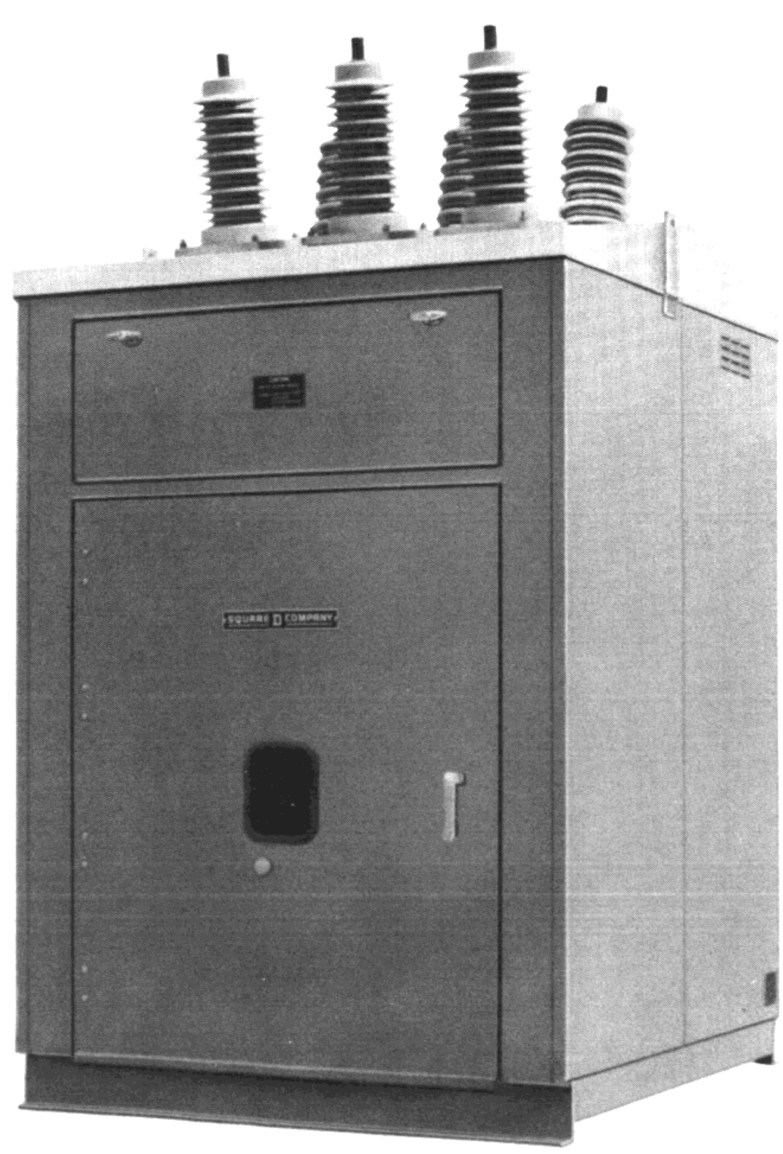
October, 1984
Supersedes Manual 6060-2 dated 12/83

Manual 6060-2

Installation & Maintenance Manual
FLUARC™
SF_6 SUBSTATION CIRCUIT BREAKERS
Type FC



SQUARE D COMPANY

TABLE OF CONTENTS

	Page
List of Illustrations	3
Introduction	4
Standard Ratings	5
Handling Precautions	6
Pre-Service Check-Out	6
Gas Servicing	6
Enclosure	7
Operation Theory of SF_6	8
Operating Mechanism Description	8
Inspection and Maintenance	9
General Maintenance	9
Operating Mechanism Lubrication	9
Contact Erosion Measurement	10
Motion Analysis	12
Operation of Breaker	12
Internal Wiring	13
Bushings	14
CT Replacement	14
Outline Dimensions	15
Life Expectancy Curve	16
Troubleshooting Guide	17
Replacement Parts	18

LIST OF ILLUSTRATIONS

Figure		Page
1	Breaker Identification	4
2	Enclosure	7
3	Internal Unit (Front View)	8
4	Internal Unit (Rear View)	8
5	Stored Energy Mechanism	9
6	Contact Erosion Indication	10
7	Internal Unit Detail (Rear View)	11
8	Internal Unit Detail (Side View)	11
9	Slow-Closing Single Interrupter	11
10	Charging Springs Manually	11
11	Slow Closing with Hydraulic Jack	11
12	Motion Analyzer	12
13	Elementary Diagram	13
14	Connection Diagram	13
15	Bushing	14
16	Bushing Mounting	14
17	CT Mounting	14
18	Outline	15
19	Life Expectancy Curve	16

Table		
1	Standard FC Ratings	5
2	Troubleshooting Guide	17
3	Replacement Parts	18

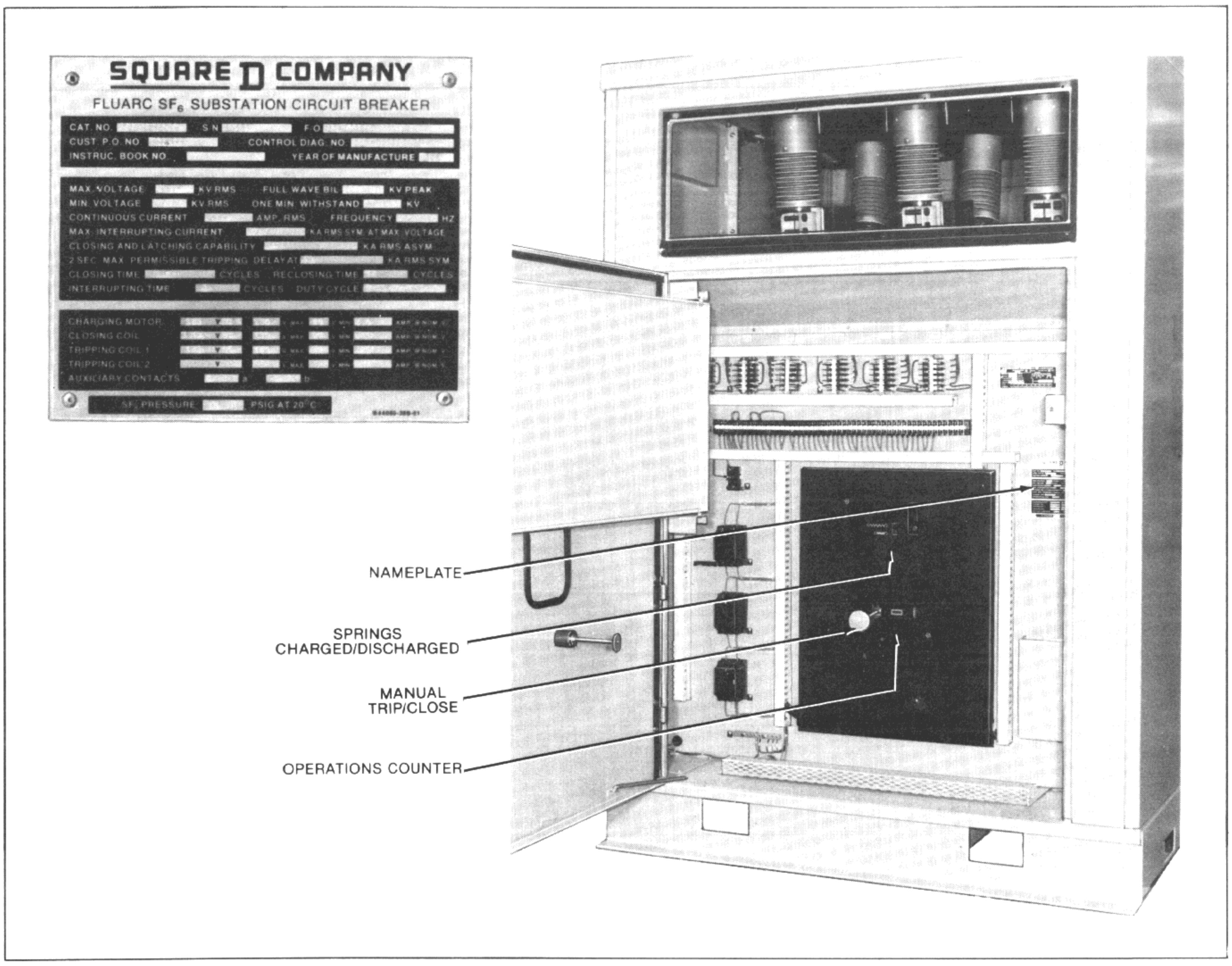


Figure 1

INTRODUCTION

The use of SF_6 gas (sulfur hexafluoride) equipment by utilities for High Voltage and Extra High Voltage application is relatively common. Square D company's FLUARC circuit breaker is a low-pressure, sealed-interrupter type for applications at 10 kV through 38 kV.

The type FC substation circuit breaker uses three (3) sealed interrupters. These interrupters are filled with SF_6 gas at the factory and sealed for life. FIELD CHARGING OF THE INTERRUPTERS IS NOT REQUIRED.

Designed for low maintenance techniques, the FC circuit breaker is housed in a painted steel enclosure protected by a stainless steel roof.

The breaker should be utilized within the design limitations described on the nameplate. See Table 1 for complete ratings.

STANDARD FC RATINGS

Breaker Type	FCS-1	FCS-2	FCS-3
Rated Frequency	60 Hz	60 Hz	60 Hz
Nominal Operating Voltage	14.4kV	23kV	34.5kV
Maximum Design Voltage	15.5kV	25.8kV	38kV
Basic Insulation Level	110kV	125kV	150kV
60 Hz Withstand:			
Voltage Dry	50kV	60kV	80kV
Voltage Wet	45kV	50kV	75kV
Minimum External Creep Distance	20.5 in.	47 in.(1200A) 44 in.(2000A)	47 in.(1200A) 44 in.(2000A)
Minimum External Strike Distance Terminal to Ground	13.46 in.	21.77 in.	21.77 in.
Minimum External Strike Distance Between Bushing Terminals Phase to Phase	14.63 in.(1200A) 13.75 in.(2000A) 12.88 in.(3000A)	14.63 in.(1200A) 13.75 in.(2000A)	14.63 in.(1200A) 13.75 in.(2000A)
Interrupting Time	5 Cycles	5 Cycles	5 Cycles
Time Between Coil Energization And Contact Parting	40-60 msec.	40-60 msec.	40-60 msec.
Spring Charging Time	10-13 sec.	10-13 sec.	10-13 sec.
Closing Time	50-90 msec.	50-90 msec.	50-90 msec.
Reclosing Time	0.2 sec.	0.2 sec.	0.2 sec.
Continuous Current	1200A-3000A	1200A-2000A	1200A-2000A
Interrupting Capacity (Max. Voltage)	20-40kA	20-40kA	20-32kA
Momentary Rating (Peak)	54-108kA	54-108kA	54-86kA

Table 1

HANDLING PRECAUTIONS

1. Only qualified and authorized personnel should be permitted to handle or operate the breaker.
2. Delicate instruments and relays may be damaged by rough handling. HANDLE WITH CARE DURING INSTALLATION.
3. Remove blocking on relay armatures and check control circuits (except current transformer circuits) for grounds and short circuits before applying control power.
4. Check proper phasing of all circuits and connect the switchgear to the station ground before applying high voltage power.
5. Do now work around "live" parts.
6. Any switch or breaker that has been opened to de-energize the equipment being serviced should be effectively locked, tagged, and even blocked open if possible to prevent accidental energization.
7. Service current carrying parts only when these parts are disconnected from the system and grounded to the ground bus.
8. In case of fire do not use liquid fire extinguishers until all circuits have been made electrically "dead".
9. All personnel responsible for supervision and operation should be familiar with the breaker and its functions.
10. **CAUTION: If breaker is to be stored prior to installation, provisions must be made for energizing the space heaters to prevent condensation of moisture inside the enclosure.**
11. If the circuit breaker is to be stored for an extended period of time prior to placing in service, periodic exercising is necessary to maintain the high integrity of the gas seal in the interrupters. Time between exercise periods should be no greater than one year.

PRE-SERVICE CHECK-OUT

Prior to placing the breaker in service, perform the following checks:

1. Open all panels and inspect for any shipping damage such as broken parts, loose hardware, etc.
2. Using a 1000 V. megohm tester, check insulation resistance at the bushings phase to phase and phase to ground. As a rule of thumb, readings should be no less than 1000 ohms/volt (system voltage).
3. With the circuit breaker isolated from High Voltage:
   a) Check the bushing clamp down nuts for tightness (recommended torque 15 ft-lbs)
   b) Check flex connector bolts at interrupter (recommended torque 55 ft-lbs)
   c) Check flex connector bolts at insulator (recommended torque 25 ft-lbs min.)
   d) Check flex connector bolts at bushing (recommended torque 40 ft-lbs)
   e) Remove all dust and foreign particles from the bushings and interrupters by wiping with a soft dry cloth. For more extensive cleaning, a non-flammable solvent should be used.

   These checks are part of normal factory quality procedures, however, it is suggested these items be re-checked prior to actual energization.
4. Manually charge the closing springs and close and trip the breaker.
5. Apply control power and operate breaker electrically.
6. It would be advisable to perform the following:
   a) High potential dielectric test. (page 13)
   b) Bushing power factor test. (page 13)
   c) Contact resistance measurement. New breaker should read 150 or less micro ohms, using a DC test instrument.
7. If everything is found to be satisfactory, proceed to place breaker in service.

GAS SERVICING

The Fluarc interrupters are designed to be sealed for life. They are charged with SF_6 to 48.5 psig at the factory and therefore do not require charging at the time of installation.

Gas pressure can be tested at a pressure valve located at the bottom of the bottle (Figure 7). It is recommended that this practice be kept to a minimum (5 year intervals) because the gas lost during a pressure check will be greater than that expected over several years normal service.

A pressure switch that operates at 29.4 psig is provided as an integral part of the interrupter for the purpose of providing a warning of a low pressure situation.

If necessary, additional gas may be introduced into an interrupter through the pressure valve.

ENCLOSURE

The FC substation circuit breaker consists of an isolated high voltage compartment and low voltage compartment.

The high voltage compartment includes cycloaliphatic cast epoxy bushings which protrude through the stainless steel roof. The roof penetration is gasketed and extruded outward 3/16″ to prevent water leakage due to gasket aging. A maximum of two current transformers can be mounted on each bushing.

The high voltage compartment can be accessed through the rear door as well as through two access panels located at the top-front and top-rear of the enclosure. CAUTION: DO NOT ATTEMPT TO OPEN HIGH VOLTAGE ACCESS DOOR AND PANELS WHILE BREAKER IS ENERGIZED.

The low voltage compartment is isolated from the high voltage compartment by a steel barrier. A hinged panel for relays, terminal strips and other instrumentation is accessable through the hinged gasketed front door. A padlockable vault-type handle with a three-point latch is provided on both the front and rear doors. Wind stops are also provided.

The large viewing window provides easy viewing of the circuit breaker operations counter, mechanical open/close indicator and closing spring charge indicator.

An emergency trip button, that can be padlocked in the trip position, is provided. The switch (ANSI 69) prevents reclosing the breaker manually or automatically until it is reset manually.

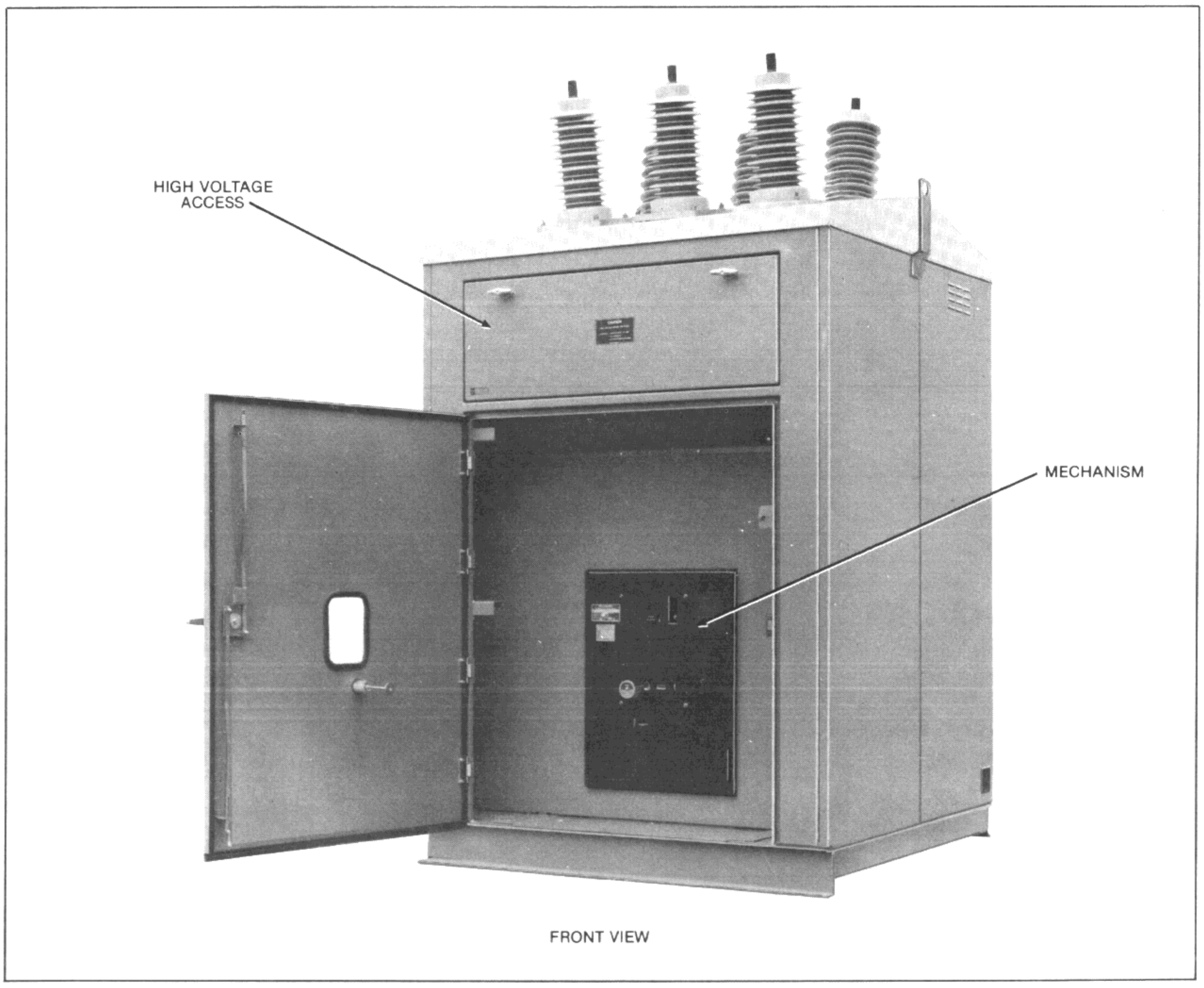


Figure 2

OPERATION THEORY OF SF_6

The FLUARC® system of arc interruption utilizes a puffer type interrupter. It moves the gas through a nozzle system across the arc.

As the arcing contacts part, the gas is compressed into the arc region. The action of the gas absorbs the arc energy and full interruption takes place at a current zero.

This system provides a soft high speed interruption, quiet operation, long interrupter life and reduced maintenance.

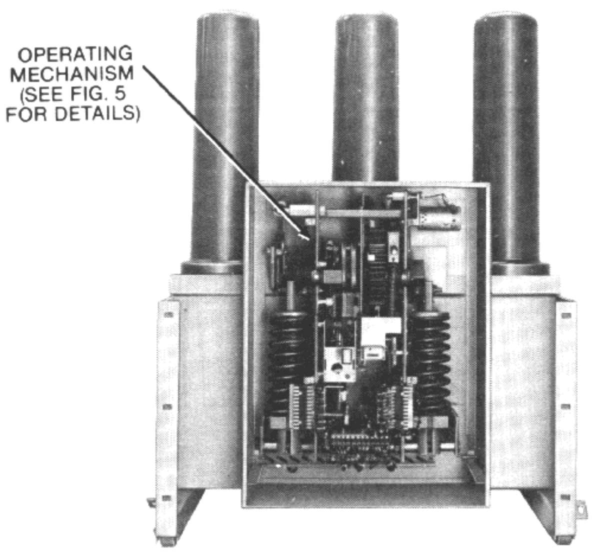


Figure 3

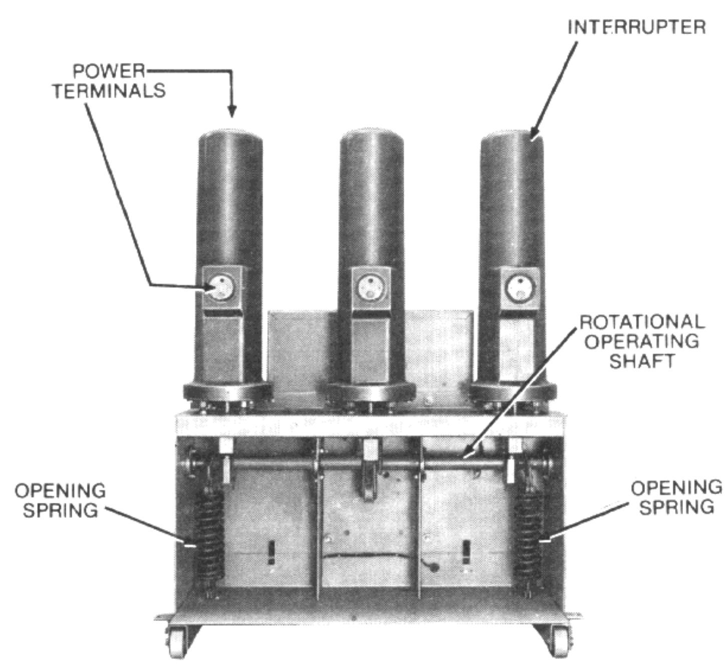


Figure 4

OPERATING MECHANISM DESCRIPTION

A stored energy mechanism is located in the control housing and consists of high energy closing springs and a ratcheting system for charging these springs. The breaker is prevented from being closed until the springs are fully compressed. Opening and closing speeds are independent of the method by which the springs are charged (manual or electrical).

The springs can be charged either electrically through the gear motor or manually through the use of the manual charging handle (Figure 10). After the springs are fully charged, the breaker may be closed either electrically by energizing the closing solenoid or manually by pulling out the CLOSE/OPEN button. Depress the same button to trip the breaker (Figure 5).

The closed/open status of the breaker can be determined by a mechanical flag showing through the escutcheon plate of the mechanism. In the same general location is a flag that indicates whether the closing springs are CHARGED or DISCHARGED (Figure 5).

INSPECTION AND MAINTENANCE

General Maintenance

The FC Breaker has been manufactured and tested with the concept of maintenance-free operation within the limits of predictable conditions. The mechanical life of the mechanism is 10,000 operations. The mechanical operations counter is incremented on CLOSE operations.

The life of the SF_6 interrupters can be predicted by use of the graph (Figure 19) showing the relationship of interrupting current vs. number of operations. The interrupter chambers are pressurized with SF_6, sealed and are maintenance free.

The need for inspections and possible interrupter replacement should be based upon the frequency of operation, types and levels of interruptions.

Suggested maintenance interval of the mechanism is every 3000 operations or 36 months, whichever comes first. Adverse environmental conditions would make more frequent maintenance adviseable.

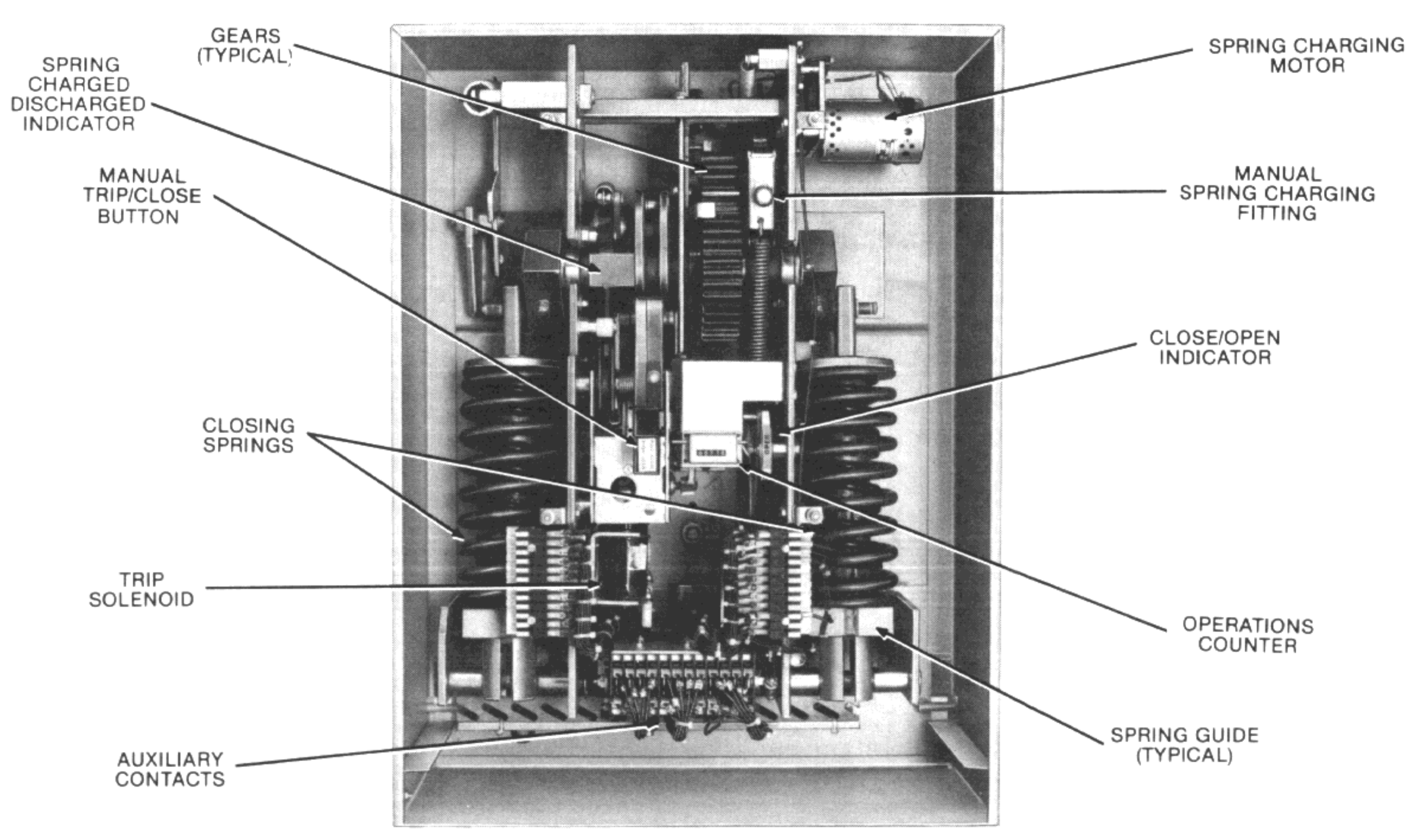
Specific inspections and/or maintenance would be as follows:

- Operating Mechanism
- Contact Erosion
- Bushing Dielectric Test
- Sequence of Operation

Operating Mechanism Lubrication

A good preventive maintenance program should include cleaning and lubrication of parts subject to wear through friction. The lubrication points may be identified in Figures 5, 7 and 8.

Lubrication should be as follows:
- Pivot Points and Bearings:
  10W-40 Automotive Oil—"MS" Duty
- Spring Guides and Gears:
  Automotive Molybdenum Disulfide Grease (Shell)



STORED ENERGY MECHANISM

Figure 5

Contact Erosion Measurement

This procedure describes the method required for checking the arcing contact erosion of each bottle.

WARNING: The primary circuit must be de-energized before proceeding.

1. Check to insure that primary circuit as well as control power has been disconnected.

2. Insure that the breaker is in the Open position and the mechanism springs, both closing and opening, are discharged. This can be accomplished by operating the close/open button by first pulling then pushing.

CAUTION: Only perform wear evaluation on one bottle at a time. Reconnect one bottle before proceeding to the next. This is important because the connecting rods are adjusted to different lengths and cannot be interchanged without re-adjustment.

NOTE: The upper and lower pins of the connecting rod are different lengths. The shorter pin is used at the lower position as shown in Figure 7.

3. Identify the location of the connecting rod in figures 7 and 8. See Figure 7 for connecting rod details. This device is to be removed as follows.

a) Make certain the jam nut is tight.
b) Remove one lower circlip.
c) Position the manual charging lever so that it rests on the rotational operating shaft and under the operating mechanism head of the bottle being evaluated (Figure 9).
d) Lift the manual charging lever slightly to remove the load from the operating mechanism head. The lower pin in the connecting rod can now be removed. Release the manual charging lever slowly.
e) Remove one upper circlip. While holding the connecting rod, remove the upper pin. If a motion analyzer adapter is mounted on the center bottle (Figure 12), loosen the set screws and remove the adapter at this time.

4. Attach a continuity tester between the primary conductors of the bottle under evaluation.

5. Using the manual operating handle as shown in Figure 9, operate the mechanism head upward until continuity is obtained. Observe the wear mark located on the stationary rod of the bottle (Figure 6). If the operating mechansim head covers the wear mark before continuity is made, it is necessary to replace the bottle.

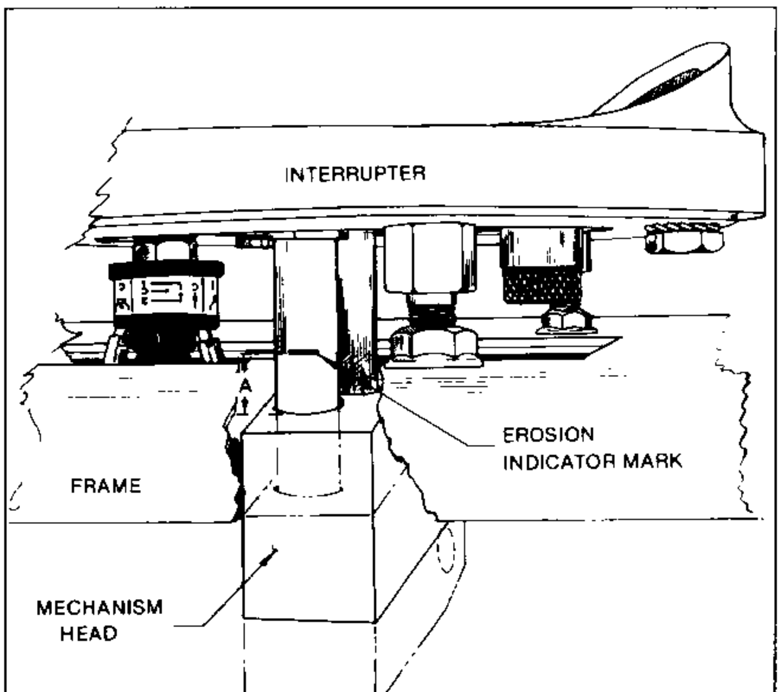
6. After checking the bottle, reconnect it. Replace the connecting rod by reversing the procedure outlined in Item #3.

7. With the connecting rods properly installed and all three bottles restored to normal service, execute a manual close/open operation. This will insure that the breaker is operating properly mechanically.

8. Reconnect the breaker control power and put the breaker through an electrical close/open operation.

The breaker is now ready for primary power energization.

An alternate method of slow-closing an interrupter would be through the use of a hydraulic jack as shown in Figure 11.



CONTACT EROSION INDICATION

- NEW BREAKER A = 6mm
- 50% LIFE A = 3mm
- END OF LIFE A = 0

Figure 6

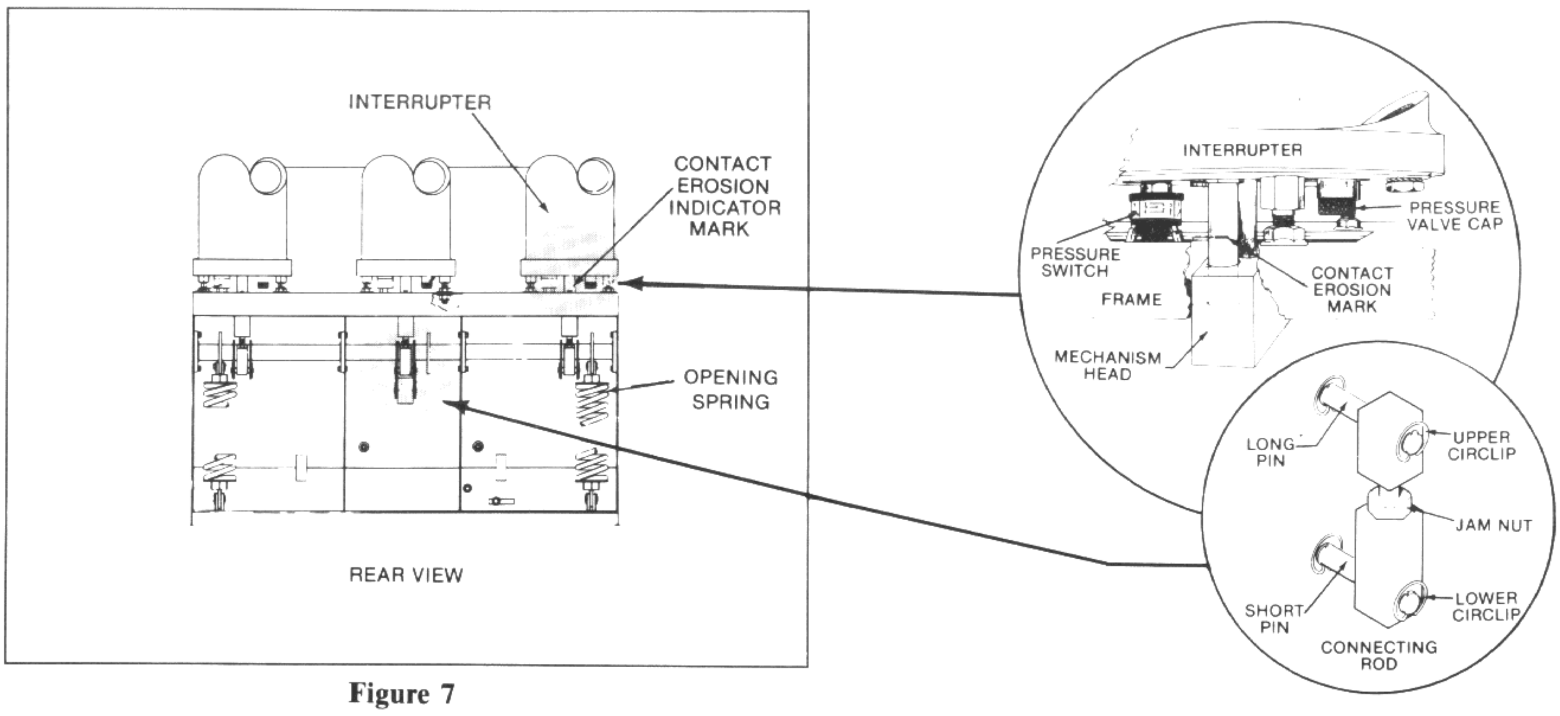


Figure 7

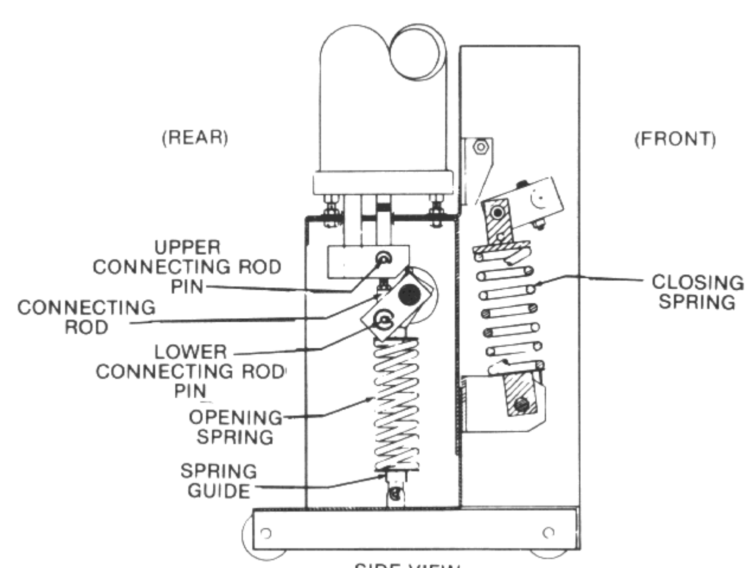
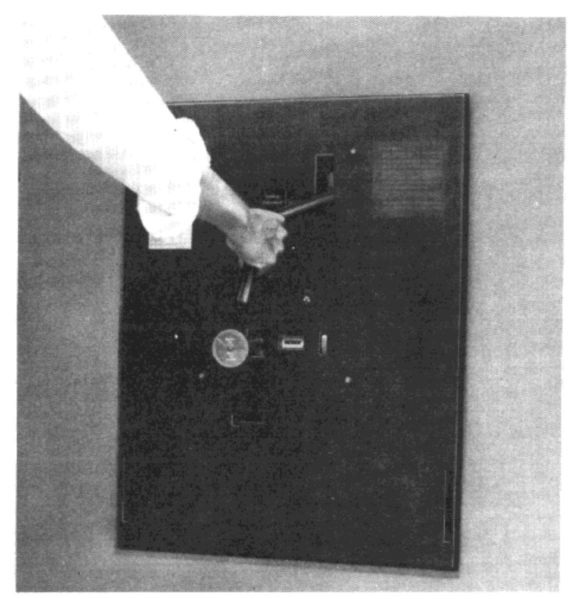
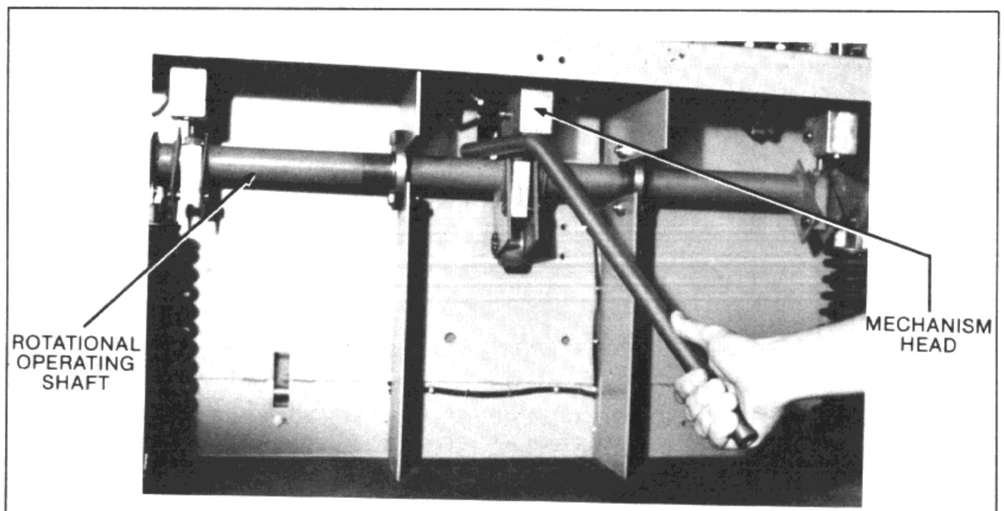


Figure 8



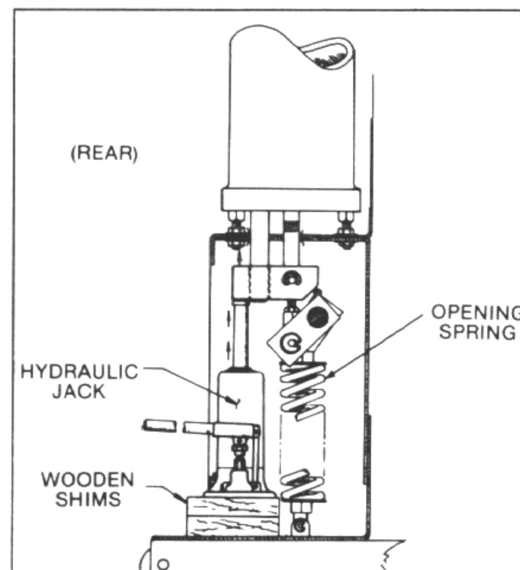
CHARGING SPRINGS MANUALLY

Figure 10



SLOW-CLOSING SINGLE
INTERRUPTER

Figure 9



SLOW-CLOSING SINGLE INTERRUPTER W/JACK

Figure 11

Motion Analysis

A motion analyzer may be attached to the breaker for the purpose of analyzing tripping and closing motion. An adapter is furnished for attachment of the recorder as shown in Figure 12.

The transducer shown in Figure 12 is that of a Doble motion analyzer although the method is compatible with a Cincinnati Analyzer as well as M & G linear motion analysis equipment.

Operating parameters as measured by motion analysis equipment should be as follows:

Closing Time	50-90 mSec.
Opening Time	40-60 mSec.
Closing Speed	11.1-13.1 ft/sec.
Opening Speed	7.5- 9.5 ft/sec.

Velocities are measured at the point of contact make or break.

The operating times and velocities should remain within the above criteria throughout the entire life of the breaker. No adjustments should be necessary. Any deviation should be checked by qualified personnel.

OPERATION OF BREAKER

1. Refer to Figure 13 and 14 for Elementary and Connection diagrams.

2. Charging of the closing springs is controlled by 52LS/bb. When the springs are discharged and power is available on terminals 61 and 62, the closing springs charging motor will run to charge the closing springs. When the springs are charged, the contact 52LS/bb opens stopping the motor.

3. The breaker is electrically closed by operating the closing solenoid 52X. The closing signal is applied across terminals 2 and 4. The closing springs must be charged. Contacts 52/b and 52Y/b pass current to the closing solenoid 52X. When the breaker closes, contacts 52/b and 52/a change state. Contact 52/b opens the closing solenoid circuit. Contact 52/a energizes the anti-pump relay 52Y. Contact 52Y/b opens, preventing the closing solenoid from being re-energized until 52Y is de-energized, and contact 52Y/a seals the anti-pump relay until the close signal is removed from terminals 2 and 4. The anti-pump relay 52Y limits the breaker to one closing operation per close signal applied across terminals 2 and 4. The Latch Check Switch (52 LC) is open when Trip Mechanism is activated.

4. The breaker is electrically tripped by applying a signal across terminal 65 and 6. If the breaker is closed (contact 52/a closed), the trip solenoid will operate, tripping the breaker. Contact 52/a opens, de-energizing the trip solenoid when the breaker is open.

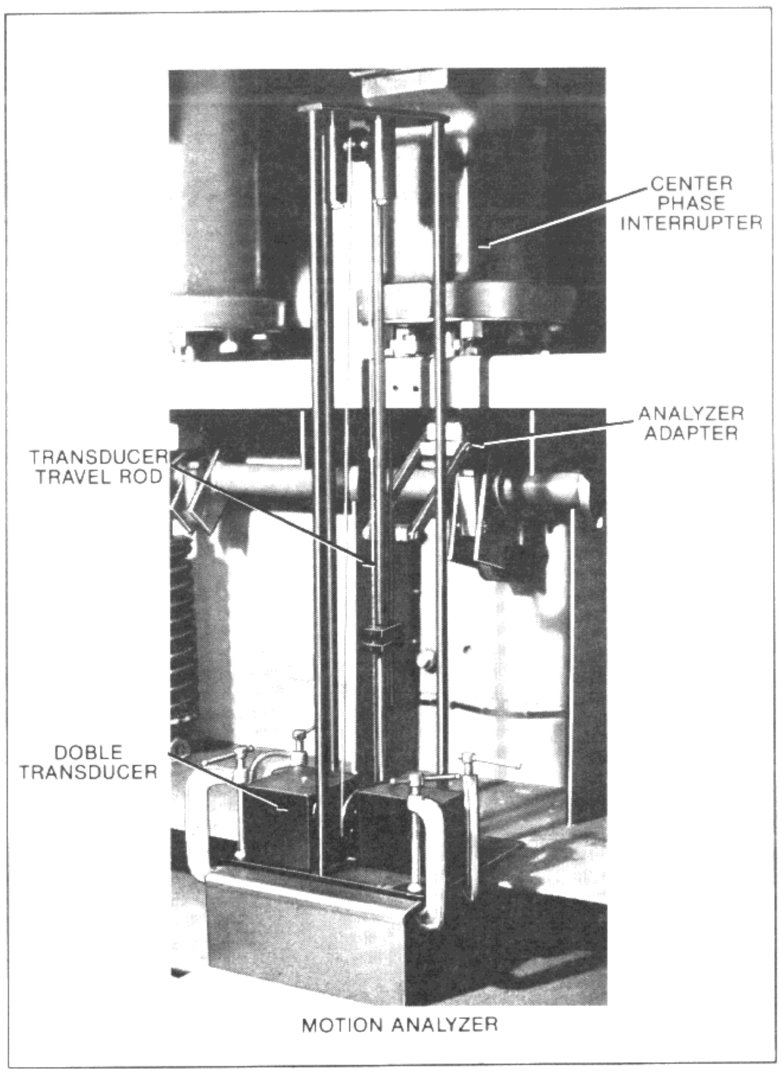


Figure 12

5. Remote status indicators are connected to indicate if the breaker is open or closed. Contact 52/a, connected to terminal 8, is closed when the breaker is closed. Contact 52/b, connected to terminal 10, is closed when the breaker is open.

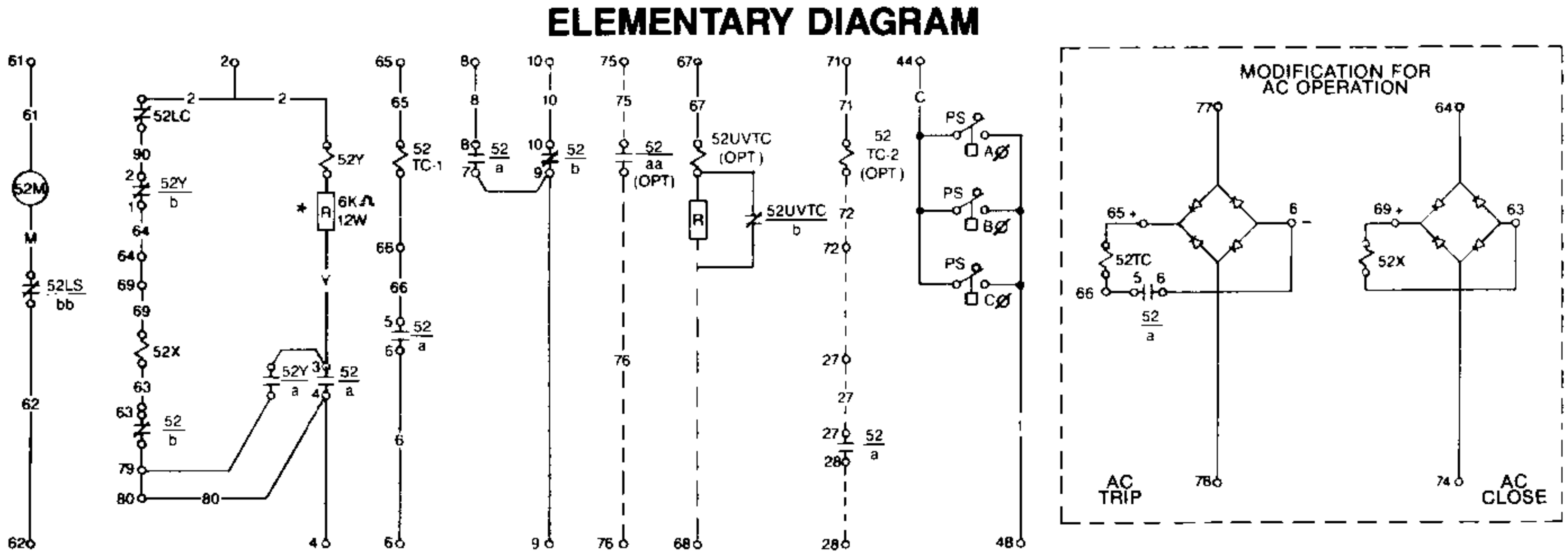
6. An optional remote status indicator to indicate the status of the closing springs is available.

7. An additional trip coil is available as an option. When the second trip coil is provided, applying power across terminals 71 and 28 will cause the breaker to trip. Contact 52/a opens the trip coil current when the breaker is open.

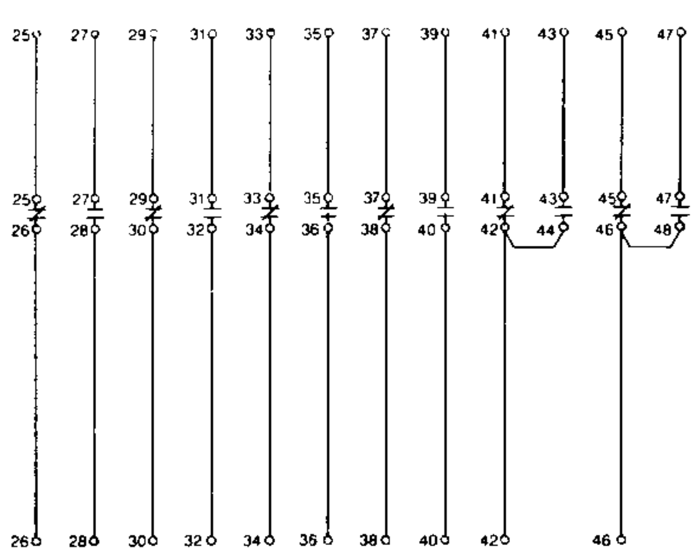
8. An undervoltage trip coil is available as an option. The breaker is tripped when there is loss of voltage across terminals 67 and 68.

9. A pressure switch (PS) is located at the bottom of each interrupter (Figure 7). The switch is designed to operate when the gas pressure falls below 29.4 psig.

ELEMENTARY DIAGRAM



*RESISTOR USED ON 250 VDC CONTROL ONLY



52 LC	Latch Check Switch
52 UVTC	Undervoltage Trip Coil (Optional)
52TC-1,2	Breaker Trip Solenoid (1 standard, 2 optional)
52X	Breaker Closing Solenoid
52Y	Anti-Pump Relay
52M	Closing Springs Charging Motor
52Y/a	Anti-Pump Relay Contact-Normally Open
52Y/b	Anti-Pump Relay Contact-Normally Closed
52LS/aa	Closing Springs Charged Limit Switch-Open When Springs Are Not Charged. Closed When Springs Are Charged.
52LS/bb	Closing Springs Charged Limit Switch-Closed When Springs Are Not Charged. Open When Springs Are Charged.
52/a	Auxiliary Switch Contacts-Open When Breaker Is In the Tripped (Open) Position, Closed When Breaker Is In The Closed Position.
52/b	Auxiliary Switch Contacts-Closed When Breaker Is In the Tripped (Open) Position, Open When Breaker Is In The Closed Position.
P.S.	Pressure Switch, Switch Closes at 2 Bar (29 psig) Relative Pressure

Figure 13

NOTES:
Breaker shown in open position, closing springs discharged.

CONNECTION DIAGRAM

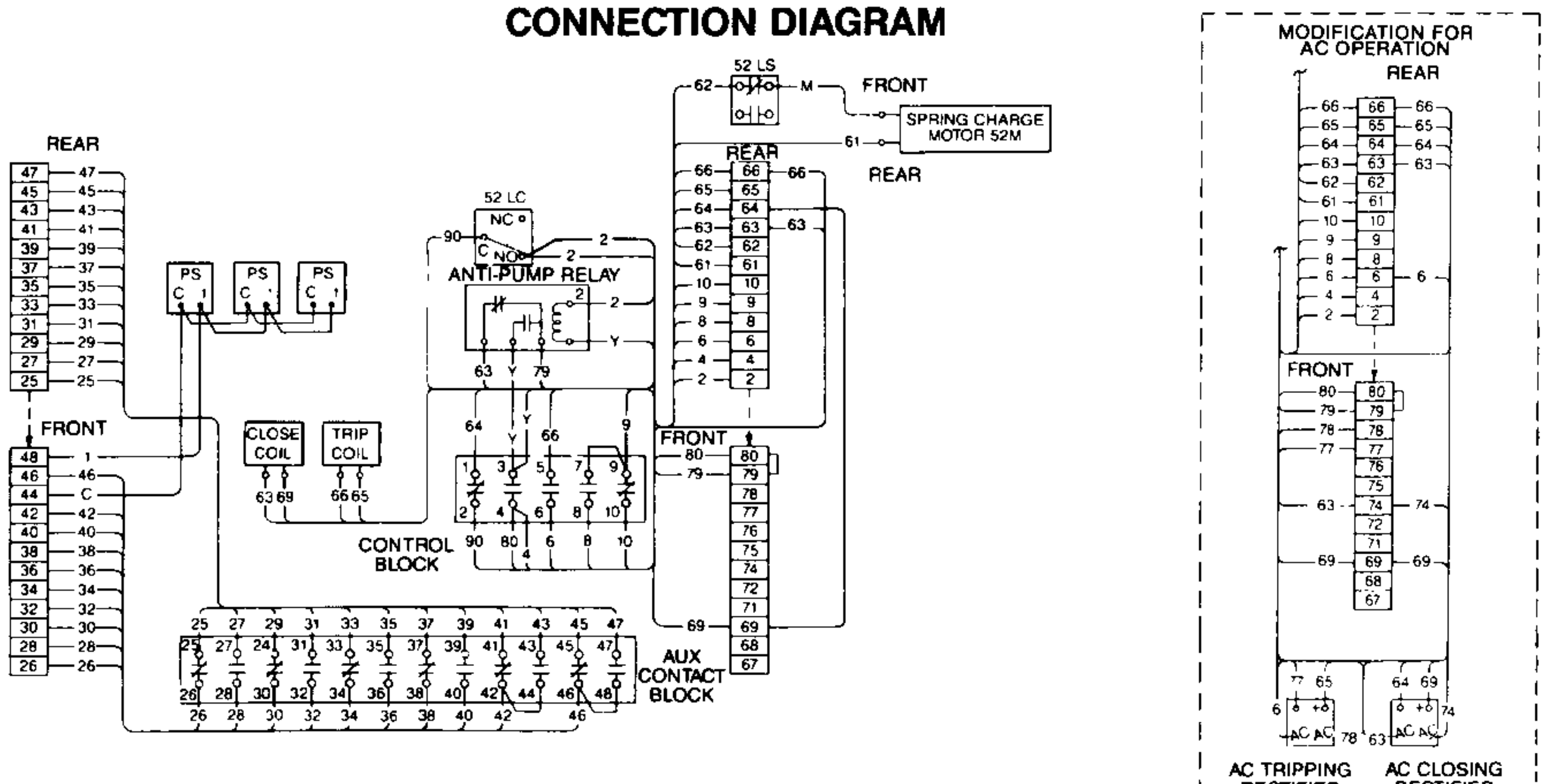


Figure 14

BUSHINGS

The bushings (Figure 15) are solid cycloaliphatic epoxy condensor type. They are mounted through a roof opening (Figure 16) that is extruded for protection from water "roll off" entering the high voltage compartment. An "O" ring is added around the extrusion that completes the weather seal.

Depending upon environmental conditions, the user should establish the period between dielectric tests. If there is no previously established period for bushing tests, then a 5 year period is recommended. One or more of the following tests are suggested.

HIGH POTENTIAL DIELECTRIC TEST

Apply a test voltage, (line to ground) in accordance with the values listed in the following table for a period of one minute:

Rated Maximum Voltage	Test Voltage at 60 Hz
15.5 kV	50 kV
25.8 kV	60 kV
38.0 kV	80 kV

The bushings are considered to have passed the test if no internal or external breakdowns occur.

POWER FACTOR TEST

(a) Disconnect ground from bushing.
(b) Using an appropriate test set and following test set instructions, connect test leads between top terminal of bushing and the bushing ground screen.
(c) OBSERVE GOOD SAFETY PRACTICES PER INSTRUCTIONS
(d) Following test set instructions, record power factor reading to be used as a "bench mark" for subsequent readings.

CT REPLACEMENT

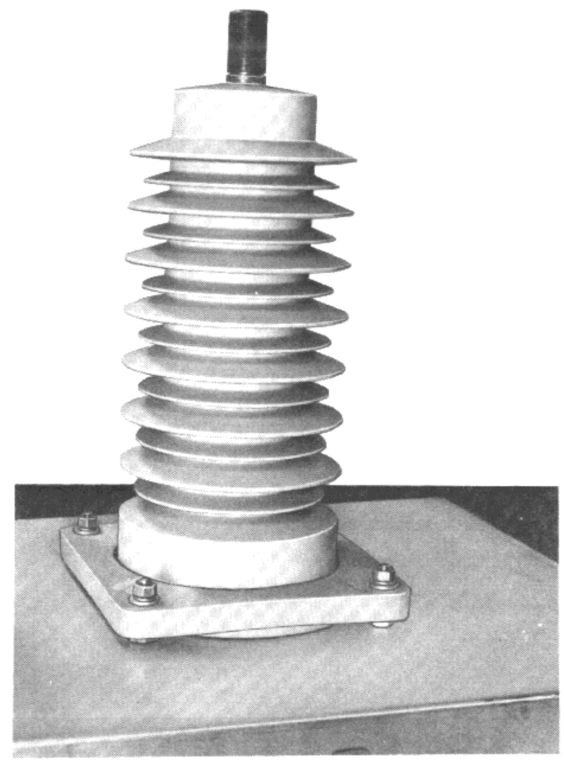
1. Disconnect flexible connector between bottom of the bushing and the entrance to the interrupter.

2. Disconnect CT wiring at CT.

3. Remove the two (2) retainer devices that hold the CT in place and remove CT.

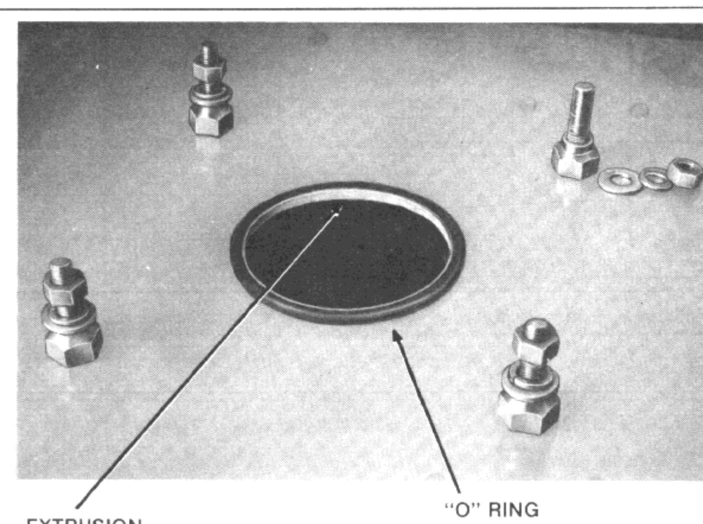
4. BE CERTAIN TO OBSERVE POLARITY MARKS WHEN INSTALLING NEW CT.

5. Install replacement CT by following directions in reverse order. Observe recommended torque values, items 3-b, 3-c and 3-d under pre-service checkout.



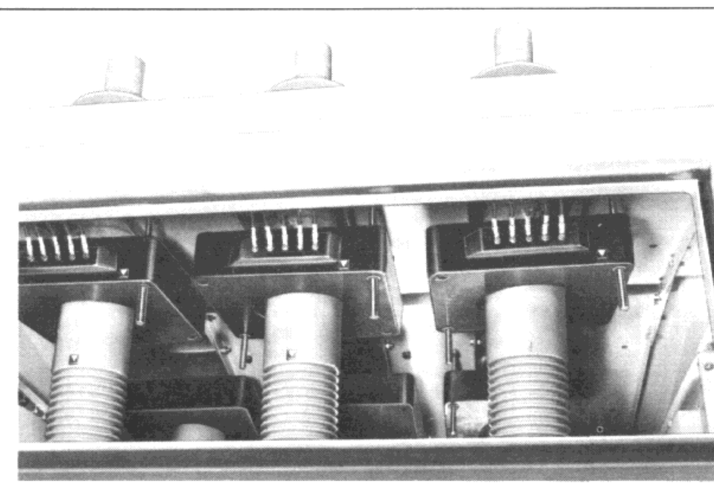
BUSHING

Figure 15



BUSHING MOUNTING

Figure 16



CT MOUNTING

Figure 17

DIMENSIONS

Type FC Breaker

ALL DIMENSIONS IN INCHES (NOT FOR CONSTRUCTION)

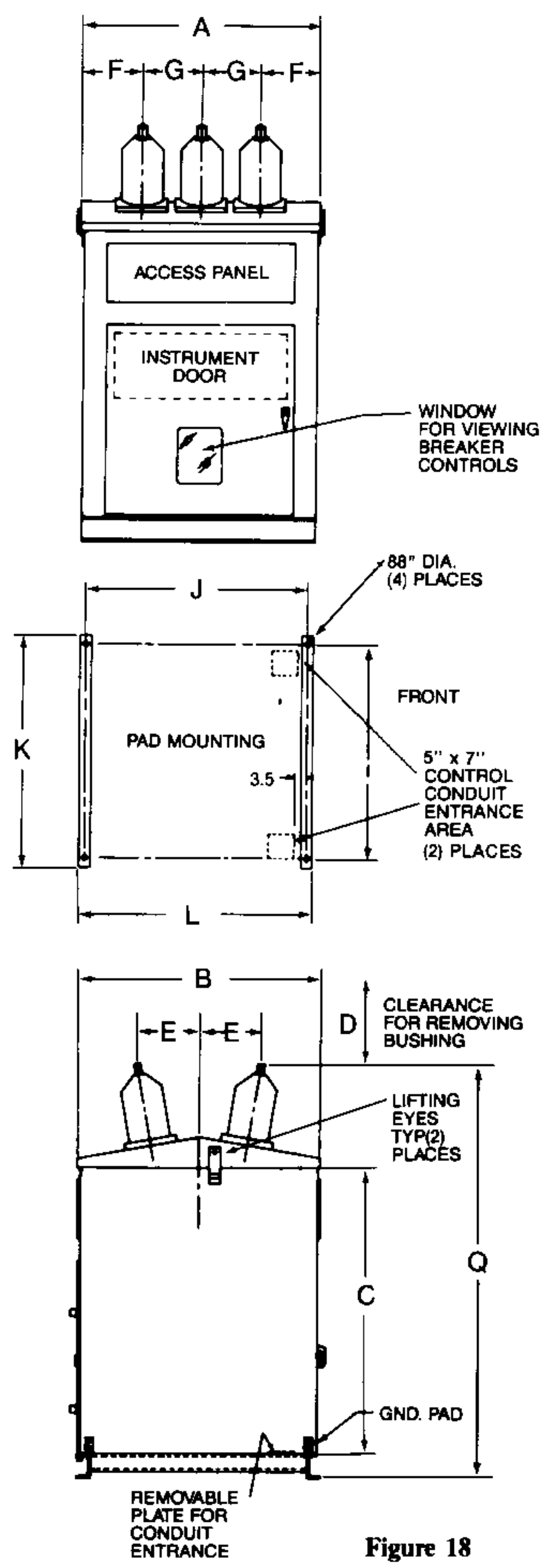
Bil	A	B	C	D	E	F	G	I	J	K	L	Q(Min.)
110kV	63.56	64.61	79.52	24.00 ①	16.00 ③	16.03	15.75	57.00	63.50	63.00	66.00	113.50 ④
125kV	63.56	64.61	79.52	25.00 ②	16.00	16.03	15.75	57.00	63.50	63.00	66.00	113.50
150kV	63.56	64.61	79.52	20.00 ②	16.00	16.03	15.75	57.00	63.50	63.00	66.00	113.50

① 3000A—20.00

② 2000A—25.00

③ 3000A—17.00

④ 3000A—109.50



Approximate Weight:
2000A-4000 lbs
OTHERS-3500 lbs

Uplift:
453 lbs. max—10 msec.

Figure 18

LIFE EXPECTANCY CURVE TYPE FC

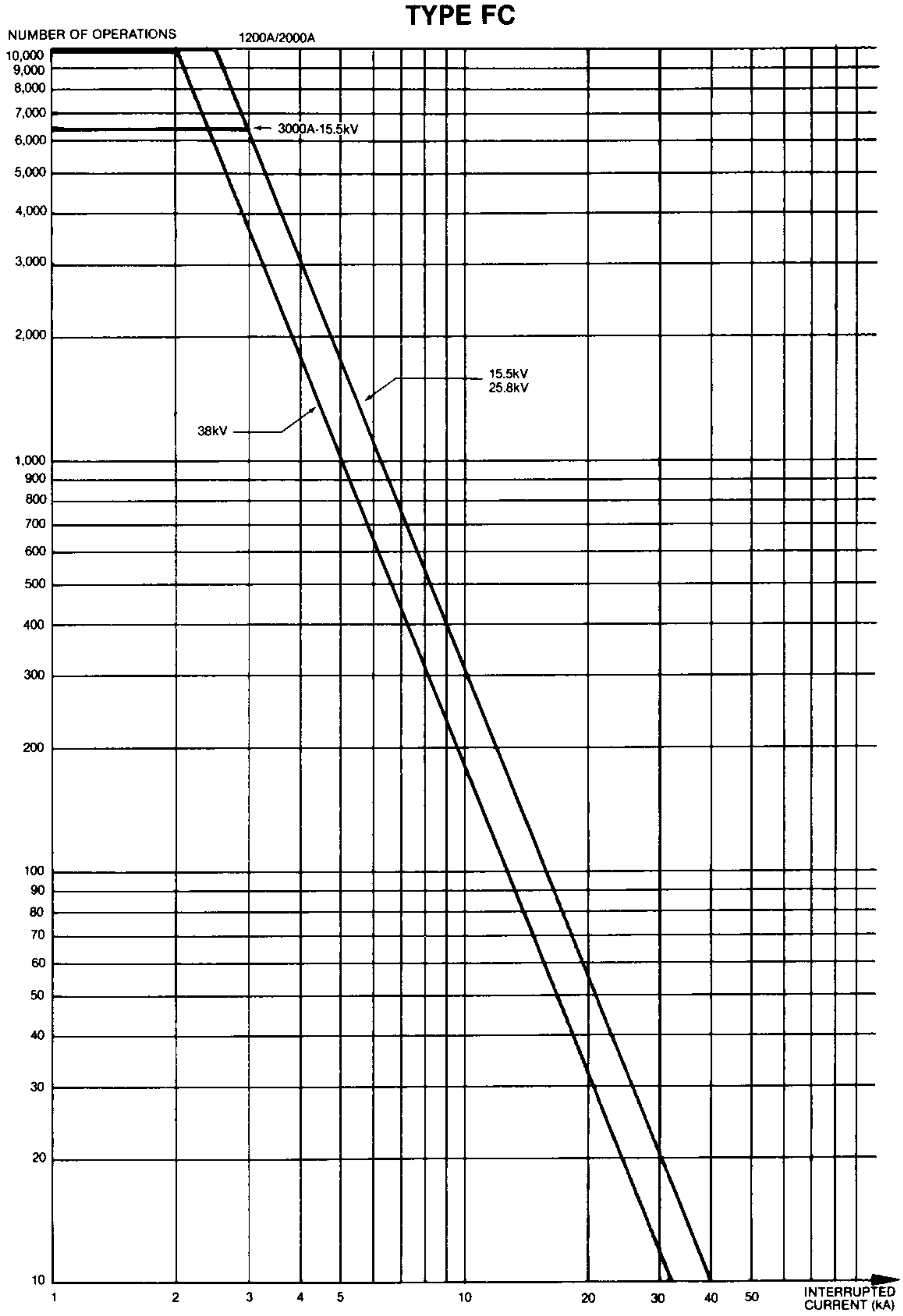


Figure 19

TROUBLESHOOTING GUIDE

These instructions allow shutdown periods to be kept to a minimum. If the suggested remedies fail to solve the problem, consult the factory.

Problem	Possible Cause	Probable Reason & Remedy
MECHANISM DOES NOT CHARGE AUTOMATICALLY	Electrical Charging motor	Low voltage at the terminals of the motor. Correct the voltage. Replace the motor if necessary.
	End-of-charging switch	Check condition of switch. Replace it if necessary.
	Wiring	Check connections.
BREAKER WILL NOT CLOSE (The indicator stays green)	Closing solenoid	Bad connection. Check the circuit. Defective coil. Replace the coil.
	Anti-Pump Relay	Check relay. Replace if necessary.
	Latch mechanism	Latch may not be pivoting properly. Clean and oil the hinge.
	Emergency Trip Assembly	Locked out—Reset.
	Latch Check Switch	Misadjusted or Defective Adjust or replace.
BREAKER CLOSES AND OPENS AT ONCE AND REMAINS OPEN	Any release (direct or indirect)	Fault in the HV main circuit or incorrect adjustment of protective circuits. Eliminate the fault. Adjust protective circuits. Check to see if protective relay time dial is set to "0".
BREAKER CANNOT BE OPENED ELECTRICALLY	Auxiliary switch	Check circuit.
	Trip solenoid	Bad connection. Check the circuit. Defective coil. Replace the coil.

Table 2

REPLACEMENT PARTS

Device	Voltage	Part No.
Spring Charging Motor	24 VDC	B44065-031-06
	48 VDC	B44065-031-01
	125 VDC	B44081-169-01
	250 VDC	B44065-031-04
	120 VAC	B44081-169-01
	240 VAC	B44065-031-04
Closing Solenoid	24 VDC	C44065-389-05
	48 VDC	C44080-590-01
	125 VDC	C44080-590-03
	250 VDC	C44080-590-02
	120 VAC	*C44080-590-04
	240 VAC	*C44080-590-02
Trip Solenoid	24 VDC	C44080-590-25
	48 VDC	C44065-389-21
	125 VDC	C44080-590-24
	250 VDC	C44080-590-23
	120 VAC	*C44080-590-24
	240 VAC	*C44080-590-22
Anti-Pump Relay	(Class 8501 Type KF)	
Bushing	(Order by Breaker S/N + Description)	
Interrupter	(Order by Breaker S/N + Description)	

*Must be used with rectifier—A44081-141-01

Table 3

SQUARE D COMPANY
330 Weakley Road, Smyrna, Tenn. 37167

Manual 6060-2 2M 12/85 P.S. Printed in U.S.A.