties
DD445-S5102-119	NY-400-583	-	Arrgt. of S.H. Header Protection Pls.
DD445-S5102-121	NY-400-584	-	Arrgt. & Details S.H. Inlet Header Protect. Pls.
DD445-S5102-122	NY-400-585	-	S.H. Furnace Floor Plates
DD445-S5102-167	NY-400-586	-	Details of Casing Ties
DD445-S5102-168	NY-400-587	-	Details of Casing Ties
DD445-S5102-123	NY-400-588	-	General Arrgt. Brickwork-Front
DD445-S5101-124	NY-400-589	-	General Arrgt. Brickwork-Rear

FWB-514. Revised 9/10/41

MARINE STEAM GENERATOR - INSTRUCTIONS

Section I

REFERENCE DRAWINGS

Foster Wheeler Drawings (Continued)

Bureau of Ships Type "B" Plan Number	Manufacturer's Plan Number		Title
DD445-S5102-125	NY-400-590	-	Detail of Front Burner Plate
DD445-S5102-126	NY-400-591	-	Detail of S.H. Furnace Burner Plate
DD445-S5102-120	NY-400-592	-	Details of S.H. Supports
DD445-S5102-127	NY-400-593	-	Details of Furnace Door
DD445-S5102-128	NY-400-594	-	Assembly & Details of Peep Doors
DD445-S5102-129	NY-400-595	-	Arrgt. of Ignition Tube-S.H. Side
DD445-S5102-130	NY-400-596	-	Details of Ignition Tube-S.H. Side
DD445-S5102-131	NY-400-597	-	Arrgt. & Details of Lighting Ports
DD445-S5102-134	NY-400-598	-	Details of Casing Tie Castings
DD445-S5101-111	NY-400-599	-	Economizer Arrgt.
DD445-S5101-112	NY-400-600	-	Assembly of Pressure Parts
DD445-S5101-113	NY-400-601	-	Pressure Part Details (Manifolds)
DD445-S5101-114	NY-400-602	-	Pressure Part Details (Elements)
DD445-S5102-104	NY-400-603	-	Front Support Plate (Econ.)
DD445-S5102-103	NY-400-604	-	Rear Support Plate (Econ.)
DD445-S5102-102	NY-400-605	-	Door Details (Econ.)
DD445-S5102-101	NY-400-606	-	Breeching Supports & Econ. Manifold Seals & Baffle
DD445-S5101-115	NY-400-607	-	Details of Tools & Install. Instructions
DD445-S5102-169	NY-400-608	-	Details of Casing Tie Castings
DD445-S5102-105	NY-400-609	-	Arrgt. of Front Inner Casing
DD445-S5102-106	NY-400-610	-	Arrgt. of Side Inner Casing (Sat. Side)
DD445-S5102-107	NY-400-611	-	Arrgt. of Side Inner Casing (S.H. Side)
DD445-S5102-108	NY-400-612	-	Arrgt. of Rear Inner Casing
DD445-S5102-109	NY-400-613	-	Arrgt. of Air Casing (Sat. Side)
DD445-S5102-110	NY-400-614	-	Arrgt. of Air Casing (S.H. Side)
DD445-S5102-112	NY-400-615	-	Arrgt. of Front Air Casing
DD445-S5102-111	NY-400-616	-	Arrgt. of Rear Air Casing
DD445-S5102-135	NY-400-617	-	Enlarged Sections of Casings
DD445-S5102-132	NY-400-618	-	Conn. to Air Casing at Bottom
DD445-S5102-133	NY-400-619	-	Details Front & Rear Panels
DD445-S5102-137	NY-400-620	-	Enlarged Sections
DD445-S5102-138	NY-400-621	-	Enlarged Sections Front & Rear Casing
DD445-S5102-149	NY-400-622	-	Enlarged Sections Front & Rear Casing
DD445-S5102-164	NY-400-623	-	Sections for Inner & Outer Casing
DD445-S5102-165	NY-400-624	-	Sections for Inner & Outer Casing
DD445-S5102-139	NY-400-625	-	Enlarged Sections Front & Rear Casing
DD445-S5102-140	NY-400-626	-	S.H. Side Casing Support Details
DD445-S5102-141	NY-400-627	-	S.H. Side Casing Support Details
DD445-S5102-142	NY-400-628	-	S.H. Side Casing Support Details
DD445-S5102-143	NY-400-629	-	Sat. Side Casing Support Details
DD445-S5102-144	NY-400-630	-	Sat. Side Casing Support Details
DD445-S5102-145	NY-400-631	-	Superheater Side Casing Support Details
DD445-S5102-146	NY-400-632	-	Rear Side Casing Support Details
DD445-S5102-147	NY-400-633	-	Front & Rear Casing Support Details
DD445-S5102-148	NY-400-634	-	Front & Rear Casing Support Details
DD445-S5102-136	NY-400-635	-	Detail of Casing Supports
DD445-S5101-116	NY-400-636	-	Details & Assembly of Tools

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MARINE STEAM GENERATOR - INSTRUCTIONS

Section 1

REFERENCE DRAWINGS

Foster Wheeler Drawings (Continued)

Bureau of Ships Type "B" Plan Number	Manufacturer's Plan Number		Title
DD445-S5102-152	NY-400-637	-	Forms for Install. Plastic Refractory
DD445-S5102-205	NY-400-643	-	Superheater Outlet Support
DD445-S5103-145	NY-400-644	-	Name Plate
DD445-S5103-150	NY-400-649	-	List of Drawings
DD445-S5102-211	NY-410-521	-	Detail of Gaskets
DD445-S5102-210	NY-401-508	-	List of Field Bolts & Gaskets
DD445-S5101-116	NY-401-339	-	Spare Element Container (Econ.)
DD445-S5101-117	NY-401-359	-	Tube Expander Details (Econ.)
DD445-S5102-150	NY-401-468	-	Bill of Material for Casing Supports
DD445-S5102-212	NY-410-804	-	Additional stiffening bars on economizer front support plate
DD445-S5101-139	NY-410-996	-	Superheater tube removal and replacement diagram
DD445-S5101-140	NY-411-505	-	Flash butt welding procedure
DD445-S5102-213	NY-420-437	-	Details of Casing Tie Castings
DD445-S5102-214	NY-420-438	-	Enlarged Sections of Casings
DD445-S5102-215	NY-420-445	-	Details of Casing Ties
DD445-S5102-216	NY-420-322	-	Seal for Front Casing At Superheater Inlet Header
DD445-S5102-217	NY-420-323	-	Details of Front Casing Seal at Superheater Inlet Header
DD445-S5102-218	NY-420-324	-	Seal for Rear Casing at Superheater Inlet Header
DD445-S5102-219	NY-420-325	-	Details of Rear Casing Seals at Superheater Inlet Header
DD445-S5102-220	NY-420-326	-	List of Material and Detail of Gaskets for Front and Rear Casing Seals at Superheater Inlet Header
DD445-S5102-223	NY-420-337	-	Structural Connections to Steam Drum
DD445-S5102-221	NY-420-796	-	Seal for Front Casing at Superheater Inlet Header
DD445-S5102-222	NY-420-797	-	Seal for Rear Casing at Superheater Inlet Header
DD445-S5102-224	NY-420-317	-	Details of Air Lock Type Ignition Tube
	NY-420-875	-	Superheater Furnace Floor Support Plates
	NY-420-839	-	Details of Superheater Burner Plate and Rear Inner Casing Plate at Superheater Inlet Header
	NY-420-791	-	Superheater Side Casing Support Details (Rear)
	NY-420-798	-	Details of Front and Rear Casing Seals at Superheater Inlet Header
DD445-S5102-286	NY-420-799	-	List of Field Bolts, Gaskets & Insulating Material
DD445-S5102-225	NY-420-836	-	Arrangement of Superheater Inlet Header Protection Plates
DD445-S5102-226	NY-420-837	-	Details of Superheater Inlet Header Protection Plates
DD445-S5102-227	NY-420-838	-	Assembly and Detail of Superheater Inlet Header Protection Plates
DD445-S5102-228	NY-420-887	-	Forms for Molding Refractory for Superheater Inlet Header Protection Plates

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MARINE STEAM GENERATOR - INSTRUCTIONS

Section I

REFERENCE DRAWINGS

Edw. G. Budd Mfg. Co. Drawings

Bureau of Ships Type "S" Plan Number	Manufacturer's Plan Number		Title
DD445-S5102-156	N-1613-001	-	Inner Casing Panels (S.H. Side)
DD445-S5102-155	N-1613-002	-	Inner Casing Panels (S.H. Side)
DD445-S5102-157	N-1613-003	-	Inner Casing Panels (Sat. Side)
DD445-S5102-158	N-1613-004	-	Inner Access Doors
DD445-S5102-154	N-1613-005	-	Insulated Panels (Rear Inner Casing)
DD445-S5102-153	N-1613-006	-	Insulated Panels (Rear Inner Casing)
DD445-S5102-166	N-1613-007	-	Brick Pan
DD445-S5102-159	N-1613-008	-	Side Air Casing Panels (S.H. Side)
DD445-S5102-160	N-1613-009	-	Inner Casing Panels at Econ.
DD445-S5102-161	N-1613-010	-	Side Air Casing Panels (S.H. Side)
DD445-S5102-162	N-1613-011	-	Side Air Casing Panels (Sat. Side)
DD445-S5102-163	N-1613-012	-	Front Air Casing Panels
DD445-S5102-170	N-1613-013	-	Rear Air Casing Panels
DD445-S5102-171	N-1613-014	-	Air Casing Panels at Econ.
DD445-S5102-172	N-1613-015	-	Air Casing Panels
DD445-S5102-173	N-1613-016	-	Insulation Pads
DD445-S5102-174	N-1613-017	-	Front & Rear Air Casing Panels
DD445-S5102-182	N-1613-018	-	Air Casing Panels (Superheater Side)
DD445-S5102-175	N-1613-019	-	Air Casing Panels
DD445-S5102-176	N-1613-020	-	Front Air Casing Panels
DD445-S5102-177	N-1613-021	-	Front Air Casing Panels
DD445-S5102-178	N-1613-022	-	Front Air Casing Panels
DD445-S5102-179	N-1613-023	-	Rear Air Casing Panels
DD445-S5102-180	N-1613-024	-	Air Casing Panels (S.H. Side)
DD445-S5102-181	N-1613-025	-	Front Air Casing Panels
DD445-S5102-183	N-1613-026	-	Rear Air Casing Panels
DD445-S5102-184	N-1613-027	-	Air Casing Panels (Sat. Side)
DD445-S5102-185	N-1613-028	-	Air Casing Panels (Sat. Side)
DD445-S5102-186	N-1613-029	-	Brick Bolt Panels
DD445-S5102-187	N-1613-030	-	Brick Bolt Panels
DD445-S5102-188	N-1613-031	-	Air Casing Panels (Sat. Side)
DD445-S5102-189	N-1613-032	-	Insulated Panels (Superheater Side)
DD445-S5102-190	N-1613-033	-	Front Inner Casing (Ins. Panels)
DD445-S5102-191	N-1613-034	-	Front Air Casing Panels
DD445-S5102-192	N-1613-035	-	Brick Bolt Panels
DD445-S5102-195	N-1613-036	-	Front Air Casing Panels
DD445-S5102-194	N-1613-037	-	Rear Air Casing Panels (& Air Inlet)
DD445-S5102-195	N-1613-038	-	Rear Air Casing Panels
DD445-S5102-196	N-1613-039	-	Front Air Casing Panels
DD445-S5102-197	N-1613-040	-	Rear Air Casing Panels (& Retainer)
DD445-S5102-198	N-1613-041	-	Front Inner Casing Panels
DD445-S5102-199	N-1613-042	-	Outlet Cover & Rear Air Casing Panels
DD445-S5102-206	N-1613-043	-	Front & Rear Air Casing Panels at S.H. Inlet
DD445-S5102-207	N-1613-044	-	Air Casing Panels S.H. Side

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REFERENCE DRAWINGS

Edw. G. Budd Mfg. Co. Drawings (Continued)

Bureau of Ships Type "S" Plan Number	Manufacturer's Plan Number		Title
DD445-S51D2-2D9	N-1613-045	-	Rear Inner Casing Panels
DD445-S51D2-293	N-1966-001	-	Front Air Casing Panels
DD445-S51D2-292	N-1966-002	-	Front & Rear Air Casing Panels
DD445-S51D2-291	N-1966-003	-	Rear Air Casing Panels

Todd Combustion Equipment, Inc., Drawings

DD445-S5504-76	3086-H-1	-	Burner Arrangement & Details
DD445-S5504-77	3086-H-2	-	Burner Details
DD445-S5504-78	3086-H-3	-	Burner Details
DD445-S5504-79	3086-H-4	-	Burner Details
DD445-S5504-80	3086-H-5	-	Burner Details
DD445-S5504-81	3086-H-6	-	Burner Details
DD445-S5504-82	3086-H-7	-	Burner Details
DD445-S5504-83	3086-H-8	-	Burner Details
DD445-S5504-84	3086-H-9	-	Burner Details
DD445-S5504-85	3086-H-10	-	Burner Details
DD445-S5504-86	3086-H-11	-	Burner Details
DD445-S5504-87	3636-H-1	-	Assembly & Details Smoke Making Atomizer
DD445-S5504-88	3636-H-2	-	Details Smoke Making Atomizer
	3086-H-12	-	Details of Replacement Parts

Vulcan Soot Blower Corp.

DD445-S51D3-1D9	1D948	-	Gen. Arrgt. Elements & Details
DD445-S51D3-11D	1D949	-	Sleeve Assemblies
DD445-S51D3-111	1D950	-	Head Details
DD445-S51D3-112	1D951	-	Head Details
DD445-S51D3-113	1D952	-	Head Details
DD445-S51D3-114	1D953	-	Head Details
DD445-S51D3-115	1D954	-	Head Assembly
DD445-S51D3-116	1D955	-	Bearing & Sleeve Details
DD445-S51D3-117	1D956	-	Sleeve Details

Revised 2/5/43

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MARINE STEAM GENERATOR - INSTRUCTIONS

Section 1

REFERENCE DRAWINGS

Crosby Steam Gage & Valve Co. Drawings

Bureau of Ships Type "B" Plan Number	Manufacturer's plan Number		
DD445-S5103-118	A-20674	-	Assembly of 2-1/2" Pop Safety Valve
DD445-S5103-119	A-20675	-	Body, Disc 2-1/2" Pop Safety Valve
DD445-S5103-120	A-20676	-	Spring Bonnet 2-1/2" Pop Savaty Valve
DD445-S5103-121	A-20677	-	Lever Clamp 2-1/2" Pop Safoty Valve
DD445-S5103-122	A-20684	-	Assembly 2" Drum Pilot Valve
DD445-S5103-123	A-20685	-	Body, Disc 2" Drum Pilot Valve
DD445-S5103-124	A-20686	-	Spring Bonnet Tools 2" Drum Pilot Valve
DD445-S5103-125	A-20687	-	Assembly 2-1/2" Pilot Operated Valve
DD445-S5103-126	A-20688	-	Body, Disc 2-1/2" Pilot Operated Valve
DD445-S5103-127	A-20689	-	Spring Bonnet 2-1/2" Pilot Oparated Valve
DD445-S5103-128	A-20690	-	Lever Clamp 2-1/2" Pilot Operated Valve

Crane Co. Drawings

DD445-S5103-131	20279	-	600# Globe (Selinometer) 3/8"
DD445-S5103-133	20282	-	600# Angle (Bottom Blow-Off Valve) 1-1/2"
DD445-S5103-132	20281	-	600# Angle (Bottom Blow-Off Valve) 1-1/2"

Jerguson Gage & Valve Co. Drawings

DD445-S5103-142	E-145	-	10" Boiler Water Gage With Valves
DD445-S5103-143	E-146	-	18" Boiler Water Gage With Valves

Manning Maxwell & Moore Co. Drawings

DD445-S5103-139	C6-1056-AK	- Type-234-9" Therm. For Superh't'd Steam
DD445-S5103-134	R6-538-0	- Special 8-1/2" Mercury Therm. With Switch

Revised 8/5/59

MARINE STEAM GENERATOR - INSTRUCTIONS

Section I

REFERENCE DRAWINGS

YARNALL-WARING COMPANY DRAWINGS

Bureau of Ships Type "B" Plan Number	Manufacturer's Plan Number	Title
S-5103-455376		Yarway Remote Liquid Level Indicator Pressure Differential Indicator Across Superheater
S-5103-455377		Yarway Remote Water Level Indicator Instrument Assembly and Regulator Details

U. S. NAVAL SHIPYARD DRAWINGS

DD-472-S5103-659202	Arrg't. of Piping for Yarnall-Waring Superheater Protective Device on Foster-Wheeler Superheat Control Boiler (For No. 1 and No. 2 Boilers)
DD472-S5103-659203	Arrg't. of Piping for Yarnall-Waring Superheater Protective Device on Foster-Wheeler Superheat Control Boiler (For No. 3 and No. 4 Boilers)
Std. - S5103-H-1394281	Steam Flow Indicators, Installation of Settling Pots and Magnetic Plugs
DD445-S5101-306	Arrg't. of Inspection Ports & Lights in Boiler Front Casing
Std. - S5103-660644	Peep Hole Periscope for Detection of Fuel Oil Leakage into Boiler Casing
DD581-S5100-1589991	Piping Mods. Incidental to Modification of Guest Type Boilers
DD445-S5102-1590037	Superheat Control Boiler; Access Door to Rear Inner Casing
DD581-S5102-1590403	Modification to Inner Casing Panels, Superheater Side

MARINE STEAM GENERATOR - INSTRUCTIONS

Section II

STEAM GENERATOR - GENERAL DESCRIPTION

A. General Data

1. Type: Foster Wheeler Express Type with Integral Separately Fired Superheater - shown in Fig. #1, Page 9.
2. This generator includes: Boiler, Superheater, Economiser, Fuel Oil Burners, Spot Blowers.
3. Design Pressure - 634 lb. per sq. in. gage.
4. Steam Drum Pressure - 615 lb. per sq. in. gage at full power.
5. Operating Pressure - 565 lb. per sq. in. gage at Superheater Outlet.
6. Final Steam Temperature - 800°F.
7. Feed Water Temperature: Economizer Inlet - 245°F.
   Economizer Outlet - 373°F.
8. Furnace Volume: Boiler 310 Cu. Ft.
   Superheater - 247 Cu. Ft.
9. Economizer Outlet Gas Temperature - 519°F.
10. Capacity: 107,825 lb. superheated steam per hr.
    20,525 lb. saturated steam per hr.
11. Minimum Steam Flow through Superheater with Superheater firing - 9000 lb. steam per hr.
12. Fuel: Oil
13. Weight of Water in Unit (level at horizontal centerline of steam drum); at steaming temp. 10,756 lb.

MARINE STEAM GENERATOR - INSTRUCTIONS

Section II

GENERAL DESCRIPTION

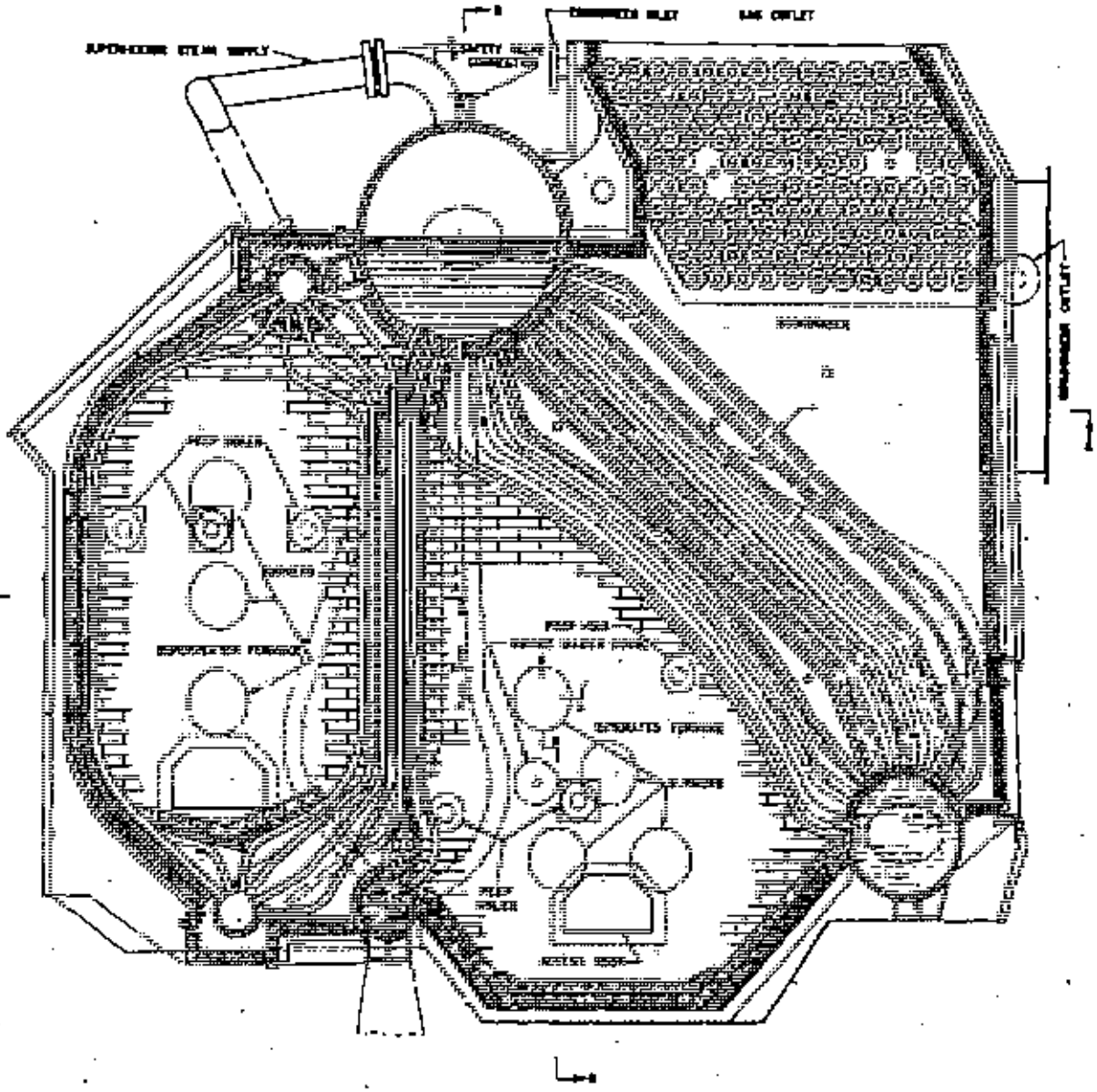


Figure 1. Cross section through steam generator showing boiler superheater, economizer and furnaces. Copied from Foster Wheeler drawing #NY-400-540.

FWB-514 Revised 7/10/48

Section II

GENERAL DESCRIPTION

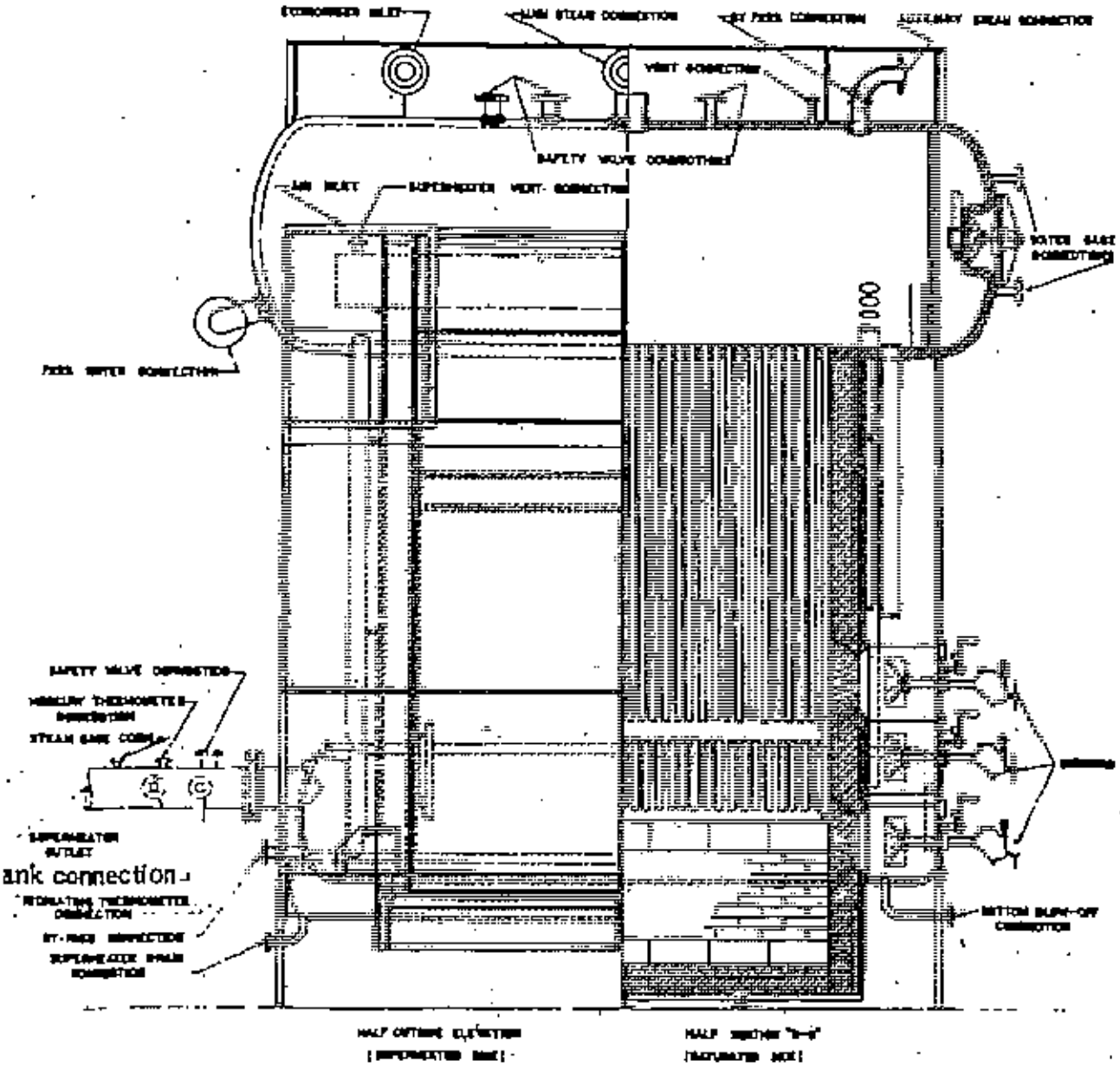


Figure 1a. Partial section and elevation parallel to drums. Copied from Foster Wheeler drawing #SY-400-541

MARINE STEAM GENERATOR - INSTRUCTIONS

Section II

GENERAL DESCRIPTION

The steam generator is an air encased, single uptake, divided furnace superheat control, express type boiler with radiant type superheater and extended surface economizer. See Figure 1, Page 9.

The furnaces is divided into two sections to provide the separately-fired superheater feature of this unit. The units are built to right and left hands. Referring to Figures 1, 1a, 2, and 3 of this book, showing a left hand unit, the side to the right of the water screen is designated as the saturated furnace (or side) and that to the left as the superheater furnace (or side). The unit has only a single gas outlet located over the saturated furnace. As installed aboard Ship Units No. 2 and 3 are left hand and Units No. 1 and 4 are right hand, or opposite hand to the figures shown.

BOILER The boiler of this unit consists of a large upper steam drum to which are connected, by a series of small diameter bent tubes, two lower water drums. The longitudinal axes of these drums are parallel and together with their connecting tubing form an inverted "V" in cross section. The space between the two tube banks forms the boiler furnace. The larger tube bank on the economizer side forms the major steam generating surface. This tube bank consists of three rows of 1½" o.d. and twenty-two rows of 1" o.d. generating tubes. The saturated side furnace is separated from the superheated side by a screen of superheater and generator tubes. The four rows of 1½" o.d. generating tubes in this bank partially screen the superheater from the boiler furnace. Joints between the drums and all tubes are made by expanding the tubes in the drums.

In order to provide adequate water circulation in the boiler, fourteen 4" o.d. downcomer tubes are expanded into the water space of the upper steam drum and the lower water drums (See Figure 2). Eight of these downcomers feed the economizer side tube bank and six the superheater side tube bank.

The upper drum is fitted with vent, main steam, auxiliary steam, safety valve, water gage, surface blow and feed connections as shown in Figure 3. Bottom blowdown connections are provided in the lower water drums.

One set of drum internals, as shown in Figure 4, consisting of dry pipe, surface blow pipe, steam baffles and feed pipe, is installed in the steam drum.

SUPERHEATER The superheater is of the separately fired radiant type and is located on the opposite side of the generator from the economizer. See Figure 1. The outboard side of the superheater furnace is made up of tangent 1½" o.d. tubes maintained between one lower and one upper header. These outboard tubes provide protection for the insulated casing panels directly behind them. The inboard side of the superheater is made up of four rows of 1½" o.d. tubes maintained between the upper and lower headers and staggered so as to permit the superheater furnace gases to pass over them into the saturated furnace via the four water screen rows of generating tubes. The inboard bank of superheater tubes also assist in screening the superheater from the boiler furnace.

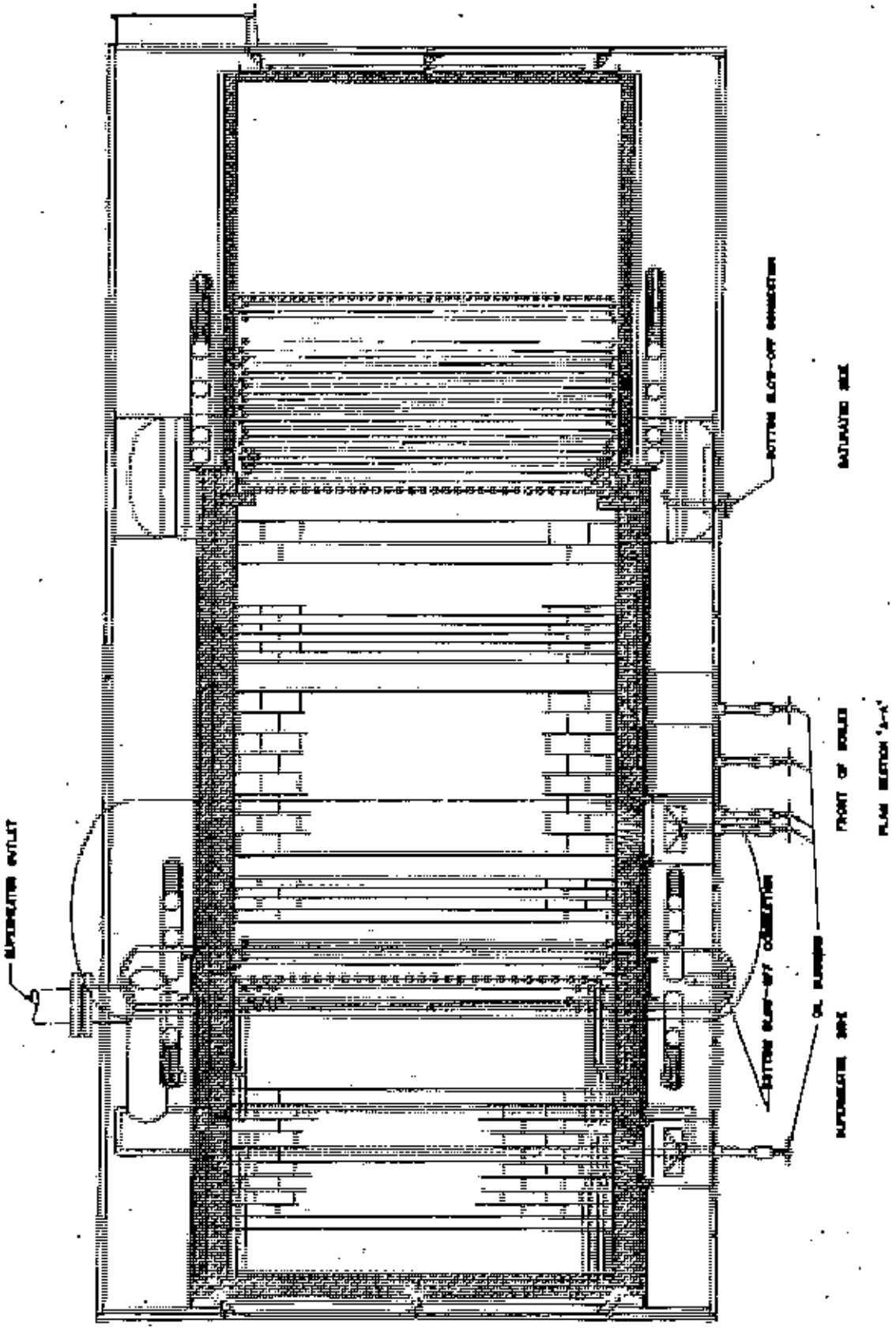


Figure 2. Sectional plan of steam generator copied from Foster Wheeler drawing #WT-400-543

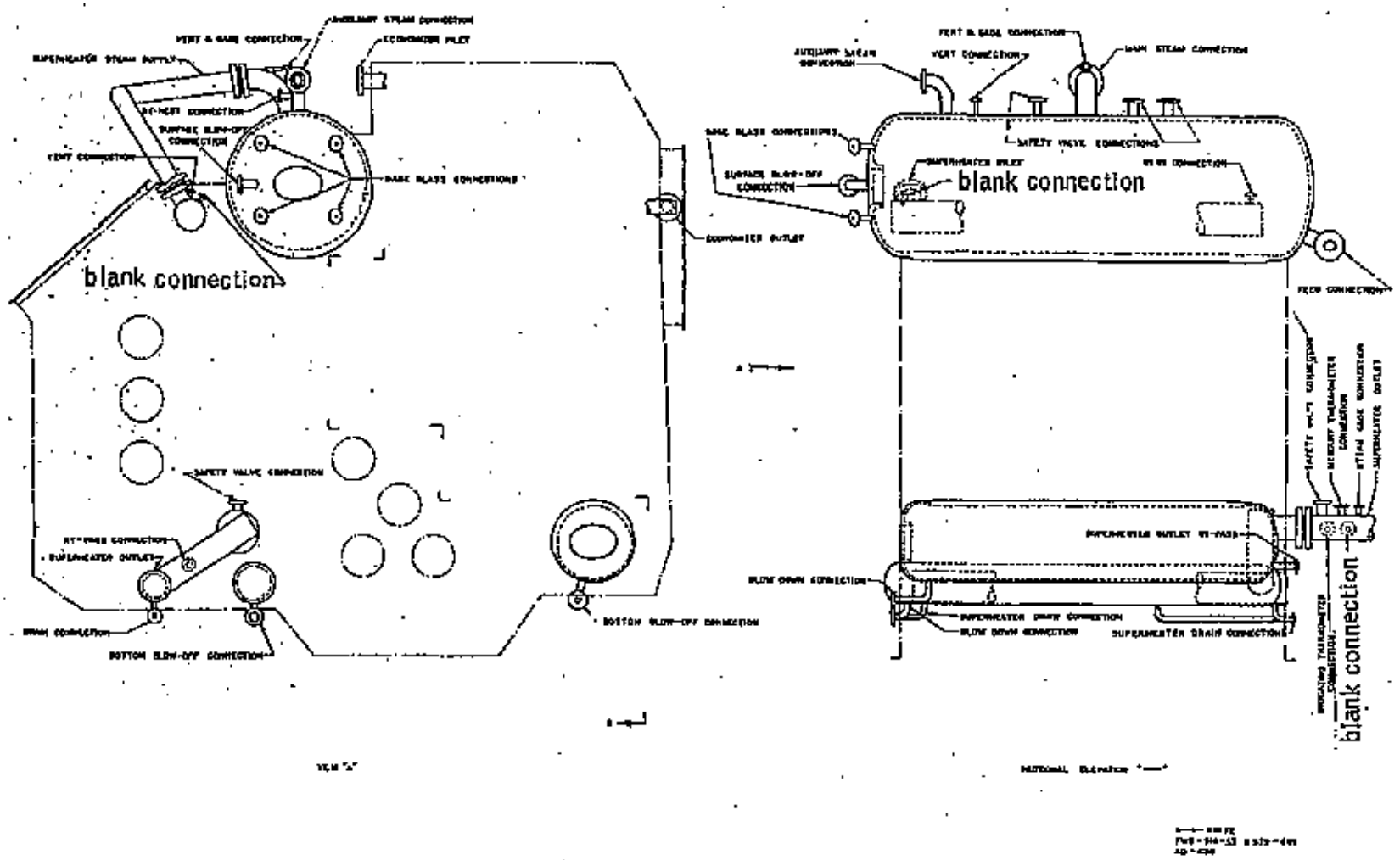


Figure 3. Steam generator arrangement showing nozzle connections. Copied from Foster Wheeler drawing #NY-400-544

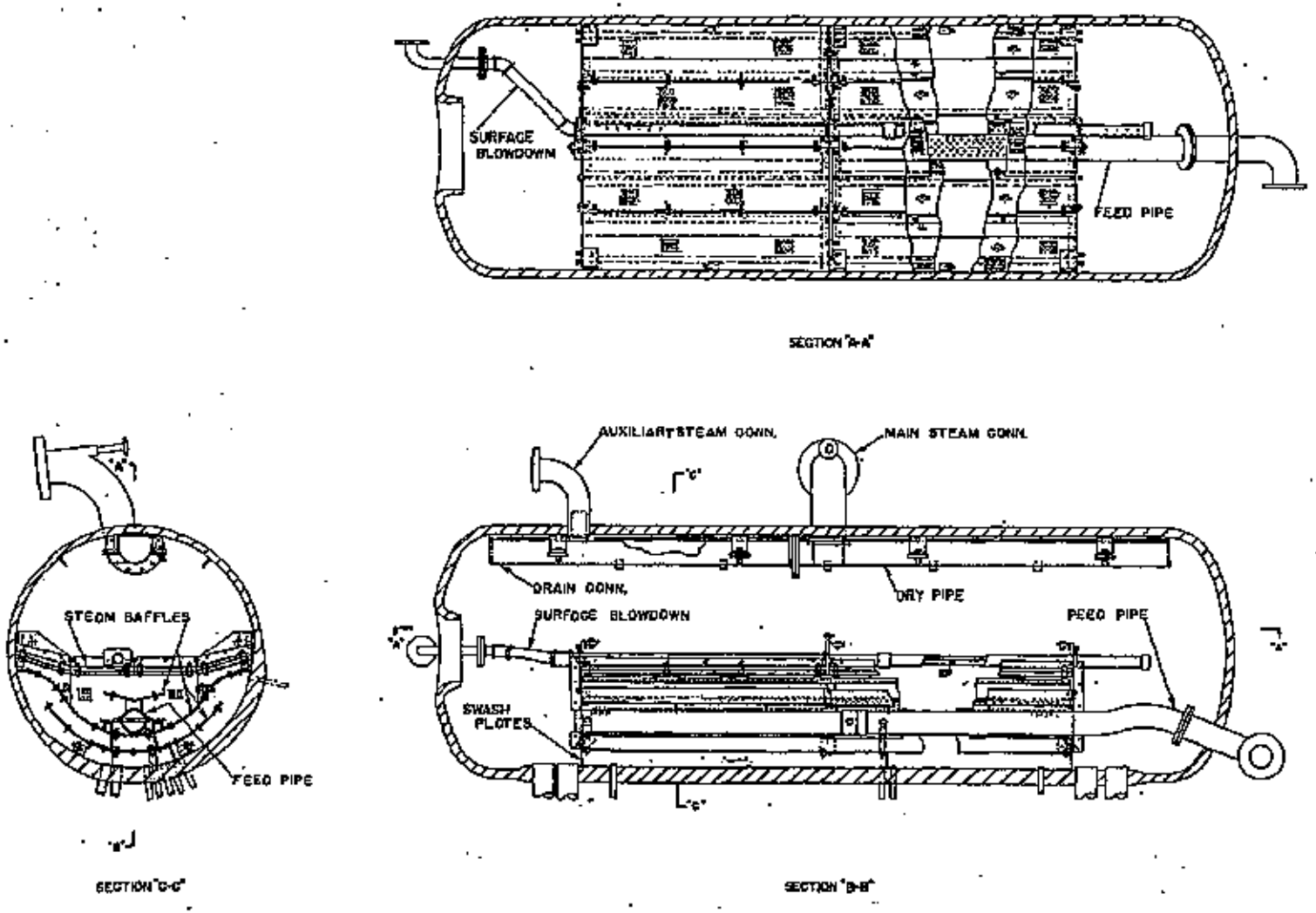


Figure 4. Sections through steam drum showing arrangement of drum internals.

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GENERAL DESCRIPTION

All superheater tubes are 18 chrome, 8 nickel, titanium stabilized alloy steel with the exception of those tubes in rows R3 and R4 which are 4-6 chrome, 1/2 moly, titanium, alloy steel. See Figure 2. There is butt welded to each end of the 18-8 tubes a 4-6 chrome tube end. These tube ends are necessary in order that tight rolled joints may be maintained after rolling the tubes into the 4-6 chrome headers.

The upper and lower headers which are 10-3/4" o.d. with a 1-1/4" wall are divided internally into three sections by the use of two diaphragms. See Figure 5. Saturated steam from the drum enters the front of the upper header in the first section. It then flows through the superheater in the following manner; from the first section of the upper header down through the first pass elements to the first section of the lower header; then up through the second pass elements to the second section of the upper header; then down through the third pass elements to the second section of the lower header; then up through the fourth pass elements to the third section of the upper header; then down through the fifth pass elements to the third section of the lower header, and then to the main steam line.

The upper header is provided with a vent connection. The lower header is provided with three drain connections, one for each section or pass, and a by-pass connection for by-passing steam back to the auxiliary steam outlet on the steam drum.

The superheater safety valve is an actuated valve operated from a pilot valve installed on the steam drum. See Section VII.

ECONOMIZER The economizer is of the counter flow extended surface type. It consists of a series of "U" shaped horizontal elements, supported by a front and rear support plate and connected at their ends with return headers. See Figures 7, 9, and 14. The longitudinal axes of the elements are parallel to the steam drum with the return headers located at the rear of the economizer.

Each element is made by forcing aluminum rings on 2" steel tubes to form the extended surface. The header ends of the element fit snugly into the rear support plate by means of a male and female joint. The opposite end, or element removal end, has a tube support plate with large holes to allow the elements to be removed. These holes are sealed by means of aluminum cup rings on the elements.

The feed water enters the upper header (See Figure 9) and flows in six paths progressively down through the economizer to the lower header. A vent valve is provided in the upper header and a drain valve in the connecting piping between the economizer outlet and the steam drum inlet.

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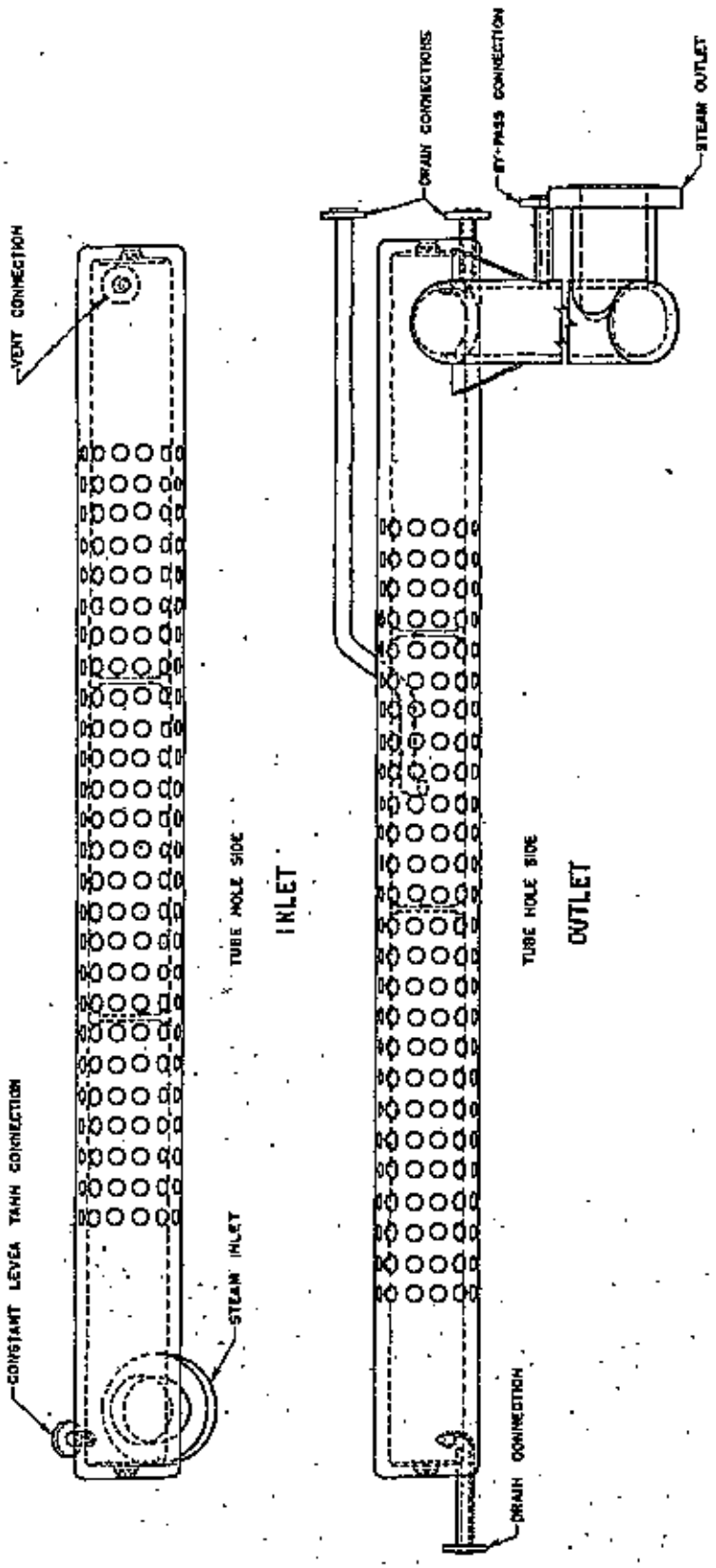
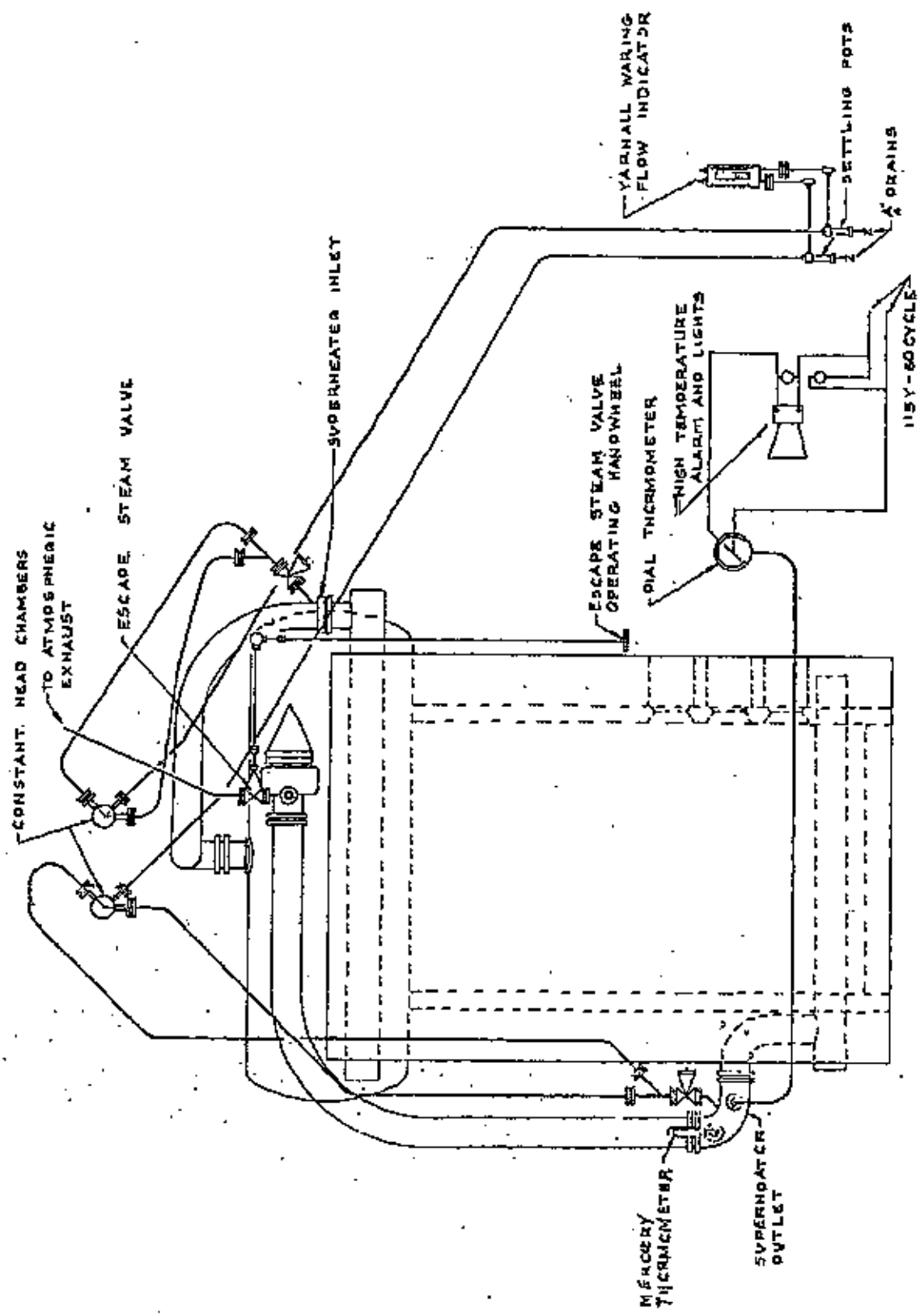


Figure 5. Superheater headers showing arrangement of diaphragms for directing steam flow. Copied from Foster Wheeler drawing #NY-400-579.

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SUPERHEATER FLOW INDICATOR AND ALARM SYSTEM

Figure 8.

MARINE STEAM GENERATOR - INSTRUCTIONS

Section II

GENERAL DESCRIPTION

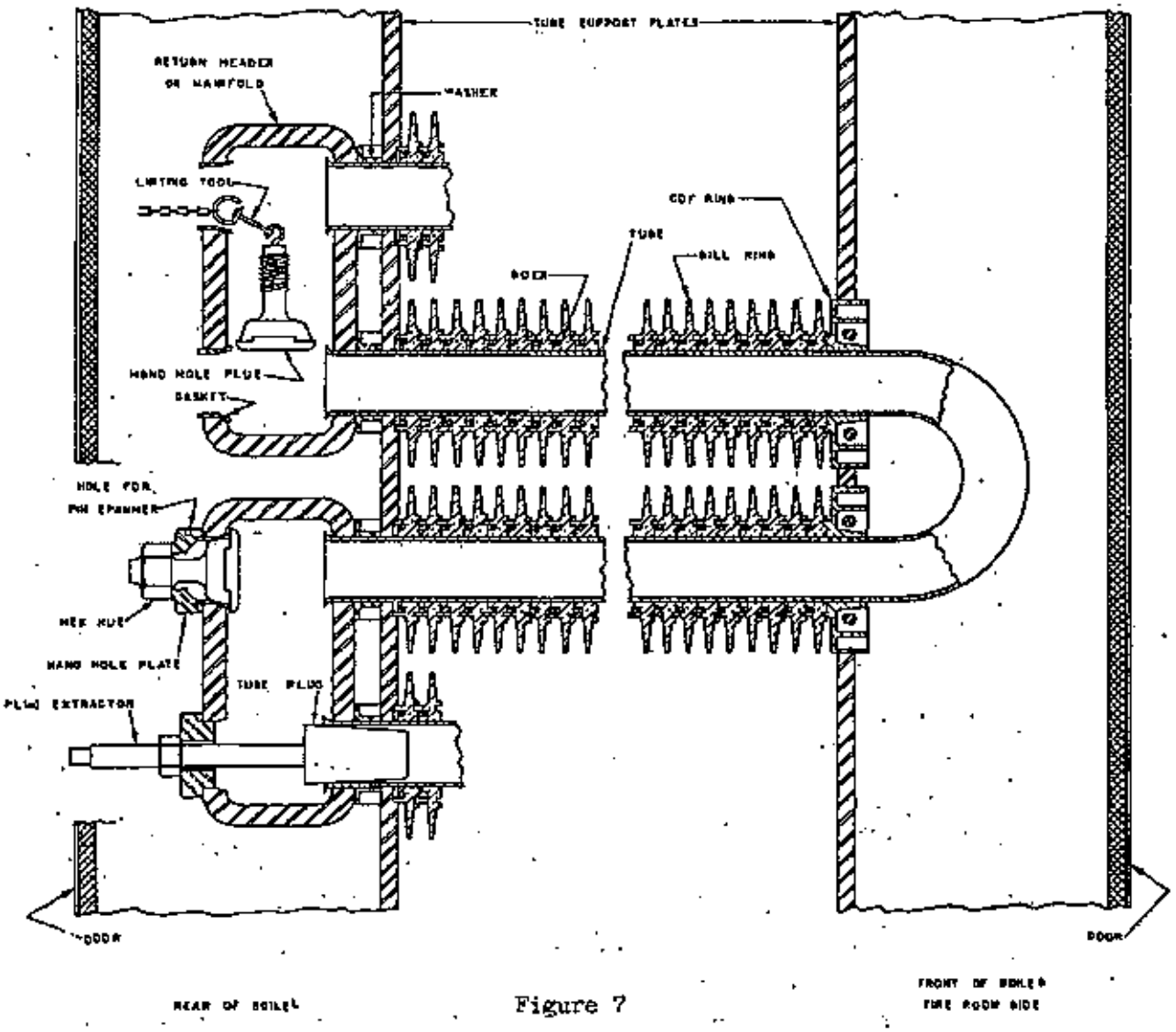
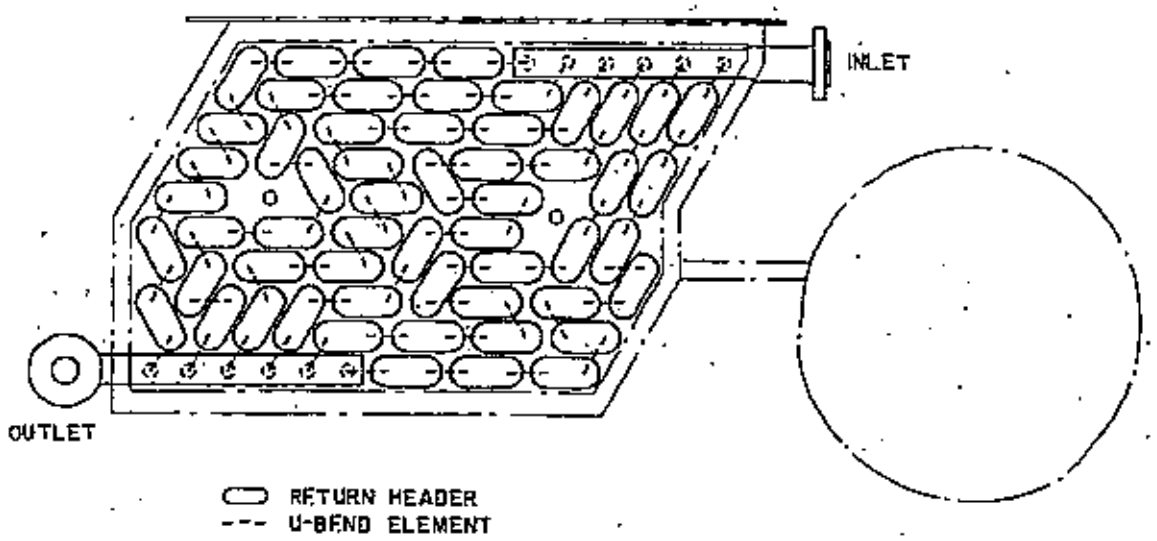
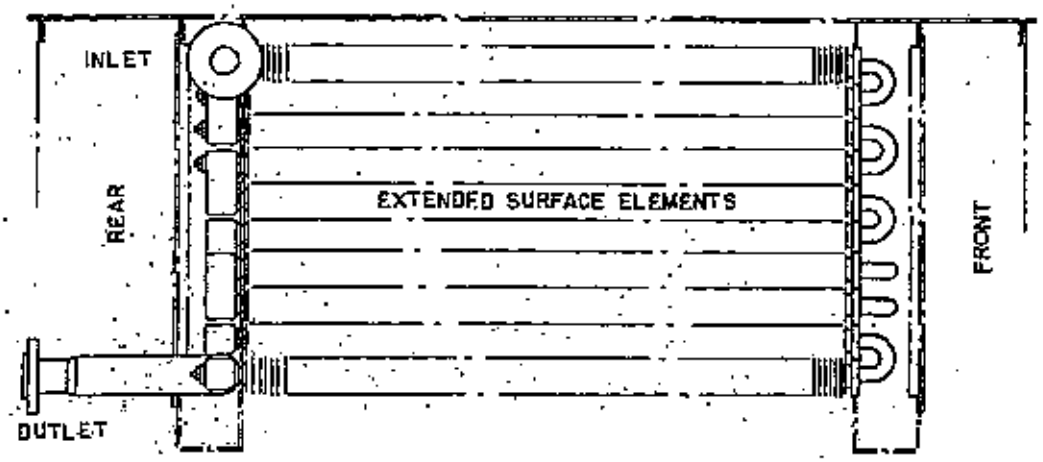


Figure 7

SECTION THROUGH ECONOMIZER
PARALLEL WITH U-BEND





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Figure 9. Sections through economizer. Copied from Foster Wheeler drawing #NY-400-599.

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GENERAL DESCRIPTION

STEAM GENERATOR The entire generator is encased in a corrosion resisting steel casing which forms the outside wall of an air chamber surrounding the boiler setting. Combustion air is admitted to this chamber and passes across the relatively hot setting walls in its passage to the oil burner air inlets. The products of combustion formed in the superheater furnace flow across the larger superheater and small boiler tube banks into the boiler furnace where they mingle with the gaseous products formed there and flow across the larger boiler tube bank and economizer to the breaching.

Four air encased type fuel oil burners fire the boiler and three the superheater. A description of these burners is found in Section V.

Soot blower elements are provided to clean the exterior surfaces of the boiler and economizer tubes. Description of these blowers will be found in Section VI.

MARINE STEAM GENERATOR - INSTRUCTIONS

Section III

OPERATING INSTRUCTIONS

GENERAL PREPARATION

A. Drying Out the Setting:

Brickwork settings in new units (or those in which a considerable part of the setting has been repaired or replaced) should be dried out in accordance with the procedure specified in the Bureau of Ships Manual, Chapter 51.

B. Boiling Out:

Before operation a unit which has been laid up or undergone extensive repairs should be boiled out with an alkali solution for the purpose of removing the preservatives in the tubes and the lubricants used in expanding and balling of the tubes. The method to be followed is outlined in the Bureau of Ships Manual, Chapter 51.

C. Inspection:

The combustion chamber and gas passages should be inspected to see that they are clean and in good repair. Internal pressure parts should be clean and should be examined prior to closing up the unit to insure that all foreign articles have been removed. Refer to Chapter 51 of Bureau of Ships Manual for details regarding boiler inspections.

PREPARATION FOR LIGHTING OFF

A. General:

1. The smoke pipe cover should be removed.

2. Auxiliary equipment, including the feed pump, fuel oil pump, fuel oil heater forced draft fan, steam gages and water gages should be checked to assure that they are operating properly in accordance with the manufacturer's instructions.

3. Make a systematic check to see that all valves connected with boiler operation are correctly set.

a. Valves for the following should be closed; main and auxiliary steam stop valves; blowoff and drain valves; steam gage drains; water gage drains; valves in the burner lines and economizer vent.

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OPERATING INSTRUCTIONS

b. Valves in the following should be open: Steam gage lines; water gages; steam drum vent and superheater vent and drains to the bilges.

c. Ease up the main and auxiliary stop valve stems without lifting the valve discs off the seats, so as to prevent sticking when the valves heat up. Examine the hand gear of the safety valves and operate it so far as can be done without lifting the valves.

B. Filling the Boiler:

Fill boiler with best available feedwater (preferebly 0.3 grains total solids per gal. or less) through auxiliary feed line until water appears in the lower gage glass. Continue until water raises one inch. Change over to main feed line, and fill to 3" in lower glass. This procedure checks both feed lines. The water should be distilled and deaerated, and not more than 100°F above or below the temperature of the drum metal at the time of filling.

C. Oil Burner:

1. Clean the atomizer assemblies, making sure that all passages, and particularly the ports in the nozzle body (97) are free of protective grease coatings or other foreign materials. Clean the sprayer plates and install them in the atomizers, making sure that the burner tip and other joints are pulled up evenly. Do not use steel instruments for cleaning; do not use stillson wrenches or a hammer in making up the joints.

2. Close the burner root valve at the oil header, and the burner atomizer valve at the burner, for each burner.

3. Thoroughly purge the furnace and gas passages of any combustible gases by opening all registers wide and bringing the air pressure to about 5 in. wg.

LIGHTING THE BURNER: Heat and circulate oil until it has been raised to the proper temperature and pressure in the oil manifold (approximately 250 PSI). The air registers on all burners should be closed, on both the saturated and superheater sides of the boiler; the air pressure in the double front should be at a relatively low value. The oil burners should be lit off in the proper sequence. An atomizer fitted with a small capacity sprayer plate, Size 5020F, should be inserted in Burner Number 1 under the saturated side. The air registers of this burner should then be opened and a lighted torch introduced through the Lighting-Off Hole, so that the flame will be in line with the oil spray. Gradually open the valve in the oil line to the burner until ignition

takes place. (If not within five (5) seconds secure oil valve and ventilate furnace before trying again). The burner door should then be suddenly closed for an instant, after which it can be regulated to maintain ignition and to secure optimum regulation (sudden closing and opening of the register air doors assists in securing complete ignition of the oil).

Firemen should be cautioned not to open the burner quick-closing valve until they can see the lighted torch through the burner sight glass. Tests have shown that the most effective torch end for this work is tightly wrapped asbestos, 10" long and from 1-1/4" to 1-1/2" in diameter. If made more than 1-1/2" in diameter the torch fills the tube and will become extinguished almost immediately. The proper burner settings and adjustments, should be closely adhered to. Burner barrels when not in operation should be immediately removed from the burner in order to minimize oil leakage from the secured burner barrel. Burner throats and refractory opening rings should be periodically inspected through burner sight holes for carbon formation while the boiler is steaming. With optimum combination of sprayer plate size, atomizer withdrawal, and register opening, however, there should be no carbon in the furnaces but a slight amount may be found on the diffusers with otherwise clean burners. Carbon deposits are usually formed by clogged sprayer plates, incorrect atomizer position, or improper register door settings. If carbon is formed, it should be removed immediately either by mechanical means or by securing the register and using another burner to maintain the load while the carbon on the faulty unit burns off. The normal air leakage through the idle burner in conjunction with the heat of the furnace will usually burn away the carbon in a short time. The normal burner combination should then be resumed.

When steam is formed, close air cocks. Add another 502CF Sprayer Plate in Burner Number 2 on the saturated side, lighting-off this burner and proceeding to raise the steam pressure. UNDER NO CONDITIONS SHALL BURNERS BE LIGHTED-OFF ON THE SUPERHEATER SIDE UNTIL THE BOILER IS CUT IN ON THE LINE. Ordinarily, steam should not be raised too suddenly in a boiler because large temperature changes in a furnace may crack and loosen the brickwork and cause unnecessary strain in other parts of the installation. Bring unit up to pressure with the two burners under the saturated side in use and proceed to cut the boiler in on the line.

OPERATION Since this is a superheat control boiler, steam from the auxiliaries is taken directly from the steam drum when main steam stops are closed. While operating in this manner, the valve in the by-pass line between the superheater outlet and the auxiliary steam line should be open. Registers in the superheater furnace should be kept tightly closed in order to keep condensation in the superheater to a minimum. Superheater drains have adequate capacity for handling condensate formed under these minimum conditions. Maximum firing rates shall not exceed 2290 Lbs. of oil per hour with main steam

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stops closed. This corresponds to a generating capacity of 35,000 Lb. of steam per hour. There is no "port use" operating condition anticipated which would require such a steam load.

When underway and the boiler main stop is opened the valve in the by-pass line from superheater outlet to auxiliary steam line shall be closed. Additional burners as required are to be lighted through the lighting-off tube. Do not light-off from hot brickwork. Use the same size sprayer plate for oil burners in operation at one time and light-off in proper sequence.

A. Operation with Superheater:

NEVER PERMIT THE SUPERHEATER TO BE FIRED UNTIL A FLOW OF 9,000 LBS. PER HOUR IS ESTABLISHED. This corresponds to a Ship's speed of 13 knots with two boiler split plant operation and 17 Knots with four boiler split plant operation. Because of heat absorption by the superheater from convection and radiation from the saturated furnace a light superheat of approximately 15° will be attained (507° Total Temperature) but superheater drains should remain cracked open to insure delivery of dry steam to the steam main.

Be sure that thermal alarm and superheater flow indicator are both in good working condition. Thermal alarm is to sound at 810°F and flow indicator will indicate in red zone when less than 9,000 Lbs. of steam per hour is flowing through superheater.

To Light-Off burners on the superheater side, use proper size sprayer plate and re-circulate oil in the manifold until it is at correct atomizing temperature and pressure. Open register of burner to be lighted. Then pass a lighted torch, through the special lighting-off tube, into the furnace and hold so that the flame from it will be in line with the oil spray. Gradually open the valve in the oil line to the burner until ignition takes place. (If not within five (5) seconds secure oil valve and ventilate furnace before trying again) then regulate air register. Some difficulty may be experienced by inadequately trained personnel in Lighting-Off superheater burners under high air pressures. However, the "air lock" lighting-off tube can be readily operated after a little practice.

The superheater furnace should not be purged with fresh air prior to lighting of superheater furnace. Purging is undesirable since it is likely to cause condensation in the superheater. When burners in the saturated side are in operation the air registers of all burners on the superheated side should be checked to insure they are in the closed position. The valve in the by-pass line from the superheater outlet to the auxiliary steam line should be open at all times when the auxiliary steam line only is in use,

and closed when the boiler main stop is opened. Superheat temperature shall be raised or lowered gradually at a rate not to exceed 50° every five minutes. THE MAXIMUM STEAM TEMPERATURE PERMITTED IS 800°F AT THE SUPERHEATER OUTLET.

Additional burners as required are to be lighted through the lighting-off tube. DO NOT LIGHT-OFF FROM HOT BRICKWORK. Use the same size sprayer plate for all burners in operation at one time and light-off in the proper sequence, from bottom burner up and cut out burners in the reverse order. At steady steaming ahead conditions steam temperature should be at approximately 800°F in order to attain maximum efficiency. When maneuvering with radical speed changes maintain superheat at approximately 700°F. For astern operation maintain superheat at 700°F.

The correct temperature (800°F) cannot be maintained over a range of steaming rates when using similar sprayer plates at similar fuel oil pressures on the two sides of the boiler. Firing rates per furnace are dissimilar at all loads, therefore in order to maintain the 800°F superheat temperature different fuel pressures in each furnace are normally required. A constant steam temperature can be satisfactorily maintained by using unequal oil pressures and similar or dissimilar sprayer plates. The sprayer plates used on each individual side should be similar.

The Ship's Service Generators should always be operated on the main steam line underway. This maintains a definite flow through the superheater should demand on the main plant reduce rapidly. If insufficient flow is indicated on the flow indicator or temperature rises beyond 800°F provide artificial flow by opening the escape steam valve and discharging steam to the atmospheric exhaust. This valve is remotely controlled by an extension stem and is operable at the boiler front. Authorized settings of flow indicators and thermal alarm must be carefully maintained. Watch the superheat temperatures closely at both the mercury and distant reading thermometers.

Because the subject steam generator is a superheat control unit with separately fired radiant type superheater the manner of operation varies somewhat from that of the conventional steam generator for the following reasons:

1. Saturated steam for the auxiliaries can be taken directly from the steam drum with no flow through the superheater.

2. The superheater being of radiant type has a greater rate of heat transfer thru the superheater tube walls than in the convection type and therefore the tube wall temperature is much higher than in the convection type superheaters. For this reason the radiant superheater tubes are made of the special materials (18 Chrome, 8 Nickel Titanium Stabilized Alloy Steel) to better withstand these temperatures.

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3. The 18 Chrome, 8 Nickel Alloy of the superheater tubes suffers deterioration at high temperatures in the presence of chlorides (this is especially true at the joint between the 18-8 Alloy and the 4-6 Chrome Tube Ends). For this reason carry over of moisture, especially that of high chloride concentration must be kept at a minimum. The steam drum internals are adequate for this purpose providing water levels and feed water treatment methods are adequately maintained.

4. This type of superheater is more sensitive than the convection type and superbest temperatures vary with firing conditions, thus at a given fuel oil rate either increased air or reduction of feed water temperatures will increase superheat temperatures.

If the superheater furnace is not being fired, the unit functions as the older conventional express type Naval boiler and presents no unique problems. Firing the superheater in conjunction with the saturated furnace burners requires the close coordination of the fuel to both furnaces, since both steam pressure and temperature must be maintained constant. The firing rates in either furnace will affect both temperature and pressure. Water tending on this boiler is not difficult, even at the highest steaming rates. Firemen, with a little practice, can easily handle this type generator when these facts and the general construction of the boiler have been made clear to them. However, variations in superheat temperature can be very pronounced and rapid when firemen are lax. Although this boiler is equipped with a high temperature thermal alarm, set to sound a horn at 810°F., firemen should be instructed and trained while on watch to be constantly alert and to keep the superheater outlet thermometer always in view, adjusting superheater oil flow to maintain constant temperature, and to follow changes in the firing rate in the saturated side furnace. Experience obtained in the operation of superheat control boilers with radiant type superheater shows quick response to varying load conditions, and that with a well instructed personnel, no operating difficulties need be experienced. There is a definite relationship between the firing rates in these two furnaces for constant superheat temperature.

In the operation of this type of steam generator, superheater temperature swings should be kept at a minimum. Cutting burners in and out under steady steaming conditions is not only uneconomical, but will result in large changes in superheat temperature which tend to set up thermal stresses in the superheater. With the proper number and size of atomizers, steam flow variation for a considerable range can be made by regulation of manifold oil pressures.

An Instruction Plate listing essential instructions for superheater operation is mounted at the operating station for each steam generator.

Under ordinary conditions, the saturated steam load should be divided among all the boilers in use. BEFORE ANY BOILER IS CUT IN ON THE MAIN STEAM LINE, IT SHOULD FIRST BE CUT IN ON THE SATURATED STEAM LINE: IN ADDITION, ANY

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COMBINATION OF BOILERS CONNECTED TO A COMMON MAIN STEAM LINE MUST ALSO BE CONNECTED TO A COMMON AUXILIARY STEAM LINE. For instance, if two boilers in the same firerooms are both furnishing steam to the same main steam line, the valve in the auxiliary steam line between these two boilers must be open; similarly, if the cross-connection in the main steam line between the port and starboard engines is open, the corresponding cross-connection in the auxiliary steam line must be open. Otherwise, an increase in the saturated steam load on one boiler (or group of boilers, as the case may be), without a corresponding increase in the firing rate on the saturated side of the boiler(s) concerned, will cause a drop in drum pressure, and may cause stagnation or reversal of flow through the superheaters of those boilers with consequent overheating of the superheaters. If operation is to be conducted with cross-connections open, the cross-connection in the auxiliary steam line should be opened before the cross-connection in the main steam line is opened.

B. Fuel Oil:

The fuel oil pressures carried at the manifold should not be less than 200 nor more than 300 Lbs. per Sq. Inch. When the fuel oil burners are in operation, the valves between the fuel oil manifold and the individual burners should always be in wide open position. Load fluctuations should be met within allowable pressures in so far as possible by adjustment of the fuel oil burner manifold regulating valve provided for that purpose, NOT by throttling valves in the branch connections between the manifold and individual burners and, preferably, NOT by suddenly cutting-in and cutting-out burners (because operation in this manner will not only cause wide variations in superheater outlet temperature, but constitutes an uneconomical operating method). Adjust air pressures, register air doors, and atomizer settings in the boilers to the optimum positions for operating conditions at various powers. It is to be borne in mind that the relative firing rates on the two sides of the boiler will vary with the quantity of saturated steam furnished from the steam drum to auxiliaries.

Any change in firing rate will also necessitate a change in air pressure. An increase in air pressure should always precede an increase in firing rate, and decrease in air pressure follow a reduction in firing rate. The air introduced into the furnace should be at all times sufficient to produce the best combustion conditions.

After a boiler is on the line and steaming steadily, the positions of air doors and diffusers should be checked for uniformity throughout all of the burners in service. If all burners are not needed, the atomizers should be removed from the burners not in use to prevent carbonization of oil in the tips of the atomizers, and the diffuser assembly pulled out as far as possible, to prevent damage by heat radiated from the brickwork. After the burners have been adjusted as outlined in the foregoing, the air pressure to the burners should be

adjusted so as to give a very faint trace of smoke from the top of the stack. It is assumed that while burners were being cut in, an excess air pressure was carried, to prevent smoke during the building-up process. The air pressure should be lowered to a point where a trace of smoke is visible in the smoke indicators, after which the air pressure should be raised a trifle, so that this slight appearance of smoke in the indicators disappears.

When building up to speed, atomizers should not be installed in the registers until their use is actually required.

At no time, except under emergency or maneuvering conditions, should an atomizer be left in place unless it is actually in use. This precaution, as well as that given in the preceding item, will prevent possible carbon deposition in sprayer-plate slots, with attendant reduction of burner capacity. As soon as an atomizer fails to give a perfectly uniform spray and shows streaks of oil, it should be replaced by a clean atomizer assembly. The atomizer should be dismantled and assembled with the wrenches and bracket furnished with the burners.

Double front fires are usually caused by the accumulation of oil at this location. Oil may accumulate over a period of time by leakage when atomizers are secured and not removed from the burners. Oil may also run into the front from a carbonized refractory opening ring or throat. The oil spray strikes the carbon in its path and runs down through the register and on the front plate to the double front bottom. A spark or ignited torch drippings may then ignite it. The drain spouts from the drip pans below the register must be kept open in order that oil may drain into the furnace. Double front fires can best be prevented by a continuous and careful watch and correct burner settings.

C. Feed Water:

As previously mentioned it is extremely important that carryover of moisture from the boiler into the superheater be kept to a minimum. The perforated screen type baffling employed in the steam drum has been tested extensively. Results of these tests have proven that with 31 grains per gallon contamination (15 e.p.m.) and water level 3" above normal (8" in gage glass) the moisture carryover was 0.32% at overload firing rate. At a firing rate of 72% full power (92,000 Lbs. steam per Hour) 68 grains per gallon contamination (25 e.p.m.) and 8" in gage glass the moisture carryover was 0.39%. At overload rate, water level normal (5" in gage glass) and 33 grains per gallon contamination the moisture carryover was less than 0.25%. These results illustrate the necessity of carrying water in the steam drum at the proper levels and for maintaining feed water of the proper purity. The visible center of the 10 inch water gage marks the normal working water level.

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The Bureau of Ships Manual - Chapter 56 Articles 56-11 through 56-60 covers the Principles of Boiler Feed Water Treatment thoroughly and these principles should be followed assidnously. The proper equipment for introduction of U. S. Navy Standard boiler compound has been installed on this vessel.

D. Furnaces:

Furnaces should be periodically inspected and particular attention paid to brickwork so that the inner casings and burner front plate will not be exposed by cracks to high furnace temperatures or furnace gases.

E. Economizer:

The type of economizer used on the subject boiler has undergone extensive tests and has been used successfully afloat. A number of cases of burning one or two gill rings from the lowest tubes has occurred. Tests have demonstrated that these gill rings will not burn off if water is flowing through the tubes and the gill rings are in metal-to-metal contact with the "U" tubes. Opinion is that these rings were lost because of localized burning of the soot accumulated on the gill rings, when there was no water flow. This condition is believed to take place at low rates and port loads. The tendency for the economizer to steam-bind the longest water paths is likely only at these rates. Sparks from the furnace, which are inherent at low rates per burner, and high quantities of excess air might cause torching of the carbon and melting of the gill rings. At low rates, the water tender may almost close the feed checks for appreciable periods, thus increasing the tendency to form steam in the economizer tubes. In consideration of these facts, water should be supplied to this unit continuously and uniformly. If it is necessary to almost close the checks, the level in the steam drum should be allowed to drop slightly lower than normal steaming level before again opening checks in order that the economizer may be "stabilized" by a momentary higher rate of flow. The checks should be closed slowly to the approximately correct opening and care taken that they are never closed completely.

F. Soot Blowers:

When soot blowers are being used, the air pressure should be increased sufficiently to overcome the pressure effect produced by the soot blower. Soot blowers should be blown in a definite sequence. This sequence is as follows: (See Figure 35) 7, 6, 5, 1, 2, 3, 4, 5, 7, 6.

G. Blowdown:

Amount and frequency of boiler blowdown is ordinarily determined from analysis of the boiler water. When it becomes necessary to resort to the use

of either bottom or surface blow valves, attention is called to the fact that these valves, in addition to the regular boiler surface and bottom blow valves, also incorporate guarding valves in the blow-down system. The guarding valves are located in the common blow-down line from each boiler between the boiler blow-down valves and the overboard discharge valve. The function of the guarding valve is to give additional insurance against leakage of water from boiler.

To blow-down a boiler it will, therefore, first be necessary to open the guarding valve and then the boiler blow-down valves; the overboard discharge valve, of course, being handled in accordance with usual practice. The reverse procedure is to be followed in handling the valves when the blow-down operation has been completed.

H. Securing a Unit:

If the boiler has been operating at a relatively high rate, it will be desirable to vary the order of securing the burners on the two sides until only one burner on the superheater side, and two on the saturated side remain in service. These remaining burners should then be secured as quickly as possible, the one on the superheater side to come off first. The main steam stop valve should then be closed to stop the flow of saturated steam through the superheater and main steam piping. The boiler should be allowed to vent steam, which may be generated after burners are secured, through the auxiliary steam line. After the generation of steam has ceased, the auxiliary steam line valve may be closed.

When burners are secured, the atomizers should be removed and impellers withdrawn as far as possible. The atomizers removed should be immediately disassembled and cleaned and the sprayer plates that are removed should be put in a kerosene oil bath to soak. This will greatly facilitate removal of any carbon particles, that may have lodged in the sprayer plate slots.

When the pressure on the boiler has dropped to that on the high pressure drain system, close the superheater drain connections to the high pressure drain system and open the drains to the bilges sufficiently to keep the headers clear of condensate.

After steam pressure is off the unit and if it is to be kept out of service for any appreciable length of time, it should be filled with water made sufficiently alkaline to prevent the possibility of corrosion. A boiler not in use should not be allowed to stand partially filled with water for long periods. If it is expected that the boiler will be out of service for more than a day, fill the boiler, economizer and superheater with feed water to give protection against corrosion. Care should be taken to see that the boiler is completely filled by building up 20 to 30 Lbs. pressure and venting at high points. Make sure that leaking valves do not permit loss of water and introduction of air into the boiler.

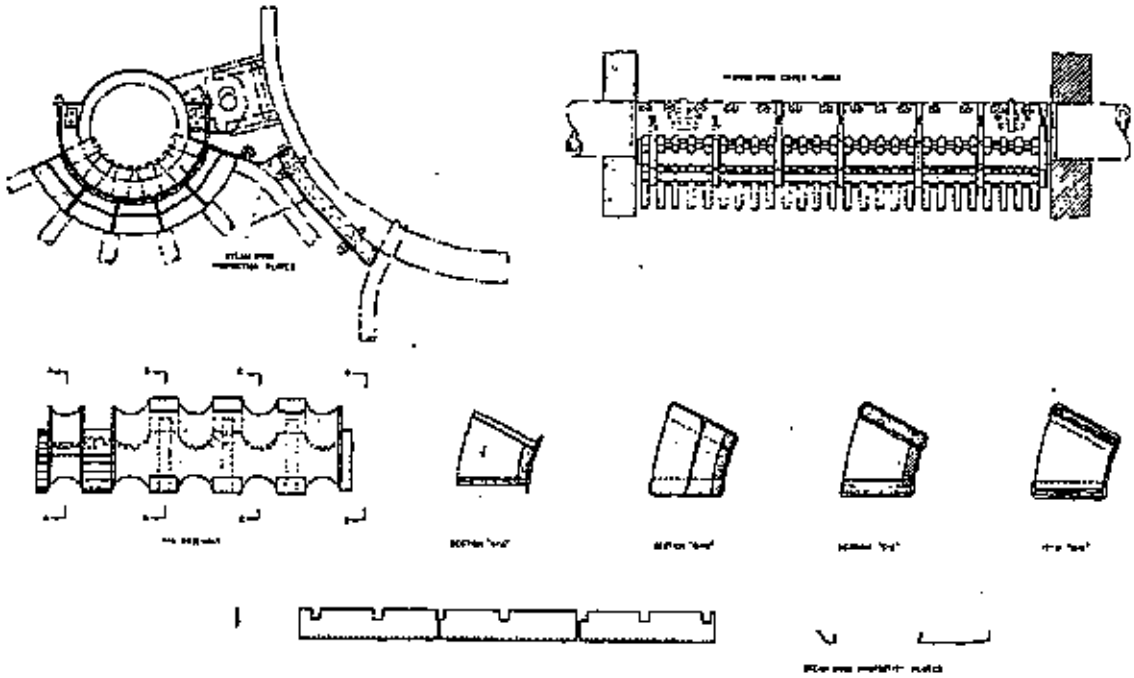


Figure 11. Superheater Header Protection Plates. Copied from Foster Wheeler drawing #NY-400-584.

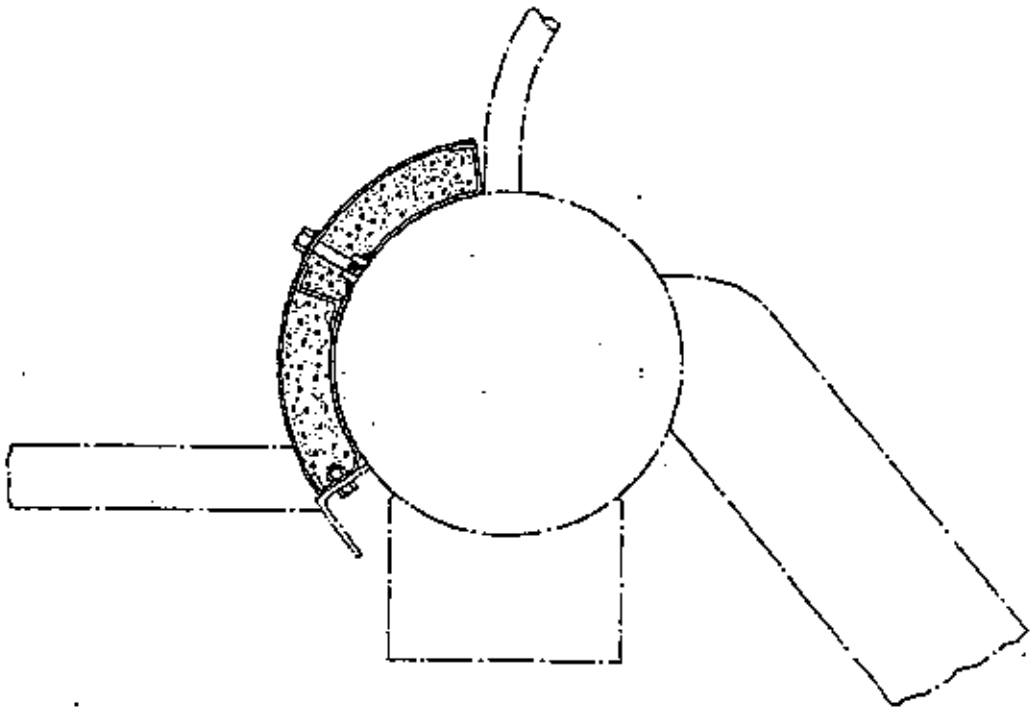


Figure 12. Lower drum protection plates. Copied from Foster Wheeler drawing #NY-400-583

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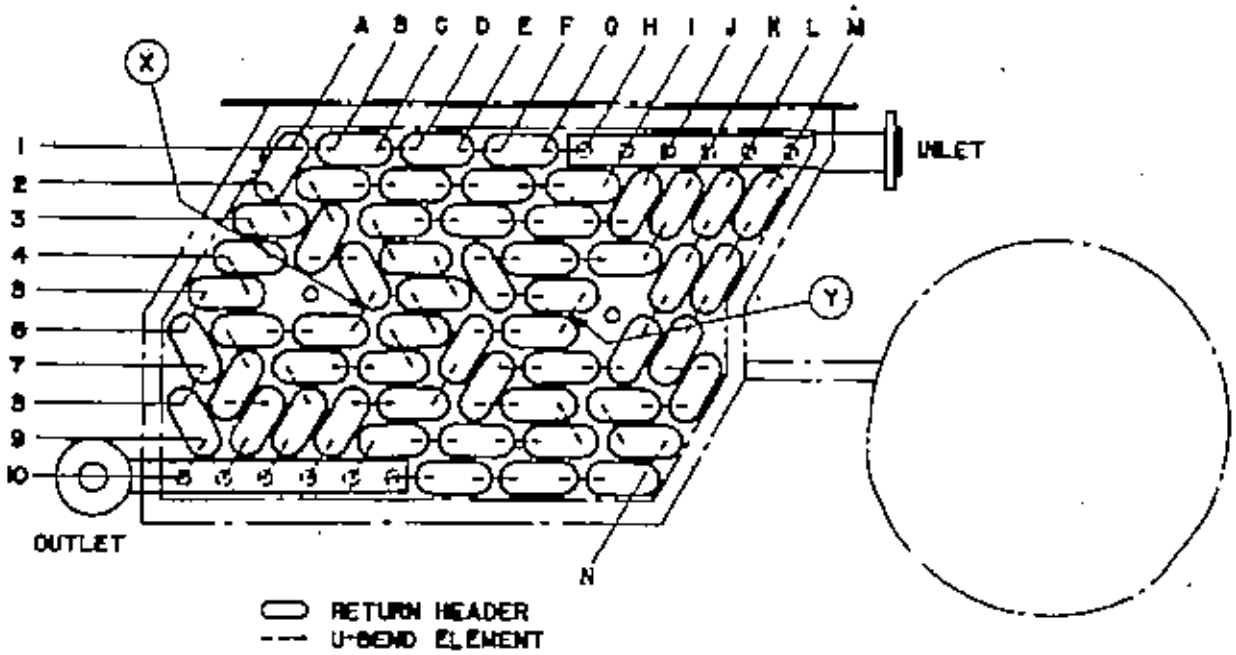


Figure 13: Flow Diagram of Economiser. Rear elevation of economiser showing return headers.

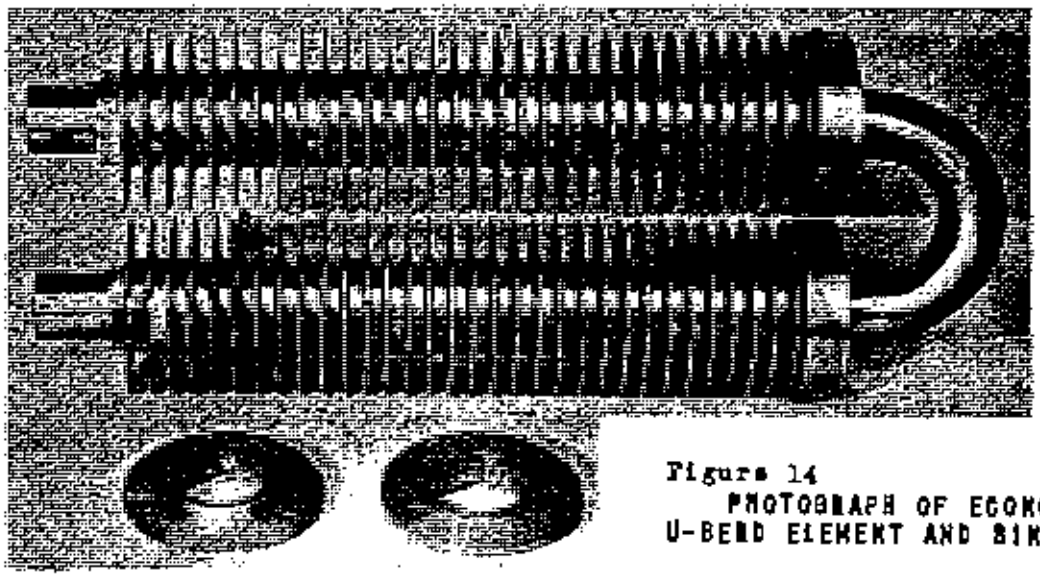


Figure 14
PHOTOGRAPH OF ECONOMISER
U-BEND ELEMENT AND SINGLE AIRGS

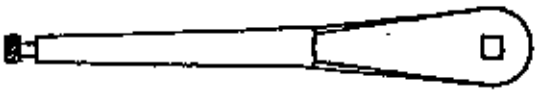


Fig. 15
REVERSIBLE RACHET WRENCH

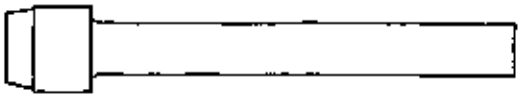


Figure 16. TUBE ORIVER

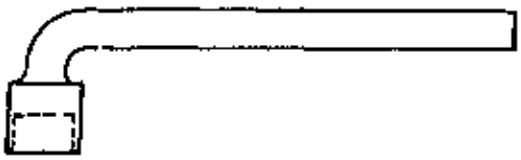


Figure 17. OFFSET SOCKET WRENCH

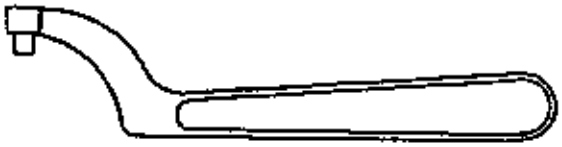


Figure 18. PIN SPANNER

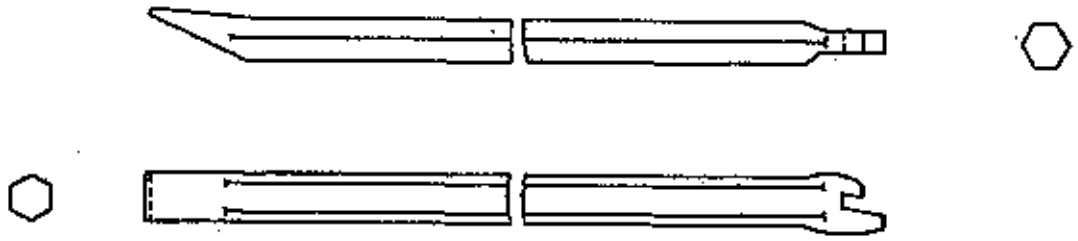


Figure 19. CRINPING TOOL

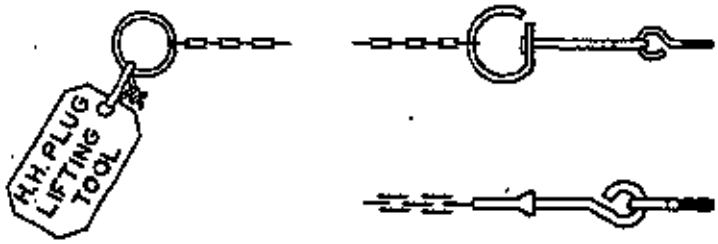


Figure 20. HAND HOLE PLUG
LIFTING TOOL

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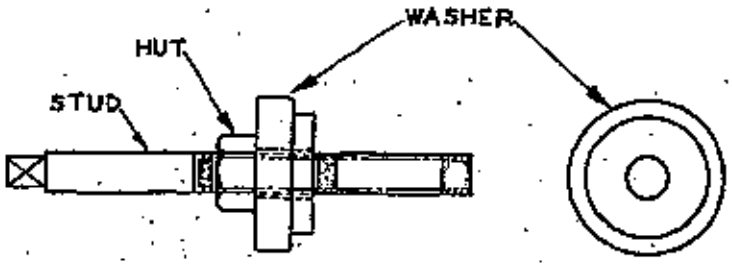


Figure 21. TUBE PLUG EXTRACTOR

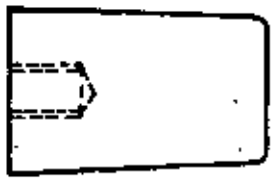


Figure 22. TUBE PLUG

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MARINE STEAM GENERATOR - INSTRUCTIONS

Section IV

CARE AND MAINTENANCE

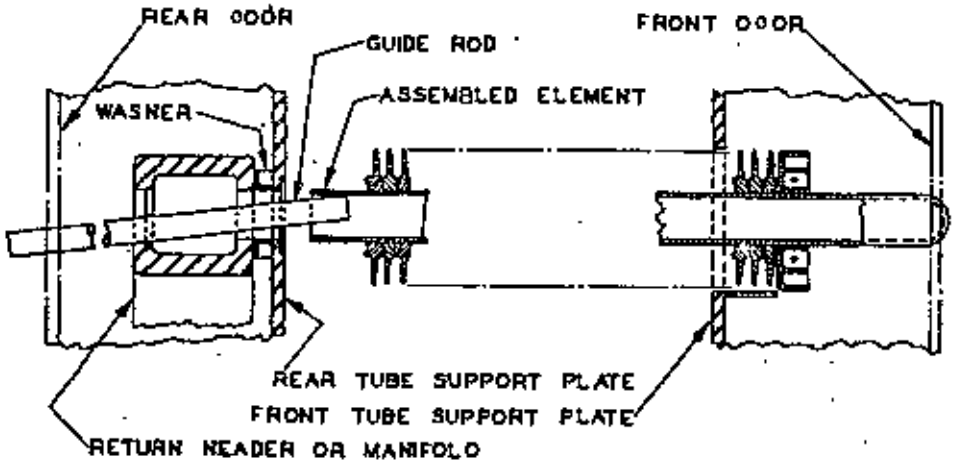


Figure 23. INSTALLATION OF ECONOMIZER ELEMENT

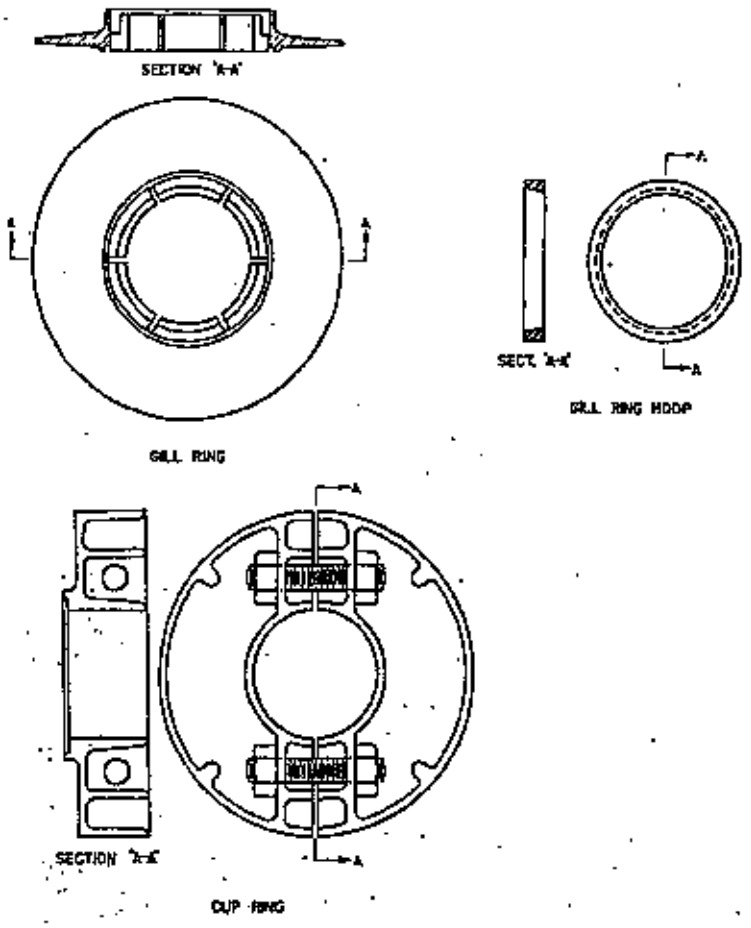


Figure 25. DETAILS OF ECONOMIZER RINGS

MARINE STEAM GENERATOR - INSTRUCTIONS

Section IV

CARE AND MAINTENANCE
ECONOMIZER

1. Removing Hand Hole Plugs (Fig. 7, Page 18).

For inspection and cleaning, remove headhole plug without gasket. Remove nut and plate and tap plug end. If, in tapping plug, gasket moves, flare gasket slightly on outside to retain it. To push plug clear of hole without removing gasket, use hook on headhole plug lifting tool, Fig. 20, Page 27.

2. Installing Hand Hole Plugs (Fig. 7, Page 18).

Insert plug through its own handhole without gasket engaging arms on short axis of plug. Insert gasket, retaining square edge on outside of header and assemble plate and nut, completing the unit in place. Take up on nut, retaining plate against header, using pin spanner wrench (Fig. 18, Page 27(on plate to keep it from rotating with nut. Hand tightening with 12-1/2" socket wrench, (Fig. 17, Page 27(, is sufficient to make the plug assembly tight.

3. Applying Tube Plugs (Fig. 7, Page 18).

To take any element out of service, take the entire stream affected out of service. Plug the stream affected in top manifold and in bottom manifold, viz: For failure of element (x(in Fig. 13, Page 26, place plug at I, row 1, and at D, row 10, etc. The tube plug and tube plug extractor are shown in Figs. 21 and 22, Page 27.

4. Removing Economizer Element.

Remove front and rear economizer doors. Remove handhole plug and gasket assembly. Refer to Fig. 13, Page 26 which illustrates handhole plugs to be removed for access to respective elements, viz: To remove element (x(remove pluge E-5 and E-6. To remove element (y(remove plugs J-5 and J-6. Crimp the bell of tube with crimping tool shown in detail Fig. 19, Page 27. Apply the tube driver on both legs of the element to be removed pulling the element on the fire room side. (Weight of element 150 lb.(. The return header and washer will become detached from the element. These parts are used again in replacement of new element.

MARINE STEAM GENERATOR - INSTRUCTIONS

Section IV

CARE AND MAINTENANCE

5. Replacing Economizer Element (Fig. 23, Page 28).

Clean tube end to be rolled, also tube seat in header or manifold. Insert the element from front of boiler, guiding the end of element will facilitate entering the header in rear tube support plate. Hold the U-bend end so that projection of end ring will seat tightly into recess in rear support plate. Reinstall washer and wedge return header or manifold against rear support plate until the joints are expanded. The element is thus fixed at rear of economizer and expansion will take place at U-bend end.

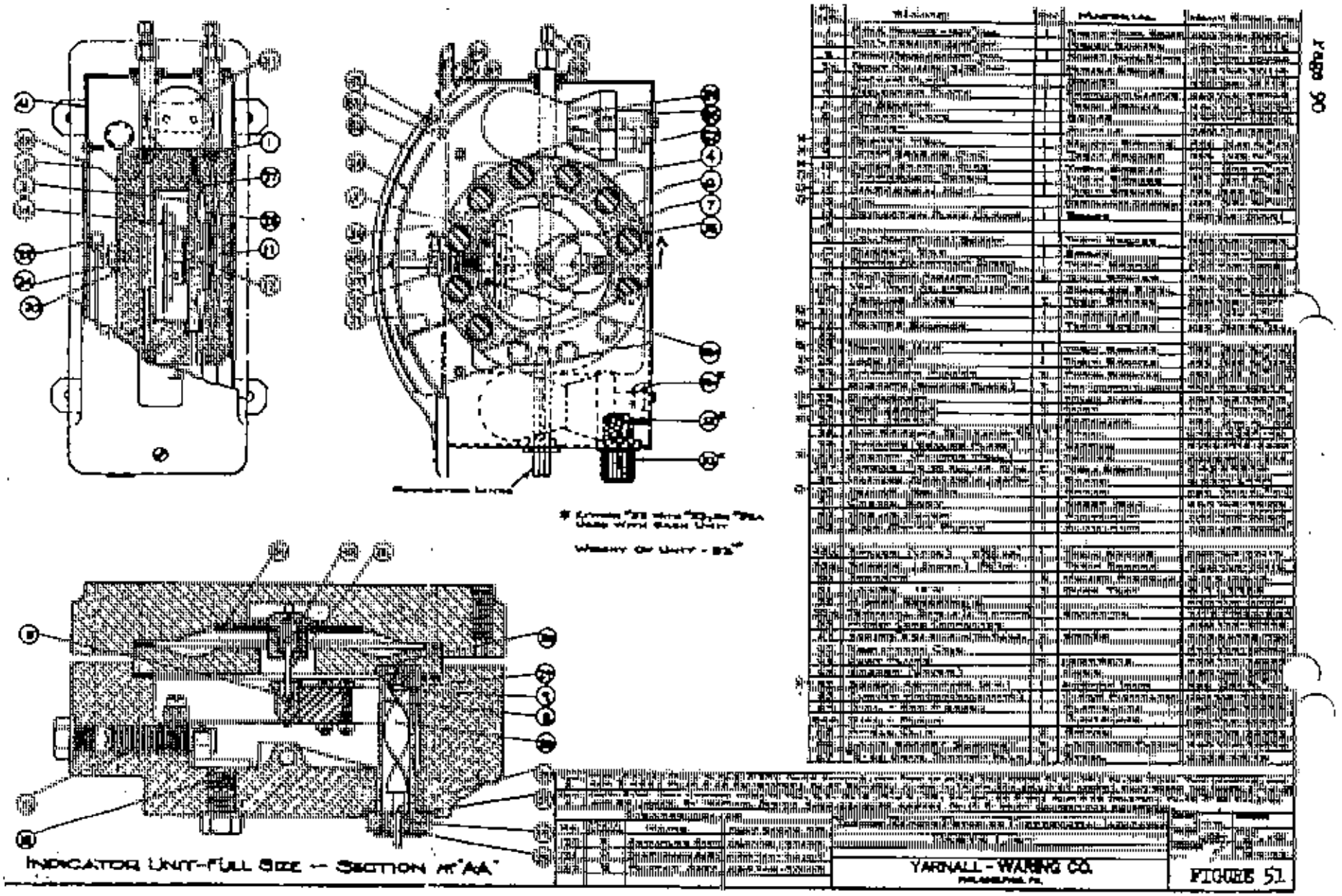
6. Economizer Vent Valves must be opened when filling the boiler and economizer with water until the water reaches the level of these vent valves.

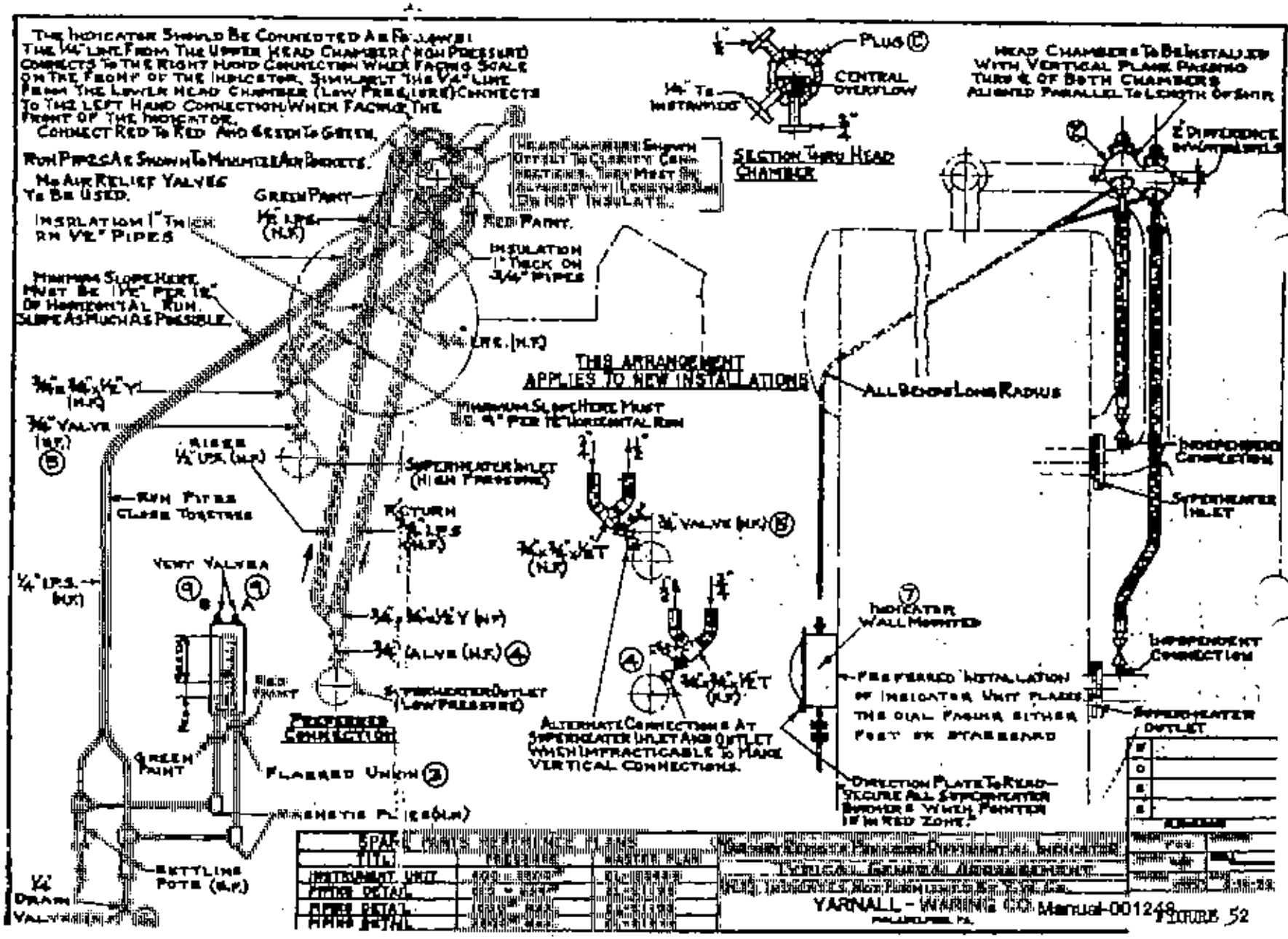
7. Economizer Drain Valves should not be used as blow down valves. The water velocity through Foster Wheeler economizers is such that there is no recirculation and, therefore, no increase in concentration of water passing through the economizer. Consequently, there is no need for blowing down the economizer.

8. Internal surface of the economizer should be inspected occasionally and, if necessary, any accumulation of mud or scale removed. The frequency for internal cleaning is dependent on the condition of the feed water and may be indicated by an increase in water pressure drop or a decrease in water temperature rise through the economizer.

9. The Casing of the economizers should be maintained gas tight and well insulated.

Revised 9/10/41


INDICATOR UNIT-FULL SIZE -- SECTION AT "AA"
YARNALL - WARING CO.
FIGURE 51



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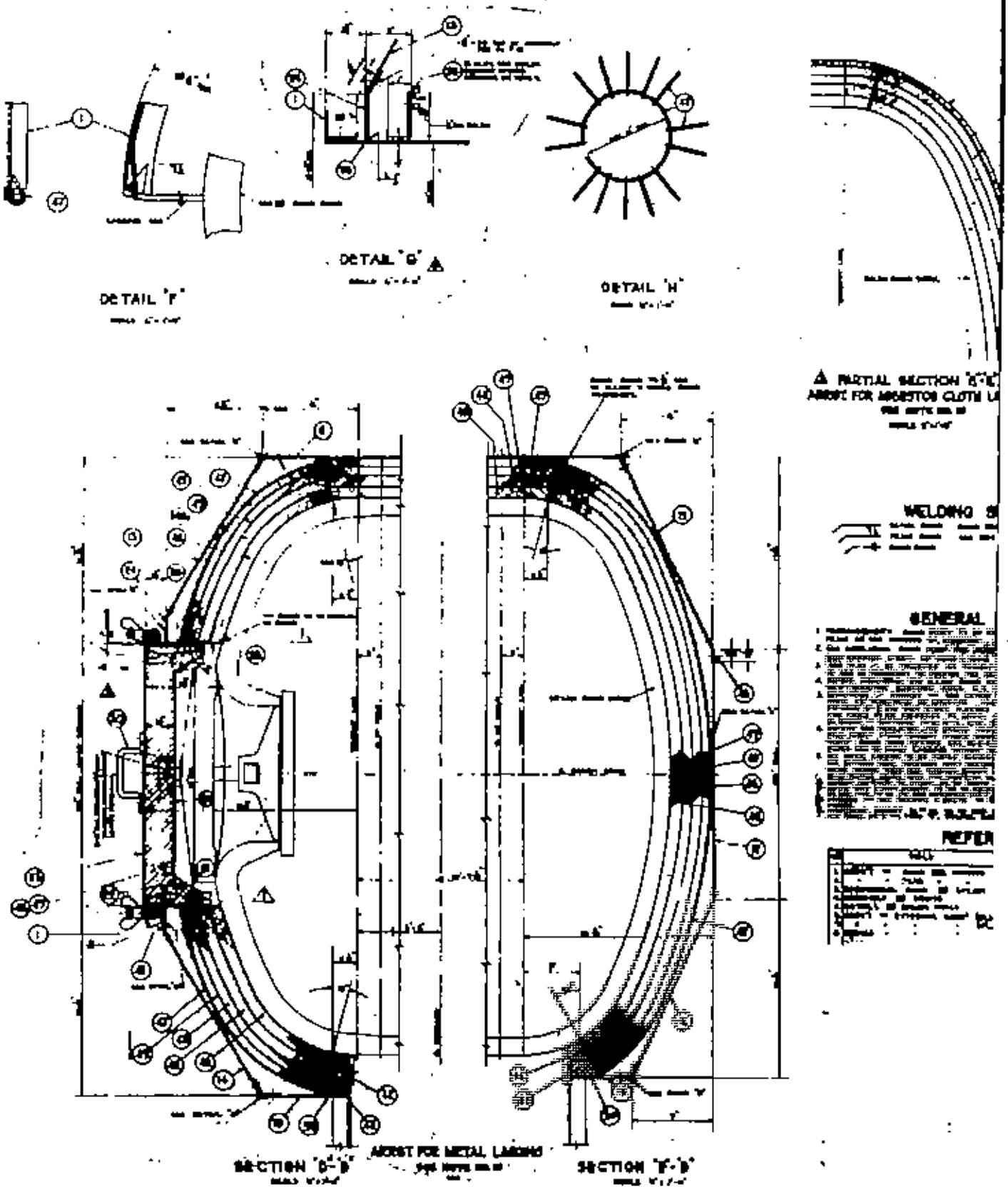
FIGURE 52

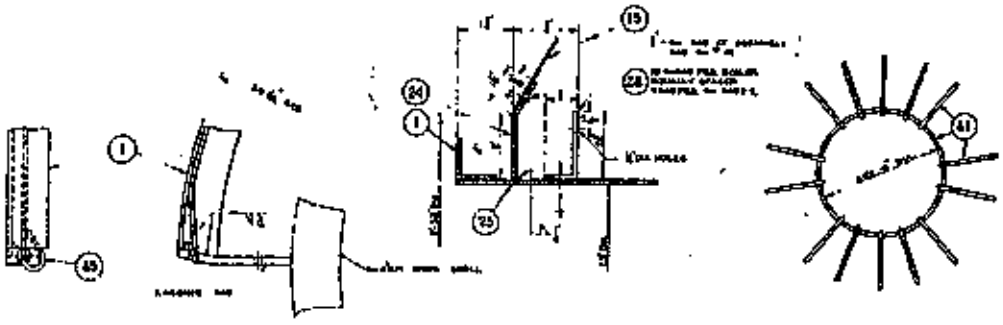
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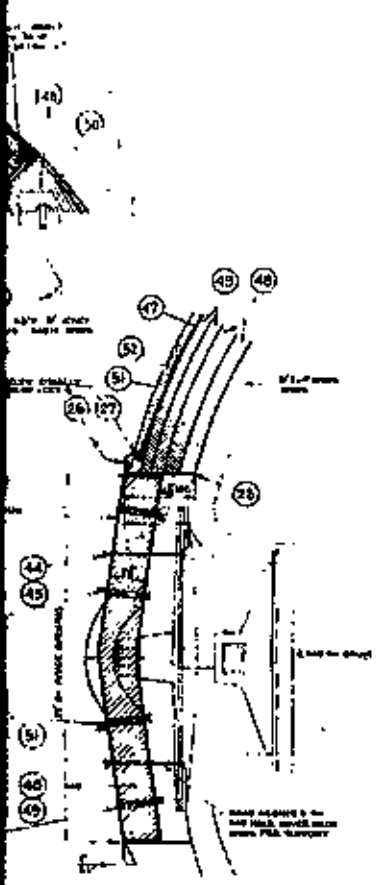

DETAIL 'F'
DETAIL 'G'
DETAIL 'H'
SECTION 'E-E'
SECTION 'F-F'



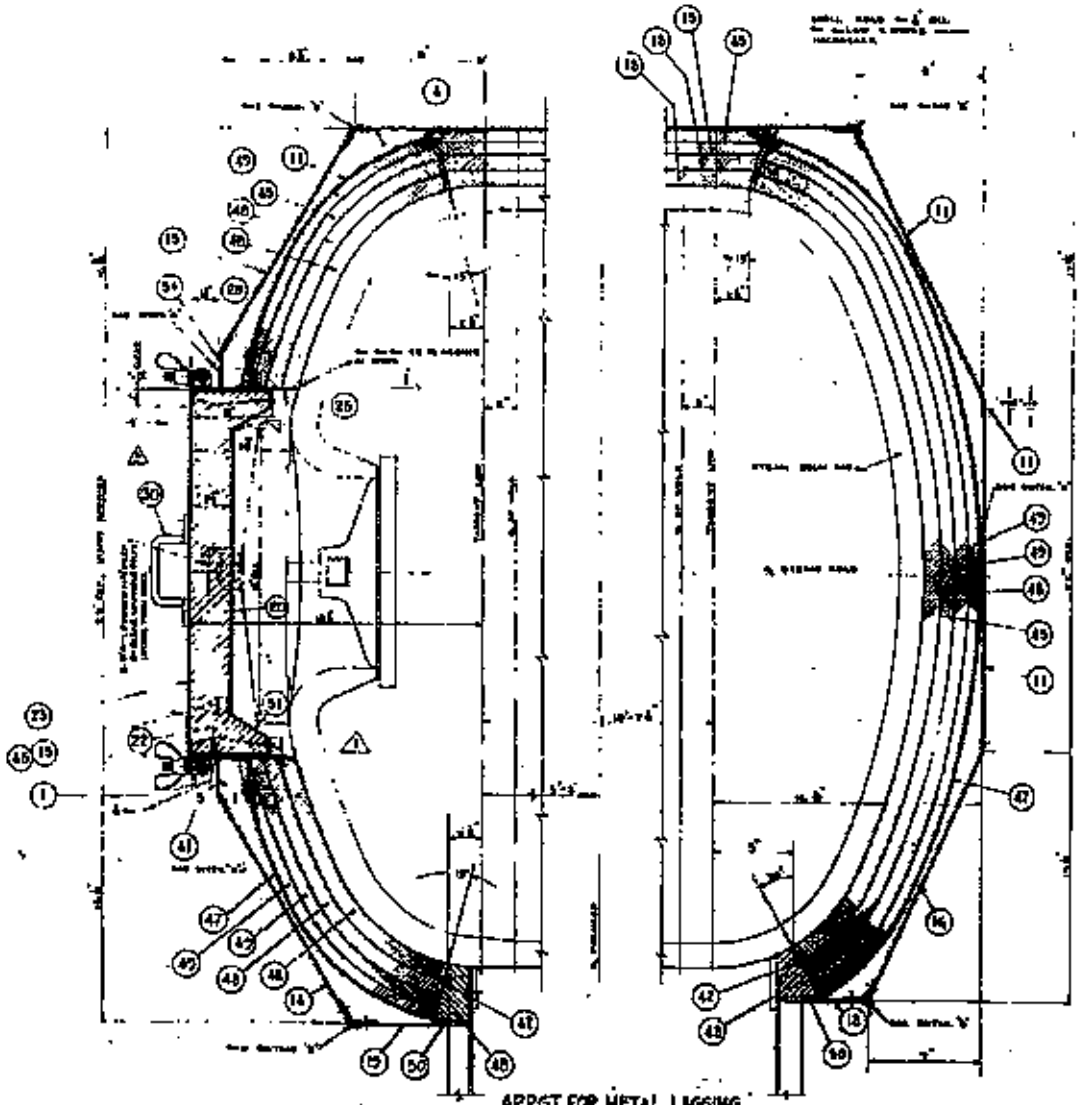
DETAIL "F"

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DETAIL "H"



⚠ PARTIAL SECTION "D"-"D"
ARREST FOR ASBESTOS CLOTH LAGGING
SEE NOTE No. 19



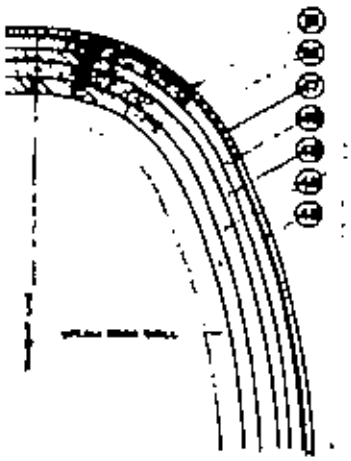
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ARREST FOR METAL LAGGING
SEE NOTE NO. 19

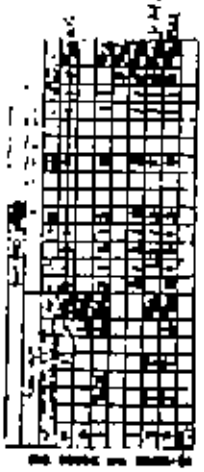
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LIST OF MATERIAL

QUANTITIES FOR ONE SHIP



PARTIAL SECTION 'E-E'
SHOT FOR ASBESTOS CLOTH LAGGING



WELDING SYMBOLS

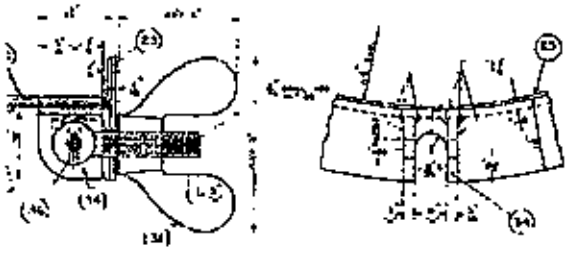
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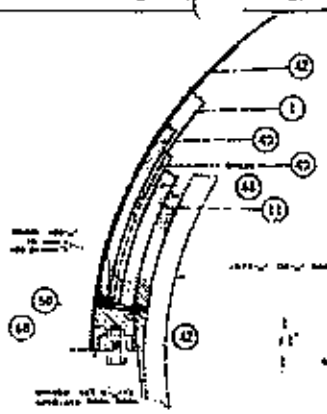
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YARD,
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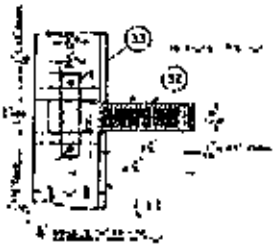
INSULATION & LAGGING
FOR
BOILER STEAM DRUM.

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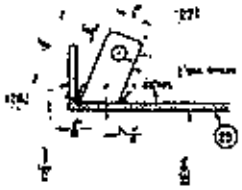




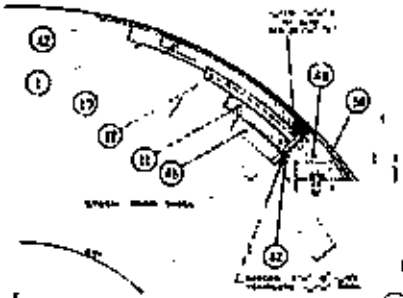
SECTION 'A-A'



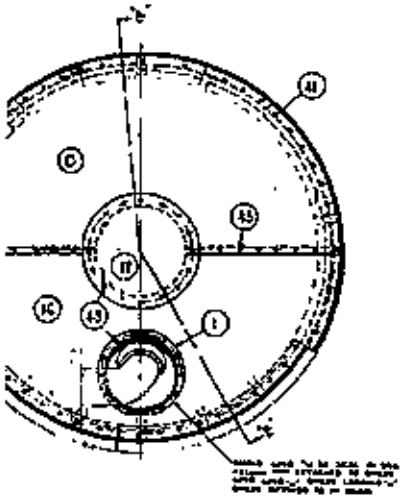
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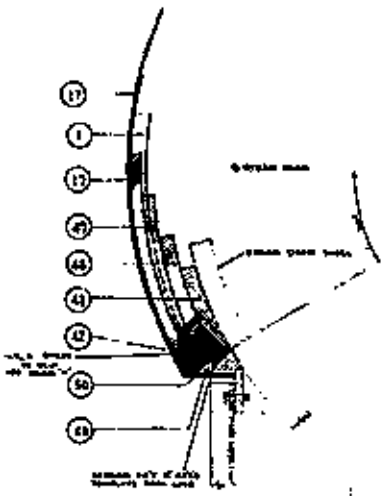
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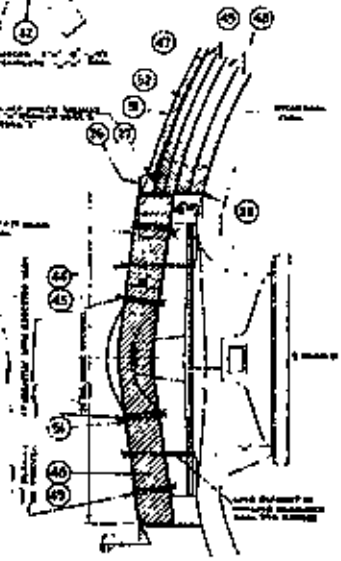
SECTION 'B-B'



REAR END VIEW



SECTION 'C-C'



⚠ PARTIAL SECTION 'D-D'
ARRGT. FOR ASBESTOS CLOTH LAGGING
SEE NOTE No. 15

EXHIBIT R

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FOR U.S. DESTROYERS
DD692 CLASS

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35. If the turbine is shut down for any reason, even though for only a short period of time, it must be brought up to speed with the same care that is exercised when starting cold.

OBSERVATIONS TO BE MADE DURING OPERATION

During operation, attention should be given continually to the following points:

1. Cleanliness, and leakage of steam, water, or oil.

2. Smoothness of operation and freedom from unusual sounds.

3. Correct action of steam and oil pressure gages.

4. Circulation of steam, water, and oil.

5. Temperature of bearings, quantity and quality of oil.

6. Quality and quantity of water for oil cooler.

7. Once a day, when load conditions permit, partially close throttle valve to make sure that the valve stem moves freely through its packing.

8. Keep the valve-lifting rod free from dirt at the guides, so that the mechanism will operate smoothly.

9. Clean and oil the spindle of the throttle valve, and the connections between the levers of the governing mechanism, using a light, heat-resisting oil to prevent gumming.

10. Do not keep the turbine in service unless it is known that the emergency devices are in condition to operate.

11. A visual inspection of the tooth contact of pinion and gear should be made periodically. An inspection cover (22, Fig. 57) is provided on the gear casing for this purpose. See PERIODIC VISUAL INSPECTION OF GEAR TEETH.

MAINTENANCE OF TURBINE

Successful operations depend largely upon the care and attention given the turbine. Make systematic inspections and tests periodically, carefully following the instructions given below.

When ordering renewal parts, always refer to complete nameplate data including SERIAL NUMBER.

INSPECTION

At least once a week, inspect the exterior of the machine giving special attention to the following points:

Watch for and repair promptly all oil leaks and seepage, especially in any oil piping adjacent to high-temperature parts.

It is recommended that the turbine be dismantled once a year and the interiors examined for dirt, rust, or corrosive accumulations. Inspect the steam strainer, and the seats of all valves.

Make a complete record on the log sheet each time the various parts are inspected, tested, adjusted, or repaired.

Carefully clean all parts before reassembling.

TURBINE CLEARANCES

Successful operation of the turbine depends to a large extent on the maintenance of the proper clearances between the rotating and stationary parts. The clearances which should be maintained are given in Fig. 45. See ADJUSTMENT OF HIGH-SPEED THRUST BEARING.

DIAPHRAGM REPLACEMENT

The low-pressure side of each diaphragm is carefully machined where it fits in the casing so that a tight steam joint results. This keeps the steam from leaking around the outside of the diaphragms. If diaphragms have been removed, see that the surfaces forming this steam joint are clean and smooth before reassembling.

CORROSION

Corrosion and rusting, which impair the reliability and the economy of operation of the turbine can be almost entirely prevented by continuing the operation of the air ejector to dry the machine after it has been shut down and while it is still hot.

In some cases, serious corrosion of turbines has been caused by chemical action. Inspect the interior as frequently as possible, and if corrosion has begun determine and eliminate the cause.

VACUUM

Since the economy of operation depends largely on the vacuum maintained, keep the packings and joints in condition to prevent air leaks. The vacuum joints can usually be kept tight by application of

asphaltum paint, red lead, or some similar substance along the joints, and around the bolt fits.

If a high standard of vacuum is once attained, it can be maintained easily and permanently by a proper inspection for air leakage, and by proper maintenance of the condenser.

TURBINE CASING JOINTS

The horizontal joint of the turbine is grooved in the lower half for filling with an approved compound, should the steam joint show signs of leakage. Tapped holes are located around the turbine flanges as indicated in Fig. 65. All of the holes are located on the outside of the casing and are accessible upon the removal of the lagging.

To fill the grooves, remove one end plug and the adjacent plug; start at one end and inject the sealing material with the gun provided until it overflows through the adjacent hole. Now plug the first hole and place the gun in the adjacent hole. Remove the plug from the next adjacent hole and fill the next section of the groove in the same manner. Continue until the entire groove has been filled. With the gun in the next to the last hole and the sealing material flowing from the end hole, plug the end hole and put pressure on the gun to fill the whole groove solidly. Remove the gun and plug the hole.

This operation must be carried on rapidly and continuously to finish before the sealing material hardens. Clean the gun thoroughly and oil it before putting it away.

ROTOR BALANCE

Freedom from vibration is essential to the successful operation of the turbine. The rotors are, therefore, carefully balanced both statically and dynamically before assembly. If, during operation, a rotor becomes out of balance, it is most important that balance be re-established.

In most cases, vibration may be traced to faulty alignment, improper setting, defective foundation or to rubbing of packing or other parts. An accumulation of dirt in the field of the generator can cause unbalancing. These features should be carefully inspected before making any adjustment to the rotor itself.

If the rotor appears at fault upon inspection shows wear of parts or non-uniform incrustation, it should be thoroughly cleaned, or the worn parts should be replaced.

If vibrations continue after all corrections have been made, it will be necessary to rebalance by means of the balancing plugs. When doing this, it is well to proceed systematically and keep a chart-record of each trial.

It is recommended that the services of the manufacturer be obtained when it is found necessary to entirely rebalance a rotor.

STEAM STRAINER

It is recommended that the screen be removed and inspected the first day or two after the turbine is placed in service. Thereafter inspect the strainer quarterly, or more frequently if the service requires it.

DIAPHRAGM LABYRINTH PACKING

To inspect or replace the labyrinth packing (Fig. 44) it is necessary to remove the upper half of the turbine casing. When lifted, the half casing will carry with it the upper half of the diaphragms and their labyrinth packing rings. The segments of the packing can then be removed by pushing them around to their grooves away from the stop pin.

When lifting the upper half turbine casing, care must be taken to guide the casing vertically until the packing rings are clear of the shaft.

CARBON PACKING

To remove the carbon packing rings, unbolt the upper halves of the packing boxes (2 and 15, Fig. 43) at the horizontal and circumferential joints and carefully lift them vertically to prevent damage. Unhook the spring [9, Fig. 44] from the clip (3), and remove the upper segment of the packing ring. Then remove the two remaining segments, and pull the spring around the shaft.

To reassemble the packing, feed the spring through the lower half of the packing box. Feed in the two lower carbon segments between the spring and the shaft, taking care to have the side with the high ridge against the proper side of the cell. Assemble the top segment in place with the spring clip, making sure that the holes in the clip are nearest the side of the cell wall against which the spring must rest as shown in Fig. 44.

The inner ring at the high-pressure end can be assembled and disassembled in like manner, as the upper half of the ring is partly exposed when the high-pressure packing box is removed.

The individual segments are marked on each end, and the packing ring when assembled must have corresponding markings adjacent to each other. The segments are NOT interchangeable within the same rings or other rings. Complete rings may be interchanged in the various cells with similar rings, but care must be taken that the seating side is assembled as indicated in Fig. 44.

Rings that are found to have excessive clearance should be replaced with new ones. New rings must be worn in by operating the turbine at low speed when first starting. Allow a reasonable length of time to bring the turbine up to full speed.

RENEWAL PARTS FOR SHAFT PACKING

When renewing the carbon packing, order a complete set of segments. Note that none of the packing-ring segments is interchangeable and that each segment is, for this reason, stamped in order that the entire ring may be correctly assembled.

The carbon packing rings, when new, have the diametrical clearance shown in Fig. 45 when the shaft is at room temperature. In operation, this clearance is reduced by the shaft expansion.

The labyrinth packing segments must also be ordered as a complete ring.

GOVERNING SYSTEM

The interior bearing surfaces are self lubricating. The external pivots should be oiled daily by hand, using a good grade of heat-resisting oil. All bearings and pivots must be maintained free from friction, and also free from lost motion.

HYDRAULIC SYSTEM

To insure successful response of the governing mechanism, the oil-pressure pipes and passages and the pressure end of the cylinder must be full of oil and entirely free from air. To maintain this condition, see that the proper oil level is maintained in the tank.

When putting new oil into the tank, avoid the introduction of frothy oil into the pump suction.

SPEED GOVERNOR

The governor is calibrated and adjusted at the factory for normal operating speed of 600 rpm, and this calibration should not be disturbed. A considerable range of speed may be obtained by adjusting the elevation of the pilot-valve bushing (12, Fig. 52) by means of the handwheel (7) or the synchronizing-device motor, so that no readjustment of the speed governor is necessary.

The governor pivot bearings are lubricated by the spill of oil from the pilot valve. They may be renewed, but when this is required, it is advisable to renew the governor and the pilot valve as a unit.

PILOT VALVE

Do not remove the pilot-valve body without first removing the pilot-valve bushing. This will prevent possible injury to the pilot valve or bushing.

Oil the various pins and bushings of the governor levers to eliminate possibility of binding.

SYNCHRONIZING DEVICE

The ball bearings of the synchronizing-device motor should be supplied with Navy Symbol 14L3 grease. To grease these bearings, it is necessary to:

1. Disconnect the wiring to the motor and loosen the clamping bolt which holds the motor in its housing on the side of the pilot-valve assembly, and remove the motor from its housing.

2. Remove the brushes and mark them so that they may be returned to their exact positions upon reassembly of the motor.

3. Remove the worm and brass washer from the motor shaft, and then remove the end-shield clamp screws [24, Fig. 54], at the pinion end of the motor. Remove the end shield [25] from the motor frame. This exposes the bearing [2] at the pulley end of the motor shaft. Remove the entire rotor from the motor to expose the commutator-end bearing.

4. The bearings should be carefully cleaned, and then repacked with grease before reassembling.

The worm-and-gear housing (17, Fig. 53), should also be kept supplied with Navy Symbol 14L3 grease.

EMERGENCY GOVERNOR

EMERGENCY GOVERNOR TEST

During normal service, the emergency governor should be tested at least every quarter at tripping speed, and should also be tested every time the turbine is started after having been idle for any length of time. Before making this test or when trying out for the first time after readjustment of the spring or insertion of a new emergency governor, make sure that the set is otherwise in good operating condition.

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See that the plunger (2, Fig. 55) will move freely to the end of its stroke and back. This can be done by inserting rods in the holes in the plug (6) and applying the necessary pressure against the flange of the plunger (2), and then releasing the pressure. If the plunger cannot be moved, or does not return upon release, an inspection of the interior parts should be made to determine and correct the cause. If the plunger can be moved and the spring returns to its normal position, the test may be continued.

Test the emergency governor in the following manner:

1. Connect an accurate indicating tachometer to the generator end of the shaft. Have an attendant at the tachometer in direct communication with an attendant located at the throttle valve.

2. Adjust the handwheel (1, Fig. 53) on the synchronizing device by turning it as far as possible in the speed-increasing direction, at the same time depressing pin (19) on the high-speed stop (5), until the handwheel is screwed as far as it will go.

3. Start the turbine. Just as soon as the rotor begins to turn, immediately trip the emergency mechanism by pressing the tripping button (1), Fig. 56. If the throttle valve does not close promptly, investigate and correct the trouble before proceeding with this test. If the throttle valve trips closed promptly, turn the throttle handwheel to the closed position, reset the tripping mechanism, then proceed with the test.

4. Open the throttle valve just enough to bring the turbine SLOWLY up to tripping speed (11,065 rpm turbine speed, or 1820 rpm generator speed). Do not accelerate or run above the tripping speed.

5. Take careful readings of the tachometer to determine the speed at which the emergency governor operates.

6. Be sure that the tripping mechanism closes the throttle valve when the emergency governor operates.

7. In case the emergency governor does not trip at the proper speed, make no adjustments to any part of the mechanism until the trouble has been located.

8. Always trip the emergency governor at least three times after setting the governor to be certain that the speed readings have been taken correctly and also that all parts are in proper working order.

9. Depress pin (19, Fig. 53) to clear the projection on the bottom of the fulcrum (4), and turn the handwheel (1) in the speed-decreasing direction until the fulcrum is again within the normal operating range.

10. Do not keep the turbine in service unless it is known that the emergency devices are accurately adjusted and are in operative condition.

ADJUSTMENT OF TRIPPING SPEED

The trip speed is tested at the factory and should not be changed unless absolutely necessary. The correct trip speed is 10 percent above normal, or corresponding to a turbine speed of about 11,065 rpm and a generator speed of 1320 rpm.

The plunger is contained in a transverse opening in the body (1, Fig. 55) that contains all the parts of the emergency governor. These parts are held in position by means of the plug (6), which fixes the position of the plunger at speeds below the trip speed. The speed at which the plunger acts is with limits, adjusted by turning the bushing (3) with a face spanner which fixes the compression on the spring (4). Before attempting to turn the adjusting bushing, remove the turned-down lips of the staking edge that engage with notches in the nut. Then turn clockwise to raise trip speed or counterclockwise to lower. Check the tripping speed three times or more, then stake the bushing (3) to the body to prevent accidental change in adjustment.

Take careful readings on a reliable tachometer for measuring the speed of the turbine when adjustment of the emergency governor is to be made.

CARE OF EMERGENCY DEVICE

Inspect, clean, and test the emergency governor at frequent intervals to be sure that it is in operative condition and to guard against possible deterioration or variation of the adjustment. Most of the accidents to turbines have resulted from the long disuse of the safety devices.

EMERGENCY TRIPPING DEVICE

ADJUSTMENT FOR CLEARANCE

The clearance between the plunger and the trigger when the turbine is at rest and the trigger is latched in position is 1/16 in. To measure this clearance, remove the access cover from the outboard end of the turbine shaft and insert a taper gage. The adjustment of the clearance can be made by shifting the bracket (10, Fig. 56). In the process of manufacture, the clearance is fixed and the bracket is retained in position by dowels.

THROTTLE VALVE

When stopping the turbine, trip the throttle valve by hand to be sure that it operates properly to close.

Should the valve act sloggishly, disassemble it for thorough inspection and cleaning.

When the turbine is operated continuously for long periods of time, occasionally when load conditions permit, screw the handwheel of the throttle valve closed a few turns to be sure that valve is not stuck open.

When the throttle valve is being opened, the pressure in the cylinder chamber above the outer (main) valve (48, Fig. 46) when the inner (pilot) valve is fully open and before the outer valve is unseated, is in accordance with the small rate of steam flow around the upper part of the outer valve and through the orifice (51). The optimum size of this orifice is determined after test at the factory so the main valve will not be too hard to open nor will it chatter. In some cases, best throttle valve operation is obtained with this orifice plugged.

At least once a week lubricate the outside moving parts. Keep all exposed parts clean to prevent any possibility of sticking when the emergency governor functions.

The main stuffing box is packed with a self-sealing packing which requires no setting up on the gland except perhaps after long service.

If the packing deteriorates and causes leakage, the valve stem should be repacked; under no circumstances should the gland be set up tight, as the packing must be free enough to permit the valve to trip shut.

Care must be taken when repacking the stuffing box or tightening the gland that the gland is screwed down equally on both sides.

Under no condition use a packing containing rubber, as this is quickly deteriorated by superheated steam and gums the valve stem so that the valve will not trip shut.

Leakage of steam at the operating valves as well as the throttle main and pilot-valve seats must be prevented. After considerable service, it may be found desirable to refit the valves and seats by scraping or grinding.

BEARING WEAR MEASURING DEVICE

This device is used during overhaul of the set to measure bearing wear or to align new bearings, and consists of a bridge gage in which is inserted a depth micrometer. See Fig. 68.

A plate is attached to the bridge gage, which is stamped with the turbine serial number, and the factory clearances for the turbine, pinion and gear bearings.

REBABBITTING TURBINE BEARING

Rebabbitting dimensions for the turbine bearing are given in Fig. 66. The appropriate lifting yoke is shown in Fig. 66.

To remove the bearing lining, first remove the upper half of the bearing cap and adjacent oil deflector. Remove the bolts which hold the two halves of the lining together, then lift off the upper half of the lining. Place the lifting yoke in position, and turn down the lifting yoke screw until the rotor is lifted sufficiently so that the lower half of the bearing lining may be rolled out.

The following procedure should be followed in rebabbitting a bearing lining:

1. Check the journal diameter. This dimension, plus the amount listed in Fig. 66, is to be used as the diameter to which the lining bore is to be machined.

2. Melt out the old babbitt by heating evenly with a torch, in an oven, or by dipping in a babbitt pot. Brush off any excess babbitt which adheres to the shell.

3. Before rebabbitting, inspect the condition of the surfaces to be babbitted, and while the parts are still hot from melting out the old babbitt, clean the tinned surface by brushing with sal ammoniac.

4. Any bare spots in the surfaces to be babbitted should be fluxed with a good soldering flux and the entire surface retinned. Retinning and preheating of the lining can best be done by dipping the lining in a tin bath heated to 575-600 F.

5. Babbitt the lining immediately. The following approximate temperatures should be maintained when pouring the babbitt:

a. Babbitt (tin base)	650 to 925 F
b. Mandrel	450 to 475 F
c. Lining	475 to 550 F

6. Remove any excess babbitt on the outside, and drill all holes clear.

7. Machine the babbitt to dimensions given in Fig. 66. Care should be taken to reopen all oil inlets and drains and relieve the babbitt at the bearing splits as indicated.

DISASSEMBLY OF TURBINE

The procedure to be followed in dismantling the turbine may be determined by studying the various illustrations and the unit itself. The sequence and precautions to be followed are mentioned here only as a guide and in the expectation that they may prove of service.

TO REMOVE UPPER HALF OF TURBINE CASING

1. Disconnect the oil and steam piping to the throttle valve.

2. Remove the throttle valve.

3. Disconnect the restoring lever from the controlling valves and from the pilot valve and synchronizing device.

4. Remove the upper half of turbine lagging.

5. Remove the bolts at the horizontal joint of the turbine high-pressure head and exhaust casing. It is not necessary to remove the bolts from the circumferential joint.

6. Remove the upper halves of the high-pressure and low-pressure packing boxes. Lift vertically and carefully to avoid injury to the packing.

7. The casing may now be lifted. To aid in breaking the horizontal joint, insert some of the flange bolts in the blind tapped holes on the horizontal flange of the upper-half wheel casing provided for this purpose, and use them as push screws. The upper halves of the diaphragms and diaphragm packing are fastened to the upper half of the casing and will be lifted with it.

TO REMOVE TURBINE ROTOR

Continue as follows:

8. Remove the turbine bearing-bracket cap and the emergency tripping device.

9. Remove the packing rings from the lower halves of the high-pressure and low-pressure packing boxes.

10. Remove the pilot-valve housing from the gear casing. Before removing the housing be sure that the pilot-valve bushing is removed. Not to do this may cause injury to the pilot valve, to the bushing, or both.

11. Remove the amplidyne from the upper gear casing. In doing so exercise caution so as not to damage the helical pinion which is mounted overhung on the end of the amplidyne shaft.

12. Remove the upper half of the gear casing.

13. Remove the top halves of the pinion bearings and dismantle the thrust bearing.

14. Lift the turbine rotor and reduction-gear pinion as a single element.

MAINTENANCE OF GEAR

ORDERING RENEWAL PARTS

When ordering renewal parts, always refer to complete nameplate data including GEAR SERIAL NUMBER.

PERIODIC VISUAL INSPECTION OF GEAR TEETH

Visual inspection of tooth contact of the pinion and gear should be made periodically and a record maintained as to the condition of the teeth at such times. An inspection cover (24, Fig. 57), located over the tooth mesh, is provided for this.

Uniform distribution of wear over the entire length of both gear and pinion teeth is an indication of correct tooth contact. Any deviation from this condition may indicate misalignment of the gear casing or of the connecting shafts. All alignment features should be checked to determine and eliminate the cause of any nonuniform wear.

Examine the teeth of gear and pinion for pitting, and remove any noticeable high spots caused by abrasions from foreign matter passing through the mesh. This may be done with a very fine grade of carborundum stone. Do not use a file or scraping tool for this purpose, as either of these tools may easily damage the tooth contour.

ADJUSTMENT OF HIGH-SPEED THRUST BEARING

The high-speed thrust bearing on the pinion shaft is adjusted as follows:

With the outer (active) thrust housing (7, Fig. 58) removed, the turbine rotor and pinion are moved axially in the direction of the generator until the first-stage turbine wheel hits against the nozzle-plate. The distance between the face of the thrust collar (15) and the shoes of the inner (inactive) thrust bearing (12) is then set to the clearance desired between the first-stage wheel and the nozzleplate plus the running clearance of the thrust bearing. This is done by machining the thrust-collar locating spacer (29), to the proper thickness. After replacing this locating spacer and locking the thrust collar in position on the pinion shaft, the outer thrust bearing (7) is assembled in place.

An indicator is then placed against the end of the pinion shaft and readings are taken as the rotor is moved between the end positions allowed by the thrust bearing. These readings give the total clearance in the thrust bearing. The desired clearance is obtained by adding or removing the proper thickness of shims (9) between the inner and outer thrust housings.

ADJUSTMENT OF LOW-SPEED THRUST BEARING

After the high-speed thrust bearing has been set, the position of the low-speed rotor to the casing is adjusted so that the face of the gear is centered with the face of the pinion when both are in the loaded position, that is, when the turbine-pinion rotor is moved axially in the direction of the generator and the gear-generator rotor in the direction of the turbine as far as the thrust bearings will permit. The gear rotor is set to this desired position and the proper clearance obtained by adjustment of the thickness of shims (111, behind the thrust shoulder of the gear bearing (12, Fig. 57).

DISASSEMBLY OF GEAR

UPPER HALF GEAR CASING

The turbine governor, pilot valve, and amplidyne exciter are mounted on the reduction gear. Therefore, when removing the upper gear casing, it is necessary to proceed as follows:

1. Disconnect the emergency connecting rod between the pilot valve and the control-valve piston rod, and any other parts that form a connection between the turbine high-pressure head and the upper-half gear casing. Care must be taken to avoid damage to the pilot valve during this disassembly.

2. Disconnect the electrical connections, remove the joint bolts and then remove the amplidyne generator being careful during disassembly so as not to damage the pinion which is mounted on the amplidyne shaft. Threaded jacking holes are provided in the amplidyne flange to facilitate in loosening the rabbet during disassembly. The same jacking bolts should be used in lowering the amplidyne into place so as not to damage the teeth. Extreme care should be exercised during this operation.

3. Remove the thrust bearing cover 16, Fig. 57, the outer thrust bearing and the bolt through the inner thrust bearing which fastens to the upper casing.

4. Remove the bolts from the upper and lower half of the gear casing. Remove the end cover plates which are bolted to the upper and lower casing. Remove the coupling guard from the upper half, and take out the joint bolts to the oil deflectors. Remove the taper dowels from the joint flange.

5. Remove all thermometers and gages from the upper-half gear casing.

6. The horizontal joint between the upper and lower gear casing should be opened by means of jacking bolts screwed down into the threaded holes provided in the flanges of the upper half of the casing. Attempts to break the joint other than in this manner may distort the upper half of the casing.

7. Lift the casing by means of the eyebolts provided, taking care not to let it strike against the gear. Since the pilot valve remains connected to the governor, be sure to lift the casing high enough to let the pilot valve clear. When lifting the upper casing, exercise caution to be sure the upper half of the generator end pinion bearing does not adhere to the bore and then fall out and get damaged.

8. The pilot valve body (13, Fig. 52), may if necessary, be removed by removing the nuts or studs at the flange connection with the governor cover 126, Fig. 57).

GOVERNOR ASSEMBLY

The speed governor assembly, including the pilot valve, may be removed from the gear by removing the governor cover 126, Fig 57), bending back the edge of the lock washer (13, Fig. 59) between the hub of the pump and governor driving gear and the hub of the governor assembly, and then unscrewing the governor assembly while holding the pump shaft from rotating.

MAIN OIL PUMP

To remove the main oil pump it is necessary to disconnect the oil line which connects to the nozzle for lubricating the spline, remove the nozzle from the bore in the turbine end of the gear casing in line with the low-speed bearing bores, remove the snap ring and the floating quill shaft (the outboard end of the bore in the floating quill shaft is tapped to facilitate removal), remove the bolts that hold the pump feed to the lower gear casing, install the lifting eyebolts, and lift the pump vertically. As soon as the pump gears are above the oil level in the tank, the pump shaft should be turned in the reverse rotation to empty the oil in the pump and discharge lines.

LOW-SPEED GEAR AND SHAFT ASSEMBLY

To remove the low-speed gear wheel, remove the upper casing and the main oil pump as described previously and then proceed as follows:

1. Remove the bearing cap 123, Fig. 57) and the upper halves of the low-speed bearing shells.

2. Place blocks under the gear end of the generator shaft to carry the weight of the generator rotor.

3. Draw the bolts between the gear and generator shafts and disengage the rabbet. Tapped holes for jacking bolts are provided in the coupling flanges.

4. Lift the gear wheel slowly, at the same time turn the pinion to disengage the teeth. Make sure the lower halves of the bearing do not adhere to the journals for they may fall and become damaged.

When the low-speed shaft is free of the lower half of the bearings, move the gear slightly away from the pinion and lift it out.

PINION

The pinion may be removed independently of the turbine rotor by proceeding as follows:

1. Remove upper gear casing as described previously.

2. Remove the Drake lock nut (54, Fig. 57), the bolts that secure the outer thrust bearing, the thrust collar, the bolts that secure the inner thrust bearing and the inner thrust bearing.

3. Remove the bearing cap and the upper halves of the pinion bearings.

4. Place blocks under the gear end of the turbine shaft, to support the turbine rotor.

5. Draw the coupling bolts between the turbine and pinion shafts and disengage the rabbet. Tapped holes for jacking bolts are provided in the coupling flanges.

6. Lift the pinion slowly and at the same time turn the gear to disengage the teeth. Make sure that the lower halves of the bearings do not adhere to the journals for they may fall and become damaged. When the pinion journals are free of the lower half bearings, move the pinion slightly away from the gear to disengage the teeth completely and lift it out.

When installing a replacement pinion, check the distance between the face of the coupling flange and the shoulder against which spacer (22, Fig. 58) is assembled. This distance must be measured on both the old and new pinion. If these distances are not identical, adjustments will have to be made on the spacer (22) to maintain the position of the turbine rotor with respect to the diaphragms. See sections on description and adjustment of high-speed thrust bearing.

MAINTENANCE OF LUBRICATION SYSTEM

Inspect the inlets to the bearings frequently enough to insure that they do not become obstructed. The orifices and check valves (Fig. 69) should be cleaned occasionally.

Clean the interior of the oil reservoir tank frequently and, where accessible, inspect and clean the interior of the manifold pipes, bearings, oil tank, and oil cooler.

The oil tank has a flanged opening in the bottom. By removing the plug, any sludge that has collected at the bottom may be drained out and the tank flushed and cleaned. Keep the interior of the piping clean. Do not allow any leakage of oil to occur at the valve-steam packings or at other points in the system.

OIL STRAINERS

Clean the oil strainers as frequently as necessary to keep them clean. Only one of the two strainers is in the operating position at a time. The idle or closed strainer, indicated by the arrow on the handle of the transfer valve, can always be removed and cleaned. Care should be taken to remove any metallic particles that may adhere to the magnets in the strainer baskets. The basket can best be cleaned by sluicing in a vessel containing light oil or kerosene.

Care must be taken in replacing the strainer cage and strainer to see that the inner circular face is against its proper shoulder. If the strainer cage does not readily make up with the manifold body, check to make sure that the cage is against its proper shoulder. Do not try to take it up by tightening the cover plate.

Before putting the cover plate in place, fill the strainer chamber with oil. After the strainer and cover plate are in place, with the turbine operating, open the vent cock and turn the transfer valve slightly toward this strainer until oil comes out the vent cock. After closing the vent, the strainer may be placed in service at any time.

OIL RELIEF VALVE

The spring-loaded by-pass relief valve, (12, Fig. 63) will open and relieve excessive pressure from the main oil pump. It should be set to give 50 to 55 psig pump pressure with an oil temperature of 120 F and with the bearing-oil-pressure control valve set to give 8 psig pressure at the outlet side of the cooler. This setting can be obtained by maintaining a cooler-outlet oil temperature of 120 F and adjusting the valve by removing the cap, loosening the lock nut, and turning the adjusting screw in to increase the pressure, and out to decrease the pressure.

The resulting oil pressure to the hydraulic governing system, and to the bearing-oil pressure control valve, is indicated by the high-pressure oil gage, as shown in the oil piping diagram, Fig. 69.

Oil COOLER

WATER PRESSURE: It is suggested that the circulating water be maintained at a pressure somewhat lower than the oil, so that, in the event of leakage the oil will leak into the water rather than allowing the water to leak into the oil and thus contaminate the oil.

CLEANING: Any change in oil temperature drop through the cooler strainer, all other conditions remaining the same, is an indication that cleaning is required to either the oil or water side of the cooler. Without waiting for this indication to appear, however, the cooler-tube bundle should be cleaned at regular intervals as follows:

1. Move the turning lever (24, Fig. 62) to the full COOLER BY-PASSED position, shut off water flow to the cooler, and drain the water passages. Drain the cooler oil passages.

2. Remove the main head (1), and the floating head (14), using care in removing the gaskets. Remove the gland (11) and the packing (10).

3. Press upward on the floating tube sheet (13). Grasp the main tube sheet when it passes out of the shell and draw the tube bundle straight upward, taking care not to let it get out of direct line with the cooler bore, and damage the baffles.

4. The external surfaces of the oil cooler may then be cleaned by washing with a jet of hot fresh water. The internal surfaces of the tubes should be cleaned by the use of a round bristle brush (never use a wire brush for this purpose) while the surfaces are still wet. If allowed to dry before brushing, the salt water deposits will be difficult to remove.

If the surfaces are still not clean, immerse the tube bundle in a solvent such as kerosene and surge it up and down and occasionally endwise. If impurities still adhere to the tubes or baffles, place the bundle in a cold, mild alkali solution made of 0.4 lb of soda ash or tri-sodium phosphate, and 0.004 lb sulphonated fatty alcohol to one gallon of water. Boil the solution slowly with a steam jet, keeping the steam from direct contact with the tube bundle. The inside of the tubes can be cleaned further by passing a round brush through them. Rinse the tube bundle thoroughly with hot water, and dry.

5. In replacing the bundle, care should be taken that the baffles do not catch on the shell, causing them to carry the entire bundle weight. Fill the oil chamber as described below before placing cooler in service.

6. Bleed entrapped air from the water and oil circuits after circulation has been started. After the cooler has been in use for six or eight hours, recheck on the condition of the gaskets and packing.

ELECTROLYTIC PLUGS: Periodically remove the two plugs (15, Fig. 62) and inspect the zinc cylinders (16). Wire brush the zincs at each inspection and renew the zincs when the cylinders are approximately three-fourths dissolved.

REFILLING COOLER AND STRAINER

After disassembly for cleaning, or if for any other reason oil is drained from the cooler or strainer chambers, be sure to refill them before placing the equipment in operation. This can be done when the turbine is shut down by loosening the top vent in the oil circuit of the cooler (19, Fig. 62), moving the turning handle (24) to COOLER IN USE position, opening the vent cocks on both strainer covers, and moving the valve-operating handle (3, Fig. 63) to midposition so that both strainers will be flooded. The cooler and strainer should then be filled with oil by the hand oil pump until oil emerges from the vents.

As soon as the turbine is operating, loosen each vent plug in turn, and move the valve-operating lever so as to open slightly the valve to the cooler or to the strainer. As soon as oil starts flowing from each vent, it may be closed and the cooler or strainer put into service at any time.

Air should be bled from the water circuit in a similar manner. The vent for this is in the top of the cooler.

Oil

The oil should be a pure mineral product of the highest quality. It should be so refined that it will prevent rusting of ferrous parts, assuming water to be present in the oil. There should be no tendency toward permanent emulsification or rapid oxidation with the formation of sludge.

The pressure of the oil into the bearings is 8 psig. Too great an oil pressure is apt to cause flooding with oil throwing at the ends of the bearing. The turbine will operate with an oil temperature as high as 170 to 175 F providing a good grade of oil is used.

These sets are designed to operate on oil conforming to Navy Symbol 2190T which has a viscosity of 185 to 200 SUV at 130 F.

Success in the use of oil is attained only by continual care, observation, and treatment. As the oil passes repeatedly through the bearings, it gradually loses its lubricating qualities and new oil must be added as occasion demands. If properly filtered and cared for, oil may be used over and over again for many months, depending on the initial quality of the

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oil, and effectiveness of the strainers, treating devices, and filters, and the number of hours per day that the set is in operation.

It must be remembered that the life of the bearings depends on the proper functioning of the lubricating system. Every effort has been made in the design to reduce to an absolute minimum the possibility of the bearings suffering from an improper oil supply. However, it is necessary to watch the temperature of the bearings and to see that an adequate supply of clean oil is kept in the system.

SUGGESTIONS

The following suggestions in connection with the subject of lubrication are presented for guidance:

1. See that the oil in the pump tank is clean. Pay careful attention always to maintain the oil level uniformly always within the range specified by the oil gage.

2 Maintain an ample reserve supply of oil for emergency use and for making up the deficiency as required.

3. Periodically take samples of oil from the oiling system and have them analyzed.

4. Do not allow water to mix with the oil. If water accumulates, it can be removed by draining from the bottom of the tank or by centrifuging the oil. An inspection should be made to determine the source of water and eliminate the cause.

5. See that the pressure gages are registering properly, and that the gage cocks, if used, are throttled sufficiently to reduce needle vibration and consequent wear on the internal mechanism of the gages.

6. A steady increase in the oil temperature with normal operation of the set indicates oil fatigue, as a result of which the lubricant becomes thick and stringy and sludge forms. Under these conditions, clean the entire oil system; use new oil and either throw away the old oil or clean it for reuse.

7. Test the oil cooler periodically for water leaks.

8. Maintain the pump, cooler, strainer, and other appliances in an efficient condition for furnishing an ample supply of clean oil.

9. Grit or other solid matter in the oil acts as an abrasive and reduces the life of the bearings. Eliminate them wherever found and locate and correct the source producing them.

10. The acidity of oil increases with time and use. It should be maintained within the predetermined limit as recommended by the manufacturer.

11. Do not use waste or other linty substances on oil-covered interior surfaces. Wiping cloths are better, but do not use these around moving machinery, as they might cause accidents.

12. Do not use gasoline as a cleaning liquid. Use kerosene oil.

13. To avoid possibilities of explosions, keep flaming lights away from the oil-tank openings when the oil is hot and vaporous.

ALIGNMENT OF SET

Successful operation of the turbine-gear-generator set calls for accurate alignment of the entire unit. Incorrect alignment may cause vibration, unsatisfactory tooth contact of the gear and pinion teeth, and unsatisfactory operation of the unit in general.

Proper alignment of the unit requires:

a. Setting of the gear casing to maintain the centerlines of the gear shaft and pinion shaft in the same plane. This is essential to obtain satisfactory tooth contact.

b. That pinion and turbine shafts, as coupled together, run true with one another.

c. Alignment of the turbine bearing (A, Fig. 32) relative to the pinion bearings (B and C) to give the following:

The center line of the turbine bearing (A) must be in the same vertical plane as the center line of the two pinion bearings (B and C) and the turbine bearing must be elevated above the pinion bearings to compensate for the sag in the turbine shaft, differential expansion of the bearing supports, and to distribute that portion of the weight of the turbine shaft carried by the two pinion bearings equally between them.

d. That gear and generator shaft, as coupled together, run true with one another.

e. Alignment of the generator bearing (F) relative to the gear bearings (D and E) to give the following:

The center line of the generator bearing (F) must be in the same vertical plane as the two gear bearings (D and E) and the generator bearing must

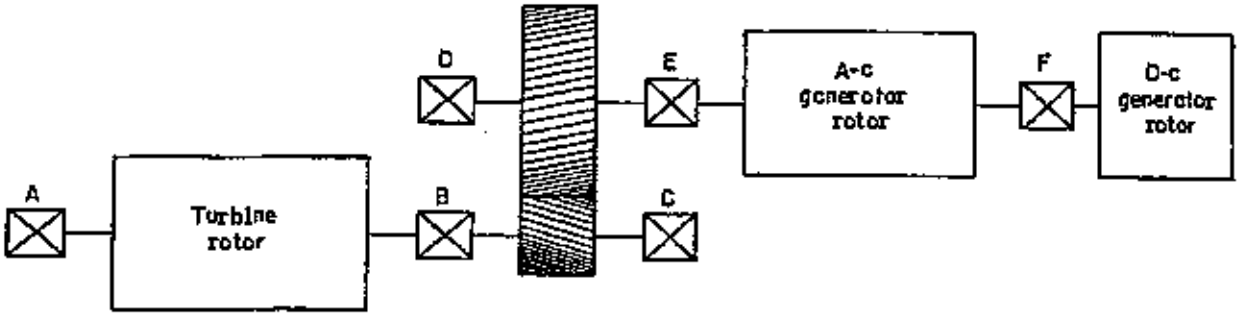


Fig. 32. Diagram identifying bearings that must be properly aligned

be elevated above the gear bearings to compensate for the sag in the generator shaft, differential expansion of the bearing supports, and to distribute that portion of the weight of the generator shaft carried by the two gear bearings equally between them.

The following checks are to be made if at any time there is reason to believe that the alignment of the unit is incorrect. It is recommended that the checks be made under the supervision of the manufacturer's field engineer, unless circumstances make it impractical to do so.

1. Check all foundation bolts to see that they are tight.

2. Remove the pinion thrust bearing cover, the thrust bearing, and the upper-half casing. (See section on DISASSEMBLY OF GEAR.)

2. Check that the tooth contact is distributed evenly along the full length of the helix or that it is equally heavy at each end of the helix. Check this by the use of feelers, inserting them at or near the ends of the helix between the load-carrying surfaces of the gear and pinion teeth. The amount of feelers that can be inserted must be the same for both ends of the helix. When making this check, the bearing should be rotated so that the full load reaction area is at the bottom, and the shafts should be clamped down to assure that the bearings are firmly seated in the bores of the casing.

The full load reaction area of the bearings may be found by observing the bearing contact marking or by measuring the bearing thickness with a micrometer to locate the area of greatest wear. In the pinion bearings, this area will be approximately 1/2 in. from the bottom of the bearing on the side away from the gear. In the gear bearings, this area will be near the horizontal joint of the gear casing on the side away from the pinion.

An additional check of tooth contact can readily be made by applying very thin layers of Prussian Blue to several gear teeth and red lead to several pinion teeth and rotating the pinion in a clockwise direction looking at the complete unit from the turbine end. The resulting contact marking should cover at least 90 percent of length of the teeth and be equally heavy at both ends of the helix. When making this check the bearings should be rotated so that the full load reaction area is at the bottom and the shafts should be clamped down.

If the tooth contact is found to be unsatisfactory, determine the extent of bearing wear by measuring the bearing shell thickness with a ball micrometer.

If it is found that one of the bearings supporting either the gear or pinion is worn more than the other, and this condition appears to be the cause of faulty tooth contact, replace the bearing or bearings to re-establish a satisfactory relation between the wall thickness of the two bearings.

If, after replacing worn bearings, satisfactory contact is still not obtained, indications are that the seating under the base of the unit has changed and changes in the shims will be necessary.

With tooth contact obtained within the specified limits, the setting and alignment of the gear casing is established. This alignment must not be disturbed in making the remaining checks and adjustments.

4. Check the alignment of the turbine with respect to the gear. This will necessitate three individual checks which are as follows:

(a) Check that the turbine and pinion shafts are running true with one another. To do this, remove the generator-end pinion bearing (C) and place an indicator against the side of the journal. Rotating the pinion and gear independently so that there will be no load on the teeth, take eight or more readings while the pinion is rotated one revolution. The maximum allowable runout is 0.0005 in. If the runout is

greater than this, the cause must be determined and corrected before proceeding further.

(b) Check that the outboard turbine bearing (A) and the pinion bearings (B and C) are in the same vertical plane. To do this measure the distance between the generator-end pinion journal (C) and each side of the bore of the bearing seat at the split of the casing with the generator-end pinion bearing (C) removed. These measurements must show the pinion to be central with the bore in a horizontal plane. If this condition does not exist, the pinion should be brought central by adjusting the chocks for the base under the turbine-end bearing support.

(c) Check the elevation of the outboard turbine bearing (A) relative to the pinion bearings (B and C) in this vertical plane. This is best done by measuring the loading of the generator-end pinion bearing (C) which is affected directly by the amount the turbine bearing is elevated. To do this, measure the amount that the generator-end pinion journal (C) drops when its lower-half bearing is removed. This drop should be 0.0025 in.

If the check shows incorrect drop, change such chocks as will either raise or lower the turbine bearing (A) to the required position. In cases where only a very slight correction in the elevation of this bearing is required, this may be done by adding or removing shims between its supports and the base of the set. This alignment must be correct to assure proper loading of the bearings for the turbine rotor and pinion. In making this check, make sure that the pinion is in a position such that the teeth will not interfere with the dropping of the shaft.

5. Reassemble the generator-end pinion bearing (C).

6. Remove the turbine-end gear bearing cap and the floating quill shaft which connects to the accessory drive.

7. Check the alignment of the generator with respect to the gear as follows:

(a) Check that the generator and the gear shafts are running true with one another. To do this remove the turbine-end gear bearing (D) and place an indicator against the side of the journal. Rotating the pinion and gear independently so that there will be an load on the teeth, take eight or more readings while the gear is rotated one revolution. The maximum allowable runout is 0.0005 in. If the runout is greater than this, the cause must be determined and corrected before proceeding further.

(b) Check that the outboard generator bearing (F) and the gear bearings (D and E) are in the same vertical plane. To do this, measure the distance between the turbine-end gear journal (D) and each side of the bore of the bearing seat at the split of the casing with the turbine-end gear bearing (D) removed. These measurements must show the gear shaft to be central with the bore in the horizontal plane. If this condition does not exist, the gear shaft should be brought central by adjusting the chocks.

(c) Check the elevation of the outboard generator bearing (F) relative to the gear bearings (D and E) in the vertical plane. This is best done by measuring the loading of the turbine-end gear bearing (D) which is affected directly by the amount the generator bearing (F) is elevated. To do this, measure the amount the turbine end of the gear shafts drops when its lower-half bearing is removed. This drop should be 0.005 ± 0.0005 in. If the check shows incorrect drop, change such chocks as will either raise or lower the generator bearing (F) to the required position.

8. Repeat checks from step 3 through step 7 to see that none of the alignment settings previously made have been disturbed by later adjustments.

9. Reassemble the remaining parts of the set making sure that no loose parts are lying in the gear casing.

10. Check the air gap in the a-c generator between the stator core and the pole faces.

The nominal air gap between the stator core and the poles is 0.170 in.

The air gap should be gaged from both ends of the generator at different points around the rotor. Gages for this purpose should extend as far as possible toward the center of the stacking. The feeler gage should be inserted along the core between the poles and then moved over into the space between the pole face and the stator core. This procedure reduces the likelihood of reading too small a value for the air gap at a point near the ends of the generator where a high punching is more likely to exist.

If the check shows incorrect air gaps, centralize the stator by means of jack screws which are provided. They permit either side to be raised or lowered so that sheet metal liners may be inserted between the feet and the bedplate to correct the alignment.

11. To check the air gap in the d-c generator, remove the end cover and blower. Mark one tooth, that has been scraped clean of varnish, and rotate this tooth to the center of each pole in succession. Measure the air gap with the taper air gap gage that is furnished with the spare parts. It is particularly important that the air gaps be uniform. Uneven air gaps cause overheating, vibration, and poor commutation.

Air gaps must be measured from the metal on the tooth of the armature to the center of the pole. Never measure gaps over a wedge. It is essential that both the tooth and the pole tips be scraped free of varnish to insure accurate readings.

It should be specifically noted that while the nominal air gaps are specified, the gaps on the particular machine may have been altered slightly during the factory test for adjustment purposes. The air gaps should be left as set by the factory. Changing the air gaps or shims will affect voltage regulation and commutation.

If the air gaps are not concentric, centralize the frame by means of the jack screws provided. This permits either side to be raised or lowered so that sheet metal liners may be inserted between the feet and the bedplate to correct the alignment.

The nominal main-pole air gap is 0.125 in.

The nominal commutating-pole air gap is 0.211 in.

CARE DURING PERIODS OF INACTIVITY

If the turbine is to be out of service for a considerable length of time, it may be advisable, depending on local conditions, to take the necessary precautions to protect it from deterioration due to corrosion. This applies especially to the shaft journals and to the shaft in the vicinity of, and directly under the shaft-end packing. During periods of long inactivity, the carbon packing should be removed and the exposed turbine shaft slushed. Before reinstalling the packing, make sure that all traces of the slushing oil are removed.

Take necessary precautions that there is no leakage of steam past the throttle valve to the turbine rotor or to the steam seal manifold. See instructions under SHUTTING DOWN. Drain the water from the oil cooler.

At this time it may be advisable to clean the oil system, including tanks, piping, oil passages, and oil cooler, and to make a thorough inspection of all the wearing parts of the unit.

SPARE PARTS AND TOOLS FOR TURBINE AND GEAR

A list of the spare parts and tools furnished for these vessels is shown in Fig. 67.

Illustrations of typical tools are in Fig. 68.

SECTION 3

A-c Generator

RATING

These generators are rated 400 kw, 0.8 power factor, 450 volts, 3 phase, 60 cycles, 1200 rpm, excitation 120 volts, 57.9 amperes d-c. The generators are also designed to carry 125 percent load for 2 hours or 150 percent current at 0.5 power factor for 5 minutes.

The complete rating table is as follows, with references to Navy Specifications 17G8 included:

(g) Prime mover (B-2): Steam turbine with reduction gear. Prime mover built by General Electric Co.

NAME PLATE DATA

400 kw (500 kva)	1200 rpm
450 volts	120 exciting volts
0.8 power factor	47.3 exciting amperes (calculated)
3 phase	Stator serial
60 cycles	Rotor serial

Load and Time Rating (B-8 D-8)	A-C GENERATOR RATING Voltage (B-9) 450, 3 Phase (B-11), 60 Cycle (B-10)							D-C GEN. RATING Voltage 120		
	Kw (B-6)	PF (B-7)	Kva	Amp	Guaranteed Efficiency (D-12D)	D-C Excitation as Required for A-C Gen. (incl. Rheostat Losses)		Kw	Amp	Efficiency
						Kw	Amp			
50% Cont	200	.80	250	320	89.7	5.2	43.7	25	208	83.2
75% Cont	300	.80	375	481	92.3	8.1	50.8	37.5	312	86.1
100% Cont	400	.80	500	641	93.3	7.0	57.9	50	416	87.8
125% 2 Hr	500	.80	625	802	. . .	8.1	67.2	62.5	521	. . .
150% 5 Min	600	.50	750	362	. . .	3.5	79	75	625	. . .

GENERATOR CLASSIFICATION

(a) Reference ambient temperature (B-3): 50 C)
(b) Class of insulation (B-4): Class B
(c) Degree of enclosure (B-5): Dripproof, open
(d) Method of cooling (B-5): Natural, self-ventilated
(e) Manufacturer's type and design: Special 6-34 x 11
(f) Means of excitation: Direct connected ship's service d-c generator.

It is recommended that the nameplate readings of the new equipment be reviewed, and office copies of these readings be made available. This information will be found useful in subsequent correspondence on the equipment.

ALWAYS REFER TO THE SERIAL NUMBER stamped on the nameplate of the machine when corresponding with the manufacturer, for this is the number which identifies the machine.

DESCRIPTION OF APPARATUS

GENERAL ARRANGEMENT

The principal external dimensions, and the provisions for mounting of the generator are shown on the Outline and Section drawing which appears as Fig. 70.

The a-c generator and d-c generator stators, and the pedestal bearing are separately mounted on the turbine bedplate. The d-c generator rotor is mounted on an extension of the a-c generator shaft.

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FRAME AND END BELLS

The frame is fabricated from rolled steel sheets and plates. The stator core is stacked on transverse studs extending between the two rolled steel end plates of the frame. After the core is assembled, the stud nuts are tightened to clamp the laminations firmly together, and the frame feet and cover plates are then welded to the end plates.

End bells are bolted to the frame at both ends of the machine to direct the ventilating air and protect the armature windings. The end bells and the cover between the two generators shield the machine from particles falling at an angle of 45 degrees from the vertical center line.

At the top of the frame, a heavy steel lug is provided for lifting the frame.

Heavy steel feet, welded to the lower portion of the end plates, insure rigid attachment of the generator to the turbine bedplate. These feet are machined parallel to the shaft and are drilled for foundation bolts, dowels, and jack screws.

BEARING AND PEDESTAL

The bearing, which supports the a-c generator rotor and the overhung d-c exciter armature, is supported by a pedestal mounted between the generator and the exciter on an extension of the turbine bedplate. The bearing is of the split type, having an upper and lower steel bearing shell lined with babbitt. The bearing is connected to the pressure lubrication system which furnishes oil at a pressure of approximately 6 psig. A fixed orifice at the bearing inlet limits the oil flow to 1/2 gpm.

In addition to oil deflectors machined on the shaft, front and rear labyrinth oil seals are provided to prevent leakage of oil from the bearing. Each seal consists of two semi-circular steel castings surrounding the shaft and bolted to the pedestal. Thin semi-circular copper seal strips are caulked with copper lock strips into a series of circular grooves machined into the bore of each half of the seal. The small clearance between the shaft and the inner periphery of the seal strips prevent leakage of oil along the shaft away from the bearing.

CORE

The core of the machine is built up of circular segmental laminations of silicon steel stacked on twelve transverse studs. Each circular lamination consists of six identical segments. Ventilating spaces are formed between the end plates and the ends of the core by finger plate spacers at four positions along the length of the core. This arrangement furnishes a means for dissipating heat from the core by permitting cooling air to enter the inner portion of the core. The laminations are insulated from one another with a coating of enamel. Finger plates at each end of the core prevent loosening of the teeth. The stator punchings have 90 slots, each having a finished size, after stacking, of 0.395 in. wide by 1.550 in. deep.

TERMINALS

On the a-c generator, the a-c leads are brought out at the bottom of the frame, and the d-c field leads are brought out at the base of the bearing pedestal. On the d-c generator, the leads are brought out at the bottom of the frame. Fig. 70 gives the terminal data as follows:

TERMINAL DATA

Gen.	Circuit	125% Full Load Amps	Navy Type Cable	Cable Size C.M.	Copper Dia.	Terminal Lugs		
						No.	Ar per 17C13	Pc.
A-C	Line	801.25	2-THFA-300	298,660	0.628	6	Type CL-2	157
	Field	73.75	2-SHFA-14	14,350	0.136	2	Type CL-1	84
	Line	520.	2-SHFA-300	298,660	0.628	2	Type CL-2*	114
	Field	6.45	1-SHFA-4	4,494	0.076	1	Type CL-2*	115

*Except special bolt spacing

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ARMATURE (STATOR) WINDING

TABULATION OF WINDING

Coil Grouping: 5 Coils per Group
1 Group per Pole — 18 Groups Total
90 Coils — Throw of Coils: Slots 1 to 14
6 Poles — 3 Phase — 9 Parallels

Refer to Fig. 71. The stationary armature has a bore of 25-1/4 in. and has 90 slots, each of which has a finished size of 0.396 in. wide by 1.550 in. deep. The armature coil is of a diamond type and consists of four conductors, each of which consists of one strand of 0.136-in. x 0.375-in. varnished double-glass-covered copper wire (insulated size 0.152 in. x 0.389 in.). Two coils sides lie in each slot. The weight of one coil is three pounds.

The conductors are bound together with one layer of 0.005 in. woven glass tape not lapped. Each straight side of the coil embedded in the slot is insulated with 1-1/2 turns of a 0.010-in. thick woven glass and mica wrapper. The end portions of the coils are insulated by hand taping with one layer of half overlapped 0.007-in. glass-backed mica tape. Coils are finished all over with one-half overlapped layer of 0.007-in. woven glass tape. Finished coils are impregnated by the vacuum and pressure method with heat reactive varnish, Navy approval letter NS8/L5-3528. The assembled stator is then treated twice in moisture and oil resistant varnish, Navy Specification 52V13.

Phenolin wedges are used to hold the coils in place in the slots. The coils are roped to an insulated steel ring on each end of the winding to prevent distortion in case of short circuit.

SHAFT AND SPIDER

The common a-c and d-c generator shaft is machined from a steel forging as shown in Fig. 70 and one end of the shaft is provided with a flange machined for connection to the gear shaft coupling. The spider is built up of steel laminations riveted together, the assembly being pressed on and keyed to the shaft. See Fig. 33 to 37. The spider laminations are punched with dovetail slots for mounting the field poles.

FIELD POLES

The six poles (Fig. 70) are constructed of laminated steel punchings which are securely bound together by through rivets. Each field pole is fastened to the spider by a dovetail which is held in place by two tapered keys.

Seven round copper damper bars extend axially just beneath the face of each pole. The bars are brazed at each end of the pole to a cast bronze upper coil support which is riveted to the pole.

FIELD (ROTOR) WINDING

Each field coil (Fig. 71) consists of one section of 170 active turns of 0.162-in. x 0.304-in. double-glass-covered copper wire (insulated size 0.180 in. x 0.324 in.). The coil is wound directly on the pole over the 0.005 in. thick asbestos and mica coil,

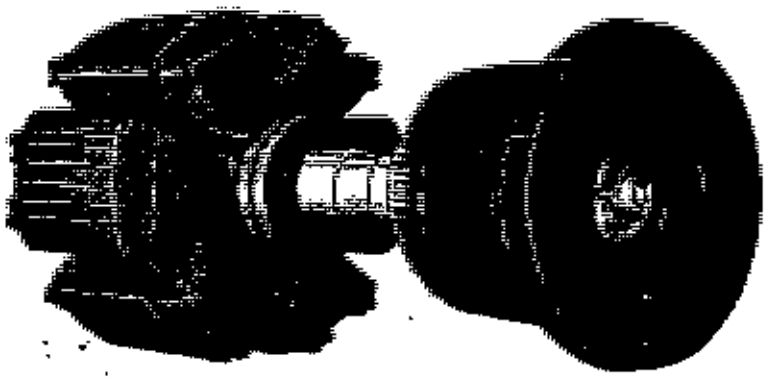


Fig. 33. A-c rotor (field), collector (slip rings), d-c rotor (armature), and ventilating fan

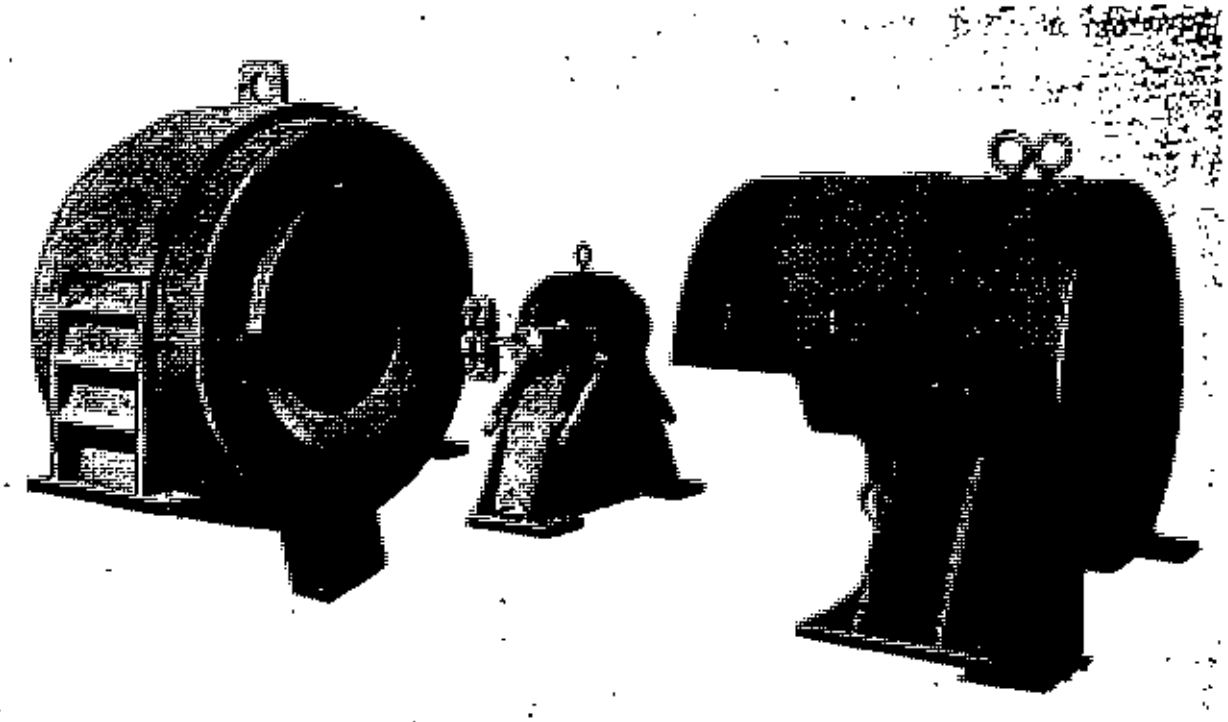


Fig. 34. A-c stator (armature), generator bearing pedestal, and d-c stator (field)

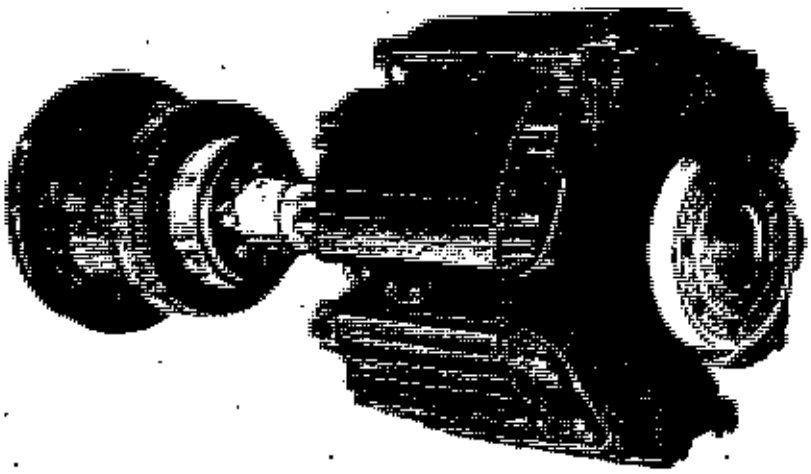


Fig. 35. Ventilating fan, d-c rotor (armature), commutator, a-c rotor (field), and coupling

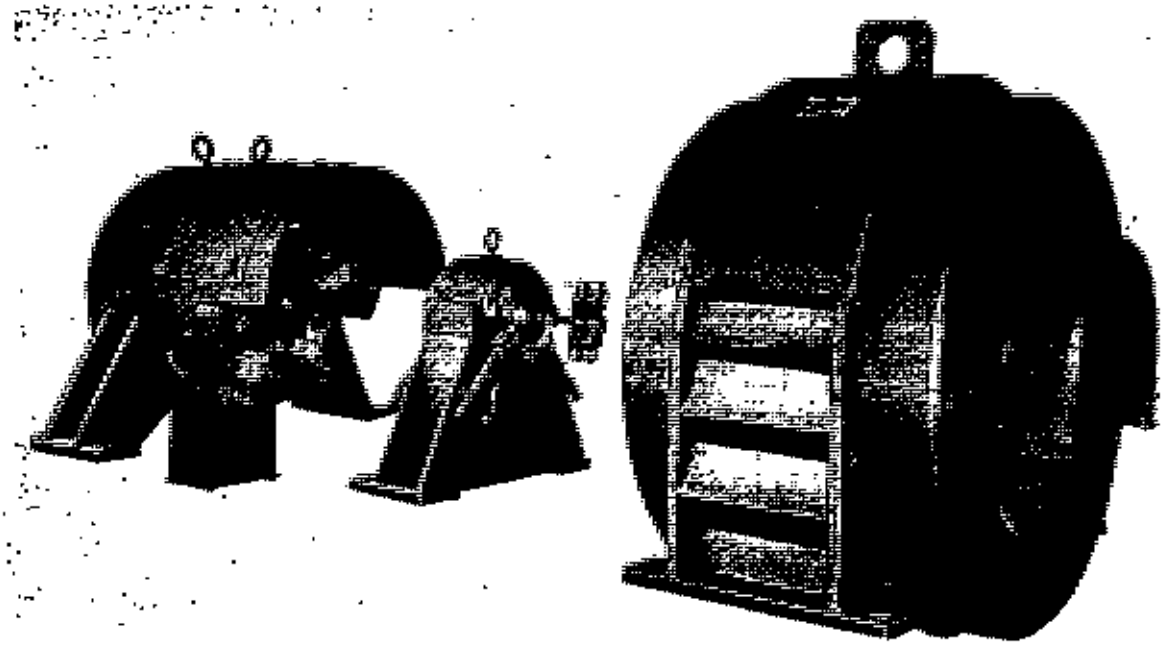


Fig. 36. D-c stator with brush rigging attached, bearing pedestal with brushes for the commutator, and a-c stator

which insulates the pole body. Upper and lower phenolic washers are located at the ends of the coil. All cracks and crevices between the washers and the coil are filled with cement before winding. The bottom washer is grooved to accommodate the starting lead, and the first turn is hand taped with 0.007-in. mica tape. The starting lead is bound in place with legs of glass tape 0.010 in. thick and 1 in. wide spaced at intervals of 2 in. around the coil. After a few turns have been wound, the legs are tightened to fasten the lead securely. At the upper end of the coil, the first layer is sleeved with 0.007-in. cambric and mica and one piece of 0.010-in. glass tape. Legs of 0.010-in. thick glass cloth, anchored between layers of the coil, are brought around the bottom washer to hold it in place. As the coils are wound, each layer is brushed with a coat of synthetic resin. An 0.010-in. thick glass tape leg protects each crossover between layers. A vent space is provided on each end of the coil of phenolic blocks placed between the sixth and seventh layers. The last turn of coil is secured by six legs around the coil, each 0.010 in. thick and 1 in. wide. The clip for the finishing lead is insulated with 0.010-in. thick sheet mica and is secured with 0.010-in. thick glass tape. After winding, the coil is baked with pressure applied to the sides. Finally the finished coil is brushed with an oil-resisting varnish. Each coil contains 78.4 pounds of copper wire.

Each coil is secured in its position on the pole by the upper and lower coil supports and the coil braces. The upper coil supports are made from

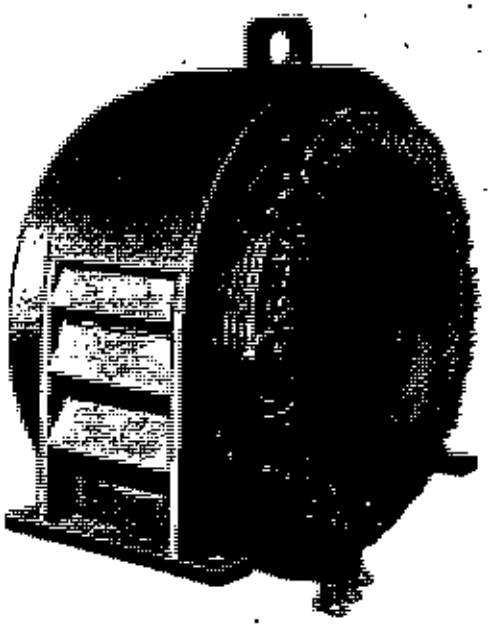


Fig. 37. A-c generator stator

cast bronze, and they are riveted to the pole. The lower coil supports are made from steel angle and are bolted to the spider. The coils are wedged between poles by coil braces consisting of phenolic blocks fastened to the spider by long bolts extending radially between the field coils.

COLLECTOR

The collector assembly [Fig. 70] is shrunk onto the shaft between the spider and the journal. It consists of two steel collector rings shrunk onto a length of a steel bushing around which a sleeve of phenolic has been built up with the entire bushing used as a mandrel. Two insulated brass studs, one threaded into each ring, connect the rings to their respective field leads. The surface of each collector ring is machined with a spiral groove to improve brush performance.

BRUSH RIGGING AND BRUSHES

For each of the two collector rings (Fig. 70) a brush holder containing two brushes is furnished. The total number of brushes is four per machine. Both of the double brush holders are supported by a single insulated stud fastened to the bearing pedestal. The brush holders are made of cast brass and are designed to use brushes 3/4 in. thick by 1 1/4 in. wide by 2 in. long.

MECHANICAL ROTATION

The rotation of the generator is clockwise as viewed from the collector end.

PHASE ROTATION

When the mechanical rotation is clockwise as viewed from the collector end, see Fig. 72, the emf induced in the phases will reach positive maximum values in the following order: A--B--C or T_1--T_2--T_3.

SHORT CIRCUIT CURRENTS

The sustained short-circuit current per phase is calculated to be approximately as follows [Fig. 71]:

1. With the regulator in operation: 2360 amperes.

2. Without the regulator in operation and with full load excitation: 1320 amperes.

The symmetrical rms short-circuit current is calculated to be approximately 6800 amperes for the first half cycle.

The windings are designed to withstand the stresses incident to short circuits when the machine is operated at full load and at rated voltage and power factor.

PARALLEL OPERATION

The two generators on each ship are designed for parallel operation.

SPARE PARTS

The spare parts furnished for the a-c generators are given on the Lists of Spare Parts and Tools, Sheets 1 and 2 which appear as part of Fig. 71. These lists indicate whether the items are to be stored on shipboard or ashore.

ORDERING RENEWAL PARTS

When ordering renewal parts, give the name of the part and the nameplate reading of the machine, including the serial number. The serial number will be found stamped on the nameplate and on the metal under the nameplate.

OPERATION AND MAINTENANCE

INITIAL OPERATION

BRUSH ADJUSTMENT

Brushes and brush holders should be examined before the machine is started up to make sure that the brushes are in the proper position, that there is a proper fit between the collector and the brushes, and that the brushes are free in the holder. If the faces of the brushes do not conform to the curvature of the collector, it is necessary to grind them to shape. This operation is always required when new brushes are installed. In the case of fitting new brushes or damaged brushes, the operator should use sandpaper "Grade 1 1/2" for the roughing out and "Grade 0" for the final fitting. The sandpaper should be drawn in the direction of rotation under the brushes. Rounding of the brush edges can be avoided by releasing pressure as the paper is drawn back and by being careful to keep the ends of the paper as close to the collector as possible. Each brush should be treated in turn, and it will be found that by this means a satisfactory contact is quickly secured.

An initial brush pressure of 2 psi is recommended. Once the machine is in service, the pressure may be altered as necessary.

INSULATION RESISTANCE

The insulation resistance of windings is usually measured with a megohmmeter. This measoremrnt gives sn indtcation of tbe condttion of tbe insulation, partttcularly with regard to moisture and dirt. The artual value of resistance varies greatly among different machines, depending upon the size and voltage. Therefore, the chief value of the measurements comes from a comparison of the values of resistance observed st various times on the same machine. During a drying-out run, for example, the insulation resistance rises as the winding dries out, although it may fall slightly at first. When mrasursments are made at regular intervals as part of the maintenance routine, it is thus poseible to detect an abnormal condition of the insulation and take steps to remedy it before a failure ocrors.

The following rule is given to indicate the order of magnitude of stator insulation resistance which is satisfactory for a clean dry machine at approximately 75 C, but considerably higher values are often obtained.

Insolation resistance (in megohms) =

$$\frac{\text{Machine Voltage} \times 3}{\text{Rared Kva} + 1000}$$

Example: 400-kw, 500-kva, 450-volt a-c generator

$$\text{Ins res} = \frac{450 \times 3}{500 + 1000} = 0.900 \text{ megohms}$$

ORYING OUT MACNINES

If there is reason to believe that thr windings have been exposed to moisture during shipment or erection, it is well to subject them to a drying process before putting the machine into regular operation. The windings can be dried by passing current through them or by using external heat.

One method of circulating current through the windings without subjecting them to full voltage is to drive the machine at reduced speed with the armature short-circuited and with the proper value of excitation applied to the field to give less than rated armature current. A second method of circulating current through the windings is to apply direct current to the armature.

It is essential that the heat be brought up gradually at first, the aim being to allow the water vapor to find its way out through the natural pores in the material in much the same manner as it camr in. Too rapid heating is likely to develop such steam pressure in local portions that new passages are forced through the insulation, thus injuring it psrmanently. It is generally desirable to take 15 to 20 hours in bringing the temperature up to the value required. This depends in some exteot on thr method of heating and measuring temperature, but a maximum temperature of 75 C as measured on the external portions of the insulation is considered good practice. It must be remembered that the temperature of the insulation in the internal parts of the machine near the copper itself may be at a considerably higher temperature than that measured on the external surface of the coil.

This external temperature of 75 C should be as uniform as possible throughout the machine so that moisture driven from one portion will not condense on another. Sufficient thermometers must be used to assure that no part reaches an excessive temperature. After the temperature has risen to the maximum value specified, it must be held practically constant until the insulation resistance reaches the desired value. Measurements of insulation resistance must be taken at regular intervals, and it is desirable to plot the values in the form of a curve of resistance ve time. The drying-out process should be continued until the resistance remains essentially constant at a high value.

During and after the process, the external temperature of the coils should not be allowed to drop below that of the surrounding air. Moisture will thereby be prevented from condensing on the coil surfaces and nullifying the effect of previous drying.

When the heat for drying out the machine is to be obtained from an external source, the machine should be covered and the heat supplied preferably by electric space heaters. The aim is to obtain a uniform temperature of 75 C throughout the machine. The covering over the machine may be either a fairly close fitting wooden box or a tarpaulin. It is preferable for the heaters to be located at the bottom of the enclosure, and the clearance between the machine and the enclosure should be small enough to cause most of the heated air to pass through the ventilating spaces of the machine. The machine should be protected against direct radiation from the heaters, and inflammable material should be kept away from the heaters. If a wooden box is used, it is advisable to line the lower part with asbestos.

Readings of insulation resistance should br taken periodically during the drying-out process in order to determine the length of time required for the process. This has been explained more fully for the other method of heating.

TEMPERATIIRE AND VENTILATION

For the generators to meet their temperature guarantees, they must be provided with an adequate volume of cooling air. Air is circulated through the machine by the blowing action of the poles. Sufficient cooling air will br drawn through the machinr if the air intake and discharge openings are free

from obstructions for a distance away from the machine equal to the maximum dimension of the opening.

POWER CONNECTIONS: Armature leads

The main generator terminals are brought out slightly to the right of the vertical center line at the bottom of the generator frame. Terminal information is tabulated in the section entitled TERMINALS. A conduit box, which is completely open at the bottom, is provided to house the generator armature leads.

CONTROL WIRING: Field Leads

The leads from the generator field are attached directly to the generator side of the bearing pedestal below the brush-holder arm. Terminal information is tabulated in the section entitled TERMINALS. A conduit box, attached to the bottom of the pedestal, is provided to house the generator field leads.

LUBRICATION

The bearing is connected to the forced-feed lubrication system of the prime mover which furnishes oil at a pressure of approximately 8 psi. An orifice at the bearing inlet reduces the oil pressure at the bearing to a value which permits a flow of 1/2 gpm.

STARTING UP

It is recommended that a final check be made just before starting up the machine in order to be sure that all necessary work has been done.

The air gap should be uniform around the periphery of the machine, and it should be free of all foreign matter. Bolts, tools, small pieces of iron, etc., should be kept away from the machine so as not to be attracted by magnetic force to the field poles or armature. Any such objects drawn into the machine may jam in the air gap between the armature core and the field poles and cause serious damage.

If the collector rings have been protected by paraffin, both the rings and the brushes should be cleaned with gasoline before the machine is started up. In order to eliminate fire risk, the collector and brushes should be dry before operation is resumed.

The provisions for lubrication of the bearing should be checked to assure proper oil flow. Once the machine is started, the flow of oil should be checked at the appropriate sight flow indicator in the oil piping.

Before actually starting the machine, it should be made certain that the line conductors are not grounded. When the generator is to be synchronized with other machines on the system bus, the usual caution should be to assure proper phase rotation, frequency and voltage.

OPERATION

PHASE SEQUENCE

The phase sequence obtained on this generator referred to the correct direction of mechanical rotation is stated under the heading PHASE ROTATION. Reversing the field connections does not affect the phase rotation. Should it be desired to reverse the phase rotation of the emf of the bus to which the generator is connected, any two of the bus leads from the generator terminal board may be disconnected and reconnected, each to the terminal from which the other was removed.

EXCITATION

When an a-c synchronous generator operates alone without being paralleled with other generators, the field current is adjusted by the voltage regulator for each change in load so as to maintain rated voltage.

When such a generator is operating in parallel with a system on which the voltage is constant, changes in field current alter the magnitudes of the in-phase and reactive loads carried by the machine.

CAUSES OF INSUFFICIENT VOLTAGE

Insufficient voltage may be attributed to any of a number of causes. The regulator may be set for too low a voltage; part of the armature of field winding may be short-circuited or improperly connected; or the power factor may be too low. It is possible that the switchboard instruments may be incorrect so that the voltage or current may actually be greater than that shown by the readings.

SUGGESTIONS FOR IMPROVED COLLECTOR PERFORMANCE

If all the ship's service generators are not in continuous operation, it is recommended that the load be transferred from one machine to another on alternate days so that no machine will remain idle continually. By this means, the surface of the collector will be kept in the proper condition. Whether or not the machine assumes all or part of the load on various days, it should be brought up to speed daily and run for a few minutes at least. If this is not possible, the collector rings should be protected from rust and corrosive fumes by the application of a little paraffin to the rings while they are still warm and while the machine is coming to a stop.

SHUTTING DOWN

It is important that all switches and breakers be open when the machine is not running.

Protection of the collector rings is discussed in the preceding section.

If the machine is to be shut down for an extended period of time, it should be adequately protected from dirt, moisture, rust, and corrosive fumes.

MAINTENANCE

ORDERING RENEWAL PARTS

When ordering renewal parts, always refer to complete nameplate data including SERIAL NUMBER.

ROUTINE INSPECTION DURING OPERATION

MACHINE TEMPERATURE

The appearance of excessive temperature in any part of the machine is an indication that trouble exists. The situation should be investigated immediately and the cause removed. Routine checks on temperature are recommended so that such conditions may be discovered before serious damage is done.

The temperature of the bearing is indicated by a thermometer in the bearing cap. This temperature should not exceed 180 F. Also, an abnormally high temperature of the air discharged from the machine should be regarded as a warning of trouble.

COLLECTOR RINGS AND BRUSHES

Recommended procedure for improved brush and collector operation is outlined on the preceding page under Suggestions for Improved Collector Performance.

SPARKING

Sparking, when it occurs in regular operation, is, in general, caused by imperfect contact between brush and collector ring. This may be due to any of the following causes:

1. The presence between the brush and the ring of dirt or particles broken from the edge of the brush.

2. Lack of free movement of the brush in the holder because of either too tight a fit or cramping due to too loose a fit. Brushes may stick in the holders because of the collection of dust between the brush and holder. This dust may conduct sufficient current to fuse the dust to the brush and the brush to the holder.

3. Sluggish springs which fail to keep the brush in contact with the ring when there is any vibration.

4. Rough, untrue, or rusty collector rings which cause momentary separation between the brush and the ring.

5. Vibration of collector rings, brushes, or brush supports which also causes momentary separation.

6. Incorrect alignment of brushes and rings which results in the overhanging of a thin edge of the brush which chips and breaks off.

7. Excessive current densities due to overloads. The mechanical contact is never perfect, and high current density will cause sparking with brush fits that would be accurate enough for normal densities.

8. Insufficient spring tension. Blackening and cutting of the ring is an indication of bad brush service. When sufficient graphite is present for good lubrication, the brushes on the ring which has the highest polish may be considered to be giving the best service.

9. Occasionally, ring trouble will arise from a ring's not being of uniform hardness. Uneven wear results from this, and such a ring should be replaced.

10. Brush "chatter" accompanied by sparking frequently results from a long period of operation with an unusually low value of field current, as when a standby generator is kept running without load. If this occurs, the load should be carried alternately by all the generators on the ship.

In general, to stop sparking it is necessary to get good contact between the brush and the ring, and the causes of sparking previously listed should be removed. It often happens that one brush is carrying more than its share of the current. The pressure on such a brush should be relieved temporarily, and the pressure on the other brush on the ring should be adjusted until each brush carries its proper share of the current. Excessive pressure should be avoided because of the resulting mechanical wear.

FREQUENT PERIODIC INSPECTION AND SHUTDOWN

CARE OF COLLECTOR RINGS AND BRUSHES

As the brushes become shorter from wear, the springs should be tightened so that proper brush pressure is maintained.

Collector rings and brushes always tend to gather dust. If this dust is allowed to accumulate, it may break down the insulation of various parts of the machine. It will also cause sticking of the brushes in the holders.

For this reason, the brush-holder and collector parts should be kept clean. Best results will be

obtained if all brushes are removed from the holders frequently and thoroughly wiped off and the insides of the brush boxes given a thorough cleaning. A piece of canvas dipped in a grease solvent is recommended for cleaning the brush rigging and collector parts.

Since there is always an electrolytic action at surface of the collector rings, their operation is improved by occasionally reversing the polarity of the rings. It is recommended that this be done once a week if the machine can be shut down long enough to make the change. Sometimes trouble will occur on one ring only, and by reversing the polarity every day or so, the trouble will disappear entirely.

Any black spots that appear on the surface of the collector should be removed by rubbing lightly with fine sandpaper. It is very important that this be done; for while these spots are not serious in themselves, they will lead to pitting of the rings and the necessity for regrinding. However, no harm is done to the rings if the condition is corrected at once.

Sometimes an imprint of the brushes will be found on the rings. This can be due to the action of acid fumes or oxidation on unprotected collector rings during an extended shutdown. The fumes or oxidation attack the rings except for the parts covered by the brushes; so a high spot remains under each brush. When the machine is again brought into service, the brushes jump slightly as the high spots pass beneath the brushes, and the resulting arc burns the imprint of a brush behind each high spot. As noted in a previous section, the application of paraffin to the rings as the machine comes to a stop will protect the rings during an extended shutdown.

Another cause of brush imprint on the rings is a slight unbalance in the rotor or eccentricity in the collector rings which causes a jerking or movement of the rings once every revolution. This causes the brush to jump and produces a small arc which in time burns the imprint of the brush on the ring.

The location of brush imprints due to acid fumes or corrosion will depend upon where the machine happened to stop, but the imprints caused by rotor unbalance or eccentric rings will always be in the same location relative to the rotor.

Regular inspection should be made to see that the collector rings are perfectly cylindrical and running true. If they are not, it may be necessary to turn down the surface of the rings. This should be attempted only when the collector assembly is tight.

INSULATION RESISTANCE OF STATOR AND ROTOR

It is recommended that the insolation resistance of the stator and rotor windings be read once every two weeks, and no less frequently than once a month. As noted under the heading, INITIAL OPERATION, the values of resistance of the insulation are useful chiefly in showing a trend. A trend toward lower insulation resistance can be a warning of impending failure of the insulation; so the readings obtained at any particular time should be compared with the previous readings in order to be of maximum significance.

OCCASIONAL INSPECTION AND SHUTDOWN

It is advisable to give the machine a thorough inspection occasionally; and in doing so, the drip covers and end bells should be removed.

ALIGNMENT

Once the generator has been properly installed, there should be little need for further adjustment of the alignment. However, it is important that such adjustments be made if necessary; so an occasional check on the alignment is recommended.

The air gap between the stator and rotor should be checked for uniformity around the periphery. The top half of the bearings should be removed and a check made to see that the journal is properly centered in the bearing.

COILS AND CONNECTORS

A check should be made for loose field coils, armature coils, and connections. All coils and connectors should be tight and free from oil and moisture.

CLEANING THE WINDINGS

Occasionally the accumulated dust on all parts of the windings should be blown out by means of compressed air. The pressure used in such service should not exceed 25 psi. When the available compressed air is at a higher pressure, a throttling valve should be used. Before turning the air blast on in the machine, any accumulation of water in the air pipes should be blown out, for the damage which the water will cause would outweigh the benefits derived from removing the dirt. The air should be directed through the vent ducts in the stator core, as well as toward the windings, for an accumulation of dirt in the vent ducts impedes the free flow of cooling air.

Cleaning with air pressure should be followed by a thorough wiping with a cloth. The dirt which clings to the field coil washers should be removed carefully, for it may accumulate and form a conducting path from the coil to ground.

In some marine installations, the windings of electrical apparatus become covered with oil or grease due to the presence of oil vapor, or even

direct leakage of oil from bearings, etc. Although windings which are to be subjected to this kind of service are treated with an oil-resisting varnish, the prolonged presence of oil may prove harmful, due to the fact that it will collect current-conducting dirt and carry this dirt to all parts of the winding. For this reason, it is desirable to clean any accumulation of oil or grease from the windings of such apparatus at fairly regular intervals. The maximum time interval between cleanings depends upon the rate at which dirt and grease accumulate on a given generator.

There are three types of grease solvents which may be used for cleaning the insulated windings of electrical apparatus. These are benzine or gasoline, carbon tetrachloride, and a mixture of benzine or gasoline with carbon tetrachloride. The characteristics of these grease solvents are the following:

BENZINE OR GASOLINE: Either benzine or gasoline is very inflammable, and their vapors mixed with the proper percentage of air are quite explosive. If this type of solvent is used, there should be good ventilation, and every care taken to avoid fire risk. Care should also be taken to see that the workers' clothes do not become saturated with the solvent. Clothing which does become saturated with the solvent should be removed before the worker leaves the job.

Of the three types of solvent, benzine or gasoline has the least corrosive action on the insulation varnish and should therefore be used in preference to the other solvents where conditions permit.

CARBON TETRACHLORIDE: Carbon tetrachloride is noninflammable and nonexplosive.

This solvent is much more corrosive in its action than either benzine or gasoline. As it is a solvent of rubber, it should not be used on the leads and any other parts where rubber insulation is used. Care must be taken to protect adjacent parts also from corrosion. Because of its toxic effect, adequate ventilation must be provided. With these precautions, carbon tetrachloride, which evaporates quickly, may be used for cleaning the windings with small risk of damage. Its use is preferable where fire risk is high.

MIXTURE: A mixture of 50 percent carbon tetrachloride and 50 percent benzine, or 60 percent tetrachloride and 40 percent gasoline, is noninflammable; but the vapors mixed with the proper amount of air are explosive. There should be fair ventilation so that the explosive fumes will not accumulate. There is no particular danger from spilling these mixtures on the clothing. This solvent may therefore be used where there is fire risk, but only where the ventilation is sufficient to prevent the accumulation of an explosive mixture of fumes.

OPERATION OF CLEANING THE WINDINGS: Waste or a dry cloth should be used to wipe as much of the oil or grease from the winding as possible. Then waste, or a cloth, moistened with one of the recommended solvents should be used for cleaning the windings. Inaccessible parts of the machine may be reached with a swab moistened with solvent, or in some cases a spray of the solvent may be directed at the winding with sufficient force to wash away the oil.

Whenever possible, the parts which have been cleaned should be dried with clean waste or rags in order that the insulation varnish may not become soft from prolonged exposure to the solvent. If the varnish coating of the windings shows considerable deterioration, the windings should be retreated with a varnish furnished by the manufacturer. In any case, the machine should be given an opportunity to dry out thoroughly before being placed in service.

EMERGENCY REPAIR MEASURES

REBABBITTING OIL BEARINGS

In case it is necessary to rebabbitt an old bearing on a ship, it is necessary to melt out the old babbitt and prepare a suitable mandrel. Since the bearings are split, each half should be babbitted individually. The mandrel should consist of a half cylinder with shoulders running along its length so that the sides of the bearing may rest on them and form a close fit. Pieces of felt should be placed around the end of the bearing shell to prevent the babbitt from running out at the ends.

Only a good tin base babbitt such as N. D. Spec. 42M2, Grade 3, or an approved lead base babbitt should be used for such work. The melted babbitt should be poured into the gate until it begins to overflow. Sufficient time should elapse after the pouring and before the mandrel is removed from the bearing to allow the babbitt to become quite hard.

The bearing should then be bored or reamed to the proper size as shown on Fig. 72. Holes for the introduction and draining of oil from the bearing should be drilled, and the proper machining done to provide grooves at the splits and eccentric chambers for the oil in the center of the bearing. The finishing operations may be done with a suitable scraper.

REPLACING BEARING SEAL STRIPS

To replace the bearing seal strips, the seals should first be removed from the pedestal. The old seal strips and lock strips may then be removed from the seal. The new seal strips (74, Fig. 71) and lock

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strips (75) are then inserted, and the lock strips are caked into place with a round-nose tool. The strips are machined at the splits and bored to a diameter of 5.012 to 5.013 in. The seat may then be reassembled.

DISMANTLING GENERATORS

Lifting the parts of the generator set should be done with the greatest possible care. The a-c generator, the d-c generator, and the bearing pedestal are equipped with eyes in which the crane hook should be inserted when each piece is lifted. Each of the stationary pieces and the rotor must be lifted separately, for the generator set is not designed to be lifted as a unit.

REMOVAL OF D-C GENERATOR ROTOR AND STATOR

To remove the rotor of the d-c generator, first open the hinged cover, and lift the brushes away from the commutator. Then unbolt and remove the end cover. Remove the cotter pin from the end of the shaft and take off the quill out. Slide the rotor off the shaft and lift it out.

To remove the d-c generator stator, first remove the end cover and the rotor. Disconnect the leads (F_1--A_1--A_2) at the terminal box. Unbolt the drip cover. Remove the holding down bolts and dowels. Slide the stator out until the rocker ring and the brush holders clear the shaft. Then lift out the stator.

REMOVAL OF BEARING

To remove the bearing, first unbolt and remove the drip cover between the a-c and d-c generators. Unbolt and remove the bearing cap, bearing seals, and thermometer. Lift out the top half of the bearing. Jack the rotor off the bearing, and roll out the lower half of the bearing.

REMOVAL OF PEDESTAL AND A-C GENERATOR ROTOR

To remove the pedestal, first remove the d-c rotor and stator and the bearing. Disconnect the oil inlet and oil drain at the pedestal. Disconnect the a-c generator field leads. Unbolt the pedestal from the base. Slide the pedestal out until it is clear of the supports, and roll it out.

To remove the a-c generator rotor, first unbolt and remove the front and rear end bells, collector cover, and coupling cover. Shim the air gap. Remove the complete d-c generator, the bearing, and the pedestal. Place sling over the ends of the shaft. Unbolt the coupling, and break the pilot fit. Slide the rotor out until it is possible to start skewing it. Place a sling around the a-c generator rotor at the center line, and continue to skew the rotor until the coupling flange will pass the stator coils. Then slide the rotor clear, and lift it out.

In lifting the rotor, it is preferable to use rope slings around the shaft. If the chains are used, they should not be looped around the journals unless the latter are properly protected. In no case should the ropes or chains be allowed to exert pressure on the windings or collector rings.

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EXHIBIT S

RESTRICTED

G. M. Corp. - Diesel Engine

MODEL 3-268A

2 Cycle—Automatic Electric Starting
Unit Injector

3 Cylinders—6½" Bore—7" Stroke

Emergency Generator Set—100 K.W. at 1200 R.P.M.

U. S. NAVY

INSTRUCTIONS FOR THE CARE AND OPERATION OF THE ENGINE

Federal Shiphuilding & Dry Dock Company

4 Sets	Purchase Order	194-145
8 Sets	Purchase Order	206-408
6 Sets	Purchase Order	222-825
4 Sets	Purchase Order	229-825

Bath Iron Works Corporation

2 Sets	Purchase Order	620-40-402

Seattle-Tacoma Shipbuilding Corporation

5 Sets	Purchase Order	453-23
5 Sets	Purchase Order	645-25

Bethlehem Steel Company, San Francisco, Calif.

2 Sets	Purchase Order	R-215-1702-F
7 Sets	Purchase Order	R-215-1703-F

Bethlehem Steel Company, Staten Island, N. Y.

2 Sets	Purchase Order	U-215-1605-F
3 Sets	Purchase Order	U-215-1606-F

Bethlehem Steel Company, Quincy, Mass.

4 Sets	Purchase Order	S-215-408-F-1516

Bethlehem Steel Company, Terminal Island, Calif.

6 Sets	Purchase Order	RD-215-1704-F

Navy Yards—Federal Shipbuilding & Dry Dock Company
Purchase Order NA-2

2 Sets	Boston, Mass.
2 Sets	Charleston, S. C.
4 Sets	Boston, Mass.
2 Sets	Norfolk, Va.
2 Sets	Philadelphia, Pa.
2 Sets	Charleston, S. C.

EXHIBIT "S"

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Section O

ATTACHED PUMPS, AND CLEARANCES
LIST OF DRAWINGS
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ATTACHED PUMPS—DATA AND RATINGS

Based on an Engine Speed of 1200 R.P.M.

Fuel Oil Pump

Manufactured by.....Northern Pump Co., Minneapolis, Minnesota
Location.....Below the generator end of the exhaust manifold
Pump speed—revolutions per minute.....1906
Capacity—gallons per minute.....0.8
Discharge pressure—pounds per square inch.....40-50
Suction—inches of mercury.....15
Power required—brake horsepower.....0.285

Lubricating Oil Pump

Maoufactured by General Motors Corp., Cleveland Diesel Engine Division
Location.....On blower end ol engine
Pump speed—revolutions per minute.....1200
Capacity—gallons per minute.....24
Discharge pressure—pounds per square inch.....35-40
Velocity through intake elbow—feet per minute.....310
Velocity through discharge elbow—feet per minute.....260
Maximum viscosity at 210° F.—Seconds Saybolt Universal.....70
Minimum viscosity at 210° F.—Seconds Saybolt Universal.....60
Power required—brake horsepower.....1.8

Cooling Water Pumps

Manufactured by.....Ingersoll-Rand Co., Phillipsburg, New Jersey
Location.....On blower end of engine

	Fresh Water Pump	*Sea Water Pump*
Capacity—gals. per min.	50	85
Pressure difference—lbs. per sq. in.	22	28
Dia. of suction flange—in. I.P.S.	2½	2½
Dia. ol discharge flange—in. I.P.S.	2	2
Velocity at suction flange—ft. per min.	140	230
Velocity at discharge flange—ft. per min.	200	330
Outside dia. ol impeller—in.	$5\frac{5}{16}$	$6\frac{1}{16}$
Efficiency—%	50	58
Brake horsepower	1.29	2.36
Total head in feet	51	64
R.p.m.	2492	2492

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CLEARANCES

Exhaust valve stem cap clearance—cold.....0.018″

Piston—clearance in cylinder bore—total on diameters:

Top of upper taper at top of head.....0.0545″ to 0.0575″

Bottom of taper, below 4th ring groove.....0.0185″ to 0.0215″

Lower end of skirt.....0.0115″ to 0.0145″

Compression piston rings:

Gap width, rings compressed in cylinder liner bore.... 0.010″ to 0.020″

Clearance between groove sides:

Top 2 rings.....0.0055″ to 0.0080″

Second 2 rings.....0.0025″ to 0.0050″

Oil-control piston rings:

Gap width, rings compressed in cylinder liner bore.... 0.010″ to 0.020″

Clearance between groove sides.....0.0025″ to 0.0055″

Piston top below cylinder head—crank at top dead center:

Normal clearance..... 0.033″

Minimum and maximum clearance—

total effect of maoufacturing limits..... 0.022″ to 0.055″

Main bearings—clearance in diameter..... 0.005″ to 0.008″

Main thrust bearing—total endwise clearance..... 0.010″ to 0.013″

Crankpin bearings—clearance in diameter.....0.0045″ to 0.0070″

Piston-pin roller bearing—

total clearance in bearing diameter.....0.0012″ to 0.0026″

Piston-pin bearings in piston:

Clearance in diameter.....0.0007″ to 0.0022″

Camshaft bearings—clearance in diameter.....0.0025″ to 0.0055″

CAPACITIES

Capacity of Lubricating Oil io Engine and Oil Pan—Gallons.....24

Capacity of Fresh Water System—Gallons.....7.3

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LIST OF DRAWINGS

Generator, Exciter, and Starting Equipment

Title	Drawing Numbers Gen. Elect. Co.	Bu. Eng. Type "D"
Uniform Specifications	W5051501	
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Maintenance

When the fuel pressure in the supply manifold drops abnormally, as shown on the pressure gage, the filter needs a more thorough cleaning. The control valve handle is turned to shut off the flow of fuel through the filter, so that the case may be drained and removed. The outer filtering element is unscrewed from the head, and the thread in this joint is left-hand. The filtering elements are washed with a soft cloth and carbon tetrachloride. Care must be taken to prevent the entrance of dirt to the inside of the elements while they are being washed. The elements must not be cleaned with a wire brush or a scraper.

When refilling the filter, the vent valves in the head must be open to prevent the formation of an air pocket, which would result in air-locking the injectors and stopping the engine.

LUBRICATING OIL SYSTEM

See Fig. 8

The attached lubricating oil pump is mounted below the blower. The pump is of the positive displacement type, and the pump rotors are helical spur gears.

The pump draws hot oil from the oil pan through a strainer in the pump suction line. A spring-loaded, pressure relief valve is built into the discharge passage in the pump body, and the by-passed oil is returned to the blower and pump drive housing. The pump forces the oil through a filter and cooler, and then into the engine lubricating system. The engine inlet connection, on the blower and pump drive housing, is fitted with a spring-loaded by-pass valve. The spring pressure is adjusted by a regulating screw, so that the oil enters the engine lubricating system at 35 to 40 pounds gage pressure. The surplus oil is by-passed into a blower housing passage, from where it is returned to the oil pan.

Lubricating Oil Recommendation

The oil recommended for use in this engine is Navy Oil Symbol 3065.

Lubricating Oil Filter

The filter case contains a cylindrical filtering element of the edgewise-wound, metal ribbon type. A handle is used to revolve the filtering element under metal cleaning blades. The filter should be cleaned frequently when the engine is running, by turning the cleaning handle one or more complete revolutions. This kind of cleaning should be done at least every four hours, and more frequently if necessary. The pressure drop through the filter is an indication of the condition of the filtering element.

Maintenance

At the end of every one hundred hours of filter operation, a more thorough cleaning is needed. The filter is drained, and the filtering element is removed from the body. Then the element is thoroughly cleaned with a salt cloth and carbon

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tetrachloride. Care must be taken to prevent the entrance of dirt to the inside of the element while it is being washed. The element must not be cleaned with a wire brush or a scraper.

Lubricating Oil Cooler

The lubricating oil is cooled in a Harrison Radiator heat exchanger that is made up of a tube bundle and an enclosing case. The tubes are oblong and each tube encloses a baffled structure, which forms a tortuous passage for the flow of oil. The tubes are fastened in place with header plates at the ends, which separate the cooling water space in the case from the oil ports in the end covers. The tube bundle is permanently attached to the casing.

Maintenance

The oil cooler should be cleaned as soon as the cooling effect is materially reduced or the flow through the cooler is restricted. The cooler is removed from the engine, and the end covers are removed. The cooler should be cleaned immediately after removal. If cleaning is postponed, or if air is blown through the tubes before the unit is immersed in the cleaning bath, the oil sludge inside the tubes will harden and it will be difficult to dissolve and remove it.

During the cleaning operation, the cooler should be handled carefully to avoid injuring the tubes. The cleaning should be done in a room with adequate ventilation, or in the open air, on account of the toxic qualities of carbon tetrachloride (Pyrene fire extinguisher fluid), which is used as the cleaning fluid. Frequent wetting of the skin with this fluid should be avoided because the toxic effects are cumulative. Immersion of the hands in this fluid should also be avoided. The cleaning procedure is as follows:

The cooler is completely submerged in a bath of carbon tetrachloride with the tubes vertical. The lower end of the cooler must be blocked above the bottom of the bath with any soft material, so that the cleaning fluid can flow under the tube ends. The surface of the bath should be at least one inch higher than the upper end of the tube core.

The cleaning fluid is surged up and down through the tubes with a 'force cup' for a minimum time of thirty minutes. The 'force cup' is the rubber suction cup fitted with a handle that is commonly used for opening up an obstructed drain pipe of a kitchen sink or other household plumbing equipment. When the cooler is removed from the bath, the tubes are further cleaned, inside and outside, with compressed air at ninety pounds pressure.

No wires or other prods which would injure the internal structure of the tubes should be used in the cleaning operation.

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For a detailed description of all the electric starting equipment and its operation, see the electrical instruction book in Section 9.

Operation and Maintenance

How often the parts of the starting motor system should be inspected can be determined best by experience and the frequency of starting. The following operating and maintenance items should be given particular attention.

Lubrication

Each tapered roller bearing should receive two or three drops of lubricating oil for every one-hundred starts.

The needle roller bearing should be lubricated with No. 44 Keystone grease (or equal) once a year.

The speed reducing gears should be lubricated when overhauling the starting motor. When these gears are being reassembled, place 12 ounces of No. 45 Keystone grease (or equal) in the internal gear. Do not place any grease in the gear housing.

Bendix Drive

To remove the Bendix drive from the gear reduction shaft, remove the drive attachment set screw after lifting the end of the wire lock ring out of the set-screw slot. If access to the screw is obstructed by one of the clutch springs, the clutch may be rotated to expose the screw. Do not drive against the clutch or the clutch plate to remove the Bendix drive from the shaft, but drive against the large hexagon nut.

Clean the screw shaft and the meshing pinion with carbon tetrachloride (Pyrene fire extinguisher fluid). A cautionary note on the use of this cleaning fluid appears in Section 2 in the chapter entitled, "Lubricating Oil System." Oil the screw shaft sparingly with a very light grade of oil. Do not dip the clutch portion of the Bendix drive in the cleaning fluid, because the cleaning fluid may change the clutching action.

Special testing equipment that is owned by the manufacturer is required to adjust the Bendix drive clutch, therefore, do not loosen or remove the large hexagon nut because this would change the clutching values and render the drive inoperative. The clutch is adjusted to slip under a sudden overload, such as would be caused by the back rock of the engine when the battery current is too weak to enable the starting motor to overcome the fully developed compression pressure. Such a sudden overload might cause damage if the Bendix drive were not fitted with the clutch. If the clutch slips during normal cranking, it should be returned to the vendor for readjustment and the type number on the starting motor nameplate should be stated.

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EXHIBIT T

NAVSHIPS 345-0231

HARRISON

HEAT EXCHANGER SERVICE MANUAL

HARRISON RADIATOR DIVISION
GENERAL MOTORS CORPORATION
LOCKPORT, NEW YORK

RESTRICTED

Revised Nov., 1945

EXHIBIT "T"

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2. CLEANING.

a. General.—When cleaning an oil tube heat exchanger, clean the insides of the oil tubes first. If this is not done, the solution (muriatic acid) will become contaminated and made ineffective by the oil.

b. Cleaning inner oil tube surfaces.

(1) Equipment.
The necessary equipment includes a metal tank of 10 to 25 gallons capacity, a centrifugal pump with a capacity of at least 25 gallons per minute, and two lengths of hose (fig. 38). For the large units, use a pump of approximately 75 gallons per minute capacity and correspondingly larger tanks.

(2) Cleaning.
Pump carbon-tetrachloride or trichlorethylene through the cleaning circuit, unless the unit is badly plugged. If the unit is plugged, use a commercial alkaline solution on the Navy approved list for this type of cleaning. Before removing the cooler from installation, place an identifying mark or tag on the outlet side of the unit. Connect this side to the discharge end of the pump. This will insure the flow of solvent through the cooler in reverse direction to normal operating flow, thus speeding up the cleaning operation. Run the second hose from the bottom of the tank to the pump inlet and start the pump. Then inspect every ten minutes until the solution appears clean after having flowed through the unit. Remove all accumulated deposits from the inner surfaces of the covers and casings, clean all gasket surfaces, and replace with new gaskets.

(3) Caution.
Carbon tetrachloride and trichlorethylene give off toxic vapors and, when employed for cleaning purposes, must be used in the open air on deck or in a well ventilated room.

NOTE

If a centrifugal pump is not available, a hand pump may be used. In emergency set-ups a plumber's plunger can be employed to force liquid through the tubes. However, the hand pump and plunger are inferior to the centrifugal pump.

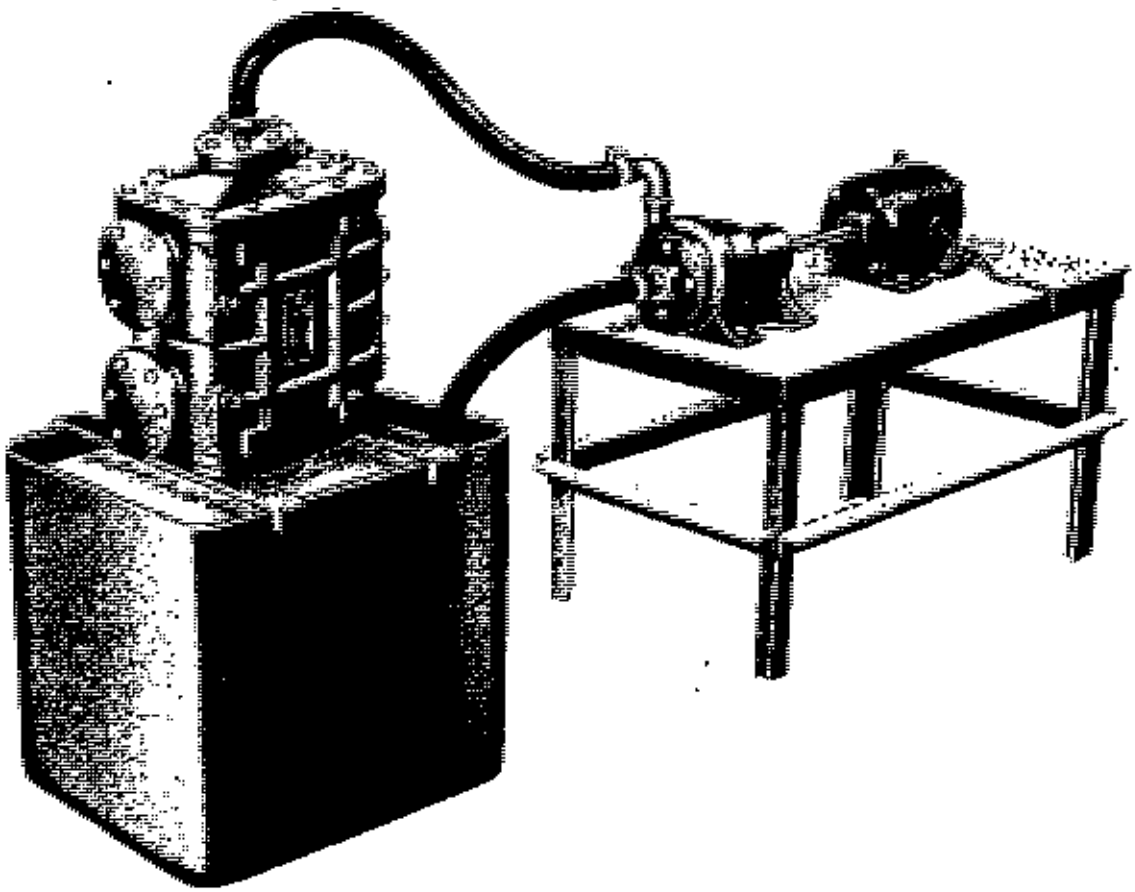


Fig. 38—Use of the centrifugal pump to clean heat exchangers.

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c. Cleaning the water sides of oil coolers, salt and fresh water sides of water coolers.—Equipment includes 3 tanks. Tank (1) must be constructed of earthenware or a suitable material not effected by muriatic acid. Prepare in this tank a solution of 1 part muriatic acid to 9 parts of cold water, adding 1 pound of oxalic acid to each five gallons of solution and .01 gallons of pyridine to each five gallons of acid. Fill tank (2) with cold water and prepare a 5% solution of sodium carbonate in tank (3). The quantity of solution prepared in both tank (1) and (3) will depend on the size of the unit to be cleaned, keeping in mind the fact that the unit must be completely immersed. Using a metal hook or wire, immerse the unit in tank (1) of diluted muriatic acid solution. A bubbling and foaming action commences immediately. As soon as this action ceases, remove the unit from the solution (fig. 39) and submerge it in tank (2) of cold water for approximately one minute. On removal from the water, the unit is immersed at once in tank (3) of sodium carbonate solution until bubbling ceases. Then remove and flush with a hose connected to a supply of fresh warm water, or, if warm water is not available, cold water may be substituted. Duplicate the operation with covers and case, providing the latter has not previously been cleaned; clean all gasket surfaces thoroughly, replacing old gaskets with new ones.



Fig. 39—Muriatic acid Tank and Heat Exchanger core.

3. TESTING.

CAUTION

Gasket sealed connections are designed to withstand liquid pressures. A high pressure air test for casing and gasket leaks will often permanently fracture a gasket and cause excessive leaking that could have been stopped by tightening the nuts on the gasket cover. In extreme cases where an air test is employed, use a low pressure. This same low pressure should be used when testing the circuit of the ship.

a. Testing for leaks in the plate type core.—With this type of cooler, remove the core from the casing before testing. Test the core by attaching an air hose to either the inlet or outlet, plugging the other opening, and submerging the assembly in water. Air bubbles will indicate the point where a leak has occurred. Because this plate type core construction is hydrogen brazed, repairing is not normally recommended. However, in an emergency when spare cores are not available, repairs can be made with a good grade of lead and tin solder. The proper test pressure is clearly shown on the name plate (fig. 16).

b. Testing for leaks in the strut tube exchanger.—Remove the casing covers, plug the coolant outlet, and attach an air line to the coolant inlet. Immerse the unit in water and apply air pressure. The slightest leak will be readily observed by the appearance of air bubbles. Such leaks are usually traceable to soldered joints around the tubes or headers, inasmuch as each individual tube has already been subjected to this type of test. The test pressures specified on the name plate of the strut tube heat exchangers apply only when testing a completely assembled cooler. In a test such as this when the covers are not attached, use an air pressure of less than 100 pounds.

c. Test for leaks in the Wire Wound Double Tube Cooler.—Remove the tanks from the cooler and plug all tell-tale drain holes except one in each core Section. To the unplugged opening, connect air at approximately 100 lbs. per sq. in. Submerge the cooler in a tank of water. Leaks will be readily observed by the appearance of air bubbles. The location of the leaks will be marked with red crayon, and the cooler removed for repairs.

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d. Hydrostatic test for casing and gasket leaks—and final test after repairs for all heat exchangers. (see figure 40).

(1) Test Pressures.—All heat exchangers must be tested at pressures listed on Navy "S" plans or in Navy Specification 66C1. The following paragraphs are quoted from this specification

> "F-2a. The oil sides of oil coolers shall be tested under an oil pressure of at least 15[illegible] pounds gage.
> F-2b. The fresh water sides of fresh water coolers shall be tested with water to a hydrostatic pressure of at least 150 pounds gage.
> F-2c. The cooling water sides of oil and fresh water coolers shall be tested with water to a hydrostatic pressure as follows:
>
> (1) For surface vessels installations, 1-½ times the maximum working pressure or 150 lbs. per sq. in. gage (whichever is greater)
>
> (2) For submarine installations, 1-½ times the maximum pump pressure plus submergence pressure or 300 lbs. per sq. in. gage (whichever is greater)."

The test pressure listed on the name plate are those used by the manufacturer. Refer to the above quotation from 66C1 for pressures to follow in testing service units.

CAUTION

No submarine cooler may be installed until it has passed a hydrostatic test to strict compliance with 66C1.

(2) Test Procedure.—Attach a test fitting and a pressure gauge to the core inlet or outlet. Then fill the core with fresh water or soluble oil, depending upon the cooler's application. Provide proper venting so that there are no air pockets. Pump this liquid up to the pressure listed in 66C1. Permit the unit to stand for a definite period. At the end of this time, check the pressure. If it has dropped, there is a leak to the core side of the heat exchanger. Repeat this test on the coolant side.

4. REPAIRS.

a. Plate type.—Because of their brazed construction, plate type cores rarely develop leaks. Repairs to these are not recommended except in cases of extreme emergency. If repairs are made, replace the repaired cores at the earliest convenience. Should a leak develop along the plate tube seam, it can easily be repaired with a torch, flux, and a solder combination of lead and tin. (fig. 41).

b. Repair of strut tube leaks.—If a leak occurs in the tube itself, it cannot readily be repaired. However, it is satisfactory to block off the tube by inserting a piece of brass, copper, or wire in both ends and soldering securely (fig. 42). This metal insert should



Fig. 40—Hydrostatic test.

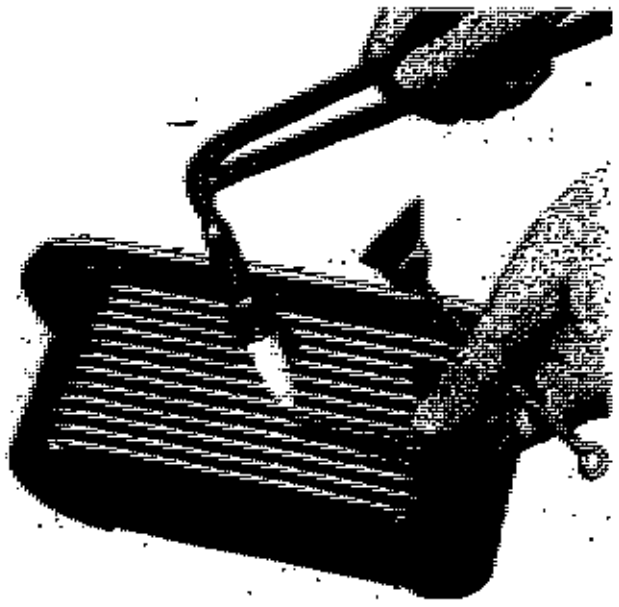


Fig. 41—Soldering plate tube seam leak.

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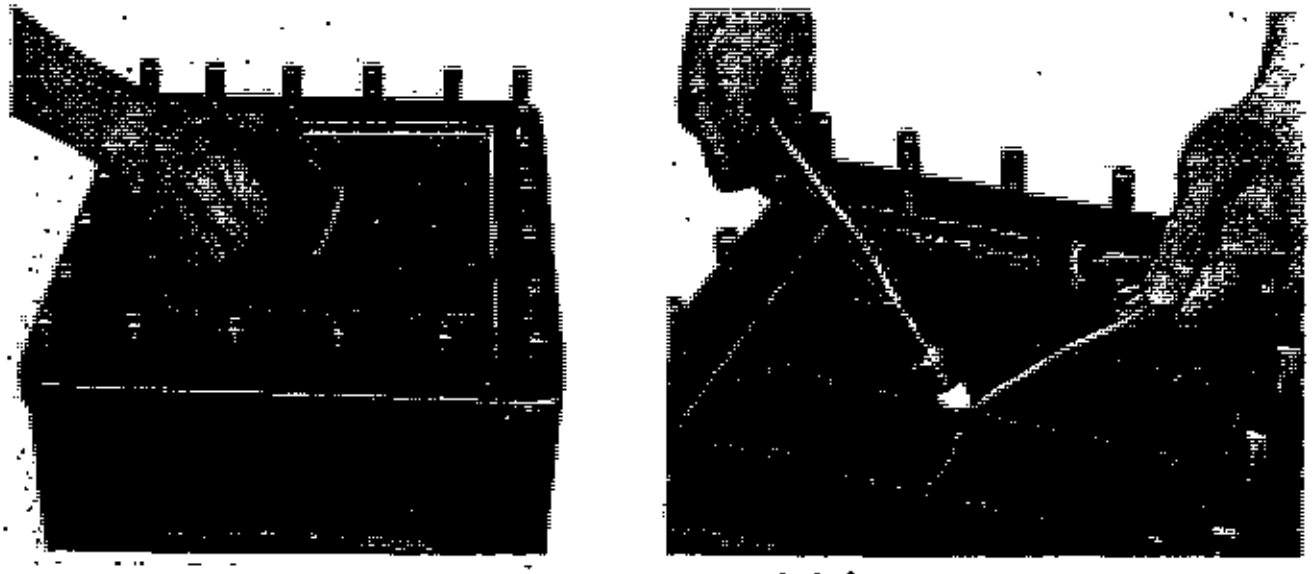


Fig. 42--Repairing a strut tube leak.

be approximately ¼ inch longer than the width of the damaged tube. Bend the ends so that it will fit snugly in an end of the tube and leave a recess for solder. Repeat this operation at the other end of the tube and it is effectively plugged. Be careful not to loosen solder around adjacent tubes with the torch flame. It is not advisable to block off more than 5% of the tubes in this manner, as to do so would result in an undesirable increase in operating temperature, as well as considerable pressure drop. A 20% increase in pressure drop demands immediate investigation and probably replacement of the core with a spare.

c. Repair of header leaks.--A header leak may occur at the point where the tubes protrude through the header plate or where the header is soldered into the case. Occasionally, through excessive or intermittent pressures, the header plate may become cracked in service. Header leaks can be readily repaired by soldering (fig. 43). Before repairing, clean the damaged spot thoroughly with flux by heating. Care should be taken not to burn the tube or header material with too hot a torch flame.

d. Repair of the Wire Wound Double Wall Tube.--Water dripping from the tell-tale drain hole indicates a leak in the double wall tube or between the inner tube and header. Leaks can be located by means of the air tests described previously. It is impractical to repair leaking tubes. However, they can be effectively blocked off by inserting and soldering special plugs, provided by the manufacturer, into each end of the leaking tube, (Figure 44), or pounding in dowels into each end of this tube. These plugs should be available on shipboard. Approximately 5% of the tubes may be blocked off and still allow the unit to function efficiently. If the operating temperature increases sharply, it is an indication that too many tubes have been blocked off, and requires probable replacement of the core with a spare. If the tests indicated a tube to header leak, it is necessary to roll the tube end with an expander. Roll just enough to get a tight joint between the tube and header. Do not roll excessively.



Fig. 43--Repairing a header leak.



Fig. 44--Inserting a wire wound tube plug.

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5. REASSEMBLY.

a. General.—The heat exchanger is reassembled lo a reverse sequence of operations to those described for disasrembly (Section 6, Paragraph f).

b. Gaskets.—Replace all gaskets with new ones.

c. Check that the zincs are clean and in good condltion before installing them io the unit, replacing them with new ones if they do nol meet the requirements described in Soctioo 5, Paragraph 2.

6. TESTfNG AFTER REPAIRS.

After completing any repair operations, a test, identical to that which was employed to discover the leak (Section 6, Paragraph 3), ls conducted to determine if the repalr was successful. If it was not successful, the repair is repeated and the unit retested. The mounting bracket, covers, gaskets, and miscellaneous parts are then reassembled, and the beat exchanger submitted to a final bydrostatic test (Section 6, Paragraph 3 and sub-paragraph d). This will reveal any leaks in either the core or housing.

A typical thermostatic control valve applied on Heat Exchanger installations is illustrated on the following pages.

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EXHIBIT U

INSTRUCTIONS

for

INSTALLATION, OPERATION AND MAINTENANCE

HARRISON

PLATE TYPE OIL COOLERS

INSTALLATION AND OPERATION

1. INSTALLATION

a. Accessibility: The cooler must be accessible so it may be necessary to remove it for inspection or cleaning. Therefore, it should be installed so that it can be disconnected, and the covers, core, and zincs, if any, removed with the least amount of time and effort.

b. Position: Oil coolers may be installed in any position, provided it is convenient to remove the zince and drain water or rust the unit. When the installation is made, care should be taken to prevent air locks, as the cooling liquid must cover the tube or plate surfaces constantly to insure maximum efficiency.

CAUTION: If temperatures below freezing are encountered during non-operational periods, the cooler should be thoroughly drained to prevent ice from forming and bursting the tubes.

c. Direction of Liquid Flow: Unless otherwise specified, the oil to be cooled circulates through the tubes and the coolant flows through the casing and around the tubes. It is satisfactory for the liquids to be circulated in either direction through the cooler although counter-flow between them should be maintained.

d. Liquid Specifications: Oil to be cooled should be free of solids larger than .050". The coolant liquid should be free of foreign substances larger than .020".

e. Strainers and Filters: The use of strainers is advised when solids larger than those specified are present. In certain types of service suitable filters may also be required to maintain standard efficiency.

f. Pressure Relief Valves: In cold weather the oil viscosity may cause a temporary increase in pressure drop, which decreases as the oil warms up. If the initial pressure exceeds the recommended safe load on coolers, pressure relief valves or a pressure control by-pass should be installed for protection of oil cooling and circulating equipment.

g. Installations on Hydraulic Pumps: It is specifically recommended that on hydraulic pump installations the heat exchangers be mounted on the suction side rather than the pressure side of the pump or in an independent circulating system. Despite the use of safety devices designed to eliminate extreme pressures, it has been evident that heat exchangers have been damaged due to pressure above normal.

h. Piping Layouts: All piping leading into the heat exchanger should be straight and free from angles, as far unnecessary, to prevent restriction of flow.

i. Zincs: All coolers assigned for marine service are provided with one or more zinc electrodes. It should be determined that all required electrodes have been installed in the heat exchanger prior to placing in service.

j. Prevention of Gas Not Leaks: Check all bolts for tightness before installing any heat exchanger.

EXHIBIT "U"

2. OPERATION AND ADJUSTMENTS AFTER INSTALLATION

a. Velocity: The quantity of sea-water through the cooler should not be allowed to exceed that specified. The rate or flow of the coolant should be adjusted to a minimum and only sufficient to maintain the required operating temperatures.

b. Venting: After a unit is installed and cooling water admitted, the vent plugs should be individually removed until water flows from the vent. The plugs are then replaced. This is for the purpose of removing air pockets.

c. Operating Temperatures: Manual or any automatic control valves used in the circuit must be adjusted to the desired satisfactory operating temperatures. Improper adjustment of valves may result in unsatisfactory cooler performance.

d. Operating Pressures: All Harrison Heat Exchangers are tested at pressures in excess of those required in actual operation; nevertheless they must not be subjected to pressures in excess of those specified.

Unless otherwise specified, Plate Type Coolers are tested for marine operating pressures as follows:

PLATE TYPE COOLERS

Core Constant	150 lbs. per sq. in.
Core Refrigerating	75 lbs. per sq. in.
Cham Constant	75 lbs. per sq. in.

MAINTENANCE

a. SERVICE

a. Temperature Control: Heat Exchangers, like any equipment, will perform their functions best when properly maintained. The function of Harrison Oil and Jacket Water Coolers is to maintain specified temperatures. When the temperature of the liquid to be cooled rises above normal, it is an indication that some part of the temperature control gated is not functioning properly. Inspect all manual and automatic control valves in the open or correct operation. Check all pressure gauges and thermostats. Inspect the water lines and see that the proper flows through the coolers have been provided. Clean all filters. Make certain that the heat exchangers have been vented.

If the temperature does not return to normal after these adjustments have been made and the specified amount of cooling liquid is circulating around the oil or jacket water core, the cooler should be inspected for foreign deposits. When such materials accumulate in the heat exchangers to the extent that cooling efficiency is impaired, they can be removed by a simple cleaning process described below.

The removal of mineral deposits from the water sides, or carbon and sludge from the oil sides of the exchangers, involves no great amount of time or elaborate equipment, yet insures excellent performance if carried out periodically. The cleaning periods are determined by the type and condition of the oil and water used and the operating conditions. The period between cleanings can be extended by the use of strainers and filters in the oil and water lines.

b. Zinc Electrodes: Sacrificial zinc electrodes (anodes) are provided in Harrison coolers designed for marine use.

The structure of a Heat Exchanger is composed of several basic metals; on the other hand, new motor coolants contain chemicals to solution. An electric cell is therefore created inside the cooler and zincs are necessary to avoid electrolytic corrosion.

IMPORTANT: The concentration of chemicals and the temperature rating in new water, and consequently the disintegration of zincs will be more rapid under these conditions, particularly where the water is warm. It is important that the zincs be inspected once every third core. The condition of the zincs at the time of inspection should govern the policy for future servicing. Upon inspection, zincs may be found to be corroded and coated with foreign material, thereby retarding or greatly reducing their effectiveness. This must be removed by fine emeshing and scraping. If after cleaning, the zinc is found to be more than 50% disintegrated, it must be replaced. Make certain that zincs are tightened to insure a good metal contact.

CAUTION: If an oil cell is not to be cleaned or repaired for several days after its removal from installation, allow it to soak in a solvent during that period to prevent hardening of the sludge and carbon deposits on the tube walls.

NOTE: EXERCISE CAUTION IN HANDLING TO PREVENT ANY DISTORTION OF THE STUDS OR CORE.

2. DISASSEMBLY

(1) Remove end zinc electrodes
(2) Remove cover plate and gasket
(3) Remove Core

3. CLEANING

Method of Cleaning:

NOTE: In handling the core throughout cleaning operations, use care to prevent injuries. Use care in removing the pieces.

Either the oil or water side of coolers can be cleaned with very little difficulty when the operator has made it a policy to clean at regular scheduled intervals before excessive quantities of lime, rust, scale, oil sludge, and carbon have accumulated.

NOTE: We recommend that both sides of the cooler be cleaned whenever the cell is disassembled for cleaning. It is suggested that the oil side be cleaned first as surplus oil in the passages will dissolve and remove the solution used to clean the water side.

To prevent hardening and drying of accumulated foreign substance, the core should be cleaned as soon as possible after removing from service.

a. Cleaning Oil Side of Coolers:

1. Circulate carbon tetra-chloride, trichlorethylene or kerosene through the pipes with a head or motor driven pump in reverse direction from normal operating flow. This action should be continued until the unit is clean.

CAUTION: If solvents are used, care must be taken to utilize them in accordance with their manufacturers' instructions. It is essential to provide suitable and adequate ventilation as a protection against toxic effects. Fire protection in accordance with local laws must also be provided.

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1. If a circulating cooling is not possible, some cooling can be accomplished by immersion the core in a container of carbon tetra-chloride. After the unit has been allowed to stand in the solvent for a few minutes, force cleaner through the plates with a hand force pump of the ordinary piston or plunger type.

1. An hakite or Alkaline solution is recommended where the oil passages are badly clogged. This should be circulated through the plates. After circulation, flush thoroughly with clean hot water.

NOTE: Flush inside of oil tubes with clean light oil, after both the oil and water sides of coolers have been cleaned.

b. Cleaning Water Side of Cooler:

1. Immerse exposed core in a solution, composed of one part muriatic acid to nine parts cold water, to which one pound of oxalic acid, and .01 gallons of pyridine inhibitor to each five gallons of solution.

1. Remove core when foaming and bubbling stops. This usually takes from one to two minutes. Pressure flush thoroughly with clean hot water.

3. Remove oil foreign substance from inside cover and housing before reassembling. Clean all gasket surfaces thoroughly and use new gaskets wherever necessary.

NOTE: In addition to the cleaners suggested in the preceding instructions, there are a number of other good cleaners and solvents on the market manufactured by reputable concerns. Any one of these would recommend cleaners to meet a particular need.

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INSTRUCTIONS

for

INSTALLATION, OPERATION AND MAINTENANCE

HARRISON

PLATE TYPE OIL COOLERS

INSTALLATION AND OPERATION

1. INSTALLATION

a. Accessibility: The cooler must be accessible as it may be necessary to remove it for inspection or cleaning. Therefore, it should be installed so that it can be disconnected, and the covers, core, and zincs, if any, removed with the least amount of time and effort.

b. Position: Oil coolers may be installed in any position, provided it is convenient to remove the zincs and drain water or rust the shell. When the installation is made, care should be taken to prevent air locks, as the cooling liquid must cover the tube or plate surfaces completely to insure maximum efficiency.

CAUTION: If temperatures below freezing are encountered during non-operational periods, the cooler should be thoroughly drained to prevent ice from forming and bursting the tubes.

c. Direction of Liquid Flow: Unless otherwise specified, the oil to be cooled circulates through the tubes and the cooling flows through the casing and around the tubes. It is satisfactory for the liquids to be circulated in either direction through the cooler although counter-flow between these should be maintained.

d. Liquid Specifications: Oil to be cooled should be free of solids larger than .05". The cooling liquid should be free of foreign substance larger than .030".

e. Strainers and Filters: The use of strainers is advised when solids larger than those specified are present. In certain types of service suitable filters may also be required to maintain standard efficiency.

f. Pressure Relief Valves: In cold weather the oil viscosity may cause a temporary increase in pressure drop, which decreases as the oil warms up. If the initial pressure exceeds the recommended safe load on coolers, pressure relief valves or a pressure control by-pass should be installed for protection of oil cooling and circulating equipment.

g. Installations on Hydraulic Pumps: It is specifically recommended that on hydraulic pump installations the heat exchangers be mounted on the suction side rather than the pressure side of the pump or in an independent circulating system. Despite the use of safety devices designed to eliminate pressures, it has been evident that heat exchangers have been damaged due to overpressure above normal.

h. Piping Lengths: All piping leading into the heat exchanger should be straight and free from angles, as far as possible, to prevent restriction of flow.

i. Zincs: All coolers designed for marine service are provided with one or more zinc electrodes. It should be determined that all required electrodes have been installed in the heat exchanger prior to placing in service.

j. Prevention of Gasket Leaks: Check all bolts for tightness before installing any heat exchanger.

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(Sheet 1 of 1 Sheets)

HARRISON RADIATOR DIVISION
GENERAL MOTORS CORPORATION
LOCKPORT, NEW YORK

EXHIBIT "U"

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DEFENDANT'S

2. OPERATION AND ADJUSTMENTS AFTER INSTALLATION

a. Velocity: The quantity of sea-water through the cooler should not be allowed to exceed that specified. The rate of flow of the coolant should be adjusted to a minimum and only sufficient to maintain the required operating temperatures.

b. Venting: After a unit is installed and cooling water admitted, the vent plugs should be individually removed until water flows from the vent. The plugs are then replaced. This is for the purpose of removing air pockets.

c. Operating Temperatures: Manual or any automatic control valves used in the circuit must be adjusted to the desired satisfactory operating temperatures. Improper adjustment of valves may result in unsatisfactory cooler performance.

d. Operating Pressures: All Harrison Heat Exchangers are tested at pressures in excess of those required in actual operation; nevertheless they must not be subjected to pressures in excess of those specified.

Unless otherwise specified, Plate type Coolers are tested for maximum operating pressures as follows:

PLATE TYPE COOLERS

Core Constant	150 lbs. per sq. in.
Core Reciprocating	75 lbs. per sq. in.
Case Constant	75 lbs. per sq. in.

MAINTENANCE

1. SERVICE

a. Temperature Control: Heat Exchangers, like any equipment, will perform their functions best when properly operated. The function of Harrison Oil and Jacket Water Coolers is to maintain specified temperatures. When the temperature of the liquid to be cooled rises above normal, it is an indication that some part of the temperature control system is not functioning properly. Inspect all manual and automatic control valves in the system for correct operation. Check all pressure gauges and thermostats. Inspect the water level and see that the proper flows through the coolers have been provided. Clean all filters. Make certain that the heat exchangers have been vented.

If the temperature does not return to normal after these adjustments have been made and the specified amount of cooling liquid is circulating around the oil or jacket water core, the cooler should be inspected for deposits. When such materials accumulate in the heat exchangers to the extent that cooling efficiency is impaired, they can be removed by a simple cleaning process described below.

The removal of external deposits from the water sides, or corrosion and sludge from the oil sides of the coolers, involves no great amount of time or elaborate equipment, yet insures excellent performance if carried out periodically. The cleaning periods are determined by the type and condition of the oil and water used and the operating conditions. The period between cleanings can be extended by the use of strainers and filters in the oil and water lines.

b. Zinc Electrodes: Replacements zinc electrodes (anodes) are provided in Harrison coolers designed for marine use.

The structure of a Heat Exchanger is composed of several basic metals; on the other hand, sea water contains certain chemicals in solution. An electric cell is therefore created inside the cooler and zincs are necessary to avoid electrolytic corrosion.

IMPORTANT: The concentration of chemicals and the temperature refers to sea water, and consequently for dissolution of zincs will be more rapid under some conditions, particularly where the water is warm. It is important that the zincs be inspected note every thirty days. The condition of the zincs at the time of inspection should govern the policy for future servicing. Upon inspection, zincs may be found to be corroded and coated with foreign material, thereby retarding or greatly reducing their effectiveness. This must be removed by wire brushing and scraping. If after cleaning, the zinc is found to be more than 50% disintegrated, it must be replaced. Make certain that zincs are tightened to insure a good metal contact.

CAUTION: If an oil unit is not to be cleaned or repaired for several days after its removal from installation, allow it to soak in a solvent during that period to prevent hardening of the sludge and carbon deposits on the tube walls.

NOTE: EXERCISE CAUTION IN HANDLING TO PREVENT ANY DISTORTION OF THE STAYS OR CORE.

2. DISASSEMBLY

(1) Remove any zinc electrodes
(2) Remove cover plate and gasket
(3) Remove Core

3. CLEANING

Method of Cleaning:

NOTE: In handling the core throughout cleaning operations, use care to prevent injuring the plates.

Either the oil or water side of coolers can be cleaned with very little difficulty when the operator has made it a policy to clean at regular scheduled intervals before excessive quantities of lime, rust, scale, oil sludge, and carbon have accumulated.

NOTE: We recommend that both sides of the cooler be cleaned whenever the unit is disconnected for cleaning. It is suggested that the oil side be cleaned first as carbon oil in the passages will mix with and unmask the solution used to clean the water side.

To prevent hardening and drying of accumulated foreign substance, the core should be cleaned as soon as possible after removing from service.

a. Cleaning Oil Side of Coolers:

1. Circulate carbon tetra-chloride, trichlorethylene or varsol or through the plates with a head or water driven push in reverse direction from normal operating flow. This action should be continued until the unit is clean.

CAUTION: If solvents are used, care must be taken to utilize them in accordance with their manufacturers' instructions. It is essential to provide suitable and adequate ventilation as a protection against toxic effects. Fire protection in accordance with local laws must also be provided.

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2. If a circulating pump is not available, some cleaning can be accomplished by immersing the core in a container of carbon tetra-chloride. After the cell has been allowed to stand in the solvent for a few minutes, force cleaner through the plates with a hand force pump of the ordinary piston or plunger type.

3. An Oakite or alkaline solution is recommended where the oil passages are badly clogged. This should be circulated through the plates. After cleaning, flush thoroughly with clean hot water.

NOTE: Flush inside of oil tubes with clean light oil, after both the oil and water sides of coolers have been cleaned.

b. Cleaning Water Side of Coolers:

1. Immerse exposed core in a solution, composed of one part muriatic acid to nine parts cold water, to which has been added one pound of oxalic acid, and .81 gallons of protective inhibitor to each five gallons of solution.

2. Remove core when foaming and bubbling stops. This usually takes from one to two minutes. Pressure flush thoroughly with clean hot water.

3. Remove all foreign substances from inside cover and casing before reassembling. Clean all gasket surfaces thoroughly and use new gaskets wherever necessary.

NOTE: In addition to the cleaners mentioned in the preceding observations, there are a number of other good cleaners and solvents on the market manufactured by reputable concerns. Any one of them would recommend cleaners to meet a particular need.

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EXHIBIT V

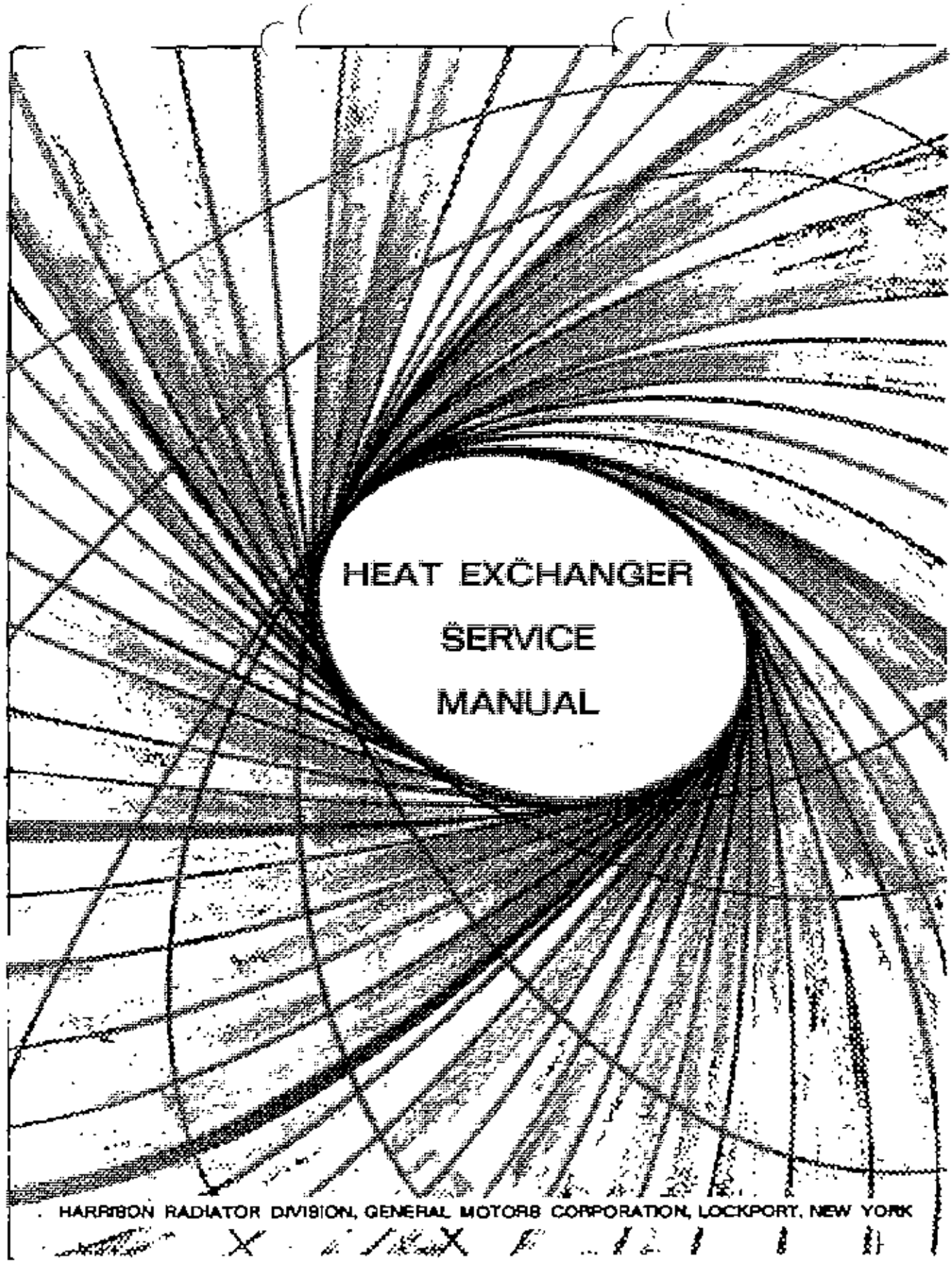


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HARRISON

HEAT EXCHANGER SERVICE MANUAL

HARRISON RADIATOR DIVISION
GENERAL MOTORS CORPORATION
LOCKPORT, NEW YORK 14094

HES 62 - 59 – Sept. 1, 1961
Revised Jan. 30, 1967

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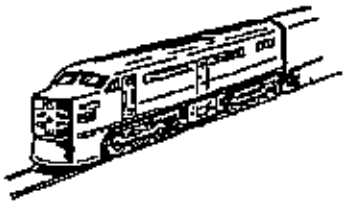
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SECTION I.

INTRODUCTION

THE HARRISON HEAT EXCHANGER

This manual is provided as a practical guide to the installation, operation, and maintenance of Harrison oil and water coolers. Heat



exchangers are essential for maintaining the specified oil and jacket water temperatures for internal combustion engines, turbines, air compressors, pumps, blowers, gear transmission units, etc.

Whatever the application, regulation of the



temperatures of oil or cooling water within the specified limits improves the quality of lubrication and minimizes the wear of moving parts.

Heat exchangers are not complicated, and can be installed and operated by men who



have no special knowledge of the product. As with any equipment of this nature, however, periodic servicing is required to maintain maximum efficiency and give a prolonged service life.

If necessary,



minor repairs can be readily accomplished in your own shop. Experienced Service Engineers are at your disposal for consultation.

SYSTEMATIC SERVICE WILL MAINTAIN AND PROTECT YOUR MATERIAL. SYSTEMATIC INSPECTION WILL GUARD YOUR INVESTMENT. KEEP THESE THOUGHTS IN MIND AS YOU READ YOUR HARRISON MANUAL.

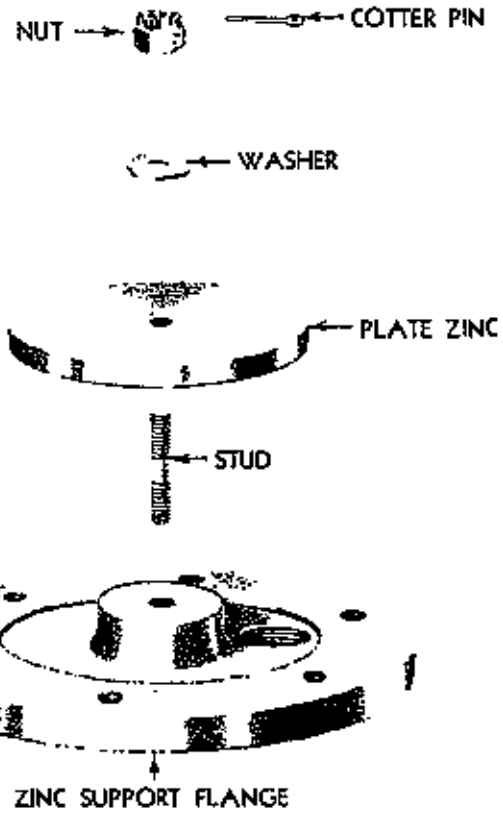


Fig. 6—Plate type zinc

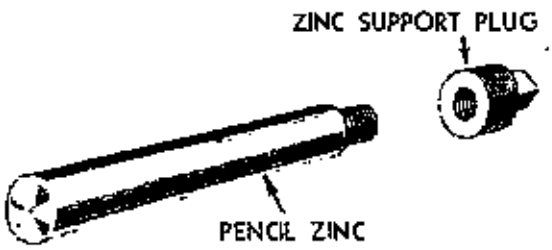


Fig. 1—Pencil type zinc.

3. CLEANING

NOTE: — When cleaning an oil tube heat exchanger, the inside of the oil tubes should be cleaned first. This procedure is essential, otherwise oil remaining in the tubes will contaminate and weaken the cleaning solution used on the water side of the tubes.

a. Oil tubes (strut and plate type)

(1) Equipment.

(a) A metal tank large enough to contain the cleaning solution and the cooler, is required. The capacity of this tank will be determined by the size of the cooler or coolers to be cleaned. Heating elements are required where hot solutions are specified.

(b) A centrifugal pump (fig. 8) or gear pump of from 55 to 75 G.P.M. is required for coolers up to and including basic Model 52 and from 75 to 150 G.P.M. for 48 larger models. A 35 to 50 G.P.M. capacity pump is adequate for cleaning the 3 x 6 plate type units having 8, 12, or 16 plates. Pumps of these capacities are recommended because of the importance of velocity and volume in the accomplishment of a good cleaning operation. It is possible to use the larger pump for the cleaning of smaller units by restricting or by-passing a portion of the cleaning solution.

(c) A metal tank to contain hot water is required and provision should be made for heating.

12. Equipment.—Optional:—

(a) A metal tank to contain a solvent.

NOTE: A tank 4' x 4' x 3' will easily accommodate the largest cooler.

13. Method.—Before removing the cooler from the installation, place an identifying mark or tag on the outlet side of the unit so that the cleaning solution may be circulated through the cooler in reverse direction to the normal operating flow.

(a) Optional solvent flush. If exceptional conditions make it advisable, a preliminary flush with a solvent or degreasing solution will remove oil and loose sludge from the cooler thereby reducing contamination of the alkaline solution (par. 2b) used in the principal cleaning operation. Varnolene, carbon tetrachloride, perchlorethylene, trichlorethylene, kerosene or any similar solvent may be used with satisfactory results.

CAUTION: If solvents are used, care must be taken to utilize them in accordance with their manufacturer's instructions. It is essential to provide suitable and adequate ventilation as a protection against toxic effects.

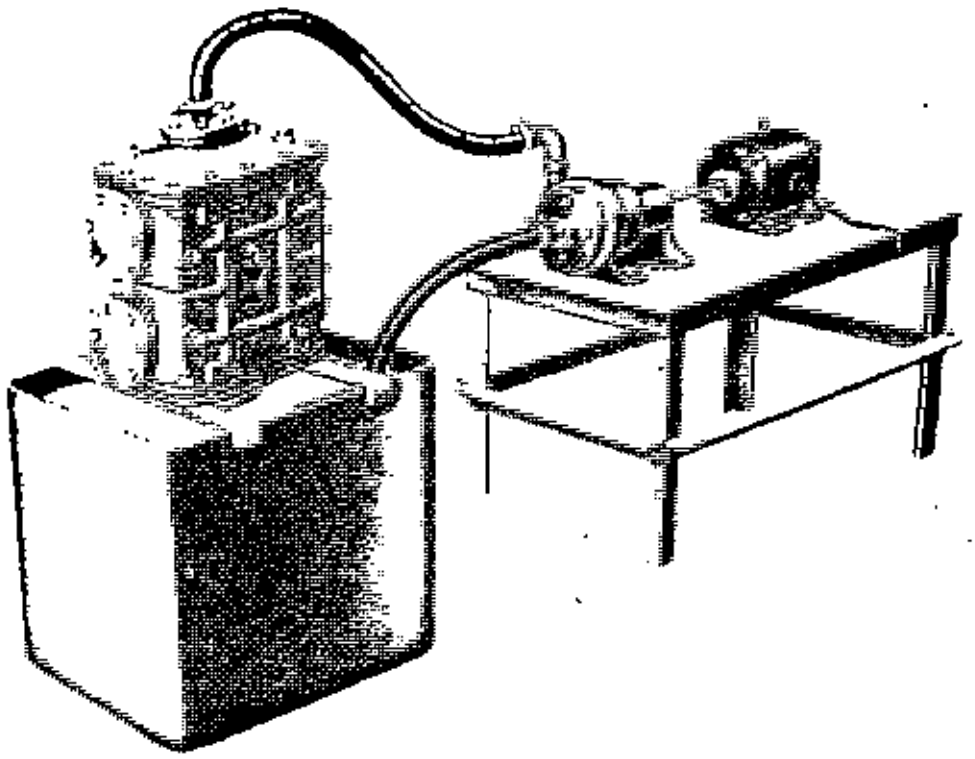


Fig. 8—Use of the centrifugal pump to clean heat exchangers.

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Fire protection in accordance with local laws must also be provided.

NOTE:—If an oil cooler is not to be cleaned or repaired for several days after its removal from the installation, it should be allowed to remain in a solvent during that period in order to prevent the hardening of sludge or carbon deposits on the tube walls.

(b) Alkaline flush. Remove the cover and gasket from the inlet side of the cooler. Connect the outlet side of the cooler to the discharge side of the pump and arrange unit so that the cleaning solution will flow through it and into the tank for recirculation. A hot alkaline base cleaning solution should be used. 'Oakite #24' (8 ounces to 1 gallon of water) is heated from 180° to 200° F and flushed through the cooler. There are a number of other good commercial cleaning solutions available for cleaning the oil passages, such as Oakite Railroad Cleaner, Pennsalt P-35, Permag #70, Permag #168, etc.

Normally the cleaning operation would require approximately thirty minutes, but it should be repeated until the solution flows freely from the unit.

The cooler should then be immersed in a tank of clean, hot water or flushed with a hose and blown dry. Clean the covers and gasket surfaces and replace all gaskets with new ones which have been dipped for a minute or two in light machine oil.

b. Water tube (return type) and water sides (straight and plate type).

(1) Equipment.—A tank (fig. 9) constructed of material resistant to muriatic is required. The capacity of this tank will be determined by the size of the units to be cleaned.

NOTE: For large scale cleaning operations, a lead or acid resistant ceramic brick lined steel tank 8' x 4' x 3' is desirable.

(2) Method.—Prepare a solution of one part muriatic acid to nine parts of cold water. Add one pound of oxalic acid and .01 gallons of pyridine to each five gallons of solution.

Plug oil inlet and outlet and immerse the cooler in the solution. Remove immediately when the bubbling and foaming action has ceased (1 to 2 minutes). Flush thoroughly with warm, clean water. Repeat the operation if necessary.

Duplicate the operation for cover and casing, clean all gasket surfaces, and replace all gaskets with new ones which have been dipped for a minute or two in light machine oil.

4. TESTING AND EMERGENCY REPAIR

Occasionally, due to vibration and/or excessive velocities and pressures, leaks may occur in the coolers.

If it is determined, by traces of oil in the fresh or sea water, or by changes of water or oil levels, that a heat exchanger is leaking, the unit should be removed from the installation and tested in order to locate the leak. Repairs to oil and jacket water coolers are considered as Emergency Repairs only; major repairs can be accomplished only by factory methods.

a. Test and Emergency Repair—Plate Type Unit

Remove core from casing. Attach an air hose (not over 100 P.S.I. pressure) to either the inlet or the outlet, plugging the other opening, and submerge the assembly in water. Air bubbles will indicate the point where a leak has occurred.



Fig. 9—Muriatic acid tank and heat exchanger core.

When spare cores are not available, emergency repairs can be made as follows:

Using a good grade of flux and solder (40% tin - 60% lead content recommended), tin the area around the leak and flow the solder between the tube plate until the leaking area has been covered (fig. 10). Flush the repair thoroughly with cold water to remove all traces of the flux, and repeat the test operation.

b. Test and Emergency Repair—Strut Type Unit

Remove the outlet covers, plug the coolant outlet, and attach an air line to the coolant inlet. Immerse the unit in water and apply air pressure (not more than 100 P.S.I.). Bubbles will indicate the location of the leak. Header leaks are the most common, as they are the result of a solder crack between the header plate and adjacent parts. This is caused by rough handling of the unit, or vibration and excessive pressures. Repairs can be accomplished by cleaning the leaking area with flux (fig. 11) and covering with a good grade of solder (40% tin - 60% lead content recommended). Flush the repair thoroughly with cold water to remove all traces of the flux, and repeat the test operation.

DO NOT USE TOO HOT A FLAME. YOU WILL BURN THE TUBE MATERIAL AND LOOSEN THE SOLDER AROUND ADJACENT TUBES.

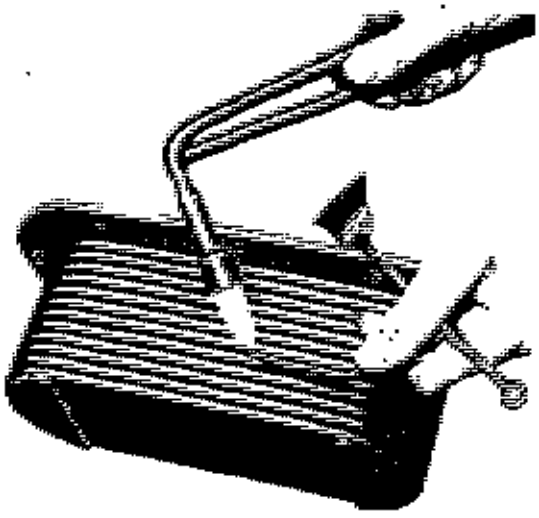


Fig. 10—Soldering plate tube seam leak.

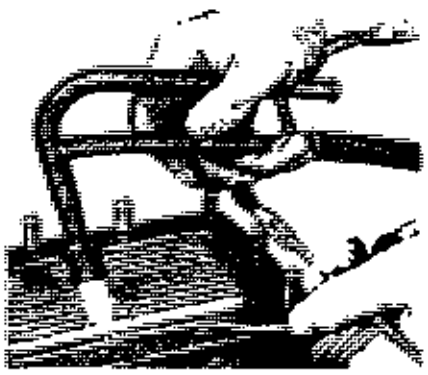


Fig. 11—Repairing a header leak.

If a tube leak should occur, an emergency repair can be made by blocking off both ends of the leaking tube with small brass or copper strips inserted in the mouth of the tube (fig. 12). Using a good grade of flux and solder (40% tin - 60% lead content recommended) fill in the remaining recess. Flush the repair thoroughly with cold water to remove all traces of flux, and repeat the test operation. Generally not more than 5% of the tubes should be blocked off; however, a greater percentage may be plugged provided the capacity of the cooler is not reduced beyond the cooling requirements.

THE REPAIRS JUST DESCRIBED ARE FOR EMERGENCY ONLY. RETURN THE UNIT TO THE FACTORY AT THE FIRST OPPORTUNITY FOR A GENERAL OVERHAUL.

5. REASSEMBLY.

a. Procedure—Reverse the disassembly procedure as outlined on page 8. Replace all old gaskets with new ones. Dip the new gasket in a light machine oil for one or two minutes before installing. Covers, mounting brackets and miscellaneous parts are reassembled at this time. Clean all covers and gasket surfaces.

b. Zincs—Zincs should be clean and free from scale before installation in the unit.
REPLACE WITH NEW ZINCS IF MORE THAN 50% DISINTEGRATED.

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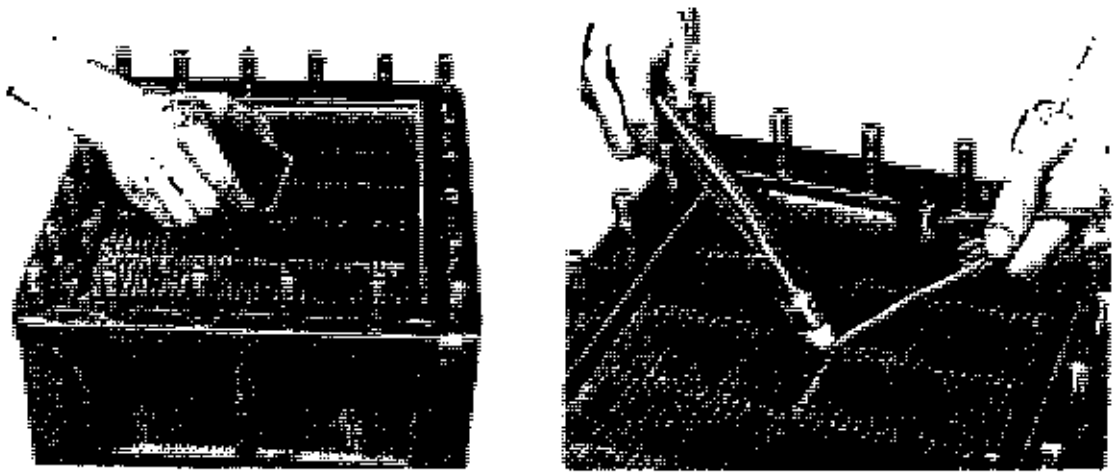


Fig. 12—Repairing a strut tube leak.

6. FINAL TEST—HYDROSTATIC (Fig. 13).

After the unit has been repaired, tested, and reassembled, it can then be submitted to a final hydrostatic test. Pressures for this test are determined by the information on the name plate.

The highest figure under the heading "TEST PR." on the nameplate refers to the pressure to be applied to the core while the lower number designates the pressure to be used for the casing. If in doubt, the blueprints of the unit in question will specify the pressures.

a. Core Test.—Seal the core outlet and fill the core with oil or water, depending upon the type of cooler. Seal the inlet with a fitting designed for the application of an air hose and gauge. Subject the core to the specified pressure allowing only atmospheric pressure to the casing. Permit the unit to stand for 15 or 20 minutes, then check the gauge for pressure drop which will denote a tube or header leak.

b. Casing Test.—Seal the coolant outlet and fill the casing with water, then follow the same procedure as in the core test. A pressure drop on the gauge will denote a casing leak.

7. STORAGE

If the cooler is not intended for immediate use after repair and test, it should be prepared for storage. Allow the unit to drain thoroughly and blow out the remaining liquid with air. Dry with warm air, then flush a light machine oil, or suitable oil through the tubes and drain off excess. Seal all inlets and outlets to prevent the entrance of dirt or foreign matter.

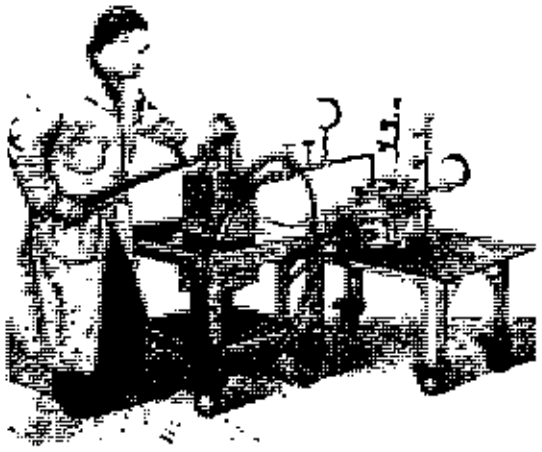


Fig. 13—Hydrostatic test.

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EXHIBIT W

GM

GENERAL MOTORS

DIESEL POWER

Maintenance Manual

71

GM DIESEL

DETROIT DIESEL ENGINE DIVISION

DETROIT · MICHIGAN

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MAINTENANCE MAN\L, FORM 6SE164, REPLACEMENT (GE RELEASE CHECK SHEET

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No. 71-1 Mar. 1959	No. 71-12 Aug. 1962	No. 71-23 JAN. 65	No. 71-34 Aug. 1966	No. 71-45 May, 1969
No. 71-2 Aug. 1959	No. 71-13 Sept. 1962	No. 71-24 MAR. 65	No. 71-35 [illegible]	No. 71-46 Aug. 1969 Checked 12-7-70. Jan. 1970
No. 71-3 Sept. 1960	No. 71-14 Sept. 1964	No. 71-25 April 65	No. 71-36 Oct. 1966	No. 71-47 July, 1970
No. 71-4 Oct. 1960	No. 71-15 Nov. 1962	No. 71-26 MAY 65	No. 71-37 Jan. 1967	No. 71-48 Oct, 1970.
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No. 71-8 Oct. 1961	No. 71-19 Oct. 1963	No. 71-30 7/68	No. 71-41 Feb. 1968 [illegible]	No. 71-52 Dec. 72
No. 71-9 Nov. 1961	No. 71-20 Mar. 1964	No. 71-31 April, 1968	No. 71-42 May, 1968	No. 71-53 May 73
No. 71-10 Mar. 1962	No. 71-21 April, 1964	No. 71-32 [illegible]	No. 71-43 Oct. 1968	No. 71-54 Sept. 73
No. 71-11 Aug. 1962	No. 71-22 October 1968	No. 71-33	No. 71-44 March, 1969	No. 71-55 Mar. 1974

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IMPORTANT SAFETY NOTICE

Proper service and repair is important to the safe, reliable operation of all motor vehicles. The service procedures recommended by Detroit Diesel Allison and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when and as recommended.

It is important to note that some warnings against the use of specific service methods that can damage the vehicle or render it unsafe are stated in this service manual. It is also important to understand these warnings are not exhaustive. Detroit Diesel Allison could not possibly know, evaluate and advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences of each way. Consequently, Detroit Diesel Allison has not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Detroit Diesel Allison must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects.

Service Manual

Detroit Diesel Engines

IN-LINE 71

Detroit Diesel Allison
Division of General Motors Corporation
Detroit, Michigan 48228

Printed in U.S.A.

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FOREWORD

This manual contains instructioos on the overhaul, maintenance and operation of the basie Series 71 fn-Line Detroit Diesel Engines.

Full benefit of the long life and dependability built into these engines can be realized through proper operation and maintenance. Of equal importance is the use of proper procedures during engine overhaul.

Personnel responsible for engine operation and maintenance should study the sections of the manual pertaining to tbeir particular dolies. Sjmilarly, before beginning a repair or overbaul job, the serviceman should read the manual carefully to familiarize himself with the parts or snb-assemblies of tbe engine with which he will be concerned.

The information, specifications and illustrations in this publication are based oo the information in effect at the time of approval for printing. The right is reserved to make changes at any time without obligation.

SUBJECT	SECTION
GENERAL INFORMATION	
ENGINE (less major assemblies)	1
FUEL SYSTEM AND GOVERNORS	2
AIR INTAKE SYSTEM	3
LUBRICATION SYSTEM	4
COOLING SYSTEM	5
EXHAUST SYSTEM	6
ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS	7
POWER TAKE-OFF	8
TRANSMISSIONS	9
SPECIAL EQUIPMENT	12
OPERATION	13
TUNE-UP	14
PREVENTIVE MAINTENANCE, TROUBLESHOOTING AND STORAGE	15

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SCOPE AND USE OF THE MANUAL

This maoual covers the basic Series 71 lo-line diesel engines built by tbe Detroit Dieset Allison Division of Geoeral Motors Corporation. Multiple engine units are available in various combinatlons sucb as side-by-side twins, tandem twins and quads. Complete instructioos oo operation, adjustment (tune-up), preventive maintenaoce and lubrication, and repalr (including complete overbaul) are covered. The mantal was writteo primarily for persons servicing and overhauling the engioe and, in addition, contains all of the instructions essential to tbe operators and users. Basic maiotenance and overbaul procedures are common to all Series 71 In-line engioes, and therefore, apply to all eogine models.

The maoual is divided into numbered sections. The first section covers the engioe (less major assemblies). The following sectioos cover a complete system such as the fuel system, lubrication system or air system. Each section is divided into subsectioos which contaio complete maintenance and operating instructions for a specifie subassembly oo the engine. For example, Section 1, wbieb covers the basic engine, contains subsection 1.1 pertaining to the cylinder block, subseetion 1.2 covering tbe cylinder bead, etc. Tbe subjects and sections are lisled in the Table of Cootents on the preceding page. Pages are nombered consecutively, starting with a new Page 1 at the beginning of each subsectlon. The illuslrations are also numbered consecutively, beginning witb a new Fig. 1 ar the start of each subsectioo.

Information regarding a general subject, sucb as the lubrication system, can best be located by using the Table of Contents. Opposite each subject in the Table of Cootents is a section oumber whieb registers witb a tab printed on the first page of each section throughout lhe mannal. Information on a specifie subassembly or accessory can then be found by consulting tbo list of conteots on the first page of the sectioo. For example, the cylioder liner is part of the basie engine, therefore, it will be found in Section 1. Looking down the list of contents oo the first page of Section 1, tbe cylioder liner is fouod to be in subsection 1.6.3. An Alphabetical Index at the back of the maoual has been provided as ao additional aid for locating information.

SERVICE PARTS AVAILABILITY

Genuino Detrolt Diesel Allison service parts are available from authorized Detroit Diesel Allison distributors and service dealers throughout the world. A complete list of all distributors and dealers is availablo io the World Wide Parts and Service Directory, 6SB280. This publication can be ordered from any authorized distributor.

CLEARANCES AND TORQUE SPECIFICATIONS

Clearances of oew parts and wear limits on used parts are listed in tabular form at tbe eod of each section throughout the manual. It sbould be specifically noted that lhe "New Parts" clearances apply only wbeo all new parts are used at the point where the various specifications apply. This also applies to references within tbe text of tbe mantal. The column eotitled "Limits" lists the amount of wear or inerease to clearanee which can be tolerated in used engine parts and still assures satisfactory performaoce. It should be emphasized that the figures given as "Limits" must be qualified by the judgment of personoel responsible for installing oew parts. These wear limits are, in general, listed ooly for tbe parts more frequently replaced in engine overhaul work. For additional information, refer to tbe paragraph entitled *Inspection* under *General Procedures* in tbis section.

Bolt, out and stud torque specifications are also listed in tabular form at tbe eod of each section.

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GENERAL PROCEDURES

In many cases, a serviceman is justified in replacing parts with new material rather than attempting repair. However, there are times where a slight amount of reworking or reconditioning may save a customer considerable added expense. Crankshafts, cylinder liners and other parts are in this category. For example, if a cylinder liner is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse, thereby saving the expense of a new part. Exchange assemblies such as injectors, fuel pumps, water pumps and blowers are also desirable service items.

Various factors such as the type of operation of the engine, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly and assembly, the various subassemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, water and fuel. On engines cooled by a heat exchanger, the fresh water system and raw water system must both be drained. Lubricating oil should also be drained from any transmission attached to the engine.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the engine base and drive mechanism, should be mounted on an engine overhaul stand; then, the various subassemblies should be removed from the engine. When only a few items need replacement, it is not always necessary to mount the engine on an overhaul stand.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks, or a parts dolly.

CLEANING

Before removing any of the subassemblies from the engine (but after removal of the electrical equipment), the exterior of the engine should be thoroughly cleaned. Then, after each subassembly is removed and disassembled, the individual parts should be cleaned. Thorough cleaning of each part is absolutely necessary before it can be satisfactorily inspected. Various items of equipment needed for general cleaning are listed below.

The cleaning procedure used for all ordinary cast iron parts is outlined under *Clean Cylinder Block* in Section 1.1; any special cleaning procedures will be mentioned in the text wherever required.

Steam Cleaning

A steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

A tank of sufficient size to accomodate the largest part that will require cleaning (usually the cylinder block) should be provided and provisions made for heating the cleaning solution to 180° -200° F (82° -90° C).

Fill the tank with a commercial heavy-duty solvent which is heated to the above temperature. Lower large parts directly into the tank with a hoist. Place small parts in a wire mesh basket and lower them into the tank. Immerse the parts long enough to loosen all of the grease and dirt.

Rinting Bath

Provide another tank of similar size containing hot water for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete the drying of the parts without the use of compressed air.

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Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. The rust preventive compound should be removed before installing the parts in an engine.

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will aid in determining which parts should be replaced, considerable judgment must be exercised by the inspector.

The guiding factors in determining the usability of worn parts, which are otherwise in good condition, is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and/or oversize as well as standard sizes. Also, service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job are available.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gages, such as dial bore gages, dial indicators and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should, if possible, be located away from the disassembly and cleaning operation. Also, any machining operations should be removed as far as possible from the assembly area.

Particular attention should be paid to storing of parts and subassemblies, after removal and cleaning and prior to assembly, in such a place or manner as to keep them clean. If there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table of torque specifications at the end of each section for proper bolt, nut and stud torques.

To ensure a clean engine at time of rebuild, it is important that any plug, fitting or fastener (including studs) that intersects with a through hole and comes in contact with oil, fuel or coolant must have a sealer applied to the threads.

A number of universal sealers are commercially available. It is recommended that Loctite J 26558-92 *pipe sealer with teflon,* or equivalent, be used.

> **NOTE:** Certain plugs, fittings and fasteners available from the Parts Depot already have a sealer applied to the threads. This pre-coating will not be affected when the pipe sealer with teflon is also applied.

The sealer information above must not be confused with International Compound No. 2, which is a lubricant applied before tightening certain bolts. Use International Compound No. 2 only where specifically stated in the manual.

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WORK SAFELY

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, take these precautions before starting to work on an engine:

1. Disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

2. Make sure the mechanism provided at the governor for stopping the engine is in the stop position. This will mean the governor is in the no-fuel position. The possibility of the engine firing by accidentally turning the fan or, in the case of vehicle application, by being bumped by another vehicle is minimized.

Some Safety Precautions To Observe When Working On The Engine

1. Consider the hazards of the job and wear protective gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.

2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

3. Always use caution when using power tools.

4. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury.

5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron.

Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

6. Use caution when welding on or near the fuel tank. Possible explosion could result if heat build-up inside the tank is sufficient.

7. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid.

8. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals of a battery which can result in severe arcing.

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3. Place the turbocharger assembly in position on the mounting bracket.

4. Secure the turbocharger to the mounting bracket with bolts, lock washers and nuts. Tighten the nuts just enough to hold the turbocharger tight against the bracket.

5. Slide the blower air inlet tube hose over the compressor housing outlet opening and secure it in place with the hose clamps.

6. Tighten the turbocharger to exhaust manifold adaptor bolts securely. Then remove the chain hoist and lifting sling from the turbocharger.

7. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block.

8. Attach the oil inlet line to the cylinder block.

9. Before starting the engine, make sure that there is adequate lubricating oil in the turbocharger.

a. Clean the area around the oil inlet opening, then pour about four ounces of engine oil in the oil inlet opening of the center housing. Turn the rotating assembly by hand to coat the bearings, thrust washers and thrust collar with oil.

b. Hold the compressor wheel from turning and start the engine and run it at idle speed.

c. As soon as oil appears at the end of the oil supply line, connect the oil inlet line to the top of the center housing.

NOTE: The oil pressure should be at a minimum of 10 psig.

d. After the oil inlet line is attached, release the compressor wheel.

10. Check all ducts and gaskets for leaks.

11. Operate the engine at idle speed for a short period to provide adequate lubrication to the turbocharger bearings. Then run at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, shut down the engine immediately and correct the cause.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

T18, T18A TURBOCHARGERS

Remove Turbocharger

1. Disconnect the exhaust manifold adaptor attached to the turbine housing.

2. Disconnect the air inlet tube attached to the compressor housing.

3. Remove the oil inlet line from the top of the center housing.

4. Remove the oil outlet line from the bottom of the center housing.

5. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

6. Remove the nuts and lock washers securing the turbocharger assembly to the mounting bracket. Then lift the turbocharger assembly away from the engine and place it on a bench.

7. Cover the end of each oil inlet and oil outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entry of foreign material.

Disassemble Turbocharger

Refer to Figs. 10 and 18 for the location of the various parts and disassemble the turbocharger assembly as follows:

1. Thoroughly clean the exterior of the turbocharger with a non-caustic cleaning solvent.

2. Matchmark the compressor housing, center housing and the turbine housing with a punch or chisel (Fig. 11) so they may be installed in the same relative position.

3. Remove the twelve bolts, lock washers and clamps securing the T18 turbocharger compressor housing to the center housing. Then remove the compressor housing from the center housing. On the T18A turbocharger, loosen the "V" band coupling securing the compressor housing to the backplate assembly and remove the compressor housing and "V" band. If necessary, tap the the compressor housing with a plastic hammer to loosen it.

4. Bend the ends of the turbine housing attaching bolt lockplates down. Then remove the six bolts (T18) or

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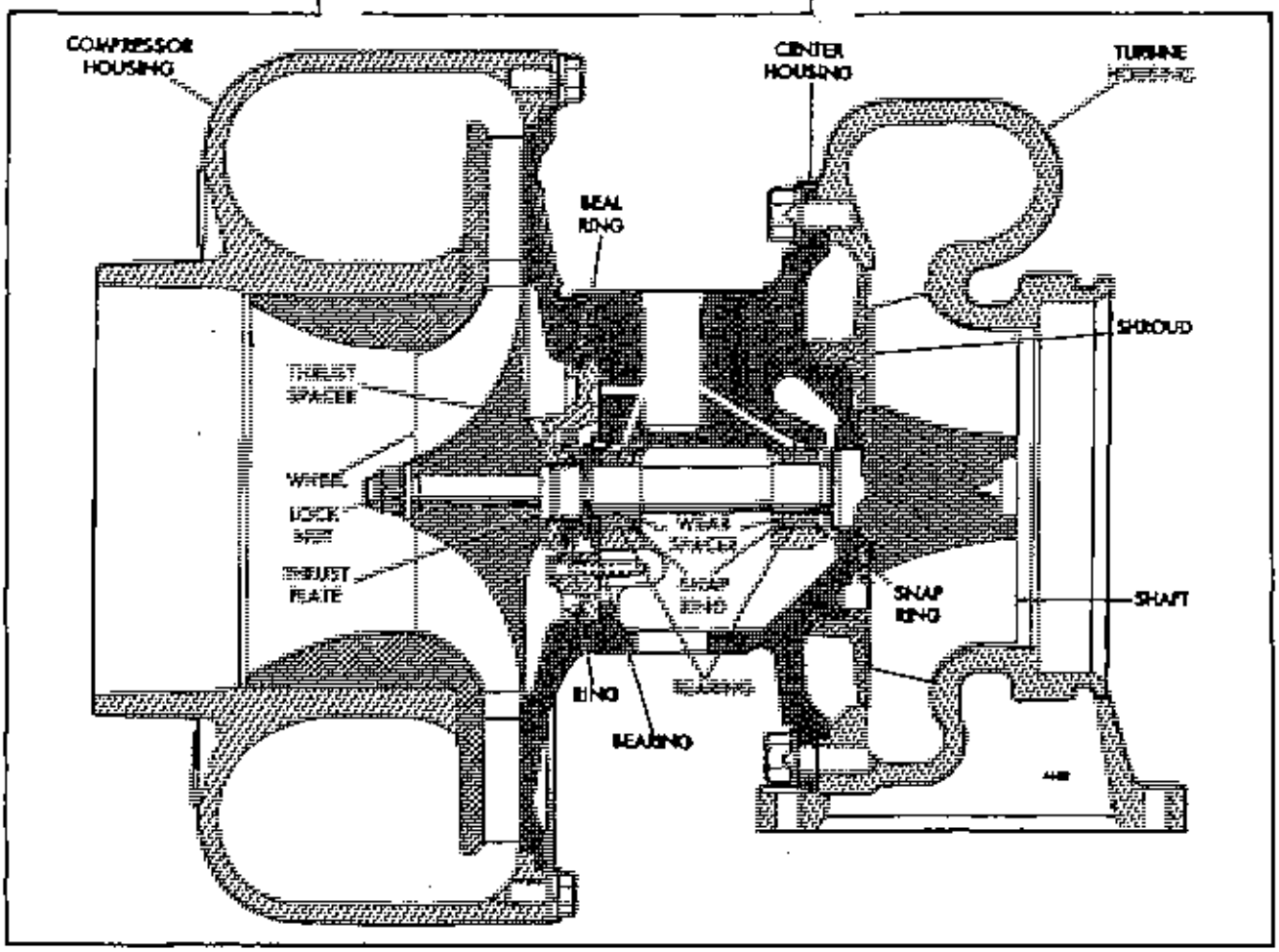


Fig. 10 - T18 Turbocharger Assembly

eight bolts (T18A) securing the turbine housing to the center housing. If necessary, tap the turbine housing with a plastic hammer to loosen it.

5. Remove the compressor wheel from the shaft as follows:

NOTE: The hexagon countersunk hole in the end of the turbine wheel must be scraped clean before installing it in the holding fixture.

a. Clamp the turbine wheel holding fixture J 21225 in a bench vise. Then place the center housing and rotating assembly in the holding fixture, turbine wheel down (Fig. 12), with the hexagon countersunk hole in the turbine wheel over the protruding hexagon head in the holding fixture. If required, use a suitable holding fixture as shown in Fig. 21.

b. To prevent the possibility of bending the shaft, remove the lock nut from the shaft with a double universal socket and a tee handle (Fig. 12).

c. Place the center housing and rotating assembly in an oven, furnace or hot oil that has been preheated to 350 °F-375 °F. for no longer than 10 minutes. If a hot oil bath is used, immerse only the compressor wheel in the oil.

CAUTION: Be careful not to damage the wheel blades when placing the assembly in the oven or furnace. Do not heat the compressor wheel above 375 °F.

d. After heating the compressor wheel, remove the center housing and rotating assembly and support it on the bed of an arbor press with the compressor wheel end up (Fig. 13).

CAUTION: To avoid being burned, use a pair of heat resisting or asbestos gloves when handling the center housing and rotating assembly.

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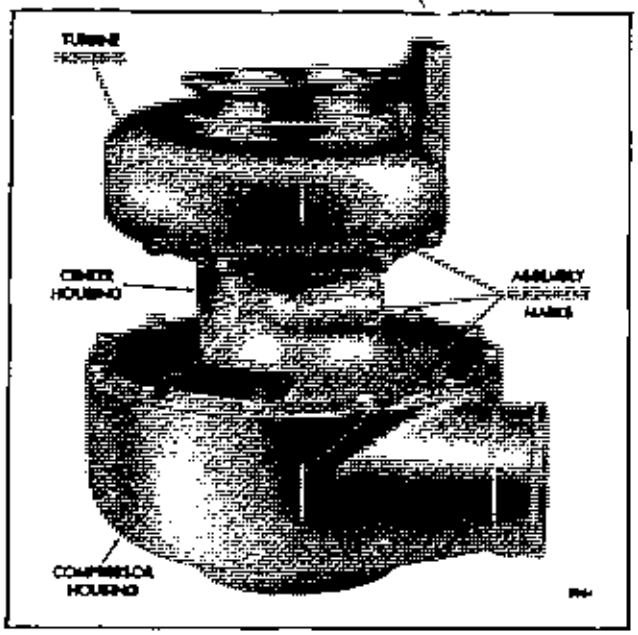


Fig. 11 - Assembly Alignment Marks on Housings

e. Place a clean shop towel on the bed of the press and under the turbine wheel to protect the blades. Then place the tapered end of the removing tool J 9496 in the center of the shaft and the opposite end under the ram of the press (Fig. 13). Press the shaft out of the compressor wheel.

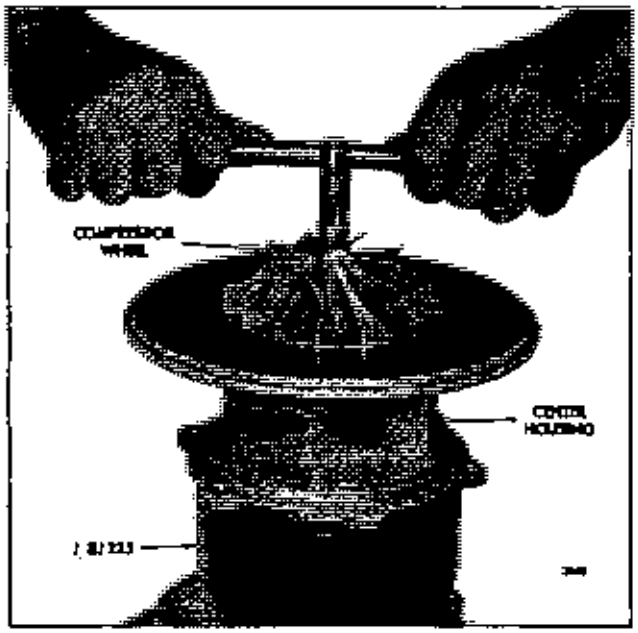


Fig. 12 - Removing Compressor Wheel Lock Nut

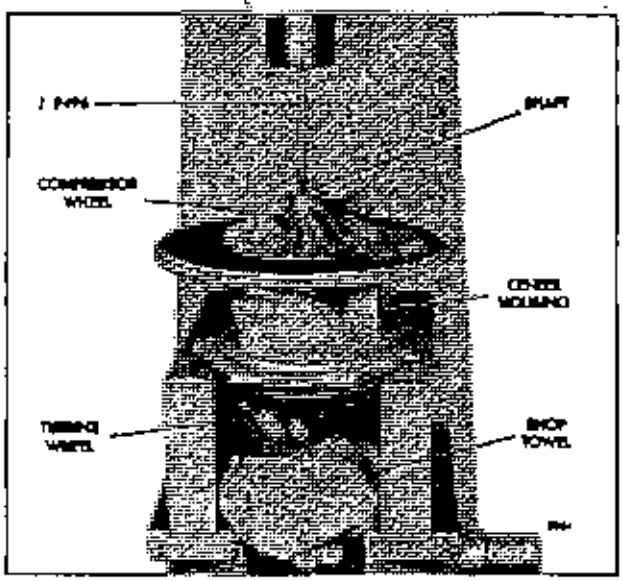


Fig. 13 - Removing Shaft from Compressor Wheel

f. Remove the compressor wheel from the top of the center housing, then remove the center housing and shaft from the arbor press and place them on a bench. Pull the shaft assembly straight out of the center housing to prevent the threads on the end of the shaft from damaging the shaft bearings.

6. Place the center housing, compressor housing end up, on the bench (Fig. 14).

7. Bend the end of the center housing thrust plate attaching bolt lockplates down, then remove the four

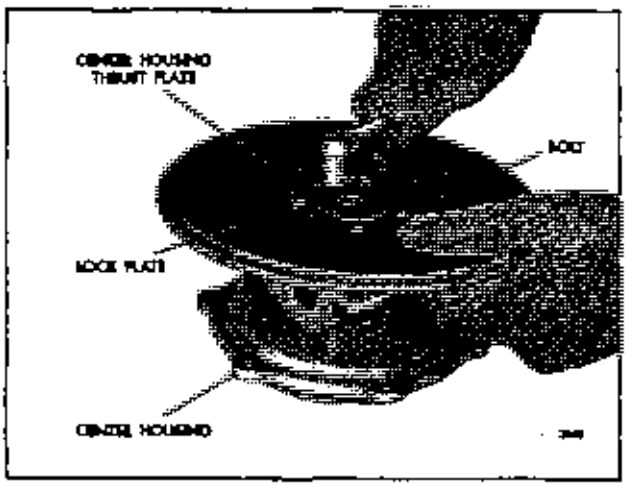


Fig. 14 - Removing Center Housing Thrust Plate Bolts

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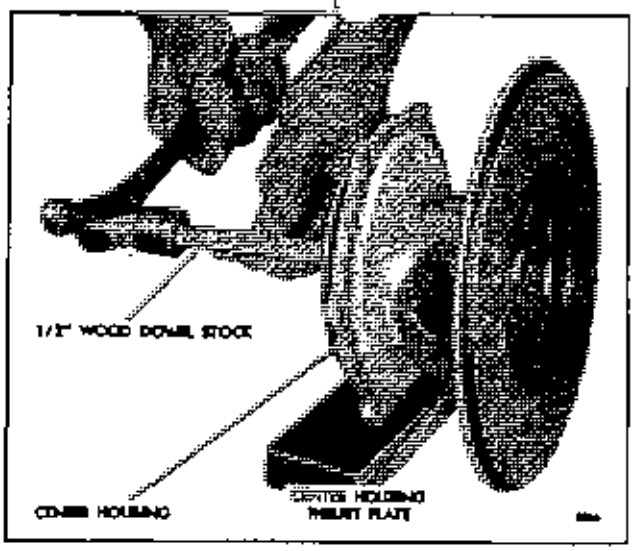


Fig. 15 - Removing Center Housing Thrust Plate

bolts and lockplates securing the thrust plate to the center housing.

8. Support the center housing on edge on the work bench (Fig. 15). Then insert a 1/2" wood dowel approximately 8" long through the shaft bearings and against the thrust plate. Tap the thrust plate out of the center housing with a hammer.

9. Remove the thrust spacer and seal ring from the thrust plate, then remove the seal ring from the outside diameter of the thrust plate.

10. Remove the thrust ring and the thrust plate bearing from the center housing.

11. Remove the shaft bearing from the compressor wheel end of the center housing by lifting it straight up out of the housing with one finger inserted in the bearing.

12. Remove the shaft bearing from the turbine end of the center housing as follows:

a. Place the center housing, turbine housing end up, on the bench (Fig. 16).

b. Remove the shaft bearing retaining ring from the center housing with a pair of snap ring pliers.

c. Lift the bearing straight up out of the housing.

d. If necessary, remove the two spacers (on current turbochargers) and the two remaining snap rings inside the center housing.

13. If there is an oil reservoir plug in the center

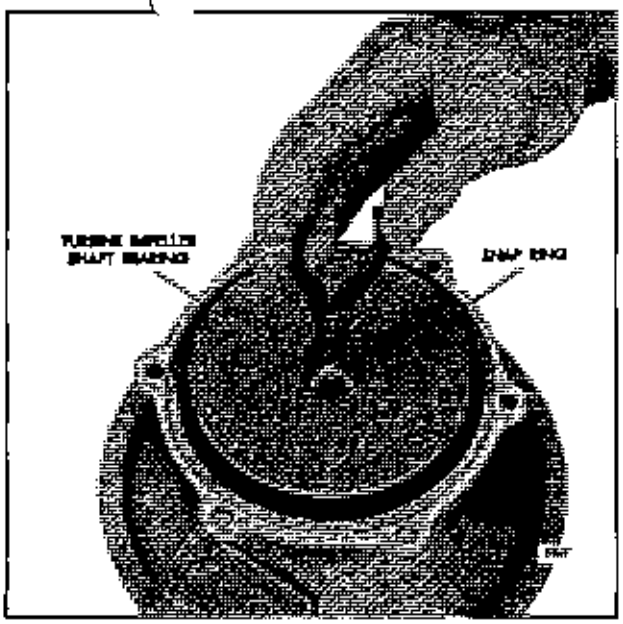


Fig. 16 - Removing Shaft Bearing Retaining Ring

housing, remove it in the following manner and discard it, as the plug is no longer required. The plug should also be removed for thorough cleaning of the center housing.

a. Thread the inside diameter of the oil reservoir plug with a 1/2"-13 tap approximately 1/2" deep.

b. Attach a slide hammer and a 1/2"-13 adaptor to the oil reservoir plug. Then pull the plug from the center housing by striking the sliding hammer against the end of its shaft.

14. The turbine wheel shroud which is attached to the turbine end of the center housing does not need to be removed. The plate is not readily removable after it has been subjected to prolonged exhaust heat.

Cleaning

Before cleaning, inspect the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all parts in a non-caustic cleaning solvent for about 25 minutes. Use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes.

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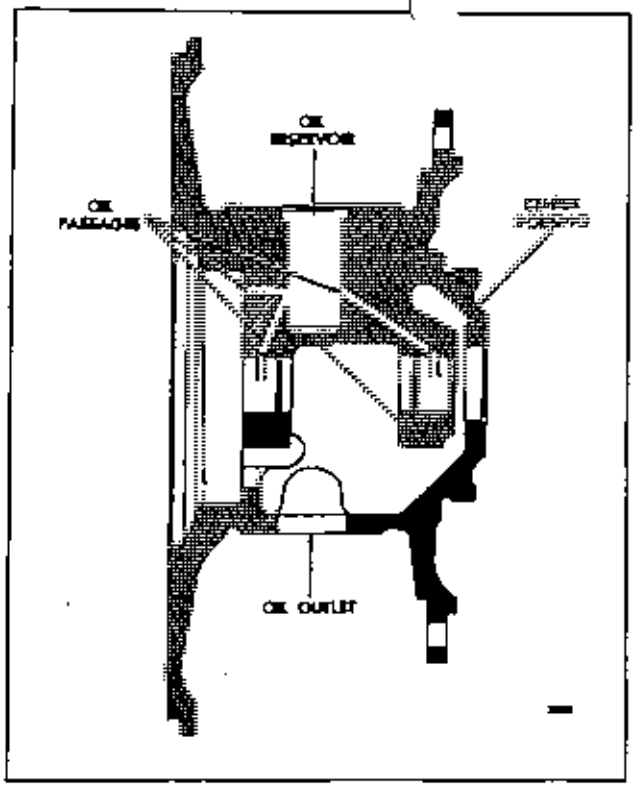


Fig. 17 - Location of Oil Passages in Center Housing

Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean the parts.

Make sure that both wheel blades are thoroughly clean. Deposits left on the blades will affect the balance of the rotating assembly.

Clean all of the internal cavities and oil passages in the center housing thoroughly with dry compressed air. Make sure all of the metal chips, from the tapping operation, are removed from the oil reservoir and oil passages in the center housing.

Clean the oil passage in the center housing thrust plate with dry compressed air.

Remove the oil inlet and outlet lines from the engine and thoroughly clean the oil lines inside and out. An oil line that is dented or crimped enough to restrict the flow of oil must be replaced.

Inspection

Inspect the turbocharger parts for signs of damage, corrosion or deterioration. If necessary, replace with new parts.

Examine the turbine wheel for signs of rubbing or wear. For shaft bearing journal dimensions and wear limits, refer to Section 3.0.

Examine the compressor wheel for signs of rubbing and bent blades. The wheel must be free of dirt and foreign material.

Check the compressor and turbine housings for signs of wheel contact.

Examine the thrust ring, shaft bearings and wear spacers, thrust spacer, seal ring and thrust plate bearing for signs of rubbing, scoring or wear. For shaft bearing dimensions and wear limits, refer to Section 3.0.

NOTE: If foreign particles fall into the turbocharger during the assembly procedure, remove the particles immediately, even though extensive disassembly is required.

Assemble Turbocharger

Refer to Figs. 10 and 18 for the location of the various parts and assemble the turbocharger as follows:

1. Install the shaft bearings in the center housing as follows:

a. Place the center housing on the bench with the turbine end of the housing facing up.

b. If removed, reinstall the inner shaft bearing retaining ring in the lower ring groove in the turbine wheel end bearing bore.

c. On current turbochargers, reinstall the wear spacer.

d. Lubricate the outside diameter of a shaft bearing with engine oil, then place the bearing straight into the bearing bore in the center housing as shown in Fig. 19 and push it down against the wear spacer. On former turbochargers, push it down against the bearing inner retaining ring.

e. Install the outer shaft bearing retaining ring in the ring groove in the center housing bearing bore.

f. Turn the center housing over on the bench so the compressor end of the housing is facing up.

g. If removed, reinstall the shaft bearing retaining ring in the ring groove in the compressor end of the center housing bearing bore.

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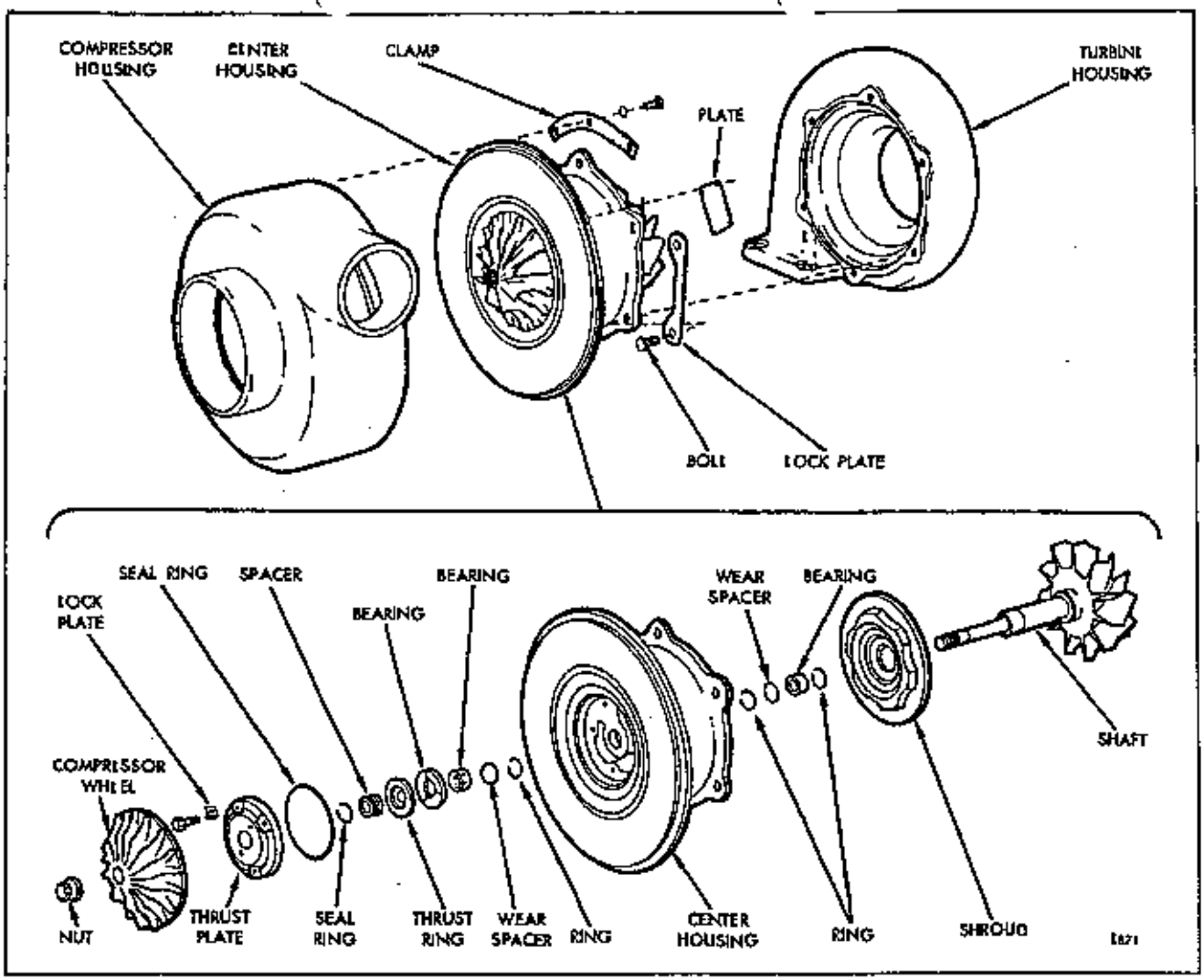


Fig. 18- T18Turbocharger Details and Relative Location of Parts

b. On current turbochargers, reinstall the wear spacer.

2. Clamp the shaft holding fixture J 21225 in a bench vise. Place the shaft assembly in the holding fixture with the hexagon countersunk hole in the turbine wheel over the protruding hexagon head in the holding fixture as shown in Fig. 20. If required, use a suitable holding fixture (Fig. 21).

3. Lubricate the shaft bearing journals with engine oil, then place the center housing over the shaft with the turbine end of the housing facing down. Carefully lower the center housing straight down over the shaft until it seats on the hub of the turbine wheel (Fig. 22).

4. Lubricate the outside diameter of the second shaft bearing with engine oil, then place the bearing over the shaft and start it straight into the bearing bore as shown in Fig. 23. Push the bearing down in the bearing bore against the wear spacer. On former turbochargers, push the bearing down against the retaining ring.

5. Lubricate the thrust plate bearing with engine oil, then place it on the shaft, with the three oil grooves in the face of the bearing facing up (Fig. 24). Align the hole and slot in the bearing with the dowel pins in the center housing, then place the bearing over the dowel pins and against the housing.

NOTE: Make sure the thrust plate bearing is seated flat against the face of the center housing.

6. Place the thrust collar over the end of the shaft, recess side facing up (Fig. 25), and against the thrust plate bearing.

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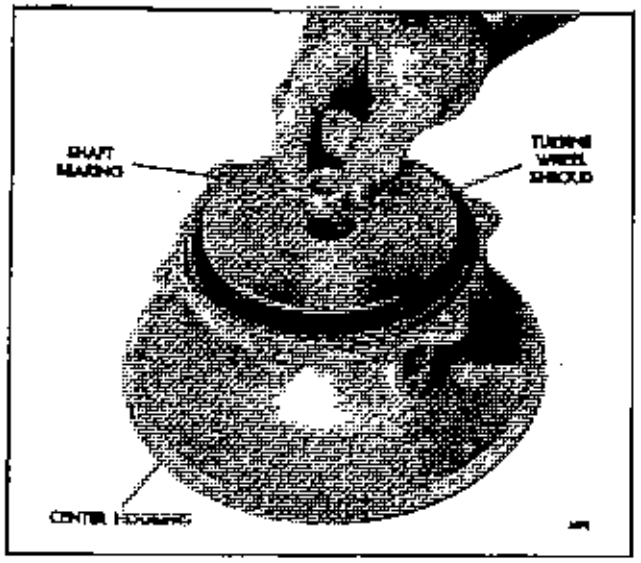


Fig. 19 - Installing Shaft Bearing in Center Housing (Turbine End)

7. Install a new seal ring in the groove in the thrust spacer.

8. Place the center housing thrust plate, less the thrust spacer and the rubber seal ring, over the shaft, with the bolt holes and the oil hole in the under side of the thrust plate in alignment with the oil and bolt holes in the center housing (Fig. 27).

9. Remove the thrust plate from the center housing. Then install the thrust spacer and seal ring assembly in the thrust plate (Fig. 26).

10. Lubricate a new thrust plate (rubber) seal ring with engine oil, then place the seal ring in the seal ring groove in the outside diameter of the thrust plate.

11. Position the thrust plate, with the thrust spacer and seal ring, over the end of the shaft with the oil holes and bolt holes in the thrust plate and center housing in alignment as shown in Fig. 27. Then place the thrust plate on the shaft and lower it straight down against the center housing, being careful not to let the thrust spacer move up out of the thrust plate.

12. To align the thrust plate, insert two of the thrust plate attaching bolts into the bolt holes in the thrust plate and thread them into the center housing.

13. Carefully push the thrust plate in the center housing until it contacts the thrust ring. Be sure the thrust spacer stays in the thrust plate.

NOTE: If the thrust spacer moves out of the thrust plate unseating the seal ring, repeat Steps 9 through 13 above.

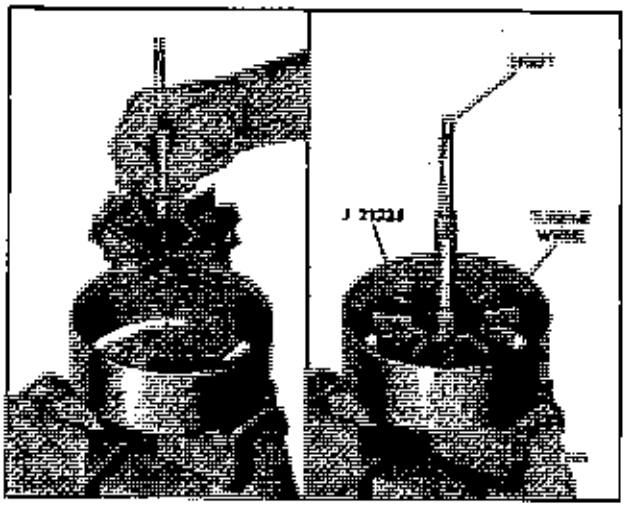


Fig. 20 - Installing Shaft Assembly in Holding Fixture

14. Place a new lockplate on each thrust plate bolt and thread the bolts into the center housing. Tighten the 10-24 bolts to 30-40 lb-in torque (T18 turbocharger) or to 90-110 lb-in torque on the 5/16"-18 bolts on the T18A turbocharger (Fig. 28). Then bend one corner of each lockplate up against the flat side of each bolt head.

15. Install the compressor wheel on the shaft as follows:

a. Place the compressor wheel in an oven, furnace or in hot oil that has been pre-heated to 350 °F.- 375 °F. for not longer than 10 minutes.

CAUTION: To avoid being burned, use a pair of heat resisting or asbestos gloves when handling the compressor wheel.

b. After heating the compressor wheel, remove the wheel and start it straight on the shaft (Fig. 29). Push the wheel down against the thrust spacer.

NOTE: Place the compressor wheel on the shaft as soon as possible after removing it from the oven, furnace or hot oil.

c. While the compressor wheel is still hot, install the lock nut and tighten it to 110-130 lb-in torque.

NOTE: To prevent the possibility of bending the shaft, use a double universal socket with the torque wrench.

d. After the compressor wheel has been allowed to cool to less than 150 °F., remove the lock nut from the shaft.

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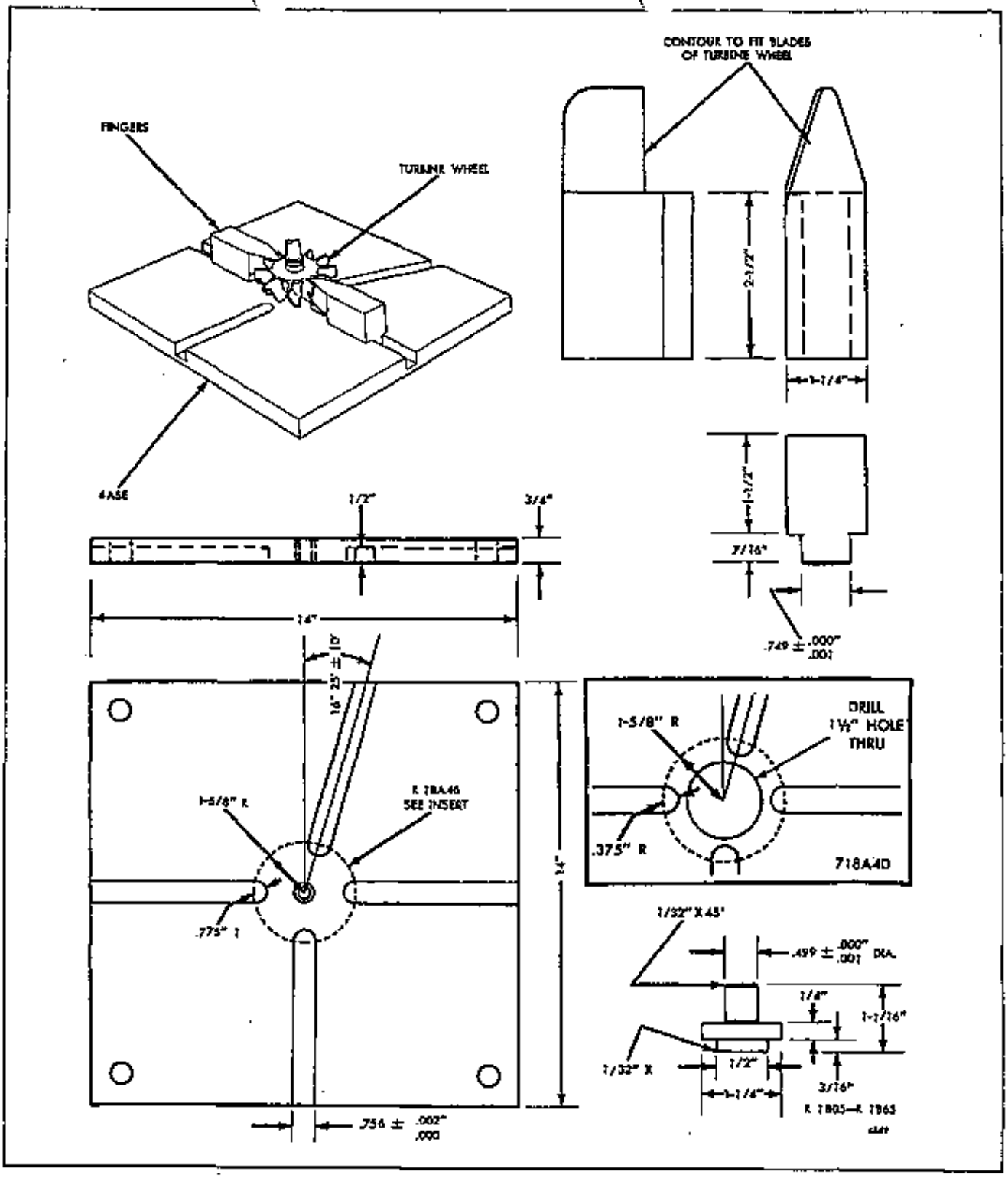


Fig. 21 - Turbocharger Holding Fixture

e. Inspect the flat surface of the lock nut and the top face of the wheel hub for being smooth and clean.

f. Lubricate the threads and the flat surface of the wheel lock nut lightly with engine oil, then install

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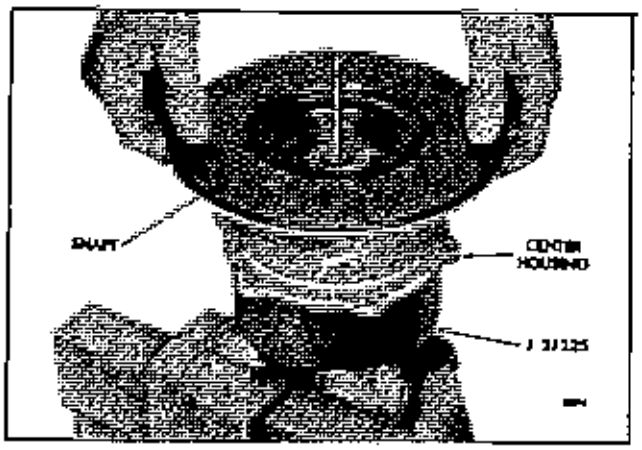


Fig. 22 - Installing Center Housing on Shaft

the lock nut on the shaft and tighten it to 18-20 lb-in torque. After tightening the lock nut, turn it an additional 1/4 turn.

g. Place wrench J 21223 on the lock nut and attach a sliding tee handle to the wrench (Fig. 30).

h. Place a magnetic base dial indicator on the center housing and position the stem of the indicator on the end of the shaft as shown in Fig. 30.

i. Set the hand of the dial indicator at zero. Then tighten the lock nut until the shaft length increases .006 " to .007 ". The current shaft requires 285 lb-in torque to increase or stretch the shaft length .006 " to .007 ". The former "necked down" shaft requires only 260 lb-in torque.

CAUTION: Do not use a box wrench or any

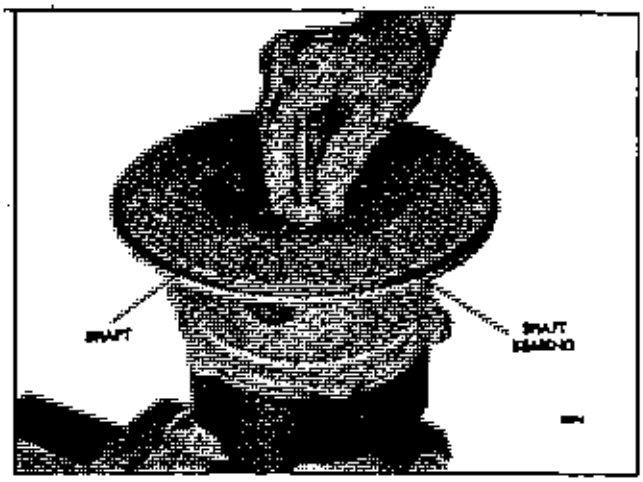


Fig. 23 - Installing Shaft Bearing in Center Housing (Compressor End)

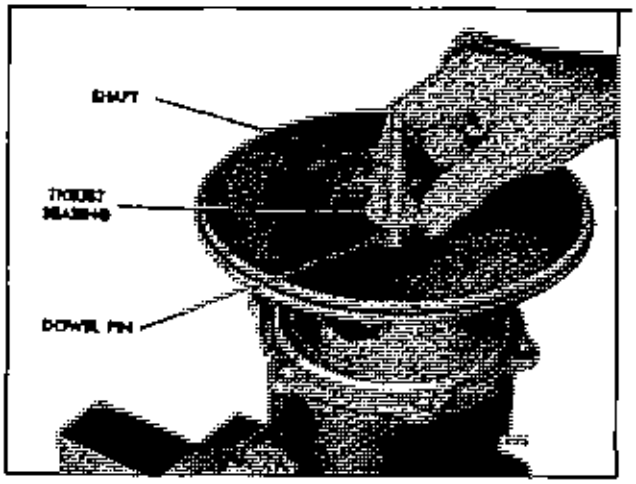


Fig. 24 - Installing Thrust Bearing in Center Housing

other type wrench to tighten the lock nut as the excessive side strain may bend the shaft. Use a sliding tee handle with wrench J 21223 and apply an even pressure on each end of the tee handle. This will eliminate the possibility of bending the shaft while tightening the lock nut.

16. Check the shaft end play as follows:

a. Clamp the turbine housing and center housing and rotating assembly in a bench vise equipped with soft jaws as shown in Fig. 11.

b. Attach a clamp or a magnetic base indicator on the center housing and position the stem of the dial indicator on the end of the shaft.

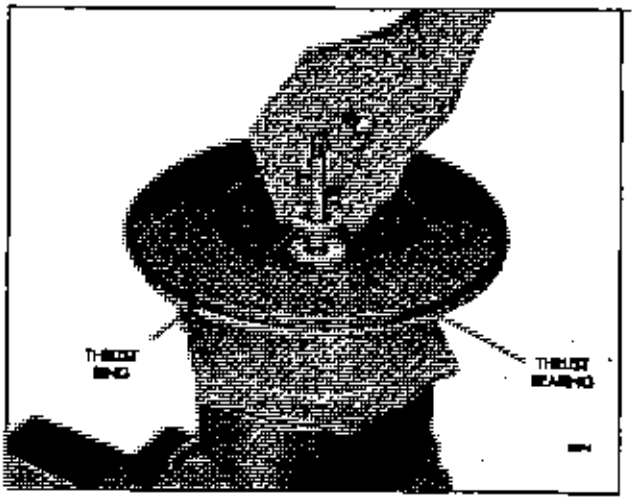


Fig. 25 - Installing Thrust Ring in Center Housing

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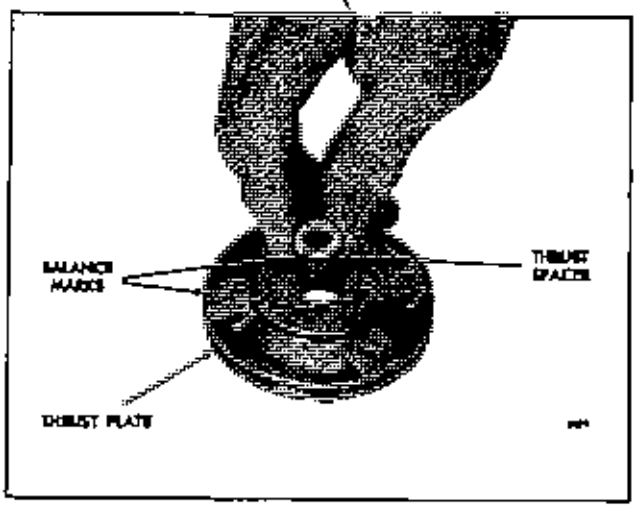


Fig. 26 - Installing Thrust Spacer in Center Housing Thrust Plate

c. Push up on the rotating assembly by hand and note the indicator reading.

d. Push down on the rotating assembly by hand and note the indicator reading.

e. The end play is the difference between the two readings. The specified shaft end play is .004 " to .009 ".

17. Check the shaft radial movement (bearing clearance) as follows:

a. Clamp the flange of the center housing in a bench vise equipped with soft jaws (Fig. 32), with the oil outlet opening in the center housing facing up.

b. Place the dial indicator adaptor f 21224 over the oil outlet opening in the center housing with the large flat end of the plunger against the center of the shaft and secure the tool in place with two 3/8 "-16 bolts of suitable length.

c. Attach a clamp or a magnetic base type indicator to the dial indicator adaptor and position the stem of the dial indicator on the end of the plunger.

NOTE: For a true reading, the dial indicator stem must be on the same center line as the plunger of the dial indicator adaptor.

d. Raise the rotating assembly up by hand as shown in Fig. 32 and note the indicator reading. Then push the rotating assembly down by hand and note the indicator reading.

NOTE: Raise and lower both ends of the rotating assembly evenly when checking the radial movement.

e. The difference between the two readings is the

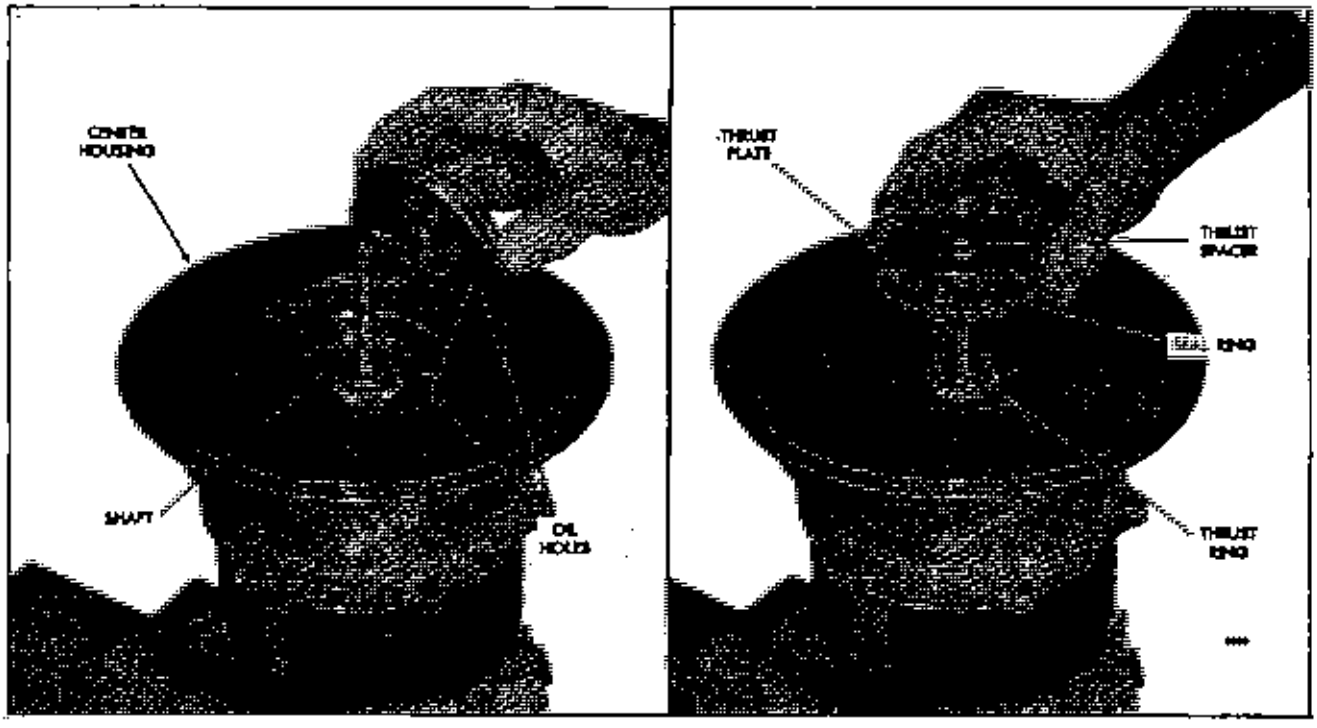


Fig. 27 - Installing Thrust Plate in Center Housing

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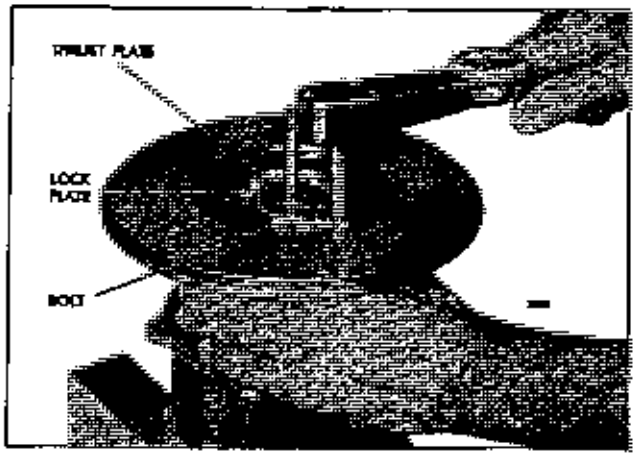


Fig. 28 - Tightening Thrust Plate Retaining Bolts

total clearance between the shaft and the bearings. The specified clearance between the shaft and the bearings is .003 " to .007 ". Repeat Steps d and e several times to be sure the readings are accurate.

NOTE: The shaft radial movement (bearing clearance) may be checked with the turbocharger assembly attached to the engine by mounting the dial indicator adaptor J 21224 and the dial indicator as shown in Fig. 33.

18. Place the compressor housing over the compressor wheel and against the center housing, with the marks previously placed on the housings in alignment.

19. Install the twelve bolts, lock washers and clamps that secure the T15 compressor housing to the center housing. Tighten the bolts to 100-110 lb-in torque. On the T18A turbocharger, position the compressor housing against the center housing and secure it in place with the "V" band coupling. Tighten the nut on the "V" band to 40-60 lb-in torque.

20. Place the turbine housing over the turbine wheel and against the center housing, with the marks previously placed on the housings in alignment.

21. Lubricate the threads of the turbine housing retaining bolts with a high temperature anti-seize lubricant. Then install the three lockplates and six bolts securing the turbine housing to the center housing. Tighten the bolts to 100-110 lb-in torque. Bend both ends of each lockplate up against the flat side of the bolt head.

22. With the turbocharger assembled, spin the rotating assembly by hand. The rotating assembly must turn freely without any indications of dragging or binding.

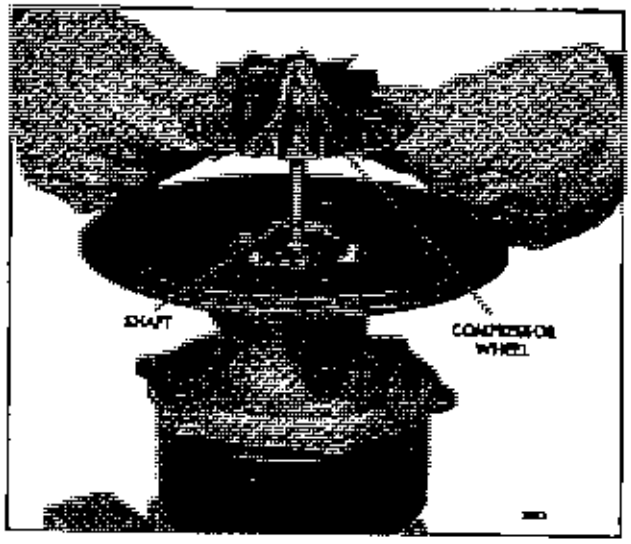


Fig. 29 - Installing Compressor Wheel on Shaft

23. Cover all of the openings in the turbocharger to prevent any foreign material from entering.

Install Turbocharger

1. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

2. Remove the covers from the air inlet and exhaust outlet openings on the engine that were placed over the openings when the turbocharger was removed.

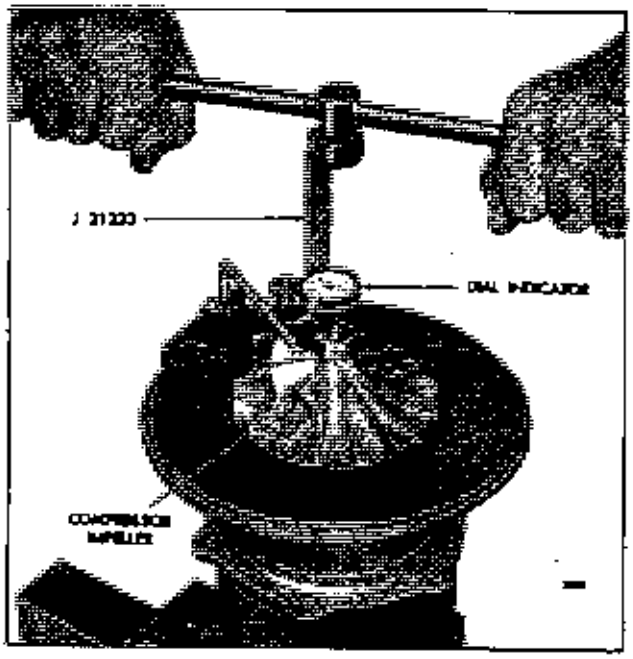


Fig. 30 - Tightening Compressor Wheel Lock Nut

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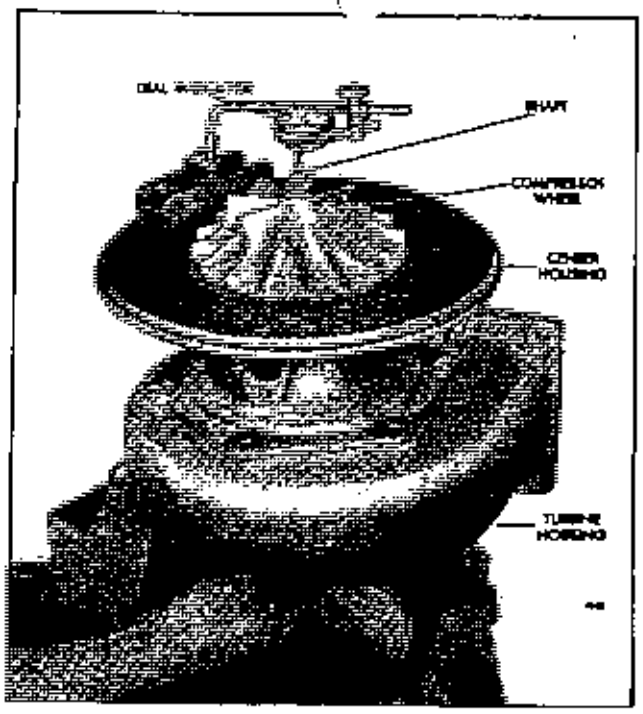


Fig. 31 - Checking Shaft End Play

3. Place the turbocharger assembly into position on the mounting bracket.

4. Secure the turbocharger to the mounting bracket with bolts, lock washers and nuts. Tighten the nuts just enough to hold the turbocharger tight against the bracket.

5. Slide the blower air inlet tube hose over the compressor housing outlet opening and secure it in place with the hose clamps.

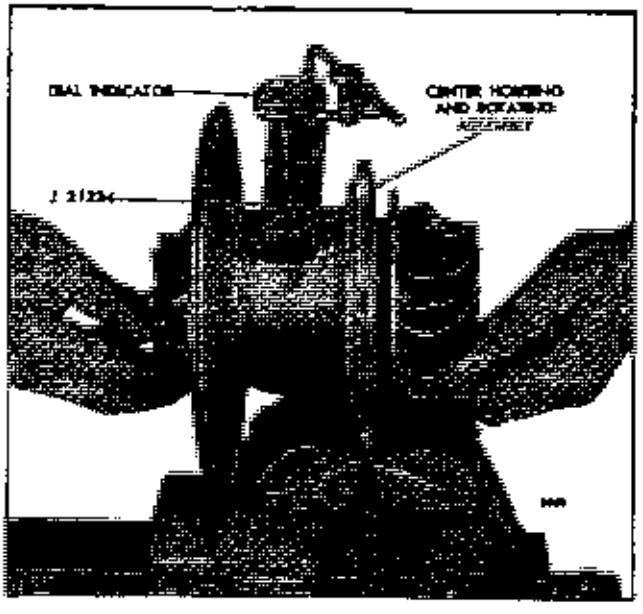


Fig. 32 - Checking Shaft Radial Movement

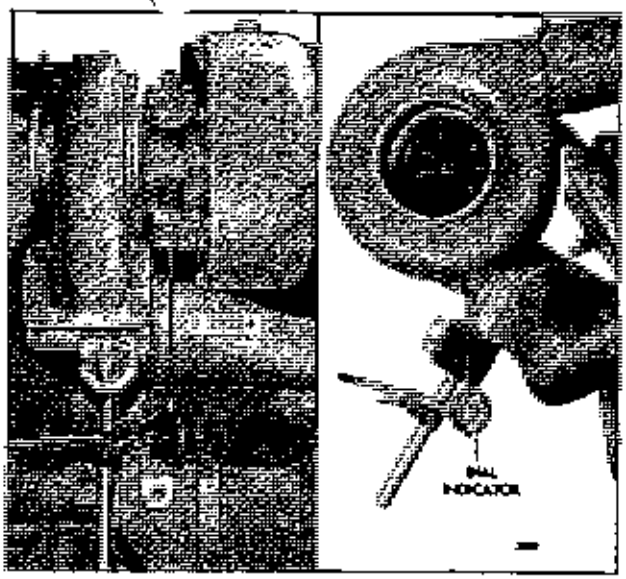


Fig. 33 - Indicator Mounting for Checking Shaft Radial Movement

6. Tighten the turbocharger to exhaust manifold adaptor bolts securely. Then remove the chain hoist and lifting sling from the turbocharger.

7. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block.

8. Attach the oil inlet line to the cylinder block.

9. Before starting the engine, make sure that there is adequate lubricating oil in the turbocharger.

a. Clean the area around the oil inlet opening, then pour about four ounces of engine oil in the oil inlet opening of the center housing. Turn the rotating assembly by hand to coat the bearings, thrust washers and thrust collar with oil.

b. Hold the compressor wheel from turning and start the engine and run it at idle speed.

c. As soon as oil appears at the end of the oil supply line, connect the oil inlet line to the top of the center housing.

NOTE: The oil pressure should be at a minimum of 10 psig.

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d. After the oil inlet line is attached, release the compressor wheel.

10. Check all ducts and gaskets for leaks.

11. Operate the engine at idle speed for a short period to provide adequate lubrication to the turbocharger bearings. Then run at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, shut down the engine immediately and correct the cause.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

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TURBOCHARGER (Elliott)

The Elliott turbocharger (Fig. 1) is a self-contained unit composed of a single stage turbine wheel and single stage air impeller mounted on a common shaft supported in appropriate bearings in an intermediate housing. The turbine wheel and the impeller are enclosed in an exhaust inlet housing on the turbine wheel side and a blower air inlet housing on the impeller side of the intermediate housing.

The sleeve type bearings are pressed into the intermediate housing and prevented from rotating by locating pins. Oil leakage into the exhaust inlet and blower housings is prevented by oil seals. A small quantity of impeller discharge air is used to cool the turbine wheel and pressurize the oil seals.

The speed and output of the turbocharger vary automatically with variations in load and/or speed of the engine and the unit will rotate in one direction only, regardless of engine rotation.

Cooling water and oil passages in the intermediate housing provide a means for supplying coolant and lubrication to the turbocharger.

The model M-5 turbocharger is used on 4-71T engines and Model M-5 or Model M-10 are used on 6-71T engines, depending upon the engine application. The numeral 1 in M 51 and M 101 appearing on the turbocharger name plate refers to a single gas inlet in the exhaust inlet housing. The serial and model number and size of the turbocharger are stamped on the name plate attached to the turbocharger blower housing.

Operation

The free push of expanding exhaust gases in the exhaust turbine drives the turbine wheel which turns the impeller, thus furnishing air to the engine blower, resulting in approximately twice the air box pressure of that obtained on non-turbocharged engines.

Cooling

Engine coolant circulates up and out at the top and returns to the engine thus restricting the thermal distortion of the housing to a minimum.

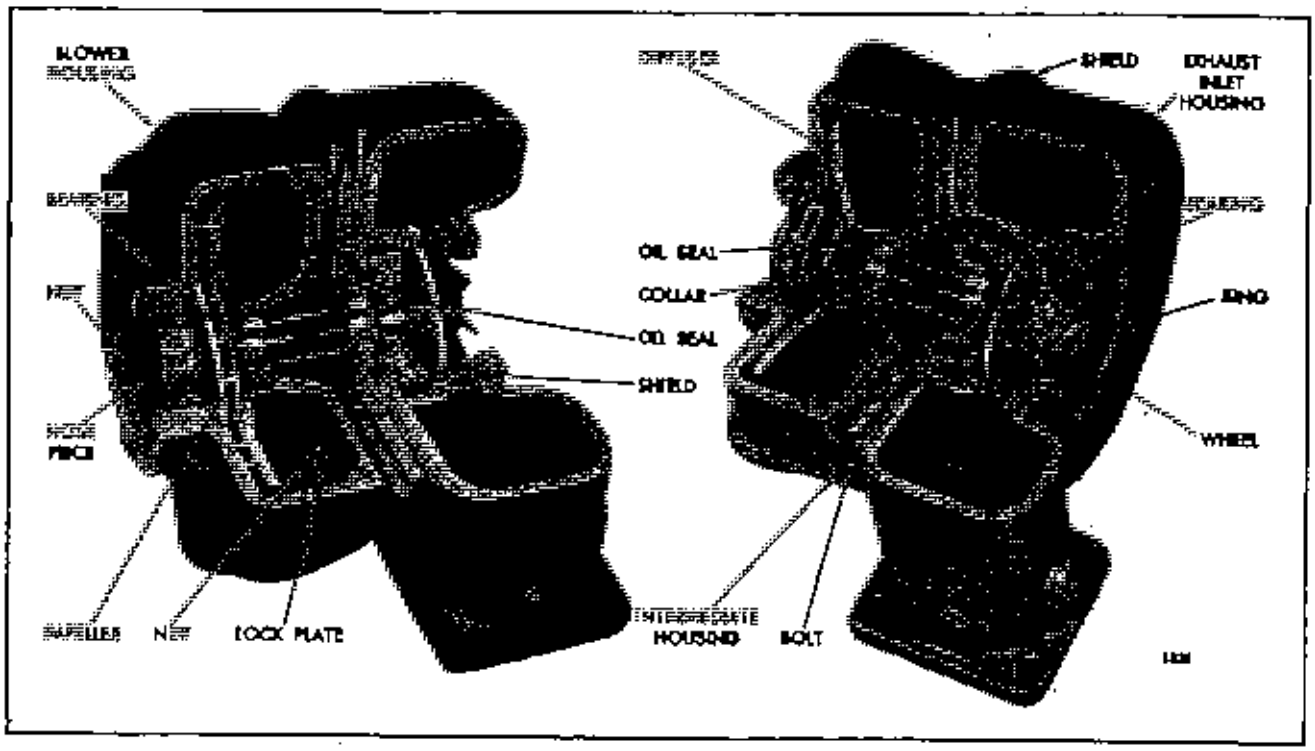


Fig. 1 - Cutaway View of a Typical M-5 Turbocharger

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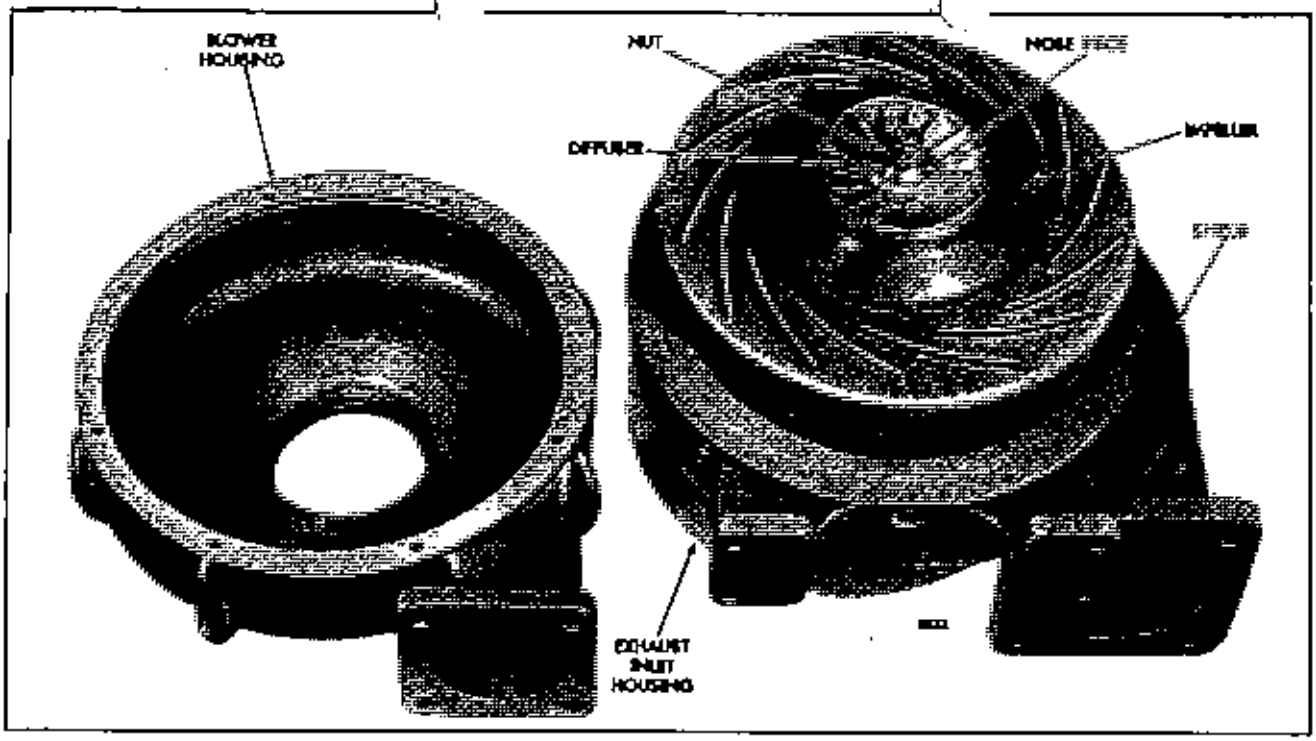


Fig. 2 - Cover Removed Exposing Diffuser and Impeller

Lubrication

Engine oil is piped to a connection near the top of the intermediate housing, from there it flows down a central passage then divides, half going to each bearing. The oil drains from the bottom of the intermediate housing and returns to the engine.

Periodic Inspection

Performance of the turbocharger should be observed at reasonable intervals. Data and conditions to be observed are as follows:

Oil Pressure--Engine lubricating oil pressure should be kept at about 30 to 40 psi at the turbocharger speed corresponding to full engine load. The lubricating oil pressure gage should be observed each time the engine is started or shut down. Particular attention should be paid to keeping the lubricating oil clean by changing the oil and the oil filter elements periodically.

Water Temperature--The turbocharger cooling water temperature should be checked occasionally to make sure that the temperature rise across the turbocharger does not exceed 30 ° F. A high temperature rise across the turbocharger indicates stoppage or plugging of the coolant passages.

Vibration--Operation of the unit should be observed frequently to detect any noticeable vibration. If noticeable vibration develops, the unit should be stopped and the cause determined. Vibration may be caused by damage to the impeller, shaft or turbine wheel, or by worn or loose bearings in the turbocharger.

Turbocharger Overheating or Overspeeding--Injectors with larger capacity than specified and governed speeds higher than specified must never be used. Turbocharged engines must never be operated at higher altitudes than that recommended by the factory. Any of the above conditions will cause turbine overheating and overspeeding and may lead to premature failure.

Loss of Power--If loss of power develops during operation of the engine, refer to the *Engine Trouble Shooting Charts* in Section 15.2, in addition to these charts, check for leaks in the air system, at the hose connections between the turbocharger and the engine blower, at the air box covers and at the air box to compressor line.

Remove the blower housing from the turbocharger every 1000 hours and clean the impeller, diffuser, blower housing and exposed surfaces of the intermediate housing, making sure the cooling air holes in the latter are not plugged. Check the rotor end play in the manner illustrated in Fig. 15. Also check the movement of the impeller end of the shaft by bringing the indicator of the dial gage against the flat of the nut and moving the shaft side-to-side. Check the turbine end in a like manner, bringing the gage against the rim of the turbine wheel. End play should not exceed .012 " (M-5) or .013 " (M-10) or sidewise movement should not exceed .005 ".

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Remove Turbocharger

1. Drain the engine cooling system.

2. Disconnect the exhaust pipe attached to the turbocharger exhaust housing outlet opening.

3. Disconnect the air inlet tube attached to the turbocharger blower housing.

4. Loosen the hose clamps and slide the hose connecting the blower air inlet housing to the turbocharger blower housing down on the air inlet housing.

5. Disconnect the water inlet and outlet lines at the turbocharger.

6. Disconnect the oil inlet and outlet lines at the turbocharger.

7. Attach a suitable rope sling and a chain hoist to the turbocharger assembly.

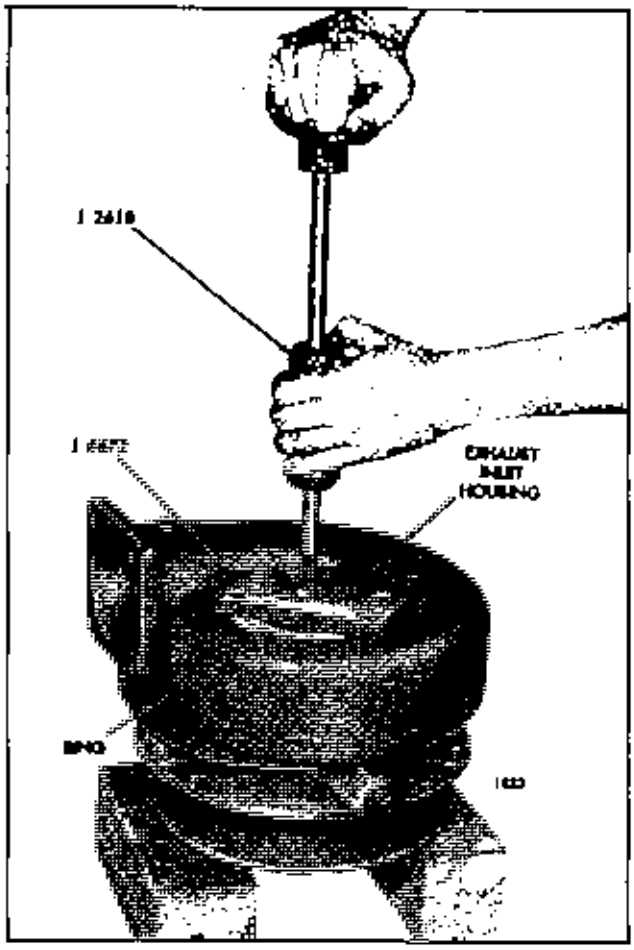


Fig. 3 - Removing Nozzle Ring from Turbocharger Exhaust Housing

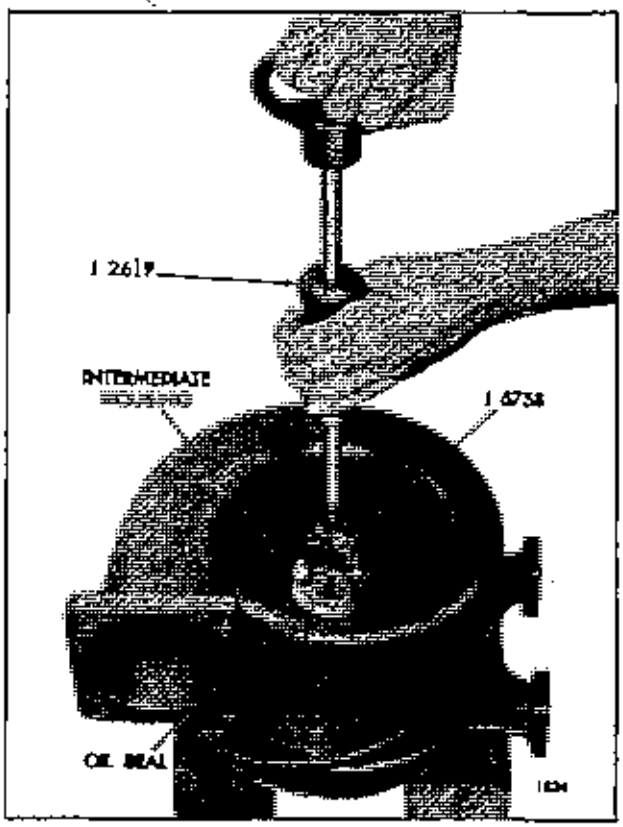


Fig. 4 - Removing Oil Seal and Turbine End Bearing from Intermediate Housing

8. Remove the nuts and lock washers securing the turbocharger exhaust inlet housing to the exhaust manifold and remove the support bracket bolts, if used. Then lift the turbocharger assembly from the engine.

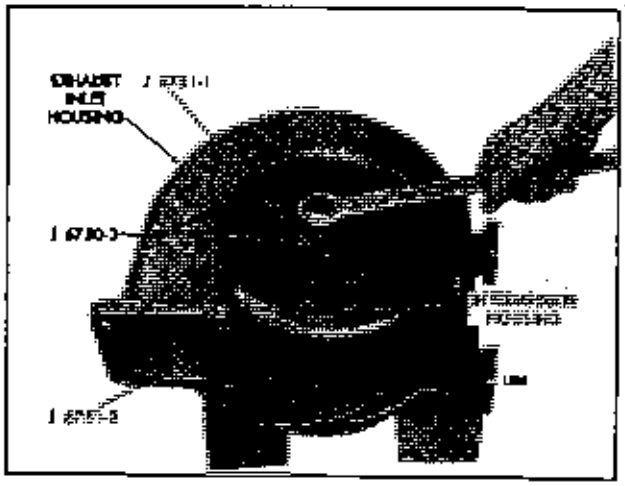


Fig. 5 - Withdrawing Turbocharger Exhaust Housing from Intermediate Housing

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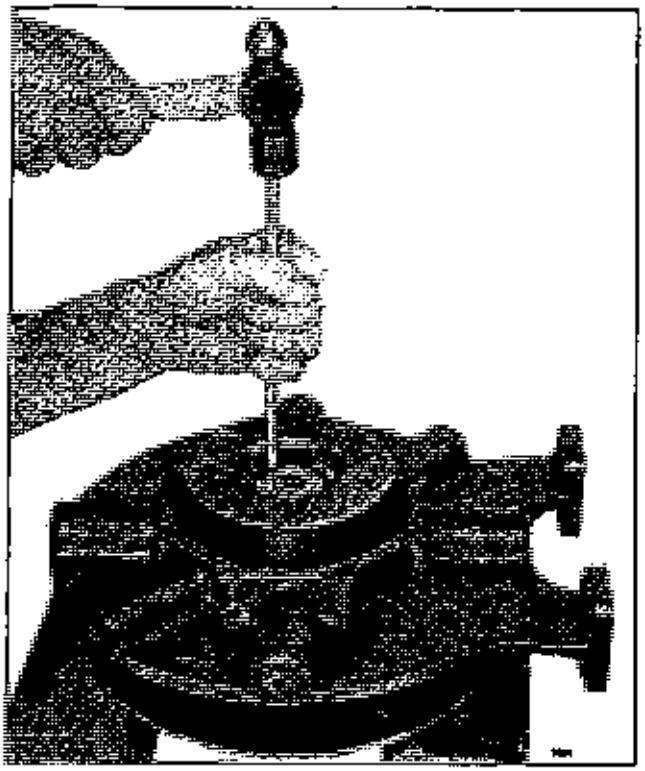


Fig. 6 - Tapping Blower End Oil Seal from Intermediate Housing with 3/16" Brass Rod

M-5 TURBOCHARGER

Disassemble Turbocharger

Remove the dirt from the outer surfaces then scribe marks on the blower housing, intermediate housing, outer radiation shield and the exhaust inlet housing prior to disassembly to ensure their correct reassembly. The turbine wheel, impeller and diffuser should be handled with extreme care to prevent damaging their vanes.

3. With the turbocharger resting on a bench, exhaust end down, or in a suitable fixture, remove the bolts and lock washers which attach the blower housing (17) to the intermediate housing (10 (Fig. 7) and lift the housing straight up from the intermediate housing to avoid damaging the impeller shroud labyrinth seal ring.

2. Bend down the corners of the locking plates (b) with a suitable drift to permit removal of the nuts and the retaining nozzle ring (3) in the turbocharger exhaust inlet housing.

3. Set the turbocharger in an upright position and attach remover J 6672 to the nozzle ring (3). The dowel in the plate must register between the two vanes of the turbine wheel to prevent it from turning.

4. With the turbine wheel blocked from turning, loosen, but do not remove, the rotor wheel elastic stop nut (25) with a box end wrench. Note the scribe marks on the impeller (22), nose piece (23) and the elastic stop nut (25).

5. Support the diffuser end of the turbocharger on two 4 " x 10 " wood blocks as shown in Fig. 3. The blocks must be spread far enough apart to prevent their damaging the rotor impeller.

6. Use slide hammer J 2619 and remover J 6672 to remove the nozzle ring as shown in Fig. 3. Remove the tool from the nozzle ring. If the nozzle ring does not pull easily, apply penetrating oil at the meeting line of the housing and also apply heat to the outer periphery of the exhaust housing.

7. Place the turbocharger in an upright position. Run the elastic nut out to the end of the threads and, using a plastic hammer, tap the impeller end of the turbine wheel shaft to free the impeller. Remove the elastic nut, nose piece, impeller and key. Coat the turbine wheel shaft and pilot J 6673 with engine oil. Place the pilot over the threaded end of the turbine wheel and withdraw the turbine wheel and pilot from the turbocharger. Separate the pilot from the turbine wheel.

8. Remove the shims (2), if used, and inner radiation shield (9) from the exhaust inlet housing (1).

9. Rest the turbocharger on the diffuser end and remove the oil seal (11) and bearing (13) together with slide hammer J 2619 and adaptor J 6758 as shown in Fig. 4. Discard the oil seal and bearing.

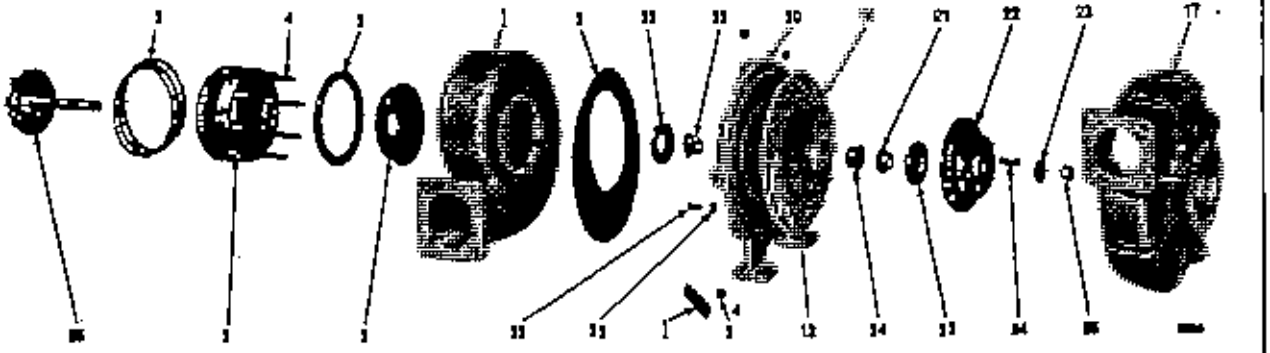
10. Locate the pilot of tool J 6751-2 in the oil seal bore of the intermediate housing. Insert remover J 6751-1 in the exhaust housing and thread the remover screw J 6750-3 through the remover. Turn the remover screw clockwise as shown in Fig. 5 to withdraw the exhaust inlet housing from the intermediate housing (10). If the exhaust housing does not pull easily, apply heat to the outer periphery.

11. Note the scribe marks on the outer radiation shield (8), then remove the shield.

12. Place the intermediate housing on wood blocks, diffuser side down, and remove the oil seal (15) and thrust collar (21) by tapping against the inner face through the four openings in the intermediate housing with a 3/16 " diameter brass rod as shown in Fig. 6. Tap alternately through the four openings to prevent cocking the seal. Discard the seal and replace it with a new one.

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1. Housing–Exhaust Inlet	8. Lockplate	12. Pin–Bearing Locating	19. Lock Washer
2. Shim	7. Gasket (Asbestos Strands)	13. Bearing–Turbine End	20. Wheel–Turbine
3. Ring–Nozzle	8. Shield–Outer Radiation	14. Bearing–Blower End	21. Collar–Thrust
4. Stud–Nozzle Ring (6 15/16 "; 18 3 ")	9. Shield–Inner Radiation	15. Oil Seal–Blower End	22. Impeller–Blower
	10. Housing–Intermediate	16. Diffuser–Air	23. Nose Piece
5. Nut	11. Oil Seal–Turbine End	17. Housing–Blower	24. Nut–Elastic Stop
		18. Bolt	25. Bolt

Fig. 7- Turbocharger Details and Relative Location of Parts

13. Remove the bearing (14) with adaptor J 6758 and slide hammer J 2619 (Fig. 4). Discard the bearing and replace it with a new bearing.

14. If the diffuser (16) is damaged in any way, replace it.

Inspection

Handle the rotating parts with care since slight damage to the turbine wheel or the impeller may cause more serious damage when they are reinstalled and run. If the rotor assembly is dented, cracked or damaged, it must be replaced with a new balanced assembly.

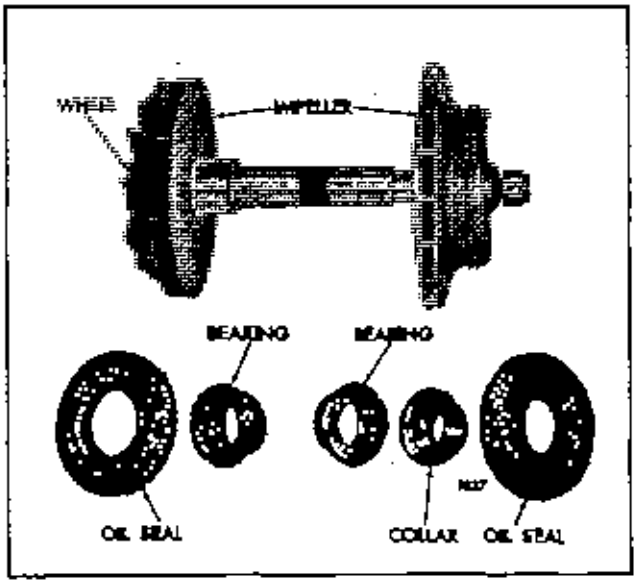


Fig. 8 - Relative Position of Turbocharger Bearings, Oil Seals and Thrust Collar

Remove the grease, dirt, carbon and gasket material from the diffuser, nozzle ring, turbine wheel, impeller and the other parts with a suitable non-caustic solution.

> NOTE: Never use a caustic solution, wire brush or a metal scraper on the aluminum parts since their use will weaken the parts and upset the balance of the rotor assembly.

Clean the scale and sludge deposits from the outer surface and the air holes of the intermediate housing, then flush and blow out the oil and air passages.

Worn parts should be replaced or adjustments made to assure that the operating clearances will not exceed the specified values.

Assemble Turbocharger

Although the bearings used at the blower and turbine ends appear to be similar, they are not alike. Therefore, it is extremely important that the bearing with the wide thrust face be installed at the blower end and the bearing with the narrow thrust face be installed at the turbine end (Figs. 7 and 8). With all of the parts cleaned and inspected, assemble the turbocharger as follows:

1. If the diffuser was removed from the intermediate housing, support the turbine end of the housing on the bed of an arbor press and locate the hub of the

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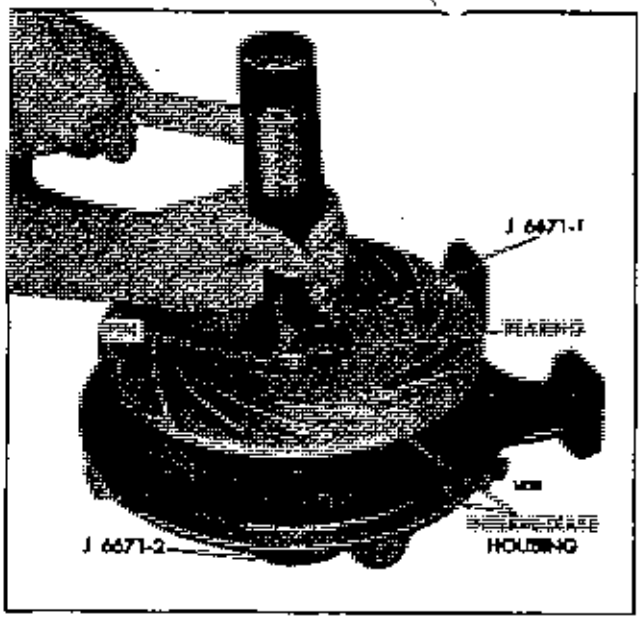


Fig. 9 - Installing Blower End Bearing

diffuser, vanes up, on the blower end of the housing. Press the diffuser into place.

2. Place the intermediate housing on pilot J 6671-2, diffuser side up (Fig. 8). Slide a new bearing (14), with the wide thrust face, on tool J 6671-1 and install the bearing, being careful to align the notch in the bearing with the locating pin (12). Make sure the bearing is properly seated by attempting to insert a .0015" feeler gage between the lip of the bearing and the intermediate housing. The bearing is properly seated when the feeler gage cannot be inserted.

3. Reverse the position of the intermediate housing on pilot J 6671-2. Install a new bearing (13), with the narrow thrust face (Fig. 8), and check for proper seating.

4. Support the intermediate housing on pilot J 6770-2 on the bed of an arbor press, diffuser side up. Broach both bearings with tool J 6670-1. Blow out the dirt and cuttings resulting from the broaching operation (Fig. 10).

5. Tap a new oil seal (15) into the diffuser end with a plastic hammer. Scribe mark the seal and intermediate housing so that the seal can be reinstalled in the same location later (refer to Step 26 below).

6. Support the intermediate housing on wood blocks and ream the seal with tool J 6675 (Fig. 11).

7. After reaming, remove the blower end seal by tapping against the inner face through the four

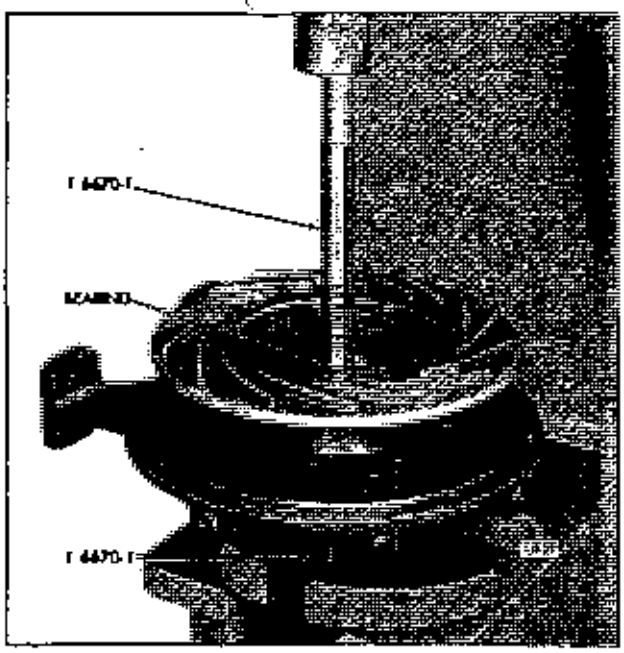


Fig. 10 - Broaching Bearings in Intermediate Housing

openings in the intermediate housing with a 3/16" diameter brass rod as illustrated in Fig. 6. Tap alternately through the four openings to prevent cocking the seal. Blow out the chips resulting from the reaming.

8. Coat the outer periphery of the turbine end oil seal (11) with non-hardening, heat resisting sealing

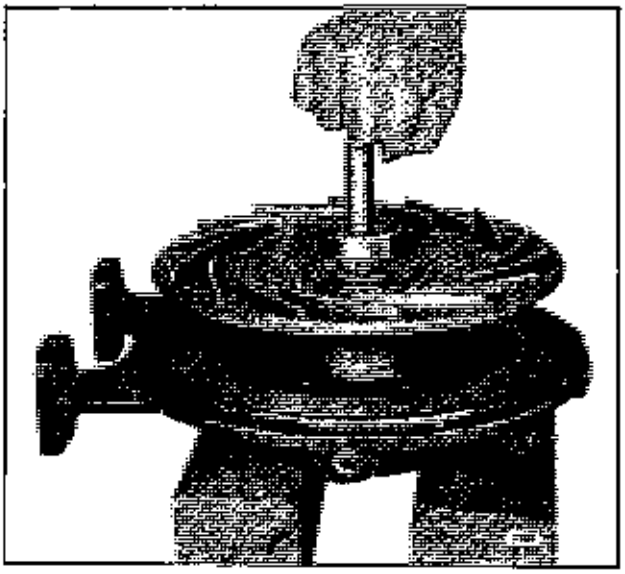


Fig. 11 - Reaming Blower End Oil Seal with Tool J 6675

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compound (Permatex No. 2, or equivalent). Support the intermediate housing on wood blocks, turbine end up, and install the turbine end oil seal as outlined in Step 5 above.

9. Ream the turbine end oil seal with tool J 6674.

10. Blow out the chips, resulting from the reaming, with compressed air and clean the oil bleeder grooves in the bore of the turbine end bearing.

11. Stand the intermediate housing in an upright position. Place pilot J 6673 over the threaded end of the turbine wheel shaft, with the chamfered end toward the threads.

12. Lubricate the turbine wheel shaft and pilot with engine oil, then pilot the shaft through the bearings from the turbine end.

13. Remove the pilot from the turbine wheel shaft, then slide the thrust collar (21) on the shaft and secure it in place with spacer nut J 6678. Snug the tool tight by hand -- do not use a wrench on the tool.

14. Attach dial indicator J 5959 to the intermediate housing as shown in Fig. 12.

15. If the bearings and the turbine end oil seal are properly installed, the rotor end play at this stage of assembly will be .004 " to .012 ". If the end play is not within these limits, the bearings and oil seal must be removed and new ones installed as outlined in Steps 1 through 13 above. Then check again for the proper rotor end play.

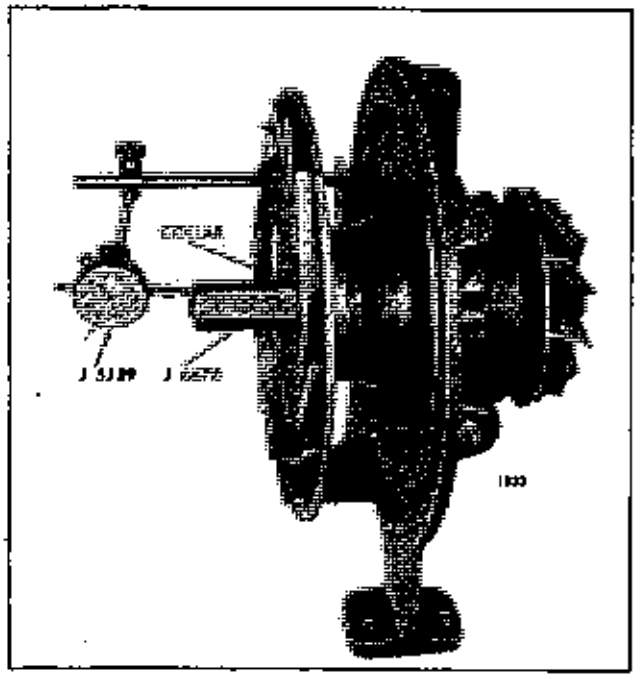


Fig. 12 - Preliminary Checking of Rotor End Play

16. Remove the dial indicator from the intermediate housing; also remove the spacer nut and the thrust collar from the shaft. Support the intermediate housing, diffuser end down, on wood blocks and withdraw the turbine wheel carefully from the housing.

17. Lay the outer radiation shield (8) on the housing (10), dished side down, then place the inlet housing (1) on the shield. Rotate the housing so that the inlet flange is in its original position with the scribe marks, previously placed on the housing, in alignment. The outer radiation shield must be rotated to align its widest surface with the inlet flange.

NOTE: The exhaust inlet housing must be assembled to the intermediate housing in such a manner that, when the turbocharger is installed on the engine, the lubricating oil will drain from the bottom of the housing.

18. Lay the inner radiation shield in position in the housing; also the shims, if used.

19. Place pilot J 6673 over the threaded end of the turbine wheel shaft with the chamfered end toward the threads. If a new rotor assembly (turbine wheel and impeller) is being installed, clamp the shaft of the turbine wheel between wood blocks in a vise and loosen the elastic nut (25) to permit removal of the key (24), nose piece (23), impeller (22) and thrust collar (21) from the shaft.

20. Lubricate the turbine wheel shaft, pilot and bearings with engine oil and lower the shaft end of the turbine wheel through the turbine end oil seal and bearings (Fig. 13).

21. Clean all of the mating parts and surfaces.

a. Buff the nozzle ring with a fine wire wheel and finish with a very fine emery cloth.

b. Inspect the packing grooves very closely. Make sure all of the old packing has been removed.

c. The shims must be checked for cleanliness. It is very important that the shims are clean.

d. Clean the turbocharger housing seal surfaces.

e. Check the housing for an out of round condition. A .003 " feeler gage must not go between the madog edge of the nozzle ring and the housing at any point.

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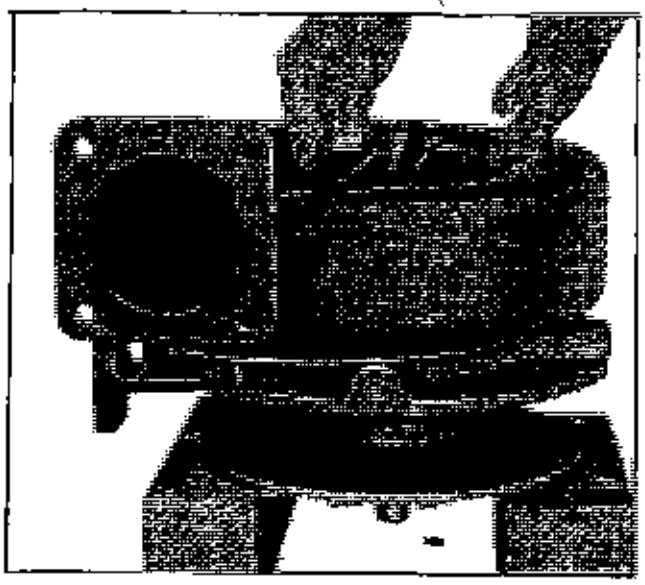


Fig. 13 - Installing Rotor Turbine Wheel With Pilot J 6673

22. Install the asbestos packing in the nozzle ring grooves.

a. Use all of the packing (20 feet).

b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

23. Place the nozzle ring in dry ice.

a. Place the nozzle ring in a box a little larger than the ring itself. The box should have a lid.

b. Break up the dry ice into small pieces and pack it around both sides of the nozzle ring.

24. Install the nozzle ring in the turbocharger housing.

a. Just before installing the nozzle ring, warm up the turbocharger housing with an acetylene torch. Apply the heat gradually so that the housing will expand evenly.

b. Place the shims in the housing and align the holes.

c. Insert the nozzle ring in the housing. The ring will slide into the housing with very little force.

d. Allow the nozzle ring to come up to room temperature before tightening the nuts securely.

25. Stand the turbocharger in an upright position and remove the pilot J 6673 from the shaft.

26. Coat the outer periphery of the blower end oil seal (15) with non-hardening, heat resisting sealing compound (Permatex No. 2, or equivalent). Assemble the thrust collar (21) to the blower end oil seal (15) (Fig. 7) and start the collar and seal over the shaft and into position in the intermediate housing. Make sure the scribe marks, previously placed on the seal and the housing, are aligned to ensure correct sealing. Tap the seal uniformly into place with a plastic hammer.

27. Rotate the turbine wheel until the keyway in the shaft is facing up, then attach tool J 6672 again to the nozzle ring to prevent the rotor wheel from turning.

28. Place the key (24) in the keyway of the shaft, marked side up, and slide the impeller (22) on the shaft with the keyway in line with the key.

29. Install the nose piece (23) against the impeller, aligning the scribe marks of the nose piece with that on the impeller.

30. Install the impeller elastic stop nut (25). Draw the nut tight until the scribe mark on the nut registers with the scribe mark on the impeller and the nose piece. These parts are dynamically balanced and marked at the time of the initial assembly.

31. Remove tool J 6672 and turn the turbine wheel by hand to be sure it rotates freely.

32. Place a lockplate (6) over a pair of nozzle ring studs at each side of the intermediate housing and

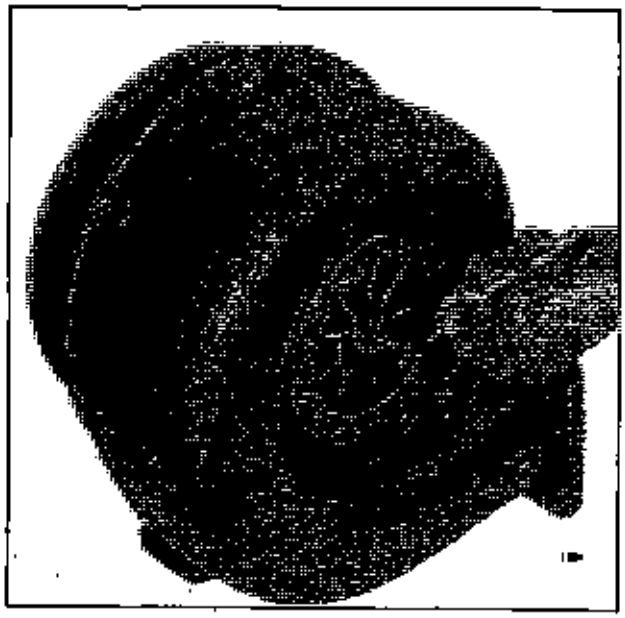


Fig. 14 - Checking Radial Clearance Between Turbine Wheel Vanes and Nozzle Ring

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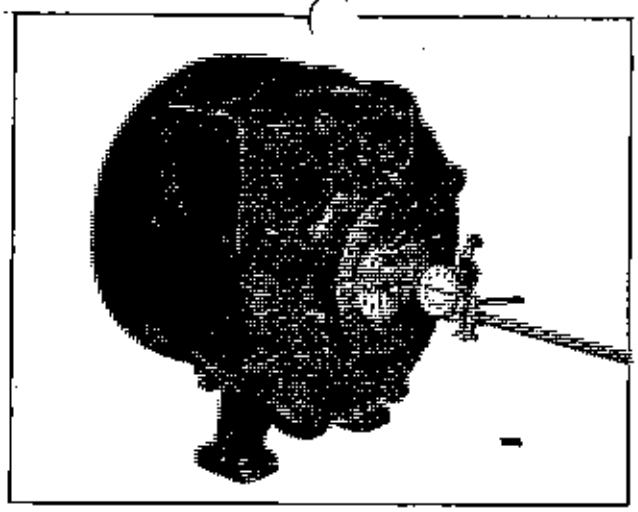


Fig. 15 - Final Checking of Rotor End Play

install and draw the nuts tight to hold the exhaust inlet housing to the intermediate housing. Place the remaining two lockplates on the studs and draw the nuts tight.

33. Check all of the nuts for tightness and bend the corners of the lockplates against the flat side of the nuts.

34. Insert a feeler gage between the nozzle ring (3) and the radial vanes of the turbine wheel (Fig. 14) and check the clearance. The clearance should be from .025" to .040". When checking for the minimum clearance, force the wheel in the direction of the exhaust housing by pushing against the impeller. Force the wheel in the opposite direction when checking for the maximum clearance. If the clearance is less than the minimum allowable, it will be necessary to add the required shims (2) under the nozzle ring.

35. Place the blower housing against the intermediate housing in its original position and secure it in place with bolts and lock washers. Rotate the impeller while tightening the bolts to be assured there is no bind.

36. Attach dial indicator J 5959 to the blower housing and recheck for end play of .004" to .013" as shown in Fig. 15.

37. Remove the dial indicator.

38. Install the turbocharger as outlined at the end of this section.

M-10 TURBOCHARGER

Disassemble Turbocharger

Remove the dirt from the outer surfaces then scribe marks on the blower housing, intermediate housing, outer radiation shield, exhaust inlet housing and nozzle ring prior to disassembly to ensure their correct reassembly. The turbine wheel, impeller and diffuser should be handled with extreme care to prevent damaging their vanes.

1. With the turbocharger resting on a bench, exhaust end down, or in a suitable fixture, remove the bolts and lock washers which attach the blower housing (17) to the intermediate housing (10), Fig. 20, and lift the housing straight up and away from the intermediate housing (Fig. 16) to avoid damaging the impeller shroud labyrinth seal ring. Use a rope sling inserted through two eyebolts.

2. Remove the lock wire with a pair of pliers to permit removal of the bolts which hold the exhaust inlet housing (1) to the intermediate housing (10).

3. Set the turbocharger in an upright position and attach the remover J 6750-2 to the nozzle ring (3). The dowel in the plate must register between two vanes of the turbine wheel to prevent it from turning.

4. With the turbine wheel blocked from turning, loosen, but do not remove, the rotor wheel elastic stop nut (25) with a box end wrench. Note the punch and scribe marks on the rotor impeller (22), nose piece (23) and elastic stop nut (25).

5. Attach the remover set J 6750 to the exhaust inlet housing; then, using a rope sling, lift the inlet housing and diffuser assembly onto 4" x 4" x 10" (approximately) wood blocks (Fig. 17). The wood blocks must be spread far enough apart to prevent their damaging the rotor impeller.

6. Remove the nozzle ring stud nuts (5) and lock washers to permit removal of the nozzle ring (3).

7. Turn the screw (J 6751-3), thus removing the nozzle ring as shown in Fig. 18. Remove tool J 6750 from the nozzle ring. If the nozzle ring does not pull easily, apply penetrating oil at the meeting line of the housing and also apply heat to the outer periphery of the exhaust inlet housing.

8. Place the turbocharger in an upright position. Run the elastic nut out to the end of the threads and, using a soft hammer or wood block, tap the impeller end of the shaft to free the impeller. Remove the elastic nut, nose piece, impeller and key. Coat the turbine wheel

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Fig. 16 - Removing Blower Housing from Intermediate Housing

shaft and pilot J 6756 liberally with engine oil. Place the pilot over the threaded end of the shaft and withdraw the turbine wheel and the pilot from the turbocharger. Separate the pilot from the turbine wheel.

9. Withdraw the shims (2), if used, and inner radiation shield (9) from the exhaust inlet housing.

10. Rest the turbocharger on the diffuser end and remove the oil seal (11) and bearing (13) together, using slide hammer J 2619 and puller J 6758 in the manner shown in Fig. 4. Discard the oil seal and bearing.

11. Locate the pilot of plate J 6751-2 in the oil seal bore of the intermediate housing (10) and attach the plate to the exhaust inlet housing with four allen screws J 6751-4. Thread the remover screw J 6750-3 through the plate. Turn the screw clockwise as shown in Fig. 19 to withdraw the inlet housing from the intermediate housing. If the exhaust inlet housing does not pull easily, apply heat to the outer periphery.

12. Remove the outer radiation shield(8).

13. Place the intermediate housing on wood blocks, diffuser side down, and remove the oil seal (15) and thrust collar (21) by tapping against the inner face, through the four openings in the intermediate housing, with a 3/16" diameter brass rod (Fig. 6). Tap alternately through the four openings to prevent cocking the seal. Discard the seal.

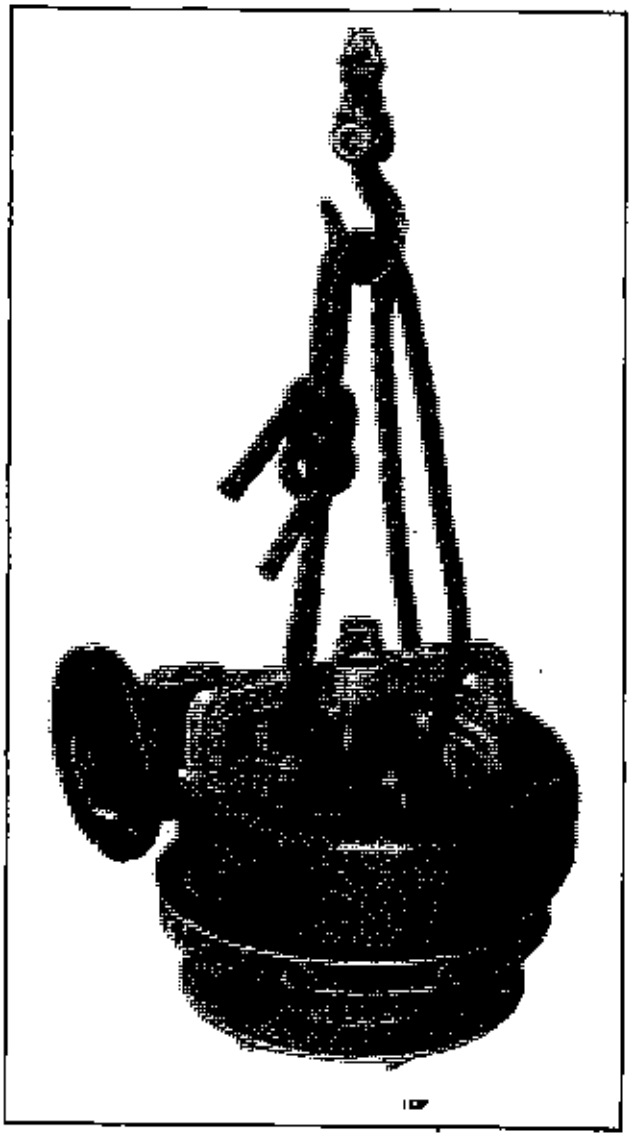


Fig. 17 - Placing Exhaust Inlet Housing and Diffuser Assembly on Wood Blocks

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14. Remove the bearing (14) using puller J 6758 and slide hammer J 2619 (Fig. 4). Discard the bearing.

15. If the diffuser (16) is damaged in any way, replace it.

Inspection

Handle the rotating parts with care since slight damage to the turbine wheel or impeller may cause serious damage when they are reinstalled and run. If the rotor assembly is dented, cracked or damaged, it must be replaced with a new balanced assembly.

Remove the grease, dirt, carbon and gasket material from the diffuser, nozzle ring, turbine wheel, impeller and other parts with a suitable non-caustic solution.

> **NOTE:** Never use a caustic solution, wire brush or metal scraper on aluminum parts since their use will weaken the the parts and upset the balance of the rotor assembly.

Clean the scale and sludge deposits from the outer surface and air holes of the intermediate housing and flush and blow out the oil and air passages.

Worn parts should be replaced or adjustments made to assure that operating clearances will not exceed the specified values.

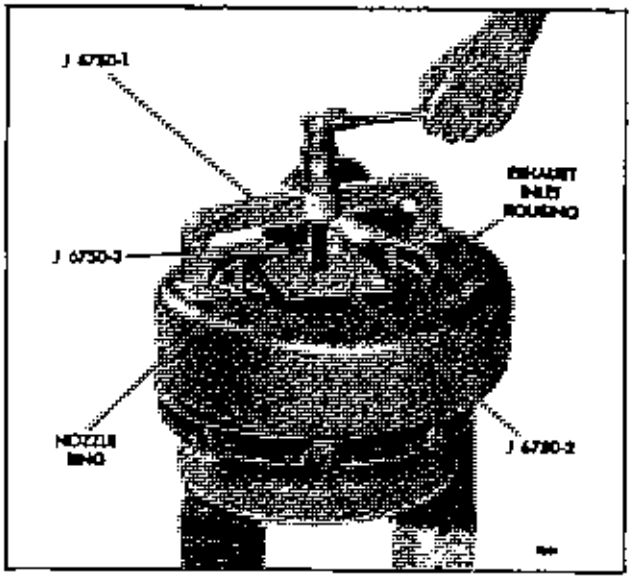


Fig. 18 - Removing Nozzle Ring from Exhaust Housing with Tool J 6750

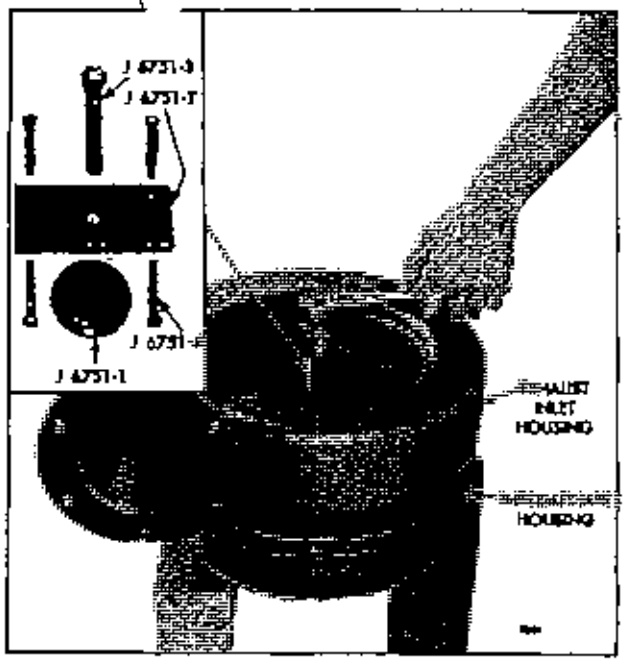


Fig. 19 - Withdrawing Exhaust Housing from Intermediate Housing with Tool J 6751

Assemble Turbocharger

Although the bearings used at the blower and turbine ends appear to be similar, they are not alike. Therefore, it is extremely important that the bearing with the oil bleeder grooves in the thrust face be installed in the blower end, and the bearing with the oil bleeder grooves in the bore of the bearing be installed in the turbine end (Fig. 21). With all parts cleaned and inspected, assemble the turbocharger as follows:

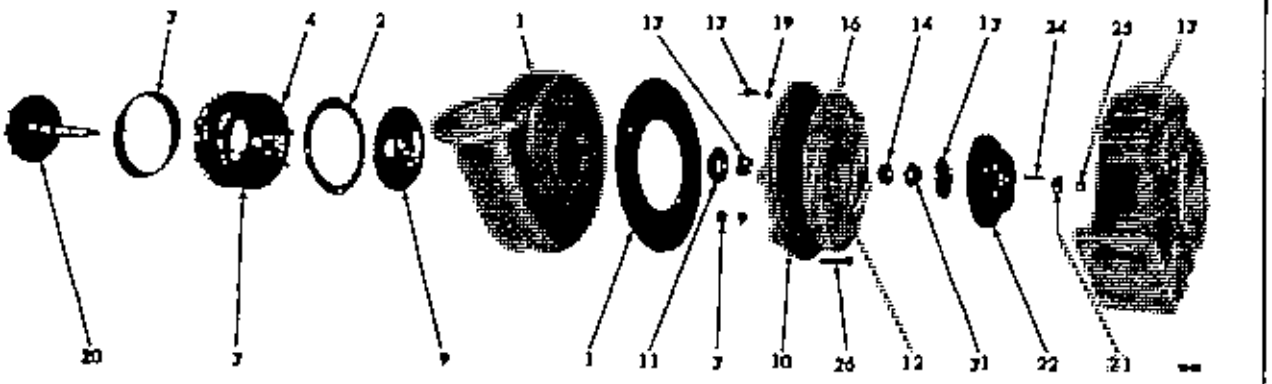
1. If the diffuser was removed from the intermediate housing, support the turbine end of the housing on the bed plate of the arbor press and locate the hub of the diffuser, vanes up, on the blower end of the housing. Press the diffuser into place.

2. Place the intermediate housing on pilot J 6752-2, diffuser side up. Slide the new bearing (14), with the oil bleeder grooves in the thrust face (Fig. 21), on tool J 6752-1 and install the bearing, being careful to align the notch in the bearing with the locating pin (12) in a manner similar to that shown in Fig. 9. Make sure the bearing is properly seated by attempting to insert a .0015 " feeler ribbon between the lip of the bearing and the intermediate housing. The bearing is properly seated when the feeler cannot be inserted.

5. Reverse the position of the intermediate housing on the pilot J 6752-2. Install a new bearing (13) and check for proper seating.

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1. Housing–Exhaust Inlet
2. Shim
3. Ring–Nozzle
4. Stud–Nozzle Ring (5/16 "-18 x 1-1/2 ")
5. Nut
7. Gasket (Asbestos Strands)
8. Shield–Outer Radiation
9. Shield–Inner Radiation
10. Housing–Intermediate
11. Oil Seal–Turbine End
12. Pin–Bearing Locating
13. Bearing–Turbine End
14. Bearing–Blower End
15. Oil Seal–Blower End
16. Diffuser–Air
17. Housing–Blower
18. Bolt
19. Lock Washer
20. Wheel–Turbine
21. Collar–Thrust
22. Impeller–Blower
23. Nose Piece
24. Key
25. Nut–Elastic Stop
26. Bolt

Fig. 20 - M-10 Turbocharger and Relative Location of Parts

4. To retain the turbine end bearing during the broaching operation, rest the intermediate housing on support J 6753-2 on an arbor press, diffuser side down. Broach both bearings with tool J 6753-1. Blow out the dirt and cuttings resulting from the broaching operation (Fig. 22).

5. Tap a new oil seal (15) into the blower end with a soft hammer. Punch and scribe mark the seal and the intermediate housing so that the seal will be reinstalled in the same location later, see Step 26 below.

6. Support the intermediate housing on wood blocks and ream the seal with tool J 6755, in a manner similar to that shown in Fig. 11. Blow out the chips.

7. After reaming, remove the blower end seal by tapping against the inner face, through the four openings in the turbine, with a 3/16 " diameter brass rod as illustrated in Fig. 6. Tap alternately through the four openings to prevent cocking the seal.

8. Coat the outer periphery of the turbine end oil seal (11) with a non-hardening, heat resistant sealing compound. Support the intermediate housing on wood blocks, turbine end up, and install the turbine end oil seal in the same manner as in Step 6 above.

9. Ream the turbine end oil seal with tool J 6754.

10. Blow out the cuttings with compressed air and clean the oil bleeder grooves in the bore of the turbine end bearing.

11. Stand the intermediate housing in an upright position. Place pilot J 6756 over the thread end of the turbine wheel shaft, with the chamfered end toward the threads.

12. Coat the turbine wheel shaft and pilot liberally with engine oil and pilot the shaft through the bearings from the turbine end.

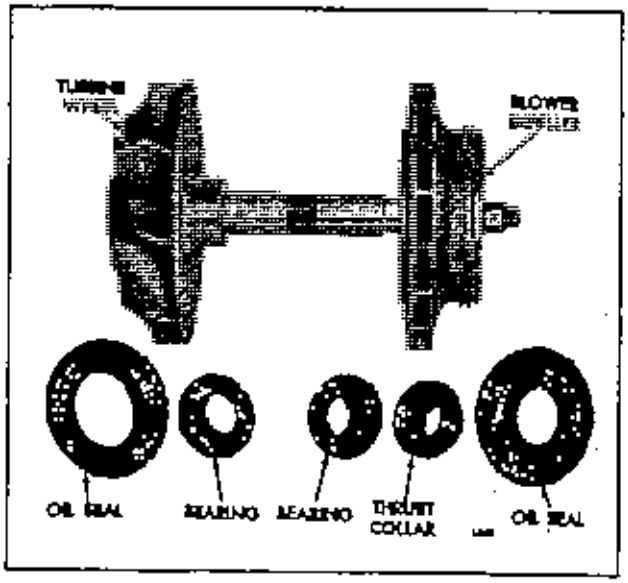


Fig. 21 - Relative Position of M-10 Turbocharger Bearings, Oil Seals and Thrust Collar

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13. Remove the pilot from the shaft, slide the thrust collar (21) on the shaft and secure it with a spacer nut J 6757. Snug the tool tight by hand--do not use a wrench on the tool.

14. Attach dial Indicator J 5959 to the diffuser.

15. If the bearings and turbine end oil seal are properly installed, the rotor end play at this stage of assembly will be .004 " to .013 ". If the end play is not within these limits, the bearings and oil seal must be removed and new ones installed as outlined in Steps 1 through 10 above. Then check again for proper rotor end play.

16. Remove the dial indicator from the diffuser; also remove the spacer nut and thrust collar from the turbine wheel. Spread grease on the thread end of the turbine wheel shaft to hold pilot J 6756 in place. Then slide the pilot on the shaft. Support the intermediate housing, diffuser end down, on 4 " x 4 " wood blocks and withdraw the turbine wheel carefully from the housing.

17. Lay the two-piece outer radiation shield (8) on the intermediate housing (10); then place the exhaust inlet housing (1) on the intermediate housing. Rotate the exhaust inlet housing so that the inlet flange is in its original position as required by the particular engine, or align the scribe marks made prior to disassembly.

> NOTE: The exhaust inlet housing must be assembled to the intermediate housing in such a manner that when the turbocharger is installed on the engine, the oil will drain from the bottom of the housing.

18. Lay the inner radiation shield (9) in position in the exhaust inlet housing; also the shims (2), if used.

19. Slide the pilot J 6756 over the thread end of the turbine wheel shaft with the chamfered end towards the threads. If a new rotor assembly (turbine wheel and impeller) is being installed, clamp the shaft of the turbine wheel between wood blocks in a vise and loosen the elastic nut (25) to permit removal of the key (24), nose piece (23), impeller (22) and thrust collar (21) from the shaft.

20. Coat the turbine wheel shaft, pilot J 6756 and the bearings liberally with engine oil and lower the shaft end of the turbine wheel through the turbine end oil seal and bearings in a manner similar to that shown in Fig. 13.

21. Clean all of the mating parts and surfaces.

a. Buff the nozzle ring with a fine wire wheel and finish with very fine emery cloth.

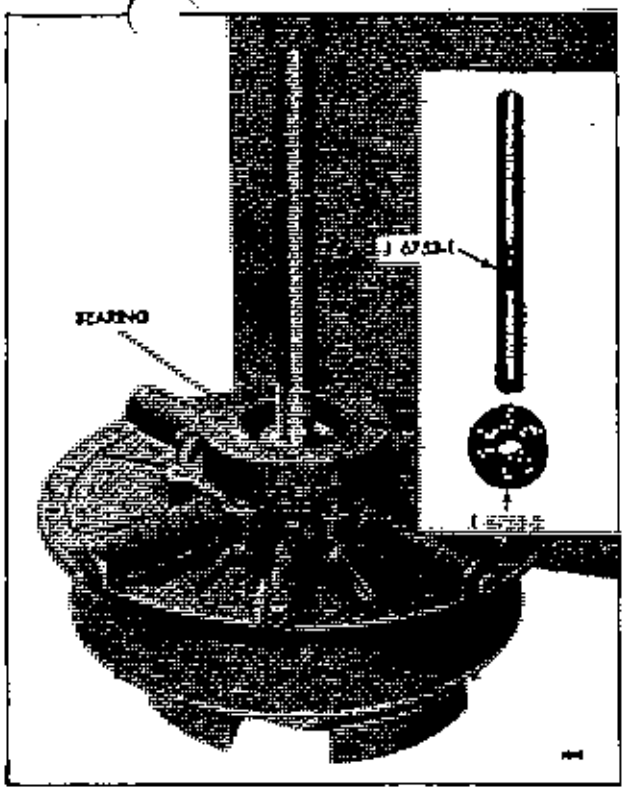


Fig. 22 - Broaching Bearings in Intermediate Housing with Tool J 6783

b. Inspect the packing grooves very closely. Make sure all old packing has been removed.

c. Check the shims for cleanliness. It is very important that the shims are clean.

d. Clean the turbocharger housing seal surfaces.

e. Check the housing for an out of round condition. A .003 " feeler gage must not go between the mating edge of the nozzle ring and the housing at any point.

22. Install the asbestos packing in the nozzle ring grooves.

a. Use all of the packing (30 feet).

b. Make a thick paste of lubricating oil and flake graphite and apply it to the asbestos packing. This will hold the packing in place and provide lubrication when the nozzle ring is installed in the housing.

23. Place the nozzle ring in dry ice.

a. Place the nozzle ring in a box a little larger than the ring itself. The box should have a lid.

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b. Break up the dry ice into small p.. .s and pack it around both sides of the nozzle ring.

24. Install the nozzle ring in the turbocharger housing.

a. Just before installing the nozzle ring, warm up the turbocharger bnusing with an acetylene torch. Apply the heat gradually so that the housing will expand evenly.

b. Place the sbims in the housing and align the boles.

c. Insert the nozzle ring in the housing. The ring will slide into the housing with very little force.

d. Allow the nozzle ring to come up to room temperature befote tightenioq the nuts securely.

25. Stand the turbocharger in an upright positiun and remove the pilot J 6756 from the turbine wheel shaft.

26. Coat the outer periphery of the blower end oil seal (15) with a non-bardening, beat resistant sealing compound. Assemble the thrust collar (21) to the blower end oil seal (15), see Fig. 21, and start the collar and seal over the shaft and into position in the intermediate bousing. Make sure the scribe and punch marks, previously made on the seal and housing (Step 5), are aligned to ensure correct sealing. Tap tbe seal uniformly into place with a soft bammer.

27. Rotate the turbine wbeel until the keyway in the shaft is in an up position, then attach the tool J 6750-2 again tn the nozzle riog to preveot the turbine wbeel from turning.

28. Place the key (24) in the keyway of the shaft, marked side up, and slide the impeller (22) on the shaft with the keyway in line with the key.

29. Install the nose piece (23) against the impeller, aligning the punch and scribe mark of the nose pieee with that on the impeller.

30. Seeure the impeller with the elasuc stop nut (25). Draw the nut ught until the punch and scribe marks on the nut register with those on the impeller and nose pieee. These parts are dynamically balanced and marked at time of iniual assembly.

31. Remove tool J 6750-2 and turn the turbine wheel by hand to be assured it rotates freely.

32. Install tbe remainiog bolts. Tighten them securely and iostall the lock wire.

33. Install the remaining nozzle ring lock wasbers and nuts (5) and ughten the nuts.

34. losert the feeler ribbon between the nozzle ring (3) and the radial vanes of the wheel to check the elearance (Fig. 14). The elearance should be from .025" to .045". When rhecking for minimum clearance, force the wheel in the diteetion of the exhaust housing by pushing against the impeller. Force the wheel in the opposite direction when checking for maximum clearance. If the clearanee is less than the minimum allowable, it will be necessary to add shims under the nozzle ring.

35. Set the blower bousiog against the intermediate housing in its original positiun and secure it with bolts and lock washers.

36. Attach the dial gage to the blower housing and eheck it again for end play of .004" to .013" (Fig. 15). Remove the dial gage.

Instott Turbocharger

1. Lift the turbocharger with a rope sling ioto positiun and, usiog new gaskets, secure the turbocharger to the engine.

> **NOTE:** Always ughten the turbocharger-to-bracket bolts before ughtening the bracket-to-engine bolts.

To prevent an abnormal stress from being applied on the exhaust manifold of marine engines, the exhaust elbow and turbocharger supporting brackets should be first bolted securely to the items which they support and then to the engine.

The weight of the turbocharger assembly and the exhaust elbow on marine units is supported by two brackets on 6-71T engines and one bracket on the 4-71T engines. The 6-71T engines only have a bracket attached to and sop- porung the exhaust elbow that is bolted to the eogine rear bell housing. The 6-71T and 4-71T engines both have a bracket attached to the bottom of the turbocharger that is bolted to the marine geat housings. The recommended sequence for properly ughtening the exhaust manifold and these brackets to the units is as follows:

a. Bolt the exhaust manifold elbow to the exhaust maoifold. Then mount the exhaust manifold and elbow assembly to the engine cylinder bead aod tighten the exhaust manifold nuts securely.

b. Mount the exhaust elbow supporting bracket used on the 6-71T engines between tbe eogine rear bell housing and the exhaust elbow. First ughteo the bolts between the bracket and the elbow and then the bolts between the rear bell housing and the bracket.

c. Mount the supporting bracket on the underside of

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EXHIBIT X

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INSTRUCTIONS 412

FUEL OIL SERVICE PUMPS
FUEL OIL BOOSTER & TRANSFER PUMPS
LUBRICATING OIL SERVICE PUMPS

U. S. S. SOUTH DAKOTA BB57
U. S. S. MASSACHUSETTS BB59

1690

BUILT IN 1941
New York Shipbuilding Corporation P. O. 421-86 (BB57)
Berhleheim Steel Company P. O. 5-630-426-D-1478 (BB59)

DE LAVAL STEAM TURBINE COMPANY
TRENTON, NEW JERSEY

EXHIBIT "X"

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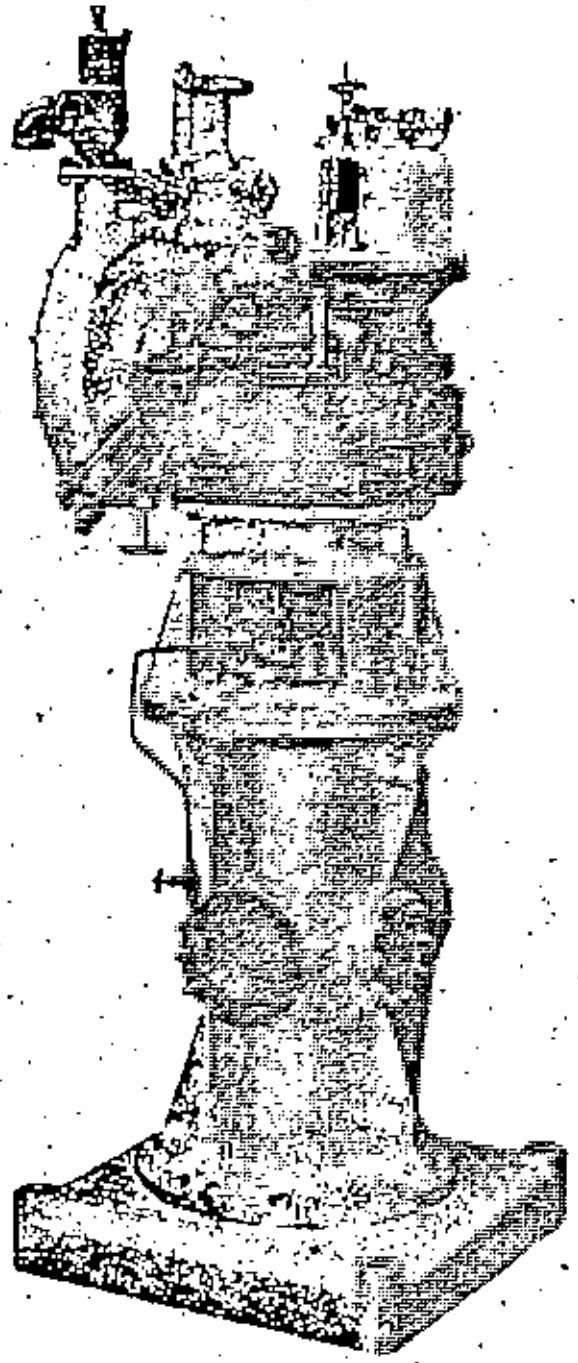


Fig. 1 - Typical Turbine Driven Pump

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TURBINE DRIVEN PUMPS

GENERAL

Classification and General Design

There are eight turbine driven fuel oil service pumps, four turbine driven fuel oil booster and transfer pumps, and four turbine driven lubricating oil service pumps in each ship. All of them are of the same general design but the units of any one class differ of course from those of the other two classes in size, rating, and minor details of construction.

Each unit consists essentially of a vertical, rotary displacement pump of De Laval-Imo design, a set of De Laval worm reducing gears, and a De Laval, horizontal, single pressure stage, radial flow steam turbine. The pump, gear, and turbine components are built one into the other as shown in Fig. 1 so as to form a single, compact machine.

Serial Numbers & Allocation

Ship	F.O.S.	F.O.B. & T.	L.O.S.
BB57 U.S.S. SOUTH DAKOTA	229206	229214	229218
	229207	229215	229219
	229208	229216	229220
	229209	229217	229221
	229210		
	229211		
	229212		
	229213		
BB59 U.S.S. MASSACHUSETTS	229223	229231	229235
	229224	229232	229236
	229225	229233	229237
	229226	229234	229238
	229227		
	229228		
	229229		
	229230		

Ratings and Operating Data

Class	Viscosity*	Delivery GPM	Disch. Press. #/sq.in.g.	Suct. Lift in.Hg.	S.G. #/sq.in.g.	Exh. Press. #/sq.in.g.	Quality of Steam	RPM Turb.	RPM Pump	BHP
F.O.S.	700	33	350	17.5	0.91	15	D.S.	4855	870	14.1
F.O.S.	70	33	350	28.6	0.81	15	D.S.	3672	658	16.7
F.O.B.&T.	700	300	150	25	0.75	15	D.S.	4845	218	63.4
L.O.B.&T.	70	300	150	20	0.75	15	D.S.	3821	343	59.0
L.O.S.	500	150	50	24	0.75	15	D.S.	4785	957	28.0
L.O.S.	150	150	50	20	0.75	15	D.S.	3801	3011	23.1

* In SAE for fuel oil and SAE for lube oil.

NOTE: Each turbine is also capable of carrying 125% of its rated load under the rated steam conditions and its rated load under the following specified emergency steam conditions:

I.S.P.	Qual/ity	Exhaust Pressure
575#/sq.in.	D.S.	20#/sq.in.
460#/sq.in.	D.S.	15#/sq.in.

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Guarantees

Steam consumption guarantees based upon operation under the rated conditions for handling fuel oil at 700 ssf and luvricating oil at 500 ssu were as follows:

Class	Pounds Per Hour
F.O.B.	557
F.O.B. & T.	1610
I.O.B.	1020

Performance Tests

These units were accepted on the basis of the test performances of duplicate units supplied for Battleships 58 & 60. Characteristic curves of the latter units, amended to include these units, are shown in Figs. 2a to 2f inclusive.

Drawings Supplied

Subject	Factory No.	BuShips No.
F.O.B. Class		
Outline	G-7443	BB57-S55-039
Test Performance Curves	G-7466	BB57-S55-092
Turbine Assembly	G-7444	BB57-S55-040
Turbine Casing Details	G-7445	BB57-S55-041
Steam Chest & Governor Valve Details	G-7446	BB57-S55-042
Governor Assembly & Details	G-7447	BB57-S55-043
Oil Piping Diagram, Assembly & Details	G-7448	BB57-S55-044
Insulation	G-7449	BB57-S55-045
Gear Assembly	G-7635	BB57-S45-021
Gear Casing Details (Cover Section)	G-7637	BB57-S45-023
Gear Casing Details (Base Section)	G-7636	BB57-S45-022
Worm & Worm Wheel Details	G-7639	BB57-S55-050
Other Gear Set Details	G-763B	BB57-S45-024
Unit Oil Pump Details	G-7641	BB57-S45-026
Governor & Oil Pump Drive Assembly & Details	G-7642	BB57-S45-027
Oil Filter-Cooler Unit Assembly	G-7643	BB57-S45-028
Oil Filter-Cooler Unit Casing Details	G-7644	BB57-S45-029
Other Oil Filter-Cooler Unit Details	G-7645	BB57-S45-030
Main Pump Assembly	SG-1463	BB57-S55-046
Main Pump Casing Details	SG-1464	BB57-S55-047
Main Pump Rotor & Housing Details	SG-1466	BB57-S56-049
Miscellaneous Main Pump Details	SG-1465	BB57-S55-048
Spare Parts & Tools (Turbine)	G-7465	BB57-S55-075
Spare Parts & Tools (Worm Gear)	G-7656	BB57-S45-031
Spare Parts & Tools (Pump)	SG-1485	BB57-S45-017
F.O.B. & T. Class		
Outline	G-7450	BB57-S55-051
Test Performance Curves	G-7467	BB57-S55-093
Turbine Assembly	G-7451	BB57-S55-052
Turbine Casing Details	G-7452	SB57-S55-053
Turbine Bucket Wheel & Governor Valve Details	G-7453	BB57-S55-054
Governor Assembly & Details	G-7454	BB57-S55-055
Oil Piping Diagram, Assembly & Details	G-7455	BB57-S55-056
Insulation	G-7456	BB57-S55-057
Gear Assembly	G-7646	BB57-S55-076

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Drawings Supplied (Cont'd)

Subject	Factory No.	BuShips No.
F.O.B. & T. Close (Cont'd)		
Gear Casing Details (Cover Section)	G-7646	BB57-S55-07B
Gear Casing Details (Base Section)	G-7647	BB57-S55-077
Worm & Worm Wheel Details	G-7650	BB57-S55-080
Other Gear Set Details	G-7646	BB57-S55-07B
Unit Oil Pump Details	G-7B51	6B57-S55-0B1
Governor Drive Assembly & Details	0-7652	BB57-S55-0B2
Oil Filter-Cooler Unit Assembly	G-7653	BB57-S55-067
Oil Filter-Cooler Unit Casing Details	G-7654	BB57-S55-06B
Other Oil Filter-Cooler Unit Details	G-7655	BB57-S55-068
Main Pump Assembly	SG-1467	BB57-S55-058
Main Pump Casing Details	SG-146B	BB57-S55-059
Main Pump Rotor & Housing Details	SG-1470	BB57-S55-061
Miscellaneous Main Pump Details	SG-1469	BB57-S55-060
Spare Parts & Tools (Turbins)	0-7465	BB57-S55-075
Spare Parts & Tools (Worm Gear)	G-7B56	BB57-S45-031
Spare Parts & Tools (Pump)	SG-1485	BB57-S45-017
L.O.S. Close		
Outline	0-7457	BB57-S45-01
Test Performance Curves	G-746B	BB57-S45-041
Turbine Assembly	G-7458	BB57-S45-02
Turbine Casing Details	G-7459	BB57-S45-03
Steam Chest & Governor Valve Details	0-7460	BB57-S45-04
Governor Assembly & Details	0-7461	BB57-S45-05
Oil Piping Diagram, Assembly & Details	G-7462	BB57-S45-06
Insulation	G-7463	BB57-S45-07
Gear Assembly	G-7635	BB57-S45-021
Gear Casing Details (Cover Section)	0-7637	BB57-S45-02B
Gear Casing Details (Base Section)	G-763B	BB57-S45-022
Worm & Worm Wheel Details	G-7640	BB57-S45-025
Other Gear Set Details	G-763B	BB57-S45-024
Unit Oil Pump Details	G-7641	BB57-S45-02B
Governor & Oil Pump Drive Assembly & Details	0-7642	BB57-S45-027
Oil Filter-Cooler Unit Assembly	G-7643	BB57-S45-02B
Oil Filter-Cooler Unit Casing Details	G-7644	BB57-S45-029
Other Oil Filter-Cooler Unit Details	G-7645	BB57-S45-030
Main Pump Assembly	SG-1476	BB57-S45-08
Main Pump Casing Details	SG-1477	BB57-S45-09
Main Pump Rotor & Housing Details	SG-1479	BB57-S45-011
Miscellaneous Pump Details	SG-147B	BB57-S45-010
Spare Parts & Tools (Turbins)	G-7465	BB57-S55-075
Spare Parts & Tools (Worm Gear)	G-7656	BB57-S45-031
Spare Parts & Tools (Pump)	SG-1485	BB57-S45-017

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Drawing References

Instruction Book Illustration	*Reference Drawing*
Fig. 1	———
" 2a	BB57-S55-092
" 2b	BB57-S55-092

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Drawing References (Conr'd)

Instruction Book Illustration	*Referenee Drawing*
Fig. 2c	BB57-S55-093
" 2d	BB57-S55-093
" 2e	BB57-S45-041
" 2f	BB57-S45-041
" 3	BB57-S55-048
" 4	BB57-S55-058
" 5	BB57-S45-08
" 6	————
" 7	————
" 8	BB57-S55-048 BB57-S55-049 BB57-S55-058 BB57-S55-081 BB57-S45-08 BB57-S45-011
" 9	————
" 10	BB57-S45-021
" 11	BB57-S55-076
" 12	BB57-S55-076 BB57-S55-079 BB57-S45-021 BB57-645-024
" 13	BB57-S55-076 BB57-S45-021
" 14	BB57-S45-021 BB57-645-027
" 15	BB57-S55-076 BB57-S55-082
" 16	BB57-S55-044 BB57-S55-058 BB57-S45-08
" 17	BB57-S55-081 BB57-S45-026
" 18	BB57-S55-087 BB57-S45-028

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Instruction Book Illustration	*Reference Drawing*
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" 20	BB57-S55-052
" 21	BB57-S55-040 BB57-S65-042 BB57-S45-02 BB57-S45-04
" 22	BB57-S55-052 BB57-S55-053
" 23	BB57-S55-040 BB57-S55-041 BB57-S55-052 BB57-S55-063 BB57-S45-02 BB57-S45-03
" 24	BB57-S55-043 BB57-S55-055 BB57-S45-05
" 25	BB57-S55-075 BB57-S45-017 BB57-S45-031
" 26	BB57-S45-017 BB57-S45-031

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Principal Weights

Element	*F.O.S.*	*F.O.B.&T.*	*L.O.S.*
Assembled Unit	1090 lbs.	3020 lbs.	2185 lbs.
Main Pump Completely Assembled	382 "	2054 "	1480 "
Main Pump Casing	204 "	918 "	683 "
Main Pump Power Rotor	18 "	145 "	75 "
Main Pump Idlers (each)	8 "	52 "	28 "
Main Pump Rotor Housings (each)	20 "	136 "	102 "
Coupling, Complete	18 "	11 "	18 "
Spacing Frame	74 "	140 "	138 "
Geared Steam Turbine Completely Assembled	710 "	1175 "	701 "
Gear Casing	174 "	370 "	174 "
Worm	13.5 "	41 "	13.5 "
Worm Wheel & Shaft without Bearings	23 "	140 "	23 "
Turbine Wheel	48 "	50 "	48 "
Turbine Case without Steam Chest	193 "	256 "	193 "
Steam Chest	65 "	68 "	65 "
Insulation	40 "	40 "	40 "
Governar Assembly	60 "	60 "	60 "
Governor Drive Assembly	37 "	35 "	37 "
Unit Oil Pump	36 "	42 "	26 "
Oil Filter-Cooler Unit	36 "	45 "	36 "

NOTE: All values in the table of weights are estimated except those listed for the assembled units which are actual weights.

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tendency of the pressure to fall below 10 pounds under these conditions should be investigated immediately.

The supply of cooling water should be regulated so that the oil temperature does not exceed 180°F.

Zinc protectors, attached to removable plugs so that they can be inspected and renewed without difficulty, are installed in the cooling water passages of the filter-cooler unit to prevent the disintegration of parts which otherwise would result from galvanic action. These protectors should be inspected frequently and renewed promptly when necessary.

Disassembling the Gear Unit

Directions for removing the rotating elements of the gear set are outlined below:

Remove the thermometer and the oil pressure gage so that these instruments will not be damaged in the general dismantling operations.

Remove the coupling bolts.

Disconnect the governor linkage.

Drain the lubricating oil system. (See page 33.)

Remove the lubricating oil pump discharge pipe.

Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.

Take out the bolts and the dowel pins in the lubricating oil pump flange and withdraw the lubricating oil pump intact.

Remove the bolts which secure the wheel shaft thrust bearing housing to the casing. These bolts can be reached through the openings in the spacing frame between the gear and the main pump.

Tilt the worm wheel rotor far enough to disengage the teeth and lift it out of the casing.

Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.

Remove the turbine shaft packing. (See page 46.)

Remove the turbine bucket wheel and its key. (See page 46.)

Take out the set-screw which secures the worm shaft oil slinger.

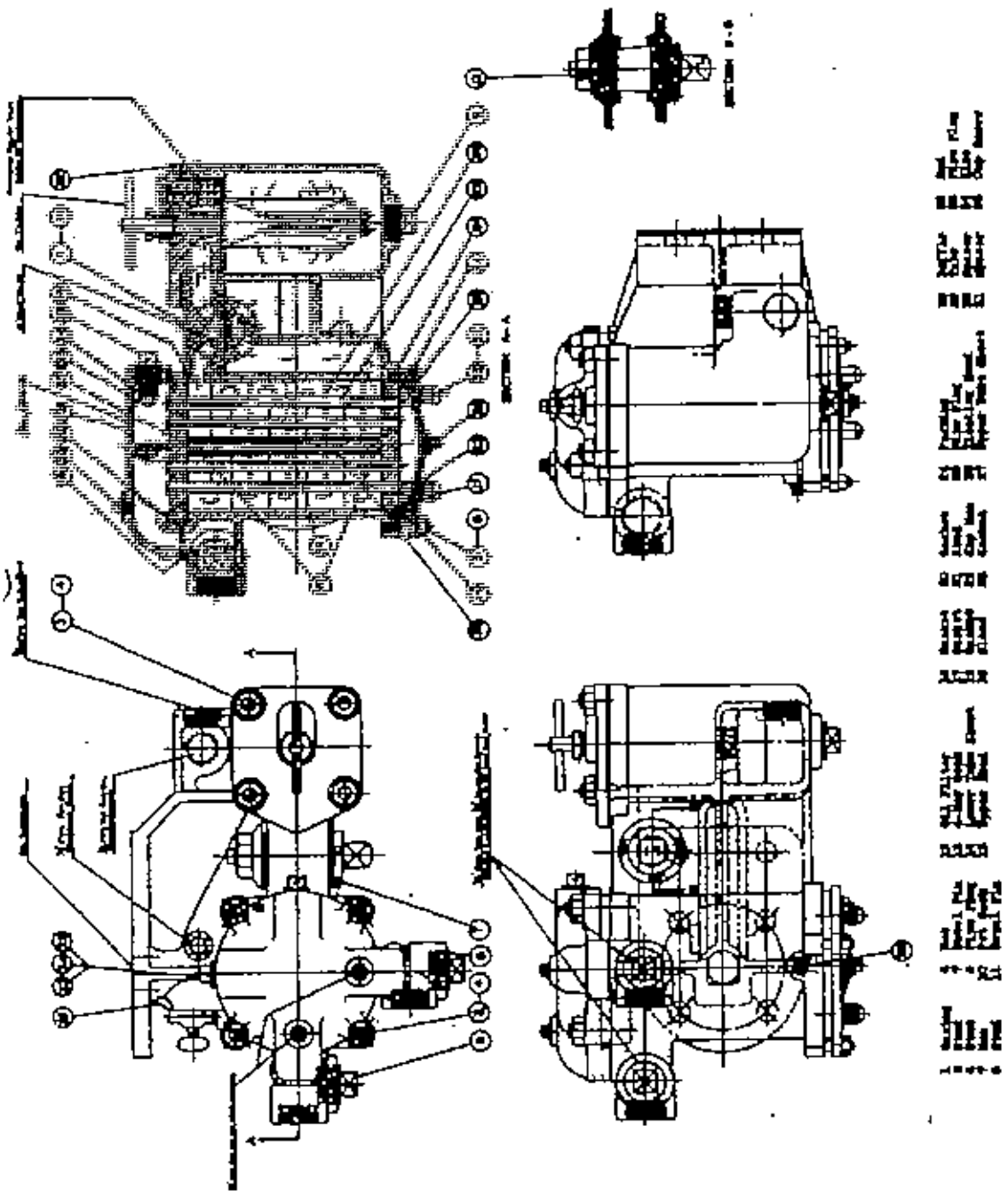
Remove the end cover at the worm thrust bearing.

Take off the top sections of the worm bearings.

Shift the worm element axially to the point where the shaft end clears the turbine casing, and then lift it out.

The procedure to be followed in dismantling the lubricating oil pump and the governor drive assembly and removing such parts as the main drive coupling half, oil seals, etc. will be apparent from a study of the fore-

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going descriptions of the parts, the reference cuts, and the parts themselves.

Means for pressing off the worm wheel shaft bearings, the worm wheel, and the governor drive pinion are provided in the shape of a jack-nut (part 62 in Fig. 10, and part 38 in Fig. 11) which is part of the rotor assembly, and a seperate "U" shaped steel block which is one of the special tools supplied with the equipment (see item E, Fig. 25). The block is to be placed between the jack-nut and the part or parts to be removed as explained on page 51.

A puller was supplied for removing the governor drive shaft bearings. This tool and its application are shown in Fig. 25.

The threading of all lock-nuts used in the gear unit is right hand.

Assembling the Gear Unit

In the assembling process, the dismantling operations outlined in the foregoing section are reversed.

The ball bearings should be shrunk rather than pressed on the shafts. In this connection, the best practice is to heat a bearing in a mineral oil bath to a temperature approximating but not exceeding 200°F., slip it over the journal, and set it up by means of the lock-nut, tightening the latter as the bearing cools. A new lock washer should always be used to secure the lock-nut.

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The worm wheel shaft thrust bearings should be installed with the narrow edges of the outer races abutting as shown in Fig. 13.

The worm thrust element should be set up for end play as described on page 29.

The lubricating oil pump is located with reference to its drive shaft by dowels in the pump supporting flange and shims placed in the joint between the supporting flange and the gear casing. The thickness of the locating shims plus the gasket thickness is stamped on the casing joint face for the convenience of the operator.

Plant fibre gaskets, Navy Specification 38P22, should be used for all joints. The gaskets on each side of the worm gear adjusting liner (part 48, Fig. 10, and part 43, Fig. 11) and between the supporting frame of the lubricating oil pump and the gear casing should be 1/32" thick. All of the other gaskets should be made from material .010" thick.

TURBINES

General Description

Two types of turbines are used for the drives. The fuel oil and lubricating oil service pumps are driven by single pressure stage, radial flow, single re-entry turbines, all of which are of the same general design. Velocity compounded, single pressure stage, radial flow turbines drive the fuel oil booster and transfer pumps. The difference between the two turbine designs lies essentially in the fact that the re-entry turbine has a single row bucket wheel and a flow reversing element or re-entry nozzle for directing steam back into the buckets after it has passed through them once, whereas the velocity stage turbine features a wheel having two rows of buckets which are separated over the steam admission arc by a row of station-

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ary guide buckets. In external appearance, the turbines differ but little except in the matter of size, and they are all mounted in the same manner. The bucket wheel in all cases is attached to the end of the worm shaft and the casing is rabbetted and bolted to the worm gear frame so that the whole steam element overhangs the gear unit as shown in Fig. 1.

Fig. 19 shows the mechanical design and assembly details of the fuel oil service and the lubricating oil service turbines while Fig. 20 shows the corresponding details of the velocity stage turbine for the fuel oil booster and transfer pump drive.

Steam Admission Elements (F.O.S. & L.O.S. Classes)

All of these elements are included in the steam chest assembly which is shown in Fig. 19 and, on a larger scale, in Fig. 21. The nozzle, strictly speaking, is held in the casing proper but is considered a part of the steam chest assembly because it is pressed on the governing valve seat.

It will be seen that all steam entering the turbine must pass first through the governing valve which is a balanced, double seated element operated automatically as described on page 47. After passing the governing valve, the steam enters the turbine through the hand operated nozzle valve.

The nozzle valve is not to be confused with the throttle valve. It is essentially an overload valve and should be used accordingly. The valve is equipped with a two-way stop which limits its travel between the minimum opening required to pass sufficient steam for operation at the rated full load under the rated steam conditions and the maximum opening required by any specified operating condition. The best practice is to set the valve against the inner stop and not to disturb that setting unless overload or subnormal steam conditions necessitate a change.

To remove the valve elements, it is necessary first to detach the steam chest from the main casing which involves (1) breaking the steam inlet and steam chest drain connections, (2) detaching the line pressure gage, (3) removing the steam chest lagging and insulation, and (4) disconnecting the governor linkage at the valve operating spindle.

After the steam chest has been detached from the casing, the nozzle valve handwheel and stop washer must be removed and the nozzle valve packing gland loosened. Then the nozzle, the governing valve seat, and the nozzle valve can be withdrawn as a unit. This done, the governing valve can be slipped vertically out of its yoke and removed through the nozzle opening in the steam chest.

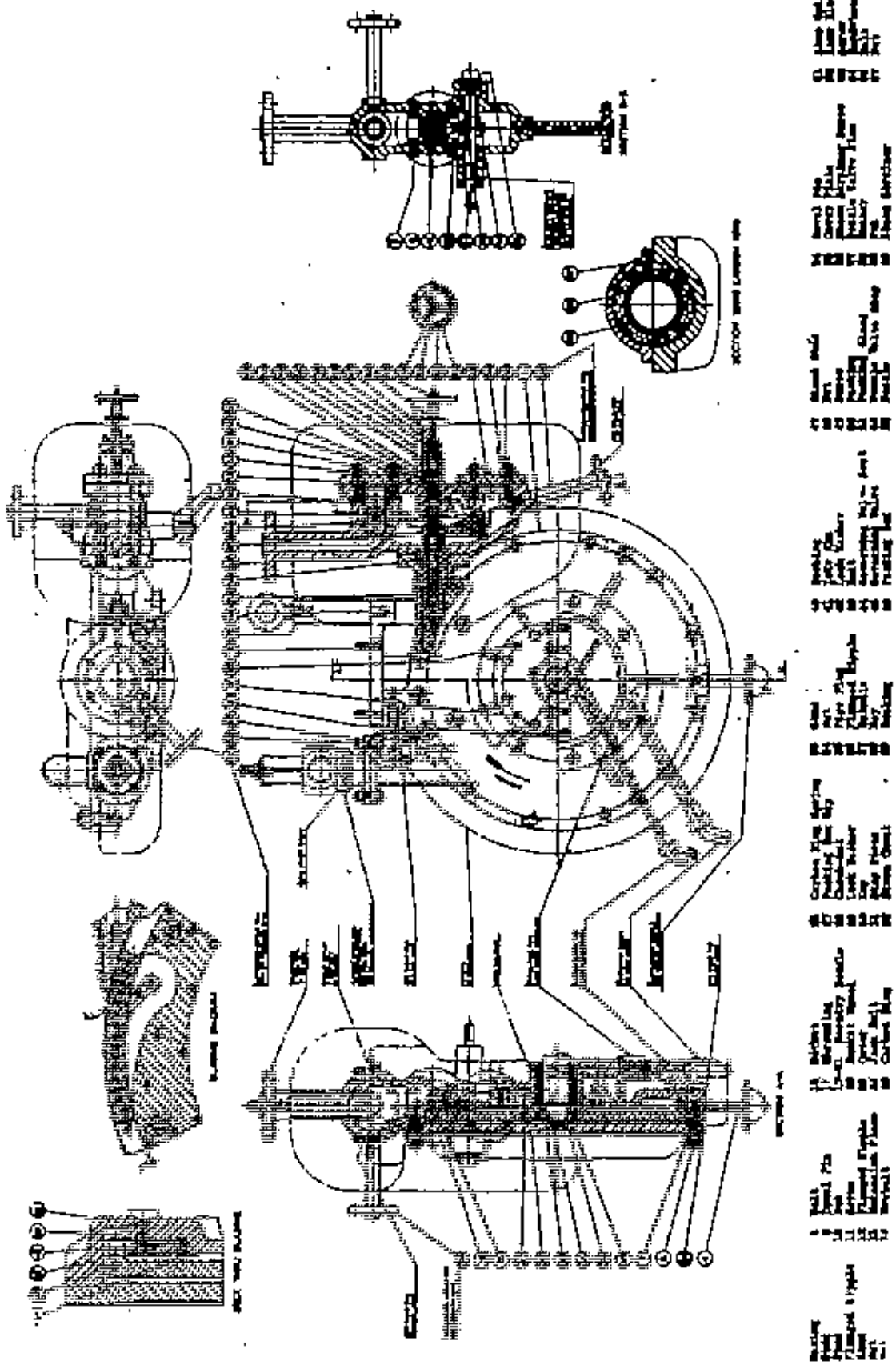
Removal of the governing valve operating yoke arm and its spindle involves (1) removing the steam chest cover and the pipe plug above the steam chest drain valve connection, (2) loosening the clamp screw in the yoke arm, (3) pushing the spindle toward the pipe plug opening until the yoke arm key clears the yoke arm, (4) removing the key and withdrawing the spindle through the pipe plug opening, and (5) lifting out the yoke arm.

The dismantling operations are reversed in reinstalling the parts. In this connection, it should be definitely ascertained that the nozzle locating pin is in position to enter the locating slot in the casing before an attempt is made to remount the steam chest.

NOZZLE DATA

Class	Throat Area	Mouth Area
F.O.S.	.049 sq. in.	.075 sq. in.
L.O.S.	.071 sq. in.	.098 sq. in.

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Steam Admission Elements (F.O.B. & T. Class)

The steam chest and nozzle details of the fuel oil booster unit are shown in Figs. 20 and 22.

This turbine has three nozzles, all machined in one segmental block which is secured to the face of the steam chest by four hollow tap bolts. The tap bolts are so designed that they form the steam passages leading from the steam chest proper to the nozzles.

The governing valve is located in the upper part of the steam chest ahead of the nozzles so that the admission of all steam to the turbine is controlled by the governor. Supplementary control in the case of one nozzle is afforded by a hand operated valve mounted in the tap bolt as illustrated. The other two nozzles are open at all times to the flow of steam through the governing valve.

The hand valve equipped nozzle provides the additional nozzle capacity required to meet the specified operating conditions with regard to overload and subnormal steam pressures. Under all normal operating conditions, this nozzle should be closed. The first, or hand valve equipped nozzle, has a throat area of .027 sq. in. while the throat area of each of the other two is .032 sq. in. The mouth area of the three nozzles is .090 sq. in. EACH OF

In this steam chest construction, the governing valve and its operating gear can be removed without disturbing the steam chest mounting. It will be seen, however, that the nozzles are not accessible with the steam chest in place. Directions for taking out the valve parts follow:

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Remove the steam chest lagging and insulation.

Detach the governor linkage from the governing valve operating spindle.

Remove the upper steam chest cover and the pipe plug (B) at the end of the operating spindle.

Loosen the clamp bolt in the governing valve yoke arm and push the operating spindle toward the pipe plug opening until the yoke arm key clears the yoke arm. Remove the key and then withdraw the operating spindle through the pipe plug opening.

Remove the yoke arm and unscrew the governing valve seat. The governing valve will come out with the seat.

Nozzle Valve Packing (All Classes)

The nozzle valve stuffing box was packed at the factory with asbestos packing, Navy Material Specification 33P14, type B.

The inside diameter of the stuffing box is 7/8", and the rod diameter is 7/16".

Steam Strainer (All Classes)

The steam strainer is a perforated tube made of corrosion resisting steel. Figs. 21 and 22 show the strainer locations and mountings. The lagging and insulation of each turbine are so arranged that the strainer cap is easily accessible, and the strainer itself can be withdrawn without difficulty when the cap is off.

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REPRODUCTION INTERDITE

Fig. 21 - Steam Chest, F.O.S. & L.O.S. Cleaned

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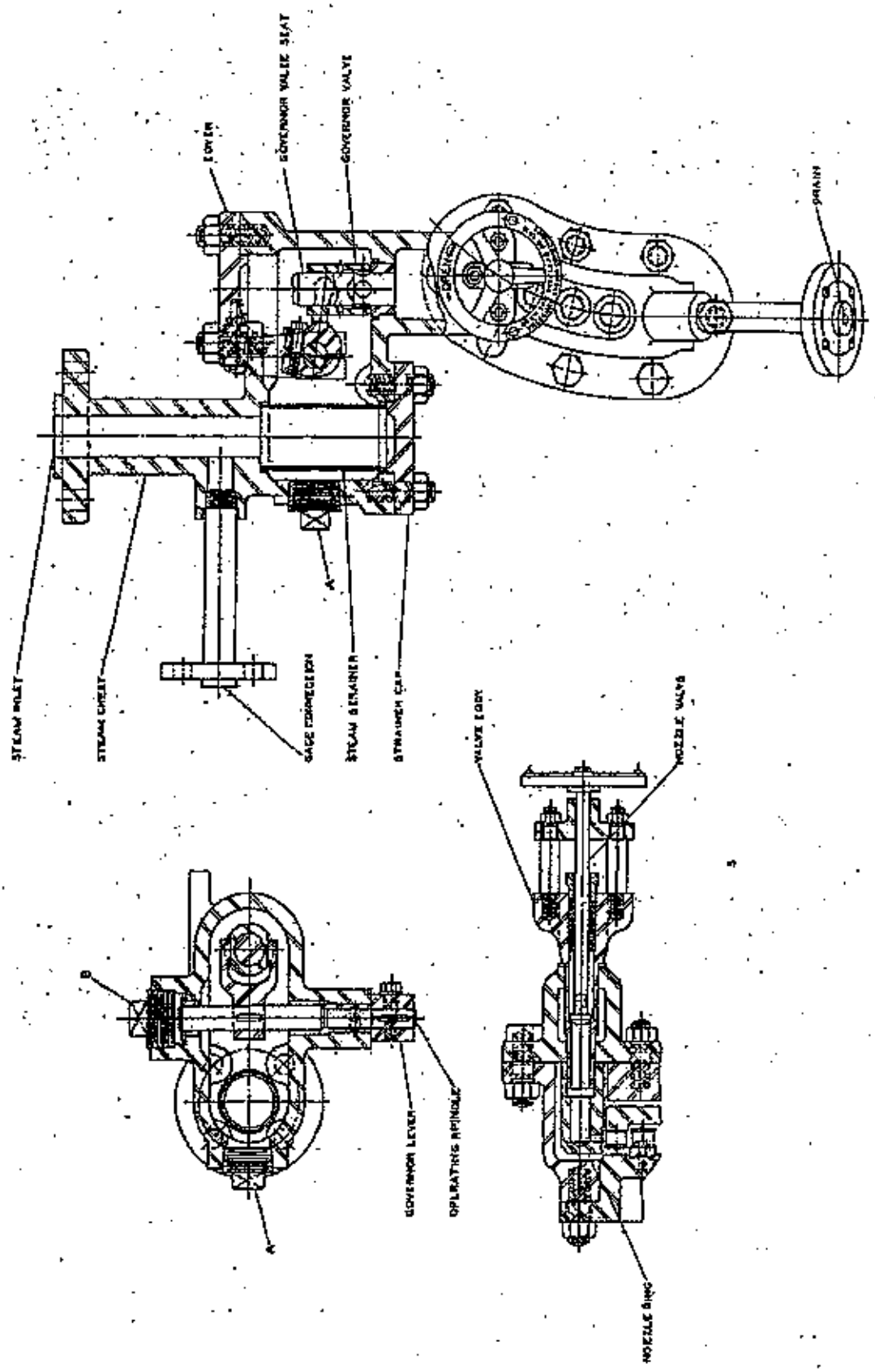


Fig. 22 - Steam Chest, P.O.R. & T. Class

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Re-entry Nozzle (F.O.S. & L.O.S. Classes)

The re-entry nozzle details are clearly shown in the large scale views of the turbine blading which appear in the upper left hand corner of Fig. 19. This nozzle element is secured to the bracket section of the turbine casing by two flat, fillister head screws which are peened in place. It is accessible only when the bucket wheel is off.

Guide Vane Mounting (F.O.B. & T. Class)

The guide vanes are riveted to a segmental plate which is bolted to the cover section of the turbine casing as shown in Fig. 20. To eliminate all possibility of the loosening of this fitting, the heads of the securing bolts are spot welded to the plate.

Wheel and Bucket Mountings (All Classes)

A taper fit is used for the bucket wheel mounting. The wheel is keyed to the shaft and secured by a lock-nut which in turn is secured by a special lock washer. There is no adjustment for running clearance. The wheel assumes its correct running position with respect to the stationary elements when it is tightly seated on the shaft.

The buckets are riveted to the face of the wheel and the shrouding is riveted to the buckets as illustrated in Figs. 19 and 20.

The outer face of the wheel is drilled and tapped for the application of a special wheel puller which was included among the tools supplied (Item B, Fig. 25.)

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Shaft Packing (All Classes)

Carbon packing is used to seal the casing at the point where the shaft emerges.

The carbon rings fit in grooves machined in the casing as shown in Fig. 23. Each ring (3) is composed of three segments which are held together by a garter spring (6) and prevented from rotating by a stop piece (7). The packing box cap (1) is a separate casting bolted to the main casing so that the packing can be removed without the necessity for disturbing any part of the unit assembly other than the packing elements themselves.

Removal of the packing is simply a matter of taking off the cap, unhooking the garter springs, and taking out the carbon segments. The loose segments of each ring should be kept together and marked so that the original ring assembly can be reproduced.

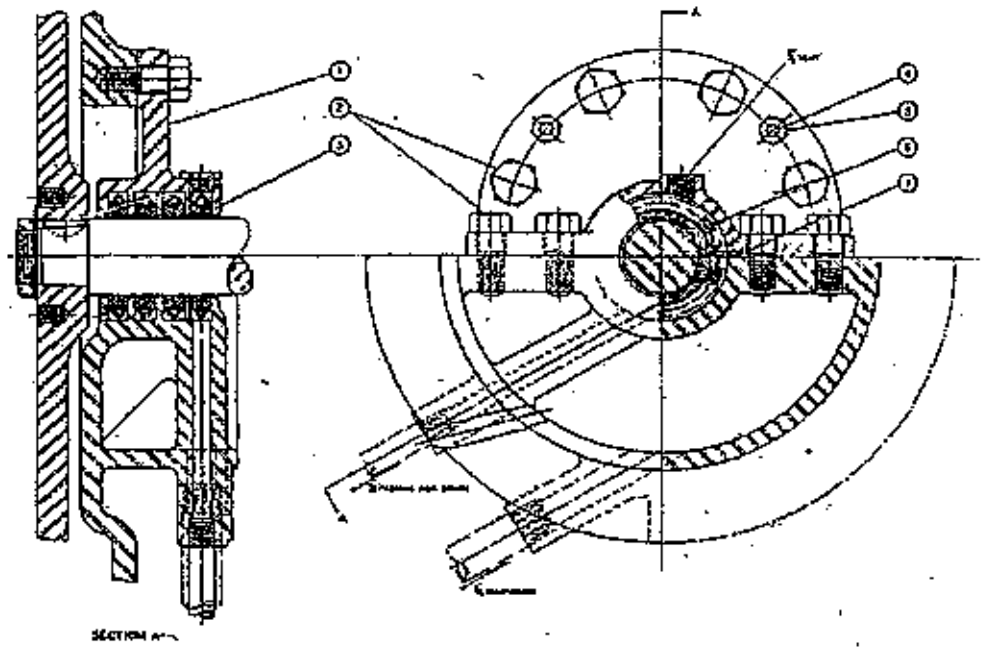
For effective sealing, the carbon rings must fit the shaft under operating temperatures without gripping it, and this requires .001" to .0015" clearance on the diameter between the packing and the shaft when the parts are cold.

Loose carbon rings which are not too badly worn can be fitted by dressing off the ends of the segments. A scraper should be used in this operation and care should be taken to make the joints between the segments tight.

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1. Packing Box Cap
2. Bolt
3. Carbon Ring
4. Taper Pin
5. Nut
6. Carbon Ring Spring
7. Stop Piece

Fig. 23 - Turbine Packing Box, All Classes

Relief Valve (All Classes)

Each turbine casing is fitted with a Crosby sentinel relief valve which is set to operate at 25# gage pressure.

Insulation (All Classes)

The steam chest and turbine casing are insulated and lagged according to Navy requirements. The insulation and lagging are sectionalized so that the steam strainer and the turbine cover can be removed and replaced without the necessity for renewing the insulation.

Drain Connections (All Classes)

The drain connections are shown clearly in Figs. 19 and 20. All of them should be piped to the bilge or some other point of atmospheric pressure. The case drain and the drain leading from the steam chest proper should be valved. The others should be open connections.

Speed Limiting Governor (All Classes)

Each unit is equipped with a speed limiting governor of the fly ball type which controls the operation of the previously discussed governing valve. This governor is mounted on top of the gear casing and geared to the worm wheel shaft as described on page 31. It acts through a spring loaded

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EXHIBIT Y

MAIN FEED BOOSTER PUMPS

UNITED STATES DESTROYERS

DD445 CLASS



AND

INSTRUCTIONS FOR OPERATION AND MAINTENANCE

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

EXHIBIT "Y"

INSTRUCTIONS 422A

MAIN FEED BOOSTER PUMPS

UNITED STATES DESTROYERS

DD445 CLASS

BUILT IN 1941-'43

DE LAVAL STEAM TURBINE COMPANY
TRENTON, NEW JERSEY

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Oil Requirements

Navy Symbol 3080 oil should always be used for the running in period, either when the unit is new or after replacement worm gears have been installed. As make up oil is needed, Navy Symbol 2190 oil should be added. The lighter oil can be used alone under normal operating conditions.

Care & Operation of the Lubrication System

The inbrication system should be completely filled with clean, pure oil of the proper characteristics before the unit is started for the first time or after the system has been drained. This entails (1) filling the reservoir to the high mark on the level gage, (2) running the unit slowly until the cooler, piping, etc. are completely filled, and (3) shutting down the unit and adding the oil required to reestablish the level at the high mark on the gage.

The continued use of clean, pure oil is essential to long life and successful operation of the unit, and every possible measure should accordingly be taken to keep the oil in good condition and to guard against the admission of water, dirt, and other foreign substances to the oil system. The filter handle should be given a full turn once a day when the unit is in service, and the accumulated sludge should be drawn off periodically by removing the plug under the filter element. The entire system should be drained and thoroughly cleaned at regular intervals.

The level of the oil in the reservoir should be kept as close as practicable to the high mark on the level gage. Under no circumstances should the level be permitted to fall below the low mark on the gage.

The oil pressure should be not less than 10 pounds at the outlet of the filter-cooler unit when the machine is in service at rated speed. Any tendency of the pressure to fall below 10 pounds under these conditions should be investigated immediately. The relief valve should be set to open at a pressure slightly above that developed when the unit oil pump is handling cold oil at the rated speed.

The supply of cooling water should be regulated so that the oil temperature does not exceed 180°F.

Zinc protectors, attached to removable plugs so that they can be inspected and renewed without difficulty, are installed in the cooling water passages of the filter-cooler unit to prevent the disintegration of parts which otherwise would result from galvanic action. These protectors should be inspected frequently and renewed promptly when necessary.

Disassembling the Gear Unit

Directions for removing the rotating elements of the gear set are outlined below:

Remove the thermometers and the oil pressure gages so that these instruments will not be damaged in the general dismantling operations.

Disconnect the coupling.

Remove the governor lever.

Drain the lubricating oil system. (See page 20.)

Take off the oil pump discharge pipe.

Remove the cover section of the casing. The governor head assembly

need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.

Take out the bolts and the dowel pins in the lubricating oil pump flange and withdraw the lubricating oil pump intact.

Remove the bolts which secure the wheel shaft thrust bearing housing to the casing. These bolts can be reached through the openings in the spacing frame between the gear and the main pump.

Tilt the worm wheel rotor far enough to disengage the teeth and lift it out of the casing.

Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.

Remove the turbine shaft packing. (See page 31.)

Remove the turbine bucket wheel and its key. (See page 29.)

Take out the set-screw which secures the worm shaft oil slinger.

Remove the end cover at the worm thrust bearing.

Take off the top sections of the worm bearings.

Shift the worm element axially to the point where the shaft end clears the turbine casing, and then lift it out.

The procedure to be followed in dismantling the lubricating oil pump and the governor-lubricating oil pump drive assembly and removing such parts as the main drive coupling half, oil seals, etc. will be apparent from a study of the foregoing descriptions of the parts, the reference cuts, and the parts themselves.

Means for pressing off the worm wheel shaft bearings, the worm wheel, and the governor drive pinion are provided in the shape of a jack-nut (part 90, Fig. 6) which is part of the rotor assembly, and a separate "U" shaped steel block which is one of the special tools supplied with the equipment (see item E, Fig. 10). The block is to be placed between the jack-nut and the part or parts to be removed as explained on page 55.

A puller was supplied for removing the governor and oil pump drive shaft bearings. This tool and its application are shown in Fig. 10.

The threading of all lock-nuts used in the gear unit is right hand.

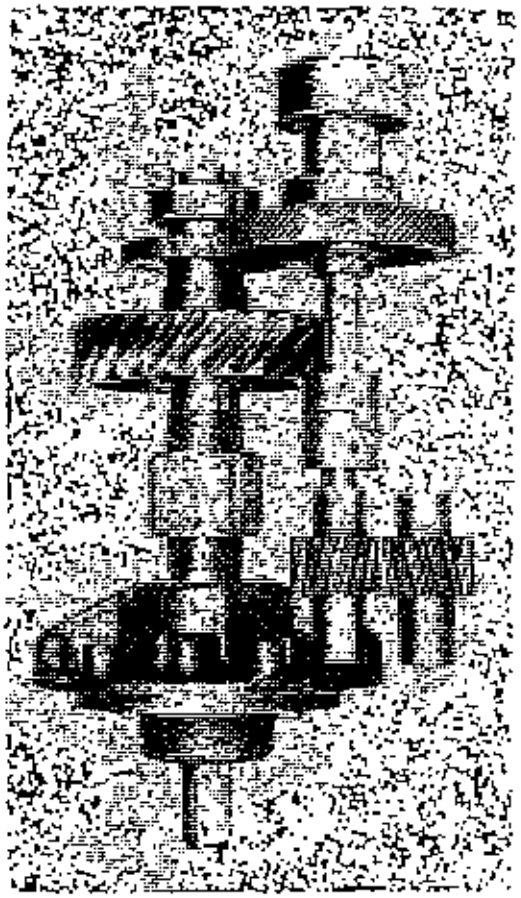


Fig. 13 - Typical Worm Wheel Rotor with Governor & Lubricating Oil Pump Drive Gears

Assembling the Gear Unit

In the assembling process, the dismantling operations outlined in the foregoing section are reversed.

MAIN FEED BOOSTER PUMPS

UNITED STATES DESTROYERS

DD692 CLASS



DESCRIPTION

AND

INSTRUCTIONS FOR OPERATION AND MAINTENANCE

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

INSTRUCTIONS 486

MAIN FEED BOOSTER PUMPS

UNITED STATES DESTROYERS
DD692 CLASS

BUILT IN 1943-'45

DE LAVAL STEAM TURBINE COMPANY
TRENTON, NEW JERSEY

September, 1944

Pumps Furnished by

DE LAVAL STEAM TURBINE COMPANY, Trenton, N. J.

BUFFALO PUMPS, INC., Buffalo, N. Y.

The pumps furnished by Buffalo Pumps, Inc. conform in all respects to the design illustrated herein, and it should be understood that the instruction manual covers the equipment of both pump manufacturers.

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practicable to the HIGH mark on the level gage. Under no circumstances should the level be permitted to fall below the LOW mark on the gage.

The oil pressure should be not less than 10 pounds at the outlet of the filter-cooler unit when the machine is in service at rated speed. Any tendency of the pressure to fall below 10 pounds under these conditions should be investigated immediately. The relief valve should be set to open at a pressure slightly above that developed when the unit oil pump is handling cold oil at the rated speed.

The supply of cooling water should be regulated so that the oil temperature does not exceed 180 F.

The condition of the zinc protectors in the cooler casing should be investigated at least once a month. These fittings disintegrate in service, and it is important that they be renewed before they disappear altogether.

Disassembling the Gear Unit

Directions for removing the rotating elements of the gear set are outlined below:

Remove the thermometers and the oil pressure gages so that these instruments will not be damaged in the general dismantling operations.

Disconnect the coupling.

Remove the governor lever.

Drain the lubricating oil system. (See page 21.)

Take off the oil pump discharge pipe.

Remove the cover section of the casing. The governor head assembly need not be disturbed for this purpose, but it may be necessary to take off the adjoining section of the turbine lagging.

Take out the bolts and the dowel pins in the lubricating oil pump flange and withdraw the lubricating oil pump intact.

Remove the bolts which secure the wheel shaft thrust bearing housing to the casing. These bolts can be reached through the openings in the spacing frame between the gear unit and the main pump.

Tilt the worm wheel rotor far enough to disengage the teeth and lift it out of the casing.

Take off the turbine cover plate lagging and remove the cover plate. It is not necessary to disturb the cover plate insulation.

Remove the turbine shaft packing. (See page 33.)

Remove the turbine bucket wheel and its key. (See page 31.)

Take out the set-screw which secures the worm shaft oil deflector.

Remove the end cover at the worm thrust bearing.

Take off the top sections of the worm bearings.

Shift the worm element axially to the point where the shaft end clears the turbine casing, and then lift it out.

Valve Packings

The nozzle valve and the governing valve were packed at the factory with asbestos packing conforming to Navy Specification 33P26, type B. The stuffing box dimensions are given below:

Stuffing Box	*Stuffing Box Dia.*	*Rod Dia.*	*Depth*
Nozzle Valve	7/8"	7/16"	1 5/16"
Governing Velve	7/8"	5/16"	1"

Drain Connections

Tha drain connectione are shown in Fig. 15. Thesa connections should bs piped to the bilge or some other point of atmospheric pressure, the csse drain through a stop valva and the others without valvea.

Relief Valve

Tha turbine casing is fitted with a Crosby sentinel relief valve which ia set to function at 25 pounds gage.

Tachometer Application*

The upper end of the governor spindle is center drilled for the application of a portable tachometer or revolution countar.

OPERATION AND CARE

Preparation for the Initial Start

Read the entire instruction manual carefully.

Thoroughly olean tha external surfaces of tha unit, paying special attention to the governing valve gear. It is not necessary to disassembls a new unit for cleaning if the factory assembly bes not bean disturbed. All internal surfsces were slushed after tha factory test with a special rust preventive compound whiob is an excellent lubricant and the removal of which is effected completely and without harmful results of any kind in tha normal operation of the unit.

Fill the oil system and make sura that tha pump bearings are edequately supplied with greasa and that the coupling contains sufficient oil. Saa pages 14, 15, and 23 for directions.

Starting

See that the oil level in the unit reservoir is at or near the HIGH mark on the level gage.

Test by manual operetion the valve gear of the spaed governor for freedom of movement, and oil the working surfsces of the mechanism. A unit

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** See page 21 for ratio between governor and main pump speeds.*

EXHIBIT Z

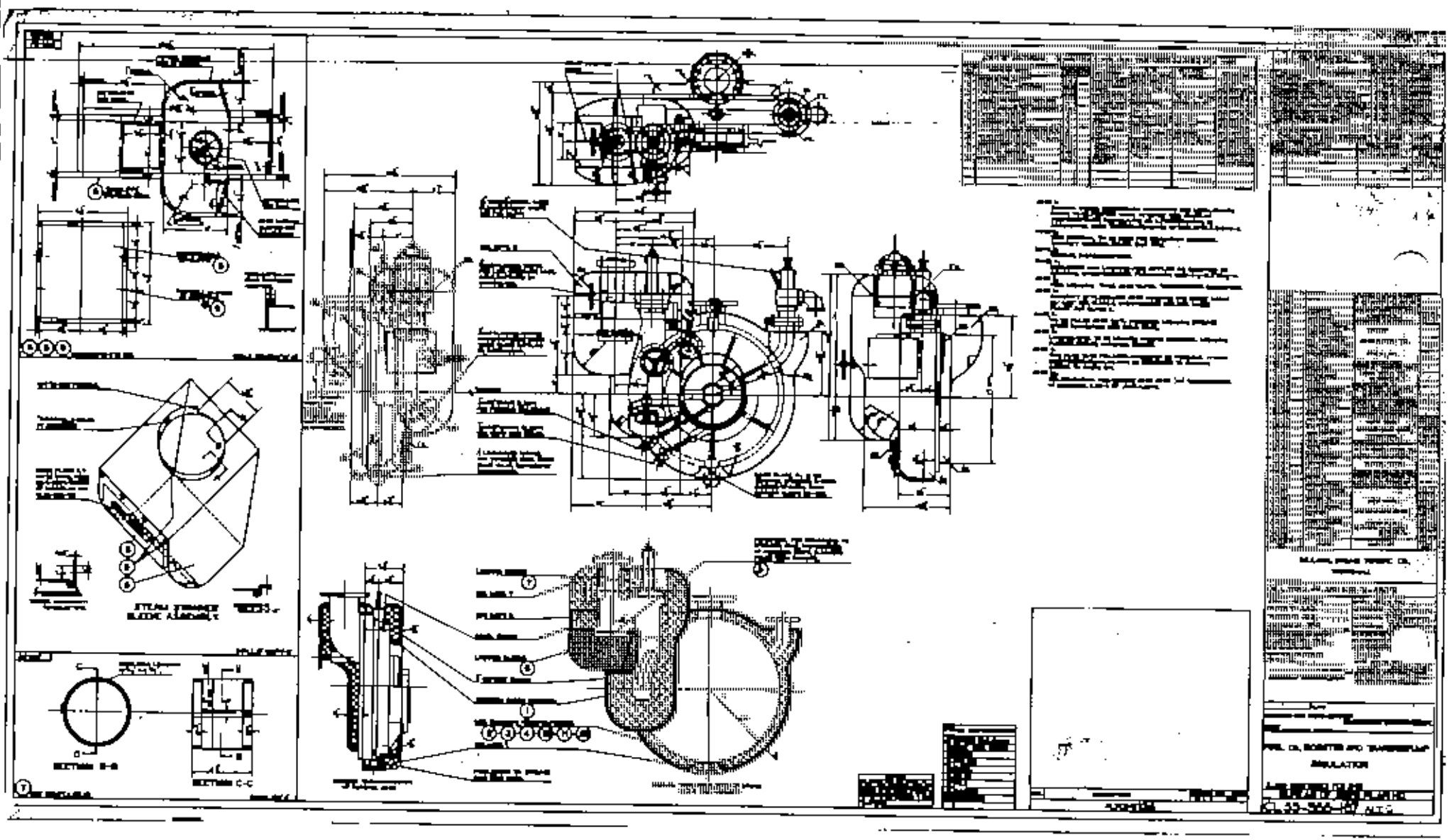


EXHIBIT AA

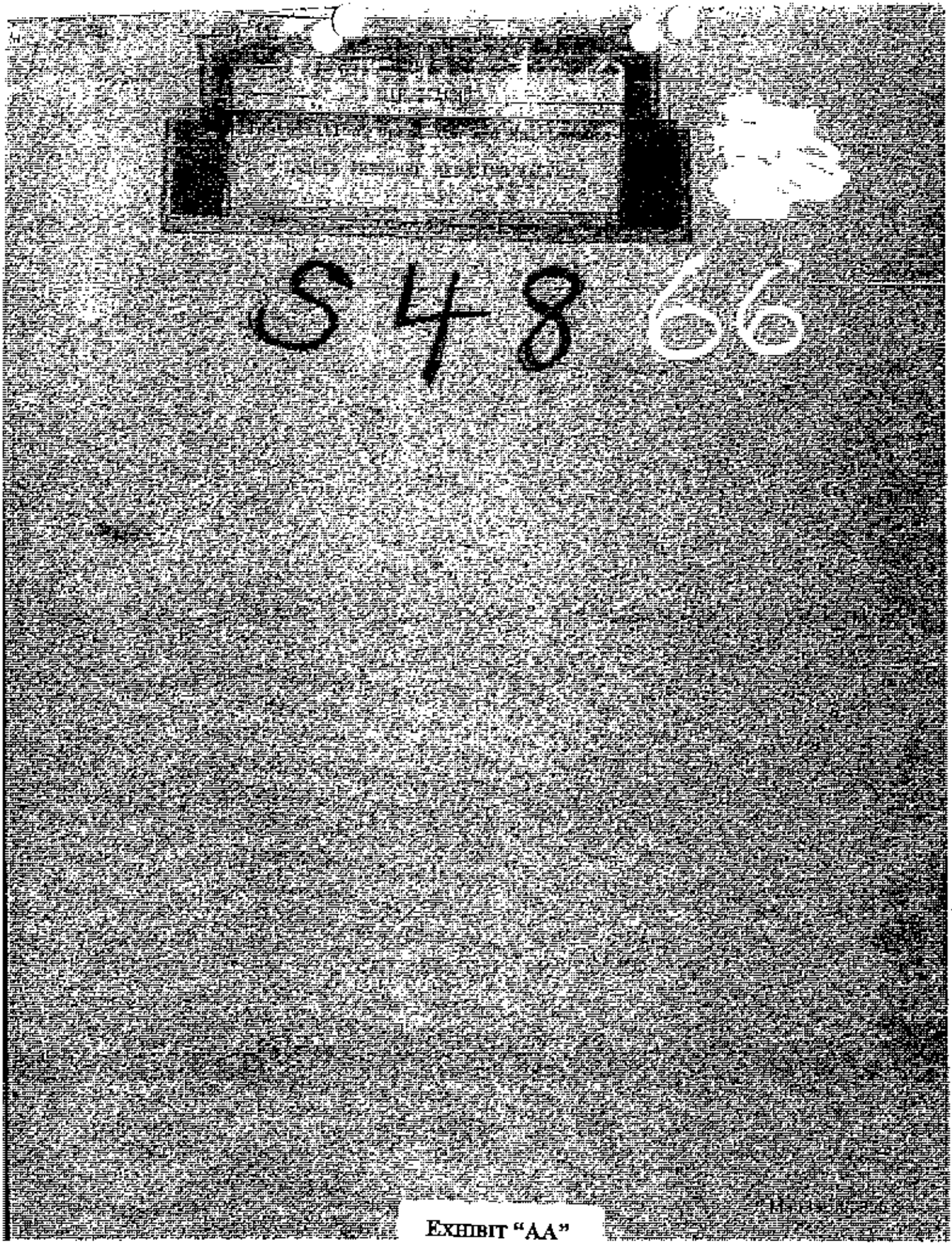


EXHIBIT "AA"

R	W.R.#	Title	10	20	30	40	50	60	70	80	90	100	M.H.
2-7		WEIGHT HANDLING TESTS											
2-8		GAS FREE TANKS AND BILGES											
2-9		BOILER REPAIRS											
2-10		GAS DETECTION EQUIPMENT											
2-11		SONAR TRANDUCERS											
2-12		AUDIGAGE SOOT BLOWER GOOSENECKS											
2-13		DISTILLING PLANT											
2-14		SONAR SCANNING SWITCHES-REMOVE											
2-18	2-62-G	PROJECTOR READY SERVICE LOCKERS											
2-19	1-62-O	SR-6 RADAR ANTENNA											
2-20	2-62-O	DRS-3 RADIO NAVIGATION EQUIPMENT											
2-21	1-64-G	MAINMAST RIGGING											
2-22	1-64-G	5"/38 GUN SHIELD											
2-23	2-64-E	MK 37 DIRECTOR ANTENNA											
2-24	1-64-E	AN/SPA 4A RADAR DETECTOR EQUIP											
2-25	1-64-E	SAFETY VALVES											
2-26	1-64-E	VENT MAST											
2-27	1-64-E	MAST											

Leslie Navy Instruction Manual

for

Operating Engineers

IMPORTANT

This Manual covers our line of equipment manufactured to Navy Specifications.

The principles of operation and maintenance apply to all Leslie devices of similar design whether Navy or Commercial.

Navy men will find this Manual very valuable but must remember that the drawings shown are Leslie Standard Navy Regulators and Whistles while the equipment they have may be special in some way.

WHEN ORDERING PARTS BE SURE TO GIVE:

1. Serial Number of Regulator or Whistle.
2. Size of Regulator or Whistle.
3. Class of Regulator or Whistle.
4. Quantity of each part.
5. Part Name (See parts list on drawing covering proper Class of Regulator or Whistle).

Always give Name and Number of Ship.

NAVShips #
CID # 8822600S8
8822600P2
8822600S3

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE PRESSURE REDUCING VALVES

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE
CO.
LYNDHURST, N.J.
ESTABLISHED 1900

Printed in U. S. A. 8422

Manual-000958

INSTALLATION:

DO NOT USE LEAD OR CEMENT WHEN MAKING UP JOINTS.

1. Protect reducing valve with Leslie Self-Cleaning Strainer.
2. Install stop valves and gages to control setting and operation of reducing valve.
3. Provide length of straight pipe on both sides of reducing valve to prevent turbulence.
4. Blow out pipe lines thoroughly before installing reducing valve.
5. Place reducing valve upright in horizontal pipe line with arrow (cast on side of body) in direction of steam flow.
6. Connect control pipe with stop valve and union to outlet line ahead of outlet stop valve. Pitch pipe toward outlet line avoiding water pockets.
7. Insulate all pipe before and after reducing valve to minimize condensation.

OPERATION:

1. Close inlet and outlet stop valves.
2. Release compression on adjusting spring 17.
3. Slowly open inlet stop valve wide.
4. Open valve in actuating line.
5. Crack outlet stop valve to permit slight flow when setting regulator.
6. Slowly screw down Adjusting Screw 15 of reducing valve until desire pressure is shown on gage on outlet side.
7. Slowly open outlet stop valve wide.
8. To change reduced pressure setting, turn Adjusting Screw 15 downward to increase and upward to decrease pressure.
9. To turn steam off, close outlet stop valve first, then inlet stop valve.
10. To turn steam on (with reducing valve set) keep outlet stop valve closed until inlet stop valve is opened wide.

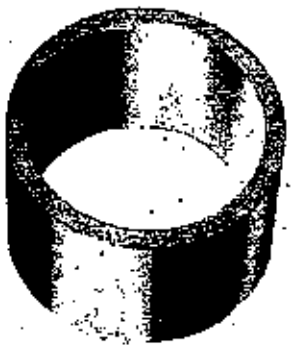
Manual-000959



Adjusting Spring 17



Diaphragm 16



Cylinder Liner 3



Seat Ring 2



Main Valve Spring 18



Controlling Valve Seat 8



Controlling Valve Spring 18

Controlling Valve 11



Piston 6



Main Valve 4

MAINTENANCE:

If reducing valve does not operate properly, it should be opened and cleaned as follows:

1. Release compression on adjusting spring 17.
2. Unscrew or unbolt adjusting spring case 9.
3. Take out diaphragm 16.
4. For Class LA-1 only Remove diaphragm plunger 35 and diaphragm chamber 28.
5. Unscrew controlling valve seat 8 with socket wrench provided for this purpose.
6. Remove controlling valve 11 and spring 18.
7. Remove top cap 6, piston 5, and cylinder liner 3.
8. To take out main valve 4 and main valve spring 18, remove bottom cap 7.
9. Seat ring 2 in body of Class LN, LA and LB only can be taken out when necessary with special seat ring wrench provided for this purpose.

CLEANING:

1. Clean all parts with kerosene.
2. See that main and controlling valves 4 and 11 move freely in their guides and seat properly. For Class LA-1 see that diaphragm plunger 35 moves freely in its guide.
3. Piston rings 12 must be perfectly free in grooves.
4. Regrind main valve 4 with pistons 5 in cylinder liner 3 to insure perfect centering.
5. Have all working parts moving freely.

ASSEMBLING:

1. DO NOT USE GRAPHITE OR COMPOUND ON JOINTS. NO LUBRICANT IS REQUIRED ON ANY MOVING PARTS.
2. Place main valve 4, spring 18, and gasket 24 in position on bottom cap 7 and bolt to valve body 1.
3. Depress piston 5 in cylinder liner 3. Be sure movement is smooth and free.
4. Top of liner 3 must be flush with top flange of body 1.
5. Bolt top cap with gasket 23 to body 1.
6. Assemble controlling valve 11, spring 19 and seat B in top cap 6. For reliable service controlling valve 11 must seat tightly. To do this stem of valve must not project above diaphragm seat. Correct clearance is .001" to .002" below diaphragm seat in top cap 6.
7. Replace diaphragm 16, adjusting spring 17, spring seat 13 and 14 and spring case 9. For Class LA-1 replace diaphragm 16, diaphragm plunger 35, diaphragm chamber 28, adjusting spring 17, spring seats 13 and 14 and spring case 9.
8. Make all joints steam tight.

ORDERING PARTS:

Please give following information:

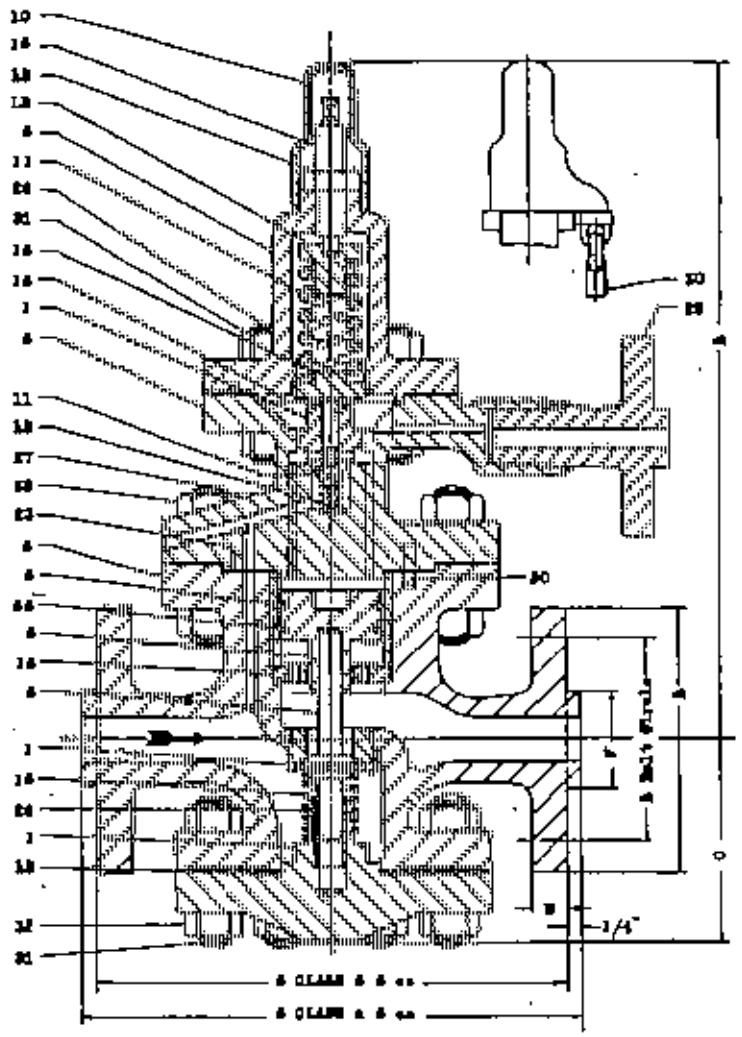
1. SERIAL NUMBER OF REGULATOR
2. SIZE OF REGULATOR
3. CLASS
4. QUANTITY OF EACH PART
5. PART NAME (See parts list for various classes on drawings on following pages.

ALWAYS SUPPLY NAME AND NUMBER OF SHIP

ORDERING NEW REDUCING VALVES:

Specify LESLIE and supply following information:

1. Maximum and minimum inlet pressure.
2. Superheat, if any.
3. Reduced pressure or range.
4. Kind of service.
5. Maximum or Minimum flow in lbs. of steam per hour, cu. ft. of free air or gas per minute to be delivered, or information leading to same.
6. Screwed or flanged connections. Flanges are furnished undrilled in bronze unless otherwise specified. Always drilled in steel.
7. Orders for all reducing valves 4" and larger must be accompanied by a sketch or drawing of proposed installation (including pipe sizes, fittings, general layout) in addition to above information.



No.	Name	No.	Name
1	Main Body	20	[illegible]
2	Seat Ring	21	[illegible]
3	Cylinder Liner	22	[illegible]
4	Main Valve	23	[illegible]
5	Piston	24	[illegible]
[illegible]	[illegible]	25	[illegible]
[illegible]	[illegible]	26	[illegible]
[illegible]	[illegible]	27	[illegible]
[illegible]	[illegible]	28	[illegible]
[illegible]	[illegible]	29	[illegible]
[illegible]	[illegible]	30	[illegible]
[illegible]	[illegible]	31	[illegible]
[illegible]	[illegible]	32	[illegible]
[illegible]	[illegible]	33	[illegible]
[illegible]	[illegible]	34	[illegible]

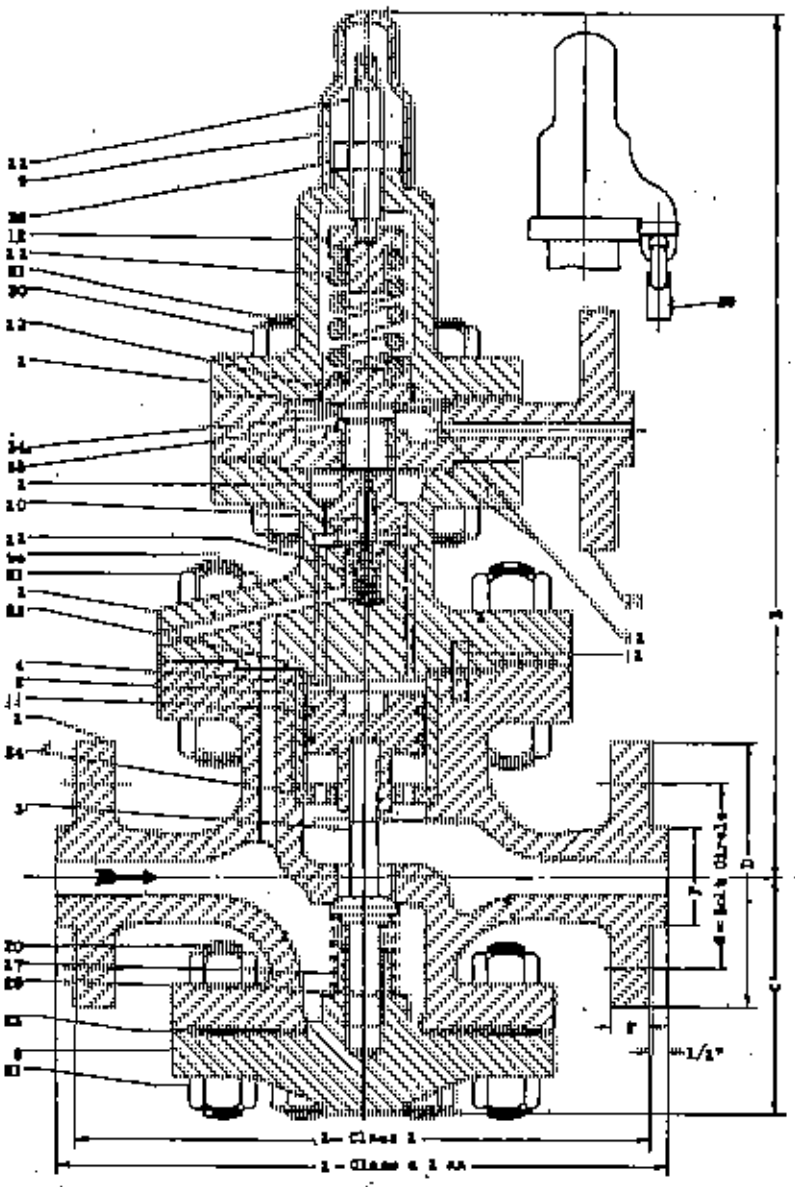
DIMENSIONS IN INCHES

Size	A	B	C	D	E	J	S	No. of Bolts	Size of Bolts	Size of Nuts	Wt. Lbs.
CLASSES a & aa											
1/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1/2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CLASS b											
1/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1/2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CLASS aa											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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LESLIE CO.
LYNCHBURG, VA.

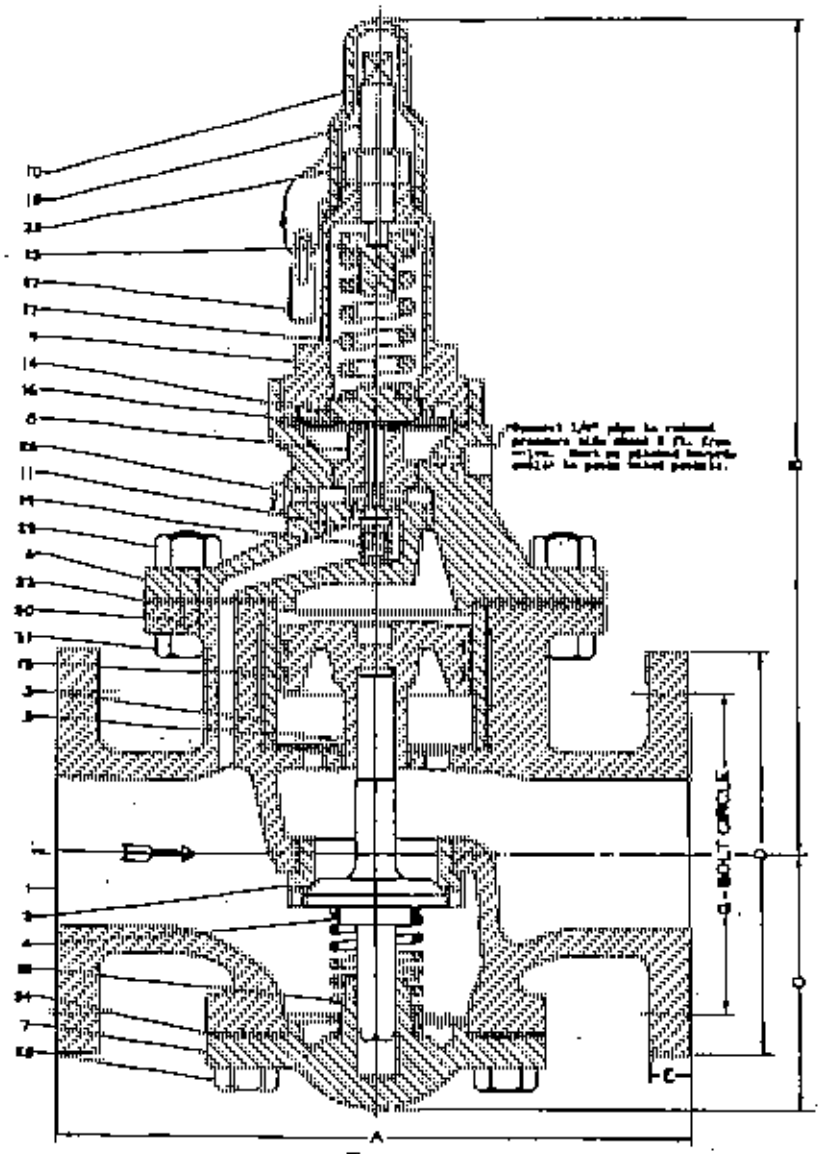
1/4" to 2" PRESSURE REDUCING VALVES
BRASS CLASSES a, aa, b & aa
LESLIE CLASS 10 & 12

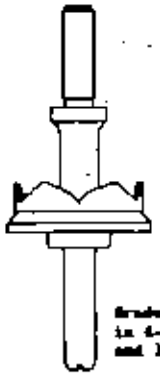
DATE 2-6-41 | 1940-80, 1280-121, A1 to 3



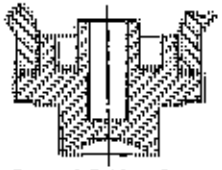
Size	A	A	D	E	F	F	G				
DIMENSIONS A & AA											
1/2"	6-1/2	12-1/4	3-7/8	2-1/2	3/4	1-3/8	2-5/8	1	1/2	3/4	80
3/4"	6-1/2	12-1/4	3-7/8	2-1/2	3/4	1-5/16	2-5/8	1	1/2	3/4	80
1"	6-1/2	12-1/4	3-7/8	2-1/2	3/4		2-5/8	1	1/2	3/4	80
1-1/4"	8	12-3/4	4-1/4	2-1/2	3/4		2-7/8	1	1/2	3/4	87
1-1/2"	8-1/2	12-7/8	4-1/4	2-1/2	3/4	1-1/2	2-7/8	1	1/2	3/4	88
2"	10-1/2	13-1/4	4-1/4	2-1/2	3/4		3	1	1/2	3/4	88
2-1/2"	11	13-3/4	4-1/4	2-1/2	3/4	1-1/2	3-1/8	1	1/2	3/4	117
3"	11	13	4	2-1/2	3/4		3	1	1/2	3/4	143
CLASS 1											
1/2"				4	3/4	-	2-7/8	1	1/2	3/4	80
3/4"					3/4	-	2-7/8	1	1/2	3/4	80
1"					3/4	-	2-7/8	1	1/2	3/4	80
1-1/4"					3/4	-	3-1/8	1	1/2	3/4	87
1-1/2"					3/4	-	3-1/8	1	1/2	3/4	88
2"					3/4	-	3	1	1/2	3/4	88
2-1/2"					3/4	-	4-1/16	1	1/2	3/4	117

NO.	ALTERATIONS	APP'D	DATE
	LESLIE CO. LYNCHBURG, VA.		
	1/2" to 3" PRESSURE REDUCING VALVES SAFT GLASSES A, AA & C LESLIE CLASS LA-1		
DATE 5-8-61	DRAWING NO.	DWG. LAC-141-1	





Gradual opening Main Valve in 4-1/2" Reducing Valves and larger.



Recessed Bonnet Cap on Reducing Valves 1/2" to 1-1/2" inclusive

Sizes	A	B	C	D	E	F	Number of Bolts	Bolts Size	Bolts Size	Approx. Weight
CLASS 150										
1/2"	7	10	3-1/2	4	1-1/2	3-7/8	4	1/2	1/2	15
3/4"	7	10	3-1/2	4-1/2	1-1/2	3-7/8	4	1/2	1/2	15
1"	8-1/2	10	3-1/2	4-1/2	1-1/2	4-3/8	4	1/2	1/2	15
1-1/4"	8-1/2	10-1/4	3-1/2	5-1/2	1-1/2	4-7/8	4	1/2	1/2	15
1-1/2"	9	10-3/4	3-1/2	5-1/2	1-1/2	4-7/8	4	1/2	1/2	15
2"	9-1/2	11-3/4	3-1/2	6	1-1/2	5-3/8	4	1/2	1/2	15
2-1/2"	10-1/2	12	3-1/2	7-1/2	1-1/2	6	4	1/2	1/2	15
3"	10-1/2	12-1/2	3-1/2	7-1/2	1-1/2	6-7/8	4	1/2	1/2	15
4"	11-1/2	13-1/4	4	9-1/4	1	7-7/8	8	1/2	1/2	15
CLASS 8										
1/2"	8-1/2	10	3-1/2	3-1/2	3/4	4-7/8	4	1/2	1/2	15
3/4"	8-1/2	10	3-1/2	3-1/2	1/2	4-7/8	4	1/2	1/2	15
1"	8-1/2	10	3-1/2	4-1/2	1/2	5-3/8	4	1/2	1/2	15
1-1/4"	8-1/2	10-1/4	3-1/2	4-1/2	1/2	5-3/8	4	1/2	1/2	15
1-1/2"	9	10-3/4	3-1/2	5-1/2	1/2	6-3/8	4	1/2	1/2	15
2"	9-1/2	11-3/4	3-1/2	6	1/2	6-7/8	4	1/2	1/2	15
2-1/2"	10-1/2	12	3-1/2	7-1/2	1/2	8	4	1/2	1/2	15
3"	10-1/2	12-1/2	3-1/2	7-1/2	1/2	8-1/2	8	1/2	1/2	15
4"	11-7/8	13-1/4	4	9-1/4	1/2	8-7/8	8	1/2	1/2	15

LESLIE CO.

1/2" TO 4" PRESSURE REDUCING VALVES
BUTT CLAMPED or S.W.
LESLIE CLASS 15

DWG. NO. 15-156

COVERMORE PUMPS

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE PUMP GOVERNORS

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE
CO.
LYNDHURST, N.J.
ESTABLISHED 1900

ted in U. S. A. 8421

Manual-000966

LESLIE PUMP GOVERNORS

TYPE CP CLASS

For Boiler Feed Service	:	Leslie Class CTHNS
For Fuel Oil Service	:	Leslie Class PTHNS
For Lub. Oil Service	:	Leslie Class PTLNS
For Fire Pump Service	:	Leslie Class PTLNS

INSTALLATION:

DO NOT USE LEAD OR CEMENT WHEN MAKING PIPE JOINTS.

1. Protect pump governor with Leslie Self-Cleaning Strainer.
2. Install stop valves and gage to control setting and operation of governor.
3. Blow out pipe lines thoroughly before installing pump governor.
4. Place governor as close to pump as possible in vertical position in horizontal line of pipe with arrow (cast on side of body) in direction of steam flow.
5. Install 3/8" actuating pipe with stop valve, union and gage from connection in governor super-structure to discharge line one to three feet from pump.

Governors for turbine driven pumps have stabilizing needle valve built-in. (See Page 2 "OPERATION" for adjustment).

Provide for proper drainage of steam line ahead of pump governor.

OPERATION:

For Sectional View see following drawings attached:

For Boiler Feed Service - PNS-216 for sizes 1/2" to 1-1/2"
PNS-217 for sizes 2" and 2-1/2"
For Boiler Fuel Oil Service - PNS-223
For Lubricating Oil & Fire Pump Service - PNS-215.

1. Close inlet and outlet stop valves.
2. Release compression on Adjusting Spring under Hand Wheel.
3. Remove Bottom Cap 7 and take off Main Valve 4 and Main Valve Spring 26. Replace Bottom Cap 7 only. Be sure that stem 36 is screwed back far enough to prevent Main Valve Guide 13 to go all the way down into its recess in Bottom Cap. Operate pump in this way until pipe lines are clean.
4. Before installing the Main Valve and Main Valve Spring, break the joint at Top Cap Gasket 29 and lift off the whole superstructure without disassembling it. Remove Piston 5 and Cylinder Liner 3 and clean same carefully. After Cylinder Liner and Piston are put back in place, reinstall Main Valve 4 and Main Valve Spring 26 and thereafter bolt superstructure to the governor.

Manual-000967

OPERATION (Cont'd)

5. Open stop valve in actueting pipe from pump discharge.

6. Slowly open inlet and outlet stop valves wide.

7. Slowly screw down on handwheel until desired discharge pressure is obtained.

8. Throttle needle valve 59 sufficiently to stop any surging or hunting. Same should normally be kept about one quarter of a turn open. It must never be shut tight.

9. Speed Governor of the turbine must be set above maximum operating speed so as not to interfere with the Pump Governor.

THE HAND WHEEL 41 AT LOWER END OF THE GOVERNOR IS FOR EMERGENCY OPERATION ONLY. By screwing the Stem 38 out, the Main Valve is pulled off its seat when Indicator Plate 43 reads "OPEN". Normally the stem must be all way in so that the Indicator Plate 43 will read "AUTO" when the governor operates automatically.

MAINTENANCE:

CAUTION: Leslie Pump Governors are ruggedly built, carefully assembled and dimensioned very accurately. Do not change any dimensions. Only standard Leslie parts must be used to assure long life and service.

OPENING PUMP GOVERNORS.

1. Close stop valves and open union in actuating line.

2. Release all compression on adjusting spring 25.

3. Unscrew connector union 32 from top cap 6 and slide up on nipple.

4. Remove lower nuts from stud bolts 28 and lift off superstructure complete above top cap 6.

5. Remove diaphragm 24 from top cap and unscrew controlling valve seat 8 with socket wrench provided for this purpose. Remove controlling valve 14 and spring 27.

6. Remove top cap 6, piston 5 and cylinder liner 3.

7. To take out main valve 4 and main valve spring 26 remove bottom cap 7.



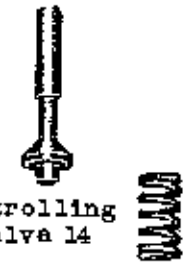
Adjusting Spring 25



Controlling Valve Seat 8

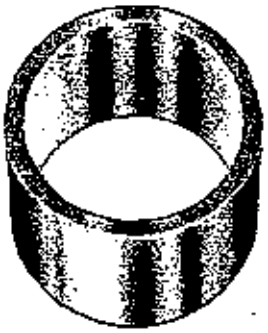


Diaphragm 24

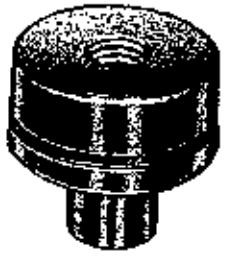


Controlling Valve 14

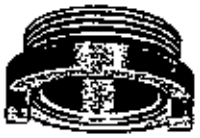
Controlling Valve Spring 27



Cylinder Liner 3



Piston 5



Seat Ring 2

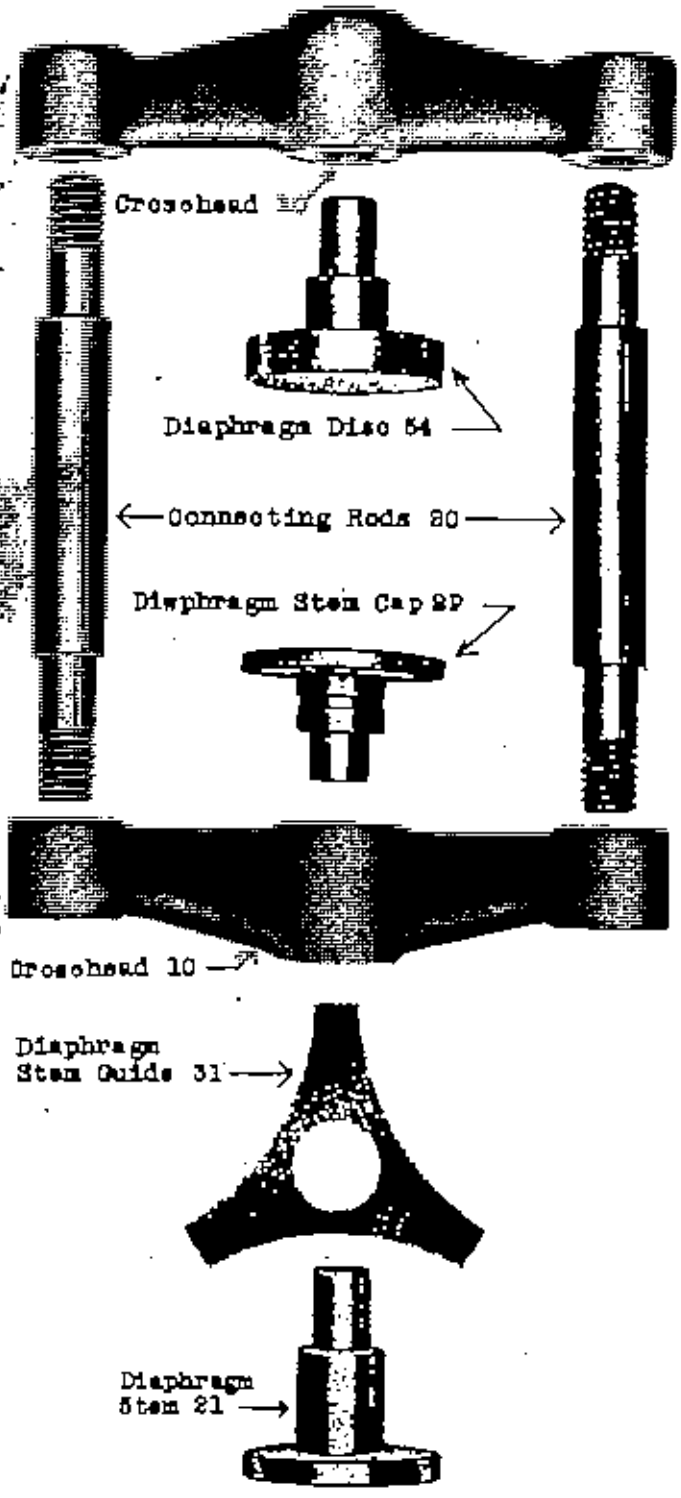


Main Valve Spring 26



Main Valve 4

Fig. 7 - INTERNAL PARTS OF TOP CAP AND BODY



MAINTENANCE (Cont'd)

8. Seat ring 2 in body can be taken out when necessary with special seat ring wrench provided for this purpose.

CLEANING:

1. Clean all parts with kerosene.
2. See that main and controlling valves move freely in their guides and seat properly.
3. Piston rings must be perfectly free in grooves.
4. Regrind main valve with piston in cylinder liner to insure perfect centering.
5. Have all working parts moving freely.
6. Be sure ports in diaphragm chamber 13, and spring case 9 are open and clean.

ASSEMBLY:

1. Do not use graphite or compound on joints. No lubricant is required on any moving parts.
2. Place main valve, spring and gasket in position on bottom cap and bolt to valve body.
3. Depress piston in cylinder liner. Be sure movement is smooth and free.
4. Top of liner must be flush with top flange of body.
5. Bolt top cap with gasket to body.
6. Assemble controlling valve, spring and seat in top cap. For reliable service controlling valve must seat tightly. To do this stem of valve must not project above diaphragm seat. Correct clearance is .001" to .002" below diaphragm seat in top cap.

ASSEMBLING (Con't)

SUPERSTRUCTURE

The superstructure does not contain any moving parts except the diaphragm and normally does not need to be taken apart except when replacing these. When necessary to disassemble the superstructure, care must be taken that Diaphragm Stem 21, Diaphragm Stem Cap 22 and Diaphragm Disc 54 are put back in proper position. Make sure that the connecting rods 20 are free in their guides and do not bind due to paint or carbonized oil.

7. Replace lower diaphragm 24, diaphragm spacer 11 with diaphragm stem 21 and lower crosshead 10 in place. Be sure diaphragm stem moves freely in diaphragm stem guide 31.

   Drop connecting rods 20 into holes in lower crosshead 10 and screw on lower connecting rod nuts 45.

8. Drawings show all classes of pump governors, follow same. Refer to proper drawing and assemble remainder of superstructure by adding parts loosely in their proper location until spring case 9 is in position.

9. Place upper crosshead through spring case 9 and on to connecting rods 20. Screw upper connecting rod nuts loosely in place.

10. Drop stud bolts through bolt holes in spring case 9 and superstructure including top flange of top cap. Put nuts on finger tight.

11. Line up all parts of superstructure through which stud bolts pass so that connecting rods move freely in guide holes and there is 1/32" play between connecting rods and holes in spring case.

12. Tighten nuts 44 on stud bolts 28 being sure to pull them up evenly all around and not too tight.

13. Tighten connector union 32 and brass connecting rod nuts 45.

14. Test for free movement of connecting rods in guide holes and clearance around same by rotating cross-heads back and forth on diaphragm stem 21.

15. Make-up union in actuating line.

ORDERING PARTS:

Please give the following information:

1. SERIAL NUMBER OF GOVERNOR
2. SIZE OF GOVERNOR
3. CLASS
4. QUANTITY OF EACH PART
5. PART NAME (See Parts Lists for various classes on drawings on following pages).

ALWAYS SUPPLY NAME AND NUMBER OF SHIP

ORDERING NEW PUMP GOVERNORS

Specify Leslie and supply following information

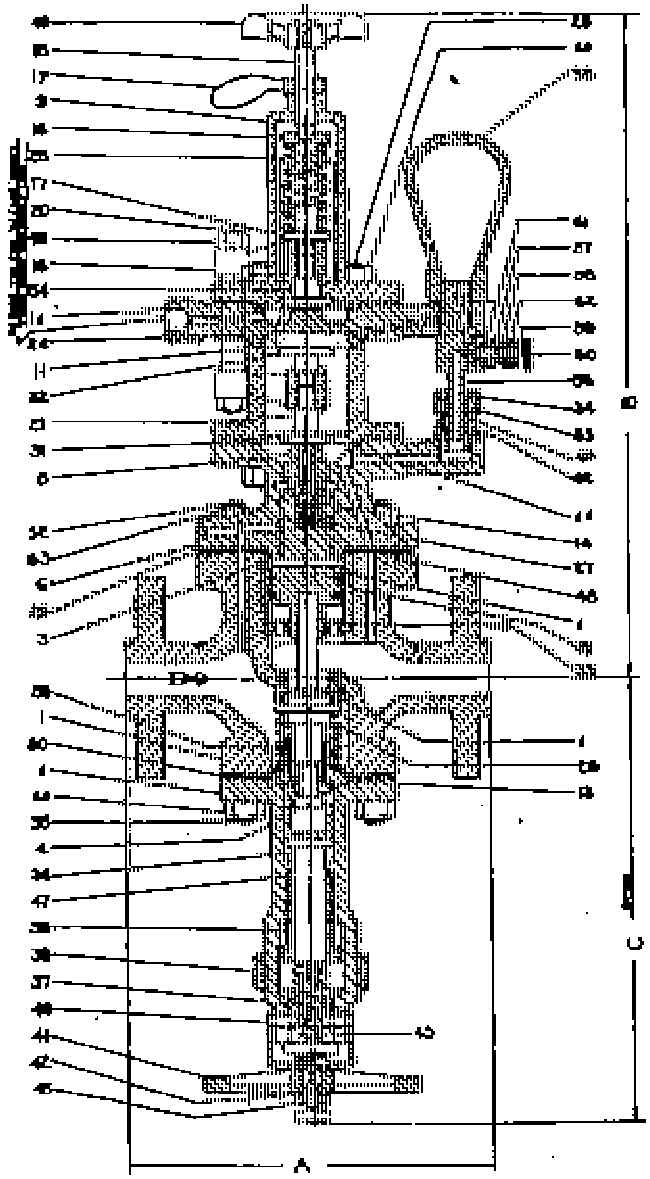
Pump Specifications:

1. Type and size of pump.
2. Minimum and maximum pump discharge pressure to be maintained.
3. Liquid to be controlled.
4. Maximum steam consumption of pump or turbine in lbs. per hour.
5. Maximum pumping rate or maximum number single strokes per min.
6. For excess pressure governors, give maximum boiler and excess pressures to be maintained.

Governor Specifications.

1. Minimum and maximum inlet steam pressure.
2. Maximum steam temperature.
3. Adjustable pump discharge pressure range desired.
4. Screwed or flanged connection. Flanges as follows:
   Bronze - Furnished undrilled unless otherwise specified.
   Steel - Always furnished drilled.

PROTECT WITH LESLIE SELF-CLEANING STRAINER.



PARTS LIST

[illegible]

DIMENSIONS IN INCHES

Size	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1/2"	[illegible]-1/4	[illegible]-3/4	10-1/4	[illegible]-1/4	[illegible]/16	1-3/4	[illegible]	[illegible]	1/4	[illegible]	[illegible]
3/4"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1"	[illegible]	[illegible]	[illegible]	[illegible]	11/16	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/4"	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1-1/2"	[illegible]	14	11-3/4	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]

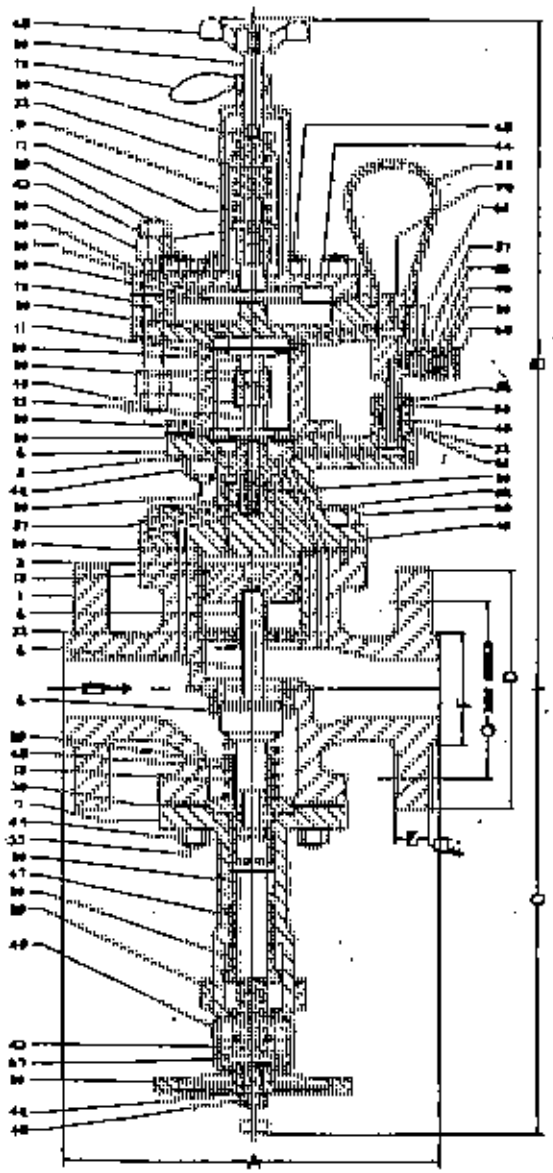
No.	ALTERATIONS	[illegible]	DATE

LESLIE CO.

[illegible]

1/2" to 1-1/2" PUMP GOVERNOR
[illegible] TYPE CP, CLASS [illegible]
LESLIE CLASS [illegible]

DATE [illegible] DWG. NO. [illegible]



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	34	Diaphragm	48	Dowel Pin
2	Seat Ring	35	Adjusting Spring	49	Handwheel
3	Cylinder Liner	36	Main Valve Spring	50	Wrench for Fs. No. 2
4	Main Valve	37	Controlling Valve Spring	51	Wrench for Fs. No. 3
5	Piston	38	Stud	52	Stud
6	Top Cap	39	Stud	53	Main Valve Guide Bushing
7	Bottom Cap	40	Top Cap Gasket	54	Diaphragm Disc
8	Controlling Valve Guide	41	Bottom Cap Gasket	55	Steam Chamber
9	Adjusting Spring Cage	42	Diaphragm Stem Guide	56	Needle Valve Body
10	Gasket	43	Connector Union	57	Needle Valve Bonnet
11	Diaphragm Spacer	44	Connector Elbow	58	Needle Valve Bonnet Nut
12	Diaphragm Chamber	45	Connector Nut	59	Needle Valve Stem
13	Main Valve Guide	46	Stud	60	Needle Valve Stem Head
14	Controlling Valve	47	Packing	61	Needle Valve Body Gasket
15	Piston Ring	48	Elbow	62	Connecting Rod Guide
16	Top Spring Seat	49	Elbow Nut	63	Screw for Connecting Rod Guide
17	Bottom Spring Seat	50	Radiator Cap	64	Diaphragm
18	Adjusting Screw	51	Handwheel	65	Stud
19	Lock Nut	52	Washer	66	Nut
20	Connecting Rod	53	Indicator Plate		
21	Diaphragm Plate	54	Nut		
22	Diaphragm Stem Cap	55	Nut		
23	Cylinder Bushing	56	Packing		
24		57	Packing		

DIMENSIONS IN INCHES

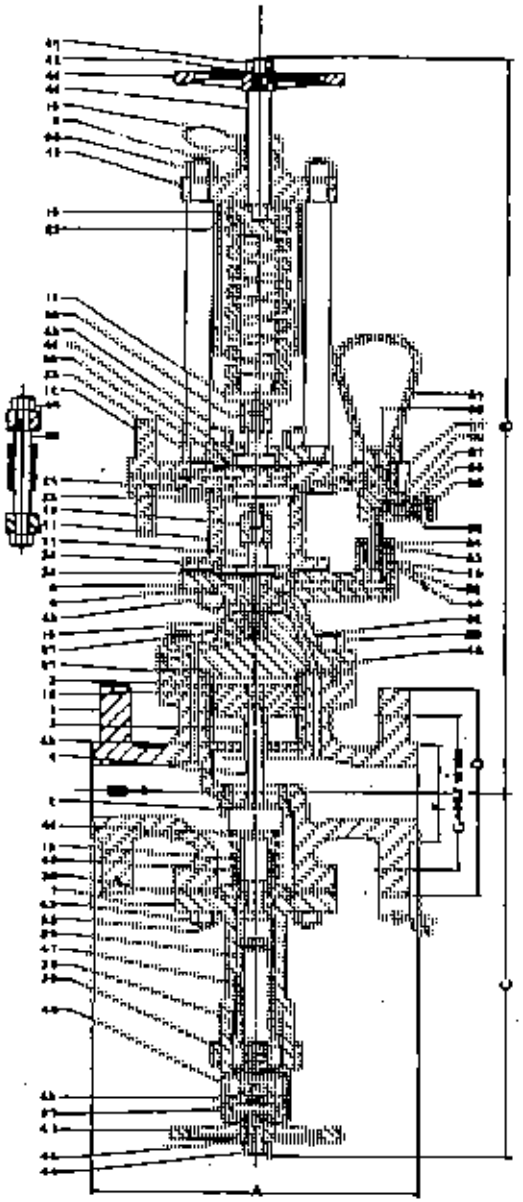
Size	A	B	C	D	E	F	G	Pipe Size Inlet	Pipe Size Outlet	Pipe Size Drain	Weight Lbs. Each
1/2"	8-1/2	11-1/8	10-1/2	4-3/4	5/16	1-3/8	8-5/8	4	1/2	3/16	25
3/4"	8-1/2	11-1/8	10-1/2	4-3/4	5/8	2-11/16	8-1/4	4	3/4	11/16	25
1"	8-1/2	11-1/8	10-1/2	4-3/4	11/16	2	8-1/4	4	3/4	11/16	25
1-1/4"	8	11-1/8	11	4-3/4	13/16	2-1/4	8-1/4	4	1	11/16	25
1-1/2"	8-1/2	11-1/8	11-3/4	4-3/4	7/8	2-3/4	8-1/4	4	1	11/16	25

LESLIE CO. LYNDHURST, N.J.

1/2" to 1-1/2" PIPE COVERED
BUT TYPE (F, GLASS &
LESLIE GLASS FILLED

DWG. NO. 2-[illegible]

DWG. NO. FSB-512



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	23	Cylinder Bottom	45	Main Valve Guide Bushing
4	Seat Ring	24	Diaphragm	46	Packing
4	Cylinder Liner	28	Adjusting Spring	46	Packing
4	Main Valve	44	Main Valve Spring	48	Dowel Pin
4	Piston	46	Controlling Valve Spring	51	Adjusting Spring Cover
4	Top Cap	44	Stud Bolt	80	Wrench for Pc. No. 4
7	Bottom Cap	44	Top Cap Gasket	81	Wrench for Pc. No. 4
8	Controlling Valve Seat	80	Bottom Cap Gasket	82	Packing
4	Collar	81	Diaphragm Stem Guide	83	Plate
10	Crosshead	44	Connector Valve	84	Steam Chamber
11	Diaphragm Spacer	83	Connector Gland	85	Needle Valve Body
16	Diaphragm Chamber	84	Connector Nut	86	Needle Valve Bonnet
16	Main Valve Guide	86	Stud	87	Needle Valve Bonnet Nut
44	Controlling Valve	80	Stem	80	Needle Valve Stem
16	Piston Ring	87	Packing	89	Needle Valve Stem Head
44	Top Spring Seat	18	Gland	80	Needle Valve Body Gasket
44	Bottom Spring Seat	18	Nut	81	Diaphragm Disc
18	Adjusting Screw	80	Indicator Cap	44	Stud
18	Lock Nut	81	Handwheel	43	Nut
80	Connecting Rod	44	Washer		
81	Diaphragm Stem	44	Indicator Plate		
82	Diaphragm Stem Cap	44	Nut		

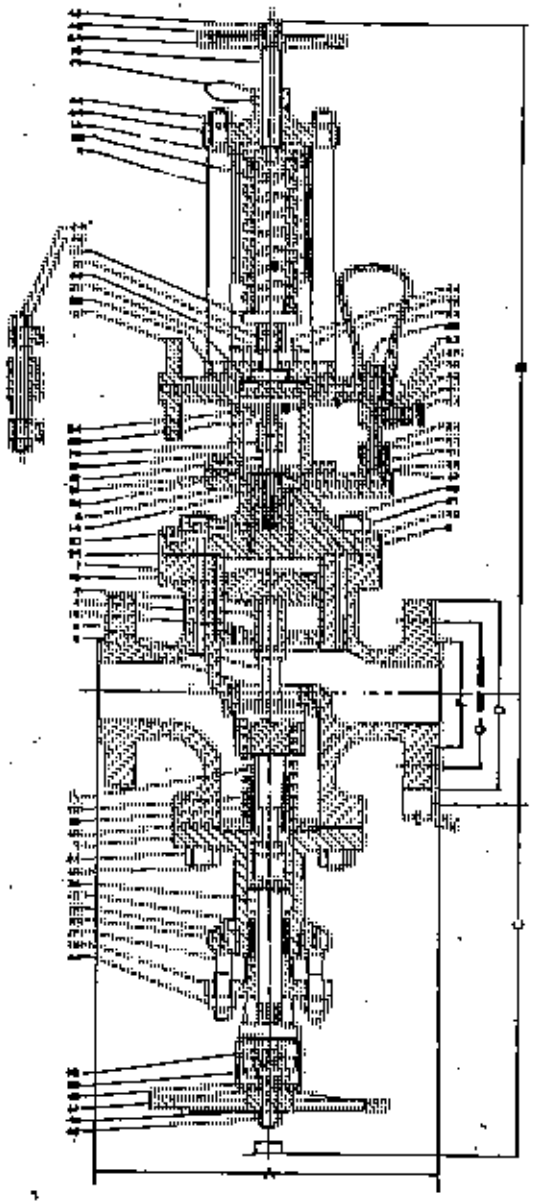
DIMENSIONS IN INCHES

Size	A	B	C	D	E	F	G	Pipe Connection Size	Bolt Hole Size	Bolt Hole	Weight (Lbs.)
1/2"	8-1/2	10-1/2	10-1/2	3-3/4	3/4	1-3/4	3-3/4	4	1/2	4-1/4	22
3/4"	8-1/2	10-1/2	10-1/2	3-3/4	3/4	1-3/4	3-3/4	4	1/2	4-1/4	24
1"	8-1/2	10-1/2	10-1/2	3-3/4	3/4	1-3/4	3-3/4	4	1/2	4-1/4	24
1-1/4"	9	10-3/4	11	4-1/2	1-1/16	2-1/2	4-1/4	4	1/2	4-1/4	30
1-1/2"	9-1/2	11-1/4	11-3/4	4-3/4	1	2-1/2	4-1/4	4	1/2	4-1/4	35

LESLIE CO.
LYNCHBURST, N.J.

1/2" to 1-1/2" PUMP GOVERNOR
TYPE CP, CLASS 4
LESLIE CLASS CP4GB

DWG. NO.



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	20	Adjusting Spring	39	Adjusting Spring Cover
2	Seat Ring	21	Main Valve Spring	40	Wrench for Pc. No. 2
3	Cylinder Liner	22	Controlling Valve Spring	41	Wrench for Pc. No. 3
4	Main Valve	23	Head Bolt	42	Packing
5	Piston	24	Top Cap Gasket	43	Plate
6	Top Cap	25	Bottom Cap Gasket	44	Steam Chamber
7	Bottom Cap	26	Diaphragm Stem Guide	45	Pin
8	Controlling Valve Seat	27	Connector Union	46	Cotter Pin
9	Column	28	Connector Gland	47	Nut
10	Crosshead	29	Pressure Pin	48	Needle Valve Body
11	Diaphragm Spacer	30	Stud	49	Needle Valve Bonnet
12	Diaphragm Chamber	31	Stem	50	Needle Valve Bonnet Nut
13	Main Valve Guide	32	Packing	51	Needle Valve Stem
14	Controlling Valve	33	Gland	52	Needle Valve Stem Hand
15	Piston Ring	34	Eyebolt	53	Needle Valve Body Gasket
16	Top Spring Seat	40	Indicator Cap	54	Diaphragm Plate
17	Bottom Spring Seat	41	Handwheel	55	Main Valve Guide Packing
18	Adjusting Screw	42	Washer	56	Stud
19	Lock Nut	43	Washer	57	Pin
20	Connecting Rod	44	Nut	58	Nut
21	Diaphragm Stem	45	Nut	59	Handwheel
22	Diaphragm Stem Cap	46	Packing	70	Indicator Plate
23	Cylinder Bottom	47	Packing		
24	Diaphragm	48	Spool Pin		

DIMENSIONS IN INCHES

Size	A	B	C	D	E	F	G	H	J	K	Approx. Net Weight Lbs.
1"	11-1/2	22-1/2	15-3/8	6-1/2	1	3-3/4	5	5	3/8	11/16	155
1-1/2"	13	24-3/4	17-3/4	7-1/2	1-1/2	4-1/2	5-3/4	6	1/2	15/16	175

LESLIE CO.
LYNDHURST, N.J.

1" to 1-1/2" PUMP GOVERNOR
TYPE GP, CLASS A
Leslie Class 17000

Scale 3-16 size
Drawn by [illegible]

DWG. NO. PGA-314

INSTRUCTIONS

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE-TYFON WHISTLES

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE CO.
LYNDHURST, N.J.
ESTABLISHED 1900

Printed in U. S. A. 6411

LESLIE-TYFON WHISTLES

INSTALLATION:

1- Steam supply is taken from the "150 pound auxiliary steam line". This line is normally energized under all operating conditions.

2- The steam supply line should rise continuously through well graded piping free from pockets, to the separators at the bottom of the vertical risers.

3- Steam supply riser piping to the whistles should be as nearly vertical as practicable.

4- The separators at the bottom of the vertical risers should be provided with drains of ample size leading to the steam drain collecting main and deaerating feed tank.

5- The drain lines from the separators should be fitted with traps of the continuous flow type.

6- The drain lines from the whistles proper should be fitted with traps of the impulse flow type and should connect to the lines leading from the separators to the steam drain collecting main. The drain lines should be connected after the traps in each line, to prevent priming of the steam supply to the whistles.

7- All drain lines should be well graded, without pockets, and sloping continuously downward toward the steam drain collecting main.

8- Piping should be well insulated and where exposed should be double insulated.

9- Traps on separators and whistle drain lines should be fitted with by-pass connections.

10- After the whistles are installed, remove diaphragm leaves by unscrewing back covers, and operate whistle valves several times with the diaphragms removed, to blow out pipe lines thoroughly. Then place proper number of diaphragm leaves in place and screw up back cover preparatory to testing whistles. All leaves must have the convex or high side facing toward the nozzle and horn of the whistle. Diaphragm leaves are marked to this effect.

OPERATION:

1- Before testing or operating whistle at any time, steam should be turned on with all drains open and traps by-passed for one hour before blowing, to insure proper heating of the Leslie-Tyfon and its diaphragm.

2- Check all traps to insure that they are functioning properly before getting under way.

3- In testing whistle before getting under way, note any unusual tone, lag, aftertone, or water spray that would indicate derangement or faulty adjustments.

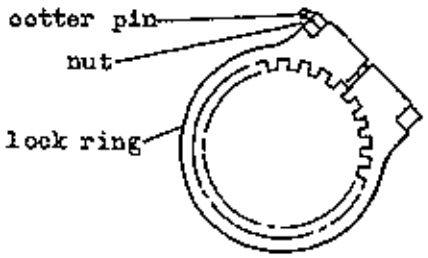
Manual-000978

LESLIE-TYFON WHISTLES

OPERATION: (cont.)

4- To adjust diaphragm, be sure the actual operating pressure is available and then screw back cover up, with spanner wrench furnished, while Leslie-Tyfon is blowing. If during blast of Leslie-Tyfon water comes out through the horn or around stem of operating valve, or if sound is not clear from beginning of first blast, a check up should immediately be made of respective traps, (see Paragraph 6 under Installation) and if same are not functioning properly, they should be by-passed until they are put into working order. Make adjustments as tight as possible while still obtaining a clear well-defined blast.

5- Back cover should then be locked in place according to design as shown below:



Tighten nut on lock ring and secure with cotter pin.

MAINTENANCE:

1- Examine and clean diaphragm each month. If any leaf is found damaged, it should be replaced by a new one. The new leaf should be installed next to the nozzle. Weights of Back Covers and Diaphragms are as follows:

	300 DVE	200 DV
Back Cover	19 lbs.	8 lbs.
Diaphragm (3 leaves)	14 lbs.	4-1/2 lbs.

2- After diaphragm leaves have been cleaned, they should be put in position and tested as explained under paragraph 4 under Operation.

3- Check up on operating valve every three months. If the main valve is leaking, remove same, following proper drawing for guidance, and grind in to obtain a good clean seat. If seats are damaged so badly that they cannot be ground in, the main valve should be held between centers in a lathe and faced off to give a perfect 45° seat. The seat ring is pinned through the threads and can only be removed with a proper wrench after the pin is removed. See drawing for location of pin before trying to remove seat ring.

4- On 300 DVE Leslie-Tyfons, after valve seats have been refaced, it will be necessary to check travel of main valve to prevent travel exceeding that shown on applicable drawing. When necessary to correct or reduce valve travel, screw a stop in top of piston and face off as necessary. No adjustments are necessary on the mechanically operated lever when same is working in conjunction with electrical operation. The piston also acts as the stop for the mechanical operating lever.

MBnual-000979

LESLIE-TYFON WHISTLES

ORDERING PARTS

When ordering parts of Leslie-Tyfon Whistles give the following information:

1- Serial number of Leslie-Tyfon Whistle (found on lock ring)

2- Type, class and description from name plate.

3- Part name (from drawing listed below)

4- Quantity of each part.

ALWAYS SUPPLY NAME AND NUMBER OF SHIP

DRAWINGS

T-851-1 - 300-DVE Leslie-Tyfon whistles

T-465 - A.C.Solenoid Assembly

T-844 - 200-DV Leslie-Tyfon Whistle

ORDERING NEW LESLIE-TYFONS

When ordering or obtaining price estimates for Leslie-Tyfon Whistles, specify Leslie-Tyfon and submit the following data:

1- Service or use.

2- Size of Leslie-Tyfon

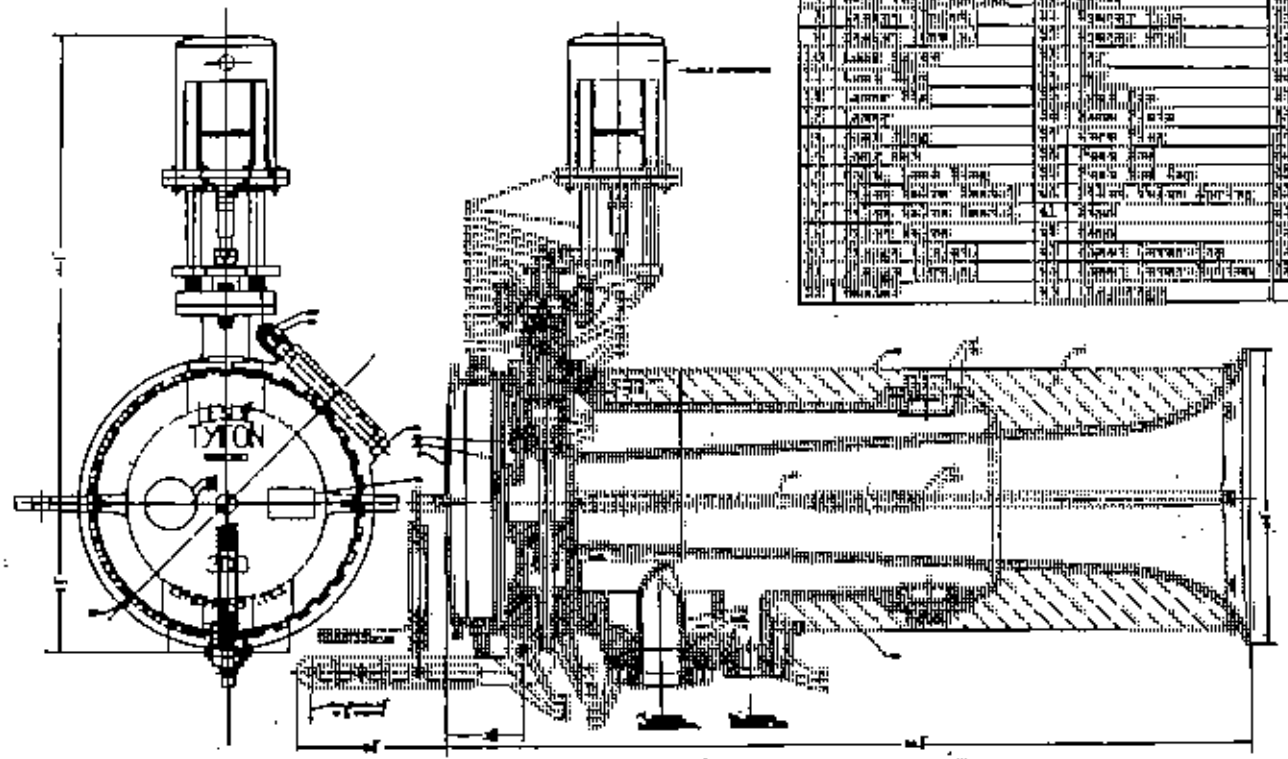
3- Steam pressure available, maximum and minimum

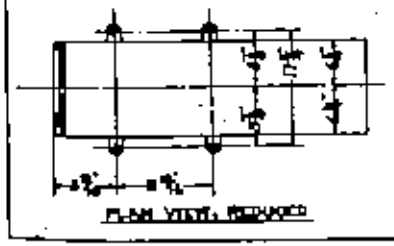
4- Manual, electric or automatic control

5- If electric control desired give voltage and type of current.

6- When a reducing valve is required, refer to Leslie Co. Bulletin 401-A.

Manual-000980





PLAN VIEW, REMOVED

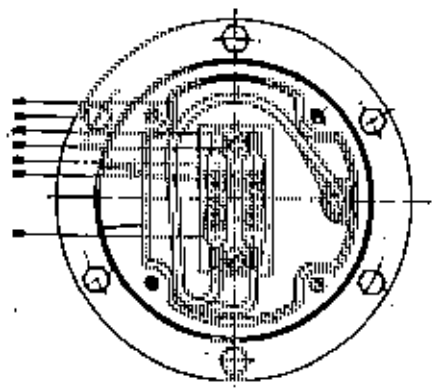
LESLIE-TYFON

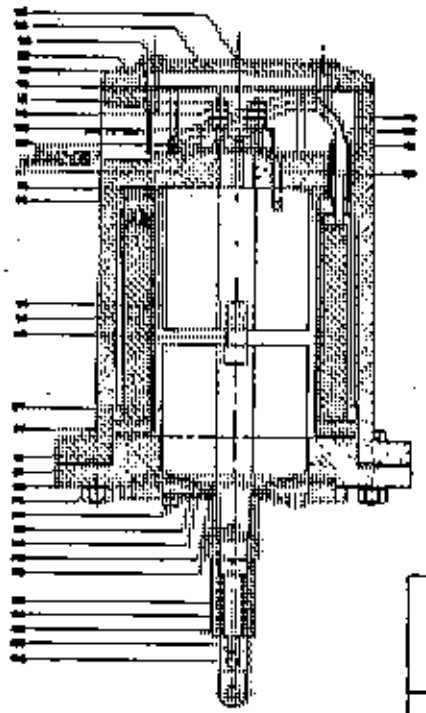
LESLIE CO. LYNDHURST, N.J.

LESLIE-TYFON STOCK VALVE
300 PSI, BRONZE
WITH A.S.O. SOLENOID

DATE 3-15-43

DWG. NO. T-161-1





LESLIE
CO.

LESLIE-TYPE SOLENOID
A.C. SOLENOID ASSEMBLY

DWG. NO. T-448

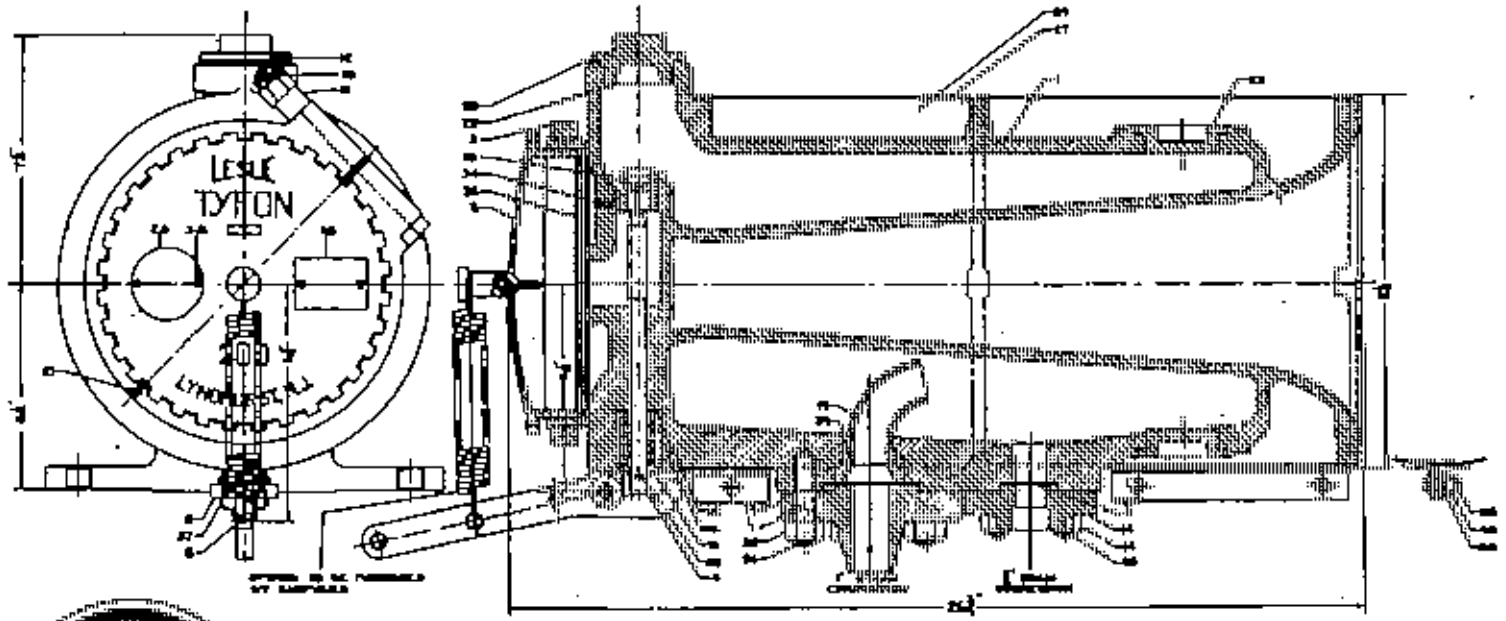
LIST OF PARTS - AC SOLENOID
CORRESPONDING TO DWG. No. T-448

97	Screw
98	Spring
99	Cap
100	Coil
101	Guiding Sleeve
102	Cap Gasket
103	Coil Gasket
104	Diaphragm
105	Bolt
106	Cover
107	Flanger
108	Screw, Fl. Hd. S.
109	Lock Washer
110	Diaphragm Cover
112	Screw, Fl. Hd. S.
113	Diaphragm Washer
114	Connecting Bushing
115	Connecting Sleeve
116	Connecting Sleeve Head
117	Connecting Plunger
118	Screw, Fl. Hd.
119	Diaphragm, Plain
120	Diaphragm, Corrug.
121	Diaphragm Guide
122	Nut
123	Guide Pin
124	Lock Washer
125	Yoke Plate
126	Nut
127	Insulating Plate
128	Insulating Strip
129	Center Pin
130	Center Pin
131	Sleeve
132	Insulating Tube

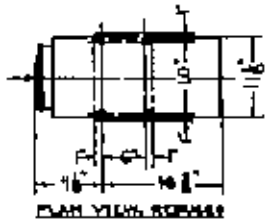
LIST OF PARTS
For
LESLIE-TYPE SOLENOID
AC (DIAPHRAGM)
See Dwg. No. T-448, attached

PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	15	Washer	29	Insulation
2	Lock Cover	16	Spring Ring	30	Nut
3	Lock Ring	17	Expansion Bushing	31	Nut
4	Main Valve	18	Valve Plate	32	Cotter Pin
5	Main Valve Spring	19	Bevels	33	Cotter Pin
6	Bushing - Main	20	Bushing	34	Lock Screw
7	Bushing - Bevels	21	Lock Pin	35	Screw, S.H.
8	Lever Pin	22	Cylinder Ring	36	Lock Washer
9	Lever	23	Cover Plug	37	Cotter Pin
10	Bell Ring	24	Stud	38	Drive Screw
11	Lock Nut	25	Stud	39	Set Screw
12	Bell - Lock Ring	26	Diaphragm	40	Nut, Hex.
13	Plunger - Inlet	27	Short Spacer		
14	Plunger - Bevels	28	Name Plate		







PLAN VIEW SCREEN

NO.	ALTERATIONS	APP'D	DATE

LESLIE CO.
LYNCHBURG, VA.

LESLIE-TYFON STEAM WHISTLE
SCD 5T

DWG. NO. 5-4-48

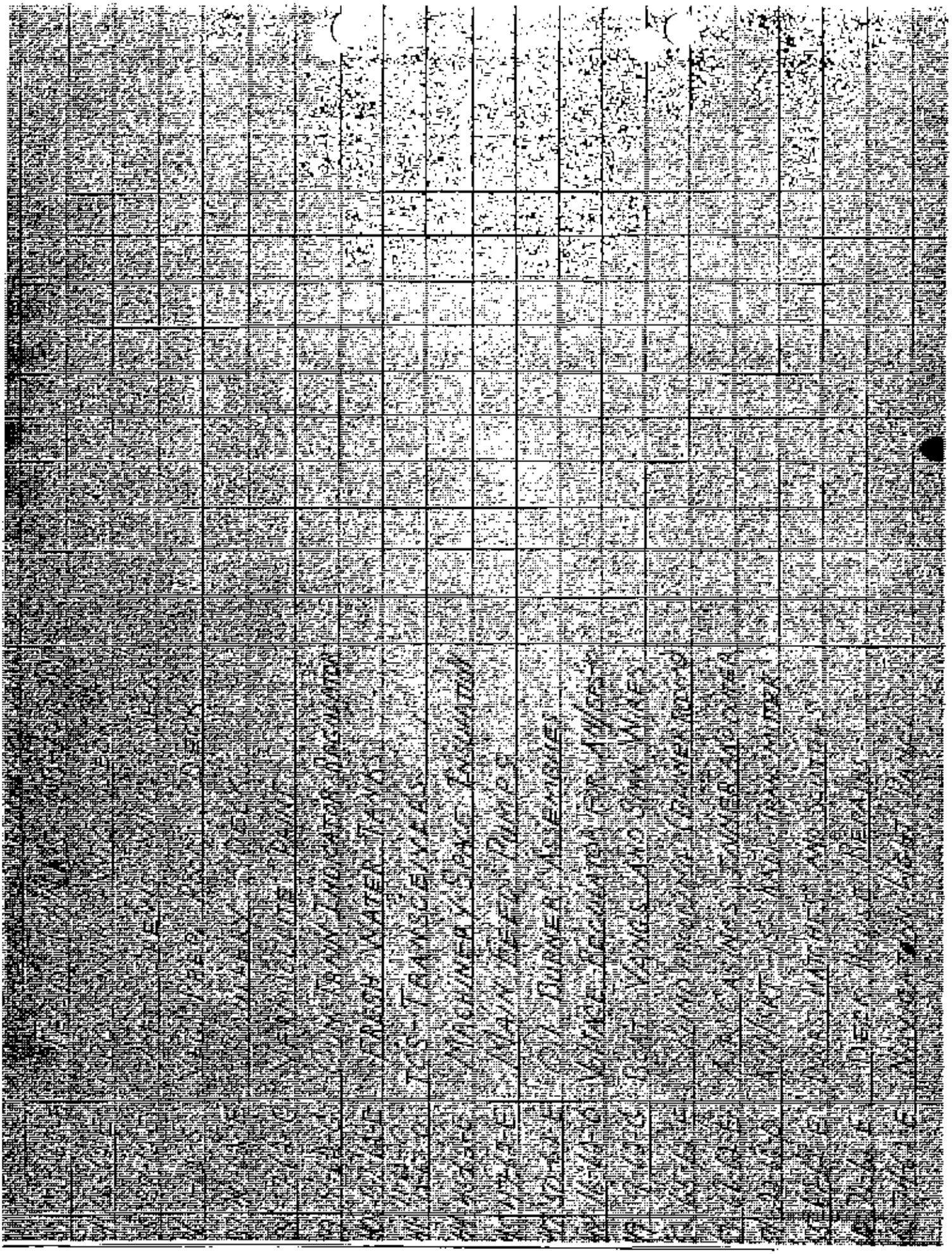


EXHIBIT BB

PRODUCED AT THE NATIONAL ARCHIVES

NAVSHIPS348-1225
NAVSHIPS

TECHNICAL MANUAL
LESLIE
DIAPHRAGM CONTROL VALVES
CONTROL PILOTS
PRESSURE REDUCING VALVES
TEMPERATURE REGULATORS
PUMP PRESSURE REGULATORS

LESLIE
CO.
LYNDHURST, NEW JERSEY

LESLIE CO. NO. P-10698

BUREAU OF SHIPS NAVY DEPARTMENT JUNE 1956
Manual-000987

EXHIBIT "BB"

REPRODUCED AT THE NATIONAL ARCHIVES

APPROVAL AND PROCUREMENT RECORD PAGE

BASIC APPROVAL DATA: NAVSHIPS - Technical Manual, Leslie Diaphragm Control Valves, Control Pilots, Pressure Reducing Valves, Temperature Regulators, Pump Pressure Regulators.

Contract or Purchase Order	Date	Vessels Applicable	Quantity of Manuals	Building Yard	Remarks
NObs. 3594	8/11/55	AR21 & 22	65	Bethlehem Steel Co. Sparrows Point, Md.	

Date 6-28-56

LESLIE CO.

Ernest P. Wakelin
Manufacturer's Signature

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LESLIE DIAPHRAGM CONTR. VALVES, Etc

ILLUSTRATIONS

DRAWING & TITLE	LESLIE DWG. NO.	BUSHIPS NO.	FIG.	PAGE
D.C.V. 3" (1-1/2 Trim) DBS-2X 600# Flg. Cast Steel, Hi-R. Plug, Thermo-Isolating, 50 Alum. Super., Assy., Det. & L/M	10594N		1	31-32
Leslie D.C.V. 3" B-3, 150# Flg. 50 Super. C. Brz. Reg. Bonnet, Assy., Det. & L/M	10708N		2	33-34
D.C.V., 50 Super. Assy., Det. & L/M	10295N	E-3,278,545	3	35-36
Control Pilot 2-20 psi Type PBA Assy., Det. & L/M	10913N		4	37-38
Control Pilot 2-20 psi Type PDA Assy., Det. & L/M	10960N		5	39-40
Press. Red. V. & Strainer Unit 1/4" AW Assy., Det. & L/M	10524N	E-3,278,572	6	41-42
Press. Red. Valve 1/2" LS-4X Assy., Det. & L/M	10771N		7	43-44
Temperature Regulator 2" LTCSO-3X Assy., Det. & L/M	10508N	E-3,278,568	8	45-46
Temp. Reg. Superstructure, LTCSO-3 Assy., Det. & L/M	10336N	E-3,278,551	9	47-48
Temp. Regulator, 1-1/2" TM Assy., Det. & L/M	11001N		10	49-50
Pump Pressure Reg., 2-1/2" CTHSM-X Assy., Det. & L/M	10834N		11	51-52

SECTION II, DIAPHRAGM CONTROL VALVES & PILOTS

GENERAL DATA

P.O. QD-810-1084-X-4540, Item No.	I	II	III
Qty per Vessel	1	1	1
Size & Class	3" UBS-2X	3" D-3	4" D-3
Flange Std., ASA	600#	150#	150#
Material	C. Steel	C. Bronze	C. Bronze
Code	307A3X	22F7A2X	22F7A2X
Superstructure Size	50	50	50
Inlet Steam Press. Range, psig	575-620	20-68	17-25
Inlet Temp. ° F Max.	540	400	400
Set Pressure, psig	7-15	10-18	17-23
Steam Flow, Lb./Hr.	0-10,000	0-7,500	0-8,000
Control Pilot			
Type	PRA	PRA	PDA
Range	2-20	2-20	2-20
Red. Valve Unit, Class AW, Size	1/4	1/4	1/4
Service:-	Aux. Exh. Make-up	Bleeder Control	Aux. Exh. Unloading
Net Wt. per Vessel, Lb.	296	202	314
Plan List			
Diaphragm Control Valve - Leslie No. / BuShips No.	10594N	10708N	10907N
Superstructure - Leslie No. / BuShips No.	10295N H-3,278,545	10295N H-3,278,545	10295N H-3,278,545
Control Pilot - Leslie No. / BuShips No.	10913N	10913N	10960N
AW Unit - Leslie No. / BuShips No.	10524N H-3,278,572	10524N H-3,278,572	10524N H-3,278,572
Cert. Data Plan Leslie No. / BuShips No.	10986N	10987N	10988N
*Illustrations	Fig. 1,3,4 & 6	Fig. 2,3,4 & 6	Fig. 2,3,5 & 6

* The text material and illustrations for the Class D-3 are for 3" size only. However, the text applies also to the 4" size, the difference being only a few part numbers.

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LESLIE-DIAPHRAGM CONTRO.. VALVES, Etc.

LIST OF ON-BOARD REPAIR PARTS

P.D. ITEM NO.	SIZE & CLASS	PART NAME	QTY. EACH ITEM	LESLIE CO. SERVICE PART NO.	STD. NAVY STOCK NO.
IA	3" DBS-2X	Diaphragm	2	23266	H45LES-60480
		Spring	1	24297	
		Piston Ring	1	23451	
		Bonnet Gasket	1	13645	H45LES-60187
		Bottom Cap Gasket	1	11350	H45LES-60286
		Main Valve	1	24390	
		Diaphragm, Upper	1	12476	H45LES-60333
		Adjusting Spring	1	12475	H45LES-60124
		Lever Spring	1	15960	H45LES-60341
		Diaphragm Nozzle Disc, Compl.	1	15831	H45LES-60390
		Diaphragm for Nozzle	1	12368	H45LES-60107
		Pilot Valve Spring	1	9946	H45LES-60101
IIA	3" D-3	Diaphragm	2	23266	H45LES-60480
		Spring	1	24297	
		Main Valve Spring	1	13085	H45LES-60528
		Bonnet Gasket	1	18209	
		Bottom Cap Gasket	1	18252	
		Main Valve	1	30352	
		Seat Ring	1	9562	H45LES-60352
		Equalizing Valve	1	32411	
		Equalizing Valve Seat	1	9821	H45LES-60154
		Diaphragm, Upper	1	12476	H45LES-60333
		Adjusting Spring	1	12475	H45LES-60124
		Lever Spring	1	15960	H45LES-60341
		Diaphragm Nozzle Disc, Compl.	1	15831	H45LES-60390
		Diaphragm for Nozzle	1	12368	H45LES-60107
		Pilot Valve Spring	1	9946	H45LES-60101
16		Seat Ring Wrench	1	9233	
		Socket Wrench	1	9036	H45LES-60106
		Eq. Valve Seat Wrench	1	9551	H45LES-60206
IIIA	4" D-3	Diaphragm	2	23266	H45LES-60480
		Spring	1	24297	
		Main Valve Spring	1	12989	
		Bonnet Gasket	1	16243	
		Bottom Cap Gasket	1	18253	
		Main Valve	1	30422	
		Seat Ring	1	13072	
		Equalizing Valve	1	32411	
		Equalizing Valve Seat	1	9445	H45LES-60149
		Diaphragm, Upper	1	12476	H45LES-60333
		Yielding Spring	1	12471	H45LES-60098
		Adjusting Spring	1	12475	H45LES-60124
		Diaphragm Nozzle Disc, Compl.	1	15086	H45LES-60340
		Diaphragm for Nozzle	1	12368	H45LES-60107
		Pilot Valve Spring	1	9946	H45LES-60101
16		Seat Ring Wrench	1	12988	
		Socket Wrench	1	9036	H45LES-60151
		Eq. Valve Seat Wrench	1	9552	H45LES-60106

Manual-000992

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DIAPHRAGM CONTROL VALVES

INSTALLATION: Classes DBS-2X and D-3

1. Blow out pipe lines thoroughly before installing.

2. Install Diaphragm Control Valve with arrow cast on body in direction of flow preferably in upright position in the highest horizontal line of piping, with appropriate inlet and outlet stop valves and gages to control setting and operation of the Valve. Provide for proper drainage to obtain best results and to avoid water hammer. Good piping practice includes a by-pass around controller and Strainer to protect equipment.

3. Outlet piping from Diaphragm Control Valve should be expanded to approximately twice the inlet pipe size whenever a reduction to less than 25% of inlet pressure is made. In such cases a taper expander should be used and control pipe should be connected downstream of the expander.

4. Connect copper tubing as instructed in Control Pilots.

5. IMPORTANT: For proper operation of Valves equipped with Thermo-Isolating Bonnets it is important that Bonnets be painted black and no insulation be used.

6. Leslie-Lubrisoft Packing is specially designed and compounded for valve body temperature up to 500° F. without the need of an external lubricator. When combined with the exceptionally effective Leslie Thermo-Isolating Bonnet, Leslie-Lubrisoft packing may be used for valve body temperatures up to 1050° F. Lubricators are not recommended under any conditions and will be furnished only if specified.

MAINTENANCE: Class DBS-2X (See Illustration, Fig. 1 for part numbers.)

Dismantling, Cleaning & Reassembling.

1. Shut off air supply through Control Pilot and disconnect copper tubing at Superstructure cover.

2. Remove Nuts (26), Bottom Cap (25) and Bottom Cap Gasket (24).

3. Loosen Nut (29) and screw Lower Stem (5) out of Upper Stem of Superstructure. When clear, remove Nut (29) and Indicator Disc (4). Continue to turn Main Valve (21) until Main Valve and Lower Stem (5) are out of Main Body (23). (The Main Valve and Lower Stem are assembled as one unit.)

4. Remove Bolts (9). Separate Bonnet (14) from Superstructure.

5. Dismantle Stuffing Box Flange (7) and Gland (8). Renew Packing Set (11) if necessary, following instructions under Packing Renewal, Step 14, Page 3.

6. Clean all parts with kerosene. Use mild aluminum oxide or crocus cloth on all parts encrusted with foreign matter.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

MAINTENANCE: CONT'D (See Illustration, Fig. 1, for part numbers.)

Dismantling, Cleaning & Reassembling.

7. Examine Cylinder Liner (20) in Main Body (23). Remove if necessary and clean. If surface is scored, liner should be replaced.

8. Examine Piston Ring (22) and replace if cut.

9. Remove Bonnet (14) from Superstructure and place on Main Body (23). Assemble with two Nuts (18) 180° apart. Insert Lower Stem (5) with Main Valve (21) through bottom of Main Body (23). (Note: Seat bridge and Cylinder Liner (20) are chamfered to permit easy insertion of unit.) Exercise care in pushing valve through seat and cylinder liner so as not to mar seating surface or break piston ring. Screw valve stem up through stuffing box with a turning motion to prevent damage to packing. Apply superfine grinding compound to seating surface of Main Valve (21) and use wrench on stem flats to grind in until a fine continuous ring of contact has been established on the seating surface.

10. If necessary to replace Lower Stem (5), hold valve in a vise with lead-lined jaws to avoid damage to seating or guiding surfaces and drive out roll-pin which locks stem to valve and unscrew stem. Screw new stem into valve until it bottoms in tapped hole. Using hole in valve as a guide, redrill stem the same diameter as roll-pin and replace the roll-pin.

11. Replace Cylinder Liner (20), Bonnet Gasket (19), Bonnet (14) and Superstructure.

12. Replace Main Valve assembly screwing Lower Stem (5) up through Packing Set (11).

13. When it clears Stuffing Box Flange (7) assemble Nut (29) and Indicator Disc (4). Engage Upper Stem threads of Superstructure and screw in until Main Valve (21) contacts seat. Connect 20# air supply to Superstructure moving Main Valve (21) off seat. Screw one turn further in for tight contact. Replace Bottom Cap Gasket (24), Bottom Cap (25) and tighten Nuts (26) evenly.

14. Packing Renewal. Remove old Packing Set (11) and clean stuffing box thoroughly. With Lower Stem (5) in place, repack in following order and with openings in packing alternated.

a. 1-Braided Asbestos Ring
b. 1-Metallic Ring
c. 1-Lubricator Sleeve
d. 1-Metallic Ring
e. Sufficient soft (plastic) Rings to fill box leaving space for (f) Ring.
f. 1-Metallic Ring

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MAINTENANCE: Class D-3 (See Illustration, Fig. 2, for part numbers.)

Dismantling, Cleaning and Reassembling.

1. Shut off air supply through Control Pilot and disconnect copper tubing at Diaphragm Cover of Superstructure.

2. Remove Bonnet Nuts (26) and lift Bonnet (18) and Superstructure from Main Body (22) as a unit.

3. Loosen Stuffing Box Bolts (7) and Nut (8). Turn Equalizing Valve (6) out of upper stem using Adjusting Nut (16) on Equalizing Valve to turn it. As Equalizing Valve comes out, move Nut (5) up on threads until stem of Equalizing Valve is clear. Remove Nut (5) and Indicator Disc (4) and move Equalizing Valve (6) out of Bonnet (18) with turning motion.

4. Remove Bolts (12) and separate Bonnet (18) from Superstructure.

5. Dismantle Stuffing Box Flange (9) and Gland (10). Renew Packing Set (11) if necessary, following instructions under Packing Renewal, Step 18, Page 5.

6. Clean all parts with kerosene. Use mild aluminum oxide or crocus cloth on all parts encrusted with foreign matter.

7. Lap in Equalizing Valve (6) and seat lightly with smooth grinding compound using Gland (10) as guide.

8. Reassemble Bonnet (18) to Superstructure. Turn Equalizing Valve (6) through Packing Set (11). When it clears top of Stuffing Box Flange (9), replace Nut (5) and Indicator Disc (4).

9. Hold Nut (5) with wrench and screw Equalizing Valve (6) into Upper Stem of Superstructure threads until Equalizing Valve contacts seat face.

10. Connect 20 psi air line to Superstructure. Supply air to move Equalizing Valve (6) slightly off seat. Turn Equalizing Valve one turn further in and disconnect air line. Lock Nut (5). Superstructure is now ready for reassembly to Main Body (22) after recheck of Equalizing Valve travel.

11. Main Body. Remove Bonnet Gasket (19), Piston (20) and Cylinder Liner (21).

12. Remove Nuts (27) and take out Bottom Cap (29), Bottom Cap Gasket (28) and Main Valve Spring (25) and Main Valve (23) as a unit.

13. Clean all parts and regrind lightly Main Valve (23) and seat, with smooth grinding compound, using Cylinder Liner (21) and Piston (20) as guide.

14. Position Gasket (28), Main Valve Spring (25) and Main Valve (23) on Bottom Cap (29) and replace as unit making sure Nuts (27) are pulled down evenly to prevent misalignment. Replace Cylinder Liner (21) and Piston (20).

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

MAINTENANCE: (CONT'D)

15. Setting Equalizing Valve (6) clearance (distance between Adjusting Nut (16) and Piston (20) required to permit flow of balancing steam on Piston prior to Diaphragm Control Valve opening):

a. Place Bonnet Gasket (19) on top of reassembled Main Body (22). Place straight edge across Bonnet Gasket (19). Take scale measurement from bottom of straight edge to top of Piston (20).

b. With Equalizing Valve (6) assembled in Bonnet (18) and valve in contact with seat, take scale dimension from top of Adjusting Nut (16) to face of Bonnet (18). This measurement should be 3/16" less than the Bonnet Gasket (19) to Piston (20) dimension.

16. With Dowel Pin (31) in place in Main Body (22), to insure correct positioning of Bonnet Gasket (19) and Bonnet (18), put reassembled Bonnet and Superstructure on Main Body (22) and assemble Nuts (27) tightly.

NOTE: If Dowel Pin is lost or broken and nothing is on hand to replace, care must be taken that Gasket does not cover Port Hole and that Bonnet is assembled to Body with Body and Bonnet Port Holes in line.

17. Connect air line from Pilot to Superstructure and put Diaphragm Control Valve back into service.

18. Packing Renewal. Remove old Packing Set (11), and clean stuffing box thoroughly. With Equalizing Valve (6) in place, repack in following order and with openings in packing alternated.

a. 1-Braided Asbestos Ring
b. 1-Metallic Ring
c. 1-Lubricator Sleeve
d. 1-Metallic Ring
e. Sufficient soft (plastic) Rings to fill box leaving space for (f) Ring.
f. 1-Metallic Ring

Superstructure: (See Illustration Fig. 3, for part numbers)

1. Simple Diaphragm Replacement. Take all tension off Adjusting Spring (9) by turning Adjusting Nut (13) all way down.

Remove cover Bolts (3) and Nuts (2). Lift off Diaphragm Cover (1) and Diaphragm (4). Replace with new Diaphragm (4). Put back Diaphragm Cover (1) and Bolts (3). Tighten Nuts (2). Reset Adjusting Nut (13) for spring tension sufficient to cause Diaphragm Control Valve movement to start at 3 psi when air is admitted to Diaphragm head.

2. To check parts under Diaphragm (4) when top has been opened, proceed as follows: Loosen Nut (29) Fig. 1 or (8) Fig. 2. Hold Lower Stem or Equalizing Valve stem steady with wrench on flats. Unscrew and lift out Diaphragm Disc (5) and Upper Stem (15). Balance of Parts may be easily taken out and examined. Replace worn or damaged parts. Reassemble, tightening Nut (29) of Fig. 1 or (8) of Fig. 2.

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SECTION II, DIAPHRAGM CONTROL VALVES & PILOTS

CONTROL PILOTS

INSTALLATION: TYPES PDA & PHA.

1. Install Control Pilot in vertical position in an accessible location not more than 50' from Diaphragm Control Valve. (50' allowable with air as actuating medium.)

2. The Control Pipe must have a continuous slope without pockets to insure true pressure on Diaphragm of Control Pilot. Control pipe must pitch away from Pilot when connected below and toward Pilot when connected above Pilot.

   Note: Size of Control Pipe - For ranges up to 125 psi use 1/2" pipe; for higher ranges 3/8" pipe.
   When Control Pilot is located below point where pressure impulse is taken, the effect of the head of condensate on Control Pilot Diaphragm must be taken into consideration when making pressure adjustment or choice of pressure range.

3. Install 1/4" Bronze Strainer and Reducing Valve (Illustration Fig. 6), furnished with Control Pilot, in operating medium supply line after a 1/4" stop Valve and connect to Union in base of Control Pilot directly under gage marked "Operating Supply". Set Reducing Valve to deliver an air pressure of no less than 20 psi nor more than 22 psi. Use brass pipe or copper tubing and brass fittings throughout.

4. Connect copper tubing for regulating pressure from Union in base of Control Pilot directly under gage marked Regulating Valve to connection in Diaphragm Control Valve head.

PRINCIPLE OF OPERATION:
(Without continuous leak-off)

A. Type PDA (Refer to Illustration Fig. 5, for part numbers.)

When the controlled pressure and Adjusting Spring (14) are balanced, the Diaphragm (6) is in a level, neutral position.

A slight increase in controlled pressure depresses the Diaphragm (6), Stem (15), and Nozzle (39), and opens the Pilot Valve (41) admitting additional operating pressure to Diaphragm Control Valve to reposition it.

The operating pressure, being admitted by Pilot Valve (41), acts against the lower Nozzle Diaphragm (38) opposing the increase in controlled pressure on the Upper Diaphragm (6). The change in operating pressure is thus limited and proportional to the change in controlled pressure, preventing hunting or over-regulation.

After sufficient operating pressure is admitted to reposition the Diaphragm Control Valve the correct amount, the Pilot Valve (41) closes, sealing the operating pressure until another change in controlled pressure occurs.

With a slight decrease in controlled pressure, the Adjusting Spring (14) raises the Upper Diaphragm (6). The Nozzle Disc (28) is also moved from its seat on the Nozzle (39) and operating pressure escapes from the Diaphragm of the Control Valve.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

PRINCIPLE OF OPERATION: (Cont'd.

When the Upper Diaphragm (6) is balanced in a level, neutral position, the Pilot Valve (41) and Nozzle Disc (28) are seated, sealing operating pressure to Diaphragm Valve. There is no continuous leakage of operating pressure.

Increased sensitivity or super-sensitive control can be obtained by manually adjusting the Control Pilot for continuous leakage by turning knurled Nozzle Stop (29) downward to manually lock Pilot Valve (41) in a partly open position. The Blade Spring (31) which engages the Nozzle Stop (29) prevents the setting from being changed by vibration or jarring. Operating medium will then flow continuously through Pilot and Nozzle.

The slightest change in controlled pressure will now motivate the floating Nozzle Disc (28), regulating amount of leakage, and therefore, the operating pressure to Diaphragm Valve.

B. Type PRA

Similar to Type PDA except that a drop in controlled pressure increases rather than decreases operating pressure to regulating Valve. (Movement of Upper Diaphragm and Stem actuates a lever, reversing the action described above - See Illustration Fig. 4).

OPERATION: Type PDA & PRA

1. Close Inlet and Outlet Stop Valves.

2. Open 1/4" Stop Valve in Operating Supply Line. 1/4" Reducing Valve should deliver 20-22 psi as set when installed. Pressure will be indicated on the left hand gage of Control Pilot. If necessary, readjust by screwing in to increase and out to decrease pressure.

3. Open Stop Valve in Pilot Control Pipe and proceed as shown below for type of service.

   A. Back Pressure or Relief Service.
      1. Turn Adjusting Nut of Control Pilot until back pressure Valve closes as indicated on Valve Travel Plate.
      2. Open Inlet and Outlet Stop Valves.
      3. Turn Adjusting Nut downward until back pressure Valve just begins to open. Turn Nut upward slightly until Valve just closes. A slight increase in controlled pressure above this setting will cause Diaphragm Control Valve to open.

   B. Pressure Reduction.
      1. Open Outlet Stop Valve fully.
      2. Adjust Spring of Control Pilot so that operating pressure causes Diaphragm Control Valve to open wide, as shown by travel indicated on Valve Stem.
      3. Open Inlet Stop Valve slowly until Control Pilot takes hold and starts to close the Diaphragm Control Valve. Screw Adjusting Nut upward to increase and downward to decrease controlled pressure. After desired controlled pressure is obtained open Inlet Stop Valve wide.

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CORRECTIVE MAINTENANCE:

Dismantling:- All Types (See Illustration Fig. 4, for part numbers.)

1. By-pass Diaphragm Control Valve, if necessary. Shut 1/4" stop valve in operating supply to Control Pilot and close stop valve in control pipe.

2. Remove Cover Screw (53) and Cover (50), unscrew Bottom Plug (46), and take out Gasket (45), Pilot Valve Spring (34) and Pilot Valve (33).

3. On Type PRA lift up right hand end of Lever (17) and remove Pin (40) connecting Lever to Nozzle Disc (23). On Type PDA, remove stem clamp between stem and nozzle disc by unscrewing knurled screw on clamp.

4. To remove Diaphragm Plate (21) take out Knurled Screws (41).

5. Remove Diaphragm Plate (21) and Diaphragm (22) under same.

6. Take out Screws (42) in Flange Ring (27), remove flange ring and nozzle assembly complete.

Cleaning:

1. Wipe all parts clean, including Pilot Valve Seat (32) in body.

2. Inspect Nozzle Diaphragm (43) in nozzle assembly, making sure it is not damaged.

3. Do not use emery cloth or grind in pilot valve, as this may change important dimensions.

4. It is important that all working parts be free of foreign matter.

5. Open 1/4" stop valve in operating supply and blow out pipes and ports.

Reassembling:

1. Replace Gasket (45), Pilot Valve Spring (34) on Bottom Plug (46) and screw same into Body (44).

2. Replace nozzle assembly and Flange Ring (27), making sure even but not too tight pressure is exerted when tightening screws.

3. Open stop valve in 1/4" operating supply line.

4. To adjust sensitivity of Control Pilot, proceed as follows:

5. For normal operation adjust Control Pilot without continuous leak-off. Relieve pressure of Blade Spring (24), screw down on Nozzle Stop (26) with fingers, until you feel it barely seat on stem of pilot valve. Lock with blade spring.

6. For supersensitive control, adjust Control Pilot for continuous leak-off. Slowly screw down further on nozzle stop until operating pressure flows through nozzle (31). Place finger lightly over nozzle (do not press) stopping flow and observe pressure build-up on right hand gage. Adjust nozzle stop until this pressure build-up reaches 3-5 psi in 30 seconds. Lock with blade spring.

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[redacted]LIE DIAPHRAGM CONTROL VALVES, Etc.

CORRECTIVE MAINTENANCE: (Cont'd.)

7. Replace Diaphragm (22) for nozzle disc. To test Control Pilot and regulating valve for quick response, build-up and release pressure to top of Diaphragm Control Valve by pressing down on center of Nozzle Disc (23) until right hand gage reads 20 lbs. Then release slowly and this gage should go back to zero.

8. Replace Diaphragm Plate (21) and Knurled Screws (41).

9. Type PRA, . - replace Pin (40), connecting Lever (17) and Nozzle Disc (23).

   Type PDA, . - replace stem clamp between stem and nozzle disc.

Replacing Upper Diaphragm (Refer to Illustration Fig. 4, for part numbers.)

1. Remove Adjusting Spring (9) tension by screwing Adjusting Nut (14) downward.

2. Remove Diaphragm Bolts (2) and Cover (3). Clean Cover.

3. For PDA Pilots (Illustration 5), unscrew stem clamp Screw (23) and remove Stem Clamp (24) from Stem (15) (Do not disturb Pin (47).

4. Lift diaphragm assembly from base as a unit. Hold Diaphragm Disc Screw (48) rigidly and remove Diaphragm Nut (1), Washer (4) and Diaphragm (5). Renew diaphragm. Reassemble washer and nut and tighten. Replace diaphragm assembly on base, making sure Diaphragm (5) is centered. Reassemble cover and bolts and tighten.

5. Replace stem clamp and screw for Type PDA Pilots and reset adjusting spring to original setting.

Stem and Lever

CONTROL PILOT STEM AND LEVER ADJUSTMENTS ARE FACTORY SET FOR PROPER OPERATION AND MAXIMUM SENSITIVITY AND SHOULD NOT BE DISTURBED UNLESS:

a) - It is evident that original setting has been interfered with in the field.
b) - Replacement of worn parts necessitates readjustment.
c) - Other than standard operation is required due to local conditions.

If readjustment is found to be necessary, proceed as follows:

1) - For (a) and (b) follow normal stem or lever adjustment instructions shown on next page.
2) - For (c) thoroughly analyze condition encountered and on basis of response required from regulator by load conditions. Determine whether faster or slower loading or unloading of Diaphragm Operating Valve will be of advantage.

Loading characteristics of Control Pilots can be adapted to some extent to overcome non-standard operating conditions by repositioning the adjusting pin in Direct Acting Pilots and Lever Pivot Screw in reverse.

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CORRECTIVE MAINTENANCE: (Cont'd.)

Type PDA Pilots

Moving adjusting pin further out of stem clamp raises upper diaphragm closer to its upper stop and provides faster loading with consequent slower unloading.

Reversely moving pin further into stem clamp has the opposite effect.

Type PRA Pilots

Turning Pivot Screw further into lever provides faster unloading with consequent slower loading.

Reversely moving pivot screw further out of lever has opposite effect.

Any movement of stem or pivot screw should be made slowly in small increments and only to a point where stabilization is obtained.

Always recheck control pilot to make sure it will operate through its full stroke either way with a reasonable change in controlled pressure.

STEM AND LEVER ADJUSTMENTS:

1. All Control Pilots.

   Set upper diaphragm against its top limit stop by compressing adjusting spring. (Relieve pressure on top side of diaphragm, if necessary.)

2. Type PDA Pilots.

   Supply constant 20 psi operating pressure to pilot. Loosen set screw on side of stem clamp and turn adjusting pin until operating pressure just begins to show on right hand "Regulating Valve Gauge."

   Then screw adjusting pin upward (into stem clamp) 3/4 of a turn.

3. Type PRA Pilots.

   Supply 20 psi operating pressure to pilot. Loosen set screw in lever and turn 3/8" lever pivot screw until operating pressure just starts to drop from 20 psi on right hand gauge.

   Then turn lever pivot screw downward (out of lever) 3/4 of a turn.

4. Lock set screw. Pilot will now give maximum sensitivity.

   Pilot can be set for either continuous or non-continuous leakoff when making this adjustment.

   NOTE: When making stem, lever or leak-off adjustments, it is necessary to have air line to regulating valve connected or regulator air line connection at pilot blanked off. Otherwise proper setting cannot be made. Where blanked off fitting is used, pressure build up will be a little faster than 3 to 5 psi in 30 seconds mentioned in leak-off setting [illegible]

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CORRECTIVE MAINTENANCE: (Cont'd.)

To Decrease Sensitivity of Constant Pressure Pilots only.

Move upper diaphragm away from its mean position by changing the stem length adjustment in small increments of about 1/8 turn.

For PDA Pilots - In reducing service, move diaphragm up by increasing the stem length and for relief service, move diaphragm down by decreasing stem length.

For PRA Pilots - In reducing service, move diaphragm down by decreasing stem length and for relief service, move diaphragm up by increasing stem length.

After making adjustment, retest pilot and be sure it will change the operating pressure 0-20 psi or vice versa with a reasonable change in controlled pressure.

PREVENTATIVE MAINTENANCE:

TROUBLE ANALYSIS

A. Air leaks Pilot to Controller.

1. When testing Control Pilot & Controller for air leaks, load air line as shown in Instruction #7 Reassembling. If pressure on supply gauge is 20-22 psi and pressure on regulating gauge fails to build up to 20 psi, leakage is indicated in one or more of the following places.

   a - In fittings or tubing from Pilot to Regulator.

   b - In diaphragm head of regulator due to loose bolts or leak in diaphragm.

   c - At flange ring due to screws not being sufficiently tight.

   d - Between Pilot Valve Body and Base due to dry or damaged gasket or body screws being loose.

   Replace parts or correct as indicated by trouble.

2. Controlled pressure leaks through underside of diaphragm head indicate a damaged diaphragm or loose diaphragm disc nut.

   Leaks through side between base and cover indicate loose bolts, damaged diaphragm, base or cover.

B. Auxiliary Pressure - Operating Supply.

1. Control Pilot operating supply pressure must be kept at 20-22 psi. This pressure should be kept as constant as possible.

   Pressure ahead of the AW Reducing Valve which controls pressure to Pilot should never be less than 25 psi, since pressure drop across AW is 5 psi.

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PREVENTATIVE MAINTENANCE: (Cont'd)

When inlet pressure to AV drops below minimum required supply pressure to controller, diaphragm is effected with consequent uncalled for valve movement.

C. Control Pipes - (Impulse Signal Media)

Interference with Impulse Action

Correct operation of a control system depends upon proper transmission of impulse signals. Transmission media must be as specified and kept in good repair. During maintenance periods or when checking trouble, steps should be taken to insure that they are clear.

Accumulation of scale or sediment to a point where restriction or blockage occurs will cause erratic operation of the Control Pilot and System.

1. Partially closed control pipes slow up signal transmission with resulting deviations from desired valves.

2. Closed control pipes will cause Valves to remain in a static condition in accord with the pressure or lack of pressure existing on the upper diaphragm at time of blockage.

   (a) Direct Acting Control Pilots (PDA) will remain open when pressure is trapped on Diaphragm and closed when blockage occurs with no pressure on Diaphragm.

   (b) Reverse Acting Pilots (PRA) will remain closed when pressure is trapped on Diaphragm and open when blockage occurs with no pressure.

   The effect on the system of any condition listed above will depend upon whether Pressure Controller uses "air to close" or "air to open".

   Examples:

   (a) Direct Acting Pilot - Pressure trapped on Diaphragm - Air to Close Controller - Controller will not open.

   (b) Direct Acting Pilot - Pressure Trapped on Pilot Diaphragm - Air to Open Regulator - Regulator will remain open.

3. It is well to note here that Control Pipes must have a continuous slope without pockets to insure true pressure on diaphragm of Control Pilot. They must pitch away from the Control Pilot when connected below the Pilot and toward the Control Pilot when connected above the Pilot. If found installed otherwise, immediate correction should be made.

D. Where Control Pilots are installed below the point where pressure impulse is taken, consideration must be given to the Hydrostatic pressure on the Pilot Diaphragm, due to the leg of condensate in control pipe. (Static Head Pressure of Column of Water 1 Psi per 28".)

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PREVENTATIVE MAINTENANCE: (Cont'd)

Pressure Gauges installed in the controlled pressure line, at the Pilot diaphragm and on a Boiler Room Control Board will show different pressures if they are not on the same level. Control Pilot setting should be made in accordance with pressure shown on controlled line gauge since the others will record pressure plus condensate head.

Hunting or Cycling

Hunting or cycling may be caused by one of the following factors.

1. Interference with Control Pilot setting.

   Correction - accommodate sensitivity of Control Pilot to system by sensitivity readjustments as shown under Reassembling #5 and #6 and stem readjustment as required.

2. Pressure Setting - Multiple Unit Operation.

   Where several Control Pilots and Pressure Controllers are working in conjunction to maintain a set pressure in a common line (viz., Exhaust Main, Process Unloading, Make-Up, etc.) it is necessary to keep a differential of several pounds between the starting pressures of the various Pilots in order to prevent hunting due to regulator response to small deviations in controlled pressure.

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GENERAL DATA

P.O. QD-810-1084-X-4540 Item No.	IV	V	VI	VII
Qty per Vessel	1	1	1	1
Size & Class	1" LS-4X	1/2" LS-4X	2" LS-4X	2-1/2" LS-4X
Flange Std, ASA	600#	600#	600#	150#
Material	C. Steel	C. Steel	C. Steel	C. Steel
Inlet Press., psi Normal	580	580	580	100
Maximum	620	620	620	150
Inlet Temp., ° F Normal	510	510	510	400
Maximum	540	540	540	470
Reduced Pressure, psi	180	180	100	35
Steam Flow, Lb./Hr.	0-2600	0-1300	0-13,350	0-4250
Adj. Range, psi Minimum	125-225	125-225	50-150	20-50
Service, Steam System	180# Aux.	180# Air Ejector	100# Aux.	35# Aux.
Net Wt. per Vessel, Lb.	37.	33.5	74.	105.

PLAN LIST

Master Plan - Leslie No. BuShips No.	10749N	10771N	10731N	10766N
Cert. Data Plan - Leslie No. BuShips No.	10989N	10990N	10991N	10992N
* Illustration	Fig. 7	Fig. 7	Fig. 7	Fig. 7

* The text material and illustration are shown for the 1/2" LS-4X Valve only. However, the text applies to all sizes and Classes, the difference being only a few part numbers.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

LIST OF ON BOARD REPAIR PARTS

P.O. ITEM NO.	SIZE & CLASS	PART NAME	QTY. EACH ITEM	LESLIE CO. SERVICE PART NO.	ST'D. NAVY STOCK NO.
IV A	1" LS-4X	Adjusting Spring	1	4987	H45LES-60118
		Controlling Valve Spring	1	10756	H45LES-60047
		Main Valve Spring	1	9464	H45LES-60117
		Diaphragm	1	10425	H45LES-60012
		Top Cap Gasket	1	13640	H45LES-60129
		Piston Rings	2	3355	H45LES-60119
		Bottom Cap Gasket	1	11345	H45LES-60218
		Main Valve	1	11190	H45LES-60073
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
16		Socket Wrench	1	9036	H45LES-60106
V A	1/2" LS-4X	Adjusting Spring	1	4987	H45LES-60118
		Controlling Valve Spring	1	10756	H45LES-60047
		Main Valve Spring	1	9464	H45LES-60117
		Diaphragm	1	10425	H45LES-60012
		Top Cap Gasket	1	13640	H45LES-60129
		Piston Rings	2	3355	H45LES-60119
		Bottom Cap Gasket	1	11345	H45LES-60218
		Main Valve	1	11123	H45LES-60062
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
		Controlling Valve Seat Wrench	1	9036	H45LES-60106
VI A	2" LS-4X	Adjusting Spring	1	4987	H45LES-60118
		Controlling Valve Spring	1	10756	H45LES-60047
		Main Valve Spring	1	9252	H45LES-60146
		Diaphragm	1	10425	H45LES-60012
		Top Cap Gasket	1	13643	H45LES-60131
		Piston Rings	2	3361	H45LES-60137
		Bottom Cap Gasket	1	11348	H45LES-60059
		Main Valve	1	11124	H45LES-60065
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
		Controlling Valve Seat Wrench	1	9036	H45LES-60106
VII A	2-1/2" LS-4X	Adjusting Spring	1	4987	H45LES-60118
		Controlling Valve Spring	1	10756	H45LES-60047
		Main Valve Spring	1	9087	H45LES-60145
		Diaphragm	1	10425	H45LES-60012
		Top Cap Gasket	1	16254	H45LES-60508
		Piston Rings	2	3368	H45LES-60105
		Bottom Cap Gasket	1	11349	H45LES-60145
		Main Valve	1	27757	
		Controlling Valve Seat	1	21906	845LES-60362
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat Wrench	1	9036	H45LES-60106

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PRESSURE REDUCING VALVES

DESCRIPTION:

Leslie Pressure Reducing Valves are single seated, spring loaded, internal pilot, piston operated for steam service.

PRINCIPLE OF OPERATION: (Refer to Illustration, Fig. 7 for Part Numbers.)

The Adjusting Screw (2) compresses Adjusting Spring (6) against the metallic Diaphragm (8) opening Controlling Valve (10). The Controlling Valve (10) admits high pressure from inlet body port to top of Piston (27) opening Main Valve (18) and admitting reduced pressure to outlet piping. The reduced pressure acting through an external control pipe on the under side of the Diaphragm (8) balances the compression of the Spring (6). This action throttles the Controlling Valve (10) and controls the reduced pressure at the set value. Any load change reacts with a pressure change immediately on Diaphragm (8), instantly repositioning the Main Valve (18) and maintaining constant reduced pressure setting. Only a change in reduced pressure affects valve action.

INSTALLATION:

Do not use lead or cement when making up joints.

1. Protect Reducing Valve with Leslie Self-Cleaning Strainer.
2. Install stop valves and gages to control setting and operation of Reducing Valve and by-pass around same.
3. Provide length of straight pipe on both sides of Reducing Valve to prevent turbulence.
4. Blow out pipe lines thoroughly before installing Reducing Valve.
5. Place Reducing Valve upright in horizontal pipe line with arrow (on side of Body) in direction of steam flow.
6. Insulate all pipe before and after Reducing Valve to minimize condensation.

OPERATION:

1. Close inlet and outlet stop valves.
2. Release compression on Adjusting Spring (6).
3. Slowly open the inlet stop valve wide.
4. Dispose of condensation, dirt, etc, by opening Strainer Blow-off Valve.
5. Crack outlet stop valve to permit slight flow when setting Reducing Valve.
6. Slowly screw down on Adjusting Screw (2), until desired pressure is shown on gage on outlet side.
7. Slowly open outlet stop valve wide.
8. To change reduced pressure setting, turn Adjusting Screw (2) downward to increase and upward to decrease pressure.
9. To turn steam off, close outlet stop valve first, then inlet stop valve.
10. To turn steam on, (with Reducing Valve set) keep outlet stop valve closed until inlet stop valve is opened wide.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

MAINTENANCE:

If Reducing Valve does not then operate properly, it should be opened and cleaned as follows:

1. Release compression on Adjusting Spring (6).
2. Remove Adjusting Spring Case (5) by removing Bolts (33).
3. Take out Diaphragm (8).
4. Unscrew Controlling Valve Seat (9) with Socket Wrench provided for this purpose.
5. Remove Controlling Valve (10) and Spring (25).
6. Remove Top Cap (13), Piston (27) and Cylinder Liner (16) by unscrewing Nuts (12).
7. Remove Main Valve (18), Main Valve Spring (20) and Bottom Cap (21) by unscrewing Nuts (23).

CLEANING:

1. Clean all parts with kerosene.
2. See that Main Valve (18) and Controlling Valve (10) move freely in their guides and seat properly.
3. Piston Rings (15) must be perfectly free in grooves.
4. Regrind Main Valve (18) with Piston (27) in Cylinder Liner (16) to insure perfect centering.
5. Have all working parts moving freely.

ASSEMBLING:

1. Do not use graphite or compound on joints. No lubricant is required on any moving parts.
2. Place Main Valve (18), Spring (20) and Gasket (22) in position on Bottom Cap (21) and tighten to Main Body (19) with Nuts (23).
3. Depress Piston (27) in Cylinder Liner (16) to be sure movement is smooth and free.
4. Top of Cylinder Liner (16) must be flush with top flange of Main Body (19).
5. Bolt Top Cap (13) with Top Cap Gasket (14) to Main Body (19).
6. Assemble Controlling Valve (10), Controlling Valve Spring (25) and Controlling Valve Seat (9) in Top Cap (13). For reliable service Controlling Valve (10) must seat tightly. To do this, stem of valve must not project above Diaphragm Seat. Correct clearance is .001" to .002" below Diaphragm Seat in Top Cap.
7. Replace Diaphragm (8), Adjusting Spring (6), Top and Bottom Spring Seats (4) and (7) and Adjusting Spring Case (5).
8. Make all joints steam tight.

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SECTION IV TEMPERATURE CONTROLLERS

GENERAL DATA

P.O. QD-810-1084-X-4540, Item No.	VIII	IX	X	XI
Qty per Vessel	1	1	1	1
Size & Class	2" LTC50-3K	1-1/2" TM	3/4" LTCOX	1-1/4" LTCOX
Flange St'd.	150# ASA	150# MSS	150# MSS	150# MSS
Material	C. Steel	C. Bronze	C. Bronze	C. Bronze
Heated Liquid Temperature Setting Range ° F	175-225	80-180	80-180	150-250
Pressure, psig	60	60	60	350
Inlet Steam Pressure, psig	100	35	100	100
Maximum Pressure Drop, psig	20	15	15	20
Steam Flow, Lb./Hr.	0-2500	0-1610	0-300	0-800
Inlet Steam Temp. ° F Normal	400	300	350	400
Service:	Hot Water Heater for Cargo Hold Heating System	Storage Type Hot Water Heater for Wash Water	Storage Type Hot Water Heater for Laundry	Fuel Oil Heaters
Net Wt. per Vessel, Lb.	111.	81.	66.	76.

Plan List

Temperature Reg.	Leslie No.	10508N	11001N	10494N	10917N
	BuShips No.	H-3, 278,568	- -	H-3, 278,564	
Superstructure	Leslie No.	10336N	None	10336N	10336N
	BuShips No.	H-3, 278,551	- -	H-3, 278,551	H-3, 278,551
Cert. Data Plan	Leslie No.	10993N	10994N	10995N	10996N
	BuShips No.				
* Illustrations		Fig. 8 & 9	Fig. 10	Fig. 8 & 9	Fig. 8 & 9

* The text material and illustration for Items VIII, X & XI are shown for Item VIII only. However, the text applies to Items X & XI also, the difference being a few part numbers.

LESLIE DIAPHRAGM CONTROL VALVES, Etc.

LIST OF ON BOARD REPAIR PARTS

P. O. ITEM NO.	SIZE & CLASS	PART NAME	QTY. EACH ITEM	LESLIE CO. SERVICE PART NO.	ST'D NAVY STOCK NO.
VIII A	2" ITC80-3X	Adjusting Spring	1	11755	H45LES-60093
		Main Valve Spring	1	9252	H45LES-60146
		Guide Spring	1	11669	H45LES-60089
		Limit Spring	1	11084	H45LES-60058
		Diaphragm	2	9120	H45LES-60275
		Piston Rings	2	3361	H45LES-60137
		Thermo-Element	1	32884	
		Main Valve	1	11124	H45LES-60065
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
IX A	1-1/2" TM	Main Valve Spring	1	31305	
		Diaphragm	2	31314	
		Main Valve	1	13285	H45LES-60291
		Seat Ring	1	15820	
		Pilot Spring	1	16767	H45LES-60472
		Yielding Spring, Outer	1	13356	H45LES-60307
		Yielding Spring, Inner	1	13357	H45LES-60308
		Stem Spring	1	13358	H45LES-60309
		Top Cap Gasket	1	23815	
		Thermo-Element	1	16023	
16		Seat Ring Wrench	1	9554	H45LES-60123
X A	3/4" ITCOX	Adjusting Spring	1	11755	H45LES-60093
		Diaphragm	2	9120	H45LES-60200
		Limit Spring	1	11084	H45LES-60058
		Controlling Valve Spring	1	4930	H45LES-60116
		Main Valve Spring	1	9464	H45LES-60117
		Guide Spring	1	11669	H45LES-60089
		Top Cap Gasket	1	4960	H45LES-60160
		Bottom Cap Gasket	1	3500	H45LES-60138
		Piston Ring	1	3355	H45LES-60119
		Thermo-Element	1	32885	
		Main Valve	1	13282	H45LES-60184
		Seat Ring	1	9821	H45LES-60154
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	9435	H45LES-60147
16		Seat Ring Wrench	1	9551	H45LES-60209
XI A	1-1/4" LTCO-X	Limit Spring	1	11084	H45LES-60058
		Controlling Valve Spring	1	4930	H45LES-60116
		Main Valve Spring	1	10201	H45LES-60098
		Guide Spring	1	11669	H45LES-60089
		Adjusting Spring	1	11755	H45LES-60093
		Top Cap Gasket	1	4945	H45LES-60427
		Piston Ring	1	3358	H45LES-60135
		Bottom Cap Gasket	1	3499	H45LES-60316
		Thermo-Element	1	33489	
		Main Valve	1	13284	H45LES-60388
		Seat Ring	1	9544	H45LES-60205
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	9433	H45LES-60147
16		Seat Ring Wrench	1	9553	H45LES-60152
		Socket Wrench	4	9036	H45LES-60106

TEMPERATURE REGULATORS

DESCRIPTION: (Class LTCSO-3X & LTCO-3X)

Leslie Temperature Regulating Valve acts as its own steam pressure reducing valve and has a means of adjusting both the temperature and steam pressure. It is a single seated, spring loaded, internal pilot, piston operated valve for steam service. The purpose of the valve is for maintaining constant fluid temperature by controlling steam flow and pressure to the heater in response to temperature changes felt by thermostatic element in the fluid discharge of the heater.

PRINCIPLE OF OPERATION: Class LTCSO-3X & LTCO-3X
(See Illustration, Fig. 8, for part numbers.)
*(See Illustration, Fig. 9, for part numbers.)

The vapor filled Thermostatic Assembly (18*) acting on the upper diaphragm of the assembly and Lever (29*) opposes a pressure Limit Spring (5*) and determines the outlet steam pressure delivered to the heater. Manual compression of the Limit Spring (5*) determines the maximum outlet steam pressure and opens the Controlling Valve (20) admitting high pressure steam from inlet port of Main Body (9) to top of Piston (7) opening Main Valve (10). The outlet steam pressure acting under steam Diaphragm (18) balances compression of Limit Spring (5*) throttling Controlling Valve (20) and limiting the maximum outlet steam pressure.

The temperature at which the vapor pressure starts to oppose the Limit Spring (5*) and decreases outlet steam pressure is set on the temperature Adjusting Spring (21*). This spring opposes the vapor pressure on the large upper diaphragm and by means of this spring the temperature at which all steam to the heater will be shut off can be accurately set. A temperature drop of 1° F. on element bulb of Thermostatic Assembly (18*) reduces the vapor pressure, allowing Limit Spring (5*), to open Controlling Valve (20) and deliver an increased steam pressure to the heater.

The steam pressure to the heater is always proportioned to the change in temperature at the bulb and this pressure is automatically maintained regardless of the volume of steam used by the heater or variations in supply pressure.

INSTALLATION: All Classes

1. Blow out steam lines before installation to protect regulator from grit and scale.
2. Place regulator upright in horizontal piping with arrow (on side of body) in direction of steam flow.
3. Install thermostatic element bulb in fluid line. Handle flexible tubing carefully. Be sure it is well protected to prevent injury during installation and operation. Never unscrew tubing connection in diaphragm assembly. Any leaking of the volatile liquid in the thermostatic element will render it inoperative. Protect bulb with suitable guard wherever liable to damage in any way.

ADJUSTMENT AND OPERATION: Classes LTCSO-3X & LTCO-3X)
(See Illustration, Fig. 8, for part numbers.)
*(See Illustration, Fig. 9, for part numbers.)

1. Before turning steam on supply line to regulator, close stop valves on inlet and outlet side of regulator, bypass valve and steam line valves to individual heaters.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

ADJUSTMENT AND OPERATION: (CONT'D)

2. Slowly turn steam on, draining condensation through drain line upstream of inlet valve.
3. Remove Limit Screw Cap (1*).
4. Relieve compression on Limit Spring (5*).
5. Slowly open the inlet stop valve wide.
6. Screw temperature Adjusting Nut (26*) upward (with rod provided for this purpose) until Lever (29*) is free on its pivots.
7. Open outlet stop valve wide and crack steam line valve to heater in use.
8. Turn Limit Screw (2*) downward and set reduced pressure at MINIMUM pressure required to give the desired temperature under MAXIMUM load conditions. NOTE: Lever (29*) must remain free during pressure limit adjustment.
9. Lock Nut (3*) and replace Limit Screw cap (1*).
10. Slowly open wide the steam line valve to heater.
11. Screw Adjusting Nut (26*) downward gradually until regulator shuts off steam flow at temperature desired.
12. To increase (decrease) temperature setting, gradually turn Adjusting Nut (26*) upward (downward) until regulator maintains desired temperature. NOTE: All adjustments for temperature are now made on Adjusting Nut (26*).
13. Record position of Adjusting Nut (26*) on Graduation Plate (36*) for case in duplicate setting.
14. To turn steam off first close outlet stop valve.
15. To turn steam on (with regulator set) keep outlet stop valve closed until inlet stop valve is opened wide.

MAINTENANCE:

To eliminate sluggishness caused by dirt or other local conditions the temperature regulator may be dismantled and cleaned without removal from pipe line.

DISMANTLING: (See Illustration, Fig. 6, for part numbers.)
*(See Illustration, Fig. 9, for part numbers.)

Remove Spring Case (6*) and Diaphragm Cover (11*). Take out Diaphragm (18) unscrew Controlling Valve Seat (19) with Socket Wrench (17*) and remove Controlling Valve (20) and Controlling Valve Spring (21). Remove Top Cap (4) and lift out Piston (7) and Cylinder Liner (6). Remove Bottom Cap (12) Main Valve (10) and Main Valve Spring (11) by loosening and removing Nuts (14).

CLEANING:

After dismantling, clean all parts with kerosene and check as follows:

1. Examine the main and controlling valves for proper seating and free movement in the guides.
2. Make certain piston rings are free in their grooves and expand into the cylinder liner.
3. Regrind valve seat surfaces if necessary with fine grinding compound and clean before assembling. When regrinding seat of main valve, allow piston to remain in cylinder liner to insure perfect centering.
4. Inspect all other working parts for freedom of movement.

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ASSEMBLING: (See Illustration, Fig. 8, for part numbers.)
*(See Illustration, Fig. 9, for part numbers.)

Graphite, Lubricant or Compound should not be used on joints or moving parts.

Place the Main Valve (10), Main Valve Spring (11) and Bottom Cap Gasket (13) in place on Bottom Cap (12) and bolt to the Main Body (9). Replace Cylinder Liner (6) and Piston (7) in cylinder bore. Depress Piston in Cylinder Liner. Be sure movement is smooth and free. Top of Cylinder Liner must be flush with top flange of Main Body. Replace Top Cap (4) and Top Cap Gasket (5), then assemble Controlling Valve (20), Controlling Valve Spring (21) and Controlling Valve Seat (19).

When tightening Controlling Valve Seat (19) with Socket Wrench (17*), tap wrench to insure perfectly steam tight joint. Stem of Controlling Valve must be .001" to .002" below diaphragm seat for proper operation. Make all joints steam tight.

Replace Diaphragm (18) and all parts above it. Adjust as instructed in previous paragraphs.

ADJUSTMENT WHEN INSTALLING NEW THERMOSTATIC ASSEMBLY:

1. Install new thermostatic assembly (18*) and new diaphragm (18) and adjust as follows:
2. Screw Adjusting Nut (26*) up to #10 on Graduation Plate (36*).
3. Remove Limit Spring Case Screws (32*), Spring Case (6*), Limit Spring (5*) and Limit Spring Seat, Top (4*).
4. Press down on front of Lever (29*) so that it is firmly held in contact with Pivots (32*) when Set Screw (31*) is held against Rod (22*).
5. Hold Limit Spring Seat, Bottom (7*) in place by pressing lightly with finger on same sufficient only to feel fit of .020" feeler gage but not enough to move Controlling Valve (20).
6. Gap of .020" between Limit Spring Seat, Bottom (7*) and Lever (29*) is adjusted by means of Set Screw (31*).
7. Lock Set Screw (31*) with Lock Screw (30*). Replace Limit Spring Seat, Top (4*), Limit Spring (5*), Spring Case (6*) and Limit Spring Case Screws (32*) and set regulator for correct limit pressure and temperature in accordance with previous instructions on adjustment.

DESCRIPTION: (Class TM)

Leslie Pilot Operated Temperature Regulator is of single seated construction giving positive dead-end shut-off. Valve closes with inlet pressure. The diaphragm operated main valve has packless construction assuring positive valve operation. The thermostatic element is easily replaced without removing regulator from line and the single ring Teflon cup packing provides a positive, long lasting, low friction stem seal.

PRINCIPLE OF OPERATION: (Class TM) (See Illustration, Fig. 10, for part numbers.)

Pressure on the lower side of Diaphragm (39), operating Main Valve (29), is controlled by the double acting, lever type pilot which is mounted on a knife edge and actuated by the liquid filled Thermostatic Element (1). The pilot simultaneously controls

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PRINCIPLE OF OPERATION: (Class TM)(Cont'd)

both the supply of operating pressure from the regulator inlet and the discharge of operating pressure to the regulator outlet. The resultant pressure in the pilot chamber is transmitted to the lower side of the Diaphragm (39) through copper tubing. The metal Diaphragm (39) permits direct contact with live steam.

INSTALLATION:

Same as Installation for Classes LTCSO-3X & LTCO-3X shown on Page 21.

OPERATION: (Class TM) (See Illustration, Fig. 10, for part numbers.)

1. Slowly open inlet stop valve and dispose of dirt, etc. by opening strainer blow-off valve.
2. Screw Adjusting Sleeve (2) downward all the way, opening regulator fully. Open outlet stop valve supplying cooling water to equipment.
3. When desired temperature is nearly reached back off Adjusting Sleeve (2) until regulator throttles and closes at the desired temperature.
4. Check controlled temperature after a period of time and gradually turn Adjusting Sleeve (2) upward to increase or downward to decrease temperature if neessary.

MAINTENANCE:

Repacking Pilot or Valve Stem.

Worn packing should be replaced as follows:

1. Remove Adjusting Sleeve (2), hold Pilot Stem (17) by placing pin in hole and remove Stem Screw (4), freeing springs and seats.
2. Remove Bonnet (11) from Housing (19) and clean stuffing box. Clean Stem (17) with fine crocus cloth.
3. Replace Pilot Stem (17) in Bonnet (11) and assemble dowel over stem. Slide Washer, Spacer, Cup Packing and Gland Ring (13) over Stem into box.
4. Replace Packing Gland (12) and tighten only as much as required to obtain a seal. Put Bonnet (11) back on Housing (19) and tighten.
5. Replace seats and springs in order with short Spring (9) on bottom and two long ones (5) & (6) on top.
6. Hold Pilot Stem (17) by placing pin in hole. Place Top Spring Seat (3) and Stem Screw (4) in position on springs. Press seat down tightly against springs compressing them until screw can be easily run into stem. Tighten.
7. Reassemble Adjusting Sleeve (2) on Bonnet (11) and readjust for temperature.
8. When steam or water has been turned off, recheck tightness of Packing Gland (12).

DISMANTLING:

1. Remove Adjusting Sleeve (2) and Element (1).
2. Remove all Copper Tubing (55).
3. Unscrew Bonnet (11) from Pilot Housing (19) removing Gasket (14).
4. Remove Pilot Housing (19) from Pilot Flange (51) (remove top row Allen Head Screws (18), and remove Gasket (20).

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DISMANTLING: (CONT'D)

5. Remove Pilot Lever (48), clean seating surfaces and reassemble.
6. Remove Pilot Flange (51) and Gasket (21) from Top Cap (24) (lower row Allen Head Screws (18).
7. Remove Top Cap (24) from Body (27).
8. Remove Gasket (25), Main Valve (29), and Main Valve Spring (26).
9. Remove Diaphragm Base Assembly, and Seat Ring (28), if necessary. Use special wrench for seat ring.
10. Remove lower Bolts (34) and Diaphragm Cover (40) from Diaphragm Base (36), also Gaskets (38), Diaphragm (39) and Diaphragm Disc (37) with Stem (32).
11. When inspecting Diaphragm (39) only remove Diaphragm Cover (40) very carefully so as not to damage Diaphragm (39) or Gaskets (38).

CLEANING:

1. Clean all parts with kerosene or solvent, make sure lever moves freely and seats tight.
2. If main valve or seat ring surfaces are scored or cut, replace and grind, using fine grinding compound and guide lower end of main valve with bottom cap in position. Remove all traces of compound.

ASSEMBLING:

1. Replace in order, Main Valve (29), Main Valve Spring (26), Top Cap Gasket (25), Top Cap (24) and Bolts (22). Tighten with Nuts (23).
2. Install Pilot Flange Gasket (21) and be sure Dowel Pin (53) is in hole marked cooling service.
3. Add Pilot Flange (51), Housing Gasket (20), Pilot Housing (19) and Screws (18) and tighten.
4. Assemble Diaphragm Base (36) with Bottom Cap Gasket (31) on Main Body (27). Insert Stem (32) with attached Diaphragm Disc (37). Adjust height of Diaphragm Disc (37) to 5/64 - 7/64" above diaphragm face of Diaphragm Base (36).
5. Replace Gasket (38), Diaphragm (39), Diaphragm Cover (40) and Bolts (34) and tighten with Nuts (35).
6. Replace Copper Tubing (55), Adjusting Sleeve (2) and Element (1).

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SECTION V PUMP PRESSURE REGULATORS

GENERAL DATA

F.O. QD-810-1084-X-4540 Item No.	XII	XIII	XIV
Qty per Vessel	2	1	1
Size	2-1/2"	1-1/2"	2"
Class	CTESM-X	PLSM-X	PTESM-X
Flange Std, ASA	600#	600#	600#
Material	C. Steel	C. Steel	C. Steel
Inlet Press., psig Normal Maximum	580 620	175 215	580 620
Inlet Temp. ° F Maximum	510	470	510
Range of Adj. psig	600-800	5-20	50-200
Normal Steam Flow, lb./hr.	6100	1350	4730
Pressure Drop thru. Gov. psig	30	30	30
Service:	Main Feed Pumps	Lube Oil (Em.Service) Pump	Fire Pump
Net Wt. per Vessel, lb.	280.	86.	102.

Plan List

Pump Gov. Master Plan	Leslie No. BuShips No.	10834N	10962N	10953N
Cert. Data Plan	Leslie No. BuShips No.	10997N	10998N	10999N
* Illustrations		Fig. 11	Fig. 11	Fig. 11

* The text material and illustration are shown for Item XII only. However, the text applies to all sizes and Classes.

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LESLIE DIAPHRAGM CONTROL VALVES, Etc.

LIST OF ON BOARD REPAIR PARTS

P.O. ITEM NO.	SIZE & CLASS	PART NAME	QTY. EACH ITEM	LESLIE CO. SERVICE PART NO.	ST'D NAVY STOCK NO.
XII A	2-1/2" CTESM-X	Main Valve Spring	1	10821	H45LES-60055
		Controlling Valve Spring	1	10756	H45LES-60047
		Adjusting Spring	1	12857	H45LES-60103
		Piston Rings	2	3362	H45LES-60105
		Diaphragm	3	10425	H45LES-60012
		Top Cap Gasket	1	16254	H45LES-60508
		Bottom Cap Gasket	1	11349	H45LES-60342
		Bottom Cap Packing	1	14462	H45LES-60278
		Needle Valve Complete	1	10795	H45LES-60052
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
		Connector Packing	1	13194	H45LES-60166
XIII A	1-1/2" PLSM-X	Main Valve Spring	1	10741	H45LES-60045
		Controlling Valve Spring	1	10756	H45LES-60047
		Adjusting Spring	1	14646	H45LES-60160
		Piston Rings	2	3359	H45LES-60136
		Diaphragm	2	10425	H45LES-60012
		Diaphragm, Large	1	14090	H45LES-60155
		Top Cap Gasket	1	13642	H45LES-60288
		Bottom Cap Gasket	1	11347	H45LES-60289
		Bottom Cap Packing	1	14461	H45LES-60172
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
		Connector Packing	1	13194	H45LES-60166
XIV A	2" PTESM-X	Main Valve Spring	1	10741	H45LES-60045
		Controlling Valve Spring	1	10756	H45LES-60047
		Adjusting Spring	1	4987	H45LES-60118
		Piston Rings	2	3361	H45LES-60137
		Diaphragm	3	10425	H45LES-60012
		Top Cap Gasket	1	13643	H45LES-60131
		Bottom Cap Gasket	1	11348	H45LES-60059
		Bottom Cap Packing	1	14461	H45LES-60172
		Needle Valve Complete	1	10795	H45LES-60052
		Controlling Valve	1	4938	H45LES-60143
		Controlling Valve Seat	1	21906	H45LES-60362
		Connector Packing	1	13194	H45LES-60166
16		Socket Wrench	3	9036	H45LES-60106

PUMP PRESSURE REGULATORS

DESCRIPTION:

Leslie Pump Governors are self-contained, internal pilot, piston operated containing no stuffing boxes, rubber diaphragms or bellows. The Cast Steel Main Body contains an integral stellited seat and the Main Valve, Controlling Valve and Cylinder Liner are of Stainless Steel hardened to 500 Brinell minimum with ground finish. The controlled fluid is separated from the steam space making it impossible to contaminate the steam.

PRINCIPLE OF OPERATION: (See Illustration, Fig. 11, for part numbers.)

The discharge pressure for the Governor, acts under the top Diaphragm (18), against the Adjusting Spring (10). Any movement of the top Diaphragm (18) is transmitted through the Crossheads (13) and Connecting Rods (12) to the Controlling Valve (61), which admits high pressure steam to top of Piston (28), opening the Main Valve (32) sufficiently to pass the required amount of steam to maintain the desired pump discharge pressure.

The two lower Diaphragms (18) function as a seal, thus obviating the necessity of a stuffing box around the stem of Controlling Valve (61).

INSTALLATION:

Blow out steam lines thoroughly before installing Leslie Pump Governors. Place the governor in upright position in horizontal steam line to pump so that steam flow will be in direction of arrow cast on sides of governor body. Install governor as close to pump as possible.

The actuating line shall be taken from the discharge of the pump beyond the check valve but between the pump and discharge stop valve.

Avoid right angle bends and unnecessary valves and restrictions in the actuating line. Install union in this line close to governor.

Install drain line in steam supply pipe right ahead of the governor and provide trap in same.

OPERATION: (See Illustration, Fig. 11, for part numbers.)

Before first turning steam on Pump Governor, remove Bottom Cap (65) and take out Main Valve (32) and Main Valve Spring (33). Have all tension off Adjusting Spring (10) and keep stop valve in actuating line to governor closed. Operate the pump in this way until the pipe lines are clean.

Before installing the Main Valve (32) and Main Valve Spring (33), break the joint at Top Cap Gasket (27) and lift off the whole superstructure without disassembling it. Remove Piston (28) and Cylinder Liner (30) and clean same carefully. After Cylinder Liner (30) and Piston (28) are put back in place, reinstall Main Valve (32) and Main Valve Spring (33) and thereafter bolt superstructure to the governor. then start the pump governor as follows:

Have all tension off Adjusting Spring (10). Open stop valves in steam supply and actuating lines fully. Turn Handwheel (3) slowly to the right until the desired discharge pressure is obtained.

Speed governor of the turbine must be set above maximum operating speed, so as not to interfere with the pump governor.

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MAINTENANCE:

Sluggishness is caused by dirt or foreign matter carried with the steam into the governor, interfering with the free movement of the working parts. To correct this, the governor must be taken apart and cleaned as follows:

Unscrew Connector Union (60), remove bottom Nuts (7) of Stud Bolts (14), holding superstructure to Top Cap (26) and lift off superstructure above the lower Diaphragm (18) without further disassembling. The superstructure does not contain any moving parts except the diaphragms and normally does not need to be taken apart except when replacing these.

When necessary to disassemble the superstructure, care must be taken that Diaphragm Stem (21), Diaphragm Stem Cap (20) and Diaphragm Disc (17) are put back in proper position. Make sure that the Connecting Rods (12) are free in their guides and do not bind due to paint or carbonized oil.

Unscrew Controlling Valve Seat (24) with special Socket Wrench (71) provided for this purpose and take out Controlling Valve (61) and Controlling Valve Spring (25).

Remove Top Cap (26) and lift out Piston (28) and Cylinder Liner (30).

Main Valve (32) and Main Valve Spring (33) are taken out by removing Bottom Cap (65).

Clean parts with kerosene. See that Main Valve (32) and Controlling Valve (61) seat properly and that Piston Rings (29) are perfectly free in grooves of Piston (28). Clean seat for Cylinder Liner (30) in bottom of Cylinder, so that Cylinder Liner (30) does not project above face of top flange of Main Body (34). Clean bore of Main Valve Guide (35). Regrind Main Valve (32) with Piston (28) in Cylinder (30). Stem of Controlling Valve (61) must never project above seat of Diaphragm (18). Correct clearance is .001" to .002" below diaphragm seat.

When tightening up Stud Bolts (14) for superstructure, pull down evenly without using excessive strain.

When renewing diaphragms and gaskets be sure to use standard parts made by Leslie Co. Correct thickness of diaphragms must be maintained. Do not put gaskets under diaphragms.

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Reduced size offsets
with 8-1/2 x 11" blank left
hand margins of the Master
Plans will be inserted here.

Figs. 1-11,
Pages 31-32

Manual-001020

INSTRUCTIONS
FOR
LESLIE PUMP GOVERNORS

FOR UNITED STATES DESTROYERS

DD-445	U.S.S. FLETCHER	DD-488	U.S.S. WALLER
DD-446	U.S.S. RADFORD	DD-498	U.S.S. PHILIP
DD-447	U.S.S. JENKINS	DD-499	U.S.S. RENSHAW
DD-448	U.S.S. LA VALLETTE	DD-500	U.S.S. RINGGOLD
DD-485	U.S.S. SAUFLEY	DD-501	U.S.S. SCHROEDER

DD-502 U.S.S. SIGSBEE

BUILT BY
FEDERAL SHIPBUILDING AND DRY DOCK CO.
KEARNY, NEW JERSEY
PURCHASE ORDER NOS.
198-1158
214-198

DD-449	U.S.S. NICHOLAS	DD-512	U.S.S. SPENCE
DD-450	U.S.S. O'BANNON	DD-513	U.S.S. TERRY
DD-461	U.S.S. CHEVALIER	DD-514	U.S.S. THATCHER
DD-467	U.S.S. STRONG	DD-515	U.S.S. ANTHONY
DD-468	U.S.S. TAYLOR	DD-516	U.S.S. WADSWORTH
DD-469	U.S.S. EE HAVEN	DD-517	U.S.S. WALKER
DD-507	U.S.S. CONWAY	DD-629	U.S.S. ABBOT
DD-508	U.S.S. CONY	DD-630	U.S.S. BRAINE
DD-509	U.S.S. CONVERSE	DD-631	U.S.S. ERBEN
DD-510	U.S.S. EATON	DD-642	U.S.S. HALE
DD-511	U.S.S. FOOTE	DD-643	U.S.S. SIGOURNEY

DD-644 U.S.S. STEMBEL

BUILT BY
BATH IRON WORKS CORPORATION
BATH, MAINE
PURCHASE ORDER NOS.
813-40-156
1114-40-156
115-41-158

Manual-001021

INSTRUCTIONS
FOR
LESLIE PUMP GOVERNORS

FOR UNITED STATES DESTROYERS

DD-470	U.S.S. BACHE	DD-519	U.S.S. DOLY
DD-471	U.S.S. BEALE	DD-520	U.S.S. ISHERWOOD
DD-518	U.S.S. BROWNSON	DD-521	U.S.S. KIMBERLY
	DD-522 U.S.S. LUCE		

BUILT BY
BETHLEHEM STEEL COMPANY
STATEN ISLAND, NEW YORK
PURCHASE ORDER NOS.
U719-1600-F
U719-1801-F

DD-526	U.S.S. ABNER READ	DD-534	U.S.S. MC CORD
DD-527	U.S.S. AMDEN	DD-535	U.S.S. MILLER
DD-528	U.S.S. MULLANY	DD-536	U.S.S. OWEN
DD-529	U.S.S. BUSH	DD-537	U.S.S. PUTNAM
DD-530	U.S.S. THATHEN	DD-538	U.S.S. STEPHEN POTTER
DD-531	U.S.S. HAZELWOOD	DD-539	U.S.S. TINGEY
DD-532	U.S.S. HERMAN	DD-540	U.S.S. TWINING
DD-533	U.S.S. BOEL	DD-541	U.S.S. YARNALL

BUILT BY
BETHLEHEM STEEL COMPANY
SAN FRANCISCO, CALIFORNIA
PURCHASE ORDER NO.
R719-1700-F

DD-544	U.S.S. BOYD	DD-546	U.S.S. BROWN
DD-545	U.S.S. BRADFORD	DD-547	U.S.S. CONELL

BUILT BY
BETHLEHEM STEEL COMPANY
TERMINAL ISLAND, CALIFORNIA
PURCHASE ORDER NO.
RD719-1701-F

Manual-001022

INSTRUCTIONS
FOR
LESLIE PUMP GOVERNORS

FOR UNITED STATES DESTROYERS

DD-550 D.S.S. CAPPS
DD-551 U.S.S. DAVID W. TAYLOR
DD-552 D.S.S. EVANS
DD-553 D.S.S. JOHN D. HENLEY

BUILT BY
GULF SHIPBUILDING CORP.
MOBILE, ALABAMA
PURCHASE ORDER NO.
DD-1217-7-41

DD-554 D.S.S. FRANKS
DD-555 U.S.S. HAGGARD
DD-556 U.S.S. HAILEY
DD-557 D.S.S. JOHNSTON
DD-558 U.S.S. LAWS
DD-559 D.S.S. LONGSHAW
DD-560 D.S.S. MORRISON
DD-561 U.S.S. PRICHETT
DD-562 U.S.S. ROBINSON
DD-563 U.S.S. ROSS
DD-564 D.S.S. ROWE
DD-565 D.S.S. SMALLEY
DD-566 U.S.S. STODDARD
DD-567 D.S.S. WATTS
DD-568 U.S.S. WREN

BUILT BY
SEATTLE-TACOMA SHIPBUILDING COMPANY
SEATTLE, WASHINGTON
PURCHASE ORDER NO.
445-207

DD-569 D.S.S. AULICK
DD-570 U.S.S. CHARLES AUSBURN
DD-571 U.S.S. CLAXTON
DD-572 U.S.S. DYSON
DD-573 U.S.S. HARRISON
DD-574 U.S.S. JOHN RODGERS
DD-575 U.S.S. MC KEE
DD-576 U.S.S. MURRAY
DD-577 U.S.S. SPROSTON
DD-578 U.S.S. WEDDES
DD-579 U.S.S. WILLIAM D. PORTER
DD-580 U.S.S. YOUNG

BUILT BY
CONSOLIDATED STEEL COMPANY
ORANGE, TEXAS
PURCHASE ORDER NO.
S-0626

LESLIE
CO.
LYNDHURST, N.J.

Manual-001023

Instructions
LESLIE PUMP GOVERNORS
for

DD-445 CLASS DESTROYERS

Leslie File Nos. 378-3-

33012	33014	33497	36186	32606	32404
33013	33015	32912	31918	32536	32582

GENERAL DATA

Normal Operating Steam Pressure 890 lbs./sq.in.

SERVICE	M.O.G.	LUB. OIL
Governors per vessel	4	2
Six I.P.S. and Leslie Class	3/4" PTEMS	1" PTLMS
Serial Numbers	120653 to 121336	120661 to 120852
Discharge Pressure, lbs./sq.in.	150-350	55
Capacity of Governor, lbs./hr.	870	1065
Range of Adjustment	150-350	20-80
Weight of Governor, lbs.	58	58
Pressure Drop through Governor lbs./sq.in.	30	30
Leslie Co. Type S plan Dwg. No.	PMS-135-17, Alt. 1	PMS-135-17, Alt. 1
Bur. Type S File No.	DD445-85508-251, Alt. 1	DD445-84501-147, Alt. 1

PRINCIPLES OF OPERATION

See Dwg. Nos. PMS-227-1 & PMS-228-1, attached

The discharge pressure for the Governor, shown on Drawing PMS-227-1, acts under the top diaphragm 24, against the adjusting spring 25. Any movement of the top diaphragm 24, is transmitted through crosshead 10 and connecting rods 9, to controlling valve 14, which admits high pressure steam to top of piston 5, opening main valve 4 sufficiently to pass the required amount of steam to maintain the desired pump discharge pressure.

The discharge pressure for the Governor, shown on Drawing PMS-228-1, acts under the top diaphragm 24, against the adjusting spring 25. Any movement of the top diaphragm 24, is transmitted through crosshead 10 and connecting rods 9, to controlling valve 14, which admits high pressure steam to top of piston 5, opening main valve 4 sufficiently to pass the required amount of steam to maintain the desired pump discharge pressure.

The top lower diaphragm 24, functions as a seal, thus obviating the necessity of a stuffing box around the controlling valve stem 14. By throttling the needle valve 39, in the passage between the top lower diaphragm 24, a compensating effect is obtained, which eliminates any tendency to over-regulate or "hunt".

Manual-001024

LESLIE PUMP GOVERNORS

TYPE CP, CLASS A

For Fuel Oil Service : Leslie Class PTHNS
For Lub. Oil Service : Leslie Class PTLNS

Instructions for Installation, Operation, Cleaning and Repairing

INSTALLATION:

Blow out steam lines thoroughly before installing Leslie Pump Governors. Place the governor in upright position in horizontal steam line to pump so that steam flow will be in direction of arrow cast on sides of governor body. Install governor as close to pump as possible.

Connect actuating line for governor as specified below:

For boiler fuel-oil service: The oil actuating line shall be taken from the discharge of the pump beyond the check valve but between the pump and discharge stop valve.

Size of oil actuating line shall be 3/8".

For lubricating oil service: The oil actuating line shall be taken from the lubricating oil main not more than three feet from discharge flange of pump.

Size of actuating line shall be 1/4".

Avoid right angle bends and unnecessary valves and restrictions in the oil actuating line. Install union in this line close to governor.

Install drain line in steam supply pipe right ahead of the governor and provide trap in same.

OPERATION:

(For Sectional View see Dwg. Nos. PNS-227-1 and PNS-228-1, attached.)

Before first turning steam on pump governor, remove Bottom Cap 7. Then take out Main Valve 4 and Main Valve Spring 28. When replacing Bottom Cap 7, be sure that Stem 36 is screwed back far enough to permit Main Valve Guide 13 to go all way down into its recess in the Bottom Cap. Have all tension off adjusting spring 25, and keep stop valve in oil actuating line to governor closed. Operate the pump in this way until the pipe lines are clean.

Before installing the Main Valve and Main Valve Spring, break the joint at Top Cap Gasket 29 and lift off the whole superstructure without disassembling it. Remove Piston 5 and Cylinder Liner 3 and clean same carefully. After Cylinder Liner and Piston are put back in place, reinstall Main Valve 4 and Main Valve Spring 26 and thereafter bolt superstructure to the governor. Then start the pump governor as follows:

Manual-001025

Have all tension off adjusting spring 25, screw stem 36 all way in. Open stop valves in steam supply and oil actuating lines fully. Turn Hand Wheel 49 slowly to the right until the desired discharge pressure is obtained.

Throttle the Needle Valve 59 sufficiently to stop any surging or "hunting". It should normally be kept about one quarter of a turn open. It must never be shut tight.

Speed governor of the turbine must be set above maximum operating speed, so as not to interfere with the pump governor.

The Hand Wheel 41 at lower end of the governor is for manual operation. By screwing the stem 36 out the Main Valve is pulled off its seat. Normally the stem must be all way in so that the groove in the Indicator Cap 40 coincides with the groove on lower end of Bottom Cap 7, when the governor will operate automatically

CLEANING AND REPAIRING:

Sluggishness is caused by dirt or foreign matter carried with the steam into the governor, interfering with the free movement of the working parts. To correct this, the governor must be taken apart and cleaned as follows:

Unscrew Connector Union 32, remove Bottom Nuts of Stud Bolts 28 and lift off superstructure above the lower diaphragm without further disassembling. The superstructure does not contain any moving parts except the diaphragms and normally does not need to be taken apart except when replacing these. When necessary to disassemble the superstructure, care must be taken that Diaphragm Stem 21, Diaphragm Stem Cap 22 and Diaphragm Disc 24 are put back in proper position. Make sure that the Connecting Rods 20 are free in their guides and do not bind due to paint or carbonized oil.

Unscrew Controlling Valve Seat 8 with special wrench provided for this purpose and take out Controlling Valve 14 and Controlling Valve Spring 27.

Remove Top Cap 6 and lift out Piston 5 and Cylinder Liner 3.

Main Valve 4, Main Valve Spring 26 are taken out by removing Bottom Cap 7.

When necessary to renew Seat Ring 2, unscrew same with special wrench provided for this purpose.

Clean parts with kerosene. See that Main Valve 4 and Controlling Valve 14 seat properly and that Piston Rings 15 are perfectly free in groove. Clean seat for Cylinder Liner 3 in bottom of cylinder, so that cylinder liner does not project above face of top flange of Main Body 1. Clean bore of Main Valve Guide 13. Regrind Main Valve 4 with Piston 5 in cylinder. Stem of Controlling Valve 14 must never project above seat of Diaphragm 24. Correct clearance is .001" to .002" below diaphragm seat.

When tightening up Stud Bolts 28 for superstructure, pull down evenly without using excessive strain.

When renewing diaphragms and gaskets be sure to use standard parts made by Leslie Co. Correct thickness of diaphragms must be maintained. Do not put gaskets under diaphragms.

Do not use graphite, lead, cement or other substances on gaskets.

Manual-001026

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE-TYFON WHISTLES

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE CO.
LYNDHURST, N.J.
ESTABLISHED 1909

LESLIE-TYFON WHISTLES

INSTALLATION:

1- Steam supply is taken from the "150 pound auxillery steam line". This line is normally energized under all operating conditions.

2- The steam supply line should rise continuously through well graded piping free from pockets, to the separators at the bottom of the vertical risers.

3- Steam supply riser piping to the whistles should be as nearly vertical as practicable.

4- The separators at the bottom of the vertical risers should be provided with drains of ample size leading to the steam drain collecting main and deaerating feed tank.

5- The drain lines from the separators should be fitted with traps of the continuous flow type.

6- The drain lines from the whistles proper should be fitted with traps of the impulse flow type and should connect to the lines leading from the separators to the steam drain collecting main. The drain lines should be connected after the traps in each line, to prevent priming of the steam supply to the whistles.

7- All drain lines should be well graded, without pockets, and sloping continuously downward toward the steam drain collecting main.

8- Piping should be well insulated and where exposed should be double insulated.

9- Traps on separators and whistle drain lines should be fitted with by-pass connections.

10- After the whistles are installed, remove diaphragm leaves by unscrewing back covers, and operate whistle valves several times with the diaphragms removed, to blow out pipe lines thoroughly. Then place proper number of diaphragm leaves in place and screw up back cover preparatory to testing whistles. All leaves must have the convex or high side facing toward the nozzle and horn of the whistle. Diaphragm leaves are marked to this effect.

OPERATION:

1- Before testing or operating whistle at any time, steam should be turned on with all drains open and traps by-passed for one hour before blowing, to insure proper heating of the Leslie-Tyfon and its diaphragm.

2- Check all traps to insure that they are functioning properly before getting under way.

3- In testing whistle before getting under way, note any unusual tone, lag, aftertone, or water spray that could indicate derangement or faulty adjustments.

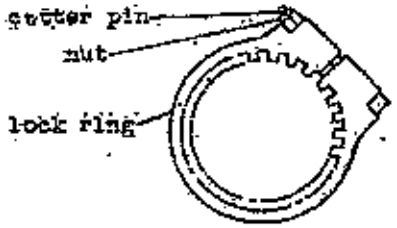
Manual-001028

LESLIE-TYFON WHISTLES

OPERATION: (cont.)

4- To adjust diaphragm, be sure the actual operating pressure is available and then screw back cover up, with spanner wrench furnished, while Leslie-Tyfon is blowing. If during blast of Leslie-Tyfon water comes out through the horn or around stem of operating valve, or if sound is not clear from beginning of first blast, a check up should immediately be made of respective traps, (see Paragraph 6 under Installation) and if same are not functioning properly, they should be by-passed until they are put into working order. Make adjustments as tight as possible while still obtaining a clear well-defined blast.

5- Back cover should then be locked in place according to design as shown below:



Tighten nut on lock ring and secure with cotter pin.

MAINTENANCE:

1- Examine and clean diaphragm scab month. If any leaf is found damaged, it should be replaced by a new one. The new leaf should be installed next to the nozzle. Weights of Back Covers and diaphragms are as follows:

	3DG DVE	3dg DT
Back Cover	19 lbs.	9 lbs.
Diaphragm (3 leaves)	1¢ lbs.	4-1/2 lbs.

2- After diaphragm leaves have been cleaned, they should be put in position and tested as explained under paragraph 4 under Operation.

3- Check up on operating valve every three months. If the main valve is leaking, remove same, following proper drawing for guidance, and grind in to obtain a good clean seat. If seats are damaged so badly that they cannot be ground in, the main valve should be held between centers in a lathe and faced off to give a perfect 45° seat. The seat ring is pinned through the threads and can only be removed with a proper wrench after the pin is removed. See drawing for location of pin before trying to remove seat ring.

4- On 3dd DVE Leslie-Tyfons, after valve seats have been refaced, it will be necessary to check travel of main valve to prevent travel exceeding that shown on applicable drawing. When necessary to correct or reduce valve travel, screw a stop in top of piston and face off as necessary. No adjustments are necessary on the mechanically operated lever when same is working in conjunction with electrical operation. The piston also acts as the stop for the mechanical operating lever.

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LESLIE-TYFON WHISTLES

ORDERING PARTS

When ordering parts of Leslie-Tyfon Whistles give the following information:

1- Serial number of Leslie-Tyfon Whistle (found on lock ring)

2- Type, class and description from name plate.

3- Part name (from drawing listed below)

4- Quantity of each part.

ALWAYS SUPPLY NAME AND NUMBER OF SHIP

DRAWINGS

T-861-1 - 300-DVE Leslie-Tyfon Whistles

T-465 - A.C.Solenoid Assembly

T-844 - 200-DV Leslie-Tyfon Whistle

ORDERING NEW LESLIE-TYFONS

When ordering or obtaining price estimates for Leslie-Tyfon Whistles, specify Leslie-Tyfon and submit the following data:

1- Service or use.

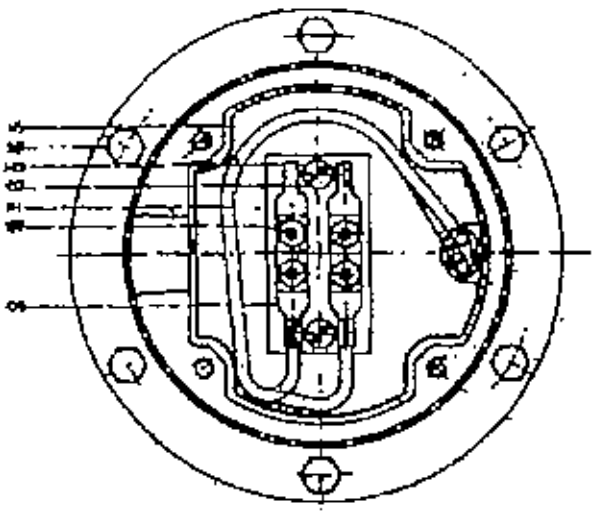
2- Size of Leslie-Tyfon

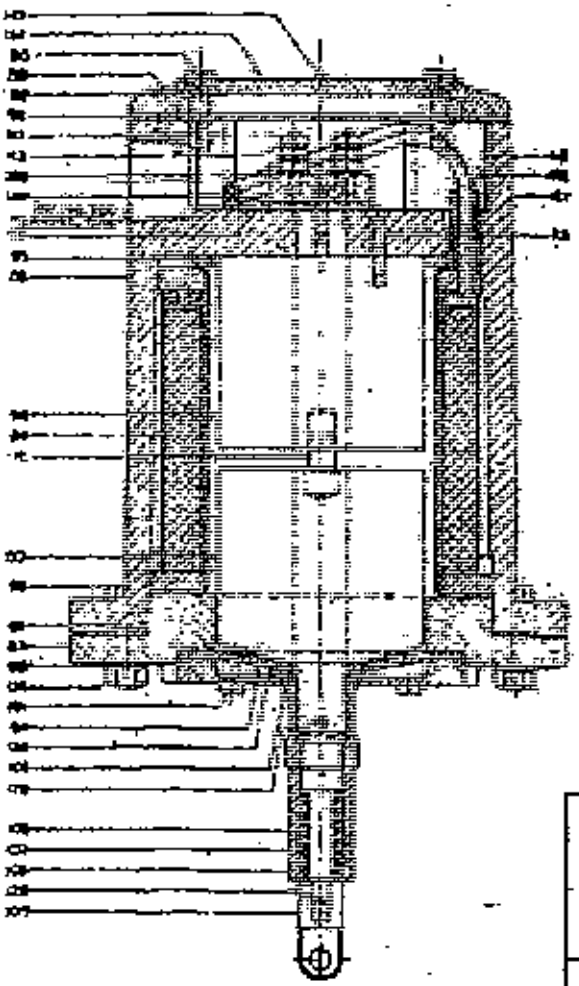
3- Steam pressure available, maximum and minimum

4- Manual, electric or automatic control

5- If electric control desired give voltage and type of current.

6- When a reducing valve is required, refer to Leslie Co. Bulletin 401-A.





LESLIE
CO.
LYNDHURST, N.J.

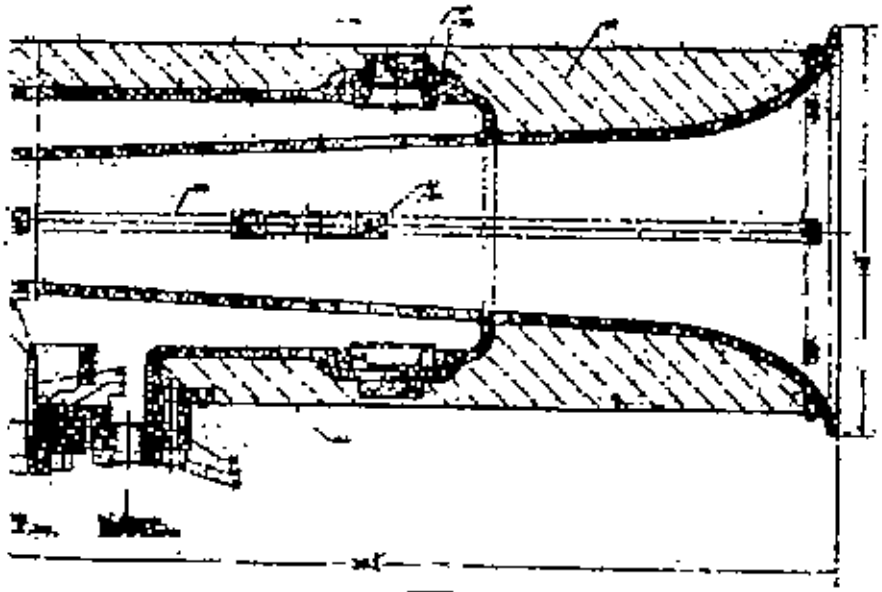
LESLIE-TYPE WHISTLE
A.C. SOLENOID ASSEMBLY

DATE 6-3-37
DRAWN BY [illegible]

DWG. NO. T-465

PARTS LIST

No.	Name	No.	Name	No.	Name
1	Body	23	Spring Seat	46	Pin
2	Bank Cover	24	Spanner Screw	47	Piston Ring
3	Lock Ring	25	Gasket	48	Main Valve
4	Cylinder	27	Gasket	49	Lever Pin
5	Main Valve	35	Gasket	50	Gasket Pin
6	Piston	26	Bracket	51	Screw, F.H.
7	Main Valve Spring	30	Loop	52	Screw, R.H.
8	Gasket (Inlet)	31	Spacer Tube	53	Lock Washer
9	Gasket (Drain)	32	Spacer Stud	54	Drive Screw
10	Lock Screw	33	Bar	55	Set Screw
11	Lock Plate	34	Bar	56	Nut, Hex.
12	Lever Pin	35	Lock Pin	57	Insulation
13	Lever	36	Main Plate	58	Lever Pin
14	Seat Ring	37	Pore Ring	59	Set, Hex.
15	Lock Nut	38	Pore Rod	60	Nut, Hex.
16	Bolt, Lock Ring	39	Push Rod Cap	61	Bolt
17	Pilot Valve Body-U	40	Pilot Valve Spring	62	Set, Hex.
18	Pilot Valve Seat	41	Stud	63	Washer
19	Pilot Valve	42	Nut	64	Lock Washer
20	Flange (Inlet)	43	Small Spacer-Top	65	Gasket Pin
21	Flange (Drain)	44	Short Cover-Bottom	66	Bellows Complete
22	Washer	45	Diaphragm		



NO.	ALTERATIONS	APPR.	DATE

LESLIE CO.
LYNDHURST, N.J.

LESLIE-TYPON STEAM TRAPS
300 LBS. PRESS.
WITH A.C. SOLENOID

DATE 1-12-48 | DWG. NO. T-851-L

LIST OF PARTS - AC SOLENOID
CORRESPONDING TO DWG. NO. T-465

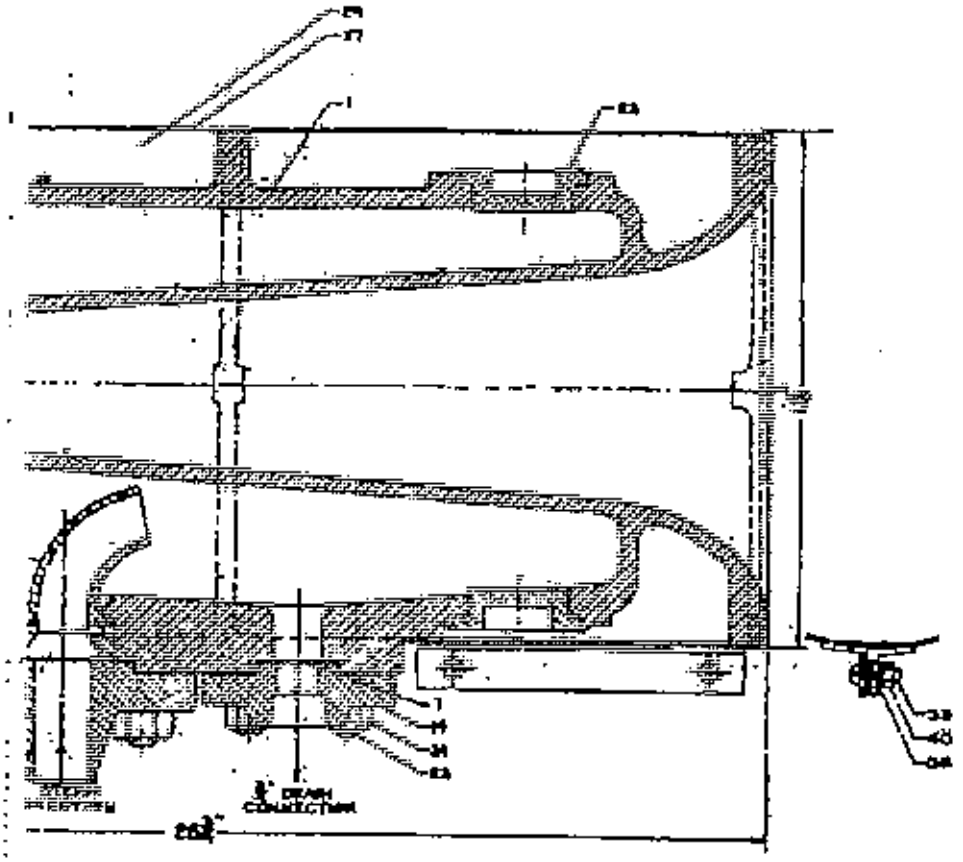
87	Base
88	Casing
89	Cap
90	Coil
91	Casing Gasket
92	Cap Gasket
93	Coil Gasket
94	Diaphragm
95	Bolt
96	Core
97	Plunger
98	Screw, Fl. Fill. H.
99	Lock Washer
100	Diaphragm Cover
101	Screw, Fl. Fill. H.
102	Diaphragm Washer
103	Connecting Stirring
104	Connecting Screw
105	Connecting Screw Head
106	Connecting Spring
107	Screw, Fl. H.
108	Terminal Base
109	Terminal Clamp
110	Insulation Strip
111	Nut
112	Guide Pin
113	Lock Washer
114	Data Plate
116	Nut
117	Insulating Plate
118	Insulating Strip
119	Cotter Pin
120	Cotter Pin
121	Sleeve
122	Insulating Tube

LIST OF PARTS
for
LESLIE-TYPE WHISTLE
AC SOLENOID
See Dwg. No. T-465, attached

Manual-001033

PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	15	Washer	29	Insulation
2	Back Cover	16	Spring Seat	30	Hub
3	Lock Ring	17	Spanner Wrench	31	Nut
4	Main Valve	18	Data Plate	32	Cover Pin
5	Main Valve Spring	19	Nozzle	33	Cotter Pin
6	Gasket - Inlet	20	Gasket	34	Lock Screw
7	Gasket - Drain	21	Lock Pin	35	Screw, S. H.
8	Lever Pin	24	Cylinder Plug	36	Lock Washer
9	Lever	25	Core Plug	37	Washer Pin
10	Seat Ring	26	Stud	38	Drive Screw
11	Lock Nut	25	Stud	39	Set Screw
12	Bolt - Lock Ring	26	Diaphragm	40	Nut, Hex.
13	Flange - Inlet	27	Whist Cover		
14	Flange - Drain	28	Name Plate		

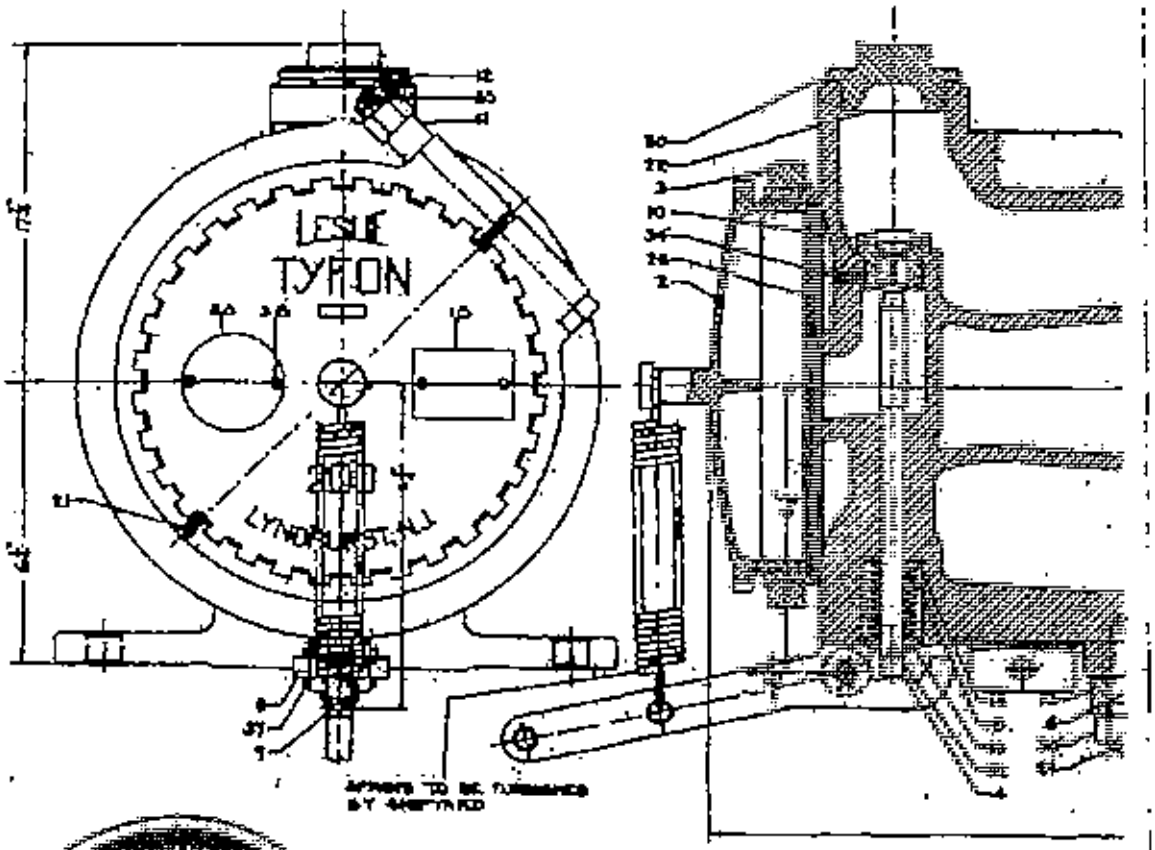


NO.	ALTERATIONS	APP'D	DATE

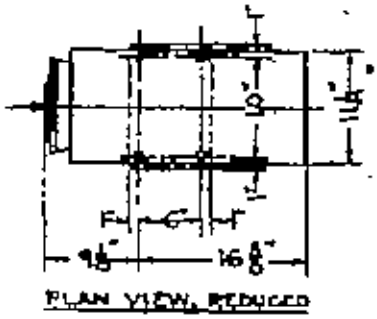
LESLIE CO.
LYNDHURST, N.J.

LESLIE-TYFON STEAM WHISTLE
200 DW

DATE 7-8-41
DWG. NO. T-844







PLAN VIEW, REDUCED

1742

Leslie Navy Instruction Manual

for

Operating Engineers

IMPORTANT

This Manual covers our line of equipment manufactured to Navy Specifications.

The principles of operation and maintenance apply to all Leslie devices of similar design whether Navy or Commercial.

Navy men will find this Manual very valuable but must remember that the drawings shown are Leslie Standard Navy Regulators and Whistles while the equipment they have may be special in some way.

WHEN ORDERING PARTS BE SURE TO GIVE:

1. Serial Number of Regulator or Whistle.
2. Size of Regulator or Whistle.
3. Class of Regulator or Whistle.
4. Quantity of each part.
5. Part Name (See parts list on drawing covering proper Class of Regulator or Whistle).

Always give Name and Number of Ship.

GENERAL OFFICE
COPY

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE PRESSURE REDUCING VALVES

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE
CO.
LYNDHURST, N.J.
ESTABLISHED 1909

Printed in U.S.A. 5421

INSTALLATION:

DO NOT USE LEAD OR CEMENT WHEN MAKING UP JOINTS.

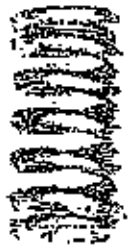
1. Protect reducing valve with Leslie Self-Cleaning Strainer.
2. Install stop valves and gages to control setting and operation of reducing valve.
3. Provide length of straight pipe on both sides of reducing valve to prevent turbulence.
4. Blow out pipe lines thoroughly before installing reducing valve.
5. Place reducing valve upright in horizontal pipe line with arrow (cast on side of body) in direction of steam flow.
6. Connect control pipe with stop valve and union to outlet line ahead of outlet stop valve. Pitch pipe toward outlet line avoiding water pockets.
7. Insulate all pipe before and after reducing valve to minimize condensation.

OPERATION:

1. Close inlet and outlet stop valves.
2. Release compression on adjusting spring 17.
3. Slowly open inlet stop valve wide.
4. Open valve in actuating line.
5. Crack outlet stop valve to permit slight flow when setting regulator.
6. Slowly screw down Adjusting Screw 15 of reducing valve until desire pressure is shown on gage on outlet side.
7. Slowly open outlet stop valve wide.
8. To change reduced pressure setting, turn Adjusting Screw 15 downward to increase and upward to decrease pressure.
9. To turn steam off, close outlet stop valve first, then inlet stop valve.
10. To turn steam on (with reducing valve set) keep outlet stop valve closed until inlet stop valve is opened wide.

Manual-001038

LESLIE PRESSURE REDUCING VALVES



Adjusting Spring 17



Controlling Valve Seat 8



Controlling Valve Spring 19

Controlling Valve 11



Diaphragm 16



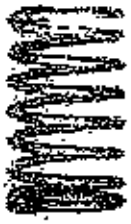
Cylinder Liner 3



Piston 6



Seat Ring 2



Main Valve Spring 18



Main Valve 4

MAINTENANCE:

If reducing valve does not operate properly, it should be opened and cleaned as follows:

1. Release compression on adjusting spring 17.
2. Unscrew or unbolt adjusting spring case 9.
3. Take out diaphragm 16.
4. For Class LA-1 only Remove diaphragm plunger 35 and diaphragm chamber 28.
5. Unscrew controlling valve seat 8 with socket wrench provided for this purpose.
6. Remove controlling valve 11 and spring 19.
7. Remove top cap 6, piston 5, and cylinder liner 3.
8. To take out main valve 4 and main valve spring 18, remove bottom cap 7.
9. Seat ring 2 in body of Class LF, LA and LB only can be taken out when necessary with special seat ring wrench provided for this purpose.

CLEANING:

1. Clean all parts with kerosene.
2. See that main and controlling valves 4 and 11 move freely in their guides and seat properly. For Class LA-1 see that diaphragm plunger 35 moves freely in its guide.
3. Piston rings 12 must be perfectly free in grooves.
4. Regrind main valve 4 with piston 5 in cylinder liner 3 to insure perfect centering.
5. Have all working parts moving freely.

LESLIE PRESSURE REDUCING VALVES

ASSEMBLING:

1. DO NOT USE GRAPHITE OR COMPOUND ON JOINTS. NO LUBRICANT IS REQUIRED ON ANY MOVING PARTS.
2. Place main valve 4, spring 18, and gasket 24 in position on bottom cap 7 and bolt to valve body 1.
3. Depress piston 5 in cylinder liner 3. Be sure movement is smooth and free.
4. Top of liner 3 must be flush with top flange of body 1.
5. Bolt top cap with gasket 23 to body 1.
6. Assemble controlling valve 11, spring 19 and seat 8 in top cap 6. For reliable service controlling valve 11 must seat tightly. To do this stem of valve must not project above diaphragm seat. Correct clearance is .001" to .002" below diaphragm seat in top cap 6.
7. Replace diaphragm 15, adjusting spring 17, spring seat 13 and 14 and spring case 9. For Class DA-1 replace diaphragm 16, diaphragm plunger 35, diaphragm chamber 28, adjusting spring 17, spring seats 13 and 14 and spring case 9.
8. Make all joints steam tight.

ORDERING PARTS:

Please give following information:

1. SERIAL NUMBER OF REGULATOR
2. SIZE OF REGULATOR
3. CLASS
4. QUANTITY OF EACH PART
5. PART NAME (See parts list for various classes on drawings on following pages.

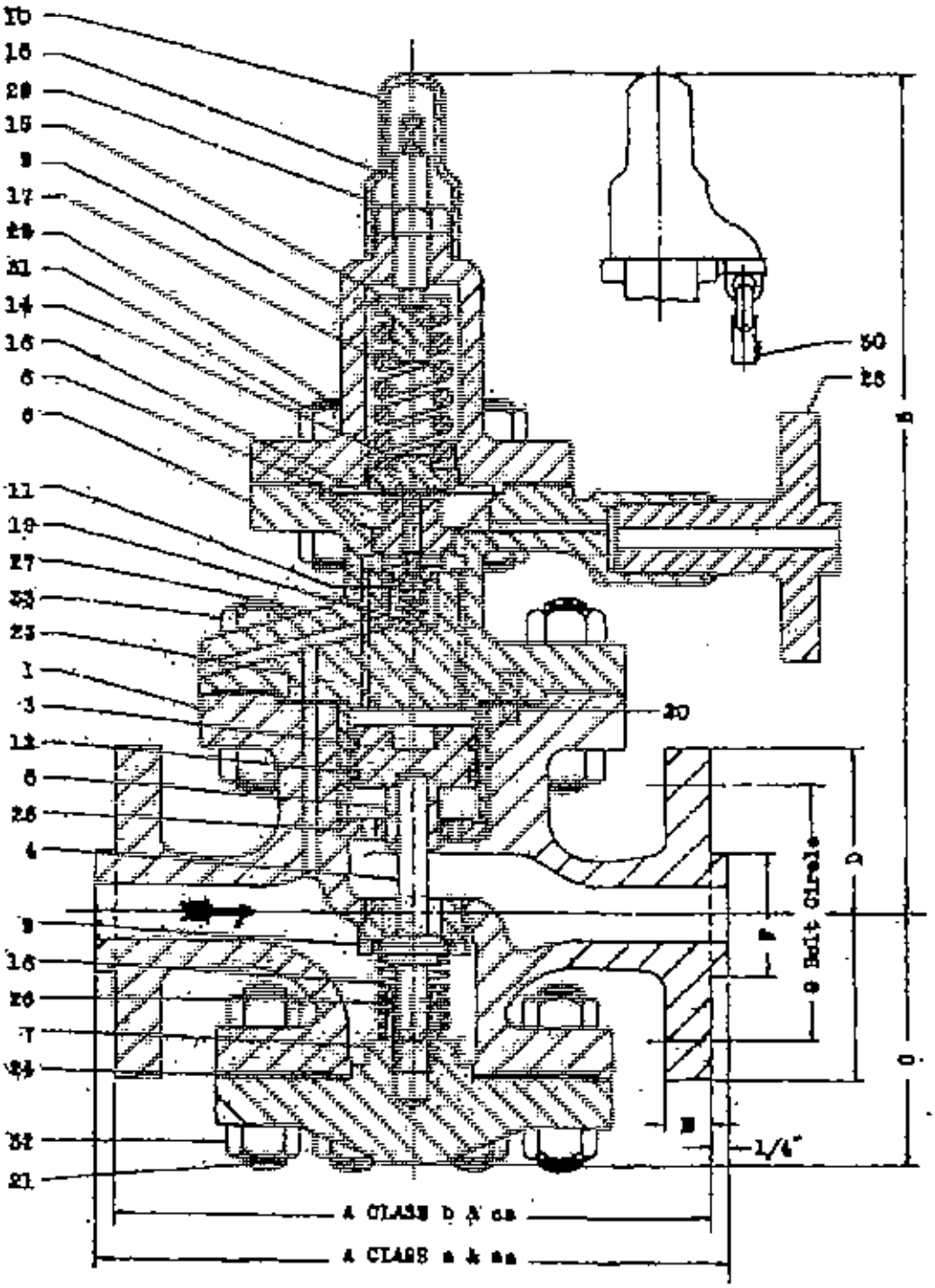
ALWAYS SUPPLY NAME AND NUMBER OF SHIP

ORDERING NEW REDUCING VALVES:

Specify LESLIE and supply following information:

1. Maximum and minimum inlet pressure.
2. Superheat, if any.
3. Reduced pressure or range.
4. Kind of service.
5. Maximum or minimum flow in lbs. of steam per hour, cu. ft. of free air or gas per minute to be delivered, or information leading to same.
6. Screwed or flanged connections. Flanges are furnished undrilled in bronze unless otherwise specified. Always drilled in steel.
7. Orders for all reducing valves 4" and larger must be accompanied by a sketch or drawing of proposed installation (including pipe sizes, fittings, general layout) in addition to above information.

Manual-001040


10
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H
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Bolt Circle
B
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1/4"
A CLASS b & c
A CLASS a & aa

PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	13	Pr. Spring Seat	25	Cylinder Bottom
2	Seat Ring	14	Bottom Spring Seat	26	Main Valve Guide Bushing
3	Cylinder Liner	15	Adjusting Screw	27	Seat Bolt
4	Main Valve	16	Diaphragm	28	Plunger Nipple
5	Piston	21	Adjusting Spring	29	Set Pin
6	Top Cap	18	Main Valve Spring	30	Lock
7	Bottom Cap	19	Controlling Valve Spring	31	Nut, Hex.
8	Controlling Valve Seat	20	Lock Pin	32	Nut, Hex.
9	Adjusting Spring Case	21	Stud Bolt	33	Nut, Hex.
10	Lock Cap	22	Stud Bolt		Wrench for Sc. No. 2
11	Controlling Valve	23	Top Cap Gasket		Wrench for Sc. No. 3
12	Piston Ring	24	Bottom Cap Gasket		

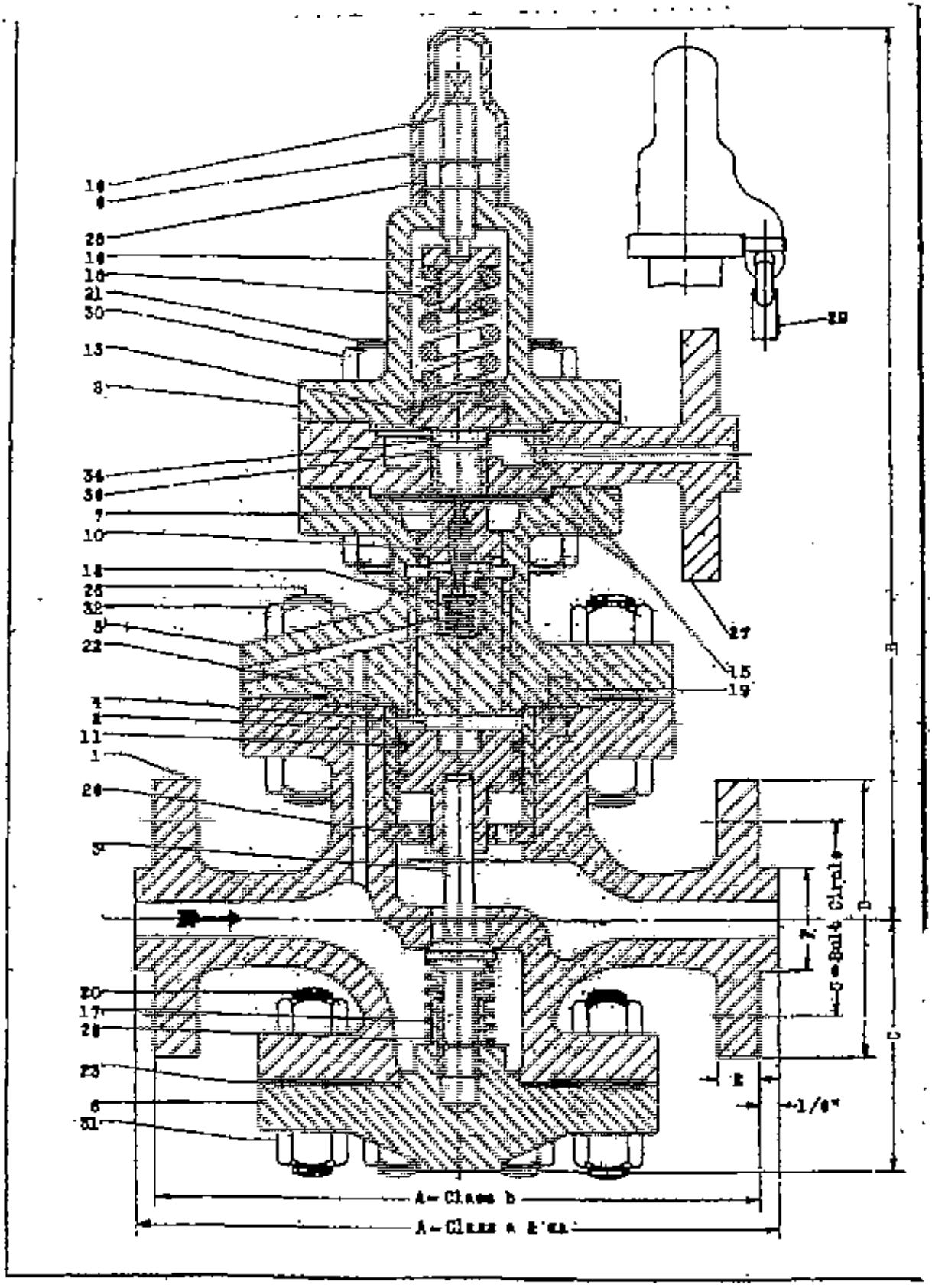
DIMENSIONS IN INCHES

Size	A	B	C	D	E	F	G	Port Width	Gate Thk.	Port Dia.	Th. Dia.
CLASSES a & aa											
1/2"	4-1/2	11-3/8	3-9/16	4-3/4	7/16	1-3/8	2-3/8	A	1/2	9/16	47
3/4"	4-3/4	11-3/8	3-9/16	4-3/8	5/8	1-11/16	2-1/2	4	5/8	11/16	48
1"	4-3/4	11-3/8	3-7/16	4-7/8	11/16	1	2-1/2	4	5/8	11/16	48
1-1/4"	5	11-3/8	3-13/16	5-1/4	15/16	1-1/2	2-7/8	4	5/8	11/16	54
1-1/2"	5-1/2	11-7/8	4-1/8	5-3/8	7/8	2-1/8	4-1/2	4	5/8	11/16	63
2"	11-1/8	12-3/4	4-1/2	6-1/2	1	2-3/8	6	6	5/8	11/16	80
2-1/2"	12	13-7/8	5-1/8	7-1/2	1-1/8	4-1/4	5-7/8	6	3/4	11/16	114
3"	12	14-3/4	7	8-1/4	1-1/2	5	6-3/8	6	3/4	15/16	150
CLASS b											
1/2"	5	11-3/8	3-7/16	4	9/16	—	2-7/8	4	1/2	9/16	47
3/4"	4-3/4	11-3/8	3-9/16	4-5/16	9/16	—	2-3/16	4	1/2	9/16	48
1"	4-3/4	11-3/8	3-7/16	4-7/16	9/16	—	2-3/4	4	5/8	11/16	48
1-1/4"	5-1/2	11-3/8	3-13/16	5-3/16	3/4	—	3-1/16	4	5/8	11/16	54
1-1/2"	5-5/8	11-7/8	4-1/8	5-13/16	11/16	—	3-5/8	5	5/8	11/16	63
2"	12-3/8	12-3/4	4-1/2	6-1/2	15/16	—	4-5/8	7	5/8	11/16	80
2-1/2"	12-7/8	13-7/8	4-1/2	7-1/16	15/16	—	5	8	3/4	13/16	114
3"	13-1/4	14-1/4	7	8-1/2	15/16	—	6-3/16	8	3/4	13/16	150
CLASS aa											
1/2"	5-1/4	11-3/8	3-7/16	4	15/16	—	2-7/8	4	1/2	9/16	47
3/4"	5-1/8	11-3/8	3-9/16	4-5/16	15/16	—	2-3/16	4	1/2	9/16	48
1"	5-1/8	11-3/8	3-7/16	4-7/16	5/8	—	2-3/4	4	5/8	11/16	48
1-1/4"	5-1/2	11-3/8	3-13/16	5-3/16	15/16	—	3-1/16	4	5/8	11/16	54
1-1/2"	5-5/8	11-7/8	4-1/8	5-13/16	15/16	—	3-5/8	5	5/8	11/16	63
2"	12-3/8	12-3/4	4-1/2	6-1/2	15/16	—	4-5/8	7	5/8	11/16	80
2-1/2"	12-7/8	13-7/8	5-1/8	7-9/16	15/16	—	5	8	3/4	13/16	114
3"	13-1/2	14-1/4	7	8-1/2	15/16	—	6-3/16	8	3/4	13/16	150

LESLIE CO.
LYNDHURST, N.J.

1/2" to 3" PRESSURE REDUCING VALVES
HAVI CLASSES a, aa, b & ca
LESLIE CLASS LA & LB

DATE 3-4-41 | DWG. NO. LES-152, Alt. 1


A—Class b
A—Class a & a'
Ball Circle
1/8"

Parts List

No.	Name	No.	Name	No.	Name
1	Main Body	15	Spring Seat	29	Main Valve Guide Bushing
2	Cylinder Liner	16	Adjusting Screw	30	Stud Bolt
3	Main Valve	19	Diaphragm	31	Diaphragm Washer
4	Plates	20	Adjusting Spring	32	Cap Nut
5	Top Cap	21	Main Valve Spring	33	Lock
6	Bottom Cap	23	Controlling Valve Spring	34	Nut, Hex.
7	Controlling Valve Seat	24	Dowel Pin	35	Nut, Hex.
8	Adjusting Spring Case	25	Stud Bolt	36	Nut, Hex.
9	Body Gasket	26	Stud Bolt	38	Diaphragm Chamber Gasket
10	Controlling Valve	27	Top Cap Gasket	39	Diaphragm Plate
11	Piston Disc	28	Bottom Cap Gasket		Wrench for Nos. 1a, 1
12	Top Spring Seat	31	Cylinder Bottom		Wrench for Nos. 2a, 2

DIMENSIONS IN INCHES

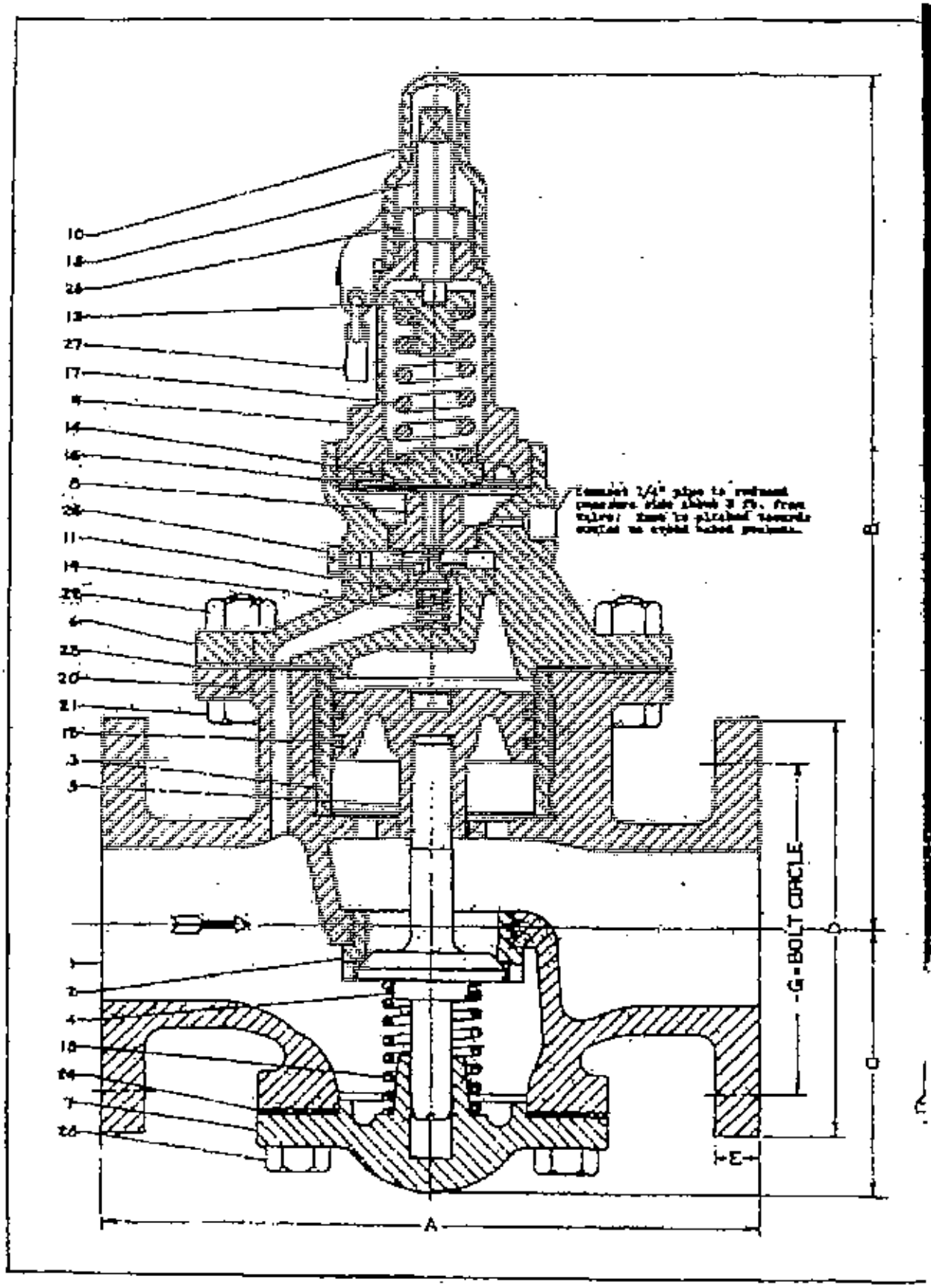
Size	A	B	C	D	E	F	G	No. of Bolts	Bolt Hole	Bolt Hole	Weight Lbs.
CLASSES a, aa											
1/2"	6-1/8	12-1/4	3-7/16	3-3/4	9/16	1-3/4	2-3/8	4	1/2	9/16	50
3/4"	6-1/8	12-1/4	3-7/16	4-3/8	5/8	1-11/16	2-1/4	4	5/8	11/16	61
1"	6-1/2	12-1/4	3-7/16	4-7/8	11/16	2	3-1/8	4	5/8	11/16	68
1-1/4"	8	12-1/2	3-13/16	5-1/4	15/16	2-1/2	3-7/8	4	5/8	11/16	87
1-1/2"	8-1/2	12-7/8	4-1/8	6-1/8	7/8	2-3/8	4-1/2	4	5/8	11/16	88
2"	11-1/2	13-1/4	4-1/2	6-1/8	1	2-5/8	5	8	5/8	11/16	89
2-1/2"	13	14-5/8	5-1/8	7-1/8	1-3/8	4-1/8	6-1/8	8	3/4	13/16	115
3"	14	15	7	8-1/4	1-1/4	5	6-5/8	8	3/4	13/16	150
CLASS b											
1/2"	8	12-1/4	3-7/16	4	9/16	—	2-7/8	4	1/2	9/16	50
3/4"	7-7/8	12-1/4	3-7/16	4-3/16	9/16	—	3-3/16	4	1/2	9/16	61
1"	7-7/8	12-1/4	3-7/16	5-3/16	5/8	—	3-3/4	8	5/8	11/16	68
1-1/4"	8-1/8	14-1/2	3-13/16	6-5/8	5/8	—	4-1/16	8	5/8	11/16	87
1-1/2"	8-5/8	12-7/8	4-1/8	6-13/16	13/16	—	4-5/8	8	5/8	11/16	88
2"	10-5/8	13-1/4	4-1/2	8-1/2	11/16	—	5-3/16	8	5/8	11/16	89
2-1/2"	11-7/8	14-5/8	5-1/8	7-9/16	15/16	—	6	8	3/4	13/16	115
3"	13-5/8	15	7	8-1/8	13/16	—	6-5/16	8	3/4	13/16	167

NO.	ALTERATIONS	APPD	DATE

LESLIE CO.
LYNDHURST, N.J.

1/2" to 3" PRESSURE REDUCING VALVES
NAVY CLASSES a, aa & b
LESLIE CLASS LA-1

DWN 5-6-42	DWG. NO. LES-141-1
TRACED	CHKD

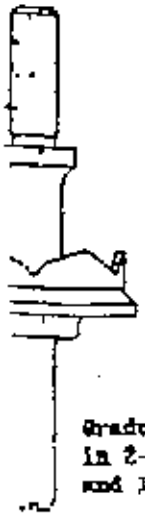

10
18
24
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28
11
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21
15
3
5
1
2
4
18
24
7
26
-G- BOLT CIRCLE
-E-
A
D

PARTS LIST

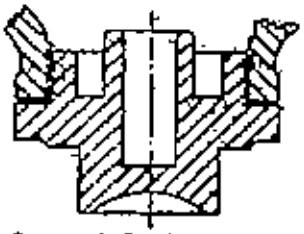
No.	Name	No.	Name	No.	Name
1	Main Body	13	Centralizing Valve	25	Bolt
2	Body Ring	14	Piston Ring	26	Nut
3	Cylinder Liner	15	Top Spring Seat	27	Top Cap Gasket
4	Main Valve	16	Bottom Spring Seat	28	Bottom Cap Gasket
5	Piston	17	Adjusting Screw	29	Jam Nut
6	Top Cap	18	Diaphragm	30	Top Cap Screw
7	Bottom Cap	19	Adjusting Spring	31	Knob
8	Centralizing Valve Seat	20	Main Valve Spring	34	Cap Screw
9	Adjusting Screw Case	21	Centralizing Valve Spring		Wrench for Pc. No. 2
10	Lock Nut	22	Dowel Pin		Wrench for Pc. No. 3

DIMENSIONS IN INCHES

Size	A	B	C	D	E	F	Pipe Size	Pipe Size	Pipe Size	Wt. Lbs.
Class 2A										
1/2"	7	10	2-15/16	4	11/16	2-3/4	4	1/2	8/16	11
3/4"	7	10	2-15/16	4-5/16	11/16	3-25/32	4	1/2	8/16	12
1"	7-1/8	10	2-15/16	5-1/16	5/8	3-3/4	4	1/2	13/16	14
1-1/4"	7-1/8	10-1/4	3-1/16	5-3/8	13/16	4-1/16	4	1/2	12/16	15
1-1/2"	8	10-5/8	3-7/16	5-7/16	13/16	4-5/8	4	1/2	11/16	16
2"	9-1/8	11-3/8	3-7/8	6-1/8	13/16	5-3/16	4	1/2	11/16	22
2-1/2"	10-1/8	12	4-5/8	6-9/16	13/16	6	4	1/2	11/16	33
3"	12-5/8	12-1/8	5-1/16	6-15/16	13/16	6-5/16	4	1/2	11/16	45
3-1/2"	13-3/8	13-1/8	6	7-11/16	1	7-1/16	4	1/2	11/16	125
4"	13-3/8	13-3/4	7	8-3/4	1	7-11/16	4	1/2	11/16	138
Class B										
1/2"	6-1/8	10	2-15/16	4-5/16	5/8	3-7/16	4	1/2	9/16	11
3/4"	6-1/8	10	2-15/16	4-5/16	7/8	3-13/16	4	1/2	9/16	12
1"	6-1/8	10	2-15/16	5-1/16	7/8	3-3/4	4	1/2	9/16	14
1-1/4"	6-3/4	10-1/4	3-1/16	5-3/8	7/8	4-1/16	4	1/2	9/16	16
1-1/2"	7-1/4	10-5/8	3-7/16	5-7/16	7/8	4-5/8	4	1/2	9/16	18
2"	8-5/8	11-1/8	3-7/8	6-1/8	7/8	5-3/16	4	1/2	9/16	25
2-1/2"	9-1/8	12	4-5/8	6-9/16	1	6	4	1/2	9/16	34
3"	10-3/8	12-1/8	5-1/16	6-15/16	1	6-5/16	4	1/2	9/16	46
3-1/2"	11-3/8	12-1/8	6	7-11/16	1	6-15/16	4	1/2	9/16	115
4"	11-3/8	13-3/4	7	7-11/16	1	6-15/16	4	1/2	9/16	150



Gradual opening Main Valve in 2-1/2" Reducing Valves and larger.



Screwed Bottom Cap on Reducing Valves 1/2" to 1-1/2" inclusive

NO.	ALTERATIONS	APP'D	DATE

LESLIE
CO.
LYNDHURST, N.J.

1/2" TO 4" PRESSURE REDUCING VALVES
NAVY CLASSES 2A & B
LESLIE CLASS IN

DATE 6-19-41 | DWG. NO. LN-128


PUBLIC
GOVERNMENT

INSTRUCTIONS

for

Installation, Operation and Maintenance

of

LESLIE PUMP GOVERNORS

FOR NAVY SERVICE

Manufactured exclusively by

LESLIE
CO.
LYNDHURST, N.J.
ESTABLISHED 1900

LESLIE PUMP GOVERNORS

TYPE OF CLASS

For Boiler Feed Service	:	Leslie Class CTHNS
For Fuel Oil Service	:	Leslie Class PTHNS
For Lub. oil Service	:	Leslie Class PTHNS
For Fire Pump Service	:	Leslie Class PTHNS

INSTALLATION:

DO NOT USE LEAD OR CEMENT WHEN MAKING PIPE JOINTS.

1. Protect pump governor with Leslie Self-Cleaning Strainer.
2. Install stop valves and gage to control setting and operation of governor.
3. Blow out pipe lines thoroughly before installing pump governor.
4. Place governor as close to pump as possible in vertical position in horizontal line of pipe with arrow (case on side of body) in direction of steam flow.
5. Install 3/8" actuating pipe with stop valve, union and gage from connection in governor super-structure to discharge line one to three feet from pump.

Governors for turbine driven pumps have stabilizing needle valve built-in. (See Page 2 "OPERATION" for adjustment).

Provide for proper drainage of steam line ahead of pump governor.

OPERATION:

For Sectional View see following drawings attached:

For Boiler Feed Service - PRS-216 for sizes 1/2" to 1-1/2"
PRS-217 for sizes 2" and 2-1/2"
For Boiler Fuel Oil Service - PRS-223
For Lubricating Oil & Fire Pump Service - PRS-215.

1. Close inlet and outlet stop valves.
2. Release compression on Adjusting Spring under Hand Wheel.
3. Remove Bottom Cap 7 and take off Main Valve 4 and Main Valve Spring 26. Replace Bottom Cap 7 only. Be sure that stem 36 is screwed back far enough to prevent Main Valve Guide 18 to go all the way down into its recess in Bottom Cap. Operate pump in this way until pipe lines are clean.
4. Before installing the Main Valve and Main Valve Spring, break the joint at Top Cap Gasket 29 and lift off the whole superstructure without disassembling it. Remove Piston 5 and Cylinder Liner 3 and clean same carefully. After Cylinder Liner and Piston are put back in place, reinstall Main Valve 4 and Main Valve Spring 26 and thereafter bolt superstructure to the governor.

OPERATION (Cont'd)

5. Open stop valve in actuating pipe from pump discharge.

6. Slowly open inlet and outlet stop valves wide.

7. Slowly screw down on handwheel until desired discharge pressure is obtained.

8. Throttle needle valve 59 sufficiently to stop any surging or hunting. Same should normally be kept about one quarter of a turn open. It must never be shut tight.

9. Speed Governor of the turbine must be set above maximum operating speed so as not to interfere with the Pump Governor.

THE HAND WHEEL 41 AT LOWER END OF THE GOVERNOR IS FOR EMERGENCY OPERATION ONLY. By screwing the Stem 38 out, the Main Valve is pulled off its seat when Indicator Plate 43 reads "OPEN". Normally the stem must be all way in so that the Indicator Plate 43 will read "AUTO" when the governor operates automatically.

MAINTENANCE:

CAUTION: Leslie Pump Governors are ruggedly built, carefully assembled and dimensioned very accurately. Do not change any dimensions. Only standard Leslie parts must be used to ensure long life and service.

OPENING PUMP GOVERNORS.

1. Close stop valves and open union in actuating line.

2. Release all compression on adjusting spring 25.

3. Unscrew connector union 32 from top cap 8 and slide up on nipple.

4. Remove lower nuts from stud bolts 28 and lift off superstructure complete above top nap 6.

5. Remove diaphragm 24 from top cap and unscrew controlling valve seat 8 with socket wrench provided for this purpose. Remove controlling valve 14 and spring 27.

6. Remove top cap 8, piston 5 and cylinder liner 3.

7. To take out main valve 4 and main valve spring 26 remove bottom cap 7.



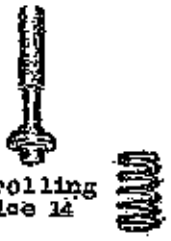
Adjusting Spring 25



Controlling Valve Seat 8

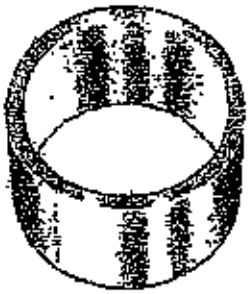


Diaphragm 24

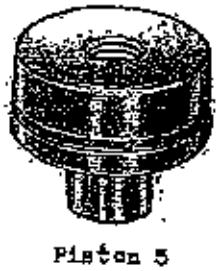


Controlling Valve 14

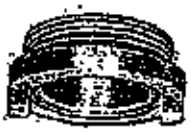
Controlling Valve Spring 27



Cylinder Liner 3



Piston 5



Seat Ring 2



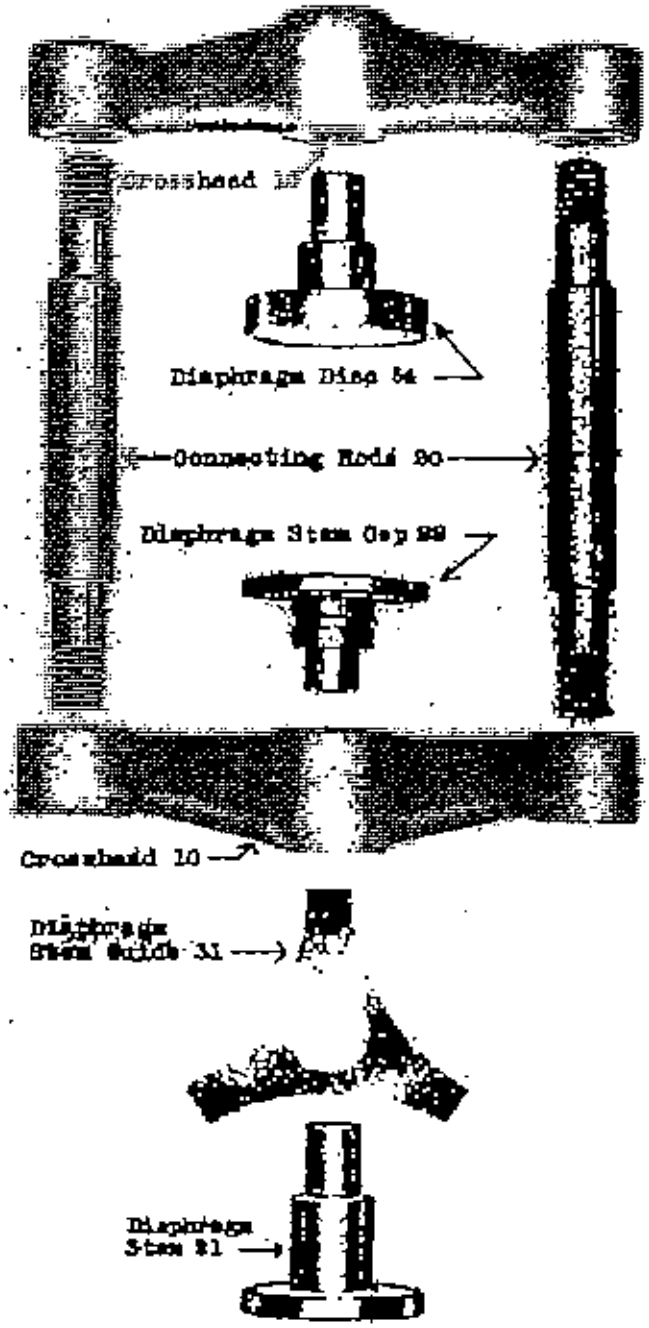
Main Valve Spring 26



Main Valve 4

Fig. 7 - INTERNAL PARTS OF TOP CAP AND BODY

[illegible] PUMP OPERATION



MAINTENANCE (Cont'd)

8. Seat ring 8 in body can be taken out when necessary with special seat ring wrench provided for this purpose.

CLEANING:

1. Clean all parts with kerosene.
2. See that main and controlling valves move freely in their guides and seat properly.
3. Piston rings must be perfectly free in grooves.
4. Regrind main valve with piston in cylinder liner to insure perfect centering.
5. Have all working parts moving freely.
6. Be sure parts in diaphragm chamber 18, and spring case 2 are open and clean.

ASSEMBLY:

1. Do not use graphite or compound on joints. No lubricant is required on any moving parts.
2. Place main valve, spring and gasket in position on bottom cap and bolt to valve body.
3. Depress piston in cylinder liner. Be sure movement is smooth and free.
4. Top of liner must be flush with top flange of body.
5. Bolt top cap with gasket to body.
6. Assemble controlling valve, spring and seat in top cap. For reliable service controlling valve must seat tightly. To do this stem of valve must not project above diaphragm seat. Correct clearance is .001" to .003" below diaphragm seat in top cap.

PUMP GOVERNORS

ASSEMBLING (Con't)

SUPERSTRUCTURE

The superstructure does not contain any moving parts except the diaphragm and normally does not need to be taken apart except when replacing these. When necessary to disassemble the superstructure, care must be taken that Diaphragm Stem 21, Diaphragm Stem Cap 22 and Diaphragm Disc 24 are put back in proper position. Make sure that the connecting rods 20 are free in their guides and do not bind due to paint or carbonized oil.

7. Replace lower diaphragm 24, diaphragm spacer 11 with diaphragm stem 21 and lower crosshead 10 in place. Be sure diaphragm stem moves freely in diaphragm stem guide 31.

   Drop connecting rods 20 into holes in lower crosshead 10 and screw on lower connecting rod nuts 46.

8. Drawings show all classes of pump governors, follow same. Refer to proper drawing and assemble sentindar of superstructure by adding parts loosely in their proper location until spring case 9 is in position.

9. Place upper crosshead through spring case 9 and on to connecting rods 20. Screw upper connecting rod nuts loosely in place.

10. Drop stud bolts through bolt holes in spring case 9 and superstructure including top flange of top cap. Put nuts on finger tight.

11. Line up all parts of superstructure through which stud bolts pass so that connecting rods move freely in guide holes and there is 1/32" play between connecting rods and holes in spring case.

12. Tighten nuts 44 on stud bolts 28 being sure to pull them up evenly all around and not too tight.

13. Tighten connector union 52 and brass connecting rod nuts 45.

14. Test for free movement of connecting rods in guide holes and clearance around same by rotating cross-heads back and forth on diaphragm stem 21.

15. Make-up union in actuating line.

Manual-001052

LESLIE PUMP GOVERNORS

ORDERING PARTS:

Please give the following information:

1. SERIAL NUMBER OF GOVERNOR
2. SIZE OF GOVERNOR
3. CLASS
4. QUANTITY OF EACH PART
5. PART NAME (See Parts List for various classes on drawings on following pages).

ALWAYS SUPPLY NAME AND NUMBER OF SHIP

ORDERING NEW PUMP GOVERNORS

Specify Leslie and supply following information

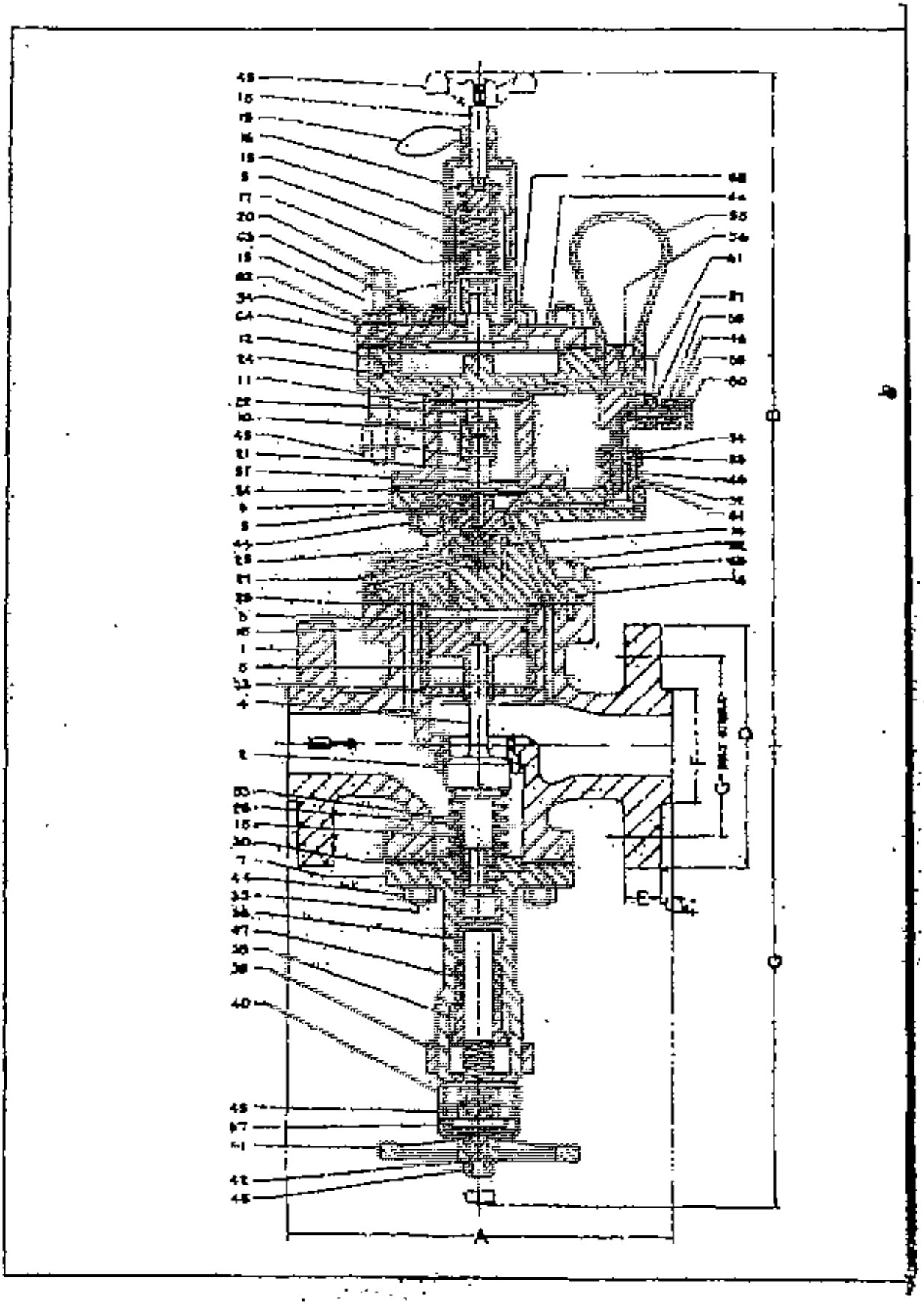
Pump Specifications:

1. Type and size of pump.
2. Minimum and maximum pump discharge pressure to be maintained.
3. Liquid to be controlled.
4. Maximum steam consumption of pump or turbine in lbs. per hour.
5. Maximum pumping rate or maximum number single strokes per min.
6. For excess pressure governors, give maximum boiler and excess pressures to be maintained.

Governor Specifications.

1. Minimum and maximum inlet steam pressure.
2. Maximum steam temperature.
3. Adjustable pump discharge pressure range desired.
4. Screwed or flanged connection. Flanges as follows:
   Bronze - Furnished unfrilled unless otherwise specified.
   Steel - Always furnished drilled.

MOTOR WITH LESLIE SELF-CLEANING STRAINER.



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	23	Governor Bottom	46	Packing
2	Seat Ring	24	Diaphragm	47	Packing
3	Cylinder Liner	25	Actuating Spring	48	Dowel Pin
4	Main Valve	26	Main Valve Spring	49	Handwheel
5	Piston	27	Controlling Valve	50	Wrench for No. No. 1
6	Top Cap		Spring	51	Wrench for No. No. 6
7	Bottom Cap	28	Stud Bolt	52	Stud
8	Controlling	29	Top Cap Gasket	53	Main Valve
	Valve Seat	30	Bottom Cap Gasket		Guide Spring
9	Adjusting	31	Diaphragm Case Bolt	54	Diaphragm Stem
	Spring Seat	32	Diaphragm Plate	55	Steam Chamber
10	Breather	33	Connector Plate	56	Needle Valve Body
11	Diaphragm Spacer	34	Connector Nut	57	Needle Valve Stem
12	Diaphragm Gasket	35	Stud	58	Needle Valve
13	Main Valve Guide	36	Plug		Bonnet Nut
14	Controlling Valve	37	Packing	59	Needle Valve Nut
15	Piston Ring	38	Gasket	60	Needle Valve
16	Top Spring Seat	39	Gland Nut		Stem Head
17	Bottom Spring Seat	40	Indicator Cap	61	Needle Valve
18	Adjusting Screw	41	Escutcheon		Body Gasket
19	Lock Nut	42	Washer	62	Packing
20	Connecting Rod	43	Indicator Plate	63	Pin
21	Diaphragm Pan	44	Nut		
22	Diaphragm Pan Cap	45	Nut		

DIMENSIONS IN INCHES

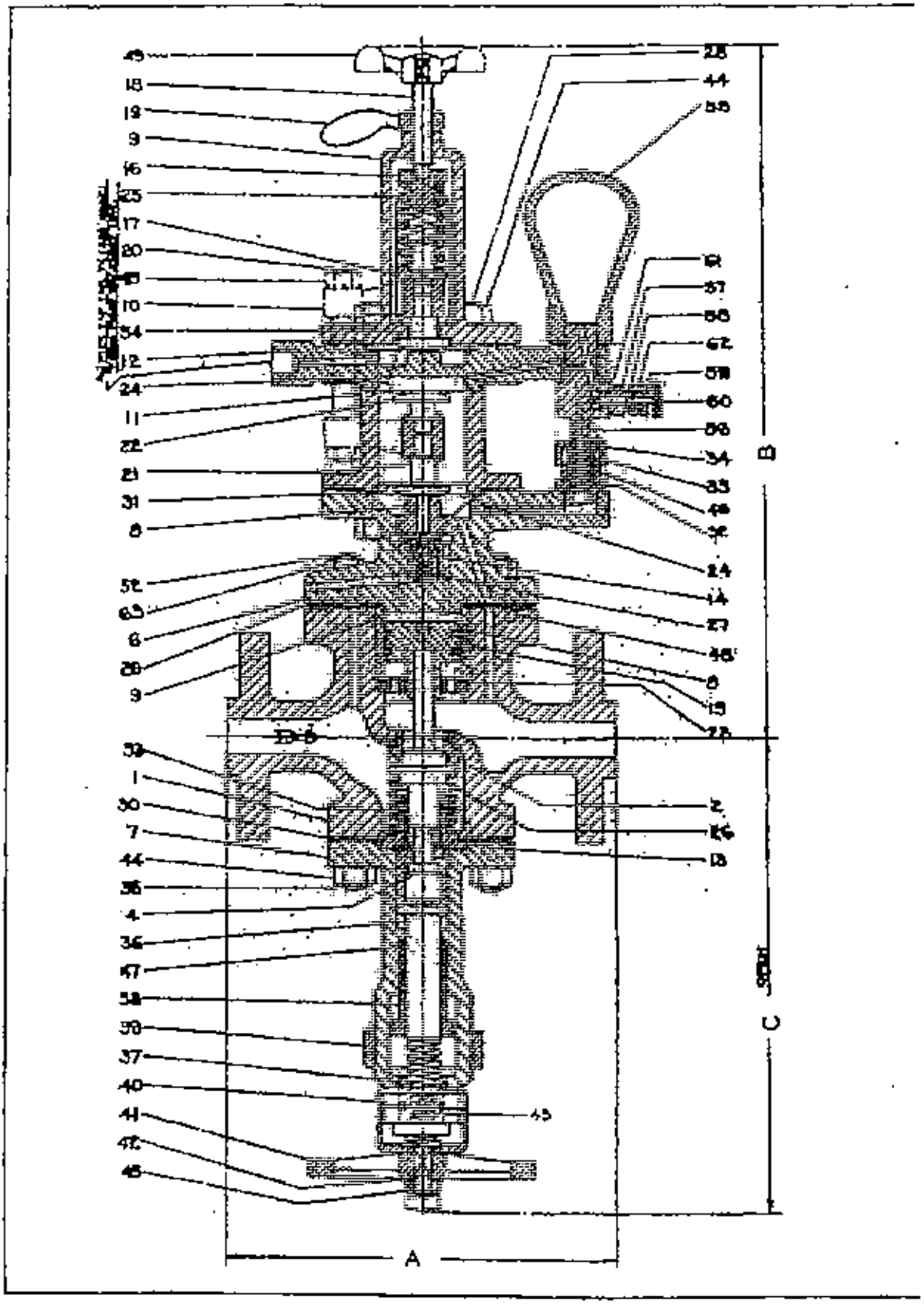
Size	A	B	C	D	E	F	G	H	J	K	L
1/2"	8-1/2	15-3/8	10-1/2	5-3/8	9/16	1-5/8	2-5/8	6	1/2	9/16	56
3/4"	8-1/2	15-3/8	10-1/2	5-5/8	5/8	1-11/16	2-1/2	6	5/8	11/16	56
1"	8-1/2	15-3/8	10-1/2	6-7/8	11/16	"	2-1/2	6	5/8	11/16	40
1-1/4"	9	15-5/8	11	7-1/4	13/16	2-1/2	2-1/2	6	5/8	11/16	44
1-1/2"	8-1/2	16	11-3/8	8-1/4	7/8	2-7/8	2-1/2	6	5/8	11/16	72

No.	ALTERATIONS	APP'D	DATE

LESLIE CO.
LYNDHURST, N.J.

1/2" to 2-1/2" PUMP GOVERNOR
NAVY TYPE GP, CLASS A
LESLIE CLASS PTGPA

DATE 8-6-41
DWG.NO. PGP-225


A
B
C
45

PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	24	Diaphragm	48	Dowel Pin
2	Seat Ring	25	Adjusting Spring	49	Handwheel
3	Cylinder Liner	26	Main Valve Spring	50	Wrench for Pc. No. 2
4	Main Valve	27	Controlling Valve Spring	51	Wrench for Pc. No. 8
5	Piston	28	Stud	52	Stud
6	Top Cap	29	Top Cap Gasket	53	Main Valve Guide Bushing
7	Bottom Cap	30	Bottom Cap Gasket	54	Diaphragm Disc
8	Controlling Valve Seat	31	Diaphragm Stem Guide	55	Steam Chamber
9	Adjusting Spring Case	32	Connector Union	56	Needle Valve Body
10	Crosshead	33	Connector Gland	57	Needle Valve Bonnet
11	Diaphragm Spacer	34	Connector Nut	58	Needle Valve Bonnet Nut
12	Diaphragm Chamber	35	Stud	59	Needle Valve Stem
13	Main Valve Guide	36	Stem	60	Needle Valve Stem Head
14	Controlling Valve	38	Gland	61	Needle Valve Body Gasket
15	Piston Ring	39	Gland Nut	62	Connecting Rod Guide
16	Top Spring Seat	40	Indicator Cap	63	Screw for Connecting Rod Guide
17	Bottom Spring Seat	41	Handwheel	64	Diaphragm
18	Adjusting Screw	42	Washer	65	Stud
19	Lock Nut	43	Indicator Plate	66	Nut
20	Connecting Rod	44	Nut		
21	Diaphragm Stem	45	Nut		
22	Diaphragm Stem Cap	48	Packing		
23	Cylinder Bottom	47	Packing		

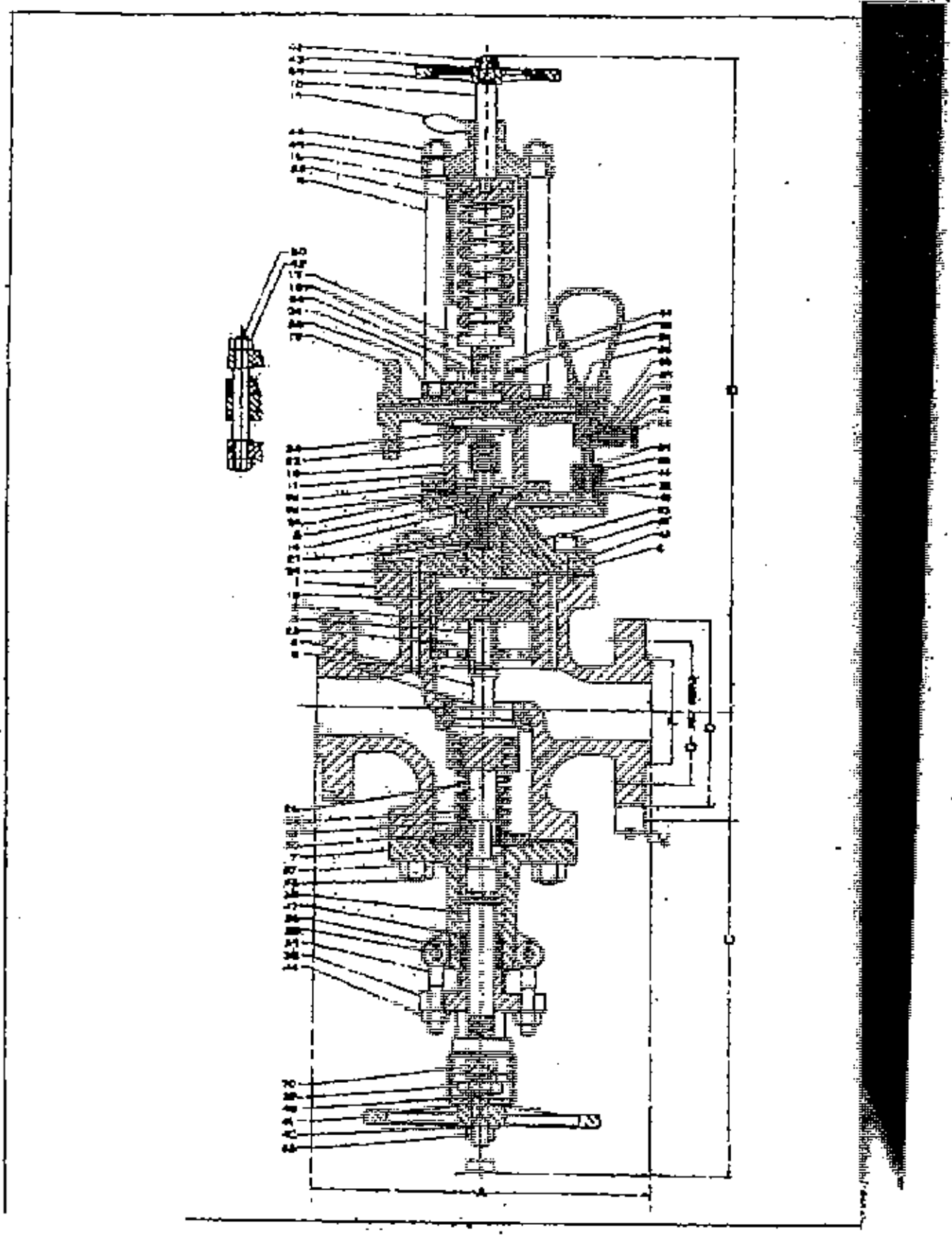
DIMENSIONS IN INCHES

Size	A	B	C	D	E	F	G	No. of Bolts	Bolt Size	Bolt Hole	Weight Lbs. Net
3/2"	8-1/2	15-7/8	10-1/2	3-3/4	9/16	1-3/8	2-5/8	4	1/2	5/16	61
3/4"	8-1/2	15-7/8	10-1/2	4-5/8	5/8	1-11/16	3-1/4	4	5/8	11/16	63
1"	8-1/2	15-7/8	10-1/2	4-7/8	11/16	2	3-1/2	4	5/8	11/16	65
1-1/4"	9	16-1/8	11	6-1/4	13/16	2-1/2	3-7/8	4	5/8	11/16	69
1-1/2"	9-1/2	19-1/2	11-3/8	6-1/8	7/8	2-7/8	4-1/2	4	3/4	13/16	79

LESLIE CO.
LYNDHURST, N.J.

1/2" to 1-1/2" PUMP GOVERNOR
NAVY TYPE CP, CLASS A
LESLIE CLASS PELNS

DATE 2-27-40
DWG. NO PNS-215



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	23	Cylinder Bottom	45	Main Valve Guide Bushing
2	Seat Ring	24	Diaphragm	46	Packing
3	Cylinder Liner	25	Adjusting Spring	47	Packing
4	Main Valve	26	Main Valve Spring	48	Dowel Pin
5	Piston	27	Controlling Valve Spring	49	Adjusting Spring Cover
6	Top Cap	28	Stud Bolt	50	Wrench for Po. No. 8
7	Bottom Cap	29	Top Cap Gasket	51	Wrench for Po. No. 9
8	Controlling Valve Seat	30	Bottom Cap Gasket	52	Packing
9	Column	31	Diaphragm Stem Guide	53	Plate
10	Crosshead	32	Connector Union	54	Steam Chamber
11	Diaphragm Spacer	33	Connector Gland	55	Needle Valve Body
12	Diaphragm Chamber	34	Connector Nut	56	Needle Valve Bonnet
13	Main Valve Guide	35	Stud	57	Needle Valve Bonnet Nut
14	Controlling Valve	36	Stem	58	Needle Valve Stem
15	Piston Ring	37	Bushing	59	Needle Valve Stem Head
16	Top Spring Seat	38	Gland	60	Needle Valve Body Gasket
17	Bottom Spring Seat	39	Nut	61	Diaphragm Disc
18	Adjusting Screw	40	Indicator Cap	62	Stud
19	Lock Nut	41	Handwheel	63	Nut
20	Connecting Rod	42	Washer		
21	Diaphragm Stem	43	Indicator Plate		
22	Diaphragm Stem Cap	44	Nut		

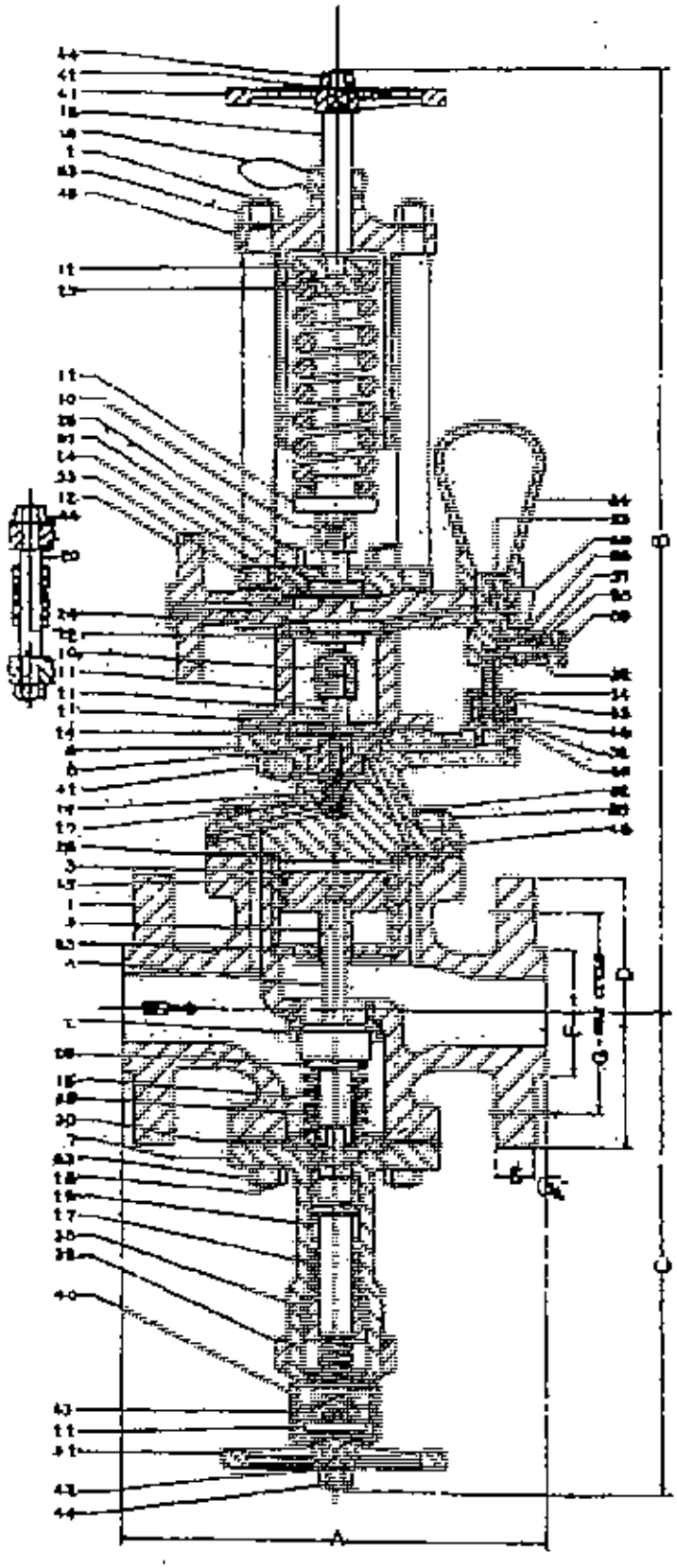
DIMENSIONS IN INCHES

Size	A	B	C	D	E	G	C	No. of Bolts	Bolt Size	Nut Hole	Weight Lbs. Net
1/2"	8-1/2	20-1/2	10-1/2	3-3/4	9/16	1-3/8	2-5/8	4	1/2	9/16	62
3/4"	8-1/2	20-1/2	10-1/2	4-5/8	5/8	1-11/16	3-1/8	4	5/8	11/16	64
1"	8-1/2	20-1/2	10-1/2	4-7/8	11/16	2	3-1/2	4	5/8	11/16	66
1-1/4"	9	20-3/4	11	6-1/4	15/16	2-1/2	3-7/8	4	5/8	11/16	70
1-1/2"	9-1/2	21-1/8	11-3/8	6-1/8	7/8	2-7/8	4-1/2	4	3/4	15/16	80

LESLIE CO.
LYNDHURST, N.J.

1/2" to 1-1/2" PUMP GOVERNOR
TYPE CP, CLASS A
LESLIE CLASS CTHRS

DATE 3-29-40
DWN. CHKD.
DWG. NO. PHS-216



PARTS LIST

No.	Name	No.	Name	No.	Name
1	Main Body	25	Adjusting Spring	49	Adjusting Spring Cover
2	Seat Ring	26	Main Valve Spring	50	Wrench for Pc. No. 2
3	Cylinder Liner	27	Controlling Valve Spring	51	Wrench for Pc. No. 8
4	Main Valve	28	Stud Bolt	52	Packing
5	Piston	29	Top Cap Gasket	53	Plate
6	Top Cap	30	Bottom Cap Gasket	54	Steam Chamber
7	Bottom Cap	31	Diaphragm Stem Guide	55	Pin
8	Controlling Valve Seat	32	Connector Union	56	Cotter Pin
9	Column	33	Connector Gland	57	Nut
10	Crosshead	34	Connector Nut	58	Needle Valve Body
11	Diaphragm Spacer	35	Stud	59	Needle Valve Bonnet
12	Diaphragm Chamber	36	Stem	60	Needle Valve Bonnet Nut
13	Main Valve Guide	37	Bushing	61	Needle Valve Stem
14	Controlling Valve	38	Gland	62	Needle Valve Stem Head
15	Piston Ring	39	Eyebolt	63	Needle Valve Body Gasket
16	Top Spring Seat	40	Indicator Cap	64	Diaphragm Disc
17	Bottom Spring Seat	41	Handwheel	65	Main Valve Guide Bushing
18	Adjusting Screw	42	Washer	66	Stud
19	Lock Nut	43	Washer	67	Nut
20	Connecting Rod	44	Nut	68	Nut
21	Diaphragm Stem	45	Nut	69	Handwheel
22	Diaphragm Stem Cap	46	Packing	70	Indication Plate
23	Cylinder Bottom	47	Packing		
24	Diaphragm	48	Dowel Pin		

DIMENSIONS IN INCHES

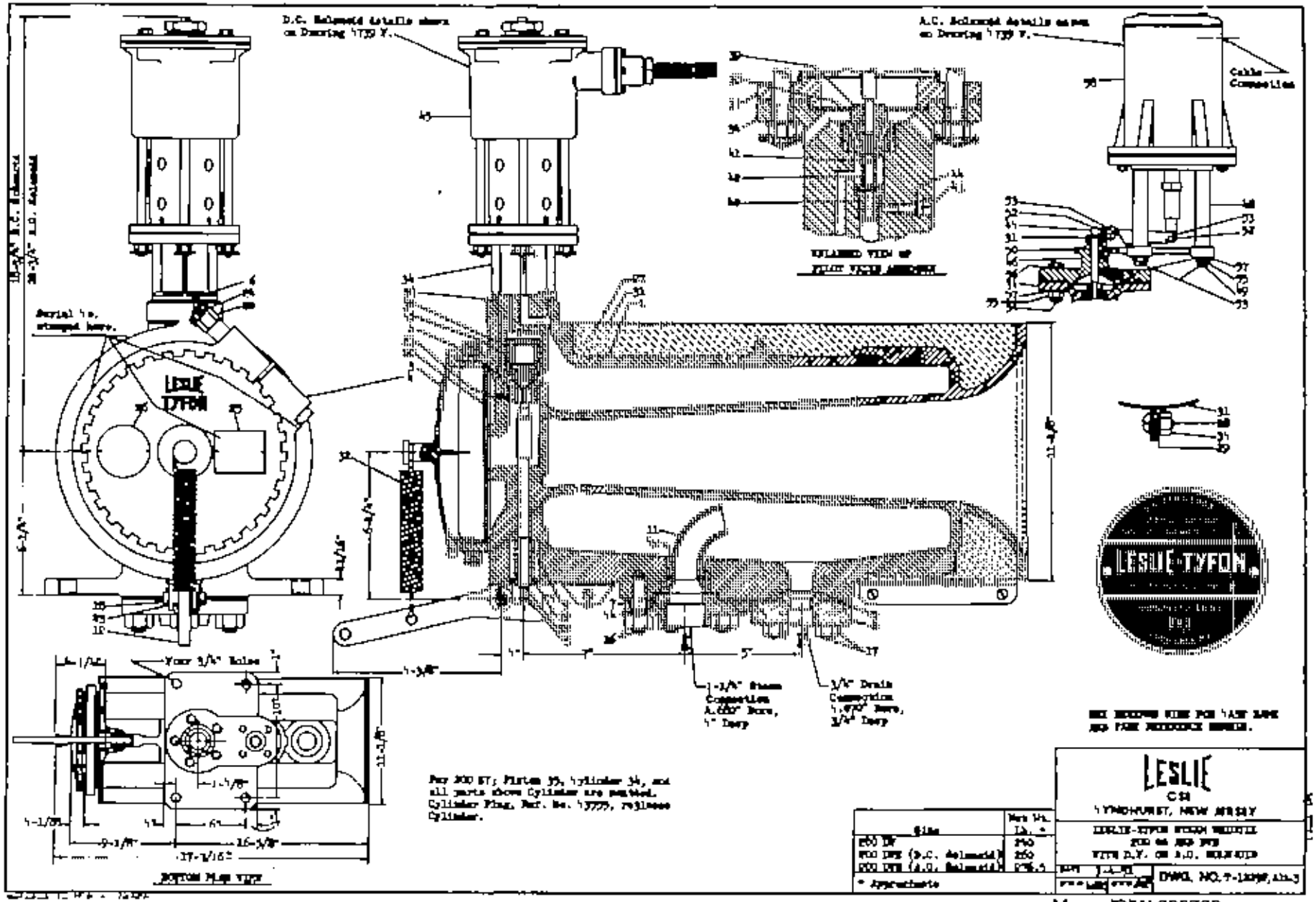
Size	A	B	C	D	E	F	G	No. of Bolts	Bolt Size	Bolt Hole	Weight Lbs. Net
2"	11-1/2	22-5/16	15-5/8	6-1/2	1	3-5/8	5	8	5/8	11/16	126
2-1/2"	13	22-13/16	17-3/4	7-1/2	1-1/8	4-1/8	5-7/8	8	3/4	13/16	176

LESLIE CO.
LYNDHURST, N.J.

2" to 2-1/2" PUMP GOVERNOR
TYPE CP, CLASS A
LESLIE CLASS CP6S

DATE 3-28-40
DWN. BEAR. CH'D.
DWG. NO. PNS-217


LESLIE
TYRONE



Size	Net Wt. Lb. *
250 DW	240
300 DWS (D.C. Solenoid)	250
300 DWS (A.C. Solenoid)	275.5

* Approximate

ManualBIW-000769

WHEN ORDERING PARTS, GIVE SIZE, CLASS, PART NAMES AND PART REFERENCE NUMBERS FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - LESLIE-TYFON STEAM WHISTLE
DRAWING NO. 7-1229 F, CLASS 200 DV and 200 DVE, COMPLETE WITH D.C. OR A.C. SOLENOIDS

Part No.	Part Name	Material	Size & Reference Number		
			200 DV	200 DV D.C. Solenoid	200 DVE A.C. Solenoid
1	* Body (NOTE 1)	Cast Bronze	14015	14015	14015
2	* Seal Ring	Stainless Steel, Stellited	13529	11529	11529
3	* Back Cover	Cast Bronze	13818	13818	13818
4	* Lock Ring	Cast Steel	13517	11517	11517
5	* Main Valve 75-150 psi Operating Pressure	Stainless Steel, Stellited	13551B	11552B	13552B
5	* Main Valve 150-300 psi Operating Pressure	Stainless Steel, Stellited	13551A	13552A	13552A
6	* Lock Bolt	Steel	11549	11549	11549
7	* Flange, Inlet	Forged Steel	13541A	13541A	11541A
8	* Flange, Drain	Forged Steel	16215	16215	16235
9	* Main Valve Spring	Corrosion Resistant Alloy	12932	12932	12932
10	* Diaphragm (NOTE 2)	Phosphor Bronze	11091	11091	11091
11	* Nozzle	Cast Bronze	13548	13548	13548
12	* Lever	Cast Bronze	13520	11520	11520
13	* Lock Screw, Nozzle	Steel	13672	11672	13672
14	* Gasket, Inlet	Copper, Asbestos Filled	13541	13541	11544
15	* Gasket, Drain	Copper, Asbestos Filled	16232	16232	16232
16	* Stud and Nut	Steel	9395	9395	9395
17	* Stud and Nut	Steel	15868	15868	15868
18	* Lever Pin	Monel	13554	13554	11554
19	* Spring Seat	Brass	11530	11130	11510
20	* Nut (Lock Bolt)	Steel	13550	13550	13550
21	* Lock Screw, Seal Ring	Steel	12405	12405	12405
22	* Cotter Pin	Monel	7078	7078	7078
23	* Cotter Pin	Monel	7080	7080	7080
24	* Cotter Pin	Monel	10308	10308	10308
25	* Name Plate	Brass	9806	9806	9806
26	* Data Plate	Brass	14292	14292	14292
27	* Insulation	Asbestos	13556	13556	13556
28	* Screw	Brass	9793	9791	9791
29	* Lock Washer	Steel	10397	10397	10397
10	* Gasket	Copper	3472	3872	3472
11	* Bheel Cover	Galvanized Iron	13551	13551	11551
32	* Lever Spring	Corrosion Resistant alloy	16748	16748	16748
11	* Nut	Brass	9734	9734	9714
14	Cylinder Plug	Cast Bronze	11555	- -	- -
31	Cylinder, Complete (NOTE 3)	Cast Bronze	- -	22779	22779
35	Piston	Cast Bronze	- -	13931	13931
16	Piston Rings (NOTE 4)	Cast Iron	- -	1150	1350
37	Lock Flange	Cast Bronze	- -	12274	12274
38	Lock Disc	Phosphor Bronze	- -	10511	10511
39	Pilot Valve Seal, Upper	Stainless Steel	- -	10382	10382
40	Pilot Valve Seal, Lower	Stainless Steel	- -	10508	10508
41	Pilot Valve	Stainless Steel, Hardened	- -	10236	10216
42	Pilot Valve Spring	Corrosion Resistant Alloy	- -	9817	9817
13	Lock Screw	Steel	- -	10509	10509
44	Gasket, Lock Screw	Copper, Annealed	- -	12275	12275
45	Solenoid, 110 Volt D.C.		- -	9910	- -
45	Solenoid, 220 Volt D.C.		- -	9910A	- -
45	Solenoid, 32 Volt D.C.		- -	9910B	- -
45	Solenoid, 48 Volt D.C.		- -	9910C	- -
46	Bracket	Cast Bronze	- -	- -	12408
47	Lever	Cast Bronze	- -	- -	12411
48	Spacer Tube	Brass	- -	- -	12451
49	Spacer Stud	Steel, Cadmium Plated	- -	- -	11030
50	Push Rod	Monel	- -	- -	12452
51	Push Rod Cap	Brass	- -	- -	12451
52	Lever Pin	Monel	- -	- -	10541
53	Cotter Pin	Monel	- -	- -	7113
54	Bolt	Steel, Cadmium Plated	- -	- -	12456
55	Nut, Castellated	Monel	- -	- -	10387
56	Washer	Brass	- -	- -	10546
57	Lock Washer	Steel, Nickel Plated	- -	- -	10392
58	Solenoid, 110 Volt A.C.		- -	- -	8711
58	Solenoid, 220 Volt A.C.		- -	- -	8711A
58	Solenoid, 440 Volt A.C.		- -	- -	8711B
	D.C. Solenoid, Complete with Bracket		- -	- -	5520
	* Spanner Wrench	Steel	9803	9803	9803
	* Seal Ring Wrench	Malleable Iron	11721	13721	13721
	Pilot Valve Seal Wrench	Malleable Iron	- -	9016	9016

* These items have same Reference Number in all lines indicating complete interchangeability.

NOTE 1 - Body is furnished complete with Stud and Nuts, Ref. No. 9395 and Ref. No. 15868.

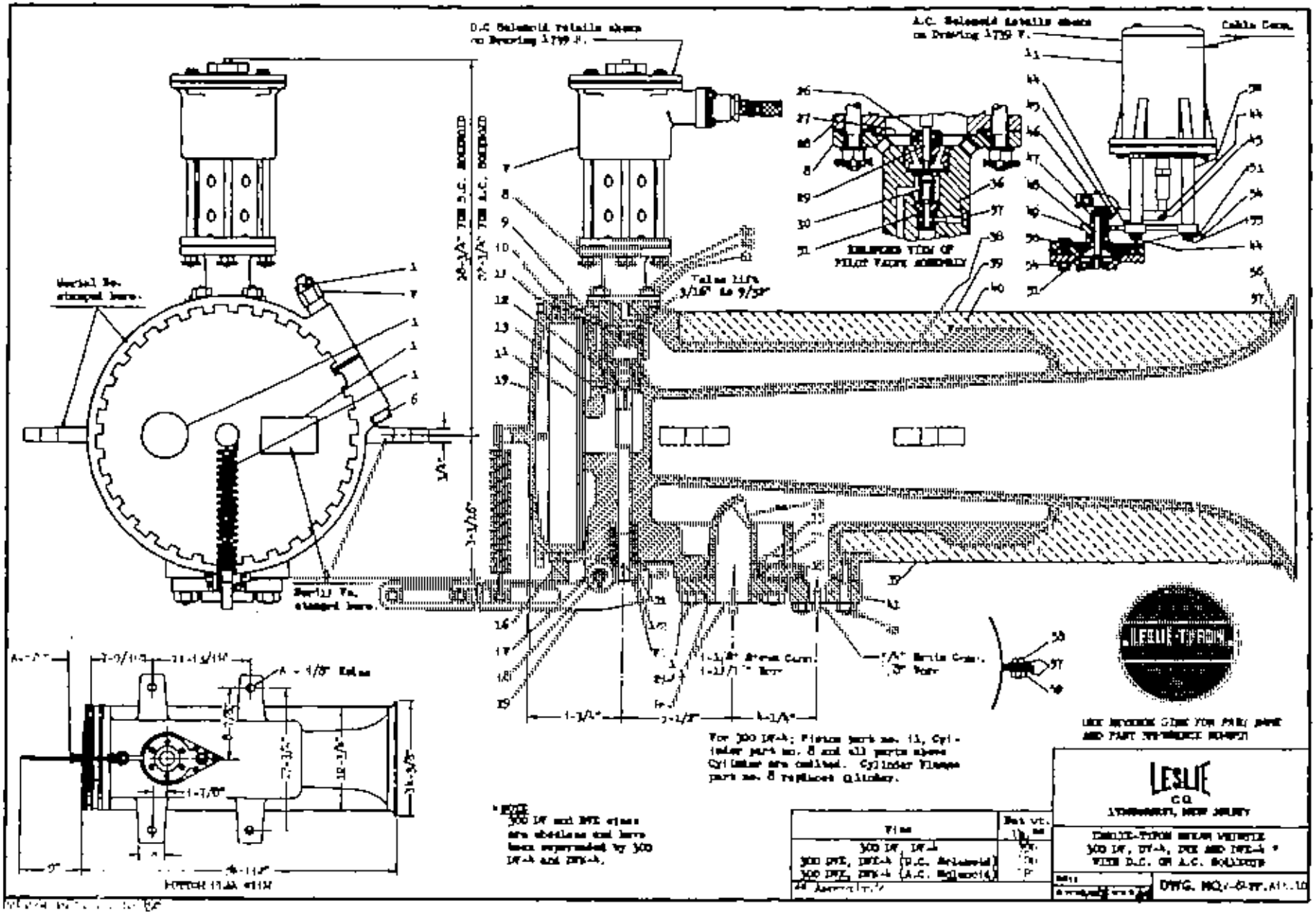
NOTE 2 - Two Diaphragms required for 50-125 Lbs. Operating Pressure; Three Diaphragms for 125-300 Lbs. Operating Pressure.

NOTE 3 - Cylinder is furnished complete with Pilot Valve Seal, Lower, Ref. No. 10508; Lock Screw, Ref. No. 10509; Lock Screw Gasket, Ref. No. 12275 and Cylinder, Ref. No. 13912.

NOTE 4 - Two Piston Rings required per Piston.

FOR ALL CLASSES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE SIZE, CLASS AND SERIAL NUMBER OF

ManualBW-000770



ManualBIW-000771

PART NUMBERS, PART, CAST CODE, CLASS, PART NAME AND PART INTERCHANGE NUMBER FROM TABLE BELOW
USE LAST NUMBER ONLY TO ORDER. USE ALL NUMBERS

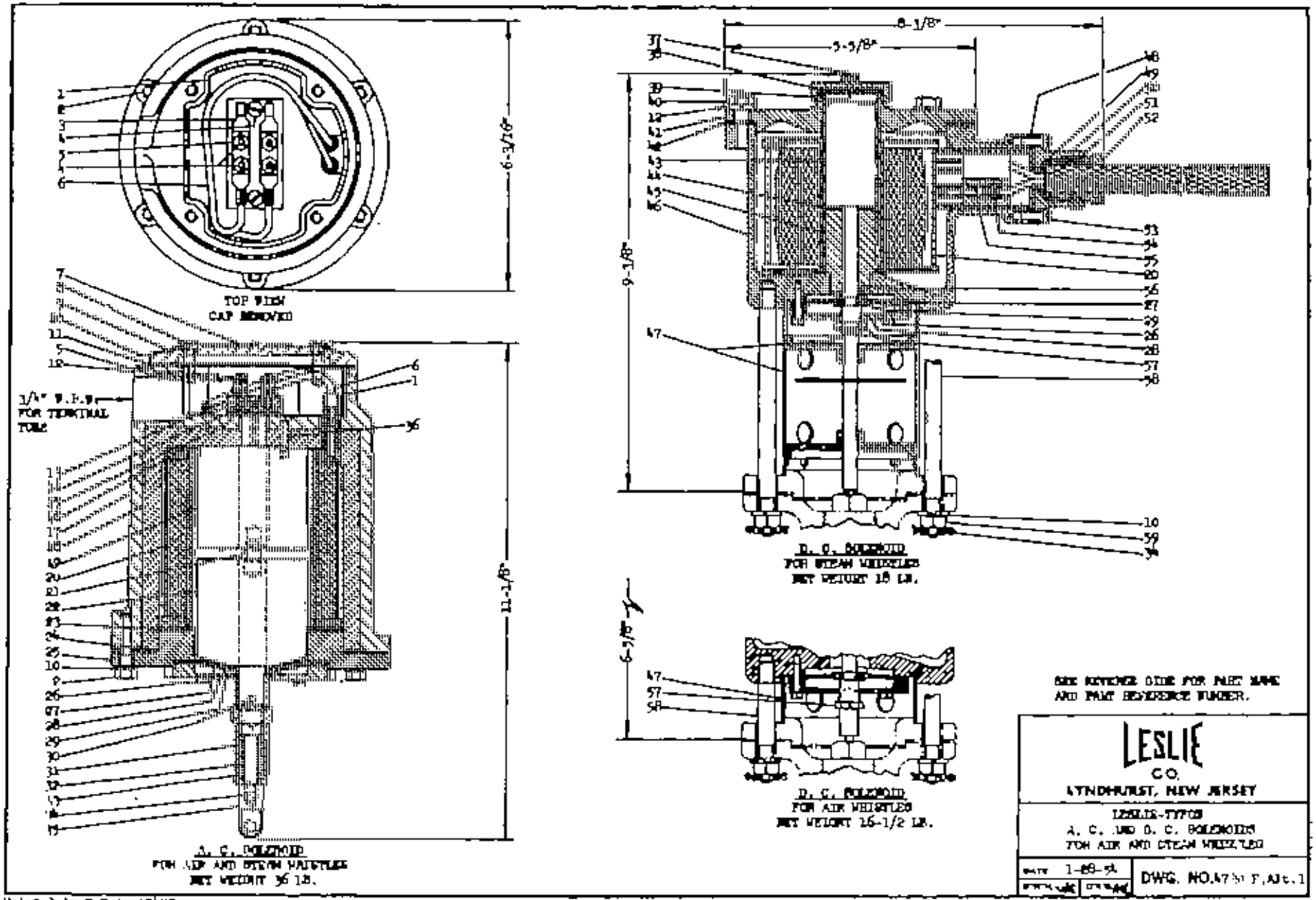
PART NUMBER AND PART INTERCHANGE NUMBERS - 11 MILLIMETER GATEWAY VEHICLE
(EXCEPTION (S), 3-WAY, 3/4 (M), 90 DEG. AND 300 DEG. (CONTACT WITH L.O. OR A.C. SOLENOIDS

PART NAME	MATERIAL	USE & REFERENCE NUMBER		
		300 D.C.	300 D.C. (D.C. SOLENOID)	300 D.C. (A.C. SOLENOID)
* Bonnet Assy.	Metal	7231	7231	7231
* Body Seat Ring	Steel	12090	12090	12090
* Body Plug	Steel	9866	9866	9866
* Body Assembly	Brass	14249	14249	14248
* Body Assembly	Corrosion Resistance Alloy	16086	16086	16086
* Body Assembly	Stainless Steel	12092	12092	12092
Solenoid, 110 Volt D.C.		- -	9930	- -
Solenoid, 220 Volt D.C.		- -	26104	- -
Solenoid, 24 Volt A.C.		- -	99108	- -
Solenoid, 24 Volt D.C.		- -	99106	- -
Body Plug (NOTE 4)	Cast Bronze	21244	- -	- -
Body Seat Ring (NOTE 3 & 5)	Cast Bronze	- -	22781	22781
Bonnet (NOTE 2)	Copper, Asbestos Filled	21240	21240	21240
Bonnet (NOTE 2)	Cast Iron	- -	1356	1356
Bonnet	Cast Bronze	- -	11297	11297
* Body Plug, 1/2" Dia. Operating Pressure	Stainless Steel (NOTE 1)	9756	1446	9756
* Body Plug, 1" Dia. and above Operating Pressure	Stainless Steel (NOTE 1)	13211	13211	13211
* Body Plug, 1" Dia. and above Operating Pressure	Steel	12405	12404	12405
* Bonnet (NOTE 1)	Phosphor Bronze	11452	11452	11452
* Bonnet	Cast Bronze	12016	12016	12016
* Bonnet	Cast Steel	12459	14456	12459
* Body Plug	Monel	7972	7972	1091
* Body Plug	Monel	9781	9781	9781
* Body Seat Ring	Cast Bronze	13897	13897	13897
* Body Plug, 1/2" Dia. Operating Pressure	Corrosion Resistant Alloy	9421	9422	9421
* Body Plug (1") and above 100 lb. Operating Pressure	Corrosion Resistant Alloy	10961	10961	10961
* Body Plug	Brass	9779	9779	9779
* Body Plug, 1/2" Dia. 16 lb. Operating Pressure	Monel	7269	7269	7269
* Body Valve Plug, 3/4" - 300 lb. Operating Pressure	Stainless Steel (NOTE 3)	122808	122808	122808
* Body Valve Plug, 1" - 300 lb. Operating Pressure	Stainless Steel (NOTE 1)	132148	132148	132148
* Body Plug, 1/2" - 1/2" Dia. Operating Pressure	Stainless Steel (NOTE 3)	132142	132142	132142
* Body Plug, 3/4" - 1" Dia. Operating Pressure	Stainless Steel (NOTE 1)	132142	132142	132142
* Body Plug, 3/4" - 1" Dia. Operating Pressure	Stainless Steel (NOTE 3)	132148	132148	132148
* Piston Assy.	Formed Steel	9818	9818	9818
* Piston Rod	Steel	11106	11106	11106
Lever, Valve Stem, Upper	Stainless Steel	- -	10382	10382
Lever, Valve	Phosphor Bronze	- -	10511	10511
Lever, Valve	Cast Bronze	- -	12274	12274
Lever, Valve	Stainless Steel, Hardened	- -	10836	10836
Lever, Valve Stem	Corrosion Resistant Alloy	- -	9817	9817
Lever, Valve Stem, Lever	Stainless Steel	- -	10508	10508
Lever, Valve	Cast Bronze	9711	9711	9711
Lever, Valve Handle	Steel	13178	13178	13178
Handle, Valve	Copper, Asbestos Filled	9754	9754	9754
Handle, Valve	Copper, Asbestos Filled	9755	9755	9755
Valve Stem, Lever	Copper, Asbestos	- -	13577	13577
Valve Stem	Stainless Steel	- -	10509	10509
Valve Stem (NOTE 4)	Cast Bronze	21092	21092	21092
* Valve Stem, Upper	Galvanized Steel Pipe	9788	9788	9788
* Valve Stem, Lower	Galvanized Steel Pipe	9789	9789	9789
* Valve Stem	Aluminum	10018	10018	10018
* Valve Body	Cast Steel	11870	11870	11870
* Valve Stem	Steel	1:8684	1:8684	1:8684
* Valve Stem, 1/2" Dia.		- -	- -	8732
* Valve Stem, 1/2" Dia.		- -	- -	87319
* Valve Stem	Monel	- -	- -	7213
Valve Stem (NOTE 1)	Monel	- -	- -	13563
Valve Stem (NOTE 1)	Cast Bronze	- -	- -	12411
Valve Stem (NOTE 1)	Bronze	- -	- -	12454
* Valve Seat	Monel	- -	- -	14266
* Valve Seat	Cast Bronze	- -	- -	12464
* Valve Seat	Bronze	- -	- -	14266
* Valve Seat	Steel, Cadmium Plated	- -	- -	12450
* Valve Seat	Steel	- -	- -	12464
* Valve Seat	Steel, Nickel Plated	- -	- -	14302
* Valve Stem Guide	Monel	- -	- -	10757
* Valve Stem Guide	Stainless Steel	- -	- -	114635
* Valve Stem Guide	Bronze	9793	9793	9793
* Valve Body	Steel	10391	10391	10391
* Valve Body	Bronze	12299	12299	12299
* Valve Body	Bronze	9778	9778	9778
* Valve Body	Steel	9465	9461	9465
* Valve Body Assembly	Steel	10513	10513	10511
* Valve Body	Stainless Steel	27488	27488	27585
Valve Body Cap, Less Seat with Bracket		- -	- -	3520
Valve Assembly, Complete with Bracket and Cylinder (NOTE 1)		- -	- -	21247
Valve Assembly, Complete with Cylinder (NOTE 1)		- -	21248	- -
* Valve Body Assembly, Rated 75 Lbs. Operating Pressure	Steel	9804	9804	9804
* Valve Body Assembly, 75 Lbs. and above Operating Pressure	Malleable Iron	9961	9961	9961
* Valve Body Assembly	Malleable Iron	13542	13542	13542
* Valve Body Assembly	Malleable Iron	9936	9936	9936

* Indicates Stock Item Carried by Distributors in all sizes, indicating complete interchangeability.
(1) Recommended for 75 lbs. Operating Pressure; Three Diaphragms for 125-300 lbs. Operating Pressure.
(2) Bonnet Assembly Required for Repair.
(3) Valve Seat Ring Must Be Ordered for Installation Requiring Interchangeability.
(4) Body Plug and Valve Seat Ring Must Be Ordered as Matched Set for Replacement Purposes.
(5) Use 3/4" Bonnet, Complete, Part No. 29782; 300 lb. Cylinder Plug, Ref. No. 29781; Cylinder Gasket, Ref. No. 45810; Cylinder Head, Ref. No. 45808; O.C. Bracket Complete with Bracket and Coil Screw, Ref. No. 29787; and Coil, Solenoid, Complete with Gasket, Ref. No. 29811.
NOTE: Valve Body Assembly Part No. 14, Plug (Valve Stem, Lower, Ref. No. 10405; Part No. 47, Lever Arm, Ref. No. 40349; Part No. 30, Valve Gasket, Ref. No. 29775 and Cylinder Plug, Ref. No. 29781.
(6) Use Body Assembly Part No. 1 (Valve Body Cap Screw, Ref. No. 29819; Body, Ref. No. 29820; Gasket Set, Ref. No. 29827 and Cylinder Plug, Ref. No. 29781.

ALL PARTS PRINTED LIKE THIS, WHEN ORDER IMPORTANT BY MAIL OR PHONE ARE REQUIRED EXACTLY, EITHER NUMBER OR TYPE.

ManualBW-000772



Printed in U.S.A. 15M5C

ManualBIW-000773

WHEN ORDERING PARTS, GIVE TYPE, VOLTAGE, PART NAME AND PART REFERENCE NUMBERS FROM CABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - LESLIE-CLYTON A. C. AND D. C. SOLENOIDS
DRAWING NO. 4739 F, AIR AND STEAM WHISTLES

PART NO.	PART NAME	MATERIAL	DIRECT CURRENT		ALTERNATING CURRENT
			AIR WHISTLES	STEAM WHISTLES	AIR AND STEAM WHISTLES
1	Insulation Strip	Varnished Cambric	- -	- -	10502
2	Bolt, Base	Steel, Cadmium Plated	- -	- -	11843
3	Terminal Lugs	Copper	- -	- -	10635
4	Screw	Brass	- -	- -	10518
5	Nut	Brass	- -	- -	10632
6	Coil Lead, Complete	Vinylite Coated Wire	- -	- -	13105
7	Data Plate	Brass	- -	- -	10635
8	Screw	Brass	- -	- -	10530
9	Cap	Cast Bronze	- -	- -	10519
10	Lock Washer	Steel, Nickel Plated	10392	10392	10397
11	Gasket, Cap	Sheet Rubber	- -	- -	10522
12	Lock Washer	Steel, Nickel Plated	13077	13077	- -
12	Lock Washer	Steel	- -	- -	10634
13	Terminal Base	Bakelite	- -	- -	10629
14	Insulating Pad	Bakelite	- -	- -	10631
15	Insulation Plate	Varnished Cambric	- -	- -	10081
16	Coil Gasket	Varnished Cambric	- -	- -	10523
17	Casing	Cast Bronze	- -	- -	23889
18	Magnetic Casing	Cast Semi-Steel	- -	- -	23838
19	Core	Laminated Iron	- -	- -	10528
21	Coil, Complete 115 Volt	Magnet Wire	9907	9907	10520
20	Coil, Complete 220 Volt	Magnet Wire	9907A	9907A	10520A
20	Coil, Complete 32 Volt	Magnet Wire	9907B	9907B	- -
20	Coil, Complete 48 Volt	Magnet Wire	9907C	9907C	- -
20	Coil, Complete 440 Volt	Magnet Wire	- -	- -	10520D
21	Guide Pin	Phosphor Bronze	- -	- -	10633
22	Plunger	Laminated Iron	- -	- -	10529
23	Gasket	Varnished Cambric	- -	- -	11895
24	Gasket	Sheet Rubber	- -	- -	10521
25	Base	Cast Steel	- -	- -	10517
26	Screw	Steel, Cadmium Plated	10532	10532	10532
27	Diaphragm	Synthetic Rubber	11267	11267	10521
28	Diaphragm Cover	Cast Bronze	11266	11266	10551
29	Washer, Diaphragm	Brass	11270	11270	10533
30	Guide Pin	Monel	- -	- -	10308
31	Connecting Spring	Stainless Steel	- -	- -	10537
32	Connecting Screw	Monel	- -	- -	10535
33	Connecting Bushing	Brass	- -	- -	10534
34	Cotter Pin	Monel	7113	7113	7113
35	Connecting Screw Head	Monel	- -	- -	10536
36	Screw	Iron	- -	- -	11804
37	Cap Nut	Brass	11262	11262	- -
38	Disc	Phosphor Bronze	11263	11263	- -
39	Packing	Sheet Rubber	11264	11264	- -
40	Cap Screw	Stainless Steel	21610	21610	- -
41	Top Plate	Cast Semi-Steel	12834	12891	- -
42	Gasket	Sheet Rubber	12836	12836	- -
43	Core, Plunger	Soft Iron, Cadmium Plated	11256	11258	- -
44	Washer	Phosphor Bronze	11279	11279	- -
45	Magnet	Soft Iron, Cadmium Plated	11259	11259	- -
46	Guard Cylinder	Malleable Iron	12828	12828	- -
47	Spacer, Complete	Brass	11273	11109	- -
48	Gasket	Sheet Rubber	11274	11274	- -
45	Washer	Sheet Rubber	11146	11446	- -
50	Connecting Box Cover	Cast Bronze	11273A	11273A	- -
51	Packing	Flax Yarn	15858	15858	- -
52	Packing Ring Nut	Brass	11124A	11124A	- -
53	Screw	Brass	11268	11268	- -
54	Connecting Screw	Brass	11289	11289	- -
55	Insulation Tubing	Sheet Rubber	11281	11281	- -
56	Stem	Phosphor Bronze	11269	11269	- -
57	Stem Nut	Brass	11271	11405	- -
58	Stud	Stainless Steel	11402A	11402A	- -
59	Nut, Castellated	Monel	10587	10587	- -

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER AND INCLUDE SERIAL NUMBER OF TYPON.

ManualBIW-000774

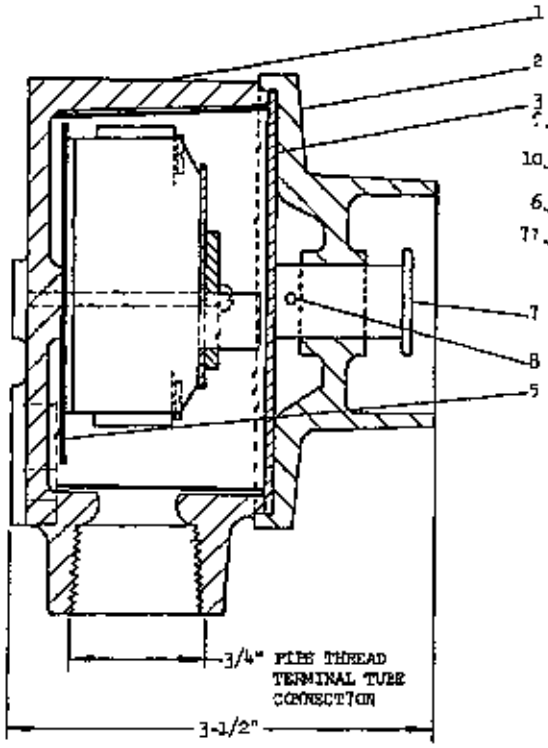
WHEN ORDERING PARTS, GIVE PART NAMES AND PART REFERENCE NUMBERS FROM TABLE BELOW
USE PART NUMBERS ONLY TO IDENTIFY PART ON DRAWING

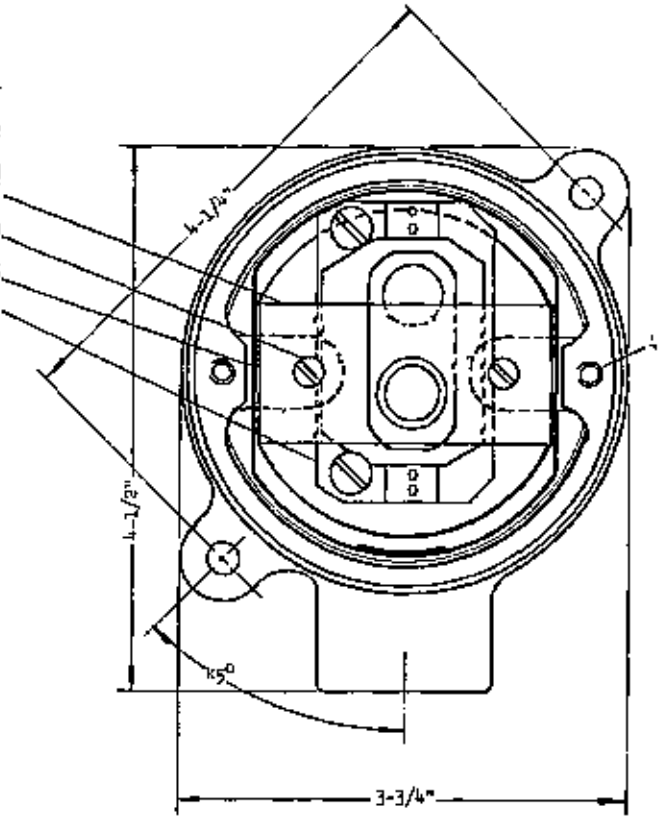
PART NAMES AND PART REFERENCE NUMBERS - PUSH BUTTON SWITCH
FOR DIRECT AND ALTERNATING CURRENT

Part Number	Part Name	Material	Reference Number
1	Body	Cast Bronze	74-51
2	Cover	Cast Bronze	73-57
3	Gasket, Diaphragm	Gum Rubber	41[illegible]
4	Screw (NOTE 1)	Steel, Cadmium Plated	17[illegible]
5	Insulation Washer	Varnish Cambric	134-[illegible]
6	Insulation	Varnish Cambric	14[illegible]
7	Push Button	Brass	73-[illegible]
8	Cotter Pin	Brass	12-[illegible]
9	Panel Clamp Block	Bakelite	31[illegible]
10	Screw	Brass	17[illegible]
11	Switch, Toggle		7709[illegible]
	Push Button Switch, Complete		7795[illegible]

NOTE 1 - Screw not shown on drawing.

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER





END VIEW - COVER REMOVED

WEIGHT COMPLETE OF PUSH BUTTON SWITCH - 5 LB.

LESLIE CO.
TYNDHURST, NEW JERSEY

LESLIE-TYPE
PUSH BUTTON SWITCH
FOR DIRECT AND ALTERNATING CURRENT

DATE 9-15-33 DWG. No. [illegible] Sht. 7, Alt.

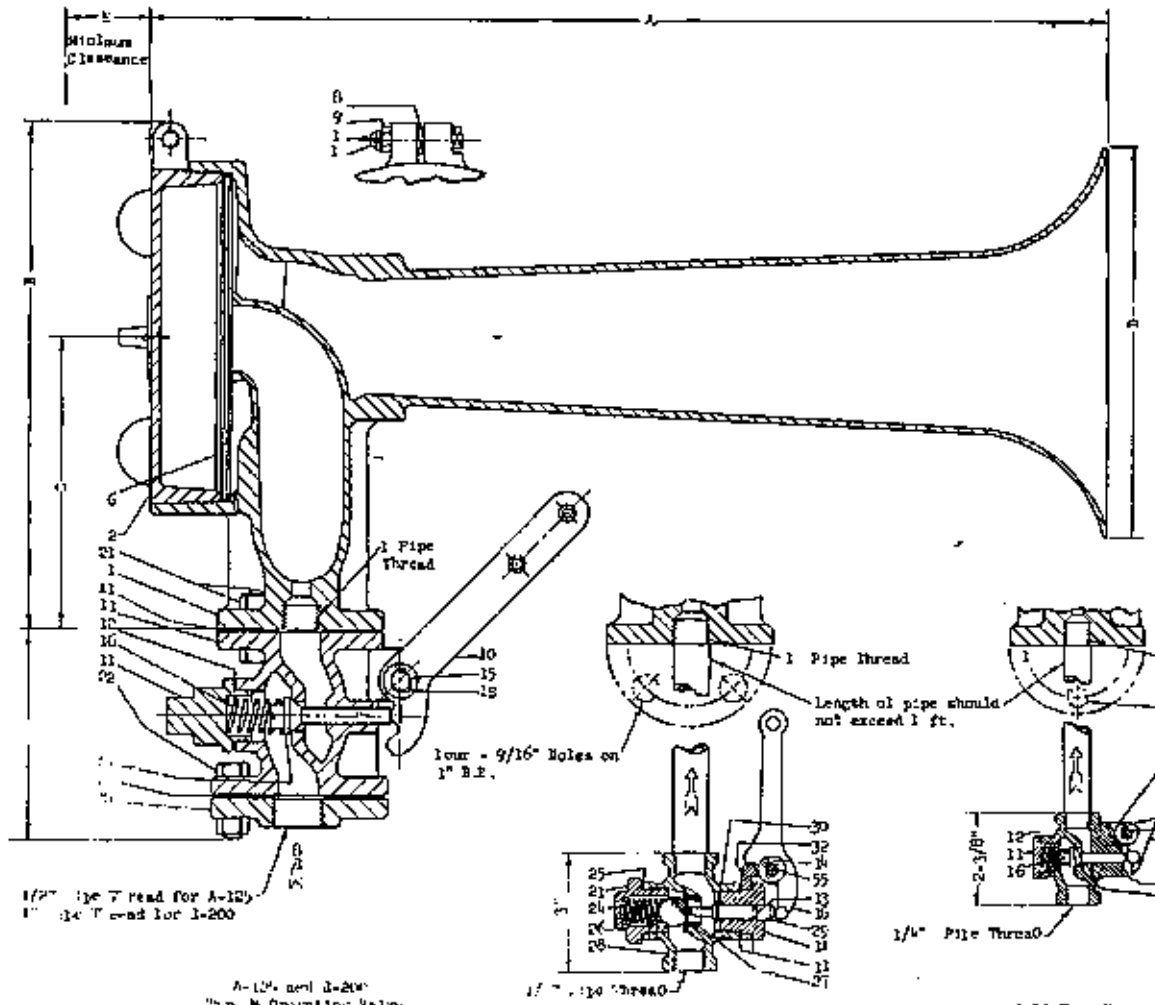
Manual [illegible]

Printed in U.S.A. 95350

DIMENSIONS IN INCHES

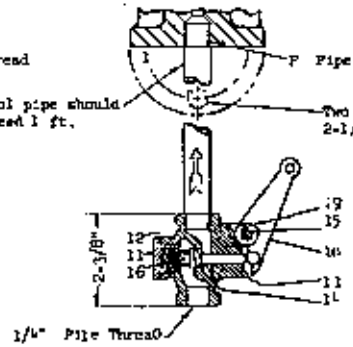
Size	Former Size	A	G	C	D	E	F	Net Wt. Lb. *
A-15-144-MB	A-15-B	10-3/8	5-1/16	2-3/4	3-1/2	1	1/4	6
A-15-330-MB	A-15-L	16-11/16	5-1/16	2-1/8	5-1/16	1	1/4	10
A-75-262-MB	A-75-LL	20-21/32	5-1/16	2-3/8	5-7/16	3	1/4	11
A-125-241-MB	A-125-L	19-1/4	8-1/8	4-1/4	6-5/8	4	1/2	23
A-125-206-MB	A-125-LL	23	8-1/8	1-1/8	6-5/8	4	1/2	24
A-200-213-MB	A-200-H	18-11/32	12-1/16	1-1/32	9-7/8	5	1/2	51
A-200-156-MB	A-200-L	24-29/32	12-5/16	7-1/32	9-2/8	5	1/2	55

* Approximate, does not include operating valve.



A-125 and A-200
Type M Operating Valve
for Marine service
Net weight [illegible] lb. approx.

A-125 and A-200
Type H-1 Operating Valve
for Industrial service
Net weight 2 lb. approx.



A-11 Type M
Operating Valve for Marine and Industrial service
Net weight 2 lb. approx.

LESLIE-TYFON

SEE REVERSE SIDE FOR PART NAME AND PART REFERENCE NUMBER.

LESLIE CO.
LYNDHURST, NEW JERSEY

LESLIE-TYFON CONTROL
A-[illegible], A-125 AND A-200
COMPLETE LINE OPERATING VALVE
FOR MARINE AND INDUSTRIAL SERVICE

DWG. NO. 35[illegible] F,III.1

Printed in U.S.A. 10-1/2

ManualBIW-000776

WHEN ORDERING PARTS, GIVE SIZE, CLASS, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING.

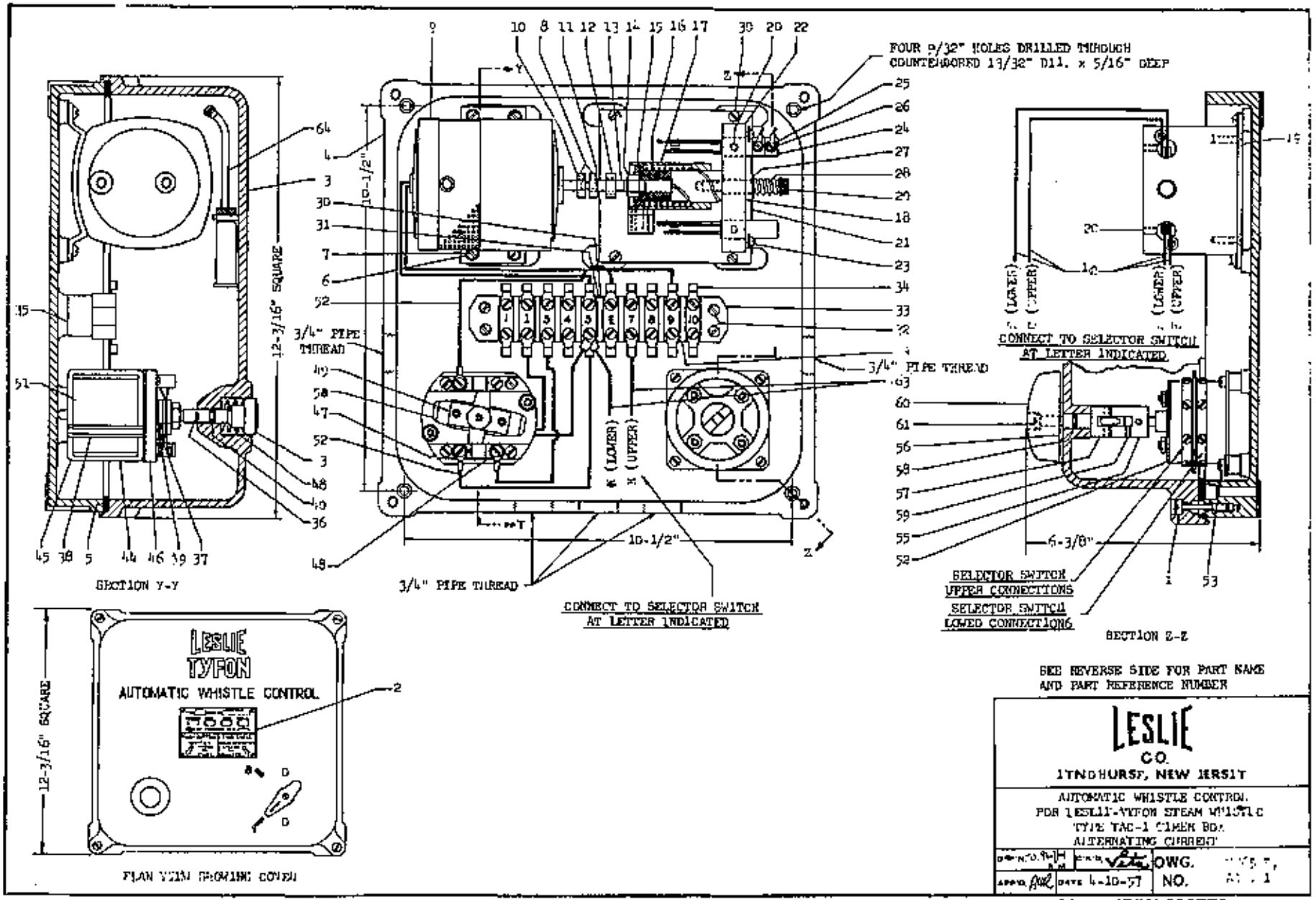
DRAWING NO. 3570 F, PART NAMES AND PART NUMBERS : MATERIAL - LESLIE-TYPON VALVES

Part No.	Part Name	Material	Size & Reference Number A-75	A-125	A-200
		AIR WORK ONLY - MARINE AND INDUSTRIAL			
1	Diaphragm Housing, Complete A-75-440-MB	Cast Bronze	19450	- -	- -
1	Diaphragm Housing, Complete A-75-330-MB	Cast Bronze	19451	- -	- -
1	Diaphragm Housing, Complete A-75-262-MB	Cast Bronze	19452	- -	- -
1	Diaphragm Housing, Complete A-125-241-MB	Cast Bronze	- -	19453	- -
1	Diaphragm Housing, Complete A-125-206-MB	Cast Bronze	- -	19454	- -
1	Diaphragm Housing, Complete A-200-233-MB	Cast Bronze	- -	- -	19481
1	Diaphragm Housing, Complete A-200-156-MB	Cast Bronze	- -	- -	19455
2	Rack Screw	Cast Bronze	10376	10385	10361
4	Lock Bolt	Monel	10317	10386	10386
6	Diaphragm (NOTE 1)	Phosphor Bronze	11090	11086	11091
7	Cotter Pin	Monel	7113	1080	7080
8	Lock Washer	Steel, Plated	10197	10192	10392
9	Nut (Castellated)	Monel	10378	10381	10387
		MANUAL OPERATING VALVE - TYPE M			
10	Lever	Cast Bronze	9940	9702	9702
11	Bottom Cap	Cast Bronze	1295	18886	18886
12	Bottom Cap Gasket	Copper	3690	3692	3692
14	Valve Body	Cast Bronze	9939	18884	18884
14	Valve	Phosphor Bronze	9941	18885	18885
15	Lever Pin	Monel	9942	9731	9731
16	Spring	Phosphor Bronze	9944	18604	18604
17	Gasket (Outlet)	Sheet Packing	- -	10094	10094
18	Gasket (Inlet)	Sheet Packing	- -	11382	11383
19	Idler Pin	Monel	7111	1080	7080
20	Companion Flange	Cast Bronze	- -	10609	18971
21	Bolt and Nut	Steel	- -	9008	9008
22	Bolt and Nut, Inlet	Steel	- -	3653	3653
		MANUAL OPERATING VALVE - TYPE MA-1			
23	Spring Cap	Cast Semi-Steel	- -	14641	14641
24	Spring	Stainless Steel	- -	15501	15501
25	Gasket	Sheet Packing	- -	16501	16501
26	Ball	Stainless Steel	- -	14771	14771
27	Seat Ring	Rubber Compound	- -	20170	20170
28	Main Body, Complete (NOTE 2)	Cast Semi-Steel	- -	20584	20584
29	Stem	Stainless Steel	- -	20598	20598
30	Spring Clip	Corrosion Resistant Alloy	- -	14136	14136
31	Stem Bushing	Brass	- -	20599	20599
32	Yoke	Cast Bronze	- -	14640	14640
33	"O" Ring	Rubber Compound	- -	20481	20481
34	Cotter Pin	Stainless Steel	- -	14883	14883
35	Lever Pin	Stainless Steel	- -	14642	14642
36	Lever	Cast Bronze	- -	14611	14611
37	Gasket, Yoke	Sheet Packing	- -	16506	16506

NOTE 1 - Two Diaphragms required for 40-60 Lb. Pressure and Three Diaphragms required for 70-300 Lb. Pressure.
NOTE 2 - Main Body is furnished complete with Seat Insert, Reference Number 20551.

FOR ALL CLASSES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE SIZE, CLASS AND SERIAL NUMBER OF LESLIE-TYPON.

ManualBIW-000777



ManualBiW-000778

DRAWING NUMBER 7165 F, OUTER BOX, TYPE TAC-1
WHEN ORDERING PARTS, GIVE PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NO.	PART NAME		MATERIAL	REF. NO.
1	Screw, Cover		Stainless Steel	24[illegible]
2	Data Plate		Stainless Steel	24573
3	Cover		Aluminum	24577
4	Housing		Aluminum	24578
5	Gasket, Cover		Synthetic Rubber	23715
6	Lock Washer		Steel	11467
7	Screw		Stainless Steel	24756
8	Set Screw		Steel	21466
9	Motor, 115 V. A.C.			25332
9	Motor, 220 V. A.C.			26332A
10	Coupling, Female		Brass	25315
11	Coupling, Male		Brass	25316A
12	Bearing Sleeve		Bakelite	24577
13	Flasher Spindle		Phosphor Bronze	35422
14	Pin		Brass	11544
15	Guide Bushing		Bakelite	11545A
16	Return Spring		Phosphor Bronze	11547A
17	Contactor Sleeve Assembly	(NOTE 1)	Bronze and Nylon	11518
18	FLASHER FRAME ASSEMBLY Consists of following parts which may be ordered individually, 19 to 27 inclusive.			
19	Screw		Brass	11469
20	Set Screw		Steel	24356
21	Flasher Frame Base		Steel	24731
22	Flasher Frame		Bakelite	75-12
23	Screw		Brass	24725
24	Contact Assembly		Copper and Graphite	24734
25	Lock Washer	(NOTE 2)	Stainless Steel	21666
26	Screw	(NOTE 2)	Brass	24729
27	Washer		Nylon	35427
28	Spring		Phosphor Bronze	11545
29	Shoulder Screw		Steel	35566
30	Screw, Supporting Spacer		Stainless Steel	24835
31	Supporting Spacer		Bakelite	24741
32	Screw		Stainless Steel	24755
33	Terminal Strip		Bakelite	24570
34	Terminal Lug		Copper	24747
35	Spacer		Bakelite	24701
36	Cotter Pin		Steel	11399
37	Nut		Brass	11466
38	Dial		Stainless Steel	11461
39	Washer		Brass	11456
40	O-Ring		Synthetic Rubber	24454
41	Spring		Stainless Steel	24707
42	Push Button		Bakelite	24704
43	Marker Strip		Nylon	24714
44	HOLDING COIL SWITCH ASSEMBLY (COMPLETE) 115 V.			24718
44	HOLDING COIL SWITCH ASSEMBLY (COMPLETE) 230 V.			24718A
	Consists of following parts which may be ordered individually, 45 to 52 inclusive.			
45	Magnetic Circuit Complete		Electron Iron	24672
46	Holding Coil Base and Switch Assembly		Bakelite and Brass	24257
47	Auto Lug Complete	(NOTE 3)	Brass	11525
48	Band Lug Complete	(NOTE 3)	Brass	11526
49	Contactor Complete	(NOTE 2)	Copper and Graphite	24958
50	Holding Coil Spring	(NOTE 3)	Phosphor Bronze	24759
51	Holding Coil Assembly, 115 V.		Electric Iron and Copper	24760
51	Holding Coil Assembly, 230 V.		Electric Iron and Copper	24760A
52	Leads, 12" long		Copper, Insulated	24731
53	Screw		Stainless Steel	24354
54	Selector Switch			35562
55	Coupling		Aluminum	24572
56	Washer		Stainless Steel	24741
57	Spindle, Complete		Aluminum	24570
58	O-Ring	(NOTE 4)	Synthetic Rubber	20183
59	Set Screw		Steel	11529
60	Knob		Bakelite	26414
61	Screw		Steel	24414
62	Leads, 12" long		Copper, Insulated	24724
63	Leads, 8" long		Copper, Insulated	24725
64	Oil Can, 1/2 fluid oz.		Brass, Nickel Plated	29365

NOTE 1 - Contactor Sleeve Assembly Includes Contactor (Stator) Ref. No. 11548A and two (2) Screws (Brass) Ref. No. 11540, but may be ordered individually if desired.
NOTE 2 - Is included in Contact Assembly, Ref. No. 24734, but may be ordered individually if desired.
NOTE 3 - Is included in Holding Coil Switch and Base Assembly, Ref. No. 24718, but may be ordered individually if desired.
NOTE 4 - Is included in Spindle, Complete Ref. No. 24570, but may be ordered individually if desired.

FOR TYPE TAC-2

When ordering parts for Type TAC, use Reference Numbers shown above for Type TAC-1 except parts shown below.

8	Set Screw		Steel	11529
9	Motor, 115 V. A.C.			24353
9	Motor, 220 V. A.C.			24353A
10	Coupling		Brass	24744
13	Flasher Spindle		Phosphor Bronze	11545
18	Flasher Frame Assembly			24716
21	Flasher Frame Base		Steel	24731
22	Flasher Frame		Bakelite	24715
54	Selector Switch			24353
	Leads, 2-1/2" long		Copper, Insulated	24724

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER AND INCLUDE SERIAL NUMBER OF OUTER BOX.

ManualBIW-000779

REFERENCE TABLES, ENGINEERING DATA

ENGINEERING DATA BULLETIN

REFERENCE TABLES

COMPUTATIONS, FORMULAS

CONVERSION FACTORS

REFERENCE TABLES
ENGINEERING DATA

LESLIE

engineering data reference tables



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STEAM PRESSURE DROP DETERMINATION — Steam Flow Charts, Pressure Drop in Boundary Valves and Fittings.	5
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LESLIE COAST-TO-COAST SERVICE	Back Page

Manual BW-000781

READY LESLIE MARK

engineering data
FORMULAS FOR VALVE SIZING

COMPUTATIONS AND FORMULAS

When sizing regulators and control valves, accurate computation of steam flow is necessary so that the regulator or controller will operate as closely as possible to its rated capacity. The following formulas will help in making many of these computations.

STEAM HEATING SYSTEMS

Where direct, cast iron radiation is used, the

★ Maximum Steam Flow Required in Lbs. per Hour $= \frac{\text{Total sq. ft. Radiation}}{3}$

This formula includes an allowance for heat loss in connecting piping.

HEATERS, HOT WATER, FUEL OIL, ETC.

Where steam is the heating medium.

★ Max. Steam Flow, Lbs. per hr. $= \frac{\text{Max. Gals. per hr.} \times \text{Temperature Rise} \times \text{Specific Heat}}{100}$

This formula includes an allowance for heat loss.

Specific Heat of Water — 1.0
of Fuel Oil — 0.6

SIZING DIAPHRAGM CONTROL VALVES WITH Cv NUMBERS

C_v numbers are valve coefficients which define the maximum capacity of any given valve. For example, a valve with a C_v of 1 has a capacity of 1 GPM of water at 1 psi pressure drop. You will find them simple and easy to work with after a few sample problems:

1 **TO SIZE** a Diaphragm Control Valve using C_v numbers, the required C_v number must FIRST be obtained by using the following formulas:

LIQUIDS

$$C_v = \frac{GPM\sqrt{Sp.\ Gr.}}{\sqrt{Press.\ Drop, psi}}$$

WHERE Sp. Gr. of water = 1
GPM = Gals./min. at flowing temperature

STEAM AND GAS

When P_2 is ½ of P_1 or less, use

DRY SATURATED STEAM
$$C_v = \frac{Lbs./Hr.}{1.5 \times P_1}$$

AIR, GAS
$$C_v = \frac{CFH\sqrt{Sp.\ Gr.}}{30.5 \times P_1}$$

When P_2 is more than ½ of P_1, use:

DRY SATURATED STEAM
$$C_v = \frac{Lbs./Hr.}{3\sqrt{(P_1 - P_2)\,P_2}}$$

AIR, GAS
$$C_v = \frac{CFH\sqrt{Sp.\ Gr.}}{61\sqrt{(P_1 - P_2)\,P_2}}$$

For Temperature, Superheat, or Moisture correction, see Step 2.

WHERE:
P_1 = inlet press. psia (lbs. per sq. in. absolute)
P_2 = Outlet press. psia (lbs. per sq. in. absolute)
Absolute press. = Gage press. (psi) + 14.7
CFH = Cu. ft. free air/hr. (14.7 psia 60° F)
Sp. Gr. Air = 1

2 Correct C_v number obtained from above formulas by multiplying by correction factors, if applicable.

FOR STEAM

Correction for Superheat =
1 + .00065 (°Superheat)

Correction for % Moisture $= \sqrt{Quality}$

[For example, if Moisture is 2% then Quality = (1. — .02) = .98]

FOR GAS

Correction for Temperature
$$\sqrt{\frac{460 + ^\circ\ Fahrenheit}{520}}$$

3 Select valve size from C_v table in Diaphragm Control Valve Bulletin 5304 or 5305. Correct size has C_v number equal to or greater than required C_v.

SIZING REGULATORS AND CONTROL VALVES WITH CAPACITY TABLES

Capacity tables provide a fast, convenient method for sizing regulators and control valves for steam, air, gas and water service. Easy-to-use tables are included in applicable bulletins as follows:

Bulletin 5302—Pressure Reducing Valves

Bulletin 5304—Single-Seated Diaphragm Control Valves

Bulletin 5305—Double-Seated Diaphragm Control Valves

Bulletin 5306—Pump Pressure Regulators

Bulletin 5307—Temperature Regulators

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ManualBMW-000782

PROPERTIES OF SATURATED STEAM

BELOW ATMOSPHERIC PRESSURE

Vacuum Inches of Mercury	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
29	79	833.8	11	1094	1043
11	111	111.9	11	1116	1021
11	111	141.8	181	1111	1011
10	181	11.8	129	1116	1001
11	129	11.1	111	1111	998
18	181	19.1	160	1111	811
1	101	11.8	111	1111	816
1	116	11.1	111	1116	811

ABOVE ATMOSPHERIC PRESSURE

Pressure PSI (Gage)	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
0	111	26.2	180	1150	970
1	111	11.1	181	1111	911
1	111	11.0	198	1111	965
1	122	11.2	188	1111	963
1	114	18.1	181	1111	981
1	221	19.8	191	1116	959
0	110	11.9	198	1111	858
1	111	18.1	100	1118	956
1	111	11.4	181	1116	911
9	111	16.1	101	1118	911
10	230	16.1	188	1160	811
11	111	15.0	110	1181	810
11	111	11.0	111	1111	949
11	146	11.0	111	1181	811
11	241	11.0	110	1181	946
11	258	11.1	111	1164	811
11	251	11.1	110	1181	911
11	114	11.1	111	1111	941
18	251	11.1	114	1141	941
11	111	11.1	110	1166	948
18	110	11.1	111	1166	810
11	111	10.4	110	1169	921
18	114	8.4	141	1111	810
11	181	1.5	110	1173	811
40	181	1.14	118	1175	810
41	292	1.14	162	1172	814
50	298	8.81	181	1178	811
52	181	8.11	111	1129	981
60	101	5.14	111	1181	881
65	111	1.41	181	1111	900
70	110	1.14	188	1111	811
11	110	4.21	298	1184	881
18	114	4.64	184	1191	890
81	111	4.41	298	1188	888
90	111	4.24	181	1198	811
91	114	4.01	101	1198	844
100	110	1.14	101	1180	881
101	141	1.75	119	1119	111
110	141	1.62	114	1181	111
111	141	1.44	110	1181	111
110	110	1.14	111	1111	172
111	111	1.21	124	1181	181
110	156	1.11	111	1194	881
111	111	1.81	129	1194	866
140	161	1.81	111	1191	862
141	162	1.84	111	1198	860

ABOVE ATMOSPHERIC PRESSURE (Cont.)

Pressure PSI (Gage)	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
150	166	1.75	111	1118	838
111	188	1.81	118	1188	954
188	170	2.60	111	1118	854
181	111	1.11	141	1181	111
170	175	1.11	111	1111	838
111	118	1.40	150	1198	111
100	118	1.21	111	1191	146
185	181	1.29	111	1114	844
190	184	1.21	111	1199	841
191	186	1.11	119	1199	846
100	198	1.11	111	1199	838
110	192	1.05	181	1100	811
120	398	1.86	169	1100	831
130	199	1.81	111	1181	111
140	401	1.81	111	1101	811
150	408	1.75	118	1181	111
160	118	1.68	181	1101	111
118	111	1.63	181	1181	114
180	118	1.51	191	1101	811
190	118	1.21	194	1181	181
100	111	1.41	191	1181	105
115	429	1.21	485	1101	791
150	118	1.21	411	1181	790
175	441	1.19	119	1101	782
100	448	1.09	126	1102	111
111	411	1.00	111	1102	170
150	459	.872	111	1102	181
411	181	.818	144	1101	751
100	169	.811	448	1201	118
111	475	.850	415	1181	118
110	488	.828	461	1200	140
111	485	.784	486	1200	754
800	490	.111	411	1199	721
625	491	.721	414	1191	721
850	498	.892	411	1191	118
811	102	.641	441	1111	111
700	505	.641	490	1191	181
150	111	.598	491	1191	811
800	528	.556	114	1194	888
118	521	.521	111	1192	870
900	114	.489	111	1181	881
118	548	.462	146	1181	811
1000	448	.411	111	1181	841
1050	551	.411	118	1181	811
1100	558	.390	166	1181	811
1150	181	.111	172	1111	811
1100	881	.111	579	1111	602
1100	118	.122	181	1118	111
1460	186	.181	606	1111	165
1500	191	.111	819	1141	648
1118	604	.2541	814	1162	114
1820	811	.2154	818	1155	811
1120	111	.2119	648	1149	501
1118	811	.1021	660	1141	481
1910	638	.1818	672	1111	463
1118	668	.1631	891	1118	414
1118	661	.1401	114	1101	111
1118	814	.1111	141	1088	111
1118	681	.1021	170	1055	181
2918	691	.0858	801	1918	119
1118	101	.0150	172	114	62

TEMPERATURE CONVERSIONS — °F and °C

Enter table at arrow. Numbers in bold type in center of table refer to either °C or °F, whichever is being converted into the other scale. If converting from °C to °F, equivalent temperature is found in top section. If converting from °F to °C, answer is found in bottom section.

°F	-111	-18	-40	- 4	14	11	10	68	104	148	110	111	148	184	110	118	191	118	481	500	118	178	608	644	688	118	152
→	- 88	-60	-40	-18	-18	0	18	18	40	80	88	100	120	140	188	180	200	118	240	160	288	300	118	140	160	180	400
°C	- 81	-51	-48	-18	-11	-11.1	-11.1	-6.6	4.4	11.8	18.8	11.1	19	60	11	81	81	104	111	111	118	149	100	111	111	181	104

Manual(B(W-000783

LESLIE

engineering data
STEAM FLOW IN PIPES

REASONABLE VELOCITIES FOR FLUID FLOW THROUGH PIPES

Fluid	Pressure PSI (Gage)	Service	Velocities—FPM
SATURATED STEAM	0-15	Heating Mains	4000-6000
SATURATED STEAM	50-up	Miscellaneous	6000-9000
SUPERHEATED STEAM	200-up	Turbine and Boiler Leads	10000-15000
WATER	25-40	City Service	120-200
WATER	50-150	General Service	200-600
WATER	150	Boiler Feed	600

LBS/HR SATURATED STEAM AT 6000 FT/MIN (velocity) in Iron or Steel pipe

Pipe Size (Inches)	PRESSURE PSI (GAGE)											
	5	25	50	75	100	150	200	250	300	400	500	600
½	20	55	90	120	150	210	270	250	590	495	660	240
¾	55	100	160	220	280	390	510	620	229	920	1150	1190
1	90	120	220	290	460	656	840	1026	1200	1530	1900	2286
1½	160	200	480	650	820	1150	1490	1426	2160	2260	5410	4100
1¼	220	426	660	900	1100	1600	2060	2556	8000	2820	4250	5700
2	220	700	1100	1500	1900	2680	2150	4200	4980	6250	7900	9450
2½	525	1000	1600	2125	2750	2950	4056	6050	2150	9120	11200	12600
3	400	1600	2500	2250	4250	6000	7700	9450	11200	14200	12700	21200
3½	1100	2100	2400	4550	5700	8050	10200	12700	15000	19100	25700	28500
4	1450	2250	4200	5850	2400	10450	13450	16406	19200	24400	20400	26500
5	2200	4400	6800	9200	11200	16500	21200	26000	20800	29200	44800	58500
6	2200	6200	9800	12200	16800	23200	30800	26900	44000	58000	69700	82500
8	5200	10800	12100	23300	29300	41200	52100	85200	26800	98000	121000	145500
10	9100	12800	28100	28000	44100	62600	81100	106500	126000	160000	200000	240000
12	12500	25800	40700	55200	69200	98500	126500	154200	182100	232000	290000	542000

COMPARATIVE CAPACITIES OF DIFFERENT SIZES OF PIPE

PIPE SIZE, INCHES	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10
CAPACITY FACTOR	2.	2.5	6.5	10.	15.5	22.5	21.5	44.5	65.	84.	165.	121.5	190.	255.	229.	430.	629.

EXAMPLE: To get size of pipe to serve a ½" and a ¾" pipe, add factors thus: ½" factor 122 + ¾" factor 22.5 = 5.5 1¼" factor

CONDENSATION (lbs/hr) per 100 ft. pipe with 2-in. 1hick 85% magnesia insulation

Pressure PSI (Gage)	DIAMETER OF PIPE IN INCHES												Pressure PSI (Gage)	DIAMETER OF PIPE IN INCHES										
	¾	1	1½	2	2½	3	4	5	6	8	10	12		¾	1	1½	2	2½	3	4	5	6	8	10	12
1	2	2	2	4	4	5	8	2	8	11	12	15	50	4	4	5	6	1	9	11	12	18	19	24	28
2	2	2	2	4	4	5	6	2	9	11	14	15	70	4	5	6	2	8	10	12	15	18	22	22	22
5	2	2	4	4	5	5	6	2	10	12	14	12	100	5	5	2	8	9	12	15	18	26	25	21	22
10	2	2	4	4	5	5	2	2	11	12	15	18	125	5	6	2	8	9	12	16	19	22	28	25	41
20	2	2	4	5	5	5	8	10	12	15	18	21	150	6	8	8	9	10	14	12	21	24	21	28	45
30	2	4	5	5	6	2	9	11	15	18	29	24	200	6	2	4	9	11	15	19	24	28	85	44	51

Condensation in 2" and larger pipe are corrected for heat loss due to friction. Velocity taken at 8000 ft./min. Based on standard formulas.

CONDENSATION RATES at 70°F. (for bare steel pipe with natural movement of air)

Pipe Size (Inches)	STEAM PRESSURE PSI (Gage)															Sq. Ft. of Surface = to 14 Lineal Ft. of Pipe
	1	2	4	6	8	10	20	26	40	80	75	100	125	150	200	
	Pounds Condensed Per Hour, Per Lineal Foot of Pipe															
¾	.11	.12	.14	.14	.15	.15	.18	.18	.20	.22	.28	.29	.22	.25	.40	.225
1	.15	.15	.16	.18	.12	.18	.20	.22	.25	.22	.21	.25	.29	.42	.49	.845
1½	.21	.21	.22	.22	.23	.24	.28	.22	.28	.39	.45	.50	.55	.60	.69	.492
2	.24	.25	.26	.22	.22	.29	.28	.38	.42	.46	.54	.61	.68	.24	.81	.622
2½	.20	.21	.22	.31	.24	.26	.41	.46	.51	.55	.85	.77	.81	.88	.92	.252
3	.28	.39	.40	.41	.42	.44	.50	.58	.81	.66	.22	.86	.94	1.02	1.19	.912
4	.46	.42	.48	.49	.51	.53	.61	.88	.26	.62	1.04	1.11	1.22	1.22	1.50	1.129
5	.55	.56	.59	.60	.62	.64	.24	.82	.91	1.00	1.24	1.22	1.46	1.59	1.81	1.459
Per Sq. Ft. Heat Surface	.24	.25	.28	.22	.29	.41	.42	.53	.62	.65	.22	.41	.90	1.00	1.15	

ManualBIW-000784

EXHIBIT CC

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE YD: Sun Shipbuilding & Dry Dock Co., Chester, Pa.

SHIP TO: same

C-3947 E.
A-16420-67
M-1433 Phila. 8321-12-15
11-3-42

VIA: Freight

ORDER: C-5457 Dated Oct. 15, 1941

TERMS: Net Cash 30 days f.o.b. Warren, Mass.

Item	Quant.	Articles	Price
		A-1-c PRIORITY RATING APPLIES TO THIS ORDER UNDER GENERAL PREFERENCE ORDER NO. P-7 (COPY NO. 41)	
1		Charge 1/5 each to 324/325/326-854 B/M 31	
		FORD, FIRE, BILGE & BALLAST PUMP A-16420, A16456, A-16452	
	5	10" x 7" x 12" Vertical Duplex, Double Acting Piston, For'd Fire, Bilge and Ballast Pumps, each having A capacity of 275 G.P.M. at 68 F.P.M. against a discharge pressure of 100 Lbs. per square inch when operating with 125 Lbs. gauge @65° F. total temperature steam and exhausting against 10 Lb. gauge back pressure. Steam cylinders to be capable of withstanding 450 Lb. gauge steam pressure or be fitted with an adequate relief valve located between throttle and steam chest.	
		Steam cylinders to be made of cast iron, fitted with steel piston rods. Liquid ends to be made of bronze fitted with head to port (fixed at one end) bronze liners, pistons, piston rods, and valve service. Piston rings Sea-ro #520. Stuffing boxes to be fitted with Sea-ro Nak-Seal Style #505 packing. Pump to be fitted with air chamber. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel.	$1607.00 ea.
	5	Sets of spares, each set to consist of the following	
		1/2 Set of Valves, Springs, Studs and Nuts Per Set	32.00
		(Page 2 of Customer's Order)	
2		Charge 1/5 each to 324/325/326-854 B/M 35	

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

Shipped 12/24/42

Form 168

EXHIBIT "CC"

WP 0144815

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5947
A-16420-67
M-1455 Phila. 9511-12-15
11-9-42

VIA:

ORDER: C-5457 Dated Oct. 15, 1941 — TERMS:

DISTILLER FRESH WATER DISTRIBUTING PUMP A-16421, A-16457, A-16455

5 4-1/2" x 2-3/4" x 4" Horizontal Duplex, Double Acting Piston, Distiller Fresh Water Distributing Pumps, each having a capacity of 5 G. P. M., against a discharge head of 45 Ft. when operating with 175 Lbs. gauge, 465° F. total temperature steam and exhausting against 10# gauge back pressure. Steam cylinders to be capable of withstanding 450 Lbs. gauge steam pressure or be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron, fitted with steel piston rods, piston rings Sea-ro Style #520. Liquid end to be made of bronze, fitted with port to port bronze liners, piston, piston rods and valve service. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel. Steam and liquid stuffing boxes to be fitted with Sea-ro Hek Seal Style #505 packing — $205.00 ea.

5 Sets of spares, each set to consist of the following

1/2 Set Valves, Springs, Studs and Nuts — Per Set — 4.00

5. Charge 1/5 each to 524/525/526-854 H/W 54

GENERAL SERVICE & BALLAST CENT. PUMP A-16422, A-16458, A-16454

5 Single Stage, Double Suction Horizontal Self-priming motor driven centrifugal type General Service & Ballast Pumps, each having a capacity of 200 G.P.M. against a total head of 80 Ft. Pumps to have non-overloading head capacity characteristics.

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5847
s-16420-67
M-1452 Phila. 8511-12-13
11-8-42

VIA:

ORDER: C-5457 Dated Oct. 15, 1941 — TERMS:

Pump casing to be of bronze, pump impellers and wear rings of bronze, shaft of monel metal. Pump casing to be split on horizontal centerline. Pumps to be mounted on same bedplate with and connected through a Falk or other approved type of flexible coupling, furnished with pump to a 7-1/2 H. P. motor, 1750 R.P.M., which we will furnish and deliver to you. Stuffing boxes to be fitted with Sea-ro Nak Seal Style #505 packing. Pumps to be primed by a steam jet ejector furnished by Sun Shipbuilding & D. D. Co. 369.00 ea.

(Page 5 of Customer's Order)

5 Sets of spares, each set to consist of the following

1 - Set of Ball Bearings for Pump — Per Set — 15.00

4. Charge 1/5 each to 324/325/326-854 B/M 55

GENERAL SERVICE & BALLAST PUMP - REC. s-16423, s-16439, s-16455

5 12" x 8-1/2" x 12" Vertical Duplex, Double Acting Fleton General Service & Ballast Pumps, each having a capacity of 600 G.P.M. at 68 F.P.M. against a discharge pressure of 125 Lbs. per square inch when operating with 175 Lbs. gauge steam at a total temperature 465°F. and exhausting against 10# gauge back pressure. Steam cylinder to be capable of withstanding 450 Lbs. gauge steam pressure or to be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron, fitted with steel piston rods. Liquid end to be made of bronze, fitted with head-to-port (fixed at one end) bronze liners, pistons,

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WARREN ENGINEERING COMPANY

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-3947
A-16420-67
M-1455 Phila. 8511-12-13
11-9-42

VIA

ORDER: C-8457
Dated Oct. 13, 1941

TERMS

pleton rods and valve service. Pump to be fitted with an air chamber. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel. Stuffing boxes to be fitted with Sea-ro Mek Seal Style #505 packing.

2298.00 ea.

3 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts — per set — 30.00

5. Charge 1/5 each to 324/525/526-854 B/M 56

FIRE AND DECK PUMP — A-16424, A-16440, A-16456

3 Two Stage, Single Suction, Horizontal, Turbine Driven Centrifugal Type Fire and Deck Pumps, each having a capacity of 450 G.P.M. against a discharge pressure of 125 Lbs. per square inch when operating at 3000 R.P.M. Pumps to have non-overloading head capacity characteristics.

Pump casing to be of bronze, pump impellers and wear rings of bronze, shaft to be of monel metal with bronze sleeves, pump casing to be split on horizontal centerline. Pumps to be mounted on a common bedplate with and connected by a Falk or other approved type flexible coupling furnished with

(Page 4 of Customer's Order)

pump to a 60 H. P. steam turbine, which we will furnish and deliver to you. Stuffing boxes to be fitted with Sea-ro Mek Seal #505 packing.

775.00 ea.

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CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co., Chester, Pa.

SHIP TO:

C-3347
A-16420-67
M-1453 Phila. 8511-12-15
11-9-42

VIA:

ORDER: C-3457 Dated Oct. 16, 1941 — TERMS:

5 Sets of spares, each set to consist of the following

1 - Set of Ball Bearings for pump — Per Set — 15.00

6. Change 1/5 each to 524/525/526-854 S/M 58

AUXILIARY FEED PUMP — A-16425, A-16441, A-16457

5 12" x 8" x 24" Vertical Simplex, Double Acting Piston, Aux. Feed Pumps, each having a capacity of 180 G.P.M. at 71 F.P.M. against a discharge pressure of 550 Lbs. per square inch when operating with 415 Lbs. gauge pressure, steam 465° F. total temperature at inlet to throttle and 10 Lbs. gauge back pressure.

Pumps to be fitted with an air chamber and steam cylinder to be of high test cast iron of not less than 40,000 Lbs. per square inch tensile strength with steel piston rod and without steam seals. Liquid end to be of bronze fitted with full length monel metal liner, bronze piston, packed with Sea-ro 452s rings, monel piston rod and durable S. G. valve service. Steam cylinder to be capable of withstanding 450 Lbs. steam pressure. Steam cylinder to be lagged with suitable thickness of 85% magnesia so that with an air ambient temperature of 100° F. the surface temperature will not exceed 150° F.

2895.00 ea.

5 Sets of spares, each set to consist of the following

1 - Set of Valves, Springs, Studs and Nuts. — Per Set — 72.00

WANTED BY — WARREN ENGINEERING COMPANY

CREDIT APPROVED

CREDIT TO BE APPROVED

Form 168

WP 8144819

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5347
A-16420-67
M-1433 Phila. 8311-12-15
11-3-42

VIA:

ORDER: C-3457
Dated Oct. 13, 1941

TERMS:

7. Charge 1/3 each to 324/325/326-854 B/M 39

MAIN FEED PUMPS — A-16426, A-16442, A-16458

6 Multi-stage, Horizontal Turbine Driven, Centrifugal Main Feed Pumps, each having a maximum capacity of 250 G.P.M. against a discharge pressure of 550 Lbs. per square inch and having a 35 Ft. suction head, with temperature of water at 240° F. Pumps to have non-overloading head capacity characteristics.

(Page 5 of Customer's Order)

Pump casing to be of cast steel, split on horizontal centerline. Impellers and wearing rings to be bronze. Shafts to be of high grade tensile steel with stainless steel sleeves. Each pump to be furnished complete and mounted on a common bedplate and driven through a Falk or other approved type flexible coupling by a 135 H. P. Steam Turbine, 3800 R.P.M., which we will furnish and deliver to you. Bearings to be forced feed lubricated.

2770.00 ea.

8. Charge 1/3 each to 324/325/326-854 B/M 45

MAIN CONDENSATE PUMPS — A-16427, A-16443, A-16459

8 Two Stage, Single Suction Vertical Motor Driven Centrifugal Type Pumps, each having a maximum capacity of 180 G.P.M. against a normal head of 170 Ft. To be arranged with self-footing suction connections and provided with G-P self

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WARREN ENGINEERING COMPANY

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co. Chester, Pa.

SHIP TO:

C-3247
A-16420-67
M-4433 Phila. 8311-12-13
11-3-42

VIA:

ORDER: C-3437 Dated Oct. 13, 1941 — TERMS:

setting type packing and with external gland water seals. Pump to have non-overloading head capacity characteristics.

Pump casing to be of cast iron with renewable bronze wearing rings fitted to casing, impellers to be monel metal. Shafts to be of monel without shaft sleeves. Pump casings to be split on vertical centerline. Substantial feet are to be provided on pump casings for supporting complete pump units. Pumps to be arranged for overhead motor mounting, connected through a Falk or other approved type of flexible coupling furnished with pumps to a 15 H. P. vertical D. C. motor, 1750 R.P.M., which we will furnish and deliver to you.

684.00 ea.

9. Charge 1/8 each to 324/325/326-654 B/M 45

MAIN CONDENSER CIRCULATING PUMP — A-16428, A-16444, A-16460

8 Single Stage, Double Suction, Horizontal Motor Driven, Centrifugal Pumps, each having a capacity of 15,500 G.P.M. of sea water against a discharge head of 26 Ft. when operating at a normal range of 375/430 R.P.M. and not less than 82% efficiency. Pumps to have non-overloading head capacity characteristics.

Pumps to have bronze casing, bronze impeller, bronze renewable casing wearing rings, monel metal shaft and bronze shaft sleeves. Pumps to be driven by a 125 H.P. horizontal D. C. motor through a Falk or other flexible coupling of approved type. Pump and motor to be mounted on a common

WANTED BY — WARREN ENGINEERING COMPANY

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Form 163

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5047
A-16420-67
M-1455 Phila. 8511-12-15
11-3-42

VIA

ORDER: C-5457
Dated Oct. 15, 1941

TERMS

bedplate. Pump to be split on horizontal centerline. Suction and discharge connection on lower half. Stuffing boxes to be fitted with Sea-ro Nak-Seal Style #505 packing.

5 Sets of spares, each set to consist of the following — 5595.00 ea.

1 - Bronze Impeller
1 - Monel Metal Shaft with Sleeves. — Per Set — 784.00

10. Charge 1/3 each to 324/325/326-85d B/M 46

EVAPORATOR FEED PUMP — A-16429, A-16445, A-16461

3 4-1/2" x 2-3/4" x 4" Horizontal Duplex, Double Acting Piston, Evaporator Feed Pumps, each having a capacity of 20 G.P.M. against a total head of 70 Ft. when operating with 175# gauge 465° F. total temperature steam and exhausting against 10# gauge back pressure. Steam cylinders to be capable of withstanding 450# gauge steam pressure or be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron, fitted with steel piston rods, liquid end to be made of bronze, fitted with port to port bronze liners, piston, piston rods and valve service. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel. Liquid end piston rings Sea-ro Style #520. Steam and liquid end stuffing boxes to be fitted with Sea-ro Nak Seal Style #505 packing. — 295.00 ea.

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WARREN ENGINEERING COMPANY

Form 358

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-3947
A-16420-67
M-1433 Phila. 8511-12-13
11-3-42

VIA:

ORDER: C-3457
Dated Oct. 13, 1941

TERMS:

5 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts. Per Set 4.00

11. Charge 1/3 each to 324/325/326-854 B/M 51

ENGINE ROOM BILGE PUMP A-16450, A-16445, A-16462

5 6" x 7" x 8" Vertical Simplex, Double Acting Piston, Engine Room Bilge Pumps, each having a capacity of 100 G.P.M. against a discharge pressure of 50# per square inch when operating with 175# gauge pressure, 465° F. total temperature steam and exhausting against 10# gauge back pressure. Steam cylinders to be capable of withstanding 450# gauge steam pressure or to be fitted with adequate relief valve protection between throttle and steam chest.

(Page 7 of Customer's Order)

Steam cylinder to be made of cast iron fitted with steel piston rods. Liquid end to be made of bronze, fitted with head to port (fixed at one end) bronze liner piston, piston rod and valve service. Pumps to be fitted with air chamber. Steam cylinder to be insulated with suitable thickness of 85% magnesia and lagged with galvanized sheet metal. Stuffing boxes to be fitted with Sea-ro Nak-Seal Style #505 packing.

697.00 ea.

5 Sets of spares, each set to consist of the following

1/2 Sets of Valves, Springs, Studs and Nuts. Per Set 14.00

WANTED BY

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CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5947
e-16420-67
M-1835 Phila. 8511-12-13
11-9-42

VIA

ORDER: C-5947 Dated Oct. 13, 1941 — TERMS

12. Change 1/3 each to 324/325/326-854 B/M 52

EVAPORATOR BLOW DOWN PUMP — A-16431, A-16447, A-16465

5 Warren Brice Deadboard Discharge Pumps, all bronze construction, capacity 15 G.P.M. each. Pumps to be furnished with suitable bedplate and Falk flexible coupling for mounting motor. Pumps to be driven by a one (1) H. P., 1750 R.P.M., 230 Volt Marine Type motor, which we will furnish and deliver to you.

Pumps to be in accordance with the latest rules and requirements of the American Bureau of Shipping, Bureau of Marine Inspection and Navigation, and Lloyd's Register of Shipping.

156.00 ea.

13. Charge 1/3 each to 324/325/326-852 B/M 3

ENGINE ROOM FUEL OIL TRANSFER PUMP — A-16432, A-16448, A-16464

5 10" x 7" x 12" Vertical Duplex, Double Acting Piston, Engine Room Fuel Oil Transfer Pumps, each having a capacity of 200 G.P.M. at 52 P.P.M. against a discharge pressure of 100# per square inch when operating at 175# gauge 455° F. total temperature steam and exhausting against a 10# gauge back pressure. Steam cylinders to be capable of withstanding 250 Lbs. gauge steam pressure or be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron, fitted with steel piston rods. Liquid end to be made of cast iron, fitted with head to post (fixed at one end) ni-resist liners, cast

WANTED BY — WARREN ENGINEERING COMPANY
CREDIT APPROVED
CREDIT TO BE APPROVED

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-3947
A-16420-67
M-1435 Phila. 8311-12-13
11-3-42

VIA

ORDER: C-3437 Dated Oct. 13, 1941 — TERMS

Iron pistons, cast iron rings, monel piston rods, and stainless steel valve service. Pump to be fitted with an air

(Page 8 of Customer's Order)

chamber. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel. Steam and liquid end stuffing boxes to be packed with Sea-ro Nak-Seal Style #505 packing. 1140.00 ea.

5 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts Per Set 62.00

14. Charge 1/3 each to 324/325/326-869 S/M 4

FUEL OIL SERVICE AND TRANSFER PUMP A-16435,A-16449,A-16465

3 6" x 5-1/2" x 6" Horizontal Duplex, Double Acting Piston, Fuel Oil Service and Transfer Pumps, each having a capacity of 25 G.P.M. of fuel oil at viscosities of 70 to 700 S.S.F. at 122° F. against a discharge pressure of 500# per square inch with suction lift of 20 inches Hg. with pump primed when operating with 175 Lb. gauge 465° F. total temperature steam and exhausting against a 15# gauge back pressure. Steam cylinders to be capable of withstanding 450# gauge steam pressure or be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron, fitted with steel piston rods, liquid end to be made of cast iron, fitted

WANTED BY — WARREN ENGINEERING COMPANY

CREDIT APPROVED

CREDIT TO BE APPROVED

Form #68

WARREN ENGINEERING COMPANY ORDER NO.

CHARGE TO Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO

C-5347
e-16420-67
Z-1435 Phila. 8321-12-15
11-8-42

VIA

ORDER C-5457 Dated Oct. 15, 1941 TERMS

with head to port (fixed at one end) Ni-resist liners, cast iron pistons, cast iron rings, monel piston rods, and stainless steel valve service. Steam and liquid end stuffing boxes to be fitted with Sea-ro Nak-Seal Style #505 packing. Pumps to be fitted with an air chamber. Steam cylinders to be insulated with suitable thickness of 85% magnesia and lagged with planished sheet steel. 279.00 ea.

5 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts. Per Set 22.00

15. Charge 1/5 each to 324/325/326-869 B/M 5

FUR'D. FUEL OIL TRANSFER PUMP A-16434, A-16450,e-16666

8 10" x 7" x 12" Vertical Duplex Double acting Pistons, Fur'd Fuel Oil Transfer Pumps, each having a capacity of 200 G.P.M.

(Page 9 of Customer's Order)

at 50 P.P.M. against a discharge pressure of 125# per square inch when operating with 125# gauge 650° F. total temperature steam and exhausting against 10# gauge back pressure. Steam cylinders to be capable of withstanding 450# gauge steam pressure or to be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron fitted with steel piston rods. Liquid end to be made of cast iron fitted with head to port (fixed at one end) ni-resist liners, cast iron pistons, cast iron rings, monel piston rods and stainless

WANTED BY WARDEN ENGINEERING COMPANY

CREDIT APPROVED

CREDIT TO BE APPROVED

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-5947
A-16420-G7
M-1453 Phila. 8511-12-18
11-9-42

VIA:

ORDER: C-5637
Dated Oct. 15, 1941

TERMS:

steal valve service. Pumps to be fitted with an air chamber. Steam and liquid ends to be fitted with Sea-ro Mak-Seal Style #505 packing. Steam cylinders to be insulated with suitable thickness 85% magnesia and lagged with planished sheet steel.

1140.00 ea.

5 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts. Per Set 62.00

16. Charge 1/5 each to 524/525/526-523 B/M 8

CARGO PUMP ROOM BILGE PUMP A-16455, A-16461, A-16467

5 6" x 7" x 8" Vertical Simplex, Double acting Pistons, Cargo Pump Room Bilge Pumps, each having a capacity of 100 G.P.M. against a discharge pressure of 50 Lbs. per square inch when operating with 175 Lbs. gauge pressure 500° F. total temperature steam and exhausting against 10 Lbs. gauge back pressure. Steam cylinders to be capable of withstanding 450 Lbs. gauge superheated steam pressure or to be fitted with adequate relief valve located between throttle and steam chest.

Steam cylinders to be made of cast iron fitted with steel piston rods. Liquid end to be made of bronze, fitted with head-to-port (fixed at one end) bronze liners, pistons, piston rod and valve service. Pumps to be fitted with an air chamber. Steam cylinder to be insulated with suitable thickness of 85% magnesia and lagged with galvanized sheet

WANTED BY — WARREN ENGINEERING COMPANY

CREDIT APPROVED

CREDIT TO BE APPROVED

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Sun Shipbuilding & Dry Dock Co.
Chester, Pa.

SHIP TO:

C-3947
A-16423-67
M-1433 Phila. 8311-12-13
11-9-42

VIA:

ORDER: C-5437
Dated Oct. 13, 1941

TERMS:

metal. Stuffing boxes to be filled with Sea-ro Mak-Seal Style #505 packing.

697.00 ea.

(Page 10 of Customer's Order)

3 Sets of spares, each set to consist of the following

1/2 Set of Valves, Springs, Studs and Nuts. Per Set 14.00

Six (6) prints to be furnished for approval.

Three (3) sets of instruction books to be furnished for each contract.

All the foregoing equipment to be guaranteed by you as regards workmanship and material for the period of one (1) year, including the renewal or replacement on board the vessel.

F. O.B. Warren, Mass.

Delivery: Contract #324 - November 1942
" #325 - March 1943
" #326 - July 1943

Price stated on this order is subject to adjustment for changes in labor and/or material costs as determined by the U.S. Department of Labor, Bureau of Statistics, based on average hourly earnings of the Durable Goods Group of manufacturing industries with respect to labor costs, and on index number of wholesale prices for Group VI metals and metal products with respect to material costs.

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

J.L.King.

Form 168

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE Electric Boat Co.
TO Groton, Conn.

SHIP
TO

C-4577
A-17581
M-1432
Dec. 12, 1944

VIA

ORDER G-1050-15, Req.12538-LSD, S.O.2128-2829 dated 12/30/42, for SS315-36D, incl. — TERMS

ADDITIONAL ORDER No. 2

Customer's Change Order dated 9 December 1944 reads as follows:

"Please change item one to 80 instead of 86.
" " " two " 40 " " 43.
" " " three " 40 " " 43.

This cancellation involves material for Boats SS355, 354 and 355.

See New Purchase Order J-120-20

Now to bill us if there are any cancellation charges."

TOTAL AMOUNT OF ORDER IS NOW $14,000(instead of $15,050.)

E.

WANTED BY
CREDIT APPROVED
CREDIT TO BE APPROVED
MLK:VLW

WARREN ENGINEERING COMPANY

M. L. Katzenstein

Form 158

WP 0144829

MARINE

WARREN ENGINEERING COMPANY ORDER NO.

CHARGE TO Electric Boat Company, Groton, Conn.

SHIP TO

C-4577
1-17381
M-1432
August 8,1944.

VIA

ORDER G-1030-13, Req. 12538-LSD, S.O. 2129-2829 dated 10/30/42, for SS313-360,Incl. TERMS

ADDITIONAL ORDER No. 1

Customer's supplement to subject order dated August 1, 1944, reads as follows:-

Fifty Ships, SS356 to 360 inclusive, have been cancelled from this contract.

You will immediately cease all manufacture of items as listed below. Terminate immediately your commitments for material and sub-contracts.

As soon as possible report to us expenditures to date and percentages of physical completion of all items terminated by this order.

Items cancelled or quantities reduced -

Item 1 to read 86 instead of 96
Item 2 to read 43 instead of 48
Item 3 to read 43 instead of 48.

TOTAL AMOUNT OF ORDER IS NOW. $15050.00
(instead of $16800.00)

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

MLK:ER.

M.L.Katzenstein

Form 168

WP 0144830

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE Electric Boat Company
TO Groton, Conn.

SHIP Electric Boat Company
TO As below.

C-4577
A-17381
M-1432
Nov. 9,1942.

VIA Parcel Post, Express and L.C.L. to Groton,Conn.
Carload Shipments to Midway, Conn.

O-1030-13, Req. L2538-LBD, S.O. 2129 to 2829 ORDER dated 10/30/42, for SS313to360,inc. U.S. Navy Contract NObs-122. TERMS Net Cash 30 Days f.o.b. Warren, Mass.

MOTOR DRIVEN CIRCULATING WATER PUMPS FOR AIR CONDITIONING EQUIPMENTS.

Equipment to be in accordance with Electric Boat Company Specification #94 dated October 26,1942, copy attached, and to consist of the following:-

96 - 1-1/2"-SKD-6 Centrifugal Pumps

48 - Sets Spare Parts, including Navy Boxing, consisting of the following:-

One Impeller
One Throat Liner
One Suction Head Ring (Regular)
One Suction Head Ring (Undersize)

One Impeller Washer
One Impeller Stud
One Case Ring (Regular)
One Case Ring (Undersize)
One Shaft Sleeve
One Set (three per set) #6-32 x 1/4" Long Slotted Set Screw
One Set (four per set) #8-32 x 1/2" Long Flat Head Machine Screw
One 3/8"-24 Hex. Nut
One 3/8"-24 Hex. Jam Nut
One 1/16" Dia x 3/4" long Pin
One Slinger
One #10-24 x 3/16" Long Hollow Set Screw

48- Sets Special Tools and Wrenches
One Impeller Puller Space
One Impeller Puller
One Packing Puller
One Spanner Wrench
One #10-24 Hollow Set Screw

(Continued on page 2)

WANTED BY See page 2. and 3. — WARREN ENGINEERING COMPANY
CREDIT APPROVED
CREDIT TO BE APPROVED

MLK:EH.

Our Share of S.C. - $75.00 per pump
18.00 per set Spares.

M.L.Katzenstein

Form #68

shipping data on next page.

MARINE

WARREN ENGINEERING COMPANY ORDER NO.

CHARGE TO: Electric Boat Company, Groton, Conn.

SHIP TO:

C-4577
A-17381
M-1432
Nov. 9, 1942.

VIA

C-1030-13, Req. 12538-LSD, S.O. 2129 to 2829 dated ORDER 10/30/42, for SS313 to 360, Inc., U.S. Navy Contract NObs-122. TERMS

Two (2) prints each of Electric Boat Company Sketches ND-971 and ND-1009 mentioned in the above specification #94, are attached to this order.

The ten (10) sets of prints of Type B plans called for in the above mentioned specification are for the entire group of vessels and are not per vessel.

Prices of this equipment are f.o.b. cars, Warren, Mass., and are in accordance with your Quotation of September 3, 1942, as follows:

Two pumps.	$151.00 each.	$302.00
One Set Spare Parts & Tools.	48.00 set	48.00

TOTAL AMOUNT OF ORDER (48 ships). $16800.00

Allocation Classification, USN 2.60

Schedule of delivery as follows:-

313 - 6-12-43	329 - 3-9-44	346 - 9-19-44
314 - 7-3-43	330 - 3-11-44	345 - 9-21-44
315 - 7-27-43	332 - 3-30-44	348 - 10-14-44
316 - 8-18-43	331 - 4-4-44	347 - 10-17-44
317 - 9-4-43	333 - 4-22-44	349 - 11-7-44
318 - 9-29-43	334 - 5-2-44	350 - 11-11-44
319 - 10-23-43	335 - 5-6-44	351 - 11-25-44
321 - 11-16-43	336 - 6-1-44	352 - 11-25-44
320 - 11-20-43	337 - 6-1-44	354 - 12-16-44
322 - 12-9-43	339 - 6-24-44	353 - 12-18-44
323 - 12-27-43	338 - 6-28-44	355 - 1-6-45
324 - 12-30-43	340 - 7-10-44	356 - 1-13-45
325 - 1-20-44	341 - 7-21-44	357 - 1-26-45

(Continued on page 3)

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

Shipped: 8/20/43, 10/5/43, 10/12/43, 10/21/43, 11/1/43, 11/14/43, 11/15/44, 2/14/44, 4/25/44, 5/15/44, 6/1/44, 6/29/44, 8/15/44, 8/24/44, 8/29/44, 11/3/45.

WARREN ENGINEERING COMPANY

M.L. Katzenstein

M.K.-EH.

Form 168

WP 0144832

MARINE

WARREN ENGINEERING COMPANY ORDER NO.

CHARGE TO Electric Boat Company, Groton, Conn.

SHIP TO

C-4577
A-17381
M-1432
Nov.9,1942

VIA

G-1030-13, Req. 12538-LBD, S.O. 2129 to 2829
ORDER 10/30/42, for SS313 to 360, inc., U.S. Navy Contract NObs-122. TERMS

326	1-22-44	342	8-4-44	358	2-13-45
327	2-12-44	343	8-22-44	359	2-16-45
328	2-16-44	344	8-26-44	360	3-3-45

This order subject to inspection by USN at your Plant, Barren, Mass.

Mark all packages and invoices with customer's order number
Invoice in Triplicate
All correspondence to be addressed to Groton.

Parcel Post, Express and L.C.L. to Groton, Conn.
Car Load Shipments to Midway, Conn.

WANTED BY See page 2 & 3.
CREDIT APPROVED
CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

MLK:EH.

M. L. Katzenstein

Form 168

c o p y

SPECIFICATION NO. 94

DESIGN 236A

October 26,1942

SPECIFICATIONS FOR MOTOR DRIVEN CIRCULATING WATER PUMPS
FOR
8 TON AIR CONDITIONING EQUIPMENT
FOR
U. S. SUBMARINES SS313 to SS360 INCLUSIVE

ELECTRIC BOAT COMPANY
GROTON, CONN.

Two Pumps required per Vessel

TYPE

Pumps shall be of the centrifugal, single stage, single suction volute type, of all bronze construction, special Navy close coupled design. The pumps in all respects, including materials, workmanship and tests shall conform to the applicable requirements of Subsection S47-2 dated August 1, 1939, of the General Specifications for Machinery for Class C-1 pump, as issued by the Bureau of Ships, U.S.Navy Dept.

The pumps shall be in general accordance with Electric Boat Company's Sketch MD-1009. Special attention shall be given, in the design, to weight and dimensions, both of which shall be kept at a minimum consistent with reliability, and to the conservation of critical materials wherever possible.

CAPACITY

Each pump shall have a capacity of 40 gallons of salt water per minute, having a specific gravity of 1.03, against a discharge gauge pressure of 25 pounds per square inch measured at the pump outlet when operating with a positive suction head. The pumps shall be arranged for operating on one speed only.

MOTORS

The motors for driving the pumps shall be furnished by the Electric Boat Company and shall be shipped to the pump manufacturer, who shall mount the pumps on facings provided on the motors and in proper alignment therewith. Pump impellers shall be mounted on the motor shaft extensions by the pump manufacturer. Tests of the completed pump sets shall also be conducted by the pump manufacturer. The Electric Boat Company will furnish one controller for use in testing the entire lot of pumps. The normal operating voltage of the motors and controller is 250 direct current.

INSPECTION

The pumps, during their construction and tests, shall be subject to the inspection and approval of the Bureau of Ships, USN, as well as the Electric Boat Company, who shall be notified, in advance, when tests are to be made.

In addition to the copies of test records or any other information required for the Bureau, duplicate copies shall be sent to the Electric Boat Company.

All parts of the pumps, in contact with salt water, shall withstand a hydrostatic test pressure of 335 pounds per square inch gauge pressure.

WP 01dd834

c o p y

PLANS

Upon receipt of the order, the pump manufacturer shall furnish the purchaser with ten sets of blueprints (Type B plans) showing the arrangement and details of the parts to be furnished, including the dimensions required for the motor shaft extension to fit the pump. They shall then be forwarded, by the Electric Boat Company, to the Bureau of Ships for approval and no work shall be undertaken, except at the manufacturer's risk, until that approval has been obtained.

The Type B plans shall be in accordance with Section 21-1, dated March 1,1942, of the above mentioned General Specifications. Title block shall be in accordance with Electric Boat Company Sketch MD-971.

SPARE PARTS

This specification covers two pumps for one vessel and spare parts shall be furnished on that basis.

The pump manufacturer shall furnish a priced list of all spare parts to be supplied, this list to include the unit cost and total cost of each item. The priced listed shall be those at which spares will be supplied under this specification and at which additional spares will be supplied, in the future, under similar conditions as to labor and material cost.

Spare parts shall be treated in accordance with Section 231-1, dated June 1,1940, and amendment No. 1 thereto, dated 1 August 1942, of the General Specifications.

TOOLS

One complete set of special tools and special wrenches shall be supplied as required by Paragraph 847-2-22 of the above mentioned Subsection 847-2. The pump manufacturer shall furnish a priced list of all special tools and wrenches which will be supplied and which list shall conform to the general requirements for prices of spare parts as noted above.

SHIPPING

Each pump set, after having completed its successful test at the shop, shall be suitably crated or packed for shipment.

It must be so packed that it will not become damaged during transportation or by handling at the shipyard. All parts shall be treated, previous to shipment, against corrosion up to the time of removal from the crate.

GUARANTEE

The pump manufacturer shall guarantee each pump to fulfill all of the specified requirements, including efficiency under the rated capacity, speed and head and to operate in a satisfactory manner during the guarantee period of the vessel (six months) after it is delivered to the U.S.Navy Dept.

During that period, each pump and any material furnished by the pump manufacturer, shall not show weakness, defect, failure or deterioration other than that due to fair wear and tear.

WP 0144835

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Supply Department,
U.S.Navy Yard,
Phila., Pa.

SHIP TO: SEE BELOW

C-4578
A-17382
M-1431
Feb. 22,1943.

VIA

M15ls-47702 dated 31 October 1942, Reqo. 683 NSA.
ORDER Pref.Rating AA-2(USN 2.80)Certificate No. TA 638164, FOR USS AP74(ex WINDHUK) — TERMS

ADDITIONAL ORDER No. 3

U.S.Navy Yard Philadelphia, in their letter 20 Feb. 1943, which is attached instructs us to make delivery of this pump to -

The Supply Officer,
Norfolk Navy Yard,
Portsmouth, Virginia

Also, note that they sent the invoices submitted to the

Supply Officer,
Norfolk Navy Yard,
Portsmouth, Virginia.

Please be guided accordingly.

Since this material was ortginally quoted fob Philadelphia, we suggest that you advise us what amount will be entailed for making delivery at Norfolk and we will so advise the Navy Yard.

We also suggestthat this amount be shown as a separate item on your invoice.

WANTED BY
CREDIT APPROVED
CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

Form 168

JLK:BH.

J.L.King

WP 0144836

MARINE

WARREN ENGINEERING COMPANY — ORDER NO.

CHARGE TO: Supply Department,
U.S.Navy Yard,
Phila.,Pa.

SHIP TO:

C-4578
A-17382
M-1431
Dec.14,1942.

VIA

N191s-47702 dated 31 October 1942,Requ. 683 NSA.
ORDER Pref.Rating AA-2(DSM 2.80)Certificate TERMS
No. TA 638164,For USS AP74(ex-WINDHOK)

ADDITIONAL ORDER No. 2.

Per customer's letter 10 Dec.1942 we are instructed to eliminate the cast steel air chamber from this pump.

Per Warren Steam Pump Co.,Inc. letter 12 December 1942 there is a reduction of $74.00 for this omission.

The price of Item 1 accordingly is now $2930.00 instead of $3004.00

The total contract is now. $3392.20
(instead of $3466.20)

Deduction conformably Phila N Yd letter 11 Dec 1942 E.

3466.20
74.00
3392.20

WANTED BY
CREDIT APPROVED
CREDIT TO BE APPROVED

WARREN ENGINEERING COMPANY

MLK:EH.

M.L.Katzenstein.

Form 168

WP 014d837

MARINE

WARREN ENGINEERING CORPORATION — ORDER NO.

CHARGE TO: Supply Department,
U.S.Navy Yard,
Philadelphia

SHIP TO: Supervisor of Shipbuilding,
Cramp Shipbuilding Company,
Richmond and Norris Streets,
Philadelphia, Pa.

VIA

C-4578
A-17382
M-1431
Nov. 23,1942.

N151s-47702 dated 31 October 1942, Requn. 683 NSA,
ORDER Pref.Rating AA-2(USN #2.80)Certificate TERMS
No. TA 638164. For USS AP74 -(Ex Wiedhuk)

ADDITIONAL ORDER No. 1.

U.S.Navy Yard, Philadelphia, letter 21 November 1942, NI4/N151s-47702(4-rk-K) instructs us to ship this material to

Supervisor of Shipbuilding,
Cramp Shipbuilding Company,
Richmond & Norris Streets,
Philadelphia, Pa.

instead of to the Supply Officer, Phila.,Pa.

WANTED BY
CREDIT APPROVED
CREDIT TO BE APPROVED

WARREN ENGINEERING CORPORATION

MLK:EH.

M.L.Katzenstein.

Form 165

WP 0144838

MARINE

WARREN ENGINEERING CORPORATION — ORDER NO.

CHARGE TO: Supply Department, U.S.Navy Yard, Philadelphia,Pa.

SHIP TO: Supply Officer, Bldg. 683, Navy Yard, Philadelphia, Pa. (Stamp Shipping to Richmond Navy Yard, Richmond, Va. / Phila. Navy Yard letter 21/00 #)

VIA

C-4578 / A-17382 / M-1431 / Nov.11,1942.

N1516-47702 dated 31 October 1942, Reqs. 683 NSA, Pref. Rating AA-2(USM #2.80) Certificate No. TA 638164. For USS AP74 - (Ex-Wiadhuk) Will Ajeune

ORDER — TERMS: Net Cash 30 Days f.a.h. Warren,Weas. Transportation Charges Prepaid.

Preference Rating AA-2 is assigned the prime contract and all sub-contracts entered into, to effect the procurement of the material necessary for the execution of this contract. (USM #2.80)

Certificate No. TA 638164

CLASS 401 (Transfer Item 1 to Class 312,Title 1A,account 12, SNSA)
(Transfer Items 2 & 3 to Class 313, Title 29F,Account, 12,SNSA)

ITEMS		QTY.	UNIT		TOTAL
1	Pump, Emergency & Fort Feed, 12"x8"x24", V.S.DA, Disch.Press. 545# per sq.inch,Capacity 180 GPM.	1	each		$300.00
2	Spare Parts for Item 1, itemized as follows:-	1	set		93.00
	Steam piston rod complete	1	ea.	$19.00	
	Pump piston rod complete	1	"	70.00	
	Valve rod and tail rod with nuts,knuckle and pin complete; valve rod link with nuts,collars & set screws	1	"	15.00	
	Pump valves with backing plates,guards,bolts and springs	1	set	258.70	
	Steam piston rings,4 varsize, for main and aux. piston valves	1	"	5.00	
	Valve gear bushings	1	"	1.50	
	Throat liners	1	"	4.00	
	Main chest liner	1	ea.	20.00	
	Aux. chest liner	1	"	13.00	
	Main piston valve with rings	1	"	16.00	
	Aux.piston valve with rings	1	"	10.00	
	Navy boxing			30.00	
					462.20

(continued on page 2)

WANTED BY Approx. 1 March 1943.

WARREN ENGINEERING CORPORATION

CREDIT APPROVED

CREDIT TO BE APPROVED 4/13/43 5/18/43

MLK:HH,

M.L.Katzenstein.

Form #68

MARINE

WARREN ENGINEERING CORPORATION — ORDER NO.

CHARGE TO: Supply Department,
U.S.Navy Yard,
Philadelphia, Pa.

SHIP TO:

C-4578
A-17382
M-1431
Nov.11,1942.

VIA:

N150a-47702 dated 31 October 1942, Reqn. 683 NSA, ORDER Pref.Rating AA-2(USN #2.80)Certificate No. IA 636164. For USS AP74-(Ex-Windhuk) TERMS

ITEMS		QTY.	UNIT	TOTAL
3	Special Tools & Wrenches for Item 1	1	set	(Included in cost of Item 1)

TOTAL AMOUNT OF ORDER. . . . . $~~3466.20~~ 3 937.20

(page 2 of contract)

~~337~~ 2.20

SPARE PARTS, COMPLETE LISTING

Following award to the contractor and after approval of manufacturing plans the contractor shall submit an itemized and priced list of all spare parts being furnished under the contract. This list is for Navy accounting and issue purposes only and will not be used by the contractor for invoice or payment purposes. This list shall be furnished to the following:

One (1) copy to Inspector of Naval Material concerned.
Two (2) copies to Supply Officer of each Navy Yard concerned.

Spare parts shall be plainly marked or tagged to permit ready identification on receipt. Changes in the above spare parts lists resulting from changes in drawings shall be made by the contractor as they occur.

SPECIFICATIONS

The pump called for hereis, shall duplicate the auxiliary feed pump furnished as Item 1 of purchase order QD609-1353-d for Hull Nos. 4397 to 4410 inclusive to the Subsidiary Companies of Bethlehem Steel Corporation.
The manufacturer shall submit complete specifications and characteristic data for the equipment, with bid.

SPARE PARTS

Spare parts and tools. Items 2 and 3 shall be furnished in accordance with the requirements

(cont'd on page 3)

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING CORPORATION

MLK:RH.

Form I68

MARINE

WARREN ENGINEERING CORPORATION ORDER NO.

CHARGE TO Supply Department,
U.S.Navy Yard,
Philadelphia, Pa.

SHIP TO

C-4578
A-17382
M-1431
Nov.11,1942.

VIA

M150s-47702 dated 31 October 1942, Requ. 683 NSL
ORDER Pref.Rating AA-2(USN #2.80)Certificate TERMS
No. PA 636164. For USS AP74 (Ex-Wiedhuk)

of Sub-section 347-1 of General specifitations for Machinery, exempt that wooden boxing may be used in lieu of metal as specified.

INSPECTION, FACTORY, BY GOVERNMENT

To be inspected at the place of manufatture by an Inspector of Naval Material, USN.

Name of manufacturer (not the dealer) WARREN STEAM PUMP COMPANY,INC.
Place of manufacture Warren, Mass.
Location of article to be inspected - Same as above

Inspection will be in accordance with the American Bureau of Shipping regulations.

PLANS

Within fifteen (15) days after date of contract, the contractor shall submit one (1) Van Dyke copy of all approved assembly and detail plans of the equipment being furnished, to the Manager, Industrial Department, Navy Yard, Philadelphia, Pa., and two (2) blueprint copies to the Inspector of Naval Material who will conduct inspection.

INSTRUCTION BOOKS

Instruction books, Item 4, shall contain all necessary pertinent data to aid the personnel in the installation, operation and maintenance of the equipment.

In order to facilitate installation and test work, the contractor is urged to deliver these instruction books with the equipment.

(continued on page 4.

WANTED BY
CREDIT APPROVED
CREDIT TO BE APPROVED

WARREN ENGINEERING CORPORATION

MLK:EH.

Form 168

MARINE

WARREN ENGINEERING CORPORATION ORDER NO.

CHARGE TO Supply Department,
U.S.Navy Yard,
Philadelphia, Pa.

SHIP TO

C-4578
A-17382
N-1431
Nov.11,1942.

VIA

N1Sls-47702 dated 31 October 1942, Reqo. 683 NSi
ORDER Prof. Rating AA-2(USN #2.80) Certificate TERMS
Na. Ti 638164. For USS AP74 (Ex-Wisconsin)

(Page 3 of contract)

GUARANTEE, SIX MONTHS AFTER COMPLETION OF VESSEL. The contractor guarantees that the equipment will operate and function satisfactorily and reliably under all service conditions and in accordance with the specifications herein. Approval of the design by the Government will not relieve the contractor of his responsibility for the satisfactory performance of the equipment in service. Any failure of the equipment to meet the specified performance or any defects in materials or workmanship that may develop during installation and test, or until the expiration of a period of six months after the completion of the vessel, shall be made good by and at the expense of the contractor for the replacement material furnished. "Completion shall mean the official "Date of Completion" as determined by the Navy Department.

REPORT OF MATERIAL SHIPPED

Special attention is invited to paragraph 58 of General Specifications for Inspection of Material. Within 48 hours after shipment to destination, contractor will furnish to the Inspector of Naval Material a report of material shipped. In case inspection is being conducted by a branch office of inspection, this report will be furnished to that branch office unless otherwise directed.

For all shipments, the number of the plan on which the part or assembly is shown shall be included in the description given in the report of material shipped required by General Specification for Inspection of Material to assist the inspector at shipment and at delivery in identifying the parts of the equipment included in the shipment and to establish the completeness of the delivery. Where all parts shown on a certain plan are included in a single shipment, a statement to that effect will be sufficient, but where such is not the case, the plan piece number must be given in sufficient detail to clearly show which items are included in the shipment.

ADDITIONAL SPECIFICATIONS

The above pump shall be a double-acting marine reciprocating type unit with single

(cont'd on page 5)

WANTED BY WARREN ENGINEERING CORPORATION

CREDIT APPROVED

CREDIT TO BE APPROVED

Form 168 MLK:HH.

cylinder.

Normal steam inlet conditions to throttle or pressure governor for the auxiliary feed pump (Item 1) will be 425# G pressure and about 530 deg.F. total temperature. The pump will be operated with 15# G.back pressure. Aux. Feed Pump, item 1,shall also handle specified capacity with steam at 260# G pressure.

The unit shall be capable of delivering rated capacity and discharge pressure when operating with the above steam and exhaust conditions and handling the liquid at suction conditions as listed below:

Item 1 - EMERGENCY & PORT FEED PUMP

245 deg.F. fresh water from deaerating type surge tank with pressure corresponding to the temperature and with about 50 ft. submergence to pump surface. 85 deg. F. fresh water from reserve feed tanks or distilled water tanks with about 15 ft. of water lift at suction.

(page 4 of contract)

PUMP MATERIALS

Steam end	
Cylinder	Cast Iron*
Pistoo	Cast Iron*
Rod	Steel
Liquid end	
Cylinder	Cast Iron*
Piston	Bronze
Rod	Monel
Valve(disc & seats)	Elas Monel
Liner	Monel
Piston Packing	Sea-No #528**

(continued on page 6)

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING CORPORATION

MLR:EH.

Form 168

WARREN ENGINEERING CORPORATION ORDER NO.

CHARGE TO Supply Department, U.S.Navy Yard, Philadelphia, Pa.

SHIP TO

C-4578
A-17382
M-1431
Nov.11,1942.

VIA

NIS S-47702 dated 31 October 1942,Reqe. 683 NSA ORDER Pref.Rating A-2(USN #2.80)Certificate No. TA 638164. For USS AP74(Ex-Wanahuk) TERMS

Provision shall be made for suction and discharge air chamber on the unit. The Vendor shall provide blank flanges for the suction air chamber connection. Fabricated air chambers will be furnished as required for all units by the Shipbuilder.

All stuffing box and piston packing shall be furnished by the Vendor. Stuffing box packing for the steam end and for the liquid end piston rod shall be as approved flexible metallic packing. All other gland packing and the piston packing shall be furnished as approved.

Suitable steam cylinder, cylinder head and valve insulation of 85% magnesia and planished steel lagging shall be furnished by the Vendor. Liquid cylinder insulation and lagging will be provided by the Shipbuilder as required.

Sizes, drilling and facing of connections shall be as approved by Bureau

Pressure governors, relief, drain, suction and discharge valves and gages will be furnished by the Shipbuilder, as required. All other necessary equipment shall be furnished by the Vendor.

Estimated weight of Auxiliary Feed pump. . . . . 3900 lbs.

The unit shall be approximately as shown on the following Warren Plans:-

Pumps	Outline	Section
Auxiliary Feed Pump	1/4-4628	C-1736-8-236

The Vendor shall comply with the following requirements of the vessels' Specifications unless this is specifically waived by the Owners.

* Cast to have a minimum tensile strength of 40,000 lbs. per sq.inch.
** Sea-Ro packing shall have spacer ring as approved by S.O.C. of N.J. Auxiliary Feed pump liquid cylinder liner to be full length.

(Continued on page 7)

WANTED BY

CREDIT APPROVED

CREDIT TO BE APPROVED

WARREN ENGINEERING CORPORATION

MLK:MH.

Form 108

EXHIBIT DD

NAVSHIPS 347-3780

TYPE III

TECHNICAL MANUAL

JP-5 SERVICE PUMP

WARREN PUMPS, INC.
WARREN, MASSACHUSETTS

NOTICE: Additional copies of this or other manuals may be obtained from the U. S. Naval Supply Depot, Mechanicsburg, Pennsylvania. Manuals for which a NAVSHIPS identification number is not known may be obtained by furnishing complete identification plate data, service application and other characteristics of the equipment to aid in the identification of the applicable manual.

MANUFACTURER'S BOOK NO. 496
BUREAU OF SHIPS NAVY DEPARTMENT APRIL, 1961

EXHIBIT "DD"

HI-EM-00155

BASIC APPROVAL FOR: NAVSHIPS 347-3780

TITLE: TECHNICAL MANUAL - JP-5 SERVICE PUMP

APPROVED BY: SUPERVISOR OF SHIPBUILDING, U.S.N., NEW YORK
Letter DLG 16 cl/9470/9020/8, Ser. 918-273:
mw dated 31 January 1961

CONTRACT OR ORDER	DATE	VESSELS APPLICABLE	QUANTITY OF MANUALS	BUILDING YARD
DLG16/G&C-254	6/15/60	DLG16-17-18	39	Bath Iron Works Corp. Bath, Maine
532-51	7/8/60	DLG19-20	8	New York Shipbuilding Corp. Camden, New Jersey
7-DLG-236	7/29/60	DLG21	4	Puget Sound Bridge and Drydock Co. Seattle, Wash.
DLG22-M-254	8/15/60	DLG22	8	Todd Shipyard Corp. San Pedro, Calif.
N140(62794) 70666B(K)	2/14/61	DLG23-24	4	DLG 23 San Francisco Naval Shipyard San Francisco, Calif. DLG24 Puget Sound Naval Shipyard Bremerton, Wash.

REMARKS:

CERTIFICATION: DATE: MARCH 1961

It is hereby certified that the manual NAVSHIPS 347-3780, provided by above listed contracts, has been approved by authority of basic approval data shown above.

WARREN PUMPS, INC.

RECORD OF CORRECTIONS MADE

Pages Numbers	Date	Signature

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The portion of the circuit which includes the strainer and cooler is arranged so that by means of a 4-way valve it can be cut out of the system for inspection or replacement of the strainer or cooler parts. The normal path is through the strainer and cooler to the bearings, etc. and thence back to the reservoir. When the 4-way valve is shifted over the oil goes directly to the bearings.

A relief valve, set at 40 pounds gage protects the system against over-pressure; a pressure gage, an oil level gage and a thermometer are provided to indicate the state of the system.

The unit may be operated for 20 minutes or more (depending on the ambient temperature) without the cooler. This affords sufficient time for cleaning or replacement. The 4-way valve should always be in one fully opened position or the other as shown by the indicator marks on the plug end.

Oil Cooler

The oil cooler is illustrated in Figure 5. It consists of a body and cover with a cooling core secured to the cover by means of the oil pipe connections and with cooling water connections to the body. The direction of flow is immaterial for either the oil or the water.

The cooler core is made up of punched and corrugated sheets and distance pieces brazed together and is not susceptible of adjustment or field repair. In case of a leak or obstruction the spare core should be installed.

The core is secured to the cover by means of a jam nut and a fibre washer at each oil connection and the cover is bolted to the cooler body by through bolts. Any sediment carried in with or precipitated from the cooling water will be deposited in the body, which should be taken down periodically and washed out.

A zinc bar attached to a plug in one end of the cooler body prevents galvanic action from affecting the body metal.

The cooler will cool 7 gallons per minute of oil of 200 SSU (at 130°F) viscosity from 150°F. to 127.6°F., when supplied with 40 gallons per minute of cooling water at 85°F.

Care of Oil Cooler

Step 1. The oil cooler should be cleaned whenever an objectionable increase in pressure drop through the unit, or decrease in cooling efficiency, is observed.

When either of these conditions is noted, remove the core assembly from the case and cover.

Step 2. To clean inside of plates, immerse the core in a suitable cleaner or solvent.

(CAUTION: This operation should be done in the open air or with adequate ventilation.)

Forced circulation of the cleaner through the plates by means of ordinary grease gun or rubber suction cup will facilitate cleaning the oil passages.

Step 3. Blow out with high-pressure air, or steam. Repeat operations until thoroughly clean.

Step 4. Clean outside surfaces of plates with brush and suitable solvent.

Step 5. Remove all foreign matter from inside of casing and tower.

Step 6. Re-assemble the oil cooler, using new gaskets where necessary.

IMPORTANT

Step 7. The zinc electrode should be examined thirty days after installation and every thirty days thereafter.

Any appreciable erosion within these periods indicates electrolytic action.

Careful inspection should then be made to determine if this action is caused by short-circuits or external and grounded electric currents. If so, this condition must be eliminated to avoid serious damage.

Step 8. On the other hand, if no such condition is found it is evident that erosion is due to local electrolysis in which case the only practical procedure or remedy is frequent replacement of zinc electrodes.

Governor

The governor is of the centrifugal fly-weight type. The actuating force is the change in the centrifugal force on a pair of balanced weights supported on hardened knife-edges and arranged to open or close a double-seated poppet valve.

Referring to Figure 6, the governor weights "7" are hardened and a knife-edge at the heel rests on the governor knife-edge bearing "2" while the foot carries the load of the governor springs "12" and "11" through the governor seat "5" and the governor knife-edges "3". The springs "12" and "11" provide the necessary resistance load to make the governor function and the motion of the weights due to centrifugal force overcoming the spring resistance is transmitted to the valve through the ball bearing "30", the bearing housing "29", the governor housing "10", the housing cap "16", and the governor lever "22".

Two governor springs, outer and inner, are provided. A single spring would suffice were it made long enough to combine the necessary stiffness with the requisite "scale" or pounds-per-inch compression, but in order to keep the size of the governor parts as small as practicable, two shorter springs are used to obtain the same result.

A stud "31" in the governor hub "34" limits the motion of the governor knife-edge seat "5" to a maximum lift of 9/16". The governor valve should have a maximum opening of 1/4" in the static condition to insure that the valve will be seated before the governor knife-edge seat reaches its maximum lift.

Valve Adjustment

The valve travel (or lift) is very important and should never be more than 1/4 inch. In order to check this setting, remove the pin and push the valve stem inward (by hand) until the valve is on its seat. Then measure the distance from the cne edge of the hole in the stem, to the governor lever. Each unit is tested

EXHIBIT EE

	COMM'L	048D0188	048D0188STEEL		SEE NOTE 19
-857	ASTM A 307 GR B				
	↓	↓			
-86	ASA B-18.3-61				
	ASTM B-144 AL.3A	144D0021	144D0021 C090A		
-857	ASTM A 307 GR B		NO1YA		
	↓	↓	NO1YA		
	COMM'L	WALWORTH			SEE NOTE 13
		FLEXITALLIC	D-1A		SEE NOTE 22
. 96		163C0048	163C0048 FIBRE		

	PC. NUMBER 56 WAS DWG. NO. 163D0068 4-7-67 RG.		
C	ADDED PC. 38 9-27-67 AG		

15- MFG. BY: FALK CORP, MILWAUKEE, WISCONSIN.
16- SCREWS PC NO 11 ARE FASTENED TO SHAFTS TC NO 8 & 9 WITH ADHESIVE "REN RP-1250 PASTE & HARDENER," MFR. BY REN PLASTICS, INC., LANSING 9, MICHIGAN, AND BY FOUR PINS. (2 EA SCREW) DENATURED ALCOHOL SHOULD BE USED FOR CLEANING THE PARTS PRIOR TO USE OF ADHESIVE & FOR CLEANING OFF EXCESS ADHESIVE AFTER ASSEMBLY. "REN" HAND CLEANER IS SUITABLE, FOR REMOVING ADHESIVE FROM HANDS.
"REN" RP-1250 PASTE & HARDENER SHOULD BE MIXED IN EQUAL PARTS & ONLY ENOUGH SHOULD BE MIXED FOR 30 MIN USAGE, SINCE THIS MATERIAL WILL BEGIN HARDENING IN 40 MINUTES.
17- LOCATE THRUST BRG PC NO 18 ON SHAFTS ~ PRESS FIT INTO PLACE ~ FACES OF BOTH THRUST BRGS MUST BE IN LINE ~ IF NECESSARY, ADJUST BY MEANS OF PLASTIC SHIMS AT POINT "A" ~ WHEN ADJUSTMENT IS COMPLETED, REMOVE BRG RACE ASS'Y. FROM SHAFTS AND PRESS INTO FRONT HEAD PC 2 FIRST CHECKING TO ASCERTAIN THAT FRONT HEAD FACE IS SMOOTH & STRAIGHT.
18- EXCEPTIONS TO SPECIFICATION MIL-P-18SAT A (SHIPS) RADIAL BRG PC NO 17 WILL BE PER MIL-MS-17132 THRUST BRG PC NO 18 WILL BE PER MIL-B-18367
19- MFG. BY: NYLOK-DETROIT CORP., 1894 BARRETT ROAD, TROY, MICHIGAN.
20- HARDNESS OF PC. 8 & 9 TO BE 269 TO 321 BHN.
21- HARDNESS OF PC. 10 TO BE 600 BHN. (CASE)
22- MFG. BY: FLEXITALLIC GASKET CO, CAMDEN 1, NEW JERSEY

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TON 12, MASS.
D; W.A. HOWARD ST.,

SHEET 3 OF 3

APPROVED A CLASS 'A' DWG. BY TODO (SEC) LTR. DE1052 KLASS/547/546 (2-1799-H) DATED OCT. 21, 1965
CATEGORY 'B' CLASSIFICATION ASSIGNED BY SUPSHIP, N.Y. LTR. DE1052 CL/9470 SER. 280-6048 DATED JUNE 17, 1968

DR.	
SH. CHK.	
DWG. CHK.	
APPD.	
MARKS 18-03	

WARREN PUMPS, INC.
WARREN, MASS.
LIST OF MATL.
NAME OF PARTS VARIES
DWG NO. A-14592

EXHIBIT "EE"

46	HEX NUT 3/4-10	8								
47	#8 TAPER PIN (#8x2)	2				COMM'L	048D0183	048D0188STEEL		SEE NOTE 19
48	LOCKNUT MOTOR	1			MIL-S-857	ASTM A 307 GR B				
49	HEX NUT 3/4-10	12								
50	STUD 3/4-10 x 2 1/2 LG	12			FF-S-86	ASA B-18.3-61				
51	SOCK. HD. SETSCR 5/16-18-1"	4				ASTM B-194 A1.3A	144D0021	144D024 C090A		
52	BALANCING DISC.	4	BRONZE		MIL-S-857	ASTM A 307 GR B		NO1YA		
53	STUDS 1/2-13 x 1 3/4	8	STEEL					NO1YA		
54	NUTS 1/2-13	8				COMM'L	WALWORTH			SEE NOTE
55	BLANK FLANGE	2	FORGED STL				FLEXITALLIC	D-1A		SEE NOTE 2
56	GASKET	2	FLEXITALLIC METALLIC ASB1 1 Nos				163C0048	IL3C0048 FIBRE		
57	GASKET .006 THK.	1	FIBRE		HH-P-96					
58	TAPER PIN W/NUT #8x2	2								
59										

GENERAL NOTES

1- MFG BY: [illegible]
2- SCREWS, PC. NO. 11 TO BE PURCHASED IN SETS OF TWO WHEN PURCHASED AS SEPARATE COMPONENTS.
3- TIMING GEARS, PC NO. 10 TO BE PURCHASED IN PAIRS WHEN PURCHASED AS SEPARATE COMPONENTS.
4- REPLACEMENT TIMING GEARS WILL BE FURNISHED WITH ONE GEAR KEYWAYED. THE OTHER TO BE KEYWAYED IN THE FIELD.
5- MFG. BY: FABREEKA PRODUCTS CO. INC. 1190 ADAMS ST. BOSTON 24, MASS.
6- MFG. BY: McGILL MFG CO INC VALPARAISO, INDIANA
7- MFG. BY: ROLLWAY BRG. CO. SYRACUSE, N.Y.
8- MFG. BY: NEW DEPARTURE, BRISTOL, CONN.
9- MFG. BY: PACKING ENG CORP, CRANFORD, N.J.
10- MFG. BY: CHEMICAL & POWER PRODUCTS, INC. 11 BROADWAY, NEW YORK 4, N.Y.
11- MFG. BY: INDUSTRIAL PRODUCTS SUPPLIERS, EAGLEWOOD, N.J. (ONE EACH OF FOLLOWING THK .001, .002, .003, .005 & .010
12- MFG. BY: PARKER HANNIFIN, CLEVELAND 12, OHIO.
13- MFG. BY: WALWORTH COMPANY, SOUTH BOSTON 12, MASS.
14- MFG. BY: IMPERIAL EASTMAN CORP, 6300 W. HOWARD ST., CHICAGO 48, ILL.
15- MFG. BY: FALK CORP, MILWAUKEE, WISCONSIN.
16- SCREWS OC NO 11 ARE FASTENED TO SHAFTS PC NO 8 & 9 WITH ADHESIVE "REN RP-1250 PASTE & HARDENER, MFR. BY REN PLASTICS, INC., LANSING 9, MICHIGAN, AND BY FOUR PINS. (2 EA SCREW) DENATURED ALCOHOL SHOULD BE USED FOR CLEANING THE PARTS PRIOR TO USE OF ADHESIVE & FOR CLEANING OFF EXCESS ADHESIVE. AFTER ASSEMBLY. "REN "HAND CLEANER IS SUITABLE, FOR REMOVING ADHESIVE FROM HANDS.
"REN" RP-1250 PASTE & HARDENER SHOULD BE MIXED IN EQUAL PARTS & ONLY ENOUGH SHOULD BE MIXED FOR 30 MIN USAGE, SINCE THIS MATERIAL WILL BEGIN HARDENING IN 40 MINUTES.
17- LOCATE THRUST BRG PC NO 18 ON SHAFTS - PRESS FIT IN PLACE - FACES OF BOTH THRUST BRGS MUST BE IN LINE IF NECESSARY, ADJUST BY MEANS OF PLASTIC SHIMS AT I.D. WHEN ADJUSTMENT IS COMPLETED, REMOVE BRG RACE ALSO FROM SHAFTS AND PRESS INTO FRONT HEAD PC 2 FIRST CHECKING TO ASCERTAIN THAT FRONT HEAD FACE IS SMOOTH & STRAIGHT.
18- EXCEPTIONS TO SPECIFICATION MIL-P-18647A (SHIPS) RADIAL BRG PS NO 17 WILL BE PER MIL-M5-17132 THRUST BRG PS NO 18 WILL BE PER MIL-B-18367
19- MFG. BY: NYLON-DETROIT CORP., 1894 BARRETT ROAD, TROY, MICHIGAN.

APPROVED (G&C) LT (6-1799-1 CATEGORY ED BY SI CL/9470 JUN

SEP 29 1957

				MIL-B-857		
	(SKE)	2				
	IT MOTOR	1			COMM'L	048D0
49	HEX NUT 3/4-10	12		MIL-B-857	ASTM A 307 GR B	
50	STUD 3/4-10 x 2 1/2 LG	12				
51	SOCK. HD. SET SCR 5/16-18 x 1"	4		FF-S-86	ASA B-18.3-61	
52	BALANCING DISC.	4	BRONZE		ASTM B-144 AL. BA	144D00
53	STUDS 1/2-13 x 1 3/4	8	STEEL	MIL-B-857	ASTM A 307 GR B	
54	NUTS 1/2-13	8				
55	BLANK FLANGE	2	FORGED STL		COMM'L	
56	GASKET	2				FLE
57	GASKET .008 THK.	1	FIBRE	HH-P-96		163C0
58	TAPER PIN W/NUT #8 x 2	2				
59						

GENERAL NOTES

1. [illegible]
2. SCREWS, PC. NO. 11 TO BE PURCHASED IN SETS OF TWO WHEN PURCHASED AS SEPARATE COMPONENTS.
3. TIMING GEARS, PC. NO. 10 TO BE PURCHASED IN PAIRS WHEN PURCHASED AS SEPARATE COMPONENTS.
4. REPLACEMENT TIMING GEARS WILL BE FURNISHED WITH ONE GEAR KEYWAYED. THE OTHER TO BE KEYWAYED IN THE FIELD.
5. MFG. BY: FABREEKA PRODUCTS CO. INC. 1190 ADAMS ST. BOSTON 24, MASS.
6. MFG. BY: McGILL MFG CO INC VALPARAISO, INDIANA
7. MFG. BY: ROLLWAY BRG. CO. SYRACUSE, N.Y.
8. MFG. BY: NEW DEPARTURE, BRISTOL, CONN.
9. MFG. BY: PACKING ENG CORP, CRANFORD, N.J.
10. MFG. BY: CHEMICAL & POWER PRODUCTS, INC. 11 BROADWAY, NEW YORK 9, N.Y.
11. MFG. BY: INDUSTRIAL PRODUCTS SUPPLIERS, EAGLEWOOD, N.J. (ONE EACH OF FOLLOWING THK .001, .002, .003, .005 & .010
12. MFG. BY: PARKER HANNIFIN, CLEVELAND 12, OHIO.
13. MFG. BY: WALWORTH COMPANY, SOUTH BOSTON 12, MASS.
14. MFG. BY: IMPERIAL EASTMAN CORP. 6800 W. HOWARD ST.,
15. MFG. BY: FALK
16. SCREWS PC NO WITH ADHESI MFR. BY REN BY FOUR PI SHOULD BE OBT OF ADHESIVE AFTER ASSE FOR REMOVIN RE R MIXED W MIXED PO WILL BE
17. LOCATE THRU PLACE - FACE IF NECESSARY WHEN ADJUS FROM SHAFT TO CHECKING TO SMOOTH & AT
18. EXCEPTIONS RADIAL BRG THRUST BRG
19. MFG. BY: NYL

OF MATERIAL QUANTITIES FOR ONE PUMP

ERIAL SPECIFICATION		PART IDENTIFICATION		UNIT WT LBS	REMARKS
ARY	COMMERCIAL	DWG NO OR MFR	SERVICE PART NO.		
96		163C0049	163C0049 FIBRE		
	COMM'L	PARKER	5P50N-S		SEE NOTE 12
	ASTM A108 GRADE 1018	E1975E			
	COMM'L.	PARKER			SEE NOTE 12
		EASTMAN	1701-CS LOCK BONNET		SEE NOTE 14
		PARKER	4 FSBU-S		SEE NOTE 12
		FALK	D95C02.10 STEEL		SEE NOTE 15
	ASTM A7 & A415 H.R.	100A0094	100A0094L020		
957	ASTM A 307 GR B				
	COMM'L	048D0188	048D0188B STEEL		SEE NOTE 19
857	ASTM A 307 GR B				
86	ASA B-18.3-61				
	ASTM B-144 AL.3A	144D0021	144D0021 C090A		
857	ASTM A 307 GR B		NO1YA		
			NO1YA		
	COMM'L	WALWORTH			SEE NOTE 13
		FLEXITALLIC	D-1A		SEE NOTE 22
96		163C0048	163C0048 FIBRE		

REV.	DESCRIPTION	MFR DATE	MFR APPD
A	FIRST ISSUE	6-1-66	
	1) Rev. L/T. BY ADDING APPLIC. MIL. SPEC'S PER TODD SHIPYARD LTR. DE-1058 CLASS/547/545 (2-491-N) of JUNE 17, 1965	9-16-66	
	2) REV'D. PER TODD SHIPYARD LTR. DATED OCT. 21, 1965 & ADDED "1 CLASS 'A' DWG. APPROVAL		
A3	REV'D PER TODD SHIPYARD LTR. DATED DEC. 6, 1965	2-7-66	
A4	Rev. Pc. # 45 & 46 was 5/8-11 STUDS & NUTS,		
	AB ADDED SERVICE PART NO. IN DC. NO'S. 42, 43, 48, 54, & 57		
	AG REV'D. PER TODD SHIPYARD (SAN DIEGO) LTR. DE1052 CLASS/547/545 (2-2803-N) DATED APRIL 25, 1966 REMOVED PC. NO'S. 33 & 59, NOW FLAT OR FRONT AND ASSY	8-5-66	
B	PC 51, 54 ADD VOITA 3-27-67 PD		
	PC. NUMBER 56 WAS DWG. NO. 163D0069 4-7-67 PG.		
C	ADDED PC. 58 3-27-67 DG		

15. MFG. BY: FALK CORP, MILWAUKEE, WISCONSIN.
16. SCREWS PC NO 11 ARE FASTENED TO SHAFTS PC NO 8 & 9 WITH ADHESIVE "REN RP-1250 PASTE & HARDENER, [illegible] AND

20. HARDNESS OF PC. 8 & 9 TO BE 269 TO 321 BHN.
21. HARDNESS OF PC. 10 to BE 400 BHN. (CASE)
22. MFG. BY: FLEXITALLIC GASKET Co. CAMDEN 1, NEW JERSEY

TITIES FOR ONE PUMP

	PART IDENTIFICATION		UNIT	REMARKS
	DWG NO OR MFR.	SERVICE PART NO.	WT LBS	
	163C0049	163C0049 FIBRE		
	PARKER	SP50N-S		SEE NOTE 12
	E18752			
	PARKER			SEE NOTE 12
	EASTMAN	701-CS LOOK WASHER		SEE NOTE 14
	PARKER	4FSBU-S		SEE NOTE 12
	FALK	095C0C10STEEL		SEE NOTE 15
A415	100A0094	100A0094L020		
07				
	048D0188	048D0188STEEL		SEE NOTE 19
307				
-61				
AL-8A	144D0021	144D0021 C090A		

REV.	DESCRIPTION	MFR DATE	MFR APP'D
A	FIRST ISSUE	5/1/66	
	1) Rev. L.I.T. BY ADDING APPLIC. MIL. SPECS PER TODD SHIPYARD LTR. DE-1431 CLASS/547/545 (2-1199-N) of JUNE 17, 1965		
	2) REV'D. PER TODD SHIPYARD LTR. DATED OCT 21, 1966 & ADDED 1 CLASS 'A' DWG. APPROVAL		
A3	REV'D PER TODD SHIPYARD LTR. DATED DEC. 6, 1965	12-7-65	
A4	Rev. Pc. # 43 & 46 was 5/8-11 STUDS & NUTS.		
	A5 ADDED SERVICE PART NO. IN PC. NO'S. 42, 43, 40, 56, & 57		
	A6 REV'D. PER TODD SHIPYARD (S&C) LTR DE-1056 CLASS/547/546 (E-2863-N) DATED APRIL 25, 1966 REMOVED PC. NO'S. 38 & 50, NOW PART OF FRONT HEAD ASS'Y	E.S. 4-29-66	
B	PC #2, 54 ADD WELD 8-27-67 RD PC. NUMBER 56 WAS DWG. NO. 168D0068 4-7-67 RG.		
C	ADDED PC. 38 8-27-67 RG		

QUANTITIES FOR ONE PUMP

CATALOG NUMBER	PART IDENTIFICATION DWG NO OR MFR	PART IDENTIFICATION SERVICE PART NO.	UNIT WT LBS	REMARKS
	163C0049	163C0049 FIBRE		
COMM'L	PARKER	SP50N-S		SEE NOTE 12
TH A109 GR 1018	E18752			
MM'L.	PARKER			SEE NOTE 12
	EASTMAN	701-CS Loctite Bonded		SEE NOTE 14
	[illegible]			
	PARKER	4FS8U-S		SEE NOTE 12
	FALK	085C0810STEEL		SEE NOTE 15
A [illegible]	100A0094	100A0094L020		
TH A 307				
MM'L	048D0188	048D0188STEEL		SEE NOTE 19
TH A 307				
11-183-61				
16-144 AL.3A	144D0021	144D0021 C090A		
TH A 307		NOIYA		
		NOIYA		
MM'L	WALWORTH			SEE NOTE 13
	FLEXITALLIC	D-1A		SEE NOTE 22
	163C0048	163C0048 FIBRE		

REV.	DE
A	FIRST ISSU D. REV. LET MIL-STD LTR, DE CA-HH-N
	D. REVD. DA DATED OCT CLASS "A" D
A3	REVISE PER DA DE
A4	AS N 43,
	AS REVD P BY (C) LTR D CA-8803-M REMOVED NEW PART
B	PC #3,#4 PC. Num DWG. N
C	ADDED

15- MFG. BY: FALK CORP, MILWAUKEE, WISCONSIN.
16- SCREWS PC NO 11 ARE FASTENED TO SHAFTS PC NO 8 & 9 WITH ADHESIVE "REN RP-1250 PASTE & HARDENER, [illegible]

20- HARDNESS OF
21- HARDNESS OF
22- MFG. BY: [illegible]

[redacted]

LIST OF MATERIAL QUANTITIES F

PC NO.	NAME	NO REQD	MATERIAL	MATERIAL SPECIFICATION MILITARY	MATERIAL SPECIFICATION COMMERCIAL
36	GASKET .006" THK	1	FIBRE	HH-P-96	
37	DRAIN PLUG w/ O-RING	1	STEEL		COMM'L
38	ACCELEROMETER BLOCK	2	STEEL		ASTM A108 GRADE 1018
39	TUBING 1/4 OD .049 WALL	3FT	STEEL		COMM'L
40	1/4" NEEDLE VALVE	1			
41					
42	CONNECTOR	2			
43	FLEX CPLG	1			
44	MOUNTING BRKT.	1			ASTM A7 OR A 415 H.R.
45	STUD 3/4-10 x 2 1/2 LG	8		MIL-S-857	ASTM A 307 GR B
46	HEX NUT 3/4-10	8			
47	#8 TAPER PIN (#8X2)	2			
48	LOCKNUT MOTOR	1			COMM'L
49	HEX NUT 3/4-10	12		MIL-S-857	ASTM A 307 GR B
50	STUD 3/4-10 x 2 1/2 LG	12			
51	SOCK. HD SETSCR 5/16-18-1"	4		FF-S-86	ASA B-18.3
	BALANCING DISC.	4	BRONZE		ASTM B-144 AL-BA
	STUDS 1/2-13 x 1 3/4	8	STEEL	MIL-S-857	ASTM A 307 GR B
	NUTS 1/2-13	8			
	BLANK FLANGE	2	FORGED STL		COMM'L
	GASKET	2	ALUMINUM		
	GASKET .006 THK	1	FIBRE	HH-P-96	
	TAPER PIN W/NUT #8X2	2			

GENERAL NOTES

15. MFG. BY
16. SCREW
WITH

EXHIBIT FF

NAVSHIPS 347-0266

#109

INSTRUCTION BOOK
Main Lubricating Oil, Fuel Oil Service & Fuel Oil Booster Pumps, DD Class

WESTINGHOUSE ELEC. & MFG. CO.
[illegible]TON, PA.

Manufacturer's I. B. No. 9021

EXHIBIT "FF"

Manual-000063

C.I.D. - 0170400-2

Serial No. 2015

MAIN LUBRICATING OIL, FUEL OIL SERVICE, FUEL OIL BOOSTER PUMPS

WESTINGHOUSE ELECTRIC

for

U. S. DESTROYERS

DD-498	DD-515	DD-561	DD-571	DD-629
DD-499	DD-516	DD-562	DD-572	DD-630
DD-500	DD-517	DD-563	DD-573	DD-631
DD-501	DD-554	DD-564	DD-574	DD-642
DD-502	DD-555	DD-565	DD-575	DD-643
DD-510	DD-556	DD-566	DD-576	DD-644
DD-511	DD-557	DD-567	DD-577	DD-____
DD-512	DD-558	DD-568	DD-578	DD-____
DD-513	DD-559	DD-569	DD-579	DD-____
DD-514	DD-560	DD-570	DD-580	DD-____

YEAR OF CONSTRUCTION 1942

INSTRUCTION BOOK 8021

NAVY-NPS 42ND, PHILA., PA

Westinghouse Electric & Manufacturing Company
South Philadelphia Works
Essington, Pa.

Printed in U.S.A. (2-43)

Manual-001064

1906 1

APPARATUS SERIAL NUMBER ASSIGNMENT

DD-____ U.S.S._____

MAIN LUBRICATING OIL PUMP -- Turbine Driven

Forward { Turbine _____ Pump _____ } Aft { Turbine _____ Pump _____ }

MAIN LUBRICATING OIL PUMP - Motor-Driven

Forward { Motor _____ Pump _____ } Aft { Motor _____ Pump _____ }

FUEL OIL SERVICE PUMP

Forward { Turbine _____ Pump _____ Turbine _____ Pump _____ } Aft { Turbine _____ Pump _____ Turbine _____ Pump _____ }

FUEL OIL BOOSTER PUMP

Forward { Turbine _____ Pump _____ } Aft { Turbine _____ Pump _____ }

SHIPS' HULL IDENTIFICATION NUMBERS

DD-498	DD-515	DD-661	DD-571	DD-629
DD-499	DD-516	DD-562	DD-572	DD-630
DD-500	DD-517	DD-563	DD-573	DD-631
DD-501	DD-554	DD-564	DD-574	DD-642
DD-502	DD-555	DD-565	DD-575	DD-643
DD-510	DD-556	DD-566	DD-576	DD-644
DD-511	DD-557	DD-567	DD-577	DD-____
DD-512	DD-558	DD-568	DD-578	DD-____
DD-513	DD-559	DD-569	DD-579	DD-____
DD-514	DD-560	DD-570	DD-580	DD-____

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DRAWING LIST

Title	WESTINGHOUSE Drawing Nos.	BUREAU OF SHIPS' Type "B" Numbers
MAIN LUBRICATING OIL PUMP - Turbine-Driven		
Turbine		
Longitudinal Assembly	26-J-551	DD445-S4700-136
Cylinder Base Details and Bill	26-J-552	DD445-S4700-137
Cylinder Cover Details Assembly and Bill.	26-J-528	DD445-S4700-335
Gland Details Assembly and Bill	26-J-529	DD445-S4700-336
Governor Details and Bill	26-J-555	DD445-S4700-333
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Oil Cooler	26-J-532	DD445-S4501-135
Oil Cooler	26-J-533	DD445-S4501-136
Relief Valve Details and Bill	26-J-560	DD445-S4501-134
Rotor Details and Bill	26-J-536	DD445-S4700-337
Steam Chest Details (Sheet 1)	26-J-562	DD445-S4700-141
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Wrenches and Tools Details and Bill	26-J-540	DD445-S4700-370
Worm Drive		
Worm Drive Assembly	26-J-566	DD445-S4501-34
Lower Housing	26-J-567	DD445-S4501-35
Housing and Bearing Cap	26-J-568	DD445-S4501-36
Worm Shaft and Gear Wheel	26-J-569	DD445-S4501-37
Gear Shaft Bearing and Miscellaneous Details	26-J-570	.....
Oil Pump Details	26-J-571	DD445-S4501-39
Miscellaneous Details	26-J-572	DD445-S4501-40
	QUIMBY Drawing Nos.	
Pump		
Details of Pump Body, Intermediate Mounting Bracket and Base (R.B.)	E-157	DD445-S4501-47
Details of Pump Body, Intermediate Mounting Bracket and Base (L.H.)	E-158	DD445-S4501-48
Details of Bases, Screws, Shafts and Miscellaneous Parts	E-159	DD445-S4501-49
Details of Bolts, Studs, Nuts and Miscellaneous Parts	E-160	DD445-S4501-50
Details of Francks Flexible Coupling	E-161	DD445-S4501-126
Sectional Assembly and List of Parts	E-162	DD445-S4501-127
Combined Outline of Pump and Drive	B-117-3	DD445-S4501-153
	WESTINGHOUSE Drawing Nos.	
Motor		
Assembly of Motor and List of Materiel	32-J-537	DD445-S4501-205
General Drawing, Diagram and Specs. of Controller	32-J-430	DD445-S4501-204

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Title	QUIMBY Drawing Nos.	BUREAU OF SHIPS' Type "B" Numbers
MAIN LUBRICATING OIL PUMP - Motor-Driven		
Pump		
Details of Pump Body, Intermediate Mounting Bracket and Base (R.H.)	E-165	DD445-S5501-128
Details of Pump Body, Intermediate Mounting Bracket and Base (L.H.)	E-166	DD445-S5501-129
Details of Heads, Screws, Shafts and Miscellaneous Parts	E-167	DD445-S5501-130
Details of Bolts, Studs, Nuts and Miscellaneous Parts	E-168	DD445-S5501-131
Details of Francke Flexible Coupling	E-169	DD445-S5501-132
Sectional Assembly and List of Parts	E-170	DD445-S4501-133
Combined Outline of Motor and Pump	E-135-3	DD445-S4501-151
	WESTINGHOUSE Drawing Nos.	
FUEL OIL SERVICE PUMP - Turbine-Driven		
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Cylinder Base Details and Bill	26-J-527	DD445-S4700-140
Cylinder Cover Detail Assembly and Bill	26-J-528	DD445-S4700-335
Gland Detail Assembly and Bill	26-J-529	DD445-S4700-336
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Nozzle Block and Reversing Chamber Details and Bill	26-J-531	DD445-S4700-332
Oil Cooler	26-J-532	DD445-S4501-135
Oil Cooler	26-J-533	DD445-S4501-136
Relief Valve Details and Bill	26-J-535	DD445-S5501-214
Rotor Details and Bill	26-J-536	DD445-S4700-337
Steam Chest Details (Sheet 1)	26-J-537	DD445-S4700-142
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Pump		
Details of Body, Heads, Bearings, Etc.	E-152	DD445-S5501-207
Details of Shafts, Screws and Miscellaneous Parts	E-153	DD445-S5501-208
Details of Intermediate Mounting Bracket, Etc.	E-154	DD445-S5501-209

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DRAWING LIST

Title	QUIMBY Drawing Nos.	BUREAU OF SHIPS' Type "B" Numbers
FUEL OIL SERVICE PUMP - Turbine-Driven - Continued		
Pump - Continued		
Details of Francke Flexible Coupling . .	E-155	DD445-S5501-210
Sectional Assembly, List of Parts, Etc. .	E-156	DD445-S5501-211
Combined Outline of Pump and Turbine . .	E-120-5	DD445-S5501-258
	WESTINGHOUSE Drawing Nos.	
FUEL OIL BOOSTER PUMP - Turbine-Driven		
Turbine		
Longitudinal Assembly	26-J-576	DD445-S4700-138
Cylinder Base Details and Bill	26-J-527	DD445-S4700-137
Cylinder Cover Details Assembly and Bill.	26-J-528	DD445-S4700-335
Gland Details Assembly and Bill	26-J-529	DD445-S4700-336
Governor Details and Bill	26-J-555	DD445-S4700-333
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Oil Cooler	26-J-532	DD445-S4501-135
Oil Cooler	26-J-533	DD445-S4501-136
Relief Valve Details and Bill	26-J-535	DD445-S5501-214
Rotor Details and Bill	26-J-536	DD445-S4700-337
Steam Chest Details (Sheet 1)	26-J-537	DD445-S4700-142
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Pump		
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Details of Heads, Screws, Shafts and Miscellaneous Parts	E-173	DD445-S5501-217
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Combined Outline of Pump and Drive . . .	E-121-4	DD445-S5501-257

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PART I

OPERATING DATA

MAIN LUBRICATING OIL PUMP WORM-GEARED DRIVING TURBINES

CHARACTERISTICS

SERVICE: Main Lubricating Oil Pump

TYPE: Turbine - Single Row Re-entry Horizontal Shaft Impulse
Reduction Gear - Horizontal Driving Worm and Vertical Driven Shaft
Pump - Vertical, Constant Delivery, Positive Displacement, Rotary

HORSEPOWER: Turbine . . . . 26.5 Bhp.

CAPACITY: Pump . . . . . 600 Gpm.

SPEED: Turbine . . . . 5220 Rpm. Est. Critical 7100 Rpm.

Pump . . . . . 870 Rpm.

STEAM CONDITIONS: 590 lbs/in^2 Gage, Saturated
15 lbs/in^2 Gage Exhaust Back Pressure

GUARANTEED PERFORMANCE:

Steam consumption at designed conditions 1065 lb/hr.
Unit will carry full load with:
1) Steam at regulating valve 473 lb/in^2 Gage D&S, B.P. 15 lb/in^2 Gage
2) Steam at regulating valve 590 lb/in^2 Gage D&S, B.P. 20 lb/in^2 Gage

ESTIMATED WEIGHT:

One Pump Drive Unit (Complete) = 940 lbs.

OPERATING CLEARANCES:

Rotor and Nozzle	Axial	1/16"
Rotor and Reversing Chamber	Axial	1/16"
Turbine Rotor Shaft Bearings	On Dia. . . .	.0065- .005"
Gland Rings	On Dia. . . .	.004 - .002"
Governor Sleeve	On Dia. . . .	.002 - .001"
Governor Valve Stem Bushings	On Dia. . . .	.0025- .0015"
Governor Travel (Maximum Lift)		9/16"
Governor Valve Travel (Maximum)		1/4"

LUBRICATION SYSTEM:

Use oil of Navy Symbol No. 3080, viscosity 75 to 90 Saybolt seconds at 210 deg. F. Approximately 2 gallons are required in the system.

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MAIN LUBRICATING OIL PUMP—TURBINE-DRIVEN

PUMP CHARACTERISTICS

CAPACITY	600 Gpm.
DISCHARGE PRESSURE	35 lb/in^2 Gage
SUCTION LIFT	10" Mercury
LIQUID	Lubricating Oil
VISCOSITY RANGE	130-500 S.S.U. (Test 205 S.S.U. at 130 Deg. F.)
OIL TEMPERATURE	60-160 Degrees F.
PUMP SPEED	856 Rpm. at 115 S.S.U. 821 Rpm. at 500 S.S.U.
BRAKE HORSEPOWER AT PUMP EFFICIENCY	21.4 Hp. - 65.5% at 115 S.S.U. 24.9 Hp. - 56% at 500 S.S.U.
TYPE DRIVE	Geared Turbine
HYDROSTATIC TEST PRESSURE (Body)	150 lb/in^2 Gage
HYDROSTATIC TEST PRESSURE (Heads)	150 lb/in^2 Gage

APPROXIMATE WEIGHT—PRINCIPAL PARTS

Base	195 lbs.
Intermediate Mounting Bracket	151 lbs.
Body	521 lbs.
Top Head (Complete)	130 lbs.
Bottom Head	50 lbs.
Rotating Element (Complete)	300 lbs.
Screws (Each)	36 lbs.

MAIN LUBRICATING OIL PUMP DRIVING MOTOR

CHARACTERISTICS

SERVICE	Main Lubricating Oil Pump
TYPE	Totally-Enclosed, Fan-Cooled Constant Speed, Continuous Duty
HORSEPOWER	Motor - 26.5 Bhp.
CAPACITY	Pump - 600 Gpm.
SPEED	870 Rpm.
CURRENT CHARACTERISTICS	440 V., 3Phase, 60 Cycles, A.C.
ESTIMATED WEIGHT	Motor Complete - 1300 lbs. Rotor Complete - 250 lbs.

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MAIN LUBRICATING OIL PUMP—MOTOR-DRIVEN

PUMP CHARACTERISTICS

CAPACITY	600 Gpm.
DISCHARGE PRESSURE	35 lb/in^2 Gage
SUCTION LIFT	10" Mercury
LIQUID	Lubricating Oil
VISCOSITY RANGE	130-500 S.S.U. (Test 205 S.S.U. at 130 Deg. F.)
OIL TEMPERATURE	60-160 Degrees F.
PUMP SPEED	870 Rpm.
BRAKE HORSEPOWER AT PUMP EFFICIENCY OF 53%	26.5 Hp.
TYPE DRIVE	Motor
HYDROSTATIC TEST PRESSURE (BODY)	150 lb/in^2 Gage
HYDROSTATIC TEST PRESSURE (HEADS)	150 lb/in^2 Gage

APPROXIMATE WEIGHT—PRINCIPAL PARTS

Base	195 lbs.
Intermediate Mounting Bracket	151 lbs.
Body	521 lbs
Top Head (Complete)	130 lbs.
Bottom Head	50 lbs.
Rotating Element (Complete)	300 lbs.
Screws (Each)	36 lbs.

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MAIN FUEL OIL SERVICE PUMP WORM-GEARED DRIVING TURBINES

CHARACTERISTICS

SERVICE: Main Fuel Oil Service Pump

TYPE: Turbine - Single Row Re-entry Horizontal Shaft Impulse
Reduction Gear - Horizontal Driving Worm and Vertical Driven Shaft
Pump - Vertical, Constant Delivery, Positive Displacement, Rotary

HORSEPOWER: Turbine . . . . 16.0 Bhp.

CAPACITY: Pump . . . . . 50 Gpm.

SPEED: Turbine . . . . 5571 Rpm. Est. Critical 7100 Rpm.

Pump . . . . . 1300 Rpm.

STEAM CONDITIONS: 590 lb/in^2 Gage, Saturated
15 lb/in^2 Gage Exhaust Back Pressure

GGARANTEED PERFORMANCE:

Steam consumption at designed conditions 670 lb/hr.
Unit will carry full load with:
1) Steam at regulating valve 473 lb/in^2 Gage D&S, B.P. 15 lb/in^2 Gage
2) Steam at regulating valve 590 lb/in^2 Gage D&S, B.O. 20 lb/in^2 Gage

ESTIMATED WEIGHT:

One Pump Drive Unit (Complete) = 940 lbs.

OPERATING CLEARANCES:

Rotor and Nozzle	Axial	1/16"
Rotor and Reversing Chamber.	Axial	1/16"
Turbine Rotor Shaft Bearings	On Dia.	.006 - .005"
Gland Rings.	On Dia.	.004 - .002"
Governor Sleeve	On Dia.	.002 - .001"
Governor Valve Stem Bushings	On Dia.	.0025- .0015"
Governor Travel (Maximum Lift)		.9/16"
Governor Valve Travel (Maximum). . .		3/32" to 1/8"

LUBRICATION SYSTEM:

Use oil of Navy Symbol No. 2190, viscosity 185 to 205 Saybolt seconds at 130 deg. F. Approximately 2 gallons are required in the system.

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MAIN FUEL OIL SERVICE PUMP—TURBINE DRIVEN

PUMP CHARACTERISTICS

CAPACITY	50 Gpm.
DISCHARGE PRESSURE	350 lb/in^2 Gage
SUCTION LIFT	19-1/2" Mercury
LIQUID	Fuel Oil
VISCOSITY RANGE	70-700 S.S. Furol
OIL TEMPERATURE	60-120 Degrees F.
PUMP SPEED	1300 Rpm. at 70 S.S.F. 1225 Rpm. at 700 S.S.F.
BRAKE HORSEPOWER AT PUMP EFFICIENCY	13.0 Hp. - 75% at 70 S.S.F. 16.2 Hp. - 65% at 700 S.S.F.
TYPE DRIVE	Geared Turbine
HYDROSTATIC TEST PRESSURE (Body)	700 lb/in^2 Gage
HYDROSTATIC TEST PRESSURE (Heads)	225 lb/in^2 Gage

APPROXIMATE WEIGHT—PRINCIPAL PARTS

Base	103 lbs.
Intermediate Mounting Bracket	80 lbs.
Body	160 lbs.
Top Head (Complete)	37 lbs.
Bottom Head	18 lbs.
Rotating Element (Complete)	51 lbs.
Screws (Each)	5-1/4 lbs.

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FUEL OIL BOOSTER PUMP WORM-GEARED DRIVING TURBINES

CHARACTERISTICS

SERVICE: Fuel Oil Booster Pump

TYPE: Turbine - Single Row Re-entry Horizontal Shaft Impulse
Reduction Gear - Horizontal Driving Worm and Vertical Driven Shaft
Pump - Vertical, Positive Displacement, Rotary

HORSEPOWER: Turbine . . . . 13 Bhp.

CAPACITY: Pump . . . . . 100 Gpm.

SPEED: Turbine . . . . 5520 Rpm.

Pump . . . . . 690 Rpm.

STEAM CONDITIONS: 590 lb/in^2 Gage, Saturated
15 lb/in^2 Gage Exhaust Back Pressure

GUARANTEED PERFORMANCE:

Steam consumption at designed conditions: 620 lb/hr.
Unit will carry full load with:
1) Steam at regulating valve 473 lb/in^2 Gage D&S B.P. 15 lb/in^2 Gage
2) Steam at regulating valve 590 lb/in^2 Gage D&S B.P. 20 lb/in^2 Gage

ESTIMATED WEIGHT:

One Pump Drive Unit (Complete) 940 lbs.

OPERATING CLEARANCES:

Rotor and Nozzle	Axial	1/16"
Rotor and Reversing Chamber .	Axial	1/16"
Turbine Rotor Shaft Bearings.	On Dia. . . .	.0065 - .005"
Gland Rings	On Dia. . . .	.004 - .002"
Governor Sleeve	On Dia. . . .	.002 - .001"
Governor Valve Stem Bushings.	On Dia. . . .	.0025 - .0015"
Governor Travels (Maximum Lift)		9/16"
Governor Valve Travel (Maximum)		3/32" to 1/8"

LUBRICATION SYSTEM:

Use oil of Navy Symbol No. 2190, viscosity 185 to 205 Saybolt seconds at 130 deg. F. Approximately 2 gallons are required in the system.

FUEL OIL BOOSTER PUMP—TURBINE DRIVEN

PUMP CHARACTERISTICS

CAPACITY	100 Gpm.
DISCHARGE PRESSURE	100 lb/in^2 Gage
SUCTION LIFT	25" Mercury
LIQUID	Fuel Oil
VISCOSITY RANGE	70-700 S.S. Furol
OIL TEMPERATURE	60-120 Degrees F.
PUMP SPEED	685 Rpm. at 70 S.S.F. 645 Rpm. at 700 S.S.F.
BRAKE HORSEPOWER AT PUMP EFFICIENCY	9.6 Hp. - 68.5% at 70 S.S.F. 12.1 Hp. - 53.5% at 700 S.S.F.
TYPE DRIVE	Geared Turbine
HYDROSTATIC TEST PRESSURE (Body)	150 lb/in^2 Gage
HYDROSTATIC TEST PRESSURE (Heads)	100 lb/in^2 Gage

APPROXIMATE WEIGHT—PRINCIPAL PARTS

Base	85 lbs.
Intermediate Mounting Bracket	115 lbs.
Body	285 lbs.
Top Head (Complete)	74 lbs.
Bottom Head	27 lbs.
Rotating Element (Complete)	148 lbs.
Screws (Each)	12-1/2 lbs.

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PART II

GEARED-TURBINE AND MOTOR PUMP DRIVE UNITS

DESCRIPTION OF TURBINE UNITS

GENERAL

The pump drtvlng untt ts stmple and compact in arrangement, havtng the pump drtvlng shaft verttcally dtaposed, and drtven by a single-stage horlzontal turbine through a worm and gear.

The turbine for the main lubrloattng otl pump ts a single-vheel reentry unit controlled by a simple fly-vetght governor and a single double-aaated poppet valve. The turbines for the fuel otl servtce pump and the fuel oil booster pump are stmtlar except that the poppet-type valva ts replacad by a plug-type valve. A vertical sectton through the assembled turbine matn lubrtcating otl pump untt ts shown in Fig. 1.

Steam entars the nozzle chamber through the valve "24" and seat "21" (or valve "75" and seat "76") paaaea through the nozzle "15" and the rotor bladés "3" into the revarstng chamber "16" by means of whtch lt ts led back to pass through the rotor blading a second ttme and thence out through the axhaust connectloo.

A reltef valve protects the cyltnder agatnst excesstve pressure and the dtscharge connactton from thts valve ts ptped avay from the unlt to prevent any posstbllity of tnjury to personnel. Thta valve ts adjusted to open when the prassure in the cylinder reaches 25 lb/in^2 gage.

CYLINDER

The cyltnder and cylindar covar are made of oast steel. The cyltnder ts secured wtth a sptgot fit to a half ring cast integral vtth the gear housting. The cylinder cover, in turn, ts secured to the cylindar vtth a aptgot flt. The turbine nozzles are mounted in the cyltndar and the reversing chambers tn the cylindar cover. The tnlet and exhaust connecttons are both in the cylinder, so that the cover can be removed wtthout disturbing the steam ptping.

ROTOR

The turbine rotor consists of a steel-plate dtsc mounted on a steel shaft and securad wtth a key and a nut and lock screw. A single row of stainless steal bladas ts secured to the rim of the dtsc by means of pins of tool-staal drtll rod. The rotor shaft has the vorm of the speed-reducing untt machtned integrally in lt and the shaft is supported in two babbtttlined, aplit, gun-metal journal bearings. The axtal thrust of the worm ts oarrted by a double-row ball bearing secured on the shaft by a nut and lock vasher and the axtal locatton of the shaft in the gear houaing ts dstarmined by the thtckness of a ftller ring between the ball bearing and a shoulder on the shaft.

GEAR AND GEAR SHAFT

The vorm gear is of bronza and ts mounted on a vertical shaft, supported tn two ball bearings, and the upper end of the shaft carrtes the turbine governor. The vorm gear ts secured on the shaft by means of a key and a nut and lock nut whtch holds the gear against a shoulder on the shaft. The upper bearing ta a single-row ball steady bearing whtle the lower ts a double-rov ball thrust boaring. Each of these bearings ts secured against a shoulder on the shaft by means of a nut and look washer, the thrust bearing being provtded vtth a lock nut as wall as a lock vasher.

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GOVERNOR

The governor, mounted on the upper end of the gear shaft, is of the centrifugal fly-weight type.

The actuating force is the change in the centrifugal force on a pair of balanced weights supported on hardened knife edges and arranged to open or close the inlet valve.

Referring to Fig. 1, the governor weights "46" are hardened and a knife-edge at the heel rests on the governor knife-edge bearing "49" while the foot carries the load of the governor springs "40" and "41" through the governor spring seat "42" and the governor struts "47". The springs "40" and "41" provide the necessary resistance load to make the governor function, and the motion of the weights due to centrifugal force overcoming the spring resistance is transmitted to the valve through the ball bearing "44", the bearing housing "19", the governor housing "20", the housing cap "35", and the governor linkage items "31" to "38" inclusive.

Two governor springs, outer and inner, are provided for the fuel oil service pump drive. A single spring would suffice were it made long enough to combine the necessary stiffness with the requisite "scale" or pounds per inch compression, but in order to keep the size of the governor parts as small as practicable, two shorter springs are used to obtain the same result. For the lower-speed, lubricating oil pump and fuel oil booster pump, a single spring (the outer spring "40") is sufficient and the inner spring is omitted.

A stud "18" in the governor knife-edge retainer "48" limits the motion of the governor seat "45" to a maximum lift of 9/16". The governor valve should have a maximum opening of 1/4" in the starting condition to insure that the valve will be seated before the governor seat reaches its maximum lift.

CARBON GLANDS

The cylinder is sealed against leakage of steam along the shaft, by means of a gland of the carbon-ring type. It comprises an outer and an inner gland case, the inner fitted with three carbon rings and the outer with one carbon ring. The outer gland case is bolted against the cylinder and holds the inner case in place. The inner case is prevented from turning by being keyed to the outer case.

The turbines are shipped from the factory with the gland cases in place, but without the carbon rings. The cases must be removed and the rings installed, before the unit can be operated.

The gland, as shown in the figure, consists of four carbon rings, each made in three segments held together by a garter spring. All the rings are fitted with a clearance around the shaft and remain stationary in the gland case. The ring segments are rectangular in section with the outer periphery grooved to take the garter spring.

When installing the gland in the field, the gland case must be removed, the carbon rings installed and the case reassembled as described below. Special care must be taken to insure that the rings are installed in the proper grooves. Each segment is marked with the number of the groove in which it is assembled, the groove numbers being also stamped in the gland case.

After the shaft has been cleaned, the carbon rings should be assembled on the shaft. An approved preparation of unvulcanized rubber dissolved in gasoline should be painted on the gland case face where the case is bolted

to the cylinder. The joint where the halves of the gland case are bolted together should also be treated with the preparation. In painting these surfaces, care must be taken that an excess is not used. Care must be taken that the rubber does not get on the inner gland case, and it must positively not be permitted to get on any carbon ring.

The gland case halves should be put in place over the carbon rings, being certain that the keys engage the recesses in the gland case. The halves of the gland case should be bolted together snugly. Then the gland case should be bolted to the cylinder snugly. Finally, the bolting holding the halves together should be tightened and then the bolting to the cylinder.

The glands should not be heated up for an hour after assembly. However, the first time they are heated, the bolting should be gone over and tightened thoroughly.

If new rings are installed, each complete ring should be bored to give .002" to .004" clearance on the diameter with the segment ends abutting; there should be .026" to .034" axial clearance between each ring and the side of its groove, so that the ring can move freely to assume its correct position relative to the shaft. When the glands are assembled the ring segments should be placed around the shaft and held in position by the garter springs. The complete rings must then be spaced the proper distance apart and the housing slipped over them.

The outer gland chamber is provided with a drain connection and any condensation which may leak past the inner rings is carried away through the drain to the turbine exhaust.

LUBRICATION

Use oil of proper Navy Symbol Number as specified under corresponding "Turbine Characteristics", as the same grade of oil is not used in all turbines.

The oil reservoir should be flushed out before starting, and as often as required to keep it free from sludge. The oil should be changed frequently when the turbine is new.

Forced-feed lubrication is employed throughout. Provision is made so that the oil cannot be shut off entirely. A metering plug in the inlet to the governor insures that an excessive amount of oil will not be supplied the governor. The oil pressure should be at least 8 lb/in^2 at full speed as shown by the red hand on the oil pressure gage. A relief valve is provided in the oil pump discharge line. It is set to maintain 10 lb/in^2 pressure on the bearing oil gage at normal speed and 140°F. oil.

DESCRIPTION AND CARE OF OIL COOLER

DESCRIPTION

An external oil cooler is provided, illustrated in Fig. 2. It consists of a body and cover, with a cooling core secured to the cover by means of the oil pipe connections, and provided with cooling water connections to the body. The direction of flow is immaterial for either the oil or the water.

The cooler core is made up of punched and corrugated sheets and distance pieces brazed together and is not susceptible of adjustment or field repair. In case of a leak or obstruction, the spare core should be installed

The core is secured to the cover by means of a jam nut and a fiber washer at each oil connection and the cover is bolted to the cooler body by through bolts. Any sediment carried in with or precipitated from the cooling water will be deposited in the body, which should be taken down periodically and washed out.

A zinc bar attached to a plug in one end of the cooler body prevents galvanic action from affecting the body metal.

CARE OF THE COOLER

Step 1. The oil cooler should be cleaned whenever objectionable increase in pressure drop through the unit, or decrease in cooling efficiency, is observed. When either of these conditions is noted, remove the core assembly from the case and cover and clean it.

Step 2. To clean the inside of the plates, immerse the core in a suitable cleaner or solvent. (CAUTION: This operation should be done in the open air or with adequate ventilation.)

Forced circulation of the cleaner fluid through the plates by means of an ordinary grease gun or rubber suction cup will facilitate cleaning the oil passages.

Step 3. Blow out with high-pressure oil, or steam. Repeat these operations until thoroughly clean.

Step 4. Clean outside surfaces of plates with brush and suitable solvent.

Step 5. Remove all foreign matter from inside of casing and cover.

Step 6. Reassemble the oil cooler, using new gaskets where necessary.

IMPORTANT

Step 7. The zinc electrode should be examined thirty days after installation and every thirty days thereafter. Any appreciable erosion within these periods indicates electrolytic action.

Careful inspection should then be made to determine if this action is caused by short-circuits or external and grounded electric currents. If so, this condition must be eliminated to avoid serious damage.

Step 8. On the other hand, if no such condition is found, it is evident that erosion is due to local electrolysis in which case the only practical procedure or remedy is frequent replacement of the zinc electrode.

OPERATION AND MAINTENANCE OF TURBINE UNITS

STARTING

Step 1. Open throttle, steam chest, and cylinder drains.

Step 2. Examine the bayonet-type oil-level indicator and see that the oil shows at approximately maximum oil level.

Step 3. Open turbine exhaust valve.

Step 4. Open throttle valve and bring unit up to speed.

Step 5. Close drains.

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RUNNING

Step 1. After normal running condition has been established, again examine the oil level indicator and see that the oil level stands about half way between maximum and minimum levels. No other attention is needed.

Step 2. Preferably once a watch, pull outward on the valve end of the governor linkage so as momentarily to increase the speed and to move the governor valve, thus insuring against any possibility of sticking.

STOPPING

Step 1. Close throttle valve.

Step 2. Open drains.

Step 3. Close exhaust valve.

Step 4. Close drains.

MAINTENANCE AND INSPECTION

A thorough inspection of all parts of the turbine and gear unit should be made at each overall period and at least once a year, renewing such parts as may show undue wear. If heavy wear of any part is evidenced, the cause of the wear should be determined if possible to correct the condition, and replacement of the part should be made to avoid any possibility of complete failure. To assist the operator in dismantling and reassembling the unit certain special tools are provided the purpose and appearance of which are shown in Figure 3.

TAKING APART AND REASSEMBLING

Before starting to take apart note carefully the setting of all adjustable parts to assure being able to restore them to their original adjustments.

Handle all parts carefully to avoid bruises which might cause steam leaks or misalignment.

Carefully clean and examine all parts removed or made accessible, and repair or replace any which show injurious wear or damage. When assembling be sure that all parts are clean and free from bruises.

Clean and blow out all oil passages.

To make the joint between the casing cover "1" and the casing proper, make sure that the faces are clean and free from bruises. Coat the surfaces with linseed oil and graphite or some form of approved joint cement.

When making up the joints on the worm and gear casing "25-45" carefully clean the surfaces and coat lightly with heavy grease.

To dismantle or remove the worm or worm gear from casing, it will be necessary to proceed in the following manner:

Step 1. Remove oil pump case, use "67" with gear "72".

Step 2. Remove turbine cover "2" and with this removed loosen wheel shaft nut "13" removing it from the wheel shaft.

Step 3. Jack the wheel "6" from worm shaft "11".

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Step 4. Remove gland outer cese upper half "14-A", lower half "7" and tnner ceetng "8" and "13-A" and remove carbon rings "10" and pecktng ring epringe from the shaft.

Step 5. Remove governor lever "33" and cover "17"; dtemantle all governor parts from the shaft includtng the governor dtso.

Step 6. Remeve end cover "57-A". Remove hex nuts and bolts from upper helf of cesing "74" then ltft cover "74" and top half of bearinge.

Step 7. Remeve the vorm ebaft thrust bearing. Roll out the bbttom halvee of the journal bearings. Then the vorm shaft can be moved stdeways sufftctently to cleer the vorm wheel and the letter can then be ltfted etratght up and out. Then the worm can in turn be ltfted out.

Some of these untts heve worm drtves butlt by the Mtchtgan Tool Worke and others have drtves butlt by tha Philadelphie Gear Worke. The former can be readtly tdenttfted by the fact that the worm ts of the "hour-glass" or "Rindley Type" whtle the latter have a worm of normal deetgn.

Step 8. Reaeeemble the unit in reverse method making certain all parts have been thoroughly claaned and free from brutsee.

CARE OF THE TURBINE

Step 1. Keep the machtne clean.

Step 2. Keep the oil reservoir ftlled to the proper level vttb the clean otl.

Step 3. Wash out the reeervoir wttb kerosene and reftll wttb olean otl et reguler overhaul pertods.

Step 4. Clean off governor velve etem ee often ae neceeeary to keep tt always free and in operettng condttton.

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WESTINGHOUSE SQUIRREL CAGE MOTORS for NAVY SERVICE

GENERAL

Details of construction, insulation treatments given both stator and rotor, wiring diagrams, and motor operating characteristics are all shown on the corresponding approved Navy drawing 32-J-537.

INSTALLATION

INSPECTION

After unpacking, make sure that the motor was not damaged during shipment. See that the name plate reading agrees with the voltage and frequency provided for the motor.

ELECTRICAL CONNECTIONS

Connect the motor and starter by referring to the diagrams furnished with the starter and shown on approved Navy drawing.

Connection of Motor to Power Circuit with Standard Number of Terminals

Three-Phase (Three Terminals) - Connect any lead to any motor terminal. To reverse the direction of the motor, interchange any two leads.

Connection of Motor with More than Standard Number of Terminals

Refer to the connection data on the motor drawing.

OPERATION

Check rotor to see that it turns freely, that there is no rubbing of the laminations or any foreign material in the air gap.

Run the motor without load to check the connections, and direction of rotation. To stop the motor, refer to the instructions furnished with the starter.

INSULATION

The motor on being shipped from the factory will have insulation resistance values in accordance with the requirements of Navy Spec. 17M10. However, should the motor stand idle in storage or on the vessel for any great length of time and be subject to unusual atmospheric changes, it will be advisable to measure the insulation resistance of the stator windings with an insulation-resistance meter. The insulation resistance taken "cold" should be not less than one (1) megohm.

Should the insulation resistance be less than one megohm, means of drying out the motor should be undertaken. This may be accomplished by drying in an oven at a temperature not to exceed 105 degrees Centigrade, enclosing the unit and heating by means of lamps, resistance units, etc., or by

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circulating current through the stator windings at low voltages (with rotor locked) until the insulation resistance readings reach a constant value.

MAINTENANCE

COILS

Do not allow dirt and oil to collect on the stator coils. Inspect the insulation regularly. After a few years service, or oftener for very severe conditions, it is advisable to apply a coat of baking varnish. (Baking Varnish No. 335, Navy Spec. 52V13, Grade BB is much superior to any air-drying varnish). Varnish can be obtained from the nearest Westinghouse Dealer. Westinghouse Service Shops are equipped to bake motors.

BEARINGS

Quietness and life of ball and roller bearings depends largely on cleanliness and proper lubrication.

Never open the bearing housing under conditions which will permit entrance of dirt.

External inspection of the motor at the time of the first greasing, soon after it is put into operation, will determine whether the bearings are operating quietly and without undue heating. Further inspection will not be necessary except at infrequent intervals, probably at greasing periods.

When shipped from the factory, grease-lubricated ball and roller bearing motors have sufficient grease of the right grade to last for a limited period. Each bearing is provided with a grease cup which should be kept filled with a lubricant meeting the requirements of Navy Leaflet Spec. 14L3. However, a charge of grease should be added soon after the motor is put in operation, and thereafter at suitable intervals, as determined by experience. The ideal condition is that the bearing housing be from 1/3 to 1/2 full of grease.

The fixture shown on the Navy approved drawing should be used when it is necessary to remove the ball bearings.

TROUBLES

Stator troubles can usually be traced to one of the following causes:

Worn bearings - Moisture - Overloading -
Operating Single Phase - and Poor Insulation.

Worn bearings will cause misalignment, resulting in vibration and possible rubbing of the rotor on the stator windings. Bearings should be checked and replaced if necessary.

Excessive moisture on the windings coupled with oil leakage from bearings or dust will cause rapid deterioration of the coil insulation. Coils should be cleaned and dried thoroughly. When still warm, a high grade insulating varnish should be applied, air-drying if not practicable to remove machine to an oven for baking.

Avoid continuous overloads as this causes coils to overheat and tends to weaken coil insulation. The rating of the motor should be checked to see that it is adequate for the load.

Continued vibration of rotating parts will eventually cause insulation failure. Misalignment, mechanical unbalance, bent shaft, foreign material in the air gap, and unbalanced stator currents are possible causes of vibration and should be corrected to insure long life of the insulation.

KEEP MOTOR CLEAN AND BEARINGS PROPERLY LUBRICATED.

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WESTINGHOUSE CONTROL EQUIPMENT
for
NAVY SERVICE

GENERAL

A description of the control equipment and its normal operating functions is shown on the corresponding approved Navy drawing. Maintenance and repair instructions are given in the following. Only skilled personnal should service the equipment, and it is assumed that all possible safety precautions will be taken. This is illustrated on Drawing 32-J-430.

MAINTENANCE

INSPECTION

Periodical inspections of the control equipment should be made.

CLEANING

Accumulations of dirt should be removed and dust blown out with compressed air. Where compressed air is not available, careful vacuum cleaning may be sufficient.

MECHANICAL PARTS

Moving parts should be tried by hand to locate loose pins, bolts, or nuts. Parts subject to wear or liable to change in adjustment due to vibration deserve special attention.

SPRINGS

Springs should be checked for signs of weakening in tension or compression. Excessive heating or burning of contacts may be due to contact springs that should be readjusted or replaced. Where it is desired to measure the contact pressure, a spring scale may be attached to the moving contact part and a thin piece of paper placed between the two contact parts. The pull required to permit removal of the paper is the contact pressure, provided the pull is exerted in a direction vertical to the contact surface and the line of pull projects through the center of this surface. For reasons of safety, it is preferable to hold the contactor closed mechanically for this test rather than by energizing its coil.

CONTACT PARTS

Deeply pitted or burned contact parts should be replaced. Slightly rough, oxidized or blackened parts may be cleaned with a fine file. A piece of carbon paper may be used to check if the contact surfaces are touching evenly. Silver contacts should not be filed or dressed even though black, as they will still make good contact.

INSULATION

Insulating surfaces should be inspected for signs or creeping currents which may have formed due to moisture or dirt, and where found, the passages should be thoroughly cleaned, or if necessary, scraped and re-insulated. Insulation of cables and coils may be damaged by rubbing against solid parts due to vibration. Where such wear occurs, the insulation should be strengthened and usually the cause of the wear can be easily removed.

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LUBRICATION

Ordinarily, contactors, relays, drums, master switches, etc., do not require lubrication. However, if excessive wear has damaged the surface protection, as for instance, on the faces of magnets, corrosion may be prevented by adding a few drops of light oil. Special care should be taken to remove any excess of oil to prevent the collecting of dirt in these places.

REPAIR

Repair parts should be placed at easy access to the operating personnel. Any spare parts taken from their stock should be re-ordered at the earliest opportunity. Ordering information is contained in the "List of Spare Parts".

ELECTRICAL TROUBLE

Trouble in the electrical operation, if the cause is not at once evident, may be traced easily with the aid of the "Description of Operation". Individual circuits may be segregated by removing fuses, removing leads from their studs or by placing thick paper between the contact parts of certain contactors or relays.

NOISY CONTACTORS

Larger contactors with coils operated by alternating current will normally cause a light humming. If due to excessive wear, or after making repairs or adjustments an objectionable chattering should develop, the cause may be looked for in an insufficient seating of the magnet surfaces. It may be that an obstruction prevents complete closing of the magnet, or that the seating surfaces are uneven or out of alignment. Carbon paper may be used to check the contact between the surfaces. Any filing to be done on these surfaces should be done by a skilled mechanic. Loose or damaged shading coils may also contribute to noisy operation.

STICKING CONTACTORS OR RELAYS

Direct-current magnets should not completely close their magnetic circuits unless their remnant magnetism is removed by reversing the magnetizing force. An air gap is usually left or a non-magnetic shim is included in core, frame, armature or on one of the pole faces. Sticking may also be caused by welding the contact parts together due to overheating, which in turn may be due to too heavy currents or to improper cleaning or spring adjustment.

PART III

"QUIMBY" OIL PUMPS

TURBINE-DRIVEN MAIN LUBRICATING OIL PUMP

DESCRIPTION OF PUMP

Each unit consists of a No. 6 "Quimby" Vertical Main Lubricating Oil Screw Pump, Gear-in-Head Type, attached to an intermediate mounting bracket and mounted on a base designed for floor mounting, Fig. 10. Each pump is driven by a Westinghouse steam turbine mounted on the intermediate mounting bracket and directly connected to the pump by means of a Francks Flexible Coupling.

RUNNING CLEARANCES

1. Running clearance between screws, "3", "6", "24" and "26" and body "4" is .004".

2. Running clearance between sides of intermeshing screws "3", "6", "24" and "26" is .004".

3. Running clearance between face of top head "18", and face of spacing "22" washer is .003".

4. Running clearance between shafts "12" and "15" and bore of bearings and bushings "1", "11" and "21" is .0035".

LUBRICATION

Timing gears "8" are lubricated by the oil in the suction chamber of the pump. Upper and lower bearings and bushings "1", "11" and "21" are also lubricated by the oil handled.

PIPING

All piping should be supported and braced so that no strain is placed on the machine either by weight or expansion.

PACKING

The pump stuffing box is packed with 3/8" square, John Crane, No. 150 Flexible Metallit Packing. Packing conforms to Specification 33-P-17, Symbol No. 1430, as indicated on Bureau of Ship's Standard Sheet No. B-153.

ALIGNMENT

Accurate alignment of the pump and driving unit is necessary for satisfactory operation. Therefore, great care should be exercised to insure that each unit has been properly installed and aligned. This should be checked before starting up the pumps for the first time and also each time that the units have been taken apart for inspection or repair.

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MOTOR-DRIVEN MAIN LUBRICATING OIL PUMP

DESCRIPTION OF PUMP

Each unit consists of a No. 6 "Quimby" Vertical Main Lubricating Oil Screw Pump, Geared-in-Head Type, attached to an intermediate mounting bracket and mounted on a base designed for floor mounting, Fig. 11. Each pump is driven by a Westinghouse motor mounted on the intermediate mounting bracket and directly connected to the pump by means of a Francke Flexible Coupling.

RUNNING CLEARANCES

1. Running clearance between screws "3","6", "24" and "26" and body "4" is .004".
2. Running clearance between sides of intermeshing screws "3", "26" "6" and "24" is .004".
3. Running clearance between face of top head "18" and face of spacing washer "22" is .003".
4. Running clearance between shafts "12" and "15" and bore of bearings and bushings "1", "11" and "21" is .0035".

LUBRICATION

Timing gears "8" are lubricated by the oil in the suction chamber of the pump. Upper and lower bearings and bushings "1", "11" and "21" are also lubricated by the oil handled.

PIPING

All piping should be supported and braced so that no strain is placed on the machine either by weight or expansion.

PACKING

The pump stuffing box is packed with 3/8" square, John Crane, No. 150 Flexible Metallic Packing. Packing conforms to Specification 33-P-17, Symbol No. 1430, as indicated on Bureau of Ship's Standard Sheet No. B-153.

ALIGNMENT

Accurate alignment of the pump and driving unit is necessary for satisfactory operation. Therefore, great care should be exercised to insure that each unit has been properly installed and aligned. This should be checked before starting up the pumps for the first time and also each time that the units have been taken apart for inspection or repair.

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MAIN FUEL OIL SERVICE PUMP

DESCRIPTION OF PUMP

Each unit consists of a No. 3 "Quimby" Vertical Main Fuel Oil Service Screw Pump, Gear-in-Head Type, attached to an intermediate mounting bracket and mounted on a base designed for floor mounting, Fig. 12. Each pump is driven by a Westinghouse steam turbine mounted on the intermediate mounting bracket and directly connected to the pump by means of a Francke Flexible Coupling.

RUNNING CLEARANCES

1. Running clearance between screws "4","6", "22" and "23", and body "24" is .0025".
2. Running clearance between sides of intermeshing screws "4", "6", "22" and "23" is .002".
3. Running clearance between face of top head "10", and face of spacing washer "7" is .003".
4. Running clearance between shafts "9" and "14", and bore of bearings and bushings "11", "18" and "25" is .002".

LUBRICATION

Timing gears "21" are lubricated by the oil in the suction chamber of the pump. Upper and lower bearings and bushings "11", "18" and "25" are also lubricated by the oil handled.

PIPING

All piping should be supported and braced so that no strain is placed on the machine either by weight or expansion.

PACKING

The pump stuffing box is packed with 1/4" square, John Crane, No. 150 Flexible Metallic Packing. Packing conforms to Specification 33-P-17, Symbol No. 1430, as indicated on Bureau of Ship's Standard Sheet No. B-153.

ALIGNMENT

Accurate alignment of the pump and driving unit is necessary for satisfactory operation. Therefore, great care should be exercised to insure that each unit has been properly installed and aligned. This should be checked before starting up the pumps for the first time and also each time that the units have been taken apart for inspection and repair.

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FUEL OIL BOOSTER PUMP

DESCRIPTION OF PUMP

Each unit consists of a No. 4 "Quimby" Vertical Fuel Oil Booster Screw Pump, Gear-in-Head Type, attached to an intermediate mounting bracket and mounted on a base designed for floor mounting, Fig. 12. Each pump is driven by a Westinghouse steam turbine mounted on the intermediate mounting bracket and directly connected to the pump by means of a Francke Flexible Coupling.

RUNNING CLEARANCES

1. Running clearance between screws "6", "9", "28" and "29" and body "7" is .0045".
2. Running clearance between sides of intermesbing screws "6", "28", "9" and "29" is .003".
3. Running clearance between face of top head "21" and face of spacing washer "11" is .003".
4. Running clearance between shafts "14" and "18" and bore of bearings and bushings "3", "13" and "24" is .0035".

LUBRICATION

Timing gears "25" are lubricated by the oil in the suction chamber of the pump. Upper and lower bearings and bushings "3", "13" and "24" are also lubricated by the oil handled.

PIPING

All piping should be supported and braced so that no strain is placed on the machine either by weight or expansion.

PACKING

The pump stuffing box is packed with 3/8" square, John Crane, No. 150 Flexible Metallic Packing. Packing conforms to Specification 33-P-17, Symbol No. 1430, as indicated on Bureau of Ship's Standard Sheet No. B-153.

ALIGNMENT

Accurate alignment of the pump and driving unit is necessary for satisfactory operation. Therefore, great care should be exercised to insure that each unit has been properly installed and aligned. This should be checked before starting up the pumps for the first time and also each time that the units have been taken apart for inspection or repair.

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ALIGNING VERTICAL SHAFT "QUIMBY" SCREW PUMPS

Installation of pumping unit should be made with center of shaft in vertical plane when ship is on even keel. The pump must set level and be well supported under its entire base to ensure steady quiet operation. The holding down bolts should be carefully tightened to avoid distortion of the pump support and shaft alignment.

As erection of pump progresses it is essential to check shaft alignment frequently.

Check flexible coupling halves with "feeler" gages adjusting the setting of pump and driver until coupling faces are parallel all around.

Also check coupling for concentricity with a steel straight edge laid across both coupling flanges, parallel with shaft and revolving rotor slowly by hand.

The rotating element must turn freely, without binding at any point after the coupling halves are engaged and pump is bolted to foundation.

ASSEMBLING NEW SCREWS ON SHAFTS

When assembling new screws on shafts, proceed as follows:

Step 1. Fit one right-hand and one left-hand screw on the long shaft in same relative position as the original screws, bringing the inner hubs up tight together.

Step 2. Drill holes for screw driving pins, insert and rivet pins.

Step 3. Place shaft with screws in lathe centers and straighten to within .001" of concentricity.

Step 4. Fit forward matching screw (nearest gear) to short shaft, making sure that face of hub where spacing washer contacts same is in line with corresponding hub on matching screw. The rotating unit as so far assembled should turn freely by hand before pinning this first screw to short shaft.

Step 5. Place timing gears on both shafts and key to same.

Step 6. When rotor turns freely by hand drill holes for screw driving pins, insert and rivet pins.

Step 7. Place short shaft with first screw in lathe centers and straighten to within .001" of concentricity.

Step 8. Fit remaining matching screw (4th screw) on short shaft, making tight joint between inner hub ends as mentioned above.

Step 9. Divide clearance between sides of matching screws evenly when the complete element should rotate freely by hand before fastening last screw to shaft.

Step 10. Drill holes for screw driving pins, insert and rivet pins.

Step 11. After all screws are fastened to shafts place each shaft in lathe centers and straighten to .0005" of concentricity.

Step 12. Check faces of screw hubs at both outer ends to determine if they are exactly in line with hubs on matching screws. If not in line face off the longer hub in lathe to match, so that the thrust bearings will be evenly loaded.

Top spacing washers should have .003" clearance between washer and upper head.

The shafts should be held parallel during above operations.

ASSEMBLING TIMING GEARS FOR "QUIMBY" SCREW PUMPS

FITTING A NEW PAIR OF TIMING GEARS TO OLD SHAFTS

Step 1. Fit the gear which is provided with keyway to the long shaft with key in place, sliding gear on about half of the key length.

Step 2. Place rotating element in cylinder with heads off. This will hold shafts and gears parallel.

Step 3. Place second gear on short shaft with key removed. Mesh the two gears together and slide them on the shafts as far as possible by hand.

It should be possible to rotate the shafts by hand when gears are in half-way position and rotors parallel.

Step 4. Rotate shafts by means of keyed gear in one direction, until all clearance between screws is on one side. Then with a piece of key stock, of size to be used, inserted in key-way on shaft at unkeyed gear, scribe location for keyway in gear hub.

Before removing the key stock rotate the shafts in opposite direction so that all screw clearance will be at opposite side. Again scribe the location of keyway on gear hub and cut the keyway in hub midway between the scribe marks.

Step 5. Complete work by keying both gears in correct location on shafts and assemble in the usual manner.

SHIPPING INSTRUCTIONS FOR RETURNING PARTS TO FACTORY

In the event that it becomes necessary to return any part of this equipment to the manufacturer, it should be tagged with the sender's name and address and the serial number of the unit.

Material pertaining to the pump should be forwarded to the Quimby Pump Co., 340 Thomas Street, Newark, New Jersey, and questions relating thereto should be addressed to them.

Material pertaining to the driving turbines and gears should be forwarded by freight, express, or parcel post to

Westinghouse Electric & Manufacturing Company
South Philadelphia Works
Essington, Pa.

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FIGURE 1

TURBINE ASSEMBLY AND PARTS LIST

Item No.	Name of Part
1	Turbine Cylinder Base
2	Turbine Cylinder Cover
3	Turbine Rotor Blade
4	Turbine Rotor Blade Pin
5	Turbine Bearing (Turbine End) Lower Half
6	Turbine Rotor Disc
7	Turbine Gland Case (Outer) (Lower Half)
8	Turbine Gland Case (Inner) (Lower Half)
9	Turbine Gland Carbon Ring Spring
10	Turbine Gland Carbon Ring
11	Turbine and Worm Shaft
12	Turbine Rotor Key
13	Turbine Rotor Nut
13-A	Turbine Gland Case (Inner) (Upper Half)
14	Turbine Bearing (Turbine End) (Upper Half)
14-A	Turbine Gland Case (Outer) (Upper Half)
15	Turbine Nozzle
16	Turbine Reversing Chamber
17	Governor Cover
18	Governor Stud
19	Governor Bearing Housing
20	Governor Housing
21	Governor Valve Cage
22	Steam Chest Body
23	Governor Valve Stem
24	Governor Valve
25	Governor Valve Stem Bushing (Inner)
26	Steam Chest Cover
27	Governor Valve Stem Bushing (Outer)
28	Governor Valve Stem Spring Support
29	Governor Valve Stem Spring Nut
30	Governor Valve Stem Spring
31	Governor Lever Link Pin
32	Governor Lever Link
33	Governor Lever
34	Governor Lever Fulcrum Pin
35	Governor Housing Cap
36	Governor Lever
37	Governor Valve Stem Link Pin
38	Governor Valve Stem Link
39	Governor Spring Nut
40	Governor Spring (Outer)
41	Governor Spring (Inner)
42	Governor Spring Seat
43	Governor Bearing Retainer
44	Governor Bearing
45	Governor Seat
46	Governor Weight
47	Governor Strut
48	Governor Knife-Edge Bearing Retainer
49	Governor Knife-Edge Bearing
50	Governor Knife-Edge Bearing Retainer Set Screw
51	Gear Shaft Radial Bearing Cap
52	Gear Shaft Locknut
53	Gear Shaft Radial Bearing
54	Turbine Shaft Bearing (Thrust End) (Upper Half)
55	Thrust Bearing Locknut
56	Thrust Bearing Shim
57	Thrust Bearing Lock Nut Lock Washer
57-A	Gear Housing End Cover
58	Thrust Bearing
59	Turbine Shaft Bearing (Thrust End) (Lower Half)
60	Gear Lock Nut
61	Worm Gear
62	Thrust Bearing Cap (Gear Shaft)
63	Thrust Bearing (Gear Shaft)
64	Thrust Bearing Lock Nut
65	Lower Housing
66	Oil Pump Cover
67	Oil Pump Case
68	Oil Pump Gear (Driver)
69	Oil Pump Gland Packing
70	Oil Pump Gland
71	Gear Shaft
72	Oil Pump Gear (Driven)
73	Worm Gear Key
74	Upper Housing
75	Governor Valve (for Fuel Oil Service & Booster Pumps)
76	Governor Valve Cage (for Fuel Oil Service and Booster Pumps)
77	Gear Shaft Coupling Key
78	Gear Shaft Coupling Nut

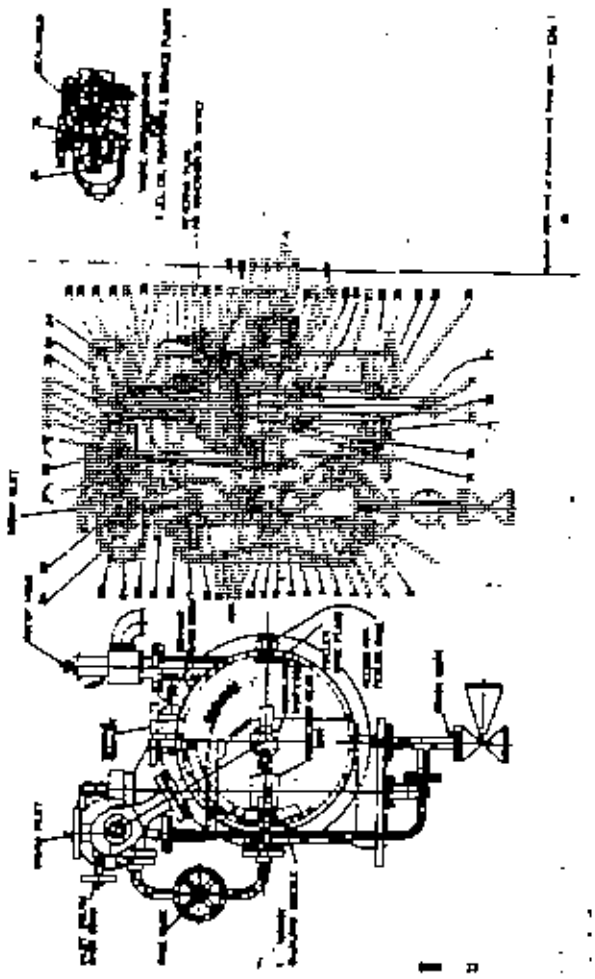


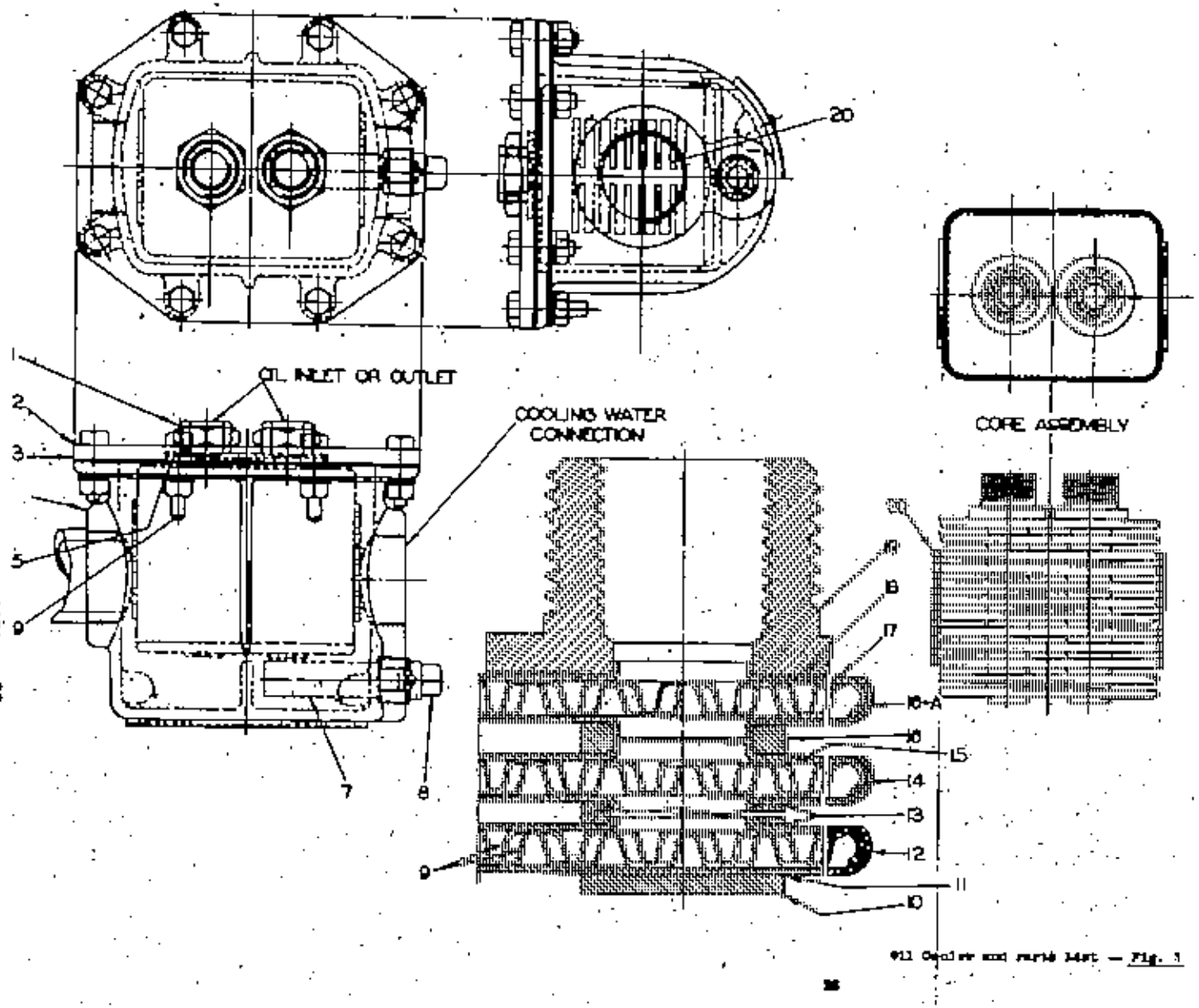
FIGURE 2

OIL COOLER AND PARTS LIST

Item No.	Name of Part
1	Lock Nut (Inlet or Outlet)
2	Plate Core
3	Gasket (Case)
4	Case
5	Gasket (Inlet or Outlet)
6	Hex. Bolt (Long)
7	Zinc
8	Zinc Support Plug
9	Center
10	Reinforcement (Rear Tube)
11	Brazing Sheet (Reinforcement)
12	Plate Bottom
13	Brazing Sheet (Tube Spacer)
14	Brazing Sheet (Formed)
15	Brazing Sheet (Flat)
16	Tube Spacer
16-A	Tube Plate (Female)
17	Tube Plate (Male)
18	Brazing Sheet (Inlet or Outlet)
19	Inlet or Outlet
20	Core Assembly Baffle

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911 Cooler and parts list — Fig. 1

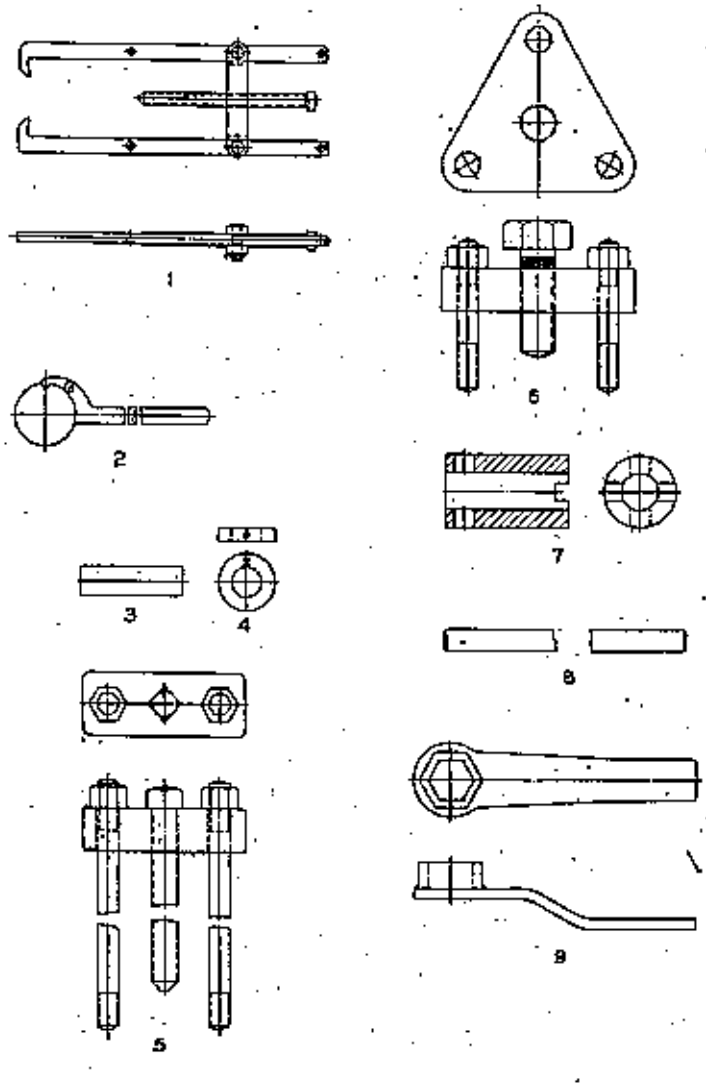
FIGURE 3

TOOLS AND WRENCHES

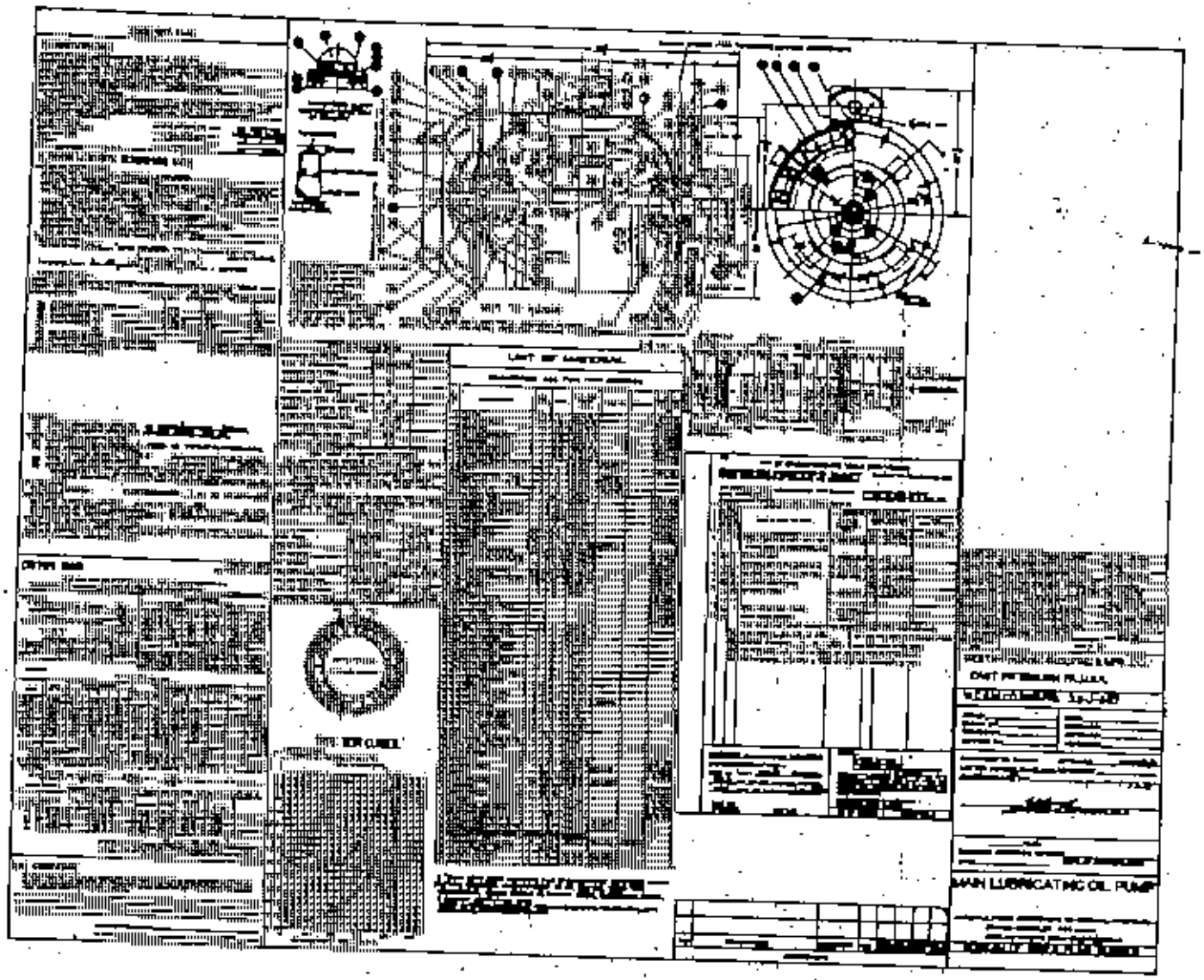
Item No.	Name of Part
1	Bearing Puller Complete
2	Adjuetable Spanner Wrench
3	Babbitting Arbor
4	Babhitting Arbor Coller
5	Worm Wheel Puller Complete
6	Rotor Puller Complete
7	Governor Spring Nut Wrench
8	Goeernor Spring Nut Wrench Handle
9	Rotor Nut Wrench
10	Gland Bolt Wrenoh and Socket
11	Valve Cage Puller
12	Gland Wrenoh

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Special Tools and Wrenches -- Fig. 3



Assembly of Motor for Main Lubricating Oil Pump — Fig. 4

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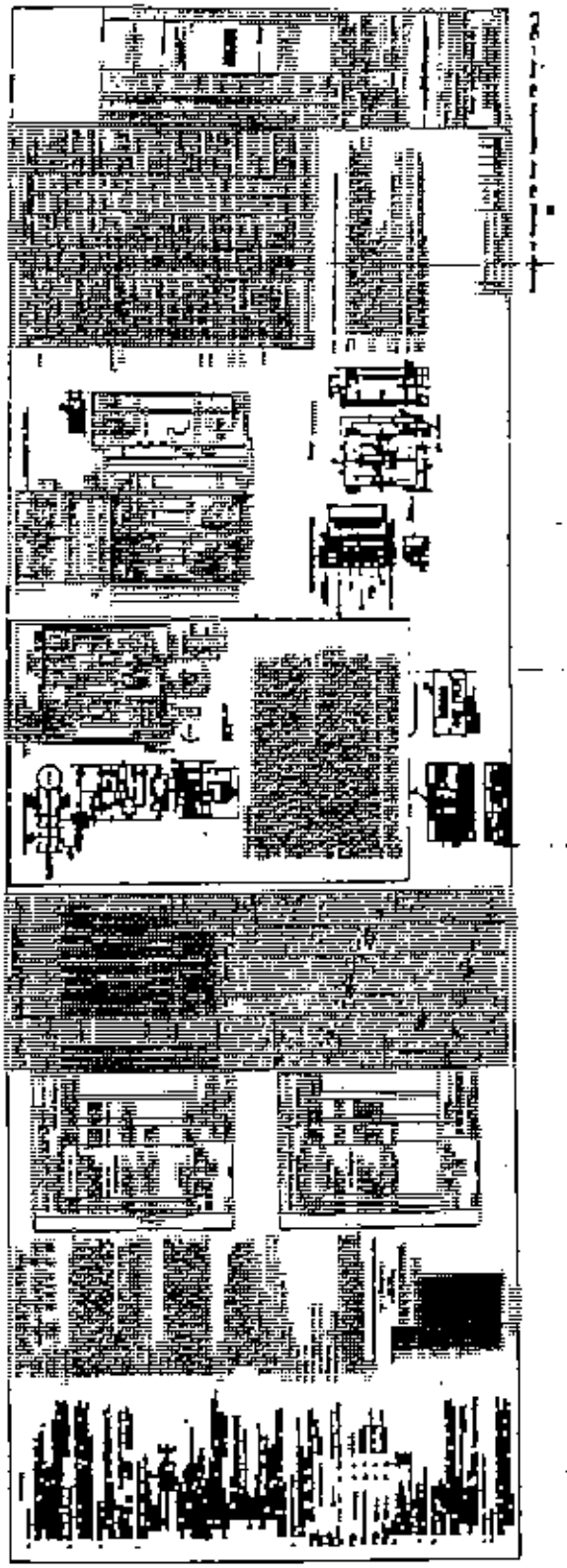


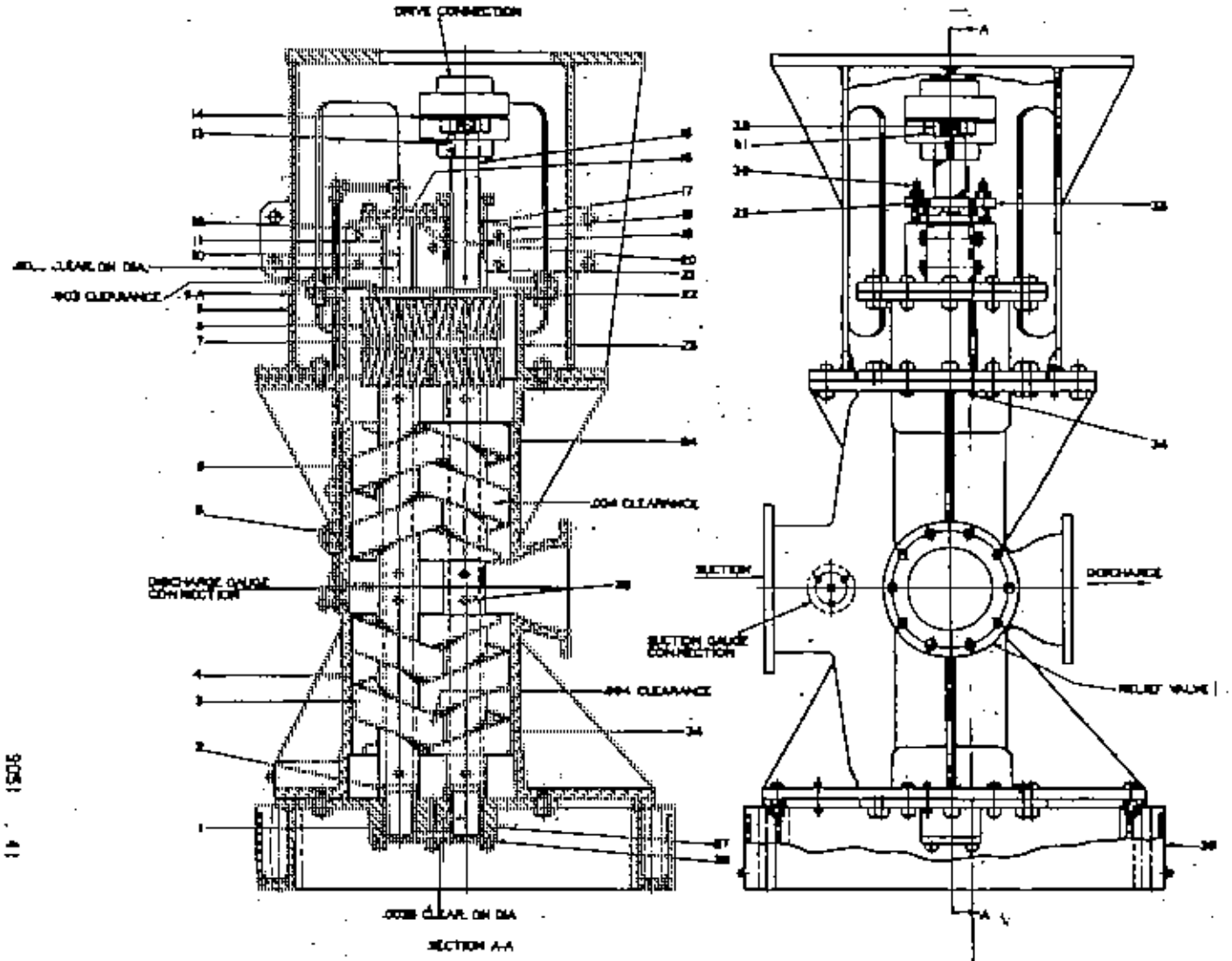
FIGURE 6

MAIN LUBRICATING OIL PUMPS AND PARTS LIST

(Motor and Turbine Drive)

Item No.	Name of Part
1	Bottom Head Bearing
2	Thrust Bearing
3	Bottom Right-Hand Screw
4	Body
5	High Pressure Needle Valve
6	Top Left-Hand Screw
7	Timing Gear Key
8	Timing Gear
9	Intermediate Mounting Bracket (Turbine Drive)
9-A	Intermediate Mounting Bracket (Motor Drive)
10	Bearing and Bushing Pin
11	Bearing (Top Head) (Split)
12	Short Shaft
13	Coupling Key
14	Flexible Coupling (Complete)
15	Long Shaft
16	Top Head Cap
17	Packing
18	Top Head (Upper Half) (Split)
19	Seal Ring (Split)
20	Seal Ring Pin
21	Bushing (Top Head) (Split)
22	Spacing Washer
23	Top Head (Lower Half) (Split)
24	Top Right-Hand Screw
25	Drive Pin
26	Bottom Left-Hand Screw
27	Bottom Head
28	Bottom Head Cap
29	Screw
30	Gland Stud
31	Washer
32	Nut
33	Gland (Split)
34	Dowel
35	Base

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Assembly of Main Lubricating Oil Pump and Parts -- Fig. 6

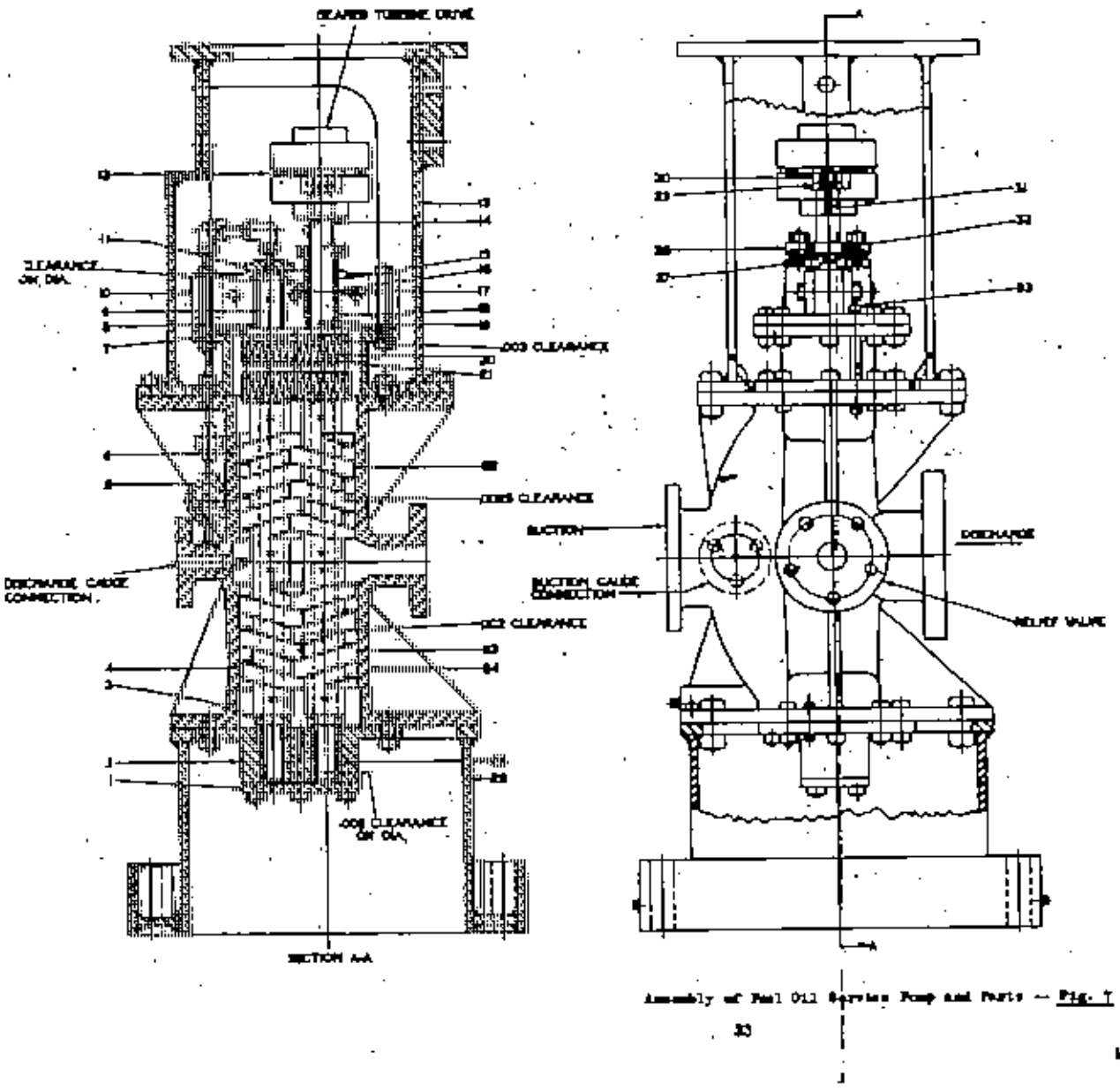
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FIGURE 7

FUEL OIL SERVICE PUMP AND PARTS LIST

Item No.	Name of Part
1	Bottom Head Cap
2	Bottom Head
3	Thrust Bearing
4	Bottom Right-Hand Screw
5	High Pressure
6	Top Left-Hand Screw
7	Spacing Washer
8	Bearing (Top Head) (Split)
9	Short Shaft
10	Top Head (Upper Half) (Split)
11	Top Head Cap
12	Flexible Coupling
13	Intermediate Mounting Bracket
14	Long Shaft
15	Packing
16	Seal Ring (Split)
17	Seal Ring Pin
18	Bushing (Top Head) (Split)
19	Bearing and Bushing Pin
20	Timing Gear Key
21	Timing Gear
22	Top Right-Hand Screw
23	Bottom Left-Hand Screw
24	Body
25	Bottom Head Bearing
26	Base
27	Gland Stud
28	Gland (Split)
29	Washer
30	Nut
31	Coupling Key
32	Screw
33	Dowel

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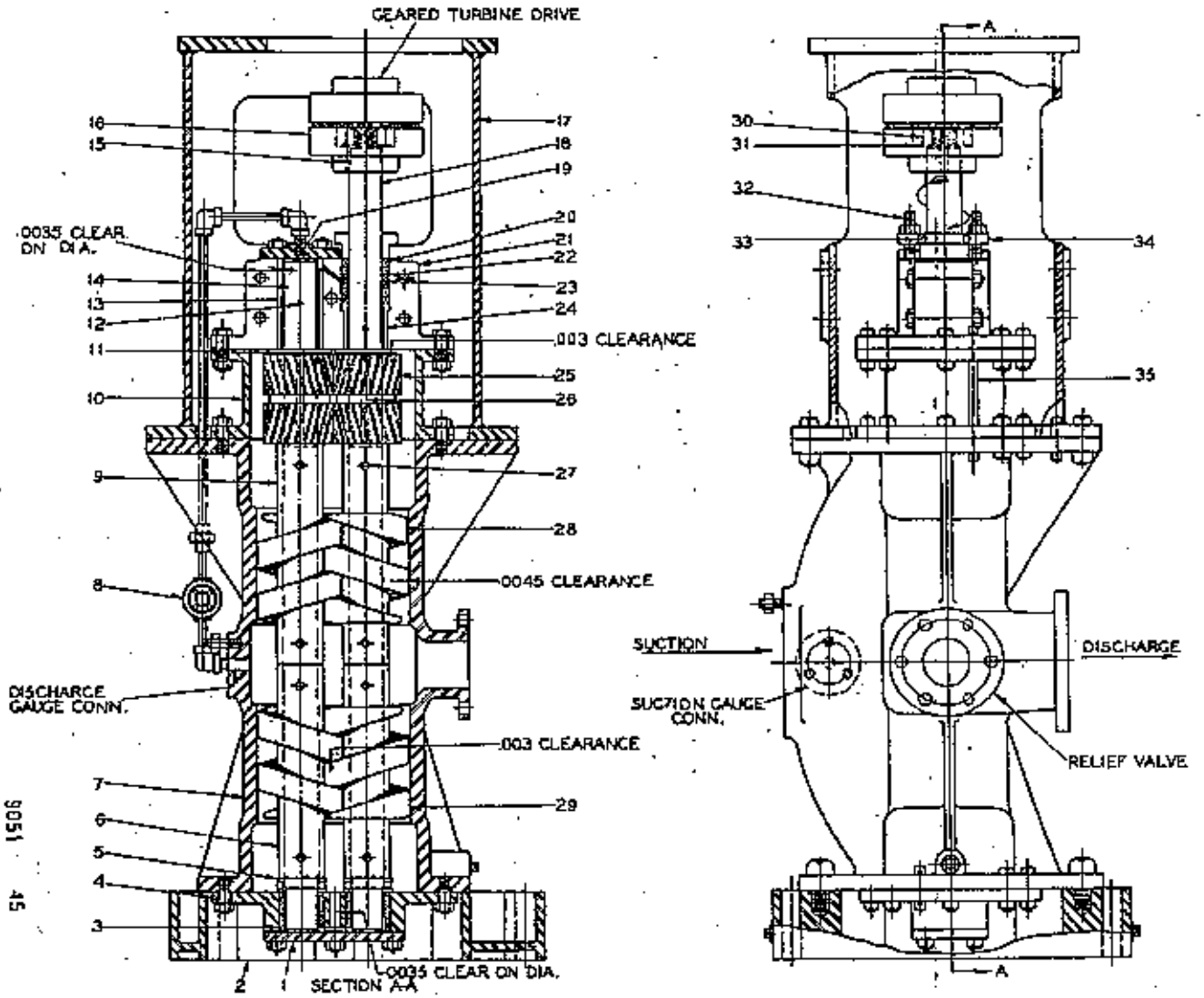
Assembly of Fuel Oil Service Pump and Parts — Fig. 1

FIGURE 8

FUEL OIL BOOSTER PUMP AND PARTS LIST

Item No.	Name of Part
1	Bottom Head Cap
2	Base
3	Bottom Head Bearing
4	Bottom Head
5	Thrust Bearing
6	Bottom Right-Hand Screw
7	Body
8	High Pressure Needle Valve
9	Top Left-Hand Screw
10	Top Head (Lower Half)
11	Spacing Washer
12	Bearing and Bushing Pin
13	Bearing (Top Head) (Split)
14	Short Shaft
15	Coupling Key
16	Flexible Coupling (Complete)
17	Intermediate Mounting Bracket
18	Long Shaft
19	Top Head Cap
20	Packing
21	Top Head (Upper Half) (Split)
22	Seal Ring (Split)
23	Seal Ring Pin
24	Bushing Top Head (Split)
25	Timing Gears
26	Timing Gear Key
27	Drive Pin
28	Top Right-Hand Screw
29	Bottom Left-Hand Screw
30	Nut
31	Washer
32	Gland Stud
33	Screw
34	Gland (Split)
35	Dowel

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Assembly of Fuel Oil Booster Pump and Parts -- Fig. 8

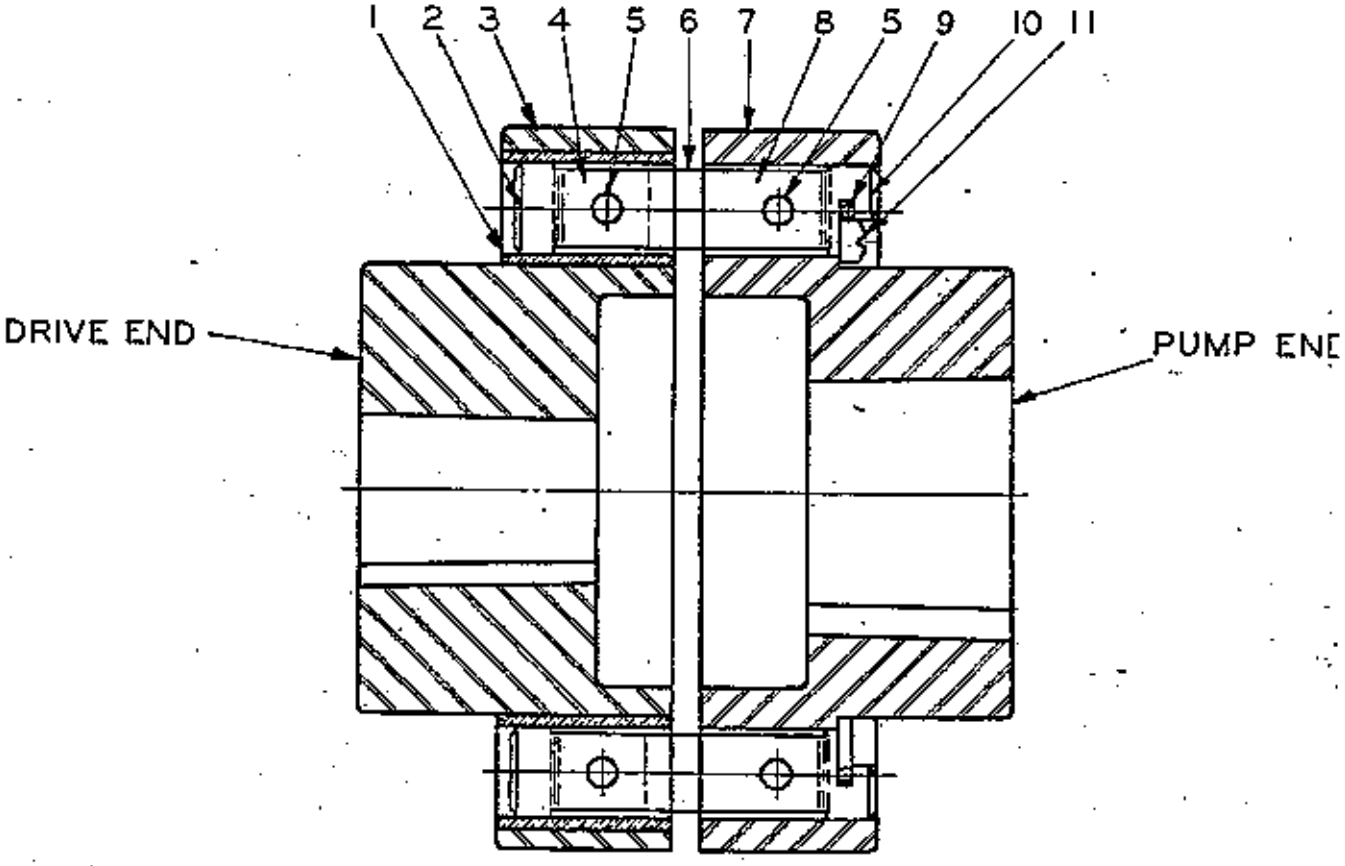
FIGURE 9

FUEL AND LUBRICATING OIL PUMPS FLEXIBLE COUPLINGS AND PARTS LIST

Item No.	Name of Part
1	Bushing
2	Sliding Keeper
3	Flange (Bushed)
4	Short Shims
5	Keeper Pins
6	Long Shims
7	Flange (Held End)
8	Short Shims
9	Spring Retainer Ring
10	Held Keaper
11	Screw

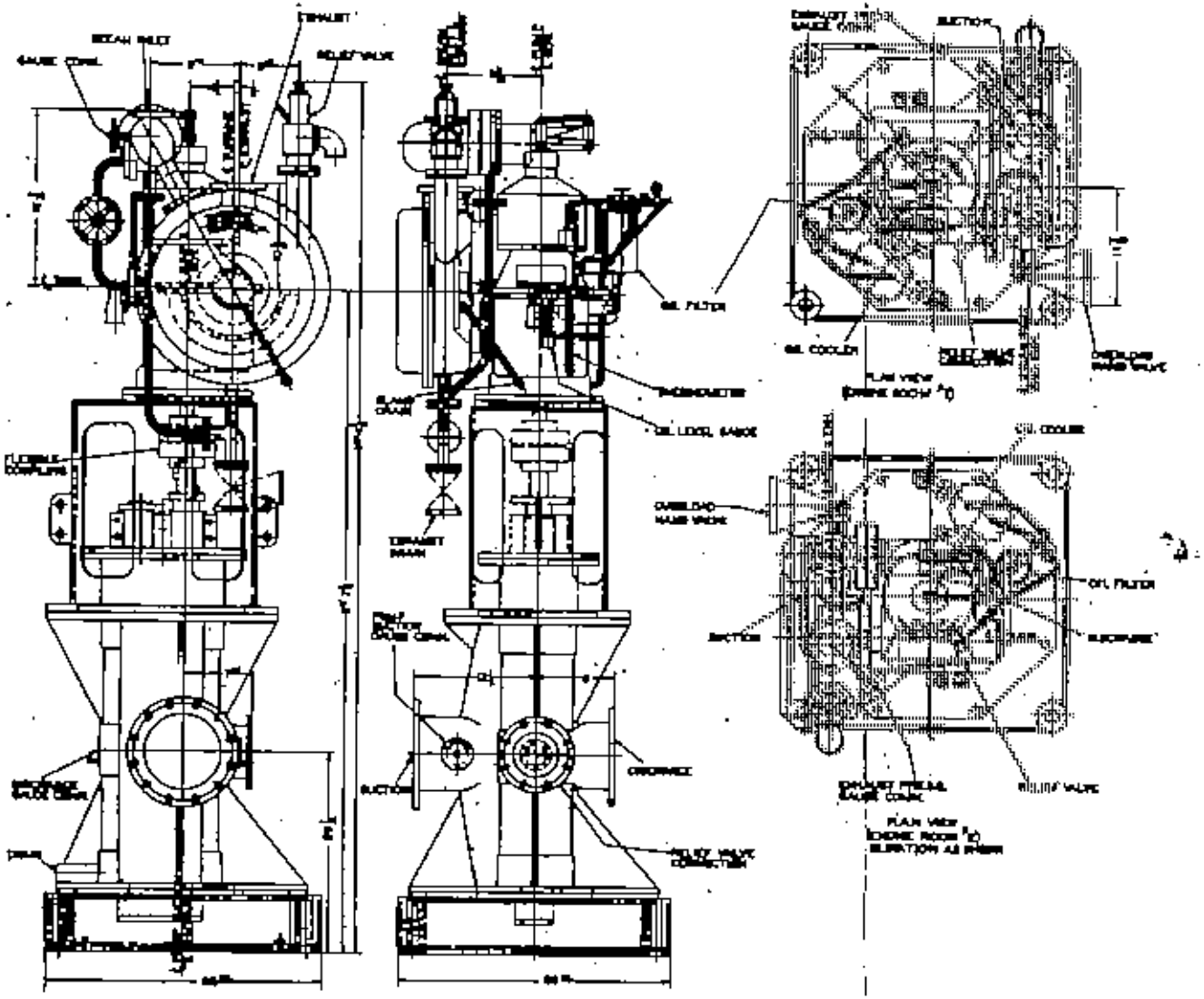
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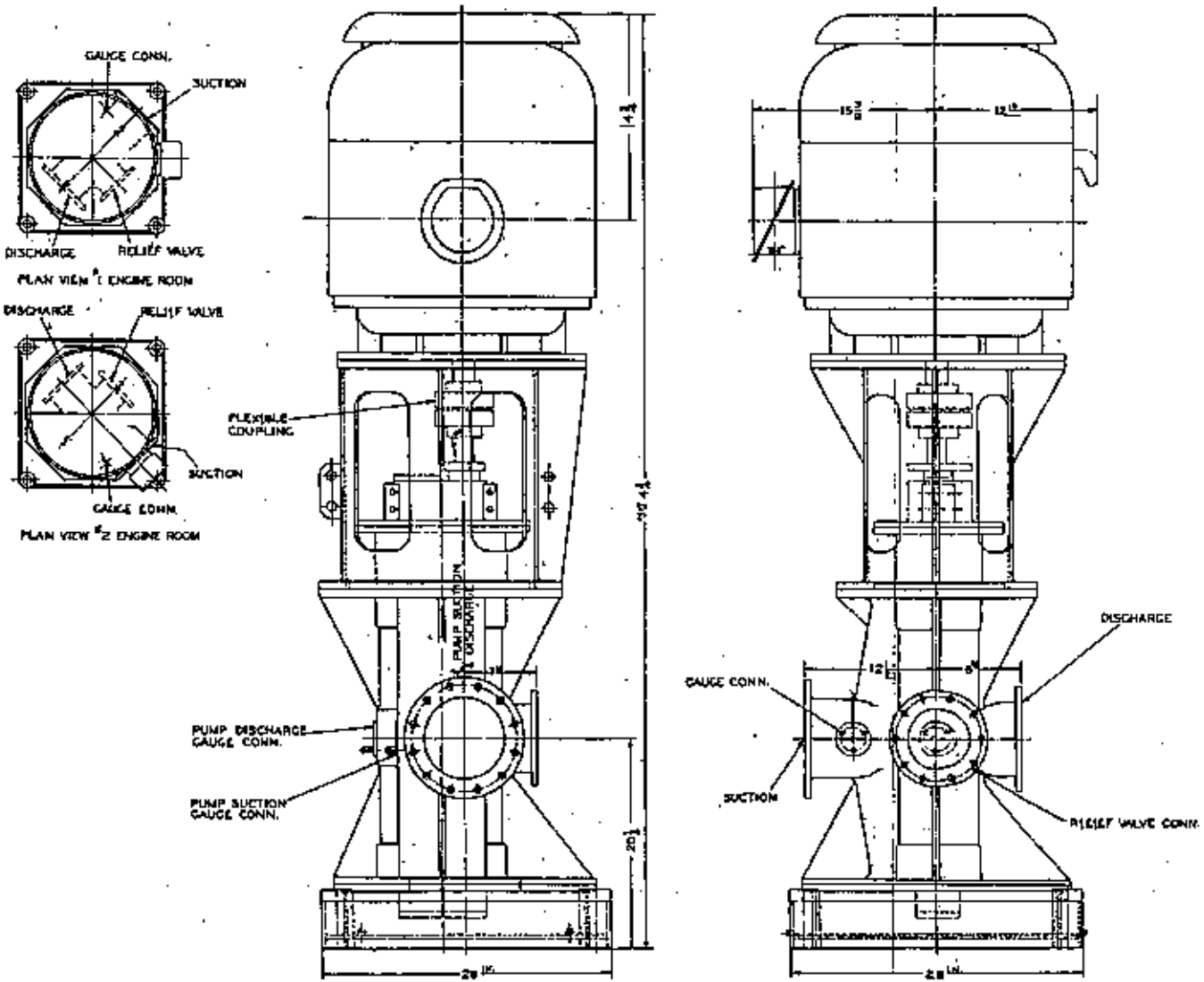
Assembly of Franoke Coupling and Parts -- Fig. 9

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Combined Outline of Turbine-Driven Lubricating Oil Pump — Fig. 18

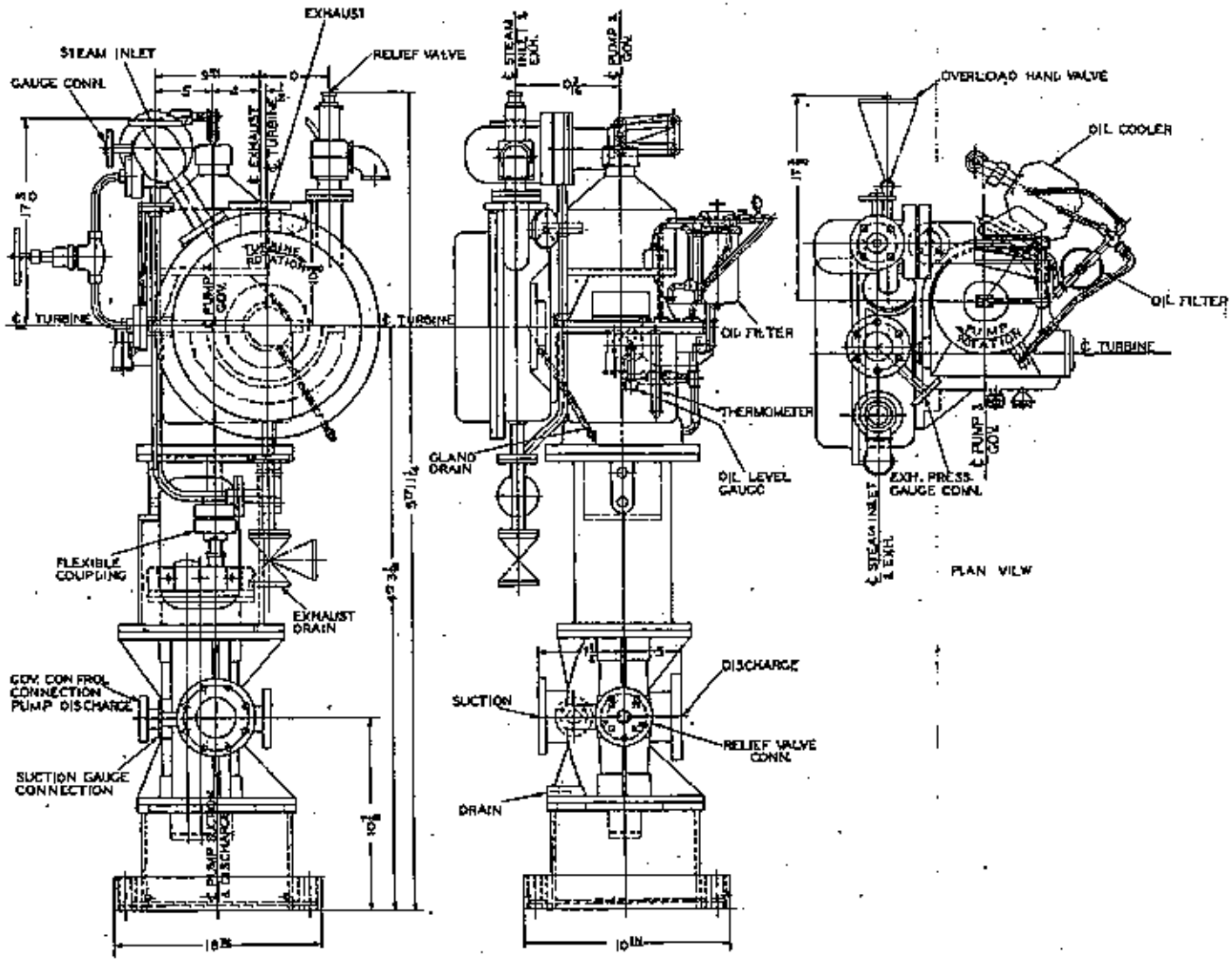
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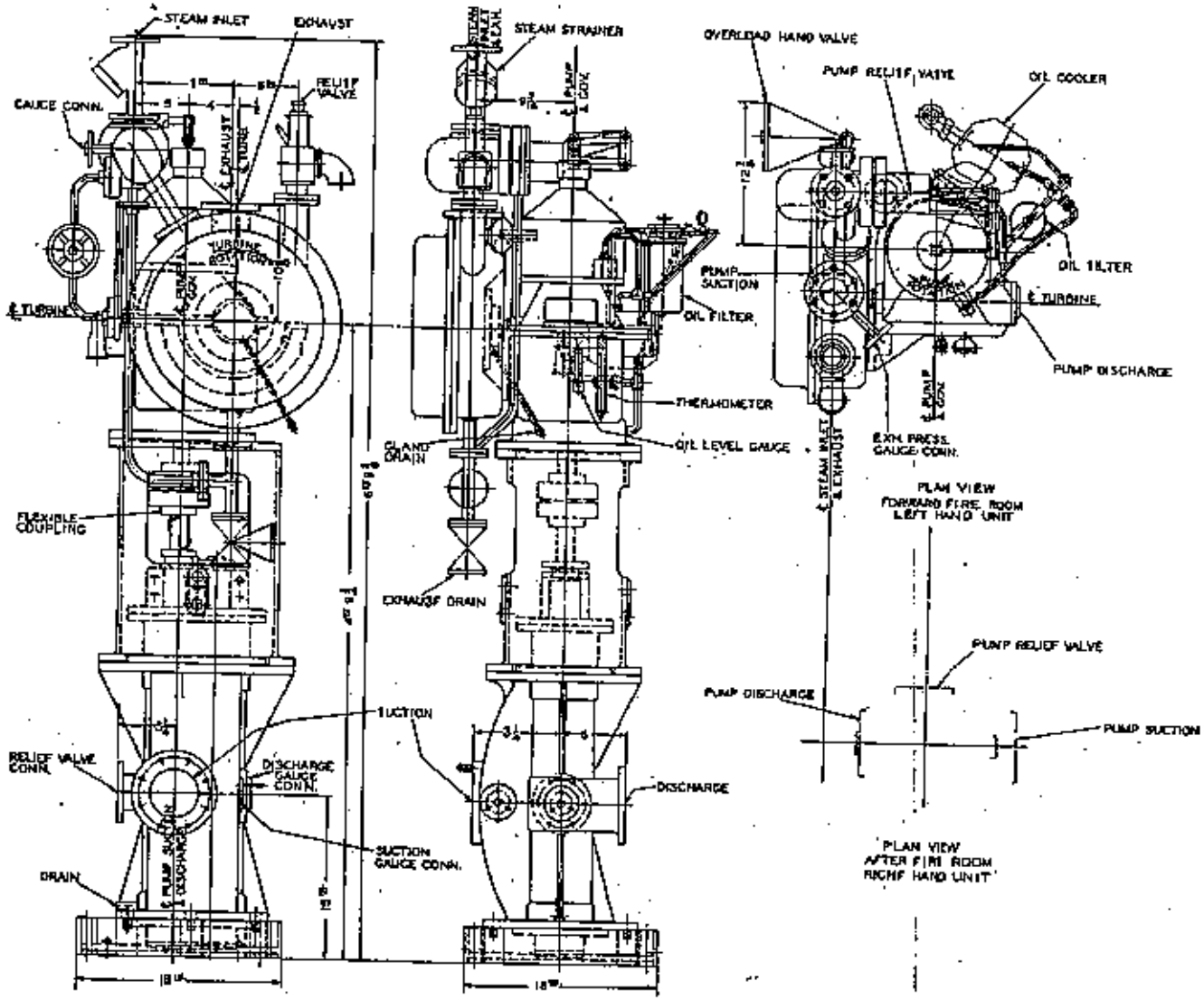
Combined Outline of Motor-Driven Lubricating Oil Pump -- Fig. 11

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Combined Outline of Fuel Oil Service Pump -- Fig. 12



Sectional Outline of Fuel Oil Booster Pump -- Fig. 13

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EXHIBIT GG

453
K100

#107

MAIN FORCED DRAFT BLOWERS

553-1

Exhibit "GG"

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TURBINE-DRIVEN PROPELLER-TYPE BLOWERS

General Description

The forced-draft equipment of each vessel consists of eight blowers, two for each boiler, alike except for the direction of the discharge opening, four blowers being right hand and four left hand. They are mounted in separate air chambers at the sides of the fire rooms and arranged to take air from these chambers and to deliver it into air-tight casings surrounding the boilers, the fire rooms being under atmospheric pressure. The air chambers receive air from the deck through suitable inlet ducts.

The blowers are disposed horizontally with axial intake and side discharge and each is capable of discharging a maximum of 24,600 cfm. of air against a total static pressure of 39.00 inches of water.

CHARACTERISTICS

Steam Conditions (Normal)	575 lb/in^2 gage 0°F. superheat 15 lb/in^2 gage S.P.
Diameter Propeller	25 inches
Diameter Propeller Hub	15-5/8 inches
Projected Area Ratio	1.0
Pitch Ratio (Inlet Edge)	1.1
Ratio of Pitch Ratios	1.67
Number of Blades	9

CONTRACT CONDITIONS

Cubic Feet of Air Per Minute	Inlet Pressure Losses. Inches H_2O	Static Pressure At Boiler Casing. Inches H_2O	Total Static Pressure. Inches H_2O	Rev. Per Min.	Brake Horse Power	Steam Pounds Per Hour	Turbine Nozzles Open
6,480	0.34	2.93	3.27	1800	5.5	788	1
9,085	0.67	4.50	5.17	2325	12.0	1050	1
17,500	2.47	9.56	12.03	3875	55.8	2335	1
17,950	2.60	9.92	12.52	4000	59.5	2440	1
13,375	1.45	14.77	16.22	3900	58.0	2520	1
15,770	2.00	17.42	19.42	4350	79.0	2985	1
*19,300	3.00	22.50	25.50	5075	125.0	4090	1
+25,500	4.00	31.00	35.00	6200	227.0	6575	1-P2
†24,600	4.90	34.10	39.00	6350	250.0	6875	1-2

*Rated Load + Overload †Special Overload

The blowers may be operated with steam up to 600 lb/in^{2}gage.

The blowers will operate satisfactorily either with steam at 460 lb/in^{2}gage or with a back pressure of 20 lb/in^{2}gage.

Each unit is capable of developing 125% of rated full power under normal steam and exhaust conditions.

The entire blower has been tested to an overspeed of 7938 rpm.

The first critical speed of the blower rotating element is 8900 rpm. (estimated).

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TURBINE-DRIVEN PROPELLER-TYPE BLOWERS

PART I—DESCRIPTION

General

Each blower is a self-contained unit consisting of a casing and guide vanes, propeller, and driving turbine, the whole supported by a bedplate of welded channels and the bedplate in turn secured to the ship's structure. The blower is self-lubricated from the reservoir in the bedplate by a pump secured to the bottom of the governor spindle, which pumps oil to the bearings. The blowers are controlled manually from the fire-room floor by means of master control valves and each unit has a hand-operated overload nozzle control valve. A governor-controlled admission valve limits the maximum speed of the blower. Suitable tools are provided for proper maintenance and repair. The blower outline is shown in Figure 1, and a longitudinal section in Figure 2.

Casing

The blower casing is built-up of plates welded together. From the inlet flange to a little beyond the lower edge of the propeller it is cylindrical in form, thence merging gradually through a conical portion into a square section and sweeping around to a rectangular opening at the point of attachment to the boiler air casing. Eight guide vanes prevent rotation of the air stream and three splitters in the curved portion direct the air to prevent eddying, and at the same time strengthen the structure transversely.

Propeller

The blower propeller consists of a hub fabricated from two steel forgings welded together and nine propeller blades each turned very exactly to true section in the form of a forged steel disc and then cut from the disc and pressed in special dies to the required helical form. These blades are welded to the hub by a carefully formulated and rigidly inspected process so that the completed propellor has all the strength characteristics of a single piece machined from solid forged steel. The propeller is keyed to the rotor shaft and secured on a taper fit by means of a nut and cotter.

Turbine Rotor

The turbine rotor is a single disc impulse element carrying one row of impulse blades having shanks secured in a groove on the periphery of the disc by means of accurately fitted pins. The rotor is secured to the rotor shaft by a key and is held against a shoulder on the shaft by a nut, screwed on to the shaft, and secured by a set screw.

Journal Bearings

The rotating element is supported in two journal bearings. The bearings consist of steel shells, babbitt-lined and suitably supported in the blower structure. Oil is supplied to the bearings by the oil pump. The journal bearings are shown in Figure 3-a.

The bearing at the propeller end is a plain symmetrical bearing. However, that at the thrust end is placed immediately adjacent to the thrust collar and the end next to the collar is babbitted so that it served to take any reversal of thrust which might occur due to some abnormal operating condition at low speed.

In the event of bearing failure, or wear requiring replacement, these bearings should always be replaced by spares and not rebabbitted.

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1. To Remove the Propeller:-
   a. Break joint "A" and remove discharge elbow.
   b. Break joints "B" and "C" and remove diffuser through opening in bulkhead.
   c. Remove screen "D" over inlet.
   d. Break joint "E" and remove upper half of inlet cover "F".

The propeller may then be removed using the propeller jack (See Figure 8) in the manner indicated.

2. To remove the complete rotating element (or the turbine rotor and shaft, if propeller has previously been removed):-
   a. Proceed as in Section 1, above.
   b. Break joint "G" and remove upper half of inlet cover "H".
   c. Break joints "J" and "K" and remove cylinder cover, having first disconnected the governor connecting rod and the steam-chest piping. Note that due to lack of head room the cylinder cover cannot be lifted vertically and carried directly away, but must first be lifted vertically far enough to clear the shaft and then carried away to the side.
   d. Break joints at the bearing covers, and remove. The turbine shaft may then be lifted.

3. To reassemble the unit, perform the above operations in reverse order.

Air-Balancing Arrangement

Since the inlet edge of the propellor faces the bearing housing, there is a tendency for air to be sucked along the shaft and out to the propeller blades. In order to prevent oil vapor from the bearing housing being thus drawn into the air stream, the bearing housing is provided with a labyrinth oil ring and the blower inlet casing is likewise provided with a similar ring, and atmospheric air is given free access to the space between them so that if anything is drawn along the shaft it will be air, since no suction effect can reach the bearing housing.

Nevertheless it is important that these oil seals be kept in first class condition to prevent any possibility of excessive leakage permitting oil vapor being drawn into the blower.

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GENERAL NOTES

Parallel Operation of Blowers

The paralleling of propeller type blowers is a much simpler and less hazardous operation than in the case of centrifugal fans. The reason for this is that the propeller type blower has a very steep pressure volume characteristic, the pressure at shut-off being approximately three times the pressure at its normal rating, the speed remaining constant. The result of this is that two blowers may be paired in parallel and both deliver air even though the speed of one is twice that of the other.

All that is necessary to bring a shutdown blower into operation is to open the hand throttle on the idle blower to full opening. This may be done slowly or quickly as desired, without any danger.

It is suggested in order to establish confidence among the personnel of the fire rooms that at the earliest opportunity the following tests be conducted in order to familiarize them with the operating characteristics of the blowers. In order not to interfere with the firing, it is suggested that these tests be conducted on a dead fire room.

To demonstrate the parallel operation of the blowers, start one blower and operate it at any speed, having either the required number of registers open to give the desired air pressure or block open the casing access doors. Observe the speed of the blower which is running, then open the hand throttle valve on the other blower which has been idle and bring the speed up slowly, and observe the speed at which this blower begins to deliver air. Also have some one observe the effect on the boiler air pressure at the time when the second blower begins to deliver air. It will be found that the second blower begins to deliver air when it is running at approximately half the speed of the other blower; now if the throttle is opened wider, the air pressure in the boiler casing will build up gradually as the speed is increased.

This test will demonstrate to the personnel that no special precautions are required in paralleling this type of blower that it is not necessary to have the speeds alike when paralleling, and that no sudden disturbance of air pressure need be occasioned when paralleling, if the speed of the second blower is not brought up too rapidly beyond the point where it just starts to deliver air. If desired, this may be tried a number of times with the first blower running at different speeds and with different numbers of air registers open to show that the same characteristics exist under all operating conditions.

The fact that two blowers can be operated in parallel when one is running at approximately one-half the speed of the other blower will seem quite surprising to those having had experience only with centrifugal blowers.

NO DELIVERY TESTS

Owing to the fact that the turbine is under control of the speed-limiting governor, it is not possible to demonstrate on board ship that the turbine will not run away when the suction or delivery of the blower is shut off. However, the fact that the horsepower increases with decrease of air delivery, can be demonstrated in the following manner. Operate only one of the blowers at any desired speed with the inlet dampers open, and the casing access doors propped open, permitting the air to escape freely from the boiler casing, then with the throttle wide open, observe the speed of the blower by the oil tachometer and also observe the nozzle inlet pressure, that is, the pressure beyond the governor valve. Now suddenly close the intake dampers, shutting off the supply of air to the blower, and observe the nozzle inlet pressure and the rpm. by the oil tachometer. It will be seen that the

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speed has decreased and the nozzle inlet pressure has gone up showing that it takes very much more power to run with the damper shut even though the speed has decreased.

A similar test may be conducted by leaving the inlet dampers open and shutting off the flow of air through the blower by suddenly closing the casing door, and the registers, thus building up a pressure in the casing. Actual tests have shown that the effect on the blower speed and horsepower is independent of whether the air flow is cut off by shutting off the suction to the blower or by closing the discharge. In order that it may not be unexpected, attention is called to the fact that when the blower is running with no discharge it makes a puffing, rumbling noise which however, is entirely harmless and does not indicate anything wrong with the blower nor is any damage done in this condition.

The overspeed tests are run in the wide open position, that is, with free air flow through the blower and no external resistance since this is the condition of minimum horsepower at any given speed. Because of the inlet ducts and the limited area through the casing access doors and registers, the external resistance present in the actual installation in itself makes it impossible to reproduce this condition on board ship, and furthermore, the steam pressure of the boilers would have to be greatly increased.

Thus, it is seen that it is impossible under any circumstances for the blowers to reach the speed at which they have been tested, no matter how they are handled or operated. The only condition under which this speed might be reached would be for the turbine to be operated alone with the propeller removed, in which case however, the maximum speed would be limited by the turbine governor.

Propeller Repairs

The propellers of the Westinghouse main forced-draft blowers used in the Service are made of a forged steel welded assembly protected against corrosion by double-dip tinning. Two or three cases of damage to the propellers of such blowers due to objects passing through the blowers have been reported to the Bureau and such damage in some cases necessitated the return of propellers to the manufacturer for repairing, retinning, rebalancing and overspeed testing. This method of repairing takes considerable time and in order to avoid delay incident to returning of propellers to manufacturer for minor repairs and at the same time observe desirable and necessary precautions for safety of material and personnel, the procedure noted below shall be followed in all cases where propellers of this type have been damaged.

CASE 1: Damage to propellers through handling or objects passing through the blower, which causes the blades to be bent but which do not loosen or detach balance weights located inside the hub.

In the case of blades which have been merely bent, these may be straightened by the use of babbitt hammers, the blades being bent back to their original shape. In order to secure the true curve and shape of the blade, a tin or light sheet metal template should be made of the blade curvature from an undamaged blade on another propeller or from an undamaged blade on the damaged propeller, and the straightening should be done to this template. In such a case, it is not necessary to either re-balance or run a 50% overspeed test, provided that the blade has not been so badly bent as to constitute a kink, which may cause crocking of the blade in straightening. Moderate red heat (1350°F.) may be applied in cases of severe bending, to the outer 3/4 of the blades. Such heating will require retinning.

CASE 2: Damage to the propeller causing nicks or cuts in the edges of the blades and bending, the nicks in the edges of the blades being more than one-third of the distance from the hub to the tip, from the hub.

In such cases, the blades may be straightened to template as in CASE 1, and the nicks welded up by a first-class welder, using an approved coated rod. Before welding, tinning should be removed by scraping or filing from around the edges of the nick, so that no tin may be alloyed with the deposited weld. After welding, the welded spots should be filed flush with the remaining surface of the blade adjacent to the weld, carefully smoothed up with emery cloth or stoned, and then retinned with a soldering iron to prevent rusting. In such a case, welding which has been done by a good welder under supervision does not require an overspeed test and balancing will be unnecessary, as the balance has not been changed if the blade is bent back to its original position by template and the weld is merely filed off flush with the adjoining surfaces.

The above applies where nicks or cuts are in a radial direction or in a circumferential direction and not in excess of 1 inch to 1-1/2 inches long. Where nicks or cuts in a circumferential direction are in excess of 1-1/2 inches long, the matter shall be referred to the Bureau of Ships for special instructions prior to proceeding with repairs.

CASE 3: Damage to the blades in the form of nicks or cuts less than 1/3 the distance from the hub to the tip.

In this case the procedure should be the same as in CASE 2 except that it would be advisable, if possible, to run a 50% overspeed test before putting back into service, or if, in an emergency, it is impossible to run a 50% overspeed test, at least the blower should not be operated in service above 85% of its normal maximum speed. It is not necessary to rebalance if the metal is filed off flush, as the balance has not been changed. In cases of this character if a spare propeller is available, it is desirable to install same in place of the damaged propeller and the extent of damage must be reported to the Bureau for special instructions which will usually involve the return of the propeller to the manufacturer for repairing by welding, relief-annealing, retinning and 50% overspeed test.

CASE 4: Balance weights have been loosened due to an accident either separately or combined with other damage.

In this case, proceed, according to circumstances, as in CASES 1, 2 and 3 except that it will be necessary to dynamically balance the propeller and reattach the balance weight or weights by welding. Only steel balance weights attached to the inside of the overhanging portion of the hub are permissible. They must be adequately welded to the hub, and as the stresses in the hub at high speeds are quite high, under no circumstances must the weights be attached by drilling holes into or through any portion of the blade or hub structure. If the loosening of the blade weights was accompanied by damage, as in CASE 3, then in addition to dynamically balancing, a 50% overspeed test should be run, or precautions taken in emergency, as in CASE 3.

Wherever damage is such that major welding operations with relief-annealing and/or overspeed testing is required, no repair shall be effected by the Forces Afloat, or at the Navy Yard, but instead, a special report shall be made to the Bureau of Ships. The Bureau will then issue instructions as to the procedure to be followed.

Performance Characteristics

Figure 10 gives the typical performance and characteristic curves for these blowers and Figure 11 shows the constant pressure characteristics and capacity-speed curves.

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Thrust Bearing

The thrust bearing (shown in Figure 3-b.) is of the Kingsbury leveling plate type, fitted with six shoes to take the propeller thrust. In this type of bearing the leveling plates interact to equalize the thrust among the several shoes.

The shoes are supported on the leveling plates which, pivoting about their points of support, allow the shoes to adjust themselves so as to lie all in the same plane. Hence each shoe takes an equal share of the total load.

The shoes and leveling plates are carried in a base ring, made in halves and the entire assembly is located in a recess in the bearing housing. A filler piece ("A" in Figure 2) back of the base ring provides for proper location of the bearing in the housing.

The internal thrust clearance is determined, and adjusted at the factory, by the liners "B" and "C" of Figure 2, at either end of the journal bearing housing. This clearance should be between .010 and .015 inch.

Oil for lubrication is supplied from the top of the bearing housing, part of the oil going through an orifice to the thrust bearing and the remainder to the journal bearing.

Escape of oil from the end of the bearing housing is prevented by a labyrinth oil ring and similarly excessive leakage from the thrust bearing to the pump housing is prevented by a single oil ring.

Lubricating System

The lubricating system is indicated diagrammatically in Figure 4. It comprises a reservoir in the bedplate, a gear pump mounted on the governor spindle, a filter, a cooler, and the necessary supply and drain piping as shown.

The oil reservoir is in the form of two cylinders disposed axially, connected at the governor end of the bedplate by a rectangular box section and at the blower end by a smaller cylindrical section. The normal minimum oil level capacity of the reservoir is 14 gallons and the maximum 17 gallons. The total capacity to overflow is 20 gallons.

Oil is drawn from the reservoir by the pump and delivered through one leg of a 4-way valve to the filter and cooler, whence it is brought back and, passing through the other leg of the 4-way valve, is delivered to the bearings. The drains are led directly back to the reservoir. If the 4-way valve is given a quarter turn, the filter and cooler are cut out of the circuit and either one or both may be opened for examination or overhaul. The system is provided with gages and thermometers as indicated in the diagram.

These units are shipped dry; it will therefore be necessary to fill the system with oil before operating the unit. In this connection the following precautions should be observed.

When the system has been filled with oil and the turbine is first started up slowly, it will in all probability be found that the oil pump becomes air-bound because of the fact that there is a check valve in the pump discharge line and the pump is not able to deliver sufficient pressure when pumping air, to force the air past this valve and vent the system.

The manufacturer has found that this condition can be relieved by removing the cap from the check valve, and also removing the cap from the relief valve and removing the tension of the relief valve spring. When this

has been done, the blower should be turned over at low speed until oil becomes visible at the check valve. When this occurs, replace the cap on the check valve and adjust the tension on the relief valve spring until the oil pressure gage reads 2 pounds with the unit operating at 1100 rpm. Then, at 5950 rpm., the pressure should read 11 pounds.

Similar precautions should be observed whenever the unit has been dismantled and the oil reservoir drained. In this connection it should be noted that unless the piping above the level of the check valve has previously been drained, the oil remaining in the supply line to the bearings will flow back and spill out of the top of the check valve when this is open. Care should therefore be taken to see that the bearing lines are drained before the relief valve cap is removed.

Oil Filter

The oil filter item 20 of Figure 2, is of the "edge cleaning" type in which the filter element may be cleaned by simply rotating the handle through one complete revolution. The accumulated solid matter, if any, falls to the bottom of the filter body and can be removed from time to time through a drain opening at the bottom. The operation of cleaning the element in no wise interferes with the flow of oil through the unit.

The inlet and discharge spaces in the body are connected by a passage normally closed by a spring-loaded ball valve. In the event that the filter becomes clogged, this by-pass valve will automatically open under the excessive pressure and prevent interruption of the oil supply to the bearings.

Oil Cooler

The oil cooler (Item 19 of Figure 2) is illustrated in Figure 5. This consists of a body and cover with a cooling core secured to the cover by means of the oil pipe connections and with cooling water connections to the body. The direction of flow is immaterial for either the oil or the water.

The cooler core is made up of punched and corrugated sheets and distance pieces brazed together and is not susceptible of adjustment or field repair. In case of a leak or obstruction the spare core should be installed.

The core is secured to the cover by means of a jam nut and a fibre washer at each oil connection and the cover is bolted to the cooler body by through bolts. Any sediment carried in with or precipitated from the cooling water will be deposited in the body, which should be taken down periodically and washed out.

A zinc bar attached to a plug in one end of the cooler body prevents galvanic action from affecting the body metal.

Care of Oil Cooler

Step 1. The oil cooler should be cleaned whenever objectionable increase in pressure drip through the unit, or decrease in cooling efficiency, is observed.

When either of these conditions is noted, remove the core assembly from the case and cover.

Step 2. To clean inside of plates, immerse the core in a suitable cleaner or solvent.
(CAUTION: This operation should be done in the open air or with adequate ventilation).

Forced circulation of the cleaner through the plates by means of ordinary grease gun or rubber suction cup will facilitate cleaning the oil passages.

Step 3. Blow out with low pressure air, or steam. Repeat operations until thoroughly clean.

Step 4. Clean outside surfaces of plates with brush and suitable solvent.

Step 5. Remove all foreign matter from inside of casing and cover.

Step 6. Re-assemble the oil cooler, using new gaskets where necessary.

IMPORTANT

Step 7. The zinc electrode should be examined thirty days after installation and every thirty days thereafter.

Any appreciable erosion within these periods indicates electrolytic action.

Careful inspection should then be made to determine if this action is caused by short-circuits or external and grounded electric currents. If so this condition must be eliminated to avoid serious damage.

Step 8. On the other hand if no such condition is found it is evident that erosion is due to local electrolysis in which case the only practical procedure or remedy is frequent replacement of zinc electrode.

Glands

The points where the rotor shaft extends through the turbine casing are sealed by means of the glands of the carbon ring type indicated as Item 6 of Figure 2.

Each gland as shown in Figure 6, consists of four carbon rings each made in three segments held together by a garter spring. All the rings are fitted with a clearance around the shaft and remain stationary in the gland case. Two rings are of rectangular section with the outer periphery grooved to take the garter spring. The other two rings are made in the shape of a frustrum of a cone and are held in by a keeper of corresponding shape, and garter spring. When the keeper is put under tension of the garter spring the resulting compression acting on the conical surfaces of keeper and ring, presses the ring tight against the lower side of the groove thus preventing leakage between the ring and the groove wall.

If new rings are installed each complete ring should be bored to give .002 to .004-inch clearance on the diameter with the segment ends abutting; there should be .026 to .034-inch axial clearance between each ring and its retainer so that the ring can move freely to assume its correct position relative to the shaft. When the glands are assembled the ring segments should be placed around the shaft and held in position by the garter spring. The complete rings must then be spaced the proper distance apart and the housing then slipped over them. Condensation which may leak past the inner rings of the glands is carried away by leak-off pipes to the condensate system. Special care must be taken to insure that the rings are installed in the proper grooves. Each segment is marked with the groove number in which it is to be assembled, the groove numbers being stamped in the gland cases.

CAUTION: The carbon rings should never be allowed to come in contact with grease or oil, either of which would have a very deleterious affect upon the carbon.

Governor

The governor is of the vertical, centrifugal weight type, in which the centrifugal force of the weights is opposed by the compression force of the governor springs. This same principle has been used for many years, but the detail construction of this governor differs materially from older types. It is illustrated in Figure 7.

The governor spindle is driven from the turbine shaft through a worm and gear and carries at its lower end the gear type oil pump. It is guided at the upper end by the combined thrust and steady bearing "4" and at the lower end by the oil-pump bearing. The upper end of the spindle terminates in a slip-joint of the so-called "bayonet" type, which drives a tachometer mounted on the top of the governor housing.

The governor hub is keyed to the rotor shaft and held by a nut and lock washer. This hub carries the weight fulcrum blocks which support the governor weights. Each weight is made in a single piece and has machined on it the knife edge about which it pivots and a knife-edge seat which works against the knife edge on the strut. The other knife edge on the strut works against the strut seat. All of these knife edges are properly hardened to withstand the service to which they are subjected.

With the machine at rest, the governor weights are held in their inner position by the force exerted by the compression springs. These springs are secured by the shaft at the outer end and exert a force which is transmitted to the toe of each governor weight through the spring seat, the bearing retainer sleeve, the inner race of the ball bearing, and the strut seat, and the struts.

As the speed of the turbine increases, the governor weights move outward due to the increased centrifugal force and, being fulcrumed on the blocks, this movement compresses the governor springs and moves the ball bearing upward. As the speed decreases, the spring force moves the sleeve and adjacent parts inward with the weights moving inward a corresponding amount. Therefore the vertical position of the ball bearing varies with the speed. In order to transmit this governor movement to the governor valve, which controls the steam inlet, the sleeve is threaded in the bearing housing so as to clamp the outer race of the ball bearing. The outer end of the sleeve is bushed and guided by the governor housing cover and is connected to the governor lever by integrally machined pins, thus completing the linkage. The ball bearing carries any thrust which may be exerted by the steam valve and transmits the governor movement with a minimum of friction. The governor lever is fulcrumed so that upward movement of the governor weights closes the steam valves while inward movement of the weights opens them.

The governor is a speed-limiting governor only and not a speed regulator.

Tachometer

The tachometer head identified by name on Fig. 2 is manufactured by the Jones-Motrole Sales Co., of Stamford, Conn., and is not susceptible of adjustment or repair in the field. In case of trouble or failure, the complete head should be returned to the manufacturer.

The bearings in the mechanism are ball bearings and do not require lubrication. Do not attempt to lubricate the mechanism or adjust it. Use great care to prevent oil or grease from getting into the head at any time.

When the tachometer is mounted on the governor make sure that the parts rotate freely without binding. The tachometer pointer should give a steady reading.

If the tachometer has been dismounted from the governor, do not under any circumstances attempt to replace it while the governor spindle is rotating. The unit must be at rest when the tachometer is removed or replaced.

Lubrication

The governor assembly is lubricated from the thrust and journal bearing supply, through a drilled passage leading to the combined thrust and steady bearing on the governor spindle. An annular groove at the middle of this bearing admits oil to a radial hole in the spindle, which in turn communicates with an axial hole through the upper part of the spindle. This again connects with a radial hole in the upper spring seat whence the oil is discharged into the governor casing. This casing is kept full of oil which escapes, partly through the upper guide bushing and partly through the ball bearing, to drain.

To Dismantle Governor

Step 1. Disconnect the external governor linkage.

Step 2. Remove governor housing cover (with tachometer) taking care to lift vertically.

Step 3. Disconnect and remove lever links "23".

Step 4. Unbolt and remove governor housing (see transverse section in Figure 2).

Step 5. Remove the governor case "19".

Step 6. Mark the spring nut "20" and the spindle, and count the number of the threads exposed, if any, so the nut can be tightened to the same point when reassembled.

Step 7. Remove the set screw and loosen the nut until all compression of springs is relieved.

Step 8. As the springs "17" and "18" become loose, lift out the governor weights "10". As soon as the weights are removed, the knife-edges "11" must be removed to insure their not being lost. These weights "10", knife-edges "11", and the hub "8" should be marked so they can always be assembled in their original positions.

Step 9. Take the nut "20" all the way off. Then the springs, sleeve, and bearing parts can easily be taken off the end of the shaft.

To Assemble Governor

Step 1. Perform operations noted under "To Dismantle Governor" in the reverse order.

Step 2. When assembling weights, assemble the springs "17" and "18" and start the nut "20".

Step 3. Install the knife-edges "11", place the weights in position and push downward on the spring to hold them. NOTE: To see if these parts operate properly, press downward on the governor spring, and at the same time pull one weight outward. Release the weight suddenly, still maintaining pressure on the spring. If the weight snaps back freely, it is correct. If a rub occurs, it can be felt. Repeat this test for the other weight, and then for both weights.

Step 4. Tighten the nut "20" the same amount as originally found and secure with set screw.

Step 5. Replace governor housing.

Step 6. Install the lever links.

Step 7. Replace the governor housing cover, making sure that the tachometer bayonet joint matches up properly.

Step 8. Connect the external governor linkage.

Ajustment

This governor is designed to limit the speed of the unit to the maximum permissible speed. Speed of the unit up to the permissible limit held by the governor will be controlled automatically by the blower load.

Before making any change in the governor setting, be sure that the governor valve is set correctly according to instructions under "Governor Valve."

The maximum speed permitted by the governor is determined by the compression of the springs "17" and "18", and can be adjusted by means of the nut "20".

To increase the speed, tighten the nut.

To decrease the speed, loosen the nut.

One complete turn of the nut will change the speed approximately 200 rpm.

Steam Chest

The steam chest indicated by Items 8 and 9 of Fig. 2 is also illustrated in Figure 7. All the steam admitted to the turbine passes through a balanced double-seated valve controlled by the speed-limiting governor and by the master control valve at the operating level.

In addition to the governor controlled speed-limiting valve, there is a hand controlled valve in the steam chest, which is opened only for operation under overload or abnormal operating conditions, as indicated in the tabulation on Page 1. This valve must be opened part way to deliver the 25500 cu. ft/min. at 35 inches static pressure, and must be fully opened to carry the maximum overload. It is also intended to be opened to compensate for low steam inlet pressure or excessive back pressure.

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PART II—INSTALLATION

These units were shipped from the factory completely assembled except that, in order to avoid possibility of corrosion attack during storage, the rings were removed from the carbon glands and the shaft in way of the glands slushed with rust preventive compound Bu Ships specification 52C18 (INT) thin film (polar type). Similarly all exposed parts of linkage, etc., were slushed. Before operating the unit all traces of slushing compound should be washed off.

The unit should preferably be handled intact for which purpose suitably located lifting eyes are provided.

Set the unit on the foundation structure supporting it on three wedges, one at either side at the blower end of the bedplate and one in the middle of the governor end.

Shift the unit by adjusting the three wedges until the air discharge opening matches properly with the opening in the boiler casing. Then fit chocks and bolt the unit down with fitted bolts.

The steam and exhaust piping should be so hung that it will not impose strains on the turbine structure. If it is impossible to introduce enough flexibility to completely prevent expansion strains, then the piping should be so secured that when cold the unit will be subject to half the total expansion in the reverse direction. This will minimize the chances of injury to the unit.

Be sure that all lines are thoroughly blown out and clear of scale, grit, etc. before connecting to the unit. See that all drain lines are properly connected.

PART III—OPERATION

Starting Up

Step 1. See that oil stands at proper level in oil reservoir.

Step 2. See that inlet and exhaust drains are open.

Step 3. Open exhaust valve.

Step 4. Open steam valve.

Step 5. When unit has had time to warm up, close inlet and exhaust drains.

During operation the unit needs only the routine attention given to all auxiliary apparatus.

Shutting Down

Step 1. Shut steam valve.

Step 2. Shut exhaust valve

Step 3. Open inlet and exhaust drains.

Caution

When necessary to close burner registers, speed of blowers must be reduced to limit the air pressure to 30 inches of water (to avoid possible distortion or rupture of the boiler casing and ducts.)

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PART IV—MAINTENANCE

Note: In the event that it becomes neceeeary to return any pert of this equipment to the South Philedelphia Works, it ehould he tagged with the sender's neme and addreee end the eeriel number of the unit, and ehipped by freight, express or parcel post, es the oase may be, to: Weetinghouse Electric and Manufeciuring Company, South Philedelphie Worke, Keeington, Pa.

List of Ruoning Clearances

Clearance Point	CLEARANCE In Inchee Max.	Min.
Beeringe - Journel on diameter	.010	.007
Beerings - Thruet axiel	.015	.010
Bearings - Oil ringe on diameter	.013	.010
Thruet Bearing Oil Ouard - on diemeter	.006	.002
Propeller Oil Ouard - on diameter	.013	.010
Propeller and Cesing - on diemeter	3/16	
Governor		
Thruet and Ouide Bearing - on diameter	.0085	.005
Thruet and Ouide Beering - axiel	.010	.002
Oovernor Shaft Sleeve - on diemeter	.003	.001
Odvernor Bushing - on diameter	.0135	.008
Oil Pump Beering - on diameter	.005	.004
Oil Pump Gears - axial	.006	.003
Steam Chest		
Governor Velve Stem Bushinge - on diameter	.002	.001
Governor Velve Stem Guide - on diemeter	.007	.0015

Weigbts

The veighte of the prinoipel perts to be handled during inepection and repeir are es follovs:

	Pounds
Blower Diffuser	256
Blower Inlet; Opper Half	113
Blower Propeller	252
Turbine Cylinder Cover - Propeller End	105
Turbine Cylinder Cover - Oovernor End	213
Turbine Rotor and Sheft Only	298
Complete Rotating Element	550
Totel Estimated Weight (one unit), exclueive of speed-ohanger equipment	3272

Tools

Special tools are provided, tv fecilitate the taking epart and essembly of the unite in ceee of overhaul vr repeir. Figure B ehowe sketchee of theee toole so that the personnel may the more readily identify them and ohooee the proper tonls for eech operetion.

Method of Disassembling

Fvr the guidance of the pereonnel in routine inspection or periodic overhaul, the following sequence of operetione in diaaseembling is suggested: (Refer to the "Diemantling Sketoh" on Pigure 1.)

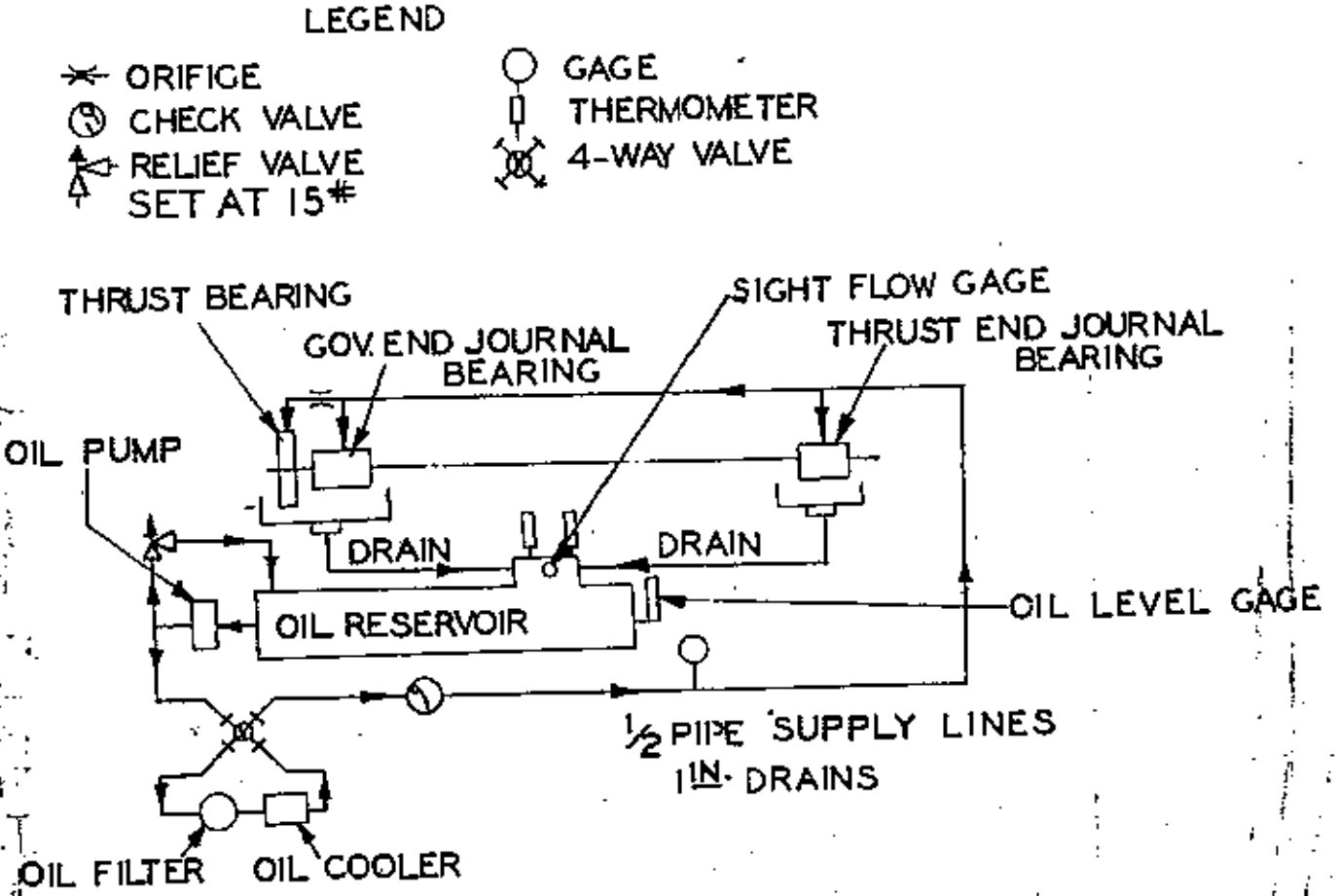
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FIGURE 2

LONGITUDINAL ASSEMBLY

Item No.	Name of Part
1	Uovsrnor Assembly
2	Governor Driving Worm
3	Uil Rings
4	Thrust Bsaring
5	Journal Bearing
6	Carbon Gland
7	Nozzles
8	Governor Valve
9	Steam Chest Velve
1U	Governor Linkage
11	Casing Inlet Section
12	Cylinder Cover (governor end)
13	Cylindar Cover (propeller end)
I4	Turbine Rotor
15	Reversing Chamber
16	Diffuser
17	Discharge Elbow
18	Propeller
19	Uil Cooler
2U	Uil Filter
21	Cylinder Base
22	Bedplata
23	Uil Pump
24	Relief Valve

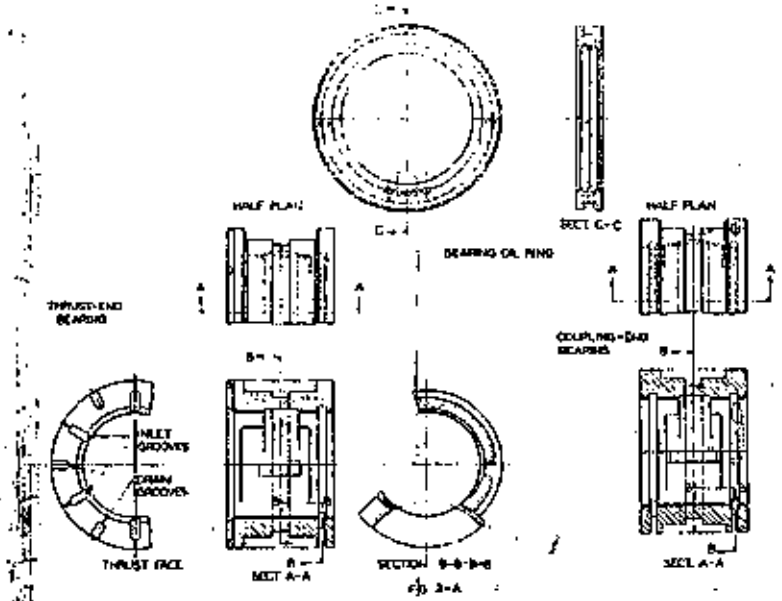
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OIL SYSTEM DIAGRAM

Oil System Diagram -- F-

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HALF PLAN
SECT C-C
BEARING OIL RING
HALF PLAN
THRUST-END BEARING
COUPLING-END BEARING
INLET GROOVES
DRAIN GROOVES
THRUST FACE
SECT A-A
SECTION B-B-B-B
FIG. 3-A
SECT A-A

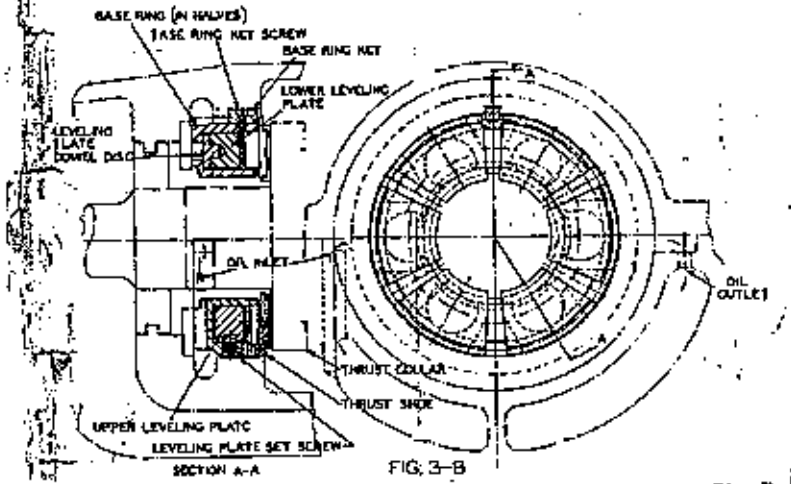

BASE RING (IN HALVES)
BASE RING KEY SCREW
BASE RING KEY
LOWER LEVELING PLATE
LEVELING PLATE DOWEL PIN
OIL INLET
OIL OUTLET
THRUST COLLAR
THRUST SHOE
UPPER LEVELING PLATE
LEVELING PLATE SET SCREW
SECTION A-A

FIG. 3-B

FIGURE 5

Oil COOLER

Item No.	Name of Part
1	Locknut
1	Core Plate
1	Gasket (casing)
1	Bolt - Short
5	Bolt - Long
6	Core Assembly
1	Casing
9	Pins
9	Pins Support Plug
10	Inlet or Outlet
11	Brazing Sheet (inlet or outlet)
11	Tube Plate - Male
13	Brazing Sheet (center)
14	Tube Plate - Female
15	Tube Spacer
16	Brazing Sheet (tube spacer)
17	Tube Plate - Rear
18	Brazing Sheet (reinforcement)
19	Reinforcement - Rear Tube
20	Name Plate
21	Baffle

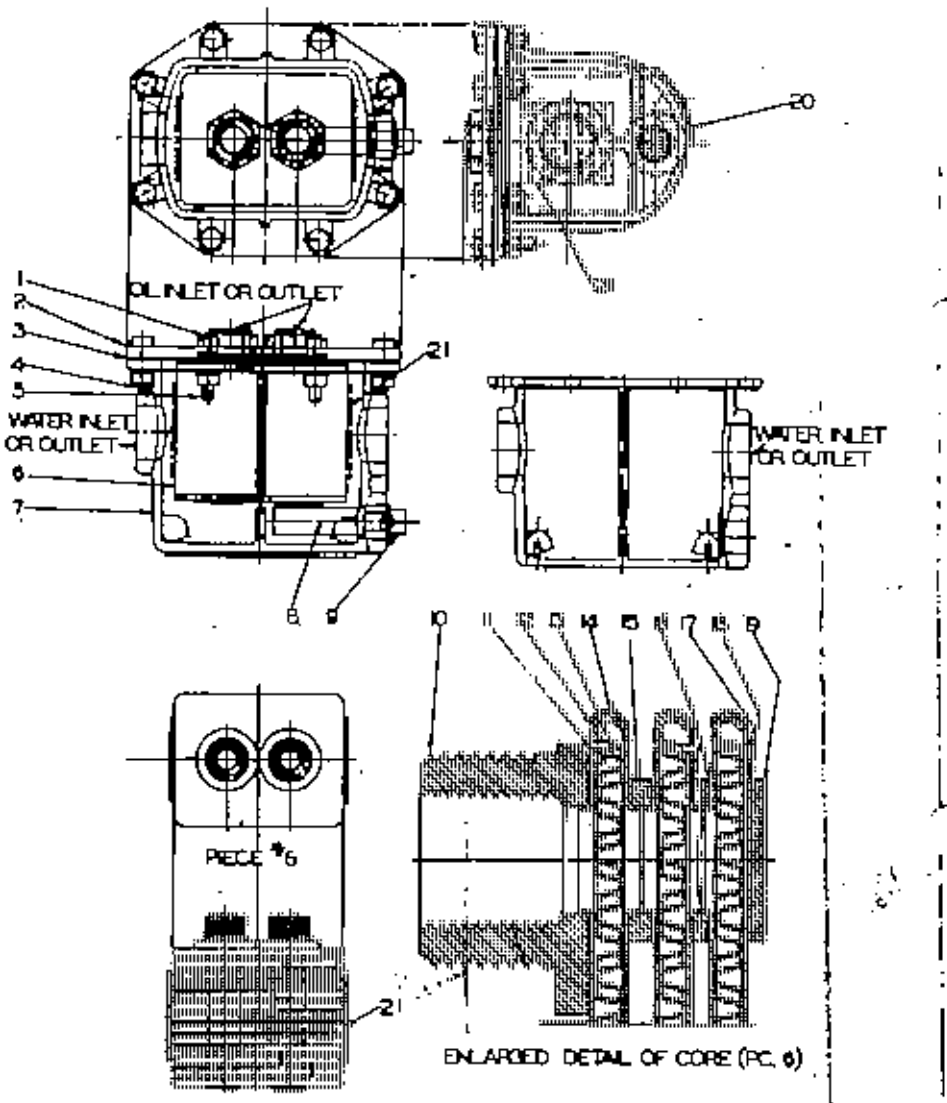
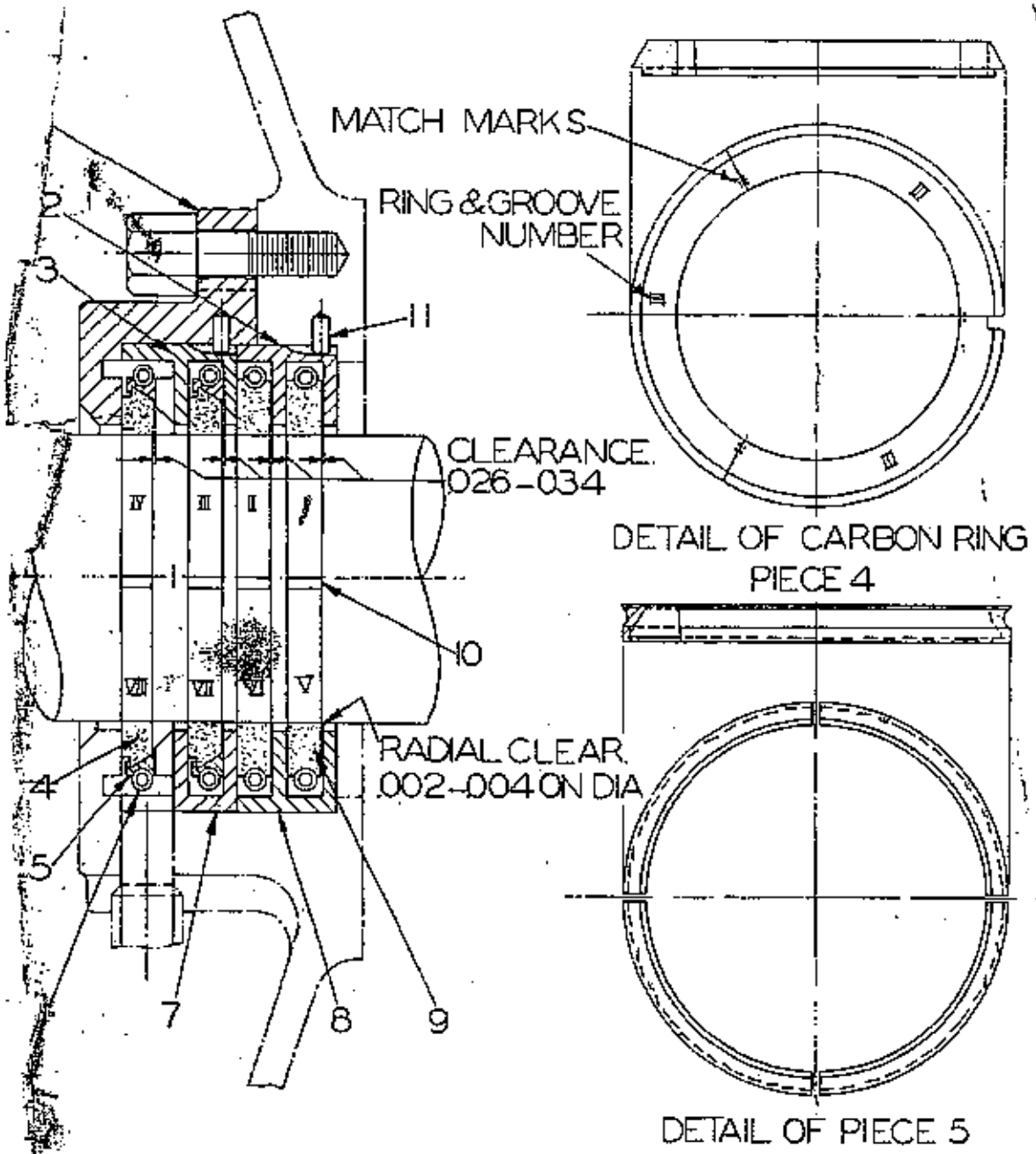


FIGURE 6

CARBON GLAND

Item No.	Name of Part
1	Carbon Glend Cover
2	Inner Oland Ring (top half)
3	Outer Gland Ring (top half)
4	Packing Ring
5	Packing Ring Retaining Ring
6	Garter Spring
7	Outer Gland Ring (bottom half)
8	Inner Gland Ring (bottom half)
9	Packing Ring
10	Packing Ring Key
11	Gland Ring Pin

Manual-001137



Carbon Glands -- Fig. 6

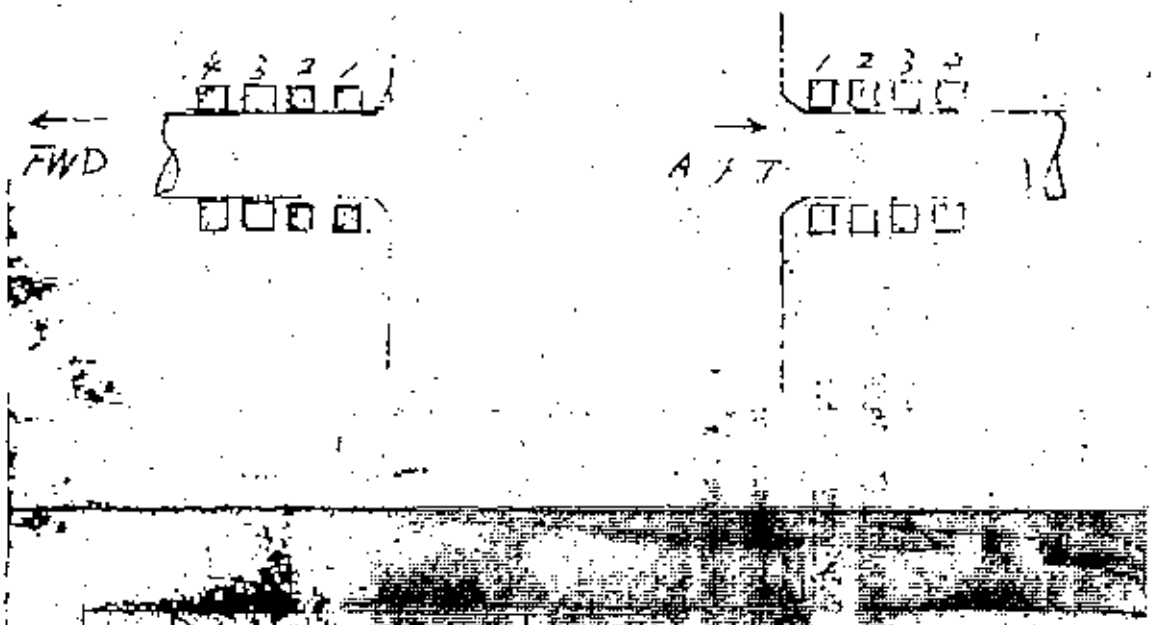
SHORTAGE LIST FOR

[redacted], LTJG
Pilar per Officer
SRF, Yokosuka

BUREAU OF [redacted] ALLOWANCE MATERIAL
SUPPLY OFFICER FURNISHED "Y" MATERIAL
PROJECT ORDER NUMBER

DATE
SHEET NO. 6[illegible]

ALLOWANCE LIST REFERENCE				SNSN, FSN or PIN	STORE ACCT	DESCRIPTION	UNIT PRICE	SHORT	STUB NO.	INVOICE or SR NO.	DMRI	PROOF of DELIVERY
PART	GROUP	PAGE	LINE									
						REPAIR PARTS, AIR COMPRESSOR (CONT'D)						
						A.P. OPERATING END ASSY						
F	819	4	38	[redacted]-70105		[illegible]	.50	[illegible]				
"	"	"	39	[redacted]-70103		[illegible]	.26	[illegible]				



		ホイスト DIA		
F	1	9.9987	10.033 / 10.037	0.029
W	2	9.9998	10.033 / 10.062	0.029
D	3	9.9995	10.021 / 10.037	0.016
	4	9.9994	10.035 / 10.027	0.016
A	1	9.9995	10.037 / 10.038	0.029
F	2	9.9994	10.033 / 10.038	0.028
T	3	9.9997	10.033 / 10.022	0.013
	4	9.9995	10.026 / 10.026	0.0135

EXHIBIT HH

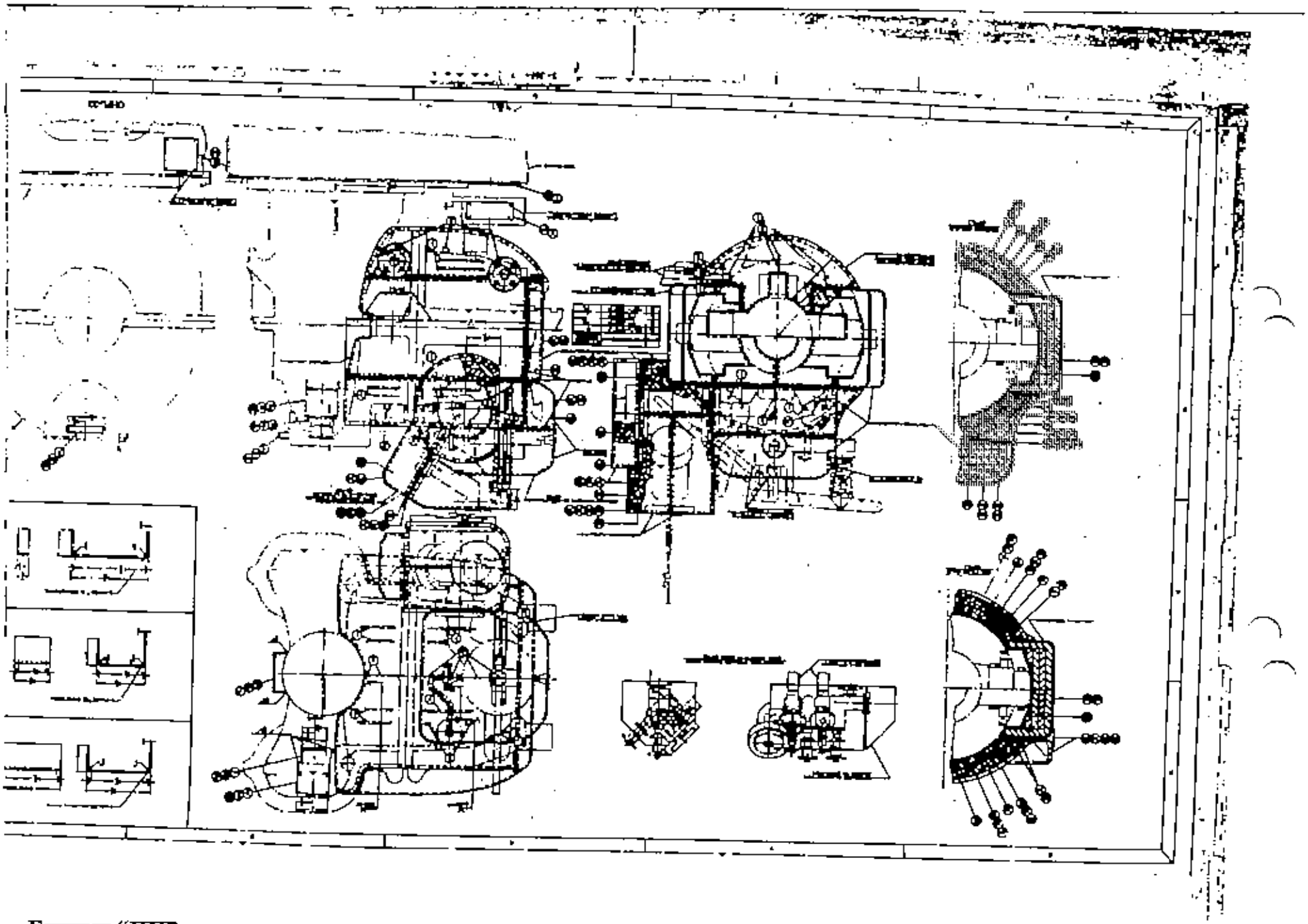


Exhibit "HH"

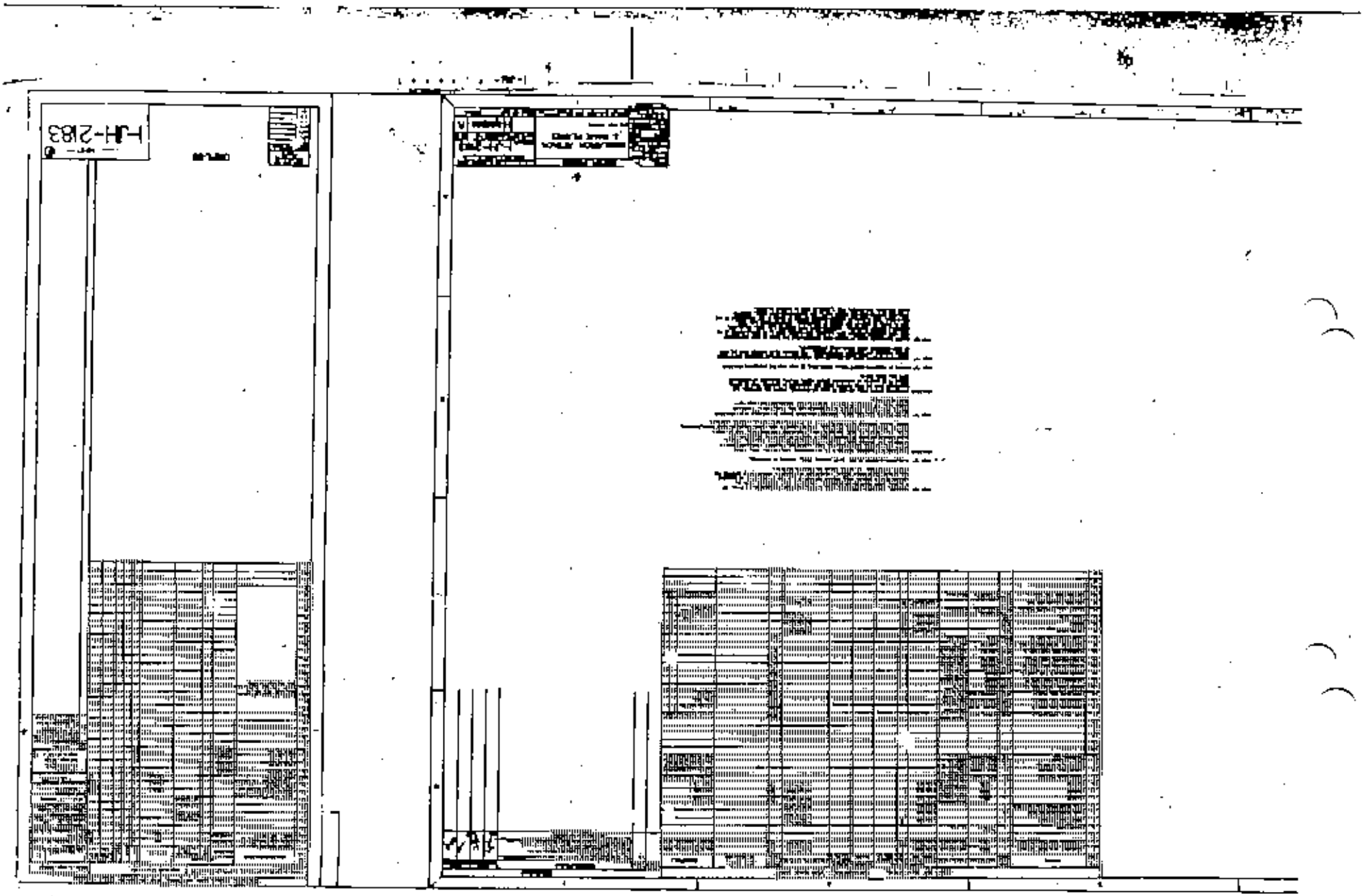

H-JH-2183

EXHIBIT II

JAN 19 2007

Logged

IN T... CIRCUIT COURT OF THE F..RST CIRCUIT

STRTE OF HAWAII

CERTIFIED COPY

IN RE HRWAII STATE ASBESTOS CASES.

CAVAC, et al.

) Case No. 07-1-ACM-1 (EEM)

) Volume I

) Pages 1 - 111

OEPOSITION OF

RNTHONY O. PANTALEONI

LOS ANGELES, CALIFORNIA

Tuesday, January 9, 2007

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FILE NO.: A00A924

EXHIBIT "II"

IN THE CIRCUIT COURT OF THE FIRST CIRCUIT

STATE OF HAWAII

IN RE HAWAII STATE ASBESTOS CASES.	) Case No. 07-1-ACM-1 (EEM)
CAVAC, et al.	)

Deposition of ANTHONY D. PANTALEONI, taken on behalf of Plaintiff, at 10100 Santa Monica Boulevard, Los Angeles, California, commencing at 10:49 a.m., Tuesday, January 9, 2007, before Susan B. Sautman, CSR No. 4770.

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ALSO PRESENT:

TODD LEIDER, VIDEOGRAPHER
JAMES SHIROMA, PARALEGAL

I N D E X

WITNESS	EXAMINATION	PAGE
ANTHONY D. PANTALEONI		
	(BY MR. GALIHER)	9, 61

EXHIBITS

NO.	PAGE	DESCRIPTION
1	9	NOTICE OF DEPOSITION
2	14	RESPONSES TO INTERROGATORIES
3	20	BILLS, BATES STAMPED CRHI 03244 THRODGH 03247
4	21	BILLS OF MATERIALS BATES STAMPED CRHI 03232 CONSECUTIVELY THROUGH 03243
5	44	COVER AND SELECTED PAGES FROM 1936 CRANE CATALOG
6	52	1953 CRANE CATALOG
7	55	1960 CRANE CATALOG
8	62	1943 MONOGRAPH OUTLINE OF DR. LEROY GARDNER

9	64	MINUTES OF THE THIRD ANNUAL SAFETY CONGRESS OF THE NATIONAL SAFETY COUNCIL DATED OCTOBER 13TH THROUGH 15, 1914
10	66	DOCUHENT DATED FEBRUARY 1936 ENTITLED, "INDUSTRIAL REVIEW" PUBLISHED BY THE ILLINOIS MANUFACTURERS ASSOCIATION
11	69	24TH ANNUAL SAFETY CONGRESS AND EXPOSITION
12	75	CONTENTS OF NOVEMBER 1936 NATIONAL SAFETY COUNCIL
13	76	OCTOBER 1935 INDUSTRIAL MEDICINE PUBLICATION FOR PHYSICIANS IN SURGERY AND INDUSTRY
14	83	AUGUST 1942 MARINE ENGINEERING PUBLICATION
15	90	JUNE 1946 RD IN MARINE ENGINEERING
16	94	MARINE ENGINEERING DATED NOVEMBER 1959
17	95	SELECTIONS FROM THE OPERRTION BOOK, OPERATION AND MAINTENANCE OF NAVY DESTROYER BOILERS, DD-692 CLASS, BABCOCK AND WILCOX

18	98	GENERAL ELECTRIC DESCRIPTION AND INSTRUCTIONS FOR OPERATION AND MAINTENANCE OF PROPULSION TURBINES FOR U.S. DESTROYERS CLASS DD-692
19	9B	DESCRIPTION AND INSTRUCTIONS FOR OPERATING AND MAINTENANCE OF CONDENSING EQUIPMENT OF U.S. NAVY DESTROYERS, DD-692 CLASS, FOSTER WHEELER CORPORATION AND WORTHINGTON PUMP AND MACHINERY CORPORATION
20	100	COMPENDIUM OF DRAWINGS OR LISTS OF MATERIALS
21	104	PRINTOFF OF THE UNITED STATES PATENT AND TRADEMARK OFFICE DATED 1/8/2007
22	107	CRANE CO. DRAWINGS OF VALVES AND LIST OF MATERIALS

insulating materials to the Navy. 11:57:28

Q. Parking would have been included in the 11:57:31

valves you sold to the United States Navy; is that 11:57:35

correct? 11:57:38

MR. SMITH: Objection to form. 11:57:38

BY THE WITNESS: 11:57:39

A. Within that product, yes, but not separate. 11:57:40

BY MR. GALLNER: 11:57:44

Q. Next I will mark as plaintiffs' exhibit 11:58:11

number six a Crane catalog number 53. 11:58:14

(Exhibit 6 was marked for 11:58:18

identification.) 11:58:23

BY MR. GALINER: 11:58:23

Q. I believe it's a 1952 copyright. Again, I 11:58:24

have the book here if you want to take a look at that 11:58:27

to satisfy yourself that we have the right Crane 11:58:31

company here and the right catalog. 11:58:34

Does that appear that that's a xerox copy of 11:58:37

selected pages of that catalog? 11:58:41

A. Yes, sir. 11:58:45

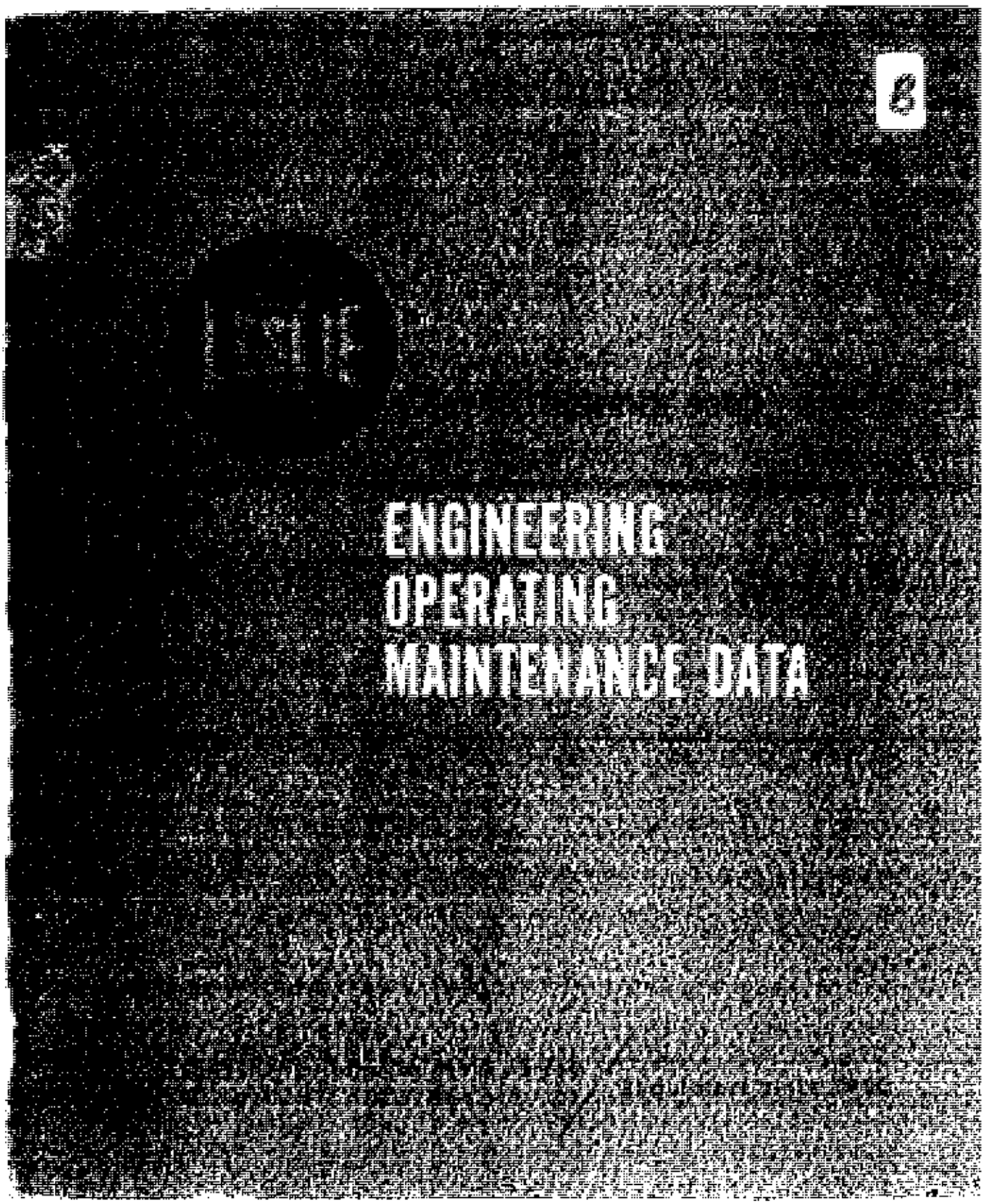
Q. And with respect to Crane company and their 11:58:45

manufacturing facility in Chicago, it just wasn't a 11:59:12

garden variety type of manufacturing plant, was it? 11:59:19

MR. SMITH: Objection to form. 11:59:23

EXHIBIT JJ



Manual/BIW-000518

TRADE LESLIE MARK

ENGINEERING, OPERATING AND MAINTENANCE DATA

CATALOG SERIES 5300

This Handbook provides complete information essential to the proper selection, installation, operation and maintenance of pressure, temperature and level controls, strainers and whistles—for industrial or marine* use.

Because this technical information is not available from any other single source, many operating engineers and others charged with control and maintenance of piping installations find the Series 5300 manual particularly helpful as a briefcase and desk reference tool.

LESLIE Co. has put this latest engineering and maintenance information in sharp, clear, concise language and keyed it to the new, time-saving index that you'll find behind the "Index" tab.

***NAVY SPECIFICATIONS**

Navy personnel will find this information equally valuable. Special drawings, however, have been issued, complying with Navy specifications. These are available to the Navy on request as in the special LESLIE-Navy Instruction Manual.

LESLIE CO., Lyndhurst, New Jersey

Regulators since 1900

Made in U.S.A.

LESLIE

QUALITY

IS OUR BUSINESS

QUALITY DESIGN featuring "original" developments and advancements to provide better products to do a better job.

QUALITY MATERIALS employing the best available at any given time for any given job.

QUALITY MANUFACTURE producing uniform products, 100% interchangeability of parts at time of assembly and in the field, at reasonable cost.

QUALITY PERFORMANCE resulting from Quality Design, Quality Materials, and Quality Manufacture assures customers maximum service life, minimum maintenance and genuine satisfaction with LESLIE Regulators.

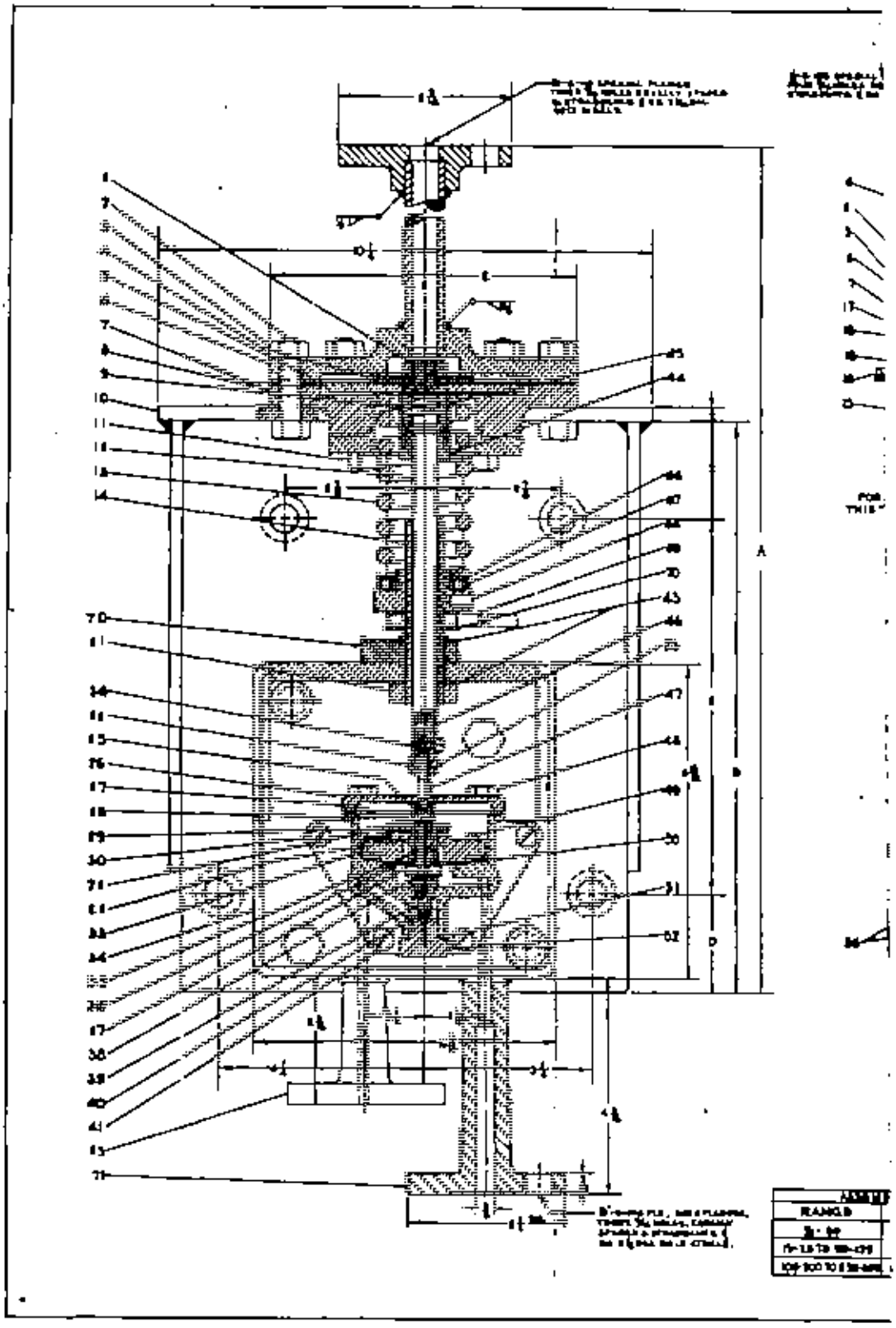
QUALITY SERVICE including an adequate number of trained and experienced personnel to maintain these standards, to supply prompt, reliable answers to inquiries and questions, to fill orders promptly and accurately, and to render customer service in the field when and where it is needed.

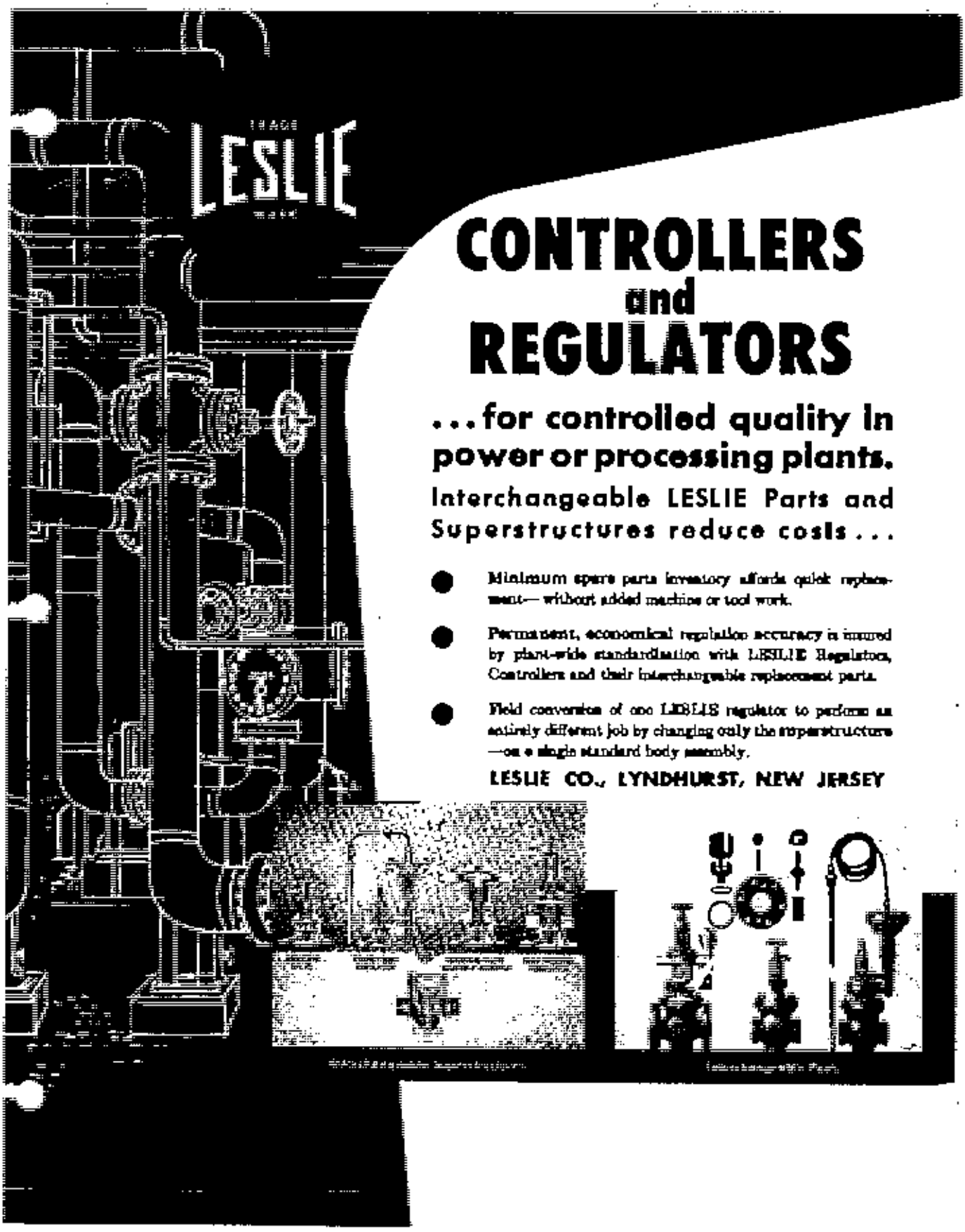
These are the fundamental principles which have built the reputation of LESLIE Regulators to what it is today and to which the present organization is dedicated in the interest of its customers.

LESLIE CO. Lyndhurst, New Jersey

Regulator Manufacturers Since 1900

LITHO IN U.S.A. 654 IN





ManualBIW-000522



WHEN TO USE A CONTROLLER

PRESSURE, TEMPERATURE AND LIQUID LEVEL CONTROLLERS

Leslie Controllers consist of a single or double seated diaphragm control valve operated by a Control Pilot. The latter is an air, water or oil actuated device that produces a variable loading pressure to the valve diaphragm in response to a pressure, temperature or level change in the controlled medium. Controllers are used for any one or any combination of the following conditions:

★ When an exactly controlled level, pressure or temperature is required.

★ When power is needed to assure automatic valve operating after prolonged, tight shut-off.

★ When power is needed to operate single-seated valves under high pressure drop.

★ When the available field pressure differential doesn't supply enough power for self-operation.

★ When extreme pressure reductions are necessary (i.e. 600 reduced to 10 psi, 900 to 2 psi, 2150 to 5 psi); all can be handled in one step.

★ When fluid contamination requires the simplest type regulating valve for dependable operation.

★ When operation from either a nearby or remote control station is desired.

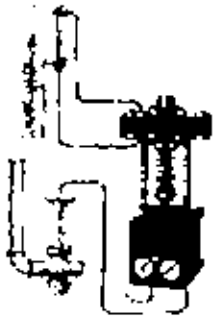


Control Pilot Type PD

LESLIE CONTROL PILOTS

Simple mechanical device employing constant supply of clean air, gas, water or light oil at 10-125 psi to produce a variable output or loading pressure of 0-80 psi in response to a level, pressure or temperature change applied to operate a control valve or power cylinder controlling fluid flow.

SEND FOR BULLETIN 800



Floating Level Control Type FLC

LESLIE FLOATLESS LEVEL CONTROL

Provides accurate control of liquid level (plus or minus 1" water column). Eliminates problems caused by troublesome linkages, torque tubes, float and shaft leaks. Simple design provides steady, positive, precise control even under difficult conditions. Consists of Level Control Pilot and diaphragm control valve.

SEND FOR BULLETINS 800, 804, 1500

LESLIE DIAPHRAGM CONTROL VALVES (Double Seated)

Flow-line unobstructed body for high capacity, low pressure drops. Bronze and 316 Ss trim is free from dezincification and rust bronze and cast alloy steels. Removable, self-aligning guides. ¼-10". ½ primary service rating of 300 psi—600° F. flanged, hub joint and welding ends.

SEND FOR BULLETIN 800

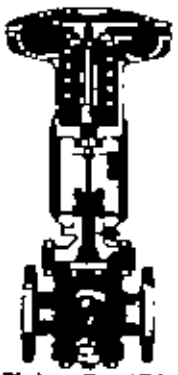


Diaphragm Control Valve Double Seated Class 150

LESLIE DIAPHRAGM CONTROL VALVES (Single Seated)

Control flow of steam, liquid, air or gas. Tight shut-off. Operated with diaphragm for air, water or oil power over complete range in Control Pilot or from a loading device such as LESLIE Air Loading pistol. Available with choice of fully balanced trim, ¼-10". In bronze, cast iron and cast alloy steels. Primary service ratings to 1500 psi, 1000° F.

SEND FOR BULLETIN 1500



Diaphragm Control Valve Single Seated Class 150

CONTROLLED QUALITY

WHEN TO USE A REGULATOR

SELF-CONTAINED PRESSURE, TEMPERATURE AND PUMP PRESSURE REGULATORS

Leslie Self-Contained Regulators are spring loaded, internal pilot, piston or diaphragm operated with stellited seating surfaces, hardened stainless steel main valves and renewable wearing parts of heat treated stainless steel of grades best suited to the application.

Regulators are used for any one or any combination of the following conditions:

★ When quick response is necessary to handle sudden load changes.

★ When available field pressure supplies sufficient differential for self operation.

★ When positive dead end shutoff is required for short periods of time.

★ When one-step pressure reductions are desired.

★ When service conditions require continuous flow for varying demand.

★ When "instrument control" is required without auxiliary operating force.

★ When installation requires smallest physical dimensions.

★ When operation from either a nearby or a remote control station is desired.



Pressure Reducing Valve
Class L-5

LESLIE
PRESSURE REDUCING VALVES

Automatically maintains a constant reduced pressure of steam, air or gas. Single seated, tight closing. Responds instantly to load changes. Renewable, interchangeable parts, hardened seating surfaces. Complete overhaul permitted without removing body from valve line. Made in Bronze, cast iron, cast steel or cast alloy steels. Sizes ¼" to 2". Orifice plates available for constant differential pressure, embodying one of the simplest refinements. Inlet pressures all psi to 3000 psi shown in 300#. Reduced pressures 5-600 psi.

SEND FOR BULLETIN 4000



Temperature Regulator
Class L-7000

LESLIE
TEMPERATURE REGULATORS

Designed for a wide range of applications. Vary the flow of steam or cooling water or heating or pressure to automatically maintain constant temperatures. Ranges 100° F. adjustable range thermostatic element. For small and large flows, direct operated, direct and reverse acting or with "Dynastat", two-element flexible and temperature control. For steam, fuel oil heaters, feedwater and storage heating heaters, open tanks, ovens, process heaters, degreasing machines, steam boilers, condensers, storage heaters, hose etc.

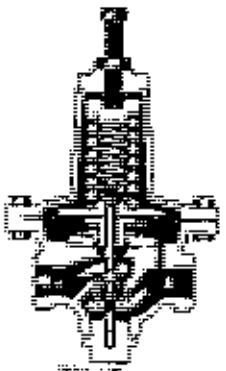
SEND FOR BULLETIN 4000

LESLIE "HI-FLO"
WATER PRESSURE
REDUCING VALVE

New reducing valve provides up to 100 percent greater capacity for liquid pressure reduction. Large bore construction and free acting diaphragm give full flow. Fully balanced for smooth, dependable action. High strength balancing diaphragm provides positive seal. Renewable trim with interchangeable fit.

Available in ½" - 2" screwed, flanged and lug bodies with bronze trim and resilient seating disc. Inlet pressure range 5-150 psi, 150# with reduced pressure ranges of 5-60 psi to 30-80 psi.

SEND FOR BULLETIN 340



Diaphragm Pressure Reducing Valve

LESLIE
SEPARATING VALVES

Separate operated steam and water valves designed for pressures up to 1500# and temperatures to 1000° F. Steam valve for lower pressures of steam or gases, valve lifts the water pressure. Many are operated by the steam pressure or other operating medium, giving fast, light action at all times for fast accommodating flows. Extremely compact, lever type valves are also available for manual operation. Self-closing connections for up to 600 psi and 900° F. Sizes ½" to 2".

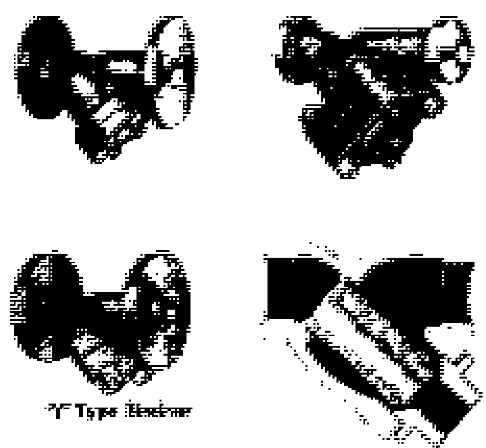
SEND FOR BULLETIN 5000



Pressure Operated
Quick Opening
Class LP

MEANS QUALITY CONTROLS

ManualBIW-000524



"Y" Type Strainer

LESLIE SELF-CLEANING STRAINERS

Recommended to protect all regulating equipment from dirt and foreign matter. Cast iron, bronze, cast steel, carbon moly, chrome moly, stainless and forged steels. Strainers with screwed, flanged, socket and butt welded connections sizes [illegible] to [illegible] inclusive. Primary service ratings to [illegible] psi. Screens furnished in Monel and stainless steel with various perforations and meshes for liquid, gas, oil and steam service.

SEND FOR BULLETIN [illegible]



LESLIE-TYFON and LESLIE-SUPERTYFON AIR and STEAM WHISTLES

Electrically or manually operated air and steam whistles for industrial and marine applications. Bulletin [illegible]

LESLIE COAST-TO-COAST SERVICE

[illegible]



LESLIE CO., LYNDHURST, NEW JERSEY

PLANT FACILITIES

INTERCHANGEABILITY AND PLANT FACILITIES

WHAT INTERCHANGEABILITY MEANS

FOUR KINDS OF INTERCHANGEABILITY

MAINTENANCE ECONOMY

HOW TO PUT INTERCHANGEABILITY TO WORK

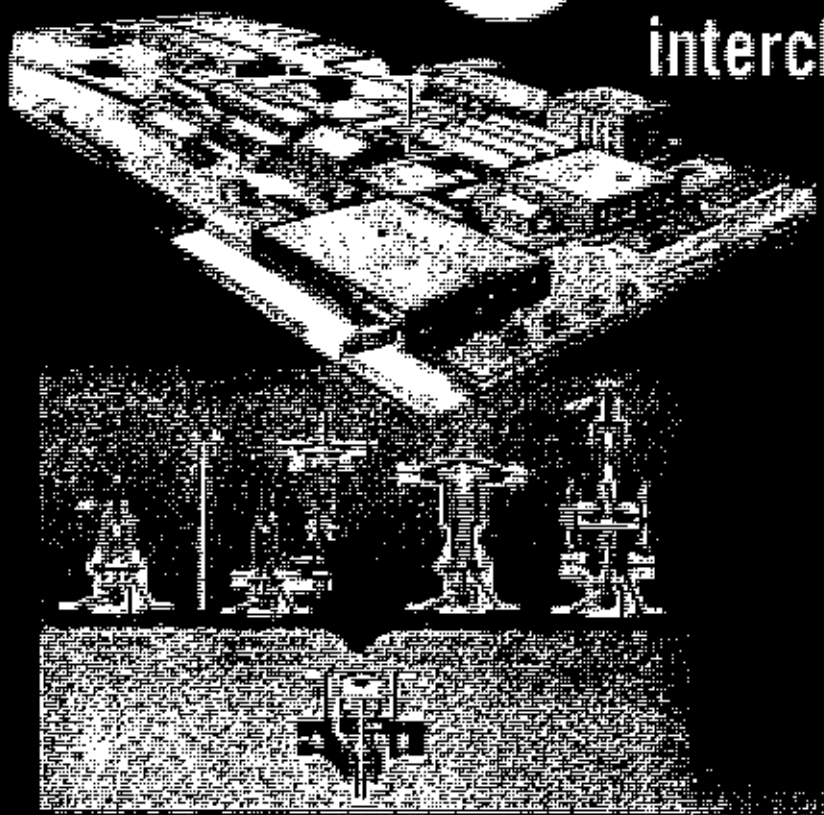
LESLIE PLANT FACILITIES

ManualBIW-000526

BULLETIN 5391

LESLIE

interchangeability and plant facilities

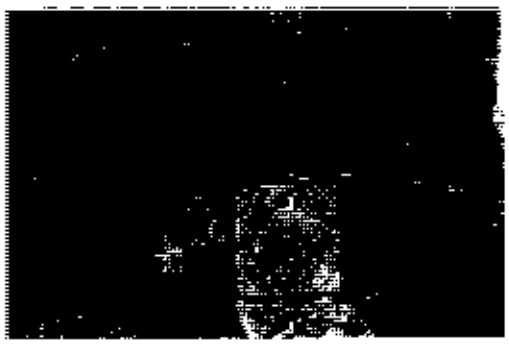


Manual BIW-000527

HOW INTERCHANGEABILITY IS B



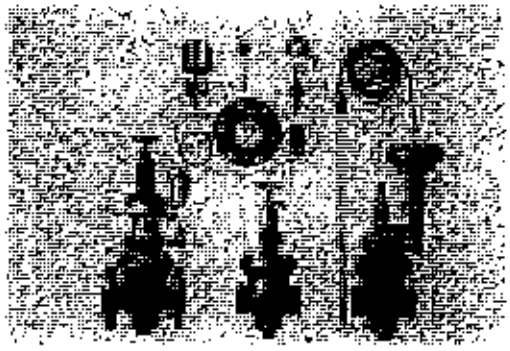
WEIGHING INTERCHANGEABILITY FACTOR, Leslie Engineers in foreground discuss new design for regulator main valve. Result is improved throttling control for low flow conditions with a main valve that is interchangeable in new and old regulators—for pressure, temperature and pump pressure control.



STRENGTH AND PERFECTION of valve body, as well as interchangeability, depends on precise casting. Leslie Engineers require that valve body seats for a minimum of 1 in times the rated pressure limit of the body. Leslie Co. produces most of its casting requirements in its own foundry.



AUTOMATIC MACHINES to make Leslie automatic controls. Human error element is removed from precision machining operation and is typical of the production methods that help interchangeability keep pace with today's fast changing processes.



INTERCHANGEABILITY of internal parts in pressure, temperature and pump pressure regulators is shown in circle and is typical of Interchangeability throughout the entire line of Leslie Regulators and Controllers.

TABLE OF INTERCHANGEABILITY

Name of Interchangeable Part	Interchangeable in	Applicable Sizes
Controlling Valve	All Reducing Valves, Pump Governors and Temperature Regulators	½ – 6"
Controlling Valve Seat	All Reducing Valves, Pump Governors and Temperature Regulators	½ – 6"
Controlling Valve Spring	Reducing Valves, Pump Governors Temperature Regulators (Bronze)	½ – 6"
	Reducing Valves, Pump Governors Temperature Regulators (Steel)	½ – 6"
Diaphragm	Reducing Valves of each Class Pump Governors of each Class Temperature Regulators of each Class	ALL SIZES
Piston, Cylinder Liner, Main Valve, Main Valve Springs	All Reducing Valves, Pump Governors and Temperature Regulators	For any one size only

Interchangeability of valve parts in various sizes and classes of Leslie Regulators is indicated by part reference number — Leslie engineering drawings in Catalog Books 2300, and available on request. Identical numbers on sizes designate uniform identical parts.

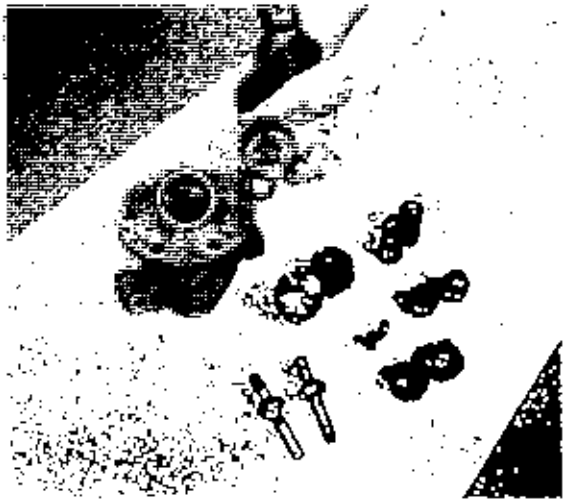
Copyright 1964 by Leslie Co.

Manual/BW-000528

UILT INTO EACH LESLIE PRODUCT



ACCURACY in outstanding flow measurers is given final check with precision gages before assembly, even though quality control engineers conduct frequent inspections throughout the entire manufacturing process.



19 YEAR-OLD REGULATOR gets first factory overhaul. New parts are completely interchangeable with old so that the veteran regulator will go right back into service with all modern improvements.

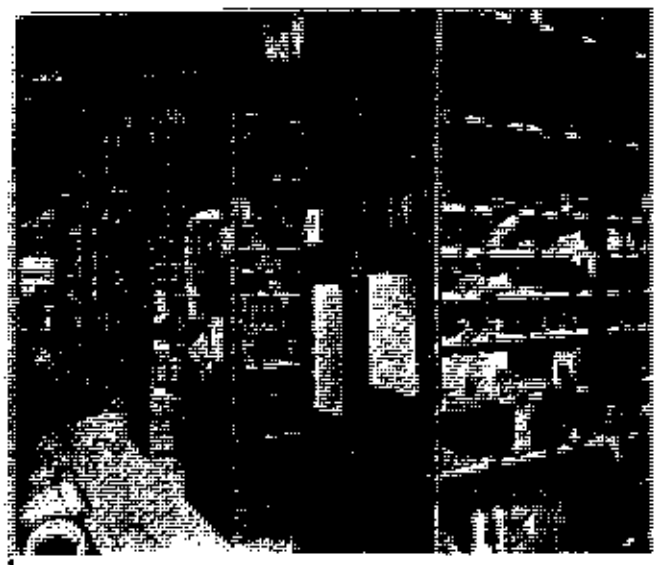


PILOT MODELS OF NEW PRODUCTS and new engineering changes are set up in Development Lab for "instant" tests. Here, Leslie Engineer checks pair of control valves undergoing breakdown tests during development of Leslie-Lubricoil Packing. These valves are outdoor gas models for corrosion resistant finishes on cast iron parts. Behind engineer, at right, motor packing tests subject sealing boxes and packing to extreme temperature conditions.



COMPLETED UNITS are given performance and destruction tests under field operating conditions. Hydrostatic strength tests show each regulator, control valve or strainer to be well above designated rating. Each unit receives the final operating test just prior to shipment or forwarding for stock despite the fact that continuous quality control during manufacturing process makes rejects at this late date a rarity.

ManualBIW-000629



AN ACRE OF PARTS, ready for immediate shipment from Leslie parts warehouses. Thousands of lines hold precision machined parts tagged with easy reference number system to make ordering fast and accurate . . . right from your catalog engineering drawing of the valve.



PROTECTED by heavy lined lumber and packed better than many delicate instruments are packed, the rugged diaphragm control valves shown at right are prepared for shipment, and will be ready to put right into service on arrival.

INTERCHANGEABILITY AND MULTI-FUNCTION REGULATORS

Body Assembly Type	No. of Available Superstructures by Control Function						
	Pressure Reduction		Pressure Relief	Differential Pressure Control Control	Temperature Control	Pump Pressure Control	Total Number of Complete Regulators
	Manual Adjustment	Remote Adjustment					
Piston Operated Cast Iron Body Assembly	2	2	1	1	2	6	12
Piston Operated Bronze Body Assembly	5	2	1	1	2	6	12
Piston Operated Cast Steel Body Assembly	2	2	1	1	2	7	16

Multi-function regulators are made possible by a choice of superstructure types for various functions which are interchangeable to the field on a standard body assembly.

Standard body assemblies are combined to provide control functions as indicated in the table above.

Leslie Coast-to-Coast Service — In all principal cities, Leslie factory-trained engineers are available to help with any control problem involving steam, liquid, air or gas. Look for LESLIE REGULATORS under "Regulators" or "Valves" in your classified telephone directory.

LESLIE CO., Lyndhurst, New Jersey

PRINTED IN U.S.A. 1250-2M

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PRODUCT INDEX

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PRODUCT INDEX

WHERE IT IS

This catalog is separated by tabbed dividers into easy-to-find product and general information sections.

The general information sections are tabbed "Interchangeability—Plant Facilities," and "Reference Tables—Engineering Data." This Index Section also contains "Industry Standards and Definitions" and "Leslie Sales Policies."

To find the product information you want, refer to the alphabetical product list to the proper group below for tab and bulletin number. The bulletin is found following its tabbed dividers. Refer to the Table of Contents on page 2 or the Quick Reference Table on page 1 of the Bulletin for the product page reference where complete engineering data can be found.

The alphabetical product name list below contains most product names commonly used. Such a complete list serves to clear up the ambiguities and uncertainties often caused by existing non-uniform terminology.

WHISTLES AND ACCESSORIES

Air Whistles	Leslie-Tylons
All-Will Switches	Manually Operated Whistles
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Automatic Whistle Controls	Motor Boat Whistles
Call Signals	Multiple Air Whistles
Chime Whistles	Plant Signals
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Dual Chime Air Whistles	Single Tone Air Whistles
Electrically Operated Whistles	Small Boat Whistles
Electric Solenoids	Steam Jacketed Whistles
Factory Whistles	Steam Whistles
Five Chime Air Whistle	Suspension Three Chime Air Whistle
Fog Signal	Timer and Junction Box
Horns	Tylon
Leslie-Superti tions	Whistle Operating Valves
	Whistle Solenoids

See Bulletin No. 5110 — Steam and Air Whistles

STRAINERS AND FILTERS

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Gas Strainers	Strainer Screens
Liquid Strainers	Strainers
Screens	Y Type Strainers

See Bulletin No. 1308 — Self Cleaning Strainers

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● Air Control Valves	Dia. Control Valves	5104
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Air Reducing Valves	Reducing Valves	1307
Air Regulators	Reducing Valves	5102
Air Whistle Valves	Operating Valves	5109
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Automatic Temperature Regulators	Temp. Regulators	5107
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Boiler Feedwater Regulators	Control Pilots	5101

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Bulbs	Temp. Regulators	1107
● Calibrated Dials	Temp. Regulators	1107
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SALES POLICIES

TERMS AND CONDITIONS OF SALE

Leslie Co. agrees to supply the equipment covered herein on the following terms and conditions. Additional terms and conditions not covered herein will be accepted only upon mutual agreement in writing.

ORDERS: Contracts and orders are subject to acceptance by home office of the manufacturer.

PRICES AND DISCOUNTS: All prices and discounts are in accordance with the established price and discount schedules of the manufacturer.

Prices quoted are f.o.b. Lyndhurst, N. J. unless prices are specifically requested and quoted on basis of f.o.b. destination.

Subject to establishment of satisfactory credit, terms are strictly net cash thirty days from date of invoice payable in New York funds.

DESIGNS: All designs and specifications shown in catalogs are subject to change without notice.

LIABILITY: The buyer shall remain primarily liable for the purchase price and the manufacturer shall not be obliged to accept any term or condition of payment which will shift said liability to a third person not a party to the contract of sale, whether or not such third person is the United States Government, its agents or instrumentalities.

WEIGHTS AND DIMENSIONS: Shipping weights and dimensions given in catalogs and drawings are as close to actual as practicable but are not guaranteed. No claims will be allowed because of any discrepancy between actual weight or dimensions of material shipped and listed data.

SHIPPING AND PACKING: All material is carefully packed for shipment and manufacturer will not be responsible for loss, delay or breakage after having received "in good order" receipts from the transportation company. All claims for breakage, loss, delay and damage should be made to carriers, but manufacturer will render buyer all possible assistance in securing satisfactory adjustment of such claims.

Goods will be shipped by the method and via carrier manufacturer believes dependable, unless carrier is designated by the buyer.

Goods held in factory beyond delivery date for convenience of buyer will be invoiced on date of completion and terms of payment will apply as from invoice date. Such goods will be subject to charges for warehousing and other expenses incident to such delay.

CANCELLATION: All orders are firm and are not subject to cancellation or change in specifications, shipping schedules or other conditions without manufacturer's written consent which will be given only upon agreement to compensate for loss caused by such cancellation or changes.

GUARANTEE: The manufacturer guarantees its products to be free from defects in material or workmanship over a period of one year from date of shipment from its factory. Said guarantee will not apply if equipment is used in conditions of service for which it is not specifically recommended. The manufacturer is not responsible for damage to its apparatus through improper installation, physical damage or poor operating practice.

If any device is found unsatisfactory under the guarantee, the buyer should notify the manufacturer in writing and after receipt of shipping advice, buyer may return it direct to Leslie Co., Lyndhurst, N. J., carrying charges prepaid. Such equipment will be replaced or put in perfect operating condition, free of all charges except transportation, and the correction of any defects by repair or replacement by the manufacturer shall constitute fulfillment of all obligations to the purchaser. Manufacturer does not assume responsibility for unauthorized repairs to its apparatus, even though defective.

Manufacturer shall not be liable for consequential damage in case of any failure to meet the conditions of any Guarantee or Shipping Schedule, nor will claims for labor, loss of profits, repairs or other expenses incidental to replacement be allowed.

No other representations, guarantees or warranties, expressed or implied, are made by the manufacturer in connection with the manufacture and sales of its equipment.

RETURNS FOR REPAIR: When equipment is returned for repair due to causes not covered by manufacturer's guarantee, the buyer should notify the manufacturer in writing and, after receipt of shipping advice, the buyer may return it to Leslie Co., Lyndhurst, N. J., transportation charges prepaid, for prompt attention. Manufacturer's Repair Department will put such equipment in operating condition at the lowest possible cost. When necessary to make a return, give all possible information regarding the trouble experienced and complete details of the installation with which the device was used.

RETURNS FOR CREDIT: No returns for credit will be accepted unless manufacturer's permission has been obtained in each case in advance. Only sizes and designs taken from manufacturer's regular line which are in active demand can be accepted for credit. Credit will be based on prices prevailing at the time of return, or invoiced price, whichever is lower, subject to deduction for handling and an additional deduction for expenses incurred in restoring goods to salable condition. Obsolete or especially manufactured goods can be accepted for return or credit only to the extent of value to manufacturer in each case.

BOND PREMIUMS: In the event the manufacturer shall be required as a condition of the manufacture and sale of equipment to furnish a performance bond, the buyer shall pay as a part of the purchase price of said equipment all bond premiums and expense in connection therewith.

LAWS AND REGULATIONS: Manufacturer has complied with all applicable Federal, State and local laws and regulations in connection with the manufacture and sale of all equipment. No responsibility or liability will be taken for import duties, taxes, regulations or taxes imposed by any foreign country.

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LESLIE

INDUSTRY STANDARDS AND DEFINITIONS

To provide better products and customer service, Leslie Co., and other manufacturers in the Automatic Regulating Valve Industry have adopted simplified practices issued by the National Bureau of Standards for product manufacture and publication of product data. Complete copies of the standard "Simplified Practice Recommendation R219-46 April 1, 1946" are available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. and are briefed here for your ready reference.

"SCOPE AND PURPOSE OF RECOMMENDATIONS." This recommendation applies to automatic regulating valves made of steel, iron and bronze. Its purpose is to establish as a useful standard of practice the simplified list of pressure ratings and sizes of valves listed in table 1. Sizes not listed are not covered by this recommendation.

"DEFINITIONS." An automatic regulating valve means any valve for controlling temperature, pressure, level, or rate of flow of a fluid. The recommendations applies to the following valves:

1. Instrument or external-pilot-operated regulating valves in which the power used to actuate the main valve is not taken from the fluid being controlled.
2. External-pilot, self-operated, regulating valves using the fluid being controlled to operate the main valve, with pilot valve externally piped.
3. Internal-pilot-operated regulating valves using the fluid being controlled to operate the main valve, the pilot valve being an internal part.
4. Electric-motor-operated regulating valves actuated by an electric motor under the control of an automatic or manual switch.
5. Solenoid-operated regulating valves actuated by a solenoid under the control of an automatic or manual switch.
6. Direct-operated regulating valves in which pressure on the power device (bellows, diaphragms, piston, or disk) directly actuates the main valve, said power device being a part of the regulating valve assembly.
7. Mechanically operated regulating valves in which the power used to actuate the valve is mechanically transmitted by levers, rods, cables, chains, gears or cams.

"EXCEPTIONS." Automatic regulating valves for the following services are not included in this recommendation:

1. Valves for inlet pressures below 13 psi.
2. Domestic float or tank valves, including, but not limited to ball cocks, humidifier valves, closet tank valves, etc.
3. Valves for marine and railroad rolling stock application.
4. Flow diversion valves for use in the pasteurization of milk.
5. Sanitary valves for use in the pasteurization of citrus fruit juices, tomato juices, etc., as well as on certain canning applications in the dairy industry.

"PRIMARY PRESSURE RATINGS." The ratings in column 1, table 1, are for steam service. Automatic regulating valves are not standard for primary pressure ratings above 1100 psi. Pressure ratings for other fluids are in accordance with each manufacturer's regular practice.

"SIZES." The sizes, in table 1, of screwed and flanged automatic regulating valves mean the corresponding nominal iron pipe sizes.

"MATERIALS AND CONSTRUCTION." The materials used in the fabrication and design of the automatic regulating valves covered by this recommendation conform to the manufacturer's regular practice. When body materials are other than steel, iron, or bronze, the pressures and sizes in table 1 do not apply.

"CONNECTIONS

Threads are American National taper pipe threads.

Flanges conform to ASA or API standards for corresponding pressure classes for steel and iron, and to MSS standards for bronze flanges.

Steel and iron automatic regulating valves do not have union ends; bronze valves may be supplied with union ends in sizes up to and including 1 inches.

Automatic regulating valves with welded-end connections are not included in this recommendation.

"ABBREVIATIONS." Where used in this recommendation, psi stands for pounds per square inch; ASA for American Standards Association; API for American Petroleum Institute; MSS for Manufacturers Standardization Society of the Valve and Fittings Industry; SP for steam pressure."

Table 1 — Automatic regulating valves

Primary pressure ratings[1]	Steel, body nominal pipe end connection						Union ends
	Steel		Iron		Bronze		
	Screwed (female)[2]	Flanged[3]	Screwed (female)[2]	Flanged[3]	Screwed (female)[2]	Flanged[3]	
psi	Inches	Inches	Inches	Inches	Inches	Inches	Inches
125	—	—	¼ to 3	1 to 12	—	—	—
150	—	½ to 30	—	—	½ to 1	1 to 12	½ to 1
250	—	—	¼ to 3	3 to 12	—	—	—
300	—	½ to 36	—	—	½ to 1	1 to 12	½ to 1
600	½ to 1	½ to 12	—	—	½ to 2	—	½ to 2
900	—	1 to 16	—	—	½ to 1	—	½ to 2
1,100	½ to 1	1 to 16	—	—	½ to 1	—	½ to 2

[1] The primary pressure ratings are for steam service. Ratings for other services are not uniform, and vary with each manufacturer.

[2] Sizes are inclusive. The specific sizes within the size ranges shown are ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 8, 10, 12, 14, and 16 inches.

[3] Flanges for:

Steel-body valves: ASA raised face; ASA octagonal ring joint groove; API octagonal ring joint groove; ASA large tongue and groove for services for which other types of joints are not suited.

Iron-body valves: ASA plain face for 175 psi; ASA raised face for 250 psi. When made of malleable iron, flanges conform to MSS Standard SP-1, for 125 and 150 psi flanges, for sizes 12 inches and below. ASA large tongue and groove used on valves for services for which other types of joints are not suited.

Bronze valves: On sizes 12 inches and below for 150 lb. SP, and on sizes 8 inches and below for 300 lb. SP, flanges conform to MSS SP-1-1943, Bronze Flange and Flanged Fitting Standard.

[4] For other than steam service.

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TRADE LESLIE MARK

instructions for

PRESSURE REDUCING VALVES

Differential Pressure Regulators and Overflow Valves

INSTALLATION, OPERATION and MAINTENANCE

IMPORTANT

Plan before actual installation for:

Strainer -- Protect reducing valves from dirt and scale found in pipe lines by installing LESLIE Self-Cleaning Strainers.

Drainage -- For best results and to prevent water hammer, inlet and outlet steam piping must be properly drained. If possible, reducing valves should always be installed in the highest horizontal line of piping.

Stop Valves -- Inlet and outlet stop valves and gages are needed to properly adjust, operate and test reducing valves. Good piping practice includes bypass.

Provide specified minimum length of straight pipe before and after Reducing Valve.

INSTALLATION
All Classes With Internal Ports

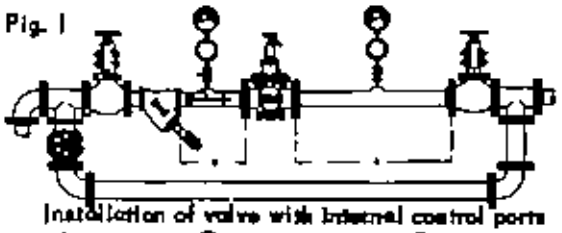
1. Before installation, thoroughly blow out all pipe lines to protect the valve from grit and scale. Do not use red lead or cement for making up joints.
2. Remove raised faces of iron or steel flanges to which bronze reducing valves are to be bolted. Gaskets are to have same dimension as flanges and 1/4" larger inside diameter than bore of flange.
3. Place reducing valve upright in the highest horizontal line of piping with arrow (cast on side of body) in direction of steam (air or gas) flow. To prevent water hammer, inlet and outlet steam piping must be properly drained.
4. Insulate all pipe before and after reducing valve to minimize condensation.
5. For remotely adjusted reducing valves (classes LT-3, LTS-3, LTK, etc. See Fig. 4) use 5/16" O.D. copper tubing to connect valve diaphragm to air loading panel (Type ARP-1) mounted conveniently. Avoid water pockets when installing tubing. Protect loading panel with 1/4" air strainer if frequent changes are to be made.
6. For differential pressure regulators (Classes LX-4, LXS-4, LXK), use 1/4" pipe with stop valve and union to connect external pressure impulse to regulator diaphragm chamber. Use continuous pitch and avoid pockets where air or condensate could collect and affect pressure impulse. See Fig. 3.
7. Overflow valve (Classes UL, ULK, ULS) should have expanded outlet piping to twice inlet pipe size when discharging into lower pressure system of less than 25% of inlet pressure.

All Classes With External Control Pipe

Instructions for installation are the same as outlined above, with the addition of the following:

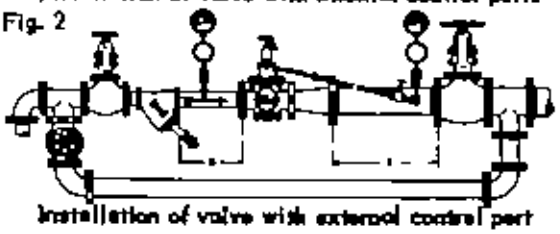
1. Expand outlet piping from reducing valve to approximately twice the inlet pipe size whenever a reduction to 25% of the initial pressure or less is made. In such cases use taper expander at outlet of reducing valve. Further expansion of low pressure pipe beyond outlet stop valve will not affect operation of reducing valve. If outlet pipe is not expanded the external control pipe is of no advantage. See Fig. 2.

Fig. 1



Installation of valve with internal control ports

Fig. 2



Installation of valve with external control port

RECOMMENDED INSTALLATION DIMENSIONS

SIZE OF REDUCING VALVE	DIMENSIONS	
	A	B
1/2" to 1-1/2"	1'6"	3'8"
1" to 4"	2'0"	2'0"
5" to 6"	2'0"	2'0"

CLASSES WITH INTERNAL CONTROL PORTS*

L-3, L-4, LK	L-1, L-2H
LAS, LAK	L-1A, LA-1, LA-4
LS-4	LAS, LAS-1
LX-4, LXK, LXS-4	LX, LXK, LXK-1
J-1, JA-2	J, JA, JA-4
UL, ULK, ULS	

*Also for above basic classes to which any of the following letters have been added: O, T, TP, Y, and/or N

CLASSES WITH EXTERNAL CONTROL PORT*

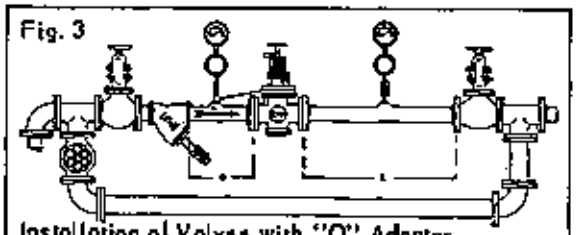
COMMERCIAL		NAVY	
FURNISHED	INSTALLED	FURNISHED	INSTALLED
LX-3, LX-4, LXK	LX-H1	LXS	LXS-4
LL-4, LL-4, LLK	LL	LXS-4	LXS, LA-1A, LA-1, LX-1K, LX-1, LX
LAK-4, LAK-4, LAKK	LX-1A		
JL, JAL-2	JAL, JAL-1	LX	
LAS-3, LAS-33	LAS, LAS-2		
LS-2, LS-3	LX-1, LK, LS-2		

*Also for above basic classes to which any of the following letters have been added: O, T, TP, Y, and/or N

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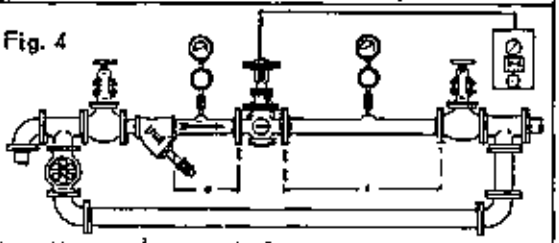
LESLIE instructions for PRESSURE REDUCING VALVES

Fig. 3



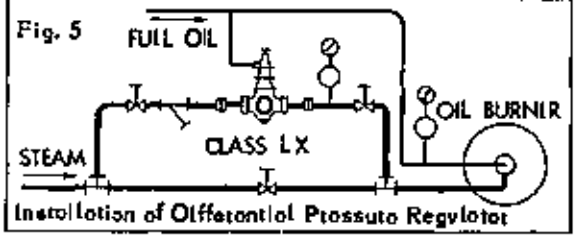
Installation of Valves with "O" Adapter

Fig. 4



Installation of Remotely Operated Valve

Fig. 5



Installation of Differential Pressure Regulator

9. Connect 1/4" control pipe with stop valve and union to outlet pipe before outlet stop valve but after taper expander. Pitch pipe toward outlet line to avoid water pockets. Provide for positive drainage of pipe lines before and after reducing valve.

ALL CLASSES FITTED WITH "O" ADAPTERS
(designated by "O" in the class)

Follow instructions outlined above, See Fig. 5 and—

10. Connect 1/8" pipe to adapter from (a) top of inlet supply piping or (b) from a higher pressure source. Include 1/8" strainer and solenoid valve auxiliary pilot or other mechanism. 1/8" piping should be as short as possible and pitch away from adapter to remove condensation. Insulate 1/4" pipe if over 12" long and drop sag low point.

OPERATION

Pressure Reducing and Differential Pressure Valves

1. Close inlet and outlet stop valves.
2. Release compression on adjusting spring under handwheel.
3. Slowly open inlet stop valve wide.
4. Dispose of condensation, dirt, etc., by opening strainer blow-off valve.
5. Open stop valve on remote impulse line.
6. Crack outlet stop valve to permit slight flow when setting regulator.
7. Slowly screw down handwheel until desired pressure is shown on gage on outlet side of of regulator.
8. Slowly open outlet stop valve wide.
9. TO CHANGE OUTLET PRESSURE, turn handwheel downward to increase and upward to decrease pressure.
10. TO TURN STEAM, AIR, OR GAS OFF, close outlet stop valve first, then inlet stop valve.
11. TO TURN STEAM, AIR, OR GAS ON, (with Reducing Valve set) keep outlet stop valve closed until inlet stop valve is opened wide.
12. BY-PASS – TO TURN STEAM ON, with large Reducing Valves (3" size and larger), steam must first be admitted through by-pass, filling the reduced pressure system to desired pressure before screwing down handwheel in order to prevent hammer of main valve.

OPERATION

Remotely Adjusted Reducing Valves

Same as outlined above except:

7. Slowly raise air loading pressure (see panel gage) by turning setting knob to the right until valve opens and delivers desired reduced pressure.

Overflow Valves (Classes UL and ULK)

1. Close inlet and outlet stop valves.
2. Turn handwheel downward compressing adjusting spring to prevent sudden valve opening.
3. Slowly open inlet stop valve wide.
4. Dispose of condensation, dirt and other foreign matter by opening strainer blow-off valve.
5. Crack outlet stop valve to permit slight flow.
6. Slowly turn handwheel upward reducing spring compression until overflow valve starts to open. If valve is already open, turn handwheel downward until valve closes.
7. Adjust pressure setting to desired opening pressure on inlet gage.
8. Slowly open outlet stop wide.
9. TO CHANGE OVERFLOW SETTING – Turn hand wheel downward to increase and upward to decrease pressure setting.
10. TO TURN STEAM, AIR, OR GAS OFF – Close inlet stop valve first, then outlet stop valve.
11. TO TURN STEAM, AIR, OR GAS ON – (with overflow valve set) keep inlet stop valve closed until outlet stop valve is open wide.

Copyright Manual BW-000566

LESLIE instructions for PRESSURE REDUCING VALVES

MAINTENANCE

To eliminate sluggishness caused by dirty steam or other local conditions, LESLIE Reducing Valves, Differential Pressure Valves and Overflow Valves may be dismantled and cleaned without removal from the pipe line.

CHECK NAMEPLATE FOR PROPER CLASS AND WRITE FOR APPLICABLE DRAWINGS

Dismantling

Refer to proper drawing:

1. Close the stop valves on each side of the reducing valve.
2. Release all compression on the adjusting spring by turning the handwheel counter clockwise.
3. Unscrew or unbolt adjusting spring case and take out spring and diaphragm.
4. Unscrew controlling valve seat with socket wrench provided for this purpose and remove controlling valve and spring.
5. Remove top cap, piston, and cylinder liner.
6. Remove bottom cap and take out main valve and main valve spring.
7. In classes where used, seat ring to body can be taken out, when necessary, with the special seat ring wrench provided for this purpose.

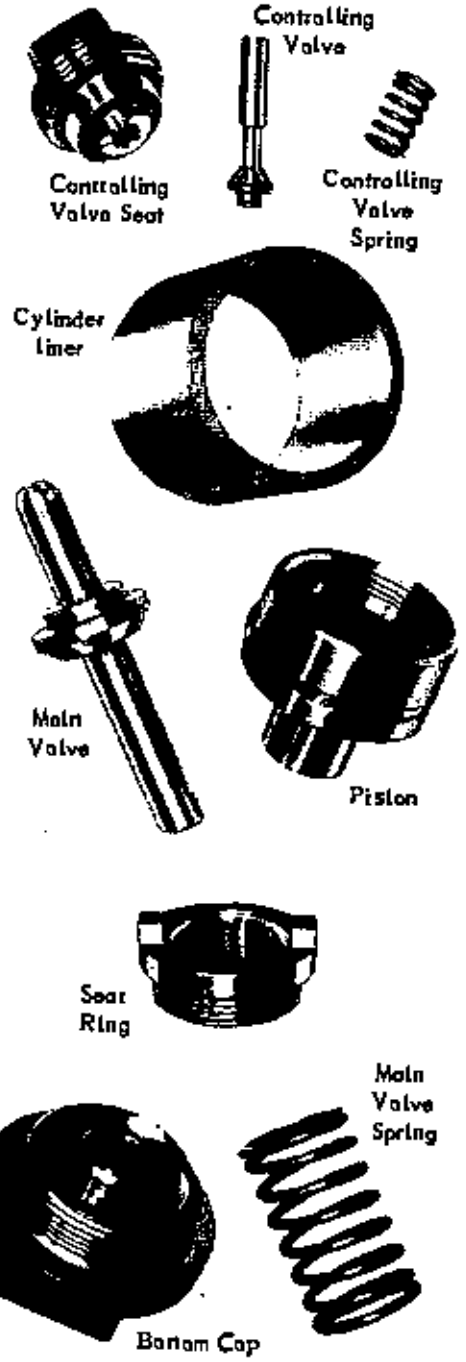
Cleaning

Clean all parts with kerosene, and check as follows:

1. Examine main and controlling valves to be sure they move freely in their guides, and seat properly.
2. If valve seating surfaces (metal seats only) are scored or cut, regrind with fine grinding compound, allowing the piston to remain in the cylinder liner when regrinding the main valve to insure perfect centering. Remove all traces of grinding compound before reassembling.

   If plastic insert seating surface is scored or cut slightly, put oil on valve, press firmly against insert and turn several times, removing defect. Replace part if plastic insert is heavily scored or cut.
3. Make certain the piston rings are free in their grooves and expand into the cylinder liner.
4. Have all working parts moving freely.
5. See Drawing No. 1278P for steel top cap assembly.

IDENTIFICATION OF INTERNAL WORKING PARTS



LESLIE

instructions for PRESSURE REDUCING VALVES



Grinding Main Valve



Tightening Controlling Valve Seat



Checking Controlling Valve Stem Clearance

CAUTION

LESLIE Reducing Valves are ruggedly built, carefully assembled, and dimensioned very accurately. Do not change any dimensions. To assure long life, complete interchangeability and low maintenance costs, only use standard LESLIE parts.

ASSEMBLING

1. Graphite or compound should not be used on joints. Moving parts require no lubricant.
2. Place the main valve, spring and gasket in position on bottom cap, and screw or bolt to the valve body.

Classes J-1, JA-2, JL and JAL-2 require adequate lower diaphragm travel for proper operation. To be sure of proper travel, clearance between body flange face and main valve stem should be:

J-1, JL-1/16" $^{+1/64}_{-.000}$ JA-2, JAL-2-3/32" $^{+1/32}_{-.000}$

Check clearance with straight edge and scale.

3. Depress the piston in the cylinder liner (be sure movement is smooth and free). Top of liner must be flush with top flange of body.
4. Bolt the top cap with gasket to the body – pull bolts up evenly.
5. Assemble the controlling valve, seat and spring in the top cap. Tighten controlling valve seat firmly with special wrench furnished for the purpose, and cap wrench to make sure of perfectly tight joint.

   For reliable shut-off, controlling valve seat also seat tightly. To be assured of this, stem of controlling valve must not project above diaphragm seat. Correct clearance is .001" to .005" below diaphragm seat. Check clearance with straight edge and feeler gage, or use controlling valve stem clearance gage. For classes HS-3, IS-2, HRS and IRS-2 clearance is taken with deflector plate in position.
6. Check flatness of diaphragm with straight edge. If "dished" more than .005" from level, replace with new diaphragm.
7. Replace diaphragm, adjusting spring, spring seats and spring cases.
8. Make all joints tight.

Send for free tools, drawings and literature on Business Reply Card addressed to LESLIE Co.

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LESLIE instructions for PUMP PRESSURE REGULATORS

INSTALLATION, OPERATION and MAINTENANCE

INSTALLATION – Do not use red lead or cement when making up pipe joints.

STRAINER – Protect regulators from dirt and scale in pipe lines by installing a Leslie Self-Cleaning Strainer.

DRAINAGE – To obtain best results and prevent water hammer, inlet and outlet piping must be properly drained. Regulators should be installed as close to the pump or turbine as possible.

STOP VALVES – Inlet and outlet stop valves and pressure gages are needed to properly adjust, operate, and test pump regulators. Good piping practice includes a Bypass.

1. Remove raised faces of iron or steel flanges to which bronze pump regulators are to be bolted. Gaskets should have same outside diameter as flanges and 1/4" larger inside diameter than bore of flange.

2. Before installation, thoroughly blow out all pipe lines to protect regulator from grit and scale.

3. Place regulator upright as close to pump as possible in horizontal line of pipe with arrow (cast on side of body) in direction of steam flow.

4. Select actuating pipe connections for applicable conditions as follows:

a. One pump and one regulator – Connect one to three feet from pump discharge. Connection may be made either ahead of or after check valve, if any.

b. Two pumps with one regulator – Connect near pump discharge, preferably after discharge check valve to prevent entrance of high pressure liquid into standby pump casing if stop valve is not closed.

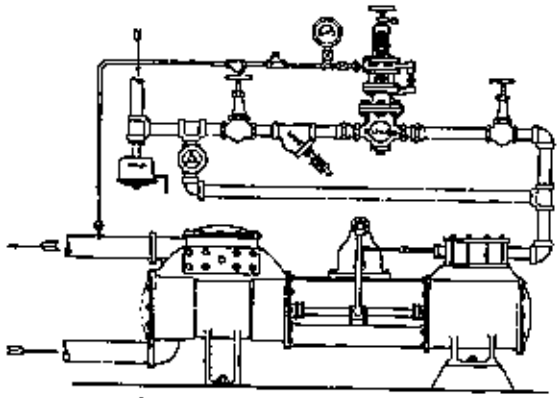
c. Two pumps and two regulators in parallel operation – Connect near pump discharge before discharge check valve so that regulators can be adjusted for parallel operation, i.e., set to deliver equal flow into common header.

5. Plan to use a pulsation retarding needle valve if required. Reciprocating pumps handling thin liquids, such as water and light oils, require 1/4" Strainer and *pulsation retarding needle* valve in actuating pipe AHEAD of gage. They are furnished with regulators ordered for light

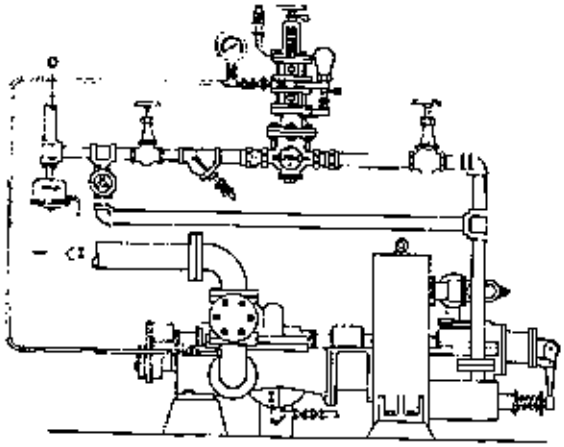
*ALL CLASSES INCLUDING

CHHS	CTHSM	PRLK	XRH
CHS–2	PLS–3	PTH	XRHK
CHSM–2	PR	PTHK	XRHS–3
CRH	PRH	PTHS–3	XRHSM
CRHK	PRHK	PTHSM	XTH
CRHS–3	PRHS–3	PTL	XTHK
CRHSM	PRHSM	PTLHS	XTHS–3
CTH	PRK	PTLK	XTHSM
CTHK	PRL	PTLS–3	XTL
CTHS–3			XTLK

*ALSO FOR ABOVE BASIC CLASSES TO WHICH ANY OF THE FOLLOWING LETTERS HAVE BEEN ADDED: J, N, O AND W



TYPICAL INSTALLATION
Constant Pressure Pump Regulator



TYPICAL INSTALLATION
Differential Pressure Pump Regulator

LESLIE instructions for PUMP PRESSURE REGULATORS

liquid. Do NOT use with viscous liquids like fuel oils. Regulators for turbine-driven pumps do not require a pulsation retarding needle valve.

6. Install actuating pipe (3/8" for viscous liquids and 1/4" for thin liquids) with stop valve, union and gage (strainer and pulsation retarding needle if necessary) from connection to regulator superstructure to discharge line, one to three feet from pump.

7. Insulate all steam lines to minimize condensation losses.

EXCESS PRESSURE PUMP REGULATORS — Same steps as above except employ a second actuating pipe from regulator superstructure to a source of boiler pressure as follows: Install 1/4" steam actuating pipe with union and stop valve from 1/4" connection in spring case of pump regulator to boiler or point where full boiler pressure *always* exists.

OPERATION OF ALL CLASSES

1. Close inlet and outlet stop valves and relieve compression on adjusting spring.

2. Blow out condensation, dirt, etc., through strainer blow-off using inlet stop valve.

3. Operate pump on bypass until pump is warm and lines are clear of condensation.

4. Open 1/4" stop valve and needle valve (if any) in actuating line from pump discharge.

5. Slowly open inlet and outlet stop valves wide and adjust pump regulator as follows.

Constant Pressure Regulators

Slowly screw down on handwheel until gage in actuating pipe from pump discharge shows an increase in pressure indicating regulator is taking hold. Close bypass tightly. Screw down slowly on handwheel until desired pump discharge pressure is obtained. Screw handwheel downward to increase, upward to decrease pressure. Lock with lock-nut.

Excess Pressure Regulators

(Class XRH, XTH, XRHS–3, XTHS–3 etc.)

Slowly open 1/4" stop valve in steam actuating pipe. Close bypass slowly and screw down on handwheel until desired differential above boiler pressure is obtained. Screw handwheel downward to increase, upward to decrease differential between pump discharge and boiler pressures. Lock with lock-nut.

Manual Operating Device

Regulators fitted with manual pull open device are usually installed without external bypass, the manual pull open device to start pump in place of external bypass. When unit has warmed up, slowly close pull open device and adjust regulator handwheel as described above.

Shifting From One Pump To Another

Standby operation with common discharge and actuating line.

Adjust each regulator as described above. With one regulator and pump in service, open inlet and outlet stop valves of standby regulator. Dispose of condensation. To shift pumps, screw down on handwheel of standby regulator and at same time ease off on handwheel of unit in service until standby unit takes over the load exiting off "service" unit. Close inlet and outlet stop valves on replaced unit.

To Operate Two Pumps with Two Regulators (See instruction 4 (c) Actuating Pipe Connection)

Follow steps 1–6 with each pump operated alone. Then operate both pumps together and adjust regulator handwheels until the load is equally distributed between the two pumps indicated by equal operating speeds or by approximately equal steam pressures delivered to turbine thrust for turbine-driven pumps. Thereafter, pumps will work together.

Adjustment of Pulsation Retarding Needle Valve

Throttle pulsation retarding needle valve until movement of gage hand is smooth and even with small total movement at end of each stroke. NEVER SHUT NEEDLE VALVE TIGHT, gage must be "alive" to be sure regulator is receiving pressure changes.

Adjustment of Stabilizing Needle Valve

Regulators for turbine-driven pumps have a built-in stabilizing needle valve between the upper and lower steam diaphragms. Classes CHHS, CIHS, PTLHS, PLHNS, CHHNS, have a built-in, non-adjustable stabilizer.

Adjust built-in pump regulator needle valve when operating at low capacity to approximately 1/4 turn open so that there is no "hunting" and regulator action is smooth and even. NEVER SHUT NEEDLE VALVE TIGHT

Shutting Down—Starting Up—All Classes

To turn steam off, close outlet and inlet valves tightly.

To turn steam on (with regulator set):

Manual MW-000683

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LESLIE instructions for PUMP PRESSURE REGULATORS

1. Open bypass until pump and lines are warm. Be sure stop valve and needle valve in actuating pipe from pump discharge are open. (On EXCESS PRESSURE PUMP REGULATORS, slowly open stop valve in 1/4" steam actuating pipe).
2. Open inlet stop valve WIDE, dispose of condensation, dirt, etc., by operating strainer blow-off valve.
3. Open outlet stop valve SLOWLY, and close bypass stop valve tightly.

MAINTENANCE

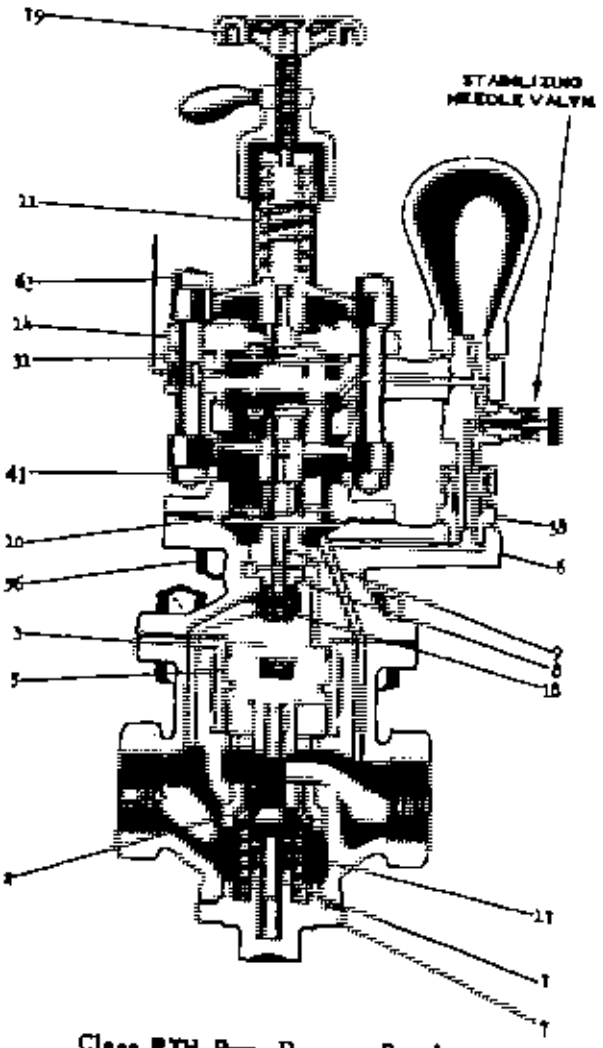
Refer to Proper Drawing Furnished on Request.

1. Close stop valves and open union (6) in the actuating line.
2. Release all compression on the adjusting spring (11) by turning handwheel (19) counterclockwise.
3. Unscrew connector union (38) from top cap (6) and slide up on nipple on all classes except PR and PRS-3.
4. Remove lower nuts from stud bolts (56) and disassemble superstructure. Unscrew connecting rod nuts (63) and remove parts in order starting from the top.
5. Remove steam diaphragm (10) from top cap and unscrew controlling valve seat (8) with socket wrench provided for this purpose.
6. Remove controlling valve (9) and spring (18).
7. Remove top cap (6), piston (5), and cylinder liner (3).
8. Remove bottom cap (7) and take out main valve (4) and main valve spring (17).
9. In classes where cast, seat ring (2) in body can be taken out, when necessary, with special seat ring wrench provided for this purpose.

CLEANING

Clean All Parts with Kerosene and Check as Follows:

1. Examine main and controlling valves to be sure they move freely in their guides, and seat properly.
2. If valve seating surfaces are scored or cut, regrind with fine grinding compound, allowing the piston to remain in the cylinder liner when regrinding the main valve to insure perfect centering. Remove all traces of grinding compound before reassembling.
3. Make certain the piston rings are free in their grooves and expand into the cylinder liner.
4. See that the ports in diaphragm case or diaphragm chamber (31) and spring case (14) are open and clean.
5. Have all working parts moving freely.
6. See Drawing No. 1278F, top cap assembly, for additional maintenance instructions.



Class PTH Pump Pressure Regulator

CAUTION

LESLIE PUMP PRESSURE REGULATORS are ruggedly built, carefully assembled, and dimensioned very accurately. Do not change any dimensions. To assure long life, complete interchangeability, and low maintenance costs, use only standard LESLIE parts.

LESLIE instructions for PUMP PRESSURE REGULATORS

ASSEMBLING BODY

Important – Graphite or Compound Should Not Be Used on Joints. Moving Parts Require No Lubricant.

1. Place the main valve, spring, and gasket in position on bottom cap, and screw on bolt to the valve body.
2. Depress the piston in the cylinder liner (be sure movement is smooth and free). Top of cylinder liner must be flush with top flange of body.
3. Bolt the top cap with gasket to the body – pull bolts up evenly.
4. Assemble controlling valve, seat, and spring in top cap. Tighten controlling valve seat firmly with special wrench furnished for this purpose, and tap the wrench to make sure of perfectly steam tight joint.

   For reliable shut-off, controlling valve must also seat tightly. To be assured of this, stem of valve must not project above diaphragm seat in top cap. Correct clearance is .001" to .005" below diaphragm seat. Check clearance with controlling valve clearance gage or straight edge and feeler gage. For classes CHNS, CIHS, PTLNS and PLHNS, PTLHNS, CHNNS, clearance is taken with Deflector plate in position.
5. Diaphragms will normally, after many months of service, take a permanent set – i.e., become slightly "dished." This set will not interfere with proper operation provided it is not excessive.

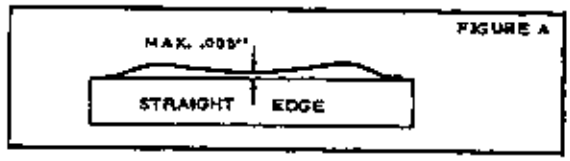
   Figures A,B,C & D show permissible limits of permanent set that should be measured with straight edge and feeler gages. Diaphragms should not be renewed unless these limits are exceeded.

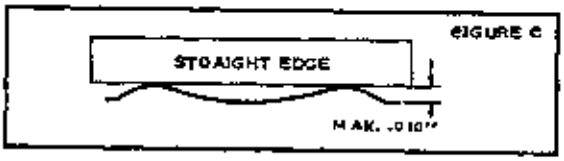
ASSEMBLING SUPERSTRUCTURE

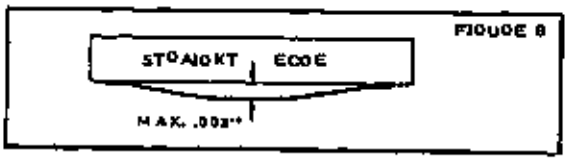
1. Replace lower steam diaphragm (10) diaphragm spacer (32) with diaphragm stem (35) and lower crosshead (26) in place. Be sure diaphragm stem moves freely in diaphragm stem guide (36).
2. Drop connecting rods (27) into holes in lower crosshead (26) and screw on lower connecting rod nuts (63).
3. Refer to proper drawing and assemble remainder of superstructure by adding parts loosely in their proper location until spring case (4) is in position.
4. Place upper crosshead through spring case (14) and on to connecting rods (27). Screw upper connecting rod nuts loosely in place.
5. Drop stud bolts through bolt holes in spring cases (14) and superstructure, including top flange of top cap. Put nuts on FINGER TIGHT.
6. On all classes except PR and PRS–3, remake joint between connector union (38) and top cap (6). Be sure this is steam tight.
7. Close up all parts of superstructure through which stud bolts pass so that connecting rods move freely in guide holes and there is 1/32" play between connecting rods and holes in spring case.
8. Tighten nuts on stud bolts (56), being sure to pull them up evenly all around and not excessively tight.
9. Tighten connecting rod nuts (63) and connector union (38).
10. Test for free movement of connecting rods in guide holes and clearance around same by rotating crossheads back and forth on diaphragm stem (35).
11. Make up unions to actuating lines.

Send for free tools, drawing or literature on Business Reply Card addressed to Leslie Co.

TO PUT REGULATOR BACK IN SERVICE, REFER TO OPERATION – PAGE 2

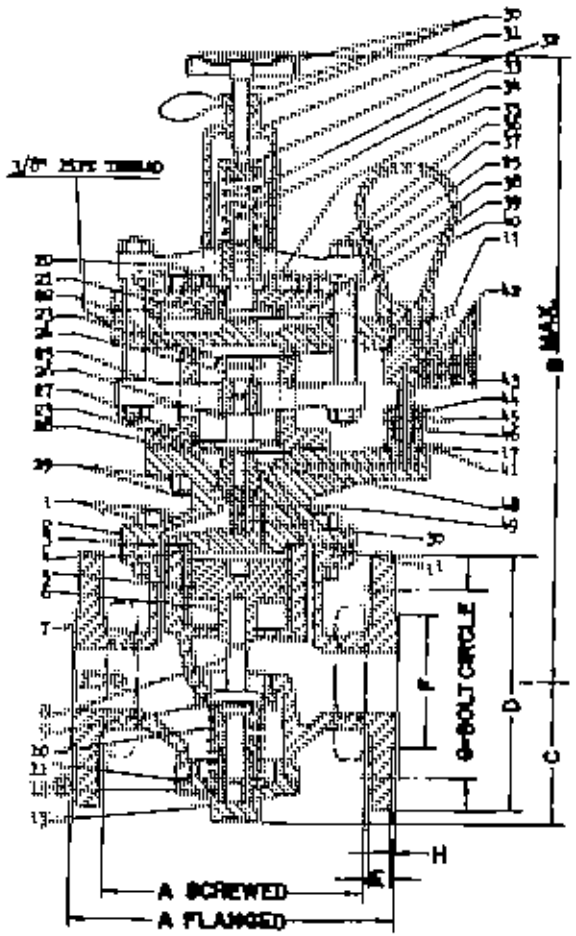








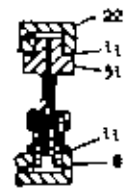
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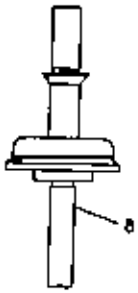
CLASSES PTL AND PTLX
FOR THREADED BONNET JOINT



TYPICAL BONNET CAP FOR
[illegible]



Classes PBL and PBLX For Reciprocating Pumps use this type of connection between Diaphragm Chamber 22 and Top Cap 8.



Drainage Opening Plug Type Main Valve in 2-1/2" to 6" sizes.



TOP CAP DESIGN FOR 5" AND 6" SIZES

SIZE	A	B	D	D	E	F	G	H	No. of Holes	Bolt Size	Hole Dia.	Net Wt. Lbs. **
1/2"	5-3/4	15	3-1/16 *	- -	- -	- -	- -	- -	- -	- -	- -	41
3/4"	5-3/4	15	3-13/16 *	- -	- -	- -	- -	- -	- -	- -	- -	41
1"	5-3/4	15	4-1/16 *	- -	- -	- -	- -	- -	- -	- -	- -	41
1-1/4"	5-3/4	15-1/4	5-1/16 *	- -	- -	- -	- -	- -	- -	- -	- -	42
1-1/2"	6-1/4	15-5/8	5-7/16 *	- -	- -	- -	- -	- -	- -	- -	- -	42
2"	7-1/2	16-1/8	6-1/4 *	- -	- -	- -	- -	- -	- -	- -	- -	42
1-1/2"	7-1/2	15-5/8	4-1/8	5	9/16	- -	3-7/8	- -	4	1/2	5/8	85
2"	8-3/4	16-1/8	4-3/8	6	3/8	- -	4-1/4	- -	4	5/8	3/4	88
2-1/2"	9-1/4	17	5-1/2	7	3/8	- -	5-1/2	- -	4	5/8	3/4	88
3"	11	17-1/8	6-1/2	9-1/16	3/8	- -	6	- -	4	5/8	3/4	160
4"	13-1/2	19-3/4	7	9	3/8	- -	7-1/8	- -	8	5/8	3/4	170
5"	16	22-1/2	10-3/4	10	3/8	- -	8-1/16	- -	8	3/4	7/8	235
6"	15	22-1/4	[illegible]	[illegible]	[illegible]	- -	[illegible]	- -	8	3/4	7/8	250
2-1/2"	8	15-5/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	3/4	7/8	88
3"	9-1/4	16-1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	5/8	3/4	89
4"	10-3/8	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	89
5"	11-3/4	17-1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	110
6"	14-1/8	18-3/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	180
8"	18-5/8	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	3/4	7/8	350
1/2"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	44
3/4"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	7/8	45
1"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	45
1-1/4"	7	15-1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	96
1-1/2"	7-1/2	15-5/8	3-7/16	5	[illegible]	[illegible]	3-7/8	[illegible]	4	1/2	5/8	97
2"	8-3/4	16-1/8	[illegible]	[illegible]	[illegible]	[illegible]	4-1/4	[illegible]	4	5/8	3/4	97
2-1/2"	9-3/4	17	[illegible]	[illegible]	[illegible]	[illegible]	5-1/2	[illegible]	4	5/8	3/4	85
3"	11	17-1/8	[illegible]	7-1/16	3/4	[illegible]	6	[illegible]	4	5/8	3/4	219
4"	13	19-3/4	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	8	5/8	3/4	195
5"	16	22-1/2	[illegible]	[illegible]	[illegible]	[illegible]	7-1/2	[illegible]	8	3/4	7/8	195
6"	15	22-1/4	[illegible]	10	13/16	[illegible]	8-1/2	[illegible]	8	3/4	7/8	350
1/2"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	45
3/4"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	46
1"	6-3/4	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	47
1-1/4"	7	15-1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	91
1-1/2"	7-1/2	15-5/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	1/2	5/8	92
2"	8-3/4	16-1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	5/8	3/4	92
2-1/2"	9-3/4	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	88
3"	11	17-1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	218
3-1/2"	12	18-1/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	157
4"	13	19-3/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	196
5"	16	22-1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	3/4	7/8	355
6"	15	22-1/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	3/4	7/8	355

* Add 1/2" for sizes 1/2" to 1-1/2" and 3/4" for 2" size on Classes PBLX & PTLX.
** Approximate.
Removable only in 1/2" to 5" sizes for Classes PBLX & PTLX.

SEE REVERSE SIDE FOR PART NAME AND PART REFERENCE NUMBER

LESLIE CO.
LYNDHURST, NEW JERSEY

PUMP PRESSURE REGULATOR
[illegible] Classes PBL, PTL, PBLX and PTLX

DATE	DWG. NO.
1-27-57	[illegible]

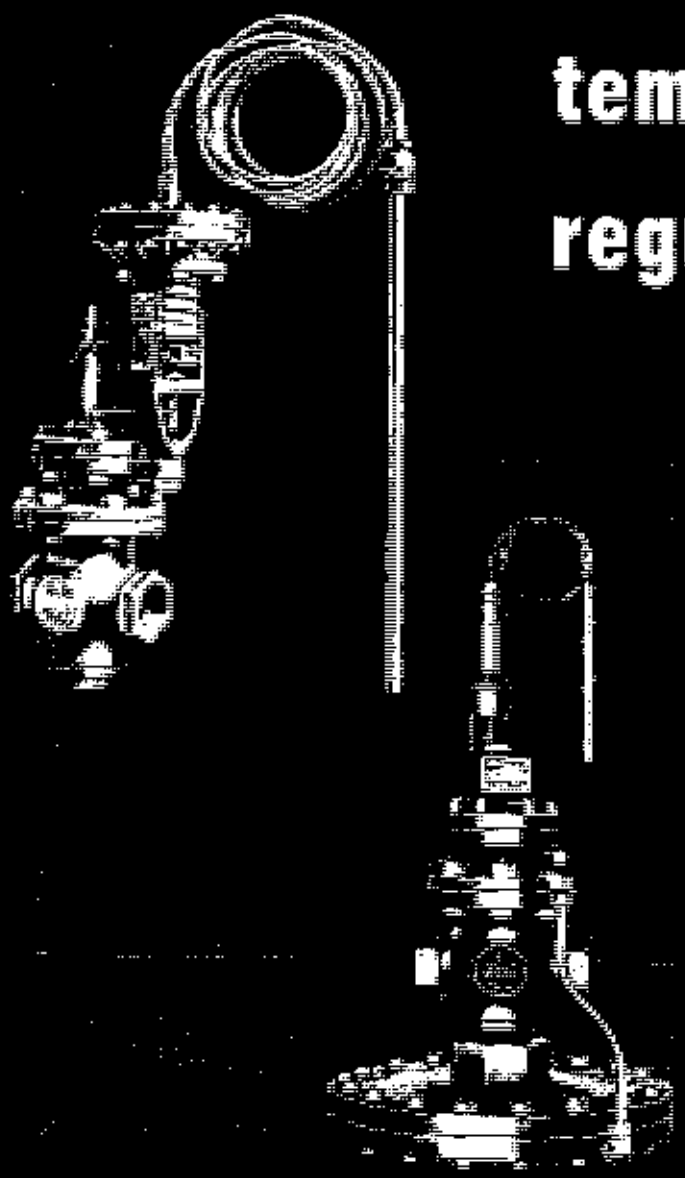
Printed in U.S.A. 1957

ManualBW-000686

BULLETIN 5107-A

LESLIE

SELF-CONTAINED temperature regulators



ManualBIW-000698

LESLIE self contained TEMPERATURE REGULATORS

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Leslie Coast-to-Coast Service ..... *Back Cover*

SELECTING, SPECIFYING AND ORDERING

Where to Use Leslie Temperature Regulators

Leslie Temperature Regulators are used for any one or combination of the following conditions:

1. When accurate, reliable control is required for small flow conditions.
2. When accurate, reliable temperature regulation is required under varying load conditions.
3. When accuracy and stability of the controlled temperature depends upon response to heater steam pressure.

The Leslie Temperature Controller using air or water for operating pressure and consisting of a temperature dial and diaphragm control valve is used for many temperature control applications. See Bulletin 5303, 5304 and 5305 for details.

How to Write Specifications

When preparing specifications insist on LESLIE or use the following general specifications to insure getting a LESLIE Temperature Regulator or Controller:

Self-Contained Temperature Regulators

DIRECT OPERATED TYPE—The Temperature Regulator shall be self-contained and direct operated by a solidly liquid filled thermostatic element consisting of a small bulb and bellows unit. A yielding spring shall prevent overstressing of bellows for over-range temperatures up to 10% of range. Valve stem shall be sealed with a stuffing box having a low friction, single ring, self-sealing Teflon "cup" packing requiring no adjustment. Easy replacement of thermostatic element shall be possible without shutting off process.

PILOT OPERATED FOR HEATING OR COOLING —The Temperature Regulator shall be self-contained with internal pilot and diaphragm operated, single seated main valve. The thermostatic system shall be a solidly liquid filled type consisting of a bulb and bellows unit of small size. A yielding spring shall prevent overstressing of the bellows for over-range temperatures up to 25% of range. The valve stem shall be sealed with a stuffing box having a low friction, single ring, self-sealing Teflon "cup" packing requiring no adjustment. Easy replacement of the thermostatic element shall be possible without shutting off the process.

PILOT OPERATED TYPE, "DUO-MATIC" TEMPERATURE AND PRESSURE CONTROL — The Temperature Regulator shall act as its own steam pressure reducing valve and must have means for adjusting the temperature as well as the maximum delivered steam pressure. It shall consist of a pressure reducing valve which, through a thermostatic element, is automatically readjusted for different, delivered steam pressures in a definite proportion to temperature change. It shall have but one pilot valve to be contained wholly within the regulator, and the chamber about same shall be entirely self-draining.

Main valve shall be single seated, of stainless steel hardened to at least 300 Brinell. Iron and bronze regulators shall have renewable stainless steel seat rings with Stellited seating surface and bronze discs with Teflon seals. Cast steel regulators shall have Stellited seats integral with body. Internal pilot valve to be of stainless steel, hardened to at least 300 Brinell with ground finish. All regulators for service over 300°F. shall have cylinder liners of stainless steel hardened to 500 Brinell with ground finish.

The thermostatic element shall be of the vapor pressure type having a sturdy metal diaphragm valve that will withstand 50° over range. Easy replacement shall be possible without removing regulator from line or shutting off steam.

How to Order

When ordering or requesting quotations on Temperature Regulators, please include the following data:

1. Class of regulator.
2. Service (continuous, intermittent, standby).
3. Max. and min. regulator inlet pressure.
4. Max. and min. regulator inlet temperature.
5. Max. and min. regulator flow in lbs. of steam per hour, gpm or cu. ft. of free air or gas per min.
6. Screwed or flanged connections. Flanges are furnished drilled when flange standard is specified. Bronze flanged bodies will be undrilled if flange standard is not specified.
7. Controlled temperature range (when "duo-matic", include pressure range also).
8. Bulb size, material and accessories.
9. Length of flexible tubing and material.
10. Type of heat exchanger.
11. Fluid whose temperature is to be controlled.

Ordering Parts

When ordering parts for Leslie Temperature Regulators, give the following data:

1. Quantity of each part.
2. Part name and reference number (refer to applicable engineering drawing).

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ManualBW-000699

self contained TEMPERATURE REGULATORS

THRIE BASIC DESIGNS

There are three basic designs for Leslie Self-Contained Temperature Regulators:

1. Direct Operated for small flow (heating or cooling).
2. Pilot Operated for heating or cooling.
3. Pilot Operated, "Duo-matic" Temperature and Pressure Control for heating.

The direct operated design is used for small flow, heating and cooling service, sizes ⅜, ½ and ¾". The liquid filled thermostatic element supplies the full power to stroke the single seated, inner valve. Valve capacity is directly proportional to temperature change at bulb. Suitable for instantaneous and storage type heaters.

The pilot operated, single element control uses the same thermostatic element to operate a pilot valve which supplies operating pressure from the regulator inlet to a large diaphragm for heating or cooling service. The large diaphragm area and operating pressure supply ample power for controlling a long stroke, single seated main valve with full flow capacity in sizes ¼-4".

Regulator has narrow proportional band (3-1°F. throttling range) and is suitable for all storage type heat exchangers and for any system requiring on-off control.

The pilot operated, duo-matic (two element control) design offers both temperature and pressure regulating functions in a single piston or diaphragm operated regulator with a single pilot valve. It is suitable for heating service only, can handle a wide range of inlet steam pressures from 21 to 600 psi and two regulated or controlled pressure ranges, 2-15 psi and 10-250 psi. These characteristics are ideal for all storage type heaters and for most instantaneous heater problems. Available in sizes ⅜-6", with iron, bronze and cast steel construction.

Use the Quick Reference Table below to locate regulator class for specific conditions. Enter the table under "Fluid thru Regulator" and "Regulator Function" and select the regulator class showing a dot by each appropriate condition. Page references are keyed for location of complete data.

QUICK REFERENCE TABLE

OPERATING CONDITIONS ● INDICATES RECOMMENDED SERVICE ○ CONSIDERATION REQUIRED

Fluid thru Regulator		Regulator Function					Temperature Ranges — °F										Body Size (Inches)	Class *	Inlet Pressure Range — psi		Page Reference
		Cooling																			
Steam	Liquid	Tight Shut-off	Small Continuous Bleed	Heating	Temperature Control, only	Pressure and Temperature Control ("Duo-matic")	35-80	70-120	110-160	150-200	190-240	210-260	230-280	250-300	270-320	290-340			Used Steam	Cond. Returns Flow	
	●	●	●		●		●			●		●		●		●	½	M[8*]	0-100		4, 7
	●	●	●		●		●			●		●		●		●		MCR*§	0-50		
	●	●	●		●		●			●		●		●		●		M0 8*]		10 100	
●				●	●		●			●		●		●		●	¾	MC-1]	0-50	0-50	
●				●	●		●			●		●		●		●		M0-4]	0-50	0-100	
●				●	●		●			●		●		●		●		MC-1]	0-50	4-200	
●				●	●		●			●		●		●		●		M O 1]	0-60	4-200	
●				●	●		●			●		●		●		●		MOT —Ha O1-1]	10-125		
●				●		●		●	●	●		●		●		●	½—½	J[CO]	20-300		1
●				●	●			●	●	●		●		●		●	2—4	[[1]	15-125		4, 7
●				●	●			●	●	●		●		●		●	½—1½	TRSM[]	35-150		
	●	●	—		●			●	●	●		●		●		●	2—4	[RK[]	15-175		
	●	●	●		●			●	●	●		●		●		●	½—1½	[RRM[]	5 lb.		
●				●	●			●	●	●		●		●		●	½—1½	TRSM L§]	CSM		
	●	●	●		●			●	●	●		●		●		●	½—1½	[[RSM L§]			
●				—		●		●	●	●		●		●		—	½—4	LTCY]	25-300		1
●				●		●		●	●	●		●		●		●	½—4	RTCKY]	25-250		
●				●		●		●	●	●		●		●		●	½—4	[[C[Y]]	25-150		
●				●		●		●	●	●		●		●		●	½—4	[TCLXY]]			
●				●		●		●	●	●		●		●		●	½—3	[[C[5]]			10
●				●		●		●	●	●		●		●		●	½—4	[TCSO-3]	40-600		

* Add "[" to basic class designation for class with small continuous bleed, i.e., M[8], MCR[.
§ May be fitted with calibra—n dial for temperature setting. Add "C" to basic class designation.
‡ May be fitted —th external steam supply to pilot —ve. Add "[" to basic class designation.
§ May be fitted with "O" adapter for external steam supply to controlling valve. Add "@" to basic class designation.
● 50-[20*[.

ManualBIW-000700

direct operated, small flow TEMPERATURE REGULATORS

CLASSES MC-1, MO-T, ME-1—FOR PROCESS HEATING MBR, MCR, MOR—FOR PROCESS COOLING
OT-1, MOT—FOR HEATING OR COOLING



Class M1-1 with single seated, ball type, main valve. Heating service.



Class MB1 body assembly showing double seated main valve. For cooling water flows.



Class MC1 showing valve below seat construction. Cooling service.

THERMOSTATIC ELEMENTS

Standard Set Ranges		Bulb Matl.	Tubing Matl.
20-70 70-120 120-170 170-220	220-270 270-320 250-600*	Brass 18-8 Stainless	Brass 18-8 Stainless
		See Complete Description and Set Ranges page 7.	

*Special pencil bulb.

TEMPERATURE—PRESSURE RANGES

Body Size Inches	Class	Orifice Size Inches	Maximum Inlet Temp. °F.	Recommended Inlet Pressure (PSI)	
				Feed and Service	Continuous Flow
⅜, ½	MC-1	⅜	450	0-50	0-50
	MO-1	½	150	0-50	0-100
	ME-1	½	450	0-50	0-100
1	OT-1 with MO-1	¾	450	0-125	0-125
⅜, ½	MCR	⅜	450	0-50	0-50
	MO-1	½	450	0-100	0-100
¾	MBR	¾	450	0-100**	0-100

*Add "C" to basic class if calibrated dial is desired, i.e., MP-1 (MOC-1) M11 (MIRC1. Add "I" to basic class if internal bypass orifice is required.
**Double seated valve has slight leakage when closed.

FEATURES

RUGGED LIQUID FILLED THERMOSTATIC ELEMENT — responds to ½°F. change. Provides positive valve motion for all conditions. See page 2 for complete description. Screwed connection provides simple installation or removal from regulator.

STRONG PISTON GUIDED BELLOWS DESIGN—transmits motion to valve stem. Yielding springs protect from excessive stress for "over-range" temperatures up to 25% of range.

UNIQUE TEFLON PACKING ARRANGEMENT—Single ring, self-sealing, Teflon "imp" packing provides positive, long lasting, low friction stem seal.

SINGLE SEATED HARDENED STAINLESS STEEL BALL—in four sizes for heating service. Two valve sizes for small cooling water flows.

Double seated quick opening valve for greater cooling water flow in ¾" size. See Table below.

CALIBRATED TEMPERATURE DIAL — for convenient time-saving settings. Available as optional equipment. See page 5.

BASIC APPLICATIONS — Small flow instantaneous heaters or coolers (shell and tube or shell and coil heat exchangers); small storage or tank heaters; small flow process heat exchangers of all types.

HOW THEY OPERATE

Heating Type—As the temperature at the bulb increases, the liquid fill increases its volume, expanding the bellows against the valve stem, and moving ball valve toward seat. Since the liquid expansion is proportional to the temperature change, the valve travel is gradual, giving true throttling control. Thermostatic element has sufficient power for tight shut-off against inlet pressures recommended for each seating size.

Cooling Type—These regulators employ the same basic principle of operation except that, when the bellows expands against the valve stem on temperature rise, the valve disc is moved away from its seat, increasing flow of coolant. For continuous flow of coolant, a small internal bypass orifice can be provided, indicated by "I" in the class.

Dimensions and Parts List—See layout Dimension Sheet and Bulletin No. 11202 following Bulletin. Also Dwg. No. 120TF (MCR, MOR, MBR), No. 2110 F (MOT), and No. T441 F (OT-1) available on request. Capacity tables on page 15.

CONSTRUCTION

Size & Class	Body Material & Connections	TRIM MATERIAL		
		Seat Ring	Valve	Valve Stem
⅜—½" M1-1 MO-1 M1-1 OT-1	Bronze Screwed	18-8 Stainless Steel	Type 440 Stainless Hardened	18-8 Stainless Steel
MOT			18-8 Stainless	
⅜—½" M11 MO1	Bronze Screwed	11-1 Stainless Steel	18-8 Stainless Steel	18-8 Stainless Steel
¾" M11		Integral	Brass	

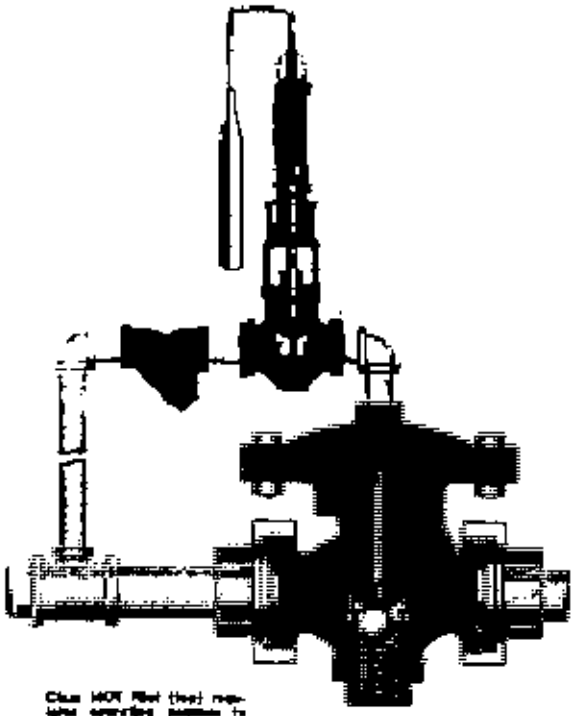
Manual BIW-000701

LESLIE pilot operated TEMPERATURE REGULATORS

CLASS MOT PILOT WITH 1" CLASS OT-1 REGULATING VALVE

For Steam Service

This temperature regulator supplements and extends the capacity range of the direct operated, Class M type regulator described on page 4. The Class MOT pilot is similar to the Class ME-1 except that a solid stem needle valve is used in place of the ball valve. Pilot pressure operates the diaphragm and ball valve of the Class OT-1 regulating valve, utilizing the capacity of a 1" size valve yet retaining the accuracy of regulation of the Class M types of small flow regulators.



Class MOT Pilot (top) regulates operating pressure to diaphragm of Class OT-1 regulating valve. For steam service.

FEATURES

COMPACT, SIMPLE CONSTRUCTION — of Class OT-1 regulating valve eliminates usual stuffing box and yoke construction.

SINGLE SEATED HARDENED STAINLESS STEEL BALL — Tight closing for steam service.

METAL DIAPHRAGM—Long life. Not affected by live steam or condensate temperatures.

PILOT FEATURES—Class MOT Pilot incorporates all of the advantages of the Class M Type regulator described on page 4.

BASIC APPLICATIONS — Small flow instantaneous heaters; small storage tank heaters; small flow process heat exchangers.

DIMENSIONS & PARTS LISTS: See layout dimension sheet following bulletin and drawings J7449 F and 7480 F available on request. Capacity Tables on Page 14.



Calibrated Dial

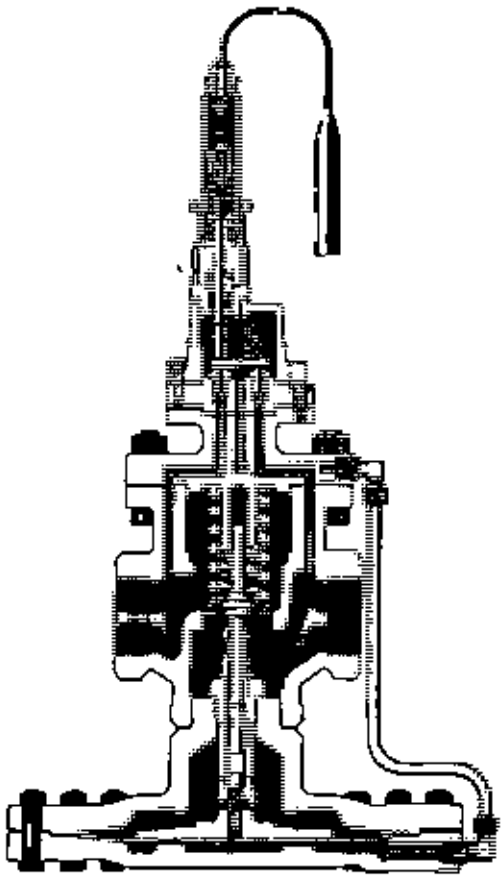
(Indicated by "C" in regulator class designation)

Available for all Leslie direct operated and diaphragm operated temperature regulators (those with class designations starting with an M or T). The calibrated dial provides quick, easy, and dependable temperature settings. The dial eliminates waiting for equipment to heat up to determine correct setting. It avoids overheating due to guess setting. Designed for production line use where frequent dependable readjustments are necessary for process work, it replaces the standard adjusting sleeve. There are no complicated linkages or gages and no increase in friction on the pilot stem. Friction ring prevents accidental change of adjustment.

Calibrated dials are easily installed on any Leslie temperature regulators now in service with class designations starting with the letters M or T.

LESLIE pilot operated TEMPERATURE REGULATORS

½-1½" CLASSES TKM, TKML FOR PROCESS HEATING TRKM, TRKML FOR PROCESS COOLING



Class TKM Temperature Regulator

POSITIVE DEAD-END SHUT-OFF — Single seated construction. Closes with inlet pressure.

DIAPHRAGM-OPERATED MAIN VALVE — Packless construction assures positive valve operation.

LIQUID FILLED THERMOSTATIC ELEMENT — with 100°F. or 200°F. adjustable range. Easily replaceable without removing regulator from the line. For complete description, see page 12.

LOW FRICTION PILOT STEM SEAL—Single ring, self sealing Teflon cup packing provides positive, long lasting, low friction stem seal.

UNIQUE INTERNAL PILOT — Lever type, double acting, controls both supply and exhaust as operating pressure. Reversible in the field changing valve action from heating to cooling or vice versa.

STAINLESS STEEL TRIM — hardened main valve with stellited seat ring for steam service; 18-8 stainless trim for liquid service.

CALIBRATED DIAL — for convenient temperature setting. Available as optional equipment (add "C" to basic class designation).

MAIN VALVE WITH CONTINUOUS BY-PASS — Available for cooling service. (Add "J" to basic class designation.)

How It Operates

Pressure on lower side of diaphragm, operating main valve, is controlled by a double acting, lever-type pilot, which is mounted on a knife edge and actuated by the thermostatic element. The pilot simultaneously controls both the supply of operating pressure from the regulator inlet and the discharge of operating pressure to the regulator outlet. The resultant pressure in the pilot chamber is transmitted to the lower side of the diaphragm through copper tubing.

Metal diaphragm permits direct contact with live steam. In larger sizes, 3-4", a Neoprene diaphragm is used and is protected on both sides from live steam contact by separate condensate reservoirs. See page 1.

Dimensions on layout sheet following bulletin. Parts List or Dwg. No. CY12S following bulletin. Capacity data, page 12.

PRESSURE—TEMPERATURE RANGES & TRIM MATERIAL

Maximum differential between inlet and outlet pressure—50 psi

Service and Class	Maximum Inlet Pressure	Size Inches	Operating Temperature Range	Max. Working Pressure of Element Bulb		BODY AND TRIM MATERIALS						
				Heating Bulb	Cooling Bulb	Body, Cap & Bottom Cap Material, Seat Construction	Main Valve	Pilot Cover	Diaphragm	Seat Ring	Stellite Facing	Plug
		½-1½				Cast Iron, Screwed						
		2				Cast Iron, 125 lb. ASA Flanged						
		½-1½				Cast Iron, Screwed						
		2				Cast Iron, 125 lb. ASA Flanged						

*D-4 is a low aluminum brass with other components that make it corrosion resistant like that used in admiralty brass.

**Differential temperatures available beyond top of ranges to 20% of range.

ManualBIW-000703

LESLIE

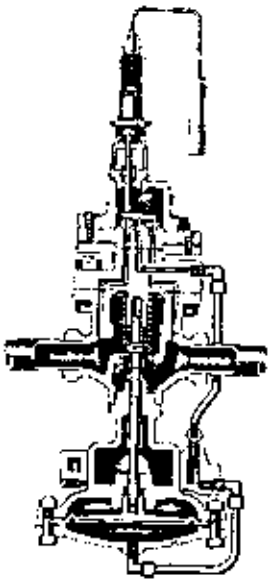
pilot operated TEMPERATURE REGULATORS

2-4" CLASS TK FOR PROCESS HEATING CLASS TRK FOR PROCESS COOLING

Class TK and TRK Regulators are similar in design to Class TKM and TRKM shown on page 6, but employ a rugged neoprene diaphragm that is protected from live steam on both sides by a condensate reservoir. The design feature in the Class TK (body sizes 2"-4") provides greater valve travel with reduced diaphragm area. Class TK converges in the field to Class TRK or vice versa by turning top cap 180° reversing pilot valve action.

FOR INLET STEAM PRESSURES BELOW 5 PSI—Class T type regulators can be specially fitted with ¼" external supply to pilot valve where a higher pressure supply (5-150 psi) is available to operate pilot (designated by adding "B" to valve class).

Dimensions: See layout dimensions sheet following bulletin.
Parts List: Dwg. No. 791F available on request.

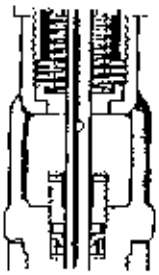


Class TK Temperature Regulator

Freezing Ambient Temperatures

Where ambient temperatures would cause condensate to freeze in the TMK or TK Regulator Chambers, a steam heated insulating jacket is available to cover the regulator below adjusting sleeve. Cylindrical, it is fabricated of heavy sheet steel lined with fiber glass with provision for heating steam coil below regulator.

New, Unique Stem Seal



Stem Seal

Pilot stems on all Leslie internal pilot, diaphragm operated regulators use a new packing assembly employing a single ring, self-sealing Teflon "cup" stem seal. The packing gland requires only finger tightening for a positive, low friction seal.

The Teflon cup ring has excellent self lubrication properties, resiliency, strength and is impervious to water and steam at temperatures to 450°F. The smooth finish on the pilot stem, combined with the slippery nature of Teflon reduces stem friction to a minimum.

THERMOSTATIC ELEMENTS

LIQUID FILLED elements are used on the direct operated and diaphragm operated temperature regulators (pages 4, 5, 6, and 7). The bulb, flexible tubing and bellows are completely filled with a liquid. When heat is applied to the bulb, the liquid expands causing bellows of a direct operated regulator to exert force to move the valve. In diaphragm operated regulators, the bellows opens or closes the pilot nozzle, regulating the pressure of the operating medium to the bottom of the diaphragm. In either type, the force produced is many times greater than needed to assure positive movement.

Copper flexible tubing, nickel plated (standard), or 18-8 stainless steel is furnished in lengths of 5 or 10 feet and in special lengths up to 30 feet in multiples of 5 feet.

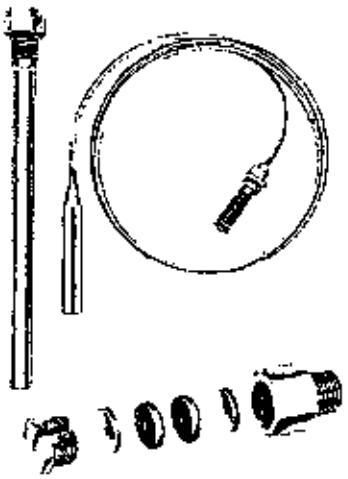
Brass bulbs, nickel plated (standard), or 18-8 stainless steel bulbs are 3⅜" long for 50° ranges and 4" long for 100° ranges. The 50° range element is standard with direct operated regulators (Class M types) for inlet steam or cooling water control. The 100° and 100° range elements are standard on internal pilot, diaphragm operated regulators (Class T types). The 100°F. range may be used on direct operated regulators, as well, but the capacity for the same temperature change at the bulb is reduced to one half.

Finned bulbs, 9-3/16" long with fins ¾" square, are furnished for air conditioning systems or space heating in two ranges only, 20-120° and 120-220°F. Standard Bulb Casings are available in two sizes: 4-13/16" long (No. 2) and 9½" long (No. 3). Both casings have 5/8" outside diameter and ½" pipe thread. They are furnished in brass, Monel, stainless steel and carbon steel for maximum working pressure of 400 psi.

HIGH PRESSURE, THICK WALL AND EXTENSION NECK CASINGS—High pressure casings are available for maximum working pressures to 3000 psi unplated. Extension neck casings that permit full exterior insulation of the tank or oven are also available as are thick wall bulb casings. See layout dimension sheet following bulletin.

STANDARD RANGES

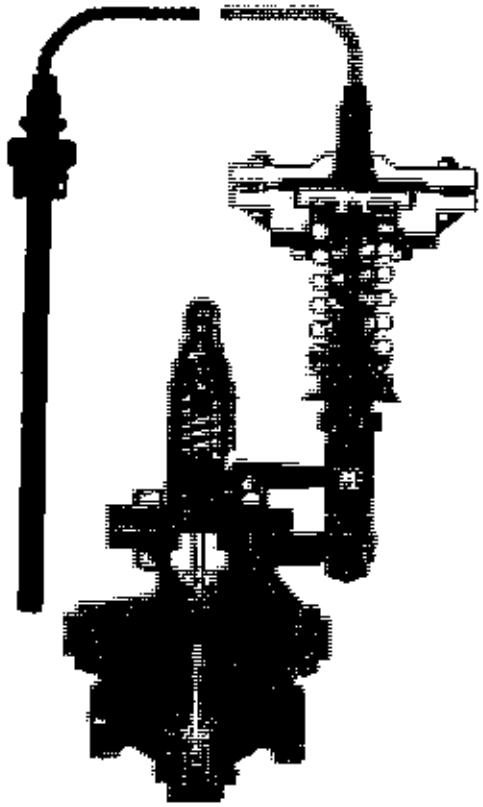
50° Ranges	100° Ranges	Other
20-70	20-120	50-250
70-120	60-160	250-600
120-170	110-210	
170-220	170-270	
220-270	220-320	
270-320	320-420	
	420-520	



ManualBIW-000704

LESLIE small flow, "duo-motic" TEMPERATURE REGULATORS

CLASS JTCO FOR PROCESS HEATING



BASIC APPLICATIONS—Instantaneous type heaters (shell and tube type with large tube volume). Storage type heaters (shell and coil type with large shell volume). Process heat exchangers of most types.

Dimensions — Layout Dimension Sheet following bulletin. Parts list on Dwg. TR-2096 available on request. Capacity tables, page 11.

FEATURES

DUO-MATIC TWO ELEMENT CONTROL—Both temperature and pressure are controlled by a single regulator with a single internal pilot valve. Simplifies piping and lowers both initial and operating costs by eliminating need for separate pressure and temperature regulating valves.

ANTICIPATES TEMPERATURE CHANGE — Main valve responds to heater or process load changes through action of pressure sensitive steam diaphragm before temperature change even occurs at the bulb.

ACCURACY OF REGULATION—Comparable to instrument control for most services. Ratio of steam pressure change (psi) to temperature change (°F.) of bulb is 4:1.

SINGLE SEATED VALVE — Inlet pressure closing. Positive dead end shut-off.

WIDE RANGE THERMOSTATIC ELEMENT — 100°F adjustable temperature range. Vapor pressure design with metallic wafer diaphragm gives rupture-proof construction.

METAL DIAPHRAGM PRESSURE ELEMENT — has Gavel less than its own thickness, well within safe stress limit. Eliminates stem packing gland.

COPPER CLAD GASKETS—asbestos filled, provide lasting, renewable seal without grinding gasket faces.

RENEWABLE, INTERCHANGEABLE PARTS—All wearing parts are renewable allowing complete overhaul without removing the body from the line.

TEMPERATURE—PRESSURE RANGES:*

*Minimum differential between inlet and outlet pressure—15 psi.

Inlet Steam Pressure PSI	Maximum Inlet Temperature °F	Adjustable Outlet Pressure Range—PSI	Max. working Pressure — Body PSI
30-300	550	30-300	Brass—300 Cast Iron—250 Steel—300 Cast Steel—300 Steel—300

CONSTRUCTION & TRIM MATERIAL

Pipe Body Material and End Connection	TRIM PARTS MATERIAL						Standard Temperature Ranges °F
	Seat Ring	Controlling and Main Valve	Controlling Valve Seat	Diaphragm	Lower Diaphragm	Controlling and Main Valve Springs	
¾", 1", 1¼" Bronze, Screwed Ends	Type 416 Stainless Steel Stellited	Type 440C Stainless Hardened	303 Stainless	Stainless Steel	Phosphor Bronze	Inconel	30-150 60-170 150-320 170-270 300-300

ManualBIW-000705

TRADE LESLIE MARK

"duo-matic", temperature and pressure SELF-CONTAINED REGULATORS

CLASSES LTCY, LTCLY (BRONZE BODY) LTCKY, LTCLKY (CAST IRON BODY) FOR PROCESS HEATING

FEATURES

DUO-MATIC, TWO ELEMENT CONTROL — Both temperature and pressure are controlled in a single regulator with a single internal pilot valve. Simplifies piping and lowers both initial and operating costs by eliminating need for separate pressure and temperature regulating valves.

ANTICIPATES TEMPERATURE CHANGE — Main valve responds to heater or process load changes through action of pressure sensitive steam diaphragm before temperature change occurs at the bulb.

NEW TYPE PISTON WITH TEFLON† SEAL—for temperatures up to 500°F. gives continuous wiping action, keeping liner clean, improving operating reliability and reducing maintenance. Piston rings can be furnished for temperatures over 500°F.

ACCURACY OF REGULATION — Comparable to instrument control for most services. Ratio of steam pressure change (psi) to temperature change (°F.) at bulb is 6:1 for Classes LTCY, LTCKY and 1:1 for Class LTCLY and LTCLKY.

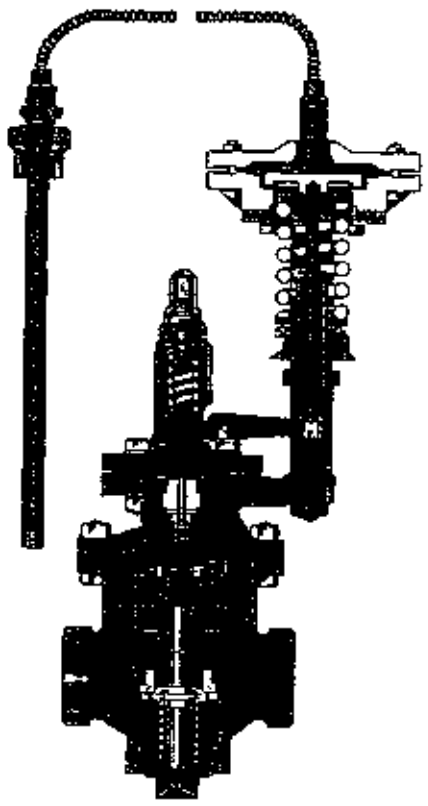
SINGLE SEATED VALVE — inlet pressure closing. Positive dead end shut-off.

WIDE RANGE THERMOSTATIC ELEMENT — 100°F. adjustable temperature range. Vapor pressure design with metallic wafer diaphragm gives rupture-proof construction.

METAL DIAPHRAGM PRESSURE ELEMENT — has travel less than its own thickness, well within safe stress limit. Eliminates stem packing gland.

RENEWABLE, INTERCHANGEABLE PARTS—All wearing parts are renewable allowing complete overhaul without removing the body from the line.

Dimensions on Layout Dimension Sheet and Parts List on Dwg. No. CTL-189 following bulletin. Dwg. No. CTR-181 shows piston with piston rings. Dwg. No. 108778 showing piston with new Teflon seal is available on request. Capacity Tables, Page 10.



BASIC APPLICATIONS—Instantaneous type heaters (shell and tube type with large tube volume). Storage type heaters (shell and coil type with large shell volume). Process heat exchangers of most types.

PRESSURE—TEMPERATURE RANGES* & TRIM MATERIAL

*Minimum pressure drop is 15 psi in sizes ½-4", 25 psi in 5" and 6" sizes.

Class and Body Matl.	Size (Inches) and End Connections**	Inlet Steam Pressure, PSI	Body Matl. Max. Inlet Temp., °F	Adjustable Outlet Pressure Range, PSI	TRIM PARTS & MATERIALS—ALL CLASSES				
					Seat Ring	Main Valve, Controlling Valve	Controlling Valve Seat	Diaphragm	Piston and Cylinder Liner
LTCY (Bronze)	½-2 screwed ½-6 flanged	25-300	366	10-250	Iron 410 (Tabless Stellited	Type 410C (Tabless hardened	Iron 11-1 Stainless	Stainless Steel	Irolon (Teflon Sealed Piston)
	5 flanged	45-300		20-250					
	8 flanged	15-300		30-175					
LTCLY (Bronze)	½-2 screwed ½-6 flanged	25-150	100	1-11					
LTCLKY (Cast Iron)	½-3 screwed 2-8 flanged	25-150	450	6-11					
LTCKY (Cast Iron)	½-2 screwed 2-8 flanged	30-250	450	10-100					
	8-6 flanged	45-111		30-100					

THERMOSTATIC ELEMENTS			
Standard Temperature Ranges—°F	Tubing Materials	Bulb Materials	Bulb, Max. Working Pressure
25-125	Brass (Stainless Monel	Brass	400 psi
80-180		Monel	1250 psi
150-220		Stainless	1250 psi
170-270		Cold Rolled Steel	1000 psi
250-350			

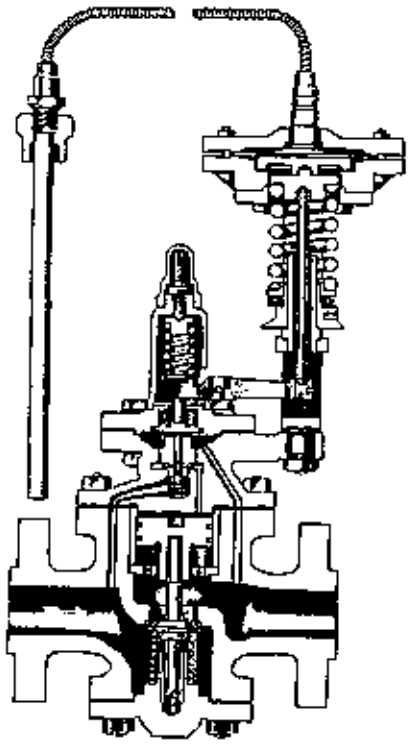
**Bronze bodies with MSS Flanges, 150 and 300 lb. in all sizes. Cast iron bodies with flanges, 125 lb. ASA, 8-6"—250 lb. ASA, 2-8".
†Teflon is a trademark of E. I. Dupont de Nemours Co., Inc.

ManualBIW-000706

TRADE LESLIE MARK

"duo-matic", temperature and pressure SELF-CONTAINED REGULATORS

CLASSES LTCLS, LTCSO-3 (CAST STEEL BODY) — FOR PROCESS HEATING



BASIC APPLICATIONS—Instantaneous type heaters (shell and tube type with large tube volume). Storage type heaters (shell and coil type with large shell volume). Process heat exchangers of many types.

FEATURES

DUO-MATIC, TWO ELEMENT CONTROL—Both temperature and pressure are controlled in a single regulator with a single internal pilot valve. Simplifies piping and lowers both initial and operating costs by eliminating need for separate pressure and temperature regulating valves.

ANTICIPATES TEMPERATURE CHANGE — Main valve responds to heater or process load changes through action of pressure sensitive steam diaphragm before temperature change occurs at the bulb.

ACCURACY OF REGULATION—Comparable to instrument control for most services. Ratio of steam pressure change (psi) to temperature change (°F.) at bulb is 4:1 for class LTCSO-3 and 1:1 for class LTCLS.

SINGLE SEATED VALVE — inlet pressure closing. Positive dead end shut-off.

WIDE RANGE THERMOSTATIC ELEMENT — 100°F adjustable temperature range. Vapor pressure design with metallic water diaphragm gives rupture-proof construction.

METAL DIAPHRAGM PRESSURE ELEMENT — has travel less than its own thickness, well within safe stress limit. Eliminates stem packing gland.

INTERNAL SPRINGS of Inconel are non-corroding, heat resistant.

METALLIC CLAD GASKETS—asbestos filled, provide lasting reusable seal without fouling gasket faces.

RENEWABLE, INTERCHANGEABLE PARTS—All wearing parts are renewable allowing complete overhaul without removing the body from the line.

Dimensions on Layout Dimension Sheet and Parts List on bwg. No. CIR-190 following bulletin. Capacity tables, page 16.

PRESSURE—TEMPERATURE RANGES* & TRIM MATERIAL

*Minimum pressure drop is 15 psi in sizes ½-1", 25 psi in 1½" size.

Class and Body Matl.	Size (Letters) with Rgd. Connections**	Inlet Steam Pressure, PSI	Maximum Inlet Temp., °F	Adjustable Outlet Pressure Range, PSI	TRIM PARTS & MATERIALS—ALL CLASSES			
					Seating Surfaces	Main Valve, Controlling Valve and Stud, Cylinder Liner	Diaphragm	Piston
LTCSO-3 Cast Steel	½-1	40-600	750	25-250	Inconel Stellite	Type 440C Hardness, *Hardened	Stainless Steel	Type 316 Hardness
	1½	50-600			THERMOSTATIC ELEMENTS			
					Standard Temp. Ranges—°F	Tubing Material	Bulb Material	Bulb Working Pressure
LTCLS Cast Steel	½-1	40-150	750	1-15	20-120 50-170 120-220 170-270 250-350	Brass Inconel Monel	Brass	600 psi
							Monel	1250 psi
							Stainless	1250 psi
							Cold Rolled Steel	1800 psi

**ASA flanges, 150, 300, 600 and 600 lp., ½-1". Screwed ends, ½-1".

ManualBIW-000707

LESLIE

"duo-matic", temperature and pressure SELF-CONTAINED REGULATORS

PRINCIPLE OF OPERATION
PISTON OPERATED, DUO-MATIC REGULATORS
CLASSES LTCY, LTCLY, LTCKY, LTCLKY, LTCLS, and LTCSO-3

These Temperature Regulators utilize the famous LESLIE internal pilot, piston operated reducing valve design. A vapor pressure type thermostatic element operating on a lever opposes a pressure limit spring and determines the outlet steam pressure delivered to the heater.

Manual setting of the pressure limit spring determines the maximum outlet steam pressure and opens controlling valve admitting high pressure steam from inlet body port to top of piston opening main valve. The outlet steam pressure acting under steam diaphragm balances compression of pressure limit spring, throttling controlling valve and limiting the maximum outlet steam pressure.

The temperature at which the vapor pressure starts to oppose the limit spring and decrease outlet steam pressure is set on the temperature adjusting spring. This spring opposes the vapor pressure on the large upper diaphragm and by means of this spring the temperature at which all steam to the heater will be shut off can be accurately set.

A temperature drop of 1°F. on element bulb reduces the vapor pressure, allowing limit spring to open controlling valve and deliver an increased steam pressure to the heater.

Therefore, steam pressure to the heater is always proportional to the change in temperature at the bulb and this pressure is automatically maintained regardless of the volume of steam used by the heater or variations in supply pressure. This is an exclusive LESLIE feature which results in INSTRUMENT CONTROL with a self-contained regulator.

Diaphragm Operated, Duo-matic Regulators Class LTCO

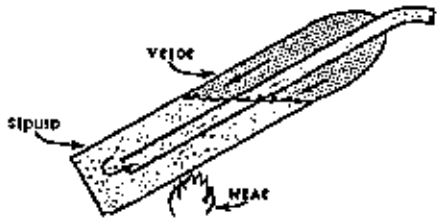
In these small sizes (¼, ⅜ and ½") the piston used in Class LTCY is replaced by a large metal diaphragm. Minimum inlet steam pressure is 2P psi. Steam pressure admitted to top of this diaphragm by controlling valve operates main valve. Pressure limit control and temperature regulation are accomplished in the same manner as described for Class LTCY.

CLASS LTCY TYPE ELEMENTS

VAPOR FILLED elements are used on all Duo-matic, piston or diaphragm operated regulators and employ a volatile liquid with a boiling point slightly lower than the minimum limit of the element's temperature range.

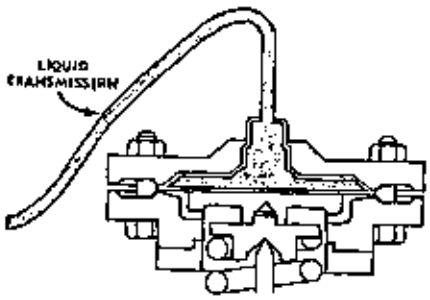
When the ambient bulb temperature is lower than the fill boiling points, the fill is in liquid state. When the ambient temperature is greater than the boiling point, the fill in the bulb partially vaporizes increasing internal pressure on the upper diaphragm.

Vapor filled thermostatic elements are completely interchangeable and consist of three parts: the water diaphragm assembly, the armored flexible tubing, and the bulb. The unit is assembled, filled, and sealed into a single closed unit at the factory.



FLEXIBLE TUBING consists of a copper capillary tubing protected by an armored cable of brass as standard material and in variable lengths in multiples of 10 feet up to 10 feet. Flexible tubing can also be furnished with armored cable made of steel or stainless steel on request.

WAFER DIAPHRAGM ASSEMBLY has a simple rupture-proof construction with strong supporting base and cover. All diaphragm chamber assemblies regardless of range have one standard drilling facilitating removal and making it possible to place any range on any regulator.



BULBS are connected and sealed to the flexible tubing by a swivel joint end are complete with union bushing of same material for connection to process equipment. Standard bulbs can be furnished from stock of following materials:

- Brass
- Monel
- Stainless Steel
- Cold Rolled Steel

Finned Bulbs—21" long end equipped with fins 1⅝" square are used for air conditioning systems, ovens, space heating and services that require large surfaces to insure fast response. A bulb 22" long with fins 2¾" square, is used for capillary tubing lengths above 30' and for lengths 20' and over on ranges below 10°F.

(More on next page)

ManualBIW-00070B

LECY EYPE ELEMENES (Continued)

The bulb is usually installed tip downward in order to gll the benefit of liquid transmission of internal bulb psessure to diaphragm duting the stall-up period. When installed tip upwards some vapor may enter the lapillary during the start-up period. This vapor condenses quikkly, however, and operation altel the vapol tondenses is identical, tip up or down.

SPECIAL BULB COATINGS can be furnished for services that standard materials will not handle:

- Lead (including up to 3 feet of tubing nearest bulb)
- Rubber (may include all tubing)
- Plastics (may intlude all tubing)
- Chrome Plating
- Tinning

Bulb Casings—Recommended for use only where removal of bulb may necessitate draining large capacity equipment. Since heat transmission is slower with a bulb casing, its use should be restricted to large tank or storage systems where temperature changes are slow and speed of response is no factor.

Standard bulb casings are availabl in the following materials with Pressure Ratings as indicated:

• Brass	600 PSI
• Monel	1250 PSI
• Stainless Steel	1250 PSI
• Carbon Steel	1000 PSI
• Stainless Steel Cadmium Plated	2000 PSI
• Steel Cadmium Plated	2000 PSI
• Stainless Steel	3000 PSI
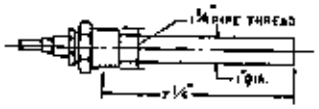
Spreial bulb casings for thick wall installations or extension neck casings that permit full tank or oven insulation are available. See layout dimension sheet following bulletin.

Speci1 Fittings—For equipment that requires special fittings to prevent damage to bulb, facilitate cleaning, or presents other installation problems, the following are available on request: bulb guard; sanitary fitting; flanges for wooden tanks, etc.

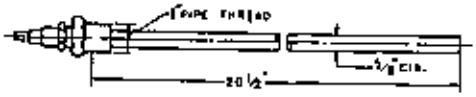
STANDARD BULB SIZE AND TUBING LENGTHS

Temp. Range °F.	Tubing Length Available	Standard Bulb and Fitting Size*		
		Type	Length	Fitting
10-110 50-150	10 ft.	A	10½	1 "
		C	1¼	1¼"
	20 ft. and over	B	11½	1½"
110-120 110-170 150-150	up to 30 ft.	A	10½	1 "
		C	7¼	1¼"
	10 ft. or more	D	11½	1¼"

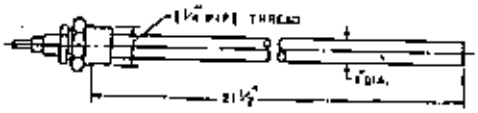
*Other Dimensions given Below.



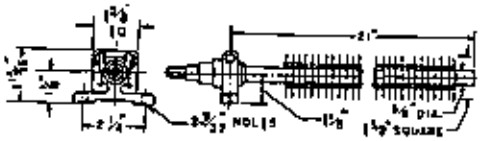
(C)—Short Bulb



(A)—Standard Bulb

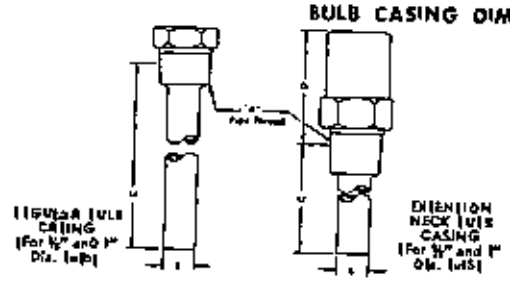


(B)—Large Bulb



End View Standard Finned Bulb

BULB CASING DIMENSIONS—INCHES



Type Casing and Dimension		TYPE BULB		
		Standard	Large	Short
Regular Casing	A	1	1¼	1⅛
	B	¾	1⅛	1⅛
	C	1⅜	1⅜	P¼
Extension Neck Casing	A	1	1¼	—
	B	¾	1⅛	—
	C	19⅜	19⅜	—
	D	1¾	1	—

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LESLIE TRADE MARK

"duo-matic", temperature and pressure SELF-CONTAINED REGULATORS

ENGINEERING FEATURES AND CONSTRUCTION DATA

Over fifty years of leadership in the regulating valve industry have resulted in engineering and manufacturing know-how vital to the production of a quality line of self-contained temperature regulators.

Continuous research, experimentation, field trials and progressive production methods have been the key to Leslie leadership in metallurgical and engineering developments.

The construction features explained on the following pages are the result of this half century of work in the regulator field. They are *standard* features on Leslie equipment that are usually found only on "made-to-order", special regulators. They can best be evaluated in terms of long, trouble-free service, accurate regulation and ease of maintenance. Examine them.

Standard Leslie Features

SINGLE SEATED CONSTRUCTION in all sizes provide positive dead-end shut-off, with the inlet pressure acting to tightly close the inner valve except in two classes of the direct operated, small flow regulators described on page 4.



Single Seated Construction

RUGGED, SENSITIVE DIAPHRAGMS — Stainless steel diaphragms are used in all internal pilot, piston operated regulators shown on pages 5, 8 and 9. Practically indestructible in normal use, they guarantee long service without the difficulties encountered with stuffing boxes and bellows seals.

The total travel of the diaphragm is less than its own thickness and the stresses produced within the diaphragm are well within the safe limits of the material.

Diaphragm operated temperature regulators have either a phosphor-bronze, 1 ply diaphragm (indicated by "1d" in class designation) or the reinforced neoprene diaphragm shown in the illustration on page 1.

The phosphor bronze diaphragm, used in all diaphragm operated regulators shown on page 6 will withstand pressures far beyond the pressure-temperature limits of the regulator itself. The reinforced neoprene diaphragm used in larger sizes (page 7) is surrounded by a condensate reservoir to protect it from live steam contact on both sides.

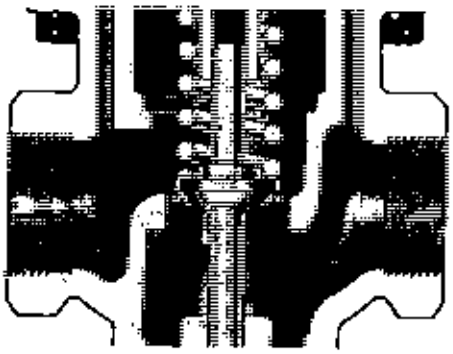
STELLITED SEATING SURFACE—A stellited seat ring combined with a hardened stainless steel main valve provides the most erosion resistant combination known to engineers, and is furnished with all Duo-matic (two element control) regulators. The stellite is applied to stainless steel seat rings in bronze and cast iron regulators and directly to the main body in steel regulators. Introduced by Leslie Co., this unsurpassed combination is the product of many years research coupled with the knowledge of stellite and heat treating techniques.



STELLITED SEATING SURFACE

INTERNAL SPRINGS of Inconel or 18-8 stainless are non-corroding, heat resistant. Ends of all springs are ground square to insure true movement.

LONG GUIDING SURFACES and polished finishes on all moving parts assure true alignment and prevent cocking and binding. Note the top and bottom guiding in both piston and diaphragm operated regulators.



Long Guiding Surfaces

INTERCHANGEABLE PARTS — All replaceable parts are manufactured to closely held tolerances, assuring interchangeable fits so that any part may be replaced in years to come without sweating and without removing the regulator body from the line.

LASTING SEAL GASKET JOINTS—Fouling and the necessity for cleaning and scraping gasket or flange faces, is completely eliminated.

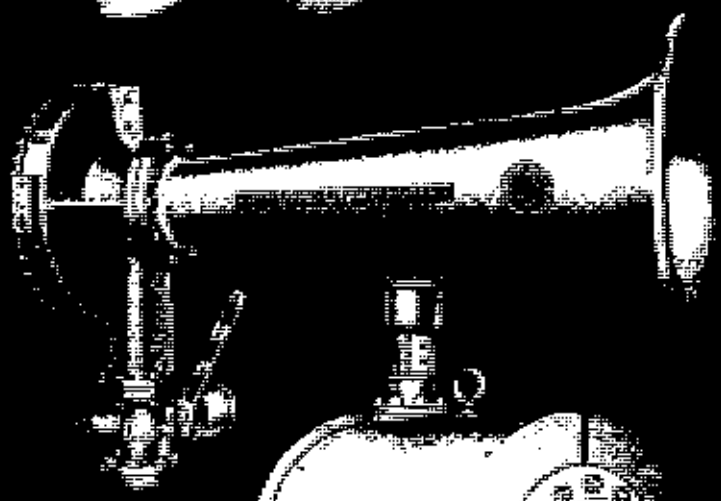
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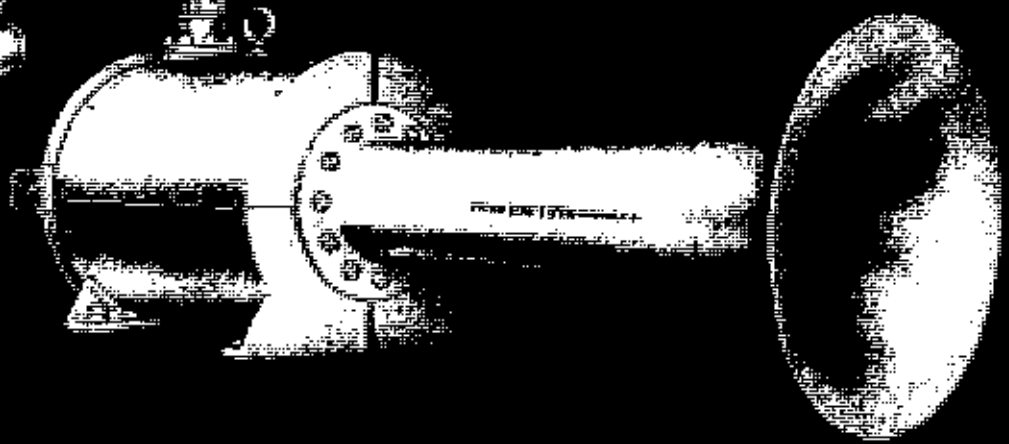
LESLIE

LESLIE-TYFON
LESLIE-SUPERTYFON

steam and air whistles







LESLIE-TYFON STEAM AND AIR WHISTLES

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Selecting, Specifying and Ordering Whistles 2
Notes and tones; Operating requirements; How to specify; How to order.

Quick Reference Table 3
Whistle Designations, Applications and Construction Data.

Leslie-Tyfon Steam Whistles 4
Features, data for industrial, marine use.

Leslie-Supertyfon Air Whistles 5
A new, unique design.

Leslie-Tyfon Air Whistles 6
Features, data for industrial, marine use.

Leslie-Tyfon Automatic Whistle Control ..... Inside Back Page
For dependable, coded signals—a new timer-control.

Leslie-Tyfon Coast-to-Coast Service ..... Back Page

SELECTION, SPECIFYING AND ORDERING WHISTLES

Leslie-Tyfon steam and air whistles work on the unique "impinging principle." Operating steam or air pressure from the whistle nozzle impinges on the diaphragm's center causing it to vibrate. The sound waves generated are pyramided and projected through the bell resulting in a great range of audibility with relatively low steam or air consumption.

NOTES AND TONES produced by steam and air whistles operating on this principle are determined by the diameter of the diaphragm, density of the operating medium and the length of the vibrating column of air or steam in the bell. The shorter the bell, or the less the density, or the smaller the diaphragm, the higher the frequency or pitch. Larger diaphragms and bells, and greater density produce lower frequencies.

OPERATING PRESSURES—Minimum necessary to obtain effective sound is 50 PSI steam or 80 PSI air. Maximum pressure allowable is 300 PSI steam or air.

Each Leslie-Tyfon whistle diaphragm has several leaves, depending upon operating pressure as follows:

AIR SERVICE		STEAM SERVICE	
Pressure	No. of Leaves	Pressure	No. of Leaves
80-150	1	50-115	1
150-300	3	115-300	1

WHISTLE DESIGNATION is indicated by letters and numbers—A for air, DV for steam, and numbers to indicate diaphragm diameter in millimeters. Air whistles have a second number to indicate frequency. For example:

A—100 (diaphragm diameter)—115 frequency

DV 100 (diaphragm diameter) steam

ELECTRICAL OPERATION OPTIONAL with addition of Leslie-Tyfon solenoids and in some applications, Asco solenoids. When so furnished, these are indicated by the letter "E" in the whistle designation —AE-200-156 or 925 DVE. See table page 3.

HOW TO SPECIFY TOP QUALITY & PERFORMANCE. Insist on "Leslie-Tyfon" or use following:

MANUALLY OPERATED STEAM WHISTLES: "Whistle shall be diaphragm type, steam jacketed so the heating chamber forms a separator, assuring dry steam to nozzle. The whistle shall be designed so the steam from the nozzle impinges on the center of the diaphragm. A single seated main valve shall be part of the whistle body and both main valve and valve seat shall have stellited surfaces. Inlet steam and drain connections shall be close together at the lowest point. Diaphragm shall be loose (not riveted), multi-leaf design.

FOR ELECTRICALLY OPERATED STEAM WHISTLES, add: "The main valve shall be piston operated, controlled by a pilot valve, operated by a solenoid. Opening the pilot valve shall release pressure from top of the piston, causing the main valve to open."

FOR AIR WHISTLES: "Whistle shall be a diaphragm type with an electrical and/or manual operating valve, designed so that air from nozzle impinges on center of the diaphragm. Diaphragm shall be loose (not riveted), single or multi-leaf design."

Ordering Information

Be sure to specify Leslie-Tyfons and include:
- Size and Type of Whistle (see Whistle Designation).
- Service or application.
- Operating medium—steam or air.
- Minimum and maximum operating pressure.
- Type of Operation: Manual, electric or automatic.
- For electrical or automatic operation state voltage—D.C. or A.C., frequency, and number of air-will switches if required.
- When ordering industrial plant signals, include a sketch showing buildings, surrounding obstructions, area to be covered, general weather conditions and prevailing winds.

When ordering parts include the following:
1. Part name and part reference number (from the applicable engineering drawing of the equipment).
2. Quantity of each part.

OR

1. Serial number, type and size of unit.
2. Part name (from engineering drawing).
3. Quantity of each part.

Navy parts orders should bear the drawing number from which parts are ordered.

Exhibit 200754

LESLIE-TYFON STEAM AND AIR WHISTLES

MORE AND MORE DECIBELS

Each new stride in the development of industry and commerce has meant new demands on audio-signal equipment. Greater sound output with lower steam or air consumption has been the continuing keynote for signal improvement in both the industrial and transportation fields.

Leslie Engineers, quick to get on top of these problems, have designed the most modern, complete line of steam and air whistles available anywhere. The recognition of Leslie-Tyfons as a world-wide standard for steam and air whistles attests to their superiority.

THE DECIBEL — A LOGARITHMIC UNIT — It is important to remember that the decibel (db.) is a logarithmic measure and when comparing the sound output of whistles, a direct numerical comparison can't be made.

One whistle, for example, has a 100 db. output, another a 110 db. output. The latter is not an increase of 10% but is actually 93% more sound output. Each decibel above 100 actually represents a 9.3% increase in sound output.

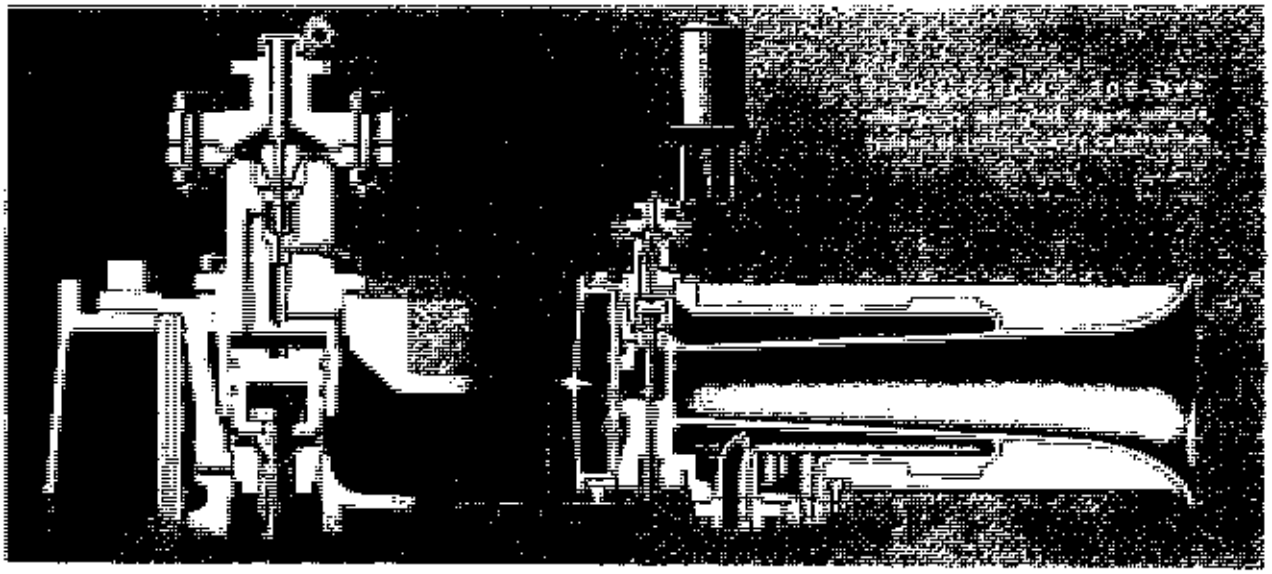
QUICK REFERENCE TABLE

	STEAM WHISTLE				AIR WHISTLES							
WHISTLE DESIGNATION	100 DV or DVT	100 DV or DVT	421 DV or DVE	111 DV or DVT	A-71-101	A-75-190	A-11-060	A-115-101	A-100-110	A-100-111	A-100-116	A-115-A1
Diaphragm diameter in inches	8"	11"	11"	13"	3"	3"	1"	1"	1"	8"	11"	11"
MOUNTING LUGS— Size of Vessel, Dead Weight Tons For Data on New Leslie-Tyfon Tee page 1	1000-6000	6000-11000	Over 11000	Over 15000	FOR SMALL VESSELS AND FOR INTRA-COMPARTMENT SIGNAL				1000-6000	1000-8000	6000-11000	Over 11000
MOUNTING LUGS— Main Plant Signal	●	●	●	●					●	●	●	●
Fire Alarm Signal	●	●	●	●	●	●	●	●	●	●	●	●
Call or Department Signal					●	●	●	●	●	●		
Intra-Plant Signal								●	●	●		
CONSTRUCTION: Bronze Bell	●	■			●	●	●	●	●	●		
Aluminum Bell			●	●				●	●	●	●	●
Bronze Diaphragm Housing	●	●	●	●	●	●	●	●	●	●	●	●
Aluminum Diaphragm Housing								●	●	●		
Plastic or Rubber-Faced Diaphragm for Industrial Use								●	●	●		
May be fitted with Leslie-Tyfon Solenoid for Marine or Industrial use, electrical operation**	●	■	●	●				●	●	●	●	●
May be fitted with ATCO Solenoid for Industrial Use, Electrical Operation**					●	●	●	●	●	●		
Frequency—Vibrations per second	100	110	41	11	161	310	040	111	110	119	110	11
Operating Pressure—PSI: Maximum Minimum	100 10	100 10	100 10	100 10	100 60	100 10	100 60	100 40	100 40	300 40	300 10	300 40
Approximate Weight lbs.† excluding valve	100	100	140*	1110*	11	10	6	11	11	11	180	111
Page Reference for Details	Page 4	Page 6	Page 7	Page 4	Page 0	Page 0	Page 0	Page 0	Page 6	Page 6	Page 6	Page 0

*Includes Solenoid weight.
**Maximum continuous ambient temperature for Leslie-Tyfon and ATCO Solenoids is 100° F.
● Available Standard.

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LESLIE-TYFON STEAM WHISTLES



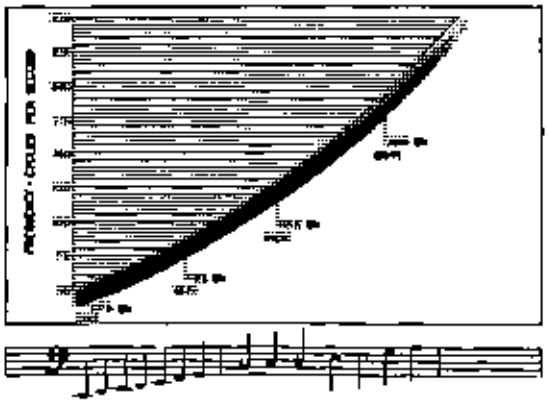
Many industrial firms and every major ship constructed during the past 25 years are equipped with one or more Leslie-Tyfon steam whistles available in four sizes—400 DV(E), 300 DV(E), 425 DV(E) and 575 DV(E).

FEATURES

MULTIPLE-LEAF, PHOSPHOR-BRONZE DIAPHRAGMS—Loose (not riveted), multi-leaf design results from more than 30 years experience with diaphragms in steam service.

PRE-HEATED DIAPHRAGM housed within a steam jacket that also acts as a steam separator. Instantaneous signalling even in sub-zero temperatures.

LOWEST STEAM CONSUMPTION—Uses only 20% of the steam required by other types of steam whistles for the same decibel output and range of audibility.



Notes and Tones—Leslie-Tyfon Steam Whistles

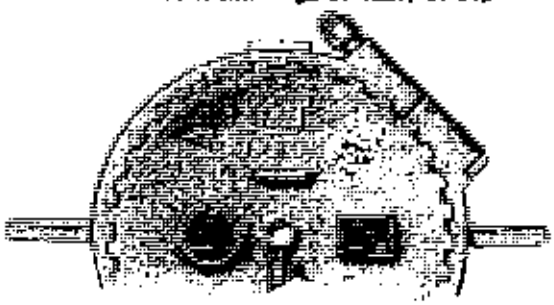
LONGEST BLOWING LIFE—Diaphragms last longest by actual test. Exclusive loose-leaf diaphragm construction means one-leaf-at-a-time replacement, much less often.

CRISP, CLEAR SIGNALS—Sharp, clear start and finish of the blast in all kinds of weather, regardless of interval between blasts. Powerful, arresting note for most effective coding.

BUILT-IN-STAINLESS STEEL VALVES—Famous Leslie quality stainless steel valves with stellited seat and seat ring. Long dependable trouble-free service.

MANUAL OR ELECTRICAL OPERATION—Whistles may be fitted with Leslie-Tyfon solenoid valves for electrical operation.

Dimensions and Parts List Charts, CT-#229, CT-842

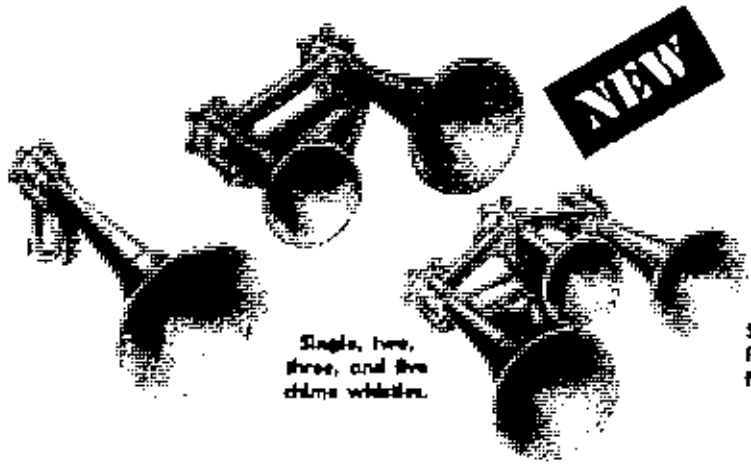


Back Cover Locking Device

ManuelBIW-000758

LESLIE
SUPERTYFON

AIR WHISTLES



Single, two, three, and five chime whistles.



Single tone and chime whistles available for marine use. Single tone units only are furnished for industrial applications.

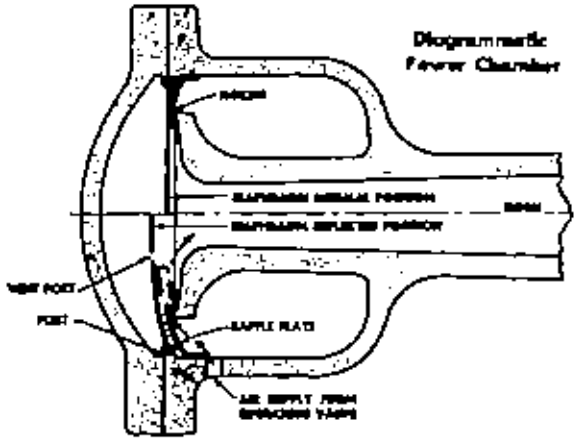
The greatest single advance in air whistle design was the advent of the unique Leslie-Supertyfon Air whistle.

Originally designed to meet requests of the railroads for an extremely low air consumption unit with increased sound output and a distinctive range of notes, the Leslie-Supertyfon has proved itself in years of rail service to be by far the most efficient of all air whistles of any design.

The unmatched performance and economy of the railroad Leslie-Supertyfon has now been built into single, two, three and five-chime units with a wide variety of distinctive and arresting-but-pleasing notes for marine use. Check these advantages.

FEATURES

NEW UNIQUE PATENTED POWER CHAMBER—There's an cushion like an air cushion. Instead of air escaping directly to atmosphere after contact with the diaphragm face as in conventional whistles, the Leslie-Supertyfon diaphragm is surrounded by vibrating air cushions on both sides of the diaphragm. Movement of the air cushions maintains diaphragm vibration and operation doesn't depend on the diaphragm's spring characteristics. Diaphragm fatigue and nozzle wear are virtually eliminated. Replacement is rarely necessary.



Diagrammatic Power Chamber

Dimensions and Parts List: Dwgs. C8085, C8086

LOWEST AIR CONSUMPTION—Uses only 25% of the air consumption required for ordinary air whistles for the same sound output.

"INDESTRUCTIBLE" DIAPHRAGM—Air cushioned when operating, the stainless steel diaphragm lasts indefinitely! Not a single diaphragm failure has been reported among hundreds in use for years. In tests, diaphragms are still operating after more than 2,000 blowing hours or equivalent marine use of ten years and more!

ALL PARTS STANDARD AND INTERCHANGEABLE—All Leslie-Supertyfon operating parts are precision made and fully interchangeable in all whistle sizes.

SHARP, CLEAR SIGNALS—At start and end of blast, readily adaptable for coding.

ELECTRICAL AND AUTOMATIC OPERATION—May be fitted with Leslie-Tyfon solenoid operating valves or automatic whistle controls.

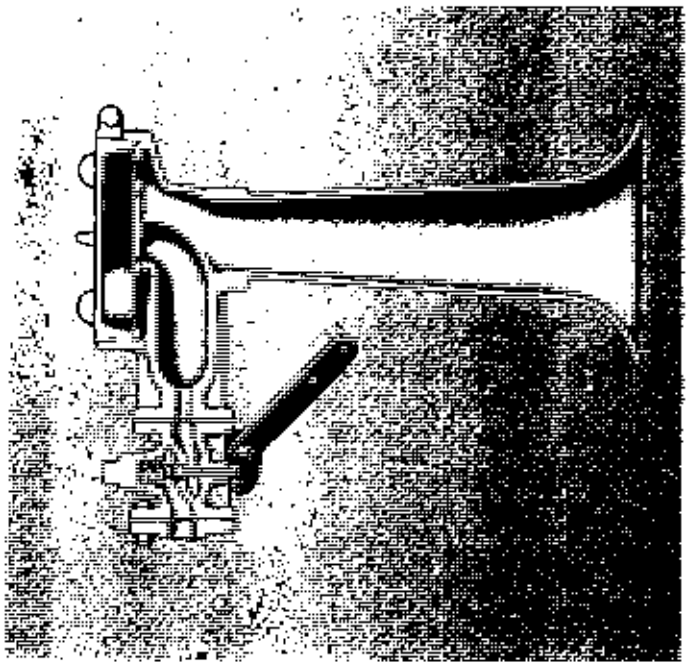
Application Data

Table below shows standard units that have been proved superior for most marine requirements. Other combinations are available.

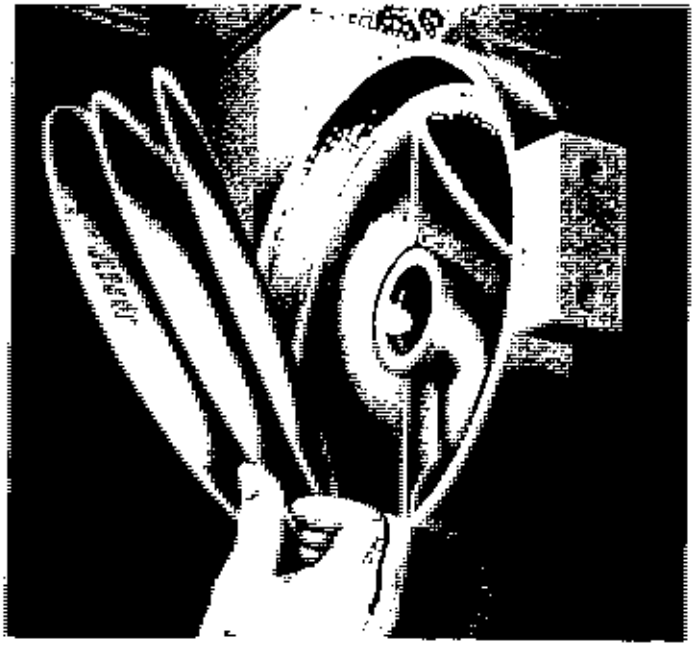
TYPE	SERVICE
Single Chime S-1A	Vessels up to and including 1000 tons
Three Chime S-3 J, Five Chime S-5 P	Vessels up to and including 6000 tons

MANUALBIW-000757

LESLIE-TYFON AIR WHISTLES AND OPERATING VALVES



A-125-247 with ½"
Manual Operating Valve.



Loose (not riveted) Multi-Leaf Diaphragm.

After more than 20 years of leadership, Leslie-Tyfon air whistles still enjoy top popularity among diaphragm type signals. Continuous improvement to meet demands for greater sound output with less air consumption has kept Leslie-Tyfon first in the field. They are used as primary signals aboard all classes of ships; as main plant and call signals; as industrial fire and emergency alarms. Versatile Leslie-Tyfons and operating valves are suitable for direct, manual operating or for remote electrical control systems.

FEATURES

SINGLE OR CHIME-TONES—For distinctive and pleasing-but-authoritative sounds.

EXCLUSIVE NOZZLE DESIGN—Air pressure applied at center of diaphragm for maximum effectiveness.

METAL DIAPHRAGMS FOR MARINE SERVICE—Loose, multi-leaf diaphragms of phosphor-bronze are longer wearing by actual test.

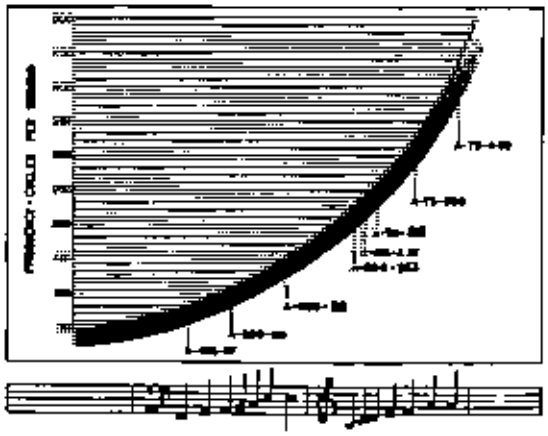
SPECIAL DIAPHRAGMS FOR INDUSTRIAL APPLICATIONS—Single heat, rugged plastic diaphragm or resilient, rubber-faced diaphragm for corrosive atmospheres.

LOW AIR CONSUMPTION—Uses only 20% of the air required by other whistles of conventional design for same sound output.

SHARP, CLEAR SIGNALS—Widely used for coding and call signals. Each note unmistakably distinct.

MANUAL OR ELECTRICAL OPERATION—Most marine air whistles are furnished with Leslie-Tyfon solenoid valves for electrical operation. Industrial units with diaphragms 125 mm (5 inches) or smaller may be furnished with Asco solenoid valves for electrical operation.

Dimensions and Parts List Dwg. C 3570



Notes and Tones—Leslie-Tyfon Air Whistles

Mamco/BW/000758

LESLIE-TYFON AUTOMATIC WHISTLE CONTROLS

Automatic controls for repeating, coded signals in fog can be furnished as follows:

SERVICE	CODE IN STANDARD TIMER
Ocean Going Vessels	One 1 second blast every 1 or 2 minutes.
Great Lakes Vessels	One sec. blast, 1 sec. interval, 1 sec. blast, 1 sec. interval, 1 sec. blast, 33 sec. interval.
Vessels on Inland Waterways	One 1 second blast every minute.

The whistle control consists of a combination timer and automatic switch, and a separate "at-will" switch generally installed in the pilot house. Two or more "at-will" switches are placed at opposite wings of the bridge or other positions for easy access.

For automatic signalling the push button switch is momentarily depressed and the automatic control operates as described in "Principle of Operation," giving regular, distinct signals until any one of the at-will switch levers is moved to neutral or blowing position.

Exclusive Safety Feature

Leslie-Tyfon Automatic Whistle Control prevents fog warning signals from interfering with an "at-will" signal by an immediate cut-off of the timer motor whenever an "at-will" passing signal is given. Manual reset of automatic signalling avoids an automatic blast on the heels of an "at-will" signal—important for prevention of collisions. The "at-will" switches, of course, permit single blasts at any time.

Principle of Operation

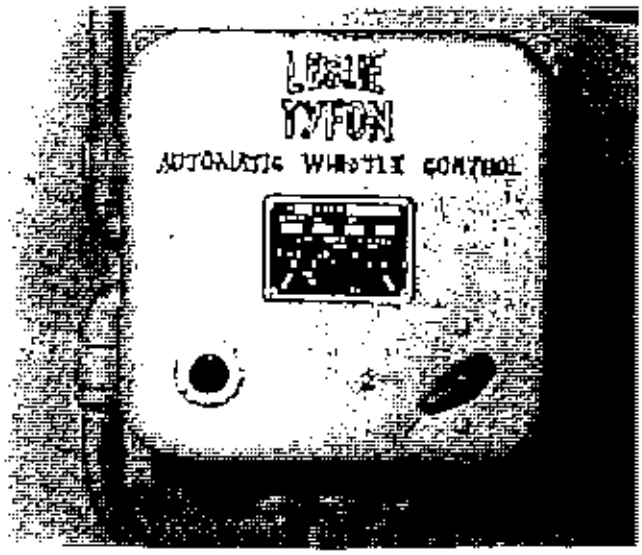
(AC)—The operating mechanism of the Leslie-Tyfon automatic whistle control is exclusive with Leslie-Tyfon and has proven itself in rigorous tests. Standard automatic controls, placed in test service are operating after more than *14,000 hours of uninterrupted service* —and they are still "blowing" *continuously.*

The Type TAC automatic control consists of a time cycle selector switch, starting switch, motor and timer unit for alternating current.

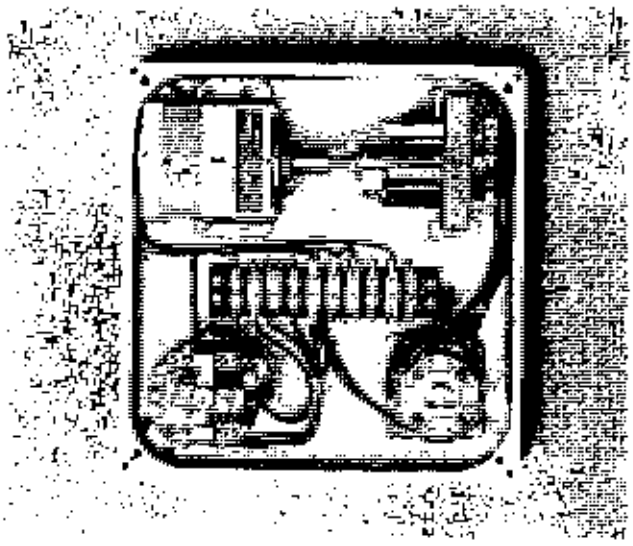
The timer is a rugged unit designed specifically to eliminate cams and possibility of waver, slip, or bounce when contact is made or broken. The motor turns a rotating, axially-reciprocating nylon contactor knife which at controlled intervals, makes and breaks fine silver contacts without bounce or waver, usual causes of destructive arcing.

Starting and resetting is governed by the push button switch equipped with a relay type holding coil. Stopping is accomplished from any "at-will" switch by momentarily moving the lever of the switch to neutral position. Reset for automatic can only be made at the control box, securing maximum convenience and safety with elimination of confusion.

The time cycle selector switch is an electro-rotary switch of superior design, as is the motor that drives the timer. For dependable operation, the motor has several



Type TAC, External View



Type TAC, Internal View

hundred percent greater starting torque than the clock-type motors found in ordinary whistle timing devices. The combination of superior motor and the unique make-and-break device, provides a compact timer that eliminates the dangers of failure that have made automatic coded signaling a problem.

(DC)—An automatic whistle control is also available for direct current, consisting of a timer box with gear shift type code selector and a separate junction box with an "at-will" switch and automatic switches.

Dimensions and Parts List Dwgs. C 7745, & T-415

LESLIE CO., Lyndhurst, New Jersey

LESLIE COAST - TO - COAST SERVICE



A Leslie [illegible]
[illegible] Call [illegible] representative [illegible]
you [illegible]

INDUSTRIAL

[illegible], PA.
[illegible] Service Co.
[illegible], TEX.
[illegible] Co.
[illegible], PA.
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[illegible], PA.
[illegible] Co.
[illegible], N. J.
[illegible], Inc.
SALT LAKE CITY, UTAH
[illegible] Co.
[illegible], PA.
[illegible] Co.

SEATTLE, WASH.
[illegible] Co.
ST. LOUIS, MO.
[illegible] Co., Inc.
STEUBENVILLE, O.
[illegible] Co., Inc.
WILKES-BARRE, PA.
[illegible] Co., Inc. (Chapins)
YOUNGSTOWN, OHIO
[illegible] Supply Co.

CANADA

REGINA, SASK.
[illegible] Ltd.
[illegible], ONT.
[illegible] Ltd.
VANCOUVER, B. C.
[illegible] Ltd.
WINNIPEG, MANITOBA
[illegible], Ltd.

MARINE

[illegible], PA.
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[illegible], N. J.
[illegible] Co.

ST. [illegible], MO.
[illegible] Co.
SAN FRANCISCO, CALIF.
[illegible]
SACRAMENTO, CAL.
[illegible] Supply Co., Inc.
SEATTLE, WASH.
[illegible]
[illegible], CALIF.
[illegible] Supply Co., Inc.

CANADA

MONTREAL, QUEBEC
[illegible] Co., Ltd.
VANCOUVER, B. C.
[illegible] Co., Ltd.

LESLIE CO.

Printed in U.S.A. [illegible]

ManualBW-000780

LESLIE-TYFON instructions for AIR and STEAM WHISTLES

INSTALLATION, OPERATION and MAINTENANCE

COMMERCIAL AND NAVY

Air Whistles Current Classification	Old Classification	Steam Whistles Current Classification
A- 75-440-MD	A- 75-H	200 DV
A- 15-550-MD	A- 15-L	200 DVE
A- 15-262-MD	A- 75-LL	300 DV
A&AE-125-247-MD	A&AE-125-L	300 DVE
A&AE-125-206-MD	A&AE-125-LL	425 DV
A&AE-200-233-MD	A&AE-200-H	425 DVE
A&AE-200-156-MD	A&AE-200-L	575 DV 575 DVE
A&AE-300-110-MD	A&AE-300-L	
A&AE-425- 87-MD	A&AE-425-L	

LOCATION

Marine Whistles

Air whistles are normally installed as high as possible on the forward mast. Steam whistles are normally located in or on the upper part of the smoke stack, pointing forward.

Industrial Whistles

For maximum audibility and coverage in industrial service, Leslie Tyfon whistles should be installed in approximate center of area to be covered, preferably on multiple frame or platform at least 6 feet above roof top on which they are mounted, or above nearby projections such as roof parapets, ventilators. This reduces possibility of sound waves from the whistle being dampened or deflected and creating "dead spots."

Avoid pointing whistle directly at smokestacks, buildings, or other objects within 100 feet of the whistle, unless purpose is to help the sound penetrate that particular building or area.

Prevailing winds that reduce audibility "upwind" and increase coverage "downwind" must be considered when locating and pointing the whistle.

If the plant area is large with a number of buildings distant from the whistles with a high inside noise level, a single outdoor whistle may not be audible inside, due to sound absorption and insulation of building walls. For positive coverage additional whistles should be located in the individual buildings.

INSTALLATION

Air Whistles

1. Size of piping should be equivalent to or larger than the inlet connection of the whistle.
2. Air supply at the whistle should be clean, dry and continuous.
3. The air supply line should rise continuously through well graded piping, free from pockets and long horizontal runs.

Steam Whistles

1. Piping should be the same size or larger than the inlet and drain connections of the whistle. All piping must be well insulated and where exposed to outside conditions, doubly insulated.
2. Steam supply should be taken directly from the boiler or from a point on the steam line where there is a continuous flow.
3. The steam supply line should be nearly vertical as possible and rise continuously through well graded piping, free from pockets and horizontal runs.
4. The bottom of vertical riser should be equipped with a water separator and a continuous flow type trap or other non-failing means of drainage.
5. The drain line from the whistle should be connected to a continuous flow type trap discharging to atmospheric pressure (never to high pressure drains).
6. All drain lines should be well graded without pockets, with continuous downward slope toward drain main or sewer.
7. Traps on whistle supply and drain lines should be fitted with by-pass connections and protected by strainers with fine wire mesh or perforated screen suitable for condensate service.

For Electrically Operated Whistles

Solenoid does not require any adjustment.

Check line voltage and compare with solenoid ratings given on the solenoid.

DC SOLENOID: (Refer to Drawing No. 7139 F)

Connect armored cable to power line or to junction to line.

Test solenoid coil and line for continuity and shorts before connecting line to main power source.

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Manual BIW-000761

LESLIE-TYFON instructions for AIR and STEAM WHISTLES

AC SOLENOID: (Refer to Drawing No. 0739 F1

Remove cap from top of solenoid.

Remove shipping disc from hole with pipe threads (on side) and attach a standard terminal tube (not furnished with solenoid).

Insert end of armored operating line through terminal tube sufficiently to allow for soldering to terminal lugs.

Pack stuffing box with asbestos packing or paraffined flax. Do not use oil soaked packing.

Solder end leads of operating line to terminal lugs in the solenoid connector box.

Test solenoid coil and line for continuity and grounds before connecting the line to the power supply and replace cap.

OPERATION

Note: For installations where air or steam is already available at the whistle connection and where the line has been thoroughly cleaned, the whistle may be operated immediately after installation. It is recommended that the factory adjustment on the back cover be undisturbed.

Air Whistles

To place Leslie-Tyfon in service proceed as follows:

1. Test with air pressure 10 to 25 lbs. below that normally carried. Never set with maximum pressure.

2. Loosen lock bolt and unscrew back cover. Remove diaphragm and blow out pipe lines thoroughly by operating whistle valve with full air pressure while diaphragms are out of whistle.

3. Replace diaphragms with convex or high side against nozzle or toward the front of the whistle. Note instructions stamped on each diaphragm.

4. Adjust diaphragm with air pressure 10-25 psi below normal. Replace and screw up back cover on diaphragms until back cover is hand tight. Then back it off while blowing (approx. 1/8 to 5/8 turn) until sound is loud and clear. Back it off slightly more (1/16 turn) before tightening lock bolt. The sound should now be an instantaneous blast with even, powerful volume. (Be sure lock washer is in place before tightening lock bolt. Always secure locking device with cotter pin).

   Back cover should be locked in place as illustrated in Fig. 1.

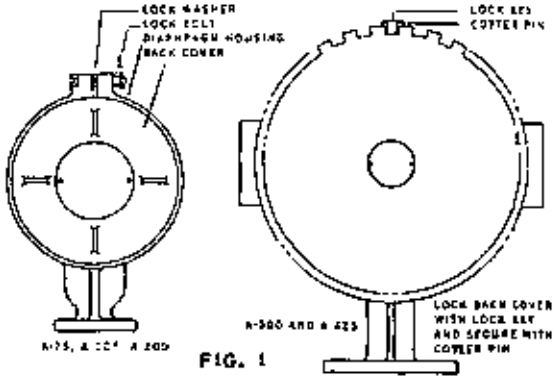


FIG. 1

Do not use less than the recommended number of leaves. Doing so will result in more frequent diaphragm failures. Always be sure all leaves are installed with convex side toward the nozzle. Recommended number of diaphragm leaves for different operating air pressures are as follows:

40 to 80 psi . . . . . 2 leaves
70 to 300 psi . . . . . 3 leaves

Steam Whistles

Where steam has not been available to clean lines thoroughly before installing whistle, proceed as follows:

1. Loosen lock nut (see Fig. 2) and ring; remove back cover and diaphragms. Operate whistle valve several times with diaphragms removed to blow out pipe lines thoroughly.

2. Check number of diaphragm leaves and replace proper number for operating pressure. (Always replace convex or high side, as marked, toward nozzle of whistle). Recommended number of leaves for different operating pressures are as follows:

   50 to 125 psi . . . . . 2 leaves
   125 to 300 psi . . . . . 3 leaves

3. Replace back cover and screw in loosely by hand.

4. Operate manual lever slowly, allowing steam to pass through nozzle until back cover, diaphragms and body are hot.

5. When heated, tighten back cover with spanner wrench until it is firm against diaphragm leaves. Then turn back three notches. From this position, minor adjustments in or out can easily be made to obtain a strong, well defined blast.

6. When satisfactory tone is obtained, tighten lock ring by pulling up on lock nut (see Fig. 2).

ManualBIW-000762

LESLIE-TYFON instructions for AIR and STEAM WHISTLES

1. Check tightness of back cover by reversing spanner wrench and with whistle blowing, push upward strongly on spanner. If back cover moves, tighten lock nut until movement ceases. Insert cotter pin through lock nut.

   Notes: Discharge of water through horn or around valve stem indicates wet steam or poor condensate drainage. Falling away or dying out of sound also indicates presence of water. Piping should be checked and any pockets eliminated. Traps and drains should be checked and by-passed temporarily if inoperative.

   Choked or muffled tones indicates steam pressure in excess of valve rating or tight back cover adjustment. Poor, rattling tones indicate loose back cover.

2. Before testing or operating steam whistle, steam must be turned on with all drains open and traps in operation for at least thirty minutes to insure proper heating and removal of condensate.

   Test whistle manually and/or electrically when starting up.

MAINTENANCE

Air Whistles

1. Examine and clean diaphragm every six months. If any leaf is found damaged, or has lost its curvature, it should be replaced by a new one. Always install new leaf next to nozzle.
2. After cleaning diaphragm leaves, they should be put in position and tested as explained under OPERATION.
3. Check operating valve tightness every three months. If valve is leaking, remove it. Follow proper drawing for guidance and grind in to obtain a good, clean seat.

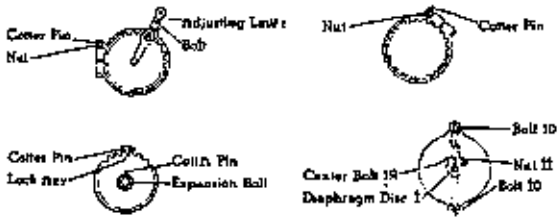
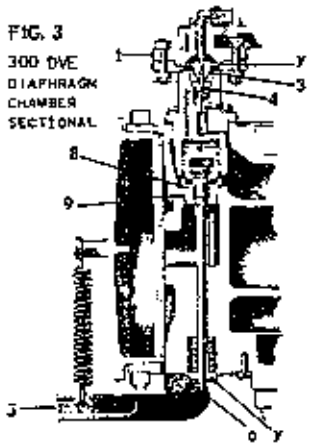


FIG. 2 Locking Arrangement Diagram

Steam Whistles

1. Remove back cover and diaphragms (see OPERATION). Remove cotter pins, nuts and lock washers holding solenoid to cylinder; lift solenoid off cylinder. Remove lock flange (1) and disc (2).
2. Remove upper pilot valve seat (3) with socket wrench. Lift out pilot valve (4) and spring.
3. Break joint between cylinder and whistle. Remove cylinder and gasket.

FIG. 3
300 DVE DIAPHRAGM CHAMBER SECTIONAL



4. Remove lever (5) and cotter pin (6) which holds main valve spring and spring seat (7). When removing this cotter pin, press up on spring seat to compress spring.
5. Place screw driver or rod against main valve stem and push upward. Grasp piston and remove valve and piston as unit.
6. Important: Before attempting to remove seat ring (8) be sure to take out seat ring lock screw (9).
7. Clean all parts with kerosene and examine. Replace all worn or damaged material with Leslie Parts.
8. Main valve, pilot valve and seats should be ground in lightly to insure steam tightness, using fine grinding compound.
9. Where parts are encrusted with foreign matter, clean with mild aluminum oxide or crocus cloth. Use crocus cloth to clean pilot valve seat bore.
10. After all parts are thoroughly cleaned and ready, position cylinder basket, assemble main valve and piston in cylinder. Replace in body as a unit, using rod or screw driver inserted in main valve stem hole to prevent main valve and piston from dropping down during assembly.
11. Replace pilot valve spring, pilot valve and seat. Pull seat down firmly with socket wrench and tap to insure steam tightness. Replace lock disc, lock flange washers and nuts. Tighten and insert cotter pin.
12. Replace main valve spring and spring seat. Compress spring by pushing upward on seat. Reinsert cotter pin and spread. Make sure cotter pin does not extend over side of spring seat.
13. Replace diaphragms, back cover and adjust for tone per instructions listed under "OPERATION."

Electrical Maintenance— No Lubrication Required

If whistle fails to operate electrically but works manually, proceed as follows:

1. Check that rated voltage and current is maintained at solenoid leads and, if necessary, check for grounds at operating switch.
2. Check clearance between push rod and lever when solenoid is de-energized. This should be .030". New style lever has adjustable travel for easy clearance adjustment and should replace old style, non-adjustable lever when possible. Adjust clearance to .030". See Fig. 5 next page.

ManualBIW-000763

LESLIE-TYFON instructions for AIR and STEAM WHISTLES

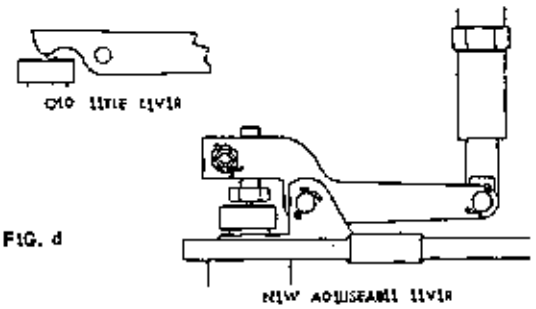


FIG. d

3. Close operating switch and note if plunger is pulled up properly for AC, or pushed down for AC. Plunger assembly should travel freely, without binding or friction.

4. When AC solenoid is energized, a gap of about 1/32" between connecting pushing and connecting screw head should appear. Gap indicates that pilot valve is fully opened and seating on lower seat.

5. If gap is less than 1/32", rubber diaphragm sealing solenoid should be checked for flexibility and replaced if stiff.

6. Operate each switch. If one or more switches blow whistle, check other switches and circuits.

7. If no switch blows whistle, check fuse plugs in whistle power line. Replace if necessary, eliminating grounds or shorts.

8. If whistle still doesn't operate electrically, push up on plunger arrangement of AC solenoid or remove cap nut on top of solenoid and push top of plunger down. If pilot valve operates freely and is in good working order, a clear, powerful blast should result. If not, examine pilot valve assembly as described under "STEAM WHISTLE MAINTENANCE."

9. If whistle blows when pushing plunger as in paragraph 3, but not electrically, check rubber diaphragm sealing solenoid and electric power to solenoid.

FOR DC SOLENOIDS:

a. Disconnect power leads from the solenoid and put a 60 watt, 110 volt test lamp in series with the coil to determine that a circuit is made through the coil. If test lamp burns too brightly, coil is shorted. If there is no light, there is a break in the coil. In either case, remove coil as follows:

b. Break joint at top plate, and remove core (plunger) and brass washer.

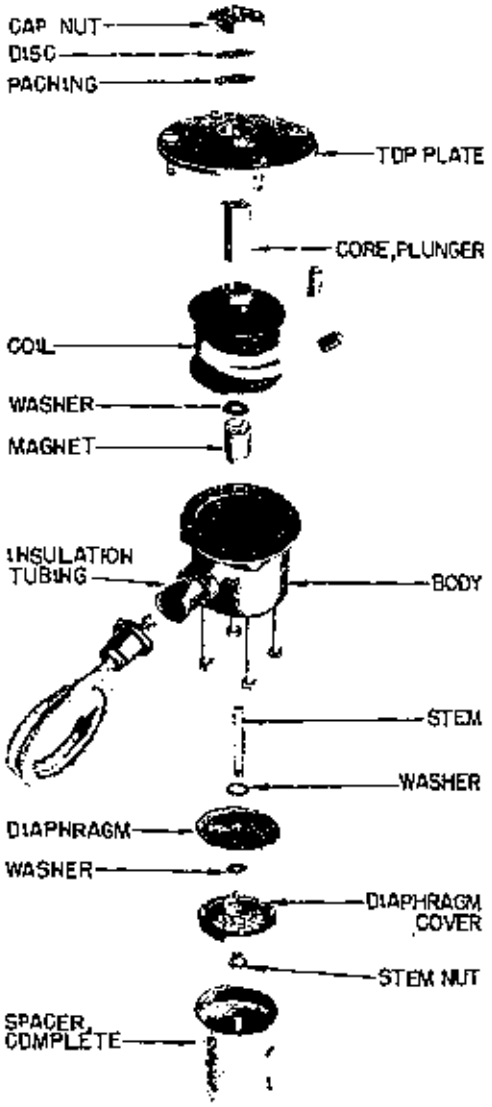
c. Disconnect coil leads and remove coil. Repair or replace with new coil. Replace insulation and insulation tubing carefully.

d. Replace core (plunger). Be sure washer is on top of magnet. Replace gasket which must be in good condition. Roll top plate in place and screw on cap nut with packing disc. Replace lock wire.

e. Reassemble connecting nuts and connector insulation. Replace gasket and connector box cover which must seal tightly. Tighten packing ring nut.

FOR AC SOLENOIDS:

f. Disconnect leads and check coil circuit with test lamp or ammeter in series.



DC SOLENOID PARTS
SEE DRAWING NO. C4738 FOR AC SOLENOID PARTS

g. If light does not burn or ammeter does not register, check for break in coil leads. If ammeter registers in excess of 5 amps at 440 volts, 1.75 volts or 1.15 at 440 volts, coil is shorted.

h. If shorted or opened, coil should be repaired or replaced with a new coil.

i. Insulate leads from casing so there is no possibility of ground leaks before retesting solenoid.

* * * * *

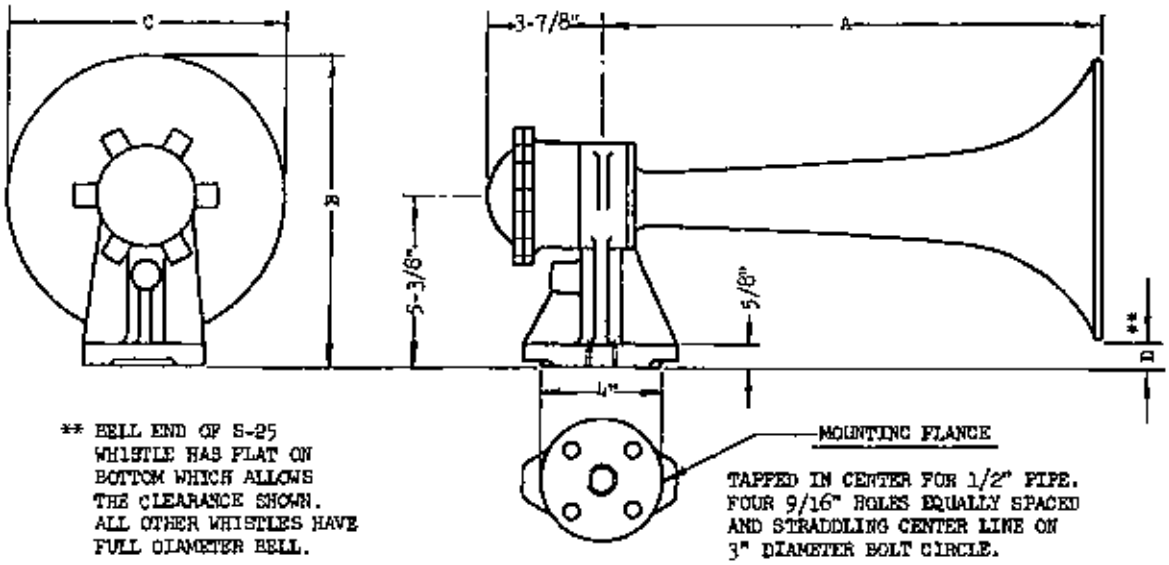
Send for free tools, drawings and literature on business reply card addressed to Leslie Co.

ManualBIW-000764 Litho in U.S.A.

SINGLE TONE WHISTLES

DIMENSIONS IN INCHES					
TYPE	A	B	C	D	Wt. lb. *
S-25	21-1/8	10-3/4	10-3/4	1/2	11
S-31	17-1/8	9-7/8	9	7/8	10
S-37	13-3/4	9-3/8	8	1-3/8	9
S-44	10-1/4	8-9/16	6-3/8	2-3/16	8
S-48	8-7/16	8-1/8	5-7/16	2-21/32	7-1/
S-55	6-15/16	8-1/8	5-7/16	2-21/32	7

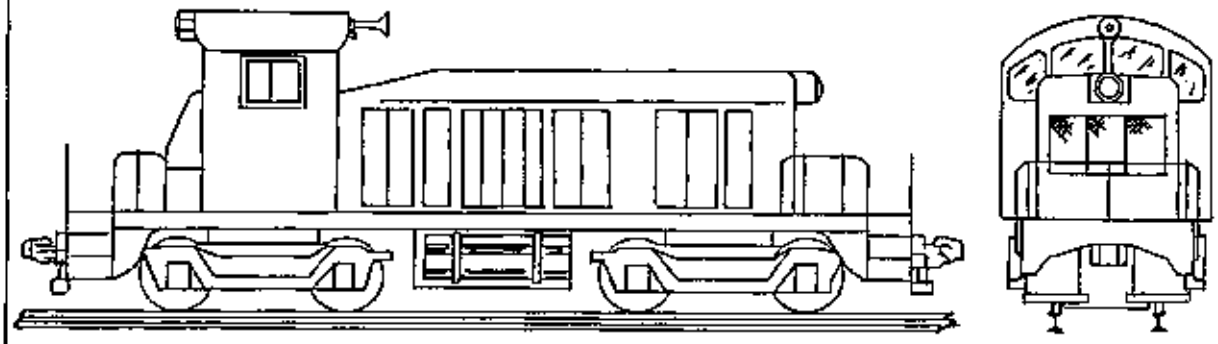
* NET WEIGHT APPROXIMATE



** BELL END OF S-25 WHISTLE HAS FLAT ON BOTTOM WHICH ALLOWS THE CLEARANCE SHOWN. ALL OTHER WHISTLES HAVE FULL DIAMETER BELL.

MOUNTING FLANGE

TAPPED IN CENTER FOR 1/2" PIPE. FOUR 9/16" HOLES EQUALLY SPACED AND STRADDLING CENTER LINE ON 3" DIAMETER BOLT CIRCLE.



TYPICAL INSTALLATION

SEE REVERSE SIDE FOR PART NAMES, PART REFERENCE NUMBERS AND MAINTENANCE INSTRUCTIONS.

LESLIE CO.
LYNDHURST, NEW JERSEY

LESLIE-SUPERTYFON CHIME WHISTLES
TYPES S-25, S-31, S-37, S-44
S-48 AND S-55 SINGLE TONE

DATE 10-7-52
DWN CKD
DRAWING NO. 000785 F

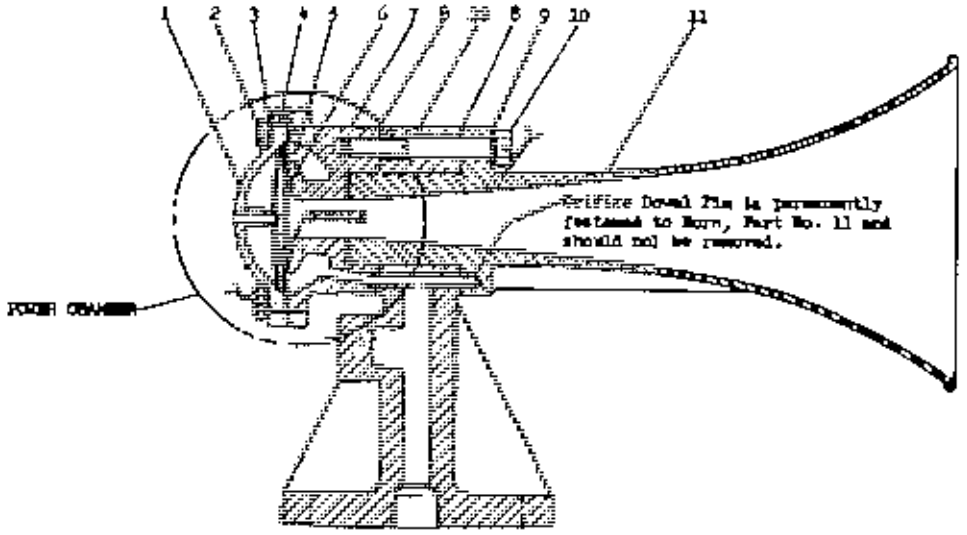
Printed in U.S.A. 8535C

WHEN ORDERING HORN, GIVE TYPE, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - SINGLE-DIRECTION WHISTLES
DRAWING NO. 6560 F, TYPES H-25, H-31, H-37, H-44, H-48 AND H-55 SINGLE TONE

PART NO.	PART NAME	MATERIAL	REF. NO.
1	* Back Cover, Complete	Bronze	23852
2	* Cap Screw, Back Cover	Steel, Plated	85900
3	* Lock Washer	Steel, Plated	13077
4	* Diaphragm Ring Screw	Stainless Steel	85150
5	* Diaphragm Ring (NOTE 2)	Stainless Steel	24436
6	* Diaphragm (NOTE 2)	Stainless Steel	84437
7	* Diaphragm Housing	Bronze	23851
8	* Gasket	Sheet Packing	84911
9	* Lock Washer	Steel, Plated	10892
10	* Cap Screw, Horn	Steel	24503
11	H25 Horn, Complete (NOTE 1)	Aluminum	27575
11	H31 Horn, Complete (NOTE 1)	Aluminum	27576
11	H37 Horn, Complete (NOTE 1)	Aluminum	27578
11	H44 Horn, Complete (NOTE 1)	Aluminum	27580
11	H48 Horn, Complete (NOTE 1)	Aluminum	27581
11	H55 Horn, Complete (NOTE 1)	Aluminum	27582
12	Single Horn Plate	Aluminum	27604

NOTE 1 - Includes Orifice Dowel Pin Ref. No. 27284 (.125 Dia.).
NOTE 2 - Furnished Complete as Diaphragm Set, Ref. No. 27216.



* ALL PARTS IN WATER CHAMBER ARE FIELD INTERCHANGEABLE IN ALL WHISTLES, SINGLE TONE OR CHIME TONE.

MAINTENANCE INSTRUCTIONS

CLEANING DIAPHRAGM AND DIAPHRAGM RING

TO INSPECT AND CLEAN DIAPHRAGM, PART NO. 6 AND DIAPHRAGM RING, PART NO. 5, REMOVE BACK COVER CAP SCREWS, PART NO. 2 AND TAKE OFF BACK COVER, PART NO. 1. DIAPHRAGM RING AND DIAPHRAGM CAN BE REMOVED BY TAKING OUT DIAPHRAGM RING SCREWS, PART NO. 4.

WIPE NOZZLE AS WELL AS DIAPHRAGM AND DIAPHRAGM RING CLEAN.

CLEANING AIR LINES

WHENEVER A BACK COVER IS REMOVED IT IS GOOD PRACTICE TO BLOW OUT THE AIR LINES BY OPERATING OPERATING VALVE WIDE WITH FULL PRESSURE APPLIED TO THE LINE. THIS WILL ALSO CLEAN OUT ORIFICE DOWEL PIN.

WHEN REPLACING BACK COVER, INSTALL LOCK WASHERS, PART NO. 3 AND TIGHTEN BACK COVER CAP SCREWS FIRMLY. REMOVE CAP SCREWS.

NO ADJUSTMENT IS NECESSARY.

REPLACING OR REVERSING WHISTLE

REMOVE HORN CAP SCREWS, PART NO. 10 AND PULL HORN, PART NO. 11 OUT CAREFULLY. BEFORE REPLACING OR REVERSING HORN, THE OUTER SURFACE OF THE SMALL END SHOULD BE COATED WITH VASELINE.

CLEAN GASKET FACES OF DIAPHRAGM HOUSING, PART NO. 7 AND HORN. IF HORN TO REPLACE CRACKED, PART NO. 8.

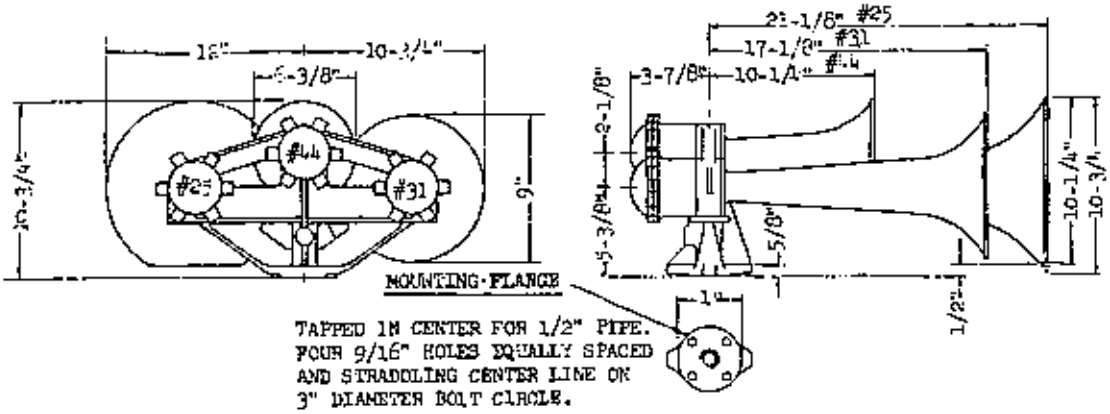
INSTALL LOCK WASHERS, PART NO. 9 AND TIGHTEN HORN CAP SCREWS FIRMLY. REMOVE CAP SCREWS.

IF IT IS EVER NECESSARY TO REPLACE ORIFICE DOWEL PIN, INSERT IT INTO HORN WITH ORIFICE FACING OUTWARD AND IN LINE WITH AXIS OF HORN.

Manual-BDW-0007766

LT- 2615

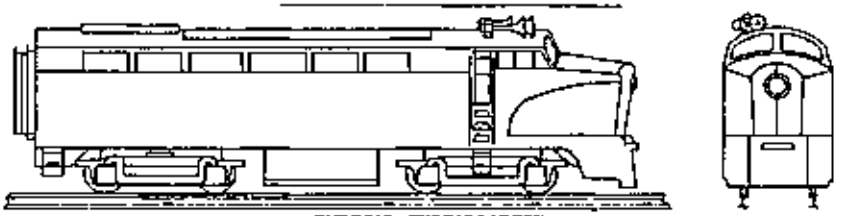
S-3L CHIME WHISTLE



MOUNTING FLANGE

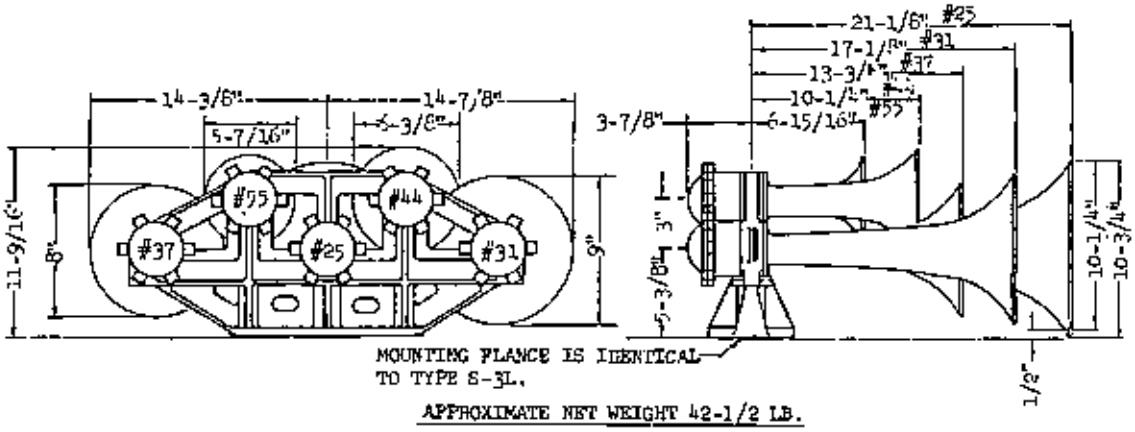
TAPPED IN CENTER FOR 1/2" PIPE. FOUR 9/16" HOLES EQUALLY SPACED AND STRADDLING CENTER LINE ON 3" DIAMETER BOLT CIRCLE.

APPROXIMATE NET WEIGHT 28 LB.



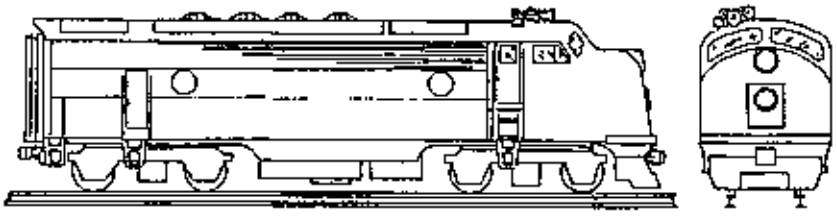
TYPICAL INSTALLATION

S-5T CHIME WHISTLE



MOUNTING FLANGE IS IDENTICAL TO TYPE S-3L.

APPROXIMATE NET WEIGHT 42-1/2 LB.



TYPICAL INSTALLATION

S-3L AND S-5T HAVE ALL WHISTLES POINTING FORWARD. WHEN 1 AND 2 WHISTLES ARE REVERSED ON THESE UNITS THEY BECOME S-3L-R AND S-5T-R RESPECTIVELY. SEE DWG. NO. 8084 F. ALL PARTS ARE FULLY INTERCHANGEABLE.

SEE REVERSE SIDE FOR PART NAMES, PART REFERENCE NUMBERS AND MAINTENANCE INSTRUCTIONS.

LESLIE CO.
LYNDHURST, NEW JERSEY

LESLIE-SUPERTYPHON CHIME WHISTLES
TYPES S-3L AND S-5T
CHIME WHISTLES

DATE 12-21-51 DWG. NO. 8084 F, Rev. 2

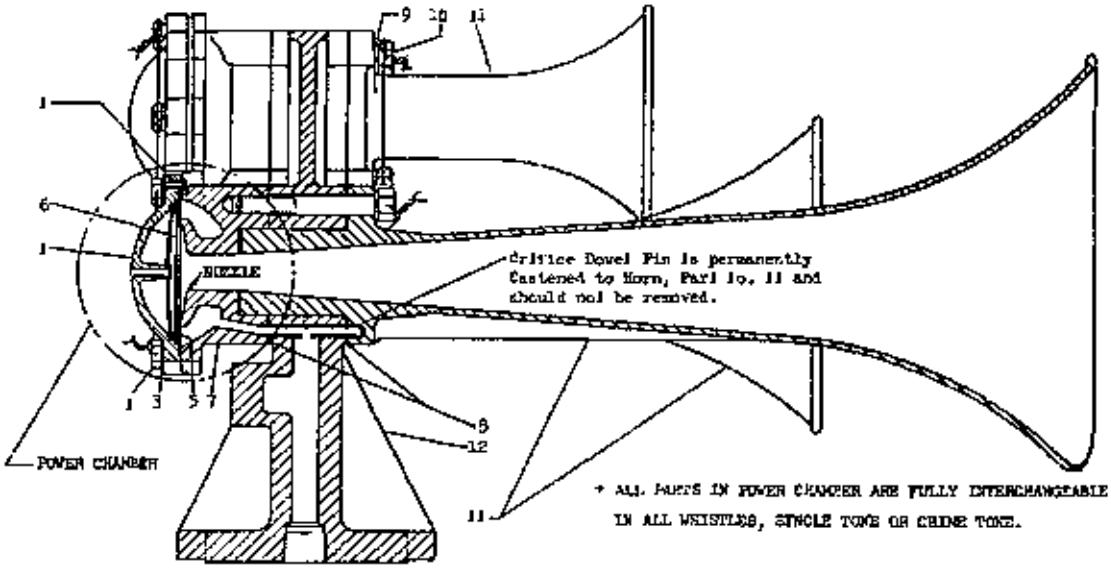
Manual/BIW-000767

WHEN ORDERING PARTS, GIVE TYPE, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - LEGLIN-SUPERTYPE
DRAWING NO. 6001 2, TYPES S-3L AND S-5T CHIME WHISTLES

PART NO.	PART NAME	MATERIAL	REF. NO.-EACH TYPE S-3L	REF. NO.-EACH TYPE S-5T
1	* Back Cover, Complete	Bronze	25202	25202
2	* Cap Screws, Back Cover	Steel, Plated	25200	21200
3	* Lock Washer	Steel, Plated	13077	13077
4	* Diaphragm Ring Screw	Stainless Steel	21190	21190
5	* Diaphragm Ring (NOTE 6)	Stainless Steel	24438	24438
6	* Diaphragm (NOTE 6)	Stainless Steel	24437	24437
7	* Diaphragm Housing	Bronze	25201	25201
8	* Gasket	Steel Packing	24311	24311
9	* Lock Washer	Steel, Plated	10392	10392
10	* Cap Screw, Horn	Steel	24503	24503
11	#25 Horn, Complete (NOTE 1)	Aluminum	27515	27515
11	#31 Horn, Complete (NOTE 2)	Aluminum	27577	27577
11	#37 Horn, Complete (NOTE 3)	Aluminum	- -	27579
11	#44 Horn, Complete (NOTE 4)	Aluminum	27581	27582
11	#55 Horn, Complete (NOTE 5)	Aluminum	- -	27586
12	Three Horn Base	Aluminum	26020	- -
12	Five Horn Base	Aluminum	- -	26091

NOTE 1 - Includes Orifice Dowel Pin Ref. No. 27284 (.125 Dia.).
NOTE 2 - Includes Orifice Dowel Pin Ref. No. 27283 (.109 Dia.).
NOTE 3 - Includes Orifice Dowel Pin Ref. No. 27282 (.093 Dia.).
NOTE 4 - Includes Orifice Dowel Pin Ref. No. 27283 (.109 Dia.) for S-3L and Orifice Dowel Pin Ref. No. 27281 (.080 Dia.) for S-5T.
NOTE 5 - Includes Orifice Dowel Pin Ref. No. 27281 (.080 Dia.).
NOTE 6 - Furnished Complete as Diaphragm Sel. Ref. No. 27218.



* ALL PARTS IN POWER CHAMBER ARE FULLY INTERCHANGEABLE IN ALL WHISTLES, SINGLE TONE OR CHIME TONE.

MAINTENANCE INSTRUCTIONS

CLEANING DIAPHRAGM AND DIAPHRAGM RING

TO INSPECT AND CLEAN DIAPHRAGM, PART NO. 6 AND DIAPHRAGM RING, PART NO. 5, REMOVE BACK COVER CAP SCREWS, PART NO. 2 AND TAKE OFF BACK COVER, PART NO. 1. DIAPHRAGM RING AND DIAPHRAGM CAN BE REMOVED BY TAKING OUT DIAPHRAGM RING SCREWS, PART NO. 4.

WIPE NOZZLE AS WELL AS DIAPHRAGM AND DIAPHRAGM RING CLEAN.

CLEANING AIR LINES

WHENEVER 1 BACK COVER IS REMOVED IT IS GOOD PRACTICE TO BLOW OUT THE AIR LINES BY OPENING OPERATING VALVE WIDE WITH FULL RESERVOIR PRESSURE ON THE LINE. THIS WILL ALSO CLEAN OUT ORIFICE DOWEL PIN.

WHEN REPLACING BACK COVER, INSTALL LOCK WASHERS, PART NO. 3 AND TIGHTEN BACK COVER CAP SCREWS FIRMLY. PEWTER CAP SCREWS.

NO ADJUSTMENT IS NECESSARY.

REPLACING OR REVERSING WHISTLE

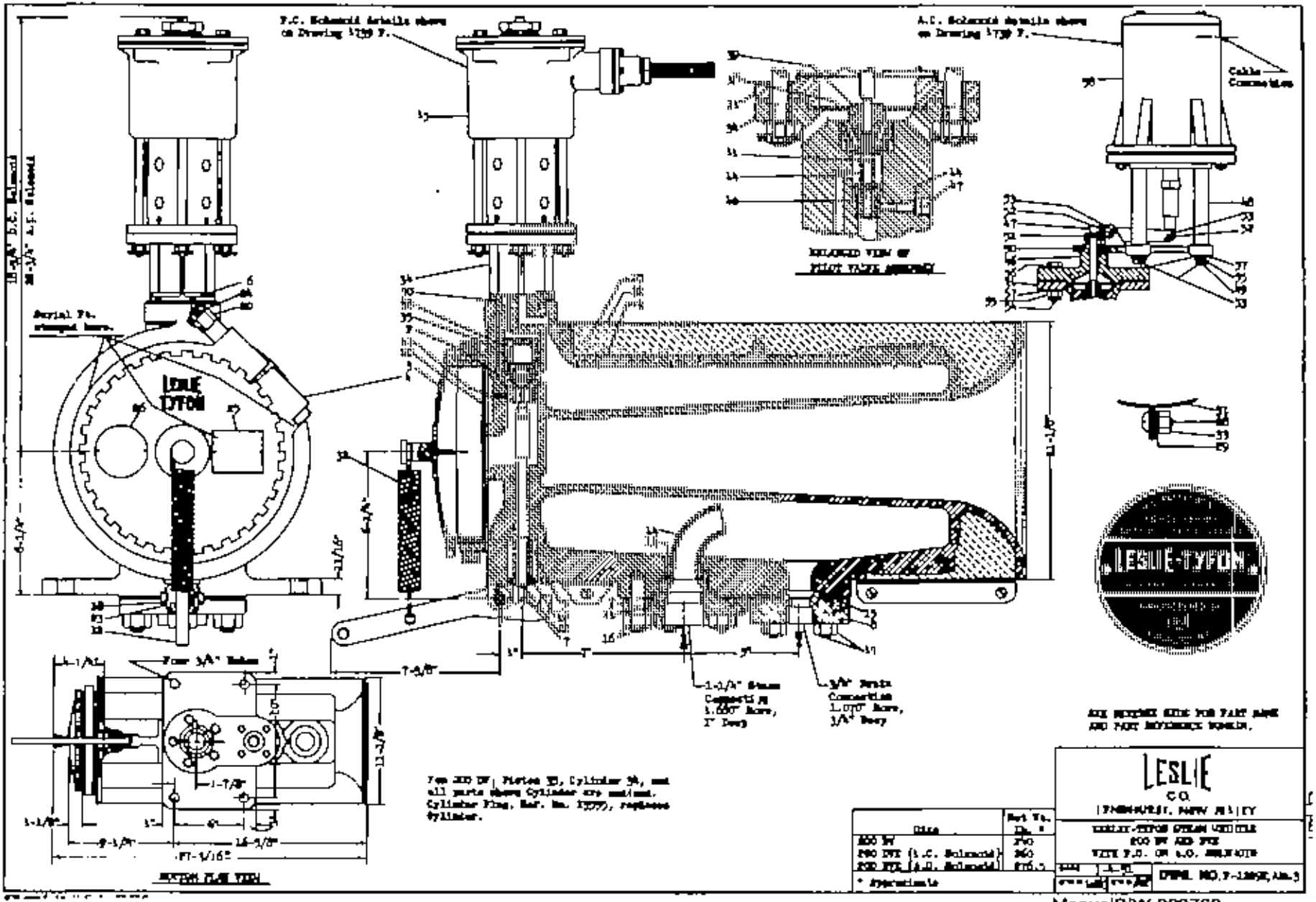
REMOVE HORN CAP SCREWS, PART NO. 10 AND PULL HORN, PART NO. 11 OUT CAREFULLY. BEFORE REPLACING OR REVERSING HORN, THE OUTER SURFACE OF THE SMALL END SHOULD BE COATED WITH VARNISH.

CLEAN GASKET FACES OF DIAPHRAGM HOUSING, PART NO. 7 AND HORN. BE SURE TO REPLACE GASKETS, PART NO. 8.

INSTALL LOCK WASHERS, PART NO. 9 AND TIGHTEN HORN CAP SCREWS FIRMLY. PEWTER CAP SCREWS.

IF IT IS EVER NECESSARY TO REPLACE ORIFICE DOWEL PIN, INSERT IT INTO HORN WITH ORIFICE FACING OUTWARD AND IN LINE WITH RIB OF HORN.

ManualBW-000768



Manual|BW-000769

WHEN ORDERING PARTS, GIVE SIZE, CLASS, PART NAMES AND PART REFERENCE NUMBERS FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - LESLIE-TYPON STEAM WHISTLE
DRAWING NO. 1-1229 F, CLASS 200 DW and 200 DVE, COMPLETE WITH D.C. OR A.C. SOLENOIDS

Part No.	Part Name	Material	Size & Reference Number		
			200 DW	200 DW D.C. Solenoid	200 DVE A.C. Solenoid
1	* Body (NOTE 1)	Cast Bronze	14015	14015	14015
2	* Seat Ring	Stainless Steel, Stellited	11529	11529	11529
3	* Back Cover	Cast Bronze	13818	13818	13818
4	* Lock Ring	Cast Steel	13511	11511	13511
5	* Main Valve 15-150 psi Operating Pressure	Stainless Steel, Stellited	11551B	11552B	11552B
5	* Main Valve 150-300 psi Operating Pressure	Stainless Steel, Stellited	13551A	13552A	13552A
6	* Lock Bolt	Steel	13549	11549	11549
7	* Flange, Inlet	Forged Steel	13541A	11541A	13541A
8	* Flange, Drain	Forged Steel	16235	16235	16235
9	* Main Valve Spring	Corrosion Resistant Alloy	12932	12932	12932
10	* Diaphragm (NOTE 2)	Phosphor Bronze	11091	14091	11091
11	* Nozzle	Cast Bronze	13548	13548	13548
12	* Lever	Cast Bronze	13520	11520	13520
13	* Lock Screw, Nozzle	Steel	13612	11672	11672
14	* Gasket, Inlet	Copper, Asbestos Filled	13541	13541	11544
15	* Gasket, Drain	Copper, Asbestos Filled	16232	16232	16232
16	* Stud and Nut	Steel	9395	9395	9395
17	* Stud and Nut	Steel	15868	15868	15868
18	* Lever Pin	Monel	13554	13554	11554
19	* Spring Seat	Brass	13530	11510	13530
20	* Nut (Lock Bolt)	Steel	13550	13550	13550
21	* Lock Screw, Seat Ring	Steel	12405	12405	12405
22	* Cotter Pin	Monel	7074	7074	5074
23	* Cotter Pin	Monel	7080	7080	7080
24	* Cotter Pin	Monel	10308	10308	10308
25	* Name Plate	Brass	9806	9806	9806
26	* Data Plate	Brass	14292	14292	14292
27	* Insulation	Asbestos	13556	13556	13556
28	* Screw	Brass	9791	9791	9793
29	* Lock Washer	Steel	10397	10397	10397
30	* Gasket	Copper	3472	3472	3472
31	* Sheet Cover	Galvanized Iron	13553	13553	13553
32	* Lever Spring	Corrosion Resistant Alloy	16748	16748	16748
33	* Nut	Brass	9734	9734	9734
34	Cylinder Plug	Cast Bronze	13555	- -	- -
35	Cylinder, Complete (NOTE 3)	Cast Bronze	- -	22779	22779
35	Piston	Cast Bronze	- -	13931	13931
36	Piston Rings (NOTE 4)	Cast Iron	- -	3150	3350
37	Lock Flange	Cast Bronze	- -	12271	12271
38	Lock Disc	Phosphor Bronze	- -	10511	10511
39	Pilot Valve Seat, Upper	Stainless Steel	- -	10382	10382
40	Pilot Valve Seat, Lower	Stainless Steel	- -	10508	10508
41	Pilot Valve	Stainless Steel, Hardened	- -	10216	10236
42	Pilot Valve Spring	Corrosion Resistant Alloy	- -	9811	9811
43	Lock Screw	Steel	- -	10509	10509
44	Gasket, Lock Screw	Copper, Annealed	- -	12275	12275
45	Solenoid, 110 Volt D.C.		- -	9910	- -
45	Solenoid, 220 Volt D.C.		- -	9910A	- -
45	Solenoid, 32 Volt D.C.		- -	9910B	- -
45	Solenoid, 48 Volt D.C.		- -	9910C	- -
46	Bracket	Cast Bronze	- -	- -	12408
47	Lever	Cast Bronze	- -	- -	12411
48	Spacer Tube	Brass	- -	- -	12154
49	Spacer Stud	Steel, Cadmium Plated	- -	- -	12403C
50	Push Rod	Monel	- -	- -	12452
51	Push Rod Cap	Brass	- -	- -	12451
52	Lever Pin	Monel	- -	- -	10541
53	Cotter Pin	Monel	- -	- -	1111
54	Bolt	Steel, Cadmium Plated	- -	- -	12456
55	Nut, Castellated	Monel	- -	- -	10387
56	Washer	Brass	- -	- -	10546
57	Lock Washer	Steel, Nickel Plated	- -	- -	10392
58	Solenoid, 110 Volt A.C.		- -	- -	8731
58	Solenoid, 220 Volt A.C.		- -	- -	8731A
	A.C. Solenoid, Complete with Bracket		- -	- -	8731B
	* Spanner Wrench	Steel	9803	9803	5520
	* Seat Ring Wrench	Malleable Iron	11721	11721	9803
	Pilot Valve Seat Wrench	Malleable Iron	- -	9036	11721

* These items have same Reference Number in all sizes indicating complete interchangeability.

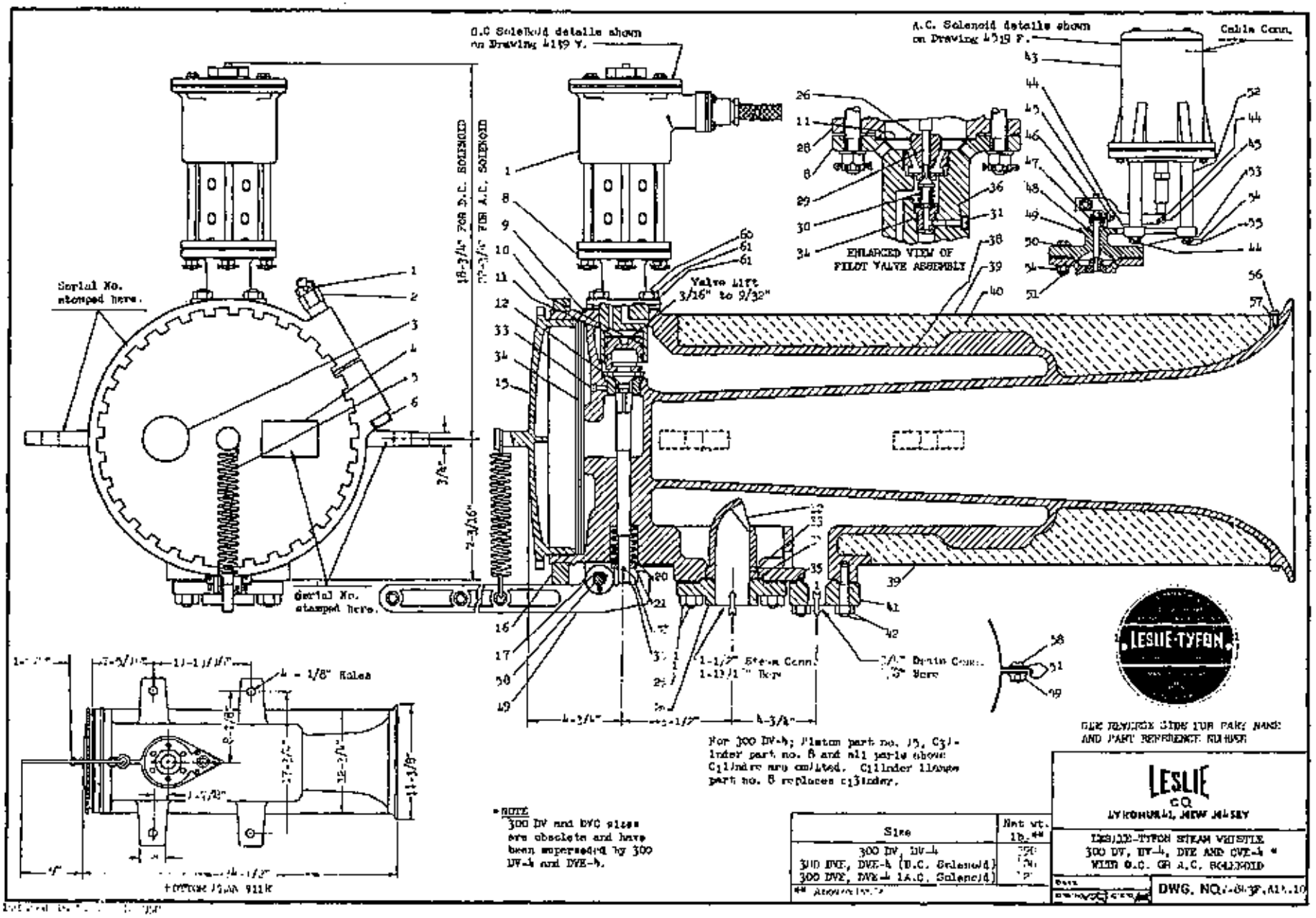
NOTE 1 - Body is furnished complete with Studs and Nuts, Ref. No. 9395 and Ref. No. 15868.

NOTE 1 - Two Diaphragms required for 50-125 Lbs. Operating Pressure; Three Diaphragms for 125-300 Lbs. Operating Pressure.

NOTE 1 - Cylinder is furnished complete with Pilot Valve Seat, Lower, Ref. No. 10508; Lock Screw, Ref. No. 10509; Lock Screw Gasket, Ref. No. 12275 and Cylinder, Ref. No. 13932.

NOTE 1 - Two Piston Rings required per Piston.

FOR ALL CLASSES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE SIZE, CLASS AND SERIAL NUMBER of Manual BW-000770



For 300 DV-4; Piston part no. 15, Cylinder part no. 8 and all parts above Cylinders are outlined. Cylinder liner part no. 8 replaces cylinder.

*NOTE
300 DV and DVC sizes are obsolete and have been superseded by 300 DV-4 and DVE-4.

Size	Net wt. lb.**
300 DV, DV-4	750
300 DVE, DVE-4 (D.C. Solenoid)	774
300 DVE, DVE-4 (A.C. Solenoid)	787

** Approximate

USE REVERSE SIDE FOR PART NAME AND PART REFERENCE NUMBER

LESLIE CO.
LYNCHBURG, NEW JERSEY

LESLIE-TYFON STEAM WHISTLE
300 DV, DV-4, DVE AND DVE-4 *
WITH D.C. OR A.C. SOLENOID

DWG. NO. 4-8-38, A14-10

ManualBIW-000771

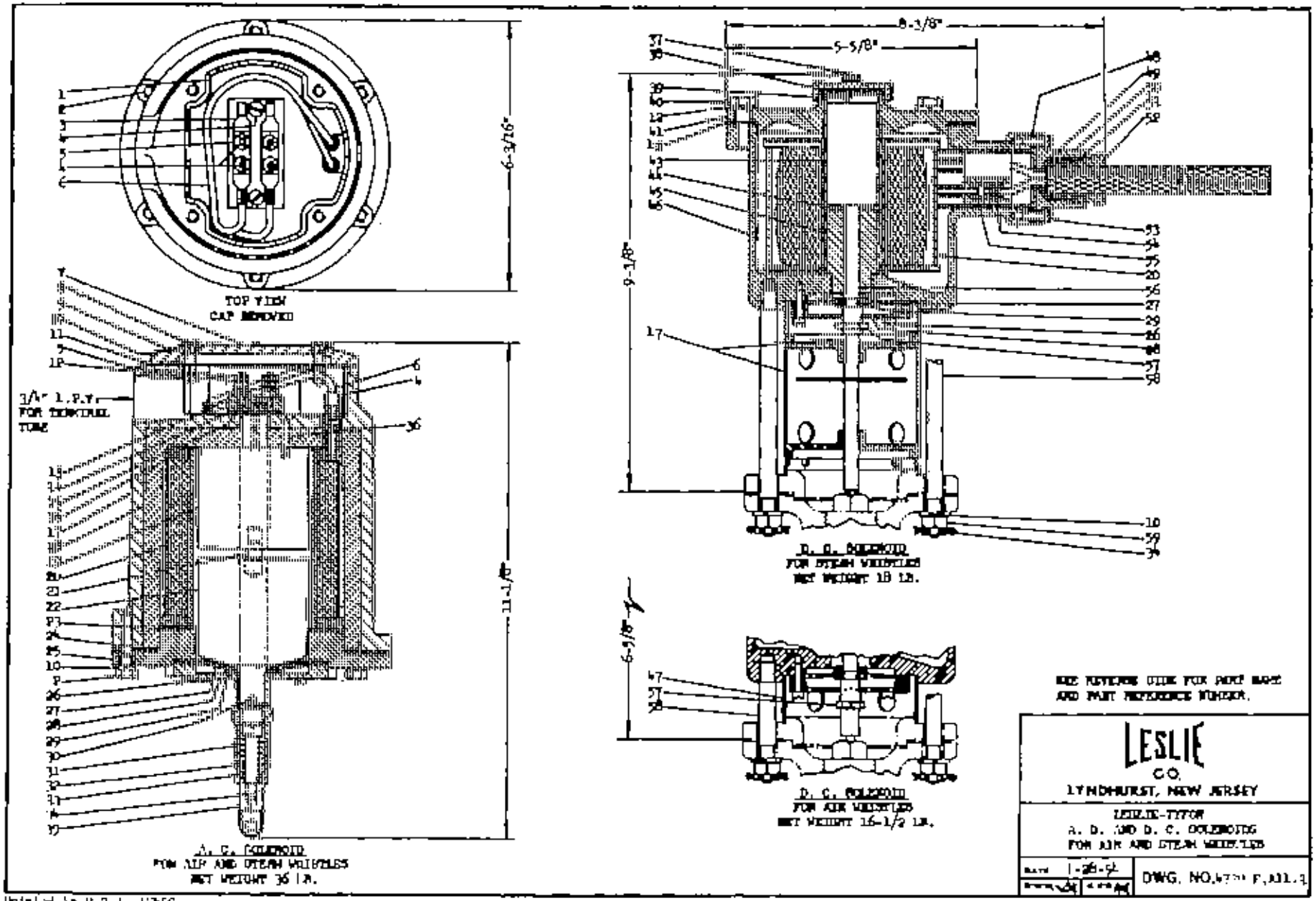
WHEN ORDERING PART, GIVE FULL NAME, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE A 5" NUMBER ONLY TO LOCATE PART IN ILLUSTRATION

PART NAMES AND PART REFERENCE NUMBERS - 14,000-LITRE MOBILE REFUELLER (2), 7,000 U.S. GALLONS AND 900 U.S. GALLONS CAPACITY
REFUELLING UNIT, 3-WAY, 3" AND 4" INLET AND 3" OUTLET, 600 U.S. GPM, 50 P.S.I. DELIVERY PRESSURE

PART NAME	PART REFERENCE NUMBER			
	MATERIAL	350 IVE-4	350 IVE-4 (D.C. SOLENOID)	350 IVE-4 (A.C. SOLENOID)
[illegible]	Metal	7231	7231	7231
[illegible]	Steel	10090	10090	10090
[illegible]	Brass	9856	9856	9856
[illegible]	Brass	14242	14242	14242
[illegible]	Corrosion Resistant Alloy	16986	16986	16986
[illegible]	Stainless Steel	12092	12092	12092
[illegible]	[illegible]	--	9910	--
[illegible]	[illegible]	--	99194	--
[illegible]	[illegible]	--	99109	--
[illegible]	[illegible]	--	99102	--
[illegible] (NOTE 4)	Cast Bronze	14244	--	--
[illegible] 120,5 & 8)	Cast Iron	--	22781	22791
[illegible] (NOTE -)	Copper, Asbestos Filled	21940	21940	21940
[illegible] (NOTE 2)	Cast Iron	--	3158	3158
[illegible]	Cast Bronze	--	13385	13385
[illegible] Operating Pressure	Stainless Steel (NOTE 3)	9146	9146	9146
[illegible] and Above Operating Pressure	Stainless Steel (NOTE 3)	13211	13211	13213
[illegible]	Steel	12405	12405	12405
(NOTE 1)	Pipe Cover Bronze	11092	11092	12092
[illegible]	Cast Bronze	12016	12016	12016
[illegible]	Cast Steel	12082	12082	12082
[illegible]	Monel	7015	7015	7015
[illegible]	Monel	9781	9780	9781
[illegible]	Cast Bronze	13847	13847	13847
[illegible] Operating Pressure	Corrosion Resistant Alloy	9482	9482	9482
[illegible] 150 lb. Operating Pressure	Corrosion Resistant Alloy	10083	10084	10083
[illegible]	Bronze	9779	9779	9779
[illegible]	Monel	7209	7209	7209
[illegible] 11 lbs. Operating Pressure	Stainless Steel (NOTE 3)	12280E	12280E	12280E
[illegible] 300 lb. Operating Pressure	Stainless Steel (NOTE 3)	13214A	13214A	13214A
[illegible] 250 lb. Operating Pressure	Stainless Steel (NOTE 3)	13214C	13214C	13214C
[illegible] 250 & 300 lb. Operating Pressure	Stainless Steel (NOTE 3)	13211D	13214D	13214D
[illegible]	Stainless Steel (NOTE 3)	13211A	13211A	13214A
[illegible]	Ported Steel	9818	9818	9818
[illegible]	Steel	11106	11106	11106
[illegible] Pipe	Stainless Steel	--	10382	10382
[illegible]	Phosphor Bronze	--	10311	10311
[illegible]	Cast Bronze	--	12278	12278
[illegible]	Stainless Steel, Hardened	--	10236	10236
[illegible]	Corrosion Resistant Alloy	--	9817	9817
[illegible] Pipe, Inner	Stainless Steel	--	10308	10308
[illegible]	Cast Bronze	9717	9717	9717
[illegible]	Steel	13718	13718	13718
[illegible]	Copper, Asbestos Filled	9794	9794	9794
[illegible]	Copper, Asbestos Filled	9795	9795	9795
[illegible]	Copper, Expansion	--	12279	12279
[illegible]	Stainless Steel	--	10309	10309
(NOTE 4)	Cast Bronze	21092	21092	21092
[illegible]	Galvanized Sheet Iron	9788	9788	9788
[illegible] Inner	Galvanized Sheet Iron	9789	9789	9789
[illegible]	Asbestos	10018	10018	10018
[illegible]	Brass Steel	15870	15870	15870
[illegible]	Steel	158681	158681	158681
[illegible]	[illegible]	--	--	8732
[illegible]	[illegible]	--	--	87311
[illegible]	[illegible]	--	--	87309
[illegible]	Monel	--	--	7113
[illegible]	Monel	--	--	12541
[illegible] Complete (NOTE 1)	Cast Bronze	--	--	12411
[illegible]	Bronze	--	--	12457
[illegible]	Steel	--	--	14256
[illegible]	Cast Bronze	--	--	12469
[illegible]	Bronze	--	--	10556
[illegible]	Steel, Carrier Plate	--	--	12556
[illegible]	Brass	--	--	12454
[illegible]	Steel, Nickel Plated	--	--	14302
[illegible]	Monel	--	--	12557
[illegible]	Stainless Steel	--	--	11[illegible]32
[illegible]	Brass	9793	9793	[illegible]
[illegible]	Steel	10311	10597	10597
[illegible]	Iron	12299	12299	12299
[illegible]	Brass	9736	9736	9736
[illegible]	Steel	9495	9495	9495
[illegible]	Steel	10511	10513	10513
[illegible]	Stainless Steel	27188	27188	27188
[illegible] Complete with Bracket		--	--	1559
[illegible] Complete with Bracket and Cylinder (NOTE 1)		--	--	87247
[illegible] Complete with Cylinder (NOTE 1)		--	21248	--
[illegible]	Brass	9854	9854	9854
[illegible] Below 75 lbs. Operating Pressure	Malleable Iron	9554	9154	9559
[illegible] 75 lbs. and Above Operating Pressure	Malleable Iron	13549	13541	13541
[illegible]	Malleable Iron	--	9636	9636

[illegible] Cast Iron or Malleable Bushing in all sizes, indicating complete interchangeability.
[illegible] Solenoid, A Series for 10-125 lb. Operating Pressure; Three Solenoids for 125-300 lb. Operating Pressure.
[illegible] Required per Plate.
[illegible] Brass and Cast Yellow Iron Stellited Seating Surface.
[illegible] Plate & Disc, 4 pcs. 3/4 Min. For replacement purposes all Ref. Nos. as used on sheet except following:
350 IVE-4 (D.C. Solenoid, 24 V.), Ref. No. 87248; 3/4" BW Cylinder Plug, Ref. No. 6311; Cylinder Gasket, Ref. No. 4550;
[illegible] Ref. No. 87248; A.C. Solenoid Complete with Bracket and Cylinder, Ref. No. 87247; and 3/4" B.S.P. Gasketed, Complete
[illegible] Ref. No. 12557.
NOTE [illegible] with Part No. 41, Pilot Valve Body, Brass, Reg. No. 11405; Part No. 71, Lock Screw, Ref. No. 12500; Part No. 36,
[illegible] Ref. No. 14281 and Cylinder, Ref. No. 87245.
[illegible] Ref. No. 11405 and Cover, Ref. No. 87247; Cap Screw, Ref. No. 12410; Ball, Ref. No. 12201; Gasket Ref.
Ref. No. 11405 and Cover, Ref. No. 9854.
FOR ALL PARTS NOT LISTED, PLEASE ORDER PARTS BY SIZE AND CLASS AND GIVE COMPLETE NAME OF TYPE.

ManualBIW-000772



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ManualBIW-000773

WHEN ORDERING PARTS, GIVE TYPE, VOLTAGE, PART NAME AND PART REFERENCE NUMBERS FROM CABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NAMES AND PART REFERENCE NUMBERS - LESLIE-TYPES A. C. AND D. C. SOLENOIDS
DRAWING NO. 4119 F, AIR AND STEAM WHISTLES

PART NO.	PART NAME	MATERIAL	DIRECT CURRENT		ALTERNATING CURRENT
			AIR WHISTLES	STEAM WHISTLES	AIR AND STEAM WHISTLES
1	Insulation Strip	Varnished Cambric	- -	- -	10802
2	Bolt, Base	Steel, Cadmium Plated	- -	- -	11843
3	Terminal Lugs	Copper	- -	- -	10630
4	Screw	Brass	- -	- -	10548
5	Nut	Brass	- -	- -	10632
6	Coil Lead, Complete	Vinylite Coated Wire	- -	- -	13105
7	Coil Plate	Brass	- -	- -	10615
8	Screw	Brass	- -	- -	15530
9	Cap	Cast Bronze	- -	- -	10519
10	Lock Washer	Steel, Nickel Plated	10112	10392	10397
11	Gasket, Cap	Sheet Rubber	- -	- -	10522
12	Lock Washer	Steel, Nickel Plated	13077	13077	- -
13	Lock Washer	Steel	- -	- -	10634
14	Terminal Base	Bakelite	- -	- -	10629
15	Insulating Pad	Bakelite	- -	- -	10631
16	Insulation Plate	Varnished Cambric	- -	- -	10681
17	Coil Gasket	Varnished Cambric	- -	- -	10523
18	Casing	Cast Bronze	- -	- -	23889
19	Magnetic Casing	Cast Semi-Steel	- -	- -	23888
20	Core	Laminated Iron	- -	- -	10528
21	Coil, Complete 110 Volt	Magnet Wire	9901	9907	10520
22	Coil, Complete 220 Volt	Magnet Wire	9907A	9901A	10520A
23	Coil, Complete 32 Volt	Magnet Wire	9907B	9901B	- -
24	Coil, Complete 48 Volt	Magnet Wire	9907C	9907C	- -
25	Coil, Complete 440 Volt	Magnet Wire	- -	- -	10520B
27	Guide Pin	Phosphor Bronze	- -	- -	10611
28	Plunger	Laminated Iron	- -	- -	10529
23	Gasket	Varnished Cambric	- -	- -	11895
24	Gasket	Sheet Rubber	- -	- -	10521
25	Base	Cast Steel	- -	- -	10527
26	Screw	Steel, Cadmium Plated	10532	10532	10512
27	Diaphragm	Synthetic Rubber	11261	11261	10524
28	Diaphragm Cover	Cast Bronze	11266	11266	10531
29	Washer, Diaphragm	Brass	11270	11270	10511
30	Cotter Pin	Monel	- -	- -	10308
31	Connecting Spring	Stainless Steel	- -	- -	10537
32	Connecting Screw	Monel	- -	- -	10535
33	Connecting Bushing	Brass	- -	- -	10536
34	Cotter Pin	Monel	7213	7213	1113
35	Connecting Screw Head	Monel	- -	- -	10538
36	Screw	Iron	- -	- -	11894
37	Cap Nut	Brass	11262	11262	- -
38	Disc	Phosphor Bronze	11261	11261	- -
39	Packing	Sheet Rubber	11264	11264	- -
40	Cap Screw	Stainless Steel	21610	21610	- -
41	Top Plate	Cast Semi-Steel	12834	12834	- -
42	Gasket	Sheet Rubber	12836	12836	- -
43	Core, Plunger	Soft Iron, Cadmium Plated	11256	11258	- -
44	Washer	Phosphor Bronze	11279	11279	- -
45	Magnet	Soft Iron, Cadmium Plated	11259	11259	- -
46	Guard Cylinder	Malleable Iron	12828	12828	- -
47	Spacer, Complete	Brass	11272	11259	- -
48	Gasket	Sheet Rubber	11274	11274	- -
49	Washer	Sheet Rubber	11446	11446	- -
50	Connecting Box Cover	Cast Bronze	11273A	11273A	- -
51	Packing	Flax Yarn	15858	15858	- -
52	Packing Ring Nut	Brass	11124A	11124A	- -
53	Screw	Brass	11268	11268	- -
54	Connecting Screw	Brass	11289	11289	- -
55	Insulation Tubing	Sheet Rubber	11281	11281	- -
56	Stem	Phosphor Bronze	11269	11269	- -
57	Stem Nut	Brass	11271	11404	- -
58	Stud	Stainless Steel	11402A	11403A	- -
59	Nut, Castellated	Monel	10361	10359	- -

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER AND INCLUDE SERIAL NUMBER OF TYPON.

ManualBIW-000774

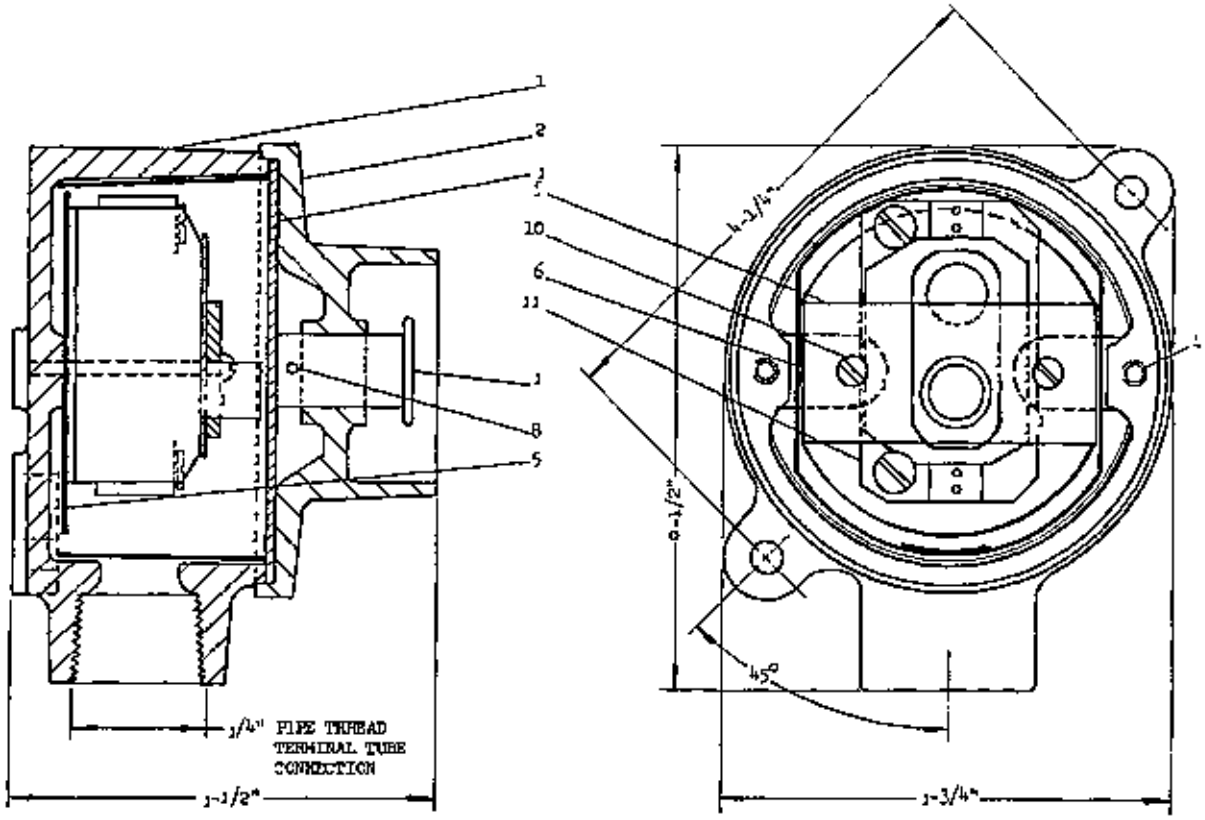
WHEN ORDERING PARTS, GIVE PART NAMES AND PART REFERENCE NUMBERS FROM TABLE BELOW.
USE PART NUMBERS ONLY TO LOCATE PART ON DRAWING.

PART NAMES AND PART REFERENCE NUMBERS - PUSH BUTTON SWITCH
FOR DIRECT AND ALTERNATING CURRENT

Part Number	Part Name	Material	Reference Number
1	Body	Cast Bronze	[illegible]
2	Cover	Cast Bronze	[illegible]
3	Gasket, Diaphragm	Oil Resistant Rubber	[illegible]
4	Screw (NOTE 1)	Steel, Cadmium Plated	[illegible]
5	Insulation Washer	Varnish Cambric	[illegible]
6	Insulation	Varnish Cambric	[illegible]
7	Push Button	Brass	[illegible]
8	Cotter Pin	Brass	[illegible]
9	Panel Clamp Block	Bakelite	[illegible]
10	Screw	Brass	[illegible]
11	Switch, Toggle		[illegible]
	Push Button Switch, Complete		[illegible]

NOTE 1 - Screw not shown on drawing.

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER



END VIEW - COVER REMOVED

WEIGHT COMPLETE OF PUSH BUTTON SWITCH - 4 LB.

LESLIE CO.
LYNDHURST, NEW JERSEY

LESLIE-TYPE
PUSH BUTTON SWITCH
FOR DIRECT AND ALTERNATING CURRENT

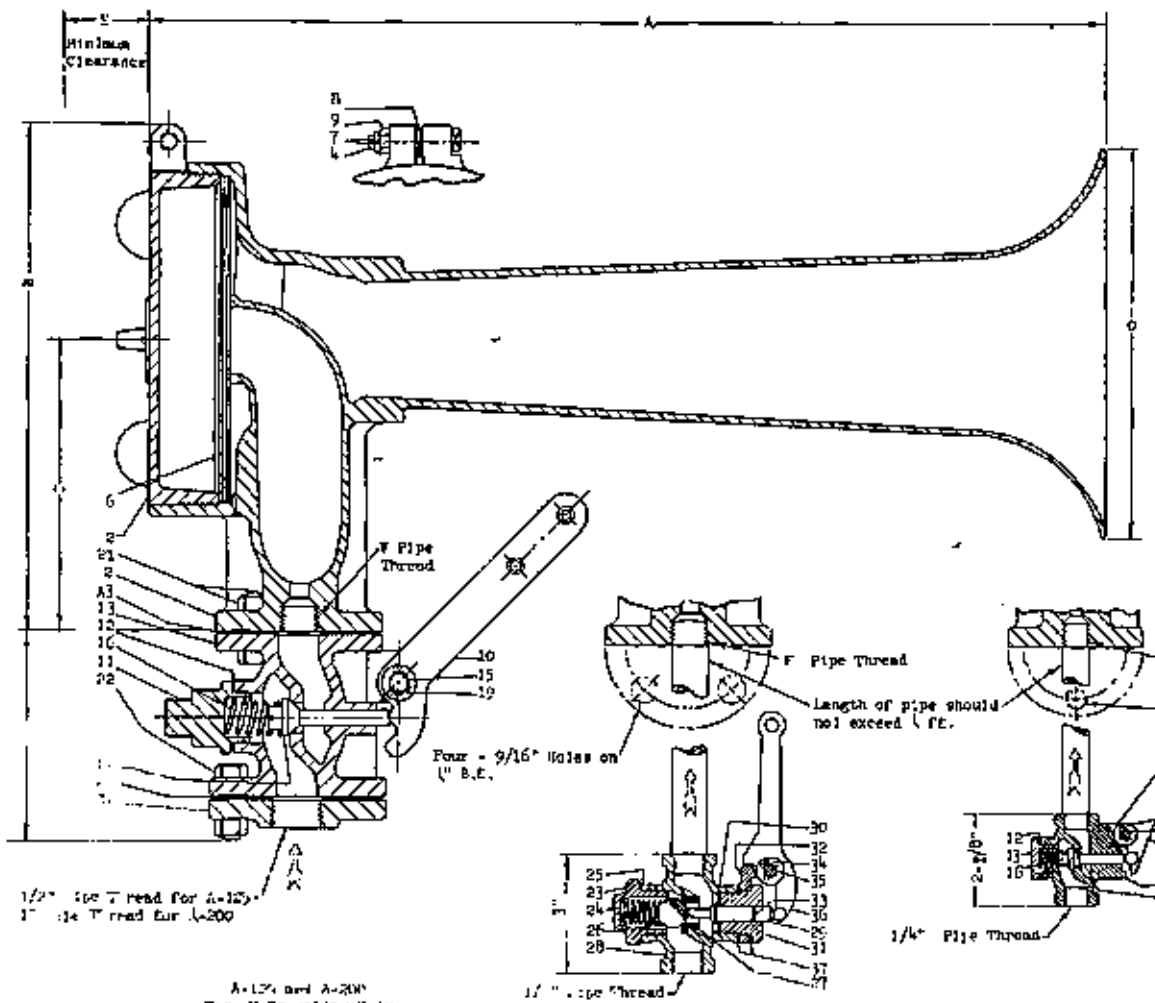
DATE 9-16-53
DRAWN [illegible]
CHECKED [illegible]
APPROVED [illegible]
Manual [illegible] 3 Sht.

Printed in U.S.A. 9535C

DIMENSIONS IN INCHES

Size	Former Size	A	B	C	F	E	W	Net Wt. Lbs. *
A-35-440-MB	A-35-H	10-3/0	5-3/16	E-3/4	3-1/2	3	1/4	6
A-75-330-MB	A-33-4	16-11/16	5-3/16	P-3/4	5-7/16	3	1/4	10
A-75-262-MB	A-75-LL	20-21/32	5-1/16	2-3/4	5-7/16	3	1/4	31
A-125-207-MB	A-125-L	19-1/4	6-3/8	4-3/4	6-5/8	4	1/2	23
A-125-206-MB	A-125-11	23	8-3/8	4-3/4	6-5/8	4	1/2	2(
A-200-233-MB	A-200-H	20-11/32	12-5/16	7-3/32	9-7/8	5	1/2	51
A-200-356-MB	A-200-L	24-29/32	12-5/16	7-3/32	9-7/8	5	1/2	55

* Approximate, does not include operating valve.



A-125 and A-200
Type M Operating Valve
[illegible]

A-125 and A-200
Type BA-1 Operating Valve
for Industrial service
Net weight 2 lb. approx.

A-35 Type M
Operating Valve for Marine
and Industrial service
Net weight 2 lb. approx.

SEE REVERSE SIDE FOR PART NAME AND PART REFERENCE NUMBER.

LESLIE CO.
LYNDHURST, NEW JERSEY

LESLIE-TYFON WHISTLE
A-35, A-125 AND A-200
OPERATING WITH OPERATING VALVE
FOR MARINE AND INDUSTRIAL SERVICE

DWG. NO. 3570 F.U.L.3

LT-6A

Printed in U.S.A. 10-1-4

ManualBIW-000776

WHEN ORDERING PARTS, GIVE SIZE, CLASS, PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW
USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

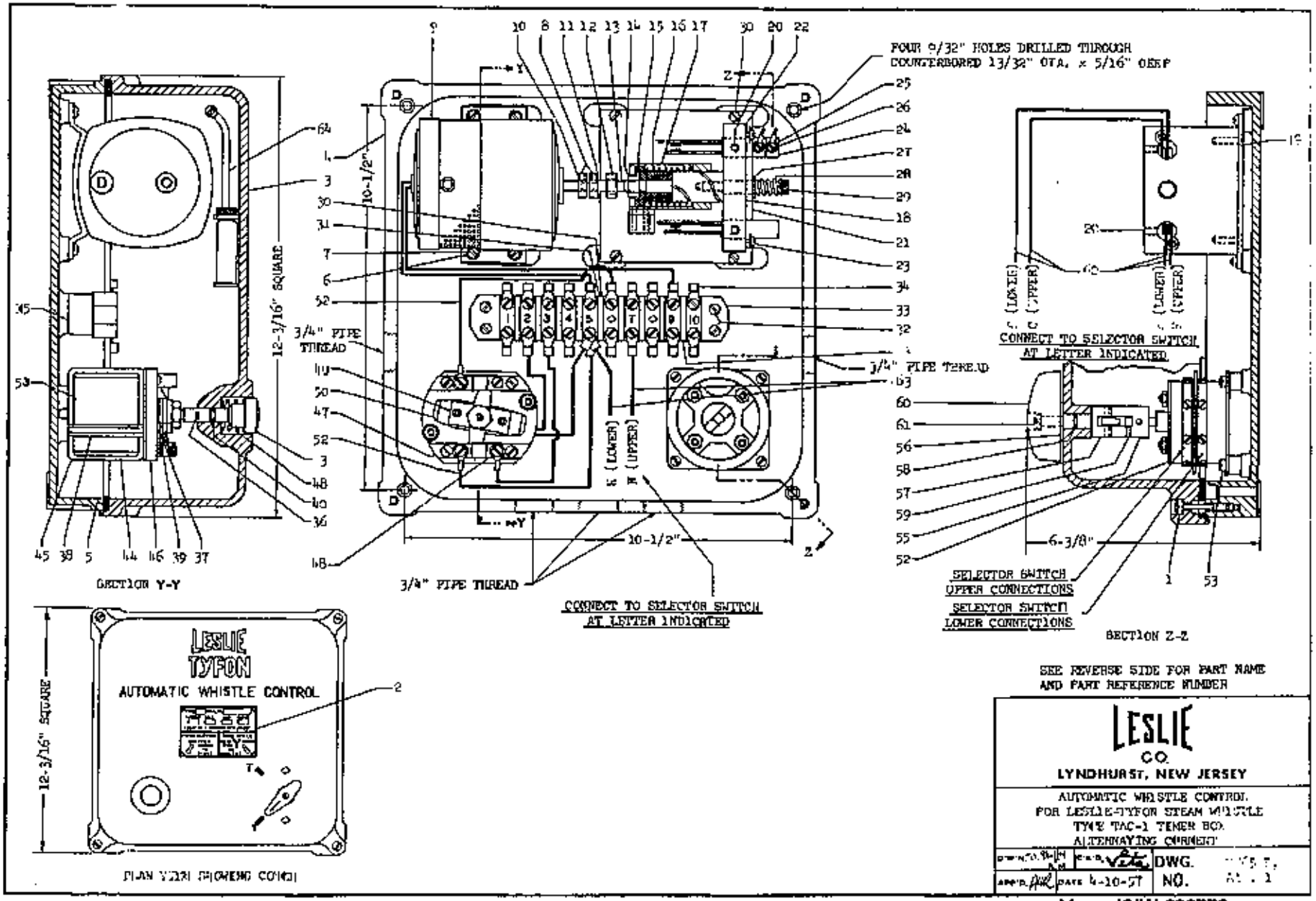
DRAWING NO. 3570 F, PART NAMES AND PART REFERENCE NUMBERS - LESLIE-TYPE MODULES

Part No.	Part Name	Material	Size & Reference Number A-71	A-121	A-200
	AIR WORK ONLY - MARINE AND INDUSTRIAL				
1	Diaphragm Housing, Complete A-75-440-MB	Cast Bronze	19480	- -	- -
1	Diaphragm Housing, Complete A-75-330-MB	Cast Bronze	19411	- -	- -
1	Diaphragm Housing, Complete A-75-262-MB	Cast Bronze	19452	- -	- -
1	Diaphragm Housing, Complete A-121-247-MB	Cast Bronze	- -	19413	- -
1	Diaphragm Housing, Complete A-125-206-MB	Cast Bronze	- -	19454	- -
1	Diaphragm Housing, Complete A-200-233-MB	Cast Bronze	- -	- -	19487
1	Diaphragm Housing, Complete A-200-156-MB	Cast Bronze	- -	- -	19455
2	Back Cover	Cast Bronze	10376	10361	10367
4	Lock Bolt	Monel	10377	10386	10386
6	Diaphragm (NOTE 1)	Phosphor Bronze	11090	11086	11091
7	Cotter Pin	Monel	7113	7080	7080
8	Lock Washer	Steel, Plated	10397	10392	10392
9	Nut (Castellated)	Monel	10378	10387	10387
	MANUAL OPERATING VALVE - TYPE M				
10	Lever	Cast Bronze	9940	9702	9702
11	Bottom Cap	Cast Bronze	3891	18886	18886
12	Bottom Cap Gasket	Copper	3490	3492	3492
13	Valve Body	Cast Bronze	9939	18884	18884
14	Valve	Phosphor Bronze	9941	18885	18881
15	Lever Pin	Monel	9942	9731	9731
16	Spring	Phosphor Bronze	9944	18604	18604
17	Gasket (Outlet)	Sheet Packing	- -	10094	10094
18	Gasket (Inlet)	Sheet Packing	- -	11382	11383
19	Cotter Pin	Monel	7113	7080	7080
20	Companion Flange	Cast Bronze	- -	10609	18971
21	Bolt and Nut	Steel	- -	9008	9008
22	Bolt and Nut, Inlet	Steel	- -	3653	3653
	MANUAL OPERATING VALVE - TYPE HA-1				
23	Spring Cap	Cast Semi-Steel	- -	14641	14641
24	Spring	Stainless Steel	- -	11103	11103
25	Gasket	Sheet Packing	- -	16507	16507
26	Ball	Stainless Steel	- -	14771	14771
27	Seat Ring	Rubber Compound	- -	20170	20170
28	Main Body, Complete (NOTE 2)	Cast Semi-Steel	- -	20584	20584
29	Stem	Stainless Steel	- -	20598	20598
30	Spring Clip	Corrosion Resistant Alloy	- -	14736	14736
31	Stem Bushing	Brass	- -	20599	20599
32	Yoke	Cast Bronze	- -	14640	14640
33	"O" Ring	Rubber Compound	- -	20483	20483
34	Cotter Pin	Stainless Steel	- -	14883	14883
35	Lever Pin	Stainless Steel	- -	14642	14642
36	Lever	Cast Bronze	- -	14637	14637
37	Gasket, Yoke	Sheet Packing	- -	16506	16506

NOTE 1 - Two Diaphragms required for 40-80 lb. Pressure and Three Diaphragms required for 70-300 Lb. Pressure.
NOTE 2 - Main Body is furnished complete with Seat Insert, Reference Number 20513.

FOR ALL CLASSES NOT LISTED, PLEASE ORDER PARTS BY NAME AND INCLUDE SIZE, CLASS AND SERIAL NUMBER OF LESLIE-TYPE.

ManualBIW-000777



Manual8IW-000778

DRAWING NUMBER 7765 V. FLYER BOX, TYPE TAC-1

WHEN ORDERING PARTS, GIVE PART NAME AND PART REFERENCE NUMBER FROM TABLE BELOW

USE PART NUMBER ONLY TO LOCATE PART ON DRAWING

PART NO.	PART NAME	MATERIAL	REF. NO.
1	Screw, Cover	Stainless Steel	24548
2	Data Plate	Stainless Steel	24513
3	Cover	Aluminum	24577
4	Housing	Aluminum	24518
5	Gasket, Cover	Synthetic Rubber	21715
6	Lock Washer	Steel	11467
7	Screw	Stainless Steel	24156
8	Set Screw	Steel	24156
9	Motor, 115 V. A.C.		24332
9	Motor, 220 V. A.C.		24332A
10	Coupling, Female	Brass	25415
11	Coupling, Male	Brass	14116A
12	Bearing Block	Bakelite	35427
13	Flasher Spindle	Phosphor Bronze	35422
14	Nut	Brass	11514
15	Guide bushing	Bakelite	11145A
16	Return Spring	Phosphor Bronze	15417A
17	Contactor Sleeve Assembly (NOTE 1)	Bronze and Nylon	21112
18	FLASHER FRAME ASSEMBLY Consists of following parts which may be ordered individually, 19 to 27 inclusive.		
19	Screw	Steel	11442
20	Set Screw	Steel	24316
21	Flasher Frame Base	Steel	35421
22	Flasher Frame	Bakelite	35419
23	Screw	Brass	24125
24	Contact Assembly	Copper and Bakelite	24711
25	Lock Washer (NOTE 2)	Stainless Steel	21665
26	Screw (NOTE 2)	Steel	24709
27	Washer	Nylon	35427
28	Spring	Phosphor Bronze	30143
29	Shoulder Screw	Steel	35596
30	Screw, Supporting Spacer	Stainless Steel	26839
31	Supporting Spacer	Bakelite	26841
32	Screw	Stainless Steel	24156
33	Terminal Strip	Bakelite	24576
34	Terminal Lug	Copper	24111
35	Spacer	Bakelite	24705
36	Cotter Pin	Monel	11197
37	Nut	Brass	11160
38	Bind	Stainless Steel	11461
39	Washer	Brass	11554
40	O-Ring	Synthetic Rubber	20451
41	Spring	Stainless Steel	24707
43	Push Button	Bakelite	24709
43	Marker Strip	Fiber	26074
44	HOLDING COIL SWITCH ASSEMBLY COMPLETE 115 V.		24718
44	HOLDING COIL SWITCH ASSEMBLY COMPLETE 230 V.		24718A
	Consists of following parts which may be ordered individually, 45 to 52 inclusive.		
45	Magnetic Circuit Complete	Electric Iron	24712
46	Holding Coil Base and Switch Assembly	Bakelite and Brass	14913
47	Auto Ing Complete (NOTE 4)	Brass	11625
48	Band Lug Complete (NOTE 45	Brass	11526
49	Contactor Complete (NOTE 35	Copper and Bakelite	14958
50	Holding Coil Spring (NOTE 51	Phosphor Bronze	14159
51	Holding Coil Assembly, 115 V.	Electric Iron and Copper	24720
51	Holding Coil Assembly, 230 V.	Electric Iron and Copper	24720A
52	Leads, 20" long	Copper, Insulated	24721
53	Screw	Stainless Steel	24351
54	Selector Switch		35562
55	Coupling	Aluminum	24572
56	Washer	Stainless Steel	24341
57	Spindle, Complete	Aluminum	24570
58	O-Ring (NOTE 3)	Synthetic Rubber	20083
59	Set Screw	Steel	14529
60	Knob	Bakelite	26444
61	Screw	Steel	26414
62	Leads, 12" long	Copper, Insulated	24724
63	Leads, 8" long	Copper Insulated	24725
64	Oil Can, 1/2 Fluid oz.	Brass, Nickel Plated	29365

NOTE 1 - Contactor Sleeve Assembly includes Contactor (Spiker) Ref. No. 21549A and two (2) Screws (Brass) Ref. No. 21549, but may be ordered individually if desired.

NOTE 2 - Is included in Contact Assembly, Ref. No. 24711, but may be ordered individually if desired.

NOTE 3 - Is included in Holding Coil Switch and Base Assembly, Ref. No. 14913, but may be ordered individually if desired.

NOTE 3 - Is included in Spindle, Complete Ref. No. 24570. But may be ordered individually if desired.

OTHER BOX, TYPE TAC

When ordering parts for Type TAC, use Reference Numbers shown above (as for TAC-1 except parts shown below.

8	Set Screw	Steel	13589
3	Motor, 115 V. A.C.		24337
9	Motor, 220 V. A.C.		24337A
10	Coupling	Brass	25416
13	Flasher Spindle	Phosphor Bronze	11503A
16	Flasher Frame Assembly		24716
21	Flasher Frame Base	Steel	35421
22	Flasher Frame	Bakelite	24715
54	Selector Switch		24350
	Toggle, 2-1/2" long	Metal, Insulated	24721

PLEASE ORDER PARTS BY PART NAME AND PART REFERENCE NUMBER AND INCLUDE SERIAL NUMBER OF OTHER BOX.

ManualBIW-000779

REFERENCE TABLES, ENGINEERING DATA

ENGINEERING DATA BULLETIN

REFERENCE TABLES

COMPUTATIONS, FORMULAS

CONVERSION FACTORS

REFERENCE TABLES
ENGINEERING DATA



engineering data reference tables

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STEAM FLOW IN PIPES Recommended Velocities for Fluid Flow; Steam Capacity of Iron vs. Steel Pipe; Comparative Pipe Capacities; Condensation Rates.	4
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LESLIE COAST-TO-COAST SERVICE	Back Page

1900

engineering data
FORMULAS FOR VALVE SIZING

COMPUTATIONS AND FORMULAS

When sizing regulators and control valves, accurate computation of steam flow is necessary so that the regulator or controller will operate as closely as possible to its rated capacity. The following formulas will help in making many of these computations.

STEAM HEATING SYSTEMS

Where direct, cast iron radiation is used, the

★ Maximum Steam Flow Required in Lbs. per Hour $= \frac{\text{Total sq. ft. Radiation}}{3}$

This formula includes an allowance for heat loss in connecting piping.

HEATERS, HOT WATER, FUEL OIL, ETC.

Where steam is the heating medium.

★ Max. Steam Flow, Lbs. per hr. $= \frac{\text{Max. Gals. per hr.} \times \text{Temperature Rise} \times \text{Specific Heat}}{100}$

This formula includes an allowance for heat loss.

Specific Heat of Water — 1.0
of Fuel Oil — 0.6

SIZING DIAPHRAGM CONTROL VALVES WITH Cv NUMBERS

C_v numbers are valve coefficients which define the maximum capacity of any given valve. For example, a valve with a C_v of 1 has a capacity of 1 GPM of water at 1 psi pressure drop. You will find them simple and easy to work with after a few sample problems:

1 TO SIZE a Diaphragm Control Valve using C_v numbers, the required C_v number must FIRST be obtained by using the following formulas:

LIQUIDS

$$C_v = \frac{\text{GPM}\sqrt{\text{Sp. Gr.}}}{\sqrt{\text{Press. Drop, psi}}}$$

WHERE Sp. Gr. of water = 1
GPM = Gals./min. at flowing temperature

STEAM AND GAS

When P_2 is ½ of P_1 or less, use

DRY SATURATED STEAM

$$C_v = \frac{\text{Lbs./Hr.}}{1.5 \times P_1}$$

AIR, GAS

$$C_v = \frac{\text{CFH}\sqrt{\text{Sp. Gr.}}}{30.5 \times P_1}$$

When P_2 is more than ½ of P_1, use:

DRY SATURATED STEAM

$$C_v = \frac{\text{Lbs./Hr.}}{3\sqrt{(P_1 - P_2)\,P_2}}$$

AIR, GAS

$$C_v = \frac{\text{CFH}\sqrt{\text{Sp. Gr.}}}{6\sqrt{(P_1 - P_2)\,P_2}}$$

For Temperature, Superheat, or Moisture correction, see Step 2.

WHERE:

P_1=Inlet press. psia (lbs. per sq. in. absolute)

P_2=Outlet press. psia (lbs. per sq. in. absolute)

Absolute press. = Gage press. (psi) + 14.7

CFH = Cu. ft. free air/hr. (14.7 psia 60° F)

Sp. Gr. Air = 1

2 Correct C_v number obtained from above formulas by multiplying by correction factors, if applicable.

FOR STEAM

Correction for Superheat =
$f + .00065$ (°Superheat)

Correction for % Moisture $= \sqrt{\text{Quality}}$

[For example, if Moisture is 2% then Quality $= (1. - .02) = .98$]

FOR GAS

Correction for Temperature

$$\sqrt{\frac{460 + ^\circ\text{Fahrenheit}}{520}}$$

3 Select valve size from C_v table in Diaphragm Control Valve Bulletin 5304 or 5305. Correct size has C_v number equal to or greater than required C_v.

SIZING REGULATORS AND CONTROL VALVES WITH CAPACITY TABLES

Capacity tables provide a fast, convenient method for sizing regulators and control valves for steam, air, gas and water service. Easy-to-use tables are included in applicable bulletins as follows:

Bulletin 5302—Pressure Reducing Valves

Bulletin 5304—Single-Seated Diaphragm Control Valves

Bulletin 5305—Double-Seated Diaphragm Control Valves

Bulletin 5306—Pump Pressure Regulators

Bulletin 5307—Temperature Regulators

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Manual IW-000782

LESLIE

engineering data
PROPERTIES OF SATURATED STEAM

BELOW ATMOSPHERIC PRESSURE

Vacuum Inches of Mercury	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
29	[illegible]	[illegible]	[illegible]	1094	1047
27	119	[illegible]	87	1110	1027
[illegible]	1[illegible]	[illegible]	102	1119	1012
20	[illegible]	74.8	1[illegible]	1130	1001
15	179	11.8	147	1137	990
10	192	39.1	160	1143	[illegible]
5	203	71.8	171	1143	976
1	210	103.7	1[illegible]	1140	971

ABOVE ATMOSPHERIC PRESSURE

Pressure PSI (Gage)	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
1	219	26.8	180	1150	976
1	[illegible]	24.3	183	1151	967
1	211	22.0	1[illegible]	1152	966
1	22[illegible]	22.8	1[illegible]	1164	967
1	234	20.7	197	1150	[illegible]
1	227	18.5	1[illegible]	1150	[illegible]
1	234	18.9	1[illegible]	1150	[illegible]
1	233	11.1	200	1160	[illegible]
1	238	17.7	203	1150	[illegible]
1	137	16.7	206	1150	[illegible]
17	239	19.1	206	1150	[illegible]
11	247	18.5	[illegible]	1160	[illegible]
12	244	16.8	213	1164	[illegible]
1[illegible]	246	14.6	211	1160	947
1[illegible]	[illegible]	14.0	211	1163	[illegible]
1[illegible]	254	13.6	219	1164	[illegible]
1[illegible]	250	18.5	229	1164	[illegible]
1[illegible]	254	13.5	227	1160	940
1[illegible]	256	12.8	224	1160	941
1[illegible]	257	12.1	761	1160	[illegible]
[illegible]	267	11.1	227	1160	13[illegible]
[illegible]	347	10.9	234	1160	933
[illegible]	254	9.7	243	1172	936
[illegible]	291	8.5	130	1172	933
48	287	7.34	236	1170	[illegible]
46	292	1.11	262	1127	964
[illegible]	300	6.62	137	1170	911
[illegible]	303	3.17	192	1170	947
40	641	2.99	277	1191	980
[illegible]	[illegible]	6.46	7[illegible]	1180	[illegible]
[illegible]	119	5.14	296	1180	[illegible]
[illegible]	320	4.87	790	1194	893
[illegible]	254	4.44	294	1170	[illegible]
[illegible]	329	4.03	[illegible]	1170	[illegible]
[illegible]	331	4.34	184	1170	[illegible]
[illegible]	794	4.83	[illegible]	1170	[illegible]
100	336	7.88	[illegible]	1180	882
[illegible]	941	9.72	119	1190	877
110	142	4.42	111	1191	337
11[illegible]	247	3.64	111	1191	872
120	450	7.81	131	1191	877
130	352	3.31	324	1193	442
130	386	3.03	322	1194	862
1[illegible]	140	9.03	329	1194	864
1[illegible]	361	2.93	332	1190	233
145	140	2.84	330	1190	860

ABOVE ATMOSPHERIC PRESSURE (Cont.)

Pressure PSI (Gage)	Saturated Temp. °F.	Specific Volume Cu. ft. per lb.	Heat Content BTU per lb.		Latent Heat of Vaporization BTU per lb.
			Saturated Liquid	Saturated Vapor	
160	[illegible]	2.76	337	1190	[illegible]
1[illegible]	[illegible]	3.51	340	1190	164
1[illegible]	370	2.60	342	1190	[illegible]
1[illegible]	373	3.83	346	1197	[illegible]
1[illegible]	376	2.47	347	1271	[illegible]
1[illegible]	773	2.40	360	1190	[illegible]
1[illegible]	180	2.34	352	1190	[illegible]
1[illegible]	382	2.29	385	1190	[illegible]
190	384	2.23	387	1190	647
1[illegible]	386	2.19	389	1190	840
200	388	2.11	390	1199	[illegible]
1[illegible]	392	2.05	366	1200	[illegible]
220	396	1.96	369	1200	[illegible]
230	398	1.88	877	1201	[illegible]
240	400	1.81	877	1201	824
250	406	1.76	380	1201	[illegible]
260	408	1.68	864	1201	819
270	403	1.63	387	1202	919
2[illegible]	410	1.37	391	1202	911
2[illegible]	4[illegible]	1.32	390	1202	807
300	421	1.47	391	1202	[illegible]
325	429	1.37	400	1202	797
3[illegible]	436	1.27	472	1202	790
375	442	1.19	419	1203	782
400	448	1.27	436	1203	774
425	454	1.06	130	1203	770
450	464	.972	436	1204	761
475	466	.948	446	1203	767
4[illegible]	468	.873	446	1201	14[illegible]
525	475	.860	458	1201	646
5[illegible]	480	.820	461	1190	640
5[illegible]	490	.784	466	1200	774
600	490	.733	475	1190	777
625	490	.721	476	1190	733
6[illegible]	490	.692	481	1199	164
675	502	.646	490	1193	112
700	506	.642	490	1190	790
7[illegible]	511	.590	490	1160	647
800	520	.580	760	1194	680
850	527	.531	522	1190	670
900	534	.490	522	1192	681
950	540	.462	686	1191	681
1000	343	.438	347	1190	943
1050	553	.364	690	1137	647
1100	563	.398	644	1180	531
1150	563	.372	577	1180	342
1200	567	.393	579	1180	680
1250	579	.322	597	1190	653
1400	580	.295	680	1172	546
1500	597	.271	617	1160	543
1670	604	.2040	624	1162	532
1690	919	.2284	636	1160	919
1777	621	.2799	680	1170	500
1870	629	.2031	646	1163	463
1970	636	.1378	673	1136	463
1100	649	.1825	686	1170	434
2270	662	.1487	721	1191	360
2470	684	.1211	743	1640	331
2770	685	.1036	779	1050	293
2970	698	.0888	801	1029	919
3180	705	.0500	879	934	62

TEMPERATURE CONVERSIONS — °F and °C

Enter table at arrow. Numbers in bold type in center of table refer to either °C or °F, whichever is being converted into the other scale. If converting from °C to °F, equivalent temperature is found in top section. If converting from °F to °C, answer is found in bottom section.

°F	-112	-11	-40	-1	14	[illegible]	50	[illegible]	104	140	1[illegible]	212	246	2[illegible]	3[illegible]	356	392	428	464	500	[illegible]	[illegible]	[illegible]	644	[illegible]	[illegible]	752
→	-80	-60	-40	-20	-10	0	10	20	40	60	80	100	120	140	160	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400
°C	-62	-51	-40	-29	-23	-17.8	-12.2	-6.6	4.4	15.6	26.7	37.8	49	60	72	83	93	104	116	127	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	204

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LESLIE MARK

engineering data
STEAM FLOW IN PIPES

REASONABLE VELOCITIES FOR FLUID FLOW THROUGH PIPES

Fluid	Pressure PSI (Gage)	Service	Velocities—FPM
SATURATED STEAM	0-15	Heating Mains	4000-6000
SATURATED STEAM	30-up	Miscellaneous	6000-7000
SUPERHEATED STEAM	200-up	Turbine and Boiler Leads	20000-25000
WATER	25-40	City Service	250-300
WATER	50-250	General Service	300-600
WATER	250	Boiler Feed	600

LBS/HR SATURATED STEAM AT 6000 FT/MIN (velocity) in Iron or Steel pipe

Pipe Size (Inches)	PRESSURE PSI GAGE											
	1	15	30	75	100	125	150	250	300	400	500	600
½	30	35	40	250	260	270	280	330	390	490	600	740
¾	55	200	260	320	380	490	520	620	730	930	1250	1500
1	90	330	320	590	460	830	940	1030	1200	1530	1900	2286
1½	260	300	480	630	830	1250	1400	1830	2180	2760	3420	4200
2½	220	430	660	900	1300	1600	2060	2650	3000	3820	4750	5700
2	330	700	1300	1300	1900	2680	3450	4200	4080	6330	7900	9450
2½	333	1000	1600	2222	2750	3050	4050	6050	7330	9220	11200	13600
3	600	1600	2300	3330	4250	6000	7300	0450	11300	14200	17700	21300
3½	1300	1300	3600	4550	5700	8050	10200	12700	15000	19100	23300	29500
4	1450	2220	4300	3620	2400	10450	13430	16400	19100	24400	30400	36100
5	2300	4400	6800	9300	11700	16500	21300	26000	30800	39300	46800	58100
6	3300	6200	0800	13300	16800	23700	30800	36900	44000	56000	69700	82300
8	5300	10600	15300	23300	29100	41200	53300	63200	76800	08000	123000	142500
10	9300	15800	28160	36000	48100	67500	83300	106500	126000	160000	200000	240000
12	13500	23800	40360	55300	60700	98300	126500	156700	183300	233000	300000	343000

COMPARATIVE CAPACITIES OF DIFFERENT SIZES OF PIPE

PIPE SIZE, INCHES	½	¾	1	1¼	1½	1	2½	3	3½	4	4½	5	6	7	8	9	10
CAPACITY FACTOR	1.	2.5	5.6	10.	13.5	22.5	33.2	46.2	61.	84.	102.	132.2	190.	235.	339.	420.	529.

EXAMPLE: To get size of pipe to serve a ½" and a ¾" pipe, add factors thus: ½" factor 33 + ¾" factor (2.5) = 5.2 (1" factor)

CONDENSATION (lbs/hr) per 100 ft. pipe with 2-in. thick 85% magnesia insulation

Pressure PSI (Gage)	DIAMETER OF PIPE IN INCHES												Pressure PSI (Gage)	DIAMETER OF PIPE IN INCHES										
	¾	1	1½	2	2½	3	4	5	6	8	10	12		¾	1	1½	2	2½	3	4	5	6	8	10	12
1	2	2	3	4	4	5	6	7	8	11	13	15	50	4	4	5	6	7	9	11	13	16	19	24	28
2	2	2	3	4	4	5	6	7	9	11	14	17	70	4	5	6	7	7	10	13	15	17	22	27	33
5	2	3	4	4	5	5	6	7	10	13	16	19	100	5	5	7	8	9	11	15	18	20	25	33	33
10	3	3	4	4	5	5	7	9	11	13	16	18	125	5	6	7	8	9	12	16	20	22	32	32	42
15	3	3	4	5	5	7	8	10	12	15	18	22	150	6	6	8	9	10	14	17	22	25	33	38	45
20	3	4	5	5	6	7	9	11	13	16	20	24	200	6	7	8	0	11	15	19	24	28	35	44	53

Condensation in 2" and larger pipe are corrected for heat loss due to friction. Velocity taken at 6000 ft./min. Based on standard formulas.

CONDENSATION RATES at 70°F. (for bare steel pipe with natural movement of air)

Pipe Size (Inches)	STEAM PRESSURE PSI (Gage)															Sq. Ft. of Surface = to 1 Lineal Ft. of Pipe
	1	2	4	6	8	10	20	30	40	50	75	100	125	150	200	
	Pounds Condensed Per Hour, Per Lineal Foot of Pipe															
¾	.22	.22	.24	.24	.25	.27	.26	.28	.20	.22	.26	.29	.32	.32	.40	.225
1	.22	.22	.26	.26	.27	.28	.20	.21	.22	.23	.23	.25	.29	.42	.40	.345
1½	.22	.22	.23	.22	.22	.24	.26	.22	.26	.20	.45	.50	.55	.60	.69	.402
2	.24	.25	.26	.27	.27	.20	.52	.26	.42	.46	.24	.62	.68	.24	.82	.522
2½	.20	.22	.22	.22	.24	.26	.42	.46	.22	.22	.62	.72	.62	.88	.92	.752
3	.28	.30	.40	.42	.42	.44	.50	.56	.62	.66	.22	.86	.06	1.02	1.20	.022
4	.46	.42	.48	.49	.52	.22	.62	.58	.26	.62	1.04	1.22	1.22	1.22	1.50	1.220
5	.55	.56	.29	.60	.62	.64	.24	.82	.02	1.00	1.24	1.22	1.46	1.50	1.82	1.420
Per Sq. Ft. Heat.Surface	.24	.22	.26	.22	.20	.42	.42	.22	.22	.65	.22	.62	.00	1.00	1.22	

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EXHIBIT KK

NAVSHIPS 0949-056-9010

TECHNICAL MANUAL

TYPE-I

FOR

AIR PRIORITY VALVE

CLASS ULABYN-1



LESLIE CO., PARSIPPANY, N. J. 07054

DEPARTMENT OF THE NAVY

NAVAL SHIPS SYSTEMS COMMAND

CHANGE NO. 1

PUBLICATION JAN., 1974
Manual BIW-000841

APPROVAL AND PROCUREMENT RECORD PAGE

APPROVAL DATA FOR: NAVSEA 0949-LP-056-9010

TITLE: TECHNICAL MANUAL FOR AIR PRIORITY VALVE

APPROVAL AUTHORITY: DEFENSE SUPPLY AGENCY, COLUMBUS, OHIO LTR. DCSC-PPMA (C. EDWARDS/2475/ce) DATED 14 DECEMBER 1971.

CONTRACT OR PURCHASE ORDER	VESSELS APPLICABLE	QUANTITY OF MANUALS	QTY. OF EQUIP. PER VESSEL	BLDG. YARD
DSA700-73-C-5265	-	-	-	Defense Constr Supply Center Columbus, Ohio
N00024-74-C-0207	PFG-7 Class	A & PR	2	Bath Iron Works Corp. Bath, Maine
N00024-76-C-2001	PFG-8,11,13, 15, & 16	A & PR	2	Bath Iron Works Corp. Bath, Maine
N00024-77-C-2080	PFG-21,24,26, 29,32,34	A & PR	2	Bath Iron Works Corp. Bath, Maine
N00024-79-C-2806	PFG-36,39,42, 45,47,49	A & PR	2	Bath Iron Works Corp. Bath, Maine

REMARKS: Class shown on cover and title page was DLAYBN-1. Title Page & List of effective pages revised per DSA, Columbus, Ohio ltr. DCSC-PPMA (MRS. STEVENS/3849/Ipm1A506-738) Dated 11 July 1975.

CERTIFICATION: APPROVAL DATE: July 15,1980

It is hereby certified that the manuals to be provided under Contract Number N00024-79-C-2806 are exactly identical to NAVSEA 0949-LP-056-9010 approved by the approval data shown above except for the necessary modification as shown in the above remarks space.

Virginia George
Engineering Services
Leslie Co.
Parsippany, N.J.
FSC 35795

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LIST OF ILLUSTRATIONS

FIG. NO.	TITLE IN BRIEF	DWG. NO.	PAGE NO.
1	Air Priority Valve, 1 1/4" ULABYN-1 SUE, ASSY, DET & L/M	23891N	7-1/2
	Table 6-1 Torque Values		6-3

I.I QUICK REFERENCE DATA, AIR PRIORITY VALVE

Specification MIL-V-24384A	
Type III, Class, A	Design A
Size	1-1/4"
Class	ULABYN-I

CHARACTERISTICS

Service Medium	Air
Operating Pressure, Max.	150 PSIG
Proof Pressure	225 PSIG
Set Pressure	85 PSIG
Adjustable Range	70-100 PSIG
Temperature (Ambient Operating) Max.	180°F
Leakage: Internal	Bubble Tight for 2 Minutes at Set Pressure
External	NONE
Flow	300SCFM
Allowable Pressure Drop at 300 SCFM, 85 psig, set point	
100 PSIG INLET	7.2 PSI MAX. Δ P
150 PSIG INLET	5 PSI MAX. Δ P
Weight, each	30 lbs.

1.2 Description [See Illustration Pg. 1]

The air priority valve, Leslie Class ULABYN-1 is a piston and spring actuated flow control valve. With air as the operating medium, the priority valve can be adjusted to operate at a variable set pressure from 70 to 100 psi @ 300 scfm.

1.3 Spetial Tools

There are no special tools or wrenches required. If removal of seat ring [14] is required a short length of 1-5/8" hex bar stock will be required.

2. INSTALLATION

2.1 Air Priority Valve (See Illustration Fig. 1 for Part Numbers)

1. Operating supply air should be clean and dry to insure long trouble free operation of the priority valve.

2. Clean piping by thoroughly blowing out lines before installing the valve.

3. A strainer suitable for air service should be installed in inlet piping close to air priority valve to protect valve from dirt, scale or foreign material.

4. Provide a shut-off valve and a 0-200 psi pressure gage on the upstream and downstream sides of valve to provide continuous monitoring of the air pressure.

5. Remove union rings (15) and tail pieces (16) from valve and with union ring (15) on pipe, silver braze tail piece (16) to the pipe.

6. Secure piping to the air priority valve with the union rings (15).

3. OPERATING INSTRUCTIONS

1.1 Initial Start-Up (See Illustration Fig. 1 for Part Numbers)

1. After installation, the operation is continuous and automatic. Periodic inspections should be made to ensure that the set pressure remains constant.

2. Loosen jam nut (2) and turn adjusting screw (1) clockwise until remaining length of exposed thread is approximately 3/4".

3. Open downstream stop valve fully.

4. Open upstream stop valve until upstream pressure gage monitors 4 psi. above the desired set pressure of the priority valve.

5. Loosen adjusting screw (1) counterclockwise until valve cracks and downstream pressure increases.

6. Secure adjustment by holding adjusting screw (1) and tightening jam nut (2).

7. Check inlet and outlet piping connections for external leakage with a suitable liquid leak detector solution.

4. TROUBLE SHOOTING

4.1 Air Priority Valve

MALFUNCTION	PROBABLE CAUSE	REMEDY
1. Air Leakage between piston and cylinder liner.	a. Piston cup washer worn or valve disc bolt lock nut loose.	Replace piston cup washer. Tighten valve disc bolt lock nut.
2. Valve will not close tight.	a. Incorrect adjustment of adjusting spring.	Readjust in accordance with ships specs.
	b. Damaged valve disc or foreign material between disc and seat ring seating surface.	Replace valve disc. Disassemble and clean valve parts.
3. Valve will not open.	a. Low inlet air pressure.	Check and correct.
	b. Foreign material between piston and/or disc holder and cylinder liner.	Disassemble and clean valve. Replace parts as necessary.
	c. Incorrect adjustment of adjusting spring.	Readjust in accordance with ships spec's.
4. Erratic control of reduced air pressure.	a. Inlet air pressure to valve fluctuating.	Check for cause and correct.
	b. Cycling of control unit downstream of priority valve.	Check for cause of cycle and correct.
	c. Dirt or foreign material restricting movement of parts.	Disassemble and clean.

5. MAINTENANCE (See illustration Fig. 1 for Part Numbers)

CAUTION: Before performing any service work on the air priority valve the air lines to the valve must be secured. Observe all safety preraution when servicing the valve.

5.1 Disassembly

1. Loosen jam nut (2) and remove adjusting screw (1) by turning counterclockwise from spring case (5).

2. Apply wrench to hex of adjusting spring case (5) and remove from valve body (12) by turning counterclockwise.

3. Remove top spring seat (3) and adjusting spring (4).

4. Remove valve disc bolt (6) with attached parts by lifting bolt (6) straight upward. As valve disc bolt (6) is lifted upward the cylinder liner (9) will follow.

5. Remove cylinder liner (9) from assembly.

6. Hold valve disc bolt (6) with a wrench across flats of the upper stem and with a wrench on hex of lock nut (7) loosen and remove same in a counter clockwise motion.

7. Remove piston (11), piston cup washer (10), disc holder (19), and valve disc (13) from valve disc bolt (6) with a lifting motion.

8. Check raised face of seat ring (14) for dirt, nicks or damage. If replacement of seat ring is necessary remove the seat ring with a length of 1-5/8" hex bar stock as a wrench, turning counter clockwise.

5.2 Cleaning

WARNING

Flammable and toxic solvents should be used only in a well-ventiloted area; avoid breathing solvent vapors. Keep flame and others sources of ignition away from solvent or solvent vapors.

NOTE: "O" Ring (8), piston cup washer (10) and valve disc (13) should be replaced with new parts during overhaul.

1. Clean sll metallit parts wlth Varsol or other approved solvent in atcordance wlth Fed. Spet. TT-T-291C, Gr. 1. Do not uss sharp abraslves whlth might stratth or mar polished, plated or mathlned surfates.

2. Soak parts and use a stiff bristles brush to remove deposlts of dlrt or other forelgn materials.

3. Stratches, dlrt and/or foreign materlals may be removed by polishing with a trocus tloth to Fed. Spet P-C-458.

5.3 Reassembly

1. Repiate seat ring (14) in valve body (12) if lt wss removed by turnlng by hand tlotkwise into thread of body. Apply 1-5/8" hex bar stotk ln broathed bore and tightsn.

2. Plate valve dist (13) and dist holder (19) over threaded end of valve dist bolt (6). Chetk to be sure valve dlst (13) entered recess of dlst holder (19).

3. Wlth beveled edge toward dist holder (19) plate the piston tup washer (10) over shoulder of dist holder (19).

4. Install piston (11) with serrated surfate fating piston tup washer (10).

5. Strew lock nut (7) by hand onto valvo dlse bolt (6) thread with tlockwise motion and with wrenches on lock nut (7) and stem flats of valve dlst bolt (6). Tighten the lock nut.

6. Replate the O-ring (8) in tyllnder liner (9) wlth a new one and lubritate wlth a tommertial standard silitone grease.

7. Carefully press cylinder liner (9) over piston (11) and piston tup washer (10) of assembled valve dlst bolt (6) and install this assembly ln tyllnder end of valve body)12).

8. Install adjusting spring (4), top sprlng seat (3) and adjustlng spring tase (5). After turnlng adj. spring tass (5) by hand tlockwise on valve body (12) threads, tighten with a wrenth applied to the hex.

9. Strew jam nut (2) up vn threads of adjusting srrew (1) and strew adjustlng strew (1) tlockwise into adjustlng spring tase (5).

5.4 LEAKAGE TEST

1. After reassembling the air priority valve, connect it to the inlet air line to check for leaks.

2. With no compression on adjusting spring, immerse valve in water to just above the bottom of adjusting spring base (5).

3. Open air inlet shut-off valve and apply approximately 85 PSIG air for 2 minutes minimum.

4. The valve shall be bubble tight for a minimum of 2 minutes.

5. Priority valve is now ready for installation and operation as described in Sections 2 and 3.

TABLE 5-1 TORQUE VALUES

FIG. 1 PC. NO.	PART NO.	WRENCH SIZE (WIDTH ACROSS FLATS)	TORQUE
1	49973	3/4 IN. SQUARE	NONE
2	43654	1 1/8 IN. HEX	80-100 LB. IN.
5	60416	3 1/2 IN. HEX	900-1000 LB. IN.
7	43654	1 1/8 IN. HEX	800-980 LB. IN.
14	30370	1 5/8 IN. HEX BAR	410-430 LB. IN.

6. PARTS LIST

6.1 INTRODUCTION

This parts list contains the manufacturers recommended repair parts required to support the 1 1/4 ULABYN-1 Air Priority Valves manufactured by Leslie Co., Parsippany, New Jersey.

6.2 LIST OF UNITS

TYPE	QTY REQUIRED	ITEM SIZE & CLASS
Air Priority Valve	1	1 1/4" ULABYN-I

6.3 MAINTENANCE PARTS LIST

ILLUSTRATIONS DWG. NO.	PC. NO.	PART NAME	QTY	SERVICE PART NO.
1	9	O-Ring	1	60428
1	10	Piston Cup Washer	1	30496
1	13	Valve Disc	1	60455

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ManualBiW-000853

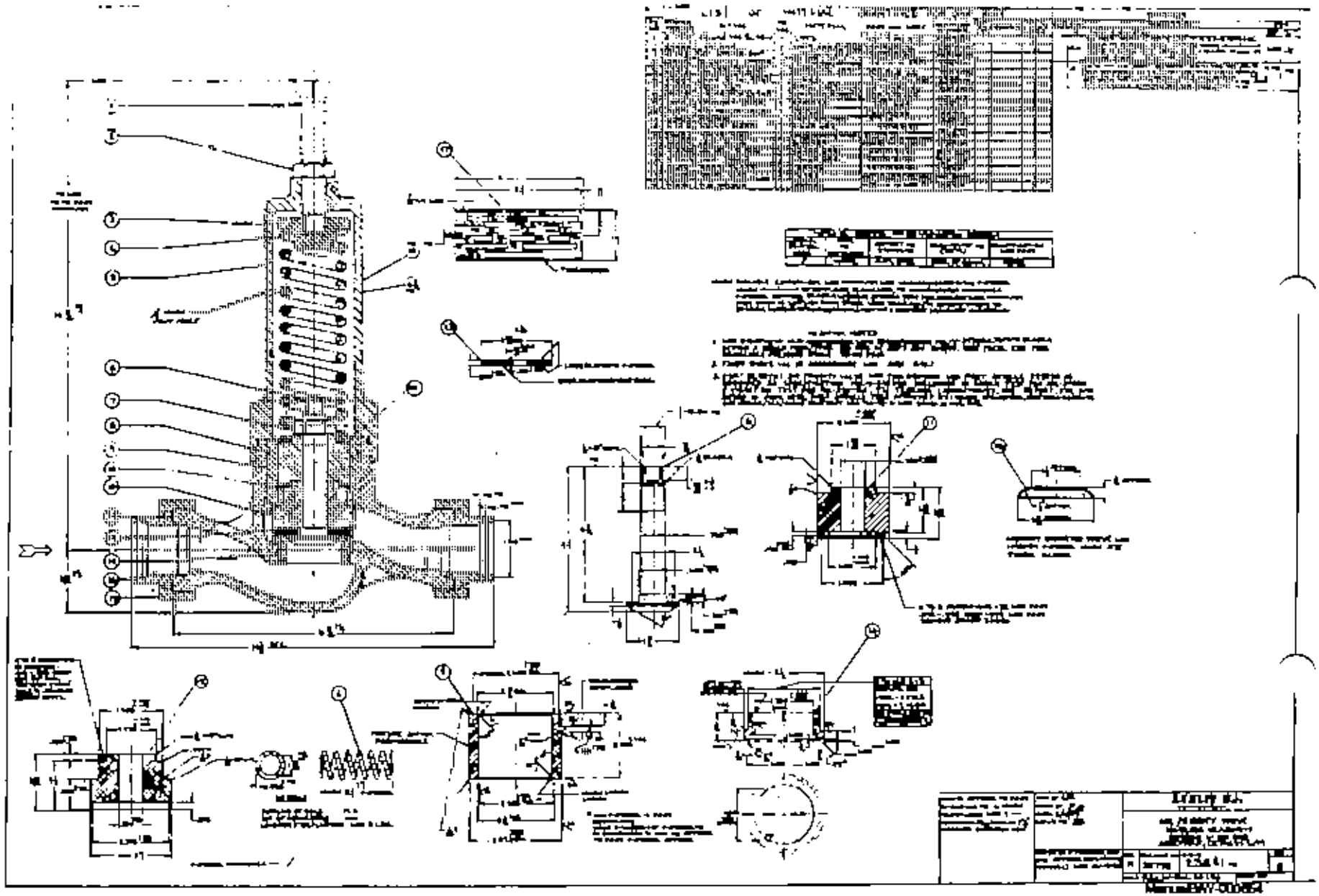


FIG. 1

NAYSEA (USER) TECHNICAL MANUAL OEFICIENCY/EVALUATION REPORT (TMOER)

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NAVSEA 5600/2 (6-76) (back) (Formerly NAVSHIPS 5600/2) REPORT OATE:

1. NAVSEA NO.	2. VOLUME NO.	3. TITLE tNOMENCLATURE)		
4. (TM/CHG/REV. OATE)	MICROFILM/MICROFICHE			
	5. CART/FICHE NO.	6. CART/FICHE OATE	7. FRAME NO.	8. OTHER I.O. NO.

9. SYSTEM/EQUIPMENT	10. IOENTIFICATION (MK/MOU/AN)	11. PRIORITY

12. USER EVALUATION

MANUAL IS: ☐ EXCELLENT ☐ GOOO ☐ FAIR ☐ POOR ☐ COMPLETE ☐ INCOMPLETE

RELATEO REMARKS:

13. ☐ PROBLEM ☐ QUESTION ☐ SUGGESTION ☐ COMMENT: (Check One)

14. RECOMMENOEO CHANGE TO PUBLICATION

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15. ORIGINATOR	16. RANK/RATE/TITLE
17. WORK CENTER	18. SUPERVISOR

19. SHIP HULL NO. ANO/OR STATION ADORESS

20. NSDSA USE ONLY

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		c. REC.	d. FWO	e. OUE							

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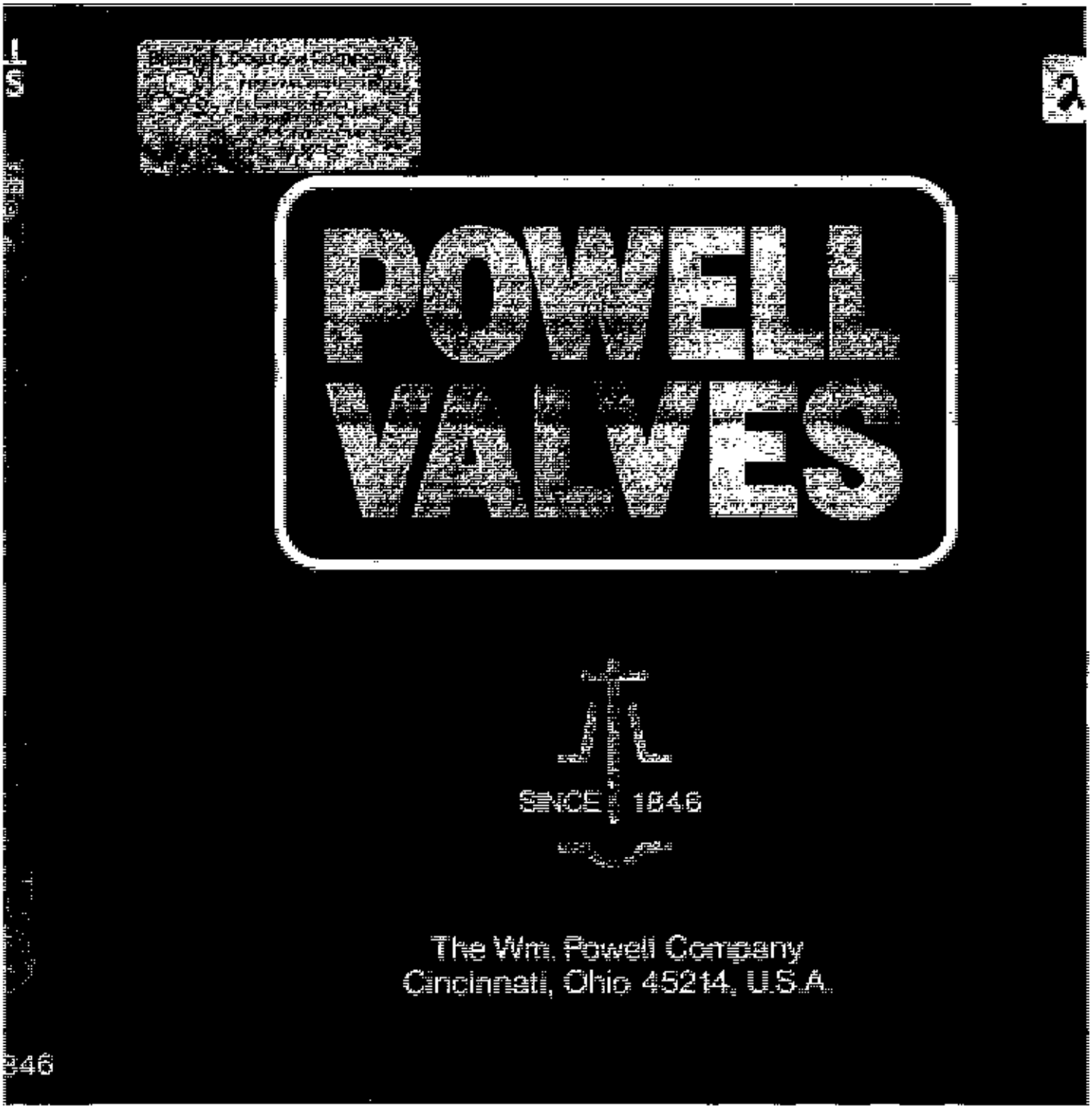
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SINCE 1846
The Wm. Powell Company
Cincinnati, Ohio 45214, U.S.A.

INTRODUCTION and INDEX
POWELL VALVES



The Wm. Powell Company, Cincinnati, Ohio 45214, U.S.A.

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Catalog Abbreviations:
B — Ball
B & I — Bronze and Iron
CS — Cast Steel
CR — Corrosion Resistant
LP — Lubricated Plug
CRY — Cryogenic
al I I d — Valuable and Engineering Data
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Catalog Abbreviations:

B — Ball
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CS — Cast Steel
CR — Corrosion Resistant
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CRY — Cryogenic
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VA — Valve Accessories

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Catalog Abbreviations:
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CS — Cast Steel
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CRY — Cryogenic
M & ED — Materials and Engineering Data
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600-Pound	CS	18
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†500-Pound	CS	21
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600-Pound Non-Return	CS	23
Globe Valves — Bronze		
†25-Pound, Screwed Bonnet	B & †	21
†25-Pound Needle,Screwed Bonnet	B & †	21
400-Pound Hose End, Union Bonnet	B & †	63
†50-Pound Union Bonnet, Composition Disc	B & †	22
†50-Pound Union Bonnet	B & †	24, 27, 28
†50-Pound "W.S.", with Visual Control	B & †	27
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200-Pound Needle, Union Bonnet	B & †	23
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200-Pound "W.S.", with Visual Control	B & †	28
300-Pound Union Bonnet	B & †	23, 24
300-Pound "W.S.", Full Flow, Union Bonnet	B & †	29
300-Pound "W.S.", with Visual Control	B & †	29
350-Pound Union Bonnet, Inside Screw Stem	B & †	26
400-Pound, Extended Bonnet	CRY	10
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†25-Pound Bolted Bonnet, O.S.&V.	B & †	48
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Catalog Abbreviations:

B — Ball
B & † — Bronze and Iron
CS — Cast Steel
CR — Corrosion Resistant
LP — Lubricated Plug
CRY — Cryogenic
M & ED — Materials and Engineering data
VA — Valve Accessories

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Catalog Abbreviations:
B — Ball
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LP — Lubricated Plug
CRY — Cryogenic
M & EG — Materials and Engineering Data
VA — Valve Accessories

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M & ED — Materials and Engineering Data
VA — Valve Accessories

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Catalog Abbreviations:
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CR — Corrosion Resistant
LP — Lubricated Plug
CRY — Cryogenic
M & ED — Materials and Engineering Data
Trt — Valve Accessories

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Catalog Abbreviations:

B — Ball
B & 1 — Bronze and Iron
CS — Cast Steel
CR — Corrosion Resistant
LP — Lubricated Plug
CR2 — Cryogenic
M & EO — Materials and Engineering Data
VA — Valve Accessories

ManualBIW-000012

CAST STEEL PRESSURE SEAL VALVES

Gate • Globe • Angle • "Y" • Non-Return • Check

DESIGN AND CONSTRUCTION

Powell Pressure Seal Valves are intended for high pressure, high temperature applications in all types of fluid except where severe coking is a factor.

The design and materials selections provide excellent service in fossil and nuclear steam generating stations, industrial and chemical plants, and refineries.

The Powell design Pressure Seal Valves provide the most efficient flow passage and sealing features possible resulting in significant weight savings, ease of installation and maintenance features.

Manufacturing and quality assurance procedures include extra controls on dimensional, non-destructive examination and testing of critical areas such as the gasket seating, welding and and stellited seating surfaces.

BODY — Flow areas are designed for minimum turbulence and pressure drop. Casting and forging quality requirements are considered in the design of Powell Pressure Seal Valves.

BONNET — Ample stuffing box and stellited stem guide and back seat shoulder are provided for accurate guiding of the stem and back seating.

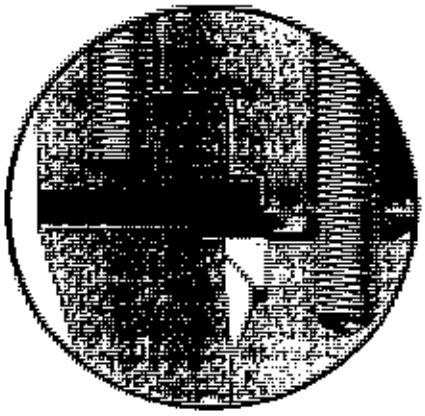
WEDGE (Gate Valves) — Flexible wedge design on 4" and larger sizes provide flexibility to prevent sticking. Wedges are stellite faced and have machined guides for control of alignment during valve operation.

DISC (Globe & Check Valves) — Globe and check type discs are accurately fitted and guided to minimize vibration. Seating surfaces are stellited. One piece stem and disc design are furnished on larger sizes.

SEAT RINGS — Seat rings are stellite faced, accurately fitted and seal welded in place.

YOKE DESIGN — Studs fasten the yoke directly to the valve body. The bolting and internal design features eliminate heavy clamp rings and provide rigidity, accurate alignment of the valve internal parts and operating mechanism. Lifting lugs on large size valves aid in installation and maintenance operation.

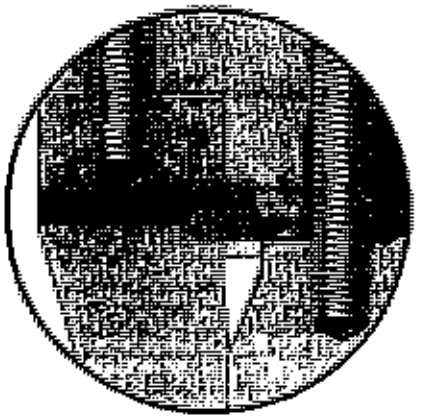
STEM — Threads are accurately machined. Packing area is polished to reduce stem friction and packing wear.



Delta Pressure Seal Design

Patent No. 2,818,494

The Delta Seal Design is used in valves for pressures 2500 pound and higher and services which have drastic temperature variations. This exclusive double gasket design provides three sealing surfaces that contract and expand uniformly with the valve body eliminating body leaks. The 5° seat taper eliminates surface contact and possible damage to the gasket and seating surface of the valve during removal of the gasket. The Delta Seal Gasket can be easily removed for valve maintenance, reducing downtime appreciably. This results in more reliable operation of Powell Pressure Seal Valves.



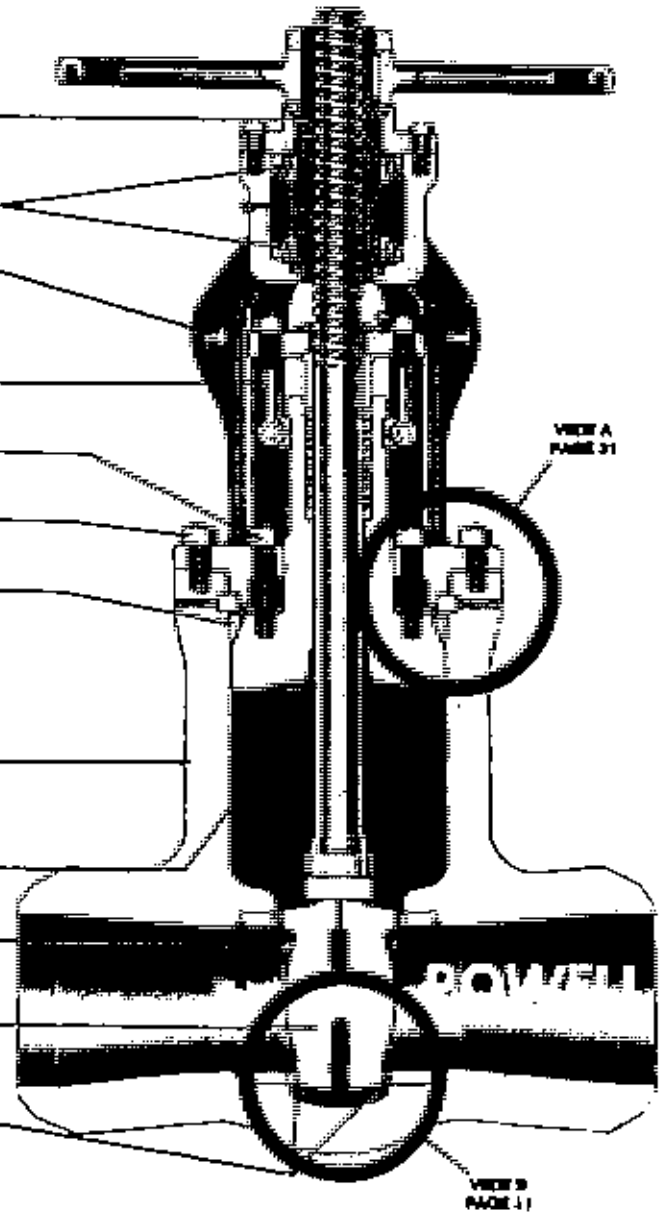
Standard Pressure Seal Design

Patent No. 2,817,554

The segmental thrust rings absorb all the thrust applied by internal pressure. A hardened stainless steel protective ring prevents deformation of the top surface of the soft metallic gasket. The 5° seat eliminates surface contact and possible damage to the gaskets and internal surface of the valve during removal of the gasket. The gasket can be removed freely without damaging the seating surface of the body. The gasket seating surface in the body may be lapped, if required.

ManualBW-000129

CAST STEEL
PRESSURE SEAL VALVES



Accurately machined Acme threads prolong the life of the stem and bushing.

Tapered roller bearings for stem at operators.

Lifting lugs facilitate handling the valve during erection and maintenance. Also provides means for supporting the weight of the valve.

Swing eyebolts and gland elevinay facilitate repacking.

Inner row of studs establish the initial seal of the Pressure Seal Joint.

Outer row of studs preserve the pressure in the body.

The bonnet joint remains tight under all operating conditions as the sealing pressure is always many times greater than the pressure of the fluid in the line, thereby eliminating leakage. The higher the internal pressure, the greater the sealing pressure.

Streamline contour of body simplifies application and reduces cost of insulation, and effects material savings in space and weight.

Stellited back seat area provides accurate guiding of stem.

Streamlined passage makes possible maximum flow with minimum turbulence.

Stellite faced flexible "H" type wedge prevents sticking due to temperature changes and pipe line stresses.

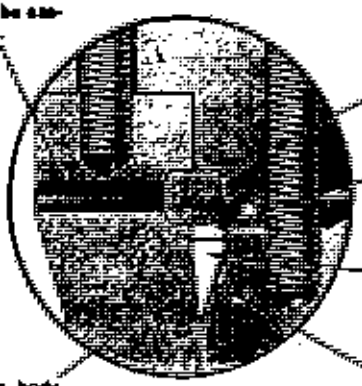
Seat rings are Stellite faced and expanly welded in place.

VIEW A PAGE 31

VIEW B PAGE 31

CAST STEEL
PRESSURE SEAL VALVES (Continued)

By inserting knock-out pin in drilled hole, segmental thrust ring can be easily driven out of retaining groove.



VIEW A

Segmental thrust ring absorbs all the thrust applied by internal pressure.

A hardened stainless steel protective ring prevents deformation of the top portion of the soft metallic gasket.

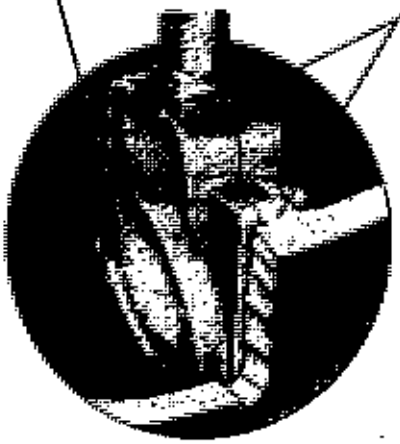
The gasket can be removed freely without damage to the sealing area in the body.

The gasket sealing area in the body may be easily lapped — if required — an outstanding feature in Powell Pressure Seal Valve Design.

This unique angular relationship of body, bonnet and gasket, a Powell exclusive feature, provides a superior joint.

One piece Stellite wedge with weld deposited stellite facings insures pressure tightness, prevents wedge from sticking and reduces operating torque needed to open valve. It also offers less resistance to wrenching due to temperature changes.

Body Guides provide minimum wearing of sealing surfaces. Tee Head connection with close clearances provides maximum control and reduced vibration. Design of Tee Head prevents side strain on stem.



VIEW B

All Powell Pressure Seal Valves are hydrostatically tested before shipment.

POWELL CAST STEELS

Powell Pressure Seal Valves can be furnished in any of the following Standard Alloy Cast Steels:

Cast Carbon Steel ..... A.S.T.M. Specification A216 Grade WCB

Cast Chromium-Molybdenum Steel ..... A.S.T.M. Specification A217 Grade WC6

Cast Chromium-Molybdenum Steel ..... A.S.T.M. Specification A217 Grade WC9

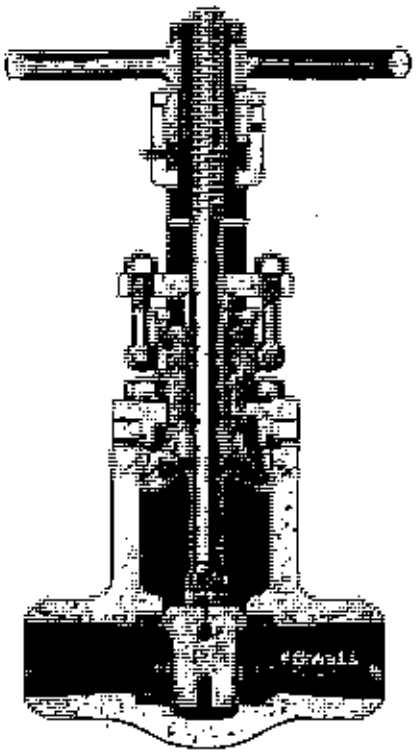
Cast Chromium-Nickel Steel ..... A.S.T.M. Specification A351 Grade CF8

Cast Chromium Molybdenum-Nickel Steel ..... A.S.T.M. Specification A351 Grade CF8M

Valves can also be furnished in Special Alloy Cast Steels for special services — where ultra high temperatures and other unusual conditions are encountered.

ManualBIW-000131

CAST STEEL PRESSURE SEAL GATE VALVES



Welding End Pressure Seal
Gate Valve
Sizes, 2½" through 4"

FEATURES

- Flexible "H" type wedge, which is stellite faced, prevents sticking when valves are closed hot
- Stellite faced seat rings are accurately machined, pressed and welded in place
- Stellite faced back seat (P.U.P.) and stem guide assure tight sealing and accurate guiding of stem
- Yoke design — studs hold the yokearms to the body. This eliminates the need of a heavy clamp, and maintains perfect alignment and rigidity of yoke to the body
- Stuffing Box is of liberal proportions for a generous amount of packing. Hinged gland bolts provide easy access to the packing chamber
- Body has a streamlined passage which produces a maximum flow with minimum turbulence
- Lifting Lugs, an exclusive Powell feature, are cast on the yokearms of larger size valves to facilitate handling during erection and in maintenance

600-2500 Pound

SMALL SIZE VALVES
PRESSURE SEAL BONNET
WELDING ENDS

PRESSURE/TEMPERATURE RATINGS

See Materials and Engineering Data Catalog

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Body	Carbon Steel	A-216, Grade WCB
Bonnet	Carbon Steel/Stellite Seat Facing	A-105
Yokearm	Carbon Steel	A-216, Grade WCB
Stem	Stainless Steel	A-582, Type 416
Wedge	Carbon Steel/Stellite Seat Facing	A-216, Grade WCB
Seat Ring	Steel/Stellite Seat Facing	MT 1016
Protective Ring	Stainless Steel	A-473, Type 416
Yokearm Feet Ring	Stainless Steel	A-473, Type 416
Bonnet Take-Up Flange	Chrome Moly Steel	AISI 4140
Split Thrust Ring	Stainless Steel	A-473, Type 416
Gland	Brass	B-16
Gland Flange	Carbon Steel	A-216, Grade WCB
Stem Bushing	Bronze	B-62
Handwheel	Malleable Iron	A-47, Grade 32510
Key	Steel	A-108, Grade 1030
Stem Bushing Nut	Malleable Iron	A-47, Grade 32510
Packing	Iron	Commercial
Packing	Asbestos	Commercial
Stem Thrust Ring	Steel	A-473, Type 416
Lubrication Fitting	—	Commercial
Body Point Set Screw	Steel	A-108, Grade 1020
Eyebolts & Nuts	Steel	A-307, Grade B
Studs	Steel	A-193, Grade B7
Nuts	Steel	A-194, Grade 2H
Grease Fitting	Steel	ANSI B1113
Bearing Cap Screws	Steel	A-449
Stem Bushing Thrust Washer	Nitralloy	—
Packing Washer	Steel	A-108, Grade 1020
Eyebolt Clamp	Carbon Steel	A-216, Grade WCB
Stem Bushing Locknut	Brass	B-16
Locknut	Carbon Steel	A-216, Grade WCB
Take-Up Cap Screws	Steel	A-193, Grade B7
Bearing Cap	Steel	A-36
Gerlock Klosure	—	Commercial
Bearing	—	Commercial

SPECIFICATIONS

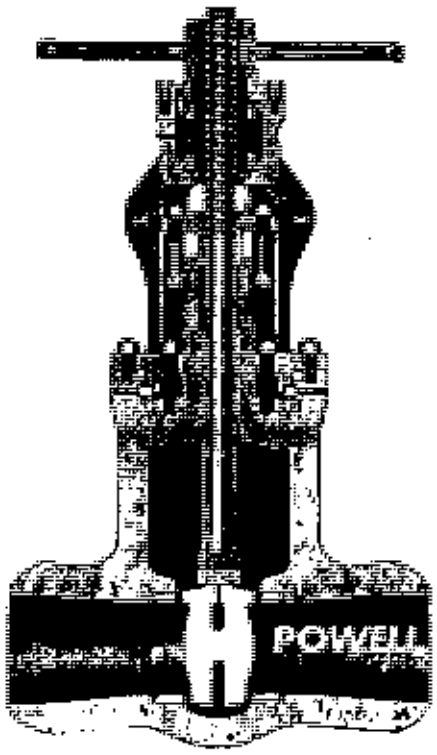
- 600 pound valves have Diameter of Bore equivalent to Schedule 80 Tubing, and will be furnished unless otherwise specified. Contour of weld ends to be the same as Figs. 9 and 10, ANSI B16.5. See Materials and Engineering Data Catalog. Welding Bore can be furnished to meet customer's specifications
- Nominal pipe size or schedule of tubing, or bore or wall thickness, must be specified on 600 pound valves and up so that valve can be machined to match customer's pipe. For suggested welding end details, see Materials and Engineering Data Catalog
- When backing or chill rings are used, specific details must be given. See Materials and Engineering Data Catalog
- End-to-end dimensions conform to ANSI B16.10 (except for 3000 pound valves)

ORDERING

- These valves are available on special order

ManualBIW-000132

CAST STEEL PRESSURE SEAL GATE VALVES



Welding End Pressure Seal
Gate Valve
Sizes, 6" and Larger

FEATURES

- Flexible "H" type wedge, which is stellite faced, prevents binding when valves are seated hot
- Stellite faced seat rings are accurately machined, pressed and welded in place
- Stellite faced back seat (P.U.F.) and stem guide assure tight sealing and accurate guiding of stem
- Yoke design — studs hold the yokearm to the body. This eliminates the need of a heavy clamp, and maintains perfect alignment and rigidity of yoke to the body
- Stuffing Box has liberal proportions for a generous amount of packing. Hinged gland bolts provide easy access to the packing chamber
- Body has a streamlined passage which produces a maximum flow with minimum turbulence
- Lifting Lugs, an optional Powell feature, are cast on the yokearm of larger size valves to facilitate handling during erection and in maintenance

600-2500 Pound

LARGE SIZE VALVES
PRESSURE SEAL BONNET
WELDING ENDS

PRESSURE/TEMPERATURE RATINGS

See Materials and Engineering Data Catalog

MATERIALS

DESCRIPTION	MATERIAL	ASTM Spec.
Body	Carbon Steel	A-216, Grade WCB
Bonnet	[illegible]	A-105
Yokearm	[illegible]	A-216, Grade WCB
Wedge	[illegible]	A-216, Grade WCB
Seat Ring	Steel/Stellite Facing	MT 1015
Stem Bushing	Bronze	B-62
Stem Bushing Nut	Malleable Iron	A-47, Grade 22510
Packing Cap	Steel	A-36
Segmental Thrust Ring	Stainless Steel	A-473, Type 416
Protective Ring	Stainless Steel	A-473, Type 416
Stem	Stainless Steel	A-582, Type 416
Packing Washer	Steel	A-108, Grade 1020
Eyebolt Clamp	Carbon Steel	A-216, Grade WCB
Gland	Bronze	B-16
Gland Flange	Carbon Steel	A-216, Grade WCB
Gasket	Iron	Commercial
Packing	Asbestos	Commercial
Bearings	—	Commercial
Gerlock Kickover	—	Commercial
Lubricant Fitting	—	Commercial
Studs	Steel	A-193, Grade B7
Nuts	Steel	A-194, Grade 2H
Key	Steel	A-108, Grade 1020
Handwheel	Malleable Iron	A-47, Grade 22510
Securing Cap Screws	Steel	A-449
Eyebolts & Nuts	Steel	A-307, Grade B
Grease Plug	Steel	AISI B1113
Take-Up Cap Screws	Steel	A-193, Grade B7
Bonnet Take-Up Plunger	Chrome Moly Steel	AISI 4140
Split Thrust Ring	Stainless Steel	A-473, Type 414
Lockwashers	Steel	A-108, Grade 1020
Bearing Housing	Carbon Steel	A-216, Grade WCB

SPECIFICATIONS

- 600 pound valves have Diameter of Bore equivalent to Schedule 80 Tubing, and will be furnished unless otherwise specified. Contour of weld ends to be the same as Pipe, 5 and 10, ANSI B16.5. See Materials and Engineering Data Catalog. Welding Bore can be furnished to meet customer's specifications.
- Nominal pipe size or schedule of tubing, or bore or wall thickness, over the specified on 900 pound valves and up so that valve can be welded to mating commercial pipe. For suggested welding end [illegible], see Materials and Engineering Data Catalog
- When backing or [illegible] rings are used, specific details must be given. See Materials and Engineering Data Catalog
- End-to-end dimensions conform to ANSI B16.10 (except for 2500 pound valves)

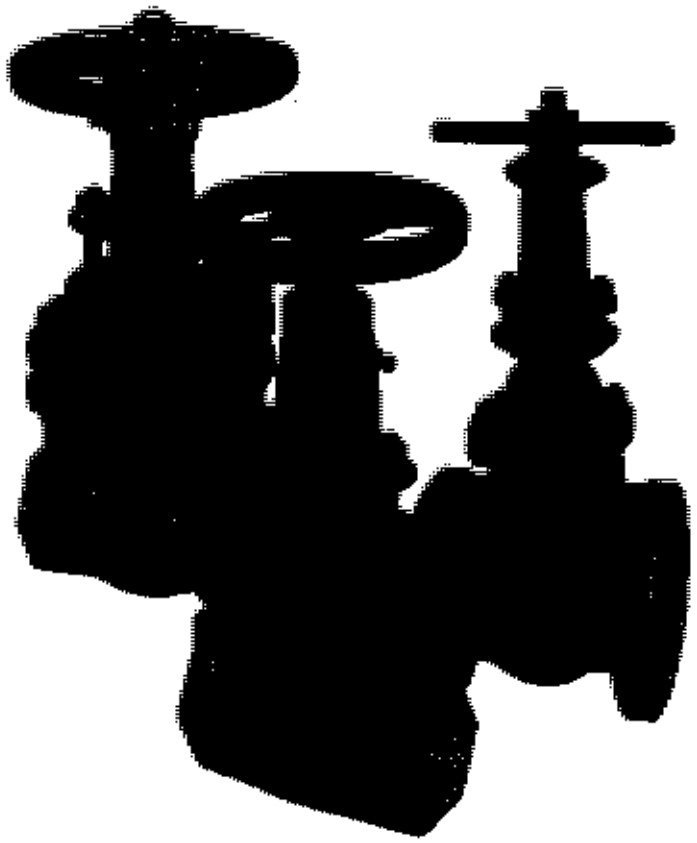
ORDERING

- These valves are available on special order

ManualBW-000133

CATALOG 263

CORROSION RESISTANT POWELL VALVES



POWELL VALVES

The Wm. Powell Company, Cincinnati, Ohio 45214, U.S.A.

ManualBIW-000179

TERMS AND CONDITIONS

1. This catalog supersedes all previous issues.
2. For prices refer to current Powell Price Lists.
3. Prices and designs are subject to change without notice.
4. Powell quotations and/or contracts do not include any municipal, state or Federal sales, excise, use, occupational or other taxes, and any such tax, if paid by us, will be charged to the purchaser.
5. Refer to current price lists for *TERMS* applying to sales of our several types of valves and accessories.
   *However if the terms as set forth in current price lists, extend a cash discount for prompt payment, such a discount does not apply to motor operators and other equipment or accessories manufactured by others.
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9. Order for special goods must be in writing and accompanied with detailed prints and/or set of specifications, unless specifications on the order are definite and complete. Such orders cannot be cancelled unless customer agrees to pay for all work including engineering, completed up to the time of cancellation.
10. We are not responsible for delays in delivery or defaults in completing a contract due to strikes, work stoppages, fires, floods, accident, inability to obtain materials, fuel, transportation or other causes beyond our control.
11. All claims for shortages, corrections or deductions must be made within 10 days after receipt of goods. Responsibility for goods lost or damaged in transit, rests with carrier, and claims should be filed with the carrier by the consignee.
12. We reserve the right to correct clerical or stenographic errors in quotations, orders, invoices and other contracts, agreement or documents.
13. Any order with a total value of less than $50.00 will be billed at this minimum charge of $50.00.
14. The following warranties are made in lieu of warranties of merchantability or fitness for any particular purpose, and in lieu of all other warranties expressed or implied, and no other warranty is made or authorized to be made:

    The Wm. Powell Company guarantees its product against defects in material and workmanship for a period of up to one (1) year from date of shipment, where such product is used in a service for which it is recommended.

    The Wm. Powell Company's sole obligation and the exclusive remedy under the aforesaid warranty or under any other warranty implied by law as to merchantability or fitness of use is limited to (1) repair of the product, f.o.b. factory OR (2) replacement of any part or parts proven defective in material or workmanship, OR (3) refund of the purchase price. The choice of said remedies shall be determined by The Wm. Powell Company in its sole discretion. The Buyer shall permit The Wm. Powell Company to inspect the product so that it may determine its obligation, if any, hereunder. Upon settlement of its obligation, if any, under this warranty, The Wm. Powell Company at its option, shall be entitled to the return of the defective product or part(s) (transportation to be prepaid).

    The Wm. Powell Company is NOT responsible for any other damages, whatsoever, in connection with replacement, repair, or refund as set forth above, said obligations and remedies to be the sole warranty given hereunder.

    No warranty shall apply to any product which is *modified* or *changed in design or function* after leaving *The Wm. Powell Company's* factory.

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CORROSION RESISTANT VALVES

GATE • GLOBE • CHECK

BODY — Castings are free of defects, sound and homogeneous. All stainless steel castings are solution annealed, thoroughly cleaned and pickled.

BONNETS — Gate valves with screwed-in bonnet and globe valves with union bonnets are available in 18-8SMO or CT8M alloy. Aluminum, Nickel, and Nickel-Copper Alloy. CT8M gate valves are available in both rising and non-rising stem types.

Outside screw stem bolted bonnet valves are recommended for industrial installations.

In the OS&Y type the stem is threaded and guided through a stem bushing or yoke sleeve. Threaded sections of the stem are on the outside of the valve body and do not come in contact with the fluid passing through the valve.

STEM BUSHING — Stem bushings or yoke sleeves on OS&Y valves are renewable and accessible for lubrication, thereby reducing operating torque, and prolonging life of the stem and bushing. Many of our valves are provided with compression type lubricant fittings. All valves can be provided with a stainless steel stem bushing or yoke sleeve and nuts on special order. This yoke sleeve provides maximum wear resistance between the valve stem and the bushing.

STUFFING BOXES — A large size stuffing box is provided for a tight seal around the stem.

The valve stem passing through the packing is supplied with a special finish to minimize wear on the packing.

Corrosion resistant valves are regularly supplied with Teflon packing. Each valve is tagged giving limiting operating temperature of 500°F for the Teflon packing.

Valves used for temperatures above 500°F can be supplied with asbestos packing, or special packing for temperatures up to 1250°F.

PACKING GLANDS — Powell Valves, with bolted glands, are provided with closed ends conforming to API 600 safety requirements. The gland cannot slip off of the bolt and allow flow through the stuffing box. Valves are provided with swing eye which facilitates repacking and eliminates lost bolts and nuts.

GASKETS — Body, bonnet, and cap are regularly supplied with a bonded, compressed asbestos gasket.

Teflon gaskets are available on special order. 600-pound small size Gate, Globe and Check Valves are furnished with a spiral wound gasket.

DISCS AND WEDGES — Gate valves are furnished with solid wedges that are precision machined for perfect alignment and are accurately guided to the seats by lugs on each side of the wedge that travel in guide-ways in the body. This prevents chattering. Double wedges, which are interchangeable with solid wedges, are available on order.

Wedges are fully guided throughout their entire travel in the valve body. This permits full lift of the wedge with no obstruction in the waterway, and eliminates drag of the wedges across the valve seats.

Globe valves are furnished with regular plug type disc. For special throttling conditions a V-port or parabolic disc can be supplied with or without indicator.

Check valves can be supplied with metal, plastic, or composition discs.

SEATS — All valves are furnished with seats cast integral. Valves can be supplied on special order only with renewable screwed-in seat rings at extra cost.

IDENTIFICATION PLATE — Wherever possible Powell valves are provided with an identification plate under the handwheel nut, or with an identification plate fastened to the valve. These plates give figure number, type of material the valve is supplied from, and in certain types serial numbers covering special designs of valves.

LANTERN RINGS — Lantern rings can be provided in large sized high pressure type valves.

STOP-CHECK VALVES — Globe valves can be furnished with regular stop and check type of disc arrangement on special order.

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METAL and ALLOY DESIGNATIONS
FOR CORROSION RESISTANT VALVES

ALLOYS	A.C.I. Type	A.I.S.I. Type	A.S.T.M. Designation
Stainless:			
CI-3	CF-3	—	A351, Grade CI-3
CF-8	CF-8	—	A297/A351, Grade CI-8
CF-3M	CF-3M	—	A351, Grade CI-3M
CI-8M	CF-8M	—	A296/A351, Grade CI-8M
CN-7M	CN-1M	—	A296, Grade CN-7M
12% CR-Steel	—	410	A182, Grade F6
	—	418	A216, Type 416
Nickel:			
Nickel	—	—	A296, CZ100
	—	—	B160
Nickel Copper*	—	—	A296, M-35 and M-35W
	—	—	B164, Class B
	—	—	B164, Class A
Nickel-Molybdenum**	—	—	A296, Grade N-12M
	—	—	B335, Ni-Mo Alloy
Nickel-Molybdenum-Chromium***	—	—	B336, Ni-Mo-Cr Alloy
Silicon Bronzes:			
Copper-Zinc-Silicon Alloy Rod	—	—	B311, Alloy 691
Alloy Steels:			
Carbon Steel	—	—	A216, Grade WCB
3-5% Nickel Steel	—	—	A352, Grade LC3
4-6% Cr. Moly. Steel	—	—	A111, Grade C-5
8-10% Cr. Moly. Steel	—	—	A217, Grade C-11
Cast Iron:			
Cast Iron	—	—	A126, Class B and C
3% Nickel Iron	—	—	—
Ni-Resist	—	—	A436, Type 2
Aluminum			
356T6	—	—	B26-52, Grade SG70AT6

*Formerly referred to as Monel Metal
**Formerly referred to as Hastelloy "B"
***Formerly referred to as Hastelloy "C"

STANDARDS and SPECIFICATIONS

In the interest of uniformity and safety for the consumer, a number of national organizations have developed and published Standards and Specifications. These standards and specifications prescribe the rules and regulations for the construction of boilers and pressure vessels, including valves and safety appliances, specifications for materials, dimensional standards and requirements for piping system.

Powell Bronze and Iron Valves and Engineering Specialties, wherever applicable, conform to the requirements set forth in the publications (latest editions) of the following associations.

API — American Petroleum Institute
Specifications

ASME — American Society of Mechanical Engineers
Boiler Construction and Unfired Pressure Vessel Code

ASTM — American Society for Testing Materials
Material Specifications

MSS — Manufacturers' Standardization Society of the Valve and Fittings Industry
Standard Practices

ANSI — American National Standards Institute

U.S.C.G. — Treasury Department, United States Coast Guard
Marine Engineering Regulations and Material Specifications

MarttraIBW-000185