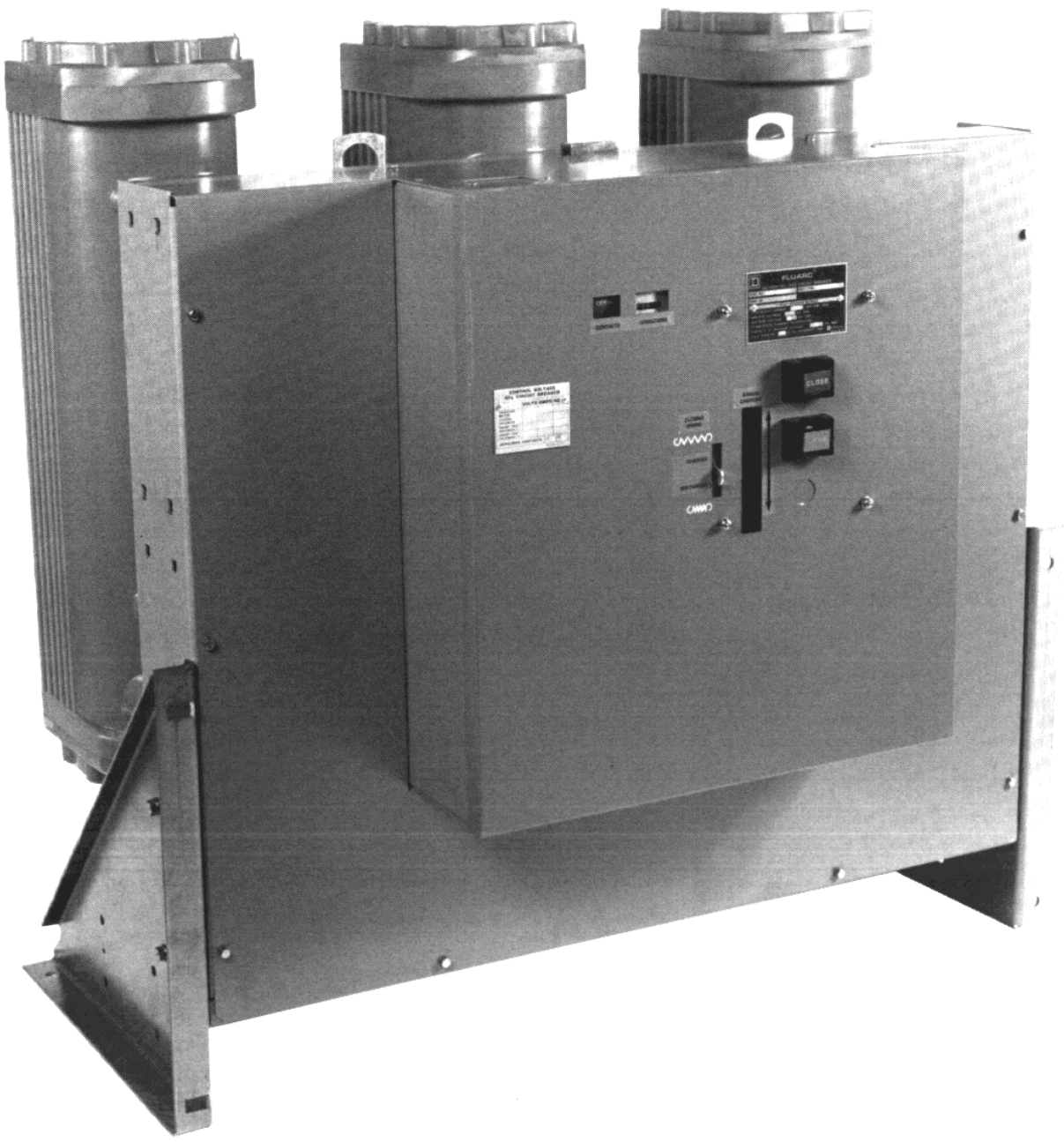
September, 1990

Instruction Manual 9880-2

Instruction and Maintenance Manual

FLUARC®
Type FG4
SF_6 Circuit Breakers



SQUARE D

NOTICE

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this manual to warn of potential hazards and to call attention to additional information which clarifies or simplifies a procedure.

WARNING! Used where there is a hazard of bodily injury or death. Failure to follow a "WARNING" instruction may result in bodily injury or death.

CAUTION: Used where there is a hazard of equipment damage. Failure to follow a "CAUTION" instruction may result in damage to equipment.

NOTE: Provides additional information to clarify or simplify a procedure.

Work on this equipment must be performed by qualified personnel who have training in the operation and maintenance of electrical power systems. Work on these devices requires training and experience with high capacity circuits and equipment and an understanding of the hazards involved.

CONTENTS

ILLUSTRATIONS

Figure

Tables

1.0 INTRODUCTION

This manual covers the operation and maintenance of Square D Type FG4 three–phase high voltage circuit breakers for applications at 10 kV through 38 kV, 60 Htz.

Designed for low maintenance requirements, the type FG4 circuit breaker uses three sealed interrupters. These interrupters are filled with sulfur hexafluoride (SF_6) gas at the factory and sealed for life. *Field charging of the interrupters is not required.*

Standard equipment on the breaker includes an electric charging motor, close and trip solenoids, an anti–pump relay, and 11 auxiliary contacts for customer use.

The breaker is designed to be operated at ambient temperatures from –30°C to +40°C. It should be used within the ratings stamped on the nameplate.

Read these instructions carefully and look at the circuit breaker to become familiar with its components before installing or operating it.

WARNING: Hazard of electrical shock or burn. Work on these circuit breakers must be performed by qualified personnel with training in the operation and maintenance of electrical power systems. Prior to doing any work on these devices, read and understand this instruction manual.

2.0 HANDLING, RECEIVING, AND STORAGE

1. Avoid impacts to the breaker. Interrupters are pressurized to 36 psig with SF_6 gas.
2. Make sure all ratings on the packing slip correspond with those on your purchase order before taking receipt.
3. Inspect the packing crate for damage before accepting delivery. Notify the shipper and Square D Company immediately in the case of damage or if there are missing parts.
4. The breaker weighs approximately 600 lbs. See figure 1 for lifting points.
5. Store the breaker in a dry, well–ventilated indoor area until it is put into service. Cover the crate with heavy plastic or other suitable covering to protect against water or chemical splashings, dust, dirt, plaster, etc.
6. The circuit breaker is shipped in the *open* position with the mechanism discharged.

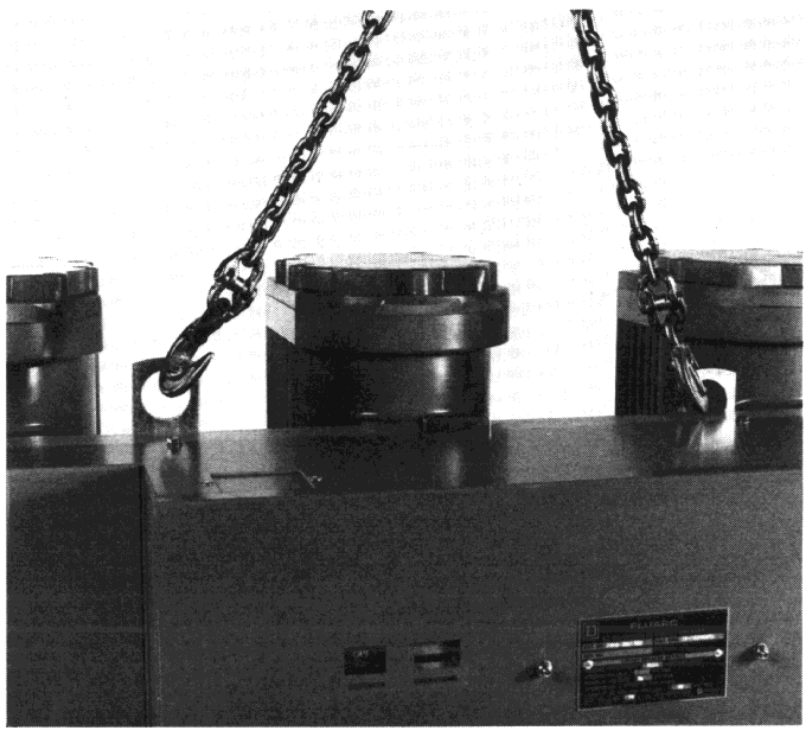


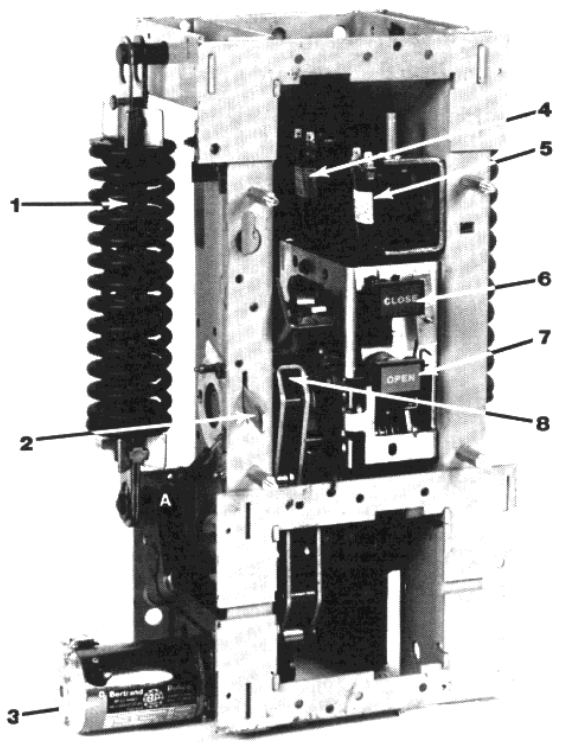
Figure 1: Breaker Lifting

3.0 OPERATING MECHANISM

The stored–energy mechanism consists of high energy closing springs and a ratcheting system for charging these springs (figure 2). The breaker cannot be 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 are charged one of two ways:

- electrically by the gear motor immediately after the breaker closes.
- manually with the manual charging handle.



1. Closing Springs
2. Mechanism Charged Indicator
3. Charging Motor
4. Trip Solenoid
5. Close Solenoid
6. Close Button
7. Open Button
8. Manual Charging Lever

Figure 2: Operating Mechanism Description

4.0 INTERRUPTERS

Type FG4 interrupters are "sealed for life," in accordance with IEC standards, and *do not require any gas servicing*. The interrupters are filled at the factory with sulfur hexafluoride gas (SF_6) to 36 psig, measured at 20°C.

Measurement of arcing contact wear (see section 9.3) is the only interrupter maintenance required.

Each interrupter has a pressure switch which operates at 22 psig in the unlikely event of a gas leak. The interrupters can interrupt 12 kA at least once at pressures between 0 psig and 22 psig. The pressure switches must be wired into the controls by the customer.

5.0 BREAKER CONTROLS SCHEMATIC

Refer to the control schematic supplied with the breaker if it is available. It may vary slightly from the one shown below.

The breaker control schematic in figure 3 shows standard FG4 breaker control wiring. The breaker controls consist of the breaker charging motor, close and trip solenoids, anti–pump relay, and the auxiliary switches.

Control contacts are shown for the FG4 with *main contacts open and all operating springs discharged.*

As shown, the breaker operating springs start to charge as soon as control voltage is applied. When the springs are fully charged, contact M2 opens, shutting off the charging motor. The auxiliary contacts QF open and close in synchronism with the main contacts. When the main contacts are open, type "a" contacts are open and type "b" contacts are closed.

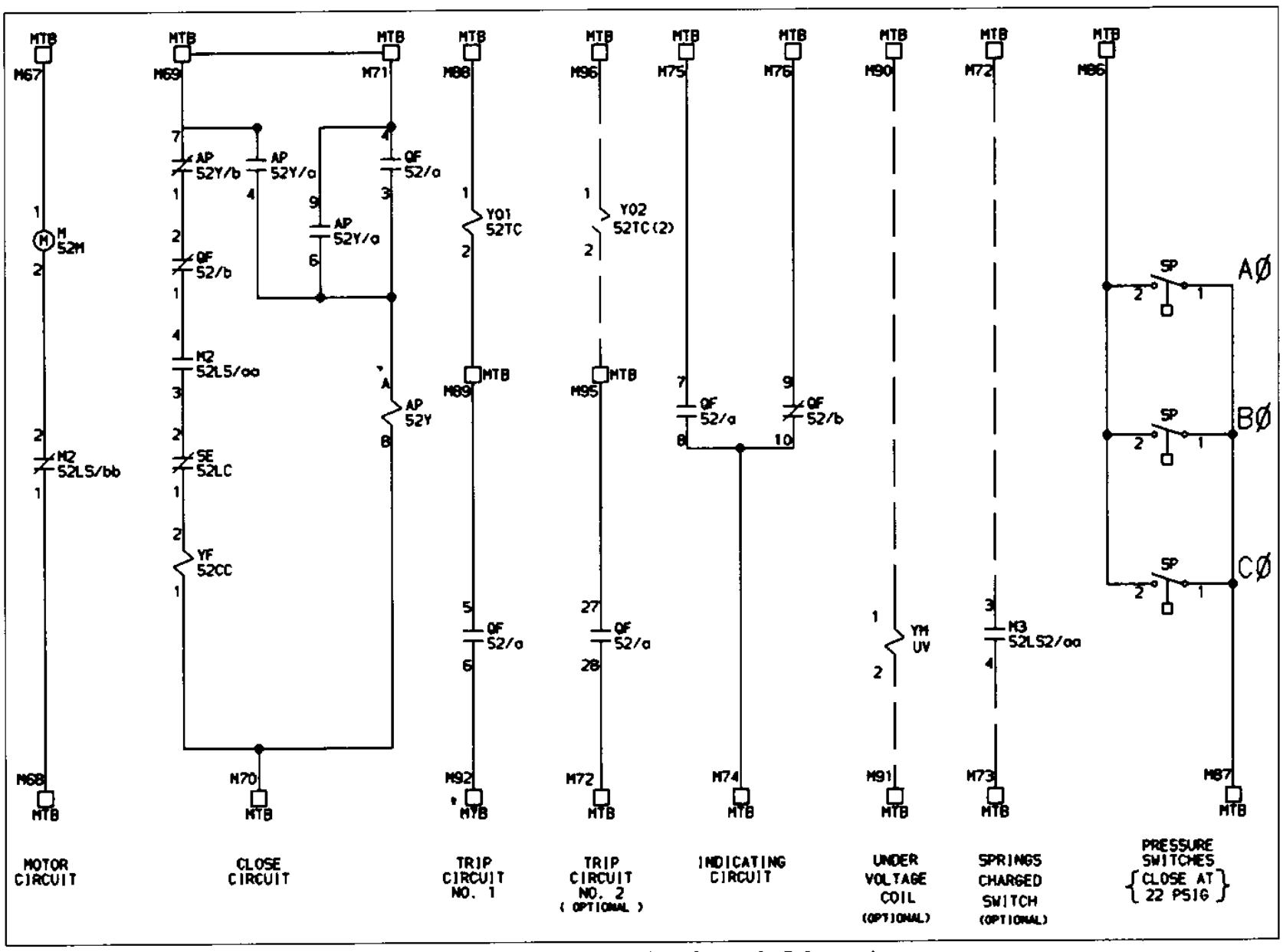


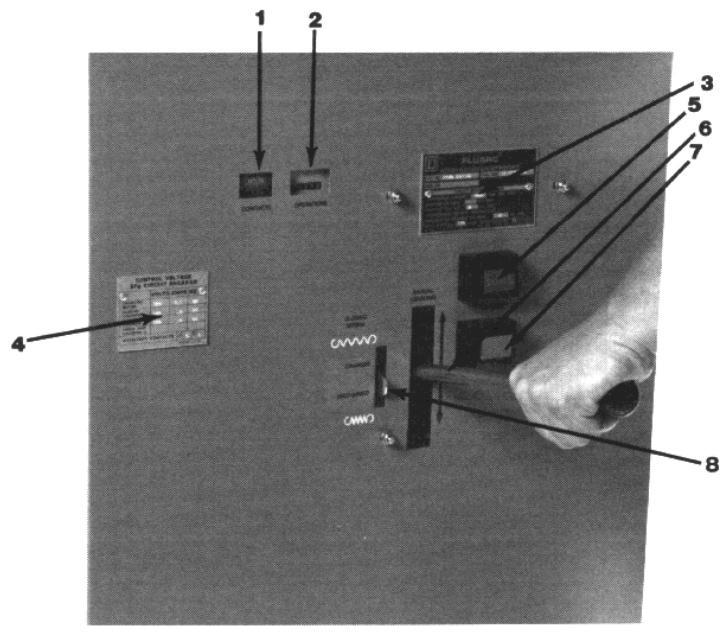
Figure 3: Standard Breaker Controls Schematic

6.0 OPERATION

To manually operate the breaker, manually charge the operator springs, then press the *close* and *open* buttons to close and open the breaker (see figure 4).

The breaker may be closed and opened electrically by means of the close and open solenoids. See figure 3 for the standard controls schematic.

The status of the breaker is given by indicators on the front of the breaker (figure 4). Each close–open cycle advances the operations counter by one. The counter advances on the close stroke.



1. Circuit Breaker Contacts Indicator
   - Green: circuit breaker open
   - Red: circuit breaker closed
2. Operations Counter
3. Breaker Rating Nameplate
4. Control Nameplate
5. Close Button
6. Manual Charging Handle
7. Open Button
8. Mechanism Charged Indicator

Figure 4: Breaker Controls

7.0 SAFETY PRECAUTIONS

WARNING: Hazard of bodily injury or equipment damage.

All maintenance must be performed by qualified personnel in accordance with local codes and ordinances, and under the following conditions:

- The breaker must be removed from its cell and isolated from the high voltage.
- Control voltage must be removed from the controls.
- The breaker must be in the open position.
- All breaker springs must be discharged.

All instructions in this manual assume the customer has taken the above steps to obtain safe conditions prior to performing maintenance or testing.

8.0 PRE-SERVICE CHECKOUT

Prior to placing the breaker in service:

1. Inspect for any shipping damage such as broken parts or loose hardware.

2. Wipe off any dust or grime from the interrupters with a dry cloth. For more extensive cleaning, use a non–flammable solvent.

3. To check the mechanical operation of the breaker, manually charge the closing springs. Next, manually close and trip the breaker.

4. Test the electrical operation of the breaker by applying control power. Next, open and close the breaker electrically.

5. Contact resistance on a new interrupter should read 20 micro ohms or less, with 100 amperes DC flowing from terminal to terminal.

6. Conduct high–pot tests to test insulation. With the breaker open, high–pot test each terminal to the breaker frame and across the terminals on each pole at 60 kV (AC or DC) for one minute. The breaker frame and all terminals (except the one being tested) are to be grounded during these tests.

If everything is found to be satisfactory, place the breaker in service.

9.0 MAINTENANCE

The suggested maintenance interval of the breaker is every 3000 operations or three years, whichever comes first. Adverse environmental conditions or interruption of high fault currents may make more frequent maintenance necessary.

Maintenance falls into three basic categories:
- inspection, cleaning, and lubrication
- contact wear measurement
- sequence of operation

Metric hardware is used on FG4 breakers. If required, torque non–lubricated bolts per table 1.

Table 1
Torque Specifications (Metric Class 5.8)

Bolt Size	Foot-Pounds
M8 — 1.25	14
M10 — 1.50	22
M12 — 1.75	40
M14 — 2.00	70

9.1 Cleaning and Lubrication Materials

WARNING: Hazard of bodily injury or property damage. Follow the safety precautions described in section 7 before cleaning and lubricating the breaker.

Use the materials shown in table 2 to clean and lubricate the breaker. Disassembly is not normally required.

Table 2
Cleaning And Lubrication Materials

Applications	Materials
Cleaning	Non–flammable solvent
Lubricating pivot points and bearings	SAE 10W40 motor oil
Lubricating spring guides and gears	Automotive ball joint grease (molybdenum disulfide type)

CAUTION: Hazard of equipment damage. Never spray the breaker with a high pressure cleaning solution, as this may damage the "sealed–for–life" bearings and cause the bearings to seize.

9.2 Lubrication Points

Lubrication points are identified in figures 5, 6, 7, 8, and 9. Wipe off grime and dirt before adding new oil and grease.

9.2.1 Lubrication — Interrupter Linkage

Oil the interrupter linkage joints as shown in figure 5. Bearings on interrupter shafts are greased for life and do not need lubrication.

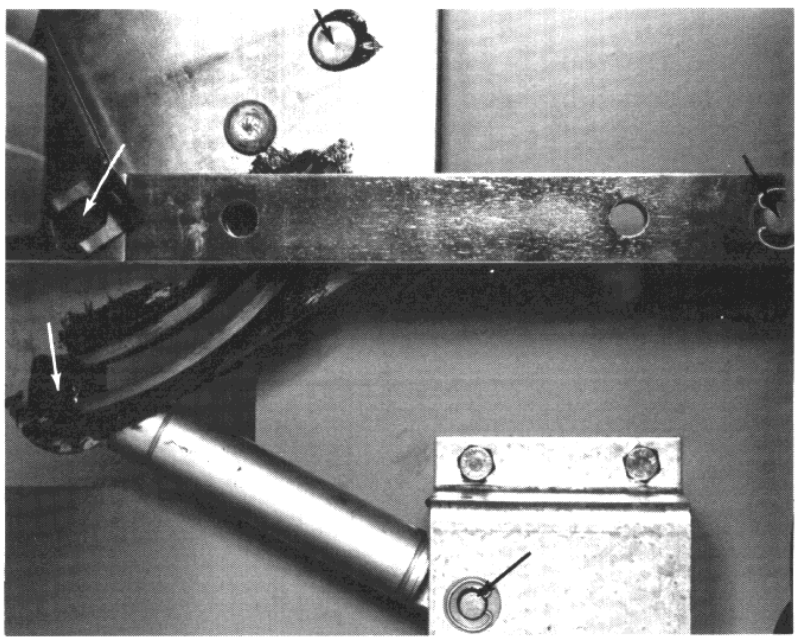


Figure 5: Lubrication — Interrupter Linkage

9.2.2 Lubrication — Mechanism

Step 1. Locate all mechanical bearing surfaces such as rotary shafts within bearings or parts sliding against each other. Apply a sufficient amount of multi–grade oil directly to the surfaces to be lubricated. Operate the mechanism a few times and relubricate. Wipe away excess lubricant carefully so dirt is not forced into lubricated areas.

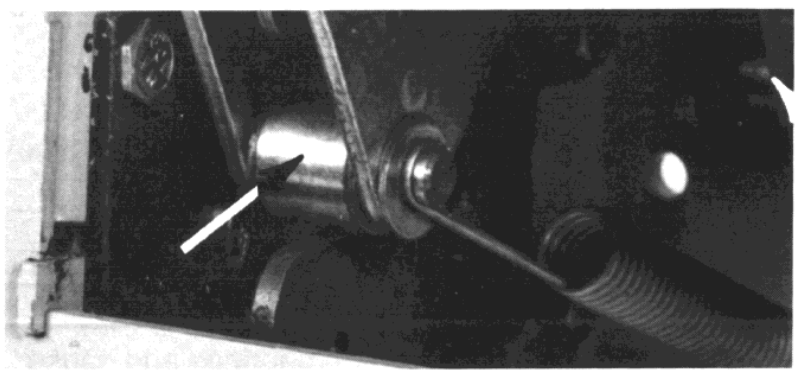


Figure 6: Lubrication — Charging Cam

Step 2. Lubricate the opening and closing spring guides (figure 7) with molybdenum disulfide grease.

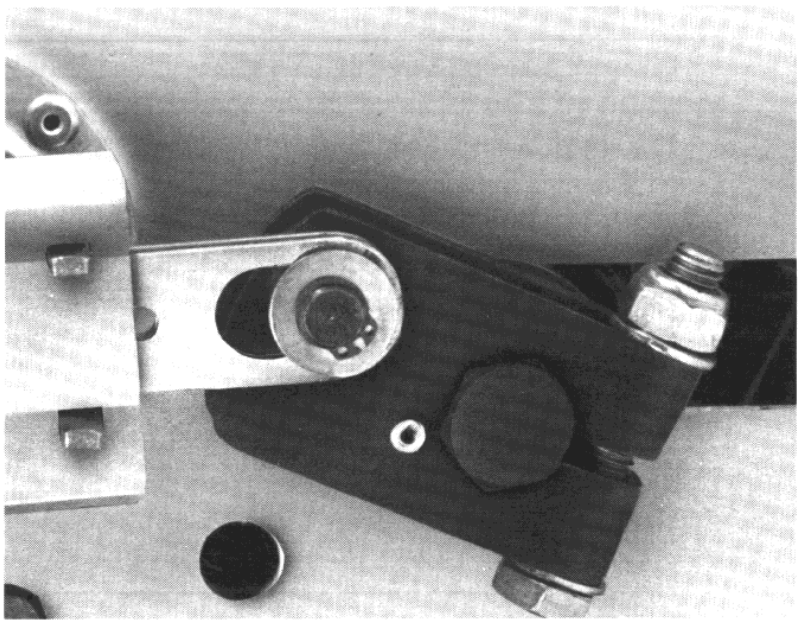


Figure 7: Lubrication — Spring Guides

Step 3. Lubricate the close and trip latch surfaces (figure 8) and mechanism charging gears (figure 9) using molybdenum disulfide grease.

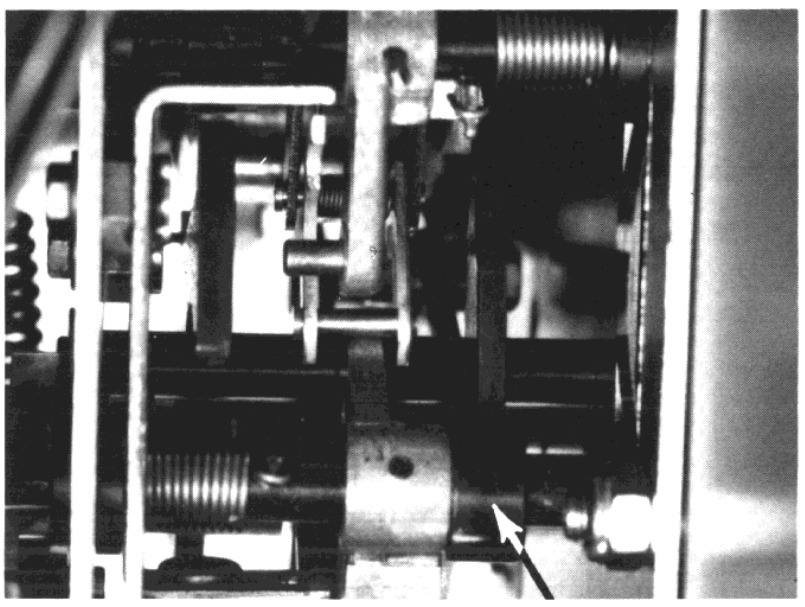


Figure 8: Lubrication — Close and Trip Latches

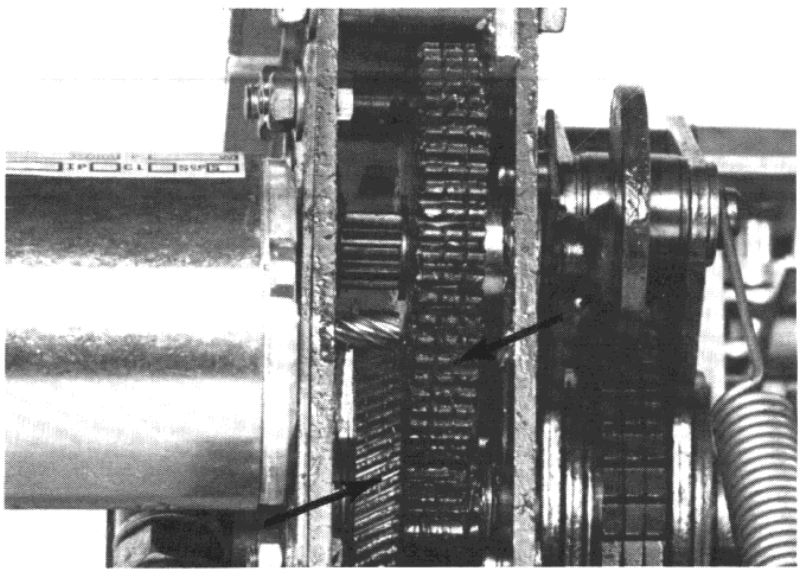


Figure 9: Lubrication — Motor Gears

9.3 Arcing Contact Wear Measurement

WARNING: Hazard of bodily injury or equipment damage. Follow the safety precautions described in section 7 before starting this procedure.

Required parts:

- two 3/16" diameter pins or bolts (approximately 3/4" – 1" long)

Required tools:

- test light or ohmmeter for testing continuity
- needle–nose pliers
- 9/16" wrench or 9/16" socket and ratchet

To measure arcing contact wear, the closing springs must be removed and the breaker slow closed (figure 10) until the arcing contacts "make." Observe the wear on the opening spring guide. FG4 interrupters must be replaced when the arcing contacts are worn out.

Follow these steps to measure contact wear:

1. Open and close the breaker manually to discharge all springs.

2. Remove the cover from the front of the breaker.

3. Begin manually charging the closing springs gradually, one notch at at time.

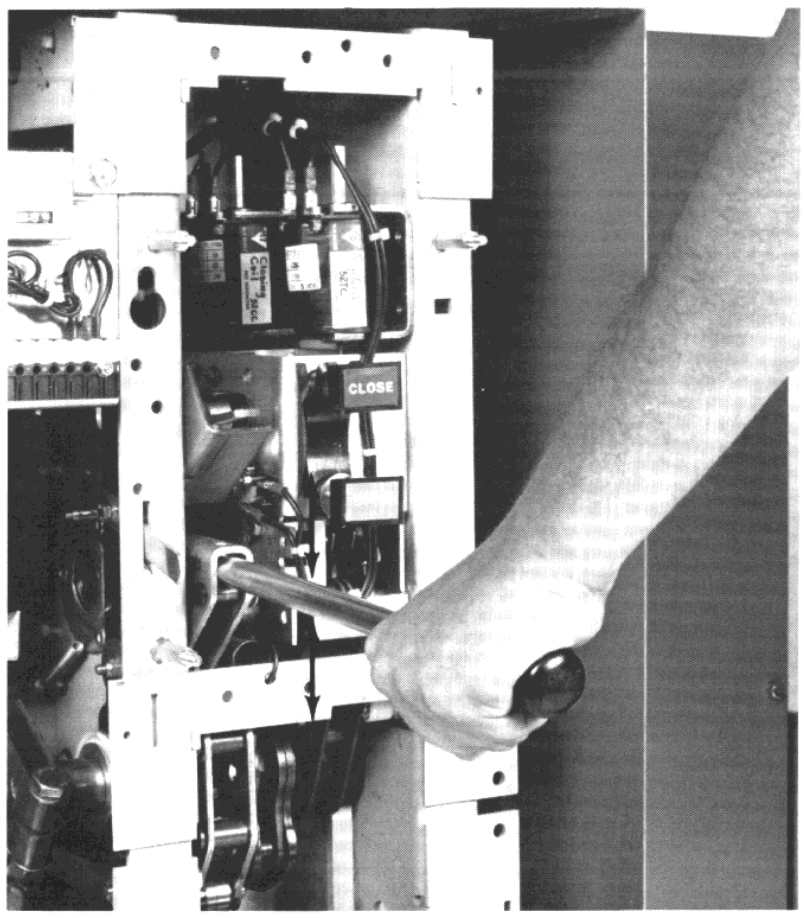


Figure 10: Slow Closing the Breaker

4. Observe the closing springs (figure 11). Stop charging *just before* a pin can be placed through the second hole in the spring guide.

5. While continuing to put slight pressure on the charging handle, insert a 3/16" diameter pin or bolt in the hole (figure 11). Do this on both closing springs.

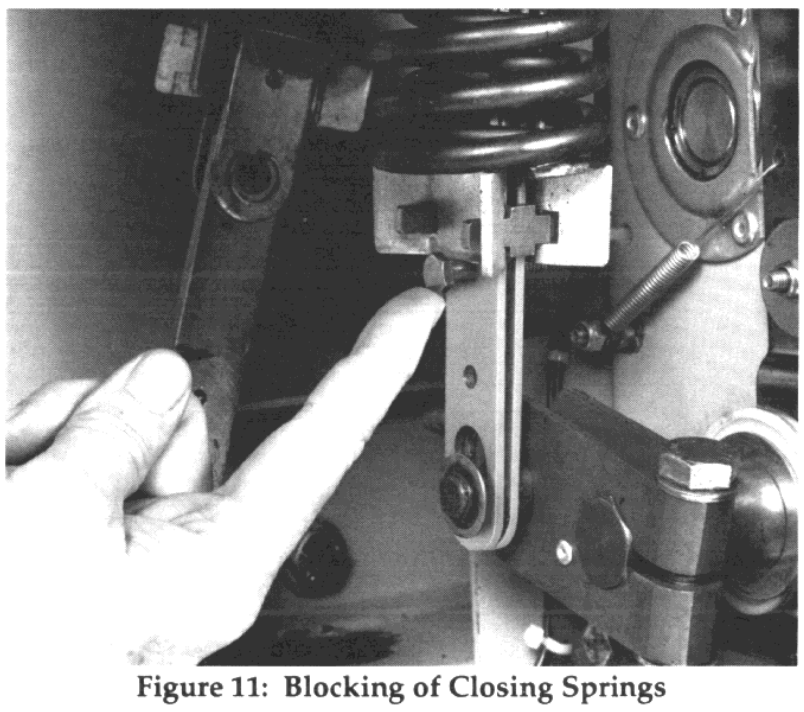


Figure 11: Blocking of Closing Springs

6. Release the charging handle. The force of the springs should now be held on the inserted pins or bolts.

   If the spring force is not held by the pins, remove the pins and finish charging the springs. Then close and open the breaker (as in step 1) and repeat steps 3–6. When performed correctly, the springs will be slack on the mechanism and can be safely removed (figure 12).

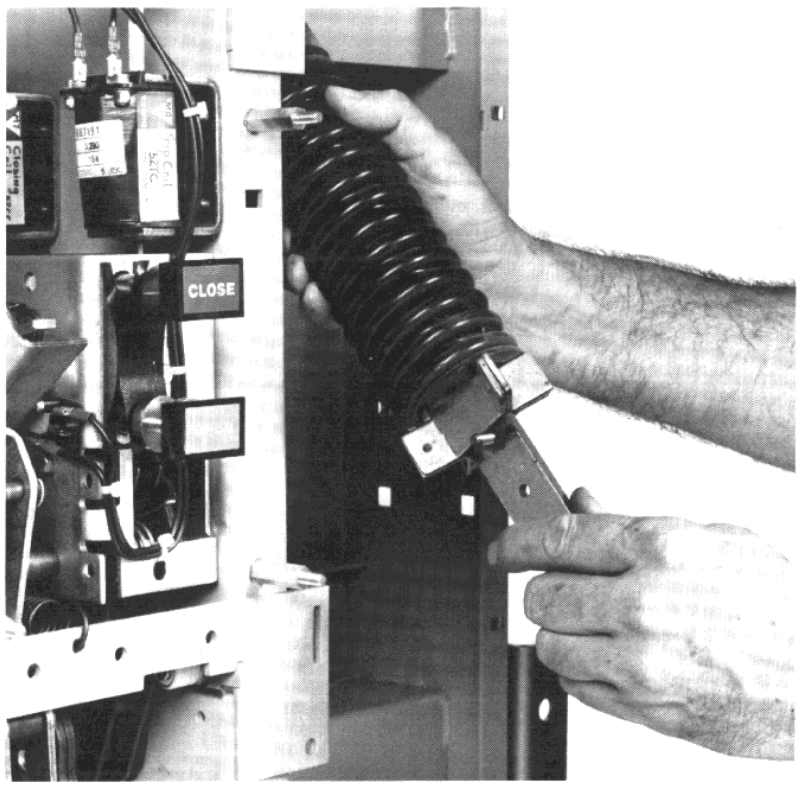


Figure 12: Removal of Closing Springs

7. Remove the snap ring from the crank end of the closing spring. Slide the spring assembly toward the fixed end and then off the shaft (figure 12). Remove both left and right closing springs. Note the position of washers and bushings so they can be placed in the same order and position when reassembled.

8. With the closing springs removed, slowly charge the mechanism manually until it clicks (closing latch sets).

9. Attach a test light or ohmmeter (figure 13) between the terminals of each interrupter to indicate the contact "make" point.

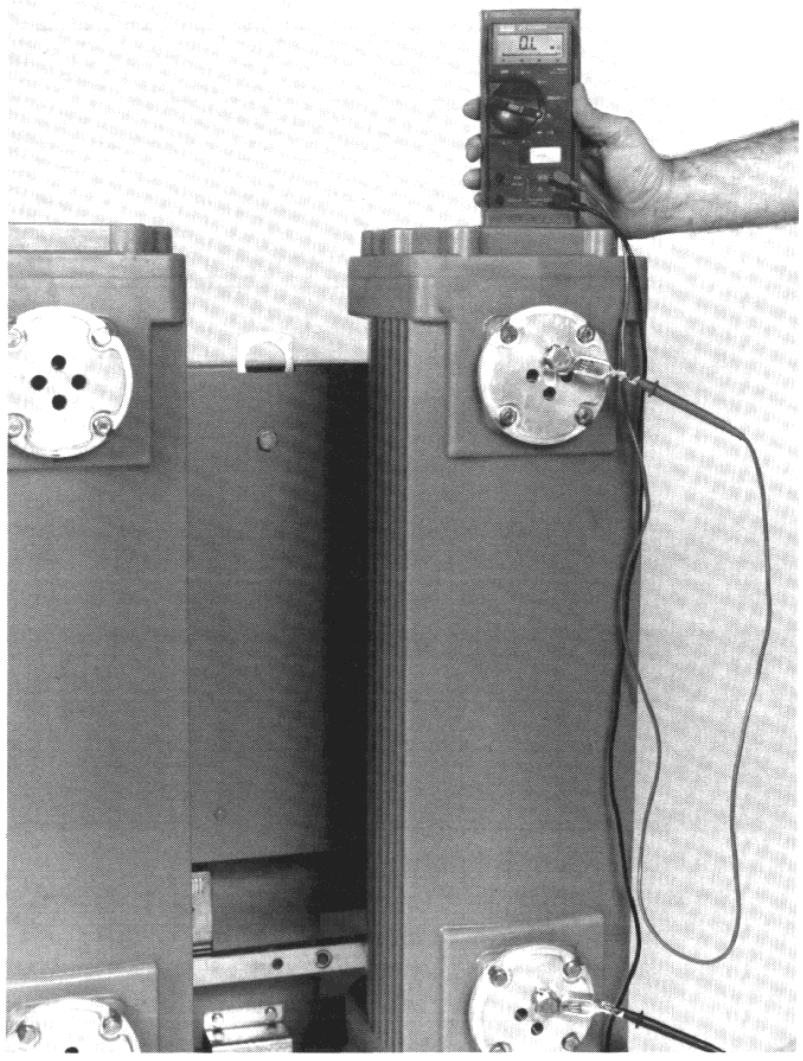


Figure 13: Monitoring Interrupter for Contact Closure

10. Push in and hold the *close* button. Begin slow closing the breaker with the charging handle.

11. Continue slow closing the breaker. Stop as soon as the arcing contacts just "make," as indicated by the light or ohmmeter.

12. Use the manual charging handle to barely hold the arcing contacts closed (the moment the light comes on). Observe the red wear dot on the opening spring guide (figure 14). For a new interrupter, dimension "H" measures .41 inches (10.5 mm).

    While making the wear measurement, DO NOT close the arcing contacts to the point where they remain closed (as indicated by the light staying on) when pressure is removed from the charging handle. This will give a false wear indication.

If the bottom edge of the red dot (marked "F" in figure 14) is at or below the top of the frame (marked "G"), the arcing contacts are worn out. All three interrupters should be replaced as a set (no adjustment exists). *Contact Square D Company for complete instructions if this becomes necessary.*

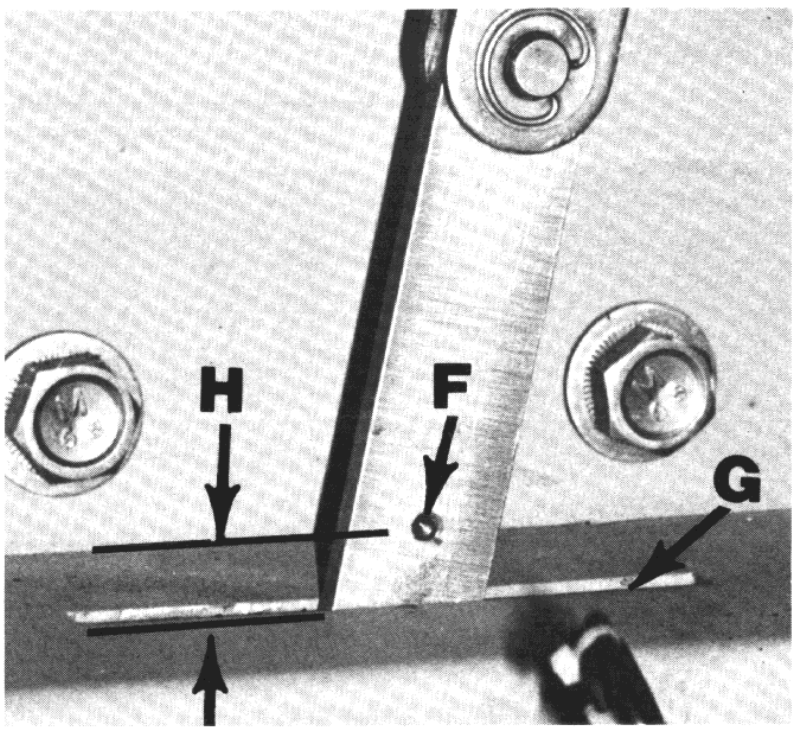


Figure 14: Measuring Contact Wear

13. After completing the wear measurement on the first interrupter, continue slow closing the breaker until it is completely closed. Then trip the breaker.

14. Repeat steps 8–13 for the other two poles.

15. After reinstalling the springs, manually charge the mechanism until the pins (inserted in step 5) can be removed. Remove the pins.

16. Fully charge the mechanism manually and then close and trip the breaker to ensure proper mechanical operation. Replace the breaker covers. The breaker is now ready to be re–energized.

10.0 AUXILIARY CONTACT CONVERSION AND ADJUSTMENT

New parts required: none

Required tools:
- 8 mm open–end wrench
- 13 mm wrench
- thin bladed screwdriver

FG4 breakers are shipped with eleven auxiliary contacts for customer use—five "a" and six "b" contacts. These contacts may be field converted from a to b, or vice versa.

To convert, loosen the locknut on the end of the auxiliary switch (figure 15a) and use a thin bladed screwdriver to pry the contact cam (figure 15b) away from the plastic driver.

Rotate the cam to the desired position. Slide the contact stack back into place and tighten the locknut. Auxiliary contact cams can be adjusted in 9° increments.

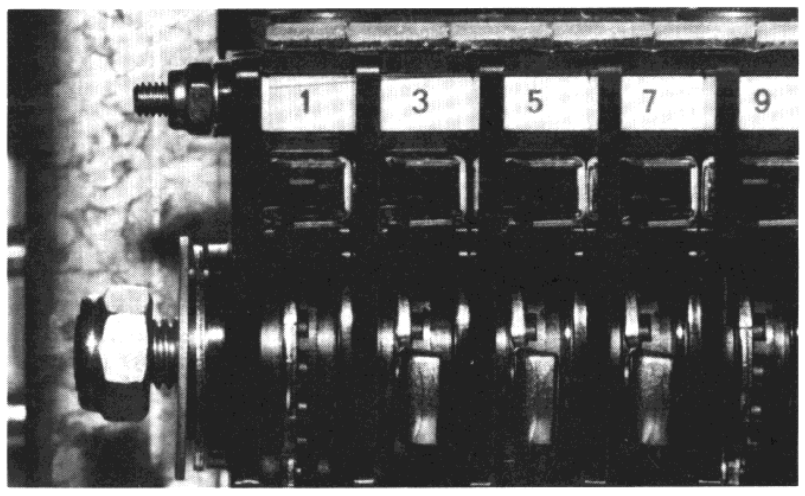


Figure 15a:
Auxiliary Switch Adjustment—Loosening Locknut

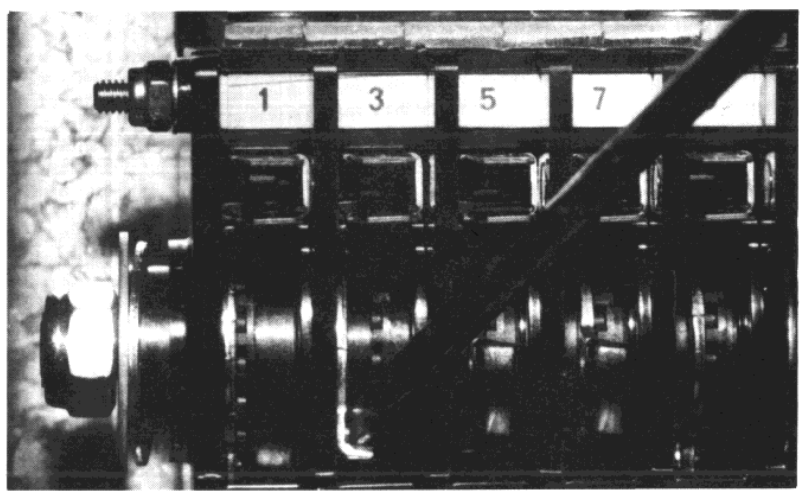


Figure 15b:
Auxiliary Switch Adjustment—Prying Contact Cam

11.0 OPERATING SPEED AND TIME MEASUREMENTS

A potentiometer assembly (figure 16) is available from Square D Company for measuring opening and closing speeds and times. This assembly is used in conjunction with a Doble Motion Analyzer Recorder. *Contact Square D Company for full instructions if needed.*

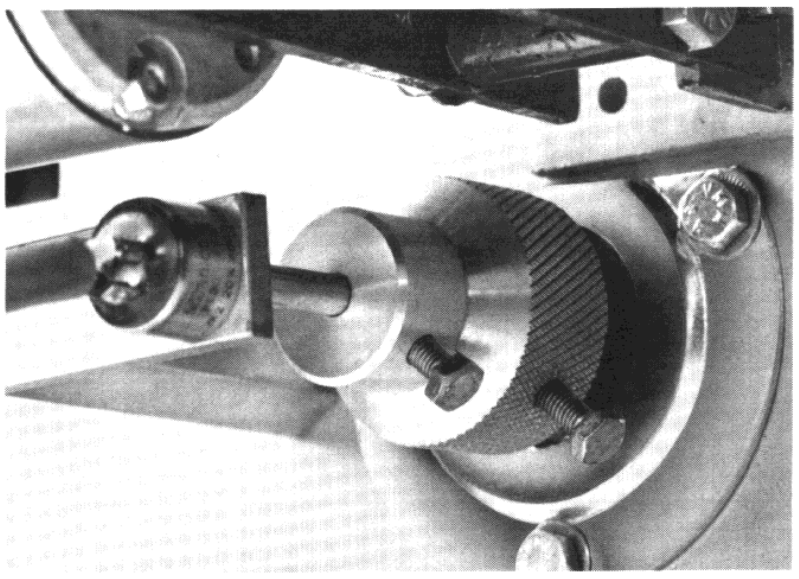


Figure 16:
Potentiometer Mounting for Speed Measurement

Operating times and speeds when measured with the above equipment should be as follows:

Closing Time	60 – 90 msec.
Opening Time	45 – 65 msec.
Closing Speed	7.25 – 8.5 ft/sec.
Opening Speed	8.5 – 9.5 ft/sec.

Operating times are measured from the instant the solenoid is energized to the point arcing contacts make or break. Speeds are measured at the point of contact make or break. Operating times and speeds must remain within the above range for the life of the breaker. No adjustments can be made.

12.0 BREAKER LIFE EXPECTANCY

The life of the breaker is 10,000 close-open cycles at 2500 amps RMS. The life of the breaker may be reduced from 10,000 operations, depending on the number and level of interruptions made. Figure 17 shows the breaker life as a function of the current switched. The life remaining may be determined by measuring arcing contact wear per section 9.3. The curve shown below applies to all voltage ratings.

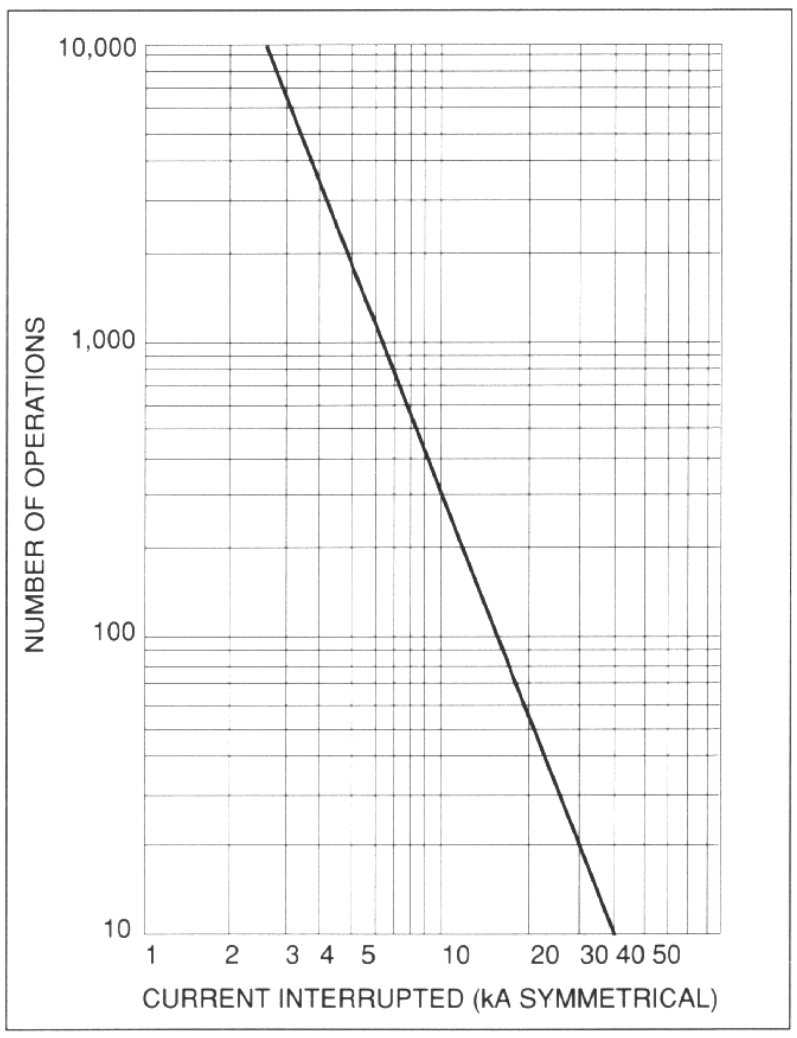


Figure 17: Life Expectancy Curve — All FG4 Ratings

13.0 GAS SERVICING

Gas servicing of the FG4 interrupters is *not required.* However, servicing is possible if necessary.

The gas pressure can be checked, or SF_6 gas added, through a valve located below the pressure switch (figure 18) on the bottom of the interrupter. A special gas filling tool (part number 44081-399-50) is required (figure 19). *Contact Square D Company for detailed instructions if gas servicing becomes necessary.*

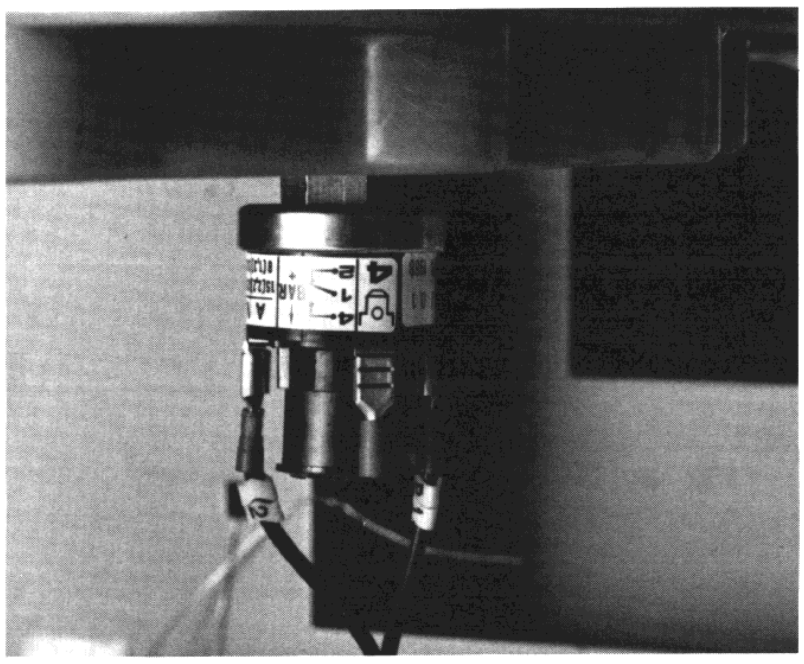


Figure 18: Pressure Switch

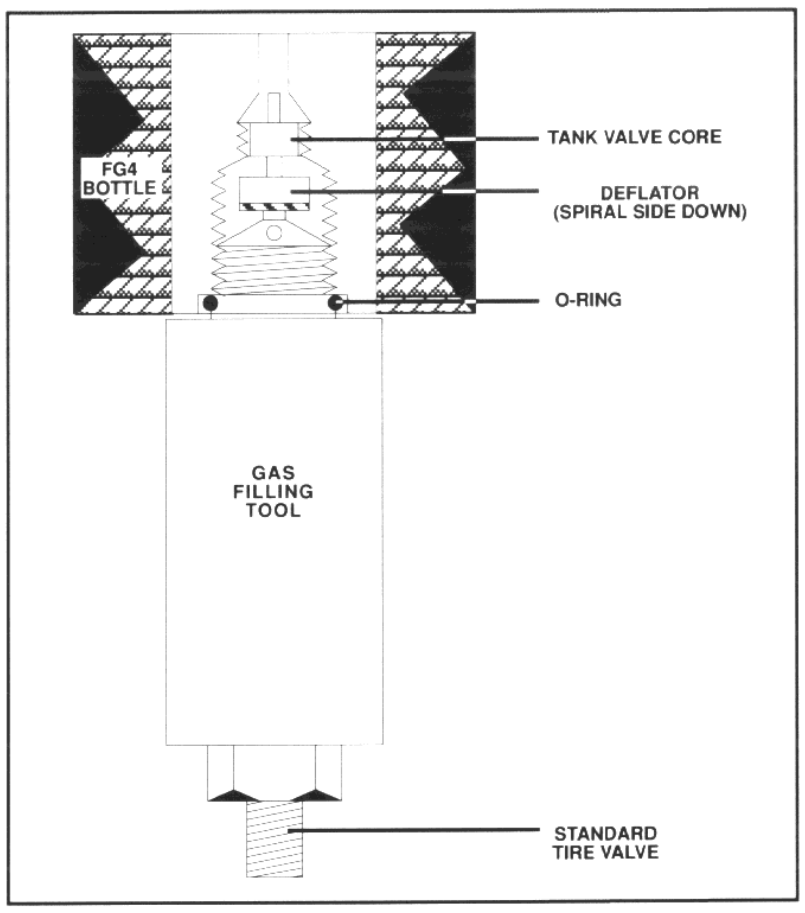


Figure 19: Gas Filling Tool

Table 3

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 AND REMEDY
Mechanism does not charge automatically	Electrical charging motor	Voltage across motor terminals too low • Correct the voltage • Replace the motor if necessary
	End of charging switch	• Check condition of switch • Replace switch if necessary
	Wiring	• Check connections of auxiliary circuits
Breaker will not close (indicator remains green)	Closing solenoid	Bad Connection • Check circuit Defective solenoid • Replace the solenoid
	End of charging switch	• Check condition of switch • Replace the switch if necessary
	Latch sub–assembly mechanism	Close Interlock out of position • Clean and oil Interlock Hinge Shaft
	Charging ratchet system	Mechanism is not getting charged • Change the mechanism
Breaker closes and opens immediately and remains open on subsequent attempts to close	Continuous trip signal applied	Fault in the HV main circuit or protective relays adjusted incorrectly • Eliminate the fault • Adjust protective relay
Breaker opens and closes alternately	Anti–pump relay	• Replace the relay
Breaker cannot be opened electrically	Auxiliary switch	• Check circuit
	Trip solenoid	Trip control power connections • Check the circuit Defective solenoid • Replace the solenoid • Check protective circuit

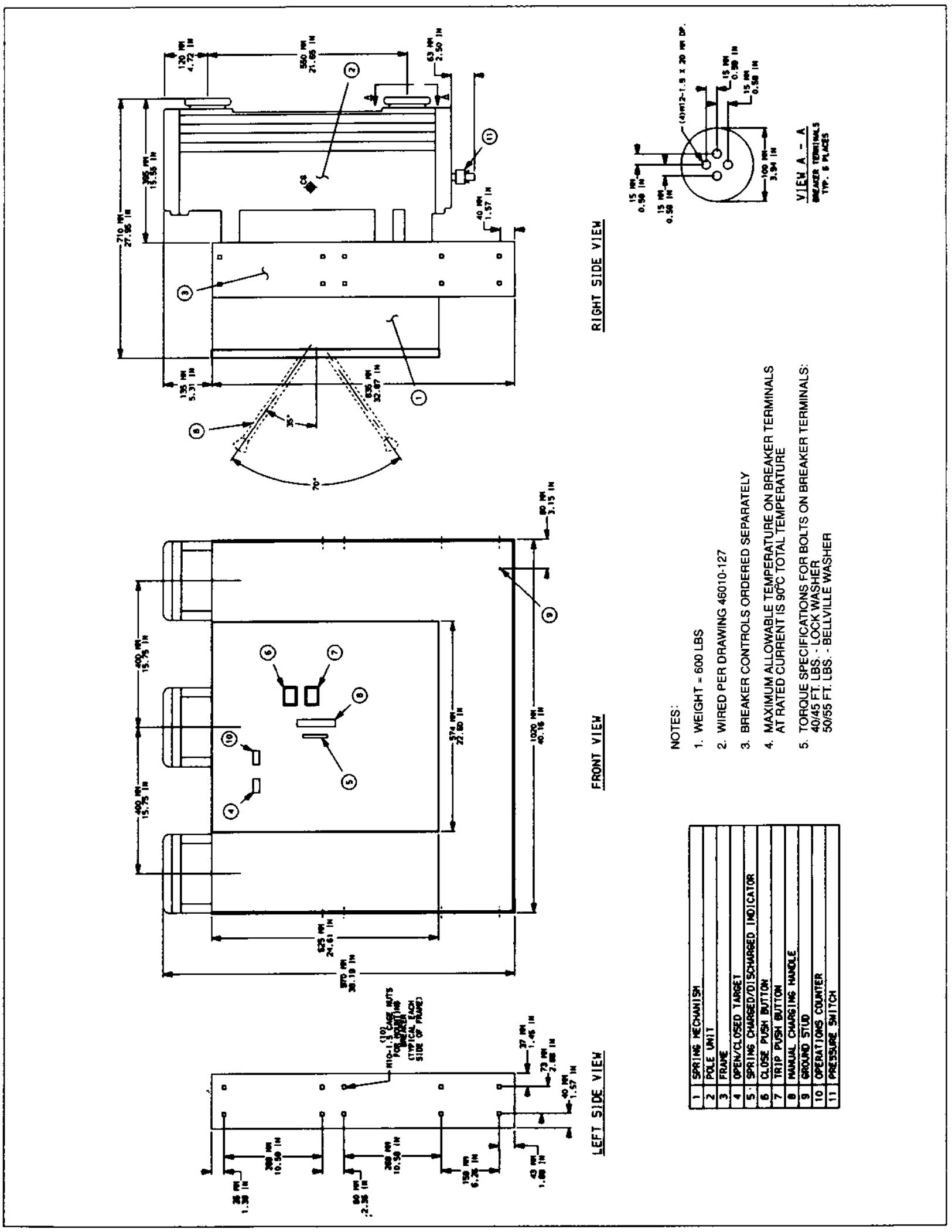


Figure 20: FG4 Breaker Outline

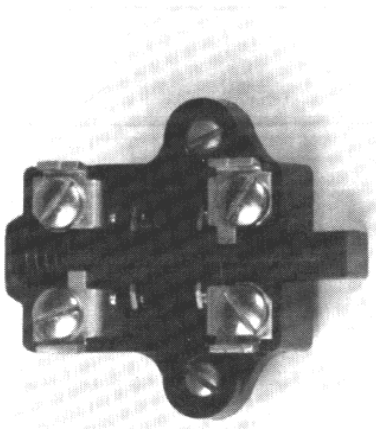
Table 4

PART NUMBERS AND DATA

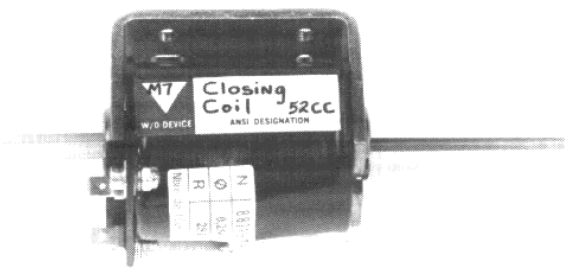
Device	Voltage	Part No.	Rating
Spring Charging Motor	24 VDC	886657	12 Amp*
	48 VDC	886658	6 Amp
	125 VDC	886661	4 Amp
	250 VDC	886662	2 Amp
	120 VAC	886661	4 Amp
	240 VAC	886662	2 Amp
Closing Solenoid	24 VDC	887 191AM	11.5 OHMS ± 10% FOR ALL
	48 VDC	887 191AJ	43 OHMS
	125 VDC	887 191AE	298 OHMS
	250 VDC	887 191AB	1130 OHMS
	120 VAC	887 191AF	196 OHMS
	240 VAC	887 191AB	1130 OHMS
Trip Solenoid	24 VDC	887 191BN	7.4 OHMS ± 10% FOR ALL
	48 VDC	887 191BL	17.6 OHMS
	125 VDC	887 191BF	196 OHMS
	250 VDC	887 191BC	725 OHMS
	120 VAC	887 191BF	196 OHMS
	240 VAC	887 191BB	1130 OHMS
	125 VDC (3 AMP)	887 191BJ	43 OHMS
Anti–Pump Relay	24 VDC	8501KFD12 24 VDC	
	48 VDC	KUP11D55 48 VDC	
	125 VDC	8501KFD12 11OV	
	250 VDC	8501KFD12 11OV	
	120 VAC	8501KF12 120/60	
	240 VAC	KUMP11A58 240 VAC	
FG4 Interrupter (with pressure switch)		730992B/730759D	
End of Charging Switch		25710904	
Latch Mechanism Sub–Assembly		887600B	
5 Auxiliary Contact Block		877942K	
9 Auxiliary Contact Block		877942C	
Motion Analysis Potentiometer Assembly		46010-078-50	
Gas Filling Tool		44081-399-50	

* Approximate maximum current draw

REPLACEMENT PARTS

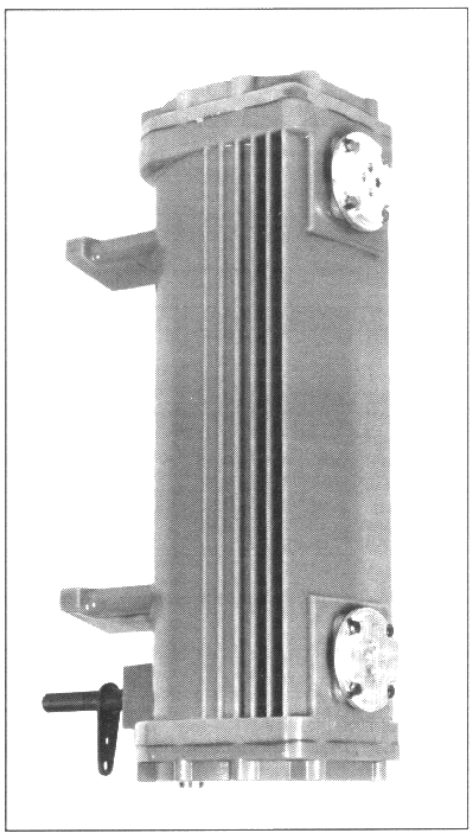


End of Charging Switch

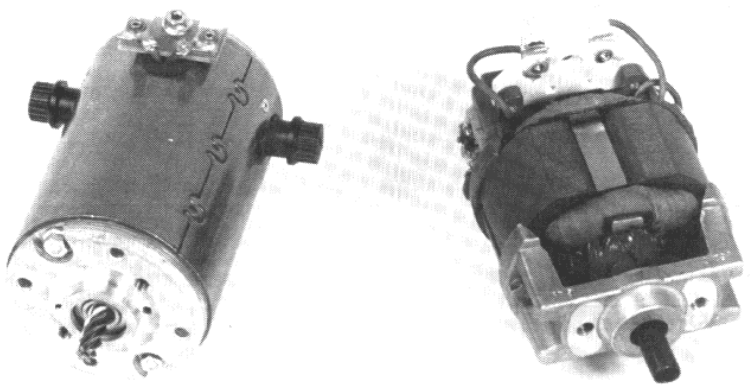


Closing Solenoid

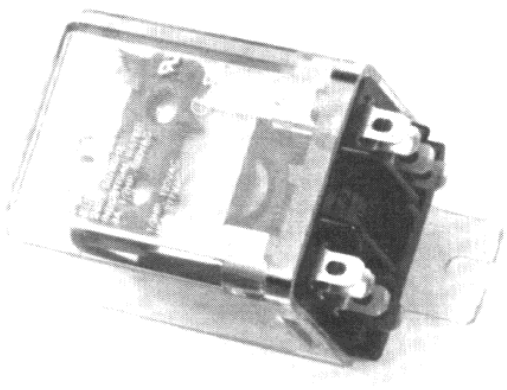
Trip Solenoid



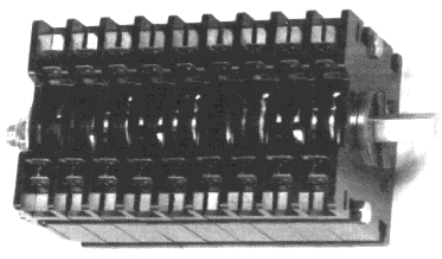
Interrupter



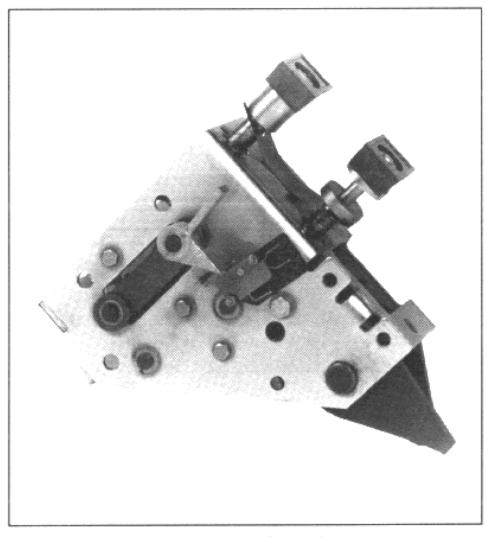
Charging Motor



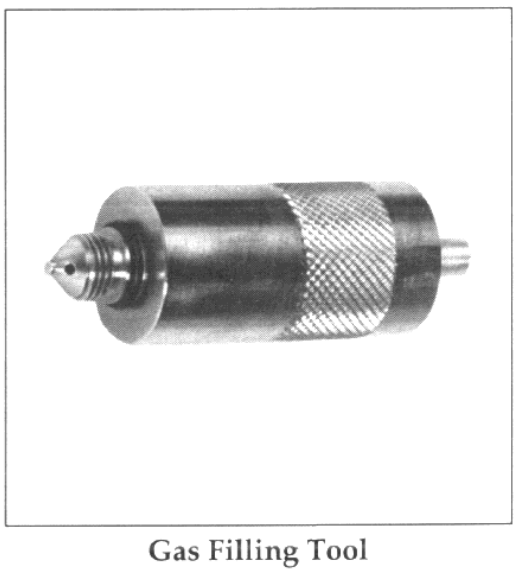
Anti–Pump Relay



Auxiliary Switch



Latch Mechanism



Gas Filling Tool

Figure 21: Replacement Parts

Square D Company
Power Equipment Business
330 Weakley Rd., Smyrna, TN 37167 USA

SQUARE D COMPANY
POWER EQUIPMENT BUSINESS
Dedicated to Growth • Committed to Quality

Manual 9880-2
IM 101

Printed in USA