SIEMENS

# Instructions

Instructions For Pneumatic
Operating Mechanism
Type SA-7 For $SF_6$
Circuit Breakers

# DESCRIPTION



## INTRODUCTION

The $SF_6$ circuit breaker is one of the most important units in electrical power systems. The protection, stability, and continuity of service of the entire system depend largely on the efficiency of its operation. Designed for use on 34.5 through 69 kV systems, Siemens Type SP circuit breakers protect electric utility systems by interrupting fault currents and switching line, load, and exciting currents. Type SP circuit breakers combine high interrupting capabilities, short arcing time, and approximately 270 milliseconds reclosing with long contact life to provide excellent reliability, fast fault clearing, and easy maintenance.

Siemens outdoor circuit breakers are precision built devices designed to function efficiently under normal operating conditions. They are designed and manufactured to operate within the ANSI C37 standards applicable to the breaker rating.

The successful field performance of these breakers depends as much on proper installation and maintenance as it does on good design and careful manufacture. Refer to these sections before performing any installation or maintenance.

Factory adjustments are carefully made and the breaker is given rigorous mechanical tests after which the adjustments are re-checked. All control wiring is given a 1500 volts withstand test.

The instructions included in this book are necessary for safe installation, maintenance and operation and to aid you in obtaining longer and more economical service from your Siemens circuit breakers. For proper installation and operation — resulting in better service and lower maintenance costs — this information should be distributed to your operators and engineers.

By carefully following these instructions, difficulties should be avoided. However, they are not intended to cover all details or variations that may be encountered during the installation, operation and maintenance of this equipment.

Should additional information be desired, including replacement instruction books, contact your Siemens representative.

Distinctive signal words (DANGER, WARNING, CAUTION) are used in this instruction book to indicate degrees of hazard that may be encountered by the user. For the purpose of this manual and product labels these signal words are defined below.

**DANGER** Indicates death, severe personal injury or substantial property damage **will** result if proper precautions are not taken

**WARNING** Indicates death, severe personal injury or substantial property damage **can** result if proper precautions are not taken

**CAUTION** Indicates minor personal injury or property damage **can** result if proper precautions are not taken.

### ⚠ DANGER

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off control voltage.

Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices, instructions and maintenance procedures contained herein.

The successful and safe operation of this equipment is dependent upon proper handling, installation, operation and maintenance.

## QUALIFIED PERSON

For the purpose of this manual, a qualified person is one who is familiar with the installation, construction and operation of the equipment, and the hazards involved In addition, he has the following qualifications:

a) Is trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices
b) Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices
c) Is trained in rendering first aid

# INSTALLATION AND MAINTENANCE ALERTS



## OPERATING

**DANGER**

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

This equipment should be installed, operated and maintained only by qualified persons thoroughly familiar with equipment INSTRUCTION MANUALS and drawings.

No attempt to operate the breakers should be made until all shipping braces and/or ties have been removed, the breaker has been inspected and the breaker has been filled with $SF_6$ gas.

The wiring and schematic connection diagrams supplied with the breaker should be used when testing and checking the operating mechanism and control circuits. Check all wiring for looseness.

## MAINTENANCE

Work on the breaker should be performed only by qualified personnel. The breaker should be in the open position and with the operator's pneumatic system at zero psi or, if supplied, the main hand valve closed. In addition, all electric power to the breaker and its controls should be disconnected and properly grounded. When performing maintenance or adjustments requiring the breaker to be closed and charged, the release latch should be blocked in position to prevent accidental tripping and possible injury.

**DANGER**

Hazardous voltage and mechanisms. Severe personal injury due to electrical shock, burns and entanglement in moving parts; or property damage will result if safety instructions are not followed.

1. Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off control voltage.
2. Never trip or close the breaker while working on it, since the parts move rapidly and can cause injury.
3. Discharge the breaker's energy storage system before performing maintenance or inspection.
4. Breaker and its mechanism must be disconnected from all electrical power before performing maintenance or inspection. Grounding leads should be properly attached and framework grounded.
5. Never operate the breaker manually while it is energized or control power is connected.
6. Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices, instructions and maintenance procedures contained herein. The successful and safe operation of this equipment is dependent upon proper handling, installation, operation and maintenance.

**NOTE** The breaker may be tripped with the piston in any position; however, the linkage will not re-latch for a close operation until the piston is reset to its full open position.

# INSTALLATION AND MAINTENANCE ALERTS



## MAINTENANCE CLOSING DEVICE

The breaker may be "slow opened-closed" for adjustment and alignment inspection using the maintenance closing device.

**DANGER**

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

1. Pneumatic system must be a zero psi or, if supplied, the hand shut off valve closed when using the maintenance closing device.
2. Never use the hand closing device when the breaker is energized or control power is connected.
3. Remove the maintenance closing device before oeprating the breaker.

The hand closing device is a screw type jack with a ratchet handle and is supplied separately as an installation and maintenance tool. The closing device is attached to the piston rod extending at the bottom of the mechanism (see Figure 2, Page 62) for maintenance use only. For slow opening with the closing device, observe the holding latch engagement with the piston cross head while jacking the closing device in the closing direction. When it is observed that the holding latch is not loading, insert a screw driver through the opening in the frame side and hold the latch back from engagement while "jacking" the closing device toward the open position. Remove the screw driver as soon as cross head has moved past the latch.

## CURRENT TRANSFORMERS

Check all current transformers visually for any damage to the transformer and transformer leads.

**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

## PRE-OPERATIONAL CHECKS

When installing, adjusting, maintaining, inspecting or replacing parts of a breaker, the following pre-operational checks should be followed for ease of operation and safety.

1. Read both the circuit breaker and operator instruction books supplied with the breaker.
2. Check for proper installation and/or alignment by following the "Installation" section.
3. Check for proper adjustment by following the "Adjustment" section.
4. Check for the proper maintenance procedures by following the "Maintenance" and "Parts Replacement" sections.
5. Do not fast operate the breaker until the items listed above are completed and functioning properly.
6. The breaker should be "slow opened-closed" for adjustment and alignment inspection using the maintenance closing device, unless otherwise noted.
7. Refer to the "Installation and Maintenance Operating

# DESCRIPTION



Each breaker consists of three individual pole units mounted on a mechanism and control cabinet and connected mechanically to the operating mechanism. Each pole unit consists of two $SF_6$ gas bushings mounted on a grounded metal housing shaped like a large pipe tee which contains the interrupter. Each interrupter is mechanically connected to the operating mechanism through a connecting rod, operating shaft assembly, lever, tie bar, and horizontal pull rod. A spring acts to open the breaker and the pneumatic operating mechanism closes the breaker. Bushing type current transformers, when ordered, are mounted to each pole unit. The circuit breaker is filled with 5 psig of $SF_6$ gas at the factory to maintain a positive pressure. In the field, $SF_6$ gas is added to 80 psig at 70° F during installation. Certain ratings of the type SP circuit breaker are shipped with (3 or 6) external capacitors for Short Line Fault protection.

## SUPPORTING FRAMEWORK

To facilitate shipment the breaker was designed to offer a low profile. Four legs are shipped separately and must be assembled to the breaker to raise the breaker to the proper height. The leg assemblies normally have (2) sets of cabinet mounting holes. Reference should be made to the outline drawing to assure proper location of the mounting bolts, however, the following criteria for mounting the cabinet would generally apply.

1. For all 34.5 kV ratings and below use the lower set of holes.
2. For 46/69 kV, with long bushings providing extra creep and strike, use the lower mounting holes. Check by counting the number of sheds on the bushings. There should be 13 for this requirement.
3. For all other 46/69 kV ratings, use the upper holes.

This will ensure proper height of the breaker with respect to ANSI Standard C2.

## PNEUMATIC OPERATING MECHANISM

A Type SA-7 electro-pneumatic mechanism is used to operate the Type SP breaker. The mechanism is mechanically and electrically trip-free. Each mechanism is complete with its own storage reservoir, motor driven compressor, pressure switches, pressure gauge, and safety valve. The reservoir, at normal operating pressure, contains sufficient air for five immediate closing operations without operation of the compressor. A drain valve is provided to remove condensed moisture from the reservoir. The air supply system meets all the requirements of the ASME codes. The weatherproof cabinet has a large access doorway, sealed with rubber gaskets, to provide easy access for inspection and maintenance. A heater provides continuous inside-outside temperature differential, with additional thermostatically controlled heaters for winter use. Included in the housing are necessary auxiliary switches, cut-off switch, latch check switch, alarm switch and operation counter. The control relays and three control switches (one each for the control circuit, compressor motor, and heater circuit) are also mounted inside. Terminal blocks on the top and side of the housing are provided for control and transformer wiring. The SA-7 mechanism provides reclosing speeds of approximately sixteen cycles.

**⚠ DANGER**

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

1. Pneumatic system must be at zero psig before using the maintenance closing device.
2. Never use the hand closing device when the breaker energized or control power is connected.
3. Remove the maintenance closing device before operating the breaker.

## OPERATING LINKAGE

The components of the operating linkage contained in the mechanism cabinet are as follows:

1. An adjustable horizontal pull rod which connects the mechanism bellcrank lever to the tie bar and operating lever assemblies.
2. The tie bar and pole unit operating lever assemblies which convert horizontal motion into rotational motion at the pole unit operating shafts.

3. The opening spring which is connected to the horizontal tie bar and provides the force necessary to open the breaker.
4. A hydraulic shock absorber which minimizes overtravel at the end of the opening stroke.

## BUSHINGS

Two bushings are bolted to each pole unit tank. These bushings are $SF_6$ gas insulated and support the lead which carries the current from the external customer connection terminal to the internal end of the lead which plugs into a contact assembly on the interrupter.

## CURRENT TRANSFORMERS

**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

Current transformers are mounted to the pole unit pipe and located concentrically about it. Transformers are usually of the multiratio type, having five leads to provide a range or ratios. Transformer leads are brought through flexible conduit to the mechanism cabinet where they are connected to terminal blocks. The transformers are normally of the relaying accuracy class, however, single ratio metering accuracy transformers and linear couplers are available.

## THE $SF_6$ PUFFER INTERRUPTER

The interrupter is a subassembly mounted inside each pole unit pipe. Electrical connections to the bushings are made through plug-in connections which are part of the interrupter subassembly. Each interrupter assembly consists of a stationary contact assembly and a moving contact assembly surrounded by an insulating interrupter tube.

## RUPTURE DISC AND GUARD

A rupture disc and guard assembly is mounted to each pole unit pipe access cover assembly. Should the pressure in the pole unit pipe accidentally reach 150 psig $\pm$ 10 psig the disc would rupture exhausting the $SF_6$ gas to atmosphere. The guard acts as a baffle directing the exhausted gas and rupture disc fragments upward.

## PRESSURE GAUGE

A Bourdon tube type pressure gauge (0 to 100 psig) for indicating the $SF_6$ gas pressure of all three phases is mounted inside the cabinet. Fluctuations will be noted with ambient temperature changes.

## GROUND PADS

Two NEMA standard ground pads are mounted on the breaker frame, one on the left front and one on the right rear.

## LIFTING LUGS

Four lifting lugs are welded to the breaker top.

## CHARACTERISTICS OF SULFUR HEXAFLUORIDE

Sulfur hexafluoride in a pure state is inert and exhibits exceptional thermal stability. It has excellent arc quenching properties. These characteristics combined with its good insulating properties make it an excellent medium for use in circuit breakers.

Chemically, $SF_6$ is one of the most stable compounds. In the pure state, it is inert, non-flammable, non-poisonous, odorless, and produces no harmful effects on personnel. However, after the gas has been exposed to an electric arc, there will be some breakdown of the gas. Molecular sieve filters are used in the apparatus to remove most of the gaseous by-products and some of the gas-borne powders. These by-products are injurious and exposure to them should be avoided by maintenance personnel. The precautions to be followed in handling the gas are covered in detail in MAINTENANCE/ADJUSTMENT AND LUBRICATION section.

There is some depreciation of the gas after extended periods of arcing; however, such decomposition is very slight and has a negligible effect upon dielectric strength and arc interrupting ability. Furthermore, the solid arc products formed at arc temperatures are the metallic fluorides, which are good insulators under the conditions used in the breaker.

Sulfur hexafluoride is furnished in standard industrial type cylinders, color-coded green at the top end and the balance silver for easy identification. The cylinders have special size (.965" diameter.-14 thds/inch Nat. Std. left hand) pressure connections supplied for absolute safety. The adapter for connection to the cylinder is a CGA #590 bullet-shaped coupling nipple with .960 left hand, external male thread, 14 thds/inch. The gas is stored in the cylinders at approximately 300 pounds pressure which is the vaporization pressure at 75° F, and each cylinder contains 115 pounds of gas. Smaller cylinders containing 25 pounds of gas are also available.

The pressure developed while operating are only a fraction of those developed in a liquid medium. The pressure from arcing in $SF_6$ is generated from the thermal expansion of the gas rather than from the formation of a large amount of dissociation products, such as occurs in a liquid medium. Furthermore, shock pressures are neither produced nor transmitted as in the liquid medium.

The breaker requires approximately 15 lbs. of sulfur hexafluoride ($SF_6$) to fill to the recommended operating pressure, shown on the density chart (Figure 7, Page 69).

## TEMPERATURE COMPENSATED PRESSURE SWITCH

The breaker has a temperature compensated pressure switch, which is located inside the cabinet with a remote temperature sensing bulb located outside the roof of the cabinet adjacent to pole unit #2. The switch will alarm at 70 psig and cut out at 65 psig. The switch measures the pressure of all three phases which are tied together with stainless steel tubing. Quick disconnect fittings are used to facilitate any future maintenance. With these fittings, one phase can be degassed while the other phases can remain at 75 psig. See Figure 14, Page 77) for switch details.

# RECEIVING, HANDLING AND STORING



## RECEIVING AND SHIPMENT

All Type SP breakers are assembled and production tested at the factory, after which they are carefully inspected and prepared for shipment. Breakers covered by this instruction book are normally shipped completely assembled, except for the four legs and position indicator which are removed to facilitate shipment and external capacitors when supplied. However, when required for overseas shipment, a breaker may be shipped knocked-down. Each pole unit is shipped from the factory with approximately 5 psig $SF_6$ gas to insure a dry atmosphere during transit in order to protect the insulation.

**NOTE** Upon receipt of a circuit breaker, it should be examined for any damage sustained in transit. Damage should be reported immediately to the carrier and the nearest Siemens sales office.

## UNPACKING PARTS AND ACCESSORIES

Check all parts against the shipping list as they are unpacked and identified. Search the packing material carefully for bolts, nuts, screws, etc., which may have loosened in transit. Instruction books, cards, or leaflets shipped with the breaker should be kept with the breaker.

## HANDLING PROCEDURE

**WARNING**

These breakers are top heavy due to their high center of gravity and may cause serious personal injury, death or damage to the circuit breaker.

To prevent:

Follow instructions below during handling to prevent the breaker from tipping over and/or being suddenly dropped.

The weight of the breaker is listed on the nameplate. Breakers must be lifted by hooking onto four lifting eyes on the breaker housing roof. Four cables of the proper length (two 7' long and two 9' long) should be used to avoid interference with the bushings. Two cables must be approximately 2 feet longer than the other two to lift the breaker correctly.

**WARNING**

Pressurized bushings may burst during handling and can cause serious personal injury, death or damage the breaker during handling.

To prevent:

Do not strike, shock or strain the bushings or in any way cause the bushings to rupture.

Do not move the breaker if the $SF_6$ pressure in any pole unit is above 10 psig.

When moving breaker, do not lash the breaker down by the bushings. The shipping braces and the wooden skids on which the breaker is mounted should not be removed until the breaker is installed.

## STORAGE OF BREAKER AND BREAKER PARTS

Even though the breaker may not be placed into service immediately, installation in its permanent location is recommended. If this is not practicable, it should be stored in a place where it can be protected from mechanical damage. The following precautions should be taken:

Each pole unit is shipped from the factory charged with approximately 5 psig of $SF_6$ gas to insure a dry atmosphere during transit in order to protect the insulation. This positive pressure must be maintained during storage. Pressure readings should be monitored and recorded monthly during storage. If for some reason the shipping pressure is lost in a pole unit and leakage is suspected, the source of leakage should be located and repaired. The breaker should be purged of moist atmosphere by evacuating to approximately 2 millimeters of mercury. Hold for 30 minutes. Then $SF_6$ should be admitted to a pressure of 5 psig and maintained during storage.

All accessories, spare parts, and tools should be stored indoors and protected from dirt and moisture. Machined

parts, pinned joints, etc. of the operating mechanism should be protected against corrosion. This is best accomplished by closing the cabinet doors and energizing the space heaters. This is recommended even if it requires the use of a temporary electrical circuit to the heaters. The air compressor should be run for a minimum of 15 minutes every three (3) months.

**NOTE** The Type SP breaker has been completely assembled, tested, and inspected at the factory and requires a minimum of field checks during installation. If the breaker is shipped knocked-down, additional installation time and tools will be required. See Appendix III for assembly of a knocked-down SP breaker.

The installation checklist located at the end of this section is intended to provide a tabulation of those checks and tests necessary to effect a proper installation. Actual measured values should be entered on the blank spaces rather than an indication that the values were within the prescribed tolerances as the installation checklist is also intended to be used as a reference when inspection and maintenance is performed.

## TOOLS AND SERVICE EQUIPMENT

The following material and equipment is required for the installation of the Type SP circuit breaker, and should be available before commencing work. These items are not supplied by Siemens.

1. Leak-tec for leak testing.
2. 2 ton crane with a working height of 15 feet.

**⚠ WARNING**

These breakers are top heavy due to their high center of gravity and may cause serious personal injury, death or damage to the circuit breaker.

To prevent:

Follow instructions below during handling to prevent the breaker from tipping over and/or being suddenly dropped.

3. One pair of hook chains 7 feet long, and one pair of hook chains 9 feet long. (The preceding chains will require shorteners for knock-down breaker assembly).
4. 10 foot "A" frame step ladder to work at the top of the breaker.
5. Shim material — various thicknesses.
6. Wrenches — standard sizes of open end or box type.
7. 0 to 100 ft.-lb. and 0 to 400 ft.-lb. torque wrench and sockets.
8. Thermometer accurate within 2°F.
9. ¼ inch blade screwdriver.
10. Timing equipment and mounting hardware — see Final Tests Page 13.
11. Corrosive-resistant conductive joint compound and wire brush or steel wool.

**⚠ WARNING**

Poor grounds may cause serious personal injury or death due to electrical shock.
To prevent:

The circuit breaker must be connected to a permanent, low resistance ground.

Avoid poor grounds because they can give a false feeling of security to those working on the circuit breaker.

12. Ductor or equivalent 100 Amp. DC source with micro-ohmmeter.
13. 2 cloth slings each 4 feet long — for knock-down breaker assembly only.
14. Two .375"-16 x 3" long studs — for knock-down breaker assembly only.
15. Thread sealant for installing position indicator cover (Silicone RTV sealant W981015 or equivalent).

The following items are more difficult to procure and are provided by Siemens with each breaker order:

1. Adapter fitting for $SF_6$ filling.
2. Service hose for $SF_6$ filling.
3. SA-7 mechanism hand closing jack.
4. $SF_6$ gas, if ordered.
5. Timer mounting bracket.

## SELECTING THE LOCATION

The breaker should be installed with sufficient space for cleaning, inspecting, opening doors, and operating the hand closing device. Refer to the outline drawing located in the pocket of the mechanism cabinet door.

The foundation should be prepared before the breaker arrives and should be level within .25" at the four stud locations. Use shims to level with breaker when setting breaker on foundation. Consult the outline for necessary dimensions and foundation bolt locations. The breaker foundation should be high enough to prevent flood water from entering the mechanism housing.

## PLACEMENT OF THE CIRCUIT BREAKER

Remove the breaker from its shipping skids and place on the permanent foundation. The precautions described under "Handling Procedure", RECEIVING, HANDLING AND STORING section, page 7, should be observed.

**WARNING**

Pressurized bushings may burst during handling and can cause serious personal injury, death or damage the breaker during handling.

To prevent:

Do not strike, shock or strain the bushings or in any way cause the bushings to rupture.

Do not move the breaker if the $SF_6$ pressure in any pole unit is above 10 psig.

See "Supporting Framework", DESCRIPTION Section, page 4, for proper leg attachment.

Note that the breaker must be lifted in order to assemble the four legs which are removed to facilitate shipment. The legs should be first assembled to the breaker, then the breaker assembly bolted to the foundation. Bolts should be firm but not tight to allow proper alignment. Insert shims, if necessary, under the legs to level the breaker before tightening the foundation bolts. The circuit breaker should be level so that moving parts within the breaker can operate freely; otherwise, friction may develop and undue strains may be imposed which could result in breaker malfunction. When breaker and legs are properly aligned and leveled, tighten all bolts securely to the torque value specified on Fig. 1, Page 61.

The breaker is shipped from the factory with a shipping brace-mounted to connect the 3 pole unit pipe flanges. The pole unit shipping brace need not be removed, however, it should be painted with a finish coat if left on permanently. This brace can be removed by removing the three access cover bolts that fasten the brace to the pole unit pipes. After removal of the brace, replace the access cover bolts and tighten to 55 ft.-lbs.

If the breaker was shipped knocked-down, follow assembly instructions in Appendix III-A, Page 113 at this time.

## GROUNDING CONNECTIONS

Two NEMA standard ground pads are mounted on the breaker mechanism housing, one on the left side and one on the right side. A connection should be made from these pads to the station grounding network. The grounding conductor should be capable of carrying the maximum short circuit current for the duration of the fault. All joints must be clean, bright and free from burrs or surface roughness.

**WARNING**

Poor grounds may cause serious personal injury or death due to electric shock.

To prevent:

The circuit breaker must be connected to a permanent, low resistance ground.

Avoid poor grounds because they can give a false feeling of security to those working on the circuit breaker.

## CONTROL WIRING

All control wires to the circuit breaker should be in conduit where practicable. A control wiring diagram is located in the pocket on the inside of the mechanism cabinet door. The control wiring should be installed so that trouble with any other equipment cannot be communicated to the

control wiring of this breaker The breaker requires the full-rated control voltage as specified on the nameplate in order to perform a close or trip operation.

The proper wire size should be selected to minimize the voltage drop, otherwise, tripping time could be increased

## CONNECTING CURRENT TRANSFORMERS

**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

Bushing type current transformers, supplied only when ordered, are mounted externally around the pole unit pipe. (See Figure 1, Page 61.)

Transformers are usually of the multi-ratio type with five leads to provide a wide range of ratios. These leads are brought into the mechanism cabinet to terminal blocks. Each lead has an identification indicating the transformer tap to which it is connected lettered on the terminal block marking strips. Refer to the table on current transformer nameplate, which is mounted to the inside of the cabinet door, to determine transformer taps required to obtain the desired ratio. Care must be exercised so as not to confuse the polarity of the transformers. If there is any question as to the proper method of connection, refer to the polarity, ratio, and connection diagrams. These diagrams were supplied with detail drawings.

**CAUTION**

Improper operation can cause breaker damage.
To prevent:

Do not operate the breaker until it has been filled with $SF_6$ gas to at least the lockout pressure.

## CHECKING THE PNEUMATIC OPERATING MECHANISM

Read carefully the Operating Mechanism Instruction Book (Appendix I) included with this instruction book for information on the operating and maintenance of the pneumatic mechanism. Be certain the air compressor crankcase is filled with oil to the proper level. Inspect all insulated wiring for damage. The air compressor may now be energized and allowed to pump to normal operating pressure. During compressor pump-up, check for air leaks and operation of the pressure switches at the proper pressures as indicated on the mechanism nameplate.

## INSTALLATION OF EXTERNAL CAPACITORS

Some ratings require external capacitors which are shipped separately from the breaker and must be mounted during field installation of the breaker. Normally only (3) capacitors are required and are mounted on the side of the breaker for which short line faults might be expected on the electrical system. In some applications this may be possible on either side of the breaker in which case (6) capacitors may be used. (See Figure 6, Page 67.) Refer to breaker nameplate for actual capacitor application.

Mounting is on the side of the breaker for which short line faults might be expected on the electrical system. In some applications such as for cable circuits the external capacitance of the circuit may be sufficient to preclude the necessity for adding capacitors to the breaker. For applications without capacitors please review with your Siemens factory representative.

Before installation of the capacitors, it is important that the following procedure be adhered to so as to ensure proper performance.

**NOTE** It is recommened that any storage of the capacitor be done at room temperature with the capacitors in their upright position.

The field mountng procedure is as follows. (See Figure 6, Page 67.)

1. Attach the 15.25 x 6.625 x .5" steel lower mounting straps to the bushing flanges on breaker terminals using four .375-16 x 1.5" hex steel bolts and .375" steel lockwashers. Note that the straps on terminals #1 and #5 must face outward 30° (See Fig. 6, Page 67.) Torque the mounting bolts to 15 ft. lbs. The lower mounting straps must not touch any metal on the current transformers.
2. Lift at a 40° angle and place the capacitors on each lower mounting strap in the proper direction as indicated on the capacitor. Fasten with two .5-.13 Nylok hex head screws and torque 30 ft. lbs.
3. Attach the 18.88 x 3 x .25" aluminum bar upper mounting straps to the capacitors and bushing studs using two .5-13 x 1.75 hex steel bolts and .5" lock washers and one 1.5-12 nut. Torque the .5-13 x 1' hex steel bolts to 30 ft. lbs. and the 1.5-2 nut to 50 ft. lbs.

## FILLING A DE-ENERGIZED BREAKER WITH $SF_6$

Each breaker is shipped with a positive pressure of approximately 5 psig of $SF_6$, therefore, evacuation is not required before filling. Before filling with $SF_6$ check the pressure gauge to confirm that pressure has not been lost due to damage or leakage. If pressure is reduced to 0 psig it will be necessary to find and repair the cause of the leakage and then pull a vacuum to 2 mm of hg and hold for 30 minutes before filling with $SF_6$. Maintaining the vacuum for a period of time is not required unless there has been exposure of the interior pole unit assemblies to the atmosphere in which case the procedures in the maintenance section should be followed.

**⚠ WARNING**

Hazardous gas pressure levels may cause serious personal injury or death, or damage to the circuit breaker.
To prevent:

Do not add $SF_6$ to an energized breaker if pressure has fallen below the lockout value.

If pressure is below lockout, take the breaker out of service, isolate from the electrical system and correct the cause of the lower pressure before filling.

If pressure is below lockout, do not operate the breaker. Open an adjacent breaker to isolate the breaker from the system.

**⚠ DANGER**

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

1. Pneumatic system must be at zero psig before using the maintenance closing device.
2. Never use the hand closing device when the breaker energized or control power is connected.
3. Remove the maintenance closing device before operating the breaker.

Before the breaker is operated or placed into service it must be filled with sulfur hexafluoride gas to the proper pressure taking into consideration the ambient temperature (see Figure 7 or breaker nameplate, Page 68.)

**Equipment required.**

1. $SF_6$ pressure regulator (preferred) or the $SF_6$ cylinder adapter - supplied with the breaker tool kit.
2. Hose - supplied with the tool kit.

3. Female Quick Disconnect Fitting - supplied with the tool kit.
4. Wrenches
   a. 11/16
   b. 5/8
   c. 1" or 8" and 10" adjustable wrenches
   d. 3/4"
   e. 3/8" Hex Key
5. Thermometer for ambient temperature measurement.

Approximately 15 lbs. of $SF_6$ will be required to completely fill a breaker. To fill breaker proceed as follows:

1. Remove cap from the $SF_6$ cylinder fitting and attach the $SF_6$ pressure regulator or the special adapter.
2. Attach and tighten hose to regulator or adapter.
3. Attach female quick disconnect to the end of hose loosely.
4. "Crack" $SF_6$ cylinder valve and allow $SF_6$ gas to flow through hose exhausting at the loose fitting, thereby purging air from hose.
5. Shut off cylinder valve and tighten quick disconnect to the hose.
6. Remove cap from the breaker fill valve fitting and attach the quick disconnect with hose.
7. Open $SF_6$cylinder valve slowly and fill to proper $SF_6$ pressure determined by ambient temperature measurement and referring to Figure 7, Page 68.

**WARNING**

Rupture disc fragmentation may cause possible serious personal injury.
To prevent:

Do not over pressurize the breaker.

8. After proper pressure is obtained, shut cylinder valve and disconnect the female quick disconnect from the breaker fill valve fitting **first** before any other fitting is loosened. Replace the cap on the breaker fill valve.

The relation between fill pressure and temperature is given by P (psig) = .22T + 66. If the ambient temperature is 70°F, then fill to 80 psig. A spread of ± 1 psig is allowed in the filling pressure. Refill and check for leaks if the pressure falls below the minimum curve shown in Figure 7, page 68.

The moisture content of the $SF_6$ should be no higher than 300 ppmv. If the pole units have not been opened or exposed to a humid atmosphere, it will not be necessary to check for moisture after filling from an $SF_6$ bottle. If there is reason to suspect high moisture, do not use the rubber filling hose for checking. Use stainless steel tubing for this purpose.

## BREAKER INSPECTION

The Type SP breaker has been completely assembled, tested, and inspected at the factory. However, to preclude breaker malfunction due to shipping damage, it is recommended that a final check should be made for loose hardware, wire connections and locking devices that are visible without disassembling any components.

## FINAL TESTS

**DANGER**

Hazardous voltge and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

1. Pneumtic system must be at zero psig before using the maintenance closing device.
2. Never use the hand closing device when the breaker energized or control power is connected.
3. Remove the maintenance closing device before operating the breaker.

Start with normal air pressure (governor shutoff) on the pneumatic mechanism. To check the breaker timing properly, a digital interval timer, graphic travel time analyzer or slide wire/oscillograph may be used.

If the graphic travel time analyzer is used, it may be mounted on the mechanism housing as shown in Figure 4, Page 65. The operation indicator is removed and replaced with the timer mounting bracket which threads onto the housing. The end of the horizontal linkage tie bar is provided with a .190-32 tapped hole for the timer connection. The timer is fastened to the bracket with two .250-.20 x 3.5" hex steel bolts, .250 lock washers and .250-20 hex steel nuts.

The contact part time should now be measured during a trip operation. If the contact part time exceeds 32 ms (1.9 cycles), the difficulty may be due to one of the following reasons:

1. Incorrect zero setting on the graphic recorder.
2. Excessive voltage drop in the d-c control cable to the breaker.
3. Misadjustment of the trip unit. Refer to section "Tripping" Appendix I page 96.

   At this point a close operation and an open-close operation should be performed. Contact part time and contact make time should be measured. Contact make time should be within 90 to 100 milliseconds for DC control voltage (84-94 milliseconds for AC control voltage) measured from energization of the close coil. If graphic time travel analyzer is used, a measurement of a close velocity should be used as a substitute for contact make time. (Limits are 5.5 to 9.0 ft./sec.) during the last 1" of travel before contact touch. (See Figure 3A, Page 63.) After the final timing test and contact resistance is measured, the breaker should be left in the open position. The closing curve should not indicate any significant discontinuity throughout the breaker travel. If a change in velocity is obvious or if the contact make time or close velocity is not within the allowable limits, the difficulty may be due to improper setting of the throttle. Information on adjustent of the throttle is given in OPERATION section of the Mechanism Instruction Book. If the difficulty cannot be cleared up by adjustment of the throttle, refer to INSPECTION, MAINTENANCE and ADJUSTMENT section of the Mechanism Instruction Book.
4. The trip velocity is adjusted at the factory and need not be checked or adjusted before installation. If, however, you check the velocity (limits are 14.6-16.2 ft. per sec. between 1" and 4" of travel, see Figure 3A, Page 63) and find it out of limits, be sure your timer is functioning properly. Recorders can at times give erroneous results. If the tail spring is readjusted to a higher velocity when it is not necessary, damage could result to the breaker. Recheck your results with another recorder. If the breaker is still out of specification, consult the factory.

## LINE CONNECTIONS

Line connections should have sufficient flexibility and support to limit the load on the bushings (150 lbs. max.). Conductor and connector must have adequate current carrying capacity to prevent heat transfer into the breaker bushing. All joints must be clean, bright and free from burrs or surface roughness, and assembled using "joint compound".

Special consideration must be shown in the connection of an aluminum or tin-plated conductor to a copper alloy terminal. Galvanic action could occur, resulting in serious corrosion unless the mating surfaces are properly protected. Several different means of protecting the surfaces are available. A heavy coating of corrosion resistant, conductive compound such as Alcoa No. 2 Electrical Joint Compound on both surfaces, in conjunction with tin plating of the copper alloy terminal is recommended. The mating surfaces must be cleaned just prior to, or through, the application of the compound. The use of this compound also serves to minimize the surface formation of oxide films that have a higher resistance than the primary material.

## BUSHINGS

The bushings are especially designed to be self-cleaning and must not be coated with any grease or any other material. If cleaning is necessary use alcohol.

## INSTALLATION OF POSITION INDICATOR AND COVER

The position indicator and its plexiglass housing are shipped inside the breaker cabinet to prevent breakage during shipping. The indicator is to be mounted on the left side of the housing. Feed the threaded end of the indicator through the hole and attach to the horizontal lever assembly. The plexiglass housing is then screwed in the pipe fitting on the housing. A standard thread sealant (Silicone RTV W981015 or equivalent) should be put on the cover threads before assembly for weather tightness.

## FINAL INSTALLATION, CONNECTIONS AND INSPECTION SUMMARY

Station _____ Bus or Line _____

Installation Date _____

1. Nameplate Data

   1.1 Breaker Type _____ Amp. _____

   Serial-S.O. _____ I.B. PB-3468-04

   1.2 Mechanism Type SA-7 I.B. APPENDIX-I

   Control Diagram _____ Control Voltage _____

   Compressor and Heater Voltage _____

2. General Condition of Breaker when Received: _____

**NOTE** The following checks are to be made after the breaker has been set, leveled, and bolted to its permanent foundation and external capacitors, if required, have been installed.

3. Breaker Bolted to its Permanent Foundation and Shipping Braces Removed. _____

4. Grounding Connections Installed (Left) _____

   (Right) _____

**⚠ CAUTION**

Improper operation can cause breaker damage. To prevent:

Do not operate the breaker until it has been filled with $SF_6$ gas to at least the lockout pressure.

5. Control Wiring Installed _____

6. Current Transformer _____

**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

6.1 Connections made _____

7. Pneumatic Mechanism (APPENDIX I)

7.1 Air Compressor:

7.1.1 Proper Oil Level to bottom thread of fill hole _____

7.2 Energize air compressor motor and allow to pump to operating presssure. Check for leaks. Maximum allowable leak rate is 5 psig/hour. _____ psig/hour

7.3 Pressure switch operation:

7.3.1 Governor switch; opens on rising pressure (190 psig), differential - 12 psig. _____ psig

7.3.2 Low pressure alarm; closes on falling pressure (140 psig), differential - 12 psig. _____ psig

7.3.3 Low pressure cut-out; opens on falling pressure (130 psig), differential - 12 psig. _____ psig

7.4 Fill breaker with $SF_6$ (See Figure 7, page 68, or housing nameplate.)

$SF_6$ Pressure _____ psig

Ambient Temperature _____ °F

8. Breaker Inspection

   8.1 Final check for visible loose hardware. _____

9. Timing Tests (These tests are to be made at normal operating voltage and rated air pressure 190 psig.)

   9.1 Trip coil energized until contacts part (32 milliseconds max.) _____ milliseconds

   9.2 Close coil energized until contacts touch (90 to 100 msec. DC, 84 to 94 msec. AC) _____ millseconds

   9.3 Check pole unit indicator to be within tolerance in closed position.

   _____ Phase 1

   _____ Phase 2

   _____ Phase 3

   9.4 Contact penetration or engagement limits (.60" to .95"). (Required only if 9.3 is out of tolerance.)

   (Pole 1) _____ in.

   (Pole 2) _____ in.

   (Pole 3) _____ in.

10. Contact Resistance Terminal to Terminal Measured with Ductor or Equivalent 100 amp d-c Source (80 micro-ohms max. for 2000A or Copper bushing leads or 100 micro-ohms max. for 1200A or Aluminum bushing leads or 60 micro-ohms max. for 3000A breaker).

    (Pole 1) _____ micro-ohms

    (Pole 2) _____ micro-ohms

    (Pole 3) _____ micro-ohms

11. Position Indicator and Cover Installed _____

12. $SF_6$ Pressure Switch Operation

    Temperature-Compensated Sw.

    Alarm Switch #1 Closes _____ PSIG Alarm at _____ °F

    Cutout Switch #2 Opens _____ PSIG Cutout at _____ °F

    Switch Differential is 2 to 8 PSIG

the temperature-compensated switch operation con be checked by dropping the pressure at the quick disconnect fill fitting inside the cabinet. The switch should be set to operate to follow the curve in Figure 7, Page 68 within +2 psig. -0 psig
See Figure 14, Page 77 for setting directions.

13. Operation Counter Reading as Left _____

14. $SF_6$ Gas Pressure as Left

$SF_6$ Pressure _____ psig

Ambient Temperature _____ °F

15. Check all labels and nameplates attached to the breaker to be sure that they are securely fastened in place and are readable.

# PRINCIPLES OF OPERATION



## CLOSING

**CAUTION**

Improper operation can cause breaker damage. To prevent:

Do not operate the breaker until all tests and inspections are done.

To close the breaker, a low energy electrical signal actuates an air valve on the Type SA-7 pneumatic mechanism. High pressure air stored in the reservoir operates against the piston. The closing force is transmitted to a vertical pull rod in the mechanism cabinet, through a bellcrank to the horizontal linkage which charges the opening spring and draws the moving contacts to the closed position. Having reached the full closed position the air valve is de-energized and a mechanical latch in the Type SA-7 mechanism is engaged to hold the breaker in the closed position.

## OPENING

Energy for opening is stored in the opening accelerating spring located around the horizontal tie bar inside the mechanism cabinet and in a spring at the base of the Type SA-7 mechanism piston permitting the breaker to be tripped with a low energy electrical signal. When tripped, the springs transmit their energy to a single, horizontal linkage located in the mechanism cabinet to a lever at each interrupter which transfers the motion to the moving contact assemblies. As the breaker opens, the moving contacts move downward and an electrical arc is formed in the chambers of the interupters between the moving and stationary contacts. The internal construction of the interrupter assures efficient extinction of the arc. Since the interrupter performance is velocity dependent, the opening spring controls the moving contact velocity throughout the opening stroke. A hydraulic shock absorber provides the necessary shock absorbing action at the end of the opening motion.

## PNEUMATIC OPERATING MECHANISM

The Type SA-7 pneumatic mechanism is used to operate the Type SP breaker. Details of the operation of the mechanism are contained in Instruction Book APPENDIX I.

## BELLCRANK ASSEMBLY

The primary function of the bellcrank assembly is to convert the vertical motion of the mechanism into horizontal motion. To accomplish this, the vertical pull rod from the operating mechanism is attached to a bellcrank lever. The motion of this lever is transmitted through a horizontal pull rod to a tie bar crank housing. The tie bar is attached to the three operating levers. With the breaker and mechanism in the open position, the piston is at the upper limit of its travel. A position indicator is located externally on the left-hand side of the mechanism cabinet and is attached to the horizontal tie bar. Its motion and position coincide with that of the bellcrank lever. Closed and open position overtravel stop bolts are positioned to contact the bellcrank lever.

## OPERATING SHAFT ASSEMBLIES

Attached to the horizontal tie bar through the operating levers are the operating shaft assemblies. These convert horizontal motion of the operating linkage through rotary motion to straight line motion of the moving contact connecting rods. Each of the three operating shaft assemblies incorporates a spring loaded chevron seal arrangement to prevent $SF_6$ gas leakage from the interrupters.

## OPENING SPRINGS

The opening spring is located inside the mechanism cabinet and is positioned around the horizontal tie bar. This is the main force to open the breaker at the proper velocity and provide the proper contact part time. When the breaker closes, the spring is compressed and is in position for the next open operation.

## INTERRUPTER ASSEMBLIES

(Figure 9 and 9A, Page 70)

The interrupter assembly is designed to be manufactured as a complete unit. An insulating tube houses the stationary contact and moving contact assemblies. The tube has the dual function of providing the mechanical support for the stationary and moving contact assemblies and the inside diameter is utilized as the cylinder wall for the piston in the moving contact assembly. Because of this multi-function design, the interrupter has spring-loaded finger type contacts for the bushing leads. This interrupter is attached to the pipe assembly at the operating rod end with a flanged and bolted connection. There are no other insulating supports between the interrupter assembly and the aluminum pipe. The $SF_6$ is communicated to the interrupter through stationary contact vent holes and the operating rod end, which is open to the pipe.

With the interrupter in the closed position the main current path is through the auxiliary fingers which are parallel to the arcing fingers. Since the auxiliary fingers are not arced during interruption, they maintain low resistance electrical contact for the life of the interrupter.

During the opening operation, the piston compresses $SF_6$ between the support plug and cylinder wall. When the arcing contacts have parted, the compressed gas flows along the arc, sweeping hot gases upstream through the Teflon orifice and downstream through the hollow moving contact. The hot gases and arc products are contained within the pipe.

For 31.5 and 40 kA interrupting ratings, a tank liner is provided to maintain dynamic insulation to ground during interruption.

## HYDRAULIC SHOCK ABSORBER

A hydraulic shock absorber is mounted on the mechanism bellcrank assembly and is contacted by the bellcrank lever during the opening stroke. This shock absorber serves to control the deceleration phase of the opening stroke and minimizes overtravel. The hydraulic shock absorber is factory sealed and adjusted and normally requires no maintenance. If breaker overtravel on opening or close-opening exceeds the specified limits the shock absorber must be readjusted using the procedure outlined in "Hydraulic Shock Absorber", MAINTENANCE, ADJUSTMENT and LUBRICATION Section, Page 57. If the shocks cannot be adjusted, it must be replaced with a new one.

# INSPECTION



The intent of this section is to identify the parameters which can be used to establish and carry out a proper program to assure reliability of the equipment.

Of primary importance in carrying out an effective program is that the individuals involved understand the equipment, how it is to function, and the potential problems should out-of-specification conditions exist.

It is desireable to maintain a permanent record of each circuit breaker. Included in this log should be the complete records of all installation, inspection, maintenance, and lubrication work performed. Installation, Periodic, 3 Year Inspection, 6 Year Inspection and Major Inspection Checklists should be included as well as information relative to the number of faults and associated current magnitudes the breaker has been required to interrupt.

Record keeping of this type will permit accurate evaluation of the conditions of the breaker at all times and assure reliable service if the suggested procedures are followed. In addition, it will permit the comparison of present-day values of such items as contact resistance, contact engagement, etc., to previously obtained data.

Many of the tests, which are made, are diagnostic type tests which will provide information relative to potential problems. This is to say that when one analyzes the test results and compares the results with previous test data, it can be determined whether a change is normal or whether it is one which requires attention.

An effective maintenance program begins during the installation of the equipment. A copy of an Installation Checklist follows INSTALLATION Section of this book. Adherence to the procedures identified on the Installation Checklist and verification that the items checked are within the allowable tolerances will assure a proper installation. This information is then to be used as a base reference for future maintenance. The checklists do not provide an in-depth description of the checks and tests to be made. This information is contained in the text of this instruction book. Breakers installed in areas of severe environmental conditions may require more frequent inspection procedure. It is recommended that frequent visual inspections be made by operators while touring the switchyard in order to observe any obvious abnormal conditions.

## GENERAL

Thorough, periodic inspection is important to satisfactory operation. Inspection and maintenance frequency depends on installation, site, weather and atmosphere conditions, experience of operating personnel and special operation requirements. Because of this, a well-planned and effective maintenance program depend largely on experience and practice.

**DANGER**

Hazardous voltage and mechanisms will cause serious personal injury or death from electrical shock, burns and entanglement in rapidly moving parts. To prevent:

1. Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off control voltage.
2. Never trip or close the breaker while working on it, since the parts move rapidly and can cause injury.
3. Discharge the breakers' mechanical systems before performing maintenance or inspection.
4. Secure the operator against accidental tripping when adjustments require breaker in closed position.
5. Breaker and its mechanism must be disconnected from all electrical power before performing maintenance or inspection. Grounding leads should be properly attached and framework grounded.
6. When using the maintenance closing device on pneumatic operators the pneumatic system must be at zero psig.
7. Never slow operate the breaker while it is energized or control power is connected.
8. Remove the maintenance closing device before operating the breaker.
9. Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices, instructions and maintenance procedures contained herein. The successful and safe operation of this equipment is dependent upon proper handling, installation, operation and maintenance.

Failure to properly maintain the equipment can result in severe personal injury, product failure and prevent successful functioning of connected apparatus. The instructions contained herein should be carefully reviewed, understood and followed. The following maintenance procedures should be performed regularly:

STEP 1

Be sure that the circuit breaker and its mechanism is disconnected from all electric power, both high voltage and control voltage, before it is inspected or repaired.

STEP 2

**Make sure that the pressure in the air tank is reduced to zero before working on breaker or operator mechanism.**

STEP 3

After the circuit breaker has been disconnected from power lines, attach the grounding leads properly before touching any of the circuit breaker parts.

STEP 4

Check the oil level in the air compressor pump and motor bearings. Replenish as necessary.

STEP 5

Keep the mechanism clean and follow instructions for lubrication.

STEP 6

Be sure the circuit breaker is well grounded.

STEP 7

See that bolts, nuts, washers, cotter pins and all terminal connections are in place and tight.

STEP 8

At all inspections operate the circuit breaker by hand to see that the mechanism works smoothly and correctly before operating it with power.

This checklist does not represent an exhaustive survey of maintenance steps necessary to ensure safe operation of the equipment. Particular applications may require further procedures. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the local Siemens sales office.

The use of unauthorized parts in the repair of the equipment, tampering by unqualified personnel, or incorrect adjustments will result in dangerous conditions which can cause severe personal injury or equipment damage. Follow all safety instructions contained herein.

## STRAINERS

**AIR COMPRESSOR** — Inspection of the air compressor intake strainer should be made annually and the strainer repaced. A clogged intake strainer causes excessive running of the compressor operating time.

## DRAINING OF STORAGE TANK

The drain valve on the storage tank should also be used occasionally to keep the tank free of accumulated moisture.

## AIR SYSTEM

All pipe joints in the air system were sealed at the factory with Loctite "pipe thread sealed with teflon." (W946015) If pipe joints are opened or disturbed, it will be necessary to reseal the joint with a new application of sealant.

## PERIODIC INSPECTION PROCEDURE

Periodic Inspections should be made at monthly and semi-annual intervals to assure continued satisfactory performance of the breaker. At the end of this section is a Periodic Inspection Checklist.

## 3 YEAR INSPECTION PROCEDURE

An inspection should be made every 3 years and used as an additional guideline in determining the necessity of maintenance. This inspection includes checks which may be made externally. At the end of the section is a copy of a 3 Year Inspection Checklist which identifies those items which can be checked without removing the gas from the breaker. By making the checks identified on the list, it can be verified whether or not the breaker is satisfactory for continued service without performing a 6 Year or Major Inspection.

## 6 YEAR INSPECTION PROCEDURES

An inspection should be made every 6 years and used as an additional guideline in determining the necessity of maintenance. This inspection includes checks which may be made externally. At the end of this section is a copy of a 6 Year Inspection Checklist which identifies those items which can be checked without removing the gas from the

**breaker. By making the checks identified on the list, it can be verified whether or not the breaker is satisfactory for continued service without performing a Major Inspection.**

## MAJOR INSPECTION

Major Inspection is that which requires removal of the gas from the breaker to determine the condition of the interrupters, contacts, and other internal components. The following are some of the factors to be considered in determining the frequency of a major inspection procedure.

Whichever comes first:

Twenty times the accumulated interrupting rating, i.e., 20 full-rated faults, 40 half-rated faults, etc or 600 kA whichever comes first.

2,000 mechanical operations.

Information received from 3 Year and 6 Year Inspections.

Accumulated experience of breaker characteristics and duty.

**Pole unit contact touch during slow closing, is .19 inch or less from the pole unit indicator closed position marks (Figure 11, page 72, View 'X-X').**

# INSPECTION

## PERIODIC INSPECTION CHECKLIST

Station _____ Bus or Line _____

Date of Inspection _____

1. Nameplate Data

   1.1 Breaker Type _____ Amp. _____

   Serial-S.O. _____ I.B. PB-3468-04

   1.2 Mechanism Type SA-7 I.B. APPENDIX-I

   Control Diagram _____ Control Voltage _____

   Compressor and Heater Voltage _____

## MONTHLY CHECKS

2. General Condition of Breaker _____

3. Pneumatic Mechanism (APPENDIX I)

   Operation Counter Reading _____

   Drain water from air storage tank. _____

4. Breaker Checks

   $SF_6$ Gas Pressure

   $SF_6$ Pressure _____ psig.

   Ambient Temperature _____ °F.

## 6 MONTH CHECKS
(In Addition to Monthly Checks)

5. Pneumatic Mechanism (APPENDIX I)

| | |
|---|---|
| Check condition and tightness of "V" belt. ⅜" to ¾" deflection with 5 pounds pressure applied vertically to center of the belt. | _____ inch |
| Check air compressor oil level | _____ |
| Drain enough air from air storage tank to start and run air compressor. | _____ |
| Check compressor cut-out switch for proper setting. Check air compressor air cleaner element and clean if necessary. See page 95 for cleaning instructions. | _____ |
| Inspect exposed hardware, control wire terminals, and tube fittings for tightness. | _____ |
| Check all labels and nameplates attached to the breaker to be sure that they are securely fastened in place and are readable. | _____ |

## ANNUAL CHECK
(In addition to monthly check and 6 month check)

| | |
|---|---|
| Change compressor oil. Fill to bottom thread of fill hole. See page 95 for oil type and amount. | _____ |
| Check contact position indicator with breaker in closed position. See Figure 11, page 72. | Pole 1 _____<br>Pole 2 _____<br>Pole 3 _____ |

## 3 YEAR INSPECTION CHECKLIST

Station _____ Bus or Line _____

Date of Inspection _____

1. Nameplate Data

   1.1 Breaker Type _____ Amp. _____

   Serial-S.O. _____ I.B. PB-3468-04

   1.2 Mechanism Type SA-7 I.B. APPENDIX-I

   Control Diagram _____ Control Voltage _____

   Compressor and Heater Voltage _____

**WARNING**

Hazardous voltage.
Death or serious personal injury due to electrical shock could result.

To prevent:

Prior to performing inspection of the breaker, trip the breaker and open adjacent breaker disconnect switches, solidly ground all bushing trip terminals to remove residual electrical charge and open all A-C and D-C switches.

2. General Condition of Breaker: _____

3. Breaker Hold Down Bolts Tight _____

4. Grounding Connections Tight (Left) _____

   (Right) _____

> **CAUTION**
>
> Improper operation can cause breaker damage.
> To prevent:
>
> Do not operate the breaker until all tests and inspections are done.

5. Pneumatic Mechanism (APPENDIX I)

5.1 General Checks:

5.1.1 Condition of mechanism. Corrosion of hardware. Loose hardware. _____

5.1.2 Lubricate in accordance with "Lubrication" in MAINTENANCE/ ADJUSTMENT AND LUBRICATION Section of the Mechanism Instruction Book. _____

5.1.3 Connections on terminal blocks, switches, and relays: tight and no corrosion. _____

5.1.4 Heaters operating properly. _____

5.1.5 Wiring: deteriorate or damaged insulation. _____

5.2 Air Compressor:

5.2.1 Change air compressor oil. Fill to bottom thread of fill hole. See page 95 for oil type and amount. _____

5.2.2 Condition and tighten of "V" belt. _____

5.3 Open reservoir drain valve and lower pressure to 130 psig. Close drain valve and compressor knife switch and allow to pump to normal pressure. Pump-up time from low pressure cut-out point (130 psig) to normal operating pressure (190 psig) should be less than 30 minutes. Failure of this test requires maintenance of the air system. _____ min.

5.4 Pressure switch operation:

5.4.1 Governor switch; opens on rising pressure (190 psig) Differential - 12 psig. _____ psig.

5.4.2 Lower pressure alarm; closes on falling pressure (140 psig), Differential - 12 psig. _____ psig.

5.4.3 Low pressure cut-out; opens on falling pressure (130 psig) Differential - 12 psig. _____ psig.

5.5 Operation rundown starting at governor shutoff with compressor knife switch open.

5.5.1 Number of operations before low pressure cut-out switch opens (5 minimum) _____

5.5.2 Number of operations after low pressure cut-out switch opens with low pressure cut-out switch contacts jumpered (1 minimum). _____

**WARNING**

Operation with jumper may cause damage to the circuit breaker.

To prevent:

Remove jumper after test.

5.6 Leak Rate: Beginning at 190 psig with compressor de-energized, the maximum allowable pressure drop is 5 psig/hr. in the air system. _____ psi/hr.

5.7 Minimum operating voltages (See Mechanism nameplate for voltage ranges)

Close _____ Vd-c

Trip _____ Vd-c

6. Breaker Checks

6.1 Check contact position indicator with breaker in closed position.

(Pole 1) _____

(Pole 2) _____

(Pole 3) _____

6.2 Check minimum contact touch. Install ohmmeter or light out device between bushings on each pole, jack breaker slowly closed and check position of pole unit indicator when circuit is obtained. The position of the indicator should be greater than .19 inch from the full closed position marks. If not, major inspection is required. (If your breaker does not have pole unit indicators go to next step).

(Pole 1) _____ in.

(Pole 2) _____ in.

(Pole 3) _____ in.

6.3 Install timing device rod onto tie bar and maintenance hand jack on mechanism. Install ohmmeter or light out device between bushings on each pole, jack breaker slowly toward the closed position, and mark timing device rod with reference to housing for each pole when circuit is obtained. Continue to jack breaker closed to the point where the SA-7 mechanism just latches, loosen jack to load mechanism and mark full closed position on the timer rod. Measure contact engagement as determined by the difference in position.

Dimensions should be between .60 and .95 inches. (Refer to "Closed Position Adjustments", MAINTENANCE/ADJUSTMENT and LUBRICATION Section if required).

(Pole 1) _____ in.

(Pole 2) _____ in.

(Pole 3) _____ in.

6.4 Jack breaker to the open position.

Measure horizontal pull rod travel from full closed to full open position. (4.937 ± .060 inches) Remove maintenance hand jack from mechanism and timing device rod from tie bar.

_____ in.

7. Contact resistance terminal-to-terminal measured with ductor or equivalent 100 amp d-c source. 115 micro-ohms maximum for used contacts (2000A) or 135 micro-ohms maximum for used contacts for the 1200 Ampere breaker. 75 micro-ohm maximum for used contacts for 3000 A breaker. If maximum micro-ohms values are greater than those listed a major inspection is required.

(Pole 1) _____ micro-ohms

(Pole 2) _____ micro-ohms

(Pole 3) _____ micro-ohms

8. $SF_6$ Pressure Switches (See Installation Checklist) for checking instructions.

Temperature-Compensated Sw.

Alarm Switch #1 Closes _____ PSIG Alarm at _____ °F

Cutout Switch #2 Opens _____ PSIG Cutout at _____ °F

Switch Differential is 2 to 8 PSIG

9. Operation Reading as Left _____

10. $SF_6$ Gas Pressure as Left

$SF_6$ Pressure _____ psig

Ambient Temperature _____ °F

## 6 YEAR INSPECTION CHECKLIST

Station _____ Bus or Line _____

Date of Inspection _____

1. Nameplate Data

   1.1 Breaker Type _____ Amp. _____

   Serial-S.O. _____ I.B. PB-3468-04

   1.2 Mechanism Type SA-7 I.B. APPENDIX-I

   Control Diagram _____ Control Voltage _____

   Compressor and Heater Voltage _____

**WARNING**

Hazardous voltage.
Death or serious personal injury due to electrical shock could result.

To prevent:

Prior to performing inspection of the breaker, trip the breaker and open adjacent breaker disconnect switches, solidly ground all bushing trip terminals to remove residual electrical charge and open all A-C and D-C switches.

2. General Condition of Breaker: _____

3. Breaker Hold Down Bolts Tight _____

4. Grounding Connections Tight

(Left) _____

(Right) _____

> **CAUTION**
>
> Improper operation can cause breaker damage. To prevent:
>
> Do not operate the breaker until all tests and inspections are done.

5. Pneumatic Mechanism (APPENDIX I)

5.1 Wire Check:

5.1.1 Inspect wiring for damaged or deteriorated insulation. _____

5.1.2 Inspect wiring for possible grounds or short circuit. _____

5.1.3 Connections on terminal blocks, switches, and relays, tight and no corrosion. _____

5.1.4 Heaters: electrical continuity and terminals not shorted to ground. _____

5.2 Lubricate in accordance with "Lubrication" in MAINTENANCE/ADJUSTMENT and LUBRICATION section. _____

5.3 Air Compressor:

5.3.1 Change air compressor oil. Fill to bottom thread of fill hole. See page 95 for oil type and amount. _____

5.3.2 Condition and tighten of "V" belt. _____

5.3.3 Remove air filter, clean in kerosene and reinstall. _____

5.4 Open reservoir drain valve and lower pressure to 130 psig. Close drain valve and compressor control switch and allow to pump to normal pressure. Pump-up time from low pressure cut-out point (130 psig) to normal operating pressure (190 psig) should be less than 30 minutes. Failure of this test requires maintenance of the air system. _____ min.

5.5 Pressure switch operation:

5.5.1 Governor switch; opens on rising pressure (190 psig) Differential - 12 psig. _____ psig.

5.5.2 Low pressure alarm; closes on falling pressure (140 psig), Differential - 12 psig. _____ psig.

5.5.3 Low pressure cut-out; opens on falling pressure (130 psig). Open reservoir drain valve and reduce pressure to 0 psig. Open compressor control switch. Differential - 12 psig. _____ psig.

5.6 Mechanism dimensional checks (breaker open):

5.6.1 Trip assembly air gap (Refer to Fig. 14A Std. Type or Fig. 14B W Type, pages 104 and 105). _____ in.

5.6.2 Trip assembly free travel before kickoff spring is engaged (W Type Trip Assembly only — Refer to Fig. 14B, page 105). _____ in.

5.6.3 Clearance between top of trip rod plunger and catch (Refer to Fig. 14A Std. Type or Fig. 14B W Type, pages 104 and 105). _____ in.

5.6.4 Armature air gap when breaker trips (.032-0/+0.015) Refer to Fig. 14A or 14B, pages 104 and 105. _____ in.

5.6.5 Clearance between the trip free trigger and roller lever (.032 ± .005 inches). _____ in.

5.7 Mechanism mounting bolts tight (250 ft.lbs.). _____ ft.lbs.

6. Breaker Checks

6.1 Install maintenance hand jack on the mechanism and check that mechanism horizontal pull rod and tie bar and all three interrupter connecting rods operate freely and without interference during a manual (hand jack) operation.

Interrupter 1 _____

Interrupter 2 _____

Interrupter 3 _____

Mechanism _____

6.2 Check contact position indicator with breaker in closed position (Ref. Figure 11, page 72, or use gauge 7358D12H14 (Ref. Figure 4, page 65).

6.3 Check minimum contact touch. (Ref. to "Lubrication" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section.

(Pole 1) _____

(Pole 2) _____

(Pole 3) _____

6.4 Check contact engagement by installing the timing device rod onto tie bar. Place ohmmeter or light out device between bushings on each pole, jack breaker slowly toward the closed position and mark timing device rod with reference to the mounting bracket for each pole when circuit is obtained. Continue to jack breaker closed to the point where the SA-7 mechanism just latches, loosen jack to load mechanism and mark full closed position on the timer rod.
Measure contact engagement as determined by the difference in position. Dimension should be between .60 and .95 inches. (Refer to "Closed Position Adjustment" in MAINTENANCE/ ADJUSTMENT and LUBRICATION Section if required).

Interrupter 1_____ in.

Interrupter 2_____ in.

Interrupter 3_____ in.

6.5 Check lever system closed position stop clearance (.027-.037 inches). (Refer to Fig. 4 and "Closed Position Adjustment" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.6 Check travel of horizontal pull rod assembly (4.937 ± .060 inches). (Refer to Fig. 4 and "Closed Position Adjustments" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.7 Check lever system open position stop clearance. There should be no clearance between the bellcrank lever and the stop bolt. (Refer to Fig. 4 and "Open Position Adjustments" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.8 Final check for loose hardware. Remove maintenance hand jack. Reconnect the bushing line connections. (See "Line Connections" in INSTALLATION Section, page 14.)

_____

7. Mechanism Operational Checks. Reference APPENDIX I.

7.1 Breaker trips manually with .0 32 inch shim on moving armature.

_____

7.2 Overtravel on closing position (.125 inches minimum).

_____ in.

8. Operation run-down starting at governor shut-off with compressor de-energized. Operations must be made electrically.

   8.1 Number of operations before low pressure cut-out switch opens (5 minimum). _____

   8.2 Number of operations after low pressure cut-out switch opens with low pressure cut-out switch contacts jumpered (1 minimum). _____

> **WARNING**
>
> Operating with jumper in may cause damage to the circuit breaker.
> To prevent:
>
> Remove jumper after test.

9. Minimum operating voltage. (See mechanism nameplate for voltage range). Close _____ Vd-c

10. Timing Tests: (These tests are to be made at normal operating voltage and rated air pressure with 80 psig $SF_6$ in the interrupters. Attach timing device to tie bar. (See Fig. 4, page 65).

    10.1 Trip coil energized until contacts part. (32 milliseconds max.) _____ milliseconds

    10.2 Opening velocity-measured between 1 inch and 4 inches travel. (14.6 ft./sec. to 16.2 ft./sec.). (See Fig. 3A, page 63). _____ ft./sec.

    10.3 Close coil energized until contacts touch. (90 to 100 milliseconds DC, 84 to 94 milliseconds AC). _____ milliseconds

    10.4 Reclose time (if required) trip coil energized until contacts touch (approximately 270 milliseconds). (See Fig. 3B, page 64). _____ milliseconds

    10.5 Rebound on opening. (.50 inch max.). (See Fig. 3A, page 63). _____ in.

    10.6 Overtravel on opening. Limit is ±0.1" from full open position. (See Fig. 3A, page 63). _____ in.

    10.7 Overtravel on close-open. Limits are + 0.2" - 0.1" from full open position. (See Fig. 3A, page 63). Remove timing device. _____ in.

11. Leak Rate: Beginning at 190 psig with the compressor motor de-energized the maximum allowable pressure drop is 5 psig/hr. in the air system.

_____ psi/hr

12. Contact resistance terminal to terminal measured with ductor or equivalent 100 amp d-c source 115 micro-ohms max. for used contacts on the 2000 ampere breaker; 135 micro-ohms max. for used contacts on 1200A breaker. 75 micro-ohm maximum for used contacts with 3000A breakers. If maximum micro-ohm values are greater than those listed a major inspection is required.

(Pole 1) _____ micro-ohms

(Pole 2) _____ micro-ohms

(Pole 3) _____ micro-ohms

13. Capacitor Tests

13.1 Measure capacitance of external capacitors if so equipped. The value should be 5000 pf + 10% -0

(Pole 1) _____ pf

(Pole 2) _____ pf

(Pole 3) _____ pf

14. $SF_6$ Pressure Switches (See Installation Checklist) for checking instructions.

Temperature-Compensated Sw.

Alarm Switch #1 Closes _____ PSIG Alarm at _____ °F

Cutout Switch #2 Opens _____ PSIG Cutout at _____ °F

Switch Differential is 2 to 8 PSIG

15. Operation Counter Reading as Left _____

16. $SF_6$ Gas Pressure as Left

$SF_6$ Pressure _____ psig

Ambient Temperature _____ °F

## MAJOR INSPECTION CHECKLIST

Station _____ Bus or Line _____

Date of Major Inspection _____

Installation Date _____

1. Nameplate Data

   1.1 Breaker Type _____ Amp. _____

   Serial-S.O. _____ I.B. PB-3468-04

   1.2 Mechanism Type SA-7 I.B. APPENDIX-I

   Control Diagram _____ Control Voltage _____

   Compressor and Heater Voltage _____

**WARNING**

Hazardous voltage.
Death or serious personal injury due to electrical shock could result.

To prevent:

Prior to performing inspection of the breaker, trip the breaker and open adjacent breaker disconnect switches, solidly ground all bushing trip terminals to remove residual electrical charge and open all A-C and D-C switches.

2. General Condition of Breaker: _____

3. Breaker Hold Down Bolts Tight _____

4. Grounding Connections Tight

(Left) _____

(Right) _____

> **CAUTION**
>
> Improper operation can cause breaker damage. To prevent:
>
> Do not operate the breaker until all tests and inspections are done.

5. Pneumatic Mechanism (APPENDIX I)

5.1 Wire Check:

5.1.1 Test wiring for damaged or deteriorated insulation. _____

5.1.2 Inspect wiring for possible grounds or short circuit. _____

5.1.3 Connections on terminal blocks, switches, and relays, tight and no corrosion. _____

5.1.4 Heaters: electrical continuity and terminals not shorted to ground. _____

5.2 Air Compressor:

5.2.1 Change air compressor oil. Fill to bottom thread of fill hole. Refer to page 95 for oil type and amount. _____

5.2.2 Condition and tighten of "V" belt. _____

5.2.3 Remove air filter, clean in kerosene and reinstall. _____

5.3 Open reservoir drain valve and lower pressure to 130 psig. Close drain valve and compressor control switch and allow to pump to normal pressure. Pump-up time from low pressure cut-out point (130 psig) to normal operating pressure (190 psig) should be less than 30 minutes. Failure of this test requires maintenance of the air system. _____ min.

5.4 Pressure switch operation:

5.4.1 Governor switch; opens on rising pressure (190 psig) Differential - 12 psig. _____ psig.

5.4.2 Low pressure alarm; closes on falling pressure (140 psig) Differential - 12 psig. _____ psig.

5.4.3 Low pressure cut-out; opens on falling pressure (130 psig). Open reservoir drain valve and reduce pressure to 0 psig. Open compressor control switch. Differential - 12 psig. _____ psig.

5.5 Mechanism dimensional checks (breaker open):

5.5.1 Trip assembly air gap (Refer to Fig. 14A Std. Type or Fig. 14B W Type, page 104). _____ in.

5.5.2 Trip assembly free travel before kickoff spring is engaged (W Type Trip Assembly only — Refer to Fig. 14B, page 105). _____ in.

5.5.3 Clearance between top of trip rod plunger and catch (Refer to Fig. 14A Std. Type or Fig. 14B W Type, pages 104 and 105). _____ in.

5.5.4 Armature air gap when breaker trips (.032-0/+0.015) Refer to Fig. 14A or 14B, pages 104 and 105. _____ in.

5.5.5 Clearance between the trip free trigger and roller lever (.032 ± .005 inches). _____ in.

5.6 Mechanism mounting bolts tight (250 ft.lbs.). _____ ft.lbs.

6. Internal Inspection:

6.1 Remove $SF_6$ gas from pole units. As per page 51 - Removal of the Interrupter, section a.

**WARNING**

Hazardous arc products may cause serious personal injury.
To prevent:

Refer to MAINTENANCE Section for precautions to be observed when handling arced $SF_6$ gas.

6.2 Remove interrupter cover plates.

Interrupter 1 _____

Interrupter 2 _____

Interrupter 3 _____

| | | |
|---|---|---|
| 6.3 | Remove bushings #1, #3, and #5. Remove interrupters (Fig. 9, page 70), dismantle and wipe all surfaces clean with alcohol and check for excessive interrupter orifice erosion. The diameter of this orifice should not exceed 1.156 inches in diameter. (Refer to Fig. 8, page 69). If the diameter exceeds 1.156 inches at any point, the entire interrupter assembly must be replaced. This can be checked with orifice wear gauge 7249A38H01. Refer to Removal of Interrupter, page 51. | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| | Check bushing plug-in contacts for wear. If silverplate is worn off or if contacts are worn, replacement is required. Check bushing leads at end where they plug into interrupter. If silverplate is worn off, replacement is required. | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| 6.4 | Replace piston seal ring as shown in Fig. 9, page 70 and described in text. (See "Replacing Interrupter Seal Ring" in MAINTENANCE/ ADJUSTMENT and LUBRICATION Section.) | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| 6.5 | Replace moving contact Teflon guide seals. (See Fig. 9, page 70.) | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| 6.6 | Check all hardware on moving contact assembly for tightness. | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| 6.7 | Wipe clean the inside of the interrupter tube with alcohol and apply Molykote G-N (00337271095) sparingly to the moving contact assembly. See LUBRICATION, Fig. 15, page 78. | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |
| 6.8 | Reassemble interrupters after inspection and replacement of necessary parts. Clean inside of pole unit pipes. Install interrupter in pipes and install cover plates with new desiccant (see Fig. 12, View "X", page 73). Immediately prior to intallation of desiccant (1657B11H01) remove moisture protective foil covering. Use Dow Corning No. 111 (W962026) to hold coverplate gasket in place. Install bushings #1, #3 and #5. | Interrupter 1 _____ in.<br>Interrupter 2 _____ in.<br>Interrupter 3 _____ in. |

6.9 Install maintenance hand jack on the mechanism and check that mechanism horizontal pull rod and tie bar and all three interrupter connecting rods operate freely and without interference during a manual (hand jack) operation.

Interrupter 1 _____

Interrupter 2 _____

Interrupter 3 _____

Mechanism _____

6.10 Check contact position indicator with breaker in closed position, (Figure 11, page 72).

(Pole 1) _____

(Pole 2) _____

(Pole 3) _____

6.11 Check minimum contact touch. (Ref. to "Lubrication" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section.

(Pole 1) _____

(Pole 2) _____

(Pole 3) _____

6.12 Check contact engagement by installing the timing device rod onto tie bar. Place ohmmeter or light out device between bushings on each pole, jack breaker slowly toward the closed position and mark timing device rod with reference to the mounting bracket for each pole when circuit is obtained. Continue to jack breaker closed to the point where the SA-7 mechanism just latches, loosen jack to load mechanism and mark full closed position on the timer rod.

Measure contact engagement as determined by the difference in position. Dimension should be between .60 and .95 inches. (Refer to "Closed Position Adjustment" in MAINTENANCE/ ADJUSTMENT and LUBRICATION Section if required).

Interrupter 1 _____ in.

Interrupter 2 _____ in.

Interrupter 3 _____ in.

6.13 Check lever system closed position stop clearance (.027-.037 inches). (Refer to Fig. 4 and "Closed Position Adjustment" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.14 Check travel of horizontal pull rod assembly (4.937 ± .060 inches). (Refer to Fig. 4 and "Closed Position Adjustments" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.15 Check lever system open position stop clearance. There should be no clearance between the bellcrank lever and the stop bolt. (Refer to Fig. 4 and "Open Position Adjustments" in MAINTENANCE/ADJUSTMENT and LUBRICATION Section, page 65.)

_____ in.

6.16 Final check for loose hardware. Pull vacuum to 2mm of mercury and hold for 30 minutes and fill with $SF_6$. (See "Filling De-energized Breaker With $SF_6$ Gas in INSTALLATION Section.) Remove maintenance hand jack. Reconnect the bushing line connections. (See "Line Connections" in INSTALLATION Section, page 14. _____

7. Mechanism Operational Checks. Reference APPENDIX I.

7.1 Breaker trips manually with .0 32 inch shim on moving armature. _____

7.2 Overtravel on closing position (.125 inches minimum). _____ in.

8. Operation run-down starting at governor shut-off with compressor de-energized. Operations must be made electrically.

8.1 Number of operations before low pressure cut-out switch opens (5 minimum). _____

8.2 Number of operations after low pressure cut-out switch opens with low pressure cut-out switch contacts jumpered (1 minimum). _____

**⚠ WARNING**

Operating with jumper in may cause damage to the circuit breaker.
To prevent:

Remove jumper after test.

9. Minimum operating voltage. (See mechanism nameplate for voltage range). Close _____ Vd-c

10. Timing Tests: (These tests are to be made at normal operating voltage and rated air pressure with 80 psig $SF_6$ in the interrupters. Attach timing device to tie bar. (See Fig. 4, page 65.)

10.1 Trip coil energized until contacts part. (32 milliseconds max.) _____ milliseconds

10.2 Opening velocity-measured between 1 inch and 4 inches travel. (14.6 ft./sec. to 16.2 ft./sec.). (See (Fig. 3A, page 63.) _____ ft./sec.

10.3 Close coil energized until contacts touch. (90 to

10.4 Reclose time (if required) trip coil energized until contacts touch (approximately 270 milliseconds). (See Fig 3B, page 64.) _____ milliseconds

10.5 Rebound on opening. (.50 inch max.). (See Fig. 3A, page 63). _____ in.

10.6 Overtravel on opening. Limit is ± 0.1" from full open position. (See Fig. 3A, page 63.) _____ in.

10.7 Overtravel on close-open. Limits are + 0.2" - 0.1" from full open position. (See Fig. 3A, page 63.) Remove timing device. _____ in.

11. Leak Rate: Beginning at 190 psig with the compressor motor de-energized the maximum allowable pressure drop is 5 psig/hr. in the air system. If leak exceeds 5 psig/hr., see page 94 for corrective action. _____ psi/hr

12. Contact resistance terminal to terminal measured with ductor or equivalent 100 amp d-c source 80 micro-ohms maximum for new contacts; 115 micro-ohms maximum for used contacts on the 2000 ampere breaker; 100 micro-ohms for new contacts, 135 micro-ohms for used contacts on 1200A breakers.
60 Micro-ohm maximum for new contacts; 75 Micro-ohm maximum for used contacts for 3000 A breakers.
The micro-ohms across the interrupter only should not exceed 30 for the 3000 A breakers.

(Pole 1) _____ micro-ohms
(Pole 2) _____ micro-ohms
(Pole 3) _____ micro-ohms

13. Capacitor Tests

13.1 Measure capacitance of external capacitors if so equipped. The value should be 5000 pf + 10% - 0

(Pole 1) _____ pf
(Pole 2) _____ pf
(Pole 3) _____ pf

14. $SF_6$ Pressure Switches (See Installation Checklist) for checking instructions.

Temperature-Compensated Sw.

Alarm Switch #1 Closes _____ PSIG Alarm at _____ °F

Cutout Switch #2 Opens _____ PSIG Cutout at _____ °F

Switch Differential is 2 to 8 PSIG

15. Operation Counter Reading as Left _____

16. $SF_6$ Gas Pressure as Left

$SF_6$ Pressure _____ psig

Ambient Temperature _____ °F

This instruction book section describes procedures to be followed when adjustments or part replacement is necessary as determined by the Installation, Periodic, 3 Year, 6 Year or Major Inspection Checklist or by circuit breaker malfunction. The step-by-step instructions given should be followed carefully to assure proper equipment operation. Reference to the included instruction leaflets and instructions books may be necessary.

## WARNING

Oxygen deficiency and hazardous arc products could cause serious personal injury or death.

To prevent:

1. Do not breathe large volumes of the sulfur hexafluoride gas ($SF_6$); in the pure state the gas is colorless, odorless, tasteless and non-toxic.
2. Toxic decomposition products are formed in the gas when arcing occurs in it.
3. Do not breathe gas containing these toxic products, especially within a few minutes after the covers have been removed or until the decomposition products are safely diluted with fresh air.
4. If for some reason a significant amount of arc-formed toxic gas is present, an unpleasant stinging odor or iritation of the upper respiratory tract and eyes should give an early and sufficient warning within seconds to the personnel in the vicinity before a significant toxic reaction should occur.
5. The absence of any detectable odor or nasal irritation should indicate safe working conditions.
6. Molecular sieves are incorporated in all $SF_6$ breakers.
7. This material is efficient in removing the chemically active product formed during arcing.
8. A sufficient amount of this filter material is used to remove the expected toxic gases produced from arcing between maintenance operations on the breaker.
9. Usually only a small percentage of gas remains in the vessel after releasing the gas to atmosphere, and most of it escapes after opening the cover plates.
10. Caution should be observed to prevent the inhalation of the fine metallic fluoride dust.
11. A dust mask should be worn while doing this work, and it is also advisable to avoid skin irritation by wearing gloves and keeping other parts of the body covered.
12. It is recommended that workmen exposed to arc powders wash carefully to remove the metal salts from their skin.

## MAINTENANCE TOOLS, MATERIALS AND EQUIPMENT

The following tools, material, and equipment are recommended to perform maintenance, adjustment and lubrication on the breaker:

PI — Periodic Inspection
3I — 3 Year Inspection
6I — 6 Year Inspection
MI — Major Inspection

| | | | | | |
|---|---|---|---|---|---|
| (PI) | (3I) | (6I) | (MI) | 1. | Wrenches — Standard sizes of open end and box type and allen wrenches. ¼", ⅜" and ½" drive ratchets, ratchet extensions and sockets. |
| (PI) | (3I) | (6I) | (MI) | 2. | Thermometer |
| (PI) | (3I) | (6I) | (MI) | 3. | Screwdrivers — ⅛", ¼" and ⅜" blade, Phillips screwdriver #1 with 10" blade. |
| | (3I) | (6I) | (MI) | 4. | Ten foot "A" frame stepladder. |
| | (3I) | (6I) | (MI) | 5. | Ductor or equivalent 100 ampere DC source with a micro-ohmmeter. |
| | (3I) | (6I) | (MI) | 6. | Feeler gauges and 6" and 12" measuring rules. |
| | (3I) | (6I) | (MI) | 7. | Mechanism hand closing jack. |
| | (3I) | (6I) | (MI) | 8. | Timing device rod. |
| | | | (MI) | 9. | Leak-tec for leak testing. |
| | | | (MI) | 10. | 1½" ton crane with a working height of 20 feet and 2 cable slings (for removing the bushings, and if so equipped, the capacitor assemblies). |
| | | | (MI) | 11. | 0-50 ft. lb. torque wrench — ⅜" drive, (Snap-on Model TE 50 FFU-A Recommended) and 0-100 ft. lb. torque wrench. |
| | | (6I) | (MI) | 12. | Timing equipment and mounting hardware. (See "Final Tests" in INSTALLATION Section). |
| | | | (MI) | 13. | Corrosive resistant conductive joint compound and wire brush. |
| | | (6I) | (MI) | 14. | Capacitance measuring device — Doble or equivalent high voltage type. |
| | | | (MI) | 15. | Slip-joint pliers. |
| | | | (MI) | 16. | Linemans pliers with side cutters. |
| | | | (MI) | 17. | Small vacuum pump (Welsh Duo-Seal Model 1400B (0.9CFM) or equivalent) with vacuum gauge measuring down to at least 1 mm of mercury. |

| | | | |
|---|---|---|---|
| | (MI) | 18. | Hammer |
| | (MI) | 19. | 1/16" diameter pin punch. |
| | (MI) | 20. | Alcohol and clean, lint-free cloths. |
| | (MI) | 21. | Dust mask and gloves. |
| | (MI) | 22. | $SF_6$ gas (15 lbs.) |
| | (MI) | 23. | Service hose and adapter for $SF_6$ filling (72-180-624-501 and W136005). |
| (6I) | (MI) | 24. | Timer mounting bracket, 9" Torpedo Level. |
| | (MI) | 25. | Long 6mm allen wrench or 1/4" drive socket with 6mm allen wrench attachment. |
| | (MI) | 26. | Orifice wear gauge (7249A38H01). ① |
| | (MI) | 27. | Short 5/16" allen adapter W380008. |
| | (MI) | 28. | Interrupter spanner wrench 72-180-786-801 ① |
| | (MI) | 29. | X washers (3 required, 6 supplier). ①, ② |
| | (MI) | 30. | Cover plate gaskets (3). ①, ② |
| | (MI) | 31. | Bushing gaskets (3).①, ② |
| | (MI) | 32. | Guide seals (6). ①, ② |
| | (MI) | 33. | Seal rings (3). ①, ② |
| | (MI) | 34. | Loctite — medium strength 242 ①, ②, ③ (W946024) |
| | (MI) | 35. | Molykote 00337271095 grease. ①, ② |
| | (MI) | 36. | Beacon 325 (W962010) grease. ①, ② |
| | (MI) | 37. | Dow Corning No. 111 (W962026) grease. ①, ② |
| | (MI) | 38. | Desiccant (3 bags of Molecular Sieve (1657B11H01) and 6 long nylon cable ties. ①, ② |
| | (MI) | 39. | Silicone RTV sealant (W981015) ①, ② |
| | (MI) | 40. | Linkage setting gauge 7358D12H14 ① |

① Available from Siemens as Major Inspection Tool and Parts Kit, Part No. 1658B22G01.
② Available from Siemens as Major Inspection Parts Kit, Part No. 1658B23G01.
③ Shelf life 1 year.

## GENERAL

Thorough, periodic inspection is important to satisfactory operation. Inspection and maintenance frequency depends on installation, site, weather and atmospheric conditions, experience of operating personnel and special operation requirements. Because of this, a well-planned and effective maintenance program depend largely on experience and practice.

Failure to properly maintain the equipment can result in severe personal injury, product failure and prevent successful functioning of connected apparatus. Inspection and maintenance can be improved and simplified by using the gauge and tools available from Siemens identified as Major Inspection Tool kit 1658B22G01. The instructions contained herein should be carefully reviewed, understood and followed. The following maintenance procedures should be performed regularly:

STEP 1

Be sure that the circuit breaker and its mechanism is disconnected from all electric power, both high voltage and control voltage, before it is inspected or repaired.

STEP 2

After the circuit breaker has been disconnected from power lines, attach the grounding leads properly before touching any of the circuit breaker parts.

STEP 3

Inspect the operating mechanism periodically and keep the bearing surfaces of the toggles, rods and levers adequately lubricated where required. See LUBRICATION OF MECHANISM, page 98.

STEP 4

Keep the mechanism clean.

STEP 5

Be sure the circuit breaker is well grounded.

STEP 6.

See that bolts, nuts, washers, cotter pins and all terminal connections are in place and tight.

STEP 7

Inspect the bushing (insulator) supports, as the vibration due to the operation of the circuit breaker may cause the bushings to move slightly and result in loose hardware.

**DANGER**

Hazardous voltage and mechanisms will cause serious personal injury or death from electrical shock, burns and entanglement in rapidly moving parts. To prevent:

1. Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off control voltage.
2. Never trip or close the breaker while working on it, since the parts move rapidly and can cause injury.
3. Discharge the breakers' mechanical systems before performing maintenance or inspection.
4. Secure the operator against accidental tripping when adjustments require breaker in closed position.
5. Breaker and its mechanism must be disconnected from all electrical power before performing maintenance or inspection. Grounding leads should be properly attached and framework grounded.
6. When using the maintenance closing device on pneumatic operators the pneumatic system must be at zero psig.
7. Never slow operate the breaker while it is energized or control power is connected.
8. Remove the maintenance closing device before operating the breaker.
9. Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices, instructions and maintenance procedures contained herein. The successful and safe operation of this equipment is dependent upon proper handling, installation, operation and maintenance.

STEP 8

Clean and, if necessary, dry the insulating materials across the interrupter and to ground or parts of different potential.

STEP 9

At all inspections operate the circuit breaker by hand to see that the mechanism works smoothly and correctly before operating it with power.

This checklist does not represent an exhaustive survey of maintenance steps necessary to ensure safe operation of the equipment. Particular applications may require further procedures. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the local Siemens sales office.

The use of unauthorized parts in the repair of the equipment, tampering by unqualified personnel, or incorrect adjustments will result in dangerous conditions which can cause severe personal injury or equipment damage. Follow all safety instructions contained herein.

## ORDERING REPLACEMENT PARTS

When ordering replacement parts for a Siemens Circuit Breaker, it is very important to give complete information. This information should include:

1. Breaker serial number. (On breaker and operator nameplates.)
2. Type of operator, (On operator nameplate)
3. Type of breaker.
4. Rated amperes of breakers.
5. Rated voltage of breaker.
6. Description of part — Use instruction book description insofar as possible.
7. Operator instruction book number. (On breaker nameplate).
8. Instruction book reference number.
9. Number of pieces required.

While the operator can be identified by the serial number alone, all additional information that is given will serve as a check to be certain that the part or parts furnished are correct for the operator in question. Without this serial number Siemens cannot be sure of the correct identity of the desired parts.

If any doubt exists as to the instruction book reference number of the description, a dimensional sketch of the desired part will help to properly identify it.

Siemens recommends that a supply of repair parts be kept on hand so that emergency repairs can be made without waiting for shipment of parts from the factory. A list of recommended spare parts is sent with the breaker.

Before removing any part to be replaced, observe its function and adjustment. This usually saves adjustment time during its installation.

## BUSHING WEATHERCASE REPLACEMENT ITEMS

1. Bushing weathercase removal spanner wrench 72-180-784-801. ③
2. Seal. ③
3. Gasket. ③
4. "O" Ring. ③
5. Bushing to flange gasket. ③
6. Short 5/16" allen wrench stub 72-180-495-501. ③
7. Loctite 242. ② ③
8. Desiccant (1 bag of Molecular Sieve 1657B11H01 and 2 long nylon cable ties. ③
9. Cover plate gasket (1). ③
10. Dow Corning No. 111 grease (W962026). ③
11. Weathercase - ordered separately.

② Shelf life 1 year.
③ Available from Siemens as Bushing Weathercase Replacement Kit, Part No. 1658B21G01

## MAINTENANCE/ADJUSTMENT

## PNEUMATIC OPERATING MECHANISM

For maintenance, adjustment and lubrication of the Type SA-7 pneumatic mechanism. Refer to APPENDIX I.

## OPERATING LINKAGE

(Figure 4, page 65)

## CLOSED POSITION ADJUSTMENTS

Using the hand closing jack, close the breaker until it latches. The indicator on each pole unit should be on the vertical mark on the pole unit shaft seal housing. Verify the closed position setting by using the gauge 7358D12H14. Position the gauge with the holes over the bolt heads on the end of the operating shafts on phases 1 and 2 as shown in Fig. 4, page 65. The center phase operating lever — pull rod pin should be in the closed position slot as shown on the drawing. If the pin is not in the slot, adjust the horizontal pull rod as required. Adjust the closed position stop bolt on the mechanism frame to the .027-.037 in. dimension on the drawing. Tighten the locknut.

## OPEN POSITION ADJUSTMENTS

Unlatch the mechanism and jack the breaker open. Position the gauge with the holes over the bolt heads on the end of the operating shafts on phases 1 and 2 as shown in Fig. 4, page 65. The center phase operating lever — pull rod pin should be in the open position slot. If the pin is not in the slot, loosen the locknut and adjust the open position stop bolt on the mechanism as required. Tighten the locknut and adjust the hydraulic shock absorber per the Instruction Book. Check contact engagement per 6.12 of the Major Inspection Checklist. Resolve the hand closing jack before operating breaker.

## INTERRUPTER AND BUSHINGS

The internal parts of the pole unit, specifically the interrupter and tank liner (when used), are made up of solid insulation. Maintaining these assemblies dry is important and they should not be exposed to inclement weather during their maintenance. The interior of the pole unit should not be left open for extended periods of time. The bushings should be in place or the ends covered when work is not in progress to limit exposure to atmospheric moisture, dirt, dust, etc.

**⚠ WARNING**

Hazardous arc products may cause serious personal injury.
To prevent:

Refer to MAINTENANCE Section to precautions to be observed when handling arced $SF_6$ gas.

## REMOVAL OF THE INTERRUPER

(Reference Figs. 1, 5 and 11, pages 61, 66, and 72)

To inspect or perform maintenance on the interrupter, it must be removed from the pipe. The procedure is as follows:

a. Evacuate the gas from the breaker by connecting the Female Quick Disconnect fitting 4043B97G02 (supplied with the Installation Tool Kit) to the service connection. It is possible to service only one pole unit without removing gas from the two pole units. To do this disconnect the quick disconnect fittings at the cover plate. Then attach the Female Quick Disconnect to the fitting on the cover plate to evacuate the gas.

b. Remove the (6) .375-16 x 2.5 cylinder head cap screws from the side bushing split clamp rings that fasten to the pipe. A 5/16" allen wrench is required. Remove the capacitor assembly if so equipped. (See "Installation of External Capacitors" in INSTALLATION Section.)

c. Remove the split clamp rings and pull the bushing straight out from the pipe. Be extremely careful not to damage the voltage shield. This shield need not be removed. The shield is used on the 46 and 69kV breaker only.

d. Remove the (8) .5-13 x 3 hex steel bolts, nuts and lockwashers holding the coverplate and remove the coverplate. A ¾" socket, ratchet, 6" extension and ¾" box end wrench is required. If the breaker has been subjected to a number of fault interruptions, a cup full of arc product powders may drop out. Observe the precautions outlined at the beginning of MAINTENANCE/ ADJUSTMENT and LUBRICATION Section for handling arced $SF_6$ gas products.

e. Remove the hitch pin and washer that fastens the connecting rod levers to the operating shaft assembly.

f. Remove one "X" washer (Ref. Figure 11, page 72) by squeezing tabs with a pair of pliers and discard. Remove the pin and the 2 brass washers.

g. Carefully remove the connecting rod levers and spacers from the operating shaft assembly.

h. Remove the (3) .375-16 x 1.62 hex steel bolts and lockwashers that fasten the interrupter to the pipe. A 9/16" socket, ratchet and 12" extension is required.

i. Rotate interrupter as required and carefully slide out of the pipe. (The interrupter weighs about 40 pounds). Do not let the interrupter fall when it separates from the line side bushing. Place a piece of cardboard or wood between the interrupter and pipe casting.

## DISASSEMBLY OF THE INTERRUPTER (23 kA)

(Figure 9, page 70)

With the interrupter placed on a level, clean surface, disassembly can proceed as follows:

a. Using the interrupter spanner wrench 72-180-786-801 remove the 2 large nuts at the center of the interrupter tube.

**NOTE** Medium strength adhesive has been applied to these nuts. Do not damage the polished surface of the large nuts as they are voltage grading devices.

b. Remove the (2) cylinder head cap screws and Belleville washers holding the contact carrier to the interrupter. Pull out the contact carrier assembly. Do not damage the polished surface of this voltage grading device.

c. Pull on the interrupter connecting rod (Fig. 11, page 72) and slowly remove the moving contact assembly from the interrupter tube. The lip of the seal ring used on 23KA interrupters must be depressed to clear the holes in the interrupter tube during removal.

d. Slide the interrupter contact assembly off the moving contact assembly and over the connecting rod.

## INSPECTION OF THE INTERRUPTER

a. Check the inside diameter of the Teflon orifice (see Fig. 8, page 69). If the diameter is greater than 1.156 inches, replace the entire interrupter assembly. This dimension can be easily checked with orifice wear gauge 7249A38H01. If orifice is out of tolerance remove and replace interrupter.

b. Check the connecting rod for scratches, crazing or elongation of the pin holes. If any of the above are evident, replace rod.

c. Inspect the rest of the interrupter parts (tube, stationary contact assembly, valve and valve spring, and bushing finger contact assemblies) for excessive wear or damage. Do not over tighten the valve spring set screws.

d. Check the 12 set screws on the interrupter contact assembly transfer fingers for tightness using a long allen wrench (see Fig. 9, page 70).

e. The 23kA interrupter piston ring must be replaced at this time.

## REPLACING INTERRUPTER PISTON RING

To replace the interrupter piston ring, first remove the old seal ring. Be careful not to scratch the seal groove. Remove the "O" ring from the new piston ring and discard the "O" ring. Slide the new piston ring over the moving contact assembly. Orient the piston ring as shown in Fig. 9, page 70.

## REPLACEMENT OF INTERRUPTER GUIDE SEALS

a. If necessary remove both interruter guide seals by prying out with a small screwdriver. Refer to Figure 9, page 70. Be careful not to damage the seal groove.

b. Replace with new split ring guide seals by inserting carefully into seal grooves. The split in the inner ring should be supported by the seal groove.

## CLEANING AND LUBRICATING INTERRUPTER

Wipe the entire interrupter and components clean with a lint-free cloth saturated with alcohol. Wipe the inside of the interrupter tube also. Clean out all Loctite particles.

Apply a very light film of Molykote grease 00337271095 to the surface of the moving contact assembly as shown in Figure 9, page 70. Apply a light film of Beacon 325 Grease (W962010) to the moving contact assembly a shown in Figure 9, page 70.

## ASSEMBLY OF THE INTERRUPTER

a. Slide the interrupter contact assembly onto the moving contact assembly (Figure 9, page 70). Be certain the radiused end of the interrupter contact assembly is free of nicks, scratches or dents.

b. Slide the moving contact assembly into the interrupter tube slowly while carefully guiding the seal past the openings in the interrupter tube.

c. Rotate the moving contact assembly to line up the contact carrier mounting holes with the contact carrier. (Figure 9, page 70.)

d. Install (2) cylinder head cap screws and Belleville washers to hold the contact carrier to the moving contact. The Belleville washers must be placed on the convex position against the bolt head. Tighten to torque specified in table, page 58.

e. Apply medium strength adhesive (Loctite 242), Siemens Spec. (W946005) to the threads of the large nuts. Use the interrupter spanner wrench 72-180-786-801 to install both nuts into the moving contact assembly.

Make sure the nuts and the contact carrier are oriented as shown in Figure 9, page 70.

## DISASSEMBLY OF THE INTERRUPTER (31.5/40 kA)

(Figure 9A, Page 70)

With the interrupter placed on a level, clean surface, disassembly can proceed as follows:

a. Remove the two (2) button head cap screws holding the moving contact shields to the interrupter and remove the shields.

b. Remove the two (2) cylinder head cap screws and Belleville washers holding the contact carrier to the interrupter. Pull out the contact carrier assembly. Do not damage the polished surface of this voltage grading device.

c. Pull on the interrupter connecting rod (Fig. 11, page 72) and slowly remove the moving contact assembly from the interrupter tube.

d. Slide the interrupter contact assembly off the moving contact assembly and over the connecting rod.

e. Remove the six (6) radially located button head cap screws and carefully pull the stationary contact assembly from the end of the interrupter tube assembly.

## INSPECTION OF THE INTERRUPTER

a. Check the inside diameter of the Teflon orifice (see Fig. 8, page 69). If the diameter is greater than 1.156 inches, replace the entire interrupter assembly. This dimension can be easily checked with orifice wear gauge 7249A38H01. If orifice is out of tolerance remove and replace interrupter.

b. Check the connecting rod for scratches, crazing, or elongation of the pin holes. If any of the above are evident, replace rod.

c. Inspect the rest of the interrupter parts (tube, stationary contact assembly, valve and valve spring, and bushing finger contact assemblies) for excessive wear or damage. Do not over tighten the valve spring set screws.

d. Check the 12 set screws on the interrupter contact assembly transfer fingers for tightness using a long allen

## REPLACEMENT OF INTERRUPTER GUIDE SEALS

a. If necessary remove both interruter guide seals by prying out with a small screwdriver. Refer to Figure 9, page 70. Be careful not to damage the seal groove.

b. Replace with new split ring guide seals by inserting carefully into seal grooves. The split in the inner ring should be supported by the seal groove.

## CLEANING AND LUBRICATING INTERRUPTER

Wipe the entire interrupter and components clean with a lint-free cloth saturated with alcohol. Wipe the inside of the interrupter tube also. Clean out all Loctite particles.

Apply a very light film of Molykote grease 00337271095 to the surface of the moving contact assembly as shown in Figure 9A, page 70. Apply a light film of Beacon 325 Grease (W962010) to the moving contact assembly as shown in Figure 9A, page 70.

## ASSEMBLY OF THE INTERRUPTER

a. Before starting assembly the M8 stationery contact radial bolts and the M10 moving contact shield bolts should be wire brushed to remove all traces of locking compound. Just prior to their respective installation apply medium strength adhesive (Loctite 242 W946024) to the threads.

b. Slide the stationery contact assembly into the end of the interrupter tube assembly, install the (6) radial screws and tighten to 18 ft.lbs.

c. Slide the interrupter contact assembly onto the moving contact assembly (Figure 9, page 70). Be certain the radiused end of the interrupter contact assembly is free of nicks, scratches or dents.

d. Slide the moving contact assembly into the interrupter tube slowly while carefully guiding the seal past the openings in the interrupter tube.

e. Rotate the moving contact assembly to line up the recess into which the contact carrier fits. Install the contact carrier and the (2) cylinder head cap screws and Belleville washers to hold the contact carrier to the moving contact. The Belleville washers must be in place on the convex position against the bolt head. Torque to specified value in table on page 58.

f. Locate the (2) halves of the moving contact shield through the holes in the interrupter tube and so that they surround the tube. Install the (2) M10 moving contact shield bolts and tighten to the torque specified in the table on page 58.

## REPLACING THE INTERRUPTER

a. Insert the interrupter into the pipe, rotating slightly as required to get past the operating shaft assembly. Keep the stationary contact end of the interrupter centered so that the interrupter can be inserted onto the bushing. This can be facilitated by lifting through the removed bushing opening using a thin cloth tape or rope sling looped around the contact carrier at the midpoint of the interrupter. Use care to be sure interrupter is held in position while centering. Bolt the interrupter to the pipe using (3) .375-16 x 1.62 steel bolts and lockwashers. Torque to 18 ft lbs.

b. Fasten the connecting rod levers to the operating shaft using the washers, spacer and hitch pin. (See Figure 11, page 72.) Replace the pin, brass washers and new "X" washer in the connecting rod. Squeeze the "X" washer closed tightly.

c. Hold new bushing gasket in place with Dow Corning No. 111 grease (W962026). Apply a thin film of Beacon 325 (W962010) to the silver plated area of the bushing lead. Install the bushing into the pipe, making sure that the bushing lead slides into the contact carrier of the interrupter. Be careful not to damage the voltage shield (46 and 69 kV only).

d. Install the split clamp rings as shown in Figure 6, page 67, and bolt the bushing assembly to the pipe using (6) .375-16 x 2.5 Nylok cylinder headcap screws. Apply Molykote to threads to prevent seizing. Be certain the epoxy flange of the bushing is centered on the aluminum flange of the pipe before tightening. Use the short allen wrench adapter 72-180-784-501 and crowfoot W380007, 4-3/8" drive ratchet and 3/8" drive torque wrench. Torque to 25 ft. lbs. Replace the capacitor assembly if so equipped. (See "Installation of External Capacitors" in INSTALLATION Section.)

e. Attach a new bag of desiccant to the coverplate. See Figure 12, page 73 for specific details. Hold new gasket in place with Dow Corning No. 111 grease (W962026). Bolt the coverplate to the pipe using (8) .5-13 x 3 hex steel bolts, nuts and lockwashers. Using the cross tightening technique, torque to 55 ft. lbs. Reconnect the line connection to the bushing. (See "Line Connections" in INSTALLATION Section.)

f. Pull vacuum to 2 mm of mercury and hold for 30 minutes and fill the pole units with $SF_6$ to the normal operating pressure curve (Figure 7, page 68). (See "Filling De-energized Breaker With $SF_6$ Gas" in INSTALLATION Section.)

g. Use Leak-tec or equivalent to check for leak at the bushing and coverplate gasket. No leakage is allowed. If leakage is found, make necessary repairs to eliminate the leakage.

## FILLING AN ENERGIZED BREAKER WITH $SF_6$ GAS

The preferred method of adding $SF_6$ gas to the breaker is with the breaker de-energized and isolated from the electrical system. However, $SF_6$ gas may be added to an energized breaker if the pressure has not fallen below lockout. The procedure for adding gas is the same as for filling the breaker during installation outlined on page 12.

**WARNING**

Hazardous gas pressure levels may cause serious personal injury or death, or damage to the circuit breaker.
To prevent:

Do not add $SF_6$ to an energized breaker if pressure has fallen below the lockout value.

If pressure is below lockout, take the breaker out of service, isolate from the electrical system and correct the cause of the lower pressure before filling.

If pressure is below lockout, do not operate the breaker. Open an adjacent breaker to isolate the breaker from the system.

## OPERATING SHAFT ASSEMBLY

(Figure 11, page 72)

Normally, maintenance will not be required on the operating shaft assembly as it is factory lubricated and sealed for the life of the breaker.

## OPENING SPRING

(Figure 4, page 65)

The opening spring has been adjusted at the factory to provide the correct opening velocity. If field adjustment is necessary, loosen the (2) .375" clamp bolts on the 1.5" adjustment nut with the breaker in the open position. Unscrew adjusting nut which lengthens opening spring, to reduce opening velocity. To increase opening velocity, shorten open spring by screwing in the adjusting nut. When proper velocity is obtained, lock adjusting nut by tightening the (2) .375" clamp bolts.

## REPLACING THE WEATHERCASE

(Figure 10, page 71)

If a weathercase is damaged, it can be replaced without replacing the conductor.

a. Disconnect the gas piping to the pole unit cover plate. Exhaust the gas by attaching the Female Quick Disconnect Fitting 4043B97G02 to the fitting on the cover plate. Remove the capacitor assembly at the bushing, if so equipped (see "Installation of External Capacitors" in INSTALLATION Section), and disconnect the line connection from the appropriate bushing.

b. Remove the (6) .375-16 x 2.5 socket head cap screws from the split rings which clamp the bushing to the interrupter pipe. A 5/16" allen wrench is required.

c. Remove the split clamp ring and pull the bushing out from the pipe. Either bushing weighs about 60 lbs. Be careful not to damage the voltage shield (46 and 69 kV only).

d. Using a spanner wrench 72-180-784-801 unscrew the retainer and remove the gasket and washer. Do not scratch the retainer. Heat may have to be applied to help break the retainer free. If necessary, place the bushing lead in a vise to hold while loosening. Do not scratch the bushing lead.

e. Pull the lead through the weathercase and pull the seal bushing out. Remove the "O" ring. Clean the threads of the lead with a wire brush. Clean "O" ring, groove, regrease and install new "O" ring.

f. Install a new weathercase onto the lead, then install the new seal.

g. Apply Dow Corning No. 111 grease (W962026) to the washer and new gasket, and install.

h. Install the retainer with the spanner wrench 72-180-784-801 and torque to 100 ft. lbs.

i. Installation of the weathercase is described in "Replacing the Interrupter", sections c and d.

j. The coverplate must now be removed as described in "Removal of the Interrupter", section d and the desiccant replaced and coverplate reinstalled as described in "Replacing the Interrupter", sections f and g.

## POLE UNIT REPLACEMENT INSTRUCTIONS

See detailed instructions on page 75.

## REPLACEMENT OF THE RUPTURE DISC

(Figure 12, page 73)

Normally maintenance will not be required on the rupture disc assembly. If the rupture disc is accidentally damaged due to overpressure, replacement is as follows:

a. Remove the 6 steel bolts and lockwashers fastening the rupture disc guard and retainer.

b. Remove the gasket, aluminum shim plates if supplied, the broken rupture disc and the inner gasket.

c. Wipe the groove clean. Apply grease Dow Corning No. 111 (W962026).

d. Install new inner gasket, new rupture disc, aluminum shims if required, and outer gasket. The flat surface of the rupture disc should be installed toward the inner section of the pipe. The outer gasket must extend beyond the coverplate surface by .060 to .090".

e. Add or remove aluminum shim as required to achieve this value. Replace the retainer and guard orienting the guard to vent upward.

f. Replace the 6 bolts and lockwashers and tighten evenly all around. (The two longer bolts are used to hold the guard to the coverplate.)

g. Pull vacuum to 2 mm of mercury and hold for 30 minutes and fill the breaker with $SF_6$ as described in "Filling De-energized Breaker With $SF_6$ Gas" in INSTALLATION Section.

h. Check for leakage with Leak-tec or equivalent.

## CHECKING EXTERNAL CAPACITORS

The breaker must be out of service and in the open position with adjacent disconnect switches open before checking the external capacitors. The capacitors can be checked while connected to the breaker. The capacitance should be measured using a reliable capacitance bridge. The capacitance is 5000 pf $^{+10\%}_{-0}$. If the capacitance is not within these limits, the capacitor must be replaced.

## LEAK CHECKING

(Figures 5 and 7, pages 66 and 68)

The breaker has been thoroughly leak tested at the factory and will be essentially leak-free between the major maintenance periods. There are a minimum of leak sources. The "O" rings, gaskets, and fittings shown on Figure 5, page 66 provide the sealing to atmosphere on each phase.

Before beginning a leak check, pay careful attention to the pressure and temperature of the $SF_6$ gas. If the initial pressurizing is done according to the normal operating pressure curve in Figure 7, page 68, any other readings should fall on the same curve.

Use Leak-tec or equivalent to detect leaks. No leakage is permitted at any of the joints. During maintenance, if any seal has been removed, that seal only should be leak-checked after a vacuum has been obtained and $SF_6$ added to the pole unit.

## CURRENT TRANSFORMERS

For current transformer test procedures and maintenance, refer to pages 109 and 110.

## PAINT

In areas on the circuit breaker where the paint requires attention due to blistering, peeling, cracking or chipping of the finish or rusting of the base metal, the following remedial action is recommended.

1. Remove loose particles of paint with a sharp putty knife, scraper and/or wire brush.
2. Use sandpaper to feather the edges of the paint to the base metal. Remove dust.
3. Brush on the area to be repaired, overlapping onto the bonded paint surface 6 to 8 inches, a phosphating agent such as Ospho, Kephosor Resticide.
4. Allow one hour to dry.
5. Apply a primer coat; a good oil resistant primer is acceptable.
6. Sufficient drying time must be allowed before the final coat(s) are applied. A pint can of the finish coat is supplied with each breaker for use in repairs of this type.

## HYDRAULIC SHOCK ABSORBER

The hydraulic shock absorber is factory adjusted and normally requires no maintenance. If overtravel is outside the specified limits, the hydraulic shock absorber must be readjusted. Limits are shown in Figure 3A — View A, page 63.

To readjust loosen the M6 (Figure 4, page 65) socket head set screw on the mechanism and, with the breaker in the open position, screw shock in one turn (360°) at a time to reduce the overtravel. The shock absorber should be unscrewed out one turn (360°) at a time if breaker travel does not reach full position. Do not screw in further than one turn from fully compressed position. This fully compressed position can be determined by screwing a shock in as far as it will go by hand until solod with the breaker in the open position. Check progress of adjustments by performing tripping and close-open operations.

If overtravel is correct for a tripping operation but excessive for a close-open test, the possibility of a defective shock absorber is indicated. Replace with a new shock.

After adjustment is complete, tighten the socket head set screw on the bell crank.

## LUBRICATION

Mechanism lubrication is covered in the Mechanism Instruction Book APPENDIX I and should be performed at least once every 3 years. All other parts of the breaker have been lubricated at the factory and further lubrication is required only if that particular item has been disassembled.

a. Molykote 00337271095 is applied sparingly to the moving contact assembly shaft (Figure 9, page 70).

b. Molykote 00337271095 is applied to all the pins in the horizontal linkage (Figure 4, page 65), sliding surfaces and sleeve bearings on the mechanism.

c. Dow Corning No. 111 grease is applied to the gasket and washer of the weathercase (Figure 10, page 71).

d. Beacon #325 (W962010) is applied to the shaft seal, and needle and roller bearings on the mechanism. Maintenance is not expected on the shaft seal for the life of the breaker (Figure 11, page 72), on the moving contact of the interrupter (Figure 9, page 70), and on the bushing lead.

e. Dow Corning No. 11 (W962026) is applied to coverplate gaskets and to bushing to flange gaskets.

f. G.E. Versalube (W962028) is applied to the close control valve poppet sets and piston ring. These normally require no relubrication. See Figures 1 and 2, pages 124 and 125.

g. SAE 20 non-detergent engine oil is used in the air compressor crankcase and for lubrication of the mechanism cylinder housing.

h. Molykote 00337271095 grease is applied to the shock absorber plunger, contact face and lever "striking" surface.

## RECOMMENDED TORQUE VALUES

Following is a tabulation of recommended torque values to be used on the Type SP breaker during installation and maintenance.

1. Leg attaching bolts — 250 ft. lbs.
2. Breaker to foundation hold down bolts — 400 ft. lbs.
3. Capacitor mounting straps to brushing — 15 ft. lbs.
4. Capacitors to lower capacitor mounting straps — 30 ft. lbs.
5. Capacitors to upper capacitor mounting strap — 30 ft. lbs.
6. Upper capacitor mounting strap to bushing stud — 50 ft. lbs.
7. Mechanism mounting bolts — 250 ft. lbs.
8. Contact carrier to interrupter mounting contact bolts M8 bolts — 18 ft. lbs. ¼ inch bolts — 10 ft. lbs.
9. Interrupter to pipe bolts — 18 ft. lbs.
10. Bushing clamp ring bolts — 25 ft. lbs. (epoxy bushings)
11. Coverplate — 55 ft. lbs.
12. Bushing weathercase retainer — 100 ft. lbs.
13. Spring adjusting nut lock bolts — 30 ft. lbs.
14. Interrupter tube assembly to stationary contact assembly M8 bolts — 18 ft. lbs.
15. Moving contact shield assembly to interrupter assembly M10 bolts — 25 ft. lbs.

## ENGLISH/METRIC CONVERSION FACTORS

| | | |
|---|---|---|
| 1 in. | = | 2.54 cm |
| 1 ft. | = | 30.48 cm |
| 1 lb. | = | .454 kg |
| 1 ft.-lbs. | = | 13.825 kg-cm = 1.356 Nm |
| 1 psi | = | 51.715 mm Hg |
| 1 psi | = | 6.895 kPa |
| 1 psi | = | .0703 kg/sq $cm^2$ |
| 1 psi | = | .0689 BAR |
| °F | = | 1.8°C + 32 |

## TABLE 1 — OPERATING CHARACTERISTICS

| | | |
|---|---|---|
| A. | $SF_6$ Switches: | |
| | Fill to $SF_6$ Pressure at 70° F | 80 ± 1 psig |
| | $SF_6$ Pressure Alarm at 70° F Closes | 70 psig ± 2 psig } 2-8 psi diffferential |
| | $SF_6$ Pressure Cutout at 70° F Closes | 65 psig + 1 psig, − 0 psig } non-adjustable |
| | Weight of $SF_6$ to Fill Breaker | 15 lbs. |
| B. | Air Switches: | |
| | Rated Air Pressure | 190 psig |
| | Air Compressor Governor Opens | 190 psig } 12 psi differential |
| | Air Pressure Alarm Closes | 140 psig } factory set |
| | Air Pressure Cutout — Close Opens | 130 psig } |
| C. | Operating Requirements: | |
| | Timing Data | |
| | Contact Part Time | 32 ms max. |
| | Open Velocity (1" to 4") | 14.6 — 16.2 ft./sec. |
| | Closing Time | 90 to 100 msec DC Control<br>84 to 94 msec AC Control |
| | Reclosing Time | 270 msec approx. |
| | Rebound on opening | .50 in. max. |
| | Overtravel on opening | ±.1 in. from full open position |
| | Overtravel in close-open | ±.2 in. to −.1 in. from full open position |
| | Adjustments (Using Hand Jack) | |
| | Mechanism Close Stop Setting | .027 — .037 in. |
| | Contact Engagement | .60 - .95 in. measured at travel device |
| | Mechanism Open Stop Setting | Solid |
| | Shock Absorbers Open Shock Setting | 1 turn from fully compressed position, min. |
| | $\phi$2 Operating Lever | 2.5 ± .025" in closed position |
| | Stroke at Horizontal Oper. Rod | 4.937 ± .060 |
| | Accel. Spring | 18.38" nom. (open) |

D. Other Characteristics:

| | 1200A | 2000A | 3000A |
|---|---|---|---|
| Maximum Pole Unit Resistance (Micro Ohms) | 100 (New)<br>135 (Used) | 80 (New)<br>115 (Used) | 60 (New)<br>75 (Used) |
| Pole Unit Torque (Closing) (Fingers Engaged) | 17 Ft. Lbs. Maximum<br>45 Ft. Lbs. ± 10 Ft. Lbs. | | |

| Voltage Tests (60 Hz) Breaker Rating | 60 Hz — 1 Min. Factory Test | Field Test (If required) |
|---|---|---|
| 38 KV | 80 KV rms | 60 KV rms |
| 48.3 KV | 105 | 79 |
| 72.5 KV | 160 | 120 |
| IEC Ratings | | |
| 36 KV | 70 KV rms | |
| 52 KV | 95 | |
| 72.5 KV | 140 | |

E. Capacitors (if applicable)

5000 pf + 10%
- 0

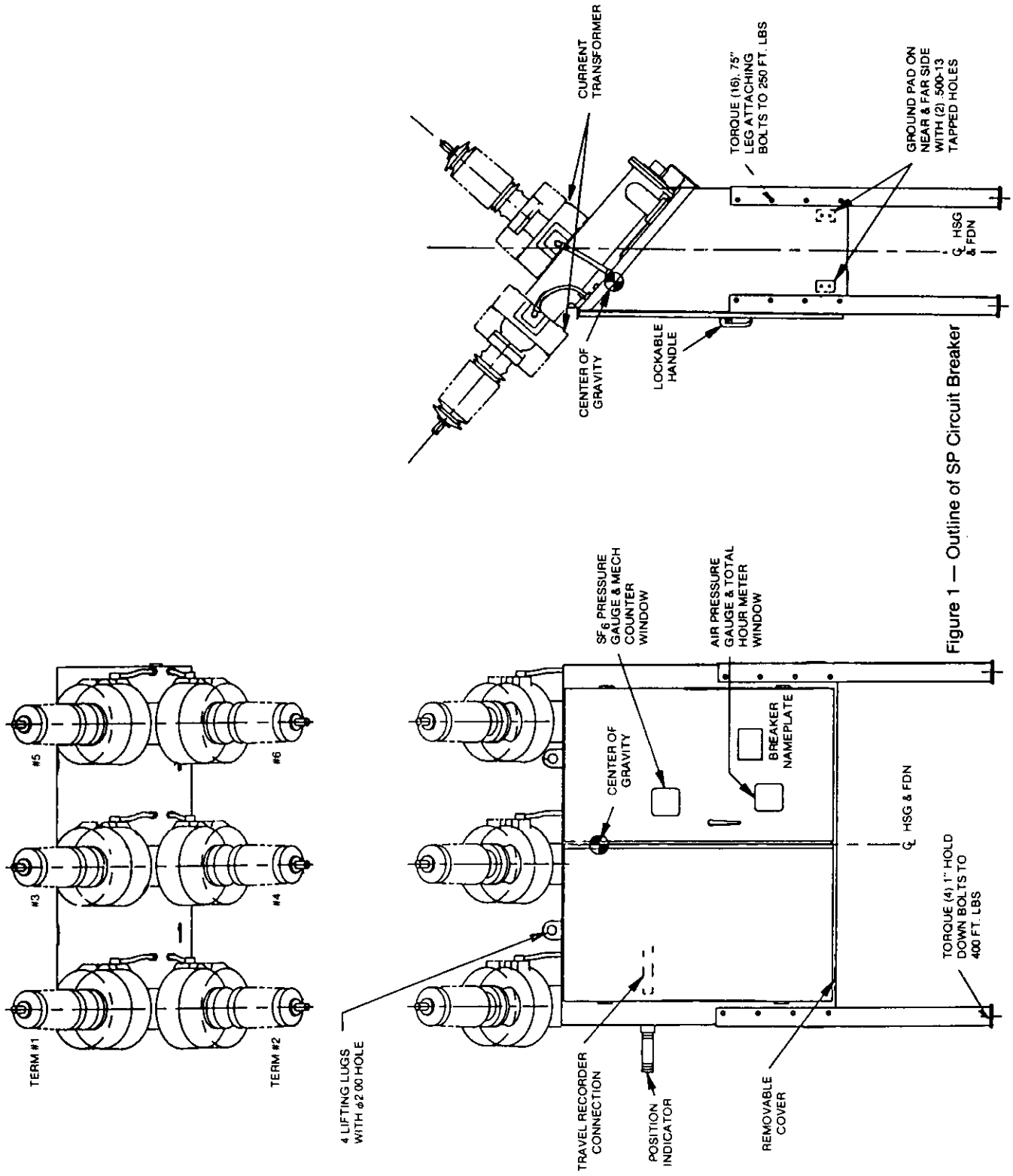



Figure 1 — Outline of SP Circuit Breaker

# ILLUSTRATIONS



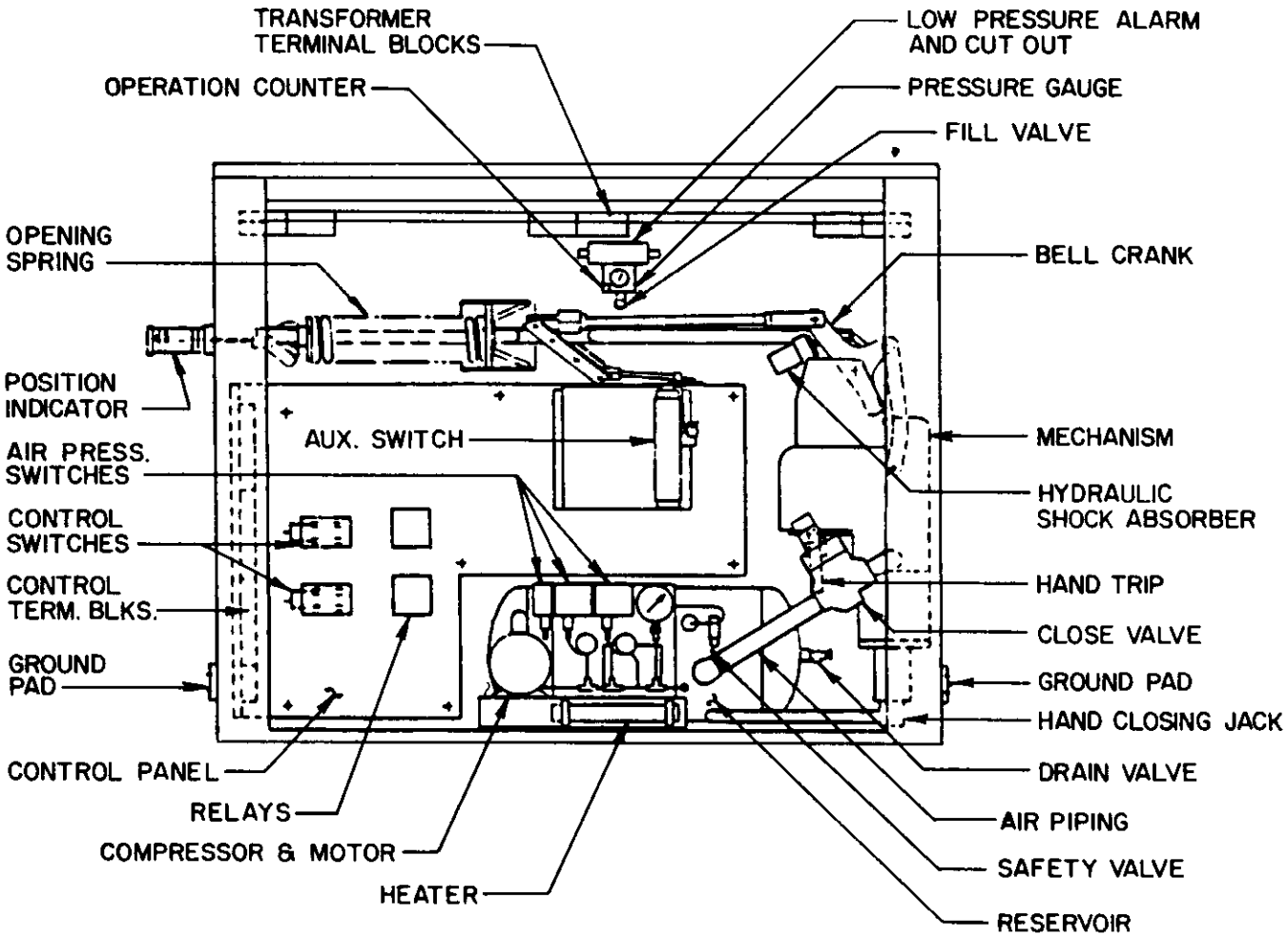



Figure 2 — Mechanism Cabinet

2872C32

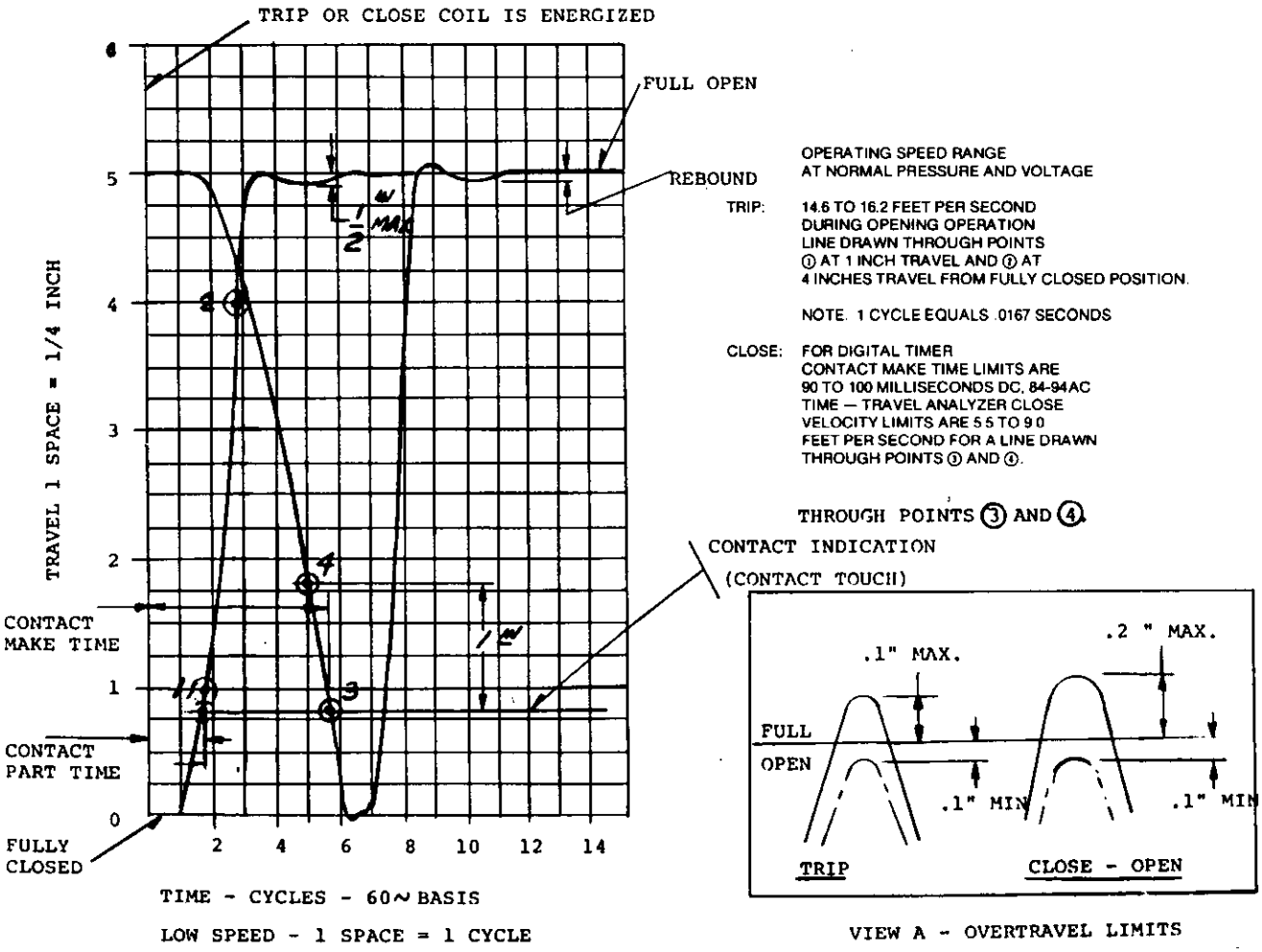



Figure 3A — Typical Trip and Close — Open Timing Curve

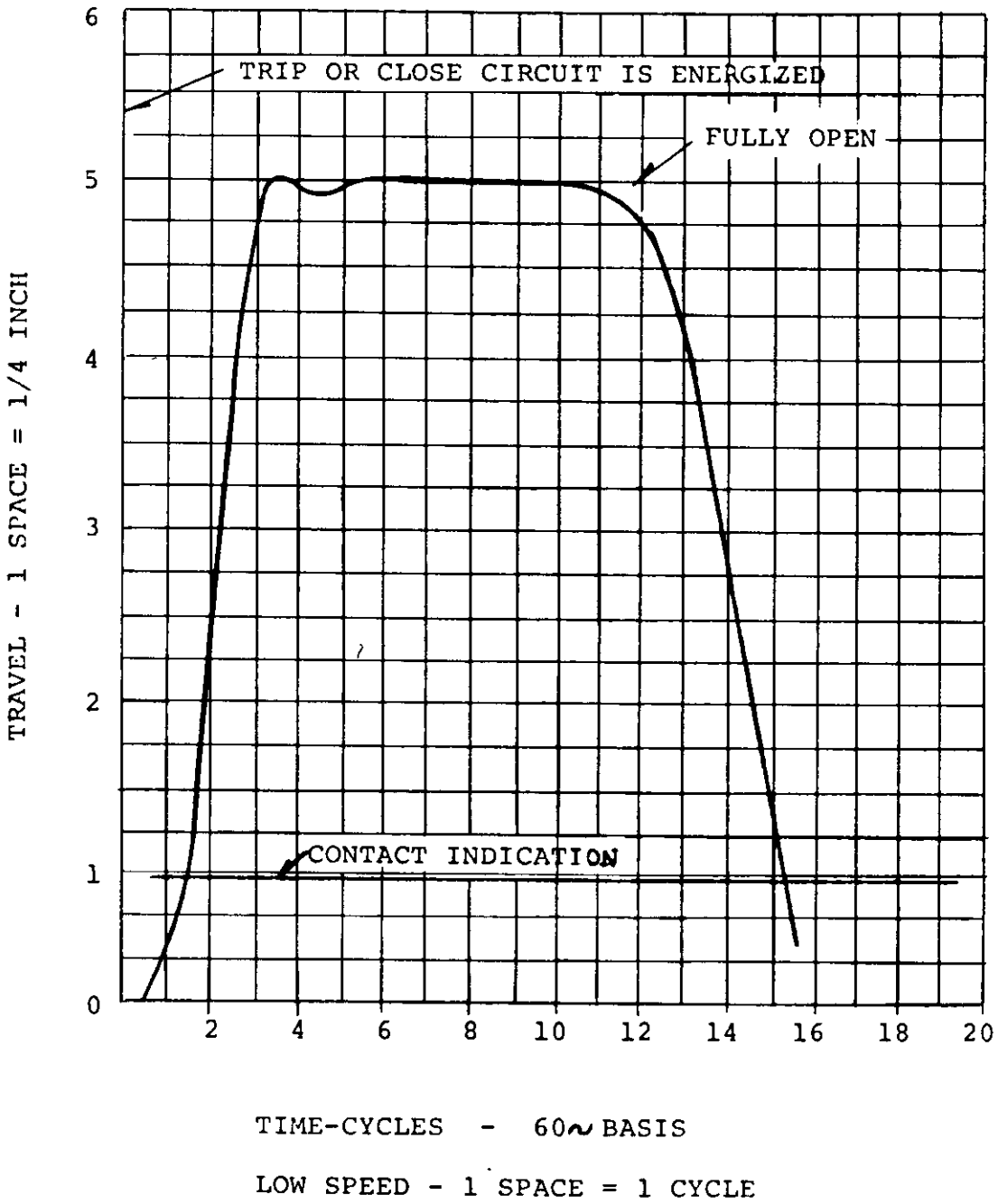



Figure 3B — Typical Reclose Timing Curve

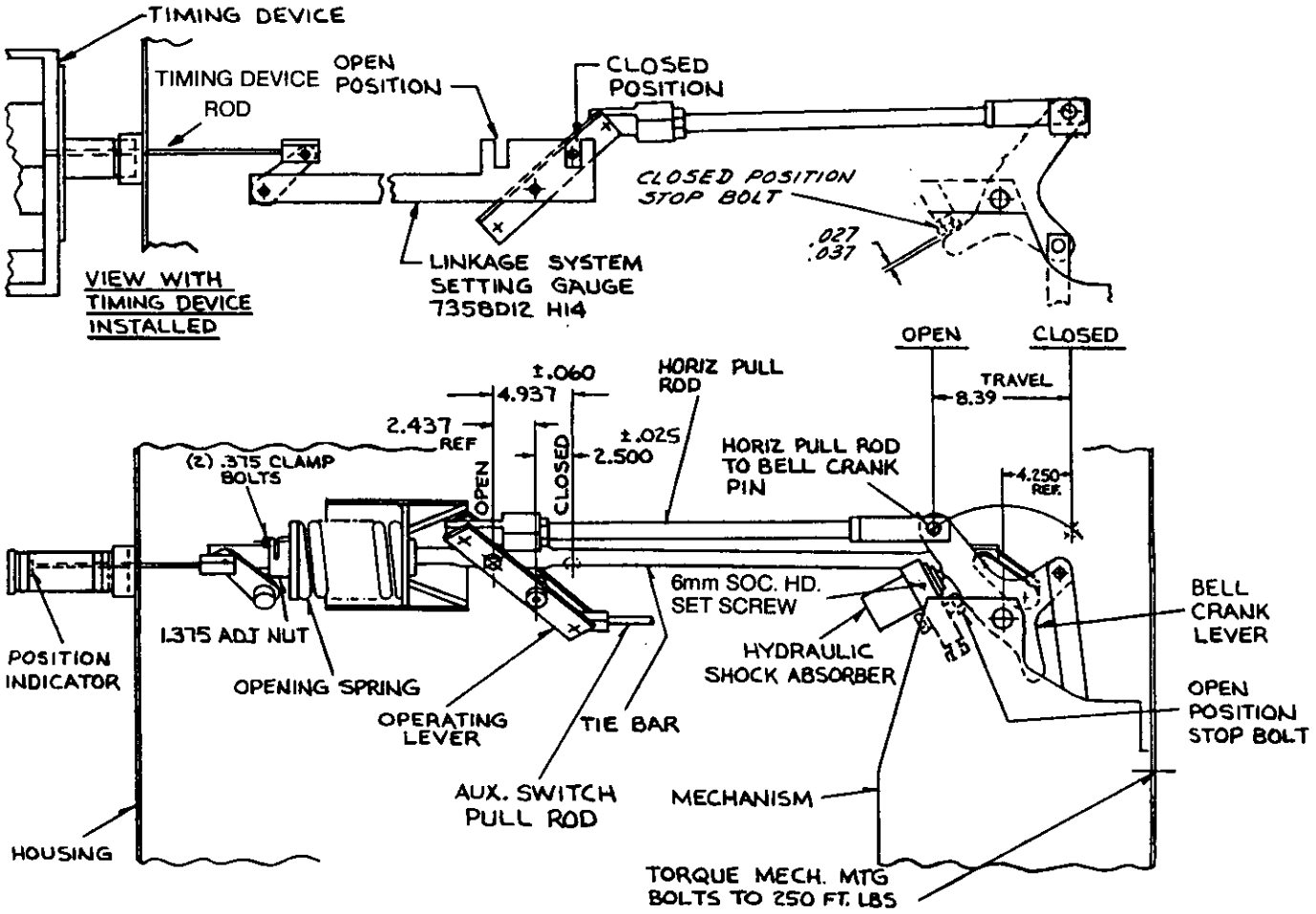



Figure 4 — Horizontal Linkage

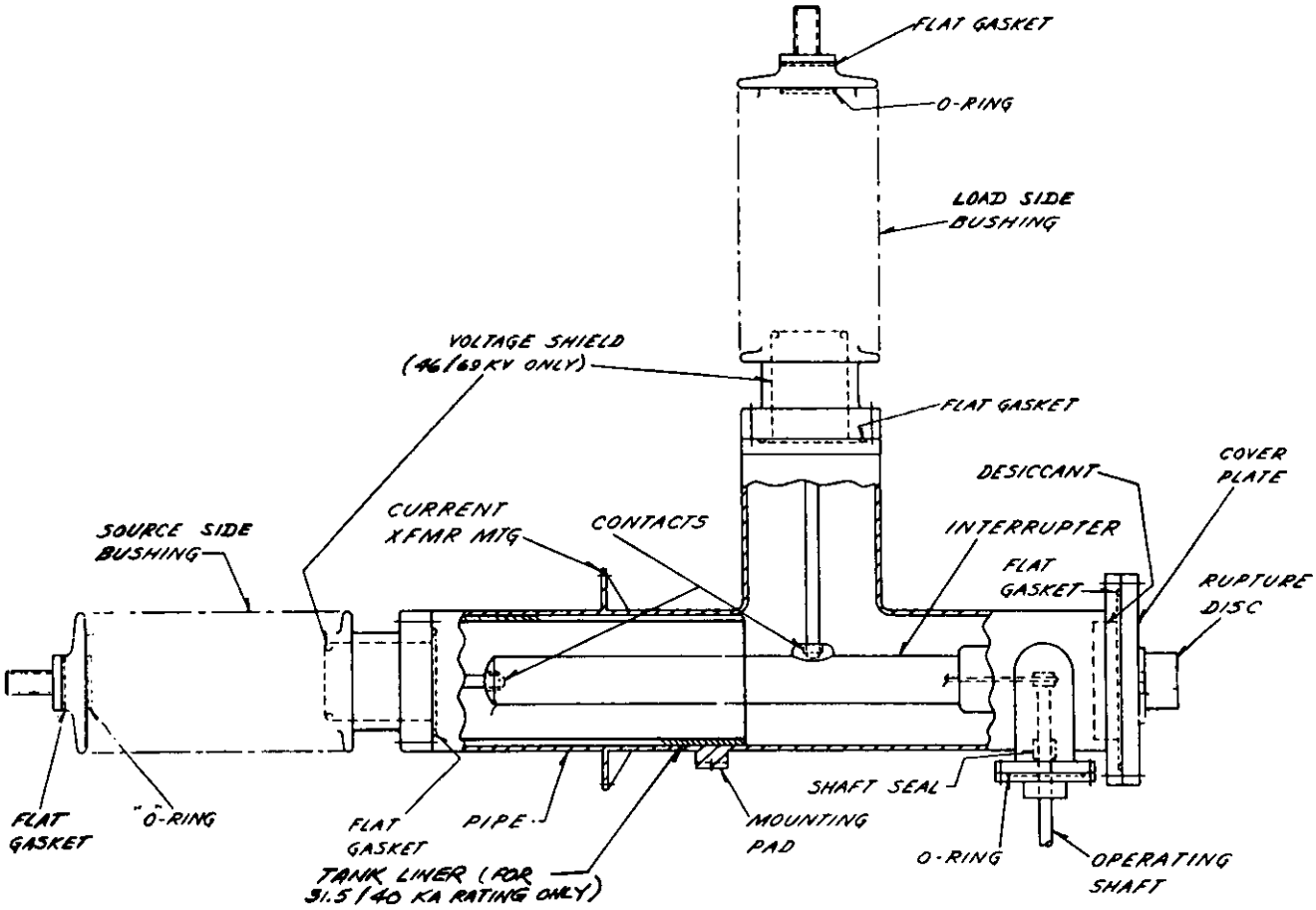
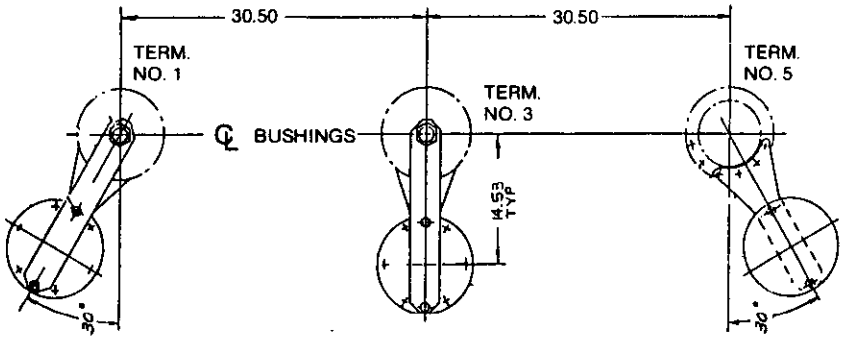
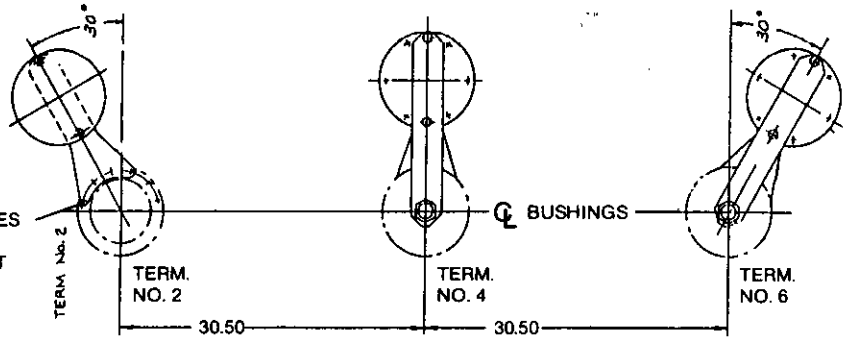



Figure 5 — Pole Unit




VIEW B-B
TERMINALS 1-3-5




VIEW A-A
TERMINALS 2-4-6

(6) .375-16 UNC TAPPED HOLES IN BUSHING FLANGE (PORCELAIN BUSH) OR SPLIT CLAMP RING (EPOXY BUSH)

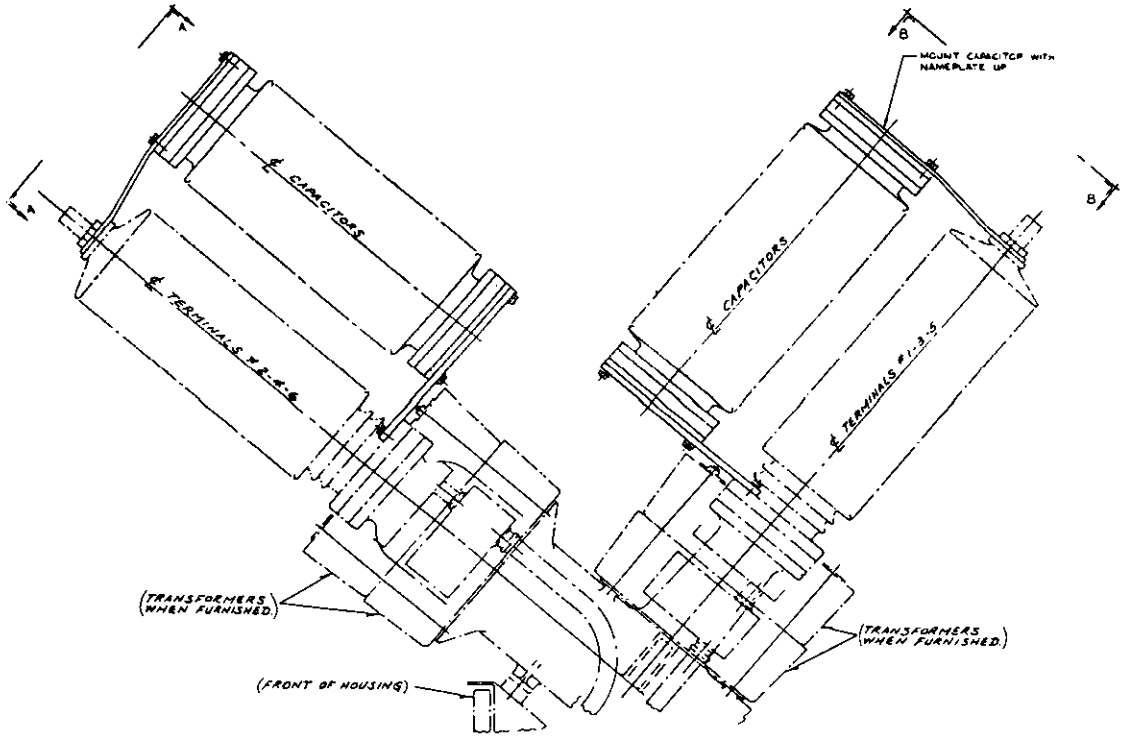



Figure 6 — Capacitor Mounting

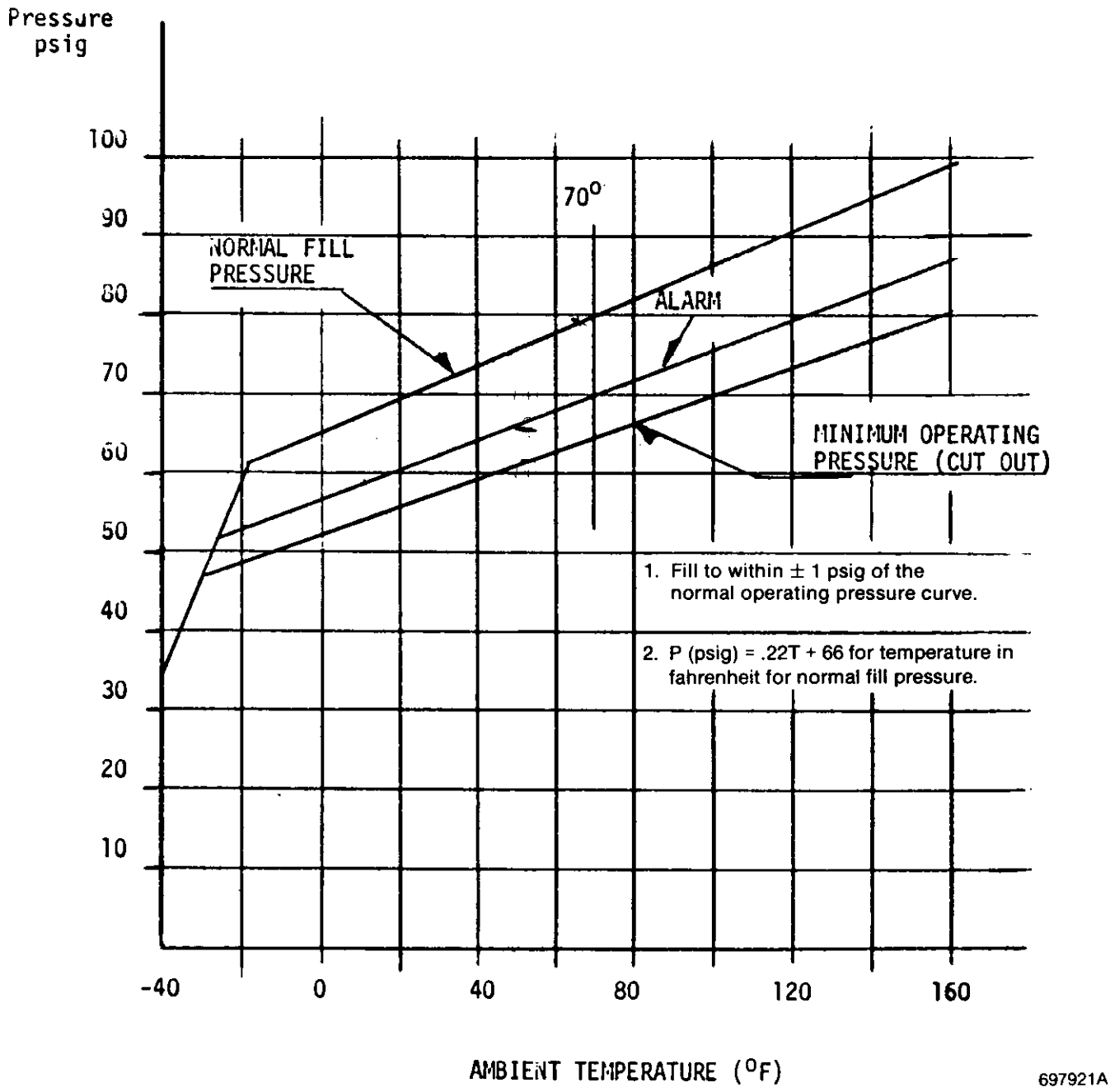



Figure 7 — Pressure Versus Temperature Curve for $SF_6$ Gas System

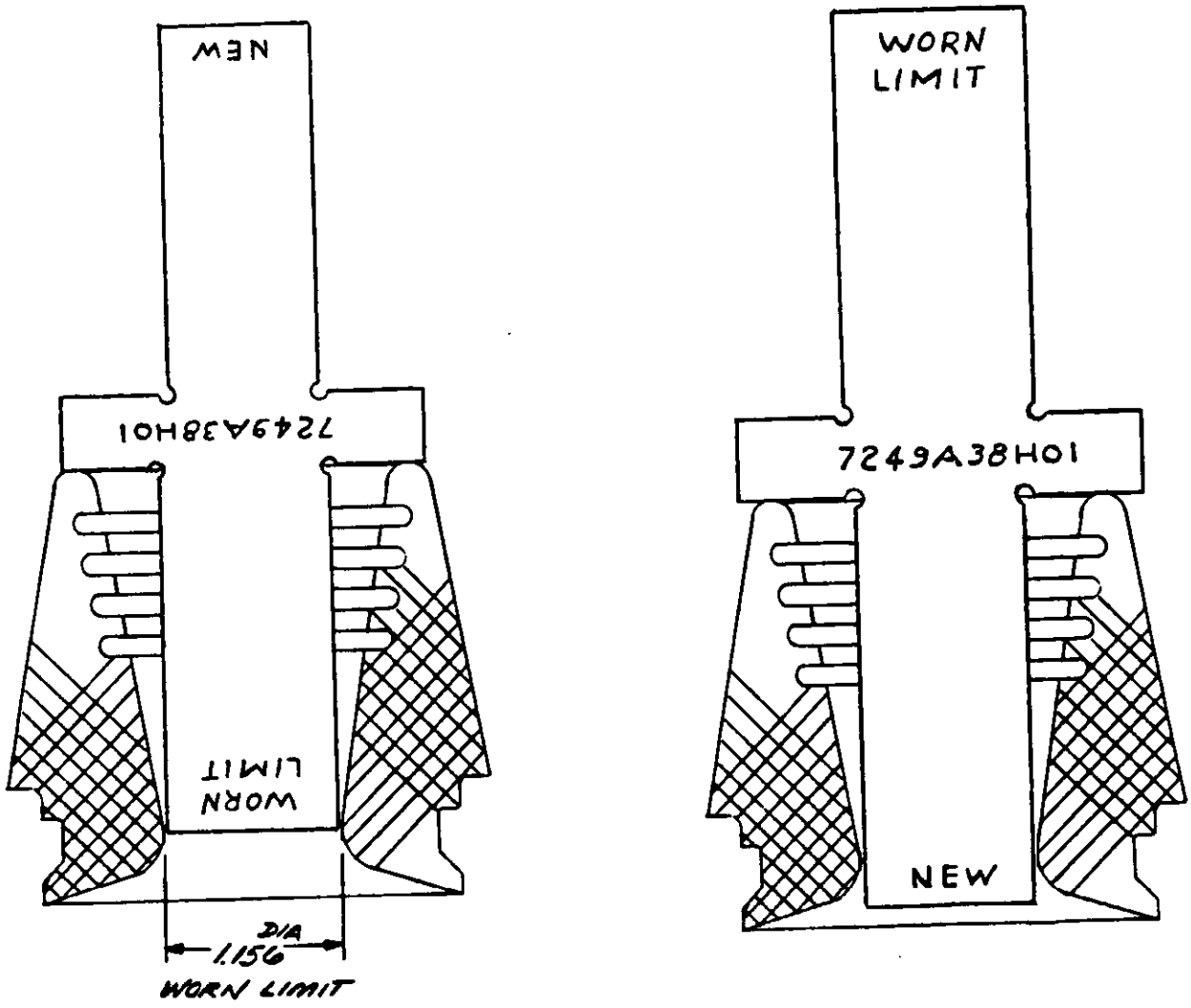



Figure 8 Teflon Orifice Wear Gauge

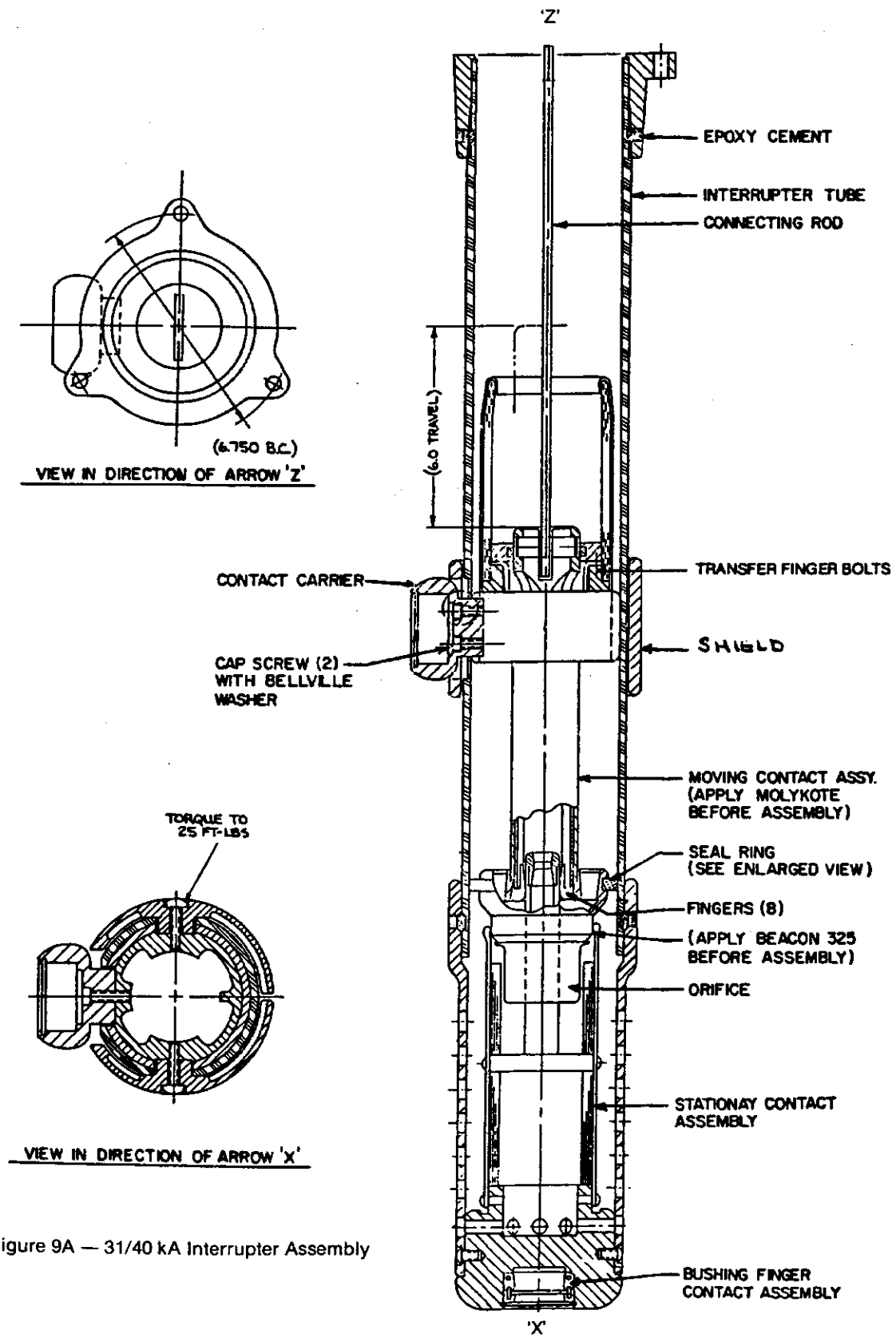



Figure 9A — 31/40 kA Interrupter Assembly

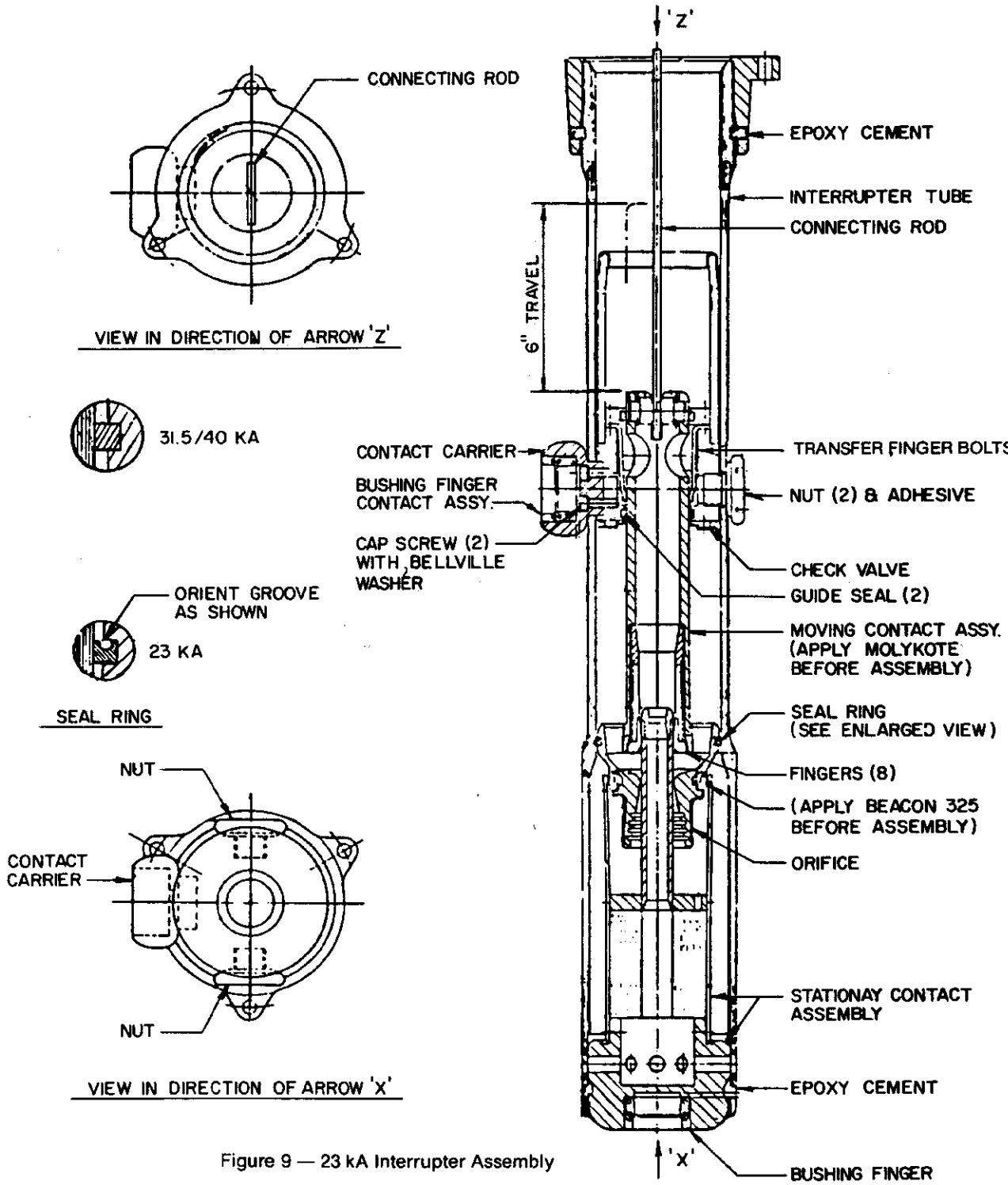



Figure 9 — 23 kA Interrupter Assembly

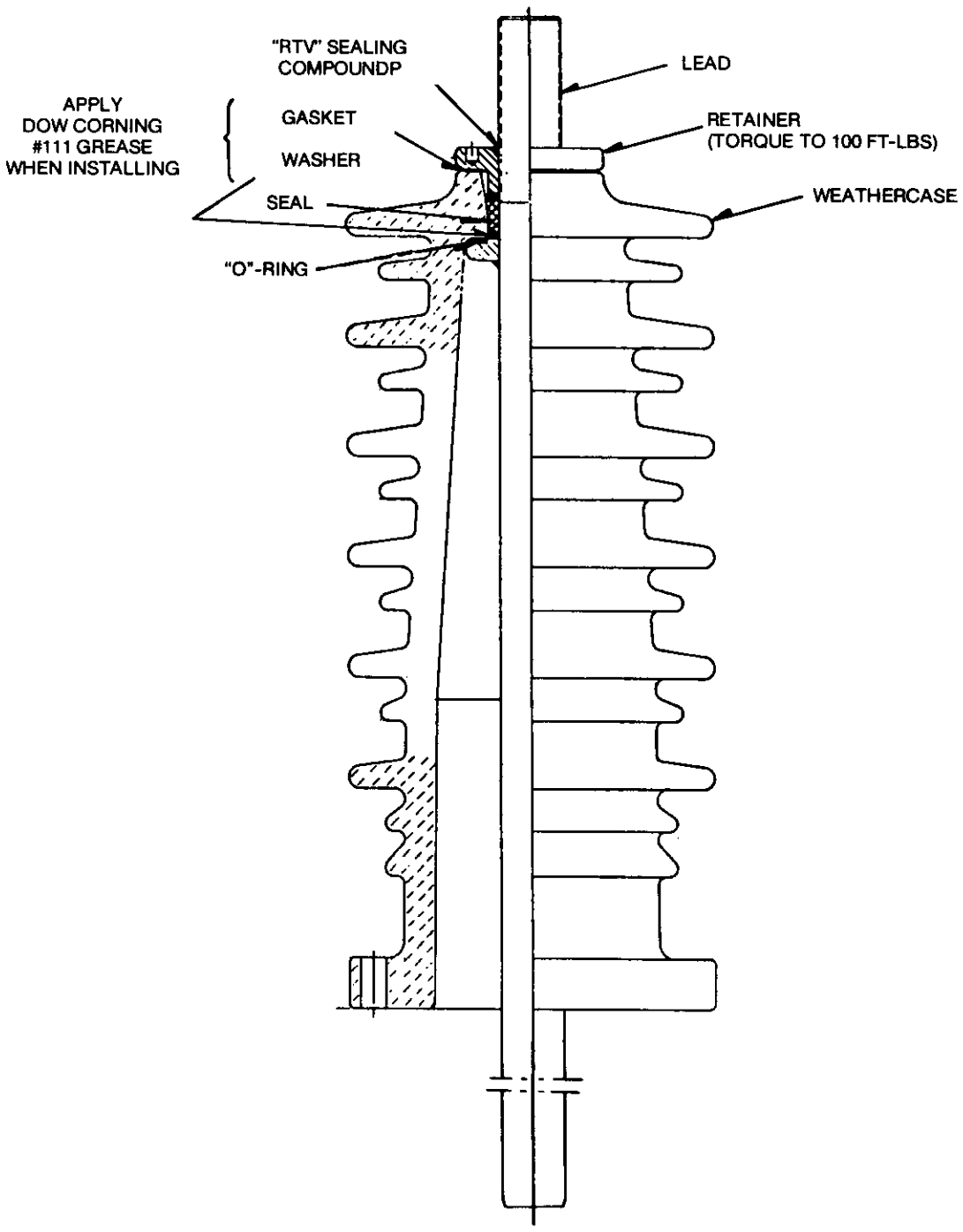



Figure 10 — Bushing

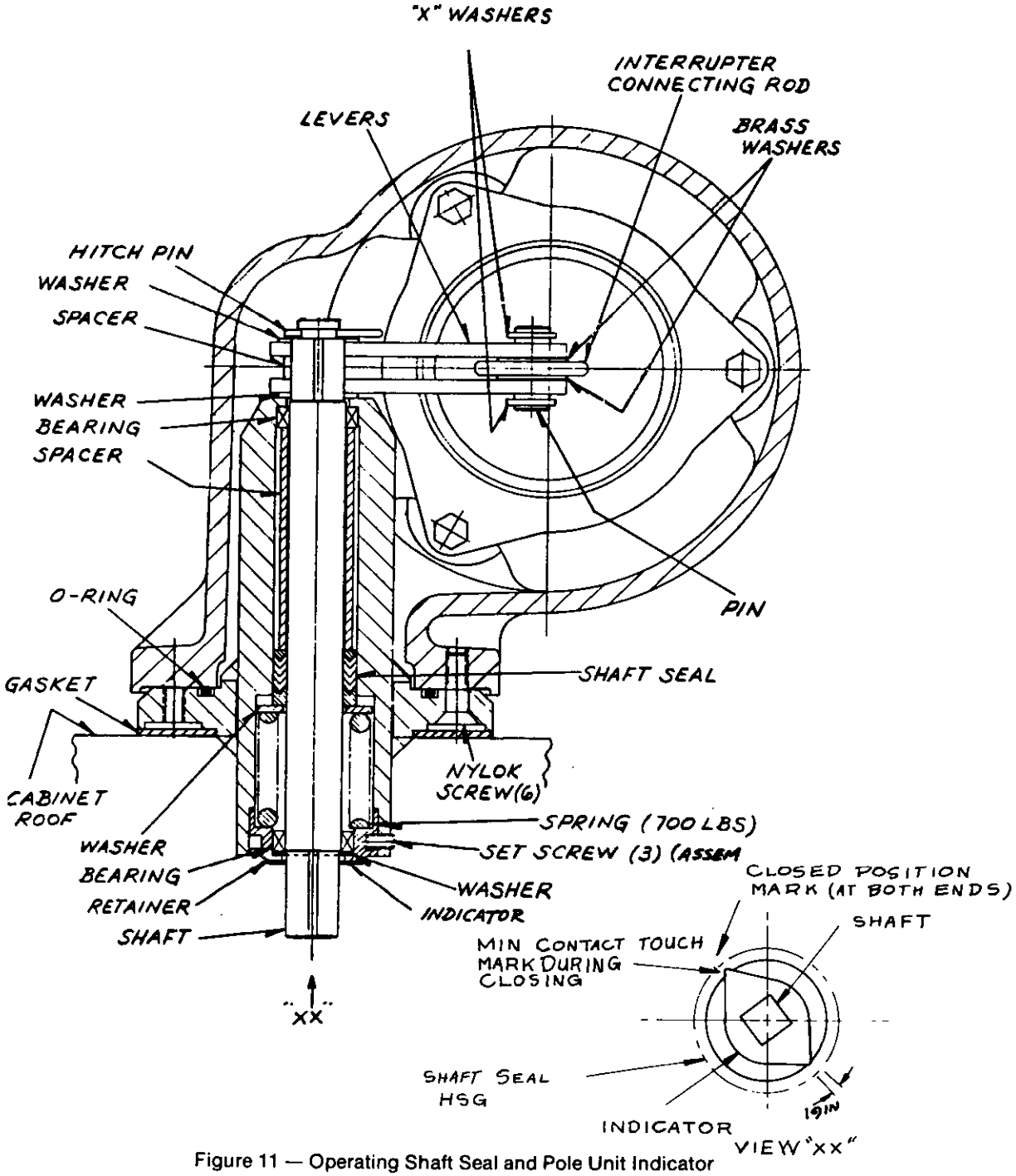
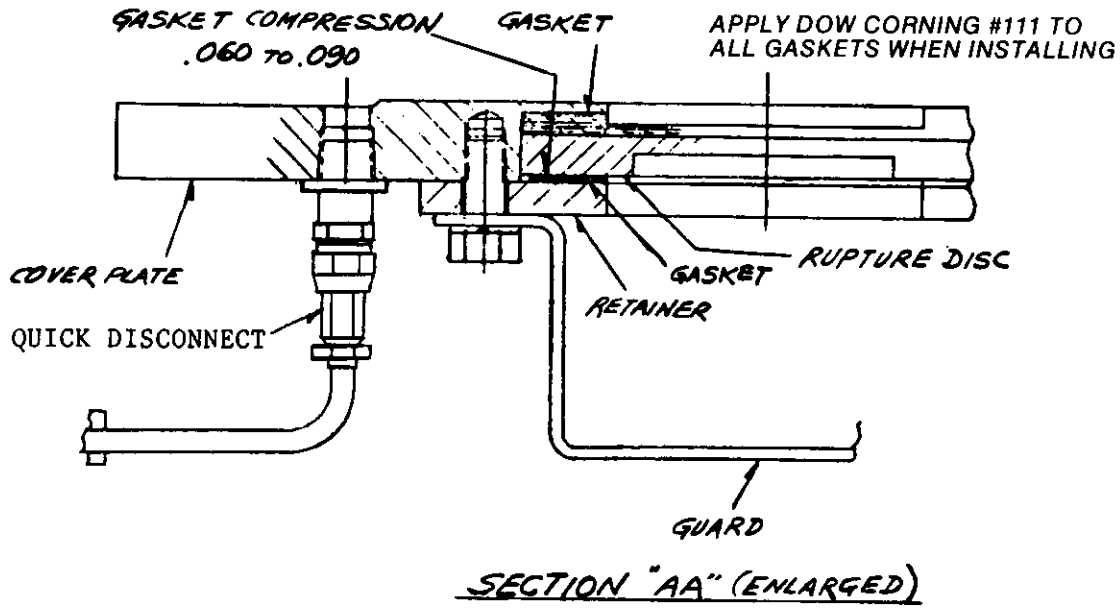



Figure 11 — Operating Shaft Seal and Pole Unit Indicator



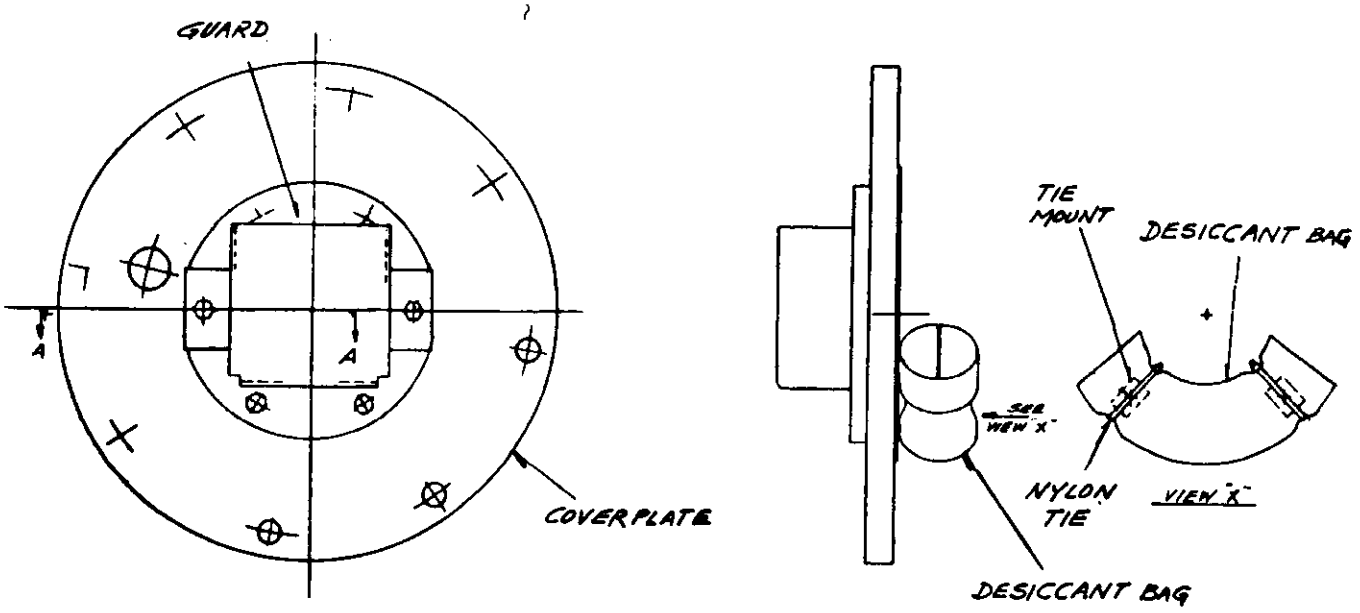




Figure 12 — Access Cover Plate Assembly

# ILLUSTRATIONS

**FOR $\phi$1 OR $\phi$3 UNIT REPLACEMENT**

1. Breaker must be removed from service, capacitors and weathercase leads grounded, and disconnects opened.
2. Trip breaker to open position if all 3 pole units are at normal operating pressure - otherwise jack breaker to open position.
3. Reduce air operating pressure to 0 psig.
4. Pole unit gas pressure to be reduced to 0 psig.
5. Identify and tag current transformer and pressure switch wires at the terminal blocks. Remove current transformer and pressure switch leads from terminal blocks.
6. Remove flex conduit nuts for current transformers and pressure switches from housing top connection and pull leads thru top of housing. (See view "C".)
7. Remove pole unit capacitor if supplied. (Approx. weight - 90 lbs. each, and store upright.)
8. Disassemble linkage from pole unit operating shaft. Save all parts for re-use.
   Unbend locking plate (512A405H06) and remove .312"-18 x .88" bolt from operating shaft (inside of housing). Remove cotter pin and hardened pin from lever assembly.
   Remove levers from pole unit operating shaft. Maintain lever and spacer orientation and identification for later re-installation. (See view "D".)
9. Remove three .312 nuts, lockwashers, and flat washers from pole unit. Save for re-use. (See view "A".)
10. Install cloth slings around aluminum pole unit casting. Figure #2 shows sling and chain locations for lifting pole unit with two and four current transformers. The chains to be used are referenced in this installation book under part 3 installation, tools and service equipment, item #3. Attach chains to slings, protect busing with wood or heavy cardboard, straddle bushing with chains for lateral stability.

**⚠ CAUTION**

Severe damage to the aluminum casting will occur if lifting is attempted at this time.

To prevent:

Do not attempt to lift pole unit at this time. Remove slack from cable and slings.

11. Remove two .500-13 bolts and lockwashers from pole unit mounting foot. Save for re-use. See figure #3, view "B" location.
12. Lift pole unit at a 40° angle and remove from housing top. (Each pole unit weighs 300 pounds. Each current transformer on the pole unit weighs 100 lbs.)
13. Remove gasket from housing top and discard. Scrap and clean old sealant from housing top.
14. Lower pole unit on to resting surface which will permit clearance between the operating shaft and the floor.

**NOTICE**

The pole unit mounting foot must be in full contact with the resting surface in order to prevent the pole unit from falling over.

15. Remove current transformers from pole unit if required.

**NOTICE**

Each current transformer weighs approximately 100 lbs. Care must be taken during removal and installation not to damage the weathercase, sheds, or threaded current carrying lead.

16. Open shipping crate and install current transformers (if not supplied) on the new pole unit.

**⚠ WARNING**

Pressurized bushings may burst during handling and can cause serious personal injury, death or damage the breaker during handling.

To prevent:

Do not strike, shock or strain the bushings or in any way cause the bushings to rupture.

Do not move the breaker if the $SF_6$ pressure in any pole unit is above 10 psig.

**NOTICE**

The current transformers must be re-installed on the same pole unit terminal in order to maintain the original circuit characteristics.

17. Sling and lift new pole unit at a 40° angle per instructions in step (10).
18. Install the three supplied aligning studs (.375"-16 x 3" long) into pole unit shaft seal housing. (See Figure #1.)
19. Remove pole unit operating shaft guard assembly by removing the .312"-18 bolt, lockwasher, flat washer, and pipe. (See Figure #1.) These items are not required for pole unit installation but should be installed on the removed pole unit.

    Prior to pole unit installation, be sure that the operating shaft extends approximately 1-7/16" beyond the shaft seal housing. Shaft can be pulled out using a slight twisting and pulling motion with a large pair of pliers. There is a mechanical stop inside of the pole unit which prevents the operating shaft from being pulled out beyond 1-7/16".
20. Lift pole at a 40° angle into position above cabinet. Apply sealant liberally to both sides of shaft seal gasket. (Gasket and sealant are supplied.) Install gasket on to pole unit by aligning holes in gasket with aligning studs.

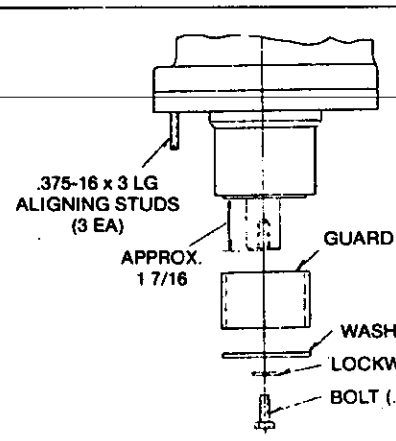



**FIGURE 1**

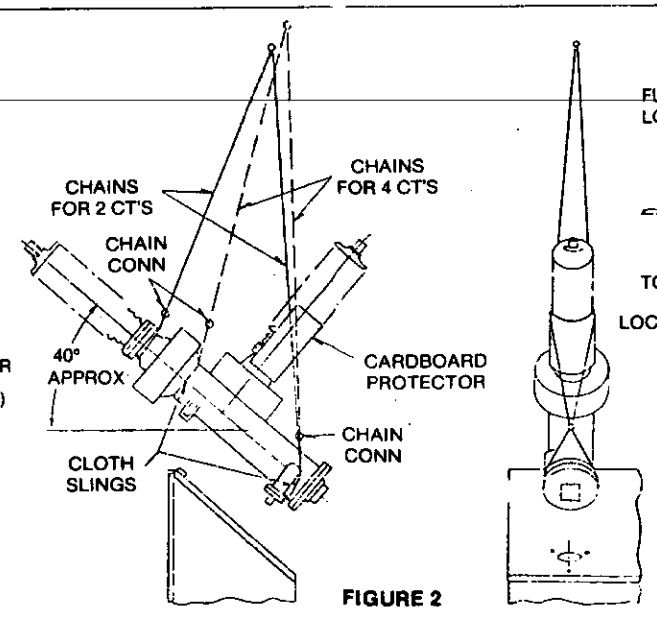
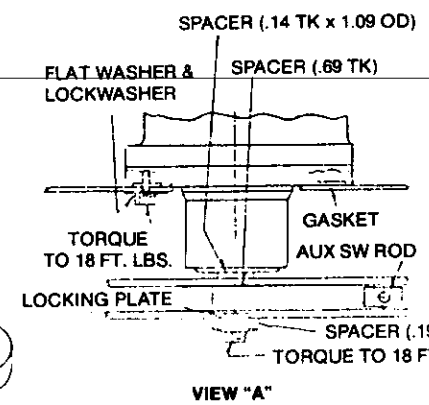



**FIGURE 2**
POLE UNIT LIFTING METHOD



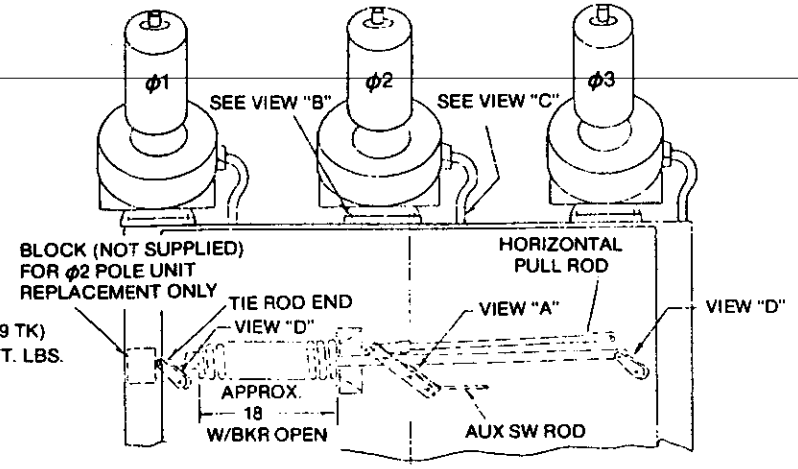
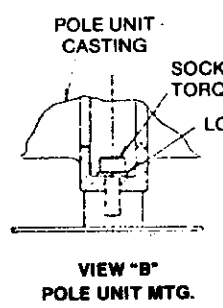
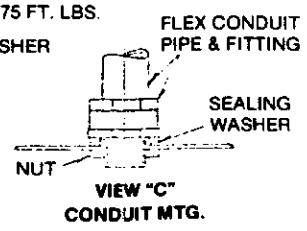
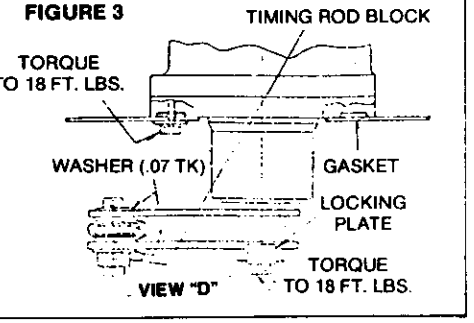




**FIGURE 3**



Feed current transformer wires and conduits into holes in cabinet top. The sealing washer is to be mounted on the outside of the housing. Do not secure conduit with nut at this time. See view "C" for typical section of conduit installation.

21. Lower pole unit toward cabinet top using the aligning studs. Suspend pole unit about one inch (1") above installed position.

**WARNING**

Failure to assemble mechanism and all pole units in the open position may result in personal injury and/or breaker damage.

To prevent:

Pole unit and breaker mechanism must be in the open position before linkage is assembled.

To open pole unit completely rotate the interrupter operating shaft counterclockwise when facing shaft.

Visually check the opening spring to ensure that the mechanism is open by observing that the horizontal tie bar end is braced against the shipping block.

22. Lower pole unit onto housing top while aligning and re-installing back lever, spacers and front lever removed in step 8 (removed in step 7 of $\phi$2 pole unit replacement). To align pole unit operating shaft with linkage holes, rotate pole unit operating shaft slightly.

**NOTICE**

By design, the tolerances are close in the lever system. Care and patience must be exercised during assembly not to damage the lever system.

23. Set pole unit onto housing top using aligning studs (see Figure #1).
24. Secure pole unit mounting foot to hosuing top by reinstalling the two .500"-13 bolts and lockwashers. Torque to 75 ft-lbs. (See view "B".)
25. Remove aligning studs one at a time and secure pole unit by re-installing the three .375"-16x312-18 studs, flat washers, and lockwashers. Torque to 18 ft. lbs. (See view "A".)
26. Re-install hardened pins, cotter pins, and locking plate (512A405H06) under head of .312"-18x.88" bolt. Torque .312-18 bolt to 18 ft. lbs. and bend locking plate back. (See view "A" or "D".)
27. Secure current transformers conduits to housing top with nut. (See view "C".) Route wires thru wire duct to terminal block and reconnect as marked on wire tags.
28. Repressurize pole unit(s) per this instruction book. Check adjustments and time breaker per this instruction book, readjust if required. Return breaker to service.

**FOR $\phi$2 POLE UNIT REPLACEMENT**

1. Same as steps 1 thru 7 for $\phi$1 or $\phi$3 replacement.
2. Remove hand jack access cover at bottom of mechanism cabinet. Loosely install hand jack on to mechanism.
3. Measure the distance between the left inside of the cabinet and the tie rod end. (See Figure #3 for location.)
4. Manufacture a block .38" to .5" longer than the cabinet to rod end dimension. Use 4" x 6" oak wood or metal for the block. The block will be used to restrain a spring load of approximately 1000 lbs.
5. Hand jack breaker toward the closed position and install the block between the cabinet and tie rod end. Position block near the top of cabinet reinforcing supports.
6. Jack breaker toward the open position until the spring load is being held by the block. Turn jack until it is loose on mechanism.
7. Disassemble linkage from $\phi$2 pole unit operating shaft. Save all parts for re-use. Unbend locking plate and remove .312"-18x.88" bolt from operating shaft (inside of housing). Remove cotter pins and hardened pins from lever assembly. Do not apply excessive force to the horizontal pull rod or auxiliary switch rod. Remove the front lever from pole unit operating shaft. The back lever will be removed as the pole unit is lifted from cabinet. Maintain lever and spacer orientation and identification for later re-installation. (See view "A".)
8. Same as steps 9 thru 26 for $\phi$1 or $\phi$3 pole unit replacement.
9. Hand jack breaker toward closed position and remove block. Then jack breaker to open position and remove hand jack.
10. Same as steps 27 and 28 for $\phi$1 and $\phi$3 pole unit replacement.

## TEMPERATURE COMPENSATED ALARM AND CUTOUT SWITCH

The pressure switch has two alarm contact elements. The first contacts are set to close at 70 psig at 70°F for alarm operation. The second set of contacts will open at 65 psig at 70°C for breaker cutout. (See $SF_6$ density curve for other temperatures.) The leads from the pressure switch contacts are brought to the breaker control cabinet terminal blocks. The switches can be wired to either open or close on falling pressure.

The pressure switch settings have been set and checked at the factory and should not need adjusting. However, because of the vibration and shock association with shipment, it is recommended the settings be rechecked before the breaker is put in service.

Check the pressure and temperature at which the contacts make against the $SF_6$ density curve, Figure 7, page 68. Reset the switch by adjusting screw "A".

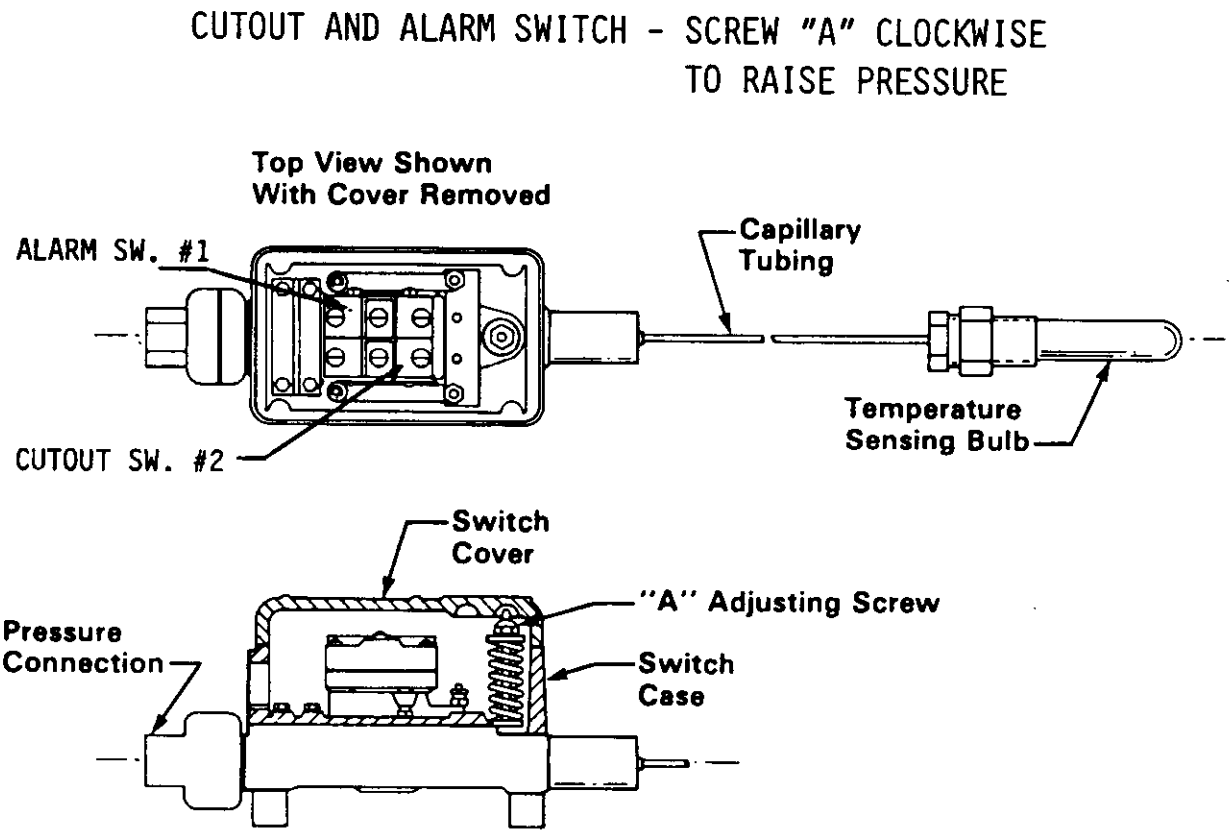



Figure 14 — Temperature Compensated $SF_6$ Switch

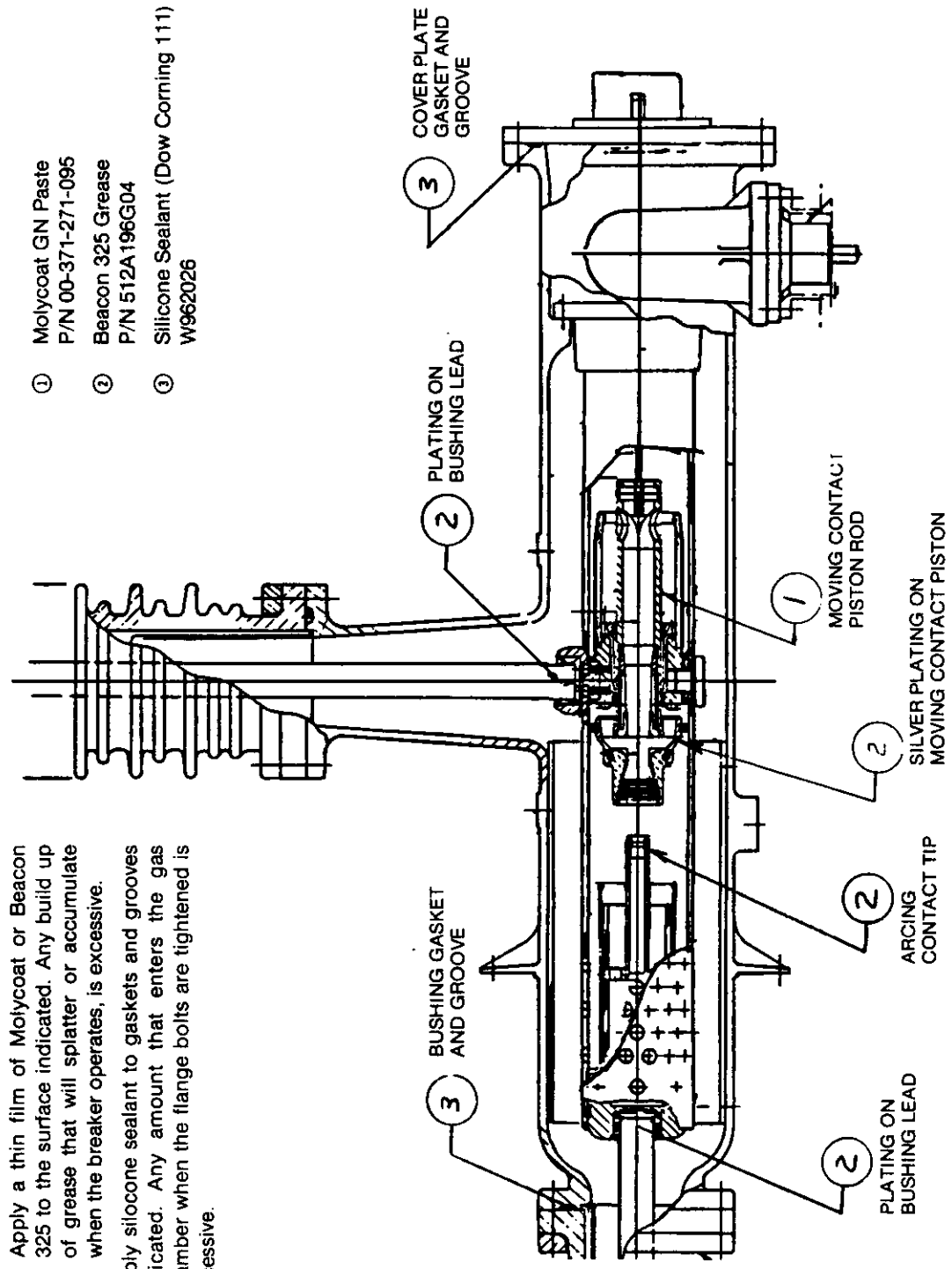



Figure 15 — Lubrication Application

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## ILLUSTRATIONS - APPENDIX

# APPENDIX I



## INTRODUCTION

Type SA-7 circuit breaker operating mechanism is closed by compressed air, opened by springs, and is both electrically and mechanically trip free. Since the closing energy is derived from compressed air which can be stored in a reservoir over a relatively long period of time with a low current consumption by means of a motor driven compressor, the mechanism is especially suited to applications where it is desired to eliminate large batteries required for solenoid mechanisms, or where fast reclosing is required.

Siemens outdoor circuit breakers are precision built devices designed to function efficiently under normal operating conditions. They are designed and manufactured to operate within the ANSI C37 standards applicable to the breaker rating.

The successful field performance of these breakers depends as much on proper installation and maintenance as it does on good design and careful manufacture. Refer to these sections before performing any installation or maintenance.

Factory adjustments are carefully made and the breaker is given rigorous mechanical tests after which the adjustments are re-checked. All control wiring is given a 1500 volts withstand test as per ANSI C37 standards.

The instructions included in this book are necessary for safe installation, maintenance and operation and to aid you in obtaining longer and more economical service from your Siemens circuit breakers. For proper installation and operation — resulting in better service and lower maintenance costs — this information should be distributed to your operators and engineers.

By carefully following these instructions, difficulties should be avoided. However, they are not intended to cover all details or variations that may be encountered during the installation, operation and maintenance of this equipment.

Should additional information be desired, including replacement instruction books, contact your Siemens representative.

Distinctive signal words (DANGER, WARNING, CAUTION) are used in this instruction book to indicate degrees of hazard that may be encountered by the user. For the purpose of this manual and product labels these signal words are defined below.

**DANGER** Indicates death, severe personal injury or substantial property damage **will** result if proper precautions are not taken.

**WARNING** Indicates death, severe personal injury or substantial property damage **can** result if proper precautions are not taken.

**CAUTION** Indicates minor personal injury or property damage **can** result if proper precautions are not taken.

### ⚠ DANGER

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off control voltage.

Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices, instructions and maintenance procedures contained herein.

The successful and safe operation of this equipment is dependent upon proper handling installation, operation and maintenance.

## QUALIFIED PERSON

For the purpose of this manual, a qualified person is one who is familiar with the installation, construction and operation of the equipment, and the hazards involved. in addition, he has the following qualifications:

a) Is trained and authorized to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.
b) Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

# APPENDIX I

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## RECEIVING, HANDLING, AND STORING

## RECEIVING, HANDLING, AND STORING

Each mechanism and its associated equipment is tested at the factory and should be in good condition when received. Inspection should be made immediately to see that no damage has occurred in shipment. If damage is evident, or indication of rough handling is visible, a claim for damage should be filed at once with the carrier (Transportation Company), and the nearest Siemens Sales Office notified promptly.

Unpacking should be done carefully to prevent damage, and all parts should be checked with the shipping list to insure against leaving any parts in the packing material. The mechanism should be accompanied by the proper identification tag and this instruction book.

**WARNING**

Hazardous mechanism.
Serious personal injury or damage to the circuit breaker will occur from misuse.

To prevent:

Keep clear of all mechanism parts when removing the safety pin used to hold mechanism triggers and latches in place during transit.

If the mechanism is not placed in service immediately, it should be kept in a clean dry place, protected from corrosion and moisture. This may be accomplished by closing the mechanism housing doors and energizing the space heaters provided in it. This procedure is recommended even if it requires the use of a temporary wire circuit to the heaters. In case this is impracticable, all machined parts, especially on the latching surfaces of the latch and rollers should be coated with grease or rust inhibiting material. Additional protection may be obtained by the use of silica gel, activated alumina or similar dehydrating agents. Two or three small bags of the material should be hung in the mechanism housing near the parts requiring protection. It should be remembered that complete protection may not be provided in spite of the above precautions. Periodic inspections should be made to determine the condition of the apparatus.

# APPENDIX I



## GENERAL

Included within the dust-tight sheet metal housing, the following pieces of apparatus which combined are designated as a complete operating mechanism:

(1) An air compressor, air storage reservoir and the necessary attachments and accessories for controlling the air supply.

(2) A pneumatic mechanism consisting of the air cylinder and piston, a lever system for connecting the piston to the pull rod of the breaker, and a trigger for rapidly disengaging the breaker pull rod from the piston, and a holding latch for maintaining the mechanism and breaker closed.

(3) A control panel to provide the necessary relays and interlocks for remote electrical control.

(4) A number of accessories essential to the proper functioning of the unit such as a trip magnet assembly, control valve, 2-pole and 11-pole auxiliary switches, a latch check switch, space heaters, thermostat, fused knife switches for the establishing and protection of the electrical circuits, and terminal blocks for terminating all wiring where it will be readily accessible for connections on installation.

## COMPRESSOR AND AIR SYSTEM

The compressor is single stage and air cooled type. The pressure governor switch which regulates the pressure in the storage reservoir, operates to start the compressor as soon as the pressure in the reservoir has dropped to a predetermined differential below the pressure setting and stops the compressor as soon as the pressure has been raised to a predetermined value as shown on the mechanism nameplate for each application. Power to operate the compressor is furnished by a 230/115 volt, single-phase motor through a "V" belt drive. Unless the order specifies differently, the motors when shipped will be connected for 230 V a-c to prevent damage to the motor from overvoltage. D.C. or 3 phase motors may be supplied for special applications.

The reservoir tank fulfulls the requirements of State Inspection Codes and all equipment is manufactured under A.S.M.E. requirements with close inspection. A safety valve is supplied on the reservoir to prevent pressure from building up to a dangerous level should the pressure governor switch fail to turn off the compressor motor.

At a pressure slightly above the minimum satisfactory operating pressure, a low pressure cut-off switch operates to open the closing circuit, thus preventing the mechanism from attempting to operate the breaker when there is insufficient air pressure to complete the operation. A seal-in interlock on the closing relay is wired in parallel with this low pressure cut-off switch so that should the low pressure cut-off switch open its contacts during a closing operation, the breaker will complete the closing operation. The minimum setting of the low pressure cut-off switch is set high enough above the actual minimum to insure enough air to complete the closing operation. The operating range of all pressure switches and safety valves are set at the factory and should not need changing.

If anything should go wrong with the compressor or air equipment so that normal pressure is not maintained, a low pressure alarm switch is provided that can be used to sound an alarm at the substation indicating that the pressure is only slightly above the setting of the low pressure cut-off switch.

The schematic diagram for the air system is shown on Figures 8 thru 11, page 101. This diagram together with the control diagram, the various position figures, and the explanation of the mechanism operation should give a more complete understanding of the overall operation.

## PNEUMATIC MECHANISM AND CONTROL

Referring to Figures 1, 2, 3 and 14 while following this description will facilitate the understanding of the construction and functioning of the mechanism, pages 99, 100, 104 and 105.

The mechanism is both electrically and mechanically trip-free in all positions. The mechanical trip-free feature is obtained by a system of linkages, which transmit the movement of the closing piston to the breaker pull rod, which is maintained in position by a trigger. Figure 1, page 99 illustrates this arrangement of the linkage for the open position of the mechanism. Tripping the trigger, frees the system of linkages, permitting movement of the closing piston independent of the breaker. This condition is illustrated by Figure 3 which shows the mechanism in the trip-free position.

# APPENDIX I



## MAIN FRAME

The mechanism is built up about the main frame which serves as a housing for all of the levers and triggers, supports and control valve, main cylinder and auxiliaries and includes the mounting pads for mounting the mechanism to the breaker.

## CYLINDER AND CLOSING PISTON

The cylinder is clamped by four studs between the top plate which is a part of the frame, and the removable bottom plate. While these plates are made of steel, they are given a corrosion resistant protective finish. The main closing piston is fastened to and approximately at the center of the piston rod. The upper end of the piston rod carries the cross-head, which serves as a means of attaching the system of linkages and also provides an engagement surface for the main holding latch to maintain the mechanism in the closed position. The lower end of the piston rod extends through the spring housing and serves as a means for attaching the hand closing device. An adjustable packing gland around the piston rod, minimizes the air losses during closing operations.

## RETRIEVING SPRING ASSEMBLY

The spring housing is part of the bottom plate of the cylinder and supports the retrieving springs. The retrieving springs, which are compressed during the closing stroke, supply the force required to move the piston back to the open or starting position following a trip-free operation, and reset the system of linkages from the position shown in Figure 3, page 100 to the open position in Figure 1, page 99.

## LEVER SYSTEM
### (Figures 1, 2, and 3, pages 99 and 100)

The closing links are attached to the crosshead by pin "B". Rollers on each end of pin "B" run between the guide rails and serve the dual purpose of guiding the upper end of the piston rod and reducing the friction resulting from the side thrust of the closing links. Pin "C" joins the upper end of the closing links to one end each of the intermediate link and the cam lever. Pin "A" connects the other end of the cam lever to the connecting link. Rollers at each end of this pin run between the guide rails to constrain pin "A" to move in a vertical plane. The bell crank lever converts the vertical motion of the connecting link to horizontal motion for connecting to the breaker pull rod.

In order to transmit the motion of the closing piston to the breaker pull rod, points A, B and C must be maintained in approximately the same relative position as shown in Figure 1 or Figure 2. This is accomplished by the following arrangement. The intermediate link is connected at one end by pin "C" to the cam lever and closing links, and at the outer end by the thrust pin to the trip-free lever through hole "E". As long as point "E" remains a fixed point, the intermediate link will maintain points A, B and C in the same relative position of Figure 1, and the closing piston and breaker pull rod are effectively coupled and move in unison. By regulating point "E" so that it can either be maintained as a fixed center or released at will, the means are at hand to make the mechanism mechanically trip-free. The releasable function of point "E" is accomplished by locating the thrust pin midway between the fulcrum point of the trip-free lever and the free or roller end. It will be noted from Figure 1 and Figure 2 that the line through "C"-"E" is always below the trip-free lever fulcrum pin. Thus the component of the breaker load, which appears as a thrust on the intermediate link will tend to rotate the trip-free lever in a counterclockwise direction about the trip-free lever fulcrum pin.

## TRIP-FREE TRIGGER

A trigger, free to rotate on needle bearings about a fulcrum pin and positioned approximately tangential to the direction of motion of the trip-free lever, provides the final releasable means of regulating the fixation of point "D". The end of the trigger in engagement with the roller on the trip-free lever is shaped in such a manner that there is a slight tendency for the trigger to rotate clockwise whenever there is a load on the breaker pull rod. This moment, in addition to the moment provided by the trip-free trigger spring, keeps the trigger against the trip-free trigger stop on the trip-free lever, insuring a definite engagement of the trigger with the roller. The long horn on the trip free lever serves to maintain the trip-free trigger in the tripped position whenever the mechanism is in any intermediate position between fully closed or fully retrieved positions.

To guard against the possibility of a shock causing the trip-free trigger to release, a catch is provided that engages the trip-free trigger in the latched position. Normally there

# APPENDIX I



is no load on the catch, however, the catch must be released prior to tripping the trip-free trigger. An arm on the catch, interposed between the trip rod and the trip-free trigger, serves to release the catch before the trip rod engages the trip-free trigger.

## TRIP MAGNET ASSEMBLY (Figures 14A and 14B, pages 104 and 105)

The trip assembly is located on the underside of the mechanism frame, directly under the trip free trigger. The mechanism may be provided with either of two types of trip assembly. The **W** type is shown in Figure 14B and the SGC type is shown in Figure 14A. The adjustments of these two are slightly different and reference to the figures will identify the type provided and the necessary adjustment. The trip rod is threaded into and locked to the trip armature, which provides the means for adjusting the trip rod position for proper tripping. When the trip coil is energized, the armature and trip rod is pulled upward by the magnetic forces. The trip rod engages the catch rotating it away from the trigger, further movement of the rod causes the trigger to be rotated which will release the mechanism and breaker linkage to be opened by the breaker accelerating spring.

In the unenergized position the gap between the magnet pole face and the armature is adjustable as shown on the Figs. 14A and B.

## HOLDING LATCH

In order to maintain the mechanism and its connected load in a closed position (Figure 2, page 100), a spring biased holding latch engages the upper edge of the cross head. The relation between the engaging surface at the lower end and the fulcrum point at the upper end of the latch is such that the load on the pull rod tends to hold the latch in engagement.

## CLOSING PISTON SNUBBER

To help absorb the energy of all of the rapidly moving parts that must be suddenly decelerated at the end of a closing stroke, a collar extension on the underside of the closing piston seals off the large opening in the bottom plate as the piston approaches the closed position. This traps air between the underside of the piston and the bottom plate and rapidly builds up a back pressure to cushion the shock.

## CONTROL VALVE AND MANIFOLD ASSEMBLY

The control valve assembly combines both the inlet and exhaust functions in a single compact unit, and consists of a main valve operated by an electropneumatic pilot valve as illustrated in Figures 4 to 7, page 101.

The solenoid pilot valve is double acting. For example, when the inlet seat is closed the exhaust port is open. The pilot valve inlet has a composition to metal seat and is spring-biased closed. The valve is opened either by energizing the pilot valve coil or by manually operating the push button on top of the coil which in both cases moves the valve stem down and opens the valve. The valve remains open only while the coil is kept energized or the button held down. As soon as the coil is de-energized or the button is released, the spring bias closes the inlet seat and opens the exhaust seat.

The main control valve is double acting also. When the inlet seat is closed the exhaust seat is open. This blocks the high pressure air from entering the mechanism cylinder and at the same time allows the air in the cylinder to exhaust to atmosphere.

As shown in Figure 4, page 101 the operating piston and exhaust poppet seat have a common body. The inlet poppet is driven by a stem attached to the operating piston poppet. The inlet seat is held tightly closed by a spring bias and the air pressure acting upon the underside of the inlet poppet. This also holds the exhaust poppet open and operating piston to the top of its bore.

When the pilot valve is opened, it allows high pressure air to enter above the operating piston forcing it down. Thus it closes the exhaust seat and opens the inlet seat allowing the air to flow to the mechanism cylinder. When the pilot is closed, the air from above the operating piston is exhausted and allows the exhaust seat to open and the inlet seat to close.

A manifold links the control valve with the operating mechanism and controls the volume of air permitted to enter the mechanism cylinder. The manifold accomplishes this by means of an adjustable throttle valve as shown in Figures 4 to 7. The position of the throttle valve is regulated by the throttle cam lever, which in turn is controlled by the position of the breaker. For the start and early part of the closing operation, the breaker load is relatively light for most breakers. In order to prevent the breaker contacts from attaining unnecessarily high velocities during this lightly loaded portion of the closing stroke, with a corresponding drop in pressure in the closing cylinder, the flow of air is restricted by having the throttle valve in the metering position. Thus, the air is forced to reach the cylinder through the slight throttle valve opening (Figures 5 and 9). Shortly before the breaker contact load is picked up, the throttle valve is opened to provide maximum air flow (Figures 6 and 10, page 101).

When the breaker is tripped, the air above the closing piston must be exhausted to atmosphere to allow the piston to return to the full open position. This must be accomplished rapidly to insure quick operation in the event reclosing is a necessity. The air which is being forced from above the piston is at a pressure great enough to overcome the force of the throttle valve retrieve spring. Therefore, the exhaust air has an almost unrestricted flow through the manifold and out the control valve exhaust port to atmosphere (Figures 7 and 11, page 101).

## CONTROL SCHEME

To provide for remote and semi-automatic control of the admission of air to the mechanism, and the cutting off of the air at the end of a closing operation, a control panel is included as part of the standard equipment. The steel panel is located in a convenient position on the left-hand side of the housing in order to provide maximum accessibility and unrestricted working space around the mechanism. The equipment on the standard panel includes a closing relay, a cut-off relay, and control knife switches. Referring to a typical diagram, Figure 16, page 107, the closing relay designated as "X" and the cut-off relay designated as "Y" are pictured in the de-energized position. The arrangement of the two relays as shown provides an electrically trip-free, non-pumping device and is commonly designated as an X-Y control scheme.

An auxiliary switch contact designated as "aa" in the cut-off relay coil (52Y) circuit, and a circuit opening contact of the cut-off relay in the closing relay (52X) circuit is provided. This auxiliary switch contact is part of the mechanism auxiliary switch. The position of this contact is determined by the position of the mechanism piston.

On a closing operation, one normally open 52X contact closes and seals in the closing relay coil circuit, another normally open 52X contact closes in the cut-off relay coil circuit. The close coil is simultaneously energized by closing of normally open 52X contacts. As the mechanism approaches the closed position, the "aa" switch makes contact energizing the cut-off relay coil, and this opens the cut-off relay contact in the closing relay coil circuit, which returns the closing relay to the de-energized position. Simultaneously, the two normally closed cut-off relay contacts, in the pilot valve coil (52CC) circuit, open. To provide the non-pumping feature, a normally open cut-off relay contact is connected in parallel with the cut-off switch "aa" contact and with the low pressure cut-off and latch check switches. If a protective relay trips the breaker immediately upon closing, the cut-off relay contact in parallel with the "aa" contact seals in the "Y" coil even though contact "a" opens on the opening stroke of the breaker. The "Y" coil remains energized holding open the normally closed contact in the "X" coil circuit. The closing circuit is locked out until the operator releases the control switch to the neutral position and initiates a second closing operation. If the breaker is required to close immediately after a trip operation, the latch check switch would prevent energization of the closing relay coil until the mechanism piston is in the fully retrieved position.

The electrically trip-free feature of the breaker is provided by the "a" contacts in series with the trip coil. If required, the breaker will trip as soon as the "a" contacts are closed.

## LOW PRESSURE CUT-OUT SWITCH

To insure against the mechanism attempting to close when there is insufficient air pressure in the reservoir to complete the operation, a low pressure cut-out switch, located in the air supply system between the inlet valve and the reservoir, has its contact connected in the closing circuit between the operators control switch and the closing circuit. The low pressure cut-out switch contact is normally closed, but opens before the critical operating pressure is reached.

The low pressure alarm and low pressure cut-out switches are fed from an air manifold. This arrangement desensitizes these switches to momentary pressure transients.

# APPENDIX I



To further insure against a possible faulty operation due to the low pressure cut-out switch opening its contacts during a closing operation, "make" contacts of the closing relay are provided to by-pass the low pressure cut-out switch.

As soon as the closing relay is energized, the "make" contacts "seal-in" and insures the admission of air to the mechanism to complete the closing operation. These "seal-in" contacts also insure the completion of any closing operation once started, even though the operator might release the control switch before the mechanism has had time to complete the operation.

If the breaker is closed on a fault, and the operating pressure is near the lower limit, the low pressure cut-out switch contacts may open momentarily just after the breaker reaches the closed position. Should this occur while the operator is still maintaining the control switch closed, and after the cut-off relay has caused "X" seal-in to drop out, the breaker would reclose. Employing a normally open cut-off relay contact in parallel with the low pressure cut-off switch insures against this faulty operation.

Two contacts of the cut-off relay are situated in the pilot valve coil circuit to de-energize the inlet valve at the conclusion of the closing stroke.

One of the fused knife switches on the control panel is provided to take the power off from the control circuit locally during maintenance periods and also provide over-load protection. One of the other fused knife switches is provided for the compressor motor circuit, and the other for the heater circuit.

## LATCH CHECK SWITCH

The latch check switch is attached to the SA-7 mechanism frame and is operated by the trigger. When the trigger is not engaged, the latch check switch contacts are open. The switch contacts are in the close coil, coil "X" relay circuit. This prevents energizing the close circuit until the trigger is seated latching the mechanism linkage. With the trigger seated the latch check switch contacts are closed permitting energizing the close circuit.

## AUXILIARY SWITCHES

The auxiliary switches for the DC control circuit are mounted on the back of the cabinet. Spare contacts are wired to terminal blocks.

These switches serve as circuit interlocking devices, to prevent the energizing of the breaker closing solenoid if the breaker is already closed, or to prevent the trip coils from becoming energized when the breaker is open.

Each rotor contact can be set to function as a 52a or a 52b, according to functional requirements. Adjustment can also be made at intermediate steps of 15 degrees.

To adjust the "making" or "breaking" point of any stage, use needle-nose pliers. Refer to Figure 17, page 108.

## OPERATION COUNTER

An operation counter, mounted on the pressure gauge bracket, is operated by the auxiliary switch operating arm. The counter records on the opening stroke.

## HEATERS

Three heaters are provided in the housing. One of these heaters is to be energized continuously winter and summer to maintain a temperature differential between the inside and outside in order to prevent undesirable moisture condensation within the housing. The other two heaters are thermostatically controlled to maintain this differential in cold weather.

## HAND CLOSING DEVICE

A screw type jack, with a ratchet handle is available for closing the breaker during maintenance and inspection periods.

# APPENDIX I



## DANGER

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

The hand closing device must not be used to close the breaker on an energized circuit.

## WARNING

Hazardous mechanism.
Serious personal injury or damage to the circuit breaker will occur from misuse.

To prevent:

Accidental opening insert the safety pin, supplied with the breaker, through the two holes in the side plates of the frame.

## SAFETY PIN

The safety pin passes behind the catch and directly above the tail section of the trip-free trigger blocking the trigger in the latch position. **This pin must be removed before putting the breaker back in service.**

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## CLOSING

Starting with the mechanism and breaker in the open position (Figure 1, page 99), and with the trigger engaging the trip-free lever to maintain the linkages in the relative position shown, closing the control switch energizes the "X" coil which closes the "X" contacts in the pilot valve coil circuit, thus energizing the pilot valve coil. This opens the inlet valve which admits compressed air stored in the reservoir to the closing cylinder. The high pressure air acts on the piston to close the mechanism. When the breaker is nearly closed, the "aa" auxiliary switch contact closes energizing the cut-off relay "Y" which simultaneously (1) opens its "Y" contacts in the pilot valve coil circuit initiating the shutting off of compressed air to the closing piston, (2) opens its contact in the closing relay coil circuit de-energizing the closing relay and opening its "seal-in" contact "X" and (3) closes the "seal-in" "Y" contact in parallel with the "aa" switch and the "Y" contact in parallel with the latch check switch and low pressure cut-out switch to maintain the control relays locked out until the control switch is released. The point, where the "aa" switch makes up its contacts, is so near the end of the closing stroke, that the mechanism and breaker continue on in to the fully closed position before the closing air is actually shut off. As the mechanism reaches the fully closed position (Figure 2, page 100), the holding latch engages the cross head on the upper end of the piston rod, keeping the mechanism and breaker closed.

## OPENING

Starting with the breaker in the closed position (Figure 2), when the control switch or protective relay energizes the trip coil circuit, the trip rod on the moving armature of the trip magnet disengages the trigger which has been restraining the roller on the trip-free-lever. The connected breaker load acting through the cam lever and intermediate links on the trip-free lever cause it to rotate about its fulcrum pin releasing the breaker (Figure 3, page 100). The long horn on the trip-free lever maintains the trigger in the released position until the mechanism is fully retrieved. As the cam lever rotates about pin A, the cam extension disengages the holding latch. This action permits two heavy retrieving springs, which are confined between the main closing piston and the bottom of the spring housing, and which were compressed during the closing operation, to move the piston to the open position. If the speed of the breaker contacts is greater than the piston speed, the extreme trip-free position shown in Figure 3, page 100 may be approached. If the piston retrieving speed is greater than the breaker pull rod speed, as will be the case in some applications, the piston will "overtake" the breaker, completely retrieving the levers and resetting the trigger as shown in Figure 1, before the breaker and mechanism have reached the full-open position.

## CLOSE-OPEN

The close-open operation is merely a combination of the closing and tripping operations described previously. When the breaker closes on a fault, the protective relay energizes the trip coil, disengaging the trigger just before the mechanism reaches the closed position. This releases the connection between the piston and the breaker pull rod and the breaker is allowed to immediately re-open unimpeded, (Figure 3, page 100). The cam lever being in a released position keeps the holding latch from engaging the cross head as the piston reaches the closed position. Opening the exhaust valve exhausts the air from the main cylinder, releasing the closing piston. In this instance, however, there is enough delay introduced by exhausting the air from the cylinder to allow the breaker to reach the full open position (Figure 3) before the piston starts to return to the open position. Once the piston starts to move, however, the retrieving action is rapidly accomplished.

## OPEN-CLOSE

Reclosing requires the use of a separately mounted reclosing relay of either the SGR-12 or RC type. When the trip-free trigger is disengaged by the protective relay energizing the trip coil, the action described previously under "Opening"takes place. As the trigger resets, a latch checking switch makes contact completing the reclosing circuit, energizing the pilot valve coil. This admits high pressure air to the cylinder and the mechanism immediately recloses.

Should the fault that caused the protective relay to trip the mechanism still exist as the mechanism recloses the breaker, the mechanism will function as described in detail under the description of the "close-open" operation, and the breaker and mechanism will return to the open position Due to the lockout feature of the Type SGR-12 and RC relay, the mechanism must be closed by the operator before another reclosing operation can be performed.

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## INSPECTION, MAINTENANCE ADJUSTMENT

### INSPECTION

Since operating conditions vary greatly from one area to another and even between installations in the same locality, it is difficult to recommend any time interval for inspection and maintenance. The important consideration in this respect is that a regular schedule is established and maintained in order that the condition of the equipment is known, and any deficiencies corrected before they can develop into a serious condition. The circuit breaker is highly dependent upon the proper functioning of the mechanism. Therefore, it should always be kept in good condition.

Refer to instructions of the compressor unit for recommendations for inspection and maintenance.

### OPERATING

**⚠ DANGER**

Hazardous voltage and mechanisms. Death, or severe injuries from electrical shock, burns and entanglement in moving parts will occur from misuse.

To prevent:

This equipment should be installed, operated and maintained only by qualified persons thoroughly familiar with equipment, INSTRUCTION MANUALS and drawings.

No attempt to operate the breaker should be made until all shipping braces have been removed, and the breaker has been inspected and adjustments checked.

The wiring and schematic connection diagrams supplied with the breaker should be used when testing and checking the operating mechanism and control circuits. Check all wiring for looseness.

Do not reconnect D.C. supply voltage until system pressure has built up to a value greater than minimum operating

When checking out operator run down, do not operate more than one operation below lockout pressure.

### MAINTENANCE

Work on the breaker should be performed only by qualified personnel. The breaker should be in the open position and with the operator's pneumatic system at zero psig. In addition, all electrical power to the breaker and its controls should be disconnected and properly grounded. When performing maintenance or adjustments requiring the breaker to be closed and charged, the release latch should be blocked in position to prevent accidental tripping and possible injury.

**⚠ DANGER**

Hazardous voltage and mechanism will cause serious personal injury or death from electrical shock, burns and entanglement in rapidly moving parts.

To prevent:

1. Do not trip or close breaker unless you are clear of all moving parts.
2. Discharge the breakers' mechanical systems before performing maintenance or inspection:
   - 2.1 The position indicator must read OPEN.
   - 2.2 Remove air from system. Must be at 0 psig.
3. Insert the maintenance pin to secure the operator against accidental tripping when adjustments require breaker in closed position.
4. Disconnect the breaker and its mechanism from all electrical power before performing maintenance or inspection. Grounding leads should be properly attached and framework grounded.

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**NOTE** The breaker may be tripped with the piston in any position; however, the linkage will not reset for a close position until the piston is reset to full open position.

## MAINTENANCE CLOSING DEVICE

The breaker may be "slow opened-closed" adjustment and alignment inspection using the maintenance closing device.

**DANGER**

Hazardous voltage and mechanism will cause serious personal injury or death from electrical shock, burns and entanglement in rapidly moving parts.
To prevent:

1. Pneumatic system must be at zero psig and the pressure bleed valve must be open when using the maintenance closing device.
2. Never slow operate the breaker while it is energized or control power is connected.
3. Remove the maintenance closing device before operating the breaker.
4. Keep hands free of the breaker while the operator or jack is descending.

Keep the area immediately below the mechanism spring housing clear of any obstructions whenever operating the mechanism, as the lower end of the piston rod protrudes through the opening in the spring housing when the mechanism is in the closed position.

There is considerable blast from the exhaust valve when the closing air is exhausted from the main cylinder. Therefore, maintenance personnel should be cautioned to keep clear of the area immediately in front of the valve whenever the mechanism operated pneumatically.

**WARNING**

Hazardous mechanism.
Serious personal injury or damage to the circuit breaker will occur from misuse.

To prevent:

Keep hands and all tools outside of the side plates of the frame whenever the mechanism is in the closed and latched position.

Extra care to be used in the space immediately in front of the trip free lever, as this lever travels at a rapid speed.

In order to be sure of the mechanism's good condition and check its readiness for satisfactory operation, especially in applications where the mechanism is not called on to operate for extended periods of time, several operations should be made at each inspection period.

## LATCHES AND TRIGGERS

The holding latch and cross-head are made of hardened steel machined to shape. The engaging surfaces of the holding latch and cross-head may be polished with fine emery cloth if they become dirty. **Do not attempt to grind the surfaces nor change their angle.** Apply a thin film of rust inhibiter Beacon 325 (Siemens W962010) to the latch, cross-head, and outside surface of the roller on the trip-free lever. This inhibiter is carefully selected to be free flowing at all anticipated temperatures, non-hardening, and self-healing (does not completely wipe off in one operation). The latching surfaces should be examined at every inspection to make sure of their condition.

If while adjusting the breaker contacts, it becomes desirable to open the mechanism slowly with the hand closing device after the mechanism has been closed and latched (Figure 2, page 100), the main holding latch can be disengaged easily by first taking the load off the latch by pulling the mechanism slightly into the overtravel position and then keeping the latch disengaged until the cross-head passes the end of the latch as the mechanism is let out. (The latch may be disengaged by inserting a screwdriver through a hole in the side frame just behind the guide rail and prying back on the latch.)

The trip-free trigger is cast from a tough, high strength non-ferrous alloy, tipped with a highly corrosion resistant,

file hard stellite latching face. The latching face has been accurately ground to the correct angle. **Do not attempt to regrind this surface nor change the angle.** The needle bearings in the roller and the trip-free trigger are packed with Beacon 325 (Siemens W962010) and should not require repacking more often than every 18 months.

The grease on the roller guides should be examined periodically for contamination with dust or other foreign matter. If this condition is evident, the old coating should be washed off with a solvent and a new coating of grease applied.

## AIR LEAKAGES

A good overall check for air leaks in the air supply system is to make a "leak test". Observe the loss in pressure on the pressure gauge over four to six hours at a stable ambient temperature in order to determine the rate of pressure drop. Allow the system to cool for about two hours before reading pressures if the reservoir has just been filled from atmospheric pressure. A pressure drop of a few psig will be observed due to contraction of the air on cooling. When the mechanisms leave the factory, the air system will not lose more than five pounds psig per hour, but there is no need for alarm if the leakage exceeds this figure unless it becomes progressively worse.

The first place to check for leaks is the pilot valve. This may be determined by applying a soap solution to the pilot valve exhaust port. Leakage here is generally due to dirt particles on the valve seat. "Cracking" the valve several times by pressing the manual operating button will usually serve to dislodge the dirt and make the valve seal properly. At this point, it should be stated that general recommendations require that the complete valve with coil be carried as a renewal; part for important power station installations rather than attempting repair of this small pilot valve. If necessary, disassembly of the pilot valve and replacement of parts may be accomplished by following instructions detailed in Appendix IV, Figure 1. A listing of parts available in a service kit is given.

Checking for leaks past the main inlet poppet seat can be accomplished easily. Obtain a standard pipe plug and drill a small hole through it. Insert the plug in the exhaust port and apply soap solution to the hole and threads. Caution: Immediately remove pipe plug upon determining if leakage exists. If a leak is detected here after having previously determined that the pilot valve is tight, indicates that the main inlet poppet seal is not sealing properly. The quickest method and one that is generally successful is to "crack" the valve by bumping the manual operating button on the pilot valve several times. If the leak persists, the control valve can be disassembled and inspected. Directions for disassembly of the valve are given in Appendix IV Figure 2. A listing of parts available in a service kit is given

If the control valve "blows" through the exhaust port when the coil is energized, it is an indication that the exhaust poppet is not seating properly. If this cannot be corrected by pushing the manual operating button, disassemble valve as described in Appendix IV and check for damage or dirt on seats.

If the leak is not in the control valve unit, all other connections including the safety valve should be checked with a soap solution.

## AIR COMPRESSOR UNIT

The air compressor unit is equipped with a Type "FW-60" (Figure 15, page 106) air compressor and the complete system is fully automatic in operation.

The air compressor and motor are mounted on a bedplate. Power is transmitted by single "V" belt drive with adjustable belt take-up.

Completely equipped with motor and electrical protective and control devices, the compressor unit is ready to connect to the line and start operation after checking the level of compressor oil.

It is important that the wiring to the motor be strictly in accordance with the National Electrical Code regulations. Consult regulations or local inspector regarding size of wire and proper fuse protection. The use of wire smaller than required for the installation will result in unsatisfactory operation and possible damage to the motor.

## AIR COMPRESSOR

The single stage, single cylinder air compressor is lubricated by the controlled splash system and is air cooled.

Proper rotation of the compressor is right-hand (clockwise) when facing the oil fill plug of the crankcase (as indicated by the arrow).

The compressor is filled with oil before leaving factory Check oil level before starting compressor

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## APPROXIMATE OIL CAPACITY

Type "FW-60" ..... 1/3 Pint
Type "FW-60T" ..... 2/3 Pint

The oil filling plug should be removed and the oil level observed periodically. If the oil level is at the low mark on the exterior of the crankcase, add sufficient oil to raise the level to a point one thread above the bottom of the fill hole. A high grade non-detergent automobile engine oil - SAE-20 for temperatures above freezing or SAE-20W for temperatures below freezing may be used.

At least every six months a sample of oil should be drained from the crankcase to determine its condition which will govern the necessity for complete draining and refilling the crankcase. The necessity for this should conform to good automobile engine practice.

Also at six month intervals or more often, if environment dictates, the condition of the air filter should be checked. The filter in the type FW-60 compressor is a cellular type material and may be cleaned in kerosene or other solvent. See Figure 15, page 106

Leakage of air back through the compressor air intake indicates a faulty check valve. Disassemble the check valve, clean the valve body thoroughly, clean and remove any rough edges on the Teflon valve disc by rubbing lightly on very fine emery or #600 sandpaper held on a smooth, flat surface. Examine the surface of the brass valve body on which the Teflon valve disc seats. If this surface is found to be rough or distorted, replace the complete valve.

The syphon valve at the side of the air reservoir tank should be opened during inspection or maintenance of the breaker to drain accumulated water resulting from condensation. Leave the drain valve open only as long as solid water runs, then close tightly.

The safety valve ordinarily requires no attention. It is set to blow off at 250 psi. If, after blowing off, the valve fails to seat tightly, it is usually due to dirt on the seat. Opening and closing the safety valve slowly by means of the ring on its stem, with the compressor running, usually cleans the valve seat and restores proper seal, if valve does not seat replace.

The compressor belt should be maintained tight enough to prevent excessive slippage, but not tight enough to place undue strain on the motor and compressor bearings which will result in excessive heating of these bearings and increase the power required. When installing a new belt or adjusting old belt for normal wear, the correct tension is obtained by having a deflection of between 3/8 to 3/4 inch with approximately 5 pounds pressure applied vertically at center of belt.

## PRESSURE GAUGE

It is advisable to check the pressure gauge with a master gauge to verify the correctness of its indication before checking pressure switch adjustments.

## PRESSURE SWITCHES

The settings of the pressure switches should be checked against the values stamped on the mechanism nameplate at each regular inspection period. **Governor Switch**. Pressures higher than normal will cause the breaker to slam hard on closing, while pressures lower than normal reduce the reserve capacity stored in the reservoir. If the pressure gauge reading, at the time the compressor has just completed recharging the reservoir, indicates that the switch is not cutting off at the proper pressure, may be corrected with adjustment of the slotted stud on top of the switch. **Low Pressure Cut-Off Switch**. Too low a setting of the low pressure cut-off switch nullifies the purpose of the switch, i.e., to prevent the mechanism from attempting to close when there is insufficient air to complete the operation. Too high a setting would result in the switch opening prematurely and there by reduce the number of operations that are possible from a fully charged reservoir. The governor switch is normally set to start the compressor at a pressure well above the operating pressure of the cut-out switch, thus the cut-out is not normally called on to operate except in the event the compressor is out of operation. Since this switch may remain idle over long periods, its readiness to operate in an emergency should be checked at each inspection period. **Low Pressure Alarm**. The low pressure alarm switch is intended to give a warning to the operator in the event that the compressor fails to recharge the reservoir. Therefore, in order to forestall erroneous indication of the alarm, the setting of the alarm switch should be checked.

Refer to Pressure Switch section in back of this book, pages 133 and 134.

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## ORIFICE

The orifice is installed in the 1/8 inch tube connecting to the air supply manifold. When pressure is dropped on the manifold system, check that the cut-off switch responds without abnormal delay. A clogged orifice can result in a damaged breaker, clean orifice if clogged.

## TRIPPING

The latch and trigger on this mechanism do not require delicate adjustment, and therefore no adjustment is provided.

An adjustment for the overtravel of the trip-free lever is provided and should be checked occasionally. With the mechanism in the open position (Figure 1, page 99), there should be approximately .030 ± .005" clearance between the trip-free lever roller and stellite tip on the trip-free trigger to insure positive resetting of the trigger. More clearance than is necessary at this point will impose severe hammering of the trip-free lever roller and the trigger, when the closing air is admitted to the cylinder. Adjustment of this clearance is made by turning the trip-free lever stop in or out of the strut on the main frame. The small nut on the upper end of the steel follower stem should be finger tight only when the mechanism is in the open position to insure against putting any initial compression on the rubber bumper.

The air gap for the trip armature should be set as shown on Figure 14A or 14B, pages 104 and 105, depending on the type of Trip Assembly provided with the mechanism. The length of the trip rod should release the trip-free lever when the armature air gap is 1/32".

This adjustment has been made at the factory and should not require changing. The adjustment is made by loosening the hex nut on the underside of the armature and screwing up or down on the trip plunger

The **W** type trip assembly Figure 14A has a "kick off" spring on the lower end of the trip rod which serves to speed up the retrieving of the armature after the trip coil is de-energized. When the armature is sealed in against the pole faces of the magnet, this spring should be compressed about 1/16". Thus for an armature air gap of 3/16", the gap between the underside of the resilient stop bar and the top of the kick off spring should be 1/8" If it is ever necessary to change this factory set adjustment, be sure to keep the trip rod from turning in respect to the armature by holding the trip rod with a screw driver while loosening and tightening the kick off adjusting nuts.

One last check which should be made is to ascertain that there is a minimum of twelve thousandths clearance between the top of the trip rod and the catch which it strikes. Clearance at this point is necessary to prevent shock-out of the mechanism on a closing operation. This clearance may be obtained by varying the air gap. Care should be exercised in widening the air gap excessively as this will increase the minimum operating voltage of the trip unit and slow down its operation.

## OVERTRAVEL

The overtravel of the piston should be approximately 1/8". There is no adjustment of the overtravel, but it should be checked to determine that it exists, as it is essential in order to allow time for the latch to snap into place. Furthermore, if it is not present it may indicate that the interrupter travel is incorrect and the linkage should be checked. See page 65 of the breaker instruction book. To check the overtravel with the mechanism in the closed position, hold down the pushbutton on the intake valve, and note the travel of the cross-head roller pin extension.

## THROTTLE AND THROTTLE CAM LEVER

The throttle cam lever has been set at the factory to give the most satisfactory closing performance of the breaker and should not require adjustment.

The throttle is adjusted to obtain correct breaker closing time by holding the throttle stem and turning the elastic stop nut in or out, whichever is necessary. The valve is held toward the closed position by the retrieve spring.

With the breaker in the open position, the gap between the throttle stem and the lever is approximately 3/16". When any adjustments are made to the above items, it is imperative to check breaker operation and compare it with the typical operating curves shown in the breaker instruction book. See Figure 12, page 102 and Figure 13, page 103.

# APPENDIX I



In case unsatisfactory operation develops, the following are suggested points to check in order to isolate the trouble.

A. IF THE MECHANISM FAILS TO CLOSE THE BREAKER

1. Check to see that the correct control voltage is available.
2. Check the closing relay to see that it closes its contacts.
3. Check the intake valve coil circuit.
4. Check the pressure of the air in the reservoir to see that it agrees with the normal pressure given on the nameplate.
5. Check the admission of air to the main closing cylinder by observing whether there is a momentary discharge of air from the exhaust valve, when the bottom on the pilot valve is momentarily closed then released.
6. Check the breaker stop to make sure there is no interference.
7. Check to see that the trip-free trigger is reset properly. Two things to look for if the trigger does not reset are—(1) The trip-free lever stop being set too low thus limiting the travel of the trip-free lever; and (2) The breaker traveling too far in the open position so that the main closing piston hits the top plate, preventing the retrieving springs from re-setting the trip-free lever.

B. IF THE MECHANISM CLOSES THE BREAKER, BUT FAILS TO KEEP IT CLOSED

1. Check the minimum operating voltage of the cut-off relay and increase it if it is too low.
2. Check the two-pole mechanism switch contacts to see if they are closing too soon, so as to cut-off the air to the cylinder before the mechanism is closed and latched.

**NOTE:** Trouble shooting may require the use of elementary and connection diagram. See nameplate for drawing number for that breaker.

3. Close the mechanism by means of the push button on top of the pilot valve and observe the overtravel of the roller on the cross-head pin. This should be about 1/8" to allow the latch time to reset.
4. Check the resetting of the trip-free trigger to make sure that the upper end of the trigger is against the stop on the trip-free lever, and that the trigger is in full engagement with the roller on the trip-free lever.
5. Check the engagement between the catch and the trip-free trigger to make sure that it resets properly.
6. Block the shunt trip armature open and perform a close operation. If the breaker closes successfully under this condition, the shunt trip is shocking the trip-free trigger out of position. This situation may be corrected by increasing the gap between the trip rod plunger and the trip-free trigger catch as outlined under Part 4.

C. IF THE MECHANISM FAILS TO TRIP

1. Check the voltage at the trip coil.
2. Check the terminals and contacts on the 11 pole auxiliary switch to be sure that they are making good contact.
3. Observe whether the trip rod rises when the control switch is moved to the position for tripping. (See Figure 14A, page 104 and Figure 14B, page 105.)
4. Raise the trip rod manually and observe whether the catch is disengaged prior to attempting to rotate the trigger, and that the trigger is moved sufficiently to release the roller on the trip-free lever. Also, check that the lower armature seats up against the upper stationary armature.

D. ON RECLOSING DUTY, IF THE MECHANISM TRIPS BUT FAILS TO RECLOSE

1. Check the contacts on the latch check switch to see that they are making good contact.
2. Make the checks outlined in A1 to A7.

# APPENDIX I



## LUBRICATION

The mechanism has been lubricated at the factory and should be relubricated at least once every 3 years. If the breaker operates frequently or is installed in a dusty or corrosive atmosphere more frequent lubrication is recommended.

To lubricate the mechanism proceed as follows:

1. Coat all pins, sliding surfaces, and tip of shock absorber with Molykote (00337271095).
2. Coat all needle and roller bearings with Beacon #325 (W962010).
3. Remove 1/4" pipe plug from the top plate of the mechanism cylinder housing and add 1 oz. of SAE 20 non-detergent engine oil. Replace the 1/4" pipe plug.
4. The close pilot valve has been lubricated at the factory and must be relubricated with GE Versalube (G322L) W962028 when parts are replaced.
5. The poppets and piston in the close control valve main body will not normally require lubrication. If this valve is dismantled for maintenance, the poppet seats and piston ring should be lubricated with GE Versalube (G332L) W962028 before reassembly.

**NOTE:** Lubrication amount is not critical. Parts should be evenly coated. Excessive lubrication will not affect the operation of the breaker mechanism or linkage.

# ILLUSTRATIONS



'A' Cam Lever Pin
'B' Cross Head Pin
'C' Closing Link Pin
'D' Trip-Free Trigger Pin
'E' Trip-Free Lever Pin

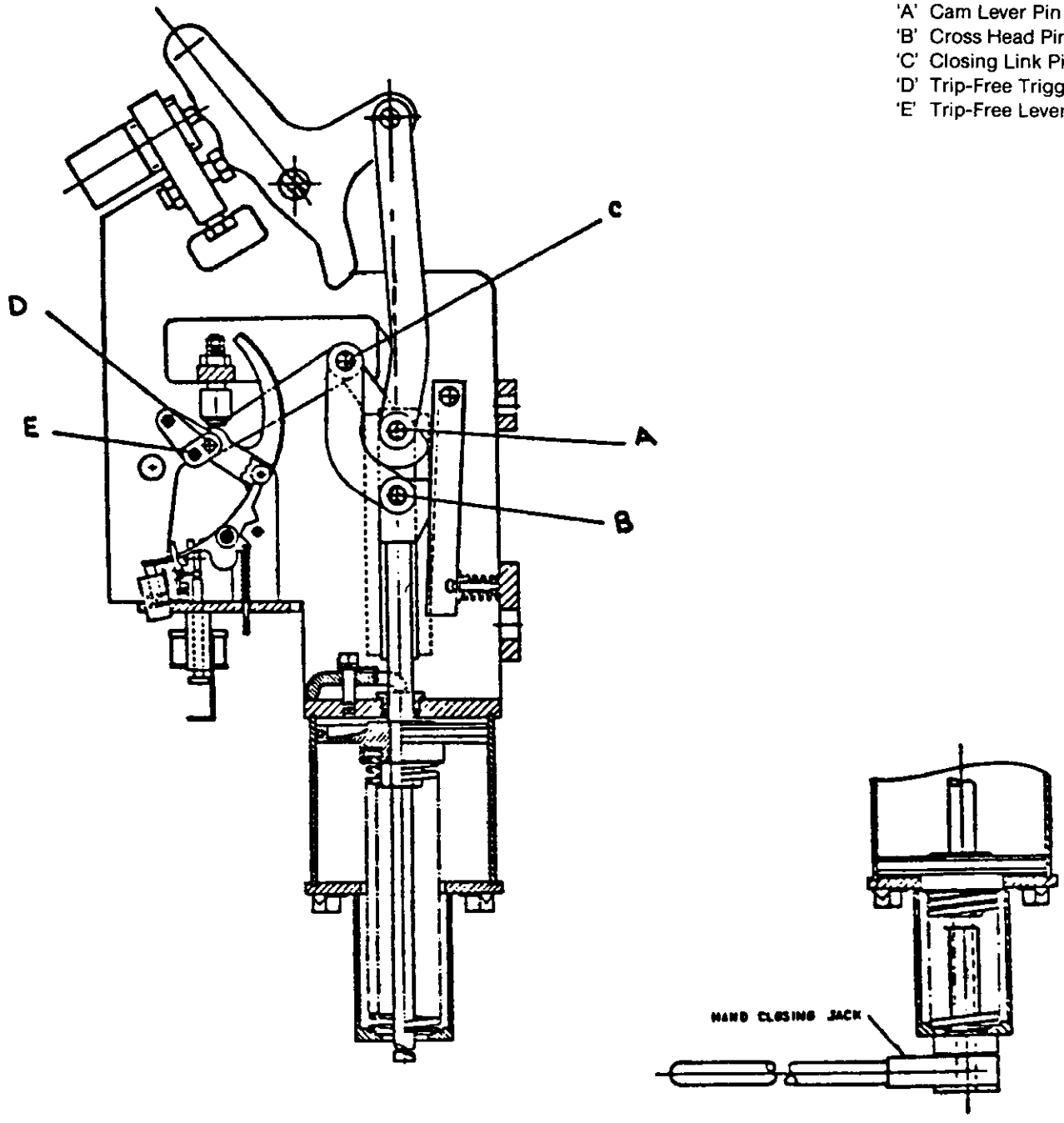



Figure 1 — Operating Mechanism In Open Position

# ILLUSTRATIONS



'A' Cam Lever Pin
'B' Cross Head Pin
'C' Closing Link Pin
'D' Trip-Free Trigger Pin
'E' Trip-Free Lever Pin

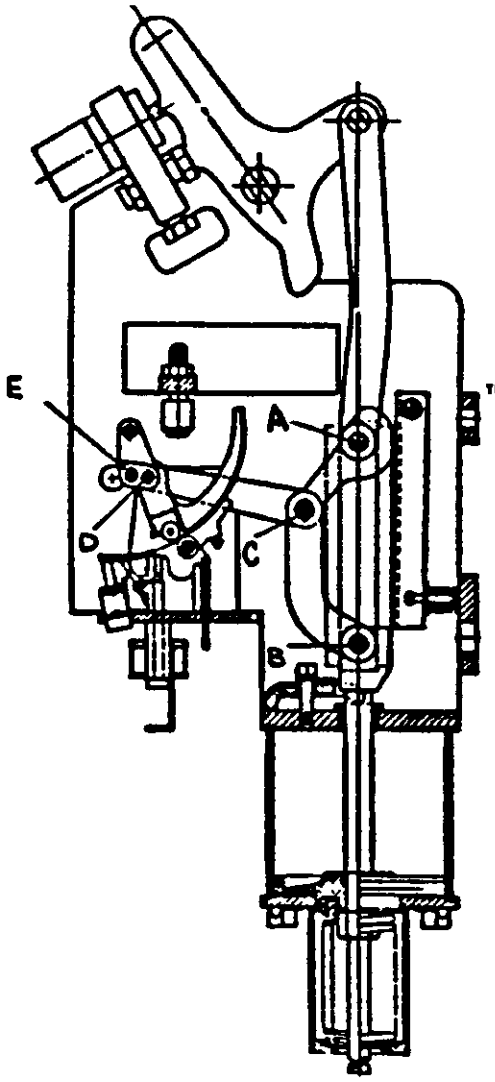



Figure 2 — Operating Mechanism In Closed Position

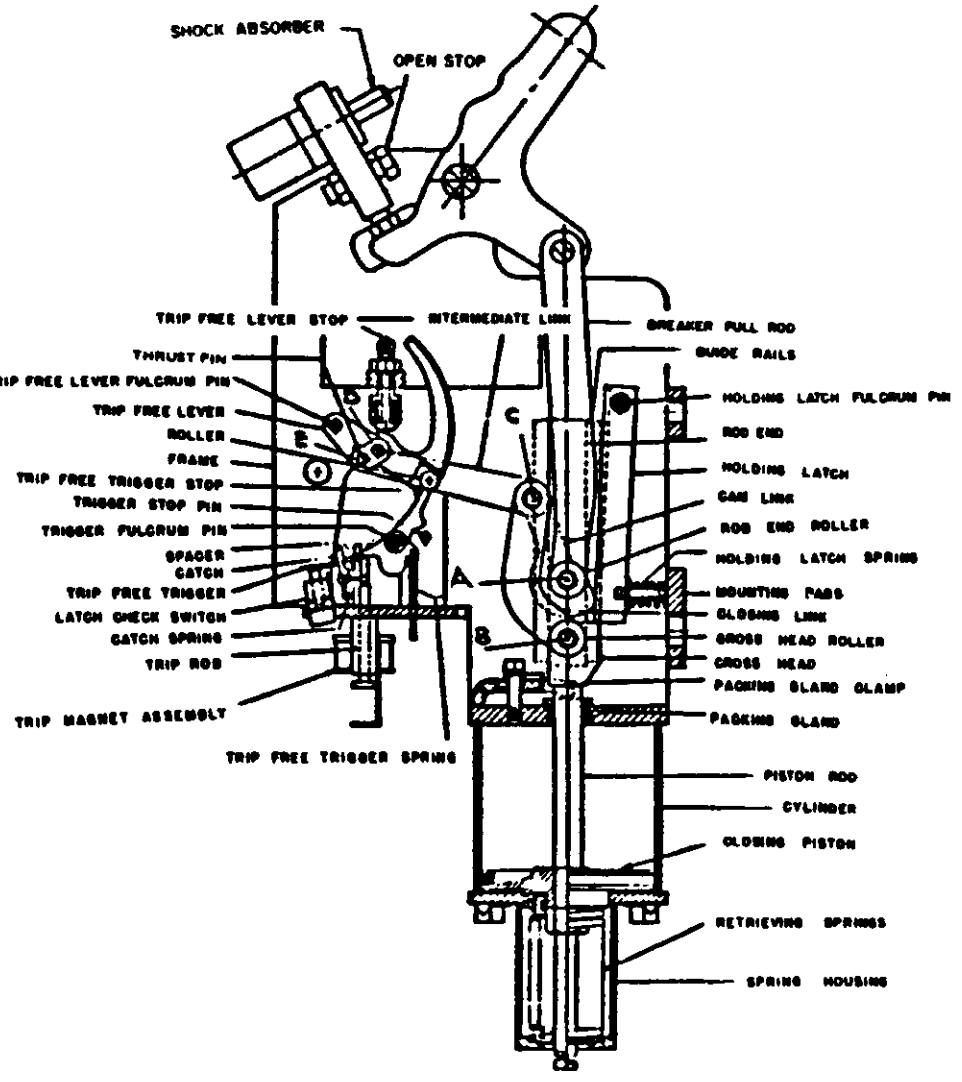



Figure 3 — Operating Mechanism In Trip-Free Position

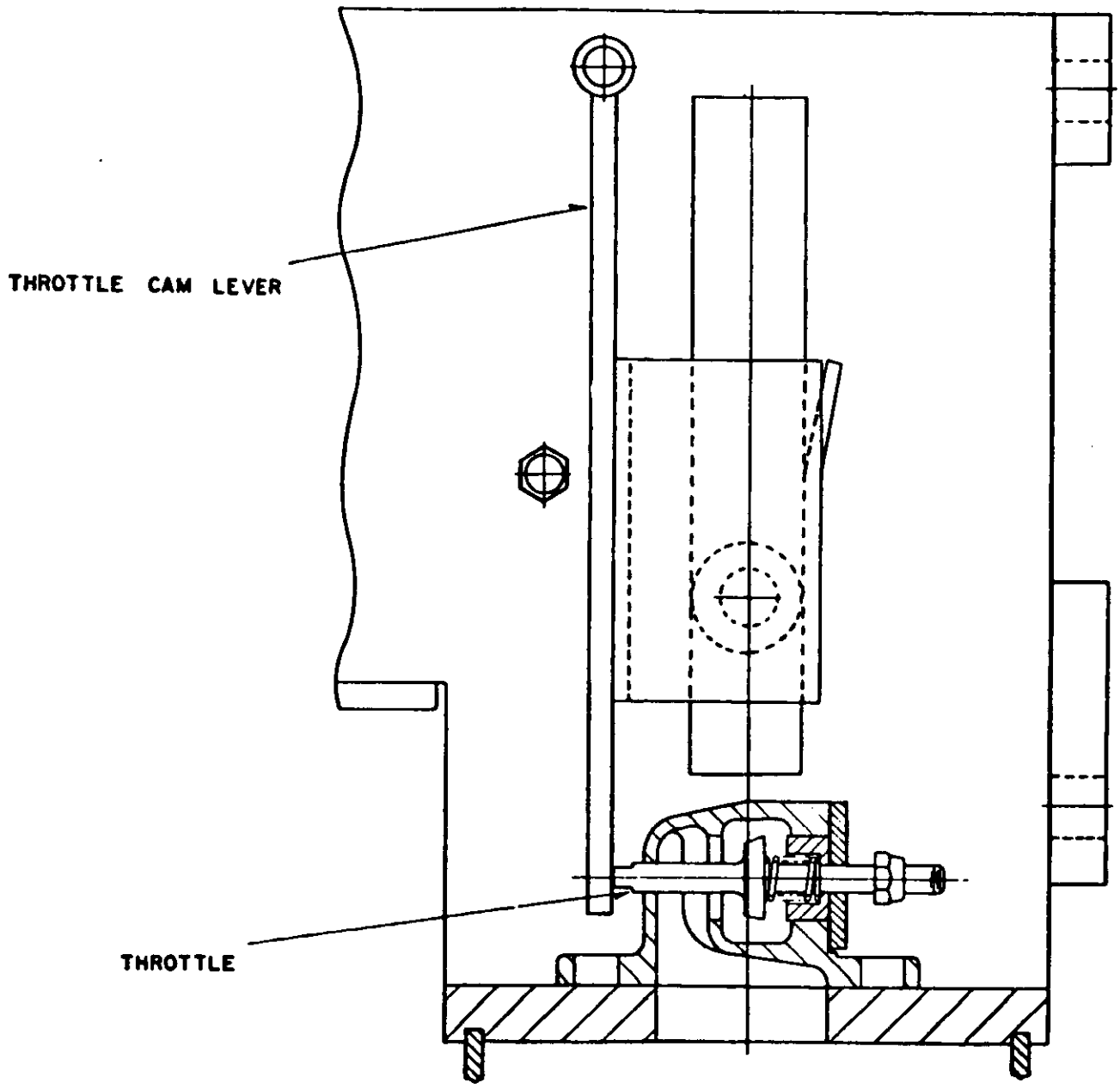
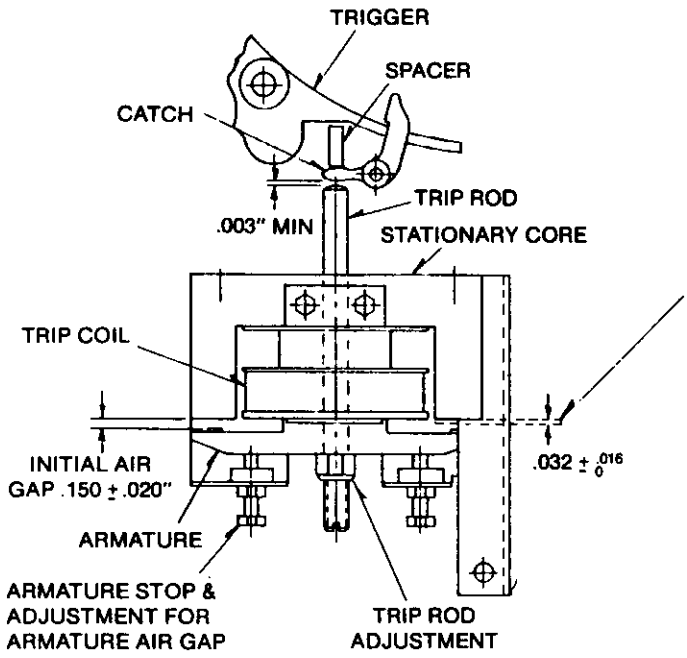



Figure 13 — Throttle Valve Lever (Mechanism Closed)

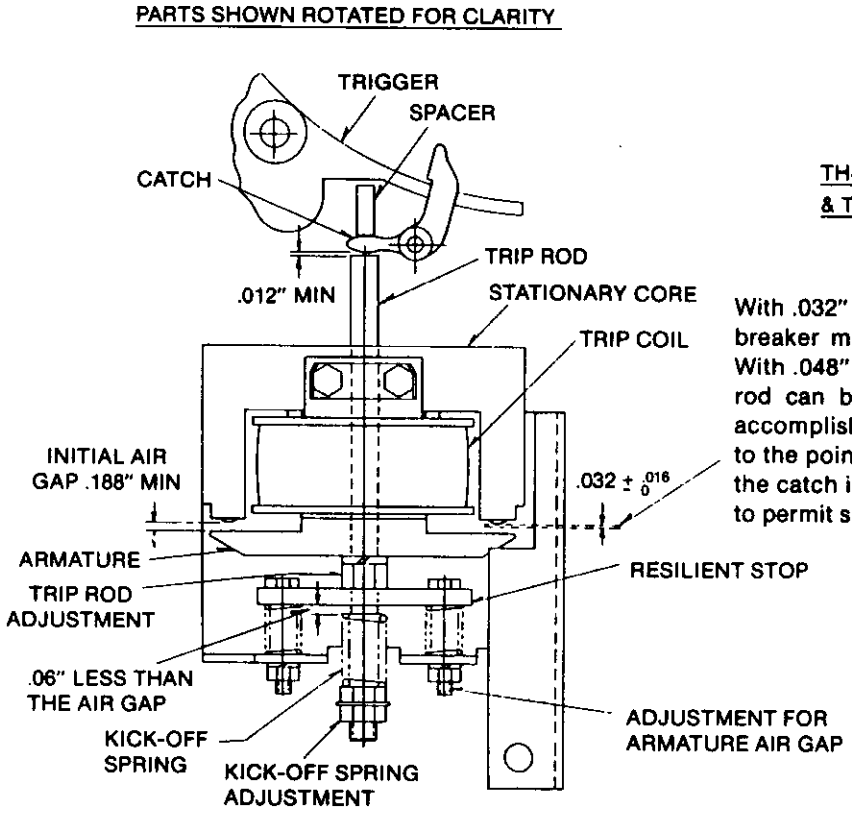
PARTS SHOWN ROTATED FOR CLARITY

THE ADJUSTMENTS APPLY TO BOTH SINGLE COIL & TWO COIL TRIP ASSEMBLIES




With .032" shims placed in the air gap (on both sides), the breaker must trip when the trip rod is raised manually. With .048" shims in both sides, it should not trip. The trip rod can be adjusted up or down (in ¼ turn steps) to accomplish this. If it is found the trip rod is being raised to the point that the gap between the top of the trip rod & the catch is less than .003", the air gap may be increased to permit slight additional travel.

Figure 14A — Std. Trip Magnet Adjustment




THE ADJUSTMENTS APPLY TO BOTH SINGLE COIL & TWO COIL TRIP ASSEMBLIES

With .032" shims placed in the air gap (on both sides), the breaker must trip when the trip rod is raised manually. With .048" shims in both sides, it should not trip. The trip rod can be adjusted up or down (in ¼ turn steps) to accomplish this. If it is found the trip rod is being raised to the point that the gap between the top of the trip rod & the catch is less than .012", the air gap may be increased to permit slight additional travel.

Figure 14B — Type "W" Trip Magnet Assembly

# ILLUSTRATIONS

Page 106

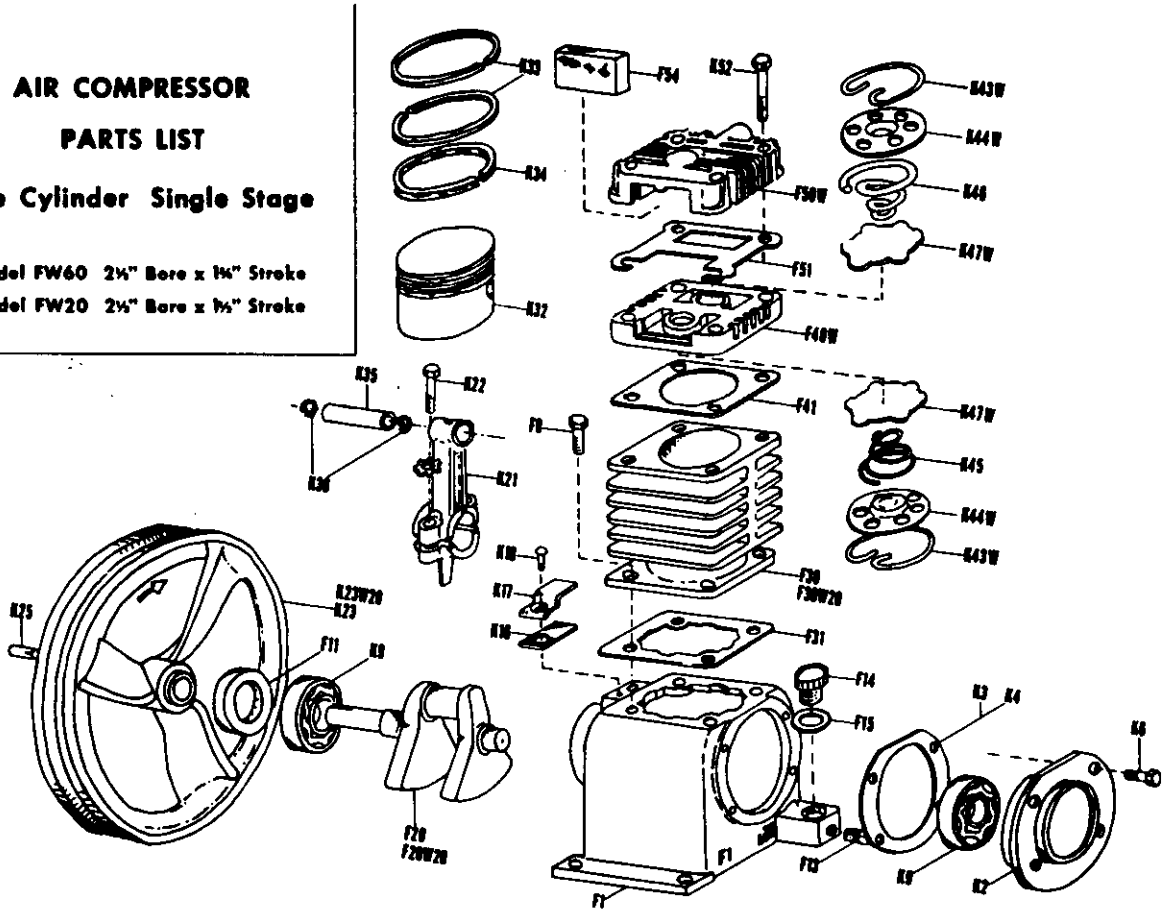
Figure 15 — "FW-60" Air Compressor Parts
"FW-60T" Air Compressor Parts

**AIR COMPRESSOR**

**PARTS LIST**

**One Cylinder Single Stage**

**Model FW60 2½" Bore x 1¾" Stroke**
**Model FW20 2½" Bore x 1½" Stroke**



## PARTS LIST MODEL F & FU

**NOTE:** The ( ) number indicates the total number of pieces required for a complete pump repair.

**IMPORTANT**

When ordering parts, please give compressor model, serial number and part number. Order assemblies when possible.

| PART NO. | DESCRIPTION |
|---|---|
| F1 | Crankcase |
| K2 | Bearing Plate |
| L3 | Bearing Plate Gasket .031 |
| L4 | Bearing Plate Gasket .015 |
| K6 | Bearing Plate Bolt [10 ft.-lb.] (4) ¼-20 x ⅝ |
| F8 | Crankcase Bolt [10 ft.-lb.] (4) ¼-20 x ⅝ |
| K9 | Main Bearing (2) |
| F11 | Oil Seal [before Feb. '76] |
| K11E | Oil Seal [after Feb. '76 - 1½ OD] |
| F13 | Oil Drain Plug ½NPT |
| F14 | Fill Cap [Includes F15] |
| F15 | Fill Cap Gasket |
| F16 | Breather Valve |
| F17 | Breather Valve Retainer |
| F18 | Breather Valve Stud |
| F20A | Crankshaft |
| F20 | Crankshaft Assembly [F20A and L21K] |
| L21K | Connecting Rod [Includes K22] |
| K21 | Connecting Rod [Includes K22] |
| L22 | Rod Bolt w/lock washer [10 ft.-lb.] (2) ¼-20 x 1¼ |

| PART NO. | DESCRIPTION |
|---|---|
| F30 | Cylinder |
| F31 | Cylinder Gasket |
| K32 | Piston |
| K33 | Compression Ring (2) |
| K34 | Oil Ring with Expander |
| K35 | Piston Pin |
| K36 | Pin Retainer (2) |
| F40 | Valve Plate |
| F41 | Valve Plate Gasket |
| K43 | Valve Retainer (2) |
| K44 | Valve Bumper (2) |
| K45 | Valve Spring Intake (1) |
| K46 | Valve Spring Discharge (1) |
| K47 | Valve Disc (2) |
| F50 | Head |
| F51 | Head Gasket |
| K52 | Head Bolt 5/16-18x2 [22 ft lb ] (4) |
| F54 | Filter Insert |
| F54P | Package of air filter inserts |
| BSF54 | Filter Muffler Assembly |

| PART NO. | DESCRIPTION |
|---|---|
| FU80 | Head-Unloader Type |
| KU81 | Unloader Piston |
| KU82 | "O" Ring |
| KU83 | Unloader Spring |
| KU84 | Unloader Washer |
| KU85 | Unlaoder Retainer |
| KU86 | ¼ x ⅛ Tube E1 |

## ASSEMBLIES

| | |
|---|---|
| F119 | Breather Valve Assembly |
| K145 | Suction Valve Assembly - Includes K47, K45, K44, K43 |
| K146 | Discharge Valve Assembly - Includes K47, K46, K44, K43 |
| K132 | Piston, Pins and Rings |
| F133 | Piston Ring Set includes 2 of K33 and 1 of K34 |
| F100 | Gasket Set L3, L4, F31, F41, F51 |
| F140 | Valve Plate with Valves installed including F41 and F51 Gaskets |
| FU180 | Head Assembly FU80 with |

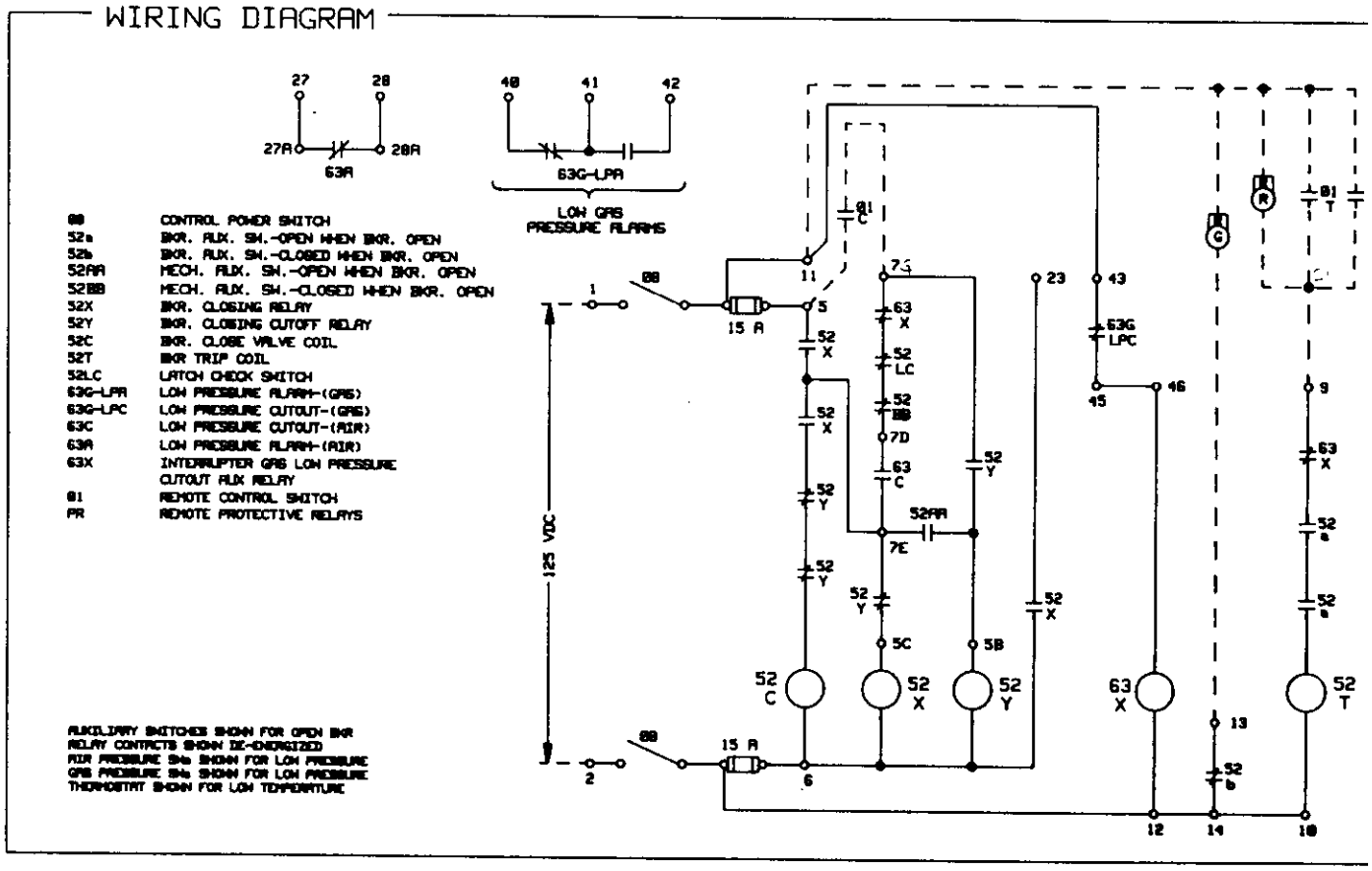
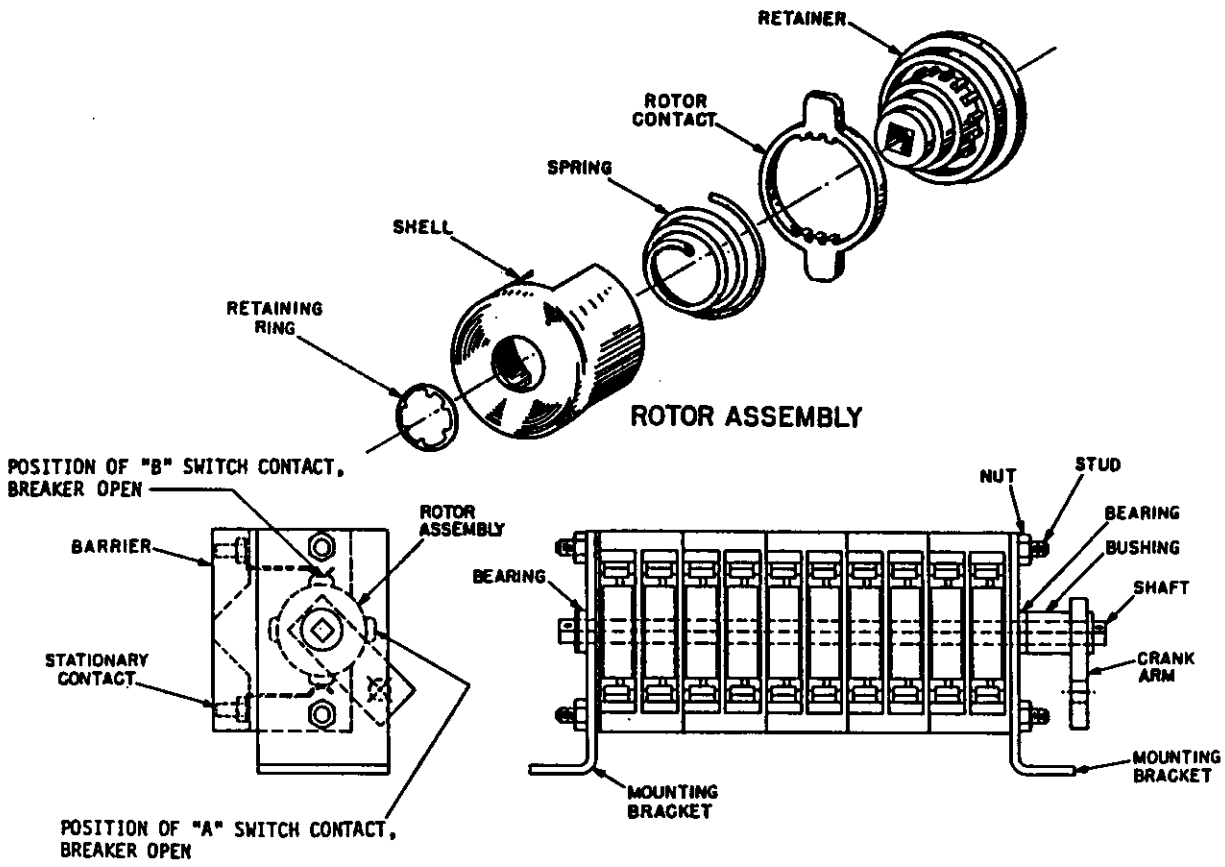



Figure 16 — Typical Schematic

**NOTE:**

Refer to mechanism nameplate of each individual breaker for the actual schematic drawing number.




**ADJUSTMENTS**

To adjust the making point of any stage:

(a) Using a pair of pliers, press the rotor contact to one side against the spring. This disengages the rotor contact from the teeth in the molded base of the retainer.

(b) Turn the rotor in either direction to the new position, releasing pressure against the spring until the rotor contact falls into place, reengaged by teeth in the newly desired position.

Contact surfaces are kept clean by complete wiping action of contacts during operation.

Figure 17 — Typical Auxiliary Switch

# APPENDIX II



## RELAYING TYPE CURRENT TRANSFORMERS FIELD TESTING

**WARNING**

Current transformer operation may be incorrect due to support plate contacting the circuit breaker bushing.

To avoid:

Maintain clearance between current transformer support plate and circuit breaker bushing.

During any inspection of a circuit breaker the clearance between the transformer mounting plate and the bushing should be checked. A minimum of .062 inch is acceptable.

## RATIO TEST

The voltage method and the current method are two common ways to measure transformer ratio. Since the voltage test requires simple apparatus to conduct, this method is discussed here.

Refer to Fig. 1. The burden or short circuit should be removed from all other transformers on the same pole.

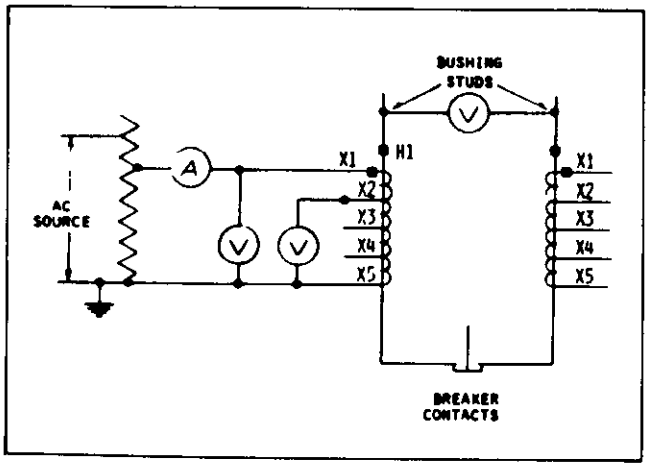



**Fig. 1 - Ratio Check Connections**

Some appropriate voltage below saturation, approximately 25% of the accuracy class, should be applied to the full winding of the secondary and the primary voltage read with a high impedance, 20,000 ohms/volt low range meter. The turns ratio is approximately equal to the voltage ratio. Refer to Table 1 for suggested impressed voltages.

After the overall ratio is measured, the tap ratios can be measured by comparing the tap voltage to the full winding voltage. Tap voltage can be determined by the ratio:

$$\frac{\text{Full Winding Volts}}{\text{Full Winding Turns}} = \frac{\text{Tap Voltage}}{\text{Tap Turns}}$$

A vacuum tube voltmeter is a good instrument for reading the primary. The turns ratio and accuracy class may be found on the transformer nameplate located on the mechanism housing door.

With the voltage in Table 1 applied on the respective transformers, the ammeter will read a very low current. If by accident a saturating voltage is applied the current will rise rapidly. When this occurs the voltage should be run slowly and continuously to zero and then the correct voltage applied.

**Table 1**
**Voltage Applied on Secondary - Full Winding**

| C.T. Ratio | Accuracy Class | | | |
|---|---|---|---|---|
| | C100 | C200 | C400 | C800 |
| 600/5 | 24V (.2V)* | 48V (.4V) | 96V (.8V) | — |
| 1200/5 | — | 48V (.2V) | 72V (.3V) | 120V (.5V) |
| 2000/5 | — | — | 100V (.25V) | 200V (.5V) |
| 3000/5 | — | — | 60V (.1V) | 120V (.2V) |
| 4000/5 | — | — | 100V (.25V) | 200V (.25V) |
| 5000/5 | — | — | 100V (.1V) | 200V (.2V) |

*NOTE: Figures in ( ) = Primary Volts

After the test the voltage should be run slowly and continuously to zero to prevent residual remaining in the core of the transformer.

# APPENDIX II



**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

## POLARITY TEST WITH OSCILLOSCOPE

A test set-up wired as per Fig. 2 may be used for polarity check. The voltage applied should be lower than the saturation voltage so the values established by Table 1 for the ratio test are safe to use. Again any other transformers on the same pole should be open circuited.

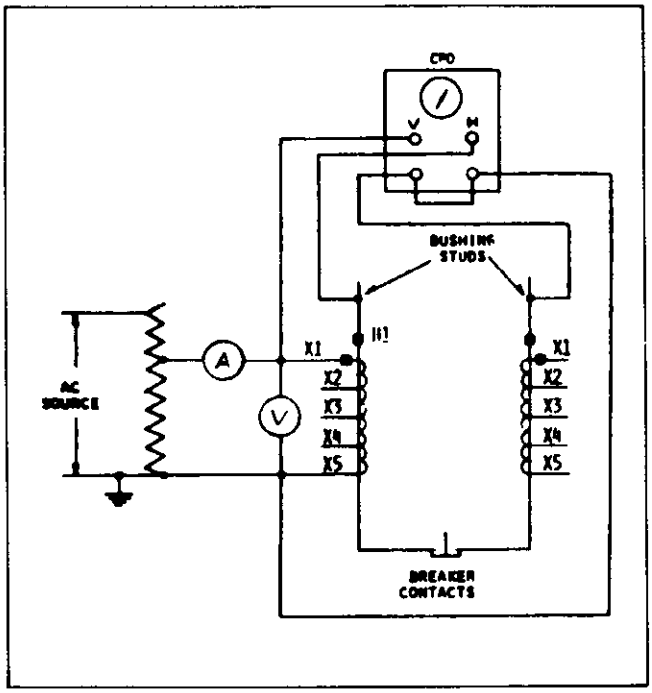



**Fig. 2 - Polarity Check Connections**

Fig. 2 shows a single channel cathode ray oscilloscope with the secondary voltage applied to the vertical input terminals and the primary voltage applied to the horizontal input terminals with the polarity as shown. If the slope of the line on the oscilloscope is positive as shown, then the polarity agrees with the terminal marking.

If the ratios of the transformer taps have been checked, and are correct, then the polarity of the individual taps will be correct. So it is only necessary to check the polarity of the total winding.

If a dual channel oscilloscope is used the primary and secondary voltages should be connected on separate channels. The polarity is correct if the resulting wave forms are in agreement which they should be since the same voltage is applied to both channels.

With the voltages in Table 1 applied on the respective transformers the ammeter will read a very low current. If by accident a saturating voltage is applied the current will rise rapidly. When this occurs the voltage should be run slowly and continuously to zero and then the correct voltage applied.

After the test the voltage should be run slowly and continuously down to zero to prevent residual remaining in the core of the transformer.

# APPENDIX II



If the polarity is proven to be incorrect then the transformer is mounted upside-down on the bushing.

**DANGER**

Hazardous voltage.
Will cause personal injury or death, or damage to circuit breaker.

To prevent:

Current transformers must not be operated with an open circuit and must be either connected to a burden or short circuited and grounded at the terminal blocks.

If a short circuit is to be made, the connection should be across the taps of the highest ratio, otherwise, dangerous voltages may occur across the open transformer secondary terminals.

## INSULATION RESISTANCE

Insulation resistance between the current transformer secondary and ground may be measured with a 500 or 1000 volt megger or other conventional insulation test instrument.

The neutral ground must be disconnected from ground. All burdens should be removed. A wire jumper should be connected from X1 to X5 on each transformer. The neutral ground wire can then be used to test all the transformers simultaneously.

One megohm is usually considered the minimum insulation resistance acceptable. Any low reading should be thoroughly investigated and corrective action taken.

# APPENDIX II

# APPENDIX III-A



## ASSEMBLY OF KNOCK-DOWN "SP" BREAKER WITH INTERNAL ACCELERATING TRIP SPRING

The following are detailed instructions for completing a breaker assembly that has been shipped as sub-assemblies, (knocked-down). For complete information on breaker description, installation, adjustment and maintenance refer to I.B. PB-3468-04. When the "SP" breaker is shipped disassembled the shipping package consists of:

(1) A housing containing the mechanism, air system, electrical control system, and separately packaged details;

(2) Three-pole unit assemblies filled with 5 psig of $SF_6$ gas—complete with interrupter, bushings, current transformers, and pressure switches.

The mechanism and linkage system within the housing are shipped in the open position. A shipping block, located between the horizontal tie bar rod end and the left side of the housing, restrains an accelerating spring preload of approximately 1000 pounds. The pole units are also shipped in the open position.

The housing (without the pole units) as received may be assembled on the prepared mounting location following instructions in I.B. PB-3468-04. Assembly of the pole units onto the housing is as follows:

The breaker is shipped with the mechanism in the open position. This can be visually checked by observing that the horizontal tie bar end is braced against the shipping block. The pole units are also shipped in the open position. Both the mechanism and pole units will be field assembled in the open position.

**⚠ DANGER**

Hazardous shipping block.
Serious personal injury or death from entanglement in rapidly moving parts.

To prevent:

Do not remove the shipping block located between the horizontal tie bar rod end and the cabinet.

The shipping block is restraining a spring load of approximately 1000 pounds.

The shipping block will be removed after two of the pole units are installed.

1. From top of cabinet, remove hole plugs from current transformer conduit and pressure switch conduit holes for all three phases. (See Figure 1, page 118, in Appendix III.) Remove protective covering from pole unit mounting pad bolt holes.

2. Remove hand jack access cover at the bottom of the mechanism cabinet.

3. Install hand jack on mechanism until hand tight - **DO NOT** jack mechanism at this time.

4. Remove horizontal linkage shipping support assembly and linkage hardware **ONLY** from Phase 2 pole unit position on housing. (See Figure 2A, page 119.)

   For Phase 2 pole unit position, unbend locking plate and remove .312"-18 bolt and locking plate. Remove three .375"-16 bolts, .375" steel lockwashers, and .375" extra wide steel washers Scrape sealant from around horizontal linkage shipping support. Pry or lift shipping support from housing. Remove the spacer from between the horizontal operating links as the shipping support is being removed. Remove all hardware— all hardware will be reused for Phase 2 pole unit installation except the locking plate and gasket.

# APPENDIX III-A



**CAUTION**

Excessive force may damage the linkage system.

To prevent:

Do not apply excessive force to the linkage system while disconnected from support or pole unit.

5. The lever at the Phase 2 location is to be disconnected as follows: (See Figure 4, page 65 of Instruction Book -"Maintenance/Adjustment and Lubrication".)

   (a) Remove the pin which connects the Phase 2 horizontal pull rod to the Phase 2 operating lever. Remove only the cotter pin nearest the breaker doors. The aluminum rod can now rest on the auxiliary switches. Save all pins and washers for re-installation.

   (b) Remove the pin which connects the auxiliary switch pull rod to the Phase 2 operating lever. Remove only the cotter pin nearest the breaker doors. This auxiliary switch rod assembly can be rested on the auxiliary switch bracket. Save all pins and washers for re-installation.

   (c) Remove the remaining pin which connects thru the tie bar. Remove only the cotter pin nearest the breaker doors. When removing the pin do not drop or lose the spacers which are between the Phase 2 operating levers and the tie bar. These spacers must be re-installed in the same position when the pole unit is installed. Maintain orientation of operating levers so that levers can be re-installed in their original orientation.

6. Remove crating and lift Phase 2 pole unit by installing cloth slings around aluminum casting. Each pole unit is identified as Phase 1, 2 or 3. Figure 3, page 120, shows sling and chain locations for lifting pole unit with 2 and 4 current transformers. The chains to be used are referenced in this instruction book under PART 3 - INSTALLATION, Tools and Service Equipment, Item #3. Attach chains to slings, protect bushing with wood or heavy cardboard, straddle bushing with chains, and lift at a 40° angle. Straddling the bushing gives the pole unit lateral stability.

**WARNING**

Pressurized bushings may cause possible serious personal injury or death, or damage to the circuit breaker during handling.

To prevent:

Do not strike, shock or strain the bushings or in any way cause the bushings to rupture.

Do not move the breaker if the $SF_6$ pressure is above 10 psig.

**NOTICE**

THE POLE UNITS ARE MARKED $\phi 1$, $\phi 2$, and $\phi 3$. THESE MUST BE INSTALLED IN THE CORRECT POSITION AS SHOWN IN FIGURE III-1, PAGE 118.

7. Install two aligning studs (.375"-16 x 3" long) into Phase 2 pole unit shaft seal housing. See Figure 1, page 75 for location of holes in housing used for aligning during pole unit installation.

8. Remove pole unit operating shaft guard assembly by removing the .312"-18 bolt, lockwasher, flat washer, and pipe. (See Figure 4, page 121). These items are not required for pole unit installation. Be sure that the operating shaft extends approximately 1-7/16" beyond the shaft seal housing prior to pole unit installation. There is a mechanical stop inside of the pole unit which prevents the operating shaft from being pulled out beyond 1-7/16".

9. Lift Phase 2 pole unit at 40° angle, into position above cabinet. Apply sealant (supplied with breaker) liberally to both sides of new gasket (7249A43H02). Install gasket onto pole unit by aligning holes in gasket with aligning studs. Feed current transformer and pressure switch wires and conduits thru holes provided. The sealing washer is to be mounted on outside of housing. Do not secure conduit pipe with nut at this time. See Figure 2D, page 119 for typical section of conduit pipe.

10. Lower Phase 2 pole unit toward cabinet top using the aligning studs. Suspend pole unit about one inch (1") above installed position.

**⚠ WARNING**

Failure to assemble mechanism and all pole units in the open position may result in personal injury and/or breaker damage.

To prevent:

Pole unit and breaker mechanism must be in the open position before linkage is assembled.

To open pole unit completely rotate the interrupter operating shaft counterclockwise when facing shaft.

Visually check the opening spring to ensure that the mechanism is open by observing that the horizontal tie bar end is braced against the shipping block.

11. With Phase 2 pole unit one inch (1") above installed position, assemble rear lever to the square operating shaft of Phase 2 pole unit.

12. Lower Phase 2 pole unit onto housing. Fasten pole unit mounting foot to housing with two .500"-13 bolts and .500" lockwashers. (See Figure 2C and Figure III-3 for mounting location.) Remove aligning studs and secure with three .375"-16 x .312-18 studs, flat washers, and lockwashers. (See Figure 2B and Figure 2C, page 119, for details and torque values.)

13. Reassemble the remaining Phase 2 linkage system using the lever, pins, spacers, washers, and hardware removed in Steps 7a, 7b, and 7c. to align pole unit operating shaft with linkage holes, rotate pole unit operating shaft slightly.

    Use a new locking plate (512A405H06) under head of .312"-18 x .88" bolt. Torque .312"-18 x .88" bolt to 18 ft.-lbs. and bend locking plate back. (See Figure 2B, page 199 for details.)

    Use cotter pins W336104 when assembling the linkage system.

**NOTICE**

BY DESIGN THE TOLERANCES ARE CLOSE IN THE LEVER SYSTEM. CARE AND PATIENCE MUST BE EXERCISED DURING ASSEMBLY SO AS NOT TO DAMAGE THE LEVER SYSTEM.

14. Secure Phase 2 current transformer conduit piping to housing with nut. (See Figure 2D, page 119.) Route current transformer wires to terminal blocks and connect as marked on wires.

15. Remove horizontal linkage shipping support assembly and linkage hardware from Phase 3 pole unit position on housing. (See Figure 2A, page 119.)

    For Phase 3 pole unit position, unbend locking plate and remove .312"-18 bolt and locking plate. Remove three .312 nuts, .312 steel lockwashers, and .312 extra wide steel washers. Scrape sealant from around horizontal linkage shipping support. Pry or lift shipping support off housing. Remove the spacer from between the horizontal operating links as the shipping support is being removed. Retain all hardware — all hardware will be reused for Phase 3 pole unit installation except the locking plate and gasket.

16. Lift Phase 3 pole unit by installing cloth slings around aluminum casting. Figure III-3 shows a sling and chain location for lifting pole unit with 2 and 4 current transformers. The chains to be used are referenced in this instruction book under PART 3 - INSTALLATION, Tools and Service Equipment, Item #3. Attach chains to slings, protect bushing with wood or heavy cardboard, straddle bushing with chains, and lift at a 40° angle. Straddling the bushing gives the pole unit lateral stability.

**⚠ WARNING**

Pressurized bushings may cause possible serious personal injury or death, or damage to the circuit breaker during handling.

To prevent:

Do not strike, shock or strain the bushings or in any way cause the bushings to rupture.

Do not move the breaker if the $SF_6$ pressure is above 10 psig.

**NOTICE**

THE POLE UNITS ARE MARKED $\phi$1, $\phi$2, AND $\phi$03. THESE MUST BE INSTALLED IN THE CORRECT POSITION AS SHOWN IN FIGURE 1, PAGE 118.

17. Install two aligning studs (.375"-16 x 3" long) into Phase 3 pole unit shaft seal housing. See Figure 1, page 119 for location of holes in housing used for aligning during pole unit installation.

18. Remove Phase 3 pole unit operating shaft guard assembly by removing the .312-18 bolt, lockwasher, flat washer, and pipes. (See Figure 4, page 119.) These items are not required for pole unit installation. Be sure that the operating shaft extends approximately 1-7/16" beyond the shaft seal housing prior to pole unit which prevents the operating shaft from being pulled out beyond 1-7/16".

19. Lift Phase 3 pole unit, at 40° angle, into position above cabinet and apply sealant liberally to both sides of new gasket (7249A43H02). Install gasket on to pole unit by aligning holes in gasket with aligning studs. Feed current transformer and pressure switch wires and conduits thru provided holes. The sealing washer is to be mounted on outside of housing. Do not secure conduit pipe with nut at this time. See Figure 2D, page 119 for typical section of conduit pipe.

20. Lower Phase 3 pole unit toward cabinet top using the aligning studs. Suspend pole unit about one-inch (1") above installed position.

**⚠ WARNING**

Failure to assemble mechanism and all pole units in the open position may result in personal injury and/or breaker damage.

To prevent:

Pole unit and breaker mechanism must be in the open position before linkage is assembled.

To open pole unit completely rotate the interrupter operating shaft counterclockwise when facing shaft.

Visually check the opening spring to ensure that the mechanism is open by observing that the horizontal tie bar end is braced against the shipping block.

21. Lower Phase 3 pole unit onto cabinet while aligning and installing back lever, spacer, and front lever. To align pole unit operating shaft with linkage holes, rotate pole unit operating shaft slightly.

22. Fasten Phase 3 pole unit mounting foot to housing with two .500"-13 bolts and .500" lockwashers. (See Figure 2C, page 118 and Figure 3, page 75 for mounting location.) Remove aligning studs and secure with three .375"-16 x .312-18 studs, flat washers, and lockwashers. (See Figure 2B and Figure III-2C, page 119 for details and torque values.)

    Use a new locking plate (512A405H06) under head of .312"-18 x .88" bolt. Torque .312"-18 x .88" bolt to 17 ft.-lbs. and bend locking plate back. (See Figure 2B, page 119 for details.)

23. Secure Phase 3 current transformer conduit pipes to housing with nut. (See Figure 2D, page 119.) Route current transformer wires to terminal blocks and connect as marked on wires.

24. Jack mechanism toward closed position until shipping blocks can be removed.

25. Jack breaker to fully open position. Remove and hand jack from mechanism. (See "Hand Closing Device".)

26. For Phase 1 pole unit installation repeat Steps 16 thru 23. Connect $SF_6$ gas manifold to all three phases and continue with breaker installation as outlined in Section 3 of this instruction book.

# APPENDIX III-B



## ASSEMBLY OF KNOCK-DOWN "SP" BREAKERS WITH BUSHINGS REMOVED

The breaker has been shipped with the bushings removed and coverplates bolted in their place. The pole units were shipped with 5 psig $SF_6$ gas to keep all the internal components dry. Work on one bushing at a time to minimize the pole unit from being exposed to moisture. Remove the 5 psig $SF_6$ by opening the fill valve before removing coverplates. When coverplate is removed, clean gasket surface and install new seal gasket. Grease gasket with Dow Corning No. 111 silicone grease. See Figure 5, page 122. For 46 kV and 69 kV ratings, attach voltage shields. Assemble bushing by plugging into interrupter contacts and fasten with clamp rings and new hardware.

**⚠ CAUTION**

Improper assembly procedure may cause bolts to sieze.

To prevent:

Before assembling hardware apply Molykote GN to threads of bolts.

Clamp rings should be oriented per Views A and B of Figure 5, page 122. Torque to 25 ft. lbs. and repeat procedure on next bushing.

Before filling with 80 psig of $SF_6$ gas, connect $SF_6$ gas manifold to all three phases. A vacuum of 2mm of mercury must be pulled and held for 30 minutes on the pole units. Part 3 of the instruction book should now be followed for continued installation, as outlined in "Installation Section", pages 9 thru 15.

# ILLUSTRATIONS



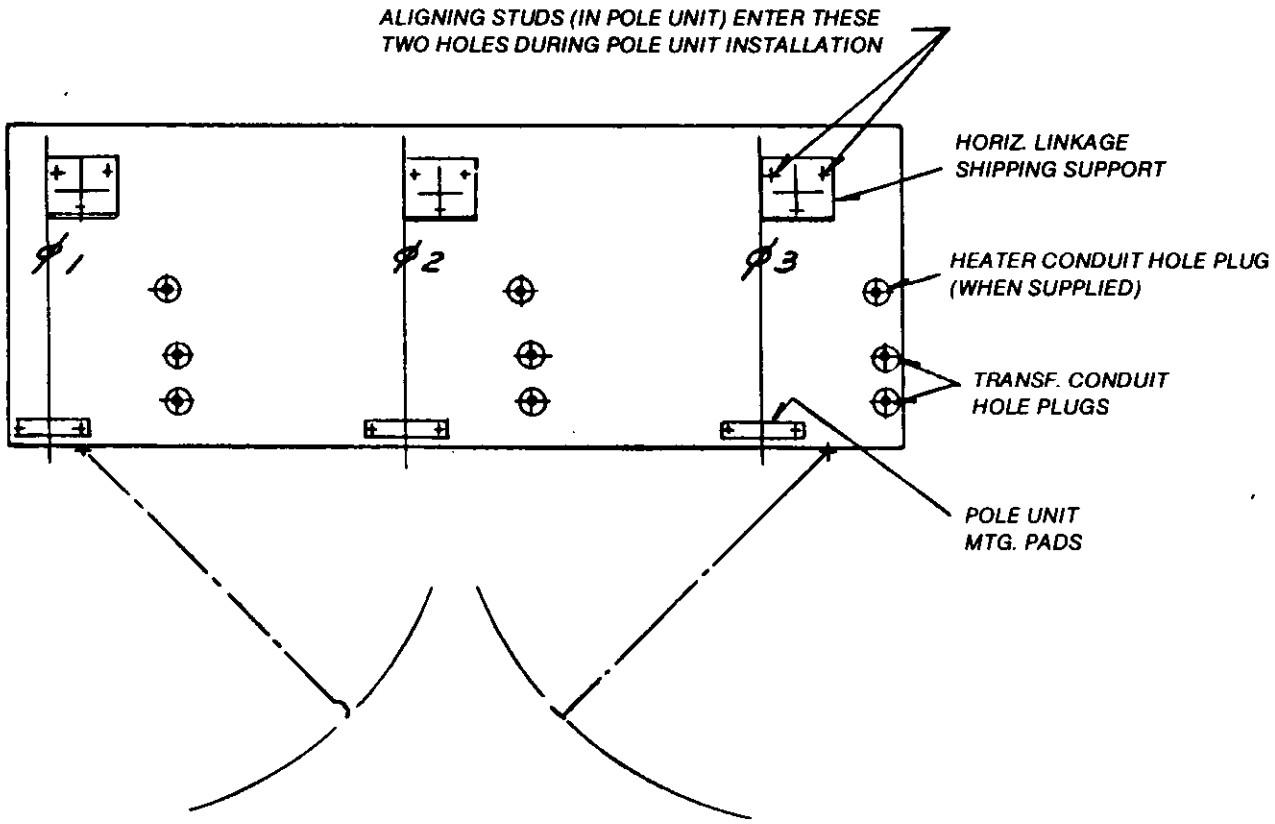
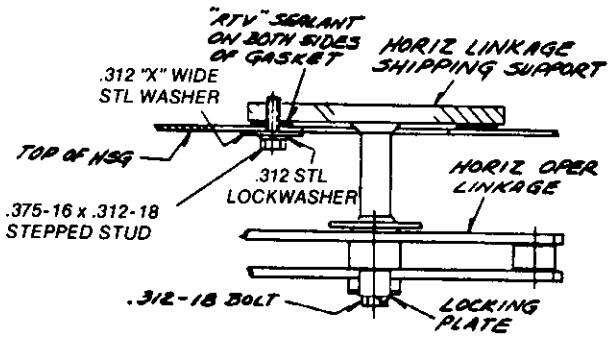
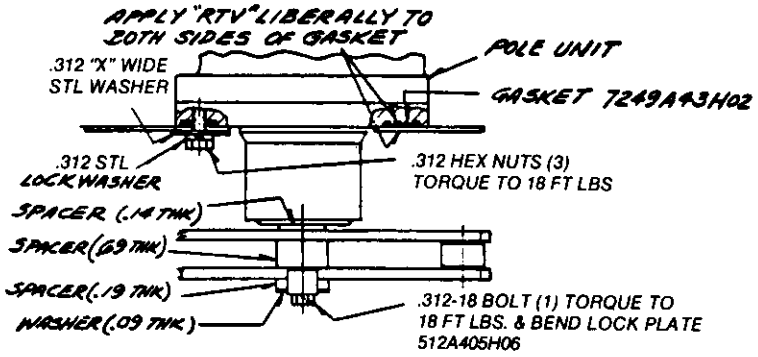


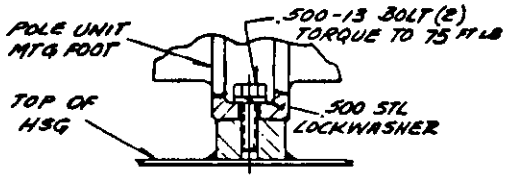

Figure 1 — Top View of Housing Without Pole Units.



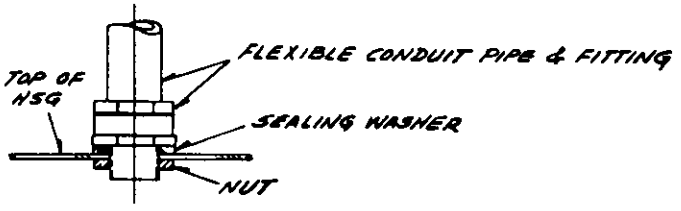

A. TYPICAL SECTION OF OPER SHAFT
(AS SHIPPED)
KNOCKED DOWN




B. TYPICAL SECTION OF OPER SHAFT
(POLE UNIT INSTALLED)




C. TYPICAL SECTION OF MTG
POLE UNIT TO HSG




D. TYPICAL SECTION OF
CONDUIT PIPE

Figure 2 — Breaker Knocked Down Details.

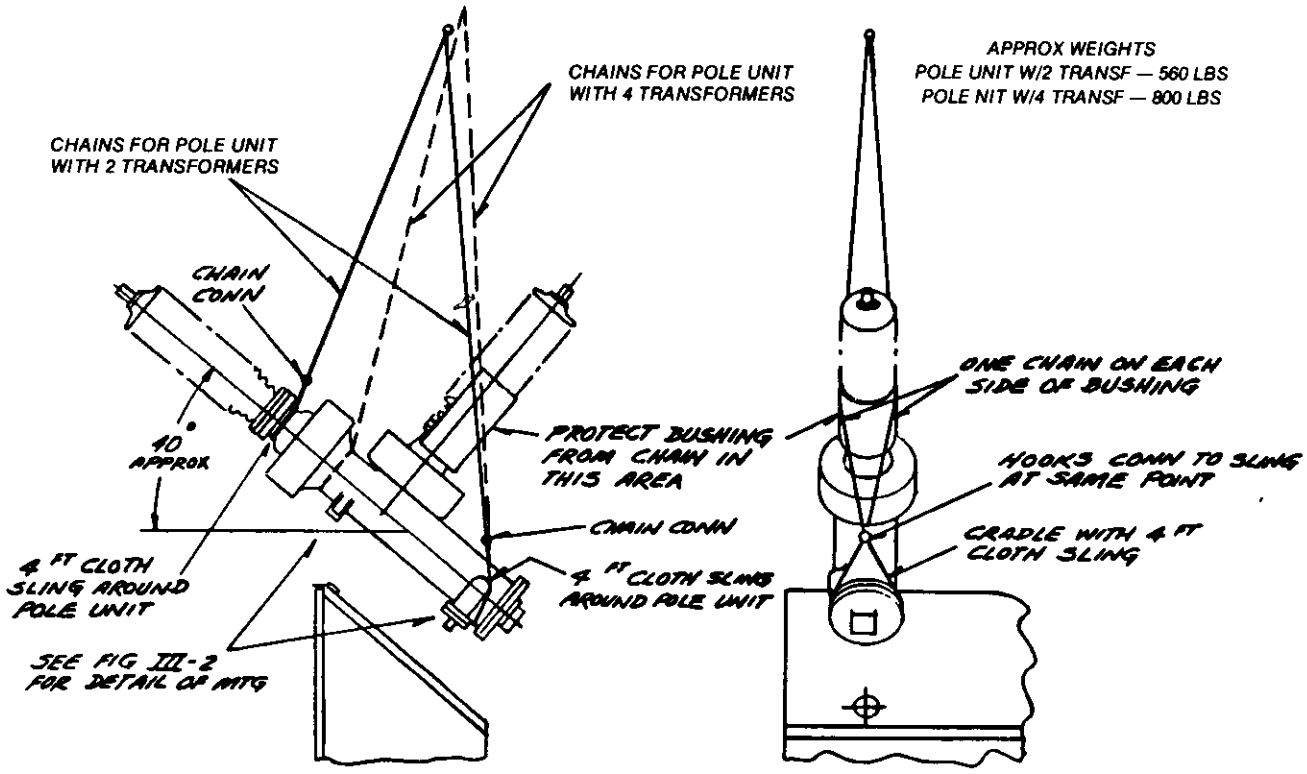



Figure 3 — Lifting of Pole Unit.

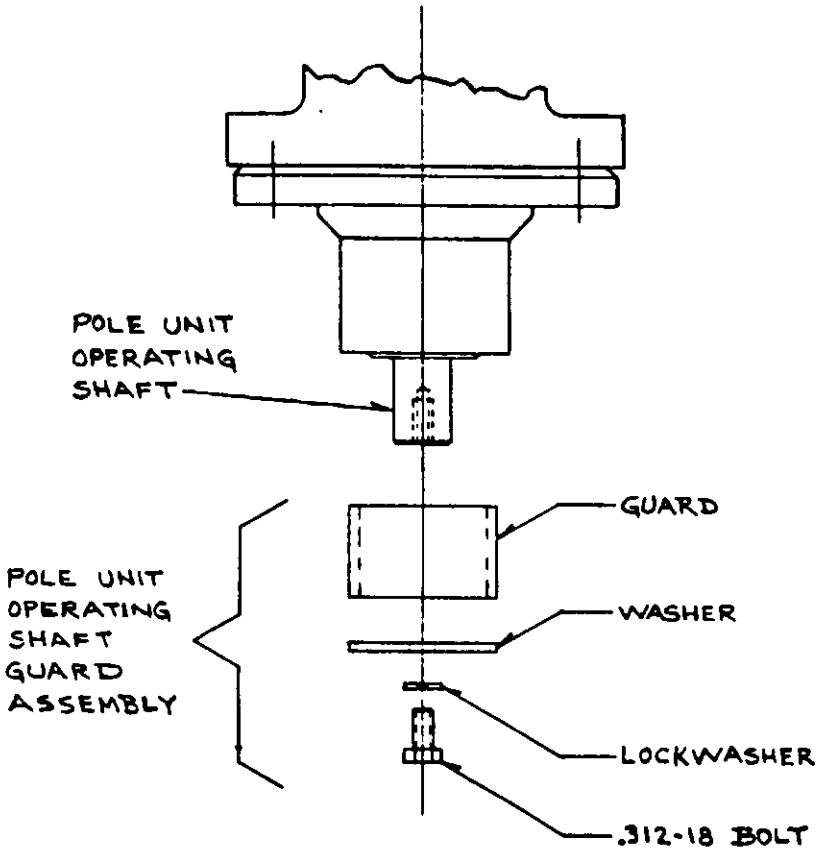



Figure 4 — Knocked Down Pole Unit Shipping Guard.

# ILLUSTRATIONS



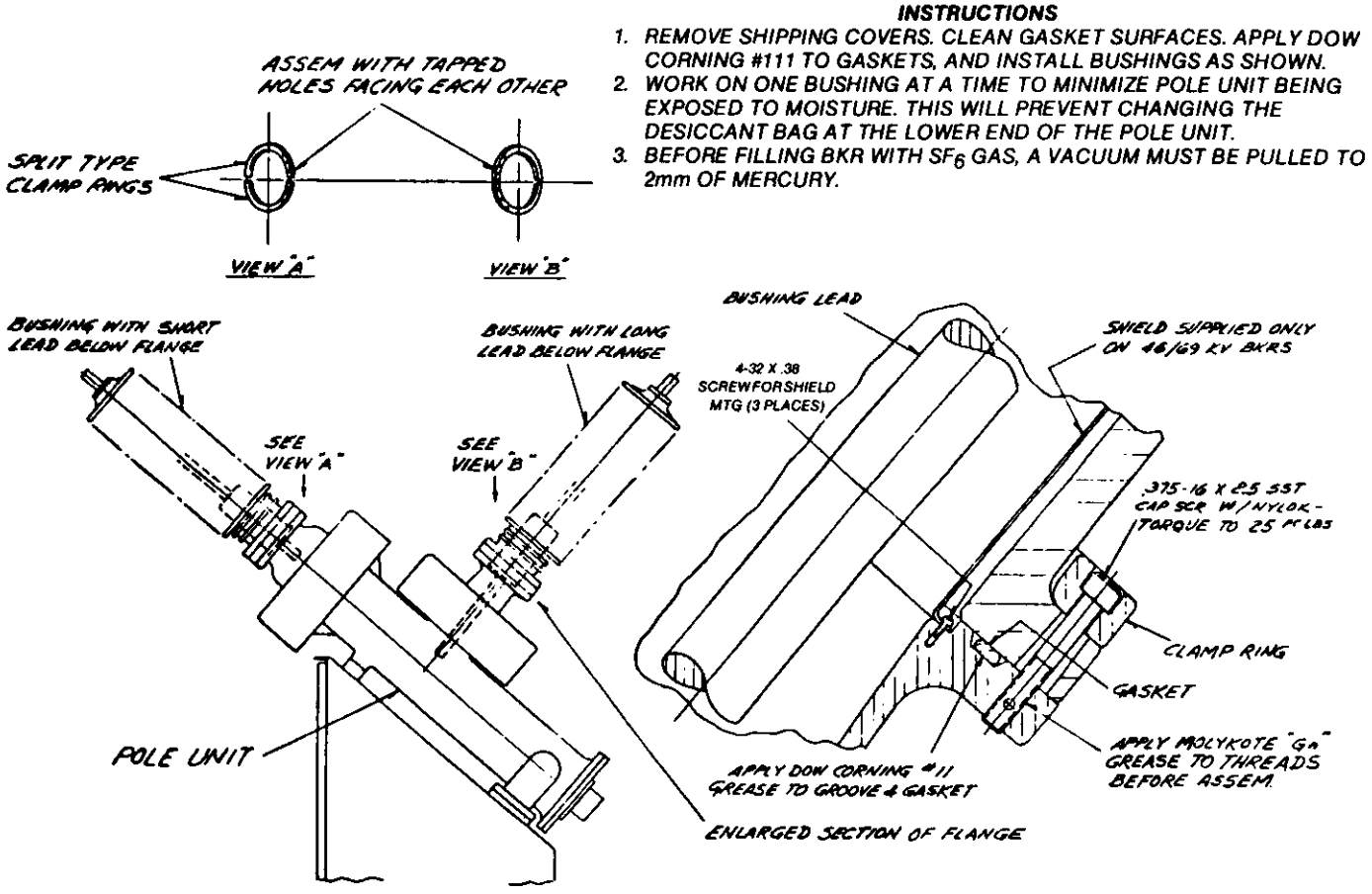



Figure 5 — Breaker Shipped Knocked Down — Bushings Removed Only.

# APPENDIX IV

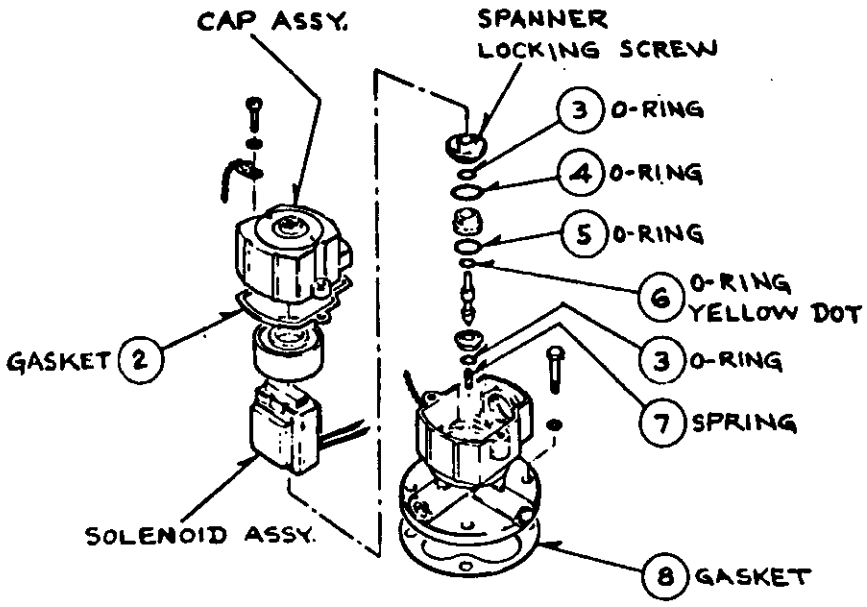


## PILOT AND CONTROL VALVE

Figure
1. Pilot Valve
2. Control Valve

# ILLUSTRATIONS

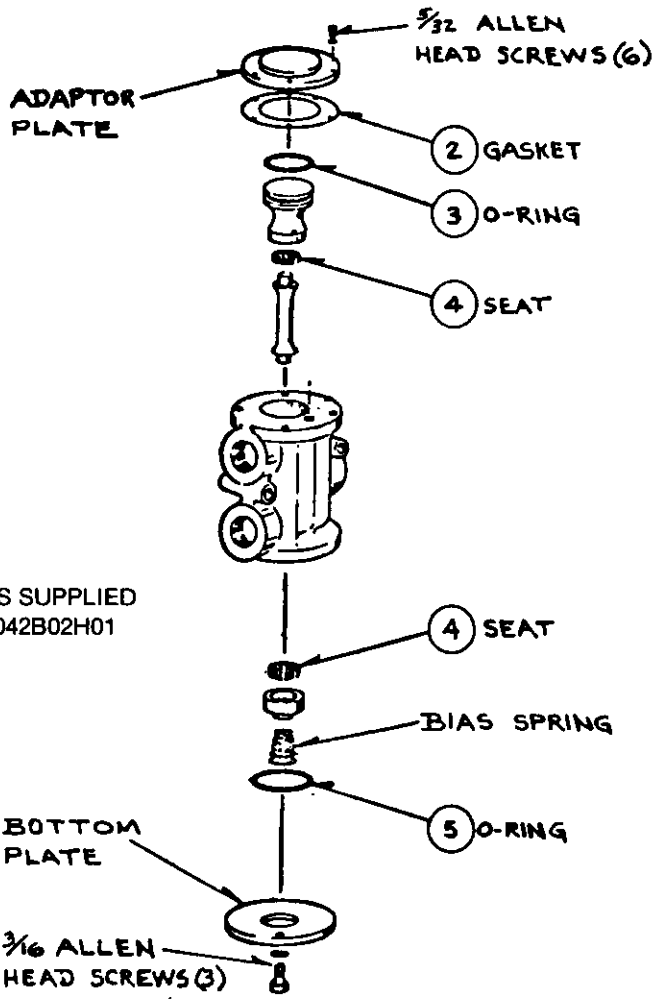





**NOTE:**
NUMBERED ITEMS SUPPLIED
IN SERVICE KIT 4042B01H01

A. REMOVE CAP ASSEMBLY AND SOLENOID BY REMOVING (2) PHILLIPS HEAD SCREWS
B. REMOVE SPANNER LOCKING SCREW USING NEEDLE NOSE PLIERS
C. REMOVE O-RINGS AND RETAIN FOR SIZING PURPOSES
D. REPLACE WITH O-RINGS FROM KIT USING OLD O-RINGS TO OBTAIN PROPER SIZE. ITEM 6 IS MARKED WITH A YELLOW DOT AND MUST BE IN THIS POSITION
E. COAT O-RINGS WITH LIGHT FILM OF LUBRICANT (GE VERSALUBE G322L) W962028
F. TIGHTEN SPANNER LOCKING SCREW UNTIL SNUG USING NEEDLE NOSE PLIERS
G. REPLACE SOLENOID AND CAP ASSEMBLY

Figure 1 — Exploded View of Closing Valve Pilot.




**NOTE:**
NUMBERED ITEMS SUPPLIED IN SERVICE KIT 4042B02H01

A. REMOVE ADAPTOR PLATE BY REMOVING SIX 5/32 ALLEN HEAD SCREWS
B. REMOVE BOTTOM PLATE BY REMOVING THREE 3/16 ALLEN HEAD SCREWS. THE BIAS SPRING PUSHES AGAINST THIS PLATE THEREFORE REMOVE THE SCREWS EVENLY
C. THE UPPER SEAT ASSEMBLY IS PUSHED OUT THROUGH THE TOP OF THE VALVE
D. THE LOWER SEAT ASSEMBLY MUST BE REMOVED THROUGH THE BOTTOM OF THE VALVE
E. COAT REPLACEMENT PARTS WITH GE VERSALUBE (G322L) W962028

Figure 2 — Exploded View of Closing Control Valve.

# APPENDIX V



## ASSEMBLY OF 3000 Amp BUSHING DETAILS

The 3000 amp design has external heat fins attached to the top of the bushing stud. These are shipped separately along with terminals and hardware. Before assembly, the lead should be cleaned with steel wool to remove all oxidation and surface contamination. Assemble the terminals to the lead first. Align outer terminals outward so as not to infringe on pole spacing when connecting your leads. Apply a thin coating of the heat transfer compound (supplied with the assembly) to the lead surface that will be adjacent to the fins. Attach the fins to the exposed lead with the clamps provided, see page 129. If capacitors are required for your rating, the upper strap must be assembled to the bushing before the terminal is assembled, see page 128.

# ILLUSTRATIONS

Page 128

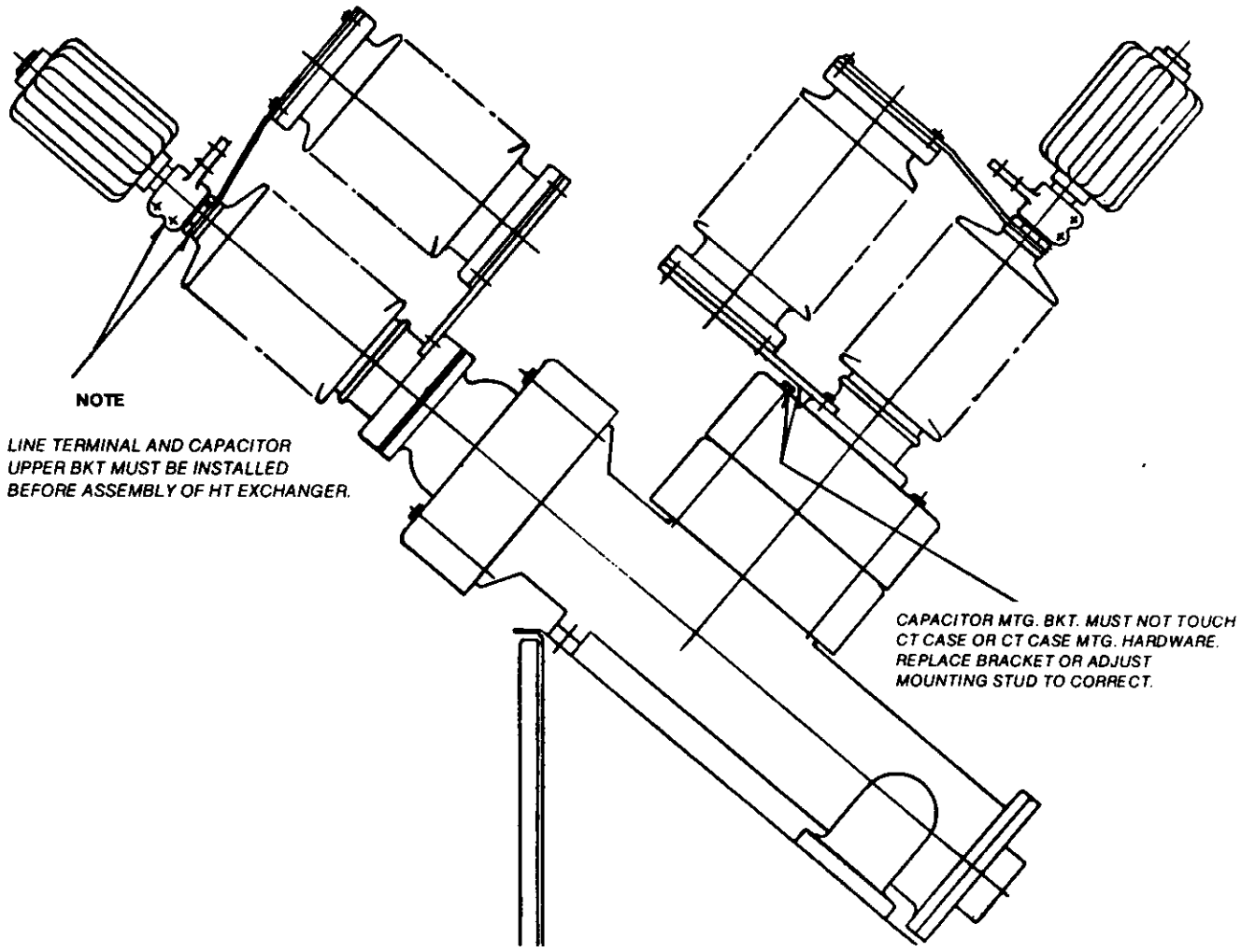



Figure 1 — With Capacitors.

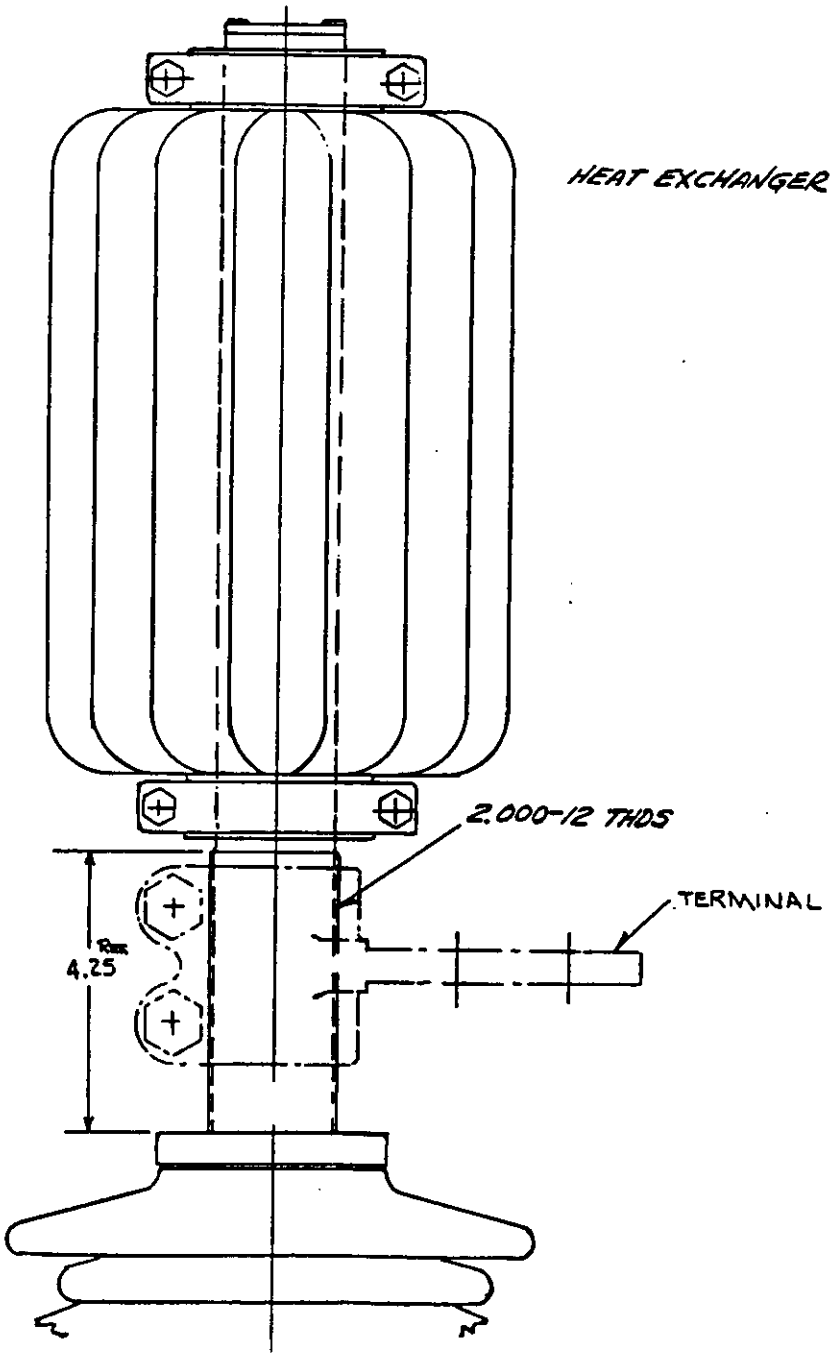


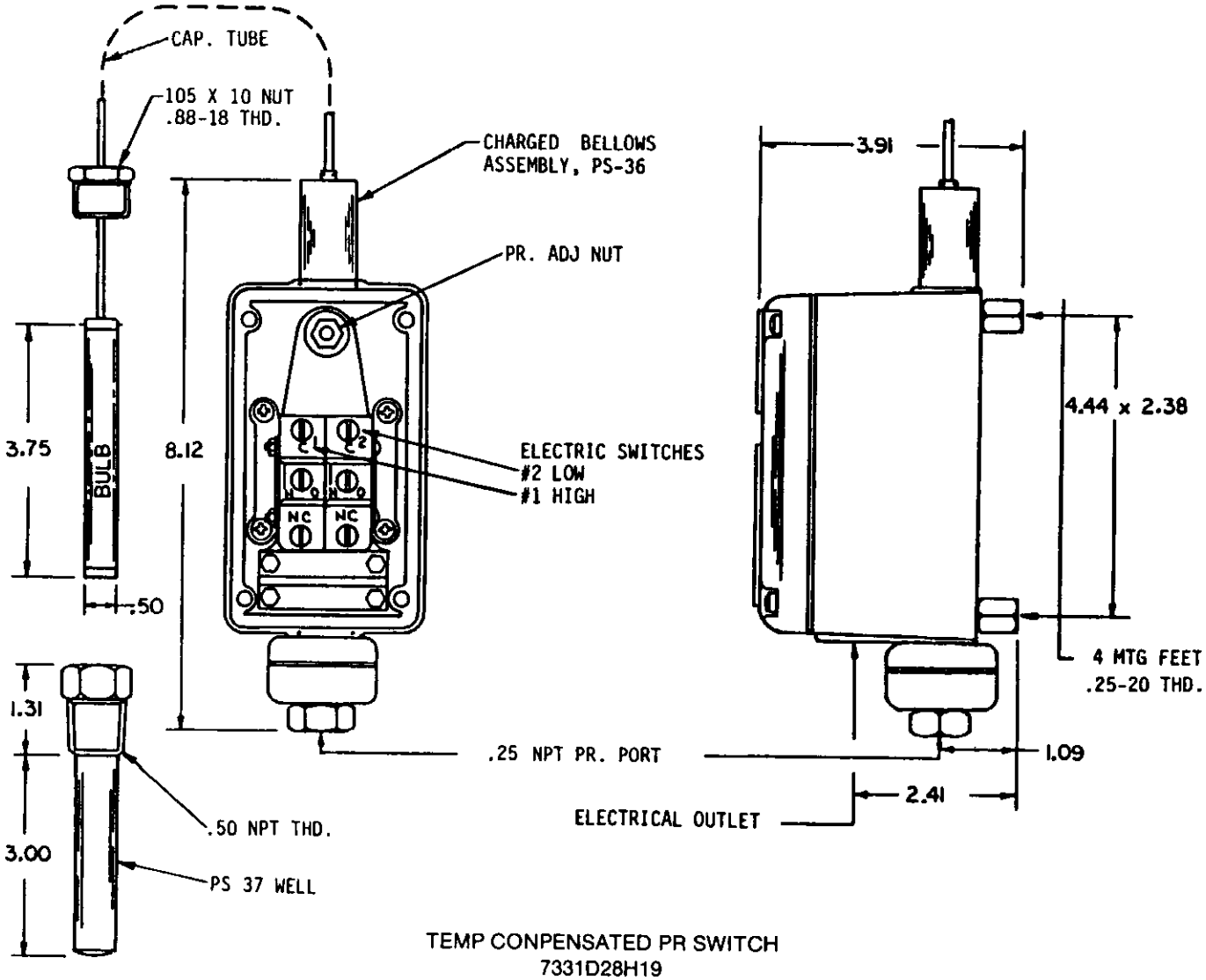

Figure 2 — Without Capacitors.

# APPENDIX VI

# APPENDIX VI



## $SF_6$ AND AIR PRESSURE SWITCHES




TEMP CONPENSATED PR SWITCH
7331D28H19

# APPENDIX VI



## SOLON PRESSURE SWITCHES
## TEMPERATURE COMPENSATED PRESSURES SWITCHES
## REMOTE BULB TEMPERATURE SENSING

Temperature Compensated Pressure Switches automatically adjust the operating points of the pressure switch to higher or lower pressures as the temperature surrounding a remote bulb varies over a given temperature range. These switches are used in, but not limited to, applications where it is desirable to maintain a gas at a constant density where the gas is contained within a constant volume.

Temperature Compensation is achieved by mounting a charged bellows assembly in the housing of the pressure switch. This charged bellows assembly with a remote bulb at the end of a capilary tube is linked to the pressure switch force balance mechanism by a spring, the rate of which determines the slope of the temperature — pressure curve. In addition, bi-metal springs are located in the switch housing to compensate for changes in ambient temperature surrounding where the bellows actuator of the charged assembly is located. Thus, only the temperature change surrounding the bulb creates pressure changes in the set points of the pressure switch.

Temperature Compensation can be applied to bellows actuated 5PS or 6PS Solon Pressure Switches. These switches are built to customer specifications particularly the slope of the pressure — temperature curve. However, the following general specifications apply:

1. All bellows pressure ranges are available from 0-15 PSI through 0-2000 PSI.
2. One to four electric switches are available.
   A. 5PS models can be supplied with one or two electric switches. Two electric switch models can be set to alarm at one pressure and trip at another pressure setting.
   B. 6PS models can be supplied with three or four electric switches. Each electric switch can be adjusted for separate or parallel pressure settings.
3. Ambient temperature compensation from -40° F to 150° F.
4. Pressure compensation from the remote bulb from -40° F to 140° F.
5. Capilary tube lengths of 8 ft., 16 ft., 24 ft.
6. Bulb ½" diameter by 3¾" long can be supplied with ½" N.P.T. male fitting or ½" N.P.T. male well.

**Johnson Controls, Inc.**
**Control Products Division**
1302 E. Monroe St.
Goshen, IN 46526

# Series P70, P72 Refirgeration Pressure Control Single Pole and Two Pole Construction

## Application

The P70 single pole and P72 two pole controls incorporate a load-carrying contact structure which provides direct control of A.C. motors within the control rating. (See cover label for the electrical rating.) The P72 heavy duty controls provide direct control of motors having integral line-interrupting overload protectors up to 3 H.P., 240 V. single phase. No starter is needed.

The controls with "all-range" construction can be used with R-12, R-22, R-500 and R-502 refrigerants.

WARNING: On ammonia installations the ammonia pressure control should be mounted separately from the electrical cabinet.

## Operation

The P70 and P72 controls are available with either CLOSE high-OPEN low or OPEN high-CLOSE low contact action. The snap-acting contacts operate from the pressure actuated bellows.

The controls have a single "sight-set" calibrated scale which shows both the cut-in and cutout settings. Adjustments can be made without removing the control cover.

## Installation

### Mounting

The control can be mounted in any position to a flat surface or panel board by inserting screws or bolts through the two holes in the back of the control's case. It is suggested however, that the pressure connection on the bellows be above the refrigerant liquid level of the equipment on which the control is used. This prevents possible accumulation of foreign matter inside the bellows by providing drainage from the sensing elements.

CAUTION: Do not mount the control in a position where dirt, sediment, or oil will affect the operation of the control.

Universal mounting bracket No. 271-51 is available, if required. (NOTE: Use only mounting screws supplied with the control to prevent damage to internal components.)

Do not install this control where the ambient temperature falls below -30° F (-34° C) or exceeds 140° F (60° C).

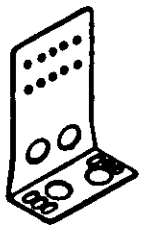


**Fig. 2 — Part No. 271-51 standard mounting bracket.**

## General Instructions

1. Avoid sharp bends or kinks in capillary tubing.
2. Be sure pressure controls installed on ammonia systems are built for ammonia service.
3. Purge all tubing and lines before connecting pressure controls.
4. Make sure control is not installed on equipment to handle a load in excess of electrical rating.

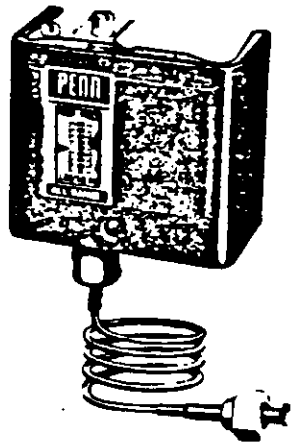


**Fig. 1 — Single function high pressure control.**

5. Coil and secure excess capillary length to avoid vibration. Allow some slack in capillary to avoid "violin string" vibration which can cause tubing to break. Do not allow tubing to rub against metal surfaces where friction can damage capillary.

## Wiring

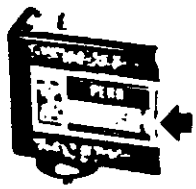
CAUTION: Disconnect power supply before wiring connections are made to avoid possible electric shock or damage to equipment.

All wiring should conform to the National Electrical Code and local regulations. Use copper conductors only. For maximum electrical rating of control, see cover label on inside of control cover.

CAUTION: Use terminal screws furnished in the contact block (8-32 x ¼"). Longer terminal screws can interfere with switch mechanism and damage the switch.

Manual reset lever (Fig. 3, left) on independent high or independent low pressure cutout controls. Lever must be pushed in and released to restart after lockout occurs.

Fig. 3



If lockout is supplied on safety cutout mechanism of "dual" controls (Fig. 4, left), lever provides for manual reset after operation of high pressure cutout.

Fig. 4

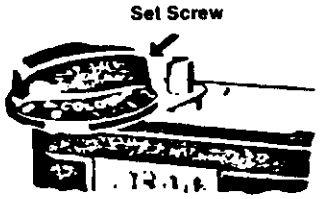



Fig. 5

Where it is desirable for the user to increase or decrease the DIFFERENTIAL ONLY, external adjusting knob is supplied on differential screw as shown in Fig. 5. Knob is provided with stops and factory assembled to permit change only within specified limits.

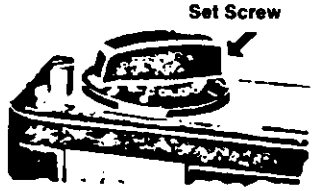



Fig. 6

External adjusting knob may be placed on range screw, as shown in Fig. 6, where it is necessary for the user to raise or lower both CUT-IN and CUTOUT points (differential remains constant). Knob is provided with stops and factory assembled to permit adjustments within specified limits.

NOTE: Knob is usually factory assembled in either position as shown in Figs. 5 or 6 above, depending upon specifications of original buyer. However, knob may be changed in the field from the differential to the range screw or vice versa by loosening set screw, removing knob and indicator plate and reversing their positions. Assuming that knob is factory assembled on range screw (Fig. 6) and set to limit adjustment to 20 psig (140 kPa), this adjustment will become approximately 10 psig (69 kPa) if knob is placed on differential screw (Fig. 5).

## Adjustments

High Pressure Cutout Models . . . contacts open high; close low.

On high pressure cutout models, the range adjusting screw "A" (see Fig. 7) raises or lowers both the cutout point and the cut-in point by the same amount. Set the cutout point first by using adjusting screw "A". The cut-in (differential) adjusting screw "B" changes the cut-in point only. If the control is equipped with lockout, the contacts must be reset manually after opening.

## Checkout Procedure

The operating point of the control should be confirmed by an accurate pressure gauge.

Before leaving the installation, at least three complete operating cycles should be observed to see that all components are functioning properly.

## Repairs and Replacement

Field repairs must not be made except for replacement of the cover or knob. For a replacement control, cover or knob, contact the nearest Johnson Controls wholesaler.

Contacts Close High; Open Low

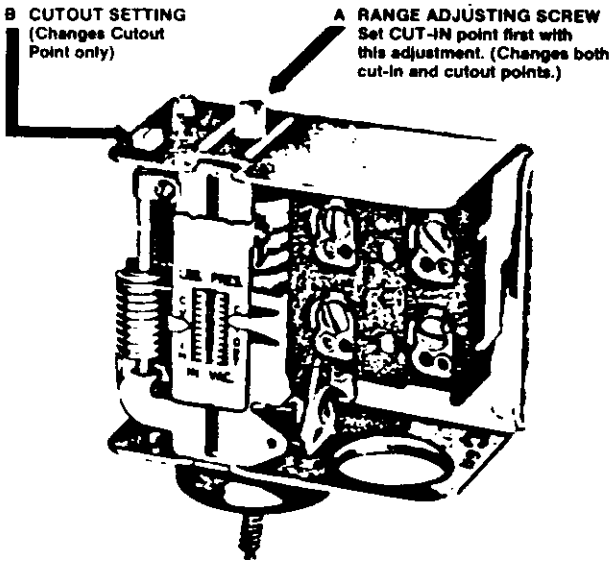



Fig. 7 — Interior view of a heavy duty single function low pressure control.

Two Pole Dual Function

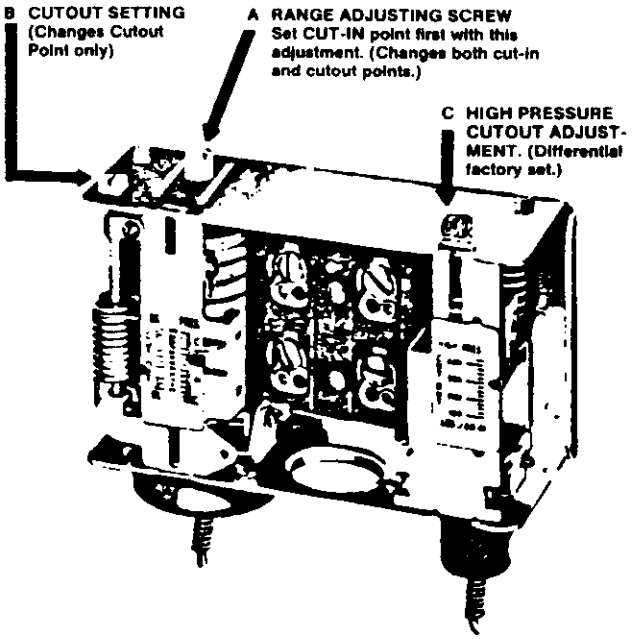



Fig. 8 — Interior view of a heavy duty

# PART REPLACEMENT



## ORDERING REPLACEMENT PARTS

When ordering replacement parts for a Siemens Circuit Breaker, it is very important to give complete information. This information should include:

1. Breaker serial number (on operator nameplates).
2. Type of operator (on operator nameplate).
3. Type of breaker.
4. Rated current of breakers.
5. Rated voltage of breaker.
6. Description of part - Use instruction book description insofar as possible.
7. Instruction book reference number.
8. Number of pieces required.

While the operator can be identified by the serial number alone, all additional information that is given will serve as a check to be certain that the part or parts furnished are correct for the operator in question. Without this serial number Siemens cannot be sure of the correct identity of the desired parts.

If any doubt exists as to the instruction book reference number or the description, a dimensional sketch of the desired part will help to properly identify it.

Siemens recommends that a supply of repair parts be kept on hand so that emergency repairs can be made without waiting for shipment of parts from the factory. A list of recommended spare parts is sent with the breaker.

Before removing any part to be replaced, observe its function and adjustment. This usually saves adjustment time during its installation.

**⚠ CAUTION**

Use of incorrect replacement parts may cause damage to the circuit breaker.

To prevent:

After replacing any part, all items outlined in the "Final Inspection, Corrections and Inspection Summary" section must be checked before operating the breaker.

# PART REPLACEMENT

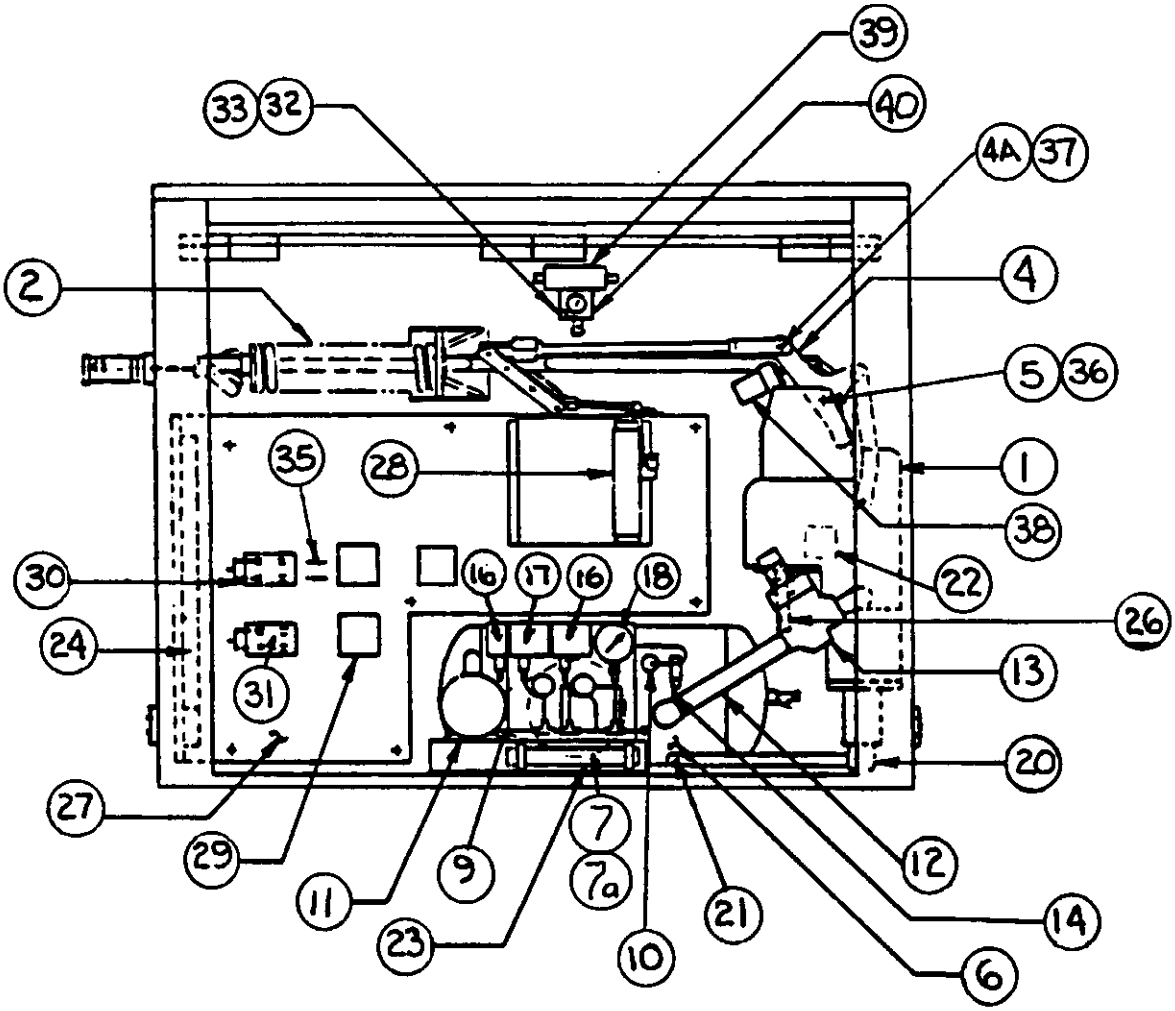



Figure 1 — Mechanism Housing Assembly

# PART REPLACEMENT

**Type SP Gas Circuit Breaker**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| ** | Mechanism house | 1D61297G06 (Siemens) | |
| 1 | Type SA-7 pneumatically operated mechanism | 72-480-154-015 (SGC) | |
| | mechanical parts | 72-480-154-015 | 1 |
| 2 | Accelerating spring | 7249A84H02 | 1 |
| 3† | Bell crank lever assembly | 1D61297G03 | 1 |
| 4 | Bell crank lever | 7360D74G04 | 1 |
| 4A | Sphere bearing | 7249A61H01 | 2 |
| 5 | Bearing — bell crank | 516B888H05 | 2 |
| 6 | Reservoir — high pressure — air | 2D38675H01 | 1 |
| 7 | Air compressor — Emglo FW60 | 266C488H01 | 1 |
| 7a | Air compressor — Emglo FW60T | W132021 | 1 |
| 8* | Pulley | 2284C01H01 | 1 |
| 9 | V belt | 2284C01H38 | 1 |
| 10 | Check valve | 513A271H01 | 1 |
| 11 | Motor 3/4 HP — air compressor | W641257 | 1 |
| 12 | Flexible hose | 2283C33H11 | 1 |
| 13 | Norgren control valve | 5594C58H04 | 1 |
| ** | Norgren valve service kit | 4042B02H01 | — |
| ** | Pilot valve section | 5494C58H03 | 1 |
| ** | Coil assembly | 4042B01H10 | 1 |
| ** | Norgren pilot valve service kit | 4042B01H01 | — |
| 14 | Safety valve | 72-180-626-101 | 1 |
| 15 | Pressure switch and gauge assembly | 2870067G05 | 1 |
| 16 | Pressure switch — low pressure alarm | 516B665H06 | 1 |
| 16 | Pressure switch — governor | 516B665H06 | 1 |
| 17 | Pressure switch — low pressure cutout | 516B665H07 | 1 |
| 18 | Pressure gauge | 1650B29H03 | 1 |
| 20 | Hand closing jack | 72-180-625-501 | 1 total |
| 21 | Closing jack handle | W109158 | 1 total |
| 22 | Mech. auxiliary switch | 72-380-155-501 | 1 |
| 23 | Housing and compressor heaters | 517B035H02 | 3 |
| 24 | Thermostat | 266C072H07 | 1 |

* Not illustrated.

† Not indicated on illustration.

For Figure 1, Page 1A

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**Type SP Gas Circuit Breaker**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| 26 | Trip coil | • | 1 |
| 27 | Control panel | | |
| 28 | Type auxiliary switch, 11 stage | 72-480-127-802 | 1 |
| 29 | Type ARD relay (52X, 63X) 4 pole 120 V DC | 1659B27H05 | 2 |
| * | Operating coil | 1253C48G01 | 2 |
| * | Contact cartridge | W500006 | 2 |
| 29 | Type ARD relay (52Y) 6 pole 120 V DC | 1659B27H12 | 1 |
| * | Operating coil | 1253C48G01 | 1 |
| 30 | Knife switch — 2 pole | 72-113-979-041 | 3 |
| 31 | Knife switch — 4 pole | 72-113-979-043 | 1 |
| 32 | Operation counter | 72-180-411-001 | 1 |
| 33 | Operation counter spring | 72-180-620-001 | 1 |
| 35 | Fuse 15 ampere | W652103 | 6 |
| 36* | Grease | W962010 | 1 |
| 37* | Grease linkage | 00337271095 | 1 |
| 38 | Shock absorber | 1654B08H02 | 1 |
| * | Toggle switch | 9042A73H01 | 1 |
| 39 | Temperature compensated pressure switch | 7331D28H19 | 1 |
| 40 | Pressure gauge | 9043A61H01 | 1 |

* Not illustrated.

• 48 V DC — 72-480-154-014
125 V DC — 72-480-154-010
250 V DC — 72-280-356-504

For Figure 1, Page 1A

NOTE. Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

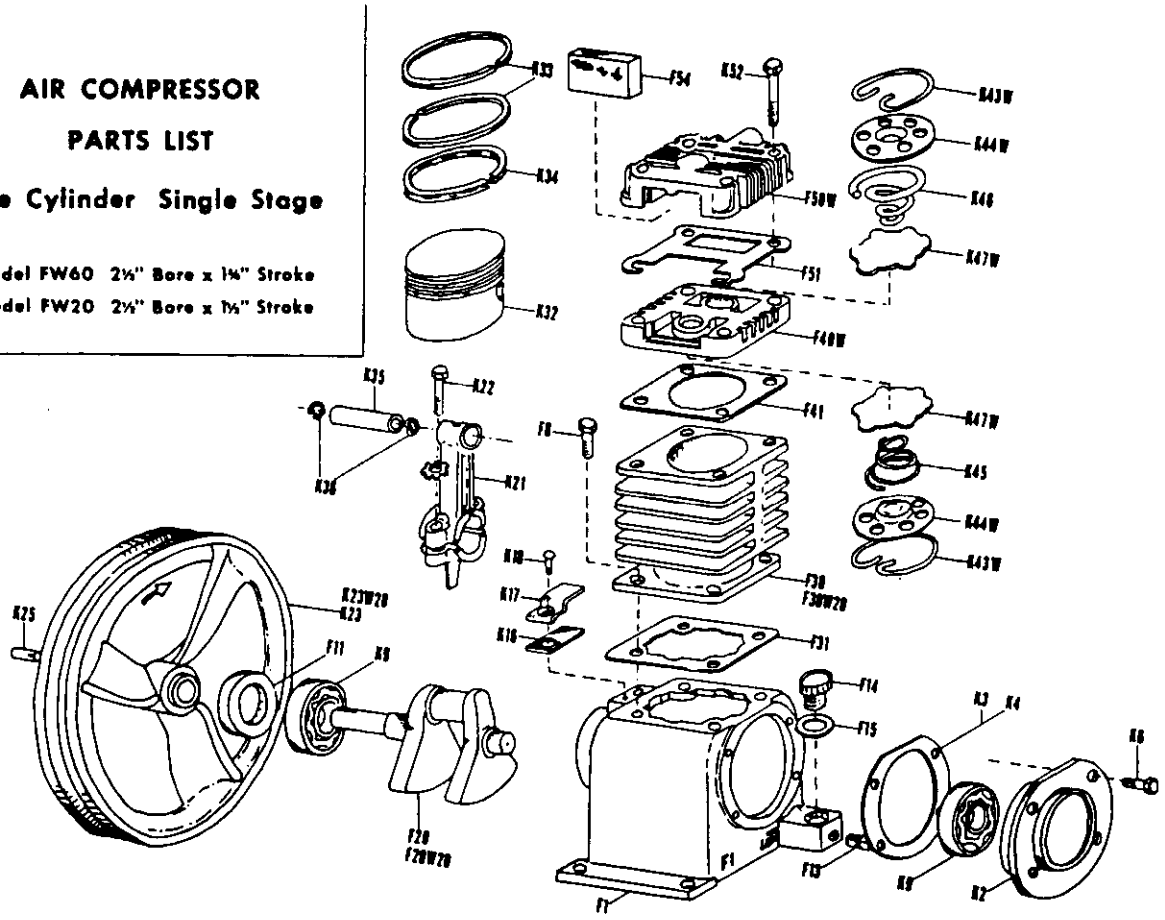
# PART REPLACEMENT

**AIR COMPRESSOR**

**PARTS LIST**

**One Cylinder Single Stage**

**Model FW60 2½" Bore x 1¾" Stroke**
**Model FW20 2½" Bore x 1½" Stroke**




## PARTS LIST MODEL F & FU

NOTE: The ( ) number indicates the total number of pieces required for a complete pump repair.

**IMPORTANT**

When ordering parts, please give compressor model, serial number and part number. Order assemblies when possible

| PART NO. | DESCRIPTION |
|---|---|
| F1 | Crankcase |
| K2 | Bearing Plate |
| L3 | Bearing Plate Gasket .031 |
| L4 | Bearing Plate Gasket .015 |
| K6 | Bearing Plate Bolt (10 ft.-lb.) (4) ¼-20 x ⅜ |
| F8 | Crankcase Bolt (10 ft.-lb.) (4) ¼-20 x ⅜ |
| K9 | Main Bearing (2) |
| F11 | Oil Seal (before Feb. '76) |
| K11E | Oil Seal (after Feb. '76 - 1⅛ OD) |
| F13 | Oil Drain Plug ½NPT |
| F14 | Fill Cap (Includes F15) |
| F15 | Fill Cap Gasket |
| F16 | Breather Valve |
| F17 | Breather Valve Retainer |
| F18 | Breather Valve Stud |
| F20A | Crankshaft |
| F20 | Crankshaft Assembly (F20A and L21K) |
| L21K | Connecting Rod (Includes K22) |
| K21 | Connecting Rod (Includes K22) |
| L22 | Rod Bolt w/lock washer (10 ft -lb ) (2) ¼-20 x 1¼ |
| K23 | 10" Flywheel (Includes K25) |
| K25 | Flywheel Key (spirol) |

| PART NO. | DESCRIPTION |
|---|---|
| F30 | Cylinder |
| F31 | Cylinder Gasket |
| K32 | Piston |
| K33 | Compression Ring (2) |
| K34 | Oil Ring with Expander |
| K35 | Piston Pin |
| K36 | Pin Retainer (2) |
| F40 | Valve Plate |
| F41 | Valve Plate Gasket |
| K43 | Valve Retainer (2) |
| K44 | Valve Bumper (2) |
| K45 | Valve Spring Intake (1) |
| K46 | Valve Spring Discharge (1) |
| K47 | Valve Disc (2) |
| F50 | Head |
| F51 | Head Gasket |
| K52 | Head Bolt 5/16-18x2 (22 ft lb.) (4) |
| F54 | Filter Insert |
| F54P | Package of air filter inserts |
| BSF54 | Filter Muffler Assembly includes element |
| L54E | Filter Element only |

| PART NO. | DESCRIPTION |
|---|---|
| FU80 | Head-Unloader Type |
| KU81 | Unloader Piston |
| KU82 | "O" Ring |
| KU83 | Unloader Spring |
| KU84 | Unloader Washer |
| KU85 | Unlaoder Retainer |
| KU86 | ⅛ x ⅛ Tube E1 |

## ASSEMBLIES

| | |
|---|---|
| F119 | Breather Valve Assembly |
| K145 | Suction Valve Assembly - Includes K47, K45, K44, K43 |
| K146 | Discharge Valve Assembly - Includes K47, K46, K44, K43 |
| K132 | Piston, Pins and Rings |
| F133 | Piston Ring Set includes 2 of K33 and 1 of K34 |
| F100 | Gasket Set L3, L4, F31, F41, F51 |
| F140 | Valve Plate with Valves installed including F41 and F51 Gaskets |
| FU180 | Head Assembly FU80 with Unloaders |
| KU181 | Unloader Assembly includes KU81, KU82, KU83, KU84 and KU85 |

Figure 2 — "FW-60" Air Compressor Parts

"FW-60T" Air Compressor Parts

# pneumatic operating mechanism type SA-7

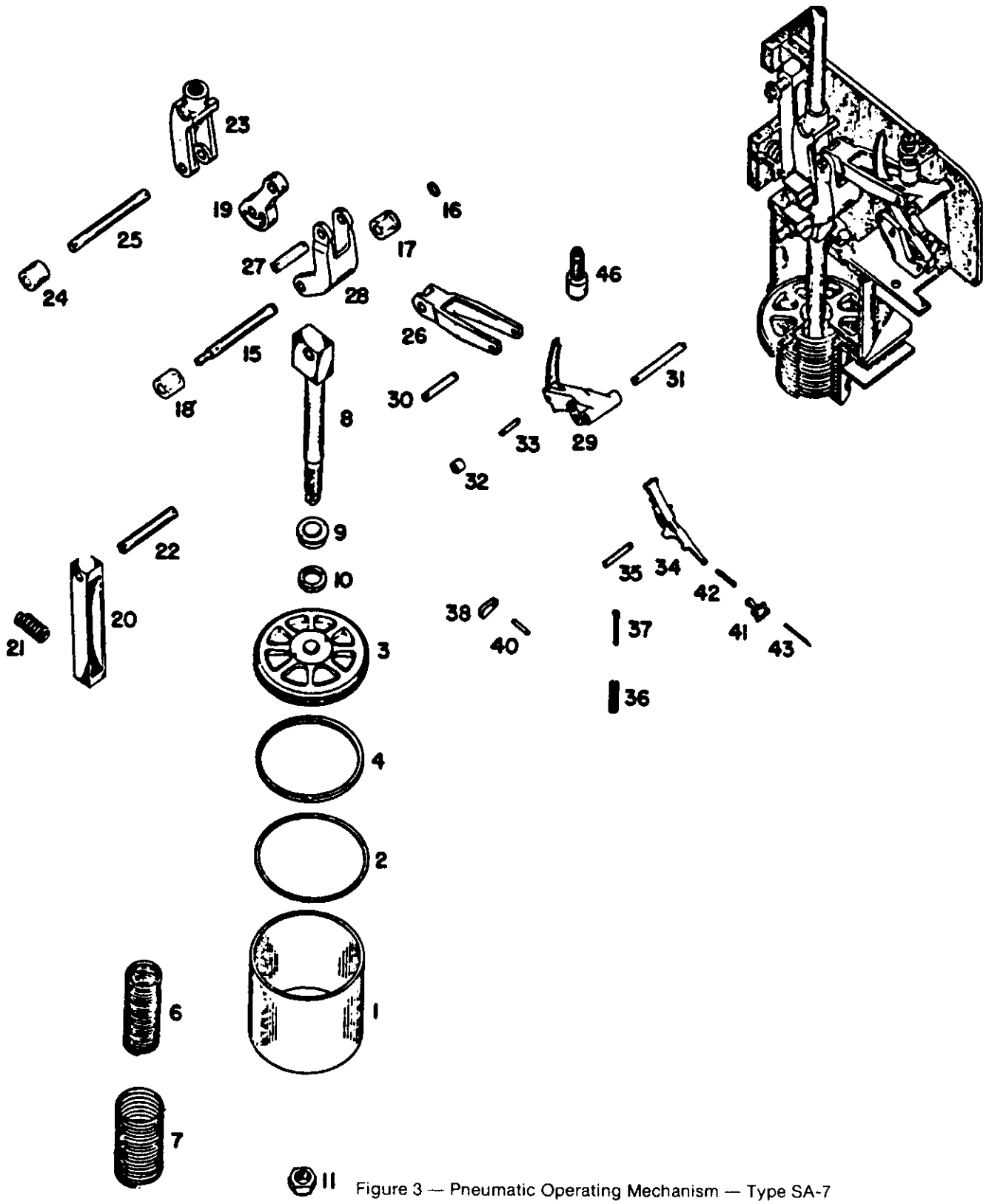



Figure 3 — Pneumatic Operating Mechanism — Type SA-7

**Type SA-7 Pneumatically Operated Mechanism**
**Mechanical Parts**

**72-480-154-015**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| ** | Mechanism | | 1 |
| 1 | Main cylinder | HW13033-1 | 1 |
| 2 | Main cylinder gasket | 23D7943H02 | 2 |
| 3 | Main closing piston | HW13036-1 | 1 |
| 4 | Piston ring | 7249A42G02 | 1 |
| 6 | Retrieving spring — inner | 72-180-553-002 | 1 |
| 7 | Retrieving spring — outer | 72-180-553-001 | 1 |
| 8 | Piston rod | HY04019-G2 | 1 |
| 9 | Bearing | 23D2992H01 | 1 |
| 10 | Packing ring | 27D3538H02 | 1 |
| 11 | Piston rod lock nut | HY04064-1 | 1 |
| 15 | Piston rod pin | HY04040-1 | 1 |
| 16 | Truarc retaining ring | HK35004-51 | 1 |
| 17 | Piston rod guide roller — right hand | HY04111-1 | 1 |
| 18 | Piston rod guide roller — left hand | HY04110-1 | 1 |
| 19 | Cam lever | HW13057-2 | 1 |
| 20 | Holding latch | HY04021-1 | 1 |
| 21 | Latch spring | 72-180-553-003 | 1 |
| 22 | Latch pin | HY04053-1 | 1 |
| 23† | Rod end | HY04023-1 | 1 |
| 24 | Breaker rod end guide roller | HY04110-1 | 2 |
| 25 | Rod end pin | HW13062-2 | 1 |
| 26 | Intermediate link | HW13114-1 | 1 |
| 27 | Intermediate link and closing lever pin | HW13062-5 | 1 |
| 28 | Closing lever | HW13058-3 & 4 | 1 |
| 29 | Trip free lever | HW13098-2 | 1 |
| 30 | Trip free lever and intermeidate link pin | HW13047-17 | 1 |
| 31 | Trip free lever fulcrum pin | HW13047-18 | 1 |
| 32 | Trip free lever roller bearing | HW13060-3 | 1 |
| 33 | Roller pin | HW13047-13 | 1 |

† Differs from illustration.

For Figure 3, Page 3A

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**Type SA-7 Pneumatically Operated Mechanism**
**Mechanical Parts**

**72-480-154-015**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| 34 | Trip free trigger | HY04024-G2 | 1 |
| 35 | Trigger pin | HW13047-14 | 2 |
| 36 | Trigger spring | 72-180-553-005 | 1 |
| 37 | Spring guide | HY04035-1 | 1 |
| 38 | Lever spacer | HY04042-1 | 1 |
| 40 | Retainer pin | HW13047-19 | 1 |
| 41 | Catch | HY04025-1 | 1 |
| 42 | Catch spring | 72-180-553-006 | 1 |
| 43 | Catch pin | HW13047-11 | 1 |
| 46 | Trip free lever stop | HY04027-G1 | 1 |
| 47 | Latch checking switch | 2876C91G01 | 1 |
| * | Throttle lever | HW13097-1 | 1 |
| * | Grease | W962010 | 1 |

*Not illustrated.

For Figure 3, Page 3A

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

**Type SA-7 Pneumatically Operated Mechanism**
**Mechanical Parts**

**1D61297G06**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| ** | Mechanism | | 1 |
| 1 | Main cylinder | 513A086H01 | 1 |
| 2 | Main cylinder gasket | 23D7943H02 | 2 |
| 3 | Main closing piston | 173C170H01 | 1 |
| 4 | Piston ring | 7249A42G02 | 1 |
| 6 | Retrieving spring — inner | 72-180-553-002 | 1 |
| 7 | Retrieving spring — outer | 72-180-553-001 | 1 |
| 8 | Piston rod | 33A2609G04 | 1 |
| 9 | Bearing | 23D2992H01 | 1 |
| 10 | Packing ring | 27D3538H02 | 1 |
| 11 | Piston rod lock nut | 26D1982H01 | 1 |
| 15 | Piston rod pin | 33A2609H15 | 1 |
| 16 | Truarc retaining ring | W32181815 | 1 |
| 17 | Piston rod guide roller — right hand | 33A2609H13 | 1 |
| 18 | Piston rod guide roller — left hand | 33A2609H12 | 1 |
| 19 | Cam lever | 23D2725H01 | 1 |
| 20 | Holding latch | 512A663H01 | 1 |
| 21 | Latch spring | 72-180-553-004 | 1 |
| 22 | Latch pin | 7252A16H01 | 1 |
| 23† | Rod end | 4043B91G01 | 1 |
| 24 | Breaker rod end guide roller | 33A2609H12 | 2 |
| 25 | Rod end pin | 512A428H23 | 1 |
| 26 | Intermediate link | 14C2635H01 | 1 |
| 27 | Intermediate link and closing lever pin | 512A428H22 | 1 |
| 28 | Closing lever | 16C4426H01 | 1 |
| 29 | Trip free lever | 23B2998H01 | 1 |
| 30 | Trip free lever and intermeidate link pin | 512A428H20 | 1 |
| 31 | Trip free lever fulcrum pin | 4042B84H05 | 1 |
| 32 | Trip free lever roller bearing | 23D7924H03 | 1 |
| 33 | Roller pin | 512A428H18 | 1 |

† Differs from illustration.

For Figure 3, Page 3A

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**Type SA-7 Pneumatically Operated Mechanism**
**Mechanical Parts**

**1D61297G06**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| 34 | Trip free trigger | 23B6021G01 | 1 |
| 35 | Trigger pin | 512A428H19 | 2 |
| 36 | Trigger spring | 72-180-553-005 | 1 |
| 37 | Spring guide | 23D5301H01 | 1 |
| 38 | Lever spacer | 23D5586H01 | 1 |
| 40 | Retainer pin | 4042B84H04 | 1 |
| 41 | Catch | 13C7974G01 | 1 |
| 42 | Catch spring | 72-180-553-006 | 1 |
| 43 | Catch pin | 512A428H16 | 1 |
| 46 | Trip free lever stop | 72-180-614-501 | 1 |
| 47 | Latch checking switch | W666874 | 1 |
| * | Throttle lever | 5503C05G01 | 1 |
| * | Grease | W962010 | 1 |

* Not illustrated.

For Figure 3, Page 3A

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**Major Inspection Tool and Parts Kit**

**S#1658B22G01**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| | Item numbers refer to Drawing 1658B22 | | |
| 1 | Gauge — orifice wear | 7249A38H01 | 1 |
| 4 | Socket — .31 hex male | 72-180-495-501 | 1 |
| 5 | Socket — spanner interrupter | 72-180-786-801 | 1 |
| 6 | Parts kit — major inspection | 1658B23G01 | 1 |
| 9 | Checking gauge | 7358D12H14 | 1 |
| 10 | Hex Driver | W380008 | 1 |

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**Major Inspection Parts Kit**

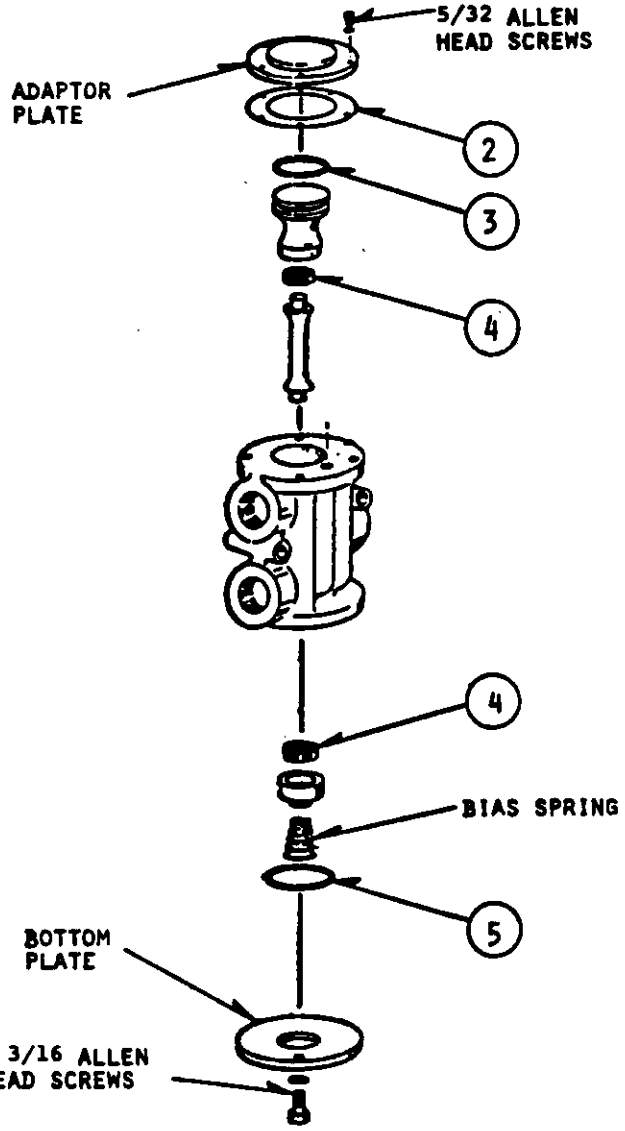
**S#1658B23G01**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| | Item numbers refer to Drawing 1658B23 | | |
| 1 | "X" washer | 00659055317 | 6 |
| 2 | Gasket — coverplate | 1656B57H02 | 3 |
| 3 | Gasket — bushing flange | 1656B57H01 | 6 |
| 4 | Seal — guide | 1655B37H02 | 3 |
| 5 | Ring — seal | 1655B37H03 | 3 |
| 6 | Loctite — type 242 | W946024 | 1 |
| 7 | Grease — Molykote | 00337271095 | 1 |
| 8 | Grease — Beacon | 512A196G04 | 1 |
| 9 | Grease — Silicone | W962026 | 1 |
| 10 | Dissicant | 1657B11H01 | 3 |
| 11 | Tie — nylon | W684314 | 6 |
| 12 | Compound — RTV sealant | W881015 | 1 |
| 13 | Seal | 7249457H02 | 1 |

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT




**Norgren Valve Service Kit**

**S#4042B02H01**

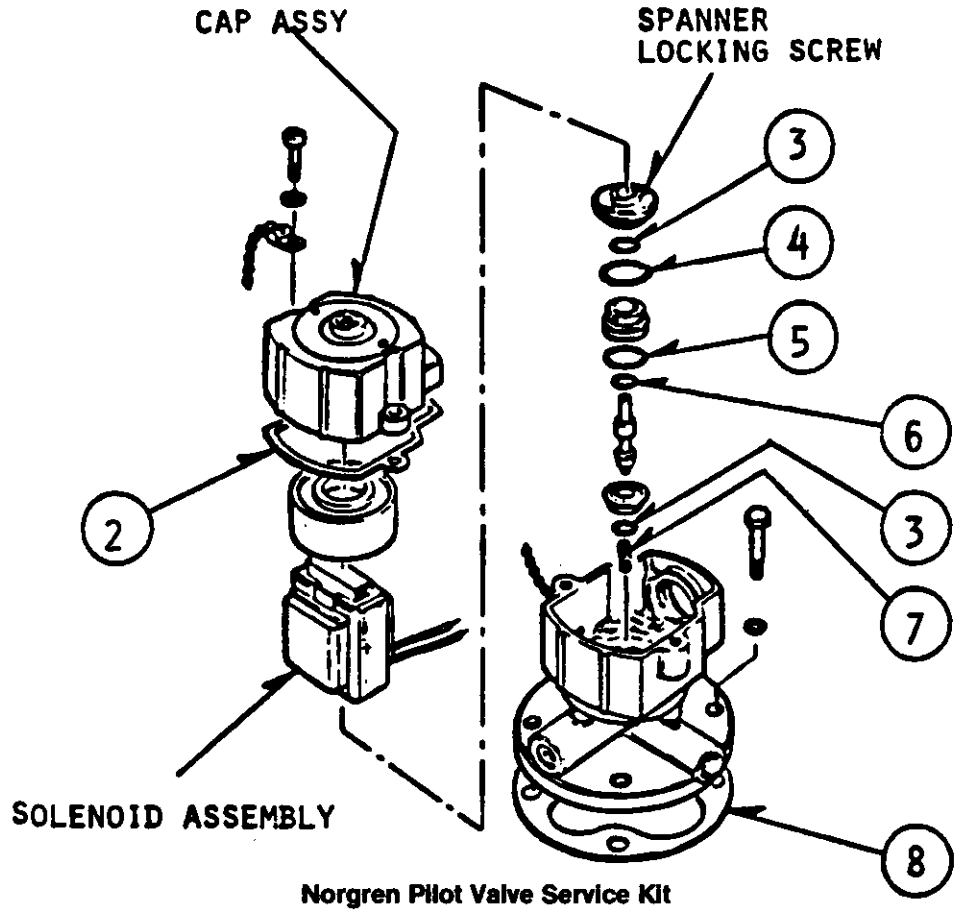
The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| 1 | Valve service kit | 4042B02H01 | 1 |
| 2 | Gasket | 4042B02H02 * | 1 |
| 3 | "O" ring | 4042B02H03 * | 1 |
| 4 | Seat | 4042B02H04 * | 2 |
| 5 | "O" ring | 4042B02H05 * | 1 |

* Parts not furnished separately — listed for descriptive purposes only.

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT




**Norgren Pilot Valve Service Kit**

**S#4042B01H01**

The following parts are most subject to wear in ordinary operation:

| Ref. No. | Name of Part | Identification Number | Number per Unit |
|---|---|---|---|
| 1 | Pilot valve service kit | 4042B01H01 | 1 |
| 2 | Gasket | 4042B01H02 * | 1 |
| 3 | "O" ring | 4042B01H03 * | 2 |
| 4 | "O" ring | 4042B01H04 * | 1 |
| 5 | "O" ring | 4042B01H05 * | 1 |
| 6 | "O" ring — yellow dot | 4042B01H06 * | 1 |
| 7 | Spring | 4042B01H07 * | 1 |
| 8 | Gasket | 4042B01H08 * | 1 |

* Parts not furnished separately — listed for descriptive purposes only.

NOTE: Parts indented are included in the part under which they are indented.
Order part by name and identification number — give complete nameplate reading.

# PART REPLACEMENT

**RECOMMENDATIONS FOR STOCK — MINIMUM LIST**

**(SGC Mechanism)**

| Total Quantity | Rec. for Stock | Identification Number | Name of Part |
|---|---|---|---|
| | 1 | • | Trip coil |
| | 1 | HY04025-1 | Catch |
| | 1 | HW13038-2 | Trip free lever |
| | 1 | HY04024-G2 | Trip free trigger |
| | 1 | 72-180-553-004 | Latch spring |
| | 1 | 72-180-553-005 | Trigger spring |
| | 1 | 72-180-553-006 | Catch spring |
| | 1 | HW13060-3 | Trip free lever roller bearing |
| | 2 | 23D7943H02 | Main cylinder gasket |
| | 1 | 266C072H07 | Thermostat |
| | 1 | 266C488H01 | Air compressor |
| | 1 | 512A430H04 | Rupture disc |
| | 1 | HY04021-1 | Holding latch |
| | 1 | 513A271H01 | Check valve |
| | 2 | 513A842H01 | Bearing |
| | 2 | 517B035H02 | Heater |
| | 2 | W500006 | Contact cartridge |
| | 1 | 1124C53H33 | "O" ring gasket |
| | 1 | 1253C48G01 | Operating coil (ARD) 120 V DC |
| | 1 | 1253C48G05 | Operating coil (ARD) 48 V DC |
| | 1 | 1650B29H03 | Pressure gauge |
| | 1 | 1253C48G02 | Operating coil (ARD) 250 V DC |
| | 1 | 1654B08H02 | Shock absorber |
| | 1 | 1658B22G01 | Major inspection tool and parts kit |

• 48 V DC 72-480-154-014
125 V DC 72-480-154-010
250 V DC 72-280-356-504

* Prices and Discounts subject to change without notice.

# PART REPLACEMENT

**RECOMMENDATIONS FOR STOCK — MINIMUM LIST**

**(Siemens Mechanism)**

| Total Quantity | Rec. for Stock | Identification Number | Name of Part |
|---|---|---|---|
| | 1 | • | Trip coil |
| | 1 | 13C7974G01 | Catch |
| | 1 | 23B2998H01 | Trip free lever |
| | 1 | 23B6021G01 | Trip free trigger |
| | 1 | 72-180-553-004 | Latch spring |
| | 1 | 72-180-553-005 | Trigger spring |
| | 1 | 72-180-553-006 | Catch spring |
| | 1 | 23D7924H03 | Trip free lever roller bearing |
| | 2 | 23D7943H02 | Main cylinder gasket |
| | 1 | 266C072H07 | Thermostat |
| | 1 | 266C488H01 | Air compressor (FW-60) |
| | 1 | 512A430H04 | Rupture disc |
| | 1 | 512A663H01 | Holding latch |
| | 1 | 513A271H01 | Check valve |
| | 2 | 513A842H01 | Bearing |
| | 2 | 517B035H02 | Heater |
| | 2 | 624B094G07 | Contact cartridge |
| | 1 | 1124C53H33 | "O" ring gasket |
| | 1 | 1253C48G01 | Operating coil (ARD) 120 V DC |
| | 1 | 1253C48G05 | Operating coil (ARD) 48 V DC |
| | 1 | 1650B29H03 | Pressure gauge |
| | 1 | 1253C48G02 | Operating coil (ARD) 250 V DC |
| | 1 | 1654B08H02 | Shock absorber |
| | 1 | 1658B22G01 | Major inspection tool and parts kit |
| | 1 | W132021 | Air compressor (FW-60T) |

• 48 V DC 72-480-154-014
125 V DC 72-480-154-010
250 V DC 72-280-356-504

# PART REPLACEMENT

## RECOMMENDATIONS FOR STOCK — MINIMUM LIST

| Total Quantity | Rec. for Stock | Identification Number | Name of Part |
|---|---|---|---|
| | 1 | 2283C33H11 | Flexible hose |
| | 1 | 2284C01H38 | V belt |
| | 1 | 2289C31G01 | Shaft seal |
| | 1 | 2876C91G01 | Latch checking switch |
| | 1 | 4042B01H09 | Coil assembly 48 V DC |
| | 1 | 4042B01H10 | Coil assembly 125/250 V DC |
| | 1 | 516B665H06 | Pressure switch — governor |
| | 1 | 516B665H07 | Pressure switch — low pressure cutout |
| | 1 | 516B665H06 | Pressure switch — low pressure alarm |
| | 2 | 7249A33H01 | Gasket |
| | 1 | 512A430H04 | Rupture disc |
| | 1 | 7351D19G05 | Replacement kit |
| | 1 | 72-480-127-802 | Auxiliary switch, 11 stage |
| | 1 | W641257 | Motor 3/4 HP |
| | 1 | 9040A92H01 | Gasket — rupture disc — seal |
| | 1 | 9040A92H02 | Gasket — rupture disc — compression |
| | 1 | 72-180-626-001 | Safety valve |
| | 1 | 9043A61H01 | Pressure gauge |
| | 1 | 72-280-380-505 | Interrupter Assembly 1200/2000 Amp (72 kV) (31.5/40 kA) |
| | 1 | 72-280-380-501 | Interrupter Assembly 1200/2000 Amp (15.5 kV) |
| | 1 | 72-280-380-506 | Interrupter Assembly 3000 Amp (72 kV) |
| | 1 | 72-280-380-503 | Interrupter Assembly 1200/2000 Amp (72 kV, 23 kA) |
| | 1 | 72-280-380-504 | Interrupter Assembly 3000 Amp (48 kV and below) |

* These replacement parts include testing and packing instructions.