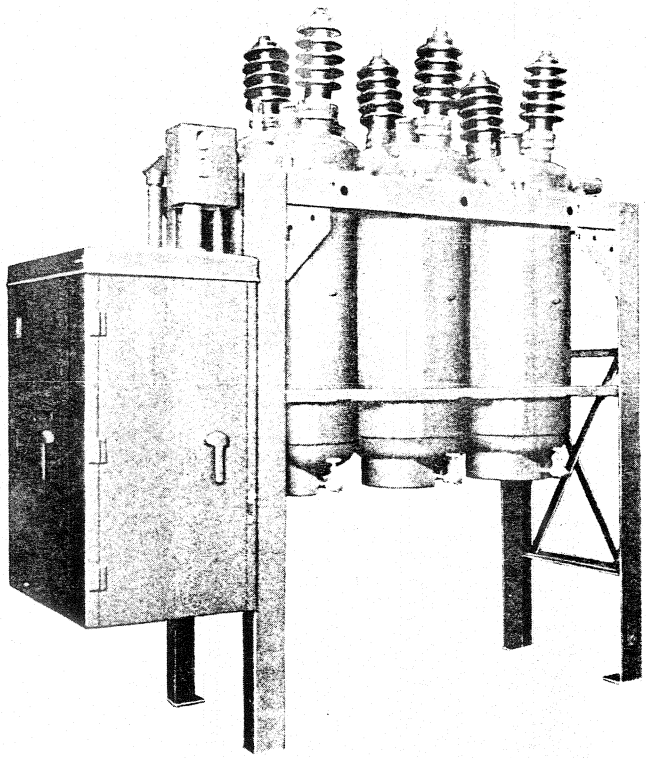
INSTRUCTIONS

GEH-2046A
SUPERSEDES GEH-2046 AND GEH-1846A

# POWER CIRCUIT BREAKERS

## OIL BLAST BREAKERS
## Types
## FK-14.4-1 and -2, 14.4 Kv
## FK-23-1 and -2, 23 Kv
## FK-34.5-1 and -2, 34.5 Kv
## 600 and 1200 Amperes



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HIGH VOLTAGE SWITCHGEAR DEPARTMENT

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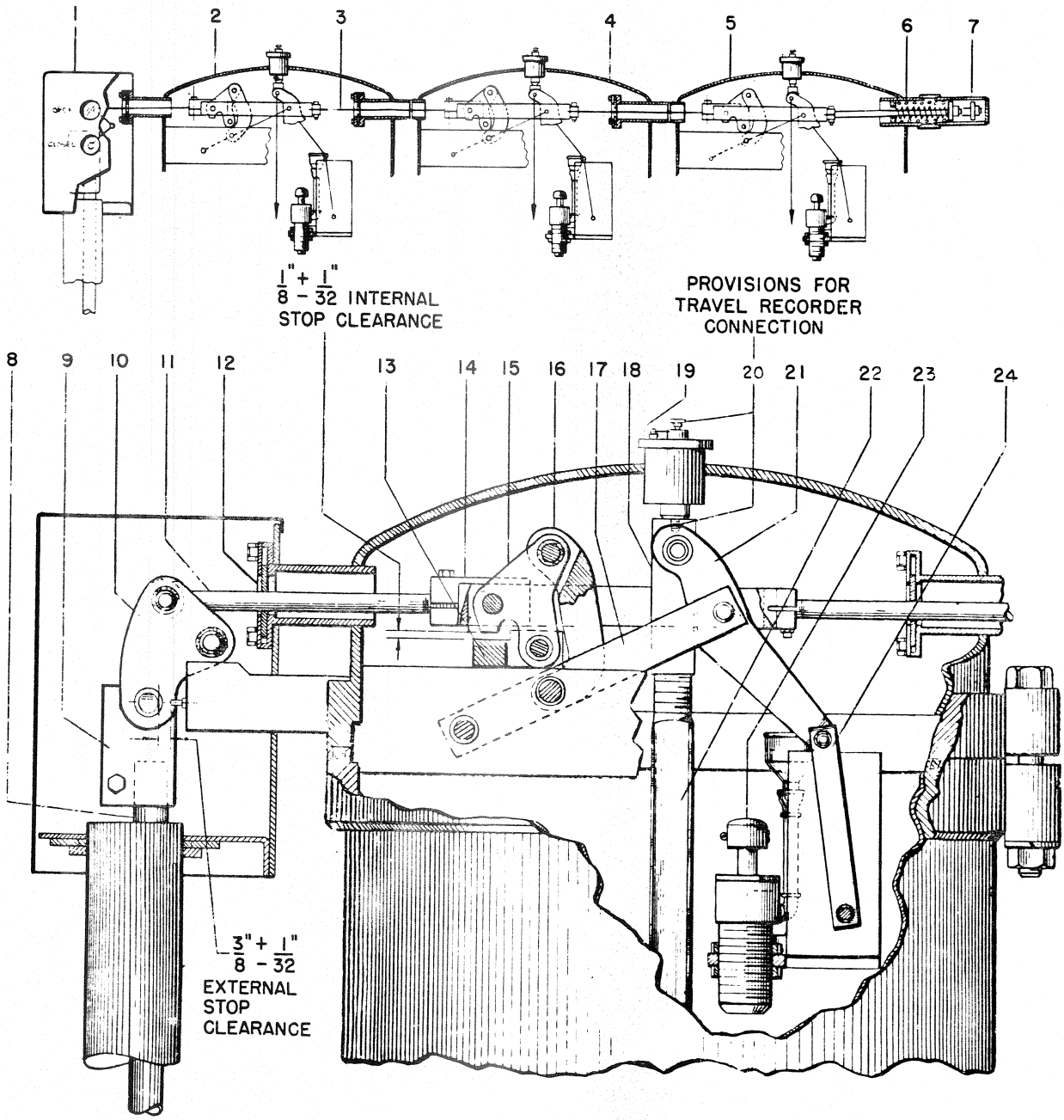



1. Front Crank Housing
2. Front Top Frame
3. Connecting Rod
4. Center Top Frame
5. Rear Top Frame
6. Opening Spring
7. Opening Spring Housing
8. Operating Rod
9. Front Coupling
10. Front Crank
11. Front Connecting Rod
12. Gas and Oil Seal
13. Stop
14. Coupling
15. Toggle Crank
16. Toggle Link
17. Beam
18. Lift Rod Coupling
19. Closing Buffer
20. Breather
21. Lever Arm
22. Lift Rod
23. Opening Dashpot
24. Rocker Arm

Fig. 1 Breaker Mechanism Linkage

Fig. 1 (233D127)

Cover (8022698)

# OIL-BLAST CIRCUIT BREAKER
# TYPES FK-14.4-1 AND -2, 23-1 AND -2 AND 34.5-1 AND -2
# 14.4, 23 AND 34.5 KV.

The Type FK Oil-blast Circuit Breakers were designed especially for applications on transmission lines where high speed reclosing performance is required. High speed interruption of faults is obtained by the use of contacts employing the oil-blast principle of circuit interruption. High speed reclosing is obtained by the use of a simple rugged linkage mechanism which operates on low-friction bearings, and by employing arc resistant materials for the interrupting contacts.

To facilitate installation, the three pole units of a triple pole breaker are mounted on a common frame. The pneumatic or solenoid operating mechanism is installed in a weatherproof housing which is mounted on the front end of the breaker framework, and the pole units are mechanically connected so as to operate simultaneously.

The FK breaker is available in a number of current and voltage ratings. A typical breaker is shown on the cover. For the complete rating information of any particular breaker, refer to the breaker nameplate, which is located inside the front door of the operating mechanism housing.

The short circuit conditions to be imposed on the breaker must not exceed its rating, nor should it be called upon to operate at voltages or currents greater than those given on the nameplate. These breakers may be used at any altitude up to 10,000 feet.

PROPER INSTALLATION AND MAINTENANCE ARE NECESSARY TO INSURE CONTINUED SATISFACTORY OPERATION OF THE BREAKER. The following instructions will provide information for placing the oil-blast breaker in service and for maintaining successful operation. It should be kept in mind that the illustrations shown in this instruction book are for illustrative purposes and may not always be an actual picture of the equipment being furnished. For final information always refer to the drawings which are furnished separately with the equipment. For additional instructions concerning the operating mechanism and auxiliary equipment, refer to the individual instruction books for these devices.

## RECEIVING, HANDLING AND STORAGE

All breakers are assembled and tested at the factory. Normally, they are shipped completely assembled, that is with the bushings, bushing current transformers, interrupters, moving contact members, and breaker linkage in place. The operating mechanism and its housing are shipped assembled on the front end of the framework.

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 with the transportation company, and the nearest General Electric Apparatus Sales Office should be notified promptly.

### UNPACKING AND HANDLING

The crating or boxing must be removed carefully. 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 carelessly driving a wrecking bar into the crates or boxes. If any parts made of insulating material are shipped separately, they should be protected from moisture, dirt, and damage due to rough handling. Check all parts against the packing list to make certain that no parts have been overlooked while unpacking. 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. The oil tanks should be cleaned and dried before they are filled with oil. The crating should not be taken from the bushings until after the breaker has reached its permanent location and all overhead work completed.

If stored outdoors, the breaker tanks should be filled with oil to protect the insulating parts. The space heater in the operating mechanism housing should be energized as soon as possible in order to prevent moisture condensation inside the housing.

If the interrupters are ever stored separately, they should be kept in a dry room. If they must be left outdoors for a short time, they should be thoroughly covered to protect them from the weather. Under extreme conditions of humidity, or if the only storage space is damp, they should be kept in containers filled with G.E. #10-C oil.

Renewal parts, especially lift rods, guides and other parts made of insulating materials, should be stored in a dry room. It may also be advisable to hang the lift rods and guides in a vertical position to minimize the possibility of warpage, if a level storage surface is not available.

## DESCRIPTION

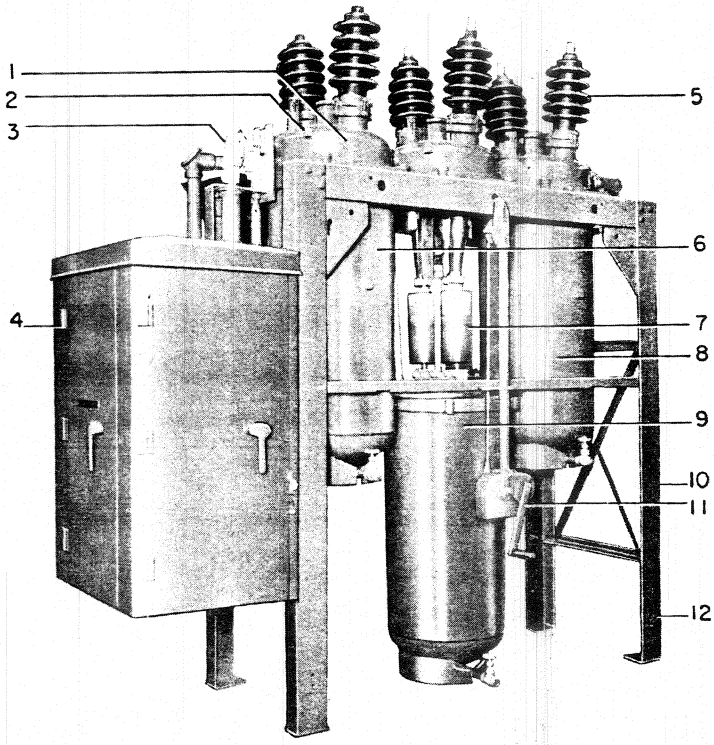
### BREAKER

Each triple pole breaker is composed of an operating mechanism and three similar pole unit assemblies mounted on a common framework as shown in Fig. 2. Each pole unit consists of an oil tank which contains the interrupters and contacts, and a top frame which houses the breaker linkage and bushing current transformers and supports the bushings and contacts.

The breaker linkage, which is assembled in the top frame of each pole unit is designed to give straight line motion to the moving contacts and to convert the motion of the operating mechanism to the proper breaker stroke. The three pole unit linkages are connected together and to the operating mechanism by adjustable connecting rods. On the first pole unit above the operating mechanism is a bell crank for changing from vertical to horizontal motion.

The motion of the interphase connecting rods is transmitted to the internal linkage through a bell crank on each pole unit. A gas and oil seal is provided around the connecting rods to form a separation between the front crank box and the front tank, and between tanks. Adjustable opening springs located on the rear pole unit at the end of the operating rod insure positive opening action at a predetermined speed and contact parting time.

*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.*




1. Top Frame and Breaker Linkage
2. Oil Fill Pipe
3. Front Crank Assembly
4. Operating Mechanism
5. Bushings
6. Front Pole Unit
7. Interrupters
8. Rear Pole Unit
9. Center Pole Tank
10. Framework
11. Tank lifter
12. Ground

Fig. 2 View of FK Breaker, With Center Pole Tank Lowered, Showing Major Assembly Units

A closing buffer and an oil filled opening dashpot are located in each pole unit. The closing buffer is used to prevent excessive overtravel of the moving contacts on closing and the opening dashpot is used to absorb the energy of the moving parts at the end of the opening stroke. The dashpots use the same kind of oil as used in the breaker tanks. They are self-contained and will operate properly whether the oil tanks are filled or not. Since very little oil is lost during breaker operation, they will require only periodic inspection.

A "breather" is mounted on the buffer to vent any oil vapor caused by circuit interruption.

A float type oil gage is installed in the top frame of each pole unit. This indicates the oil level directly through the action of a float, the position of which corresponds to the true oil level. The float is fastened to a pointer rod which is visible in a glass tube on the top of the breaker. The correct oil level at normal temperature (20 C) is indicated on the breaker outline drawing and by a painted line on the gage glass. The minimum oil level is the bottom of the visible portion of the gage glass. This corresponds to the portion of the bushing which must always be immersed in oil.

Each oil tank is suspended in place against the top frame by four bolts which clamp the tank against a gasket located in a groove on the oil tank band. The bolts must be tight to prevent oil leakage through the tank gasket during circuit interruption. This arrangement permits easy removal of the tanks for inspection and maintenance of the contacts and interrupters. A drain valve is attached to a pipe at the bottom of the tank so that all the oil can be drained. The valve should be capped or plugged to prevent any possible leakage.

Each interrupter is mounted on the lower end of each bushing by means of an adapter, which is also used to permit alignment of the interrupter. See Fig. 4. The interrupter consists essentially of a Herkolite * tube enclosing a set of six contact segments, two of which have arcing tips and a baffle stack. The Herkolite tube has two exhaust ports which allow the proper flow of oil across the contacts and through the baffles during interruption.

For a detailed explanation of the operation of the breaker refer to the section OPERATION. For complete information on the operating mechanism, see the mechanism instruction book.

## BUSHINGS

Type U bushings are used in these breakers. Bushings are built to the new NEMA and ASA standards, being interchangeable with transformer bushings and equipped with a capacitance tap for making power factor tests. The bushings are installed in the top frame from above. An adapter ring with weathertight gaskets is inserted between the support flange and the top frame to facilitate interrupter alignment by its ball seat design. Each bushing has provision for two bushing current transformers and the bushings can be installed and removed from the breaker without disturbing the transformers. For additional information on the construction of the bushings refer to INSTRUCTION BOOK GEH-1638.

## BUSHING CURRENT TRANSFORMERS

Bushing current transformers, Type BR-BY, 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 ASA C-57-13.017(C) and NEMA SG-6-250 specifications.

Type BM high accuracy metering type current transformers can also be furnished. Single or multi-ratio types are available. 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 ASA C-57-13.017 (C) and NEMA SG-6-250 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 Department by giving the proper references.

Bushing current transformers are mounted inside of the top frames. They are installed from underneath the top frame and they can be slipped over the lower end of the bushing, although the interrupters must be removed first. A supporting plate bolted to the top frame holds the transformer in place. Insulation washers above and below the transformer protect it from injury. It must be properly centered in the housing to prevent damaging it when the bushing is installed.

All transformer leads are brought out for external connections. The leads are run in conduit into the operating mechanism compartment where they are terminated at suitably marked terminal boards. 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 GEH-2020 to be sure of proper polarity and correct connections.

## 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

Fig. 2 (8022699)

* Registered Trade-Mark of General Electric Co.

t insulation requirements. Efficient ling 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 locations subject to freezing temperatures. High resistance to carbonization minimizes the sludge and carbon deposits which 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 per cent may reduce its puncturing resistance by 50 per cent.

It is recommended that G. E. #10-C oil be used in these breakers. This is a pure mineral oil with the following characteristics:

| | |
|---|---|
| Flash Point | 133 C. |
| Burning Point | 148 C. |
| Pour Point | -40 C. |
| Viscosity at 37.8 C | 57 Sec. |
| 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 26,000 volts, as measured by the standard test between 1 inch discs spaced 0.1 inch apart.

# INSTALLATION

The installation of the breaker will be facilitated by a study of these instructions and a review of the approved drawings which plement 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.

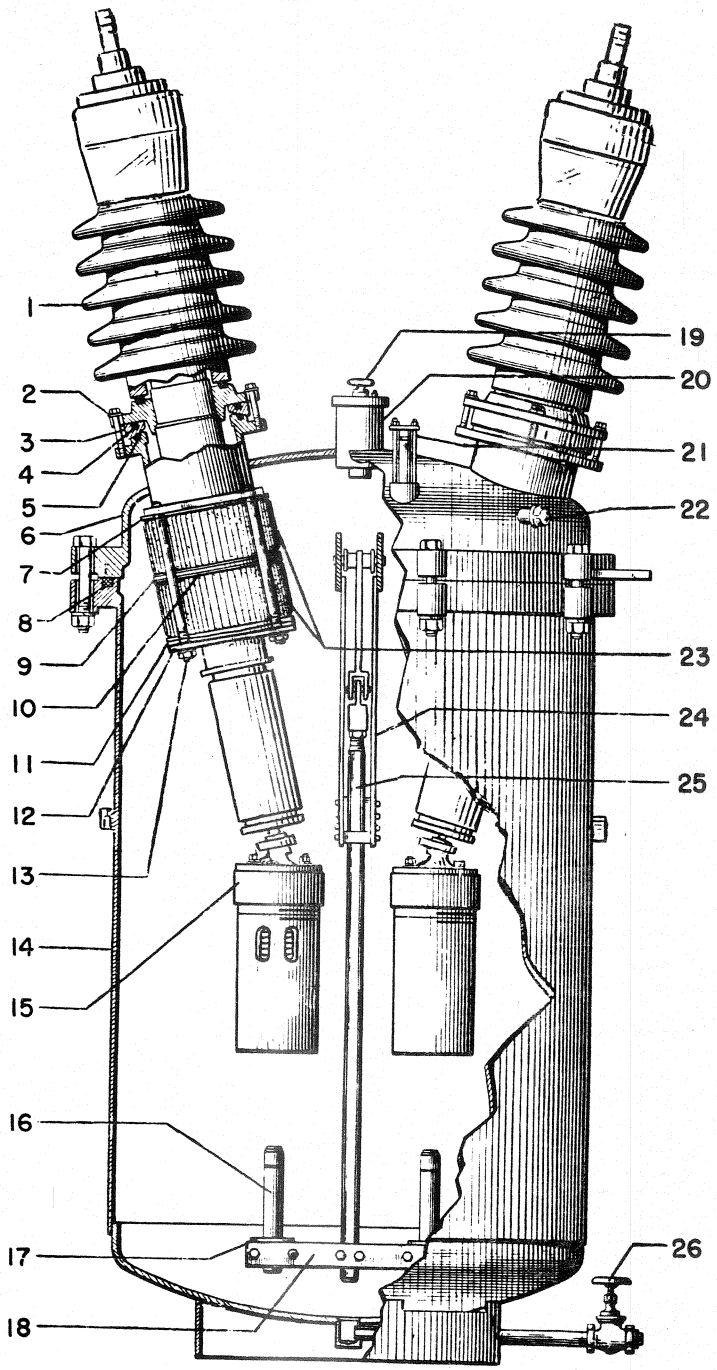
## LOCATION

The breaker should be located so that it will be readily accessible for cleaning and inspection. Sufficient space must be provided for operation of the manual closing device and tank lifter and for easy removal of the oil tanks. The breaker should be mounted high enough so that it can be operated with the oil tanks lowered without the moving contacts splashing in the oil. Where flood conditions exist, the mechanism housing should be above high water level.

## MOUNTING

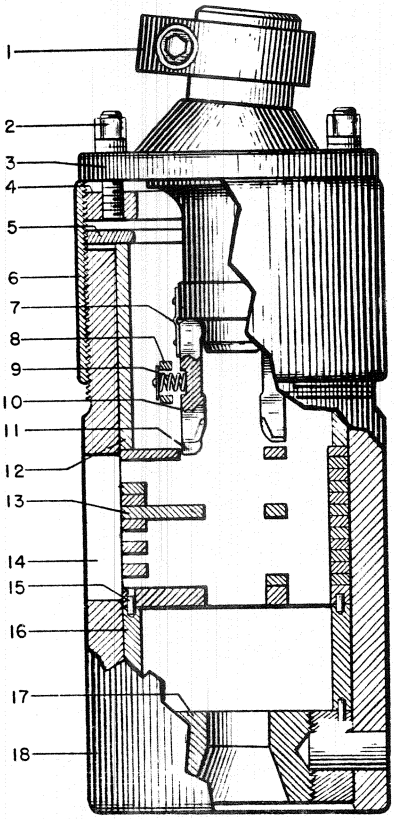
The total weight of the breaker with oil is given on the outline drawing and on the nameplate. This information will serve as a guide to the strength of the lifting means required for handling the breaker. It may be lifted by hooking into the framework. When using cable slings do not allow the slings to strike the bushings, as any strain on these may cause them to crack or break.

As the breakers are shipped assembled on their frameworks, it is only necessary correctly locate and fasten the frame in sition on its foundation. The foundation olts should be left loose to permit the frame to be properly plumbed and leveled by inserting shims under the feet of the




1. Bushing
2. Mounting Bolt
3. Adapter Ring
4. Adapter Gasket
5. Frame Gasket
6. Top Frame
7. Insulation Washer
8. Tank Gasket
9. Insulation Support
10. Insulation Washer
11. Spacers
12. Support Plate
13. Assembly Stud
14. Oil Tank
15. Interrupter
16. Contact Rod
17. Contact Block
18. Crossbar
19. Breather
20. Closing Buffer
21. Oil Gage
22. Fill Pipe
23. Current Transformers
24. Lift Rod Guide
25. Lift Rod
26. Drain Valve

Fig. 3 Cross Sectional View of Pole Unit




1. Clamping Ring
2. Assembly Nut
3. Adapter
4. Support Ring
5. Locking Ring
6. Cap Ring
7. Flexible Connector
8. Contact Retainer
9. Contact Spring
10. Contact Segment
11. Arcing Tip
12. Upper Insulating Tube
13. Baffle Stack
14. Port Opening
15. Locating Pin
16. Lower Insulating Tube
17. Throat Bushing
18. Outer Tube

Fig. 4 Cross Sectional View of Interrupter

frames where necessary. After this has been done, the foundation bolts should be tightened and the frame fastened securely to its foundation.

## 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 dead.

### 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 insofar as it is practicable. Control wires must be run separately and remote from high tension 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 entrance 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.

### GROUND CONNECTIONS

The framework of each breaker should be permanently grounded. The usual practice is to connect a heavy cable to the framework and to the ground. A grounding pad is provided on the leg of the framework to which a terminal and cable can be attached. The cable should be of sufficient size to carry 25% of the current rating of the breaker but not smaller than #4/0.

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.

## ADJUSTMENTS

Although the breaker has been completely set up, adjusted and tested at the factory, it is recommended that all adjustments be reviewed to make certain that no change has occurred during shipment and installation. The breaker should be operated slowly by hand, using the maintenance closing device, to see that it is smooth throughout closing and opening, that no binding occurs, and that no excessive play is noticeable between parts. To open the breaker slowly by hand, the load of the breaker 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 backed off to allow 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.

Using the tank lifter, as shown in Fig. 7, the tanks can be lowered, leaving the contacts and pole unit linkages accessible for inspection. The trip latch of the operating mechanism is wired in place during shipment and this wire 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 tripped open.

### PRECAUTIONS

1. Make certain that the primary circuits are open and effectively grounded.
2. Make certain that all control circuits are deenergized until electrical operation is to be performed.

Fig. 4 (2510629)

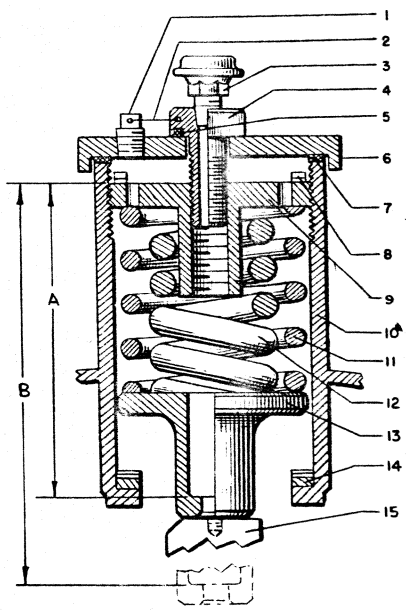



Fig. 5 (2778684)

1. Plug
2. Lockwire
3. Breather
4. Cover Bolt
5. "O" Ring
6. Cover
7. Gasket
8. Spare Shims
9. Adjusting Disc
10. Body
11. Outer Spring (Kickoff)
12. Inner Spring (Buffer)
13. Plunger
14. Shim Stack
15. Lift Rod Coupling

Fig. 5 Closing Buffer

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

4. Operation of the breaker in air is not recommended although a few air operations are permitted to check the stop clearance.

5. DO NOT USE THE MAINTENANCE CLOSING DEVICE FOR CLOSING THE BREAKER ON LOAD.

## STOP CLEARANCE ADJUSTMENT

The stop clearance adjustment is the means of determining the correct breaker linkage position with the breaker closed.

Using the maintenance closing device, slowly close the breaker until the trip latch of the operating mechanism falls into place to hold the mechanism in the closed position. Measure the stop clearance on all three poles. The internal stop clearance as shown in Fig. 1 is 1/8" ± 1/32". Measure the external stop clearance which is used as an indication of the internal stop clearance. This is 3/8" ± 1/32".

If the stop clearance must be changed, the following procedure should be followed either completely or in part in order to obtain clearance within the specified limits.

The breaker connecting rods, as well as the vertical operating rod, have right and left hand threads. Shortening of the rods will cause closing of the stop clearance. Adjustment for the first pole unit is attained by loosening the locking bolt in front coupling (9) Fig. 1 and the similar locking bolt (not shown) on the mechanism end of the operating rod (8). Turn this rod clockwise from the top to cause shortening of the rod and closing of the stop. Lengthening the rod would open up the clearance. This procedure will change the clearance on all three pole units at the same time.

Fig. 6 (8020346)

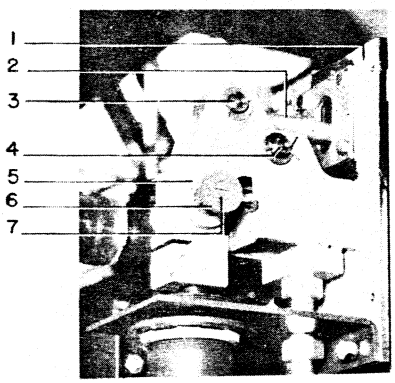



Fig. 7 (8022701)

1. Support
2. Connecting Rod
3. Connecting Rod Pin
4. Pivot Pin
5. Front Crank
6. Position Indicator
7. Pin for Operating Rod Coupling

Fig. 6 Front Crank Assembly

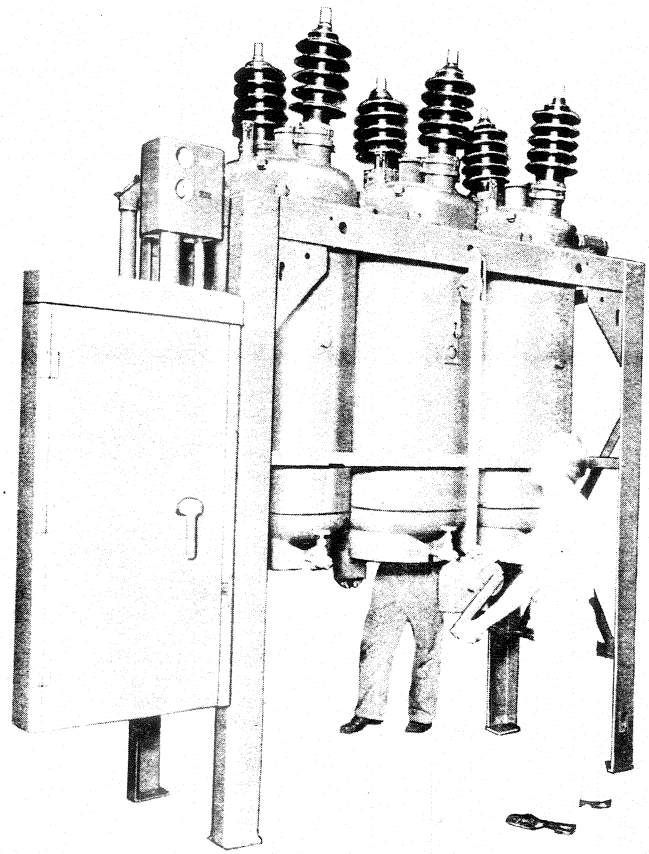


Fig. 7 Method of Mounting Tanklifter for Removal of Tanks

Tighten the locking bolts and recheck the stop clearance setting.

In a similar manner, the other two pole units are adjusted by changing the length of the connecting rod (3) Fig. 1. Adjustment of the connecting rod between pole units 1 and 2 will cause an equal change in the stop clearance of pole units 2 and 3 while the adjustment of the connecting rod between poles 2 and 3 affects only pole unit 3 stop clearances. Altering the stop clearance may affect the closing buffer adjustment, therefore maintain the 5-1/16 inch buffer dimension while adjusting the stop clearances. Final stop clearances should be measured after closing electrically with contacts in air. Readjust if necessary to above values.

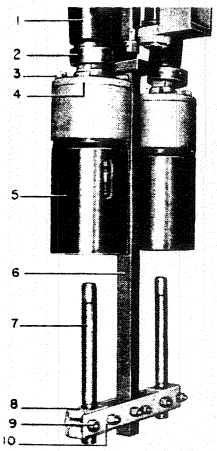
When adjustment is completed, be sure all hardware and locking bolts are tight.

## CLOSING BUFFER ADJUSTMENT

The closing buffer is set at the factory and should not require further adjustment. This unit is set in conjunction with the internal and external stops and a change in either may require adjustment of the other. With reference to Fig. 5, the dimension (A) from the top of the adjusting disc (9) to the counterbore of the plunger (13) should be 5-1/16 inches ± 1/32 inch with the breaker closed and the stops set with the proper clearance. With the breaker open, the dimension (A) should be 6-5/16 inches ± 1/16 inch. This is the correct buffer setting. The difference between the 6-5/16 inch measurement and the actual measurement (B) with the breaker open and no shims in place is the height of the shim stack (14) required under the plunger (13) to give the above correct buffer setting.

## CONTACT ADJUSTMENTS

After the pole unit mechanisms are adjusted, the contacts should be checked. Refer to Fig. 8. The interrupters (5) which are fastened to the lower ends of the bushings (1) must be aligned to a vertical position, with the ports facing 180° apart parallel with the centerline of the breaker. The use of a spirit level will assist in aligning the interrupter. By loosening the clamping ring (2), the adapter can be turned around the centerline of the bushing. Additional adjustment is possible by loosening the bushing mounting bolts and changing the seating of the bushing. When tightening these bolts extreme care must be taken to tighten all bolts evenly so as not to disturb the position of the bushing. The contact rods move up through the throat of the chamber and, therefore, the centerline of the interrupter should coincide with the centerline of the contact rod(7). The crossbar (10) is slotted so that by loosening the locknuts (9), the contact rods can be moved in or out to obtain alignment with the throat.




1. Bushing
2. Clamping Ring
3. Assembly Bolt
4. Adapter
5. Interrupter
6. Lift Rod
7. Contact Rod
8. Contact Block
9. Locknuts
10. Crossbar

Fig. 8 Breaker Unit

The contact insertion is 1-1/2 inches. This corresponds to an electrical wipe of 3/4 inch to 1-1/8 inches. To set this, the contact rod should enter the chamber a distance of 9-1/2 inches measured from the bottom of the interrupter tube (not the throat bushing). In other words, in the closed position, the tip of the contact rod (7) should be 9-1/2 inches above the bottom of the interrupter (5).

To change the contact insertion, loosen the locknuts (9) and rotate the contact rod (7) in an appropriate direction. At the same time there should be at least 7/8 inch clearance between the bottom of the interrupter and the crossbar (10), with the breaker closed, so that overtravel will not damage the interrupter or contacts. Tighten the locknuts and recheck all the contact adjustments and alignment. With the breaker properly adjusted, the contacts of the three pole units should make and break at approximately the same time, or within 1/4 inch of each other.

## STROKE

After the closed position adjustments of the breaker have been completed, it will be necessary to check the breaker in the open position.

The oil dashpots (3), Fig. 9, should be checked for proper oil level, and filled with G.E. #10-C oil if necessary. This check should be made with the plunger up, that is, with the breaker in the partially closed position so that the breaker linkage (1) is not touching the plunger. A small pipe plug (2) is located at the oil level line. Oil can be added to the dashpot by removing the reservoir on the side opposite the pipe plug. If the oil level is satisfactory, open the breaker.

The stroke of the breaker, which is the total movement of the lift rod (4) from the fully closed to the fully open position, should measure 12 inches plus or minus 1/2 inch as specified on the outline drawing. The dashpot should be the final stop of the breaker in the open position. The dashpots are threaded to permit adjustment for this purpose. Raising the dashpots shortens the stroke and lowering them lengthens it. When making adjustments, all dashpots should be made to operate at approximately the same time.

## FILLING THE TANKS

Before the final operating adjustments are made, the tanks must be filled with G. E. #10-C oil. First, however, make certain that all cotter pins, washers, bolts, lock rings, etc., are in place and properly tightened, and that all fittings and accessories have been made oil tight. Use G.E. #1201 compound 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 damaged from use.

While the oil is shipped in sealed containers, careless handling during shipment or storage may result in absorption of moisture by the oil. All new oil should be tested before being placed in the breaker. The dielectric strength of the oil when shipped is at least 26,000 volts when tested in a standard gap, with 1" disc terminals 0.1" apart. New oil of less than standard dielectric strength should not be placed in the breaker oil tanks until its insulating value has been brought up to the above standard. If further details are desired on the characteristics and maintenance of G.E. #10-C oil, obtain Bulletin GEA-4937 from the nearest Apparatus Sales Office of the 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 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 oilproof rubber hose must be used because oil dissolves the sulphur in ordinary rubber hose. This may cause trouble as sulphur attacks copper.

The normal oil level at 20 C is indicated on the outline drawing. A float type oil gage is supplied. The range between minimum and maximum is represented by the visible portion of the gage glass and covers a temperature range of 70 C, or from + 40 C to -30 C. The oil level at any intermediate temperature is represented by a proportionate part of the gage range. It is important that the oil level never falls below the minimum level. This is selected so that the lower Herkolite* of the bushing will always be immersed and prevent corona discharge from the ground sleeve.

## OPERATING MECHANISM CHECK

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

While the tanks are being filled with oil, the checks can be made on the operating mechanism. The compressor oil level should be checked and the air receiver filled to the proper pressure. The settings of all pressure switches and cutoff switches must be checked. Reference should be made to the mechanism instruction book for these adjustments.

## SPEED ADJUSTMENT

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 check the speed adjustment.

A travel analyzer should be attached to the breaker to obtain an accurate travel record of breaker performance. See Fig. 10. A #10-32 tapped hole is located in the top of the lift rod assembly, as indicated in Fig. 1, to accommodate the rod used with the travel analyzer. Access to this tapped hole is through a hole in the closing buffer assembly. The travel analyzer is readily mounted by attaching the bracket to the center phase buffer housing after unscrewing the gas vent.

The opening speed is determined by drawing a straight line through two points on the travel curve. See Fig. 11. One point is to be located on the opening curve 1-1/2 inches from the fully closed position. This is the point of contact insertion. The second point is to be located on the opening curve 6-1/2 inches (measured vertically) from the fully closed position. The slope of this line is an indication of the opening speed, which should be 8-1/2 to 9-1/2 feet per second.

If it is found necessary to readjust the opening speed of the breaker, this may be done by changing the setting on the opening springs (6), Fig. 1. By setting the springs to have less compression in the closed position, the opening speed will be reduced. It also follows that by setting the springs to have more compression in the closed position, the opening speed will be increased.

The average closing speed can be determined in a similar manner by drawing a straight line, tangent to the closing curve, through a point 2-1/2 inches from the fully closed position. The closing speed is controlled by the operating mechanism. There is no adjustment for the closing speed. For additional information, consult the mechanism instruction book paying particular attention to the section on INSTALLATION ADJUSTMENTS.

The overtravel of the lift rod must not exceed 1/4 inch. The best way to accurately measure this is to place some putty about 1/2 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 1/4 inch, check the buffer setting.

When opening in oil, the breaker should open the full stroke. The travel curve will be acceptable if the indicated rebound is less than 5% of the total stroke, provided the breaker finally comes to rest within 3% of the total stroke. A slight variation between the three pole units within the above tolerance is permissible.

Fig. 8 (8013388)



* Registered Trade-Mark of General Electric Co.

SUMMARY OF ADJUSTMENTS

1. With the tanks off:
   a. The lift rods should hang in a vertical position with approximately 1/64 inch clearance between the sides of the rod and the guide.
   b. Check the external stop clearance, and internal stop clearance after closing electrically. Refer to Fig. 1.
   c. Check the vertical alignment of the interrupters and make certain that the exhaust ports face 180° apart parallel to the centerline of the breaker.
   d. The contact insertion should be 1-1/2 inches, which is equivalent to having the contact rods enter the interrupters a distance of 9-1/2 inches.
   e. The stroke should be 12 inches plus or minus 1/2 inch.
2. With the tanks in place and filled with oil:
   a. Contact opening speed, 8-1/2 to 9-1/2 f.p.s.
   b. Overtravel, 1/4 inch maximum.
   c. Rebound, not more than 5% of stroke.
   d. Opening at rest position, within 3% of stroke.

FINAL INSPECTION

1. See that the breaker is properly set up and leveled on its foundation.
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 gland nuts, precautions should be taken to prevent damaging the packing through excessive pressure.
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 and breaker mechanisms have been lubricated.
5. Make certain that the dashpots are filled to the proper level.
6. Make certain that the tanks are filled to the proper level.
7. Make certain that the installation adjustments and operating adjustments have been thoroughly checked.
8. See that all covers and bolted connections are securely tightened and that all pipe plugs for inspection openings are properly installed and tightened 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.

Fig. 9 (8022700)

Fig. 10 (8022960)

# OPERATION

The pneumatic or the solenoid operating mechanism provides the energy for all operations of the breaker. Control voltage and pressure ranges for proper operation are given on the operating mechanism nameplate.

These mechanisms are designed for rapid closing, opening, and trip-free operations and (when requested) reclosing operation. During the closing operation, the operating mechanism moves the vertical operating rod (8), Fig. 1, in a downward direction. This motion is transmitted through the breaker linkage to the vertical lift rods (22) in each of the pole units, closing the breaker.

It follows that the opening operation is the reverse of the closing operation.

When the breaker opens under load, the contacts part drawing arcs between the tips of the contact rods and the arcing tips of the stationary contacts. The pressure generated by the arcs forces fresh oil past the arcing area, at the same time forcing the arcs between the baffles in the direction of the port openings, as shown in Fig. 13, carrying the arc products away from the contacts and out of the interrupter. Thus, rapidly lengthening and cooling the arc, its resistance is increased and at an early current zero the arc cannot re-establish itself, and interruption occurs.

# MAINTENANCE

To maintain dependable service and safety of power equipment it is recommended that a definite 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.

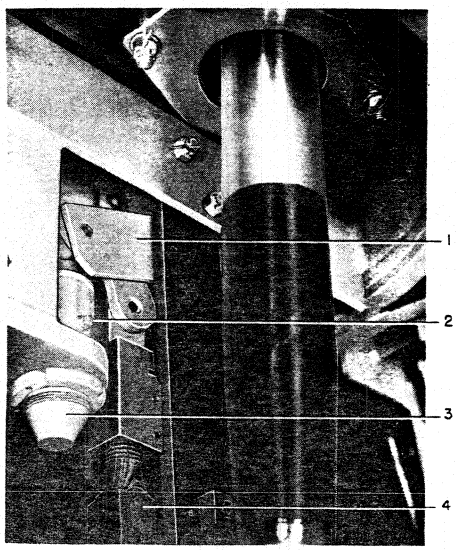
BEFORE ANY MAINTENANCE WORK IS PERFORMED, MAKE CERTAIN THAT ALL CONTROL CIRCUITS ARE DEENERGIZED AND THAT THE BREAKER PRIMARY CIRCUITS ARE OPEN AND EFFECTIVELY GROUNDED. ALSO, DO NOT WORK ON THE BREAKER OR MECHANISM WHILE IN THE CLOSED POSITION UNLESS THE PROP AND TRIP LATCH HAVE BEEN SECURELY WIRED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

PRECAUTIONS

1. Be sure the breaker is disconnected from all electric power, both high voltage and operating voltage, before inspecting or repairing.
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 tanks are well grounded.
4. Use the maintenance closing device to assist in making adjustments. This is the primary purpose of the device because it permits slow closing and opening. IT SHOULD NOT BE USED FOR CLOSING THE BREAKER ON LOAD.
5. After making any adjustments operate the apparatus by hand before attempting electrical operation.

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 which occasionally occur. Operating experience will soon establish a




1. Breaker Linkage
2. Oil Level Plug
3. Opening Dashpot
4. Lift Rod

Fig. 9 Breaker Mechanism

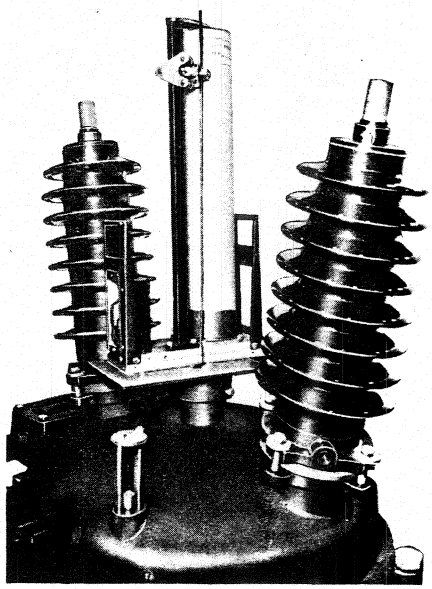


Fig. 10 Installation of Travel Analyzer

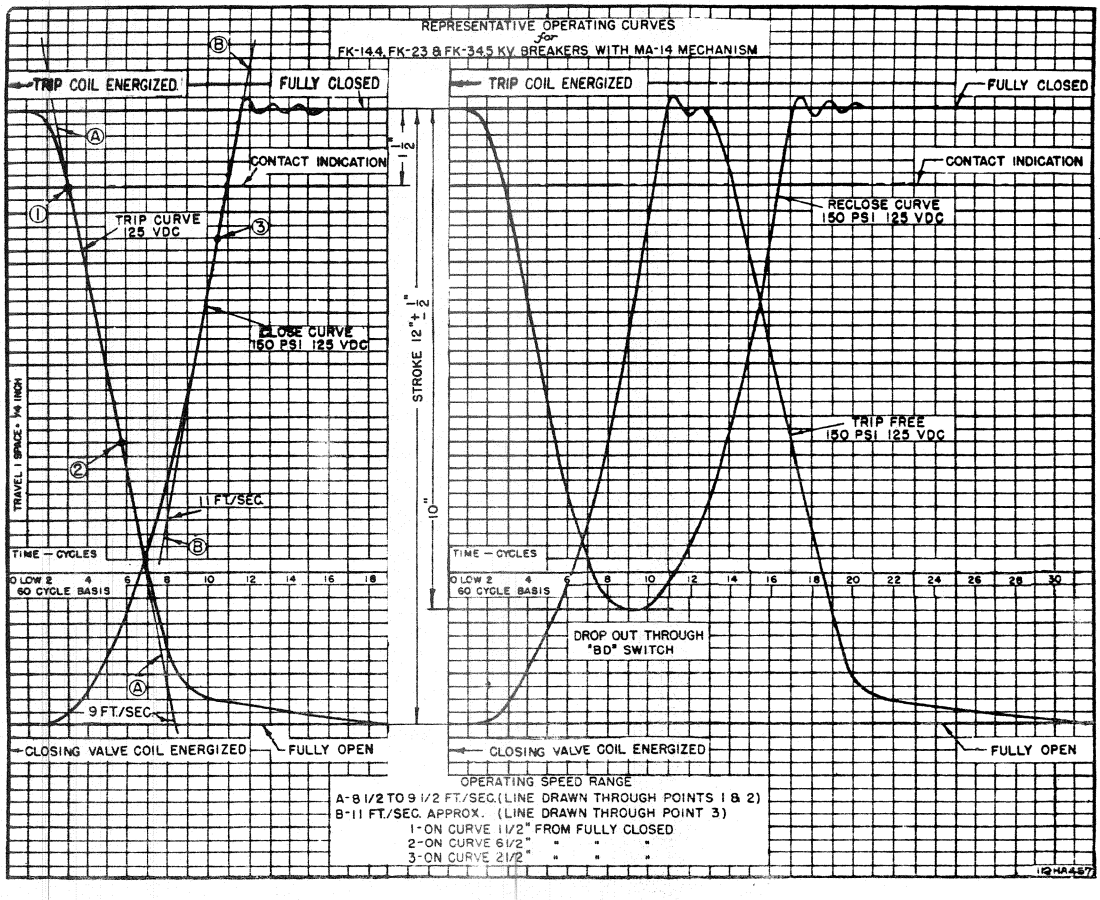



Fig. 11 Representative No-Load Travel Curves For Opening And Closing Operations

Fig. 12 Representative No-Load Travel Curves For Reclosing And Trip-Free Operations

Figs. 11 & 12 (112HA457)

maintenance schedule which will give assurance of proper breaker condition. 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.

2. 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 cork stopper should be used. The sample of oil should be at least one pint.

   Test samples should be taken only after the oil has settled for some time. Samples should be taken from the valve at the bottom of the tank and sufficient oil drawn off to make sure the sample represents oil from the tank proper and not that stored in the drain pipe. A glass receptacle 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.

3. All insulation parts should be thoroughly cleaned 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 insides of the tank.

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

5. 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. Oil may be added by removing the reservoir. The dashpots use G. E. #10-C breaker oil. The dashpots should be examined to see that the piston works freely and that there is no sludge present.

6. All bolts, nuts, washers, cotter pins, lock rings, and terminal connections should be in place and properly 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.

7. 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.

8. 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.

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

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

11. See that the oil is at the proper level in the tanks.

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

## REPAIR AND REPLACEMENT

### INTERRUPTER AND CONTACTS

With the oil tanks removed, and the breaker in the open position, the interrupter unit (6) can be lowered for inspection or repair by merely removing the four assembly nuts (3) as shown in Fig. 14. Examine the contacts for excessive burning, pitting, or wear. The contact segments (5) can be removed by simply unfastening the flexible connectors (4).

Each movable contact rod has a renewable tip (7) which can be removed. This tip is locked to the rod by peening the metal of the rod into a small notch in the tip.

If further disassembly of the interrupter is required, it will be necessary to remove the adapter assembly (3), Fig. 3 from the bushing in order to lift the interrupter unit (6), Fig. 14 free of the contact rod (8). To remove the adapter from the stud, first loosen the clamping ring (1).

Referring to Fig. 4, unscrew the support ring (4) and locking ring (5) to remove the baffle stack (13). A spanner wrench is used for this purpose. When reassembling, make certain that the exhaust slots in the baffles (13) face the exhaust ports (14). Locating pins (15) in the lower insulating tube (16) aid in their proper alignment.

When remounting the interrupter and adapter to the bushing, a spirit level should be used to insure vertical alignment. Furthermore, upon completion of maintenance work it will be necessary to review all contact adjustments as explained in the section on INSTALLATION ADJUSTMENTS.

### BUSHINGS

Little or no maintenance is required of the bushings other than a periodic cleaning of the porcelains. 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.

To remove a bushing, it will first be necessary to remove the interrupter. The bushing can be removed and installed from the top of the breaker. When reinstalling the bushing, make certain that the gaskets between the top frame and the mounting flange of the bushing are in good condition. The mounting bolts should be tightened gradually and evenly, and all interrupter adjustments should be checked.

### BUSHING CURRENT TRANSFORMERS

Transformers should be connected in accordance with instructions 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 end of the transformer carrying a white mark (3) Fig. 15 is placed upwards.

Bushing current transformers are mounted in the top frame as shown in Fig. 15. To remove the bushing current transformer, first disconnect the transformer lead wires. Loosen the clamping ring (7) and remove the interrupter unit (8). Then remove the four assembly nuts (6) permitting the supporting plate (5) and the current transformer (4) to be lowered.

Bushing current transformers may be installed either before or after the bushings are in place. Insulation washers (2) above and below the transformer protect it from injury. It must be properly centered to prevent it from becoming damaged when the bushing is installed.

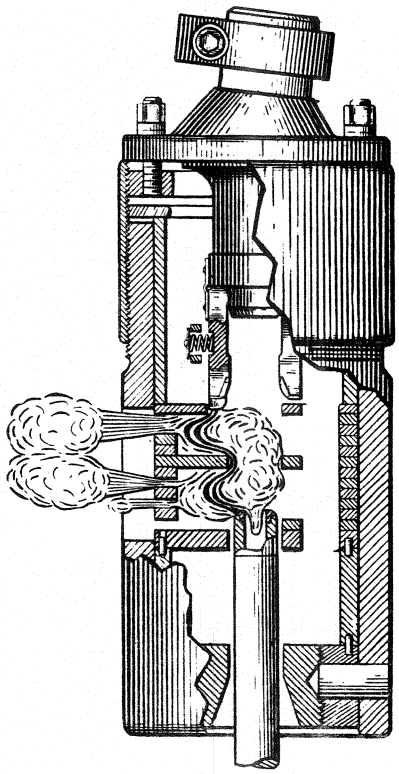
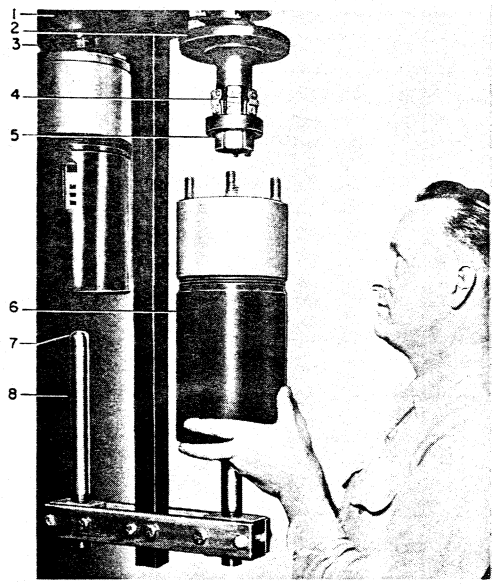


Fig. 13 Cutaway View of Interrupter Showing Arc Interruption

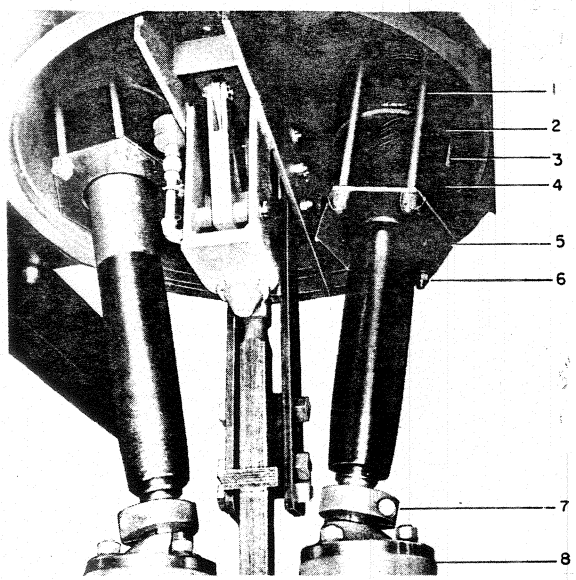
Fig. 13 (615C449)




1. Clamping Ring
2. Adapter
3. Assembly Nuts
4. Flexible Connectors
5. Contact Segments
6. Interrupter Unit
7. Contact Tip
8. Contact Rod

Fig. 14 Lowering the Interrupter for Inspection

Fig. 14 (8022702)




1. Assembly Stud
2. Insulation Washers
3. Polarity Mark
4. Current Transformer
5. Supporting Plate
6. Assembly Nut
7. Clamping Ring
8. Interrupter Unit

Fig. 15 Bushing Current Transformer Mounting

Fig. 15 (8022959)

# RENEWAL PARTS

It is recommended that sufficient renewal 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 replacements.

Renewal 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 renewal 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 front door of the operating mechanism compartment. Also furnish a complete description of each part, the quantity required, and, if possible, the number of the requisition on which the breaker was originally furnished.

A list of recommended Renewal Parts is given below.

| | | QTY. PER O.C.B. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | FK-14.4-1000-2 | FK-23-500-2 | FK-34.5-500-2 | FK-34.5-1000-2 | FK-34.5-1500-2 | | |
| FIG. NO. | REF. NO. | | | | | | CATALOG NO. | DESCRIPTION |
| 3 | 1 | 1 | 6 | - | - | - | 7B522 | Bushing |
| 3 | 1 | - | - | 6 | 6 | 6 | 7B532 | Bushing |
| 3 | 4-5 | 12 | 12 | 12 | 12 | 12 | 177V561 P-15 | Gasket "O" Ring |
| 3 | 8 | 3 | 3 | 3 | 3 | 3 | 183V376 | Gasket (Tank) |
| 3 | 15 | - | - | - | - | - | ---------- | Interrupter, Refer to Fig. 4 |
| 3 | 21 | 3 | 3 | 3 | 3 | 3 | 6370470 P-20 | Glass for Oil Gage |
| 3 | 21 | 6 | 6 | 6 | 6 | 6 | 6440357 | Gasket for Oil Gage Glass |
| 3 | 24 | 3 | 3 | 3 | 3 | 3 | 181L319 G-4 | Lift Rod Guide |
| 3 | -- | 3 | 3 | - | - | - | 0808B0632 G-1 | Moving Contact Assembly |
| 3 | -- | - | - | 3 | - | - | 0808B0632 G-2 | Moving Contact Assembly |
| 3 | -- | - | - | - | 3 | 3 | 0808B0632 G-9 | Moving Contact Assembly |
| 3 | 25 | 3 | 3 | - | - | - | 387A330 P-8 | Lift Rod |
| 3 | 25 | - | - | 3 | 3 | 3 | 387A330 P-9 | Lift Rod |
| 3 | 16 | 6 | 6 | - | 6 | 6 | 438A622 P-1 | Contact Rod |
| 3 | 16 | - | - | 6 | - | - | 103A3849 P-1 | Contact Rod |
| 3 | 17 | 6 | 6 | 6 | 6 | 6 | 176V145 | Contact Block |
| 3 | 18 | 6 | 6 | - | - | - | 6508226 P-4 | Crossbar |
| 3 | 18 | - | - | 6 | 6 | 6 | 6508226 P-2 | Crossbar |
| 3 | 26 | 3 | 3 | 3 | 3 | 3 | 438A614 G-1 | Drain Valve & Plugs |
| 4 | -- | 6 | 6 | - | 6 | 6 | 175L995 G-2 | Interrupter Complete |
| 4 | -- | - | - | 2 | - | - | 175L995 G-1 | Interrupter Complete |
| 4 | -- | 6 | 6 | - | 6 | 6 | 103L165 G-2 | Upper Contact Assembly |
| 4 | -- | - | - | 6 | - | - | 103L165 G-1 | Upper Contact Assembly |
| 4 | 7 | 36 | 36 | 36 | 36 | 36 | 6116374 P-6 | Flexible Lead |
| 4 | 8 | 6 | 6 | 6 | 6 | 6 | 176V880 P-1 | Contact Retainer |
| 4 | 9 | 36 | 36 | 36 | 36 | 36 | 6076150 | Spring |
| 4 | -- | 6 | 6 | 6 | 6 | 6 | 362A163 P-1 | Retaining Ring |
| 4 | 10 | - | - | 24 | - | - | 398A751 P-2 | Contact Segment |
| 4 | 10 | 24 | 24 | - | 24 | 24 | 398A752 G-2 | Contact Segment |
| 4 | 11 | - | - | 12 | - | - | 398A753 G-1 | Arcing Segment |
| 4 | 11 | 12 | 12 | - | 12 | 12 | 389A752 G-1 | Arcing Segment |
| 4 | 12 | 6 | 6 | 6 | 6 | 6 | 6371561 P-12 | Upper Insulation Tube |
| 4 | 13 | 6 | 6 | 6 | 6 | 6 | 267C907 G-1 | Baffle Stack |
| 4 | 16 | 6 | 6 | 6 | 6 | 6 | 362A249 G-11 | Lower Insulation Tube |
| 4 | 18 | 6 | 6 | 6 | 6 | 6 | 362A248 G-11 | Outer Tube |
| 5 | 14 | 15 | 15 | 15 | 15 | 15 | 181V112 P-2 | Shim 1/8" Thick |
| 5 | 14 | 3 | 3 | 3 | 3 | 3 | 181V112 P-3 | Shim 1/16" Thick |
| 5 | 14 | 3 | 3 | 3 | 3 | 3 | 181V112 P-4 | Shim 1/32" Thick |
| 1 | Ø | 1 | 1 | 1 | 1 | 1 | 181L319 G-1 | Front Cover Gasket |
| 1 | Ø | 3 | 3 | 3 | 3 | 3 | 183V396 | Conduit Box Gasket |
| 1 | 23 | 3 | 3 | 3 | 3 | 3 | 178L271 G-1 | Dashpot |

Ø Not Illustrated