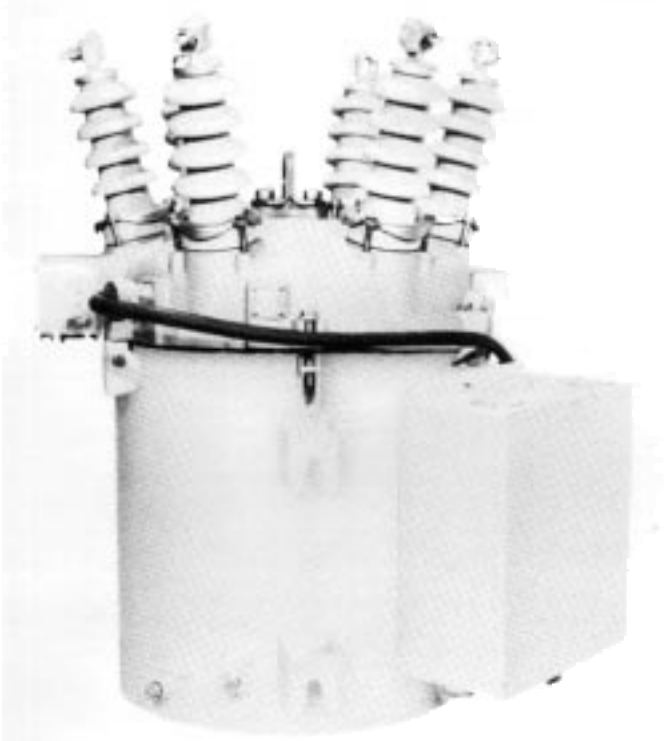
COOPER Power Systems

Type KFE Maintenance Instructions

KFE10003-E

Service Information



CAUTION
Do not energize this equipment out of oil.

RADIATION WARNING

See page 9.

Figure 1. 82049KM-A
Cooper Power System's Type KFE recloser combines vacuum interruption with hydraulic counting and electronic sensing and tripping.

CONTENTS

These instructions do not claim to cover all details or variations in the equipment, procedure, or process described, nor to provide direction for meeting every possible contingency during installation, operation, or maintenance. When additional information is desired to satisfy a problem not covered sufficiently for the user's purpose, please contact your Cooper Power Systems sales engineer.

INTRODUCTION

Service Information KFE10003E provides the maintenance instructions for Type KFE electronically controlled, three-phase vacuum reclosers. Included is a general description of the recloser and its operation, instructions for periodic inspection and routine maintenance, recommended test procedures, and instructions for shop repairs. A service-parts list keyed to exploded-view drawings of the recloser is included at the back of the manual.

DESCRIPTION

The Type KFE recloser is completely self-contained, taking operating energy directly from the system. The electronic control signals the low-energy trip solenoid to initiate tripping operation. Reclosing and trip-spring energy is provided by a high-voltage closing solenoid. Dual timing of both phase-trip and ground-trip operations is provided by proper setting of the timing-sequence selectors. Control of all recloser operations is hydraulic, except over-current sensing and trip timing which is controlled by the electronic control.

Arc interruption takes place within the three sealed, vacuum interrupters. Oil is used in KFE reclosers for electrical insulation, but is not involved in arc interruption. The oil is also used in the counting mechanism.

The moving contacts in the vacuum interrupters are pulled open by release of the opening spring. The low-energy tripper,

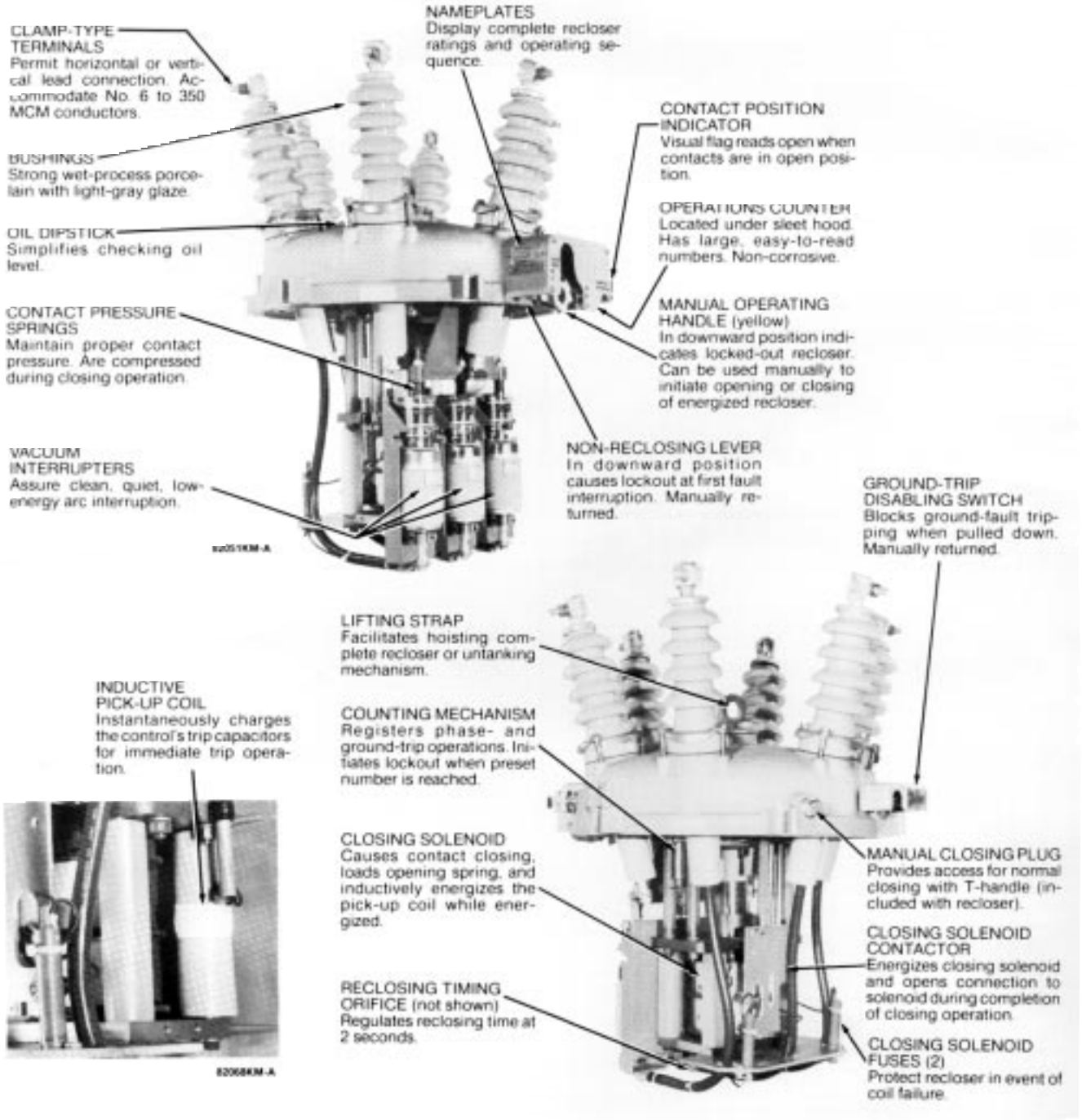


Figure 2.
Untanked view locating operating components.

82056KM-A

which is operated by the electronic control system, releases the opening spring when current above the minimum trip level, or a ground (earth) fault, is sensed.

The ground (earth) fault tripping feature senses zero sequence current with sensing current transformers, located inside the recloser. When the zero sequence current exceeds the selected minimum ground-trip level and remains above that level through the selected timing period, the electronic control operates the low-energy tripper to release the contact opening spring.

Closing energy, as well as energy to charge the opening spring, is supplied by a high-voltage closing solenoid momentarily connected phase-to-phase through a high-voltage contactor.

Figures 2A and 2B show the location of various operating components on the recloser. Major components involved in recloser operation are: the closing solenoid, the low-energy tripper, the counting mechanisms and the vacuum interrupters. Being aware of the location of these components and their part in the recloser operation will permit a quicker and clearer understanding of the recloser maintenance and repair procedures that follow.

SPECIFICATIONS AND RATING

The continuous current rating of the KFE recloser is 400 amps.

Voltage

Nominal Operating	2.4-14.4 kv
Maximum design	15.5 kv
Impulse withstand (BIL) 1.2 x 50 microsecond wave, crest	110 kv*
60 hertz withstand, rms	
Dry, one minute	50 kv
Wet, ten seconds	45 kv
RIV @9.41 kv	100μ V max
Operating frequency	50-60 hz

*Not always applicable across open contacts of vacuum interrupter. Insulation capabilities for this condition may be less than 110 kv.

Operating Times

Normal reclosing times .....1.5-2.5 seconds
Resetting time .....75-175 seconds per recloser operation

Duty Cycle

Number ot Operations	Percent of Interrupting Rating	Maximum Circuit X/R Ratio
96	15-20	
120	45-55	7
32	90-100	14
248 Total Operations		

Current and Interrupting

Minimum Trip Current (amps)	Interrupting (rms symmetrical amps) at 14.4 kv
1 Grd. *	6000
5 Grd.	6000
10 Grd. & Phase	6000
20 Grd. & Phase	6000
30 Grd. & Phase	6000
50 Grd. & Phase	6000
70 Grd. & Phase	6000
100 Grd. & Phase	6000
140 Grd. & Phase	6000
200 Grd. & Phase	6000
280 Grd. & Phase	6000
320 Grd. & Phase	6000
400 Grd. & Phase**	6000
450 Phase**	6000
560 Phase**	6000
800 Phase**	6000

RECLOSER OPERATION

The Type KFE recloser is completely self-contained, taking operating energy directly from the system. The electronic control signals the low-energy trip solenoid to initiate tripping operation. Reclosing and trip-spring energy is provided by a high-voltage closing solenoid. Dual timing of both phase-trip and ground-trip operations is provided by proper setting of the timing-sequence selectors. Control of all recloser operations is hydraulic, except over-current sensing and trip timing which is controlled by the electronic control. Major components involved in KFE recloser operations are the closing solenoid; the low-energy tripper; the counting, sequencing, and lockout mechanisms; and the electronic control Figure 3.

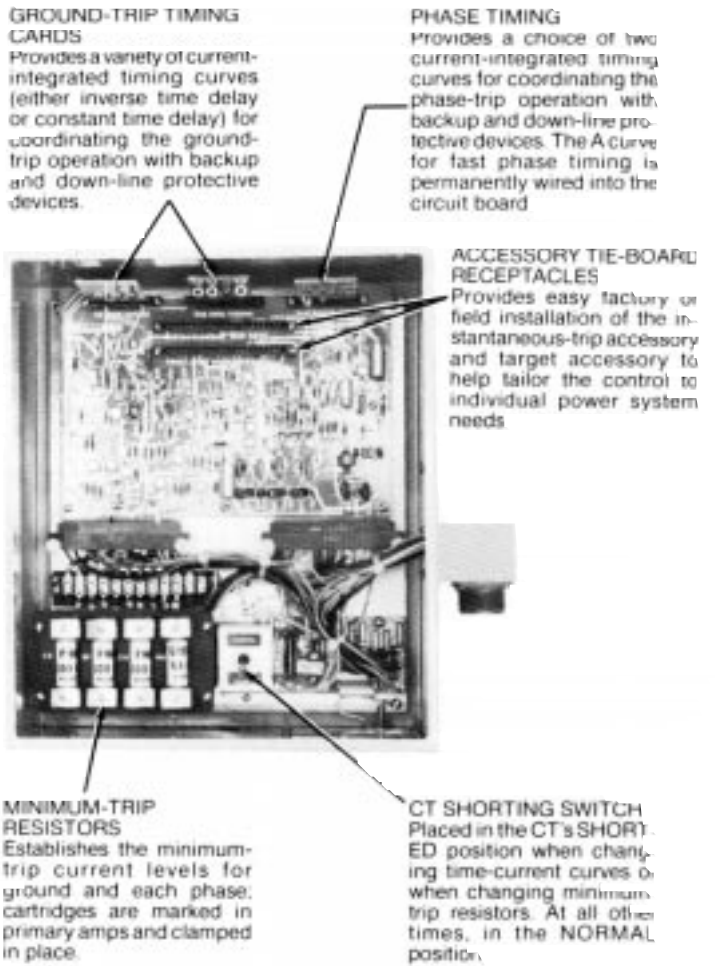


Figure 3.
Type KFE electronic control. 85708KM-A

Closing Solenoid

Energy that operates the recloser mechanism to close the vacuum interrupter contacts, compress the contact pressure springs, and charge the opening spring is obtained from the system through a high-voltage closing solenoid. As shown in Figure 4, this solenoid is connected phase-to-phase on the recloser's source side through a high-voltage contactor (switch). Selection of the closing solenoid voltage rating is based on the phase-to-phase voltage of the system on which the recloser is to be used. Low-voltage power can be employed for closing if the proper solenoid and a Low-Voltage Closing accessory are specified when the recloser is ordered.

The closing operation is best understood by considering the recloser to be connected to the line but locked out (yellow

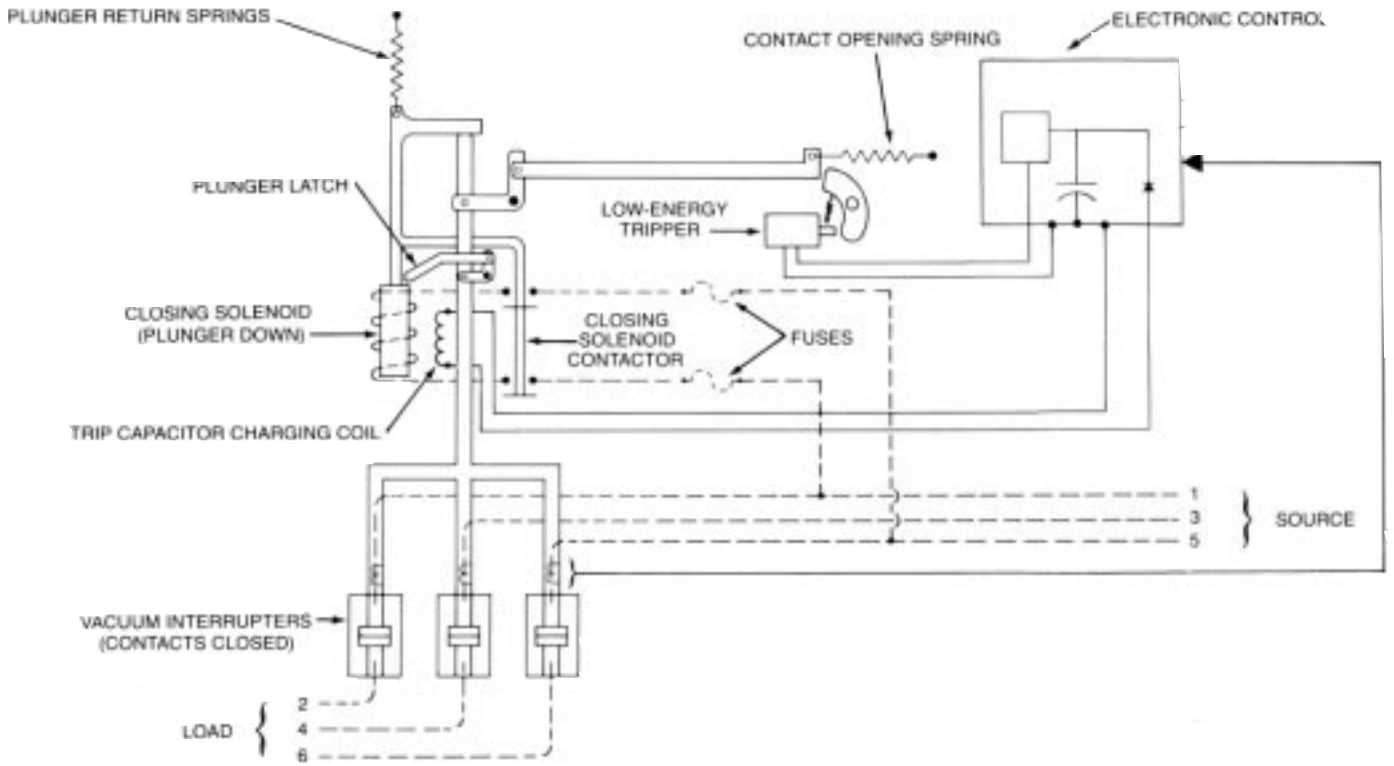


Figure 4.
Simplified diagram of recloser's major electrical and mechanical components.

manual operating handle in downward position). To close from lockout, the manual operating handle is raised to the closed position. This allows the closing solenoid contactor to close the phase-to-phase connection, thereby energizing the closing solenoid and imparting a downward acceleration to the solenoid plunger. Downward movement of the plunger causes the recloser operating mechanism to do the following:

- Contact-operating rods move downward to close vacuum interrupter contacts and compress contact-pressure springs. Closing-solenoid contactor opens.
- Opening spring is charged and recloser mechanism set up for a tripping operation.
- Plunger is latched in its downward position, charging plunger-return springs.

While the recloser contacts are closed, the solenoid plunger remains latched in its downward position. Release of the recloser-opening spring (as in a trip operation) releases the plunger latch and allows the plunger to be drawn upward under action of the plunger-return springs. Oil flow into the chamber being vacated by upward movement of the plunger is regulated by a timing orifice in its base. This retards the plunger's upward movement to accomplish the recloser's two-second reclosing time (a four-second reclosing time is also available as an accessory). As the plunger reaches the top of its stroke, the closing solenoid contactor again closes, momentarily energizing the closing solenoid, and drawing the plunger back down to repeat the closing operation.

Low-Energy Tripper

The low-energy tripping mechanism, operated from the electronic control, initiates the overcurrent tripping operation. The mechanism consists of a permanent magnet and an armature and coil assembly which operate a trip lever (Figure 5).

During the closing operation, an electromagnetic charging coil instantaneously charges the trip capacitors—in the electronic trip control—assuring that the recloser is armed and ready for an immediate trip operation if necessary. When the

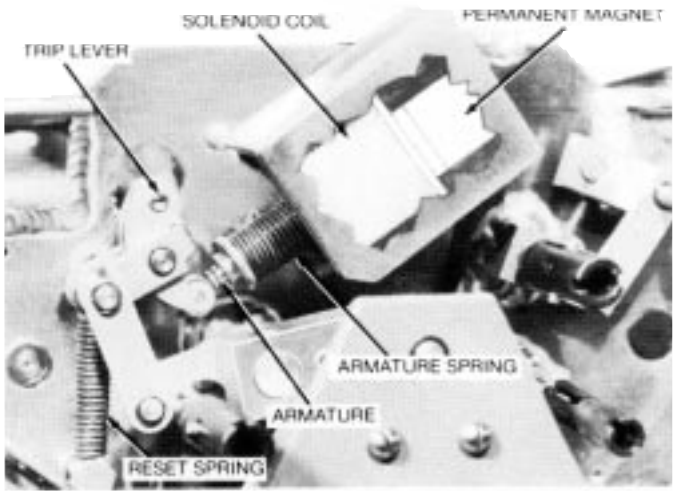


Figure 5. 82076KM-A
Low-energy tripper.

recloser is closed, the tripper-armature plunger is held in by the magnetic force of the permanent magnet. In this position, the armature spring is compressed and energized—ready to withdraw the armature when magnetically released.

During a trip operation, the stored energy in the trip capacitors energizes the solenoid coil in the low-energy tripper. This creates a counter-magnetic field which momentarily neutralizes the field of the permanent magnet—thus allowing the springdriven armature to instantaneously operate the trip lever which in turn opens the recloser contacts. As the recloser contacts open, the precharged reset spring is released and returns the solenoid plunger to its de-energized position. This low-energy trip assembly is thus re-cocked and able to perform another trip operation as soon as a closing operation is completed.

Counting and Sequencing Mechanism

Each recloser operation is counted—phase and ground—by a ratchet-rod-and-piston assembly mounted on the recloser mechanism. The counting mechanism in turn actuates the recloser's sequence mechanism and lockout mechanism.

Counting Operation

After each tripping operation, during the reclosing interval, a spring-biased pawl is moved upward by the pivoting mechanism linkage as shown by arrows in Figure 6. Being spring biased, the pawl engages the ratchet rod at the bottom of its stroke, raising the rod approximately 7,9 mm (5/16 in.). At the top of its stroke, the pawl disengages from the ratchet rod, returning to its starting position as the recloser closes.

The count is registered by a piston that is attached to the lower end of the ratchet rod and moves in an oil-filled housing. The piston is drawn upward with the ratchet rod and held there by oil trapped by a ball check valve; as the piston is drawn upward the valve opens, permitting the piston unimpeded upward travel, but downward movement only at a calibrated resetting rate. Each subsequent recloser operation further elevates the ratchet rod and piston.

The piston-and-ratchet-rod assembly begins resetting as soon as the pawl disengages from the ratchet rod as each count is completed. The reset time at 25°C is 75-175 seconds for each recloser operation counted. Following a lockout operation the dumping rod raises the check valve, resulting in a fast reset (approximately 15 seconds), permitting the count to start from zero each time. The yellow handle is raised.

Number of Operations to Lockout

Reclosers built prior to serial number 997; the upper end of the ratchet rod contains three grooves. An E-ring, set in one of the grooves, supports a cylindrical spacer (Figure7A) placed on the ratchet rod. When the cylindrical spacer engages the lockout mechanism trip lever—after it has been raised the preset number of counts—it causes the recloser to lockout. Grooves on the ratchet rod permit selection of lockout after two, three, or four trip operations.

Reclosers built after serial number 996; the upper end of the ratchet rod is equipped with an indexing stepped spacer (Figure 7B). When the step that is indexed toward the trip lever engages the lever it causes the recloser to lockout. Re-indexing the stepped spacer permits selection of lockout after two, three, or four trip operations.

The counting mechanism registers all recloser phase- and ground-trip overcurrent operations. It will also register recloser operations initiated by externally controlled remote operating accessories.

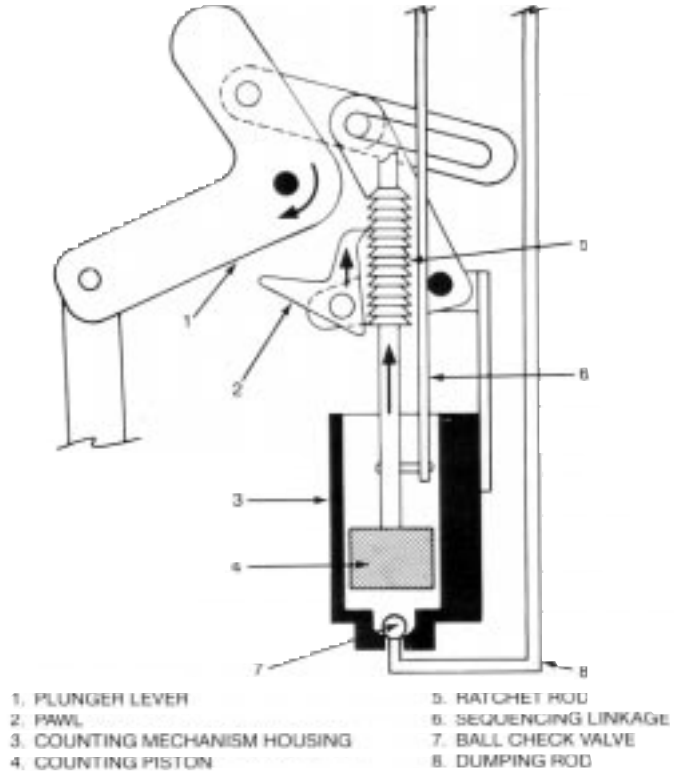


Figure 6.
Simplified diagram of counting mechanism.

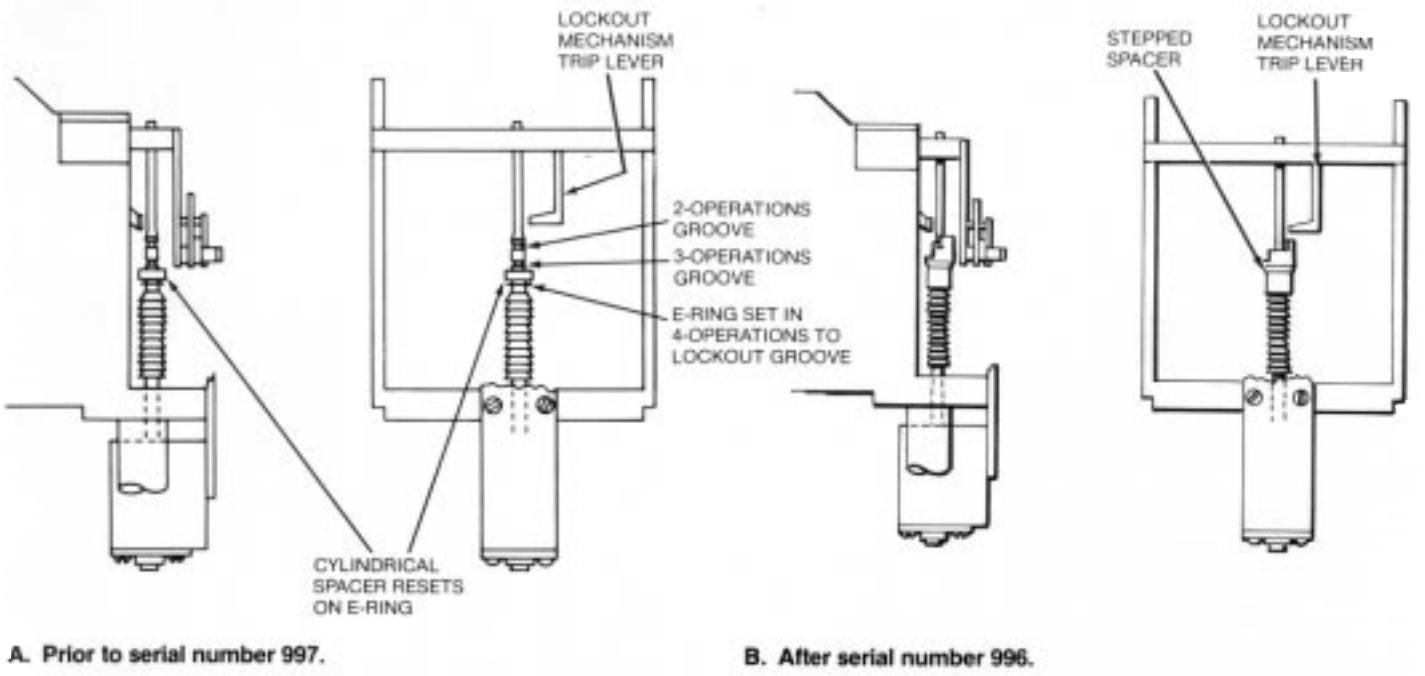


Figure 7.
Simplified diagram showing operations to lockout settings on counting mechanism ratchet rod.

Sequencing Mechanism

A sequencing mechanism, consisting of a cam rod, a phase- and ground-trip cam, and a phase- and ground-sequencing microswitches. The mechanism is actuated by movement of the ratchet rod (Figure 8).

When the recloser operates, the ratchet rod moves upward as previously described and causes a similar upward movement of the cam rod, causing a counterclockwise rotation of the cam assembly. As the recloser operates through its preset program, the sequencing switch rollers ride along the phase- and groundtrip cam edges. When the fast operations have been completed, the cam assembly will have rotated sufficiently to cause the sequencing roller to engage the sequencing switch. This switches the electronic control to its slow-timing characteristic. The sequencing mechanism will return to its reset position as the counting mechanism resets.

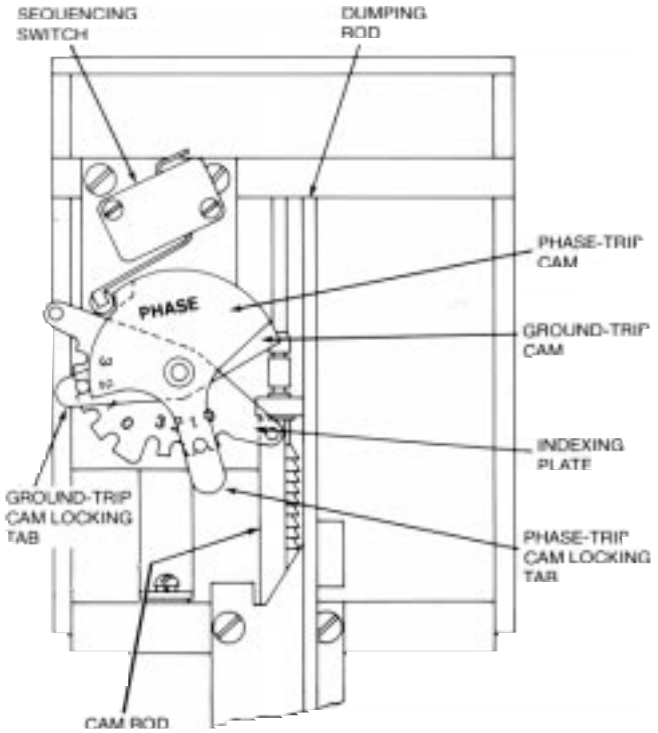


Figure 8.
Sequencing mechanism and number-of-fast operations settings.

Number of Fast Operations

The phase- and ground-trip cams are used to program the number of fast trip operations in the recloser's operating sequence. As shown in Figure 10, the cam plates contain indexing numbers (0,1, 2, 3) for both phase and ground. The operating sequence is set by simply lifting the locking tab on either the phase- or ground-trip cam and rotating it until it aligns with the desired number of operations on the fast curve. The number of slow operations will be automatically established—it will be the difference between the number of fast operations and the number of operations to lockout. In all cases, the total number of operations on both phase and ground must be the same. If four fast operations are desired, consult the factory.

Electronic Control

The Type KFE electronic control (Figures 9 and 10) utilizes solid-state circuitry and provides the intelligence for current sensing and trip timing. All the control electronics and electronic accessories are located in an external cabinet connected to the recloser with a 2,1 m (7-ft) long cable. The separate control cabinet is intended to be mounted to the recloser tank, although it can be mounted to the pole or other mounting structure at a distance equal to the cable length. The control cable is hard wired to the recloser and connected to the control with a threaded weatherproof connector.

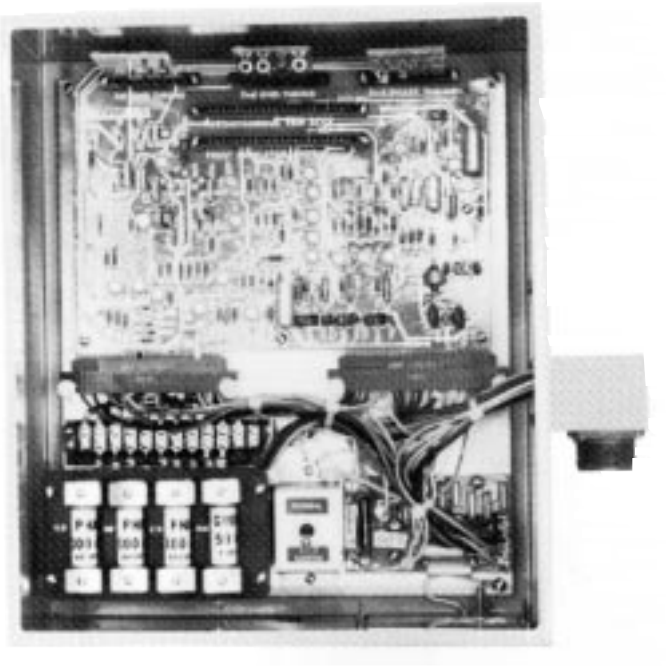


Figure 9. 85708KM-A
Type KFE recloser electronic control.

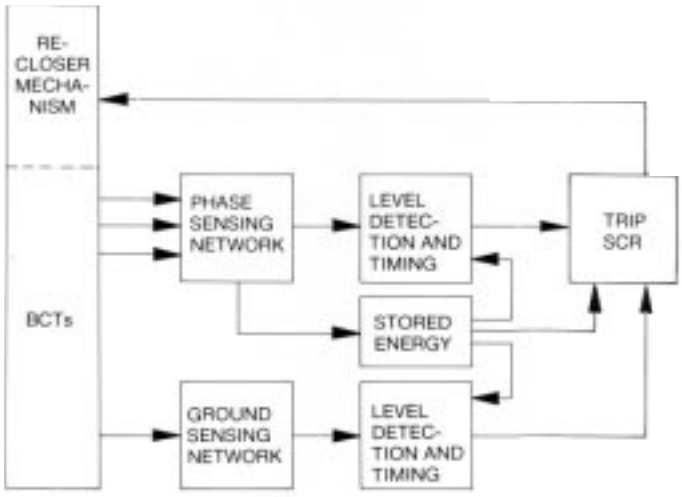


Figure 10.
Functional block diagram of the Type KFE electronic control.

Current Sensing

KFE reclosers have six 1000:1-ratio current-sensing transformers mounted on the bushings under the head—providing both phase- and ground-(zero-sequence) current sensing. The CTs are connected to the electronic control cabinet by the 2,1 m (7-ft) cable.

Minimum-Trip Selection

The minimum-trip ratings, both phase (10-800 amps) and ground (5-400 amps) are established by plug-in resistor cartridges. The cartridges are labeled with their minimum-trip current values. The minimum-trip setting of the recloser can be changed by merely changing the trip resistors. A 1-amp ground minimum-trip rating is also available by connecting a jumper between Tabs X and Y on the main circuit board and installing a 5-amp ground minimum-trip resistor.

Phase- and Ground-Trip Timing

A variety of time-current characteristic curves allow the KFE to fit specific power distribution systems. All timing starts at initiation of a fault, or when closing into a fault.

An A (fast), and B and C (delayed) phase-trip timing curves are available. For ground-trip timing, inverse curves 1 (fast) and 2 and 3 (delayed) and 9 constant time curves of from 0.1 to 15 seconds are available.

The A curve for phase timing is permanently wired on the control circuit board. The delayed phase-trip curves and all ground-trip curves are circuit cards which plug into the main control board. Phase and ground TCC circuit cards are not interchangeable. For detailed coordination planning, complete sets of curves can be ordered: specify Cooper Power System's bulletin *KFE10004-E.*

Control Power

The KFE recloser is completely self-contained; no external power source or battery is required to operate the electronics. The electronic circuitry is powered from the line by bushingcurrent transformers mounted under the head. A minimum of 5-amps primary current flow is sufficient to power the electronics and charge the trip capacitors which actuate the low-energy tripper. In addition, a pickup coil, wound on one leg of the closing solenoid frame, provides charge to the trip capacitors before recloser contacts make, thus insuring that sufficient tripping power is available immediately following a closing operation, thus eliminating the necessity of a time delay to charge trip capacitors from load or fault current.

MAINTENANCE AND INSPECTION

Frequency of Maintenance

Because reclosers are applied under widely varying operating and climatic conditions, maintenance intervals are best determined by the user based on actual operating experience. To operate properly, reclosers must be maintained when they have operated the equivalent of a complete duty cycle and before the dielectric strength has deteriorated below prescribed levels. In the absence of specific operating experience, the following recommendations and procedures are submitted as a minimum maintenance program.

- When Type KFE reclosers are operated under usual service conditions as defined in ANSI (American National Standards Institute) C37.60, “Standard Requirements for Automatic Circuit Reclosers for Alternating Current Systems,” it is recommended that the following maintenance procedure be performed at the completion of an equivalent duty cycle.

  NOTE: The standard duty cycle for the Type KFE recloser is 248 fault interruptions at the fault current distribution shown under “Specifications,” page2.ANSIC37.61-1973,”Guide For The Application, operation and Maintenance of Automatic Circuit Reclosers,” gives a procedure evaluating the actual operating duty of a recloser in terms of its standard duty cycle.

- However, if the recloser has not completed an equivalent duty cycle within *three years,* it is recommended that an external inspection, oil-level check, and a check of the dielectric strength of the oil be made at that time. (See steps 1, 2, and 8 of “Maintenance Procedure” below.)

- Also it is strongly recommended that the vacuum interrupters be replaced after 2500 operations of the recloser.

Maintenance Procedure

Each periodic maintenance inspection at the completion of a duty cycle should include at least the following:

1. Bypass and remove the recloser from service.

2. Inspect external components.
- A. Check for broken or cracked bushings. Replace as necessary.
- B. Check for paint scratches and other mechanical damage; paint to inhibit corrosion.
- C. Note counter reading and enter into the record log.
- D. Check control cabinet for damage or leaks.

3. Perform a dielectric withstand test (page 9) to check the insulation level of the recloser and the vacuum integrity of the current interrupters.

4. Untank the recloser.
- A. Loosen the six bolts that secure the head casting to the tank.
- B. Carefully pry apart the head and tank to break the gasket seal, taking care not to damage the gasket.
- C. Lift the head and mechanism assembly from the tank and allow the oil to drain off.

5. Clean all internal components.
- A. Remove all traces of carbon by wiping with a clean, lint-free cloth.

  NOTE: Although fault interruption occurs in a sealed vacuum chamber, the contacts of the closing coil contactor operate in oil and will produce carbon deposits.

- B. Flush the mechanism with clean transformer oil.

> **CAUTION**
> Never use volatile solutions, detergents, or water-soluble cleaners.

6. Check contact erosion of the vacuum interrupters.
- A. Locate the scribe mark on the moving contact rod at the top of each vacuum interrupter, Figure 11.
- B. If the scribe mark falls below the top surface of the phenolic rod guide when the recloser contacts are closed, the interrupter has reached the end of its expected life and must be replaced.

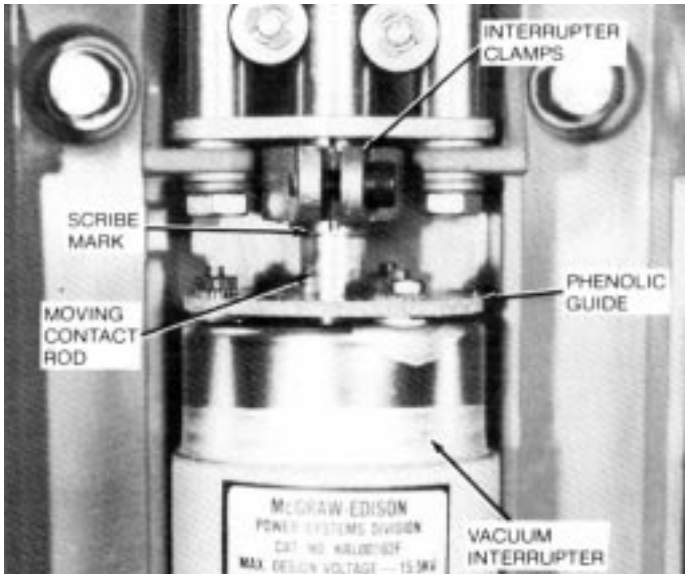


Figure 11. 85714KM-A
Scribe mark on moving contact rod indicates amount of contact erosion.

7. Check the dielectric strength of the insulating oil.
   A. An oil sample taken near the bottom of the recloser tank should have a dielectric strength of not less than 22 kv rms.
   B. Low dielectric strength indicates the presence of water or carbon deposits and the oil should be replaced.
8. If oil must be replaced, drain the tank and clean out all sludge and carbon deposits.
9. With the mechanism removed, fill the tank with new, clean insulating oil, the oil level should be 76 mm (3 inches) below the top edge of the tank. Tank capacity is approximately 125 liters (33 U.S. gallons). See "Oil Condition," page 10.
10. Examine the head gasket. Replace if it is cracked, checked, cut or otherwise damaged, or if it has been permanently deformed.
11. Retank the recloser.
   A. With the recloser contacts open (yellow handle down), lower the recloser into the oil-filled tank.
   B. As the head casting nears the tank lip, check that no wires inside the recloser head project into the gasket groove on the casting.
   C. With the head centered just above the tank, orient the sleet hood with respect to the tank mounting brackets. Align the head mounting lugs with the bolts and gently lower the recloser into the tank.

      Important Check all around that the gasket does not twist as the head is being seated. Gasket twist can occur if the head is not centered over the tank.

   D. Replace the head bolts and torque to 35-50 N-m (25-35 ft-lbs) alternating on opposite bolts. This results in evenly distributed gasket sealing pressure.
12. Repeat the high-voltage dielectric withstand test (Step 3) to make sure that dielectric clearances within the tank have not been compromised.
13. Perform the tests described on page 10 to check that the recloser is operating properly before returning recloser to service.

Insulation Level Withstand Tests

High potential withstand tests of the recloser should be performed at 37.5 kv rms, 50-60 hertz (75 percent of rated low frequency withstand voltage). The following tests should be performed.

NOTE: The control should be mounted to the recloser tank, or grounded to the tank, during the test.

Test 1: Proceed as follows:
1. Close main contacts of recloser.
2. Ground recloser tank and head.
3. Connect all three source-side bushings (1, 3, and 5) together.
4. Apply test voltage to source-side bushings.
5. The recloser should withstand the test voltage for 60 seconds.

Test 2: Proceed as follows:
1. Close main contacts of recloser.
2. Ground recloser tank and head.
3. Ground Phase A (bushing 2) and Phase C (bushing 6).
4. Apply test voltage to Phase B (bushing 3).
5. The recloser should withstand the test voltage for 60 seconds.

Test 3: Proceed as follows:
1. Open main contacts of recloser.
2. Ground recloser tank and head.
3. Connect and ground all three load-side bushings (2, 4, and 6).
4. Connect all three source-side bushings (1, 3, and 5).
5. Apply test voltage to source-side bushings.
6. The recloser should withstand the test voltage for 60 seconds.
7. Reverse connections: ground source-side bushings (1, 3, and 5); apply test voltage to load-side bushing (2, 4, and 6) for 60 seconds.
8. The recloser should withstand the test voltage for 60 seconds.

It is possible for X-radiation to result when voltage in excess of the 15.5 kv rated maximum voltage is applied across the *open-contact gap* of the vacuum interrupter in Test 3. Such radiation can become a health hazard on long exposure at close range. When performing high-voltage tests on Type KFE vacuum reclosers, personnel safety can be assured by noting the following information and taking the necessary precautions.
1. American National Standard C37.09-1964 (R169) "Test Procedure A-C High Voltage Circuit Breakers" allows tests after delivery which include application of 75 percent of rated low-frequency withstand voltage across open contacts of the interrupters. For the KFE recloser this test voltage is 37.5 kv ac rms.
2. At this test voltage, radiation is negligible when the vacuum interrupters are mounted in the recloser operating mechanism structure, installed in the oil-filled recloser tank, and have their contacts open to the nominal 9,5 mm (3/8 inch) open contact gap.
3. Testing at higher voltage than specified in 1, may cause radiation emission injurious to personnel. If testing is to be performed at higher than specified voltage, additional shielding is required.
4. Testing vacuum interrupters above 50 kv ac rms is not recommended.

Test Results: These high potential withstand tests provide information on the dielectric condition of the recloser mechanism and the vacuum integrity of the interrupters.

A. If the recloser passes the closed-contacts tests (Tests 1 and 2) but fails the open-contacts test (Test 3), a deteriorated vacuum in one or more of the interrupters may most likely be the cause. Retest each vacuum interrupter individually to determine the failed phase (or phases) and replace the vacuum interrupter(s). Retest to confirm the repair.
B. If the recloser fails the closed-contacts tests (Tests 1 or 2) the cause is likely to be found in the recloser mechanism assembly. After correcting the problem, retest the recloser with contacts closed (Tests 1 and 2) to confirm repair and the contacts open (Test 3) to check vacuum condition.

Oil Condition

Oil plays an important role in the proper functioning of the recloser. It provides the internal insulation barrier between phases and from phase to ground, and acts as the timing and counting medium. For effective recloser operation, the oil must be replaced before it deteriorates below a safe level. Oil that has been contaminated with carbon sludge or has a dielectric strength of less than 22 kv should be replaced.

New oil should always be filtered before using though it may be obtained from an approved source. Passing the oil through a blotter press will remove free water and solid contaminants such as rust, dirt, and lint. When filtering the oil, aeration should be kept to a minimum to prevent moisture in the air from condensing in the oil and lowering its dielectric strength.

Used oil must be treated before reusing. Filtering may remove absorbed and free water and other contaminants to raise the dielectric strength to acceptable levels. However, filtering does not always remove water-absorbing contaminants and the dielectric strength of the oil may fall rapidly after being returned to service. Therefore the recloser should be filled with new oil or oil that has been restored to like-new condition. Oil used in the Type KFE recloser conforms to ASTM Standard D3487, Type I; its property limits are shown in Table 1.

Table 1.
Property Limits of Insulating Oil Used in Type KFE Reclosers

Characteristic	Acceptable Value	ASTM Test Designation
Color	0.5 max.	D1500
Reaction	Neutral	
Neutralization No.	0.03 mg KoH/g max.	D974
Corrosive sulfur	Noncorrosive	D1275
Steam emulsion No.	25 seconds max.	D193s
Flash point	145ºC	D92
Pour point	-40ºc	D97
Viscosity index		
100ºC	3.0 cST/36 SUS	D445
40ºC	12.0 cST/66 SUS	D88
0ºC	76.0 cST/350 SUS	
Specific gravity at 15ºC	0.91 max.	D1298
Coefficient of expansion	0.00074.0008 (Typical at 25-100ºC)	D1903
Interfacial tension	40 dynes per cm. min.	D971
Dielectric constant	2.2	D924
Dielectric strength	30 kv min.	D877
Water content (by Karl Fischer Test)	35 parts per million max.	D1533 or D1315
Weight per liter	0.9 kg	

TESTING

The Type KFE recloser uses a low-energy magnetic trip device for opening and a high-voltage shunt solenoid for closing. It can be test-tripped with a low-voltage a-c source, but for automatic (electrical) closing a high-voltage a-c source is required. The unit can also be tested by substituting manual closing for electrical closing to eliminate the high-voltage test circuit. Test procedures for both methods of closing are included in this section.

WARNING
Do not attempt to trip the Type KFE recloser using d-c source such as a storage battery. The vacuum interrupters can be severly damaged if interruption of a d-c arc is attempted.

Personal Safety

When high-voltage closing is used, both the recloser and the high-voltage test transformer should be enclosed in a test cage to prevent accidental contact with live high-voltage parts. All metering and measuring equipment should be located outside the test cage, and proper grounding and test procedures should be observed.

CAUTION
Do not energize this equipment out of oil.

CAUTION
Solidly ground the KFE recloser to a suitable earth ground.

CAUTION
Do not attempt to trip a KFE recloser using a dc source such as a storage battery. The vacuum interrupters may be severly damaged if interruption of a dc arc is attempted. Additionallly, a dc source will not generate a trip signal within the current transformers.

IMPORTANT
When testing phase minimum-trip current, be sure to disable ground-trip function. Testing on individual phases without disabling ground-trip will cause the ground-trip fuction to operate.

Test Equipment Required

A suggested test circuit is shown in Figure 12. The following equipment is required for this circuit:

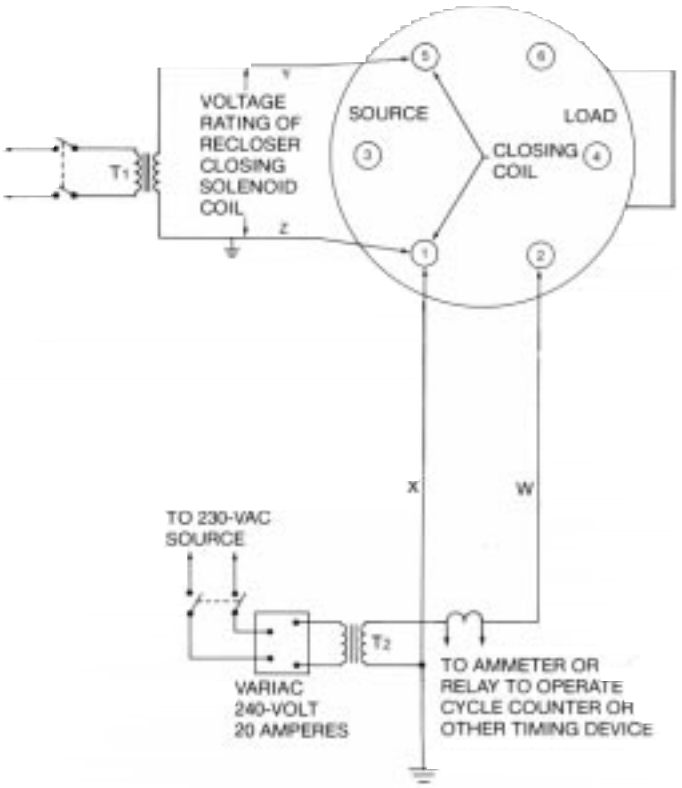


Figure 12.
Suggested test diagram for low-voltage tripping, high-voltage closing.

1. **Variable autotransformer**—240 volts, 20 amps.
2. **Low-voltage transformer T_2**—Ratio and kVa size depend upon size of recloser trip coil and maximum current to be used.
3. **Ammeter**—Full scale deflection should be at least 300% of recloser minimum trip rating. Use of current transformer may be required.
4. **Cycle counter**—or other timing device.
5. **High-voltage transtommer T_1**—Used to operate high-voltage closing solenoid. In general, a 50-kVa transformer having an impedance of about three percent will be satisfactory if the source impedance is reasonably low. Low-side rating should equal voltage of available test source. High-side should equal voltage of recloser's closing solenoid. Be sure minimum allowable voltage shown in Table 2 is maintained at recloser terminals during the two- to three-cycle interval the closing solenoid is energized.

Table 2.
Closing Solenoid Electrical Constants and Minimum Voltage

Closing Solenoid Rating (kV)	Closing Solenoid Code Number	Minimum Allowable Voltage at Recloser When Solenoid is Energized—(Volts)
50-Hz		
6.0	51	5100
11.0	52	9350
13.2	53	11220
14.4	54	12240
60-Hz		
2.4	21	2040
4.16-4.8	22	3540
6.0	31	5100
12.0-13.2	30	10200
14.4	27	12240

Test Procedure - Electrical Closing

WARNING
Solidly ground leads X and Z and interconnect to the recloser tank. DO NOT connect leads W and Y to the SAME PHASE. Dangerous voltages to ground exist on the phase connected to Y.

OPERATION OF CLOSING SOLENOID

Assemble and connect the equipment as shown in Figure 12.

1. Trip the recloser manually by moving manual operating (yellow) handle down to "LOCKOUT" position, then move the yellow handle up to its "CLOSED" position.
2. Energize the high-voltage transformer T_1. The recloser should close immediately, indicating correct operation of the closing solenoid.
3. If the recloser fails to close, disconnect from the test setup and attempt to manually close. If manual operation is correct check coil connections and fuses, then re-attempt electrical closing.
4. If the recloser still will not close electrically replace the closing coil.

PHASE MINIMUM-TRIP CURRENT

When testing phase minimum-trip level, block ground by lower ing ground disable handle.

"A" Phase (Bushings 1 and 2)

Connect leads X and W from low-voltage transformer T_2 to bushing terminals 1 and 2 respectively, and proceed as follows:

1. Program one or more "A" trip characteristics.
2. With manual operating handle in its "CLOSED" position, energize high-voltage transformer T_1 to close the recloser.
3. De-energize transformer T_1.
4. Energize variable autotransformer and slowly raise the voltage from zero, noting the ammeter reading. If current is raised gradually when tripping on an "A" trip characteristic, the minimum-trip is essentially that current at which the trip occurs.

NOTE: If the recloser fails to trip either a current transformer or control failure is probable. Inspect all current transformer wiring and control connections and retest. If proper operation is still not observed substitute a known good control and retest. Repair or replace components as required.

5. Lower the yellow handle to lockout the recloser. This will cancel count accumulation so that subsequent operation will be on first "A" curve characteristic.

"B" Phase (Bushings 3 and 4)

Connect leads X and W from low-voltage transformer T_2 to bushing terminals 3 and 4 respectively, and repeat Steps 1, 2, 3, 4 and 5 above.

"C" Phase (Bushings 5 and 6)

Before applying any voltage to "C" Phase reverse the highvoltage transformer leads; connect grounded lead Z to Bushing 5 and hot lead Y to Bushing 1. Then connect the low-voltage transformer test leads X and W to Bushings 5 and 6 respectively, and repeat Steps 1, 2, 3, 4 and 5 above.

GROUND MINIMUM-TRIP CURRENT

Accurate minimum-trip is best obtained if the first ground-trip characteristic is #1 inverse, or #1, 2, or 3 constant time. Slower tripping characteristics require very gradual increase in current. Use fastest time available. Connect leads X and W on low voltage transformer T_2 to one pair of bushing terminals (1 and 2, or 3 and 4, or 5 and 6) and use the following procedure:

1. Set the Ground-Trip Disabling Switch to "NORMAL" (up) position.
2. Move the yellow manual operating handle to its closed position and use the manual closing tool to close the recloser.
3. Energize the variable autotransformer and slowly raise the voltage from zero. Note the ammeter reading when the recloser trips and compare to plug-in trip resistor value.

NOTE: If the recloser fails to trip either a current transformer or control failure is probable. Inspect all current transformer wiring and control connections and retest. If proper operation is still not observed substitute a known good control and retest. Repair or replace components as required.

OPERATING SEQUENCE AND RECLOSING TIME—PHASE

With the test circuit connected as shown in Figure 12 and ground blocked by lowering the Ground Disable Handle, proceed as follows:

1. Move the yellow manual operating handle to its "CLOSED" position and energize the high-voltage transformer T_1 to close the recloser. Leave T_1 energized.
2. Set the variable autotransformer high enough to cause the recloser to trip readily (suggest 300 percent of phase minimum-trip resistor current rating).
3. Energize the low-voltage transformer T_2. The recloser should trip, reclose, and continue tripping and reclosing through its programmed sequence to lockout.
4. Observe the following:
A. Count the number of fast operations by watching the Contact-Position Indicator on the sleet hood.
B. Read reclosing time from the timing device arranged to record the period during which the current is not flowing. C. Count the number of operations to lockout by counting the trip operations until the yellow handle drops.

IMPORTANT
When repeating tests, be sure to allow enough time for the lockout integrator piston to reset. Time required is approximately 75-175 seconds per recloser trip operation. Fast resetting of integrator occurs immediately following lockout. Yellow handle can be raised after approximately 5 seconds (at room temperature).

OPERATING SEQUENCE AND RECLOSING TIME—GROUND

The verification of ground operating sequence is similar to phase except that the Ground Disable handle must be raised and the preset fault must be below phase minimum-trip.

With the test circuit connected as shown in Figure 12, proceed as follows:

1. Move the yellow manual operating handle to its "CLOSED" position and energize the high-voltage transformer T_1 to close the recloser. Leave T_1 energized.
2. Set the variable autotransformer high enough to cause the recloser to trip readily (make sure the setting is below phase minimum-trip resistor current rating).

3. Energize the low-voltage transformer T_2. The recloser should trip, reclose, and continue tripping and reclosing through its programmed sequence to lockout.
4. Observe the following:
A. Count the number of fast operations by watching the Contact-Position Indicator on the sleet hood.
B. Read closing time from the timing device arranged to record the period during which the current is not flowing.
C. Count the number of operations to lockout by counting the trip operations until the yellow handle drops.

OPERATION OF NON-RECLOSING LEVER

While testing on any phase as previously described, operation of the non-reclosing feature can be checked, as follows:

1. Pull down the non-reclosing lever.
2. Repeat test steps 1, 2 and 3 in the "Operating Sequence and Reclosing Time-Phase" section.
3. The recloser should not reclose after the first trip operation and the yellow handle should drop indicating recloser lockout.

Test Procedure - Manual Closing

The manual closing tool (Figure 13) permits manual closing of the main contacts of the KFE recloser for test purposes, when a high voltage source for closing is not available. Minimum-trip current and operating sequence can be tested in this manner.

Refer to instructions covering "Manual operation of Deenergized Recloser" for closing procedure when using the manual closing tool. The best procedure is to have one person operate the closing tool while another regulates the tripping circuit and observes test results.

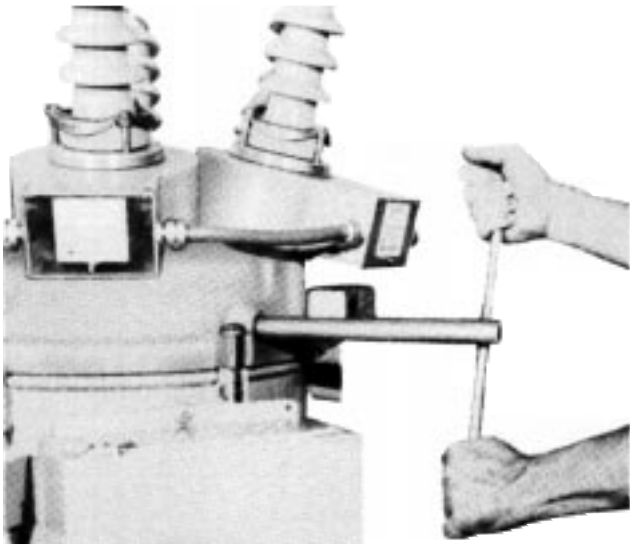


Figure 13. 82059KM-A
Closing recloser with manual closing tool (KA90R).

IMPORTANT

After each recloser trip, approximately two seconds elapse (reclosing time) while the closing solenoid plunger is moving upward. Near the end of this time period two metallic clicks will be heard. The first is the main toggle latch resetting; the second is the closing solenoid contactor closing. As soon as these clicks are heard, the closing tool can be turned to close the recloser.

PHASE MINIMUM-TRIP CURRENT

When testing phase minimum-trip level, block ground by lowering Ground Disable handle.

"A" Phase (Bushings 1 and 2)

Connect leads X and W from low-voltage transformer T_2 to bushing terminals 1 and 2 respectively, and proceed as follows:

1. With manual operating handle in its "CLOSED" position, manually close the recloser.
2. Energize the variable autotransformer and slowly raise the voltage from zero, noting the ammeter reading at which tripping occurs.

"B" Phase (Bushings 3 and 4)

Connect leads X and W from low-voltage transformer T_2 to bushing terminals 3 and 4 respectively, and repeat Steps 1 and 2 above.

"C" Phase (Bushings 5 and 6)

Connect leads X and W from low-voltage transformer T_2 to bushing terminals 5 and 6 respectively, and repeat Steps 1 and 2 above.

GROUND MINIMUM-TRIP CURRENT

Accurate minimum-trip is best obtained if the first ground-trip characteristic is #1 inverse or #1, 2, or 3 constant time. Slower tripping characteristics require very gradual increase in current. Use fastest trip available.

Connect leads X and W on low-voltage transformer T_2 to one pair of bushing terminals (1 and 2, or 3 and 4, or 5 and 6) and use the following procedure:

1. Set the Ground-Trip Disabling Switch to "NORMAL" (up) position.
2. Move the yellow manual operating handle to its closed position and use the manual closing tool to close the recloser.
3. Energize the variable transformer and slowly raise the voltage from zero. Note the ammeter reading when the recloser trips and compare to plug-in trip resistor value.

SHOP MAINTENANCE PROCEDURES

The operations described in this section should be performed under the cleanest conditions possible. The repair work,except for bushing replacement, will be simplified if the work bench is arranged so the mechanism can be inverted (bushings down). The recloser mechanism is so oriented in all procedures and illustrations in this section of the manual except where otherwise noted.

Manual Operation of the Untanked Recloser

When shop maintenance procedural steps call for operating the recloser mechanism, the manual closing tool (KA90R) can be used to close the mechanism as shown in Figure 14. The yellow manual operating handle (under the sleet hood) must be in the CLOSE position for the mechanism to latch closed.

To manually trip the mechanism, operate the yellow manual operating handle to LOCKOUT.

Bushings

Bushing maintenance generally consists of a thorough cleaning and a careful examination for chips, cracks, or other damage while the recloser is lowered for service. Bushings must be replaced whenever damage is discovered.

A damaged bushing can be replaced with the recloser either tanked or untanked, depending upon the cirumstances of the damage.

- If the bushing porcelain is accidentally chipped during installation maintenance and it is obvious that no other damage has occurred, the bushing porcelain only can be replaced without untanking the recloser.
- If the bushing has been damaged while in service or storage, the recloser must be untanked. Water or other contaminants may have entered the tank (check tank liners and test the oil),

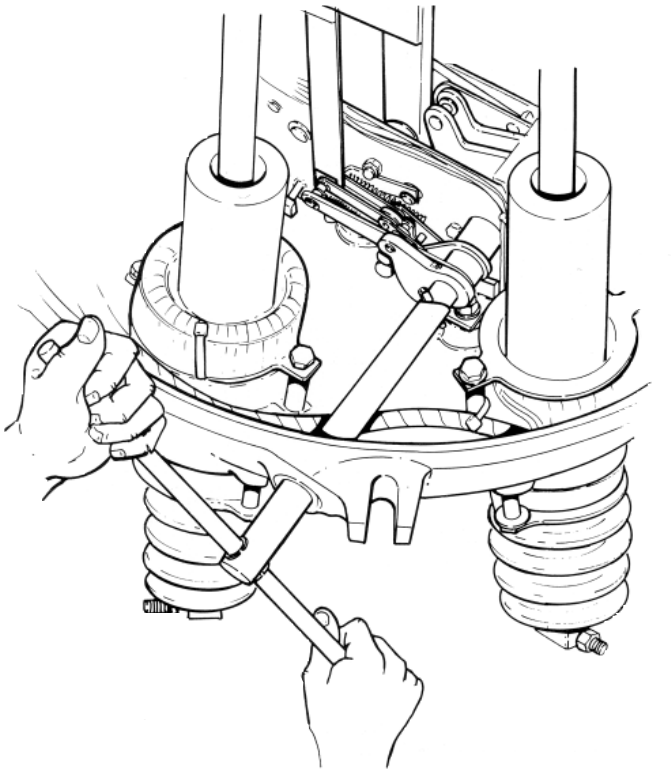


Figure14.
Manually closing an untanked recloser mechanism.

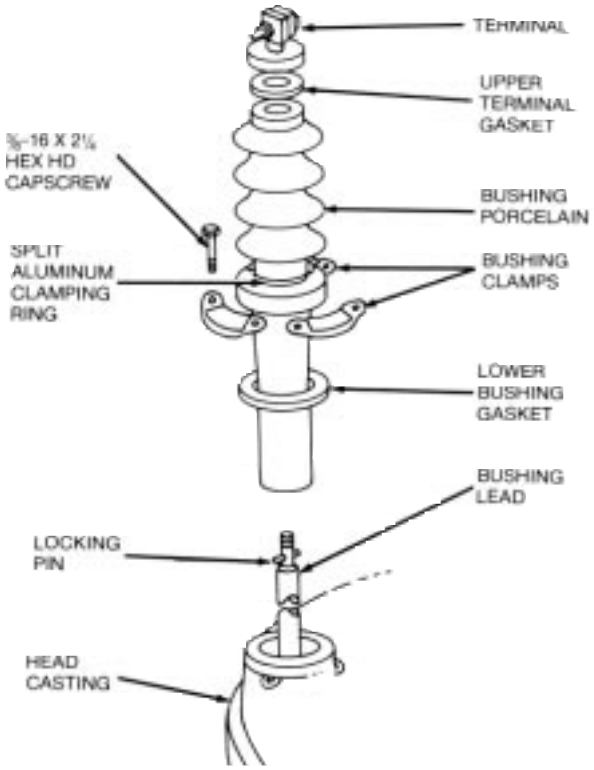


Figure 15.
Bushing assembly.

the bushing lead may be damaged (either mechanically or electrical flashover), and pieces of porcelain may have fallen into the tank (check bottom of tank and recloser mechanism for porcelain pieces).

Replacing the bushing porcelain with the recloser tanked—
Refer to Figure 15 and proceed as follows:

1. Unscrew the bushing terminal and discard the terminal gasket.

2. Remove the bushing clamps; lift the porcelain out of the head casting; remove and discard the lower bushing gasket.

3. Transfer the split aluminum clamping ring from the old to the new porcelain. Replace the ring if it is damaged.

NOTE: The split aluminum clamping ring cushions and distributes the pressure between the porcelain and the bushing clamps. Do not omit.

4. Using a new lower bushing gasket, install the new porcelain over the bushing lead and into the head. Make sure the locking pin in the top of the lead is seated at the top of the porcelain.

5. Position tihe split aluminum clamping ring with the split centered between two clamping bolts.

6. Reassemble the bushing clamps and tighten the bolts evenly a little at a time to a torque of 14-20 N-m (10-15 ft-lbs).

NOTE: Clamping forces must be applied gradually and equally, in rotation, to each bolt. This results in an evenly distributed gasket sealing pressure.

7. Install a new upper terminal gasket and reassemble the terminal to the bushing. Tighten to 28-34 N-m (20-25 ft-lbs) torque.

NOTE: Apply a very small amount of petroleum jelly to the inside face of the terminal (knurled surface only) before reassembling to the bushing.

Replacing the bushing porcelain with the recloser tanked—

1. Disconnect the appropriate bushing lead.

2. Remove the three hex head capscrews and bushing clamps that secure the bushing to the head casting and lift the bushing assembly up through the head.

3. Remove and discard the lower bushing gasket.

4. Twist off the split aluminum clamping ring from the old bushing. If it is in good condition, install it on the new bushing porcelain. If the ring is damaged, a new clamping ring must be installed.

NOTE: The clamping ring cushions and distributes the pressure between the porcelain and the clamps and must not be omitted.

5. The complete bushing assembly can be replaced or new porcelain only can be installed. If only new porcelain is to be installed, proceed as follows:

A. Unscrew the bushing terminal and withdraw the lead or rod from the bottom of the porcelain.

B. Remove and discard the terminal gasket.

C. Insert the lead or rod assembly all the way into the new porcelain until the locking pin on the lead is seated in the porcelain.

D. Reassemble the bushing terminal to the lead using a new terminal gasket.

NOTE: Apply a very small amount of petroleum jelly to the inside face of the terminal (knurled surface only) before reassembling to the bushing.

6. Reinstall the bushing assembly (new or reworked) into the head using a new gasket between the bushing and head casting. Position the bushing with the stud-end of the terminal pointing outward.

7. Position the split aluminum clamping ring with the split centered between two clamping bolts.

8. Reassemble the bushing clamps and tighten the bolts evenly a little at a time to a torque of 14-20 N-m (10-15 ft-lbs).

NOTE: Clamping forces must be applied gradually and equally in rotation to each bolt. This results in an evenly distributed gasket sealing pressure.

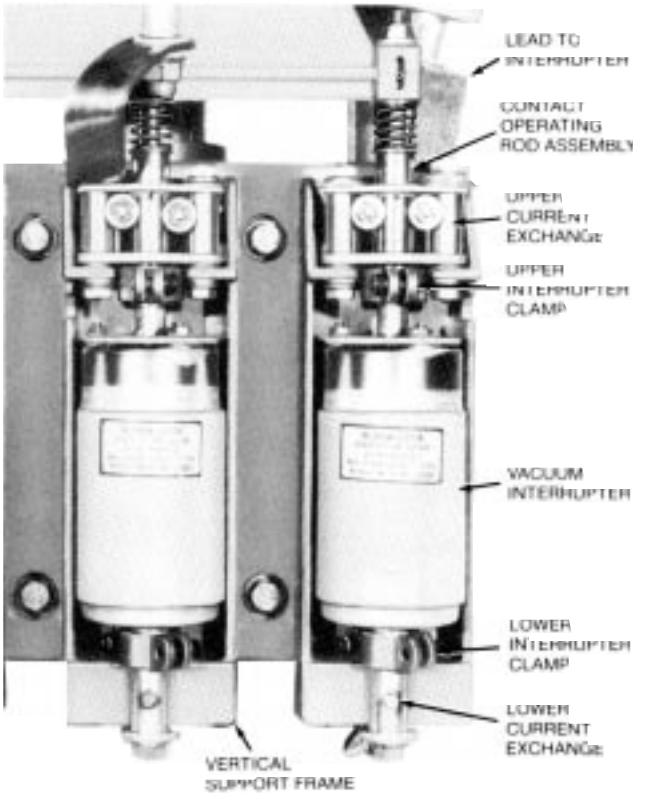
9. Reconnect the bushing leads or rods.

Vacuum Interrupters

Vacuum interrupters must be replaced:

- When they lose their vacuum, as evidenced by failure during the high-potential dielectric withstand test across open contacts;
- When the interrupter contact has eroded beyond its useful life, as evidenced by the position of the scribe mark on the moving contact rod; or
- When the interrupters have completed their mechanical life of 2500 operations.

To replace the interrupters, refer to Figure 16 and proceed as follows:



82073KM-A

Figure 16.
Parts associated with vacuum interrupter replacement (recloser in inverted position).

1. Make sure the unit is open—the yellow handle under the sleet hood is in the LOCKOUT position.

2. Disconnect the lower interrupter leads, by removing the attaching hardware.

3. Loosen and remove the upper interrupter clamp. As this clamp is loosened the contact rod will move into the interrupter due to atmospheric pressure acting upon the bellows. This action can be verified by observing the scribe mark on the moving contact rod of the interrupter. It will move upward from just above the upper clamp to above (or below) the fiber rod-guide.

NOTE: If the contact rod does not move it may have lost its vacuum, or it may be sticking in the clamping fingers of the current exchange on the contact operating rod assembly. Use a screw driver to gently spread the clamping fingers to free the contact rod.

4. Remove the hardware securing the lower coupling to the interrupter support frame.

5. Remove the interrupter assembly.

6. Remove the coupler clamps and coupling from the stationary contact rod.

7. Carefully slide the new interrupter movable contact rod into the upper coupler. Orientate the interrupter so the clamps can be installed as shown in Figure 17. Be sure the rod bottoms in the coupler.

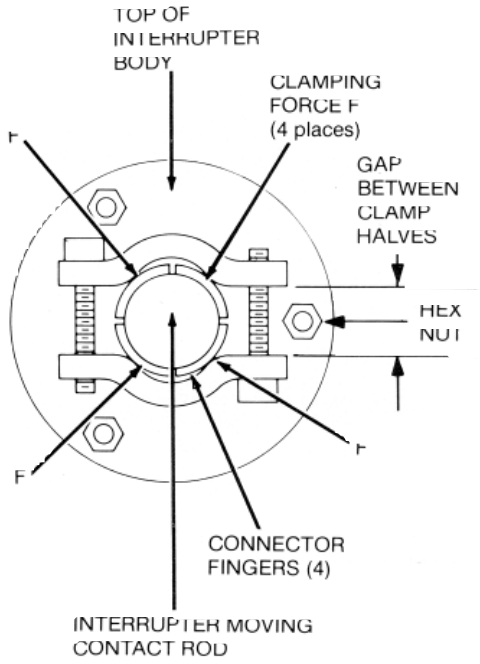


Figure 17.
Orientation of interrupter and clamp.

CAUTION

Do not twist or apply lateral pressure to the movable contact rod when installing the interrupter. Such action can damage the bellows and destroy the interrupter.

8. Install the clamps so the clamping force is applied to the center of the contact finger. Coat the threads of the clamp screws with transformer oil and tighten the two screws evenly to maintain equal gaps on each side. Tighten the screws to 8,5 N-m (75 in-lbs) torque.

9. Place the lower coupler onto the stationary contact rod. Install the hardware to secure the lower coupler to the interrupter support frame.

10. Slowly close the recloser with the manual closing tool.

11. Install the coupling clamps so the clamping force is applied to the center of the contact finger. Coat the threads of the clamp screws with transformer oil and tighten the two screws evenly to maintain the same gap on each side. Tighten the screws to 8,5 N-m (75 in-lbs) torque.

12. Open the recloser.

13. Measure the gap between the movable contact clamps and the stop. The clamp should be no more than 0,8 mm (1/32 in.) from the stop, see Figure 18. Adjust elastic stop nuts, if necessary, to change the gap.

14. Attach the lower interrupter leads with the hardware removed.

15. Manually trip and close the recloser several times to check interrupter operation.

NOTE: Contact movement may be checked by observing the movement of the scribe mark on the contact rod. on closing, the mark will travel 9,5 mm (3/8 inches).

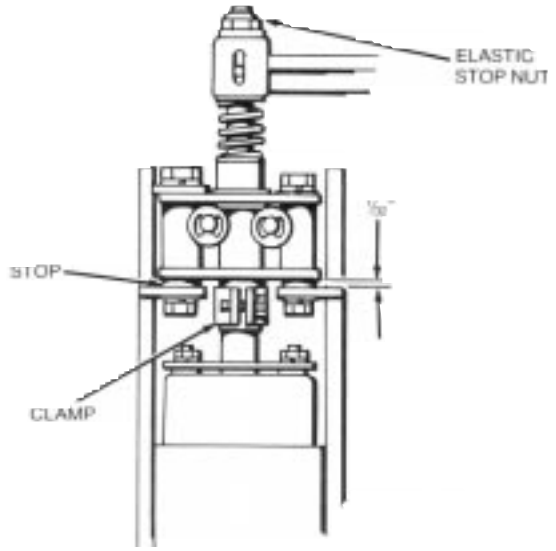


Figure 18.
Adjusting clamp-stop gap.

Closing Coil

To replace the closing coil proceed as follows (Figure 19):

1. Disconnect the lower three bushing leads.
2. Remove the two hex bolts and hardware securing the interrupter support plate to the bridge plate assembly.
3. Remove the four hex bolts securing the bridge plate assembly to the stringers and remove the bridge plate.
4. Disconnect the solenoid leads; remove the solenoid gasket and solenoid.
5. Reassemble in the reverse order of disassembly.

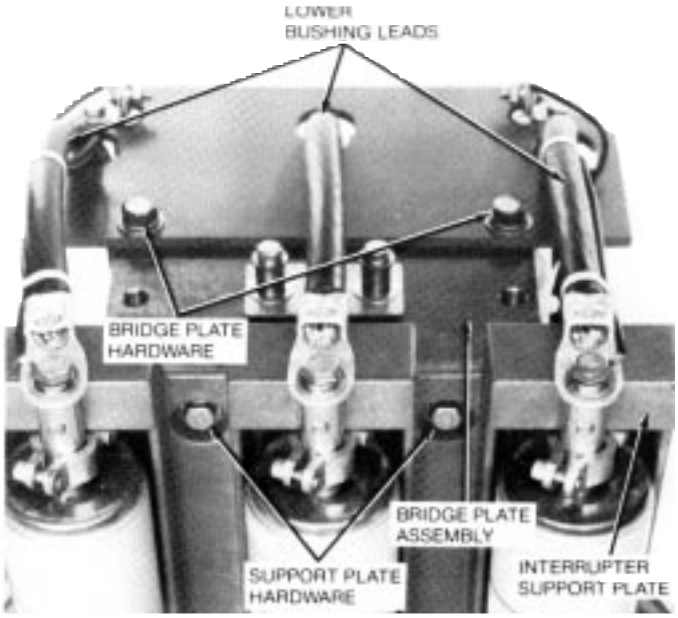


Figure 19. 85710KM-A
Closing coil replacement.

Removal of Mechanism from Head

To gain access to components mounted under the head, removal of the entire operating mechanism may be required. Proceed as follows:

1. Disconnect the three source bushing leads from the interrupter stationary contact couplings.
2. Disconnect the three load side leads from the bushings.
3. Tag and disconnect the control cable leads attached to the terminal block (Figure 20). Also remove the control cable ground lead that is attached to the mechanism frame.

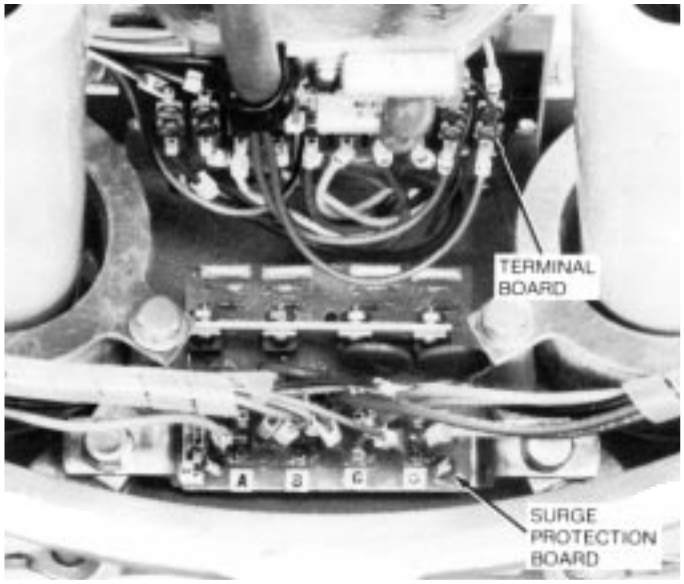


Figure 20. 85711KM-A
Control cable terminal block.

4. Uncouple the shafts of the two operating handles and indicator under the sleet hood by locking the couplings in the disconnected position as shown in Figure 21.

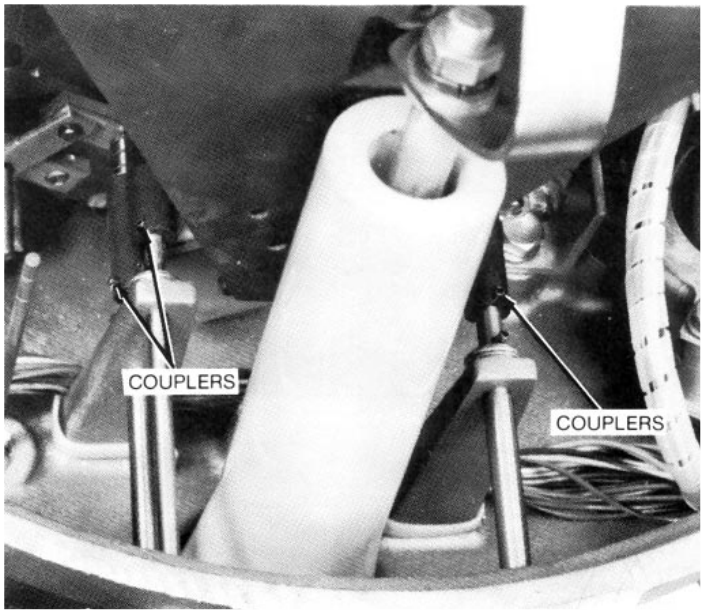


Figure 21. 85712KM-A
External operating shafts uncoupled from mechanism.

5. Close the recloser to gain access to the attaching bolt located under the main shaft (Figure 22) and remove bolt.

NOTE: Because of close clearances, the bushing at this location may have to be removed. A swivel-type socket wrench is required to remove this bolt.

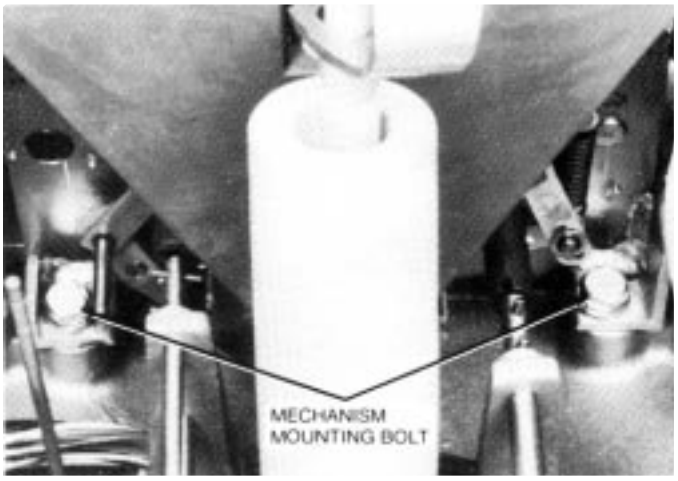


Figure 22. 85713KM-A
Removing mechanism mounting bolts from head.

6. Trip open the recloser and remove the remaining three attaching bolts.
7. Straighten the bushing leads so they will pass through the holes in the bridge plate, and lift out the entire mechanism.
8. Reassemble the mechanism and head in the reverse order of disassembly.

ADJUSTMENTS

Operations to Lockout

1. Reclosers prior to serial number 997.

The number of operations to lockout is adjustable by repositioning the cylindrical spacer on the integrator ratchet rod, Figure 23.

In order to gain access to the operations to lockout spacer it is necessary to remove the mechanism from the head, see Removal of Mechanism from Head procedure on page 14.

To change the number of operations to lockout position the cylindrical spacer above the groove for the desired number of operations and place the E-ring into that groove. Make sure the spacer is properly seated on the E-ring.

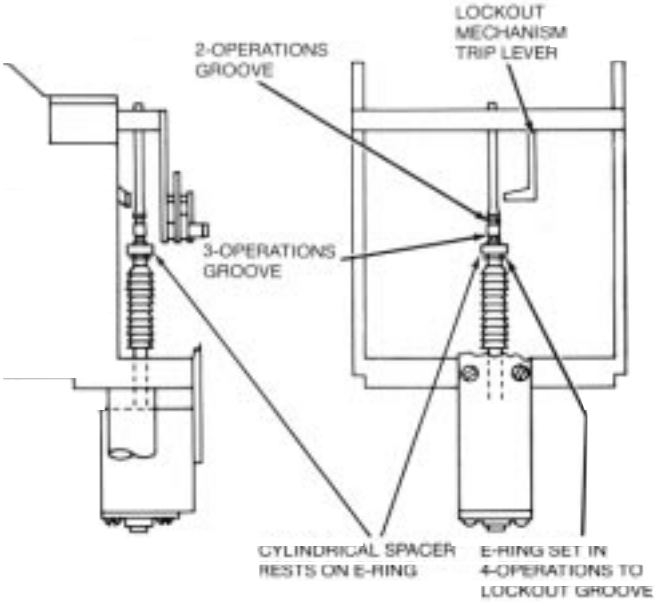


Figure 23.
Adjusting operation to lockout, repositioning spacer.

2. Reclosers after serial number 996.

The number of operations to lockout is adjusted by indexing the stepped spacer to the desired position for the number of operations to lockout desired, Figure 24.

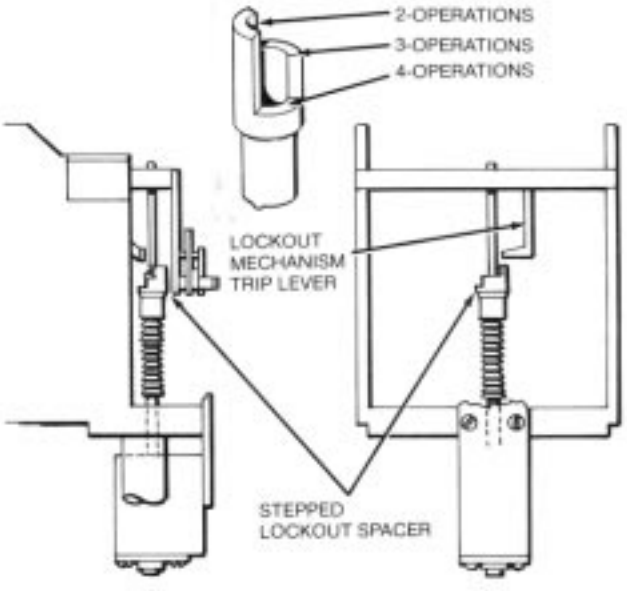


Figure 24.
Adjusting operation to lockout, indexing stepped spacer.

Number of Fast Operations

The number of fast operations is set by positioning the phase-trip and ground-trip cams (Figure 24) to the desired number of operations on the fast curve. The number of slow operations will be the difference between the total number of operations and the number of fast operations.

To adjust the cam, lift the locking tab (Figure 25) out of groove it is in and rotate it until the locking tab aligns with the desired number of operations and place the locking tab into that groove.

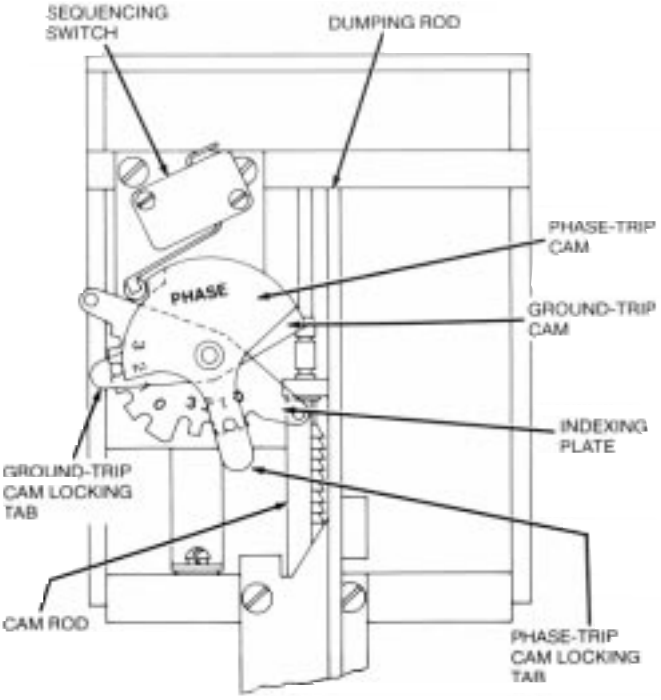


Figure 25.
Sequencing mechanism and number of fast operations settings.

TROUBLESHOOTING

The following troubleshooting guide is intended to aid malfunction diagnoses and to isolate possible causes of malfunctions.

Table 3
Troubleshooting Guide

Trouble	Condition observed	Possible Cause
Recloser wil not close electrically.	Closing coil energizes.	Mechanism jammed, repair or replace components as required.
	Closing coil does not energize.	Inspect fuses and wiring, repair or replace as required.
		Inspect closing coil contactor, replace if damaged or worn.
		Check closing coil, replace if bad.
Recloser will not trip electrically.	Trip solenoid receiving trip signal.	Inspect interrupters, contacts may be welded, replace as required.
		Mechanism jammed, repair or replace components as required.
		opening springs damaged, replace as required.
	Trip solenoid does not operate.	Check wiring between solenoid and control PCB.
		Inspect trip solenoid, replace if damaged or worn.
		Inoperative control, replace control PCB.
Overload not being detected.	Current transformer signal missing.	Broken or shorted lead, repair or replace as required.
		Damaged current transformer, replace as required.
	Control malfunction.	Replace control PCB.
	Incorrect minimum trip resistor for application.	Replace minimum trip resistor.
Ground fault not being detected.	Current transformer signal missing.	Broken or shorted lead, repair or replace as required.
		Damaged current transformer, replace as required.
	Control malfunction.	Replace control PCB.
	Incorrect minimum trip resistor for application.	Replace minimum trip resistor.
Recloser not locking out.	Sequencing mechanism malfunction.	Inspect sequencing mechanism, repair or replace as required.

WIRING DIAGRAMS

Schematic Diagram, Figure 26.
Interconnection Diagram, Figure 27.

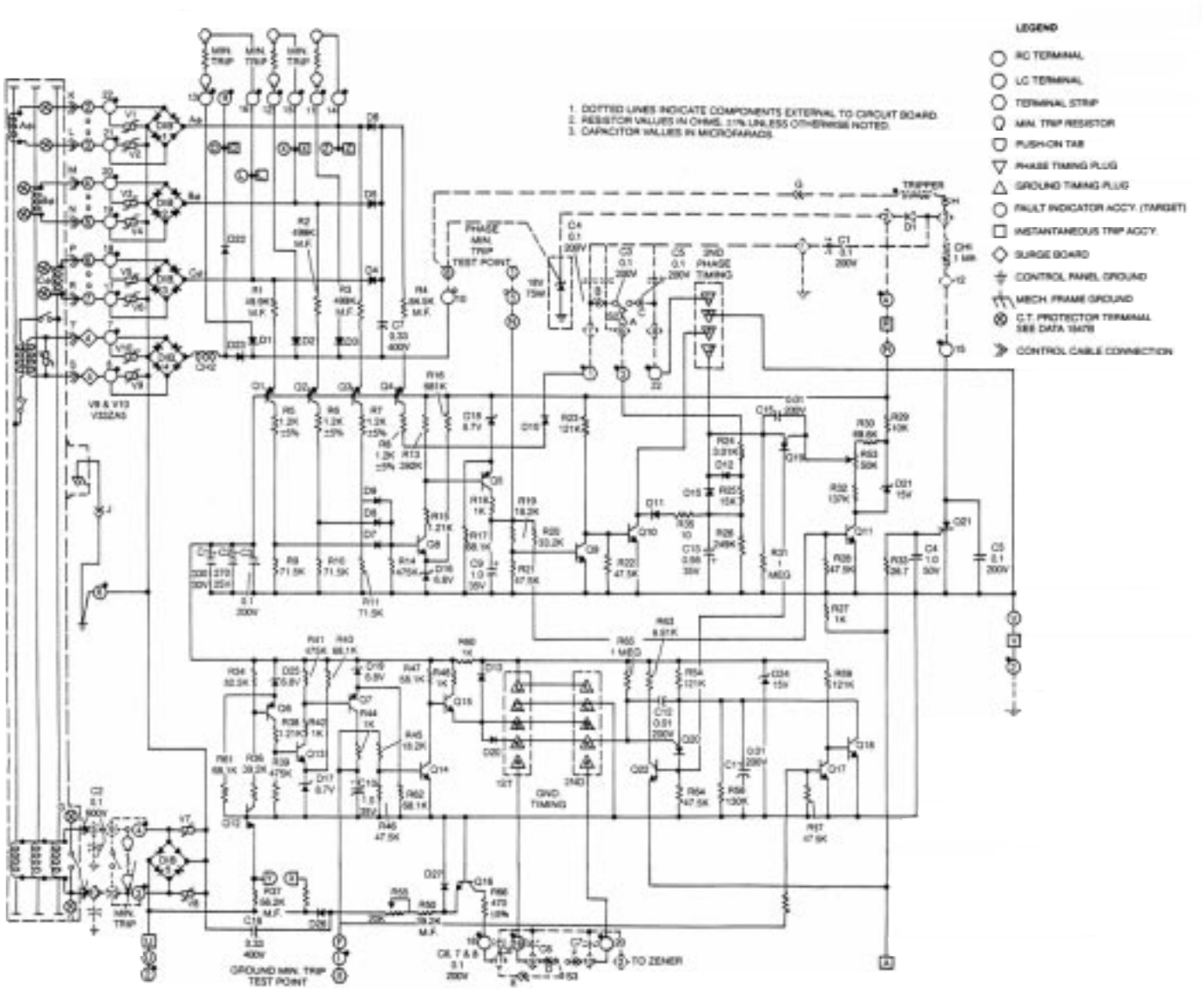


Figure 26.
Schematic wiring digram.

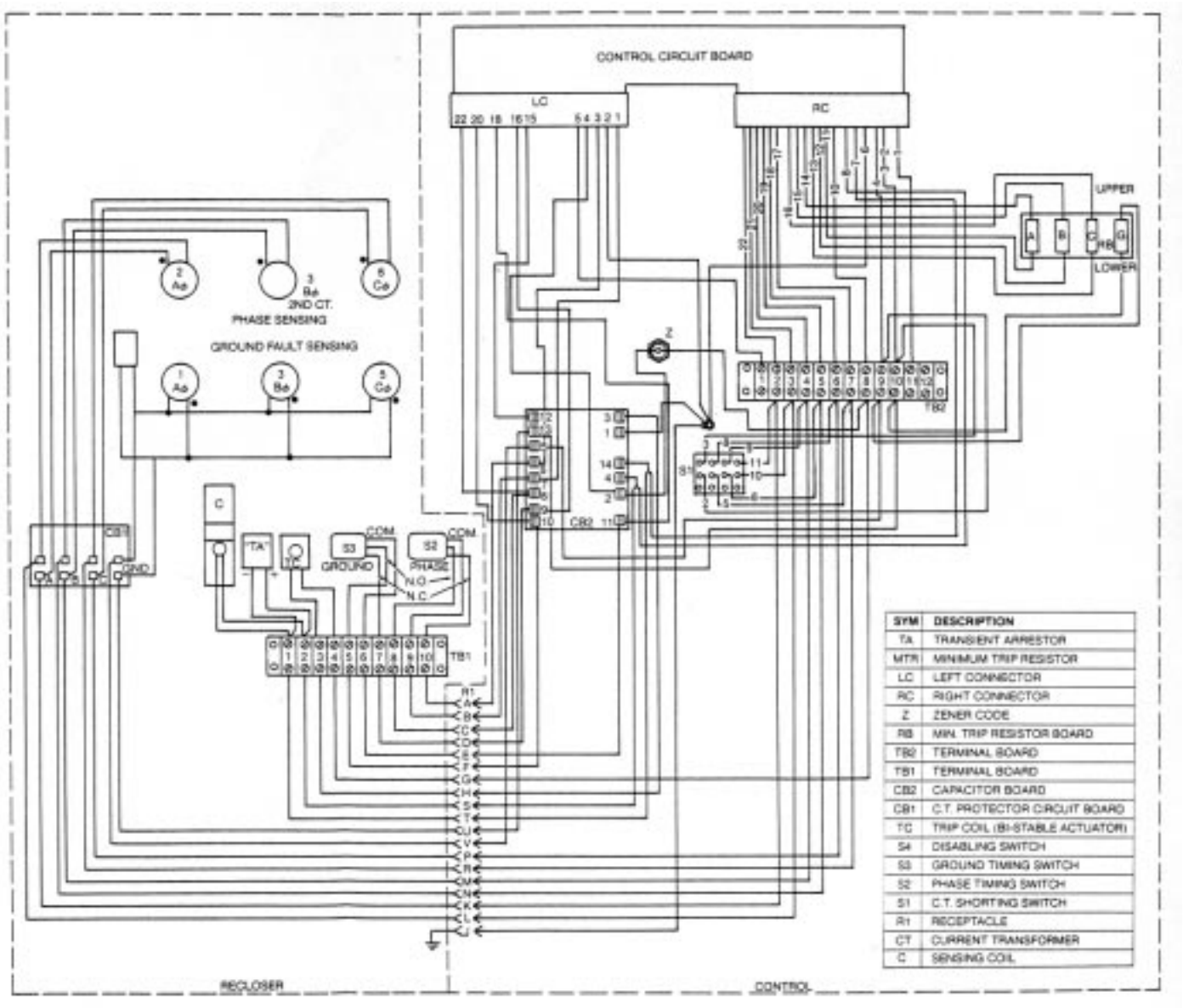


Figure 27.
Interconnection wiring diagram.

SERVICE PARTS LIST

Service parts listed and illustrated include only those parts and assemblies usually furnished for repair. Further breakdown of listed assemblies is not recommended. Because of the ease, faster receipt, and greater economy of local acquisition, the wiring, wire-end terminals, and connectors have not been included in this parts listing. All common hardware parts dimensions have been carefully checked so they also may be obtained locally.

To assure correct receipt of any parts order, always include recloser type and serial number. Because of Cooper Power System's continuous improvement policy, there may be instances where parts ordered may not look exactly the same as parts furnished; however they will be completely interchangeable without any rework of the recloser.

All parts carry the same warranty as any whole item of switchgear, i.e., against failure due to defects in material or workmanship within 15 months from date of readiness for delivery.

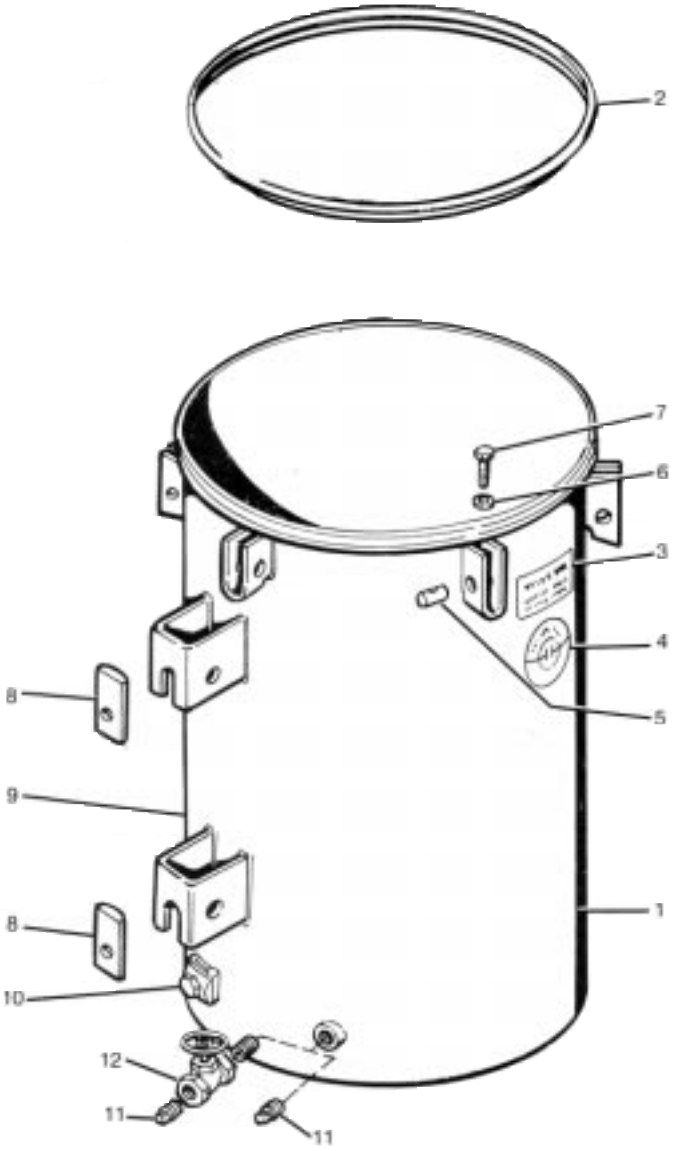


Figure 28.
Tank parts - exploded view.

Tank Parts (Figure 28)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Tank	KRK621FA	1
2	Head gasket	K522077A8	1
3	Radiation warning label	KP1015VSR	1
4	Vacuum decal	KP1041V4H	1
5	Head-bolt retainer	KP86L	6
6	Head-bolt washer	KP2028A23	6
7	Capscrew, hex hd, 1/2-13 x 3-1/2, stl	K73010115035OQ	6
8	Flat-surface mounting adapter plate	KP631D3	2
9	Ground connector	KA227H	1
10	Capscrew, hex hd, 1/2-13 x 1 stl	K730101150100Q	1
11	Pipe plug, 1/2 sq hd	KP2007A3	1
12	Gate valve and close nipple (accessory)	KA809R	1

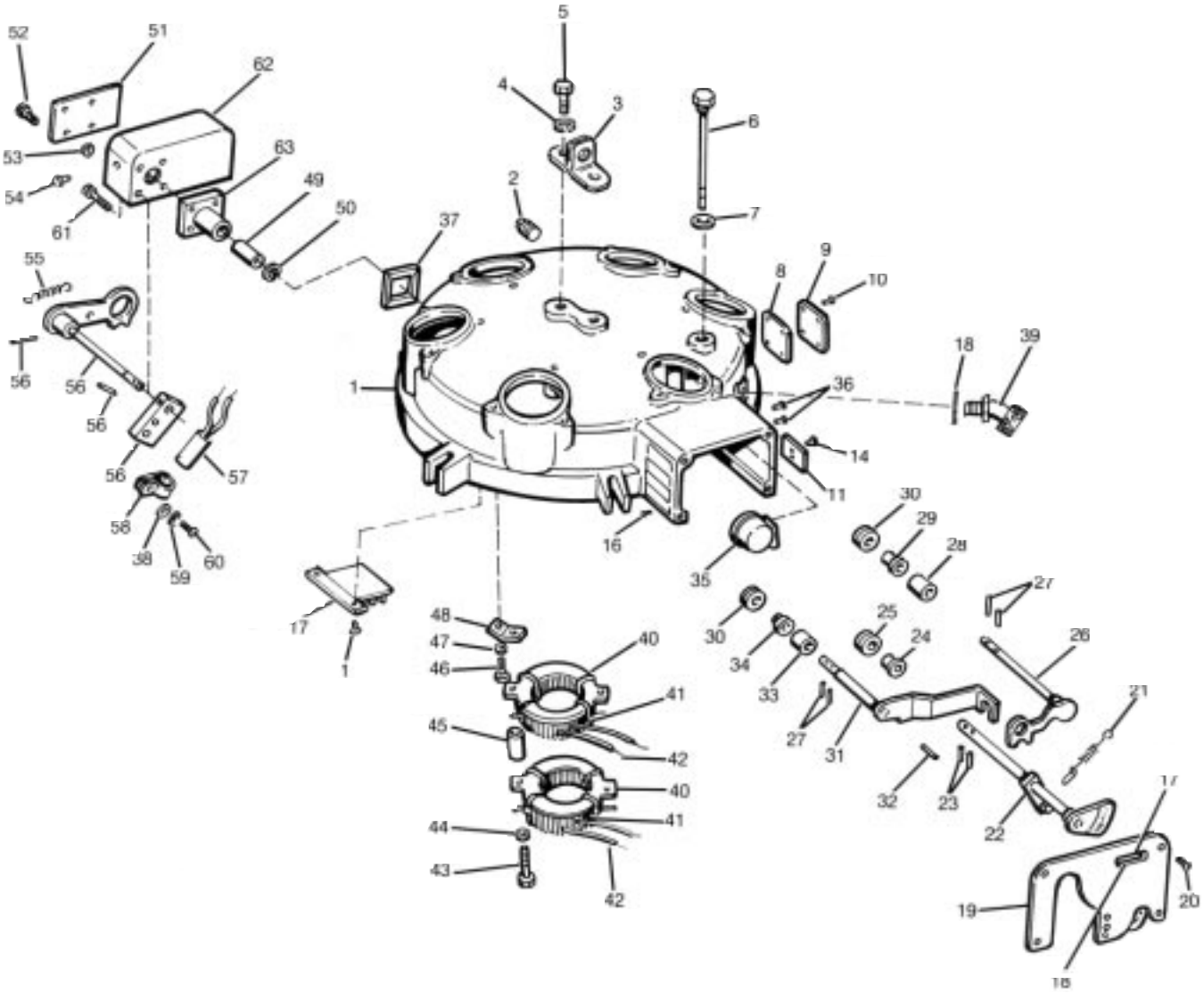


Figure 29.
Head parts - exploded view.

Head Parts (Figure 29)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Head casting	KRK671F1	1
2	Pipe plug, manual closing tool port	KP2007A4	1
3	Lifting lug	KRK388F1	2
4	Lockwasher, med.5/8, stl	K900801062000Z	2
5	Capscrew, hex hd, 5/8-11 x 1-1/2	K730101162150Q	2
6	Oil-level dipstick	KA363R	1
7	O-ring gasket	KP2000A9	1
8	Gasket, accessory wiring port	KRK406F1	1
9	Cover plate, accessory wiring port	KRK407F1	1
10	Machine screw, rd hd, 8-32 x 3/8, sst	K721515108037A	4
11	Identification plate, non reclosing	KP390R	1
12	Data plate recloser ratings	KRK625F1	1
13	Data plate closing coil voltage; add correct suffix number; 1 = 2.4 kv, 2 = 4.16-4.8 kv, 6= 6kv, 7=11 kv, 4 = 120-13.2 kv, 16 = 13.2 kv, 5 = 14.4 kv (item 13 included in closing coil kit, 11, Figure 31 B)	KP567R___	
14	Self-tapping screw, #2-56 x 3/16". sst	K751515102018A	2
15	Data plate, operating sequence	KRK684F1	1
16	Self-tapping screw, rd hd, No. 2 x 3/16, sst	K751515102018A	6
17	Circuit board and bracket assembly	KRK905F1	1
18	Reducer	KP2040A4	1
19	Cover plate	KRK127F1	1
20	Self-tapping screw, rd hd, No. 12 x 1/2, sst	K781515112050A	4
21	Counter spring	KP310F1	1
22	Indicator lever assembly	KRK121F1	1
23	Roll pin, 3/32 X 5/6. sst	K970815093062A	2
24	Bushing	KP3107A5	1
25	Flatwasher, 1/4 AN It, stl	K900101026050A	2
26	Manual operating (yellow) handle	KRK120F1	1
27	Roll pin, 1/8 X 3/4, sst	K970815125075A	4

Item No.	Description	Catalog Number	Quan. Req'd.
28	Spacer	KP3010A7	1
29	Bushing	KP3107A1	1
30	Flatwasher, 5/16. AN It, stl	K900101032056Z	4
31	Non-reclosing lever assembly	KRK125F1	1
32	Lever-stop pin, 1/4 X 7/8, sst	K970815250087A	1
33	Spacer	KP3013A38	1
34	Bushing	KP3107A4	1
35	Counter assembly	KA28C06	1
36	Self-tapping screw, rd hd, 6-32 x 3/4, sst	K751515106075A	2
37	Gasket	K999904250233A	1
38	Flatwasher, #6, brass	K900525014037A	2
39	Cord grip	KP2191A	1
40	CT support plate	KP145RE	10
41	Bushing current transformer	KA43GV1	6
42	Cable tie (secures CT to support plate)	K994904170003A	7
43	Capscrew, hex hd, 1/4-20 x 2-1/2 stl	K730101125250Y	10
44	Flatwasher, 1/4 SAE, stl	K900201025000Z	10
45	Spacer	KP3009A88	10
46	Capscrew, hex hd, 5/16-18 x 3/4, stl	K730101131075Y	10
47	Lockwasher, med, 5/16. stl	K900801031000Z	10
48	CT support bracket	KRK133F1	10
49	Spacer	KP3009A87	1
50	Retaining ring, Type C, WA-518	K970901375000M	1
51	Data plate, handle position	KRK521F1	1
52	Machine screw, rd hd, 6-32 x 1/4, sst	K721515106025A	4
53	Hex nut, 6-32; sst	K881025132006A	4
54	Spring retainer	KP1005R	1
55	Spring	KRK350F1	1
56	Switch handle assembly	KRK334F1	1
57	Switch	KA63RE3	1
58	Switch retaining clip	KP2006A19	2
59	Lockwasher, med, #6, stl	K900801006000Z	2
60	Machine screw, rd hd, 6-32 x 1/2, stl	K721501106050Z	2
61	Capscrew, socket hd, 6-32 x 3/4, stl	KP2036A18	4
62	Switch handle cover	KRK340F1	1
63	Bushing-spacer assembly	KRK338F1	1

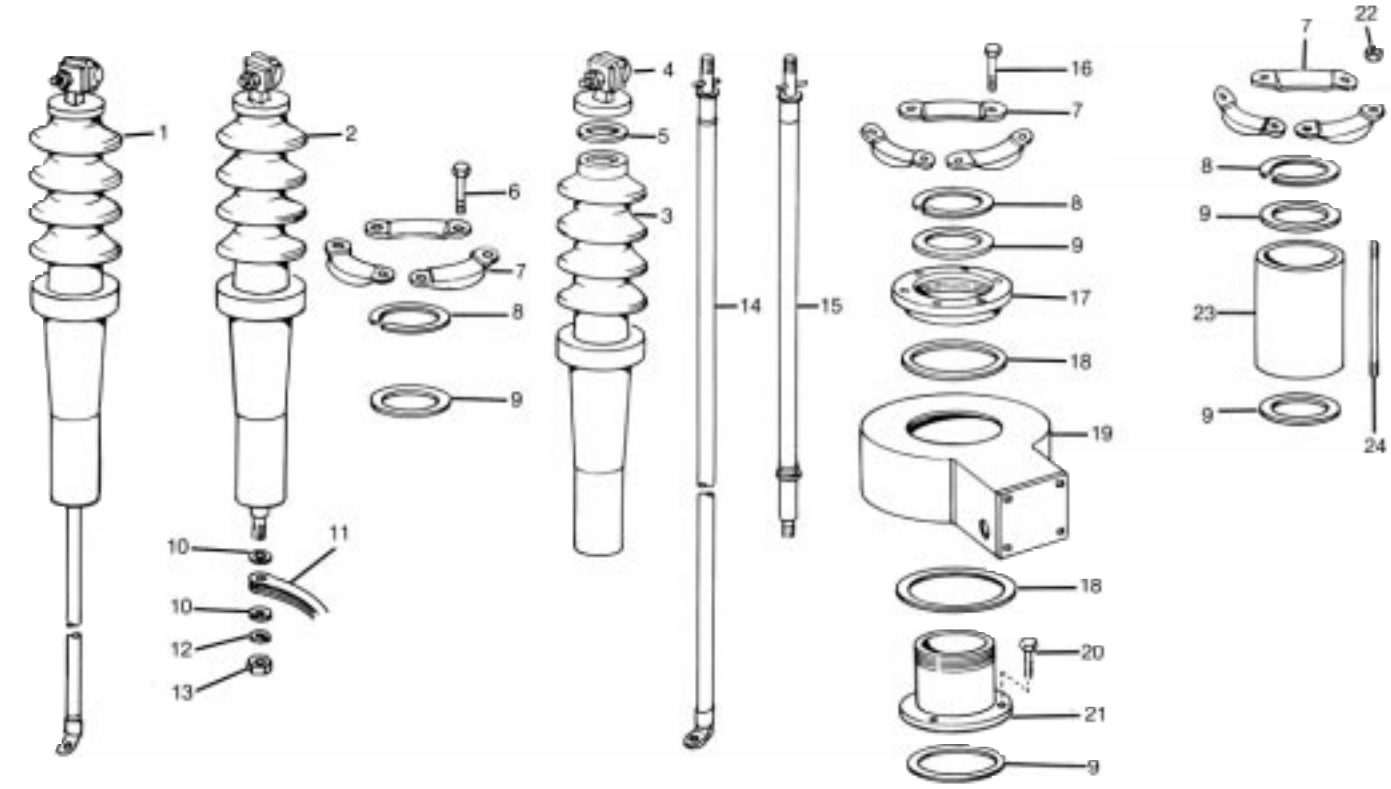


Figure 30.
Bushing parts - exploded view.

Bushing Parts (Figure 30)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Bushing assemblies:		
	Standard creepage, long lead	KA717R42	3
	Standard creepage, short lead	KA717R54	3
2	Bushing assemblies:		
	Standard creepage, accy BCT, long lead	KA717R43	3
	Standard creepage, accy BCT, short lead	KA717R55	3
2	Bushing assemblies:		
	17-inch creepage, long lead	KA717R44	3
	17-inch creepage, short lead	KA717R56	3
2	Bushing assemblies		
	17-inch creepage, accy BCT, long lead	KA717R45	3
	17-inch creepage, accy BCT, short lead	KA717R57	3
2	Bushing assemblies:		
3	Bushing ceramic:		
	Standard creepage	KP1110R	1
	Standard creepage for accy BCT	KP171 W	1
	17-inch creepage	KP1578R	1
	17-inch creepage for accy BCT	KP186W	1
4	Bushing terminal	KA143L900	1
5	Terminal gasket	KP2090A57	1
6	Capscrew, hex hd, 3/8-16 x 2-1/4, stl	K730101137225Q	3
7	Bushing clamp	KP1109R	3

Item No.	Description	Catalog Number	Quan. Req'd.
8	Bushing clamp ring	KP1111R	1
9	Bushing gasket	KP2090A66	1
10	Lower terminal washer	KP2028A3	2
11	Connecting straps, ϕ A and C	KRK659F1	4
	Connecting straps, ϕ B	KP3250A17	4
12	Lockwasher med 1/2, bronze	K900830050000A	1
13	Hex jam nut 1/2-20 brass	K880725320050H	1
14	Bushing lead assembly:		
	Std and 17" creepage, long lead	KA716R39	1
	Std and 17" creepage, short lead	KA716R41	1
	Std and 17" creepage, accy BCT, long lead	KA716R40	1
	Std and 17" creepage, accy BCT, short lead	KA716R42	1
16	Capscrew, hex hd, 3/8-16 X 2, stl, BCT accy	K730101137187Q	3
17	Clamping sleeve, BCT accy	KP170W	1
18	Flange gasket, BCT accy	KP2090A73	2
19	Replacement current transformer, BCT accy	KA159W	1
20	Capscrew, hex hd, 3/8-16 x 1-1/4, stl, BCT accy	K730101137100Q	3
21	Securing sleeve, BCT accy	KP169W	1
22	Hex nut, 3/8-16, stl, BCT accy	K880201116037Q	3
23	Bushing height spacer, BCT accy	KP275W	1
24	Securing stud, BCT accy	KP3149A40	3

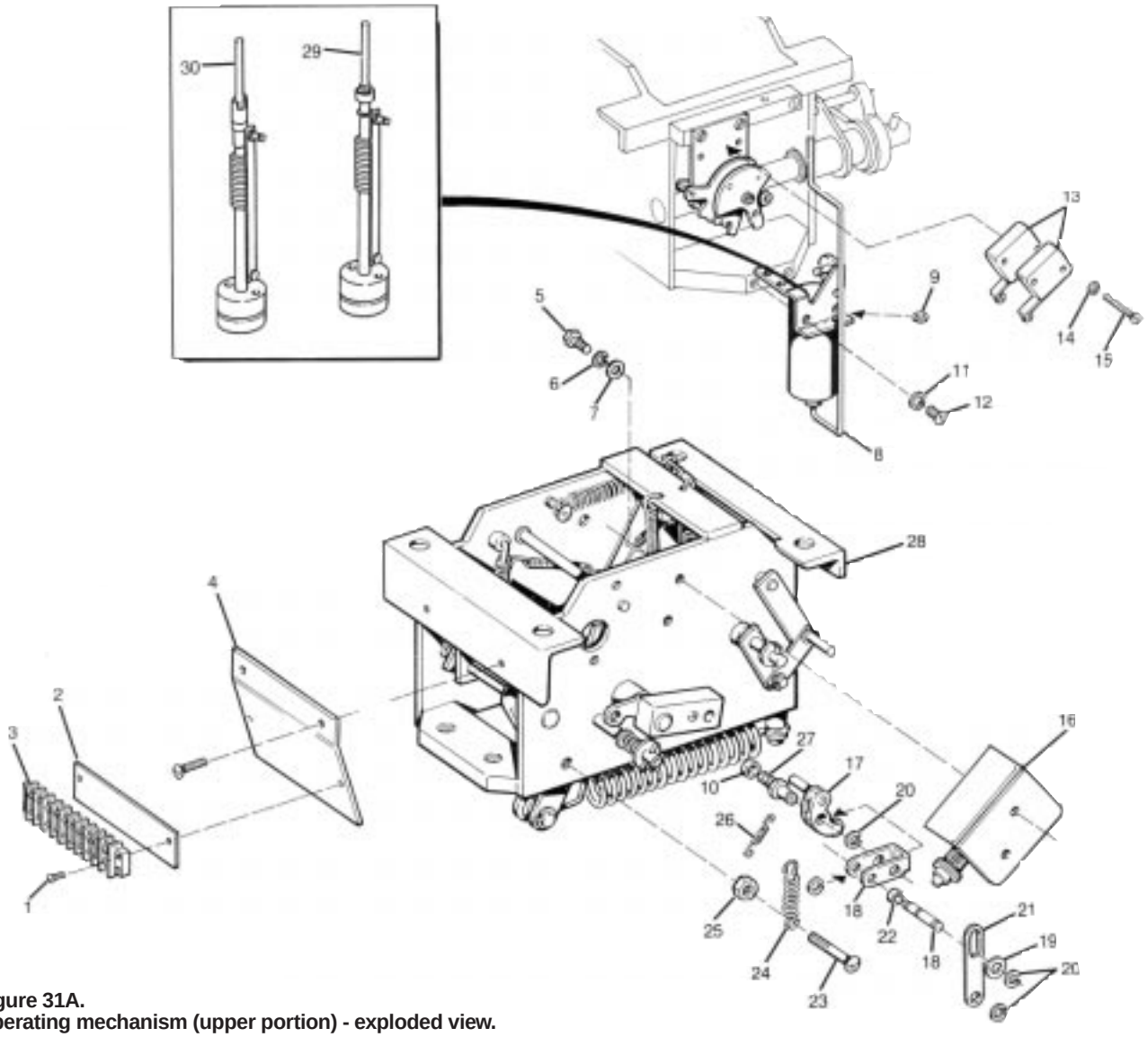


Figure 31A.
Operating mechanism (upper portion) - exploded view.

Operating Mechanism (Upper Portion) (Figure 31A)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Machine screw, #6-32 x 1/2, sts	K721515106050A	2
2	Marker strip	KP2101A214	1
3	Terminal strip	KP2101A14	1
4	Mounting plate	KRK603F	1
5	Machine screw, hex head, #8-32 x 3/8 stl	K722401108037Z	2
6	Lockwasher, med, #8, sts	K900815008000A	2
7	Flatwasher, med, #8, sts	K900215008000A	2
8	Rod	KRK637F	1
9	Retaining ring	KP2013A5	1
10	Spacer	KP3007A75	1
11	Lockwasher, countersink, #8	K999904250396A	2
12	Machine screw, flat head, #8-32 X 3/8, sts	K721615018037A	2
13	Micro switch	KP2181A1	2
14	Lockwasher, med, #4, sts	K900815004000A	2
15	Machine screw, round head #4-40 x 1, sts	K721515104100A	2
16	Flux tripper assembly	KRK651F	1

Item No.	Description	Catalog Number	Quan. Req'd.
17	Lever assembly	KRK577F	1
18	Bracket assembly	KRK579F	1
19	Flatwasher, light, 1/4, stl	K900101026050Z	1
20	Retaining ring	K970901250000M	3
21	Link	KRK305F	1
22	Spacer	KP3007A114	1
23	Machine screw, round head, 1/4-20 x 1, stl	K721501125100Y	1
24	Spring	KRK690F	1
25	Hex nut, 1/4-20, stl	K880201120025Y	1
26	Spring	KRK319F	1
27	Anchor pin	KRK580F	1
28	Frame assembly	KRK606F	1
29	Piston assembly, used prior to S/N 997	N/A	1
	E-Ring		1
	Spacer		1
30	Piston assembly, used after S/N 996	KRK498F	1

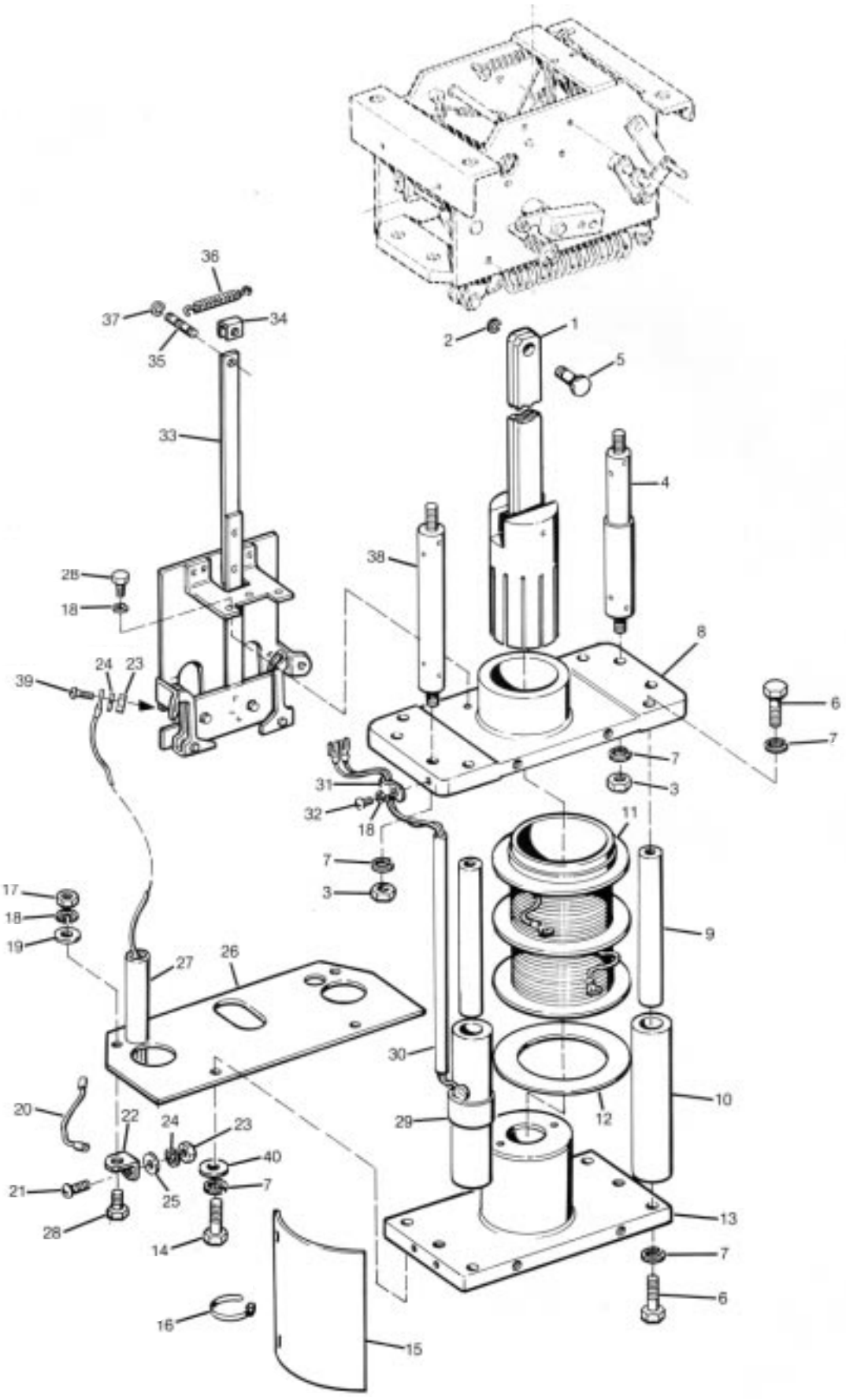


Figure 31B.
Operating mechanism (middle portion) - exploded view.

Operating Mechanism (Upper Portion) (Figure 31B)

Item No.	Deacription	Catalog Number	Ouan. Req'd.
1	Plunger assembly	KRK255F	1
2	Retaining ring	K970901375000M	1
3	Hex nut, 7/6-14, stl	K880201114043Q	4
4	Spacer assembly	KRK697F	2
5	Groove pin	KP3192A5	1
6	Capscrew, hex head, 7/16-18 x 1-1/4, sst	K730101143150Q	6
7	Lockwasher, med, 7/16, stl	K900801043000Z	12
8	Solenoid frame	KRK652F	1
9	Stringer	KP712D	3
10	Insulating tubing	KP3230A29	3
11	Closing coil kit (includes lower coil gasket 12, two fuse assemblies 27, and data plate 13, Figure 29)		
	For 50 hertz operation:		
	6.0 kv	KRK369FH	1
	11.0 kv	KRK369FJ	1
	13.2 kv	KRK369FK	1
	14.4 kv	KRK369FL	1
	For 60 hertz operation:		
	2.4 kv	KRK369FA	1
	4.16-4.8 kv	KRK369FB	1
	6.0 kv	KRK369FM	1
	7.2-7.62 kv	KRK369FC	1
	8.0-8.32 kv	KRK369FD	1
	11.0 kv	KRK369FE	1
	12.0-13.2 kv	KRK369FF	1
	14.4 kv	KRK369FG	1
12	Lower solenoid gasket	KP579D	1
13	Bridge plate assembly	KRK657F1	1
14	Capscrew, hex head, 7/16-14 x 1-3/4, stl	K730101143175Q	2
15	Barrier	KRK1016F	1
16	Cable tie	K994904170003A	7
17	Hex nut,1/4-20, stl	K88020112002SQ	2

Item No.	Description	Catalog Number	Quan. Req'd.
18	Lockwasher, med 1/4, stl	K900801025000Z	6
19	Flatwasher, med, 1/4, stl	K900201025000Z	2
20	Lead assembly	KRK653F	2
21	Machine screw, round head, 1/4-20 x 3/4, brass	K721525125075A	2
22	Mounting bracket	KRK633F	2
23	Hex nut, 1/4-20, brass	K881025120025A	4
24	Lockwasher, med, 1/4, bronze	K900830025000A	4
25	Flatwasher, 1/4, brass	K900525026068A	2
26	Cable support	KRK635F	1
27	Closing coil fuse assembly. Add suffix number to indicate voltage rating: 901—24 kv (black color band), 902—4.6 kv thru 6 kv (yellow color band), 903—11 kv thru 14.4 kv (red color band), (Item 27 included in closing coil kit, Item 11)	KA259R_	2
28	Capscrew, hex head,1/4-20 x 3/4, stl	K730101125075Q	5
29	Sensing coil	KRK658F	1
30	Insulated tube	KRK669F	1
31	Cable clip	KP2006A12	2
32	Machine screw, round head 1/4-20 x 1/2, stl	K721501125050Q	2
33	Closing coil contactor	KA430R4	1
34	Shield	KP599D	1
35	Pin	KP1306R	1
36	Spring	KP141R	2
37	Retaining ring	K970901250000M	2
38	Spacer assembly	KP106D	2
39	Machine screw. round head 1/4-20 x 1/2, brass	K721525125050A	2
40	Flatwasher, 7/16, stl	K900201043000Z	2

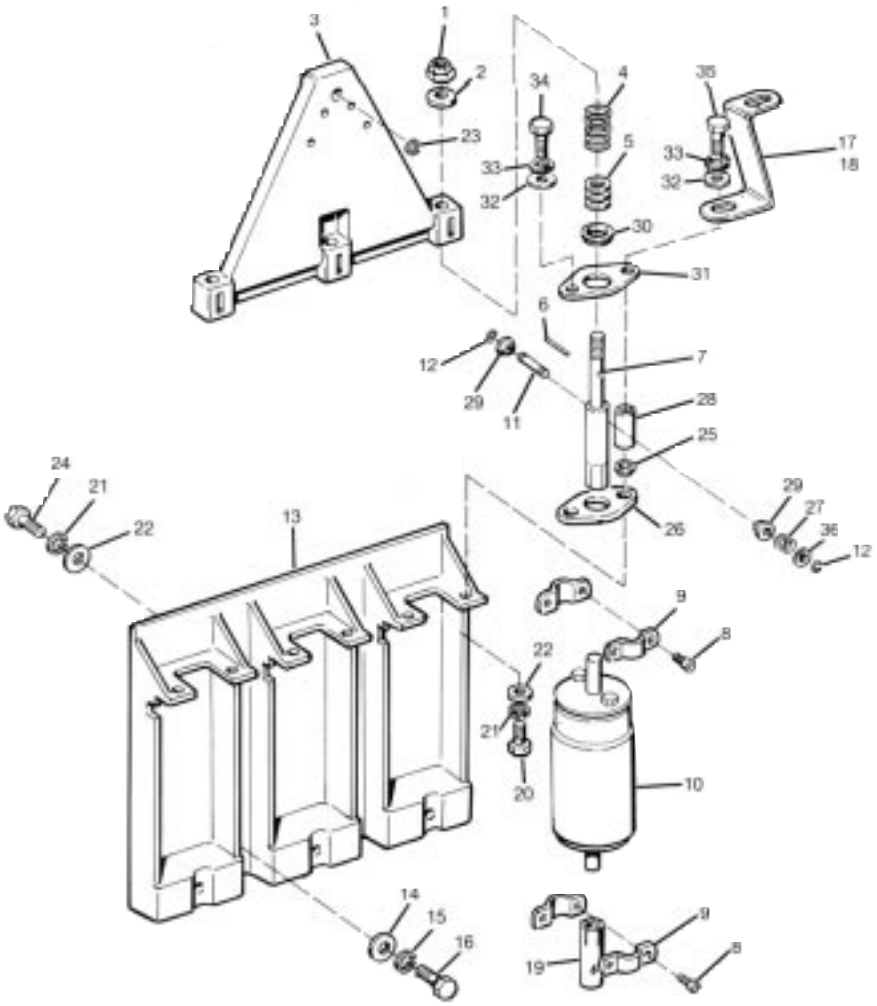


Figure 31C.
Operating mechanism (upper portion) - exploded view.

Operating Mechanism (Upper Portion) (Figure 31C)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Stop nut, elastic	KP2020A21	3
2	Spacer	KP3015A38	3
3	Yoke, contact	KRK645A	1
4	Spring, contact pressure	KRK265F1	3
5	Spacer	KP3013A38	3
6	Roll pin, 1/8" X 7/8", steel	K9708011250870	3
7	Interrupter coupling assembly	KRK645F1	3
8	Capscrew, hex head	KP2036A5	12
9	Interrupter, clamp	KP1036VS	12
10	Vacuum interrupter	KRL162F	3
11	Grooved pin	KP3122A3	6
12	Retaining pin	KP2013A44	12
13	Interrupter support frame	KRK620F1	1
14	Flat washer, med, 3/8. stl	K900201037000Z	4
15	Lockwasher, med, 3/8, stl	K900801037000Z	4
16	Capscrew, hex head, 3/8-16 x 3/4, stl	K730101137075Q	4
17	Lead	KRK659F	8
18	Lead	KP3250A17	4
19	Coupling	KRK641 F	3

Item No.	Description	Catalog Number	Quan Req'd.
20	Capscrew, hex head, 5/16-18 x 1, stl	K730101131100Q	3
21	Lockwasher, med, 5/16, stl	K90080103000Z	9
22	Spacer	KP3011A134	9
23	Retaining ring	K970901312000M	1
24	Capscrew, hex head, 5/16-18 x 11/4, stl	K730115131125A	3
25	Bushing	KP3036A36	6
26	Spacer plate	KRK642F	3
27	Contact spring	KP237GN3	6
28	Spacer	KRK643F	6
29	Contact	KRK644F	12
30	Nyliner, type #7	KRK666F	3
31	Current exchange plate	KRK656F	3
32	Flat washer, brass	K900525039087A	6
33	Lockwasher, med, 3/8. bronze	K900830037000A	6
34	Capscrew, hex head, 3/8-16 x 5/8, brass	K730125137C62A	3
35	Capscrew, hex head, 3/8-16 x 3/4, brass	K730125137075A	3
36	Wire retainer	KP2024A1	6

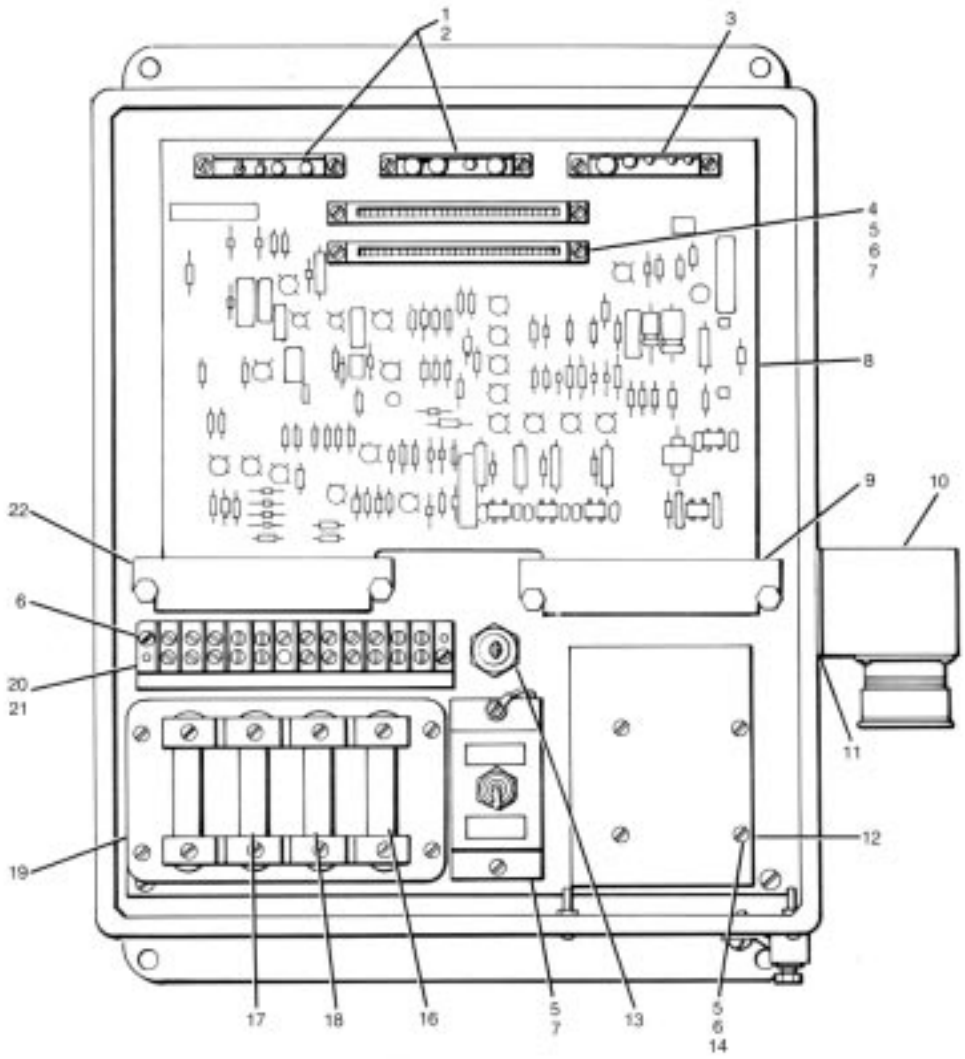


Figure 32.
Control Cabinet.

Control Cabinet (Figure 32)

Item No.	Description	Catalog Number	Quan. Req'd.
1	Ground-trip inverse time delay plug, add suffix number to indicate curve (1, 2 or 3)	KRK590F_	1
2	Ground-trip constant time delay plug, add suffix number to indicate curve (1, 2, 3, 4, 5, 6, 7, 8 or 9)	KRK673F_	1
3	Phase-trip timing plug, add suffix letter to indicate curve (B or C)	KRK592F_	1
4	Spacer	KP2134A5	10
5	Lockwasher, md, #6, st stl	K900815006000A	24
6	Machine screw, #6-32 x 1/2, rd hd, st stl	K721515106050A	12
7	Machine screw, #6-32 x 3/8 rd hd, st stl	K721515106037A	20
8	Circuit board assembly	KRK998F	1
9	Connector	KRK1009F	1
10	Receptacle and block	KRK1013F	1
11	Gasket	K999904250023A	1
12	Surge card assembly	KRK1007F	1

Item No.	Description	Catalog Number	Quan. Req'd.
13	Zener diode	KP4012A39	1
14	Spacer	KP3004A18	4
15	Switch assembly, C.T. shorting	KRK600F	1
16	Ground minimum trip resistor add suffix number to indicate minimum-trip current (10,20 30,50,70,100,140,200,280, 320 or 400 amps)	KRK596F_	1
17	Phase minimum trip resistor, add suffix number to indicate minimum-trip current (10,20 30,50,70 100,140,200,280 320,400,450,560 or 800 amps)	KRK597F_	3
18	Machine screw, #5-40, rd hd, brass	K721525105018F	8
19	Minimum trip resistor clip assembly	KRK594F	1
20	Terminal strip	KP2101A30	1
21	Marker strip	KRK665F	1
22	Connector	KRK1010F	1

COOPER Power Systems

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