7 Options

Purpose

This chapter contains information on any options you have that purchased from MART. The material in this chapter is meant to be used with material in other chapters -- for example, chapters *"Installation," "Operations,"* and *"Maintenance."*

Prerequisites

Before you read this chapter, we recommend that you read the following thoroughly:

- *"Important Safety Instructions and Warnings"* (in the front material)
- Chapter 1, *"Overview"*

Safety/Precautions

Before you install, operate, or maintain any option, read and follow these recommended safety/precaution instructions:

> ***WARNING! NEVER get inside the washer cabinet when the main power supply is ON. This could result in severe injury or death.***

> ***WARNING! Be sure that people who install and maintain the washer and options are qualified and trained for the task.***

What You Will Learn In This Chapter

In this chapter you will learn the following about each option:

- Theory of operation
- Installation
- Operations
- Maintenance
- Troubleshooting

1. Automatic Turntable/Swivel Bearings Lubrication

The automatic turntable and swivel bearings lubrication system helps ensure that these critical bearings are lubricated every set number of wash cycles.

1.1. Theory of Operation

The automatic lubrication system consists of the following: (refer to the following figure)

- Grease reservoir
- Pneumatically driven grease pump
- Grease dividing valve
- Pneumatic control valve
- Filter, regulator, lubricator
- Control Panel

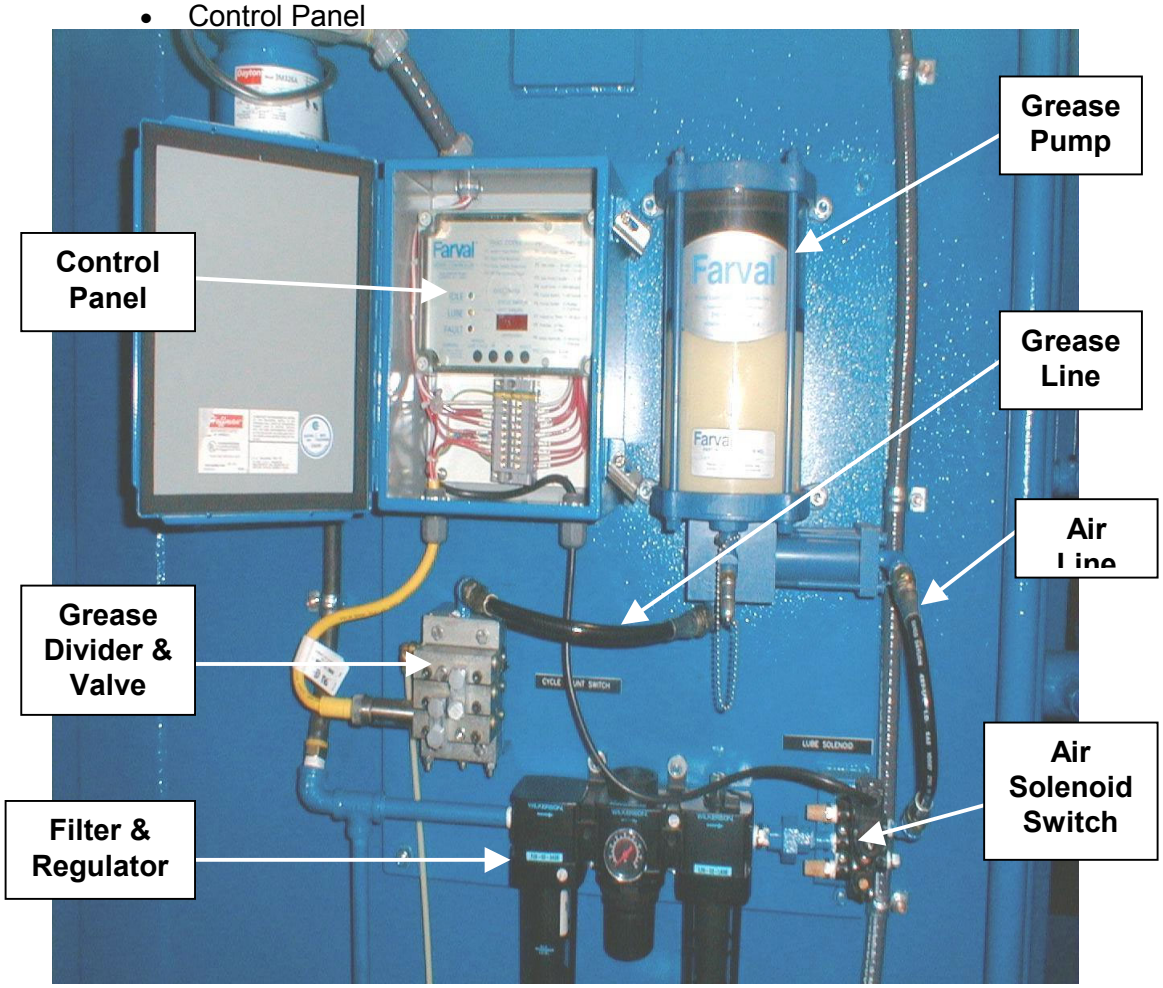

Fig. 7 - 1: Automatic Lubrication System Block Diagram

The air solenoid valve repeatedly cycles open and closed for a timed duration. Each opening and closing of the solenoid valve causes the grease pump to make one stroke. The grease is pumped from the reservoir to the grease-dividing valve. The dividing valve proportions the proper amount of grease flow from the pump to each bearing. Grease lines carry the grease flow from the dividing valve to each of the lubrication points:

- Turntable upper and lower bearings
- PBM swivel bearings

An electronic programmable controller inside the control panel mounted next to the grease pump controls the automatic lubrication system. A counter in the controller counts washer cleaning cycles and initiates a lubrication cycle after a preset number of cleaning cycles. (The factory pre-set is 1 cycle, which means that the automatic lubrication system will start every wash load.)

The duration of the lubrication cycle (which controls the number of cycles of the dividing valve and, therefore, the amount of grease pumped during a lubrication cycle) is programmable in the controller. The factory preset is for 5 cycles.

1.2. Installation

The automatic lubrication system arrives factory-installed.

1.3. Operations

Lubrication system operations are performed automatically. They may also be started manually.

The controller is programmed at the factory for an auto-lube cycle every machine wash cycle. The duration of the auto-lube cycle is factory preset for 5 cycles. These settings are initial startup settings only. You may want to change them depending on your needs.

The complete controller program with the factory presets is as follows:

Program Step	Setting	Description
Step #1	1	= Machine Counts
Step #2	0	= Counts X 1 - Each machine cycle counts 1
Step #3	1	= Run lube after every machine cycle
Step #4	1	= Number of minutes before “fault” occurs during lube
Step #5	5	= Number of switch transitions of cycle switch during lube cycle
Step #6	0	= Pulsed output to pump solenoid valve
Step #7	3	= Seconds of power on time for pulsed output
Step #8	0	= Idle mode, no lube on power up.
Step #9	1	= Normally energized fault relay, goes off during power loss.
Step #10	1	= Places controller in the operating mode

These settings set the controller for machine cycle mode. For further information on changing program settings and on the controller, refer to the supplied vendor information on the controller.

To adjust the number of wash cycles before an automatic lubrication cycle, or to change the duration of the lubrication cycle, read the vendor-supplied controller manual and adjust the controller steps as follows:

- Adjust Step # 3 to change the number of machine cycles required to initiate an automatic lubrication cycle.
- Adjust Step #4 to 1.3 times the lube cycle duration. (This depends on your setting for Step #5; determine the amount of time Step #5 requires, then adjust Step #4. *For example*, if the lube (Step #5) takes 10 minutes, set Step #4 to 13 minutes.)
- Adjust Step #5 to change the amount of grease pumped per automatic lubrication cycle.

NOTE: Step #3, Step #4 and Step # 5 are the only program changes that should ever be made in the field.

NOTE: Bearing Lubrication

Bearing lubrication is critical: Before making *any* changes to the lubrication cycle, refer to chapter "*Advanced Operations: Process-Control"* and to chapter *"Maintenance"* for information on required lubrication.

NOTE: *Use Lubriplate 1444 grease ONLY.*

Bearings are receiving too much grease: Adjust the lubrication duration. Adjust the Lube Cycle Counter to a higher number of cycles. See the *Operations* section for instructions on changing the controller program.

Bearings are receiving too little grease: Lengthen the lubrication duration. Set the Lube Cycle Counter to 1 so that a lubrication cycle is run every washer cleaning cycle. Check the system for proper operation. See the *Operations* section for instructions on changing the controller program.

Automatic Operation:

The control panel has an *off-auto* switch for controlling power to the auto-lube system. To run the system turn the switch to *auto*. The auto-lube system will function automatically until this switch is turned off.

Manual Operation:

To run the lubrication system at times other than those programmed, open the control panel door for the auto-lube system and press the *manual* button on the controller. The auto-lube system will start an (automatic) lubrication cycle.

Indicator Lights:

There are two indicator lights on the control panel. The *Lubrication Cycle* light will flash during the auto-lube cycle. The *Lubrication Fault* light will light should the controller detect a fault during an auto-lube cycle.

1.4. Maintenance

Every 8 hours of operation:

- Check the grease reservoir fill-level. Refill as required, according to the grease pump/reservoir manufacturer's instructions.
- Check the Auto-lube control panel for a fault indication. If the fault indicator is *ON*, your Auto-lube system is not providing grease to the bearings. Discontinue washer operations until the problem is corrected. Refer to section *Troubleshooting*.

NOTE: *Use Lubriplate 1444 grease ONLY.*

Every 160 hours of operation:

- Check the filter/regulator/lubricator unit. The lubricator has an oil reservoir, and is located on the right side of the washer. Add oil, if required, to the fill-level.

Refer to your vendor-supplied cutsheet for instructions.

NOTE: If the system runs out of grease, you will have to prime the system.

1.5. Troubleshooting

This section contains tables on the following problems:

- Automatic lubrication system fault light is *ON*

Problem: Automatic lubrication system fault light is ON	
Check This:	**Probable Cause(s)**
Grease Pump	Empty (refill grease reservoir)
Control valve	Stuck (replace)
Air-pressure	Not in the 75-100 PSI [1000-1400 kg/sq cm] range (check air-supply system)
Electric solenoid	Burned out (replace)
Grease dividing valve	Air bubble bled all air out of the system Stuck (disassemble, clean, & bleed)
Power	Verify that the controller has power
Step #4 in controller program	Time set too short

Fig. 7 - 2: Troubleshooting: Automatic Lubrication System Fault Light Is *ON*

NOTE: Bearing Lubrication

Bearing lubrication is critical: Before making *any* changes to the lubrication cycle, refer to chapter "*Advanced Operations: Process-Control"* and to chapter *"Maintenance" for* information on required lubrication.

NOTE: *Use Lubriplate 1444 grease ONLY*.

Bearings are receiving too much grease: Adjust the lubrication duration. Adjust the Lube Cycle Counter to a higher number of cycles. See the *Operations* section for instructions on changing the controller program.

Bearings are receiving too little grease: Lengthen the lubrication duration. Set the Lube Cycle Counter to 1 so that a lubrication cycle is run every washer cleaning cycle. Check the system for proper operation. See the *Operations* section for instructions on changing the controller program.

2. Clean Machine

The Clean Machine reduces clean out and re-charging of the cabinet reservoir. It automatically separates and collects sludge, metal particles, tramp oils, and other contaminants during the wash cycle.

2.1 Theory of Operation

The Clean Machine can be set to operate manually or on a timer, and can operate whether or not the washer is in operation. When the Clean Machine is in operation, washer solution is pumped from the washer reservoir through the Clean Machine and back into the reservoir. Eductors connected to the return line churn the reservoir solution to prevent sludge from settling and building up.

Two processes are used in the Clean Machine to separate oils, greases, and particulate matter from the cleaning solution:

- A *hydrocyclone* removes heavy particles and entrains air into the solution. Heavy particles settle out in a sludge-collection bin, from which the sludge must be periodically removed.

- Solution then flows into a chamber, where the entrained air brings oils and greases to the surface by coalescing action. A powered, rotating *skimmer* removes the oils and greases that collect on the solution surface. A *scraper* removes the collected material from the skimmer and deposits it in a collection device for further treatment, processing, or disposal.

The Clean Machine segregates the waste streams generated by washing, allowing you to:

- Collect waste oils and greases easily, and recycle them off-site
- Dispose properly of particulate matter

2.2 Installation

Install the power washer as described in chapter *"Installation."* When you charge the power washer with chemical, remember to add enough chemical to take into account the 135 gallons (511 liters) of solution that will fill the Clean Machine's separator tank.

Clean Machine
Physical Dimensions and Capacity

Length	5 feet, 3 inches	(1.60 m)
Width	2 feet, 3 inches	(.69 m)
Height	6 feet, 2 inches	(1.88 m)
Capacity	135 gallons	(511 liters)

Follow this procedure:

1. Set the *separator tank* by the *right side* of the *washer*. Leave enough room for access to the burner/heating elements, and opening the cabinet door. Be sure that when it is fully open, the door will not touch the Clean Machine.

2. Level the separator tank, if necessary. Refer to chapter *"Installation -- Leveling."*

3. Anchor the separator, using 5/8-18 bolts through the welded nuts on the feet of the tank. Refer to chapter *"Installation -- Anchoring."*

4. Refer to the following figure to install *piping* between the washer and the Clean Machine.

NOTE: Use schedule 40 black iron pipe, stainless-steel flex hose, or any other material suitable for 50% sodium hydroxide at 200° F. (93° C). All connections must be leakproof.

- *Install line #1*: 1 1/2-inch-diameter pipe from the 2-inch-diameter ball valve to the cyclone inlet.

- *Install line #2*: 2-inch-diameter pipe from the 2-inch-diameter coupling at the Clean Machine sludge tank to the 2-inch-diameter coupling at the right rear of the washer.

- *Install line #3*: 3-inch-diameter pipe from the 3-inch-diameter coupling on the Clean Machine tank to the 3-inch-diameter coupling at the right rear of the washer.

NOTE: Return pipelines to the power washer are gravity feed and must run downhill.

NOTE: Use a minimum of elbows and bends in the piping configuration. Refer to chapter *"Installation"* for more information.

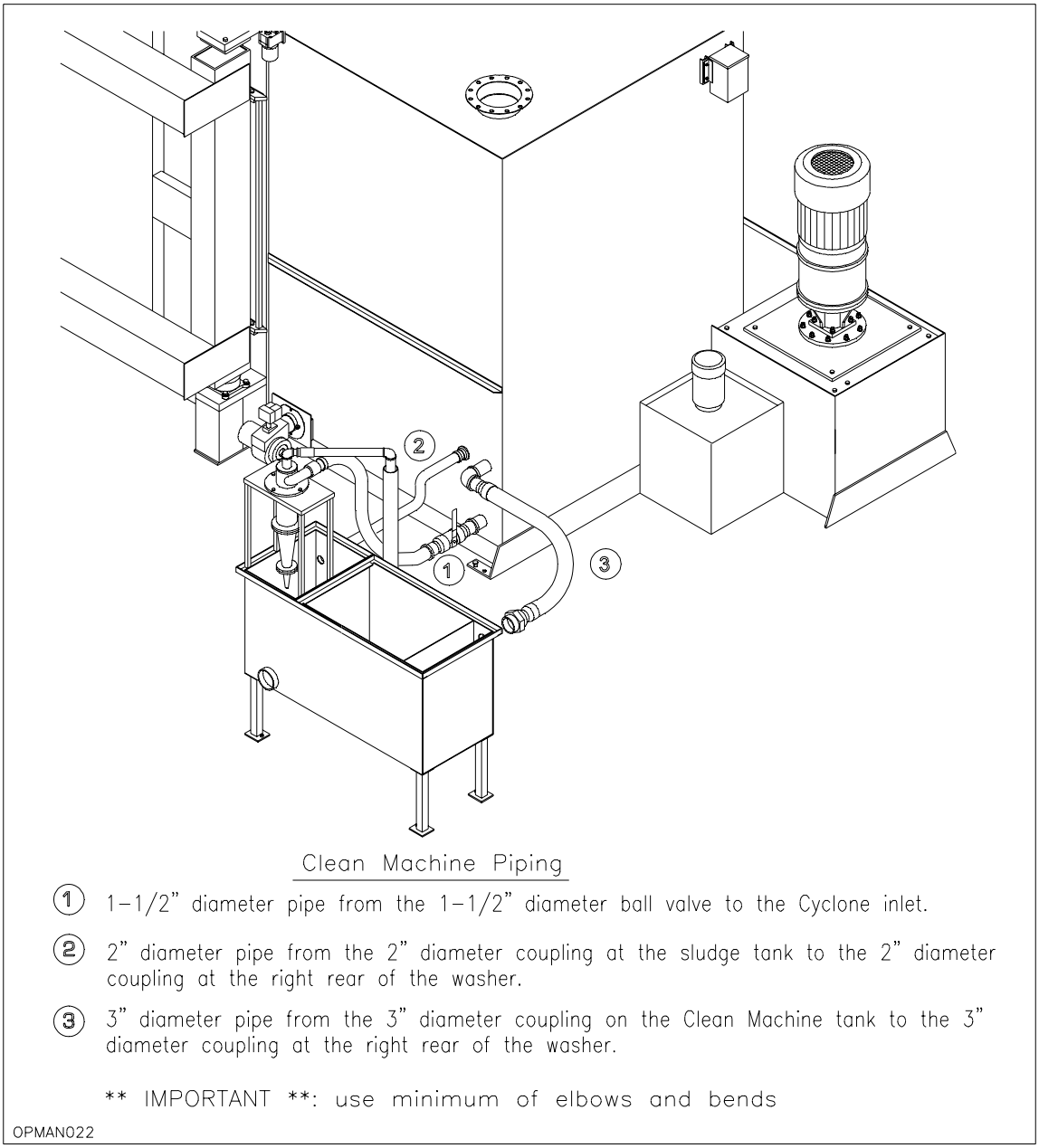

Fig. 7 - 3: Clean Machine Piping

5. Install the *wiring* between the Clean Machine and the washer as follows:

    - Run the sealtite *conduit*, located at the back of the *washer*, near the pump, to the *control box* on the *Clean Machine.*

    - Hook up the *conduit* to the *box* through the bottom of the box.

    - Install the *6 wires* to the *electrical box* as follows:
      Red Wire----------#10
      Green Wire----------Ground
      Pink Wire ----------SK
      White Wire ----------Neutral
      Black Wire----------Contactor
      Black Wire----------Contactor

6. Place an approved *container* at the *outlet* of the *skimmer assembly* to collect waste and tramp oils.

WARNING! Fill the Clean Machine's separator tank BEFORE you turn on the heat!

7. Set the *temperature controller* (aquastat), located on the side of the Clean Machine's separator tank, to 170° F (77° C). The heater replaces heat lost when the solution is in the tank -- it is NOT designed to heat solution from ambient temperature.

NOTE: Leave the heating loop *ON* for the Clean Machine's separator tank even when the washer is not in operation.

8. Verify that part of the *Clean Machine's pump flow* is directed to the washer (to agitate the solution and keep contaminates in suspension).

9. Verify that the *remainder of pump output* is directed to the Clean Machine's *separator tank*.

2.3 Operations

The Clean Machine system is designed to operate when the washer is in use, *or* after hours, when the washer is in "shut-down" (*off*) mode.

> NOTE: The maximum separation of sludge and oils will occur after a few days of washing heavily soiled parts.

To operate the Clean Machine, *follow this procedure*:

1. Set the Clean Machine's *selector switch*, located on the washer's control panel, to one of the following:

    - *Manual:* Activates the Clean Machine's pump. It will run continuously.
    - *Off:* Turns the Clean Machine's pump off.
    - *Auto:* Automatically activates and runs the Clean Machine according to the program set for circuit #2 of the 7-day clock.

      > **NOTE**: You *must* program the 7-day clock's circuit #2 for *ON/OFF* times, and set the Clean Machine's selector switch to *auto.*

2. After you activate the Clean Machine, verify the following:

    - The oil skimmer is rotating clockwise.
    - Water is being discharged from the bottom of the hydrocyclone.

> **NOTE**: To adjust the control valve on the Clean Machine pump, open the valve *completely*. Then, if you notice that water overflows from the oil skimmer tank into the sludge tank, slowly close the 1 1/2-inch-diameter (3.8 cm) valve just until water no longer overflows. Open the gauge valve on the cyclone, and note the pressure reading. The reading should be more than 15 PSI for the best separation. Close the gauge valve to protect the gauge.

2.3.1 Clean-Machine Operation: Frequency

The amount of contaminants on the parts to be washed will determine how often you should operate the Clean Machine.

Recommendations:

Heavy Soils Operate the Clean Machine on a daily, continuous basis.

Light Soils Operate the Clean Machine every other day.

> **NOTE**: If sludge builds up on the front floor of the washer reservoir, operate the Clean Machine more often.

2.3.2 Clean Machine: Chemical Management

Use the same chemical-management principles for the Clean Machine that you use for the power washer.

Refer to section *"Chemical-concentration Management"* in chapter *"Advanced Operations: Process-Control."*

2.4 Maintenance

Sludge removal is the principal maintenance required on the Clean Machine.

> **NOTE**: You do *not* have to drain the washer or the oil-skimming tank to remove accumulated sludge in the Clean Machine's sludge holding tank.

The hydrocyclone removes contaminates larger than 50 microns (table salt is approximately 100 microns in diameter). The exact rating is dependent on a number of factors, including the specific gravity of the particle, the actual particle size, and the pressure at the cyclone entrance.

The hydrocyclone expels sludge from its apex into the sludge chamber underneath. Because the hydrocyclone also discharges some water during operation, the sludge holding tank initially fills with water, up to the return outlet.

As operation continues, sludge that is removed from the washer displaces water in the sludge holding tank. Clean out the sludge when it reaches the bottom of the water return outlet.

Follow this procedure:

1. Place an approved *container* under the *5-inch (13 cm) cap*.
2. Remove the *cap* from the *sludge holding tank*.
3. Push *sludge* out through the *opening* into the *container*.
4. Replace and tighten the *cap*.

2.5 Troubleshooting

> ***CAUTION! Never run the oil skimmer in a tank where there is no oil on the solution surface. The absence of oil creates excess drag on the skimmer motor. This will damage the motor.***

This section contains tables on the following problems:

- Clean machine does not heat
- Hydrocyclone does not separate
- Oil skimmer tank overflows into cyclone separator tank
- Skimmer-wheel drain trough backs up

Problem: Clean machine does not heat	
Check This:	**Probable Cause(s)**
Aquastat	Incorrect temperature (set controller to 170°F [77°C])
Amperage	Low draw: Wires may be loose Heating element may need to be replaced
Fuses	Blown (power *OFF*, then pull out of electrical box to check)

Fig. 7 - 4: Troubleshooting: Clean Machine Does Not Heat

Problem: Hydrocyclone does not separate	
Check This:	**Probable Cause(s)**
Ball valve	Ball valve on the discharge line from the pump needs adjustment
Cyclonic separator	Clogged (remove bottom clamp & clean out debris)
Pressure at cyclone	Too low (15 PSI minimum)

Fig. 7 - 5: Troubleshooting: Hydrocyclone Does Not Achieve Cone Effect

Problem: Oil skimmer tank overflows into cyclone separator tank	
Check This:	**Probable Cause(s)**
Discharge line	Clogged overflow pipe
Ball valve setting	Improper adjustment (adjust)

Fig. 7 - 6: Troubleshooting: Oil Skimmer Tank Overflows into Cyclone Separator Tank

Problem: Skimmer-wheel drain trough backs up	
Check This:	**Probable Cause(s)**
Drain trough	Clogged
Blades	Not contacting wheel: Bend to adjust Replace if worn
Wheel	Not turning (check/tighten shaft nuts)
Motor	Motor not turning (115 V): Fuse needs to be replaced Wires need to be tightened Motor needs to be replaced

Fig. 7 - 7: Troubleshooting: Skimmer-Wheel Drain Trough Backs Up

3. Center Manifold

The optional center manifold is used to clean very narrow-diameter, hollow, long parts whose interior is inaccessible to the washing solution. Examples of such parts include gun barrels, long pipes, and turbine pumps.

The center manifold oscillates vertically inside the part as the part rotates in the center of the turntable. The center manifold cleans the interior as the power blast manifold (PBM) cleans the exterior.

3.1. Theory of Operation

A *superstructure* on the reinforced roof of the washer cabinet houses the *center manifold*, as shown in the following figure. The center manifold consists of a vertical manifold tube the length of the work height of the washer, with 2 wash nozzles located horizontally and connected to the lower end. The tube is guided through a pair of bushings in the cabinet roof. The tube is raised and lowered by a roller chain and carriage, which are driven by a gear motor.

Wash solution is piped to the vertical manifold tube through a hose attached to the back of the cabinet roof. Optionally, an extra tube may be attached to the vertical manifold tube for carrying rinse water to a pair of rinse nozzles on the lower end of the manifold. Flexible tubing is connected to the hose to carry rinse water. The fluid flow for the center manifold is provided from a tap off the flow to the power blast manifold (PBM).

Door Lock. The center manifold system incorporates an additional feature on the standard washer to help prevent accidental damage to the vertical manifold tube or parts on the turntable. An electrically actuated solenoid locks the washer cabinet door closed during operating cycles to prevent accidental opening with the center manifold in the down position. The door remains locked until the manifold returns to the *home* position. The lock functions automatically whenever the center manifold system is used (in manual *and* automatic modes).

Power is required to unlock the door. In the event of a power failure, or if power is turned off to the machine, the door-lock solenoid will de-energize and lock the door. The lock can be manually by-passed by pushing up the small pin that protrudes below the solenoid lock box and opening the door. This will probably require the assistance of another person. Be sure the manifold is in the *home* position before performing this procedure.

3.2. Installation

This option arrives with the vertical manifold and superstructure disconnected.

To install the center manifold, *follow this procedure*: (refer to the following figure)

1. Place beads of sealant around the roof opening.
2. Place the superstructure (frame and mechanism) on the pad support on the roof.
3. Connect the superstructure plate to the pad on the roof.
4. Connect the wash and rinse lines to the connections on the roof.
5. Connect bracing, if supplied.
6. Connect wires to the gear motor and to the brake assembly to the limit switch.

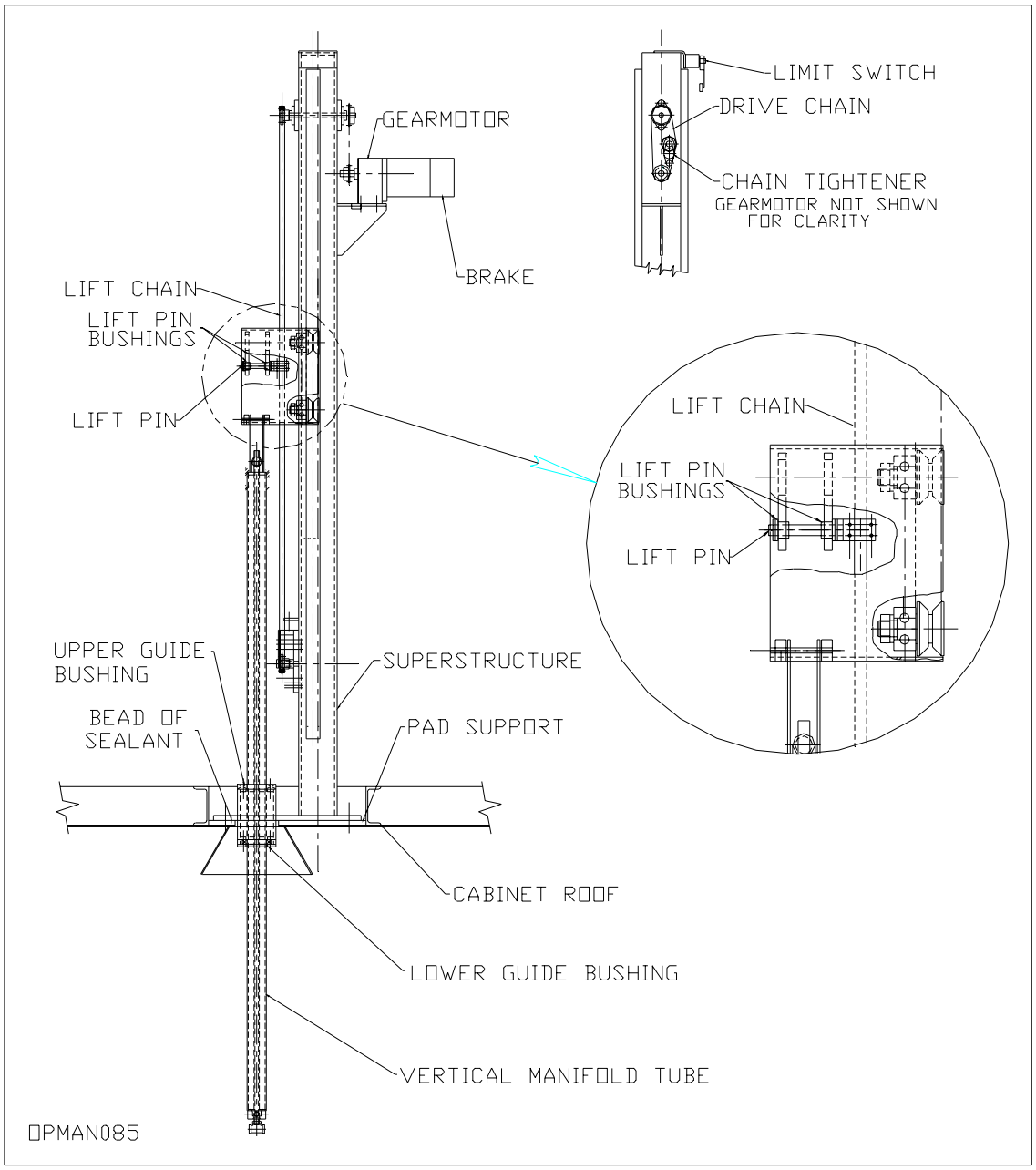

Fig. 7 - 8: Center Manifold Mechanism and Superstructure

3.3. Operations

WARNING! The minimum inside diameter of a part that can be cleaned by the center manifold is 5 inches.

To operate the center manifold, *follow this procedure*:

1. Verify that the manifold is *up* near the roof of the cabinet.

   The center manifold has an automatic *Home* (or *up*) position controlled by a limit switch at the top of the superstructure.

2. Place the part to be washed in the center of the turntable. (A special fixture may be needed to keep the part centered on the turntable and properly aligned with the center manifold.)

   WARNING! Be sure the part is centered properly, so that the center manifold does not hit the part!

3. Set the ***center manifold mode*** *selector switch*, located on the washer's control panel, to one of the following:

   - *Man:* Turns *auto* mode *OFF.* Activates the ***manifold jog*** *push button,* which lets you manually control the down/up position of the center manifold.
   - *Auto:* Returns the manifold to the *home* position, and sets *automatic cycle* as part of the wash/rinse cycle. A light on the control panel illuminates each time the center manifold strokes during operation. The center manifold works with the power blast manifold (PBM).
   - *OFF:* Returns the manifold to the *home* position, and disables *auto* cycle.

Refer to chapter *"Basic Operations"* for more information on loading and unloading parts.

3.4. Maintenance

Refer to the previous figure to help locate parts during maintenance procedures.

Every 40 Hours of Operation

Oil the chains and lift-pin bushings in the carriage.

Follow this procedure:

1. Turn the *main power supply OFF*.
2. Verify that the manifold is up near the top of the cabinet roof, in the *Home* position.
3. Inspect the lift chain; lift pin, and bushings for wear and looseness.
4. *If loose,* tighten the lift chain by using the adjuster located near the bottom of the superstructure.
5. Check the adjustment of the drive chain at the gear motor. Remove any excess play with the chain tightener.

Every 250 Hours of Operation

Teflon Bearing Plates

Inspect the Teflon bearing plates in the double-bearing housing. Look for excessive sideways movement of the center manifold or for bearing wear (hole is oblong): Replace the plates.

3.5. Troubleshooting

This section contains tables on the following problems:

- Water leaks onto cabinet roof
- Center manifold assembly does not work
- Center manifold light does not illuminate

Problem: Water leaks onto cabinet roof	
Check This:	**Probable Cause(s)**
Manifold hose	Cracked (replace) Loose (tighten)
Rinse pipefittings	Broken tubing (replace) Loose fittings (tighten)

Fig. 7 - 9: Troubleshooting: Water Leaks Onto Cabinet Roof

Problem: Center manifold assembly does not work	
Check This:	**Probable Cause(s)**
Superstructure	Damaged
Limit switch	Damaged (replace)
Electric solenoid	Burned out (replace)
Fuses	Blown (turn power *OFF* and pull out of electrical control panel to check)
Relay(s)	Need to be tightened or replaced
Overload	Tripped (reset) Chain jammed Brake not releasing

Fig. 7 - 10: Troubleshooting: Center Manifold Assembly Does Not Work

Problem: Center manifold light does not illuminate	
Check This:	**Probable Cause(s)**
Selector switch	Not set to *auto* or *manual* (manifold at *home* position)
Switch light bulb	Burned out (replace)

Fig. 7 - 11: Troubleshooting: Center Manifold Light Does Not Illuminate

4. Chemical Conductivity Controller

After you have determined an effective chemical concentration, as described in chapters *"Overview"* and *"Advanced Operations: Process-Control,"* you must monitor and maintain that concentration to provide consistent cleaning performance.

The optional Chemical Conductivity Controller automatically monitors and maintains chemical concentration by electronically measuring the (electrolytic) conductivity of the cleaning solution. This is a useful technique for figuring out when to add more detergent to a high-ionic strength cleaning solution such as those based on salts. (Potassium hydroxide, sodium hydroxide, or sodium metasilicate) This is **not** a useful technique for monitoring high emulsifying cleaners that rely on surfactants for a significant part of the cleaning mechanism.

Electrolytes are ionic compounds such as salts, acids, or bases. Added to water, or a water-based (aqueous) solution, they increase its conductivity.

Conductivity is defined as the ability of a substance to conduct electric current. All aqueous solutions conduct electricity to some degree. The addition of electrolytes increases conductivity. Since conductive liquids consist of ionic compounds (electrolytes) dissolved in water, more ions in the solution indicate higher conductivity. In applications using very pure to very concentrated chemical solutions, a rising conductivity reading indicates a generally increasing chemical concentration.

Thus, a simple electronic conductivity test can measure the makeup of a ionic solution and indicate its approximate chemical concentration. Unfortunately, compounds other than cleaning chemicals affect the conductivity of the solution (These compounds include iron oxide (rust) and carbon, both commonly found in most washing applications.) And some cleaning compounds are not conductive. Conductivity measuring systems provide an *estimate* of the strength of the chemical in the solution by measuring the *relative* conductivity of the solution.

Conductivity is expressed in millionths of a Siemen: microSiemens/cm, or μS/cm. One mS/cm equals 1000 μS/cm.

Contact your chemical supplier for a chart of conductivity vs. concentration for your chemical and to determine if conductivity measurement is an appropriate technique for controlling the concentration of your solution.

4.1. Theory of Operation

The Chemical Conductivity Controller system consists of the following:

- Conductivity controller
- Electrode-probe
- Peristaltic pump
- Tubing

For the system to function properly, the concentration of your chemical must be proportional to its conductivity.

The system measures conductivity with electronics connected to a *probe* immersed in the washer's cleaning solution. A concentrated chemical is added by a pump to maintain the conductivity of the solution at the selected set point.

The *conductivity controller* uses a set point for the minimum allowable conductivity. When the electrode probe senses that **conductivity has fallen below the set point** you have selected, it closes a relay. If the relay closes while the wash pump is operating, the *peristaltic pump* activates and pumps concentrated chemical solution into the washer's reservoir. Concentrate is only added during the wash cycle, so that mixing occurs. When the probe senses that **conductivity has risen above the set point**, the controller relay opens. This prevents the peristaltic pump from adding concentrate.

The peristaltic pump turns rollers, which squeeze concentrate through the precision-bore, high-tolerance tubing in a wave-like motion, acting like a positive-displacement pump. The concentrate comes in contact *only* with the tubing, *not* the pump. The pump is self-priming and non-siphoning.

The probe is mounted to the end of a tube. This tube is used to insert the probe into the pump suction tube. The probe can be removed without draining the washer.

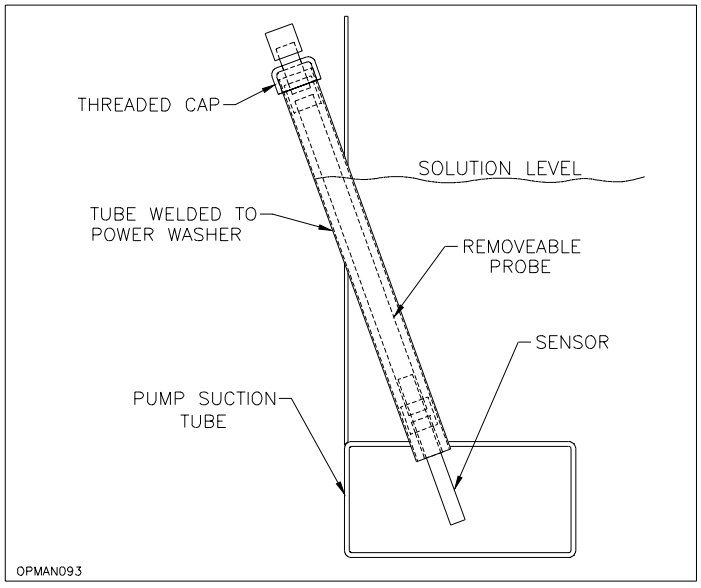

Fig. 7 - 12: Chemical Conductivity Probe

Chemical Management

When a washer is first put into service, it is easy to compute the concentration of the cleaning compound, because you started with a fixed volume of water and added a known quantity of chemical. After you begin using the washer, however, you can only *estimate* the chemical concentration -- until you drain the washer, clean it out, and recharge it with fresh water and chemical.

There are two commonly used estimating tools:

- Conductivity measuring systems
- Titration kits

Conductivity Measurement

A conductivity measuring system measures the strength of a fixed electrical current flowing between two or more electrodes that are held at a fixed distance. Since the addition of cleaning compounds (chemical) to water changes the capacity of water to conduct electricity, conductivity measuring systems can provide an *estimate* of the strength of the chemical in the solution by measuring the *relative* conductivity of the solution.

Unfortunately, compounds other than cleaning chemicals also affect the conductivity of the solution in the washer. These compounds include iron oxide (rust) and carbon, both commonly found in most washing applications.

This means that while conductivity measuring systems can be used as a control point, this is done with the understanding that the oils, greases, metal particles and other contaminants that are byproducts of the cleaning process affect conductivity.

Thus, the only true measure of chemical concentration is to use titration tests in conjunction with conductivity measurements to determine a correlation. Once you know the correlation, you can get a fairly accurate estimate of chemical concentration in the solution by using a conductivity measuring system.

Titration

Titration is the estimation of the strength of a compound by measuring the amount of another compound of known strength that is required to produce an observable reaction.

Almost all titration kits supplied with cleaning compounds use phenolphthalein (indicator P) as a reactant, and an acid (hydrochloric or phosphoric) as a neutralizer. The indicator P turns red or pink or blue when added to a sample of the solution. By counting the drops of acid it takes to turn the solution back to its original color, you can arrive at a good *estimate* of the chemical concentration.

Correlating Titration Results and Conductivity Measurements

To measure the chemical concentration in your washer's cleaning solution, titrate the solution once a week and perform a conductivity test at the same time. Your objective is to learn how chemical concentration and conductivity vary from wash to wash. Set up a graph that shows the correct concentration, and then graph the actual variance in concentration and conductivity.

After several weeks of testing and graphing, you should see a pattern -- this is the correlation between chemical concentration and conductivity. Given any conductivity reading on your graph, you will most likely see a difference between the ideal and the actual chemical concentration of the solution. Use this "compensation factor" to know how to adjust chemical concentration based on conductivity readings.

Conclusion

After you have developed a correlation between chemical concentration (the results of titration) and conductivity measurement testing, you can use a conductivity measuring system to provide a *close estimate* of the strength of the chemical in the solution.

At this point, conductivity measurement can be used for one of two purposes:

- As an indicator of the need to titrate.
- As an indicator of the need to add chemicals.

If the correlation between conductivity and titrated concentration is close enough for the purposes of the operator, then titration should only be used as a periodic check on the conductivity measuring system.

4.2. Installation

The Chemical Conductivity Controller system is factory-installed and shipped ready for use.

The electrode-probe arrives installed in the washer, based on your specifications.

4.3. Operations

Follow this procedure:

1. Check the *conductivity reading* on the *controller panel* at the chemical concentration recommended by your chemical supplier, or developed through process-control testing (refer to chapter *"Advanced Operations: Process-Control."*)

2. Adjust the *LO set point* to this reading.

> **NOTE**: Refer to the controller-vendor-supplied manual for instructions on changing ranges and setting set points.

3. Insert the *peristaltic pump suction tube* into a *barrel* of 50%-diluted chemical concentrate.

> **NOTE:** The peristaltic pump only pumps during wash cycles when chemical is needed.

4.4. Maintenance

Every 160 hours of operation:

- *Monitor* chemical usage by the peristaltic pump. Replace the empty barrel after the concentrate has been completely used.
- *Test* peristaltic pump operation:
    1. Set the controller *LO set point* 10% below the actual solution conductivity.
    2. Run a wash cycle.
    3. Verify that the pump is pumping chemical into the reservoir.
    4. Re-set the LO set point to your *control set point*.

Peristaltic Pump and Tubing

The pump has few moving parts, and no seals or valves to clog, clean, or replace. As tubing fatigues (and eventually cracks), move it to a section that has not been under the pump rollers. Then, continue pumping.

When you run low on tubing, order a new spool.

Sludge Clean-Out

During sludge clean out, clean the probe thoroughly. Follow the vendor-supplied instructions.

4.5. Troubleshooting

This section contains tables on the following problems:

- Peristaltic pump does not pump
- Concentration cannot be maintained

Problem: Peristaltic pump does not pump	
Check This:	**Probable Cause(s)**
Pump tubing	Cracked (move or replace)
Barrel	Empty of concentrate (replace)
Power	Not *ON*
Fuses	Not intact (remove and measure continuity)
Overloads	Not all of them are re-set
Probe	Dirty (clean)
Set point	Too high (set below readout level)
Pump motor	Defective (replace)

Fig. 7 - 13: Troubleshooting: Peristaltic Pump Does Not Pump

Problem: Conductivity cannot be maintained	
Check This:	**Probable Cause(s)**
Peristaltic pump tubing	Cracked (move or replace)
Barrel	Empty of concentrate (replace)
Conductivity controller	Set point incorrectly set
	Defective
Chemical	Concentration: Wrong type of chemical Wrong concentration recommended or developed Concentration not proportional to conductivity

Fig. 7 - 14: Troubleshooting: Conductivity Cannot Be Maintained

5. Internal Reservoir Cover

The internal reservoir cover provides the following benefits:

- Safety: Provides a barrier covering the wash solution reservoir. This isolates the operator from accidental contact with the hot wash solution as might occur if someone was to slip and fall.
- Catch: Catches small parts that may loosen during the cleaning cycle and fall from the turntable. The floor prevents the parts from falling into the solution and being lost in the reservoir.
- Insulation: Provides a thermal insulation cover over the reservoir tank. This slows down the heat loss from the reservoir (saves energy) especially when the cabinet door is open.

5.1. Theory of Operation

The internal reservoir cover is steel-sheet-supported by angles welded to the cabinet walls above the wash solution reservoir and below the turntable. It funnels all liquid back through an expanded-metal screen area to the reservoir.

The internal reservoir cover is removable for sludge clean out and other maintenance procedures. It is held in place by thumbscrews, which are easily removed and replaced.

5.2. Installation

If you purchase the optional internal reservoir cover, your power washer is delivered with the internal reservoir cover factory-installed and ready to use.

5.3. Operations

There are no operational procedures for the internal reservoir cover.

WARNING! Do NOT OVERLOAD the internal reservoir cover or other horizontal surfaces. The internal reservoir cover is intended as a chemical-solution cover ONLY! Horizontal surfaces are NOT designed for walking or standing! Walking on the internal reservoir cover, tank cover, or other horizontal surfaces could result in serious injury or death.

5.4. Maintenance

Clean the internal reservoir cover as required. Pay particular attention to the expanded-metal screen area: be sure that no bolts or other parts, gasket material, or debris clog the screen. **NOTE: If your internal reservoir cover has the optional chip baskets, do not stand on or in the baskets**.

If the expanded-metal screen or the optional chip baskets becomes clogged, the pump(s) may flood the false floor, resulting in cleaning solution or rinse water pouring over the doorframe into the front reservoir. Refer to section *"Troubleshooting."*

5.5. Troubleshooting

This section contains tables on the following problems:

- Water leaks over doorframe

Problem: Water leaks over doorframe	
Check This:	**Probable Cause(s)**
False floor screen area	Expanded-metal screen area clogged with bolts or other parts, gasket material, debris (clean screen)

Fig. 7 - 15: Troubleshooting: False Floor: Water Leaks Over Door Frame

6. 50 Hertz Electrical Power

This option is intended for installation sites that use 50 Hz electrical power instead of 60 Hz. The pump system has been reconfigured using V-belts to drive the pump, enabling a washer powered by 50 Hz to deliver the same performance as one powered by 60 Hz. This results in the same efficiency, pressures, and flows.

All other systems and components are the same.

6.1. Theory of Operation

The pump motor is no longer directly coupled to the pump. This option uses a V-belt drive to recover the loss in rpm and turn the pump at the same rpm it would turn at 60 Hz. The bigger sheave (pulley) is on the pump motor; the smaller, on the pump.

The pump motor is mounted on an adjustable base at the side of the reservoir. This allows for aligning the belt drive as well as tensioning the belt(s). Depending on the horsepower of the pump, the V-belt drive uses 1to 3 belts.

6.2. Installation

This option arrives factory-installed.

6.3. Operations

Operations are the same as those for a standard washer.

6.4. Maintenance

After the first 8 hours of operation, check belt tension and sheave alignment.

To adjust belt tension, *follow this procedure:*

1. Remove the *belt guard*.

2. Turn the upper and lower adjusting bolts on the motor's adjustable base to tighten or loosen belts. Turn each of the bolts *exactly* the same number of turns to maintain belt alignment.

3. Use a *belt tension checker* to verify proper tension. **NOTE:** Follow belt-tensioner directions for proper tension adjustment.

> **NOTE**: When a properly tensioned belt is running, the tight side of the belt forms a straight line from sheave to sheave. The slack side slightly bows.

To verify sheave alignment, *follow this procedure*:

1. Remove the *belt guard*.

2. Adjust belt tension.

3. Use a *level* to verify that the motor shaft and the pump shaft are parallel. (This prevents excessive wear of the sheaves and belts.)

4. Be sure that the sheaves are at the same height in the same plane, so that the belts run true.

Every 250 hours of operation:

- Visually inspect belt(s) for wear, and adjust tension as needed.

General Maintenance

- Keep belts clean. *Never* use belt dressing! This will damage belts and cause early failure.

- Be sure that air can circulate freely around the V-belt drive, and that temperatures are moderate. This will extend belt life.

- *Never* cover the expanded metal guards (vents) that protect the V-belt drive.

- Replace belts with original manufacturer's equipment or equivalent.
- Keep extra belts stored in a cool, dark, dry place.

6.5. Troubleshooting

This section contains tables on the following problems:

- Squealing sounds from pump area
- No wash cycle (no water pumped): simplex pump system
- Poor cleaning results *or* abnormal pump noise: duplex pump system

Problem:	***50 Hz electrical power -- Squealing sounds from pump area***
Check This:	**Probable Cause(s)**
Belt(s)	Slippage (tighten) Worn and frayed (replace)
Sheaves	Walls worn, with resulting belt slippage (replace)

Fig. 7 - 16: Troubleshooting: 50 Hz Electrical Power -- Squealing Sounds from Pump Area

Problem:	***50 Hz electrical power -- No wash cycle (no water pumped): simplex pump system***
Check This:	**Probable Cause(s)**
Belt(s)	Broken (replace)

Fig. 7 - 17: Troubleshooting: 50 Hz Electrical Power -- No Wash Cycle (No Water Pumped): Simplex Pump System

Problem: 50 Hz electrical power -- Poor cleaning results or abnormal pump noise: duplex pump system	
Check This:	**Probable Cause(s)**
Main pump belt(s)	Broken (replace)
Booster pump belt(s)	Broken (replace)

Fig. 7 - 18: Troubleshooting: 50 Hz Electrical Power -- Poor Cleaning Results *or* Abnormal Pump Noise: Duplex Pump System

7. Filters

The optional *Filters* remove particles as small as 1 micron from the wash solution. If you have purchased this option, your MART representative will have worked with you to select a micron rating that best suits your washer's configuration and your applications.

When you purchase replacement filters, be sure the micron-rating is appropriate for your washer's configuration: A filter with extremely fine pores could significantly increase the pressure-differential and overload the capacity of the filter housing, affecting pump pressure and flow rate.

7.1. Theory of Operation

The two filter types are:

- Bag
- Cartridge

Filter Types

Bag filters are generally recommended for 50-100 microns, although they can filter down to 1 micron at lower flow rates. Bag filters are less expensive than cartridge filters, easier to change, and re-usable. One filter at a time is inserted into the housing. Bags are constructed of polypropylene, especially selected for reliable performance in a hot, caustic environment.

Cartridge filters are rated for 1-50 microns. Multiple filters may be inserted into the housing.

Filter housings have a swing-away lid. Filter elements are inserted into the housing from the top. The housing lid is tightened with swing-bolts.

The following table shows micron comparisons to guide you in selecting filters.

Micron Comparisons

Substance	***Microns***
Table salt	100
Human hair (avg. dia.)	50-70
White blood cell	25
Talcum powder	10
Cocoa	8-10
Red blood cell	8
Bacteria (cocci)	2

Fig. 7 - 19: Micron Comparisons

NOTE: The lower limit of visibility to the naked human eye is 40 microns.

Filtering System Configurations

There are two filtering system configurations. The following diagram shows solution flow:

Wash pump ➔	Filter ➔	Manifold (PBM)
Or		
Filter pump ➔	Filter ➔	Eductor nozzles (in reservoir)

The filter-pump-driven system allows for continuous filtering operation.

7.2. Installation

The filters are delivered installed, according to the configuration you specified.

7.3. Operations

The *wash-pump-driven configuration* is fully automatic and runs during the wash cycle.

To operate the filter-pump-driven configuration, *follow this procedure*:

1. Set the *filter-pump timer*, located in the washer's electrical control panel. The standard 5-hour timer is numbered 1-10 (each number represents a 1/2-hour increment). The timer controls the length of time the filter pump operates in *auto* mode, *if* you set the selector switch to *auto* (in the following step).

2. Set the filter pump's *selector switch*, located on the washer's control panel, to one of the following:

    - *Manual:* Activates the filter pump. It will run continuously.

    - *Off:* Turns the filter pump off.

    - *Auto:* Automatically activates the filter pump at the beginning of a wash cycle and runs the filter pump for the time indicated on the *filter-pump timer.*

7.4. Maintenance

Every 40 hours of operation:

- Check the filter elements. Replace dirty elements.

If you notice that cleaning results are not as good as usual, or that more time is necessary, check the filter elements. If they are dirty, replace them.

If your washer is equipped with the optional pressure-differential gauge, replace the filter when the pressure-differential has increased by 10 PSI (142 kg/cm^2) or more.

7.5. Troubleshooting

This section contains tables on the following problems:

- Wash load not clean
- Solution leaks from filter cover

Problem: Wash load not clean	
Check This:	**Probable Cause(s)**
Filter	Dirty (change filter)

Fig. 7 - 20: Troubleshooting: Wash Load Not Clean

Problem: Solution leaks from filter cover	
Check This:	**Probable Cause(s)**
Cover gasket	Dirty (clean)
Cover clamps	Loose (tighten)

Fig. 7 - 21: Troubleshooting: Solution Leaks from Filter Cover

8. Frequency Drive

The optional *Frequency Drive* is an electronic device that controls pump motor speed. The result is control of pressure and flow output.

8.1. Theory of Operation

The *Frequency Drive* is programmable for a variety of input, output, and performance configurations in industrial applications. It can be mounted on the washer cabinet, or in another, more convenient location. If the unit is remote-mounted, the power lines run from the washer's control panel to the *Frequency Drive*, and then to the pump motor.

Refer to the vendor-supplied manual for more information.

8.2. Installation

If you specify that your *Frequency Drive* be mounted on the washer cabinet, no further installation is required.

If you intend to remote-mount the *Frequency Drive*, follow the manufacturer's installation instructions, and make appropriate electrical connections.

> ***WARNING! If you have the Frequency Drive remote-mounted, be sure a qualified electrician does the work.***

8.3. Operations

Refer to the vendor-supplied manual for instructions on configuring the *Frequency Drive* input, output, and performance parameters in order to adjust the percent of full load, which adjusts pressure and flow. The following figure shows frequency drive results.

One benefit of reduced pressure is the ability to clean delicate parts.

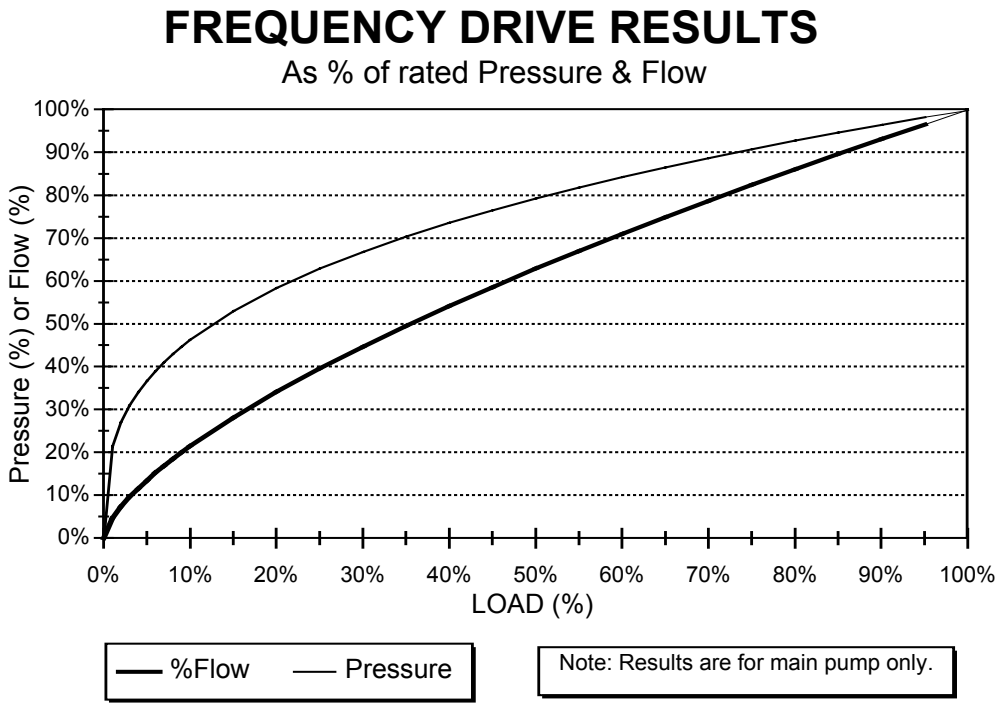

Fig. 7 - 22: Frequency Drive Results

8.4. Maintenance

Follow the manufacturer's recommended maintenance schedule and procedures for cleaning and oiling the fan.

8.5. Troubleshooting

This section contains tables on the following problems:

- Pump motor does not run

Problem: Pump motor does not run	
Check This:	**Probable Cause(s)**
Power	Not *ON*
Frequency drive	LED power indicator *not* lit (check power) LED fault-diagnostic indicator lit (refer to the vendor-supplied manual)

Fig. 7 - 23: Troubleshooting: Pump Motor Does Not Run

9. Hot-Air Blow-Off (HABO)

The optional Hot-Air Blow-Off (HABO) system "flash"-dries parts by high-velocity, direct blasts of air that blow most of the water off parts. Heat evaporates any remaining water.

All HABO systems are delivered with the following features:

- Heater contactor wired in-line with blower
- Over-temperature protection
- Duct-heater
- TEFC fan motor
- Direct-coupled aluminum, balanced fan blade
- High-velocity conversion nozzles 3 inches (7.6 cm) from the edge of the turntable

9.1. Theory of Operation

The HABO system activates after wash and rinse cycles have completed: The fan turns on while the turntable continues to rotate. Air is inducted from outside the washer cabinet by the fan and blown through the electric heating coils. The air picks up heat as it passes around the heating coils. Finally, the heated air is accelerated to high velocity as it travels through the plenum and out the nozzles to blow water off parts on the turntable.

The heating units are sized to provide a minimum of 110° F (43° C) rise above ambient to operating air temperature.

Steam-Exhaust Fan

NOTE: The HABO system removes steam using a variable-speed DC-drive centrifugal steam-exhaust fan, which replaces the standard ASE unit. The centrifugal fan differs from the standard unit in two keyways:

- The inlet is at a 90° angle from the outlet.
- The outlet ducting is *square* and connects to a *round* pipe.

Therefore, you must modify the standard installation procedures given in chapter *"Installation"* in this manual to account for these two differences. Refer to the following section, *Installation,* for more information.

The centrifugal fan runs at two speeds:

- *Low speed* provides normal steam exhaust. (It works similar to the auto steam exhaust [ASE] feature).
- *High speed* minimizes steam leakage from the cabinet during HABO.

Refer to the vendor-supplied cutsheet for instructions on setting fan speed.

Controlling HABO Heat

Thermocouples in the outside plenum on top of the washer cabinet and a temperature controller inside the electrical control panel control HABO heat.

NOTE: The *outside plenum* contains the blower unit, the thermocouples, and the heating element.

A redundant (back-up) heat-source measuring system works in conjunction with a high-level shutdown system to de-activate the HABO system if the heating element should overheat. Refer to section *"Troubleshooting."*

9.2. Installation

If you have a HABO system, you must modify standard ASE installation procedures. Refer to the following figures.

MART has available as an option flanged transition pieces to adapt the ASE fan to round ducting.

To install the HABO, *follow these guidelines*:

1. There are two couplings welded into the ASE fan blade housing. Use one of these couplings to connect a drain line back into the ASE ducting below the fan. This will allow condensed water vapor to drain back to the washer.
2. The output of the ASE fan can be rotated to any direction. Select a direction for the output that puts one of the two drain couplings on the fan in the DOWN position.
3. Remove the fan housing and rotate it to the selected direction.

4. During reassembly, thoroughly caulk all joints of the fan with a good-quality silicone caulk.

   Tip: Seal all joints with a 100% pure silicone caulking compound to prevent dripping and leaking from the steam in the exhaust.

   Tip: If at all possible, install the ASE fan **outside** to eliminate many of the nuisance dripping problems associated with steam condensing in the fan.

Tip: If your planned piping route contains any 90° elbows, install the fan at the elbow.

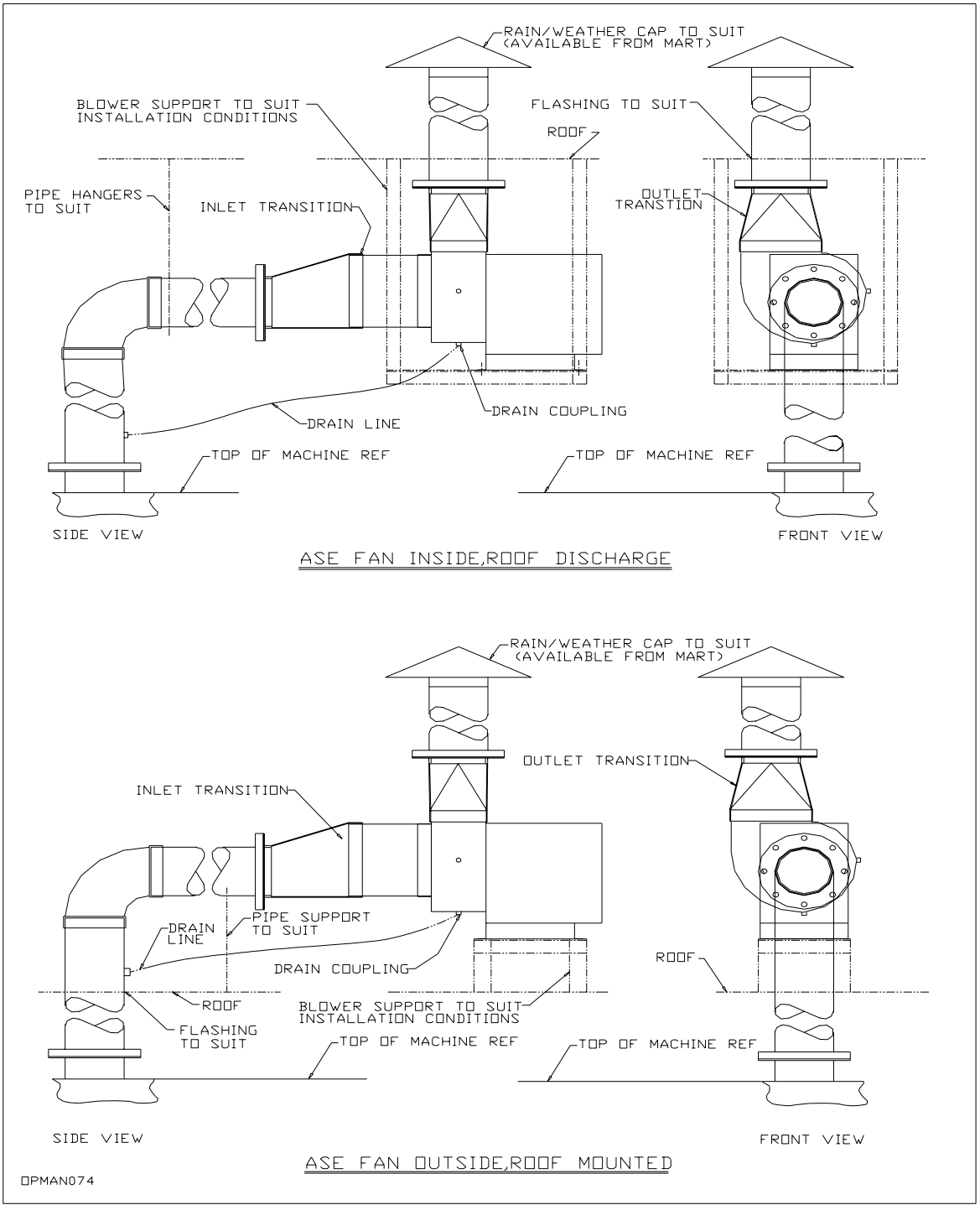

Fig. 7 - 24: HABO -- ASE Fan Installation

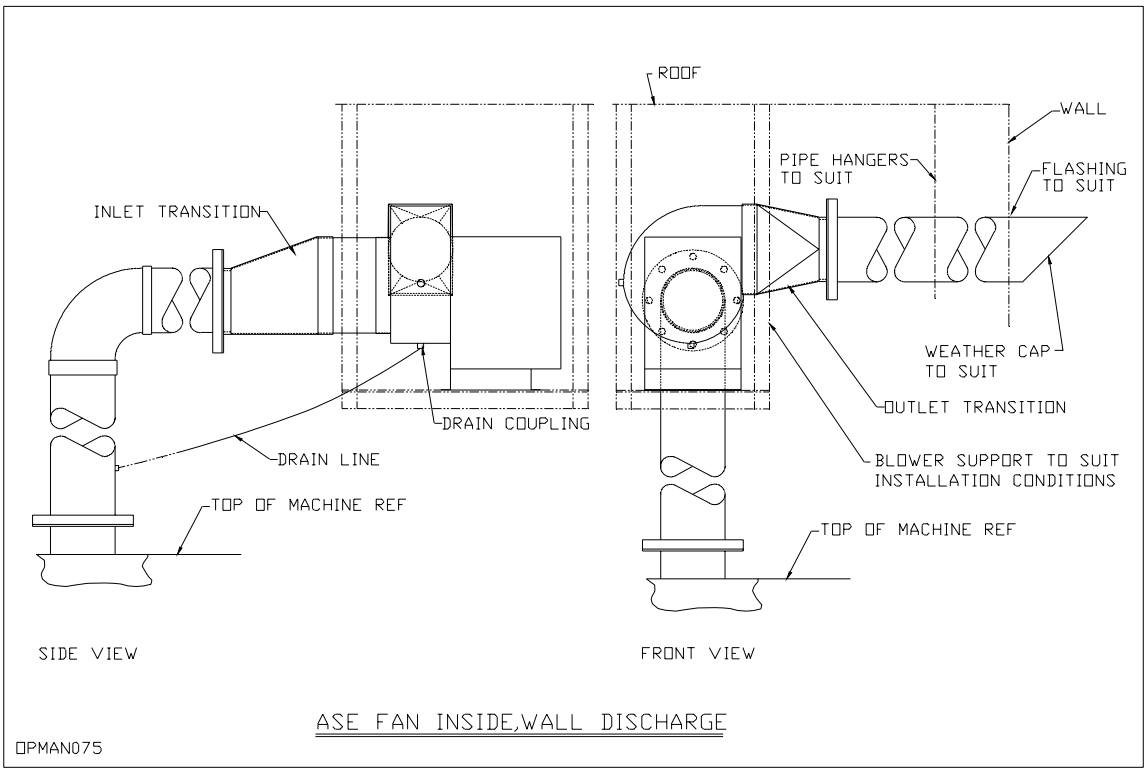

Fig. 7 - 25: HABO -- ASE Fan Installation

The HABO *inside plenum*, located in the washer cabinet and shown in the following figure, is always shipped installed.

The *outside plenum*, which contains the blower unit, the thermocouples, and the heating element, is shipped installed on smaller washers. You must install the outside plenum on larger washers.

To install the outside plenum on larger washers, *follow this procedure*:

1. Turn the *main power supply OFF*.
2. Mount the *outside plenum* on the washer *cabinet*.
3. Bolt the *plenum* to *connection points* on the *cabinet*.
4. Connect *heating-element wires* and *blower-motor wires* to the *conduit* on the washer Match corresponding wire *labels*.
5. Turn the *main power supply ON*.

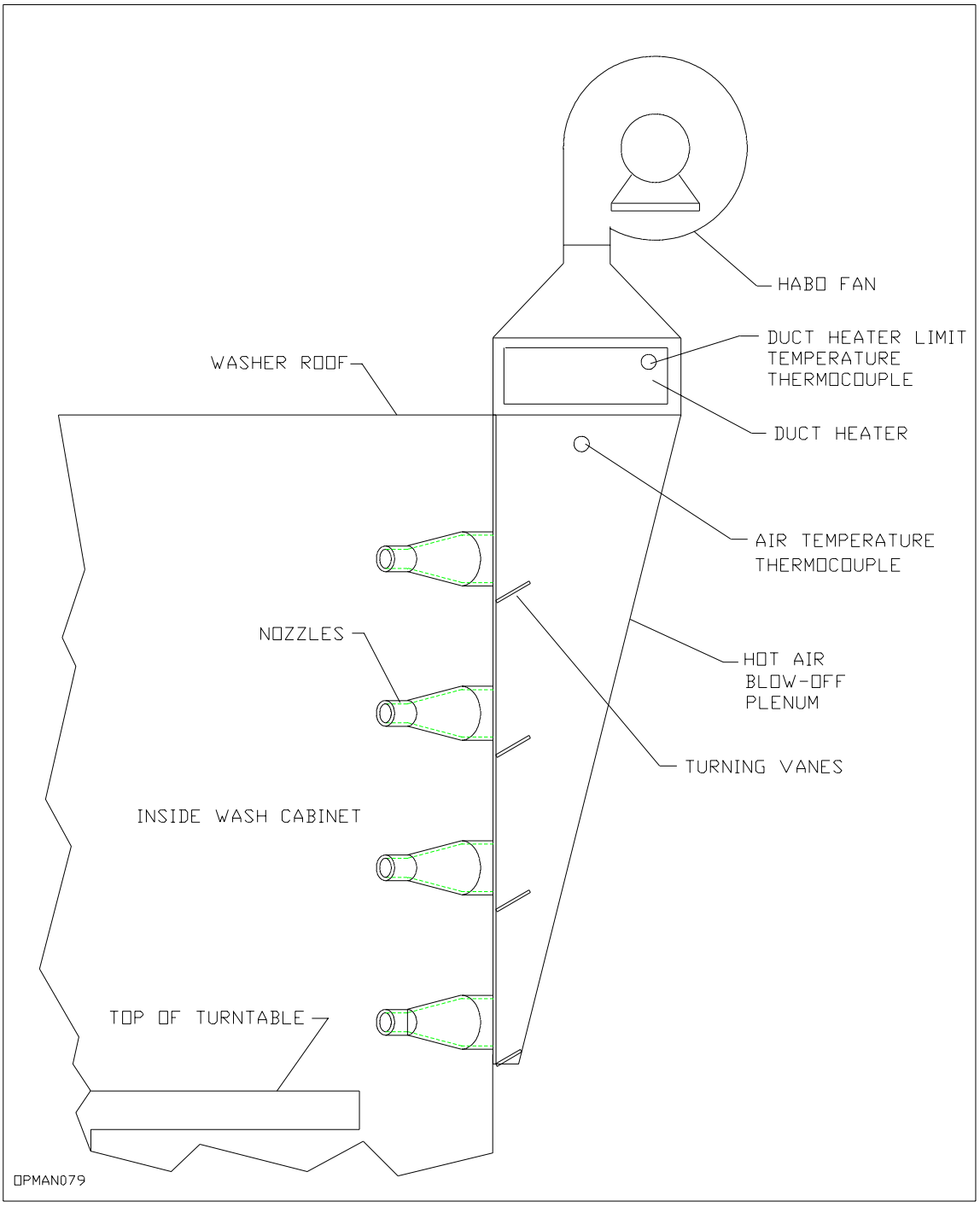

Fig. 7 - 26: Hot-Air Blow-Off (HABO) Inside Plenum

9.3. Operations

Refer to chapter *"Basic Operations"* for general washer operating procedures.

> ***WARNING! Turn the washer's main power supply OFF before opening the electrical control panel.***

Follow this procedure:

1. Position *parts on the turntable* so they will drain as best as possible. (Deep pockets or hidden areas will retain water.)

2. Place *parts as close to the nozzles as possible*. (Air velocity is highest near the outer edge of the turntable.)

3. Set the *HABO temperature controller* to the desired temperature. (The controller is located inside the electrical control panel.)

> ***WARNING! Do NOT set the HABO temperature controller above a maximum set point of 200°F (93° C)! Exceeding 200°F (93° C) may burn out the electric element, or trip the over-temp sensor system.***

4. Set the *HABO timer*, located inside the electrical control panel. Each numbered increment on the timer increases HABO duration by 30 seconds. The maximum run-time is 300 seconds. Examples are given in the following table.

HABO Timer Increments

Number	=	*Seconds*
1		30
2		60
3		90
↓		↓
10		300

5. Set the *HABO auto/off switch*, located on the control panel, to *auto*. This will activate the HABO system after the wash cycle, unless your washer is equipped with the optional auto rinse cycle (ARC). If your washer is so equipped, then the HABO system activates *after* the *rinse cycle*.

6. Refer to the vendor-supplied cutsheet for instructions on setting fan speed.

   If your washer is equipped with HABO, it is also equipped with auto steam exhaust (ASE). An added benefit of HABO is that you can also use the HABO steam-exhaust fan-speed control to adjust the amount of steam exhaust during ASE cycles.

   NOTE: If you set the ASE higher than the absolute minimum required for the desired rinse cycle, the steam exhaust wastes energy and raises operating costs. Initially, set the ASE speed control to the lowest setting that will satisfactorily keep steam in the washer during operation. If this setting does not provide an adequate rinse, adjust it higher for longer rinse cycles.

9.4. Maintenance

Every 1100 hours of operation:

- **Oil** the HABO blower motor with a standard electric-motor oil, suitable for small electric motors. For example, 10W-50 SAE oil.

  Refer to the vendor-supplied cutsheet for grease/oil points.

- **Inspect and clean** the electric heating coils:
  - Turn the *main power supply OFF*.
  - Remove the *coils* from the *upper plenum*.
  - Carefully clean any debris from the coils.
  - Insert the coils back in the upper plenum.
  - Turn the *main power supply ON*.

9.5. Troubleshooting

This section contains tables on the following problems:

- HABO heating element begins to overheat

Problem: HABO heating element begins to overheat	
Check This:	**Probable Cause(s)**
Fan	Not activating (check HABO selector switch, fuses)
Fan motor	Burned out Blown fuse
Fuses	Blown (pull out of electrical control panel to check) ... *and* ... *Be sure to shut off power **before** checking!*
Temperature controller	Heat set-point set too high (do not exceed 200°F/ 93° C)
Over-temp	Tripped (reset the over-temp device)

Fig. 7 - 27: Troubleshooting: HABO Heating Element Begins to Overheat

10. Jib Crane

The optional Jib Crane is designed to pick up parts in front of the reservoir and place them on the turntable. The crane is washer-mounted, with a hoist. The crane is sized by washer, with a load capacity compatible with that of the washer turntable. The maximum load capacity is stenciled on the boom.

NOTE: The jib-crane kit with trolley is supplied by MART. The hoist is provided by others, not by MART.

10.1. Theory of Operation

The operator pivots the horizontal lifting jib boom about a column located in the rear-center of the washer. A roller on the jib boom rides on a support over the top of the doorframe. Stops at each end of the support limit the arc-travel of the boom.

10.2. Installation

WARNING! Never cut or weld or add anything to the column or jib-crane structure!

Follow this procedure: (refer to the following two figures)

1. Mount the *column* on the *bolts* provided. The bolts are located at the rear-center of the washer. There are 2 bolts at the top of the washer cabinet, and 2 bolts at the bottom.

2. Tighten the *nuts and lock washers* on the bolts.

3. Mount the *boom track* on the *bolts* located over the top of the doorframe.

4. Make sure the *wheel stops* are at the *back of the washer* (not the front), near the column.

5. Do ***not*** tighten the boom-track bolts yet.

6. Mount the *center brace* on the *colum*n and the *boom track*.
7. Bolt the center brace to the column and the beam.
8. Tighten the boom-track *bolts*.

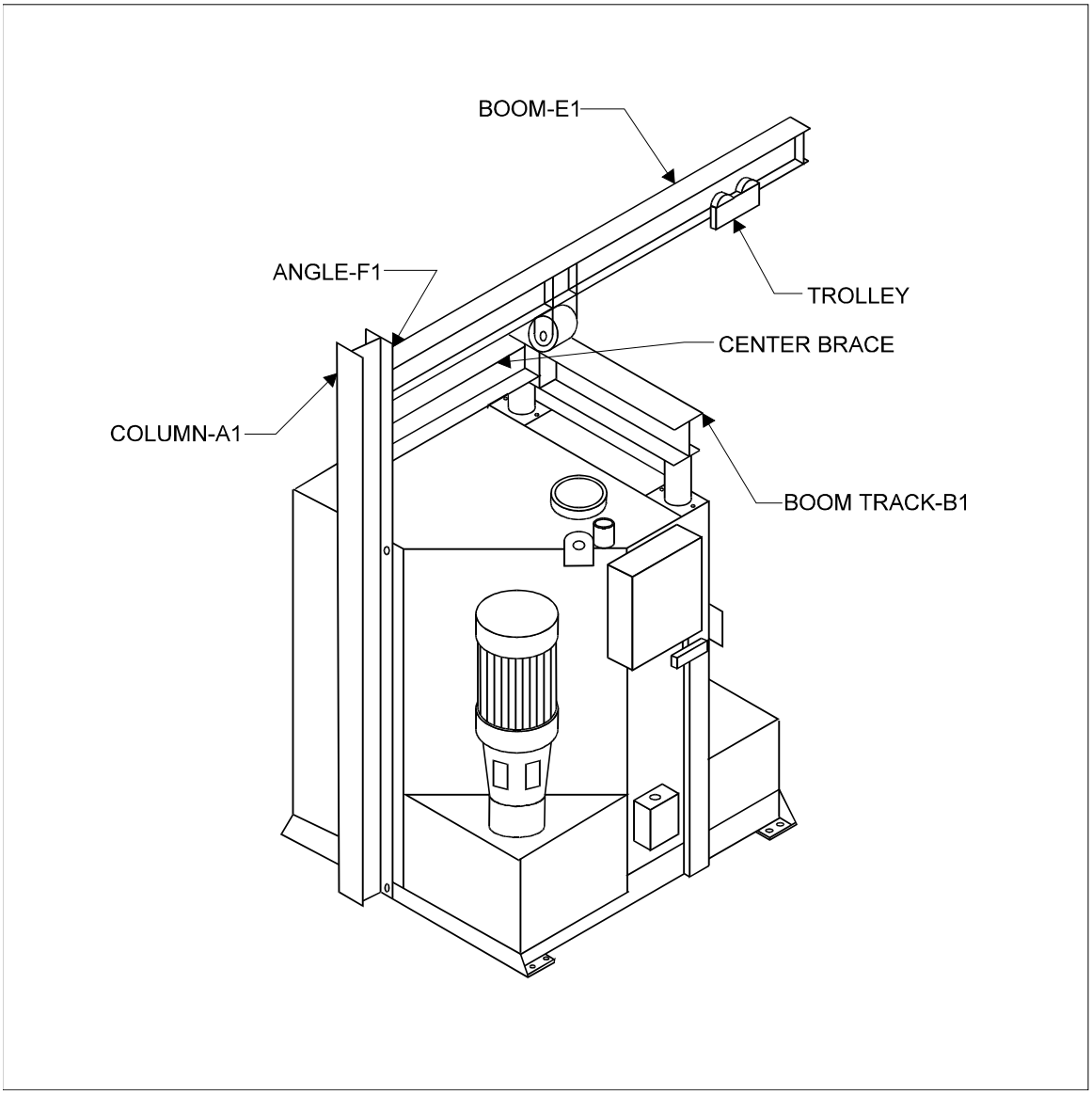

Fig. 7 - 28: Jib Crane, Washer-mounted

9. Insert the *jib-boom support-angle shaft* (pin) into the *bottom of the boom*. (Verify that there is a bronze bushing in the angle.)

10. Fit the *bronze washer* onto the ***top*** of the *boom shaft*.

11. Fit the *top support angle* onto the *shaft and the washer*. (Verify that there is a bronze bushing in the angle.)

12. Bolt the *angle* to the *column*.

13. Unbolt the *trolley stops* at the *front end* of the jib *boom*.

14. Slide the *trolley* onto the *jib boom*.

15. Re-bolt the *trolley stops* to the *front* of the jib *boom*.

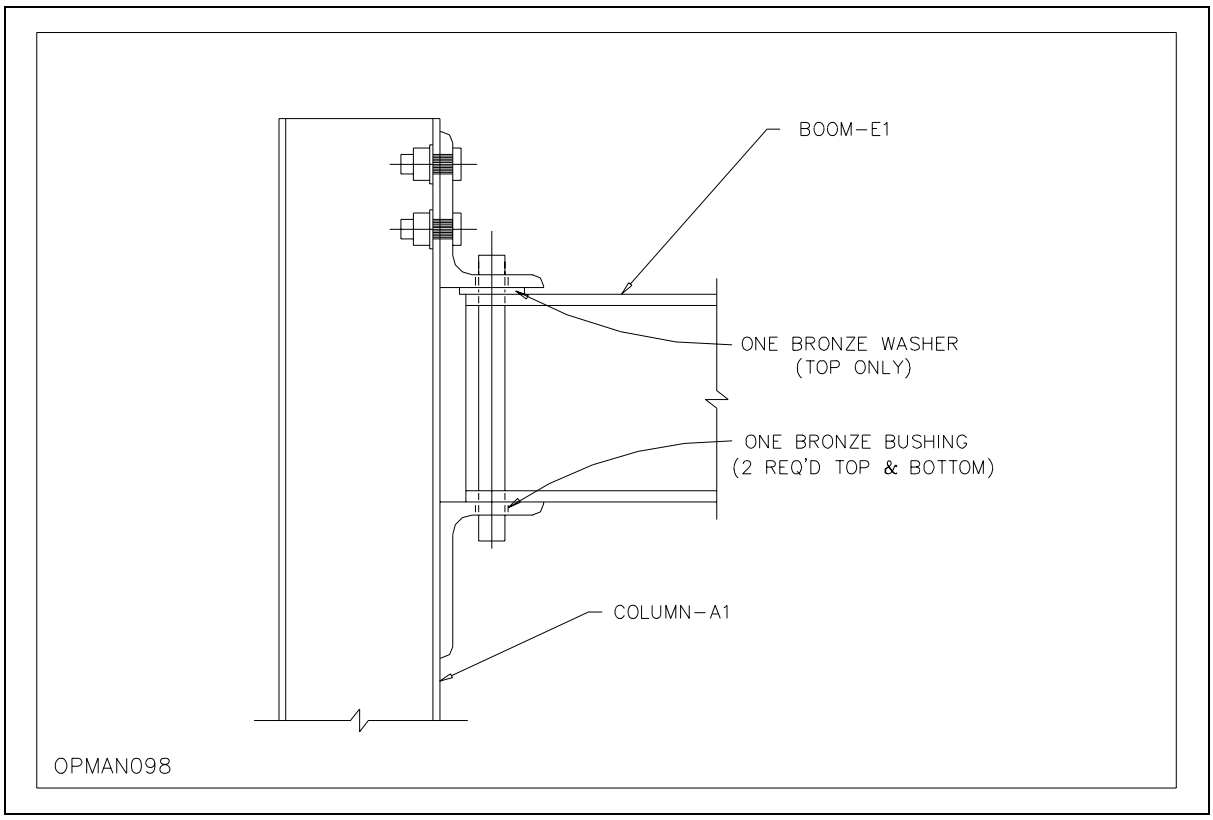

Fig. 7 - 29: Jib Boom: Bronze Bushing and Washer Locations

Since the boom is a lifting device, be sure to check the installation work:

1. Swing the *boom* manually -- and *carefully* -- to be sure it moves freely.
2. Check all *bolts* for tightness.
3. Check the *jib-boom wheel* located at the top-front of the cabinet above the door, to be sure that the *shaft pin* is actually all the way through the wheel and held in place by the cotter pin.

10.3. Operations

WARNING! Be sure you have anchored the washer to the floor BEFORE using the Jib Crane! DO NOT OPERATE the Jib Crane if you have not anchored the washer to the floor -- the washer could tip over and severely injure or kill the operator!

WARNING! Be sure the washer reservoir is filled to capacity with solution BEFORE using the Jib Crane! DO NOT OPERATE the Jib Crane if you have not filled the reservoir to capacity with solution -- the washer could tip over and severely injure or kill the operator!

To **load a part using the Jib Crane**, *follow this procedure*:

1. Hold the *door position-lock handle up* and push the door *slowly* away from the cabinet *past the first position lock* (wider than a 90° angle from the washer frame).
2. Move *parts* up to the front reservoir.
3. Attach the *hoist* to a part.

4. Lift the part.
5. Rotate and hold the *door position-lock handle up*, and push the door *slowly* toward the cabinet, until it locks in the first (90° angle) position.
6. Move the part over the *center* of the *turntable*.
7. Lower the part to the turntable.
8. Remove the hoist from the part.

To **unload a part from the washer using the Jib Crane**, *follow this procedure*:

1. Pull the door open *slowly*, until it locks in the *first* position (90° angle from cabinet frame).
2. Use the *"jog" button*, located on the control panel, to *rotate the turntable* for easy access to the *part* you wish to unload.
3. Attach the *hoist* to a *part*.
4. Lift the part.
5. Rotate and hold the *door position-lock handle up* and push the door *slowly* away from the cabinet *past the first position lock* (wider than a 90° angle from the washer frame).
6. Lower the part to the *transporter*.
7. Remove the hoist from the part.

10.4. Maintenance

Inspect the jib crane according to OSHA 29CFR Section 1910.179.

Every 160 hours of operation:

- Inspect the bronze washer on the boom shaft to be sure it is in good condition. Replace the washer if it is worn.

Every year inspect the jib crane for the following:

- Swing the boom manually -- and carefully -- to be sure it moves freely.
- Check all bolts and parts for tightness.
- Check the jib-boom wheel located at the top-front of the cabinet above the door, to be sure that the shaft pin is actually all the way through the wheel and held in place by the cotter pin.
- Verify that there are no permanent distortions; or cracked or corroded members.

Repair or replace parts as needed.

10.5. Troubleshooting

This section contains tables on the following problems:

- Boom does not swing freely

Problem: Boom does not swing freely	
Check This:	**Probable Cause(s)**
Bronze washer	Bronze washer on boom shaft has worn (replace)
Jib-boom wheel track	Dirty

Fig. 7 - 30: Troubleshooting: Boom Does Not Swing Freely

11. Oil Skimmer

The optional Oil Skimmer removes from the surface of the power washer's sump floating oils, greases, sludge, fatty acids and other contaminants that cling to the wheel. These contaminants cling to the rotating skimmer wheel, and are then scraped off into a container by spring-loaded wiper blades. Water is not removed.

The skimmer provides these benefits:

- Extension of cleaning-solution life
- Better cleaning results
- Reclamation of oil in many cases

11.1. Theory of Operation

The Oil Skimmer is mounted in a small box on the side of the power washer cabinet. Refer to the following figure.

Skimmer Assembly: The skimmer is electrically connected to the washer by a standard 120V 3-prong grounded plug. It is operated by a single-phase, 60-cycle gear motor. The skimmer is lightweight and has only one moving part.

The skimmer's *manual/off/auto* switch is located on the washer's control panel.

Skimmer Function: The lower part of the skimmer wheel is submerged in the solution. As the wheel rotates, it picks up oil and other clinging contaminants from the surface of the solution. The contaminants are collected in the run-off trough and directed to a suitable disposal container. The skimmer will remove up to 1 1/2 gallons (5.7 liters) of contaminants each hour.

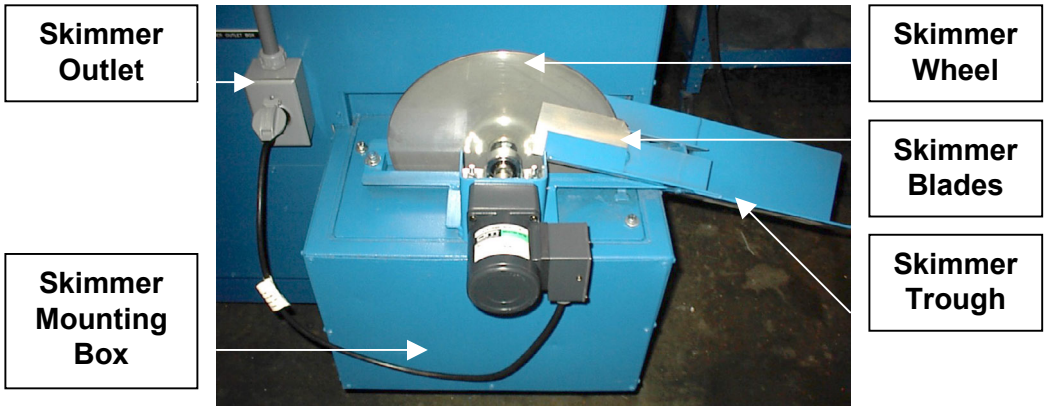

Fig. 7 - 31: Oil Skimmer Assembly

11.2. Installation

Follow this procedure:

1. Unpack the *skimmer assembly* from the turntable inside the washer cabinet.
2. Set the *assembly* into the *skimmer box*.
3. Tighten the *wing nut*.
4. Attach the *grounded plug to the outlet* on the *washer*.

11.3. Operations

The Oil Skimmer is designed to operate when the washer is in use, *or* after hours, when the washer is in "shut-down" (*off*) mode.

To operate the Oil Skimmer, *follow this procedure*:

1. Set the skimmer's *selector switch*, located on the washer's control panel, to one of the following:
    - *Manual:* Activates the skimmer. It will run continuously.
    - *Off:* Turns the skimmer off.
    - *Auto:* Automatically activates and runs the skimmer according to the program set for circuit #2 of the 7-day clock.

    NOTE: You *must* program the 7-day clock's circuit #2 for *ON/OFF* times, and set the skimmer's selector switch to *auto.*

NOTE: Oil skimming works best when the emulsified oils are allowed time to float and collect on the surface of the solution. Program your 7-day clock circuit #2 to run the Oil Skimmer several hours after washer shutdown in order to achieve the best oil-skimming results. Also, some defoamers float on the surface at higher temperatures. By skimming when the solution is cooler, less defoamer will be skimmed off with the oils.

11.4. Maintenance

Every 1100 hours of operation:

- **Oil** the skimmer motor with a standard electric-motor oil, suitable for small electric motors. For example, 10W-50 SAE oil.

  Refer to the vendor-supplied cutsheet for oil points.

During sludge clean out:

- **Clean** the wheel and frame. If necessary, remove the skimmer assembly and box cover to clean sludge out of the box.

  Refer to chapter *"Maintenance"* for more information on sludge clean out.

11.5. Troubleshooting

This section contains tables on the following problems:

- Skimmer-wheel does not skim

Problem: Skimmer-wheel does not skim	
Check This:	**Probable Cause(s)**
Drain trough	Clogged
Blades	Not contacting wheel: Bend to adjust Replace if worn
Wheel	Not turning (check/tighten shaft nuts)
Motor	Motor not turning (115 V): Fuse needs to be replaced Wires need to be tightened Motor needs to be replaced

Fig. 7 - 32: Troubleshooting: Skimmer-Wheel Does Not Skim

12. Power-Assisted Door

The optional *Power-Assisted Door* supplies power to the door of the washer cabinet, which makes heavier-weight loads easier to handle: the operator can easily open and close the door weighted with up to 20,000 pounds (9070 kg) of load.

> **NOTE**: The door can be operated manually, without power-assist.

12.1. Theory of Operation

The *Power-Assisted Door* is pneumatically powered. A tandem air/hydraulic cylinder dampens and smoothes door operation. Speed-control valves on top of the cabinet can be adjusted to regulate the general range of opening and closing speed.

You can fine-tune your control of the speed at which the door opens and closes by raising and lowering the position-lock handle, which is located at the bottom of the door. The handle works like a throttle to increase and decrease speed.

12.2. Installation

The *Power-Assisted Door* is shipped installed on the cabinet. The speed-control valves are factory pre-set for a moderate opening and closing speed range.

12.3. Operations

> ***WARNING! NEVER put hands, legs, or head inside the door! This could result in severe injury or death!***

> ***WARNING! Before you attempt to open or close the power-assisted door, be sure you have enough clearance for the full arc-travel of the door as it swings!***

WARNING! NEVER swing the power-assisted door open to a position lock at an accelerated speed! Control the speed of the door by the position-lock handle, located at the bottom of the door. Use the handle like a throttle to adjust speed.

To operate the door, *follow this procedure*:

1. Select *open* or *close* on the *power-assist selector switch*, located on the front of the door.
2. Unlatch the door, if it is latched.
3. Lift and hold the *position-lock handle up* to keep the power-assist activated.
4. Release the handle to stop the power-assist.

The position-lock handle is located at the bottom of the door. The two position lock slots hold the door open at approximately a 60° angle and a 90° angle, respectively, from the front of the cabinet.

Securing the Door

Always be sure that the open door is locked in position:

- Visually check the position lock slot, *or*
- Try to pull or push the door

Refer to chapter *"Basic Operations"* for more general information on opening and closing the door.

12.4. Maintenance

Every 160 hours of operation:

- Check the filter/regulator/lubricator unit. The lubricator has an oil reservoir, and is located on the right side of the washer. Add oil, if required, to the fill-level.

Refer to your vendor-supplied cutsheet for instructions.

12.5. Troubleshooting

This section contains tables on the following problems:

- Power-assist does not activate

Problem: Power assist does not activate	
Check This:	**Probable Cause(s)**
Control valve	Stuck (replace)
Position-lock handle limit switch	Defective
Selector switch	Defective
Air-pressure	Not in the 75-100 PSI [1000-1400 kg/sq cm] range (check air-supply system)
Electric solenoid	Burned out (replace)

Fig. 7 - 33: Troubleshooting: Power-Assist Does Not Activate

13. Pump Pressure Control Valve and Gauge

The optional pump pressure control valve allows the operator to adjust water flow and pressure to the power blast manifold (PBM). The pressure gauge indicates the amount of pressure.

13.1. Theory of Operation

The operator turns the control valve clockwise to close it, decreasing water flow to the PBM. The reduced flow results in lower pressure through the PBM nozzles. The valve will not slip, so pressure remains exactly as adjusted.

> **NOTE**: When the control valve is fully closed, the water line still carries the minimum water flow necessary to avoid damage to the pump.

A coupling welded into piping between the pump and the PBM is used as a pressure tap point for a glycerin-filled pressure gauge. The pressure tap piping is a large diameter for easy clean out.

The pressure gauge assembly includes a diaphragm seal that prevents solution from entering the gauge. Pressure on the diaphragm is transmitted through the glycerin inside the gauge to the reading dial.

13.2. Installation

This option arrives factory-installed.

13.3. Operations

While the wash pump is running, turn the control valve until the pressure you wish is indicated on the pressure gauge.

13.4. Maintenance

WARNING! NEVER disconnect the pressure gauge from the diaphragm seal! Glycerin will leak out and damage the gauge assembly!

If the gauge does not read pressure, ***and*** the control valve is open, *follow this procedure*:

1. Unscrew the diaphragm seal and gauge *together*.
2. Clean the gauge pipe out.
3. If the problem persists, replace the gauge and diaphragm-seal assembly.

13.5. Troubleshooting

This section contains tables on the following problems:

- Pump pressure gauge does not work

Problem: Pump pressure gauge does not work

Check This:	Probable Cause(s)
Gauge pipe	Clogged (clean out)
Gauge	Damaged (replace)
	Glycerin leakage (replace)
Diaphragm seal	Damaged (replace)

Fig. 7 - 34: Troubleshooting: Pump Pressure Gauge Does Not Work

14. Pump Pressure Gauge

The optional pressure gauge indicates the amount of pressure in the piping from the wash pump to the power blast manifold (PBM).

14.1. Theory of Operation

A coupling welded into piping between the pump and the PBM is used as a pressure tap point for a glycerin-filled pressure gauge. The pressure tap piping is a large diameter for easy clean out.

The pressure gauge assembly includes a diaphragm seal that prevents solution from entering the gauge. Pressure on the diaphragm is transmitted through the glycerin inside the gauge to the reading dial.

14.2. Installation

This option arrives factory-installed.

14.3. Operations

There are no operator instructions. The pump pressure gauge will indicate the pressure in the piping from the wash pump to the power blast manifold (PBM).

14.4. Maintenance

WARNING! NEVER disconnect the pressure gauge from the diaphragm seal! Glycerin will leak out and damage the gauge assembly!

If the gauge does not read pressure, *follow this procedure*:

1. Unscrew the diaphragm seal and gauge *together*.

2. Clean the gauge pipe out.
3. If the problem persists, replace the gauge and diaphragm-seal assembly.

14.5. Troubleshooting

This section contains tables on the following problems:

- Pump pressure gauge does not work

Problem: Pump pressure gauge does not work	
Check This:	**Probable Cause(s)**
Gauge pipe	Clogged (clean out)
Gauge	Damaged (replace) Glycerin leakage (replace)
Diaphragm seal	Damaged (replace)

Fig. 7 - 35: Troubleshooting: Pump Pressure Gauge Does Not Work

15. Rack and Fixture Set, or Small-Parts Basket

All parts must be secured to the turntable during the cleaning cycle. To do this, use the following:

- Rack and fixture set
- Small-parts basket

Refer to chapter *"Basic Operations - Loading and Securing Parts"* for information on using securing devices.

15.1. Theory of Operation

The rack and fixture set and small-parts basket are optionally available from MART. Refer to the following two figures.

You may want to discuss your requirements with your MART representative, especially before you alter or add to the basic configuration to customize it for an application.

15.2. Installation

There is no installation required. The rack and fixture set and small-parts basket arrive ready to use.

NOTE: Large racks or fixtures may need to be assembled.

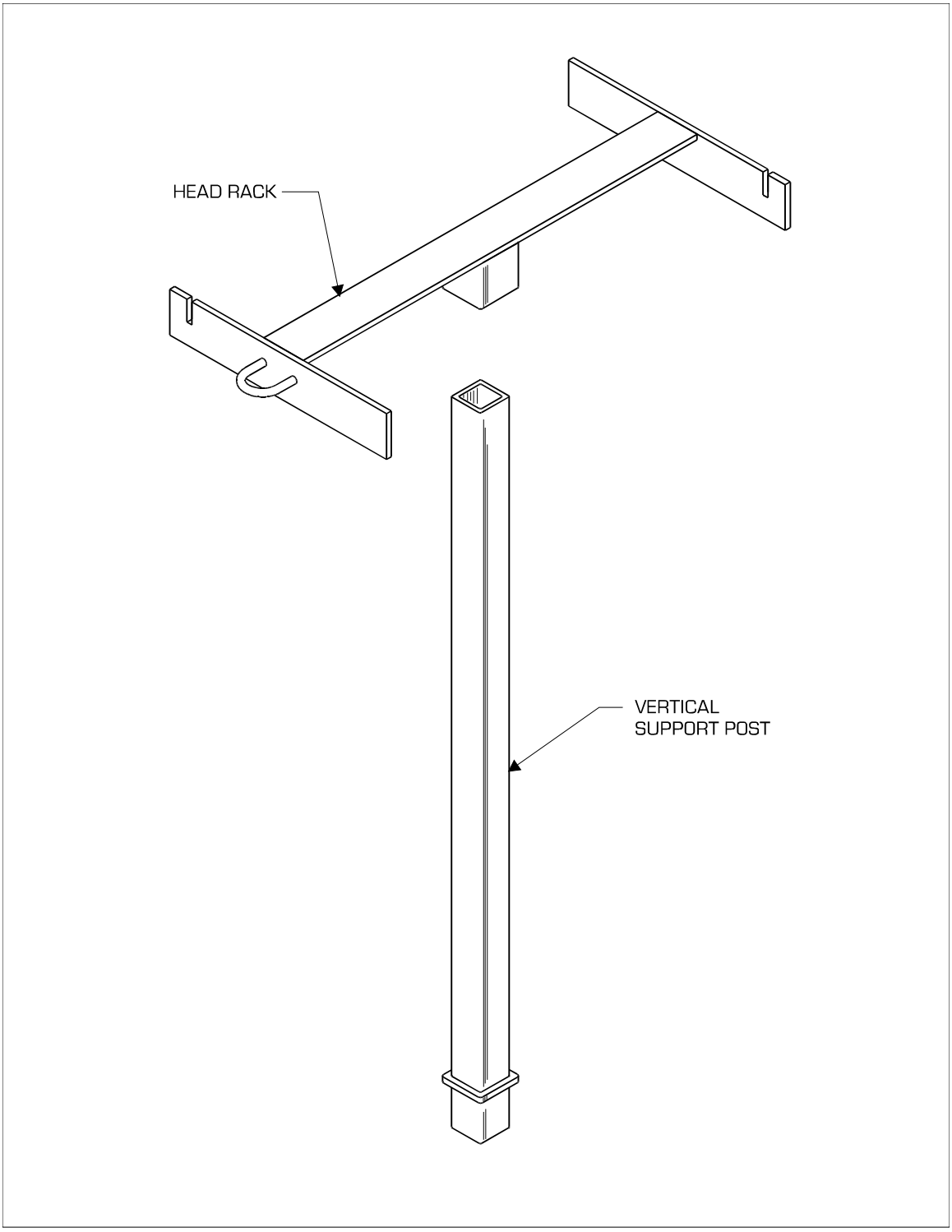

Fig. 7 - 36: Rack and Fixture Set

15.3. Operations

Refer to chapter *"Basic Operations - Loading and Securing Parts"* for information on using securing devices with the rack and fixture set.

To use the rack and fixture set, *follow this procedure*:

1. Select the appropriate 16-inch (40.6 cm) or 32-inch (81.3 cm) vertical post.
2. Insert it into a *turntable socket* that will position the *load nearest the center* of the turntable and ensure that no part of the load will hang outside the turntable.
3. Attach a *head rack* or other *fixture* to the *top* of the *centering vertical post,* facing the center of the turntable.
4. Load the *part* vertically inside the head rack or fixture.
5. Attach *securing devices*, as described in chapter *"Basic Operations - Loading and Securing Parts."*

To use the small-parts basket, *follow this procedure*: (refer to the following figure)

1. Load *small parts* into the *basket*.
2. Secure the *lid*.
3. Place the basket on the *center* of the *turntable*.
4. Attach *one end of the chain* to a *hook* located on the inner surface of the *turntable*'s outer rim.
5. Run the chain through both *basket handles*.
6. Attach the *end of the chain* or a *link* to a *hook,* located on one end of the load binder.
7. Attach the *hook* on the *other end* of the load binder to a *chain eyelet* directly across (180° angle) from the first hook.
8. Tighten the chain with the provided *load binder*.

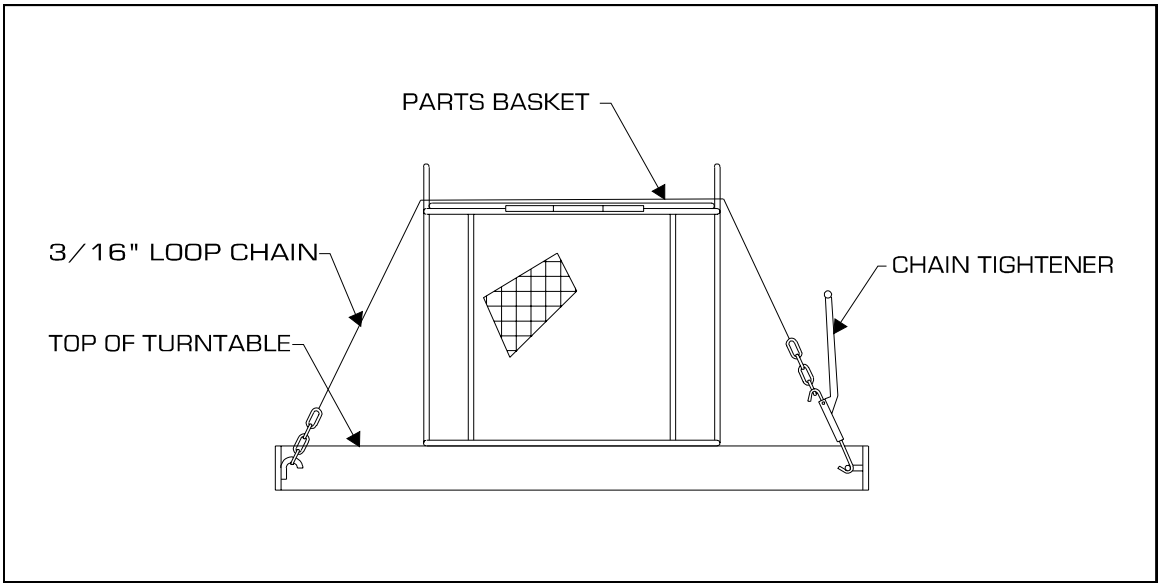

Fig. 7 - 37: Small-Parts Basket

15.4. Maintenance

Clean racks, fixtures, and baskets as required.

15.5. Troubleshooting

If you properly secure all parts, using racks, fixtures, small-parts baskets, and appropriate securing devices, no problems should arise from these options.

16. Remote Grease Fittings

The optional *Remote Grease Fittings* allow you to grease the turntable or the Power Blast Manifold (PBM) swivel bearings from the outside of the washer cabinet.

16.1. Theory of Operation

This option eliminates the need to disassemble any part of the washer or to get inside the cabinet in order to grease the turntable or the Power Blast Manifold (PBM) swivel bearings. It improves accessibility, reducing maintenance time.

This option is available for any bearing in the washer.

16.2. Installation

The optional *Remote Grease Fittings* are delivered installed, according to your specifications.

16.3. Operations

The *Remote Grease Fittings* are located on the nearest outside surface of the washer to the bearing. They are placed at a convenient height for the operator.

The remote turntable grease point is on the cabinet door. The remote swivel grease point is on the wash manifold side of the washer near the door.

16.4. Maintenance

None.

16.5. Troubleshooting

None.

17. Rinse Wand

The Rinse Wand is an optional addition to the standard rinse system. Its purpose is to manually rinse spot areas after a wash cycle.

The Rinse Wand consists of a gun-shaped handle with an extended tube that has a spray nozzle at its apex. The spray wand is hand-operated. Whenever the operator depresses the trigger, water from the supply line is released through the nozzle at line pressure.

NOTE: The water from the wand is not heated, and contains no chemicals.

17.1. Theory of Operation

Supply-line water pressure powers the spray. The wand uses a two-gallon-a-minute fan-shaped nozzle. Since water from spray is normally returned to the water reservoir, a solenoid valve connected to the solution-level control system disallows spray-wand use whenever the solution level is at the HIGH-HIGH (maximum) mark. A light on the control panel indicates this condition.

17.2. Installation

This option is factory-installed.

17.3. Operations

After a cleaning cycle has completed, open the washer door to the first door-position lock stop. Use the *jog button* to rotate the turntable as you inspect the wash load for any area that may need additional rinsing. If you find such an area, release the *jog button* to stop the turntable.

WARNING! Be sure to wear protective gear (face shield, gauntlet gloves, rubber apron)! Spray could be deflected back at you and could contain chemical residue that could cause serious chemical and scald-type burns to eyes and skin!

Follow these operating guidelines:

1. Stand back several feet from the washer.
2. Aim the wand at the part.
3. Pull the trigger and direct the spray to the area that needs to be rinsed.

Remember the following:

- Wand water is not heated. It will not flash-dry as quickly as rinse water in the washer.
- Wand water returns to the reservoir and uses part of the rinse-bank (*rinse-bank* is the available volume for rinse water). Therefore, use of the wand could result in shortened rinses or no rinse at all. Keep rinse-wand use to a minimum to avoid this problem.
- Rinse-wand water contains no chemical additives such as rust inhibitor. Therefore, excessive use of the wand could cause rusting of parts.

17.4. Maintenance

Lubricate the gun trigger periodically.

17.5. Troubleshooting

This section contains tables on the following problems:

- No hand rinse

Problem: No hand rinse	
Check This:	**Probable Cause(s)**
Light on control panel	Solution level at HIGH-HIGH (maximum) mark
Solenoid	Failed (replace)
Nozzle	Clogged (remove and clean)

Fig. 7 - 38: Troubleshooting: Rinse Wand: No Hand Rinse

18 Sludge Scraper

The Sludge Scraper removes sludge from the power washer's reservoir to a bin or barrel. The materials to be removed by the sludge scraper can be any solid material or any material that is of a consistency that will not run off of the scraper bars.

The sludge scraper provides these benefits.

- Extension of cleaning-solution life
- Better cleaning results

18.1. Theory of Operation

The washer is mounted on the sludge-scraper assembly, which replaces the original floor of the washer's reservoir. Part of the assembly extends as a chute behind the washer at a 45-degree angle.

When the Sludge Scraper is operating, angle scrapers move across the bottom of the reservoir, collecting sludge and carrying it up the chute. At the end of the chute, the sludge drops into a bin or barrel. The scrapers then move back down the chute into the washer reservoir and begin to scrape the bottom of the reservoir.

The scrapers are attached to a sprocket-mounted drag chain that continuously rotates. The drag chain is chain-driven by a gear motor through a sprocket torque-limiter.

The gear motor is a variable-speed DC-drive motor, with a speed controller located in the washer's electrical control panel. You can set the motor from low to high speed.

An external view of the sludge scraper is shown in the following figure.

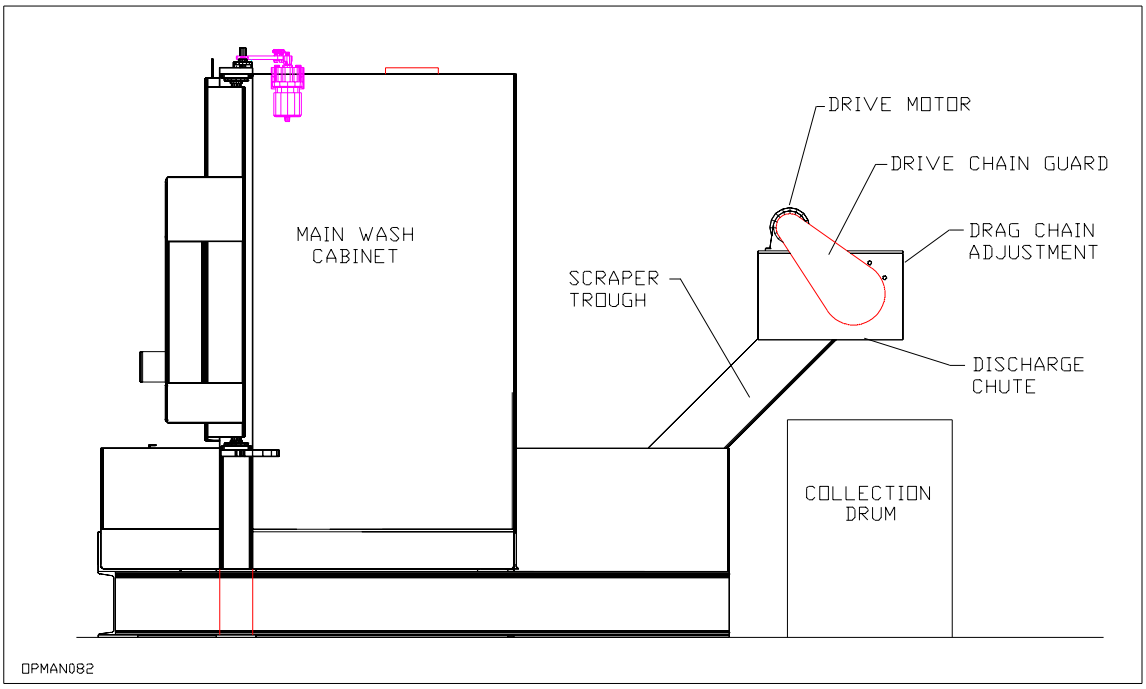

Fig. 7 - 39: Sludge Scraper -- External View

18.2. Installation

The Sludge Scraper is factory-installed.

18.3. Operations

The Sludge Scraper is designed to operate when the washer is in use, or after hours, when the washer is in "shut-down" (off) mode. A forward and reverse jog feature is provided to help free any scraper jams.

> WARNING! NEVER put your hands into the scraper chute! This could result in severe injury.

To operate the Sludge Scraper, follow this procedure:

> WARNING! Disconnect power before opening the control panel.

1. Set the Sludge Scraper timer, located in the washer's electrical control panel. The standard 10-hour timer is numbered 1-10 (each number represents a 1 hour increment). The timer controls the length of time the scraper operates in auto mode, if you set the selector switch to auto (in the following step).

2. Set the scraper's selector switch, located on the washer's control panel, to one of the following:

    - Manual: Allows manual operation of the sludge scraper using the jog buttons.

    - Off: Turns the scraper off.

    - Auto: Automatically activates and runs the scraper for the time indicated on the scraper timer. The scraper will restart start when a wash cycle begins and continues for the time set after the last wash cycle. If another wash cycle is started before the timer times out the timer is reset with the last wash cycle.

To operate the jog function, follow this procedure:

1. Set the selector switch on the control panel to manual.

2. Go to the sludge scraper's discharge area and press the forward or reverse jog button located in the small sludge scraper control panel.

18.4. Maintenance

Every 40 hours of operation:

Check chain tension.

If you need to adjust the tension of the drag chain, tighten the bolts on the take-up frame so that the drive sprocket moves back and up. Adjust both sides of the chain.

Adjust the drive chain (from the motor to the torque limiter) by sliding the motor.

Follow the manufacturer's recommendations for adjusting the torque-limiter.

Lubricate the take-up bearings. The grease fittings are located at the chute end of the sludge scraper.

Every year:

Check the DC motor brushes for wear. Replace as needed.

A diagram of the scraper is shown in the following figure.

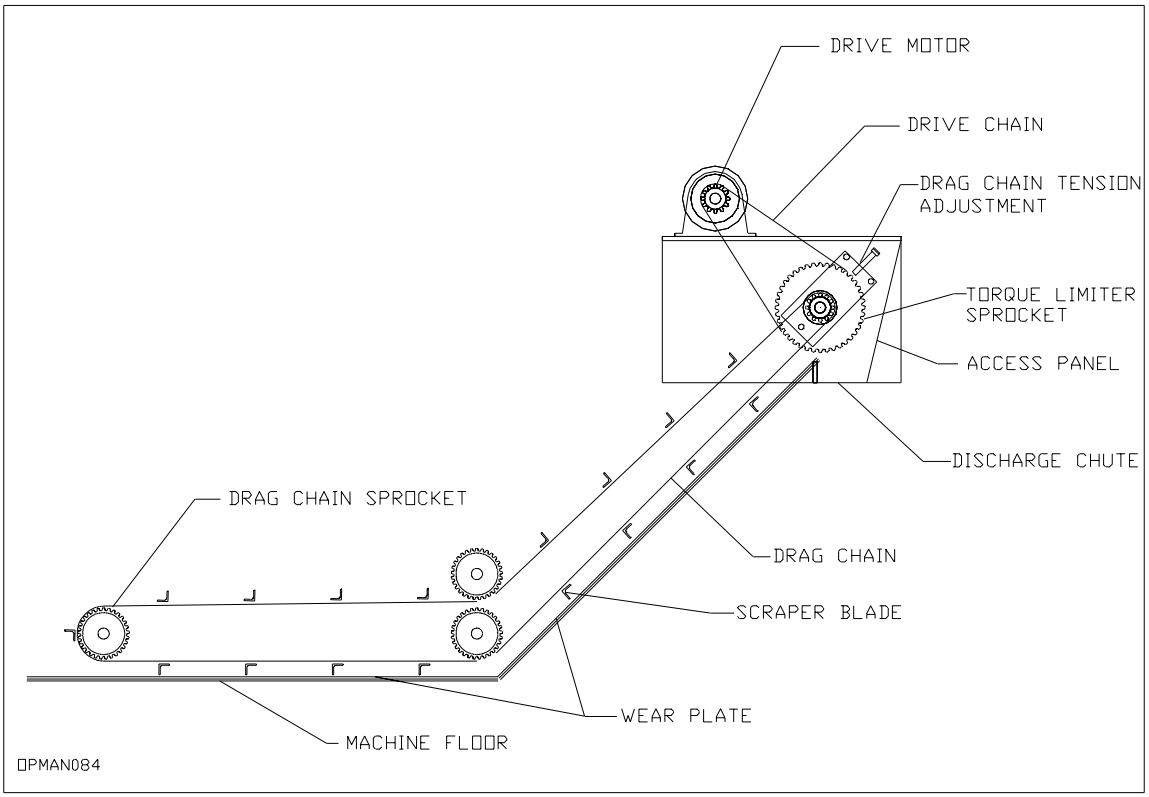

Fig. 7 - 40: Sludge Scraper -- Diagram of Parts

18.5. Troubleshooting

This section contains tables on the following problems:

- Sludge scraper drag chain does not move

Problem:	Sludge scraper drag chain does not move
Check This:	**Probable Cause(s)**
Chain	Caught on something (Use reverse jog) Broken Drive sprocket too loose (adjust tension -- tighten)
Sprockets	Chain is not on sprockets
Torque-limiter	Not adjusted correctly
Motor	Motor not turning: Selector switch OFF 7-day clock not set properly Fuse needs to be replaced Wires need to be tightened Replace brushes Motor needs to be replaced

Fig. 7 - 41: Troubleshooting: Sludge Scraper Drag Chain Does Not Move

19. Short High Impact Manifold (SHIM) System

The Short High Impact Manifold (SHIM) is designed to give you the advantage of two machines in one. A standard work height machine and a shorter work height, ultra high impact machine. When retracted you have the benefit of the entire Cabinet height to wash tall parts and, when deployed, all the blasting energy is concentrated into a smaller work area for shorter loads and baskets of parts.

19.1. Theory of Operation

Two Power Blast Manifolds are coupled together, and a set of valves directs the flow to one of the Manifolds. The Standard PBM is full height and SHIM, when deployed, reduces the work height by approximately one-half. The SHIM Manifold has a fold down horizontal upper arm. The vertical sections of the standard and SHIM manifold have the same number of nozzles so that the nozzles in the SHIM are packed more tightly together. The nozzles in the standard Manifold have a 25 degree blast pattern while the SHIM has narrower15 degree pattern nozzles, thus more than doubling the impact pressure for shorter wash loads. A SHIM manifold is shown in the following figure.

19.2 Operations

Choose the proper manifold with the selector valve. Refer to the selector valve schematic diagram below and on the front of the Power Washer door for manifold selection.

To deploy the SHIM, reposition the PBM selector valve handle, remove the locking pin in the fold down arm section, pivot the arm to its horizontal position, and replace the locking pin to hold the horizontal SHIM arm in place.

> Be sure the fold down arm is locked in the proper position for the height of the wash load. A tall wash load may hit the fold down arm and damage the PBM drive

> Do not walk on the internal reservoir cover to raise or lower the fold down arm or to switch the selector valve. Stand on the outside reservoir lid and reach into cabinet to make adjustments.

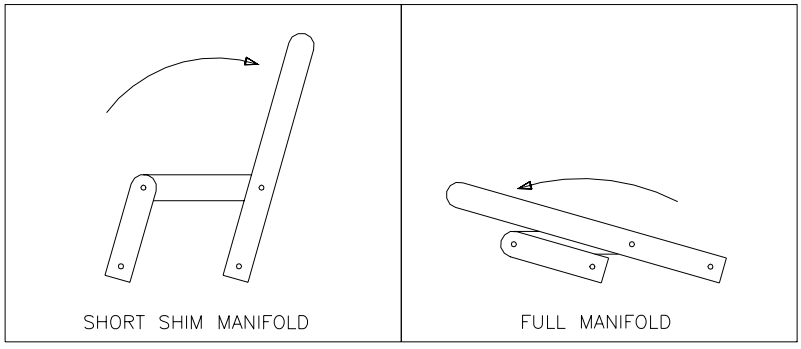

FIGURE 7-42 SHIM MANIFOLD SELECTOR VALVE SCHEMATIC

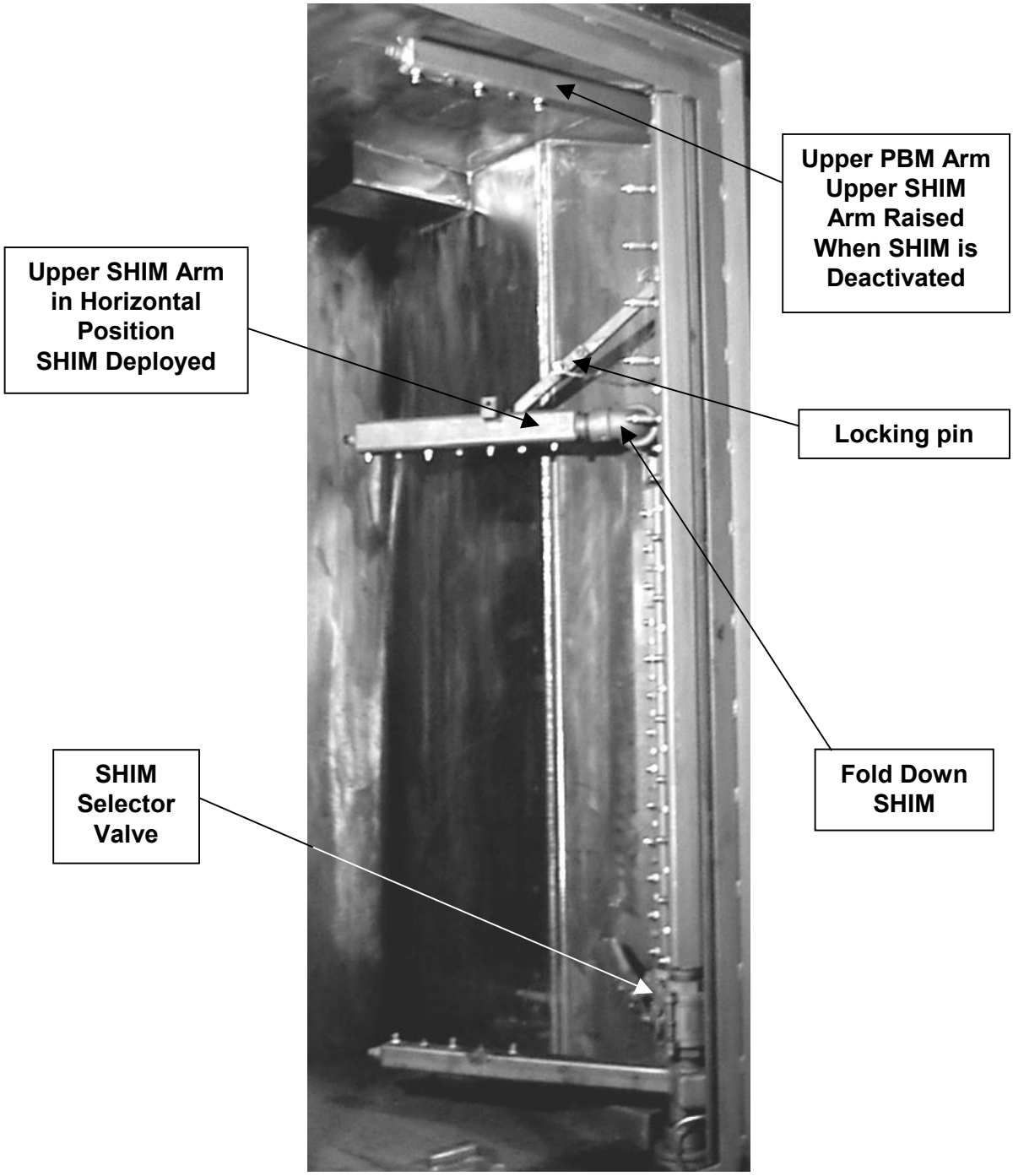

Fig. 7-43: SHIM Manifold System Tornado 40 HP

19.3. Maintenance

Lubricate Fold down Arm Swivel every 8 hours of operation or as required.
Replace worn nozzles in both manifolds as required to prevent overloading of pumping system

19.4 Troubleshooting

Use procedures in chapters *"Installation," "Advanced Operations: Process-Control,"* or *"Maintenance"* to correct a problem after you have diagnosed it.

Or, refer to your vendor-supplied manuals or cut sheets for instructions on correcting problems.

This section contains tables on the following problems:

- PBM not oscillating

Problem: PBM not oscillating	
Check This:	**Probable Cause(s)**
Linkage	Not connected Out of adjustment Loose Not connected to shaft
Bearings	Failed
Swivel	Not properly adjusted Not lubricated Not moving freely
PBM gear motor	Not rotating (check wires/fuses/overload tripped)
PBM mounting plate	Motor not securely attached to it

Fig. 7 - 44: Troubleshooting: PBM Not Oscillating