INSTRUCTIONS GEK-19868

OIL-BLAST CIRCUIT BREAKERS

Standard Types

FKA-15.5-36000-6	15.5KV,	36000	Interrupting Amperes	(Nominal 1000MVA)
FKA-38 -22000-6	38.0KV,	22000	Interrupting Amperes	(Nominal 1500MVA)
FKA-48.3-17000-6	48.3KV,	17000	Interrupting Amperes	(Nominal 1500MVA)
FKA-48.3-29000-6	48.3KV,	29000	Interrupting Amperes	(Nominal 2500MVA)
FKA-72.5-19000-3	72.5KV,	19000	Interrupting Amperes	(Nominal 2500MVA)
FKA-72.5-27000-3	72.5KV,	27000	Interrupting Amperes	(Nominal 3500MVA)
	1200 Continuous Amperes			

Capacitor Switching Types

FKA-15.5-36000-6R	15.5KV,	36000	Interrupting Amperes	24000 KVAR
FKA-38 -22000-6R	38.0KV,	22000	Interrupting Amperes	30000 KVAR
FKA-48.3-17000-6R	48.3KV,	17000	Interrupting Amperes	27000 KVAR
FKA-48.3-29000-6R	48.3KV,	29000	Interrupting Amperes	27000 KVAR
FKA-72.5-19000-3R	72.5KV,	19000	Interrupting Amperes	20000 KVAR & 15000 KVAR
FKA-72.5-27000-3R	72.5KV,	27000	Interrupting Amperes	20000 KVAR & 15000 KVAR
	1200 Continuous Amperes			

Contents

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.

POWER CIRCUIT BREAKER PRODUCTS DEPARTMENT
PHILADELPHIA, PA

GENERAL ELECTRIC

INSTRUCTIONS

GEK-19795D

SUPERSEDES GEK-19756E
and GEK-19795C

OIL-BLAST CIRCUIT BREAKERS

STANDARD BREAKERS

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1200 Continuous Amperes

CAPACITOR SWITCHING BREAKERS

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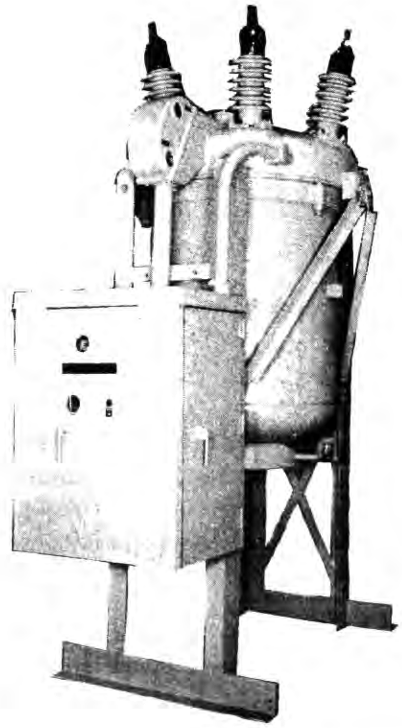
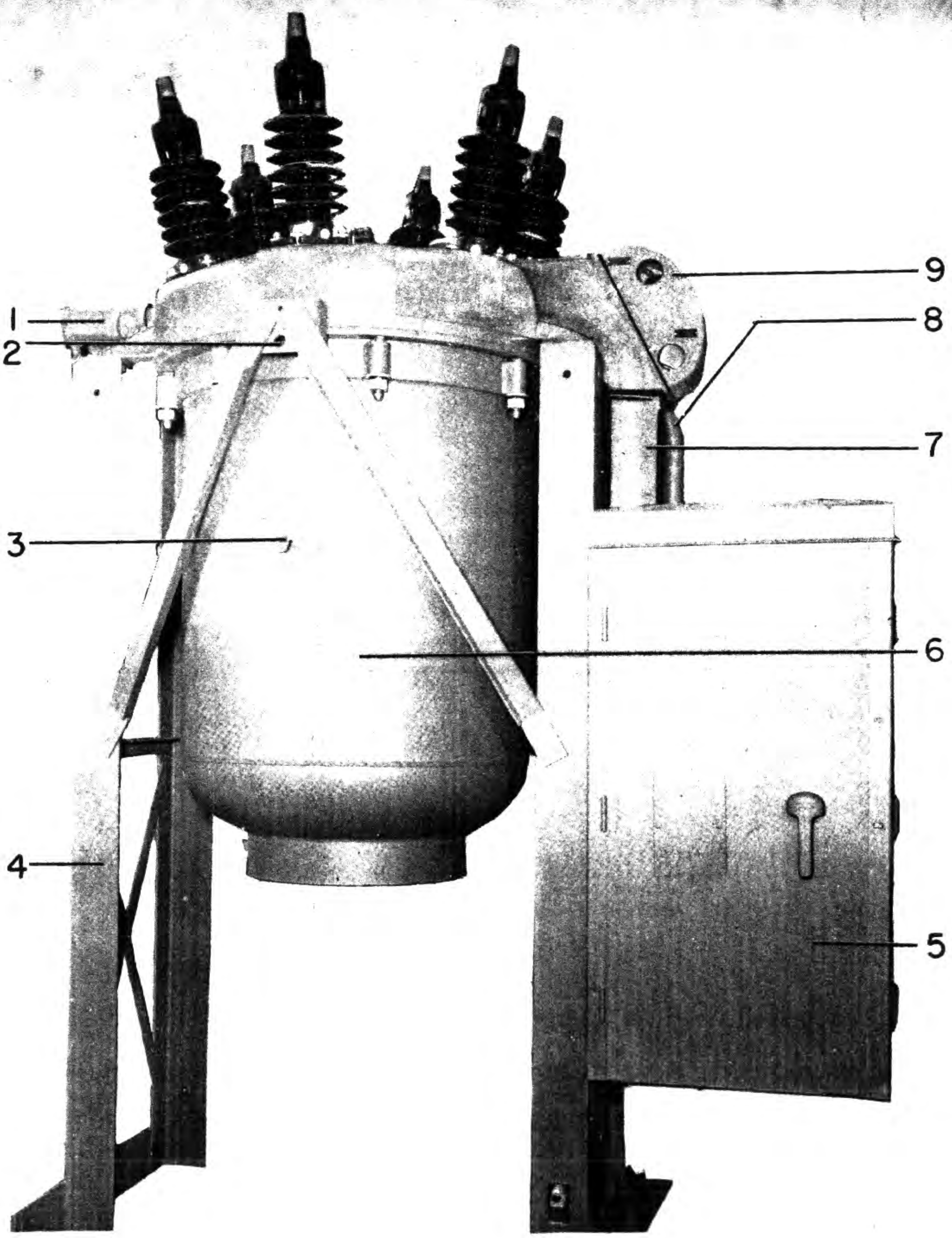
1200 Continuous Amperes

CONTENTS



GENERAL ELECTRIC



1. Opening Spring Cover Pipe
2. Tank Lifter Support Bracket
3. Tank Lug
4. Breaker Framework
5. Mechanism House
6. Breaker Oil Tank
7. Vertical Operating Rod Cover Pipe
8. BCT Conduit Pipe
9. Front Crank Assembly Cover

Fig. 1 Type FKA Breaker with tank in place

OIL-BLAST CIRCUIT BREAKERS

STANDARD BREAKERS

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INTRODUCTION

STANDARD BREAKERS

The standard type FKA 15.5-5, 38-5, 48.3-5 and 72.5-2 oil-blast circuit breakers have been designed especially for applications on transmission lines where high speed 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 and rugged linkage which operates on low friction bearings, and by employing arc resistant materials for the interrupting contacts.

The fast breaker interrupting time means less system disturbance because of a quicker clearing of the fault. The short arc lengths mean lower maintenance costs.

CAPACITOR SWITCHING BREAKERS

The capacitor switching type FKA 15.5-6R, 38-6R, 48.3-6R and 72.5-3R breakers are specially constructed type FKA oil-blast circuit breakers for capacitor switching applications. They utilize a specially designed interrupter that has a built-in wire-wound resistor so connected that during interruption it is inserted into the arcing circuit in parallel with the power arc, and upon extinguishing of the power arc the resistor is inserted in series with the main contacts. The function of this resistor is to limit the restriking voltage so that the interruption will occur at an early current zero.

Resistor equipped breakers for application on capacitor banks are not normally applied on high-speed reclosing duty.

Out-of-service reclosing operations should be made to check the mechanical operation of the breaker. If in-service high-speed reclosing is required, recommendations must be obtained from the factory.

ALL BREAKERS

To facilitate installation the three phases of the breakers are mounted in a common frame on skids mounted on the front and rear of the frame. The spring-charged mechanical operating mechanism is installed in a weatherproof housing which is mounted on the front end of the breaker framework. The three phases are mechanically connected so as to operate simultaneously.

The FKA breaker is available in a number of current and voltage ratings. For the complete rating information of any particular breaker, refer to the breaker nameplate which is located inside the operating mechanism housing on one of the doors.

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 3300 feet. Use at higher altitudes requires selection of special bushings.

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 not such assurance is given with respect to local codes and ordinances because they vary greatly.

1. Lifting Cables
2. Bushings
3. Close and Open Indicators
4. Bushing Current Transformer Lead Conduit
5. Tank Lifting Lug
6. Mechanism House
7. Right Side Door Handle
8. Oil Level Gage
9. Buffer and Kick-off Springs Housing
10. Oil Fill Pipe
11. Opening and Follow-through Springs Housing
12. Breaker Framework
13. Drain Valve
14. Grounding Pad

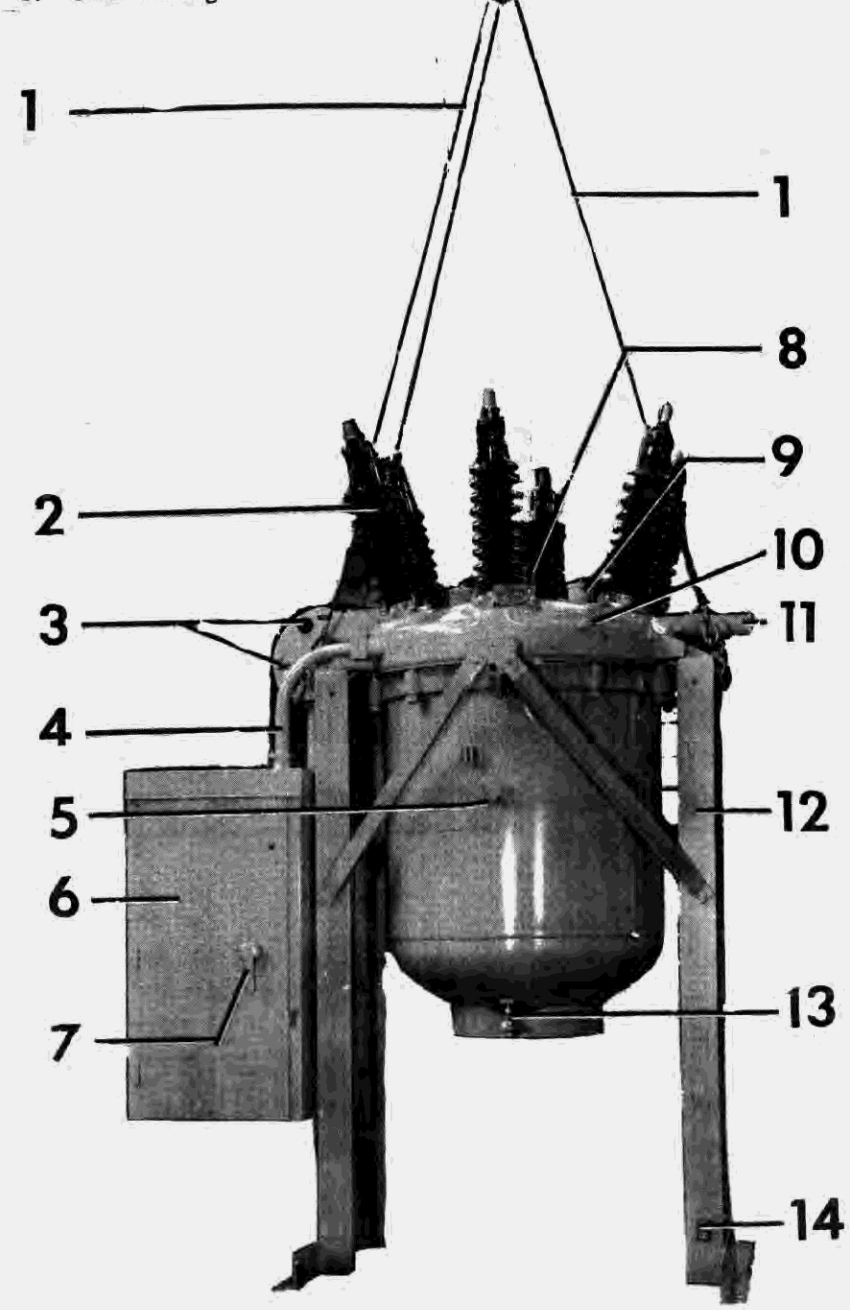


Fig. 2 View of a Type FKA Oil Circuit Breaker and the method used in lifting the breaker

Fig. 2 (8038380)

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 circuit breaker in service and for maintaining satisfactory 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.

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.

SAFETY

Each user has the responsibility to instruct 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

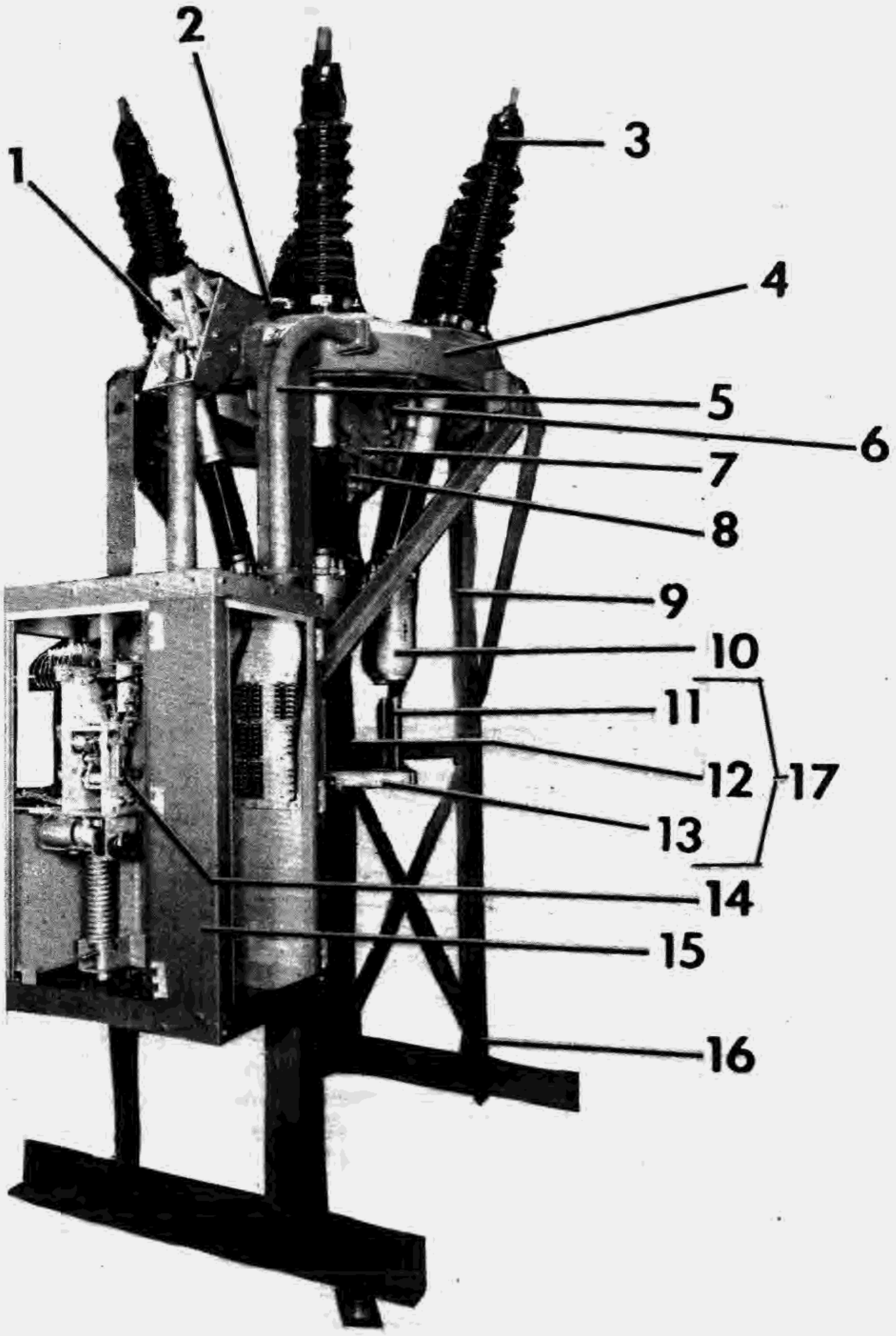


Fig. 3 (8040120A)

1. Vertical Operating Rod Coupling
2. Closing Buffer
3. Bushing
4. Breaker Dome
5. BCT Conduit Pipe
6. Bushing Current Transformer (BCT)
7. Breaker Linkage
8. Opening Dashpot
9. Framework
10. Interrupter
11. Contact Rod
12. Lift Rod
13. Crossarm
14. Mechanism
15. Mechanism House
16. Ground Pad
17. Moving Contact Assembly

Fig. 3 View of the Type FKA Oil Circuit Breaker with an ML-14-0 spring-charged operating mechanism showing major assembly units

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.

3. The term "breaker" includes all equipment mounted on the circuit breaker foundation.

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. All spring-charged mechanisms related to a breaker must be serviced only by skilled and knowledgeable personnel capable of releasing each spring load in a controlled manner. Particular care must be exercised to keep personnel clear of mechanisms which are to be operated or released. Information on construction of such mechanisms is provided in the instruction book for the particular breaker.

4. 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.

5. 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.

RECEIVING, HANDLING AND STORAGE

RECEIVING

Upon receipt of this equipment examine it for hardware which may have become loose in transit. Tighten any loose hardware and apply paint as required.

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, breaker linkage and breaker tank 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

Any 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. Cables used to lift the breaker should be as long as possible to prevent damage to the bushing. The method used in attaching these cables is shown in Fig. 2.

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 and internal parts should be cleaned and dried before the oil tanks are filled with oil. Remove the desiccant bags, and the humidity card on the lift rod. Any crating or wrapping, if used around the bushings should not be taken from the bushings until after the breaker has reached its permanent location and all overhead work has been completed.

If stored outdoors, the breaker tank 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 or moisture. Under extreme conditions of humidity, or if the only storage space is damp, they should be kept in suitable containers filled with clean and dry Type I insulating oil.

Renewal parts, especially lift rods, guides and other parts made of insulating material 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. Under extreme conditions of humidity, or if the only storage space is damp, they should be kept in suitable containers filled with clean and dry Type I insulating oil.

DESCRIPTION

BREAKER

Each circuit breaker is composed of an operating mechanism (14), Fig. 3, and a breaker assembly mounted on a common framework (9) as shown in Fig. 3. The breaker assembly consists of an oil tank (6), Fig. 1, which contains the interrupters and contacts, a breaker dome (4), Fig. 3, which houses the breaker linkage, Figs. 8 and 9, and bushing current transformers (6), Fig. (3), and also support the bushings (3), Fig. 3, and interrupters (10), Fig. 3.

The breaker linkage which is assembled in the breaker dome (8), Fig. 4, is designed to give straight-line motion to the moving contact assemblies (30), Fig. 4, and to convert the motion of the operating mechanism (14), Fig. 3, to the proper breaker stroke. The breaker linkage, Fig. 8 and Fig. 9, is connected to the operating mechanism by an adjustable connecting rod (11), Fig. 14. On the front of the breaker dome (4), Fig. 3, above the operating mechanism is the toggle linkage, Fig. 10 and Fig. 11, which is used to change the vertical operation of the operating mechanism to the horizontal operation of the breaker linkage. Contained within the breaker dome is the breaker linkage which changes the linkage horizontal movement to a straight-line vertical movement of the lift rod (18), Fig. 14. A gas and oil seal is provided around the horizontal operating rod to form a separation between the toggle linkage box (2), Fig. 10, and the interior of the breaker dome. An adjustable opening spring (25), Fig. 14 located on the back end of the opening spring coupling (23), insures positive opening action and determines contact speed and contact parting time. The follow-through spring (27), Fig. 14, is adjusted with the opening spring and insures positive opening action over the full stroke of the breaker contacts.

CLOSING BUFFER AND OPENING DASHPOT

A closing buffer (2), Fig. 3, and an oil filled opening dashpot (8) are located in each phase. 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 tank. 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.

BREAKER BREATHER

A "breather" (1), Fig. 4, is mounted on the center phase closing buffer (20), Fig. 14, to vent any oil vapor caused by circuit interruption and to maintain atmospheric pressure inside the breaker dome.

OIL GAGE

A float type oil gage (2), Fig. 4, is installed in the breaker dome (8). This indicates the oil level directly through the action of a float (15), the position of which corresponds to the true oil level. The float is fastened to a pointer rod which is visible in the glass tube of the oil gage 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 that portion of the bushing which must always be immersed in oil.

OIL TANK

The oil tank (18), Fig. 4, is suspended in place against the breaker dome (8) by eight breaker oil tank studs (2), Fig. 7, and nuts which compress a gasket (10), Fig. 4, located in a groove on the top of the oil tank band. The nuts must be tight to prevent oil leakage through the tank gasket area during circuit interruption and to prevent water seepage into the breaker during severe storms. This arrangement permits easy removal of the tanks for inspection and maintenance of the contacts and interrupters (20), Fig. 4. A drain valve (25) is attached to a drain pipe at the bottom of the tank so that the tank can be completely emptied. The valve should be capped or plugged to prevent any possible accidental leakage or contamination of the oil.

BREAKER INTERRUPTERS

STANDARD INTERRUPTER

Each interrupter (20), Fig. 4 is mounted on the lower end of each bushing (3) by means of an upper and lower adapter (5 and 6), Fig. 7, which is also used for alignment of the interrupter. See Fig. 21 for the interrupter assembly. The interrupter consists essentially of a Fiberglas tube enclosing a set of eight primary contact fingers, two of which have arcing tips, insulating tubes, and a baffle stack. The body tube has two port openings which allow the proper flow of oil across the contacts and through the baffle stack during interruption as shown in Fig. 26.

CAPACITOR SWITCHING INTERRUPTER

The capacitor switching interrupter (32), Fig. 4, is somewhat different from the standard interrupter in that it contains resistor finger assemblies and is surrounded with a resistor wound on a fiber support. In addition to the contact fingers, insulating tubes and baffle stack are contained in the standard interrupter. The resistor is electrically connected across the main contacts of the breaker and is shorted out when the breaker is in the closed position. The standard interrupter does not contain the resistor or the resistor finger assembly.

For a detailed explanation of the operation of the breaker refer to the section OPERATION.

BUSHINGS

The new low-silhouette center-clamped Type U bushings which are built to the new NEMA and ANSI standards are used in these breakers. The bushings are installed in the breaker dome from above. Weathertight gaskets are inserted between the support flange and the breaker dome. Each bushing has provisions for two current transformers and the bushings can be installed and removed from the breaker without disturbing the bushing current transformers. For additional information on the construction of bushings refer to instruction book, GEH-1638.

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 ANSIC57 .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

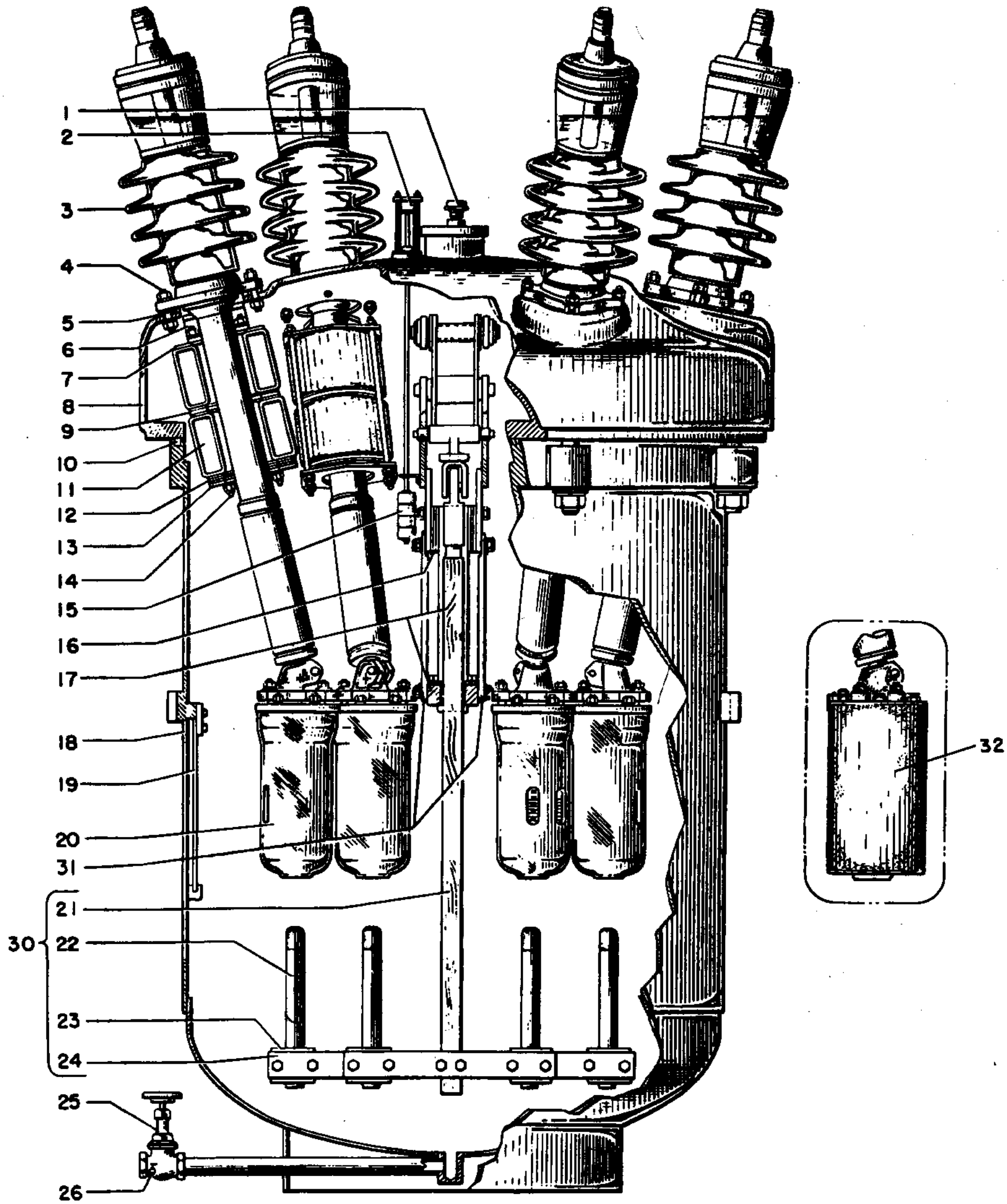
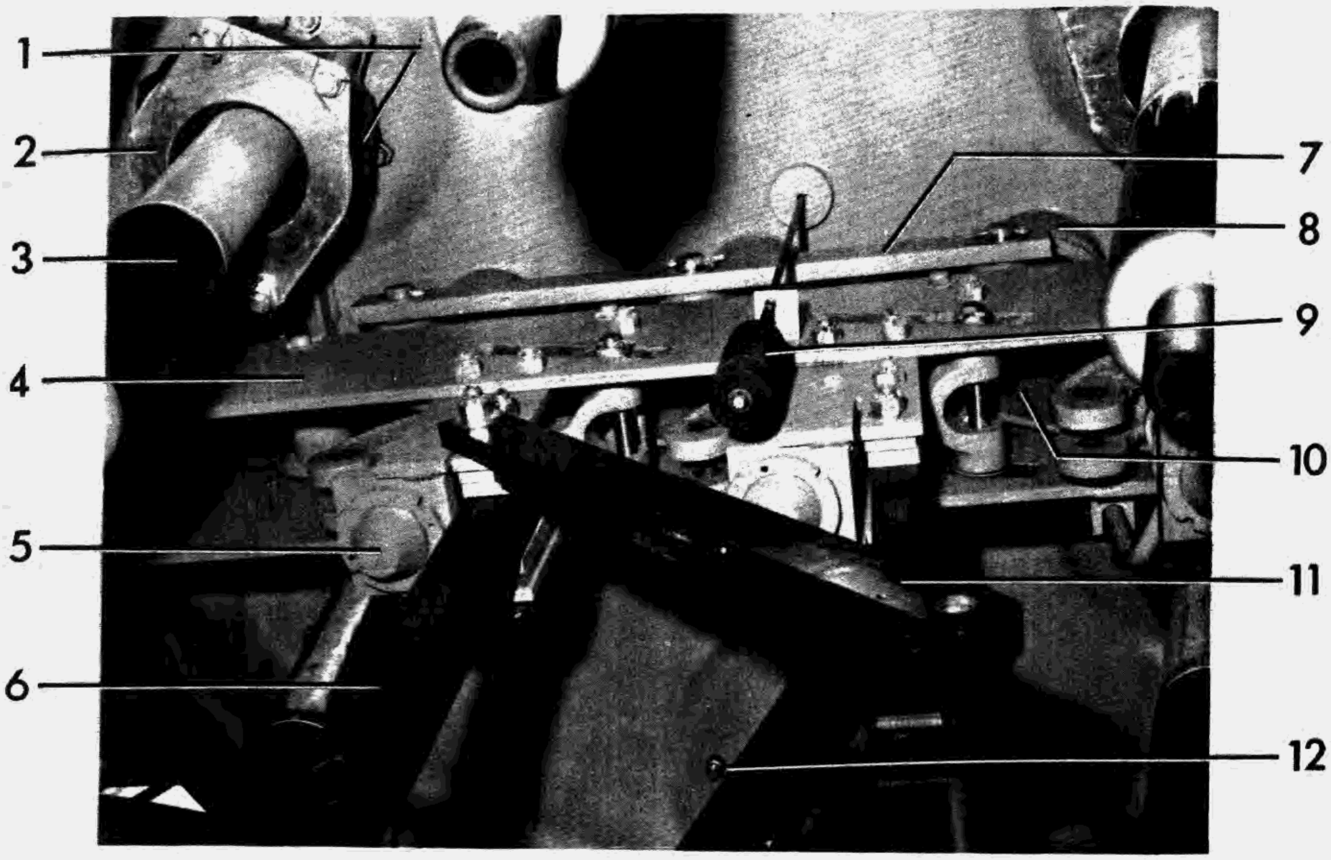


Fig. 4 Cross-sectional View of Breaker (One phase removed for simplicity)

Fig 5 (8038621)

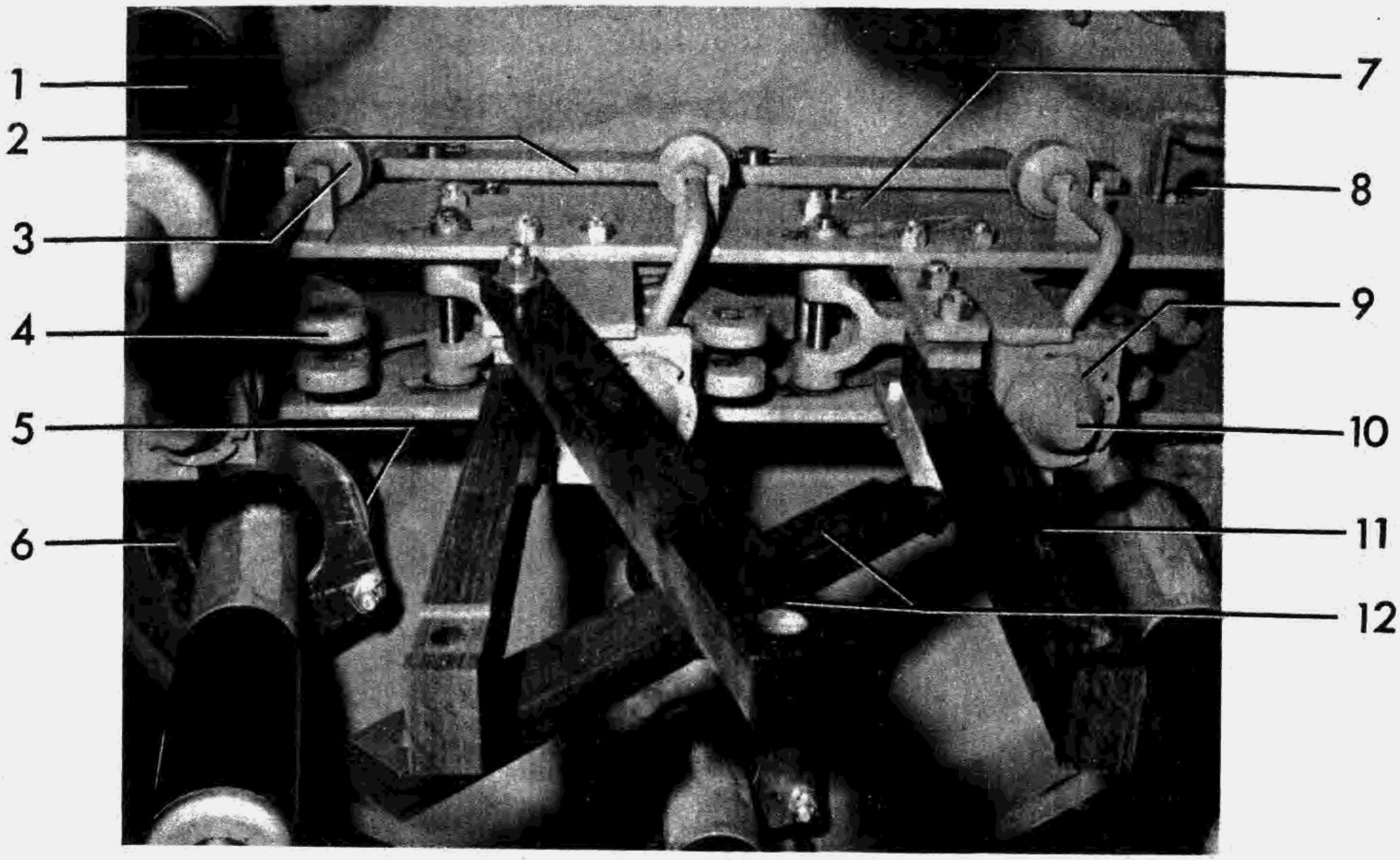


1. Bushing Current Transformer (BCT)
2. BCT Support Plate
3. Bushing
4. Linkage Support Side Plates
5. Breaker Opening Dashpots
6. Vertical Portion of the Lift Rod Guide
7. Connecting Link
8. Buffer Housing of the Rear Phase
9. Oil Level Indicator Floats
10. Beam
11. Diagonal Portion of the Lift Rod Guide
12. Bushing Mounting Studs (Underside)

Fig. 5 Right Side Vertical View of the Breaker Linkage with the interrupters, lift rods and horizontal guide plate removed.

Items for Fig. 4

1. Breather
2. Oil Gage
3. Bushing
4. Mounting Stud
5. Dome to Bushing Gasket
6. BCT Support Bracket
7. Insulation Washers
8. Breaker Dome
9. Insulation Washers
10. Tank Gasket
11. Current Transformer
12. Insulation Washers
13. Support Plate
14. Assembly Stud
15. Oil Gage Float
16. Alignment Shims
17. Lift Rod Guide
18. Oil Tank
19. Liner
20. Standard Interrupter
21. Lift Rod
22. Contact Rod
23. Contact Block
24. Crossarm
25. Drain Valve
26. Sampling Device
30. Moving Contact Assembly
31. Cross Braces
32. Capacitor Switching Interrupter



1. Bushing
2. Connecting Link
3. Opening Dashpot Breather
4. Lever
5. Bushing Current Transformer (BCT)
6. BCT Support Plate
7. Linkage Support Side Plates
8. Horizontal Rod Adjustment Access Opening
9. Lower Opening Dashpot Adjusting Nut.
10. Opening Dashpot
11. Vertical Portion of the Lift Rod Guide
12. Diagonal Portions of the Lift Rod Guide

Fig. 6 Left Side Vertical View of the Breaker Linkage with the interrupters, lift rods and horizontal guide plate removed.

Items for Fig. 7

1. Lever
2. Tank Stud
3. Bushing
4. Oil Level Float
5. Upper Interrupter Adapter
6. Lower Interrupter Adapter
7. Interrupter
8. Lift Rod
9. Contact Rod
10. Crossarm
11. Opening Dashpot Breather
12. Opening Dashpot
13. Horizontal Lift Rod Guide
14. Interrupter to Bushing Clamping Bolt
15. Breaker Rear Frame
16. Operating Mechanism - Left Door
17. Contact Block

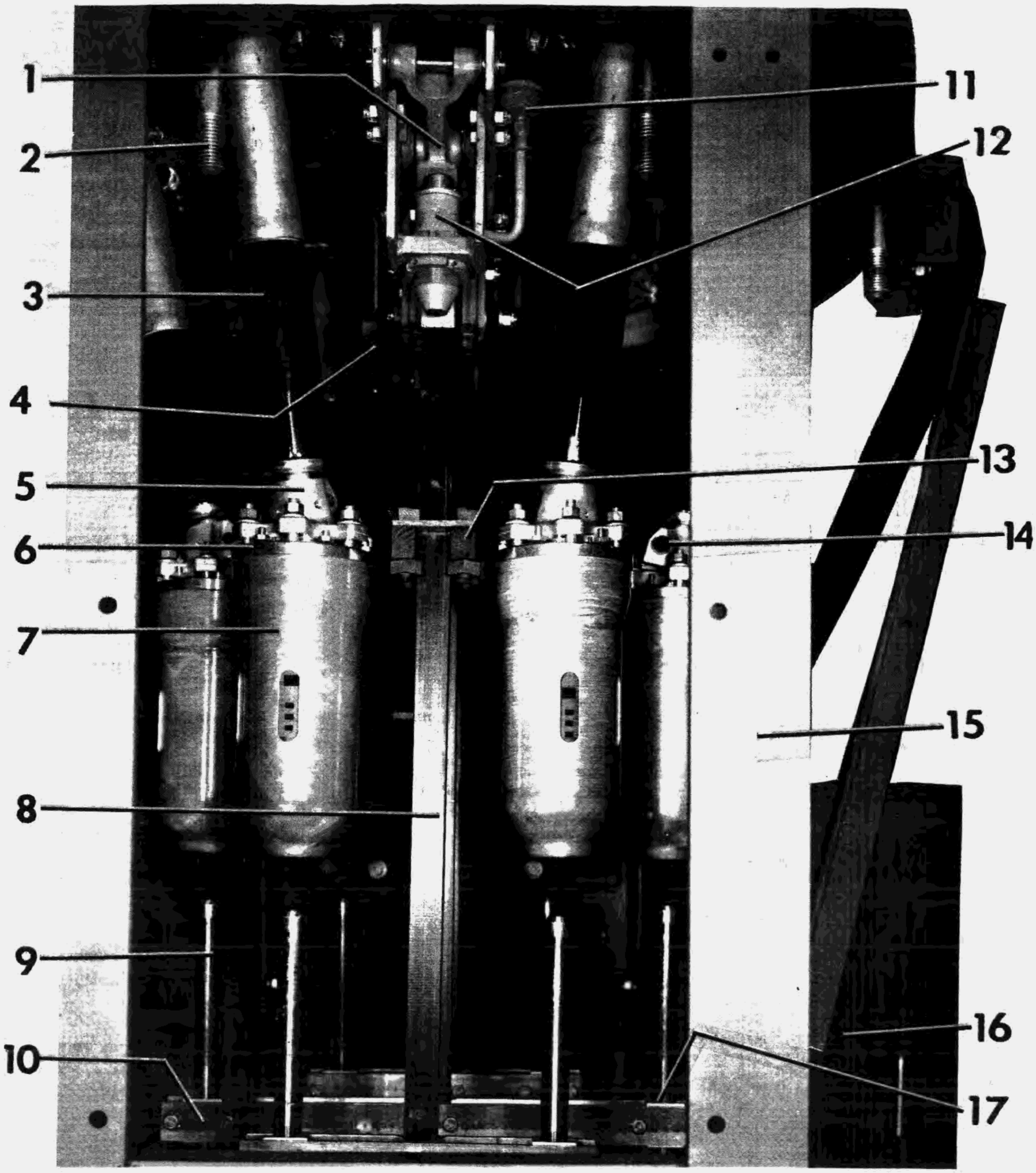


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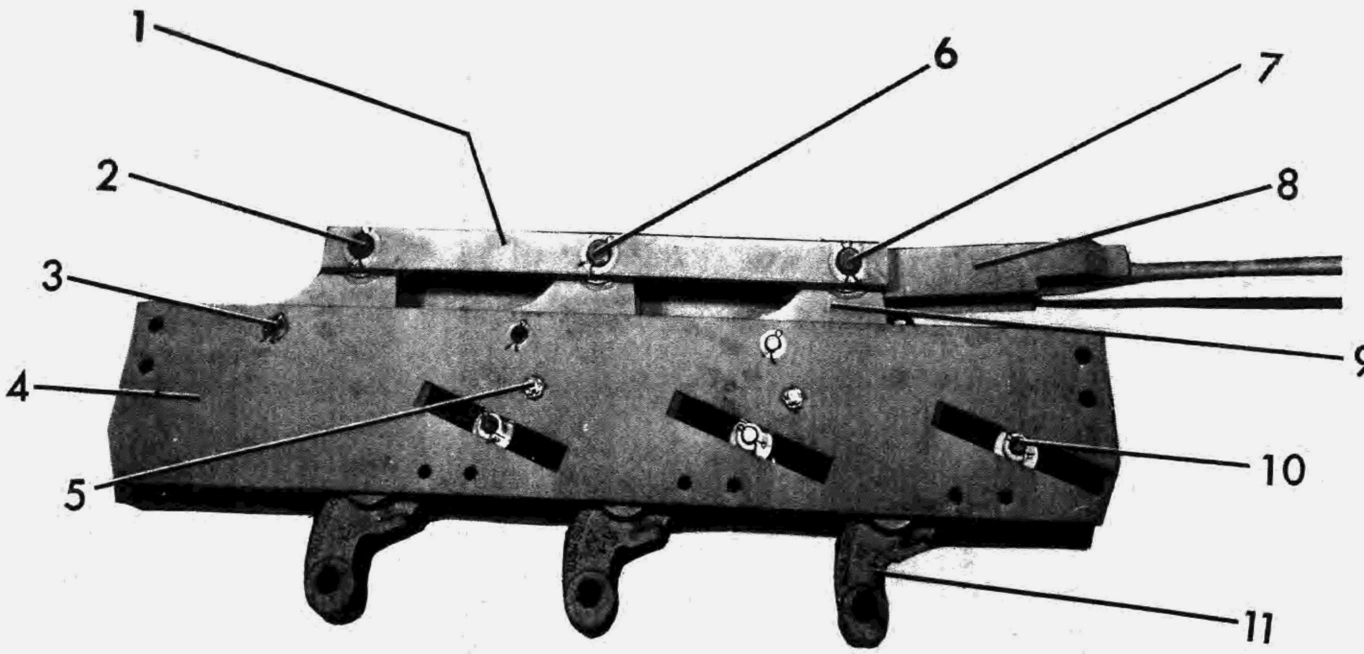
Fig. 7 Rear View of the Breaker with an ML-14-0 spring-charged operating mechanism showing the major assembly units.



1. Connecting Link
2. Horizontal Operating Rod Rear Coupling Pin
3. Beam Pin
4. Linkage Support Side Plate
5. Tie Rod
6. Connecting Link Pin
7. Opening Spring Coupling Pin
8. Opening Spring Coupling
9. Beam
10. Lever Pin
11. Lever

Fig. 8 View of the Breaker Straight Line Linkage in the breaker partially-open position just prior to assembly into the breaker dome.

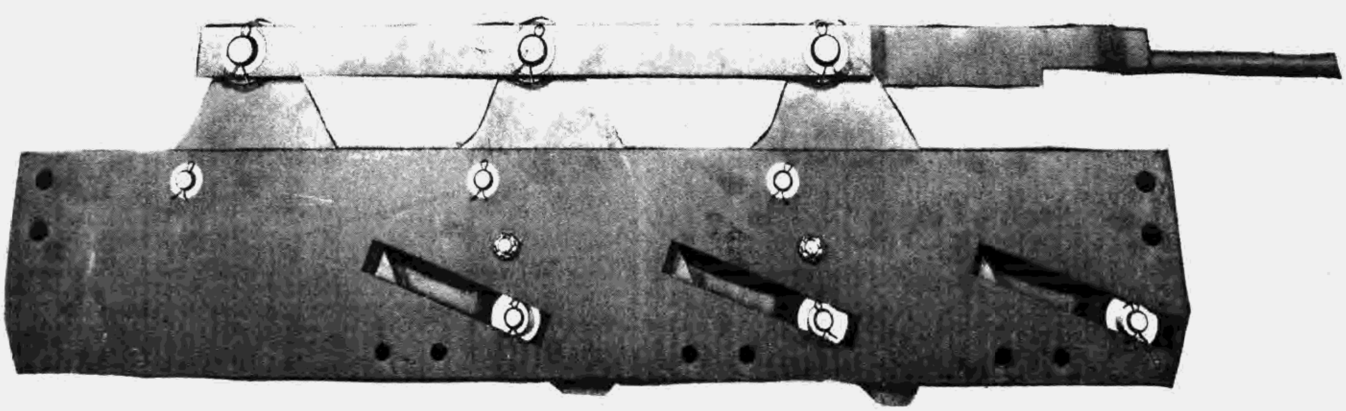


Fig. 9 View of the Breaker Straight Line Linkage in the breaker partially-closed position just prior to assembly into the breaker dome.

the Switchgear Business Department by giving the proper references.

Bushing current transformers are mounted inside the breaker dome. They are installed from underneath the breaker dome and they can be slipped over the lower end of the bushing, although the interrupter and upper adapter must be removed first. Supporting brackets bolted to the breaker dome hold the transformers in place. Insulation spacers above and below the transformer protect it from injury. The transformer must be properly centered on the brackets to prevent its being damaged when the bushing is installed.

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, 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 refinery, 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 effect 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 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 oil containing rust inhibiters must not be used in these breakers as the dielectric strength of this type of oil decreases rapidly after the oil is partially contaminated with minor amounts of arc products from arc interruptions.

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 per centimeter at 100°C	30×10^{12}
Flash Point - degrees C	
minimum	145
Pour Point - degrees C	
maximum	-40
Acidity - mg KOH/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, when tested using ASTM method D877.

INSTALLATION

BREAKER DRAWINGS

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 and inspection. Sufficient space must be provided for operation of the manual closing device and tanklifter and for removal of the oil tank. The breaker should be mounted high enough so that it can be operated with the oil tank 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 [illegible] serve as a [illegible] lifting means [illegible]. It may [illegible] into the framework as [illegible] Fig. 2. When using cable slings do [illegible] 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 to correctly locate and fasten the frame in position on its foundation. The foundation bolts should be left loose to permit the frame to be properly plumbed and leveled by inserting shims under the feet of the frame 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 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 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 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 current transformers. Remove any shorting wires from the BCT terminal boards only after the BCT circuitry is completely wired.

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 a leg of the framework to which a 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 #4/0.

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.

TANK LIFTER

The manual tank lifter (13), Fig. 15, consists of two manual ratchet lever-type cable hoists. They are attached to the lifting lugs (7), welded on the outside of the tank and to the hole (3) in the support bracket attached to the dome. To lower the tank tighten up on the lifters evenly and sufficiently to support the oil tank. Remove the nuts (4) from the tank studs, then lower the tank (17). The tank may be lowered when it is filled with oil.

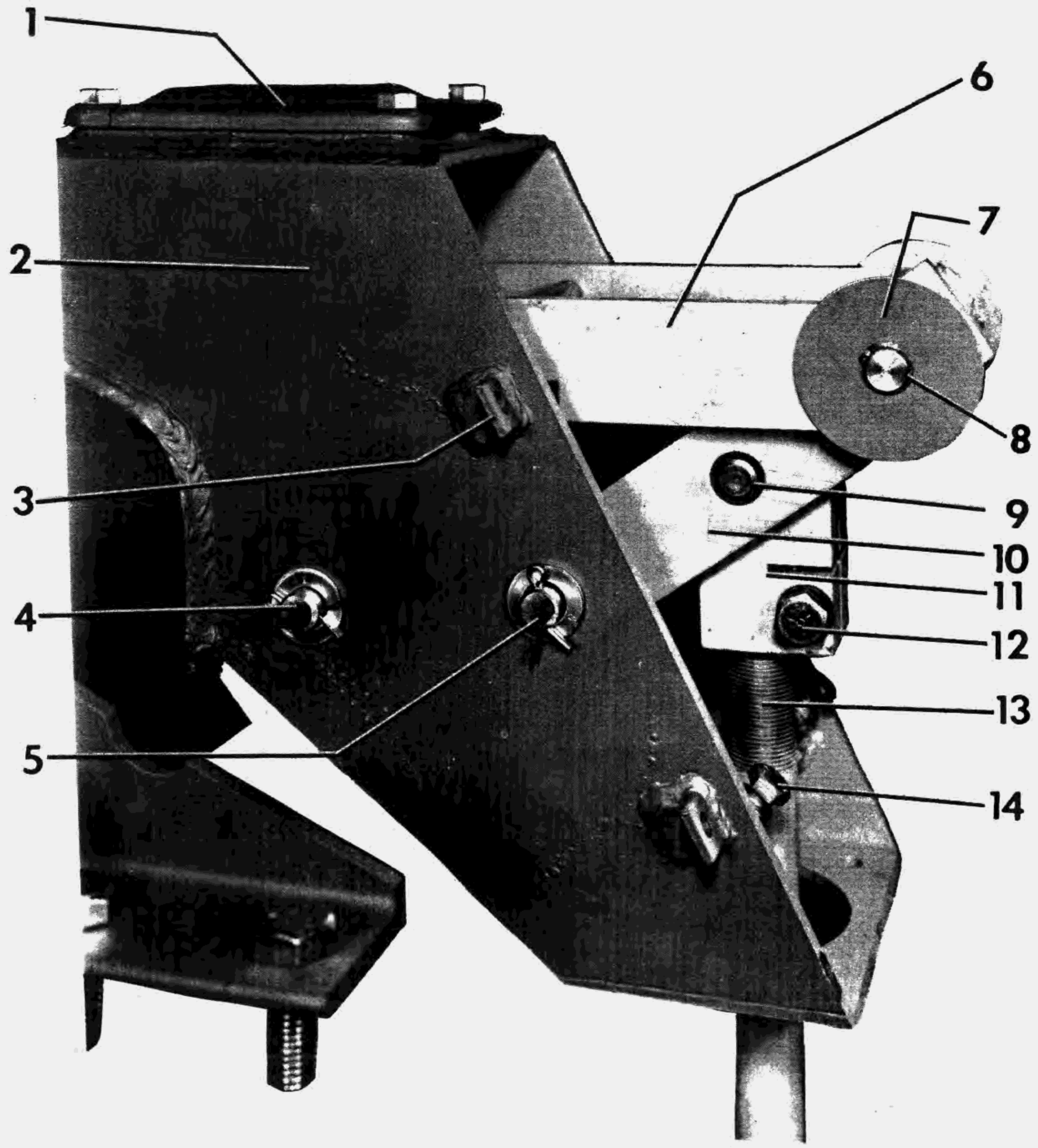
PRECAUTIONS

1. Before removing the tank 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 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 permitted, but these operations should be kept to a minimum. A few air operations can be made to check the stop clearance with the breaker not energized. Operations in air normally result in higher operation speeds (3/4 to 2 feet per second faster) consequently this should be taken into account if analyzer curves are taken with the breaker contacts operating in air.
5. DO NOT USE THE MAINTENANCE CLOSING DEVICE FOR CLOSING THE BREAKER ON LOAD.

ADJUSTMENTS

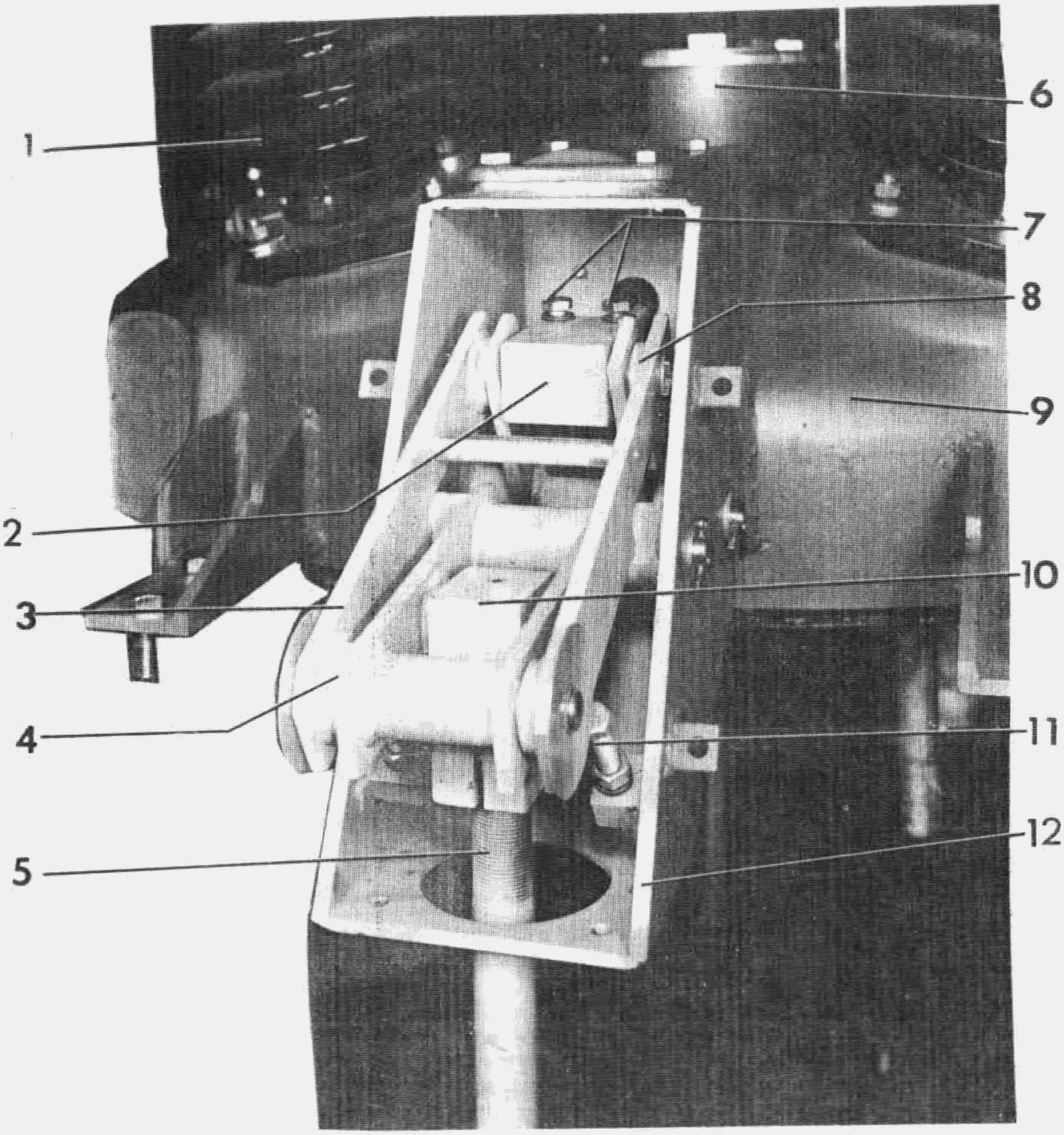
Although the breaker has been completely set up, adjusted and tested at the factory, it is recommended that all adjustments be reviewed to make certain that no change has occurred during shipment and installation. The breaker should be operated slowly by hand, using the maintenance closing device, to see that it operates

Fig. 10 (8040116)



1. Top Cover
2. Toggle Linkage Box
3. Front Cover Cleats
4. Guide Crank Pin
5. Upper Front Crank Link Pin
6. Front Link
7. Breaker Position Indicator Flag
8. Lower Front Crank Link Pin
9. Vertical Operating Rod Coupling Pin
10. Front Crank Link
11. Vertical Operating Rod Coupling
12. Vertical Operating Rod Coupling Clamping Bolt
13. Vertical Operating Rod
14. Overtravel Stop Bolt

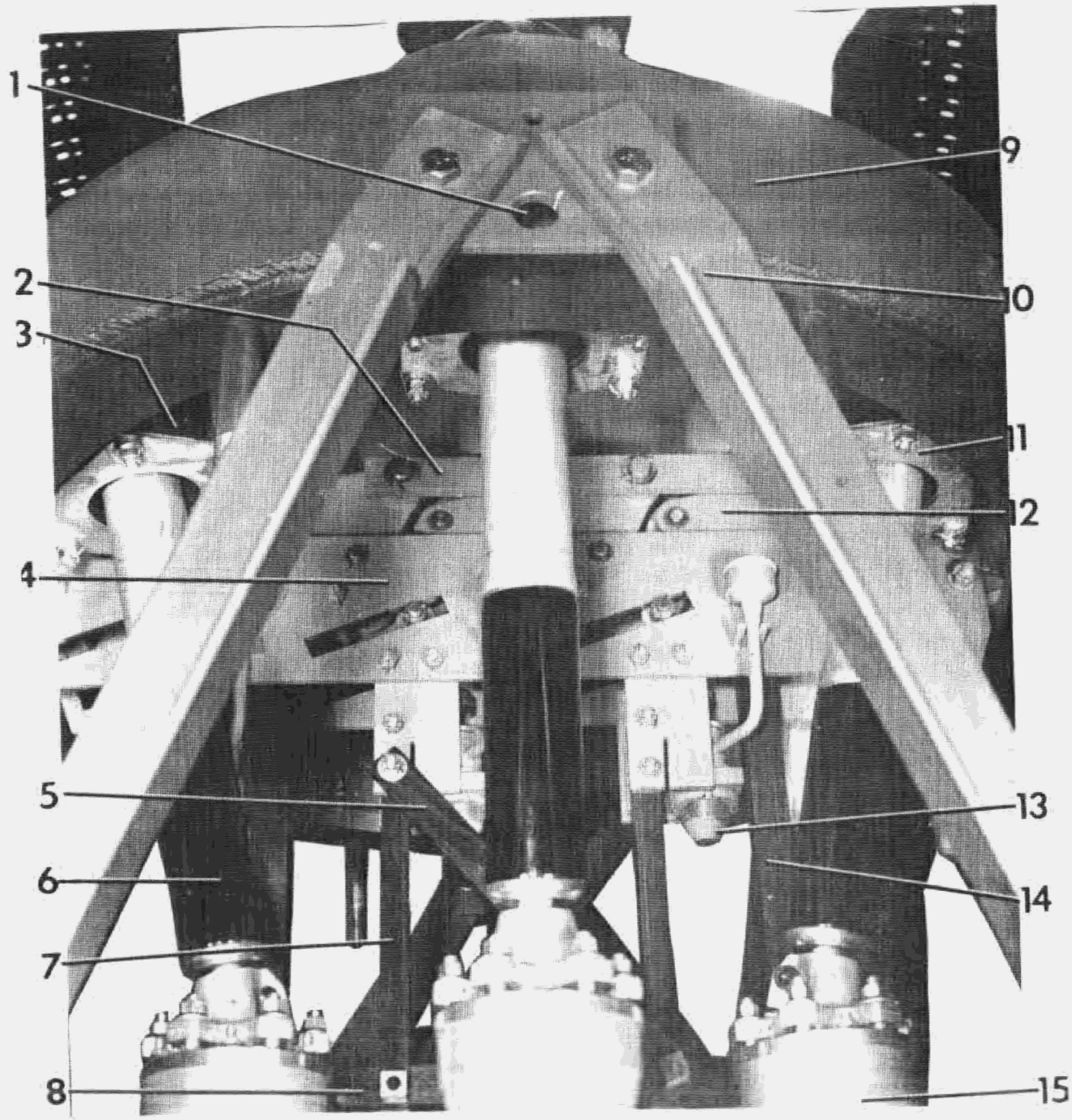
Fig. 10 View of the Breaker Toggle Linkage in the breaker-open position.



1. Breaker Bushing
2. Horizontal Operating Rod Front Coupling
3. Front Link
4. Front Crank Link
5. Vertical Operating Rod
6. Closing Buffer Housing
7. Horizontal Operating Rod Front Clamping Bolts
8. Guide Crank
9. Breaker Dome
10. Vertical Operating Rod Coupling
11. Overtravel Stop Bolt
12. Toggle Linkage Box

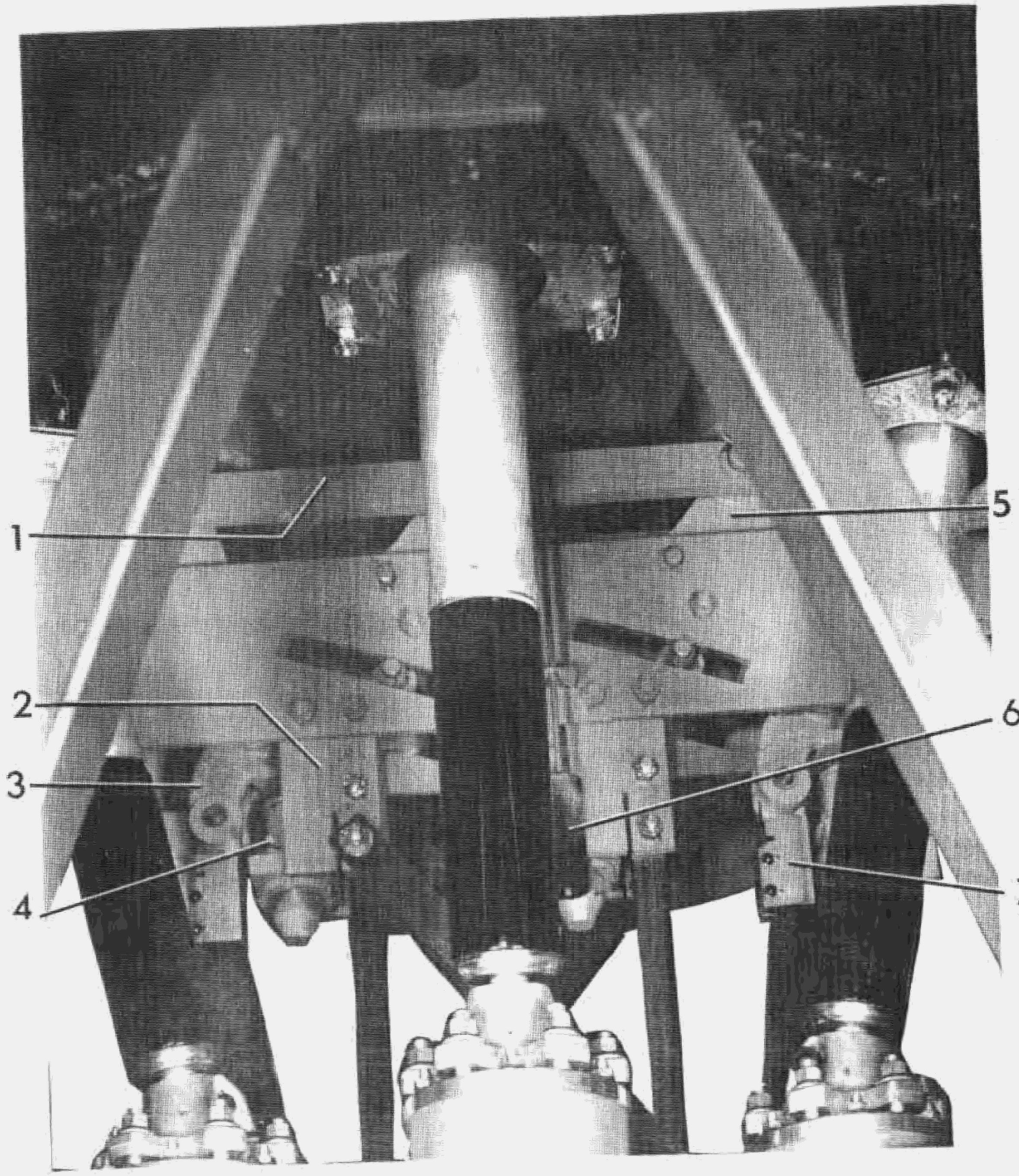
Fig. 11 View of the Breaker Toggle Linkage in the breaker-closed position.

Fig. 12 (8040127)



1. Manual Tank Lifter Hook Hole
2. Connecting Link
3. Bushing Current Transformer (BCT)
4. Linkage Support Side Plate
5. Lift Rod Guide Diagonal Brace
6. Bushing
7. Lift Rod Guide Vertical Brace
8. Lift Rod Guide Horizontal Brace
9. Breaker Dome
10. Framework Diagonal Brace
11. BCT Support Plate
12. Beam
13. Opening Dashpot
14. Lift Rod
15. Interrupter

Fig. 12 Left Side View of the Linkage as installed in the 15.5 through 48.3kV breaker. The breaker is in the closed position.



1. Connecting Link
2. Lift Rod Guide and Opening Dashpot Support
3. Lever
4. Opening Dashpot Oil Level Hole
5. Beam
6. Oil Level Float
7. Lift Rod Coupling

Fig. 13 Right Side View of the Linkages installed in the 15.5 through 48.3 kV breaker with the breaker in the open position.

smoothly throughout the closing operation, that no binding occurs, and that no excessive play is noticeable between parts. The breaker cannot be opened slowly when equipped with a spring-charged mechanism, but it can be closed slowly as explained in the mechanism instruction book. 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. 15, the tank can be lowered, leaving the contacts and pole unit mechanisms accessible for inspection. The trip latch of the operating mechanism is wired or blocked in place during shipment and this wire or 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 tripped open.

LINKAGE POSITION ADJUSTMENT (LIFT ROD SETTING)

The position adjustment is the means of determining the correct breaker linkage position when the breaker is closed.

Using a maintenance closing device, slowly close the breaker until the trip latch of the operating mechanism just falls into place to hold the mechanism in the closed position. To prevent accidental opening, insert the blocking devices per the mechanism instruction book. Measure the lift rod setting on the center phase as shown in Fig. 14. This measurement is 7-1/4 inches ± 1/8 inch as shown in Fig. 27, item D.

The first and third phase lift rod settings are ± 1/8 inch from the setting obtained on the center phase as shown in Fig. 27, item C.

EXTERNAL TOGGLE SETTING

Measure the external toggle setting. This is 7/8 inch ± 1/32 inch with the breaker in the fully-closed position as shown in section A-A of Fig. 14 and B of Fig. 27.

LIFT ROD LEVER SETTING

Measure the lift rod (18), Fig. 14, to the lever pin (28) clearance with the breaker closed. Block the trip latch of the spring-charged mechanism to prevent accidental tripping. The lift rod lever setting is measured from the rear of the lift rod (18) to the front of the lever pin (28). This should be a minimum of 2-15/16 inches. It is sufficient to measure this on Phase Three only. See Fig. 14 and L of Fig. 27.

ADJUSTMENT CHANGES

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

TOGGLE ADJUSTMENT

The breaker horizontal operating rod (11), Fig. 14, as well as the vertical operating rod (1) have right and left-hand threads. Shortening these rods will reduce these settings. Adjustment of the toggle is attained by loosening the locking bolt in the vertical operating rod coupling (3) and the similar locking bolt shown on the mechanism ena coupling of the vertical operating rod (1). Turn this rod clockwise, as viewed from the top, to cause shortening of the rod and closing of the toggle. Lengthening the rod would open up the toggle. This procedure will change the position setting of the breaker linkage of all three phases at the same time. Tighten the locking bolts and recheck the toggle setting, the lift rod setting and the lift rod lever setting.

LIFT ROD SETTING

In a similar manner, the lift rod setting of the breaker linkage is adjusted by changing the length of the breaker horizontal operating rod (11), Fig. 14. The locking bolts on both the front and rear horizontal operating rod couplings (9 and 14) will require loosening to change the length of the horizontal operating rod (11). Access to the rear locking bolts is through the two pipe plugs (1), Fig. 15. Altering the position setting may affect the closing buffer adjustment, therefore, maintain the 1/32 inch buffer dimension while adjusting the toggle and lift rod settings. Final measurements should be made after closing the breaker electrically with the breaker oil tanks in the down position and the contacts moving in air. Readjust as necessary to the proper values.

When adjustment is completed, be sure all hardware, pipe plugs, locking bolts, and locking plates are tight and waterproof.

CLOSING BUFFER ADJUSTMENT (15.5 through 72.5 kV)

The closing buffer is set at the factory and should not require further adjustment unless the opening spring, toggle linkage or lift rod setting is adjusted. The 72.5 kV closing buffer, Fig. 17, is the same as the 15.5 through 48.3 kV closing buffer except for the addition of two 1/8 inch thick washers (14) beneath the outer kick-off spring (10). These two washers are used to increase the tripping speed and decrease the tripping time of the 72.5 kV breaker. The adjustment for the two closing buffers are identical. These units are set in conjunction with the lift rod setting, the external toggle, and the lift rod lever setting and a change in any may require adjustment of the others. With reference to Figs. 16 and 17, and the breaker in the closed position, the adjusting disk (8) is turned down until it just touches the inner buffer spring (11) then backed off a one-half turn resulting in 1/32 inch ± 1/64

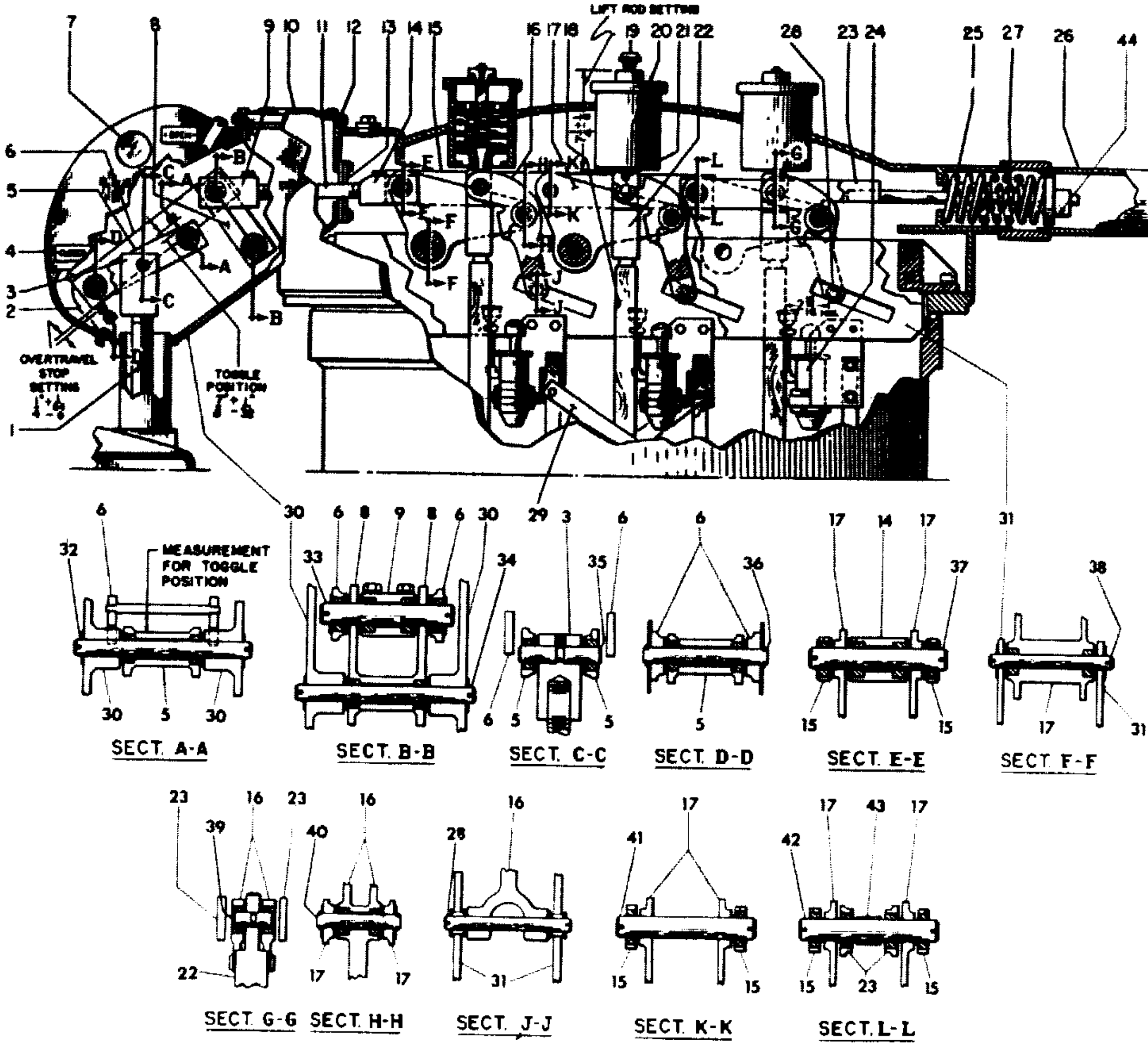
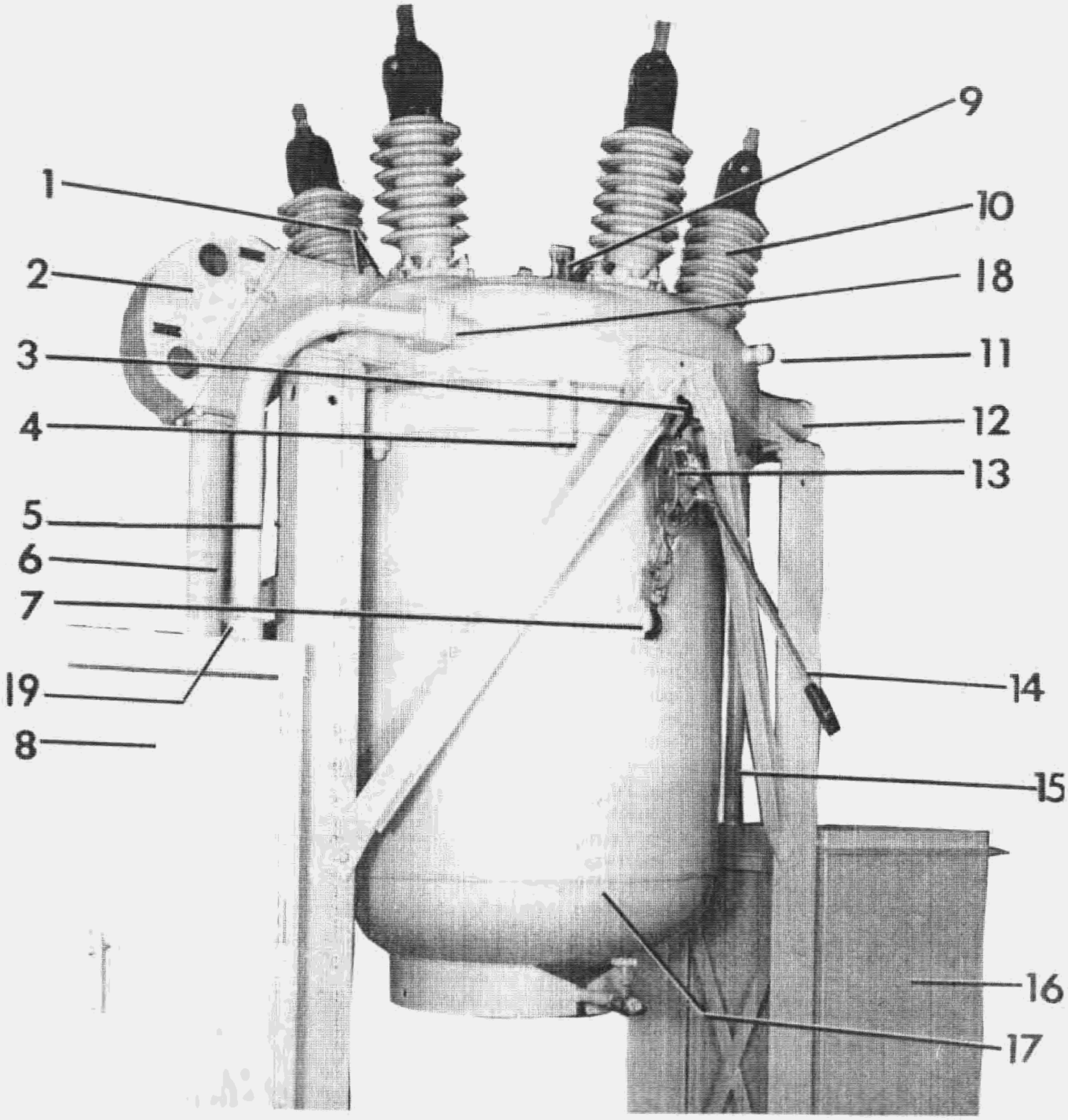


Fig. 14 Breaker Linkage

Fig. 14 (0958D0989 Rev. 0)

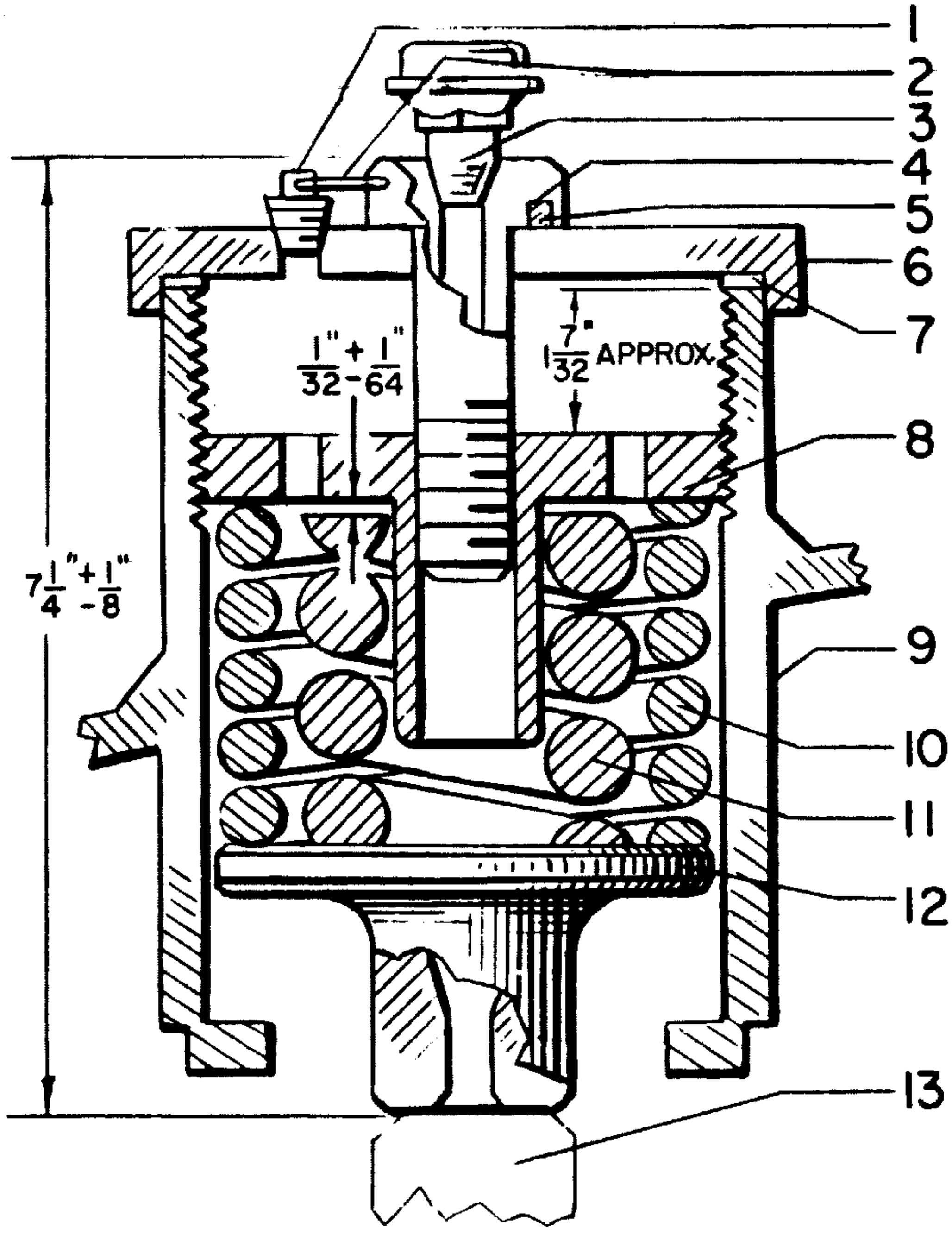
1. Vertical Operating Rod
2. Front Cover Gasket
3. Vertical Operating Rod Coupling
4. Front Cover
5. Front Crank Link
6. Front Link
7. Breaker Position Indicator Window
8. Guide Crank
9. Horizontal Operating Rod Front Coupling
10. Top Cover
11. Horizontal Operating Rod
12. Top Cover Gasket
13. Gas and Oil Seal
14. Horizontal Operating Rod Rear Coupling
15. Connecting Link
16. Lever
17. Beam
18. Lift Rod
19. Breather
20. Closing Buffer
21. Travel Recorder Rod Connection
22. Lift Rod Coupling
23. Opening Spring Coupling
24. Opening Dashpot
25. Opening Spring
26. Opening Spring Cover
27. Follow-through Spring
28. Lever Pin
29. Diagonal Cross Brace
30. Front Crank Assembly Support Box
31. Breaker Linkage Side Support
32. Upper Front Crank Link Pin
33. Front Link and Guide Crank Pin
34. Guide Crank Pin
35. Vertical Operating Rod Coupling Pin
36. Lower Front Crank Link Pin
37. Horizontal Operating Rod Rear Coupling Pin
38. Beam Pin
39. Lift Rod Coupling Pin
40. Lever and Beam Pin
41. Connecting Link Pin
42. Opening Spring Coupling Pin
43. Spacer
44. Opening Spring Retaining Nut and Guide

Items for Fig. 14



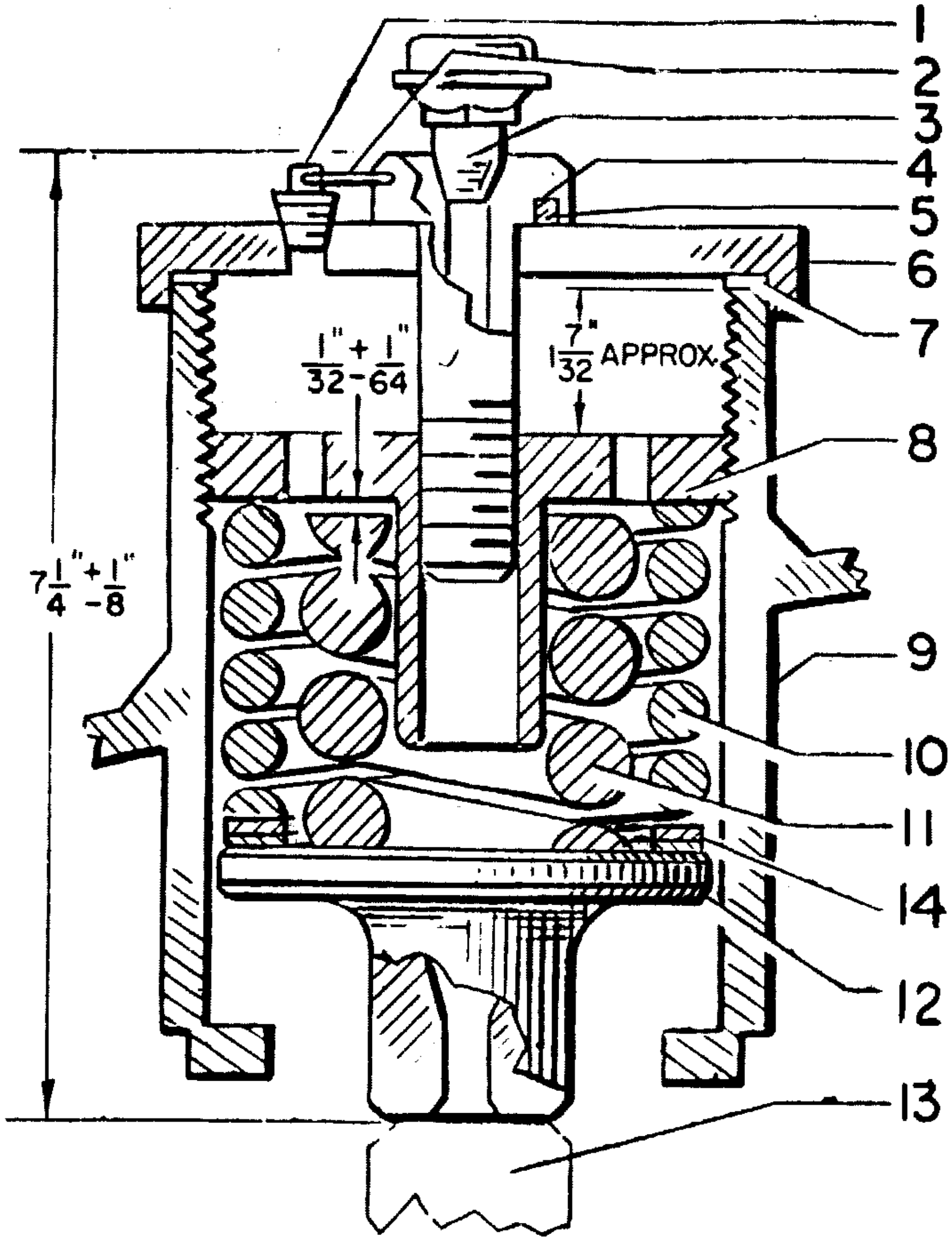
1. Horizontal Operating Rod Rear Coupling Bolt Access Hole Plugs
2. Front Cover
3. Tank Lifter Support Hole
4. Tank Supporting Nuts
5. BCT Conduit
6. Vertical Operating Rod Cover Pipe
7. Lifting Lug
8. Operating Mechanism
9. Oil Level Indicator
10. Bushing
11. Oil Fill Pipe
12. Opening Spring Cover
13. Manual Tank Lifter
14. Manual Tank Lifter Operating Handle
15. Relay House Conduit (Optional)
16. Relay House (Optional)
17. Oil Tank
18. Gasket
19. "O" Ring

Fig. 15 View of the Manual Tank Lifter used on the type FKA oil circuit breaker.



1. Plug
2. Locking Wire
3. Breather
4. Cover Bolt
5. "O" Ring
6. Cover
7. Gasket
8. Adjusting Disk
9. Buffer Housing
10. Outer Spring (Kick-off)
11. Inner Spring (Buffer)
12. Plunger
13. Coupling (Lift Rod)

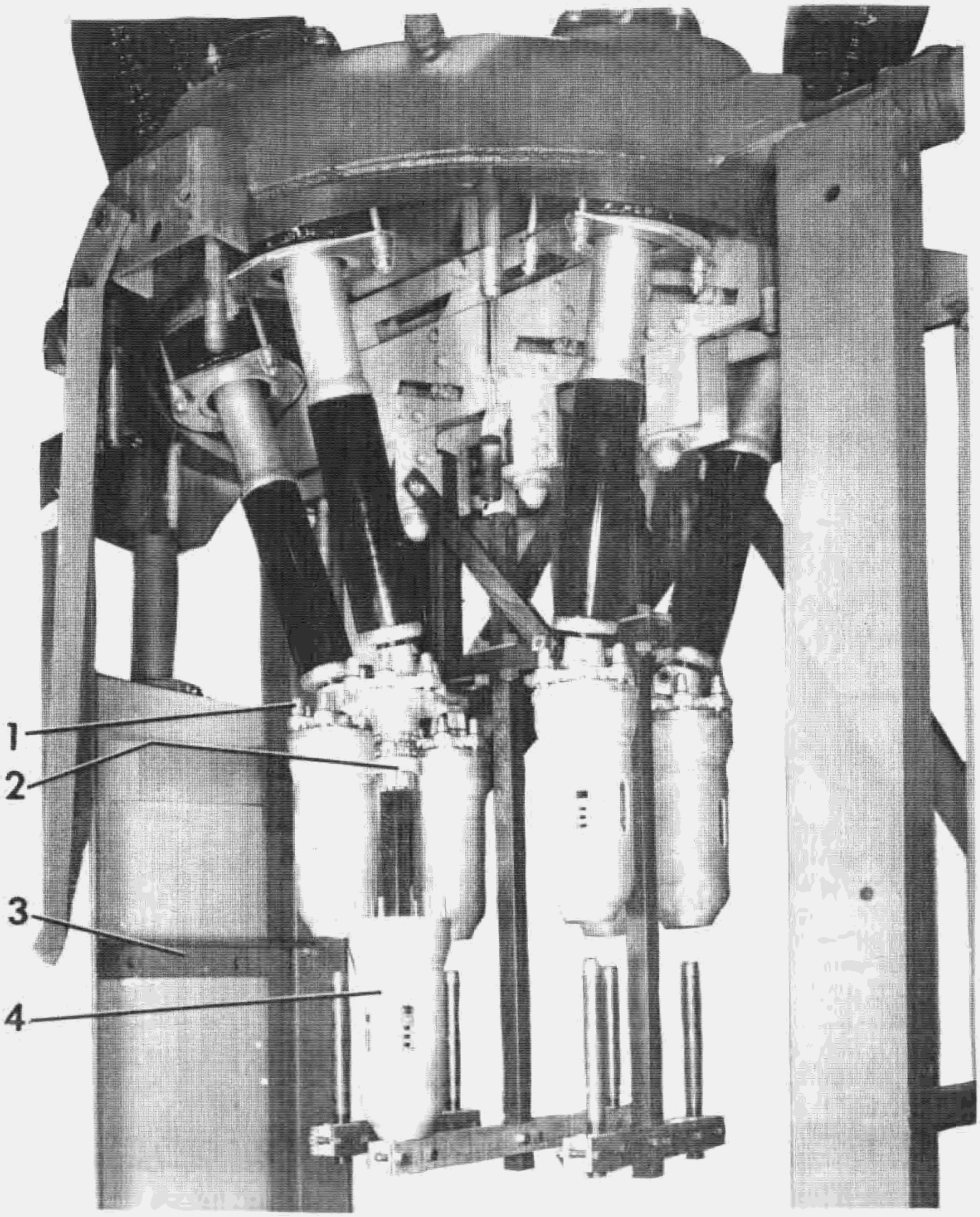
Fig. 16 Closing Buffer for 15.5 through 48.3 kV Breakers



1. Plug
2. Locking Wire
3. Breather
4. Cover Bolt
5. "O" Ring
6. Cover
7. Gasket
8. Adjusting Disk
9. Buffer Housing
10. Outer Spring (Kick-off)
11. Inner Spring (Buffer)
12. Plunger
13. Coupling (Lift Rod)
14. Two Washers (each 1/8 inch thick)

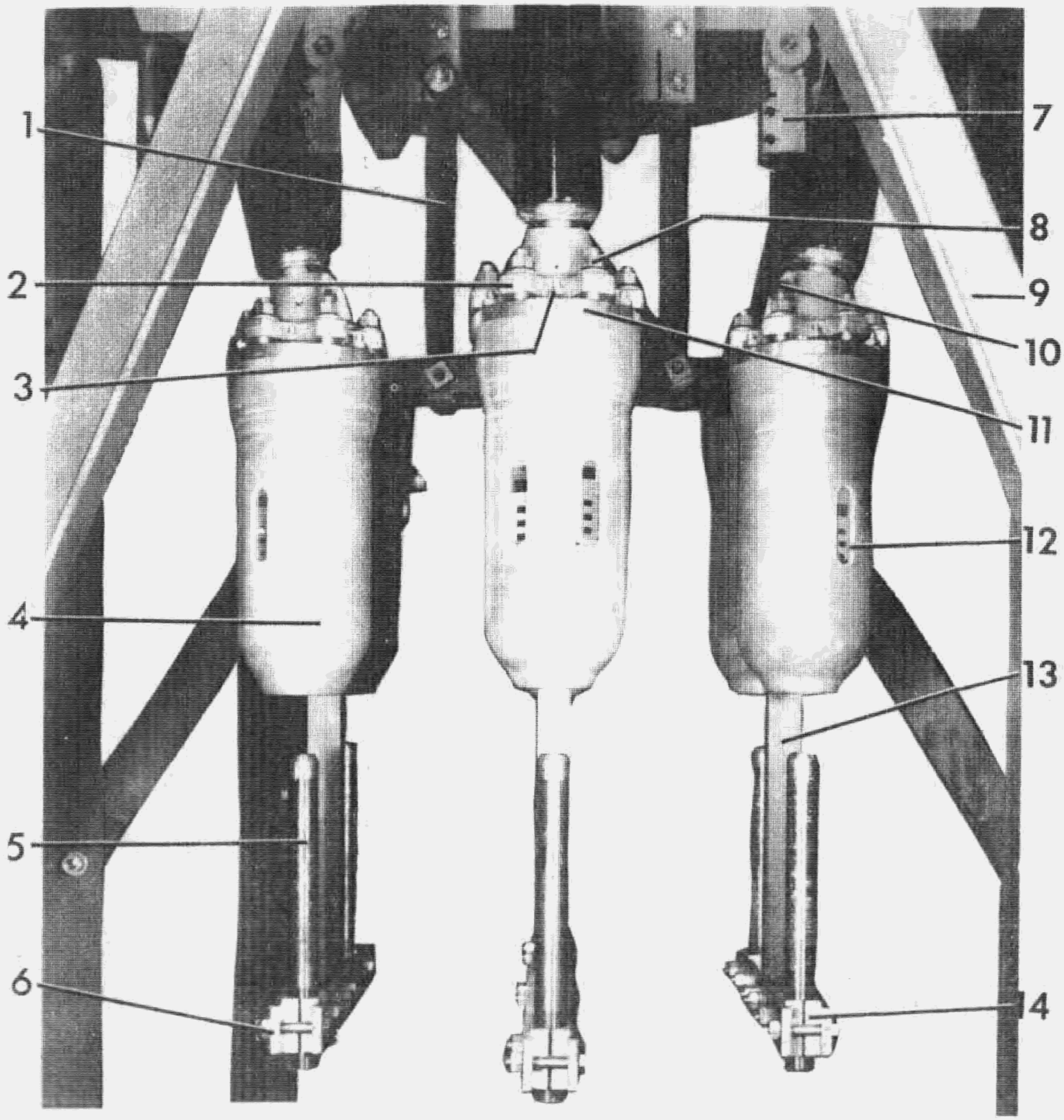
Fig. 17 Closing Buffer for 72.5 kV Breakers

Fig. 18 (8040147A)



1. Corona Nut used on 72.5 kV Breakers only
2. Finger Cluster Assembly
3. Upper Mechanism Supporting Member
4. Interrupter Tube and Associated Parts lowered for inspection of finger cluster

Fig. 18 Left Side View of the Interrupters and Associated Parts of the 72.5 kV Breaker with one interrupter tube dropped for inspection contacts



1. Vertical Member of Lift Rod Guide
2. Upper Adapter
3. Maintenance Nut
4. Interrupter
5. Contact Rod
6. Crossarm
7. Lift Rod Coupling
8. Interrupter Adjusting Nut
9. Diagonal Side Brace of Framework
10. Adapter Clamping Bolt
11. Lower Adapter
12. Exhaust Port
13. Lift Rod
14. Contact Block

Fig. 19 Right Side View of the Interrupters and Associated Parts of the 15.5 through 48.3 kV Breaker

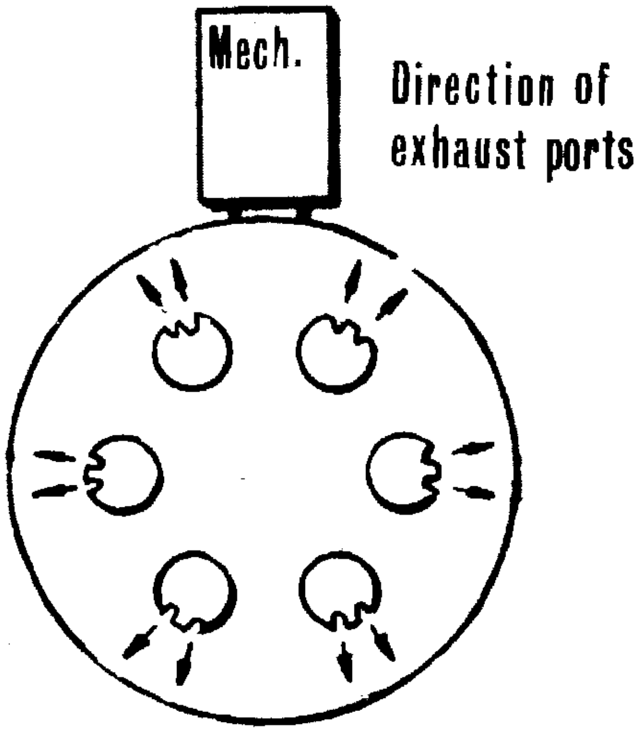


Fig. 20 View Showing the Direction in which the interrupter exhaust ports point

inch clearance with the breaker closed and lift rod and front toggle set to the proper amount as shown in F, Fig. 27. As a starting point in making this setting the top of the adjusting disk (8), Figs. 16 and 17, may be preset initially to approximately 1-7/32 inches below the top of the buffer housing (9).

When installing the cover bolt (4) insert a screwdriver or a steel or brass rod through the pipe plug (1) hole in the cover (6) and into one of the holes in the adjusting disk (8) to prevent the adjusting disk from turning while tightening the cover bolt (4). Remove the rod after the cover bolt is tight and insert the pipe plug (1) and the locking wire (2). Use Permatex #2 or similar to seal the pipe threads of the pipe plug (1). Do not use a sealer which is electrically conductive.

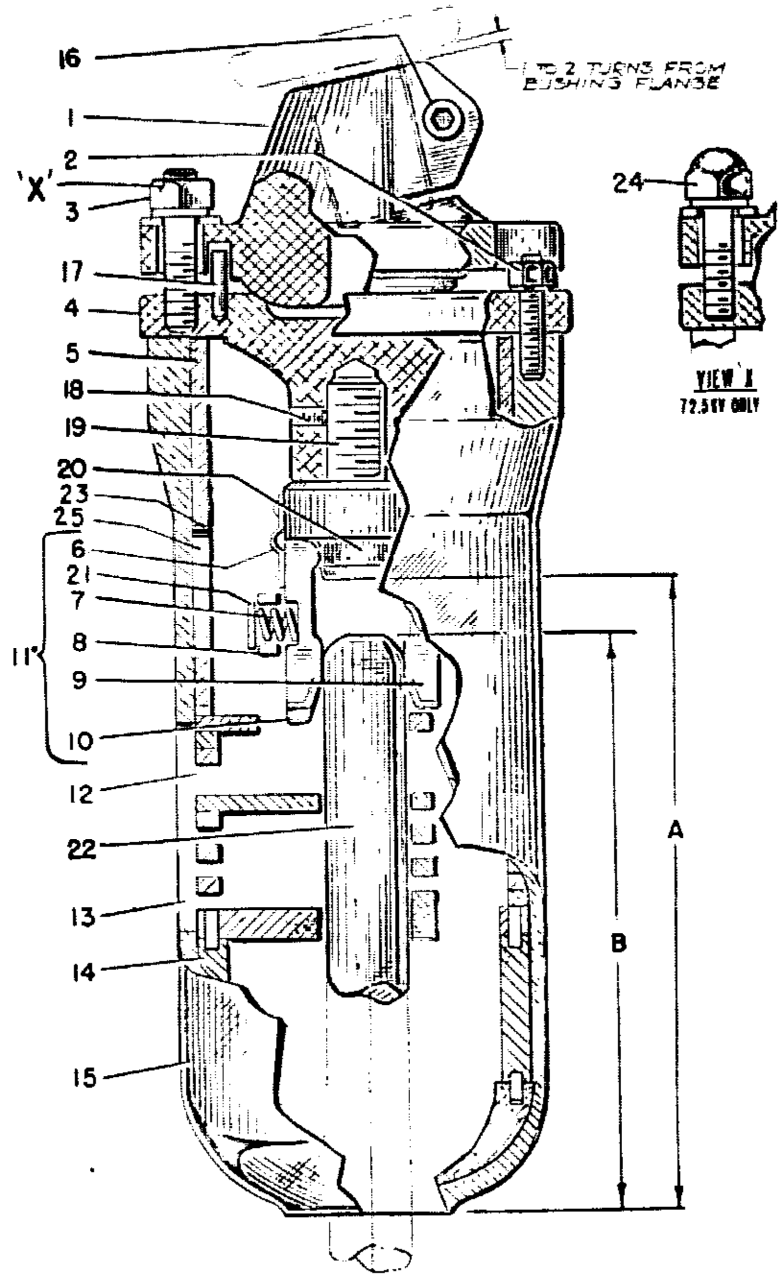
INTERRUPTER ADJUSTMENT

After the breaker linkage is adjusted, the contacts should be checked. Refer to Fig. 19. The interrupters (4) which are fastened to the lower ends of the bushings must be aligned to a vertical position, with the two exhaust ports of each interrupter facing the tank as shown in Fig. 20. The use of a spirit level will assist in aligning the interrupter. Make the upper adapter (2), Fig. 19, plumb first by using a spirit level on the underside machined surface. The adapter must be plumb when the bushing mounting nuts on top of the breaker dome are tight. The lower adapter (11) also must be removed. Loosening the adapter clamping bolt (10) allows the adapter to be moved in any direction about the vertical. After the upper adapter is plumb and the clamping bolt is tight install the lower adapter (11) which is assembled to the interrupter (4). Plumb the interrupter using a spirit level on the interrupter tube at three positions approximately 120 degrees apart. After the interrupter is plumb, slowly close the breaker to make certain the contact rod engages the contact finger cluster assembly (2), Fig. 18, properly. 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 (5), Fig. 19. The contact block (14) is slotted so that by loosening the locknuts the contact rods can be moved in or out to obtain alignment with the throat. Additional lateral adjustment, if required, is possible by loosening the bushing mounting nuts and changing the seating of the bushing. The contact block can also be turned end for end to obtain additional adjustment.

CONTACT ADJUSTMENT OF THE STANDARD INTERRUPTER (Fig. 21)

1. The contact stop clearance is 7/8 inch ± 1/16 inch; item "H", Fig. 27 This is the most important measurement in the interrupter. When this is correct the insertion, penetration and electrical wipe are correct.

   a. Use a depth gage to measure the distance from the bottom of the interrupter to the contact stop



1. Upper Adapter
2. Assembly Nut
3. Locking Nut
4. Lower Adapter
5. Upper Insulating Spacer
6. Flexible Connector
7. Contact Spring
8. Spring Cage
9. Contact Finger
10. Arcing Tip Finger
11. Contact Finger Assembly (Finger Cluster)
12. Baffle Stack
13. Exhaust Port Opening
14. Lower Insulating Spacer
15. Interrupter Tube
16. Adapter Locking Bolt
17. Locking Pin
18. Set Screw
19. Contact Assembly Support
20. Contact Stop
21. Spring Retainer
22. Contact Rod
23. Insulating Shims
24. Corona Nut - 72.5kV only
25. Intermediate Insulating Spacer

Fig. 21 Cross-sectional View of the Standard Interrupter.

Fig. 21 (0842C0619 Rev. 6)

1. Upper Adapter
2. Adjusting Nut
3. Assembly Nut
4. Locking Nut
5. Locating Clip
6. Interrupter Stud
7. Lower Adapter
8. Resistor and Resistor Wire Support
9. Resistor Cover
10. Interrupter Tube
11. Upper Insulating Spacer
12. Flexible Connectors
13. Contact Spring Cage
14. Contact Spring
15. Spring Retainer
16. Contact Finger
17. Arcing Tip Finger
18. Contact Finger Assembly (Finger Cluster)
19. Insulating Shims
20. Baffle Stack
21. Exhaust Port Opening
22. Resistor Contact Finger Spring
23. Resistor Finger Pin
24. Resistor Contact Finger Support
25. Resistor Contact Finger
26. Finger Stop
27. Lower Insulating Spacer
28. Resistor Support Spacer
29. Resistor Support Spacer Pin
30. Resistor Support Pin
31. Clamping Bolt
32. Upper Resistor Lead Screw
33. Upper Resistor Lead
34. Upper Resistor Terminal Screw
35. Contact Stop
36. Contact Rod
37. Cotter Pins
38. Lower Resistor Lead Screw
39. Lower Resistor Lead
40. Lower Resistor Terminal Screw
41. Intermediate Insulating Spacer

Items for Fig. 22

Fig. 22 (0124C3281 Rev. 3)

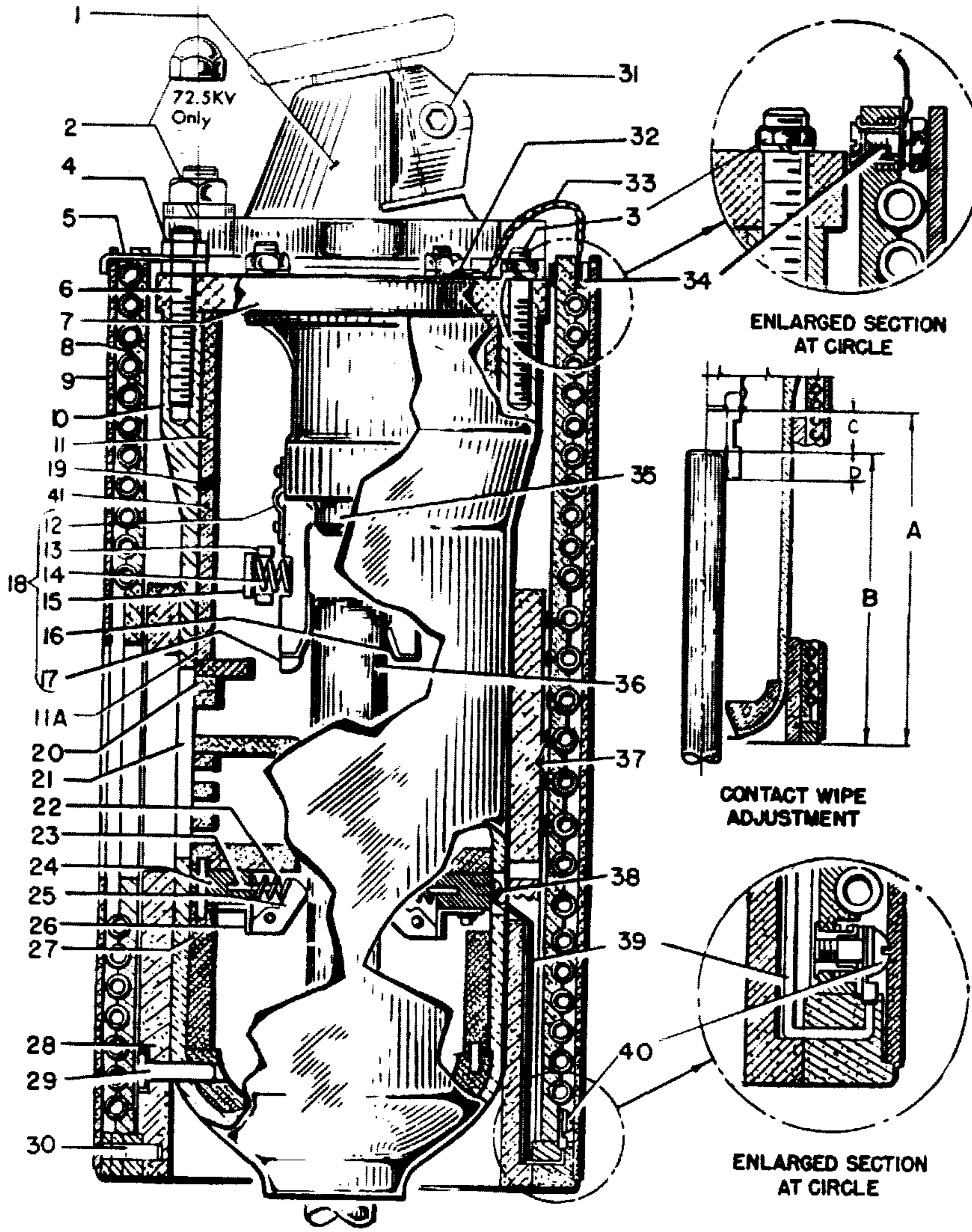


Fig. 22 Cross-section View of the Capacitor Switching Interrupter.

(20), Fig. 21, inside the interrupter.

b. Measure the insertion of the contact rod into the interrupter as a reference.

c. Item (a) minus Item (b) must be 7/8 inch ± 1/16 inch.

2. After checking and adjusting (if necessary) the contact stop clearance, check the contact rod penetration into the finger cluster assembly. This should be 1-1/8 inches ± 1/16 inch and should not require any adjustment. See "G" of Fig. 27.

The contact stop clearance of the interrupters of any one phase must be within 1/32 inch of each other so that burning of the two sets of contacts in the phase is approximately equal. The electrical wipe of each phase of the breaker should now be recorded as an indication of the setting of the contacts. This will afford a quick check of the adjustment of the contacts without the necessity of dropping the tank at a future date. The bellset wipe should be 1/2 inch to 7/8 inch. The bellset wipe is not an indication of the condition of the contacts. The bellset wipe does not equal the contact rod insertion into the contact fingers. The length of the bellset wipe dimension is due to the curved portion of the contact rod (22), Fig. 21, and the curved portion of the contact fingers (9) breaking contact. At this time the contact rod is still inserted in the finger cluster.

To change the contact insertion, loosen the locknuts and rotate the contact rod (5), Fig. 19, in the appropriate direction. At the same time there should be at least 1/2 inch clearance between the bottom of the interrupter (4) and the crossarm (6) with the breaker closed, so that overtravel will not damage the interrupter or contacts (Item J), Fig. 27. Tighten the locknuts and recheck all the contact adjustments and alignment. With the breaker properly adjusted, the contacts of the three phases should make and break mechanically at approximately the same time, or within 1/4 inch of each other between phases and within 1/32 inch of each other in a phase.

BREAKER	KV	RATED CAPACITOR SWITCHING, SINGLE BANK ONLY. (Capacitor bank nameplate rating) KVAR @ KV INDICATED	
		GROUNDED BANK	UNGROUNDED BANK
FKA-15.5-36000-6R	15.5	24000	24000
FKA-38 -22000-6R	38.0	30000	30000
FKA-48.3-17000-6R	48.3	27000	27000
FKA-48.3-29000-6R	48.3	27000	27000
FKA-72.5-19000-3R	72.5	20000	15000
FKA-72.5-27000-3R	72.5	20000	15000

CONTACT ADJUSTMENT OF THE CAPACITOR SWITCHING INTERRUPTER (Fig. 22)

The contact adjustment of the capacitor switching interrupter is made in the same manner as the contact adjustment of the standard interrupter, Fig. 21. Reference should be made to the capacitor switching interrupter, Fig. 22 for the proper item numbers.

CONTACT ROD CLEARANCE (J), Fig. 27.

The contact rod crossarm assembly must have a minimum of 1/2 inch clearance to the underside of the interrupter tube, Item J of Fig. 27. The nominal clearance is 15/16-inch.

INSPECTION

STANDARD INTERRUPTER (Fig. 21)

The standard interrupter consists essentially of a laminated glass filament tube enclosing a baffle stack and a set of eight primary contact fingers, two of which have an arcing tip. The body tube has two port openings which permit the proper flow of oil across the contacts and through the baffles during interruption as shown in Fig. 26.

CAPACITOR SWITCHING INTERRUPTER (Fig. 22)

The capacitor switching breaker is somewhat different than the standard breaker in that the capacitor switching breaker has interrupters which contain resistors and resistor finger assemblies whereas the interrupters of the standard breaker do not contain the resistors or the resistor finger assemblies.

The capacitor switching ability of the capacitor switching breakers is given in the above tabulation. At different voltages within the "K" factor range the capacitor switching ability is reduced.

With the breaker in the partially open position the resistance of the grading resistors must be checked. This can be done by adjusting the stroke of the breaker so that the contact rod (36), Fig. 22, is making contact with the resistor contact finger (25) but not making contact with the finger cluster (18). Measure from the contact rod to the bushing adapter (1) for the resistance value.

The resistance of the resistor (8) which surrounds the Fiberglas interrupter tube (10) is given in the following tabulation.

BREAKER	RESISTANCE PER INTERRUPTER IN OHMS
FKA-15.5-36000-6R	15
FKA-38 -22000-6R	83
FKA-48.3-17000-6R	150
FKA-48.3-29000-6R	150
FKA-72.5-19000-3R	526
FKA-72.5-27000-3R	526

The resistance must be plus five percent minus ten percent of the stated value per interrupter but must be within ± 5% of

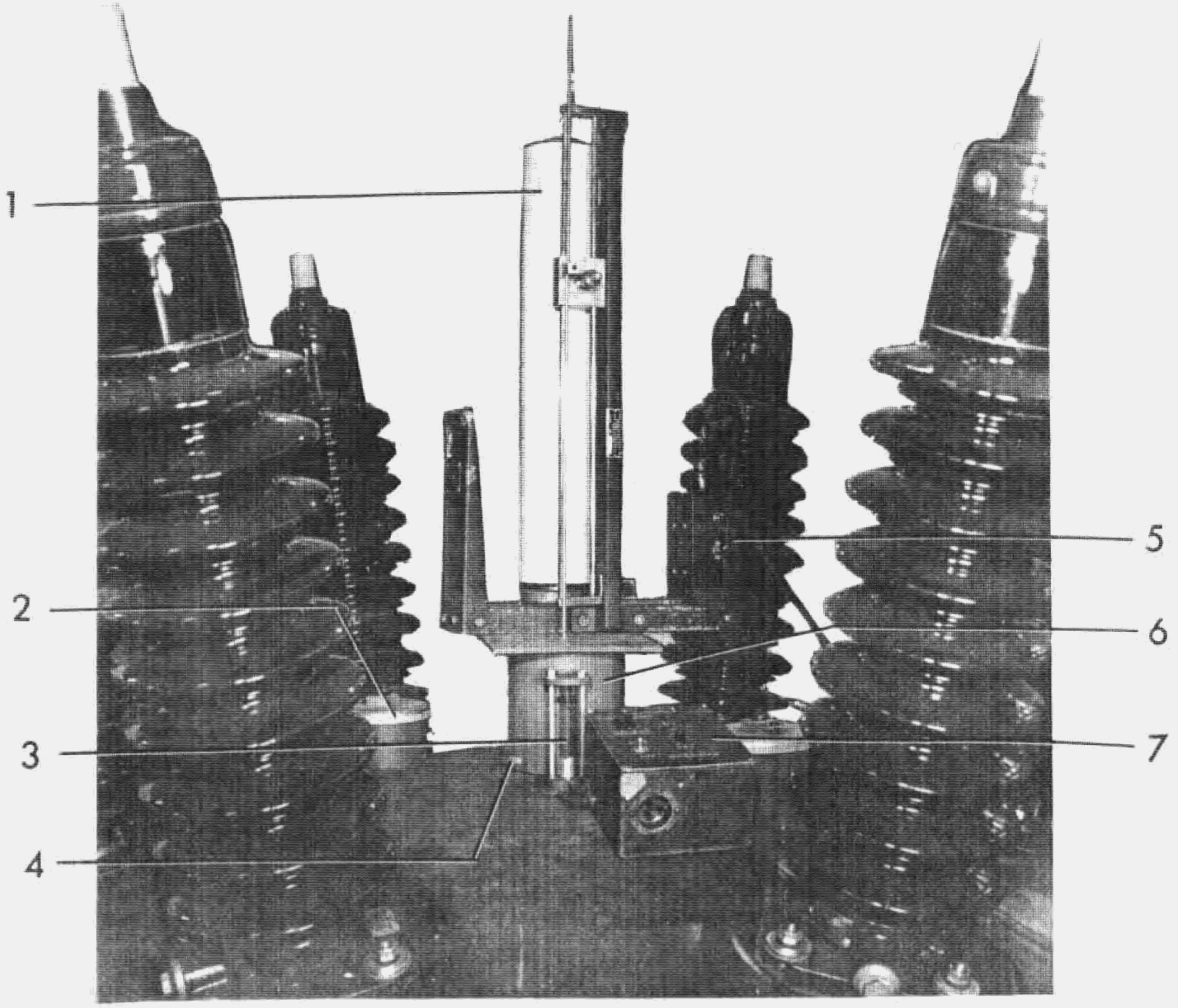


Fig. 23 (8038411)

1. Straight Line Travel Analyzer
2. Closing Buffer and Kickoff Spring Housing
3. Oil Gage
4. Bracket Tightening Screws
5. Analyzer Control Box
6. Analyzer Support Bracket
7. Breaker Control Box

Fig. 23 Installation of Travel Analyzer

each other in any one phase. The contact adjustment, contact rod clearance, and the remainder of the checks are identical with the adjustments and checks of the standard interrupter.

CONTACT RESISTANCE CHECK

If contact resistance checks (ductor readings) are to be made on the breaker they should be checked before oil is placed in the tanks and with the breaker in the fully-closed position. A 100-ampere ductor with 100 amperes flowing in the circuit should be used to measure the resistance of the contacts. Checking this way will eliminate the necessity of draining the oil should a high reading be found. A complete pole unit (bushing terminal to bushing terminal) should measure 250 microhms or less when new. The reading should not exceed 450 microhms after the breaker has been in service. If the resistance is higher than the allowable microhms, operate the breaker several times electrically. This will break down any silver oxides formed on the contact surfaces. Check the resistance again. If still high clean the contact tips and the threads of the contact rod and check the terminals on top of the bushings for any loose hardware or bad connections. Continue checking through the circuit until the problem is solved and the resistance is within the proper values.

BUSHING CURRENT TRANSFORMER CHECKS

It is a good practice to check the bushing current transformer before placing oil in the tanks. If any damage has occurred in transit or installation it can be corrected with a minimum of lost time. This procedure also insures the removal of any grounding or shorting connections which may have been left on the BCT leads after the completion of the factory tests and installation of the customer's permanent BCT circuitry.

BREAKER 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 opening dashpots (13), Fig. 12, should be checked for proper oil level, and filled with Type I insulating oil if necessary. This check should be made with the piston up, that is, with the breaker in the partially closed position so that the lever (3), Fig. 13, is not touching the piston. A small pipe plug in the oil level hole (4) is located at the oil level line. If the oil level is even with the bottom of this hole the oil level is satisfactory. Replace the pipe plug then open the breaker.

The stroke of the breaker, which is the total movement of the lift rod (18), Fig. 14, from the fully closed to the fully open position, should measure 12 inches plus or minus 1/4 inch as specified on the outline drawing. The minimum stroke of the lift rod from the fully closed position during a reclose operation must not be less than 10 inches with the breaker contacts in Type I insulating oil. 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 operation adjustments are made, the tank must be filled with Type I insulating 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 (Glyptal*), Permatex #2 or similar to seal the joints if necessary. Do not use an electrically conductive sealer as it might contaminate the oil. A plug is furnished for the outlet side of the drain valve and should be used to prevent any leakage if the valve seat becomes 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 30,000 volts when tested in a standard gap per ASTM D877, with 1 inch diameter disk terminals 0.1 inch 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 Type I insulating oil obtain instruction book GEI-28004 from the nearest Apparatus Sales Office of the Company.

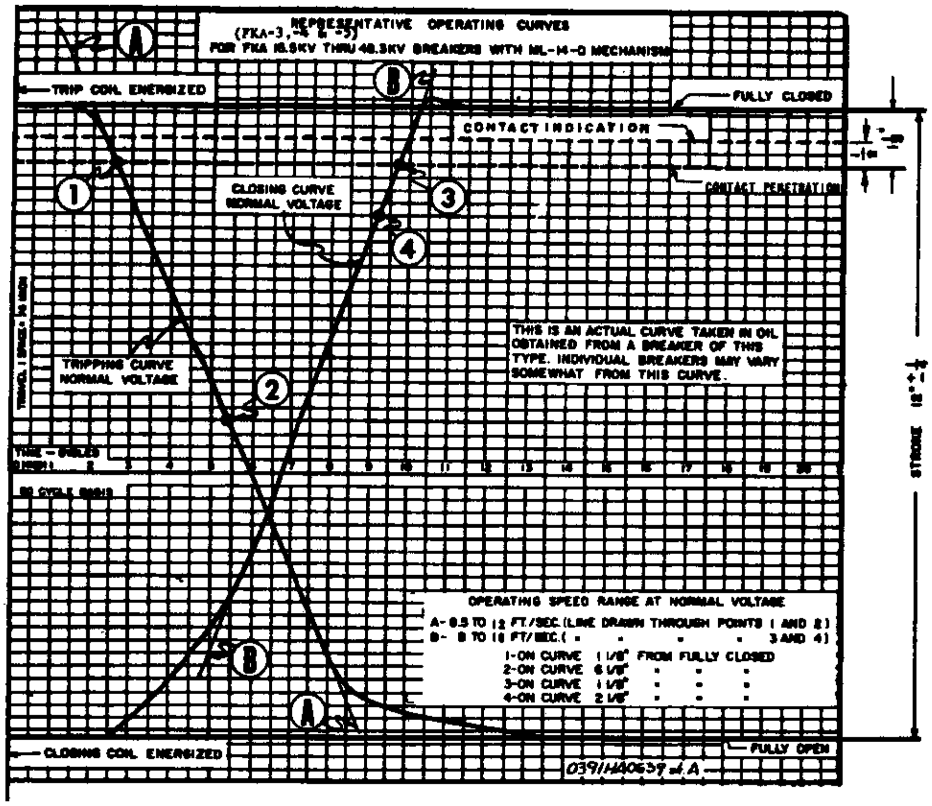
In filling, care must be taken so that moisture will not be absorbed by the oil during the filling process. When cold drums of oil are brought into a warm place, they should be allowed to stand before opening until there is no condensation on the outside and until they are thoroughly dry. The preparation and filling should be done on a clear, dry day or adequate protection of some kind provided against moisture being absorbed. Metal or 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 which is 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 end of the bushing will always be immersed and prevent corona discharge from the ground sleeve. The breaker should not be energized for at least twelve hours after filling to permit air bubbles to escape from the oil due to the possibility of air bubbles decreasing the dielectric strength of the oil.

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 the mechanism is properly checked and lubricated in accordance with the mechanism instruction book. When the spring-

*Registered trademark of the General Electric Company



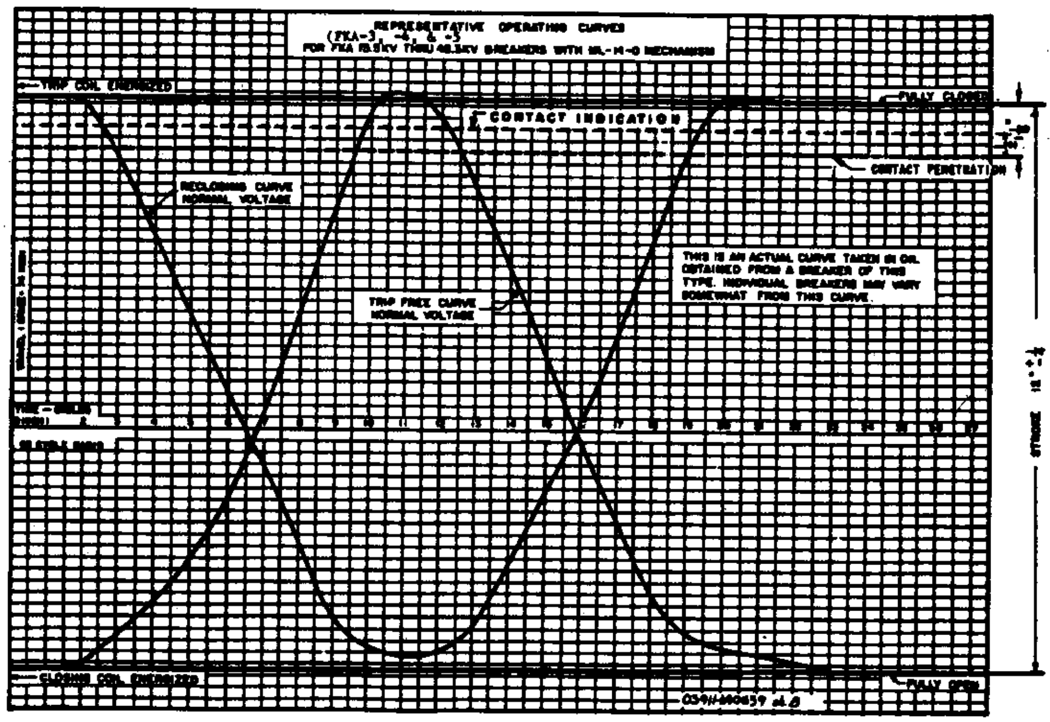
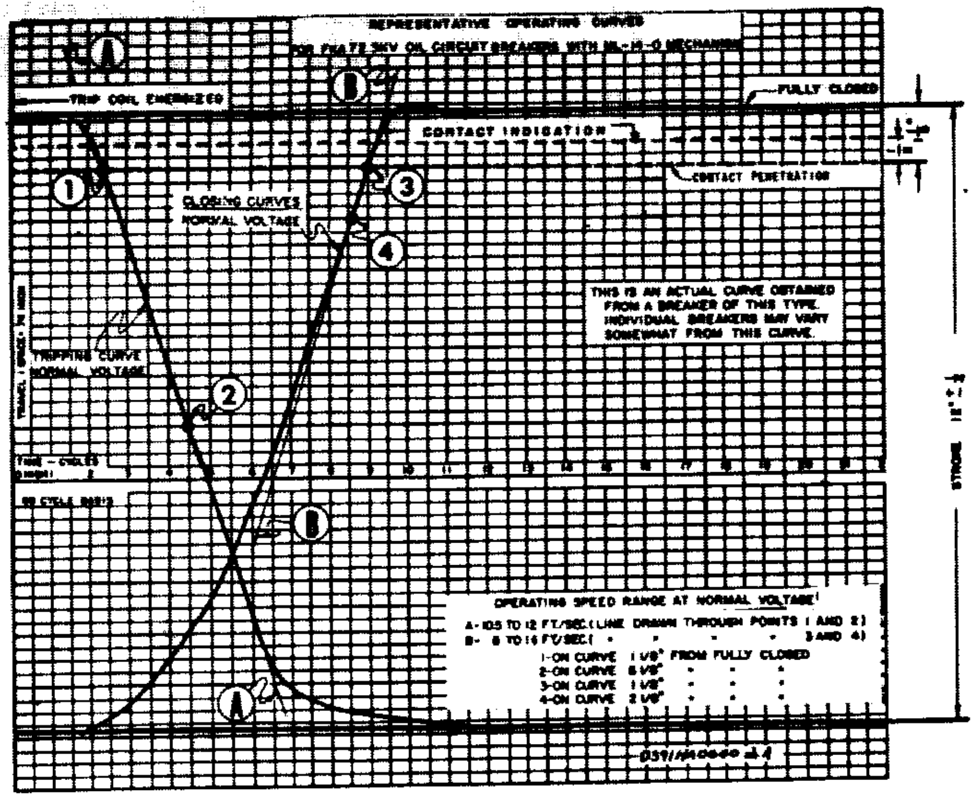


Fig. 24 Representative Travel Curves with an ML-14-0 spring-charged operating mechanism FKA-15.5 through 48.3 kV breakers, curves taken in oil.

Fig. 24 (0391HA0639 Sh. A and B Rev. 3)



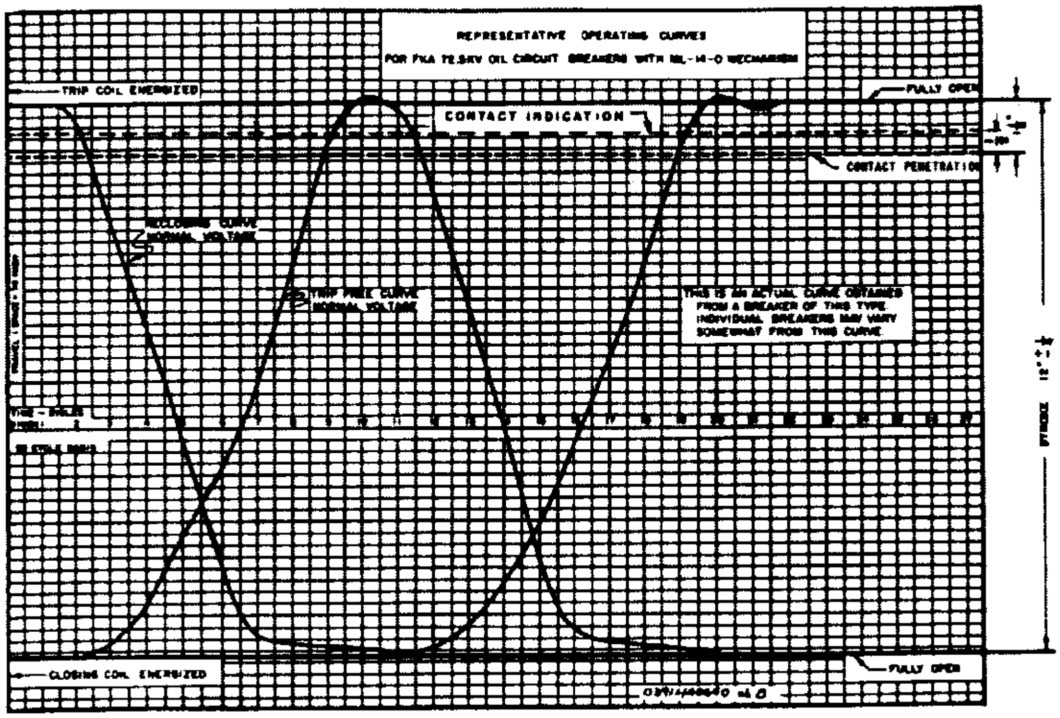


Fig. 25 Representative Travel Curves with an ML-14-0 spring-charged operating mechanism FKA-72.5 breaker, curves taken in oil.

Fig. 25 (039[illegible]0640 Sh. A and B Rev. 3) charged mechanism is used, slowly close the mechanism as described in the mechanism instruction book. The spring-charged mechanism cannot be opened slowly. If any binding occurs the cause of the binding should be located and corrected or explained before operating the breaker.

While the tank is being filled with oil, the checks can be made on the operating mechanism.

The driving and latching pawls, ratchet wheel clearance, etc., should be checked.

Reference should be made to the spring-charged mechanism instruction book for the adjustments and checks.

OPENING SPRING

15.5 THROUGH 48.3 KV BREAKERS

The opening spring (25), Fig. 14, used on the 15.5 through 48.3 kV breakers which utilize an ML-14-0 or ML-14-0Y1 has the following settings.

The nominal compressed length is 7-3/8 inches when the breaker is in the fully-closed position.

This corresponds to a nominal spring compression of 7/8 inch. This spring should not be compressed to a length less than 6-5/8 inch and when compressed to this length the spring must not go solid on overtravel when closing.

The free length of this spring is 8-1/4 inches ± 1/4 inch.

72.5 KV BREAKERS

The opening spring (25), Fig. 14, used on the 72.5 kV breakers which utilize an ML-14-0, or ML-14-0Y1 as an operator has the following settings.

The nominal compressed length is 7-1/2 inches when the breaker is in the fully-closed position.

This corresponds to a nominal spring compression of 1-1/2 inches. This spring should not be compressed to a length less than 7-1/4 inch, and, when compressed to this length, the spring must not go solid on overtravel when closing.

The free length of this spring is 9 inches ± 1/8 inch.

The springs which have a free length of 9 inches ± 1/8 inch are identical.

FOLLOW-THROUGH SPRING

The nominal follow-through spring (27), Fig. 14, compressed length is the same as the compressed length of the opening spring (25). However, the compression of the follow-through spring is different because the free length is different. The nominal compression of the follow-through spring is 5-13/32 inches for the 15.5 through 48.3 kV breakers with the ML-14 or ML-14-0Y1 operating mechanisms and 6-1/32 inches for the 72.5 kV breaker. This spring is compressed somewhat at all times in both the breaker-open and the breaker-closed positions. This spring should not be compressed to a length less than 6-1/2 inches as it will possibly take a permanent set if compressed beyond this figure. The free length of this spring is 12 inches ± 1/4 inch.

Care must be taken when removing the opening spring retaining nut and guide (44), Fig. 14, from the opening spring coupling rod (23) since there is approximately 1/2 inch of compression on the follow-through spring in the breaker fully-open position. This amounts to approximately a 20-pound spring force.

The follow-through spring is not adjustable by itself since it is adjusted at the same time the opening spring is adjusted.

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

When the breaker opens under load the contacts separate, drawing arcs between the tips of the contact rods and the arcing tips of the staionary 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. 26, 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 reestablish itself, and interruption occurs.

SPEED ADJUSTMENT

After completing the preceding installation adjustments and inspection, and after filling the tank with oil, 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. A #10-32 tapped hole is located in the top of the lift rod coupling, as indicated in the travel recorder rod connection (21), Fig. 14, to accommodate the rod used with the travel analyzer. Access to this tapped hole is by removal of the breather (19) which is screwed into the closing buffer assembly. The travel analyzer (1), Fig. 23, is readily mounted by attaching the bracket (6) to the center phase buffer housing after unscrewing the breather (19), Fig. 14.

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 (Fig. 24 and Fig. 25) 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.

OPENING SPEED

The opening speed is determined by drawing a straight line through two points on the travel curve. See Fig. 24 and Fig. 25. One point is to be located on the opening curve 1-1/8 inches from the fully-closed position. This is the point at which the contact rod penetration into the finger cluster begins when closing the breaker. This point is not where bellset wipe would occur. The second point is to be located on the opening curve 6-1/8 inches (measured vertically) from the fully-closed position. The slope of this line is an indication of the opening speed, which should be 8.5 to 12.0 feet per second with the breaker contacts in oil for the 15.5 through 48.3 kV breakers and 10.5 through 12 feet per second for the 72.5 kV breakers. 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.

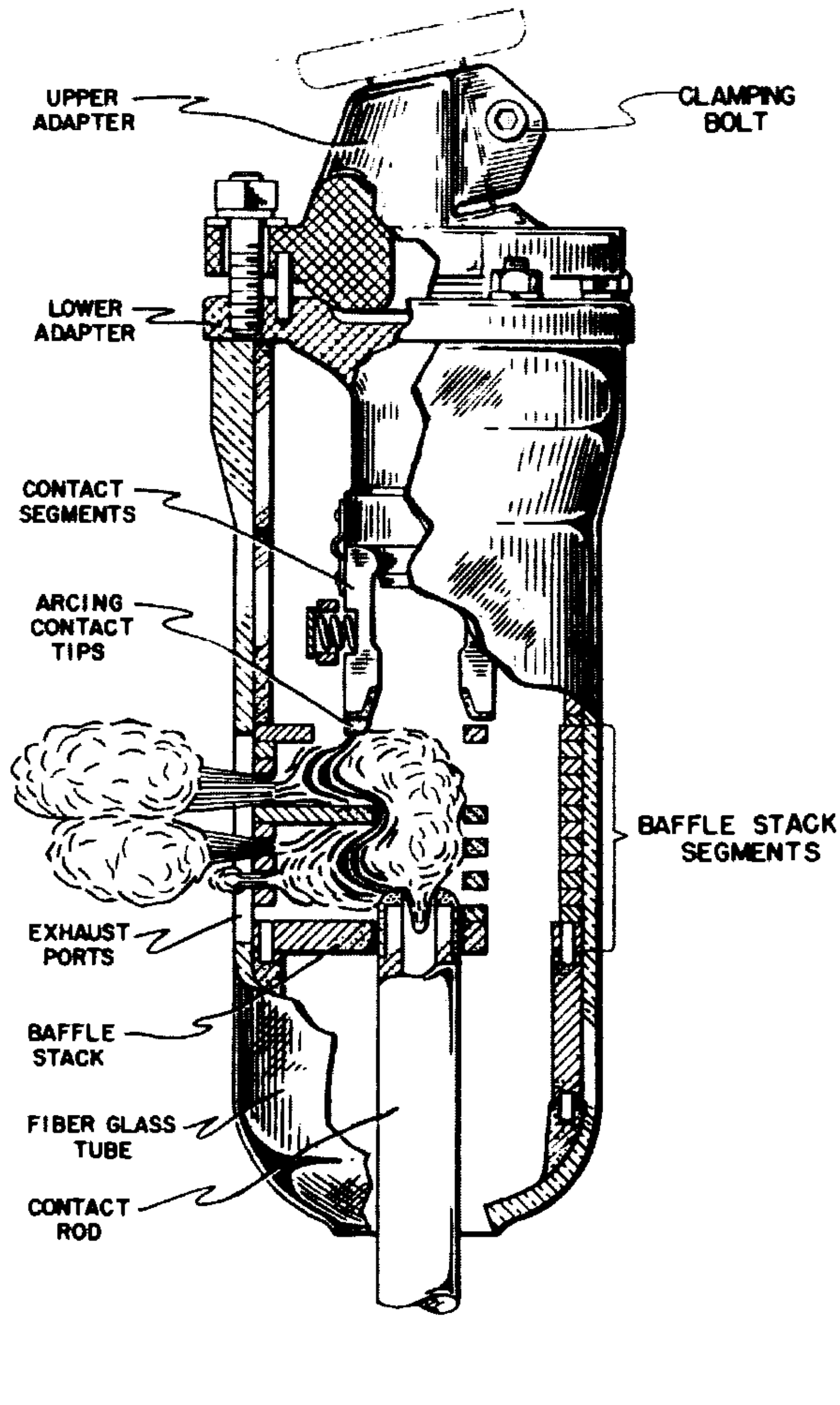


Fig. 26 Cutaway View of Interrupter showing arc interruption

Fig. 26 (0124C3280 Rev. 2)

3) Draw a straight line between the proper points as shown on the representative travel curves, Fig. 24 and 25.

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 setting on the opening spring (25), Fig. 14. 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. Any adjustment of the opening spring will change the adjustment of the contact stop clearance and the buffer clearance. After adjusting the opening spring check the contact stop clearance (H), Fig. 27 and the buffer setting (F). Readjust as necessary.

CLOSING SPEED

The average closing speed of the breaker can be determined in a similar manner by drawing a straight line through two points located 1-1/8 inches and 2-1/8 inches from the breaker fully-closed position. The closing speed is controlled by the operating mechanism and the opening spring. If changes are required the opening spring compression can be changed, but this will change the opening speed, consequently, the opening speed will require checking if the closing speed is adjusted. There is no other adjustment for the closing speed. For additional information, consult the mechanism instruction book paying particular attention to the section on INSTALLATION ADJUSTMENTS.

LIFT ROD OVERTRAVEL

The overtravel of the lift rod must not exceed 1/4 inch when closing the breaker. 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. The 72.5 kV breaker has two 1/8 inch thick washers (14), Fig. 17, under the outer spring (10). If the overtravel is excessive check that these washers are in place and that the buffer clearance is correct.

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 5/8 inch. A slight variation between the three phases within the above tolerance is permissible.

LIFT ROD OVERTRAVEL

The lift rod overtravel should be checked when the opening and closing speeds are checked. This should not exceed 1/4 inch when closing the breaker. For a more detailed explanation see OPERATION.

SUMMARY OF ADJUSTMENTS AND CHECKS

Refer to Fig. 27 for the physical location of the following items. With the tank down and the breaker interrupters exposed:

A) Check the overtravel stop setting, which is used as an indication of the internal lift rod setting. It should be 1/4 inch + 1/64 inch -0 with the breaker in the breaker fully-closed position.

B) Check the toggle position, which is an indication of the setting of the toggle linkage. It should be 7/8 inch ± 1/32 inch in the breaker fully-closed position.

C) Phase One and Phase Three lift rod settings are compared with the lift rod setting of Phase Two and must be within ± 1/8 inch of the Phase Two lift rod setting in the breaker-closed position.

D) Phase Two lift rod setting should be 7-1/4 inches ± 1/8 inch, in the breaker fully-closed position.

E) The nominal opening spring compression is one inch for the 15.5 through 48.3 kV breakers and 1-1/2 inches for the 72.5 kV breakers. The compressed length of the opening spring for the 15.5 through 48.3 kV breakers should not be less than 6-5/8 inches and for the 72.5 kV breakers not less than 7-1/4 inches. The follow-through spring should be compressed at all positions for all breakers.

F) The inner spring of the closing buffer must have 1/32 inch ± 1/64 inch clearance when the breaker is closed. A preliminary adjustment can be checked. This is the measurement from the top of the adjusting disk inside the buffer housing to the top of the buffer housing. This measurement is approximately 1-7/32 inch. There are two 1/8 inch thick washers beneath the outer spring in the buffer housing of the 72.5 kV breakers only.

G) The contact penetration, which is the insertion of the contact rod into the contact segments, is 1-1/8 inches ± 1/16 inch. This will give an electrical wipe of approximately 1/2 to 7/8 inch.

H) The contact stop clearance should measure 7/8 inch ± 1/16 inch. The contacts in any one phase should part within 1/32 inch of each other. The contacts in any phase should part within 1/4 inch of the contacts of any other phase.

J) The minimum allowable clearance between the crossarm contact block and the interrupter is 1/2 inch. The nominal clearance is 15/16 inch. This is measured in the breaker fully-closed position.

K) The breaker stroke should be 12 inches ± 1/4 inch.

L) The lift rod to lever pin clearance should be a minimum of 2-15/16 inches with the breaker in the fully-closed position. Measure on Phase Three only. It is not necessary to make this measurement on the other two phases. This measurement is an indication of the external toggle setting and the lift rod setting.

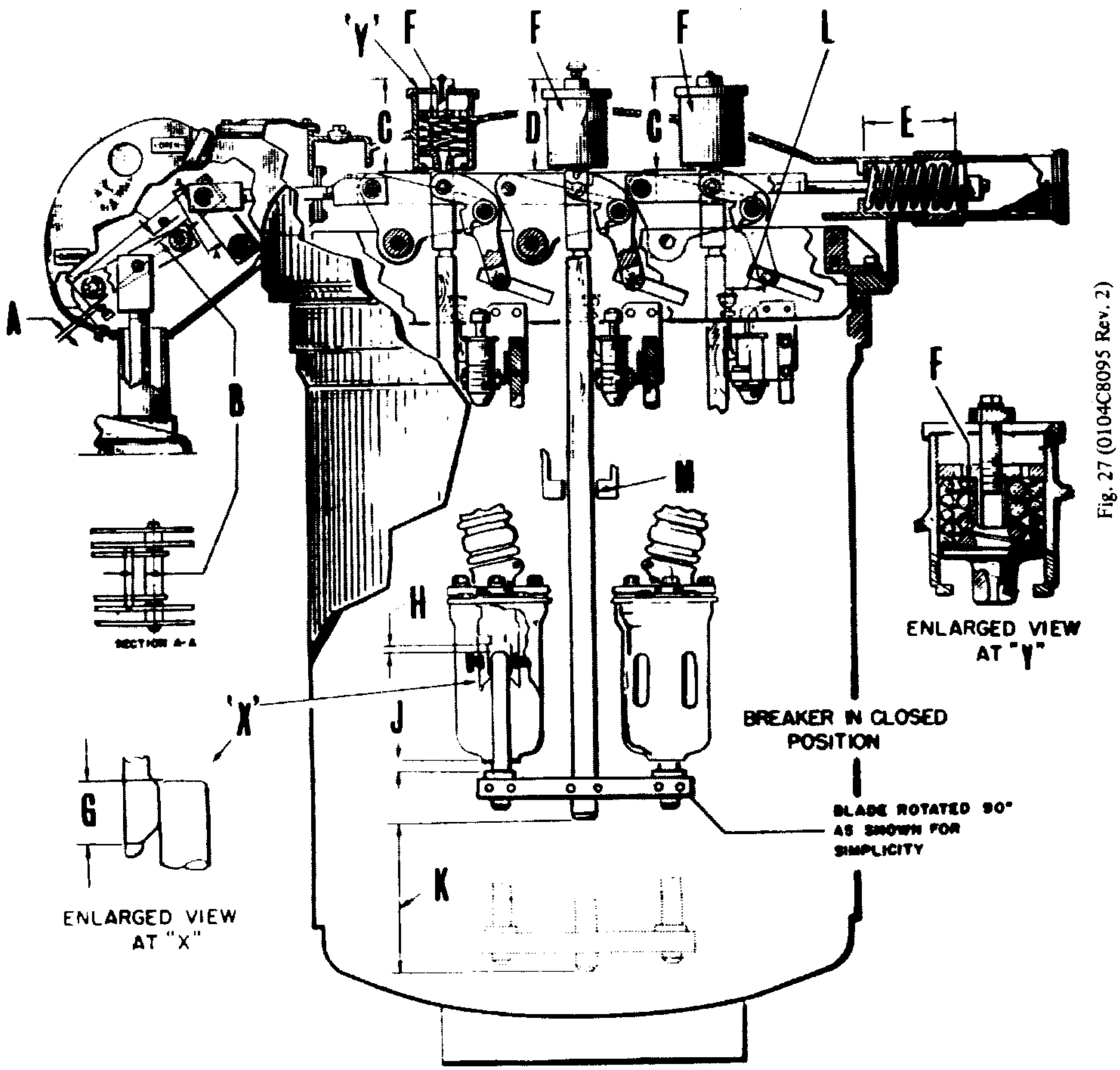


Fig. 27 Physical Location of Breaker Adjustments and Check Points

M) The lift rod 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.

With the tank in place and filled with oil:

A) The contact opening speed is 8-1/2 to 12 feet per second for the 15.5 through 48.3 kV breakers and 10-1/2 to 12 feet per second for the 72.5 kV breakers.

B) Overtravel on closing is 1/4 inch maximum.

C) Rebound on opening is not more than 5/8 inch.

D) Rebound on closing is not more than 3/8 inch.

E) Contact closing speed is 8 to 16 feet per second for 15.5 through 72.5 kV breakers.

TABLE OF ADJUSTMENTS

For future 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.

		Phase 1	Phase 2	Phase 3
External Overtravel Stop Setting (Breaker Closed)	1/4 inch + 1/64 inch -0			
Breaker Stroke	12 inches ± 1/4 inch			
Lift Rod Setting (Phase 2)	7-1/4 inches ± 1/8 inch			
Lift Rod Setting (Phases 1 and 3)	Phase 2 setting dimension ± 1/8 inch			
Lift Rod to Lever Pin Clearance (Minimum)	2-15/16 inches			
External Toggle Setting	7/8 inch ± 1/32 inch			
Preliminary Closing Buffer Setting	1-7/32 inches ± 1/32 inch			
Closing Buffer Clearance Plus Free Travel	1/32 inch ± 1/64 inch			
Contact Penetration	1-1/8 inches ± 1/16 inch			
Contact Wipe (Electrical Bellset)	1/2 inch to 7/8 inch			
Contact Stop Clearance	7/8 inch ± 1/16 inch			
Overtravel Stop Clearance	1/4 inch + 1/64 inch -0			
Contact Resistance - (Using 100-ampere ductor with 100 amperes flowing)				
New Contacts - Microhms	250			
Used Contacts - Microhms (Maximum)	450			
Part or Make Contacts in Any One Phase (Not electrical measurement)	Within 1/32 inch of each other			
Part Contacts Between Phases	Within 1/4 inch of each other			
Crossbar to Interrupter Minimum Clearance	1/2 inch			
Crossbar to Interrupter Nominal Clearance	15/16 inch			
Opening Spring Compressed Length Not less than				
(15.5 through 48.3 kV Breakers)	6 5/8 inches			
(72.5 kV Breakers)	7 1/4 inches			
Opening Spring Nominal Compressed Length				
(15.5 through 48.3 kV Breakers)	7 3/8 inches			
(72.5 kV Breakers)	7 1/2 inches			
Tripping Time (Maximum-Normal Voltage)	3.0 cycles			

TABLE OF ADJUSTMENTS (Continued)

For future 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.

		Phase 1	Phase 2	Phase 3
Opening Speed (1-1/8 inches to 6-1/8 inches) from fully closed (15.5 through 48.3 kV breakers)	8-1/2 to 12 feet per second			
Opening Speed (1-1/8 inches to 6-1/8 inches) from fully closed (72.5 kV breakers)	10-1/2 to 12 feet per second			
Closing Speed (1-1/8 inches to 2-1/8 inches) from fully closed (15.5 through 72.5 kV Breakers)	8 to 16 feet per second			
Overtravel (Maximum) On Closing	1/4 inch			
Rebound (Maximum) On Opening	5/8 inch			
Rebound (Maximum) On Closing	3/8 inch			
Closing Time (Maximum)	20 cycles			
Closing Time (Nominal)	10 to 15 cycles			
Reclosing Time (Maximum)	20 cycles			
Minimum Dropout on Reclosing (in Oil)	10 inches			
Lift Rod Clearance	1/64 inch			

Note: The opening spring housing (26), Fig. 14, must be in place before operating the breaker.

FINAL INSPECTION

1. See that the breaker is properly set up and leveled on its foundation and that the foundation bolts or 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 and oil gages 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 mechanism and breaker linkage have been lubricated.

5. Make certain that the dashpots are filled to the proper level.

6. Make certain that the oil tank is 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 using an alkyd base paint.

OPERATION

The spring-charged mechanical operating mechanism provides the energy for all operations of the breaker. Control voltage and pressure ranges, where applicable for proper operation are given on the operating mechanism nameplate.

The mechanism is 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 (1), Fig. 14, in a downward direction. This motion is transmitted through the breaker linkage to the vertical lift rods (18), closing the breaker.

MAINTENANCE

To maintain dependable service and safety of power equipment it is recommended that a definite maintenance schedule be set up and followed, as serious shutdowns can be avoided by locating potential sources of trouble at an early stage of development. 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. THE CLOSING SPRINGS OF THE SPRING-CHARGED OPERATING MECHANISM SHOULD BE GAGGED BEFORE WORKING ON THE BREAKER.

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 <u>not</u> 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 tank 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. The spring-charged mechanism uses a standard 1/2 inch drive ratchet wrench with a 5/8 inch socket to slowly close the breaker. This mechanism <u>cannot</u> be opened slowly. See the mechanism instruction book pertaining to the proper method of blocking the closing springs before attempting to close the breaker manually. THE BREAKER MUST NOT BE CLOSED SLOWLY ON LOAD.

NOTE: When the ML-14 spring-charged mechanism is used as the operator, it is advisable to wire or block the front trip latch in the latched position to prevent an accidental tripping when operating the mechanism with the manual device. This is because the ML-14 operating mechanism is mechanially trip-free. Before placing the breaker in service or operating it electrically make certain the blocking device is removed.

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

NOTE: The crossarm (13), Fig. 3, is normally approximately two inches below the surface of the oil when the breaker is open and the tank is down; consequently, care must be taken when operating the breaker manually with the tank down to prevent splashing of the oil. Either raise the tank so the oil level is above the contact rods or drain some of the oil out of the tank.

PERIODIC INSPECTION

The frequency of periodic inspection 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 maintenance schedule which will give assurance of proper breaker condition. On installations where a combination of fault duty and repetitive operation is encountered, inspection is recommended after any severe fault operation.

The contacts and baffles must be replaced after the breaker has interrupted a total of five times the rated interrupting current of the breaker. This is known as "integrated amperes" and is the sum of all currents, normal switching current as well as full rated fault current, interrupted by the breaker contacts. The baffle stack will deteriorate due to arcing at approximately the same rate as the contacts.

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 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 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 and wiped down using a clean lint-free cloth saturated with clean #10-C 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.

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. With the dashpot plunger in the up position oil may be added at this point. The dashpots use Type I 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 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.

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. If the bushing mounting nuts are not sufficiently secure tighten with approximately 40 to 50 foot pounds of torque.

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.

   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 (3), Figs. 16 and 17, located on top of the buffer 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.

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 tank and bushings.

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

REPAIR AND REPLACEMENT

STANDARD INTERRUPTER ASSEMBLY

With the oil tanks removed and the breaker in the open position, the interrupters (10), Fig. 3 can be lowered for inspection or repair by simply removing the six assembly nuts (2), Fig. 21, on the studs which pass through the lower adapter (4) and fasten into the interrupter tube (15) as shown in Fig. 21. The contact assembly (11) is now accessible and can be examined for excessive burning, pitting or wear. Since the studs fastening the upper (1) and lower (4) adapters have not been disturbed the assembly will probably not require a realignment of the interrupter. If it is necessary to change any contact fingers (9) and (10), first mark the position of the fingers containing the extended arcing tip (10) on the contact stop (20) above the flexible connector (6). Remove the flexible connectors (6) from the fingers. This permits removal of the entire contact finger assembly (11). If further disassembly of the interrupter is required the upper spacer (5) and intermediate spacers (25), insulating shims (23), the baffle stack (12) and the lower spacer (14) can be lifted out.

When reassembling the interrupter, the spacers and baffle stack are put back in the reverse order from the way in which they were taken out. Care must be taken that locating pins in the insulating spacers and baffles are properly installed in their respective locating holes. This will insure that the exhaust port of the baffle stack (12) is located in the exhaust slot opening (13) of the interrupter tube.

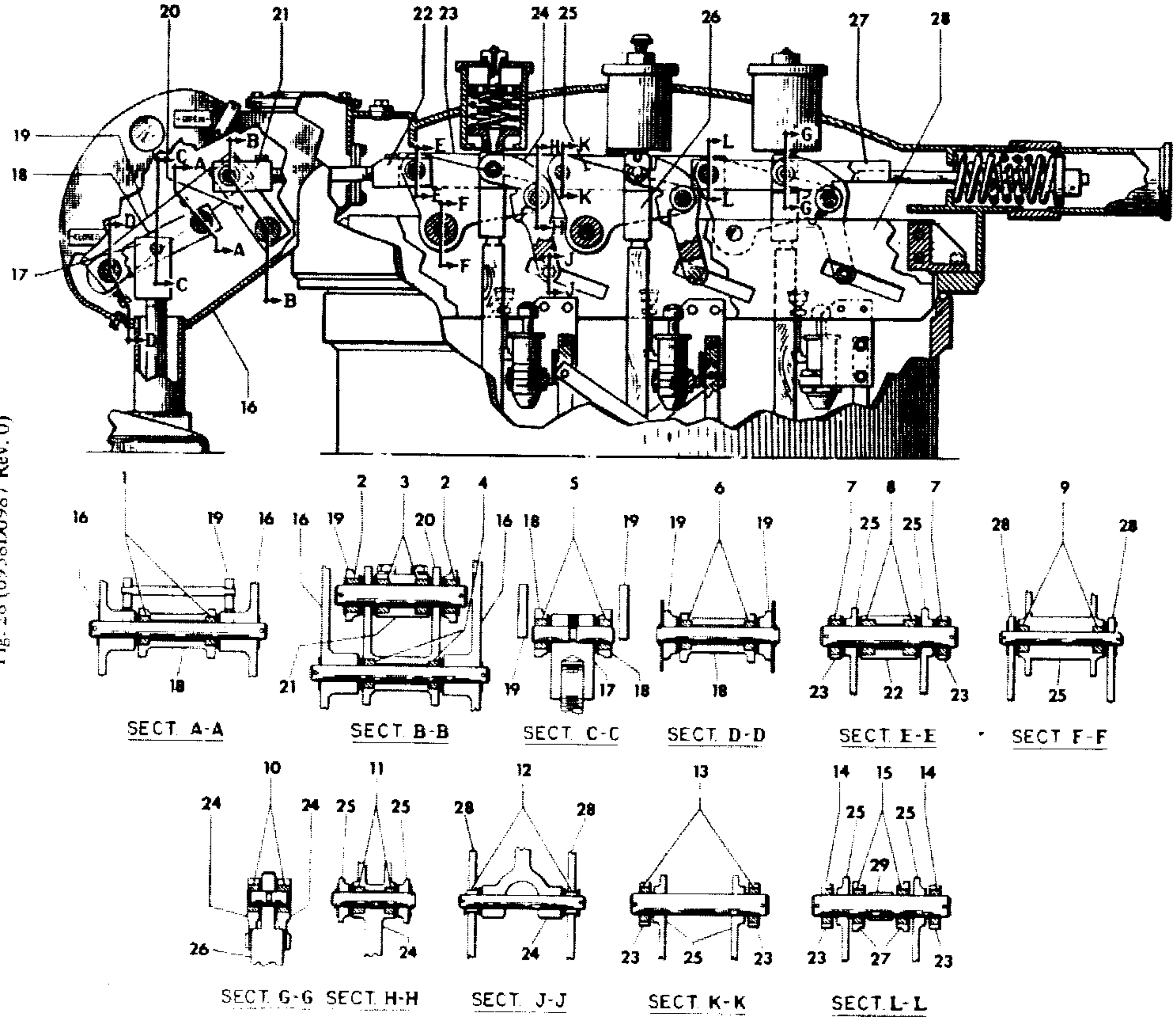


Fig. 28 (0958D0987 Rev. 0)

1. Top Front Crank Link Bushing
2. Front Link Bushing
3. Horizontal Operating Rod Front Coupling Bushing
4. Guide Crank Bushing
5. Center Front Crank Link Bushing
6. Bottom Front Crank Link Bushing
7. Front Connecting Link Bushing
8. Horizontal Operating Rod Rear Coupling Bushing
9. Beam Bushing
10. Lever Bushing (Top)
11. Lever Bushing (Center)
12. Breaker Linkage Side Support Roller
13. Center Connecting Link Bushing
14. Rear Connecting Link Bushing
15. Opening Spring Coupling Bushing
16. Front Crank Assembly Support Box
17. Vertical Operating Rod Coupling
18. Front Crank Link
19. Front Link
20. Guide Crank
21. Horizontal Operating Rod Front Coupling
22. Horizontal Operating Rod Rear Coupling
23. Front Connecting Link
24. Lever
25. Beam
26. Lift Rod Coupling
27. Opening Spring Coupling
28. Breaker Linkage Side Support
29. Spacer

Fig. 28. View of the Breaker showing bearing locations

The upper insulating spacer (5) should extend 1/64 inch to 1/32 inch above the top edge of the interrupter tube with the two 1/8 inch wide slots on the top side. This protrusion makes certain that the baffle stack (12) and spacers (5, 25 and 14) are tightly held in place when the interrupter is completely assembled. The 1/64 to 1/32 inch dimension is adjusted by the use of the insulating shims (23). The intermediate insulating spacer (25) is installed in the interrupter tube (15) with the two 1/8 inch slots on the bottom side. This assures that the insulating shims (23) are completely and firmly compressed. When the items which go into the interrupter tube are installed, put the interrupter in place on the lower adapter (4) making certain the arcing tips of the arcing t p finger (10) line up with the slots in the top plate of the baffle stack (12).

When tightening the 3/8-16 nuts (2), which fasten the interrupter tube to the adapter a torque of 200 to 250 inch-pounds should be used.

After assembly make certain that the exhaust ports of the baffle can be seen while looking into the interrupter through the exhaust port opening (13) of the interrupter tube. If the exhaust ports cannot be seen, the interrupter is incorrectly assembled and must be corrected by disassembly and rotation of the baffle to the proper location. Check for missing or crushed baffle locating pins.

If either the upper (1) or lower (4) adapter has, for some reason been disturbed, in relation to each other and the bushing, a spirit level should be used to insure vertical alignment. The upper adapter can be swivelled around the bushing lower mounting stud by loosening the clamping bolt (16) and the bushing can be slid around somewhat on the breaker dome to obtain additional adjustment. When tightening the 1/2-13 locking nuts (3) which fasten the upper and lower adapters together the torque value should be between 350 and 500 inch-pounds and care must be taken that the interrupter alignment is not disturbed. Recheck the interrupter alignment after tightening all hardware.

CAPACITOR SWITCHING INTERRUPTER

With the oil tanks removed, and the breaker in the open position, the capacitor switching interrupters can be lowered for inspection or repair by simply removing the six assembly nuts, (3), Fig. 22, the locating clip (5) and the resistor lead (33). The contact fingers (16) and (17) are now accessible and can be examined for excessive burning, pitting or wear. Since the upper adapter (1) has not been disturbed the reassembly will not require a realignment of the interrupter. If it is necessary to change any contact fingers, first mark the position of the arcing tip (17) on the contact stop (35) above the flexible connector (12) then remove the flexible connectors (12) from the fingers (16) and (17) permitting the removal of the contact segment assembly (18).

If further disassembly of the interrupter is required simply lift out the upper insulating spacer (11), the insulating shims (19), the intermediate insulating spacer (41), and the baffle stack (20). The resistor terminal screw (40) must be disconnected before removal of the resistor finger support (24). Gently raise the resistor until the resistor terminal screw (40) is exposed. Next remove the screw by using a screwdriver through the hole in the resistor support spacer (28). The remaining lower insulating spacer (27) can now be removed.

When reassembling the interrupter, care must be taken that locating pins in the insulating spacers and baffles are properly installed in their respective locating holes. This will insure that the exhaust port of the baffle stack (20) is located at the exhaust port opening (21) of the interrupter tube (10).

The upper insulating spacer (11), Fig. 22, should extend 1/64 inch to 1/32 inch above the top edge of the interrupter tube (10). This protrusion makes certain that the baffle stacks (20) and spacers (11, 41, and 27) are held in place tightly when the interrupter is completely assembled. The 1/64 inch to 1/32 inch dimension is adjusted by the insulating shims (19). The intermediate insulating spacer (41) is installed in the interrupter tube (10) with the two 1/8 inch slots on the bottom side. This assures that the insulating shims (19) are completely and firmly compressed. When the items which go into the interrupter tube (10) are installed or the interrupters are equipped with resistors, attach the lower resistor lead (39) to the resistor finger support. Attach the interrupter tube to the lower adapter (7) and install the locating clips (5) in the slots provided on the resistor and resistor cover. Make certain the exhaust openings in the resistor and cover line up with the exhaust port opening in the interrupter tube. Attach the upper lead (33) to the adapter with the lead screw (32). After the assembly is complete check the resistance of the resistors with the contact rod (36) out of the finger cluster (18), but with the contact rod still making contact with the resistor fingers (25). Check to see if the exhaust ports in the baffle stacks (20) can be seen while looking into the interrupter through the exhaust slot opening (21) in the interrupter. If it cannot be seen the interrupter is incorrectly assembled and must be disassembled and properly reassembled.

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.

If removal of a bushing is required 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 the "O" ring between the top frame and the mounting flange of the bushing is replaced with a new "O" ring. The mounting bolts should be tightened gradually and evenly to approximately 50 foot-pounds of torque, and all interrupter adjustments should be checked.

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 are mounted in the top frame as shown in Figs. 6, 18 and 29. To remove the bushing current transformer, first remove the interrupter unit and disconnect the transformer lead wires from the terminal boards which are located in the mechanism control cabinet. Cut off the terminal on the end of the BCT lead and then pull the lead through the BCT seal located at the top of the BCT conduit pipe (5), Fig. 3. Pull approximately six inches of each wire at a time through the BCT seal from the BCT side of the seal. Pry the seal out of its seat. Loosen the nut and bolt in the center of the seal. This permits easy removal of the necessary wires from the seal.

Loosen the adapter clamp bolt (10), Fig. 19, and remove the interrupter unit. Then remove the four assembly nuts (14), Fig. 4 permitting the supporting plate (13) and the current transformer (11) to be lowered.

Bushing current transformers may be installed either before or after the bushings are in place. Insulation washers 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.

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.

Frequent operation of a breaker causes the lubricant to be forced out from between the bearing surfaces. A simple lubrication will sometimes clear 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.

The LUBRICATION CHART shown gives complete information for lubricating the breakers. One column shows the recommended ANNUAL LUBRICATION which requires no disassembly. The other

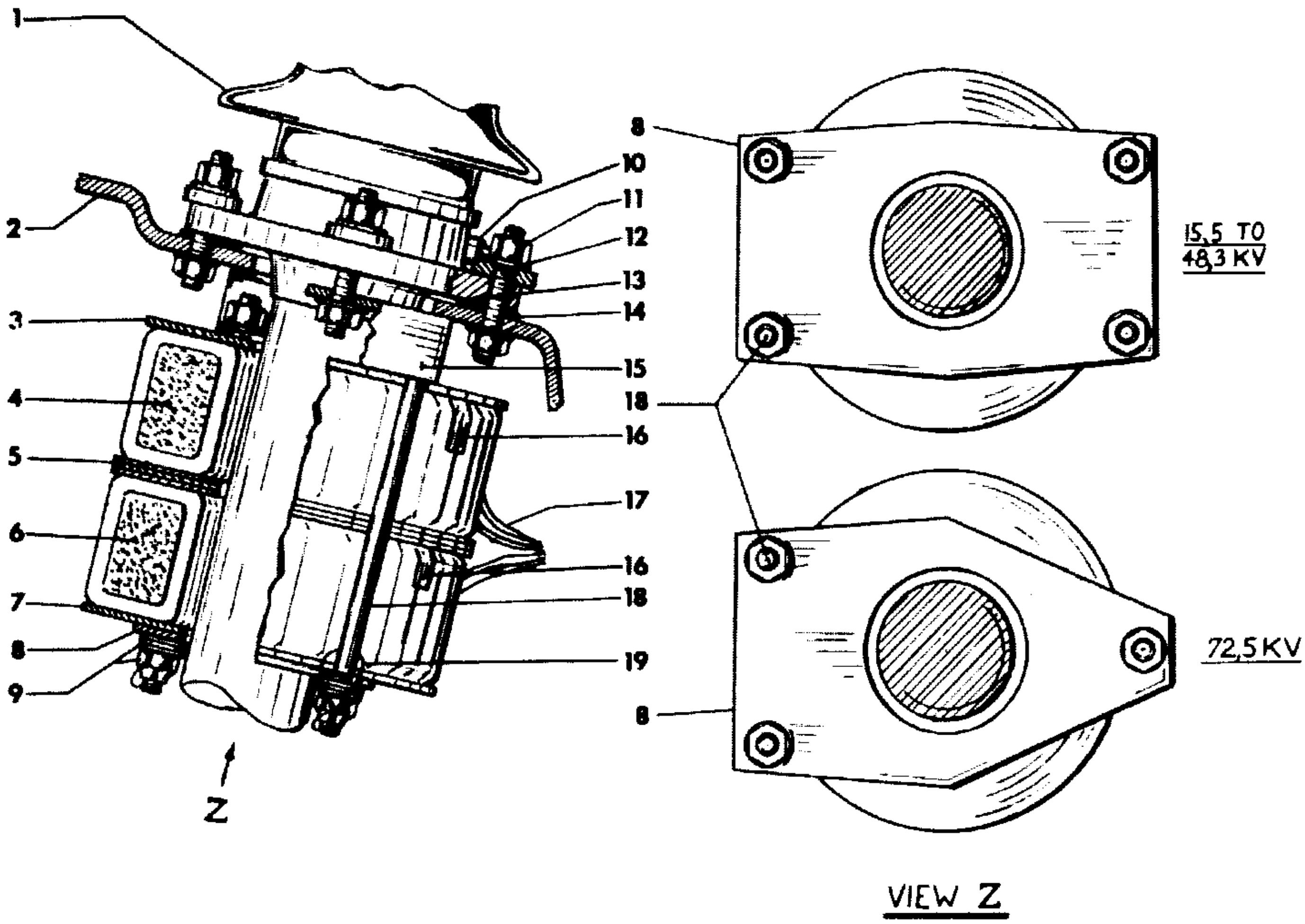


Fig. 29 (0129C0554 Rev. 0)

1. Bushing
2. Breaker Dome
3. Insulation Washer
4. Upper BCT (Position Y)
5. Insulation Washers
6. Lower BCT (Position X)
7. Insulation Washer
8. BCT Support Plate
9. Spacer Washers
10. Bushing Capacitance Tap
11. Bushing Mounting Nut
12. Bushing Mounting Stud
13. Bushing to Dome Gasket
14. Bushing to Dome Gasket Retainer
15. BCT Mounting Plate
16. White Polarity Strips
17. BCT Leads
18. BCT Mounting Stud
19. Safety Wire

Fig. 29 Bushing Current Transformer and Bushing Mounting

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)	Very light application of light machine oil SAE20 or 30.	Clean per following instructions. Apply D50H15 liberally.
Opening Dashpot	With piston in the up position, fill even with fill hole using clean Type I insulating oil.	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.		

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:

SLEEVE BEARINGS

The pins should be removed and all old oxidized grease removed by immersion in clean petroleum solvent or similar cleaner. DO NOT USE CHLOROTHANE AS IT WILL ADVERSELY AFFECT THE TEXTOLITE BUSHINGS.

If the grease in the bearings has become badly oxidized it may be necessary to use alcohol (the type used for thinning shellac) to remove it. Ordinarily, by agitating the bearings in the cleaning solution, and using a stiff brush to remove the solid particles, the bearings can be satisfactorily cleaned. Do not handle the bearings or pins with bare hands as deposits from the skin onto the bearings and pins are inducive to corrosion. If the bearings or pins are touched, the contamination can be removed by washing in alcohol. After the bearings or pins have been thoroughly cleaned, dip in clean, new, light machine oil until the cleaner or solvent is entirely removed.

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

NOTE: 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 in 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 antifreeze 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 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.

REPLACEMENT 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.

A list of replacement parts follows. This list includes both recommended renewal parts as designated by the asterisk (*) as well as a listing of parts ordered most frequently. The actual drawing number as well as the figure and part numbers in this book are given. Where parts are required that do not appear on this list, and hence no drawing number is available, the instruction book number as well as the figure and part number should be given on the purchase order.

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. All "O" rings have a limited shelf life of three years.

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 serial number, type, and rating of the breaker. The breaker nameplate is mounted on the inside of one of the doors 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. No.	Ref. No.	Quantity per Oil-Blast Circuit Breaker: FKA 15.5 36000		FKA 38 22000		FKA 48.3 17000		FKA 48.3 29000		FKA 72.5 19000		FKA 72.5 27000		Catalog No.	Description
		-6	-6R	-6	-6R	-6	-6R	-6	-6R	-3	-3R	-3	-3R		
4	*2	1	1	1	1	1	1	1	1	1	1	1	1	006370470 P020	Oil Gage Glass Tube
4	*2	2	2	2	2	2	2	2	2	2	2	2	2	006440357 P001	Gasket - Oil Gage Upper and Lower
4	*3	6	6	–	–	–	–	–	–	–	–	–	–	7B522	Bushing (TBI)
4	*3	–	–	6	6	–	–	–	–	–	–	–	–	7B955	Bushing (Non TBI)
4	*3	–	–	–	–	6	6	6	6	–	–	–	–	7B956	Bushing (Non TBI)
4	*3	–	–	–	–	–	–	–	–	6	6	6	6	7B597	Bushing (Non TBI)
4	*10	1	1	1	1	1	1	1	1	–	–	–	–	0173A9024 P004	Gasket-Tank
4	*10	–	–	–	–	–	–	–	–	1	1	1	1	0173A9024 P005	Gasket-Tank
4	19	1	1	1	1	1	1	1	1	–	–	–	–	0153B5271 G001	Tank Liner
4	19	–	–	–	–	–	–	–	–	1	1	1	1	0809B0203 G001	Tank Liner
4	21	3	3	3	3	–	–	–	–	–	–	–	–	0188B9285 P001	Lift Rod
4	21	–	–	–	–	3	3	3	3	–	–	–	–	0188B9285 P002	Lift Rod
4	21	–	–	–	–	–	–	–	–	3	3	3	3	0188B9285 P003	Lift Rod
4	*22	6	–	6	–	6	–	6	–	6	–	6	–	0269A2229 G002	Contact Rod
4	*22	–	6	–	6	–	6	–	6	–	6	–	6	0269A2219 G011	Contact Rod
4	25	1	1	1	1	1	1	1	1	1	1	1	1	0123B2600 G001	Drain Valve (1 Inch Globe)
4	30	–	–	–	–	–	–	–	–	2	–	2	–	0123B1903 G021	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	–	–	–	–	–	–	–	–	1	–	1	–	0123B1903 G022	Blade and Rod Assembly Complete - Phase 2
4	30	–	–	–	–	2	–	2	–	–	–	–	–	0123B1903 G011	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	–	–	–	–	1	–	1	–	–	–	–	–	0123B1903 G012	Blade and Rod Assembly Complete - Phase 2
4	30	–	–	–	–	–	–	–	–	–	2	–	2	0123B1903 G023	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	–	–	–	–	–	–	–	–	–	1	–	1	0123B1903 G024	Blade and Rod Assembly Complete - Phase 2
4	30	–	–	–	–	–	2	–	2	–	–	–	–	0123B1903 G015	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	–	–	–	–	–	1	–	1	–	–	–	–	0123B1903 G016	Blade and Rod Assembly Complete - Phase 2
4	30	2	–	2	–	–	–	–	–	–	–	–	–	0123B1903 G017	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	1	–	1	–	–	–	–	–	–	–	–	–	0123B1903 G018	Blade and Rod Assembly Complete - Phase 2
4	30	–	2	–	2	–	–	–	–	–	–	–	–	0123B1903 G019	Blade and Rod Assembly Complete - Phase 1 and 3
4	30	–	1	–	1	–	–	–	–	–	–	–	–	0123B1903 G020	Blade and Rod Assembly Complete - Phase 2
6	9	6	6	6	6	6	6	6	6	6	6	6	6	0181V0744 P001	Opening Dashpot Adjusting Nuts
6	10	3	3	3	3	3	3	3	3	3	3	3	3	0178L0271 G001	Opening Dashpot
12	5	2	2	2	2	2	2	2	2	2	2	2	2	0269A2175 P001	Lift Rod Guide Diagonal Brace
12	7	2	2	2	2	2	2	2	2	–	–	–	–	0269A2176 P003	Lift Rod Guide Vertical Support
12	7	–	–	–	–	–	–	–	–	2	2	2	2	0269A2176 P002	Lift Rod Guide Vertical Support
12	8	2	2	2	2	2	2	2	2	2	2	2	2	0269A2176 P001	Lift Rod Guide Horizontal Support
12	ϕ	1	1	1	1	1	1	1	1	–	–	–	–	010405847 G004	Lift Rod Guide Support Assembly Complete
12	ϕ	–	–	–	–	–	–	–	–	1	1	1	1	0104D5847 G003	Lift Rod Guide Support Assembly Complete
14	*2	1	1	1	1	1	1	1	1	1	1	1	1	0399A0298 P001	Gasket - Front Cover
14	*7	4	4	4	4	4	4	4	4	4	4	4	4	0178V0727 P001	Indicator Window - Glass (Open and Closed)
14	*0	4	4	4	4	4	4	4	4	4	4	4	4	0183V0711 P001	Indicator Window - Gasket
14	*12	1	1	1	1	1	1	1	1	1	1	1	1	0399A0298 P002	Gasket - Top Cover

Fig. No.	Ref. No.	Quantity per Oil-Blast Circuit Breaker: FKA 15.5 36000		FKA 38 22000		FKA 48.3 17000		FKA 48.3 29000		FKA 72.5 19000		FKA 72.5 27000		Catalog No.	Description
		-6	-6R	-6	-6R	-6	-6R	-6	-6R	-3	-3R	-3	-3R		
14	28	3	3	3	3	3	3	3	3	3	3	3	3	006076406 P567	Lever Pin (Steel)
14	32	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P002	Upper Crank Link Pin (Steel)
14	33	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P001	Front Link and Guide Crank Pin (Steel)
14	34	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P002	Guide Crank Pin (Steel)
14	35	1	1	1	1	1	1	1	1	1	1	1	1	183V0710 P001	Vertical Operating Rod Coupling Pin (Steel)
14	36	1	1	1	1	1	1	1	1	1	1	1	1	103A2124 P018	Lower Front Crank Link Pin (Steel)
14	37	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P004	Horizontal Operating Rod Rear Coupling Pin (Steel)
14	38	3	3	3	3	3	3	3	3	3	3	3	3	183V0713 P003	Beam Pin (Steel)
14	39	3	3	3	3	3	3	3	3	3	3	3	3	183V0740 P001	Lift Rod Coupling Pin (Steel)
14	40	3	3	3	3	3	3	3	3	3	3	3	3	103A2123 P021	Lever and Beam Pin (Steel)
14	41	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P004	Connecting Link Pin (Steel)
14	42	1	1	1	1	1	1	1	1	1	1	1	1	183V0713 P004	Opening Spring Coupling Pin (Steel)
15	18	1	1	1	1	1	1	1	1	1	1	1	1	0269A2086 P001	Gasket - Upper Portion of BCT Conduit
15	19	2	2	2	2	2	2	2	2	2	2	2	2	0161A6080 P009	"O" Ring - Lower Portion of BCT Conduit
16 & 17	5	3	3	3	3	3	3	3	3	3	3	3	3	0397A0963 P009	"O" Ring - Buffer Cover Bolt
16 & 17	7	3	3	3	3	3	3	3	3	3	3	3	3	0181V0113 P001	Gasket - Buffer Cover
16 & 17	10	1	1	1	1	1	1	1	1	1	1	1	1	0397A0851 P001	Outer Spring (Kick-off)
16 & 17	11	1	1	1	1	1	1	1	1	1	1	1	1	0103A6590 P001	Inner Spring (Buffer)
17	14	–	–	–	–	–	–	–	–	6	6	6	6	0181V0112 P002	Washer - 1/8 Inch Thick
21	All	6	–	6	–	–	–	–	–	–	–	–	–	0214X0286 G003	Interrupter Complete
21	All	–	–	–	–	6	–	6	–	–	–	–	–	0214X0286 G031	Interrupter Complete
21	All	–	–	–	–	–	–	–	–	6	–	6	–	0214X0286 G033	Interrupter Complete
21	1	6	–	6	–	–	–	–	–	–	–	–	–	0168C5764 P002	Upper Adapter
21	1	–	–	–	–	6	–	6	–	–	–	–	–	0842C0544 P005	Upper Adapter
21	1	–	–	–	–	–	–	–	–	6	–	6	–	0842C0544 P002	Upper Adapter
21	5	6	–	6	–	6	–	6	–	6	–	6	–	0103A6957 P007	Upper Insulating Spacer
21	6	48	–	48	–	48	–	48	–	48	–	48	–	0153B5228 P001	Flexible Connectors
21	7	48	–	48	–	48	–	48	–	48	–	48	–	006076150 P001	Contact Finger Spring
21	8	6	–	6	–	6	–	6	–	6	–	6	–	0176V0880 P004	Spring Cage
21	*11	6	–	6	–	6	–	6	–	6	–	6	–	0195X0154 G001	Contact Segment Assembly Complete
21	*12	6	–	6	–	6	–	6	–	6	–	6	–	0267C0907 G002	Baffle Stack
21	*20	6	–	6	–	6	–	6	–	6	–	6	–	0158A9646 P001	Contact Stop
21	21	6	–	6	–	6	–	6	–	6	–	6	–	0382A0163 P003	Spring Retainer
21	23	12	12	12	12	12	12	12	12	12	12	12	12	0103A6964P002	Insulating Shim - 0.031 Inch Thick
21	25	6	–	6	–	6	–	6	–	6	–	6	–	0103A6957 P007	Intermediate Insulating Spacer
21	9	6	–	6	–	6	–	6	–	6	–	6	–	0123B1983 G005	Interrupter Tube and Studs Assembled
22	All	–	6	–	–	–	–	–	–	–	–	–	–	0214X0286 G013	Interrupter Complete
22	All	–	–	–	6	–	–	–	–	–	–	–	–	0214X0286 G030	Interrupter Complete
22	All	–	–	–	–	–	6	–	6	–	–	–	–	0214X0286 G032	Interrupter Complete
22	All	–	–	–	–	–	–	–	–	–	6	–	6	0214X0286 G034	Interrupter Complete
22	1	–	6	–	6	–	–	–	–	–	–	–	–	0168C5764 P002	Upper Adapter
22	1	–	–	–	–	–	6	–	6	–	–	–	–	0842C0544 P005	Upper Adapter
22	1	–	–	–	–	–	–	–	–	–	6	–	6	0842C0544 P002	Upper Adapter
22	8	–	6	–	–	–	–	–	–	–	–	–	–	0153B5200 G004	Resistor and Resistor Wire Support (15 Ohms)
22	8	–	–	–	6	–	–	–	–	–	–	–	–	0153B5200 G003	Resistor and Resistor Wire Support (83 Ohms)
22	8	–	–	–	–	–	6	–	6	–	–	–	–	0153B5200 G002	Resistor and Resistor Wire Support (150 Ohms)
22	8	–	–	–	–	–	–	–	–	–	6	–	6	0153B5200 G001	Resistor and Resistor Wire Support (526 Ohms)
22	9	–	6	–	6	–	6	–	6	–	6	–	6	0143B7630 P001	Resistor Cover
22	12	–	48	–	48	–	48	–	48	–	48	–	48	0153B5228 P001	Flexible Connectors
22	13	–	6	–	6	–	6	–	6	–	6	–	6	0176V0880 P004	Spring Cage
22	14	–	48	–	48	–	48	–	48	–	48	–	48	006076150 P001	Contact Finger Spring
22	15	–	6	–	6	–	6	–	6	–	6	–	6	0382A0163 P003	Spring Retainer

Fig. No.	Ref. No.	Quantity per Oil-Blast Circuit Breaker												Catalog No.	Description
		FKA 15.5 36000		FKA 38 22000		FKA 48.3 17000		FKA 48.3 29000		FKA 72.5 19000		FKA 72.5 27000			
		-6	-6R	-6	-6R	-6	-6R	-6	-6R	-3	-3R	-3	-3R		
22	*18	–	6	–	6	–	6	–	6	–	6	–	6	0195X0154 G001	Contact Segment Assembly Complete
22	19	12	12	12	12	12	12	12	12	12	12	12	12	0103A6964P002	Insulating Shim - 0.031 Inch Thick
22	*20	–	6	–	6	–	6	–	6	–	6	–	6	0267C0907 G002	Baffle Stack
22	22	–	18	–	18	–	18	–	18	–	18	–	18	006551729 P001	Resistor Contact Finger Spring
22	23	–	18	–	18	–	18	–	18	–	18	–	18	006477415 P009	Resistor Finger Pin
22	*25	–	18	–	18	–	18	–	18	–	18	–	18	009924682 P002	Resistor Contact Finger
22	*35	–	6	–	6	–	6	–	6	–	6	–	6	0158A9646 P001	Contact Stop
22	●	–	6	–	6	–	6	–	6	–	6	–	6	0123B1983 G006	Interrupter Tube and Studs Assembled
22	●	–	6	–	–	–	–	–	–	–	–	–	–	0214X0873 G001	Resistor Complete (With Resistor, Cover, Wire-wound Tube, Hardware and Upper and Lower Leads)
22	●	–	–	–	6	–	–	–	–	–	–	–	–	0214X0873 G002	Resistor Complete (With Resistor, Cover, Wire-wound Tube, Hardware and Upper and Lower Leads)
22	●	–	–	–	–	–	6	–	6	–	–	–	–	0214X0873 G003	Resistor Complete (With Resistor, Cover, Wire-wound Tube, Hardware and Upper and Lower Leads)
22	●	–	–	–	–	–	–	–	–	–	6	–	6	0214X0873 G004	Resistor Complete (With Resistor, Corer, Wire-wound Tube, Hardware and Upper and Lower Leads)
28	1	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P009	Top Front Crank Link Bushing (Textolite)
28	2	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P067	Front Link Bushing (Textolite)
28	3	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Horizontal Operating Rod Front Coupling Bushing (Textolite)
28	4	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P009	Guide Crank Bushing (Textolite)
28	5	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P015	Center Front Crank Link Bushing (Textolite)
28	6	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P009	Bottom Front Crank Link Bushing (Textolite)
28	7	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Front Connecting Link Bushing (Textolite)
28	8	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Horizontal Operating Rod Coupling Bushing (Textolite)
28	9	6	6	6	6	6	6	6	6	6	6	6	6	006370566 P059	Beam Bushing (Textolite)
28	10	6	6	6	6	6	6	6	6	6	6	6	6	006370566 P061	Lever Bushing (Top) (Textolite)
28	11	6	6	6	6	6	6	6	6	6	6	6	6	006370566 P061	Lever Bushing (Center) (Textolite)
28	12	6	6	6	6	6	6	6	6	6	6	6	6	182V0294 P001	Lever Roller (Steel)
28	13	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Center Connecting Link Bushing (Textolite)
28	14	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Rear Connecting Link Bushing (Textolite)
28	15	2	2	2	2	2	2	2	2	2	2	2	2	006370567 P063	Spring Coupling Bushing (Textolite)
30	13	6	6	6	6	6	6	6	6	–	–	–	–	0138A7102 P004	Gasket - Bushing to Breaker Dome
30	13	–	–	–	–	–	–	–	–	6	6	6	6	0138A7102 P005	Gasket - Bushing to Breaker Dome
30	14	6	6	6	6	6	6	6	6	–	–	–	–	0399A0231P001	Gasket Retainer
30	14	–	–	–	–	–	–	–	–	6	6	6	6	0399A0231 P002	Gasket Retainer

● Not Numbered
* Recommended Renewal Part

GENERAL ELECTRIC COMPANY
SWITCHGEAR BUSINESS DEPARTMENT
PHILADELPHIA, PA 19142

GENERAL ELECTRIC

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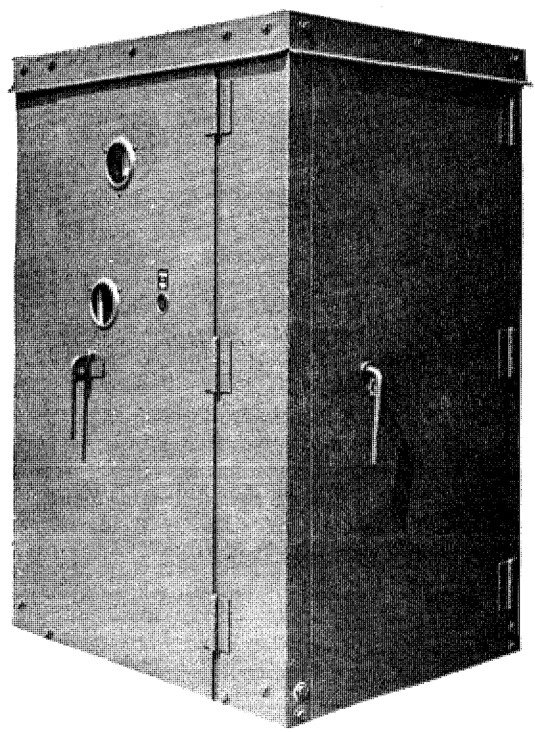
INSTRUCTIONS

GEK 7153G

SUPERSEDES GEK-7153F

SPRING-CHARGED OPERATING MECHANISM

TYPE ML-14-0 FOR OIL-BLAST CIRCUIT BREAKERS



CONTENTS

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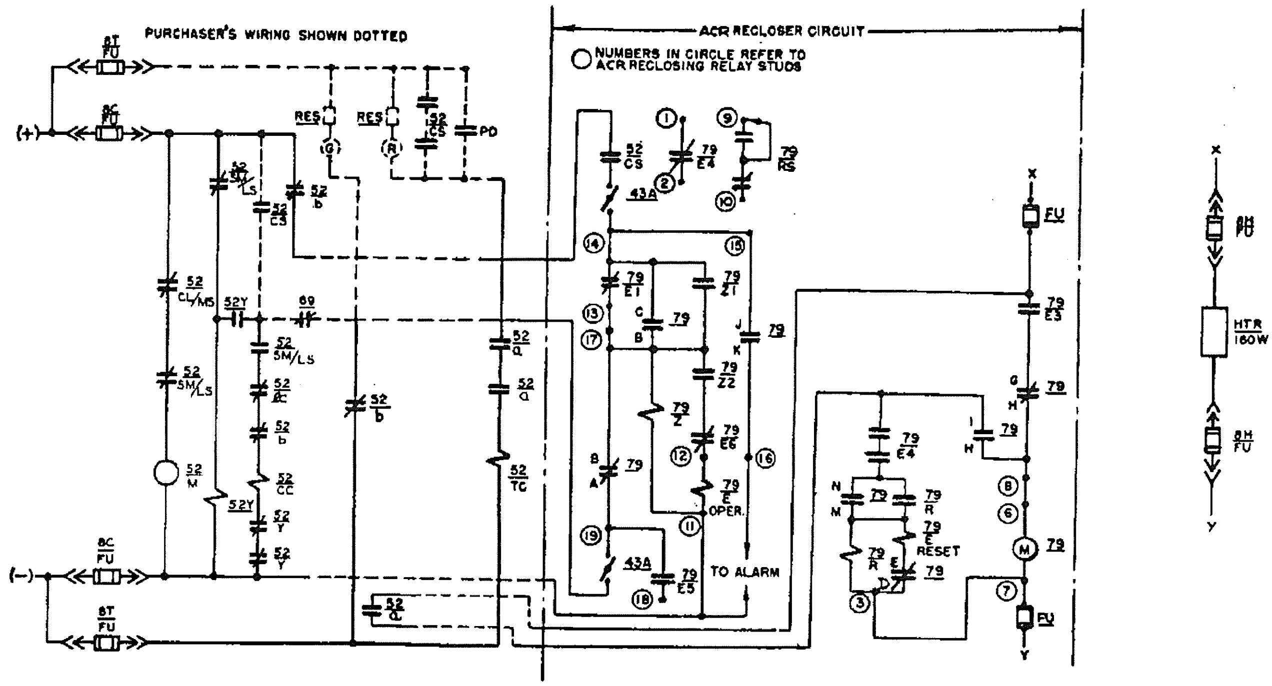


Cover (8037808)

Fig. 1 (0124C3224 Rev. 1)

8C Close Control Power-Fused Disconnect Switch
8H Heater Power-Fused Disconnect Switch
8T Trip Control Power-Fused Disconnect Switch
43A Recloser Cut-out Switch
52 Oil Circuit Breaker
- a Normally Open Auxiliary Switch-Open when 52 is open
- b Normally Closed Auxiliary Switch-Closed when 52 is open
- CC Closing Coil
- CS Control Switch
- CL/MS Closing Latch Monitoring Switch
- lc Trip Latch Checking Switch
- M Spring-charging Motor
- SM/LS Limit Switch for Spring-charging Motor
- TC Trip Coil
- Y Anti-pump Auxiliary Relay

69 Permissive Control Switch Opened by manual tripping device on the mechanism-Hand Reset to Close
79 ACR Recloser
- E Interlocking Relay and Contacts for 79
- M Recloser Timing Motor
- R Clutch Release Unit and Contacts for 79
- Z Anti-pump Unit and Contacts for 79

FU Fuse
G Green Indicating Lamp
HTR Heater
RES Resistor
R Red Indicating Lamp
PD Protective Device

Fig. 1 Typical Connection Diagram
Breaker Position – Open
Closing Springs – Discharged

(For actual wiring see connection diagram furnished with equipment)

SPRING-CHARGED OPERATING MECHANISM
TYPE ML-14-0

INTRODUCTION

The Type ML-14-0 operator is a spring operated mechanism for outdoor oil-blast circuit breakers. It is designed for high speed operation during the circuit breaker interruption of faults and high speed reclosing. It is mechanically trip-free and non-pumping when closed on short circuits. Its high speed characteristic is the result of a simple, ingenious, rugged linkage design having low-friction bearings.

The mechanism and associated operating equipment are enclosed in a weatherproof housing designed for mounting on the front end of the breaker. D-c voltage is required for the control circuit. A-c voltage is recommended for the spring-charging motor and required for the heater circuits. Since the control circuit requires very low operating currents, the necessity for large storage batteries or rectifiers is eliminated. Batteries are recommended for the d-c source. The mechanism and its accessories will operate at the standard ANSI voltage ratings. The breaker nameplate is mounted on the inside of the front door of the mechanism housing.

PROPER INSTALLATION AND MAINTENANCE ARE NECESSARY FOR CONTINUED SATISFACTORY OPERATION. The following instructions will provide information for placing the mechanism and breaker in service and for the necessary maintenance. It should be kept in mind that the illustrations in the 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 that are furnished separately with the equipment. For additional instructions on the circuit breaker, refer to the breaker instruction book.

RECEIVING, HANDLING AND STORAGE

Each mechanism is carefully inspected and packed by workmen experienced in the proper handling and packing of electrical equipment. Immediately upon receipt of a mechanism, an examination should be made for any damage sustained during shipment. 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 promptly notified.

The crating or boxing must be removed carefully using a nail puller. 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 that may have loosened in transit.

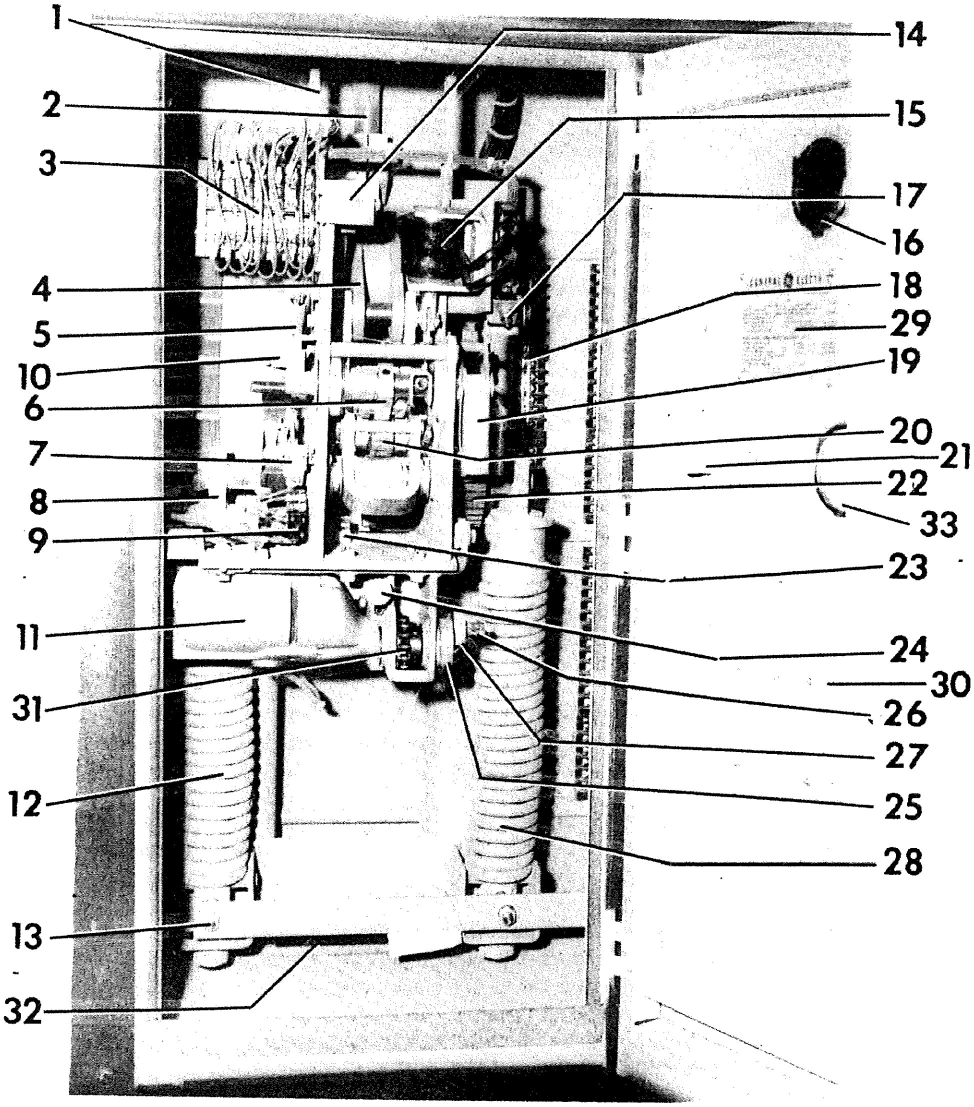
If the mechanism cannot be installed in the proper location immediately, and it is necessary to store the equipment, it should be kept in a clean, dry place protected from mechanical injury. Machined parts should be coated heavily with grease to prevent rusting. If stored for any length of time, periodic inspections should be made to see that corrosion has not taken place and to insure good mechanical condition. If possible, the space heater should be energized to prevent moisture condensation inside the mechanism housing.

Should the mechanism be stored under unfavorable atmospheric conditions, steps should be taken to dry out the mechanism before it is placed in service

DESCRIPTION

The ML-14 spring-charged operator consists of motor operated closing springs with the associated mechanism and control equipment. The unit is designed to operate large outdoor oil circuit breakers with provision for closing, opening, trip-free and reclosing operations.

The control house for this mechanism is a steel weatherproof house which contains a felt strip as a sealant around the doors. Inside this housing are located a motor for charging the closing springs, closing spring's operating mechanism, auxiliary switch and the control panel with its relaying, operating and control switches and BCT terminal boards.



1. House Support Bracket
2. Breaker Vertical Operating Rod
3. Auxiliary Switch
4. Output Crank
5. Prop Reset Spring
6. Trip Latch
7. Charge-discharge Indicator
8. Guide Block
9. Motor Limit Switches
10. Latch Checking Switch
11. Spring-charging Motor
12. Left Closing Spring
13. Closing Spring Blocking Device
14. Operation Counter
15. Trip Coil (52TC)
16. Operation Counter Window
17. Lock-out Switch (69 Device)
18. Bushing Current Transformer Terminal Boards
19. Manual Trip Lever
20. Trip Latch Roller
21. Manual Trip Push Button
22. Ratchet Wheel
23. Closing Latch Monitoring Switch Operating Lever
24. Manual Close Push Rod Button
25. Eccentric
26. Manual Charging Stud (5/8 inch hex)
27. Driving Link
28. Right Closing Spring
29. Breaker Nameplate
30. Current Transformer Nameplate
31. Driving Chain
32. Heater
33. Charge-discharge Indicator Window

Fig. 2 Front View of Mechanism

NOTE: Remove the wax paper strips which are between the door jam and the doors of the control house before energizing the heater. These strips are for paint protection during shipment and will not make a good weather seal if left in place.

Control voltages are given on the nameplate. The motor operating voltage is either a-c or d-c, but preferably a-c.

Also provided on the equipment is a manual trip device. This consists of a mechanism for manually tripping the breaker and a lock-out switch for opening the closing circuit, to prevent the breaker from closing from a remote source when it is tripped by this mechanism locally.

NOTE: This mechanism is designed for electrical closing when in use. NEVER ATTEMPT SLOW MANUAL CLOSING WITH THE BLOCKING DEVICE IN PLACE AND THE BREAKER IN SERVICE. OPERATE SLOWLY AND MANUALLY ONLY WHEN THE BREAKER HAS BEEN COMPLETELY DEENERGIZED AND ISOLATED.

INSTALLATION

During the installation of the mechanism, it is necessary to make reference to the instruction book for the oil circuit breaker that it operates.

The mechanism and housing are normally shipped fastened directly to the frame of the oil circuit breaker. The mechanism is installed and properly adjusted when received. The trip latches are fastened during shipment and this fastening should be removed after the breaker has been moved into position.

MOUNTING

If the mechanism and housing are shipped separately, or the mechanism and housing have been removed from the breaker for shipment, then it is necessary to fasten the mechanism and housing in position.

The breaker frame to which the operating mechanism is to be mounted should first be plumb. This procedure is described in the breaker instruction book. By placing a plumbed straight edge extending from top to bottom against the mechanism mounting pads on the breaker framework, determine the amount of shim washers needed to make them all flush. To this amount add an equal number of shims to each of the pads so that there is a nominal one-quarter inch thickness of shims. A single brass washer is to be placed between the steel washers and the mechanism housing and against the gasket for more effective sealing against the entrance of water. It may be necessary to add or remove steel shims to obtain the correct alignment of the vertical rod and its cover pipe.

Raise the mechanism with a crane and align the mounting stud holes in the mechanism housing to those on the breaker framework and insert the studs. Tighten all nuts securely and lock with set screws.

Install the vertical operating rod cover pipe between the front crank cover support and the top of the mechanism housing. Sometimes it is convenient to install this cover pipe prior to raising the housing into position on the breaker tank. Next install the vertical operating rod. The length of the operating rod can be adjusted by means of right- and left-hand threaded couplings on the ends to obtain the required breaker adjustment as described in the breaker instruction book.

CONNECTIONS

After the mechanism has been mounted, electrical connections can be made. Before making these, precautions should be taken to see that all leads to be connected to the mechanism are deenergized.

Run control wires in conduit insofar as it is practicable. Control wires must be run separately and remote from high tension leads and not in the same duct or parallel to high tension leads unless the distance separating the two sets of wiring is sufficient to prevent posssible communication between them as a result of short circuits.

Use control wiring of adequate size 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.

Use the proper connection diagram for each individual job for testing and making connections. The mechanism is wired completely at the factory to terminal boards mounted on the bottom of the control panel. Incoming conduits can be terminated in a removable plate in the housing floor directly under the terminal boards. This plate can be drilled to suit any conduit requirements. It is recommended that all conduits entering the mechanism housing be sealed off at their entrances to the housing.

ADJUSTMENTS

Although the mechanism has been adjusted and tested at the factory, it is advisable to check all the following points as well as those listed under FINAL INSPECTION to be sure that no change has occurred during shipment and installation. No adjustments should be altered unless this inspection indicates it is necessary.

Use manual operation for all preliminary inspection. After the mechanism is connected to the breaker, operate it slowly to see that the operation is smooth throughout the closing stroke, that no binding occurs, and that no excessive play is noticeable between parts. Electrical operation should be attempted only after it is certain that all mechanism adjustments are made correctly and that the oil circuit breaker is correctly adjusted according to its instructions.

The breaker and mechanism adjustments must be checked when the mechanism is being manually closed since the mechanism can only be operated slowly in the closing direction.

UNDER NO CIRCUMSTANCES SHOULD THE BREAKER BE TRIPPED MANUALLY OR ELECTRICALLY WITHOUT OIL IN THE TANKS UNTIL THE PROPER BREAKER INSTRUCTION BOOK HAS BEEN CHECKED TO DETERMINE WHETHER OR NOT THE BREAKER CAN BE OPERATED WITHOUT OIL IN THE TANKS.

Manual operation of the mechanism should not be attempted until the bearing surfaces of the mechanism have been checked for lubrication. Refer to the section on lubrication for the proper oils and greases.

MANUAL OPENING

The breaker can be tripped manually by operating the manual trip level (4), Fig. 3. This will give an opening operation very similar to that obtained when the breaker is tripped electrically. The breaker cannot be opened slowly, except with an optional maintenance jacking device.

MANUAL CLOSING

DISCONNECT THE POWER TO THE SPRING-CHARGING MOTOR TO PREVENT ITS OPERATION BEFORE OPERATING THE BREAKER MANUALLY AND ALSO BEFORE MANUALLY CHARGING THE CLOSING SPRINGS.

To operate the mechanism manually charge the breaker closing springs (12) and (28), Fig. 2, manually using a 5/8 inch ratchet wrench on the manual charging stud (26), Fig. 2, to turn the driving eccentric (25), Fig. 2. Turning the driving eccentric counterclockwise (pushing downward on the ratchet wrench), will advance the ratchet wheel (22) and compress the closing springs.

When the springs have reached the fully charged position the indicator (7), Fig. 2, will read "CHARGED", and the driving pawl (4), Fig. 5, will be raised from the ratchet wheel teeth. Additional turning of the eccentric will not advance the ratchet wheel. The latching and safety pawls (16), Fig. 3, work in conjunction with the driving pawl (4), Fig. 5, to prevent the ratchet wheel (73), Fig. 10, from turning backwards due to the force of the closing springs as the ratchet wrench (7), Fig. 5, is operated.

Insert the spring blocking device bar (13), Fig. 2, into both springs and manually discharge the springs against the pins by pushing the manual close button (24), Fig. 2. The springs are now blocked and slow closing of the breaker contacts can be accomplished by again turning the driving eccentric with a 5/8 ratchet wrench.

The spring blocking device is made to extend out the right door and must be removed in order to close the door. This is to prevent leaving the mechanism blocked accidentally after maintenance. Each mechanism is furnished with a blocking device and should remain in the bottom of the house since the spring centers may differ from unit to unit.

During the slow closing operation check to insure that the mechanism does not stick or bind during the entire stroke, that it latches securely in the closed position, and that it trips freely when the manual trip lever (19), Fig. 2, is operated. The breaker should not be operated electrically until it has been operated several times manually to insure freedom of action. At this time, also check the breaker adjustments as given in the breaker instruction book.

DO NOT WORK ON EITHER THE BREAKER OR MECHANISM UNLESS THE CLOSING SPRINGS AND TRIP-LATCH ARE BLOCKED. THIS PRECAUTION IS REQUIRED TO PREVENT ACCIDENTAL CLOSING OR TRIPPING. USE THE 69 LOCK-OUT SWITCH IF REMOTE CONTROL IS USED.

After the adjustments have been checked, the springs can be unblocked. Rotate the driving eccentric (25), Fig. 2, until the indicator (7), Fig. 2, reads "CHARGED" and the ratchet wheel (22), Fig. 2, no longer is advanced. The closing spring blocking device (13), Fig. 2, can now be removed. DO NOT OPERATE OR PUSH THE MANUAL CLOSE BUTTON (24), FIG. 2, WHILE THE BREAKER IS IN THE CLOSED POSITION. Damage to the linkage, ratchet wheel and pawls might occur. This damage would be caused by the energy of the springs not being absorbed by the mechanism linkage and breaker in the spring hitting a stationary linkage instead of pushing a movable linkage.

Operate the circuit breaker electrically several times. Check the control voltage as described under CONTROL POWER CHECK.

> NOTE: If the breaker secondary wiring is to be given a hi-potential test at 1500 volts a-c, remove both the major leads from the terminal connection. Failure to disconnect the motor from the circuit may cause damage to the winding insulation.

TRIP LATCH WIPE

Refer to Fig. 10 and to "U", Fig. 13. The wipe of the trip latch (50), Fig. 10, on the trip latch roller (52) should be from 3/16 inch to 1/4 inch. This can be measured by putting a film of grease on the latch (50), closing the breaker part way, and tripping. The mechanism has the proper trip latch wipe when the latch rests against the stop pin (53). No adjustment is provided and a visual inspection is usually all that is required. If this setting is not correct, look for insufficient travel of the trip shaft (24).

WHEN WORKING ON THE MECHANISM IN THE CLOSED POSITION, KEEP FINGERS CLEAR OF THE LINKAGE, AS ACCIDENTAL TRIPPING CAN CAUSE SEVERE INJURY.

Use the trip latch blocking pin tool which is inserted in the trip latch blocking pin hole (100), Fig. 9 and Fig. 12 and (24), Fig. 3, until it extends beyond the opposite frame.

TRIP LATCH CLEARANCE

Refer to Fig. 12, and to "R", Fig. 13, and "N", Fig. 14. With the breaker in

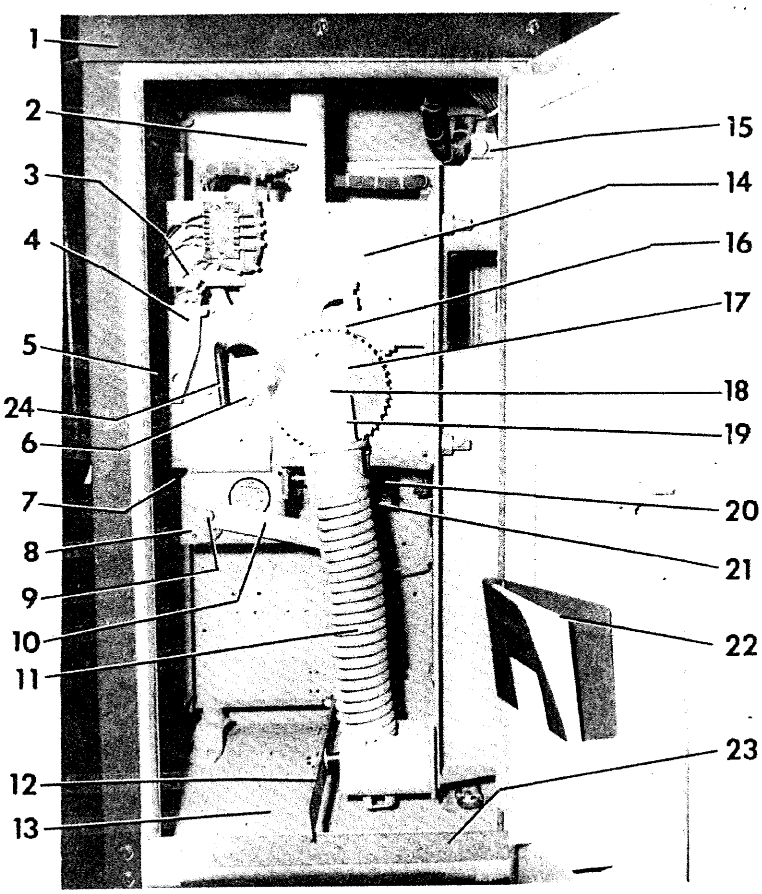


Fig. 3 (8042491)

1. Mechanism House
2. House Support Bracket
3. Lock-out Device (69 Switch)
4. Manual Trip Lever
5. Manual Trip Push Rod
6. Trip Latch Clearance Adjustment Eccentric
7. Manual Close Push Rod
8. Eccentric
9. Manual Charging Stud (5/8 inch hex)
10. Driving Link
11. Right Closing Spring
12. Closing Spring Blocking Device
13. Access Plate (Customer's Wiring)
14. Output Crank Main Shaft
15. Output Coupling
16. Latching And Safety Pawls
17. Ratchet Wheel
18. Cam Shaft
19. Guide Block
20. Closing Coil (52CC)
21. Closing Coil Plunger
22. Instruction Book
23. Weatherstrip
24. Trip Latch Blocking Pin

Fig. 3 Right Side View of Mechanism

the tripped position and the closing springs (12) and (28), Fig. 2, charged, check the clearance between the trip latch (50), Fig. 11, and the trip latch roller (52). It should measure 1/32 inch to 3/32 inch.

To change the adjustment loosen the locknut (84), Fig. 12, at the trip latch clearance adjustment eccentric (6), Fig. 3, with the breaker in the tripped position. Adjust the eccentric (25), Fig. 2, as necessary. Adjust the trip latch clearance by turning the eccentric in a clockwise direction while decreasing the clearance. This will lock the eccentric. Tighten the locknuts on the eccentric after adjusting the eccentric.

PROP CLEARANCE

Refer to (38), Fig. 10, and to "V" Fig. 13. With the breaker closed as far as possible, that is, with the springs (79), and (62), Fig. 11, blocked and the cam (39), Fig. 10, rotated so that the cam follower roller shaft (68) is at its maximum height over the prop (38), the clearance between the prop and cam shaft should be 1/16 inch to 5/32 inch. No adjustment is provided and a visual inspection is usually all that is required.

PROP WIPE

Refer to Fig. 10 and "K", Fig. 13. With the breaker closed and the linkage resting on the closing prop (38), Fig. 10, the prop wipe should be 3/16 inch to 3/8 inch from the cam follower roller shaft (68), Fig. 10, to the edge of the prop. No adjustment is provided and a visual inspection is usually all that is required.

CLOSING LATCH WIPE

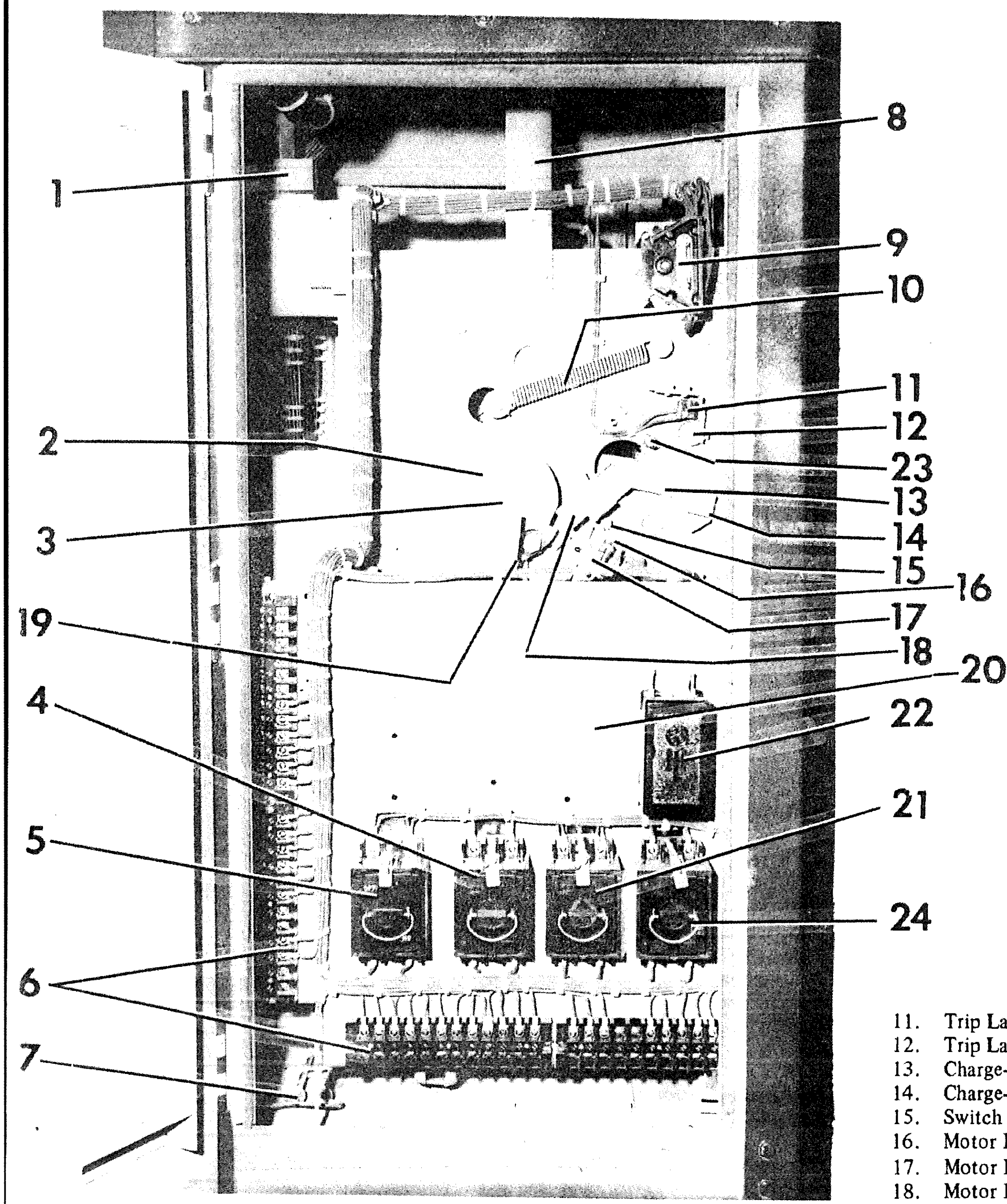
Refer to Fig. 9 and to "X" Fig. 15. The wipe between the closing latch (8) and the closing latch roller (29) should be 3/16 inch to 1/4 inch. If resetting is required, loosen, set, and retighten the adjustment screw (10), then tighten the locking nut (11).

CLOSING LATCH MONITORING SWITCH

Refer to Fig. 9 and to "T", Fig. 13. The closing latch (8) must be fully reset and the closing latch monitoring switch (16) operated before the motor (34) will start. The closing latch monitoring switch should be wiped by the operating lever (23), Fig. 2, so that the clearance between the operating lever and the switch mounting bracket (8), Fig. 6, is 0.005 to 0.032 inch. To obtain this adjustment bend the monitoring switch operating lever as necessary. Be sure the latch is fully reset before making any adjustments.

MOTOR LIMIT SWITCHES

Refer to Fig. 9 and to "Z", Fig. 15. With the closing springs blocked rotate

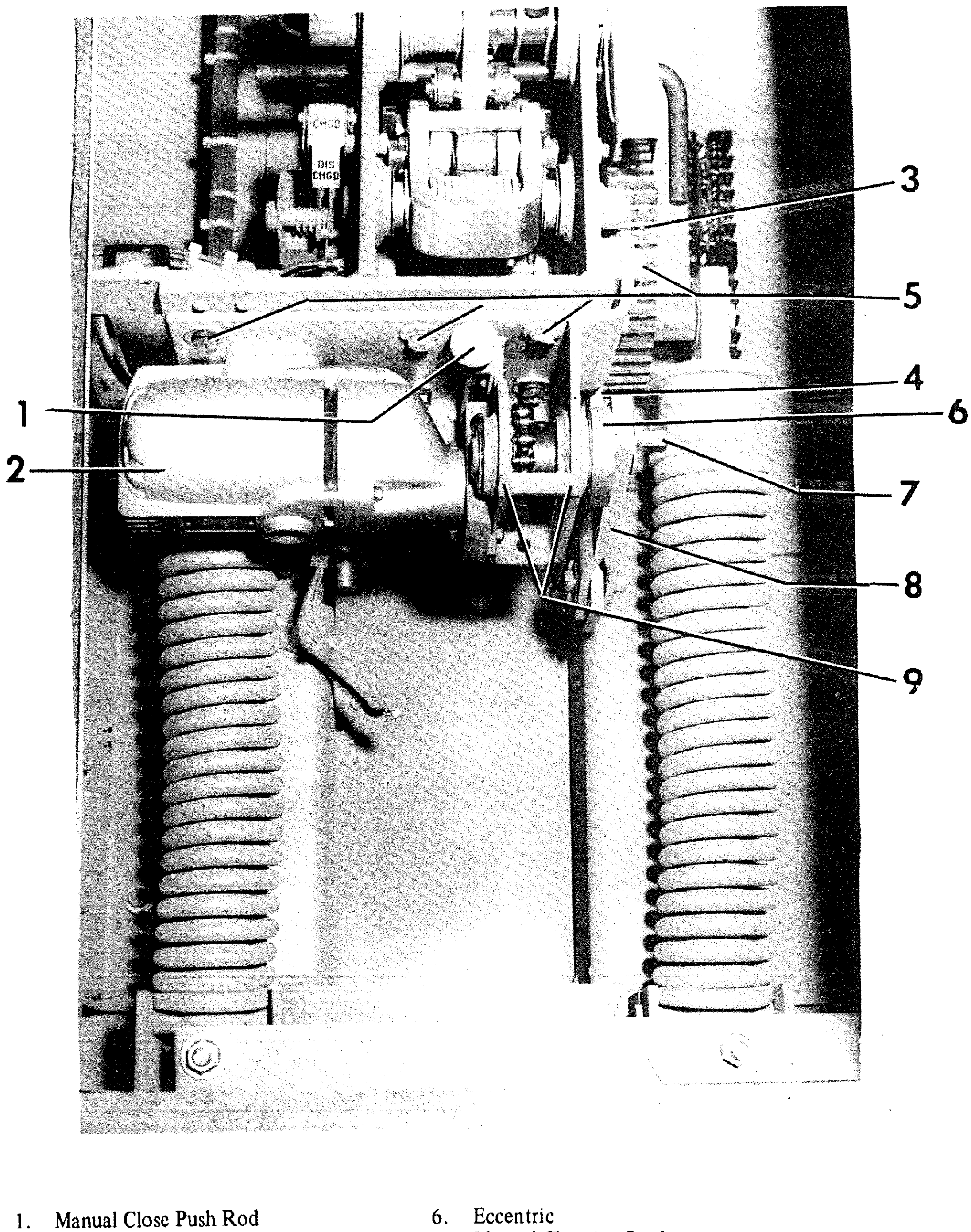


1. Output Coupling
2. Limit Switch Cam
3. Cam Shaft
4. Closing Circuit Fused Pullout
5. Trip Circuit Fused Pullout
6. Terminal Boards
7. Control House Heater
8. House Support Bracket
9. Auxiliary Switch
10. Prop Reset Spring
11. Trip Latch Checking Switch
12. Trip Latch Shaft
13. Charge-discharge Indicator Linkage
14. Charge-discharge Indicator
15. Switch Support Bolts
16. Motor Limit Switch Support
17. Motor Limit Switches
18. Motor Limit Switch Striker
19. Closing Latch
20. Control Panel
21. Control House Heater Circuit Fused Pullout
22. Cutoff and Anti-pump Relay (52Y)
23. Trip Latch Blocking Pin
24. Motor Circuit Fused Pullout (When Required)

Fig. 4 Left View of Mechanism

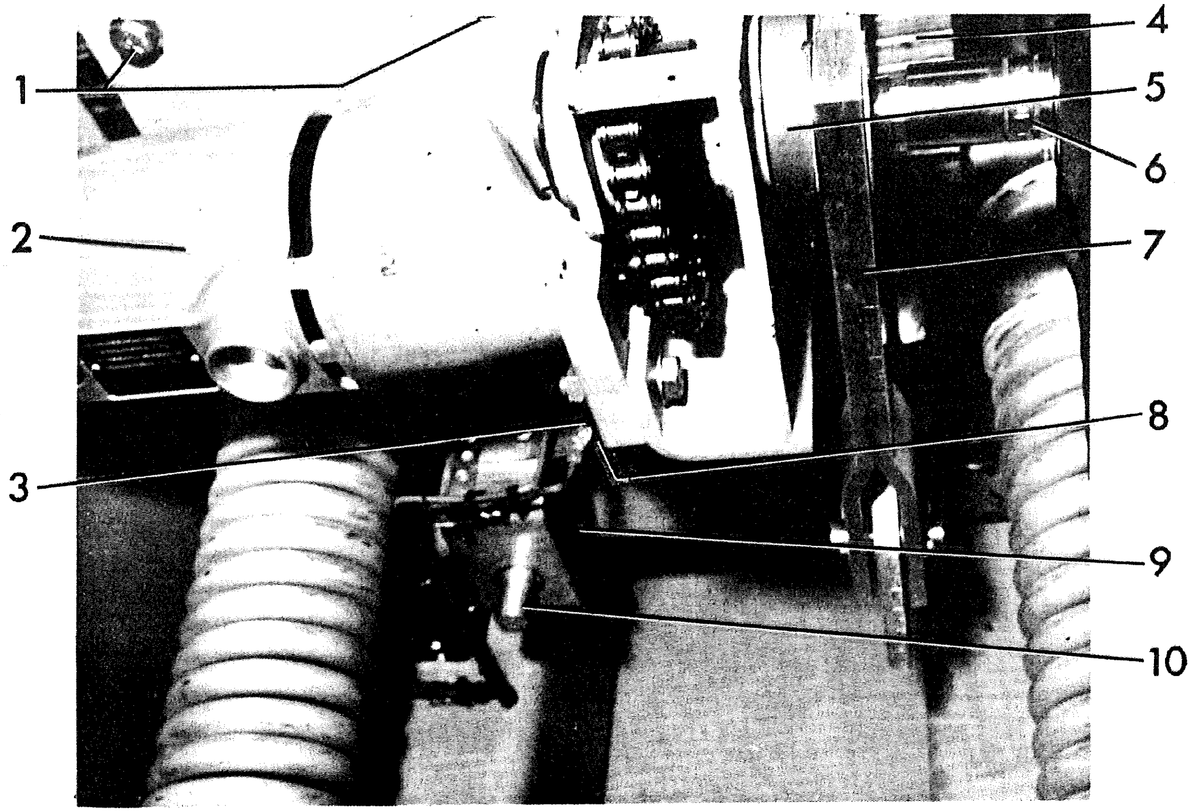
Fig. 4 (8042490)

Fig. 5 (8042488)



1. Manual Close Push Rod
2. Spring-charging Motor
3. Ratchet Wheel
4. Driving Pawl
5. Motor Mounting Bolts
6. Eccentric
7. Manual Charging Stud (5/8 Inch Hex)
8. Driving Link
9. Motor Support and Bearing Housing

Fig. 5 Driving Elements



1. Motor Support Bolts
2. Driving Motor
3. Closing Latch Monitoring Switch
4. Ratchet Wheel
5. Eccentric
6. Manual Charging Stud and Wrench
7. Driving Link
8. Monitoring Switch Mounting Bracket
9. Closing Coil (52CC)
10. Closing Coil Plunger

Fig. 6 Closing Devices

the switch cam (6) until the motor limit switch striker (26) has traveled the maximum amount (about 180 degrees rotation of the cam). Loosen the mounting bolt (28) and rotate the switch support (16), Fig. 4, until the gap between the motor limit switch striker (26), Fig. 9, and the switch support (16), Fig. 4, is 0.032 to 0.005 inch.

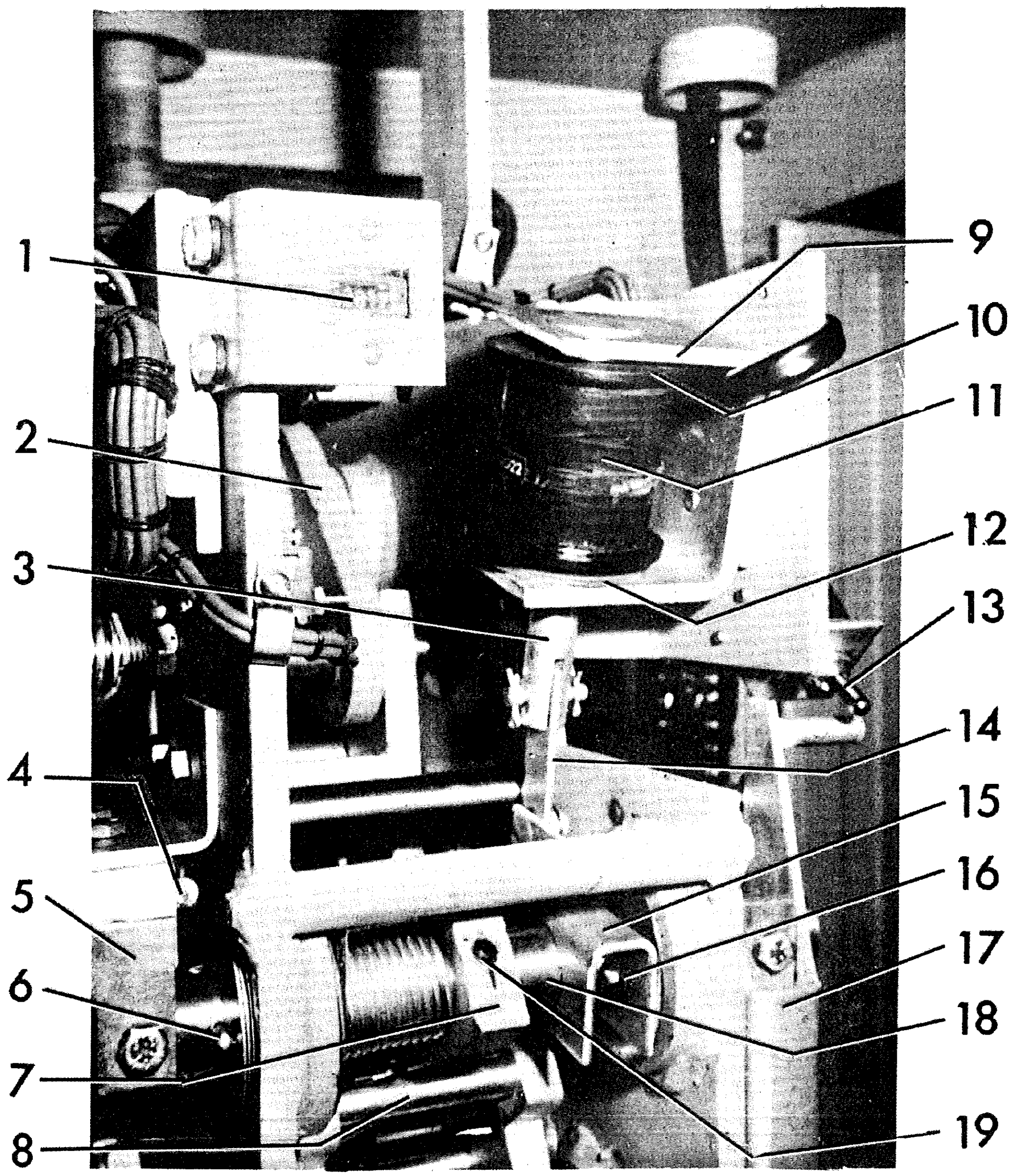
CLOSING CAM CLEARANCE

Refer to Fig. 18. The sum of "C" plus "R" should not exceed 0.170 inch. This clearance is affected by the adjustment of the breaker opening dashpots, toggle setting (FKA), internal stops (FK), and vertical operating rod length. Normally no adjustment is required; however, this clearance should be checked if the breaker settings are changed. The closing cam clearance is reduced when the breaker stroke is increased by lowering the dashpots and/or the toggle setting at its minimum (FKA) and/or internal stops at their minimums (FK) and/or shortening of the vertical operating rod.

AUXILIARY SWITCH - TYPE SB-12

Refer to Fig. 11 and to "L", Fig. 15. The auxiliary switch (19), Fig. 11, is mounted on the left side of the operating mechanism frame (2). The linkage (59) attached to the pin (40), Fig. 10, of the output crank (4) operates the auxiliary switch shaft which opens and closes the "a" and "b" contacts. The "a" contacts are open when the breaker is open and the "b" contacts are open when the breaker is closed. The "a" contacts need only to be checked to make certain they are open when the breaker is open. The "b" contacts need only to be checked to see that they are open when the breaker is closed. No adjustment is provided and a visual inspection is usually all that is required. If for some reason the auxiliary switch is removed it must be properly reinstalled. The "V" stamped on the SB-12 auxiliary switch shaft must point toward the switch terminals or 180 degrees away from the terminals to prevent overlap of the contacts. If "a" and "b" contacts overlap somewhat during the breaker stroke the auxiliary switch is assembled incorrectly and must be properly reset. Remove the switch operator from the square shaft. Rotate the square shaft until the arrow on the end of the shaft is pointing toward the upper front corner of the switch mounting plate with the breaker in the open position. Install the switch operator and make certain there is no overlap between the "a" and "b" contacts during the breaker stroke.

Fig. 7 (891583OC)



1. Operation Counter
2. Main Output Crank
3. Trip Coil Plunger
4. Trip Latch Checking Switch
5. Trip Latch Checking Switch Operating Lever
6. Trip Shaft Retaining Cotter Pin
7. Trip Latch
8. Trip Latch Stop Pin
9. Trip Coil Support Bracket
10. Trip Coil Positioning Shims
11. Trip Coil
12. Trip Coil Positioning Shims
13. Lock-out Device (69 Switch)
14. Trip Coil Link
15. Trip Crank
16. Trip Crank Adjustment Bolt
17. Manual Trip Lever
18. Trip Latch Shaft
19. Trip Latch Set Screw

Fig. 7 Tripping Devices

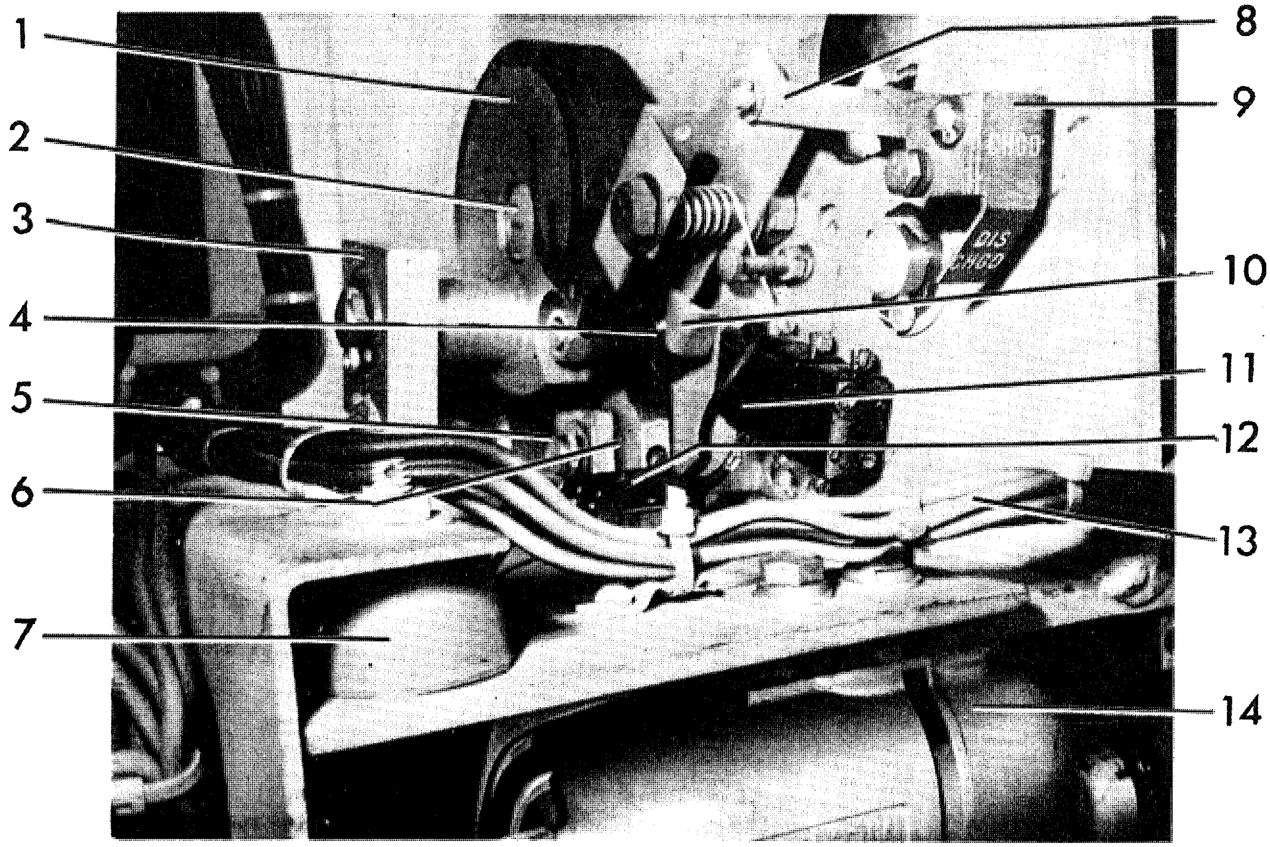


Fig. 8A (8915679B)

1. Limit Switch Cam
2. Cam Shaft
3. Guide Block
4. Closing Latch Roller
5. Closing Latch Shaft
6. Closing Latch
7. Control Panel Shock Mount
8. Charge-discharge Indicator Linkage
9. Charge-discharge Indicator
10. Motor Limit Switch Striker
11. Charging Motor Limit Switches
12. Motor Lead Terminal Board
13. Control Wiring
14. Spring-charging Motor

Fig. 8A Closing Latch and Motor Control

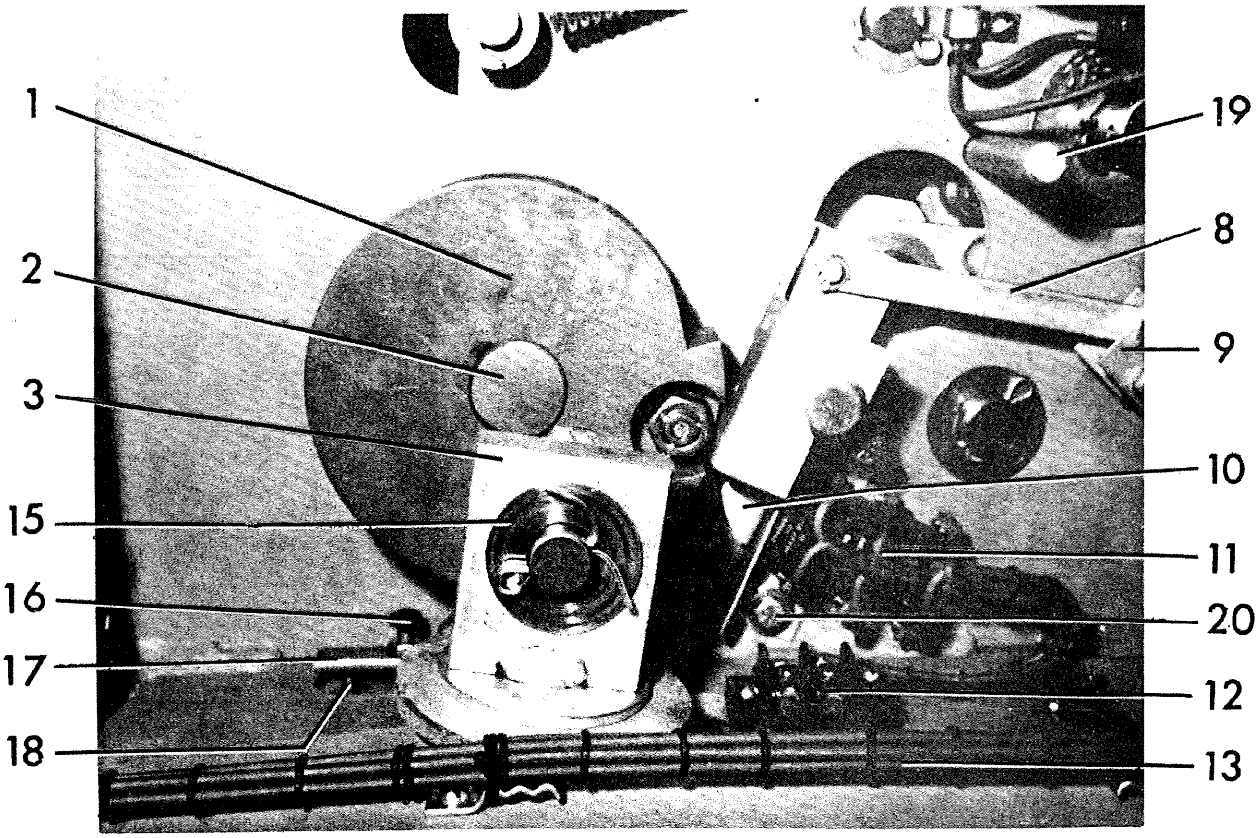
DRIVING AND LATCHING PAWL ADJUSTMENT

Refer to Fig. 12 and to "P" and "Q", Fig. 14. The driving pawl (74), Fig. 12, must advance the ratchet wheel (73) sufficiently on each stroke to allow the latching pawl (70) to fall into the ratchet teeth of the ratchet wheel. This should be checked with a major portion of the closing spring load against the driving members. With the mechanism unblocked, manually charge the closing springs with the manual charging wrench (7), Fig. 5, until they are slightly more than half charged. Slowly rotate the charging wrench until the driving pawl (74), Fig. 12, has traveled through its return stroke and check the maximum driving clearance between the driving pawl and the ratchet tooth "Q", Fig. 14. Rotate the charging wrench until the driving pawl has advanced the ratchet tooth to its maximum travel. Now check the latching clearance between the ratchet tooth and the latching pawl (70), "P", Fig. 14. The clearance should be approximately equal for both the driving and latching pawls and not less than 0.040 inch in either case when a feeler gage is inserted to approximately one-half the depth of the ratchet tooth and between the driven portion of the ratchet tooth and the flat above the tip of the pawl. 0.040 inch is a good place to start to adjust the motor mount for proper ratcheting. This corresponds to a 0.015 inch clearance between the tip of the ratchet tooth and the tip of the pawl as the pawl falls past the ratchet tooth.

If for some reason the 0.040 inch clearance cannot be maintained a somewhat less amount is satisfactory provided the mechanism will slowly close the breaker when operated manually or close the breaker normally when operated electrically and that the springs can be charged manually or electrically.

If adjustment is required for either pawl the closing springs must first be fully charged and blocked. Remove roll

Fig. 8B (8915803B)



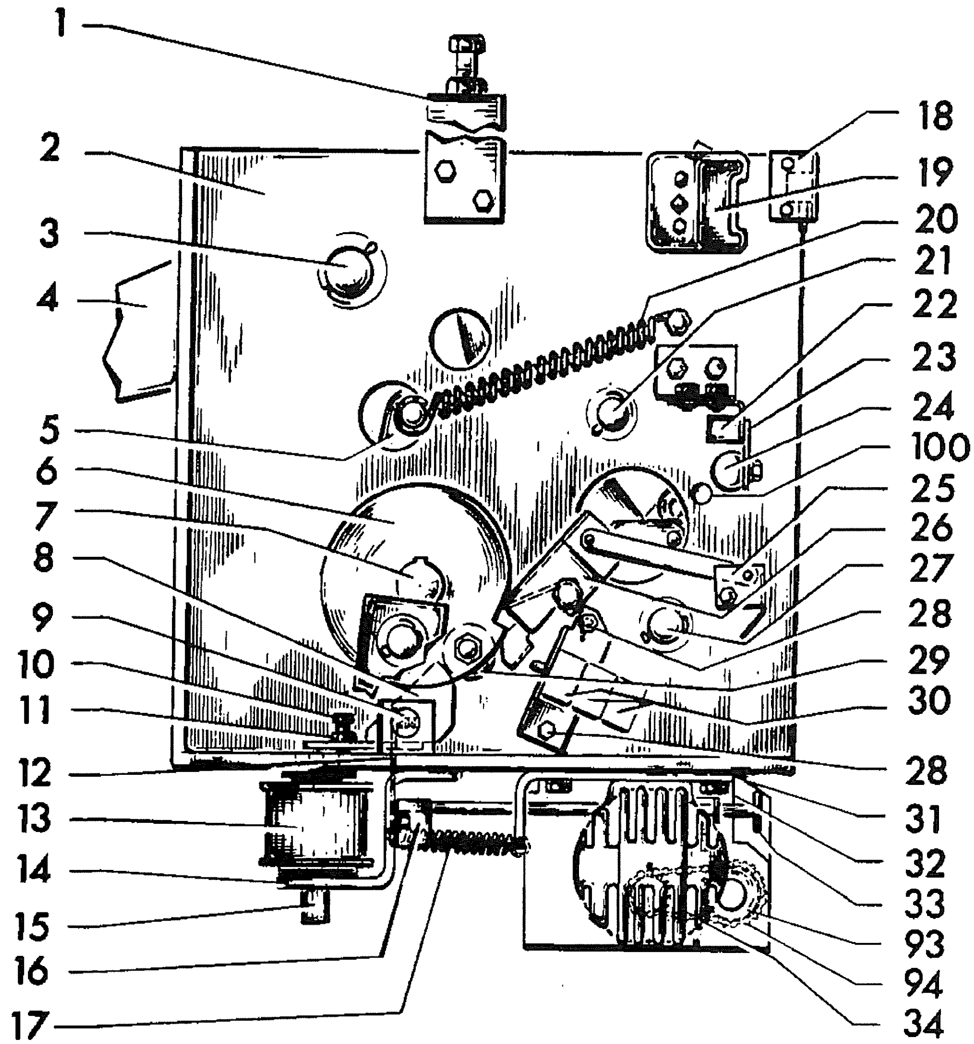
1. Limit Switch Cam
2. Cam Shaft
3. Guide Block
4. Closing Latch Roller
5. Closing Latch Shaft
6. Closing Latch
7. Control Panel Shock Mount
8. Charge-discharge Indicator Linkage
9. Charge-discharge Indicator
10. Charging Motor Limit Switch Striker
11. Charging Motor Limit Switches
12. Motor Lead Terminal Board
13. Control Wiring
14. Spring-charging Motor
15. Guide Block Roller Bearing
16. Closing Latch Wipe Adjusting Screw
17. Closing Latch
18. Closing Coil Plunger
19. Trip Latch Safety Rod
20. Motor Limit Switch Adjusting Screw

Fig. 8B Mechanism Open - Trip Latch in Place (Springs Discharged)

pin from right side of motor mounting plate by driving the pin through the side plate. Loosen the motor mounting bolts (5), Fig. 5, and move the entire motor assembly to the rear toward the breaker tanks if the clearance is under the minimum at the latching and safety pawls, and, to the front away from the breaker tanks if the clearance is under the minimum at the driving pawl. Move the motor assembly approximately twice the dimensional increase required at the pawl. Move the entire motor and motor-mount assembly in 1/64 inch increments as a small movement here results in a large movement at the pawls. Be certain the motor assembly is moved straight forward or rearward and tighten the one bolt on the right side of the mounting frame first to assure proper alignment. After tightening the remaining bolts the springs should be released and the clearance again checked as described above. Redrill and pin in the same area to prevent movement.

LATCHING PAWL TO RATCHET WHEEL CLEARANCE

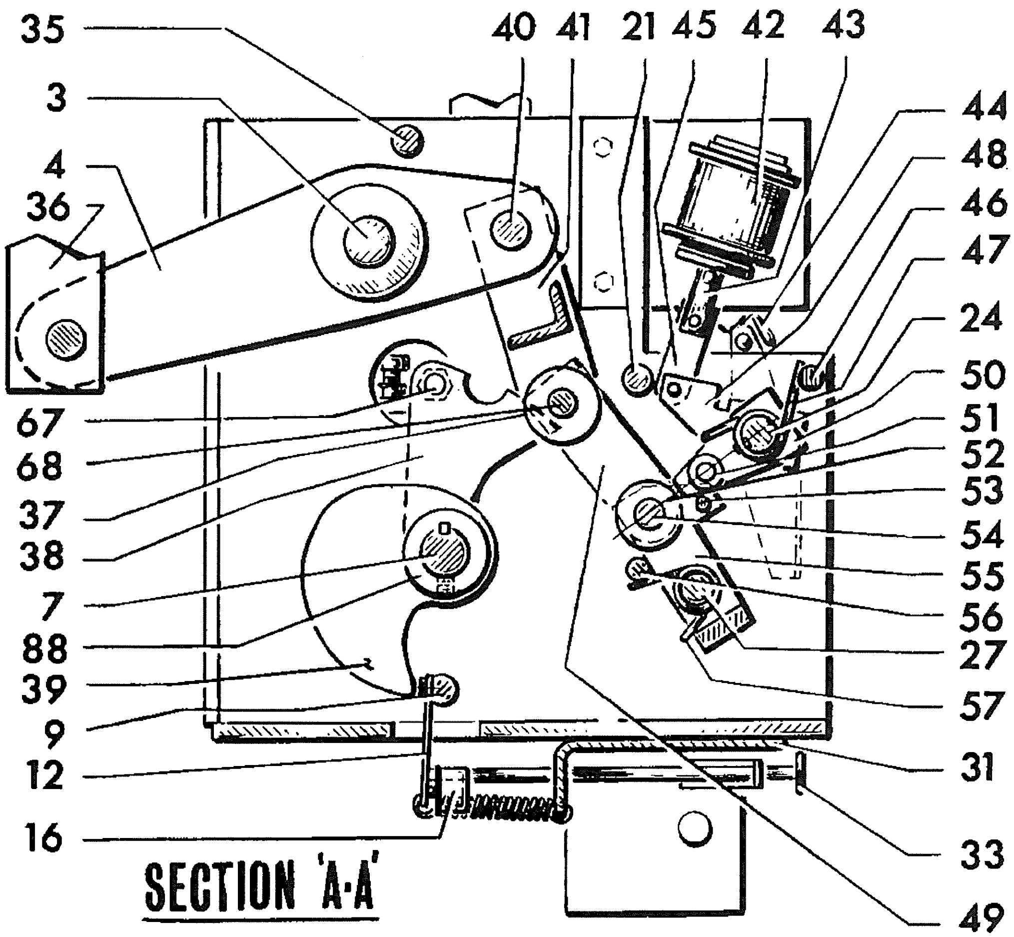
Refer to Fig. 12 and to "H", Fig. 14. The latching pawl (70), Fig. 12 (which is the outboard pawl at this location) must have a 0.015 to 0.030 inch clearance above the teeth of the ratchet wheel (73) when the closing spring (62) and (79), Fig. 11, are completely charged, "H", Fig. 14. This is checked with the closing springs completely closed and gagged by measuring the distance between the outboard latching pawl and the ratchet tooth with the pawl raised as high as possible. This is adjusted by loosening the locknut (86), Fig. 12, and adjusting the latching and safety pawls' adjustment screw (69), Fig. 12, as necessary. The safety pawl (inboard of the latching pawl) will then have up to a 0.060 inch clearance more than the latching pawl.



1. Mechanism House Support Bracket
2. Mechanism Frame
3. Output Crank Main Shaft
4. Output Crank
5. Prop
6. Limit Switch Cam
7. Cam Shaft
8. Closing Latch
9. Closing Latch Shaft
10. Closing Latch Wipe Adjusting Screw
11. Closing Latch Wipe Adjusting Screw Locknut
12. Closing Latch Monitoring Switch Operating Lever
13. Closing Coil
14. Closing Coil Support Bracket
15. Closing Coil Plunger
16. Closing Latch Monitoring Switch
17. Closing Latch Spring
18. Operation Counter
19. Auxiliary Switch
20. Prop Reset Spring
21. Stop Pin
22. Trip Latch Checking Switch
23. Trip Latch Checking Switch Operating Lever
24. Trip Latch Shaft
25. Charged-discharged Indicator
26. Motor Limit Switch Striker
27. Link Shaft
28. Motor Limit Switch Support Bolts
29. Closing Latch Roller
30. Motor Limit Switches
31. Motor Support Bracket
32. Motor Support Bracket Bolts
33. Manual Close Push Rod Button
34. Spring-charging Motor
35. Mechanism Frame Tie Rod
36. Vertical Operating Rod Lower Coupling
37. Cam Follower Roller
38. Closing Prop
39. Cam
40. Linkage to Output Crankshaft
41. Upper Link
42. Trip Coil
43. Trip Coil Plunger
44. Lock-out Switch (69 device)
45. Trip Coil Linkage

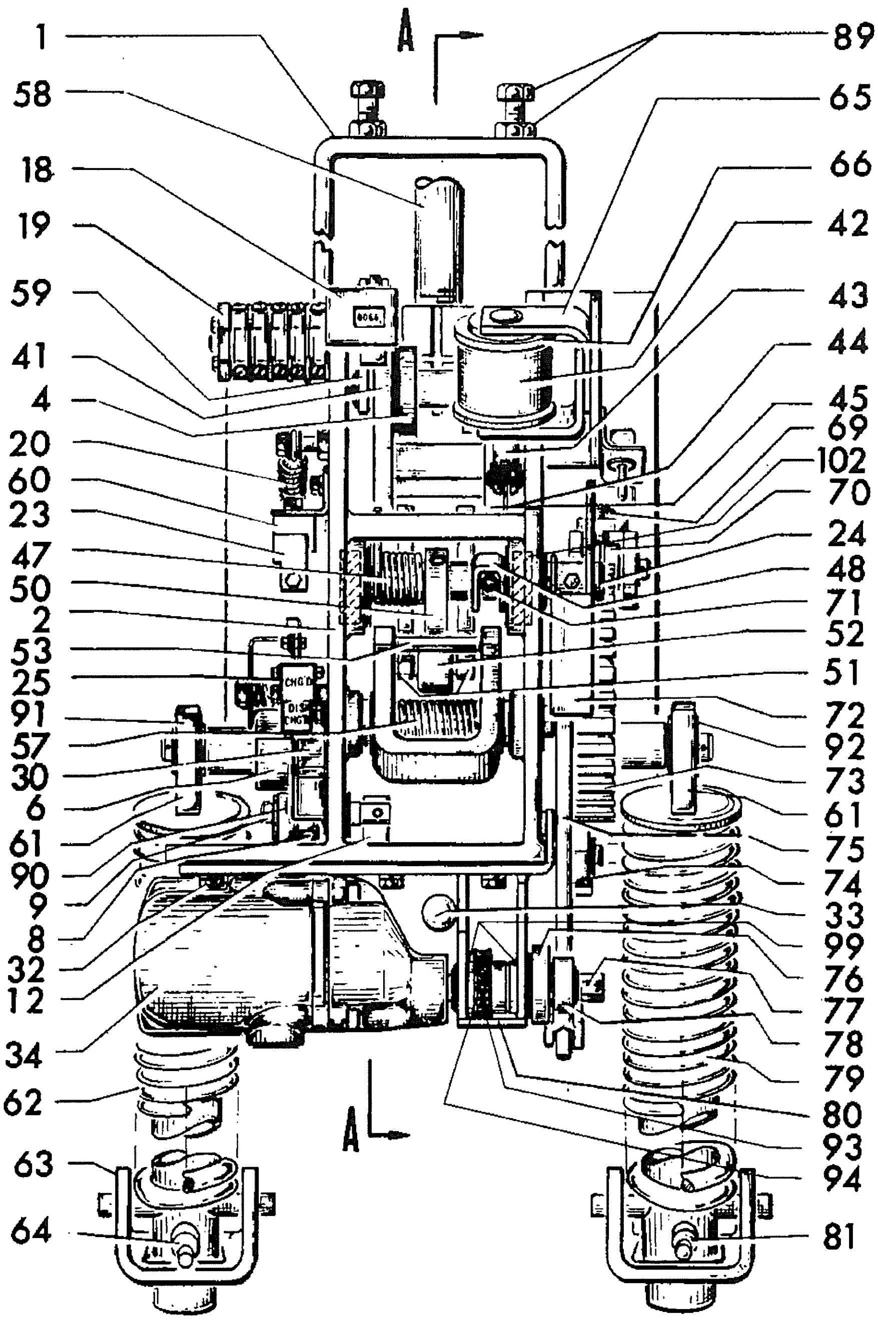
Fig. 9. Left Side View of the Mechanism Linkage in the Latch Closed Position (Spring-charged)

Fig. 9 (0832D0149 Sheet 2, View Rev. 1)



46. Mechanism Frame Tie Rod
47. Trip Latch Spring
48. Trip Crank
49. Lower Link
50. Trip Latch
51. Trip Latch Guide Roller
52. Trip Latch Roller
53. Trip Latch Stop Pin
54. Trip Latch Roller Shaft
55. Trip Latch Assembly Support Link
56. Trip Latch Clearance Adjustment Eccentric Shaft
57. Trip Latch Assembly Support Link Spring
58. Breaker Vertical Operating Rod
59. Auxiliary Switch Operating Linkage
60. Trip Latch Checking Switch Support
61. Guide Block
62. Left Closing Spring
63. Closing Spring Support
64. Left Closing Spring Blocking Device
65. Trip Coil Support
66. Trip Coil Shims
67. Prop Spacer and Reset Spring Pin
68. Cam Follower Roller Shaft
69. Latching and Safety Pawls Adjustment Screw
70. Latching Pawl
71. Trip Coil Linkage Adjustment Allen Head Bolt
72. Manual Trip Lever
73. Ratchet Wheel
74. Driving Pawl
75. Driving Crank
76. Driving Eccentric
77. Manual Charging Stud
78. Driving Link
79. Right Closing Spring
80. Motor Support Bracket
81. Right Closing Spring Blocking Device
82. Manual Trip Adjusting Bolt
83. Manual Trip Locking Nut
84. Trip Latch Clearance Adjustment Locking Nut
85. Vertical Operating Rod Locking Bolt
86. Latching and Safety Pawls Adjustment Locknut
87. Driving Pawl Return Spring
88. Cam Shaft Bearing
89. Mechanism House Adjusting Bolt and Locknut
90. Closing Latch Bearing
91. Left Guide Block Bearing
92. Right Guide Block Bearing
93. Sprocket
94. Driving Chain
95. Driving Eccentric Bearing
96. Driving Link Bushing
97. Driving Pawl Bushing
98. Driving Crank Bushing
99. Sprocket Shaft Bushing
100. Trip Latch Blocking Pin Hole
101. Locking Nut
102. Trip Latch Roller Shaft Bearing

Fig. 10 Left Side Sectional View of the Mechanism Linkage in the Latch Closed Position

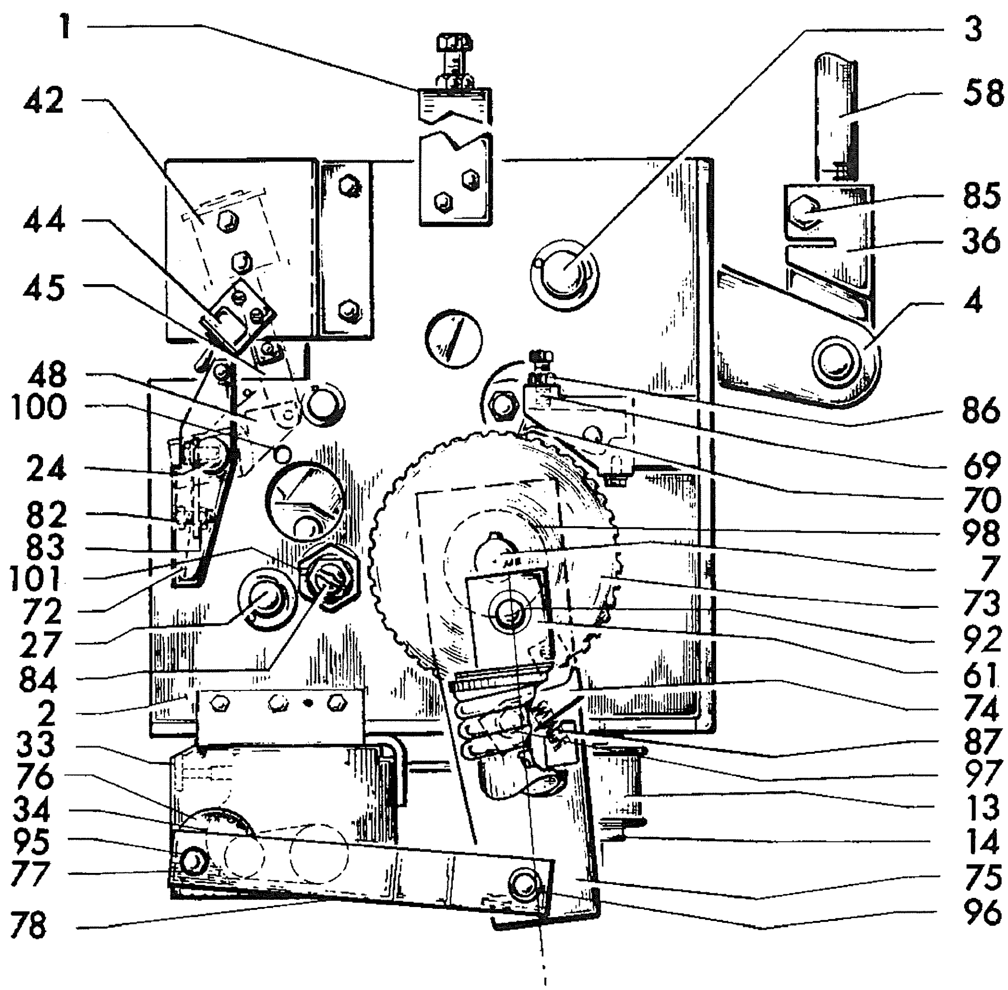


1. Mechanism House Support Bracket
2. Mechanism Frame
3. Output Crank Main Shaft
4. Output Crank
5. Prop
6. Limit Switch Cam
7. Cam Shaft
8. Closing Latch
9. Closing Latch Shaft
10. Closing Latch Wipe Adjusting Screw
11. Closing Latch Wipe Adjusting Screw Locknut
12. Closing Latch Monitoring Switch Operating Lever
13. Closing Coil
14. Closing Coil Support Bracket
15. Closing Coil Plunger
16. Closing Latch Monitoring Switch
17. Closing Latch Spring
18. Operation Counter
19. Auxiliary Switch
20. Prop Reset Spring
21. Stop Pin
22. Trip Latch Checking Switch
23. Trip Latch Checking Switch Operating Lever
24. Trip Latch Shaft
25. Charged-discharged Indicator
26. Motor Limit Switch Striker
27. Link Shaft
28. Motor Limit Switch Support Bolts
29. Closing Latch Roller
30. Motor Limit Switches
31. Motor Support Bracket
32. Motor Support Bracket Bolts
33. Manual Close Push Rod Button
34. Spring-charging Motor
35. Mechanism Frame Tie Rod
36. Vertical Operating Rod Lower Coupling
37. Cam Follower Roller
38. Closing Prop
39. Cam
40. Linkage to Output Crankshaft
41. Upper Link
42. Trip Coil
43. Trip Coil Plunger
44. Lock-out Switch (69 device)
45. Trip Coil Linkage
46. Mechanism Frame Tie Rod
47. Trip Latch Spring
48. Trip Crank
49. Lower Link
50. Trip Latch
51. Trip Latch Guide Roller
52. Trip Latch Roller

Fig. 11 (0832D[illegible]9 Sheet 1, View I Rev. 5)

Fig. 11. Front View of the Mechanism in the Latch Closed Position

Fig. 12 (0832D0149 Sheet 1, View II Rev. 5)



53. Trip Latch Stop Pin
54. Trip Latch Roller Shaft
55. Trip Latch Assembly Support Link
56. Trip Latch Clearance Adjustment Eccentric Shaft
57. Trip Latch Assembly Support Link Spring
58. Breaker Vertical Operating Rod
59. Auxiliary Switch Operating Linkage
60. Trip Latch Checking Switch Support
61. Guide Block
62. Left Closing Spring
63. Closing Spring Support
64. Left Closing Spring Blocking Device
65. Trip Coil Support
66. Trip Coil Shims
67. Prop Spacer and Reset Spring Pin
68. Cam Follower Roller Shaft
69. Latching and Safety Pawls Adjustment Screw
70. Latching Pawl
71. Trip Coil Linkage Adjustment Allen Head Bolt
72. Manual Trip Lever
73. Ratchet Wheel
74. Driving Pawl
75. Driving Crank
76. Driving Eccentric
77. Manual Charging Stud
78. Driving Link
79. Right Closing Spring
80. Motor Support Bracket
81. Right Closing Spring Blocking Device
82. Manual Trip Adjusting Bolt
83. Manual Trip Locking Nut
84. Trip Latch Clearance Adjustment Locking Nut
85. Vertical Operating Rod Locking Bolt
86. Latching and Safety Pawls Adjustment Locknut
87. Driving Pawl Return Spring
88. Cam Shaft Bearing
89. Mechanism House Adjusting Bolt and Locknut
90. Closing Latch Bearing
91. Left Guide Block Bearing
92. Right Guide Block Bearing
93. Sprocket
94. Driving Chain
95. Driving Eccentric Bearing
96. Driving Link Bushing
97. Driving Pawl Bushing
98. Driving Crank Bushing
99. Sprocket Shaft Bushing
100. Trip Latch Blocking Pin Hole
101. Locking Nut
102. Trip Latch Roller Shaft Bearing

Fig. 12 Right Side View of the Mechanism in the Latch Closed Position

This can also be checked by measuring the distance between the bottom of the latching and safety adjustment screw and the top surface of the latching pawl when the closing springs are completely charged.

TRIP LATCH CHECKING SWITCH

Refer to Fig. 10 and to "Y" and "W", Fig. 15. Rotate the trip latch (50), Fig. 10, clockwise (looking at the left side of the mechanism) by pressing the manual trip lever (17), Fig. 7, to open the latch checking switch operating lever (23), Fig. 9. Allow the trip latch to reset slowly and determine the point at which the contacts of the trip latch checking switch (22) make by using a circuit continuity tester, such as a light indicator or bell set. The contacts of the trip latch checking switch should just make when there is a 1/16 inch gap between the trip latch (50), Fig. 10, and the stop pin (53) located on the trip latch assembly support link (55). There should be a minimum of 1/64 inch between the operating lever (5), Fig. 7, and the trip latch checking switch (22), Fig. 9. Bend the trip latch checking switch operating lever (23), Fig. 9, as necessary to adjust.

TRIP COIL PLUNGER

Refer to Fig. 10 and "S", Fig. 13. The plunger (43) of the trip coil (42) must have a minimum of 1/8 inch free travel before the trip latch (50) starts to move to provide proper tripping at reduced voltages. This is adjusted by loosening the Allen set screw which is located in the trip latch shaft (24). This set screw bears against the Allen head bolt (71), Fig. 11, securing the bolt in place. Rotate the trip crank (48), Fig. 10, about the trip latch shaft until the correct free travel of the trip coil plunger is obtained. Adjust the Allen head bolt to contact the trip crank at this point. Install the Allen screw from the front side of the trip latch shaft from the front side of the trip latch shaft then tighten the Allen head adjusting bolt (71), Fig. 11. This free travel must be sufficient so that the breaker is able to trip at its minimum trip voltage. The values are in a chart under FINAL INSPECTION.

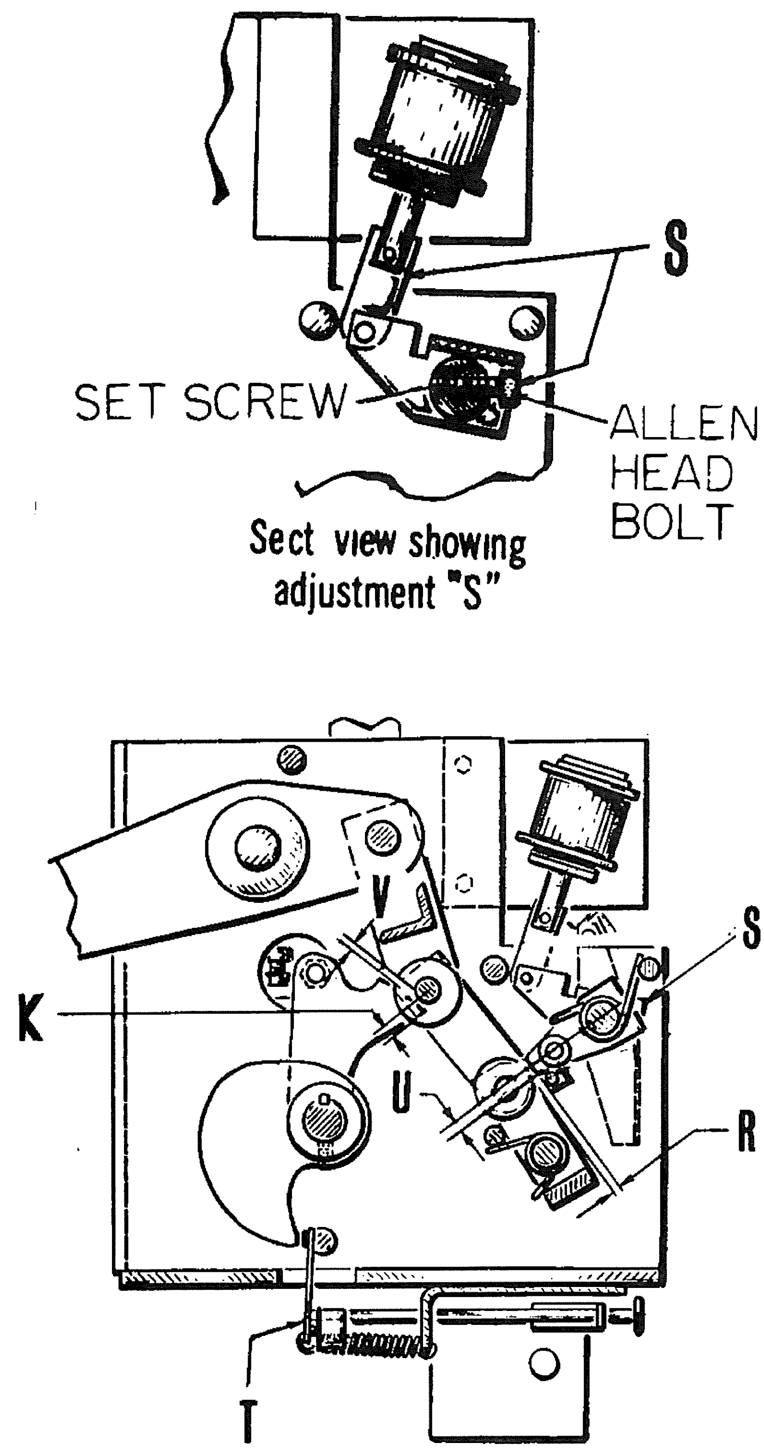


Fig. 13 Adjustment and Final Clearance Checks

Fig. 13 (0837D0149 Sheet 3, View VII and IX Rev. 4)

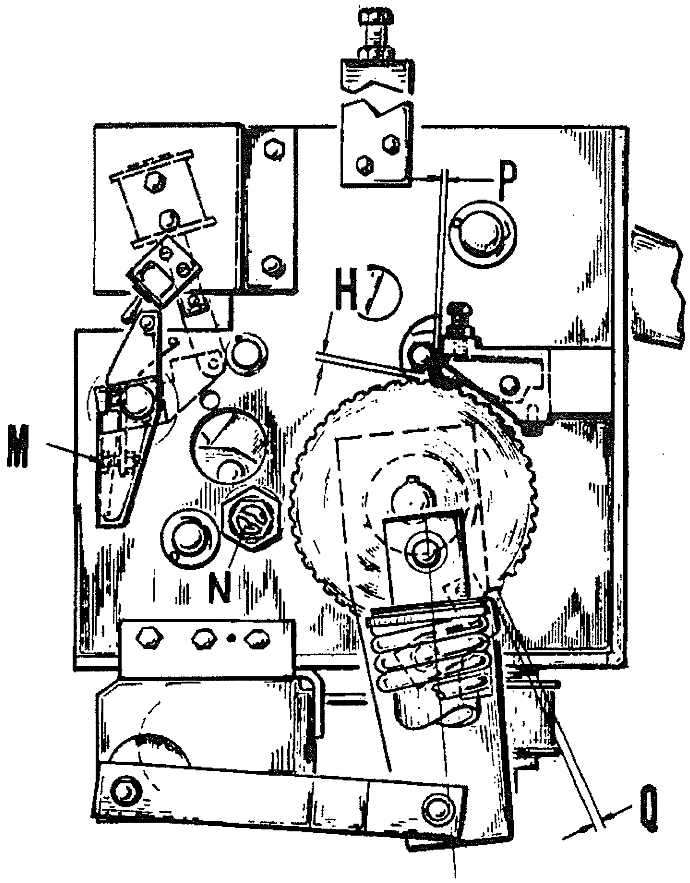


Fig. 14 Right Side View Adjustment and Final Clearance Checks

Fig. 14 (0832D0149 Sheet 3, View VIII Rev. 4)

Fig. 14A (0832D0149 Sheet 3, View VIa Rev. 4)

CLOSING COIL PLUNGER

Refer to Fig. 9 and "F", Fig. 15. The closing coil plunger (15) of the closing coil (13) must have a minimum of 1/8 inch free travel before the tang of the closing latch is contacted. If this free travel is less than 1/8 inch, remove the coil and file the plunger (18), Fig. 8B, until it has 1/8 inch free travel.

MANUAL TRIP LEVER

Refer to Fig. 2 and "M", Fig. 14. The manual trip lever (19), Fig. 2, must be adjusted so that when the push button (21), Fig. 2, is activated the mechanism trips and the 69 device (17), Fig. 2, is operated. This is adjusted by loosening the locknut (83), Fig. 12, and turning the adjusting bolt (82), Fig. 12, in the proper direction. Tighten the locknut after adjusting.

RECLOSING TIME-DELAY RELAY (79X)

This relay is an optional feature for those who desire an adjustable reclosing operation.

The reclosing cycle must be set up so that the breaker contacts open at least the minimum distance which is given in the breaker instruction book before the contacts start to reclose. The point at which they start to reclose is determined by the breaker opening speed and the setting of the time-delay relay which initiates the reclosing circuit. The operating voltage is given on the breaker nameplate and the proper opening and closing speeds are given in the breaker instruction book.

FINAL INSPECTION

After the mechanism has been installed with all mechanical and electrical

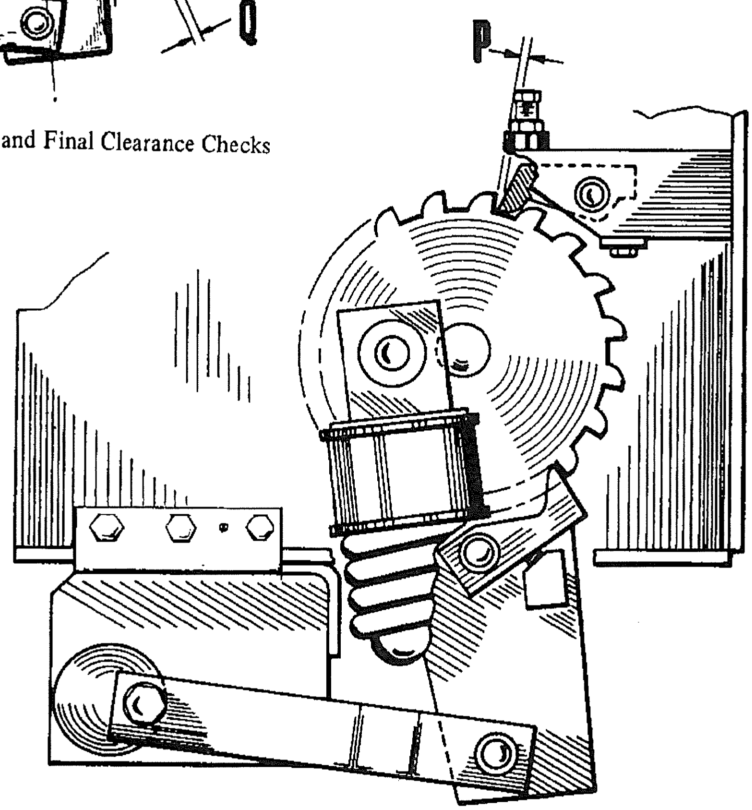


Fig. 14A Sectional View Showing Adjustment P

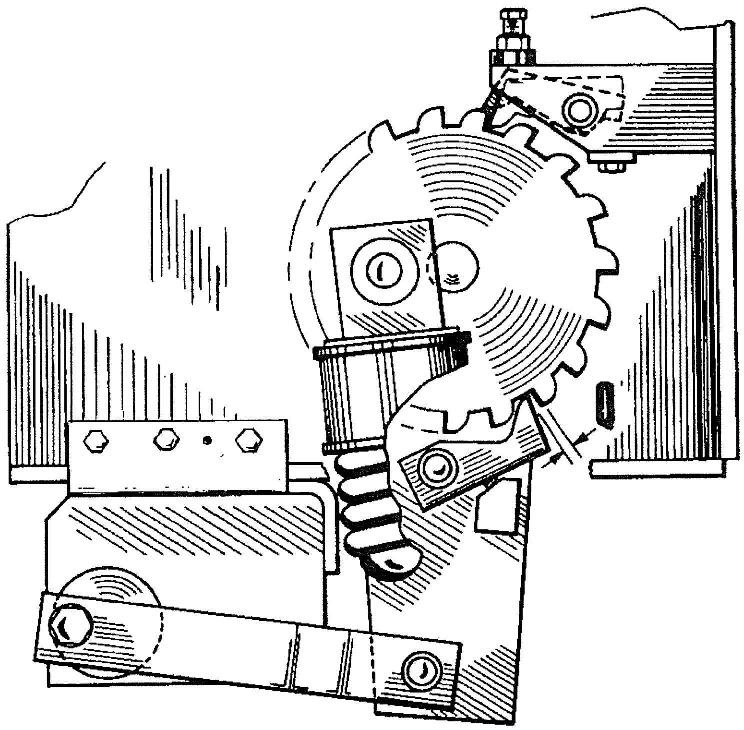


Fig. 14B Sectional View Showing Adjustment Q

connections completed, make the following inspection and test:

A. See that the mechanism is properly set up and securely fastened to the breaker framework.

B. Review the following adjustments:

C. Check that all bolts, nuts and screws are properly tightened and that all washers and cotter pins are in place with cotter pin ends effectively bent over.

D. Inspect all wiring for damage during installation work, check terminal connections for loose screws, and test for possible grounds or short circuits.

E. See that all bearing surfaces and

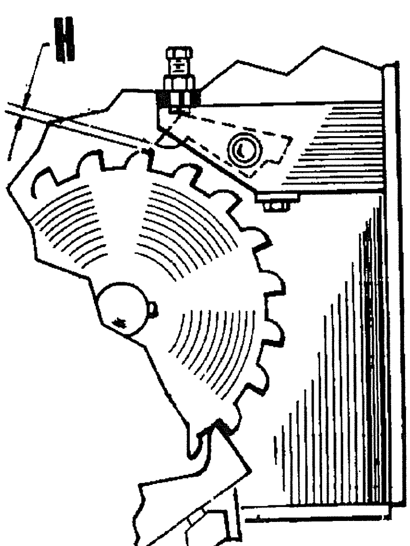


Fig. 14C Sectional View Showing Adjustment H

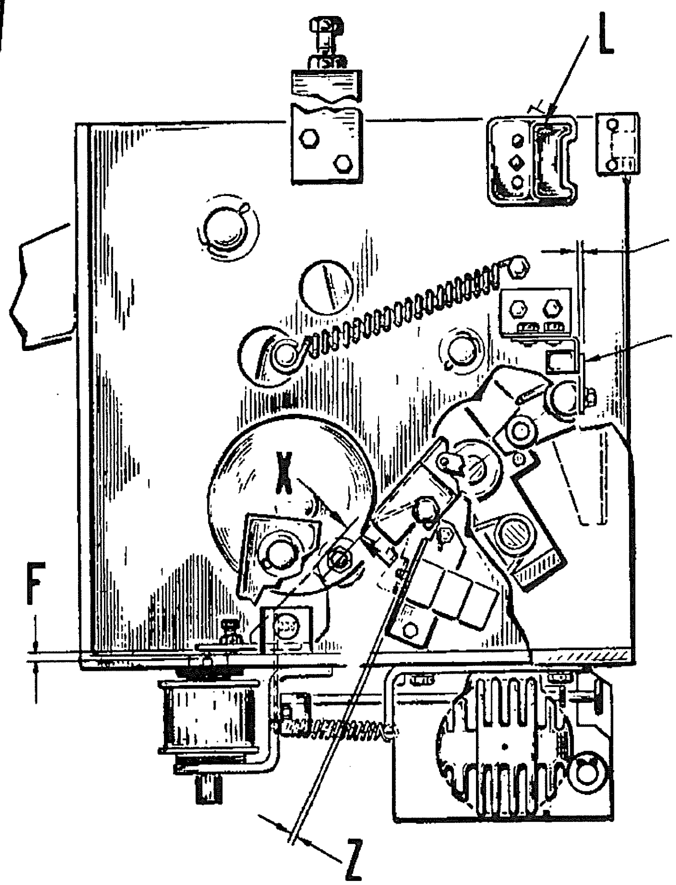


Fig. 15 Left Side View Adjustment and Final Clearance Checks

Fig. 14B (0832D0149 Sheet 3, View VIb Rev. 4)

Fig. 14C (0832D0149 Sheet 3, View VIc Rev. 4)

Fig. 15 (0832D0149 Sheet 3 View V Rev. 4)

1.	Trip latch wipe (with trip latch resting against stop pin)	(U Fig. 13)	3/16 inch to 1/4 inch
2.	Trip latch clearance	(R Fig. 13)	1/32 inch to 3/32 inch
3.	Trip latch nominal clearance	(R Fig. 13)	0.045 inch
4.	Closing prop clearance	(V Fig. 13)	1/16 inch to 5/32 inch
5.	Closing prop wipe	(K Fig. 13)	3/16 inch to 3/8 inch
6.	Closing latch wipe	(X Fig. 15)	3/16 inch to 1/4 inch
7.	Closing latch monitoring switch ("CL/MS") clearance	(T Fig. 13)	0.005 to 0.032 inch
8.	Motor limit switches ("SM/LS") maximum clearance	(Z Fig. 15)	1/32 inch
9.	Driving pawl minimum driving clearance	(Q Fig. 14)	0.040 inch
10.	Latching pawl minimum latching clearance	(P Fig. 14)	0.040 inch
11.	Latching pawl-rachet wheel clearance	(H Fig. 14)	0.015 to 0.030 inch
	The driving pawl and latching pawl clearance should be approximately equal.		
12.	Trip latch checking switch ("lc") minimum clearance	(Y Fig. 15)	1/64 inch
13.	Trip latch checking switch ("lc") contacts just make when the gap between the trip latch and the stop pin is	(W Fig. 15)	1/16 inch
14.	Trip coil plunger free travel minimum	(S Fig. 13)	1/8 inch
15.	Closing coil plunger free travel minimum	(F Fig. 15)	1/8 inch
16.	Anti-condensation heater		functioning continuously

the cylinder are properly lubricated. (Refer to OPERATION AND MAINTENANCE.)

F. Operate the breaker slowly with the manual charging wrench and note that there is no excessive binding or friction and that the breaker can be moved to the fully opened and fully closed positions.

G. Operate the mechanism electrically and check the following points:

a. Closing, opening, reclosing and trip-free times.

b. Minimum trip and closing voltage.

H. See that all points where the surface of the paint has been damaged during installation are repainted immediately.

I. Make a final check that the breaker is securely fastened to its foundation and properly leveled.

J. Check that the ground connections are properly made and tightened.

K. Make certain that all pipe plugs and bolted connections are properly tightened and that all covers and gaskets are properly installed to prevent entrance of moisture.

L. Reset the 69 switch if remote tripping is used.

CONTROL POWER CHECK

After the mechanism has been closed and opened slowly several times with the maintenance closing wrench and the mechanism adjustments are checked as described, the closed circuit operating voltages should be checked at the release coil, trip coil, and motor terminals. For electrical operation of the mechanism, the control power may be either an alternating or direct current source. The operating ranges for the closing and tripping voltages are given on the breaker nameplate. The following ranges are standard:

Nominal Voltage	Closing Range Minimum	Closing Range Maximum	Tripping Range Minimum	Tripping Range Maximum
48v d-c	36 -	52v d-c	28 -	60v d-c
125v d-c	90 -	130v d-c	70 -	140v d-c
250v d-c	180 -	260v d-c	140 -	280v d-c
115v a-c	95 -	125v a-c	95 -	125v ac-
230v a-c	190 -	250v a-c	190 -	250v a-c

If the closed circuit voltage at the terminals of the coil or motor does not fall in the specified range, check the voltage at the source of power and line drop between the power source and breaker.

When two or more breakers operating from the same control power source are required to close simultaneously, the closed circuit voltage at the closing coil or motor of each breaker must fall within the specified limits.

Electrical closing or opening is accomplished by energizing the closing or trip coil circuit. It is also possible to trip or close the breaker manually by pressing the manual trip lever (19), Fig. 2, or the manual close button (24).

OPERATION

The ML-14 operating mechanism is of the stored-energy type designed to give high speed closing and opening. The mechanism will operate on a-c or d-c voltage. The operating voltage is indicated on the breaker nameplate. Closing and opening operations are controlled electrically by the remote relaying, and mechanically by the manual close and trip levers located behind the front door of the mechanism house.

SPRING CHARGING

The mechanism consists of a high speed gear motor (11), Fig. 2, that compresses a set of closing springs (12), and (28), through the action of a simple eccentric (25), a ratchet wheel (22), and pawl (4), Fig. 5, assembly. The rotary action of the motor is converted to a short straight stroke pumping action through the eccentric and a driving link (8), Fig. 5, that carries a spring-loaded driving pawl (4), Fig. 5.

The driving pawl (4), Fig. 5, advances the ratchet wheel (17), Fig. 3, only a few degrees each stroke where it is held in position by the latching and safety pawls (16), Fig. 3. When the ratchet wheel has been rotated approximately 180 degrees the closing springs (11) and (22), Fig. 3, will be fully compressed. As the ratchet wheel continues to rotate, the spring load will shift overcenter and attempt to discharge, but will be prevented from discharging by the closing latch (8), Fig. 9. After only a few degrees of rotation, the closing latch roller (29), Fig. 9, will engage the closing latch (8), Fig. 9, and the compressed springs will be held in repose until a closing operation is required. During the last few degrees of the ratchet wheel rotation the motor limit switches (17), Fig. 4, are released and the driving pawl (4), Fig. 5, is raised from the ratchet wheel surface. This allows the motor and driving mechanism to coast to a natural stop expending all residual energy.

During the time the springs are being compressed the cutoff and anti-pump relay 52Y (22), Fig. 4, locks the closing power circuits open. The 52Y relay will

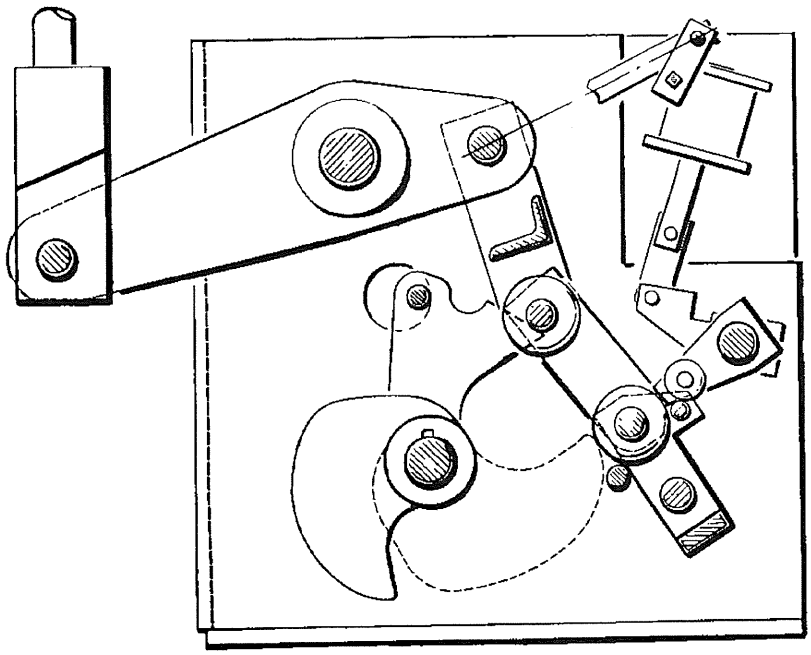


Fig. 16 Position of Linkage - Mechanism Closed
Undotted cam indicates closing spring charged.
Dotted cam indicates closing spring discharged.

Fig. 16 (0832D0149 Sheet 4, View X Rev. 1)

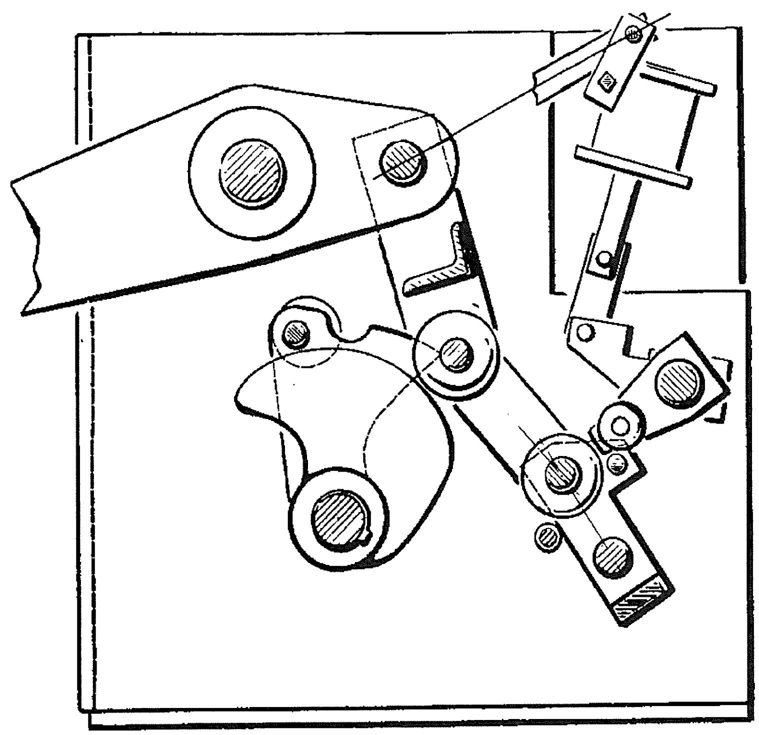


Fig. 17 Position of Linkage - Mechanism Going Closed

Fig. 17 (0832D0149 Sheet 5, View XIII Rev. 2)

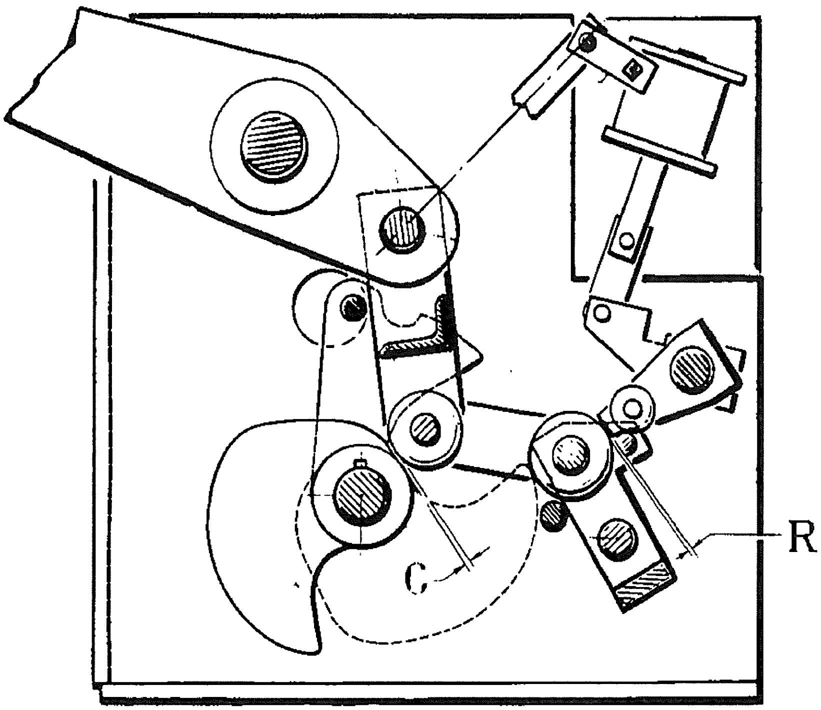


Fig. 18 (0832D0149 Sheet 5, View XII Rev. 2)

Fig. 18 Position of Linkage - Mechanism Open
Undotted cam indicates closing spring charged.
Dotted cam indicates closing spring discharged.

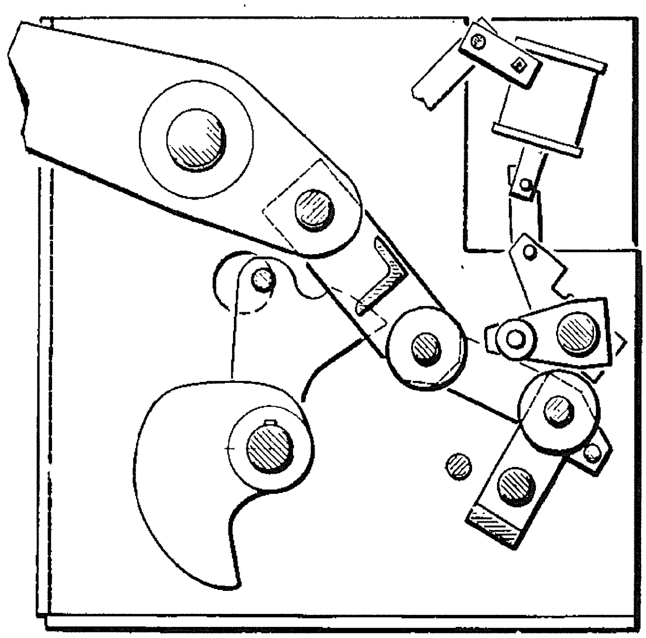


Fig. 19 (0832D0149 Sheet 4, View XI Rev. 1)

Fig. 19 Position of Linkage - Mechanism Going Open

remain energized until the springs are fully charged and the control and motor limit switch (17), Fig. 4, contacts are reset.

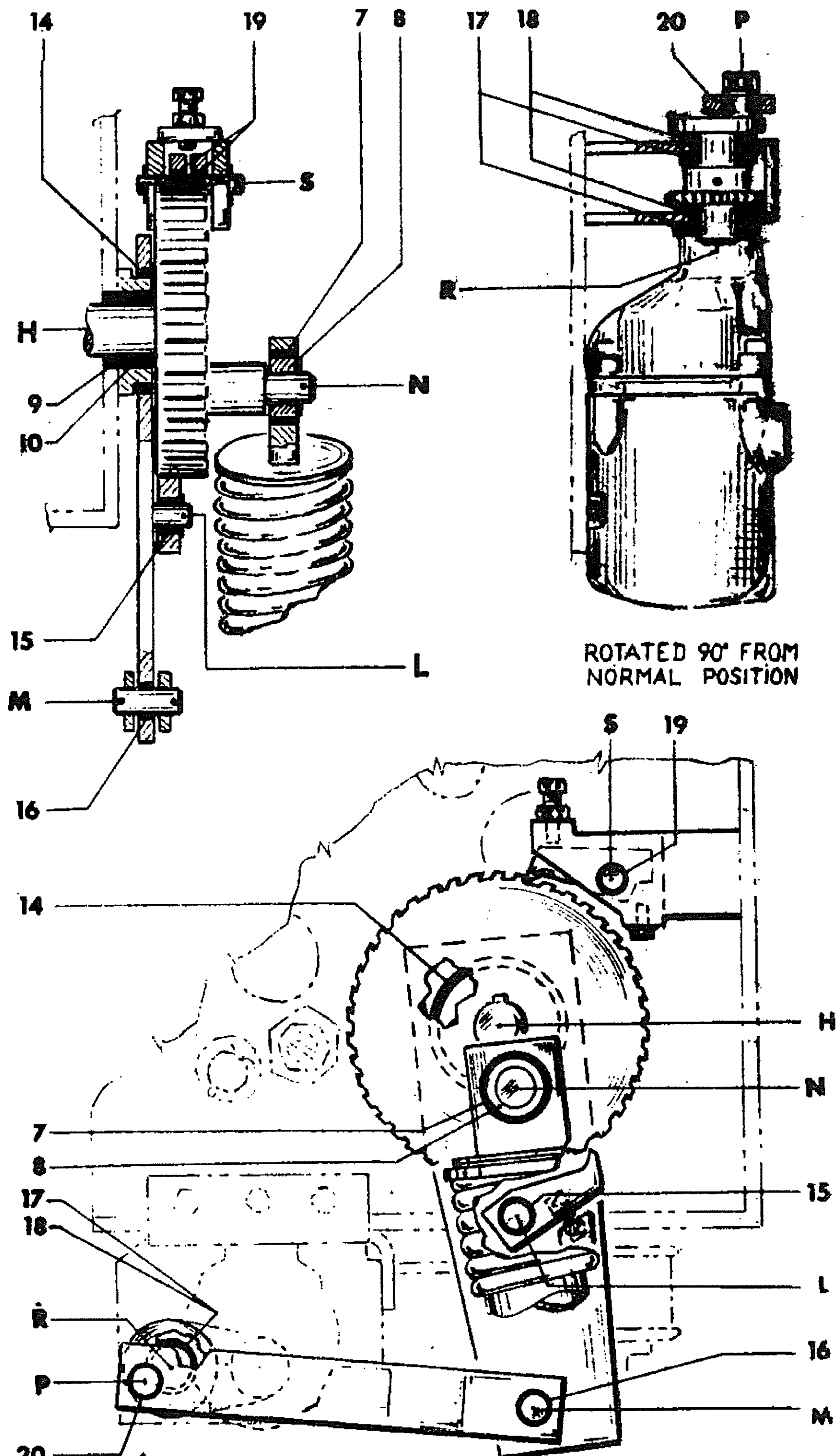
The closing springs may be charged manually if control voltage is lost. A standard 5/8 inch ratchet wrench should be used to rotate the eccentric in a counterclockwise direction until the indicator reads "CHARGED" and the driving pawl no longer engages the ratchet wheel. The use of the ratchet wrench provides for maximum safety in the event that control power is suddenly restored without warning. In this event, the motor drive will take over again and continue to charge the springs while the ratchet wrench harmlessly turns in the unloaded direction. Removing the fused pullouts (4), Fig. 4, will prevent the power from being applied when it is not required.

CLOSING OPERATION

Closing the breaker is accomplished by energizing the closing coil (20), Fig. 3, or by manually pressing the close button (24), Fig. 2. In either case, the closing latch (8), Fig. 9, is rotated away from the closing latch roller (29), Fig. 9, permitting the springs to discharge. The energy of the springs is applied to the rotation of a cam (39), Fig. 10, which closes the breaker through a simple linkage that remains trip free at all times. A monitoring switch (3), Fig. 6, operated by the closing latch (8), Fig. 9, will start the spring-charging motor (34), Fig. 9, after it is fully reset.

When the breaker is closed without power to the spring or charging motor, the cam (39), Fig. 10, is in the position of the dotted cam shown in Fig. 16. This is due to the motor not forcing the cam into the undotted cam position shown in Fig. 16 since the motor did not start charging the springs immediately upon closing the breaker as it does during a normal closing operation when the motor is energized.

DO NOT OPERATE THE MANUAL CLOSE BUTTON WHEN THE BREAKER IS CLOSED. If the button is pushed, the energy stored in the springs will be dissipated against the stop pin



1. Output Crank Bushing
2. Output Crank Main Shaft Bushing
3. Upper Link Bushing
4. Lower Link Bushing
5. Trip Latch Roller Bushing
6. Trip Latch Shaft Bearing
7. Guide Block Bearing (Outer Race)
8. Guide Block Bearing (Inner Race)
9. Cam Shaft Bearing (Outer Race)
10. Cam Shaft Bearing (Inner Race)
11. Closing Prop Bushing
12. Link Shaft Bushing
13. Closing Latch Shaft Bearing
14. Driving Crank Bushing
15. Driving Pawl Bushing
16. Driving Link Bushing
17. Driving Eccentric Shaft Bearing (Outer Race)
18. Driving Eccentric Shaft Bearing (Inner Race)
19. Latching and Safety Pawl Bushing
20. Driving Eccentric Bushing
21. Trip Latch Roller Bearing (Inner Race)
22. Trip Latch Roller Bearing (Outer Race)
23. Cam Follower Roller Bearing (Inner Race)
24. Cam Follower Roller Bearing (Outer Race)

Fig. 20A (0958D0958 View III Rev. 1)

NOTE: When replacing bronze bushings in the linkage frequently the bushings will require reaming to permit free rotation on their pins or shafts. Measure the diameter of the shaft and ream the bushing 0.001 to 0.003 inch larger than the shaft after it is inserted into place, e.g., the driving link bushing (16), Fig. 20, should be reamed to 0.748 to 0.750 inch since the shaft measures 0.746 to 0.747 inch.

Fig. 20A Bushing and Bearing Location in Mechanism

(21), Fig. 9, and the links (41), Fig. 10, causing bending of the pin and indentations on the links. When closing the breaker the energy in the springs is used and the stop pin or links are not damaged.

OPENING OPERATION

An electrical opening operation is initiated by energizing the trip coil (15), Fig. 2. This is accomplished either by actuating a remote trip circuit or by a combination of relays and current devices used to detect a fault on the load side of the breaker. When energizing the trip coil, the trip plunger rotates the trip latch (6), Fig. 2, causing the operating mechanism linkage to collapse. The energy stored in the breaker opening springs is thus released, opening the breaker. During this operation, the trip coil circuit is de-energized, and upon completion of the opening operation, the operating mechanism is returned to its normal position, ready for closing.

Manual tripping follows the same procedure except that instead of energizing the trip circuit, the manual trip lever (19), Fig. 2, is used. If the control house is closed pushing the manual trip push button (21), Fig. 2, on the surface of the front door will trip the breaker. The mechanism cannot be operated slowly while opening.

When the breaker is opened after being closed without charging the closing springs, the cam (39), Fig. 10, is in the position of the dotted cam shown in Fig. 18. This is due to the motor not forcing the cam into the undotted position shown in Fig. 18 since the motor did not start charging the closing springs immediately upon closing the breaker as it does during a normal closing operation when the motor is energized.

TRIP-FREE OPERATION

When testing the breaker the trip-free operation should be made by using the breaker contacts to energize the trip-free circuitry. This more closely simulates a breaker closing against a fault.

If the trip coil is energized while the breaker is closing, the trip coil plunger (3), Fig. 7, will force the trip latch (6), Fig. 2, away from the trip roller (20), Fig. 2, causing the mechanism linkage to collapse and the breaker to reopen. The closing cam (39), Fig. 10, will complete its closing stroke and the springs will recharge as in a normal closing operation. The position of the mechanism linkage during its operation is shown in Figures 16, 17 and 18.

A. Output crank to breaker vertical operating rod shaft
B. Output crank main shaft
C. Linkage to output crank shaft
D. Cam follower roller shaft
E. Trip latch clearance adjustment eccentric shaft
F. Trip latch roller shaft
G. Trip latch shaft
H. Cam shaft
I. Closing latch shaft
J. Link shaft
K. Stop pin
L. Driving pawl pin
M. Driving link pin
N. Guide block pin (right side)
O. Guide block pin (left side)
P. Driving eccentric shaft
R. Driving eccentric to sprocket shaft
S. Latching and safety shaft
U. Prop spacer and reset spring pin

Shaft and Pin Identification for Fig. 20A

MAINTENANCE

PERIODIC INSPECTION

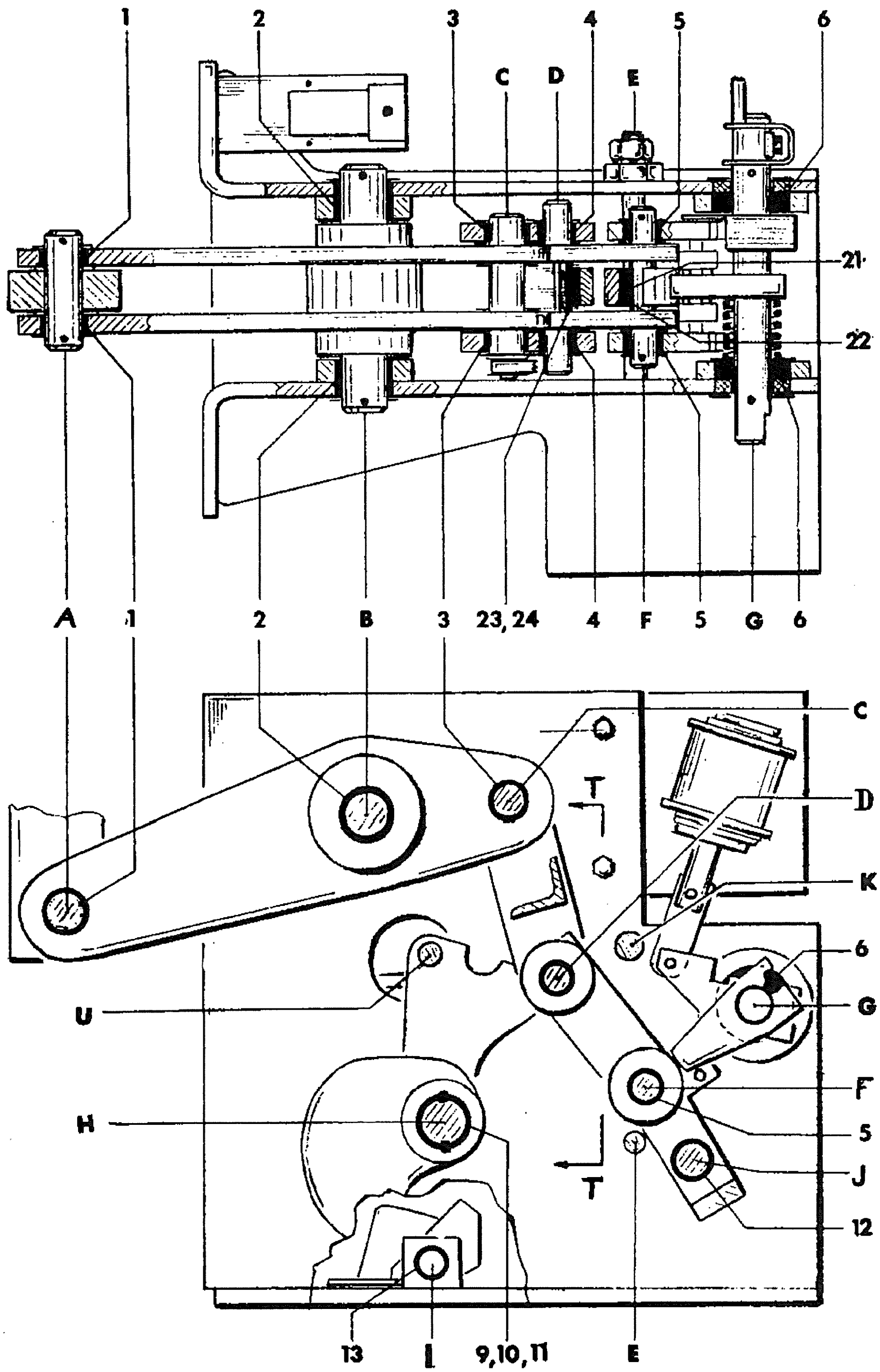
The operating mechanism of an oil circuit breaker is a very important part and must have regular systematic inspection during which every part is looked over carefully. The frequency of inspections should be determined by each operating company on the basis of the service to which the operating mechanism is subjected. Operating experience will soon establish a maintenance schedule that will give assurance of proper mechanism condition. An annual inspection and maintenance program is desirable in addition to a visual inspection at more frequent intervals. These inspections should be co-ordinated with an inspection of the breaker parts for maximum convenience.

PRECAUTIONS

1. Be sure that all primary and secondary circuits have been opened and grounded before any inspection or maintenance is attempted.
2. After any adjustment is made in the mechanism, operate manually to check the adjustment before operating electrically.
3. Use the connection diagram accompanying the operating mechanism in all cases when testing and connecting the mechanism.
4. When making adjustments in the mechanism or breaker make certain that the closing springs are blocked as described under MANUAL CLOSING.

   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. DO NOT WORK ON THE BREAKER OR MECHANISM WHILE THE SPRINGS ARE CHARGED UNLESS THEY ARE SECURED IN THAT POSITION BY THE MAINTENANCE SPRING BLOCKING DEVICE.

5. DO NOT OPERATE THE MANUAL CLOSE BUTTON WHEN THE BREAKER IS IN THE CLOSED POSITION.



1. Output Crank Bushing
2. Output Crank Main Shaft Bushing
3. Upper Link Bushing
4. Lower Link Bushing
5. Trip Latch Roller Bushing
6. Trip Latch Shaft Bearing
7. Guide Block Bearing (Outer Race)
8. Guide Block Bearing (Inner Race)
9. Cam Shaft Bearing (Outer Race)
10. Cam Shaft Bearing (Inner Race)
11. Closing Prop Bushing
12. Link Shaft Bushing
13. Closing Latch Shaft Bearing
14. Driving Crank Bushing
15. Driving Pawl Bushing
16. Driving Link Bushing
17. Driving Eccentric Shaft Bearing (Outer Race)
18. Driving Eccentric Shaft Bearing (Inner Race)
19. Latching and Safety Pawl Bushing
20. Driving Eccentric Bushing
21. Trip Latch Roller Bearing (Inner Race)
22. Trip Latch Roller Bearing (Outer Race)
23. Cam Follower Roller Bearing (Inner Race)
24. Cam Follower Roller Bearing (Outer Race)

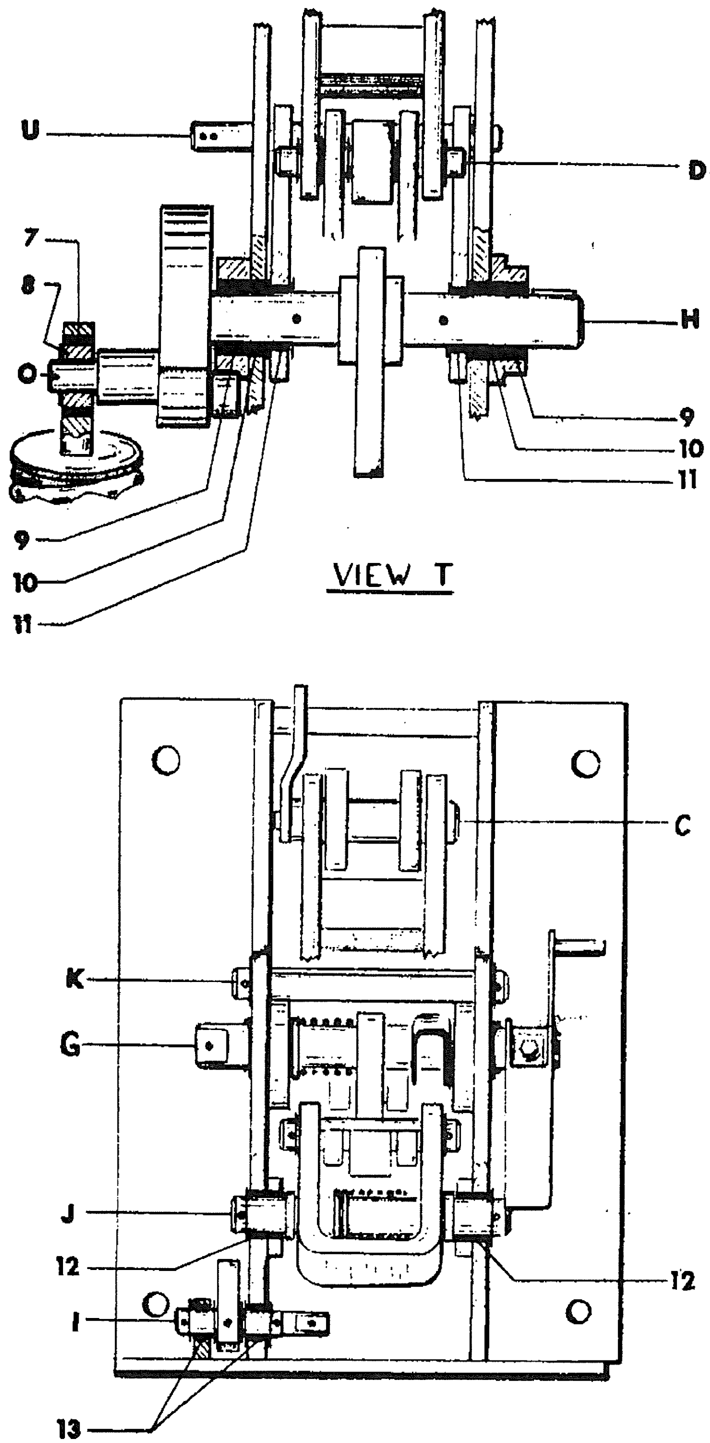
Fig. 20B (0958D0958 View I Rev. 1)

Fig. 20B Bushing and Bearing Location in Mechanism

Fig. 20C (0958D0958 View II and View T Rev. 1)

A. Output crank to breaker vertical operating rod shaft
B. Output crank main shaft
C. Linkage to output crank shaft
D. Cam follower roller shaft
E. Trip latch clearance adjustment eccentric shaft
F. Trip latch roller shaft
G. Trip latch shaft
H. Cam shaft
I. Closing latch shaft
J. Link shaft
K. Stop pin
L. Driving pawl pin
M. Driving link pin
N. Guide block pin (right side)
O. Guide block pin (left side)
P. Driving eccentric shaft
R. Driving eccentric to sprocket shaft
S. Latching and safety shaft
U. Prop spacer and reset spring pin

Shaft and Pin Identification



NOTE: When replacing bronze bushings in the linkage frequently the bushings will require reaming to permit free rotation on their pins or shafts. Measure the diameter of the shaft and ream the bushing 0.001 to 0.003 inch larger than the shaft after it is inserted into place, e.g., the driving link bushing (16), Fig. 20, should be reamed to 0.748 to 0.750 inch since the shaft measures 0.746 to 0.747 inch.

Fig. 20C. Bushing and Bearing Location in Mechanism

A careful inspection should be made to check for loose nuts or bolts and broken retaining rings. All cam, roller, and latch surfaces should be inspected for any evidence of damage or excessive wear. Lubricate the mechanism as outlined below, then, using the manual charging wrench, open and close the breaker several times to make certain that the mechanism operates freely throughout its entire stroke. Check the mechanism adjustments as specified under ADJUSTMENTS. Check all terminal connections.

OPTIONAL MAINTENANCE JACKING DEVICE

The jacking device consists of two rods that attach to the pin securing the vertical operating rod coupling (36), Fig. 10, and support a platform for a hydraulic jack.

Before installing rods and platform remove the breaker from service, disconnect the motor and control power, and discharge the closing springs by closing the breaker or install the spring blocking device. To install the jacking device, open the breaker and attach the rods and platform to the operating rod pin and contain with a washer and cotter pin. Put the jack on the platform with shims underneath to remove clearance between the top of the jack and the frame.

The breaker may now be jacked closed. The closed position is reached when the props (19), Fig. 10, fall under pin (68).

To slowly open the breaker, hold the manual trip lever in initially and allow the jack to slowly collapse by using the release valve on the jack.

> CAUTION: DO NOT ATTEMPT TO OPERATE THE BREAKER WITH THIS DEVICE WHILE THE BREAKER IS ENERGIZED.

Remove the jack, rods and platform before returning the breaker to normal operation.

INSULATION TEST

If the breaker secondary wiring is to be given a hi-potential test at 1500 volts a-c, remove both the motor leads from the terminal boards. Failure to disconnect the motor from the circuit may cause damage to the winding insulation.

LUBRICATION

In order to maintain reliable operation, it is important that all mechanisms be properly lubricated at all times. Most of the bearings and rolling surfaces utilize a new type of dry lubrication that will require no maintenance and will last the life of the equipment. Only a few bearings and surfaces listed in the chart, Fig. 20, require lubrication. These have been properly lubricated during assembly at the factory using the finest grades of lubricants available. However, even the finest oils and greases have a tendency to oxidize with age, as evidenced by hardening and darkening in color. Elimination of the hardened lubricant is essential for the proper operation of circuit breakers. Also, frequent operation of the mechanism causes the lubricant to be forced out from between the bearing surfaces. A simple lubrication will often clear up minor disturbances which might be mistaken for more serious trouble.

A definite lubrication schedule should be set up taking into consideration the frequency of operation of the mechanism and local conditions. Until such a schedule is worked out, the mechanism should be lubricated at each periodic inspection and also whenever it is overhauled, in accordance with the lubrication chart. It is also recommended that all circuit breakers and their associated operating mechanisms be operated at regular intervals to insure the user that the equipment is operating freely.

The lubrication chart is divided into two methods of lubrication. The first method outlines the maintenance lubrication which should be performed at the time of periodic maintenance, and requires no disassembly. The second method outlines a lubrication procedure similar to that performed on the breaker 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 slower.

General Electric Lubricant D50H15 is available in four-ounce collapsible tubes, order as 6591901P1. It is so packaged to insure cleanliness and to prevent oxidation.

METHOD OF CLEANING BEARINGS

Whenever cleaning is required, as indicated in the lubrication chart, the following procedures are recommended.

SLEEVE BEARINGS

Some of the sleeve bearings used throughout the linkage are Textolite; others are bronze. If contaminants are present they should be removed by immersing the link and bearing in clean petroleum solvent or similar cleaner and using a stiff brush. Do not remove the bearings from the links. DO NOT USE CARBON TETRACHLORIDE since it may be injurious to the user.

All of the sleeve bearings, for example, the bearings of the main shaft (2), Fig. 20, and the bearing of the driving link (16), should be cleaned and lubricated with G-E D50H15 lubricant at general overhaul periods.

ROLLER AND NEEDLE BEARINGS

All the roller and needle bearings, for example, the cam follower bearings (23 and 24), Fig. 20, trip latch roller bearing (21 and 22) and the cam shaft bearings (9 and 10) should be first removed from the mechanism and the inner race disassembled. They should then be placed in a container of clean petroleum solvent or similar cleaner. DO NOT USE CARBON TETRACHLORIDE. If the grease in the bearings has become badly oxidized, it may be necessary to use alcohol (the type used for thinning shellac) to remove it. Ordinarily, by agitating the bearings in the cleaning solution, and using a stiff brush to remove the solid particles, the bearings can be satisfactorily cleaned. Do not handle the bearings with bare hands as deposits from the skin onto the bearings are inductive to corrosion. If the bearings are touched, the contamination can be removed by washing in alcohol. After the bearings have been thoroughly cleaned, spin them in clean new light machine oil until the cleaner or solvent is entirely removed. Allow this oil to drain off and then repack the bearings immediately with G-E lubricant D50H15 being sure all metal parts are greased. Any removable seals should then be replaced.

PART	LUBRICATION AT MAINTENANCE PERIOD	ALTERNATE LUBRICATION (REQUIRES DISASSEMBLY)
Sleeve Bearings - Textolite Bearings -	No lubrication required.	Film of D 50H15 grease.
Sleeve Bearings - Bronze Bearings -	Light application of machine oil SAE 20 or SAE 30.	Remove bearings or links, clean per instructions and apply D 50H15 grease liberally.
Roller and Needle Bearings -	Light application of machine oil SAE 20 or SAE 30.	Clean per instructions and repack with D 50H15 grease.
Ground surfaces such as cams, ratchet teeth, etc. (Surfaces coated with M_oS_2)	No lubrication required except a light film of D 50H15 grease.	No lubrication required except a light film of D 50H15 grease.
Ground surfaces such as latches, rollers, prop, etc.	Wipe clean and apply D 50H15 grease.	Wipe clean and apply D 50H15 grease.
Sealed Bearings - trip latch roller shaft	Cannot be relubricated.	Replace when they become sluggish.
Motor Gear Box	No lubrication normally required. Lubricate when motor becomes sluggish.	Wipe clean and apply Texaco "All-Temp" or a similar lubricant.

LUBRICATION CHART

NOTE: 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 in 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 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.

Bearings that are pressed into the frame or other members such as the eccentric drive bearings contained in the motor support (9), Fig. 5, should not be removed. After removing the shaft and inner race the bearing can usually be cleaned satisfactorily with petroleum solvent or a similar cleaner and a stiff brush. Follow the procedure outlined above using a light machine oil and G-E lubricant D50H15 before reassembling the inner race and shaft.

ROLLING SURFACES

A number of rolling and rubbing surfaces in the mechanism have been lubricated with a baked-on, dry, molybdenum disulfide coating. This requires no maintenance and should last the life of the breaker.

TROUBLE SHOOTING

Failure of a mechanism to operate properly will generally fall within three general classes; failure to trip, failure to close or latch closed, and failure of closing springs to recharge. The following is a brief outline showing particular types of problems that might be encountered, together with suggestions for remedying the trouble:

FAILURE TO TRIP

1. Mechansim binding or sticking caused by lack of lubrication.
   REMEDY: Lubricate complete mechanism.

2. Mechanism binding or sticking caused by being out of adjustment.

REMEDY: Check all mechanism adjustments, latches, stops, auxiliary devices, etc., in accordance with section on ADJUSTMENTS. Examine latch and roller surfaces for corrosion. Clean as necessary.

3. Damaged trip coil.
REMEDY: Replace damaged coil after determining reason for the failure.

4. Blown fuse in trip circuit.
REMEDY: Replace blown fuse after determining cause of failure.

5. Faulty connections in trip circuit.
REMEDY: Repair broken or loose wires and see that all binding screws are tight.

6. Damaged or dirty contacts in trip circuit.
REMEDY: Recondition or replace contacts.

FAILURE TO CLOSE OR LATCH CLOSED

1. Mechanism binding or sticking caused by lack of lubrication.
REMEDY: Lubricate complete mechanism.

2. Damaged or dirty contacts in control circuit.
REMEDY: Recondition or replace contacts.

3. Blown fuse in closing circuit.
REMEDY: Replace blown fuse after determining cause of failure.

4. Faulty connection in charging circuit.
REMEDY: Repair broken or loose wires and see that all binding screws are tight.

5. Failure to latch closed.

A. Bend spring (57), Fig. 10, to increase its tension and make certain it is not binding against the sides of the trip latch assembly support link (55), Fig. 10.

B. Check to see if the manual close button has clearance between its shaft and the closing latch monitoring switch operating lever (12), Fig. 10.

C. If this does not cure the problem, remove the trip latch (50), Fig. 10, and turn it over 180 degrees; then replace. This is an on-center latch and is occasionally ground slightly off center. Make certain the breaker will trip at minimum voltage.

FAILURE OF CLOSING SPRINGS TO RECHARGE

1. Driving motor inoperative due to lack of power.
REMEDY: Check and replace fuses after determining cause of blown fuses.

2. Driving motor inoperative due to an opened or shorted winding.
REMEDY: Replace motor after checking motor limit switches for proper setting and ratchet wheel and linkage for possible foreign objects causing jamming.

3. Driving motor continues to run but does not completely charge springs.
REMEDY: Recheck the pawl clearance "P" and "Q" and readjust as necessary. Move the motor-mount assembly in increments of 1/64 inch.

REPAIR AND REPLACEMENT

The following information covers in detail the proper method of removing various parts of the mechanism in order to make any necessary repairs. This section includes only those repairs that can be made at the installation on parts of the mechanism that are most subject to damage or wear. IMPORTANT: UPON COMPLETION OF ANY REPAIR WORK, ALL MECHANISM ADJUSTMENTS MUST BE CHECKED. Refer to the section on INSTALLATION, paying particular attention to ADJUSTMENTS and FINAL INSPECTION.

TRIP LATCH CHECKING SWITCH

To remove the trip latch checking switch (4), Fig. 7, remove the two mounting screws and disconnect the lead wires. Reassemble in the reverse order and check the switch adjustments as explained under ADJUSTMENTS.

MOTOR LIMIT SWITCHES

The three switches (11), Fig. 8A and 8B are mounted in tandem.

1. Remove the opening spring per the instructions below.
2. Remove the two mounting bolts (28), Fig. 9, from the switch support (16), Fig. 4.
3. Remove the two mounting screws of the lower switch.
4. Remove the two mounting screws of the center switch.
5. Remove the two mounting screws of the upper switch.
6. Disconnect the lead wires of the switch which is to be replaced.
7. Reassemble in the reverse order and check the switch adjustment as explained under ADJUSTMENTS.

TRIP SHAFT AND LATCH

1. Remove the trip latch checking switch operating lever (5), Fig. 7.
2. Remove the cotter pins (6), Fig. 7, on both ends of the shaft.
3. Remove the set screw (19), Fig. 7, which is in the latch shaft (18), Fig. 7.

4. Remove the trip crank adjustment bolt (16), Fig. 7.

5. Place a block between the latch and the frame (either side) and drive the shaft until the latch is free of the key.

6. Remove the key and all burrs that may be raised around the keyway on the shaft. Burrs will scar the bearing surfaces if they are not removed.

7. Reassemble the parts in the reverse order. Be sure the trip latch spring (47), Fig. 11, is properly installed and the trip latch (50), Fig. 11, is aligned in the center of the trip latch roller (52), Fig. 11. Check the trip latch adjustment as described under ADJUSTMENTS.

TRIP LATCH ROLLER BEARING

1. Remove the two cotter pins at the ends of the shaft (54), Fig. 10.

2. Partially remove the shaft out the right side of the frame (2), Fig. 9, until the trip latch roller (52), Fig. 10, is free.

3. Reassemble in the reverse order with the proper spacing of washers. Be sure the trip latch roller (52), Fig. 10, rotates freely.

TRIP COIL (TC)

Refer to Fig. 7. To replace the potential trip coil (11), proceed as follows:

1. With the breaker in the open position, remove the two mounting bolts which support the coil support bracket (9).

2. Remove the upper portion of the support bracket (9), and remove the shims (10) and (12).

3. Cut the trip coil wires at the butt connectors and remove the trip coil (11).

4. When replacing the trip coil be sure to assemble the correct fiber spacers at the ends before securing the support bracket (9).

5. Adjust the trip coil location to allow 7/32 to 9/32 inch of trip coil plunger (3), before the trip latch (7), starts to move.

6. Butt connect the wires and check the operation of the trip coil electrically and mechanically.

CLOSING COIL (CC)

To remove the closing coil (20), Fig. 3, proceed as follows:

1. Block the closing springs (11) and (22), Fig. 3, as described under INSTALLATION.

2. Remove the left-hand closing spring (12), Fig. 2, as described in CLOSING SPRINGS.

3. Remove the two mounting bolts which fasten the closing coil (20), Fig. 3, support bracket to the mechanism frame (2), Fig. 9, and remove the shims above and below the closing coil.

4. Cut the closing coil wires at the butt connectors and remove the closing coil.

5. Replace the closing coil and the correct number of fiber spacers before fastening the support bracket to the mechanism frame.

6. Butt connect the wires and check that the closing coil plunger (15), Fig. 9, is not binding. Check the closing coil for electrical operation.

CLOSING LATCH

1. Remove the cotter pins at both ends of the closing latch shaft (5), Fig. 8A.

2. Remove the closing latch spring (17), Fig. 9, and the closing latch monitoring switch operating level (12), Fig. 11.

3. Remove the set screws from the closing latch (6), Fig. 8A.

4. Move the closing latch shaft (5), Fig. 8A, to the left (away from the frame) by tapping lightly on the inside end of the shaft. Rotate the shaft and continue tapping until the shaft is free. The shaft will push the outside needle bearing from its housing.

5. Reassemble in the reverse order putting the bearing into the frame last. Use a small piece of tubing or pipe when inserting the bearing to assure proper alignment of the bearing with its hole.

6. Check the latch adjustments as described under ADJUSTMENTS.

MOTOR SUPPORT

1. To remove the motor support (9), Fig. 5, first remove the closing latch spring (17), Fig. 9.

2. Remove the retaining ring which prevents the driving link (7) Fig. 6, from falling off the manual charging stud (6), Fig. 6.

3. Remove the driving link (7), Fig. 6.

4. Remove the motor leads from the terminal board (12), Fig. 8A.

5. Remove the six 3/8 inch bolts (32), Fig. 11, from the bottom of the frame (2), Fig. 9.

6. Remove the four mounting bolts from the motor (not shown).

7. Remove the retaining ring from between the motor (2), Fig. 5, and the motor support (9), Fig. 5.

8. Remove the motor (2), Fig. 5.

9. Reassemble all parts of the motor support in the reverse

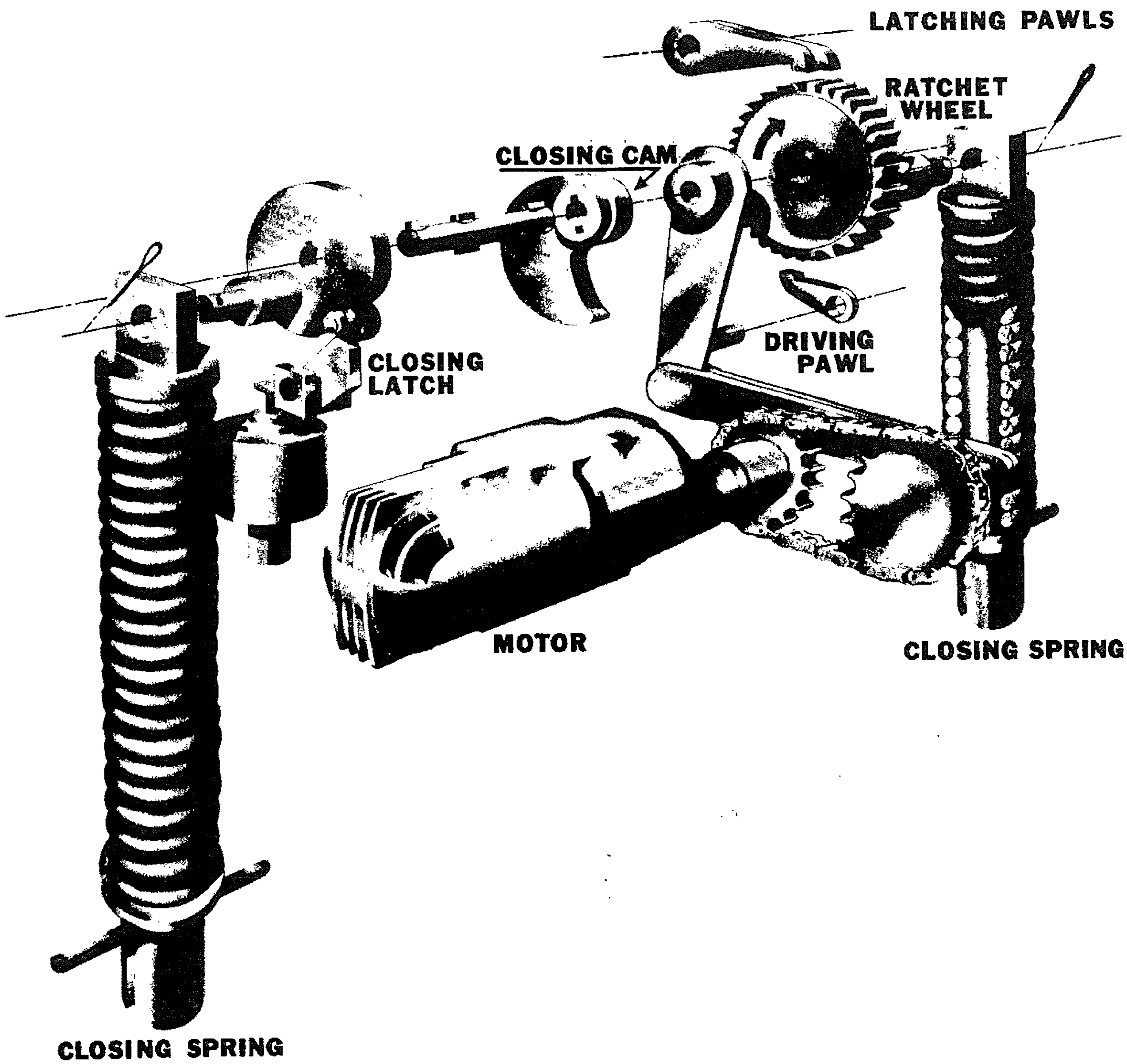


Fig. 21 (8915797)

Fig. 21. Schematic of ML-14 Mechanism

order and re-align it properly as described under DRIVING PAWL ADJUSTMENTS.

CAM

1. Remove the two set screws from the ratchet wheel (17), Fig. 3, and remove the wheel from the main shaft (18), Fig. 3.

2. Remove the two set screws from the cam (2), Fig. 4.

3. Remove the prop reset test spring (10), Fig. 4.

4. Remove the two set screws from the cam (39), Fig. 10, and move the cam to the right on the shaft (3), Fig. 4, as far as it will go. Slide the cam shaft to the left until the key is fully exposed. Remove the key and check the shaft for burrs. Remove any burrs before removing the shaft from the frame.

5. Remove the shaft out the left side of the mechanism frame (2), Fig. 9.

6. Reassemble in the reverse order using the correct number of washers and spacers to properly locate the parts.

7. Rotate the mechanism through a closing operation using the manual charging wrench (7), Fig. 5. Check the location of the cam

Fig. 22 (8915798)

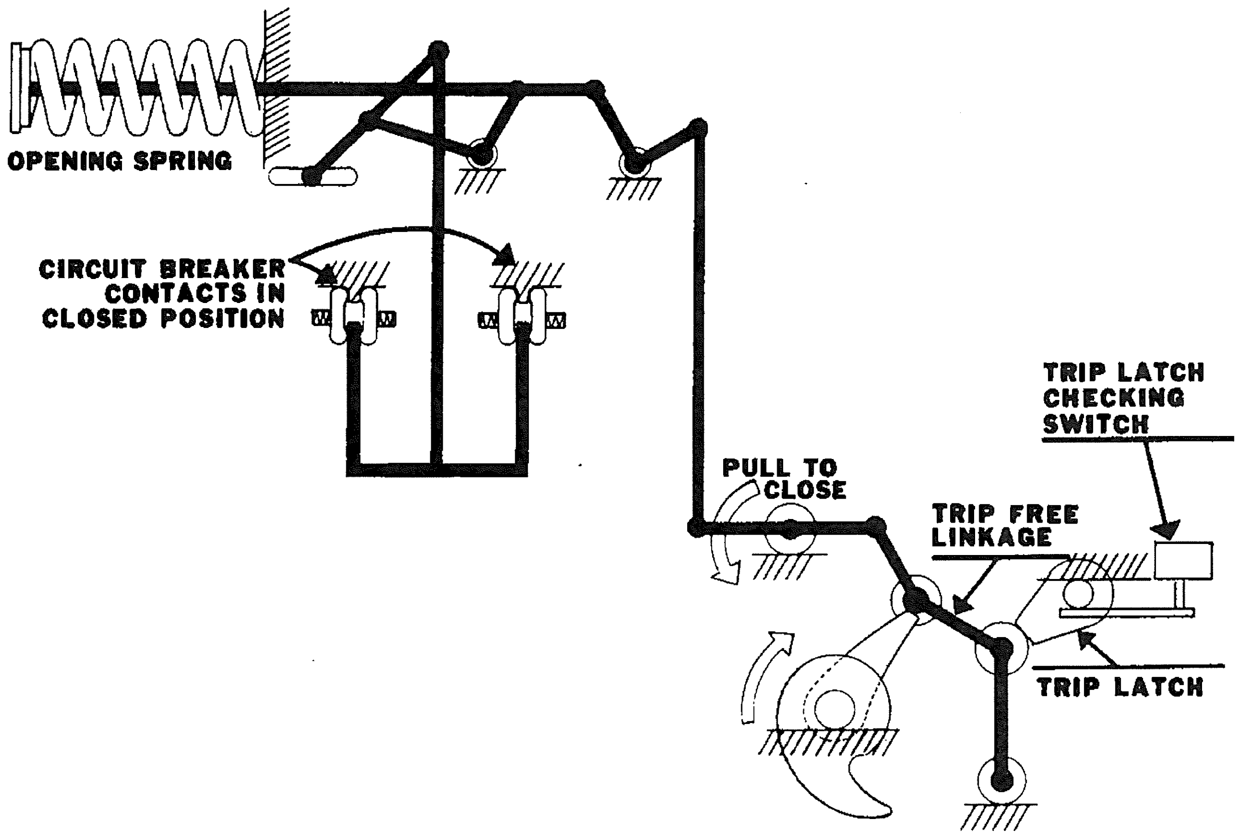


Fig. 22. Schematic of ML-14 Mechanism and Circuit Breaker in Closed Position

follower roller (37), Fig. 10, on the cam (39), Fig. 10. If necessary, adjust the cam on the cam shaft to correct the alignment. Complete the closing operation and check the location of the cam follower roller shaft (68), Fig. 10, on the prop (38). It should be approximately centered.

CLOSING SPRINGS

The closing springs (12) and (28), Fig. 2, can be removed as follows:

1. Charge the springs with the manual charging wrench and apply the spring blocking device (13) and (30), Fig. 2, as described in INSTALLATION.

2. Discharge the springs by pushing the manual close button (24), Fig. 2.

3. Rotate the cam shaft (7), Fig. 12, by using the manual charging wrench (7), Fig. 5, until the gap between the springs (12) and (28), Fig. 2, and the guide block (19), Fig. 3 and (8), Fig. 2, is two inches or more.

4. Lift both springs until they clear the lower supports, then pull forward and down until the top supports are free. Removing the left spring (12), Fig. 2, is difficult with the control panel (20), Fig. 4, assembled in the control house (1), Fig. 3. Remove the retaining cotter pin and washer from the limit switch cam (1), Fig. 8A, shaft. Remove the inner race of the bearing in the guide blocks (3). This permits the guide block (3) to slide off the shaft of the limit switch cam (1) for easy removal of the left spring (12), Fig. 2.

5. Either open the operating mechanism by pushing the manual trip lever or block the breaker in the closed position with a suitable blocking device.

6. After reassembling the springs check the breaker stroke as described in the breaker instruction book.

REPLACEMENT 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.

On the following pages a list of replacement parts will be found. This list includes both recommended renewal parts as designated by the asterisk (*) as well as a listing of parts ordered most frequently. The actual drawing number as well as the figure and part numbers in this book are given. Where parts are required that do not appear on this list, and hence no drawing number is available the instruction book number as well as the figure and part number should be given on the purchase order.

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. All "O" rings have a limited shelf life of three years.

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 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 as outlined above, the quantity required and, if possible, the number of the requisition on which the breaker was originally furnished.

FIG. NO.	REF. NO.	CATALOG NO.	QTY. PER MECH.	DESCRIPTION OF PART
2	3	0128B1722G001	1	Auxiliary Switch - SB-1 (11 Stage, 11 Circuit) (Special)
2	3	0226A9901G001	1	Auxiliary Switch - SB12 (5 Stage, 10 Circuit) (Standard)
2	*11	0193A4998P001	1	Spring Charging Motor (48v d-c)
2	*11	0193A4998P002	1	Spring Charging Motor (125v d-c and 115v a-c)
2	*11	0193A4998P003	1	Spring Charging Motor (250v d-c)
2	*11	0193A4998P004	1	Spring Charging Motor (230v a-c)
2	14	0103A3075P001	1	Operation Counter
2	16 & 33	0178V0727P001	2	Window
2	∅	0183V0711P001	2	Window Gasket
2	∅	0455A0300P001	1	Operation Counter Return Spring
2	17	0307V0199P001	1	Lock-out Switch (69 Device)
3	17	0104C8078G001	1	Ratchet Wheel – USE 0105C9310G002 SAME AS ML-13
3	∅	0414A0112P056	2	Guide Block Bearing-Outer Race
3	∅	0414A0112P057	2	Guide Block Bearing-Inner Race
4	*7	0103A2049P002	1	Control House Heater (115v a-c)
4	*7	0103A2049P001	1	Control House Heater (230v a-c)
4	10	0193A4943P001	1	Prop Reset Spring
4	*17	0456A0866P005	2	Motor Limit Switches (normally open)
4	*17	0456A0866P006	1	Rear Motor Limit Switch (normally closed)
4	22	0103A1438P060	1	Cutoff and Anti-pump Relay-52Y-(48v d-c) (12HGA35A3)
4	22	0103A1438P059	1	Cutoff and Anti-pump Relay-52Y-(125v d-c) (12HGA35A2)
4	22	0103A1438P058	1	Cutoff and Anti-pump Relay-52Y-(250v d-c) (12HGA35A1)
4	22	0103A1438P106	1	Cutoff and Anti-pump Relay-52Y-(230v a-c) (12HGA35A5)
4	*∅	006306774G008	1	Cutoff and Anti-pump Relay Coil-(48v d-c)
4	*∅	006306774G004	1	Cutoff and Anti-pump Relay Coil-(125v d-c)
4	*∅	006306774G002	1	Cutoff and Anti-pump Relay Coil- (250v d-c)
4	*∅	006306774G002	1	Cutoff and Anti-pump Relay Coil-(230v a-c)
4	∅	0193A4945P001	1	Charge-discharge Indicator Spring
5	9	0414A0112P059	2	Motor Support Housing - Outer Race
5	∅	0414A0112P060	2	Motor Support Housing - Inner Race
9	*13	006174582G039	1	Closing Coil - 52CC - (48v d-c)
9	*13	006174582G022	1	Closing Coil - 52CC - (125v d-c)
9	*13	006174582G002	1	Closing Coil - 52CC - (250v d-c)
9	*13	006174582G010	1	Closing Coil - 52CC - (230v a-c)
9	*16	0456A0866P005	1	Closing Latch Monitoring Switch (Normally Open)
9	17	0193A4946P001	1	Closing Latch Spring
9	*22	0456A0866P005	1	Trip Latch Checking Switch (Normally Open)
9	29	0414A0112P058	1	Close Latch Roller

*Recommended Renewal Parts ∅ Not Shown

FIG. NO.	REF. NO.	CATALOG NO.	QTY. PER MECH.	DESCRIPTION OF PART
10	*42	006174582G027	1Δ	Trip Coil - 52TC - (24v d-c)
10	*42	006174582G032	1Δ	Trip Coil - 52TC - (48v d-c)
10	*42	006174582G022	1Δ	Trip Coil - 52TC - (125v d-c)
10	*42	006174582G002	1Δ	Trip Coil - 52TC - (250v d-c)
10	*42	006174582G001	1Δ	Trip Coil - 52TC - (230v a-c)
10	94	0132A1416P001	1	Driving Chain and Connecting Link Complete
12	*70	0202A6386G002	1	Inner Latching Pawl with Bushing - Complete
12	*70	0202A6386G001	1	Outer Latching Pawl with Bushing - Complete
12	*74	0202A6386G003	1	Driving Pawl and Bushing - Complete
12	87	0161A4241P001	1	Driving Pawl Spring
12	∅	0193A4941P001	1	Inner Latching Pawl Spring
12	∅	0193A4941P001	1	Outer Latching Pawl Spring
20	* 1	006370567P059	2	Output Crank Bushing (Textolite)
20	* 2	006370568P051	2	Output Crank Main Shaft Bushing (Textolite)
20	* 3	006370567P059	2	Upper Link Bushing (Textolite)
20	* 4	0202A4508P001	2	Lower Link Bushing (Bronze)
20	* 5	0202A4508P001	2	Trip Latch Roller Bushing (Bronze)
20	* 6	0414A0112P037	2	Trip Latch Shaft Bearing (Ball Bearing)
20	* 7	0414A0112P056	2	Guide Block Bearing (Outer Race) (Roller Bearing)
20	* 8	0414A0112P057	2	Guide Block Bearing (Inner Race) (Roller Bearing)
20	* 9	0414A0112P050	2	Cam Shaft Bearing (Outer Race) (Roller Bearing)
20	*10	0414A0112P051	2	Cam Shaft Bearing (Inner Race) (Roller Bearing)
20	*11	0202A4508P002	2	Closing Prop Bushing (Textolite)
20	*12	006370567P042	2	Link Shaft Bushing (Textolite)
20	*13	0414A0112P061	2	Closing Latch Shaft Bearing (Needle Bearing)
20	*14	0193A4948P001	1	Driving Crank Bushing (Bronze)
20	15	0202A5595P002	1	Driving Pawl Bushing (Bronze)
20	*16	0202A5595P003	1	Driving Link Bushing (Bronze)
20	*17	0414A0112P097	2	Driving Eccentric Shaft Bearing (Outer Race) (Roller Bearing)
20	*18	0414A0112P100	2	Driving Eccentric Shaft Bearing (Inner Race) (Roller Bearing)
20	19	0202A5595P001	2	Latching and Safety Pawl Bushing (Bronze)
20	*20	0202A4508P001	1	Driving Eccentric Bushing (Bronze)
20	*21	0414A0112P053	1	Trip Latch Roller Bearing - (Inner Race)
20	*22	0414A0112P052	1	Trip Latch Roller Bearing-(Outer Race)
20	*23	0414A0112P053	1	Cam Follower Roller Bearing-(Inner Race)
20	*24	0414A0112P052	1	Cam Follower Roller Bearing-(Outer Race)

*Recommended Renewal Parts ∅ Not Shown

Δ Independent Dual Trip Coil Option – Any Voltage Combination of Two Coils

GENERAL ELECTRIC COMPANY
SWITCHGEAR BUSINESS DEPARTMENT
PHILADELPHIA, PA 19142

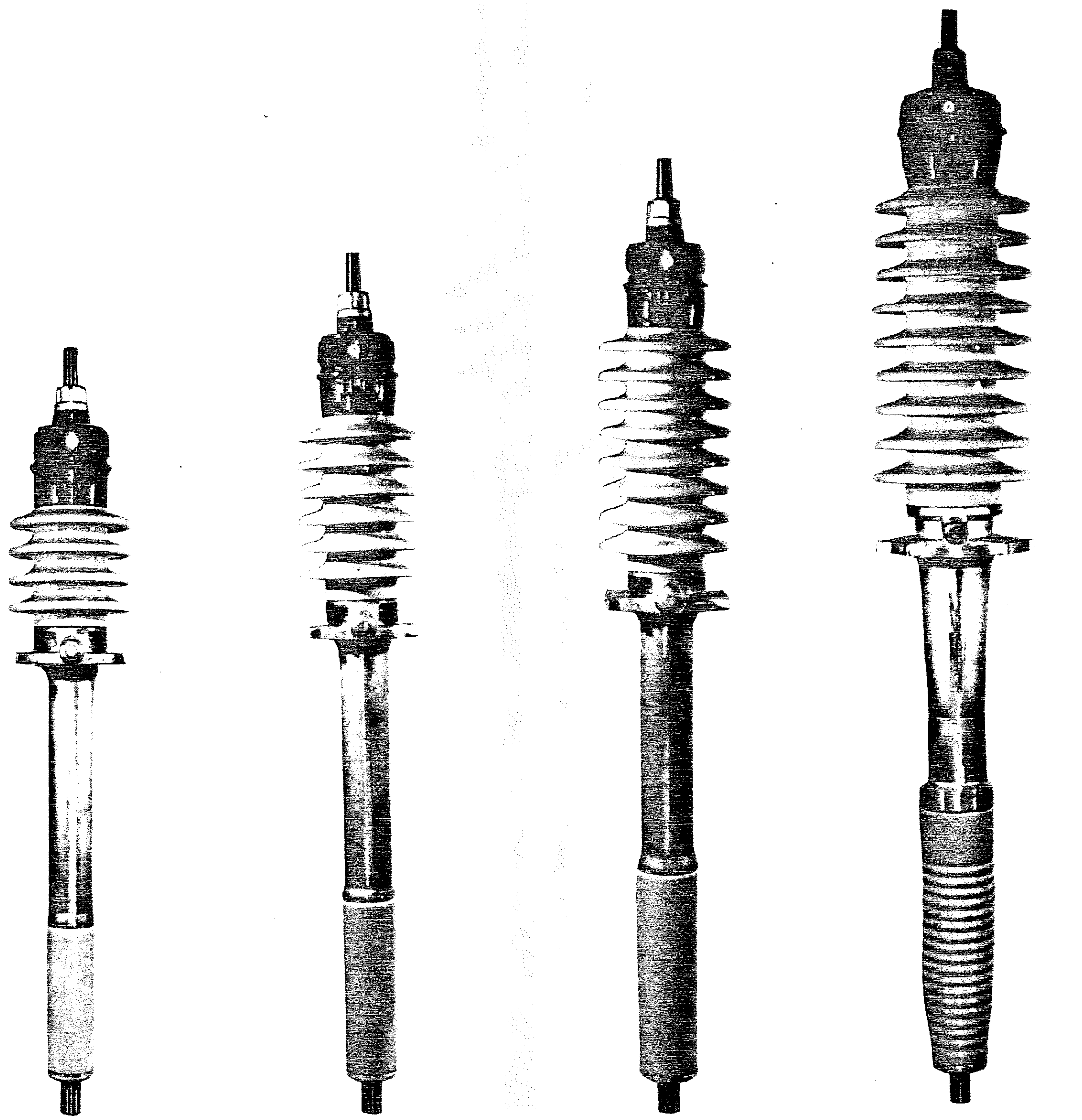
GENERAL ELECTRIC

PRINTED IN U.S.A.

INSTRUCTIONS

GEH-1638G
Supersedes GEH-1638F

APPARATUS BUSHINGS
TYPE U
23 Kv - 69 Kv



A. 23 kv 400/1200 amp   B. 34.5 kv 400/1200 amp   C. 46 kv 400/1200 amp   D. 69 kv 400/1200 amp

Fig. 1 Typical Type U bushings

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.

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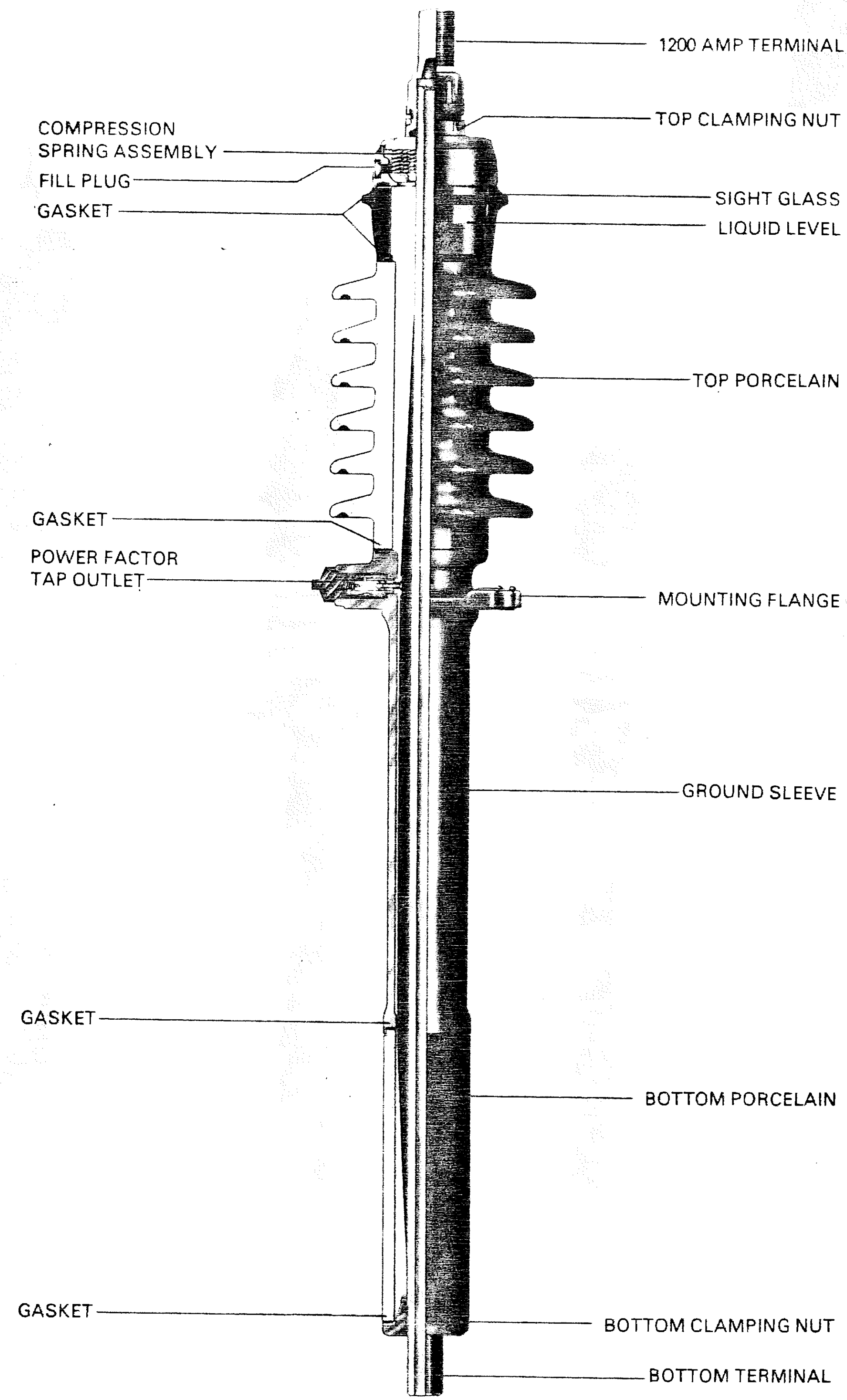


Fig. 2 Sectional view of 34.5 kv Type U bushing

INTRODUCTION

These instructions apply to a series of Type U bushings which comply with the mechanical and electrical characteristics of the American National Standards Institute standards for transformer and circuit-breaker bushings in the range from 23 kv through 69 kv. A limited number of special bushings, which are constructed similar to the ANSI line, are also covered by this publication.

The Type U bushing, Figs. 1 and 2, has an oil-impregnated paper-insulated core with a multiplicity of electrodes (Rescon* equalizers) embedded in the paper for proper distribution of electrical stresses. The core, after extensive vacuum treatment and oil impregnation, is immersed in high dielectric strength transformer oil inside a center-clamped, gasket-sealed structure consisting principally of a top porcelain, a ground sleeve, a bottom porcelain and the necessary spring-loaded, center-clamping hardware. Sufficient clamping pressure is applied in the factory to make these assembled outer parts a sealed housing for the core and the immersion oil, and for a nitrogen gas cushion above the oil level.

UNPACKING

Bushings are shipped ready for installation. As soon as a bushing is received, open the shipping crate or box carefully to avoid damage, and examine the bushing for any damage incurred during shipment. If damage or rough handling is evident, file a claim with the transportation company, and notify your General Electric Sales representative immediately.

Note the oil level as explained under the heading "Liquid Level Indication"; and examine the surface of the porcelain for small breaks or cracks which might cause leakage later, but which will not immediately affect the oil-level indication.

HANDLING

The bushing can be lifted from a horizontal position or from a vertical crate by the use of a rope sling placed under the top petticoat of the top porcelain.

STORING

A Type U bushing can be stored outdoors in the shipping crate for short periods. For long term storage, it should be in a vertical position.

Horizontal storage for short periods is permissible since the normal time associated with installation is sufficient to allow the nitrogen gas cushion above the oil level to return to the proper location. However, if proof-testing overvoltage is to be applied, rock the bushing to release any entrapped nitrogen. Then keep the bushing vertical for 48 hours prior to testing.

If a bushing must be stored for long periods in a horizontal position, adequate oil coverage of the core insulation should be provided by elevating the top end.

*-Registered trade-mark of G. E. Co. for semi-conducting material

INSTALLATION

CLEANING

Before installing the bushing, wipe the porcelains with a cloth to remove dust and dirt accumulated during transit and storage.

MOUNTING

Inclined Bushings

Bushings may be positioned in any convenient angular alignments up to 60 degrees from vertical. In

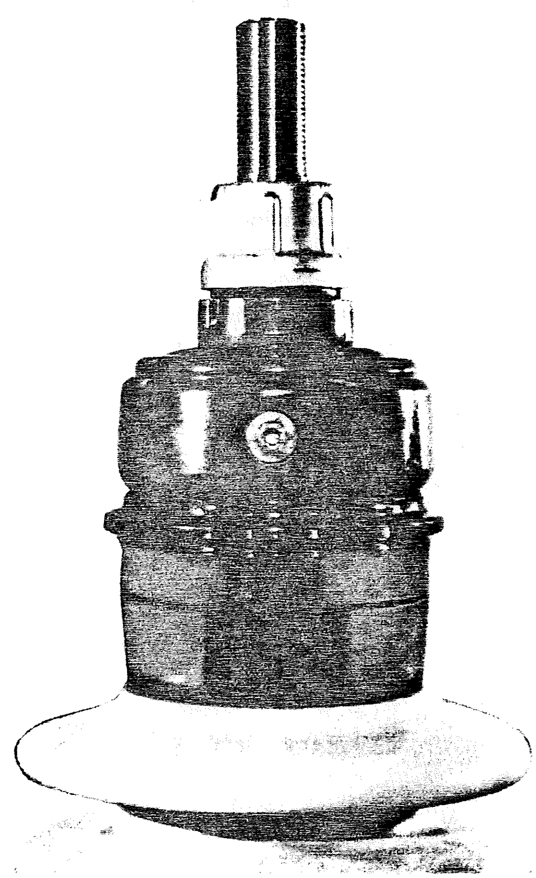
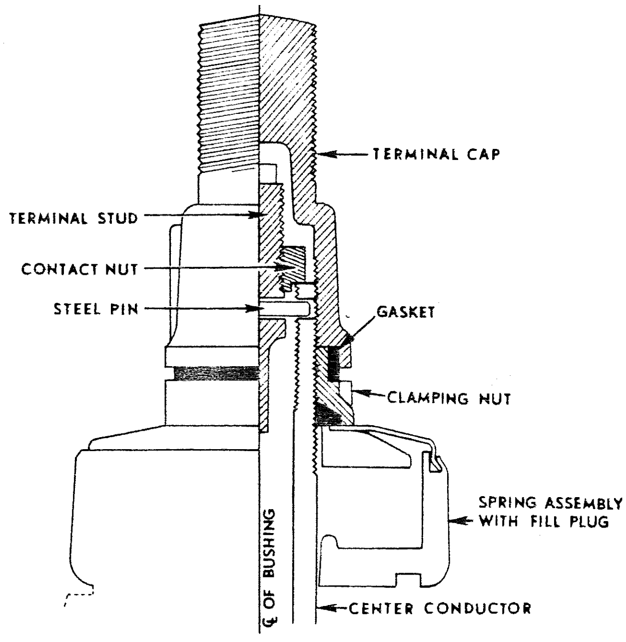
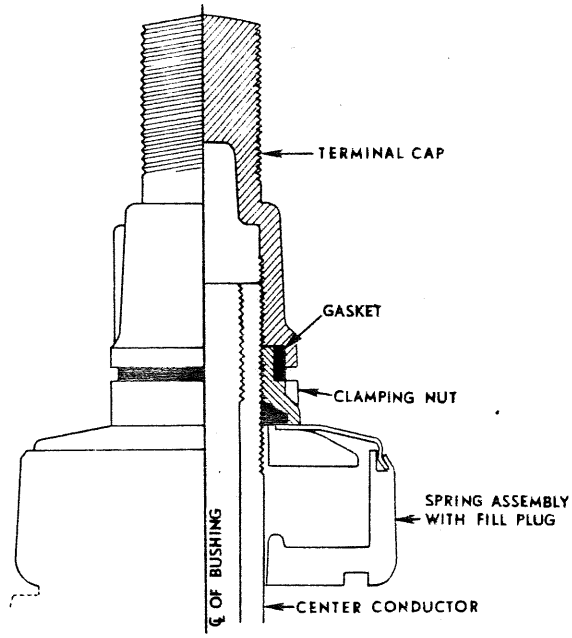


Fig. 3 Typical dome of 23 kv-69 kv Type U bushing. Liquid level indicated in sight glass by apparent change in conductor size



A. Draw-lead connected (400 amp)



B. Bottom connected (1200 amp)

Fig. 4 Top end construction for 400/1200 ampere, Type U bushing

the case of a few special 69 kv bushings with liquid-level gages, mounting should be done so that the liquid-level gage faces the lowest point of the top end.

Bolting

Tighten the mounting bolts a fraction of a turn at a time, working progressively in one direction around the bolt circle until all bolts are uniformly tight. Tighten sufficiently to seal the bushing to the apparatus. Normally, the torque values as listed below will provide adequate gasket compression for sealing.

SIZE OF BOLT Inch-Thread	TORQUE Foot-Pounds
½-13	25 (34 n.m)
⅝-11	30 (41 n.m)

LIQUID LEVEL INDICATION

The oil level in the bushing is adjusted in the factory to the normal level at approximately 25C. Unless there is subsequent mechanical damage to the bushing, which results in loss of oil, the filler level should be satisfactory for the life of the bushing. Since fluctuations in oil level will necessarily occur with changing temperatures, the column of oil in the bushing is topped with a compressible cushion of nitrogen gas to fill any space left by a varying amount of oil.

Except for a few special bushings, all are equipped with an amber-tinted, extra-heavy-walled sight glass as shown in Fig. 3. The actual oil level is visible through the glass and is readily distinguishable by the apparent magnification of the center conductor below the oil surface. On bushings rated 23 kv thru 46 kv, the normal liquid level is at the mid-point of the sight glass. On 69 kv bushings, the normal liquid level is 1/2-inch (13 mm) below the mid-point of the sight glass. A bushing is considered to have a satisfactory liquid level when any amount of oil is visible in the sight glass.

CONNECTIONS

INTERNAL ELECTRICAL CONNECTIONS

The method used in making connections between a bushing and the apparatus on which it is mounted will depend upon the type of connection used in the apparatus.

DRAW-LEAD CONNECTED BUSHINGS

Bushings with a current rating of 400 amperes are designed with a hollow core through which a flexible cable can be pulled. The cable is considered a component of the transformer on which the bushings are mounted and is not supplied as a part of the bushing.

Refer to Fig. 4A. Remove the terminal cap, the steel pin, brass nut, and the stud. Pass a wire or cord through the bushing core and attach it to the hole in the top end of the terminal stud on the flexible transformer cable. Lower the bushing into the opening in the cover, simultaneously pulling the cable up through the core. Secure the cable terminal stud to the center conductor by replacing the steel pin and threading on, and tightening, the brass nut. Coat the gasket with a thin film of light oil, and assemble it in position. Screw the terminal cap onto the center conductor until the cap makes a metal-to-metal seat on the clamping nut. Avoid excessive tightening since it will only bend the steel pin.

BOTTOM-CONNECTED BUSHINGS

Bushings rated 1200 amperes and higher are designed so that the core is the conductor. A circuit-breaker interrupter or transformer terminal may be connected to the threaded extension of the core. Refer to Fig. 4B.

EXTERNAL ELECTRICAL CONNECTIONS

External connections to the bushing must be sufficiently slack or flexible to avoid putting a mechanical strain on the bushing parts.

Terminal connectors should be of ample size to keep the bushing terminal temperature below 70C at rated current. The use of even more generously sized connectors is recommended to minimize bushing overheating during possible overloads.

POWER FACTOR MEASUREMENT

The outlet shown in Fig. 5 is located just above the mounting flange and provides a convenient means for making power factor measurements by the ungrounded specimen test (UST) method. In order to connect to the tap outlet, remove the threaded cap and connect the UST lead of the power factor measuring equipment to the terminal spring.

Reassembly of the sealing cap after the testing has been completed will ground the power factor test tap for proper operation of the bushing.

Many bushing users make it a practice to measure the UST power factor at the time of installation. This practice is endorsed by the General Electric Company and discussed in more detail under "Maintenance."

DO NOT APPLY VOLTAGE TO THE BUSHING WITH THE POWER FACTOR TAP CAP REMOVED, EXCEPT WHEN MEASURING POWER FACTOR. IF UNGROUNDED, THE TAP VOLTAGE WILL EXCEED THE INSULATION DIELECTRIC STRENGTH; THUS, RESULTING IN FLASHOVER. THE VOLTAGE ON THE POWER FACTOR TAP MUST BE LIMITED TO ONE KV FOR REVERSE UST TESTS.

TRANSFORMER-BREAKER INTERCHANGEABLE (TBI*) BUSHINGS

An outstanding feature of this line of bushings is the fact that a 1200 ampere, 16-1/2-inch (419 mm) EL, bottom-connected bushing (ANSI for oil circuit breakers) is also a 400 ampere, 21-inch (533 mm) EL,

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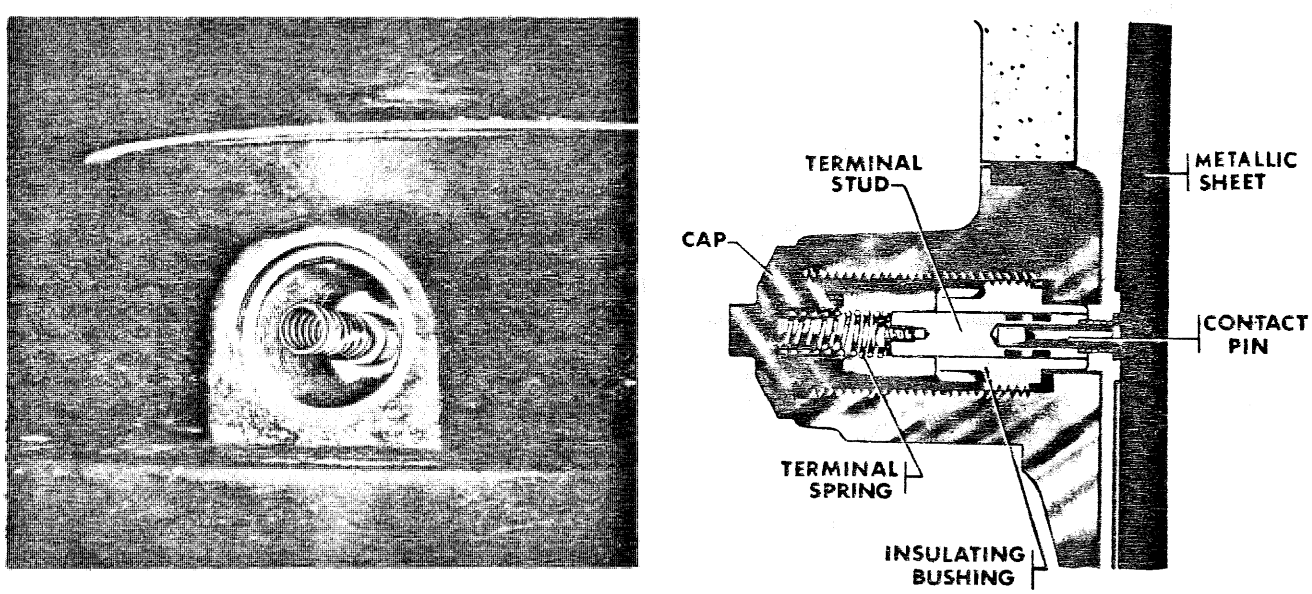


Fig. 5 Power factor tap outlet

draw-lead connected bushing for transformer use, and (with approval of the apparatus manufacturer) may usually be used as an ANSI transformer bushing. See Table 1.

CONVERSION

A series of photographs, (Fig. 6) shows the step-by-step procedure for conversion of a bushing used on a circuit breaker to one used on a transformer. Proceed as follows:

1. Remove the top terminal cap.
2. Pull up the transformer draw lead with attached stud.
3. Insert the cross pin.
4. Thread on contact nut, and tighten.
5. Assemble the terminal cap with its gasket.

AMPERE RATINGS

Interchangeable bushings are available in current ratings of 400/1200 amperes. ALL DRAW LEAD TYPE BUSHINGS ARE LIMITED TO OPERATION AT 400 AMPERES.

Examination of the illustration (Fig. 4) will show the current path from the conductor to the terminal cap.

In the case of draw-lead accessories, the current flow is from the transformer draw lead to the stud, through the threads to the contact nut and through the center conductor threads to the terminal cap. This current path is limited to 400 amperes.

In the 1200 ampere, bottom-connected bushing, the current flow is up the center conductor of the bushing, through the threads and into the terminal cap.

The nameplate lists two current ratings. The 400 ampere rating is maximum for draw lead application and the 1200 ampere rating is maximum for bottom end connected application.

DRAW-LEAD TERMINAL STUD

The draw-lead terminal stud, Fig. 7, used in TBI bushings is of the same general type used throughout the industry for many years. Unfortunately, all such studs are not identical in length. Due to the limited clearances of this line of bushings, the length of the threaded, draw-lead stud is critical. The critical dimensions of the stud furnished with the bushing are shown in Fig. 7. Any stud that complies with the dimensions shown can be used.

NAMEPLATE DATA

Nameplate data can be of special importance in answering questions about bushings.

The handling of all requests will be expedited if the factory is furnished the serial number, the catalog number, and the year of manufacture as stamped on the bushing nameplate. IT IS ABSOLUTELY NECESSARY FOR THE FACTORY TO HAVE AT LEAST THE SERIAL NUMBER.

The catalog number identifies the bushing by type and rating. In most cases, the catalog number stamped on the nameplate will include a group designation; i.e. Gr. 1, Gr. 2, etc. The group number is of importance only to the factory and indicates minor design changes. All bushings of the same catalog number are completely interchangeable, regardless of the group number.

The class symbols identify certain characteristics of the bushing to the factory. There should be no concern about them.

A careful record should be kept for the interchangeable bushings. Complete information about the application of the bushing must be given in any correspondence with the factory concerning the bushings.

TABLE I TYPE U BUSHINGS

TBI

KV	AMPERES	CAT. NO.	REMARKS
23	400/1200	7B522	16½-inch (419 mm) EL for Breakers.
34.5	400/1200	7B532	
46	400/1200	7B542	21-inch (533 mm) EL permitted for Transformers.
69	400/1200	7B590	

NON-ANSI

KV	AMPERES	REMARKS
23-34.5	2000 and 3000	17.75-inch (451 mm) EL OCB application
23-34.5	2000 and 3000	21-inch (533 mm) EL Transformer application
69	2000	16½-inch (419 mm) EL OCB and Transformer application

ORDERING ACCESSORIES

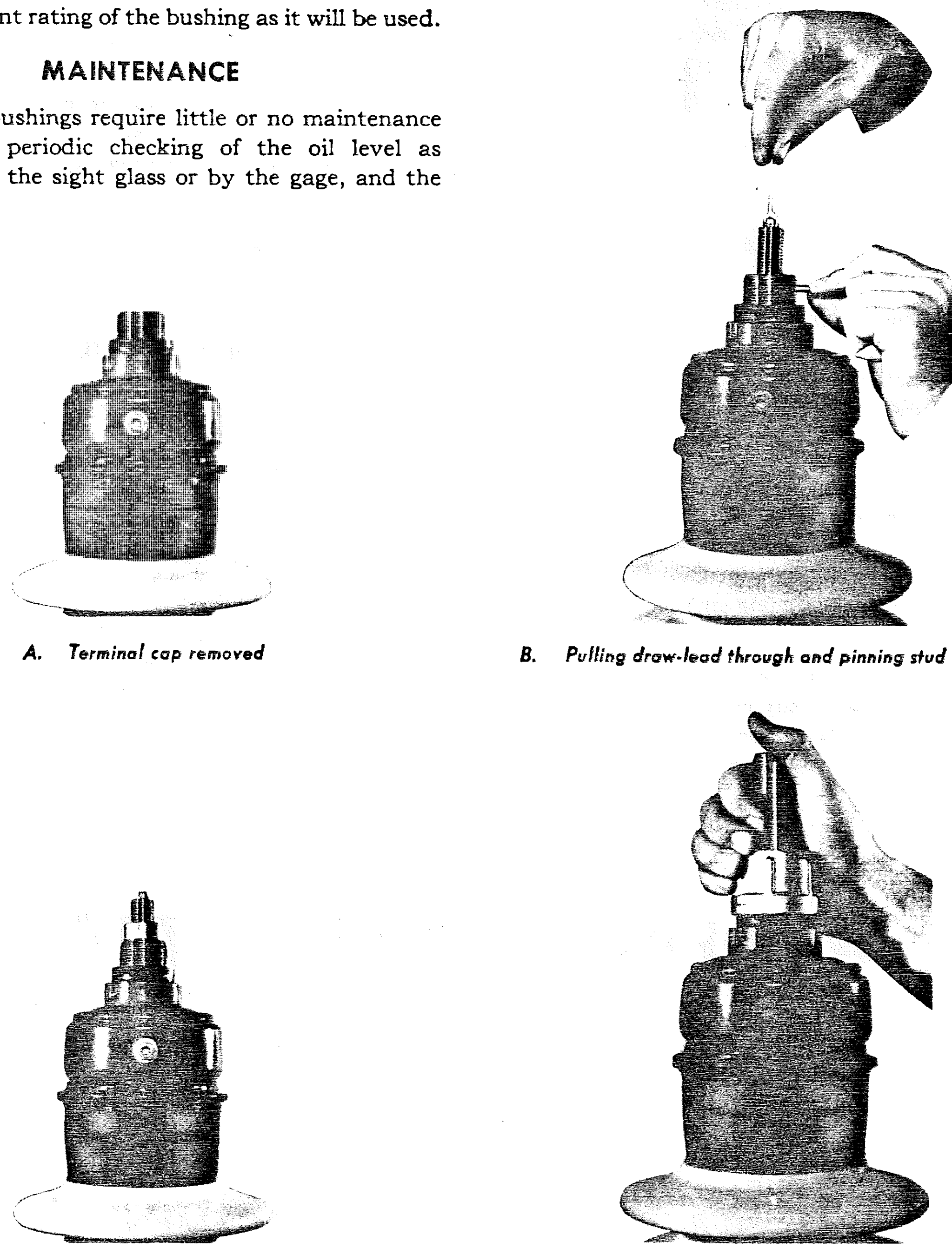
Accessories for conversion purposes may be taken from bushings being replaced in the field, or may be ordered from the factory. In ordering, give the following information:

1. Catalog number of the bushing being converted.
2. Type of apparatus on which the bushing will be used.
3. Current rating of the bushing as it will be used.

MAINTENANCE

Type U bushings require little or no maintenance other than periodic checking of the oil level as indicated in the sight glass or by the gage, and the measuring of the power factor. Bushings exposed to salt spray, cement dust and other abnormal deposits are subject to a special hazard and must be cleaned regularly to prevent flashover.

The sight glass transparency may become impaired due to reaction with atmospheric contaminants and should be regularly cleaned to deter this reaction. In the



A. Terminal cap removed

B. Pulling draw-lead through and pinning stud in place

C. Contact nut threaded on terminal stud

D. Assembling terminal cap

Fig. 6 Converting bushing from circuit breaker to transformer use

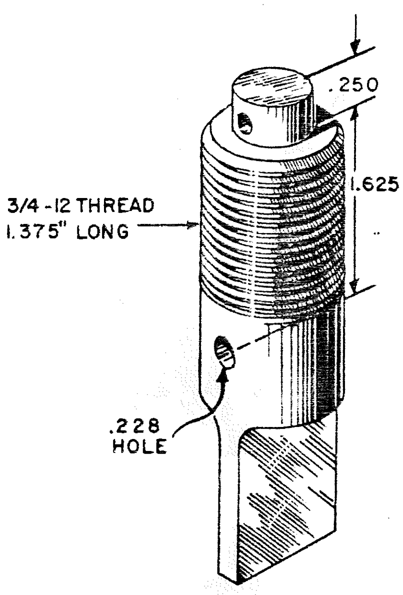


Fig. 7 Terminal stud

event that the sight glass does become opaque, it must be replaced in order to maintain visual contact with the oil.

Should it become necessary to add oil to a bushing, the fill plug in the spring assembly can be removed. Insertion of a clean standpipe, with an outside diameter of slightly less than the diameter of the hole, will provide a means of adding small quantities of oil to the bushing.

Since inconvenient service interruptions result from bushing outages, many users have programs of Planned Preventive Maintenance. The General Electric Company endorses such programs and recommends:

1. Measurement of UST power factor and capacitance at time of installation. Such measurement is a good first point for comparison with future readings since it correlates test data made under the variable conditions encountered in field measurements with those made under controlled conditions in the factory.
2. Continued measurement of UST power factor and capacitance at various intervals depends upon the importance of the particular installation and the data accumulated on the bushing. A steadily increasing pf or capacitance is cause for concern; an increase in pf of 1.5 percent, or an increase in capacitance to 110 percent of the original value, is cause for corrective action. General Electric publication GET-908 should be consulted for more detailed information on bushing maintenance.

FIELD REPAIR

The General Electric Company recommends that any repair of Type U bushings be done in the factory because of the danger of contamination to the insulation should the seal be broken. In addition, the very high vacuum and clamping pressures required necessitate the use of equipment not usually available in a service shop.

Any damage to a bushing which might make repair either desirable or necessary should be reported in detail. DO NOT ATTEMPT TO REPAIR A TYPE U BUSHING WITHOUT SPECIFIC RECOMMENDATIONS FROM THE GENERAL ELECTRIC COMPANY.

GENERAL ELECTRIC

POWER TRANSFORMER DEPARTMENT
PITTSFIELD, MASSACHUSETTS 01201

9-79 (3M)

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INSTRUCTIONS

GEH-2020F

Supersedes GEH-2020E

BUSHING CURRENT TRANSFORMERS

TYPES BR-B and BR-C

CONTENTS

GENERAL ELECTRIC

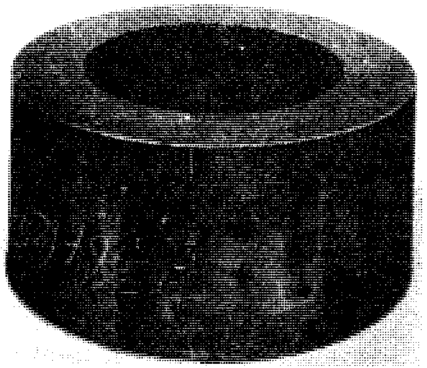


Fig. 1A Core Edge Insulation and Supports

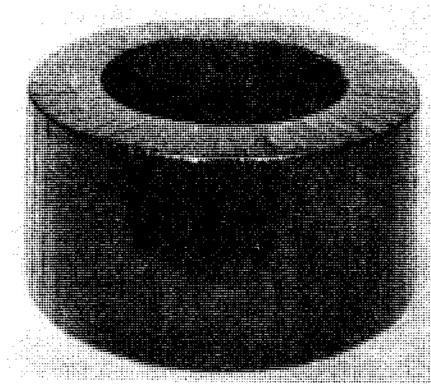


Fig. 1B Layer of Polyvinyl Tape

Fig. 1 (8024851)
Fig. 1 (8024856)

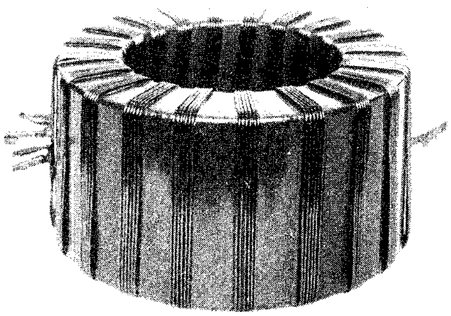


Fig. 1C 6-20 Turn Loops Distributed About Transformer

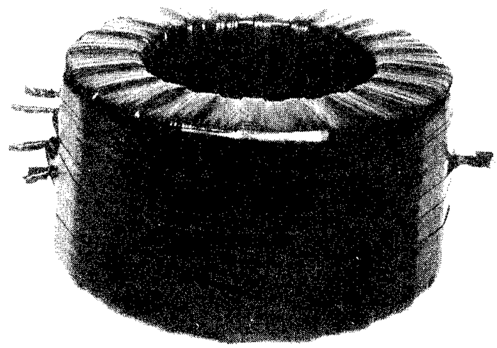


Fig. 1D Polyvinyl Tape Over Winding

Fig. 1C (802 53)
Fig. 1D (802 55)

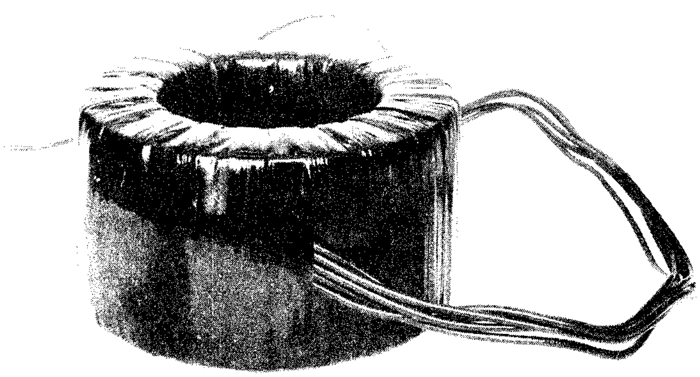


Fig. 1E Fiberglass Insulation

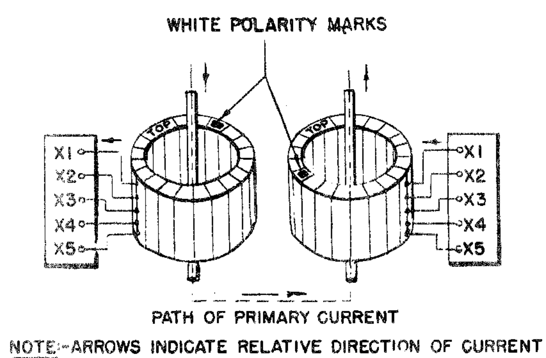


Fig. 2 Typical Arrangement of Two Transformers on One Pole of a Breaker

Fig. 1E (8024854)
Fig. 2 (K-6579950)

BUSHING CURRENT TRANSFORMERS
TYPES BR-B and BR-C

INTRODUCTION

Bushing current transformers Types BR-B (for outdoor oil-blast circuit breakers) and BR-C (for station type equipment) are employed as a means of providing a source of current supply for operating protective relays and breaker trip coils. These transformers, except those used for station equipment rated above 2000 amperes, are available with a multi-ratio winding, so that a choice of ratios is available as prescribed by NEMA SG 4-310, Fig. 3.1 (Revised 11/68). Transformers for station equipment rated above 2000 amperes are single-ratio.

These transformers have inherent limitations in their accuracies effected by the restriction of the one turn primary (bushing stud). The accuracy limitations of the transformer are not too severe for relaying service, and it is only necessary to check mathematically, as described under APPLICATION, to make certain that the rating of the transformer is not exceeded.

The rating of the transformer is determined by the application for which it is being employed. This rating defines the primary current (equipment rating) and the secondary current (induced current of the transformer) in accordance with the ANSI and NEMA standards. In addition, an accuracy class is given to each transformer. This class defines the maximum voltage that the transformer can develop on the full winding, with 20 times rated current, without exceeding a 10 percent error. From this information the maximum secondary current is thus defined in terms of the desired burden. An explanation of the method used in determining the class may be found under APPLICATION.

The transformer will safely carry a continuous secondary current of rated value and momentary overload currents equal to that of the equipment in which it is installed.

RECEIVING, HANDLING AND STORAGE

RECEIVING

Bushing current transformers are usually shipped completely assembled in the apparatus except when ordered as supply parts. Framework-mounted breakers usually have the bushings and transformers installed, while floor-mounted breakers usually are shipped with the bushing crated separately but with the transformer installed in the operative position. All transformers are assembled and tested completely at the factory. Each supply transformer is carefully inspected and packed by workmen experienced in the proper handling and packing of electrical equipment. Immediately upon receipt of a transformer, an examination should be made for any damage sustained during shipment. If injury or rough handling is evident, a damage claim should be filed at once with the transportation company, and the nearest General Electric Apparatus Sales Office notified promptly.

Fig. 3 (K-6557060)

Fig. 3 Method of Handling the Bushing Current Transformer

HANDLING

The crating or boxing must be removed carefully when uncrating supply transformers to avoid driving the wreck bar into the transformer, thus damaging

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.

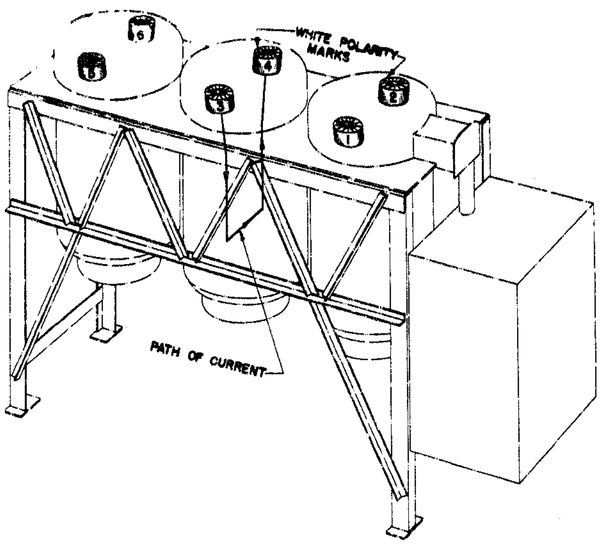


Fig. 4 Arrangement of Type BR-B Bushing Current Transformers in an Outdoor Oil Circuit Breaker

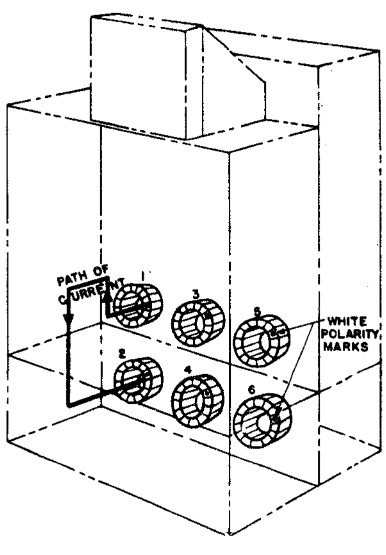


Fig. 5 Arrangement of Type BR-C Bushing Current Transformers in a Station Type Cubicle

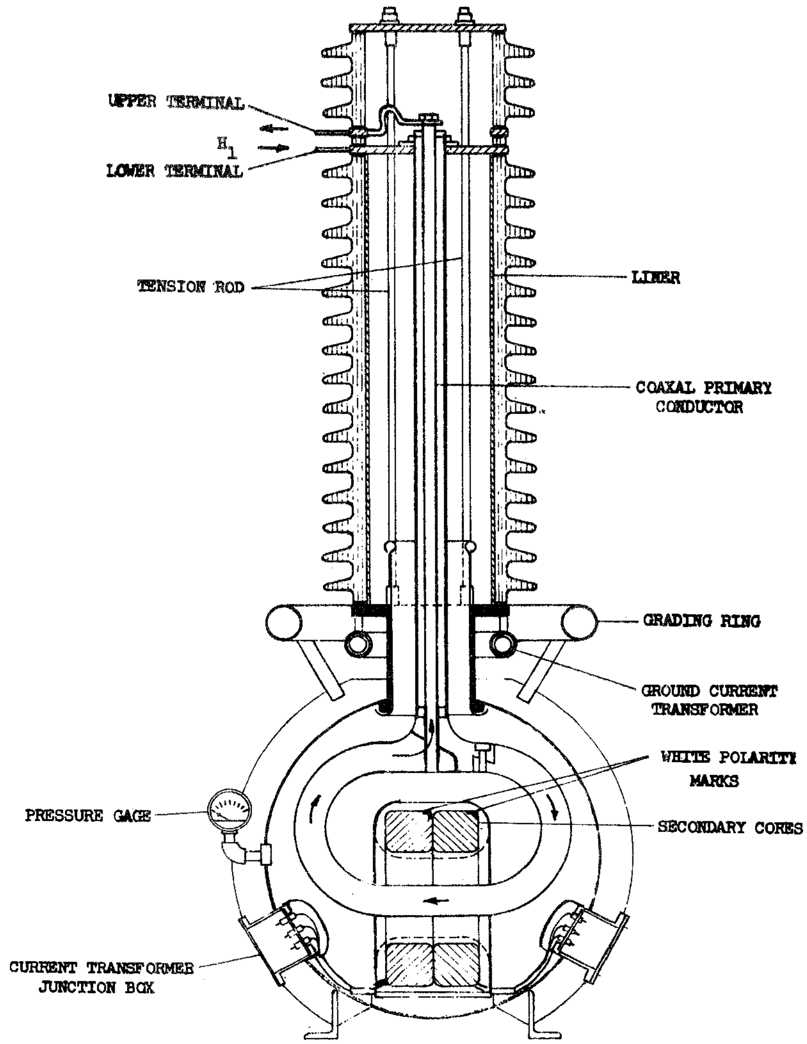


Fig. 6 Arrangement of Type BR-B Bushing Current Transformers in a Type ATB Air-blast Circuit Breaker

Fig. 4 (H-641' ?7) Fig. H-6249406) Fig. 6 (0138A6604)

the windings. The use of a nail puller is recommended to eliminate this danger.

After unpacking, the transformer should be checked for moisture. If it is detected, the transformer should be heated with dry air at a temperature not in excess of 80° C.

A method of handling the transformer is suggested by Fig. 3. Whatever method of handling is employed, care should be taken to keep the transformer flat at all times. If the transformer is handled in such a manner as to deform the shape, it will result in an increase in excitation current.

STORAGE

If the transformers are to be stored for any great length of time prior to usage it is advisable to put them in a dry location. Under no condition should they be left outside exposed to the weather. Bushing current transformers should be stored lying on their flat sides. If they are stored setting on their round sides for any length of time, it will tend to distort their shapes.

DESCRIPTION

The Type BR bushing current transformer consists of a ribbon-wound core of high-permeability low-low silicon steel on which copper wire is wound to form the secondary winding.

The winding is of the distributed type, having the first twenty turns equally distributed over the circumference of the core. The next distribution is wound adjacent to the first, on the same layer as the first. This distribution gives the transformer a low leakage reactance, thus maintaining a high degree of accuracy when the transformer is subject to overload currents. The winding may be tapped to obtain multi-ratio characteristics as shown in Fig. 2. The general construction of the transformer is clearly shown in Fig. 1.

When the number of secondary turns necessitates winding the secondary in several layers, polyvinyl chloride tape is used as insulation between the layers.

For uniformity of application and positive identification of the leads from the various taps, each lead is identified by a tag marked X1, X2, X3, X4 or X5.

INSTALLATION

LOCATION

The transformers are located in a housing of the outdoor breaker top frame, as shown in Fig. 4, in the indoor cubicle, as shown in Fig. 5, or in outdoor air-blast breakers, as shown in Fig. 6. The bushing, the stud of which constitutes the primary winding, passes through the center of the transformer.

Figs 4 and 5 show the method used for numbering the bushing transformers for identification in multi-pole breakers, a triple-pole breaker with a transformer for each of the six bushings being shown. When fewer transformers are used, the same relative position numbers are used, such as one transformer per pole, for a triple-pole breaker, may be 1-3-5, or 2-4-6. When more than six transformers are used, the location numbers follow the same order, up to a maximum of 12 as shown on the typical connection diagram, Fig. 7. Location numbers always designate the same position regardless of the total number of transformers installed.

MOUNTING

The transformers may be placed in their respective locations by the method suggested in Fig. 3. Insulation washers are to be placed above and below the transformer and sheet insulation around it to protect it from injury. Full instructions are provided in the breaker instruction book regarding the exact details.

The polarity of these transformers is subtractive, as shown in Fig. 2. With any combination of taps, the tap numerically nearest terminal X_1 has the same polarity as X_1. To retain this polarity it is imperative that the transformer be installed with the white polarity mark as shown in Figs. 4 or 5.

CONNECTIONS

All secondary leads are brought out from their transformers to terminal boards mounted either on the transformers, on the frame of the apparatus, or in the mechanism house, see Fig. 7. The method of bringing out the leads varies and for these details refer to the power circuit breaker instruction book. Not under any condition should more than two, or less than two, leads be connected externally to the terminal block except when a change of burden or ratio is being made. Always short circuit the secondary of the transformer by a jumper across the winding before making the change and be sure to remove the jumper when the change has been completed. It is usually desirable to ground one corresponding lead of each transformer for safety purposes. Always refer to the approved wiring diagram furnished separately with the equipment.

INSPECTION

After the transformer has been installed and all connections made, the following test should be made to ensure proper polarity, proper connections, and continuity of circuit.

1. Test for accidental ground as described under INSULATION RESISTANCE.

2. Test for continuity of connections and proper polarity by connecting a d-c millivoltmeter or milliammeter across the bushing stud with the positive terminal post of the instrument connected to the "white polarity" end, as shown in Fig. 8, and touch a three volt dry cell between all combinations of secondary leads. The instrument should deflect in a positive direction when the positive side of the battery is nearest X_1 and, conversely, it should deflect in a negative direction when the negative side of the battery is nearest X_1 for correct polarity.

3. The continuity of the external relay circuit should be checked to see that neither an open circuit nor a short circuit exists. The continuity of the transformer winding is automatically checked by Test 2 above.

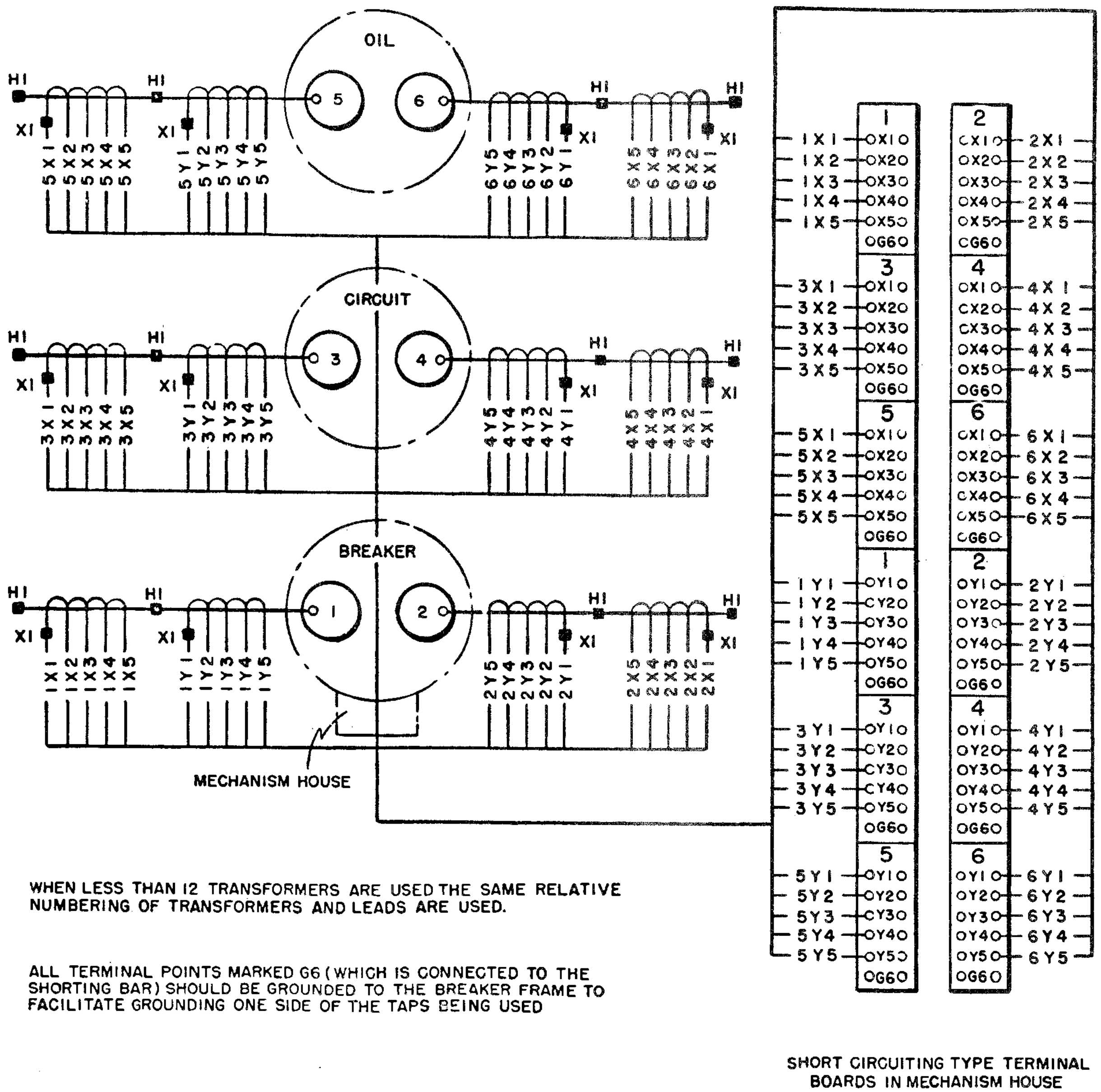


Fig. 7 Typical Connection Diagram for Bushing Current Transformers
(Refer to connection diagram supplied with breaker for relative position of transformers on the bushings.)

Fig. 7 (251C648) Rev 1

APPLICATION

EXCITATION CHARACTERISTICS

Ratio and phase-angle errors of any current transformer are caused by the excitation demands of the iron core. A part (a component) of the primary current is utilized to magnetize the core and to supply the core losses, with the result that the secondary current is less than the transformer-turn ratio would indicate. The excitation component of the primary is dependent upon the size and properties of the core, the number of secondary turns, the magnitude of the secondary burden and the amount of primary current. The errors can be calculated once the excitation characteristics of the core are known.

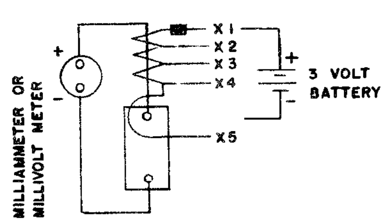


Fig. 8 Connections for Testing the Polarity of a Bushing Current Transformer

Fig. 8 (K-6579951)

EXCITATION CURVE

The excitation curve is a graphic representation of the excitation characteristics of the bushing current transformer. Data obtained from this curve can be used to calculate the performance of the current transformer under various conditions of burden, secondary turns and primary current. Fig. 9 shows a typical excitation curve as supplied with a Type BR transformer. These curves are given on log-log paper in accordance with NEMA standards.

RATIO-CORRECTION-FACTOR

The ratio error as calculated from the excitation curve is usually expressed by a term defined in the ANSI standards as Ratio-Correction-Factor (RCF) which is the factor the marked (or normal) ratio must be multiplied by to obtain the true ratio. This may be given as equal to the quotient of the actual primary current and the product of the secondary amperes times the secondary turns. That is, $RCF = I_p/NI_s$ or it can be expressed as the true ratio divided by the normal ratio.

RATIO-CORRECTION-FACTOR CURVE

The RCF curve is a graphic representation of the errors of the bushing current transformer for a particular burden, number of secondary turns, and frequency. When drawn on the special coordinate paper, not only the RCF for various values of primary and secondary current, but also the primary current corresponding to a particular value of secondary current or the secondary current corresponding to a particular value of primary current, can be read directly from the curve. Fig. 10 shows a typical RCF curve with a two ohm burden.

For example, from Fig. 10 find the secondary current corresponding to a primary current of 100 amperes on the 20 turn tap or 100 percent primary current. From the point where the primary ordinate (the curved solid line at 100 percent) intersects the RCF curve on the

Fig. 9 (369A102AJ) Sht. 1

Fig. 10 (369A102AJ) Sht. 2

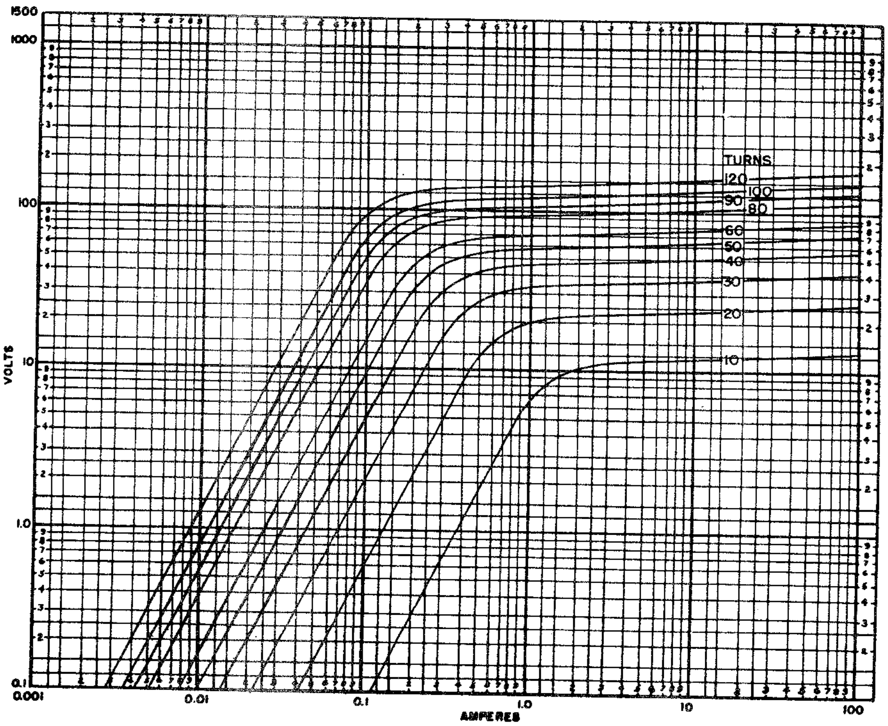


Fig. 9 Typical Secondary Excitation Characteristic Curves for Type BR, 120 Turns, 60 Cycles, C100. Secondary Resistance, 0.0023 Ohm per Turn Plus 0.0215 Ohm per Lead

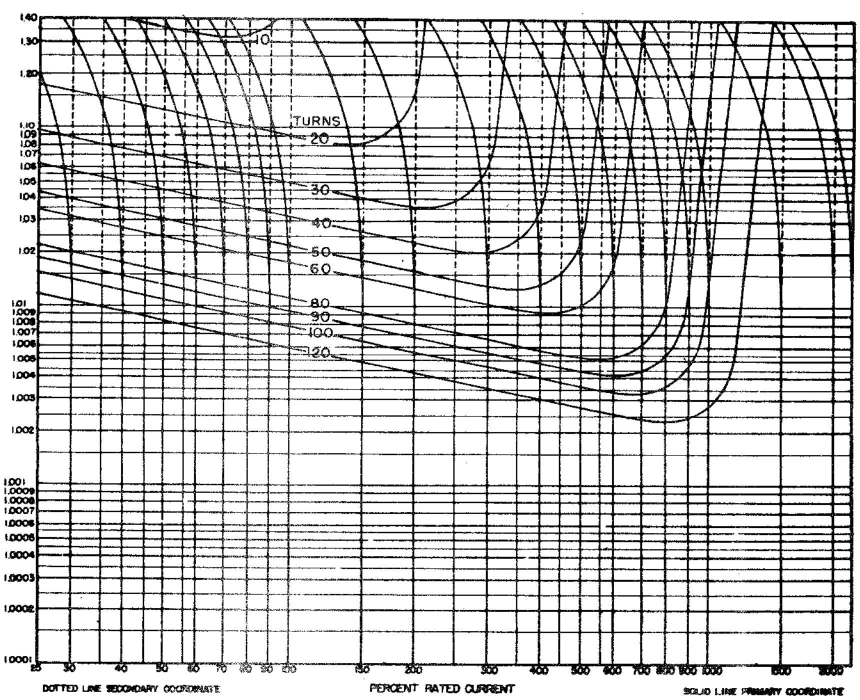


Fig. 10 Typical Ratio Correction Curves for Type BR, 120 Turns, 60 Cycles, with a B2 (2 Ohm) Burden. Excitation Characteristics of Fig. 7

tap involved, read directly down on the dotted line a percent rated secondary current of 93 percent or 4.65 amperes. The procedure would be reversed to find the primary current corresponding to a particular value of secondary current.

CHOICE OF RATIO

The proper choice of ratio can be obtained from the column of Table I that is headed by the rating of the transformer involved at a tap that will give a secondary current of the desired magnitude to operate the burden devices from the available primary current. The burden must not be so large for the tap involved that the saturation voltage of the transformer is exceeded within the desired operating range. This saturation voltage occurs at a definite flux density and is proportional to the secondary turns as can be seen by reference to the excitation characteristics of Fig. 9. If successful relay operation is desired, this point should not be exceeded. Generally speaking, the greater the burden the larger the ratio error and likewise the greater the nominal ratio the smaller the ratio error. It will be noted from the ratio characteristics of Fig. 10 that here is a gradual decrease in RCF up to a point that corresponds to saturation voltage and then a sudden rise that represents very little increase in secondary current.

DETERMINATION OF CLASS

The ANSI standards give each transformer a class based on the transformer's load-carrying ability. The class is expressed in terms of the secondary voltage that the transformer will develop without exceeding a 10 percent error in ratio at 20 times normal current on the full winding. This means, for a transformer with a standard five-ampere secondary, that the exciting current cannot be in excess of 10 percent of 20 times the normal current of five amperes, namely, 10 amperes. By these standards the transformer of Fig. 9 would be given a classification of C100. The C stands for a low-leakage impedance bushing current transformer with a calculated ratio in contrast with T for the high-leakage impedance wound-type instrument transformer with a ratio determined by test, and the 100 denotes the developed secondary voltage. Each transformer must fit into one of the following voltage classifications, 50, 100, 200, 400 or 800, such that it gives a voltage classification based on the figure that is immediately lower than that which it develops. From Fig. 9, it is apparent that at 10 amperes the transformer develops 156 volts on the full winding of 120 turns.

The internal drop of the transformer must be deducted from this voltage. For the transformer in Fig. 9, this is equal to 27.5 volts (0.0023 ohms per turn) times 120 (total number of turns) times 100 amperes (20 times rated current). This gives a voltage, at the taps, of 128.5 volts (156-27.5 volts drop) and the transformer would therefore be classed as C100.

The maximum secondary load impedance is also defined by the class. For this transformer the maximum secondary load impedance is one ohm (100 volts rated divided by 100 amperes) if the transformer is to operate within the accuracy class specified.

CALCULATION OF CHARACTERISTICS

All calculations for the application of bushing transformers are based on the ampere-turns, and since there is only one turn in the primary, the number of primary ampere-turns is the same as the primary amperes. The relationship of the primary ampere-turns to the exciting and to the secondary ampere-turns is in reality a vectorial one. For most calculations this may be considered arithmetical because the majority of relays have windings that impose burdens of large lagging phase-angles, nearly or approximately in phase with the exciting current component in the transformer. The additional burden of the internal secondary leads and of the internal impedance of the transformer will be at unity power factor, but these are generally so small in relation to the main burden that their differences in phase-angle can be neglected. The results so calculated will indicate ratio characteristics somewhat more pessimistic than would be obtained actually, but the resultant accuracy is usually within the limits of acceptability and the more complicated vectorial method is not warranted.

CALCULATING PROCEDURE

The steps necessary in calculating the transformer characteristics require a knowledge of the total burden and the use of the excitation curve. The calculations are based on

(1) computing the necessary secondary voltage to force the desired secondary current through the total burden,

(2) finding the exciting current required to produce this secondary voltage from the excitation curve (this exciting current represents the error current on a secondary basis),

(3) adding the exciting current arithmetically to the secondary current, both being expressed in ampere turns, to obtain the primary current required to produce the desired secondary current in the burden.

These steps can be expressed mathematically as follows:

(1) $E_s = I_s Z_b$

(2) I_e obtained from excitation curve, Fig. 7, at E_s on tap N

(3) $I_p = N (I_s + I_e)$

$RCF = I_p/NI_s = 1 + I_e/I_s = \%I_p/\%I_s$ where

$\%I_p = 20I_p/N = RCF\ (20)I_s$ and $\%I_s = 20I_s$

I_s = desired secondary current

I_e = exciting current on a secondary basis

I_p = required primary current

Z_b = Total secondary burden*

N = Actual secondary turns

*The total secondary burden is to include the external burden of relays, meters, and secondary leads (which can be obtained from the manufacturer) and the internal burden of secondary winding which is given on the excitation curve in ohms per turn plus ohms per lead.

The formulas apply generally but special consideration must be given each problem so that all factors are considered. Such problems as ground relaying, where all the transformers are effectively in parallel across the ground burden, result in a three-fold increase in the ratio errors. A problem involving a-c current trip requires that two conditions be investigated as

(1) relay operation with the relaying burden and

(2) trip coil operation with the added burden of the trip coil.

Sample Calculation

Find the RCF at five times normal secondary current (500% I_S), at 60 cycles, of the transformer of Figs. 9 and 10, on the eighty turn tap, with a two ohm burden.

Z_b = External Burden + Tap Resistance + Lead Resistance

$= (1 + j\ 1.734) + 80\ (0.0023) + 2\ (0.0215)$

$= 1.226 + j\ 1.734 = 2.122$ ohms

I_s at five times normal = 5 (5) = 25 amperes

$E_s = I_s \quad Z_b$

$= 25\ (2.122) = 53.05$ volts

From Fig. 9 this corresponds to a secondary exciting current of 0.133 amperes

$I_p = N\ (I_s + I_e)$

$= 80\ (25 + 0.133) = 2010.64$ amperes

$RCF = I_p / NI_s$

$= 2010.64/80\ (25) = 1.0053$

This RCF of 1.0053 checks with Fig. 10 at a secondary current of 500%.

TEMPLATE METHOD FOR DRAWING CHARACTERISTICS

The template method offers a simple, direct, and easy-to-use method of showing graphically the characteristics of bushing current transformers. Either the excitation or ratio-correction-factor curve can be drawn complete for one burden and one ratio from the two calculations necessary to locate one point on the curve. It will be found to be a great timesaver over former methods, as it will make it possible to determine the performance of bushing current transformers within a few minutes.

Fig. 17 is a replica of the template used. This template is actual size and may be cut out and used for drawing the excitation and RCF curves in an emergency on curve paper sheets, Figs. 15 and 16. One edge gives the shape of the excitation curve and the other edge gives the shape of the RCF curves. In addition, a tabulation of constants has been included in Tables III and II of this instruction book for the transformers used in General Electric breakers and equipment of various types and ratings. These constants are the only data, other than the ratio and burden, that are needed.

The accuracy of the results obtained by this method is well within the limits necessary for most relay applications. In determining the constants for breakers of superseded designs, it is suggested that the serial number of the breaker, together with complete nameplate data, be referred to the General Electric Company for exact data on the current transformers involved.

The following instructions contain all the information necessary for drawing both the excitation and RCF curves with the template. An explanation of the curves and their applications may be found in previous sections of these instructions.

HOW TO DRAW THE EXCITATION CURVE

1. Solve the following formulas for E_s and I_e:

   $E_s = CN/20$

   $I_e = D/20N$

   E_s = Secondary voltage corresponding to point "P".

   I_e = Secondary exciting current of the transformer core corresponding to point "P".

   N = Number of secondary turns under investigation.

   C and D = Constants for a particular transformer, and are obtained from Table III for 60 cycles (for other frequencies multiply C and D by the factors given in Table II).

2. Plot the value of E_s (volts) and I_e (amperes) on the special coordinate paper, entitled "Excitation Characteristics".

3. Set the template so that reference point "P" corresponds to

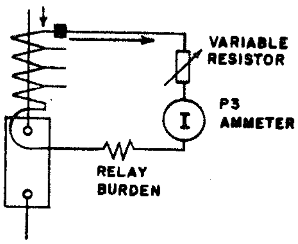


Fig. 11 Connections for the Removal of Residual Magnetism

the point plotted on the coordinate paper, and line it up horizontally by paralleling the lines on the template with the abscissa of the coordinate paper. The excitation curve will be the left and top edges of the template.

4. Draw the complete excitation curve, using the template as a guide. If the location of point "P" is such that the template does not permit the curve to be drawn to the limits of the paper, the straight-line part of the curve can be extended.

Example:

Find the 60 cycle excitation curve of the Type BR-B bushing current transformer used with a 14.4 kV, 600 ampere, oil-blast circuit breaker on the 40 turn tap.

Solution:

From Table III, C = 14 D = 222

E_s = CN/20
= 14 (40) / 20 = 28 volts

I_e = D/20N

= 222 / 20 (40) = 0.28 ampere

These points are plotted on the excitation coordinate paper; by the use of the template as a guide, the curve as given in Fig. 9 for 40 turns is obtained.

HOW TO DRAW THE RATIO-CORRECTION-FACTOR CURVE

1. Solve the following formulas for $\%I_S$ and RCF:

$$\% I_S = CN/Z$$

$$RCF = 1 + D/N (\% I_S)$$

$\% I_S$ = Percent rated secondary current (based on 5 amperes as 100 percent) corresponding to Point "Q".

RCF = Ratio-correction-factor corresponding to Point "Q".

N = Number of secondary turns under investigation.

Z = Secondary burden in ohms. This includes not only the external burden, but also the lead burden and the internal burden of the secondary winding, values for which are listed in Table III.

C and D = Constants for a particular transformer, and are obtained from Table III for 60 cycles (for other frequencies multiply C and D by the factors given in Table II).

2. Plot the values of $\% I_S$ and RCF on the special coordinate paper, entitled "Ratio Characteristics". If this point is outside the limits of the paper, extend the coordinate lines as far as necessary.

3. Set the template with its reference point "Q" corresponding to the point plotted on the coordinate paper and line it up horizontally by paralleling the lines on the template with the abscissa on the coordinate paper. The RCF curve will be the bottom and right edges of the template.

4. Draw the RCF curve using the template as a guide. If the location of "Q" is such that the curve cannot be drawn within the limits of the paper, the straightline portions of the template as well as the lines of the coordinate paper may be extended.

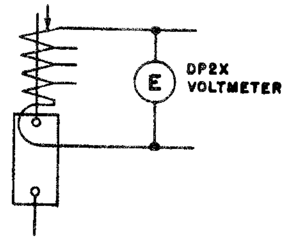


Fig. 12 Connections for the Checking of the Excitation Characteristics with Primary Current

Figs. 11 and 12 (K6579951)

Example:

Find the 60 cycle RCF curve of the Type BR-B bushing current transformer used with a 14.4 kV, 600 ampere, oil-blast circuit breaker on the 40 turn tap using a two ohm external burden.

Solution: From Table III,

Resistance per turn = 0.0023 ohms
Resistance per lead = 0.0215 ohms

C = 14 D = 222

Z = (1+j1.734)+40(0.0023)+2(0.0215)

= 1.135 + j 1.734 = 2.071 ohms

$\%I_S$ = CN/Z

= 14 (40) / 2.06 = 272 %

RCF = 1 + D/N ($\%I_S$)

= 1 + 222 / 40 (272) = 1.020

These points are plotted on the RCF coordinate paper; by the use of the template as a guide, the curve as given in Fig. 10 for 40 turns is obtained.

The ratio errors for the full range of primary currents are immediately available from this curve.

Figs. 13 and 14 (K6579951)

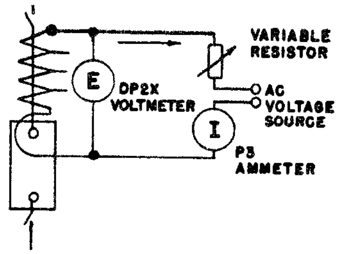


Fig. 13 Connections for the Checking of the Excitation Characteristics with Secondary Current

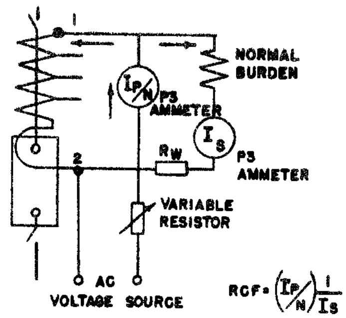


Fig. 14 Connections for the Checking of Ratio Characteristics. Note: R_W should equal resistance between points 1 and 2 through the Transformer

MAINTENANCE

Bushing current transformers generally will not require attention other than occasional inspection to see that all connections are clean and tight and that the leads have not been damaged. If the secondary of the current transformer has been accidentally opened when line current is flowing in the primary, an excessive peak voltage of many thousands of volts may be developed in the secondary that will magnetize the core and may possibly damage the insulation. This is why it was stressed in the first section of this book that great care should be exercised in changing burdens or taps to see that the secondary is not open circuited when primary current is flowing.

REMOVAL OF RESIDUAL MAGNETISM

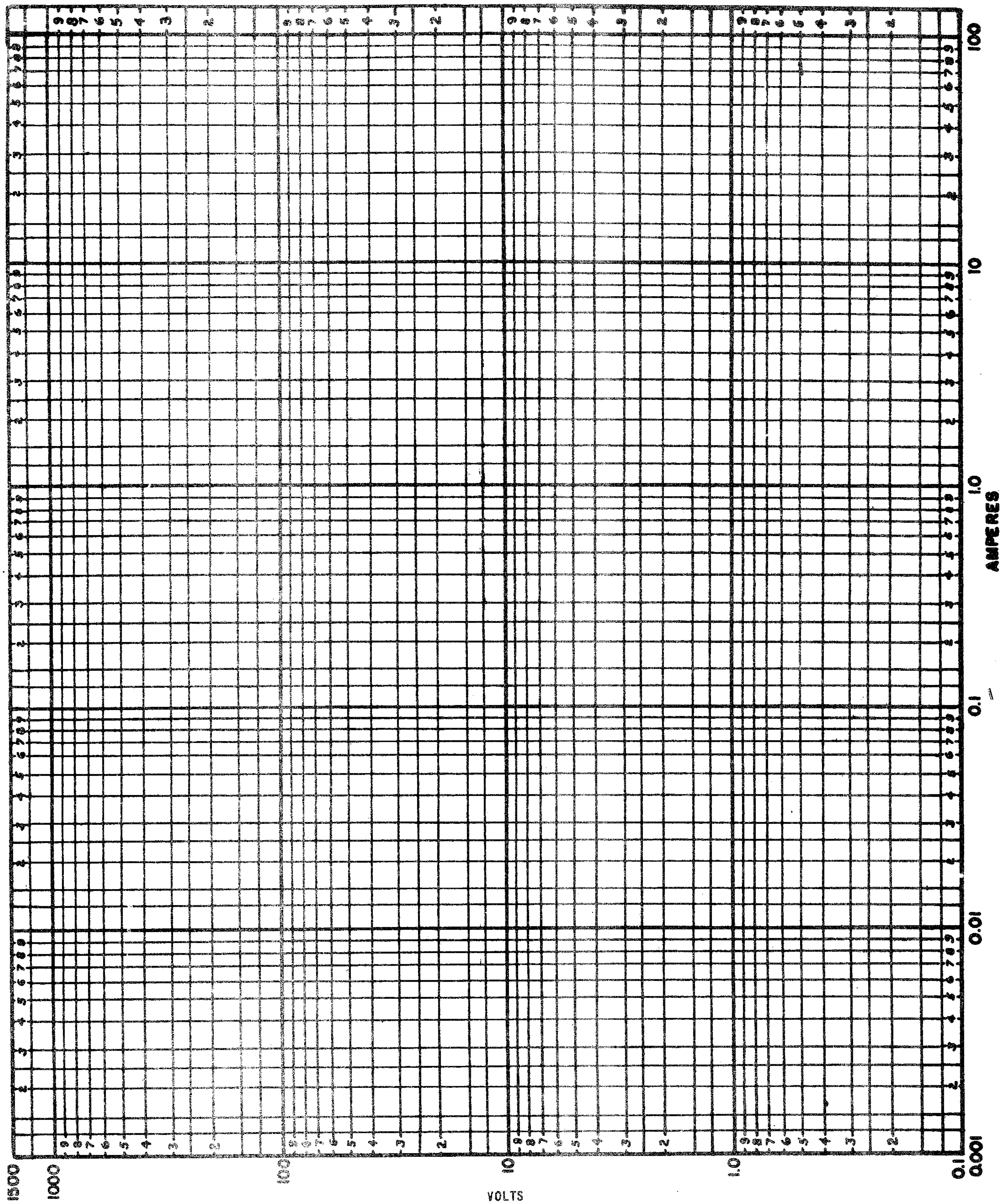
Magnetization of the core due to excessive fault current or accidental open circuiting of the secondary, which normally is not removed by load current, has the effect of increasing the ratio errors. This magnetization may be removed by exciting the core to the saturation voltage on the tap involved. The point of excitation may be obtained either with the breaker in service or out of service. To demagnetize the core with the breaker in service it is only necessary to insert a variable resistance and an ammeter in series with the burden, see Fig. 11. The resistance should be increased from zero to such a magnitude that the secondary current as determined by the ammeter reading will fall to at least one-half its original value and the resistance should be reduced to zero several times.

The magnitude of the required resistance may be determined from the excitation curve on the tap involved as equal to the saturation voltage divided by one-half the original secondary current. Thus if the saturation level is 100 volts on the 100 turn tap and the initial secondary current is five amperes the required resistance would be 100/2.5 or 40 ohms. To demagnetize the core with the breaker out of service, apply gradually either 100 amperes through the primary or 100/N amperes through tap N and reduce to zero several times with all other leads open circuited, see Figs. 12 and 13. (Note: It is the process of reducing the excitation point gradually to zero from the saturation level that demagnetizes the transformer.)

EXCITATION TESTS

The excitation characteristics of the transformer may be checked, either in or out of the power circuit breaker, by forcing a current of the desired frequency either through a one turn primary, see Fig. 12, or through any two taps of the transformer, see Fig. 13, and measuring the developed average voltage across any two taps. This excitation test, which is an open circuit test, should be performed without any burden except an averaging type voltmeter connected to the transformer. An averaging or rectifier type voltmeter such as the DP-2X (which is composed of a d-c instrument with a rectifier and is calibrated in terms of RMS sine wave voltage) is used so that the results obtained will be independent of the harmonics in the applied current or developed by the transformer.

The current can be applied to and the voltage measured from any combination of turns as mentioned above since under open circuit conditions the transformer acts like an ideal auto-transformer. The results obtained may be reduced to a common basis or number of secondary turns since both the ampere-turns and the volts-per-turn are constant for any one value of excitation. In making this test it is always desirable to demagnetize the core beforehand. This is done automatically by checking the excitation at the saturation voltage first and then reducing the current slowly to check the next point, without interrupting the circuit, continuing in this manner until the lowest point desired has been taken. It is to be noted that the breaker must be out of service since the excitation current must be under control. The exciting currents obtained from this test should check the values of the typical curve sent out with the transformer within 35%-50%. If the exciting current is



SECONDARY EXCITATION CHARACTERISTICS

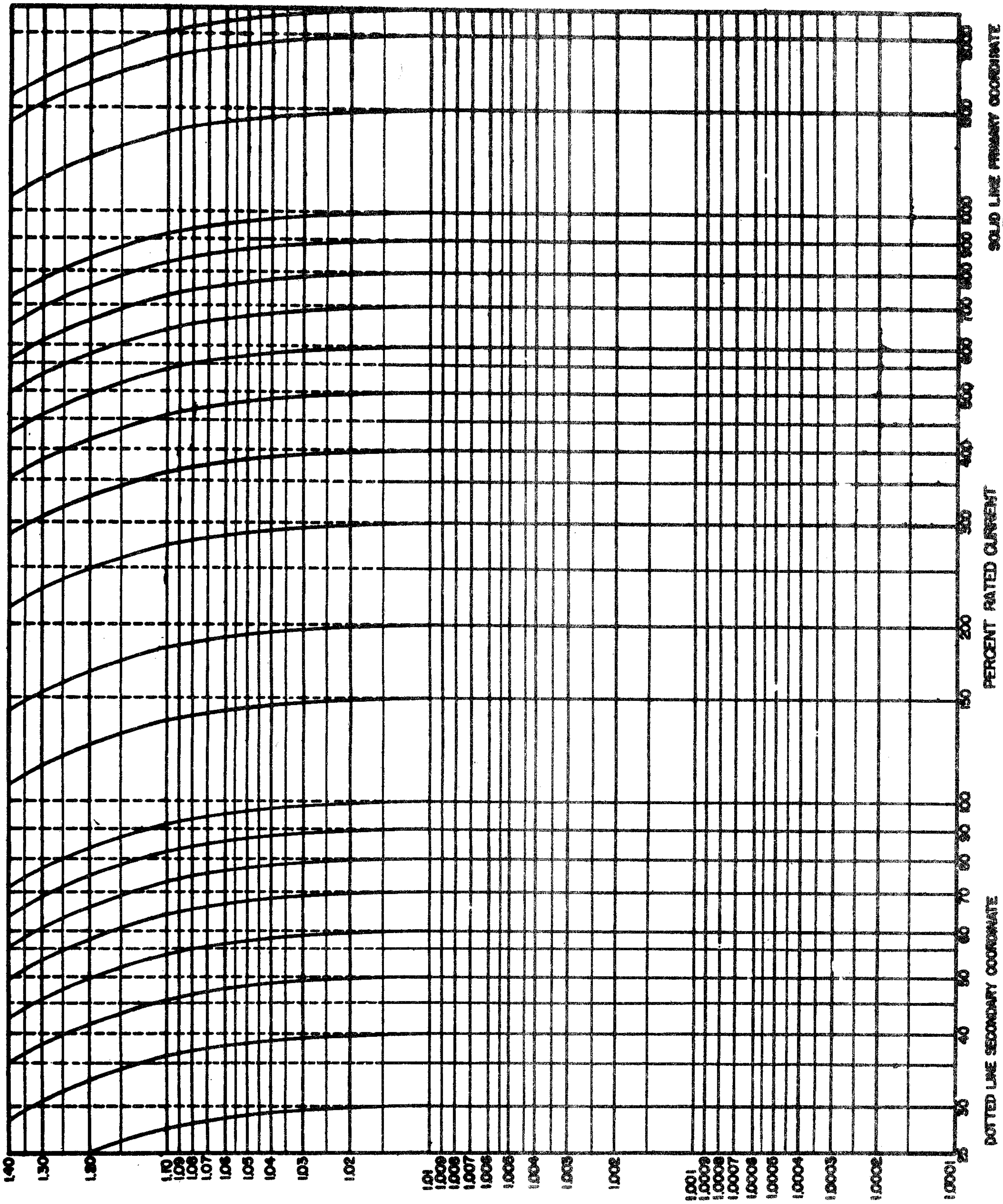
BUSHING CURRENT TRANSFORMER TYPE PL-

TURNS CYCLES, SECONDARY RESISTANCE Ω PER TURN + Ω PER LEAD

Fig. 15

Fig. 15 (8911838)

Fig. 16 (8911839)



CALCULATED RATIO CHARACTERISTICS
BUSHING CURRENT TRANSFORMER TYPE
TURNS CYCLES EXTERNAL BURDEN OHMS

Fig. 16

TABLE I
RATIO AND NUMBER OF SECONDARY TURNS BETWEEN TAPS
STANDARD TYPES BR-B AND BR-C (‡) BUSHING CURRENT TRANSFORMERS

Nominal Ratio	600/5 Amps 120 Turns		1200/5 Amps 240 Turns		2000/5 Amps 400 Turns		3000/5 Amps 600 Turns		4000/5 Amps 800 Turns		5000/5 Amps 1000 Turns	
Taps	Turns	Pri.* Amps	Turns	Pri.* Amps	Turns	Pri.* Amps	Turns	Pri.* Amps	Turns	Pri. Amps	Turns	Pri. Amps
X_2-X_3	10	50	20	100	160	800	240	1200	300	1500	100	500
X_1-X_2	20	100	40	200	80	400	200	1000	100	500	300	1500
X_1-X_3	30	150	60	300	240	1200	440	2200	400	2000	+	----
X_4-X_5	40	200	80	400	100	500	100	500	+	----	200	1000
X_3-X_4	50	250	100	500	60	300	60	300	200	1000	400	2000
X_2-X_4	60	300	120	600	220	1100	300	1500	500	2500	500	2500
X_1-X_4	80	400	160	800	300	1500	500	2500	600	3000	800	4000
X_3-X_5	90	450	180	900	160	800	160	800	+	----	600	3000
X_2-X_5	100	500	200	1000	320	1600	400	2000	700	3500	700	3500
X_1-X_5	120	600	240	1200	400	2000	600	3000	800	4000	1000	5000

‡ Type BR-C transformers are single ratio above 2000 amperes.
* Nominal rating based on 5 amperes in the secondary winding.
+ Ratios available at these taps, but are not standard.

very much greater than this it could indicate a shorted turn which might seriously affect the ratio.

RATIO TESTS

If it is desired to make a ratio check of the transformer with its specific burden this may be performed either by passing primary current through the bushing as in Fig. 11 without the variable resistor or by applying a voltage to the secondary as in Fig. 14 with the primary open-circuited. If the burden is small in magnitude it is advisable to connect, in series with the burden, a resistance (Rw) equal to the resistance between points 1 and 2 through the transformer. The ratio correction factor at a secondary current, I_s, will be equal to the quotient of the two meter readings as $RCF = (I_p/N)\ 1/I_s$. The error introduced by the method of Fig. 14 is negligible with resistor R_w in the circuit.

INSULATION RESISTANCE

Checking the transformer for accidental grounding or low leakage resistance may be most easily performed with either a 500 or 1000 volt "megger" Short circuit the secondary winding, disconnect all external leads from the terminal boards, and megger the resistance between the secondary winding and the circuit breaker frame. This resistance should have a value in megohms. If the resistance is unusually low the transformer and secondary leads should be inspected for accidental grounding.

REWINDING

If it is necessary to rewind a bushing transformer, such rewinding can be readily accomplished by observing the following instructions:

(1) Remove the outer protective binding and the succeeding layers of insulating tape and secondary winding, noting the location of the taps on the secondary winding.

(2) Wind the desired number of secondary turns around the core using an equally spaced distribution of 20 turns for the entire circumference; the next twenty turns will be wound adjacent to the first twenty. Continue this winding process until the proper number of turns are on the transformer. (The method of winding should be observed when the transformer is disassembled.) Heavy

Formex-covered wire should be used for the winding. When more than one layer is needed, the layers should be insulated by vertically wrapping two layers of polyvinyl chloride tape. (Refer to Fig. 1.)

(3) Tap the secondary winding, at points corresponding to the taps of the old winding, by removing the covering and Formex from short lengths of the secondary winding and fasten the leads to the wire thus bared with an AMP terminal. Cover the joints thus formed with Flamenol tubing.

(4) Replace the outer polyvinyl chloride insulating tape. Then wrap a horizontal protective covering of varnish-impregnated glass tape and finally one vertical layer of the same tape. All tape wrappings should be quarter-lapped except the last wrapping of polyvinyl chloride tape which should be ¾ width overlap, except double wrap over each spacing support.

(5) Fasten the nameplate on top of the transformer. The top is determined with reference to the direction of the secondary winding (Fig. 2 illustrates the method of marking).

(6) Check the excitation characteristics for accidentally shorted or grounded turns in the manner described under EXCITATION TESTS, and compare with the curve originally supplied with the transformer.

TABLE II
FREQUENCY CORRECTION FACTOR

All data is based on a frequency of 60 cycles. For other frequencies, multiply constants C and D, as obtained from Table III, by the following factors:

FREQUENCY	CORRECTION FACTOR	
	FOR C	FOR D
60	1.00	1.00
50	0.83	0.90
25	0.42	0.70

TABLE III
INTERNAL RESISTANCE (AT 75°C) AND CONSTANTS C AND D - TYPE BR-C TRANSFORMERS

TYPE AR-A1 AIR-BLAST CIRCUIT BREAKERS		BUSHING CURRENT TRANSFORMERS			
RATING		CONSTANT		INTERNAL RESISTANCE	
KV	AMPERES	C	D	Ohms per Turn	Ohms per Foot of Lead
14.4	1200 2000	12	345	0.0012	0.0019
	3000	9	373	0.0012	
	4000	7	410	0.0013	
	5000	10	496	0.0012	
TYPE AR-H AIR-BLAST CIRCUIT BREAKERS					
KV	AMPERES				
34.5	1200	14	475	0.0013	
	3000	10	496	0.0012	

TABLE IV

INTERNAL RESISTANCE AND CONSTANTS C AND D (TYPE BR-B)

	OIL CIRCUIT BREAKER			BUSHING CURRENT TRANSFORMERS			
	TYPE	RATING		CONSTANTS		INTERNAL RESISTANCE AT 75°C	
		KV	AMPERES	C	D	Ohms/Turn	Ohms/Lead*
	FKD-38-12000-0	38	1200	12	190	0.0023	0.0124
@	FKD-15.5-18000	15.5					
@	FKD-25.8-11000	25.8	1200				
	FKA-14.4-1000	15.5	1200	16	208	0.0026	0.028
	FKA-34.5-1500	38					
	FKA-46-1500 FKA-46-2500	48.3			225		
@	FK-69-2500	72.5	1200	25	290	0.0029	0.045
@	FK-69-3500						
@	FK-69-5000		2000	28	360	0.0037	0.049
@	FK-69-5000		3000				
@	FK-69-7500	72.5	2000	28	360	0.0037	0.049
@	FK-115-5000	121	1200	40	500	0.0026	0.021
@	FK-138-5000	145					
	FK-161-5000	169	1200	42	560		0.055
@	FK-115-10000	121	1600	25	500		0.055
@	FK-115-10000		2000				
@	FK-138-10000	145	1600	25	560	0.0028	0.065
@	FK-138-10000		2000				
@	FK-161-10000	169	1600				
@	FK-161-10000		2000				
	FK-230-5000	230 ϕ	1200	42	660	0.0026	0.070
	FGK-230-10000						
	FGK-230-15000		1600				
	FGK-345-25000	345 ϕ	1600	42	926	0.0031	0.080

AIR-BLAST CIRCUIT BREAKER			BUSHING CURRENT TRANSFORMERS (2000/5 ONLY)			
TYPE	RATING		CONSTANTS		INTERNAL RESISTANCE AT 75°C	
	KV	AMPERES	C	D	Ohms/Turn	Ohms/Lead ±
ATB-115-10000	115	1600	26.6	662	0.0018	0.04
ATB-115-10000		2000				
ATB-138-10000	138	1600				
ATB-138-10000		2000				

*Based on lead length to center bushing. Rear bushing has 75% of this resistance and far bushing has 125% of this resistance.

 @ Indicates revision

TABLE IV (Continued)

INTERNAL RESISTANCE AND CONSTANTS C AND D (TYPE BR-B)

AIR-BLAST CIRCUIT BREAKER			BUSHING CURRENT TRANSFORMERS (2000/5 ONLY)			
TYPE	RATING		CONSTANTS		INTERNAL RESISTANCE AT 75°C	
	KV	AMPERES	C	D	Ohms/Turn	Ohms/Lead*
ATB-230-15000	230	1600	26.6	804	0.0018	0.05
ATB-230-15000		2000				
ATB-230-20000		1600				
ATB-230-20000		2000				
ATB-345-25000	345	1600	28	1038	0.002	0.07
ATB-345-25000		2000				
ATB-500-38000	500	2000	27.5	1391	0.0025	0.08
ATB-500-38000		3000				

VACUUM CIRCUIT BREAKER			BUSHING CURRENT TRANSFORMERS			
TYPE	RATING		CONSTANTS		INTERNAL RESISTANCE AT 75°C	
	KV	AMPERES	C	D	Ohms/Turn	Ohms/Lead*
VIB-15.5-12000-3, -4	15.5	600	11	260	0.0018	0.152
VIB-15.5-16000-0, -1		800				
VIB-15.5-20000-1, -2		1200				0.0213
VIB-15.5-25000-0, -1						

@

SF_6 PUFFER TYPE CIRCUIT BREAKER			BUSHING CURRENT TRANSFORMERS			
TYPE	RATING		CONSTANTS		INTERNAL RESISTANCE AT 75°C	
	KV	AMPERES	C	D	OHMS/TURN	OHMS/LEAD *
HVB 242	242	2000	25.2	809	0.0019	0.032
		3000	17	787	0.0017	0.032
HVB 362	362	2000	26	1077	0.0019	0.032
		3000	17	1117	0.0017	0.032

* Based on lead length to center bushing. Rear bushing has 75% of this resistance and far bushing has 125% of this resistance.

ϕ For use on systems having solidly grounded neutrals.

± Based on lead lengths to end bushing current transformers. For center bushing current transformers lead resistance is 50% of end bushing current transformer lead.

For additional data on above transformers refer to Power Circuit Breaker Products Dept., Marketing Section, Philadelphia, Penna.

@ Indicates revision

NOTES

Fig. 1 . (8911837)

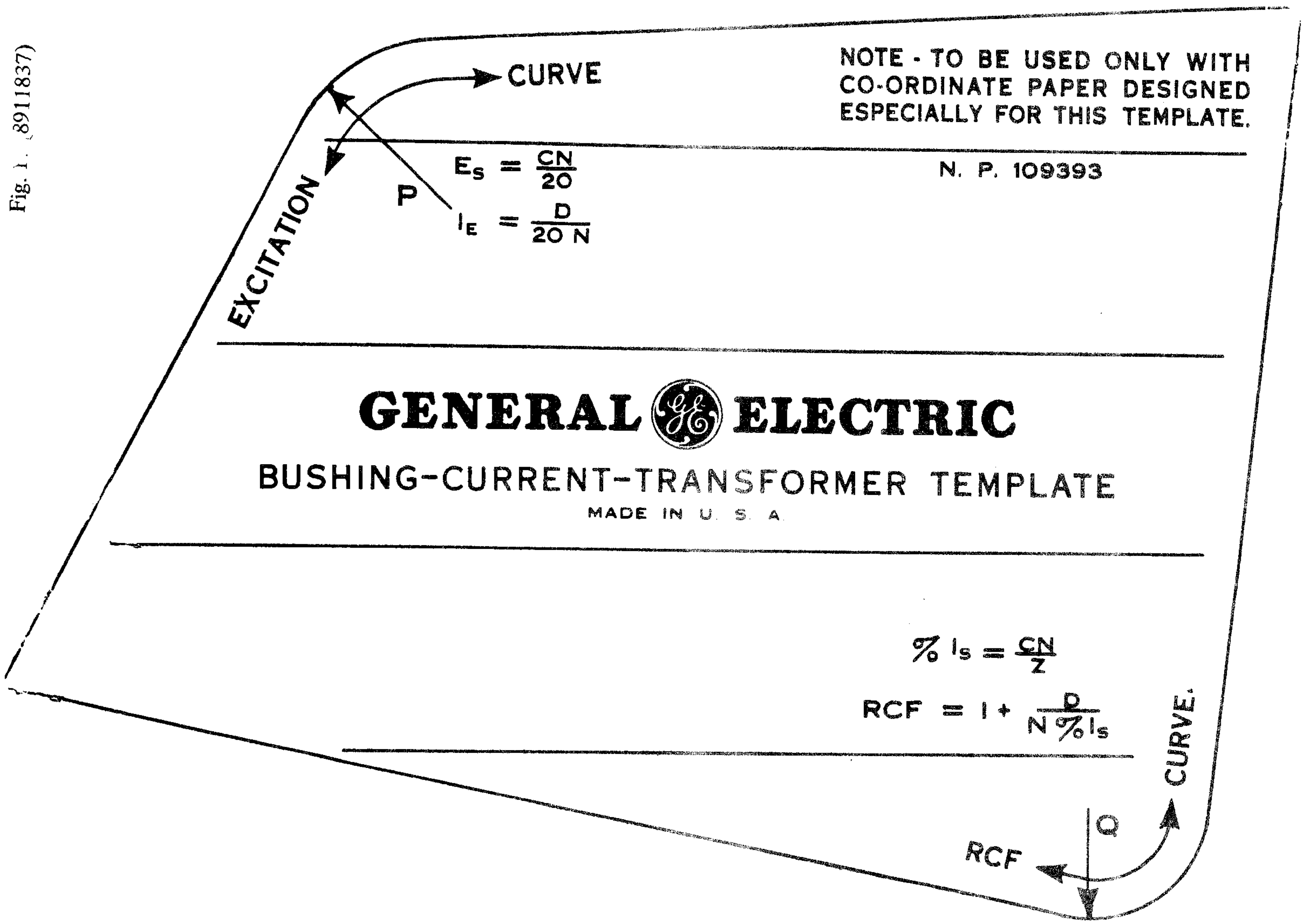


Fig. 17 Template for Drawing Excitation and RCF Curves

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INSTRUCTIONS

GEI-74670

INTRODUCTION

The Type SB-12 auxiliary switch is a multi-pole rotary switch with cam operated contacts. Several styles of bases are provided according to the mounting conditions. A typical switch is shown in Fig. 1.

The switch is made up of a series of individual stages, plus a common operating shaft, base and rear support. Each stage consists of an insulation barrier (1, Fig. 2), two moving contacts which are of the bridging type (2, Fig. 2), four stationary contacts (3, Fig. 2) and two cams (4, Fig. 2) each of which opens and closes its associated moving contact. Each moving contact with its stationary contacts is electrically insulated from the other pair in the same stage so that each stage can handle two individual circuits.

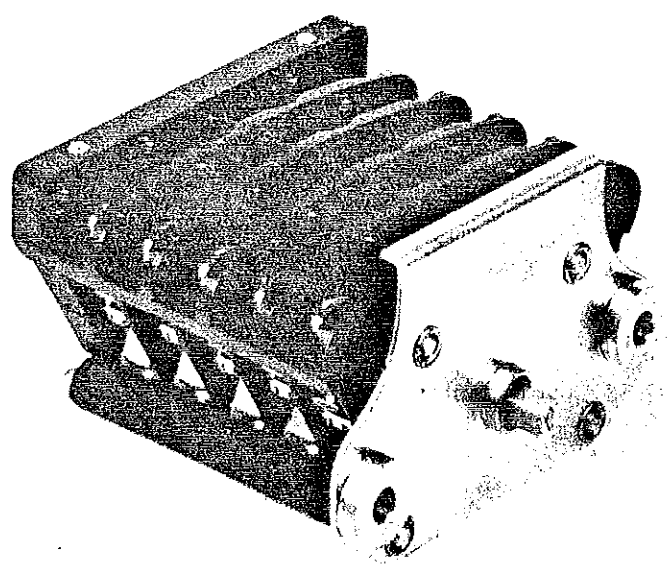

Fig. 1 Typical SB-12 Auxiliary Switch

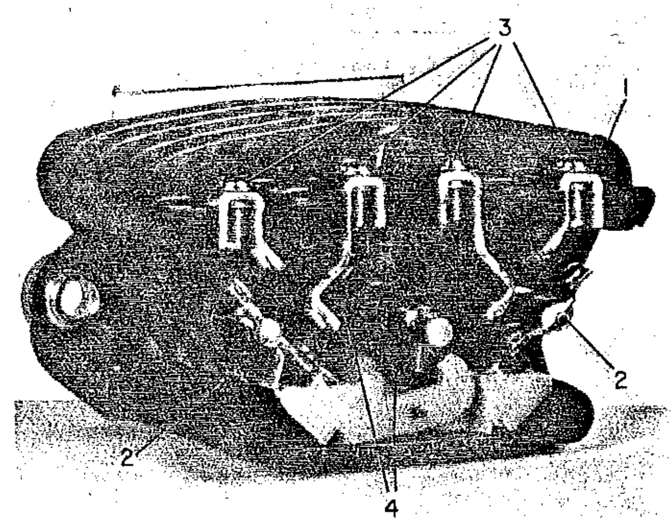

Fig. 2 Partially Dis-assembled SB-12 Auxiliary Switch

APPLICATION

This switch is operated through a mechanism and crank by a circuit breaker and performs various auxiliary functions such as operating indicating devices, alarms, providing for interlocking etc.

RATING

The rating of the switch is 600 volts. Each contact will carry 20 amperes continuous and 250 amperes for three seconds. The interrupting rating of the contacts depends upon the type and voltage of the circuit as given in Table I.

TABLE I

Interrupting Ratings in Amperes (one contact)

CIR VOLTAGE	NON INDUCTIVE	≠ INDUCTIVE CIRCUIT
VOLTS	AMPS	AMPS
24 DC	30.0	20.0
48 DC	25.0	15.0
125 DC	11.0	6.25
250 DC	2.0	1.75
600 DC	.45	.35
115 AC	75.0	50.0
230 AC	50.0	25.0
460 AC	25.0	12.0

≠ Average Trip Coil

CAM CHANGES

Changing the cam stacking in the field is not advisable. Instead the switch should be returned to the factory for change or a new switch with the desired cam arrangement should be ordered.

MAINTENANCE

When the apparatus with which the auxiliary switch is used is shut down the contacts of the switch should be checked. If they are slightly pitted or coated with oxide they should be cleaned with a fine file or burnishing tool.

INSTRUCTIONS

GEI-83957A

SUPERSEDES GEI-83957

AUXILIARY RELAY

HGA35A and B

GENERAL ELECTRIC

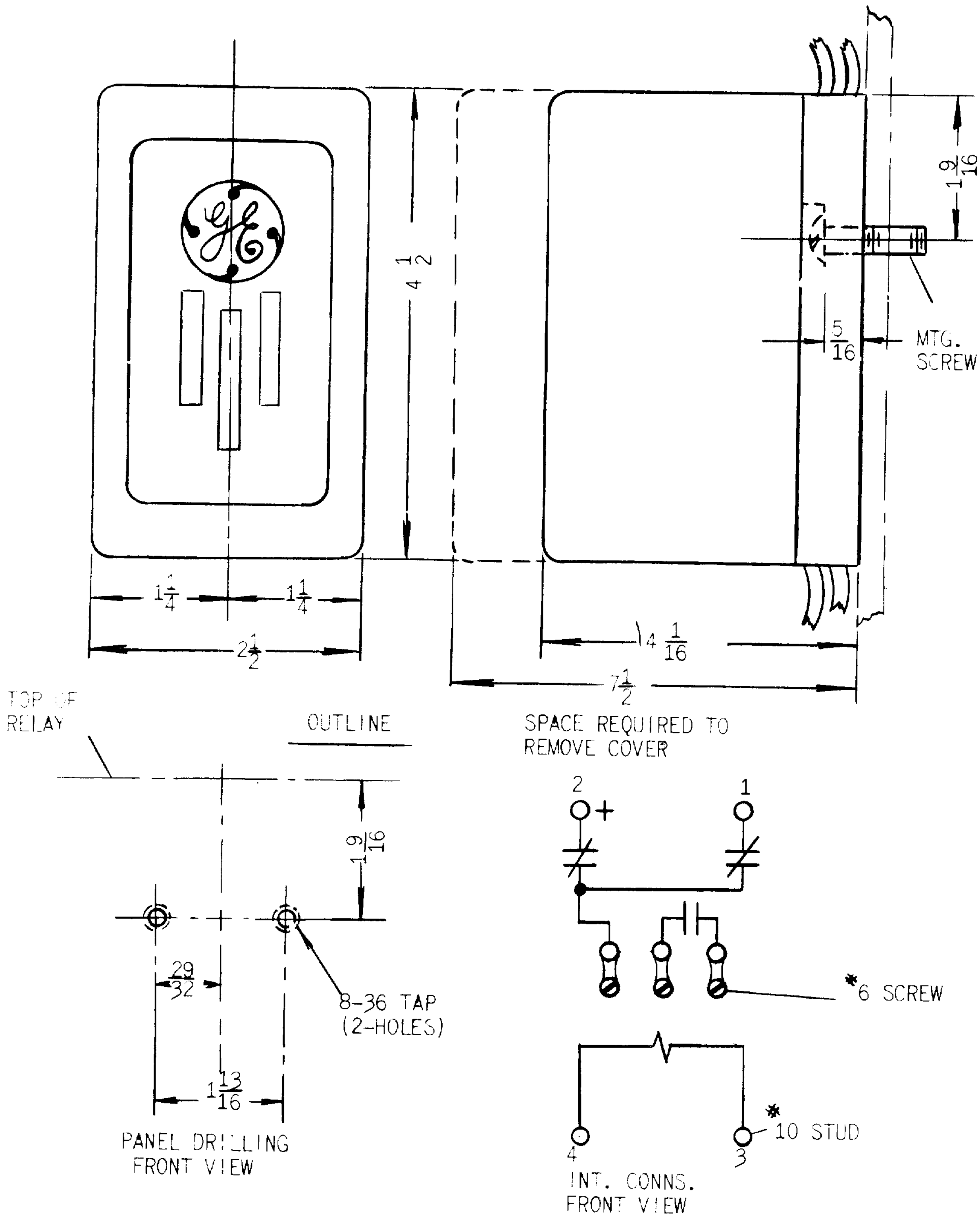

Fig. 1 (0148A4035-0) Outline, Panel Drilling And Internal Connections For The HGA35A And B Relays

AUXILIARY RELAY
HGA35A AND B

INTRODUCTION

The HGA35A relay is an instantaneous shock resistant hinged armature control relay. It achieves its shock resistant characteristic by use of a balanced armature structure pivoted in the center. The relay is supplied with one normally closed bridging contact and one normally open overlapping contact. The bridging contact has a small horseshoe magnet around each of its stationary contacts.

The HGA35B is similar to the HGA35A except the magnetic circuit has been slightly modified to achieve time delay dropout.

RATINGS

COILS

The HGA35A and B relays are available in d-c voltage ratings 250 volts or less. The operating time of the HGA35A relay is approximately 30 milliseconds while the HGA35B has a dropout time of 150 milliseconds or more.

CONTACTS

The current closing rating of the main (bridging) contacts is 30 amperes. The auxiliary contact will make, interrupt and carry continuously the coil current of the relay.

The inductive interrupting ability of the contacts is shown in the following table.

VOLTS DC	CURRENT AMPERES
24	12
48	9
125	6
250	3

The main contacts will carry 12 amperes continuously.

BURDENS

VOLTS	COIL OHMS	
	HGA35A	HGA35B
250	9600	6500
125	2460	1500
48	376	240
24	98	98

CONSTRUCTION

MOUNTING

The relay should be mounted on a vertical surface with the main (bridging) contacts at the top.

ADJUSTMENTS

MECHANICAL

1. Check that the normally closed contacts part within 1/64" of each other, that is, with one contact just making, the gap on the other should not exceed 1/64".

2. The gap on the normally open and normally closed contacts should be approximately 1/16" to 1/64".

3. Check that the normally open contact closes before the normally closed contact opens.

4. Check that the blowout magnets which are nested under the stationary contacts are assembled with the red dots toward the outside of the relay.

ELECTRICAL

The HGA35A and B relays have been adjusted at the factory to pick up at 80% or less of rated voltage.

The HGA35B has been adjusted to drop out (i.e., close the normally closed contacts) in 150 milliseconds or more upon removal of rated voltage.

CONNECTIONS

The polarity of the connections to the main contacts must be as shown on the internal connection diagram. This will cause the arc (if any) at the contacts to be blown up and away from the coil.

MAINTENANCE

CONTACT CLEANING

For cleaning contacts a flexible burnishing tool should be used. A typical burnishing tool is included in the standard XRT11A relay tool kit.

RENEWAL PARTS

For renewal parts, address the nearest General Electric Company Sales Office, specifying the quantity required and describing the parts by catalogue numbers shown in Parts Bulletin No. GEF-2623.

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