

SIEMENS-ALLIS

Switchgear

INSTRUCTIONS

**FCV-500 AND FCV-750
VACUUM CIRCUIT BREAKERS
WITH
STORED ENERGY OPERATOR
NO. 515-2V**

**18X5416-01
June, 1978**

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INTRODUCTION

This instruction manual contains installation, operation and maintenance information for Types FCV-500 and FCV-750 vacuum circuit breakers of the 13.8 kV class, with Type 515-2V stored energy operators (Fig. 2a & 2b).

WARRANTY

The sales contract carries all information on warranty coverage.

RECEIVING

Circuit breakers are shipped from the factory completely assembled. Observe weight markings on crates and ensure that capable handling equipment is used.

Remove crating carefully with the correct tools. Check each item with the shipping manifest. If any shortage or damage is found, immediately call it to the attention of the local freight agent handling the shipment. Proper notation should be made by him on the freight bill. This prevents any controversy when claim is made, and facilitates adjustment.

When handling breaker (Fig. 1) with a crane or hoist, hooks should be attached only to breaker frame. Use a spreader to prevent frame distortion and/or damage to interrupters. Do not attach lifting hooks, rope, etc., to bushings, insulating parts, fittings, etc. Do not slide breaker off shipping skid without using ramp blocks provided as interlock plunger and linkage may be damaged.

STORAGE

Indoor - The circuit breaker should be installed as soon as possible. If storage is necessary, it should be kept in a clean dry place where it will not be exposed to dirt, corrosive atmospheres or mechanical abuse.

Outdoor - Outdoor storage of circuit breakers is not recommended. If breakers must be stored outdoors, they must be covered completely and a heat source provided to prevent condensation and subsequent corrosion.

CIRCUIT BREAKER PREPARATION

Prepare the circuit breaker for insertion into its cubicle as follows:

1. Remove Packaging. Note: Circuit breakers are shipped in the closed position with the trip rod and foot lever enclosed by packaging to prevent opening during shipment.
2. Tilt the hinged panel back to expose the vacuum interrupters (Fig. 2b).
3. Examine the vacuum interrupter envelopes and supporting structure for any obvious evidence of shipping damage.

4. Wipe the outside of the interrupters and supporting insulating parts with a clean, dry cloth.
5. Observe the distance "A1" & "A2" in figure 3. An average between "A1" & "A2" will produce distance "A" which represents the additional compression imparted to the contact pressure springs from the point where the interrupter contacts make, to the point where the closing linkage has completely toggled. Distance "A" also represents the maximum allowable erosion of approximately 1/8" (3mm) of the interrupter contacts. As the contacts erode during the service life of the circuit breaker, distance "A" will become less. When distance "A" measures within .030 to .015 (.8 to .4mm) inches, the vacuum interrupter should be replaced. This distance could be checked at periods of routine maintenance and after periods of high short-circuit interruptions. The rate of erosion will vary with the application and service conditions. See contact erosion page 13.
6. Push manual trip button to open breaker.
7. Hi-pot each vacuum interrupter while in the open position, to verify that damage has not occurred during shipment. The voltage should be raised gradually, and the contact gap should sustain 27kV, 60Hz a.c. for 1 minute, or 38kV d.c. for 1 minute. If it does not, the interrupter is faulty and must be replaced.

CAUTION!!

OBSERVE THE FOLLOWING ITEMS WHEN HI-POTTING THE VACUUM INTERRUPTERS.

A. With respect to X-radiation: (No hazardous X-radiation is produced with closed contacts or with open contacts with rated operating voltage applied to them.)

- 1) Do not hi-pot the interrupters at voltages higher than listed.
- 2) Test personnel should remain at least 6 feet (180mm) away from the interrupter being tested.
- 3) Tests should be performed with normal metallic panels installed, and test personnel should position themselves to take advantage of shielding provided by metallic barriers.

B. The circuit breaker bushings and metallic mid-band on the interrupter may retain a static charge after the hi-pot test, so discharge with a grounded probe before handling.

8. Install plug jumper and energize control. (Spring charging motor should run to charge the closing springs.) Refer to Page 64 of Switchgear Instruction Book 18X9587-06 for plug jumper instructions.
9. Close the circuit breaker electrically by using the control switch on the switchgear cubicle panel. Note that the motor will immediately run to again charge the closing springs.
10. Verify that the circuit breaker is closed and remains closed by checking the mechanical position indicator.
11. Trip the circuit breaker with the control switch.
12. Repeat the close and trip operations several times.
13. Depress foot lever and close the circuit breaker with the control switch (*).
14. Release the foot lever and close and trip the circuit breaker (#).
15. It is suggested that the opening and closing times be established for the breaker when new, and periodically when routine maintenance is performed on the circuit breaker. The closing time should be within the range of .042 to .062 seconds, and the tripping time within .018 to .025 seconds. See Fig. # 19.
16. De-energize control power and remove plug jumper.
17. Coat movable primary and secondary disconnects with a film of Siemens-Allis contact lubricant, 15-171-370-002.
18. Insert breaker into its cubicle to "disconnect" position and close manually (*).
19. Complete movement of breaker to "test" position and repeat steps 9 (#) and 11.
20. Check for proper alignment between stationary and movable secondary contacts. Check for proper alignment between aux. switch bayonet on cubicle wall and operating fork on breaker.
21. With line and bus de-energized, rack breaker into fully connected position. Close and trip breaker from main control panel. If bus or line are energized, get clearance before beginning this step.
22. Lock out Kirk interlock (if provided) and repeat step 9 (*).

Open interlock and repeat steps 9 (#) and 11.

Breaker is now ready for normal operation.

(*) Breaker is trip free.

(#) Breaker will close.

CIRCUIT BREAKER DESCRIPTION

A typical circuit breaker consists of primary disconnects, vacuum interrupters, and operator sections (see Page 18). The primary disconnect section contains the main contacts which supply power to the load. The vacuum interrupters open and close the electrical system during normal and/or fault conditions. The operator section contains the mechanism used to close and open the main contacts. This mechanism consists of a stored energy operator with its associated control circuitry.

TRIPPING

The vacuum circuit breaker is tripped due to operation of the manual trip button, (44, Fig. 4b), the foot lever (Fig. 4b) or the trip solenoid, (17, Fig. 8).

INTERRUPTION

When the circuit breaker is tripped while carrying current, the contacts within the vacuum interrupters part, and an arc is established. Due to the efficiency of the vacuum interrupter, the arc is normally interrupted at the first current zero.

CLOSING

The breaker is closed by the stored energy operator straightening a toggle in the four-bar linkage (Fig. 7, Item 12). The operator is powered by precharged springs (stored energy).

STORED ENERGY OPERATOR

The stored energy operator (Figs. 6, 7 & 8) uses charged springs to power the closing operation. Opening is spring-powered also, but not with the same springs used for closing. A stored energy operator consists of three systems: spring charging drive, cam and ratchet assembly, and the four bar toggle linkage (Fig. 5, A - D). These systems are disengaged from each other except while performing their specific functions. For example - the spring charging drive and cam-ratchet assembly are disengaged except when the cam-ratchet arrangement is being charged. Similarly, the cam-ratchet and four bar linkage are free of each other except during closing.

Stored energy operated breakers normally require a single commercial relay for control. This relay is furnished to match the control voltage.

AUXILIARY SWITCH

Mounted on the breaker, the auxiliary switch is normally used to open the trip circuit when the circuit breaker is opened. As this multi-stage switch operates from the breaker disconnect blades, circuitry dependent on the position of the breaker, such as indicator lights, etc., is wired through this switch. The individual stages are easily converted to "a" or "b" without disassembling the switch (Fig. 10).

TRIP SOLENOID

Normal electrical tripping (opening) is caused by the trip solenoid (17, Fig. 8) which is designated 52TC on the schematic of Fig. 9. The trip solenoid is energized by operation of the circuit breaker control switch or the protective relays which are mounted on the switchgear.

CAPACITOR TRIP DEVICE

A capacitor trip device is commonly used with circuit breakers having an ac control supply installed in remote locations or unattended substations where battery cost and maintenance are undesirable.

In these cases, the capacitor trip device may be charged from the same stepdown transformer that is used to energize the breaker control. This stepdown transformer should be connected to the LINE side of the breaker.

To apply the capacitor trip device to existing breakers originally shipped with dc trip coils, contact your Siemens-Allis sales representative.

CIRCUIT BREAKER OPERATION

Normal -- Normal circuit breaker operation is controlled by cubicle mounted controls or other control devices. The closing springs of stored energy operated breakers will charge as soon as the breaker control is energized. Check the motor cutoff adjustment (Page 31) if springs do not charge.

Opening Breaker -- Stored energy operated breakers can be tripped manually by depressing the trip rod (44, Fig. 4b), or electrically by energizing the trip circuit. This rotates the latch that allows the closing linkage to collapse and reset.

Closing Breaker -- When the springs of a stored energy operated breaker are fully charged, it can be closed by pulling the manual close pull rod (46, Fig. 4b), or electrically by energizing the closing circuit. This rotates the latch that allows the springs to close the breaker.

Reclosing Control (Optional -- For Reclosing Applications Only)

The trip latch check system provides the necessary control to perform the reclosing function when the switchgear is equipped with reclosing relays.

The system is comprised of three elements; a magnetic actuator, a non-contacting magnetically operated hall effect switch (sensor) and a timer module. The system performs two distinct functions prior to enabling the reclosing operation.

1. It senses that the trip latch has returned to its reset position, and is ready to receive a reclosing operation.
2. Imposes a delay following latch reset to insure the linkage assembly has fully reset and then applies power to the spring release coil.

The non-contacting magnetically operated Hall effect switch and magnet actuator combine to perform proximity detection of the trip latch tail. The speed of operation and life expectancy of this proximity sensor system is not limited by mechanical actuation as no physical contact between the actuating magnet and Hall switch exist. The switch consists of a Hall sensor, trigger, and amplifier integrated on a silicon chip. Its complete encapsulation isolates the device from environmental effects.

STORED ENERGY OPERATOR DESCRIPTION OF OPERATION

SPRING CHARGING CYCLE

Energization of the Breaker Control Circuit will cause the spring charging motor (1, Fig. 7) to start charging the closing springs (6, Fig. 7). The spring charging motor (1) will drive the driving pawl (2, Fig. 6) through an eccentric drive shaft (3, Fig. 6). The driving pawl (2) will turn the ratchet wheel (4, Fig. 6) counterclockwise one tooth at a time. The holding pawl (5, Fig. 6) will hold the ratchet in position between driving strokes of driving pawl (2). This charging operation will continue turning the ratchet wheel (4) counterclockwise a tooth at a time until the closing springs (6) are fully charged (dead center). The motor will drive the ratchet wheel past this dead center position and the closing springs (6) will aid rotation driving the ratchet wheel and cams counterclockwise until spring release rollers (8, Fig. 8) on the inside surfaces of cams (7, Fig. 8) engage the spring release latch (9, Fig. 7). This arrests the motion of the ratchet wheel (4) and the cams (7) and holds the operator in the fully charged position. As the cams and ratchet wheel go over center, the motor cutoff switch (10, Fig. 6) is actuated to de-energize the spring charging motor (1). The spring charging motor then coasts to a stop, driving pawl (2) oscillating freely in the smooth toothless section of the ratchet wheel.

The motor cutoff switch (10) has four functions:

1. It de-energizes the spring charging motor (1);
2. It opens a contact in the anti-pump relay circuit;
3. It sets up the closing coil circuit;
4. It can be used to energize an indicating light to indicate that the closing springs (6) are fully charged.

NOTE:

The close latch check switch (16, Fig. 6) is in the motor circuit. The close latch check switch monitors the position of the close latch (9) and will prevent charging of the closing springs (6) electrically unless the close latch (9) is in the correct position.

As energy is stored in the closing springs, the four bar linkage (12, Fig. 7) will be positioned by the linkage reset spring (11, Fig. 8) which acts to cause cam follower rollers (14, Fig. 7) to follow the surface of cam (7, Fig. 8) until the links are in a reset position, and allowing latch rollers (20, Fig. 7) to be positioned in front of trip latch (18, Fig. 7).

See Fig. 5 for sequence of operation.

RECLOSING CONTROL (Optional – For Reclosing Applications Only)

The electronic solid state time delay module works in concert with the trip latch check system. The time delay module consists of an electronic timer and an electro-magnetic relay. The elementary diagram, Fig. 9 shows the timer module receiving power between terminals 1 and 3. Terminal 3 is tied to the common side of the closing control source. Terminal 1 is tied to the high side of the closing control source thru auxiliary contact (52B) and the closing source contact "CSC".

The time delay module is not energized until the breaker is charged, open and the closing source switch "CSC" is closed. With the latch reset at the instant "CSC" closes, the timer module's internal relay switch normally open contact operates with no intentional delay (40ms electro-mechanical delay) to connect the spring release solenoid thru timer module terminal 2 to the high side of the closing source initiating the breaker's closing sequence.

If at the time the closing source is applied, the trip latch is not reset, the timer module will assume a delaying mode of operation. Upon latch reset a predetermined delay will be imposed before the timer's relay closes energizing the spring release solenoid. The complete trip latch check system is not affected by broad variation of closing source voltage. The time delay error caused by temperature extremes of -40° to 65° C is a minus 3% to plus 5%.

BREAKER CLOSING CYCLE

Energizing the spring release solenoid (13, Fig. 7), will drive the spring release latch (9, Fig. 7), away from the spring release rollers (7, Fig. 8), on the cams (7, Fig. 7), releasing the stored energy in the closing springs (6, Fig. 7). The closing springs (6) will drive the ratchet wheel (4, Fig. 6), and the cams (7, Fig. 7), counter-clockwise at a high rate of speed. The cams (7) will engage the cam follower rollers (14, Fig. 7), of the four bar linkage (12, Fig. 7), and drive them forward causing the four bar linkage to become straight. As the four bar linkage (12) becomes straight, it drives the radius arm (15, Fig. 7), upward causing the breaker contacts to close and the opening springs to be charged. The cams (7) drive the four bar linkage (12) over toggle and against the frame thereby latching the breaker contacts in the closed position.

SPRING RECHARGE AFTER CLOSING

When the closing cycle has been initiated and the cams (7, Fig. 8), begin to turn, the motor cutoff switch (10, Fig. 6), resets itself. A "b" aux. switch of the breaker opens de-energizing the spring release solenoid (13, Fig. 7). The spring release latch (9, Fig. 7), returns to its reset position and the close latch check switch (16, Fig. 6), closes and energizes the spring charging motor (1). The closing springs (6) are then recharged as described earlier.

TRIPPING CYCLE

Energizing the trip solenoid (17, Fig. 6), will drive the trip latch (18, Fig. 6), away from latch roller (20, Fig. 7), on the four bar linkage (12, Fig. 7). This allows the four bar linkage to collapse and the breaker contacts will open. If the closing springs (6) are in the charged position, the linkage reset

spring (11, Fig. 8), will immediately reset the four bar linkage (12). If the closing springs (6) are not charged, the linkage reset spring (11) will not reset the four bar linkage (12) until just before the closing springs (6) are completely charged.

ELECTRICAL CONTROL

Schematic

The normal control for this operator is contained in a control panel mounted at the rear of the unit. It consists of the motor cutoff switch (10, Fig. 6), anti-pumping relay (30, Fig. 6), and the close latch check switch (16, Fig. 6). The control arrangement schematic diagram is shown in Fig. 9.

Spring Charging

The spring charging motor power is supplied through terminals 3 and 4, Fig. 9. The mechanical interlock is a switch operated by the breaker release lever (foot lever) which opens the motor circuit when the lever is depressed. The close latch check switch is closed when the close latch (9, Fig. 6) is in the reset position. The 88 switches are shown with the closing springs discharged. When the control is energized, the motor starts to charge the springs. The 88 switch is operated by a roll pin striker (37, Fig. 6) mounted in the ratchet wheel (4, Fig. 6). As the ratchet wheel and drive blocks charge the springs, the ratchet wheel revolves to the position of full compression, dead center. Beyond dead center position, the springs aid rotation and cause the motor cutoff switch striker to depress the actuator (35, Fig. 6) of the 88-1 switch, opening the motor circuit and the 88-3 contact in the anti-pumping relay circuit. The spring charging motor coasts to a stop with the driving pawl (2, Fig. 6) oscillating freely on the smooth portion of the ratchet wheel.

Closing

The standard control schematic for a stored energy operator is shown in Fig. 9. When the close control switch is closed, the circuit from terminal 7 through 88-2 and 52Y1 to 52B to terminal 6 energizes the closing coil, closing the breaker.

As soon as the closing springs are discharged, the 88-3 switch contact closes to energize the 52Y relay. If the close control switch remains closed, the 52Y relay remains picked up through contact 52Y2. Control switch has to be released to reset control for another closing operation. This forms the anti-pumping relay circuit which prevents the circuit breaker from reclosing immediately after a trip free operation. If control power is momentarily lost during closing, upon re-energization, the 52Y relay picks up instantaneously through contact 88-3 maintaining the anti-pumping relay circuit prior to complete spring charging.

Close Latch - Mechanical and Electrical Interlocks

The close latch (9, Fig. 7) must be fully reset to receive the cam mounted spring release rollers at the end of the charging cycle. To insure the close latch is in this fully reset position, an electrical and mechanical interlock is provided.

The close latch check switch (16, Fig. 6 and 14) consists of a snap-action type switch mounted in close proximity to the close latch. A striker plate at the tail of the close latch engages the switch's actuator slightly before the fully reset position is achieved and actuates the switch prior to the latches reaching the fully reset position. At the time of actuation, a contact closes initiating the charging sequence. The switch operates with very small differential, and this sensitivity coupled with the close latch biased engagement of the spring release rollers provides a positive sensitive interlock.

The mechanical interlock (Fig. 16) prevents charging of the springs if the close latch is not adequately reset. A linkage attached by a clevis to the close latch, extends down the side of the breaker frame to the driving pawl mechanism. An extension of the interlock linkage passes above the driving pawl constant force return spring. If the close latch fails to return to a fully reset position, the linkage extension thrusts the driving pawl's return spring downward preventing the driving pawl's engagement of the ratchet wheel, thus mechanically inhibiting either manual or electrical spring charging.

ADJUSTMENTS

Adjustable items are factory set and checked before and after numerous mechanical operations on every breaker to insure correctness. No adjustment checking should be necessary on new breakers. If a malfunction occurs, check for hidden shipping damage.

The following will help you make the correct adjustments when replacing a broken or worn part.

CIRCUIT BREAKER TIMING

A comparison of circuit breaker timing at any period of maintenance with that taken when the breaker was new will indicate the operational condition of the breaker mechanism. The normal closing and tripping tolerances are given in Item 15 on Page 3. If operation exceeds these tolerances, a maladjustment or friction is indicated.

AUXILIARY SWITCH

The type Q-10 auxiliary switch (Fig. 10) is designed so that the individual contacts may be repositioned in fifteen degree steps without disassembling the switch.

Using long-nosed pliers, move the rotor contact (16) in the slot of the shell (14), compressing spring (15). This will free the rotor from the retainer (17). Rotate the rotor to the desired position and release. Be sure the rotor springs solidly back against the retainer to fully engage the rotor and retainer teeth.

INTERLOCK PLUNGER

The foot lever breaker release (17, Fig. 4b) operates the interlock plunger (18, Fig. 4b) as well as the trip latch. Depressing the lever trips the breaker and raises the plunger. This frees the breaker so that it can be moved in its cubicle. The interlock system is in proper adjustment

when the plunger is positioned 1-11/16 to 1-13/16 inch (42.9-46mm) above the floor line, and causes tripping of breaker contacts when it is raised to a level not more than 2-1/16 inch (52.4mm) above the floor line. The latch tripping rod associated with the foot lever should be clear of the trip latch by up to 1/32 inch (0.8mm) maximum in the relaxed position (18, Fig. 6).

The foot lever can be padlocked by matching holes in the breaker frame with those in the lever arm. In the padlocked position, the foot lever will be halfway down; the breaker will be trip-free; the interlock plunger will be between 2 and 2-1/4 inches (50.8-57.2mm) from the floor line and will hold the breaker in any of the three positions within the cubicle.

TRIP LATCH ADJUSTMENTS

Trip Latch Clearance – To change the clearance between the trip latch and trip latch rollers. The “stop bar” (143, Fig. 4B) height adjustment will accomplish this purpose. Loosen “lower link stop”, (36, Fig. 11) and rotate to permit maximum “lower trip link” movement. Adjust “stop bar” height as follows:

TRIP LATCH CLEARANCE (Fig. 11)

1. First determine that .030 to .060 (0.76 to 1.52mm) clearance exists between plate (22, Fig. 3) and stop washers (54, Fig. 3) on bottom of vacuum interrupters with breaker open. (Note that this clearance is measured on different screws than distance “A”.) If this clearance is less than specified, and the gap between the latch and latch rollers is less than .030 to .060 (0.76 to 1.52 mm) proceed as follows:
 - 1.1 Loosen jam nut (146, Fig. 46).
 - 1.2 Rotate stop bar (143, Fig. 46) to rotate radius arm and four bar linkage until the .060 (1.52mm) gap is obtained over the stop washers (54, Fig. 3). This adjustment should also bring the latch and latch rollers within the specified tolerance. Retighten jam nut (146, Fig. 46).
 - 1.3 If after step 1.2 the setting of the lower link stop (36, Fig. 11) prevents the latch roller link from rotating sufficiently to achieve the required .030 to .060 (0.76 to 1.52mm) gap, readjust the lower link stop to the proper position.
2. If the gap over the stop washers (54, Fig. 3) in step 1 above is within tolerance, and the latch to latch roller gap is over .060 (1.52mm), it may be adjusted to tolerance by rotating the lower link stop (36, Fig. 11).

CAUTION

THE OPENING STOP NUTS UNDER STOP WASHERS (54, FIG. 3) SHOULD NORMALLY NOT BE ADJUSTED IN THE FIELD UNLESS A NEW VACUUM INTERRUPTER ASSEMBLY IS BEING INSTALLED ON THE CIRCUIT BREAKER.

Trip Latch Bite – Trip latch bite is established by setting the latch tail top surface 5/16” (7.9mm) below surface of self-clinching nut as shown in Fig. 20. Lock securely with jam nut. One turn of adjusting screw will alter the gap 0.062 inches (1.57mm). This setting will produce a latch bite of 0.259 to 0.111 inches (6.58 - 2.82mm) as shown.

TRIP LATCH CHECK SENSOR ADJUSTMENTS (Fig. 20A and 20B)

The magnetically operated hall effect switch (sensor) and actuating magnet are to be pre-assembled to the operator. The unit is to be adjusted by advancing the threaded bushing through the tapped hole until a gap of .040 - .000 + .015 (1.02 - .00/+ .38mm) is achieved between the surface of the switch and the top of the shrink tubing holding the magnet actuator assembly to the trip latch. With this gap achieved, the sensor may be locked in place.

Functional electrical test on breaker may be made to confirm sensors operation. The timing modules nameplate and rated voltage should be checked to insure it matches breaker closing control voltage. The timers delay adjustment has been previously set and should not be altered. Removed wire from terminal 2 on timer module and insulate. Open breaker and charge opening springs.

Apply closing voltage and observe light emitting diode (led) adjacent to delay adjustment. The led should be brightly illuminated when the trip latch is fully reset. Depress latch with manual trip lever and observe the led goes out. Release trip lever and the led should come on. This sequence confirms sensor operation. Do not apply closing control voltage for longer than two minutes while performing the test.

MANUAL CHARGING OR CLOSING SPRINGS

To charge the closing springs manually, disconnect control power before inserting the manual charging crank in the socket located in the center of the left hand operator panel. Turn the crank in a counterclockwise direction to charge the springs. The effort to charge the closing springs will fluctuate and will increase to a peak and then decrease. At the point of least effort an audible click will be heard and the effort to turn the crank will drop to near zero. The mechanism is now fully charged. Remove manual charging crank. The breaker may be closed by pulling the manual close pull rod.

CAUTION!!

MAINTAIN A FIRM GRIP ON CRANK

The closing springs are charged through the driving pawl and ratchet wheel and are thereby indexed by the holding pawl. Some springback can occur between tooth positions on the ratchet wheel.

REMOVAL OF CLOSING SPRINGS

The Closing Springs may be quickly and safely removed from the breaker. Remove two of the four bolts holding the spring bearing block at the rear of the breaker. These bolts should be diagonally opposite each other. Insert studs approximately 6" (150mm) long in place of bolts. Remove the remaining two bolts by shifting the spring load to the 6" (150mm) long studs. The spring bearing block can then be backed off by alternating backing off the studs. To install the closing springs the reverse procedure should be used. The spring bearing block top surface should be even with the bracket of the frame. The four bolts should be torqued to 50 ft. lbs. (67.8 N·m).

CAUTION: Handle this assembly carefully - do not throw or drop.

If the charging ratchet and cams are to be revolved with springs removed, it is advisable to remove two aluminum spring drive blocks (Item 38, Fig. 8) secured to the ratchet and cam crankpins by retaining rings. These drive blocks if not removed or held essentially in a horizontal position may jam while revolving the cam and ratchet assembly.

Motor Cutoff Switch — The 88 motor control switch assembly (Fig. 13) is factory adjusted. If it should become inoperative, the entire unit must be removed and inspected. Replacement may be necessary.

Motor Cutoff Switch Adjustment — This adjustment is most conveniently performed before installing the charging springs.

Advance ratchet and cam assemblies to position shown (Fig. 13). The back up pawl must occupy the ninth (9) tooth position on the ratchet as counted counterclockwise from area on ratchet periphery which lacks two teeth.

With ratchet in the position described above, adjust the motor cutoff switch vertically until its actuator makes positive contact with the "rollpin striker." Lock switch assembly in this position.

Check lateral movement of actuator. Lateral play at end of actuator (tip) should be no more than $1/16$ " (1.6 mm) max. If adjustment is necessary, snug pivot screw to just bind actuator, and then back off $1/16$ to $1/8$ turn. Rotate ratchet and cam assembly to insure actuator rides in gap between ratchet and cam without striking or binding.

Close Latch Bite Adjustment — free jam nut and place latch in horizontal position (Fig. 15). Visual accuracy. Measure "D" directly above latch pivot. Reproduce this dimension plus 0.062 " (1.6 mm) at the latch face as shown in the figure above by rotating the adjustment screw. Secure jam nut. This adjustment should produce a latch bite of 0.151 to 0.216 inches (3.8 - 5.5 mm).

Close Latch Check Switch Adjustment (Fig. 15) — This adjustment is to be performed only after completing the latch bite adjustment described above.

A clearly audible "click" should be heard from the switch with latch spaced $1/32$ " (0.8 mm) from latch adjustment screw. The latch switch actuator may be bent slightly to obtain switch operation at this point. Maximum permissible bend is $1/8$ " (3.2 mm) as shown.

If switch actuator is bent, observe latch fully closed against adjusting screw and make certain the switch actuator has not contacted the switch body. A $1/64$ " (0.4 mm) clearance should exist as shown in Fig. 15.

Free Height Adjustment (Fig. 16) — is achieved by blocking the actuating roller to the indicated height and adjusting a pair of jam nuts, located on the manual closing pull rod, to maintain the roller in this position with blocking removed. Return spring adjusting nut should be set to produce $0.5 \pm .06$ inch (12.7 ± 1.6 mm) deflection in return spring.

The following adjustments are to be made only after completing the close latch bite adjustment described on the previous page and after adjusting connecting link as shown on Fig. 16.

Trip Adjustment (Fig. 16) is made by varying the penetration of the "curved actuating rod" in its attachment clevis. A $5/16$ " (7.94 mm) drill is placed between the upper latch surface and the latch adjusting bolt. A 2.906" (73.81 mm) block is to be inserted between the actuating roller and floor. The "curved" rods upper yoke is nested against a forward roll pin in the closing latch and the lower clevis is adjusted to insure the closing latch will not move more than $1/16$ (1.6 mm) inches as measured between adjusting screw and latch surface when the $5/16$ " (7.94 mm) drill is removed.

Overtravel (Fig. 16) — no adjustment required. Check with 3.125" (79.4 mm) blocking below actuating roller. Closing solenoid link should provide freedom of latch movement without jamming.

Close Latch Mechanical Interlock — this adjustment is to be undertaken only after completing the close latch bite adjustment described above, Fig. 15.

Adjust actuator rod displacement from support angle to $1.06 \pm .015$ inches (27.0 ± 0.4 mm). See detail of adjusting nut "A" (Fig. 17).

Insert a $1/4$ " (6.35 mm) drill between upper surface of close latch and latch adjustment screw.

Check guide bushings to insure they stand off the frame $1/4$ " (6.4 mm) as shown.

Free Nut "B" below attachment clevis, and adjust Nuts "B" and "C" to depress pawl return spring and pawl until 1/16 to 3/32 (1.6 - 2.4 mm) clearance is obtained between tip of pawl and ratchet teeth. This clearance is measured during the clockwise rotation of the pawl as its tip is toward the ratchet (power stroke).

MAINTENANCE

General

Thorough, periodic inspection is important to satisfactory operation. Inspection and maintenance frequency depends on installation, site, weather and atmospheric conditions, experience of operating personnel and special operation requirements. Because of this, a well-planned and effective maintenance program depends largely on experience and practice.

Prior to performing any maintenance work, make certain all control circuits are open, and that the breaker has been completely withdrawn from the metal-clad unit.

CAUTION

DO NOT WORK ON THE BREAKER OR OPERATING MECHANISM WHILE THE BREAKER IS IN THE CLOSED POSITION. DO NOT WORK ON THE BREAKER OR OPERATOR WHILE THE CLOSING SPRINGS ARE CHARGED.

Always inspect a breaker which has interrupted heavy fault current.

All current carrying joints should be inspected to be sure all contact surfaces are free of protrusions or sharp plane changes.

Contact Erosion

A visual check of distance "A" Figure (3) with breaker closed will indicate the contact erosion. When the distance measures within .030 to .015 inches (.8 to .4mm) the interrupter assembly should be replaced. Intermediate adjustment is not recommended.

Interrupter Vacuum

CAUTION!!

OBSERVE THE FOLLOWING ITEMS WHEN HI-POTTING THE VACUUM INTERRUPTERS.

A hi-pot test should be applied to the open interrupter contacts of each phase. The voltage should be raised gradually, and the contact gap should sustain 27kV 60Hz ac, or 38kV dc, for one minute for each phase.

Hydraulic Shock Absorber

The pneumatic puffer-shock absorber assemblies of the air-magnetic circuit breaker mechanism have been replaced by a hydraulic shock absorber (138, Fig. 4b) and a stop bar (143, Fig. 4b) on the vacuum circuit breaker. The shock absorber should require no adjustment unless an entire vacuum interrupter assembly is being replaced. However at maintenance checks the shock absorber should be examined for evidence of leaking. If evidence of fluid leakage is found, the shock absorber must be re-

placed to prevent damage to the vacuum interrupter bellows. Check to determine that shock absorber (183) is not bottoming in either the open or closed positions by following "S" dimension (Fig. 46) below:

	S MIN.	S MAX.
Breaker closed	0.955	1.25
Breaker open	.100	.295

Add or subtract a shim as necessary to meet specified "S" dimension.

CAUTION

BEFORE ATTEMPTING FIRST CLOSING OPERATION OF BREAKER MAKE SURE THAT THE "S" DIMENSION IS WITHIN ITS MINIMUM AND MAXIMUM VALUES AT OPEN POSITION OF BREAKER.

Opening and Closing Time:

Closing time range .042 to .062 seconds

Opening time range .018 to .025 seconds

Mounting and adjusting hardware should be checked for tightness. Elastic stop nuts indicated by arrows in Fig. (3) should not be turned, as indicated by the "Note".

Interrupter Replacement

Replacement interrupters are furnished only as complete assemblies as shown in Fig. (3). This eliminates the need for special field assembly fixtures and avoids the risks of inadvertent damage to the vacuum interrupter bellows by field assembly.

It is recommended that one interrupter assembly be removed and replaced completely rather than removing two or more interrupters at a time. This procedure will help retain the factory set alignment at the primary disconnect bushings. Following is a step-by-step procedure for exchanging an interrupter assembly. Refer to Fig. 4a.

1. Remove hinged panel assembly (60) from the circuit breaker, after discharging springs and tripping breaker.
2. Remove hardware from the upper end of insulator bar (21) and pull insulator bar away from interrupter.
3. Loosen clamping bolt through copper bushing at the fixed end of the vacuum interrupter.
4. Loosen locking nuts (49) and (50) on adjusting screw (13).
5. Remove pin (47) at radius arm and turn adjusting screw for maximum engagement.
6. Remove .50 X 4.00 (12.7 x 101.6mm) Lg. Bolt as shown in view AA. Remove contact (15) and bar (14).
7. At this time the interrupter assembly may be moved downward to release the fixed terminal from the breaker bushing. It may be necessary to use a wedge in the clamping slit at the breaker bushing to release the interrupter.
8. Remove the pivot (12) the adjusting screw (13) with nuts (49) and (50) and reassemble to the new interrupter assembly.

9. Place spacer (36) or (98) on the fixed terminal of the new interrupter assembly and insert the fixed terminal into the hole in the breaker bushing while guiding pivot (12) into the channel of the radius arm. Pin at pivot with (47). Grease pins before assembly. Connect shock absorber.
10. Assemble Items (14) and (15) clamping the flexible conductor furnished with the interrupter assembly between them. The end of the flexible terminal should be flush with edge of (14) and (15).
11. Assemble insulator bars (21) to stud support (25).
12. Charge and trip-closed operating mechanism. Adjust (13) to produce a 1.370 inch dimension between plates (22) and (23), lock (13) by tightening lock nuts (49) and (50), lock (50) to pivot (12) first.
13. Tighten clamping bolt at fixed terminal.
14. Repeat the above steps on the other phases, if more than one interrupter assembly is being replaced.
15. Check to determine that the shock absorber is not bottoming, in either the open or closed positions. The position of the shock absorber assembly may be adjusted by varying the number of shims (164, Fig. 4b).
16. Operate the circuit breaker 50 times, then check and readjust for the 1.370 inch dimension as described in Step 12.

CAUTION

ONLY NEW REPLACEMENT INTERRUPTERS SHOULD BE READJUSTED TO 1.370 inch (34.8 mm) DIMENSION. INTERRUPTERS WITH CONTACT ERROSION SHOULD NEVER BE READJUSTED.

- 16A. The replacement procedures listed above, (replacing and adjusting one interrupter assembly at a time) should maintain the required open gap on the interrupter assemblies by reference to the the two remaining assemblies. If for any reason the adjustment on all assemblies is lost, it will be necessary to measure between a fixed portion of the underside of the interrupter assembly and the moveable stem to determine that the change in this measurement from contact closed to contact open position is on all interrupters within the range of 0.72 to 0.78 inch (19.3 to 19.8 mm).
17. Reassemble the hinged panel to the circuit breaker.
18. Hi-Pot the vacuum interrupters.
19. Verify the opening and closing times.
20. Recheck primary disconnect stud alignment with respect to other phases and floor. A slight adjustment of eye bolt at bottom of support bar (21) may be required to restore alignment. Adjustment of insulator support structure between studs is not recommended in field.

Mechanism - Stored Energy Operator

The circuit breaker mechanism should be inspected at 2000 operation intervals. This inspection should check for loose hardware and any broken parts. The control wiring should be checked

for loose connections and frayed or damaged insulation. The "close latch check switch", "trip latch check switch" (if possible), and "mechanical interlock" switch should be checked for mounting tightness. The satisfactory operation of each switch element should be assured with a continuity meter and manual manipulation of the switching element, and adjusted if necessary.

After 10,000 operations, the operating mechanism should be given a general overhaul and all worn parts replaced. Excessive wear will usually be indicated when adjustments can no longer be satisfactorily made. The general overhaul will require disassembly of the operating mechanism. All bearings and surfaces receiving wear should be examined carefully and relubricated in accordance with lubrication instructions which follow.

Closing Spring Removal

The removal of closing springs will be necessary in order to permit general overhaul of the breaker. These springs may be removed as described on Page 10.

Lubrication

NOTE: The lubricant supplied with the accessories is intended to be used exclusively on the contacts and must not be used on any part of the circuit breaker mechanism.

Recommended circuit breaker lubrication points are shown in Figure 4a and 17. The chart (Fig. 18) outlines two methods of lubrication. Refer to this chart for recommended lubricant and points of application. The first method requires no disassembly and is suggested for the prevention of problems which could be created by severe environmental or operating conditions.

The second method follows procedure similar to that performed on the breaker at the factory. Follow this procedure only in case of a general overhaul or disassembly.

Method for Cleaning Bearings

Needle and roller bearings are factory lubricated for life and should not require attention. However, the best of greases are affected by time and atmospheric conditions and may require service.

To lubricate these bearings when parts are disassembled, the following procedure is recommended. Clean in solvent, wash in alcohol, spin in light machine oil, drain and repack with Beacon P-325 grease.

DO NOT REMOVE NEEDLE BEARINGS FROM
THE RETAINING PART

HANDLING INSTRUCTIONS

- Move breaker to installation location with fork lift or crane (A).
- Carefully remove protective plastic cover or crate.
- Remove ramp pieces nailed to the pallet at the front of the breaker (B).
- Remove hold down bolts located on each side of breaker (C).
- Place ramp pieces in front of the pallet in line with breaker wheels and nail to pallet as shown by arrows in (D).
- Slowly roll breaker off pallet (E & F).

CAUTION – REMOVE PACKAGING. BREAKERS ARE SHIPPED IN CLOSED POSITION WITH THE TRIP ROD AND FOOT LEVER ENCLOSED BY PACKAGING TO PREVENT OPENING DURING SHIPMENT.

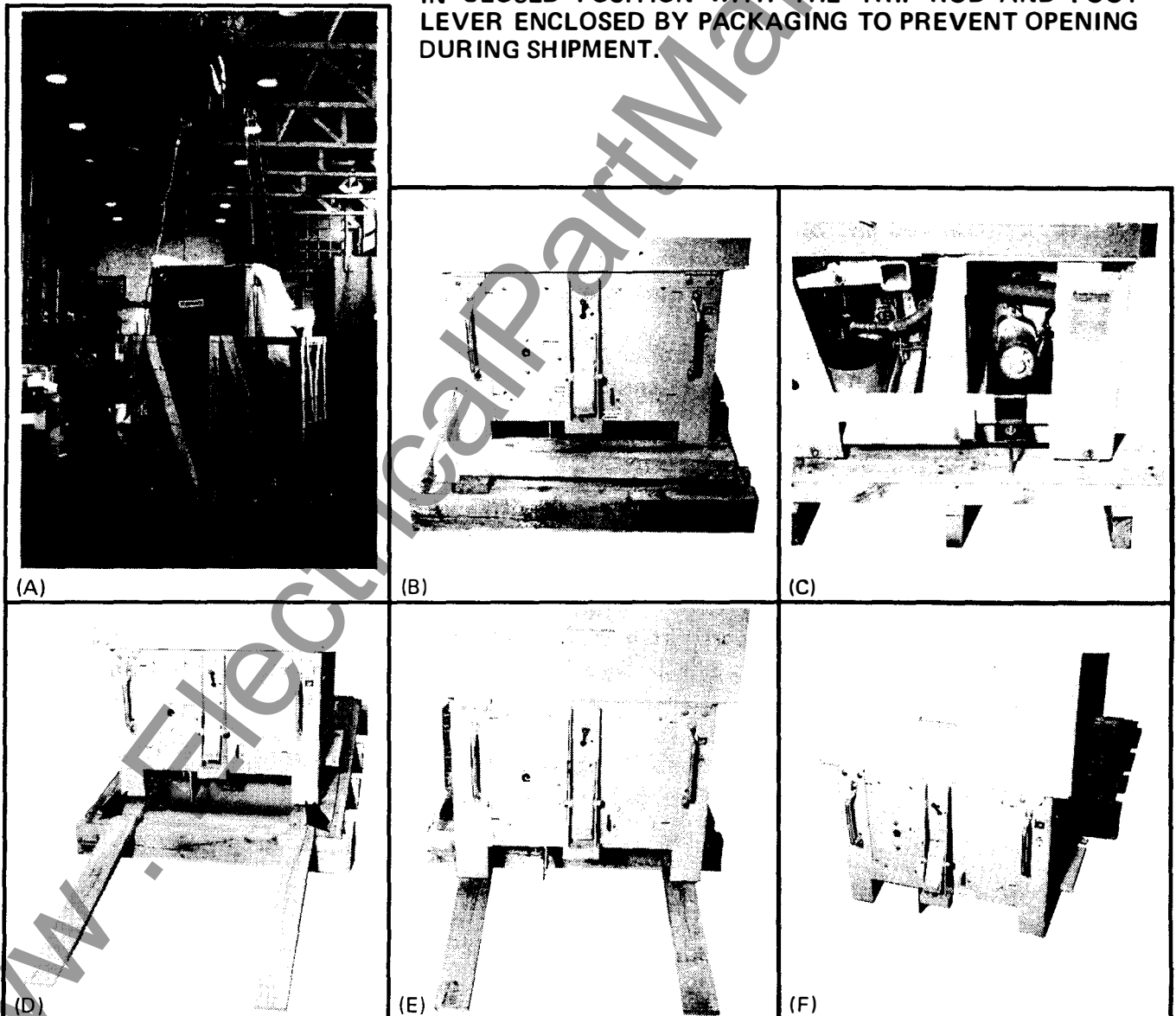


Fig. 1 – Circuit Breaker Handling Instructions

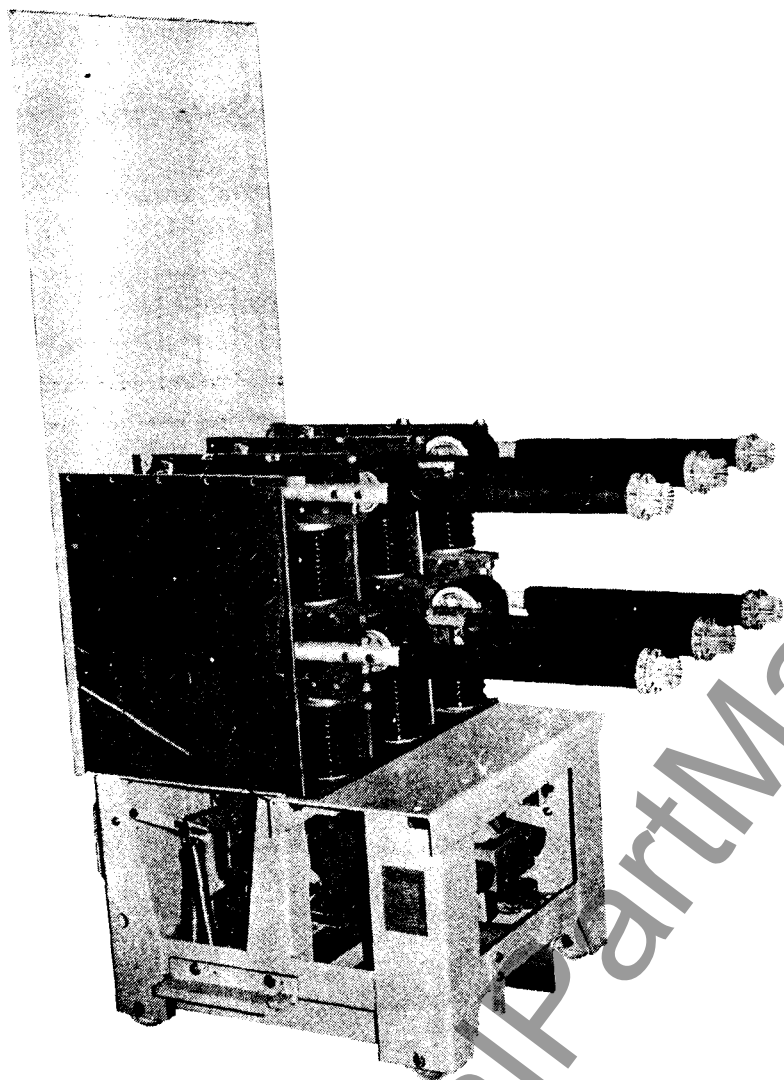


Fig. 2a — Typical FCV-500
Vacuum Circuit Breaker

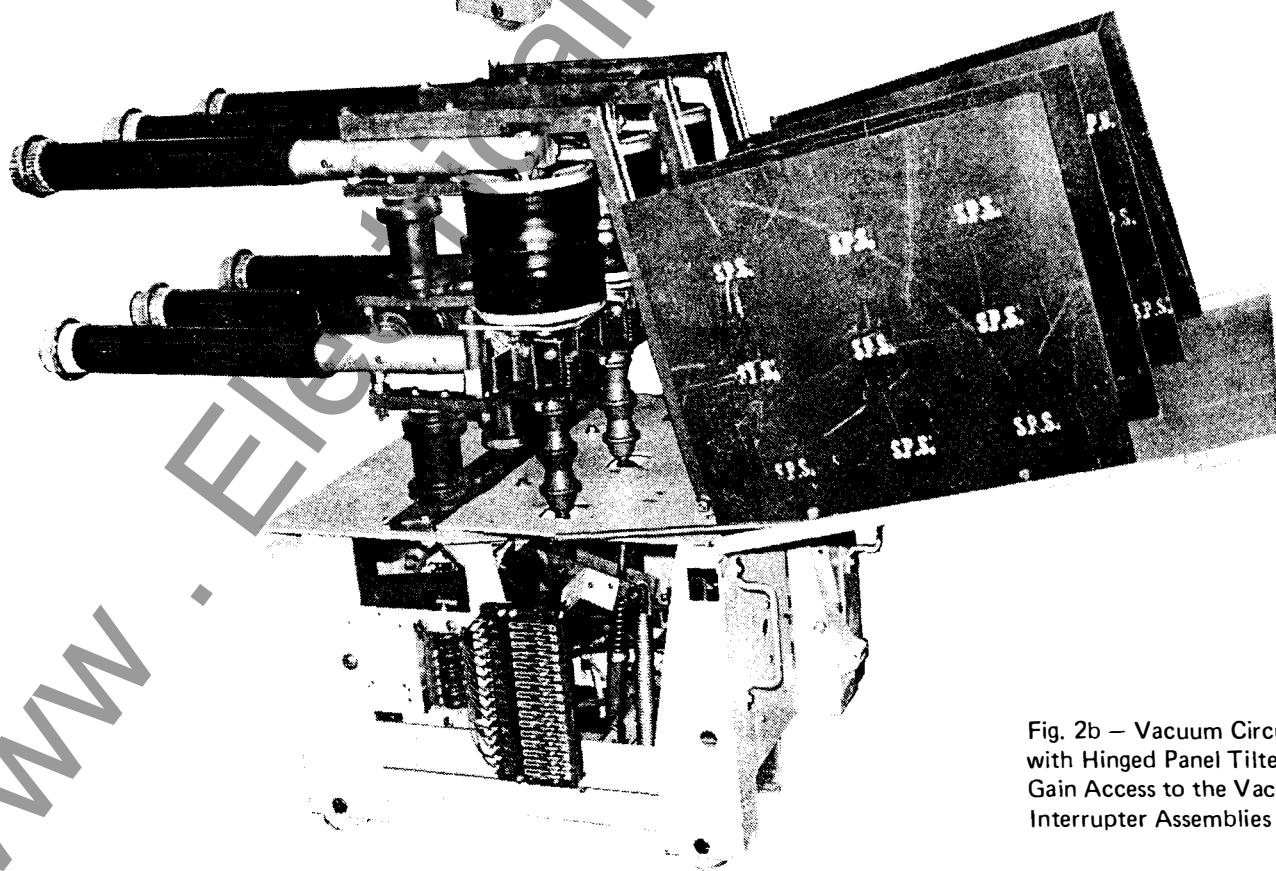


Fig. 2b — Vacuum Circuit Breaker
with Hinged Panel Tilted Back to
Gain Access to the Vacuum
Interrupter Assemblies

VACUUM CIRCUIT BREAKER

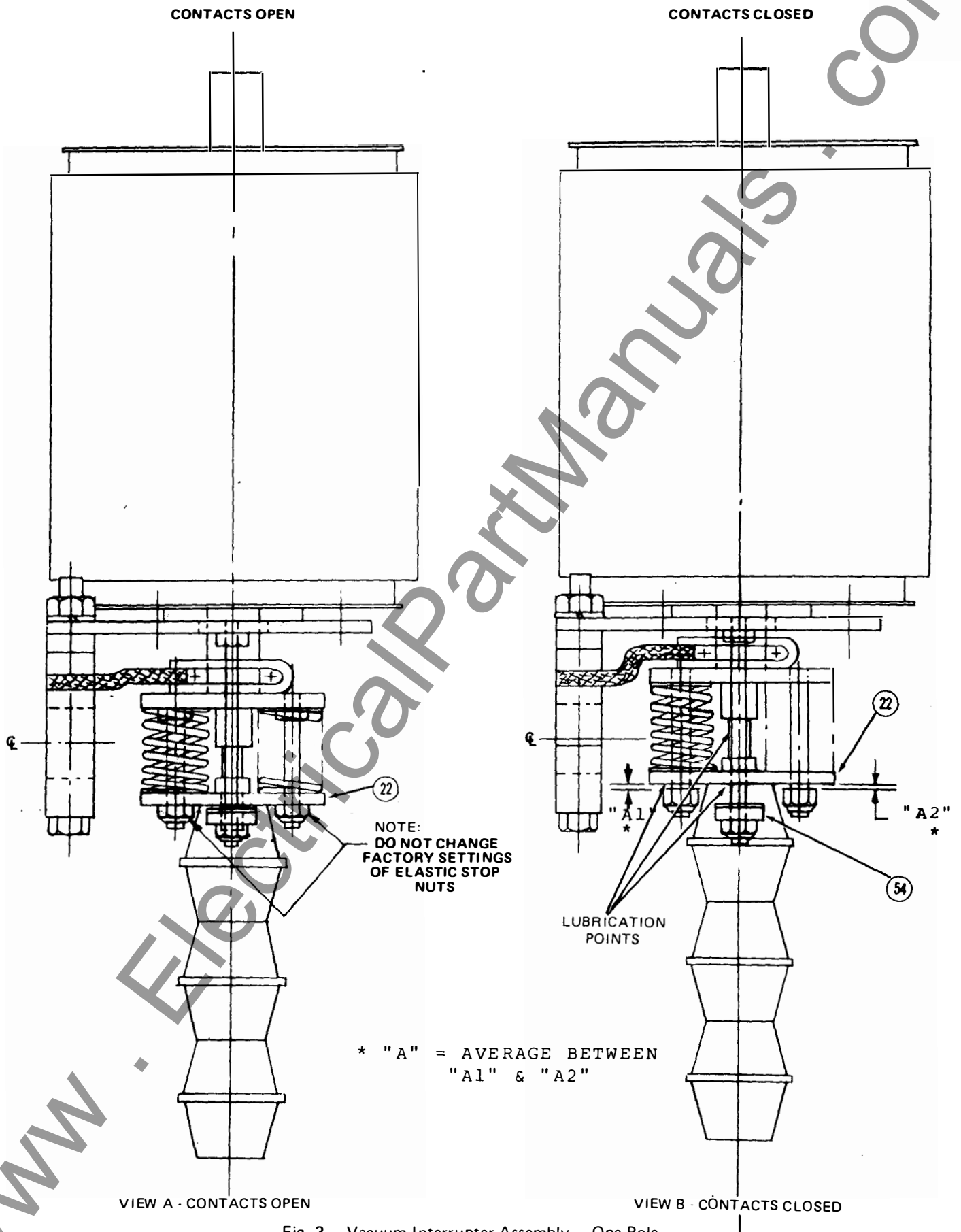


Fig. 3 - Vacuum Interrupter Assembly - One Pole

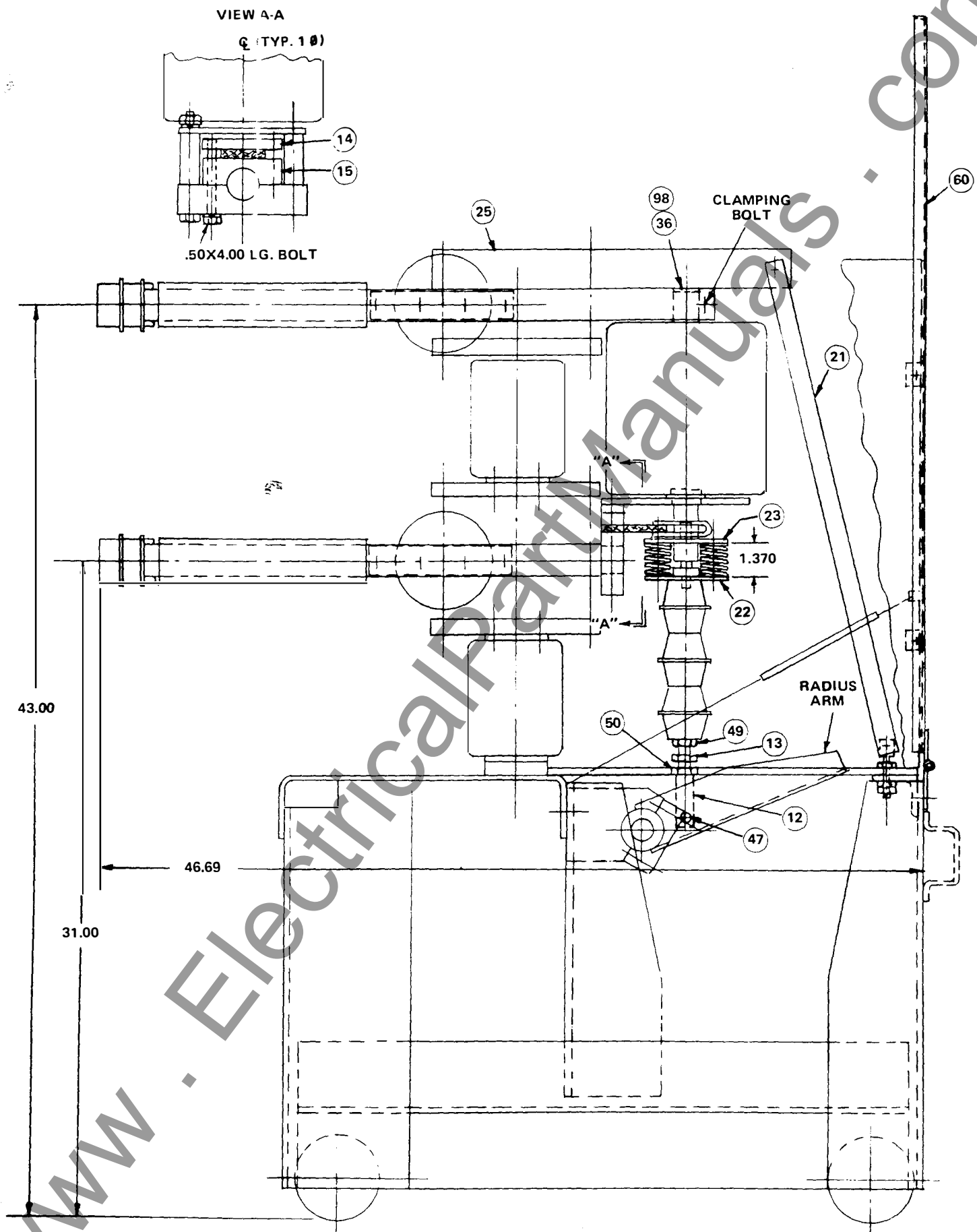


Fig. 4a - Side View of Vacuum Circuit Breaker (Shown with Contacts Closed)

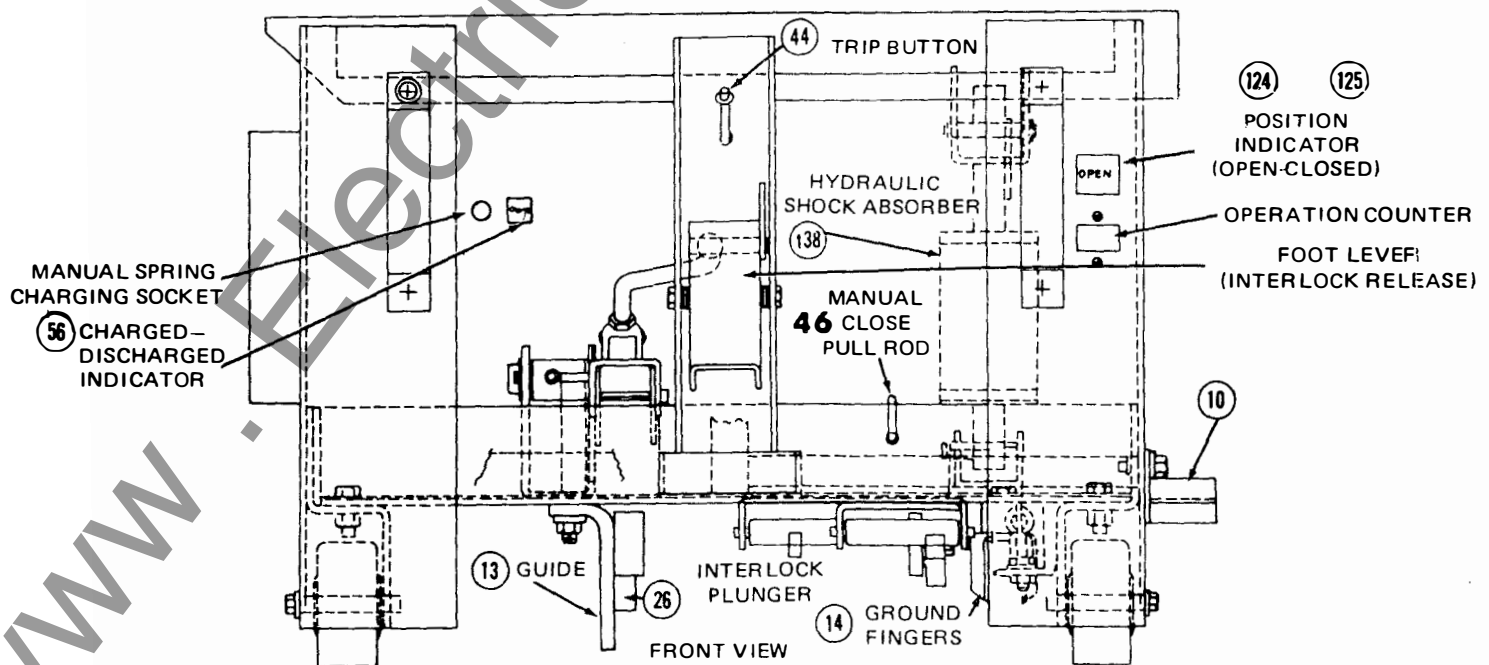
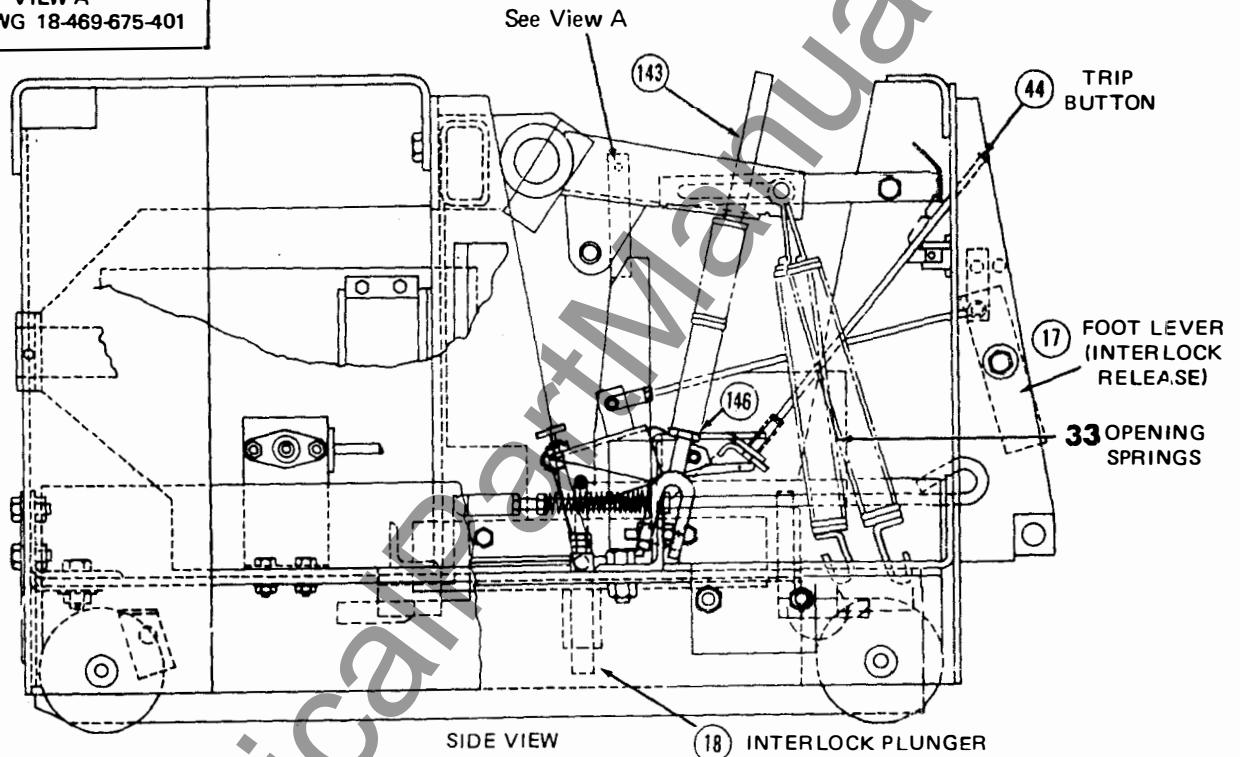
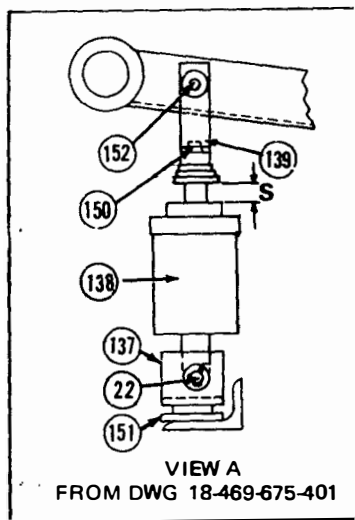
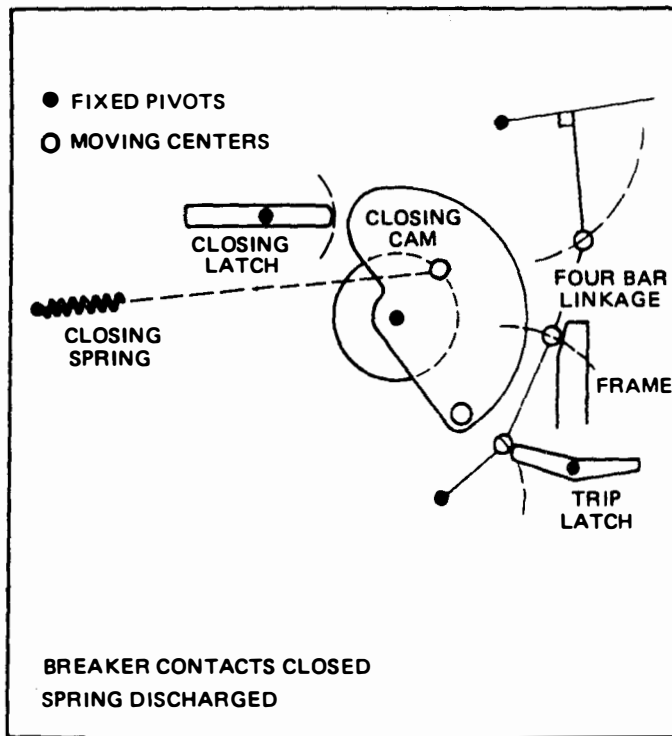
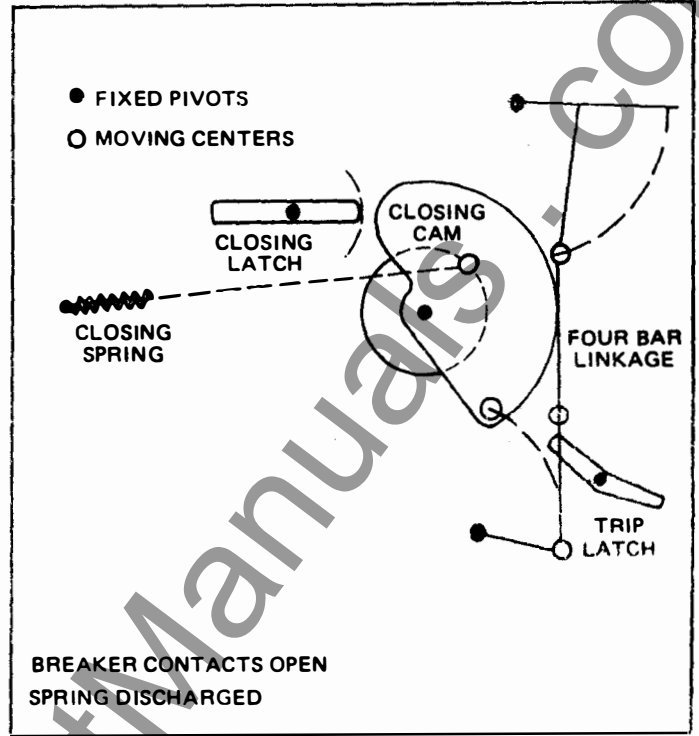


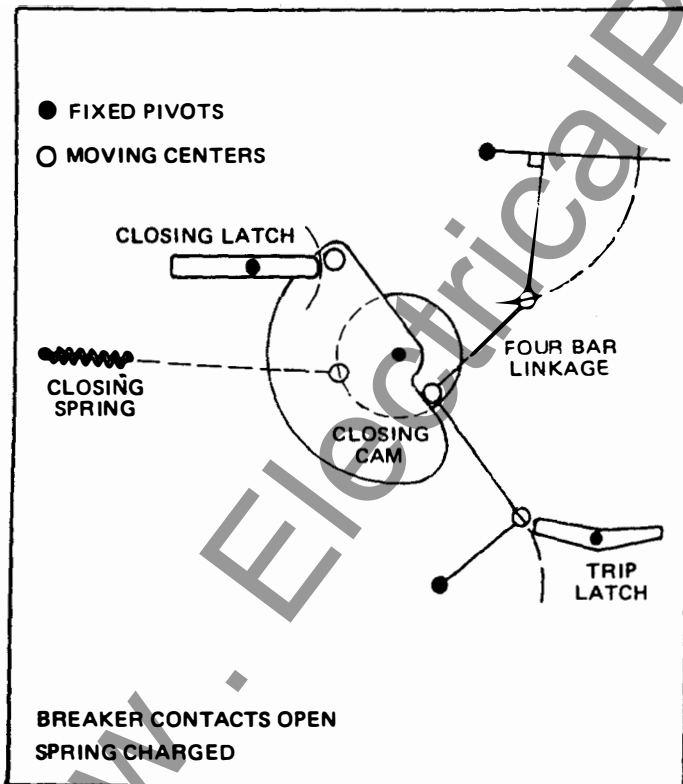
Fig. 4b - Circuit Breaker Frame & Operator Assembly



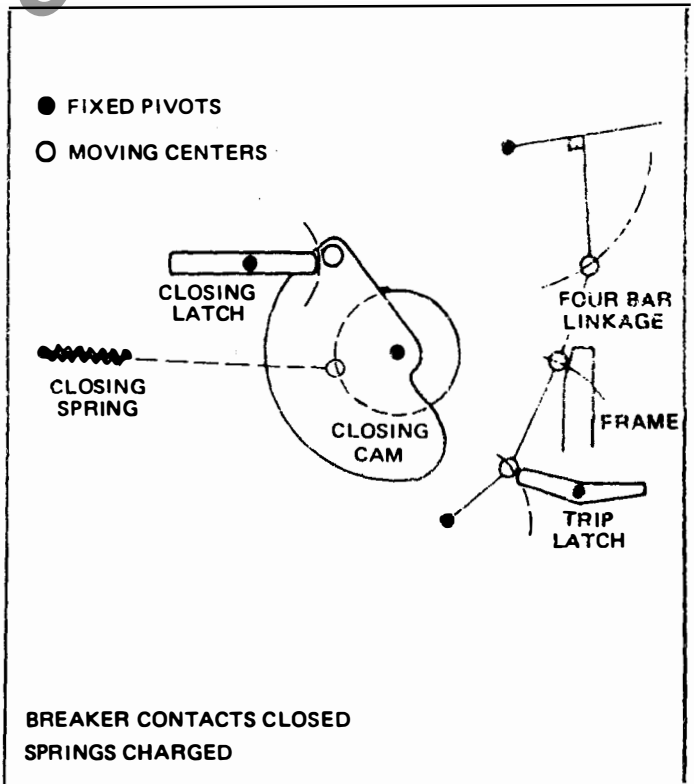
-A-



-B-



-C-



-D-

Figure 5 - Sequence of Operation

STORED ENERGY OPERATOR-COMPONENTS NOMENCLATURE

To be used with "Description of Operation" Figures 6,7 and 8.

1. Spring Charging Motor
2. Driving Pawl
3. Eccentric Drive Shaft
4. Ratchet Wheel
5. Holding Pawl
6. Closing Springs
7. Cams
8. Spring Release Rollers
9. Close Latch
10. Motor Cutoff Switch
11. Linkage Reset Spring
12. Four Bar Linkage
13. Close Solenoid
14. Cam Follower Rollers (Main Toggle Roll)
15. Radius Arm
16. Close Latch Check Switch
17. Trip Solenoid
18. Trip Latch
- 19.
20. Latch Roller
21. Manual Close Pull Rod
22. Spring Discharge Roller Free Height Adjustment
23. Spring Discharge Close Latch Yoke End Adjustment
24. Spring Discharge Roller
25. Charge Discharge Indicator
26. Discharge Indication Adjustment
27. Charge Indication Adjustment
28. Mechanical Charging Interlock Adjustment
29. Manual Charging Shaft and Gear Box
30. Anti-Pumping Relay
31. Trip Latch Bite Adjusting Screw
32. Trip Latch Bite Adjusting Screw Locking Nut
33. Close Latch Bite Adjusting Screw
34. Close Latch Bite Adjusting Screw Locking Nut
35. Motor Cutoff Switch Actuator
36. Lower Link Stop
37. Roll Pin Striker
38. Aluminum Spring Drive Blocks
39. Spring Discharge Connecting Rod

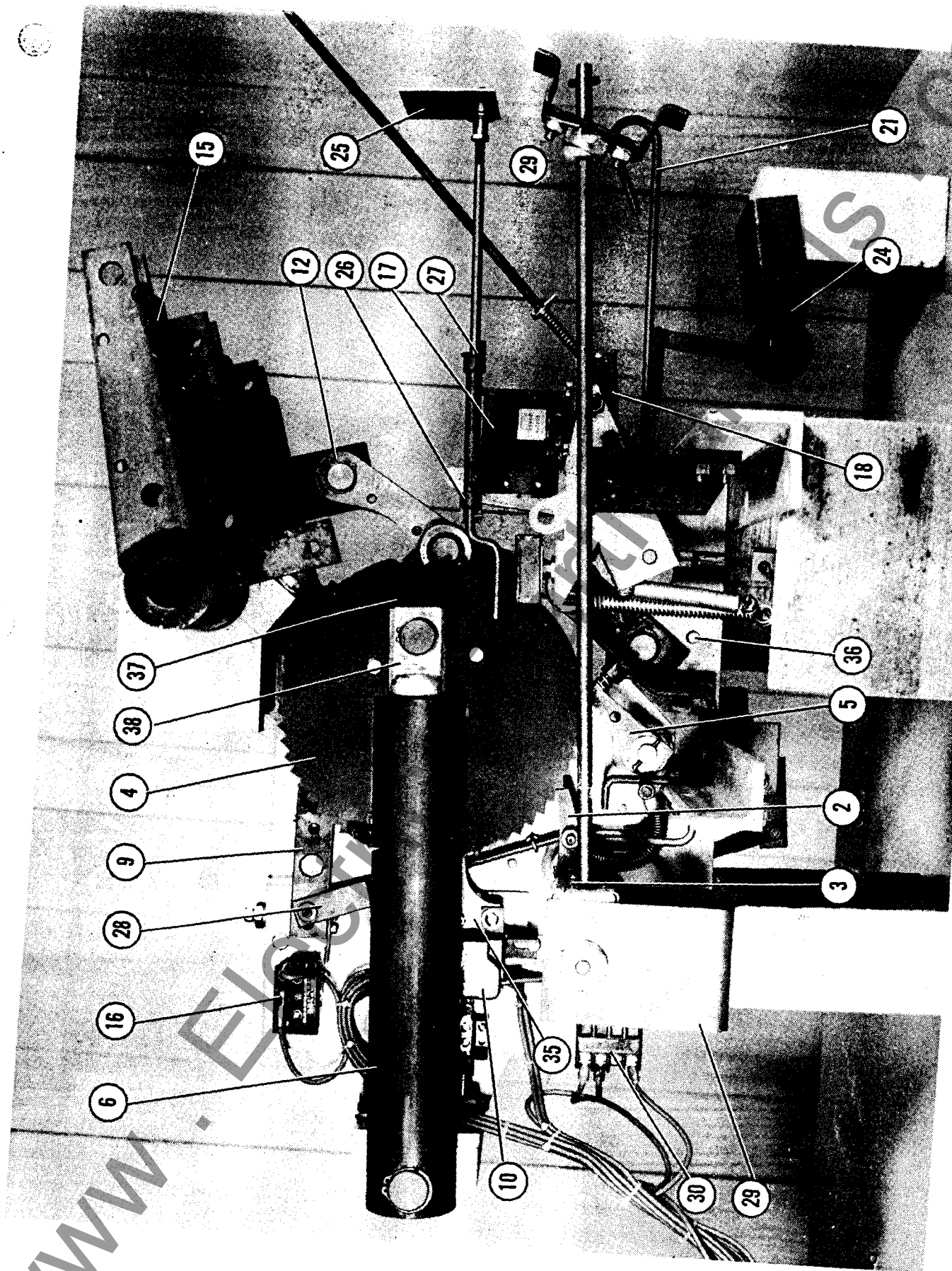


Fig. 6 — 515-2V Operator L.H. View

Fig. 6 — 515-2V Operator L.H. View

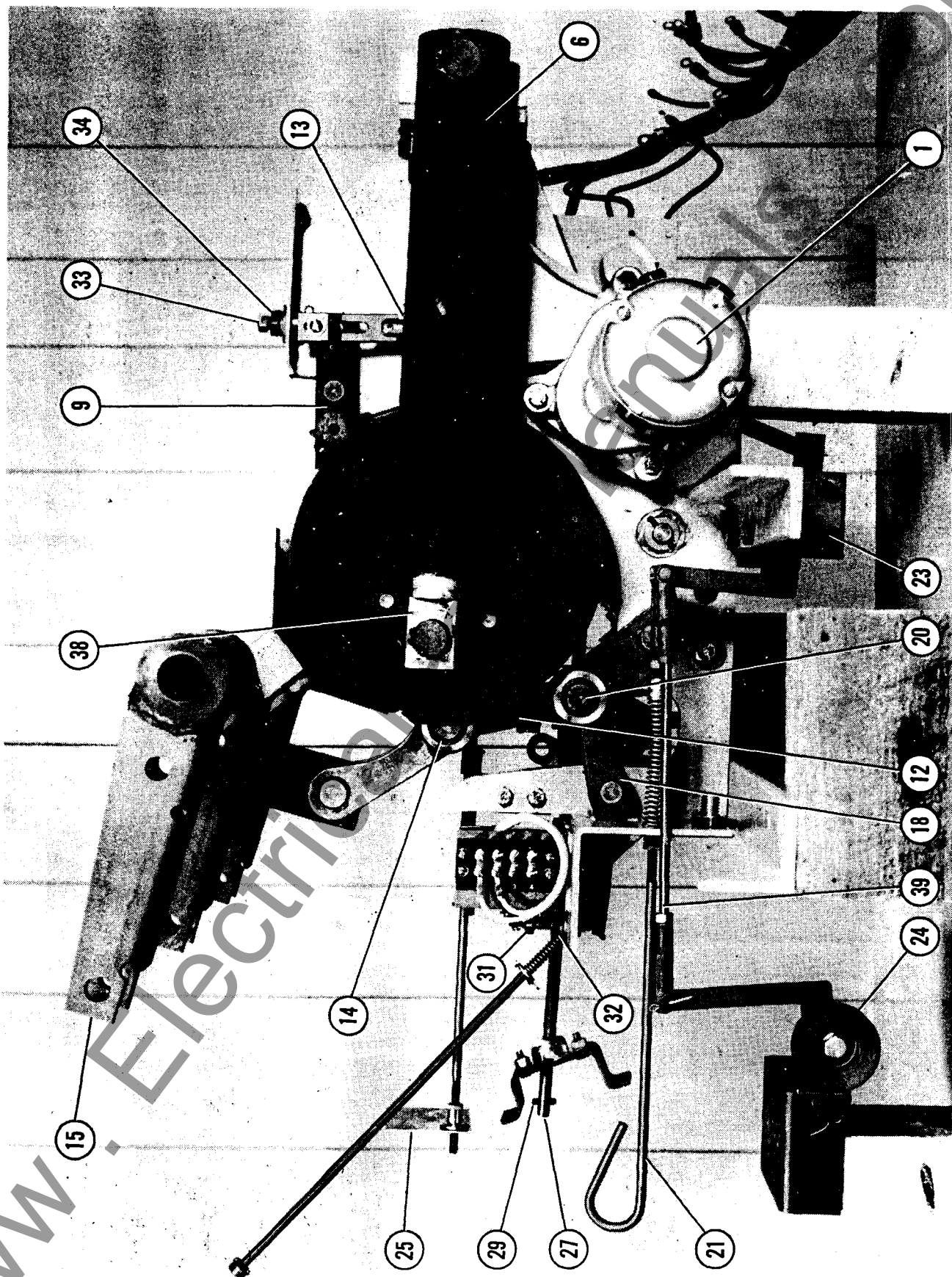


Fig. 7 — 515-2V Operator R.H. View

Fig. 7 — 515-2V Operator R.H. View

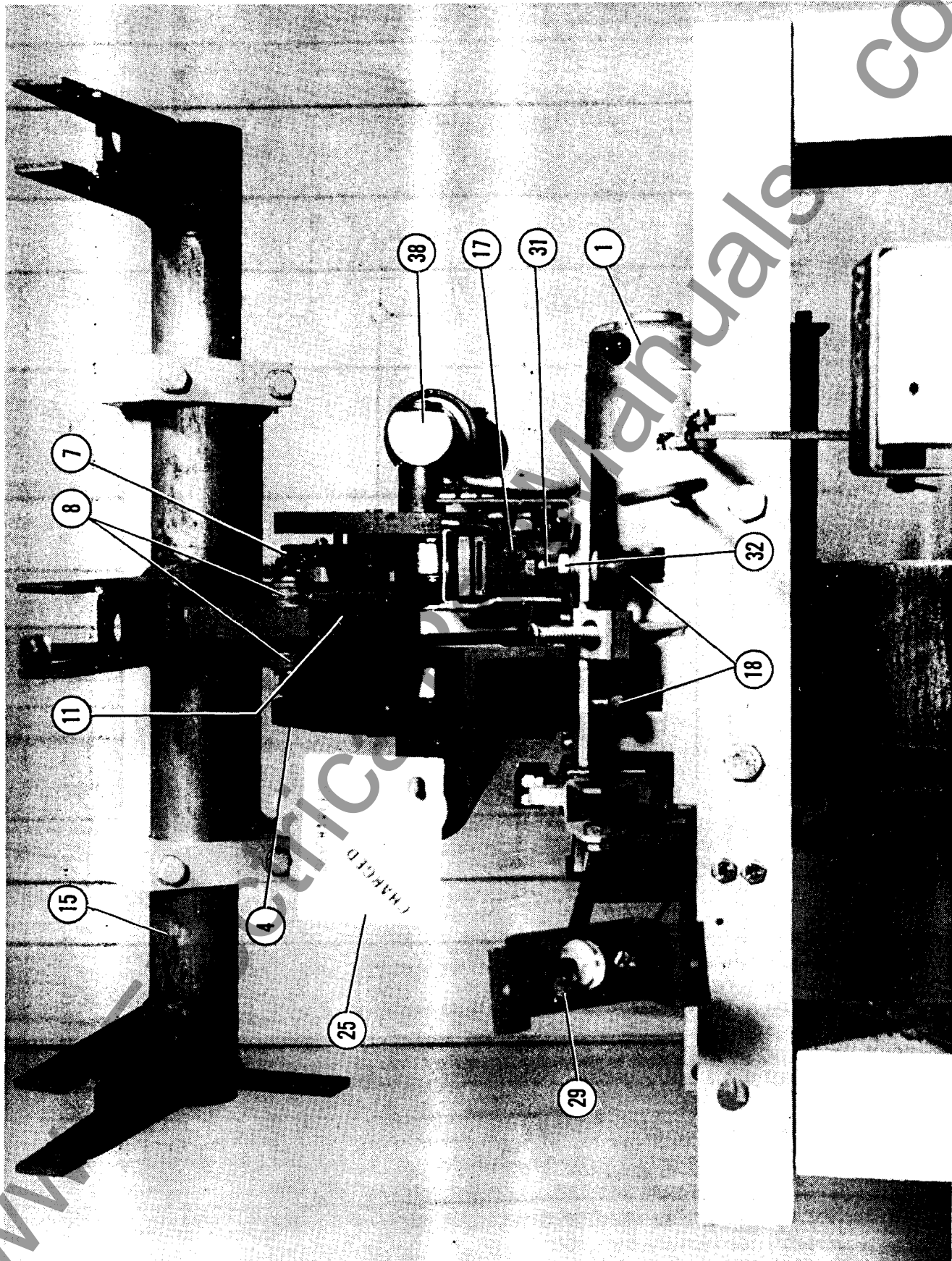


Fig. 8 — 515-2V Operator Front View

Fig. 8 — 515-2V Operator Front View

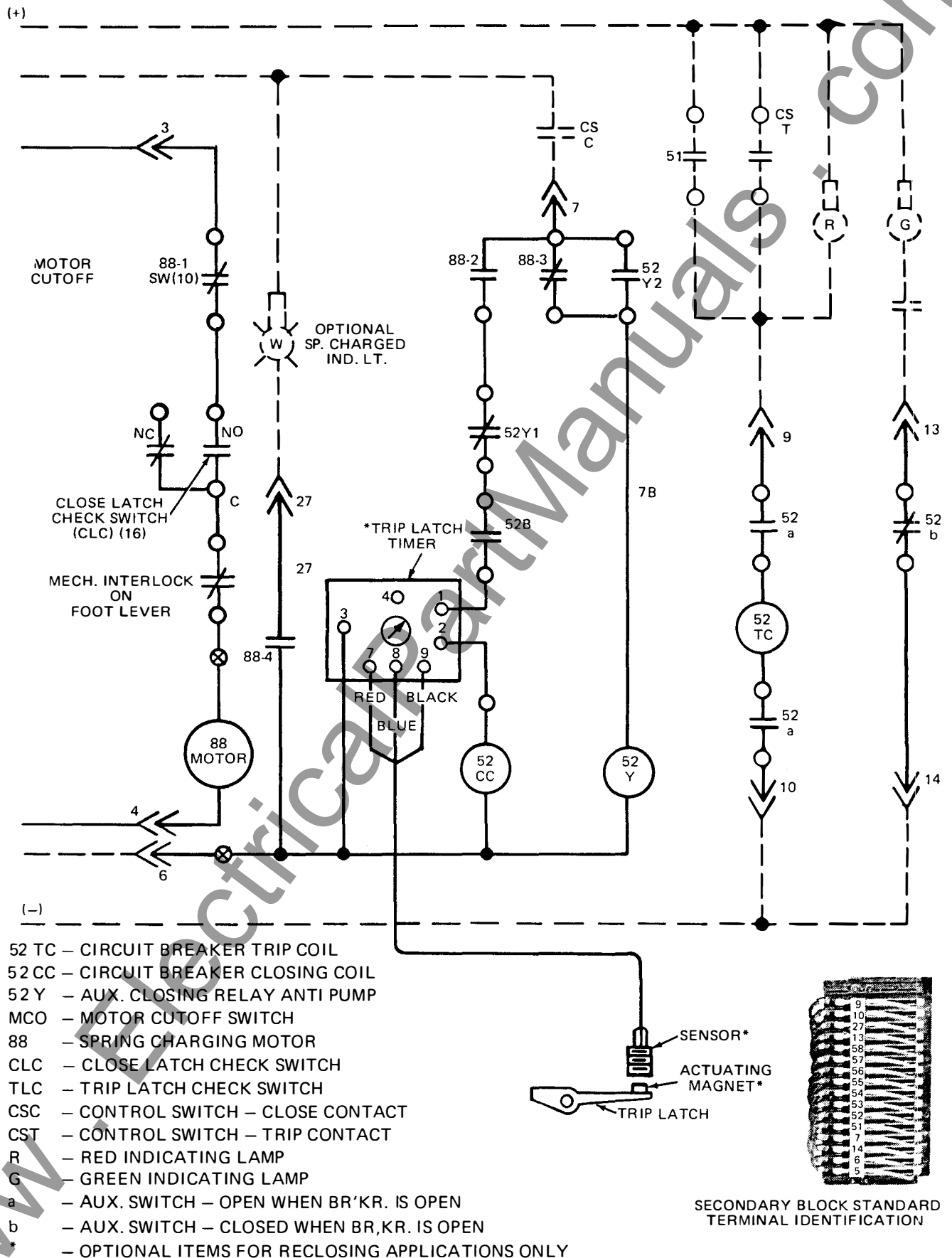


Fig. 9 - Control Scheme for Stored Energy Operator

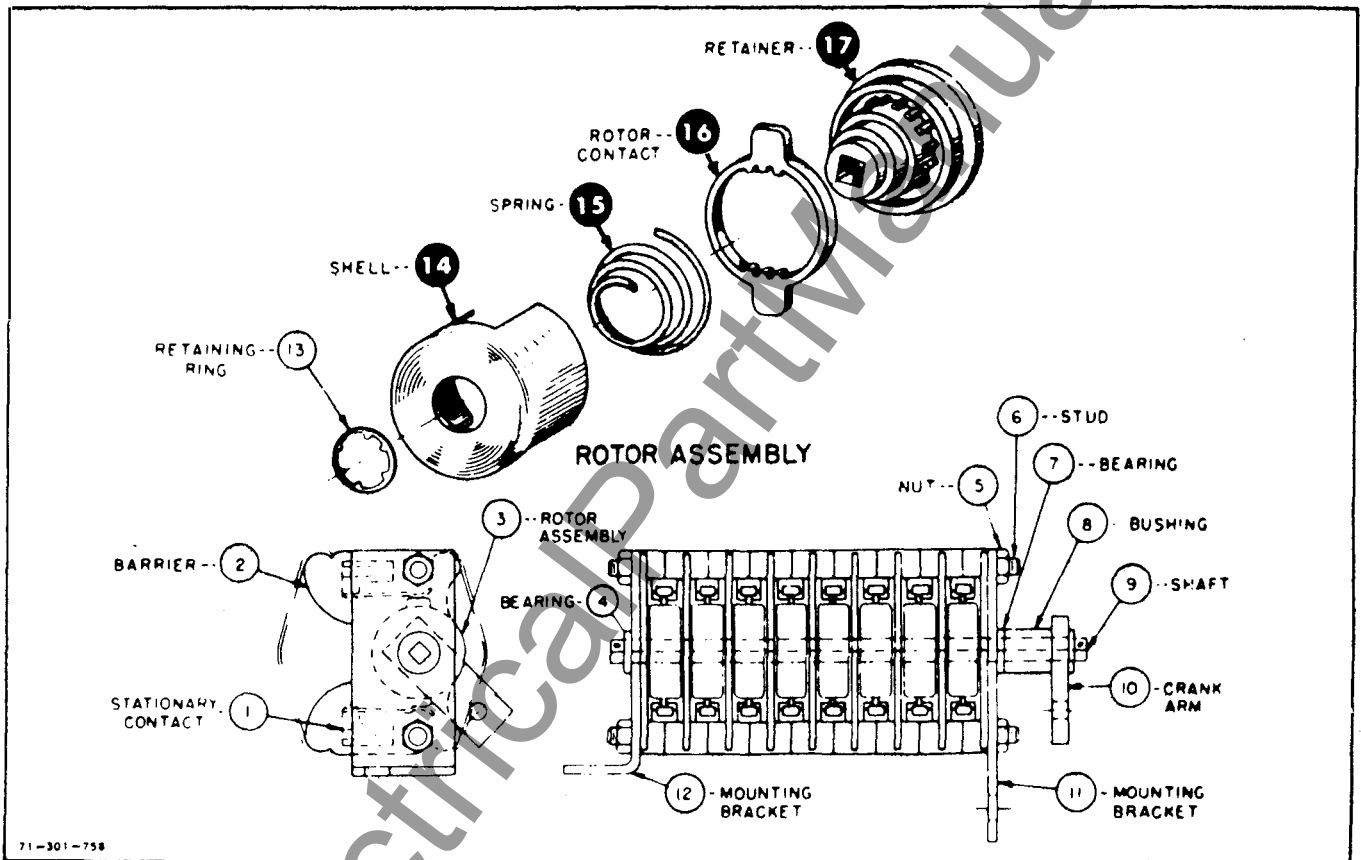


Fig. 10 - Type Q-10 Auxiliary Switch

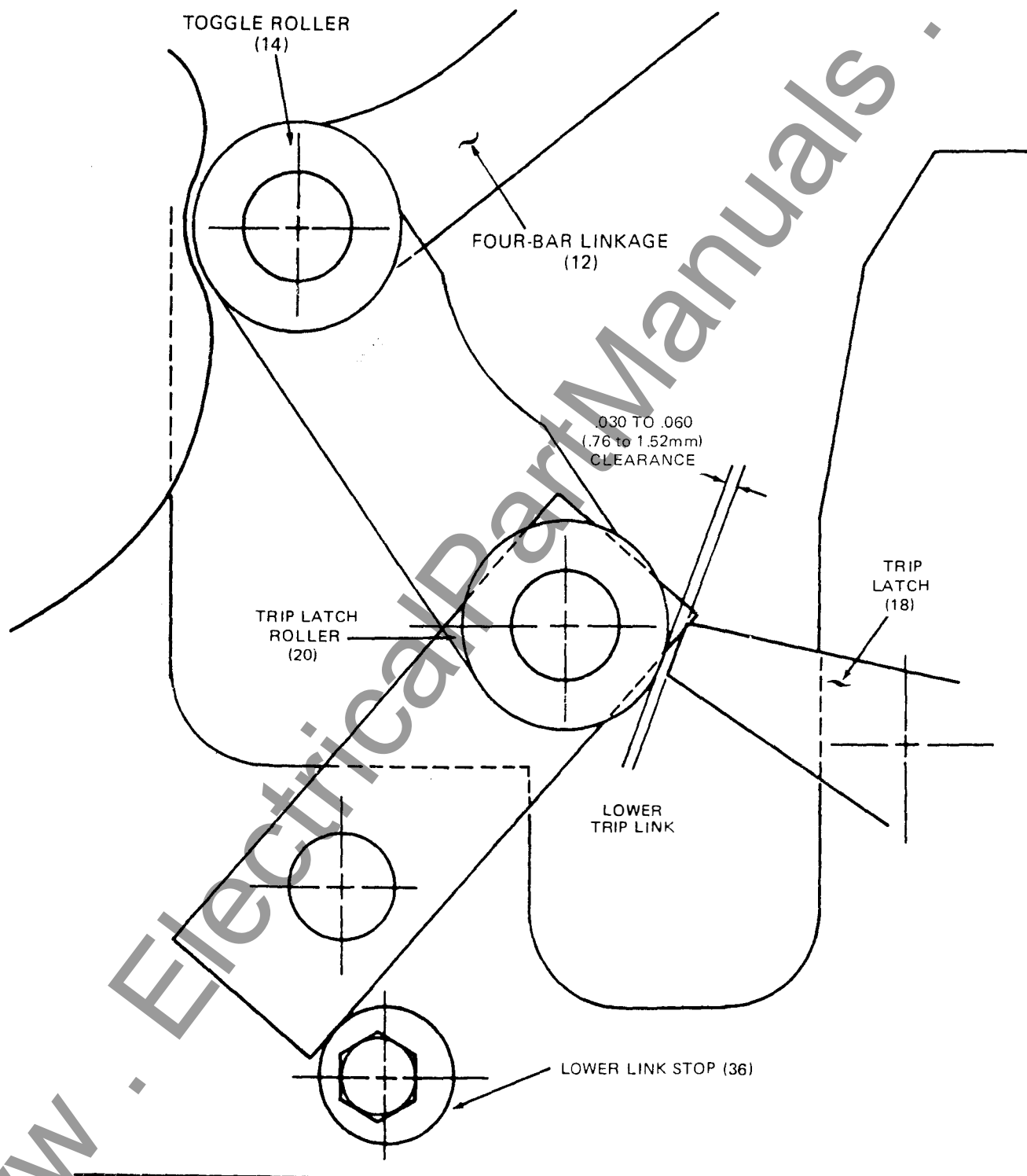


Fig. 11 – Trip Latch Clearance Adjustment

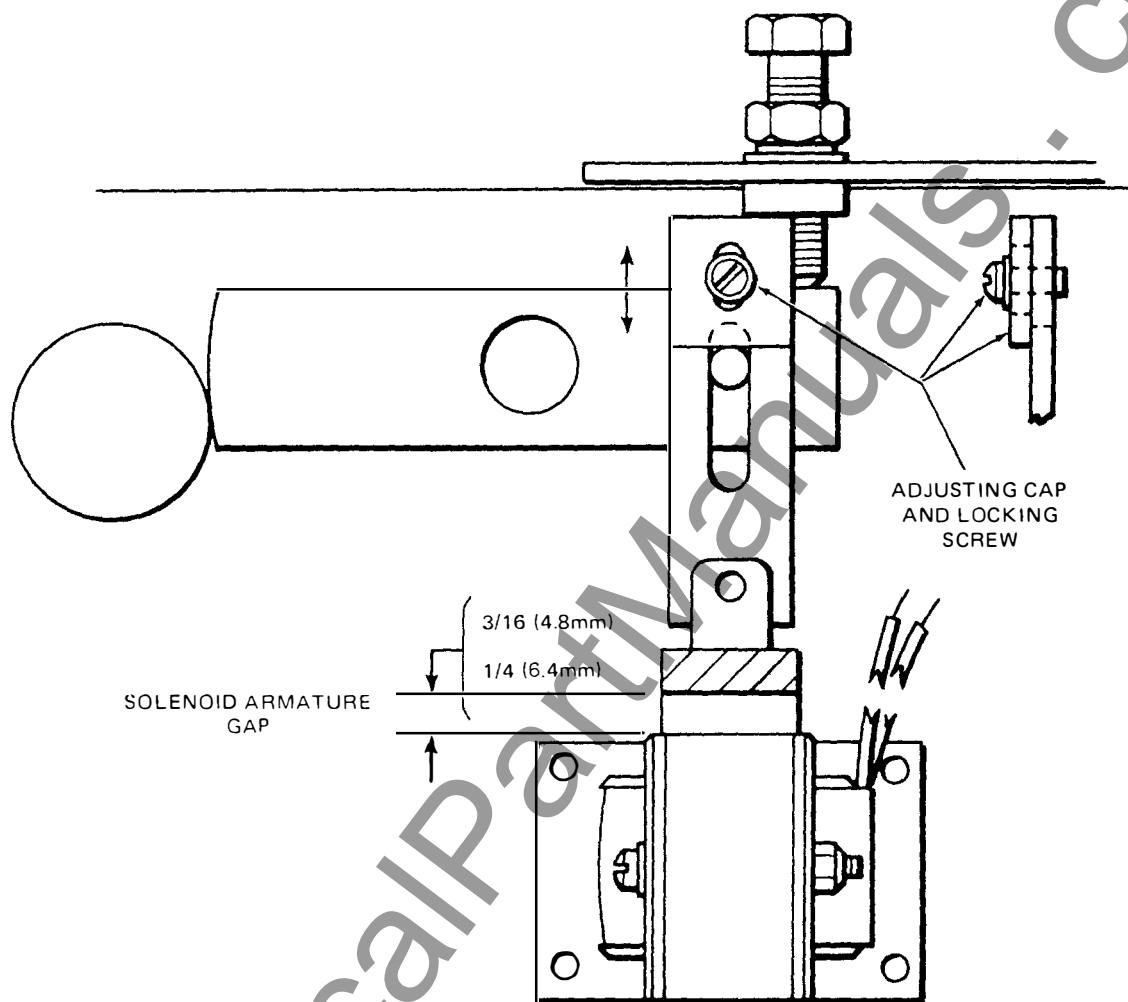


Fig. 12 — Spring Release Solenoid Armature Cap Adjustment

This adjustment is to be performed only after completing the spring release latch bite adjustment.

The purpose of this adjustment is to establish an armature gap of $\frac{3}{16}$ to $\frac{1}{4}$ inches (4.8 to 6.4mm). A suitable feeler gage of optimum thickness, (2.18) (5.56mm), should be inserted in the armature gap. That is, the space between the ground surfaces of the solenoid frame and ground "T" shaped extensions of the solenoid plunger.

The connecting link between the solenoid plunger and spring release latch should be adjusted to maintain the plunger in this position. The locking screw is released and the adjusting cap shifted until the effective length of the link supports the plunger within the indicated range.

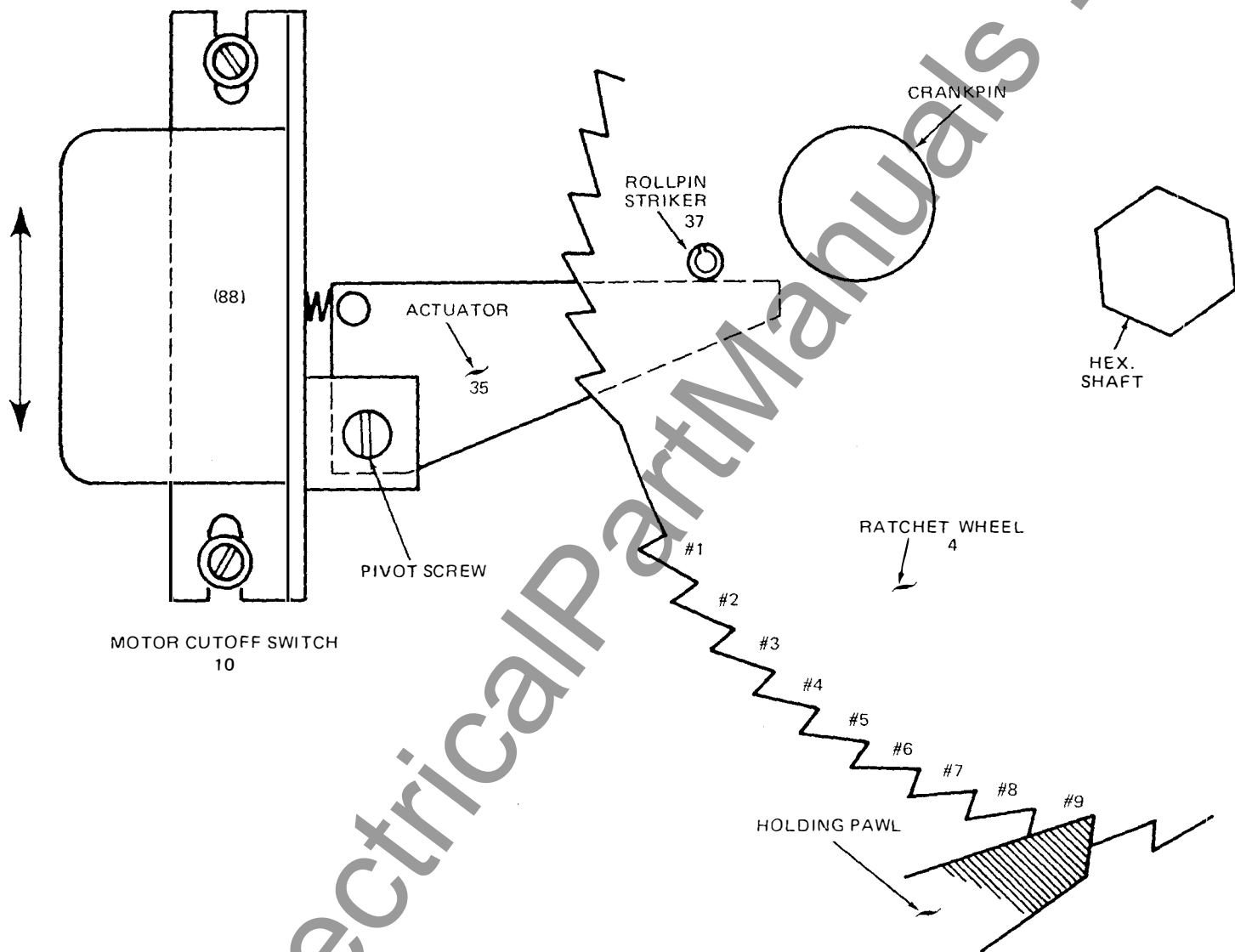


Fig. 13 – Motor Cutoff Switch

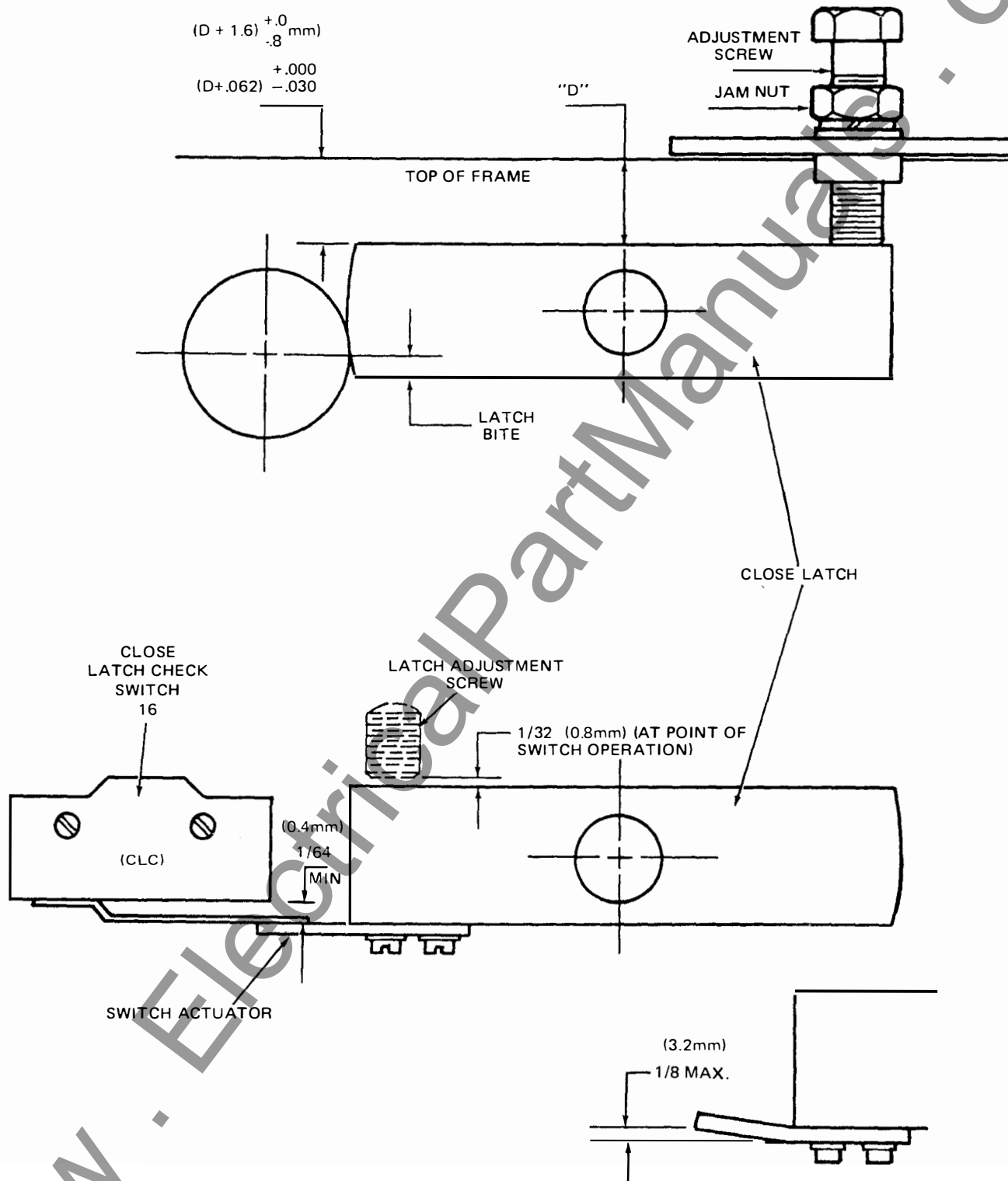


Fig. 14 — Close Latch Bite and Check Switch Adjustments

This adjustment is to be performed only after completing the close latch bite adjustment.

The purpose of this adjustment is to establish an armature gap of $\frac{3}{16}$ to $\frac{1}{4}$ inches. (4.8 - 6.4mm) A suitable feeler gage of optimum thickness, .218" (5.56 mm) should be inserted in the armature gap. That is, the space between the ground surfaces of the solenoid frame and ground "T" shaped extensions of the solenoid plunger.

The connecting link between the solenoid plunger and close latch should be adjusted to maintain the plunger in this position. The locking screw is released and the adjusting cap shifted until the effective length of the link supports the plunger within the indicated range.

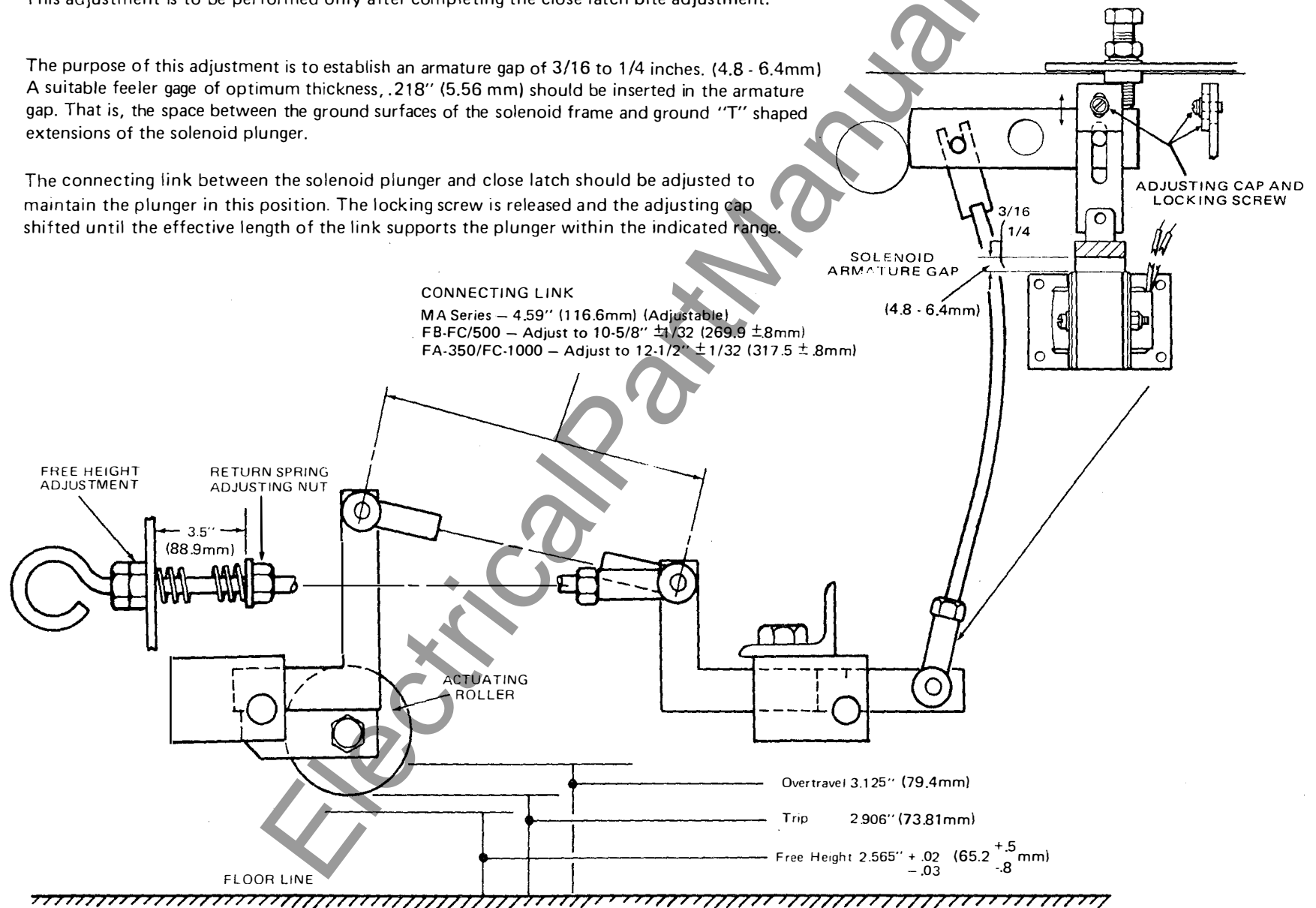


Fig. 15 — Closing Spring Discharge Mechanism

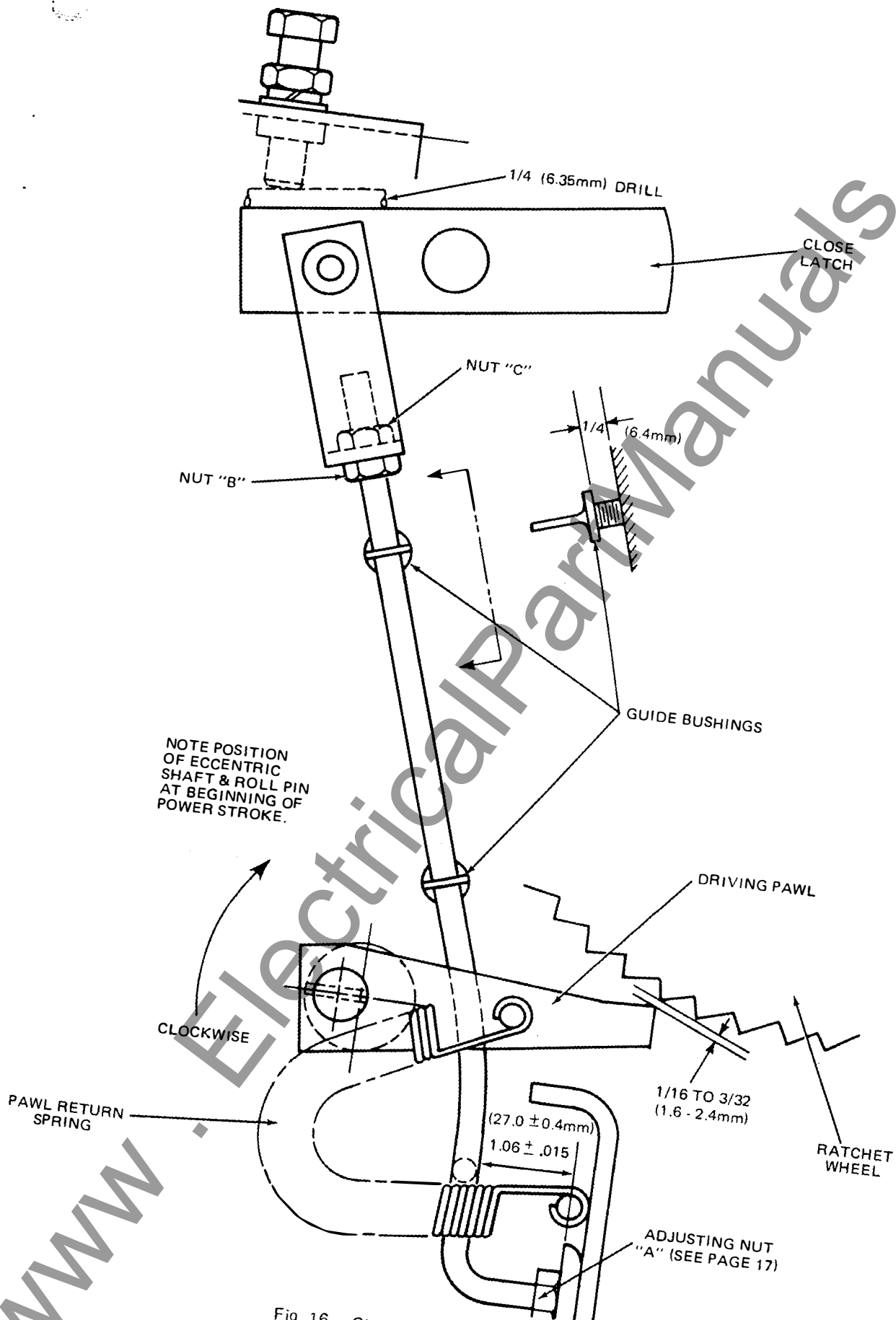


Fig. 16 - Close Latch Mechanical Interlock

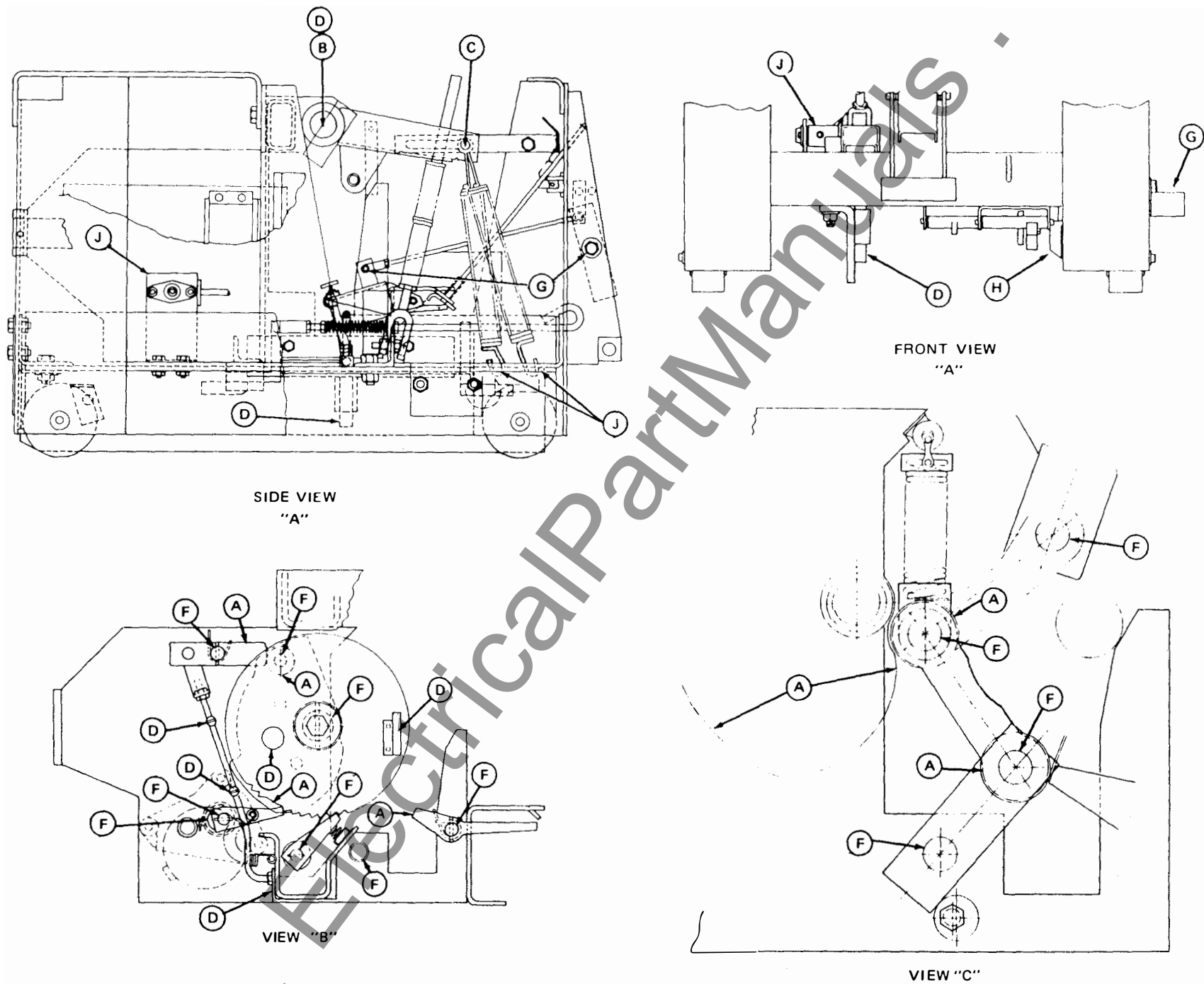


Fig. 17 – Lubrication Points on Frame and Operator (View A) Drive Assembly (View B) and Linkage Assembly (View C)

LUBRI- CATION KEY	PART DESCRIPTION	SUGGESTED LUBRICATION AT EVERY 2000 OPERATIONS OR ONCE EVERY YEAR.	ALTERNATE LUBRICATION (RE- QUIRES DISASSEMBLY) RECOM- MENDED AFTER EVERY 10,000 OPER.
A	GROUND SURFACES SUCH AS LATCHES, ROLLERS, PROPS, ETC.	WIPE CLEAN AND SPRAY WITH *MOLYCOTE 557* 15-171-270-001.	WASH CLEAN AND SPRAY WITH *MOLYCOTE 557* 15-171-270-001.
B	NYLON SLEEVE BEARINGS, SUCH AS: THE CONTACT ARM HINGE PIN.	NO LUBRICATION REQUIRED.	NO LUBRICATION REQUIRED.
C	SLEEVE BEARINGS AND PIVOT PINS, ROTATING PARTS SUCH AS DRIVE PINION, DRIVING CRANKS, WALKING BEAM PIVOT PIN, SLIDE AND PIVOT PIN.	LIGHT APPLICATION OF *MOLYCOTE PENELUBE* 15-171-270-002.	REMOVE PINS OR BEARINGS, CLEAN PER INSTRUCTIONS AND APPLY *BEACON P-290* 00-337-131-001.
D	SLIDING SURFACES	LIGHT APPLICATION OF *MOLYCOTE 557*.	WIPE CLEAN AND APPLY *MOLY- COTE 557* LIBERALLY.
E (FIG. 3)	SLIDING PARTS AT VACUUM INTERRUPTER.	LIGHT APPLICATION OF *BEACON P-325*.	LIGHT APPLICATION OF *BEACON P-325*.
F	ROLLER AND NEEDLE BEARINGS.	NO LUBRICATION REQUIRED.	CLEAN PER INSTRUCTIONS AND REPACK WITH *BEACON P-325*.
G	DRY PIVOT POINTS.	NO LUBRICATION REQUIRED.	NO LUBRICATION REQUIRED.
H	PRIMARY DISCONNECT FINGERS, GROUNDING CONTACT.	WIPE CLEAN AND APPLY A FILM OF SIEMENS-ALLIS CONTACT LUBRICANT 15-171-370-002.	
I	CHARGING SPRINGS & SPRING RETAINERS.	NO LUBRICATION REQUIRED.	WIPE CLEAN AND COAT WITH *BEACON P-325*.
J	MANUAL CHARGING BEVEL GEAR TRAIN AND MISC. PARTS.	REMOVE SNAP ON COVER & COAT TEETH LIGHTLY WITH *BEACON P-325*.	REMOVE SNAP ON COVER & COAT TEETH LIGHTLY WITH *BEACON P-325*.

Fig. 18 Lubrication Chart (For use with Fig. 3 & 17)

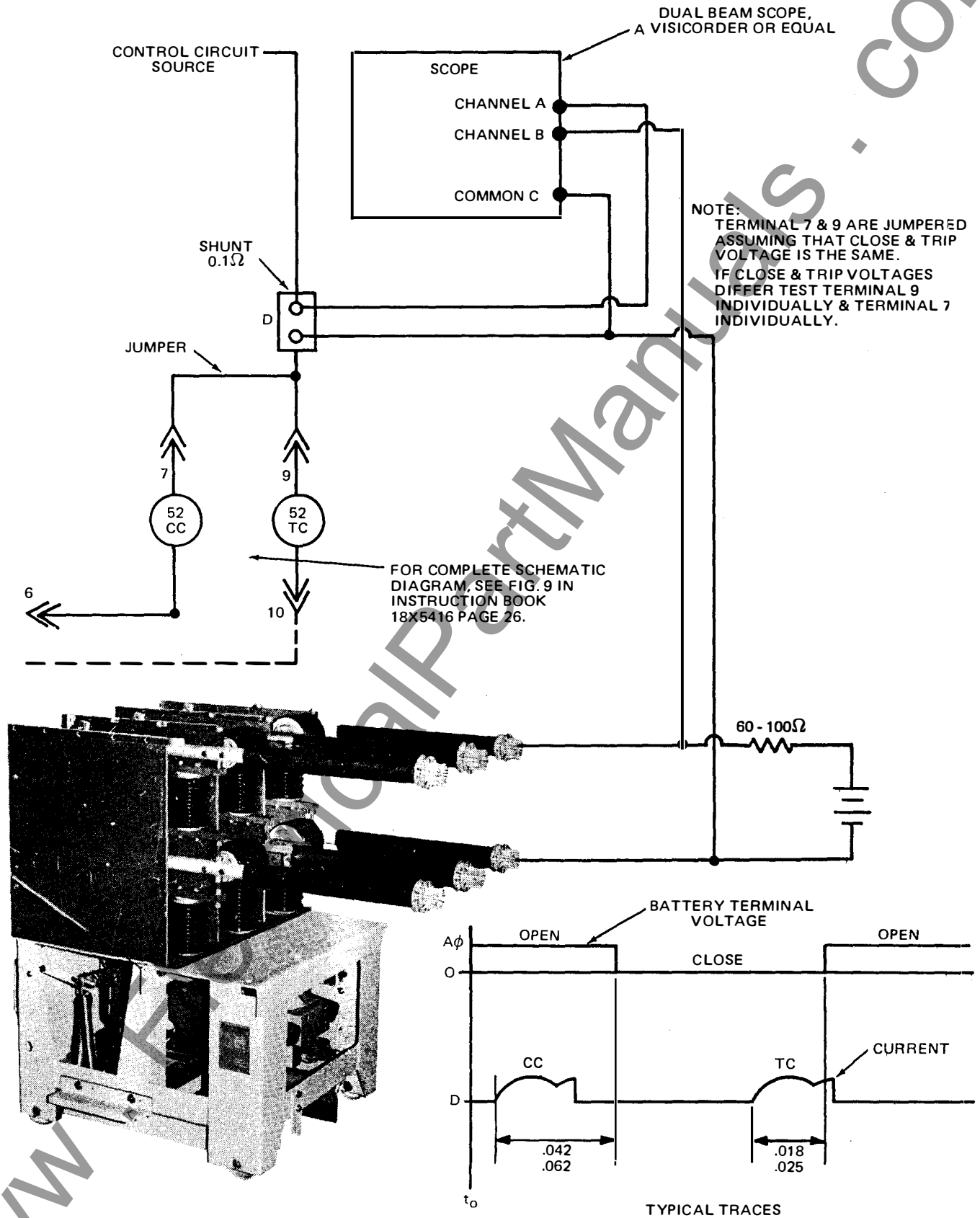
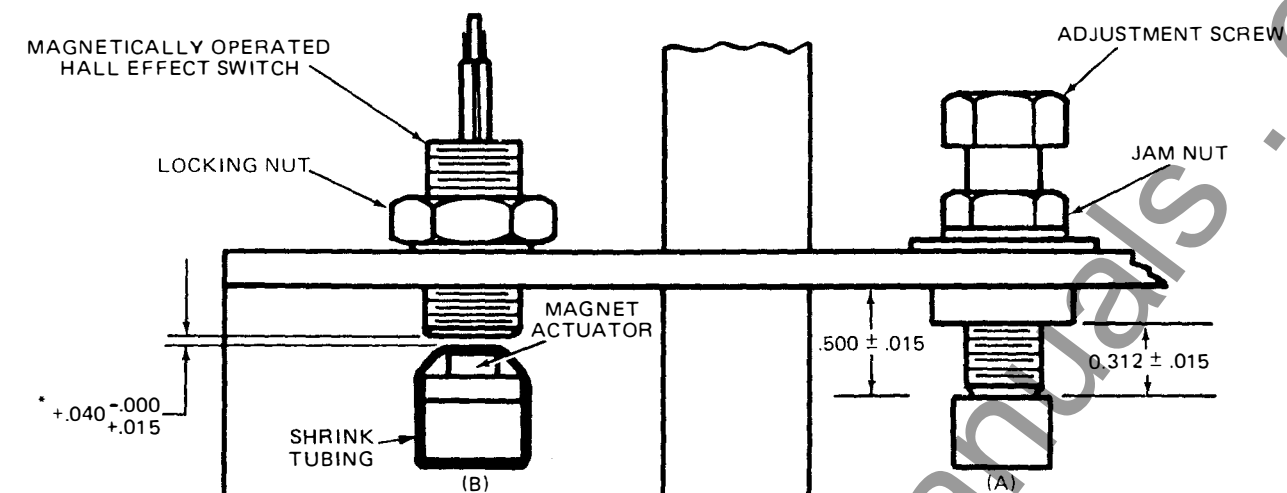


Fig. 19 — Method for Checking Opening and Closing Times



*THIS DIMENSION MUST BE BETWEEN HALL EFFECT SWITCH BASE AND TOP OF SHRINK TUBING AS SHOWN.

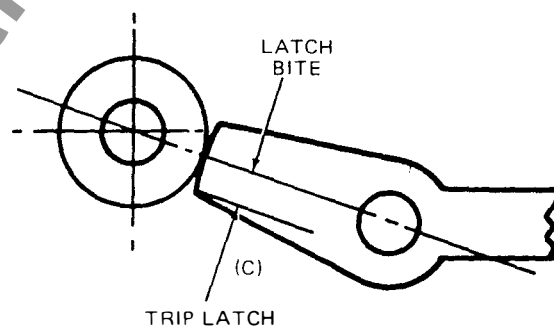
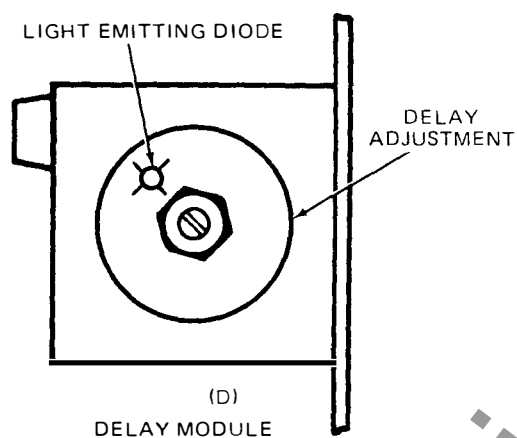


Fig. 20 – Trip Latch Bite and Check Switch Adjustments

SIEMENS-ALLIS

Switchgear

P.O. Box 14505

West Allis, Wisconsin 53214