Circuit Breaker Maintenance

Volume 2: Medium-Voltage Circuit Breakers
Part 3: Westinghouse DH and DHP Models

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Report Summary

Circuit Breaker Maintenance

Volume 2: Medium Voltage Circuit Breakers
Part 3: Westinghouse Types DH and DHP

This comprehensive guide will help utilities enhance and optimize their maintenance of Westinghouse DH and DHP circuit breakers. It consolidates industry guidelines, applicable standards, original equipment manufacturer recommendations, and hands-on experience relative to these breakers. Ultimately, optimized maintenance will increase reliability and reduce costs associated with corrective maintenance and equipment downtime.

Background

Increased awareness of breaker performance trends, reliability, and failure effects has prompted an in-depth review of breaker maintenance practices and standardized technical guidance. Circuit breaker failures are costly- both in plant downtime and in potential damage to other plant components.

EPRI therefore developed this guide to establish a working level understanding of breaker performance trends, reliability, and failure modes from which maintenance practices can be specified.

Objective

To provide utilities with a tool for developing and implementing practical, cost-effective, and technically sound maintenance for Westinghouse type DH and DHP medium voltage circuit breakers.

Approach

EPRI's Nuclear Maintenance Applications Center (NMAC) project team surveyed U.S. nuclear power plants to identify plants utilizing Westinghouse medium voltage distribution equipment. The team then performed a review and comparison of manufacturer recommendations and utility maintenance procedures. Additional information was obtained during visits to site and service organizations while breaker maintenance was being conducted. Other investigations included a review of industry operating experience and failure data from NRC, INPO, and NPRDS sources along with a review of industry standards. The project team used this collective information to identify comprehensive and optimum maintenance recommendations and detailed guidance for inspection, test, and overhaul.

Results

This maintenance guide focuses on Westinghouse DH and DHP medium voltage circuit breakers installed at nuclear power plants. Topics address breaker operation, reliability and failure data, degradation/failure mechanisms, maintenance recommendations, detailed inspection and test guidance, and replacement parts data.

In its consolidation of industry guidelines, standards, and recommendations, this guide presents practical information not previously available for the maintenance technician, planner, or engineer.

The Westinghouse guide is one of a series of guides on low and medium voltage circuit breakers. This guide is divided into three volumes, which are further divided into parts that correspond to a specific class, manufacturer, and model. Volume 1, with four parts, covers low voltage circuit breakers. Volume 2, in three parts, covers medium voltage circuit breakers. Volume 3, a stand alone document, covers molded case circuit breakers.

EPRI Perspective

Circuit breaker maintenance is an ongoing responsibility for electric power plants. Improper maintenance practices can decrease electrical system reliability and availability. Because downtime resulting from poor maintenance is costly, improving just a few maintenance activities can result in significant cost savings. This guide provides prudent test and inspection methods, which, in turn, result in more effective use of maintenance resources. Power plant personnel using this guide will thus be better equipped to establish an effective time- and condition-based maintenance program.

Project

RP2814-84
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Abstract

Medium voltage circuit breakers provide load-switching and fault-interrupting capability for electrical service to power plant equipment. They offer a means of switching electrical loads and provide controlled, coordinated short-circuit and overload protection for connected station equipment. The consequence of a medium voltage circuit breaker failure, and a growing awareness of breaker reliability, has led to a need for a detailed review of industry maintenance practices and standardized technical direction.

The Nuclear Maintenance Applications Center (NMAC) developed this guide providing the industry with practical and cost-effective maintenance guidelines for Westinghouse DH and DHP circuit breakers. Development of the guide included a comprehensive review and comparison of manufacturer recommendations and utility maintenance procedures. Additional data was accumulated during site and service organization visits while breaker maintenance was being conducted. Other investigations entailed a review of industry operating experience and failure data from NRC, INPO, and NPRDS sources along with a thorough study of industry standards. This collective information forms the basis for the maintenance guidelines and recommendations presented in this volume.

The guide is prepared for use by maintenance and technical staff personnel and is presented in a clear, concise format consolidating utility practices, manufacturer recommendations, and industry standards. The text presents detailed inspection, test, and overhaul criteria along with maintenance recommendations for Westinghouse DH and DHP circuit breakers. The corresponding technical justifications provide the utility with a sound basis for developing a comprehensive maintenance program.

To provide a clear understanding of the topic, the guide begins with a breaker description section and follows with sections on historical performance, maintenance recommendations, maintenance practices, and spare part issues. Graphic illustrations, digital photography, and electronic imagery used throughout the text enhance the guide's content.

To the end user this guide represents a single source document that may be used to establish or improve a utility maintenance program for Westinghouse medium voltage circuit breakers. Advantages to the utility will be evident in increased breaker reliability, decreased costs associated with downtime, and optimized use of maintenance resources.

Foreward

The Nuclear Maintenance Applications Center is committed to the distribution of successful and practical maintenance solutions to its member utilities. According to utility needs, this document will be reviewed and revised to reflect any enhancements to presentation or content. Utility personnel are encouraged to provide comments on this document. Proposed changes or additions may be submitted using the following address.

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Section 1.0

Introduction

1.0 Introduction

1.1 Background

Medium voltage circuit breakers are used extensively throughout the power industry. Their proper operation is essential to the safe and reliable operation of plant electrical distribution systems. An increased awareness of circuit breaker performance trends and failure effects has led to progressively more sophisticated maintenance practices within the nuclear industry. A growing need for standardized technical guidance in this area has become apparent.

Therefore, the Nuclear Maintenance Applications Center developed this guide to consolidate original equipment manufacturer recommendations, utility practices, and applicable industry standards. This document is a comprehensive maintenance guide providing a level of standardization not yet established for medium voltage circuit breaker maintenance activities.

1.2 Purpose

The purpose of this guide is to provide utilities with specific recommendations, conveyed in a clear and concise manner, to allow development and implementation of a practical, cost-effective, and technically sound maintenance program for medium voltage circuit breakers.

1.3 Scope

This maintenance guide addresses Westinghouse Types DH and DHP medium voltage circuit breakers installed at nuclear power plants. It includes all continuous current frame sizes and MVA classes for the 5kv, 7.2kv, and 15kv voltage levels.

This guide focuses primarily on medium voltage air magnetic circuit breakers, however, vacuum breakers are discussed as upgrade or retrofit packages for Westinghouse Types DH and DHP.

Contents of the guide include an engineering description of the circuit breakers and their operation, a review of OEM recommendations and utility maintenance procedures, analysis of industry failure data, maintenance recommendations, maintenance practices, and spare parts information.

1.4 Approach

This guide was developed with the intent of providing maintenance and technical staff personnel with a clear understanding of maintenance recommendations and implementation methods. In addition, the technical justification or source of each maintenance recommendation is identified.

The first step in this process was a comprehensive review of utility maintenance procedures and OEM recommendations. This was conducted to consolidate the various utility practices and reconcile any deviations from manufacturer requirements.

The next step in development of the guide entailed a thorough review of industry operating experience and failure data. Sources for this review include NRC, and INPO advisories and bulletins, Nuclear Plant Reliability Data System, and individual plant maintenance histories. Additional data gathering was accomplished during site and service organization visits while breaker maintenance was being conducted.

This collective information, along with a complete review of industry standards was used to develop maintenance recommendations for Westinghouse DH and DHP circuit breakers. These recommendations were then included in a maintenance practices section providing detailed guidance for breaker overhaul, inspection, and test.

In addition, the guide presents a section on replacement parts. A complete listing of parts and manufacturer style numbers is provided along with recommended quantities for the various maintenance activities.

Section 2.0

Circuit Breaker Description

2.0 Circuit Breaker Description

2.1 Evolution

Medium voltage air magnetic circuit breakers were first introduced by Westinghouse in 1939 as the type DH "De-Ion" series. This is a draw-out breaker for use in metal clad switchgear. It consists of an operating mechanism driving three pole units that allow separation of the moveable and stationary contacts, and an arc chute assembly that provides dissipation of the resulting arc using ceramic splitter plates and a magnetic blow out coil assembly. Initial rating of the breaker was 150MVA at 5KV and was extended to 15KV with an interrupting capacity of 1000MVA on later models. The type DH switchgear and circuit breaker assemblies were manufactured as complete units until the introduction of the type DHP model in 1963. Manufacture of the DH series for replacement or lineup addition purposes continued until 1983, when production of this model ceased.

Westinghouse began manufacture of the DHP medium voltage «Porcel-Line» air magnetic circuit breaker in 1963. This breaker, although not interchangeable with the DH breaker, is also a draw-out type for use in DHP type metal clad switchgear. The primary upgrade in the DHP line is the use of high strength porcelain insulation between all live parts and the breaker frame. Other technological advancements applied during the evolution of the DHP type breaker have included replacement of solenoid-type operating mechanisms with stored energy spring devices, use of fabricated mechanisms in place of cast units, and development of the post insulator pole unit to replace the older monolithic pole units. DHP type switchgear and circuit breakers manufactured in ratings from 5KV/75MVA to 15KV/1000MVA are still available for replacement or lineup addition purposes. Westinghouse discontinued manufacture of DHP equipment as a complete switchgear assembly in 1982.

In 1982, Westinghouse began manufacture of Vac-Clad medium voltage metal-clad switchgear and type VCP vacuum power circuit breakers. This line was upgraded to Vac-Clad-W metal clad switchgear with VCP-W vacuum power circuit breakers in 1986. The VCP-W technology is available as a retrofit/upgrade for DH style circuit breakers and as a direct breaker replacement in DHP type metal clad switchgear.

2.2 Basic Application

Medium voltage circuit breakers are used to supply power to plant loads. They provide control and protection for generators, transformers, motors, and all types of feeder circuits. Medium voltage distribution equipment is applied from 2.4 to 38KV. Historically, the trend has been to use higher voltage systems with the majority of plant electrical systems using 4.16, 7.2, and 13.8KV equipment.

Of primary importance in the application of medium voltage circuit breakers are the equipment's maximum rated voltage, continuous current rating, and short circuit duty requirements. In the basic application, a circuit breaker should be selected to carry the required load current at the specified operating voltage and provide for interruption of the available fault current.

In selecting a circuit breaker, the operating voltage should never exceed the maximum rated voltage of the breaker. The continuous current rating of the breaker should be considered a maximum rating and always be in excess of the ampere rating of the utilization equipment to provide a margin for short time overload conditions. An example of this ampacity margin would be selecting a circuit breaker with a continuous current rating in excess of 125% of the nameplate, full load amperes of an induction or synchronous motor.

In addition to voltage and current ratings, the circuit breaker must be able to withstand interruption of the available fault current. This rating is provided as the circuit breakers' maximum symmetrical interrupting capability. Application of the breaker from an interrupting standpoint should be verified by comparing the breaker interrupting capability at the operating voltage to the calculated available short circuit current at the point of application in the power system.

Because power systems continue to grow, even after the equipment has been purchased and installed, it is advisable to be on the conservative side in ampacity and short circuit ratings. Methods of calculating short circuit currents and applying medium voltage circuit breakers are further delineated in ANSI Standard C37.010 / IEEE Standard 320.

It should be noted that particular applications, such as capacitive current switching, may require consideration of other technical issues. In general, medium voltage circuit breakers should not be used in applications requiring repetitive duty, such as frequently started motors. For repetitive duty applications, consideration should be given to the use of medium voltage motor starters.

2.3 DH Circuit Breakers

2.3.1 General Description

The Westinghouse type DH circuit breaker is a three pole medium voltage air magnetic circuit breaker. It provides control and protection for electrical equipment in medium voltage applications from 5 to 15KV.

Type DH circuit breakers were provided in the following voltage levels, continuous current frame sizes, and MVA classes:

Nominal Voltage - KV	Nominal MVA Class	Continuous Current Frame Size - Amps
4.16	75	1200 / 2000
	100	1200 / 2000
	150	1200 / 2000
	250	1200 / 2000
	350	1200 / 2000 / 3000
7.2	500	1200 / 2000
13.8	250	1200 / 2000
	500	1200 / 2000
	750	1200 / 2000
	1000	1200 / 2000 / 3000

Table 2.0 - Circuit Breaker Models

A typical circuit breaker model number would be 150DH500. For this designator, the 150 indicates that the breaker has a 15KV rating. DH indicates the breaker type, and 500 delineates the circuit breaker MVA class.

Westinghouse type DH circuit breakers are electrically operated, horizontal drawout units, for use in metal clad switchgear. The breaker consists of a welded steel frame on flanged wheels supporting the center coil arc chutes, the contact assemblies, and the breaker operating mechanism. Located in the lower part of the frame is the levering-in device and the secondary contact block. Also, located on the front lower section of the frame is the control panel. This panel provides indication and control functions for the breaker. A three-piece steel barrier for personnel protection completes the circuit breaker assembly.

2.3.2 Detailed Description

The general arrangement of components on the type DH circuit breaker is shown in figures xx and xx. The operating mechanism is built to exert a force on the mechanical trip free linkage. This linkage transfers the force upwards on the pole unit operating rods to the moving contact arms. The breaker has three sets of contacts per pole: main, intermediate, and arcing, that separate or connect in a specific order. On opening, the order is main, intermediate, and arcing. The order is reversed for the closing operation. Located just above the arcing contacts are the center coil arc chutes to extinguish arcs as the contacts separate. The following detailed description is provided for each of the circuit breaker components.

2.3.2.1 Operating Mechanism

The solenoid operating mechanism and its associated trip free linkage is shown in figure xx. Figure xx depicts a spring stored energy mechanism for the type DH breaker, which will be discussed later in this section. In the solenoid operator the horizontal pull of the solenoid coil is transmitted to the insulated operating rods through a linkage assembly. The linkage assembly consists of four components: the non trip free lever, trip free lever, upper trip free link, and lower trip free link. These four components are held rigid by the cam link and the tripping cam. The tripping cam is held fixed by the tripping latch.

When the solenoid is energized, the horizontal movement of the core exerts a force on the junction of the non trip free lever and the lower trip free link. This causes the assembly to rotate about the operating center, moving from the reset position to the closed position. Figures xx and xx show the mechanism in the reset and closed positions. An upward force is then exerted on the operating rods by the trip free lever acting to close the breaker. The breaker is maintained in the closed position by the closing latch.

Release of the tripping trigger releases the tripping latch, allowing the tripping cam to rotate freely. The linkage collapses under the force of the contact springs, the air bumper springs, the accelerating springs, and the springs over the puffer rods. The junction of the upper and lower trip free links shifts to the right, and the trip free lever rotates clockwise, opening the breaker. Figure xx shows the resulting trip free position of the operating linkage. As the linkage rotates to the trip free position, the lower trip free link disengages the closing latch allowing the retrieving spring to pull the solenoid core. This moves the operating linkage back to the reset position and resets the tripping latch.

Type DH circuit breakers provided with spring stored energy operating mechanisms are of the same general design as the solenoid operated breaker. Mechanically the solenoid operated breaker and the spring stored energy circuit breaker are interchangeable. Electrically, there are slight differences between the two types.

The spring stored energy mechanism stores closing energy by compressing the closing spring. Release of this stored energy closes the circuit breaker and simultaneously charges the breaker retrieving springs to open the circuit breaker.

The mechanism consists of a main spring, an operating linkage, a motor and gear assembly for spring charging, a spring latching and release device, a motor control system, and a geared shaft for manual spring charging.

An electric motor drives the worm gear, which drives a roller cam lever by means of an attached roller on the side of the gear. As the motor runs, it rotates the worm gear clockwise, moving the roller cam lever in front of it. This movement causes the roller cam connecting link and the clevis link to form a stiff rod and rotate the crankshaft counterclockwise. Rotation of the crankshaft exerts a force on the spring rod, charging the closing spring. A transfer link connected between the latch device cam and the worm gear connecting link transfers this movement to the spring latch device. The latch maintains the spring in the fully compressed position until release of the closing trigger (mechanism release). Refer to figures xx and xx for detailed views of the spring winding linkage in the spring discharged, spring charged, and latched positions. The trigger, released electrically or manually, releases the closing spring, allowing the stored

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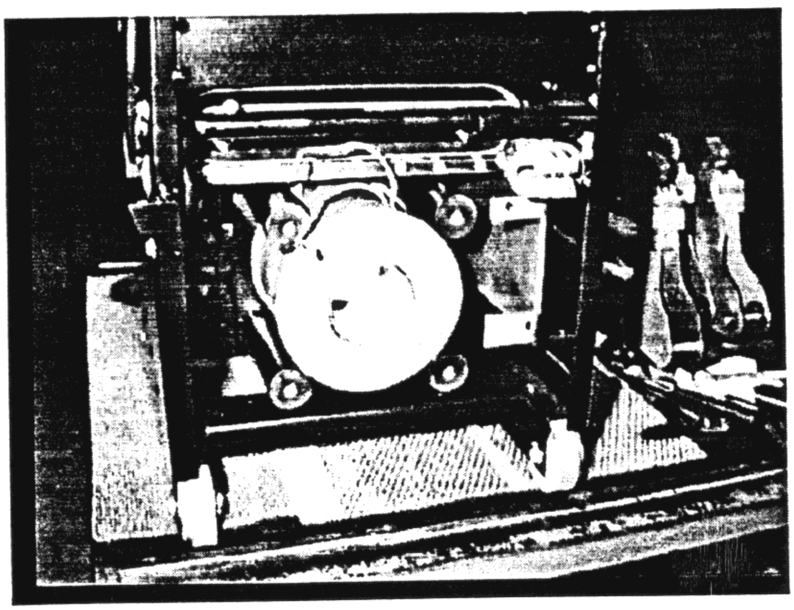
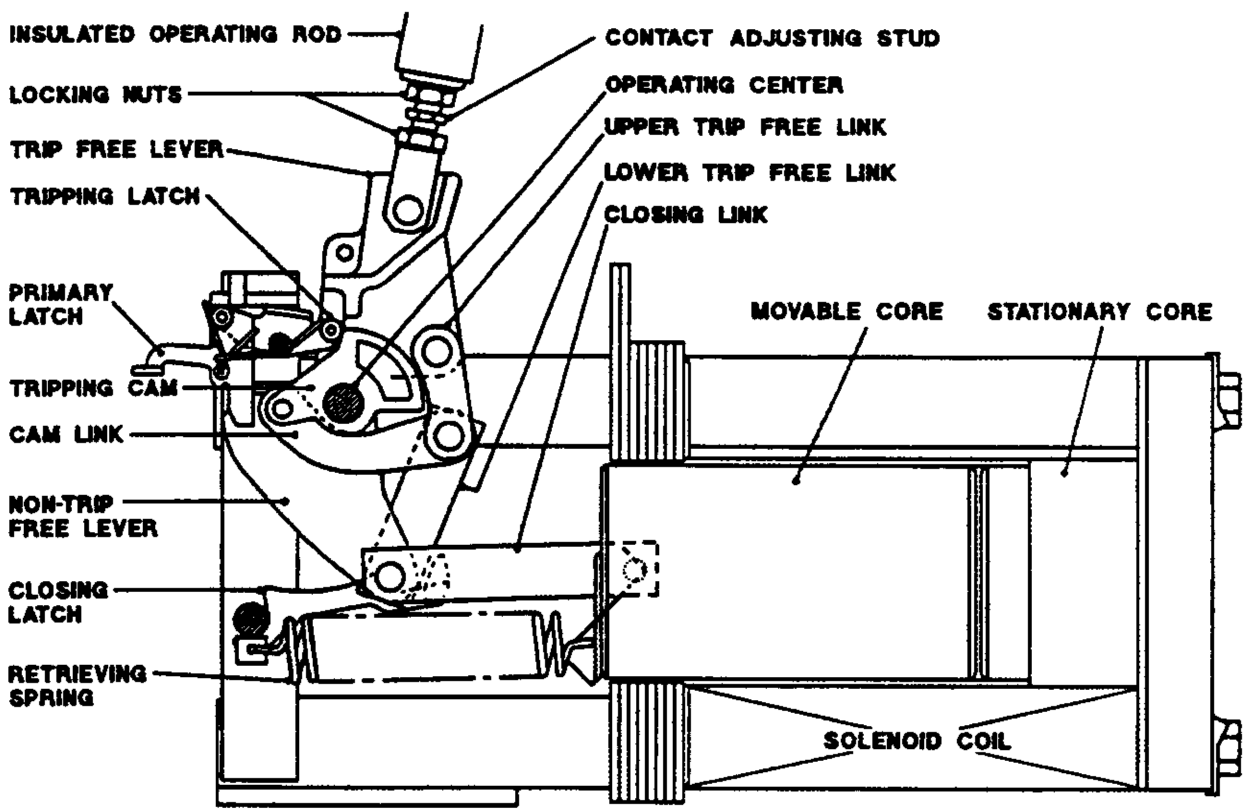


solop.pcx


INSULATED OPERATING ROD
LOCKING NUTS
TRIP FREE LEVER
TRIPPING LATCH
PRIMARY LATCH
TRIPPING CAM
CAM LINK
NON-TRIP FREE LEVER
CLOSING LATCH
RETRIEVING SPRING
CONTACT ADJUSTING STUD
OPERATING CENTER
UPPER TRIP FREE LINK
LOWER TRIP FREE LINK
CLOSING LINK
MOVABLE CORE
STATIONARY CORE
SOLENOID COIL

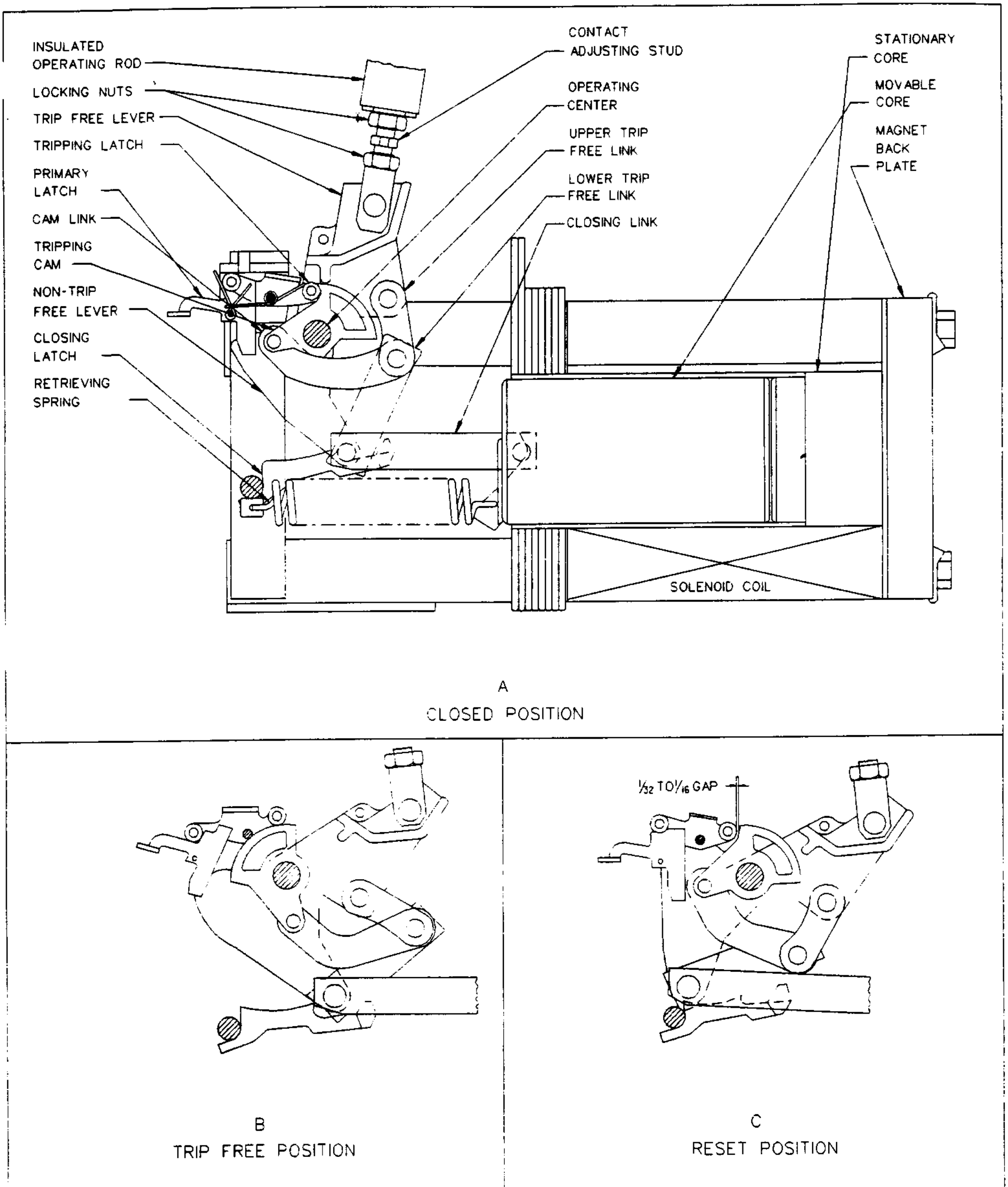


FIG. 5. Solenoid Operating Mechanism

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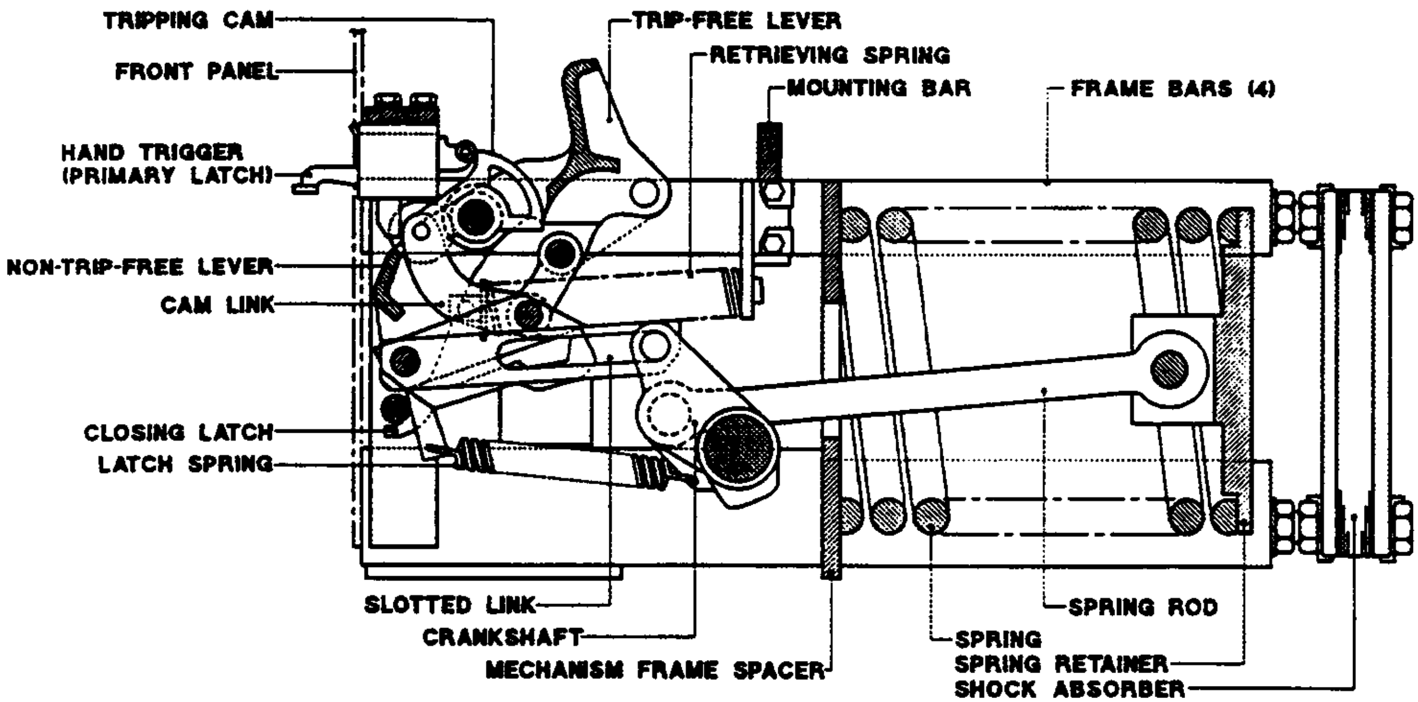
TRIPPING CAM
FRONT PANEL
HAND TRIGGER (PRIMARY LATCH)
NON-TRIP-FREE LEVER
CAM LINK
CLOSING LATCH
LATCH SPRING
TRIP-FREE LEVER
RETRIEVING SPRING
MOUNTING BAR
FRAME BARS (4)
SLOTTED LINK
CRANKSHAFT
MECHANISM FRAME SPACER
SPRING ROD
SPRING
SPRING RETAINER
SHOCK ABSORBER

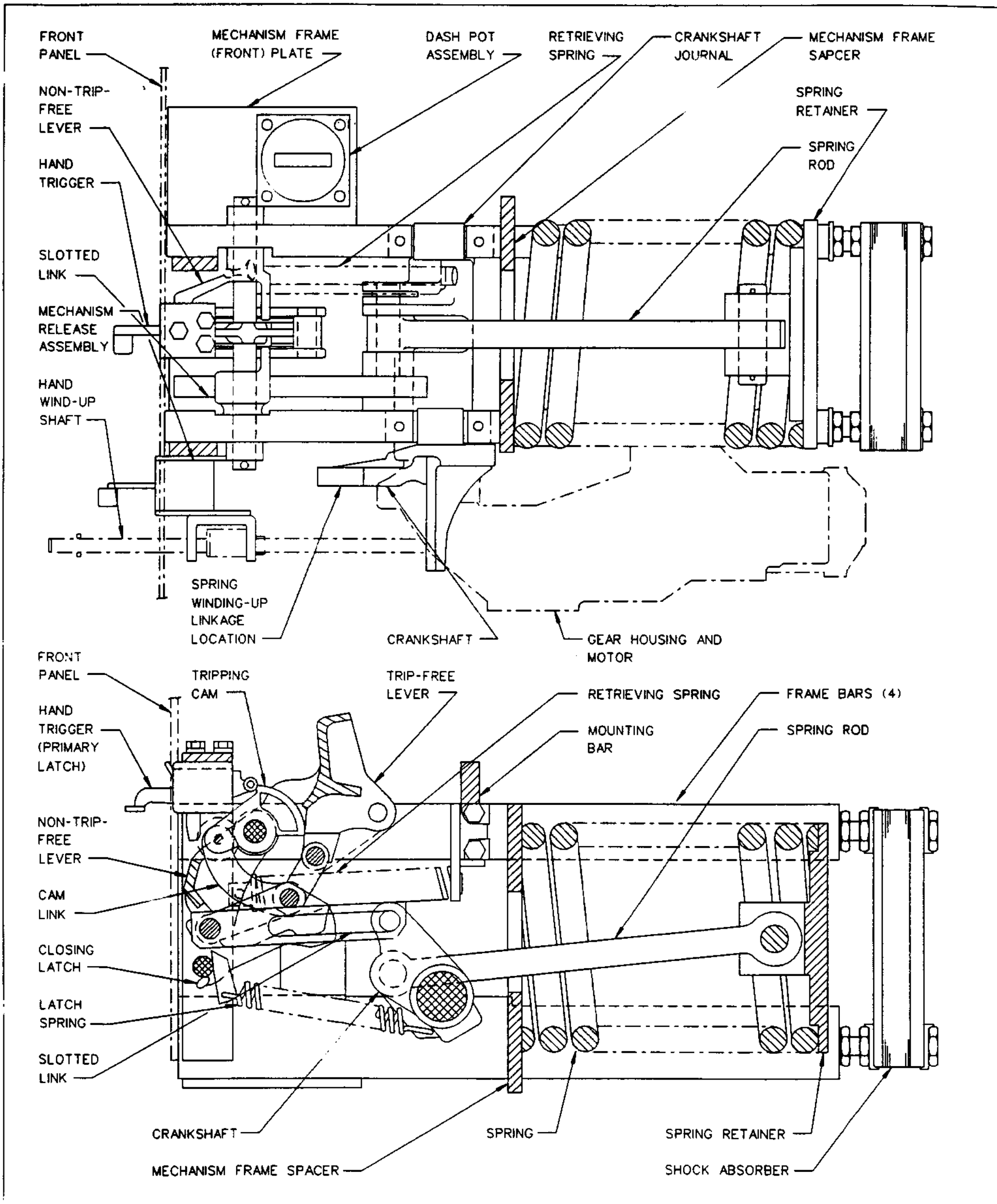

FIG. 4. General Disposition of Stored Energy (Spring) Closing Mechanism for Type DH Air Circuit Breakers
(Spring Wound up, Breaker in Open Position)

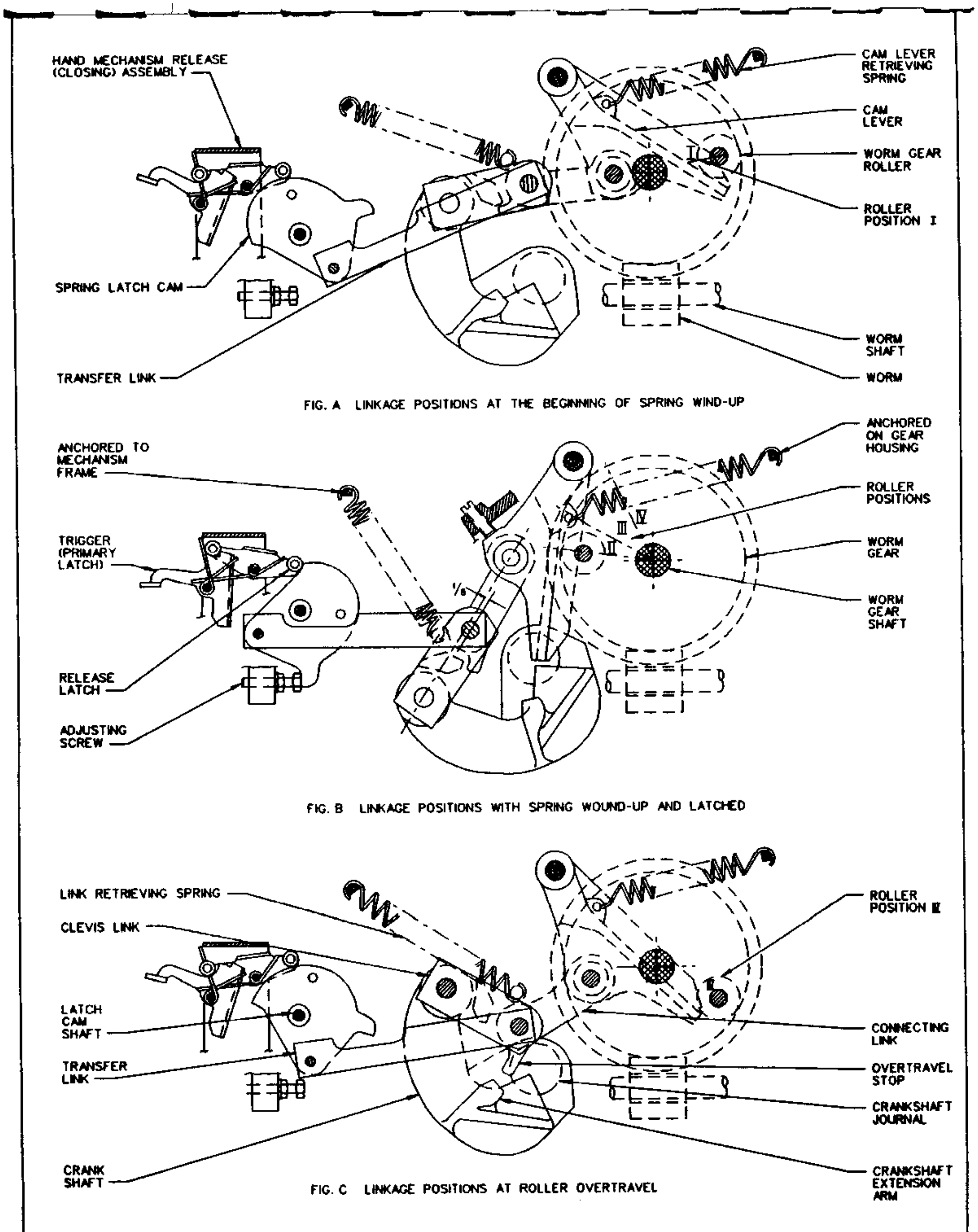

FIG. A LINKAGE POSITIONS AT THE BEGINNING OF SPRING WIND-UP

FIG. B LINKAGE POSITIONS WITH SPRING WOUND-UP AND LATCHED

FIG. C LINKAGE POSITIONS AT ROLLER OVERTRAVEL

FIG. 12 Spring Wind-up Linkage (Positions) During Spring Wind-up

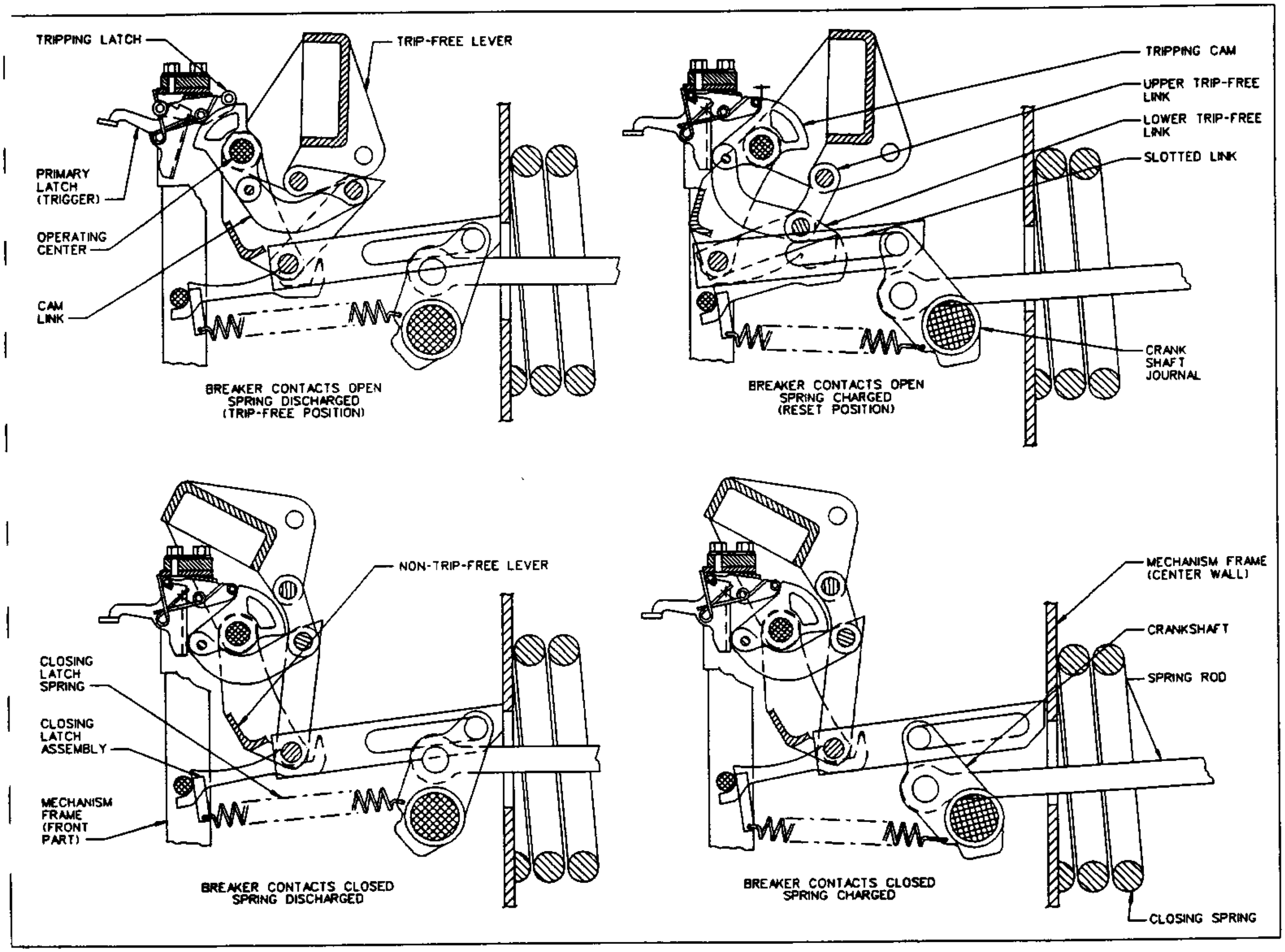

FIG. 9. Closing Spring and Breaker Linkage Positions

energy to close the breaker. The breaker is held in this position by the closing latch. Figure xx illustrates closing spring and operating linkage positions for a complete breaker cycle.

As the closing spring nears full compression the tripping trigger snaps into the latched position. Release of the tripping trigger, manually or electrically, releases the tripping latch, allowing the linkage to collapse, opening the breaker.

Figures xx and xx provide typical schematic representations for the DH breaker electrical control system. Figure xx depicts a direct current (DC) control diagram, and figure xx a control system using alternating current (AC) for the control voltage. Both diagrams represent control systems for DH type circuit breakers using spring stored energy operating mechanisms.

Referring to figure xx, and assuming the circuit breaker to be open with the spring discharged, electrical operation is as follows:

Control power is applied by closing the knife switch. At this instant, the MX relay is energized through «b» contacts of the motor limit switch (LS), and the LCST. Closure of the MX relay contacts seal-in the MX relay and complete the motor circuit. Simultaneously, a «b» contact of the MX relay opens in the Y relay (anti-pump) circuit disabling the anti-pump feature. As the motor runs, charging the closing spring, the X relay (closing relay) remains deenergized by «a» contacts of the limit switch and the LCST preventing circuit breaker closure. When the spring reaches the fully charged position, the trip latch engages the trip cam, operating the LCST switch. In turn, the spring latch cam engages the mechanism release latch, operating the limit switch and the «bb» contact of the spring latch cam microswitch. This interrupts power to the spring charging motor and deenergizes the MX relay. The «b» contact of the MX relay is now closed, partially enabling the Y relay anti-pump circuit. An «a» contact of the limit switch closes on operation of the limit switch, enabling the X relay circuit for breaker closure.

The breaker is now in the open position, with the closing spring fully charged and latched, ready for a close signal.

Electrically, the breaker is closed by an external control switch that completes the X relay circuit. Energization of the X relay completes the circuit for the mechanism release solenoid (MR), which disengages the release latch allowing the breaker to close. Closure of the circuit breaker main contacts operates the limit switch, the LCSC switch, the breaker auxiliary switch, and the latch cam micro switch. Operation of the limit switch, LCSC switch, and the auxiliary contacts completes the MX relay circuit, energizing the motor and charging the closing spring as previously described. Operation of the latch cam micro switch fully enables the Y relay circuit, providing anti-pump protection for the breaker.

Closure of the circuit breaker and subsequent operation of the auxiliary contacts arm the breaker trip coil. The breaker is tripped electrically by means of an external trip switch that energizes the trip coil disengaging the tripping latch allowing the breaker to open.

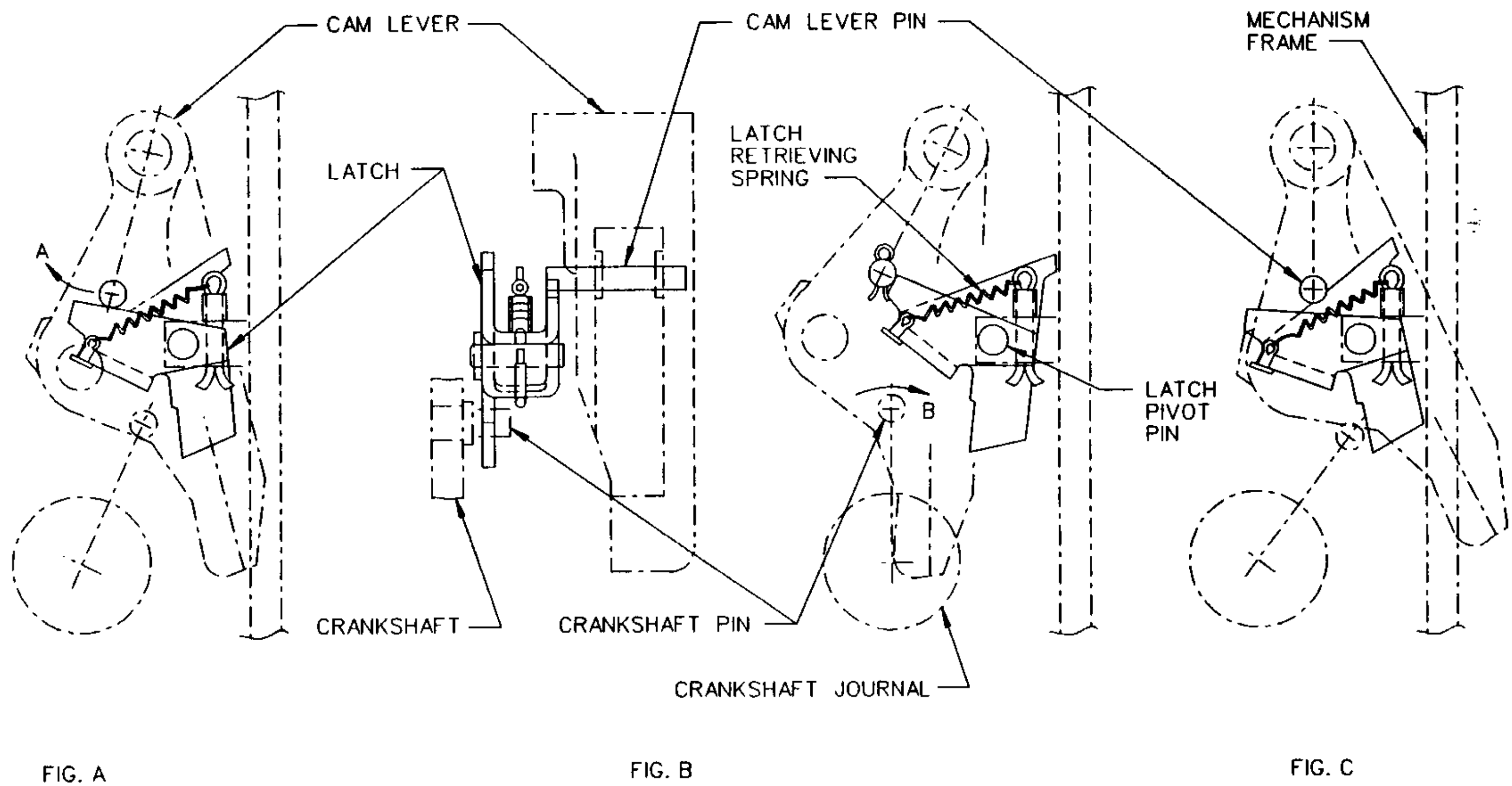

FIG. 13. Wind-up Linkage Latch Positions

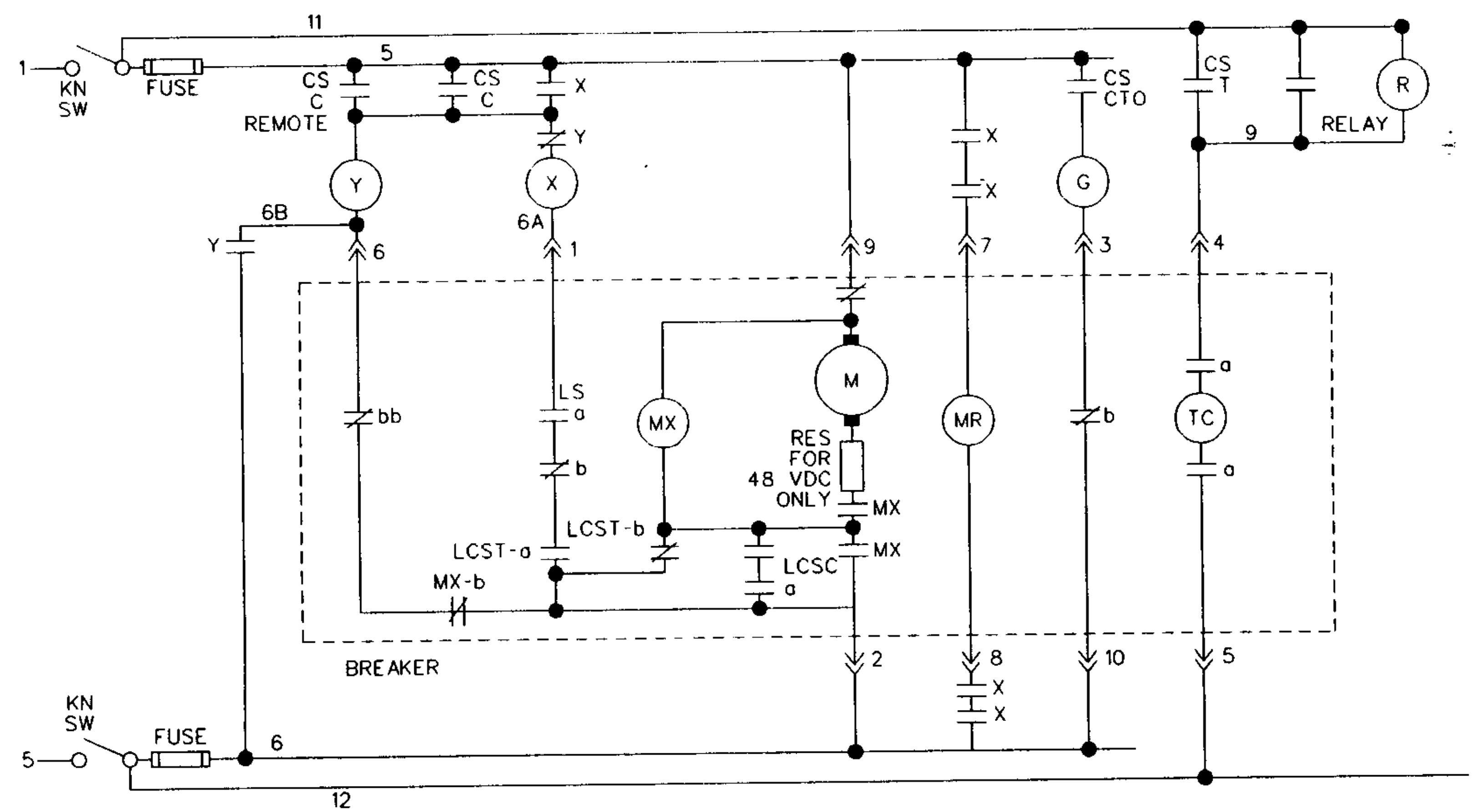

FIG. 15. Typical Schematic D-C Control Diagram for Type DH Air Circuit Breakers With Stored Energy (Spring) Closing Mechanism

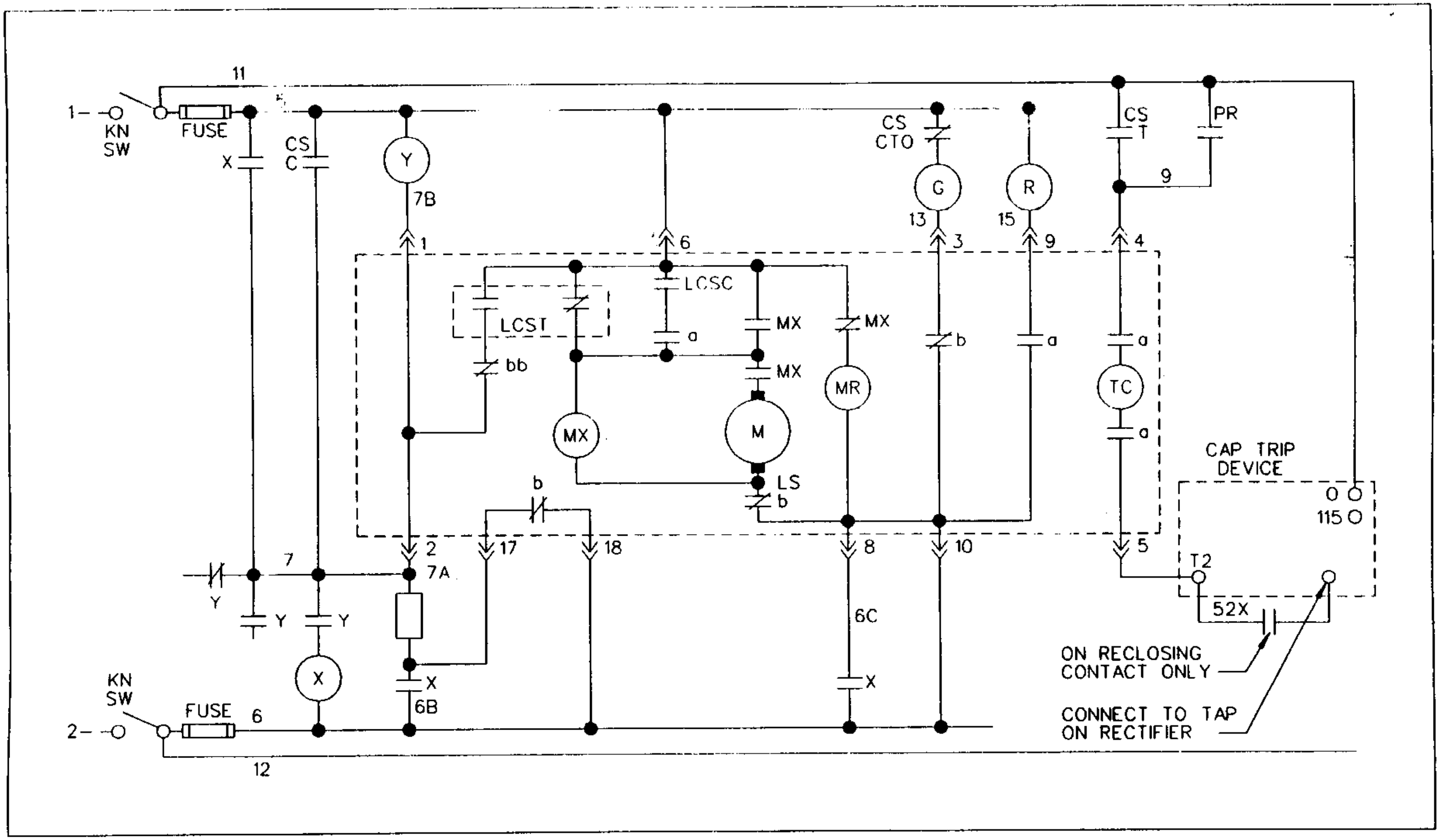

FIG. 17. Typical Schematic A-C Control Diagram for Type DH A.C.B.
With Stored Energy (Spring) Closing Mechanism

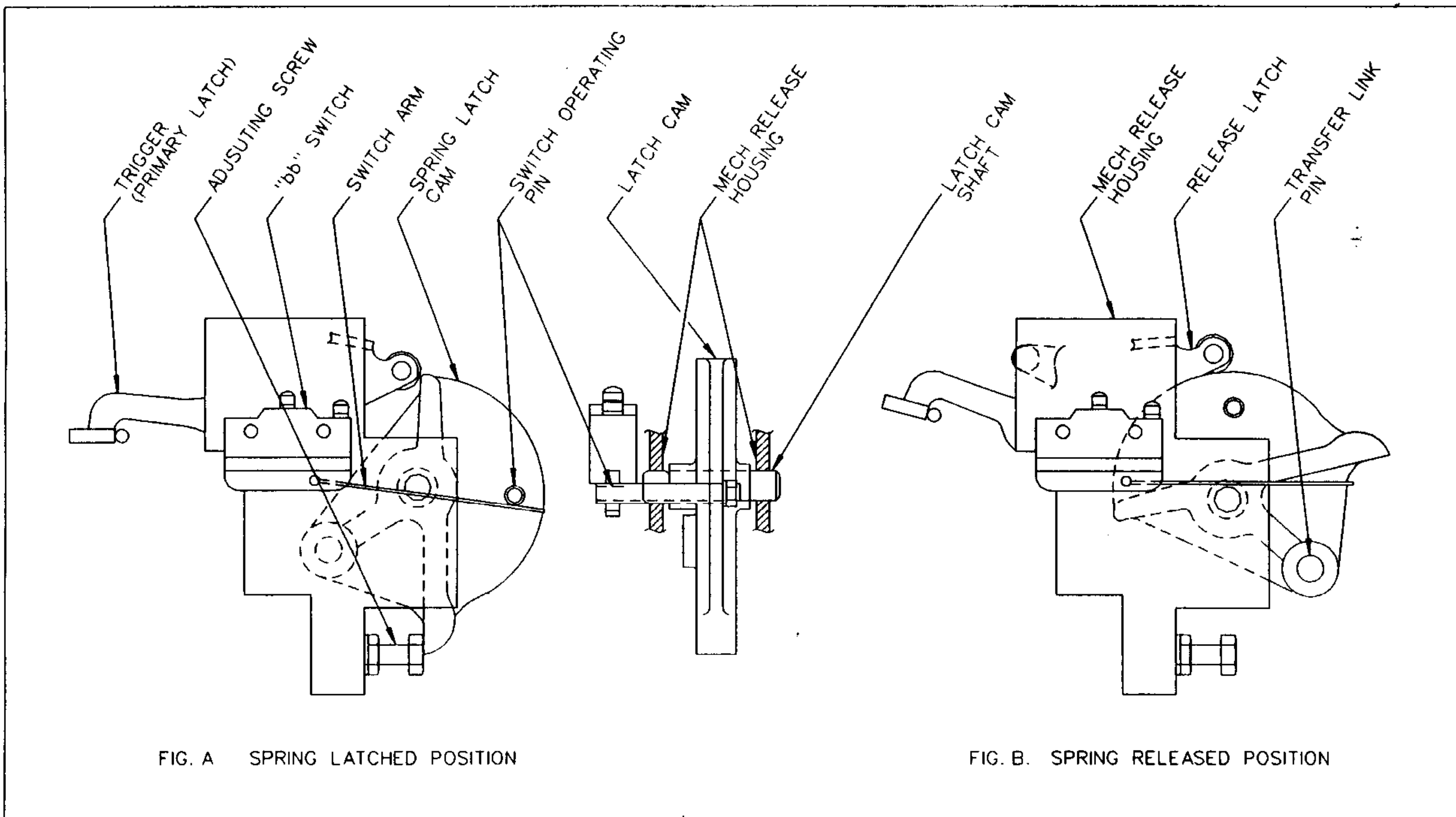

FIG. 14. Operation of Spring Latch Check Switch "bb"

Figure xx is a control diagram using alternating current for the control voltage. Here, function is the same as the previously described DC circuit with the exception of the capacitor trip device. This device is used to ensure tripping power is available upon loss of AC control voltage.

A detailed description of the various electrical control devices is provided in the following paragraphs:

Latch Cam Micro Switch («bb» contact) - The switch is mounted on the side of the mechanism release housing and is operated by a pin fastened to the spring latch cam. Referring to figure xx, the switch is in its normal position (closed) when the spring is discharged or partially charged. As the spring latch cam rotates clockwise upon spring charging, the operating pin moves toward the switch arm, causing the switch to operate as the release latch engages the cam. The switch operates immediately upon mechanism release.

Latch Check Switch Closing (LCSC) - Refer to figure xx. The switch is in its normal position (open) when the breaker is closed and latched. The switch changes state immediately upon mechanism release. The switch is mounted on a bracket on the left lower bar of the mechanism frame. An alternate arrangement of the LCSC is shown in figure xx. In this arrangement, the switch is mounted on the front panel. Operation of the switch is identical in both arrangements.

Latch Check Switch Tripping (LCST) - The switch is operated by the breaker trip lever. It has two contacts, one normally open and one normally closed. The switch is in its normal position when the trip lever is in the unlatched position. The switch is operated and the contacts change state when the trip latch engages the trip cam in the reset position.

Limit Switch - The limit switch is mounted on the gear housing above the motor. It is operated by a lever such that the «b» contact is closed when the spring is discharged or not fully charged, and opens upon completion of spring charging. Conversely, the «a» contact is open when the spring is discharged or not fully charged and closes upon completion of spring charging.

2.3.2.2 Mechanism Control Panel

The control panel is mounted on the front of the closing mechanism. Several devices are mounted on the panel. Each device is individually addressed below.

Shunt Trip Magnet - The shunt trip magnet is a small electromagnet used to trip the breaker electrically. Its coil may be specified for alternating or direct current applications. When the shunt trip magnet is energized, the core is drawn up into the magnet yoke. As the core moves upward, an extension mounted on top of the core moves against the breaker trip lever located directly above it. The force of the solenoid raises the trip lever, disengaging the primary trip latch, allowing the breaker to trip. A thin brass washer prevents residual magnetism from retaining the core in the raised position after deenergization of the coil.

Cut-Off Switch - The cut-off switch is a normally open (breaker open) auxiliary contact that functions with breaker control relaying to cut-off closing coil current after the breaker has closed. It is operated by an arm attached to the mechanism trip free lever.

Contact Position Indicator - The contact position indicator is a mechanical indication operated directly from the mechanism trip free lever to provide breaker open or closed indication.

Interlock Position Indicator - The interlock position indicator operates directly from the levering-in device shaft, providing a positive indication of the breaker interlock position. When the indicator points to the word «operate» on the control panel, the interlock is not engaged and the breaker may be closed or tripped. When the indicator points to the word «interlocked» on the control panel, the interlock is engaged and the breaker cannot be operated. The interlock is only operative when the breaker is in an intermediate position within the cell, i.e., between fully engaged and fully withdrawn. This device is also used to indicate breaker position within the cubicle.

Operation Counter - A link to the trip free lever operates the counter each time the breaker is tripped.

Auxiliary Switch - The auxiliary switch is a nine pole rotary type switch actuated by a link from the mechanism trip free lever. The switch consists of five normally open and four normally closed contacts. Each contact is rated for 20 amperes continuous current.
Latch Check Switch - The latch check switch is a snap action switch actuated by the primary latch. This switch prevents energization of the closing solenoid until the operating mechanism is in the reset position. Reset of the primary latch is the last linkage motion required to reset the operating mechanism. Reset of the latch closes the latch check switch.

Undervoltage Trip Attachment (optional) - The undervoltage trip attachment is a magnetically held device used to trip the breaker when control voltage falls below a predetermined value. Tripping force is provided by charging a spring during the breaker closing operation. The moving core and reset lever are held in place magnetically until voltage decays to the specified level. The reset lever spring then overcomes the magnetic force and rotates the reset lever clockwise. This releases the latch from its latch plate, allowing the trip spring to rotate the trip lever to trip the breaker. The device is reset by the mechanism trip free lever as the breaker opens.

Time delayed tripping on undervoltage is an alternate option with this device. The time delay function is accomplished by use of a high resistance coil in the holding magnet, with a capacitor connected in parallel. The capacitor provides a slowly decaying holding current to the coil. The time delay is adjusted by varying the capacitor charging voltage with a four step resistor.

Three Coil Trip Attachment (optional) - The three coil trip attachment is used in conjunction with the shunt trip magnet. Three instantaneous current transformer assemblies calibrated to specific current values are used to actuate the shunt trip magnet and trip the breaker if the specified current value is exceeded.

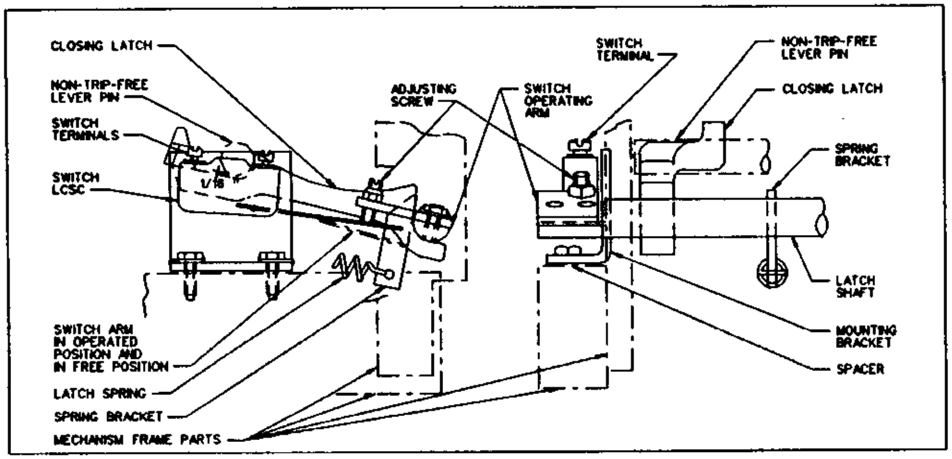

FIG. 21. Operation of Closing Latch and Closing Latch Check Switch LCSC

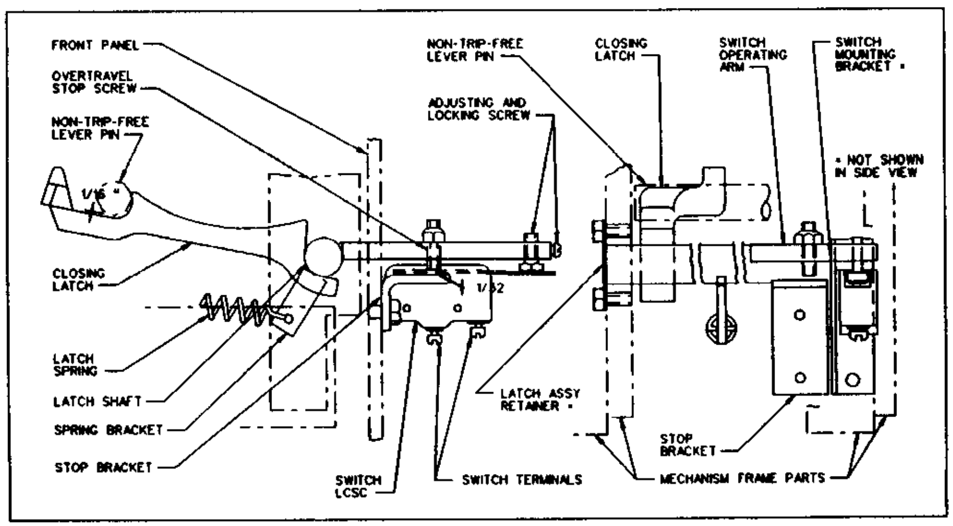

FIG. 22. Alternate Design of Closing Latch and Closing Latch Check Switch LCSC

2.3.2.3 Contacts

Three sets of contacts are provided on the type DH circuit breaker: main, intermediate, and arcing. Each set of contacts contains a moveable and a stationary component. When the breaker is tripped, the contacts separate in a specific order with the main contacts breaking first, followed by the intermediate, and then the arcing contacts. The order is reversed on the closing operation.

The moving contact assembly consists of arcing, intermediate, and main contact inlays brazed to a copper casting that is bolted between four formed copper blades. These blades hinge on the lower bushing foot, forming the moving contact arm. Refer to figure xx.

The stationary contact assembly has three sets of arcing and intermediate contacts brazed to castings mounted over pins and biased by a rear spring. On each side of the arcing and intermediate contacts are five main contact fingers. These fingers stack on mounting studs and are positioned by individual springs for each finger. Refer to figure xx.

The complete contact assembly is shaped to allow full insertion of all contacts into the arc chute assembly.

2.3.2.4 Arc Chutes

The arc chute assembly consists of an H-shaped blow-out magnet, blow-out coils, transfer arc horns, transfer stacks, a front arc horn, and a rear arc horn assembled in a rectangular «Redarta» enclosure. The chute is hinged to the breaker and completely encompasses the contact assembly when it is in its lowered, operating position. Refer to figure xx for a cross sectional view of the arc chute components.

The blow-out magnet is arranged so that the magnet core passes through the center of the arc chute. The blow-out coils are wound around the core and lie in openings cut into the chute's jacketed enclosure. One terminal of each coil is connected to a transfer arc horn and the other terminals are connected to the shading coil.

Two transfer stacks are placed in the space between the transfer arc horns and the shading coil. On each side of the transfer arc horns are the main interrupter stacks. These stacks are fabricated from insulating refractory-type material with inverted V-shaped notches molded into them. The slots are offset so that when the plates are stacked, the slots alternate from one side to the other. This causes the arc to travel a winding path, thus elongating the arc. On each side of the main interrupter stacks are two metallic arc horns that transfer the arc from the breaker arcing contacts. The front arc horn is electrically connected to the breaker moving contact, and the rear arc horn is connected to the stationary contact.

As the circuit breaker opens an arc is drawn across the arcing contacts. The arc impinges on the lower ends of the two transfer arc horns and the shading coil. The two short arc segments between the transfer arc horns and the shading coil move upward into the

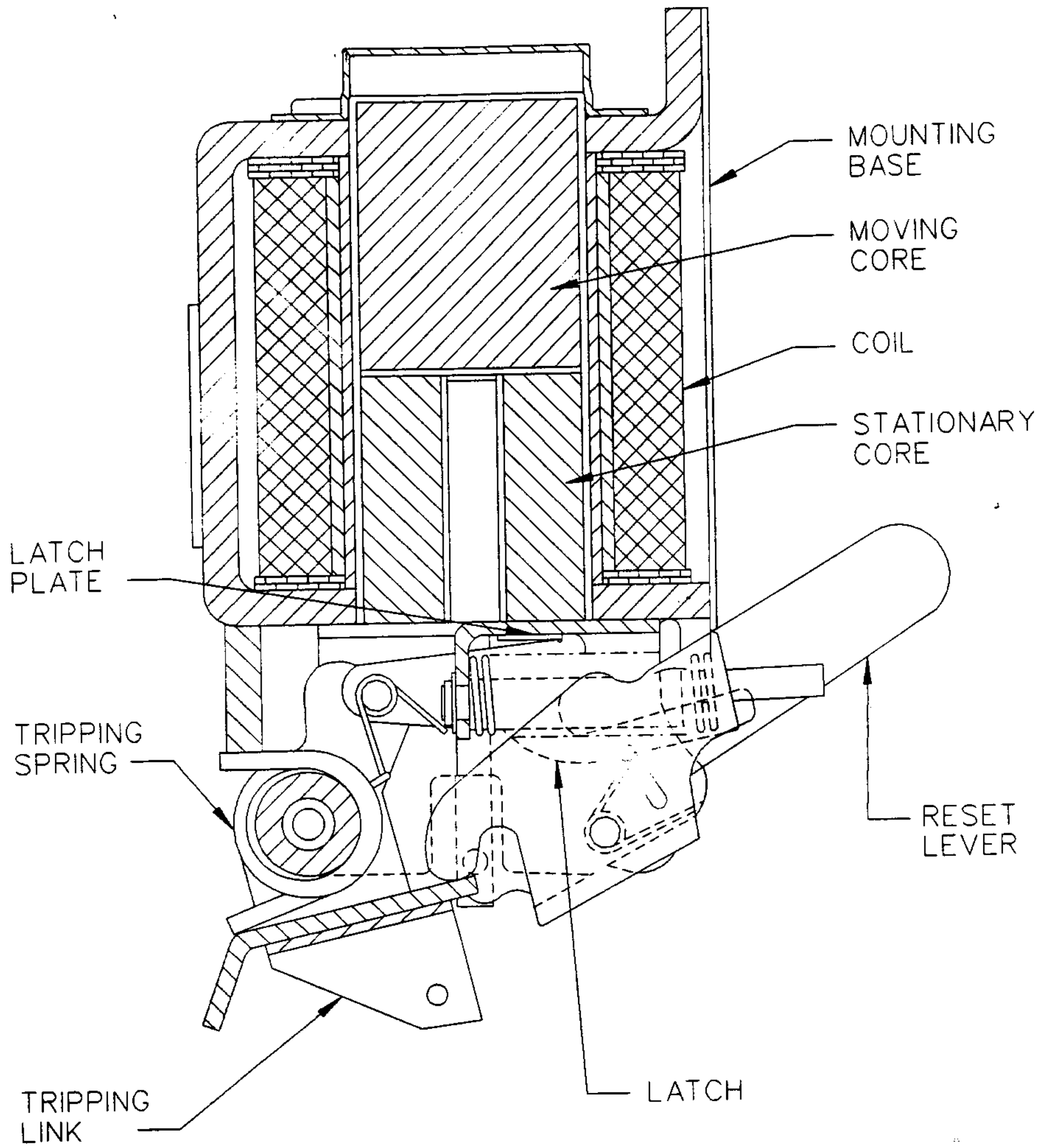

FIG. 7. Undervoltage Trip Unit

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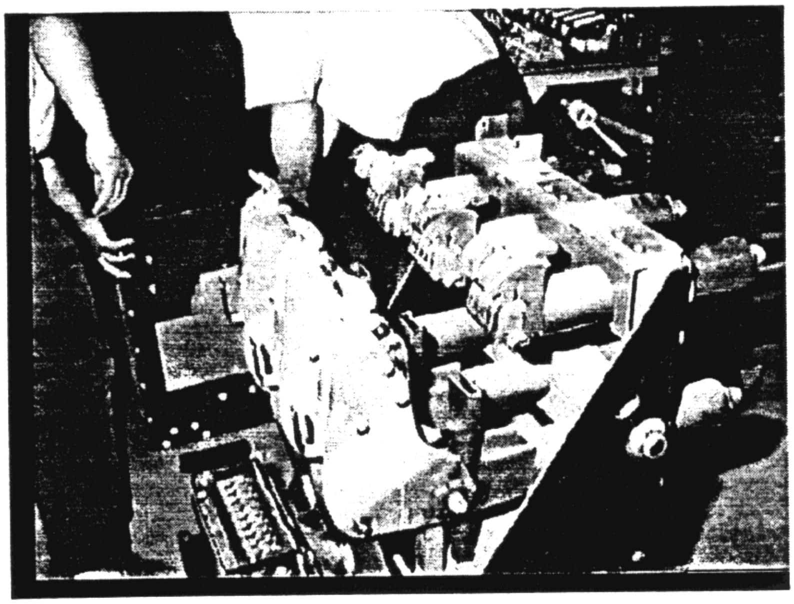

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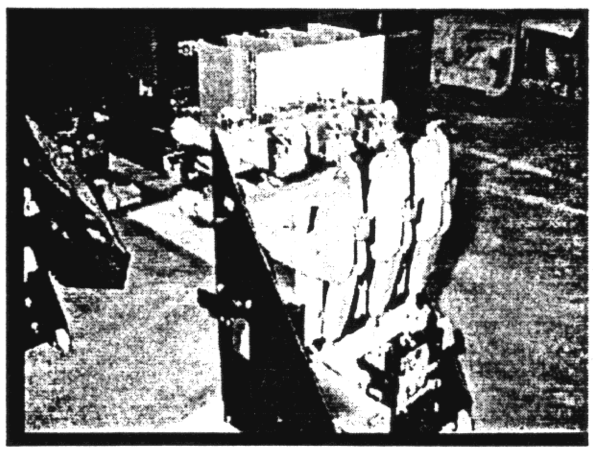

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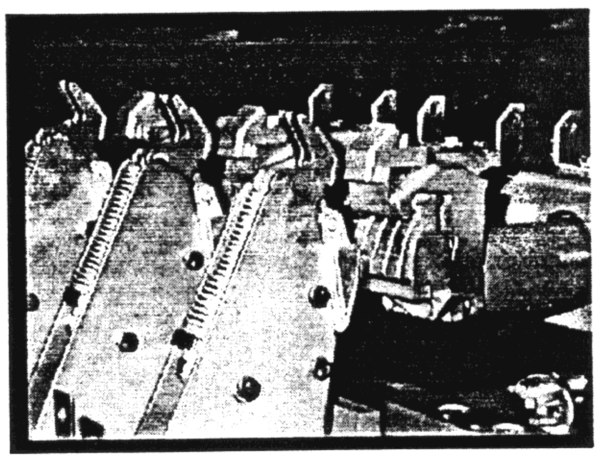

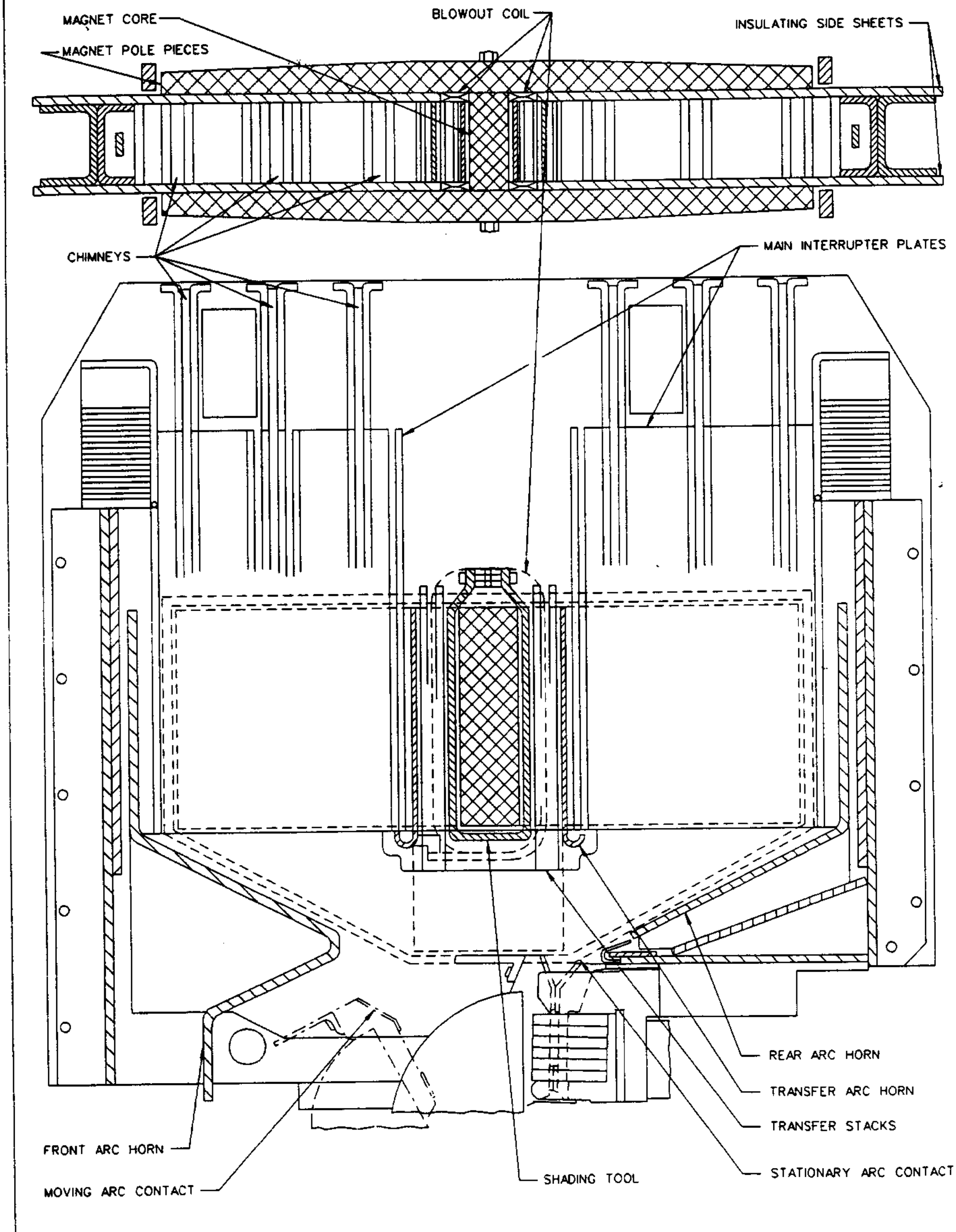

FIG. 10. Arc Chute Arrangement

transfer stacks and are quickly interrupted, placing the blow-out coil in series with the arc. As current starts to flow in the blow-out coils, a magnetic field is developed. This drives the arc, which is now two separate arcs extending from the two end arc horns to the transfer arc horns, very rapidly into the refractory plate slots. As the arc moves toward the closed end of the slots, it is lengthened, restricted, and cooled resulting in a rapid deionization of the arc space. At current zero, the dielectric strength established by deionization of the arc space interrupts the circuit and prevents the arc from restriking.

2.3.2.5 Levering-In Device

The levering-in device consists of a common shaft across the back of the circuit breaker with an arm attached to each end of the shaft. On each arm is a roller that engages a groove in the breaker cubicle. The arms are rotated by a worm gear arrangement driven by a shaft protruding through the front lower right section of the breaker. The shaft is rotated by means of a removable crank.

Before a breaker can be rolled into a cell, the roller arms must be pointing to the rear and slightly downward. This can be accomplished by placing the crank on the operating shaft, pushing in, and rotating to engage the levering-in device coupling. Note that the coupling cannot be engaged with the breaker contacts in the closed position. Rotating the shaft to the end of travel counterclockwise moves the roller arms to the desired position. At the end of travel, the interlock will release and the crank handle will move back out. In this position the indicator on the mechanism panel will point to the word «operate».

The breaker can now be rolled into the cell as far as the test position, where the roller arms strike vertical angles on the cell wall. To move the breaker from the test to the fully engaged position, place the crank on the operating shaft, push in and rotate to engage the coupling, and rotate the shaft clockwise. At the end of travel, the interlock will again fall free, pushing the crank back out. The indicator on the mechanism panel will again point to the word «operate».

To remove the breaker from the connected to the test position, repeat the process described above, rotating the crank counterclockwise.

The interlocking action described during the levering process is accomplished by pins on the breaker mechanism and levering-in device, operating at right angles to each other. With the breaker in the closed position, the mechanism pin is extended over the end of the levering device pin. This prevents the pin from moving and inhibits engagement of the levering device coupling. With the breaker in any position between test and connected, the levering device pin is extended blocking the mechanism pin, thus preventing closure of the circuit breaker.

2.3.2.6 Secondary Contacts

The secondary connector block is an eighteen point connection block mounted on the lower left-hand side of the breaker frame. The male portion of the contact block mounted on the breaker frame mates with the female half of the contact block mounted on the

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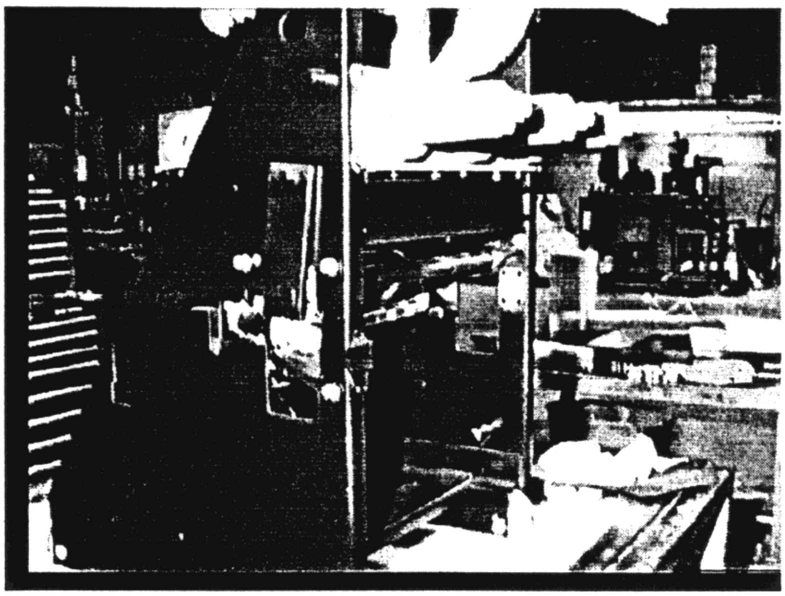

transfer stacks and are quickly interrupted, placing the blow-out coil in series with the arc. As current starts to flow in the blow-out coils, a magnetic field is developed. This drives the arc, which is now two separate arcs extending from the two end arc horns to the transfer arc horns, very rapidly into the refractory plate slots. As the arc moves toward the closed end of the slots, it is lengthened, restricted, and cooled resulting in a rapid deionization of the arc space. At current zero, the dielectric strength established by deionization of the arc space interrupts the circuit and prevents the arc from restriking.

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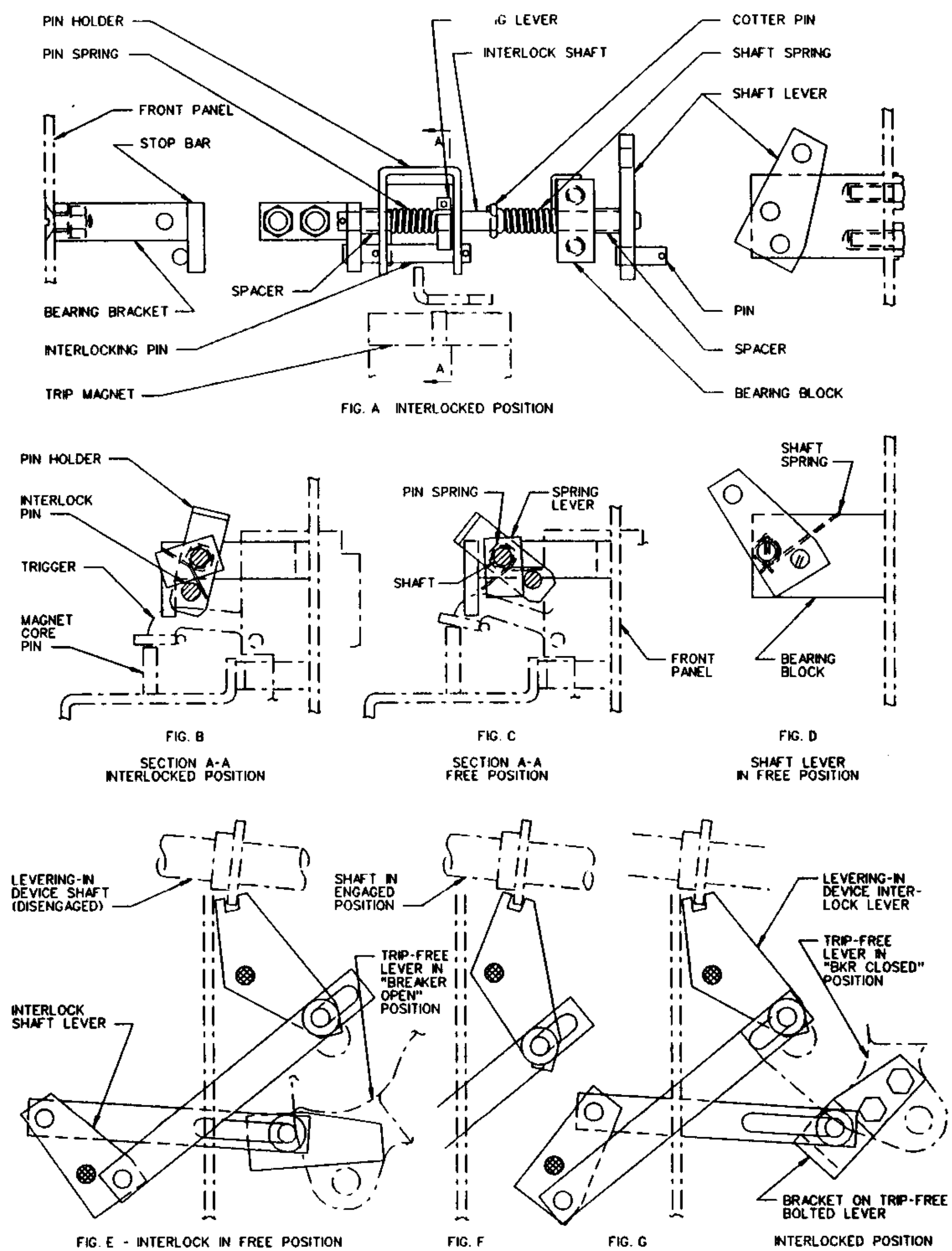

FIG. 23. Mechanical Interlock

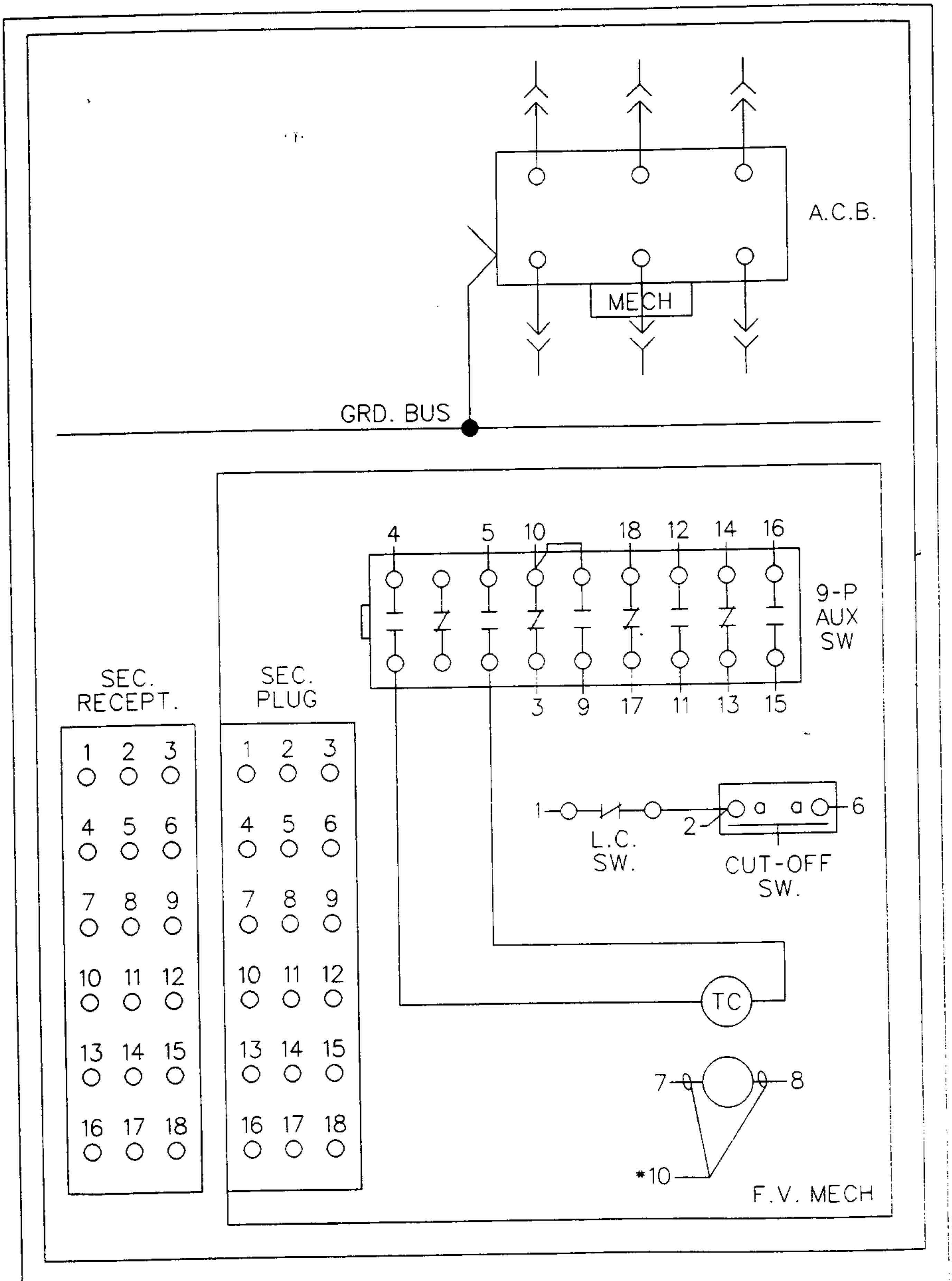

FIG. 18. Diagram of Breaker Internal Wiring

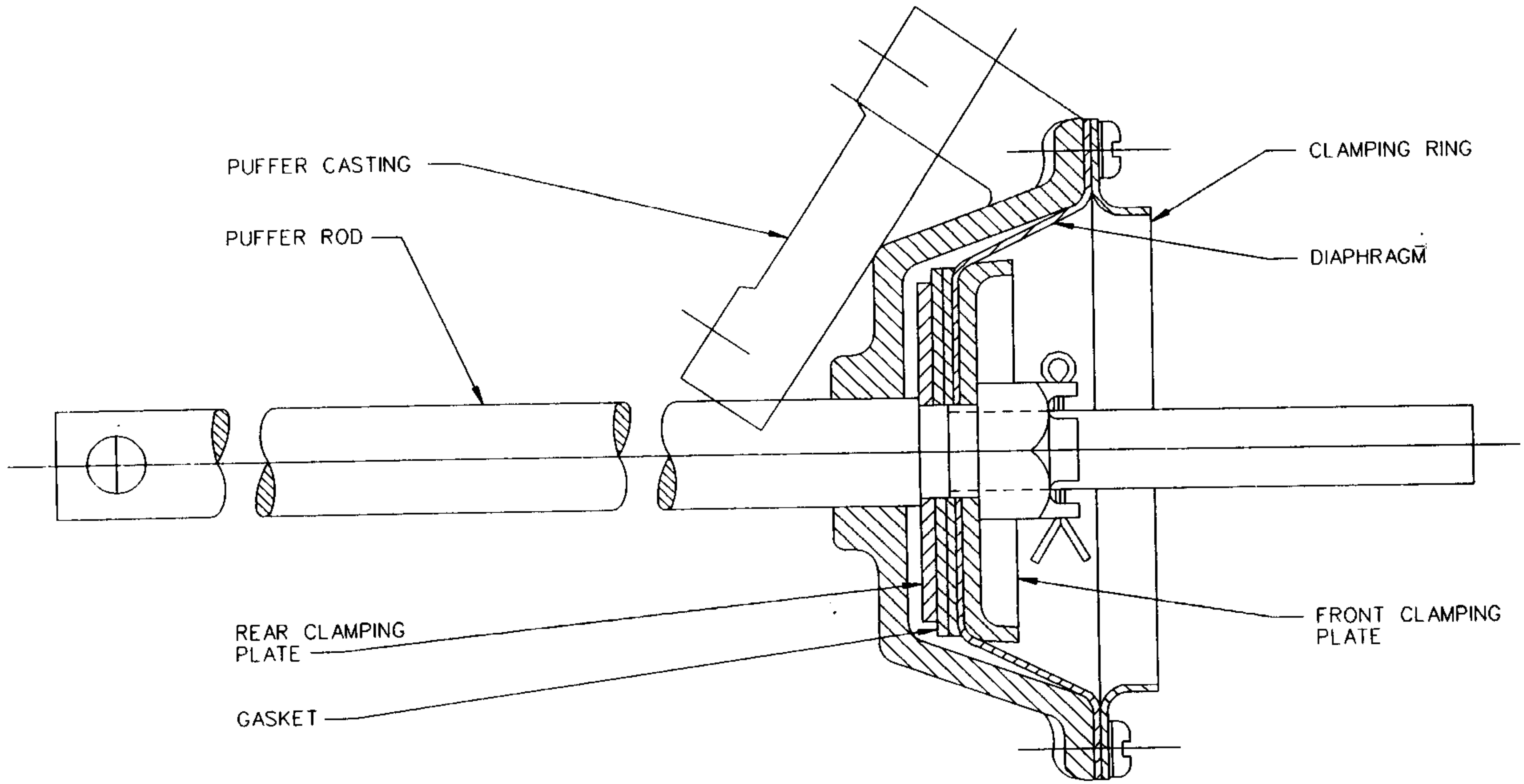

FIG. 17. Puffer Arrangement

2.4.2 Detailed Description

The general arrangement of components on the type DHP circuit breaker are shown in figures xx and xx. The following detailed description is provided for each of the circuit breaker components.

2.4.2.1 Operating Mechanism

The spring stored energy operating mechanism stores closing energy by compressing the closing spring. Release of this stored energy closes the circuit breaker and simultaneously charges the breaker opening springs.

The operating mechanism consists of a main crank with an attached hexagon shaft, a ratchet wheel, and a closing cam. This forms the crankshaft assembly.

An electric motor drives the ratchet wheel and ratcheting mechanism, causing the main crank and closing cam to rotate. A connecting rod between the main crank and the closing spring compresses the spring as the device turns. The spring compresses until the main crank rotates past center and the closing stop roller comes against the closing latch. The latch maintains the spring in the fully compressed position until release of the closing trigger. The trigger, released electrically or manually, releases the closing stop roller on the main crank, allowing the stored energy of the closing spring to close the breaker.

As the closing spring nears full compression, the tripping trigger snaps into the latched position. The closing action of the breaker rotates the main shaft, charging the tripping (opening) springs. Release of the tripping trigger, manually or electrically, releases the tripping latch, allowing the linkage to collapse and open the breaker.

Figures xx and xx provide typical schematic representations for the DHP breaker electrical control system. Figure xx depicts a DC control diagram, and figure xx a control system using AC for the control voltage. Both diagrams represent control systems for DHP type circuit breakers using spring stored energy operating mechanisms.

Referring to figure xx, and assuming the circuit breaker to be open with the spring discharged, electrical operation is as follows:

Control power is applied as the secondary contacts make up in the cubicle. This energizes the spring charging motor through a normally closed limit switch contact. As the motor runs, charging the closing spring, the latch check switch and normally open limit switch contacts remain open, preventing circuit breaker closure. When the spring reaches the fully charged position, the limit switch operates, deenergizing the spring charging motor. As the closing spring is latched into the fully compressed position, the latch check switch is operated, closing its contact in the spring release coil circuit.
At this point the breaker is in the open position, with the closing spring fully charged and latched, ready for a close signal.

Electrically, the breaker is closed by an external control switch that energizes the spring

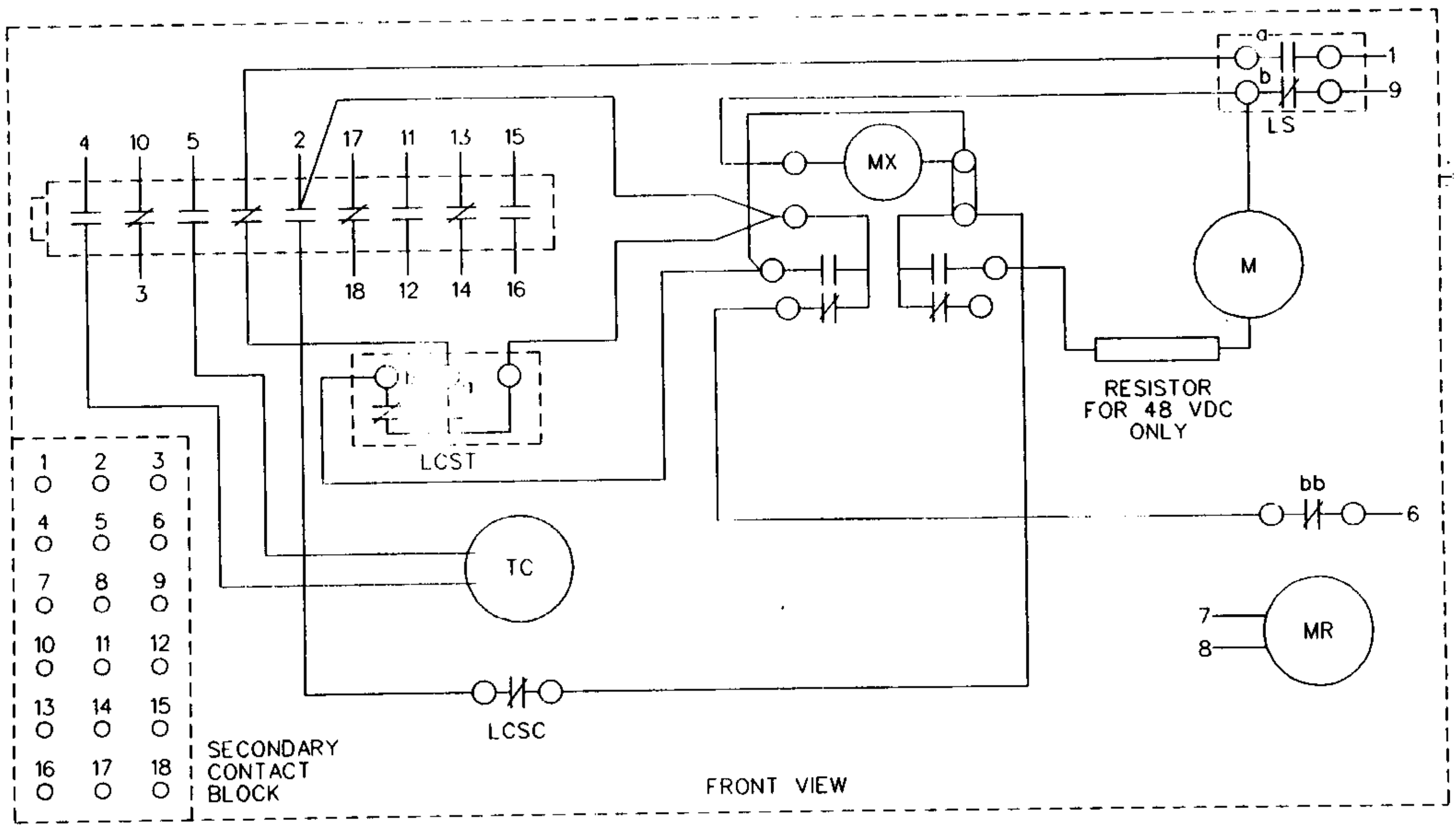

FIG. 16. Typical Breaker Wiring Diagram for D-C Control of Type DH Air Circuit Breakers With Stored Energy (Spring) Closing Mechanism

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The circuit breaker is tripped electrically by providing control power to the tripping magnet through an external switch. Energization of the tripping magnet causes the magnet plunger to lift and actuate the tripping trigger. This disengages the primary latch allowing the breaker to open.

2.4 DHP Circuit Breakers

2.4.1 General Description

The Westinghouse type DHP circuit breaker is a three-pole medium voltage magnetic air circuit breaker. It provides control and protection for electrical equipment and circuits in medium voltage applications from 4.16KV to 15.0KV.

DHP breakers are available in the following voltage levels, MVA classes, and frame sizes:

Nominal Voltage - KV	Nominal MVA Class	Continuous Current Frame Size - Amps
4.16	75	1200
	250	1200 / 2000
	350	1200 / 2000 / 3000
7.2	500	1200 / 2000 / 3000
13.8	500	1200 / 2000 / 3000
	750	1200 / 2000 / 3000
	1000	1200 / 2000 / 3000

Table 2.1 - Circuit Breaker Models

A typical circuit breaker model number would be 150DHP500. For this designator the 150 indicates that the breaker has a 15kv rating. DHP indicates the breaker type, and 500 delineates the circuit breaker MVA class.

Type DHP circuit breakers are horizontal drawout units equipped with spring stored energy closing mechanisms. The breaker is composed of three major sections: the breaker assembly, the interrupter/arc chute assembly, and the barrier assembly.

The breaker assembly consists of a chassis, an operating mechanism, a puffer assembly, a control panel, a levering-in device, interlocks, and three pole unit assemblies. Each of the three interrupter/arc chute assemblies contains arc runners, ceramic interrupter stacks, ceramic arc shields, blowout coils, baffels/deflectors, and a magnet structure within the arc chute jacket. The barrier assembly consists of a steel front sheet with an insulating shield behind it and four insulating sheets that go around the three arc chutes and pole units.

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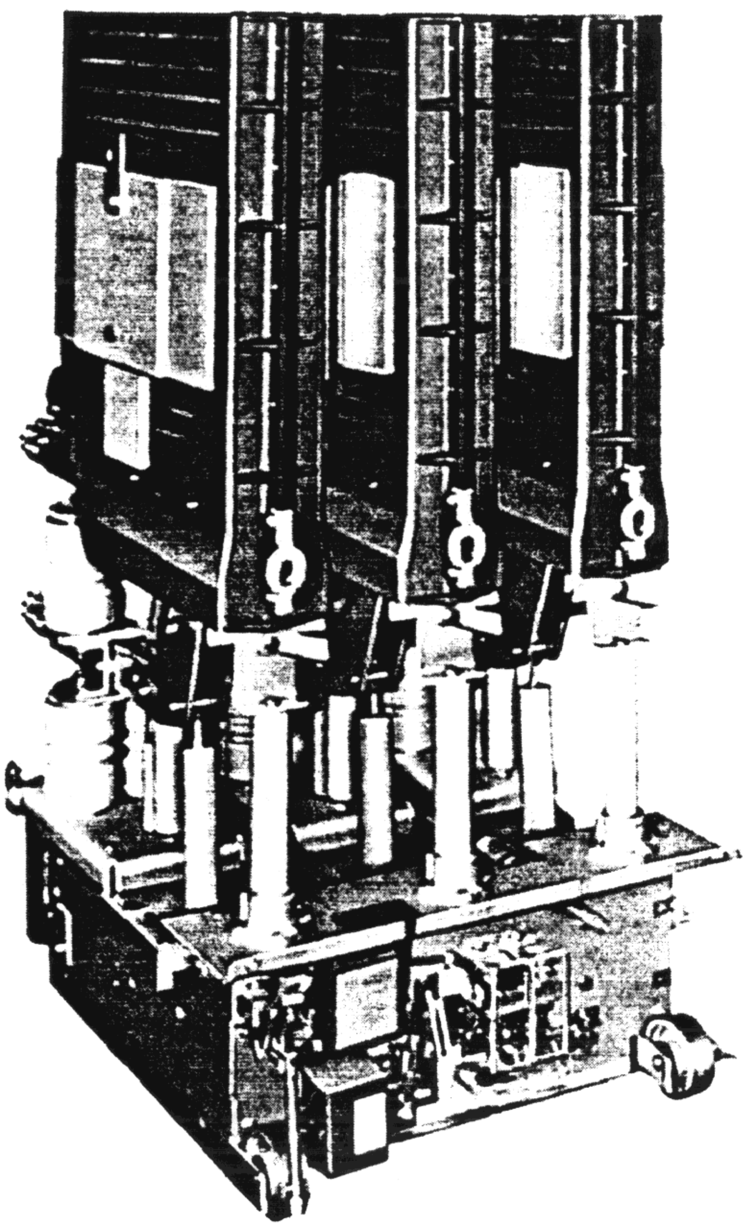

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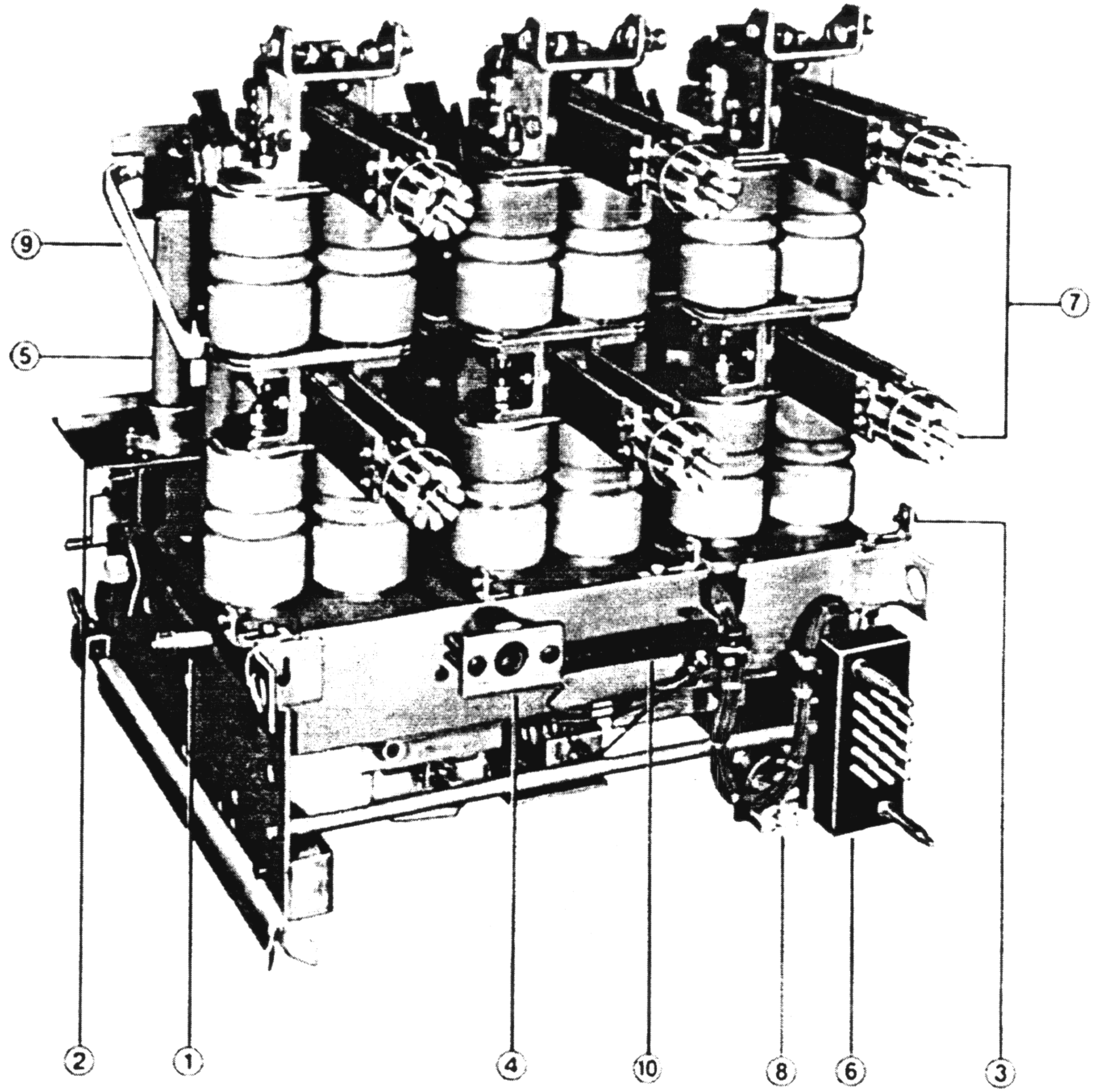
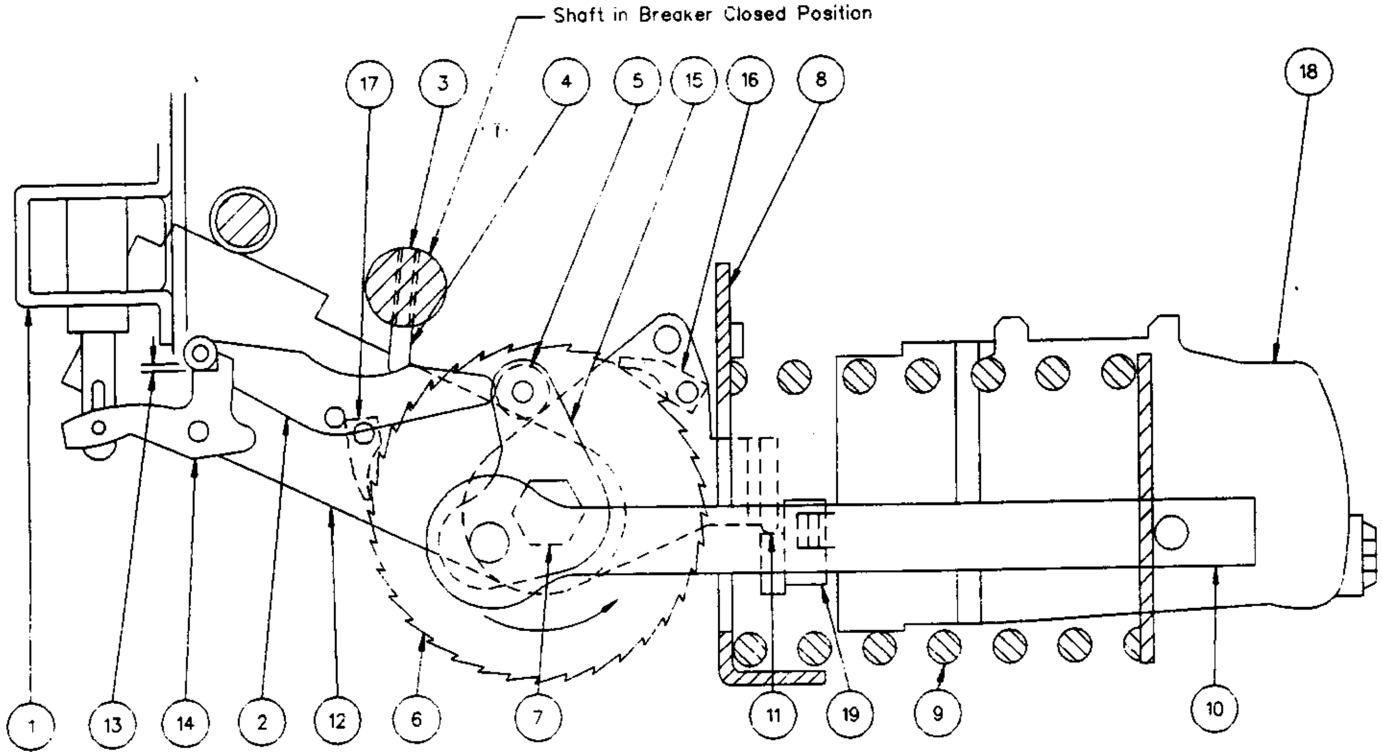




a. Stored Energy Mechanism: Spring Charged

1. Spring Release Magnet and Coil
2. Closing Latch
3. Pole Unit Operating Shaft
4. Anti-Close Interlock Screw
5. Closing Stop Roller
6. Ratchet Wheel
7. Crank Shaft
8. Mechanism Frame
9. Closing Spring
10. Connecting Rod
11. Driving Plate and Motor Ratchet Lever Assembly
12. Manual Ratchet Lever and Holding Pawl Assembly
13. Clearance .010 to .030, Breaker Closed
14. Closing Trigger
15. Main Crank
16. Drivng Pawl
17. Holding Pawl
18. Motor
19. Crank Assembly

b. Stored Energy Mechanism: Spring Discharged

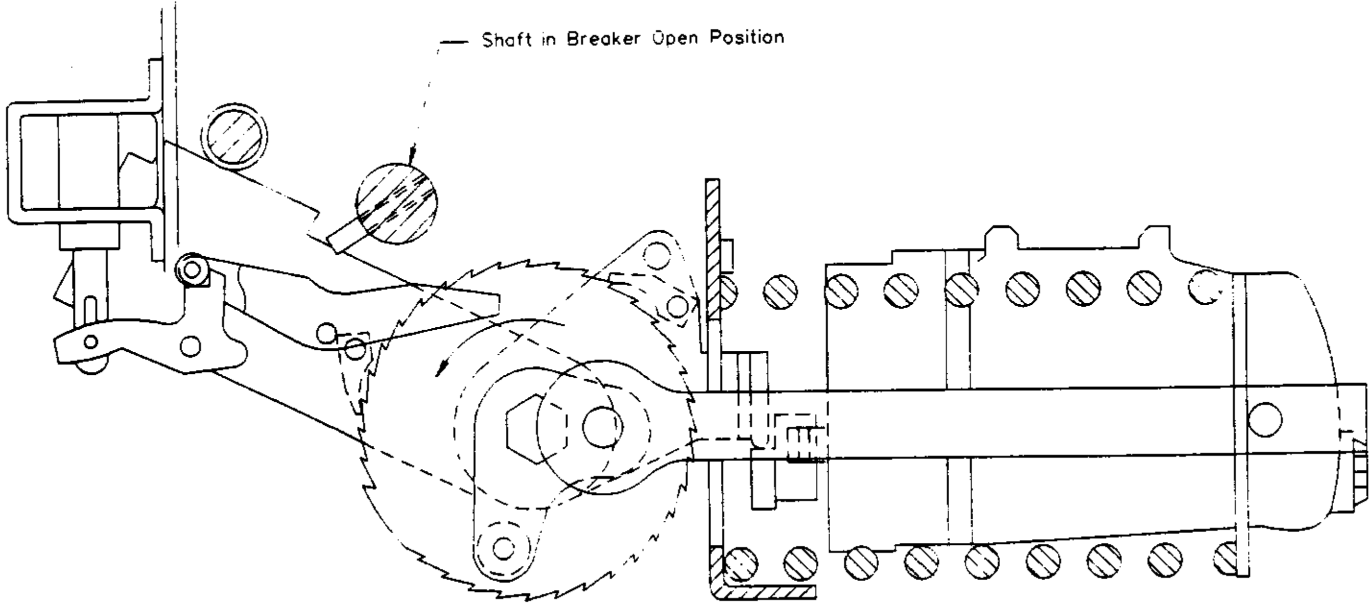


Fig. 15 Schematic views of Spring Charging Parts

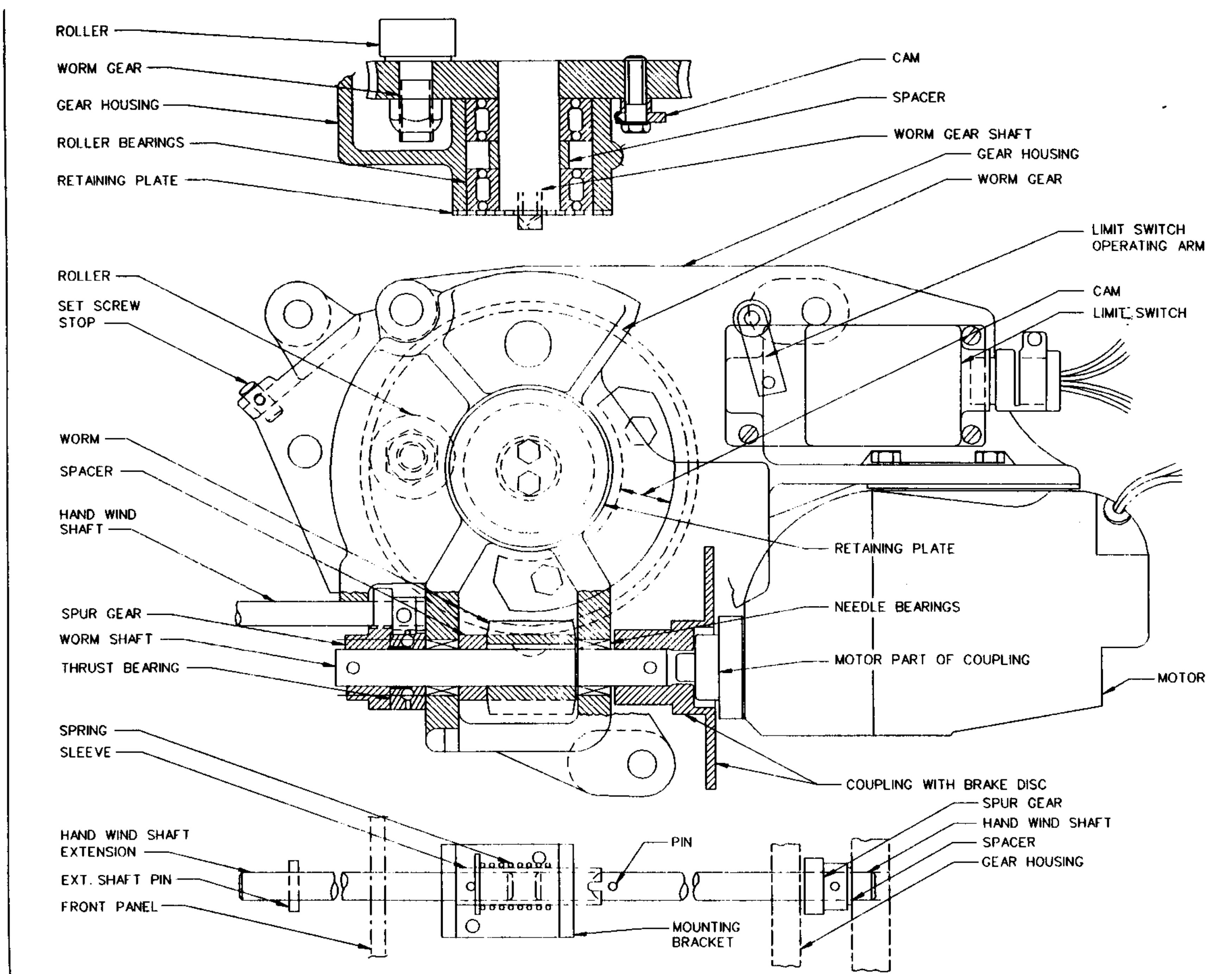


FIG. 10. General Disposition of Gear Housing and Gear Drive of Stored Energy (Spring) Closing Mechanism

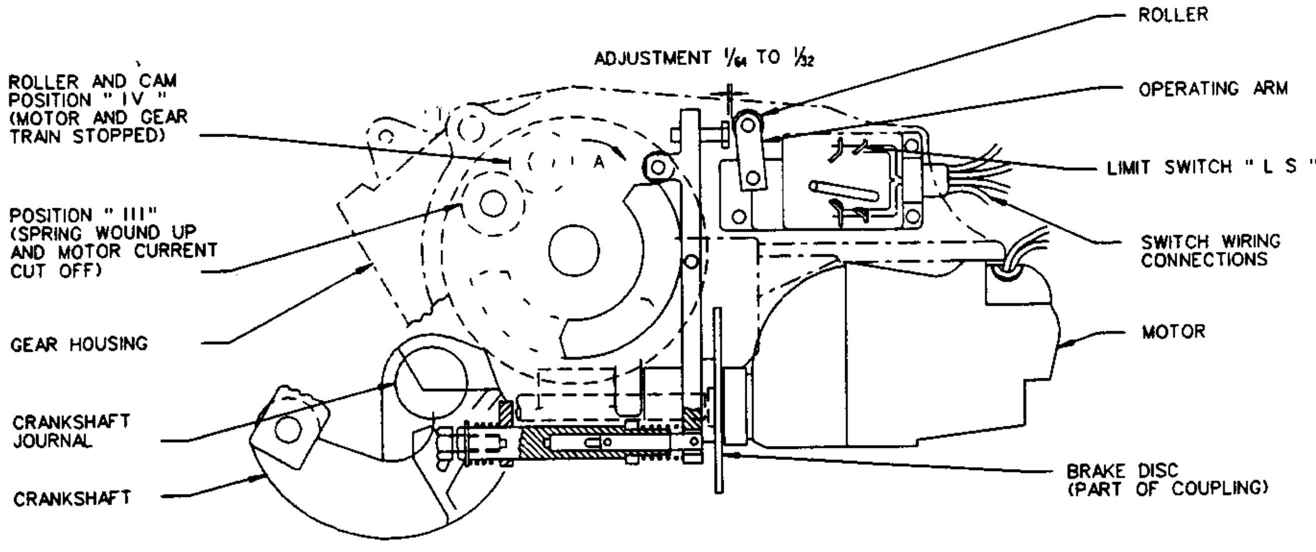


FIG. A

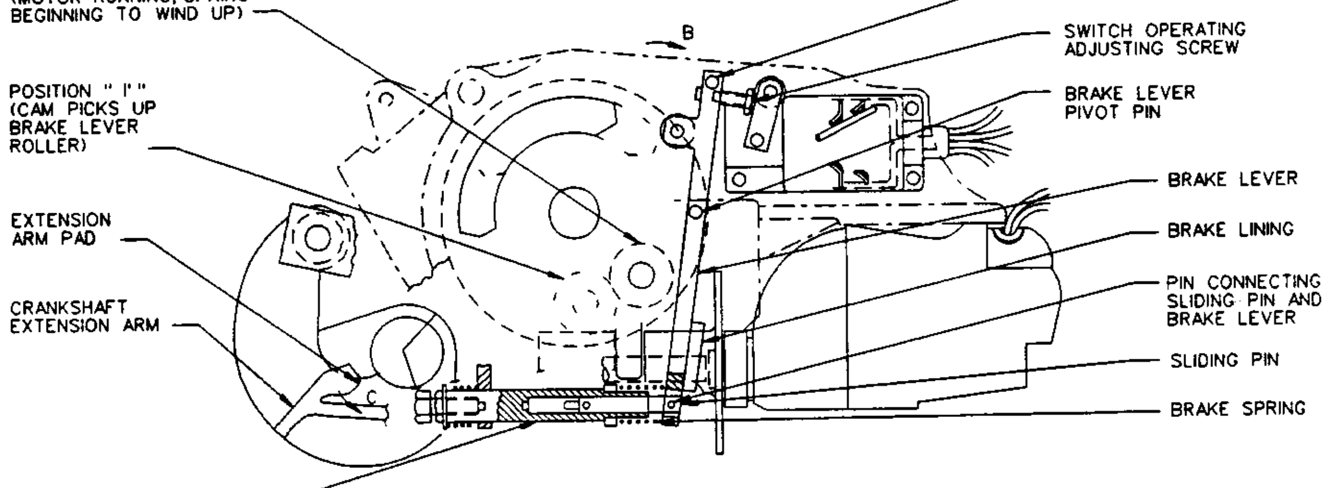


FIG. B

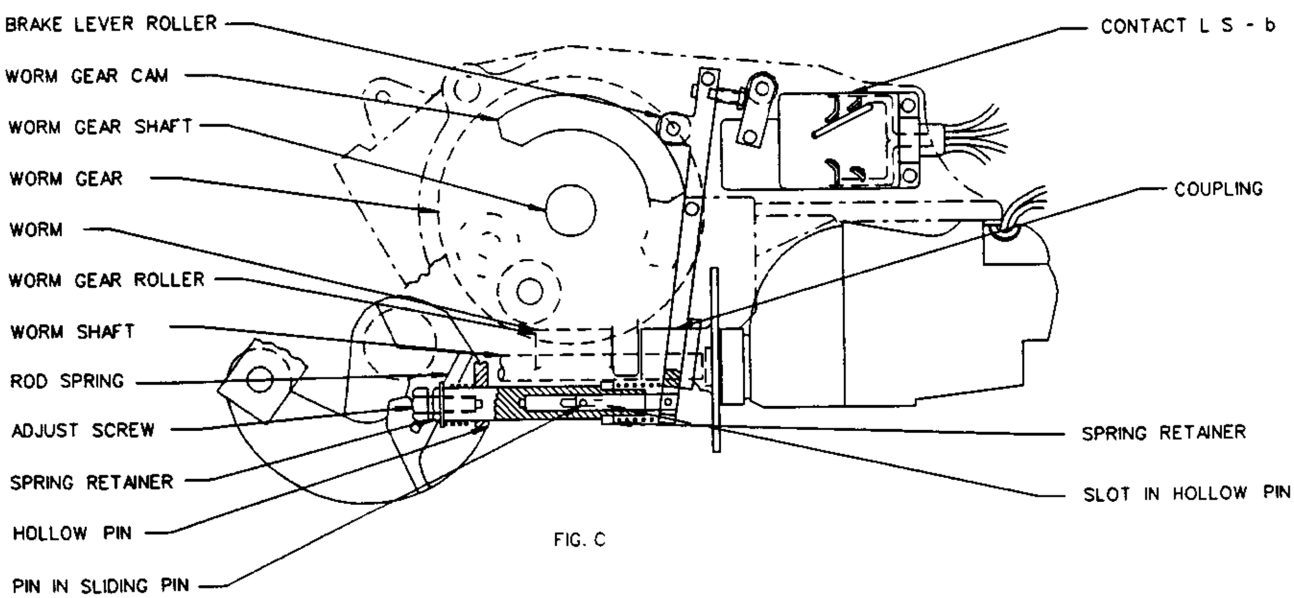
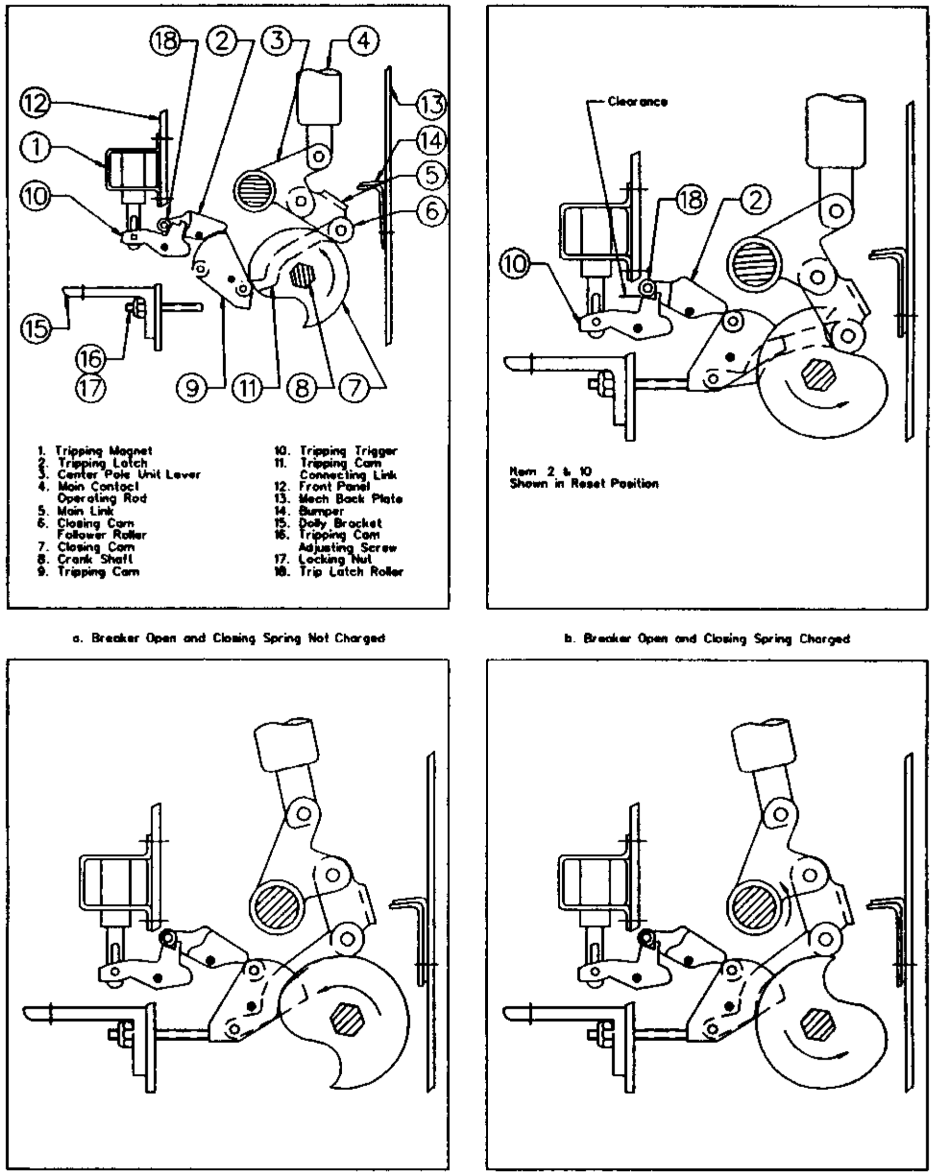


FIG. C



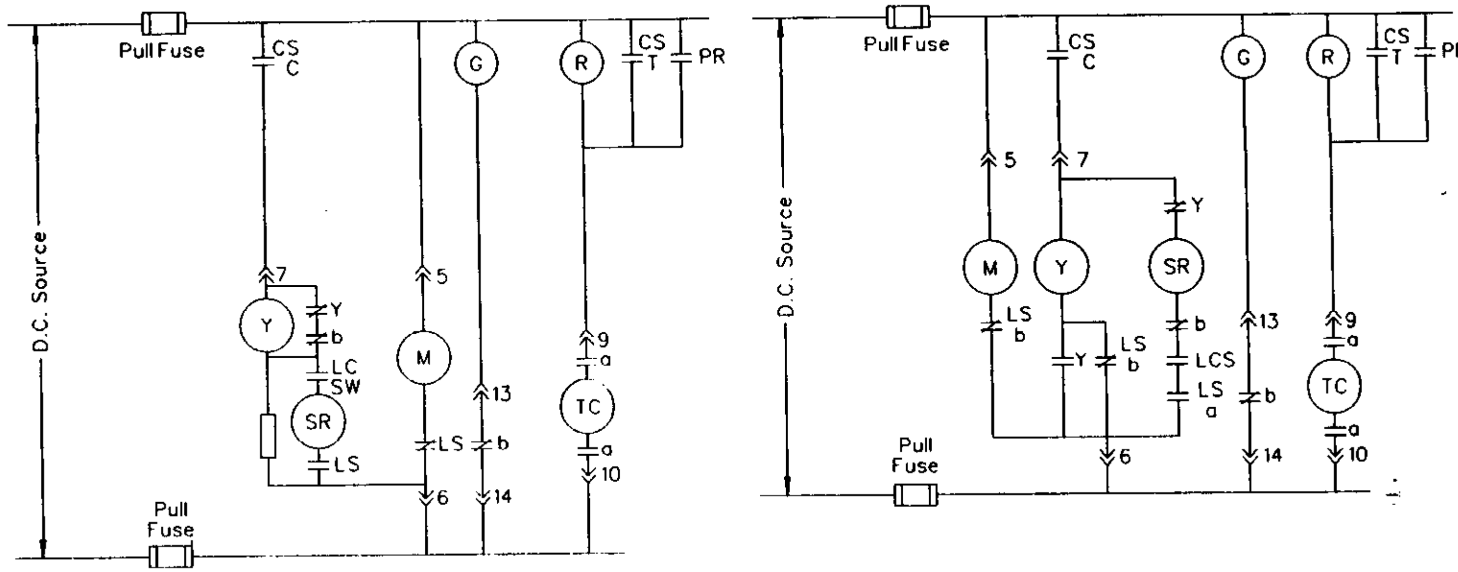
a. Breaker Open and Closing Spring Not Charged

b. Breaker Open and Closing Spring Charged

c. Breaker Closed and Closing Spring Not Charged

d. Breaker Closed and Closing Spring Charged

Fig. 13 The Four Positions of the Closing Cam and Trip Linkage



CS -- Bkr Control Switch C - Close T - Trip
Y - Control Relay
SR - Spring Release
M - Spring Charge Motor

TC - Trip Coil
PR - Protective Relay
G - Green Indicating Light
R - Red Indicating Light

Fig. 29 D-C Control Schemes - Typical

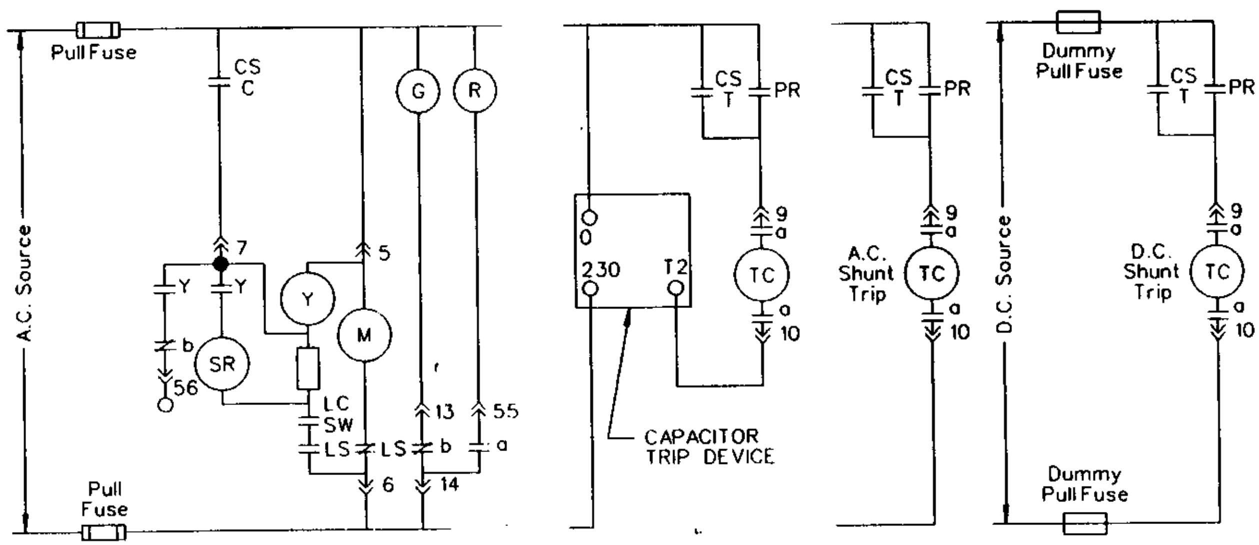


Fig. 30 A-C Control Schemes - Typical

release coil. Energization of the spring release coil (SR) disengages the release latch, allowing the breaker to close. Closure of the circuit breaker main contacts operates the limit switch, the latch check switch, and the breaker auxiliary switch. This restores power to the motor, charging the closing spring as previously described. The Y relay circuit operates to provide anti-pump protection as the breaker is cycled.

Closure of the circuit breaker and subsequent operation of the auxiliary contacts arm the breaker trip coil. The breaker is tripped electrically by means of an external trip switch or protective relay device that energizes the trip coil. This disengages the tripping latch, allowing the breaker to open.

Figure xx, depicting a control diagram using alternating current for the control voltage functions in the same manner as the previously described DC circuit with the exception of the capacitor trip device. This device is used to ensure tripping power is available upon loss of AC control voltage.

2.4.2.2 Control Panel

The control panel provides indication and control features for the breaker. It is located on the front of the breaker chassis.

Mounted on the control panel are the control relay, operation counter, auxiliary switch, motor cut-off switch, closing spring charge indicator, latch check switch, breaker position indicator, and breaker nameplate. Also mounted on the panel are the closing spring release magnet and the tripping magnet for electrical breaker operation. Additional features accessible from the control panel are the tripping trigger and spring release trigger cams for manual breaker operation, the secondary contact hand operating rod, the manual ratchet lever, and the levering-in device operating shaft. The devices mounted on the control panel are addressed individually below and in the respective sections of the circuit breaker description.

Control Relay - The control relay provides anti-pump protection for the circuit breaker. Refer to figures xx and xx for a schematic representation of the Y relay in the control circuit.

Operation Counter - A link to the trip free lever operates the counter each time the breaker is tripped.

Auxiliary Switch - The auxiliary switch is a nine pole rotary type switch actuated by a link from the mechanism trip free lever. The switch consists of five normally open and four normally closed contacts. Each contact is rated for 20 amperes continuous current. The contacts of the switch change state on breaker operation.

Cut-Off Switch (limit switch) - The cut-off switch is a normally open (breaker open) auxiliary contact that functions with breaker control relaying to cut-off closing coil current after the breaker has closed. It is operated by an arm attached to the mechanism trip free lever.

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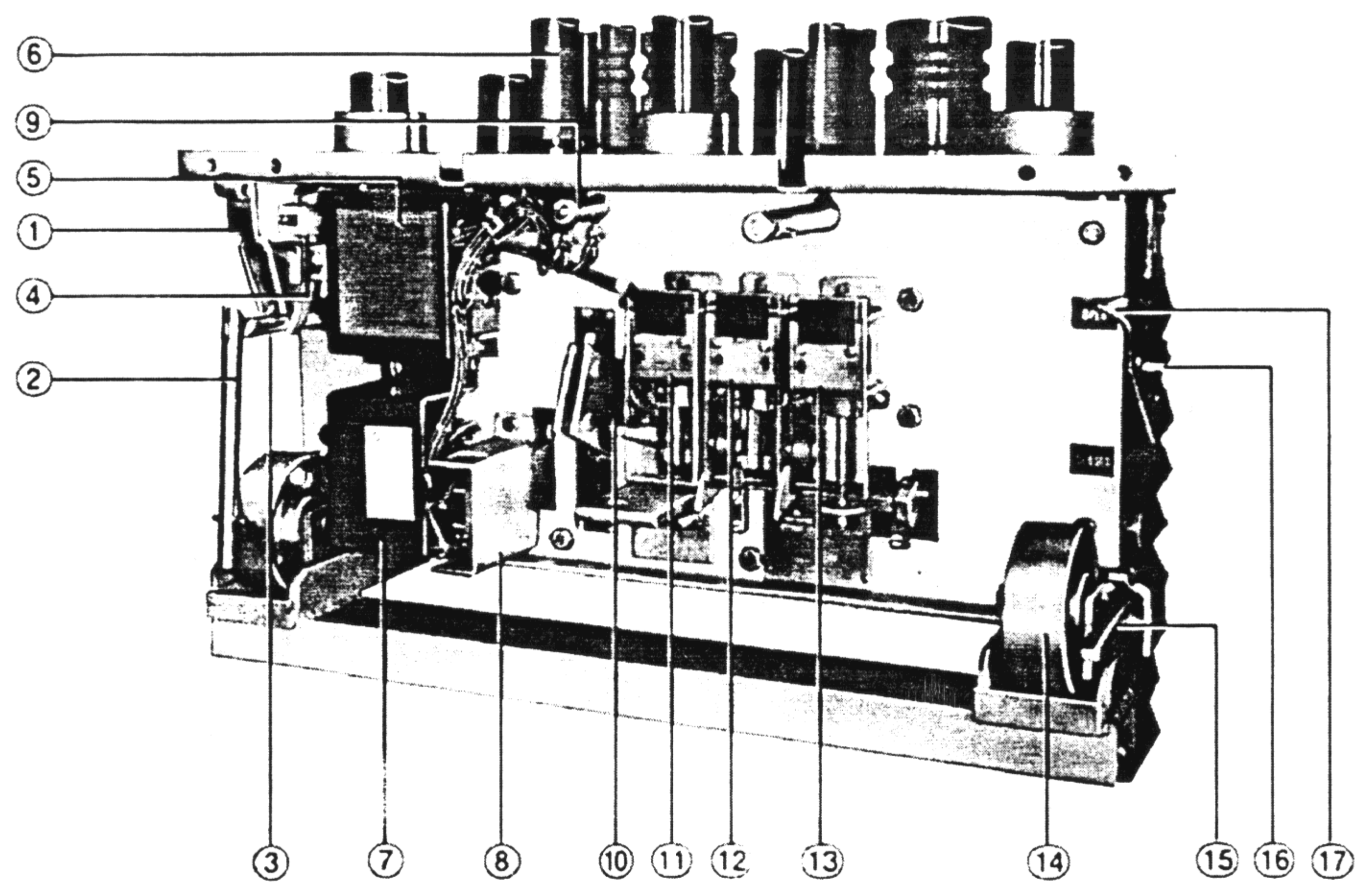


Spring Charge Indicator - The spring charge indicator is a mechanical indication operated directly from the mechanism trip free lever to provide closing spring charged or discharged indication.

Breaker Position Indicator - The breaker position indicator is a lever assembly fastened to the main shaft of the breaker operating mechanism, projecting through the right side of the breaker chassis. Movement of the lever is directly related to movement of the operating mechanism and main contacts. Open and Closed nameplates on the right side of the mechanism panel indicate position of the breaker contacts.

Latch Check Switch - The latch check switch is a snap action switch actuated by the primary latch. This switch prevents energization of the mechanism release coil until the operating mechanism is in the reset position. Reset of the primary latch is the last linkage motion required to reset the operating mechanism. Reset of the latch closes the latch check switch.

Undervoltage Trip Attachment (optional) - The undervoltage trip attachment is an electromechanical device used to trip the breaker when control voltage falls below a predetermined value. The moving core of the device is held magnetically against the stationary core and the roller lever spring. The moving core is attached to a roller lever, which restrains the UVTA tripping lever. As the coil voltage decays, the roller lever spring overcomes the magnetic attraction between the stationary and moving cores. The moving core travels downward and rotates the roller lever counterclockwise to release the tripping lever. A torsion spring around the pivot pin of the tripping lever rotates the lever counterclockwise to trip the breaker. When the breaker opens, a pin on the center pole reset lever strikes the UVTA reset lever and rotates it counterclockwise against the tripping and roller levers. The roller lever and tripping lever are rotated clockwise to reengage the stationary and moving cores. Upon breaker closure, the center pole reset lever moves away from the UVTA reset lever and the torsion spring of the tripping lever rotates it counterclockwise against the roller on the roller lever. This resets the undervoltage trip attachment. The UVTA is shown in figure xx.

Shunt Trip Magnet (optional) - The shunt trip magnet is a small electromagnet used to trip the breaker electrically. Its coil may be specified for alternating or direct current applications. When the shunt trip magnet is energized, the core is drawn up into the magnet yoke. As the core moves upward, an extension mounted on top of the core moves against the breaker trip lever directly above it. The force of the solenoid raises the trip lever, disengaging the primary trip latch, allowing the breaker to trip. A thin brass washer prevents residual magnetism from retaining the core in the raised position after deenergization of the coil.

2.4.2.3 Pole Unit Assembly

Each pole unit consists of a pole unit base, porcelain insulators, and aluminum extrusions bolted together to support the upper and lower conductors, the moving contact assembly, the stationary contacts, and the arc chute hinge assembly.

The upper and lower conductors are multiple rectangular bars. They are made of copper or aluminum. On the disconnecting end of the conductors, a round stud adaptor is

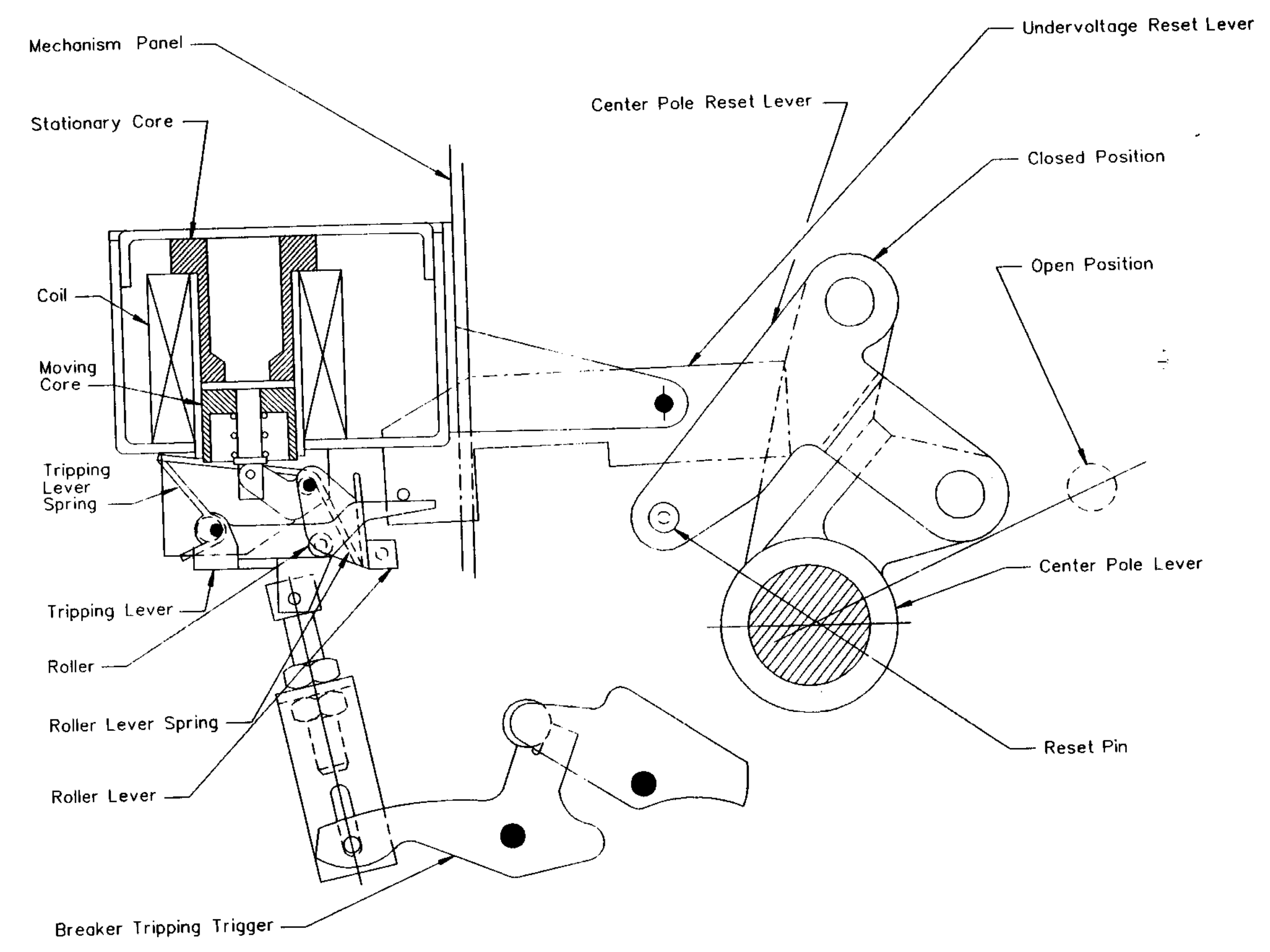


Fig. 31 Undervoltage Trip Attachment

securely bolted to the conductors. This adapts the rectangular conductors to the round primary disconnect fingers. Pole unit assemblies for 15.0kv and 4.16kv circuit breakers are shown in figures xx and xx respectively. Figure xx depicts the round stud adaptor used to attach the primary disconnect fingers to the conductors.

2.4.2.4 Contacts

Two sets of contacts are provided on the type DHP circuit breaker: main, and arcing. Each set of contacts contains a moveable and a stationary component. When the breaker is tripped the contacts separate in a specific order, with the main contacts breaking first, followed by the arcing contacts. The order is reversed during the closing operation.

Each breaker pole unit includes one arcing contact assembly and two parallel main contact assemblies. The contact assemblies are wedge-finger type with contact wipe. The moving contact penetrates the space between adjacent stationary mounted fingers that deflect as the breaker is closed.

The stationary main contacts are bolted to the top conductors of the pole unit directly below the arcing contacts. They are fabricated from a high strength silver plated copper alloy with anti-weld inserts. Referring to figures xx and xx, the number and size of stationary contact members vary, depending on ampere rating of the circuit breaker.

On the 1200 ampere breaker, there are a total of eight contact fingers per pole. Twelve contact fingers per pole are used on the 2000 amp breaker and sixteen on a breaker with a 3000 amp continuous current rating.

The moving main contact members are fastened to the moving blades of the pole unit. They are anti-weld shaped wedges and are similar in size for all breaker ratings. The blades on which the contact members mount vary in length and thickness, depending on breaker rating.

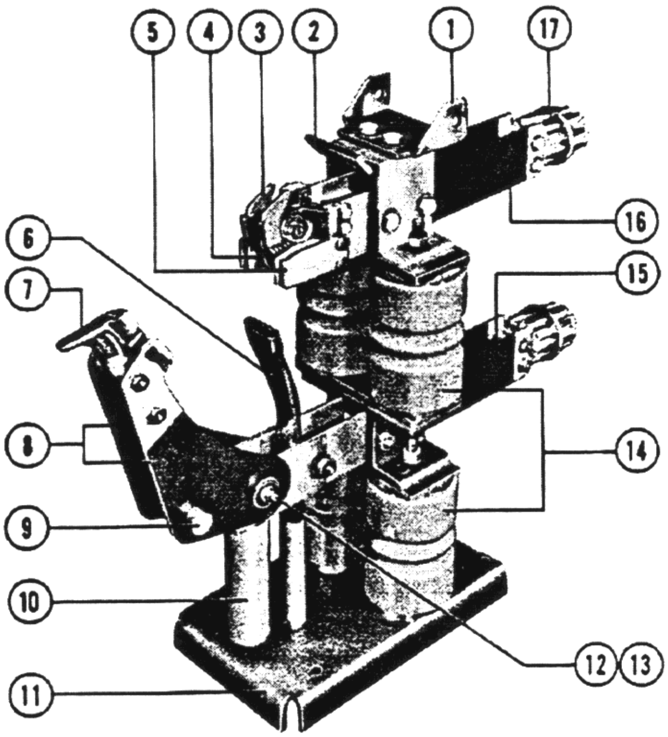
The stationary arcing contact members are connected to the top conductors of the pole unit above the main contact members. They are fabricated from the same high strength copper alloy as the main contacts, but are heavier and shaped differently. Each member contains an anti-weld insert and is mounted to allow a slight pivot as they are deflected. Compression springs are mounted behind the contact assembly to ensure proper contact pressure.

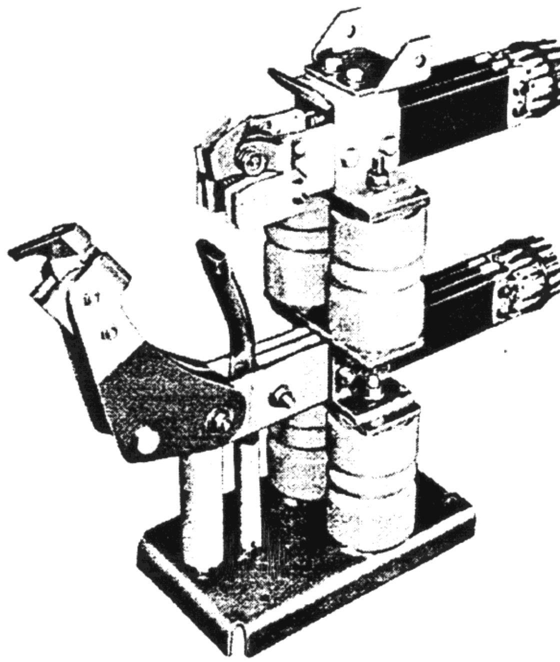
The moving arcing contact members are fastened to the moving blade assembly just above the moving main contacts. They are anti-weld shaped wedges and are similar in size for all breaker ratings.

2.4.2.5 Arc Chutes

Functionally, all type DHP arc chutes are the same. Their sizes vary depending on the rating of the circuit breaker.

The arc chute assembly consists of a laminated magnetic core (blow-out magnet), blow-out coils, transfer arc horns, transfer stacks, a front arc horn, and a rear arc horn pip1.pcx





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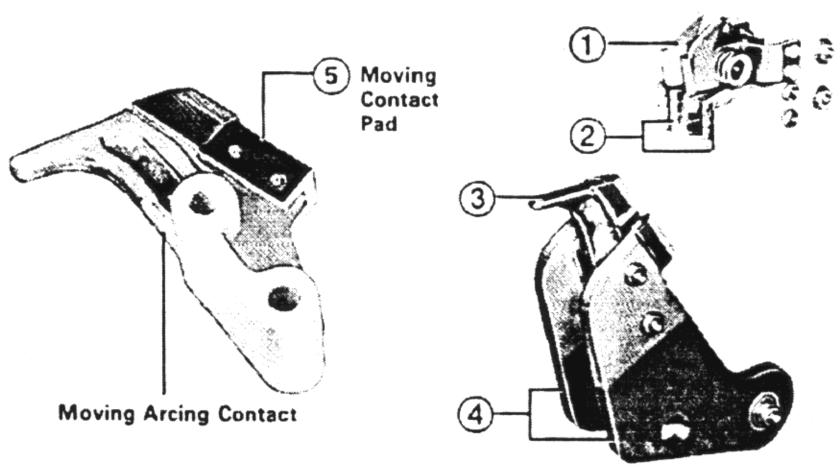
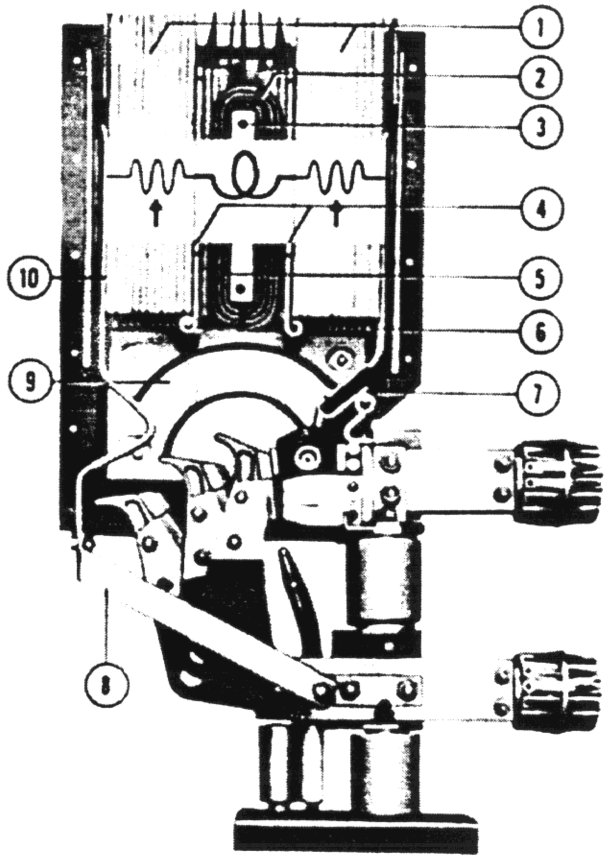


arcchu.pcx



assembled in a rectangular enclosure. The chute is hinged to the breaker and completely encompasses the contact assembly when it is in its lowered, operating position. Refer to figure xx for a cross sectional view of the arc chute components.

The blow-out magnet is arranged so that the magnet core passes through the center of the arc chute. The blow-out coils are wound around the core and lie in openings cut into the chute jacketed enclosure. One terminal of each coil is connected to a transfer arc horn, and the other terminals are connected to the shading coil.

Two transfer stacks are placed in the space between the transfer arc horns and the shading coil. On each side of the transfer arc horns are the main interrupter stacks. These stacks are fabricated from insulating refractory-type material with inverted V-shaped notches molded into them. The slots are offset so that when the plates are stacked, the slots alternate from one side to the other. This causes the arc to travel a winding path, thus elongating the arc. On each side of the main interrupter stacks are two metallic arc horns that transfer the arc from the breaker arcing contacts. The front arc horn is electrically connected to the breaker moving contact, and the rear arc horn is connected to the stationary contact.

As the circuit breaker opens an arc is drawn across the arcing contacts. The arc impinges on the lower ends of the two transfer arc horns and the shading coil. The two short arc segments between the transfer arc horns and the shading coil move upwards into the transfer stacks and are quickly interrupted, placing the blow-out coil in series with the arc. As current starts to flow in the blow-out coils, a magnetic field is developed. This drives the arc, which is now two separate arcs extending from the two end arc horns to the transfer arc horns, very rapidly into the refractory plate slots. As the arc moves toward the closed end of the slots, it is lengthened, restricted, and cooled resulting in a rapid deionization of the arc space. At current zero, the dielectric strength established by deionization of the arc space interrupts the circuit and prevents the arc from restriking.

2.4.2.6 Levering-In Device

The levering-in device is used to move the breaker between disconnected, test, and connected positions within the breaker cubicle.

The device consists of a levering nut, a guide tube, a shaft, and the levering-in interlock installed as part of the breaker chassis.

Movement of the circuit breaker into the cubicle is facilitated by the guide channel and rail latch assembly. The guide channel is an inverted U-shaped channel welded along the bottom right edge of the chassis side sheet. The guide channel, in conjunction with the guide rail welded to the compartment floor, position the breaker laterally in the cell. The rail latch, located directly in front of the guide channel, stops the breaker in the cell just before the levering screw and nut engage. The rail latch has two catching dogs that engage notches in the compartment guide rail, holding the breaker in either the disconnected or test position. To lever the breaker from the test position into the connected position, the rail latch must be depressed and the breaker pushed approximately 0.25". This engages the rotatable levering nut on the circuit breaker with

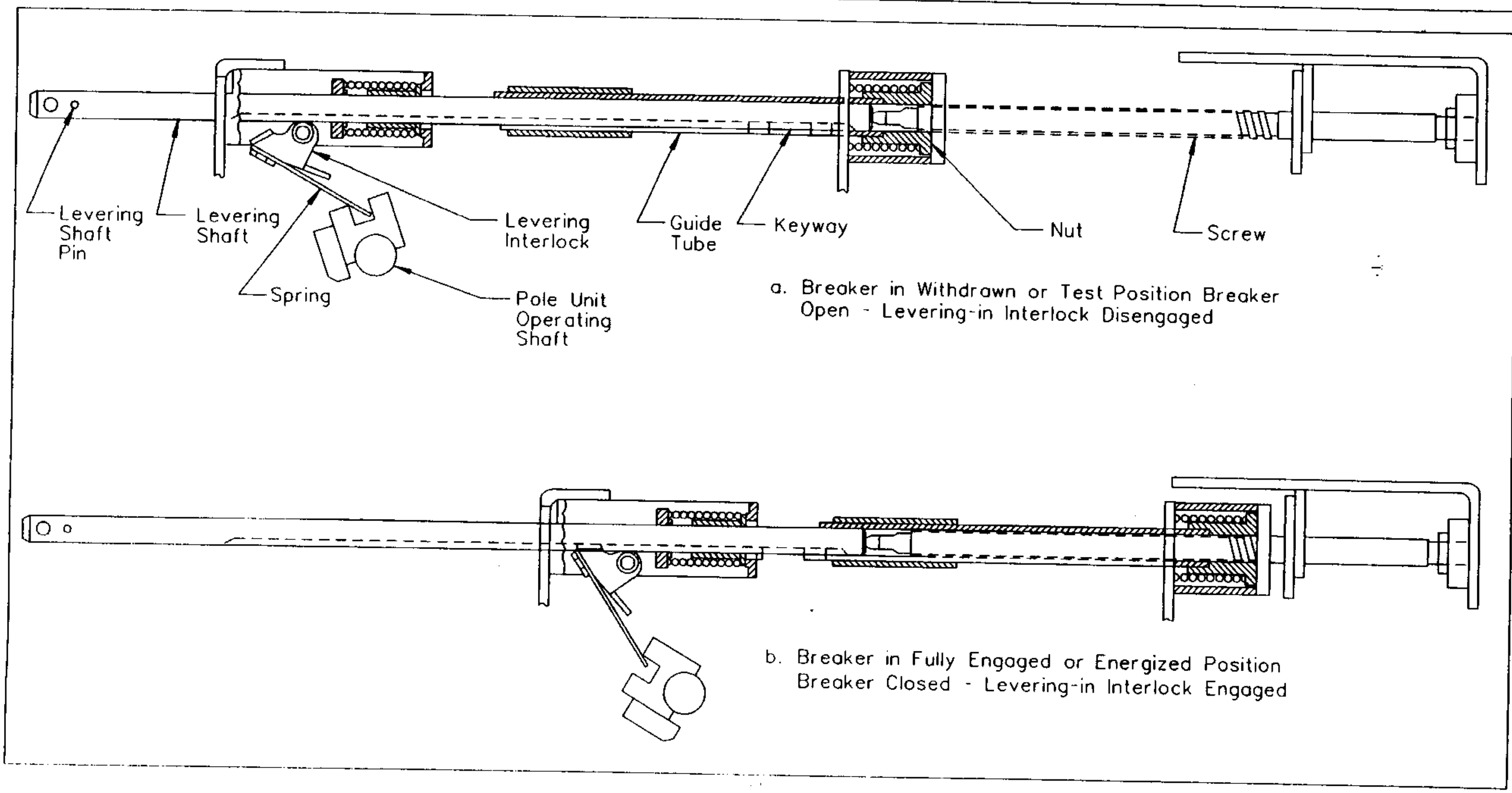
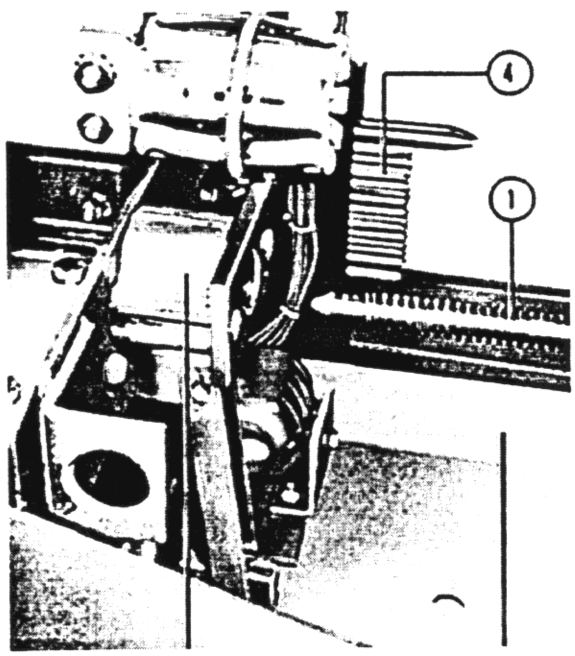


Fig. 19 Schematic of Levering-in Device and Interlock

#7

levnut.pcx



the levering screw mounted on the rear wall of the compartment. As the levering nut is rotated clockwise along the levering screw shaft, the breaker is moved into the connected position.

The levering shaft, which is accessible from the breaker control panel, is used to rotate the levering nut. Two rectangular keys welded to the levering-in shaft rotate the guide tube, which is slotted lengthwise for a distance approximately equal to the breaker travel distance. The keys slide in the guide tube slot as the breaker is moved into the cubicle. As the breaker reaches the connected position, the rear key comes out of the slot, allowing the levering-in shaft to turn freely. This prevents further travel into the breaker cell. Rotation of the shaft counterclockwise allows the key to catch and enter the guide tube slot, resulting in rotation of the guide tube and levering nut and withdrawal of the breaker.

At the end of travel, the levering nut will disengage from the screw and spin free. Pulling the breaker approximately 0.25" further engages the rail latch, locking the breaker in the test position. Manual release of the rail latch is required to move the breaker from the test to the disconnected position.

2.4.2.7 Secondary Contacts

The secondary contact assembly consists of a fifteen point male plug arranged to connect to a female receptacle mounted on the rear of the breaker cell. The male plug is mounted on a moveable bracket on the left side of the breaker chassis. The bracket can be extended to the rear with the breaker in the test position to mate with the stationary receptacle. This completes the circuit for the breaker control wiring.

The bracket and attached male plug are normally held stationary on the breaker chassis by a notch in the bar connecting the bracket to the secondary contact hand operating rod. This notch acts on the edge of the mechanism panel, holding the assembly in position.

With the breaker in the test position, the secondary contacts are engaged by lifting the hand operating rod to disengage the notch and pushing the slide bar to the rear. Final engagement of the contacts is accomplished by pushing down on the secondary contact engaging handle.

2.4.2.8 Ground Contact

The ground contact is located on the left rear of the breaker frame just above the secondary contact block. It consists of six spring loaded contact fingers that engage the ground contact mounted on the rear of the cell wall.

The ground contact provides a disconnectable means of grounding the breaker chassis after it has been inserted into the cell. The contact is engaged as the breaker is moved into the test position and remains engaged in all breaker positions, from test to (and including) connected.

2.4.2.9 Puffer Assembly

The puffer provides a jet of air through an insulating tube and nozzle to each of the contact assemblies each time the breaker is opened. The jet of air facilitates the movement of low current arcs upward into the arc chute, where they are quickly interrupted. Located in the breaker chassis, the puffer casting also serves as a chassis side sheet tie member and a mounting surface for the pole units.

The assembly consists of the puffer casting (an oblong cylinder with three air ports), a piston, and the insulating tube and nozzle for each pole unit.

The piston is linked to the operating mechanism and moves upward through the cylinder as the breaker is opened. This forces air through each of the nozzles and over the breaker contacts towards the arc chutes. Air remaining in the cylinder after the piston has passed the exhaust ports provides a dashpot effect for the breaker opening operation.

2.4.2.10 Mechanism Operated Control Switch

The mechanism operated control switch consists of rotary switches mounted on the cell wall, mechanically linked to the breaker operating mechanism. These switches supplement the contacts provided on the breaker auxiliary switch. The contacts of the MOC switch change state on breaker operation and are available for use in control, indication, and interlock functions.

An operating pin extending through the right side of the breaker frame engages a link in the cell to operate the additional switches. The pin is welded to the breaker position indicator, which moves with the operating mechanism. The link in the breaker cell may be arranged for switch operation in the test and connected breaker positions or in the connected position only.

2.4.2.11 Interlocks

All DHP type circuit breakers are equipped with several interlocks. These interlocks act as permissives for proper breaker operation and prevent improper operation. DHP interlocks are addressed individually below.

Breaker-Cell Coding Plates - This interlock consists of a notched plate in the circuit breaker cell, along with interference bars on the side of the breaker. The notches and bars are arranged so that only appropriately rated breakers may be racked into the cell.

Anti-Close Interlock - This prevents release of the closing spring if the breaker is already closed. With the breaker in the closed position, the interlock presses down on the spring release latch. If the spring release trigger is lifted it will rotate past the front latch roller without releasing the main latch to discharge the closing spring. The trigger will reset when released.

Floor Tripping and Closing Spring Release Interlocks - These interlocks act to trip the breaker and discharge the closing spring when the breaker is inserted to, or removed from the test position. Cam plates on the cell floor engage trip levers on the underside of the circuit breaker to accomplish the interlock. The trip levers on the underside of the breaker are coupled to cams on the breaker front panel, which engage the tripping and close release triggers. The floor tripping interlock also maintains the breaker in a trip free condition as it is moved from the test to the connected position. This prevents accidental closing of the breaker in an intermediate position.

Maintenance Handle - The maintenance handle has a bar welded to it to prevent use of the handle when the breaker is in the cell.

2.4.3 Operation

Normal operation of the DHP type circuit breaker is to charge the closing spring with the spring charging motor and then to close the breaker by energizing the spring release coil or lifting the spring release trigger. Tripping is accomplished by energizing the trip coil or manually lifting the tripping trigger. For maintenance purposes or in emergency operating conditions, a provision to charge the closing spring manually is available.

2.4.3.1 Manual Spring Charging

Manual spring charging is accomplished by inserting the maintenance handle into the slot in the ratchet lever that projects through the front panel. A few downward strokes of the handle charges the closing spring. The indicator on the front panel, immediately to the left of the ratchet lever, indicates «Spring Charged» when the closing spring is fully charged.

2.4.3.2 Manual Closing

The circuit breaker is closed manually by lifting the mechanism release trigger on the front panel. This frees the closing latch, allowing the stored energy of the closing spring to close the breaker.

2.4.3.3 Manual Tripping

Manual tripping of the breaker is performed in a manner similar to manual closing. Lifting the tripping trigger on the breaker front panel releases the tripping latch, allowing the linkage to collapse and open the breaker.

2.4.3.4. Electrical Closing

Electrical closing is achieved with control power being applied to the mechanism release coil through an external switch. Energization of the mechanism release coil releases the mechanism latch, allowing the stored energy of the spring to close the breaker.

2.4.3.5 Electrical Tripping

The circuit breaker is tripped electrically by providing control power to the tripping coil through an external switch. Energization of the tripping coil causes the plunger to lift and actuate the tripping trigger. This disengages the primary latch, allowing the breaker to open.

2.4.3.6 Maintenance Closing

A maintenance handle fits on the end of a shaft that extends through the right side of the breaker chassis. A downward motion of the handle slowly moves the moving contacts toward engagement with the stationary contacts. To fully close the contacts the handle is moved downward until an audible click is heard, indicating the tripping trigger has fallen into position. This procedure is to be used for inspection or adjustment ONLY where slow motion is required.

2.5 Vacuum Breaker Upgrade / Retrofit Packages

In 1986 Westinghouse introduced Vac-Clad-W World Class Medium Voltage Switchgear with Type VCP-W Vacuum Power Circuit Breakers. Along with this new product line Westinghouse offers vacuum breaker upgrade and retrofit packages for most DH and DHP circuit breakers. For the DH type breaker the existing breaker frame is refurbished and retrofitted with a VCP-W breaker. A type DHP-VR vacuum replacement circuit breaker is offered as an upgrade for type DHP breakers. In both cases the modified circuit breaker is fully compatible with the existing switchgear cell.

Section 3.0

Maintenance Guide Development

3.0 Maintanance Guide Development

The project team surveyed U.S. nuclear power plants to identify plants using Westinghouse medium voltage distribution equipment. The survey categorized the types of Westinghouse equipment in service at the various plants and requested information such as maintenance procedures, maintenance periodicities, and circuit breaker history data. A thorough study of applicable industry standards was performed as well. This collective information is summarized in this section of the guide.

3.1 Equipment Database

The equipment database was developed by means of a telephone survey. The survey entailed contacting all U.S. nuclear power plants to ascertain the manufacturer and models of medium voltage equipment used at each site. In conducting the survey, all efforts were made to ensure the site contact was knowledgeable in the area of medium voltage switchgear and circuit breakers. Initial survey questions were limited to the equipment manufacturer, the applied voltage level, the breaker MVA rating, and its continuous current frame size. Information at this level was obtained for both class 1E, and non-class applications. The survey identified plants using both DH and DHP type medium voltage circuit breakers. These breakers are applied at 5, 7.2, and 15KV over the full spectrum of MVA classes and continuous current frame sizes. Models using both spring stored energy and solenoid operating mechanisms were found to be in service.

A total of 20 plants at 14 utilities were identified which use DH and DHP type circuit breakers.

3.2 Plants Using Westinghouse Medium Voltage Distribution Equipment

Utility	Plant	Circuit Breaker	Rating
Baltimore Gas and Electric Co.	Calvert Cliffs	150-DH-???	3000 / 1200A
Carolina Power and Light Co.	Robinson 2	50-DH-???	3000 / 1200A
Commonwealth Edison Co.	Byron 1&2	50-DHP-250	3000 / 2000 / 1200A
		75-DHP-500	
	Braidwood 1&2	50-DH-350	3000 / 1200A
		75-DHP-500SE	2000 / 1200A
Consolidated Edison Co. of New York	Indian Point 2	75-DH-500	2000 / 1200A
Florida Power and Light Co.	St. Lucie 1&2	50-DHP-250	1200A
		50-DHP-350	3000A
		75-DHP-500	2000 / 1200A
New York Power Authority	Indian Point 3	75-DH-500	2000 / 1200A
Northern States Power Co.	Praire Island 1&2	50-DHP-350	2000A

Table 3.0 - Westinghouse Equipment In Service

Utility	Plant	Circuit Breaker	Rating
Pennsylvania Power and Light Co.	Susquehanna 1&2	50-DHP-250	1200A
		150-DHP-750C	2000 / 1200A
		150-DHP-1000	3000A
Rochester Gas and Electric Corp.	Robert E. Ginna	50-DH-350	3000 / 1200A
Southern Nuclear Operating Co.	Hatch 1&2	50-DHP-350	3000A
Toledo Edison Co.	Davis-Besse	50-DHP-250	2000 / 1200A
		150-DHP-750	2000 / 1200A
Union Electric Co.	Callaway	50-DHP-350	
Washington Public Power Supply Sys.	WNP 2	50-DHP-350	3000 / 1200A
		50-DHP-250	3000 / 1200A
		75-DHP-500	2000 / 1200A

Table 3.0 (Cont.) - Westinghouse Equipment In Service

3.3 Utility Maintenance Procedure Review

The development of this guide included a comprehensive review of utility maintenance procedures. This was conducted to consolidate the various utility practices and reconcile any deviations from manufacturer recommendations. All nuclear utilities in the U.S. were contacted and asked to provide a copy of their maintenance procedures.

The following table identifies the utilities and associated power plants which provided procedures for review:

Utility	Plant
Commonwealth Edison Co.	Byron
Consolidated Edison Co. of New York	Indian Point 2
Florida Power and Light	St. Lucie
New York Power Authority	Indian Point 3
Pennsylvania Power and Light Co.	Susquehanna
Southern Nuclear Operating Co.	Hatch
Union Electric Co.	Callaway
Washington Public Power Supply System	WNP2

Table 3.1 - Maintenance Procedures

3.4 Industry Standards

In preparing this maintenance guide, industry standards were reviewed to ensure compliance with the maintenance recommendations proposed by this guide, recommended by the OEM, or in actual practice as reviewed in the utility maintenance procedures.

The maintenance recommendations section of this guide (section five), provides specific information extracted from the industry standards review. A complete listing of the industry standards reviewed as part of the guide development are shown in section 8.2.

Section 4.0

Historical Performance

Circuit Breaker	Failure Description	Cause
50-DHP-250	Failed to latch closed	Operating mechanism adjustment
50-DHP-250	Failed to latch closed	Operating mechanism adjustment
50-DHP-250	Failed to close on demand	External permissive not satisfied
50-DHP-250	X relay mechanically binding preventing operation of close coil	Dirt
50-DHP-250	X relay mechanically binding preventing operation of close coil	Dirt
50-DHP-250	Cracked terminal - cubicle lockout relay	
50-DHP-250	Relay contacts fell apart	Material defect
50-DHP-250	Failed agastat relay in breaker cubicle	
50-DHP-250	Failed agastat relay in breaker cubicle	
50-DHP-250	Switchgear overcurrent relay failed	Defective logic board
50-DHP-250	Insulation breakdown	Age related
50-DHP-250SE	Arcing limit switch	Excessive wear
50-DHP-250SE	Failed to close	Breaker not fully racked in
50-DHP-250SE	Motor limit switch not making proper contact	Excessive wear
50-DHP-250SE	Operating mechanism linkage binding	Lack of lubrication / excessive wear
50-DHP-250SE	Binding relay failed to make proper contact	Oxidized contacts
50-DHP-350	Failed to close on demand	Non-design jumpers in breaker cubicle
50-DHP-350	Failed to close / binding of TOC linkage	Linkage not correctly adjusted
50-DHP-350	Closing latch was sticking	Lack of lubrication
50-DHP-350	Broken arc chute fell out of breaker	Unknown
50-DHP-350	Racking mechanism broke	Wear
50-DHP-350	Closing coil burnt	Unknown
50-DHP-350E	Closing solenoid jammed	Mounting bracket out of adjustment
50-DHP-250	Cracked X relay	Repeated removal of arc chutes
75-DHP-500	Breaker tripped	Loose current transformer wire in breaker cubicle

Table 4.0 (Cont.) - NPRDS Data

4.0 Historical Performance

4.1 OEM Recommendations and Advisories

One service advisory letter, O&MR-221, for Westinghouse DH or DHP type circuit breakers was located during the research of this maintenance guide. If anyone reviewing this document has access to a complete file of the OEM recommendations and advisories, please call BCP Technical Services, Inc., and ask for Don Horn. He may be reached at (504) 361-4236.

The maintenance guide addresses all OEM recommendations presented in the manufacturer instruction manuals. These recommendations are presented in section five of this guide and are incorporated throughout the guide's overhaul sections.

1. Operations and Maintenance Reminder 221 - Failure of a 4160v Breaker to Rack In.

   This O&MR addresses a cracked guide tube on a model DHP-350 Westinghouse circuit breaker. The utility that experienced this problem inspected the remainder of their breakers and found minor cracking on several guide tubes. The cause of the cracking was attributed to numerous racking operations over a ten year "in-service" life. The cracked guide tubes were replaced.

   As a solution to this problem, Westinghouse has made modifications to the guide tube manufacturing process to enhance thier durability. Details of the enhancement were not provided.

4.2 NPRDS Analysis

The Nuclear Plant Reliability Data System is an industry source of historical information used to evaluate the reliability of nuclear power plant components. Information for the database is provided by utilities following component failures at thier facilities. The effectiveness of the data becomes apparent when sorted and all problems for a particular component are analyzed as a group.

The NPRDS database was reviewed for problems associated with Westinghouse medium voltage circuit breakers. This industry wide review uncovered a total of thirty failure reports for type DH and DHP breakers.

The NPRDS failures are summarized in the following table:

Circuit Breaker	Failure Description	Cause
150-DHP-1000	Mechanical binding at the moving contact pivot point	Lack of lubrication
150-DHP-750	Cubicle shutter linkage bent	Improper racking
150-DHP-750	Overcurrent relay setpoint low	Design error
150-DHP-750	Auxiliary switch operating pin bent due to mechanical binding	Lack of lubrication
50-DHP-350	Bent trip lever	Improper racking

Table 4.0 - NPRDS Data

Of the thirty reported failures, five were caused by component failure, twelve by maintenance related activities, and the remainder by operational or design error. For the five instances in which component failure was cited, age or wear was identified as the major contributor in four cases. In the remaining case a clear definition of the material defect was not provided. Lubrication and mechanical adjustment were identified as the primary failure mechanisms for the maintenance related group. Detailed instruction for lubrication and mechanical adjustments are provided in sections five and six of this guide. The remaining failures were attributed to design or operational deficiencies such as improper racking of the circuit breaker or incorrect relay setpoints.

In general, the population of identified failures was not large enough to define generic component failure mechanisms. However, mechanical binding due to lack of lubrication and incorrect mechanical adjustment did indicate a need to evaluate the type and frequency of maintenance being performed.

4.3 NRC Bulletins, Notices, and Circulars

A review of the Nuclear Regulatory Commission's Nuclear Document System (NUDOCS) did not reveal any Information Event Bulletins (IEB's), Information Event Notices (IEN's), or Information Event Circulars (IEC's) listed against Westinghouse medium voltage circuit breakers.

4.4 INPO Event Reports

A review of Significant Event Reports (SER's), and Significant Operating Experince Reports (SOER's) generated by the Institute of Nuclear Power Operations did not reveal any documents associated with Westinghouse medium voltage circuit breakers.

Section 5.0

Maintenance Recommendations

5.0 Maintenance Recommendations

This section provides maintenance recommendations for Westinghouse type DH and DHP medium voltage air magnetic circuit breakers. Maintenance activities have been presented in a tabular format along with recommended periodicities of performance. Where applicable the corresponding recommendations from the OEM, and any guidance provided by industry standards have been included. The maintenance activities listed in section 5.2.1 are briefly described in section 5.2.2. The activities listed are discussed in greater detail in the overhaul sections of this maintenance guide. Section 5.2.3 provides technical justification for activities in which the proposed maintenance periodicity differs from the OEM recommendation.

This section also provides a detailed discussion of lubrication practices and offers a tabular breakdown of lubricants in use at various utilities for specific breaker applications.

The section concludes with information on personnel training and a description of recommended recordkeeping guidelines.

5.1 Summary of Maintenance Issues

5.1.1 Hardware Degradation or Failure

Hardware degradation or failure has not been a major contributor of Westinghouse medium voltage circuit breakers failing to operate as designed. A review of NPRDS, utility maintenance histories (where provided), and discussions with utility maintenance personnel indicated that component failure was typically attributable to age or normal wear and has not been a serious concern.

5.1.2 Time Based Scheduling Concens

Discussions with utility maintenance personnel identified a concern that recommended maintenance frequencies did not correlate with plant outage schedules / fuel cycles, creating problems for breaker availability to perform maintenance. Recommended maintenance frequencies proposed by this guide are in agreement with the restraints posed by an eighteen month fuel cycle. Technical justifications have been provided for those areas requiring a maintenance periodicity adjustment for this reason.

5.1.3 Breaker / Cubicle Identification and Tracking

During routine operations a breaker may be moved from one cubicle to another. Breakers may also be substituted as a result of routine maintenance. There are several problems that stem from this practice.

1. Breaker Location / Identification

   When a breaker is relocated to another cubicle, possibly on another switchgear, more often than not utilities do not have an adequate reporting system in place to track breakers by serial number and location. Most breakers are tracked by an equipment number based upon the switchgear cubicle, not on the actual breaker. The resulting problem is that preventitive and corrective maintenance work can be performed on the wrong breaker. In addition it is difficult to prove that a breaker has had maintenance peformed in the event of an audit.

An example would be that operations required a pump to be energized on Sunday, the normal breaker was removed for routine maintenance, and a spare breaker was installed and placed on line. Monday, the pump was taken off line and the breaker had minor corrective maintenance repairs completed and several scheduled preventive maintenance procedures performed. The breaker for which the corrective and preventative maintenance was intended had not been properly identified and therefore the required maintenance was not performed.

Equipment that can be relocated, should be tracked by serial number and location to ensure the correct equipment is being serviced and that maintenance is being performed on schedule.

2. Improper Breaker Relocation

   When a breaker is relocated to another cubicle and / or switchgear, operations procedures should include a verification step to ensure a like-for-like replacement is taking place. All breaker ratings and options need to be identical prior to relocation to prevent equipment or cabling damage, and possible personnel injury. This information should also be transferred to maintenance on a timely basis to ensure proper scheduling of maintenance activities.

5.2 Summary of Maintenance Recommendations

Table 5.0 presents maintenance activites and corresponding periodicities. The table is divided into six major categories. These categories are general inspection, detailed inspection, lubrication, mechanical adjustments, electrical testing, and major overhaul. Sub categories are provided to define the scope of each major category. Performance criteria are stated as derived from industry standards, OEM documentation, and proposals from this guide.

Section 5.2.2 of this guide provides a brief description of the work scope intended for each of the major categories. Section 5.2.2 provides justification for areas in which the proposed recommendations differ from OEM recommendations.

5.2.1 Maintenance Activities and Periodicities

Maintenance activities and periodicities are listed in Table 5.0.

5.2.2 Maintenance Activity Description

1. General Inspection

   The general inspection category entails a cursory inspection of circuit breaker cleanliness and function. Disassembly of the breaker is not intended for this category. Breaker interlocks and indicators should be proved functional along with verification of positive operation of the breaker operating mechanism.

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
General Inspection Cleanliness Mechanical Operation --Operating Mechanism --Interlocks --Indicators --Auxiliary Devices	Perform prior to placing breaker in service following maintenance, or any extended period out of service	The general inspection requirements are based on service duty-- Light Duty (< 100 operations/year) -- Annual Medium Duty (100-1000 operations/year) --Annual including arc chutes Heavy Duty (> 1000 operations/year) --2 months or 1000 ops	Maximum of three years or at OEM's maximum number of operations, whichever occurs first. Exception: A thorough inspection should be performed following interruption of a major fault.	Regular systematic maintenance and inspection in accordance with OEM recommendations.
Detailed Inspection Arc Chutes Primary and Secondary Disconnect Contacts Main Contacts Arcing Contacts Operating Mechanism Insulation	Perform at 18 month intervals (minimum) to 36 month intervals (maximum) Exception: Perform following interruption of any fault. Exception: Breakers applied to cyclical duty should be considered seperately. 1000 operations should be used as the baseline for performing maintenance.	The detailed inspection requirements are based on service duty-- Light Duty (< 100 operations/year) -- Annual Medium Duty (100-1000 operations/year) --Annual including arc chutes Heavy Duty (> 1000 operations/year) --2 months or 1000 ops	Maximum of three years or at OEM's maximum number of operations, whichever occurs first. Exception: A thorough inspection should be performed following interruption of a major fault.	Regular systematic maintenance and inspection in accordance with OEM recommendations.

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
Levering-In Device	Same as previous page.	Same as previous page.	Same as previous page.	Same as previous page.
Puffer Assembly				
Auxiliary Components				
Lubrication		Lubrication periodicity is not specified. Refer to the Lubrication Table in Section 5.4 for type of lubricant recommended by component. OEM specifies that a light film of lubricant be used for light duty applications and larger quantities of lubricant be applied for medium and heavy duty applications.	Lubrication and lubrication periodicity are not specified.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Primary and Secondary Disconnect Contacts	At general and detailed inspection intervals.			
Main Contacts	At detailed inspection interval.			
Arcing Contacts	At detailed inspection interval.			
Operating Mechanism (Solenoid)				
–Outer Surface of Moving Solenoid Core	At breaker overhaul.			
–Inner Surface of the Core Guide Tube	At breaker overhaul.			
–Inner Surface of the Air Bumper Cylinder	At breaker overhaul.			
–Air Bumper Pins	At breaker overhaul.			
–Latching Pin	At detailed inspection interval.			
–Upper Trip Free Link to Trip Free Lever Pin	At detailed inspection interval.			

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
--Pin Joining Upper and Lower Trip Free Links	At detailed inspection interval.	Same as previous page.	Same as previous page.	Same as previous page.
--Cam to Cam Link Pin	At detailed inspection interval.			
--Closing Link Pin	At detailed inspection interval.			
--Cam Stop Rollers	At detailed inspection interval.			
--Hand Trip Lever Pin	At detailed inspection interval.			
--Hand Trip Assembly Rollers	At detailed inspection interval.			
Operating Mechanism (Spring Stored Energy)				
--Crankshaft Arm Roller Bearing	At detailed inspection interval.			
--Connecting Link Roller Bearings (Cam Lever and Clevis Link ends)	At detailed inspection interval.			
--Worm Shaft Needle Bearing	At detailed inspection interval.			
--Worm Gear Shaft Roller Bearings	At detailed inspection interval.			
--Cam Link Roller and Connecting Pin	At detailed inspection interval.			
--Mechanism Center Pin (Through the Trip Free and Non Trip Free Levers)	At breaker overhaul.			
--Upper and Lower Trip Free Junction Pin	At detailed inspection interval.			

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
–Closing Latch Sleeve Bearing	At detailed inspection interval.	Same as previous page.	Same as previous page.	Same as previous page.
–Non Trip Free Lever and Lower Trip Free Link Junction Pin	At detailed inspection interval.			
–Slotted Link	At detailed inspection interval.			
–Crankshaft Journals and Connecting Pins (to the Slotted Link and Spring Rod)	At breaker overhaul.			
–Cam Lever and Pin	At detailed inspection interval.			
–Brake Rod Sliding Pin	At detailed inspection interval.			
–Junction Pin (Between Brake Lever and Brake Rod Sliding Pin)	At detailed inspection interval.			
–Spring Latch and Transfer Link Pin	At detailed inspection interval.			
–Spring Winding Worm	At detailed inspection interval.			
–Worm Gear	At detailed inspection interval.			
–Worm Shaft Spur Gear	At detailed inspection interval.			
Moving Contact Assembly	At detailed inspection interval.			
Levering-In Device	At detailed inspection interval.			

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
Mechanical Adjustment			Maximum three years or at OEM's maximum number of operations, whichever occurs first. Exception: Mechanical adjustments should be performed following interruption of a major fault.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Arcing Contacts	At detailed inspection interval.	As dictated by wear and alignment-- Same criteria as general and detailed inspection.		
Main Contacts	At detailed inspection interval.			
Operating Mechanism (Solenoid)		With routine inspection and lubrication adjustment should not be required until 5000 operations Part replacements may be required at > 15000 operations.		
--Tripping Latch	At detailed inspection interval.			
--Cut-Off Switch	At detailed inspection interval.			
--Latch Check Switch	At detailed inspection interval.			
--Closing Latch	At detailed inspection interval.			
Operating Mechanism (Spring Stored Energy)	At detailed inspection interval.	Mechanism is completely adjusted at the factory and under normal circumstances no adjustment is required. OEM strongly recommends that the breaker be returned to the factory if adjustment is necessary.		
--Shock Absorber	At detailed inspection interval.			
--Cam Lever Gap	At detailed inspection interval.			
--Limit Switch Operating Arm	At detailed inspection interval.			
--Mechanism Release Assembly	At detailed inspection interval.			
--Spring Latch Check Switch	At detailed inspection interval.			

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
–Closing Latch Check Switch	At detailed inspection interval.	Same as previous page.	Same as previous page.	Same as previous page.
–Brake Rod Assembly	At detailed inspection interval.			
–Tripping Cam	At detailed inspection interval.			
–Spring Winding Linkage	At detailed inspection interval.			
Electrical Testing		Not specified Electrical functional testing is recommended prior to placing breaker in service.	Maximum three years or at OEM's maximum number of operations, whichever occurs first. Exception: A thorough inspection should be performed following interruption of a major fault. Electrical functional testing should be performed following any performed maintenance.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Contact Resistance	Following any work involving the main or arcing contacts.			
Insulation Resistance (Megger)	Following any maintenance activity or extended out of service condition.			
Insulation Resistance (High Potential)	Following replacement of any component exposed to line potential.			
Closing Timing	At detailed inspection interval.			
Electrical Function	Following any maintenance activity or extended out of service condition.			
Major Overhaul	Performed at 6-9 year intervals not to exceed 10,000 operations.	Not specified	Not specified	Not specified

Table 5.0 - Maintenance Activities and Periodicities (Type DH)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
General Inspection Cleanliness Mechanical Operation --Operating Mechanism --Interlocks --Indicators --Auxiliary Devices	Perform prior to placing breaker in service following maintenance, or any extended period out of service	Based upon time, number of load switching cycles (operations), and number of fault interruptions, whichever is predominant.. Time: Not to exceed 3 years Operations: Not to exceed 1000 Fault Interruptions: Not to exceed one for a fault > 50%	Maximum of three years or at OEM's maximum number of operations, whichever occurs first. Exception: A thorough inspection should be performed following interruption of a major fault.	Regular systematic maintenance and inspection in accordance with OEM recommendations.
Detailed Inspection Arc Chutes Primary and Secondary Disconnect Contacts Main Contacts Arcing Contacts Operating Mechanism Insulation	Perform at 18 month intervals (minimum) to 36 month intervals (maximum) Exception: Perform following interruption of any fault. Exception: Breakers applied to cyclical duty should be considered seperately. 1000 operations should be used as the baseline for performing maintenance.	Based upon time, number of load switching cycles (operations), and number of fault interruptions, whichever is predominant.. Time: Not to exceed 3 years Operations: Not to exceed 1000 Fault Interruptions: Not to exceed one for a fault > 50%	Maximum of three years or at OEM's maximum number of operations, whichever occurs first. Exception: A thorough inspection should be performed following interruption of a major fault.	Regular systematic maintenance and inspection in accordance with OEM recommendations.

Table 5.0 - Maintenance Activities and Periodicities (Type DHP)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
Levering-In Device	Same as previous page.	Same as previous page.	Same as previous page.	Same as previous page.
Puffer Assembly				
Auxiliary Components				
Lubrication			Lubrication and lubrication periodicity are not specified.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Primary and Secondary Disconnect Contacts	At general and detailed inspection intervals.	At normal maintenance interval		
Main Contacts	At detailed inspection interval.	At normal maintenance interval		
Arcing Contacts	At detailed inspection interval.	At normal maintenance interval		
Operating Mechanism	At detailed inspection interval.			
–Tripping Trigger Pivot Pin	At detailed inspection interval.	At 2000 operations		
–Tripping Latch Roller	At detailed inspection interval.	At 2000 operations		
–Tripping Latch Pivot Pin	At detailed inspection interval.	At 2000 operations		
–Tripping Cam Roller	At detailed inspection interval.	At 2000 operations		
–Tripping Cam Pivot Pin	At detailed inspection interval.	At 2000 operations		
–Tripping Cam Connecting Link Pins	At detailed inspection interval.	At 2000 operations		

Table 5.0 - Maintenance Activities and Periodicities (Type DHP)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
–Closing Cam Follower Roller Pin	At detailed inspection interval.	Not specified	Same as previous page.	Same as previous page.
–Closing Stop Roller	At detailed inspection interval.	Not specified		
–Closing Trigger Pivot Pin	At detailed inspection interval.	At 2000 operations		
–Closing Latch Roller	At detailed inspection interval.	At 2000 operations		
–Closing Latch Pivot Pin	At detailed inspection interval.	At 2000 operations		
–Crankshaft Bearing	At breaker overhaul	At operating mechanism disassembly		
–Pole Shaft Bearing	At breaker overhaul	At operating mechanism disassembly		
–Trip Latch Bearings	At breaker overhaul	At operating mechanism disassembly		
–Close Latch Bearings	At breaker overhaul	At operating mechanism disassembly		
–Connecting Rod Bearing	At breaker overhaul	At operating mechanism disassembly		
–Ratchet Lever Bearings	At breaker overhaul	At operating mechanism disassembly		
–Closing Cam Folllower Roller	At detailed inspection interval.	Not specified		
–Spring Charging Motor Crank Rollex	At breaker overhaul	Not specified		

Table 5.0 - Maintenance Activities and Periodicities (Type DHP)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
Moving Contact Assembly	At detailed inspection interval	During contact replacement	Same as previous page.	Same as previous page.
Levering-In Device	At detailed inspection interval	Not specified		
Mechanical Adjustments			Maximum three years or at OEM's maximum number of operations, whichever occurs first. Exception: Mechanical adjustments should be performed following interruption of a major fault.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Arcing Contacts	At detailed inspection interval	Not specified		
Main Contacts	At detailed inspection interval	Not specified		
Operating Mechanism				
–Tripping Latch	At detailed inspection interval	Not specified		
–Holding Pawl	At detailed inspection interval	Not specified		
–Anti-Close Interlock	At detailed inspection interval	Not specified		
–Latch Check Switch	At detailed inspection interval	Not specified		
–Closing Cam Follower Roller	At detailed inspection interval	Not specified		
–Closing Trigger	At detailed inspection interval	Not specified		
–Tripping Trigger	At detailed inspection interval	Not specified		

Table 5.0 - Maintenance Activities and Periodicities (Type DHP)

Maintenance Activity	Proposed Maintenance Recommendation	OEM Maintenance Recommendation	ANSI/NFPA 70B	ANSI C37.10/NEMA SG4
Electrical Testing		Not specified	Maximum three years or at OEM's maximum number of operations, whichever occurs first.	Regular and systematic maintenance and inspection in accordance with OEM recommendations.
Contact Resistance	Following any work involving the main or arcing contacts.	Electrical function testing is recommended prior to placing the breaker in service.		
Insulation Resistance (Megger)	Following any maintenance activity or extended out of service condition.		Exception: A thorough inspection should be performed following interruption of a major fault.	
Insulation Resistance (High Potential)	Following replacement of any component exposed to line potential.			
Closing Timing	At detailed inspection interval.		Electrical functional testing should be performed following any performed maintenance.	
Electrical Function	Following any maintenance activity or extended out of service condition.			
Major Overhaul	Performed at 6-9 year intervals not to exceed 10,000 operations.	Not specified	Not specified	Not specified

Table 5.0 - Maintenance Activities and Periodicities (Type DHP)

2. Detailed Inspection

The detailed inspection category entails a thorough inspection of the breaker and breaker components for loose or missing hardware, damaged components, wear, and cleanliness. This inspection requires some disassembly. Barriers, arc chutes, and the barrier support pan should be removed to provide sufficient inspection access.

Specific inspection criteria and cleaning instructions for the components listed are provided in the overhaul sections of this document.

3. Lubrication

The specific lubrication points identified should be lubricated at the proposed frequencies. Information concerning the type of lubricant to be used for each particular component is addressed in section 5.3 and in greater detail in the guide overhaul sections.

Disassembly of the breaker operating mechanism to allow lubrication access to components such as crankshaft journals or bearings is not intended as part of the routine maintenance interval. Operating mechanism disassembly should be considered as part of breaker overhaul unless abnormalities such as sluggishness or binding are detected.

4. Mechanical Adjustments

The mechanical adjustments identified should be verified in tolerance at the recommended intervals. Specific guidance is provided in the overhaul sections of the guide for components which fail to meet required tolerances. Refer to sections 6.1.6 and 6.2.6 "Measurements and Adjustments" for guidance in correcting an out of tolerance condition.

5. Electrical Testing

Electrical testing is an integral part of circuit breaker maintenance. The tests identified are imperative to ensure correct breaker operation and prevent personnel injury upon return to service. The specified tests should be conducted as stated in the periodicity table. Guidelines for performing the electrical testing are provided in sections 6.1.7 and 6.2.7 "Post Overhaul Testing".

6. Major Overhaul

Refer to section 6.0 for overhaul guidelines.

5.2.3 Maintenance Activity Technical Justification

1. General Inspection

The OEM combines general and detailed inspection into a single routine maintenance category, and therefore does not specifically address the proposed requirements. The OEM does suggest a similar inspection process for initially placing the breaker in service.

The proposed activities consist of a cleanliness inspection and a verification of mechanical function prior to placing the breaker in service. The activities should be performed following any maintenance activity or extended out of sevice period. This inspection is considered a good standard practice and provides a final review of circuit breaker condition prior to energized service.

2. Detailed Inspection

The detailed inspection requirements proposed by this guide are in general agreement with those offered by the OEM. The differences are individually addressed below:

- The OEM detailed inspection requirements for type DH breakers are based on service duty requiring inspection at intervals of one year or 1000 operations. The guide proposes a maintenance interval of 18 months (minimum) to 36 months (maximum) allowing utilities to complete routine maintenance over the course of two fuel / outage cycles. This requirement is in accordance with industry standard NFPA 70B which states that maintenance should be performed at a maximum of three years. Additionally, OEM literature for later model circuit breakers (type DHP) state that the annual inspection is a non rigid requirement and that the maximum Maintenance interval is three years (rigid requirement). The 18 to 36 month inspection interval is further supported by the NPRDS database review indicating that component failure has not been a major concern for type DH medium voltage circuit breakers.

- The OEM criteria for performing inspection following interruption of a fault is performance following a fault greater than 50% of the breaker interrupting capability. Additional guidelines are provided in the OEM literature allowing a larger number of fault interruptions before required inspection for fault magnitudes less than 50% of breaker rating. The guide proposes a more conservative recommendation, requiring performance of maintenace following interruption of any fault. Interruption of fault current, regardless of magnitude, challenges the circuit breaker to a certain degree. As the breakers addressed by this guide are in nuclear power plant service, a detailed inspection of the breaker following interruption of a fault is prudent.

3. Lubrication

The proposed lubrication requirements are in agreement with OEM documentation. In several instances the OEM requires lubrication of type DHP operating mechanism components at 2000 cycle intervals. This requirement is bounded by the detailed inspection interval of 18 to 36 months, not to exceed 1000 operations.

4. Mechanical Adjustments

The OEM does not specify mechanical adjustment periodicity for type DHP breakers. The manual states that many years of trouble free service should be attainable follwing factory adjustment, however, some readjustment will be required from time to time. The OEM documentation for DH circuit breakers states that mechanical adjustments should be performed as dictated by wear and alignment. It further states that mechanical adjustments to the operating mechanism should not be required before 5000 operations. Performance of the identified mechanical adjustments at the detailed inspection interval encompasses the OEM requirements.

5. Electrical Testing

The electrical testing requirements proposed by the guide does not conflict with any information provided by the OEM.

6. Major Overhaul

Major overhaul requirements are not specified in the OEM literature. The type DH manual does indicate that operating mechanism part replacements may be necessary past 15000 operations. The 6-9 year proposed overhaul interval allows utilities to complete thier circuit breaker medium voltage overhaul program over the course of three fuel / outage cycles. This three year window also provides flexibility in scheduling breakers which are cycled more frequently into the earliest outage. The proposed overhaul interval of 6-9 years not to exceed 10000 operations, does not conflict with OEM requirements.

5.2.4 Vacuum Technology and Upgrade Options

Experimental vacuum interrupters were pioneered in the 1920's and refined through the 1930's, 1940's, and 1950's. The worlds first vacuum interrupter distribution breaker was introduced in the 1960's. Today, vacuum technology is used by all major suppliers for the manufacture of medium voltage breakers.

One option for utilities faced with medium voltage air-magnetic circuit breakers problems is to specify and purchase new replacement breakers. An alternate approach is to retrofit the problem breakers with vacuum or SF6 technology.

A major reason for utilities to consider the vacuum technology upgrade is the elimination of many of the parts which wear out. This varies depending on the amount of cyclic use the breaker sees. One study, performed by General Electric Corporation projected that over the life of a switchgear assembly (40 years), a user can expect to save $4,000 per breaker due to the decrease in preventative and corrective maintenance. This number was based on a recommended maintenance interval of ten years for the vacuum breaker. This savings equates to $100 per year per breaker. This must be weighed against the costs of the retrofit or replacement in addition to the costs associated with writing new procedures, revised training, and replacement of current spare part inventories.

In addition to the economic considerations, the technical aspects of the retrofit or replacement must be evaluated. Vacuum breakers rely on the vacuum in the interrupting chamber for proper interruption. Although these bottles give problems infrequently, loss of breaker vacuum is now introduced as a failure mechanism. Loss of power initiating events are factored into design basis accidents for nuclear power plants. These probability risk assesments will need to be reviewed for this possibility.

An additional concern with the upgrade to vacuum type breakers is the need for a breaker test cubicle to perform vacuum integrity verification prior to return to service.

A utility has four basic options to evaluate when addressing problems on air magnetic circuit breakers:

1. Retrofit the air circuit breakers with vacuum technology.
2. Replace the breakers with vacuum breakers.
3. Purchase replacement air-magnetic breakers.
4. Corrective maintenance or increased preventative maintenance on the problem breakers.

These options and thier advantages and disadvantages are discussed below:

1. Retrofit the air circuit breakers with vacuum technology.

   Retrofit consists of removing the arc chutes, puffers, air break contacts, and pole unit assemblies from the air magnetic breaker and replacing them with vacuum or SF6 bottles. Since the new components take up less space the existing chassis can be reused. Retrofitting costs less than a new purchase while furnishing what is essentially a new breaker. The breaker operating mechanism should be replaced as part of the retrofit as well. Some early retrofits retained the existing operating mechanism, however, various problems were experienced in this arrangement due to the force of the mechanism springs.

   Although retrofit reliability has progressed, problems are still being reported. If the retrofit option is selected it is imperative that a program to inspect, and test electrical and mechanical safety interlocks be in place.

2. Replace the breakers with vacuum breakers.

   Replacement of air magnetic breakers with new vacuum breakers is an expensive option. In addition to the cost of the new breakers , utilities must evaluate and implement the required changes to their switchgear line-ups, and revise operation and maintenance procedures for the new equipment. Additional costs include training, and restock of spare part inventories.

3. Purchase replacement air-magnetic breakers.

   Most air magnetic breakers currently in service are no longer manufactured by the OEM. In most instances replacement breakers and parts are difficult to find. Replacements can be found through secondary suppliers requiring dedication from utility engineering personnel.

4. Corrective maintenance or increased preventative maintenance on the problem breakers.

   This option is the least expensive and most easily implemented. The major disadvantage is that replacement parts may be difficult to replace or restock. The air-magnetic breaker has a proven track record and engineering solutions are in place for most of the problems which utilities have encountered.

5.3 Lubricants

As with other medium voltage breakers, lubrication is the leading cause of maintenance problems with the Westinghouse medium voltage circuit breaker. Lubrication problems stem from improper cleaning which introduces dirt or foreign objects into bushings or bearings, over lubrication causing dirt accumulation, and commingling of incompatible lubricants. Inadequate lubrication is another cause of failure, although not as common. The calculated life expectancy of any lubricated component is based on the assumption that good lubrication in proper quantity will always be available to the component. This can be accomplished by a good preventative maintenance program. The following sections address lubrication failure, failure identification, common causes and solutions, and a tabular listing of lubricants for Westinghouse medium voltage circuit breakers.

5.3.1 Lubrication Failure

The term "Lubrication Failure" is often taken to imply that there was insufficient oil or grease to the component. While this does happen, the failure analysis is normally not that simple. It is usually a combination of problems such as aging, hardening, contamination, the type of lubrication, and the operating conditions of the equipment.

5.3.2 Failure Identification

Signs of lubrication failure are grease appearance, abnormal temperatures, noise, component discoloration, retainer failure, or lack of lubricant.

The most apparent indicator of lubrication failure on circuit breakers will be grease appearance. During maintenance, the color, odor, and physical properties of the grease should be inspected to determine the condition of the lubricant. If the grease is stiff or caked and has changed in color, it indicates a lubrication failure. The original color will usually turn to a dark shade or to jet black. This can also be caused by commingling of two incompatible greases.

Abnormal temperatures, and noise, are not usually identifiable causes of lubrication failure during breaker operation. High temperatures are usually associated with rotating equipment. In addition, inaccessibility of the breaker during operation precludes close inspection during opening and closing operations. Close inspection during preventative maintenance will identify most occurrences of retainer failure, inadequate lubrication, and excessive lubrication.

5.3.3 Common Causes and Solutions

Common causes of lubrication failure include contaminated, dirty lubricant in a component, excessive lubrication, inadequate lubrication, selection of the wrong lubricant, and commingling. Many times, less experienced personnel are assigned to lubrication tasks, and lubrication condition is not given adequate review. Just the opposite should occur since lubrication is quite often the source of breaker malfunction.

Contaminants found in lubricants often act as an abrasive compound which will lap or polish ball and race surfaces, increasing the probability of early failure. Dirty lubricant can be avoided by a few simple measures. Always keep grease containers covered. Use a clean rust-resistant tools for applying lubrication. When using a grease gun or similar grease dispenser, always wipe off both the fitting and the nozzle of the grease gun. Maintaining a clean work area is particularly important.

Excessive lubrication is a common error. This can cause dirt and dust retention which is eventually introduced to the lubricated component surfaces.

Under lubrication is not as common, but still presents problems. Inadequate lubrication leads to rapid failure of the lubricated component.

Selection of the correct lubricant is very important in achieving maximum life expectancy. The equipment manufacturer recommends those lubricants which will provide ideal lubrication for the equipment operating requirements. A careful, and detailed analysis should be performed prior to change of a lubrication specification. One problem encountered in specifying alternate or equivalent lubricants is that the OEM usually specifies a lubricant by an internal part number without a description of the lubricant type.

5.3.4 Commingling of Lubricants

Commingling of incompatible lubricants can cause hardening. Care should be taken to ensure a comingling of different lubricants is not introduced. When possible the component being lubricated should be thoroughly cleaned prior to relubrication.

5.3.5 Lubrication Table

Table 5.1 provides recommended lubricants for type DH and DHP circuit breakers.

5.4 Training

The Institute of Nuclear Power Operations (INPO) has published the Guidelines for Training and Qualification of Maintenance Personnel, ACAD 92-008, which provide the framework for maintenance personnel training and qualification programs at nuclear power plants. These guidelines incorporate the results of an industry wide job and task analysis and are intended to be used in combination with plant-specific job and task analysis to develop and revise training programs.

Utilities should use these guidelines in conjunction with plant-specific job and task analysis results when establishing, upgrading, or validating maintenance training programs.

Breaker crews often consist of an experienced journeyman and an apprentice. In order to develop a training program and qualify crews, the total scope of work to be performed on-site should be defined. For the purposes of this maintenance guide, the scope of work will consist of three major areas, 1) preventative maintenance, 2) corrective maintenance, and 3) breaker overhaul.

Preventive and corrective maintenance will normally be performed by an experienced journeyman and possibly an apprentice. The maintenance apprentice should be trained on the equipment to the extent that common failure mechanisms and operating principles of the circuit breaker are readily known For both preventive and corrective maintenance, the journeyman should have specialized skills training. As a minimum, the journeyman should be able to demonstrate disassembly and assembly methods, adjustment and calibration steps, and repair and part replacement techniques. He should also be proficient with all measuring and test equipment. As mentioned earlier in the section on lubrication, it is important that maintenance personnel are trained on proper lubrication methods.

Component	Minor Maintenance (Detailed Inspection)	Major Maintenance (Breaker Overhaul)
Primary and Secondary Disconnect Contacts	Thin layer of conductive graphite lubricant	Thin layer of conductive graphite lubricant
Main Contacts	Thin layer of conductive graphite lubricant	Thin layer of conductive graphite lubricant
Arcing Contacts	Thin layer of conductive graphite lubricant	Thin layer of conductive graphite lubricant
Operating Mechanism (Solenoid)		
--Outer Surface of Moving Solenoid Core	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Inner Surface of the Core Guide Tube	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Inner Surface of the Air Bumper Cylinder	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Air Bumper Pins	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Latching Pin	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Upper Trip Free Link to Trip Free Lever Pin	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Pin Joining Upper and Lower Trip Free Links	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Cam to Cam Link Pin	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Closing Link Pin	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Cam Stop Rollers	Graphite grease (West. 1022-1)	Graphite grease (West. 1022-1)
--Hand Trip Lever Pin	Molybdenum based (West. 8577-2)	Molybdenum based (West. 8577-2)
--Hand Trip Assembly Rollers	Molybdenum based (West. 8577-2)	Molybdenum based (West. 8577-2)
Operating Mechanism (Spring Stored Energy)		
--Crankshaft Arm Roller Bearing	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Connecting Link Roller Bearings (Cam Lever and Clevis Link ends)	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Worm Shaft Needle Bearing	Light machine oil	Molybdenum disulphide based (West. 9921-4)

Table 5.1 - Lubrication (Type DH)

Component	Minor Maintenance (Detailed Inspection)	Major Maintenance (Breaker Overhaul)
--Worm Gear Shaft Roller Bearings	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Cam Link Roller and Connecting Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Mechanism Center Pin (Through the Trip Free and Non Trip Free Levers)	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Upper and Lower Trip Free Junction Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Closing Latch Sleeve Bearing	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Non Trip Free Lever and Lower Trip Free Link Junction Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Slotted Link	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Crankshaft Journals and Connecting Pins (to the Slotted Link and Spring Rod)	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Cam Lever and Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Brake Rod Sliding Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Junction Pin (Between Brake Lever and Brake Rod Sliding Pin)	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Spring Latch and Transfer Link Pin	Light machine oil	Molybdenum disulphide based (West. 9921-4)
--Spring Winding Worm	Molybdenum based (West. 8577-2)	Molybdenum based (West. 8577-2)
--Worm Gear	Molybdenum based (West. 8577-2)	Molybdenum based (West. 8577-2)
--Worm Shaft Spur Gear	Molybdenum based (West. 8577-2)	Molybdenum based (West. 8577-2)
Moving Contact Assembly	Graphite grease	Graphite grease
Levering-In Device	Molybdenum disulphide based	Molybdenum disulphide based

Table 5.1 - Lubrication (Type DH)

Component	Minor Maintenance (Detailed Inspection)	Major Maintenance (Breaker Overhaul)
Primary and Secondary Disconnect Contacts	Light coating of petrolatum	Light coating of petrolatum
Main Contacts	Graphite grease (West. 53701 AN)	Graphite grease (West. 53701 AN)
Arcing Contacts	Graphite grease (West. 53701 AN)	Graphite grease (West. 53701 AN)
Operating Mechanism		
–Tripping Trigger Pivot Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Tripping Latch Roller	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Tripping Latch Pivot Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Tripping Cam Roller	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Tripping Cam Pivot Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Tripping Cam Connecting Link Pins	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Closing Cam Follower Roller Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Closing Stop Roller	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Closing Trigger Pivot Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Closing Latch Roller	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Closing Latch Pivot Pin	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Crankshaft Bearing	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Pole Shaft Bearing	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Trip Latch Bearings	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Close Latch Bearings	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
–Connecting Rod Bearing	Light machine oil	Molybdenum disulphide based (West. 53701 QB)

Table 5.1 - Lubrication (Type DHP)

Component	Minor Maintenance (Detailed Inspection)	Major Maintenance (Breaker Overhaul)
--Ratchet Lever Bearings	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
--Closing Cam Folllower Roller	Light machine oil	Molybdenum disulphide based (West. 53701 QB)
--Spring Charging Motor Crank Rollex	Molybdenum disulphide based (West. 53701 QB)	Molybdenum disulphide based (West. 53701 QB)
Moving Contact Assembly	Graphite grease (West. 53701 AN)	Graphite grease (West. 53701 AN)
Levering-In Device	Molybdenum disulphide based (West. 53701 QB)	Molybdenum disulphide based (West. 53701 QB)

Table 5.1 - Lubrication (Type DHP)

6.0 Overhaul Guidelines

This section of the document consists of overhaul guidelines for Westinghouse type DH and DHP medium voltage circuit breakers. Overhaul guidelines for type DH and DHP breakers are individually presented in sections 6.1 and 6.2. Section 6.3 provides an overview of specialty tools and test equipment required to perform the tasks identified.

6.1 Type DH Circuit Breaker Overhaul

This section contains guidance for the overhaul of Westinghouse type DH medium voltage circuit breakers. Guidance is provided in a structured format with emphasis on critical measurements, adjustments, and testing. Diagrams and/or digital photographs are used to enhance the presentation.

The sequential approach begins with recording relevant as-found data, and progresses through breaker disassembly, inspection, cleaning, lubrication, adjustments, part replacements, and assembly. The overhaul guideline concludes with a section on testing and acceptable test criterion.

6.1.1 As-found Data

As-found data, if properly trended, is an invaluable tool for future refinement of a maintenance program. The following items should be recorded, trended, and reviewed on a periodic basis to ensure adequacy of the type and periodicity of performed maintenance. The data review process is recommended following each interval of circuit breaker major maintenance.

1. Number of breaker operations.
2. Nameplate data.
3. Breaker serial number and switchgear cubicle number.
4. General comments on breaker condition with respect to cleanliness.
5. General condition of lubricants, i.e., dried, hardened, etc..
6. Part replacements and specific reason for replacement.
7. Observe mechanical operation of the breaker. Record any deviations from normal such as sluggishness, binding, or hesitation.
8. Mechanical clearances of operating mechanism.
9. Contact wipe and overtravel.
10. Contact resistance.
11. Insulation resistance (megger).
12. Closing timing.

Record the above data at convenient points throughout the performance of the overhaul, but before any activity which may alter the as-found state. In general, any deviation or abnormality encountered during performance should be recorded.

6.1.2 Disassembly

1. Barrier Assembly Removal

   A. Remove the barrier shield bolts from the lower front of the barrier assembly.

   B. Lift off the metal barrier shield.

   C. Lift off the interphase barriers.

> *NOTE: The interphase barriers should be marked as they are removed to facilitate return to their original position upon completion of maintenance. This will ensure proper alignment of the hangar pins.*

2. Arc Chute Removal

> *NOTE: It is recommended that a table approximately the same height and width as the breaker frame be used for arc chute removal. Refer to diagram xx.*

   A. Place the arc chute table directly behind the circuit breaker frame.

   B. Disconnect the shunt straps from the front of each arc horn.

   C. Lean each arc chute assembly, gently, over onto the table.

   D. Remove the hinge pin retaining clips (two per arc chute).

   E. Remove the arc chute hinge pin (one per arc chute).

   F. Remove the arc chute assemblies from the breaker.

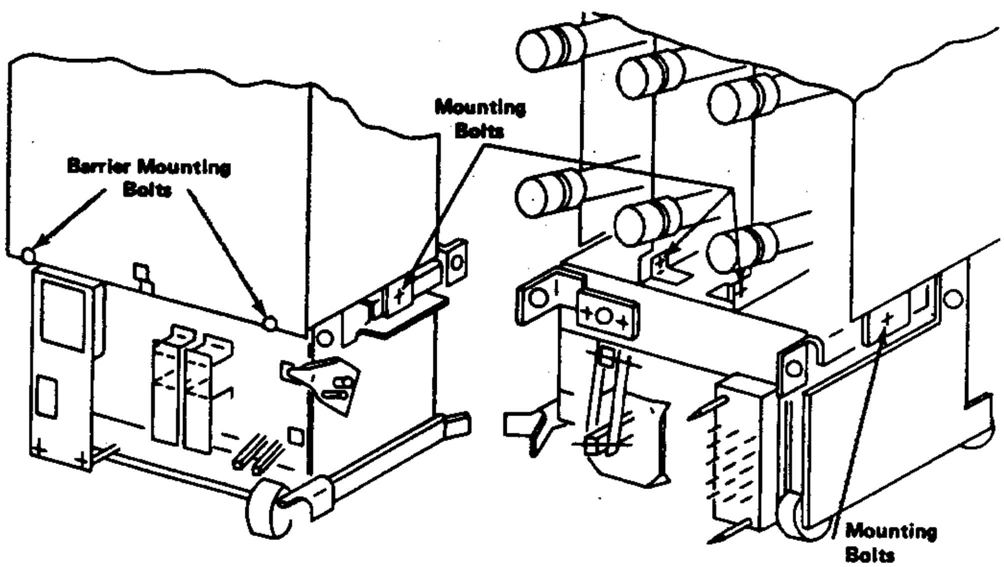
3. Moving Contact Assembly Removal

   A. Remove the contact assembly mounting bolts and lock washers. Refer to figure xx.

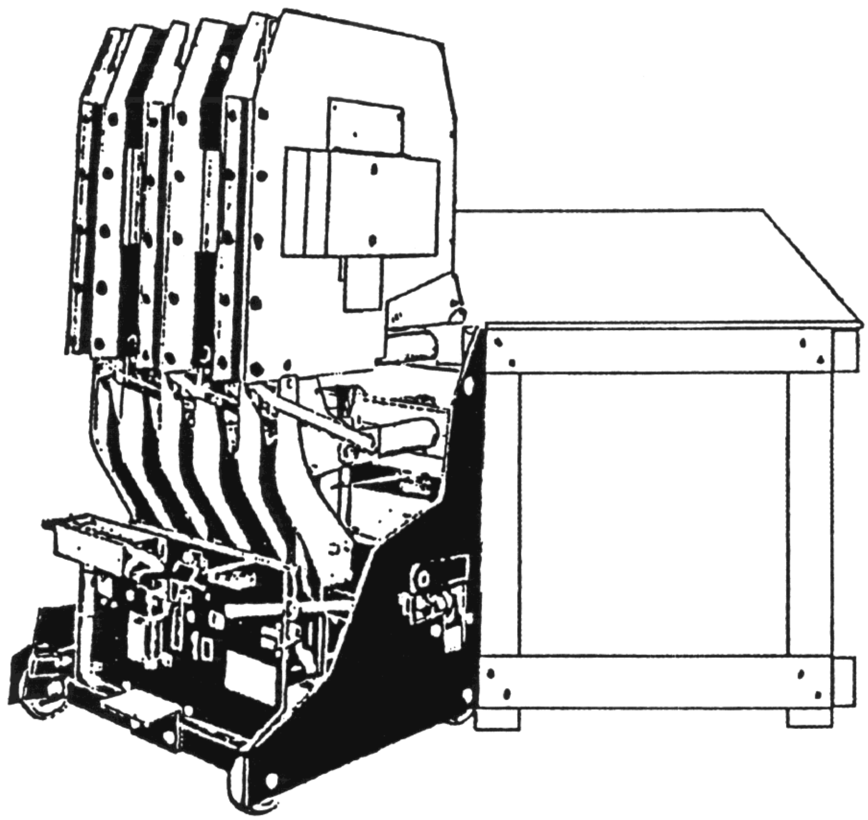
   B. Lift the contact assembly from the moving contact arm.

4. Moving Main Contact Removal

barrier.pcx



arcbnch.pcx



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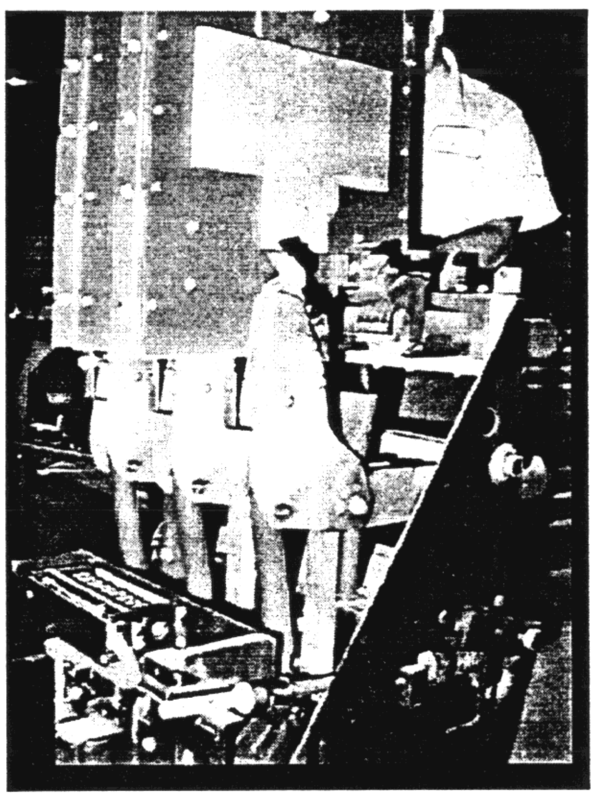


A. Remove the arcing contact flexible shunt mounting bolt.

B. Remove one of the arcing contact hinge pin snap rings.

C. Remove the arcing contact hinge pin.

D. Remove the main contact.

5. Moving Arcing Contact Removal

   A. Remove the arcing contact flexible shunt mounting bolt.

   B. Remove one of the arcing contact hinge pin snap rings.

   C. Remove the arcing contact hinge pin.

   D. Remove the arcing contact mounting bolts.

   E. Slide the arcing contact off the eyebolt.

6. Moving Contact Arm Removal

   A. Disconnect the operating rod from the contact arms by removing the connecting pin.

   B. Remove the hinge bolts which connect the moving arms to the lower stud assembly.

   C. Observe the arrangement of the spring washers, spacers, castle nuts, and cotter pins.

   D. Remove the moving contact arms.

7. Stationary Main Contact Removal

   A. Slowly loosen the finger stop mounting bolts to relieve the spring pressure.

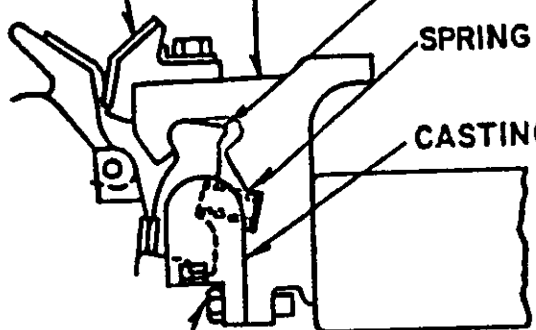
   B. As the finger stop mounting bolts become loose, slide the stationary contact and its backing spring out of the groove between the upper contact foot and the casting.

   C. Remove and save the thin strip of insulating material between the contact foot and the bottom of the finger springs.

8. Stationary Arcing Contact Removal

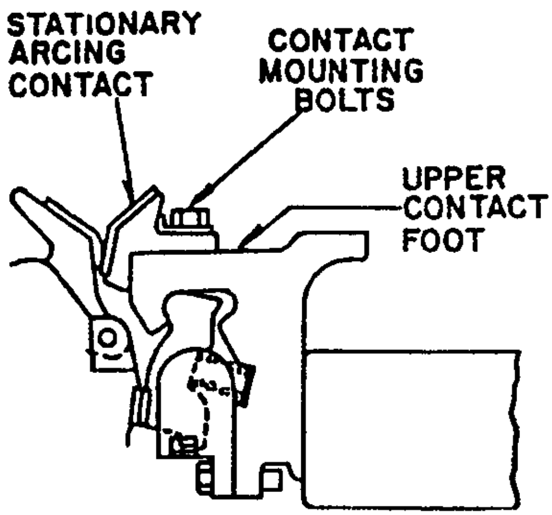
   A. Remove the contact mounting bolts from the upper contact foot.

Untitled - 5



STATIONARY ARCING CONTACT
UPPER CONTACT FOOT
STATIONARY CONTACT FINGER
SPRING
CASTING
FINGER STOP MOUNTING BOLTS (2)
UPPER STUD & BUSHING ASSY

arccon.pcx


STATIONARY
ARCING
CONTACT
CONTACT
MOUNTING
BOLTS
UPPER
CONTACT
FOOT

B. Remove the stationary arcing contacts.

9. Puffer Assembly

A. Remove the four bolts from the mechanism front panel and swing the panel to the side to allow access.

B. Remove the links to the auxiliary switch and operation counter.

C. Remove the two drive pins from the front of the levering device shaft and slip off the indicator collar.

D. Remove the puffer tube nozzles.

E. Remove the puffer tubes by removing the bolted clips at the base of the tubes where they pass through the breaker frame.

F. Disconnect the pin between the long puffer rod (lower right hand side) and the operating mechanism trip free lever.

G. Remove the four sections of the puffer assembly casting ring.

H. Remove the cotter pins and castle nuts from the two puffer rods.

I. Remove the diaphragm and diaphragm clamping plates.

J. Unbolt the puffer casting from the breaker frame.

K. Remove the puffer assembly.

10. Levering-In Device Removal

A. Disconnect the coupling pin and remove the operating shaft.

B. Remove the two mounting bolts on the non drive side of the breaker.

C. Remove the three mounting bolts on the drive side of the breaker.

D. Rotate the device, and remove through the opening on the breaker drive side.

11. Primary Disconnect Finger Removal

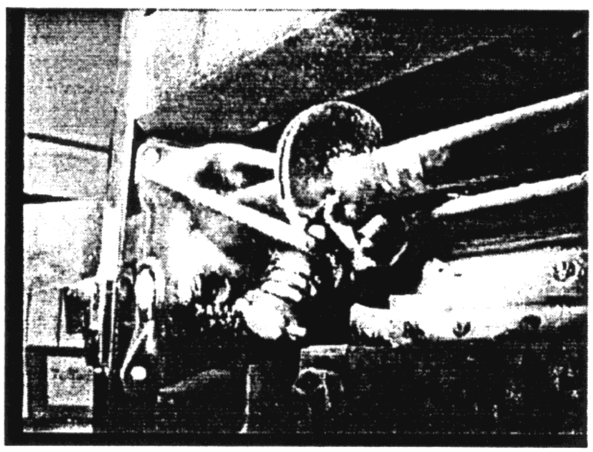
A. Compress the flat spring for an individual finger and remove the finger.

B. Remove the finger cluster.

12. Secondary Disconnect Device Removal

A. Note or scribe the position of each disconnect finger on the support frame.

Untitled - 5



B Label and disconnect the secondary wiring from the contact block.

C. Remove the secondary contact block from the slide bar.

13. Ground Contact

A. Unbolt and remove the ground contact.

14. Auxiliary Components

A. Auxiliary Switch

i. Remove the switch linkage (bolt, lockwasher, and nut) from the left hand side of the auxiliary switch.

ii. Scribe the left side cover bracket and the auxiliary switch shaft to ensure proper alignment on reassembly.

a. Label and determinate the terminal board wiring.

b. Remove the right side cover bracket mounting bolts and the right side cover bracket.

iii. Remove the right inner support bracket mounting screws (accessible from rear of frame) and right inner support bracket.

iv. Remove the auxiliary switch.

B. Shunt Trip Solenoid

i. Label and determinate the shunt trip solenoid wiring.

ii. Remove the shunt trip solenoid mounting screws.

iii. Note the orientation of the solenoid in its bracket.

iv. Remove the shunt trip solenoid.

C. Motor Cut-Off Switch (Limit Switch-Spring Stored Energy Mechanism Only)

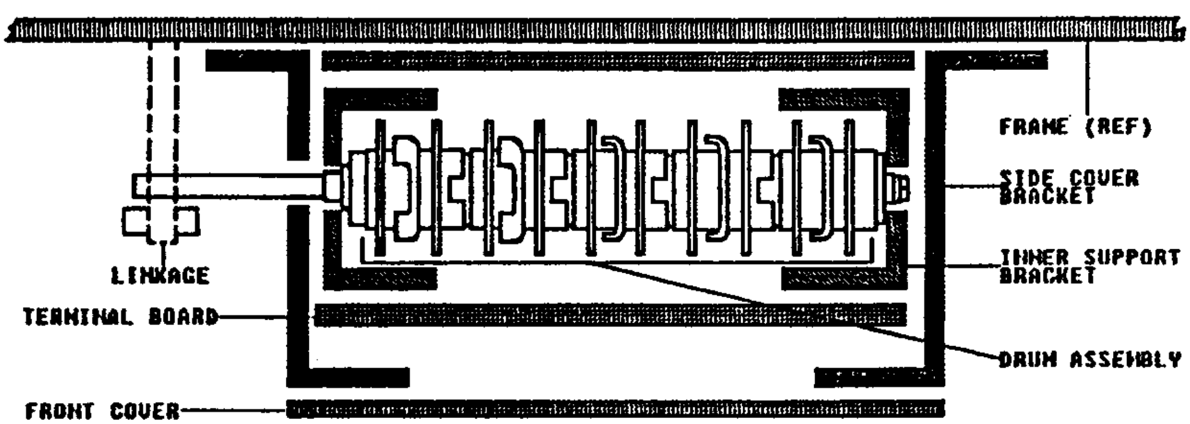
i. Remove the cut-off switch cover.

ii. Label and determinate the cut-off switch wiring.

iii. Remove the cut-off switch mounting screws.

iv. Remove the cut-off switch.

auxswch.pcx



FRAME (REF)
SIDE COVER BRACKET
INNER SUPPORT BRACKET
LINKAGE
TERMINAL BOARD
DRUM ASSEMBLY
FRONT COVER

D. Latch Check Switch

i. Label and determinate the latch check switch wiring.

ii. Remove the mounting screws.

iii. Remove the latch check switch.

E. Under Voltage Trip Attachment (UVTA)

i. Label and determinate UVTA coil wires.

ii. Disconnect UVTA linkage from the breaker tripping trigger.

iii. Remove the UVTA mounting bolts.

iv. Remove the UVTA.

F. Tripping Latch

G. Mechanism Release Magnet (Spring Stored Energy Mechanism Only)

15. Operating Mechanism

A. Solenoid Operating Mechanism

i. Remove bolting from solenoid backplate.

ii. Remove solenoid backplate. Note number and orientation of spacers.

iii. Label and determinate solenoid coil wiring.

iv. Remove the solenoid coil by pulling it toward the rear of the breaker.

v. Unbolt and remove the moving contact operating arms.

vi. Remove bolting from the breaker frame to the operating mechanism H-frame.

vii. Remove the operating mechanism / H-frame assembly.

B. Spring Stored Energy Operating Mechanism

i. Unbolt and remove the moving contact operating arms.

ii. Remove the operating mechanism frame mounting bolts.

iii. Label and determinate spring charging motor wiring.

D. Latch Check Switch

i. Label and determinate the latch check switch wiring.

ii. Remove the mounting screws.

iii. Remove the latch check switch.

E. Under Voltage Trip Attachment (UVTA)

i. Label and determinate UVTA coil wires.

ii. Disconnect UVTA linkage from the breaker tripping trigger.

iii. Remove the UVTA mounting bolts.

iv. Remove the UVTA.

F. Tripping Latch

G. Mechanism Release Magnet (Spring Stored Energy Mechanism Only)

15. Operating Mechanism

A. Solenoid Operating Mechanism

i. Remove bolting from solenoid backplate.

ii. Remove solenoid backplate. Note number and orientation of spacers.

iii. Label and determinate solenoid coil wiring.

iv. Remove the solenoid coil by pulling it toward the rear of the breaker.

v. Unbolt and remove the moving contact operating arms.

vi. Remove bolting from the breaker frame to the operating mechanism H-frame.

vii. Remove the operating mechanism / H-frame assembly.

B. Spring Stored Energy Operating Mechanism

i. Unbolt and remove the moving contact operating arms.

ii. Remove the operating mechanism frame mounting bolts.

iii. Label and determinate spring charging motor wiring.

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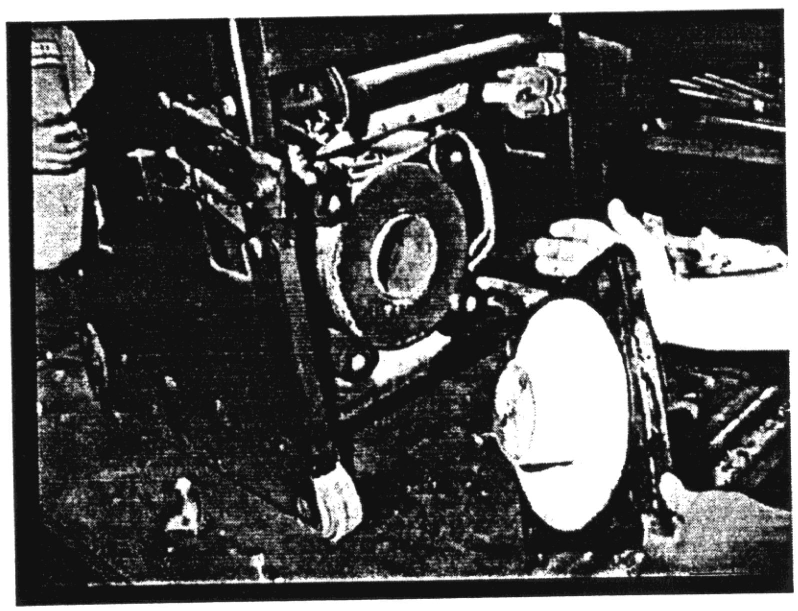

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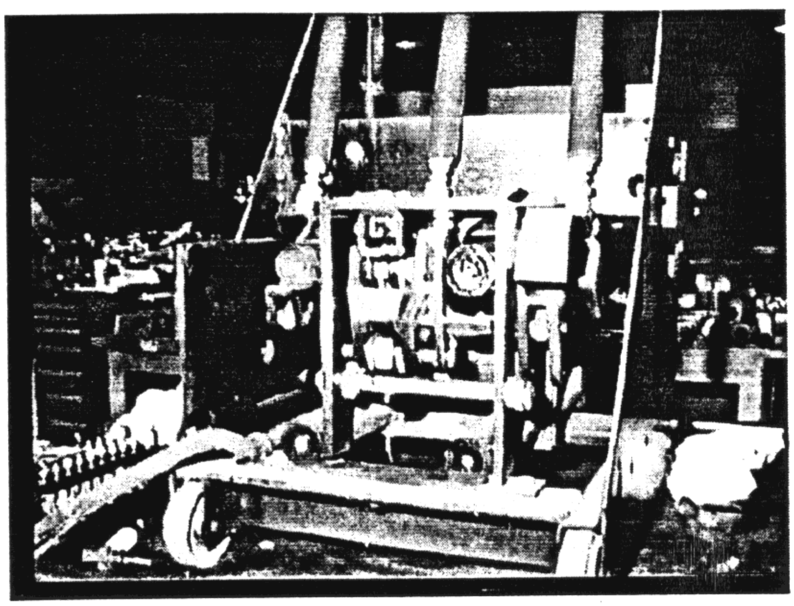

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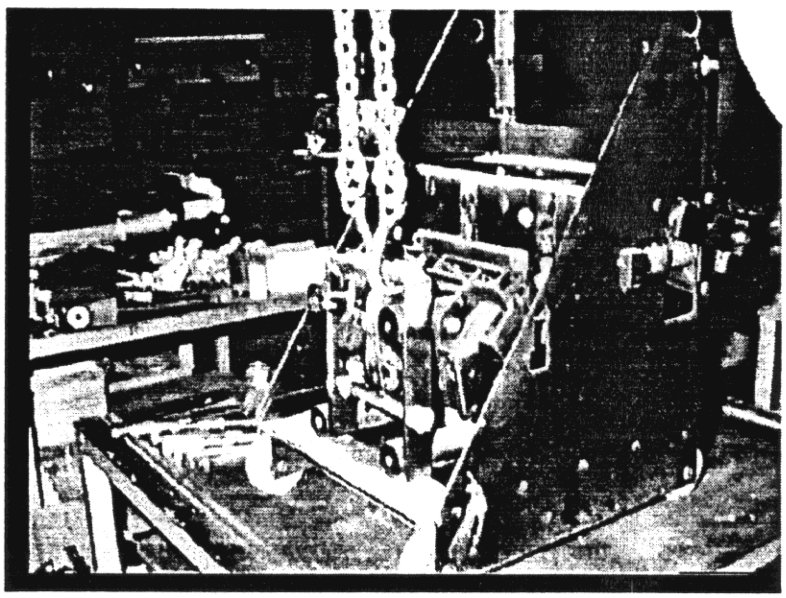

iv. Slide the operating mechanism out through the front of the breaker frame.

With the spring stored energy operating mechanism removed, further disassembly can be performed as follows.

v. Remove the spring charging motor

vi. Remove the shock absorber and closing spring assembly

vii. Remove the limit switch

viii. Remove the motor brake assembly

ix. Remove the gear housing

6.1.3 Inspection

1. Arc Chutes

   A. Inspect the arc chute assemblies for broken or cracked components, dirt, and carbon deposits. Inspect the splitter plates and barriers for erosion.

   B. If the arc chute appears excessively dirty or worn, the arc chute should be disassembled to allow a more thorough inspection.

> *NOTE: Small chips or cracks in the arc chute ceramics may be disregarded. Large cracks extending from the inverted V slot of the interrupter plate to the edge of the top plate may interfere with arc chute performance.*

i. Inspect the ceramic insulating jackets and splitter plates for cracks.

ii. Verify splitter plates are not excessively eroded.

iii. Inspect arc horns for erosion or cracking.

iv. Ensure blowout coil insulation is not cracked and shows no signs of over heating.

v. Check tightness of ceramic mounting hardware and blowout coil connectors.

2. Primary Disconnects

   Inspect the primary disconnects for signs of overheating, wear, and broken or weakened springs.

3. Secondary Disconnects

   A. Verify that all spring loaded disconnect fingers operate freely without binding.

   B. Inspect plastic insulation for cracking or damage, particularly at the mounting holes.

   C. Inspect the secondary disconnect support brackets for weld cracks.

4. Breaker Frame

   A. Inspect the frame for corrosion, and fatigue cracking in the frame welds.

   B. Inspect for bending or deformation of support arms.

5. Contact Assemblies

   > *NOTE: Contact wear is excessive when one half of the original contact thickness is worn away. Arcing contacts should be replaced if thickness is 1/16" or less.*

   A. Inspect the condition of the main and arcing contact surfaces for pitting, scoring, or excessive wear. Minor pitting or contact wear is acceptable and may be dressed using a fine file, sandpaper, or Scotch-Brite. Replating of the contact surfaces may be considered if more than half of the original contact thickness remains and the plating is flaking or peeling.

   B. Inspect the contact springs for corrosion, damage, or wear.

6. Levering-In Device

   A. Complete disassembly of the levering-in device, inspecting components for wear or damage. Particular attention should be given to the coupling, coupling pin, worm, worm shaft, and worm shaft pin.

7. Puffer Assembly

   Inspect the puffer assembly for damage or wear. Particular attention should be given to the following components.

   A. Inspect the puffer diaphragm for punctures or excessive wear.

   B. Inspect the puffer tubes and nozzles for cracks.

   C. Ensure the spring stop pins, and puffer rod pins are not bent.

D. Verify the accelerating springs are free of cracks, damage, and corrosion.

8. Operating Mechanism

Complete disassembly of the operating mechanism carefully recording component arrangement and mechanical relationships between the components. Note the size and location of all removed spacers, retainers, and bearings. Scribe or matchmarks are recommended to ensure correct reassembly.

A. Inspect the operating mechanism components for the following;

i. Solenoid Operating Mechanism

a. Inspect retrieving springs for wear and mechanical strength.
b. Inspect the mechanism frame for corrosion and weld cracks.
c. Verify the solenoid backplate and stationary core are free of corrosion.
d. Inspect solenoid coil shims for corrosion and deformation.
e. Inspect solenoid coil insulation for damage.
f. Inspect solenoid coil wiring for insulation damage.
g. Ensure the solenoid core guide tube and the moving core are smooth and free of corrosion.
h. Verify the operating center pin to be straight with proper freedom of movement through the trip free lever .
i. Inspect the air bumper assembly for corrosion and freedom of move ment.
j. Inspect the mechanism pins for wear, cracks, and deformation:

1) Latching pin
2) Upper trip free link to trip free lever pin
3) Pin joining upper and lower trip free links
4) Cam to cam link pin
5) Closing link pin
6) Air bumper retaining pins

k. Inspect the non trip free lever for bending, corrosion, and weld cracks.
l. Inspect the closing latch for weld cracks and deformation.
m. Inspect the upper and lower trip free links, the closing link, and the cam links for signs of binding.
n. Inspect the tripping cam and cam stop rollers for wear.
o. Inspect the pins, rollers, and springs of the hand trip assembly.

1) Verify freedom of movement for the front and rear rollers.
2) Inspect the trigger spring and roller lever spring for cracks and mechanical strength.
3) Ensure the trip assembly pin is straight and moves freely in the assembly.

ii. Spring Stored Energy Mechanism

> *NOTE: Components identical to those used in the solenoid operating mechanism are not repeated in this section.*

a. Inspect the crankshaft for weld cracks.
b. Inspect the crankshaft arm roller bearing for wear.
c. Inspect the LCSC micro switch for corrosion and proper contact operation.
d. Verify proper alignment of the LCSC switch operating arm.
e. Inspect the closing latch spring for cracks and mechanical strength.
f. Ensure that the crankshaft to slotted link pin and the crankshaft to spring rod pin are straight and free of cracks or excessive wear.
g. Inspect the slotted link for evidence of binding or deformation.
h. Inspect the mechanism bearings for wear and freedom of movement:

    1) Connecting link roller bearings (cam lever end, clevis link end)
    2) Worm shaft needle bearing
    3) Worm gear shaft roller bearings
    4) Closing latch sleeve bearing

i. Inspect the mechanism pins for wear, cracks, or deformation.

    1) Clevis link and connecting link pin
    2) Crankshaft and clevis link pin
    3) Brake rod sliding pin
    4) Sliding pin and brake lever junction pin
    5) Brake rod hollow pin
    6) Hand winding assembly spring latch and transfer link pin

j. Inspect the spring charging worm assembly for wear and signs of binding.

    1) Worm gear, cam, and roller
    2) Worm and worm shaft
    3) Worm to worm shaft key
    4) Worm shaft spur gear

k. Ensure the brake rod spring and brake spring are not worn or fatigued.
l. Inspect the brake disc and coupling for wear or signs of binding.
m. Inspect the motor limit switch for corrosion and proper contact operation.
n. Inspect the spring charging motor for signs of overheating

    1) Verify the motor brushes are not excessively worn.

p. Inspect the hand winding assembly to ensure proper engagement of the shaft and shaft extension.

q. Inspect the closing spring for fatigue cracks.

9. Auxiliary Components

   A. Auxiliary Switch

   B. Shunt Trip Magnet

   C. Cut-Off Switch (Limit Switch)

   D. Undervoltage Trip Attachment

   E. Mechanism Release Device

   F. MOC Switch

   G. Control Relay

   H. Wiring and Connections

6.1.4 Cleaning and Lubrication

1. Arc Chutes

   A. The arc chute components should be cleaned with dry compressed air or by wiping with a clean, dry, lint-free cloth. For dirt or carbon deposits that cannot be removed from the "Redarta" surfaces by the first two methods, a fine, non-metallic sandpaper should be used.

   B. After sanding, the area should be cleaned and coated using an approved insulating enamel.

   C. Arc chute components which fail the dielectric withstand test should be oven dried to remove absorbed moisture. Components which are oven dried should be left in the oven after the heat is turned off until they have returned to ambient temperature. This will ensure little or no moisture absorption once they are removed.

   D. Arc transfer surfaces such as the front and rear arc horns and the blowout coil transfer arc horns should be cleaned with clean cloths wetted with isopropyl alcohol.

2. Primary Disconnects

   A. Clean the disconnect fingers with a clean cloth and a mild solvent such as isopropyl alcohol.

   B. Following reattachment to the upper and lower contact studs, the finger area which mates with the male switchgear connector should be coated with a thin layer of conductive graphite lubricant.

3. Secondary Disconnects

   A. Clean each disconnect finger with a clean cloth and mild solvent such as isopropyl alcohol.

   B. Coat each finger with a thin covering of conductive graphite lubricant.

4. Contacts

   A. All main, intermediate, and arcing contact surfaces should be cleaned with an approved silver cleaner or polish. Burrs or minor pitting should be removed with fine sandpaper. Replating of the contact surfaces should be considered if the silver plating is flaking or peeling.

   > *NOTE: Contacts should be replaced if more than one half of the original contact thickness is missing.*

   B. Apply a light film of graphite based grease to the silver plated discs at the hinge point of the moving contact arms and to the knuckle joint between the main contact fingers and the contact foot.

5. Levering-In Device

   A. Clean all mechanism parts with an approved degreasing solvent.

   B. Remove solvent from the components using alcohol or a soapy water wash.

   C. Thoroughly dry the components using compressed air.

   D. Lubricate the levering-in device rollers and shutter rollers with an approved molybdenum based grease.

   E. The racking device worm gear and bearings should be coated using an ap proved general purpose grease.

6. Puffer Assembly

   A. In general the puffer assembly should not require any specific cleaning instructions. The diaphragm mounting surfaces should be smooth and free of corrosion prior to diaphragm replacement.

   B. The puffer assembly does not require lubrication.

7. Breaker Frame

   A. Clean any rust or contaminants from the breaker frame. Paint any areas of the frame requiring touch-up with an approved carbon steel coating.

   B. Clean and lubricate the breaker frame wheel bearings with an approved general purpose grease

8. Operating Mechanism

   A. Thoroughly clean all mechanism parts with an approved solvent.

   B. Remove all traces of solvent with an alcohol or mild soapy water wash.

   C. Dry the mechanism components using compressed air.

9. Solenoid Operating Mechanism

> *NOTE: Exercise care when applying lubricants to components of the operating mechanism. Excessive quantities of the lubricant will cause drippings and dust accumulation.*

   A. Lubricate the following solenoid mechanism components with a light film of graphite based grease:

      i. Outer surface of the moving solenoid core
      ii. Inner surface of the core guide tube
      iii. Inner surface of the air bumper cylinder
      iv. Air bumper pins
      v. Latching pin
      vi. Upper trip free link to trip free lever pin
      vii. Pin joining upper and lower trip free links
      viii. Cam to cam link pin
      ix. Closing link pin
      x. Cam stop rollers
      xi. Hand trip lever pin
      xii. Hand trip assembly rollers

10. Spring Stored Energy Mechanism

    Lubrication of the spring stored energy device is similar to the solenoid mechanism. The major exception is the use of bearings in the spring stored energy device. Otherexceptions include the spring wind-up linkage and the mechanism crankshaft.

   A. Lubricate the following spring stored energy mechanism components with a light film of molybdenum disulphide based grease:

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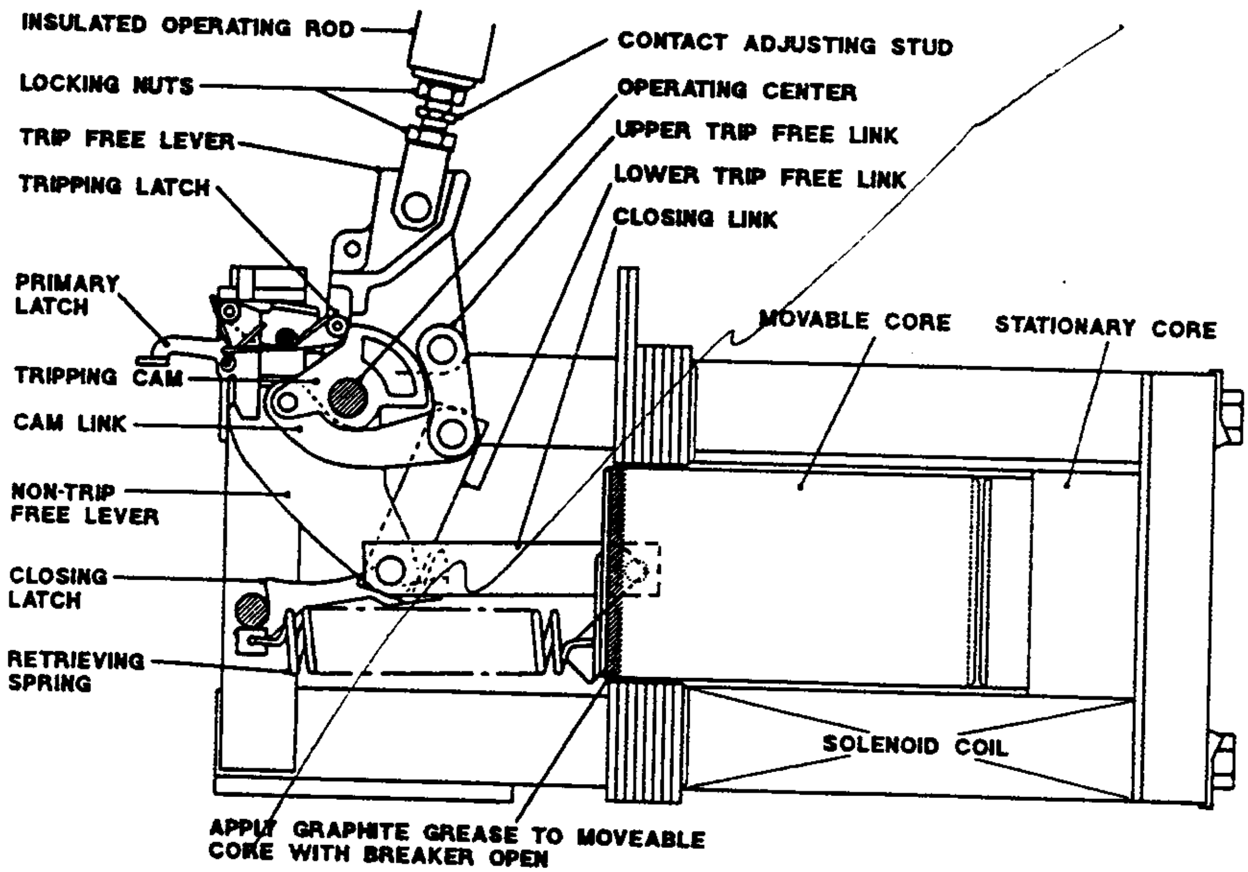

INSULATED OPERATING ROD
LOCKING NUTS
TRIP FREE LEVER
TRIPPING LATCH
PRIMARY LATCH
TRIPPING CAM
CAM LINK
NON-TRIP FREE LEVER
CLOSING LATCH
RETRIEVING SPRING
CONTACT ADJUSTING STUD
OPERATING CENTER
UPPER TRIP FREE LINK
LOWER TRIP FREE LINK
CLOSING LINK
MOVABLE CORE
STATIONARY CORE
SOLENOID COIL
APPLY GRAPHITE GREASE TO MOVEABLE CORE WITH BREAKER OPEN

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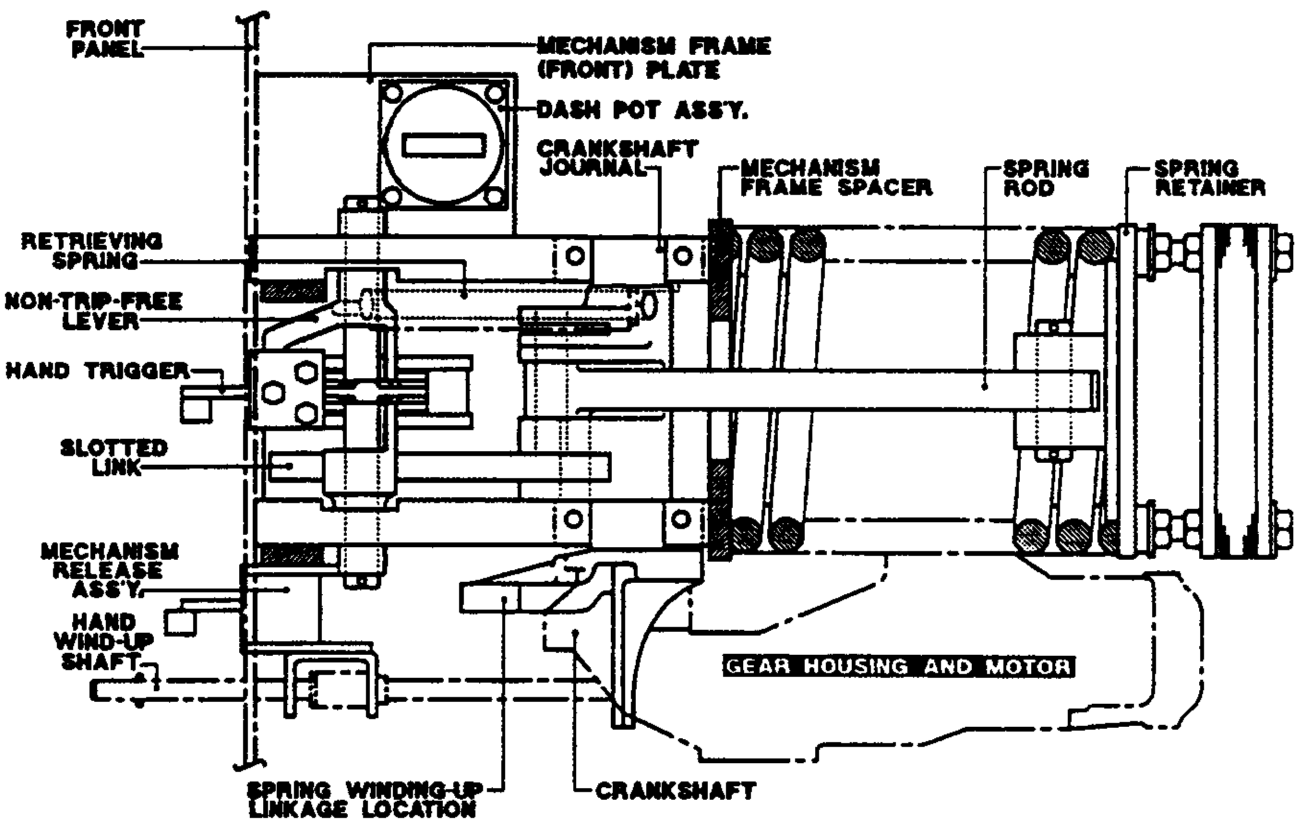

FRONT PANEL
MECHANISM FRAME (FRONT) PLATE
DASH POT ASS'Y.
CRANKSHAFT JOURNAL
MECHANISM FRAME SPACER
SPRING ROD
SPRING RETAINER
RETRIEVING SPRING
NON-TRIP-FREE LEVER
HAND TRIGGER
SLOTTED LINK
MECHANISM RELEASE ASS'Y.
HAND WIND-UP SHAFT
GEAR HOUSING AND MOTOR
SPRING WINDING-UP LINKAGE LOCATION
CRANKSHAFT

i. Crankshaft arm roller bearing
ii. Connecting link roller bearings (cam lever and clevis link ends)
iii. Worm shaft needle bearing
iv. Worm gear shaft roller bearings
v. Cam link roller and connecting pin
vi. Mechanism center pin through the trip free and non trip free levers
vii. Upper and lower trip free junction pin
viii. Closing latch sleeve bearing
ix. Non trip free lever and lower trip free link junction pin
x. Slotted link
xi. Crankshaft journals and connecting pins to the slotted link and spring rod
xii. Cam lever and pin
xiii. Brake rod sliding pin
xiv. Junction pin between brake lever and brake rod sliding pin
xv. Spring latch and transfer link pin

B. Lubricate the following spring stored energy mechanism components with a light film of molybdenum based grease (West. 8577-2 or equivalent).

i. Spring winding worm
ii. Worm gear
iii. Worm shaft spur gear

C. Open and clean the spring charging motor using compressed air.

D. Clean the motor brushes and collector ring assembly using an approved elec trical grade solvent.

11. Auxiliary Components

A. Auxiliary Switch

B. Shunt Trip Magnet

C. Cut-Off Switch (Limit Switch)

D. Undervoltage Trip Attachment

E. Mechanism Release Device

F. MOC Switch

G. Control Relay

H. Wiring and Connections

6.1.5 Assembly

Refer to disassembly notes during reassembly to ensure proper location, orientation, and size of shims, spacers, retainers, lockwashers, and other hardware.

1. Operating Mechanism

   A. Solenoid Operating Mechanism

      i. Assemble the mechanism components with the exception of the solenoid coil and backplate assembly.

      ii. Mount the assembled mechanism on the mechanism "H" frame.

      iii. Using a hoist, move the assembly into position on the breaker frame and install the mechanism frame to breaker frame mounting bolts.

      iv. Install and bolt the moving contact operating arms to the mechanism.

      > *NOTE: If convenient, installation of the solenoid coil and backplate assembly may be performed after installation of the puffer assembly and levering-in device.*

      v. Install the solenoid coil over the coil guide tube. Position the coil to facilitate termination of the coil wiring.

      vi. Connect coil wiring.

      vii. Verify freedom of movement of the mechanism moving core through the core guide tube.

      viii. Ensure the mechanism operates freely without binding.

      ix. Install and bolt the solenoid backplate.

   B. Spring Stored Energy Operating Mechanism

      i. Assemble the operating mechanism components and mount on the operating mechanism frame.

      ii. Assemble and mount the spring charging gear and wind-up linkage.

      iii. Attach the spring charging motor and couple to the gear assembly.

      iv. Install the main spring and shock absorber assembly.

      v. Assemble and mount the motor brake and limit switch.

      vi. Using a hoist, slide the mechanism frame into place through the front of the breaker frame. Bolt the mechanism frame into place.

vii. Terminate the spring charging motor wiring.

viii. Bolt the moving contact operating arms to the mechanism.

2. Puffer Assembly

A. Install and bolt the puffer casting to the breaker frame.

B. Bolt the puffer diaphragm and gasket between the clamping plates being careful not to crush the diaphragm.

C. Place the diaphragm assembly into the puffer casting and connect (pin) the long puffer rod to the mechanism trip free lever.

D. Install the castle nuts and cotter pins for the two puffer rods.

E. Install the four sections of the casting ring. Use moderate pressure on the bolting to avoid diaphragm damage.

F. Install the puffer tubes using the bolted clips at the base of the tubes. Ensure the clip rests in the puffer tube notch before securing the bolt.

G. Replace the links to the auxiliary switch and operation counter.

H. Following installation of the levering-in device, slip the indicator collar onto the levering device shaft and install the two drive pins.

I. Bolt the mechanism control panel to the front of the breaker frame.

3. Levering-In Device

A. Slide the device into position through the opening in the breaker frame drive side.

B. Rotate the device into position to align the mounting bolt holes and install the three drive side and two non drive side mounting bolts.

C. Pin the coupling to the operating shaft and install the levering-in device shaft.

D. Operate the device to ensure free movement over its entire range.

4. Moving Contact Assembly

> *NOTE: The moving contact assembly should be assembled as a unit (main contacts,arcing contacts, and moving contact arms) before mounting on the lower contact stud.*

A. Slide the moving arcing contact onto the eyebolt and install the arcing contact mounting bolts.

B. Install the arcing contact hinge pin and the hinge pin snap ring.

C. Install the arcing contact flexible shunt mounting bolt.

D. Align the contact assembly with the holes in the moving contact arms and install the three mounting bolts and lockwashers.

E. Attach the moving contact arms to the lower contact studs by installing the hinge pin bolts. Refer to the disassembly notes for proper orientation of the spring washers, spacers, castle nuts, and cotter pins.

F. Connect the operating rods to the moving contact arms with the hinge pin. Secure the hinge pin on each side with cotter pins.

5. Stationary Contact Assembly

> *NOTE: Ensure the thin strip of insulation is placed between the contact foot and the springs as the contact is assembled.*

A. Align and install the contact backing springs so that the spring seat ridges are parallel with the contact fingers, and align on each finger.

B. Install the stationary main contacts by sliding each contact finger into the groove between the contact foot and the casting.

C. Using the maintenance closing handle, slowly close the breaker moving contacts until they begin to apply pressure to the stationary contacts.

D. With the stationary main contacts held rigid, install the two finger stop mounting bolts. Return the moving contacts to the full open position.

E. Bolt the stationary arcing contact to the top of the contact foot.

6. Auxiliary Components

A. Auxiliary Switch

i. Align the scribe marks on the switch shaft with the left side cover bracket and install the switch.

ii. Install the right inner support bracket and mounting screws.

iii. Install the right side cover bracket and mounting bolts.

iv. Install the terminal board and mounting screws.

v. Terminate the switch wiring at the terminal board.

vi. Attach the switch linkage to the left side of the switch with the bolt, lockwasher, and nut.

B. Shunt Trip Solenoid

i. Install and bolt the shunt trip solenoid to the solenoid support bracket.

ii. Terminate the solenoid wiring.

C. Motor Cut-Off Switch (Limit Switch)

i. With the cut-off switch cover removed, install the switch with the two mounting screws.

ii. Terminate the cut-off switch wiring.

iii. Replace the cover.

D. Latch Check Switch

E. Under Voltage Trip Attachment

F. Three Coil Trip Attachment

G. Mechanism Operated Control Switch

H. Tripping Latch

I. Control Relay

J. Mechanism Release Magnet

7. Arc Chutes

A. Place the arc chute in an upright position, resting on its rear surface on the arcchute table.

B. Gently lean the arc chute forward into position on the circuit breaker.

C. Install the hinge pin and hinge pin retaining clips and lower the arc chute to its operating position.

D. Connect the shunt strap to the front of the arc horn.

8. Barrier Assembly

A. Install the interphase barriers, noting the position marks made during disassembly.

B. Install the metal barrier shield.

C. Install the barrier shield bolts to the lower front section of the barrier.

6.1.6 Measurements and Adjustments

1. Contact Assemblies

The stationary and moving contact assemblies should be checked for proper vertical and horizontal alignment, contact overtravel, and moving to stationary main contact clearance.

2. Contact Alignment

A. Using the maintenance closing handle, slow close the breaker to the latched position.

B. Verify that the main and arcing contacts are properly aligned in both the horizontal and vertical planes.

> *NOTE: Slight misalignment of the contacts will be corrected during overtravel and moving to stationary main contact clearance adjustments.*

3. Contact Overtravel

A. With the circuit breaker closed and latched, measure the contact overtravel through the rectangular opening on each side of the finger stop casting. Refer to figure XX.

B. The measured distance from the front edge of the rectangular opening to the bottom edge of the outside contact finger should be 1/8 (0.125) inches minimum to 5/32 (0.156) inches maximum.

C. Referring to figure XX, adjustment of the contact overtravel is performed as follows.

i. Unbend the lock tabs on the operating rod.

ii. Loosen the two locknuts at the lower end of the operating rod.

iii. Turn the adjusting stud to obtain the required overtravel.

iv. Tighten the operating rod locknuts.

v. Recheck contact overtravel.

vi. Bend the lock tabs.

D. Main Contact Clearance

i. Using the maintenance closing handle, slowly close the breaker until the stationary and moving arcing contacts on one phase just touch.

ii. Adjust the arcing contact stop nut located just below the arcing contact spring on each phase until the arcing contacts on all three phases are just touching. Refer to figure XX.

iii. In this position measure the distance between the stationary and moving main contact fingers.

iv. The measured distance between the contact fingers should be 3/8 (0.375) inches minimum and 15/32 (0.466) inches maximum.

v. This distance is adjusted by means of the arcing contact stop nut.

vi. Recheck clearances following all adjustments.

4. Operating Mechanism

A. Solenoid Operating Mechanism

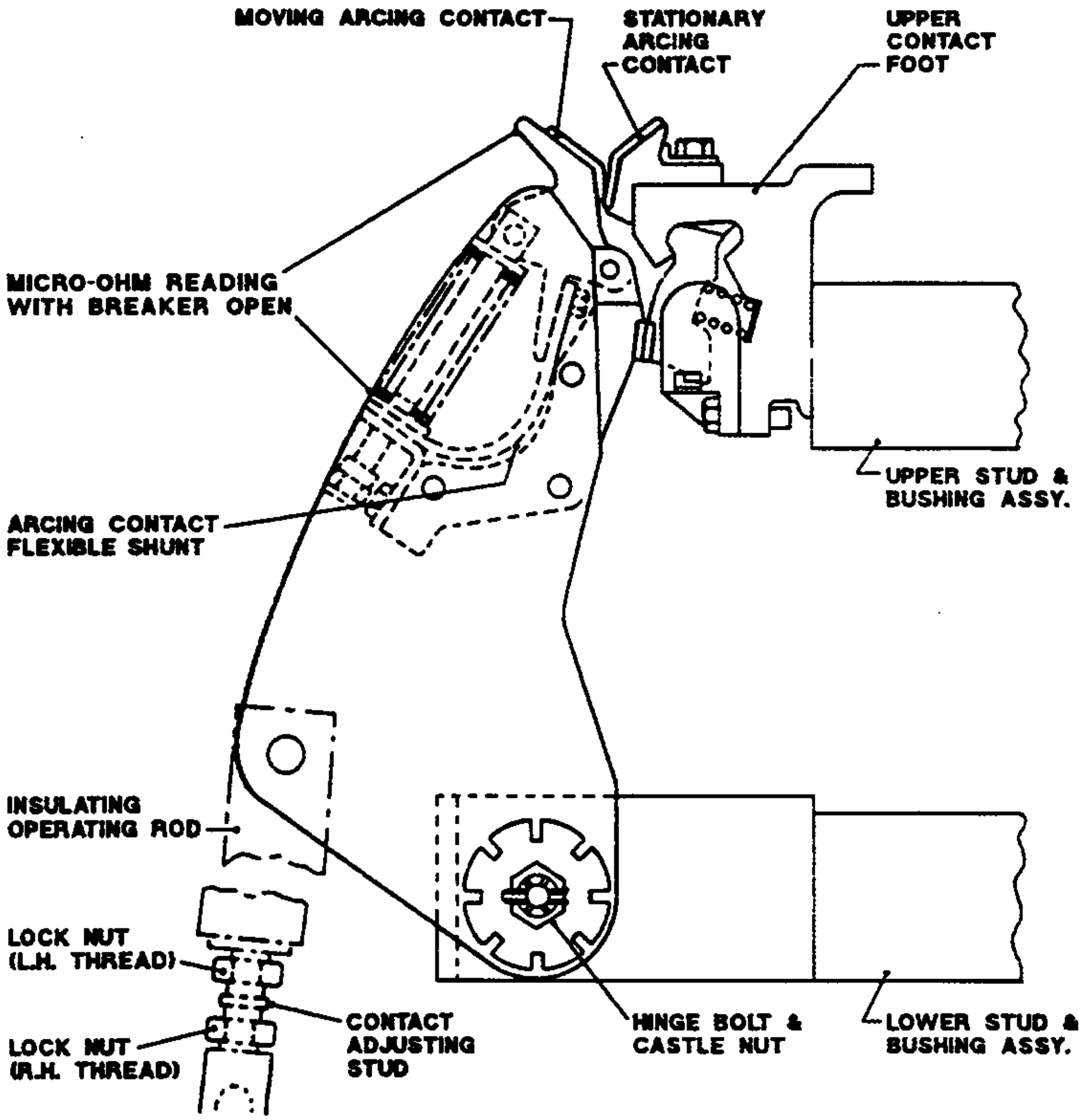
i Tripping Latch Gap Adjustment

a. With the breaker open and reset, measure the gap between the tripping latch roller and the lip of the tripping latch cam, as depicted in figure XXX. An acceptable gap is 1/32" minimum to 1/16" maximum.

b. Unbend the locktabs and loosen the locknut.

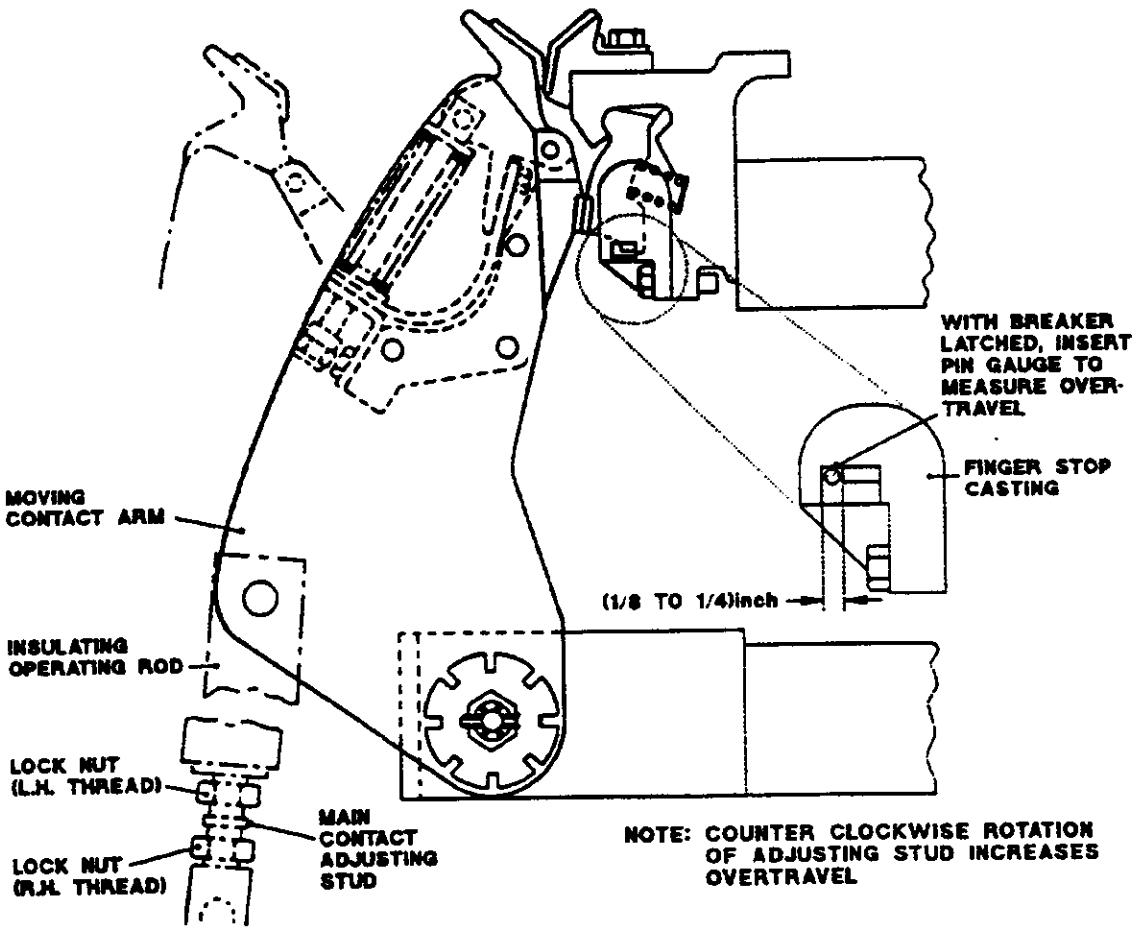
c. Adjust the stop bolt until an acceptable gap is obtained.

conadj.pcx



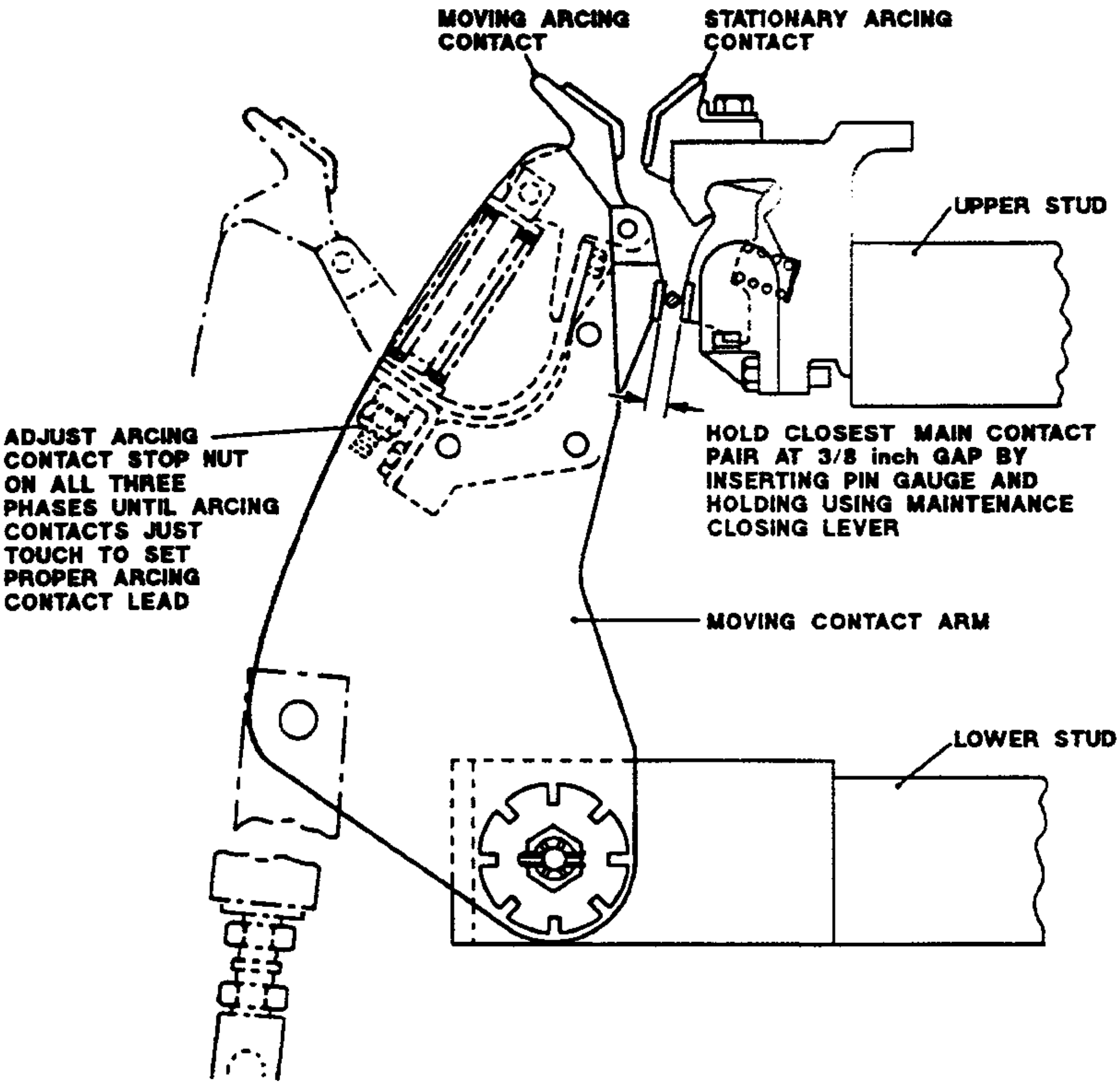
MOVING ARCING CONTACT
STATIONARY ARCING CONTACT
UPPER CONTACT FOOT
MICRO-OHM READING WITH BREAKER OPEN
UPPER STUD & BUSHING ASSY.
ARCING CONTACT FLEXIBLE SHUNT
INSULATING OPERATING ROD
LOCK NUT (L.H. THREAD)
LOCK NUT (R.H. THREAD)
CONTACT ADJUSTING STUD
HINGE BOLT & CASTLE NUT
LOWER STUD & BUSHING ASSY.

conadj1.pcx

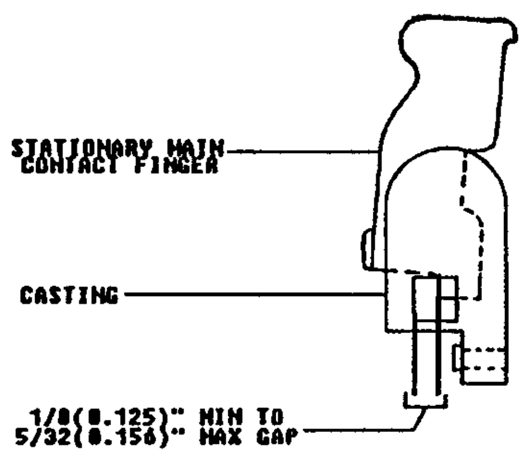


WITH BREAKER LATCHED, INSERT PIN GAUGE TO MEASURE OVER-TRAVEL
FINGER STOP CASTING
MOVING CONTACT ARM
(1/8 TO 1/4)inch
INSULATING OPERATING ROD
LOCK NUT (L.H. THREAD)
MAIN CONTACT ADJUSTING STUD
LOCK NUT (R.H. THREAD)
NOTE: COUNTER CLOCKWISE ROTATION OF ADJUSTING STUD INCREASES OVERTRAVEL

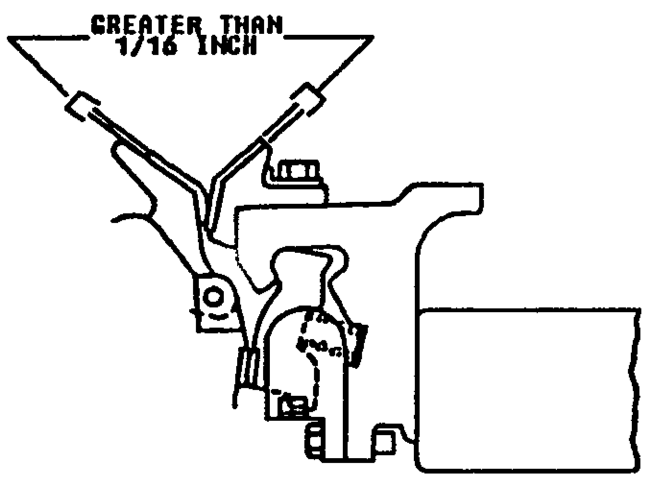
congap.pcx


MOVING ARCING CONTACT
STATIONARY ARCING CONTACT
UPPER STUD
ADJUST ARCING CONTACT STOP NUT ON ALL THREE PHASES UNTIL ARCING CONTACTS JUST TOUCH TO SET PROPER ARCING CONTACT LEAD
HOLD CLOSEST MAIN CONTACT PAIR AT 3/8 inch GAP BY INSERTING PIN GAUGE AND HOLDING USING MAINTENANCE CLOSING LEVER
MOVING CONTACT ARM
LOWER STUD

conot.pcx


STATIONARY MAIN
CONTACT FINGER
CASTING
1/8(0.125)" MIN TO
5/32(0.156)" MAX GAP

arcconw.pcx



d. Tighten the locknut and bend the locktabs.

ii. Latch Check Switch Adjustment

a. With the breaker in the open reset position lift the primary latch/trip lever to its end of travel.

b. Slowly lower the primary latch until the latch check switch clicks shut.

c. Measure the distance from the switch arm at the point where the click is heard to the top of the solenoid plunger. An acceptable gap is 1/8" minimum to 3/8" maximum.

d. Adjustment of the gap is achieved by bending the switch arm near the middle of its length until an acceptable gap is achieved.

iii. Control Cut-Off Switch Plunger Overtravel

a. Measure the distance between the top of the solenoid plunger and the top of the control cut-off switch. Refer to figure XXX. Record the value.

b. Close and latch the breaker.

c. Measure the distance between the top of the plunger and the top of the control cut-off switch. Record the value.

d. Subtract the two recorded values to obtain the plunger overtravel. An acceptable overtravel is 1/32" minimum to 1/8" maximum.

e. Adjustment of the gap is achieved by bending the switch operating arm.

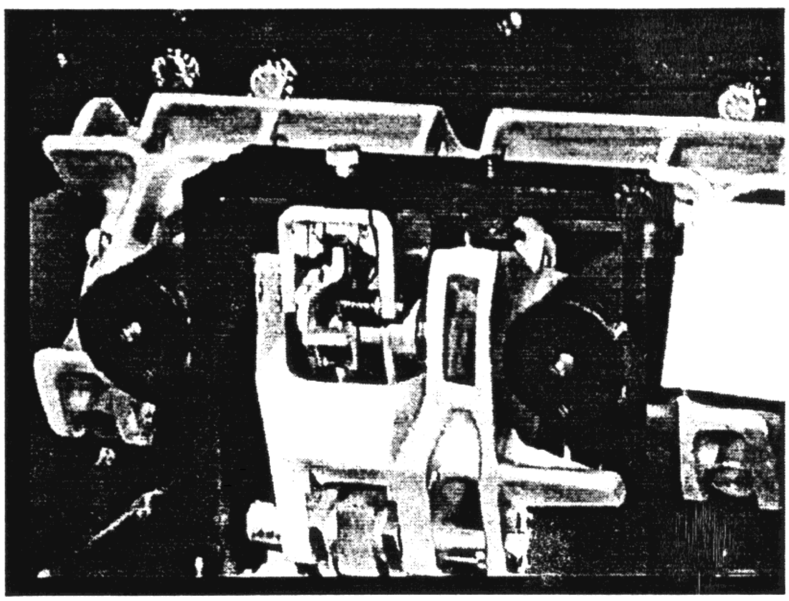
iv. Closing Latch

a. With the breaker closed and latched momentarily energize the closing solenoid and measure the overtravel of the pin at the lower end of the non trip-free lever with respect to the latch surface. The overtravel should be 1/32" to 3/32".

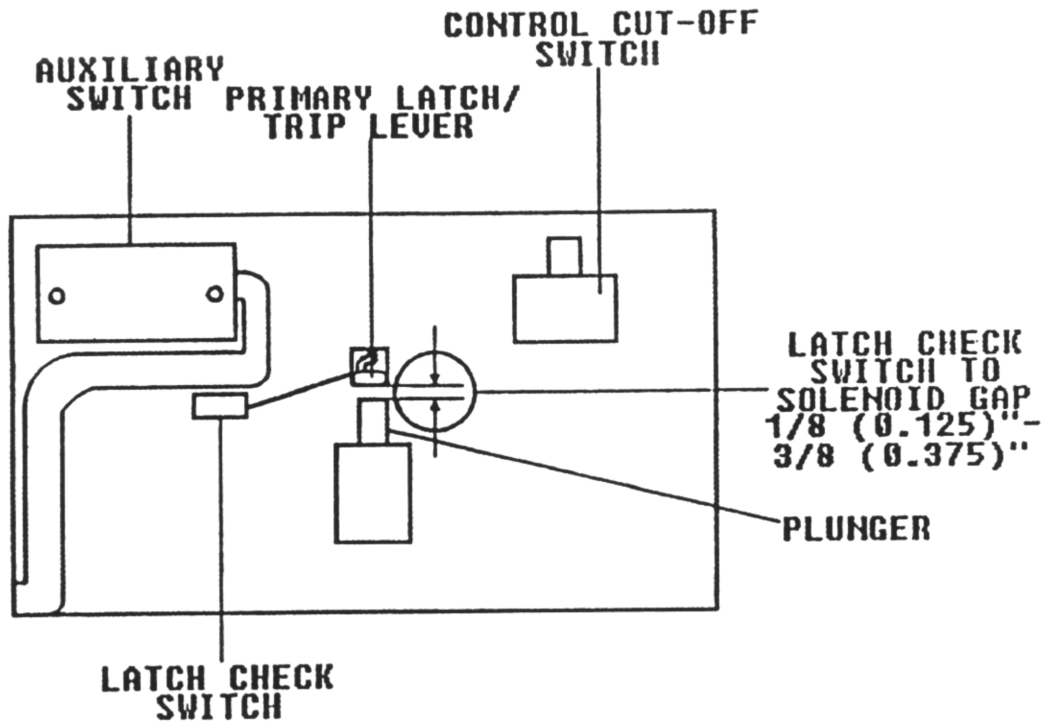
> *NOTE: Overtravel will decrease with wear in the link holes and pins. A decrease in overtravel will prevent the closing latch from moving up to its holding position.*

b. Adjustment of the overtravel is accomplished by adding steel shim washers between the magnet back plate and the four large magnetic return studs. Refer to figure XXX.

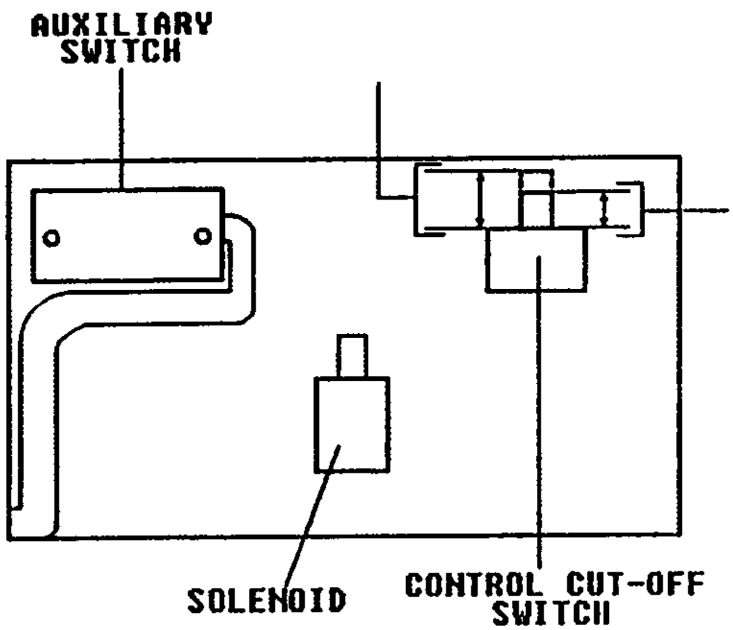
Untitled - 7



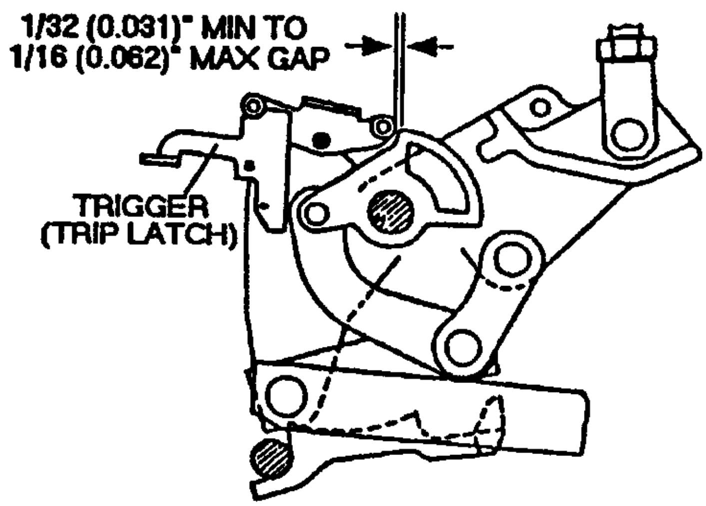
lcsadj.pcx


CONTROL CUT-OFF SWITCH
AUXILIARY SWITCH
PRIMARY LATCH/ TRIP LEVER
LATCH CHECK SWITCH TO SOLENOID GAP 1/8 (0.125)"-3/8 (0.375)"
PLUNGER
LATCH CHECK SWITCH

ccosw.pcx



tlatadj.pcx



B. Spring Stored Energy Operating Mechanism

i. Shock Absorber Adjustment

a. With the breaker closed and the closing spring discharged, measure the gap between the lip of the closing latch and the non trip free lever pin. An acceptable gap is 1/32" minimum to 1/16" maximum.

b. Adjustment of the gap is achieved by loosening the four shock absorber retaining bolts, adjusting the shock absorber, and then tightening the retaining bolts. Adjustment of the shock absorber to the right increases the gap and movement to the left decreases the gap. Refer to figure XXX.

> *NOTE: With the closing spring charged and the breaker closed the non trip free lever rests against the closing latch.*

ii. Limit Switch Operating Arm

a. With the brake lever in the extreme counterclockwise position, measure the gap between the switch operating adjusting screw and the switch operating arm roller. An acceptable gap is 1/32" minimum to 1/16" maximum. Refer to figure XXX.

b. The gap is adjusted with the switch operating adjusting screw. Loosen the locking screw, set the gap with the adjusting screw, and tighten the locking screw.

iii. Cam Lever Gap Adjustment

a. Rotate the hand winding shaft until the roller on the worm gear is tangent to the cam lever and the cam lever is in its maximum clockwise position.

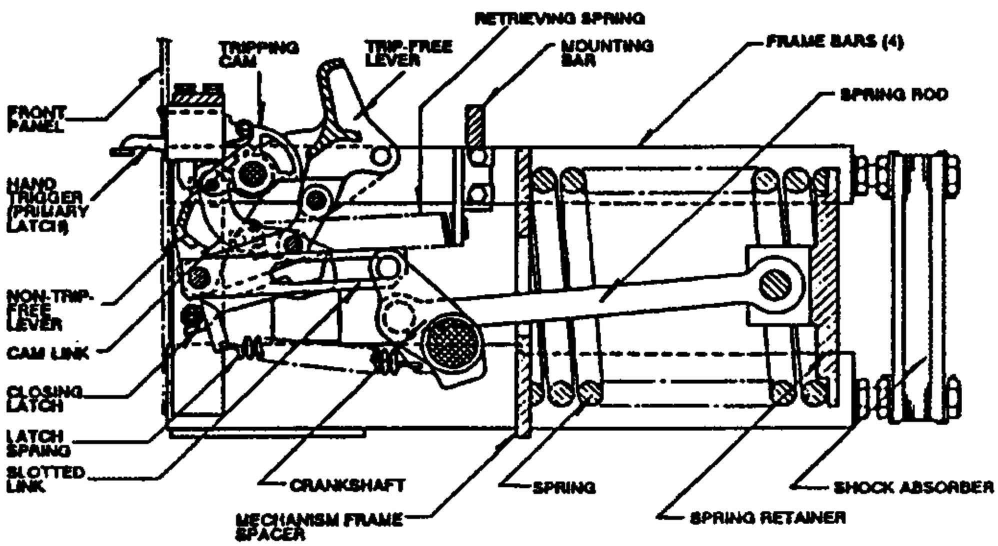
b. Referring to figure XXX, measure the distance between the cam lever and the set screw stop. An acceptable gap is 0.020".

c. Adjustment of the gap is made with the set screw stop. Loosen the locking screw, adjust the set screw stop, and retighten the locking screw.

iv. Mechanism Release Assembly

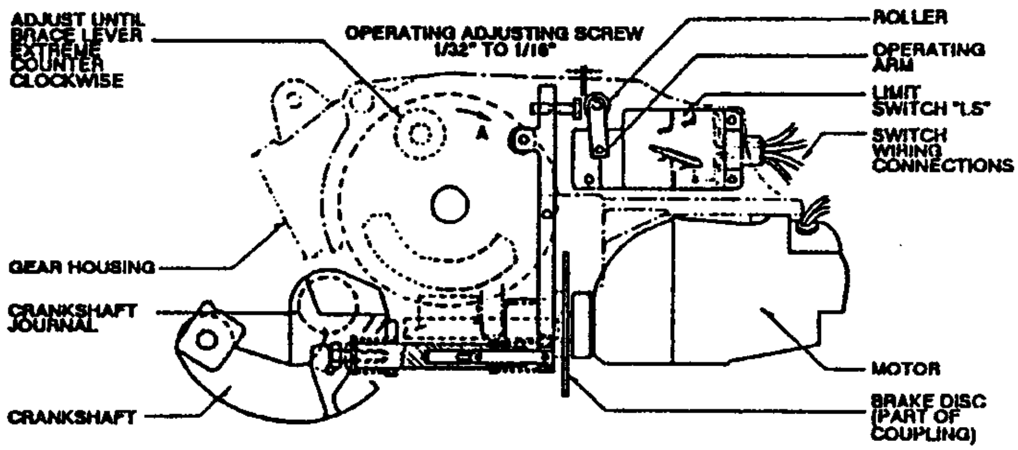
a. With the breaker in the latched position, measure the distance from the centerline of the release latch roller (where it contacts the spring latch cam face) to the lip of the spring latch cam, as shown in figure XXX. An acceptable gap is 1/32" minimum to 1/16" maximum.

sckabs.pcx



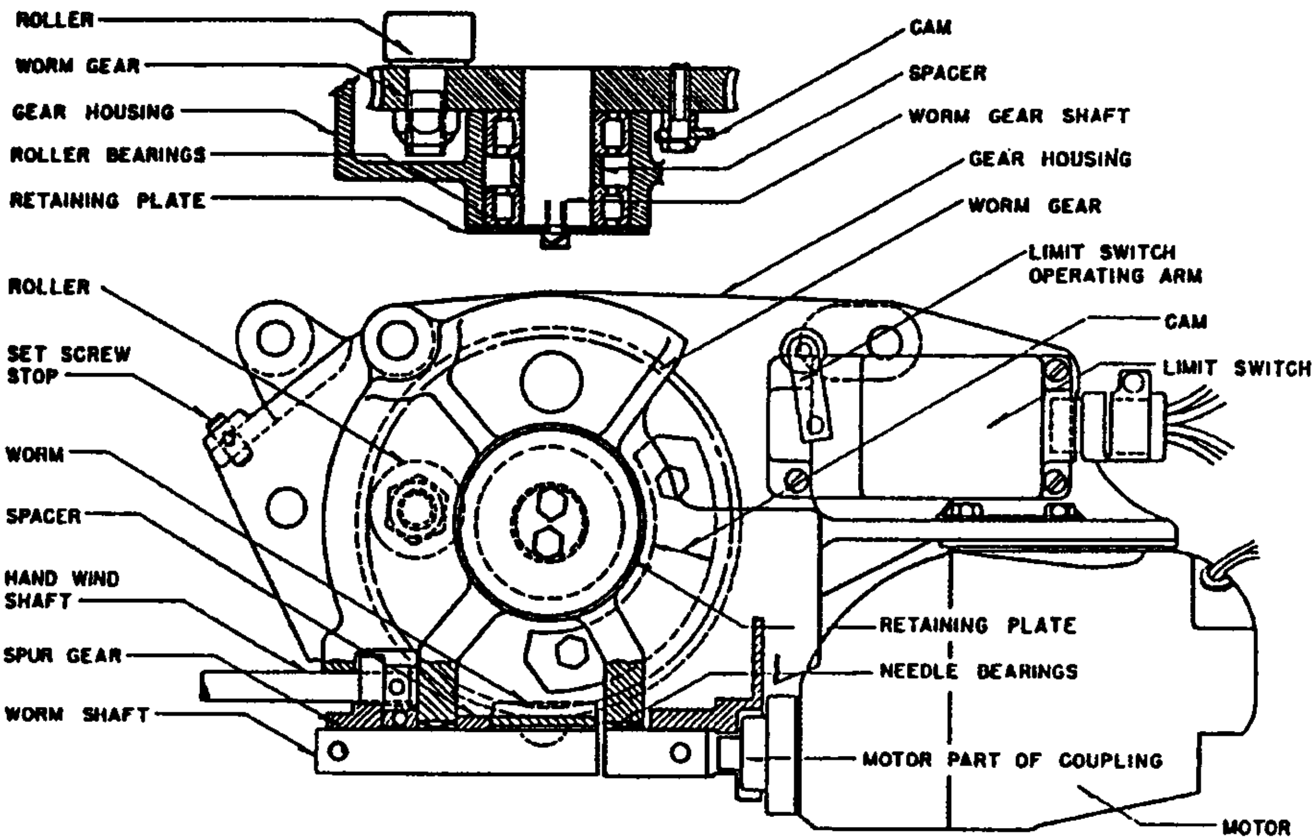
RETRIEVING SPRING
TRIPPING CAM
TRIP-FREE LEVER
MOUNTING BAR
FRAME BARS (4)
SPRING ROD
FRONT PANEL
HAND TRIGGER (PRIMARY LATCH)
NON-TRIP-FREE LEVER
CAM LINK
CLOSING LATCH
LATCH SPRING
SLOTTED LINK
CRANKSHAFT
MECHANISM FRAME SPACER
SPRING
SPRING RETAINER
SHOCK ABSORBER

lsadj.pcx

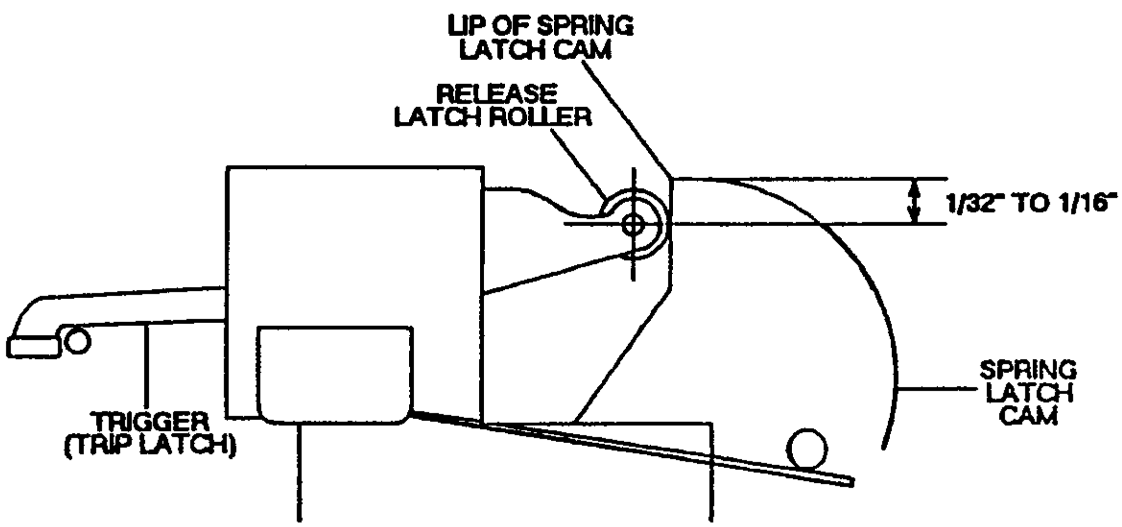


ADJUST UNTIL BRACE LEVER EXTREME COUNTER CLOCKWISE
OPERATING ADJUSTING SCREW 1/32" TO 1/16"
ROLLER
OPERATING ARM
LIMIT SWITCH "LS"
SWITCH WIRING CONNECTIONS
A
GEAR HOUSING
CRANKSHAFT JOURNAL
CRANKSHAFT
MOTOR
BRAKE DISC (PART OF COUPLING)

camlev.pcx


ROLLER
WORM GEAR
GEAR HOUSING
ROLLER BEARINGS
RETAINING PLATE
CAM
SPACER
WORM GEAR SHAFT
GEAR HOUSING
WORM GEAR
LIMIT SWITCH OPERATING ARM
CAM
LIMIT SWITCH
ROLLER
SET SCREW STOP
WORM
SPACER
HAND WIND SHAFT
SPUR GEAR
WORM SHAFT
RETAINING PLATE
NEEDLE BEARINGS
MOTOR PART OF COUPLING
MOTOR

Untitled - 6


LIP OF SPRING
LATCH CAM
RELEASE
LATCH ROLLER
1/32" TO 1/16"
SPRING
LATCH
CAM
TRIGGER
(TRIP LATCH)

b. The adjusting bolt is used to correct the gap. Loosen the bolt locknut, adjust the gap with the adjusting bolt, and tighten the locknut.

v. Spring Latch Check Switch ("bb" Switch)

a. The spring latch check switch should operate before the spring latch cam rests on the adjusting screw but not before the gap between the spring latch cam and the adjusting screw is less than 1/4". Refer to figure XXX.

b. Adjustment is achieved by bending the switch arm near the middle of its length.

vi. Brake Rod Assembly

a. Hand charge the breaker closing spring, then continue turning the hand winding shaft until the roller on the brake lever drops off the cam segment on the worm gear, and the brake lining bears against the brake disc.

b. Referring to figure XXX, measure the distance from the stop pin to the end of the slot in the hollow pin. An acceptable distance is 1/32" minimum to 1/8" maximum.

c. Adjustment of the brake rod assembly gap is made by turning the adjusting screw at the left end of the brake assembly. Loosen the lock nut, adjust the screw until an acceptable distance is obtained, and tighten the locknut.

vi. Closing Latch Check Switch

a. The closing latch check switch should operate when the gap between the non trip-free lever pin and the bottom of the switch hook is 1/16". Refer to figure XXX.

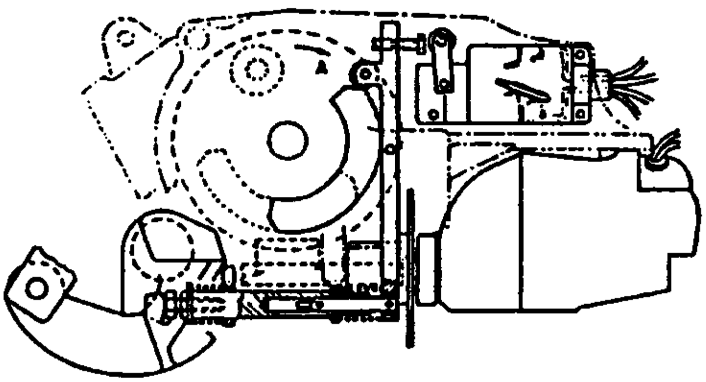
b. Adjustment of the switch is achieved by means of an adjusting screw. Loosen the locknut, adjust the screw until the proper dimension is obtained, and tighten the locknut.

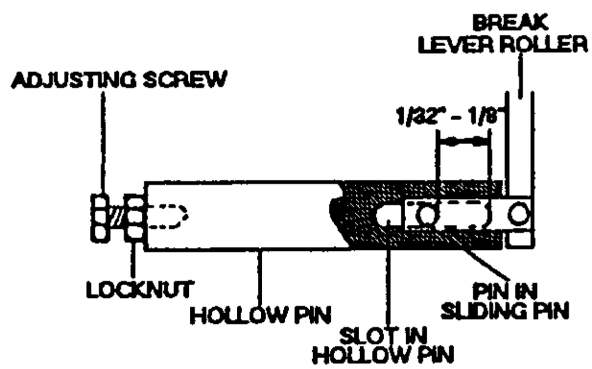
c. Figure XXX depicts the alternate mounting of the latch check switch with a suggested overtravel gap of 1/32".

vii. Tripping Cam

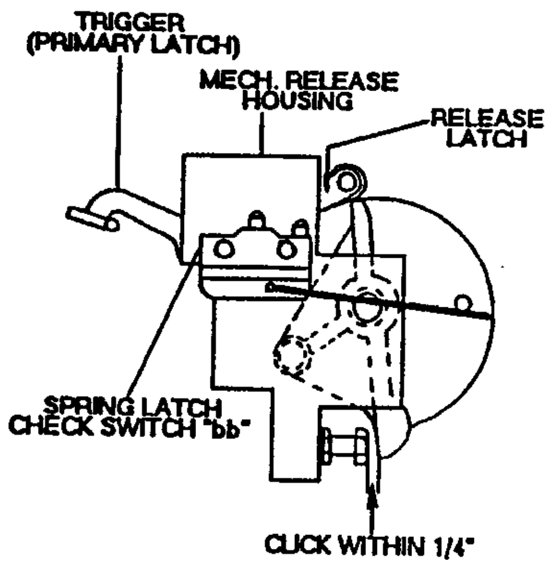
a. With the breaker open and reset, measure the gap between the tripping latch roller and the lip of the tripping latch cam as depicted in figure XXX. An acceptable gap is 1/32" minimum to 1/16" maximum.

brake.pcx




BREAK
LEVER ROLLER
ADJUSTING SCREW
1/32" - 1/8"
LOCKNUT
HOLLOW PIN
PIN IN
SLIDING PIN
SLOT IN
HOLLOW PIN

lcs.pcx


TRIGGER
(PRIMARY LATCH)
MECH. RELEASE
HOUSING
RELEASE
LATCH
SPRING LATCH
CHECK SWITCH "bb"
CLICK WITHIN 1/4"

1) Unbend the locktabs and loosen the locknut.

2) Adjust the stop bolt until an acceptable gap is obtained.

3) Tighten the locknut and bend the locktabs.

b. Spring Wind-Up Linkage

> *NOTE: This measurement should be checked after completing the cam lever, and mechanism release assembly adjustments. The mechanism release housing is doweled on the mechanism frame and should not require adjustment. Performing this check ensures that previous steps were performed correctly.*

1) With the closing spring fully charged and latched, measure the distance from the centerline of the pin connecting the clevis link and connecting link to the centerline of the crankshaft and cam lever pins. The offset should be 1/8" .

6.1.7 Post Overhaul Testing

1. Mechanical Tests

A. Visual Inspection

Visually inspect the breaker for mechanical integrity. Check for loose components and mounting hardware. Ensure all fasteners, retainers, spacers, and cotter pins have been properly restored.

B. Mechanical Function

Using the maintenance closing handle, slowly close the breaker. Verify that the operating mechanism functions smoothly without binding or excessive friction. Ensure the mechanism latches correctly with the contacts fully engaged and properly aligned. Verify the breaker position indicator indicates "Closed".

> *NOTE: The effort required to close the breaker with the maintenance closing handle should increase as the arcing contacts begin to engage.*

C. Levering-In Device Interlock

With the breaker in the closed position, attempt to operate the levering-in device. Verify that the device will not engage.

With the circuit breaker in the open position verify the function of the lever ing-in device interlock. Using the levering-in crank push in on the operating shaft and rotate the crank in the clockwise direction. Observe that the interlock indicator changes from "operate" to "interlock" as the shaft is rotated and that the crank disengages and spins free at the end of travel. At this point the indicator should once again indicate "operate". Repeat this process, turning the crank in the counterclockwise direction. Observe that the interlock indicator changes from "operate" to "interlock" during travel and that the crank disengages and spins free at the end of travel. Verify that the indicator shows "operate" at the end of travel.

D. Puffer Assembly

To ensure proper operation of the breaker puffer assembly, place a folded piece of paper (approximately 3" square) over each puffer tube nozzle and trip the breaker using the mechanical trip lever. The action of the puffer should blow the papers clear of the breaker.

E. Operating Mechanism

Using the maintenance closing handle, operate the breaker mechanism while holding the trip trigger in the trip position. Verify that the solenoid core moves freely in the solenoid. As the pressure is released from the mainte nance closing handle, ensure the operating mechanism linkage latches in the fully reset position.

For DH type circuit breakers using a spring stored energy operating mechanism, verify proper operation of the closing spring and spring charging link age by manually charging the spring with the spring charging handle.

> *NOTE: DH type breakers using a spring stored energy operating mechanism cannot be closed with the maintenance closing handle until the closing spring is fully charged.*

Using the hand winding crank, push in on the spring winding shaft to engage the coupling, then rotate the crank in the clockwise direction. Continue rotating the shaft while monitoring the hand trip trigger and the mechanism release trigger. As the spring approaches the fully compressed position, verify that the hand trip trigger falls into its latched position, followed by the mechanism release trigger falling into its latched position. With the spring in its fully charged state, inspect the linkage latch, the connecting link, and the clevis link for proper position. Refer to figure XXX for the position of these items with the spring in its fully charged position.

Verify proper operation of the closing spring by closing the circuit breaker with the mechanism release trigger. Ensure the mechanism latches correctly, with the contacts fully engaged and properly aligned. Trip the breaker with the manual trip trigger.

2. Electrical Tests

A. Secondary Contacts

Inspect the secondary contact plug wiring for tightness of connections and proper wiring arrangement. Verify proper operation of the secondary contact extension arm and interlock latch.

B. Contact Resistance

With the circuit breaker closed, perform a micro-ohm resistance test across each phase of the breaker contacts. Resistance measurements should be taken from the lower stud to the upper contact foot on each phase. Ohmic values should not exceed 60 micro-ohms and should be relatively uniform on all phases.

C. Insulation Resistance

With the circuit breaker closed perform insulation resistance testing (megger) from the breaker frame to the upper or lower stud. Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating; e.g. for a circuit breaker rated at 15kv the minimum acceptable resistance value would be 15 megohms.

Open the breaker and perform insulation resistance testing from line to load side (upper stud to lower stud) on each of the three phases. Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating.

With the circuit breaker closed, perform insulation resistance testing between phases on the breaker (A-B, A-C, B-C). Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating.

D. High Potential Testing

The following test is optional and should be performed at the discretion of the end user.

With the breaker closed perform high potential testing from the circuit breaker frame to the breaker contacts (upper or lower stud on any phase) and between phases on the breaker. Test voltages and acceptable leakage current values vary depending on the age of the equipment and the number of high potential tests previously performed.

E. Electrical Function

The following circuit breaker functional tests require electrical power. These tests may be performed by connection of a secondary contact test block or by placing the breaker in the cubicle test position and extending the secondary contact arm. The preferred method of testing is external to the cubicle using the secondary contact test block.

Apply control power to the secondary contact test block. For DH type breakers using a spring stored energy mechanism, the closing spring should charge as soon as control power is applied.

Electrically close and trip the circuit breaker several times. Verify operation of the breaker is quick and positive without hesitation in both closing and tripping.

Close the circuit breaker and energize the shunt trip magnet. Verify the breaker trips.

Test the circuit breaker undervoltage device (if installed) by connecting a variable voltage source to the secondary contact supply terminals. With the voltage source at rated voltage, close the breaker. Slowly reduce the voltage until the circuit breaker trips. Measure and record the voltage value. Verify the circuit breaker cannot be closed at the reduced control voltage value. Slowly increase the control voltage until the undervoltage device picks up. Measure and record the pick up value. Verify that the breaker will close.

F. Return To Service

Ensure the following conditions are satisfied before returning the circuit breaker to service:

i. Test equipment and auxiliary power connections are removed.
ii. Arc chutes have been installed.
iii. Arc chute shunt straps are connected.
iv. Front panel is repositioned and securely mounted.
v. Barrier assembly is installed and bolted in place.
vi. Breaker is in the open position.
vii. Charging mechanism is discharged.
viii. Levering-in device arms are in the install/withdraw position.

6.2 Type DHP Circuit Breaker Overhaul

This section contains guidance for the overhaul of Westinghouse type DHP medium voltage circuit breakers. Guidance is provided in a sequential format with emphasis on critical measurements, adjustments, and testing. Diagrams and/or digital photographs are used to enhance the presentation.

The sequential approach begins with recording relevant as-found data and progresses through breaker disassembly, inspection, cleaning, lubrication, adjustments, part replacements, and assembly. The overhaul guideline concludes with a section on testing and acceptable test criterion.

6.2.1 As-found Data

As-found data, if properly trended, is an invaluable tool for future refinement of a maintenance program. The following items should be recorded, trended, and reviewed on a periodic basis to ensure adequacy of the type and periodicity of performed maintenance. The data review process is recommended following each period of major maintenance.

1. Number of breaker operations.
2. Name plate data.
3. Breaker serial number and switchgear cubicle number.
4. General comments on breaker condition with respect to cleanliness.
5. General condition of lubricants; e.g., dried, hardened, etc..
6. Record all part replacements and specific reason for replacement.
7. Observe mechanical operation of the breaker. Record any deviations from normal such as sluggishness, binding, or hesitation.
8. Mechanical clearances of operating mechanism.
9. Contact wipe and overtravel.
10. Contact resistance.
11. Insulation resistance (megger).
12. Closing timing.

Record the above data at convenient points throughout the performance of the overhaul but before any activity which may alter the as-found state. In general, any deviation or abnormality encountered during performance of the overhaul should be recorded.

6.2.2 Disassembly

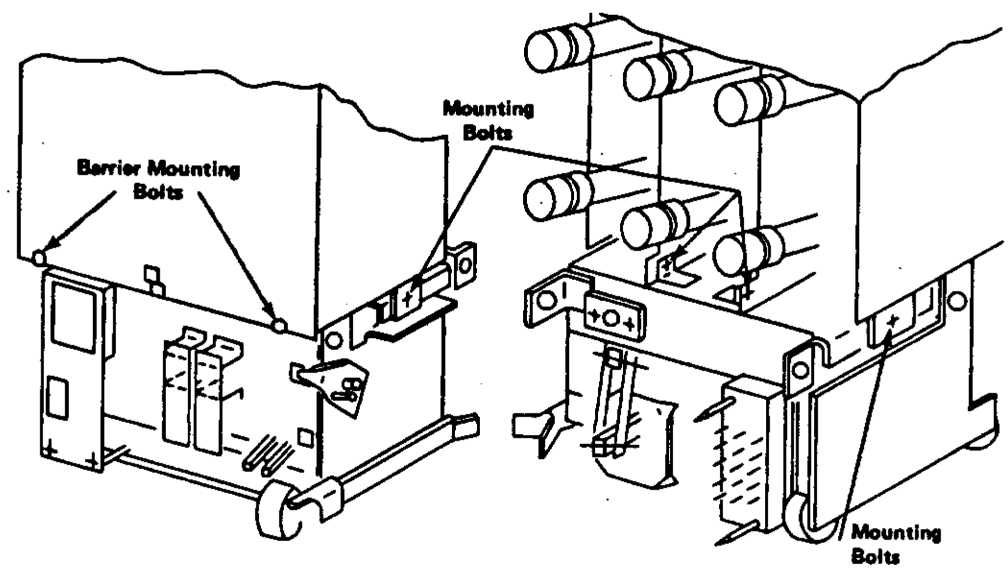
1. Barrier Assembly Removal

   A. Remove the mounting bolts from the front steel cover.

   B. Remove the bolting from the barrier sheets to the clips located behind the pole units.

   C. Remove the bolting from the sides of the barrier sheets to the breaker frame.

barrier - 1



D. Lift off the barrier assembly.

2. Arc Chute Removal

> *NOTE: Tilt only one arc chute at a time. More than one arc chute tilted could cause the breaker to tip over.*

> *NOTE: It is recommended that a table approximately the same height and width as the breaker frame be used for arc chute removal. Refer to diagram xx.*

A. Place the arc chute table directly behind the circuit breaker frame.

B. Disconnect the shunt straps from the front of each arc horn.

C. Lean each arc chute assembly, gently, over onto the table.

D. Remove the hinge pin retaining clips (two per arc chute).

E. Remove the arc chute hinge pin (one per arc chute).

F. Remove the arc chute assemblies from the breaker.

3. Pole Unit Assembly Removal

A. Disconnect the arc chute shunt straps from the lower contact stud.

B. Disconnect the moving contact lift rod by removing the 3/4' nut from the top of the lift rod and raising the contact arms until the lift rod drops out of the contact rod operating pin.

C. Remove the contact rod operating pin.

D. Remove the moving contact hinge pin and hinge springs.

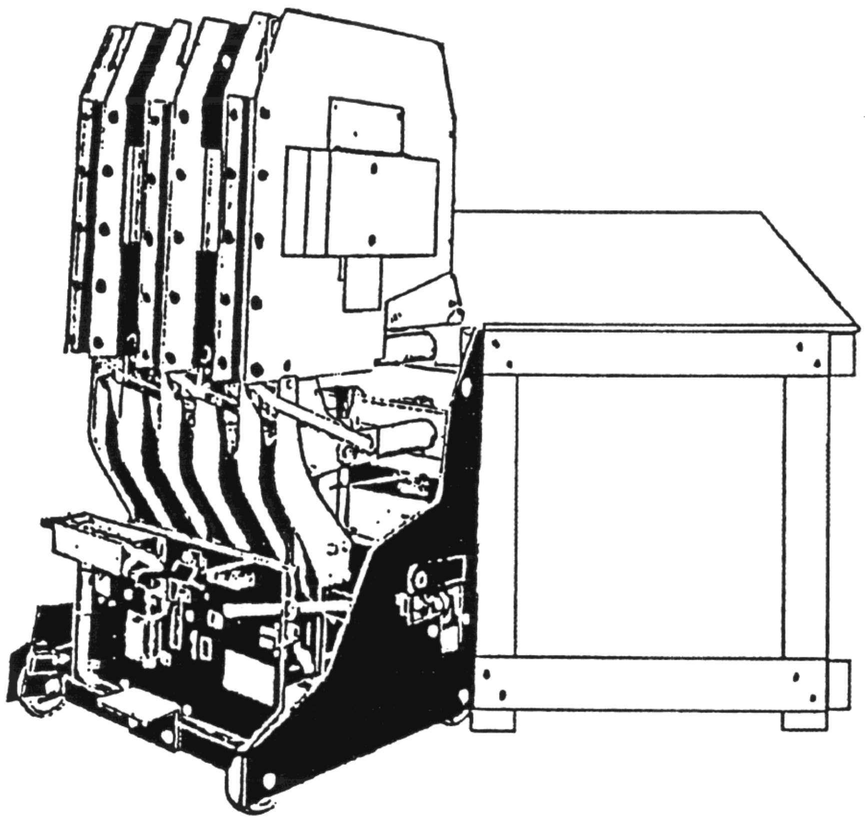
E. Remove the moving contact assembly (main contacts, arcing contacts, and contact arms).

F. Remove the pole unit mounting bolts and lift out the pole unit assembly.

4. Moving Arcing Contact

A. Remove the arcing contact mounting bolts. Note location of washers, spacers, etc..

arcbnch - 2



B. Remove moving arcing contact.

5. Stationary Arcing Contact

   A. Remove the stationary arcing contact mounting bolts, nuts, and spring spacers from the upper contact stud.

   B. Remove the stationary arcing contact.

6. Stationary Main Contacts

   A. Remove the main contact mounting bolts from the upper contact stud.

   B. Remove the main contact fingers.

   C. Unbolt and remove the main contact kickout spring.

7. Puffer Assembly

   A. On the breaker underside, disconnect the puffer operating rods by removing the cotter pins and hinge pins on the left and right puffer operating arms.

   B. Remove the puffer assembly mounting bolts and lift out the puffer casting.

8. Levering-In Device

   A. Remove the shunt connector mounting bolts from the lower stud assemblies.

   B. Unbolt the shunt connectors from the arc chute supports and remove the shunt connectors.

   C. Remove the barrier pan mounting hardware and lift off the barrier pan and arc chute support assembly.

   D. At the rear of the breaker, remove the bolting for the levering-in nut housing.

   E. Remove the levering-in nut and guide tube assembly.

9. Secondary Disconnect Device

   A. Note or scribe the position of each disconnect finger on the support frame.

   B. Label and disconnect the secondary wiring from the contact block.

   C. Remove the secondary contact block from the slide bar.

10. Ground Contact

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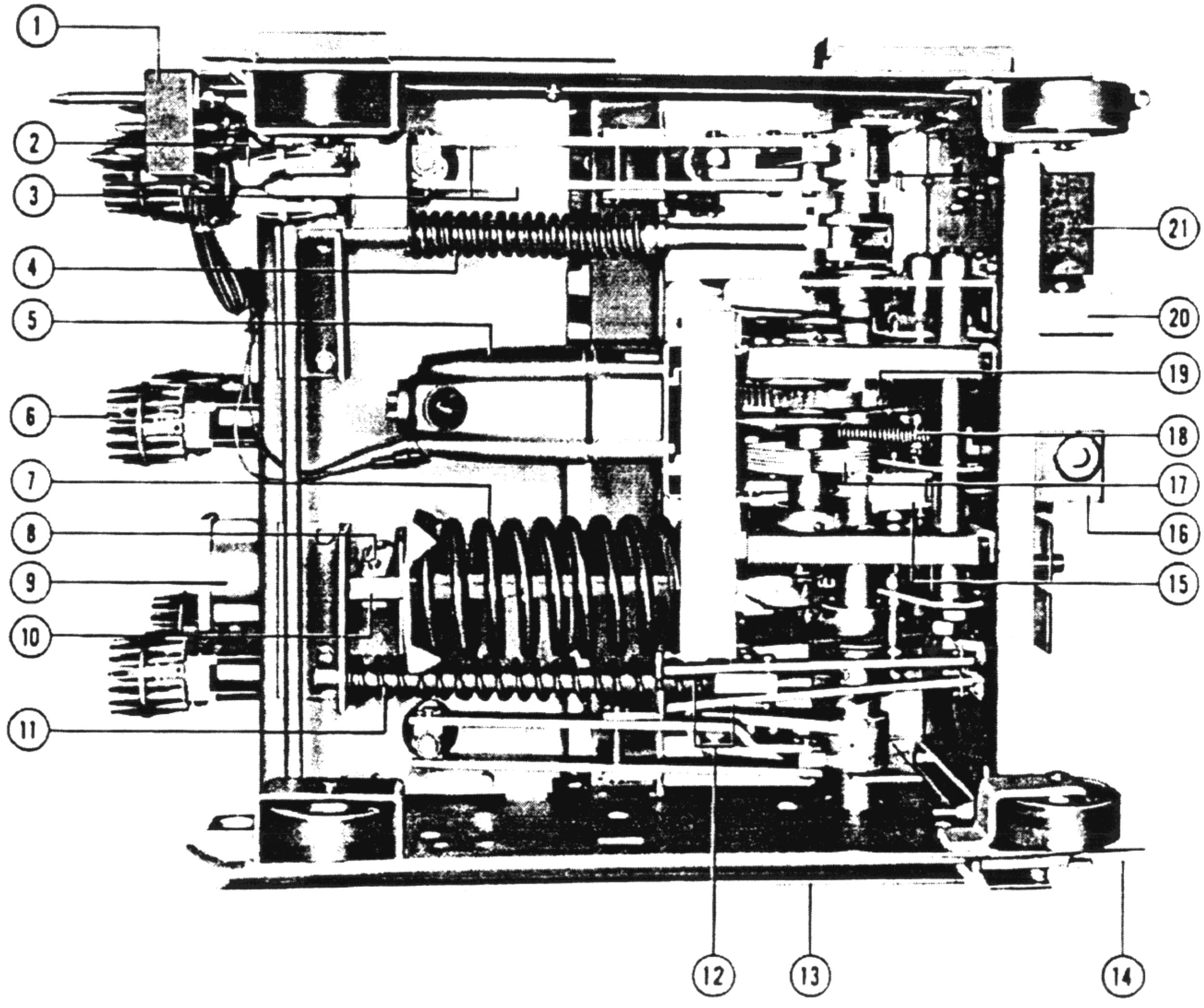

Unbolt and remove the ground contact.

11. Spring Charging Motor

> ***CAUTION: Ensure all springs are discharged prior to removal of the spring charging motor.***

A. Label and determinate the motor leads.

B. Remove the four nuts holding the motor assembly to the mechanism.

C. Remove the motor assembly.

D. Remove the motor crank by striking a sharp blow with a rubber mallet. Note that the threads are right hand.

E. Remove the motor from the mounting braket.

12. Closing Spring

> *NOTE: A closing spring removal tool will be required. This tool is available from the OEM as part number 592C864 G01. The closing spring removal tool consists of a tube, thrust washer, thrust bearing, collar, nut, and stud. Refer to figure XXX.*

A. Assemble nut, thrust bearing, thrust washer, collar, and tube on the stud as shown in figure XX.

B. Screw the stud into the end of the closing spring connecting rod as far as possible.

C. Holding the stud rigid, remove the idler links pin, and idler links.

D. Position the tube so that the slots in the tube straddle the closing spring retainer pin.

E. Tighten the spring removal tool nut so that the spring retainer backplate is movedaway from the retainer pin.

F. Drive the retainer pin out of the connecting rod.

G. Hold the end of the spring removal tool stud firm with a wrench and unscrew the nut until all tension is removed from the closing spring.

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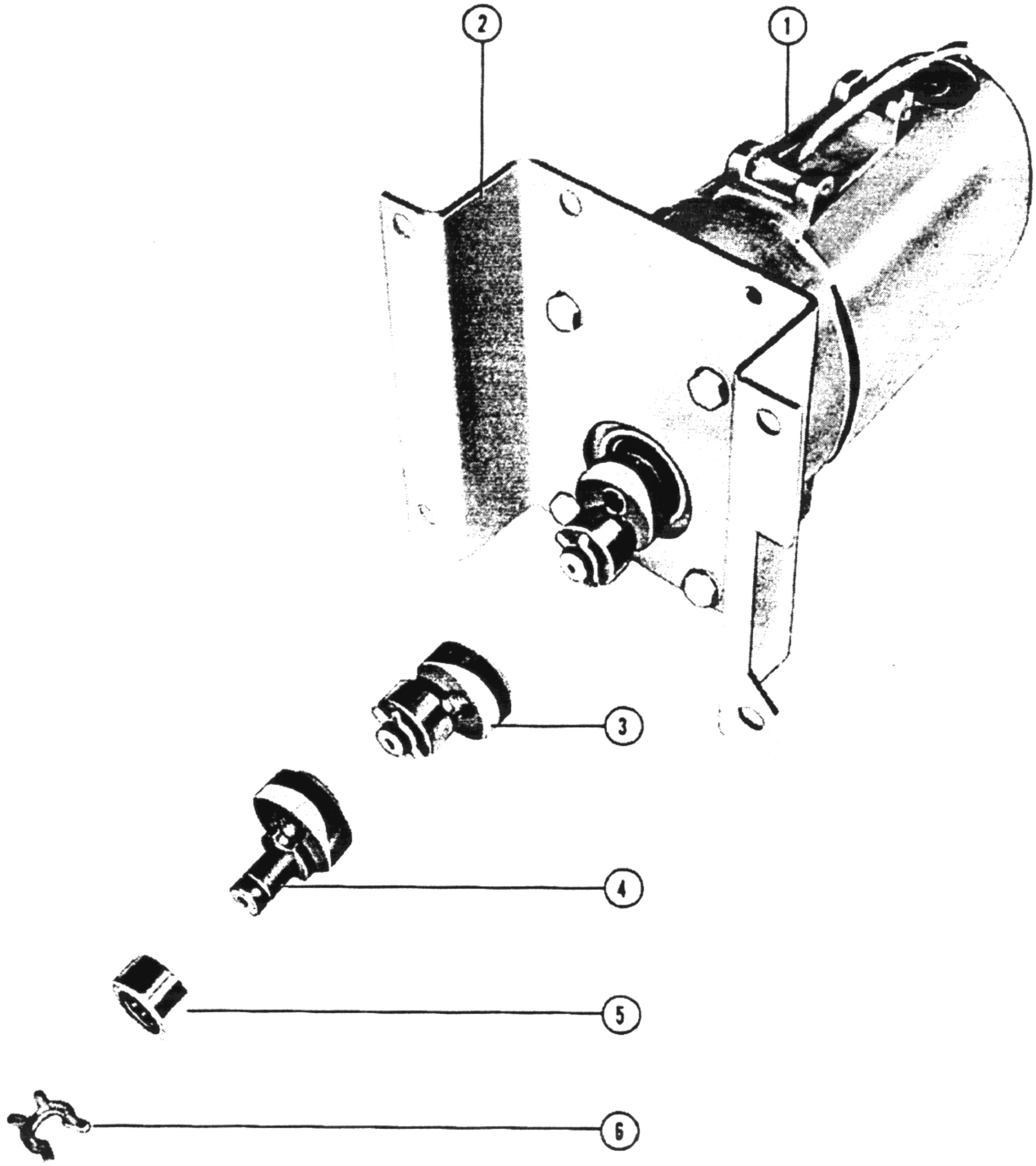

1. Motor
2. Motor Mounting Bracket
3. Crank Assembly Complete
4. Crank
5. Rollex
6. X-Washer

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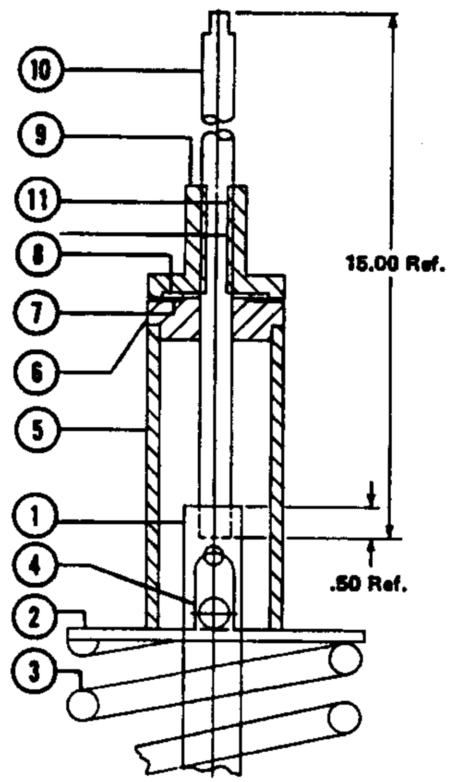

1. Connecting Rods
2. Spring Retainer
5. Tube
6. Collar
9. Special Nut
10. Stud

H. Remove the tool and the spring.

13. Auxiliary Components

A. Auxiliary Switch

i. Remove auxiliary switch cover.

ii. Remove the switch linkage (bolt, lockwasher, and nut) from the left hand side of the auxiliary switch.

iii. Scribe the left side cover bracket and the auxiliary switch shaft to ensure proper alignment on reassembly.

iv. Label and determinate the terminal board wiring.

v. Remove the right side cover bracket mounting bolts and the right side cover bracket.

vi. Remove the right inner support bracket mounting screws (accessible from rear of frame) and right inner support bracket.

vii. Remove the auxiliary switch.

B. Shunt Trip Solenoid (optional)

i. Remove the plastic cover.

ii. Label and determinate the shunt trip solenoid wiring.

iii. Remove the shunt trip solenoid mounting screws.

iv. Note the orientation of the solenoid in its bracket.

v. Remove the shunt trip solenoid.

C. Motor Cut-Off Switch

i. Remove the cut-off switch cover.

ii. Label and determinate the cut-off switch wiring.

iii. Remove the cut-off switch mounting screws.

iv. Remove the cut-off switch.

D. Latch Check Switch

i. Label and determinate the latch check switch wiring.

ii. Remove the mounting screws.

iii. Remove the latch check switch.

E. Undervoltage Trip Attachment (UVTA)

i. Label and determinate UVTA coil wires.

ii. Disconnect UVTA linkage from the breaker tripping trigger.

iii. Remove the UVTA mounting bolts.

iv. Remove the UVTA.

F. Tripping Magnet

i. Remove the plastic cover.

ii. Label and determinate the tripping solenoid wiring.

iii. Unbolt and remove the tripping magnet and plunger assembly.

G. Mechanism Release Magnet

i. Remove the plastic cover.

ii. Label and determinate the release magnet wiring.

iii. Unbolt and remove the release magnet and plunger assembly.

H. Control Relay

i. Remove the control relay cover.

ii. Label and determinate the control relay wiring.

iii. Unbolt and remove the control relay.

6.2.3 Inspection

1. Arc Chutes

A. Inspect the arc chute assemblies for broken or cracked components, dirt, and carbon deposits. Inspect the splitter plates and barriers for erosion.

B. If the arc chute appears excessively dirty or worn, it should be disassembled to allow a more thorough inspection.

> *NOTE: Small chips or cracks in the arc chute ceramics may be disregarded. Large cracks extending from the inverted V slot of the interrupter plate to the edge of the top plate may interfere with arc chute performance.*

i. Inspect the ceramic insulating jackets and splitter plates for cracks.

ii. Verify splitter plates are not excessively eroded.

iii. Inspect arc horns for erosion or cracking.

iv. Ensure blowout coil insulation is not cracked and shows no signs of over heating.

v. Check tightness of ceramic mounting hardware and blowout coil connectors.

2. Primary Disconnects

   Inspect the primary disconnects for signs of overheating, wear, and broken or weakened springs.

3. Secondary Disconnects

   A. Verify that all spring loaded disconnect fingers operate freely without binding.

   B. Inspect plastic insulation for cracking or damage, particularly at the mounting holes.

   C. Inspect the secondary disconnect support brackets for weld cracks.

4. Breaker Frame

   A. Inspect the frame for corrosion, and fatigue cracking in the frame welds.

   B. Inspect for bending or deformation of support arms.

5. Contact Assemblies

> *NOTE: Contact wear is excessive when one half of the original contact thickness is worn away. Arcing contacts should be replaced if thickness is 1/16" or less. Main contacts should be replaced when thickness has decreased to 1/32".*

A. Inspect the condition of the main and arcing contact surfaces for pitting, scoring , or excessive wear. Minor pitting or contact wear is acceptable and may be dressed using a fine file, sandpaper, or Scotch-Brite. Replating the contact surfaces may be considered if more than half of the original contact thickness remains and the plating is flaking or peeling.

> *NOTE: If contact replacement or replating is deemed necessary it should be performed on all phases to facilitate contact alignment, i.e. if one moving arcing contact requires replacement, the moving arcing contacts on all three phases should be replaced.*

B. Inspect the contact springs for corrosion, cracking, or excessive wear.

6. Puffer Assembly

   A. Inspect the puffer assembly for damage or wear. Particular attention should be given to the following components:

      i. Inspect the puffer diaphragm for punctures or excessive wear.

      ii. Inspect the puffer tubes and nozzles for cracks.

      iii. Ensure the spring stop pins, and puffer rod pins are not bent.

7. Levering-In Device

   A. Inspect the threads on the levering-in device nut for damage.

   B. Verify the shaft of the device is free of bends.

   C. Inspect the levering-in device nut housing washer for wear.

8. Operating Mechanism

   A. Complete disassembly of the operating mechanism, carefully recording component arrangement and mechanical relationships between the components.

   B. Note the size and location of all removed spacers, retainers, and bearings. Scribe or matchmarks are recommended to ensure correct reassembly.

   C. Crankshaft Subassembly

      i. Inspect the crankshaft subassembly bearings for wear and signs of over heating:

         a. Connecting rod bearing and inner race.

b. Ratchet lever bearings and bearing inserts.
c. Crankshaft bearing insert and inner race.
d. Thrust bearing and thrust bearing inside and outside race.

ii. Inspect the crankshaft subassembly pins for cracking, deformation, or excessive wear:

a. Closing stop roller pin.
b. Driving pawl stop pin.
c. Driving pawl pivot pin.
d. Holding pawl stop pin.
e. Holding pawl pivot pin.

iii. Inspect the crankshaft subassembly springs for cracking and fatigue:

a. Driving pawl spring.
b. Holding pawl spring.

iv. Inspect the major components of the crankshaft subassembly for damage or excessive wear:

a. Main crank.
b. Closing spring connecting rod.
c. Closing stop roller.
d. Closing cam.
e. Motor ratchet lever and driver plate.
f. Driving and holding pawls.
g. Ratchet wheel.
h. Limit switch cam.
i. Crankshaft.

D. Close and Trip Linkage Subassembly

i. Inspect the linkage subassembly pins for cracking, deformation, or excessive wear:

a. Closing cam follower roller pin.
b. Connecting link pin.
c. Tripping cam roller pin.
d. Tripping latch roller pin.
e. Closing latch roller pin.

ii. Inspect the major components of the linkage subassembly for damage or excessive wear:

a. Main closing link.
b. Closing cam follower roller.
c. Tripping cam connecting links
d. Tripping cam.

e. Tripping cam roller.
f. Tripping latch.
g. Tripping latch roller.
h. Tripping trigger.
i. Closing latch.
j. Closing latch roller.
k. Closing trigger.

E. Stored Energy Mechanism Main Assembly

i. Inspect the mechanism main assembly bearings for wear and signs of over heating:

a. Pole shaft bearing, casting, and inner race.
b. Crankshaft bearing, casting, and inner race.
c. Thrust bearing and thrust bearing races.
d. Trip latch bearings.
e. Closing latch bearings.

ii. Inspect the mechanism main assembly pins for cracking, deformation, or excessive wear:

a. Pole unit operating lever retainer pins.
b. Main link connecting pin.
c. Tripping latch pivot pin.
d. Trigger pivot pin.
e. Latch and trigger spring stop pin.
f. Closing latch pivot pin.

iii. Inspect the mechanism main assembly springs for cracking and fatigue:

a. Motor rachet lever retrieving spring.
b. Manual rachet lever retrieving spring.
c. Floor interllock retrieving springs.
d. Left and right opening springs.
e. Tripping latch spring.
f. Tripping trigger spring.
g. Closing trigger spring.
h. Closing latch spring.
i. Main link retrieving spring.

iv. Inspect the major components of the mechanism main assembly for damage or excessive wear:

a. Main link stop.
b. Floor interlock operating lever, connecting link, and mounting plate.
c. Pole unit operating shaft, levers, and spacers.
d. Levering-in device interlock bracket.
e. Upper and lower frame tie bolts.

f. Closed breaker interlock adjusting screw.

9. Auxiliary Components

A. Auxiliary Switch

i. Inspect for correct operation, insulation conditions, and cracks in the housing and cover.

ii. Inspect contacts for corrosion, and alignment.

B. Shunt Trip Solenoid (optional)

i. Inspect the coil for signs of overheating.

ii. Manually operate the plunger and verify freedom of movement.

C. Motor Cut-Off Switch

Inspect for correct operation, insulation condition, and housing cracks.

D. Latch Check Switch

Inspect for correct operation, insulation condition, and housing cracks.

E. Undervoltage Trip Attachment

i. Inspect coil for signs of overheating and insulation condition.

ii. Inspect for loose fasteners, and excessive linkage wear.

F. Tripping Magnet

i. Inspect the coil for signs of overheating.

ii. Manually operate the plunger and verify freedom of movement

G. Mechanism Release Magnet

i. Inspect the coil for signs of overheating.

ii. Manually operate the plunger and verify freedom

H. Control Relay

i. Inspect the coil for signs of overheating and insulation condition.

ii. Inspect contacts for correct operation, corrosion, and alignment.

6.2.4 Cleaning and Lubrication

1. Arc Chutes

   A. The arc chute components should be cleaned with dry compressed air or by wiping with a clean, dry, lint-free cloth. For dirt or carbon deposits that cannot be removed from the ceramic surfaces by the first two methods, a fine, non-metallic sandpaper should be used.

   B. After sanding, the area should be thoroughly cleaned.

   Alternative methods of cleaning arc chute ceramic components are sandblasting with a fine grain sand or grinding with an aluminum oxide disc.

   C. Arc chute components which fail the dielectric withstand test should be oven dried to remove absorbed moisture.

   Components which are oven dried should be left in the oven after the heat is turned off until they have returned to ambient temperature. This will ensure little or no moisture absorption once they are removed.

   Arc transfer surfaces such as the front and rear arc horns and the blowout coil transfer arc horns should be cleaned with clean cloths wetted with isopropyl alcohol.

2. Primary Disconnects

   A. Clean the disconnect fingers with a clean cloth and a mild solvent, such as isopropyl alcohol.

   B. Following reattachment to the upper and lower contact studs, the finger area which mates with the male switchgear connector should be coated with a thin layer of conductive graphite lubricant.

3. Secondary Disconnects

   A. Clean each disconnect finger with a clean cloth and a mild solvent, such as isopropyl alcohol.

   B. Coat each finger with a thin covering of conductive graphite lubricant.

4. Contacts

   A. All main and arcing contact surfaces should be cleaned with an approved silver cleaner or polish. Burrs or minor pitting should be removed with a fine sandpaper. Replating the contact surfaces should be considered if the silver plating is flaking or peeling.

> *NOTE: Contacts should be replaced if more than one half of the original contact thickness is missing.*

B. Apply a light film of graphite based grease to the silver plated discs at the hinge point of the moving contact arms and between the contact fingers and the stud.

5. Levering-In Device

A. Clean all mechanism parts with an approved degreasing solvent.

B. Remove solvent from the components using alcohol or a soapy water wash.

C. Thoroughly dry the components using compressed air.

D. Lubricate the threaded portions of the levering-in device with an approved molybdenum based grease. Ensure an ample amount of grease is present in the nut housing and on the nut housing washer.

6. Puffer Assembly

A. In general the puffer assembly should not require any specific cleaning instructions. The diaphragm mounting surfaces should be smooth and free of corrosion prior to diaphragm replacement.

B. The puffer assembly does not require lubrication.

7. Breaker Frame

A. Clean any rust or contaminants from the breaker frame.

B. Paint any areas of the frame requiring touch-up with an approved carbon steel coating.

C. Clean and lubricate the breaker frame wheel bearings with an approved general purpose grease.

8. Operating Mechanism

A. Thoroughly clean all mechanism parts with an approved solvent.

B. Remove all traces of solvent with an alcohol or mild soapy water wash.

C. Dry the mechanism components using compressed air.

D. The following operating mechanism components should be lubricated with a molybdenum disulphide based grease:

i. Tripping trigger pivot pin
ii. Tripping latch roller
iii. Tripping latch pivot pin
iv. Tripping cam roller
v. Tripping cam pivot pin
vi. Tripping cam connecting link pins
vii. Closing cam follower roller pin
viii. Closing stop roller
ix. Closing trigger pivot pin
x. Closing latch roller
xi. Closing latch pivot pin

E. Operating mechanism roller bearings should be lubricated with a high grade, slow oxidizing grease. The following bearings should be lubricated:

i. Crankshaft bearing
ii. Pole shaft bearing
iii. Trip latch bearings
iv. Close latch bearings
v. Connecting rod bearing
vi. Ratchet lever bearings
vii. Closing cam follower roller
viii. Spring charging motor crank rollex

9. Auxiliary Components

A. Auxiliary Switch

i. Clean the switch internals with alcohol or an approved electrical grade solvent.

ii. Burnish the auxiliary switch contacts.

iii. Apply a light coat of conductive graphite grease to the contact surfaces.

B. Under Voltage Trip Attachment (optional)

i. Clean the UVTA linkage assembly with alcohol or an approved electrical grade solvent.

ii. Lubricate the UVTA roller with a molybdenum disuphide based grease.

C. Control Relay

i. Lightly burnish the control relay contacts.

ii. Apply a thin coat of graphite based lubricant to the relay contacts.

D. Spring Charging Motor

i. Clean the motor and gear internals with an approved electrical grade solvent.

ii. Clean and lubricate the motor bearings with an approved lubricant.

iii. Clean motor gears and lubricate with an approved gear grease.

6.2.5 Assembly

Refer to disassembly notes during reassembly to ensure proper location, orientation, and size of shims, spacers, retainers, lockwashers, and other hardware.

1. Operating Mechanism

2. Closing Spring

   A. Install closing spring and closing spring retainer plate.

   B. Install the closing spring removal tool by screwing the stud into the end of the closing spring connecting rod as far as possible. Ensure the tube is positioned so that the slots in the tube will straddle the closing spring retainer pin holes when the spring is compressed.

   C. Holding the end of the spring removal tool stud firm with a wrench, tighten the nut until the spring is compressed past the retainer pin holes.

   D. Insert the retainer pin into the connecting rod.

   E. Install the idler links and idler links pin on the connecting rod.

   F. Unscrew the spring removal tool nut until the spring tension is held by the closing spring retainer plate.

   G. Remove the spring removal tool.

3. Spring Charging Motor

   A. Install the motor in the motor mounting bracket.

   B. Install the motor crank assembly by threading it onto the shaft.

   C. Position the motor such that the motor crank roller is under the operating mechanism driving plate.

   D. Bolt the motor in place with the four nuts which attach the motor to the mechanism.

E. Reterminate the motor leads.

4. Levering-In Device

   A. Position the levering-in device nut and guide tube assembly. Ensure the levering-in device interlock mates properly with the bracket on the pole unit operating shaft.

   B. Bolt the levering-in device nut housing in place at the rear of the breaker.

   C. Position the barrier pan / arc chute support assembly and bolt in place.

5. Puffer Assembly

   A. Install the puffer assembly casting and bolt in place.

   B. On the breaker underside, connect the left and right puffer operating arms using the hinge pins and cotter pins.

6. Pole Units

   A. Position the pole unit assemblies. Ensure that the puffer casting and puffer nozzles are properly aligned.

   B. Install the pole unit mounting hardware. Bolt the pole unit to the puffer casting and to the glass polyester brace.

   C. Bolt the arc chute shunt straps in place at the lower contact stud and the arc chute support assembly.

   D. Moving Contact Assembly

      i. Assemble the moving contact assembly by bolting the moving arcing contact between the moving contact blades.

      ii. Mount the moving contact assembly on the lower contact stud using the hinge pins and cotter pins.

      iii. Install the contact lift rod operating pin

      iv. Connect the moving contact lift rod by raising the moving arms until the lift rod can be inserted into the lift rod operating pin.

      v. Secure the contact lift rod with the 3/4" nut.

   E. Stationary Main Contacts

      i. Install the main contact kickout spring and bolt in place.

ii. Position the stationary main contacts on the upper contact stud and bolt in place.

F. Stationary Arcing Contacts

i. Install the stationary arcing contacts and bolt in place using the bolts, nuts, and leaf spacers.

G. Secondary Disconnect Device

i. Attach the secondary contact block to the slide bar.

ii. Terminate the secondary contact wiring.

H. Ground Contact

Bolt the ground contact to the breaker chassis.

7. Auxiliary Components

A. Auxiliary Switch

i. Align the scribe marks on the switch shaft and the left side cover bracket and install the switch.

ii. Reinstall the right inner support bracket and mounting screws.

iii. Reinstall the right side cover bracket and mounting bolts.

iv. Install the terminal board and mounting screws.

v. Terminate the switch wiring at the terminal board.

vi. Attach the switch linkage to the left side of the switch with the bolt, lockwasher, and nut.

vii. Install the cover.

B. Shunt Trip Solenoid

i. Install and bolt the shunt trip solenoid to the solenoid support bracket. Ensure the plunger arm washer rests under the tripping trigger.

ii. Terminate the solenoid wiring.

iii. Replace the switch cover.

C. Motor Cut-Off Switch (Limit Switch)

i. With the cut-off switch cover removed, install the switch with the two mounting screws.

ii. Terminate the cut-off switch wiring.

iii. Replace the cover.

D. Latch Check Switch

i. Mount the latch check switch with the mounting screws.

ii. Terminate the latch check switch wiring.

E. Undervoltage Trip Attachment (UVTA)

i. Position the UVTA linkage and mount the UVTA on the front panel.

ii. Connect the UVTA linkage to the breaker tripping trigger.

iii. Terminate the UVTA coil wires.

F. Tripping Magnet

i. Mount the tripping magnet on the front panel.

ii. Connect the plunger arm to the mechanism trip lever.

iii. Terminate the coil wiring.

iv. Install the plastic cover.

G. Mechanism Release Magnet

i. Mount the release magnet on the front panel.

ii. Connect the plunger arm to the mechanism spring release lever.

iii. Terminate the coil wiring.

iv. Install the plastic cover.

H. Control Relay

i. Mount the control relay on the front panel.

ii. Terminate the control relay coil and contact wiring.

iii. Install the control relay cover.

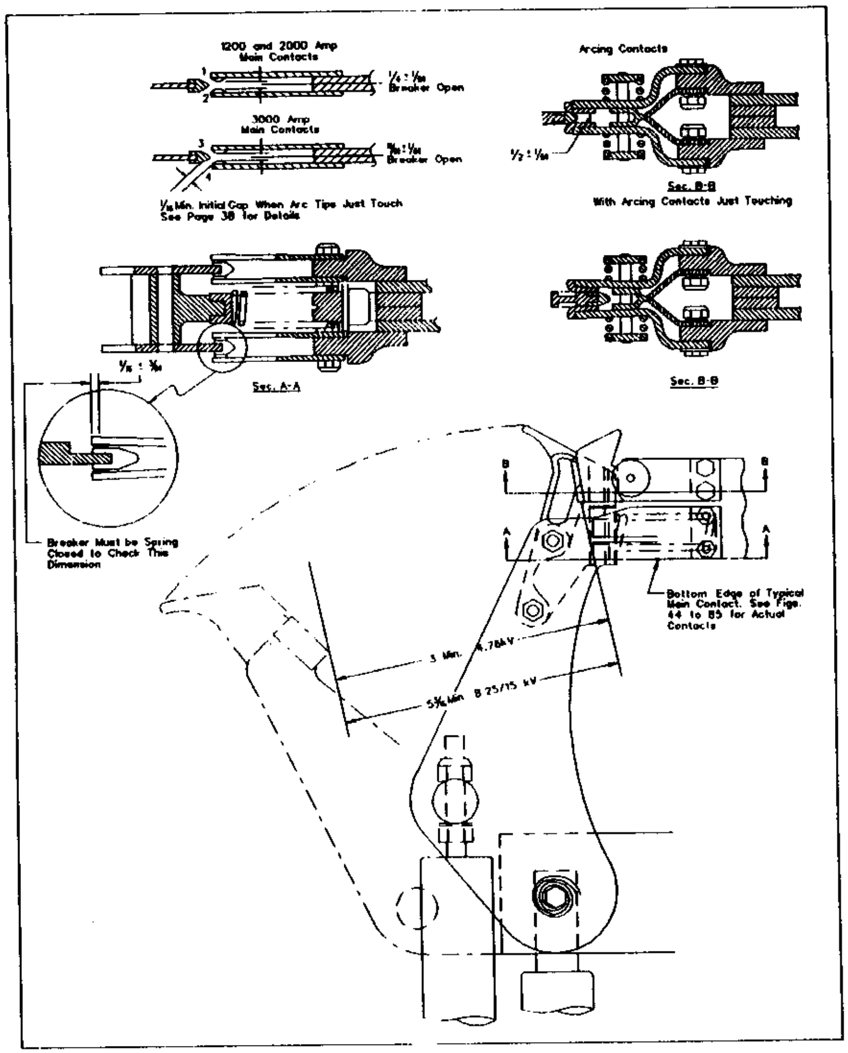

Fig. 32 Contact Adjustments

1/16 inch +/- 3/64 inch for main contact penetration.

iv. Contact penetration adjustment is performed by adjusting the moving contact operating rod. Increasing the length of the operating rod increases contact penetration, while decreasing the length of the rod decreases contact penetration.

v. To adjust the operating rod length, loosen the adjusting nut on the top of the rod, and then advance the lower operating rod nut until proper contact penetration is achieved. At this point, tighten the upper adjusting nut while holding the lower nut.

vi. Close and trip the breaker several times and then recheck the penetration measurements.

D. Stationary to Moving Clearances

i. With the breaker in the open position measure the stationary to moving contact clearances as shown on figure XXX. Verify the gap is within tolerance.

1) 3 inch minimum for 5kv breakers.

2) 5-3/16 inch minimum for 7.2 and 15 kv breakers.

2. Operating Mechanism

Strict attention to detail must be exercised during the disassembly and assembly sections for the operating mechanism. All spacers, washers, retainers, and fasteners must be positioned correctly on reassembly to ensure correct operation. As properly assembled, the basic operating mechanism itself does not require adjusting. Operating mechanism sub-components which require adjustment are described in the following section.

A. Tripping Latch

Correct adjustment of the tripping latch provides just enough clearance for the tripping trigger to move under the tripping roller without touching it with the breaker in the open, spring charged position. Adjust the tripping latch clearance as follows, referring to figure XXX.

Acceptable clearance between the tripping trigger and tripping roller is .020 to .030 inch.

i. Remove the trip plunger plastic cover.

ii. Charge the closing spring.

iii. Loosen the tripping cam adjusting screw lock nut.

iv. Turn the tripping cam adjusting screw clockwise until the trip latch roller touches the latch surface of the tripping trigger.

v. Raise the tripping trigger approximately one inch and release it. The trigger should remain in the raised position.

vi. Back the trip cam adjusting screw out very slowly until the trip latch roller and tripping cam reset.

vii. Back the trip cam adjusting screw out an additional one quarter turn.

viii. Tighten the trip cam adjusting screw lock nut.

B. Holding Pawl

The holding pawl adjustment is used to position the ratchet lever and holding pawl assembly relative to the ratchet wheel. This adjustment is performed by loosening the set screws on the holding pawl adjusting collar and moving the collar left or right so that the ratchet lever rides on one of the three adjusting surfaces. Verify that the closing spring is charging properly following adjustment.

C. Anti-Close Interlock

With the breaker in the closed, spring charged position there should be a clearance of 0.010 to 0.030 inches between the closing trigger and the closing latch roller. Refer to figure XXX. Adjusment of the anti-close interlock screw is as follows:

i. The barrier, arc chutes, and barrier support pan must be removed to make this adjustment.

ii. Ensure the breaker is closed with the closing spring charged.

iii. Adjust the anti-close interlock screw located on the breaker pole unit operating shaft until the required clearance is obtained.

iv. It is recommended that a thread lock adhesive be used on the screw threads to ensure the screw position will not change during breaker operation.

D. Latch Check Switch

The latch check switch should make contact when the tripping trigger is in the fully reset position ready for the breaker to close. Correct adjustment of the switch is for its contact to change state when the tripping trigger is 1/8 to 3/16 inches from the completely reset position as measured from the center

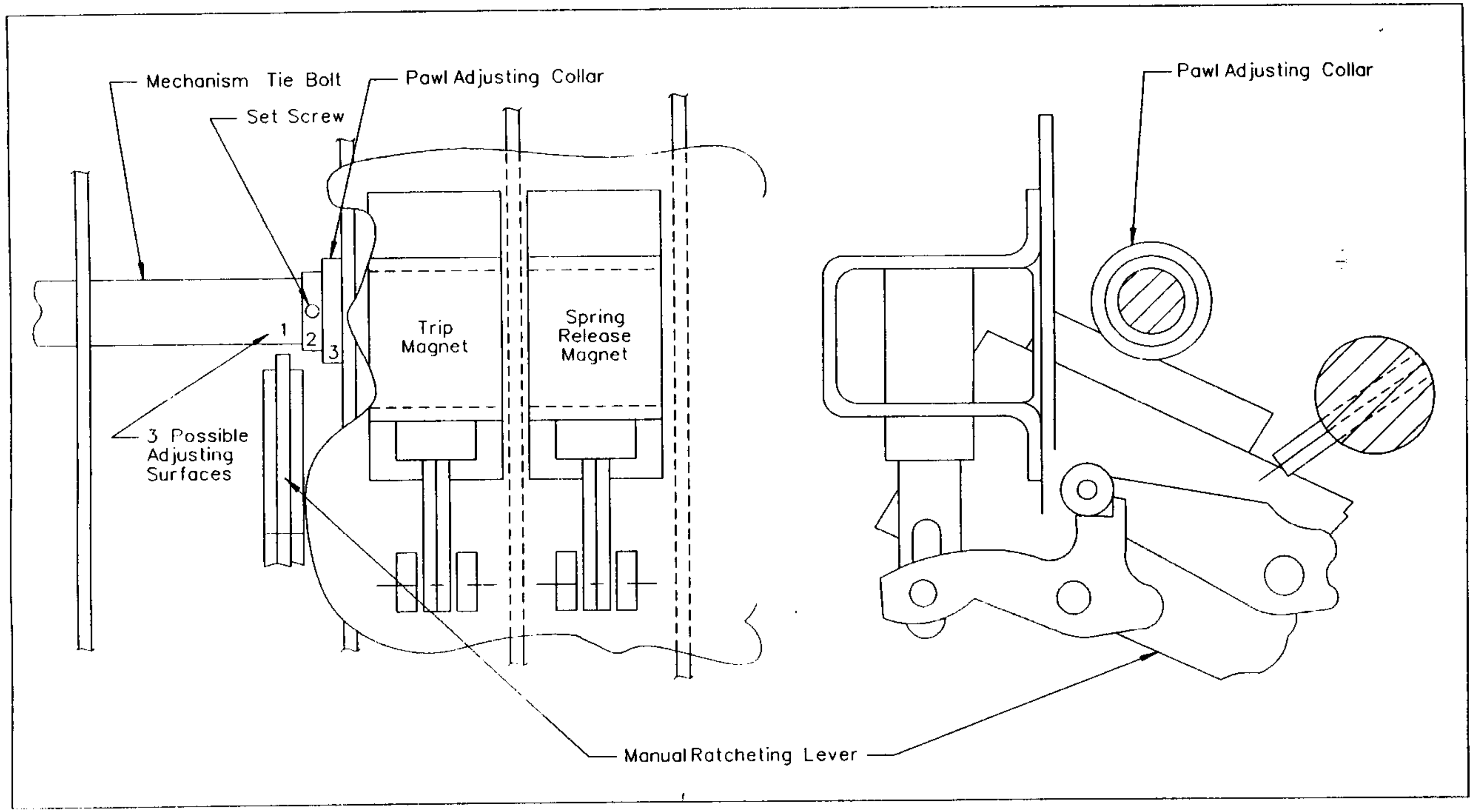

Fig. 35 Holding Pawl Adjustment

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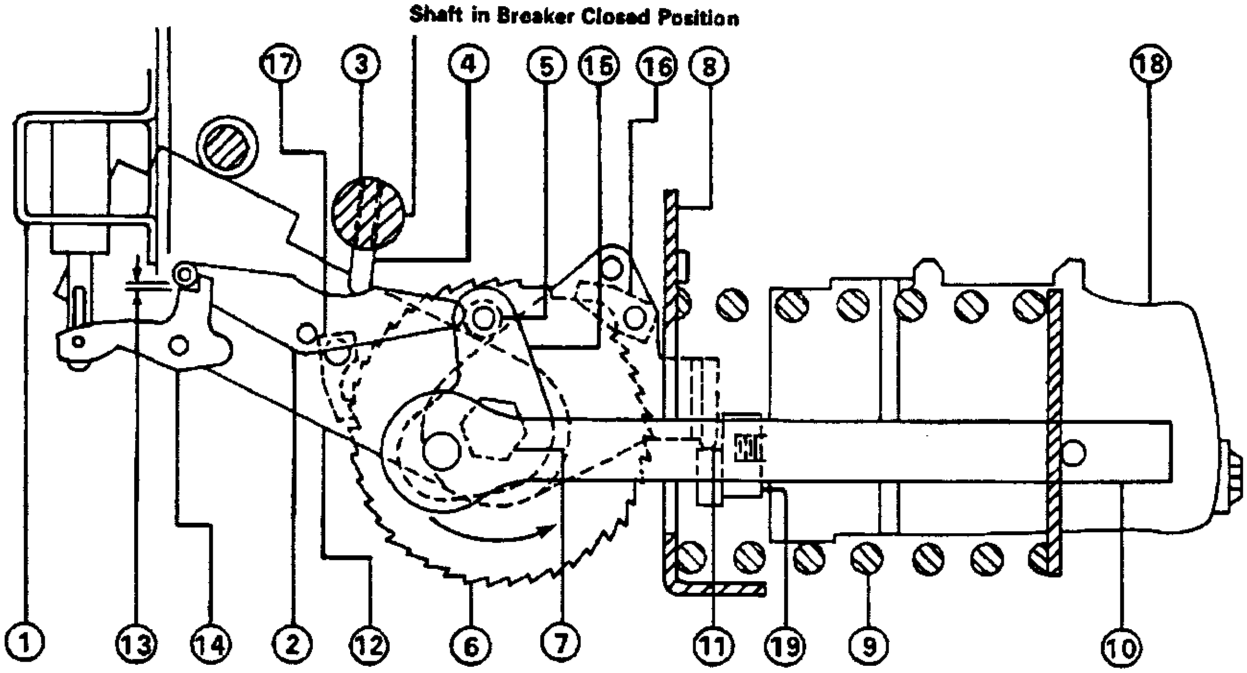
Shaft in Breaker Closed Position



Stored Energy Mechanism: Spring Charged

1. Spring Release Magnet and Coil
2. Closing Latch
3. Pole Unit Operating Shaft
4. Anti-Close Interlock Screw
5. Closing Stop Roller
6. Ratchet Wheel
7. Crank Shaft
8. Mechanism Frame
9. Closing Spring
10. Connecting Rod
11. Driving Plate and Motor Ratchet Lever Assembly
12. Manual Ratchet Lever and Holding Pawl Assembly
13. Clearance .010 to .030, Breaker Closed
14. Closing Trigger
15. Main Crank
16. Driving Pawl
17. Holding Pawl
18. Motor
19. Crank Assembly

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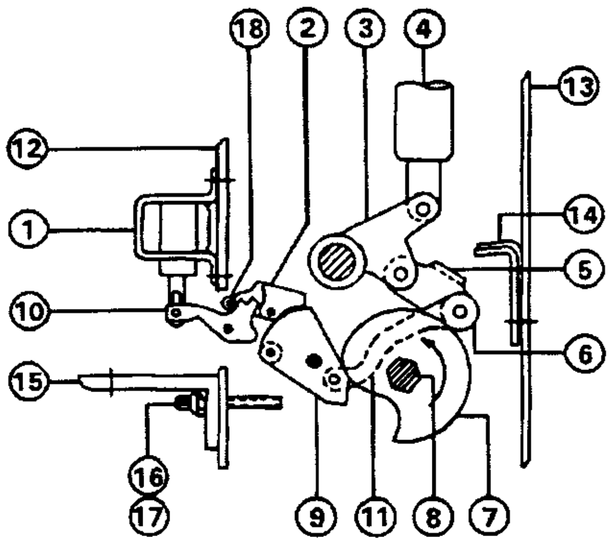
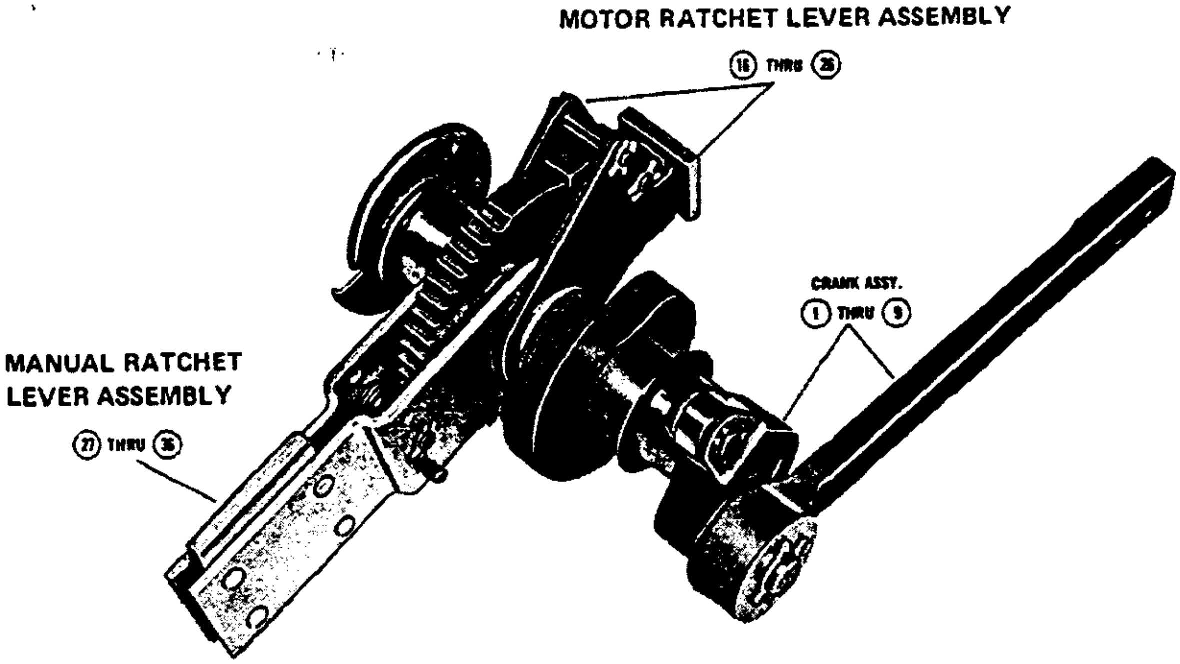
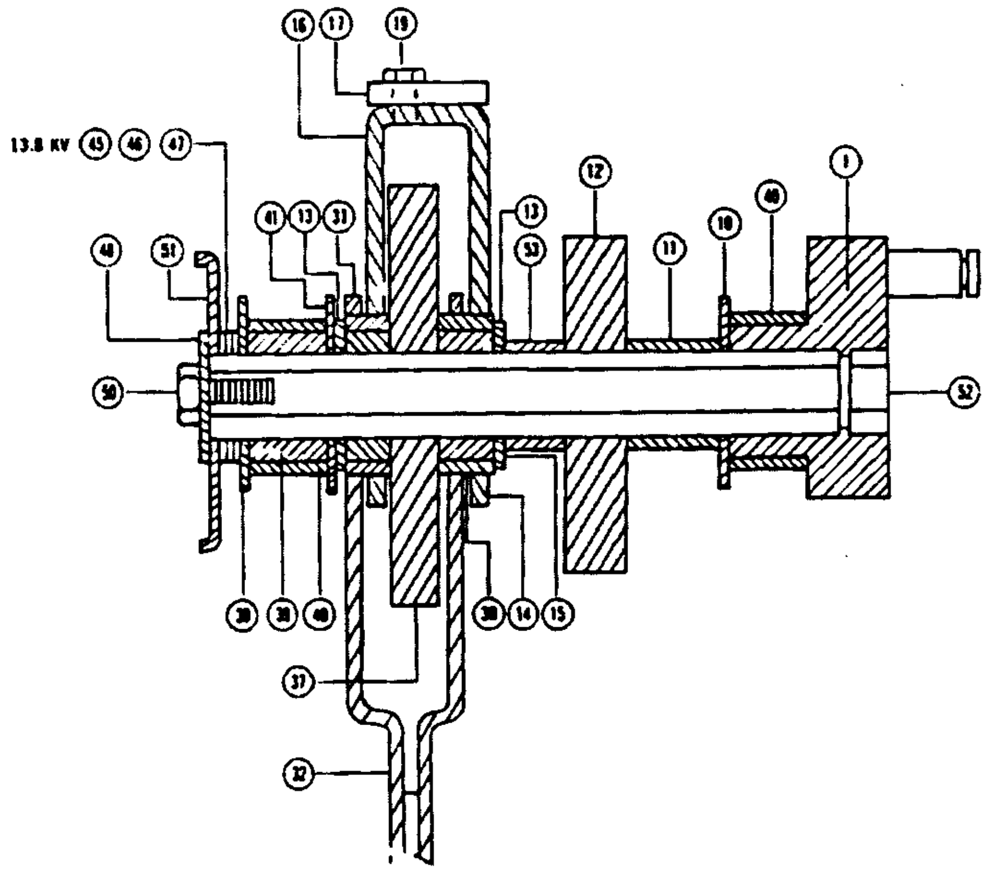


Breaker Open and Closing Spring Not Charged

1. Tripping Magnet
2. Tripping Latch
3. Center Pole Unit Lever
4. Main Contact Operating Rod
5. Main Link
6. Closing Cam Follower roller
7. Closing Cam
8. Crank Shaft
9. Tripping Cam
10. Tripping Trigger
11. Tripping Cam Connecting Link
12. Front Panel
13. Mech. Back Plate
14. Bumper
15. Dolly Bracket
16. Tripping Cam Adjusting Screw
17. Locking Nut
18. Trip Latch Roller


MOTOR RATCHET LEVER ASSEMBLY
16 THRU 26
CRANK ASSY.
1 THRU 9
MANUAL RATCHET
LEVER ASSEMBLY
27 THRU 36


16 17 19
13.8 KV 45 46 47
41 13 31
13
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53
11
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40
1
48
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52
38 39 40
38 14 15
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32

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of the trip plunger stem. Adjustment of the latch check switch is made by slightly bending the metallic operating arm of the switch.

E. Closing Cam Follower Roller

The clearance between the closing cam follower foller and the closing cam should be 0.040 to 0.060 inch measured with the breaker open and the closing spring charged.

Adjustment of the closing cam follower roller gap is made by adjusting the puffer piston connecting bolts. Counterclockwise rotation of the puffer piston connecting bolts increase the clearance.

F. Tripping Trigger

i. With the breaker closed and latched, lift the tripping trigger 1/2 inch and verify the breaker does not trip.

ii. Lift the tripping trigger 5/8 inch and verify the breaker trips.

iii. If adjustment is required loosen the trip interlock linkage set screw, adjust the linkage, and tighten the set screw.

G. Closing Trigger

i. With the breaker open and the spring charged, lift the closing trigger 1/2 inch and verify the breaker does not close.

ii. Lift the closing trigger 5/8 inch and verify the breaker closes.

iii. If adjustment is required loosen the close interlock linkage set screw, adjust the linkage, and tighten the set screw.

6.2.7 Post Overhaul Testing

1. Mechanical Tests

A. Visual Inspection

Visually inspect the breaker for mechanical integrity. Check for loose components and mounting hardware. Ensure all fasteners, retainers, spacers, and cotter pins have been properly restored.

B. Mechanical Function

i. Using the maintenance closing handle, slowly close the breaker. Verify that the operating mechanism functions smoothly without binding or excessive friction. Ensure the mechanism latches correctly with the contacts fully engaged and properly aligned. Verify the breaker position indicator indicates "Closed".

> *NOTE: The effort required to close the breaker with the maintenance closing handle should increase as the arcing contacts begin to engage.*

ii. Manually charge and release the closing spring to verify proper operation of the spring charging assembly.

iii. Charge the closing spring and manually close the breaker by lifting the spring release trigger. Verify the breaker closes and that the breaker indication is "closed".

iv. Manually trip the breaker by lifting the tripping trigger. Verify that the breaker trips and that the breaker indication is "open".

v. Manually close the breaker and recharge the closing spring. Lever the breaker into its cubicle test position. Verify that the floor trippers trip the breaker and discharge the closing springs.

> ***CAUTION: Do not rack the circuit breaker past the test position while testing the floor tripper interlocks. If the breaker does not trip before the test position remove it from the cell and investigate.***

vi. Levering-In Device Interlock

With the breaker in the closed position, attempt to operate the levering-in device. Verify that the device will not engage.

vii. Puffer Assembly

To ensure proper operation of the breaker puffer assembly, place a folded piece of paper (approximately 3" square) over each puffer tube nozzle and trip the breaker using the mechanical trip lever. The action of the puffer should blow the papers clear of the breaker.

2. Electrical Tests

A. Secondary Contacts

Inspect the secondary contact plug wiring for tightness of connections and proper wiring arrangement. Verify proper operation of the secondary contact extension arm and interlock latch.

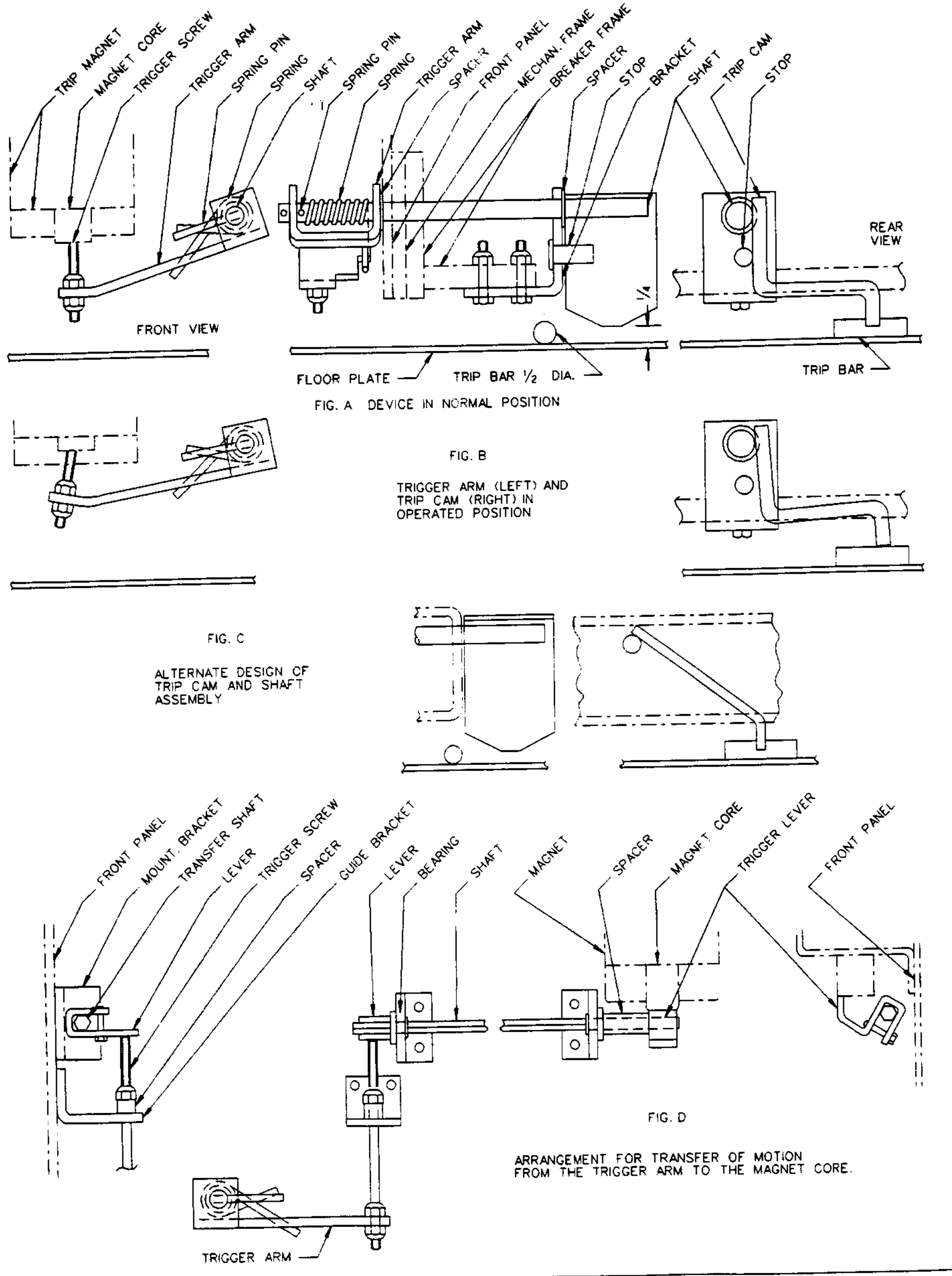

FIG. 25. Automatic Tripping Devices for 15 KV Type DH Air Circuit Breakers Except Type 150-DH-750

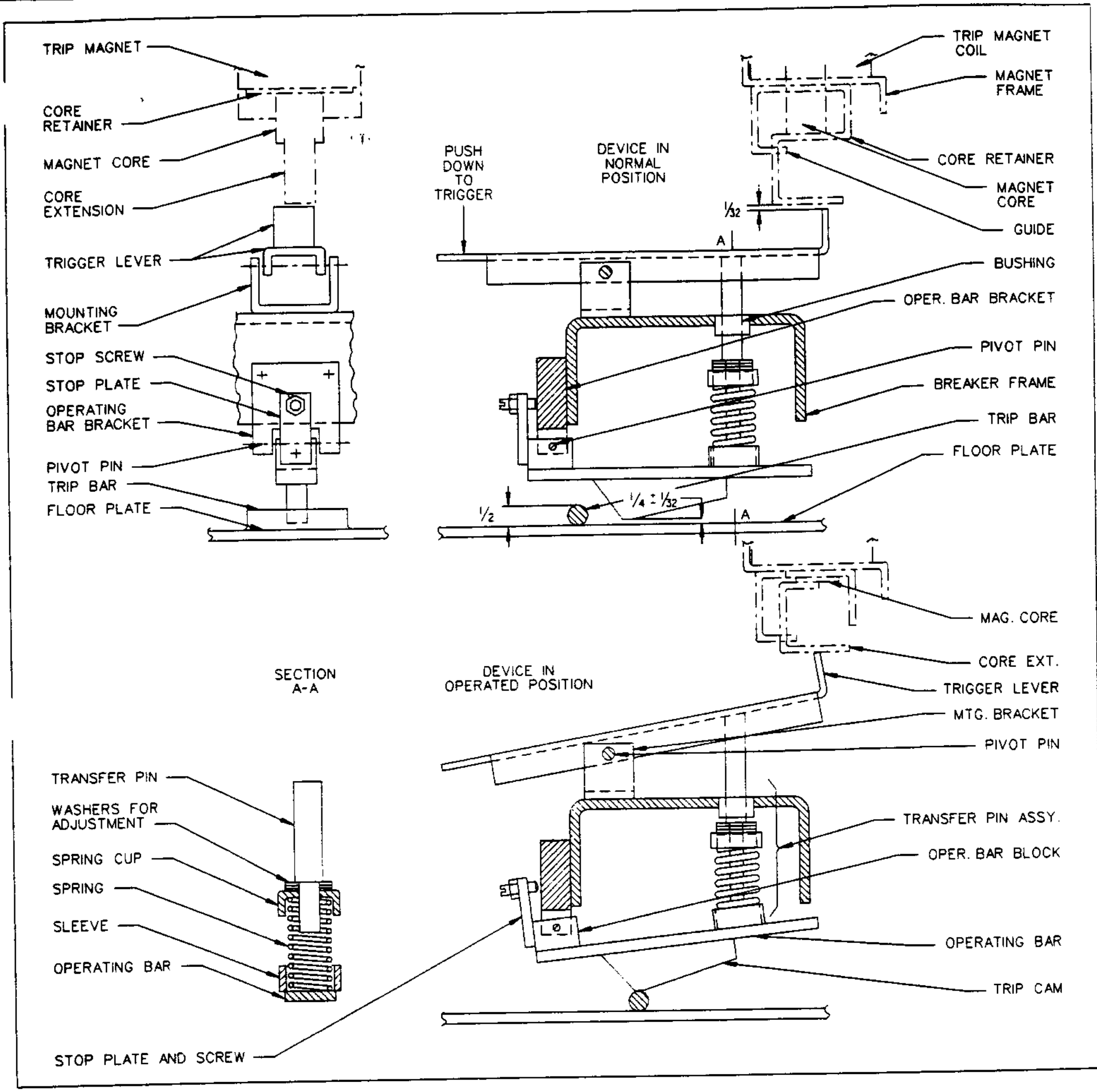

FIG 24. Automatic Tripping Devices for Type 150-DH-750 Air Circuit Breakers With Stored Energy (Spring) Closing Mechanism

B. Contact Resistance

With the circuit breaker closed, perform a micro-ohm resistance test across each phase of the breaker contacts. Resistance measurements should be taken from the lower stud to the upper contact foot on each phase. Ohmic values should not exceed 60 micro-ohms and should be relatively uniform on all phases.

C. Insulation Resistance

With the circuit breaker closed, perform insulation resistance testing (megger) from the breaker frame to the upper or lower stud. Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating, e.g. for a circuit breaker rated at 15kv, the minimum acceptable resistance value would be 15 megohms.

Open the breaker and perform insulation resistance testing from line to load side (upper stud to lower stud) on each of the three phases. Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating.

With the circuit breaker closed, perform insulation resistance testing between phases on the breaker (A-B, A-C, B-C). Ohmic values should meet or exceed one megohm for each kilovolt of circuit breaker rating.

3. High Potential Testing

The following test is optional and should be performed at the discretion of the end user.

With the breaker closed, perform high potential testing from the circuit breaker frame to the breaker contacts (upper or lower stud on any phase) and between phases on the breaker. Test voltages and acceptable leakage current values vary depending on the age of the equipment and the number of high potential tests previously performed.

4. Electrical Function

The following circuit breaker functional tests require electrical power. These tests may be performed by connection of a secondary contact test block or by placing the breaker in the cubicle test position and extending the secondary contact arm. The preferred method of testing is external to the cubicle using the secondary contact test block.

Apply control power to the secondary contact test block. The closing spring should charge as soon as control power is applied.

Electrically close and trip the circuit breaker several times. Verify operation of the breaker is quick and positive without hesitation in both closing and tripping.

Close the circuit breaker and energize the shunt trip magnet. Verify the breaker trips.

Test the circuit breaker undervoltage device (if installed) by connecting a variable voltage source to the secondary contact supply terminals. With the voltage source at rated voltage, close the breaker. Slowly reduce the voltage until the circuit breaker trips. Measure and record the voltage value. Verify the circuit breaker cannot be closed at the reduced control voltage value. Slowly increase the control voltage until the undervoltage device picks up. Measure and record the pick up value. Verify that the breaker will close.

5. Return To Service

Ensure the following conditions are satisfied before returning the circuit breaker to service:

A. Test equipment and auxiliary power connections are removed.

B. Arc chutes have been installed.

C. Arc chute shunt straps are connected.

D. Front panel is repositioned and securely mounted.

E. Barrier assembly is installed and bolted in place.

F. Breaker is in the open position.

G. Charging mechanism is discharged

6.3 Special Tools and Test Equipment

The following special tools and test equipment are recommended for performance of the maintenance activities described in this guide.

6.3.1 Suitable lifting equipment for the breaker arc chutes and operating mechanisms.

6.3.2 OEM supplied tools such as manual closing levers, breaker racking tool, secondary contact block insertion tool, and manual spring charging levers.

6.3.3 Arc chute bench (Refer to section 6.0).

6.3.4 A portable power supply to supply adjustable AC, and DC control voltages.

6.3.5 A multimeter capable of reading ohms, AC voltage, and DC voltage.

6.3.6 A DC insulation resistance tester (megger) with an adjustable output. Recom mended ranges are 500, 1000, 2500, and 5000vdc.

6.3.7 A DC high potential test set. The maximum required output should be 60kv.

6.3.8 Standard mechanic's tools, including socket wrenches, combination wrenches, pliars, screwdrivers, feeler guages, etc. .

6.3.9 Dial calipers for contact measurements.

6.3.10 Closing spring removal tool. Refer to section 6.0

6.3.11 Floor tripper alignment tool.

6.3.12 Bridge resistance measuring device for low impedance contact resistance.

6.3.13 Mechanical timing device, such as a graphic timing recorder, capable of recording operating speeds in the millisecond range.

Section 7.0

Replacement Parts

Section 8.0

References

Section 9.0

Appendices