I.B. 33-700-4

DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

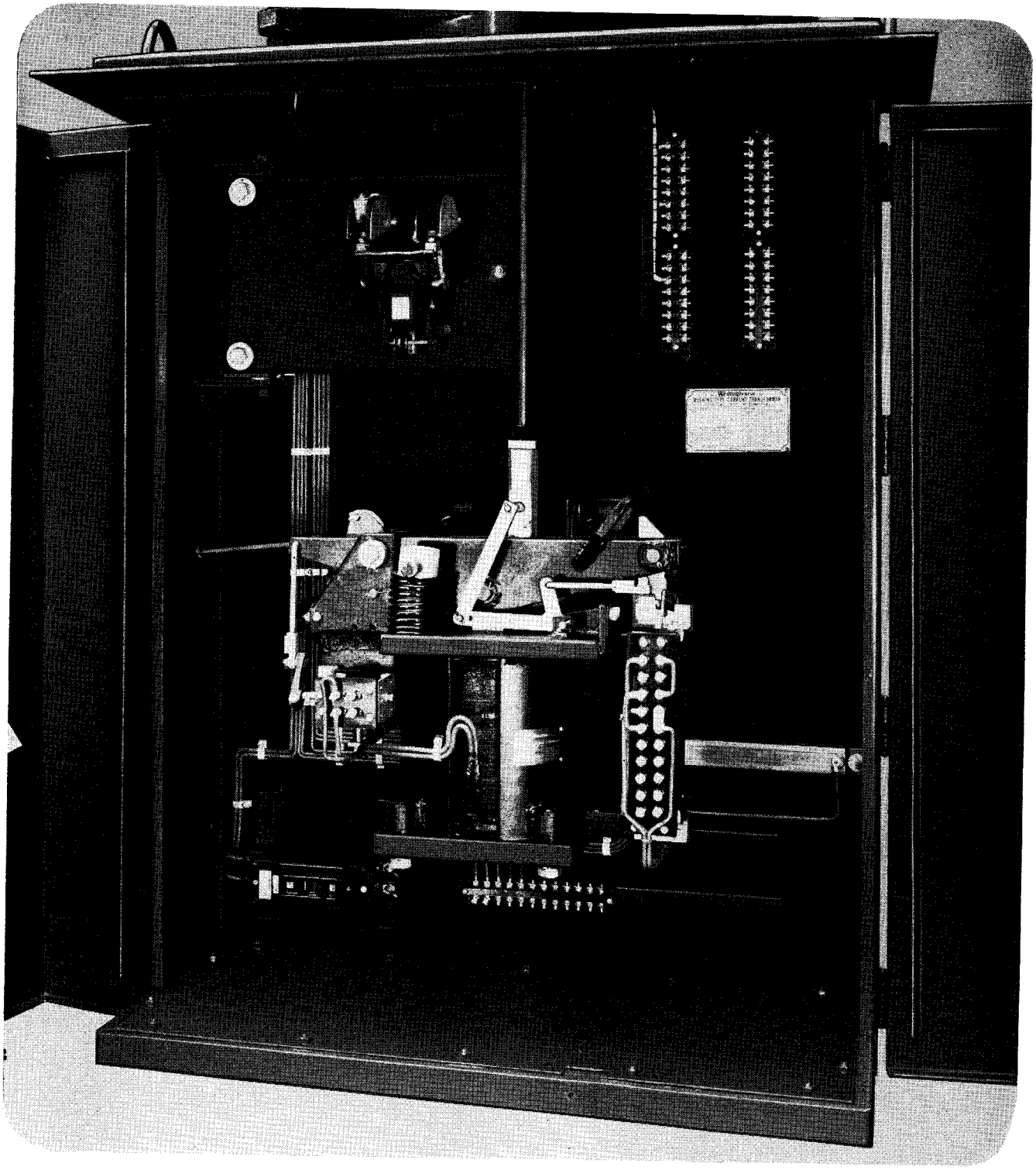
Type SAF-4
SOLENOID-OPERATED MECHANISM
for
Oil Circuit Breakers

WESTINGHOUSE ELECTRIC CORPORATION
SWITCHGEAR DIVISION
EAST PITTSBURGH PLANT • EAST PITTSBURGH, PA.

SUPERSEDES I.B. 5664-A

EFFECTIVE FEBRUARY, 1949

Printed in U.S.A.



Type SAF-4 Operating Mechanism in Outdoor Housing

A large steel housing with maximum accessibility encloses the solenoid mechanism when adapted to outdoor use. The solenoid mechanism is mechanically trip-free in all positions. The supporting bolts pass through the housing into the breaker frame, thus relieving the housing of the weight of the mechanism and also of the shock from operation.

DESCRIPTION

The SAF-4 Operating Mechanism of the direct-current solenoid type, fast in operation, and can readily be adapted to synchronizing work. Mechanically it is a fully automatic mechanism, trip-free in all positions.

A 2-pole cut-off switch is attached to the main lever of the mechanism to indicate position of the closing core, and a 10-pole auxiliary switch is attached to the automatic lever to indicate position of the contacts. A Veeder counter is supplied to record the number of operations.

Application may be made to indoor or outdoor breakers with the limits of power of the mechanism. For indoor service, it is mounted on the foundation or on the breaker structure. For outdoor service the mechanism is placed in a weatherproof metal box with enclosed connections to the breaker.

Manual operation of electrically operated breakers is obtained by means of a removable handle inserted in a socket in the operating or breaker linkage. This is accomplished without disturbing the solenoid mechanism.

The breaker is opened manually by partially closing with the hand closing device, thus relieving the load on the holding latch which can then be pushed out of the way with a screwdriver or other suitable tool. It is not safe to do this with the fingers because of the danger of being caught by the opening stroke of the mechanism.

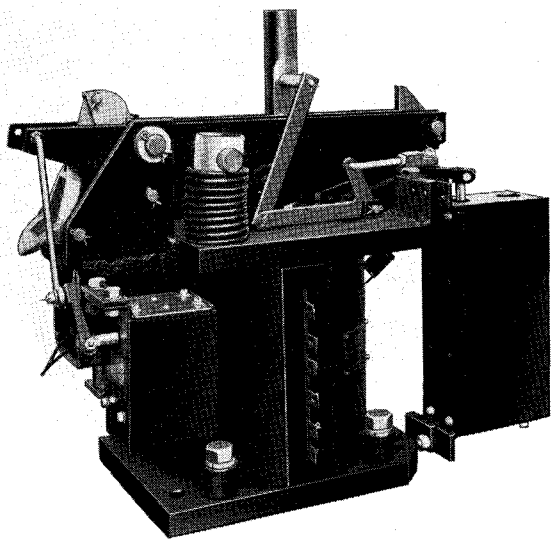


FIG. 1. Mechanism in Closed Position

RECEIVING AND STORAGE

Each mechanism is carefully inspected and tested at the factory and should be in good condition when received. Inspection should be made to see that no damage has occurred in shipment. Unpacking should be done carefully, so as not to damage the mechanism. All parts should be checked with the shipping list and care should be taken not to leave any part in the packing material. If the apparatus has been damaged in any way, file a claim immediately with the carrier and notify the nearest Westinghouse Sales Office.

If the mechanism is to be stored, it should be kept in a clean, dry place, protected from corrosion and moisture. It should never be allowed to stand where moisture can reach the wiring and insulated parts. It would also be well to apply a coating of grease or some rust inhibiting material on pins and bearings, and especially on the latching surfaces of the latch and trigger.

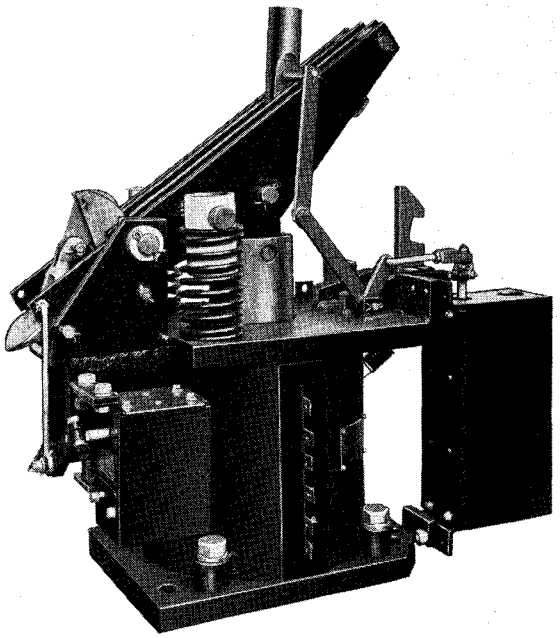


FIG. 2. Mechanism in Open Position

OPERATION

Fig. 3 shows the mechanism in the closed position and names the various parts. Referring to this figure, the breaker pull rod is connected to the automatic (inner) lever, which is pivoted to the closing (outer) lever at fulcrum "A". The closing lever is pivoted to the mechanism frame at the fulcrum "B" and connected to the moving closing core by two links.

With the mechanism in the open position shown in Fig. 5, moving the control switch on the switchboard to the position for closing closes the contactor on the control panel. This energizes the closing coil and causes the moving closing core to move downward. The closing and automatic levers rotate clockwise together about fulcrum "B", closing the breaker.

When the closed position (Fig. 3) is reached, the moving closing core stops against the stationary closing core and the holding latch engages the fulcrum pin "A", holding the circuit breaker in the closed position. Just before the closed position is reached, the two-pole auxiliary switch makes contact, causing the closing relay to start to open to de-energize the closing coil. This operation is not completed until the mechanism has completed the closing movement and the holding latch has engaged fulcrum pin "A".

To trip the mechanism and open the breaker from the closed position (Fig. 3), the trip coil is energized, raising the moving tripping core and trip rod striking the trip lever. This breaks the toggle formed by the trip lever and trip link. This permits the automatic latch to rotate counter-clock-

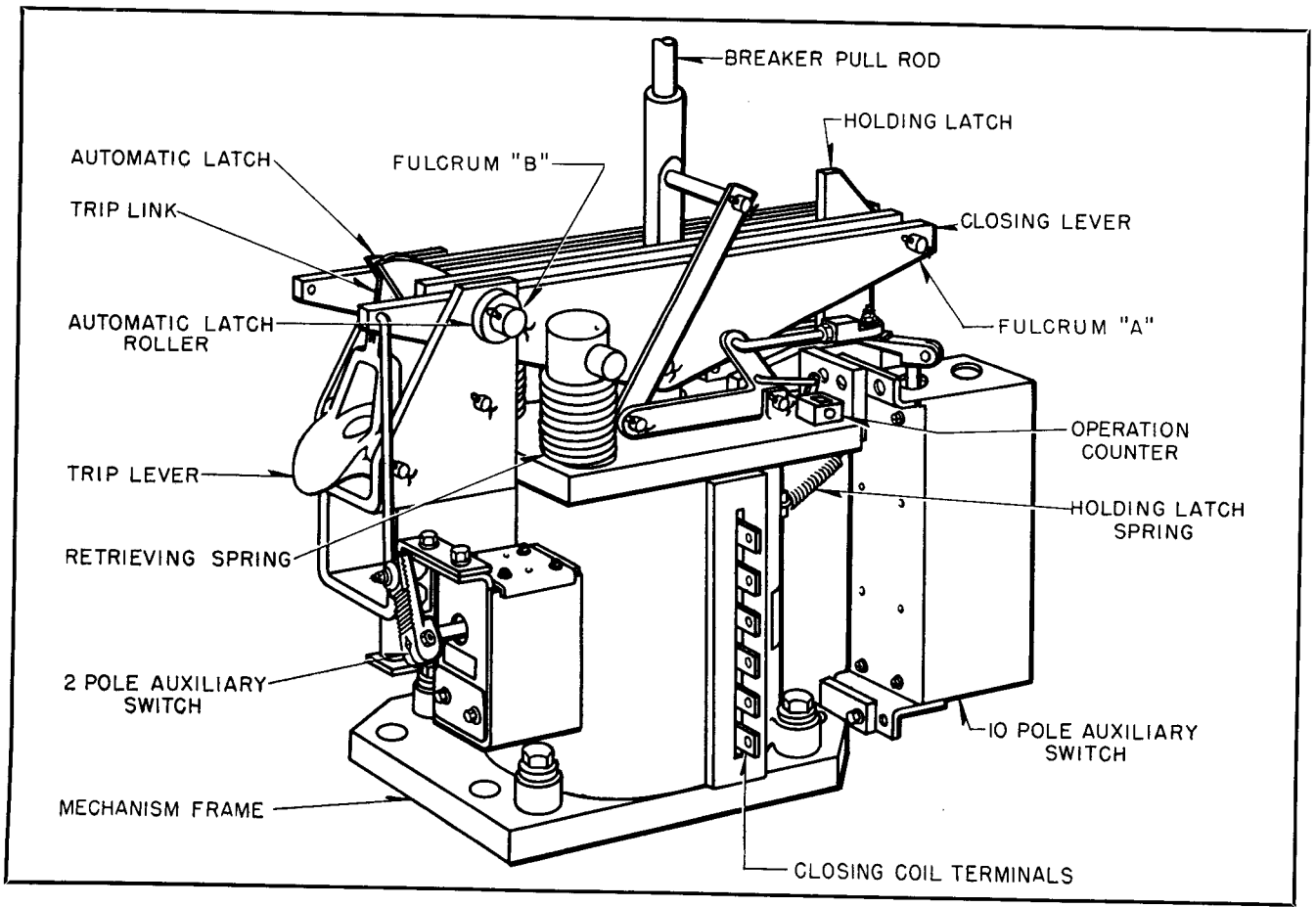


FIG. 3. Mechanism in Closed Position

wise and releases the roller. This permits the automatic lever, to which the breaker pull rod is attached, to rotate clockwise about fulcrum "A" allowing the breaker to open.

The intermediate position is shown in Fig. 4. As the levers reach this position, a block on the automatic lever strikes the holding latch, rotating it counter-clockwise disengaging it from the fulcrum pin "A". The closing lever then rotates counter-clockwise about fulcrum "B", due to the pressure of the retrieving springs, to the open position (Fig. 5), where the automatic latch re-engages the roller. The mechanism is then ready for a subsequent closing operation.

There is no accelerating spring on the mechanism. Breakers, to which this mechanism is applied, are provided with separate acceleration as necessary to produce the proper operating speed.

The 10-pole auxiliary switch is connected to indicate the position of the circuit breaker. The first and third contacts of this auxiliary switch are wider than the rest and are normally wired in series to control the trip coil circuit. The eight remaining contacts all have narrow segments and are normally arranged to provide three circuit closing and five circuit opening contacts. These extra contacts are available for indicating lights and interlocking purposes.

LATCHING DEVICES

Toggle Latch (For 8-Cycle Breaker Applications). The tripping latch consists of an automatic latch which has been hardened and ground, engaging a roller on the automatic (inner) lever. This is a slip-off latch, that is, the surface of the latch which engages the roller is ground at such

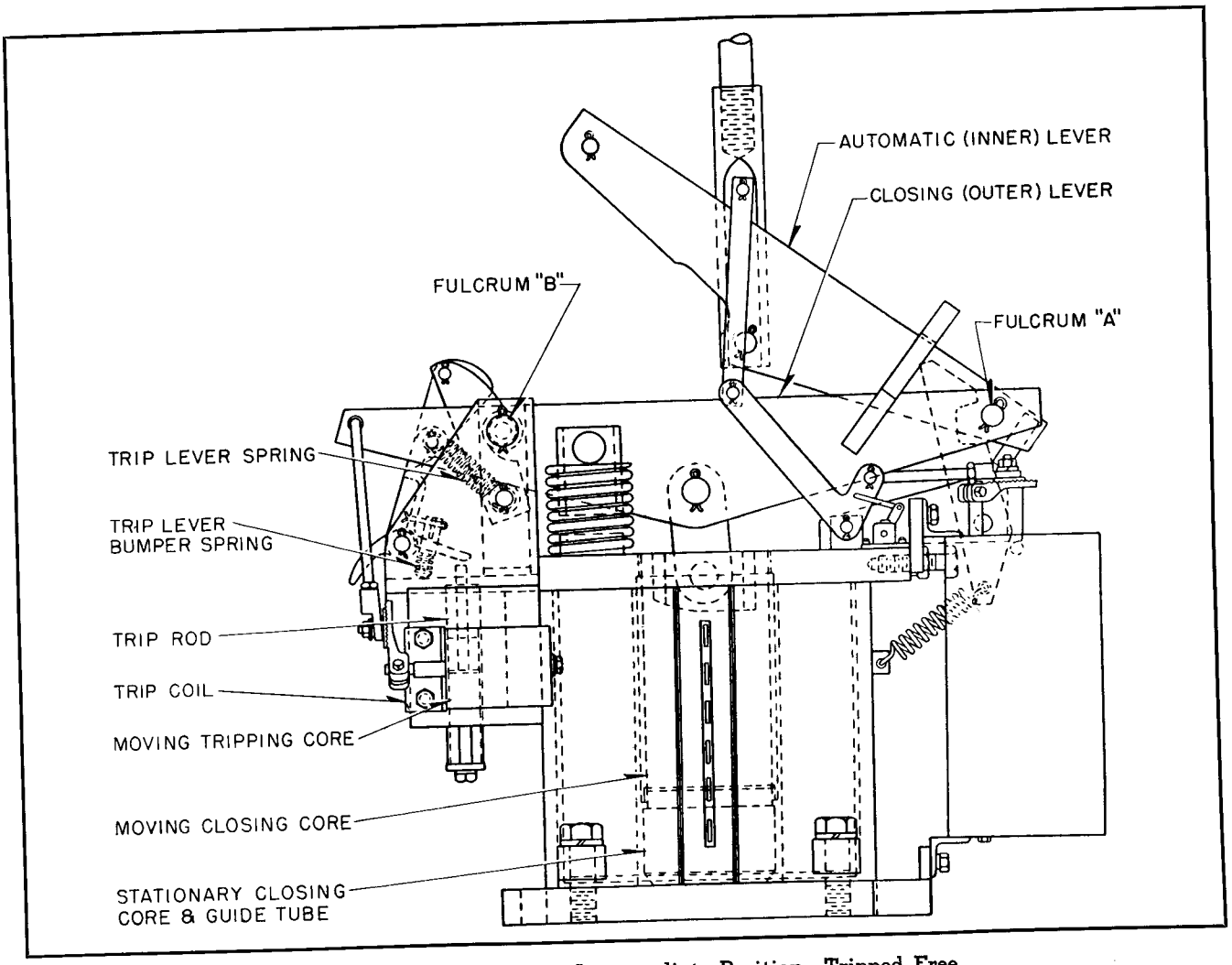


FIG. 4. Mechanism in Intermediate Position—Tripped Free

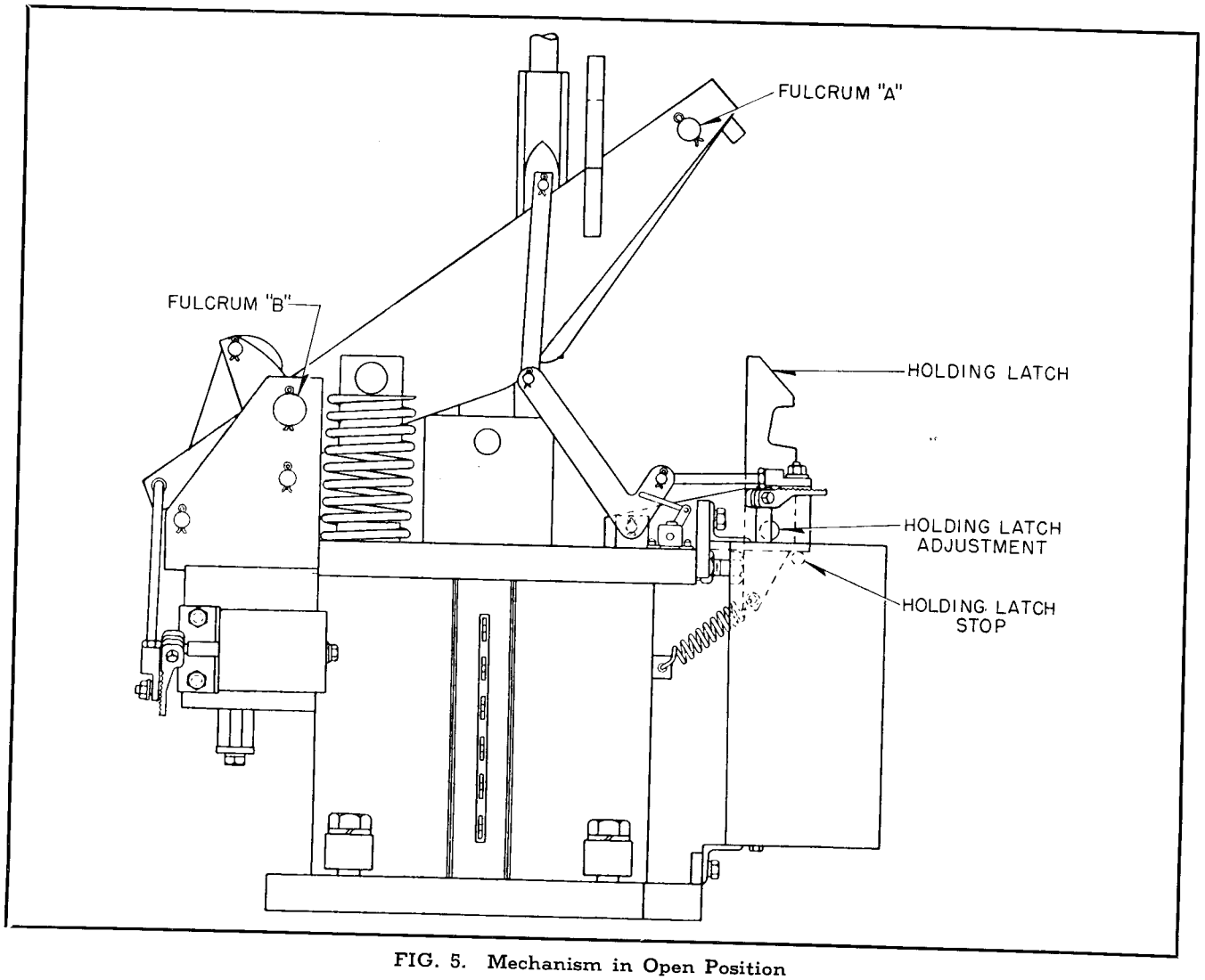


FIG. 5. Mechanism in Open Position

an angle that it tends to slip off. It is held engaged by a toggle formed by the trip link and the trip lever. This toggle is held slightly over center, against a stop, by the trip lever spring.

When the trip rod strikes the trip lever it breaks this toggle and allows the latch to slip off of the roller. When the mechanism retrieves, the toggle is broken by the roller striking the trip link attached to the automatic latch. A bumper spring is provided on the trip lever so the toggle will not be disturbed by the closing operation.

Double Latch (For 5-Cycle Breaker Applications). The double latch (Fig. 6) differs from the toggle latch principally in that a trigger replaces the toggle arrangement to hold the automatic latch engaged on the automatic lever roller. Raising the trip rod lifts the trigger allowing the latch to release the roller and automatic lever. The light weight laminated moving trip core and the

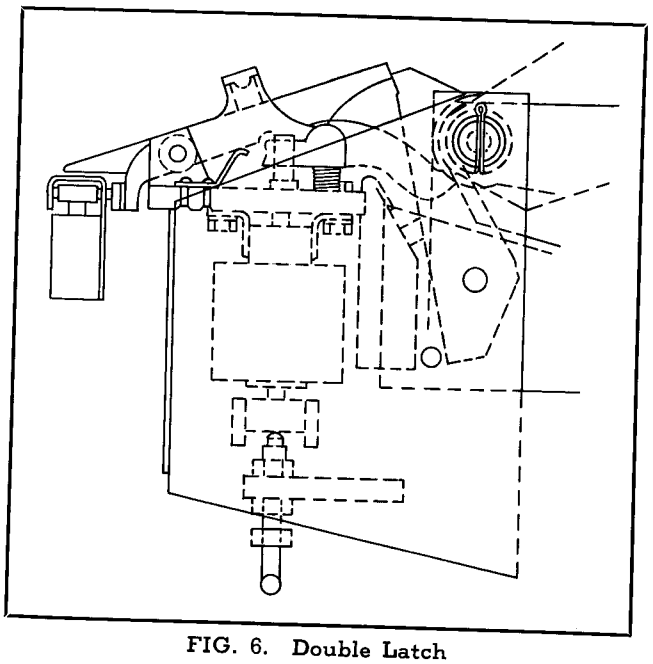


FIG. 6. Double Latch

short distance it has to travel to release the trigger both contribute to the shorter time required to release the latch. The air gap between the moving armature and stationary magnet should be between $\frac{3}{16}$ and $\frac{1}{4}$ inch to obtain best operation.

As soon as the inner lever and roller have opened a small amount the latch rotates forward again, but the trigger is retained in its raised position by the balance lever. As the mechanism retrieves, the latch is rotated back by the roller sliding down the sloping nose of the latch. At about the same time, the inner lever pushes the balance lever down, allowing the trigger to drop back in place behind the latch as it re-engages the roller.

ADJUSTMENT

The mechanism is completely adjusted and tested at the factory and it is only necessary to check to see that these adjustments have not been changed. In case the mechanism is connected to a breaker already in the field, care must be taken to see that the circuit breaker and the mechanism operate properly in unison.

The connecting link (breaker pull rod) between the mechanism and the breaker should be adjusted as to length, so that, with the mechanism in the closed and latched position, the circuit breaker is in the closed position as indicated by the toggle stops on the circuit breaker. In closing, the moving closing core is drawn down against the stationary closing core leaving not over $\frac{1}{16}$-inch clearance between the face of the holding latch and the fulcrum pin "A". This clearance is referred to as "back-lash". As the mechanism closing cores come together, the toggle stops in the pole unit will come together, and as the closing coil is de-energized, the mechanism will drop back slightly against the holding latch, permitting the breaker toggle stops to open slightly.

"Back-lash" at the holding latch is adjusted by loosening the clamp bolt in the holding latch and rotating the eccentric bushing. The "back-lash" should be just sufficient to insure positive latching of the holding latch.

Close the breaker electrically. If the breaker fails to stay closed, it may be due to the power on the closing coil being removed too soon. To investigate this possible cause of failure, check the following:

1. Make sure that the control switch is held in the closed position for a sufficient time to permit the mechanism to complete the closing stroke before power is removed.

2. Hold the contacts of the closing contactor closed manually by pushing in the armature. If the breaker stays closed, it indicates that the contacts on the cut off switch are completing the circuit through the opening coil of the cut off relay too early in the closing stroke. The adjustment of the 2 pole cut off switch can be changed by varying the length of the connecting link.

3. Check the voltage across the terminals of the closing coil ***With the coil energized*** to be sure that it is above the minimum or at least 72% of normal.

When the mechanism is detached from the breaker and placed in the open position, the closing (outer) lever will come to rest on the hub of the trip lever. Check to see that there is clearance at this point when the circuit breaker is attached.

TRIPPING ACCESSORIES

Shunt Trip. The standard shunt trip consists of a magnetic circuit, coil, and a stationary and moving core with a trip rod which extends through the top. A bracket on the bottom retains the moving core and limits its travel to about $\frac{3}{4}$". A thin brass washer prevents the moving core from being retained by the residual magnetism after tripping is completed.

4-Coil Trip Attachment. This tripping device, illustrated in Fig. 7, is to be used when transformer trip coils, capacitor trip, or undervoltage release is required. Space is provided for a total of four trip coils, including shunt trip, overload trip (with or without inverse time attachment), and undervoltage trip. Any combination of coils up to four can be used except only one undervoltage trip can be used.

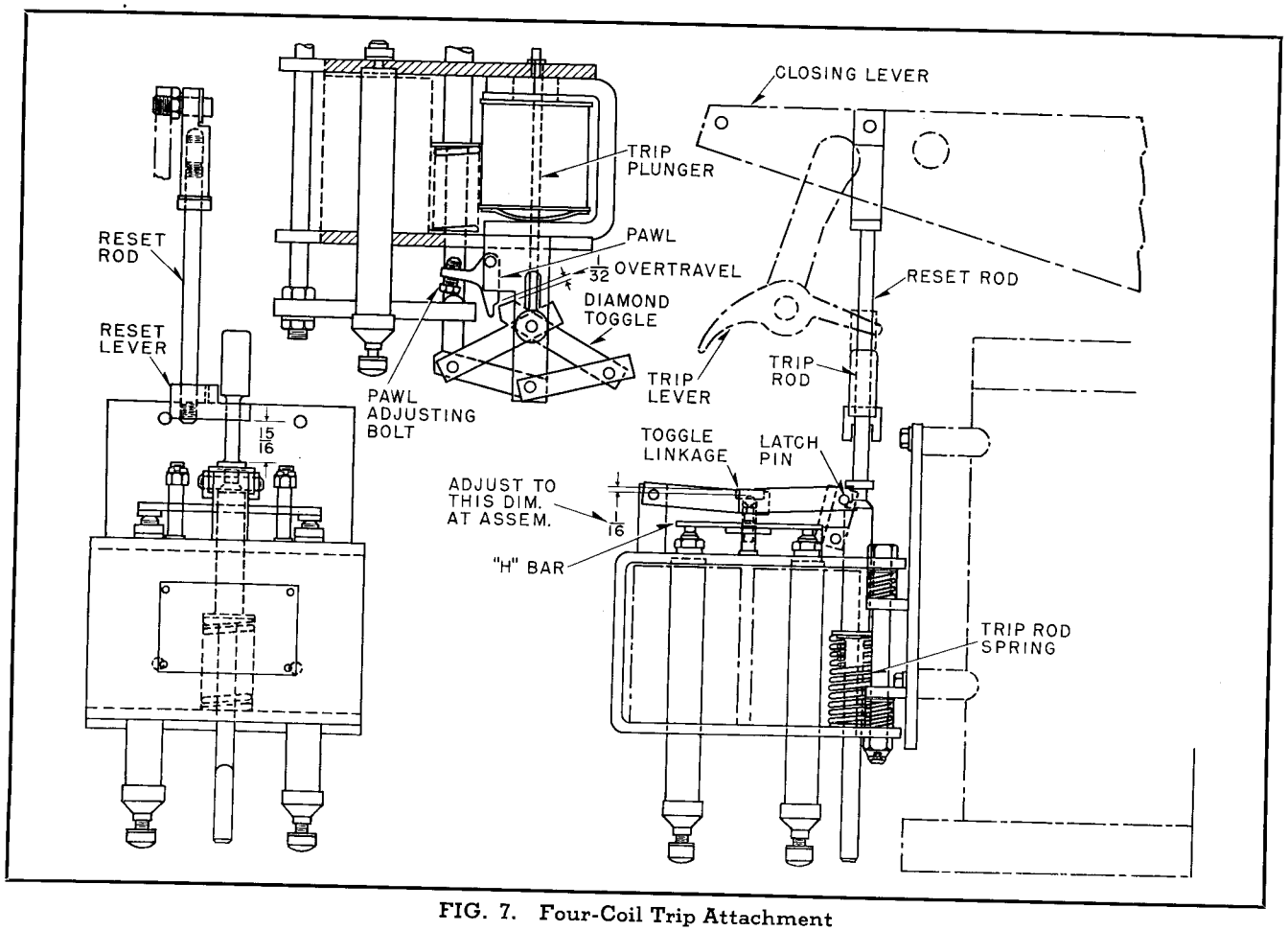


FIG. 7. Four-Coil Trip Attachment

Referring to Fig. 7, the trip rod is located under the trip lever. The trip rod is held down by a toggle linkage which engages it in the notched portion. This linkage consists of links and a "U" lever which are normally down over center. When the linkage is struck in the center from below, the toggle is broken, the latch pin moves to the left and the trip rod is forced up by the trip rod spring.

This toggle linkage is located right over the four tripping devices. An "H" shaped bar rests on the four bushings through which the trip rods slide. The operation of any one of the trip plungers tilts up that corner of the "H" bar and raises the center enough to push the toggle up over center. In case one or more of the trips are omitted, a dummy bushing is used and the operation of the others is not affected.

The force to trip the breaker comes from the trip rod spring. After tripping, and before another operation can take place, the trip rod must be reset. The reset rod connected to the mechanism closing lever carries a reset lever, which in turn acts on a shoulder on the trip rod. The movement of the closing lever in retrieving forces the trip rod down, compressing the trip rod spring, to a point where the trip rod is engaged by the latching pin. When the mechanism closes, the reset rod moves up leaving the trip rod latched ready for the next trip operation.

5-Ampere Transformer or Overload Trip. (See Fig. 8.) Calibrated for tripping on currents of from 5 to 9 amperes. It is set to pick up and trip at 5 amperes. The setting is changed by raising or lowering the moving core by means of the screw which extends from the lower end of the tube cap. The screw is secured by a lock nut which should be loosened before adjusting and retightened after the setting is changed.

Inverse Time Limit Trip. (See Fig. 9.) This has a dash pot device that is used in conjunction with the overload trip attachment where tripping is not desired unless the overload continues. The current calibration is varied by screwing the pot into or out of the cover.

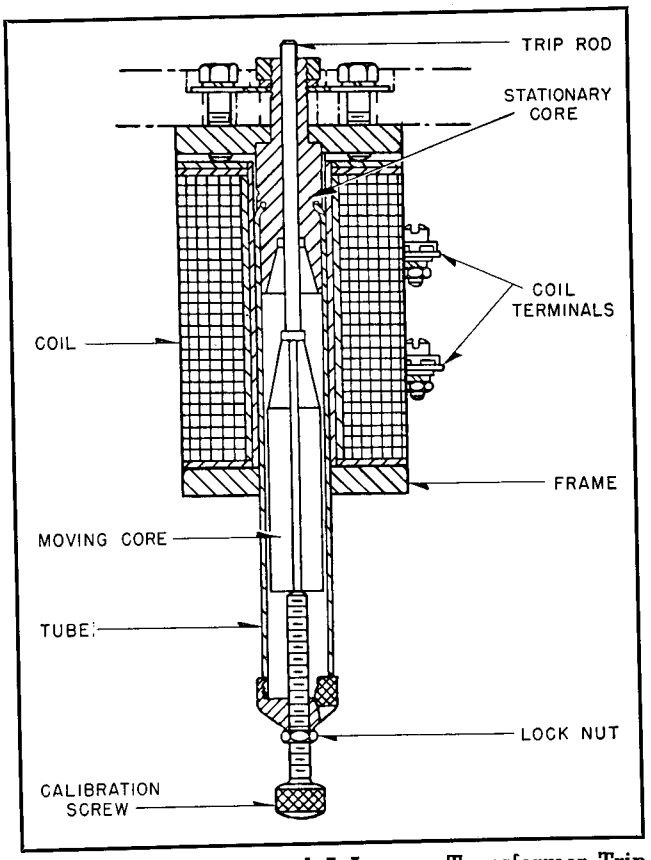


FIG. 8. Shunt Trip and 5-Ampere Transformer Trip

The time is varied by changing the number of holes in the bottom of the piston. The greater the overload the quicker the moving core will rise. The thicker the oil the slower the moving core will be in rising. Fig. 10 shows variations of the time with the variations of the overload and the effect of change in temperature on the standard oil as supplied with the dashpot. The inverse time limit attachment should not be used where the temperature falls below 15°C unless special oil which will not solidify is substituted.

Should the mechanism fail to trip, make the following checks:

1. With the mechanism closed, check the distance between the shoulder on the trip rod and the lower side of the reset lever to see that there is a minimum of $\frac{15}{16}$-inch clearance.

2. Check to be sure that there is clearance between the top side of the reset lever and the shoulder underneath the head of the trip rod.

3. With the mechanism in the open position, release the automatic latch and move the outer lever to the closed position with the hand closing lever. With the solenoid mechanism in the trip-free position and with the trip lever held in the tripped position, raise the "H" bar on the 4-coil trip attachment to release the trip rod. Check the travel of the trip rod to see that it moves approximately $\frac{7}{8}$ inch.

4. Check the setting of the toggle by placing a straight edge across the two end pins. The center pin should be a minimum of $\frac{1}{16}$-inch below the two end pins. This adjustment is controlled by the $\frac{1}{4}$-inch bolt in the center of the "H" bar. Do not attempt to set the toggle too close to center as the device will be sensitive to shock and vibration.

5. With the 4-coil trip device reset ready to trip, raise each of the individual trip plungers separately and slowly by hand to make sure that each tilts the "H" bar sufficiently to release the trip rod. This can be done by either using a screw driver under the head of the trip plunger or by inserting the screw driver through the slot in the guide tube and raising the moving core.

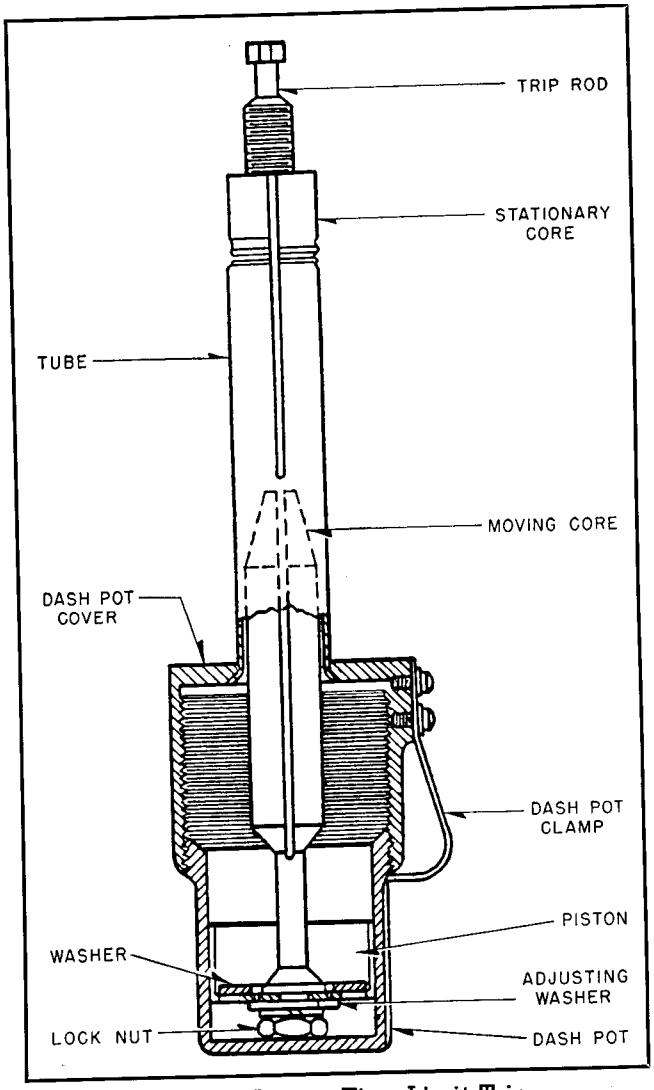


FIG. 9. Inverse Time Limit Trip

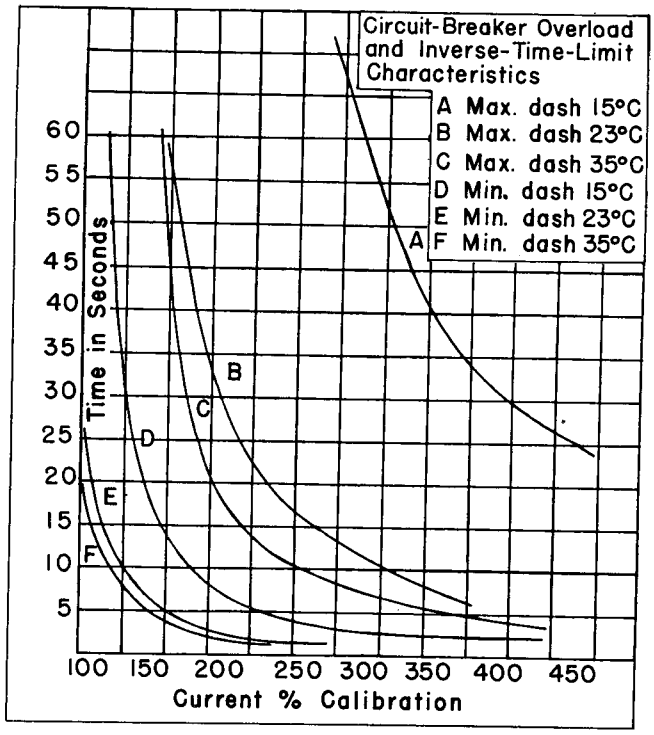


FIG. 10. Inverse Time Limit Characteristics

Undervoltage Trip. When the coil is energized, the upper core is held down against the stationary core against the pull of the spring biased across the diamond shaped toggle just below the mounting bracket. When the voltage across the undervoltage coil falls to a value of from 60 to 40 percent of normal, the undervoltage coil is no longer able to retain the upper core against the force of the spring. The spring then causes the core to rise and drives the trip rod against the "H" trip bar releasing the trip rod.

As the solenoid mechanism retrieves, the movement of the resetting rod forces the diamond shaped toggle downward, bringing the undervoltage cores together. At the end of the stroke, a small latch engages the inner end of the diamond shaped toggle to prevent the undervoltage release from tripping the breaker until the closed position of the breaker is reached. This latch is released by the rising of the resetting lever during the closing stroke of the breaker, and the tripping linkage is held in the reset position by the undervoltage coil.

Should the undervoltage attachment fail to function properly, make the following additional checks to those described above under "4-Coil Trip".

1. Check the voltage across the coil.

2. Check to see that cores are drawn together and held there when voltage is applied to the coil.

3. Check to see that linkage is retrieved far enough for the latch to engage the toggle linkage.

4. Check to see that latch does not release the toggle linkage until the coil is energized.

5. Hold the toggle linkage until the mechanism reaches the closed position, then release it slowly to see that it tilts the bar properly.

Auxiliary Switches. The auxiliary switches are adjustable both in stroke and position. These switches are adjusted and set at the factory and should be correct. Certain conditions may necessitate a change in the cut-off switch adjustment. This is accomplished by varying the length of the connecting link.

Should it be desirable to change the position of any contact on the auxiliary switch, remove the switch from the mechanism, take out the rotor and remove the bolt in the end of the shaft opposite the lever. Take off the parts, maintaining their sequence, and rotate the segment involved to the new position. Be sure to replace all parts in the proper relation and tighten up the locking bolt. Check the operation of the switch when reconnected.

High Speed Switch. A high speed switch which opens its contacts with the initial opening movement of the breaker, may be mounted on the top plate of the mechanism. An adjusting bolt is provided to set the point where the switch operates. Care should be exercised in making adjustments to see that the over-travel of the mechanism does not compress the over-travel spring in the switch to the solid position and that with the mechanism closed and latched the switch makes good contact.

When this adjustment is completed, the switch contacts will open almost simultaneously with the first movement of the automatic lever in opening. The contacts can be inspected by removing the two screws that hold the cover in place.

Latch Checking Switch. The latch checking switch is intended primarily for applications where automatic reclosuring is desired.

When the mechanism is tripped, the trip lever is retained in the tripped position by means of a locking lever until the automatic lever has returned to the retrieved position. At this point

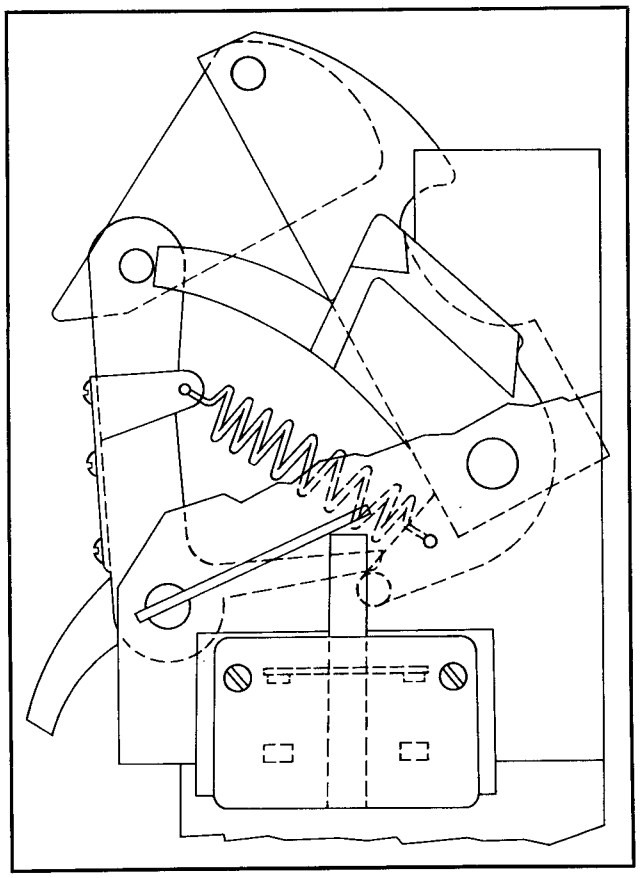


FIG. 11. Latch Check Switch—Tripped Position

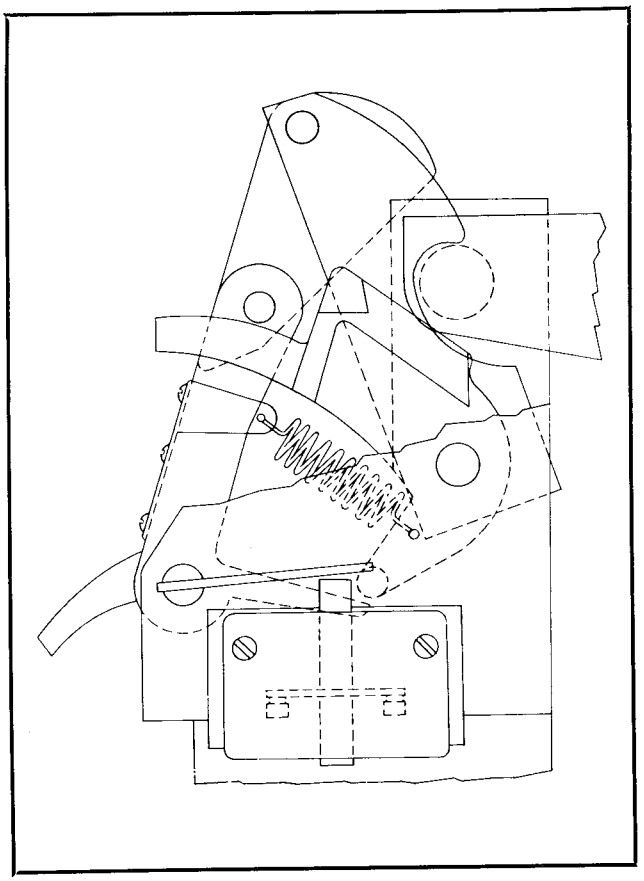


FIG. 12. Latch Check Switch—Latched Position

the locking lever is disengaged, allowing the automatic latch to reset and the switch operating lever to close the contacts of the switch. Fig. 11 shows the switch open, with the latch disengaged. Fig. 12 shows the switch closed, with the latch reset ready for a closing operation.

INSPECTION

The electric solenoid closing mechanism contains a number of moving joints and operating parts, all of which are subject to wear if not kept in the proper condition. It is desirable to inspect the mechanism at regular intervals and be assured of its good working condition, by making a number of operations. It is desirable to apply a light lubricating oil to the various pins; but the quantity of oil should be kept to a minimum, to prevent gumming. It is necessary to keep the moving parts, particularly the automatic latch and the switches, clean and free from foreign matter.

The use of a rust inhibitor on the latch surfaces is recommended.

In case there is any trouble in operation, the mechanism should be taken out of service at once, and put in proper condition. The circuit breaker is highly dependent on the proper functioning of the operating mechanism and it, therefore, should always be kept in good condition.