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Manual 6060-1

Supersedes Manual 6060-1, Dated 9/1983

Installation & Maintenance Manual

SF_6 Substation Circuit Breakers Type FB

SQUARE D COMPANY

TYPE FB SF_6 SUBSTATION CIRCUIT BREAKERS

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TYPE FB SF_6 SUBSTATION CIRCUIT BREAKERS

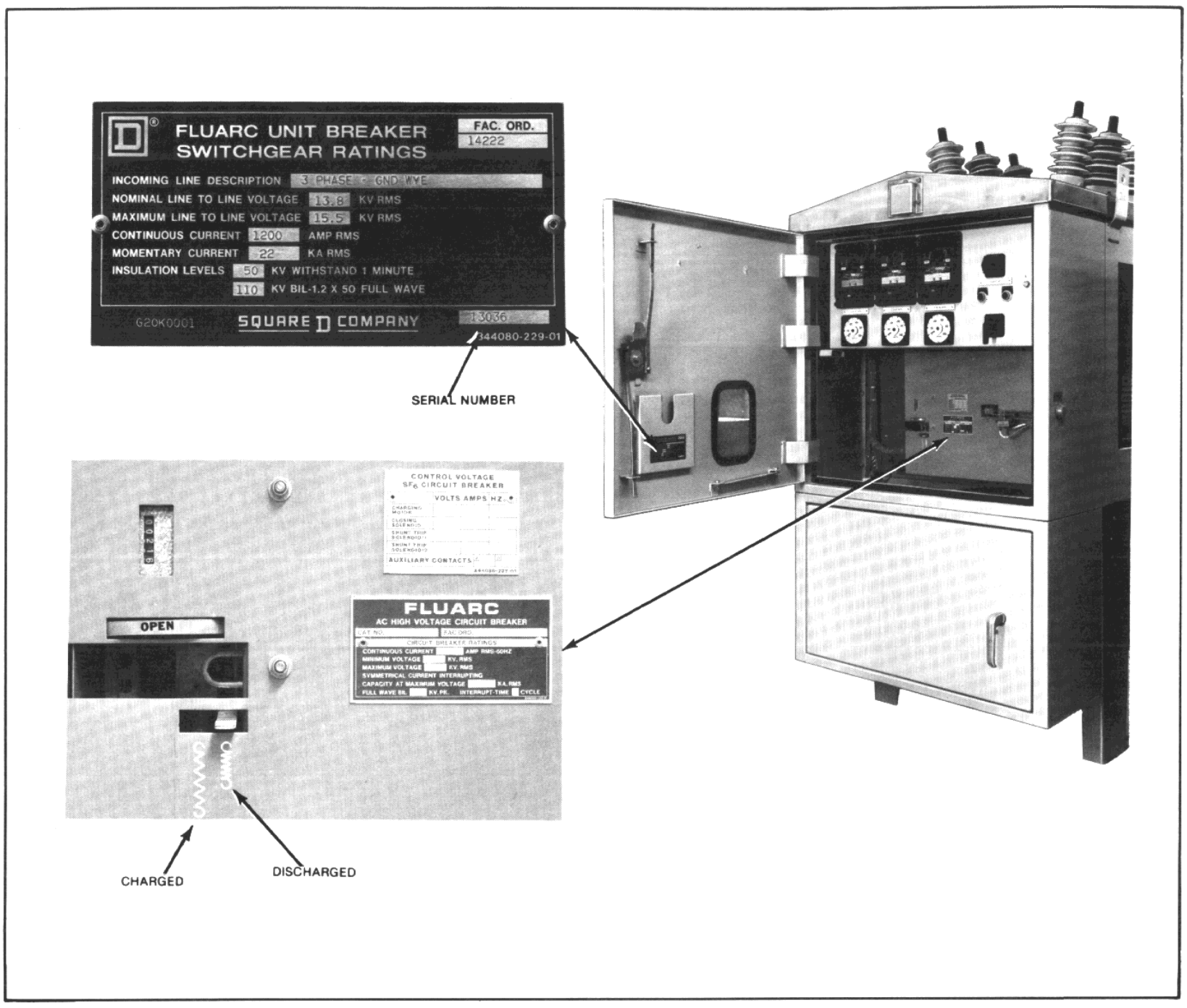

Figure 1

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 however, is a low pressure, sealed interrupter type, for applications at 2.4kV through 38kV.

The Type FB Substation FLUARC® Circuit Breaker uses three (3) sealed interrupters. These interrupters are filled with SF_6 at the factory and sealed for life. FIELD CHARGING OF THE INTERRUPTERS IS NOT REQUIRED.

Designed for low maintenance techniques, the Type FB Circuit Breaker is housed in a painted steel enclosure protected by a stainless steel roof. Overall height is variable through the use of adjustable galvanized legs.

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

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STANDARD FB RATINGS

Breaker Type	FBS-1	FBS-2	FBS-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 Voltage Wet	 50kV 45kV	 60kV 50kV	 80kV 75kV
Minimum External Creep Distance	20.5 in.	25.75 in.	47 in.
Minimum External Strike Distance Terminal to Ground	14 in.	16 in.	22 in.
Minimum External Strike Distance Between Bushing Terminals Phase to Phase	10.12 in.	11.87 in.	13.46 in.
Interrupting Time (3 Cycles - Optional)	5 Cycles	5 Cycles	5 Cycles
Time Between Coil Energization And Contact Parting	45-65 msec.	45-65 msec.	45-65 msec.
Spring Charging Time	8-11 sec.	8-11 sec.	8-11 sec.
Closing Time	85 msec.	85 msec.	85 msec.
Reclosing Time	0.3 sec.	0.3 sec.	0.3 sec.
Continuous Current	400A-1200A	400A-1200A	400A-1200A
Interrupting Capacity (Max. Voltage)	20kA	18kA	16kA
Momentary Rating (Peak)	60kA	54kA	48kA

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 not 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 of the equipment.

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, provision 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 the interrupter power pole hardware for tightness (recommended torque 20 ft-lbs)
   These checks are part of normal factory quality procedures, however, it is suggested these items be re-checked prior to actual energization.
   c) 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.

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.

CIRCUIT BREAKER ENCLOSURE

The Type FB Substation Circuit Breaker consists of an isolated high voltage compartment and low voltage compartment.

The high voltage compartment includes cycloaliphatic cast epoxy bushings which protude through the stainless steel roof. Each roof penetration is extruded outward ¼" and gasketed to prevent water leakage due to gasket aging. Up to three current transformers can be mounted on each bushing. Provisions are included on each unit and therefore require no additional mounting parts.

Two large gasketed access panels (RHS and LHS – Figure 2) allow entry into the high voltage compartment. **CAUTION: DO NOT REMOVE PANELS WHILE BREAKER IS ENERGIZED.** The bushings, CTs, sealed interrupter poles, operating linkage, contact wear indicator and strip heater are readily accessible. Secondary CT wiring is extended to terminal strips in the isolated low voltage compartment.

A filtered ventilation grill and gasketed access panel is mounted on the bottom side of the high voltage compartment. Removal of this access panel exposes the opening springs and rotary shaft mechanisms. **CAUTION: DO NOT REMOVE WHILE ENERGIZED.** Access to "live" parts is shielded by the circuit breaker support channel, however the above safety precautions should always be observed.

The low voltage compartment is isolated by a steel barrier from the high voltage compartment. A hinged panel for relay mounting, terminal strips, strip heater, circuit breaker operating mechanism – all are accessible through a hinged and gasketed front door. (An optional compartment extension is supplied where the quantity of relaying dictates.) A padlockable vault type handle with three (3) point latch is provided. A wind stop and instruction manual pocket are provided on the rear of the door.

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 is provided that includes lockout provisions and an electrical/mechanical hand reset interlock (ANSI 69 switch). This provision will preclude supervisory close and automatic reclose signals to the circuit breaker when an emergency manual trip and lockout situation exists.

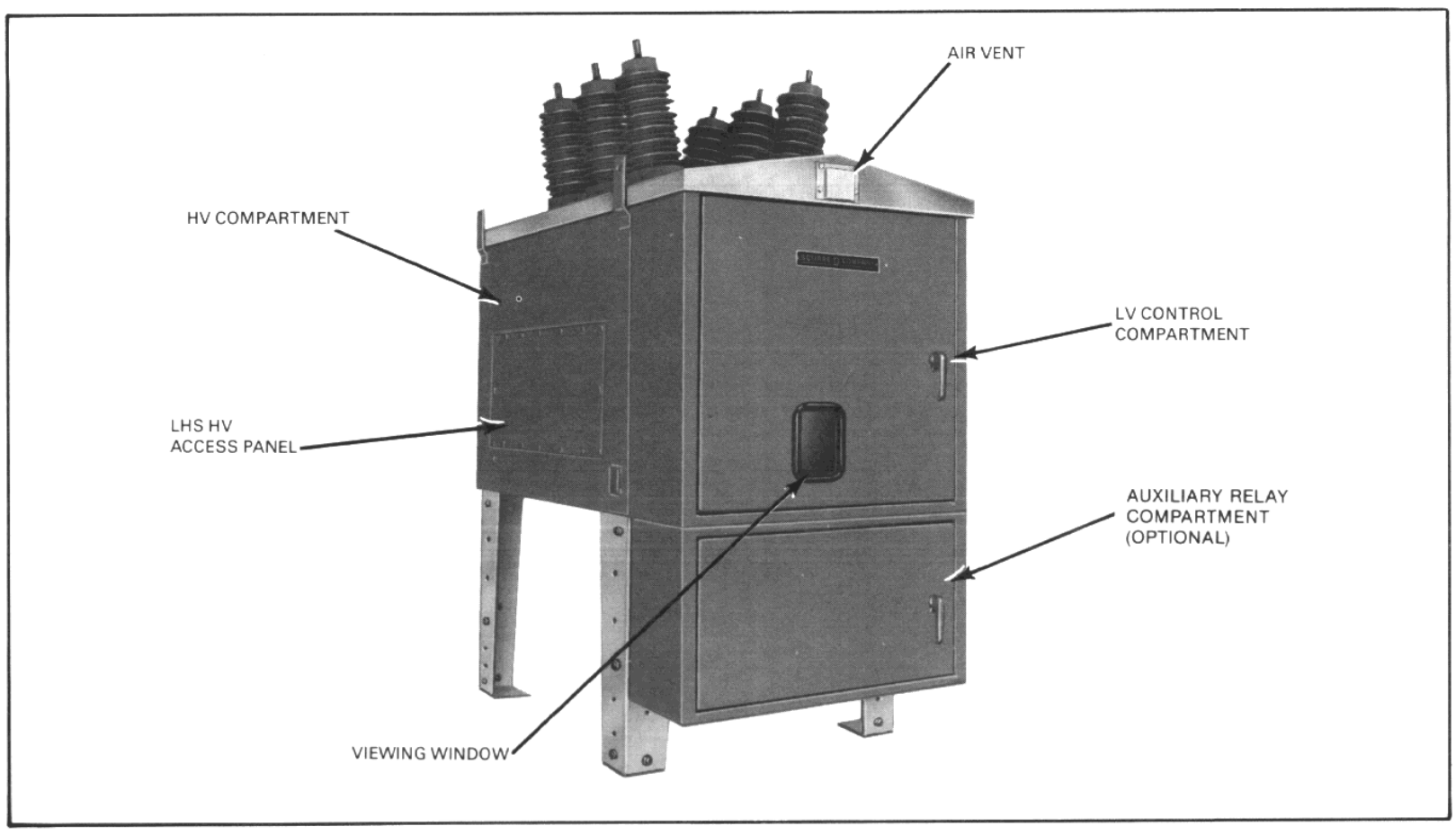


Figure 2

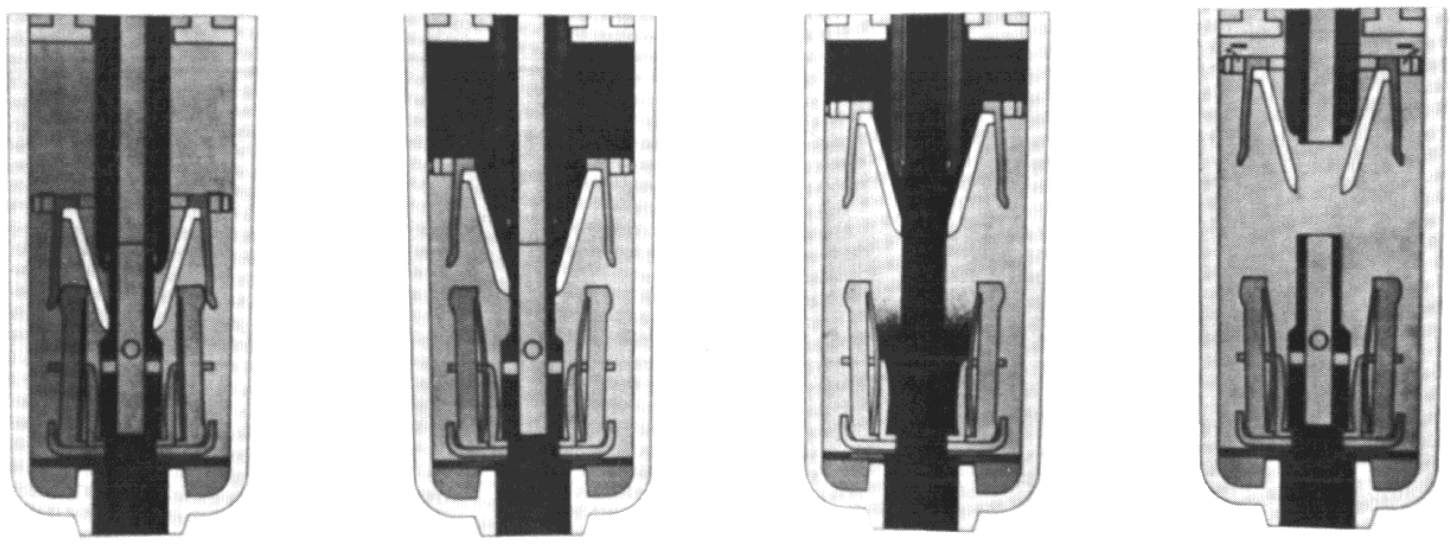
OPERATION THEORY OF SF_6

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.

FB CIRCUIT BREAKER OPERATION



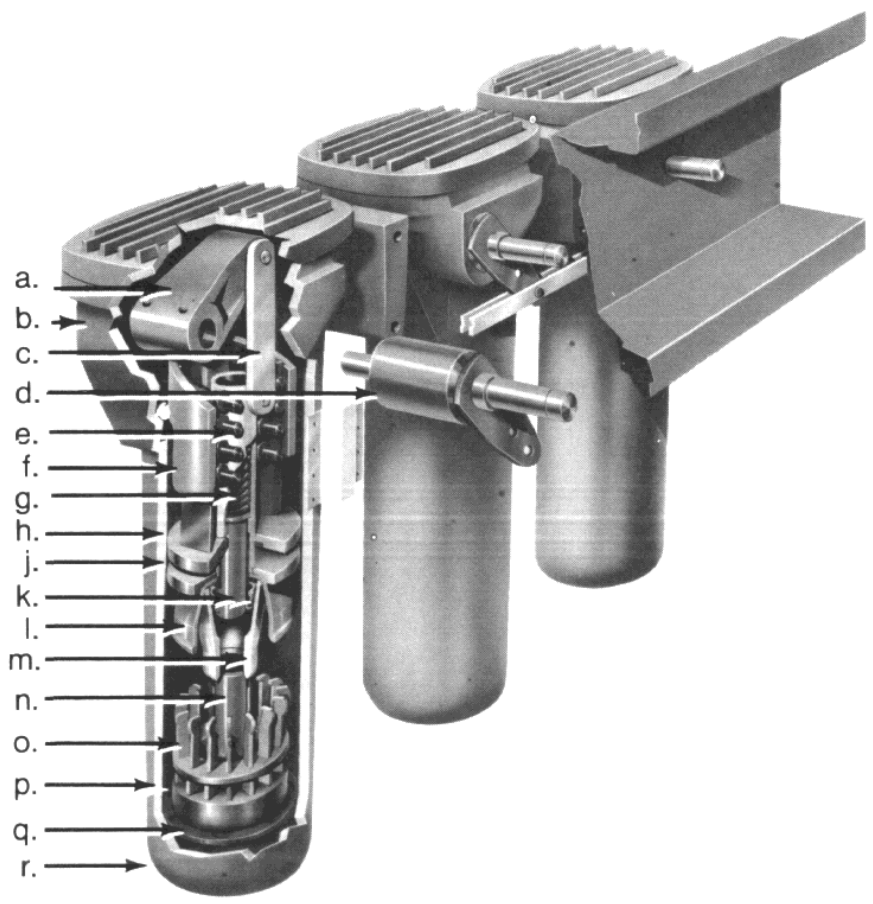
Cutaway of Fluarc SF_6 Circuit Breaker Bottle in Closed Position Prior to Interruption.

Separation of the Main Contacts Prior to Arc Inception and Compression of SF_6 Reservior.

Parting of Arcing Contacts. Puffing of the Arc Continues Until Interruption at a Current Zero.

Circuit Breaker in Open Position with Current Interrupted.

Figure 3



KEY:

a. Crank
b. Terminal
c. Operating Rod
d. Rotating Control Shaft
e. Conical Rollers
f. Cradle
g. Contact Stem
h. Cradle Base
j. Piston
k. Movable Arcing Contact
l. Movable Main Contact
m. Insulating Nozzle
n. Fixed Arcing Contact
o. Fixed Main Contact
p. Pole Enclosure
q. SF_6 Regenerating Material
r. Terminal

Figure 4

INSPECTION AND MAINTENANCE

General

The FB 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 24) showing the relationship of interrupting current vs. number of operations. The interrupter chambers are pressurized with SF_6, sealed and have no need of maintenance.

The need for inspections and possible interrupter replacement should be based upon the frequency of operation, types and levels of interruptions and environmental conditions. Specific inspections and/or maintenance would be as follows:

- Operating Mechanism
- Contact Erosion
- Ventilation Filter Condition
- Roof Bushing Dielectric Test
- Sequence of Operation
- Gas Servicing

WARNING: THROUGHOUT THESE PROCEDURES, THE OPENING AND CLOSING SPRINGS SHOULD BE DISCHARGED FOR SAFETY.

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. 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.

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.

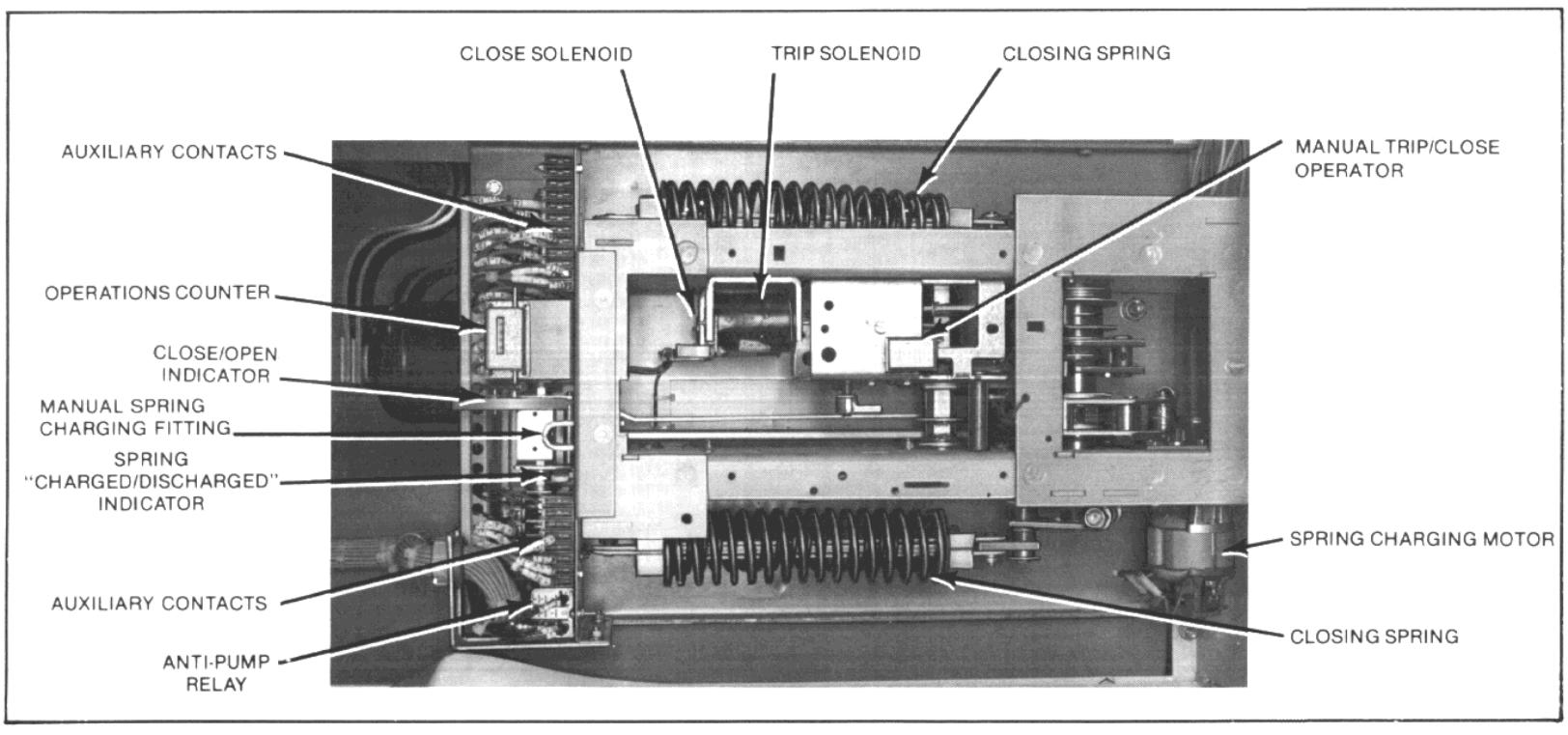


Figure 5

Operating Mechanism Lubrication

An important part of normal preventive maintenance of this breaker would be to ensure that the mechanism is clean and properly lubricated. Cleaning and lubrication should be as follows:

1. Linkages designated should be cleaned with trichlorethylene and lubricated lightly with oil. (Figures 6, 7)

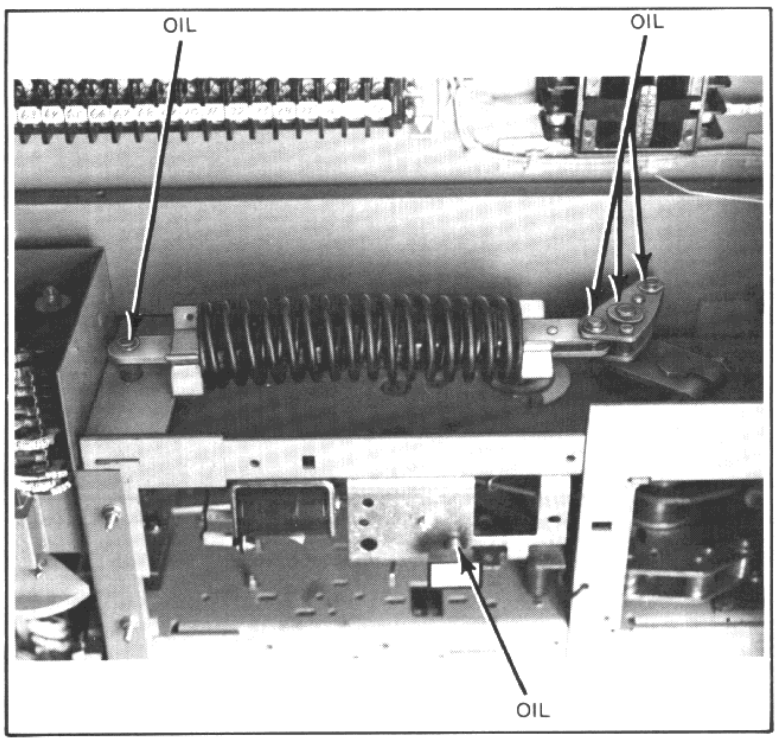


Figure 6

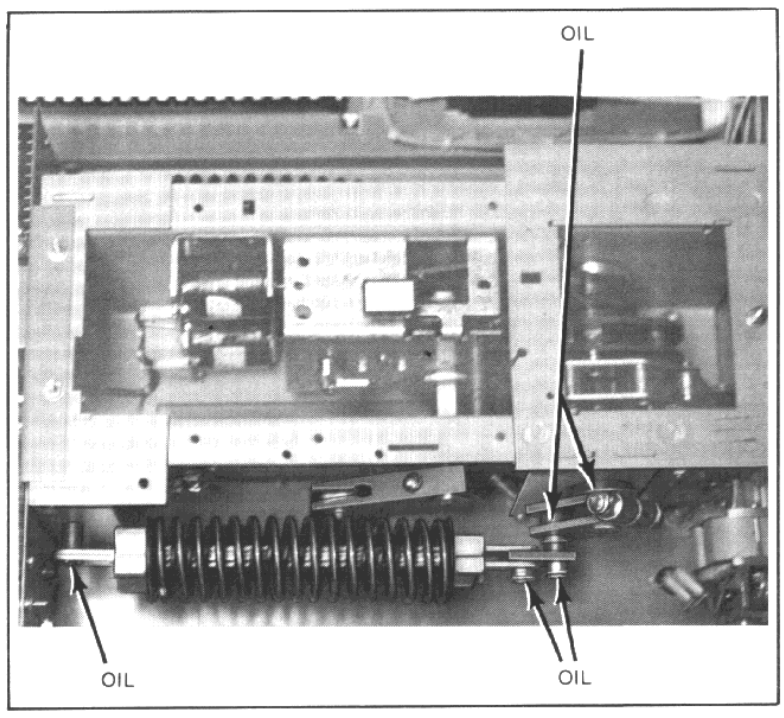


Figure 7

2. The spring guides and gears designated "G" should be greased lightly with a low temperature grease such as automotive molybdenum disulfide. (Figure 8)
3. The opening spring should be lubricated at point A with oil and point B with grease. (Figure 9)

Suggested maintenance frequency of the operating mechanism is every 3000 operations or 36 months, whichever comes first. Consideration must be given to a shorter cycle in the case of adverse environmental conditions.

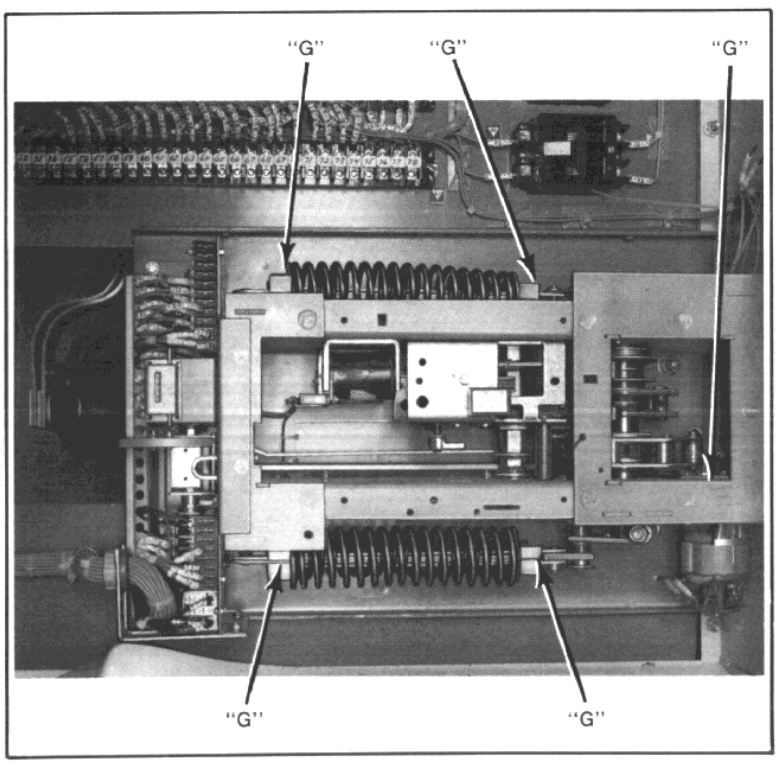


Figure 8

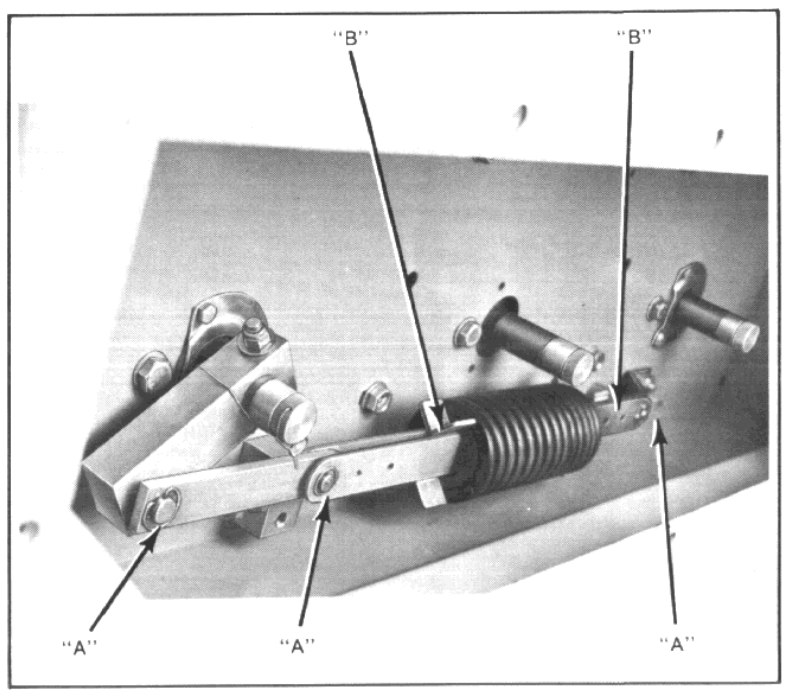


Figure 9

Contact Erosion

The total life of an interrupter is determined by a combination of interrupting current and number of operations, and can be measured through contact erosion. See (Figure 24) that depicts this phenomena graphically. Contact erosion becomes most significant after the breaker has reached 75% of its predicted life. This can be estimated by using the graph. A red and green indicator is provided in the high voltage compartment for determining whether or not the interrupters should be replaced. (See Figure 14)

To check contact erosion it is necessary to defeat and remove the closing springs and slow-close the breaker. Use the following procedure:

1. Totally remove the high voltage from the bushings and make sure the breaker is open and the springs are discharged.
2. As shown in (Figure 10), charge the mechanism manually so that the right-hand holes are just barely accessible. This should be such that a pin may be inserted.
3. Continuing to put a slight pressure on the charging handles, insert a 6mm or 10-32 diameter screw or pin through the hole as shown. Repeat for lower spring. (Figure 11)
4. Remove the snap rings on both springs (Figure 12). Be certain to note the position of the washers and the main pins so they may be replaced in the same manner when reassembling.
5. Detach and remove the springs. (Figure 13) shows top spring location after removal.

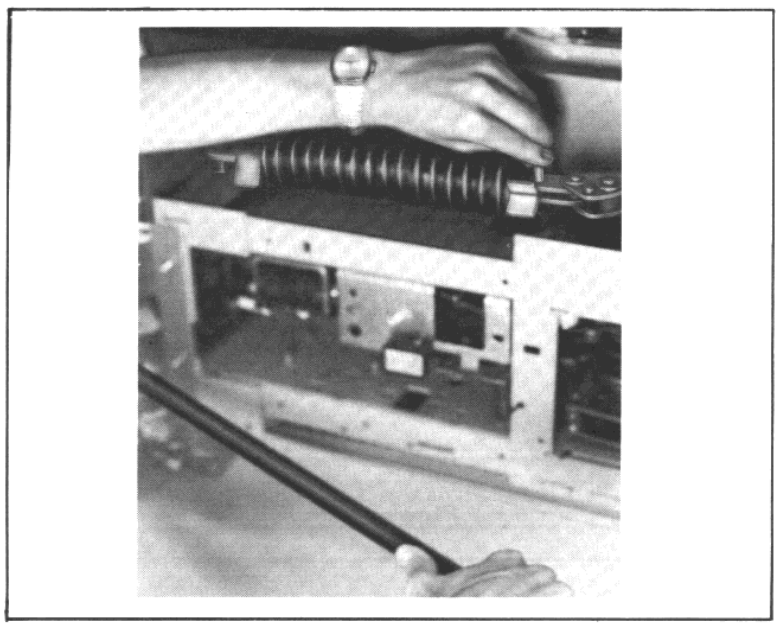


Figure 10

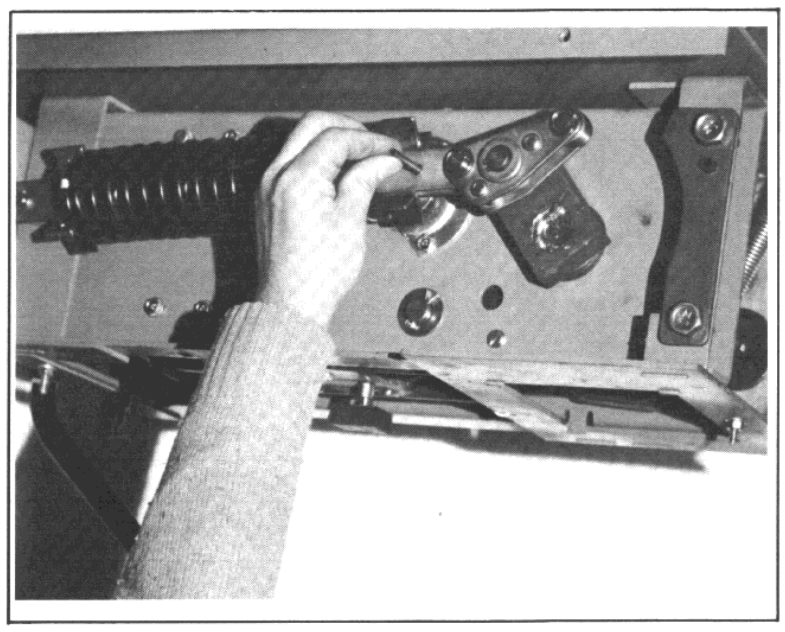


Figure 11

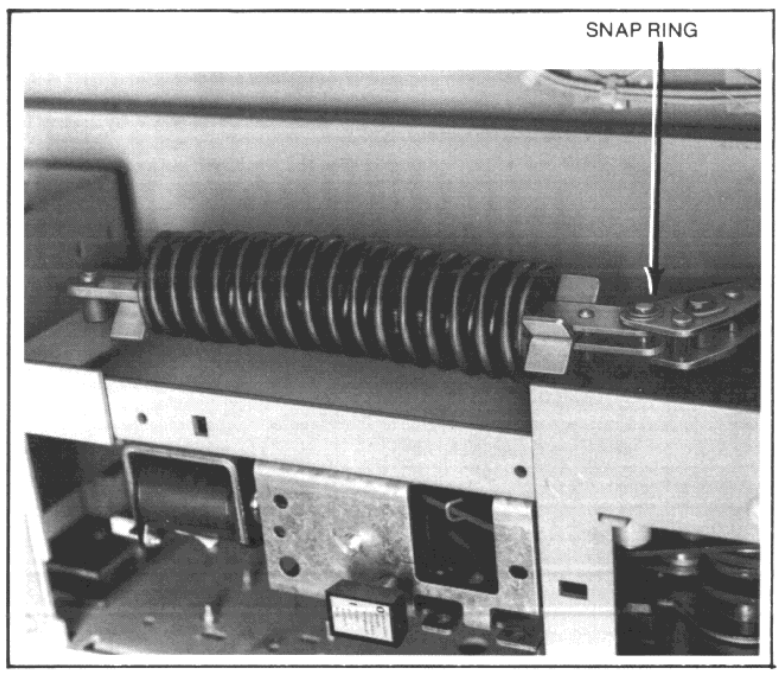


Figure 12

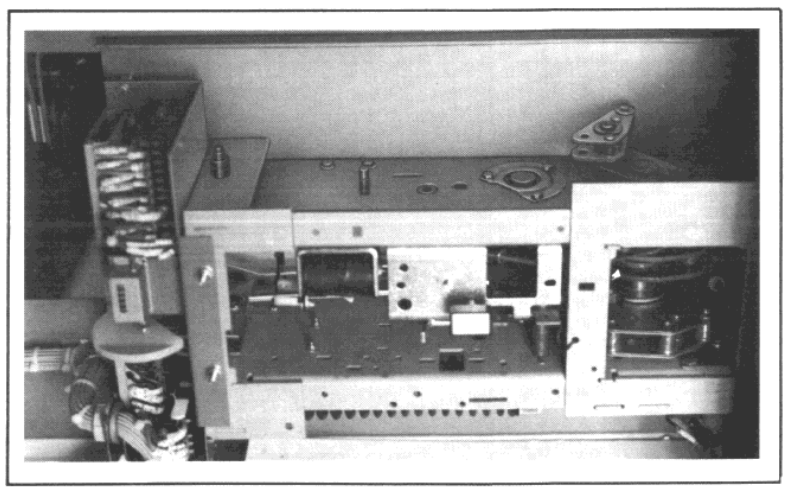


Figure 13

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Contact Erosion (continued)

6. Charge the mechanism manually until a click is heard.
7. Pull the OPEN/CLOSE button.
8. Attach a bell-set, ohmmeter or 3-phase LED test set across each interrupter. Continue to slow close the breaker through the manual charging handle and check contact "make" point on each interrupter. As long as the end of the connecting link (index) is not in the red zone (Figure 14) the contact condition is considered good. When the index area (end of link) is at the red/green transition line, the bottle(s) should be replaced.

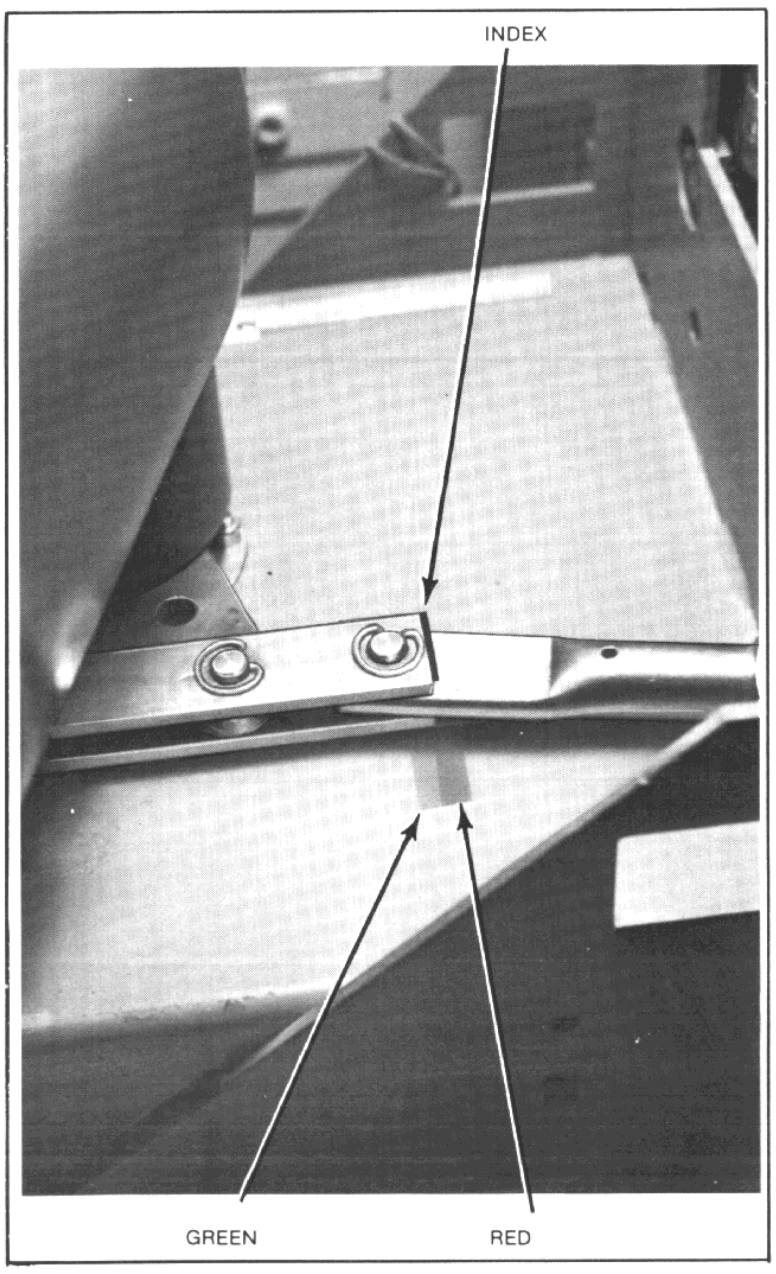

Figure 14

Ventilation Filter

The filter, located through the bottom access cover, (Figure 16) should be cleaned or replaced every 36 months, depending on environmental conditions.

To re-install the closing springs, use the following procedure:
1. Manually close the breaker fully, then trip it open, using the manual trip button.
2. Re-install both the top and bottom springs, recoupling them as shown in (Figure 15).
3. BE CERTAIN THE SPACERS, WASHERS AND PINS ARE INSTALLED IN THE SAME POSITION AS THEY WERE IN PRIOR TO REMOVAL.
4. After re-installation of the springs, charge the mechanism slightly to relieve the tension enough to be able to remove the pins that were inserted previously.
5. The mechanism should now be manually fully charged and the breaker tripped to ensure proper mechanical operation.

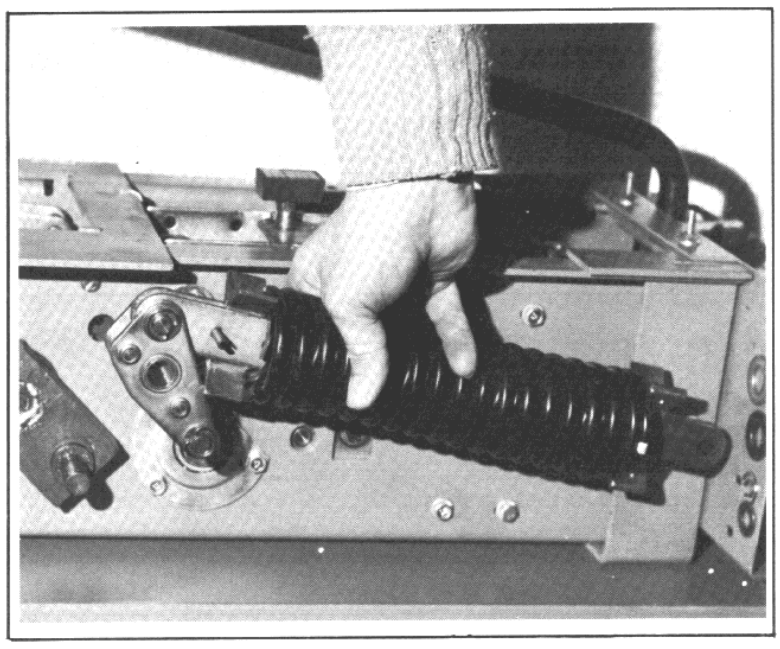

Figure 15

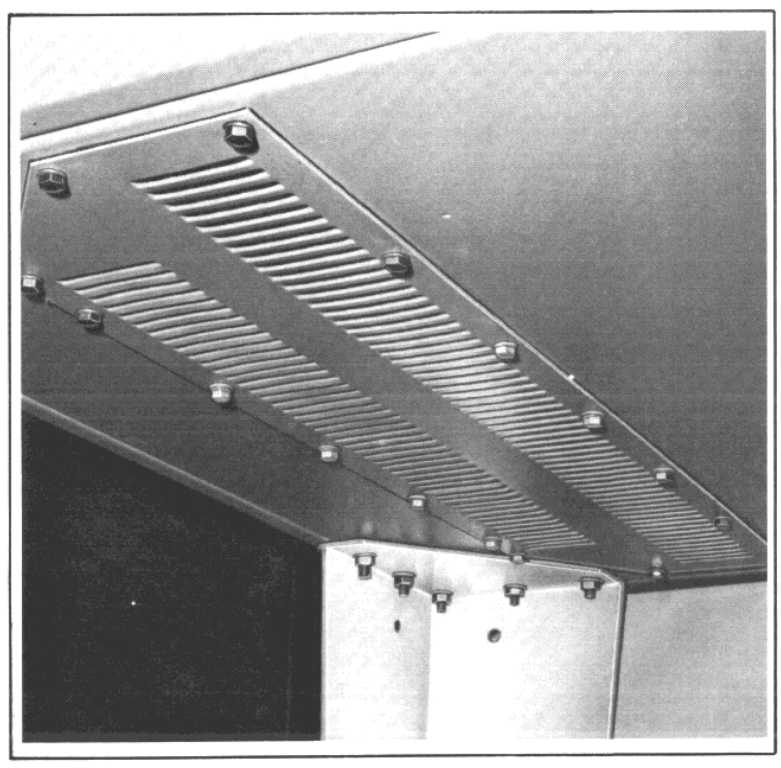

Figure 16

Bushings

The bushings (Figure 17) are solid cycloaliphatic epoxy condensor type. They are mounted through a roof opening (Figure 18) 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 (Figure 19).

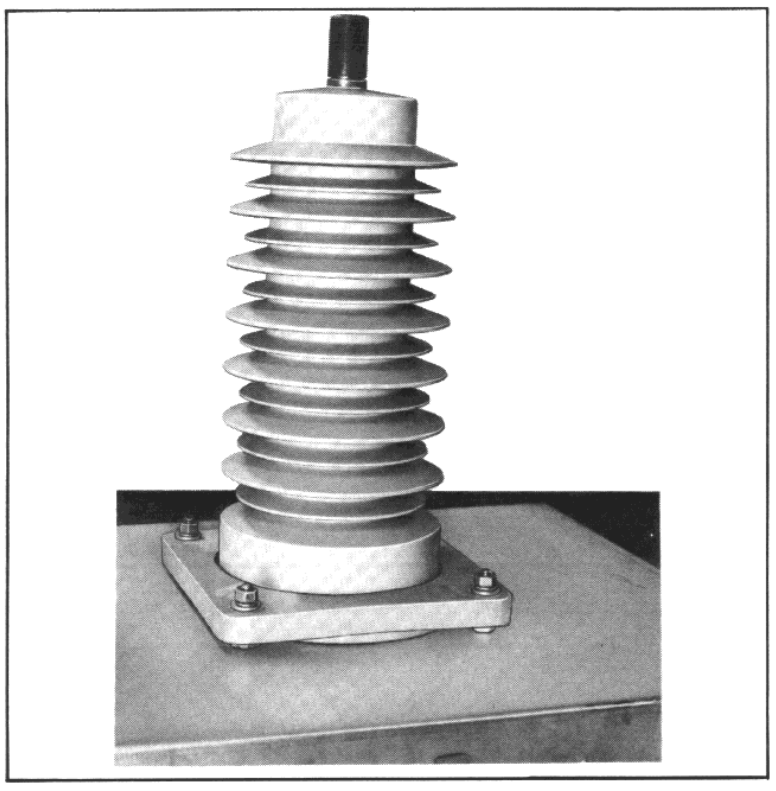

Figure 17

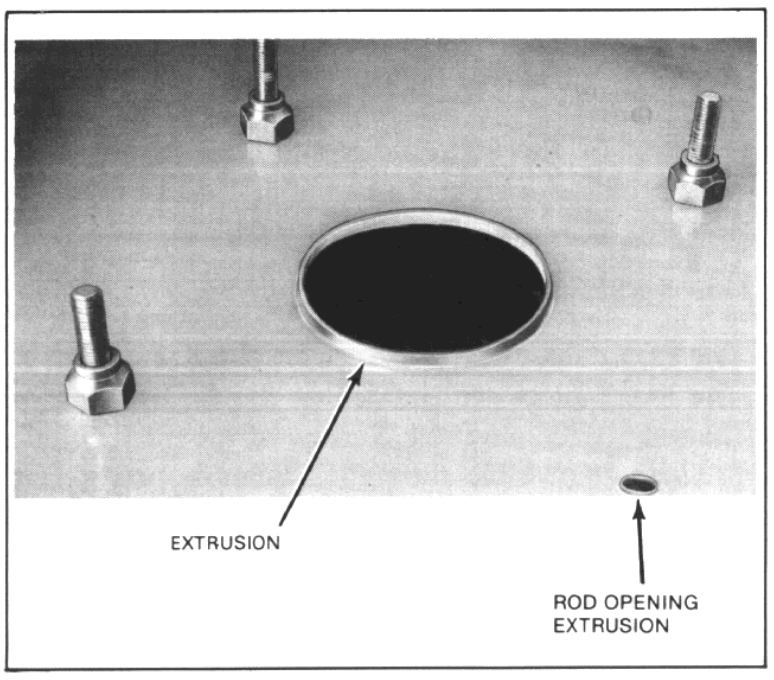

Figure 18

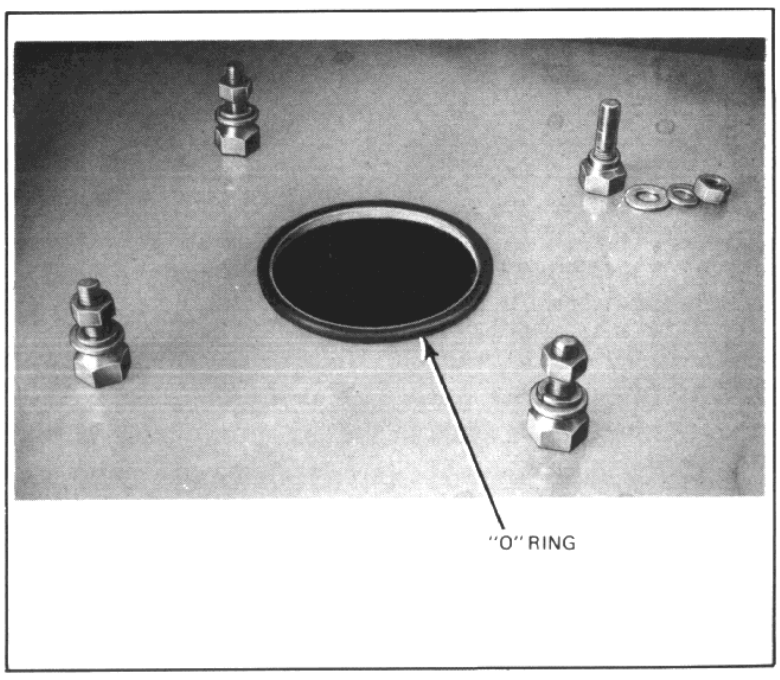

Figure 19

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

1. POWER FREQUENCY 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.

2. 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.

Breaker Exercise and Speed of Operation

At the time of normal relay maintenance it is also recommended that the breaker be totally exercised by closing and opening through all available means while checking the control functions.

The operating mechanism has been tested to 10,000 operations with a very slight (0.3 meters per second) variation over the entire range. Adjustments are not required over the life of the breaker in regard to speed of operation.

Opening Speed = 8.7-11.3 ft/sec.
Closing Speed = 6.9- 9.5 ft/sec.

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.
6. Torque flex connector bolts to 18-22 ft-lbs.

Electrical Operation Sequence

1. The breaker will close only after the closing springs are fully charged.
2. Charging of the springs is controlled by 52LS/bb. When the springs are discharged and power is available on terminals 61 and 62, the motor will charge the closing springs. When the springs are fully charged 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 69 and 70. With the closing springs fully charged, 52LS/aa is closed. As long as the breaker is open, 52/b and 52Y/b supply current to 52X. When the breaker closes 52/b opens the circuit. Contact 52/a energizes the anti-pump relay 52Y and 52Y/b opens, preventing the closing solenoid from being re-energized until 52Y is de-energized. At the same time, 52Y/a seals in the anti-pump relay until the close signal is removed from terminals 69 and 70. Contact 52LS/aa recloses as soon as the closing springs are recharged.
4. The breaker can be tripped by applying a signal across terminals 65 and 6. When the breaker is closed, 52/a is closed setting up the trip circuit. After the breaker opens, 52/a opens de-energizing the trip solenoid.

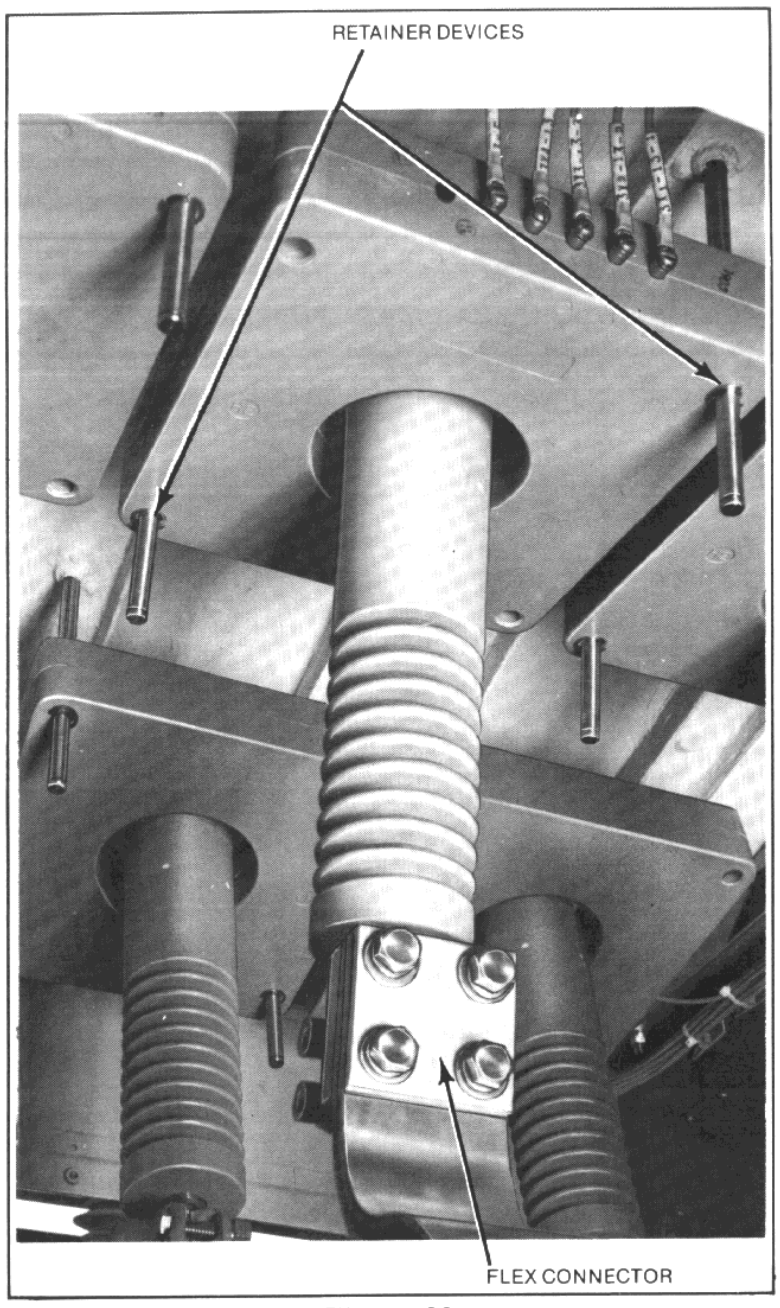

Figure 20

5. The open/closed status of the breaker may be determined remotely through the use of terminals 8, 10 and 73.
6. Some of the electrical options as shown include remote closing spring status indication, an additional trip coil, and an undervoltage trip coil.

Gas Servicing

The Fluarc interrupters are designed and sealed for life. The interrupters are charged at the factory and field charging is not required. Testing of the interrupter gas pressure is possible through a Schrader valve in the rotary shaft mechanism. However, this practice is not recommended at installation. Execution of a gas pressure check will lead to more leakage (1 to 3 pounds of pressure) of SF_6 gas from the interrupter than would be expected over a number of years of service. For conservative maintenance and inspection procedures a 5 year gas pressure check should be adequate.

TYPE FB SF_6 SUBSTATION CIRCUIT BREAKERS

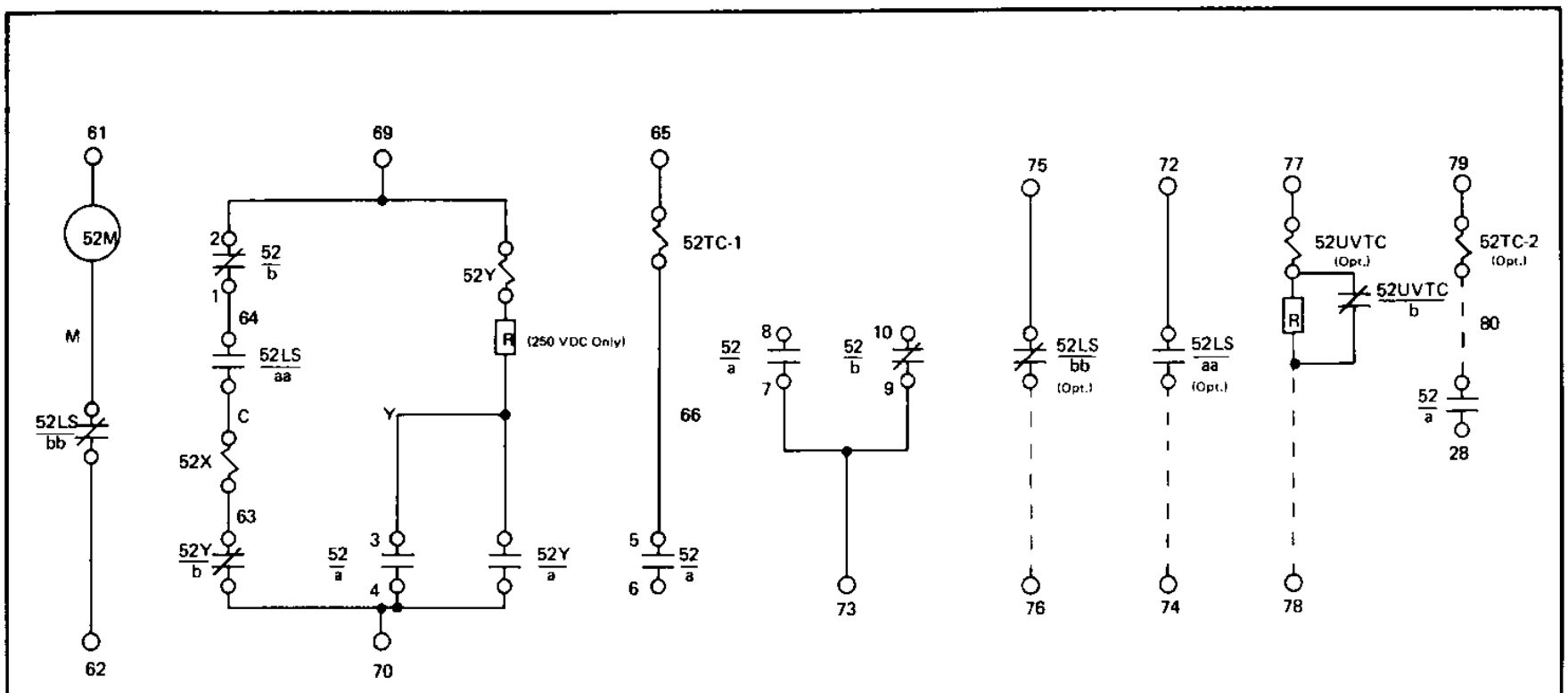

Figure 21

BREAKER INTERNAL WIRING

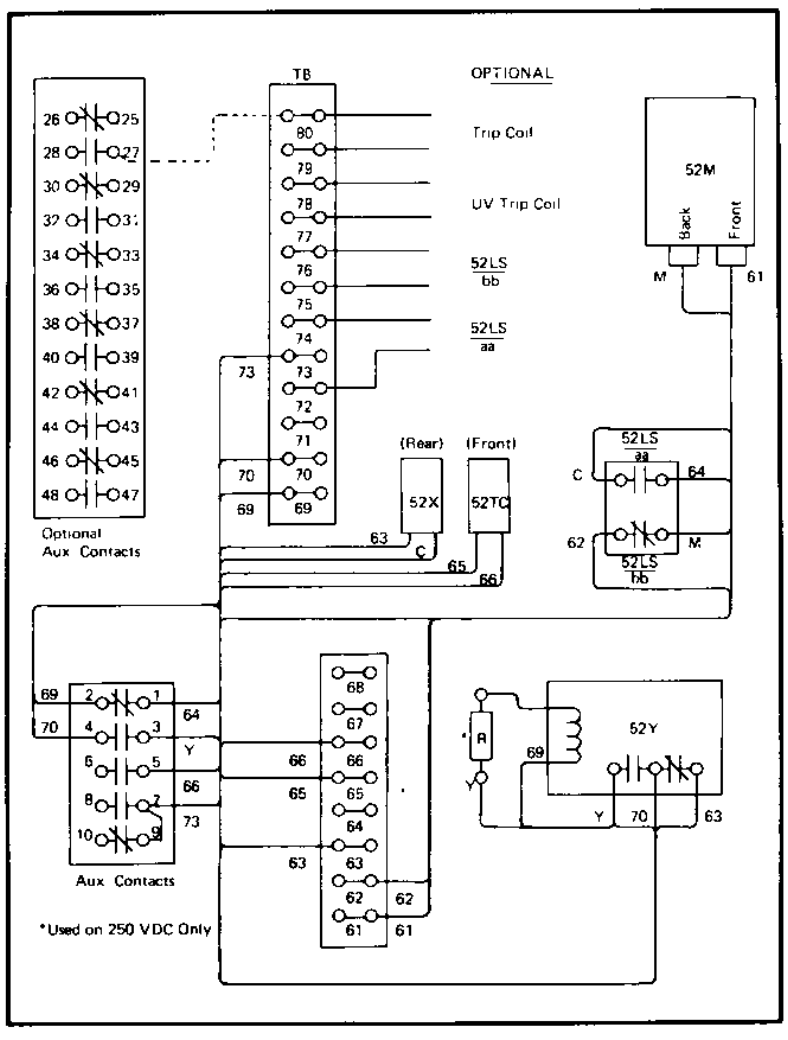

Figure 22

LEGEND:

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 Limit Switch-Open when springs are not charged. Closed when springs are charged.
52LS/bb	Closing Springs 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 open position. Open when breaker is in the closed position.

NOTES:

Breaker shown in open position, closing springs discharged.

TROUBLESHOOTING GUIDE

These instructions allow shutdown periods to be kept to a minimum. If the suggested remedies fail to solve the problem, refer to 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.
	End of charging switch	Check condition of switch. Replace if necessary.
	Latch mechanism	Latch is in pivoted position clear of its holding pin. Clean and oil the hinge.
BREAKER CLOSES AND OPENS AT ONCE AND REMAINS OPENED WHILE THE CLOSING ACTION IS MAINTAINED	Any release (direct or indirect)	Fault in the HV main circuit or incorrect adjustment of protective circuits. Eliminate the fault. Adjust protective circuits.
BREAKER CANNOT BE OPENED ELECTRICALLY	Auxiliary switch	Check circuit.
	Trip solenoid	Trip control power connections. Check the circuit. Defective coil. Replace the coil.

Table 2

SUGGESTED MAINTENANCE TOOLS

The only tools necessary for "normal" maintenance such as checking contact erosion and simple cursory inspection are as follows:

Long Nose Pliers
Continuity Tester
10mm Wrench or 6 in. Adjustable Wrench
13mm Socket or Box End Wrench
6mm-25mm or 10-32 × 1" screw

AVAILABLE REPLACEMENT PARTS

Device	Voltage	Part No.
Spring Charging Motor	24 VDC	B44065-357-01
	48 VDC	B44065-357-02
	125 VDC	B44065-357-03
	250 VDC	B44065-357-04
	120 VAC	B44065-357-05
	240 VAC	B44065-357-04
Closing Solenoid	24 VDC	C44065-033-01
	48 VDC	C44065-033-02
	125 VDC	C44065-033-03
	250 VDC	C44065-033-04
	120 VAC	C44065-033-05
	240 VAC	C44080-376-04
Trip Solenoid	24 VDC	C44080-384-01
	48 VDC	C44080-384-02
	125 VDC	C44065-034-07
	250 VDC	C44080-384-03
	120 VAC	C44065-034-08
	240 VAC	C44065-034-06
Anti-Pump Relay	(Class 8501 Type KF)	
Bushing	(Order by Breaker S/N + Description)	
Interrupter	(Order by Breaker S/N + Description)	

Table 3

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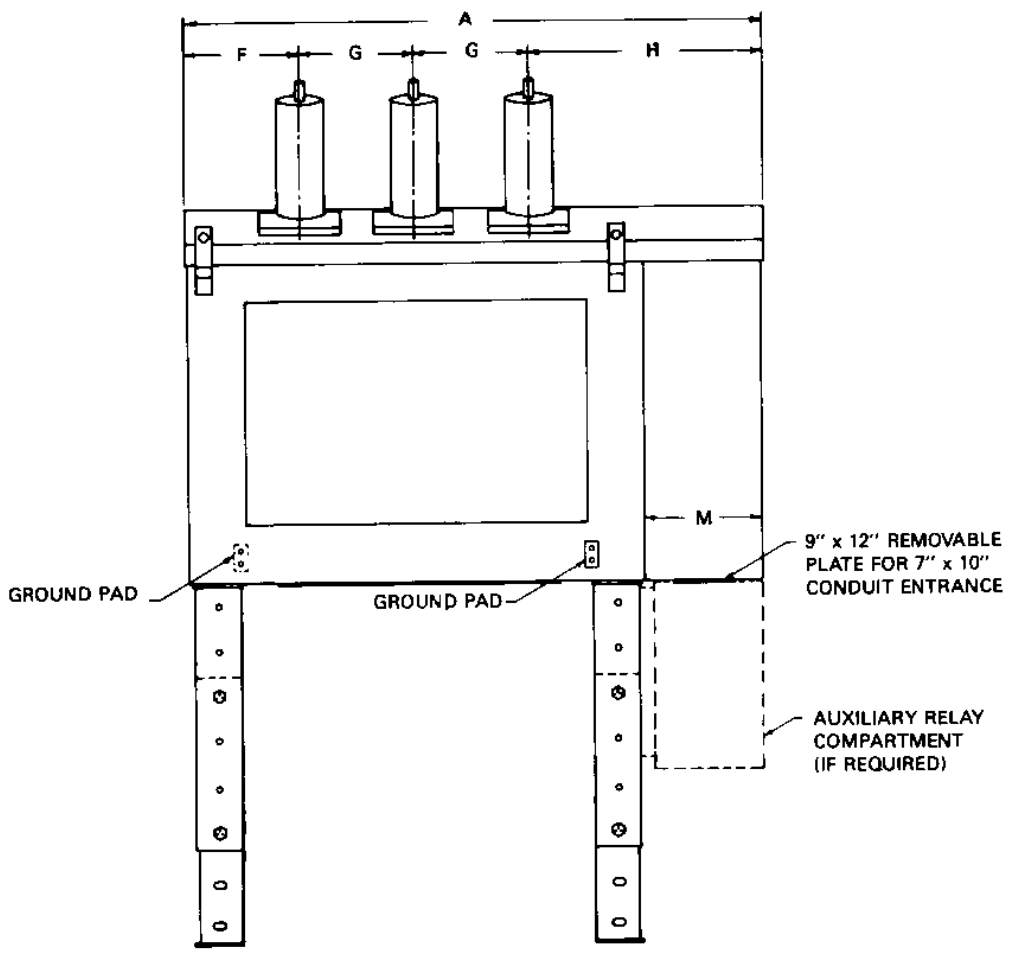
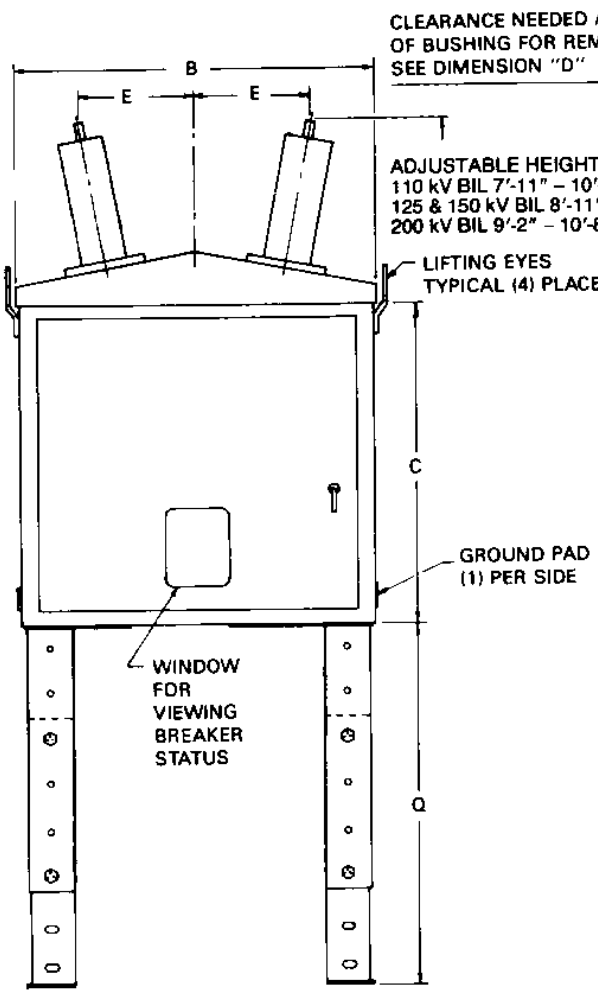
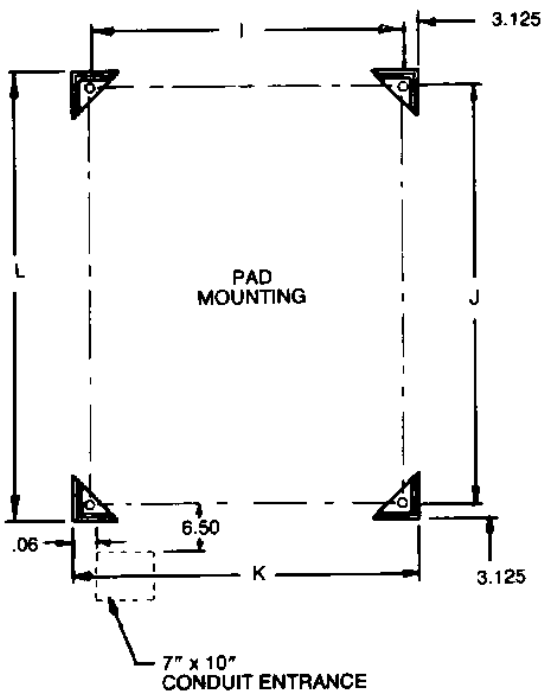
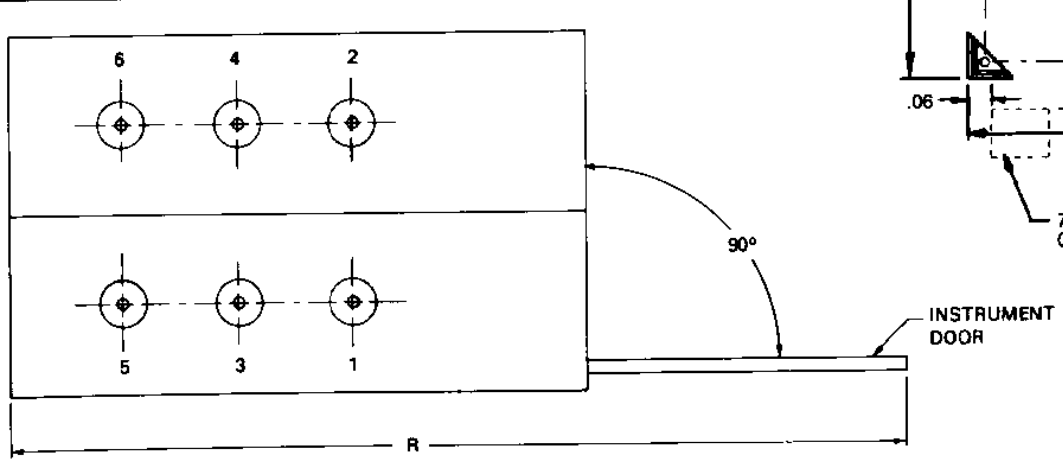
DIMENSIONS





DIMENSIONS	110kV BIL	125kV BIL	150kV BIL	200kV BIL
A	58.08	75.28	75.28	82.12
B	41.66	46.78	46.78	57.28
C	37.00	41.00	41.00	55.31
D	20.00	24.00	24.00	30.00
E	18.81	15.26	15.26	17.62
F	10.02	15.30	15.30	16.58
G	11.25	14.96	14.96	17.00
H	25.56	30.07	30.07	31.54
I	33.25	38.37	38.37	49.38
J	33.87	51.13	51.13	59.15
K	39.50	44.62	44.62	55.64
L	40.12	57.38	57.38	65.41
M	15.25	15.25	15.25	15.25
Q (MIN)	40.23	34.43	34.43	27.62
Q (MAX)	64.23	58.43	58.43	45.62
R	93.31	115.66	115.66	138.13





Weight = 2500 lbs.
Uplift = 500 lbs/leg - 10 m sec.

Figure 23

INTERRUPTER LIFE EXPECTANCY CURVE
TYPE FB

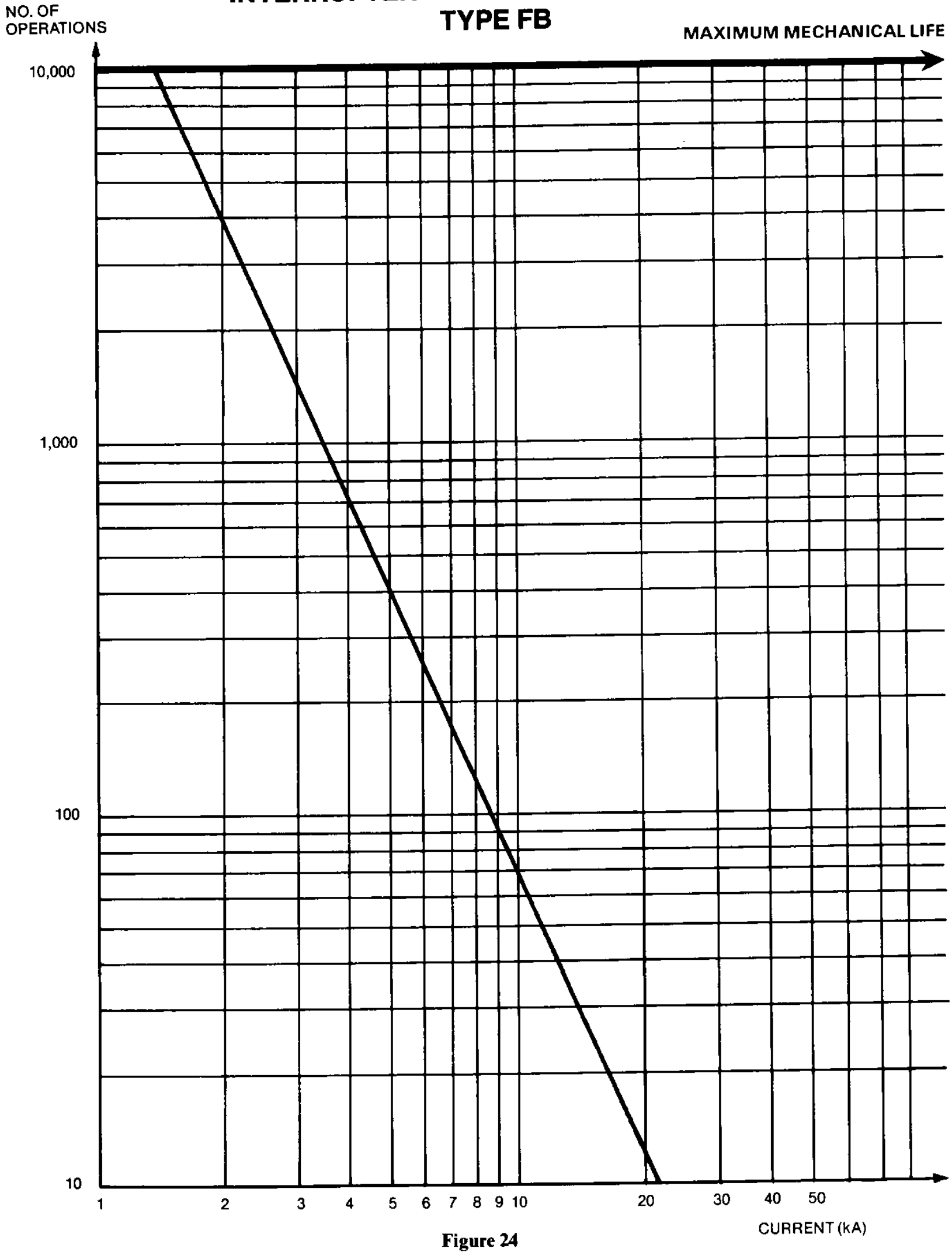


Figure 24

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

Manual 6060-1

2M 9/89 PS

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