INSTRUCTIONS

GEK-39800

HIGH CAPACITY OIL-BLAST CIRCUIT BREAKERS

TYPES

FK121-40000-8	1600 Ampere
FK121-40000-7	2000 Ampere
FK121-40000-2	3000 Ampere
FK121-63000-2	2000/3000 Ampere
FK145-40000-10	1600 Ampere
FK145-40000-5	2000 Ampere
FK145-40000-2	3000 Ampere
FK145-63000-2	2000/3000 Ampere

GENERAL ELECTRIC

NOTES

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FK121-40000-8	1600 Ampere	FK145-40000-10	1600 Ampere
FK121-40000-7	2000 Ampere	FK145-40000-5	2000 Ampere
FK121-40000-2	3000 Ampere	FK145-40000-2	3000 Ampere
FK121-63000-2	2000/3000 Ampere	FK145-63000-2	2000/3000 Ampere

INTRODUCTION

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards as of the time of manufacture but no such assurance is given with respect to local codes and ordinances because they vary greatly.

SAFETY

Each user is responsible for instructing all personnel associated with his equipment on all safety precautions which must be observed.

The following are recommendations to be considered in a user's safety program. These recommendations are not intended to supplant the user's responsibility for devising a complete safety program and shall not be considered as such. They are rather suggestions to cover the more important aspects of personnel safety related to circuit breakers. General Electric neither condones nor assumes any responsibility for user practices which deviate from these recommendations.

General

1. All personnel associated with installation, operation and maintenance of power circuit breakers should be thoroughly instructed and supervised regarding power equipment in general and, also, the particular model of equipment with which they are working. Instruction books and service advices should be closely studied and followed.

2. Maintenance programs must be well planned and carried out consistent with both customer experience and manufacturer's recommendations including service advices and instruction books. Good maintenance is essential to breaker reliability and safety.

   Local environment and breaker application must be considered in such programs, including such variables as ambient temperatures, actual continuous current, number of operations, type of interrupting duty, and any unusual local condition such as corrosive atmosphere or major insect problems.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. 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 General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

3. The term "breaker" includes all equipment mounted on the circuit breaker foundation, i.e., if the compressor is mounted on the circuit breaker frame, it is considered part of the breaker, but if it has its own separate foundation, it is not.

Specific

1. DO NOT work on an energized breaker. If work has to be performed on the breaker, take it out of service, open the disconnect switches at each side of the breaker, then close the breaker and ground each phase.

2. DO NOT work on any part of the de-energized breaker until all control and heater power has been disconnected.

3. DO NOT disassemble any portion of the air system of the de-energized breaker until the system has had the pressure reduced to zero psi by opening of the appropriate drain valves. When the air pressure has been reduced to zero, cautiously remove covers, tubes, fittings, etc.

4. DO NOT disassemble any part of the air supply system until its operating power supply has been disconnected.

5. (a) DO NOT block the operation of the relief valve or tamper with the setting which in turn could affect the safety of the pneumatic system.

   (b) If the air pressure is to be relieved from the air system, other than emergency conditions, do not use the relief valve as the device to perform this operation.

6. If there is any evidence of or suspected deterioration of breaker dielectric capability, the yard and adjacent areas should be promptly cleared of personnel. The breaker should then be de-energized by "back-ups" and isolated by disconnect switches.

7. Operational tests and checks should be made on a breaker after maintenance, before it is returned to service, to ensure that it is capable of operating properly. The extent of such tests and checks should be consistent with the level of maintenance performed.

8. Breaker warning nameplate.

(0283A7640P001 Rev. 1)

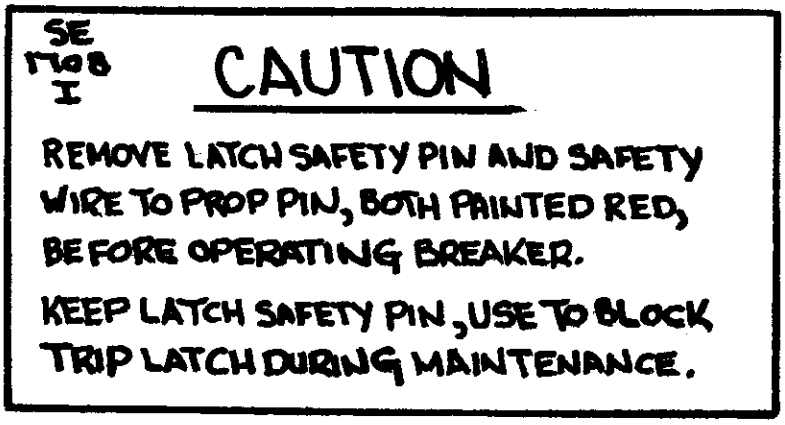
WARNING

HAZARDOUS MOVING PARTS AND HIGH PRESSURE AIR INSIDE COMPRESSOR MAY BE ON AUTOMATIC CONTROL AND COULD START AT ANY TIME. NO MAINTENANCE OR OTHER WORK SHOULD BE PERFORMED UNTIL ALL ELECTRICAL POWER AND AIR PRESSURE HAVE BEEN REMOVED FROM THE SYSTEM. READ THE APPLICABLE SECTIONS OF THE INSTRUCTION BOOK - PARTICULARLY THE SECTION ON "SAFETY."

The nameplate is mounted on the outside of the control enclosure door on Pole One and is a reminder of the preceding specific items of safety.

9. Trip latch blocking warning nameplate.

0275A6211P001



The control power should be removed locally before installing this blocking device and not energized again until the device has been removed.

The blocking device should be installed any time the breaker is removed from service for inspection or maintenance work. Refer to the pneumatic mechanism instruction book, GEK-39799. The blocking device should not be removed until the maintenance has been completed and the breaker is ready to return to service. When removed the blocking tool should be stored for future use.

Before removing the trip latch blocking device the following checks should be made. (Breaker may operate to the open position, if the trip latch is released, after the blocking device is removed.)

(a) Maintenance closing device is removed.

(b) All tools removed and personnel moved clear of operating mechanism.

(c) Control power removed.

10. (a) This breaker is designed for electrical closing when in service. NEVER ATTEMPT MANUAL CLOSING WITH THE BREAKER IN SERVICE because, under such conditions, sufficient closing speed cannot be obtained. OPERATE MANUALLY ONLY WHEN THE BREAKER HAS BEEN COMPLETELY DE-ENERGIZED AND ISOLATED.

(b) Do not operate the breaker with the maintenance closing device with pressure in the air system and/or control power connected.

(c) When the breaker is being operated with the maintenance closing device the trip latch should be blocked in the latched closed position, using the trip latch blocking device, to prevent accidental tripping since this mechanism is mechanically trip-free.

RECEIVING, HANDLING AND STORAGE

RECEIVING INSPECTION

IMPORTANT: Immediately upon receipt of this equipment examine it for any damage that might have been sustained in transit. If injury or rough handling is evident, a damage claim should be filed immediately with the transportation company, and the nearest General Electric Apparatus Sales Office should be notified promptly.

Examine the equipment for hardware which may have become loose in transit. Tighten any loose hardware and apply an alkyd type paint as required.

UNPACKING AND HANDLING

All breakers are assembled and tested at the factory. They are shipped assembled in as complete units as handling and transportation facilities will permit, if the ordering information so states.

Some breakers have the bushings and interrupters removed and shipped separately due to shipping difficulties or shipment to stations outside the continental United States of America.

On this type of shipment the interrupters are separately crated with the contents identified. The bushings are separately crated as shown in Fig. 2 and are shipped directly from Pittsfield, Massachusetts.

Each phase is shipped with the bushing current transformers, breaker mechanism, and moving contact members in place. The pneumatic operating mechanism and its housing are shipped assembled on the front phase.

The crating or boxing must be removed carefully. Particular care must be taken with the bushings as the porcelain insulating sections may otherwise become chipped or damaged. Use a nail puller to open the crates and do not allow either the crate or the bushing to be struck by tools while handling. The porcelains of the bushings and other parts are sometimes broken by driving a wrecking bar into crates or boxes carelessly. Certain other parts of the breaker are of insulating material and must be handled so that they are protected from moisture, dirt, and damage due to rough handling.

Check all parts against the packing list as they are unpacked and identified to be sure that no parts have been overlooked during the unpacking. This list is enclosed in one of the packing cases and that packing case is referred to on the memorandum of shipment as containing the packing list. Always search the packing material for hardware which may have loosened in transit. All tags should be left on the parts until they are ready for installation.

STORAGE

When the breaker can be set up immediately in its permanent location and filled with oil it is advisable to do so, even though it will not be placed in service for some time. Clean and inspect the oil tank and remove the moisture indicator card and containers of desiccant before filling the tank with oil. If the breaker is to be stored for a long period of time in some location other than the permanent one, the tank should be filled with oil to protect the components made of insulating material.

When a short storage period is involved, six months or less, it may be advantageous to replace the breather (18), Fig. 7, with a pipe plug and place desiccant and humidity indicator card in the bottom of the tanks to keep the breaker parts dry.

Inspection of the indicator card should be made every 30 days to be sure no moisture leakage points have developed. If the card indicates the presence of moisture, corrective measures should be taken immediately. After the entrance point of the moisture is determined and corrected, the saturated desiccant containers should be removed and dried out by baking at 90 to 100°C for a period of four hours. They can then be mounted in the tank in the same manner as received.

After completion of the storage period, the desiccant and the indicator card must be removed and the breather reassembled before filling the breaker with oil.

If it is impractical to make the 30 day inspection periods as suggested above, because of remoteness of location, the breakers should be filled with oil as a positive safeguard against moisture damage to the insulating parts.

The bushings may be stored outdoors in their crates as received, in a place where there is no danger of breakage.

WHEN THE INTERRUPTERS ARE SHIPPED SEPARATELY THE PARTS MADE OF INSULATING MATERIAL SHOULD BE STORED IN A DRY ROOM. These parts are all indicated by an appropriate "KEEP IN DRY PLACE" stencil on the outside of the case. When storing them indoors the cases should be opened to allow air to circulate freely. If the parts are packed in plastic loose fill it is advisable to remove the plastic material completely because it tends to collect moisture which may be absorbed by the insulating materials; the moisture may also cause corrosion of metal parts. If they must be left outdoors for a week or two, they must be thoroughly covered with a protective covering. Sufficient heat should be applied to prevent temperature changes from causing moisture condensation on the parts. Under conditions of high humidity, or if the only indoor storage space is damp, breaker components and replacement parts should be kept in containers fill with insulating oil.

Replacement parts, especially lift rods, guides, and other parts made of insulating material, should be stored in a dry room. It is also advisable to hang the lift rods and guides in a vertical position to minimize the possibility of warpage, especially if a level storage surface is not available. Under extreme conditions of humidity, or if the only storage space is damp, they should be kept in suitable containers filled with clean and moisture free insulating oil.

The space heater in the operating mechanism housing should be energized as soon as possible in order to prevent moisture condensation inside the housing.

DESCRIPTION

BREAKER

The triple pole breaker (Fig. 1) consists of three pole units mounted on a common base. Each pole unit comprises an oil tank, two bushings mounted on bushing supports together with a mechanism housing to mount the breaker mechanism linkage.

The breaker mechanism linkages located in the top of each phase are connected together so that they can be operated simultaneously by a common pneumatic operating mechanism located at the front of the breaker.

The breaker mechanism linkage transmits the motion of the pneumatic operating mechanism to the moving contact assembly, producing a straight line motion to the lift rod and moving contacts. The breaker mechanism linkage is so designed that the horizontal operating rods are always in tension in both opening and closing operations due to the spring load of the interrupter pumps and opening spring. An oil dashpot located in the pneumatic operating mechanism decelerates the opening speed prior to the fully open position, allowing the movable contacts to come to rest with little or no rebound. An adjustable opening spring, located at the end of the horizontal operating rod on the third pole, insures positive opening action for a predetermined speed and contact parting time.

The oil tanks enclose the interrupters and the insulating oil and the tanks are equipped with entrance manholes, to permit easy access to the interior of the phases for inspection and maintenance. Each tank has a drain valve and either a pipe plug screwed into the valve or a sampling valve that is attached to the drain valve. Each pole is also equipped with a float-type oil level indicator that indicates the proper level of the oil in the tank.

OPERATING MECHANISM

The operating means for closing and opening the breaker is a mechanism of the pneumatic type located in a weatherproof housing on the front pole. Instructions for the mechanism are contained in a separate instruction book, a copy of which is in the complete breaker instruction book located in the instruction book pocket which is fastened to the front door of the pneumatic operating mechanism house.

BUSHINGS

The oil-filled bushings (2), Fig. 7, on these breakers are of a hermetically-sealed construction. Type U bushings built to the new ANSI standards are used in these breakers. They are equipped with a capacitance tap (4), Fig. 7, for making power factor tests and, when used with a separate potential device, provide a voltage supply for operating relays and instruments.

For additional information on the construction of bushings refer to instruction book, GEK-1627.

BUSHING CURRENT TRANSFORMERS

Bushing current transformers Type BR-B, are used on these breakers to provide a source of current supply for operating breaker trip coils and protective relays. Relaying transformers are of the multi-ratio type having five leads which provide a wide range of ratios. Ratio and accuracy classification for standard transformers are in accordance with ANSI C57.13-4.1.3 and NEMA SG-4-3.10 specifications.

Single-ratio type BM high accuracy metering-type current transformers can also be furnished. These have compensation applied for specified loadings and cannot be used on other loadings without affecting their accuracy. The multi-ratio type has standard tap connections. Ratio and accuracy classification for standard transformers of this type are also in accordance with ANSI C57.13-4.1.3 and NEMA SG-4-3.10 specifications.

Performance data in the form of ratio curves is available for all standard transformers of standard ratios. These are supplied with the order or can be secured from the Switchgear Business Department by giving the proper references.

Bushing current transformers are mounted inside the breaker dome. The BCT's are strapped to support plates (4), Fig. 11, and raised into position, guided on three studs (5), Fig. 11, attached to the breaker dome. The BCT's are held tight to the breaker dome through the use of locking hardware at the support plates.

All transformer leads are brought out of the tanks for external connections. The leads are run in conduit through a gas and oil seal into the operating mechanism compartment where they are terminated at suitably marked terminal boards. The shorting wires should not be removed from the BCT terminal boards until the customer's permanent circuitry is installed. If it should be necessary to replace a transformer, care must be taken to see that the end of the transformer carrying the white polarity mark is placed upwards. Transformers should be connected in accordance with instructions GEK-2020, to be sure of proper polarity and correct connections.

For additional information on bushing current transformers, see the instruction book which is included in the breaker instruction book located in the pocket on the front door of the pneumatic operator.

INTERRUPTER

Each interrupter, Fig. 14, is mounted on the lower end of each bushing (2), Fig. 7, by means of a mounting adapter (2), Fig. 14, which is also used to align the interrupter to the moving contact.

The interrupter, Fig. 14, is a single break unit consisting of a fiberglass tube (38) that encloses a set of primary contact fingers (37), insulating spacers (15, 19, 40), a baffle assembly (16) and a resistor contact (39) assembly. Mounted to the adapter and shorting out the interrupter when the breaker is in the closed position is a ceramic resistor assembly (27) which serves to divide the voltage between the interrupters of a phase during interruption and limit the overvoltage developed after interruption. An oil flushing piston (6) is also mounted to the adapter to remove the carbonized oil from the baffle assembly and replace it with clean oil after each opening operation.

OIL

The high speed performance of the modern oil-blast breaker is dependent upon the use in the breaker of oil having the proper characteristics and refined under a controlled method, by a reliable refiner, to fully meet the most rigid specifications. A high dielectric strength is necessary to meet insulation requirements. Efficient cooling demands low viscosity, yet not too low as to affect the flash and burning points, which must be high to minimize the fire risk. A low freezing point is required for successful operation when installed in a location subject to freeing temperatures. High resistance to carbonization minimizes the sludge and carbon deposits that reduce the dielectric strength and cooling effect of the oil. The proper oil should not readily retain moisture in suspension, as the presence of one-tenth of one percent may reduce its puncturing resistance by 50 percent.

It is recommended that only uninhibited Type I insulating oil be used in these breakers. Inhibited Type II insulating oil containing rust inhibiters should not be used in these breakers as the cost of the inhibited oil is greater than the cost of the regular 10-C oil. If the inhibited oil is all that is available, it can be used.

Type I insulating oil is a pure mineral oil with the following characteristics:

Power Factor -	
60 cycles at 100° C-percent maximum	0.30
Resistivity - minimum	
ohms - centimeter at 100°C	30×10^{12}
Flash Point - degrees C	
minimum	145
Pour Point - degrees C	
maximum	-40°
Acidity - mgKOH/g - maximum	0.02
Viscosity - Saybolt Universal	
at 37.8°C - seconds maximum	62
at zero°C - seconds maximum	320
Color - Pale amber, clear	

Each lot of oil is subjected to a strict examination and is rejected unless it fully meets specifications, which require, in part that the oil shall withstand a potential of at least 30,000 volts, as measured by the ASTM Test Method, D877.

SPECIAL TOOLS

Special tools and accessories to facilitate installation and maintenance of parts include the following:

Maintenance closing device
Cement for gaskets
Grease for roller surfaces
bushing aligning bracket
Two bolts for bushing aligning bracket
Touch-up paint
Bushing aligning screw
Analyzer bracket
Interrupter alignment bracket
Door stop (mechanism house)

INSTALLATION AND DIMENSIONAL INSPECTION

UNIT INSTALLATION

General

The installation of the breaker will be facilitated by a study of the approved drawings which supplement these instructions. The approved drawings, which include an outline of the breaker, an outline of the operating mechanism and housing, and connection diagrams, provide information necessary for the proper installation of the breaker.

Before any work is done, these drawings and all related instruction books should be consulted.

Location

The breaker should be located so that it will be readily accessible for cleaning, inspection and maintenance. Sufficient space must be provided for opening the doors of the pneumatic operating mechanism housing and making the necessary control connections. Where flood conditions exist, the breaker foundation should be sufficiently high so that the mechanism housing is above high water level. It is also important that the breaker foundation be perfectly level, as this will assure maximum smoothness of operation.

Mounting

The total weight of the breaker less oil is given on the outline drawing and on the nameplate. This information will serve as a guide to the strength of the lifting means required for handling the breaker. It may be lifted by hooking cables in the oil tank lifting lugs of Poles One and Three as shown in Fig. 5.

Care should be taken to avoid hitting or striking the bushings with the cable slings to prevent the danger of breakage.

Foundation Requirements

The notation on our outline drawings relative to the foundation loading on oil circuit breakers performing normal rated duty states:

Downward Force: Three times the dead weight including oil.

Upward Force: One times the dead weight including oil.

Breaker Installation

Installation of the breaker is greatly simplified as the tanks are factory aligned and mounted on a unit base with the interphase connecting rods in place.

Sling the three-phase breaker as pictured in Fig. 5 and move it into location with a crane. To level the breaker, drop a plumb line from the plumb mark on the bushing potential device mounting boss (9), Fig. 7, to the center of the stem of the oil drain valve, (16), Fig. 7. Check the other two tanks to make certain they also line up properly. If necessary, shim the unit base until the plumb bob is within 1/4 inch of the mark.

The foundation bolts should be left loose to permit the breaker to be properly plumbed and leveled by inserting shims under the supporting skid where necessary. After this has been done, grouting should be applied between the breaker skid and the foundation; the foundation bolts should be tightened and the supporting skid fastened securely to its foundation.

The remaining sections on CONNECTIONS, MECHANICAL ADJUSTMENTS must be followed through to be sure no shifting of parts has been sustained in shipment. Before proceeding with the checking of the breaker all shipping braces on the bushings, inside the tank and in the mechanism house, must be removed.

The degree of readjustments required in fully assembled breakers is purely a function of the handling received in transit.

Connections

After the breaker has been located, electrical connections can be made. Before making these, every precaution must be taken to see that all leads to be connected to the breaker are de-energized.

Primary Connections

Leads should be brought down from above if possible. Ample electrical clearance must be provided between these leads and parts of the station, such as walls, channels, and framework. Leads should be properly supported so that the breaker bushings are not subjected to unnecessary strains. The bushings should not carry cable or bus bar strains. To avoid overheating, the connecting leads must be of a current-carrying capacity at least equal to the maximum operating current of the circuit, which should not exceed the breaker rating.

Connections to the breaker are made by bolted connectors fastened to the ends of the bushings. The bolts on the terminal connectors must be securely tightened to obtain good contact. All joints must be clean, bright and free from dents or burrs.

Control and Secondary Wiring

All control wires should be run in conduit to the conduit attachment plate on the floor of the control house. Control wires must be run separately and remote from high voltage leads and must not be run in the same duct or parallel to the high tension leads unless the distance separating the two sets of wiring is sufficient to prevent possible communication between them as a result of short circuits. Control wiring of adequate size should be used so that with full operating current flowing to the operating mechanism, the voltage across the terminals of the mechanism will be within the limits specified as standard for the range of control voltage. It is recommended that all conduits entering the mechanism housing be sealed off at their entrances to the housing.

Control and bushing current transformer connections are made inside the operating mechanism housing where suitable terminal boards are provided. Connection diagrams are supplied for each breaker showing the proper connections for the operating mechanism and the bushing current transformers (BCT). Remove any shorting wires from the BCT terminal boards only after the BCT circuitry is completely wired.

Ground Connections

The tanks and support skid of each breaker should be permanently grounded. A grounding pad is provided on both sides of the support skid of each breaker to which a ground cable terminal can be attached. The grounding cable should be of sufficient size to carry 25 percent of the current rating of the breaker but not smaller than #4/10.

A good, permanent, low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all, since it gives a false feeling of safety to those working around the equipment and may result in ultimate danger to both equipment and personnel.

Precautions

1. Before moving the breaker, opening the tank doors, or doing any work on the breaker, make certain that the primary circuits are open and effectively grounded on both sides of the breaker.

2. Make certain that all control circuits are de-energized until electrical operation is to be performed.

3. Exercise care when working on the operating mechanism. See the mechanism instruction book for additional precautions and instructions.

4. Operation of the breaker without oil is permitted, but these operations should be kept to a minimum using minimum operating pressure per the breaker nameplate. Do not operate the breaker without oil in the tanks at normal air pressure as damage to the breaker can result. A few operations can be made to check the interrupter setting, the wipe, and the lift rod setting with the breaker not energized.

Operations without oil normally result in higher operation speeds (2 to 5 feet-per-second faster. This should be taken into account if analyzer curves are taken with the breaker contacts operating without oil.

5. DO NOT USE THE MAINTENANCE CLOSING DEVICES FOR CLOSING THE BREAKER IF THE BREAKER IS ENERGIZED.

DIMENSIONAL INSPECTION

Adjustments

Although the breaker has been completely set up, adjusted and tested at the factory, it is recommend-d that all adjustments be reviewed to make certain that no change has occurred during shipment and installation. The trip latch of the mechanism should be blocked before manually operating the breaker to prevent any possibility of the breaker tripping out erroneously. The breaker should be operated slowly, using the maintenance closing device, to see that it operates smoothly throughout the closing operation. The breaker can be opened or closed using the maintenance closing device. When opening the breaker manually the breaker load should first be taken up by the maintenance closing device and then the holding prop of the operating mechanism pushed aside so that the maintenance closing device can be slowly backed off to permit the breaker to open. Electrical operation should only be attempted after it is certain all adjustments are correct. Details of the breaker adjustments are contained in the following paragraphs.

Complete instructions for checking the operating mechanism adjustments will be found in the operating mechanism instruction book.

The trip latch of the operating mechanism is blocked in place during shipment and this block must be removed before the adjustments can be checked. All blocks and wire used to hold parts in place during shipment must be removed before the breaker is opened.

Using the maintenance closing device in the operating mechanism, close the breaker slowly, checking that the moving contact rod located on the crossarm as it enters into the interrupter tubes to be sure that no binding occurs. Continue closing the breaker checking that all moving contacts enter the finger cluster assemblies at approximately the same time, then continue closing until the trip latch and props fall into position, and that the contact wipe is 0.75 plus or minus 0.062. Measure the lift rod setting on the center phase as shown in Fig. 9. The setting for the Phases One and Three may vary plus or minus 0.125 from the settings obtained in Phase Two. At the same time that contact alignment is being checked the pump actuating crossarm should be inspected for alignment also.

Contact Resistance Check

A contact resistance measurement (ductor reading) should be made on the breaker and the individual poles should be checked using a 100-ampere ductor with 100 amperes flowing before oil is placed into the tanks. A complete pole unit measured from bushing terminal to bushing terminal should measure 250 microhms or less when new. The reading should not exceed 450 microhms after the breaker is in service.

If the resistance is higher than the allowable microhms, operate the breaker several times. This will break down any silver oxides that have formed on the contact surfaces. If the resistance is still high clean the contact tips and the threads of the contact rods and check the terminals on the top of the bushings for any loose hardware or poor connections, and if it still persists continue checking through the circuit until the problem is located and corrected.

Grading Resistor Value

The grading resistors (27), Fig. 14, should be measured, and this value should be 1424 ohm to 1622 ohms and within 75 ohms of each other within the phase.

Bushing Current Transformer Checks

The bushing current transformers should be inspected prior to filling the tanks with oil. If any damage has occurred during transit it must be corrected. This will insure the removal of any grounds or shorting connections that may have been left on the BCT leads after completion of the factory tests and installation of the customer's permanent circuitry.

PNEUMATIC OPERATIONS (WITHOUT OIL)

A visual inspection of the mechanism should be made to see that all cotter pins are in place, all nuts, screws and terminal connections are secure, no binding present and that the mechanism is properly checked and lubricated in accordance with the instruction book.

Inspection of the compressor oil level must be made prior to charging the air receiver to the operating pressure. The settings of the pressure and cutoff switches must be checked to be sure they agree with the instruction book and the breaker nameplate.

Operation of the breaker without oil is permitted, but these operations should be kept to a minimum using minimum operating pressure per the breaker nameplate. Do not operate the breaker without oil in the tanks at normal air pressure as damage to the breaker can result. A few air operations can be made to check the interrupter setting, the wipe, front crank setting and the lift rod setting with the breaker not energized. Operations without oil normally result in higher operating speeds 2 to 5 feet-per-second faster, this should be taken into account if analyzer curves are taken with the breaker contacts operating without oil.

Adjustment of the Breaker Stroke

After the closed position of the breaker has been obtained it is necessary to check the breaker opening stroke. Make sure the opening dashpot, located in the pneumatic mechanism control house, has the correct oil level (Step 10 of Summary of Adjustments).

The dashpot is the open position stop for the breaker linkage. The stroke of the breaker is 13 inches ± ½ inch. The body of the dashpot, which is threaded, can be adjusted up or down to obtain the required stroke, after loosening the set screw and the locknut.

Linkage Adjustment

Check to make certain the bolts (11), Fig. 9, in the couplings are tight. If not, tighten them to 80 to 90 foot-pounds of torque with the breaker in the open position. Adjusting the front crank will affect the adjustment of both lift rod and interrupter settings of all phases.

The adjustment for the mechanism to the first pole of the breaker is obtained by turning the horizontal rod (3), Fig. 9. From the mechanism house, a clockwise rotation of the rod decreases the lift rod setting, counterclockwise rotation of the rod increases the lift rod setting. This will affect all three lift rods and interrupter settings. Consequently, the adjustments must be reset if they were previously correct because the turning of the horizontal operating rod of Pole One will affect the adjustment and settings.

The interrupter setting can be adjusted by rotating the contact rods (14), Fig. 7, to obtain the correct contact wipe.

FILLING THE TANKS

Before the final operating adjustments are made, the tanks must be filled with Type I unsulating oil. First, however, make certain that all cotter pins, washers, bolts, etc. are in place and properly tightened, and that all fittings and accessories have been made oil-tight. Use Permatex No. 2 or a similar nonconductive sealer to seal the joints if necessary. Plugs are furnished for the outlet side of the drain valves and should be used to prevent any leakage if the valve seats become dirty or damaged from use. A sampling valve is also furnished as a part of the drain valve but only when specified in the customer specifications.

Before bolting up the manhole covers, place a film of grease on the gaskets so that they will not be destroyed when the covers are again opened. Tighten the bolts uniformly.

The dielectric strength of the oil when shipped is at least 30,000 volts when tested in a standard gap with one-inch disk terminals 0.10 inch apart. Although the oil is shipped in sealed containers, careless handling during shipment or storage may result in absorption of moisture by the oil. All oil should be tested before being placed in the breaker. Oil having a dielectric strength of less than 22,000 volts should not be placed in the breaker oil tanks until its insulating value has been brought up to at least this value.

Customers desiring detailed information on the characteristics and maintenance of insulating oil should obtain Bulletin GEI-28004 from the nearest Sales Office of the General Electric Company. In filling, care must be taken so that moisture will not be absorbed by the oil during the filling process. When cold drums of oil are brought into a warm place they should be allowed to stand before opening, until there is no condensation on the outside and until they are thoroughly dry. The preparation and filling should be done on a clear, dry day or adequate protection of some kind provided against moisture being absorbed. Metal or oil-proof rubber hose must be used because oil dissolves the sulphur in ordinary hose. This may cause trouble, as sulphur attacks copper.

The normal oil level at 20°C is indicated on the outline drawing. A marker on the float-type oil gage (19), Fig. 7, is set to this reference point. The range between minimum and maximum is represented by the visible portion of the gage and covers a temperature range of 70°C, or from plus 40°C to minus 30°C. The oil level at any intermediate temperature is represented by a proportionate part of the gage range. With this type of gage, the oil level is indicated directly by the action of the float which assumes the true oil level. It is important that the oil level never falls below the minimum level. This is selected so that the lower porcelain of the bushing will always be immersed and prevent corona discharge from the ground sleeve.

OPERATING AND TIMING TESTS

After completing the preceding installation adjustments and inspection, and after filling the tanks with oil and the operating mechanism with air, the breaker may then be operated electrically to obtain the proper operating speed.

Starting with normal air pressure in the pneumatic mechanism close the breaker electrically and check the lift rod setting ④ , Fig. 9. It is necessary to remove the pipe plug from the "kick-off" spring housing cover to make this measurement. Some variation will probably be seen between the setting obtained with power and with manual operation.

Mount a travel analyzer with bracket furnished (see Fig. 17) to the breaker to obtain an accurate travel record of breaker performance. Typical curves are obtained on the center pole as this phase gives an average of the three phases. A 10-32 tapped hole is located in the top of the lift rod coupling (10), Fig. 10, of each pole unit to accommodate the rod used with the travel analyzer. Access to this hole is gained by the removal of the pipe plug. Because of the high speeds encountered, a straight-line type of travel analyzer is recommended.

Normally it is only necessary to take analyzer curves on the center phase of the breaker. This curve will be the accumulated result of the speeds and times of the three phases since the exact operating characteristics of the three phases are different. The operating curves (Figs. 12 and 13) and breaker speeds of these breakers were obtained from the center phase of an actual breaker. If the curves are not satisfactory and difficulties arise, analyzer curves of the other two phases will help determine where and what the problem is. When no-load trip-free operations are taken on the breaker the trip portion of the curve should be initiated through the breaker main contacts as this more closely simulates an actual trip-free breaker operation where the breaker is closed against a fault.

Opening Speed

The opening speed is determined by drawing a straight line through two points on the travel curve. Refer to Fig. 12. One point is to be located on the opening curve 3/4 inch from the fully closed position. This is the point at which the contacts part. The second point is to be located on the opening curve 8-3/4 inches (measured vertically) from the fully closed position. The slope of this line is an indication of the opening speed which should be 16 plus or minus 1 foot-per-second with the breaker contacts in oil. One method of determining the speed of the breaker using a Cincinnati straight-line analyzer and standard analyzer paper is to do the following:

1) Set the analyzer speed to high.

2) Obtain the curves.

3) Draw a straight line between the proper points as shown on the representative travel curves, Fig. 12 and 13, which is the slope of the curve.

4) Count off five cycles in the horizontal direction from a convenient point on the straight line and mark this point.

5) Measure vertically the distance from the point obtained in Step 4 to the straight line drawn in Step 3. This dimension in inches is equal to the speed of the breaker in feet-per-second.

If it is found necessary to readjust the opening speed of the breaker, change the settings on the opening spring (7), Fig. 9. By setting this spring to have less compression in the closed position, the opening speed will be reduced. It also follows that by setting the spring to have more compression in the closed position, the opening speed will be increased.

Closing Speed

The average closing speed can be determined in a similar manner. From a point 1.50 inches from the fully closed position to a point 4.00 inches from fully closed, the average speed should be from 9 to 12 feet-per-second when operating at normal pressure.

The closing speed is mainly controlled by the pneumatic operating mechanism and to some minor extent by the opening spring of the breaker. All three phases of the breaker must close and open within 180 degrees of each other and within 60 degrees in any one phase. The orifice nut on the piston rod of the closing cylinder of the operating mechanism has the largest effect on the closing speed which is not adjustable. A somewhat smaller but adjustable effect on the closing speed and closing time is the orifice adjusting screw as described in the operating mechanism instruction book. Screwing this orifice adjusting screw in all the way will slow the breaker closing speed and time. The orifice adjusting screw is effective for approximately 1/2 inch from the seated position and can vary the closing time approximately 1-1/2 cycles. For additional information, consult the instruction book for the operating mechanism paying particular attention to the section on INSTALLATION ADJUSTMENTS.

Lift Rod Overtravel

The overtravel of the lift rod must not exceed 1/2 inch when closing the breaker. The analyzer pencil always indicates more overtravel than there actually is due to clearances of the pencil support. The best way to accurately measure this is to place some putty about 5/8 inch above the pencil head on the analyzer, with the breaker in the closed position; then trip and close the breaker. If the pencil head does not touch the putty, move the putty down, and repeat this operation until the pencil head just touches the putty during the closing operation. If the overtravel is found to exceed 1/2 inch, check the trip speed. If the trip speed is on the low side of the allowable range tighten the opening spring (7), Fig. 9, which will raise the opening speed, lower the closing speed and lower the overtravel.

When opening in oil, the breaker should open the full stroke. The travel curve will be acceptable if the indicated rebound at the fully open position is less than 1/2 inch. A slight variation among the three phases within the above tolerance is permissible.

After satisfactory curves have been obtained, lock the final adjustments in position. Assemble all gaskets, covers and fittings and tighten properly.

Summary of Adjustments and Checks

Refer to Fig. 9 for the physical location.

1. The lift rods should hang in an approximately vertical position with a clearance of approximately 1/64 inch minimum between the guide block and the side of the rod in both directions.

2. The interrupters should be within 1/8 inch of plumb over their lengths and the contact finger cluster in line with the moving contact.

3. The horizontal rod between the mechanism house and the first pole of the breaker controls the lift rod settings at all breaker poles.

4. The lift rod setting in the breaker closed position should be 13.3 inches plus or minus 1/16 inch for manual adjustment. Stops by power should be held to plus or minus 1/32 inch of the manual adjustment.

5. With the breaker in the open position the pump rod should protrude beneath the bearing cap 6.00 inches plus 1/8 inch minus 1/16 inch.

6. The lift rod stroke should be 18 inches, plus or minus 1/2 inch.

7. The nominal opening spring length is 15-1/4. The minimum compressed length of the opening spring is 9-3/4. Compressing the spring to a value less than 9-3/4 might permit the spring to go solid on overtravel possibly damaging the breaker.

8. The contact wipe is 11/16 to 13/16 inch.

9. With the interrupters open, check the resistance of the grading resistors. These should check to 712 to 811 ohms for any interrupter, but can be 1424 to 1622 ohms but must be within 75 ohms of each other within the phase.

10. The opening dashpot oil level should be checked. The opening dashpot level is correct when the oil will just run out of the hole left by removing the small pipe plug in the side of the cylinder. With the dashpot plunger in the up position oil may be added at this point. The dashpot uses oil furnished with the field supplies. The dashpots should be examined to see that the piston works freely and that there is no sludge present.

11. Check the tightness of the clamping bolt(s) of the couplings to 80/90 foot-pounds torque. If a torque wrench is not available, tighten the bolt(s) so that with the breaker in the open position, a twelve-inch pipe wrench applied with moderate force cannot turn the operating rod. When this is done the clamping bolts are properly tightened.

12. When the breaker is in the closed position the pump rod should extend 1-7/16 inch from the pump bearing cap to the pump actuating button assembly.

SUMMARY OF ADJUSTMENTS AND CHECKS

TABLE OF ADJUSTMENTS

For further reference the initial adjustments and checks of the breaker at the time of installation should be written in the appropriate columns of the chart below. Record operation with power at normal (240 psig) pressure with oil in the tanks.

		Pole 1	Pole 2	Pole 3
Breaker Stroke	-18" ± 1/2"			
Lift Rod Dimension	-			
Breaker Stroke	- 18" ± 1/2"			
Lift Rod Dimension	- 13.2 to 13.3"			
Contact Wipe	- 11/16 to 13/16			
Interrupter to Crossarm Clearance	- 1/2"			
Part Contact Within the Phase	- 1/16" Max.			
Part Contact Between Phases	- 1/2" Max.			
~~Opening Spring (Compressed Length)~~	~~- 9-3/4~~			
Opening Spring (Free Length)	- 15-1/4			
Interrupter Resistor (Each Interrupter)	- 750 Ohms +8%-5%			
(Within a phase)	- within 75 ohms of each other			
Contact Resistance - New - Michrohms	- 250			
(Using 100 Ampere Ductor with 100 Amperes Flowing) - Used - Microhms	- 450			
Opening Speed - measured on opening curve 3/4 to 8-3/4 from fully closed position	- 15 to 17 Ft./Sec.			
Closing Speed - measured on closing curve 1-1/2 to 4.0 from fully closed position	- 9 to 12 Ft./Sec.			
Reclosing Time	- 20 Cycles (Min.)			
Rebound - Closing	- 1/2"			
Rebound - Opening	- 1/2"			
Lift Rod Overtravel - Closing	- 1/2"			

FINAL INSPECTION

1. See that the breaker is properly set up and leveled on its foundation and that the foundation nuts are tight.

2. See that all nuts, washers, bolts, cotter pins, lock rings, and terminal connections are in place and tightened. The gland nuts on all valves should be checked to see that they are sufficiently tight to prevent leakage. In tightening the gland nuts, precautions should be taken to prevent damaging the packing through excessive pressure. Do not wrench the bushing mounting hardware, for in doing so the interrupter alignment may be disturbed.

3. Inspect all insulated wiring to see that no damage has resulted during installation, and test for possible grounds or short circuits.

4. See that all bearing surfaces of the operating mechanism and breaker have been lubricated.

5. Make certain that the dashpot is filled to the proper level.

6. Make certain that the oil tanks are filled to the proper level.

7. Make certain that the installation adjustments and operating adjustments have been thoroughly checked and recorded in the space provided under the TABLE OF ADJUSTMENTS.

8. See that all covers and bolted connections are securely tightened and that all pipe plugs for inspection openings are properly installed, tightened and sealed to prevent the entrance of moisture.

9. See that any point, where the surface of the paint has been damaged during installation, is repainted immediately using alkyd base paint with a suitable primer if necessary.

OPERATION

To close the breaker, the pneumatic operating mechanism moves the vertical operating rod (30), Fig. 16, in the mechanism house in an upward direction. This motion is transferred through the front crank (18), located in the pneumatic mechanism on the Pole One tank, to the horizontal connecting rods (6, 9 and 19) and to the Phase Three straddle link (11). This action operates the linkage on all three pole units which, in turn, transfers the motion of the vertical lift rods (35) in each of the breaker tanks.

On opening, the lift rods and the crossarms are gradually decelerated by the dashpot (28) which is actuated by the dashpot crank six inches before the fully open position. This action eliminates the possibility of a large rebound at the end of the opening stroke.

On a fault operation the contacts part drawing an arc within the baffle assembly between the stationary contacts and the tips of the moving contacts. The pressure generated by the arcs forces the oil to flow into the arcing area and through the pathways formed by the baffle assembly to and out of the interrupter tube. Gases and arc products are thus ejected from the interrupter tube and clean oil enters the arcing area. The arcs are rapidly lengthened and cooled, its resistance is increased and at an early current zero the arc cannot reestablish itself, and interruption occurs.

MAINTENANCE

To maintain dependable service and safety of power equipment is is recommended that a definite maintenance schedule be set up and followed, as serious shutdowns can be avoided by locating potential sources of trouble in an early stage. A periodic lubrication of parts subject to wear is also vitally important for the successful operation of the breaker and operating mechanism.

BEFORE ANY MAINTENANCE WORK IS PERFORMED MAKE CERTAIN THAT ALL CONTROL CIRCUITS ARE DE-ENERGIZED AND THAT THE BREAKER PRIMARY CIRCUITS ARE OPEN AND EFFECTIVELY GROUNDED. ALSO, DO NOT WORK ON THE BREAKER OR MECHANISM WHILE IN THE CLOSED POSITION UNLESS THE PROP AND TRIP LATCH HAVE BEEN SECURELY WIRED OR BLOCKED TO PREVENT ACCIDENTAL TRIPPING.

See the mechanism instruction book for the proper method used to block the latches, props and springs.

PRECAUTIONS

1. Be sure the breaker is disconnected from all electric power, both high voltage and operating voltage, before inspecting or repairing.

   Circuit breakers are not to be considered as an isolating means for providing safety to personnel when working on lines or other electrically connected equipment.

   Visible-break isolating means with suitable grounding provisions must be used to provide visible isolation from the power lines.

2. After the breaker has been disconnected from the power lines, grounding leads should be properly attached before coming in contact with any of the breaker parts.

3. Be sure the breaker frame and tanks are well grounded.

4. Use the maintenance closing device on pneumatic mechanisms to assist in making adjustments. This is the primary purpose of the device because it permits slow closing and opening. Never use the maintenance closing device to open a breaker when it is not possible to check that the cross-arm of each phase is in the open position. The device must not be used to close the breaker on load.

5. It is advisable to drain the air receiver before working on the pneumatic operator or the breaker.

6. After making any adjustments operate the apparatus manually before attempting electrical operation.

7. Use only the paint requested for the exterior of the breaker and mechanism house for touchup or repainting.

PERIODIC INSPECTION

The frequency of periodic inspections should be determined by each operating company on the basis of the number of operations (including switching), the magnitude of currents interrupted, and any unusual operations that occasionally occur. Operating experience will soon establish a maintenance schedule which will give assurance of proper breaker conditions. On installations where a combination of fault duty and repetitive operation is encountered, an inspection is recommended after any severe fault operation.

1. The condition of the contacts should be checked. See that they are aligned, and that the contact surfaces bear with firm, uniform pressure. Since any operation of the breaker may cause contact wear, the contact compression of each interrupter should be inspected periodically.

2. The baffle stack must be replaced when the contact hole through the baffle plate just above the top exhaust port in the baffle stack is 1/4 inch in diameter larger than the diameter of the contact rod. The baffle stack plate hole is 1-3/8 inch plus or minus 1/64 inch in diameter when the baffle stack is new.

   The tip of the contact rods can be machined to remove the eroded portion of the tip but the contact rod after machining must meet the following conditions.

3. The contact fingers must not rest on the copper portion of the contact rod when the breaker is closed; they must be safely on the silver molybdenum portion of the rod.

4. The lower end of the threaded portion of the contact rod must be below the clamping bolt on the crossarm.

   If either condition 3 or 4 is not met the contact rod must be discarded.

5. The quality of the oil should be checked. Oil in service should be tested at frequent intervals; three month periods are recommended.

   If the dielectric strength of the oil tests less than 22,000 volts, it should be filtered. When sampling oil, the sample container should be a large-mouthed glass bottle. The bottle should be cleaned and dried with benzine and free from moisture before it is used. A dry cork stopper should be used. The sample of the oil should be at least one pint. Test

samples should be taken only after the oil has settled for some time. Samples should first be taken from the valve at the bottom of the tank and sufficient oil should be drawn off to make sure the sample represents oil from the tank proper and not that stored in the drain pipe. A glass receptable is desirable so that if water is present it may be readily observed. If water is found, an investigation of the cause should be made and a remedy applied. Excessive water is indicative of leakage somewhere in the breaker structure.

6. All insulation parts should be thoroughly cleaned and wiped down using a clean lint-free cloth saturated with clean insulating oil to remove all traces of carbon which may remain after the oil has been drained from the tank. It is recommended that the oil be removed and the tank cleaned at regular intervals because filtering the oil alone does not remove the carbon which adheres to the inside of the tank or to the insulating members.

7. The breaker linkage lubrication should be thoroughly checked. All bearing surfaces should be lubricated with G-E Lubricant D50H15.

8. The oil level of the opening dashpot which is located in the control house should be checked. The opening dashpot oil; level is correct when the oil will just run out of the hole left by removing the small pipe plug in the side of the cylinder. With the dashpot plunger in the up position, oil may be added at this point. The dashpots use oil that is furnished with the field supplies.

   Add a sufficient amount of clean oil, working the piston up and down approximately 1/4 inch to relieve air pockets, to bring the oil level even with the opening. Then remove the pipe plug, draining the oil to the correct level.

9. Check the alignment of the movable contacts on the crossarm with the interrupter contacts.

10. All bolts, nuts, washers, cotter pins, lock rings, and terminal connections should be in place and properly tightened. The gland nuts on the valve should be checked to see that they are sufficiently tight to prevent leakage. In tightening a gland nut precautions should be taken to prevent damaging the packing through excessive pressure.

11. Inspect the bushing supports, as the vibration due to the operation of the breaker may cause the bushings to move slightly and result in misalignment of the contacts. If the bushing mounting bolts are not sufficiently secure, tighten with approximately 65 to 70 foot-pounds of torque.

12. Clean the bushing porcelains at regular intervals, especially where abnormal conditions prevail such as salt deposits, cement dust, or acid fumes, to avoid flashover as a result of accumulation of foreign substances on their surfaces.

If a water solution under pressure is used to clean the bushing porcelains care must be taken that the stream of solution is not directed at the breather (18), Fig. 7, located on top of the mechanism housing. An excessive stream of solution directed up at the breather might permit some of the solution to enter the breather and damage the insulation. The breather may be removed and a pipe plug installed properly during a washing operation of this type. Make certain the breather is installed properly after the washing operation.

13. Check all adjustments of the breaker linkage and contacts as explained in the section INSTALLATION ADJUSTMENTS.

14. Consult the operating mechanism instruction book for maintenance recommendations on the operating mechanism.

15. See that the oil is at the proper level in the tank and bushings.

16. Check the drain valve of the three oil tanks making certain they are closed and that the pipe plug is tight to prevent leakage of the insulating oil.

17. Check the electrical operation and speed adjustments as explained under INSTALLATION, OPERATING ADJUSTMENTS.

LUBRICATION

In order to maintain reliable operation, it is important that all circuit breakers and their mechanisms be properly lubricated at all times. During assembly at the factory all bearing surfaces, machined surfaces, and all other parts of the breaker subject to wear have been properly lubricated using the best lubricants available. However, even the finest oils and greases oxidize to some extent with age, as evidenced by hardening and darkening in color. Consequently, all lubricants should be renewed periodically.

Frequency operation of a breaker causes the lubricant to be forced out from between the bearing surfaces. A simple lubrication will sometimes clean up symptoms of distress which might be mistaken for more serious trouble. It is also recommended that all breakers be operated at regular intervals to insure the user that the equipment has not become sluggish.

The correct period between maintenance lubrication depends to a great extent upon local conditions. Until a definite schedule has been worked out, the breaker should be lubricated annually and also whenever it is overhauled, as outlined in the LUBRICATION CHART. Breakers in very highly repetitive service should be checked more often.

LUBRICATION CHART		
PART	LUBRICATION AT ANNUAL MAINTENANCE PERIOD	ALTERNATIVE LUBRICATION (REQUIRES DISASSEMBLY)
Ground Surfaces (Rollers, etc.)	Wipe clean and apply D50H15. Use very thin film on magnet faces.	Same as maintenance lubrication.
Sleeve Bearings (Breaker Linkage-Textolite** and Bronze)	Very light application of light machine oil, SAE20 or 30.	Clean per instructions. Apply D50H15 liberally.
Opening Dashpot	With piston in the up position, fill even with fill hole, using oil furnished with field supplies.	Clean thoroughly and refill. Same instructions as maintenance lubrication.
Note: General Electric Lubricant D50H15 is available only in cartons containing twelve collapsible tubes of grease. This is a total of three pounds of grease to the carton. It is so packaged to insure cleanliness and to prevent oxidation.		

The LUBRICATION CHART shown gives complete information for lubricating the breakers. One column shows the recommended ANNUAL LUBRICATION which requires no disassembly. The other column, ALTERNATIVE LUBRICATION, outlines a procedure similar to that performed on the mechanism at the factory, but should be used only in case of a general overhaul or disassembly for other reasons, or if the operation of the breaker becomes sluggish. The alternative method of lubrication, however, should be undertaken after five years of service.

CLEANING

Wherever cleaning is required, as indicated in the LUBRICATION CHART, the following procedures are recommended:

Pins

The pins should be removed and all old oxidized grease removed by immersion in clean petroleum solvent or other similar cleaner. Do not use Chlorothene unless the pins are dipped into a container of light clean oil to protect the surfaces immediately after cleaning with Chlorothene. Do not handle the pins with bare hands as deposits from the skin onto the pins are inducive to corrosion. If the pins are touched, the contamination can be removed by washing in alcohol. After the pins have been thoroughly cleaned, dip in clean, new, light machine oil until the cleaner or solvent is entirely removed.

Wipe the pin clean, then apply a small amount of G-E Lubricant D50H15 to the entire surface just before reassembling.

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Bearings

If it becomes necessary to clean the bearings in alcohol (shellac thinner), be sure the alcohol is perfectly clean, and do not allow the bearings to remain on the alcohol more than a few hours. If it is desirable to leave the bearings in the alcohol for a longer time, an inhibited alcohol such as is used for anti-freeze should be used. Even then the bearings should be removed from the alcohol within twenty-four hours. Esso Anti-Freeze and Du Pont Zerone are satisfactory for this purpose. Precautions against the toxic effects of the alcohol and Chlorothene must be exercised by wearing rubber gloves and by using the alcohol in a well ventilated room; excessive exposure to the fumes can be unpleasant to personnel. Washing the bearings in the light oil and draining should follow immediately, then apply the lubricant.

Do not use Chlorothene on Textolite** bearings as it will adversely affect the Textolite**.

Gaskets

The following instructions cover the preparation of gaskets and gasket surfaces whenever it becomes necessary to replace them. Clean all gasket surfaces thoroughly to remove all oil, grease or foreign material which will prevent proper adhesion of the gaskets or sealing of the joints. Allow them to become thoroughly dry.

Rubber gaskets can be adequately cleaned if washed in warm water using a bath soap or any other non-detergent soap. Rinse thoroughly with clean water and let air dry before using. Use a good grade of rubber cement, such as Scotch Grip 847 adhesive, to hold the gasket in place during assembly.

For joints such as covers, manholes, or places where the joint has to be opened, apply a coating of grease prior to closure to prevent sticking.

REPAIR AND REPLACEMENT

BUSHINGS

Little or no maintenance is required of the bushings other than a periodic cleaning of the porcelains. Instruction book GEK-2020 shows the construction of the bushings. In locations where abnormal conditions prevail, such as salt deposits, cement dust, etc., it should be recognized that a special hazard exists and the bushings should be cleaned regularly to avoid accumulations on the external surfaces that might cause a flashover.

If removal of a bushing is required it will first be necessary to remove the interrupter. When reinstalling the bushing, make certain the gasket between the adapter plate and the mounting flange of the bushing is replaced with a new gasket. Apply D50H15 grease to the gasket before assembling the bushing.

When lowering the bushings into place in the breaker, care should be taken to see that the lower porcelains do not damage the bushing current transformers as they pass through. Proper alignment of the bushing is obtained using the bushing aligning tool supplied with the breaker tools. Mount the aligning tool on the bottom of the bushing using the two bolt holes; see Fig. 8. Attach the aligning bracket with the arrow pointing toward the low side of the bushing (away from the lift rod) so the stamping on the aligning bracket can be seen. Line up the plumb bob with the center of the tool which fits in the crossarm aligning screw. The breaker and lift rod guides have been previously plumbed. The plumb bob point should be within 1/8 inch of the center of the crossarm aligning screw. The bushing mounting bolts should be tightened gradually and evenly to approximately 65 to 70 foot-pounds of torque.

When the bushings have been shipped separately refer to the section UNPACKING AND HANDLING. When shipped in groups of three to six, they are carefully packed in crates and shipped vertically. Remove these bushings from their crates by attaching slings to lifting eyes in the mounting flange as shown in Fig. 2. Adjust the sling until the bushing is at an angle of approximately twelve degrees to the vertical, see Fig. 3, that position which it finally assumes when placed in the breaker. The bushing potential tap should face the side of the breaker as shown in Fig. 7. Wipe the bushing clean and dry.

Prior to removing the bushing from the crate for installation in the breaker, rotate the bushing so that its potential tap is at the bottom. Remove the bushing from its crate by means of a rope sling as shown in Fig. 4. The bushing can then be laid flat and the cable hooks attached to the lifting ears. A rope sling can be placed at the top of the bushing to give the proper assembly angle. When the bushing is elevated in this manner care should be taken so the bushing does not slide along the ground or support too much weight at the bottom end.

If it becomes necessary to place a bushing in service which has been stored in its individual crate and where the bushing is to be energized within 48 hours, rock the bushing gently to release any entrapped gas or air which may have lodged in the insulating structure. This procedure is not required of a bushing shipped or stored in the vertical position. To eliminate air entering the bushing insulation it is recommended that bushings be stored in a vertical position.

The bushing mounting hardware, used in sealing the bushing support openings during shipment, is used to clamp the bushing in position after the bushing alignments have been made. See Fig. 8. With the bushing in this position the pointer of the oil level gage should indicate approximately normal at a bushing temperature in the range of 20 to 25 degrees centigrade.

Fig. 11 shows how the bushing is mounted on the bushing adapter and pocket in the tank. The bushing support flange and the bushing adapter plate both have oversized bolt holes, permitting angular movement of the bushing for proper alignment.

BUSHING CURRENT TRANSFORMERS

Transformers should be connected in accordance with the instruction book, GEH-2020, to be sure of proper polarity and correct connections. If it should be necessary to replace a transformer, care must be taken to see that the surface of the transformer carrying a white mark is placed upwards.

Bushing current transformers (BCT's) are suspended from three studs mounted in bosses welded to the tank top frame. See Fig. 11. Each current transformer is held in place on its mounting plate by three nylon strapping assemblies.

To remove the BCT first remove the interrupter unit and disconnect the transformer lead wires from each other. Identify each lead as it is disconnected for ease in reassembly.

To remove the BCT's, support lower current transformer and remove three nut assemblies. The current transformer is then free to be guided down the supporting studs, Fig. 11.

When reconnecting the BCT's care must be taken that the white mark is placed upwards.

The BCT leads are brought out through a hole in the back sheet of the pneumatic mechanism control house, where there is a sealing gasket through which the cables are threaded. The leads are then connected to the terminal boards located on the right-hand side of the back sheet of the control house.

INTERRUPTER

With the breaker in the open position the interrupter tube can be lowered for inspection and repair of the contact fingers and associated parts. The shunting resistor assembly must be removed first by loosening the locking set screw in the lower connection and then loosen the top mounting bolt. Remove the lower mounting bolt. The weight of the resistor is now supported by the top bolt. The resistor assembly can now be removed by swinging the top out of the adapter mounting tang as the assembly is lowered out of the bottom connection. Care must be exercised when handling this assembly since the resistor disks are manufactured from a ceramic material.

The interrupter tubes can now be lowered by removing the eight mounting bolts and nuts, which pass through the adapter flange and clamping ring. The contact finger assembly is now accessible and can be examined for excessive burning, pitting or wear. If it is necessary to change the contact fingers remove the flexible connections from the contact block. This permits removal of the entire contact finger assembly. If further disassembly of the interrupter chamber is required the upper spacer, insulating shims, the baffle stack and the lower spacer can be lifted out exposing the resistor contact.

Removal of the resistor contact is accomplished by loosening the external connection locking set screw and then unthreading the external connection stud. The resistor contact assembly can be lifted out. Remove the contact spring by sliding it out of the slot in the contact plate.

If the interrupter adapter has been disturbed it can be realigned by loosening the adapter to bushing hardware and applying the interrupter aligning tool as shown in Fig. 18. Tightening the hardware in the proper sequence and using a spirit level on the interrupter tube mounting surface will insure vertical alignment. Once alignment is obtained tighten the mounting hardware to 45 to 50 foot-pounds torque.

When reassembling the interrupter, the parts are put back in the reverse order from the way in which they were taken out. Care must be taken that the locating pins in the insulating spacers and baffles are properly installed into their respective locating holes. This will insure that the exhaust ports of the baffle stack is located correctly to the openings in the interrupter tube.

The upper insulating spacer should extend 0.015 to 0.030 inch above the top edge of the interrupter tube. This protrusion makes certain that the baffle stack and spacers are tightly held in place when the interrupter is assembled. The 0.015 to 0.030 inch is obtained by use of insulating shims. The top insulating spacer is installed into the interrupter tube with the two deep slots on the top side to clear the contact finger block. This also assures that the insulating shims are firmly compressed.

When tightening the 0.500-13 mounting hardware which fastens the interrupter tube to the adapter, a torque of 45 to 50 foot-pounds should be used.

After assembly make certain that the exhaust ports of the baffle can be seen when looking into the interrupter through the exhaust port openings of the interrupter tube. If the exhaust ports cannot be seen, the interrupter is incorrectly assembled and must be corrected by disassembling and rotating the baffle to the correct location. Check for missing or crushed locating pins.

OIL PUMP

To remove the oil pump place the breaker into the open position, and remove the four 0.375-16 mounting screws. Care must be exercised because a sealing "O" ring between the oil pump body flange and the interrupter adapter mounting surface will be exposed.

If further disassembly is required it is obtained by compressing the internal springs, loosening the locking set screw located on the side of the pump body, and threading out the bearing cap assembly. Compression of the internal springs is obtained by inserting a piece of 0.250-20 thread stock through the hole in the top of the pump body and threading into the piston, then with spacers covering the hole in the pump body, thread a nut on the rod and slightly compress the spring. This will remove the spring load from the bearing cap assembly.

Disassembly of the bearing cap assembly is obtained by removal of the internal retaining ring. To remove the retaining ring put a screwdriver or other instrument into the notched end of the ring and pry in and up at the same time. With the end free of the groove start spiraling the ring out of the groove. The plates, buffers, and spacers located beneath the retaining ring can now be removed for examination or replacement.

Reassembly is obtained by assembling the parts in the reverse order from the way in which they were removed.

GRADING RESISTOR

The resistance of the grading resistors should be 712 to 811 ohms. If it varies more than this, disassemble the resistor for inspection.

To disassemble a resistor, remove the top locknut, lifting off the upper end cap. This permits the carbon disks to be removed for inspection and for removal of any foreign material from between the disks. Replace any damaged disks. Care must be taken that no particles of dirt are assembled between the disks. In the assembled resistor, the Belleville washers must be oriented as shown, along with the relationship of the top cap to the bottom cap before compressing the Belleville washers 0.032 to 0.046 inch.

CONTACT ROD

Replacement of the movable contact rods must be done in pairs when made within the phase of the breaker. With the breaker in the open position the contact rods can be removed by loosening the bolts at the contact ends of the crossarm and then unscrewing the contact rod.

PUMP ACTUATOR BUTTON

If it becomes necessary to rebuild the pump actuator buttons, Fig. 19, place the breaker into the open position, loosen the clamping hardware and then remove from the crossarm. Further disassembly is accomplished by removing the nut (5) at the bottom of the stud. When reassembling the Belleville washers (2) they must be stacked in series to obtain the correct load and deflection.

REPLACEMENT PARTS

It is recommended that sufficient replacement parts be carried in stock to enable prompt replacement of worn, broken, or damaged parts. A stock of such parts minimizes service interruptions caused by breakdowns and saves time and expense. When continuous operation is a primary consideration, more renewal parts should be carried, the amount depending upon the severity of the service and the time required to secure replacement.

Replacement parts may not always be identical to the original parts since improvements are made from time to time. The parts which are furnished, however, will be interchangeable.

When ordering replacement parts, address the nearest sales office of the General Electric Company, giving the complete data shown on the breaker nameplate, such as the serial number, type and rating of the breaker. The breaker nameplate is mounted on the inside of the door of the operating mechanism compartment. Also, furnish a complete description of each part as outlined above, the quantity required and, if possible, the number of the requisition on which the breaker was originally furnished.

Fig. 1 (8919064E)

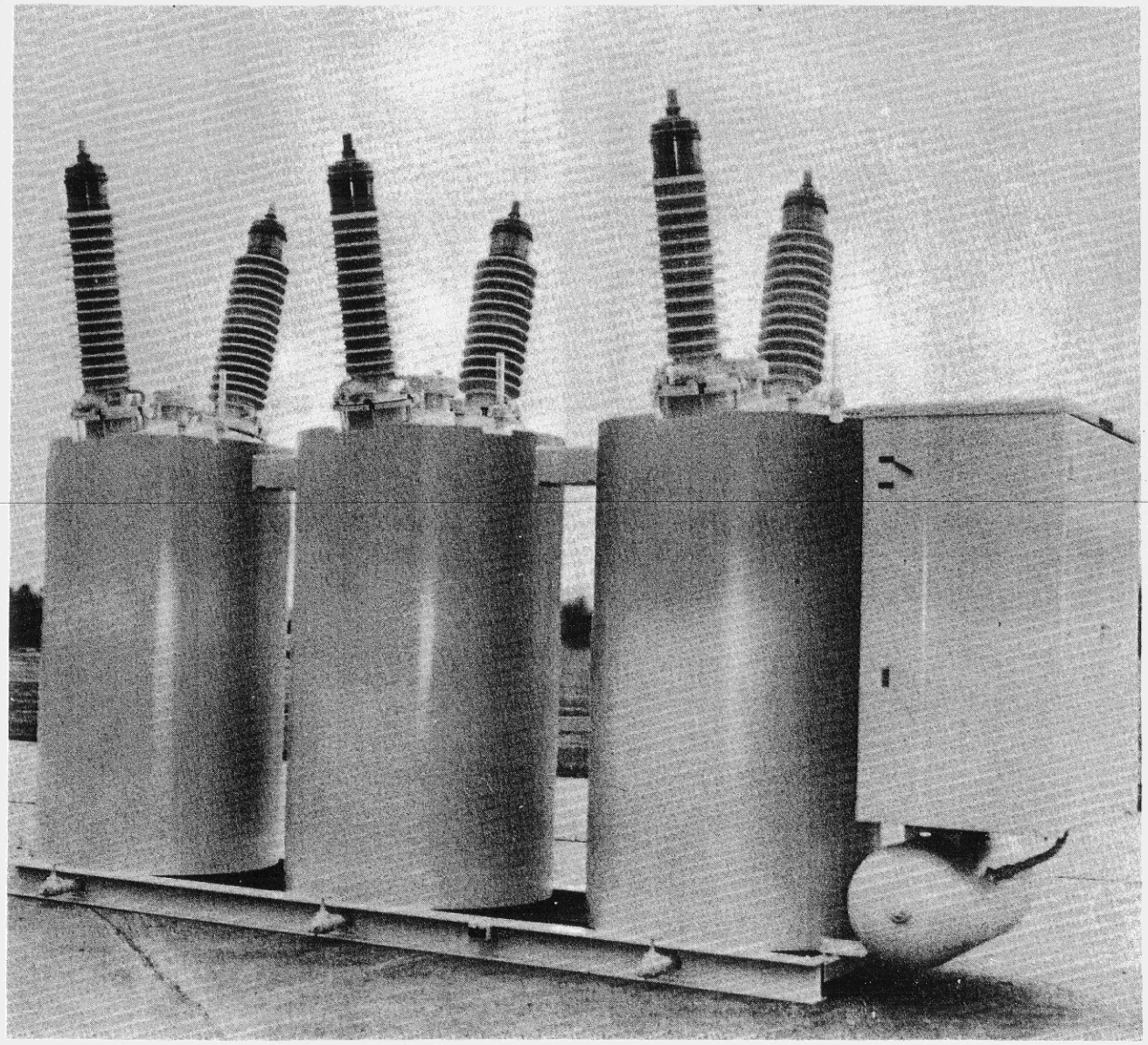


Fig. 1 Type FK-Oil Blast Circuit Breaker

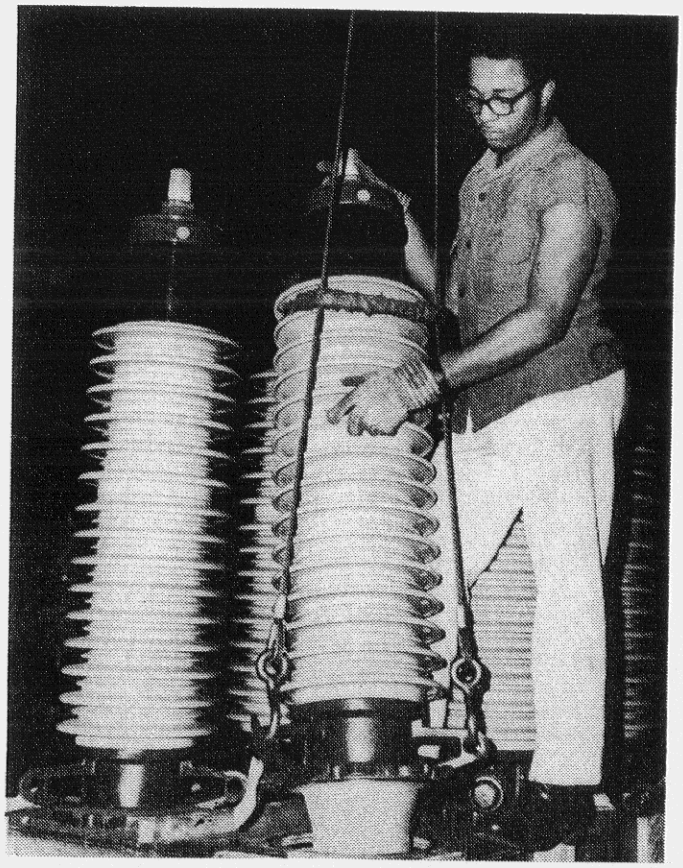


Fig. 2 (8040721)

Fig. 2 Vertical Lifting of Bushing for Removal from Shipping Crate

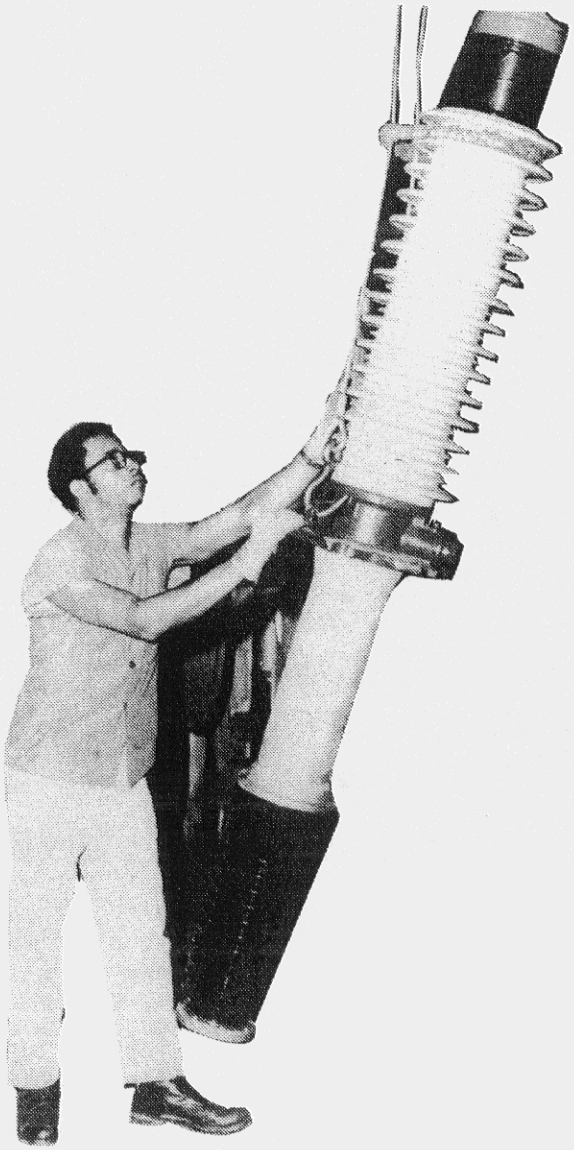


Fig. 3 (8040718)

Fig. 3 Slinging Arrangement for Installation of Bushing in Breaker

Fig. 4 (8025326)

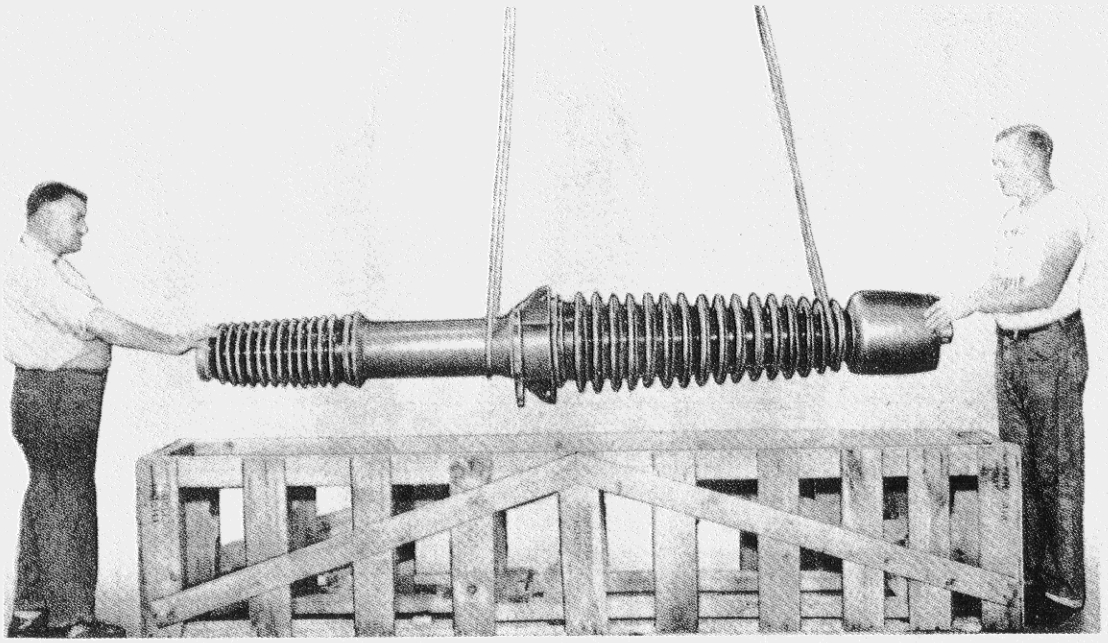


Fig. 4 Horizontal Lifting of Bushing for Removal from Crate

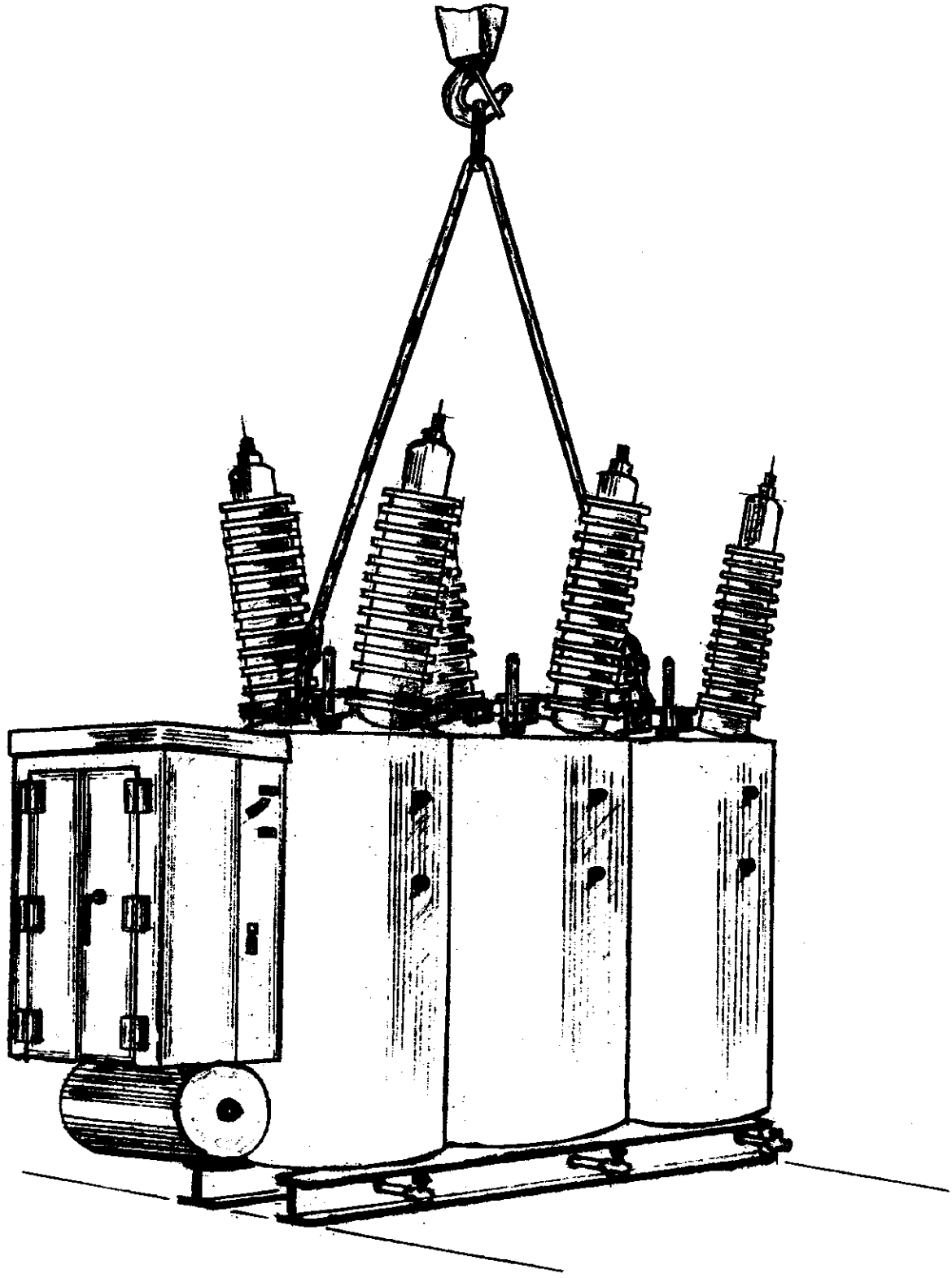


Fig. 5 (0275A6299-0)

Fig. 5 Method of Slinging The Breaker For Lifting

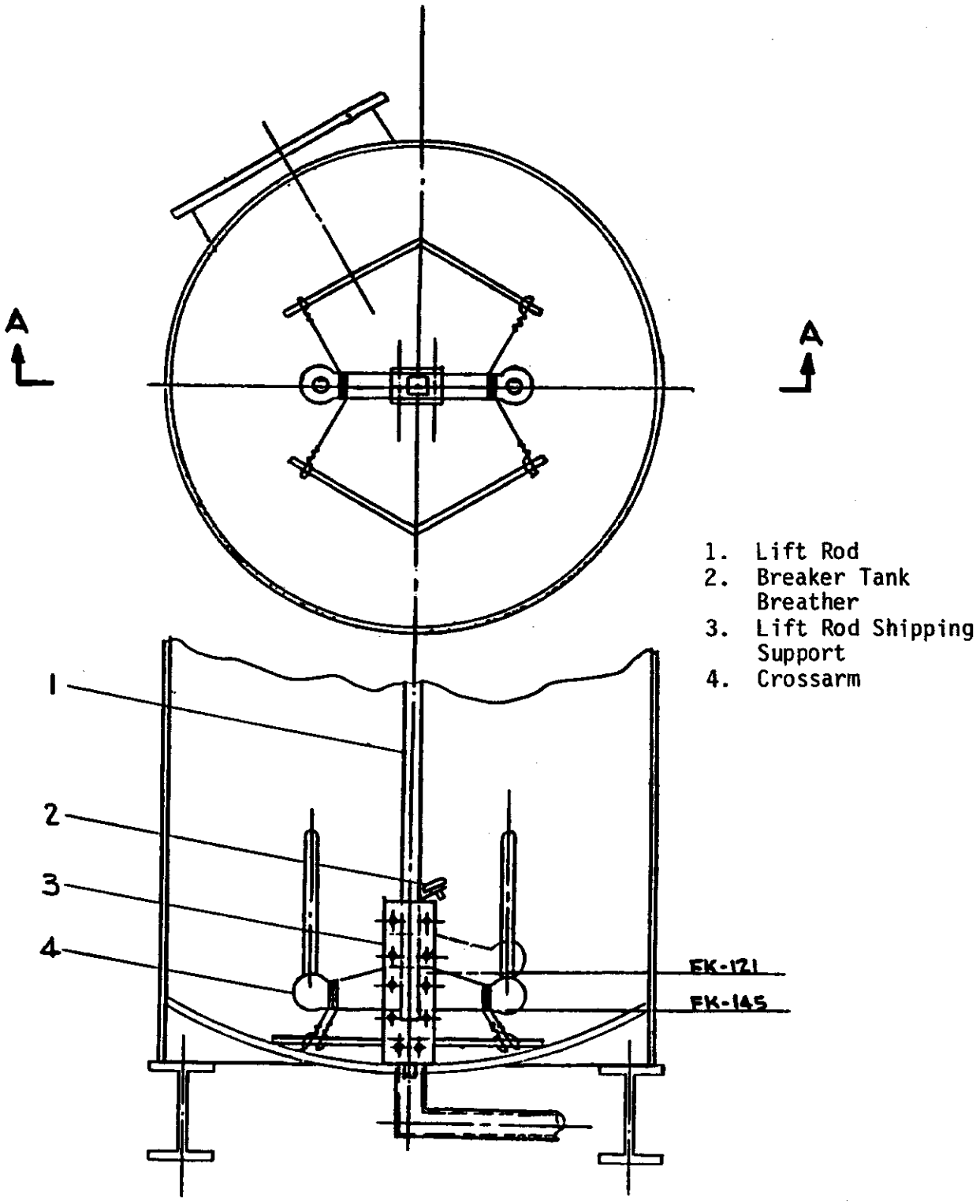


Fig. 6 (0275A6298-0)

1. Lift Rod
2. Breaker Tank Breather
3. Lift Rod Shipping Support
4. Crossarm

Fig. 6 Lift Rod Support When Bushings Are Shipped Separately

1. Bushing Oil Sight Glass
2. Bushing
3. Bushing Bolts
4. Capacitance Tap Outlet
5. Bushing Mounting Plate
6. Fill Valve Pipe
7. BCT Mounting Flanges
8. Bushing Current Transformers
9. Potential Device Mounting Boss
10. Interrupter Shield
11. Interrupter
12. Resistor Assembly
13. Crossarm
14. Moving Contact
15. Slide Prevention Rail
16. Drain Valve
17. Sampling Valve
18. Breather
19. Oil Gage Site Glass
20. Oil Level Indicator
21. Bushing Flange
22. Breaker Mechanism Box
23. Lift Rod Guide Brackets
24. Lift Rod Guide
25. Lift Rod
26. Manhole Door
27. Crossarm Hardware
28. Support Skid

Items for Fig. 7

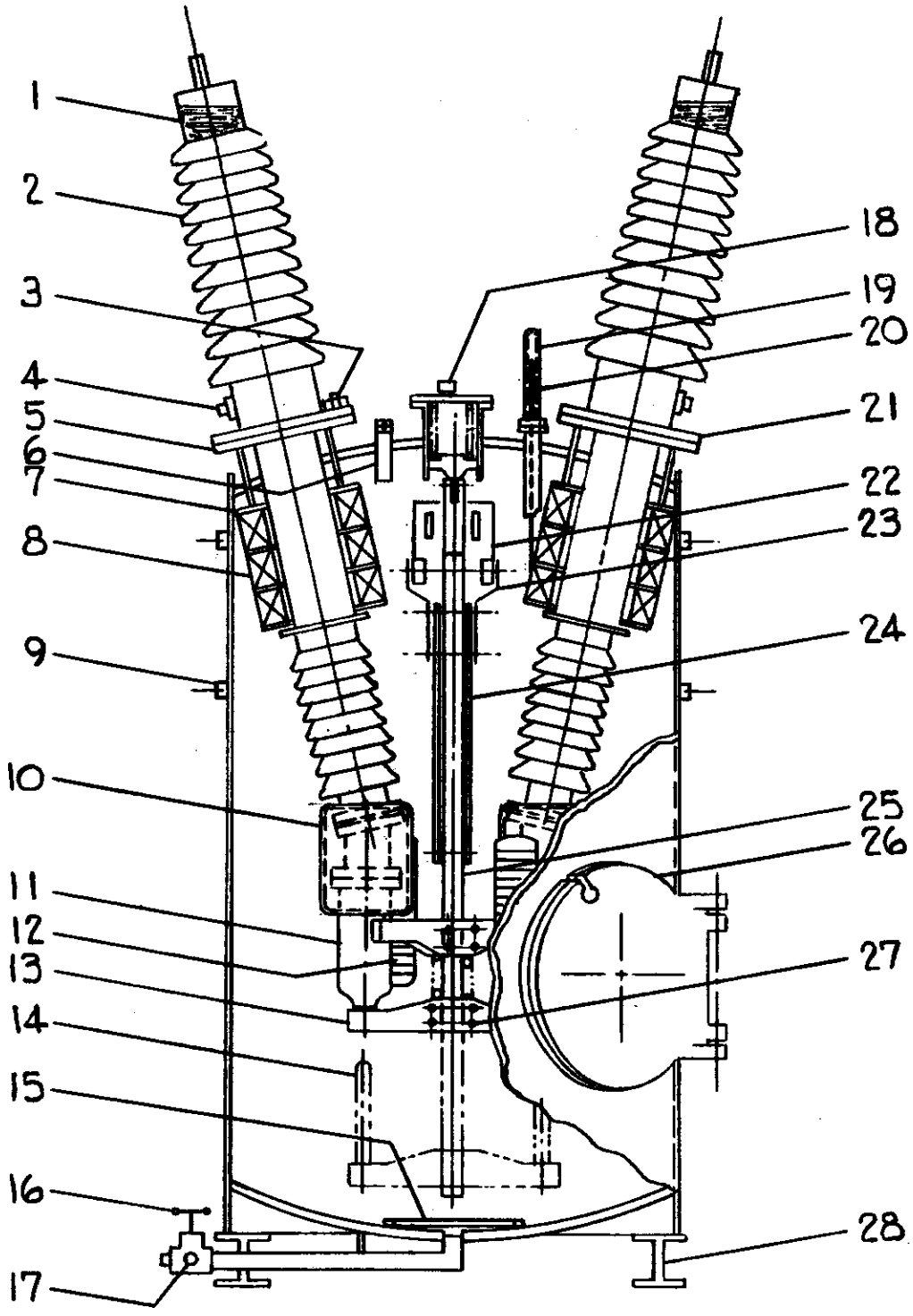


Fig. 7 (0275A6297-0)

Fig. 7 Cutaway View of Single Pole Unit

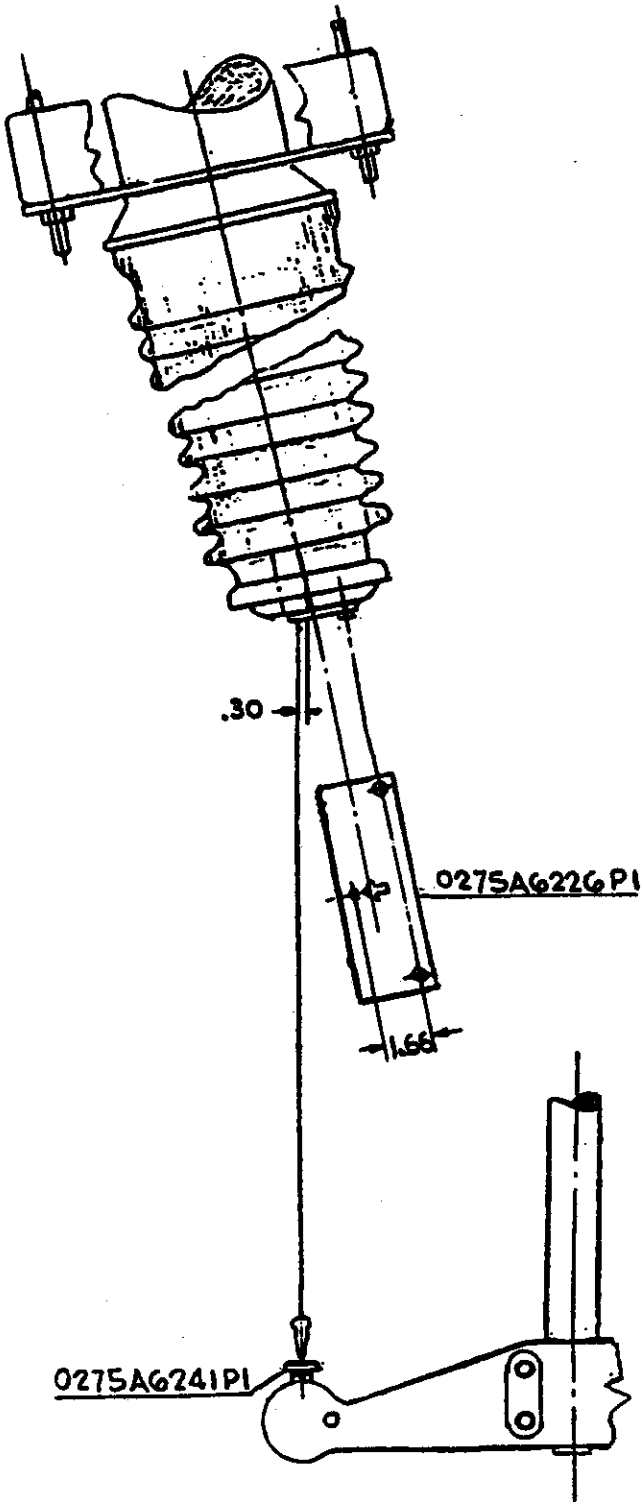


Fig. 8 (0275A6296-0)

Fig. 8 Bushing Alignment

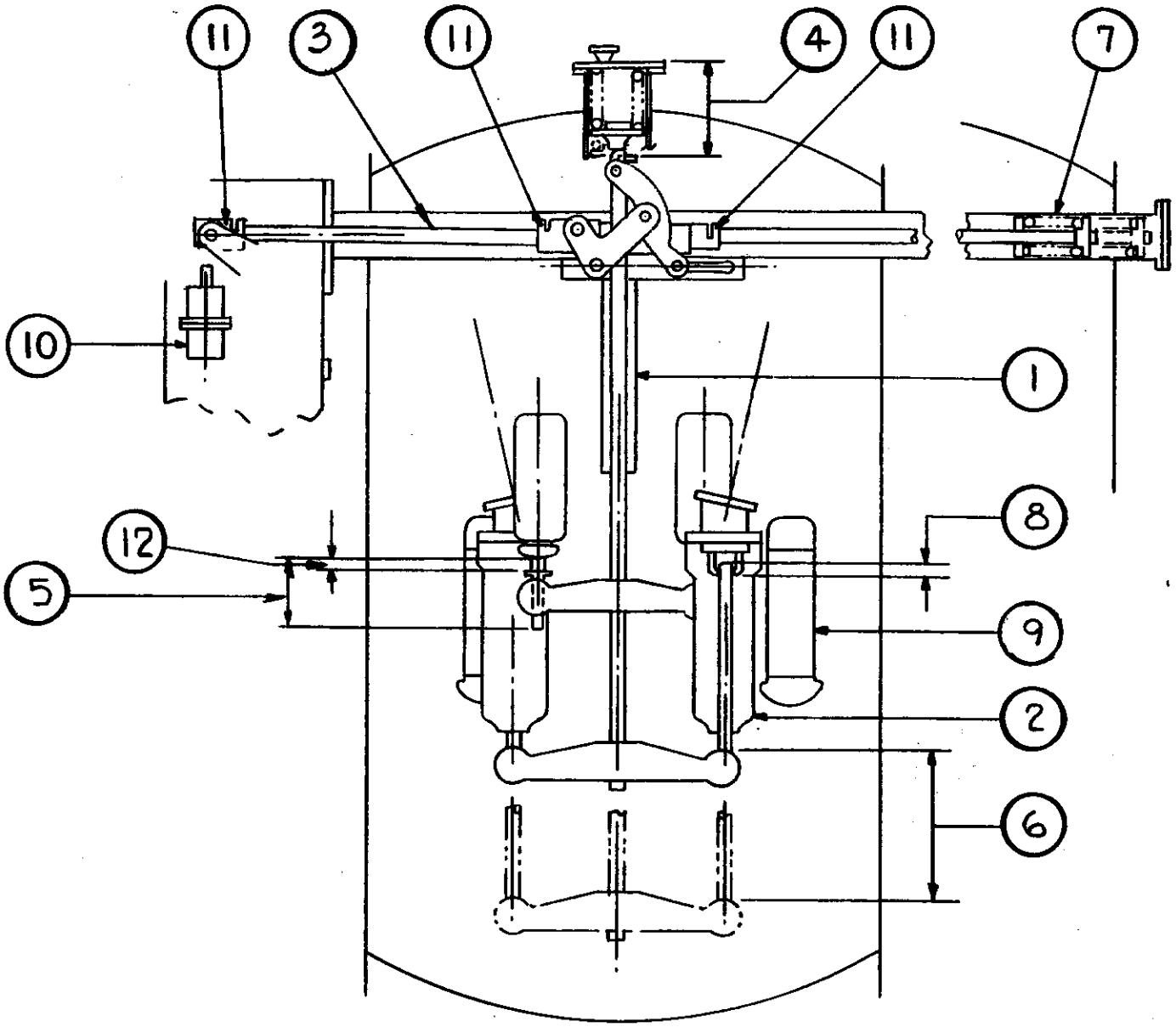


Fig. 9 (0275A6295-0)

Fig. 9 Physical Location of Breaker Adjustments and Check Points

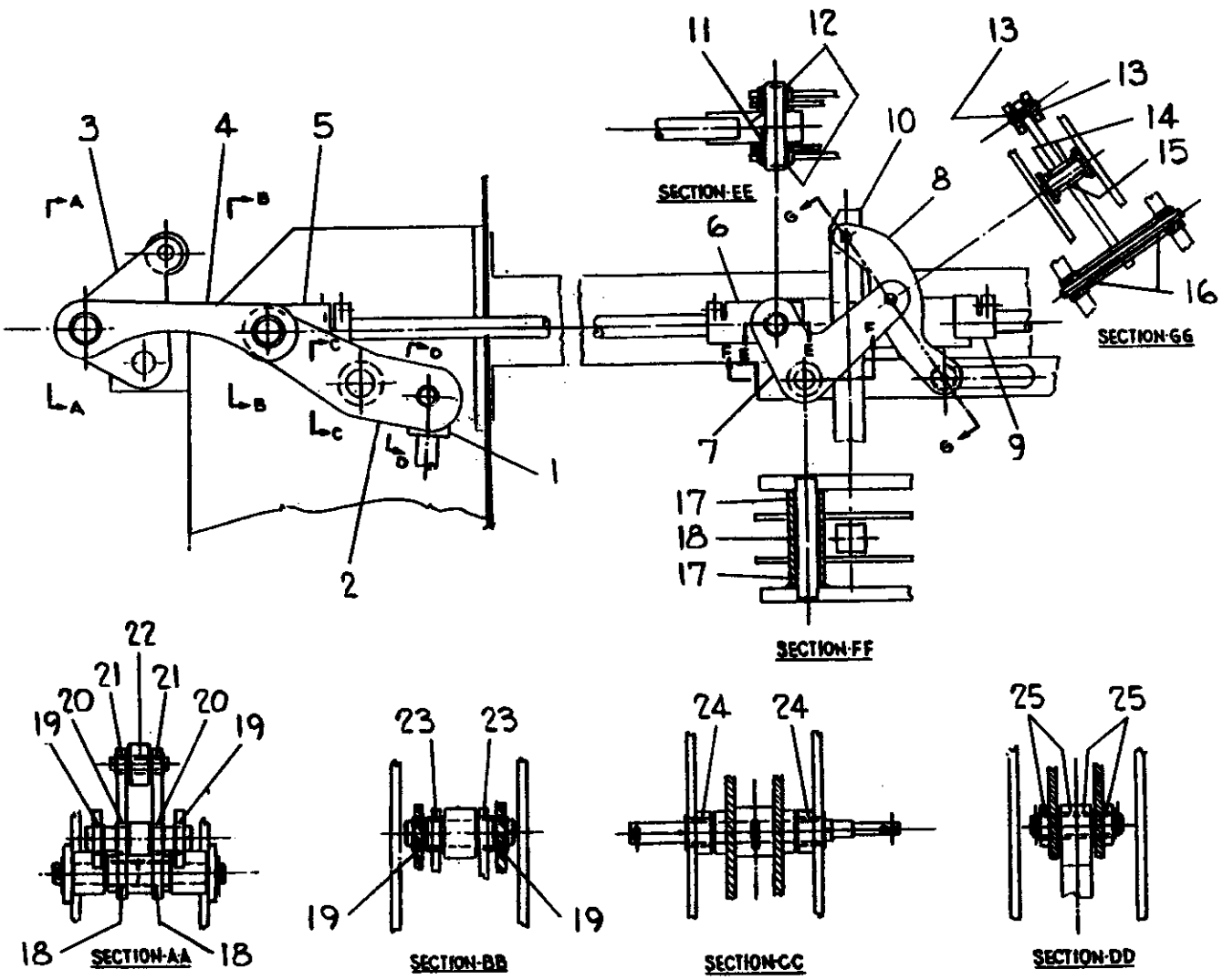


Fig. 10 (0275A6294-0)

1. Vertical Coupling
2. Front Crank
3. Dashpot Crank
4. Link
5. Front Horizontal Rod Coupling
6. Phase Horizontal Rod Coupling
7. Crank
8. Beam
9. Straddle Link
10. Lift Rod Coupling
11. Crank Bushing
12. Straddle Link Bushing
13. Lift Rod Coupling Bushings
14. Beam Bushings
15. Beam Spacer
16. Beam Lower Bushing
17. Crank Bushing
18. Crank Spacer
19. Link Bushings
20. Dashpot Crank Bushings
21. Dashpot Crank Bushings
22. Dashpot Roller Bushings
23. Front Crank Front Bushings
24. Front Crank Bushings
25. Front Crank Rear Bushings

Fig. 10 Views of Breaker Bearing Locations with MA-13-8 Operating Mechanism

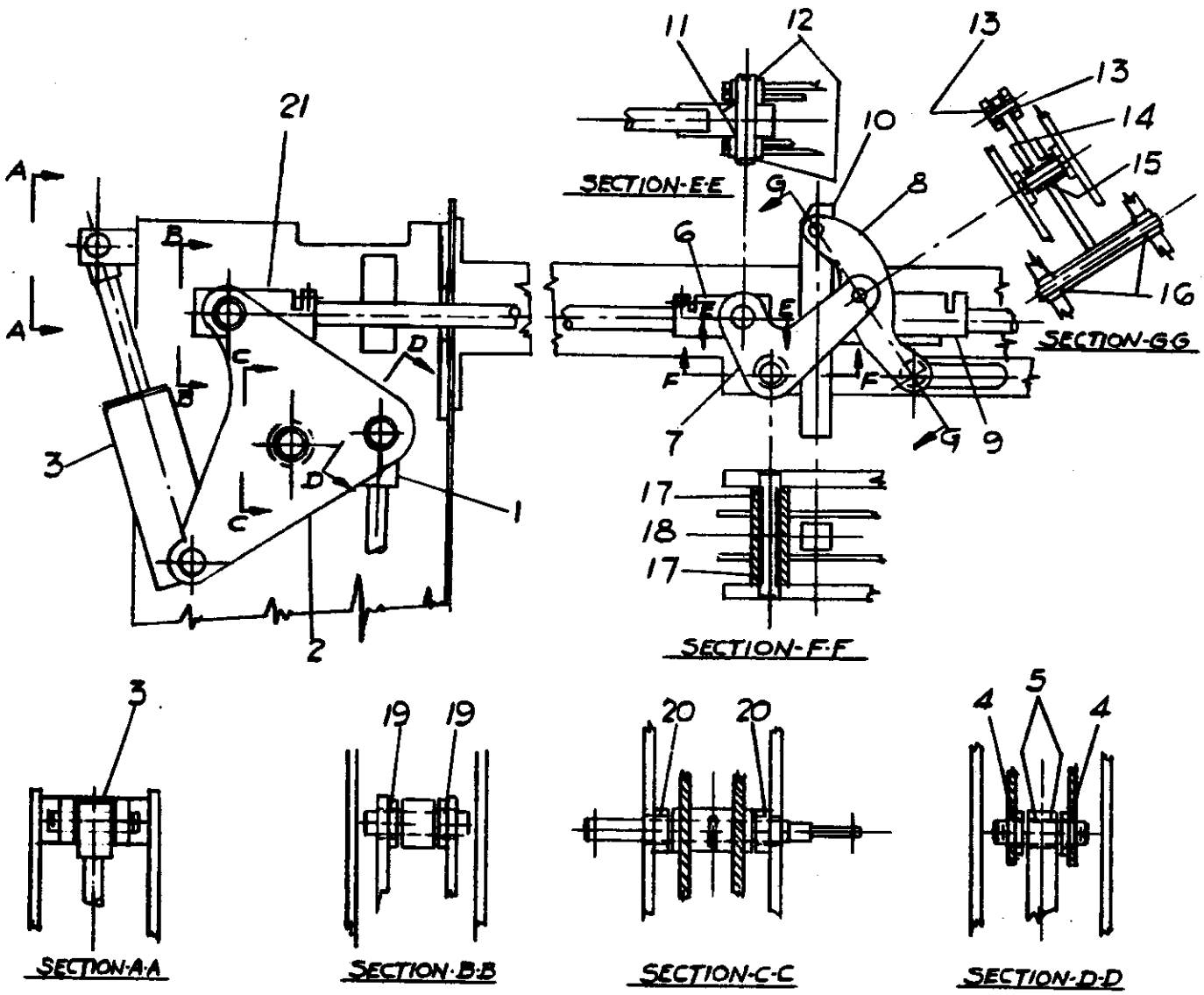
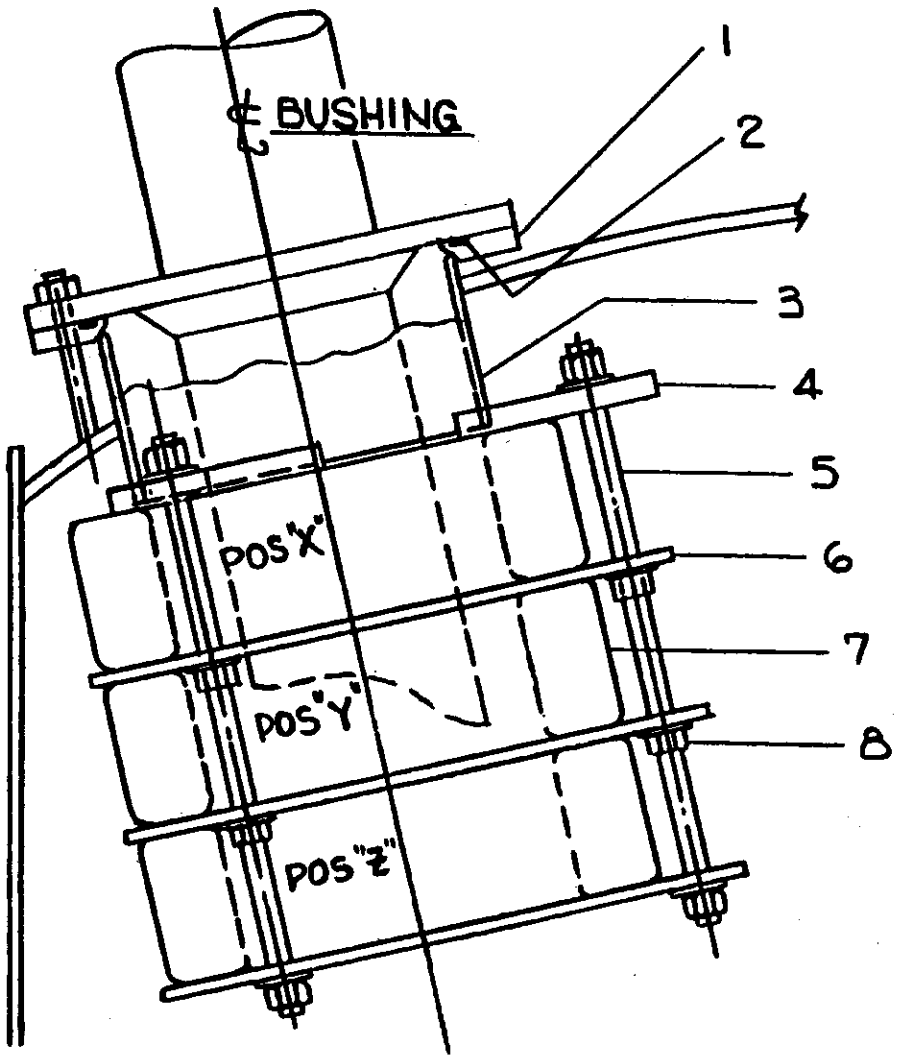


Fig. 10A (0275A6429-0)

1. Vertical Coupling
2. Front Crank
3. Dashpot
4. Front Crank Rear Bushings
5. Front Crank Rear Bushings
6. Phase Horizontal Rod Coupling
7. Crank
8. Beam
9. Straddle Link
10. Lift Rod Coupling
11. Crank Bushing
12. Straddle Link Bushing
13. Lift Rod Coupling Bushings
14. Beam Bushings
15. Beam Spacer
16. Beam Lower Bushing
17. Crank Bushing
18. Crank Sapcer
19. Front Crank Front Bushings
20. Front Crank Bushings
21. Front Horizontal Rod Coupling

Fig. 10A Views of Breaker Bearing Locations with MA-13-8-1 Operating Mechanism



1. Bushing Adapter Plate
2. Gasket
3. Bushing Pocket in Tank
4. CT Bearing Tangs
5. CT MountingStud
6. CT Mounting Plate
7. Bushing Current Transformer
8. Locking Nuts

Fig. 11 (0275A6293-0)

Fig. 11 Bushing Current Transformer and Mounting

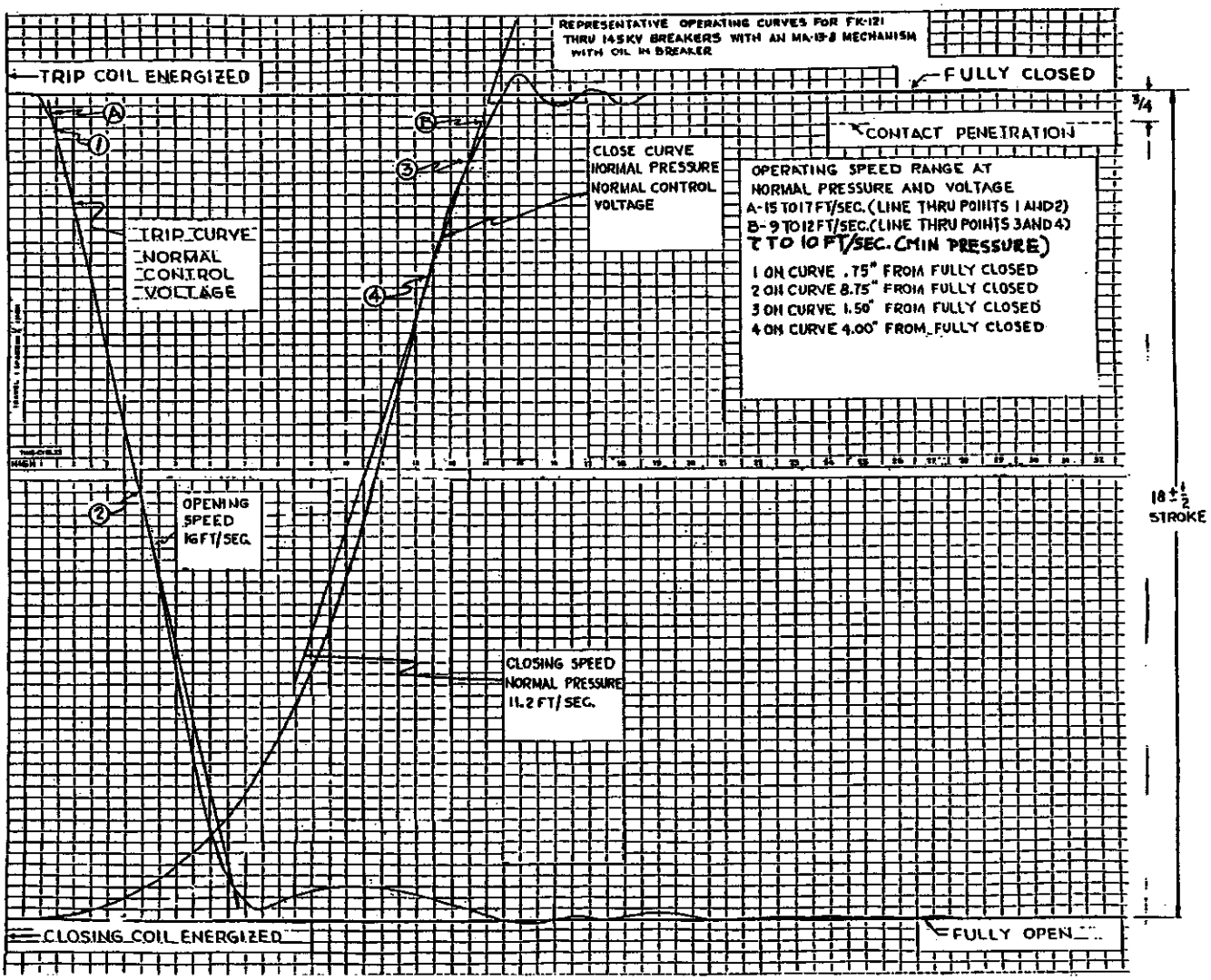


Fig. 12 (0172C4170-0)

Fig. 12 Representative No-load Travel Curves of Opening and Closing Operations with an MA13-8 Pneumatic Operating Mechanism on the Breaker and with the Breaker Contacts Immersed in Insulating Oil

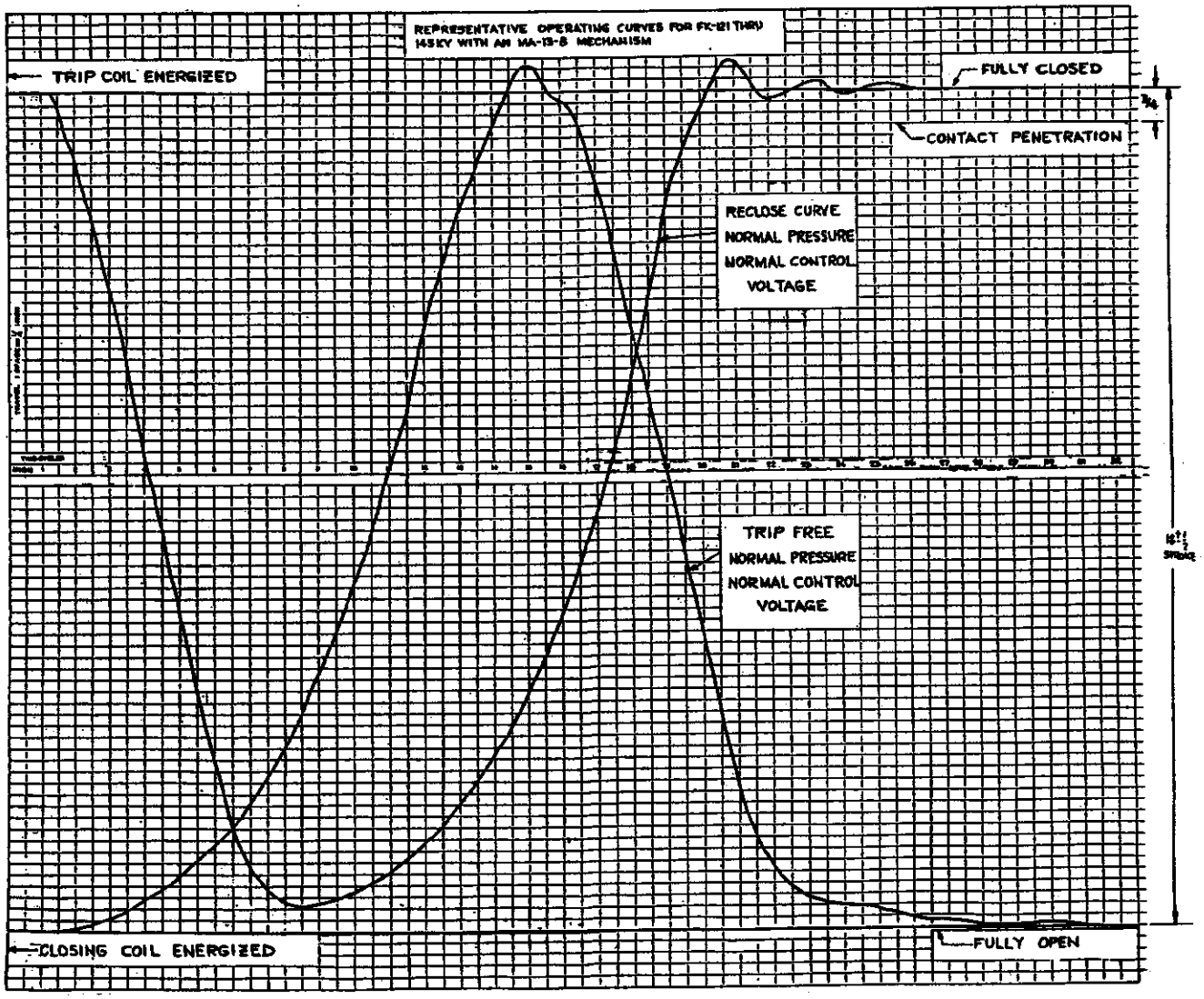


Fig. 13 (0172C4169-0)

Fig. 13 Representative No-load Travel Curves for Reclosing and Trip-free Operations with an MA13-8 Pneumatic Operating Mechanism on the Breaker and with the Breaker Contacts Immersed in Insulating Oil.

NOTES

1. Interrupter Mounting Hardware
2. Adapter
3. Pump Housing
4. Outer Pump Spring
5. Inner Pump Spring
6. Piston
7. Valve Plate
8. Retaining Ring
9. Buffer
10. Shims
11. Bearing Cap
12. Pump Rod
13. "O" Ring
14. Locating Pin
15. Upper Insulating Spacer
16. Baffle Assembly
17. Locating Pin
18. Resistor Contact Plate
19. Lower Insulating Spacer
20. Relief Valve Bolt
21. Retaining Ring
22. Relief Valve Plate
23. Relief Valve Spring
24. Relief Valve
25. Poppet Valve Spring
26. Poppet Valve
27. Resistor Assembly
28. Shield
29. Interrupter Tube Mounting Hardware
30. Flange
31. Contact Mounting Hardware
32. Contact Block
33. Flexible Lead
34. Contact Ring
35. Contact Spring
36. Spring Retainer
37. Contact Fingers
38. Interrupter Tube
39. Resistor Contact
40. Middle Insulating Spacer
41. Resistor Stud

Items for Fig. 14

*63KA and 3000 amp breakers only

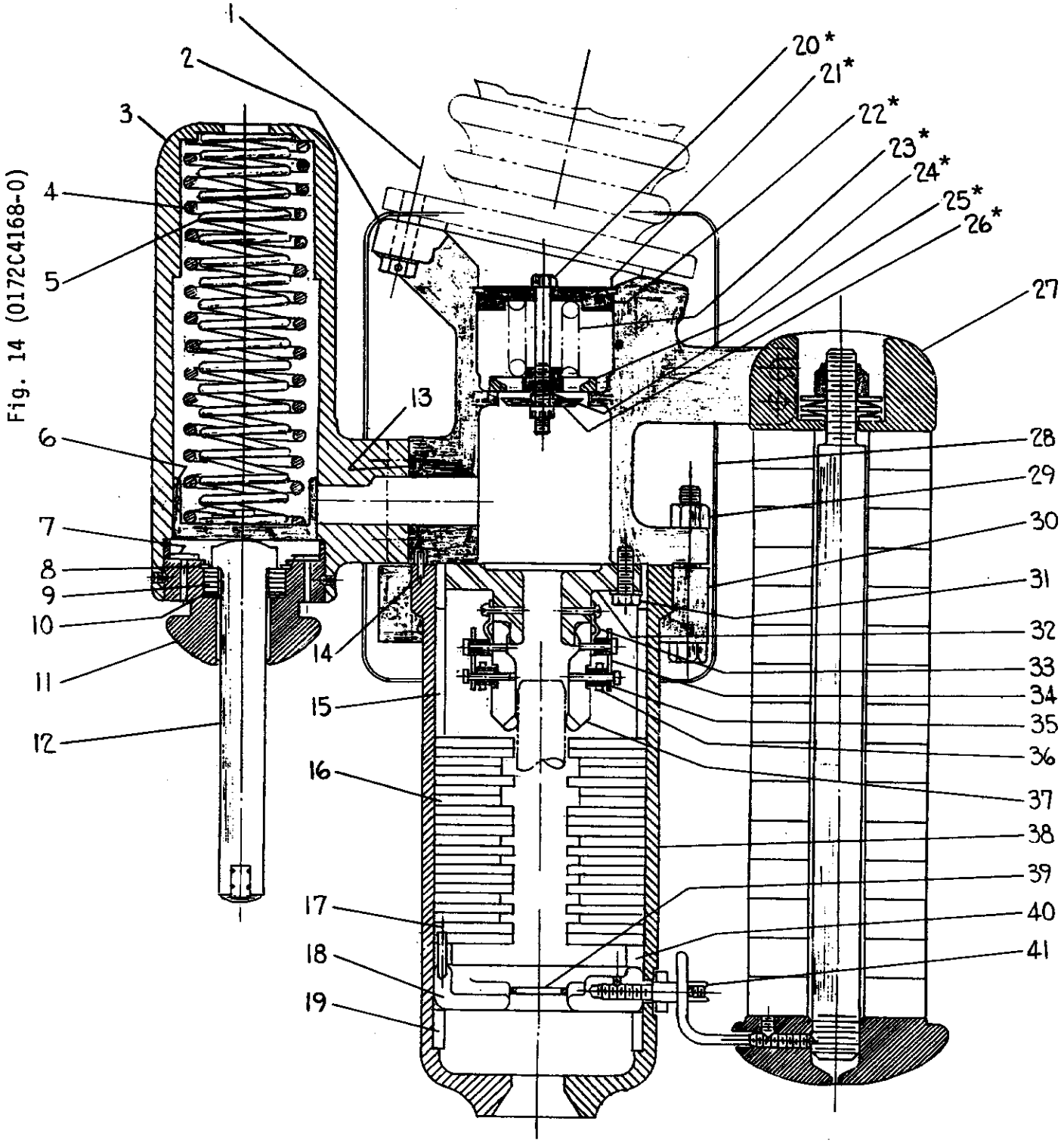


Fig. 14 Cross Sectional View of the Interrupter

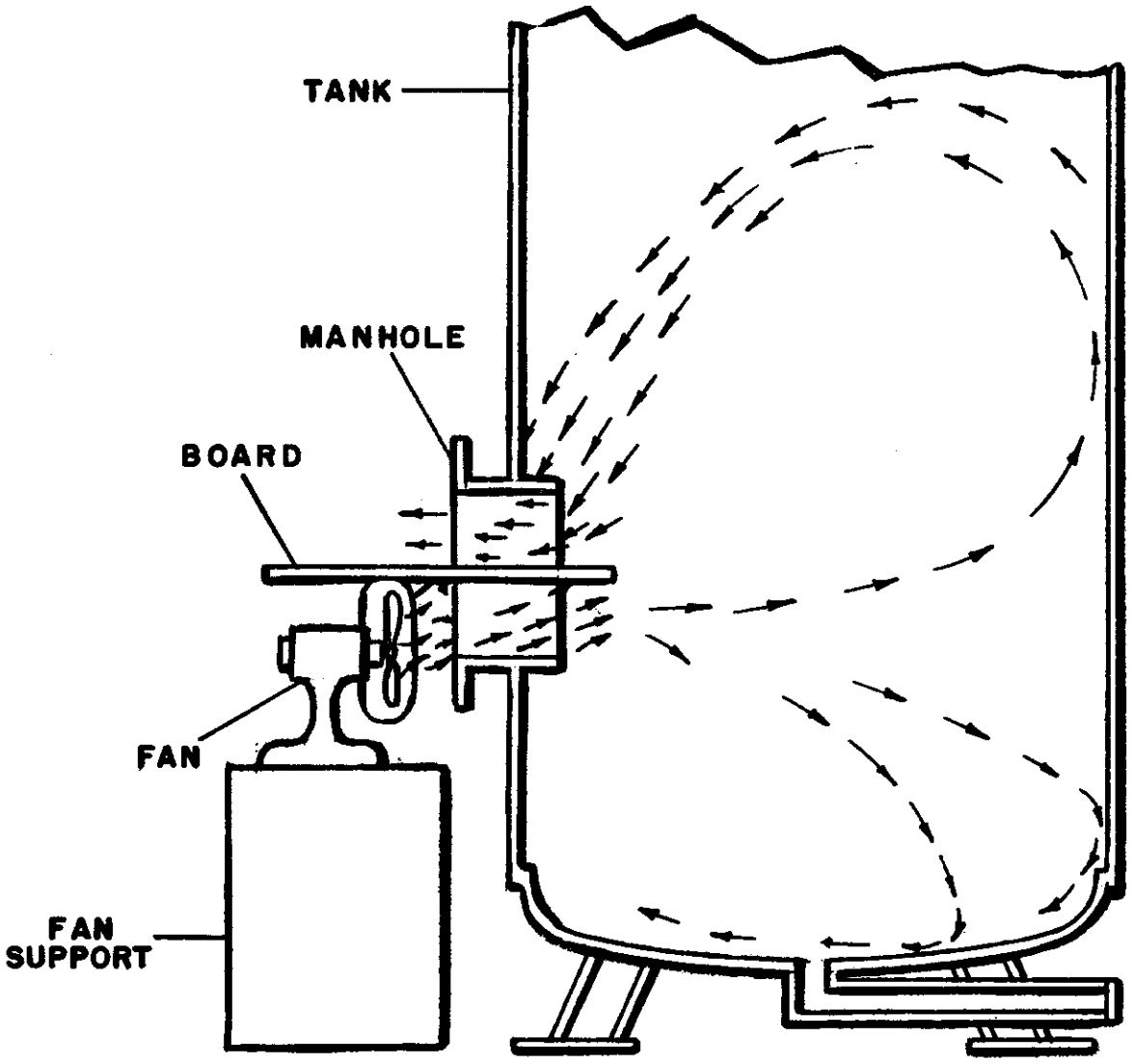


Fig. 15 (6558498 Rev. 1)

Fig. 15 Air Circulation in Tank to Remove Fumes

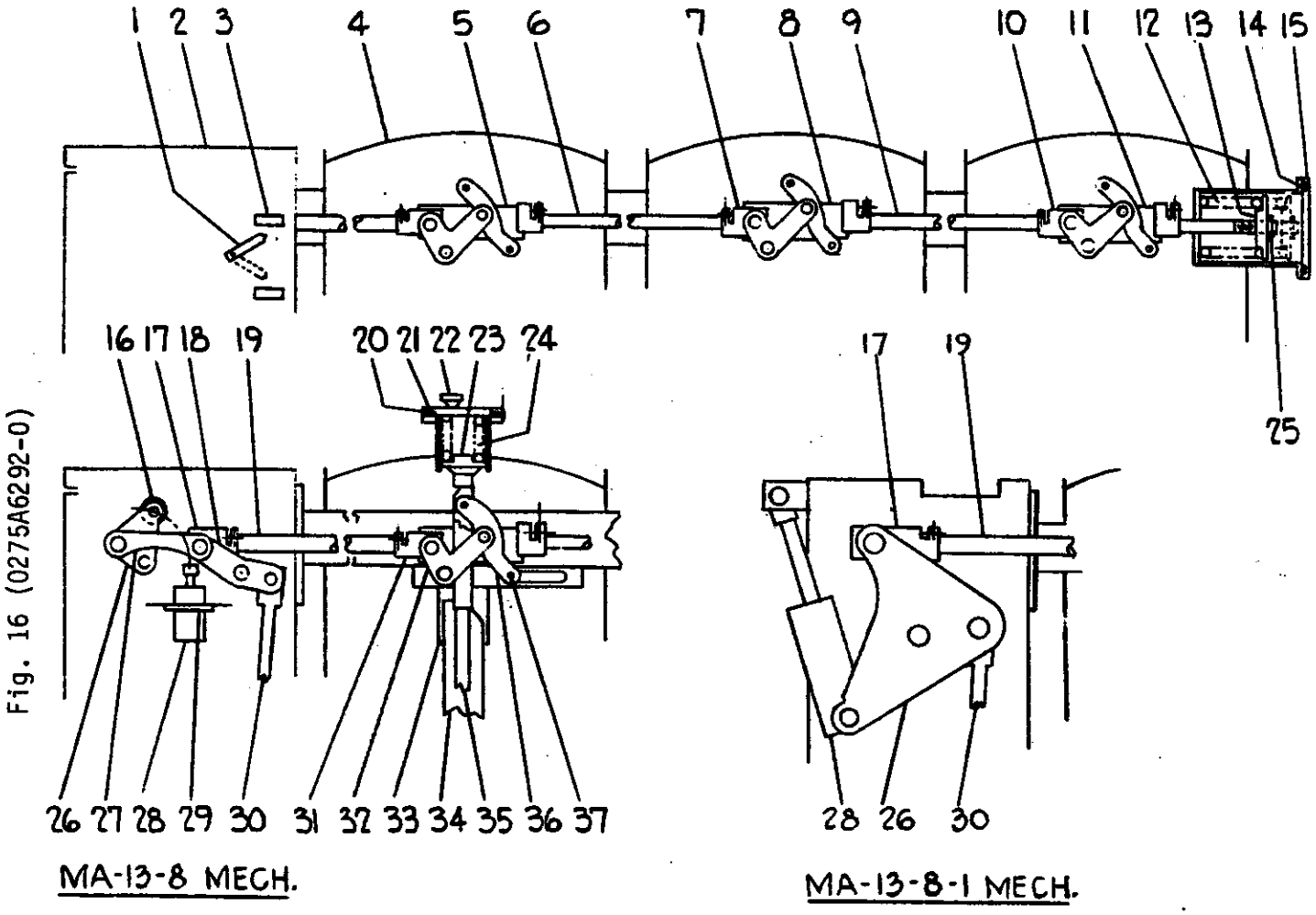


Fig. 16 (0275A6292-0)

1. Breaker Position Indicator
2. Control House Roof
3. Position Indicator Nameplate
4. Breaker Tank
5. Phase 1 Straddle Link
6. Phase 1 to 2 Interphase Rod
7. Phase 2 Coupling
8. Phase 2 Straddle Link
9. Phase 2 to 3 Interphase Rod
10. Phase 3 Coupling
11. Phase 3 Straddle Link
12. Follow-through Spring
13. Follow-through Spring Plate
14. Cover Gasket
15. Follow-through Spring Cover
16. Dashpot Roller
17. Mechanism Coupling
18. Crank
19. Front Horizontal Rod
20. Cover Gasket
21. Kickoff Spring Cover
22. Breather
23. Kickoff Spring Retainer
24. Kickoff Spring
25. Locknut
26. Dashpot Crank
27. Dashpot Link
28. Opening Dashpot
29. Opening Dashpot Locking Nut
30. Vertical Operating Rod
31. Phase 1 Coupling
32. Crank
33. Lift Rod Guide Bracket
34. Lift Rod Guide
35. Lift Rod
36. Beam
37. Roller

Fig. 16 Breaker Mechanism in Closed Position

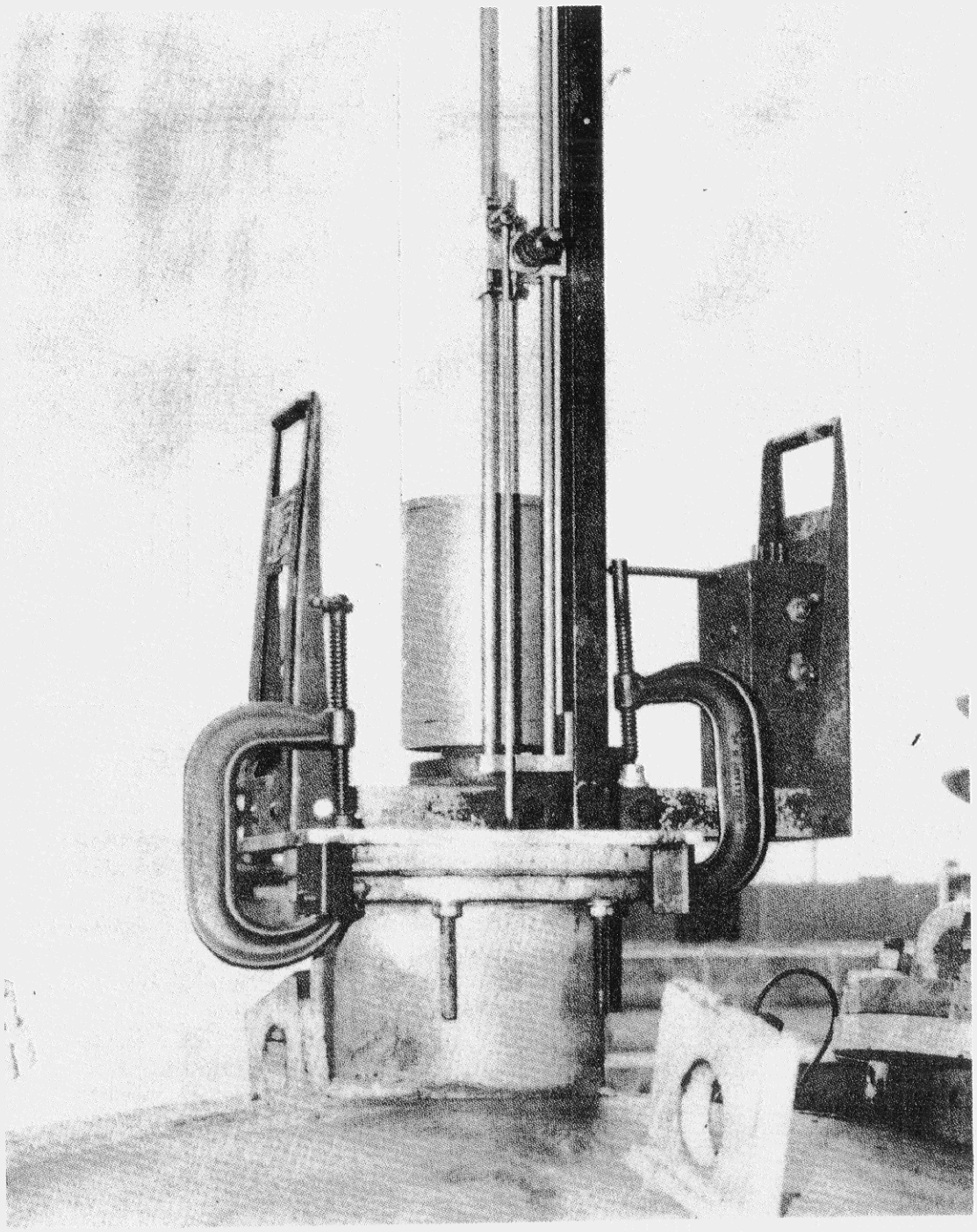


Fig. 17 (8919335V)

Fig. 17 Installation of the Travel Analyzer

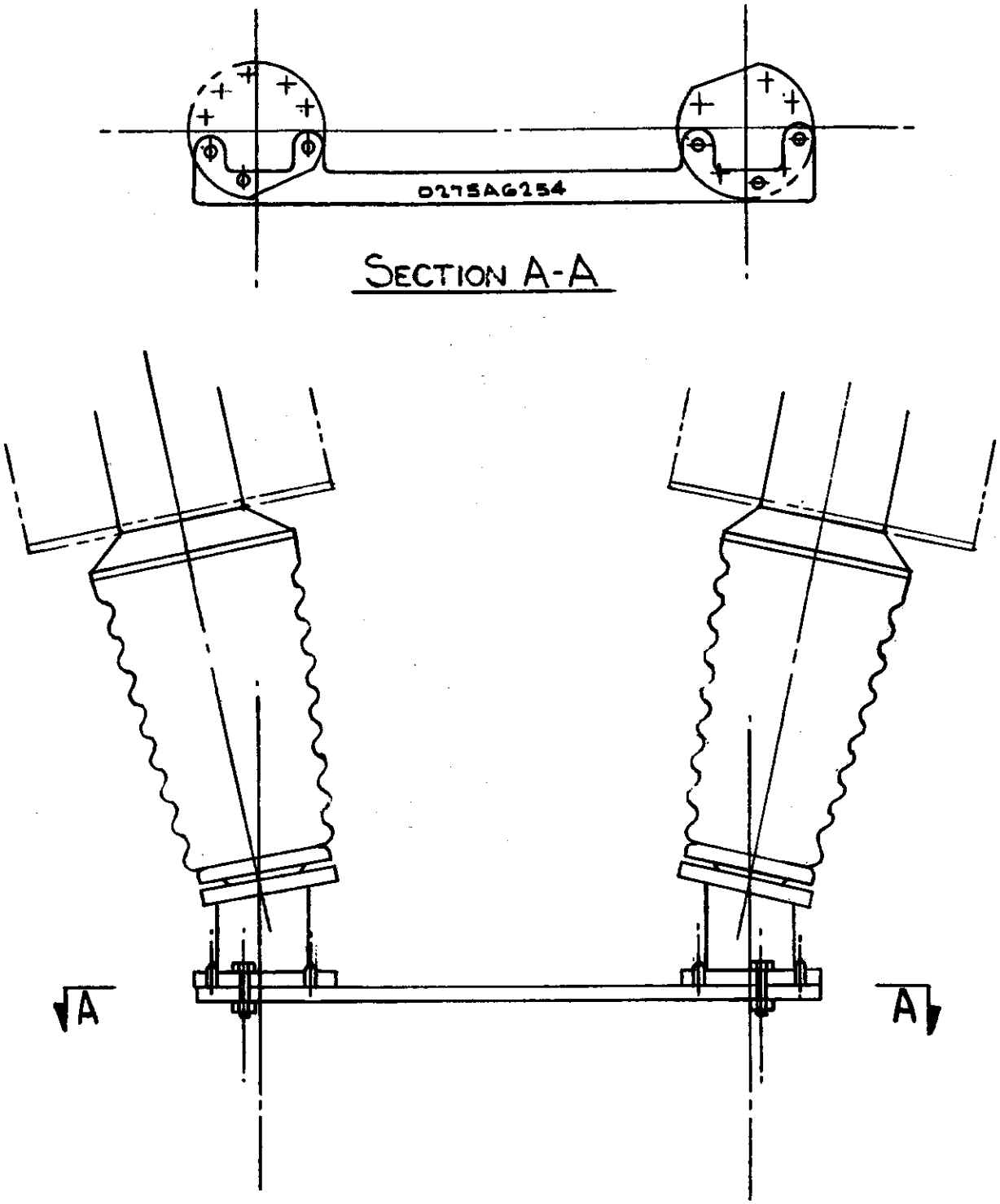


Fig. 18 (0275A6291-0)

Fig. 18 Interrupter Aligning

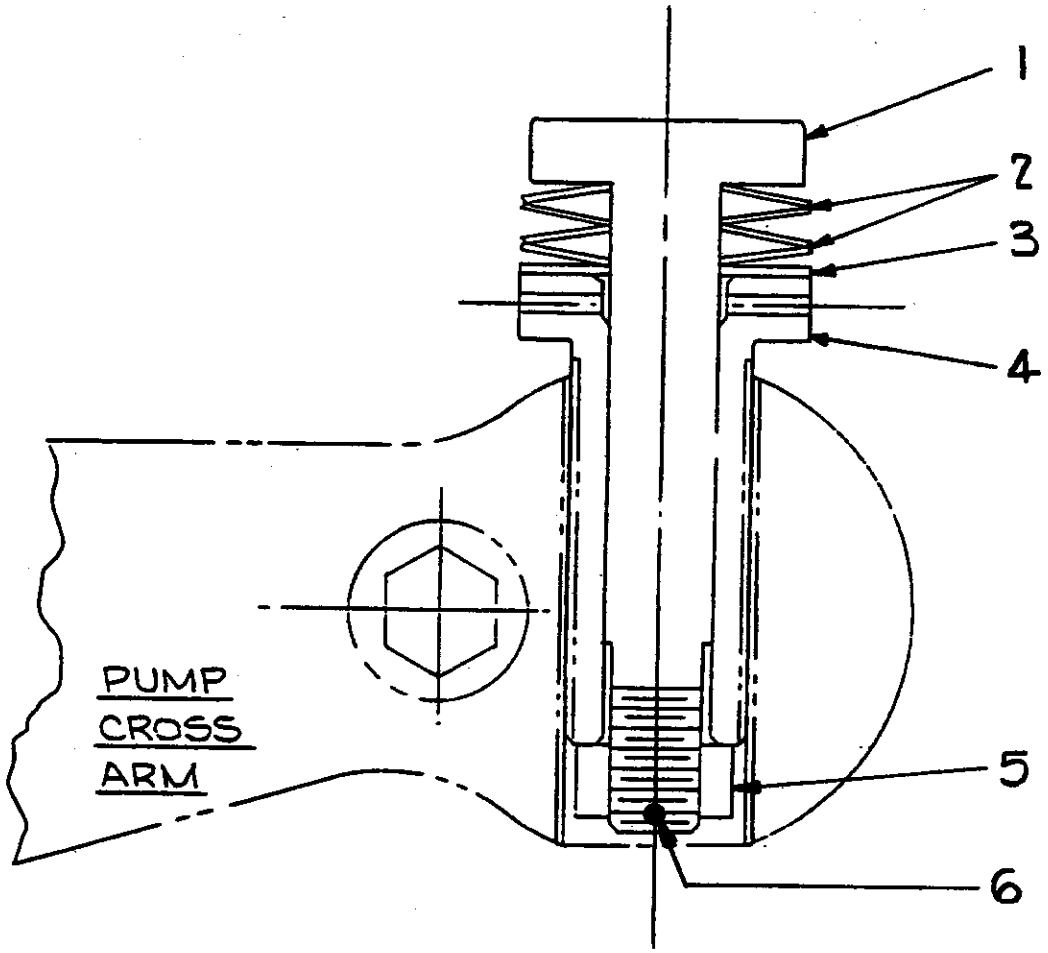


Fig. 19 (90275A6290-0)

1. Pump Actuating Button
2. Belleville Washers
3. Bearing Washer
4. Adjusting Screw
5. Lock Nut
6. Locking Pin

Fig. 19 Pump Actuating Button Assembly

NOTES