M-3, M-23A, M-23B Electric Switch Machines with Permanent Magnet Motor and Electronic Circuit Controller (ECC) and Motor Control Unit (MCU) or Electronic Biased Neutral Controller (EBNC)

ASTS USA Part No.
N429500-xx (M-3 w/EBNC) N426500-xx (M-3 w/MCU)
N429501-xx (M-23A w/EBNC) N426501-xx-(M-23A w/MCU)
N429502-xx (M-23B w/EBNC) N426502-xx (M-23B w/MCU)

- Installation
- Operation
- Troubleshooting

Proprietary Notice

Important Notice

ASTS USA constantly strives to improve our products and keep our customers apprised of changes in technology. Following the recommendations contained in the attached service manual will provide our customers with optimum operational reliability. The data contained herein purports solely to describe the product, and does not create any warranties.

Within the scope of the attached manual, it is impossible to take into account every eventuality that may arise with technical equipment in service. Please consult an ASTS USA local sales representative in the event of any irregularities with our product.

ASTS USA expressly disclaims liability resulting from any improper handling or use of our equipment, even if these instructions contain no specific indication in this respect. We strongly recommend that only approved ASTS USA spare parts are used as replacements.

Revision History

REV.	DATE	NATURE OF REVISION
0	August 2008	Initial Issue
0.a	October 2009	Revised part numbers on cover and Section 2.7.2.2.

Table of Contents

List of Figures

List of Tables

1. GENERAL INFORMATION

1.1. Introduction

This service manual covers the M-3 and M-23 switch machines using a permanent magnet motor, an Electronic Circuit Controller (ECC), and either a Motor Control Unit (MCU) or Electronic Biased Neutral Controller (EBNC). The EBNC includes a motor overload protection function; the MCU does not (protection is provided by wayside control equipment).

Existing installations using five- or three-wire control must be converted to two-wire control when installing an ECC (with either MCU or EBNC) machine. Refer to Section 4 of this manual for details on how to convert the control wiring.

The EBNC is used with the ECC to enable direct control of an M-Style switch machine using a bipolar output of a vital logic controller such as the Microlok® system or an Object Controller.

In an EBNC machine, the motor power is fed from a fixed polarity source (direction determined by the EBNC). In a MCU machine, the motor power is fed from a bipolar source (direction determined by the wayside control equipment.

The design of both the MCU and EBNC adds no height to the switch machine; a standard profile is maintained.

1.2. Description

The M-3 and M-23 switch machines with ECC consist (essentially) of a motor, gear train, motor controller, and circuit controller with electronic point detection. Each machine type uses the same base casting and is generally interchangeable as to mounting and connections in a switch layout. Some differences exist from machine to machine due to application requirements for different mounting lug hole sizes or machined lug widths. Also, the M-23 machines are taller than the M-3 machines, which may affect clearance (see dimensions in Figure 2-3 and Figure 2-4). Typical applications are shown in Figure 1-1 (M-3) and Figure 1-2 (M-23).

The M-3 and M-23 machines are normally motor-operated. The M-3 machine has no hand-throw capability, but can be operated manually using a removable hand crank. The M-23 machines have dual-control capability, with hand-throw and selector levers to allow manual operation. This dual control capability of the M-23 machines requires a different gearbox than that used on the M-3 switch machine. The M-23 machines may also be hand operated using a ratchet wrench applied to the friction clutch adjusting nut.

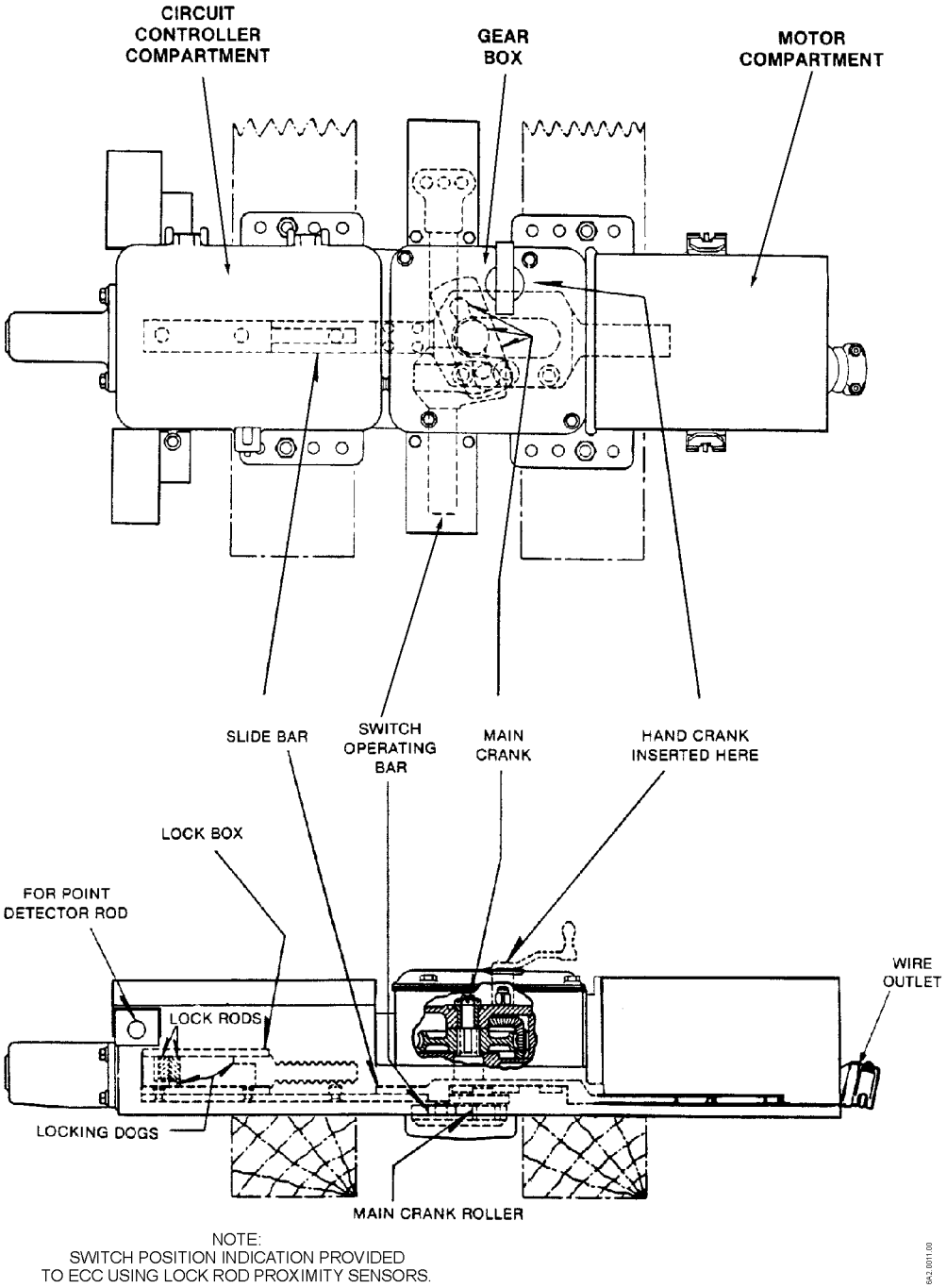


Figure 1-1. M-3 Switch Machine Outline Diagram

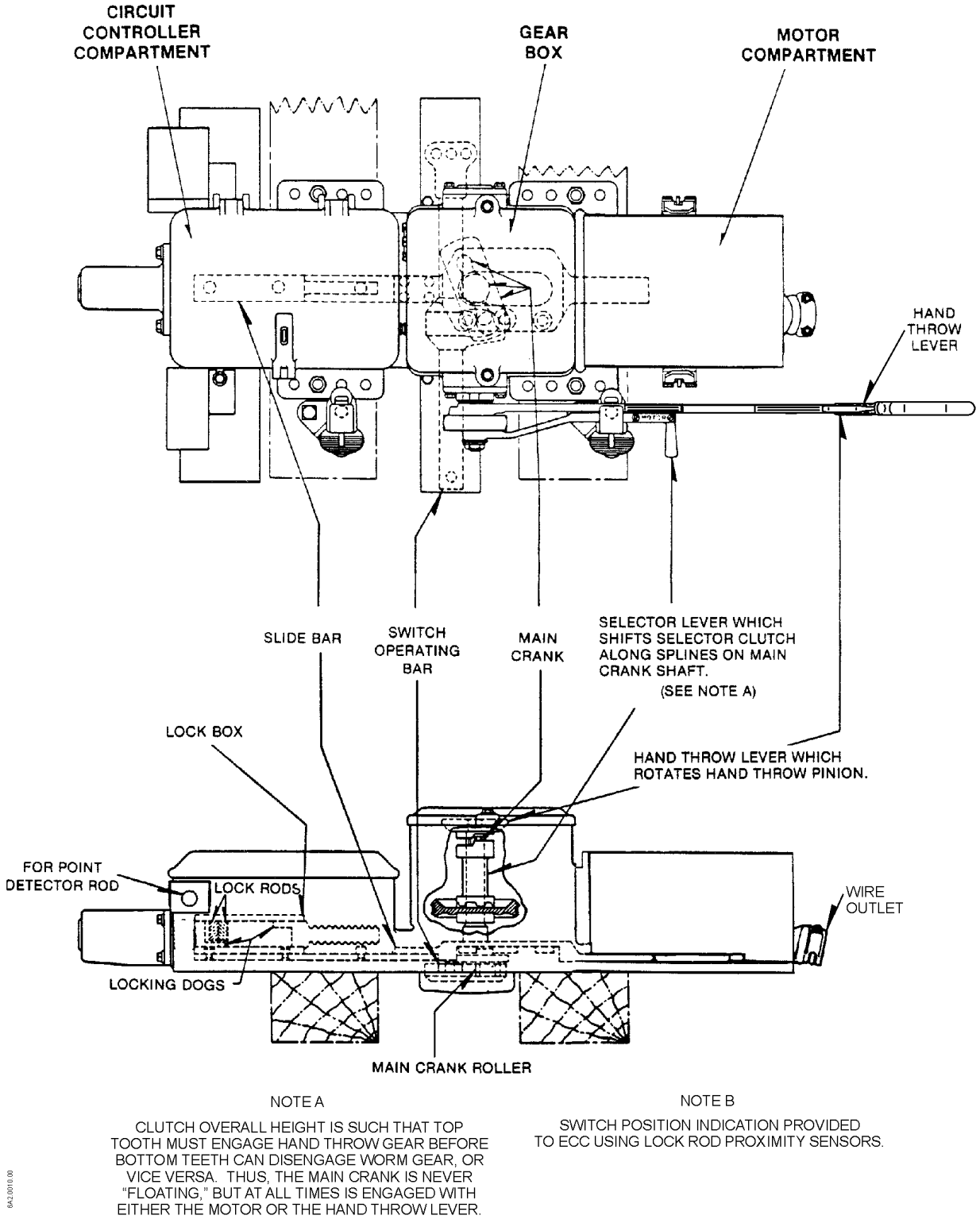


Figure 1-2. M-23 Switch Machine Outline Diagram

The M-23A and M-23B machines use different hand-throw pinions, which affects the hand-throw locking. Power operation is the same in both machines. In the M-23A, operation using the hand-throw lever gives the same mechanism stroke, including full lock rod protection and point indication, as during power operation. In the M-23B machine, however, operation using the hand-throw lever does ***not*** provide lock rod protection (the slide bar and lock box do not move full stroke).

Motors and gear ratios are available for operating the machines from 110 or 20 VDC. All M-3 machines use the same gearbox, but different gear sets. Similarly, all M-23 machines use the same gearbox, but different gear sets. Two gear ratios are available for the low-voltage (20 VDC) machines; one to provide relatively fast operation, and the other to provide slower operation at locations where current requirements must be held to a minimum. A third gear ratio is used with the high-voltage (110 VDC) motors.

The machines are completely wired at the factory with the internal wiring connected to AAR posts and a WAGO strip inside the motor compartment. An internal wiring diagram is enclosed with each machine when shipped, showing where external connections are to be made to the terminal boards. These diagrams are also included in this manual as Figure 2-5 and Figure 2-6.

1.2.1. Operating Mechanism

Three compartments are provided for both the M-3 (see Figure 1-1) and the M-23 machines (see Figure 1-2).

- **Motor Compartment.** This compartment houses the motor, motor controller (MCU or EBNC), terminal boards, and a wire outlet for the external wiring. The friction clutch of the gear train projects into this compartment.
- **Gearbox.** There are two compartments in the gearbox, one for the spur gear portion of the reduction gearing, and the other for the main crank and worm gear drive. Connection between the spur gears and the worm shaft is through the friction clutch, which projects into the motor compartment. The friction clutch protects the mechanism from shock at the end of the stroke or when travel is stopped suddenly by an obstruction in the switch point or by lock rod fouling. The gearbox also houses the hand-operating mechanism – a hand crank on the M-3 or dual-control mechanism on the M-23.
- **Circuit Controller Compartment.** This compartment contains the electronic circuit controller, locking features, point detectors, and a separate set of motor cutout contacts which open the motor circuit during manual operation.

A slide bar runs lengthwise in the base of the machine. It is driven by the main crank and operates the lock box in the circuit controller compartment. Perpendicular to the mechanism and beneath the slide bar is a switch operating bar (also driven by the main crank) to which the switch operating rod is connected (see Figure 3-1). The point detector rod and lock rods, operated by connections to the switch points, are supported in the circuit controller compartment.

Switch operation and switch locking are performed by the vertical main crank in the gearbox. The main crank is driven either by the motor or by the hand operation facilities. Refer to Section 3 for detailed operation of the switch machine.

1.2.2. Control Mechanism

The ASTS USA Electronic Circuit Controller (ECC) is designed for use in M-3 and M-23 style switch machines using permanent magnet motors. The ECC uses four vital proximity sensors: two for detecting switch point position (Normal or Reverse) and two for detecting that the machine is fully locked in position at end of stroke. Two non-vital sensors can be installed as an option when auxiliary point indication is desired.

The ECC is a microprocessor-based controller that vitally monitors the state of the four vital proximity sensors and can identify each possible sensor state (ON, OFF, SHORTED, or OPEN). The sensing threshold of each auxiliary sensor (when used) is offset from the vital point detector sensors by 1/8-inch to detect switch point displacement before the vital sensors indicate point detector bar movement. This system provides a normally ON bipolar output to warn maintenance personnel of marginal switch machine operation. With this auxiliary system, switch point displacement caused by debris build-up or expansion and contraction of the rail can be detected before switch failure occurs.

The ECC proximity sensor system is a true linear detection device with no moving parts to wear. The system requires no adjustment of the point detector bar; instead, the sensors are positioned (along serrated linear slides) and gapped with respect to the sensor target mounted on the point detector bar. The lock sensors are similarly gapped (no position adjustment is required) with respect to the target mounted on the lock box.

The ECC diagnostic indicators (LEDs) show the current state of the local machine and the indication state of an adjacent (daisy-chained) machine (where required). Table 1-1 lists the monitored items and the indications provided.

Table 1-1. ECC Diagnostic Indicators

Diagnostic	Indication State (Lit LED)		
Point Detected [1] [2]	Green = ON	Red = OFF	Flashing Red = Error
Point Locked [1] [2]	Green = ON	Red = OFF	Flashing Red = Error
Indication Input [2]	Green = Indication Input present from adjacent machine		
	Dark = No indication input power present		
Indication Output [2]	Green = Switch is locked and detected; indication output is ON		
	Dark = Switch not locked and detected; indication output is OFF		
Auxiliary Point Detected [2]	Green = Auxiliary sensor ON; auxiliary bipolar output is ON		
	Dark = Auxiliary sensor OFF; auxiliary bipolar output is OFF		
Latch Out	Red = Latched out		Dark = Not latched out
Motor Disabled	Red = Motor power disabled		Dark = Motor power enabled

[1] Separate indication for Normal and Reverse position [2] Bicolor LED

1.3. Specifications

Table 1-2. Switch Machine Physical Characteristics

Parameter	M-3	M-23
Length	63-1/2 inches	63-1/2 inches
Width	33 inches	33 inches
Height	10-1/4 inches	14 inches
Weight	810 pounds	860 pounds

Table 1-3. Switch Machine Operating Characteristics

Motor Voltage[(1)]	Time[(2)]	Gear Ratio	Clutch Setting
110 VDC	4.5 seconds	189:1	14 amps
110 VDC	8.0 seconds	360:1	10 amps
20 VDC	15 seconds	360:1	23 amps
20 VDC	26/34 seconds	528:1	12 amps

(1) Nominal voltage at motor terminals.

(2) Switch over time measured in accordance with AREMA (AAR) Manual Part 12.2.5. These times will vary depending upon motor terminal voltage and machine operating load and conditions.

Table 1-4. Switch Machine Motors

Motor Part No.	Motor Voltage
J717216-0301	110 VDC
J717216-0303	20 VDC
J717216-0501	20 VDC
J717216-0502	110 VDC

Table 1-5. Switch Machine Heaters

Heater Part No.	Electrical Characteristics
N294241	15W–115V (AC or DC)
N451589-0101	30W–115/230V (AC or DC)
N294291 and N290578-001	15W–24VDC

Table 1-6. Switch Machine Controllers

Controller	Electrical Data		
ECC	Operating Voltage	12 (10 – 16) VDC	
MCU	Operating Voltage	12 (10 – 33) VDC	
	Maximum Motor Voltage	LV: 33 VDC	HV: 140 VDC
	Motor Overload	Provided by Wayside	
EBNC	Operating Voltage	12 (10 – 33) VDC	
	Maximum Motor Voltage	LV: 33 VDC	HV: 140 VDC
	Motor Overload (HV)	Amps[1]	Time (Seconds)
		< 2.5A	No Overload
		13A	13.0 (10.4 – 15.6)
		> 16A	< 3
	Motor Overload (LV)	Amps[2]	Time (Seconds)
		< 6A	No Overload
		20A	26.4 (21.2 – 31.6)
		> 22A	< 3

(1) At below 13A, the time to overload nominally equals 169 divided by the current.

(2) At below 20A, the time to overload nominally equals 520 divided by the current.

1.4. Abbreviations, Acronyms, and Definitions

AC	Alternating Current
AAR	Association of American Railroads – Communication and Signal Section (currently known as AREMA)
AREA	American Railway Engineering Association
AREMA	American Railway and Maintenance of Way Association (formerly known as AAR)
ASTS USA	Ansaldo STS USA, Inc. (formerly known as Union Switch & Signal Inc.)
AWG	American Wire Gauge
CAUTION	Caution statements indicate conditions that could cause damage to equipment.
DC	Direct Current
ECC	Electronic Circuit Controller
EBNC	Electronic Biased Neutral Controller – Used to control fixed polarity motor power input using a bipolar logic input.
Front of Machine	The physical area of the switch machine closest to the motor.
FRA	Federal Railroad Administration
Latch-Out	A device that does not allow switch point indication to restore if the switch point moves away from the stock rail (point detection is momentarily lost). This function will be activated if the point sensors are actuated before their corresponding locking sensors are actuated.

Latch-Out Restoration	The term latch-out restoration refers to resetting the machine to an operable switch machine indication state from a latched-out condition.
LED	Light-Emitting Diode
Left-Hand Switch	The position of a switch machine designated when the machine is located on the left-hand side of the track, looking into the switch points in the direction of the arrow as shown in Figure 1-3.
LHPC	"Left-Hand Point Closed," which refers to the switch point position when the point is normally closed to the left-hand side, looking into the switch points in the direction of the arrow as shown in Figure 1-3.
PD	Point Detector or point detection (as in "PD bar").
Point Detection	The positive indication achieved when the switch points are closed adequately against the stock rail.
Locking	Locking is achieved when the lock box, connected to the slide bar, enters the narrow locking notch of the lock rods and extends a minimum of 1/2" into the locking rod.
MCU	Motor Control Unit - a high-current, solid-state device used to control motor power.
MOV	Metal Oxide Varistor (protection device for electronic components).
Non-Vital Circuit	Any circuit with a function that does not affect the safety of train operation.
PCB	Printed Circuit Board
Rear of Machine	The physical area of the switch machine furthest from the motor.
Reference Designator	An abbreviation assigned to designate an electrical component. It generally consists of a capital letter and a number. Each letter designates a particular type of component. For example, "L" identifies an inductor and "R" identifies a resistor.
Right-Hand Switch	The position of a switch machine designated when the machine is located on the right-hand side of the track, looking into the switch points in the direction of the arrow shown in Figure 1-3.
RHPC	"Right-Hand Point Closed," which refers to the switch point position when the point is normally closed to the right-hand side of the track, looking into the switch points in the direction of the arrow shown in Figure 1-3.
rms	Root-Mean-Square (method for expressing AC voltage rating)
Switch Machine Indication	A vital determination of a safe switch configuration, due to positive Indication that the switch machine has properly thrown, locked and detected switch point closure.
Switch and Lock Movement and/or Mainline Switch Machine	A device which performs the three operations of unlocking, operating, and locking a switch, movable point frog, or derail.
Vital Circuit	Any circuit with a function that affects the safety of train operation.

WAGO®	Registered trademark for WAGO Corporation.
WARNING	Warning statements indicate conditions that could cause physical harm, serious injury, or loss of life.

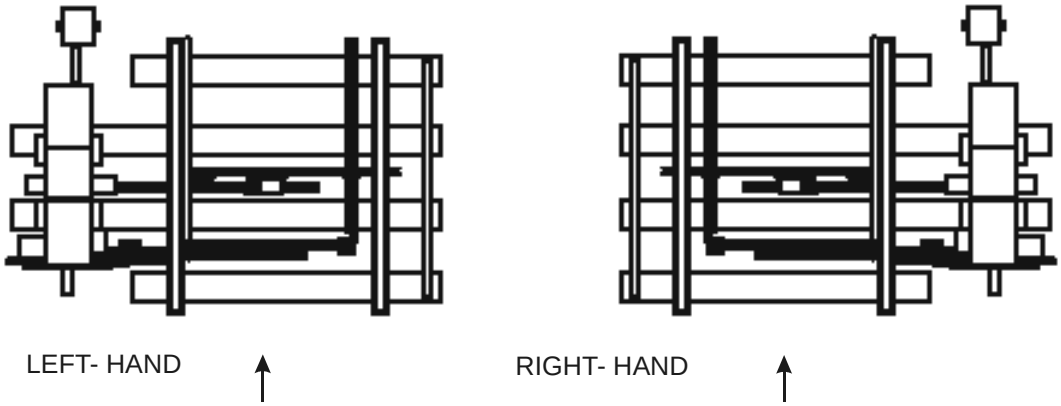


Figure 1-3. Left-Hand and Right-Hand Switch Machines

1.5. Safety

Read and thoroughly understand this manual before attempting any of the procedures listed. Pay particular attention to the **WARNING** and **CAUTION** statements that appear throughout this manual. Always observe standard precautions familiar to trained electrical technicians. Always adhere to all safety regulations stipulated by the railroad.

2. INSTALLATION AND ADJUSTMENTS

2.1. General Information

In general, the application of the M-3 and M-23 switch machines is as shown in Figure 2-1 (M-3) and Figure 2-2 (M-23), but detail mounting plans approved by the railroad should be followed when installing the machine. Mounting dimensions are shown in Figure 2-3 (M-3) and Figure 2-4 (M-23). Switch machines are assembled at the factory to suit particular layouts when sufficient information is provided in the order, but can be changed between right-hand and left-hand in the field. Conversion of the M-3 is very simple and no detail instructions are required. Detail instructions for changing the M-23 dual-control machines are given in paragraph 2.16. After the machine has been properly assembled for the layout, check the following:

a. Two 3/8-inch pipe plugs are enclosed in a bag tied in the motor compartment. They are for application to two drain holes located in the cover under the gear box compartment when the machine is in a location where blowing sand or dust is troublesome, but should not be applied unless this condition prevails – and if used should be removed at intervals to drain the compartment, especially prior to freezing weather.

b. Two other drain plugs, which consist of slotted head bolts and lock washers, are provided in the circuit controller compartment. These drain plugs are shipped in place, but not fully tightened. Like the pipe plugs, they should be left applied only at locations where blowing sand or dust is troublesome.

2.2. Mounting

Mount and secure the switch machine on ties according to the layout plans applying to the particular location. Adjust the height of the lever stand so that selector and hand-throw levers on M-23 machines are held horizontal and parallel with the top of the gearbox.

2.3. Switch Rod Installation and Adjustment

Connect the switch-operating rod and adjust the rod nuts at the switch basket to obtain the proper point pressure in accordance with local operating rules. Nothing is gained by using excessive pressure.

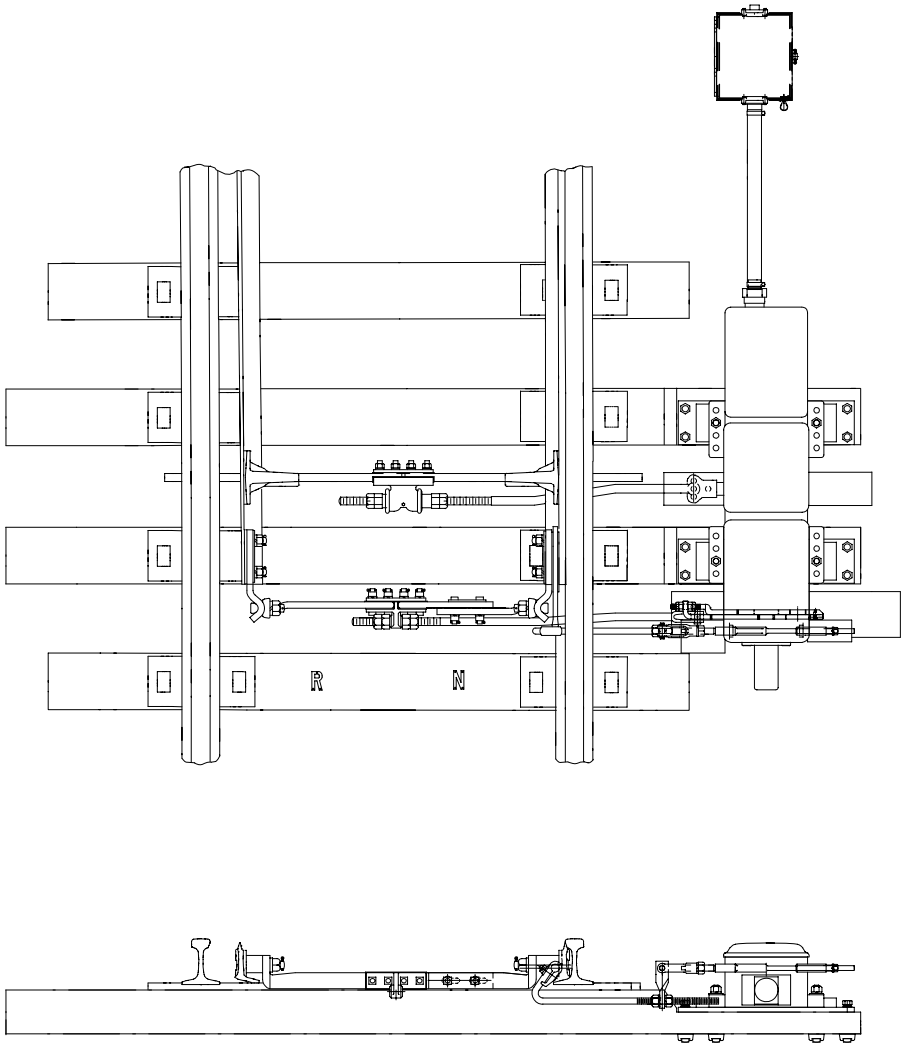


Figure 2-1. M-3 Switch Machine Typical Application

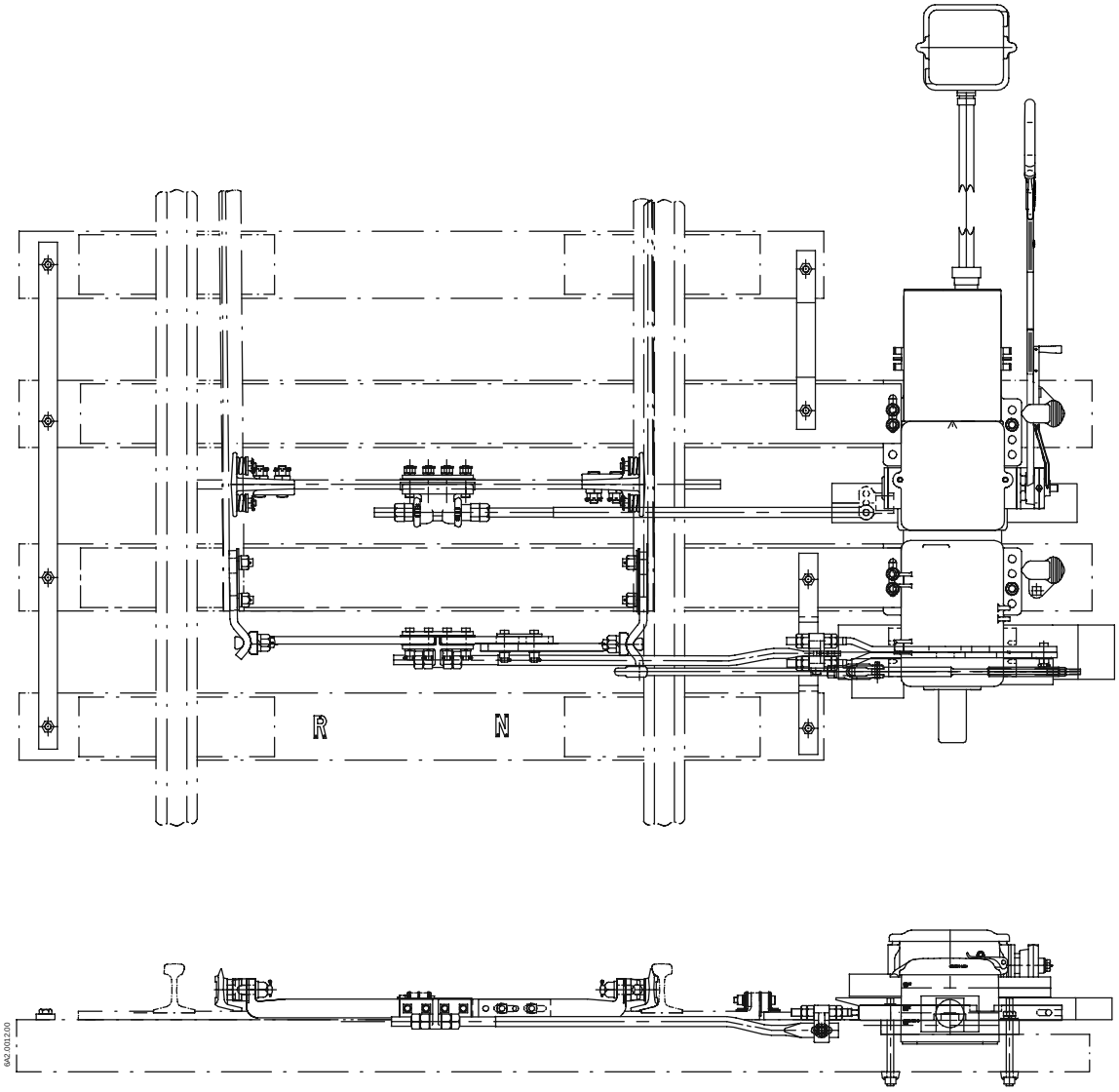


Figure 2-2. M-23 Switch Machine Typical Application

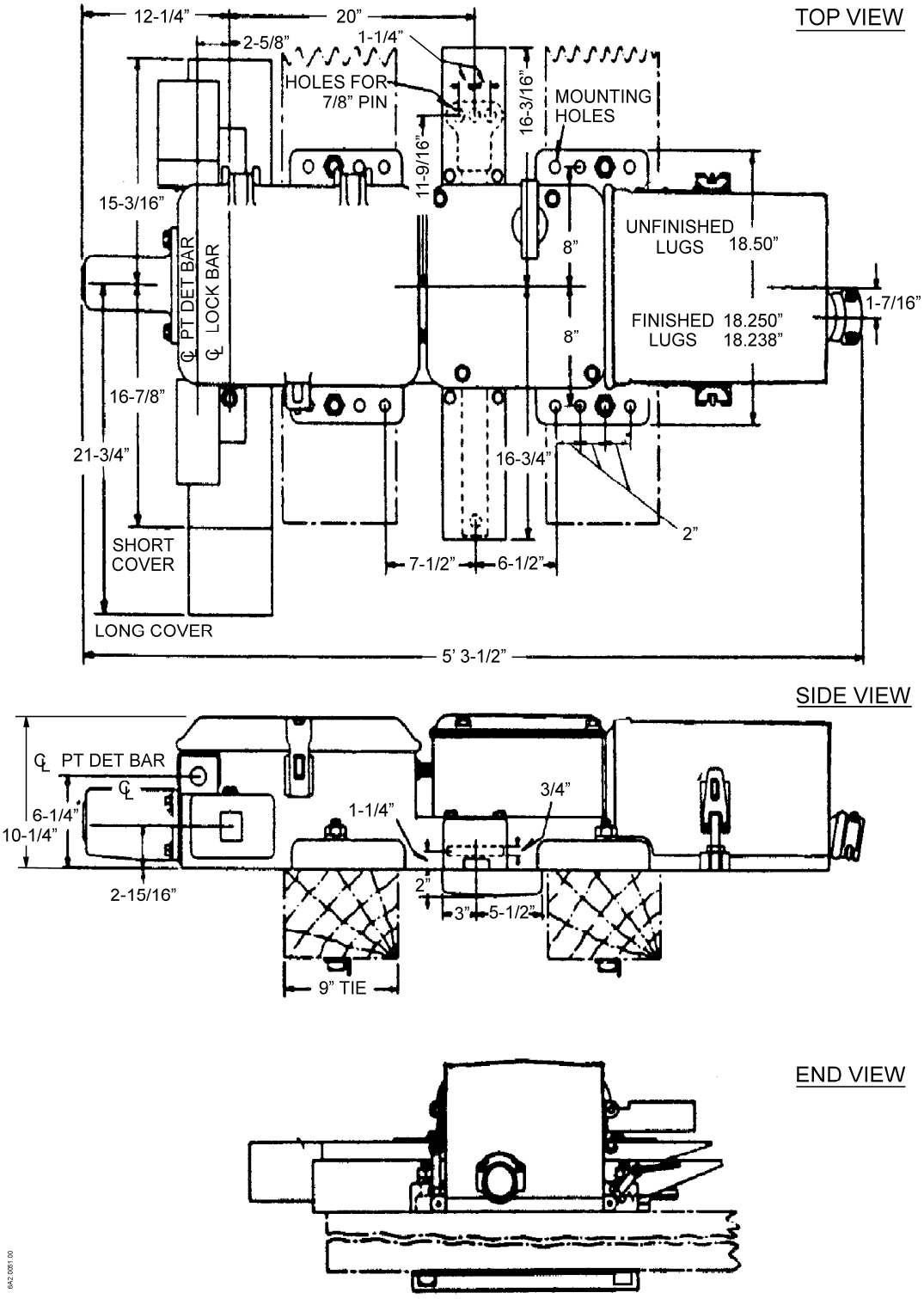


Figure 2-3. M-3 Switch Machine Typical Mounting Plan

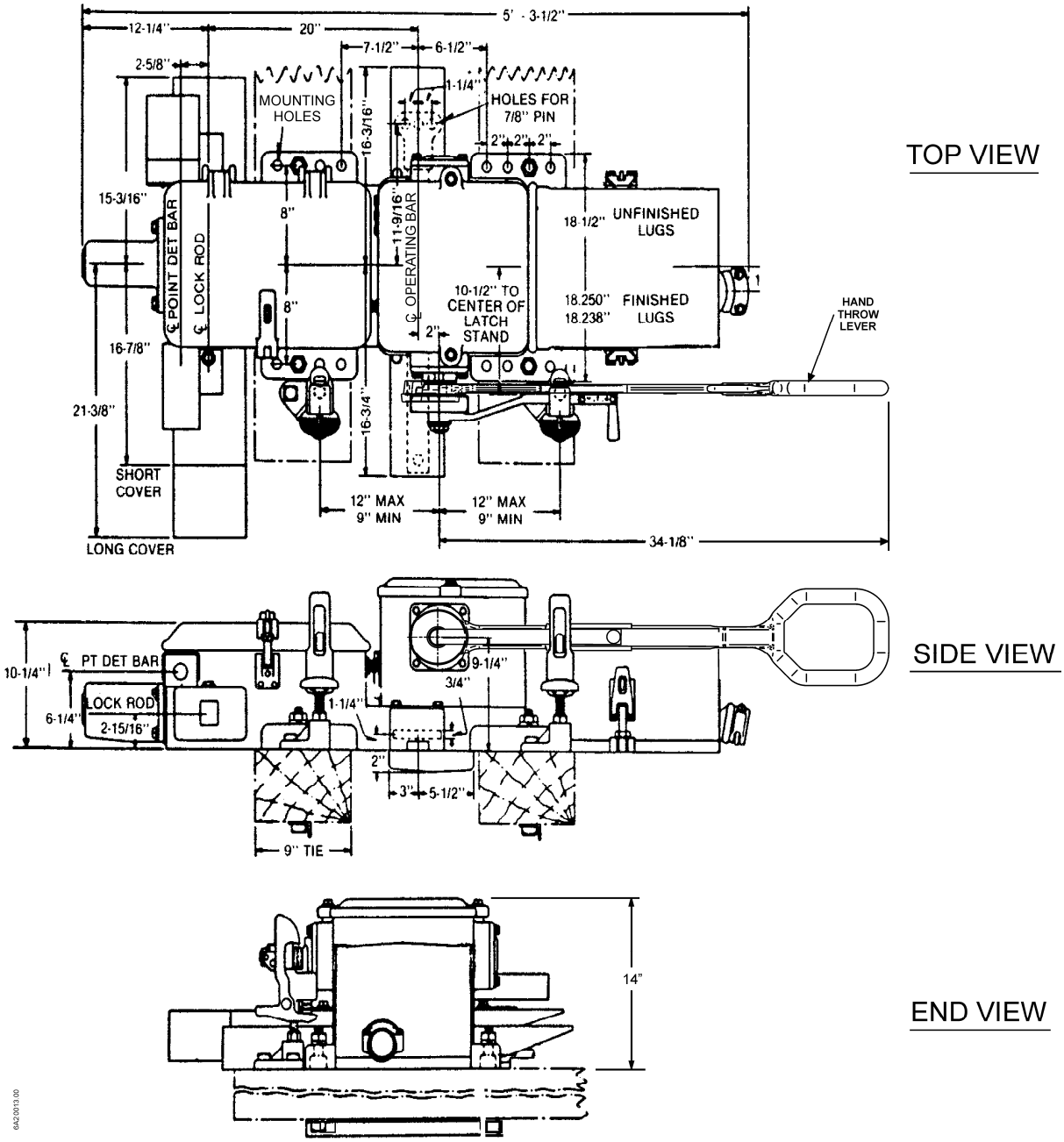


Figure 2-4. M-23 Switch Machine Typical Mounting Plan

2.4. Lock Rod Installation and Adjustment

With the covers removed and machine at mid-stroke, apply the lock rods. Be sure that the flat plate snow cover is assembled on the track side (where applicable) when applying the lock rods, be sure the rods are so assembled that the locking dogs in the lock box will enter the narrow notches first. In some instances it may be necessary to invert the lock box to suit the rod notches, in this case refer to instructions in Section 2.16.6. Preliminary adjustment should be made by setting the nuts so that the narrow notches are approximately centered on the locking dogs at each end of the stroke. (This requires that the M-23B machine be operated by power or by turning the friction clutch housing by applying a ratchet wrench to the clutch adjusting nut with the selector lever in the MOTOR position and power disconnected.) The upper narrow notch can be seen directly. Index marks are provided on the top surface opposite the notched ends for the lower notch. Make final adjustments in accordance with AREMA Signal Section or railroad instructions.

WARNING

To avoid severe personal injury, open the gold nut test link in the motor compartment prior to performing any internal machine maintenance. Always keep hands and feet clear of switch points and the internal moving parts of the machine. Ensure that loose clothing is properly secured prior to working on the switch machine.

2.5. Junction Box Jumper Configuration

2.5.1. RHPC/LHPC Jumpers

The Right-Hand Point Closed (RHPC) and Left-Hand Point Closed (LHPC) jumpers are set at the factory as specified on the order. If necessary, a machine can be changed in the field by moving the red jumper on the controller junction box between RHPC and LHPC as required.

2.5.2. Latch-Out Jumpers

The latch-out jumper for all ASTS USA M-style switch machines is set for the automatic, manual, or disable function. This configuration is set at the factory based on customer preference at the time the order was placed. To change this configuration, see Section 2.5.3.

2.5.3. Changing the Jumper Configuration

1. Ensure that the machine is in the full locked position with the lock box extended toward the gearbox.

2. Locate the Junction Box (Figure 2-5 or Figure 2-6) directly behind the ECC.

3. Unscrew the dust cover from the desired position and move the jumper to that location. Reinstall the dust cover on the unused connection.

2.6. ECC Power and Indication Input Setup

The ECC requires a continuous wayside battery feed of 12 VDC nominal, connected to WAGO Terminals 17 (N12) and 20 (B12). Indication input can be set up either for a single machine (such as an end-of-siding application) or multiple machines (such as a daisy-chained crossover).

2.6.1. Single Machine Setup

The indication input to the ECC must be jumpered on the WAGO terminal strip to receive continuous battery feed. The ECC is shipped from ASTS USA with these jumpers installed and must be removed for multiple machine applications.

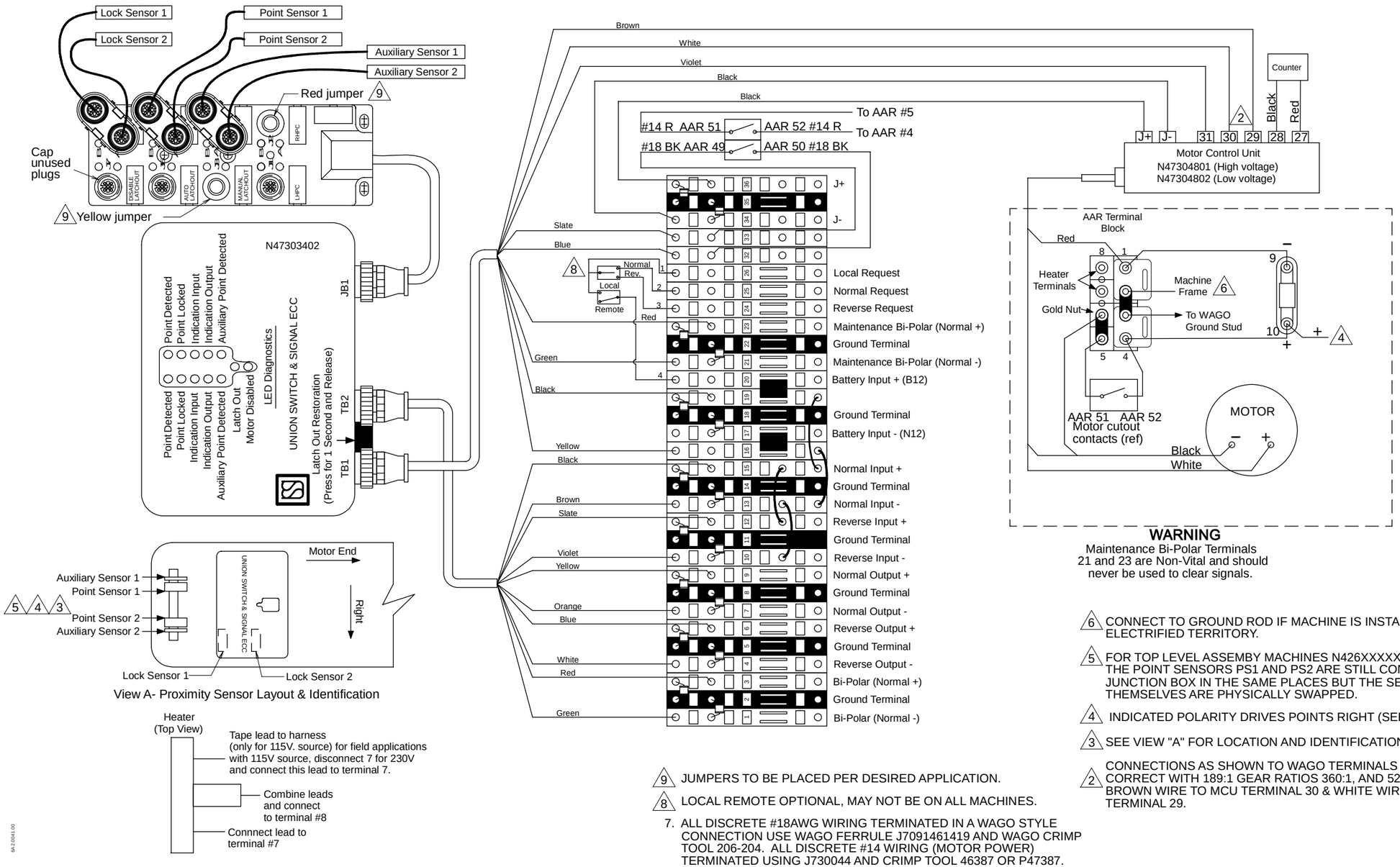
Four jumpers must be installed (refer to the wiring diagram in Figure 2-6). Terminal 16 (for N12) is connected to Terminal 13 (normal input –), which is also jumpered to Terminal 10 (reverse input –). Terminal 19 (for B12) is connected to Terminal 15 (normal input +) which is also jumpered to Terminal 12 (reverse input +).

With the above jumper configuration in place, both indication input green LEDs inside the ECC box will be lit to show that continuous power is being supplied to the indication input circuits.

2.6.2. Multiple Machine Setup

If the machine is the **first** machine in the crossover (i.e., the indication output is not dependent upon the indication input from an adjacent machine), the indication input circuits are to be jumpered as described in paragraph 2.6.1 for a single machine application.

If the machine is the **second** machine in a crossover application (i.e., requires indication input from the first machine to properly deliver indication output to the wayside), indication input jumpers are not used. The indication input circuits of the **second** machine are to be fed from the indication output of the **first** machine to ensure that both machines in the crossover are locked and detected in the correct position.



9 JUMPERS TO BE PLACED PER DESIRED APPLICATION.

8 LOCAL REMOTE OPTIONAL, MAY NOT BE ON ALL MACHINES.

7. ALL DISCRETE #18AWG WIRING TERMINATED IN A WAGO STYLE CONNECTION USE WAGO FERRULE J7091461419 AND WAGO CRIMP TOOL 206-204. ALL DISCRETE #14 WIRING (MOTOR POWER) TERMINATED USING J730044 AND CRIMP TOOL 46387 OR P47387.

6 CONNECT TO GROUND ROD IF MACHINE IS INSTALLED IN ELECTRIFIED TERRITORY.

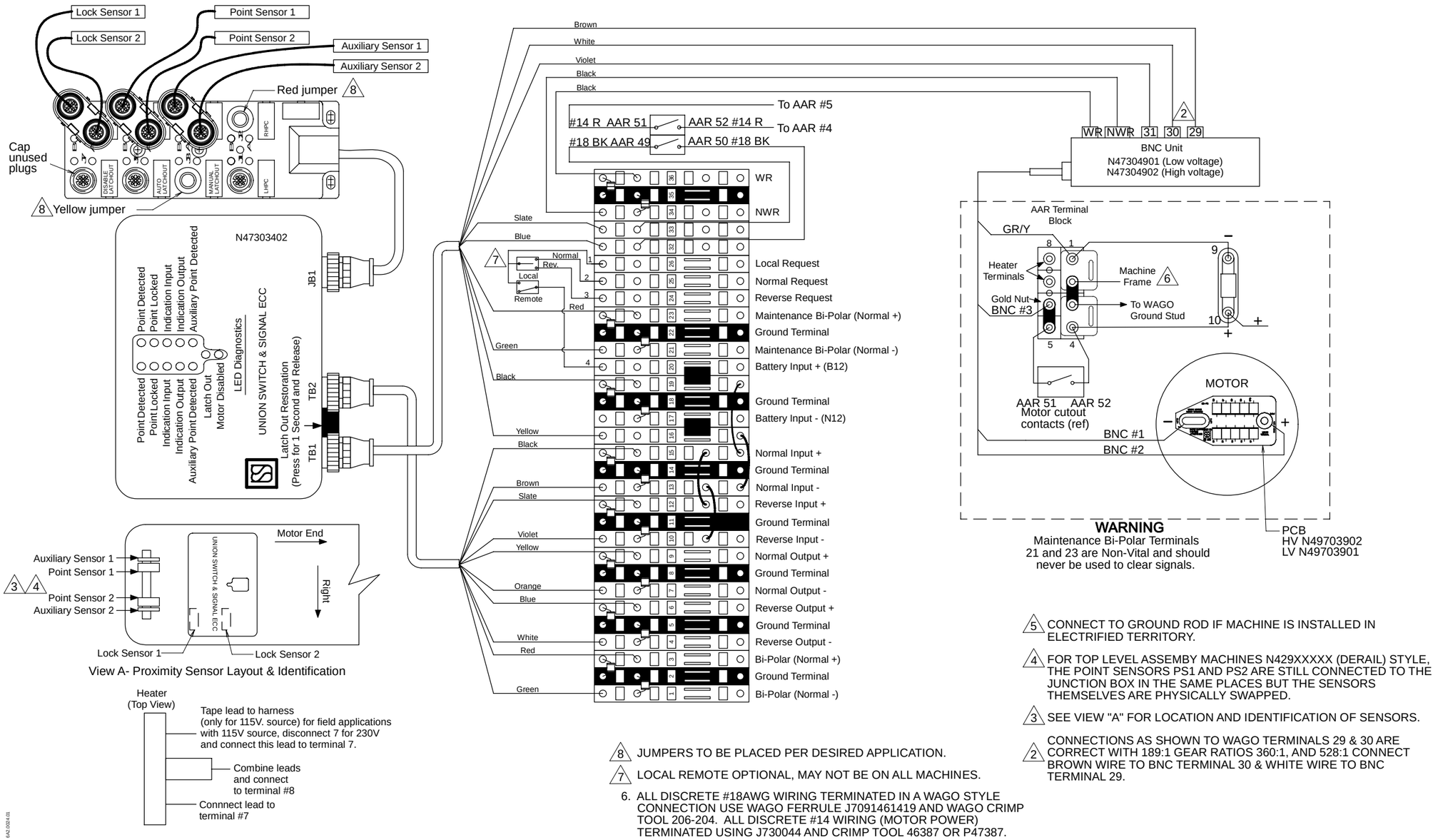
5 FOR TOP LEVEL ASSEMBY MACHINES N426XXXXX (DERAIL) STYLE, THE POINT SENSORS PS1 AND PS2 ARE STILL CONNECTED TO THE JUNCTION BOX IN THE SAME PLACES BUT THE SENSORS THEMSELVES ARE PHYSICALLY SWAPPED.

4 INDICATED POLARITY DRIVES POINTS RIGHT (SEE VIEW "A").

3 SEE VIEW "A" FOR LOCATION AND IDENTIFICATION OF SENSORS.

2 CONNECTIONS AS SHOWN TO WAGO TERMINALS 29 & 30 ARE CORRECT WITH 189:1 GEAR RATIOS 360:1, AND 528:1 CONNECT BROWN WIRE TO MCU TERMINAL 30 & WHITE WIRE TO MCU TERMINAL 29.

Figure 2-5. ECC with MCU Internal Wiring Diagram



8 JUMPERS TO BE PLACED PER DESIRED APPLICATION.

7 LOCAL REMOTE OPTIONAL, MAY NOT BE ON ALL MACHINES.

6. ALL DISCRETE #18AWG WIRING TERMINATED IN A WAGO STYLE CONNECTION USE WAGO FERRULE J7091461419 AND WAGO CRIMP TOOL 206-204. ALL DISCRETE #14 WIRING (MOTOR POWER) TERMINATED USING J730044 AND CRIMP TOOL 46387 OR P47387.

5 CONNECT TO GROUND ROD IF MACHINE IS INSTALLED IN ELECTRIFIED TERRITORY.

4 FOR TOP LEVEL ASSEMBY MACHINES N429XXXXX (DERAIL) STYLE, THE POINT SENSORS PS1 AND PS2 ARE STILL CONNECTED TO THE JUNCTION BOX IN THE SAME PLACES BUT THE SENSORS THEMSELVES ARE PHYSICALLY SWAPPED.

3 SEE VIEW "A" FOR LOCATION AND IDENTIFICATION OF SENSORS.

2 CONNECTIONS AS SHOWN TO WAGO TERMINALS 29 & 30 ARE CORRECT WITH 189:1 GEAR RATIOS 360:1, AND 528:1 CONNECT BROWN WIRE TO BNC TERMINAL 30 & WHITE WIRE TO BNC TERMINAL 29.

Figure 2-6. ECC with EBNC Internal Wiring Diagram

2.7. Wiring and Motor Control

2.7.1. WAGO Terminal Strip Connections

Figure 2-5 (with MCU) and Figure 2-6 (with BNC) show the internal wiring diagram of the ECC system). WAGO Terminal strip connections are as follows:

1. Terminals 2, 5, 8, 11, 14, 18, 22, and 35 are internally connected to the DIN rail and provide the earth ground connection for the 16 gas tube lightning arrestors. Terminal 35 also provides the earth ground connection for the switch logic control inputs. ***No other wires should be terminated to these points.***

2. Terminals 1 and 3 are for field connections to a two-wire, bipolar indication output circuit.

   a. Normal indication is defined as (+) on Terminal 3 and (–) on Terminal 1.

   b. Reverse indication is defined as (–) on Terminal 3 and (+) on Terminal 1.

   c. If there is no output, Terminals 1 and 3 are shunted.

3. Terminals 4, 6, 7, and 9 are for field connections to a four-wire indication output circuit.

   a. Normal indication is defined between Terminals 7 (+) and 9 (–).

   b. Reverse indication is defined between Terminals 4 (+) and 6 (–).

   c. If there is no output on the paired terminals, they are shunted.

WARNING

When connecting the ECC indication outputs to the drive switch correspondence relays, ensure the relay controls are properly snubbed with a resistor to minimize possible inductive kickback to the ECC when the field in the relay coil collapses.

Ensure that no external source is applied across any of the outputs.

4. Terminals 10, 12, 13, and 15 are for indication input field connections from an adjacent machine, or they can be jumpered for single machine applications.

   a. Normal indication input is defined between Terminals 13 (–) and 15 (+).

   b. Reverse indication input is defined between Terminals 10 (–) and 12 (+).

c. If the machine is used in a single machine application, battery must be fed to the indication input circuits to provide indication output. Refer to Section 2.6 for proper jumper configuration.

NOTE

Four indication input jumpers are factory installed on the WAGO terminal strip and must be removed for multiple machine applications.

5. Terminal 17 is used for connecting wayside battery N12 (–). Terminal 20 is used for connecting wayside battery B12 (+). Note that there are factory installed jumpers between paired Terminals 16 and 17 and between paired Terminals 19 and 20. Wayside battery can be fed to either available terminal of each pair.

6. Terminals 21 and 23 are for field connections to the two-wire, bipolar auxiliary sensor output.

   a. Normal auxiliary indication is defined as (+) on Terminal 23 and (–) on Terminal 21.

   b. Reverse auxiliary indication is defined as (–) on Terminal 23 and (+) on Terminal 21.

WARNING

The maintenance output is **not vital** and should never be used to clear signals.

7. Terminals 24, 25, and 26 are for field connections to use the local/remote request switch option. This function is particularly useful when conducting monthly inspections.

   For this function to work, however, the wayside must be configured appropriately. The two toggle switches in the machine (L/R and N/R) interface with the local control panel and provide the ability to control the machine as though operating directly from the local control panel. The local/remote (L/R) switch normally is to be in the remote position. When placed in the local position, battery (+) is routed to Terminal 26. The local control panel is thus activated to receive commands from maintenance personnel at the machine. The second switch (N/R) is a center OFF spring-return toggle. When held in the N position, the machine is electrically driven from the wayside controller to the normal position. If the switch is released before the stroke is complete, the motor will coast to a stop.

CAUTION

The LOCAL REQUEST overrides the dispatcher's control of the machine. **Return the L/R switch to the Remote position at completion of maintenance.**

8. Terminals 32 and 33 are the termination points for the motor cutout circuits. An open connection between these two terminals puts the ECC into motor disable, which in turn disables the motor controller. Note that WAGO connections at 32 & 33 are blue and, unlike other WAGO terminals on block, are isolated from one side to the other. This allows for alternate wiring options if external monitoring of the motor cutout contacts is desired.

9. Terminals 34 and 36 are motor controller specific. For MCU machines, they are a solid state relay for external monitoring of the motor controller disable status. For EBNC machines, they are the bipolar logic switch control inputs.

2.7.2. Motor Controllers

Two types of motor controller can be installed. Each type is available in high- or low-voltage versions. The MCU does not have an integral overload function; the EBNC does.

2.7.2.1. MCU

Terminals 29, 30, and 31 are ON MOTOR FRONT and ON MOTOR REAR signals from the ECC; they are used to turn off motor current at the end of the stroke. For example, if the motor is turning to produce motion of the lock box toward the motor compartment (front end of the machine), both ON MOTOR FRONT and ON MOTOR REAR are (**+**) relative to GND. When lock sensor LS2 turns ON, the ON MOTOR FRONT line switches to GND. In response, the motor controller opens the motor to the polarity of current that would continue motion in the same direction. If the proper motor power polarity is applied to AAR terminals the motor will then operate in the correct direction. Additionally, the counter is energized momentarily through Terminals 27 and 28 and one count is registered. Operation in the opposite direction is the same with ON MOTOR REAR switching to stop the motor; however, the counter does not respond.

2.7.2.2. EBNC

Terminals 29, 30 and 31 are ON MOTOR FRONT, ON MOTOR REAR and GND signals from the ECC. They are used in conjunction with bi-polar input WR/NWR on terminals 34 and 36 to control polarity of the motor connected on wires 1 & 2. See Figure 2-6. With WR(+) & NWR(-), wire 1 is positive with respect to wire 2. With terminal 30 high; motoring is terminated when terminal 30 switches low. The opposite motor polarity is achieved with a reversal of WR/NWR being controlled by input on terminal 29. Illumination of the green LED indicates a bi-polar input.

The EBNC provides a method of motor control from a bi-polar input that does not require any power switching relays for safe operation of a switch machine. Motor power (+) on wire 3 and (-) on GR/Y can be left permanently connected. Motor polarity is controlled entirely by the bi-polar input.

Overload protection based on the product of time and current terminates motoring after 26 seconds at 20 amperes with a low voltage machine and 15 seconds at 13 amperes with a high

voltage machine. The red LED illuminates on overload. Once motoring is terminated from an overload, it is necessary to change polarity of the bi-polar input to regain motor control.

The bi-polar input to the EBNC will operate over a range of 9 to 36 volts. The operating current closely replicates the following equation: $I=(34.76-V_{IN})/153.8$. Where V_{IN} is the input voltage to the EBNC across terminals 34 & 36 (WR-NWR). Maximum current is calculated at $V_{IN} = 9$ volts (the minimum operating voltage of the EBNC) or 0.167 amperes. Maximum line resistance (R_L), based on minimum battery voltage (V_{BATT}) is then given by: $R_L=(V_{BATT}-9.0)/0.167$. For a minimum battery voltage of 10 volts, maximum line resistance is nearly 6 ohms. This equates to 2,376 ft of #14 AWG wire or 1,188 linear ft. If two machines are operated in parallel over the same wires, 3 ohms would be the maximum wire resistance based on minimum battery voltage of 10 volts.

If the line wire resistance restrictions are too severe with a nominal 12 volt system, the bi-polar EBNC driver (N34801701) is recommended. It delivers approximately 18 VDC and is constant over an input voltage range of 9.8 to 16.2 VDC. It can drive two EBNC equipped machines simultaneously with as much as 28 ohms of line wire. See ASTS USA service manual SM 6A3.0001 for more details.

2.7.2.3. Motor Overload

The MCU-equipped machines do not provide internal motor overload protection. Protection must be provided by the wayside control equipment. Refer to Section 3.7 for further information on typical wayside equipment protection circuits.

The EBNC-equipped machines do provide internal motor overload protection (refer to Table 1-6 for specific values). This protection is based on the measured motor current as a function of time. For very low current draw conditions (only a few amps) that will not damage the motor, the EBNC takes no corrective action. For higher current draw conditions (up to the nominal clutch slip setting), the EBNC will interrupt the motor current if the current draw is maintained for a time determined by the magnitude of the current draw. For extremely high current draws, the EBNC will interrupt the motor current in less than three seconds.

2.8. AREMA Terminal Post Connections

There are ten (10) AREMA binding post terminals, labeled 1 through 10 (see Figure 2-5 and Figure 2-6).

1. Terminals 1/9 and 4/10 are termination points connecting input motor power to the machine. On MCU equipped machines this input is bipolar. On BNC equipped machines the polarity is fixed.

2. Terminals 2 and 3 are common (earth) terminals used for grounding. They are also terminals for the line to ground surge suppressor PCBs connected to Terminals 1 and 4. External ground connection should be connected at terminal 3.

3. Terminal 5 is the termination point for Terminals 10/4 through the motor cutout contacts; Terminal 6 is the termination point for the negative internal permanent magnet motor wire. A "gold nut" test link is provided between terminals 5 & 6 to remove power from the motor when performing maintenance on the machine.

4. Terminals 7 and 8 are designated for motor compartment heater wire termination.

2.9. Sensor Identification and Termination in the Junction Box

The vital point detector sensors are designated PS1 and PS2. The vital locking sensors are designated LS1 and LS2. The auxiliary point detector sensors are designated Aux1 and Aux2. It is important to note that PS1 and LS1 always work in combination together; as do PS2 and LS2 (see Figure 2-5 for ECC or Figure 2-6 for EBNC).

The four vital and two optional auxiliary (non-vital) sensors are all terminated at the Junction Box (see Figure 7-9) located in back of the ECC. All six sensor wires are brought to the junction box and screwed down in their proper positions. The labels identify which sensors connect to each terminal. If any of the four vital sensors are wired incorrectly, the corresponding LEDs on the ECC will be Flashing Red. If the auxiliary sensors are wired incorrectly, they simply will not operate. There is a yellow LED on the back end of each auxiliary sensor to determine if it is operating properly.

2.10. Point Detector and Auxiliary Sensor Adjustment

NOTE

Auxiliary sensors are optional, non-vital sensors and are only supplied when required by the customer.

2.10.1. Point Detector Sensor Gap

The vital and auxiliary (non-vital) point detector sensors (Figure 2–7) must be located at a fixed dimension to optimize sensor response and performance. The vital sensor gap should be 0.075 inch from the face of the PD target. The auxiliary (non-vital) sensor gap should be 0.040 inch from the face of the target. The tightness of the feeler gage used to check the gap between the head of the sensors and the target is not critical; it will not significantly affect sensor performance.

2.10.2. Point Detector Sensor Adjustment

The vital point detector sensors (see Figure 2–7) are mounted on serrated adjusting brackets, which can be adjusted in 1/16 inch linear increments.

Adjust the point detector bar so that the PD target is centered or equally balanced in the machine (see Figure 2–8) when the points are in the mid-stroke position. The point detector bar should

travel equidistant from the center of the controller compartment when the switch travels full stroke.

1. Move the switch machine to either full-stroke position (N or R, it is not critical). Ensure that the switch is locked with the switch point closed and up against the stock rail.

2. Loosen the PD bracket AAR nuts. Lift the serrated bracket and slide the sensor toward the PD target, keeping the bracket elevated so as not to engage the serrations.

3. Move the sensor to the target's edge until the corresponding Point Detected LED on the ECC box just turns Green.

4. Lower the serrated bracket to determine the ON/OFF threshold location in the serrations. Lift and move the sensor bracket three (3) additional serration positions (3/16 inch) toward the center of the machine to assure that the sensor is not adjusted right on the ON/OFF threshold. This will ensure that a 1/4 inch point obstruction is detected, but the points will be allowed some movement (up to 3/16 inch) so as not to cause intermittent indication failures under shock and vibration conditions.

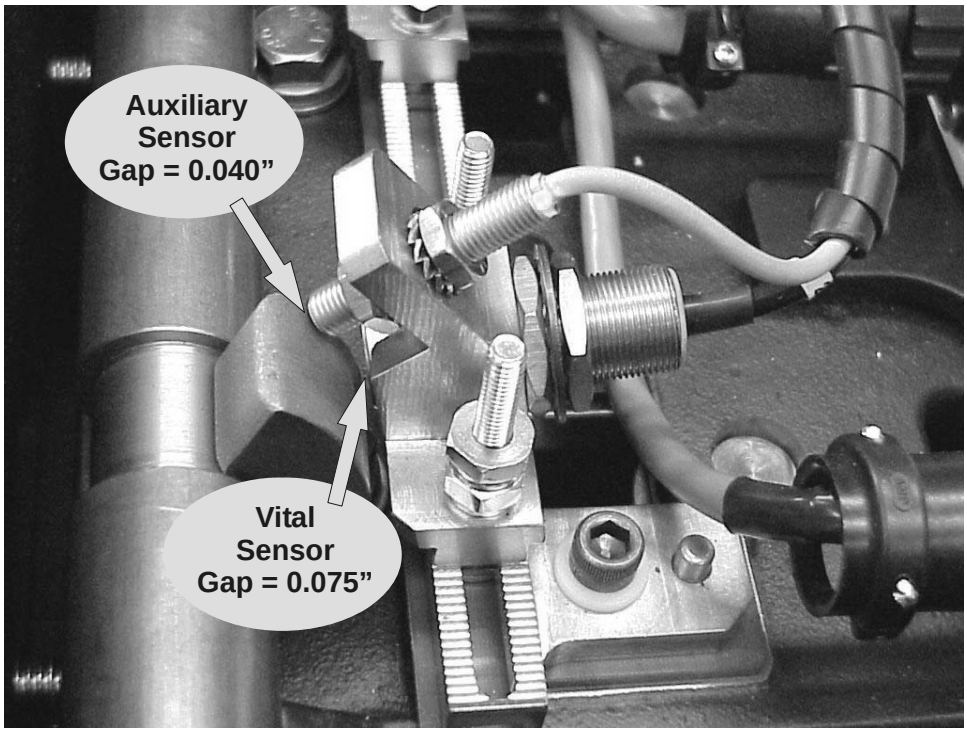


Figure 2–7. Sensor Gap Definition (Non-Vital Sensor Shown is Optional)

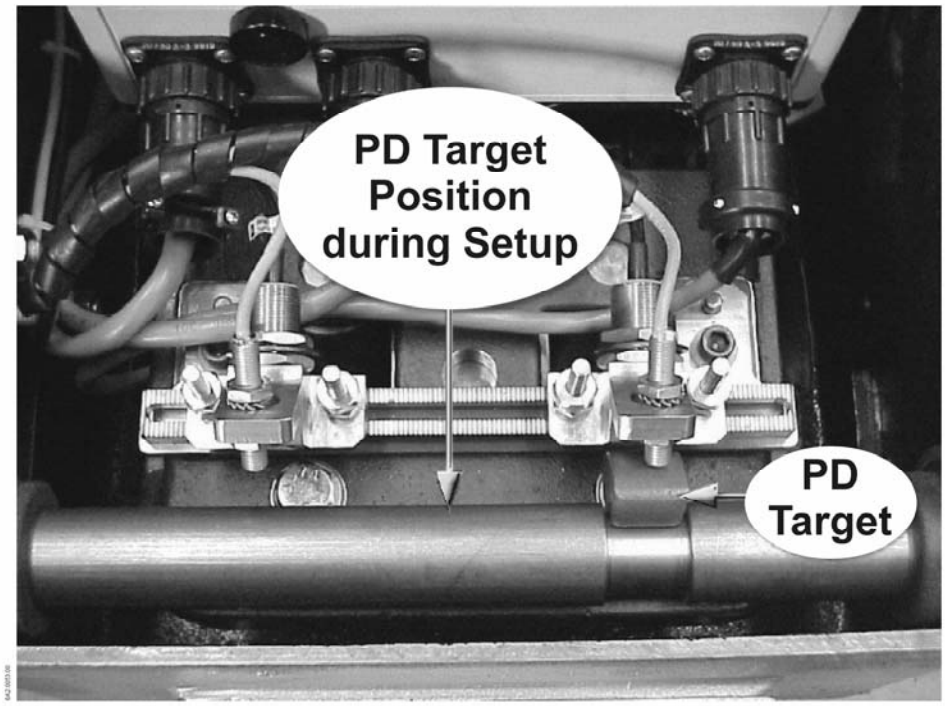


Figure 2–8. Initial Point Detector Bar Setup

5. The sensitivity of the vital sensors can be adjusted in 1/16 inch increments to accommodate for excessive lost motion in the external point detection connections.

6. Tighten the AAR hardware to properly secure the sensor bracket.

7. Place a 1/4 inch obstruction in the switch point, six inches back from tip of point. It may be necessary at this time to "float" the lock rods to allow the switch machine's slide bar to travel full stroke to properly check the point detection settings. This is accomplished by loosening the hardware on the lock rod assembly and moving the lock rods so that the lock dog of the machine can enter the narrow notch.

8. With the obstruction placed in the switch point, the corresponding normal or reverse point detected LED should be RED. If not, repeat the serrated bracket adjustment procedure (Steps 1 through 4), moving the bracket only two serrations into the target instead of three.

9. If the machine has been equipped with the optional auxiliary sensors, their position is fixed and no adjustment is required.

2.10.3. Auxiliary Sensor Adjustment (Non-Vital)

NOTE

Auxiliary sensors are optional, non-vital sensors and are only supplied when required by the customer.

1. Place the switch machine in the Normal position (operating bar based on RH or LH configuration).

2. Move the point detector bar to the Normal position matching the machine.

3. Starting with the sensor holding bracket outside the target area (at the extreme position of the bracket mounting plate), slide the sensor holding bracket toward the target until the LED for Point Detected Normal just turns green on the ECC. This is the starting point for the Vital Sensor (18 mm).

4. Slide the sensor holding bracket two more serrations into the target corresponding to the 1/8" point movement differential (each serration is 1/16 inch on center) and hand tighten to prevent movement.

5. Slide the auxiliary sensor toward the target until the LED for Auxiliary Point Detected just turns green. After ensuring a gap of 0.040 inch between the target and sensor face, secure the hardware for the sensor. Tightness of the feeler gauge between the sensor head and the target is not critical.

6. For the Reserve position (operating bar out based on RH or LH configuration), repeat Steps 1 through 5 above. This time look at the LEDs that correspond to the Reverse Position on the ECC.

2.11. Lock Box Sensor Adjustment

The lock box sensors (see Figure 2–9) thread into a holder that bolts to the controller frame. To access to the lock sensors, the ECC must be removed from the frame.

1. Remove logic control power from the switch machine.

2. Remove the ECC from the controller frame (refer to paragraph 5.4.4).

3. Move the switch machine to either full-stroke position (Normal or Reverse, it is not critical). Ensure that the switch point is closed and up against the stock rail.

4. One of the lock box sensors will be aligned with its target on the lock box. Loosen the sensor lock nut and adjust the sensor position to obtain a gap between the sensor and its target of 0.075 inch. Retighten the lock nut to hold the sensor in position.

5. Move the switch machine to the opposite full stroke position. Ensure that the switch point is closed and up against the stock rail.

6. The other lock box sensor will be aligned with its target on the lock box. Loosen the sensor lock nut and adjust the sensor position to obtain a gap between the sensor and its target of 0.075 inch. Retighten the lock nut to hold the sensor in position.

7. Reinstall the ECC onto the controller frame (refer to Section 5.5.6).

8. Restore logic control power to the switch machine.

9. Verify that the Point Locked LED (for the current switch position) is LIT.

10. Move the switch machine to the opposite position and verify that the Point Locked LED (for the current switch position) is LIT.

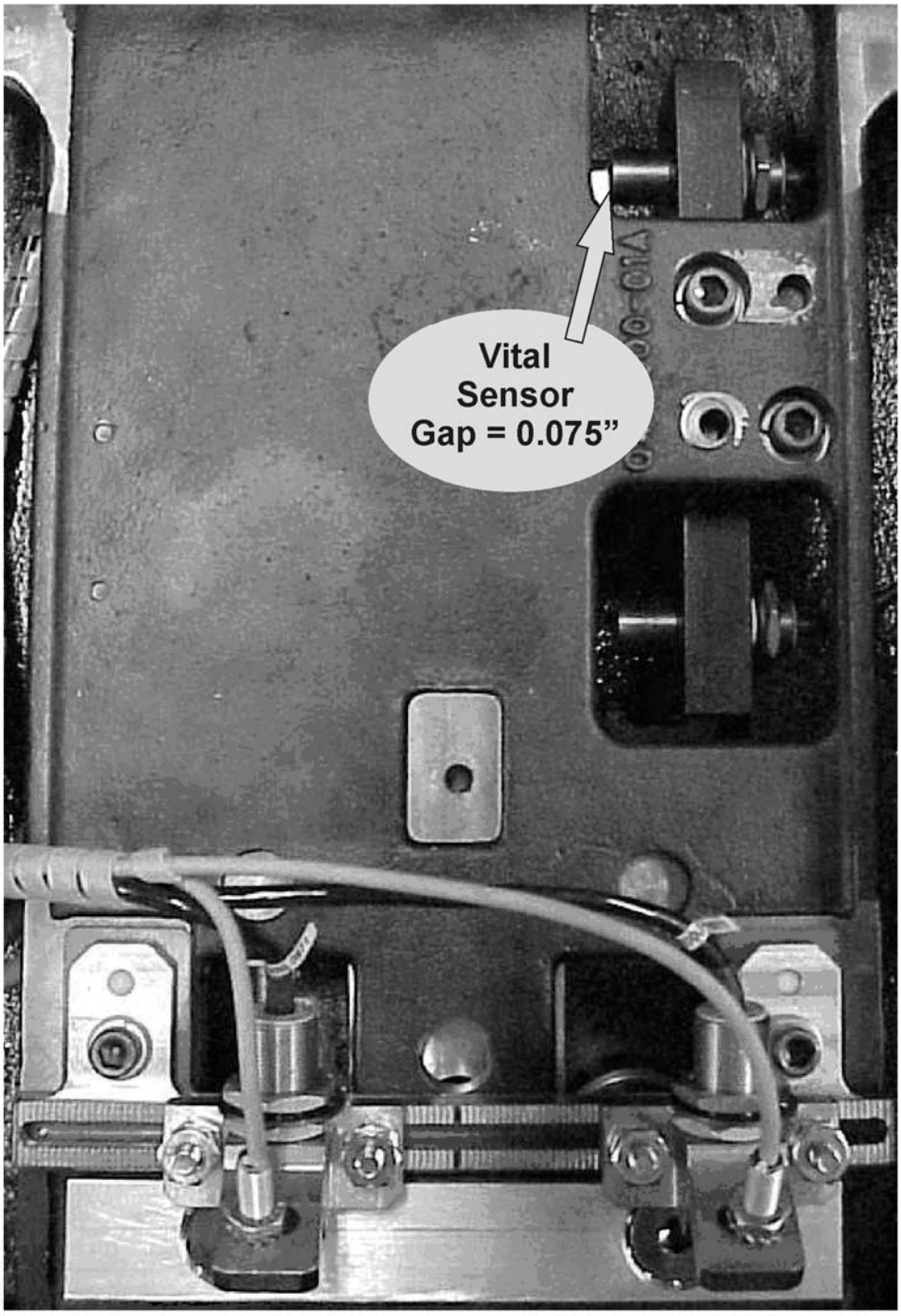


Figure 2–9. Lock Box Sensors

2.12. Lever Stand Adjustment

(For M-23 machines only.) Make final check of adjustment of lever stands to assure that their adjustment permits transfer from power to hand operation under all conditions, as follows:

1. Remove the gearbox cover so that the action of the selector clutch (see Figure 3-8) and its relation to the hand-throw pinion can be observed as the selector lever is operated from MOTOR to HAND position.

2. With the hand-throw lever in Normal, operate the machine by power to Reverse, and then back to Normal. Operate the selector lever to HAND. Check that selector clutch shifts up engaging the tooth on the bottom of the hand-throw pinion, and check that the hand-throw lever will operate the machine. If the selector clutch fails to shift up full-stroke, readjust the height of the Reverse hand-throw lever stand to bring the clutch teeth into proper alignment.

3. (Repeat step (2) for opposite end of stroke.) With the hand-throw lever in Reverse, operate the machine by power to Normal, then back to Reverse. Operate the selector lever to the HAND position. Check that selector clutch shifts up engaging the tooth on the bottom of the hand-throw pinion, and check that the hand-throw lever will operate the machine. If the selector clutch fails to shift up full-stroke, readjust the height of the Reverse hand-throw lever stand to bring the clutch teeth into proper alignment.

4. With the hand-throw lever in Normal, operate the machine by power to Reverse. Operate the selector lever to HAND. The selector clutch should ride against, but not engage, the hand-throw pinion tooth. The selector clutch spring should be compressed, taking up the clearance between the upper and lower spring cups. Now operate the hand-throw lever toward Reverse. The selector clutch should snap up into engagement with the hand-throw pinion just before the hand-throw lever is fully down in the Reverse lever stand. Check that the hand-throw lever will now operate the machine.

5. (Repeat step (4) for opposite end of stroke.) With the hand-throw lever in Reverse position, operate the machine by power to Normal. Operate the selector lever to HAND. The selector clutch should ride against, but not engage, the hand-throw pinion tooth. The selector clutch spring should be compressed, taking up the clearance between the upper and lower spring cups. Now operate the hand-throw lever toward Normal. The selector clutch should snap up into engagement with the hand-throw pinion just before the hand-throw lever is fully down in the Normal lever stand. Check that the hand-throw lever will now operate the machine.

2.13. Initial Lubrication

It is highly recommended that the switch machine be completely lubricated upon installation, prior to being placed into service. Refer to Section 5.6 for all recommended lubricants and locations to be lubricated.

As a ***minimum***, apply a light coat of gear lubricant (Lubriplate 5555 from the container shipped with the switch machine) to the teeth of the spur gear only. Put the remainder of the lubricant into the worm gear compartment to a level no higher than the top of the worm gear. See the lubrication diagrams in Figure 5-6 and Figure 5-7. All other working parts of the machine have been sufficiently lubricated at the factory and do not require additional lubrication at this point.

NOTE

When applying lubricant, it is not necessary to remove oil slushing compound with which parts are factory coated to protection against corrosion during shipment and storage.

The pins holding the lock rod control rod, point detector, control rod, and operating rod should also be lubricated at this time.

2.14. Lever Position and Interlock

In general, the position of the selector and hand-throw levers will be as shown in Figure 2-10, and the interlock will ordinarily permit the selector lever to be returned to MOTOR when the hand-throw lever is in either Normal or Reverse. However, certain deviations from these usual standards are feasible. The various arrangements are as follows:

1. Both levers must always be on the field side of the machine, that is, on the left side for LH machine for LH layout and on the right side for RH machine for RH layout. To change between RH and LH, refer to paragraph 5.5.2.

2. The hand-throw lever will always move the switch in the direction to close the near point when the lever is operated toward the motor end of the machine. This characteristic cannot be changed.

3. For the standard arrangement, the selector lever will be assembled to be toward the motor end of the machine when the lever is in its MOTOR position as shown in Figure 2-10. When desired, however, the lever can readily be assembled to be toward the circuit controller end of the machine for MOTOR position and the interlock arranged to suit, as described under “Assembly.” The cast MOTOR and HAND marker plates on the selector lever are interchangeable.

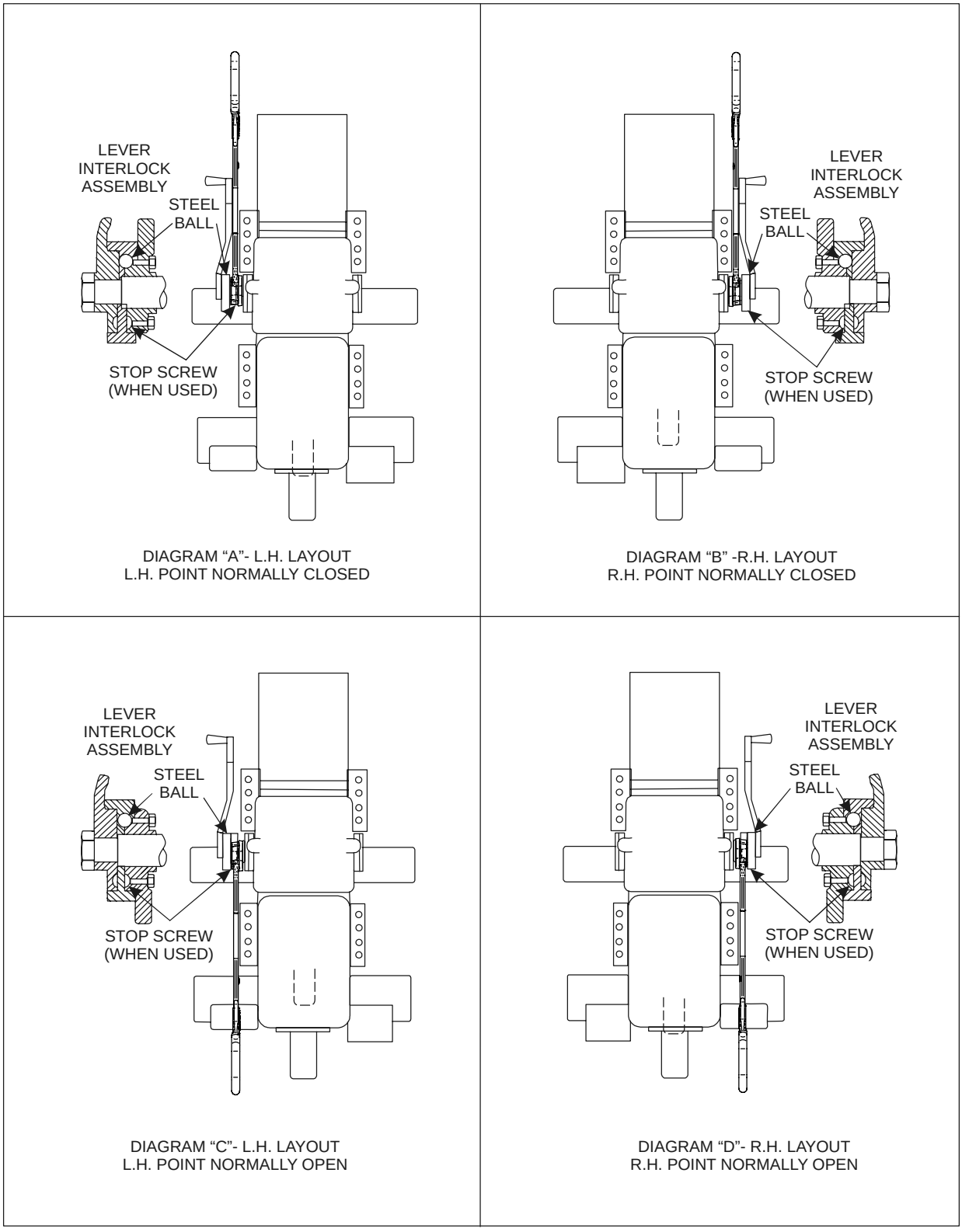


Figure 2-10. Standard Lever Interlock Assemblies (M-23)

4. The lever interlock can be arranged to either (1) allow the selector lever to be returned to MOTOR position when the hand-throw lever is in the Normal or the Reverse position, or (2) require the hand-throw lever to be in Normal position only before a selector lever can be returned to MOTOR position. Machines are shipped with option (1) assembly unless the order specifies that the hand-throw lever must be Normal only.

2.15. Three- and Five-Wire Conversion to Two-Wire Control

All ECC machines use two-wire control. Conversion from five- to two-wire control is best suited for changes implemented at the wayside house or bungalow. Conversion from three- to two-wire control can be performed either at the wayside location or within the switch machine by connecting two of the three wires together. Figure 2-11 shows typical three- and five-wire relay control systems converted to the two-wire system.

2.16. Conversion between Right-Hand and Left-Hand Operation

2.16.1. Conversion of Gearbox

NOTE

Although this procedure can be done in the field, ASTS USA recommends it be done in the shop.

2.16.1.1. Disassembly

See Figure 2-12, Figure 2-13, and Figure 2-14.

1. Remove the two 5/8 inch bolts securing the gearbox cover to the gearbox. Lift the cover; retain the cover to use as a receptacle for the parts which will be removed.

2. Place the hand-throw lever in Normal and the selector lever in Motor. The machine must be in its full stroke position. Insert a 1/2 inch drive into the adjusting nut on the friction clutch assembly (R) and turn it to drive the mechanism to its complete full stop (Figure 2-12).

3. Remove the four 1/2 inch bolts (A1) and lock washers securing the top bearing (C). (One of these bolts will be 3/4 inch longer than the others.)

4. Remove the cotter pin at the top of the main crank. Remove the 1/2 inch castle nut (B1) and washer (B2) from the top of the main crank. Lift the top bearing (C) from the dowel pins, being careful not to bend the bearing plate.

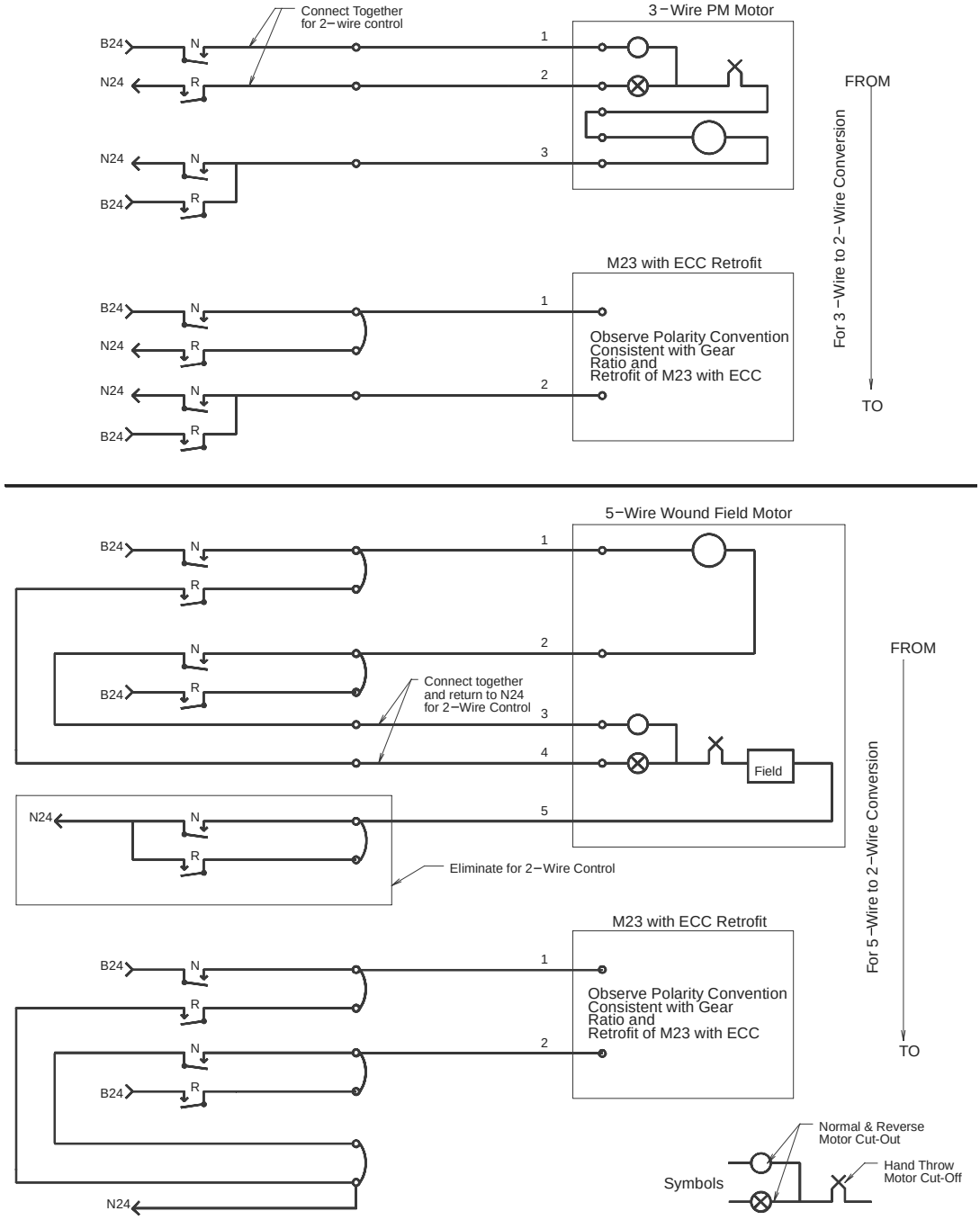


Figure 2-11. Wiring Changes from Three- or Five-Wire to Two-Wire Control

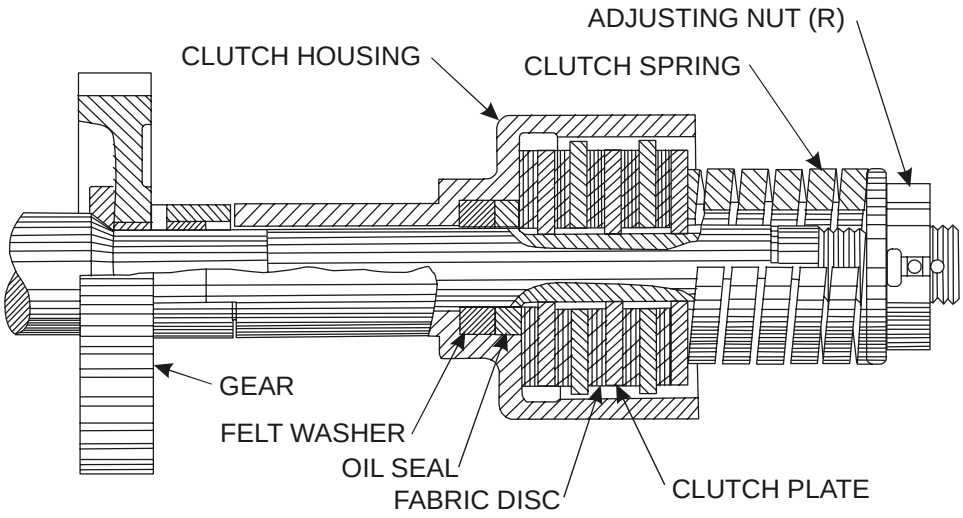


Figure 2-12. Friction Clutch Assembly

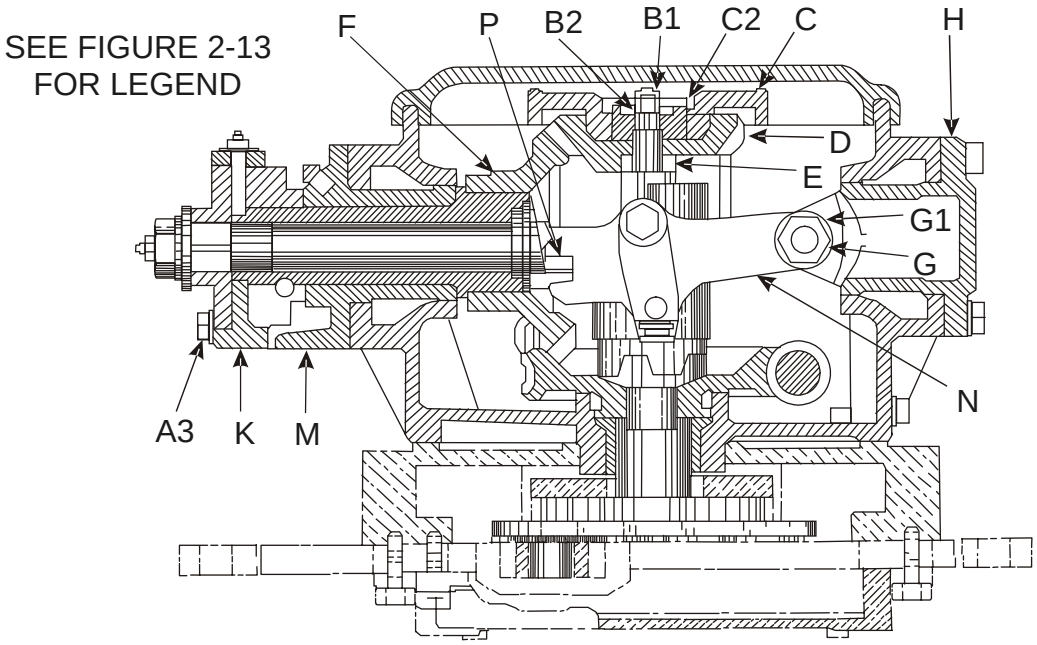


Figure 2-13. Sectional View of M23 Gearbox – From Motor End (Right-Hand Assembly Shown)

LEGEND
FOR FIGURES
2-13 & 2-14

A1 - BOLT
A2 - BOLT
A3 - BOLT
A4 - BOLT
B1 - NUT
B2 - WASHER
C - BEARING
C1 - KEY
C2 - BEARING BUSHING
D - PINION
E - COLLAR
F - GEAR
F1 - SET SCREW
G - BOLT
G1 - YOKE BUSHING
H - YOKE SUPPORT
K - LEVER SUPPORT
M - BEARING
N - YOKE
P - PIN
R - FRICTION CLUTCH

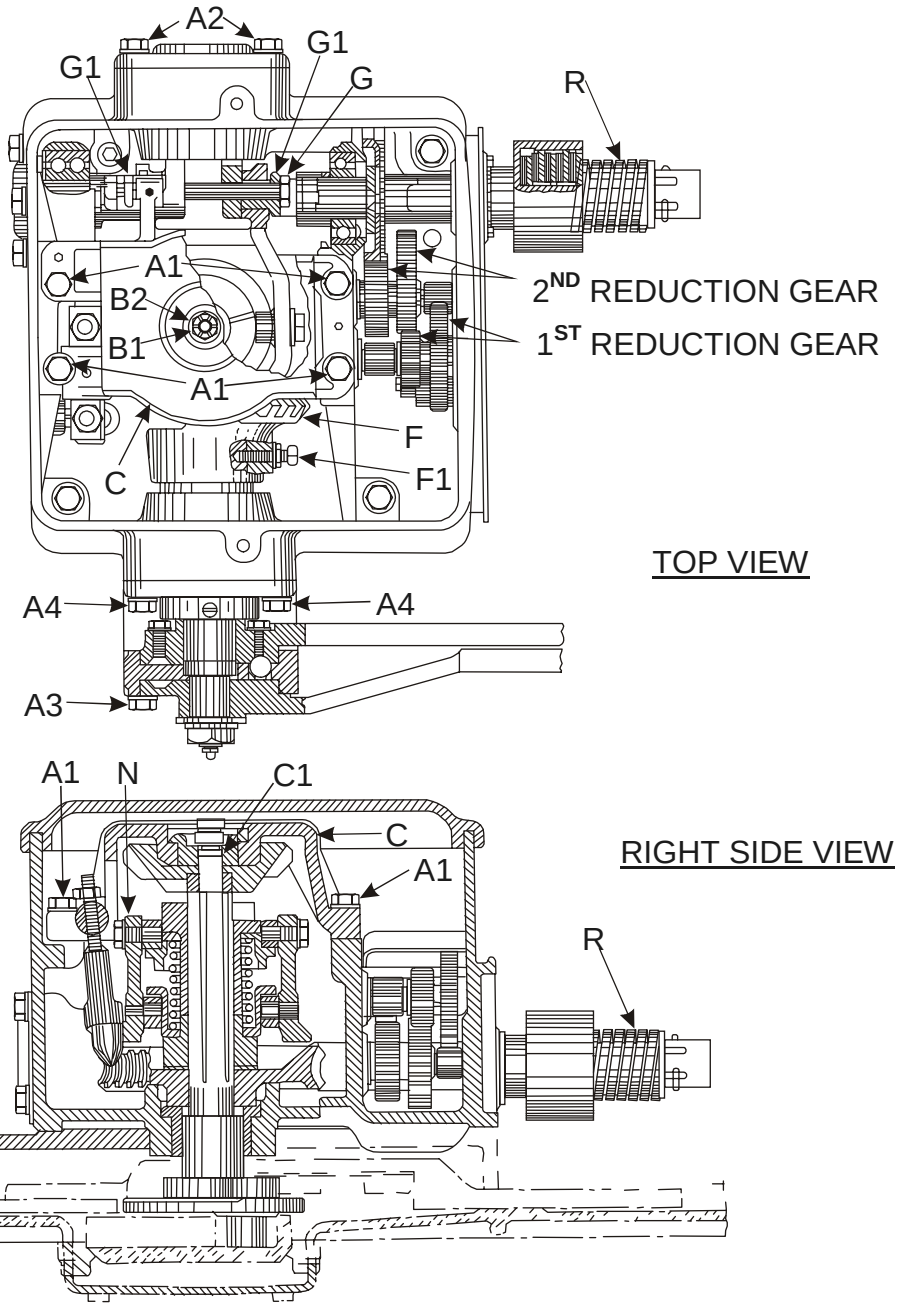


Figure 2-14. Sectional View of Gearbox

NOTE

The rectangular key (C1) may come out with the top bearing. Check under the top bearing to see if the key has been removed and, if so, place the key in a safe spot for reinstallation.

5. Remove the rectangular key (C1) from the top bearing bushing (C2). Remove the top bearing bushing, hand-throw pinion (D), and spacing collar (E) from the top end of the crank.

6. Lift the hand-throw lever to the vertical position and loosen the set screw (F1) on the hand-throw bevel gear (F).

7. Remove the two 1/2 inch bolts (A3) and lock washers that secure the lever support (K) to the gearbox. Remove the two 1/2 inch bolts (A4) and washers that secure the lever shaft bearing (M) to the gearbox.

8. Holding the levers securely and guiding the shafts from the gearbox, carefully remove the lever assembly from the gearbox. Hold the hand throw bevel gear so that as the lever shafts are removed, the bevel gear doesn't fall onto the bottom of the gearbox.

CAUTION

Removal of the lever assembly requires two persons to perform the procedure; one to remove the lever assembly and one to hold the hand throw bevel gear and prevent it from falling into the gearbox as the lever assembly is removed.

NOTE

There is a paper gasket between the lever shaft bearing and the gearbox case. Check it after removal of the lever assembly. If it is torn, it must be replaced. If it is intact on one of the two mating surfaces, it may be reused.

9. Lift the hand-throw bevel gear (F) from the gearbox.

10. Remove the 1/2 inch bolt (G), nut, and two lock washers securing the yoke eccentric bushings (G1) to the yoke support (H). Note the positions of the eccentric bushings, and take care to avoid changing their position when removing the bolt.

11. Remove the four 1/2 inch bolts and lock washers securing the yoke support (H) to the gearbox. Remove the yoke support.

NOTE

There is a paper gasket between the lever shaft bearing and the gearbox case. Check it after removal of the lever assembly. If it is torn, it must be replaced. If it is intact on one of the two mating surfaces, it may be reused.

2.16.1.2. Reassembly

1. With the gearbox disassembled, grasp the yoke (N) firmly and, lifting upward, rotate the yoke 180º. Be sure that the yoke assembly seats firmly on the main shaft after it is moved.

2. Transfer the yoke support (H) to the other side of the gearbox. Insert it into the gearbox and secure it with four 1/2 inch bolts and lock washers. When inserting the yoke support into the gearbox, be careful not to disturb the position of the eccentric bushings.

NOTE

There is a paper gasket between the lever shaft bearing and the gearbox case. Check it after removal of the lever assembly. If it is torn, it must be replaced. If it is intact on one of the two mating surfaces, it may be reused.

3. Secure the yoke to the yoke support using the 1/2 inch bolt (G), nut, and two lock washers removed during disassembly.

4. Insert the lever assembly into the hub on the opposite side of the gearbox. As the shaft enters the gearbox, position the hand-throw bevel gear (F**)** so that the gear slides onto the keyed shaft. Position eccentric pin (P) on the selector shaft of the lever assembly so that it enters the slot on the end of the yoke. Ensure the gear is firmly seated on the shaft.

CAUTION

Insertion of the lever assembly requires two persons to perform the procedure; one to insert the lever assembly and one hold and guide the hand throw bevel gear onto the lever assembly shaft.

5. With the hand-throw lever vertical, and the bevel gear firmly seated against the lever shaft, tighten the set screw (F1) in the hand-throw bevel gear (F).

6. Secure the lever shaft bearing (M) to the gearbox with the two 1/2 inch bolts (A4) and washers removed during disassembly.

7. To ensure that the motor position of the selector lever is toward the motor end of the machine, the selector lever and lever interlock must be reassembled 180º from the original position on the shaft, as follows:

   a. Remove the 7/8” hex nut, lock washer, and flat washers from the end of the selector lever shaft and slide the selector lever and lever support (K) from the shaft. Be careful not to lose the steel ball in the lever support.

NOTE

If the stop screw is used in the hub instead of the hand-throw lever, it will be necessary to also remove this lever and interchange the stop screw and cap screw (refer to Figure 2-10). Replace the hand-throw lever and fasten it in place with the clamping bolt.

b. Reassemble the lever support (K) with the hole for the steel ball on the motor side of the shaft. Insert the steel ball and reassemble the selector lever on the shaft so that the lever is 180º from its original position. (The stop screw, if used, may require positioning the hand-throw lever to align the recess with the hole in the lever support so that the steel ball will not interfere when the selector lever is applied.)

c. Reinstall the hex nut and washers on the end of the shaft to hold the selector lever in place, then secure the lever support (K) with the two 1/2 inch bolts (A3) and lock washers removed during disassembly. These bolts also secure the bottom of the lever shaft bearing.

8. Move the selector lever to MOTOR (toward the motor end of the machine) and check to make sure that it moves the yoke (N) down.

9. Interchange the MOTOR and HAND nameplates on the selector lever to correspond with the new lever positions.

10. With the hand-throw lever vertical, place the collar (E) (with the chamfer down) on top of the main crank end. Install the hand-throw bevel pinion (D), engaging the tooth marked R (for right-hand assembly) or L (for left-hand assembly) with the punched marked master tooth space in the center of the hand-thrown bevel gear (F).

11. Carefully place the hand-throw lever in Normal. Be sure that the hand-throw bevel pinion (D) remains in the proper position relative to the hand-thrown bevel gear (F).

12. With the selector lever in Motor, rotate the friction clutch housing so that the motor clutch teeth are fully engaged.

13. Place the top bearing assembly (C) on the gearbox using the dowel pins as guides, and secure it with the four 1/2 inch bolts (A1) and lock washers removed during disassembly. (The motor cutout push rod should be held back to clear the adjusting rod until bearing is down).

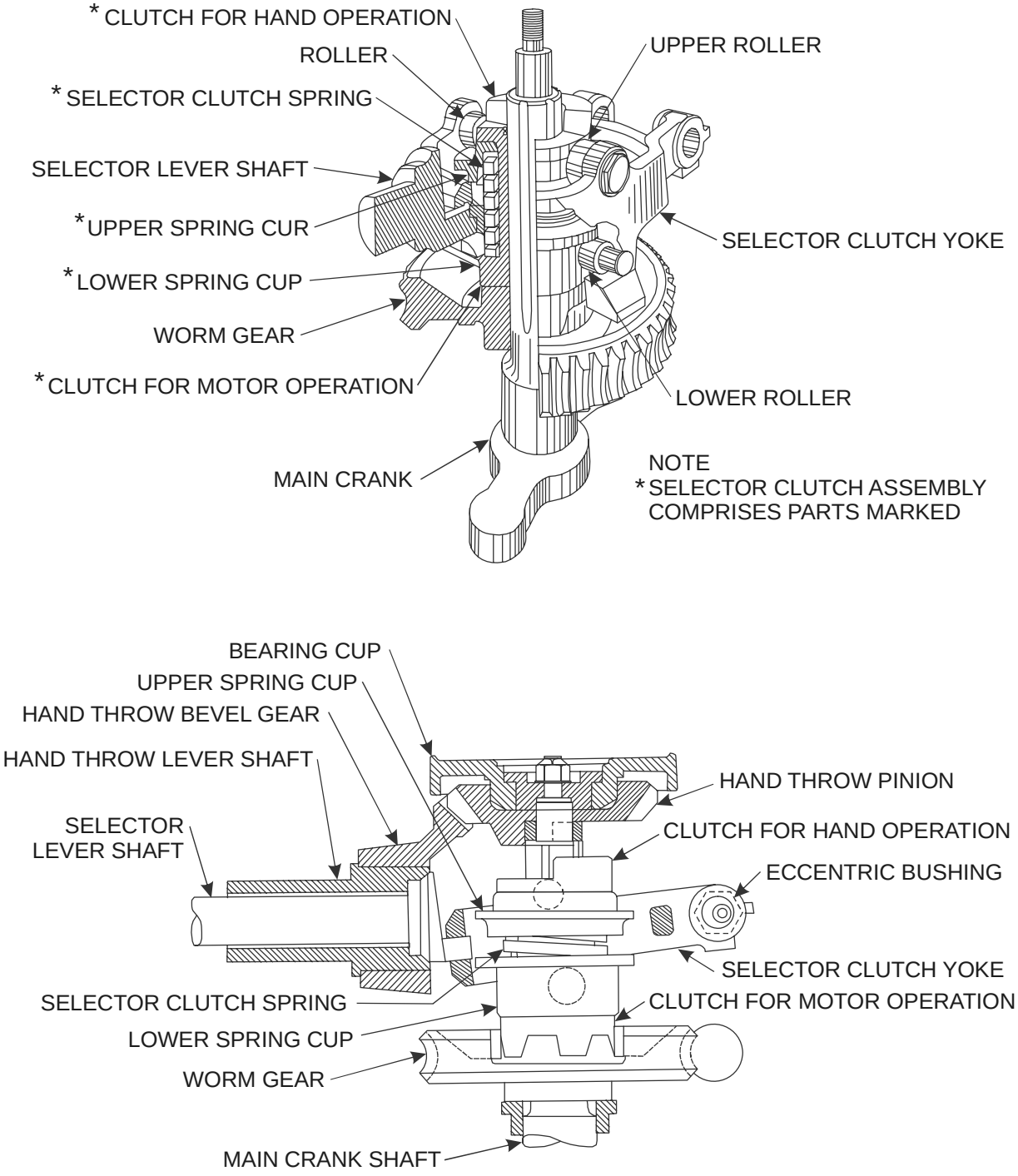


Figure 2-15. M-23 Dual Control Mechanism Sectional Views

14. Install the top bearing bushing (C2), rectangular key (C1), and washer (B2) on the top of the main crank. Tighten castle nut (B1) firmly, then back it off to the nearest cotter hole and insert a cotter pin after operating the machine manually with the hand throw lever to be sure that the mechanism does not bind. Flare the end of the cotter pin per standard installation practice.

15. Check the adjustment of the motor cutout push rod. Contacts should open when the end of the selector lever has been raised about six inches from the horizontal motor position.

16. Readjust both yoke eccentric bushings as described in Section 2.16.4, then secure it by tightening bolt (G) firmly.

17. Check that the machine can be operated by power and also that it shifts to hand-throw operation from both Normal and Reverse positions.

18. Check that all bolts are drawn down tightly on their lock washers and that all cotter pins are in place.

19. Reinstall the gearbox cover and secure it to the gearbox with the two 5/8 inch bolts removed during disassembly.

2.16.2. Lever Assembly

For removal and insertion of the lever assembly ASTS USA recommends that two persons perform the procedure; one to insert the lever assembly and one to hold and guide the hand throw bevel gear onto the lever assembly shaft. If only one person is available, ASTS USA recommends dismantling the lever assembly to move it to the other side of the gearbox.

2.16.2.1. Disassembly

1. Remove the 7/8 inch hex nut, lock washer, and flat washers from the end of the selector lever shaft and slide the selector lever from the shaft. Be careful not to lose the steel ball in the lever support.

2. Lift the hand-throw lever to the vertical position and loosen the set screw (F1) on the hand-throw bevel gear (F). Remove the hand throw lever from the lever shaft.

3. Remove the two 1/2 inch bolts (A3) and lock washers that secure the lever support (K) to the gearbox and slide the lever support from the shaft. It may be necessary to lift up on the yoke (N) to free the eccentric pin (P) on the selector shaft.

4. Remove the two 1/2 inch bolts (A4) and washers that secure the lever shaft bearing (M) to the gearbox.

5. Grasp the hand throw bevel gear and remove the shaft assembly from the gearbox case. The shaft will pull free of the bevel gear as it is pulled from the gearbox case. Be sure that the bevel gear does not fall into the case as the shaft is removed.

NOTE

There is a paper gasket between the lever shaft bearing and the gearbox case. Check it after removal of the lever assembly. If it is torn, it must be replaced. If it is intact on one of the two mating surfaces, it may be reused.

2.16.2.2. Reassembly

1. The lever assembly is to be installed on the opposite side of the gearbox case after the yoke support has been removed.

2. Place the bevel gear inside the gearbox case on the side where the lever shaft will be installed.

3. Insert the lever shaft into the opening on the gearbox case. As the shaft enters the case, position the bevel gear so that the shaft slides through the center of the bevel gear and that the keyways match. It may be necessary to lift the yoke a bit to facilitate the eccentric pin (P) on the lever shaft assembly entering the slot on the end of the yoke.

NOTE

There is a paper gasket between the lever shaft bearing and the gearbox case. Check it after removal of the lever assembly. If it is torn, it must be replaced. If it is intact on one of the two mating surfaces, it may be reused.

4. Secure the lever shaft bearing (M) to the gearbox case using the two 1/2 inch bolts (A4) removed during disassembly.

5. Put the hand throw lever on the lever shaft. The lever is keyed to the shaft and can be put on in either direction. Be sure it is positioned on the shaft so that it moves in the proper direction.

6. Slide the lever support (K) onto the lever shaft. Secure it to the gearbox case with the two 1/2 inch bolts (A3) and lock washers removed during disassembly.

7. Put the selector lever onto the lever shaft. The lever is keyed to the shaft and can be put on in either direction. Be sure it is positioned on the shaft so that it moves in the proper direction.

8. Secure the selector lever to the shaft with the 7/8 inch hex nut, lock washer, and flat washers removed during disassembly.

2.16.3. Operating Bar

1. Remove the two operating bar covers from either side of the switch machine by removing the 1/2 inch bolts and washers that secure it to the machine. These have to be installed on the other side of the switch machine when the lug is installed.

2. Remove the cotter pin, 7/8 inch nut, washer, and bolt that secure the operating bar lug to the operating bar.

3. Remove the operating bar lug and place it on the operating bar on the other side of the switch machine.

4. Secure the operating bar lug with the cotter pin, 7/8 inch nut, washer, and bolt removed in Step 2.

5. Install the operating bar covers on the sides of the switch machine. One of the covers is designed to fit over the operating bar lug and can only be installed over the lug. Secure the covers with the 1/2 inch bolts and washers removed in Step 1.

2.16.4. Selector Clutch Adjustment

The selector clutch adjustment should be checked annually. When the selector lever is in the Motor position and the selector clutch teeth are in full engagement with the teeth on top of the worm gear so the motor drives the crank, the top rollers on the operating yoke should be just clear of the upper spring cup.

This relation can be varied by adjusting the eccentric bushings (G1). As shown in Figure 2-13 and Figure 2-14, the selector clutch yoke has one end supported on and driven by the finger on the selector lever shaft, and its other end pivots on the eccentric bushings that are fixed by G. When this bolt is loosened, the eccentric bushings may be rotated to raise or lower the center line for the pivot holes in the yoke arms, affecting the elevation of the yoke rollers.

The eccentric bushings have hexagonal heads; one flat is stenciled (N) and the flats on either side of the (N) flat are marked (+) and (–). The (N) will be on top when the eccentric bearing is in its mean position. When the eccentric bushings are turned to bring the (+) mark up, the yoke and its rollers lift. Alternately when the (–) mark is up, the yoke and its rollers lower. To avoid twisting the yoke, these marks should be kept turned to a like degree (+) or (–).

Tightening bolt G holds the adjustment of the eccentric bearings. When it is necessary to adjust the eccentric bushings, check that the top rollers are free from the bearing on the upper spring cup while the selector clutch is fully down, and in addition, check that the rollers are not too high as follows:

1. Place the selector lever in the Motor position when the worm gear is not in position to receive the selector clutch, so that the teeth of “Clutch for Motor Operation,” (Figure 2-15), ride on top of the corresponding teeth of the worm gear.

2. Insert a 1/8 inch length of a #14 soft copper wire between the opposed teeth. The eccentric bushings should be adjusted the same degree (+) or (–) so that (with the bolt tight) the force between the opposed teeth will crush the wire to not more than 1/32 inch thick when the selector lever is thrown to the horizontal position for motor operation.

3. Check that the upper rollers are free to turn when the selector clutch is fully engaged with the worm gear.

2.16.5. Jumper Configuration Changeover

When the switch machine is converted from right to left-hand operation, the red RHPC/LHPC jumper has to be inserted in the proper location in the junction box. (Refer to Section 2.5.3 for this procedure.)

2.16.6. Inverting the Lock Box

The lock box dogs must enter the narrow notches of the lock rod before reaching the wide notch. In some cases it may be necessary to invert the lock box to obtain this condition. When necessary to invert the lock box, remove the lock rods and proceed as follows (see Figure 3-7):

Place the machine in the end-stroke position, which brings lock box G nearest the motor. Unscrew bolts T that hold the ECC to the case. Swing the controller upward, pivoting it about the edge of the case adjacent the wire conduit. Turn lock box G upside-down, taking care that it is reinstalled properly on the driving studs of the slide bar. Reinstall the ECC and fasten the circuit controller in place with bolts T.

2.17. Prior to Placing Machine In Operation

1. Check lids for proper fit. Adjust if necessary.

2. Check motor cutout to be certain it is operating properly. Be sure that the crank cannot be inserted without the cutout contacts being latched out (M3 machine). Adjust if necessary per Section 5.7.1 and Section 5.7.2.

3. Check wiring for proper connections.

4. Check the clutch adjustment.

With an obstruction of at least 3/8 inch between the switch point and the stock rail, electrically operate the machine. When the switch point jams against the obstruction, the worm gear and worm shaft will be stopped but the motor should continue to run during the overload time delay period, slipping the friction clutch. Motor current during this period should be within 10% of the values specified in Table 5-1, in paragraph 5.5.5.3. If necessary, readjust the friction clutch spring to obtain the specified clutch slip current (refer to paragraph 5.5.5.3).

NOTE

If the friction clutch slips too easily, the motor current may not operate the overload relay and battery exhaustion might follow. If the friction clutch adjustment is too tight, unnecessary wear on mechanical parts may occur due to absence of shock protection. In normal operation without obstruction of the switch points, the clutch might slip slightly at both ends of the power stroke.

3. OPERATION

3.1. Switch-Operating and Locking Mechanism

The main crank drives both the switch-operating bar and the slide bar. The slide bar carries the lock box with its locking dogs (which enter notches in the lock rods when the switch points are in proper position). Assuming the machine to be at one end of its stroke, operation to the opposite end of the stroke involves rotation of the main crank by the motor or by the hand crank (M-3) or hand-throw lever (M-23).

As the main crank turns, it first shifts the slide bar so as to withdraw the locking dog from the lock rod notch before the switch points start to move, then the main crank holds the slide bar in the mid-position (both locking dogs clear of the lock rods) while driving the switch-operating bar full stroke to its opposite position, and finally the main crank holds the switch-operating bar while driving the slide bar to its full-stroke position engaging the top locking dog in the corresponding lock rod notch. Refer to Figure 3-1, Figure 3-2, and Figure 3-3 to understand how the crank imparts these motions.

Assuming that Figure 3-2A shows the Normal position, a reverse movement is started by a clockwise rotation of the main crank.

Lug 1 on the main crank, acting against roller 1 on the slide bar effects the unlocking of the lock rod by causing the slide bar to move to the left one-half of its stroke. Meanwhile, roller 4 on the underside of the main crank is moved through an arc of 40 degrees in the radial portion of the groove in the switch-operating bar, thus freeing the bar for the reverse stroke. During the next 140 degrees of rotation of the main crank, roller 4 engages the straight (reverse) operating face of the groove in the switch-operating bar and moves the bar to the reverse position.

Figure 3-2B shows the relative mid-stroke positions of the switch-operating bar and the slide bar; with the main crank still rotating clockwise but not transmitting motion to the slide bar as lug 1 has become disengaged from roller 1. The surfaces of the slide bar are radial to the center of the shaft and prevent the slide bar from moving.

The full reverse position is shown by Figure 3-2C. Roller 4 on the main crank, acting in the groove, has moved the switch-operating bar to the reverse position and secured it against back thrust; lug 2 has come into contact with roller 2 during the last 40 degrees of rotation of the main crank, thus driving the slide bar to its full reverse position.

The lock box rests on and is operated from an extension of the slide bar as shown in Figure 3-2. During the first 40 degrees of rotation of the main crank, the motion of the slide bar withdraws the lower locking dog of the lock box from the lower notch of the lock rod, thus unlocking the switch points. The following 140 degrees of rotation of the crank operates the switch, and the lock rod stops with its upper notch aligned to receive the upper locking dog of the lock box. The final 40 degrees of rotation of the crank completes the stroke of the slide bar, driving the upper locking dog into the lock rod notch to lock the switch points in the reverse position.

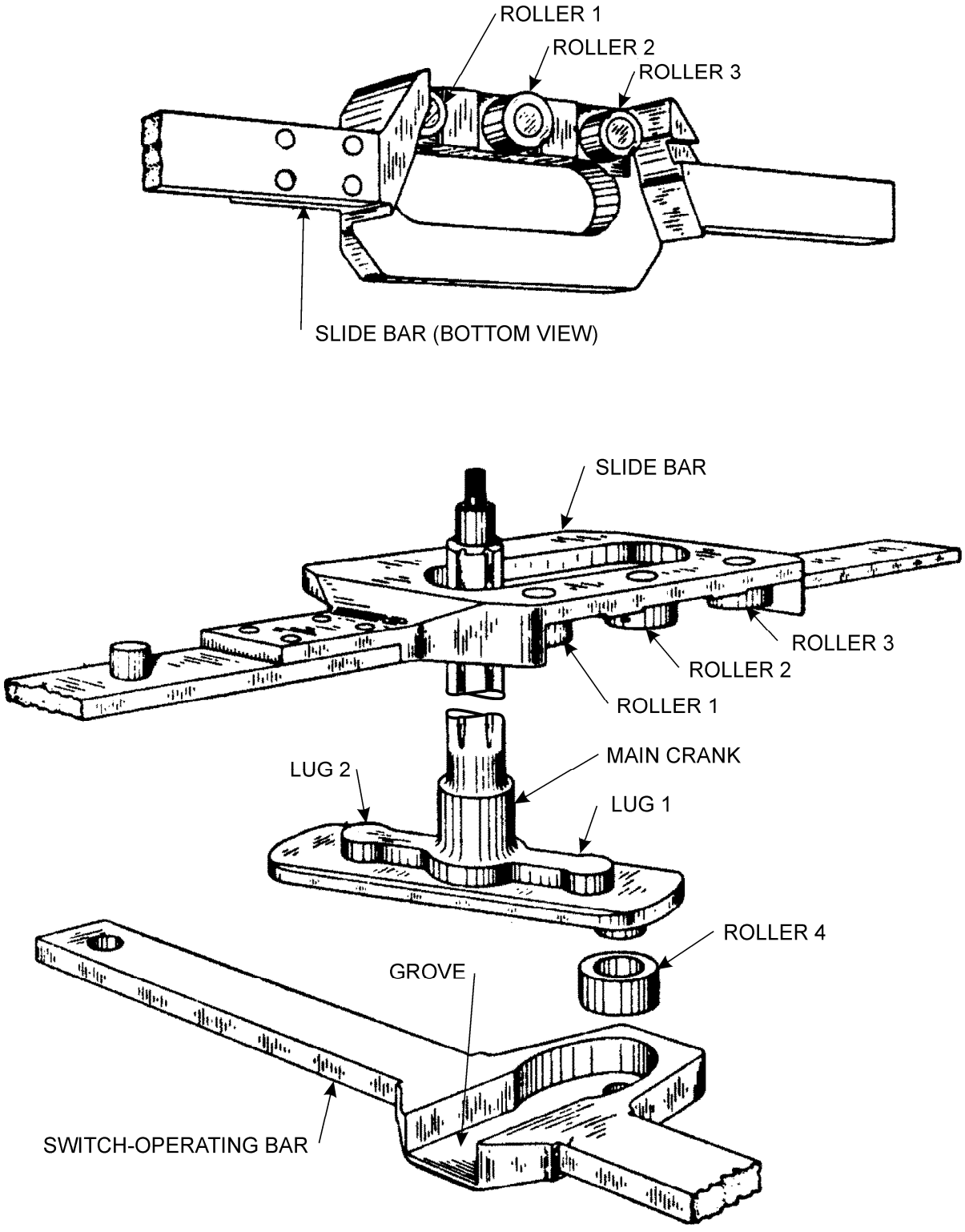
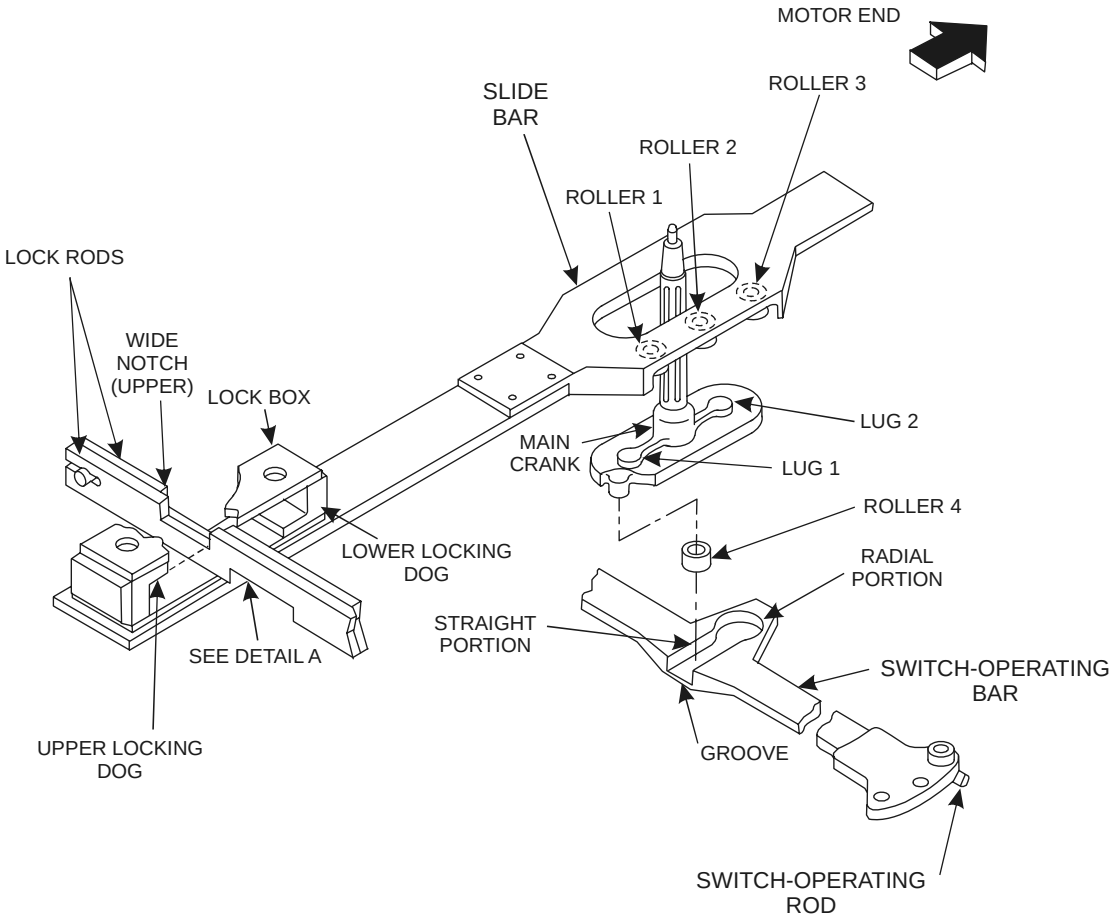
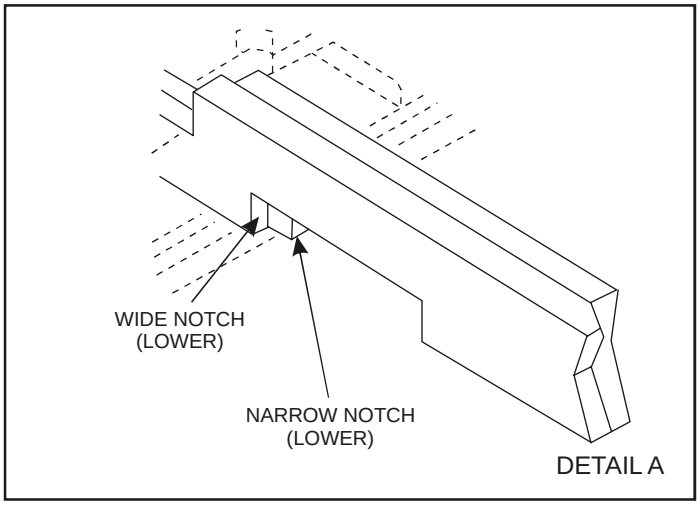


Figure 3-1. Diagram of Switch-Operating Mechanism





NOTE:
DIRECTION OF MOVEMENTS SHOWN ARE FOR A LEFT-HAND SWITCH MACHINE. THE DIRECTION OF MOVEMENTS ARE REVERSED FOR A RIGHT-HAND MACHINE. THE SLIDE BAR AND OPERATING BAR STROKE TIMING RELATIONSHIPS REMAIN THE SAME.

6A2.0052.00

Figure 3-2. Diagram of Driving Parts (Sheet 1 of 2)

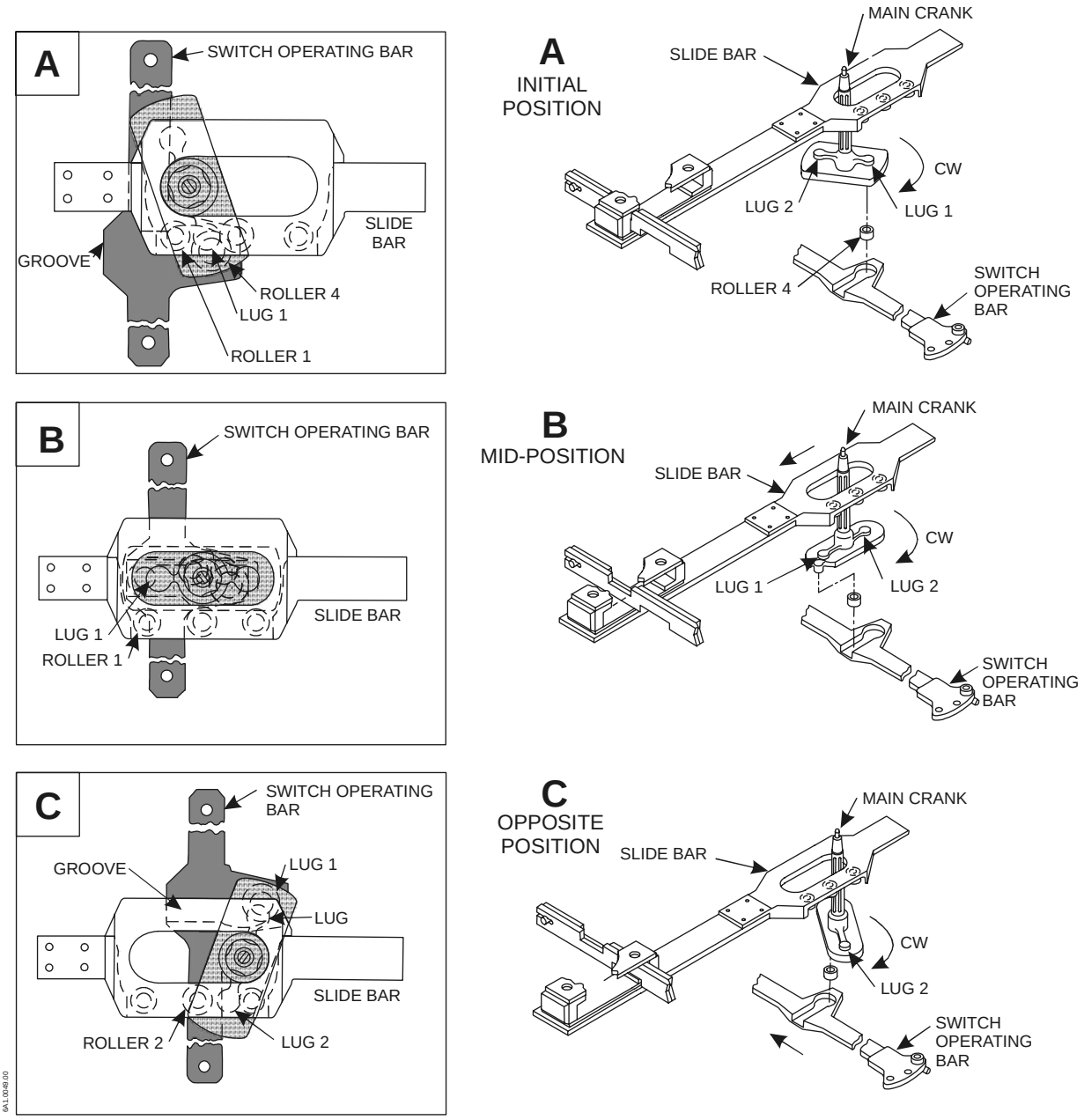


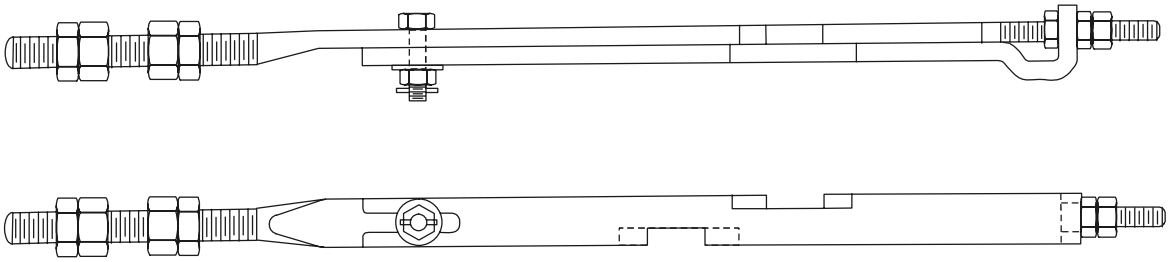
Figure 3-3. Diagram of Driving Parts (Sheet 2 of 2)

3.2. Switch Point Locking

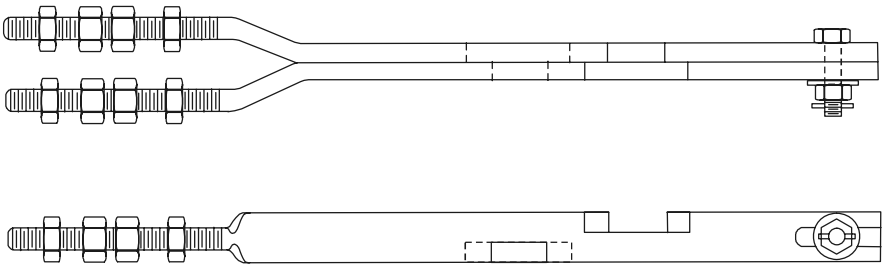
The lock rods in Figure 3-4 are comprised of two rectangular rods side-by-side. Each has a narrow notch only slightly wider than the locking dogs, this narrow notch in one rod being on top

and in the other rod on the bottom. To allow for variations in switch throw, the two rods are adjustable longitudinally with respect to each other, and each has a wide notch located alongside the narrow notch of the other. As the notch is on top of the lock rods for one position of the switch and on the bottom for the other position, and as the lock box likewise has one dog on top and the other on the bottom, it follows that the slide bar with its lock box can complete its stroke only if the lock rods are shifted by the switch points to the position corresponding to proper point closure. When the stroke is completed, the switch is secured by the locking.

The stroke of the slide bar and its lock box is such that the locking dogs provide adequate interlock with only the lock rod that the dog enters first. Therefore, the lock box and the lock rods must be so assembled that the dogs will enter the narrow notches first. The procedure for inverting the lock box (when necessary) is given in paragraph 2.16.6.



(A) TYPE GENERALLY USED WITH BALL AND SOCKET CONNECTION



(B) TYPE USED WITH RIGID CONNECTION

Figure 3-4. Adjustable Lock Rods for RH and LH Operation

3.3. Gear Train

The reduction gear train between the motor and the worm gear comprises a pinion on the end of the motor shaft, one or two reduction gears, clutch gear, friction clutch, worm shaft and worm gear (see Figure 3-5 and Figure 3-6). Note that each reduction gear actually comprises two

gears, a large gear and a small gear, made as a unit. The gear ratio is changed by changing out the reduction gears, using the combination indicated in the accompanying tabulation.

Table 3-1. Gear Ratio – Reduction Gear Relationship

Switch Machine M-3, M-23A, or M-23B		110 VDC	110 VDC	20 VDC	20 VDC
Nominal Speed*		4.5 sec.	8 sec.	15 sec.	26 sec.
Gear Ratio		189:1	360:1	360:1	528:1
Number of Teeth Clutch Gear		43	43	43	43
1st Reduction (Figure 3-5)	Gear	– –	32	32	32
	Pinion	– –	16	16	12
2nd Reduction (Figure 3-5)	Gear	– –	41	41	45
	Pinion	– –	22	22	22
Motor Pinion		12	12	12	12

* See Operating Characteristics, Paragraph 1.3.

The pinion end of the motor is supported in an opening in the gear box which locates the pinion properly relative to the other gear centers. The motor can be removed by taking out the two bolts in the motor bracket at the commutator end. (For detail information on the motor, see Section 3.6.)

The reduction gears are assembled on shafts supported in Oilite bearings. The shafts are held in place endwise by the shaft end plate which is slotted to fit over a neck in each shaft. To remove these shafts to change out the reduction gears, it is necessary to first shift the motor out of the way (see previous paragraph).

The clutch gear, which is the final spur gear, has an Oilite bushing to support it on the worm shaft. This gear is connected to the worm shaft through the friction clutch.

The worm shaft meshes with the worm gear on the main crankshaft and is supported at the end adjacent to the controller by a double-row ball bearing that takes both radial load and end thrust. It also is supported by a single-row ball bearing in the wall between the worm gear compartment and the spur gear compartment. Both ball bearings are lubricated by the worm gear lubricant. A cap on the outside seals the outer side of the double-row ball bearing, and an oil seal pressed into the opening is provided on the spur gear side of the single-row ball bearing.

LEGEND

FOR FIGS. 3-5 & 3-6

A1 - BOLT
A2 - BOLT
A3 - BOLT
A4 - BOLT
B1 - NUT
B2 - WASHER
C - BEARING
C1 - KEY
C2 - BEARING BUSHING
D - PINION
E - COLLAR
F - GEAR
F1 - SET SCREW
G - BOLT
G1 - YOKE BUSHING
H - YOKE SUPPORT
K - LEVER SUPPORT
M - BEARING
N - YOKE
P - PIN
R - FRICTION CLUTCH

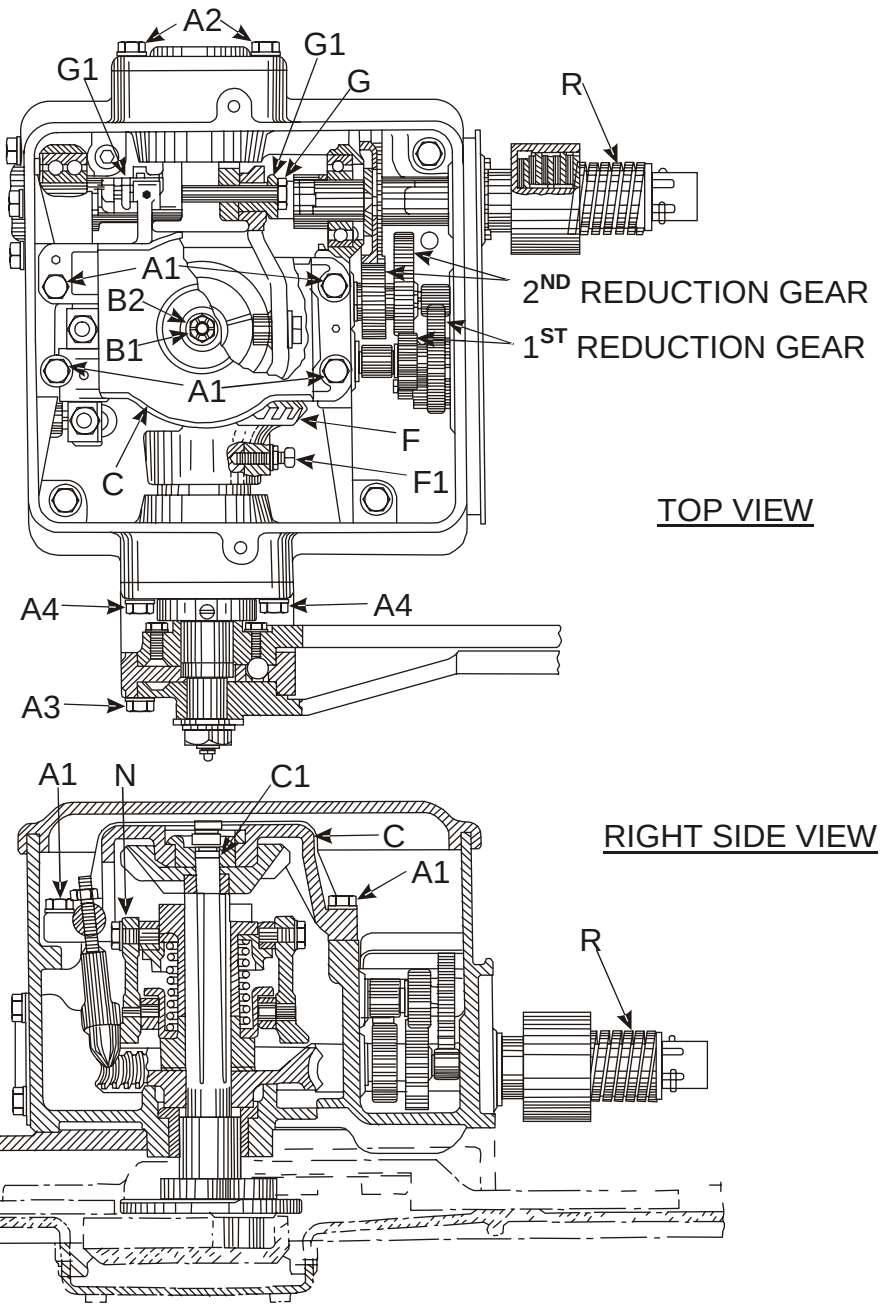


Figure 3-5. Sectional View of M-23A Gearbox

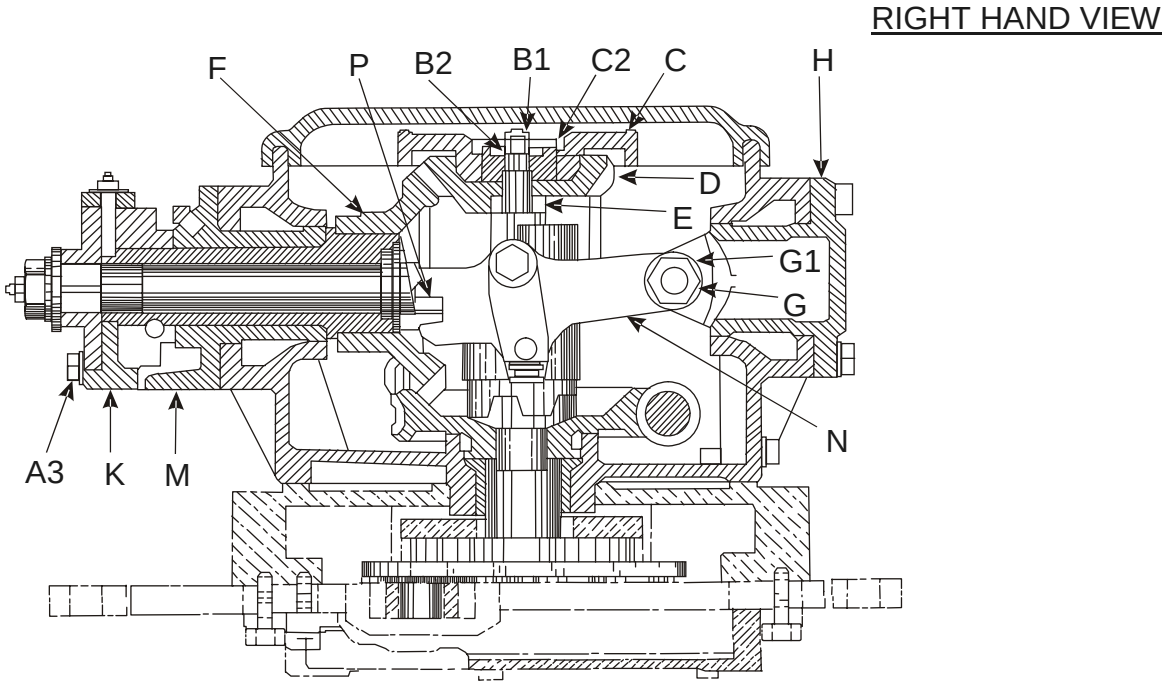


Figure 3-6. Sectional View of M-23A Gearbox, Looking from Motor End

The friction clutch housing has a tubular neck supported in an Oilite bushing pressed into the gearbox bore. The inside diameter provides slight clearance for the worm shaft. The housing has a felt washer and an oil seal to prevent seepage of oil into the friction clutch. The worm shaft is grooved and the housing has ribs to drive alternate friction discs that are compressed by the action of the heavy coil spring. This spring force is contained between the adjusting nut and Oilite thrust plate supported on the tapered shoulder on the worm shaft.

Note that the clutch gear hub has a three-finger engagement with the clutch housing tubular neck, so that the clutch housing is driven by the motor. Drive between the clutch housing and the worm shaft is through the friction discs.

3.4. Operation By Hand Crank – (M-3 Only)

Provision is made in the M-3 switch machine for hand operation by inserting a removable hand crank through the hand hole in the gearbox cover. Motor cutout contacts O (see Figure 3-7) are operated by means of a linkage to open the motor circuit (and in some cases to open a control circuit) when the hasp for the hand hole cover is released, and the crank inserted. Latch G, which can be removed if not desired, serves to hold the motor cutout contacts latched out until reset manually – a useful feature when someone other than the signal maintainer is authorized to use the hand crank.

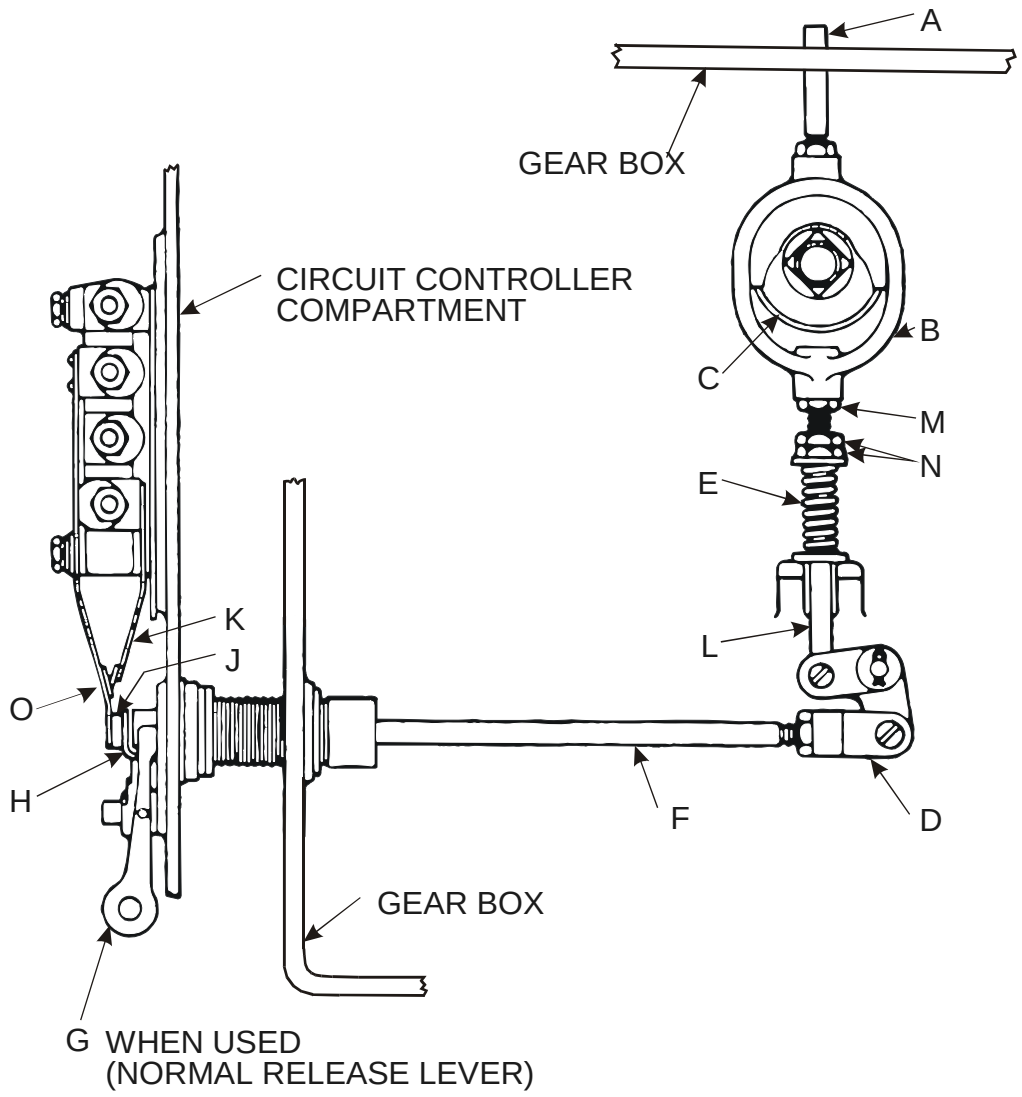


Figure 3-7. M-3 Motor Cutout Mechanism

WARNING

In certain cases, particularly on transit properties, the clearance is such that if the hand crank is left in the machine it could come in contact with the vehicle collector shoe, causing a hazardous condition. Do not permit traffic through the switch with the hand crank left in the M-3 switch machine, otherwise property damage may result. Always remove the hand crank when not in use.

3.5. Dual-Control Mechanism (M-23)

Switch operation, switch locking, and circuit controller operation are all performed by the vertical main crank in the gear compartment shown in Figure 3-8. This crank is always engaged with either (a) the motor, through the reduction gear train and its friction clutch, or (b) the hand-throw lever, through the hand-throw pinion. The selector clutch slides along splines on the shaft of the main crank and is shifted up or down by the selector lever. To permit the selector lever stroke to be completed even though the top tooth of the selector clutch may not be in alignment with the tooth space in the hand-throw pinion hub when shifting from motor position (shown) to hand-throw position, connection between the selector lever and the selector clutch is made through a coil spring mounted on the selector clutch.

NOTE

The top tooth is shown in alignment with the tooth space in the hub of the hand-throw pinion because the switch and the hand-throw lever are both in Normal position. There may be times when the switch is blocked mid-stroke by an obstruction so that the main crank will not be in Normal position, and of course, if the last motor operation left the switch in the reverse position, the teeth likewise are not aligned.

The selector clutch snaps into engagement with the hand-throw pinion when the hand-throw lever is operated to a position corresponding with the switch position. This spring connection acts similarly when returning the selector lever to the motor position; however, in this case it is the motor that must be operated to align the worm gear hub teeth to receive the selector clutch teeth. The main crank remains engaged with its original connected driving elements until it is engaged with the other elements. The clutch overall height is such that the top tooth must engage the hand throw gear before the bottom teeth can disengage from the worm gear, or vice versa. Thus the main crank is never “floating,” but is engaged with either the motor or the hand throw lever at all times.

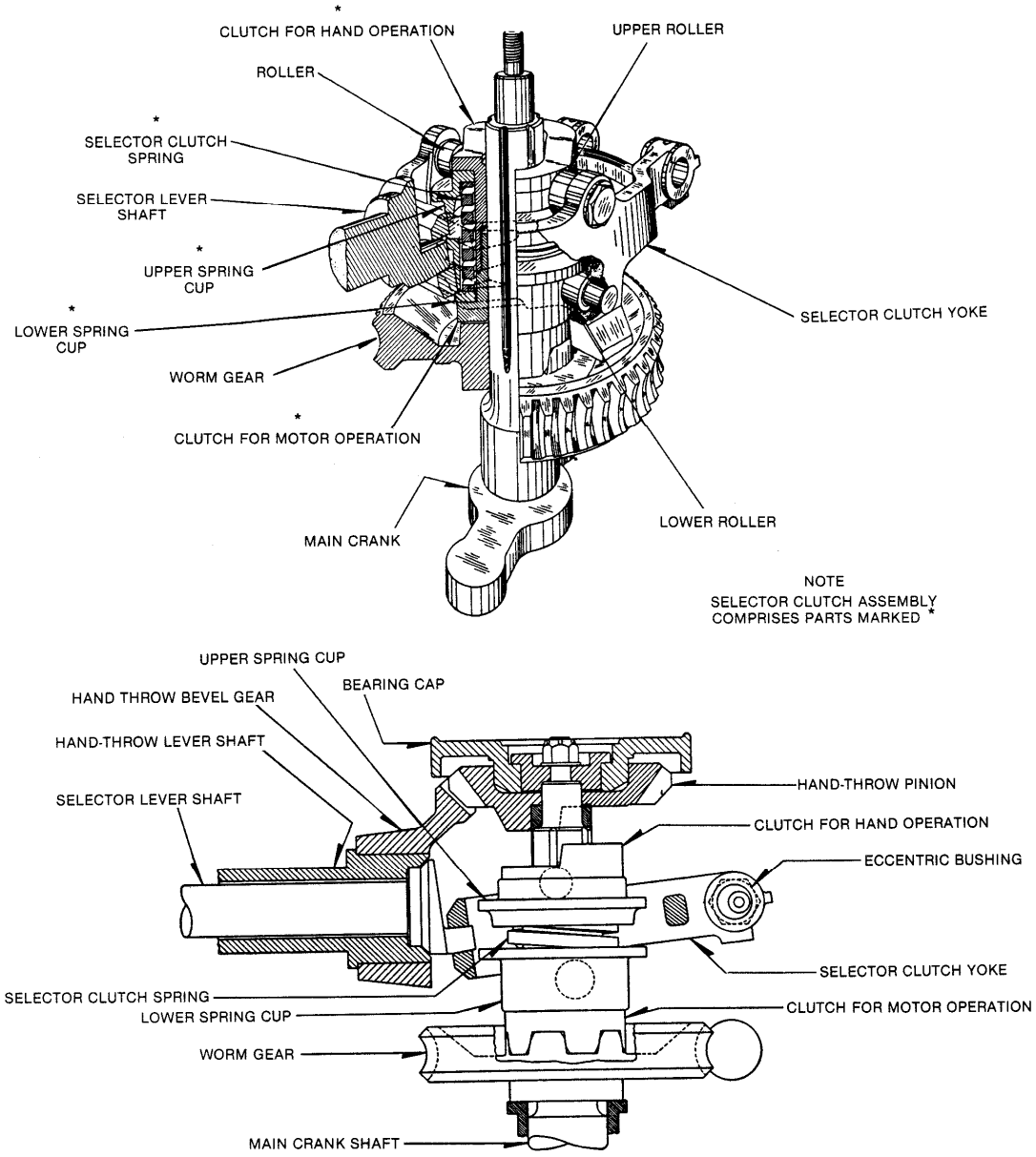


Figure 3-8. Sectional Views of M-23 Dual-Control Mechanism

NOTE

In as much as the switch operating mechanism may remain in engagement with the motor rather than with the hand-throw lever when the selector is operated to the Hand position, it is necessary to actually operate the switch by the hand-throw lever to assure that the machine is in the hand operation position.

3.5.1. Operation By Selector Lever

The selector clutch assembly is shifted up or down by 180 degrees of rotation of the selector lever, the inner crank finger of which swings the selector clutch yoke up or down. This yoke has rollers on each side engaging the upper and lower spring cups of the selector clutch assembly.

The selector clutch assembly (see Figure 3-8) has a spool-shaped core made in two parts which are screwed together and are held from becoming unscrewed in service by the splines in both portions. The upper part, or "clutch for hand operation," has a single tooth on top for engaging the hand-throw pinion, which requires strict agreement of the hand-throw lever position with the position of the switch when engaged. The lower part has five teeth for engagement with the worm gear. The upper and lower parts are separable only when the assembly is removed from the splined shaft; this arrangement is used to permit assembly of the spring and two spring cups. The spring cups are ordinarily held tightly against the upper and lower flanges of the core by the compression force of the spring.

When the selector lever is operated 180 degrees from the position shown, one end of the selector clutch yoke lifts so that its lower rollers push upward against the underside of the flange on the lower spring cup. If the switch is in the position corresponding to the position of the hand-throw lever so that the tooth of the hand-throw pinion is aligned to receive the tooth of the "clutch for hand operation," and assuming no restraining friction between the teeth at the bottom, the selector clutch assembly will shift upward without deflection of the spring. At times, however, there may be a torque load on the lower teeth when the selector lever is operated (for example, if the switch is stalled on an obstruction) and this may cause sufficient friction to hold the clutch down while the yoke is lifted. This compresses the spring as the lower spring cup is lifted by the lower rollers on the yoke, until the top of the lower spring cup engages the bottom of the upper spring cup. Further operation of the selector lever provides a positive drive to pull the lower teeth apart far enough that the chamfered corners of the teeth are in engagement instead of the nearly vertical working faces. At this point the single tooth at the top of the clutch assembly is raised sufficiently to start engaging the hand-throw pinion and will be moved into engagement with it by the spring force and any upward thrust due to the torque load on the lower teeth, provided of course the two upper teeth are aligned to permit such engagement. If these upper teeth are not aligned, the spring will hold the "clutch for hand operation" against the hand-throw pinion tooth until the hand-throw lever is operated to obtain alignment.

The spring functions in a similar manner if the worm gear teeth are not aligned when the selector lever is returned to the motor position.

Moving the selector lever out of the motor position also actuates a pair of motor cutout contacts (see Figure 3-9) to open the motor circuit and (in some cases) control a line circuit. The cutout contacts are mounted in the circuit controller compartment and are operated by a spring-return push rod projecting into the gearbox. This push rod is shifted toward the circuit controller by the action of a cam ledge on the selector clutch yoke engaging an adjustable rocker arm.

3.5.2. M-23A and M-23B Mechanisms

The mechanical difference between M-23A and M-23B mechanisms is the hand-throw pinion (see Figure 3-10). The single tooth on the hub of the hand-throw pinion on the M-23B mechanism has a shorter arc than the M-23A mechanism. This introduces sufficient lost motion between the pinion and the selector clutch to permit full stroke of the hand-throw lever (and thus the switch points) without moving the slide bar far enough for the locking dogs to engage the lock rods and, thereby, lock the switch points. The travel of the main crank is ample, however, to lock the switch-operating bar against back thrust.

3.5.3. Lever Interlock

The hand-throw and selector levers are interlocked by means of a steel ball and suitable recesses in the lever hubs, to prevent operation of the hand-throw lever unless the selector lever is in the Hand position, and also to prevent return of the selector lever from its Hand position unless the hand-throw lever is in one or the other of its full-stroke positions. The interlock can also be assembled to require that the hand-throw lever always be returned to Normal before the selector lever can be returned from its Hand position.

Details of the interlock are illustrated in Figure 2-10 and described in Section 2.14. Moreover, it is possible to apply the selector lever to its shaft in either of two ways, 180 degrees apart, so as to have the Motor position of the selector lever toward either the motor end or the circuit controller end of the machine for both right-hand and left-hand assemblies.

3.6. Motor

Two low voltage (two 20V nominal) and two high voltage (110V nominal) DC motors are available for the M-3 and M-23 switch machines. The low voltage motors are used on machines with gear ratios of 360:1 and 528:1. The high voltage motors are used on machines with gear ratios of 189:1 and 360:1.

For low voltage motors, under the most adverse conditions of load, temperature, and battery voltage, the voltage at the motor terminals should not be less than 20 VDC. High voltage DC motors should have not less than 85V at the motor terminals. The voltage at the motor terminals should be measured with the clutch slipping. Refer to paragraph 5.5.5.3 for information on the adjustment to slip the clutch.

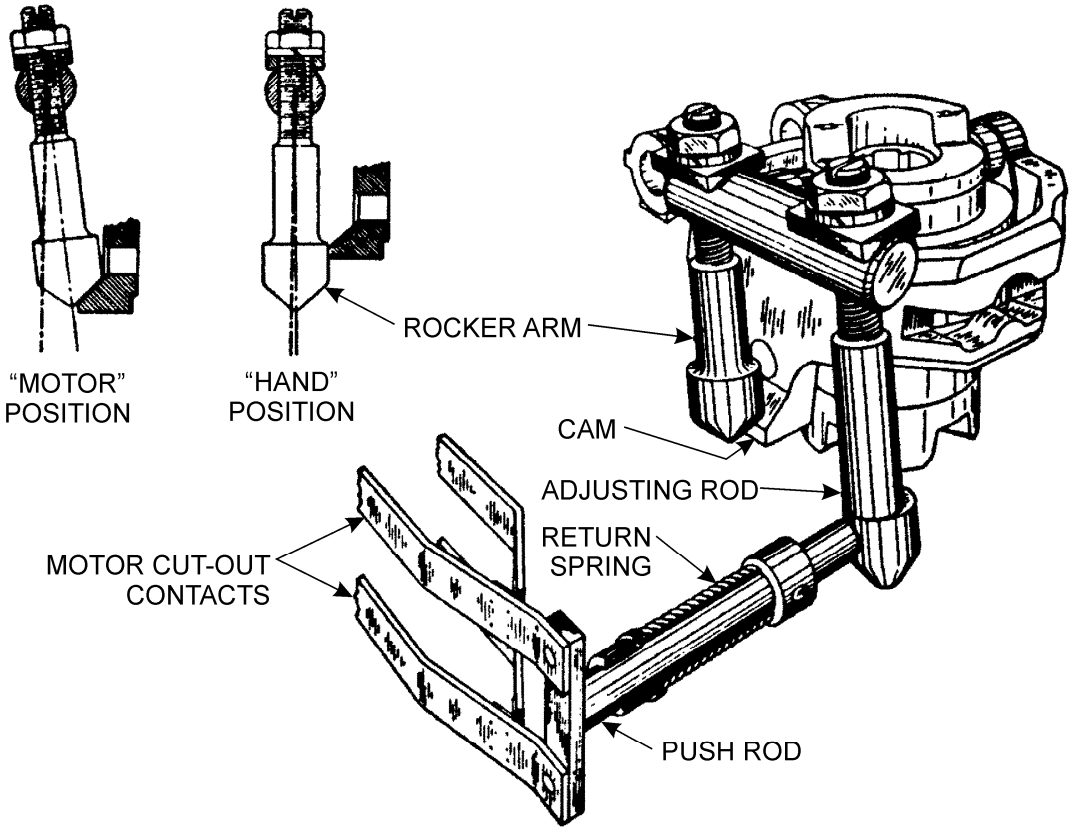


Figure 3-9. Motor Cutout Contact Assembly (M-23 Machines)

(a) BOTTOM VIEW OF HAND THROW BEVEL PINION FOR M-23A MOVEMENT

(b) BOTTOM VIEW OF HAND THROW BEVEL PINION FOR M-23B MOVEMENT

Figure 3-10. Hand-Throw Bevel Pinions (M-23 Machines)

3.7. Overload Protection

EBNC-equipped switch machines provide internal overload protection for the motor (refer to Table 1-6 for specific values); MCU-equipped switch machines do not. For the MCU-equipped switch machines, overload protection is provided by wayside equipment such as the ASTS USA Switch Machine Lock (SML) series relay. These relays (and the EBNC overload protection function) have a variable response time depending on the magnitude of the motor current; the higher the current, the shorter the response time.

The standard plug-in type relay for the overload protection of DC switch machines is the Style PN-150SO relay. This relay is used in conjunction with the style PN-150BM switch control relay and the style PP-151 magnetic stick relay for overload and short circuit protection.

When ordering an SML-series or other overload relay, the clutch slippage current or the gear ratio and type of the machine with which it is to be used should be specified. The gear ratio is stamped on the switch machine name plate.

3.8. Heaters

Fifteen (15) watt heaters are available for application in the motor compartment. The heaters operate on 24/110 VDC or 115/230 VAC. A dual element heater is available for operation on either 115 or 230 VAC.

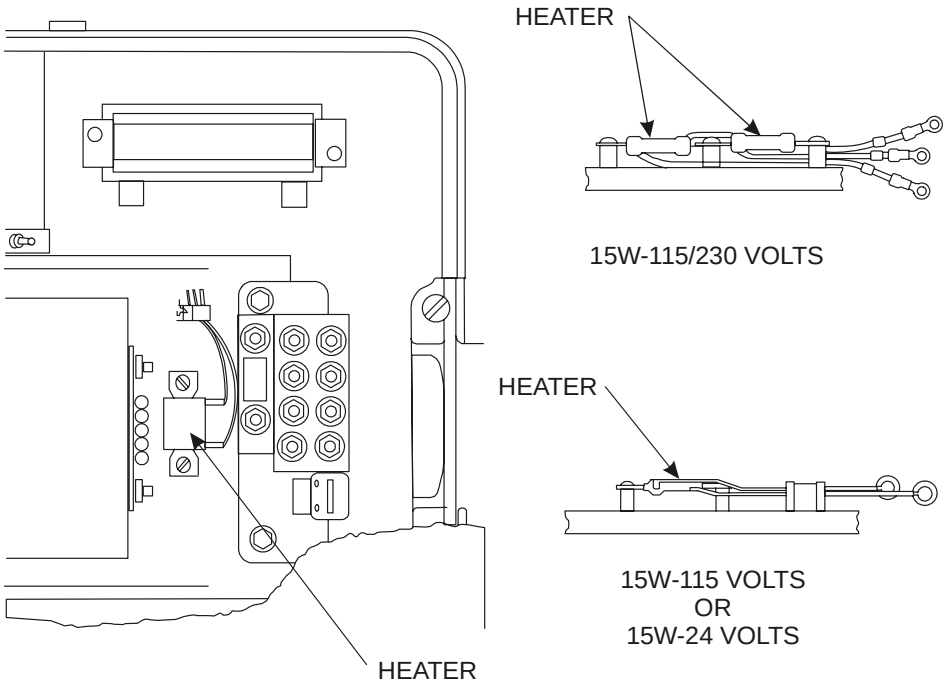


Figure 3-11. Heaters for Motor Compartments

4. FIELD MAINTENANCE

NOTE

Disable the motor control circuit before any work is performed on the switch machine, otherwise electrical shock or physical injury may result.

NOTE

The field maintenance procedures covered in this manual are those recommended by ASTS USA. The field maintenance policy of the customer will depend on actual operating experience and capability.

4.1. Preventive Maintenance

The following preventive maintenance procedures are intended to detect possible causes of switch machine failure before an actual failure occurs. Detection of such possible failures is accomplished by a scheduled maintenance process, whereby the switch machine is inspected, cleaned, lubricated, and performance-tested in the field on a periodic basis. The preventive maintenance procedures outlined herein ensure that all switch machine functions are operational.

A recommended schedule for performing preventive maintenance tasks is shown in Table 4-1. The actual time interval will depend on the customers own operating rules and/or experience.

4.1.1. Inspection

Inspection is conducted in two areas: the switch layout area and the switch machine itself. Inspection consists of observing the appearance and integrity of the switch points, switch rods, connecting rods, possible switch obstructions, electrical connections, and the interior of the switch machine. A judgment is then made as to whether a potential or obvious faulty condition exists. When any faulty condition is observed, it is to be corrected immediately.

4.1.2. Switch Layout Inspection

Perform switch layout inspection as follows:

1. Check that ties are well tamped to withstand vibration and strain caused by passing trains.
2. Check that tie plates, tie straps, rail braces, and switch fittings are secure.
3. Check that there are no signs of water accumulation around switch machine (proper drainage exists).
4. Remove any material within the layout that could obstruct switch movement.

Table 4-1. Preventive Maintenance Schedule

Interval	Functional Circuit or Equipment	Maintenance Action		
		Route Insp.	Lube	Perf. Test
Monthly	Switch Layout	X	– –	– –
Semi-annually	Switch Machine	X	– –	– –
Semi-annually	Switch Machine	– –	X	– –
Monthly	Switch Machine	– –	– –	X

4.1.3. Switch Machine Inspection

Perform switch machine inspection as follows:

1. Remove covers from switch machine circuit controller, gearbox, and motor compartments.

2. Using hand crank for M-3 or hand throw lever for M-23, operate switch back and forth as often as necessary and check for:

   a. Proper and smooth operation of switch points without undue drag or spring and with points riding on all slide plates. Also check for switch point obstructions at this time.

   b. Loose or damaged electrical connections.

   c. Burned, frayed, or broken insulation.

   d. Proper movement of switch machine main crank, slide bar lock box, switch-operating bar, and circuit-controller point-detector bar.

   e. Excessive wear, lost motion, or accumulation of foreign or conductive material.

   f. Excessive or unusual vibration and noise.

3. Electrically operate switch machine and check for:

   a. Smooth movement of switch machine motor and gears; no binding etc., should be noticed.

   b. Conditions listed in step (2), above.

4. Check that there are no signs of moisture accumulation within switch machine compartments.

5. During semi-annual inspections check for moisture in the compartments. If 3/8-inch pipe plugs are installed in two drain holes located in the crank case compartment, or slotted-head bolts with lock washers are installed in circuit controller compartment, remove plugs and allow whatever moisture is present to drain from compartment.

CAUTION

Where drain plugs are used, a moisture check should be made prior to anticipated freezing weather. A freeze-up of excessive moisture could result in improper switch machine operation.

6. Reinstall plugs in drain holes.

NOTE

These pipe plugs should have been installed initially only if the switch machine is in a location where blowing sand or dust is troublesome; otherwise, drain holes should be open. During cold weather, periodically check that the holes are open.

7. Check that motor control contacts, indication contacts, motor cutout contacts, and associated cams and linkages are clean and do not show excessive wear (refer to Section 4.2).

8. Check that all switch machine parts are properly and adequately lubricated (refer to Section 5.6).

9. Check that conduit between switch machine motor compartment and junction box is not crimped, nicked, cut, or otherwise damaged.

10. Remove two screws securing access plate over motor commutator. (Not possible on all motors.)

    a. Check that commutator is smooth and clean.

    b. Check that commutator brushes are free in their holders and are not excessively worn.

4.2. Lubrication

After the switch machine has been inspected and cleaned, it must be lubricated to ensure optimum operation. Refer to Section 5.6.

4.3. Switch Machine Performance Test

Conduct a performance test on the switch layout(s). The performance test should be done in accordance with customer's operating rules. The test should include mechanical operation of the switch mainline, and electrical tests of power distribution and switch control and indication circuits. Erratic or faulty operation and/or indications should be promptly referred to the proper authority for corrective action.

4.4. EBNC Unit Test

When an EBNC unit is installed in the switch machine and there is some question of its proper operation, it can be tested using a 12 VDC test source (power supply or battery) and multimeter.

CAUTION

Disconnect plug connectors TB1 and TB2 at the ECC ***before*** connecting an external supply at the WAGO terminal strip. Failure to do so may result in damage to the ECC and/or MCU/EBNC.

1. Disconnect plug connectors TB1 and TB2 at the ECC.
2. Connect test source common (–) to the WAGO terminal labeled 31.
3. Connect test source positive (+) to the WAGO terminals labeled 29 and 30.
4. Connect test source common to Cable #1, GR/Y.
5. Connect test source positive to Cable #1, Wire #3.
6. Set the multimeter to DC volts.
7. Connect multimeter common (–) to Cab1e #1, Wire #1.
8. Connect multimeter positive (+) to Cab1e #1, Wire #2.
9. Connect test source common (–) to the WAGO terminal labeled 36.
10. Connect test source positive (+) to the WAGO terminal labeled 34.
11. The top LED will light and the relays will switch.
12. The multimeter should display about (+)12 VDC.
13. Reverse the connections to WAGO terminals 36 and 34.
14. The top LED will light and the relays will switch.
15. The multimeter should display about (–)12 VDC.

NOTE

There are no serviceable parts within the EBNC. If it has been determined that the unit is not functional, it must be replaced.

Table 4-2. EBNC Logic Table

BiPolar Input (Motor Control) – WAGO Terminal					Motor Output Voltage	
31	**36**	**34**	**30**	**29**	**#1 (+)**	**#2 (–)**
0	-Vb	+Vb	0	X	NONE	NONE
0	-Vb	+Vb	1	X	+Vm	-Vm
0	+Vb	-Vb	X	0	NONE	NONE
0	+Vb	-Vb	X	1	-Vm	+Vm
Key	Vcontrol (–)	0	Logic Control (12 VDC Nominal)			
	Vcontrol (+)	1				
	No Effect	X				
	Vbipolar (+)	+Vb	Bipolar Control (12 VDC Nominal)			
	Vbipolar (–)	–Vb				
	+Vmotor	+Vm	Motor Output – Source from #3 and GY Input			
	–Vmotor	–Vm				

4.5. Corrective Maintenance

The following paragraphs describe the M-3, M-23A and M-23B Switch Machine field-level maintenance procedures. Field level maintenance adjustments for these machines consists of:

1. Friction clutch adjustment
2. Switch machine to switch adjustment
3. Motor control contacts adjustment

4.5.1. Friction Clutch Adjustment

A switch machine's friction clutch (see Figure 5-1) must slip at just the right amount of torque. This torque must be more than adequate to carry the switch machine's operational loading during the driving of the switch points. At the same time, to transmit this torque, the friction clutch should not be so tight as to prevent protection of the mechanism from shock.

To check the friction clutch adjustment, refer to paragraph 5.5.5.3.

CAUTION

Friction disks must be kept free of oil, otherwise motor may be damaged due to excessive clutch slippage. If contamination occurs, friction disks must be replaced.

NOTE

If clutch discs are oily and it is found that oil is entering along the shaft, it is recommended that the felt washer and oil seal be renewed in the clutch housing as described in Section 5.5.5.1.

4.5.2. Switch Machine to Switch Adjustments

If it is necessary to readjust the switch machine refer to Section 2, Installation and Adjustments, Sections 2.3, 2.4, and 2.5.

4.5.3. Motor Cutout Contact Adjustment

Refer to procedures provided in Section 5.7.1 (M-3) and Section 5.7.2 (M-23).

4.6. Repair Procedures

Repair of the switch machine in the field consists of removing and replacing the motor brushes and major switch machine assemblies. It is not recommended that major overhaul or repair to the machine, requiring disassembly to the component part level, be done in the field. The switch machine should be removed from service and sent to the ASTS USA service or repair shop for this level of repair.

To remove the switch machine from service, refer to Section 2, Installation, and reverse the procedure. To remove and replace:

1. Motor Brushes – Refer to Section 5.4.1 and 5.5.3.
2. DC Motor – Refer to Section 5.4.2 and 5.5.4.
3. Friction Clutch Assembly – Refer to Section 5.4.3 and 5.5.5.

5. SHOP MAINTENANCE

5.1. Special Tools

The following special tools are required to perform shop maintenance on the switch machine.

Maintenance tools for M-3 and M-23 switch machines are listed below. Ordering reference for the complete set of tools is X296406-001, Drawing 012764-0001.

M-3 and M-23 Maintenance Tools
Screw driver, 6” slotted
Screw driver, 10” slotted
Slip joint pliers, 6”
Machinist hammer, 12 oz. ball peen
Insulated socket wrench, 1/2”
Adjustable Crescent wrench
Adjustable Crescent wrench. 10”
Set hex. Sockets
Ratchet wrench, 1/2” drive
Extension bar, 1/2” drive, 10” long
Special pin wrench (for clutch housing packing gland)
Thin head flat wrench (1-5/32” opening)
Allen wrench – 3/16” Hex.
Clutch assembly gauge, (hand/motor clutch)
Basket Wrench, 2-1/16” open-end (ASTS USA M322680) or box wrench (ASTS USA J49124401)

5.2. Cleaning

All major mechanical parts should be thoroughly cleaned to remove accumulation of dirt, grease and grime. Use only appropriate cleaning agents for the material being cleaned and follow the manufacturer’s recommendations for use.

CAUTION

Electrical components, such as the motor, heaters, wiring harness, or ECC should never be immersed in cleaning solution, otherwise damage to these parts will occur.

5.3. Inspection

After cleaning, carefully check the case, cover, and other structural components for hairline cracks, breaks, weak points or any other signs of physical damage. During disassembly, carefully check each part for signs of damage. Replace any part found to be damaged.

5.4. Disassembly

5.4.1. Motor Brush Replacement

NOTE

When replacing motor brushes, both brushes should be replaced at the same time.

See Figure 7-1 (M-3) or Figure 7-4 (M-23). For motors with external brush covers:

Remove the motor compartment cover. Remove the motor brush/commutator covers by removing the two screws on each side of the cover. Lift and push to release the spring holder, then remove the motor brush. Install the new brush and secure it in place with the spring holder. Repeat for the other brush.

5.4.2. Motor Removal

See Figure 7-3. Remove the motor compartment cover. Tag and remove the wires attached to the surge suppressor PCB (3340; EBNC machines) or motor terminals (MCU machines), and motor compartment heater (if used). Position the wiring harness out of the way.

Remove two 1/2 inch cap screws and lock washers holding the motor frame to the switch machine base. Lift the motor assembly upward and pull it towards the conduit outlet until the pinion gear on the motor shaft clears the drive opening in the gear box case.

See Figure 7-7 or Figure 7-8. To remove the motor (10) from the frame (5), loosen the set screw (40) and gently pull the pinion gear (30) and key (35) from the motor shaft. Remove four 3/8 inch socket head screws (25) and lock washers (70), then remove the motor from motor frame.

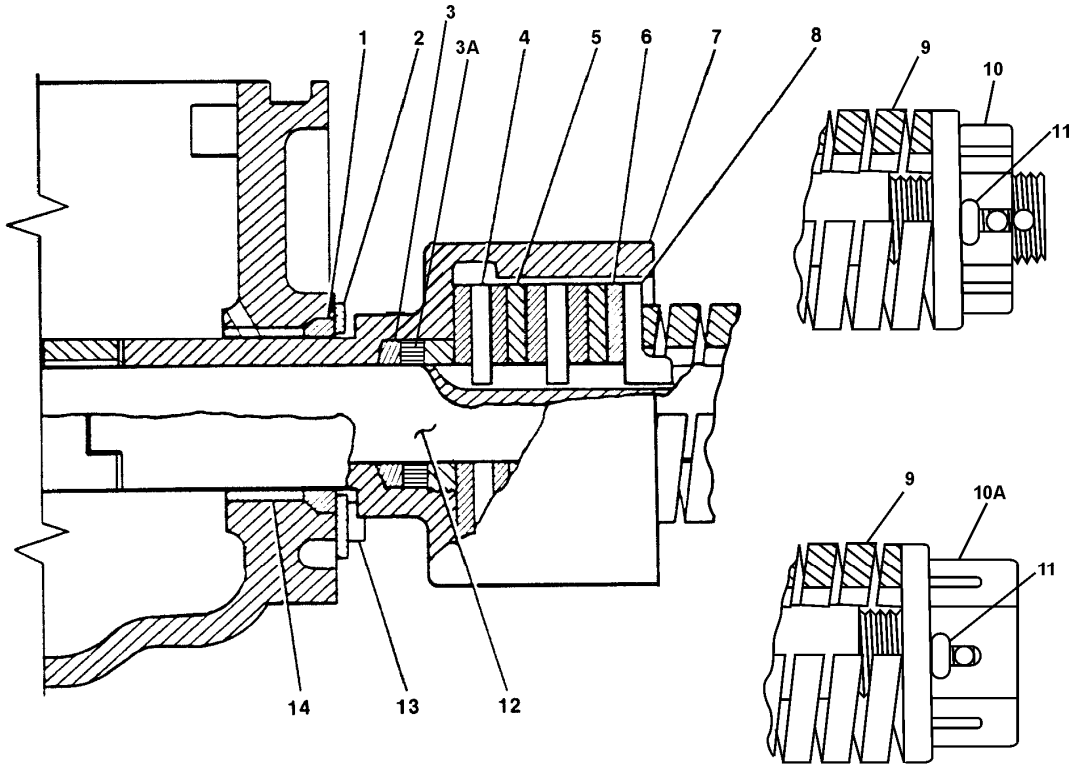
5.4.3. Friction Clutch Assembly Removal

See Figure 5-1. Remove the cotter key (11) from the clutch adjusting nut (10 or 10A), then remove the adjusting nut from the worm shaft (12). Remove the clutch spring (9). Remove the two cap screws (13) securing plate to the gear box case, then remove the plate and gasket (1). Disengage the clutch housing/tubular neck (7) from the worm gear hub. Continue pulling until the tubular neck clears the opening in gear box case, exposing worm shaft.

5.4.4. Circuit Controller Removal

See Figure 7-2. The Electronic Circuit Controller (ECC) is a self-contained and sealed unit. The unit is secured by three socket head cap screws.

To remove the ECC, disconnect the three cables from the front (point detector end) of the unit at TB1, TB2, and JB1. Remove the cap screw at the center front of the unit and the cap screw at each rear corner (junction box end). Lift the ECC out of the compartment.



Item No.	Description	ASTS USA Part No.
1	Gasket	M245192
2	Plate	M147400
3	Felt Washer	J047335
3A	Oil Seal	J7900260003
4	Clutch Plate	M146574
5	Clutch Plate	M146573
6	Clutch Disk	M146650
7	Clutch Housing	M172752
8	Clutch End Plate	M146575
9	Clutch Spring	M239322
10	Clutch Adjusting Nut M-3	M286615
10A	Clutch Adjusting Nut M-23	M438402-001
11	Cotter, 3/16” x 2” (Tin Pl.)	– –
12	Worm Shaft	M286612
13	Cap Screw, 1/4-20 x 3/4” Hex Hd. (Tin Pl.)	– –
14	Bushing	J790004

Figure 5-1. Friction Clutch Assembly

5.4.5. Gearbox Removal (M-3)

See Figure 7-1. Remove the two screws located on either side of the cotter key (2435) that links the push rods and the motor cutout contact controls. Hold the push rod (2805) at the end nearest the motor compartment and pull it until the opposite end clears the shaft (2810). Remove the push rod by lifting and pulling it until the motor cutout pushrod (2245) clears the hole in the side of the housing. Remove the four screws (2995) and washers (2200) that secure the gearbox to the base, and lift the gearbox from the base of the switch machine. If further disassembly of the gearbox is required see Figure 7-5.

NOTE

Before proceeding with further disassembly, become thoroughly familiar with the information and illustrations in Sections 1 and 3. These illustrations will aid in final disassembly of the switch machine.

5.4.6. Main Crank Removal

For all M-3 and M-23 machines, the main crank must be taken out through the bottom of the machine.

1. Remove the bottom cover and wear plates supporting the operating bar. This allows the operating bar and crank roller to drop down.

2. Rotate the crank (turn the friction clutch by hand) until the bottom end is cross-wise to the machine.

3. Unscrew the nut at the top of the main crank shaft and allow the crank to drop out through the bottom of the machine. Removing the main crank will also release the worm gear and the slide bar.

5.4.7. Main Crank Replacement (M-23 Machines)

These procedures cover replacement of a broken main crank without complete disassembly of the gear box. It is intended primarily for use in the field, but can be used in the shop (with modifications to reflect that the machine is not installed in a layout).

NOTE

It is strongly recommended that both the crank removal and crank installation procedures be reviewed before proceeding. It is **CRITICAL** that some data be recorded at specific times during disassembly to ensure that the machine is reassembled correctly.

NOTE

A minimum clearance of 14 inches is required underneath the center of the switch machine to allow removing or installing the crank through the bottom of the gear box.

5.4.7.1. Main Crank Removal

If performed in the field, obtain permission from the cognizant authority before beginning. See Figure 7-6 for the location of items called-out by number.

1. Remove power from the machine. Ensure that there is no possibility that the motor can be energized from any source.

2. Place the Motor–Hand selector lever fully to Hand. If required, move the hand-throw lever fully to Normal. If the crank is broken, the operating bar may need forced to Normal by prying over the switch points. Ensure that the hand-throw lever is fully seated in the latch stand and that the internal slide bar is at the end of its stroke.

3. Disconnect the switch operating rod at the lug on the switch machine operating bar.

4. Remove four 1/2 inch bolts and lock washers securing the gear box bottom cover. Remove the cover from the machine.

5. Remove four 5/8 inch bolts and washers securing the gear box top cover. Remove the cover from the machine.

6. Remove the cotter pin (430), castle nut (425), and flat washer (200) from the top of the crank (105).

CAUTION

Two dowel pins (one on each side) help position the top bearing cap in the gear box. If vertical force is required to remove the cap, apply the force evenly on both sides to prevent breaking the pins.

7. Remove the four 1/2 inch bolts (350 or 370) and lock washers (445) securing the top bearing cap to the casting. The bolts are two ***different lengths***; note the length of the bolt removed from each mounting hole for reference during reassembly. The brass bushing (155) will come off the crank along with the bearing cap.

8. Remove the key (160) from the machined slot in the top of the crank.

9. Mark the orientation of the hand-throw pinion (A–B gear) (95) to the timing marks on the hand-throw gear (100); the orientation must be kept the same during re-assembly. Remove the hand throw bevel pinion (A–B gear) from the top of the crank.

NOTE

The crank body must be properly aligned to allow removal of the crank through the bottom of the machine.

10. Remove the spacer (170) from the top of the crank. Rotate the crank roller stud (195) to align the body of the crank (as viewed from below the machine) parallel to the operating bar of the machine.

NOTE

It is **CRITICAL** to note the relationship between the lobe of the crank and the slide bar rollers (2065) at this time. Use Figure 5-2 (left-hand machine) or Figure 5-3 (right hand machine) to sketch this relationship for reference during reassembly.

WARNING

When the wearing brackets for the operating bar are removed, the crank may fall out through the bottom of the machine. Support the crank while removing the wearing bracket mounting hardware.

11. Remove the hardware holding the operating bar wearing brackets to the base of the machine. Remove the operating bar, roller, and crank from the machine.

NOTE

Do **NOT** try to remove a broken upper portion of the crank through the top of the machine. It must be pushed out through the bottom of the machine.

12. If the crank is broken, the remaining part of the crank may need forced out through the spring-loaded clutch assembly.

13. If damaged, remove and repair the clutch yoke assembly (180). This will ensure easy re-assembly with the new crank.

NOTE

Do **NOT** move the hand-throw lever or slide bar while the crank is removed from the machine. The orientation of the gears and slide bar will be disturbed.

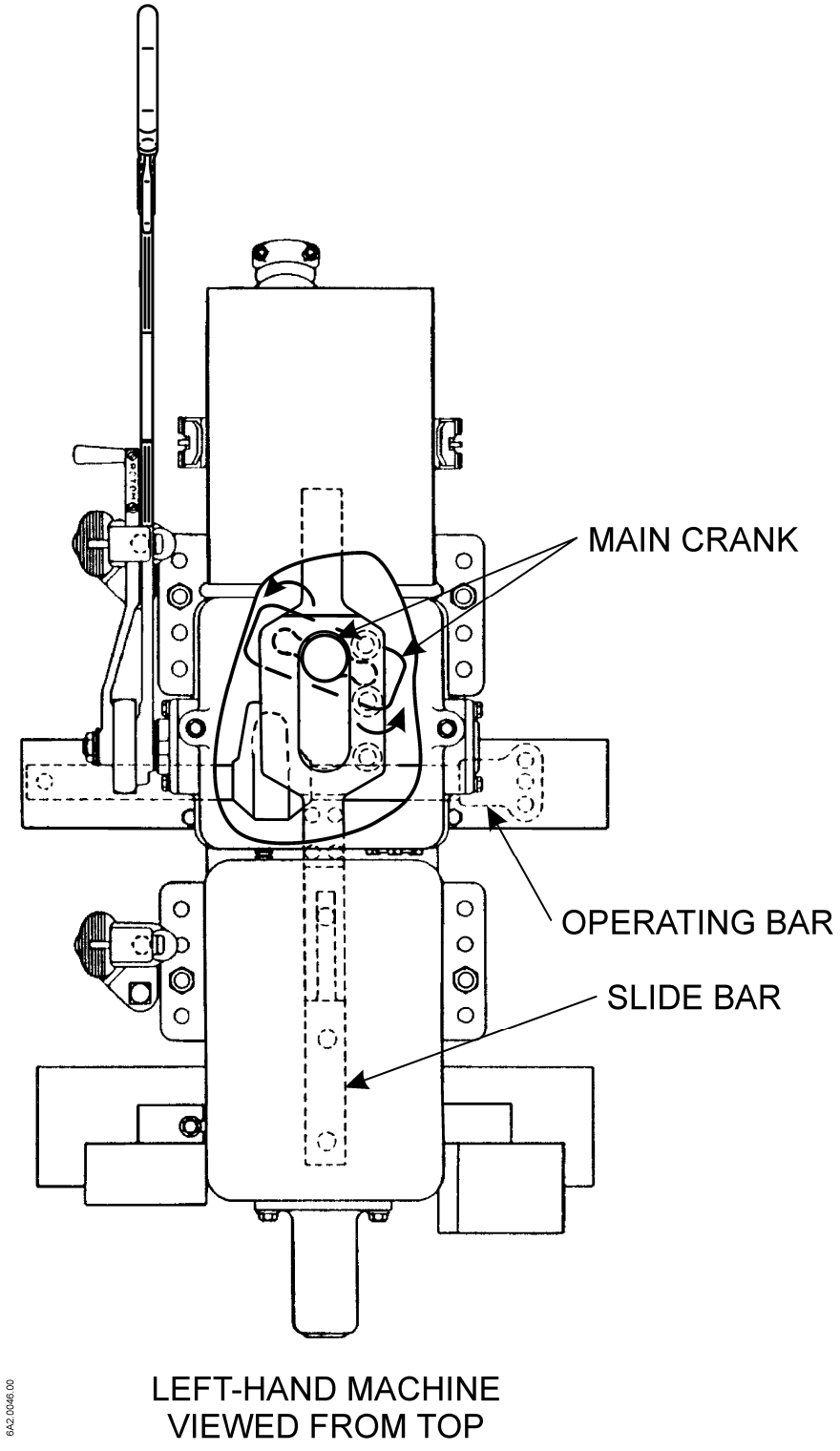


Figure 5-2. Crank Lobe/Slide Bar Rollers Relationship Sketch (Left-Hand)

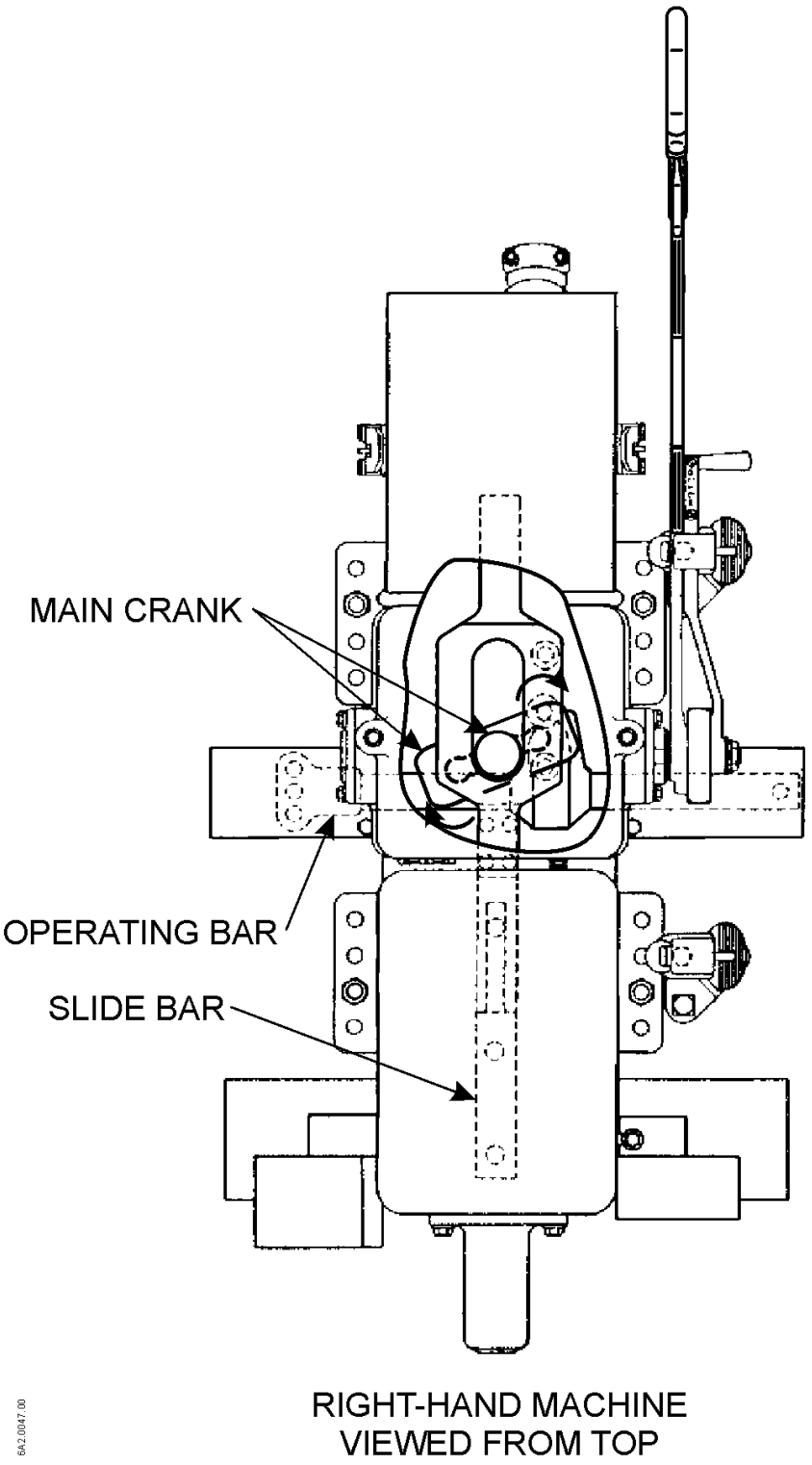


Figure 5-3. Crank Lobe/Slide Bar Rollers Relationship Sketch (Right-Hand)

5.4.7.2. Main Crank Installation

NOTE

Do **NOT** try install the replacement crank unless its machined surfaces are completely clean and smooth. There should be no nicks, coating, or film of any kind.

1. Inspect the machined surfaces of the replacement crank. If required, a solvent may be used to remove any rust inhibitor, heavy grease, or wax film.

2. Apply a light coat of grease to the machined surfaces of the replacement crank.

3. Place the operating bar and wearing brackets within easy reach. They must be installed into the machine to hold the replacement crank in position.

NOTE

The crank is installed in the same orientation for either left-hand or right-hand machines.

NOTE

It is **CRITICAL** that the machined slot at the top of the crank is aligned with the roll pin at the top of the selector clutch housing (175). If the roll pin is not oriented properly, the replacement crank cannot be fully inserted into the gear box.

4. Insert the replacement crank (from below) up through the center hole in the bottom of the gear box and into the machine. Align the crank so that the lobe directly above the roller stud is positioned between the slide bar rollers (see upper or lower views in Figure 5-4).

CAUTION

Forcing the replacement crank into the selector clutch assembly may break the roll pin. This may put the machine out-of-time with the circuit controller and lock box at the end of the hand-throw stroke.

5. Apply a thin coat of grease to the crank stud (to help hold the roller). Assemble the roller onto the stud.

6. Ensure that the crank lobe and slide bar roller relationship is the same as noted during removal of the failed crank (marked on Figure 5-2 or Figure 5-3). Reinstall the operating bar and wearing brackets to the bottom of the machine.

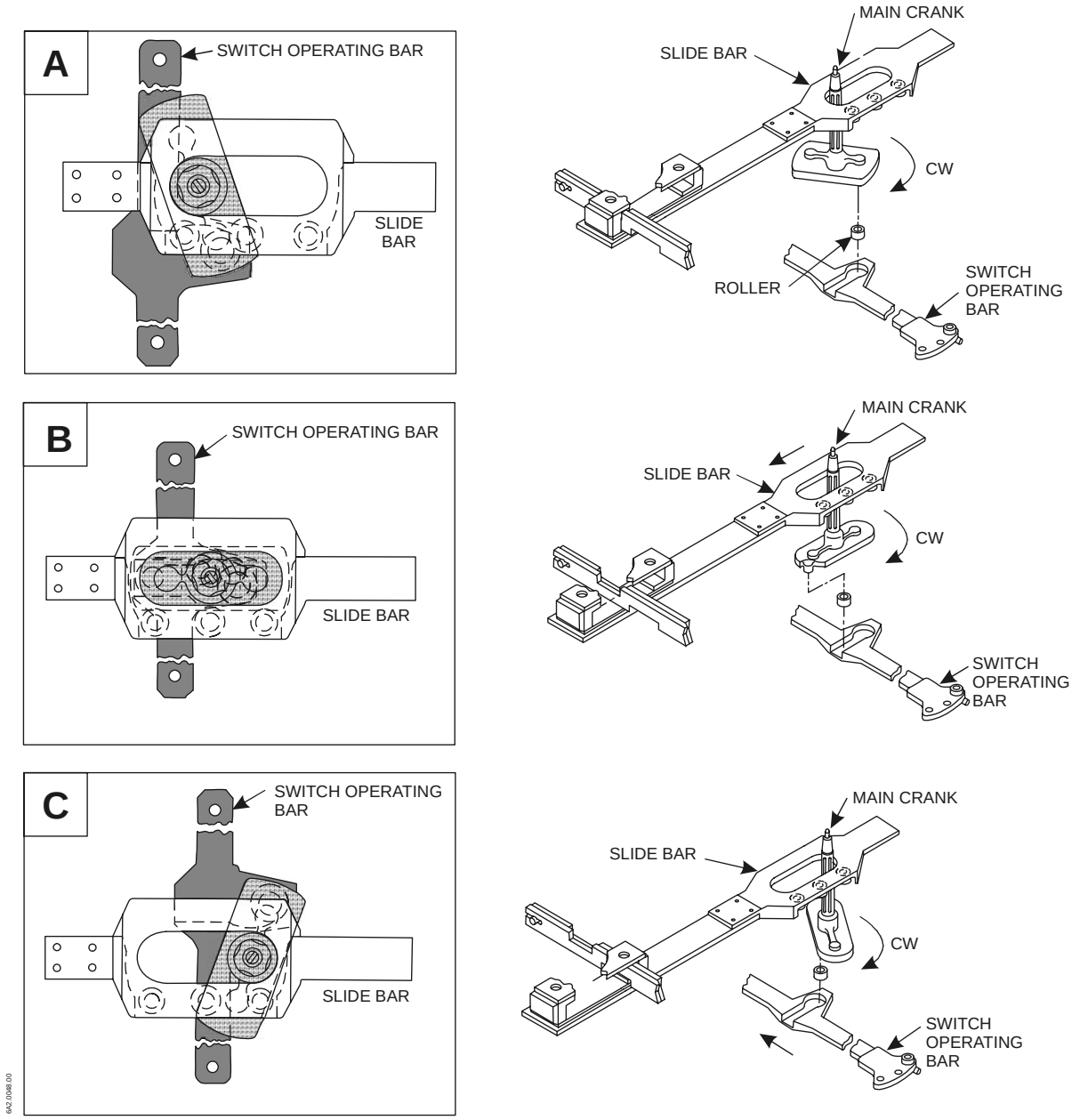


Figure 5-4. Crank to Slide Bar Relationship (Viewed from Top of Machine)

7. Reinstall the gear box bottom cover and secure it with four 1/2 inch bolts and lock washers (removed during disassembly).

8. Move the Motor–Hand selector lever to Motor. This will compress the spring and ease assembly of the top bearing housing.

9. Reinstall the spacer (170) on top of the replacement crank.

NOTE

Ensure that the hand-throw lever is on the motor side of the machine.

CAUTION

The hand-throw pinion (A–B gear) must be oriented correctly relative to the spring loaded clutch assembly.

10. Locate the applicable letter (L or R) stamp on the hand-throw gear (100), and the marks (made during disassembly) on the hand-throw pinion (A–B gear) (95). With the hand-throw lever held vertical, count the teeth on the hand-throw pinion (A–B gear) needed to align the marks (made during disassembly) with the applicable letter (L or R) stamp. Reinstall the hand-throw pinion (A–B gear) at the top of the crank in the correct position.

11. Align the motor cutout pushrods to the plunger.

12. Set the top bearing cap (10) over the two locating pins in the gear box casting. Push the bearing cap down until it seats against the casting. If required, tap the bearing cap **lightly** and **evenly** until it seats on the casting. Secure the bearing cap using four 1/2 inch bolts (different lengths; insert bolts in holes as noted during disassembly) and lock washers.

13. Reinstall the key (160) into the keyway in the top of the crank and bearing. Place the brass bushing (170) over the top of the crank. Ensure that the keyway slot in the bushing is in line with the keyway. Press down on the bushing until it seats fully into the top bearing cap.

14. Reinstall the flat washer (200) and castle nut (195) over the top of the crank. Tighten the castle nut until it is snug and the crank has been pulled up fully (threads should be exposed above the top of the nut). Loosen the nut one-half turn, then install the cotter pin to lock the nut in place.

15. Reconnect the switch operating rod to the lug on the switch machine operating bar.

16. Place the Motor–Hand selector lever to Hand and cycle the machine between Normal and Reverse. Verify that the machine operates smoothly throughout its full stroke.

NOTE

It is recommended that all track settings be checked at this time to ensure that the layout is in sound operating condition.

At this time, the Motor–Hand selector lever should be returned to Motor, and the cognizant authority notified that powered switch operation needs to be verified. Cycle the switch between Normal and Reverse using the motor. Verify that the machine operates smoothly throughout its full stroke.

17. After confirming proper operation of the machine and layout, reinstall the bottom cover using four 1/2 inch bolts and lock washers (removed during disassembly). Inspect the gear box lubricant level and add lubricant as required. Reinstall the top cover using four 5/8 inch bolts and lock washers (removed during disassembly).

5.4.8. Selector Clutch Removal

For M-23 machines, removal of the selector clutch and associated parts can readily be understood from the information given for changing between RH and LH configuration. However, when reassembling the selector clutch, note that all its overall height, including top and bottom teeth, is 5-9/32 inches maximum to 5-17/64 inches min. This dimension is adjustable by turning the top and bottom parts of the clutch assembly with respect to each other. This can best be done by inverting and placing "hand" portion on the crank splines and turning "motor" portion with screw driver or bar in motor clutch teeth. Splines in both parts must be aligned to permit reassembly. For "timing" of the dual-control gearing upon reassembly, see Section 5.5.2.

5.4.9. Worm Shaft Removal

To remove the worm shaft, it is necessary to take the gearbox off the base casting, otherwise the end of the shaft would strike the wall of the circuit controller compartment.

The slide bar can be removed through the motor compartment, after first removing the lock box and the motor.

5.4.10. Final Disassembly

After removing all major subassemblies per the above paragraphs, continue to disassemble the remaining components by referring to Figure 7-1 or Figure 7-4 and associated parts list for parts location and identification. Disassemble only to the degree necessary to repair the machine.

5.4.11. Gearbox (M-23) Disassembly

See Figure 3-5 and Figure 3-6.

1. Remove gearbox and motor compartment covers; use them as receptacles for parts removed. Place hand-throw lever in Normal position and selector lever in MOTOR position.

2. Remove 1/2 inch bolts (A1, A2, A3, and A4) securing top bearing C, yoke support H, lever support K, and lever shaft bearing M.

3. Remove castle nut B1 and washer B2 from top of main crank and lift top bearing C from dowel pins carefully to prevent bending. Remove the rectangular key C1 (Figure 3-5) from top bearing bushing C2, hand-throw pinion D and spacing collar E on top end of crank. Lift hand-throw lever to vertical position and remove set-screw F1 from hand throw bevel gear F. Remove lever assembly and lift out hand-throw bevel gear.

4. Remove 1/2 inch bolt G securing yoke eccentric bushings G1, then remove yoke support H. Positions of eccentric bushings should be noted, and care should be taken to avoid changing their position when removing the bolt.

5.5. Assembly

5.5.1. Gearbox (M-3) Reinstallation

See Figure 7-1. Place gearbox onto switch machine base. Align mounting holes in gearbox with holes in the base. Install four screws (134). Install push rod by inserting the pin into the housing and lowering the push rod. Install push rod (27) by sliding the cutout contact end through the shaft (31). Align the holes at the end of the push rod with their respective swivels and install the two screws. Mount and adjust knob to yoke.

5.5.2. Gearbox (M-23) Reassembly (Convert between RH and LH)

See Figure 3-5 and Figure 3-6.

1. Transfer the yoke support H to the other hub, rotate yoke 180 degrees, and reapply eccentric bushing bolt G without disturbing eccentric bushing positions.

2. Reapply lever assembly to the hub on opposite side of gearbox, with shaft splines entering hand-throw gear F and with eccentric pin P on selector shaft entering the slot on the end of the yoke. With hand-throw lever vertical, reapply set-screw F1 in hand-throw gear F. Reinstall 1/2 inch bolts A2 to secure yoke support H. Reinstall the two top bolts A4 to hold lever shaft bearing M in place.

3. So that “Motor” position of selector lever will be toward motor end of machine, as shown for standard assemblies in Diagram A, B, C, or D of Figure 2-10, selector lever and lever interlock must be reassembled 180^{o} from original position on shaft, as follows:

a. Remove hex nut and washers from end of selector lever shaft and slide selector lever and lever support K from the shaft. Be careful not to lose steel ball in lever support.

NOTE

If stop screw is used in hub of hand-throw lever, it will be necessary to remove this lever also and interchange stop screw and cap screw (see Figure 2-10). Reinstall hand-throw lever and fasten in place with clamping bolt.

b. Reassemble lever support K with hole for the ball on motor side of shaft. Insert steel ball and reassemble selector lever on shaft so that lever will be 180 degrees from its original position. (Stop screw, if used, may require positioning hand-throw lever to align recess with hole in lever support so that ball will not interfere when selector lever is applied.) Reinstall hex nut and washers on end of shaft to hold selector lever in place, and fasten lever support K with the two 1/2 inch bolts A3, which also secure the bottom of the lever shaft bearing.

c. Operate selector lever to motor position (toward motor end of machine) and check that it moves yoke N down.

4. Interchange MOTOR and HAND nameplates on selector lever to correspond with these lever positions.

WARNING

The MOTOR and HAND nameplates must be interchanged on the selector lever to correspond with the lever positions to avoid possible physical injury.

5. Reassemble collar E (with chamfer down) on top of crank and, with hand-throw lever vertical, apply hand-throw bevel pinion D, engaging tooth marked R (for right-hand assembly) or L (for left-hand assembly) with punched marked master tooth space on hand-throw gear F. Carefully place hand-throw lever in Normal position. Be sure that bevel pinion remains in line. With selector lever in MOTOR position, rotate friction clutch housing so that motor clutch teeth are fully engaged.

6. Reapply top bearing assembly and secure with hold down bolts A1. (Motor cutout push rod should be held back to clear the adjusting rod until top bearing is down.)

7. Apply top bearing bushing C2, rectangular key C1, washer B2, and tighten castle nut B1 firmly, then back off to nearest cotter hole and apply cotter, after operating machine by hand-throw lever to be sure that mechanism does not bind.

8. Check adjustment of motor cutout push rod. Contacts should open when end of selector lever has been raised about 6” from the horizontal motor position.

9. Readjust both yoke eccentric bushings as described in Section 5.7.3, then secure by tightening bolt G firmly.

10. Check that machine can be operated by power, and also that it shifts to hand-throw operation from both normal and reverse positions.

11. Check that all bolts are drawn down tightly on lock washers and that all cotters are in place.

12. Reinstall covers.

5.5.3. Motor Brush Reinstallation

See Figure 7-7 or Figure 7-8. Before installing the motor brushes, check that the motor commutator is smooth and free from grease and oil. To dress the commutator, use a fine grain commutator stone or a piece of No. 00 sandpaper. Never use emery cloth for cleaning the commutator or brushes. These commutators must not be undercut.

For motors with external brush covers:

> Fit brushes to commutator using No. 00 sandpaper. Install motor commutator brush in holder. Install spring hold down by pushing into slot beside brush and hooking it over the end of the brush holder. Repeat for other brush. Check that motor commutator brushes are free in the holders. Install motor brush/commutator covers with two screws on each cover. Install motor cover. Operate switch machine motor to determine if brushes are properly installed.

5.5.4. Motor Assembly Reinstallation

See Figure 7-3. Lower motor bracket onto base of switch machine so that pinion end of motor is inserted through motor shaft opening. Position motor so that pinion is mated properly with reduction gear. Align mounting holes in motor bracket at commutator end with holes in base of switch machine. Insert two l/2 inch cap screws and associated lock washer in motors mounting bracket (commutator end). Reattach wires to surge suppressor PCB (3340; EBNC machines) or motor terminals (MCU machines).

5.5.5. Friction Clutch Assembly Reinstallation

See Figure 5-1. Before assembly, check that the friction discs (6) are free of oil. If clutch discs are oily and it is found that oil is entering along the shaft, it is recommended that the felt pad and oil seal be renewed in the clutch housing. Refer to Section 5.5.5.1. If the felt washer and oil seal are not to be replaced, continue with Sections 5.5.5.2 and 5.5.5.3.

5.5.5.1. Felt Washer and Oil Seal (in Clutch Housing) Replacement

See Figure 5-5. Measure the length of clutch spring before disassembling and record this dimension as information for reassembling. Swing terminal board out of the way, remove the adjusting nut and clutch spring, and slide the clutch housing off the shaft. Remove the discs and plates and take out the small lock screw, using the special tool (ASTS USA No. N173641) to remove the packing gland nut.

Remove the old packing and clean the shaft and the inside of the clutch housing by washing with a non-flammable grease solvent. Apply a new felt washer (J047335) and oil seal (J7900260003) to the housing recess and assemble the packing gland nut. Using the spanner end of the special wrench, pull down nut only until it is flush with the bottom of the clutch housing. Then the locking screw should be inserted and drawn down securely. Coat rubbing surfaces of packing rings with gearbox lubricant. Assemble housing to the shaft. Clean lubricant from shaft surface inside the clutch space.

Old fabric discs should be discarded and replaced. Old clutch plates should be thoroughly cleaned in a non-flammable grease solvent to remove any accumulation of lubricant, and then reassembled as shown in Figure 5-5. Note that a fabric disc goes in the bottom of the housing, and the first metallic disc is one with teeth engaging the shaft.

5.5.5.2. Friction Clutch Assembly

See Figure 5-1. Install gasket (1) in gearbox opening. Install plate (2) with two 1/4 inch hex head cap screws (13). Align tubular neck of clutch assembly and worm shaft (12). Insert tubular neck of clutch assembly partially over worm shaft and through gearbox bushing. Align three finger end of tubular neck with matching slots in clutch gear hub. Push tubular neck into gear hub slots until neck/hub is in clutch gear hub. Push tubular neck into gear hub slots until neck/hub is solidly engaged. Install the following items on the worm shaft:

1. Insert clutch disc until it sits against inner wall of clutch housing.
2. Insert clutch plate in groove on worm shaft until it mates with clutch disc.
3. Insert another clutch disc.
4. Insert another clutch plate.
5. Repeat steps c and d for three remaining clutch discs and two remaining clutch plates.
6. Insert clutch end plate on worm shaft.

Slide clutch spring over worm shaft until it rests against clutch end plate. Install clutch adjusting nut on worm shaft. Tighten clutch adjusting nut in accordance with friction clutch adjustment procedures. Recheck this adjustment after a brief wearing-in period.

5.5.5.3. Friction Clutch Adjustment

Friction clutch adjustment should be checked to be sure the clutch slips at a torque which will protect the mechanism from shock, yet adequate to carry nominal operating loads. Also, for

proper operation of the overload relay the clutch must be maintained to slip at a current value above the minimum current rating of the relay or no protection will be obtained.

To check the friction clutch adjustment, apply a temporary jumper across the binding posts of the pick-up coil on the overload relay (See NOTE) and insert an ammeter in the motor circuit as follows: Connect negative ammeter lead to binding post A on switch machine terminal board and positive ammeter lead to binding post 5 or 10, depending upon switch point position. The average peak current taken by motor with clutch slipping should be within 10% of the nominal value shown in Table 5-1 for the particular motor and gear ratio involved. The motor current must be checked in both directions. If necessary, remove cotter and screw the friction clutch spring adjusting nut (see Figure 5-5) in or out to obtain desired current. After tests are completed, remove temporary jumper from overload relay.

NOTE

In addition to a temporary jumper across the binding post of the pick-up coil on the overload relay called for in the maintenance and adjustment section of this manual, all 6-1/4 amp Fusetrons on the 110 VDC side of a bridge rectifier (if used) should also be temporarily jumpered out.

Table 5-1. Adjustment to Slip the Clutch

Motor	Gear Ratio	Adjust Clutch to Slip at Amps*
110 VDC (Blue)	189:1	14(1)
	360:1	10
110 VDC (Black)	189:1	14(1)
	360:1	
20 VDC (Black)	360:1	23(2)
	528:1	
20 VDC (Blue)	528:1	12

(1) The motor current listed for gear ratio 189:1 must be checked in both directions and set for a minimum of 14 amps. A variance of about 1 to 3 amps may exist due to mechanical alignments and motor characteristics.

(2) 20 VDC black motor machines are shipped from the factory set to slip at 20 amps. The clutch may be set to slip at 23 amps for field applications, if desired.

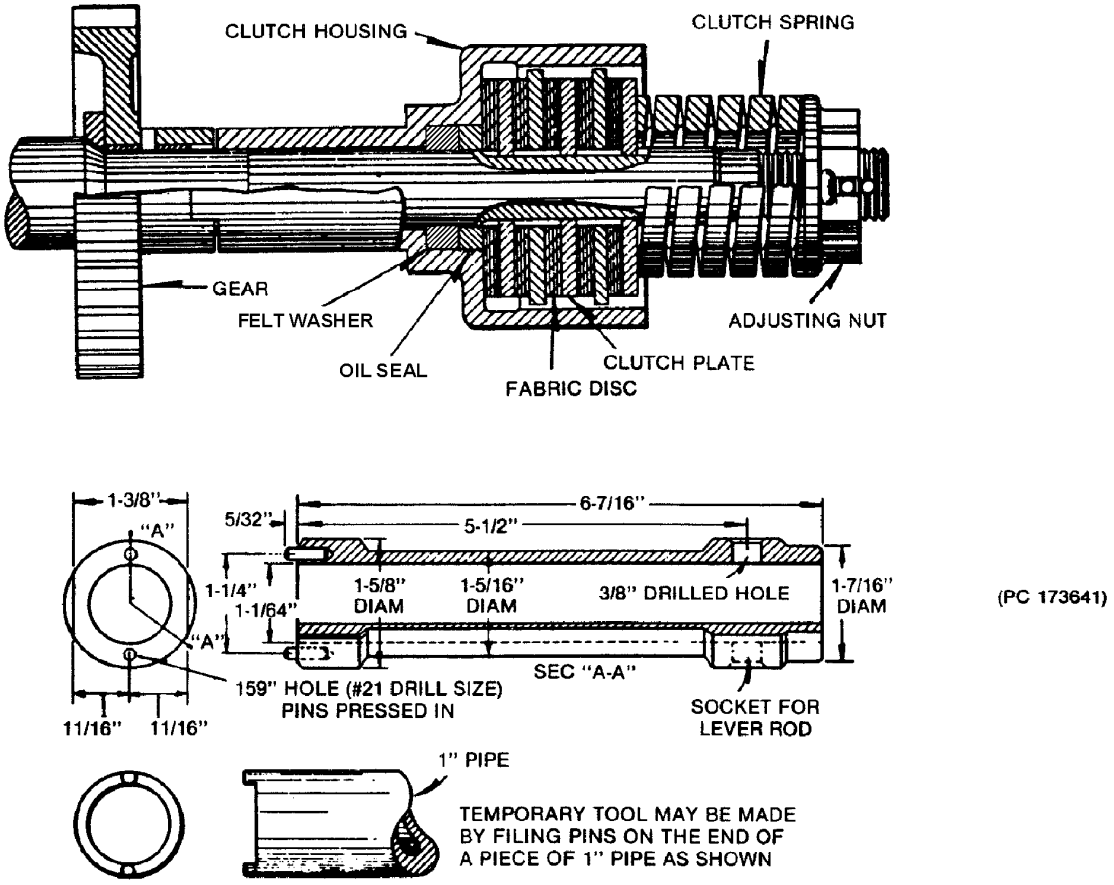


Figure 5-5. Friction Clutch Assembly and Special Wrench for Packing Gland Nut

5.5.6. Electronic Circuit Controller (ECC) Reinstallation

The ECC is located between the junction box and the point detector sensors with the text readable from the point detector side. Place the ECC in this location. Reinstall the three socket head cap screws that retain it, one from the front between the cables, one at each rear corner. Reconnect the three cables as labeled TB1, TB2, and JB1.

5.5.7. Lever Interlock Assembly

The sectional views in Figure 2-10 illustrate the lever interlock assembly. It contains recesses in both lever hubs and a steel ball carried in a hole in the lever support. In reassembling, BE CAREFUL NOT TO LOSE THE BALL when the lever is taken off.

As can be seen in the diagrams, the diameter of the ball is greater than the thickness of the wall of the lever support. Thus, with the selector lever in the MOTOR position as shown, part of the ball is held in the recess of the hand-throw lever and thereby prevents operation of the hand-throw lever. Reversing the selector lever aligns the ball recess in its hub to permit the ball to shift out of the recess in the hand-throw lever hub, thereby releasing the hand-throw lever.

While the hand-throw lever is at any position between the ends of its stroke, the ball is held in the recess in the selector lever hub and thereby locks the selector lever.

The hand-throw lever hub has two ball recesses 180^{o} apart so that at either end of the lever stroke one of the recesses will be aligned with the ball to unlock the selector lever. If it is desired to make it compulsory that the hand-throw lever be in the Normal position before allowing the selector lever to be operated, one of the ball recesses in the hand-throw lever must be plugged by the use of stop screw (ASTS USA M287186), as indicated in Figure 2-10.

When used, the stop screw must be applied to a particular recess in the hand-throw lever hub, as follows. With the hand-throw lever in the Normal position, the stop screw must be in the recess on the side of the shaft opposite to the side the selector lever is on when in its MOTOR position (see Figure 2-10).

The lever support can be assembled with the hole for the ball on either side of the lever shaft center. However, it must be assembled so that the hole for the ball is on the same side of the shaft as the selector lever is in for MOTOR position (see Figure 2-10).

The selector lever can be assembled on the square end of its shaft in either of two positions, 180 degrees apart, so as to have the MOTOR position of the lever either toward the motor compartment or toward the circuit controller compartment. Machines are shipped from the factory with the selector lever assembled for MOTOR position toward the motor compartment. If the lever assembly is reversed in the field, the transfer must be made while the crank finger on the end of the shaft is at the bottom of its stroke to force the selector clutch down toward its motor position. Be sure to reassemble the lever support to shift the hole for the ball to meet the requirements in the preceding paragraph. Similarly if a stop screw is applied to one of the ball recesses in the hand-throw lever hub as previously described, it must be shifted so as to be on the side of the shaft opposite to that for MOTOR position of the selector lever.

5.6. Lubrication

Regular and systematic lubrication is recommended; however, the period between times of lubricating depends upon the frequency of operation and upon local climatic and conditions, and therefore can be established from experience by the Supervisory Department.

Before leaving the factory all working parts of the machine except the worm gear compartment are well lubricated. Unpainted and unplated parts are coated with a special lubricant designed to protect these parts against corrosion until installation. This lubricant need not be removed since it will mix readily when new lubricants are added.

For best results, only lubricants complying with strict specifications are recommended. The recommended lubricants can be purchased in convenient quantities from ASTS USA.

Figure 5-6 and Figure 5-7 identify the areas of the switch machine that need lubrication. These points and the proper lubrication are further described in Table 5-2. The following steps present the general lubrication requirements for the switch machines.

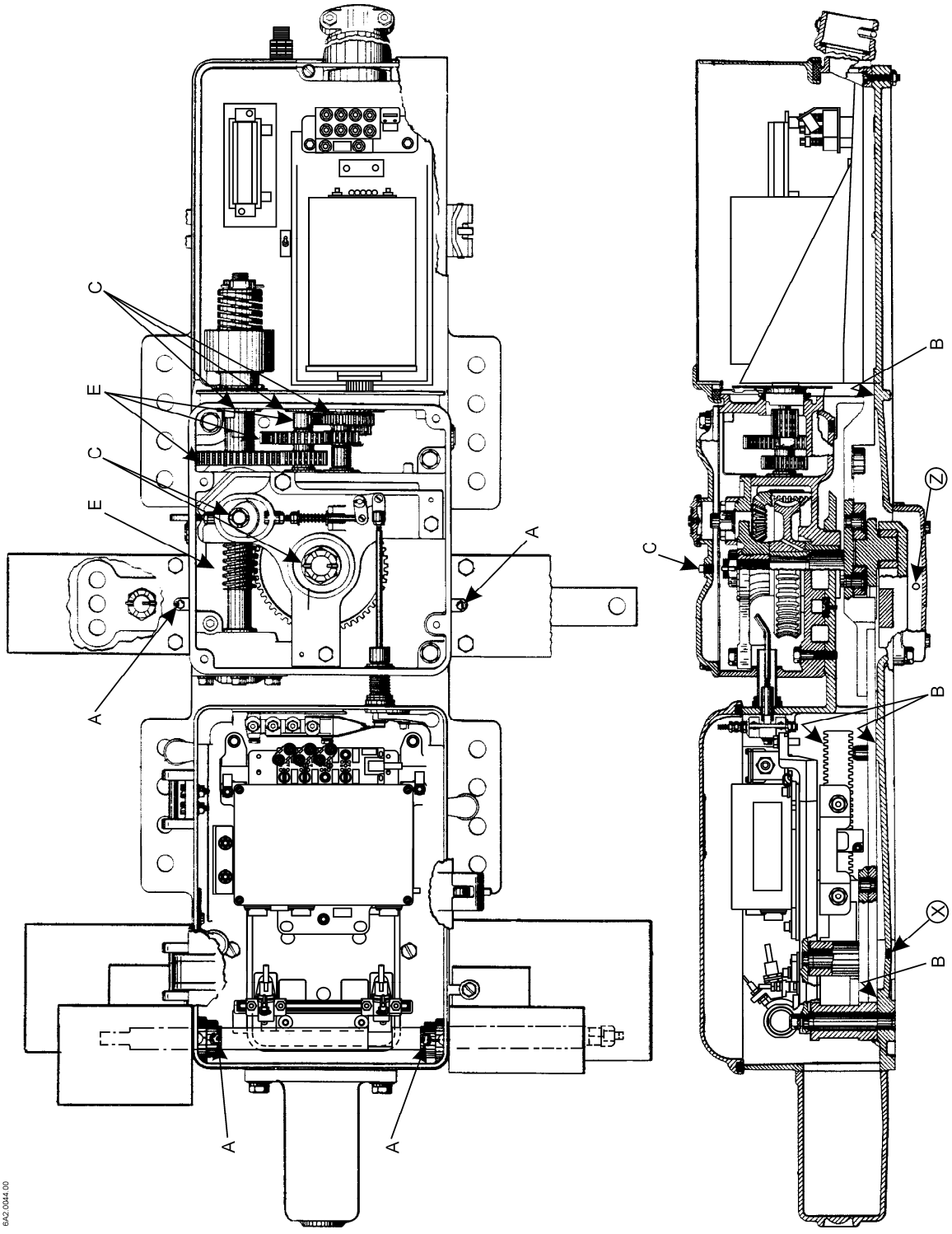


Figure 5-6. M-3 Switch Machine Lubrication Diagram

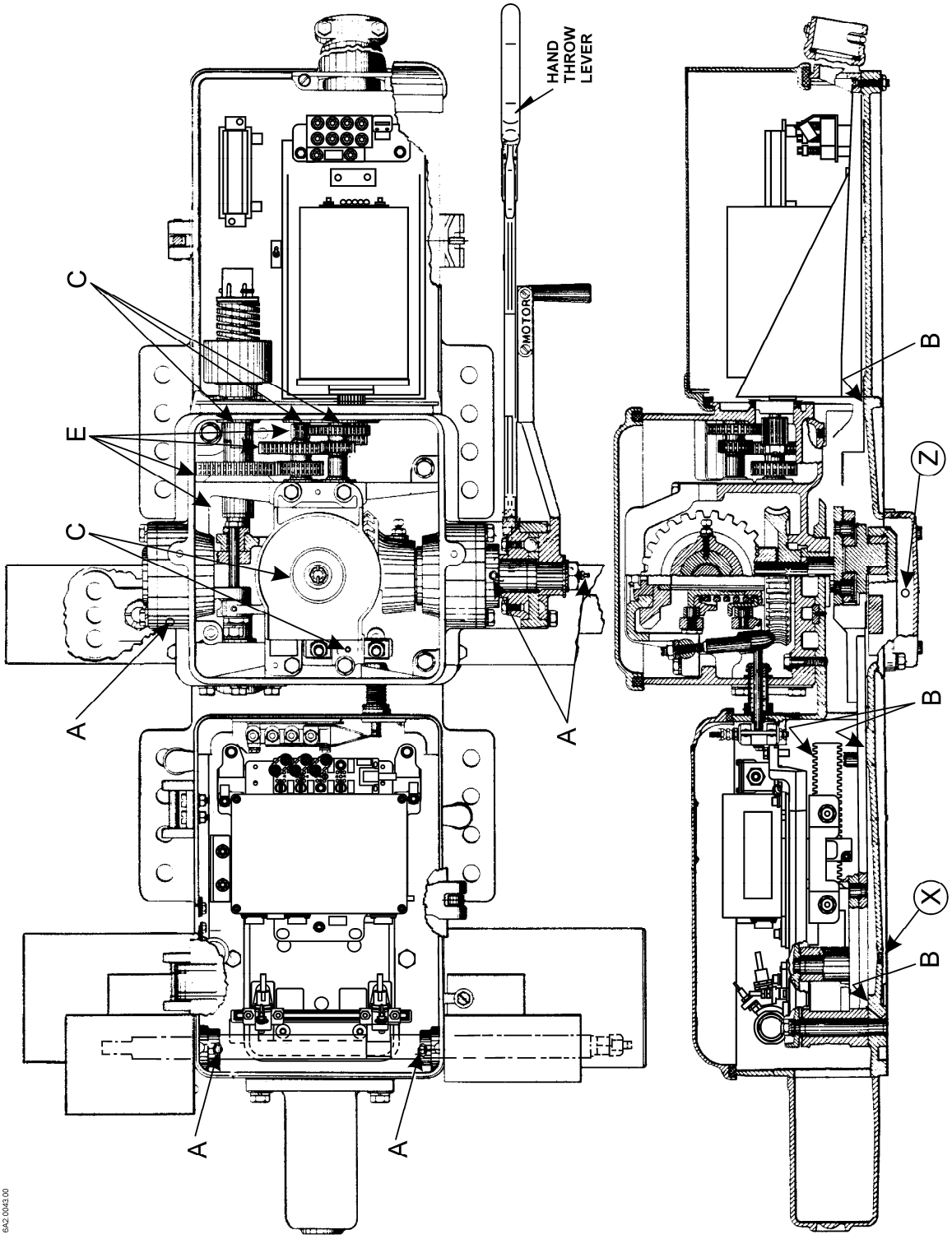


Figure 5-7. M-23 Switch Machine Lubrication Diagram

Table 5-2. M-3 and M-23 Switch Machine Lubrication Specifications

Point of Application	Type of Lubricant & ASTS USA Spec.	Known Products Complying With Spec	Method	Apply To	Remarks
A	Pressure Gun Grease Spec. M-7650-01	Alemite Solidified Oil #32 (Alemite Temprite Solidified Oil E.P. (Prime Mfg. Co)	Grease Gun	Grease Fittings	Apply until surplus is visible at edges of bearing
B	Pressure Gun Grease Spec. M-650-01 *OR* Heavy Oil (Viscosity at 210°F: 120 – 200)	Same as above	Gun or Paddle	Surface	– –
		Auto. Transmission and rear end lubricant S.A.E. 140	Pour or Paddle	Surface	
C	Medium Body Oil (Viscosity at 130° F; 185 – 220)	Automobile Engine Oil S.A.E. 30	Oil Can	Bearings & Oil Cups	A few drops periodically as required
			Pour	Recess on top crank bearing	Fill recess periodically as required
E	Low Temperature Lubricating Oil Spec. M-7652-3	Lubriplate 5555 (Fiske Brothers Refining Co)	Pour	Spur Gear Teeth	Apply light coat to teeth as required
				Gear Box	Pour in. Fill only to top of worm gear

1. Apply pressure gun grease (ASTS USA Spec. M-7650-01)
   a. Point detector bar bearings (use gun on grease fittings).
   b. Operating bar wearing plates (use gun on grease fittings).
   c. Selector and hand-throw lever shaft bearings (use gun on grease fittings).
   d. Surfaces of slide bar and lock box, using brush or paddle for application (a heavy oil, viscosity 120-200, (SAE-140) may be used as an alternate on these surfaces).
2. Apply medium body motor oil viscosity 130°F 185-220 (SAE-30), to the following parts:
   a. Yoke bearings.
   b. Spur gear journals (machines are equipped with Oilite bushings).
      1. Holes in box casting.

NOTE

Oil should be applied sparingly to clutch gear bearing to prevent seepage through clutch shaft packing to the friction discs.

c. Holes in reduction gears and in clutch gear.

d. For M-3 machines only:

1. Main crank shaft – remove oil plug in top cover. Oil will collect in a recess and be led to shaft surfaces needing lubrication.

2. Linkage connections for motor cutout.

e. M-3, M-23A and M-23B machines – fill recess on top crank bearing.

3. Apply a light oil (ASTS USA Spec. M-7610-02) – ***sparingly*** to motor commutator if brushes chatter.

4. From the container shipped with the machine, apply the gear lubricant (Spec. M-7652-3). This is a low-temperature all-weather lubricant that has little change in consistency with temperature variations. It will retain its lubricating properties at the highest temperatures encountered and not become so stiff at low operating temperatures as to require thinning. If sustained unusually low temperatures are expected, a special lubricant may be ordered. Contact your salesman or the Engineering Department for an ordering reference number.

   Apply a light coat of gear lubricant to spur gear teeth. The gear lubricant must be packed well around the worm gear and the selector clutch in the gear box. It must be replaced as necessary to keep the worm gear covered.

CAUTION

Lubrication at proper intervals is essential to ensure proper equipment operation. Do not permit grease or oil to enter spring end of friction clutch, otherwise friction clutch may malfunction.

5.7. Adjustments

5.7.1. M-3 Switch Machine Motor Cutout Contacts

See Figure 5-8 for a detail view of the motor cutout contact and actuator arrangement.

1. Remove the circuit controller cover.

2. With the hand crank cover closed (padlock hasp seated in the staple notch), check that the plunger end of the pushrod (F) clears the contact actuator bracket (H) by 1/16 to 1/8 inch (see enlarged view).

3. Release the padlock hasp and open the hand crank cover. Install the hand crank onto the top of the crankshaft. Check that the motor cutout contact(s) are open by at least 1/8 inch. If the machine includes a latchout function, check that the latch (G) is actuated.

4. Remove the hand crank.

5. If the condition in Step (2.) and/or (3) is not met, adjust the motor cutout linkage as follows:

   a. Remove power from the machine.

   b. Latch the padlock hasp onto the staple. Ensure that the hasp is fully seated in the staple notch. Measure the exposed length of pushrod (A).

   c. Remove the gear box cover.

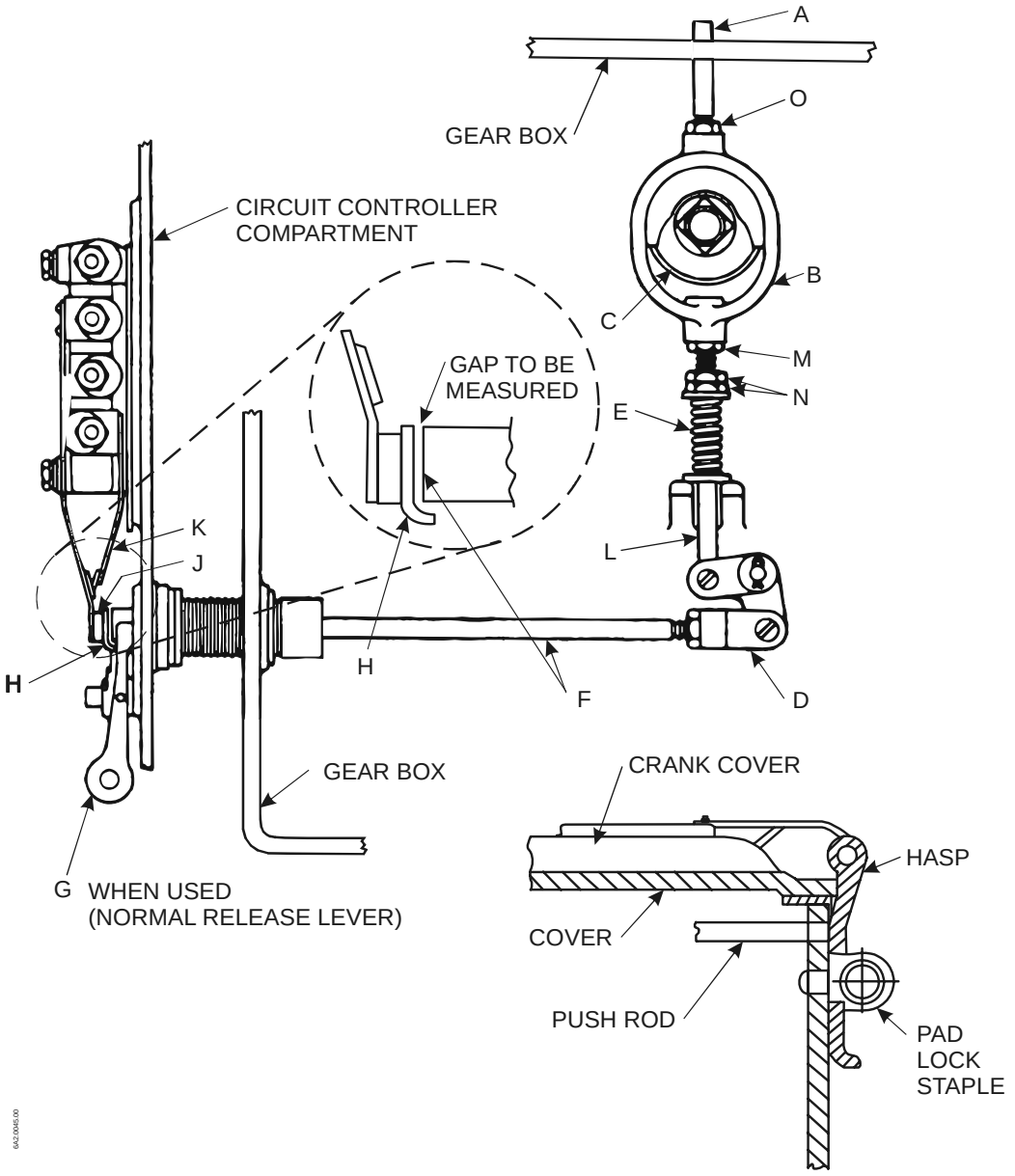
   d. Check the length of spring (E). The total length (including washers) should be 5/8 inch. Adjust nuts (N) as necessary to obtain this length. (This ensures that the spring will not act as a stop by becoming fully compressed.)

   e. Depress pushrod (A) to the distance measured in Step (b.). With the pushrod (A) in this position, the yolk (B) should be about 1/16 inch from the machined stop surface of the top bearing (C). If not, loosen locknut (O) and adjust the pushrod (A) to obtain this clearance. (This adjustment ensures maximum travel of the linkage.)

   f. Reinstall the gearbox cover using only two of the bolts removed in Step (c.).

   g. Latch the padlock hasp onto the padlock staple. Ensure that the hasp is fully seated in the machined notch of the staple.

   h. Check the adjustment of the pushrod (A) by pressing on the latched padlock hasp. There should be about 1/16 inch free play between the edge of the staple notch and the front of the hasp, then a solid connection should be felt.



Item Number	Description
A	Push Rod
B	Yoke
C	Bearing
D	Screw Jaw
E	Spring
F	Push Rod
G	Latch

Item Number	Description
H	Bracket
J	Contact Insulation
K	Contact Spring
L	Eyebolt
M	Nut
N	Nuts
O	Locknut

Figure 5-8. Adjustment of Motor Cutout Contacts (M-3 Machine)

i. If necessary, repeat Steps (c.) through (h.) to adjust the free play to about 1/16 inch, then tighten the pushrod locknut (O).

j. Reinstall the gearbox cover using the bolts removed in Step (c.). Latch the padlock hasp onto the padlock staple. Ensure that the hasp is fully seated in the staple notch.

6. Repeat Steps (2.) through (5.) (as necessary) until satisfactory adjustment is obtained.

7. Reinstall the circuit controller cover using the hardware removed in Step (1.)

8. If required, restore power to the machine.

5.7.2. M-23 Switch Machine Motor Cutout Contacts

Motor cutout contact for the Styles M-23A and M-23B should open when the selector lever is lifted six inches out of the MOTOR position (measured at the hand-grip, and open between 1/8 and 3/16 inch when the selector lever is in the HAND position. When the selector lever is in MOTOR position, the end of the push rod should be 1/16 inch clear of the contact operating bar, and the contacts should be closed with between 1-1/2 and 2 pounds pressure.

A spring bender must be used to adjust the closed pressure (when necessary). With selector lever in the MOTOR position, the rocker arm (Figure 3-9) should be screwed up or down as necessary until it just touches the machined cam surface on the selector yoke. Then the adjusting rod should be turned so that its eccentric head holds the end of the push rod 1/16 inch clear of the contact operating bar.

5.7.3. M-23 Selector Clutch Adjustment

Selector clutch adjustment should be checked occasionally. When the selector lever in the MOTOR position and the selector clutch teeth fully engaged with the teeth on top of the worm gear (so the motor drives the crank), the top rollers on the operating yoke should be just clear of the upper spring cup. To set this relation, adjust the eccentric bushings G1 (Figure 3-5).

See Figure 3-5 and Figure 3-8. Note that the selector clutch yoke has one end supported on and driven by the finger on the selector lever shaft, and its other end pivots on eccentric bushings C1 (Figure 3-5) held fixed by through bolt G. When this bolt is loosened, however, the eccentric bushings may be rotated to raise or lower the center line for the pivot holes in the yoke arms, thus affecting the elevation of the yoke rollers. The eccentric bushings have hexagonal heads for application of an adjusting wrench.

On each eccentric bushing, one flat is stenciled “N” and will be on top when the eccentric is in its mean position. The adjacent flat on one side of the “N” is stenciled (+), and when the eccentric bushings are turned to bring the (+) mark up, the yoke and its rollers are lifted. The flat on other side of the “N” is stenciled (–). The two eccentric bushings should be kept turned a like degree (+) or (–) to avoid twisting the yoke. Then tighten pivot bolt to hold the adjustment.

When necessary to adjust the eccentric bushings, check that top rollers do not bear on the upper spring cup while the selector clutch is fully down. Also check that the rollers are not too high. To do this, operate the selector lever to the MOTOR position when the worm gear is not in position to receive the selector clutch, so that the teeth of "clutch for motor operation," Figure 3-8, ride on top of the corresponding teeth of the worm gear. Insert 1/8 inch length of #14 soft copper wire between the opposed teeth. Adjust the eccentric bushings for the same degree (+) or (–) so that (with their bolt tight) when the selector lever is thrown to horizontal position for MOTOR operation, the force between the opposed teeth will crush the wire to not more than 1/32 inch thick. Also check that upper rollers are free to turn when the selector clutch is fully engaged with the worm gear.

6. TROUBLESHOOTING

Table 6-1 is a troubleshooting matrix that covers ECC failure modes (problems), the possible cause(s) of the problem, and the possible solutions to the problem.

To use the troubleshooting table, identify the problem being experienced from the left-hand "symptom" category column. The possible "causes" of the problem are listed in the right column of the table. Follow the troubleshooting sequence of each symptom by starting at "A" under "troubleshooting" section and working down.

Table 6-1. ECC Troubleshooting w/MCU

Symptom	Troubleshooting	Possible Cause
1. Motor power is present from the wayside but motor does not run. (Start at A and troubleshoot down.)	A. Motor power present on motor terminals?	If YES, motor may be bad or binding.
		If NO, go to B.
	B. Machine motor cutout contacts closed?	If YES, go to C.
		If NO, correct motor cutout open condition.
	C. Motor disable LED on ECC is lit?	If YES, go to D.
		If NO, go E.
	D. Check motor cutout circuit continuity between WAGO 32 and 33/ECC TB1-16 (blue) and TB1-14 (slate). *See Note 1.	If YES to continuity, ECC may be bad.
		If NO, check wiring continuity to motor cutout contacts (49 and 50).
	E. Motor disable LED off. Are direction voltages applied to MCU terminals 29 or 30 (ref. 31)?	If YES (~12V on 30 or 29 referenced to 31), go to F.
		If NO, ECC or TB1 harness may be bad.
	F. Check motor power present from AAR 9 to AAR 4.	If YES, go to G.
		If NO, check wire from AAR 10 to AAR 4.
	G. Check motor power present from AAR 9 to AAR 5.	If NO, check wire from AAR 10 to AAR 4.
		If YES, go to H.
	H. Check motor power present from AAR 9 to AAR 6.	If NO, check wiring continuity to motor cutout contacts (51 & 52).
		If YES, go to I.
	I. Check motor power present from AAR 9 to motor negative.	If NO, check gold nut.
		If YES, go to J.
	J. Check motor power present from motor negative to AAR 1.	If NO, check wire from AAR 6 to motor negative.
		If YES, go to K.
*Note 1: N47303401 ECC boxes used on previous generation machines use an external 750 ohm resistor in place of short to ECC.		

Symptom	Troubleshooting	Possible Cause
	K. Check motor power present from motor negative to motor positive.	If YES, go to A (beginning)
		If NO, MCU is not turning on though direction signals applied (verified at step E). Verify red and white MCU connections are properly connected. MCU may be bad.
2. Motor continues to run at end of stroke in one or both directions (causing friction clutch to slip).	A. Are both direction voltages applied to MCU terminals 29 and 30 (ref. 31) when point detected and point locked sensors indicate locked (in normal or reverse)?	If YES (~12V on 30 & 29 referenced to 31). ECC may be bad. Only 29 or 30 should be ON with machine locked at end of stroke. Both 29 and 30 should be ON during throw. Motor disable will turn both OFF. Verify not reversed.
		If NO, MCU may be shorted.
3. A single dual-colored LED is flashing RED.	A. Temporarily plug replacement sensor in junction box and monitor operation using ECC LED indications. (Use machine as a target)	If replacement sensor operates correctly, reinstall original sensor and verify target adjustment. Replace sensor if problem persists.
		If replacement sensor does not operate correctly, go to B.
	B. Junction box may contain short or open.	If replacement junction box does not correct problem go to C.
	C. ECC may be bad.	Replace ECC.
4. Latch-out LED is flashing RED.	A. Is the configuration jumper properly installed?	If YES, go to B.
		If NO, install jumper and verify operation.
	B. Junction box may be bad.	Replace jumper and then junction box to see if condition is corrected. If not , go to C.
	C. ECC may be bad.	Replace ECC.
5. All four dual-colored LEDs are flashing RED.	A. Verify jumper installed in LHPC or RHPC and jumper installed in only one of the three latch out configurations.	If jumpers correctly installed, go to B.
		If jumpers NOT correctly installed correct jumpers.
	B. Junction box may be bad or not fully seated.	Replace junction box. If problem is not corrected go to C.
	C. ECC may be bad.	Replace ECC.
6. All LEDs on the ECC dark and some or all may or may not return or appear to flash. Could also appear as a flickering condition with possible "clicking" sounds from ECC. Commonly only motor disable LED appears to flash.	A. Verify proper voltage (at least 10 Vdc) applied with proper polarity to WAGO terminals 17 and 20 with sufficient current.	If voltage is low or reversed, correct and verify operation.
		If voltage applied is correct, go to B.
	B. Remove JB1 from ECC and check for both indication inputs, motor disable, and flashing RED point locked/detected indications.	If condition is not as described, go to C.
		If condition is as described, problem is probably junction box or sensors.
	C. Check TB1 connections to ECC.	If connections are fully seated and harness good, ECC may be bad.
		If bad connection, correct by reseating connector or replacing bad harness.

Symptom	Troubleshooting	Possible Cause
7. All diagnostic LEDs are properly lit on the ECC (a continuous vertical row of GREEN LEDS is observed) yet no indication output is present on WAGO terminal strip 1 & 3.	A. Verify TB2 harness connection, red (WAGO #3) to TB2-3 and green (WAGO #1) to TB2-7.	If connections good, go to B.
		If connections bad, replace harness.
	B. ECC may be bad.	Replace ECC.
8. Sensor indication steady RED and does not turn green when target is more than 50% in front of sensor face.	A Verify proper sensor air gap adjustment. Gap should be 0.075" for vital sensors (large diameter), and 0.040" for auxiliary sensors (small diameter).	If sensor adjustment does not correct problem, go to B.
	B Temporarily plug replacement sensor in junction box and monitor operation using ECC LED indications. (Use machine as a target.)	If replacement sensor operates correctly, replace sensor.
		If replacement sensor does not operate correctly, go to C.
	C. Junction box may have bad connection.	If replacement junction box does not correct problem go to D.
	D. ECC may be bad.	Replace ECC.
9. Point Detected and Point Locked LEDs are GREEN but indication output LED is dark.	A. Is the corresponding indication input LED GREEN?	If YES, go to B.
		If NO, verify corresponding indication input at WAGO #13 and #15 or WAGO #10 and #12. Verify TB2 harness connection.
	B. Is the unit in latch-out? Indicated by RED latch out LED.	If YES, depress and hold restore button on front of ECC for at least one second.
		If NO, go to C.
	C. Is motor disabled by ECC? (Indicated by RED motor disabled LED.)	If YES, correct motor disable condition. (reference section 1B of this chart.)
		If NO, go to D.
	D. Is point and/or locking sensor for opposite switch machine ON/GREEN?	If YES, correct condition causing opposing sensor to indicate on.
		If NO, ECC may be bad.
10. The ECC does not latch-out when point detector target is removed from in front of target face and restored.	A. Is machine fully locked? A latch out condition will occur only if the machine is fully locked and the switch point moves away from the stock rail. Lock is indicated by ECC point locked indicating GREEN.	If YES, go to B.
		If NO, correct condition preventing machine from locking.
	B. Is configuration jumper in junction box installed in the disabled position?	If YES, ECC will not latch out when configured as latch out disabled.
		If NO, ECC may be bad.

Table 6-2. ECC Troubleshooting w/EBNC

Symptom	Troubleshooting	Possible Cause
1. Motor power present from wayside but motor does not run (overload circuit). (Start at A and troubleshoot down.)	A. Motor power present on motor terminals?	If YES, motor may be bad or binding.
		If NO, go to B.
	B. Machine motor cutout contacts closed?	If YES, go to C.
		If NO, correct motor cutout open condition.
	C. Motor disable LED on ECC is lit?	If YES, go to D.
		If NO, go E.
	D. Check motor cutout circuit continuity between WAGO 32 and 33/ECC TB1-16 (blue) and TB1-14 (slate). *Note 1	If YES to continuity, ECC may be bad.
		If NO, check wiring continuity to motor cutout contacts (49 and 50).
	E. Motor disable LED off. Are direction voltages applied to EBNC terminals 29 or 30 (ref. 31) and proper request present on bipolar input 34/36?	If YES (~12V on 30 or 29, ref. 31) and polarity on 34/36 correct, go to F.
		If NO, ECC, TB1 harness, or NWR/WR harness may be bad. Verify correct NWR/WR signal applied to WAGO 34/36 if missing.
	F. Check motor power present from AAR 9 to AAR 4.	If YES, go to G.
		If NO, check wire from AAR 10 to AAR 4.
	G. Check motor power present from AAR 9 to AAR 5.	If YES, go to H
		If NO, check wiring continuity to motor cutout contacts (51 and 52).
	H. Check motor power present from AAR 9 to AAR 6.	If YES, go to I
		If NO, check gold nut.
	I. Check motor power present from AAR 1 to AAR 6.	If YES, go to J.
		If NO, check wire from AAR 9 to AAR 1.
	J. Check EBNC motor connections 1, 2, 3 and Gr/Y properly attached.	If YES, EBNC may be bad. (Verify EBNC not in overload – red LED lit.)
		If NO, correct condition.
*Note 1: N473034-01 ECC boxes used on previous generation machines use an external 750 ohm resistor in place of short to ECC.		
2. Motor continues to run at end of stroke in one or both directions (causing friction clutch to slip).	A. Are both direction voltages applied to EBNC terminals 29 & 30 (reference 31) while point detected and point locked sensors indicate locked (normal or reverse)?	If YES (12V on 30 & 29 ref. 31) ECC may be bad. Only 29 or 30 should be ON when machine is locked at end of stroke. Both should be ON during throw. Motor disable will turn both off.
		If NO, EBNC may be shorted.

Symptom	Troubleshooting	Possible Cause
3. A single dual-colored LED is flashing RED.	A. Temporarily plug replacement sensor into junction box and monitor operation using ECC LED indications (Use machine as a target.)	If replacement sensor operates correctly, reinstall original sensor and verify target adjustment. Replace sensor if problem persists.
		If replacement sensor does not operate correctly, go to B.
	B. Junction box may contain short or open.	If replacement junction box does not correct problem go to C.
	C. ECC may be bad.	Replace ECC.
4. Latch-out LED is flashing RED.	A. Is the configuration jumper properly installed?	If YES, go to B.
		If NO, install jumper and verify operation.
	B. Junction box may be bad.	Replace jumper and then junction box to see if condition is corrected. If not , go to C.
		Replace jumper and then junction box to see if condition is corrected. If not , go to C.
	C. ECC may be bad.	Replace ECC.
5. All four dual-color LEDs are flashing RED.	A. Verify jumper installed in LHPC or RHPC & jumper installed in only one of the three latch out configurations.	If jumpers correctly installed, go to B.
		If jumpers NOT correctly installed correct jumpers.
	B. Junction box may be bad or not fully seated.	Replace junction box. If problem is not corrected go to C.
	C. ECC may be bad.	Replace ECC.
6. All LEDs on the ECC dark and some or all may or may not return or appear to flash. Could also appear as a flickering condition with possible "clicking" sounds from ECC. Commonly only motor disable LED appears to flash.	A. Verify proper voltage (at least 10 Vdc) applied with proper polarity to WAGO terminals 17 and 20 with sufficient current.	If voltage is low or reversed, correct and verify operation.
		If voltage applied is correct, go to B.
	B. Remove JB1 from ECC and check for both indication inputs, motor disable, and flashing RED point locked/detected indications.	If condition is not as described, go to C.
		If condition is as described, problem is probably junction box or sensors.
	C. Check TB1 connections to ECC.	If connections are fully seated and harness good, ECC may be bad.
		If bad connection, correct by reseating connector or replacing bad harness.

Symptom	Troubleshooting	Possible Cause
7. All diagnostic LEDs are properly lit on the ECC (a continuous vertical row of GREEN LEDS is observed) but no indication output present on WAGO terminals 1 and 3.	A. Verify TB2 harness connection, red (WAGO #3) to TB2-3 and green (WAGO #1) to TB2-7.	If connections good, go to B.
		If connections bad, replace harness.
	B. ECC may be bad.	Replace ECC.
8. Sensor indication steady RED and does not turn green when target is more than 50% in front of sensor face.	A. Verify proper sensor air gap adjustment. Should be 0.075" for vital sensors (large diameter). For auxiliary sensors (small diameter) gap should be 0.040".	If sensor adjustment does not correct problem, go to B.
	B. Temporarily plug replacement sensor in junction box and monitor operation using ECC LED indications. (Use machine as a target)	If replacement sensor operates correctly, replace sensor.
		If replacement sensor does not operate correctly, go to C.
	C. Junction box may have bad connection.	If replacement junction box does not correct problem go to D.
	D. ECC may be bad.	Replace ECC.
9. Point Detected and Point Locked LEDs are GREEN but indication output LED is dark.	A. Is the corresponding indication input LED GREEN?	If YES, go to B.
		If NO, verify corresponding indication input at WAGO #13 & #15 or WAGO #10 & #12. Verify TB2 harness connection.
	B. Is the unit in latch-out? Indicated by RED latch out LED.	If YES, depress and hold restore button on front of ECC for at least one second.
		If NO, go to C.
	C. Is motor disabled by ECC? Indicated by RED motor disabled LED.	If YES, correct motor disable condition. (reference section 1B of this chart.)
		If NO, go to D.
	D. Is point and/or locking sensor for opposite switch machine ON/GREEN?	If YES, correct condition causing opposing sensor to indicate on.
		If NO, ECC may be bad.
10. The ECC does not latch-out when point detector target is removed from in front of target face and restored.	A. Is machine fully locked? A latch out condition will occur only if the machine is fully locked and the switch point moves away from the stock rail. Lock is indicated by ECC point locked indicating GREEN.	If YES, go to B.
		If NO, correct condition preventing machine from locking.
	B. Is configuration jumper in junction box installed in the disabled position?	If YES, ECC will not latch out when configured as latch out disabled.
		If NO, ECC may be bad.

7. PARTS LISTS

7.1. Configuration Guide

Reference	Description
A	15-Watt, 115V Motor Heater (N294241)
B	Lock Rod Openings Closed
C	Clutch Set to Slip at 14 Amps
D	Equipped with Local/Remote Feature
E	30-Watt, 115/230V Motor Heater (N451589-0101) Wired for 115V
F	Paint Final Assembly per PP-7905 Aluminum (A040331-0101)
G	15-Watt, 115/230V Motor Heaters (N294241 and N296578-001) Wired for 115V
H	Surge Suppressor PCB (N497039-01 LV)
J	Use Crankcase Cover (Item 175) N146290-0002, C9190-Sh. 4 (Item 545) J032902 Not Required
K	Motor Compartment Heater ON/OFF switch
L	Surge Suppressor PCB (N497039-02 HV)

Table 7-1. M-3 Switch Machine Configurations

Part Number		Option Ref.	Base	Motor Assembly	Gear Box (Ratio)	Circuit Controller	Control Circuit Wiring*
Right Hand	Left Hand						
– –	N429500-13	A, D, L	N294752-001	N451161-1701 (110 VDC)	N287485 (189:1)	N426007-02	Two-Wire (EBNC)
N429500-14	– –						

* The wayside provides a fixed-polarity two-wire motor power feed; one of the wires is always (+) and the other wire is always (–). The ECC/EBNC controls the polarity applied to the motor terminals to select Normal or Reverse motion.

Table 7-2. M-23A Switch Machine Configurations

Part Number		Option Ref.	Base	Motor Assembly	Gear Box (Ratio)	Circuit Controller	Control Circuit Wiring*
Right Hand	Left Hand						
– –	N426501-01	E, F, H	N291057	N422008-01 (110 VDC)	N287073 (189:1)	N426007-04	Two-Wire (MCU)
N426501-02	– –				N287073-0001 (189:1)		
– –	N426501-03	E, F, H	N291057	N422008-01 (110 VDC)	N287072 (360:1)	N426007-04	Two-Wire (MCU)
N426501-04	– –				N287072-0001(360:1)		
– –	N426501-05	B, H	N291057	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-04	Two-Wire (MCU)
N426501-06	– –				N287073-0001 (189:1)		
– –	N426501-07	E, F	N291057	N422008-02 (20 VDC)	N287074 (528:1)	N426007-04	Two-Wire (MCU)
N426501-08	– –				N287074-0001(528:1)		
– –	N426501-09	A, D, H	N291057	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-03	Two-Wire (MCU)
– –	N426501-11	A, D, H, K	N291057	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-04	Two-Wire (MCU)
N426501-12	– –				N287073-0001 (189:1)		
– –	N426501-13	D	N293975	N451161-1703 (20 VDC)	N287074 (528:1)	N426007-04	Two-Wire (MCU)
N426501-14	– –				N287074-0001(528:1)		
– –	N426501-17	A, D, H	N291057	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-04	Two-Wire (MCU)
N426501-18	– –				N287073-0001 (189:1)		
– –	N426501-19	A, D, H	N291057	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-04	Two-Wire (MCU)
N426501-20	– –				N287073-0001 (189:1)		

Part Number		Option Ref.	Base	Motor Assembly	Gear Box (Ratio)	Circuit Controller	Control Circuit Wiring*
Right Hand	Left Hand						
– –	N426501-21	A, D, F	N291057	N451161-1703 (20 VDC)	N287074 (528:1)	N426007-03	Two-Wire (MCU)
N426501-22	– –				N287074-0001(528:1)		
– –	N426501-27	B, D, F	N293975	N451161-1703 (20 VDC)	N287074 (528:1)	N426007-04	Two-Wire (MCU)
N426501-28	– –				N287074-0001(528:1)		
– –	N426501-29	A, D, H	N293975	N451161-1701 (110 VDC)	N287073 (189:1)	N426007-03	Two-Wire (MCU)
N426501-30	– –				N287073-0001 (189:1)		
– –	N426501-31	E, F	N291057	N422008-02 (20 VDC)	N287072 (360:1)	N426007-04	Two-Wire (MCU)
N426501-32	– –				N287072-0001 (360:1)		

* The wayside provides a bipolar two-wire motor power feed to select Normal or Reverse motion; when one of the wires is (+) the other wire is (–). The ECC/MCU passes the wayside polarity to the motor terminals to obtain either Normal or Reverse motion.

Table 7-3. M-23B Switch Machine Configurations

Part Number		Option Ref.	Base	Motor Assembly	Gear Box (Ratio)	Circuit Controller	Control Circuit Wiring*
Right Hand	Left Hand						
– –	N426502-01	A, D, H	N433297	N451161-1701 (110 VDC)	N287076 (189:1)	N426007-04	Two-Wire (MCU)
N426502-02	– –				N287076-0001 (189:1)		
– –	N426502-07	E, F	N291057	N422008-02 (20 VDC)	N287077 (528:1)	N426007-04	Two-Wire (MCU)
N426502-08	– –				N287077-0001 (528:1)		
– –	N426502-09	A, D, H	N293975	N451161-1701 (110 VDC)	N287076 (189:1)	N426007-04	Two-Wire (MCU)
N426502-10	– –				N287076-0001 (189:1)		
– –	N426502-19	A, D, H	N433297	N451161-1701 (110 VDC)	N287076 (189:1)	N426007-03	Two-Wire (MCU)
N426502-20	– –				N287076-0001 (189:1)		
– –	N426502-21	A, D, H	N433297	N451161-1701 (110 VDC)	N287076 (189:1)	N426007-03	Two-Wire (MCU)
N426502-22	– –				N287076-0001 (189:1)		

* The wayside provides a bipolar two-wire motor power feed to select Normal or Reverse motion; when one of the wires is (+) the other wire is (–). The ECC/MCU passes the wayside polarity to the motor terminals to obtain either Normal or Reverse motion.

7.2. M-3 Switch Machine Parts List

Table 7-4 contains the parts list for the N429500-xx M-3 switch machines listed in Table 7-1. See Figure 7-1 (switch machine), Figure 7-2 (circuit controller end), and Figure 7-3 (motor end) for location diagrams showing the listed parts.

Table 7-4. M-3 Switch Machine Parts List

ITEM	DESCRIPTION	PART NUMBER
2005	Base, M-3	N294752-001
2015	Motor Assembly	N451161-1701
2025	Name Plate, Aluminum	J063117
2030	Plate, 1/8 x 1” CF Steel	M146595
2045	Screw, 1/2-13 x 1/2 Round Head	J507366
2050	Roller, 2” CF Steel Round	M108315
2055	Roller, 1-3/4” Steel	M074737
2060	Bar, Locking	N178100
2065	Slide Bar Cam	R146444
	Stud	M076018
	Roller	M076019
	Roller	M076020
2070	Roller, 2-1/8” Steel Alloy	M061066
2075	Bar, Operating	M146441
2080	Lug, Switch Point	M146443
2085	Wearing Bracket	M189024
2090	Key, 3/8 x 1” Steel	M146782
2095	Tubing, Rigid PVC 30” L	J034421
2100	Conduit, Outlet Component	N238223
2120	Rod, Push Component	N180861
2130	Contact, Motor	N226029
2135	Bolt, 7/8-9 x 3” Hex Head	J460113
2140	Pipe, Seamless Steel Tubing	M146723
2145	Gasket, 1/4” Felt	M147398
2150	Washer	M147409
2155	Cover, Slide Bar Cast Iron	M074911
2156	Sealant, RTV Black #9732	J041505
2160	Circuit Controller Cover, Complete	N146698
	Gasket	A067035
2165	Cover, Operating Bar Open-End	M148141
2170	Cover, Operating Bar Closed-End	R159272
2175	Crank Case Cover	M146290
2180	Motor Cover	N289299
	Gasket	M320440
2185	Cable Clamp, CH18	J700934
2190	Washer, #10 Flat Steel	J475077

ITEM	DESCRIPTION	PART NUMBER
2191	Washer, #10 Lock Steel	J047733
2195	Washer	M002423
2200	Washer	M286594
2205	Spring, Steel for Lock Movement	M181001
2210	Cover, Lock Rod	N269671
2215	Screw, Locking	PN242122
2220	Cover, Lock Rod	M165752
2225	Plate, 3/16 x 1.7” Steel	M165751
2230	Spring, Steel #12 Wire	J068431
2235	Point Detector Bar Cover, Complete	N296126
2240	Point Detector Bar Cover, Complete	N296125
2245	Nut, 2-1/8” Steel Round Lock	M223351
2250	Collar, 2” Round CF Steel	M074741
2255	Nut, 1/8” Jam	M074742
2260	Operating Crank	M071158
2270	Washer	M067454
2275	Gear Box Cover	PN152633
	Gasket	J047286-001
2280	Motor Cutout Trigger	N146670
2285	Motor Cutout Pushrod	M146675
2290	Nut, 5/16”-18 UNC 2B Jam	J048007
2295	Latch, C. Brass Cutout	M186209
2300	Stud, 1/4” Steel Hex	M181032
2310	Lead	N281552
2340	Plate, Cover	M296066
2345	Washer, W 08 SK Lock	J047821
2350	Lube Fitting, 1/8” Straight	J039137
2355	Lug, Bung Cap W-14x	J320015
2360	Screw, #6 x 1/4” Parker	J052607
2365	Screw, 1/4-20 x 3/4” Fillister Head	J052025
2370	Screw, 5/16 x 1/2” Hex Head	J050034
2375	Screw, 3/8-16 x 1-1/4” Hex Socket	J052362-0003
2380	Screw, 1/2-13 x 2” Hex Head	J050098
2385	Screw, 1/2-13 x 3/4” Hex Head	J050086
2390	Screw, 1/2-13 x 1" Hex Cap	J050088
2391	Screw, 1/2-13 x 1-1/4", Hex Head Steel Cap	J050090
2400	Screw, 1/2-13 x 1-1/2” Hex Head	J050092
2405	(RH Only) Screw, 1/2-13 x 1-1/2” Socket Head Cap	J050236
2415	Washer, 1/2” Steel Lock	J047769
2420	Washer, 7/8” Steel Lock Extra	J047773
2430	Nut, 7/8”-9 UNC 2B Heavy	J048136
2435	Cotter, 1/8 x 3/4” Spring Steel	J048618
2440	Cotter, 3/16 x 2” Spring Steel	J048636
2445	Plug, 1/4” Galvanized Steel	J032901

ITEM	DESCRIPTION	PART NUMBER
2450	Nut, 3/4” Conduit Lock	J048415
2455	Lube Fitting, 1/8” – 67° Angle	J039142
2460	Screw, 5/16-18 x 2” Hex Cap	J050045
2465	Washer, 5/16” Steel Lock Extra	J047767
2470	Nut, 5/16”-18 UNC 2B	J048006
2475	Washer, 5/16” Steel Plate	J047642
2480	Screw, #10-32 x 1/2” Flat Head	J052091
2485	Slushing Compound, M-7646	A041390
2490	Lubricant, Brake Cylinder #M-7651-2	A041353
2495	Tape, 0.010” M-7136-50	A773010
2510	Resistor, 800 Ohm – 30W	N294241
2515	Tag	S000333
2520	Cable Clamp, Burndy HP 8N	J700590
2525	Screw, #8-32 x 1-1/4” Round Head Steel	J525111
2530	Screw, #8-32 x 1/2” Fillister Head	J052256
2545	Pipe Plug, 3/8” Steel	J032902
2550	Bag, Plastic, #60F-0406	J078399
2555	Tag Form	S000169
2560	Screw, #10-32 x 9/16” Fillister Head	J522151
2570	Washer, #10 SST Lock	J475121-0109
2575	Tag Form	S001857
2580	Cover, End Component	N242441
2610	Plate, Cover	M397927-001
2615	Resistor, 800 Ohm – 30W	N294241
2620	Tag	S000333
2625	Cable Clamp, Burndy HP 8N	J700590
2630	Screw, #8-32 x 1-1/4” Round Head Steel	J525111
2635	Screw, #8-32 x 1/2” Fillister Head	J052256
2655	Wire Tag, 12" Bundle	S705.11
2695	Washer, 1/2” Steel Plate	J047503
2700	Mechanism (Gearbox) Complete, M-3	
	189:1 Gear Ratio	PN287485
	360:1 Gear Ratio (Not Currently Available)	– –
	528:1 Gear Ratio (Not Currently Available)	– –
2705	Spacer, 3/8” Round Brass	J725920
2710	Plate, Cover	M451611-2401
2720	(LH Only) Screw, 1/2-13 x 2-1/2” Hex Head Cap	J050101
2740	Spacer, 3/8” Round Brass	J725920
2745	Plate, Cover	M451611-2401
2805	Motor Cutout Push Rod	N180861
2810	Pipe Nipple	M146723
2815	Bushing	M296122
2820	Worm Gear	M074805
2825	Screw	M302256

ITEM	DESCRIPTION	PART NUMBER
2830	Stud	M074735
2835	Stud	M074736
2840	Lock Rod Support	M074738
2845	Hinge Lug	N285692
2850	Adjustable Hasp	N272961
2855	Eccentric Stud	M285680
2860	Stud	M147534
2865	Hasp	N301050
2870	Pin	M209199
2875	Rivet	M049475
2880	Yoke	M146671
2885	Rod	M146674
2890	Crank	M146673
2895	Screw Jaw	M146677
2900	Spring	M074790
2905	Washer	M065762
2910	Screw	J052202
2915	Harness Clamp	J700589
2920	Hand Crank	
	Six- Inch Length	M146694
	Nine-Inch Length	R451568-2305
2925	Washer, Lock	J047521
2930	Washer, 3/8” Steel Lock	J047768
2935	Nut, 3/8”-16 UNC	J048010
2940	Washer, 5/16” Plated. Steel Lock	J047526
2945	Washer	M002423
2950	Screw, 5/16 x 1/2” Hex Rd.	J050034
2955	Screw, 1/2 x 1-1/2” Socket Head	J050236
3005	Assembly, CC ECC M-23 Upgrade w/Aux. Sensors	N426007-02
3010	Target, Complete, M-23 Upgrade	M423228-03
3015	Bar, M-23 ECC Point Detector w/Clevis End	M423732-01
3025	Screw, 1/4-20 x 3/4" Socket Head Cap	J500124-0158
3030	Screw, 1/2-20 x 1/2” Cup-Point Set	J500124-0149
3035	Bushing, Point Detector	M423709-01
3040	Screw, 1/2-13 x 1.5" Flat Head	J500124-0164
3050	Block, Rotational Stop	M423714-01
3055	Screw, 3/8-16 x 1-1/4” Hex Head	J507372
3060	Washer, 3/8” Steel Lock Extra	J047768
3065	Lock Box Target	M423705-02
3070	Screw, 1/4-20 x 1.5" Socket Head Cap	J500124-0163
3075	Spring Pin, 3/16 x 1.5"	J068014-0009
3080	Washer, 1/4” SST Lock	J475121-0111
3085	Harness, M-23 Upgrade, Small Five-Key, TB1	N426002-01
3087	Harness, M-23 Upgrade, Small Four-Key, TB2	N426002-02

ITEM	DESCRIPTION	PART NUMBER
3090	Motor Cutout, AAR Jumper	N422701-01
3092	Motor Cutout, WAGO Jumper	N422701-03
3095	AAR Terminal Bracket Assembly	N426001-01
3100	Washer, 17/64 x 9/16” Copper	J047818
3102	Nut, #14-24 Hex Brass Nickel Plated	J480300
3104	Nut, #14-24 Hex Brass	J480301
3106	Nut, Molded	J048300
3108	Connector, #18 x 1/2"	M047290
3110	Link, Test	J071626
3115	AAR Jumper	N426003-01
3120	AAR Jumper	N422701-05
3125	PCB, Gas Tube Arrestor	N497035-01
3130	Screw, 1/2-13 x 3-1/2", Hex Head Cap Zinc Plated	J500124-0210
3135	Washer, 1/2” SST Lock	J475121-0115
3140	Spacer, AAR Bracket	M423171-01
3145	AAR Jumper	N426003-02
3150	Arrestor, High Voltage	N451552-0201
3155	Wire, #6 AWG ETFE Green	A045848-0089
3156	Terminal, Ring Tongue #10 Stud, #6 AWG	J730826
3157	Terminal, Ring Tongue 324047	J731399-0160
3160	Cord Grip, 1/2" NPT Male	J690234-0034
3170	Terminal Block	N422903-01
3172	Screw, #10-32 x 5/8” Socket Head	J500124-0004
3174	Washer, #10 SST 1/4" ID	J475120-0126
3176	Washer, #10 SST Lock	J475121-0109
3178	Nut, #10-32 Square Steel	J048224
3190	Electronic Biased Neutral Controller – High Voltage	N473049-02
3195	Screw, 3/8-16 x 4” SST Cap	J500124-0025
3197	Washer, 3/8” Split Lock	0.003351-02
3199	Cable Clamp, 5/8 x 3/4", 0.406" Mounting Hole	J690234-0037
3220	Cable Clamp, CH18	J700934
3220	Cable Clamp, CH18	J700934
3222	Screw, #10-32 x 9/16” Fillister Head	J522151
3240	Not Used	– –
3242	Not Used	– –
3340	PCB, Surge Suppressor, High Voltage (110V)	N497039-02
3500	Lubricant, Can	N320264
– –	Heater for Motor Compartment (Not Shown)	
	15W – 115V	N294241
	30W – 115/230V (Wired for 115V)	N451589-0101
	15W – 115/230V (Wired for 115V)	N294241 *and* N296578-001

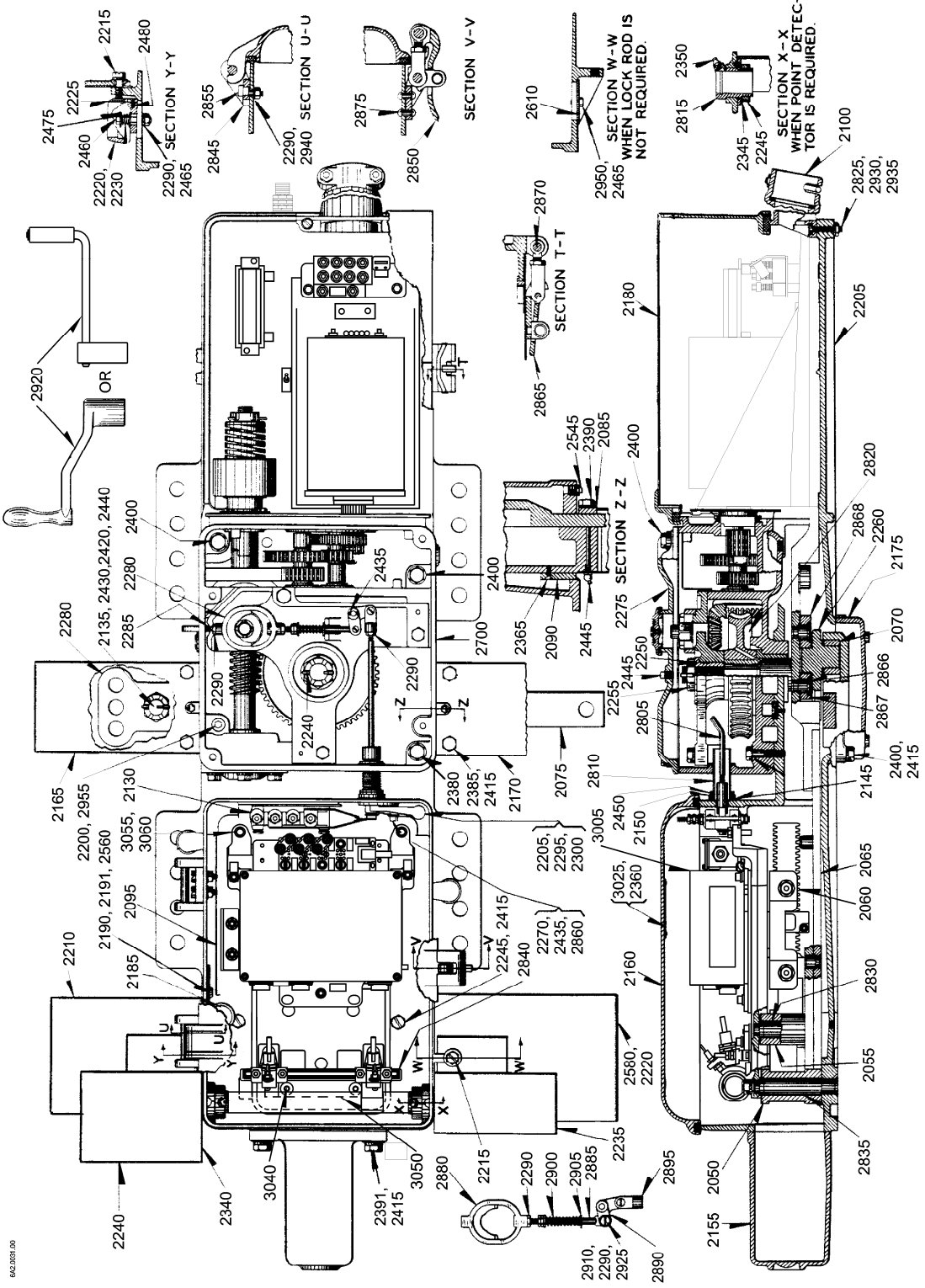


Figure 7-1. M-3 Switch Machine Parts Location

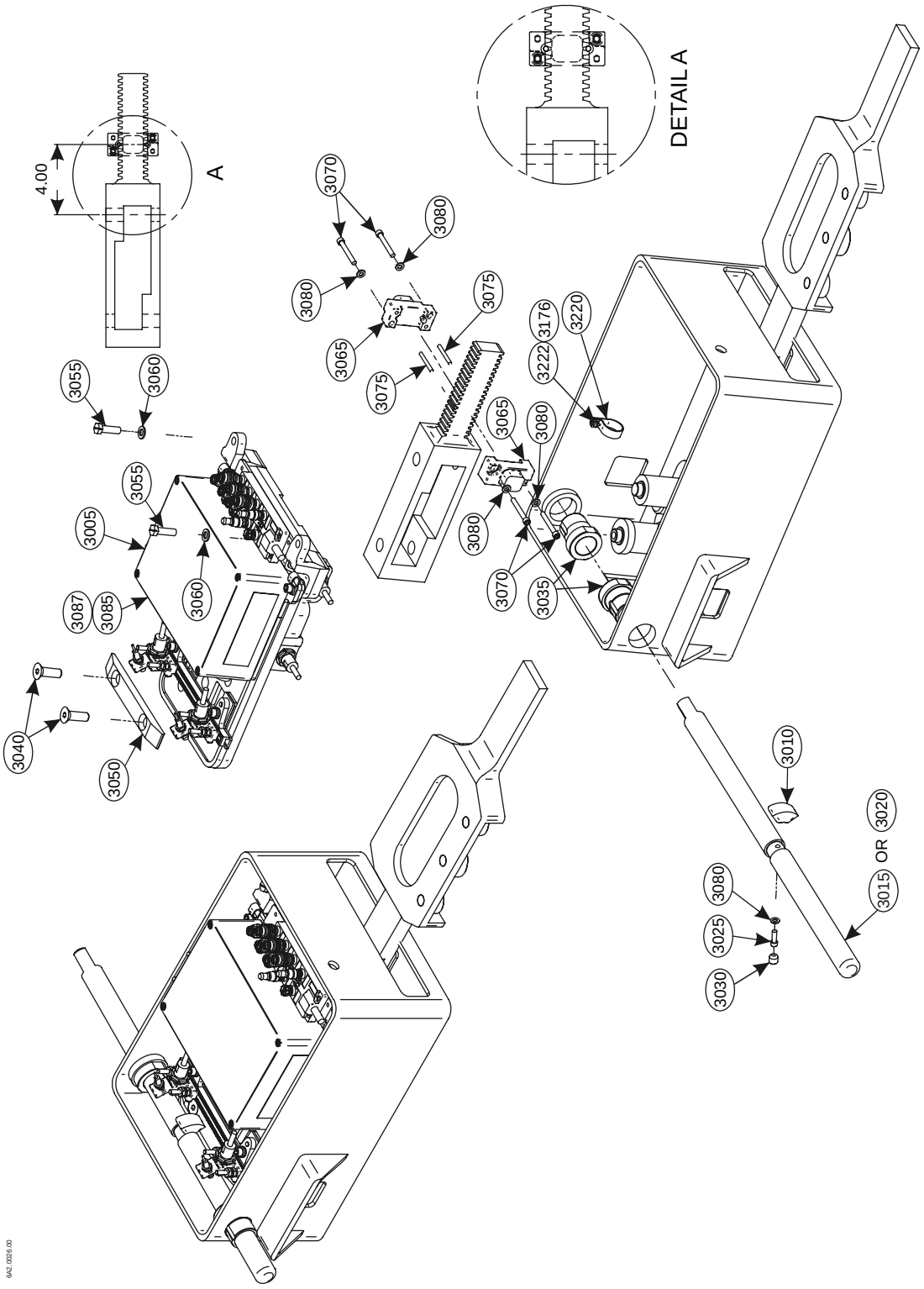


Figure 7-2. M-3 and M-23 Circuit Controller End Parts Location

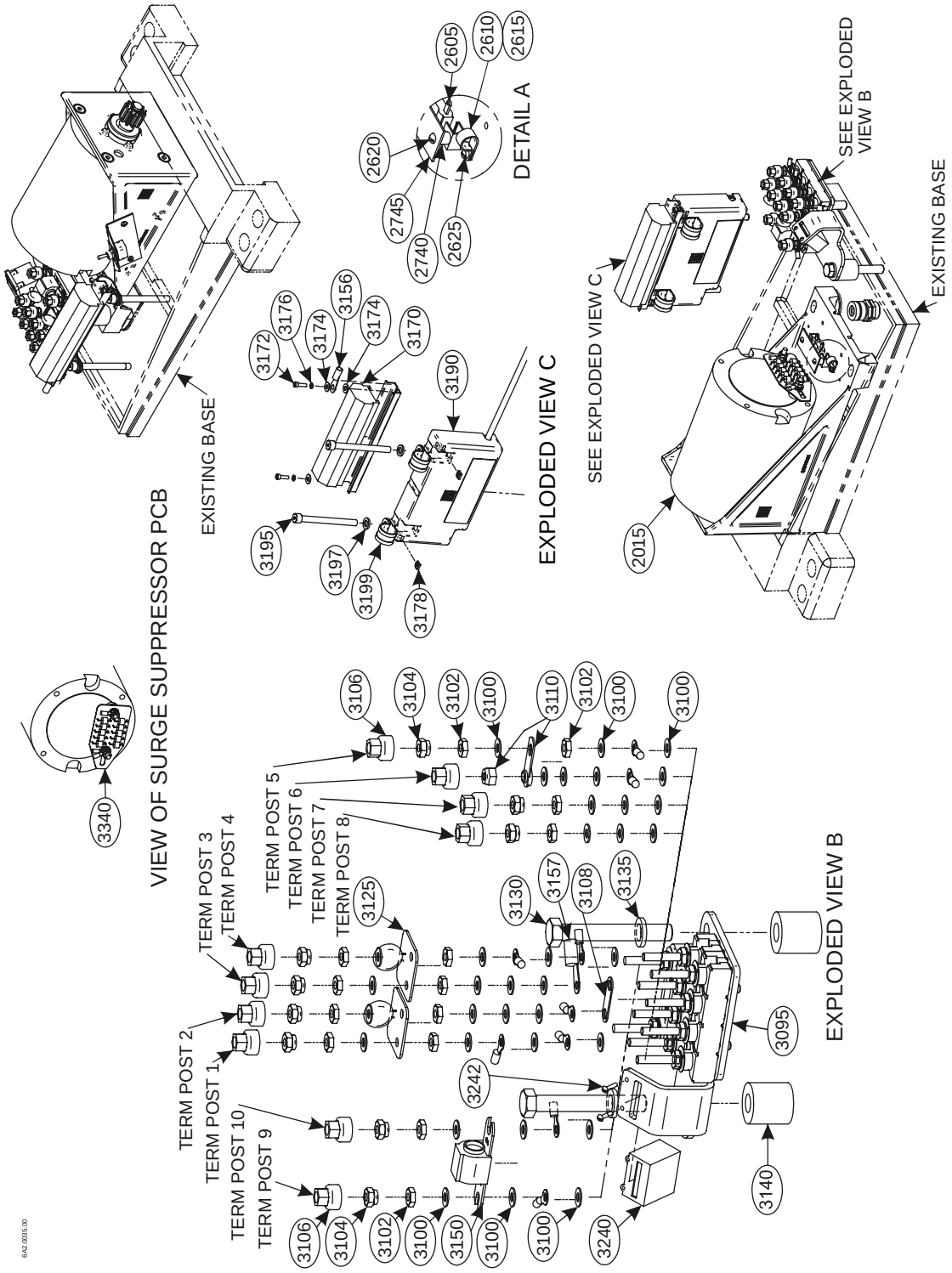


Figure 7-3. M-3 and M-23 Motor End Parts Location

7.3. M-23 Switch Machine Parts List

Table 7-5 contains the parts list for the N426501-xx (M-23A) and N426502-xx (M-23B) switch machines listed in Table 7-2 and Table 7-3. See Figure 7-4 (switch machine), Figure 7-2 (circuit controller end), and Figure 7-3 (motor end) for location diagrams showing the listed parts.

Table 7-5. M-23 Switch Machine Parts List

Item	Description	Part Number
2005	Base, M-23A Machines	
	Suffixes 01 – 09; 11 – 12; -17 – 22; -31 – 32	N291057
	Suffixes 13 – 14; 27 – 30	N293975
	Base, M-23B Machines	
	Suffixes 01 – 02; 19 – 22	N433297
	Suffixes 07 – 08	N291057
	Suffixes 09 – 10	N293975
2015	Motor Assembly, M-23A Machines (110 VDC)	
	Suffixes 01 – 04	N422008-01
	Suffixes 05 – 06; 09; 11 – 12; 17 – 20; -29 – 30	N451161-1701
	Motor Assembly, M-23A Machines (20/36 VDC)	
	Suffixes 07 – 08; 31 – 32	N422008-02
	Suffixes 13 – 14; 21 – 22; -27 – 28	N451161-1703
	Motor Assembly, M-23B Machines (110 VDC)	
	Suffixes 01 – 02; 09 – 10; 19 – 22	N451161-1701
	Motor Assembly, M-23B Machines (20/36 VDC)	
	Suffixes 07 – 08	N422008-02
2025	Screw, 3/8-16 x 1-1/4” Hex Head	J507372
2030	Name Plate, Aluminum	J063117
2040	Screw, 1/2-13 x 1/2” Round Head	J507366
2045	Roller, 2” CF Steel Round	M108315
2050	Roller, 1-3/4” Steel	M074737
2055	Bar, Locking	N178100
2060	Slide Bar Cam	R146444
2065	Roller, 2-1/8” Steel Alloy	M061066
2070	Bar, Operating	M146441
2075	Lug, Switch Point	M146443
2080	Wearing Bracket	M189024
2085	Key, 3/8 x 1” Steel	M146782
2090	Tubing, Rigid PVC 30" L	J034421
2095	Conduit, Outlet Component	N238223
2115	Push Rod, Motor Cutout	N286607
2125	Contact, Component	N226028
2130	Screw, 7/8-9 x 3” Hex Head	J460113
2135	Pipe Nipple, 3/4" Brass Tubing	M286599
2140	Gasket, 1/4” Felt	M147398

Item	Description	Part Number
2145	Washer	M147409
2150	Cover, Slide Bar Cast Iron	M074911
2151	Sealant, RTV Black #9732	J041505
2155	Circuit Controller Cover	N149924
2160	Operating Bar Cover	M148141
2165	Cover, End Closed	R159272
2170	Crank Case Cover	M146290
2175	Motor Cover	N289299
2180	Cable Clamp, CH18	J700934
2185	Washer, #10 Flat Steel	J475077
2190	Washer	M002423
2195	Washer	M286594
2200	Coil, Spring	M286589
2205	Cover, Lock Rod	N269671
2210	Screw, Locking	PN242122
2215	Cover, Lock Rod	M165752
2225	Spring, Steel #12 Wire	J068431
2230	Point Detector Bar Cover, Complete	N296126
2235	Point Detector Bar Cover, Complete	N296125
2240	Nut, 2-1/8” Steel Lock	M223351
2245	Lever, Selector	M274597
2250	Hand Throw Lever	M423131-02
2255	Plate, Motor	M287198
2260	Plate, Hand	M287199
2265	Clamp, Harness	J703005
2295	Plate, Cover	M296066
2300	Screw, 1/4-20 x 7/16” Fillister Head	J052174
2305	Screw, #6 x1/4” Parker	J052607
2310	Screw, 1/4-20 x 3/4” Fillister Head	J052025
2320	Screw, 5/16 x 1/2” Hex Head	J050034
2325	Screw, 3/8-16 x 1-1/4” Hex Socket	J052362-0003
2330	Screw, 1/2-13 x 2” Hex Head	J050098
2335	Screw, 1/2-13 x 3/4” Hex Head	J050086
2340	Screw, 1/2-13 x 1” Hex Cap	J050088
2350	Screw, 1/2-13 x 1-1/2” Hex Head	J050092
2355	Plate, Cover	M397927-001
2360	Screw, 1/2 x 1-1/2” Socket Head Cap	J050236
2365	Screw, 1/2-13 x 1-3/4”	J050237
2370	Washer, 3/8” Steel Lock Extra	J047768
2375	Washer, 1/2” Steel Plate Lock	J047769
2380	Washer, 7/8” Steel Lock Extra	J047773
2390	Nut, 7/8”-9 UNC 2B Heavy	J048136
2395	Screw, #10-32 x 9/16” Fillister Head	J522151
2400	Cotter, 3/16 x 2” Spring Steel	J048636

Item	Description	Part Number
2405	Ball, 3/4” STD Steel	J066012
2410	Nut, 3/4” Conduit Lock	J048415
2415	Bushing, 1-1/8” Hex Steel	M308325
2420	Lube Fitting, 1/8” 67° Angle	J039142
2425	Screw, 5/16-18 x 2” Hex Cap	J050045
2430	Washer, 5/16” Steel Lock Extra	J047767
2435	Nut, 5/16”-18 UNC 2B	J048006
2440	Washer, 5/16” Plate Steel	J047642
2445	Screw, #10-32 x 1/2” Flat Head	J052091
2450	Screw, 3/8-16 x 1/2” Hex Head	J050049
2455	Bushing, 1/2 x 0.502” Oilite Bearing	M399589
2465	Washer, W-08 SKF Lock	J047821
2475	Lug, Bung Cap W-14X	J320015
2480	Cable Clamp, 3 Position Ring, 1-1/2" Dia. Max.	J700589
2485	Washer, #10 SST Lock	J475121-0109
2490	Tag Form	S001857
2505	Cover, End Component	N242441
2506	Cover, Long Closed Lock Rod	N242439
2510	Tag, Instruction	S000264
2515	Pipe Plug, 3/8” Steel	J032902
2610	Tag	S000333
2615	Cable Clamp, Burndy HP 8N	J700590
2620	Screw, #8-32 x 1-1/4” Round Head Steel	J525111
2625	Screw, #8-32 x 1/2” Fillister Head	J052256
2640	Bag, Plastic #60F-0406	J078399
2645	Wire Tag, 12" Bundle	S705.11
2650	Terminal Connector	M120343
2660	Tag Form	S000169
2675	Slushing Compound, M-7646	A041390
2680	Lubricant, Brake Cylinder #M-7651-2	A041353
2685	Tape, 0.010” M-7136-50	A773010
2695	Tag	N451640-2902
2700	Washer, 1/2” Steel Plate	J047503
2715	Terminal Connector	M022725
2740	Spacer, 3/8” Round Brass	J725920
2745	Plate, Cover	M451611-2401

Item	Description	Part Number
2760	Gear Box, M23A (189:1)	
	(Left Hand) Suffixes 01; 05; 09; 11; 17; 19; 29	N287073
	(Right Hand) Suffixes 02; 06; 12; 18; 20; 30	N287073-0001
	Gear Box, M23A (360:1)	
	(Left Hand) Suffixes 03; 31	N287072
	(Right Hand) Suffixes 04; 32	N287072-0001
	Gear Box, M23A (528:1)	
	(Left Hand) Suffixes 07; 13; 21; 27	N287074
	(Right Hand) Suffixes 08; 14; 22; 28	N287074-0001
	Gear Box, M-23B (189:1)	
	(Left Hand) Suffixes 01; 09; 19; 21	N287076
	(Right Hand) Suffixes 02; 10; 20; 22	N287076-0001
	Gear Box, M23B (360:1)	
	(Left Hand) Not Currently Available	– –
	(Right Hand) Not Currently Available	– –
	Gear Box, M-23B (528:1)	
	(Left Hand) Suffix 07	N287077
	(Right Hand) Suffix 08	N287077-0001
2770	Screw,1/2-13 x 2-1/2” Hex Head	J050101
2805	Stud	M074735
2810	Stud	M074736
2815	Lock Rod Support	M074738
2820	Hinge Lug	N285692
2825	Adjustable Hasp	N272961
2830	Eccentric Stud	M285680
2835	Pin	M209199
2840	Rivet	J049475
2845	Rivet	J049452
2850	Ventilator	N070109
2855	Screw, 1/2-13 x 1-1/4” Hex	J050090
2860	Bushing	M296122
2865	Lubricating Fitting, 1/8” Straight	J039137
2870	Machine Screw, No. 12-28 x 1-1/8” Rd. Hd. S. (Plated)	J052614
2875	Nut	M035216
2880	Washer	N218713
2885	Plate	M165751
2890	Screw, 5/16"18 x 1-3/4" Hex Head Steel Cap	J050044
2895	Washer, 5/16” Steel Plated.	J047642
2900	Nut 5/16-18 UNC	J048006
2905	Washer, 5/16” Plated Steel Lock	J047526
2910	Hasp	N301050
2915	Bolt	J050048
2920	Stop Screw (When Used)	M287186
2925	Nut, 3/8 Hex Jam	J048010

Item	Description	Part Number
3005	Assembly, Circuit Controller, ECC wo/Aux, wo/L-R	
	M-23A Suffixes 09, 21 – 22, 29 – 30	N426007-03
	M-23B Suffixes 19 – 22	
	Assembly, Circuit Controller, M-23 ECC w/Aux, wo/L-R	
	M-23A Suffixes 01 – 08, 11 – 14, 17 – 20, 27 – 28, 31 – 32	N426007-04
	M-23B Suffixes 01 – 02, 07 – 10	
3010	Target, Complete, M-23 Upgrade	M423228-03
3015	Bar, Point Detector w/Clevis End	M423732-01
3020	Bar, Point Detector w/Threaded End	M423717-01
3025	Screw, 1/4-20 x 3/4" Socket Head Cap	J500124-0158
3030	Screw, 1/2-20 x 1/2” Cup Point Set	J500124-0149
3035	Bushing, Point Detector	M423709-01
3040	Screw, 1/2-13 x 1.5" Flat Head	J500124-0164
3050	Block, Rotational Stop	M423714-01
3055	Screw, 3/8-16 x 1-1/4” Hex Head	J507372
3060	Washer, 3/8” Steel Lock Extra	J047768
3065	Lock Box Target	M423705-02
3070	Screw, 1/4-20 x 1.5" Socket Head Cap	J500124-0163
3075	Spring Pin, 3/16" x 1.5"	J068014-0009
3080	Washer, 1/4” SST Lock	J475121-0111
3085	Harness, M-23 Upgrade, Small Five-Key TB1	N426002-01
3087	Harness, M-23 Upgrade, Small Four-Key TB2	N426002-02
3088	Motor Cutout, AAR Jumper (Not Shown)	N422701-06
3089	Motor Cutout, WAGO Jumper (Not Shown)	N422701-07
3090	Motor Cutout, AAR Jumper (Not Shown)	N422701-01
3092	Motor Cutout, WAGO Jumper (Not Shown)	N422701-03
3093	MCU to WAGO Jumper (Not Shown)	N426003-03
3095	AAR Terminal Bracket Assembly	N426001-01
3100	Washer, 17/64 x 9/16” Copper	J047818
3102	Nut, 14-24 Hex Brass Nickel Plated	J480300
3104	Nut, 14-24 Hex Brass	J480301
3106	Nut, Molded	J048300
3108	Connector, #18 x 1/2"	M047290
3110	Link Test	J071626
3115	AAR Jumper	N426003-01
3120	AAR Jumper	N422701-05
3125	PCB, Gas Tube Arrestor	N497035-01
3130	Screw, 1/2-13 x 3-1/2", Hex Cap Zinc Plated	J500124-0210
3135	Washer, 1/2” SST Lock	J475121-0115
3140	Spacer, AAR Bracket	M423171-01
3145	AAR Jumper	N426003-02
3150	Arrestor, High Voltage	N451552-0201
3155	Wire, #6 AWG ETFE Green	A045848-0089
3156	Terminal, Ring Tongue #10 Stud, #6 AWG	J730826

Item	Description	Part Number
3157	Terminal, Ring Tongue, 324047	J731399-0160
3160	Cord Grip, 1/2" NPT Male	J690234-0034
3170	Terminal Block	N422903-01
3172	Screw, #10-32 x 5/8” Hex Socket Head Cap	J500124-0004
3174	Washer, #10 SST 0.250" ID	J475120-0126
3176	Washer, #10 SST Lock	J475121-0109
3178	Nut,#10-32 Square Steel	J048224
3190	Motor Control Unit, High Voltage (110V)	
	M-23A Suffixes 01 – 06; 09; 11 – 12; 17 – 22; 29 – 30	N473048-01
	M-23B Suffixes 01 – 02; 09 – 10; 20 – 22	
	Motor control Unit, Low Voltage (24V)	
	M-23A Suffixes 07 – 08, 13 – 14. 27 – 28; 31 – 32	N473048-02
	M-23B Suffixes 07 – 08	
3195	Screw, 3/8-16 x 4” SS Cap	J500124-0025
3197	Washer, 3/8” Split Lock	0.00335102
3199	Cable Clamp, 5/8 x 3/4”, 0.406" Mounting Hole	J690234-0037
3220	Cable Clamp, CH18	J700934
3222	Screw, #10-32 x 9/16” Fillister Head	J522151
3240	Counter, 6 Digit 24V, E6B628GM	J620921-0051
3242	Screw, #4 x 1/2” Round Head Type B	J525056
3244	Ferrule, #20 AWG Grey, #216-222	J709146-1427
3250	Tubing, Spiral Wrap	A774186
3500	Lubricant, Can	N320264
– –	Heater For Motor Compartment (Not Shown)	
	15W – 115V	N294241
	30W – 115/230V (Wired for 115V)	N451189-0101
	15W – 115/230V (Wired for 115V)	N294241 *and* N296578-001

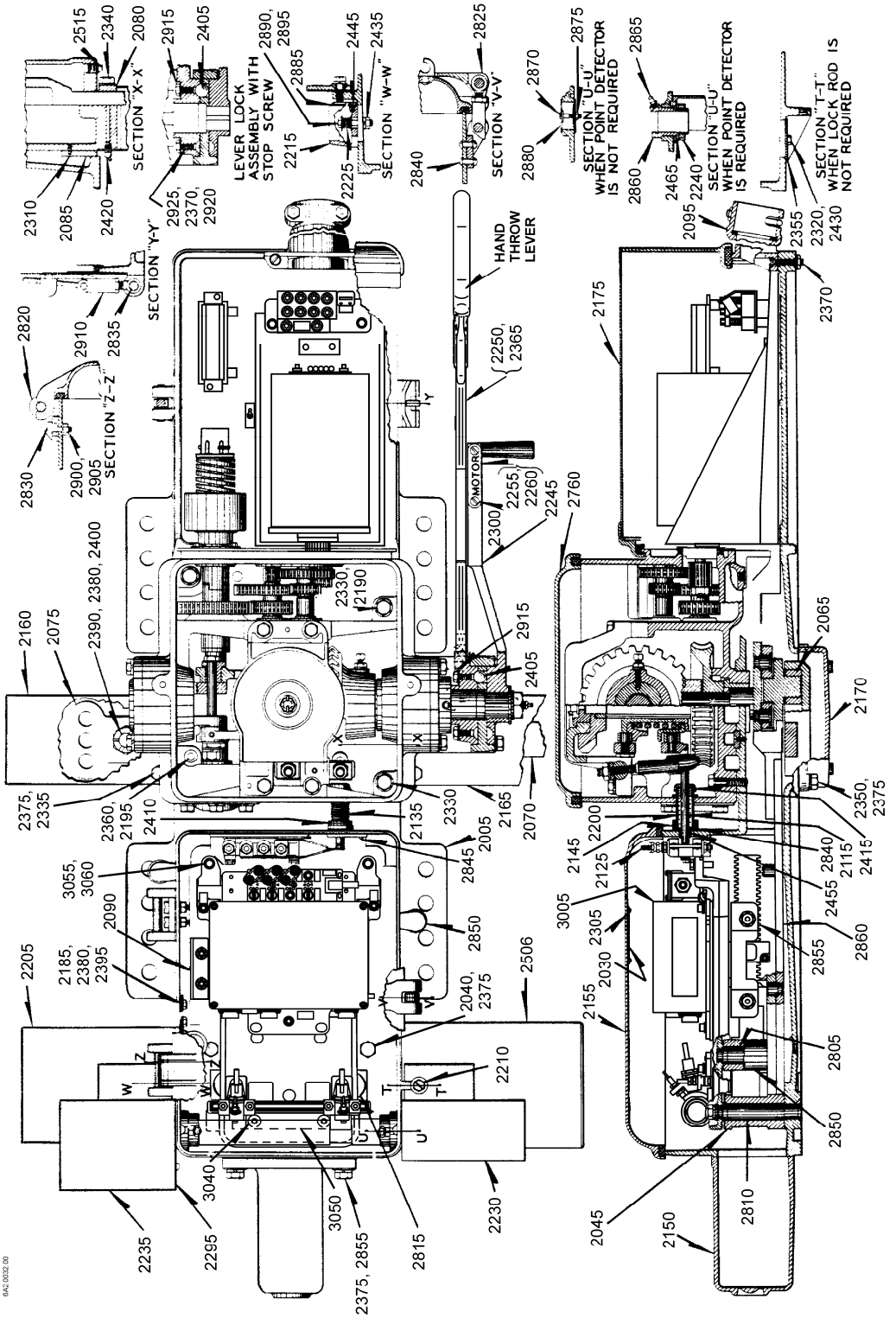


Figure 7-4. M-23 Switch Machine Parts Location

7.4. M-3 Gear Box Parts List

Table 7-6 contains the parts list for the N287485 M-3 gear box listed in Table 7-1. See Figure 7-5 for a location diagrams showing the listed parts.

Table 7-6. M-3 Gear Box Parts List

Item	Description	Part Number
5	Gear Box Complete (Includes Bushings and Oil Seals)	N287085-002
10	Bearing, Top Component	PN146606
15	Shaft, Worm	M286612
20	Housing, Clutch	N172752
25	Plate, End	M146575
30	Plate, Clutch	M146574
35	Plate, Clutch	M146573
40	Disc Lining, 3/16” Thick	M146650
45	Spring, Steel Friction Clutch	M239322
50	Nut, Adjusting	M286615
55	Gasket, Felt	J047335
60	Washer	M245192
65	Plate,0.0966 x 48 x 120” Steel	M147400
70	Gasket, 1/32 x 36” Vellum	M147410
75	Bearing Cap, Cast Iron	M274596
80	Gear, Clutch	N286583
85	Gear, Bevel	M286995
90	Gear, Bevel	M146377
95	Shaft, 3/4” Steel	M149700
100	Reduction Gear (189:1 Gear Ratio)	M286576
105-115	Not Used	– –
120	Shaft, End Plate	M286587
125	Pin, 1/4 x 1-1/4” Dowel	J048925
130	Bushing, Oilite 2 x 1/4"	J079694
135	Not Used	– –
140	Gear, Shaft	M292426
145	Hasp, Lug	M165738
150	Screw, 1/4-20 x 3/4” Hex Head SST	J500097-0112
155	Screw, ,5/16 x 3/4” Hex Head	J050036
160	Screw, 1/2-13 x 1-1/4” Hex Head	J050090
165	Screw, 1/2-13 x 1-1/2” Hex Head	J050092
170	Washer, 5/16” Plate Steel Lock	J047526
175	Washer, 1/2” Plate Steel Lock	J047783
180	Pipe Plug, 1/2” Steel	J032904
185	Ball Bearing, Angular Contact D-Row 35 mm	J066032
190	Ball Bearing, Single Row	J066246
195	Washer, WH-07 SKF Lock	J047810
200	Nut, N 07 SKF Lock	J048575

Item	Description	Part Number
205	Key, 9 WDF 3/4 x 3/16”	J048755
210	Cotter, 3/16 x 2” Spring Steel	J048636
215	Ring, External Retaining	J790076
220	Oil Seal, Garlock 556	J790261
225	Worm Gear	M074805
305	Bushing, Oilite STD WROT	J790008
310	Bushing, Oilite AA-1011-5	J790007
315	Bushing, Oilite A-1704-4	J790004
320	Bushing for Crank (Not Shown)	M451393-0501
325	Bushing, Oilite 1.003” OD	J790291
330	Oil Seal, Oilite 1.0025” OD	J790290
335	Bushing, Oilite A-1110-1	J790328

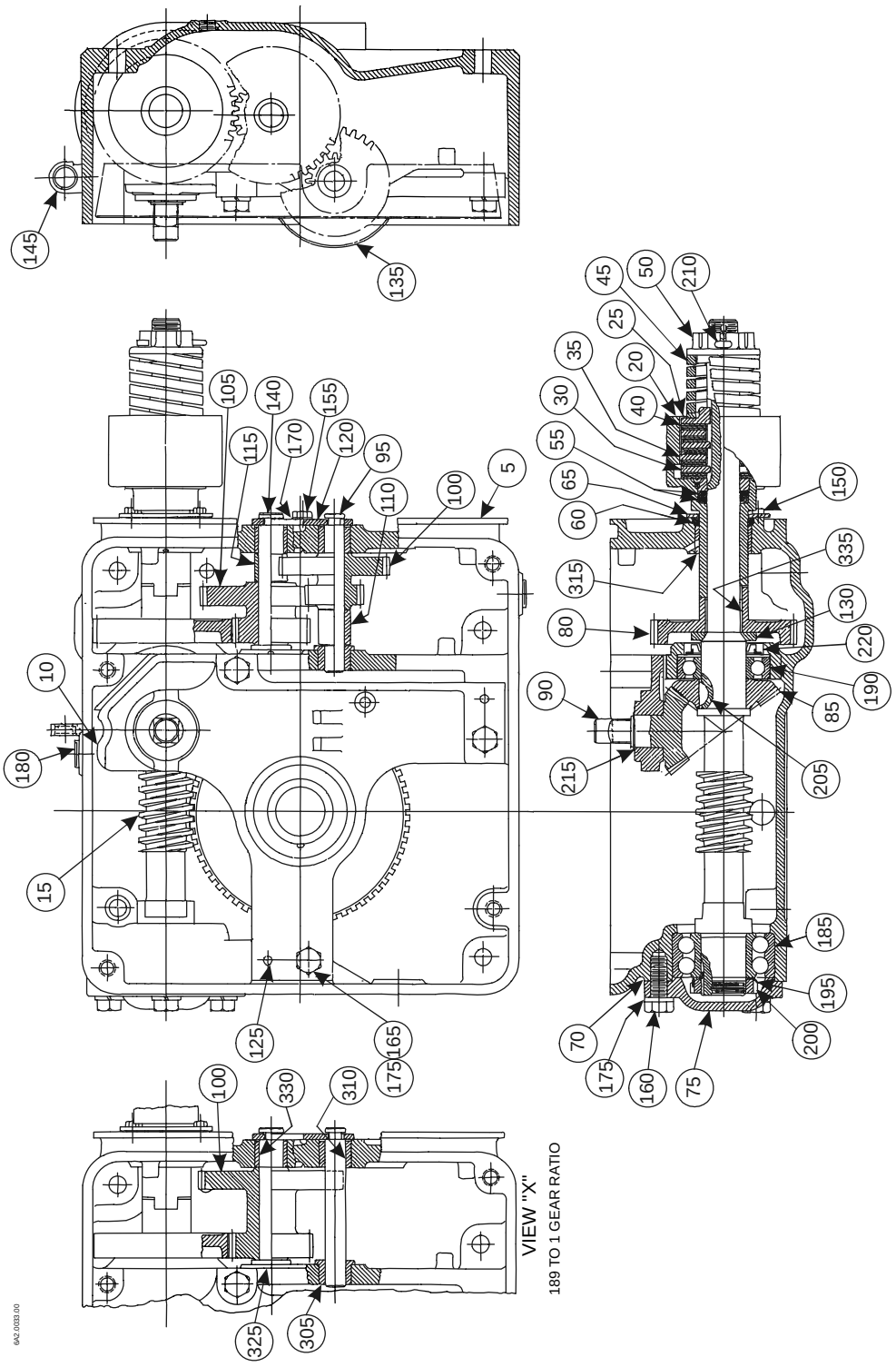


Figure 7-5. M-3 Gear Box Parts Location

7.5. M-23 Gear Box Parts List

Table 7-7 contains the parts list for the N28707x and N28707x-0001 M-23 gear boxes listed in Table 7-2 and Table 7-3. See Figure 7-6 for a location diagrams showing the listed parts.

Table 7-7. M-23 Gear Box Parts List

Item	Description	Part Number
5	Gearbox (Includes Bushings & Oil Seals)	N286623
10	Top Bearing	M274599
15	Worm Shaft	M286612
20	Friction Clutch Housing	N172752
25	Friction Clutch End Plate	M146575
30	Friction Clutch Plate	M146574
35	Friction Clutch Plate	M146573
40	Friction Clutch Disk	M146650
45	Friction Clutch Spring	M239322
50	Friction Clutch Adjusting Nut	M438402-001
55	Felt Gasket	J047335
60	Washer	M245192
65	Plate	M147400
70	Gasket	M147410
75	Bearing Cap	M274596
80	Clutch Gear (Includes Bushing)	N286583
85	Spacer	M286593
90	Worm Gear	M286620
95	Hand-Throw Bevel Pinion for Style M-23A Machines	M286616
	Hand-Throw Bevel Pinion for Style M-23B Machines	M286617
100	Hand Throw Bevel Gear	M286611
105	Main Crank	M302731
110	Hand Throw Lever Shaft	M286618
115	Selector Lever Shaft	M286619
120	Shaft	M149700
125	First Reduction Gear (189:1 Gear Ratio)	M286576
	First Reduction Gear (360:1 Gear Ratio)	M286577
	First Reduction Gear (528:1 Gear Ratio)	M286579
130	Second Reduction Gear (360:1 Gear Ratio)	M286578
	Second Reduction Gear (528:1 Gear Ratio)	M286580
135	Spacer (360:1 and 528:1 Gear Ratio)	M286591
140	Spacer (360:1 and 528:1 Gear Ratio)	M286592
145	Shaft End Plate	M286587
150	Dowel	J048925
155	Bushing	M169502
160	Key	M174967
165	Not Used	– –
170	Bushing	M169503

Item	Description	Part Number
175	Selector Clutch	PN302735
180	Selector Clutch Yoke	PN286622
185	Roller	M217537
190	Roller	M217538
195	Roller Stud	M261981
200	Washer	J475187
205	Eccentric Bushing	M261980
210	Not Used	– –
215	Shaft	M286596
220	Washer	M286584
225	Cam Follower Link	M286614
230	Cutout Rod Adjuster Link	M286613
235	Washer	M286595
240	Screw, 1/2-13 x 6” Hex Head	J050251
245	Gasket	M286585
250	Yoke Support	M274598
255	Lever Shaft Bearing	M274603
260	Shaft	M292426
265	Lever Support	M274602
270	Not Used	– –
275	Gear Box Cover	N288677
280	Bushing, Oilite	J079694
285–305	Not Used	– –
310	Lube Fitting, 1/8” P.T.	J039137
315	Plate Washer, 7/8” S. Plated.	J047508
320	Lock Washer, 7/8” Plain S. Plated	J047742
325	Set Screw, 3/8”-16 x 1-1/2” Square	J050621
330	Jam Nut, 3/8”-16 UNC 2B	J048010
335	Lock Washer, 3/8” Plain S. Plated	J475121-0113
340	Jam Nut, 7/8”-9 UNC 2B	J048069
345	Cotter, 3/16 x 2” Spring Steel	J048636
350	Screw, 1/2-13 x 2-1/2” Hex Head	J050101
355	Cap Screw, 1/2”-13 x 4-3/4”, Hex. Plated	J050107
360	Screw, 5/8-11 x 2” Hex Head	J050115
365	Cap Screw, 1/2”-13 x 1-1/2” Hex Plated	J050092
370	Cap Screw, 1/2”-13 x 1-3/4” Hex Plated	J050095
375	Cap Screw, 1/2”-13 x 1-1/4” Hex Plated	J050090
380	Screw, 1/4-20 x 3/4” Hex Head SST	J500097-0112
385	Not Used	– –
390	Cap Screw, 5/16”-18 x 3/4” Hex Plated	J050036
395	Lock Washer, 5/16” Plain S. Plated	J047526
400	Nut, 1/2”-13 UNC 2B	J048013
405	Ball Bearing (Double Row)	J066032
410	Ball Bearing	J066246

Item	Description	Part Number
415	Lock Washer	J047810
420	Lock Nut	J048575
425	Castle Nut	J048057
430	Cotter Pin, 3/32 x 1”	J048613
435	Plug, 1/2” Pipe	J032904
440	Jam Nut, 1/2”-13 UNC 2B	J048016
445	Lock Washer, 1/2” Plain S. Plated	J047783
450	Washer, 9/16” SAE LT TP	J047877
455	Oil Seal, Garlock 556	J790261
460	Screw, 1/2-13 x 2-1/2” Hex	J050101
505	Bushing, Oilite STD WROT	J790008
510	Bushing, Oilite AA 1011 5	J790007
515	Bushing, Oilite A 1704 4	J790004
520	Bushing, Oilite Flange	J790262
525	Bushing, Oilite 1.003” OD	J790291
530	Bushing, Oilite 1.0025” OD	J790290

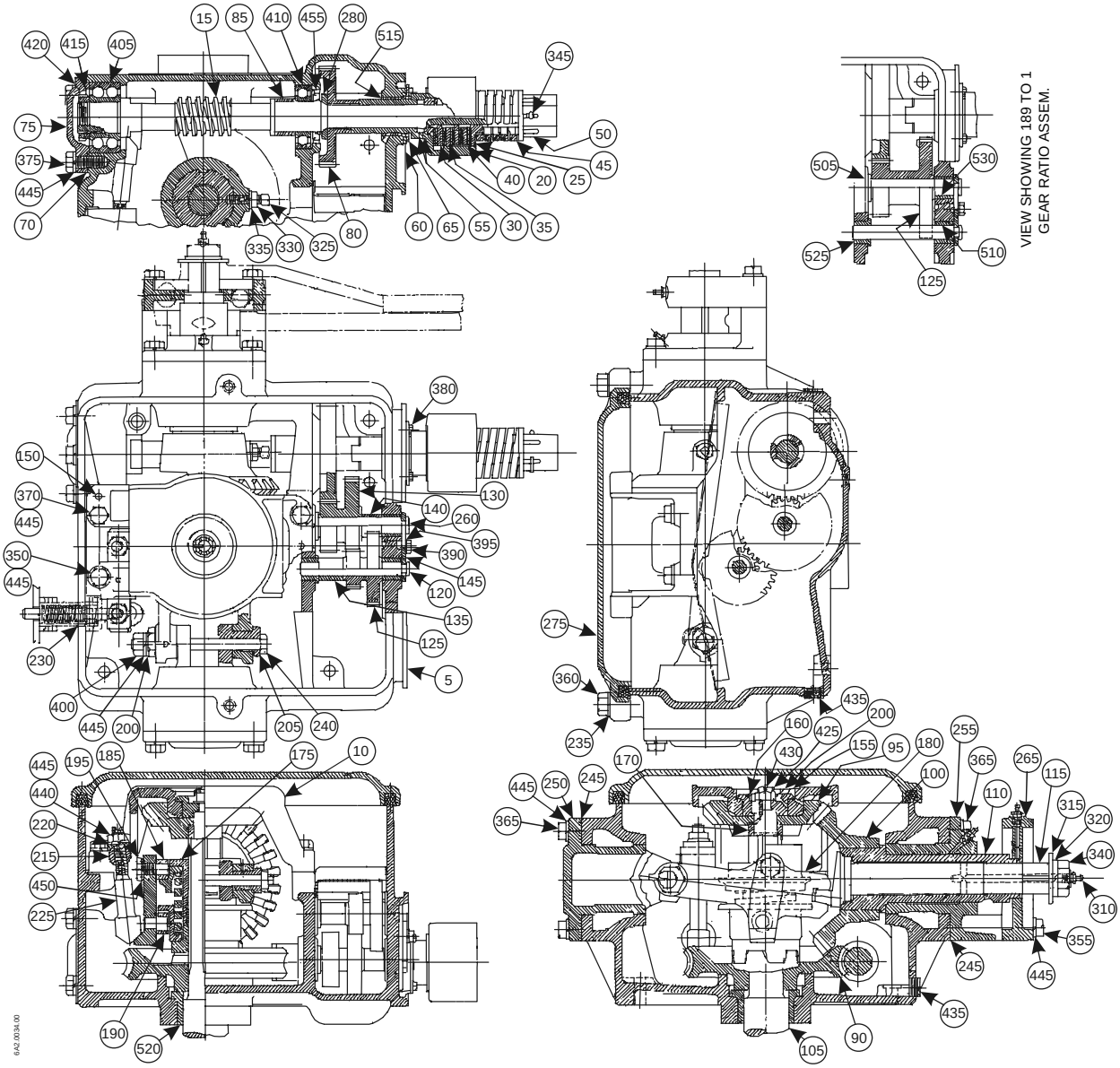


Figure 7-6. M-23 Gear Box Parts Location

7.6. Motor Assemblies

Table 7-8 contains the parts list for the N451161-17xx motor assemblies listed in Table 7-1, Table 7-2, and Table 7-3. See Figure 7-7 for a location diagrams showing the listed parts.

Table 7-9 contains the parts list for the N422008-xx motor assemblies listed in Table 7-2 and Table 7-3. See Figure 7-8 for a location diagrams showing the listed parts.

Table 7-8. Motor (Blue) Assembly (N451161-17xx) Parts List

Item	Description	Part Number
05	Motor Frame Adapter	M410006-02
10	Motor (Blue), Electric 110 VDC (189:1 Gear Ratio)	J717216-0301
	Motor Brush Kit	X410000-04
	Motor Brush Spring Kit	X410000-05
	Motor (Blue), Electric 20 VDC (528:1 Gear Ratio)	J717216-0303
	Motor Brush Kit	X410000-06
	Motor Brush Spring Kit	X410000-07
15-20	Not Used	– –
25	Screw, 3/8 x 1” Flat Head SST	J500124-0002
30	Gear, 1-1/2” Steel Round	M451161-1601
35	Key, 3/16” Square Steel	M451161-1305
40	Screw, #10-32 x 1/4” Allen Head	J507363
45	Snap Ring, External Retaining	J792852
50-55	Not Used	– –
60	(-0303 Motor Only) 17/64 x 9/16” Copper	J047818
65	(-0303 Motor Only) Washer, 5/16” Lock External Countersink	J475143-0001
70	Washer, 3/8” Lock External Countersink	J475143-0002

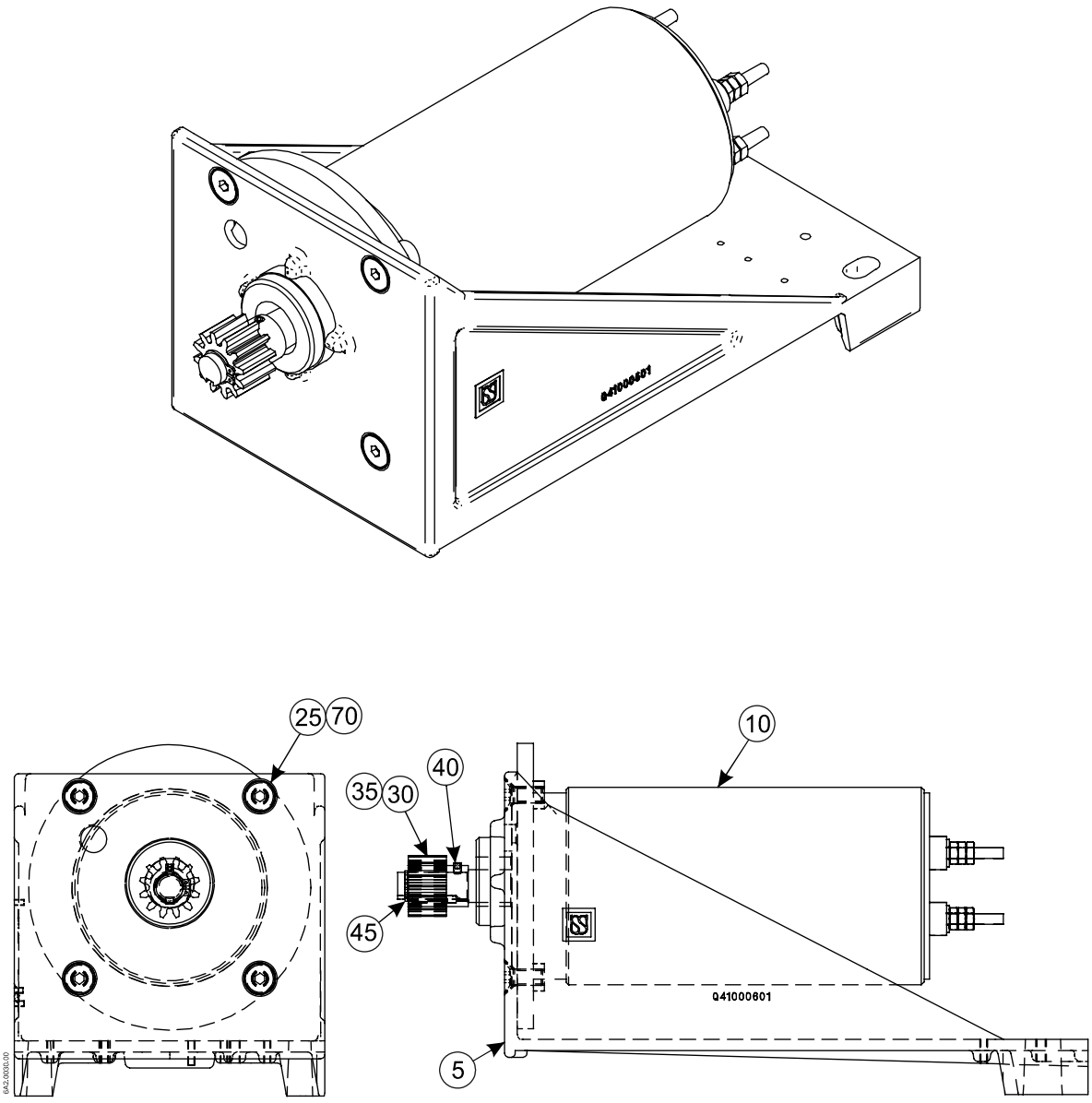


Figure 7-7. Motor (Blue) Assembly (N451161-17xx) Parts Location

Table 7-9. Motor (Black) Assembly (N422008-xx) Parts List

Item	Description	Part Number
5	Motor (Black), Electric 20 VDC (528:1 Gear Ratio)	J717216-0501
	Motor Brush Kit	X410000-04
	Motor Brush Spring Kit	X410000-05
	Motor (Black), Electric 110 VDC (189:1 Gear Ratio)	J717216-0502
	Motor Brush Kit	X410000-06
	Motor Brush Spring Kit	X410000-07
10	Motor Frame Adapter	M410006-02
15	Screw, 3/8 x 1” Flat Head SST	J500124-0002
20	Gear, 1-1/2” Steel Round	M451161-1601
25	Key, 3/16” Square Steel	M451161-1305
30	Screw, #10-32 x 1/4” Allen Head	J507363
35	Snap Ring, External Retaining	J792852
40	Washer, 3/8” Lock External Countersink	J475143-0002

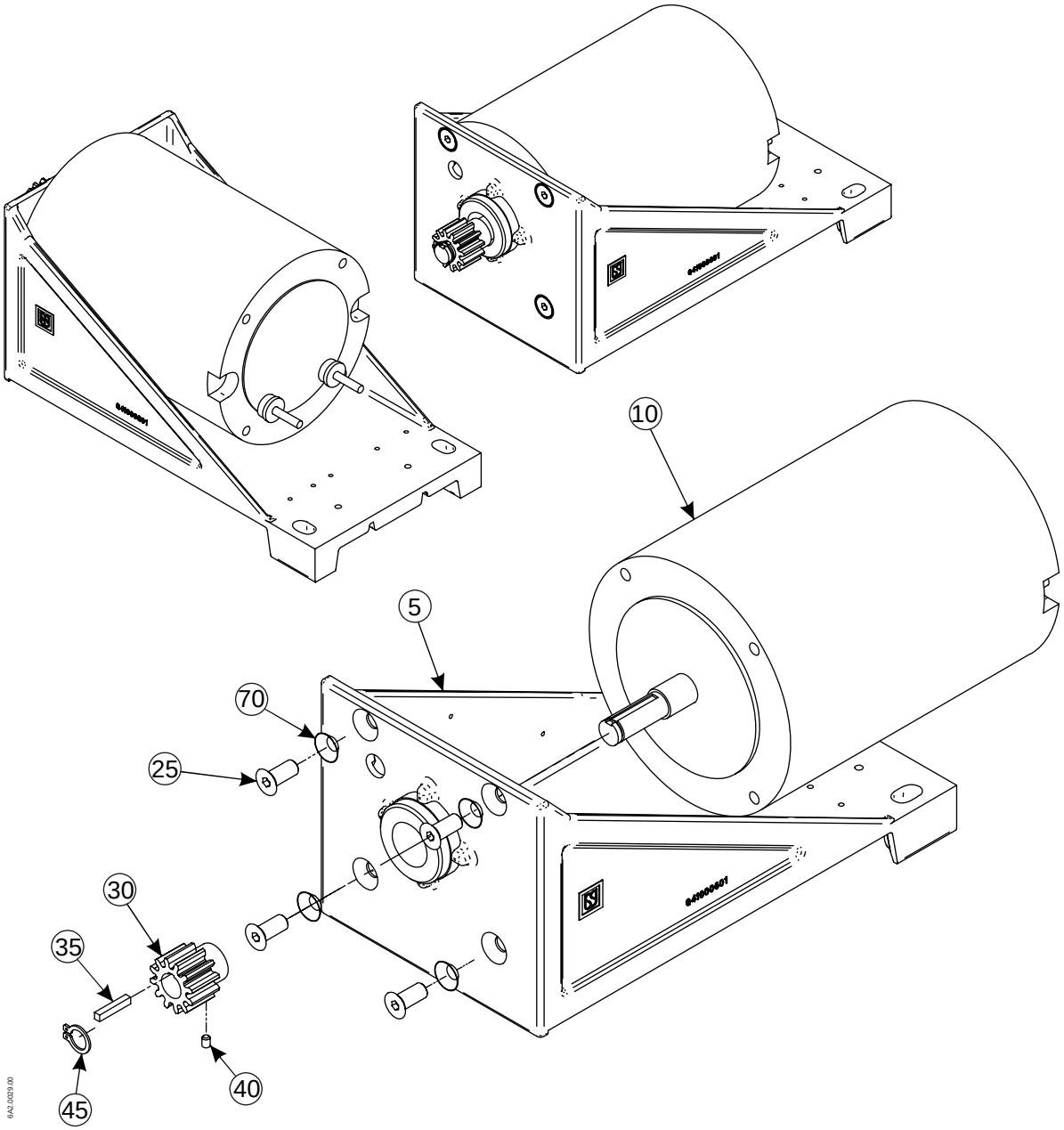


Figure 7-8. Motor (Black) Assembly (N422008-xx) Parts Location

7.7. Circuit Controller Assembly

Table 7-10 contains the parts list for the N426007-xx circuit controller assemblies listed in Table 7-1, Table 7-2, and Table 7-3.. See Figure 7-9 for a location diagrams showing the listed parts.

Table 7-10. Circuit Controller Assembly Parts List

Item	Description	Part Number
01	Frame, Retrofit Controller	M423700-02
02	Insulator, Sensor Bracket	M423703-01
03	Assembly, Point Detector Sensor w/Auxiliary Sensors	
	–01; –03 Controllers	N426006-01
	–02; –04 Controllers	N426006-02
04	Plate, Junction Box Mounting	M423728-01
05	Box, Switch Machine Controller	N473034-02
06	Lock Box Sensor Bracket, Complete	M423706-02
07	Assembly, Local/Remote Switch	
	–01; –02 Controllers Only	N422528-01
08	Screw, 5/16-18 x 1" Socket Head Cap	J500124-0153
09	Washer, 5/16” Spring Lock	J475138-0112
10	Screw, 3/8-16 x 1" Socket Head Cap	J500124-0141
11	Washer, 3/8” Steel Lock Med.	J047779
12	Pin, 1 x 0.250”	M423718-01
13	Screw, 1/4-20 x 3/4" Socket Head Cap	
	–01; –02 Controllers Only	J500124-0158
14	Washer, 1/4" High Collar Lock	
	–01; –02 Controllers Only	J047521
15	Proximity Sensor, Inductive Custom,18 x 50 mm	J738104-0025
16	Washer, M18 Lock, Internal Tooth	
	–01; –02 Controllers Only	J475121-0138
17	Dowel Pin, 3/8 x 3/4"	J048722-0009
18	Harness Clamp	J703005
19	Proximity Sensor Junction Box Kit	J709146-1852
20	Screw, #8-32 x 3/4” Fillister Head SST	J525270-0112
21	Washer, #8 Lock SST	J475121-0108
22-29	Not Used	– –
30	Tubing, Spiral Wrap	A774186

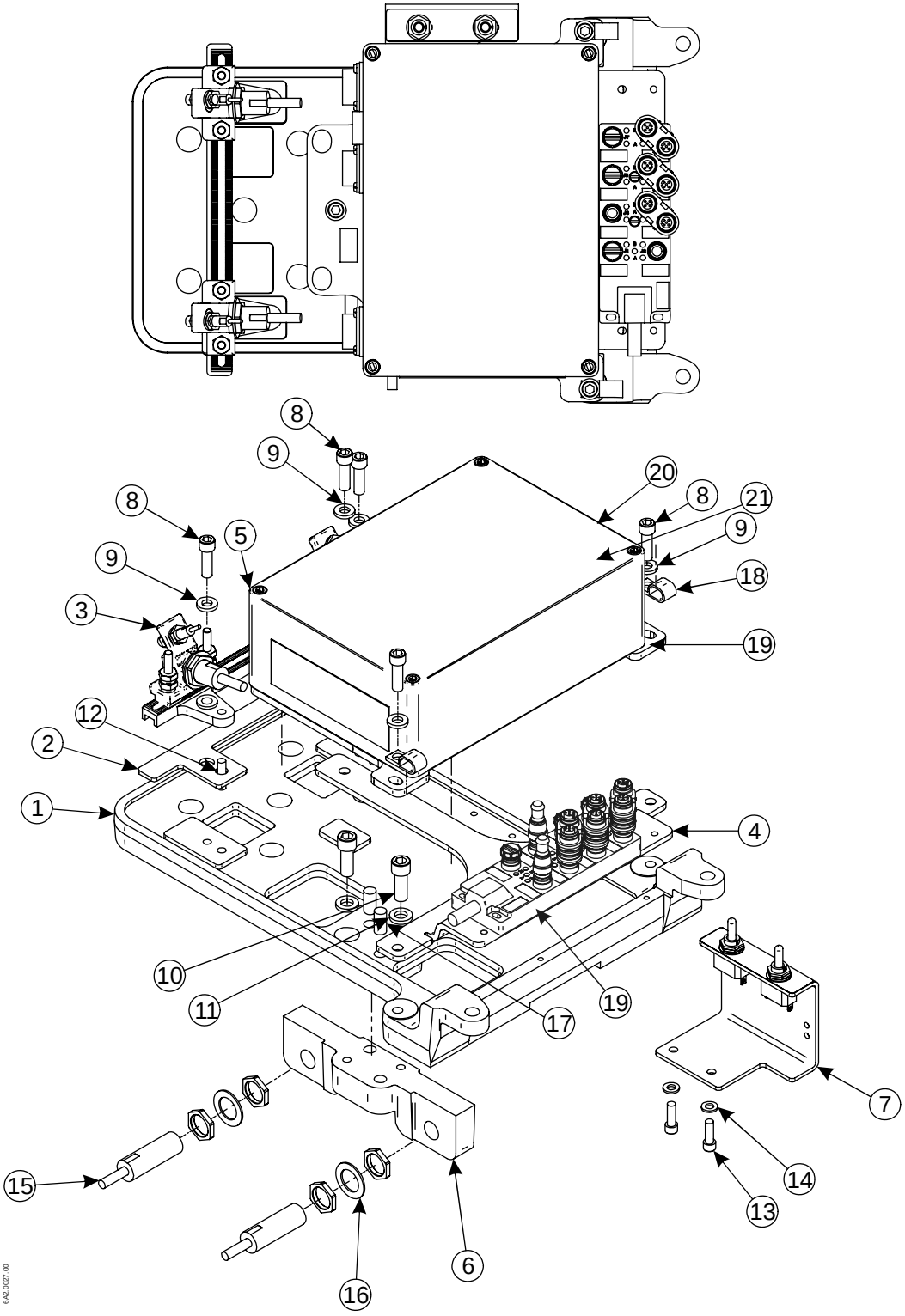


Figure 7-9. Circuit Controller Assembly Parts Location

7.8. Point Detector Sensor Assembly

Table 7-11 contains the parts list for the N426006-xx point detector sensor assemblies listed in Table 7-10. See Figure 7-9 for a location diagrams showing the listed parts.

Table 7-11. Point Detector Sensor Parts List

Item	Description	Part Number
01	Nut, #14-24 Hex Brass	J480301
02	Insulator, 5/16" Bolt	M423708-01
03	Proximity Sensor, Inductive Custom 8 x 40 mm	
	–02, –04 Controllers Only	J738104-0027
04	Proximity Sensor, Inductive Custom 18 x 50 mm	J738104-0025
05	Washer, M18 Lock Internal Tooth	J475121-0138
06	Sensor Holder	M423702-02
07	Plate, Sensor Bracket	M423701-02
08	Terminal Post	M130593
09	Washer, 5/16" Lock internal Tooth	
	–02, –04 Controllers Only	J475120-0162

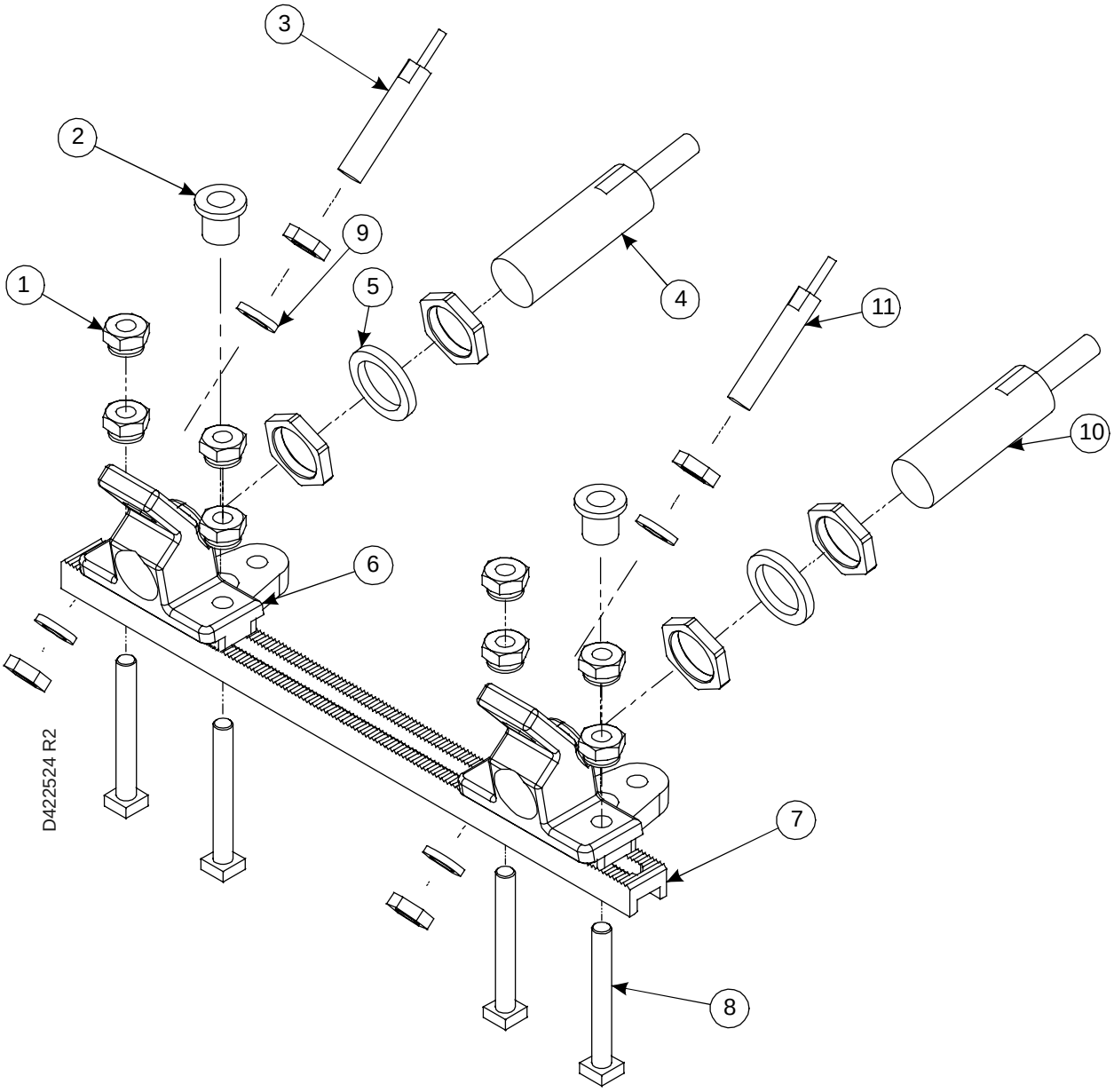


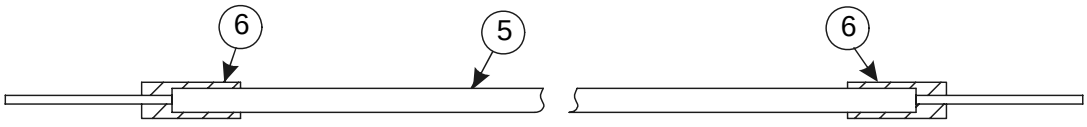
Figure 7-10. Point Detector Sensor (N426006-xx) Parts Location

7.9. Local/Remote Switch Assembly (Optional)

Table 7-12 contains the parts list for the N422528-01 local/remote switch assembly listed in Table 7-10. See Figure 7-11 for a location diagram showing the listed parts.

Table 7-12. Local/Remote Switch Assembly Parts List

Item	Description	Part Number
01	Bracket, Local/Remote Switch	M423729-01
02	Switch, Sealed Toggle #8530K2	J725707-0674
03	Switch, Toggle SPST #8530K9	J725707-0602
04	Label, M-23 Upgrade	M423722-01
05	Cable, Five Conductor 20 AWG	A045849-0331
06	Shrink Tubing, 3/8"	A774244
07	Terminal, Pre-Insulated Diameter G	J730299
08	Ferrule, 20 AWG, Grey #216-222	J709146-1427



VIEW SHOWING PREPERATION OF CABLE (IT.5)

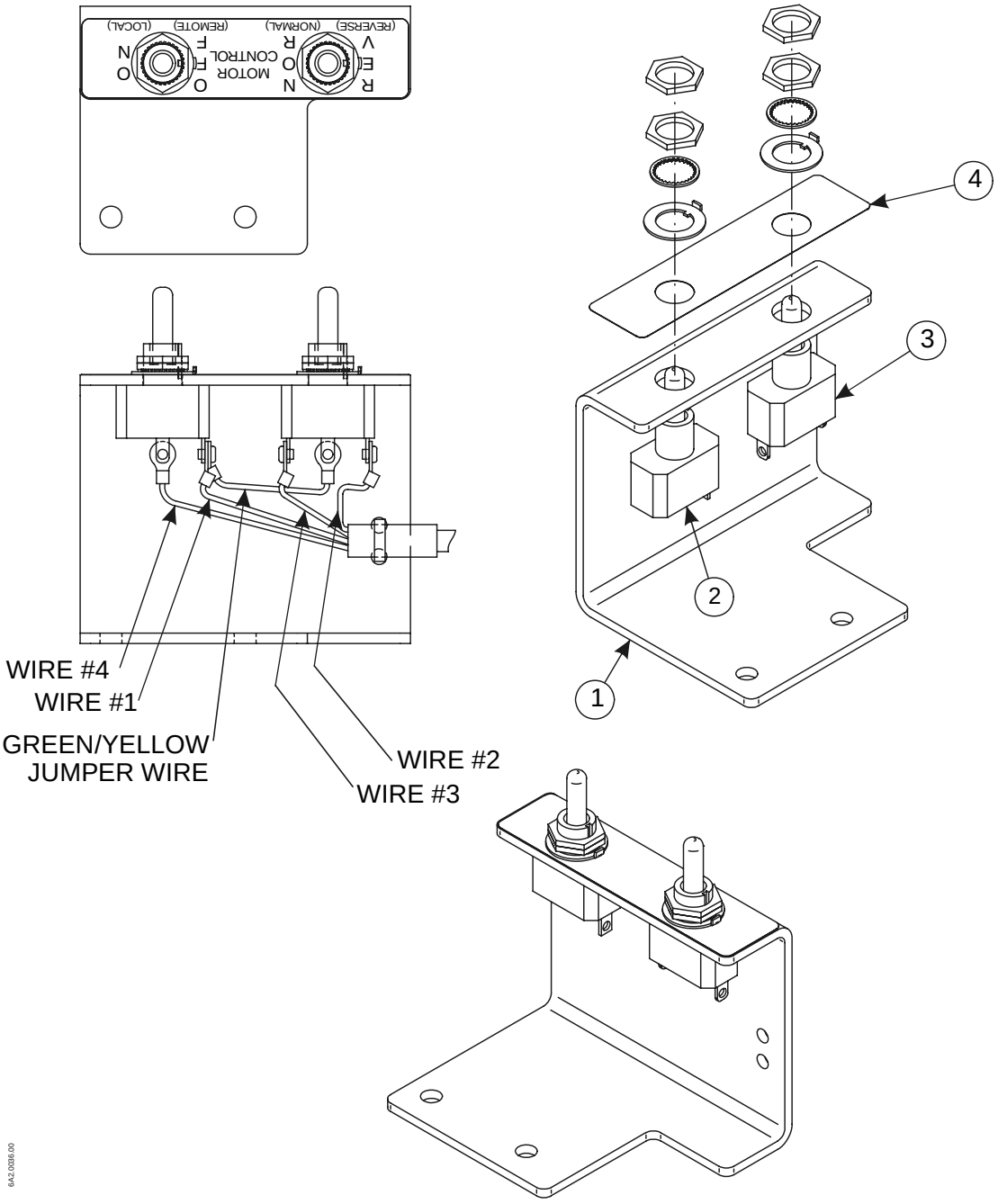


Figure 7-11. Local/Remote Switch Assembly Parts Location

8. RAIL TEAM AND TECHNICAL SUPPORT

The Rapid Action Information Link Team (RAIL Team) is a group of experienced product and application engineers ready to assist you to resolve any technical issues concerning this product. Contact the RAIL Team in the United States at 1-800-652-7276 or by e-mail at railteam@ansaldo-sts.us.

End of Manual