

## 6. DC SWITCHGEAR

### 6.1 CATHODE BREAKER (8000 AMP)

(Refer to Drawing 34-0001-00-707: 8000 Amp Cathode Breaker Schematic)

#### A. Power Inputs

1. 700 VDC Power from respective Rectifier positive bus
2. 125 VDC Control Power

#### B. Power Outputs

1. 700 VDC Power to DC Main bus

#### C. Control Inputs

1. Lockout Relay command to Trip Cathode Breaker, 86 (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic)
2. Control interlocks from respective Transformer-Rectifier AC Breaker, 52R/a & 52R/b (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic)
3. Lockout Relay command to Trip Cathode Breaker, 186 (Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic)

#### D. Control Outputs

1. NONE

#### E. Annunciator

1. NONE

#### F. Data Transmission System (DTS)

DTS functions are listed with respect to this schematic. A DTS output for this schematic is a supervisory indication.

1. DTS Supervisory Indication Outputs:
  - a. Breaker Closed and in the Connected Position, 72/a in series with 72/TOC
  - b. Breaker Open, in Test Position, or in Disconnected Position, 72/b paralleled by 72/TOC

#### G. Operational Description

##### 1. Power Circuit

- a. 700 VDC power enters the line side of the feeder breaker from the respective Rectifier positive bus.
- b. A 10,000 amp, 50 mv shunt detects the current flowing in the Cathode circuit. The shunt provides a proportional signal to the following devices: Reverse Current relay (32), forward Current Relay (76), Current Transducer (XD-A), and Watt Transducer (XD-W).
- c. The 32 relay contains one channel of operation (for a more detailed description of operation for the 32 relay refer to the Calibration and Operation Manual):

- d. Instantaneous Overcurrent which responds to reverse currents

The 76 relay contains four channels of operation (for a more detailed description of operation for the 76 relay refer to the Calibration and Operation Manual):

- (1) Instantaneous Overcurrent which responds to high current faults
  - (2) Short-Time Overcurrent which responds to low current arcing faults which do not trip other channels
  - (3) Long-Time Overcurrent which prevents damage to the contact rails during heavy overloads
  - (4) Rate of Rise which responds to bolted or arcing faults which are too far away to trip the Instantaneous channel
- e. XD-A outputs a 0-1ma signal proportional to the current flowing through the Cathode Breaker, to the Ammeter (AM) and the Remote Terminal Unit (RTU). AM is rated 0-2ma and scaled 0-20,000 amps.
  - f. In addition to the signal from the shunt, XD-W also detects the voltage on the load side of the Cathode breaker. XD-W outputs a 0-1ma signal proportional to the load seen by the Cathode Breaker to the RTU.
  - g. The Breaker is kirk-key interlocked with the Negative Disconnect switch (89N-2) located in the Rectifier #2 enclosure. The key interlocks are configured so that the Cathode breaker must be opened before opening the 89N-2.

## 2. Control Circuit

The Cathode Breaker control circuit provides 3 functions: Breaker trip functions, Breaker close functions, Indication functions.

### a. Breaker Trip Functions:

The Breaker's trip circuit is between external terminals 4 and 2.

The following conditions apply power to the breaker's trip circuit:

- (1) (Lockout Relay) sends trip to breaker  
The 186 relay is tripped by the devices listed in Section 6.2 (page 46). When 186 is tripped, all feeder breakers are opened through normally open contacts. Upon 186 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit. Also, a normally closed contact opens and prevents energizing the Master Control Relay (01X) until 186 has been reset.
- (2) (Forward Overcurrent Relay) overcurrent detected  
As discussed in Section 6 (page 43), 76 detects various overcurrent conditions in the feeder circuit. When an overcurrent condition is detected, 76 shorts pins 11 and 12 which applies 125 VDC to the breaker's trip circuit.
- (3) CS (Breaker Control Switch) sends trip to breaker  
When CS is placed in the trip position, CS/T normally open contact closes, which applies 125 VDC to the breaker's trip circuit.
- (4) (Reverse Current Relay) reverse current detected  
When 32 detects reverse current, pins 11 and 12 are shorted which applies 125 VDC to the breaker's trip circuit.
- (5) 52R (Transformer-Rectifier AC Breaker) opens  
When 52R opens, 52R/b closes which applies 125 VDC to the breaker's trip circuit.
- (6) (AC Switchgear Lockout Relay) sends trip to breaker

The respective 86 relay is tripped by functions as listed in Section 3.4 (page 22). When 86 is tripped, the Cathode breaker is opened through normally open contacts. Upon 86 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit. Also, a normally closed contact opens and prevents energizing the Master Control Relay (01X) until 86 has been reset.

**b. Cathode Breaker Closing Functions:**

The Breaker's close circuit is between external terminals 3 and 5. The close circuit consists of an anti-pumping circuit and the closing coil circuit (for a detailed description of these circuits refer to the breaker Installation/Maintenance Instructions bulletin IB 4.2.7-4C).

The following conditions apply a breaker close command to breaker terminal 3:

- (1) Master control relay (01X) is momentarily energized and closes 01X normally open contacts. When 01X contacts close, 125 VDC is applied to the breaker's closing circuit.

Before 01X can be energized the breaker must be in the connected position (72/TOC is closed), Lockout Relay 186 reset (186/R is closed), Lockout Relay 86 reset (86/R is closed), and the Transformer-Rectifier AC breaker is closed (52R/a is closed). Once the above conditions exist, the following conditions energize 01X:

- (a) Manual/Auto Switch (43) is placed in the Manual position and Cathode Breaker Control Switch (72CS) is placed in the Close position.

Placing 43 in the Manual position closes contact 43/M. Placing 72CS in the Close position closes 72CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit.

- (b) Manual/Auto Switch (43) is placed in the Auto position.

Placing 43 in the Auto position closes contact 43/A. When this contact is closed, 125 VDC is applied to the breaker's closing circuit.

- (2) Breaker is racked out to the test position and 72CS (Cathode Breaker Control Switch) is placed in the close position.

Racking the breaker to the test position closes the normally open 72/TOC. Placing 72CS in the close position closes contact 72CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit. This provides a test closing function for the breaker.

**c. Indication Functions:**

- (1) Breaker in Manual Mode (W) is energized when local control has been selected by the Manual/Auto Selector Switch (43).
- (2) Breaker Open (G) is energized when the breaker is open.
- (3) Breaker Closed (R) is energized when the breaker is closed and the breaker trip coil is intact.

## 6.2 CATHODE BREAKER (6000 AMP)

(Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic)

### A. Power Inputs

1. 700 VDC Power from Rectifier #3 positive bus
2. 125 VDC Control Power

### B. Power Outputs

1. 700 VDC Power to DC Main bus

### C. Control Inputs

1. Lockout Relay command to Trip Cathode Breaker, 86-3 (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic)
2. Control interlocks from Transformer-Rectifier #3 AC Breaker, 52R3/a & 52R3/b (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic)

### D. Control Outputs

1. Lockout Relay command to Trip each DC Breaker, 186/T (Refer to Drawing 34-0001-00-707: 8000 Amp Cathode Breaker Schematic) and (Refer to Drawing 34-0001-00-709: Feeder Breaker Schematic) and (Refer to Drawing 34-0001-00-710: Gap Breaker Schematic)
2. Lockout Relay Allow Reset of each DC Breaker, 186/R (Refer to Drawing 34-0001-00-707: 8000 Amp Cathode Breaker Schematic) and (Refer to Drawing 34-0001-00-709: Feeder Breaker Schematic) and (Refer to Drawing 34-0001-00-710: Gap Breaker Schematic)

### E. Annunciator

Annunciator functions are listed with respect to this schematic. An Annunciator output for this schematic is an input into the annunciator. Refer to Section 7.1, Table 7.1-1, page 62 for window locations.

1. Annunciator Outputs:
  - a. DC Switchgear Grounded Structure, 64Y
  - b. DC Switchgear Hot Structure, 64D

### F. Data Transmission System (DTS)

DTS functions are listed with respect to this schematic. A DTS output for this schematic is a supervisory indication.

1. DTS Supervisory Indication Outputs:
  - a. Breaker Closed and in the Connected Position, 72-3/a in series with 72-3/TOC
  - b. Breaker Open, in Test Position, or in Disconnected Position, 72-3/b paralleled by 72-3/TOC

### G. Operational Description

1. Power Circuit
  - a. VDC power enters the line side of the feeder breaker from the Rectifier #3 positive bus.

- b. A 7500 amp, 50 mv shunt detects the current flowing in the Cathode circuit. The shunt provides a proportional signal to the following devices: Reverse Current relay (32), forward Current Relay (76), Current Transducer (XD-A), and Watt Transducer (XD-W).
- c. The 32 relay contains one channel of operation (for a more detailed description of operation for the 32 relay refer to the Calibration and Operation Manual):
- d. Instantaneous Overcurrent which responds to reverse currents

The 76 relay contains four channels of operation (for a more detailed description of operation for the 76 relay refer to the Calibration and Operation Manual):

- (1) Instantaneous Overcurrent which responds to high current faults
  - (2) Short-Time Overcurrent which responds to low current arcing faults which do not trip other channels
  - (3) Long-Time Overcurrent which prevents damage to the contact rails during heavy overloads
  - (4) Rate of Rise which responds to bolted or arcing faults which are too far away to trip the Instantaneous channel
- e. XD-A outputs a 0-1ma signal proportional to the current flowing through the Cathode Breaker, to the Ammeter (AM) and the Remote Terminal Unit (RTU). AM is rated 0-2ma and scaled 0-20,000 amps.
  - f. In addition to the signal from the shunt, XD-W also detects the voltage on the load side of the Cathode breaker. XD-W outputs a 0-1ma signal proportional to the load seen by the Cathode Breaker to the RTU.
  - g. A Voltage Transducer (XD-V) detects the voltage on the load side of the Cathode Breaker. XD-W outputs a 0-1ma signal proportional to the bus voltage, to the Voltmeter (VM) and the RTU. VM is rated 0-1ma and scaled 0-1000 VDC.
  - h. A Ground Structure Relay (64) is connected between the Positive DC Switchgear frame and ground. 64 provides two functions: Grounded Structure and Hot Structure (for a detailed description of the internal operation of this relay see the Operation and Calibration Manual).

If the Switchgear frame becomes grounded, 64 energizes 64Y (Grounded Structure Relay), which provides indication to the Annunciator.

If a fault exists between Switchgear bus and frame, 64 energizes the Lockout Relay (186) and 64D (Hot Structure Relay). 186 deenergizes the entire station by tripping all DC Breakers. 64D provides indication to the Annunciator.

- i. The Breaker is kirk-key interlocked with the Negative Disconnect switch (89N-1) located in the Rectifier #3 enclosure. The key interlocks are configured so that the Cathode breaker must be opened before opening the 89N-1.

## 2. Control Circuit

The Cathode Breaker #1 control circuit provides 3 functions: Breaker trip functions, Breaker close functions, Indication functions

**a. Breaker Trip Functions:**

The Breaker's trip circuit is between external terminals 4 and 2.

The following conditions apply power to the breaker's trip circuit:

(1) (Lockout Relay) sends trip to breaker

The 186 relay is tripped by functions listed in Section 6.2 (page 46). When 186 is tripped, all feeder breakers are opened through normally open contacts. Upon 186 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit. Also, a normally closed contact opens and prevents energizing the Master Control Relay (01X) until 186 has been reset.

(2) (Forward Overcurrent Relay) overcurrent detected

As discussed in Section 6.2 (page 46), 76 detects various overcurrent conditions in the feeder circuit. When an overcurrent condition is detected, 76 shorts pins 11 and 12 which applies 125 VDC to the breaker's trip circuit.

(3) 72CS (Breaker Control Switch) sends trip to breaker

When 72CS is placed in the trip position, 72CS/T normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

(4) (Reverse Current Relay) reverse current detected

When 32 detects reverse current, pins 11 and 12 are shorted which applies 125 VDC to the breaker's trip circuit.

(5) 52R3 (Transformer-Rectifier #3 AC Breaker) opens

When 52R3 opens, 52R3/b closes which applies 125 VDC to the breaker's trip circuit.

(6) (AC Switchgear Lockout Relay) sends trip to breaker

The 86-3 relay is tripped by functions as listed in Section 3.4 (page 22). When 86-3 is tripped, the Cathode breaker is opened through normally open contacts. Upon 86-3 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit. Also, a normally closed contact opens and prevents energizing the Master Control Relay (01X) until 86-3 has been reset.

**b. Breaker Closing Functions:**

The Breaker's close circuit is between external terminals 3 and 5. The close circuit consists of an anti-pumping circuit and the closing coil circuit (for a detailed description of these circuits refer to the breaker Installation/Maintenance Instructions bulletin IB 4.2.7-4C).

The following conditions apply a breaker close command to breaker terminal 3:

(1) Master control relay (01X) is momentarily energized and closes 01X normally open contacts. When 01X contacts close, 125 VDC is applied to the breaker's closing circuit.

(2) Before 01X can be energized the breaker must be in the connected position (72-3/TOC is closed), Lockout Relay 186 reset (186/R is closed), Lockout Relay 86-3 reset (86-3/R is closed), and the Transformer-Rectifier #3 AC breaker is closed (52R3/a is closed). Once the above conditions exist, the following conditions energize 01X:

(a) Manual/Auto Switch (43) is placed in the Manual position and Breaker Control Switch (72CS) is placed in the Close position.

Placing 43 in the Manual position closes contact 43/M. Placing 72CS in the Close position closes 72CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit.

(b) Manual/Auto Switch (43) is placed in the Auto position.

Placing 43 in the Auto position closes contact 43/A. When this contact is closed, 125 VDC is applied to the breaker's closing circuit.

(c) Breaker is racked out to the test position and 72CS (Breaker Control Switch) is placed in the close position.

Racking the breaker to the test position closes the normally open 72-3/TOC. Placing 72CS in the close position closes contact 72CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit. This provides a test closing function for the breaker.

c. **Indication Functions:**

- (1) Breaker in Manual Mode (W) is energized when local control has been selected by the Manual/Auto Selector Switch (43).
- (2) Breaker Open (G) is energized when the breaker is open.
- (3) Breaker Closed (R) is energized when the breaker is closed and the breaker trip coil is intact.
- (4) Lockout Reset (G) is energized when the Lockout relay (186) is reset.
- (5) Auto Trip (A) is energized when the Lockout relay (186) is tripped.

## 6.3 DC FEEDER BREAKERS

(Refer to Drawing 34-0001-00-709: Feeder Breaker Schematic)

### A. Power Inputs

1. 700 VDC Power from Positive Bus
2. 125 VDC Control Power

### B. Power Outputs

1. 700 VDC Power from each DC Feeder to the contact rail served

### C. Control Inputs

1. Lockout Relay command to Trip each DC Breaker, 186/T (Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic) for TPS or (Refer to Drawing 34-0001-00-711: Gap Breaker Schematic w/ LOR & 64) for TBS
2. Lockout Relay Allow Reset of each DC Breaker, 186/R (Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic) for TPS or (Refer to Drawing 34-0001-00-711: Gap Breaker Schematic w/ LOR & 64) for TBS
3. Trip command from trackside emergency trip switch, ETS
4. 450% overcurrent command to trip each DC Breaker, 51BX (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic) for TPS only

### D. Control Outputs

1. NONE

### E. Annunciator

1. NONE

### F. Data Transmission System (DTS)

DTS functions are listed with respect to this schematic. A DTS output for this schematic is a supervisory indication. A DTS input for this schematic is a 24 VDC supervisory control signal.

The DC Feeder Schematic is a typical for all DC Feeders (except Gap Acceleration Breakers). The DTS points listed below are typical for each feeder.

1. DTS Supervisory Indication Outputs:
  - a. Breaker Closed and in the Connected Position, 172/a in series with 172/a TOC
  - b. Breaker Open, in Test Position, or in Disconnected Position, 172/b paralleled by 172/b TOC
2. DTS Supervisory Control Inputs:
  - a. Breaker Close, SC/C
  - b. Breaker Trip, SC/T

### G. Operational Description

The DC Feeder Schematic shows a typical feeder circuit with Load Measuring and Rate of Rise functions. Specific feeder designations and contact rail terminations are tabled at the bottom of the schematic.

#### 1. Power Circuit

- a. 700 VDC power enters the line side of the feeder breaker from the Positive Bus. A load measuring circuit is in parallel with the feeder breaker.



- b. The load measuring circuit consists of the 2 pole 129 Load Measuring Contactor switching in both terminals of Load Measuring Resistor LMR. A 25 amp fuse protects both legs of the parallel load measuring circuit (fuses 9 and 10).
- c. Voltage transducer XD-V detects the voltage on the load side of the feeder breaker and outputs a 0-1ma signal to the 182 Reclosing Relay. The 182 relay uses the voltage signal during load measuring to determine whether a fault exists on the rail served.
- d. A 5000 amp, 50 mv shunt detects the current flowing in the feeder circuit. The shunt provides a proportional signal to both the 150 Rate of Rise Relay and ammeter AM. **NOTE: A 7500/50 shunt is used in Feeder #3 at Grant Circle and Feeder #4 at Columbia Heights since these feeders are 6000 Amp.**
- e. The 150 relay contains four channels of operation (for a more detailed description of operation for the 150 relay refer to the Calibration and Operation Manual):
  - (1) Instantaneous Overcurrent which responds to high current faults
  - (2) Short-Time Overcurrent which responds to low current arcing faults which do not trip other channels
  - (3) Long-Time Overcurrent which prevents damage to the contact rails during heavy overloads
  - (4) Rate of Rise which responds to bolted or arcing faults which are to far away to trip the Instantaneous channel
- f. The ammeter AM is 100 mv rated and 10KA-0-10KA scaled. **NOTE: A 15KA-0-15KA scale is used in Feeder #3 at Grant Circle and Feeder #4 at Columbia Heights since these feeders are 6000 Amp.**
- g. A Surge Arrestor (SA) is provided to minimize track voltage surges.

## 2. Control Circuit

The DC Feeder control circuit provides 3 functions: Breaker trip functions, Breaker close functions, Indication functions

### a. Breaker Trip Functions:

The Breaker's trip circuit is between external terminals 4 and 2.

The following conditions apply power to the breaker's trip circuit:

- (1) (Lockout Relay) sends trip to breaker

The 186 relay is tripped by functions listed in Section 6.2 (page 46) for TPS feeders and Section 6.5 (page 58) for TBS feeders. When 186 is tripped, all feeder breakers are opened through normally open contacts. Upon 186 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

The Master Control Relay (01X) prevents automatic, manual, and supervisory reclosure. This is accomplished by providing contacts in series with 01X coil, latching around the manual and supervisory close functions with a normally open 01X contact, and removing power to 182 (Reclosing Relay) pin 6.

After a 186 trip is performed, automatic reclosure should not be attempted. Therefore, the 186 normally closed reset contact is opened and deenergizes 01X.

- (2) (Rate of Rise Relay) overcurrent detected

As discussed in Section 6.3 (page 50), 150 detects various overcurrent conditions in the feeder circuit. When an overcurrent condition is detected, 150 shorts pins 11 and 12 which applies 125 VDC to the breaker's trip circuit.

After an overcurrent condition occurs, a reclosure should be attempted. Therefore, 150 does not deenergize 01X.

(3) SC/T (Supervisory Control Trip) sends trip to breaker

The SC/T relay is controlled through the Data Transmission System (DTS). Upon SC/T trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After a supervisory control trip is performed, automatic reclosure should not be attempted. Therefore, the SC/T normally closed contact is opened and deenergizes 01X.

(4) ETS (Emergency Trip Station) sends trip to breaker

The ETS contains relays which are controlled by external trip switches which are located at trackside. If any of these trip switches are activated, the ETS normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After an emergency trip station trip is performed, automatic reclosure should not be attempted. Therefore, the ETS normally closed contact is opened and deenergizes 01X.

(5) 51BX (450% Overcurrent) sends trip to breaker

When a 450% overcurrent is detected by relay 51B in any one of the Rectifier-Transformer Feeders, auxiliary relay 51BX is energized closing its normally open contacts which provide 125 VDC to all feeder breaker's trip circuit.

**b. Breaker Closing Functions:**

The Breaker's close circuit is between external terminals 3 and 5. The close circuit consists of an anti-pumping circuit and the closing coil circuit (for a detailed description of these circuits refer to the breaker Installation/Maintenance Instructions bulletin IB 4.2.7-4C).

The following conditions apply a breaker close command to breaker terminal 3:

(1) (Recloser Relay Close) normally open contacts closes. When 182/C contact closes, 125 VDC is applied to the breaker's closing circuit.

182/C closes under the following conditions:

(a) Control power present at 182 terminals 6, 11, and 13. Power is removed from terminal 6 when 01X (Master Control Relay) is deenergized. Power is removed from terminals 11 and 13 when there is a loss of 125 VDC control power.

(b) The breaker is open. Breaker status is determined by a 172/b contact between 125 VDC and 182 terminal 5. 172/b is closed when the breaker is open, and open when the breaker is closed.

(c) The rail voltage is above the preset value.

(d) The load measuring circuit determines that the rail is unfaulted. Load measuring is performed when the rail voltage is below the preset value.

When load measuring is performed, 182/LM energizes 129 (load measuring contactor) to initiate load measuring circuit discussed in Section 6.3 (page 50).

If 182 determines there is a fault, another load measure is performed after a preset time delay. Upon repeated faulted load measures, 182 energizes 182/LOX which opens a normally closed contact and deenergizes 01X (master control relay).

If 182 determines there is not a fault after load measuring, 182/LOX is deenergized and 182/C is energized.

For additional operational instructions refer to Operational Manual.

- (2) Feeder Breaker is racked out to the test position and 172CS (Breaker Control Switch) is placed in the close position.

Racking the breaker to the test position closes the normally open 172/TOC. Placing 172CS in the close position closes contact 172CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit. This provides a test closing function for the breaker.

c. **Indication Functions:**

- (1) Breaker in Local Mode (W) is energized when local control has been selected by the Local/Remote Selector Switch (43).
- (2) Breaker Open (G) is energized when the breaker is open.
- (3) Breaker Closed (R) is energized when the breaker is closed and the breaker trip coil is intact.

## 6.4 DC GAP ACCELERATION BREAKERS

(Refer to Drawing 34-0001-00-710: Gap Breaker Schematic)

### A. Power Inputs

1. 700 VDC Power from Positive Bus
2. 125 VDC Control Power

### B. Power Outputs

1. 700 VDC Power from each DC Feeder to the contact rail served

### C. Control Inputs

1. Lockout Relay command to Trip each DC Breaker, 186/T (Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic) for TPS or (Refer to Drawing 34-0001-00-711: Gap Breaker Schematic w/ LOR & 64) for TBS
2. Lockout Relay Allow Reset of each DC Breaker, 186/R (Refer to Drawing 34-0001-00-708: 6000 Amp Cathode Breaker Schematic) for TPS or (Refer to Drawing 34-0001-00-711: Gap Breaker Schematic w/ LOR & 64) for TBS
3. Trip command from trackside emergency trip switch, ETS
4. 450% overcurrent command to trip each DC Breaker, 51BX (Refer to Drawing 34-0001-00-703: Rectifier-Transformer Feeder Schematic) for TPS only

### D. Control Outputs

1. NONE

### E. Annunciator

1. NONE

### F. Data Transmission System (DTS)

DTS functions are listed with respect to this schematic. A DTS output for this schematic is a supervisory indication..

The DC Gap Breaker Schematic is a typical for all DC Gap Acceleration Breakers. The DTS points listed below are typical for each feeder.

1. DTS Supervisory Indication Outputs:
  - a. Breaker Closed and in the Connected Position, 172/a in series with 172/a TOC
  - b. Breaker Open, in Test Position, or in Disconnected Position, 172/b paralleled by 172/b TOC
2. DTS Supervisory Control Inputs:
  - a. Breaker Close, SC/C
  - b. Breaker Trip, SC/T

### G. Operational Description

The DC Feeder Schematic shows a typical feeder circuit with Load Measuring and Rate of Rise functions. Specific feeder designations and contact rail terminations are tabled at the bottom of the schematic.

#### 1. Power Circuit

- a. 700 VDC power enters the line side of the feeder breaker from the Positive Bus. A load measuring circuit is in parallel with the feeder breaker.

- b. The load measuring circuit consists of the 2 pole 129 Load Measuring Contactor switching in both terminals of Load Measuring Resistor LMR. A 25 amp fuse protects both legs of the parallel load measuring circuit (fuses 9 and 10).
- c. Voltage transducer XD-V detects the voltage on the load side of the feeder breaker and outputs a 0-1ma signal to the 182 Reclosing Relay. The 182 relay uses the voltage signal during load measuring to determine whether a fault exists on the rail served.
- d. A 5000 amp, 50 mv shunt detects the current flowing in the feeder circuit. The shunt provides a proportional signal to the ammeter AM.
- e. The ammeter AM is 100 mv rated and 10KA-0-10KA scaled.
- f. A Surge Arrestor (SA) is provided to minimize track voltage surges.

## 2. Control Circuit

The DC Feeder control circuit provides 3 functions: Breaker trip functions, Breaker close functions, Indication functions

### a. Breaker Trip Functions:

The Breaker's trip circuit is between external terminals 4 and 2.

The following conditions apply power to the breaker's trip circuit:

#### (1) (Lockout Relay) sends trip to breaker

The 186 relay is tripped by functions listed in Section 6.2 (page 46) for TPS Gap breakers or Section 6.5 (page 58) for TBS Gap breakers. When 186 is tripped, all feeder breakers are opened through normally open contacts. Upon 186 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

The Master Control Relay (01X) prevents automatic, manual, and supervisory reclosure. This is accomplished by providing contacts in series with 01X coil, latching around the manual and supervisory close functions with a normally open 01X contact, and removing power to 182 (Reclosing Relay) pin 6.

After a 186 trip is performed, automatic reclosure should not be attempted. Therefore, the 186 normally closed reset contact is opened and deenergizes 01X.

#### (2) SC/T (Supervisory Control Trip) sends trip to breaker

The SC/T relay is controlled through the Data Transmission System (DTS). Upon SC/T trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After a supervisory control trip is performed, automatic reclosure should not be attempted. Therefore, the SC/T normally closed contact is opened and deenergizes 01X.

#### (3) ETS (Emergency Trip Station) sends trip to breaker

The ETS contains relays which are controlled by external trip switches which are located at trackside. If any of these trip switches are activated, the ETS normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After an emergency trip station trip is performed, automatic reclosure should not be attempted. Therefore, the ETS normally closed contact is opened and deenergizes 01X.

(4) 51BX (450% Overcurrent) sends trip to breaker

When a 450% overcurrent is detected by relay 51B in any one of the Rectifier-Transformer Feeders, auxiliary relay 51BX is energized closing its normally open contacts which provide 125 VDC to all feeder breaker's trip circuit.

(5) If either adjacent feeder breaker trips when Gap Breaker is in the Remote Mode.

The adjacent feeder normally closed auxiliary 172/b closes, which applies 125 VDC through 43/R (Remote Mode selected) to the breaker's trip circuit.

After an adjacent breaker trip, a reclosure should be attempted. Therefore, 01X is not deenergized.

**b. Breaker Closing Functions:**

The Breaker's close circuit is between external terminals 3 and 5. The close circuit consists of an anti-pumping circuit and the closing coil circuit (for a detailed description of these circuits refer to the breaker Installation/Maintenance Instructions bulliten IB 4.2.7-4C).

The following conditions apply a breaker close command to breaker terminal 3:

(1) 182/C (Recloser Relay Close) normally open contacts closes. When 182/C contact closes, 125 VDC is applied to the breaker's closing circuit.

182/C closes under the following conditions:

- (a) Control power present at 182 terminals 6, 11, and 13. Power is removed from terminal 6 when 01X (Master Control Relay) is deenergized. Power is removed from terminals 11 and 13 when there is a loss of 125 VDC control power.
- (b) The breaker is open. Breaker status is determined by a 172/b contact between 125 VDC and 182 terminal 5. 172/b is closed when the breaker is open, and open when the breaker is closed.
- (c) The rail voltage is above the preset value.
- (d) The load measuring circuit determines that the rail is unfaulted. Load measuring is performed when the rail voltage is below the preset value.

When load measuring is performed, 182/LM energizes 129 (load measuring contactor) to initiate load measuring circuit discussed in Section 6.4 (page 54).

If 182 determines there is a fault, another load measure is performed after a preset time delay. Upon repeated faulted load measures, 182 energizes 182/LOX which opens a normally closed contact and deenergizes 01X (master control relay).

If 182 determines there is not a fault after load measuring, 182/LOX is deenergized and 182/C is energized.

For additional operational instructions refer to Operational Manual.

- (2) Feeder Breaker is racked out to the test position and 172CS (Breaker Control Switch) is placed in the close position.

Racking the breaker to the test position closes the normally open 172/TOC. Placing 172CS in the close position closes contact 172CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit. This provides a test closing function for the breaker.

c. **Indication Functions:**

- (1) Breaker in Local Mode (W) is energized when local control has been selected by the Local/Remote Selector Switch (43).
- (2) Breaker Open (G) is energized when the breaker is open.
- (3) Breaker Closed (R) is energized when the breaker is closed and the breaker trip coil is intact.

## 6.5 DC GAP ACCELERATION BREAKER w/ LOCKOUT AND GROUND STRUCTURE

(Refer to Drawing 34-0001-00-711: Gap Breaker Schematic w/ LOR & 64)

### A. Power Inputs

1. 700 VDC Power from Positive Bus
2. 125 VDC Control Power

### B. Power Outputs

1. 700 VDC Power from each DC Feeder to the contact rail served

### C. Control Inputs

1. Trip command from trackside emergency trip switch, ETS

### D. Control Outputs

1. Lockout Relay command to Trip each DC Breaker, 186/T (Refer to Drawing 34-0001-00-709: Feeder Breaker Schematic) and (Refer to Drawing 34-0001-00-710: Gap Breaker Schematic)
2. Lockout Relay Allow Reset of each DC Breaker, 186/R (Refer to Drawing 34-0001-00-709: Feeder Breaker Schematic) and (Refer to Drawing 34-0001-00-710: Gap Breaker Schematic)

### E. Annunciator

Annunciator functions are listed with respect to this schematic. An Annunciator output for this schematic is an input into the annunciator. Refer to Section 7.2, Table 7.2-1, page 65, for window locations.

1. Annunciator Outputs:
  - a. DC Switchgear Grounded Structure, 64Y
  - b. DC Switchgear Hot Structure, 64D

### F. Data Transmission System (DTS)

DTS functions are listed with respect to this schematic. A DTS output for this schematic is a supervisory indication..

The DC Gap Breaker Schematic is a typical for all DC Gap Acceleration Breakers. The DTS points listed below are typical for each feeder.

1. DTS Supervisory Indication Outputs:
  - a. Breaker Closed and in the Connected Position, 172/a in series with 172/a TOC
  - b. Breaker Open, in Test Position, or in Disconnected Position, 172/b paralleled by 172/b TOC
2. DTS Supervisory Control Inputs:
  - a. Breaker Close, SC/C
  - b. Breaker Trip, SC/T

### G. Operational Description

The DC Feeder Schematic shows a typical feeder circuit with Load Measuring and Rate of Rise functions. Specific feeder designations and contact rail terminations are tabled at the bottom of the schematic.

#### 1. Power Circuit

- a. 700 VDC power enters the line side of the feeder breaker from the Positive Bus. A load measuring circuit is in parallel with the feeder breaker.



- b. The load measuring circuit consists of the 2 pole 129 Load Measuring Contactor switching in both terminals of Load Measuring Resistor LMR. A 25 amp fuse protects both legs of the parallel load measuring circuit (fuses 9 and 10).
- c. Voltage transducer XD-V detects the voltage on the load side of the feeder breaker and outputs a 0-1ma signal to the 182 Reclosing Relay. The 182 relay uses the voltage signal during load measuring to determine whether a fault exists on the rail served.
- d. A 5000 amp, 50 mv shunt detects the current flowing in the feeder circuit. The shunt provides a proportional signal to the ammeter AM.
- e. The ammeter AM is 100 mv rated and 10KA-0-10KA scaled.
- f. A Surge Arrestor (SA) is provided to minimize track voltage surges.
- g. A Ground Structure Relay (64) is connected between the Positive DC Switchgear frame and ground. 64 provides two functions: Grounded Structure and Hot Structure (for a detailed description of the internal operation of this relay see the Operation and Calibration Manual).

If the Switchgear frame becomes grounded, 64 energizes 64Y (Grounded Structure Relay), which provides indication to the Annunciator.

If a fault exists between Switchgear bus and frame, 64 energizes the Lockout Relay (186) and 64D (Hot Structure Relay). 186 deenergizes the entire station by tripping all DC Breakers. 64D provides indication to the Annunciator.

## 2. Control Circuit

The DC Feeder control circuit provides 3 functions: Breaker trip functions, Breaker close functions, Indication functions

### a. Breaker Trip Functions:

The Breaker's trip circuit is between external terminals 4 and 2.

The following conditions apply power to the breaker's trip circuit:

- (1) (Lockout Relay) sends trip to breaker

The 186 relay is tripped by functions listed in Section 6.5 (page 58). When 186 is tripped, all feeder breakers are opened through normally open contacts. Upon 186 trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

The Master Control Relay (01X) prevents automatic, manual, and supervisory reclosure. This is accomplished by providing contacts in series with 01X coil, latching around the manual and supervisory close functions with a normally open 01X contact, and removing power to 182 (Reclosing Relay) pin 6.

After a 186 trip is performed, automatic reclosure should not be attempted. Therefore, the 186 normally closed reset contact is opened and deenergizes 01X.

(2) SC/T (Supervisory Control Trip) sends trip to breaker

The SC/T relay is controlled through the Data Transmission System (DTS). Upon SC/T trip, the normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After a supervisory control trip is performed, automatic reclosure should not be attempted. Therefore, the SC/T normally closed contact is opened and deenergizes 01X.

(3) ETS (Emergency Trip Station) sends trip to breaker

The ETS contains relays which are controlled by external trip switches which are located at trackside. If any of these trip switches are activated, the ETS normally open contact closes, which applies 125 VDC to the breaker's trip circuit.

After an emergency trip station trip is performed, automatic reclosure should not be attempted. Therefore, the ETS normally closed contact is opened and deenergizes 01X.

(4) If either adjacent feeder breaker trips when Gap Breaker is in the Remote Mode.

(5) The adjacent feeder normally closed auxiliary 172/b closes, which applies 125 VDC through 43/R (Remote Mode selected) to the breaker's trip circuit.

After an adjacent breaker trip, a reclosure should be attempted. Therefore, 01X is not deenergized.

**b. Breaker Closing Functions:**

The Breaker's close circuit is between external terminals 3 and 5. The close circuit consists of an anti-pumping circuit and the closing coil circuit (for a detailed description of these circuits refer to the breaker Installation/Maintenance Instructions bulliten IB 4.2.7-4C).

The following conditions apply a breaker close command to breaker terminal 3:

(1) 182/C (Recloser Relay Close) normally open contacts closes. When 182/C contact closes, 125 VDC is applied to the breaker's closing circuit.

182/C closes under the following conditions:

- (a) Control power present at 182 terminals 6, 11, and 13. Power is removed from terminal 6 when 01X (Master Control Relay) is deenergized. Power is removed from terminals 11 and 13 when there is a loss of 125 VDC control power.
- (b) The breaker is open. Breaker status is determined by a 172/b contact between 125 VDC and 182 terminal 5. 172/b is closed when the breaker is open, and open when the breaker is closed.
- (c) The rail voltage is above the preset value.
- (d) The load measuring circuit determines that the rail is unfaulted. Load measuring is performed when the rail voltage is below the preset value.

When load measuring is performed, 182/LM energizes 129 (load measuring contactor) to initiate load measuring circuit discussed in Section 6.5 (page 58).

If 182 determines there is a fault, another load measure is performed after a preset time delay. Upon repeated faulted load measures, 182 energizes 182/LOX which opens a normally closed contact and deenergizes 01X (master control relay).

If 182 determines there is not a fault after load measuring, 182/LOX is deenergized and 182/C is energized.

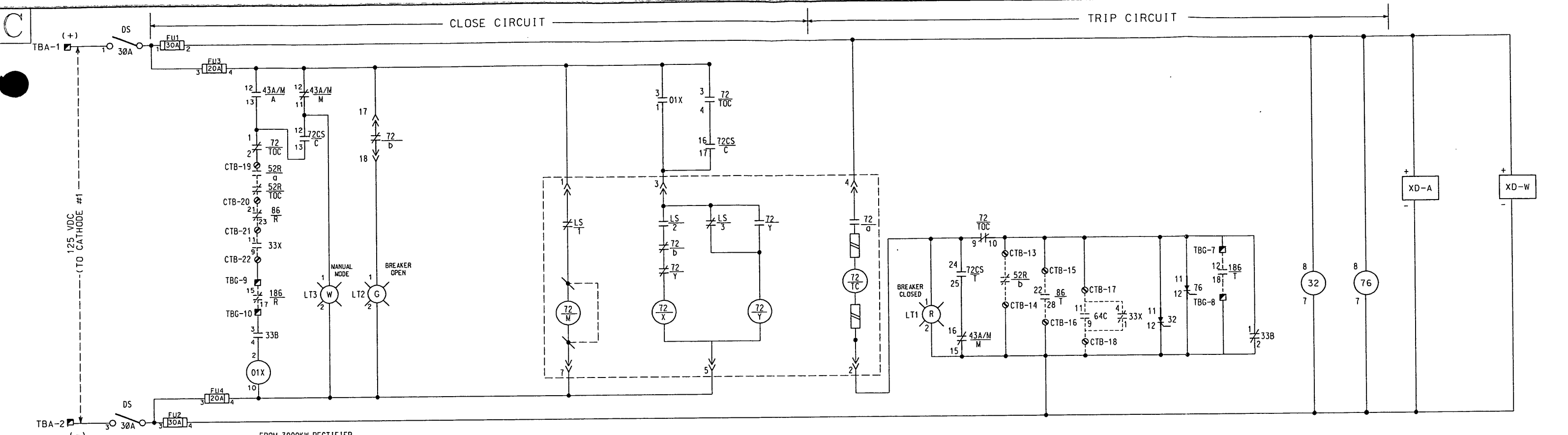
For additional operational instructions refer to Operational Manual.

- (2) Feeder Breaker is racked out to the test position and 172CS (Breaker Control Switch) is placed in the close position.

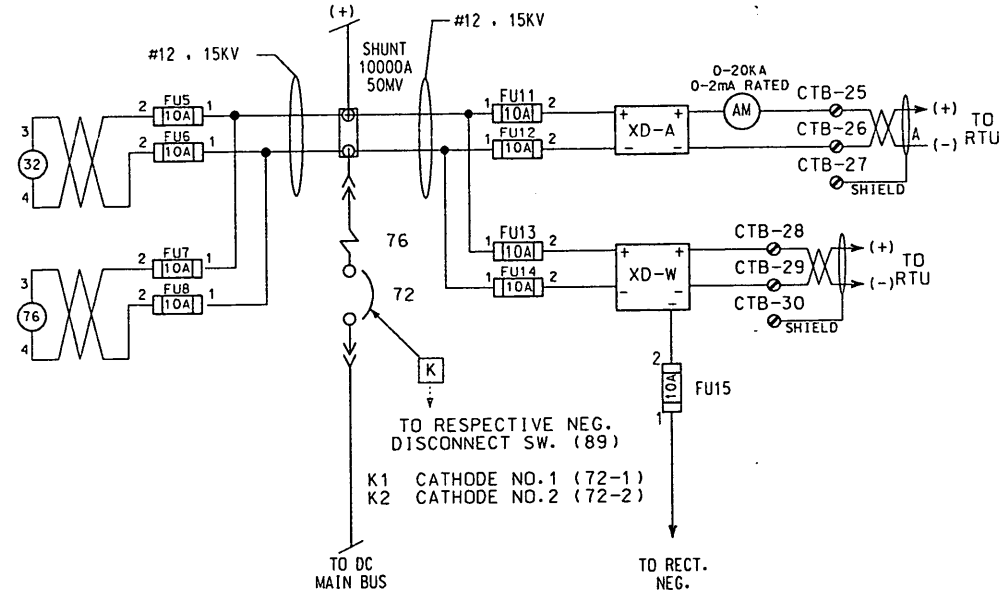
Racking the breaker to the test position closes the normally open 172/TOC. Placing 172CS in the close position closes contact 172CS/C. When both of these contacts are closed, 125 VDC is applied to the breaker's closing circuit. This provides a test closing function for the breaker.

c. **Indication Functions:**

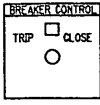
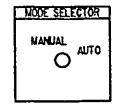
- (1) Breaker in Local Mode (W) is energized when local control has been selected by the Local/Remote Selector Switch (43).
- (2) Breaker Open (G) is energized when the breaker is open.
- (3) Breaker Closed (R) is energized when the breaker is closed and the breaker trip coil is intact.
- (4) Lockout Reset (G) is energized when the Lockout relay (186) is reset.
- (5) Auto Trip (A) is energized when the Lockout relay (186) is tripped.



FROM 3000KW RECTIFIER  
(REF. DWG. 34-0001-00-705)

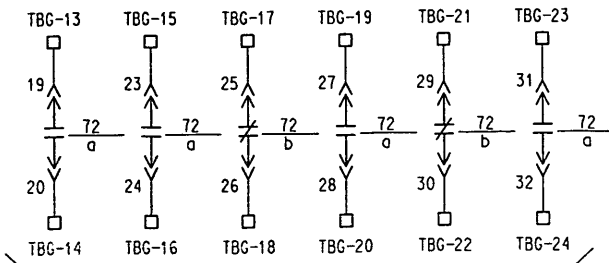
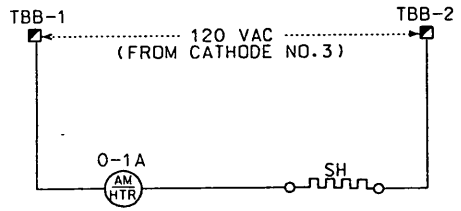
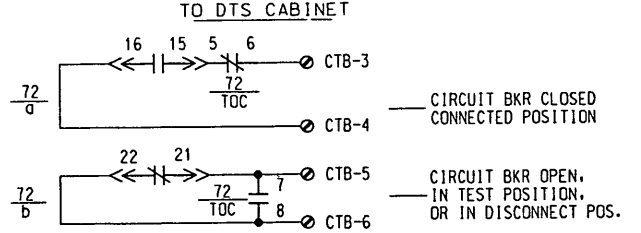


72CS  
BREAKER CONTROL



| DECK | 43A/M CONTACTS | MANUAL | AUTO |
|------|----------------|--------|------|
| 1    | 120-11-011     | X      |      |
| 1    | 120-11-013     | X      |      |
| 1    | 160-11-015     | X      |      |
| 1    | 11-017         |        | X    |

| DECK | CONTACTS   | POSITION |     |     |       |
|------|------------|----------|-----|-----|-------|
|      |            | TRIP     | NAT | MAN | CLOSE |
| 1    | 120-11-013 |          |     |     | X     |
| 1    | 160-11-017 |          |     |     | X     |
| 2    | 210-11-028 | X        |     |     |       |
| 2    | 240-11-025 | X        |     |     |       |
| 3    | 310-11-032 | X        | X   |     |       |
| 3    | 350-11-036 | X        | X   |     |       |
| 4    | 420-11-043 | X        | X   |     |       |
| 4    | 460-11-047 | X        | X   |     |       |
| 5    | 510-11-052 | X        | X   |     |       |
| 5    | 550-11-056 | X        | X   |     |       |



SPARE  
BREAKER AUXILIARY SWITCHES

NOTES:

- TOC (TRUCK OPERATED CONTACTS) ARE SHOWN W/BREAKER IN CONNECTED POSITION.
- 186 LOR CONTACTS ARE SHOWN IN NORMAL POSITION.
- 72CS BREAKER CONTROL SWITCH IS SHOWN IN THE NORMAL POSITION.
- #6 AWG. IS WIRED TO TB-1,2 TO EACH CUBICLE FOR 125VDC CONTROL BUS.
- ALL CONTROL WIRE TO BE #14 AWG. 1KV MIN UNLESS OTHERWISE SPECIFIED.

CONTRACT No.: 227043

SUBCONTRACTOR: LACH ELECTRIC CORP.  
BY: L. D. KUKREJA DATE:

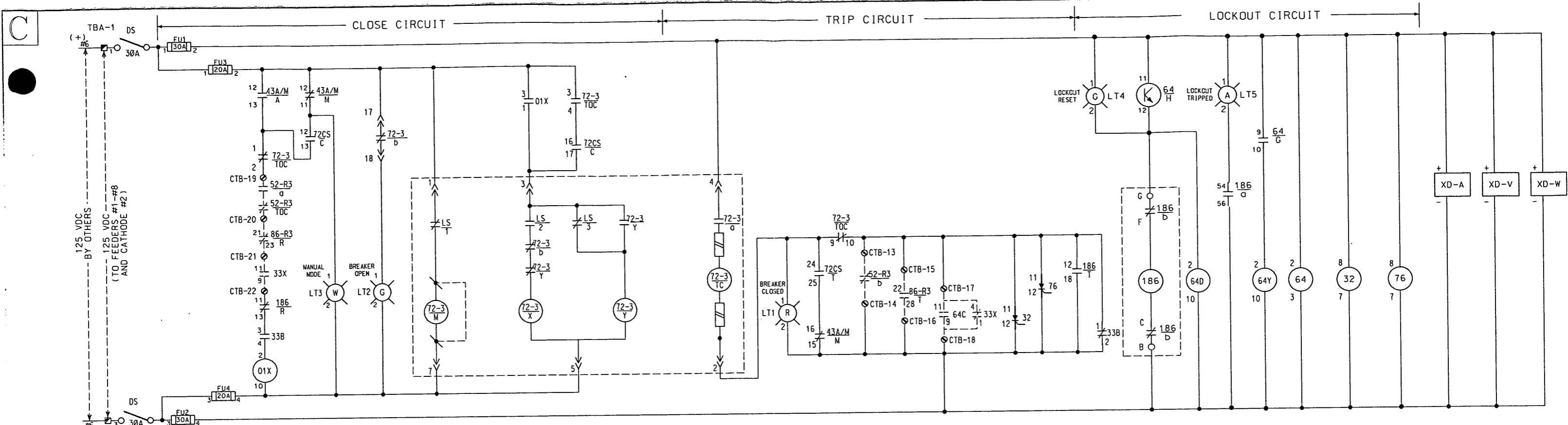
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| B    | 8-96  | UPDATED 52R/TOC CONTACT STATUS | DEG |
| A    | 6-96  | UPDATE PER CUSTOMER COMMENTS   | DEG |
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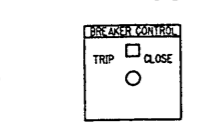
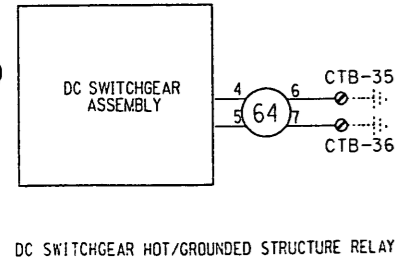
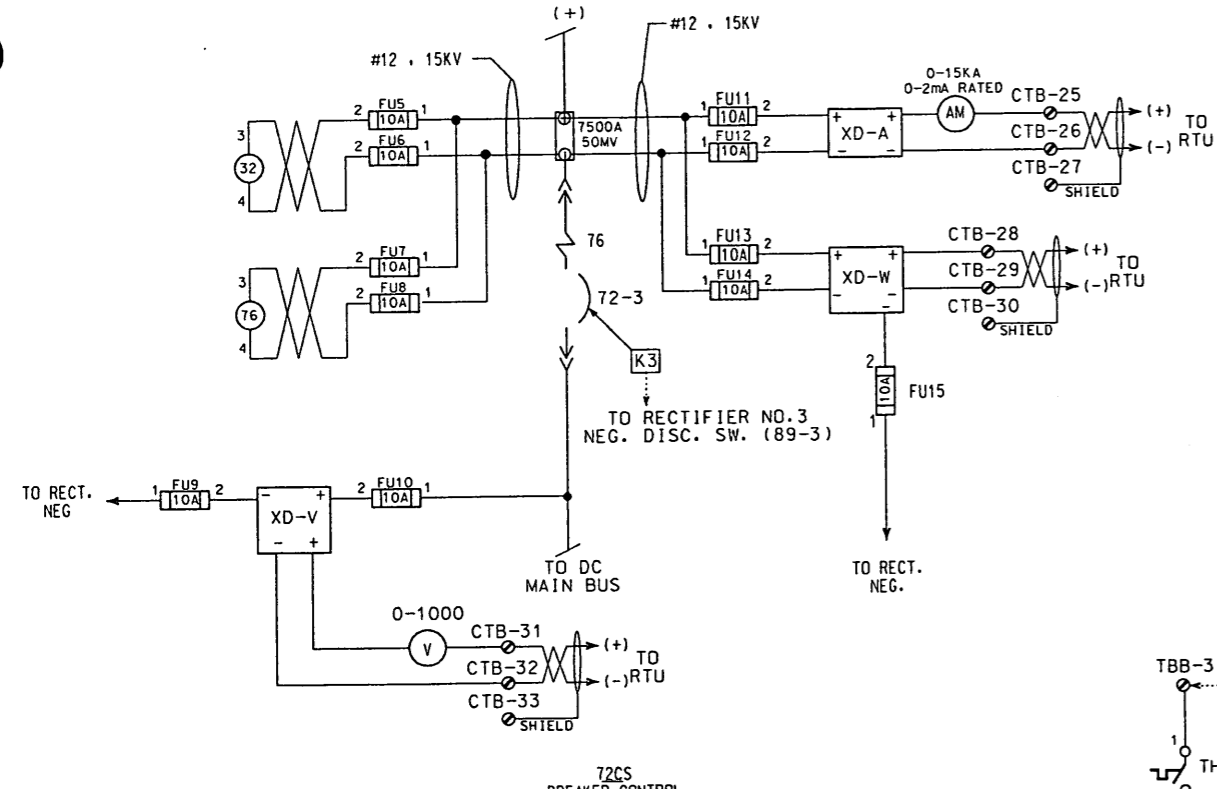
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| <b>TITLE</b><br>CATHODE BKR. SCHEMATIC (8KA)<br>TRACTION POWER SUBSTATION (72-1 AND 72-2)<br>MID "E" ROUTE, STAGE SSE-13<br>WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY |                         |  |                     |
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*D. R. Wilson 3/19/96*

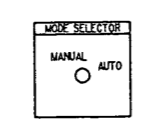
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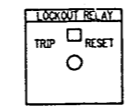
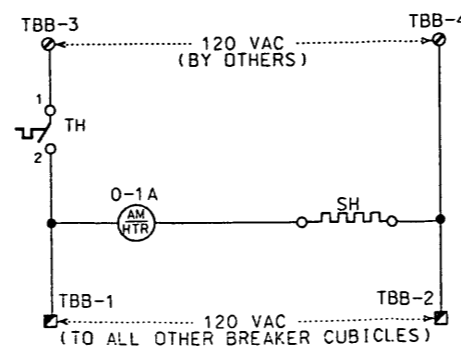
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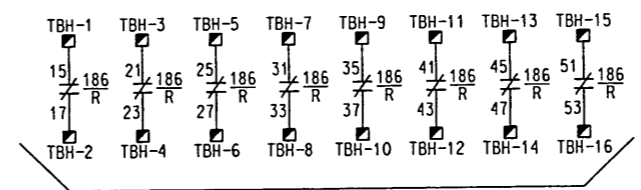
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|-----|-------------|------|-----|-----|----------|
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| 1   | 16-0-II-017 | X    |     |     | CLOSE    |
| 2   | 21-0-II-028 | X    |     |     | CLOSE    |
| 2   | 24-0-II-025 | X    |     |     | CLOSE    |
| 3   | 31-0-II-032 | X    | X   |     | CLOSE    |
| 3   | 35-0-II-036 | X    | X   |     | CLOSE    |
| 4   | 42-0-II-043 | X    | X   |     | CLOSE    |
| 4   | 46-0-II-047 | X    | X   |     | CLOSE    |
| 5   | 51-0-II-052 | X    | X   |     | CLOSE    |
| 5   | 55-0-II-056 | X    | X   |     | CLOSE    |



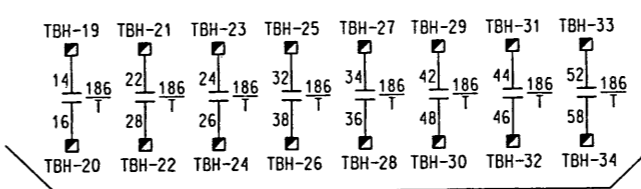
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|-----|-------------|--------|------|
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| 1   | 16-0-II-015 | X      |      |
| 1   | 16-0-II-017 | X      |      |



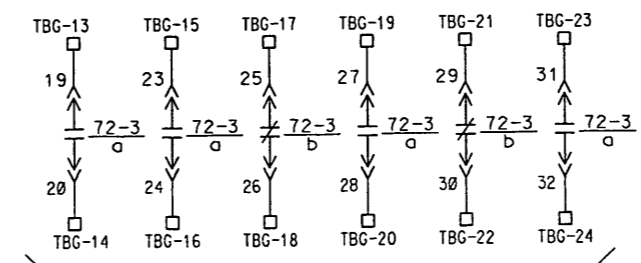
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|-----|--------------|------|-------|
| 1   | 11-0-II-013  | X    |       |
| 1   | 12-0-II-018  | X    |       |
| 1   | 15-0-II-017  | X    |       |
| 1   | 14-0-II-016  | X    |       |
| 2   | 21-0-II-023  | X    |       |
| 2   | 22-0-II-028  | X    |       |
| 2   | 25-0-II-027  | X    |       |
| 2   | 24-0-II-026  | X    |       |
| 3   | 31-0-II-033  | X    |       |
| 3   | 32-0-II-038  | X    |       |
| 3   | 35-0-II-037  | X    |       |
| 3   | 34-0-II-036  | X    |       |
| 4   | 41-0-II-043  | X    |       |
| 4   | 42-0-II-048  | X    |       |
| 4   | 45-0-II-047  | X    |       |
| 4   | 44-0-II-046  | X    |       |
| 5   | 51-0-II-053  | X    |       |
| 5   | 52-0-II-058  | X    |       |
| 5   | 55-0-II-057  | X    |       |
| 5   | 54-0-II-056  | X    |       |



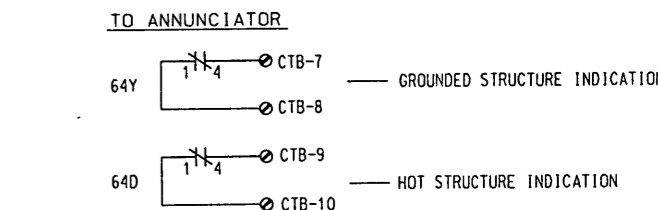
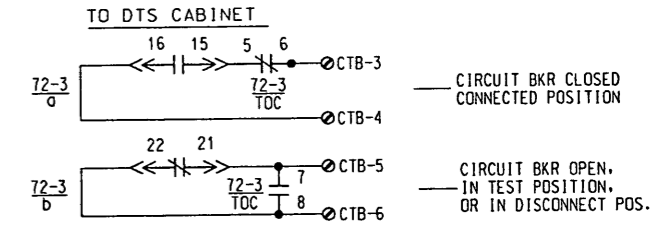
186 LOCKOUT RELAY RESET  
TO 72-1, 72-2, 72-3, & 172-1 THRU 172-6



186 LOCKOUT RELAY TRIP  
TO 72-1, 72-2, 72-3, & 172-1 THRU 172-6



SPARE BREAKER AUXILIARY SWITCHES



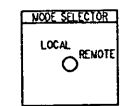
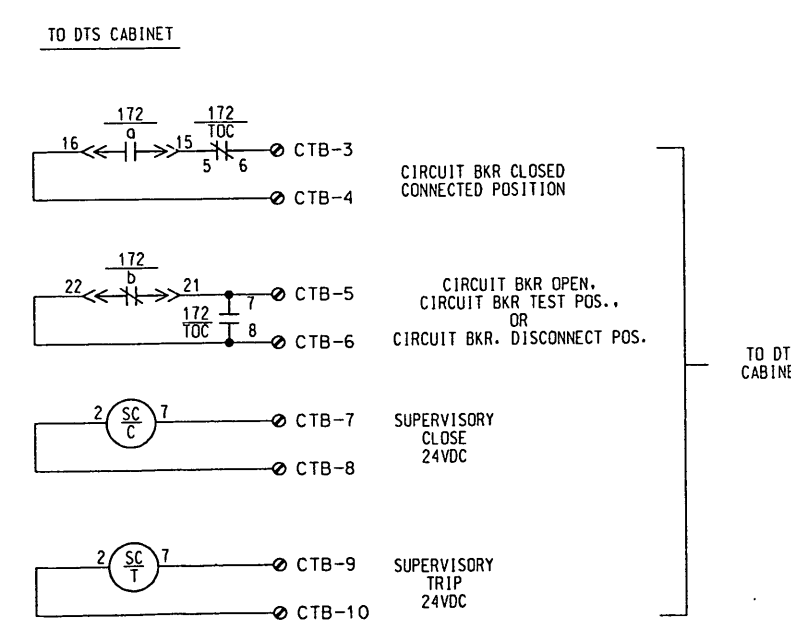
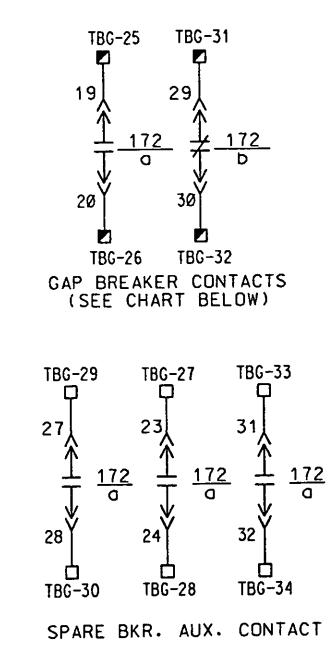
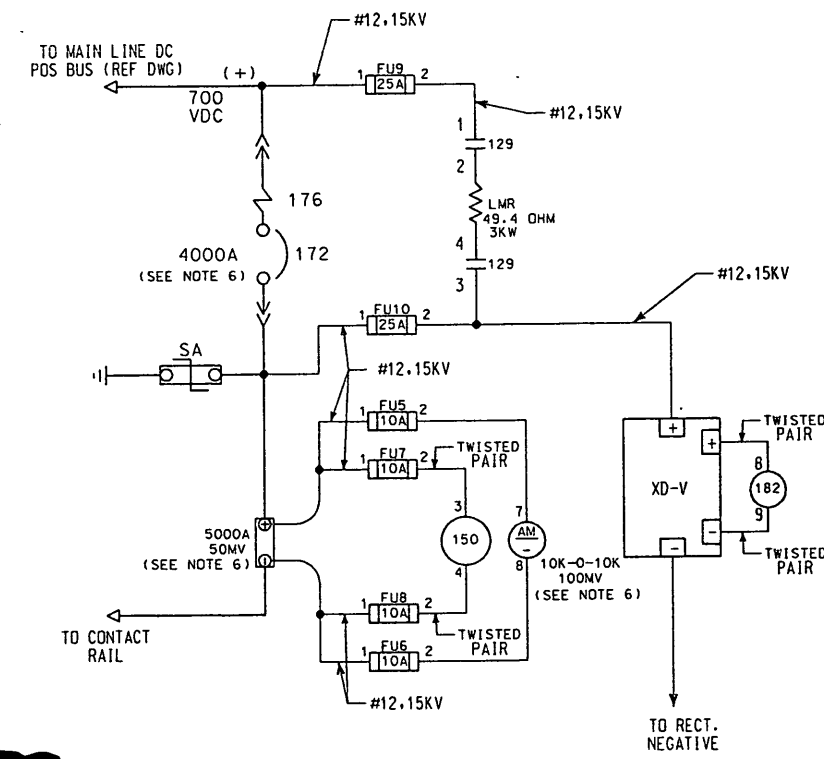
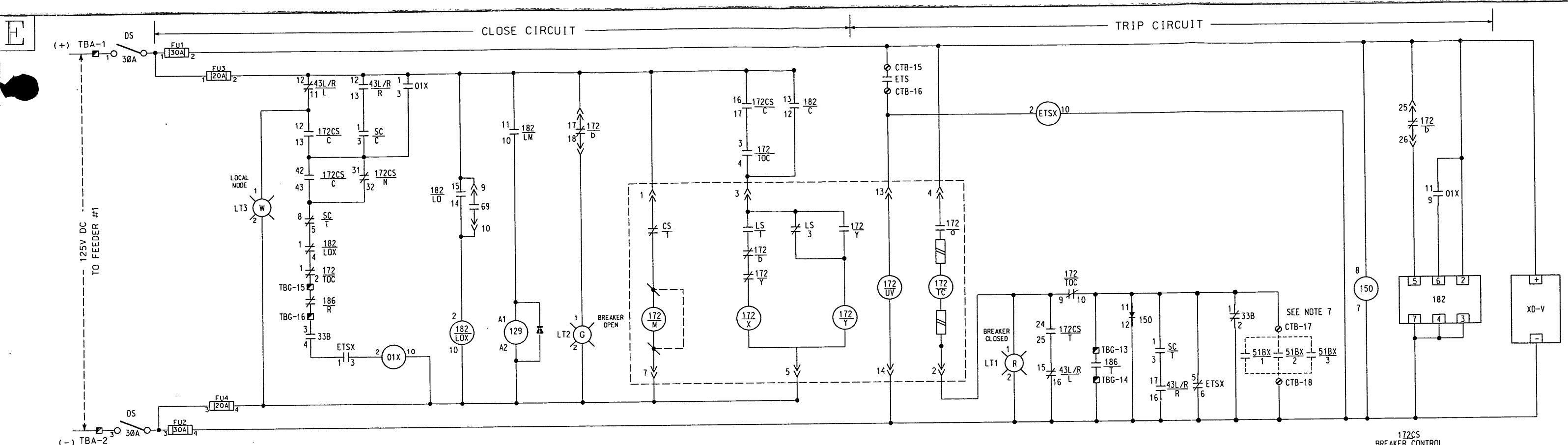
- NOTES:
- TOC (TRUCK OPERATED CONTACTS) ARE SHOWN W/BREAKER IN CONNECTED POSITION.
  - 186 LOR CONTACTS ARE SHOWN IN NORMAL POSITION.
  - 72CS BREAKER CONTROL SWITCH IS SHOWN IN THE NORMAL POSITION.
  - #6 AWG. IS WIRED TO TB-1,2 TO EACH CUBICLE FOR 125VDC CONTROL BUS.
  - ALL CONTROL WIRE TO BE #14 AWG. 1KV MIN. UNLESS OTHERWISE SPECIFIED.

CONTRACT NO.: 227043

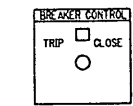
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BY: L. D. KUKREJA DATE:

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|  |               | SMC ELECTRICAL PRODUCTS<br>P.O. BOX 880<br>BARBOURSVILLE, WV 25504 |  |
| TITLE: CATHODE BKR. SCHEMATIC (6KA)<br>TRACTION POWER SUBSTATION (72-3)<br>MID "E" ROUTE. STAGE SSE-13<br>WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY |               |  |  |
| DWN BY: <i>Dee</i><br>CHN'D BY: <i>Dee</i>   | DATE: 2-13-96 | JWS NO: 34-0001-00-708   | SCALE:   |
| 11-96 PRE-CONSTRUCTION UPDATES<br>8-96 UPDATED 52R/TOC CONTACT STATUS.   | DEG           | SHEET OF   | 000100GH   |
| 6-96 ADDED AMBER LTS FOR LOCKOUT TRIP<br>6-96 UPDATE PER CUSTOMER COMMENTS   | DEG           | CAD REV:   | 000100GH   |
| DATE:  | REVISIONS:    | BY:  | LIMITS UNLESS NOTED * FRAC # 010 DEG # 003 DEGREE # 1/2" |

*Dee* 2/13/96



| DECK | 43L/R CONTACTS | LOCAL | REMOTE |
|------|----------------|-------|--------|
| 1    | 12-0-11        | X     |        |
| 1    | 12-0-13        |       | X      |
| 1    | 16-0-15        | X     |        |
| 1    | 16-0-17        |       | X      |



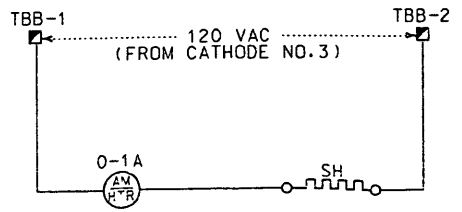
| DECK | CONTACTS | POSITION |      |       |
|------|----------|----------|------|-------|
|      |          | TRIP     | INAC | CLOSE |
| 1    | 12-0-11  | X        |      |       |
| 1    | 16-0-13  |          | X    |       |
| 2    | 21-0-11  | X        |      |       |
| 2    | 24-0-11  | X        |      |       |
| 3    | 31-0-11  | X        | X    |       |
| 3    | 35-0-11  | X        | X    |       |
| 4    | 42-0-11  | X        | X    |       |
| 4    | 46-0-11  | X        | X    |       |
| 5    | 51-0-11  | X        | X    |       |
| 5    | 55-0-11  | X        | X    |       |

- NOTES:
1. TOC (TRUCK OPERATED CONTACTS) ARE SHOWN W/BREAKER IN CONNECTED POSITION.
  2. 186 LOR CONTACTS ARE SHOWN IN NORMAL POSITION.
  3. 172CS BREAKER CONTROL SWITCH IS SHOWN IN THE NORMAL POSITION.
  4. #5 AWG. IS WIRED TO TB-1,2 TO EACH CJBICLE FOR 125VDC CONTROL BUS.
  5. ALL CONTROL WIRE TO BE #14 AWG, 2KV MIN UNLESS OTHERWISE SPECIFIED.
  6. FEEDERS NO. 4 AT COLUMBIA HEIGHTS AND NO. 3 AT GRANT CIRCLE ARE 6000A. THIS REQUIRES A 7500A/50MV SHUNT AND A 15KA-0-15KA AMMETER.
  7. 51BX CONTACTS ARE NOT REQUIRED FOR TIE BREAKER STATIONS.

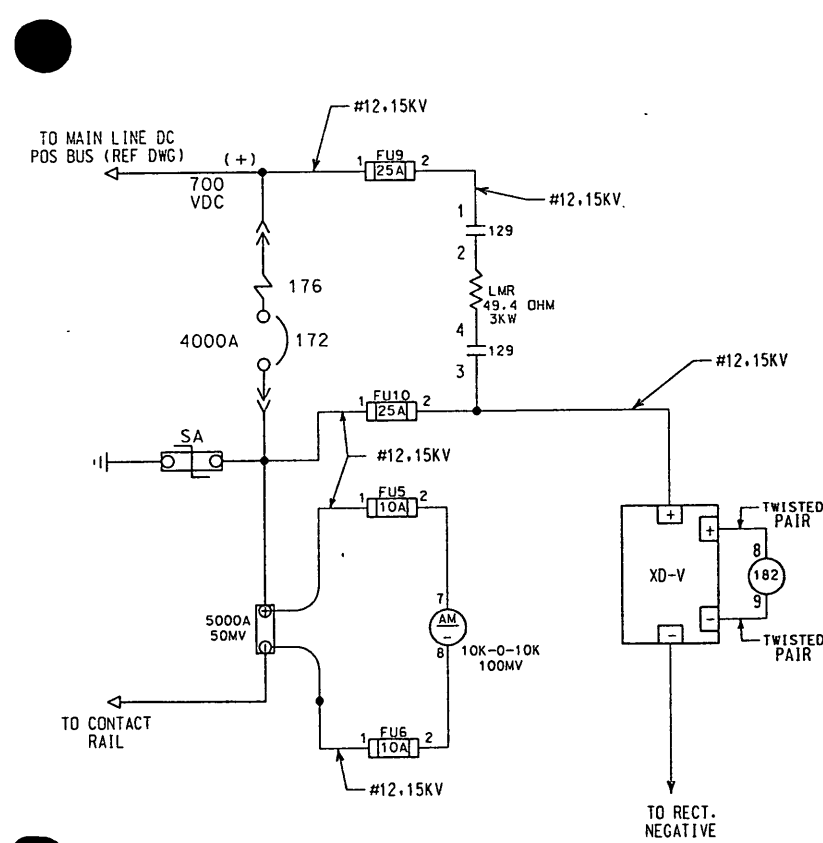
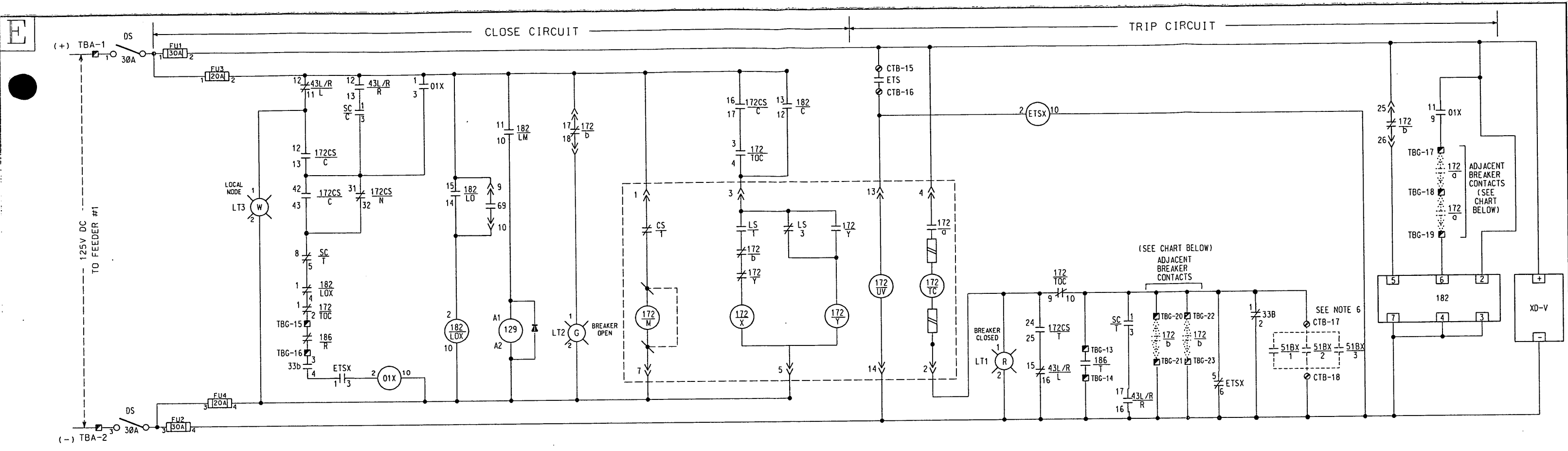
*D. Raison 3/19/99*

CONTRACT No.: 227043  
 SUBCONTRACTOR: LACH ELECTRIC CORP.  
 BY: L.D. KUKREJA DATE:

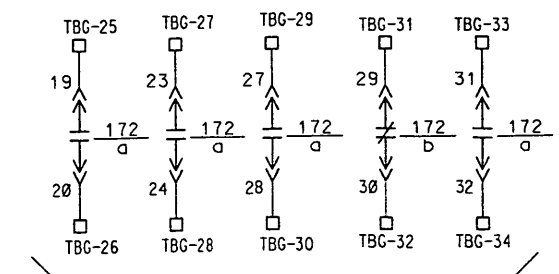
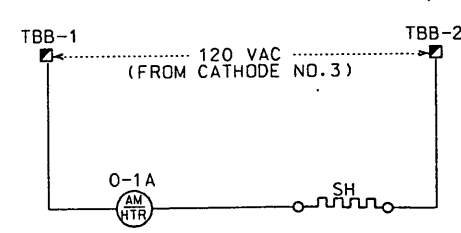
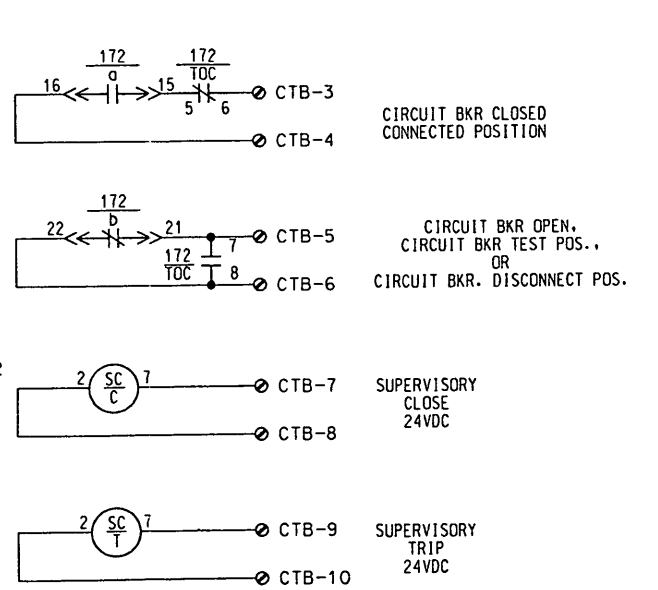
| STATION          | GAP BREAKER                          | ADJ. BREAKERS                                |
|------------------|--------------------------------------|--|
| GRANT CIRCLE     | FEEDER NO.5<br>FEEDER NO.6           | FEEDER NO.1 & 3<br>FEEDER NO.2 & 4           |
| COLUMBIA HEIGHTS | FEEDER NO.5<br>FEEDER NO.6           | FEEDER NO.1 & 3<br>FEEDER NO.2 & 4           |
| GEORGIA AVE.     | TIE BREAKER NO.5<br>TIE BREAKER NO.6 | TIE BREAKER NO.1 & 3<br>TIE BREAKER NO.2 & 4 |
| CHAPIN ST.       | TIE BREAKER NO.5<br>TIE BREAKER NO.6 | TIE BREAKER NO.1 & 3<br>TIE BREAKER NO.2 & 4 |



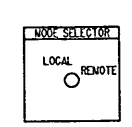
|   |   |  |  |
|---|---|--|--|
|   |   | SMC ELECTRICAL PRODUCTS<br>P.O. BOX 880<br>BARBOURSVILLE, WV 26504 |  |
| <b>FEEDER BREAKER SCHEMATIC</b><br>TRACTION POWER SUBSTATION/TIE BREAKER STATION<br>MID "E" ROUTE, STAGE SSE-13<br>WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY |   |  |  |
| E 08-97<br>D 11-96<br>C 10-96<br>B 08-96<br>A 06-96<br>SV14   | FACTORY TEST UPDATES<br>PRE-CONSTRUCTION UPDATES<br>UPDATED PER CUSTOMER COMMENTS<br>UPDATED LABEL IN 172CS DETAIL<br>UPDATED PER CUSTOMER COMMENTS | DEG<br>DEG<br>DEG<br>DEG<br>DLB                                    | DATE<br>2-13-96<br>SCALE<br>SHEET<br>OF<br>CAD FILE<br>000100GJ<br>REVISIONS |



TO DTS CABINET

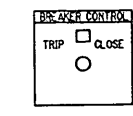


SPARE BREAKER AUXILIARY SWITCHES



| BOX | 43L/R CONTACTS | LOCAL | REMOTE |
|-----|----------------|-------|--------|
| 1   | 12Q-II-011     | X     |        |
| 1   | 11-013         |       | X      |
| 1   | 16Q-II-015     | X     |        |
| 1   | 11-017         |       | X      |

172CS BREAKER CONTROL



| BOX | CONTACTS   | POSITION |     |       |
|-----|------------|----------|-----|-------|
|     |            | TRIP     | NAT | CLOSE |
| 1   | 12Q-II-013 |          |     | X     |
| 1   | 16Q-II-017 |          |     | X     |
| 2   | 21Q-II-028 | X        |     |       |
| 2   | 24Q-II-025 | X        |     |       |
| 3   | 31Q-II-032 | X        | X   |       |
| 3   | 35Q-II-036 | X        | X   |       |
| 4   | 42Q-II-043 | X        | X   |       |
| 4   | 46Q-II-047 | X        | X   |       |
| 5   | 51Q-II-052 | X        | X   |       |
| 5   | 55Q-II-056 | X        | X   |       |

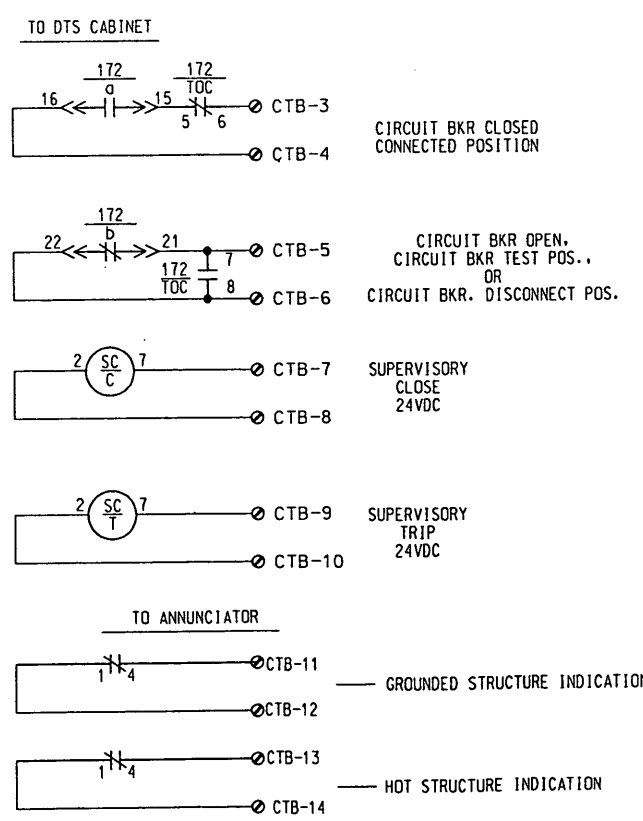
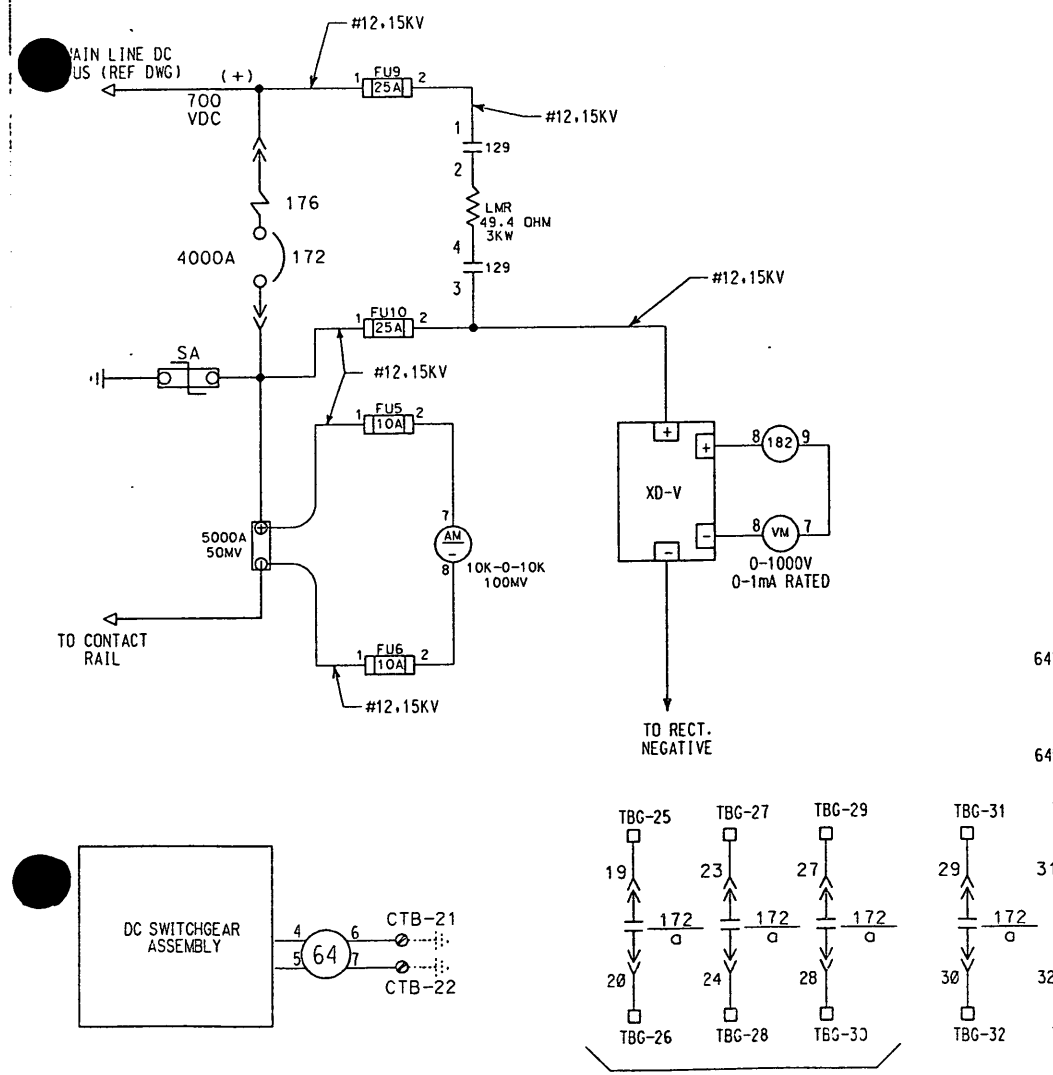
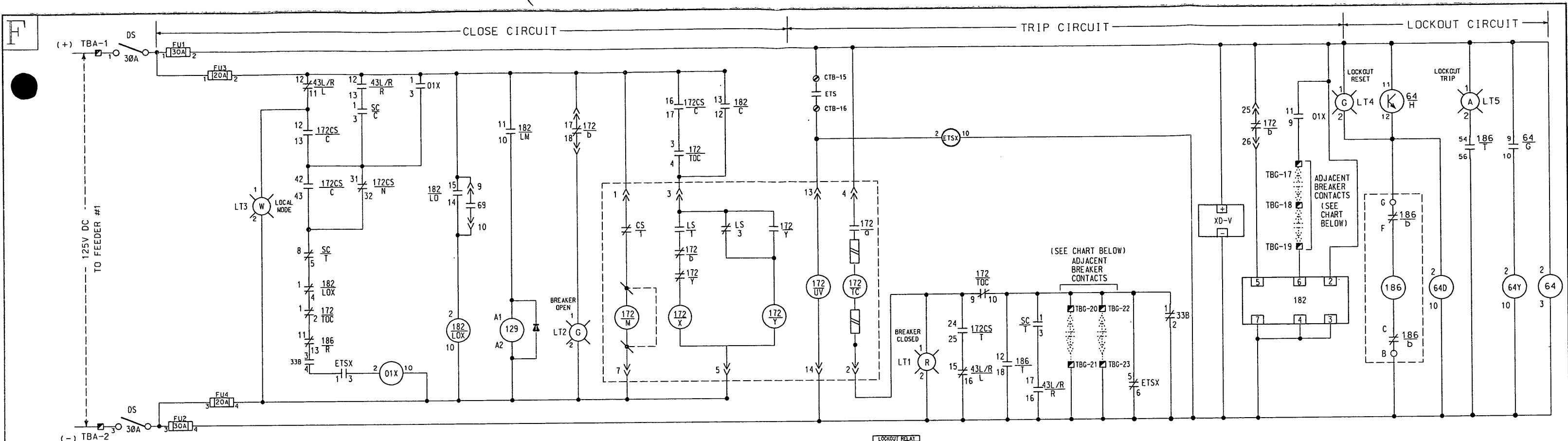
- NOTES:
- TOC (TRUCK OPERATED CONTACTS) ARE SHOWN W/BREAKER IN CONNECTED POSITION.
  - 186 LOR CONTACTS ARE SHOWN IN NORMAL POSITION.
  - 172CS BREAKER CONTROL SWITCH IS SHOWN IN THE NORMAL POSITION.
  - #6 AWG. IS WIRED TO TB-1,2 TO EACH CUBICLE FOR 125VDC CONTROL BUS.
  - ALL CONTROL WIRE TO BE #14 AWG. 2KV MIN UNLESS OTHERWISE SPECIFIED.
  - 51BX CONTACTS ARE NOT REQUIRED IN TIE BREAKER STATIONS.

CONTRACT No.: 227043  
 SUBCONTRACTOR: LACH ELECTRIC CORP.  
 BY: L.D. KUKREJA DATE:

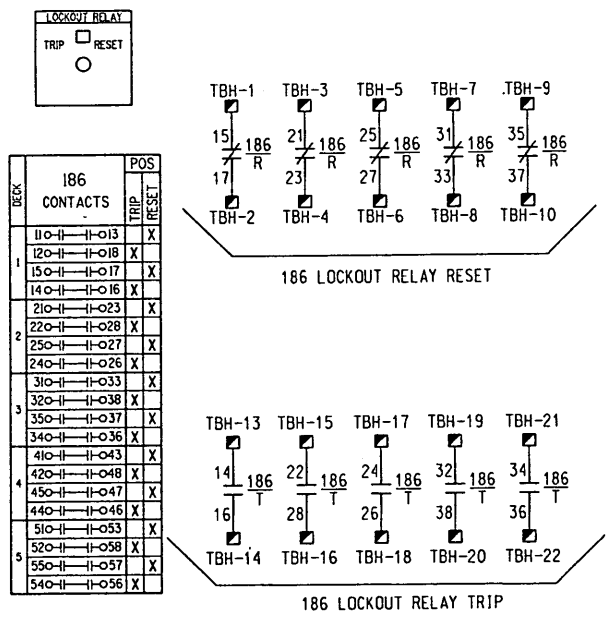
| STATION          | GAP BREAKERS               | ADJ. BREAKERS                      |
|------------------|----------------------------|------------------------------------|
| GRANT CIRCLE     | FEEDER NO.5<br>FEEDER NO.6 | FEEDER NO.1 & 3<br>FEEDER NO.2 & 4 |
| COLUMBIA HEIGHTS | FEEDER NO.5<br>FEEDER NO.6 | FEEDER NO.1 & 3<br>FEEDER NO.2 & 4 |
| GEORGIA AVE.     | TIE BREAKER NO.5           | TIE BREAKER NO.1 & 3               |
| CHAPIN ST.       | TIE BREAKER NO.5           | TIE BREAKER NO.1 & 3               |

|   |   |  |   |
|---|---|--|---|
|   |   | SMC ELECTRICAL PRODUCTS<br>P.O. BOX 880<br>BARBOURSVILLE, WV 25504 |   |
| <b>TITLE</b><br>GAP BREAKER SCHEMATIC<br>TRACTION POWER SUBSTATION/TIE BREAKER STATION<br>MID "E" ROUTE, STAGE SSE-13<br>WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY |   |  |   |
| 1-26-99<br>11-96<br>10-96<br>8-96<br>6-96   | REVISED PER SUBMITTAL MARKUPS<br>PRE-CONSTRUCTION UPDATES<br>UPDATED PER CUSTOMER COMMENTS<br>MOVED SC/C CONTACT IN CLOSE CKT<br>UPDATED LABEL IN 172CS DETAIL<br>UPDATED PER CUSTOMER COMMENTS | REA<br>DEG<br>DEG<br>DEG<br>DLB                                    | DATE<br>2-13-96<br>SCALE<br>SHEET<br>OF<br>000100GK |
| LIMITS UNLESS NOTED • FRAC • 010 DFC • 003 DFGREE ± 1/2"  |   |  |   |

*Handwritten signature and date: 3/19/95*



| STATION      | GAP BREAKER      | ADJ. BREAKERS        |
|--------------|------------------|----------------------|
| GEORGIA AVE. | TIE BREAKER NO.6 | TIE BREAKER NO.2 & 4 |
| CHAPIN ST.   | TIE BREAKER NO.6 | TIE BREAKER NO.2 & 4 |



- NOTES:
- TOC (TRUCK OPERATED CONTACTS) ARE SHOWN W/BREAKER IN CONNECTED POSITION.
  - 186 LDR CONTACTS ARE SHOWN IN NORMAL POSITION.
  - 172CS BREAKER CONTROL SWITCH IS SHOWN IN THE NORMAL POSITION.
  - #6 AWG. IS WIRED TO TB-1,2 TO EACH CUBICLE FOR 125VDC CONTROL BUS.
  - ALL CONTROL WIRE TO BE #14 AWG, 2KV MIN UNLESS OTHERWISE SPECIFIED.

CONTRACT No.: 227043  
 SUBCONTRACTOR: LACH ELECTRIC CORP.  
 BY: L.D. KUKREJA DATE: 11-4-96

| SYM | DATE    | REVISIONS  | BY  |
|-----|---------|--|-----|
| F   | 1-26-99 | REVISED PER SUBMITTAL MARKUPS  | REA |
| E   | 08-97   | UPDATED G4 CUST CONN TB PTS.   | DEG |
| D   | 11-96   | PRE-CONSTRUCTION UPDATES   | DEG |
| C   | 10-96   | UPDATED PER CUSTOMER COMMENTS  | DEG |
| B   | 0-96    | ADDED AMBER LTS FOR LOCKOUT TRIP. MOVED SC/C IN CLOSE CIRCUIT. AND UPDATED LABEL IN 172CS DETAIL | DEG |
| A   | 6-96    | UPDATED PER CUSTOMER COMMENTS  | DLB |

**SMC ELECTRICAL PRODUCTS**  
 P.O. BOX 880  
 BARBOURSVILLE, WV 25504

**GAP BREAKER SCHEMATIC**  
 WITH 186 & 64 (TIE BREAKER STATION ONLY)  
 MID "E" ROUTE, STAGE SSE-13  
 WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DATE: 2-13-96  
 DRAWING NO: 34-0001-00-711  
 SHEET: OF  
 000100GM



**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY               |                   |                               |  |                              |       |
|--------------------------|-------------------|-------------------------------|--|------------------------------|-------|
| UNIT                     | DESIG.            | PART NO.                      | DESCRIPTION  | MFG.                         | Total |
| Nameplate                | NAMEPLATE         | 32-0314-00-301                | Equipment Nameplate-Stamp as follows: Use SO# for S/N, Model No. FBK-94, 700 Volts, 800 Max Volts, 125KA SC Amps, DC Hz                                    | SMC                          | 1     |
| Nametags                 | NAMETAGS          | BY DESCRIPTION                | Nametags;3-Ply Laminated Plastic,Beveled Edges,Black w/White Core,Drill for #6-32 Stainless Steel Screws,Per Attached List                                 | Promark                      | 1     |
| Unit No.1<br>Feeder No.2 | 129               | LTNS60-SDAJ                   | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                          | 150               | C4280-508                     | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/BI Directional,C4280-025 Case   | SMC                          | 1     |
|                          | 172               | FBK-S-4000 (BY DESC.)         | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                          | 182               | C4280-560                     | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                          | 01X,182/LOX,ETS X | RR3PAULDC110                  | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                          | 172/TOC           | 271887T03                     | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                          |                   | 836876T01                     | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                          | 172SD             | 271985T01                     | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                          | 33B               | 9007-AP221                    | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                          | 43L/R             | 24201B                        | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                          | 72CS              | 2457D                         | Switch-Breaker Control   | Electroswitch                | 1     |
|                          | AM                | 103-124-AEXX                  | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                          | AM/HTR            | 2PB-AAC-001                   | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                          | COND              | EMT-1-1/2"                    | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                          | COND-B            | PB500D                        | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                          | COND-F            | TC-505                        | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                          | COND-LN           | LN-105                        | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                          | D1                | 1N4007                        | Diode-1000V,1A   | Motorola                     | 1     |
|                          | DS-CP             | A-1102                        | Disconnect Switch-250VDC,30A   | Fiinor                       | 1     |
|                          | FU1,2             | JKS-30                        | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                          | FU1-4             | J60030-2S                     | Fuse Holder,2P,600V  | Buss                         | 2     |
|                          | FU3,4             | JKS-20                        | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                          | FU5-10            | PS120X127PRE                  | Fuse Holder  | Ferraz                       | 6     |
|                          | FU5-8             | D100RB010V                    | Fuse-1000VDC,10A   | Ferraz                       | 4     |
|                          | FU9-10            | D100RB025V                    | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                          | INS-SH            | 255716                        | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                          | LMR               | C3313                         | Resistor-Load Measuring  | SMC                          | 1     |
|                          | LT1               | 22RL120LRXPLRD                | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
| LT2                      | 22RL120LGXPLGN    | Ind. Light-LED, 125VDC, Green | Control Concepts   | 1                            |       |
| LT3                      | 22RL120LYXPLWE    | Ind. Light-LED, 125VDC, White | Control Concepts   | 1                            |       |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY               |                      |                       |  |                            |       |
|--------------------------|----------------------|-----------------------|--|----------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                       | Total |
|                          | RB08                 | SR2P-06               | Relay Base-8 Pin   | Idec                       | 2     |
|                          | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                       | 3     |
|                          | SA                   | 6007-003              | Surge Arrestor-750VDC  | SMC                        | 1     |
|                          | SC/C,SC/T            | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                       | 2     |
|                          | SH                   | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                  | 1     |
|                          | SHUNT                | H-5000-50             | Shunt-5000A, 50mv  | Canadian Shunt             | 1     |
|                          | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric           | 1     |
|                          | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric           | 2     |
|                          | TBJ,TBG,CTB          | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric           | 8     |
|                          | TM-1                 | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burdny                     | 5     |
|                          | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                        | 1     |
| Unit No.2<br>Feeder No.4 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectrica Scientifica | 1     |
|                          | 150                  | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case   | SMC                        | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                        | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                        | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                       | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                        | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                        | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                        | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                   | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch              | 1     |
|                          | 72CS                 | 2457D                 | Switch-Breaker Control   | Electroswitch              | 1     |
|                          | AM                   | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                   | 1     |
|                          | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                    | 1     |
|                          | COND                 | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                    | 3     |
|                          | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                          | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                       | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                   | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                     | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                       | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                       | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                       | 2     |
|                          | FU5-10               | PSI20X127PRE          | Fuse Holder  | Ferraz                     | 6     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY                   |             |                       |  |                  |       |
|------------------------------|-------------|-----------------------|--|------------------|-------|
| UNIT                         | DESIG.      | PART NO.              | DESCRIPTION  | MFG.             | Total |
|                              | FU5-8       | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 4     |
|                              | FU9-10      | D100RB025V            | Fuse-1000VDC,25A   | Ferraz           | 2     |
|                              | INS-SH      | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|                              | LMR         | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|                              | LT1         | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|                              | LT2         | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|                              | LT3         | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|                              | RB08        | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|                              | RB11        | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|                              | SA          | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|                              | SC/C,SC/T   | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|                              | SH          | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|                              | SHUNT       | H-5000-50             | Shunt-5000A, 50mv  | Canadian Shunt   | 1     |
|                              | TBA         | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|                              | TBB,TBF     | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 2     |
|                              | TBJ,TBG,CTB | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 8     |
|                              | TM-1        | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy           | 5     |
|                              | XD-V        | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC              | 1     |
| Unit No.3<br>Cathode<br>No.2 | 32          | C4280-555             | Relay-Reverse Current,125VDC,C4280-025 Case  | SMC              | 1     |
|                              | 72          | FBK-S-8000 (BY DESC.) | Breaker-8000A,800VDC,1P,"00",D/O,E/O,125vdc Cont.,12 Aux Sw,Kirk Lock Prov.,Permissive switch,Shutter Act.,Nr Operations Counter, ODFBK-10A Trip Device,W/Wheel Assembly | ABB              | 1     |
|                              | 76          | C4280-509             | Relay-Dc Overcurrent,100ms TD,Variable Pwr Supply (24-125VDC),Uni/BI Directional,C4280-025 Case  | SMC              | 1     |
|                              | 01X         | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec             | 1     |
|                              | 33B         | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D         | 1     |
|                              | 43M/A       | 24201B                | Control Switch-2 position,maintained,Manual/Auto,Escutcheon engraved per Sketch #2   | Electroswitch    | 1     |
|                              | 72/TOC      | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|                              |             | 836876T01             | Actuator Assy.-Includes Plunger, Spring,and Hardware   | ABB              | 1     |
|                              | 72CS        | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|                              | 72SD        | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|                              | AM          | 103-111-FGXX          | Ammeter-0-2ma Rated,0-20ka Dc Scale  | Yokogawa         | 1     |
|                              | AM/HTR      | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|                              | COND        | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)          | 3     |
|                              | COND-B      | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-F      | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-LN     | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64527 |
|-----|-------|

| Sum of QTY               |                      |                       |  |                              |       |
|--------------------------|----------------------|-----------------------|--|------------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                          | FU5-8,FU11-15        | PSI20X127PRE          | Fuse Holder  | Ferraz                       | 9     |
|                          |                      | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                       | 9     |
|                          | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                          | K1                   | KFX002510SM           | Key Interlock, Type FX,With 1/4" Bolt Projection, Key Removable in Extended Position   | ABB                          | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                          | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                          | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                         | 1     |
|                          | SH                   | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                          | SHUNT                | H-10000-50            | Shunt-10000A, 50mv   | Canadian Shunt               | 1     |
|                          | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                          | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                          | TBJ,TBG,CTB          | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 8     |
|                          | XD-A                 | 3299-518              | Transducer-Current,0-50mv In,0-1ma Out   | SMC                          | 1     |
|                          | XD-W                 | 3299-787              | Transducer-Watt,0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT  | SMC                          | 1     |
| Unit No.4<br>Feeder No.6 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                          | 72CS                 | 2457D                 | Switch-Breaker Control   | Electroswitch                | 1     |
|                          | AM                   | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                          | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                          | COND                 | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                          | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                          | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY               |                      |                       |  |                              |       |
|--------------------------|----------------------|-----------------------|--|------------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                     | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                          | FU5,6                | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                       | 2     |
|                          | FU5-6,9-10           | PSI20X127PRE          | Fuse Holder  | Ferraz                       | 4     |
|                          | FU9-10               | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                          | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                          | LMR                  | C3313                 | Resistor-Load Measuring  | SMC                          | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                          | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                          | RB08                 | SR2P-06               | Relay Base-8 Pin   | Idec                         | 2     |
|                          | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                         | 3     |
|                          | SA                   | 6007-003              | Surge Arrestor-750VDC  | SMC                          | 1     |
|                          | SC/C,SC/T            | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                          | SH                   | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                          | SHUNT                | H-5000-50             | Shunt-5000A, 50mv  | Canadian Shunt               | 1     |
|                          | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                          | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                          | TBJ,TBG,CTB,TB       | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 9     |
|                          | TM-1                 | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                       | 5     |
|                          | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
| Unit No.5<br>Feeder No.5 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96

Revision Date: 2/24/97

Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY                   |                |                       |  |                  |       |
|------------------------------|----------------|-----------------------|--|------------------|-------|
| UNIT                         | DESIG.         | PART NO.              | DESCRIPTION  | MFG.             | Total |
|                              | 72CS           | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|                              | AM             | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa         | 1     |
|                              | AM/HTR         | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|                              | COND           | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2", Cut to Length,Bend as Required  | (blank)          | 3     |
|                              | COND-B         | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-F         | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-LN        | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|                              | D1             | 1N4007                | Diode-1000V,1A   | Motorola         | 1     |
|                              | DS-CP          | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|                              | FU1,2          | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|                              | FU1-4          | J60030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|                              | FU3,4          | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|                              | FU5,6          | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 2     |
|                              | FU5-6,9-10     | PSI20X127PRE          | Fuse Holder  | Ferraz           | 4     |
|                              | FU9-10         | D100RB025V            | Fuse-1000VDC,25A   | Ferraz           | 2     |
|                              | INS-SH         | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|                              | LMR            | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|                              | LT1            | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|                              | LT2            | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|                              | LT3            | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|                              | RB08           | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|                              | RB11           | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|                              | SA             | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|                              | SC/C,SC/T      | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|                              | SH             | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|                              | SHUNT          | H-5000-50             | Shunt-5000A, 50mv  | Canadian Shunt   | 1     |
|                              | TBA            | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|                              | TBB,TBF,TBH    | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 3     |
|                              | TBJ,TBG,CTB,TB | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 9     |
|                              | TM-1           | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy           | 5     |
|                              | XD-V           | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC              | 1     |
| Unit No.6<br>Cathode<br>No.1 | 32             | C4280-555             | Relay-Reverse Current,125VDC,C4280-025 Case  | SMC              | 1     |
|                              | 72             | FBK-S-8000 (BY DESC.) | Breaker-8000A,800VDC,1P,"00",D/O,E/O,125vdc Cont.,12 Aux Sw,Kirk Lock Prov.,Permissive switch,Shutter Act.,Nr Operations Counter, ODFBK-10A Trip Device,W/Wheel Assembly | ABB              | 1     |
|                              | 76             | C4280-509             | Relay-Dc Overcurrent,100ms TD,Variable Pwr Supply (24-125VDC),Uni/BI Directional,C4280-025 Case  | SMC              | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY               |                |                       |   |                              |       |
|--------------------------|----------------|-----------------------|---|------------------------------|-------|
| UNIT                     | DESIG.         | PART NO.              | DESCRIPTION   | MFG.                         | Total |
|                          | 01X            | RR3PAULDC110          | Relay-Control, TPDT, 110vdc Coil  | Idec                         | 1     |
|                          | 33B            | 9007-AP221            | Switch-Limit, 1no, 1nc, Plunger Type  | Square D                     | 1     |
|                          | 43M/A          | 24201B                | Control Switch-2 position, maintained, Manual/Auto, Escutcheon engraved per Sketch #2   | Electroswitch                | 1     |
|                          | 72/TOC         | 271887T03             | Cell Switch-8 Contact with Crank and Stud   | ABB                          | 1     |
|                          |                | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                          | 1     |
|                          | 72CS           | 2457D                 | Switch-Breaker Control  | Electroswitch                | 1     |
|                          | 72SD           | 271985T01             | Secondary Disconnect for Type FBK Breaker   | ABB                          | 4     |
|                          | AM             | 103-111-FGXX          | Ammeter-0-2ma Rated, 0-20ka Dc Scale  | Yokogawa                     | 1     |
|                          | AM/HTR         | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled   | Modutec                      | 1     |
|                          | COND           | EMT-1-1/2"            | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required   | (blank)                      | 3     |
|                          | COND-B         | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                          | COND-F         | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                          | COND-LN        | LN-105                | Locknut for 1-1/2" Conduit  | Neer                         | 4     |
|                          | DS-CP          | A-1102                | Disconnect Switch-250VDC, 30A   | Filnor                       | 1     |
|                          | FU1,2          | JKS-30                | Fuse-600Vac, 200Vdc, 30A  | Buss                         | 2     |
|                          | FU1-4          | J60030-2S             | Fuse Holder, 2P, 600V   | Buss                         | 2     |
|                          | FU3,4          | JKS-20                | Fuse-600Vac, 200Vdc, 20A  | Buss                         | 2     |
|                          | FU5-8, FU11-15 | PS120X127PRE          | Fuse Holder   | Ferraz                       | 9     |
|                          |                | D100RB010V            | Fuse-1000VDC, 10A   | Ferraz                       | 9     |
|                          | INS-SH         | 255716                | Bushing-Secondary Insulation  | Chromolox                    | 1     |
|                          | K2             | KFX002510SM           | Key Interlock, Type FX, With 1/4" Bolt Projection, Key Removable in Extended Position   | ABB                          | 1     |
|                          | LT1            | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red   | Control Concepts             | 1     |
|                          | LT2            | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green   | Control Concepts             | 1     |
|                          | LT3            | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White   | Control Concepts             | 1     |
|                          | RB11           | SR3P-06               | Relay Base-11 Pin   | Idec                         | 1     |
|                          | SH             | S-815131123           | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                          | SHUNT          | H-10000-50            | Shunt-10000A, 50mv  | Canadian Shunt               | 1     |
|                          | TBA            | 264B903G20            | Terminal Block-600V, 100A, 2pt  | General Electric             | 1     |
|                          | TBB, TBF       | EB25B04C              | Terminal Block-600v, 4pt, W/Cover, Ring Term.   | General Electric             | 2     |
|                          | TBJ, TBG, CTB  | EB25B12C              | Terminal Block-600v, 12pt, W/Cover, Ring Term.  | General Electric             | 8     |
|                          | XD-A           | 3299-518              | Transducer-Current, 0-50mv In, 0-1ma Out  | SMC                          | 1     |
|                          | XD-W           | 3299-787              | Transducer-Watt, 0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT  | SMC                          | 1     |
| Unit No.7<br>Feeder No.3 | 129            | LTNS60-SDAJ           | Dc Contactor-750 VDC, 60A, 2P   | Microelectronica Scientifica | 1     |
|                          | 150            | C4280-508             | Relay-Dc Overcurrent, Variable Pwr Supply (24-125VDC), Uni/Bi Directional, C4280-025 Case   | SMC                          | 1     |
|                          | 172            | FBK-S-6000 (BY DESC.) | Breaker-6000A, 800VDC, 1P, "01", D/O, E/O, 125vdc Cont., 12 Aux Sw, Permissive Switch, UVR, Shutter Act., Nr Operations Counter, ODFBK-7A Trip Device, W/Wheel Assembly | ABB                          | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64527

| Sum of QTY |                      |                |  |                  |       |
|------------|----------------------|----------------|--|------------------|-------|
| UNIT       | DESIG.               | PART NO.       | DESCRIPTION  | MFG.             | Total |
|            | 182                  | C4280-560      | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC), C4280-026 Case                    | SMC              | 1     |
|            | 01X,182/LOX,ETS<br>X | RR3PAULDC110   | Relay-Control, TPDT, 110vdc Coil   | Idec             | 3     |
|            | 172/TOC              | 271887T03      | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|            |                      | 836876T01      | Actuator Assy.-Includes Plunger, Spring, and Hardware                                  | ABB              | 1     |
|            | 172SD                | 271985T01      | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|            | 33B                  | 9007-AP221     | Switch-Limit, 1no, 1nc, Plunger Type   | Square D         | 1     |
|            | 43L/R                | 24201B         | Control Switch-2 position, maintained, Local/Remote, Escutcheon engraved per Sketch #1 | Electroswitch    | 1     |
|            | 72CS                 | 2457D          | Switch-Breaker Control   | Electroswitch    | 1     |
|            | AM                   | 103-124-AEXX   | Ammeter-100-0-100mv Rated, 15KA-0-15KA DC Scale  | Yokogawa         | 1     |
|            | AM/HTR               | 2PB-AAC-001    | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|            | COND                 | EMT-1-1/2"     | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required                          | (blank)          | 3     |
|            | COND-B               | PB500D         | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-F               | TC-505         | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-LN              | LN-105         | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|            | D1                   | 1N4007         | Diode-1000V, 1A  | Motorola         | 1     |
|            | DS-CP                | A-1102         | Disconnect Switch-250VDC, 30A  | Filnor           | 1     |
|            | FU1,2                | JKS-30         | Fuse-600Vac, 200Vdc, 30A   | Buss             | 2     |
|            | FU1-4                | J60030-2S      | Fuse Holder, 2P, 600V  | Buss             | 2     |
|            | FU3,4                | JKS-20         | Fuse-600Vac, 200Vdc, 20A   | Buss             | 2     |
|            | FU5-10               | PSI20X127PRE   | Fuse Holder  | Ferraz           | 6     |
|            | FU5-8                | D100RB010V     | Fuse-1000VDC, 10A  | Ferraz           | 4     |
|            | FU9-10               | D100RB025V     | Fuse-1000VDC, 25A  | Ferraz           | 2     |
|            | INS-SH               | 255716         | Bushing-Secondary Insulation   | Chromolox        | 1     |
|            | LMR                  | C3313          | Resistor-Load Measuring  | SMC              | 1     |
|            | LT1                  | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|            | LT2                  | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|            | LT3                  | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|            | RB08                 | SR2P-06        | Relay Base-8 Pin   | Idec             | 2     |
|            | RB11                 | SR3P-06        | Relay Base-11 Pin  | Idec             | 3     |
|            | SA                   | 6007-003       | Surge Arrestor-750VDC  | SMC              | 1     |
|            | SC/C, SC/T           | RR2PAULDC24    | Relay-Control, DPDT, 24vdc Coil  | Idec             | 2     |
|            | SH                   | S-815131123    | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)          | Chromolox        | 1     |
|            | SHUNT                | H-7500-50      | Shunt-7500A, 50mV  | Canadian Shunt   | 1     |
|            | TBA                  | 264B903G20     | Terminal Block-600V, 100A, 2pt   | General Electric | 1     |
|            | TBB, TBF             | EB25B04C       | Terminal Block-600v, 4pt, W/Cover, Ring Term.  | General Electric | 2     |
|            | TBJ, TBG, CTB        | EB25B12C       | Terminal Block-600v, 12pt, W/Cover, Ring Term.   | General Electric | 8     |
|            | TM-1                 | YA44-2N        | Terminal-Type YA, 1000 KCMIL, Long Barrell, Double Indent, Nema 2-Hole Pad             | Burdny           | 5     |



**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64527 |
|-----|-------|

| Sum of QTY               |                      |                       |   |                            |       |
|--------------------------|----------------------|-----------------------|---|----------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION   | MFG.                       | Total |
| Unit No.8<br>Feeder No.1 | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out  | SMC                        | 1     |
|                          | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P   | Microelectrica Scientifica | 1     |
|                          | 150                  | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC                        | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Permissive Switch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                        | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case   | SMC                        | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil  | Idec                       | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud   | ABB                        | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                        | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker   | ABB                        | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type   | Square D                   | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1   | Electroswitch              | 1     |
|                          | 72CS                 | 2457D                 | Switch-Breaker Control  | Electroswitch              | 1     |
|                          | AM                   | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale  | Yokogawa                   | 1     |
|                          | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled   | Modutec                    | 1     |
|                          | COND                 | EMT-1-1/2"            | Condiut-EMT Thinwall,1-1/2",Cut to Length,Bend as Required  | (blank)                    | 3     |
|                          | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                          | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit  | Neer                       | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A  | Motorola                   | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A  | Filnor                     | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A  | Buss                       | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V   | Buss                       | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A  | Buss                       | 2     |
|                          | FU5-10               | PSI20X127PRE          | Fuse Holder   | Ferraz                     | 6     |
|                          | FU5-8                | D100RB010V            | Fuse-1000VDC,10A  | Ferraz                     | 4     |
|                          | FU9-10               | D100RB025V            | Fuse-1000VDC,25A  | Ferraz                     | 2     |
|                          | INS-SH               | 255718                | Bushing-Secondary Insulation  | Chromolox                  | 1     |
|                          | LMR                  | C3313                 | Resistor-Load Measuring   | SMC                        | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red   | Control Concepts           | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green   | Control Concepts           | 1     |
|                          | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White   | Control Concepts           | 1     |
|                          | RB08                 | SR2P-06               | Relay Base-8 Pin  | Idec                       | 2     |
| RB11                     | SR3P-06              | Relay Base-11 Pin     | Idec  | 3                          |       |
| SA                       | 6007-003             | Surge Arrestor-750VDC | SMC   | 1                          |       |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64527 |
|-----|-------|

| Sum of QTY                   |               |                       |  |                  |       |
|------------------------------|---------------|-----------------------|--|------------------|-------|
| UNIT                         | DESIG.        | PART NO.              | DESCRIPTION  | MFG.             | Total |
|                              | SC/C,SC/T     | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|                              | SH            | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromotox        | 1     |
|                              | SHUNT         | H-5000-50             | Shunt-5000A, 50mv  | Canadian Shunt   | 1     |
|                              | TBA           | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|                              | TBB,TBF       | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 2     |
|                              | TBJ,TBG,CTB   | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 8     |
|                              | TM-1          | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy           | 5     |
|                              | XD-V          | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC              | 1     |
| Unit No.9<br>Cathode<br>No.3 | 32            | C4280-555             | Relay-Reverse Current,125VDC,C4280-025 Case  | SMC              | 1     |
|                              | 64            | C4280-600             | Relay-Ground Structure,Variable Pwr Supply (24-125VDC),C4280-027 Case  | SMC              | 1     |
|                              | 72            | FBK-S-6000 (BY DESC.) | Breaker-6000A,800VDC,1p,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Kirk Lock Prov.,Permissive switch,Shutter Act.,Nr Operations Counter, ODFBK-10A Trip Device,W/Wheel Assembly | ABB              | 1     |
|                              | 76            | C4280-509             | Relay-Dc Overcurrent,100ms TD,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC              | 1     |
|                              | 186           | 7805D                 | Relay-Lock Out   | Electroswitch    | 1     |
|                              | 01X,64D,64Y   | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec             | 3     |
|                              | 33B           | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D         | 1     |
|                              | 43M/A         | 24201B                | Control Switch-2 position,maintained,Manual/Auto,Escutcheon engraved per Sketch #2   | Electroswitch    | 1     |
|                              | 72/TOC        | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|                              |               | 836876T01             | Actuator Assy.-Includes Plunger,Spring,and Hardware  | ABB              | 1     |
|                              | 72CS          | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|                              | 72SD          | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|                              | AM            | 103-111-FGXX          | Ammeter-0-2ma Rated,0-15KA DC Scale  | Yokogawa         | 1     |
|                              | AM/HTR        | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|                              | COND          | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2", Cut to Length,Bend as Required  | (blank)          | 3     |
|                              | COND-B        | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-F        | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-LN       | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|                              | DS-CP         | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|                              | FU1,2         | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|                              | FU1-4         | J60030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|                              | FU3,4         | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|                              | FU5-8,FU11-15 | PSI20X127PRE          | Fuse Holder  | Ferraz           | 9     |
|                              |               | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 9     |
|                              | INS-SH        | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|                              | K3            | KFX002510SM           | Key Interlock,Type FX,With 1/4" Bolt Projection, Key Removable in Extended Position  | ABB              | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GRANT CIRCLE TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64527 |
|-----|-------|

| Sum of QTY |                |                |  |                  |       |
|------------|----------------|----------------|--|------------------|-------|
| UNIT       | DESIG.         | PART NO.       | DESCRIPTION  | MFG.             | Total |
|            | LT1            | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|            | LT2,LT4        | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green  | Control Concepts | 2     |
|            | LT3            | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|            | LT5            | 22RL120LYXPLAR | Ind. Light-LED, 125VDC, Amber  | Control Concepts | 1     |
|            | RB11           | SR3P-06        | Relay Base-11 Pin  | Idec             | 3     |
|            | SH             | S-815131123    | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac) | Chromolox        | 1     |
|            | SHUNT          | H-7500-50      | Shunt-7500A, 50MV  | Canadian Shunt   | 1     |
|            | TBA,TBF        | 264B903G20     | Terminal Block-600V,100A,2pt   | General Electric | 2     |
|            | TBB            | EB25B04C       | Terminal Block-600v,4pt,W/Cover,Ring Term.                                 | General Electric | 1     |
|            | TBJ,TBG,CTB,TB | EB25B12C       | Terminal Block-600v,12pt,W/Cover,Ring Term.                                | General Electric | 11    |
|            | TH             | 2E206          | Thermostat-SPDT 30-110 Deg F Adj   | Dayton           | 1     |
|            | VM             | 103-111-FAXX   | Voltmeter-0-1ma Rated,0-1KV DC Scale                                       | Yokogawa         | 1     |
|            | XD-A           | 3299-518       | Transducer-Current,0-50mv In,0-1ma Out                                     | SMC              | 1     |
|            | XD-V           | 3181-071       | Transducer-Voltage,0-800vdc In,0-1ma Out                                   | SMC              | 1     |
|            | XD-W           | 3299-787       | Transducer-Watt,0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT                      | SMC              | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY               |                      |                       |  |                             |       |
|--------------------------|----------------------|-----------------------|--|-----------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                        | Total |
|                          | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric            | 1     |
|                          | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric            | 2     |
|                          | TBJ,TBG,CTB          | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric            | 8     |
|                          | XD-A                 | 3299-518              | Transducer-Current,0-50mv In,0-1ma Out   | SMC                         | 1     |
|                          | XD-W                 | 3299-787              | Transducer-Watt,0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT  | SMC                         | 1     |
| Unit No.2<br>Feeder No.2 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifca | 1     |
|                          | 150                  | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case   | SMC                         | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                         | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                         | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                        | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                         | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                         | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                         | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                    | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch               | 1     |
|                          | 72CS                 | 2457D                 | Switch-Breaker Control   | Electroswitch               | 1     |
|                          | AM                   | 103-124-AEEX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                    | 1     |
|                          | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                     | 1     |
|                          | COND                 | EMT-1-1/2"            | Condiut-EMT Thinwall,1-1/2", Cut to Length,Bend as Required  | (blank)                     | 3     |
|                          | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                        | 4     |
|                          | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                        | 4     |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                        | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                    | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                      | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                        | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                        | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                        | 2     |
|                          | FU5-10               | PSI20X127PRE          | Fuse Holder  | Ferraz                      | 6     |
|                          | FU5-8                | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                      | 4     |
|                          | FU9-10               | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                      | 2     |
|                          | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                   | 1     |
|                          | LMR                  | C3313                 | Resistor-Load Measuring  | SMC                         | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts            | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts            | 1     |

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

**BILL OF MATERIAL**

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64552

| Sum of QTY  |                   |                       |   |                              |       |
|-------------|-------------------|-----------------------|---|------------------------------|-------|
| UNIT        | DESIG.            | PART NO.              | DESCRIPTION   | MFG.                         | Total |
|             | LT3               | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White   |                              |       |
|             | RB08              | SR2P-06               | Relay Base-8 Pin  | Control Concepts             | 1     |
|             | RB11              | SR3P-06               | Relay Base-11 Pin   | Idec                         | 2     |
|             | SA                | 6007-003              | Surge Arrester-750VDC   | Idec                         | 3     |
|             | SC/C,SC/T         | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil   | SMC                          | 1     |
|             | SH                | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)  | Idec                         | 2     |
|             | SHUNT             | H-5000-50             | Shunt-5000A, 50mv, Silver Plated  | Chromolox                    | 1     |
|             | TBA               | 264B903G20            | Terminal Block-600V,100A,2pt  | Canadian Shunt               | 1     |
|             | TBB,TBF           | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.  | General Electric             | 1     |
|             | TBJ,TBG,CTB       | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.   | General Electric             | 2     |
|             | TM-1              | YA44-2N               | Terminal-Type YA,1000 KCMIL, Long Barrell, Double Indent,Nema 2-Hole Pad  | General Electric             | 8     |
|             | XD-V              | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out  | Bumdy                        | 5     |
| Unit No.3   | 129               | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P   | SMC                          | 1     |
| Feeder No.4 |                   |                       |   | Microelectronica Scientifica | 1     |
|             | 150               | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC                          | 1     |
|             | 172               | FBK-S-6000 (BY DESC.) | Breaker-6000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Permissive Switch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|             | 182               | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case   | SMC                          | 1     |
|             | 01X,182/LOX,ETS X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil  | Idec                         | 3     |
|             | 172/TOC           | 271887T03             | Cell Switch-8 Contact with Crank and Stud   |                              |       |
|             |                   | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                          | 1     |
|             | 172SD             | 271985T01             | Secondary Disconnect for Type FBK Breaker   | ABB                          | 1     |
|             | 33B               | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type   | ABB                          | 4     |
|             | 43LR              | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1   | Square D                     | 1     |
|             | 72CS              | 2457D                 | Switch-Breaker Control  | Electroswitch                | 1     |
|             | AM                | 103-124-AEEXX         | Ammeter-100-0-100mv Rated,15KA-0-15KA DC Scale  | Electroswitch                | 1     |
|             | AM/HTR            | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled   | Yokogawa                     | 1     |
|             | COND              | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2", Cut to Length,Bend as Required   | Modutec                      | 1     |
|             | COND-B            | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit   | (blank)                      | 3     |
|             | COND-F            | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|             | COND-LN           | LN-105                | Locknut for 1-1/2" Conduit  | Neer                         | 4     |
|             | D1                | 1N4007                | Diode-1000V,1A  | Neer                         | 4     |
|             | DS-CP             | A-1102                | Disconnect Switch-250VDC,30A  | Motorola                     | 1     |
|             | FU1,2             | JKS-30                | Fuse-600Vac,200Vdc,30A  | Filnor                       | 1     |
|             | FU1-4             | J60030-2S             | Fuse Holder,2P,600V   | Buss                         | 2     |
|             | FU3,4             | JKS-20                | Fuse-600Vac,200Vdc,20A  | Buss                         | 2     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY               |                      |                        |  |                              |       |
|--------------------------|----------------------|------------------------|--|------------------------------|-------|
| UNIT                     | DESIG.               | PART NO.               | DESCRIPTION  | MFG.                         | Total |
|                          | FU5-6,9-10           | PSI20X127PRE           | Fuse Holder  | Ferraz                       | 6     |
|                          | FU5-8                | D100RB010V             | Fuse-1000VDC,10A   | Ferraz                       | 4     |
|                          | FU9-10               | D100RB025V             | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                          | INS-SH               | 255716                 | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                          | LMR                  | C3313                  | Resistor-Load Measuring  | SMC                          | 1     |
|                          | LT1                  | 22RL120LRXPLRD         | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                          | LT2                  | 22RL120LGXPLGN         | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                          | LT3                  | 22RL120LYXPLWE         | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                          | RB08                 | SR2P-06                | Relay Base-8 Pin   | Idec                         | 2     |
|                          | RB11                 | SR3P-06                | Relay Base-11 Pin  | Idec                         | 3     |
|                          | SA                   | 6007-003               | Surge Arrestor-750VDC  | SMC                          | 1     |
|                          | SC/C,SC/T            | RR2PAULDC24            | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                          | SH                   | S-815131123            | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                          | SHUNT                | H-7500-50              | Shunt-7500A, 50MV,Silver Plated  | Canadian Shunt               | 1     |
|                          | TBA                  | 264B903G20             | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                          | TBB,TBF              | EB25B04C               | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                          | TBJ,TBG,CTB          | EB25B12C               | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 8     |
|                          | TM-1                 | YA44-2N                | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                       | 5     |
|                          | XD-V                 | 3181-071               | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
| Unit No.4<br>Feeder No.6 | 129                  | LTNS60-SDAJ            | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.)  | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                          | 182                  | C4280-560              | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110           | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                          | 172/TOC              | 271887T03<br>836876T01 | Cell Switch-8 Contact with Crank and Stud<br>Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                          | 1     |
|                          | 172SD                | 271985T01              | Secondary Disconnect for Type FBK Breaker  | ABB                          | 1     |
|                          | 33B                  | 9007-AP221             | Switch-Limit,1nc,1nc,Plunger Type  | Square D                     | 1     |
|                          | 43L/R                | 24201B                 | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                          | 72CS                 | 2457D                  | Switch-Breaker Control   | Electroswitch                | 1     |
|                          | AM                   | 103-124-AEXX           | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                          | AM/HTR               | 2PB-AAC-001            | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                          | COND                 | EMT-1-1/2"             | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                          | COND-B               | PB500D                 | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                          | COND-F               | TC-505                 | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY               |                      |                       |  |                              |       |
|--------------------------|----------------------|-----------------------|--|------------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                     | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                          | FU5,6                | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                       | 2     |
|                          | FU5-10               | PSI20X127PRE          | Fuse Holder  | Ferraz                       | 4     |
|                          | FU9-10               | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                          | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                          | LMR                  | C3313                 | Resistor-Load Measuring  | SMC                          | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                          | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                          | RB08                 | SR2P-06               | Relay Base-8 Pin   | Idec                         | 2     |
|                          | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                         | 3     |
|                          | SA                   | 6007-003              | Surge Arrestor-750VDC  | SMC                          | 1     |
|                          | SC/C,SC/T            | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                          | SH                   | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                          | SHUNT                | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt               | 1     |
|                          | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                          | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                          | TBJ,TBG,CTB,TB       | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 9     |
|                          | TM-1                 | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Bumdy                        | 5     |
|                          | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
| Unit No.5<br>Feeder No.1 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                          | 150                  | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case   | SMC                          | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

SO# 64552

| Sum of QTY                   |                |                       |  |                  |       |
|------------------------------|----------------|-----------------------|--|------------------|-------|
| UNIT                         | DESIG.         | PART NO.              | DESCRIPTION  | MFG.             | Total |
|                              | 43L/R          | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch    | 1     |
|                              | 72CS           | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|                              | AM             | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa         | 1     |
|                              | AM/HTR         | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|                              | COND           | EMT-1-1/2"            | Condiut-EMT Thinwall,1-1/2", Cut to Length,Bend as Required  | (blank)          | 3     |
|                              | COND-B         | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-F         | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-LN        | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|                              | D1             | 1N4007                | Diode-1000V,1A   | Motorola         | 1     |
|                              | DS-CP          | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|                              | FU1,2          | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|                              | FU1-4          | J60030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|                              | FU3,4          | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|                              | FU5-10         | PSI20X127PRE          | Fuse Holder  | Ferraz           | 6     |
|                              | FU5-8          | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 4     |
|                              | FU9-10         | D100RB025V            | Fuse-1000VDC,25A   | Ferraz           | 2     |
|                              | INS-SH         | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|                              | LMR            | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|                              | LT1            | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|                              | LT2            | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|                              | LT3            | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|                              | RB08           | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|                              | RB11           | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|                              | SA             | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|                              | SC/C,SC/T      | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|                              | SH             | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|                              | SHUNT          | H-5000-50             | Shunt-5000A, 50mv, Silver Plated   | Canadian Shunt   | 1     |
|                              | TBA            | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|                              | TBB,TBF,TBH    | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 3     |
|                              | TBJ,TBG,CTB,TB | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 9     |
|                              | TM-1           | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy           | 5     |
|                              | XD-V           | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC              | 1     |
| Unit No.6<br>Cathode<br>No.2 | 32             | C4280-555             | Relay-Reverse Current,125VDC,C4280-025 Case  | SMC              | 1     |
|                              | 72             | FBK-S-8000 (BY DESC.) | Breaker-8000A,800VDC,1P,"00",D/O,E/O,125vdc Cont.,12 Aux Sw,Kirk Lock Prov.,Permissive switch,Shutter Act.,Nr Operations Counter, ODFBK-10A Trip Device,W/Wheel Assembly | ABB              | 1     |



**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage S6E-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY               |               |                |   |                            |       |
|--------------------------|---------------|----------------|---|----------------------------|-------|
| UNIT                     | DESIG.        | PART NO.       | DESCRIPTION   | MFG.                       | Total |
|                          | 76            | C4280-509      | Relay-Dc Overcurrent,100ms TD,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case | SMC                        | 1     |
|                          | 01X           | RR3PAULDC110   | Relay-Control,TPDT,110vdc Coil  | Idec                       | 1     |
|                          | 33B           | 9007-AP221     | Switch-Limit,1no,1nc,Plunger Type   | Square D                   | 1     |
|                          | 43M/A         | 24201B         | Control Switch-2 position,maintained,Manual/Auto,Escutcheon engraved per Sketch #2              | Electroswitch              | 1     |
|                          | 72/TOC        | 271887T03      | Cell Switch-8 Contact with Crank and Stud   | ABB                        | 1     |
|                          |               | 836876T01      | Actuator Assy.-Includes Plunger, Spring,and Hardware  | ABB                        | 1     |
|                          | 72CS          | 2457D          | Switch-Breaker Control  | Electroswitch              | 1     |
|                          | 72SD          | 271985T01      | Secondary Disconnect for Type FBK Breaker   | ABB                        | 4     |
|                          | AM            | 103-111-FGXX   | Ammeter-0-2ma Rated,0-20ka Dc Scale   | Yokogawa                   | 1     |
|                          | AM/HTR        | 2PB-AAC-001    | Ammeter-0-1A Rated And Scaled   | Modutec                    | 1     |
|                          | COND          | EMT-1-1/2"     | Conduit-EMT Thinwall,1-1/2", Cut to Length,Bend as Required                                     | (blank)                    | 3     |
|                          | COND-B        | PB500D         | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                          | COND-F        | TC-505         | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                          | COND-LN       | LN-105         | Locknut for 1-1/2" Conduit  | Neer                       | 4     |
|                          | DS-CP         | A-1102         | Disconnect Switch-250VDC,30A  | Filnor                     | 1     |
|                          | FU1,2         | JKS-30         | Fuse-600Vac,200Vdc,30A  | Buss                       | 2     |
|                          | FU1-4         | J60030-2S      | Fuse Holder,2P,600V   | Buss                       | 2     |
|                          | FU3,4         | JKS-20         | Fuse-600Vac,200Vdc,20A  | Buss                       | 2     |
|                          | FU5-8,FU11-15 | PSI20X127PRE   | Fuse Holder   | Ferraz                     | 9     |
|                          |               | D100RB010V     | Fuse-1000VDC,10A  | Ferraz                     | 9     |
|                          | INS-SH        | 255716         | Bushing-Secondary Insulation  | Chromolox                  | 1     |
|                          | K2            | KFX002510SM    | Key Interlock,Type FX,With 1/4" Bolt Projection, Key Removable in Extended Position             | ABB                        | 1     |
|                          | LT1           | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red   | Control Concepts           | 1     |
|                          | LT2           | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green   | Control Concepts           | 1     |
|                          | LT3           | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White   | Control Concepts           | 1     |
|                          | RB11          | SR3P-06        | Relay Base-11 Pin   | Idec                       | 1     |
|                          | SH            | S-815131123    | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)                      | Chromolox                  | 1     |
|                          | SHUNT         | H-10000-50     | Shunt-10000A, 50mv,Silver Plated  | Canadian Shunt             | 1     |
|                          | TBA           | 264B903G20     | Terminal Block-600V,100A,2pt  | General Electric           | 1     |
|                          | TBB,TBF       | EB25B04C       | Terminal Block-600v,4pt,W/Cover,Ring Term.  | General Electric           | 2     |
|                          | TBJ,TBG,CTB   | EB25B12C       | Terminal Block-600v,12pt,W/Cover,Ring Term.   | General Electric           | 8     |
|                          | XD-A          | 3299-518       | Transducer-Current,0-50mv In,0-1ma Out  | SMC                        | 1     |
|                          | XD-W          | 3299-787       | Transducer-Watt,0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT   | SMC                        | 1     |
| Unit No.7<br>Feeder No.3 | 129           | LTNS60-SDAJ    | Dc Contactor-750 VDC,60A,2P   | Microelectrica Scientifica | 1     |
|                          | 150           | C4280-508      | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case          | SMC                        | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY |                   |                       |  |                  |       |
|------------|-------------------|-----------------------|--|------------------|-------|
| UNIT       | DESIG.            | PART NO.              | DESCRIPTION  | MFG.             | Total |
|            | 172               | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB              | 1     |
|            | 182               | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC              | 1     |
|            | 01X,182/LOX,ETS X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec             | 3     |
|            | 172/TOC           | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|            |                   | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB              | 1     |
|            | 172SD             | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|            | 33B               | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D         | 1     |
|            | 43L/R             | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch    | 1     |
|            | 72CS              | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|            | AM                | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa         | 1     |
|            | AM/HTR            | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|            | COND              | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)          | 3     |
|            | COND-B            | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-F            | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-LN           | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|            | D1                | 1N4007                | Diode-1000V,1A   | Motorola         | 1     |
|            | DS-CP             | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|            | FU1,2             | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|            | FU1-4             | J60030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|            | FU3,4             | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|            | FU5-10            | PSI20X127PRE          | Fuse Holder  | Ferraz           | 6     |
|            | FU5-8             | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 4     |
|            | FU9-10            | D100RB025V            | Fuse-1000VDC,25A   | Ferraz           | 2     |
|            | INS-SH            | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|            | LMR               | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|            | LT1               | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|            | LT2               | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|            | LT3               | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|            | RB08              | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|            | RB11              | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|            | SA                | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|            | SC/C,SC/T         | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|            | SH                | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|            | SHUNT             | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt   | 1     |
|            | TBA               | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|            | TBB,TBF           | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 2     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY               |                      |                       |  |                            |       |
|--------------------------|----------------------|-----------------------|--|----------------------------|-------|
| UNIT                     | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                       | Total |
|                          | TBJ,TBG,CTB          | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric           | 8     |
|                          | TM-1                 | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                     | 5     |
|                          | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                        | 1     |
| Unit No.8<br>Feeder No.5 | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectrica Scientifica | 1     |
|                          | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                        | 1     |
|                          | 182                  | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                        | 1     |
|                          | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                       | 3     |
|                          | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                        | 1     |
|                          |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                        | 1     |
|                          | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                        | 4     |
|                          | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                   | 1     |
|                          | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch              | 1     |
|                          | 72CS                 | 2457D                 | Switch-Breaker Control   | Electroswitch              | 1     |
|                          | AM                   | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                   | 1     |
|                          | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                    | 1     |
|                          | COND                 | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                    | 3     |
|                          | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                          | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                          | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                       | 4     |
|                          | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                   | 1     |
|                          | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                     | 1     |
|                          | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                       | 2     |
|                          | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                       | 2     |
|                          | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                       | 2     |
|                          | FU5,6                | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                     | 2     |
|                          | FU5-6,9-10           | PSI20X127PRE          | Fuse Holder  | Ferraz                     | 4     |
|                          | FU9-10               | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                     | 2     |
|                          | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                  | 1     |
|                          | LMR                  | C3313                 | Resistor-Load Measuring  | SMC                        | 1     |
|                          | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts           | 1     |
|                          | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts           | 1     |
|                          | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts           | 1     |
|                          | RB08                 | SR2P-06               | Relay Base-8 Pin   | Idec                       | 2     |
|                          | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                       | 3     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY                   |               |                       |  |                  |       |
|------------------------------|---------------|-----------------------|--|------------------|-------|
| UNIT                         | DESIG.        | PART NO.              | DESCRIPTION  | MFG.             | Total |
|                              | SA            | 8007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|                              | SC/C,SC/T     | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|                              | SH            | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|                              | SHUNT         | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt   | 1     |
|                              | TBA           | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|                              | TBB,TBF       | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 2     |
|                              | TBJ,TBG,CTB   | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 8     |
|                              | TM-1          | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Bumdy            | 5     |
|                              | XD-V          | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC              | 1     |
| Unit No.9<br>Cathode<br>No.3 | 32            | C4280-555             | Relay-Reverse Current,125VDC,C4280-025 Case  | SMC              | 1     |
|                              | 64            | C4280-600             | Relay-Ground Structure,Variable Pwr Supply (24-125VDC),C4280-027 Case  | SMC              | 1     |
|                              | 72            | FBK-S-6000 (BY DESC.) | Breaker-6000A,800VDC,1p,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Kirk Lock Prov.,Permissive switch,Shutter Act.,Nr Operations Counter, ODFBK-10A Trip Device,W/Wheel Assembly | ABB              | 1     |
|                              | 76            | C4280-509             | Relay-Dc Overcurrent,100ms TD,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC              | 1     |
|                              | 186           | 7805D                 | Relay-Lock Out   | Electroswitch    | 1     |
|                              | 01X,64D,64Y   | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec             | 3     |
|                              | 33B           | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D         | 1     |
|                              | 43M/A         | 24201B                | Control Switch-2 position,maintained,Manual/Auto,Escutcheon engraved per Sketch #2   | Electroswitch    | 1     |
|                              | 72/TOC        | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|                              |               | 836876T01             | Actuator Assy.-Includes Plunger, Spring,and Hardware   | ABB              | 1     |
|                              | 72CS          | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|                              | 72SD          | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|                              | AM            | 103-111-FGXX          | Ammeter-0-2ma Rated,0-15KA DC Scale  | Yokogawa         | 1     |
|                              | AM/HTR        | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|                              | COND          | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)          | 3     |
|                              | COND-B        | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-F        | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|                              | COND-LN       | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|                              | DS-CP         | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|                              | FU1,2         | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|                              | FU1-4         | J60030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|                              | FU3,4         | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|                              | FU5-8,FU11-15 | PSI20X127PRE          | Fuse Holder  | Ferraz           | 9     |
|                              |               | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 9     |
|                              | INS-SH        | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**COLUMBIA HEIGHTS TRACTION POWER SUBSTATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64552 |
|-----|-------|

| Sum of QTY |                   |                |   |                  |       |
|------------|-------------------|----------------|---|------------------|-------|
| UNIT       | DESIG.            | PART NO.       | DESCRIPTION   | MFG.             | Total |
|            | K3                | KFX002510SM    | Key Interlock, Type FX, With 1/4" Bolt Projection, Key Removable in Extended Position | ABB              | 1     |
|            | LT1               | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red   | Control Concepts | 1     |
|            | LT2,LT4           | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green   | Control Concepts | 2     |
|            | LT3               | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White   | Control Concepts | 1     |
|            | LT5               | 22RL120LYXPLAR | Ind. Light-LED, 125VDC, Amber   | Control Concepts | 1     |
|            | RB11              | SR3P-06        | Relay Base-11 Pin   | Idec             | 3     |
|            | SH                | S-815131123    | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)         | Chromolox        | 1     |
|            | SHUNT             | H-7500-50      | Shunt-7500A, 50MV, Silver Plated  | Canadian Shunt   | 1     |
|            | TBA, TBF          | 264B903G20     | Terminal Block-600V, 100A, 2pt  | General Electric | 2     |
|            | TBB               | EB25B04C       | Terminal Block-600v, 4pt, W/Cover, Ring Term.   | General Electric | 1     |
|            | TBJ, TBG, CTB, TB | EB25B12C       | Terminal Block-600v, 12pt, W/Cover, Ring Term.  | General Electric | 11    |
|            | TH                | 2E206          | Thermostat-SPDT 30-110 Deg F Adj  | Dayton           | 1     |
|            | VM                | 103-111-FAXX   | Voltmeter-0-1ma Rated, 0-1KV DC Scale   | Yokogawa         | 1     |
|            | XD-A              | 3299-518       | Transducer-Current, 0-50mv In, 0-1ma Out  | SMC              | 1     |
|            | XD-V              | 3181-071       | Transducer-Voltage, 0-800vdc In, 0-1ma Out  | SMC              | 1     |
|            | XD-W              | 3299-787       | Transducer-Watt, 0-1000VDC; 0-50mv INPUT; 0-1ma OUTPUT                                | SMC              | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/98  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY                       |                      |  |  |                              |       |
|----------------------------------|----------------------|--|--|------------------------------|-------|
| UNIT                             | DESIG.               | PART NO.   | DESCRIPTION  | MFG.                         | Total |
| Nameplate                        | NAMEPLATE            | 32-0314-00-301   | Equipment Nameplate-Stamp as follows: Use SO# for S/N, Model No. FBK-94, 700 Volts, 800 Max Volts, 125KA SC Amps, DC Hz                                    | SMC                          | 1     |
| Nametags                         | NAMETAGS             | BY DESCRIPTION   | Nametags;3-Ply Laminated Plastic,Beveled Edges,Black w/White Core,Drill for #6-32 Stainless Steel Screws,Per Attached List                                 | Promark                      | 1     |
| Unit No.1<br>Tie Breaker<br>No.3 | 01X,182/LOX,ETS<br>X | RR3PAULDC110   | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                                  | 129                  | LTNS60-SDAJ  | Dc Contactor-750 VDC,80A,2P  | Microelectronica Scientifica | 1     |
|                                  | 150                  | C4280-508  | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/BI Directional,C4280-025 Case   | SMC                          | 1     |
|                                  | 172                  | FBK-S-4000 (BY DESC.)  | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 182                  | C4280-580  | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                                  | 43L/R                | 24201B   | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS                 | 2457D  | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM                   | 103-124-AEXX   | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR               | 2PB-AAC-001  | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | DS-CP                | A-1102   | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                                  | FU1,2                | JKS-30   | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4                | J60030-2S  | Fuse Holder,2P,600V  | Buss                         | 2     |
|                                  | FU3,4                | JKS-20   | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                                  | FU5-10               | PSI20X127PRE   | Fuse Holder  | Ferraz                       | 6     |
|                                  | FU5-8                | D100RB010V   | Fuse-1000VDC,10A   | Ferraz                       | 4     |
|                                  | FU9-10               | D100RB025V   | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                                  | INS-SH               | 255716   | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                                  | LMR                  | C3313  | Resistor-Load Measuring  | SMC                          | 1     |
|                                  | LT1                  | 22RL120LRXPLRD   | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                                  | LT2                  | 22RL120LGXPLGN   | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3                  | 22RL120LYXPLWE   | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08                 | SR2P-06  | Relay Base-8 Pin   | Idec                         | 2     |
|                                  | RB11                 | SR3P-06  | Relay Base-11 Pin  | Idec                         | 3     |
|                                  | SA                   | 6007-003   | Surge Arrestor-750VDC  | SMC                          | 1     |
|                                  | SC/C,SC/T            | RR2PAULDC24  | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                                  | SH                   | S-815131123  | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                                  | SHUNT                | H-5000-50  | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt               | 1     |
|                                  | TBA                  | 264B903G20   | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                                  | TBB,TBF              | EB25B04C   | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                                  | TBJ,TBG,CTB          | EB25B12C   | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 8     |
| TM-1                             | YA44-2N              | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad | Burdny   | 5                            |       |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY                       |                      |                       |  |                              |       |
|----------------------------------|----------------------|-----------------------|--|------------------------------|-------|
| UNIT                             | DESIG.               | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                                  | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
|                                  | D1                   | 1N4007                | Diode-1000V,1A   | Motorola                     | 1     |
|                                  | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                                  | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                                  |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                                  | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                                  | COND                 | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2", Cut to Length, Bend as Required   | (blank)                      | 3     |
|                                  | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
| Unit No.2<br>Tie Breaker<br>No.4 | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                                  | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                                  | 150                  | C4280-508             | Relay-Dc Overcurrent, Variable Pwr Supply (24-125VDC), Uni/Bi Directional, C4280-025 Case  | SMC                          | 1     |
|                                  | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 182                  | C4280-560             | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC), C4280-026 Case  | SMC                          | 1     |
|                                  | 43L/R                | 24201B                | Control Switch-2 position, maintained, Local/Remote, Escutcheon engraved per Sketch #1   | Electroswitch                | 1     |
|                                  | 72CS                 | 2457D                 | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM                   | 103-124-AEEX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A   | Filhor                       | 1     |
|                                  | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4                | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |
|                                  | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                                  | FU5-10               | PSI20X127PRE          | Fuse Holder  | Ferraz                       | 6     |
|                                  | FU5-8                | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                       | 4     |
|                                  | FU9-10               | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                                  | INS-SH               | 255716                | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                                  | LMR                  | C3313                 | Resistor-Load Measuring  | SMC                          | 1     |
|                                  | LT1                  | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                                  | LT2                  | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3                  | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08                 | SR2P-06               | Relay Base-8 Pin   | Idec                         | 2     |
|                                  | RB11                 | SR3P-06               | Relay Base-11 Pin  | Idec                         | 3     |
|                                  | SA                   | 6007-003              | Surge Arrester-750VDC  | SMC                          | 1     |
|                                  | SC/C,SC/T            | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |

## BILL OF MATERIAL

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY                       |                        |                       |   |                              |       |
|----------------------------------|------------------------|-----------------------|---|------------------------------|-------|
| UNIT                             | DESIG.                 | PART NO.              | DESCRIPTION   | MFG.                         | Total |
|                                  | SH                     | S-815131123           | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                                  | SHUNT                  | H-5000-50             | Shunt-5000A, 50mv, Silver Plated  | Canadian Shunt               | 1     |
|                                  | TBA                    | 264B903G20            | Terminal Block-600V, 100A, 2pt  | General Electric             | 1     |
|                                  | TBB, TBF               | EB25B04C              | Terminal Block-600v, 4pt, W/Cover, Ring Term.   | General Electric             | 2     |
|                                  | TBJ, TBG, CTB          | EB25B12C              | Terminal Block-600v, 12pt, W/Cover, Ring Term.  | General Electric             | 8     |
|                                  | TM-1                   | YA44-2N               | Terminal-Type YA, 1000 KCMIL, Long Barrell, Double Indent, Nema 2-Hole Pad  | Burndy                       | 5     |
|                                  | XD-V                   | 3181-071              | Transducer-Voltage, 0-800vdc In, 0-1ma Out  | SMC                          | 1     |
|                                  | D1                     | 1N4007                | Diode-1000V, 1A   | Motorola                     | 1     |
|                                  | 33B                    | 9007-AP221            | Switch-Limit, 1no, 1nc, Plunger Type  | Square D                     | 1     |
|                                  | 172/TOC                | 271887T03             | Cell Switch-8 Contact with Crank and Stud   | ABB                          | 1     |
|                                  |                        | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                          | 1     |
|                                  | 172SD                  | 271985T01             | Secondary Disconnect for Type FBK Breaker   | ABB                          | 4     |
|                                  | COND                   | EMT-1-1/2"            | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required   | (blank)                      | 3     |
|                                  | COND-F                 | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                                  | COND-B                 | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                                  | COND-LN                | LN-105                | Locknut for 1-1/2" Conduit  | Neer                         | 4     |
| Unit No.3<br>Tie Breaker<br>No.2 | 01X, 182/LOX, ETS<br>X | RR3PAULDC110          | Relay-Control, TPDT, 110vdc Coil  | Idec                         | 3     |
|                                  | 129                    | LTNS60-SDAJ           | Dc Contactor-750 VDC, 60A, 2P   | Microelectronica Scientifica | 1     |
|                                  | 150                    | C4280-508             | Relay-Dc Overcurrent, Variable Pwr Supply (24-125VDC), Uni/Bi Directional, C4280-025 Case   | SMC                          | 1     |
|                                  | 172                    | FBK-S-4000 (BY DESC.) | Breaker-4000A, 800VDC, 1P, "01", D/O, E/O, 125vdc Cont., 12 Aux Sw, Permissive Switch, UVR, Shutter Act., Nr Operations Counter, ODFBK-7A Trip Device, W/Wheel Assembly | ABB                          | 1     |
|                                  | 182                    | C4280-560             | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC), C4280-026 Case   | SMC                          | 1     |
|                                  | 43L/R                  | 24201B                | Control Switch-2 position, maintained, Local/Remote, Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS                   | 2457D                 | Switch-Breaker Control  | Electroswitch                | 1     |
|                                  | AM                     | 103-124-AEEX          | Ammeter-100-0-100mv Rated, 10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR                 | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled   | Modutec                      | 1     |
|                                  | DS-CP                  | A-1102                | Disconnect Switch-250VDC, 30A   | Filnor                       | 1     |
|                                  | FU1, 2                 | JKS-30                | Fuse-600Vac, 200Vdc, 30A  | Buss                         | 2     |
|                                  | FU1-4                  | J60030-2S             | Fuse Holder, 2P, 600V   | Buss                         | 2     |
|                                  | FU3, 4                 | JKS-20                | Fuse-600Vac, 200Vdc, 20A  | Buss                         | 2     |
|                                  | FU5-10                 | PSI20X127PRE          | Fuse Holder   | Ferraz                       | 6     |
|                                  | FU5-8                  | D100RB010V            | Fuse-1000VDC, 10A   | Ferraz                       | 4     |
|                                  | FU9-10                 | D100RB025V            | Fuse-1000VDC, 25A   | Ferraz                       | 2     |
|                                  | INS-SH                 | 255716                | Bushing-Secondary Insulation  | Chromolox                    | 1     |
|                                  | LMR                    | C3313                 | Resistor-Load Measuring   | SMC                          | 1     |
|                                  | LT1                    | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red   | Control Concepts             | 1     |



**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64513

| Sum of QTY                       |                               |                       |  |                              |       |
|----------------------------------|-------------------------------|-----------------------|--|------------------------------|-------|
| UNIT                             | DESIG.                        | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                                  | LT2                           | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3                           | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08                          | SR2P-06               | Relay Base-8 Pin   | Idec                         | 2     |
|                                  | RB11                          | SR3P-06               | Relay Base-11 Pin  | Idec                         | 3     |
|                                  | SA                            | 6007-003              | Surge Arrestor-750VDC  | SMC                          | 1     |
|                                  | SC/C,SC/T                     | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                                  | SH                            | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                                  | SHUNT                         | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt               | 1     |
|                                  | TBA                           | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                                  | TBB,TBF                       | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                                  | TM-1                          | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                       | 5     |
|                                  | XD-V                          | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
|                                  | D1                            | 1N4007                | Diode-1000V,1A   | Motorola                     | 1     |
|                                  | 33B                           | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                                  | 172/TOC                       | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                                  |                               | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                                  | 172SD                         | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                                  | TBJ,TBG,CTB,TB                | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 9     |
|                                  | COND                          | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                                  | COND-F                        | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-B                        | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-LN                       | LN-105                | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
| Unit No.4<br>Tie Breaker<br>No.6 | 01X,182/LOX,64D,<br>64Y,ET SX | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                         | 5     |
|                                  | 129                           | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                                  | 172                           | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 182                           | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                                  | 43L/R                         | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS                          | 2457D                 | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM                            | 103-124-AEEXX         | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR                        | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | DS-CP                         | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                                  | FU1,2                         | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4                         | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |
|                                  | FU3,4                         | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                                  | FU5-6                         | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                       | 2     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96

Revision Date: 2/24/97

Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY                       |                 |                |  |                            |       |
|----------------------------------|-----------------|----------------|--|----------------------------|-------|
| UNIT                             | DESIG.          | PART NO.       | DESCRIPTION  | MFG.                       | Total |
|                                  | FU5-6,9-10      | PSI20X127PRE   | Fuse Holder  | Ferraz                     | 4     |
|                                  | FU9-10          | D100RB025V     | Fuse-1000VDC,25A   | Ferraz                     | 2     |
|                                  | INS-SH          | 255716         | Bushing-Secondary Insulation   | Chromolox                  | 1     |
|                                  | LMR             | C3313          | Resistor-Load Measuring  | SMC                        | 1     |
|                                  | LT1             | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red  | Control Concepts           | 1     |
|                                  | LT2,LT4         | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green  | Control Concepts           | 2     |
|                                  | LT3             | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White  | Control Concepts           | 1     |
|                                  | LT5             | 22RL120LYXPLAR | Ind. Light-LED, 125VDC, Amber  | Control Concepts           | 1     |
|                                  | RB08            | SR2P-06        | Relay Base-8 Pin   | Idec                       | 2     |
|                                  | RB11            | SR3P-06        | Relay Base-11 Pin  | Idec                       | 5     |
|                                  | SA              | 6007-003       | Surge Arrestor-750VDC  | SMC                        | 1     |
|                                  | SC/C,SC/T       | RR2PAULDC24    | Relay-Control,DPDT,24vdc Coil  | Idec                       | 2     |
|                                  | SH              | S-815131123    | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)             | Chromolox                  | 1     |
|                                  | SHUNT           | H-5000-50      | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt             | 1     |
|                                  | TM-1            | YA44-2N        | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad                 | Burndy                     | 5     |
|                                  | XD-V            | 3181-071       | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                        | 1     |
|                                  | 64              | C4280-800      | Relay-Ground Structure,Variable Pwr Supply (24-125VDC),C4280-027 Case                  | SMC                        | 1     |
|                                  | 186             | 7805D          | Relay-Lock Out   | Electroswitch              | 1     |
|                                  | VM              | 103-111-FAXX   | Voltmeter-0-1ma Rated,0-1KV DC Scale   | Yokogawa                   | 1     |
|                                  | D1              | 1N4007         | Diode-1000V,1A   | Motorola                   | 1     |
|                                  | 33B             | 9007-AP221     | Switch-Limit,1no,1nc,Plunger Type  | Square D                   | 1     |
|                                  | 172/TOC         | 271887T03      | Cell Switch-8 Contact with Crank and Stud  | ABB                        | 1     |
|                                  |                 | 836876T01      | Actuator Assy.-Includes Plunger, Spring, and Hardware                                  | ABB                        | 1     |
|                                  | 172SD           | 271985T01      | Secondary Disconnect for Type FBK Breaker  | ABB                        | 4     |
|                                  | TH              | 2E206          | Thermostat-SPDT 30-110 Deg F Adj   | Dayton                     | 1     |
|                                  | TBJ,TBG,CTB,TB  | EB25B12C       | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric           | 10    |
|                                  | TBA,TBF         | 264B903G20     | Terminal Block-600V,100A,2pt   | General Electric           | 2     |
|                                  | TBB,TBH         | EB25B04C       | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric           | 2     |
|                                  | COND            | EMT-1-1/2"     | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required                             | (blank)                    | 3     |
|                                  | COND-F          | TC-505         | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                                  | COND-B          | PB500D         | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                       | 4     |
|                                  | COND-LN         | LN-105         | Locknut for 1-1/2" Conduit   | Neer                       | 4     |
| Unit No.5<br>Tie Breaker<br>No.1 | 01X,182/LOX,ETS | RR3PAULDC110   | Relay-Control,TPDT,110vdc Coil   | Idec                       | 3     |
|                                  | X               |                |  |                            |       |
|                                  | 129             | LTNS60-SDAJ    | Dc Contactor-750 VDC,60A,2P  | Microelectrica Scientifica | 1     |
|                                  | 150             | C4280-508      | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case | SMC                        | 1     |

## BILL OF MATERIAL

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY |             |                       |  |                  |       |
|------------|-------------|-----------------------|--|------------------|-------|
| UNIT       | DESIG.      | PART NO.              | DESCRIPTION  | MFG.             | Total |
|            | 172         | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB              | 1     |
|            | 182         | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC              | 1     |
|            | 43L/R       | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch    | 1     |
|            | 72CS        | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|            | AM          | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa         | 1     |
|            | AM/HTR      | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|            | DS-CP       | A-1102                | Disconnect Switch-250VDC,30A   | Filnor           | 1     |
|            | FU1,2       | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss             | 2     |
|            | FU1-4       | J80030-2S             | Fuse Holder,2P,600V  | Buss             | 2     |
|            | FU3,4       | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss             | 2     |
|            | FU5-10      | PSI20X127PRE          | Fuse Holder  | Ferraz           | 6     |
|            | FU5-8       | D100RB010V            | Fuse-1000VDC,10A   | Ferraz           | 4     |
|            | FU9-10      | D100RB025V            | Fuse-1000VDC,25A   | Ferraz           | 2     |
|            | INS-SH      | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|            | LMR         | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|            | LT1         | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|            | LT2         | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|            | LT3         | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|            | RB08        | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|            | RB11        | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|            | SA          | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|            | SC/C,SC/T   | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec             | 2     |
|            | SH          | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox        | 1     |
|            | SHUNT       | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt   | 1     |
|            | TBA         | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric | 1     |
|            | TBB,TBF     | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric | 2     |
|            | TBJ,TBG,CTB | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric | 8     |
|            | TM-1        | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy           | 5     |
|            | XD-V        | 3181-071              | Transducer-Voltage 0-800vdc In,0-1ma Out   | SMC              | 1     |
|            | D1          | 1N4007                | Diode-1000V,1A   | Motorola         | 1     |
|            | 33B         | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D         | 1     |
|            | 172/TOC     | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|            |             | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB              | 1     |
|            | 172SD       | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|            | COND        | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)          | 3     |
|            | COND-F      | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-B      | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 2/24/97  
Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64513

| Sum of QTY                       |                      |   |  |                              |       |
|----------------------------------|----------------------|---|--|------------------------------|-------|
| UNIT                             | DESIG.               | PART NO.                                  | DESCRIPTION  | MFG.                         | Total |
| Unit No.6<br>Tie Breaker<br>No.5 | COND-LN              | LN-105                                    | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                                  | 01X,182/LOX,ETS<br>X | RR3PAULDC110                              | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                                  | 129                  | LTNS60-SDAJ                               | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                                  | 172                  | FBK-S-4000 (BY DESC.)                     | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 182                  | C4280-560                                 | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                                  | 43L/R                | 24201B                                    | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS                 | 2457D                                     | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM                   | 103-124-AEXX                              | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR               | 2PB-AAC-001                               | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | DS-CP                | A-1102                                    | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                                  | FU1,2                | JKS-30                                    | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4                | J60030-2S                                 | Fuse Holder,2P,600V  | Buss                         | 2     |
|                                  | FU3,4                | JKS-20                                    | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                                  | FU5-6                | D100RB010V                                | Fuse-1000VDC,10A   | Ferraz                       | 2     |
|                                  | FU5-6,9-10           | PSI20X127PRE                              | Fuse Holder  | Ferraz                       | 4     |
|                                  | FU9-10               | D100RB025V                                | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                                  | INS-SH               | 255716                                    | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                                  | LMR                  | C3313                                     | Resistor-Load Measuring  | SMC                          | 1     |
|                                  | LT1                  | 22RL120LRXPLRD                            | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                                  | LT2                  | 22RL120LGXPLGN                            | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3                  | 22RL120LYXPLWE                            | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08                 | SR2P-06                                   | Relay Base-8 Pin   | Idec                         | 2     |
|                                  | RB11                 | SR3P-06                                   | Relay Base-11 Pin  | Idec                         | 3     |
|                                  | SA                   | 6007-003                                  | Surge Arrestor-750VDC  | SMC                          | 1     |
|                                  | SC/C,SC/T            | RR2PAULDC24                               | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                                  | SH                   | S-815131123                               | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                                  | SHUNT                | H-5000-50                                 | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt               | 1     |
|                                  | TBA                  | 264B903G20                                | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                                  | TBB,TBF              | EB25B04C                                  | Terminal Block-600v,4pt,W/Cover, Ring Term.  | General Electric             | 2     |
|                                  | TBJ,TBG,CTB          | EB25B12C                                  | Terminal Block-600v,12pt,W/Cover, Ring Term.   | General Electric             | 8     |
|                                  | TM-1                 | YA44-2N                                   | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                       | 5     |
|                                  | XD-V                 | 3181-071                                  | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
|                                  | D1                   | 1N4007                                    | Diode-1000V,1A   | Motorola                     | 1     |
| 33B                              | 9007-AP221           | Switch-Limit,1no,1nc,Plunger Type         | Square D   | 1                            |       |
| 172/TOC                          | 271887T03            | Cell Switch-8 Contact with Crank and Stud | ABB  | 1                            |       |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
 Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
 Revision Date: 2/24/97  
 Rev. No.: 1

**GEORGIA AVENUE TIE BREAKER STATION  
 DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64513 |
|-----|-------|

| Sum of QTY |         |            |   |         |       |
|------------|---------|------------|---|---------|-------|
| UNIT       | DESIG.  | PART NO.   | DESCRIPTION   | MFG.    | Total |
|            |         | 836876T01  | Actuator Assy.-Includes Plunger, Spring, and Hardware         | ABB     | 1     |
|            | 172SD   | 271985T01  | Secondary Disconnect for Type FBK Breaker                     | ABB     | 4     |
|            | COND    | EMT-1-1/2" | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required | (blank) | 3     |
|            | COND-F  | TC-505     | Connector for 1-1/2" EMT Thinwall Conduit                     | Neer    | 4     |
|            | COND-B  | PB500D     | Bushing for 1-1/2" EMT Thinwall Conduit                       | Neer    | 4     |
|            | COND-LN | LN-105     | Locknut for 1-1/2" Conduit                                    | Neer    | 4     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64539 |
|-----|-------|

| Sum of QTY                       |                      |                           |   |   |               |   |
|----------------------------------|----------------------|---------------------------|---|---|---------------|---|
| UNIT                             | DESIG.               | PART NO.                  | DESCRIPTION   | MFG.  | Total         |   |
| Nameplate                        | NAMEPLATE            | 32-0314-00-301            | Equipment Nameplate-Stamp as follows: Use SO# for S/N, Model No. FBK-94, 700 Volts, 800 Max Volts, 125KA SC Amps, DC Hz                                     | SMC   | 1             |   |
| Nametags                         | NAMETAGS             | BY DESCRIPTION            | Nametags;3-Ply Laminated Plastic,Beveled Edges,Black w/White Core,Drill for #6-32 Stainless Steel Screws,Per Attached List                                  | Promark   | 1             |   |
| Unit No.1<br>Tie Breaker<br>No.2 | 01X,182/LOX,ETS<br>X | RR3PAULDC110              | Relay-Control,TPDT,110vdc Coil  | Idec  | 3             |   |
|                                  |                      | 129 LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P   | Microelectronica Scientifica  | 1             |   |
|                                  |                      | 150 C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC   | 1             |   |
|                                  |                      | 172 FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Permissive Switch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB   | 1             |   |
|                                  |                      | 172/TOC                   | 271887T03   | Cell Switch-8 Contact with Crank and Stud   | ABB           | 1 |
|                                  |                      |                           | 836876T01   | Actuator Assy.-Includes Plunger, Spring, and Hardware                               | ABB           | 1 |
|                                  |                      | 172SD                     | 271985T01   | Secondary Disconnect for Type FBK Breaker   | ABB           | 4 |
|                                  |                      |                           | 182 C4280-560   | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC),C4280-026 Case                  | SMC           | 1 |
|                                  |                      | 33B                       | 9007-AP221  | Switch-Limit,1no,1nc,Plunger Type   | Square D      | 1 |
|                                  |                      | 43L/R                     | 24201B  | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1 | Electroswitch | 1 |
|                                  |                      | 72CS                      | 2457D   | Switch-Breaker Control  | Electroswitch | 1 |
|                                  |                      | AM                        | 103-124-AEEX  | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale                                      | Yokogawa      | 1 |
|                                  |                      | AM/HTR                    | 2PB-AAC-001   | Ammeter-0-1A Rated And Scaled   | Modutec       | 1 |
|                                  |                      | COND                      | EMT-1-1/2"  | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required                       | (blank)       | 3 |
|                                  |                      | COND-B                    | PB500D  | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer          | 4 |
|                                  |                      | COND-F                    | TC-505  | Connector for 1-1/2" EMT Thinwall Conduit   | Neer          | 4 |
|                                  |                      | COND-LN                   | LN-105  | Locknut for 1-1/2" Conduit  | Neer          | 4 |
|                                  |                      | D1                        | 1N4007  | Diode-1000V,1A  | Motorola      | 1 |
|                                  |                      | DS-CP                     | A-1102  | Disconnect Switch-250VDC,30A  | Filnor        | 1 |
|                                  |                      | FU1,2                     | JKS-30  | Fuse-600Vac,200Vdc,30A  | Buss          | 2 |
|                                  |                      | FU1-4                     | J60030-2S   | Fuse Holder,2P,600V   | Buss          | 2 |
|                                  |                      | FU3,4                     | JKS-20  | Fuse-600Vac,200Vdc,20A  | Buss          | 2 |
|                                  |                      | FU5-10                    | PSI20X127PRE  | Fuse Holder   | Ferraz        | 6 |
|                                  | FU5-8                | D100RB010V                | Fuse-1000VDC,10A  | Ferraz  | 4             |   |
|                                  | FU9-10               | D100RB025V                | Fuse-1000VDC,25A  | Ferraz  | 2             |   |
|                                  | INS-SH               | 255716                    | Bushing-Secondary Insulation  | Chromolox   | 1             |   |
|                                  | LMR                  | C3313                     | Resistor-Load Measuring   | SMC   | 1             |   |
|                                  | LT1                  | 22RL120LRXPLRD            | Ind. Light-LED, 125VDC, Red   | Control Concepts  | 1             |   |
|                                  | LT2                  | 22RL120LGXPLGN            | Ind. Light-LED, 125VDC, Green   | Control Concepts  | 1             |   |
|                                  | LT3                  | 22RL120LYXPLWE            | Ind. Light-LED, 125VDC, White   | Control Concepts  | 1             |   |
|                                  | RB08                 | SR2P-06                   | Relay Base-8 Pin  | Idec  | 2             |   |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64539

| Sum of QTY                       |                      |                       |   |                              |       |
|----------------------------------|----------------------|-----------------------|---|------------------------------|-------|
| UNIT                             | DESIG.               | PART NO.              | DESCRIPTION   | MFG.                         | Total |
|                                  | RB11                 | SR3P-06               | Relay Base-11 Pin   | Idec                         | 3     |
|                                  | SA                   | 6007-003              | Surge Arrestor-750VDC   | SMC                          | 1     |
|                                  | SC/C,SC/T            | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil   | Idec                         | 2     |
|                                  | SH                   | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)  | Chromolox                    | 1     |
|                                  | SHUNT                | H-5000-50             | Shunt-5000A, 50mv,Silver Plated   | Canadian Shunt               | 1     |
|                                  | TBA                  | 264B903G20            | Terminal Block-600V,100A,2pt  | General Electric             | 1     |
|                                  | TBB,TBF              | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.  | General Electric             | 2     |
|                                  | TBJ,TBG,CTB          | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.   | General Electric             | 8     |
|                                  | TM-1                 | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad  | Bumdy                        | 5     |
|                                  | XD-V                 | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out  | SMC                          | 1     |
| Unit No.2<br>Tie Breaker<br>No.4 | 01X,182/LOX,ETS<br>X | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil  | Idec                         | 3     |
|                                  | 129                  | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P   | Microelectronica Scientifica | 1     |
|                                  | 150                  | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case  | SMC                          | 1     |
|                                  | 172                  | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,Permissive Switch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 172/TOC              | 271887T03             | Cell Switch-8 Contact with Crank and Stud   | ABB                          | 1     |
|                                  |                      | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware   | ABB                          | 1     |
|                                  | 172SD                | 271985T01             | Secondary Disconnect for Type FBK Breaker   | ABB                          | 4     |
|                                  | 182                  | C4280-560             | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                          | 1     |
|                                  | 33B                  | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type   | Square D                     | 1     |
|                                  | 43L/R                | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1   | Electroswitch                | 1     |
|                                  | 72CS                 | 2457D                 | Switch-Breaker Control  | Electroswitch                | 1     |
|                                  | AM                   | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale  | Yokogawa                     | 1     |
|                                  | AM/HTR               | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled   | Modutec                      | 1     |
|                                  | COND                 | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2", Cut to Length,Bend as Required   | (blank)                      | 3     |
|                                  | COND-B               | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                                  | COND-F               | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                         | 4     |
|                                  | COND-LN              | LN-105                | Locknut for 1-1/2" Conduit  | Neer                         | 4     |
|                                  | D1                   | 1N4007                | Diode-1000V,1A  | Motorola                     | 1     |
|                                  | DS-CP                | A-1102                | Disconnect Switch-250VDC,30A  | Filnor                       | 1     |
|                                  | FU1,2                | JKS-30                | Fuse-600Vac,200Vdc,30A  | Buss                         | 2     |
|                                  | FU1-4                | J60030-2S             | Fuse Holder,2P,600V   | Buss                         | 2     |
|                                  | FU3,4                | JKS-20                | Fuse-600Vac,200Vdc,20A  | Buss                         | 2     |
|                                  | FU5-10               | PSI20X127PRE          | Fuse Holder   | Ferraz                       | 6     |
|                                  | FU5-8                | D100RB010V            | Fuse-1000VDC,10A  | Ferraz                       | 4     |
|                                  | FU9-10               | D100RB025V            | Fuse-1000VDC,25A  | Ferraz                       | 2     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64539

| Sum of QTY                       |             |                       |  |                              |       |
|----------------------------------|-------------|-----------------------|--|------------------------------|-------|
| UNIT                             | DESIG.      | PART NO.              | DESCRIPTION  | MFG.                         | Total |
|                                  | INS-SH      | 255716                | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                                  | LMR         | C3313                 | Resistor-Load Measuring  | SMC                          | 1     |
|                                  | LT1         | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                                  | LT2         | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3         | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08        | SR2P-06               | Relay Base-8 Pin   | Idec                         | 2     |
|                                  | RB11        | SR3P-06               | Relay Base-11 Pin  | Idec                         | 3     |
|                                  | SA          | 6007-003              | Surge Arrestor-750VDC  | SMC                          | 1     |
|                                  | SC/C,SC/T   | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                         | 2     |
|                                  | SH          | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                    | 1     |
|                                  | SHUNT       | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt               | 1     |
|                                  | TBA         | 264B903G20            | Terminal Block-600V,100A,2pt   | General Electric             | 1     |
|                                  | TBB,TBF     | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric             | 2     |
|                                  | TBJ,TBG,CTB | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric             | 8     |
|                                  | TM-1        | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Burndy                       | 5     |
|                                  | XD-V        | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
| Unit No.3<br>Tie Breaker<br>No.6 | 129         | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                                  | 172         | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 172/TOC     | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                                  |             | 836876T01             | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                                  | 172SD       | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                                  | 182         | C4280-560             | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC),C4280-026 Case   | SMC                          | 1     |
|                                  | 33B         | 9007-AP221            | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                                  | 43L/R       | 24201B                | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS        | 2457D                 | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM          | 103-124-AEXX          | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR      | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | COND        | EMT-1-1/2"            | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                                  | COND-B      | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-F      | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-LN     | LN-105                | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                                  | D1          | 1N4007                | Diode-1000V,1A   | Motorola                     | 1     |
|                                  | DS-CP       | A-1102                | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                                  | FU1,2       | JKS-30                | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4       | J60030-2S             | Fuse Holder,2P,600V  | Buss                         | 2     |



**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64539

| Sum of QTY                       |                             |                       |  |                            |       |
|----------------------------------|-----------------------------|-----------------------|--|----------------------------|-------|
| UNIT                             | DESIG.                      | PART NO.              | DESCRIPTION  | MFG.                       | Total |
|                                  | FU3,4                       | JKS-20                | Fuse-600Vac,200Vdc,20A   | Buss                       | 2     |
|                                  | FU9-10                      | D100RB025V            | Fuse-1000VDC,25A   | Ferraz                     | 2     |
|                                  | INS-SH                      | 255716                | Bushing-Secondary Insulation   | Chromolox                  | 1     |
|                                  | LMR                         | C3313                 | Resistor-Load Measuring  | SMC                        | 1     |
|                                  | LT1                         | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts           | 1     |
|                                  | LT3                         | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts           | 1     |
|                                  | RB08                        | SR2P-06               | Relay Base-8 Pin   | Idec                       | 2     |
|                                  | RB11                        | SR3P-06               | Relay Base-11 Pin  | Idec                       | 5     |
|                                  | SA                          | 6007-003              | Surge Arrestor-750VDC  | SMC                        | 1     |
|                                  | SC/C,SC/T                   | RR2PAULDC24           | Relay-Control,DPDT,24vdc Coil  | Idec                       | 2     |
|                                  | SH                          | S-815131123           | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac)   | Chromolox                  | 1     |
|                                  | SHUNT                       | H-5000-50             | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt             | 1     |
|                                  | TM-1                        | YA44-2N               | Terminal-Type YA,1000 KCMIL,Long Barrell,Double Indent,Nema 2-Hole Pad   | Bumdy                      | 5     |
|                                  | XD-V                        | 3181-071              | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                        | 1     |
|                                  | 01X,182/LOX,64D,<br>64Y,ETX | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                       | 5     |
|                                  | 186                         | 7805D                 | Relay-Lock Out   | Electroswitch              | 1     |
|                                  | 64                          | C4280-600             | Relay-Ground Structure,Variable Pwr Supply (24-125VDC),C4280-027 Case  | SMC                        | 1     |
|                                  | FU5-6                       | D100RB010V            | Fuse-1000VDC,10A   | Ferraz                     | 2     |
|                                  | FU5-6,9-10                  | PSI20X127PRE          | Fuse Holder  | Ferraz                     | 4     |
|                                  | LT2,LT4                     | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts           | 2     |
|                                  | LT5                         | 22RL120LYXPLAR        | Ind. Light-LED, 125VDC, Amber  | Control Concepts           | 1     |
|                                  | TBA,TBF                     | 2648903G20            | Terminal Block-600V,100A,2pt   | General Electric           | 2     |
|                                  | TBB                         | EB25B04C              | Terminal Block-600v,4pt,W/Cover,Ring Term.   | General Electric           | 1     |
|                                  | TBJ,TBG,CTB,TB              | EB25B12C              | Terminal Block-600v,12pt,W/Cover,Ring Term.  | General Electric           | 10    |
|                                  | TH                          | 2E206                 | Thermostat-SPDT 30-110 Deg F Adj   | Dayton                     | 1     |
|                                  | VM                          | 103-111-FAXX          | Voltmeter-0-1ma Rated,0-1KV DC Scale   | Yokogawa                   | 1     |
| Unit No.4<br>Tie Breaker<br>No.1 | 01X,182/LOX,ETS<br>X        | RR3PAULDC110          | Relay-Control,TPDT,110vdc Coil   | Idec                       | 3     |
|                                  | 129                         | LTNS60-SDAJ           | Dc Contactor-750 VDC,60A,2P  | Microelectrica Scientifica | 1     |
|                                  | 150                         | C4280-508             | Relay-Dc Overcurrent,Variable Pwr Supply (24-125VDC),Uni/Bi Directional,C4280-025 Case   | SMC                        | 1     |
|                                  | 172                         | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                        | 1     |
|                                  | 172/TOC                     | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB                        | 1     |
|                                  |                             | 836876T01             | Actuator Assy.-Includes Plunger Spring,and Hardware  | ABB                        | 1     |
|                                  | 172SD                       | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB                        | 4     |
|                                  | 182                         | C4280-560             | Relay-Dc Reclosing,Variable Pwr Supply (24-125VDC),C4280-026 Case  | SMC                        | 1     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

SO# 64539

| Sum of QTY                       |                        |                |   |                            |       |
|----------------------------------|------------------------|----------------|---|----------------------------|-------|
| UNIT                             | DESIG.                 | PART NO.       | DESCRIPTION   | MFG.                       | Total |
|                                  | 33B                    | 9007-AP221     | Switch-Limit, 1no, 1nc, Plunger Type  | Square D                   | 1     |
|                                  | 43L/R                  | 24201B         | Control Switch-2 position, maintained, Local/Remote, Escutcheon engraved per Sketch #1    | Electroswitch              | 1     |
|                                  | 72CS                   | 2457D          | Switch-Breaker Control  | Electroswitch              | 1     |
|                                  | AM                     | 103-124-AEXX   | Ammeter-100-0-100mv Rated, 10KA-0-10KA DC Scale   | Yokogawa                   | 1     |
|                                  | AM/HTR                 | 2PB-AAC-001    | Ammeter-0-1A Rated And Scaled   | Modutec                    | 1     |
|                                  | COND                   | EMT-1-1/2"     | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required                             | (blank)                    | 3     |
|                                  | COND-B                 | PB500D         | Bushing for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                                  | COND-F                 | TC-505         | Connector for 1-1/2" EMT Thinwall Conduit   | Neer                       | 4     |
|                                  | COND-LN                | LN-105         | Locknut for 1-1/2" Conduit  | Neer                       | 4     |
|                                  | D1                     | 1N4007         | Diode-1000V, 1A   | Motorola                   | 1     |
|                                  | DS-CP                  | A-1102         | Disconnect Switch-250VDC, 30A   | Filnor                     | 1     |
|                                  | FU1,2                  | JKS-30         | Fuse-600Vac, 200Vdc, 30A  | Buss                       | 2     |
|                                  | FU1-4                  | J60030-2S      | Fuse Holder, 2P, 600V   | Buss                       | 2     |
|                                  | FU3,4                  | JKS-20         | Fuse-600Vac, 200Vdc, 20A  | Buss                       | 2     |
|                                  | FU5-10                 | PSI20X127PRE   | Fuse Holder   | Ferraz                     | 6     |
|                                  | FU5-8                  | D100RB010V     | Fuse-1000VDC, 10A   | Ferraz                     | 4     |
|                                  | FU9-10                 | D100RB025V     | Fuse-1000VDC, 25A   | Ferraz                     | 2     |
|                                  | INS-SH                 | 255716         | Bushing-Secondary Insulation  | Chromolox                  | 1     |
|                                  | LMR                    | C3313          | Resistor-Load Measuring   | SMC                        | 1     |
|                                  | LT1                    | 22RL120LRXPLRD | Ind. Light-LED, 125VDC, Red   | Control Concepts           | 1     |
|                                  | LT2                    | 22RL120LGXPLGN | Ind. Light-LED, 125VDC, Green   | Control Concepts           | 1     |
|                                  | LT3                    | 22RL120LYXPLWE | Ind. Light-LED, 125VDC, White   | Control Concepts           | 1     |
|                                  | RB08                   | SR2P-06        | Relay Base-8 Pin  | Idec                       | 2     |
|                                  | RB11                   | SR3P-06        | Relay Base-11 Pin   | Idec                       | 3     |
|                                  | SA                     | 6007-003       | Surge Arrestor-750VDC   | SMC                        | 1     |
|                                  | SC/C, SC/T             | RR2PAULDC24    | Relay-Control, DPDT, 24vdc Coil   | Idec                       | 2     |
|                                  | SH                     | S-815131123    | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)             | Chromolox                  | 1     |
|                                  | SHUNT                  | H-5000-50      | Shunt-5000A, 50mv, Silver Plated  | Canadian Shunt             | 1     |
|                                  | TBA                    | 264B903G20     | Terminal Block-600V, 100A, 2pt  | General Electric           | 1     |
|                                  | TBB, TBF               | EB25B04C       | Terminal Block-600v, 4pt, W/Cover, Ring Term.   | General Electric           | 2     |
|                                  | TBJ, TBG, CTB          | EB25B12C       | Terminal Block-600v, 12pt, W/Cover, Ring Term.  | General Electric           | 8     |
|                                  | TM-1                   | YA44-2N        | Terminal-Type YA, 1000 KCMIL, Long Barrell, Double Indent, Nema 2-Hole Pad                | Burndy                     | 5     |
|                                  | XD-V                   | 3181-071       | Transducer-Voltage, 0-800vdc In, 0-1ma Out  | SMC                        | 1     |
| Unit No.5<br>Tie Breaker<br>No.3 | 01X, 182/LOX, ETS<br>X | RR3PAULDC110   | Relay-Control, TPDT, 110vdc Coil  | Idec                       | 3     |
|                                  | 129                    | LTNS60-SDAJ    | Dc Contactor-750 VDC, 60A, 2P   | Microelectrica Scientifica | 1     |
|                                  | 150                    | C4280-508      | Relay-Dc Overcurrent, Variable Pwr Supply (24-125VDC), Uni/Bi Directional, C4280-025 Case | SMC                        | 1     |

## BILL OF MATERIAL

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64539 |
|-----|-------|

| Sum of QTY |               |                       |  |                  |       |
|------------|---------------|-----------------------|--|------------------|-------|
| UNIT       | DESIG.        | PART NO.              | DESCRIPTION  | MFG.             | Total |
|            | 172           | FBK-S-4000 (BY DESC.) | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,WVWheel Assembly | ABB              | 1     |
|            | 172/TOC       | 271887T03             | Cell Switch-8 Contact with Crank and Stud  | ABB              | 1     |
|            |               | 836876T01             | Actuator Assy.-Includes Plunger, Spring and Hardware   | ABB              | 1     |
|            | 172SD         | 271985T01             | Secondary Disconnect for Type FBK Breaker  | ABB              | 4     |
|            | 182           | C4280-560             | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC), C4280-026 Case  | SMC              | 1     |
|            | 33B           | 9007-AP221            | Switch-Limit, 1 no, 1nc, Plunger Type  | Square D         | 1     |
|            | 43L/R         | 24201B                | Control Switch-2 position, maintained, Local/Remote, Escutcheon engraved per Sketch #1   | Electroswitch    | 1     |
|            | 72CS          | 2457D                 | Switch-Breaker Control   | Electroswitch    | 1     |
|            | AM            | 103-124-AEXX          | Ammeter-100-0-100mv Rated, 10KA-0-10KA DC Scale  | Yokogawa         | 1     |
|            | AM/HTR        | 2PB-AAC-001           | Ammeter-0-1A Rated And Scaled  | Modutec          | 1     |
|            | COND          | EMT-1-1/2"            | Conduit-EMT Thinwall, 1-1/2", Cut to Length, Bend as Required  | (blank)          | 3     |
|            | COND-B        | PB500D                | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-F        | TC-505                | Connector for 1-1/2" EMT Thinwall Conduit  | Neer             | 4     |
|            | COND-LN       | LN-105                | Locknut for 1-1/2" Conduit   | Neer             | 4     |
|            | D1            | 1N4007                | Diode-1000V, 1A  | Motorola         | 1     |
|            | DS-CP         | A-1102                | Disconnect Switch-250VDC, 30A  | Filnor           | 1     |
|            | FU1,2         | JKS-30                | Fuse-600Vac, 200Vdc, 30A   | Buss             | 2     |
|            | FU1-4         | J60030-2S             | Fuse Holder, 2P, 600V  | Buss             | 2     |
|            | FU3,4         | JKS-20                | Fuse-600Vac, 200Vdc, 20A   | Buss             | 2     |
|            | FU5-10        | PSI20X127PRE          | Fuse Holder  | Ferraz           | 6     |
|            | FU5-8         | D100RB010V            | Fuse-1000VDC, 10A  | Ferraz           | 4     |
|            | FU9-10        | D100RB025V            | Fuse-1000VDC, 25A  | Ferraz           | 2     |
|            | INS-SH        | 255716                | Bushing-Secondary Insulation   | Chromolox        | 1     |
|            | LMR           | C3313                 | Resistor-Load Measuring  | SMC              | 1     |
|            | LT1           | 22RL120LRXPLRD        | Ind. Light-LED, 125VDC, Red  | Control Concepts | 1     |
|            | LT2           | 22RL120LGXPLGN        | Ind. Light-LED, 125VDC, Green  | Control Concepts | 1     |
|            | LT3           | 22RL120LYXPLWE        | Ind. Light-LED, 125VDC, White  | Control Concepts | 1     |
|            | RB08          | SR2P-06               | Relay Base-8 Pin   | Idec             | 2     |
|            | RB11          | SR3P-06               | Relay Base-11 Pin  | Idec             | 3     |
|            | SA            | 6007-003              | Surge Arrestor-750VDC  | SMC              | 1     |
|            | SC/C, SC/T    | RR2PAULDC24           | Relay-Control, DPDT, 24vdc Coil  | Idec             | 2     |
|            | SH            | S-815131123           | Strip Heater-150W, 240V, 8" Overall, 7" Mtg., 6-1/2" Body (Applied At 115vac)  | Chromolox        | 1     |
|            | SHUNT         | H-5000-50             | Shunt-5000A, 50mv, Silver Plated   | Canadian Shunt   | 1     |
|            | TBA           | 264B903G20            | Terminal Block-600V, 100A, 2pt   | General Electric | 1     |
|            | TBB, TBF      | EB25B04C              | Terminal Block-600v, 4pt, W/Cover, Ring Term.  | General Electric | 2     |
|            | TBJ, TBG, CTB | EB25B12C              | Terminal Block-600v, 12pt, W/Cover, Ring Term.   | General Electric | 8     |
|            | TM-1          | YA44-2N               | Terminal-Type YA, 1000 KCMIL, Long Barrell, Double Indent, Nema 2-Hole Pad   | Burndy           | 5     |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
Mid "E" Route, Stage SSE-13, Contract 227043

Release Date: 3/11/96  
Revision Date: 10/31/96  
Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64539 |
|-----|-------|

| Sum of QTY                       |                      |  |  |                              |       |
|----------------------------------|----------------------|--|--|------------------------------|-------|
| UNIT                             | DESIG.               | PART NO.   | DESCRIPTION  | MFG.                         | Total |
|                                  | XD-V                 | 3181-071   | Transducer-Voltage,0-800vdc In,0-1ma Out   | SMC                          | 1     |
| Unit No.6<br>Tie Breaker<br>No.5 | 01X,182/LOX,ETS<br>X | RR3PAULDC110   | Relay-Control,TPDT,110vdc Coil   | Idec                         | 3     |
|                                  | 129                  | LTNS60-SDAJ  | Dc Contactor-750 VDC,60A,2P  | Microelectronica Scientifica | 1     |
|                                  | 172                  | FBK-S-4000 (BY DESC.)  | Breaker-4000A,800VDC,1P,"01",D/O,E/O,125vdc Cont.,12 Aux Sw,PermissiveSwitch,UVR,Shutter Act.,Nr Operations Counter, ODFBK-7A Trip Device,W/Wheel Assembly | ABB                          | 1     |
|                                  | 172/TOC              | 271887T03  | Cell Switch-8 Contact with Crank and Stud  | ABB                          | 1     |
|                                  |                      | 836876T01  | Actuator Assy.-Includes Plunger, Spring, and Hardware  | ABB                          | 1     |
|                                  | 172SD                | 271985T01  | Secondary Disconnect for Type FBK Breaker  | ABB                          | 4     |
|                                  | 182                  | C4280-560  | Relay-Dc Reclosing, Variable Pwr Supply (24-125VDC),C4280-026 Case   | SMC                          | 1     |
|                                  | 33B                  | 9007-AP221   | Switch-Limit,1no,1nc,Plunger Type  | Square D                     | 1     |
|                                  | 43L/R                | 24201B   | Control Switch-2 position,maintained,Local/Remote,Escutcheon engraved per Sketch #1  | Electroswitch                | 1     |
|                                  | 72CS                 | 2457D  | Switch-Breaker Control   | Electroswitch                | 1     |
|                                  | AM                   | 103-124-AEEX   | Ammeter-100-0-100mv Rated,10KA-0-10KA DC Scale   | Yokogawa                     | 1     |
|                                  | AM/HTR               | 2PB-AAC-001  | Ammeter-0-1A Rated And Scaled  | Modutec                      | 1     |
|                                  | COND                 | EMT-1-1/2"   | Conduit-EMT Thinwall,1-1/2",Cut to Length,Bend as Required   | (blank)                      | 3     |
|                                  | COND-B               | PB500D   | Bushing for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-F               | TC-505   | Connector for 1-1/2" EMT Thinwall Conduit  | Neer                         | 4     |
|                                  | COND-LN              | LN-105   | Locknut for 1-1/2" Conduit   | Neer                         | 4     |
|                                  | D1                   | 1N4007   | Diode-1000V,1A   | Motorola                     | 1     |
|                                  | DS-CP                | A-1102   | Disconnect Switch-250VDC,30A   | Filnor                       | 1     |
|                                  | FU1,2                | JKS-30   | Fuse-600Vac,200Vdc,30A   | Buss                         | 2     |
|                                  | FU1-4                | J60030-2S  | Fuse Holder,2P,600V  | Buss                         | 2     |
|                                  | FU3,4                | JKS-20   | Fuse-600Vac,200Vdc,20A   | Buss                         | 2     |
|                                  | FU9-10               | D100RB025V   | Fuse-1000VDC,25A   | Ferraz                       | 2     |
|                                  | INS-SH               | 255716   | Bushing-Secondary Insulation   | Chromolox                    | 1     |
|                                  | LMR                  | C3313  | Resistor-Load Measuring  | SMC                          | 1     |
|                                  | LT1                  | 22RL120LRXPLRD   | Ind. Light-LED, 125VDC, Red  | Control Concepts             | 1     |
|                                  | LT2                  | 22RL120LGXPLGN   | Ind. Light-LED, 125VDC, Green  | Control Concepts             | 1     |
|                                  | LT3                  | 22RL120LYXPLWE   | Ind. Light-LED, 125VDC, White  | Control Concepts             | 1     |
|                                  | RB08                 | SR2P-06  | Relay Base-8 Pin   | Idec                         | 2     |
| RB11                             | SR3P-06              | Relay Base-11 Pin  | Idec   | 3                            |       |
| SA                               | 6007-003             | Surge Arrestor-750VDC  | SMC  | 1                            |       |
| SC/C,SC/T                        | RR2PAULDC24          | Relay-Control,DPDT,24vdc Coil  | Idec   | 2                            |       |
| SH                               | S-815131123          | Strip Heater-150W, 240V,8" Overall,7" Mtg.,6-1/2" Body (Applied At 115vac) | Chromolox  | 1                            |       |
| SHUNT                            | H-5000-50            | Shunt-5000A, 50mv,Silver Plated  | Canadian Shunt   | 1                            |       |
| TBA                              | 264B903G20           | Terminal Block-600V,100A,2pt   | General Electric   | 1                            |       |

**BILL OF MATERIAL**

Washington Metropolitan Area Transit Authority (WMATA)  
 Mid "E" Route, Stage SSE-13, Contract 2Z7043

Release Date: 3/11/96  
 Revision Date: 10/31/96  
 Rev. No.: 1

**CHAPIN STREET TIE BREAKER STATION  
 DC SWITCHGEAR**

|     |       |
|-----|-------|
| SO# | 64539 |
|-----|-------|

| Sum of QTY |             |              |   |                  |       |
|------------|-------------|--------------|---|------------------|-------|
| UNIT       | DESIG.      | PART NO.     | DESCRIPTION   | MFG.             | Total |
|            | TBB,TBF     | EB25B04C     | Terminal Block-600v,4pt,W/Cover,Ring Term.                                | General Electric | 2     |
|            | TBJ,TBG,CTB | EB25B12C     | Terminal Block-600v,12pt,W/Cover,Ring Term.                               | General Electric | 8     |
|            | TM-1        | YA44-2N      | Terminal-Type YA,1000 KCMIL, Long Barrell, Double Indent, Nema 2-Hole Pad | Burndy           | 5     |
|            | XD-V        | 3181-071     | Transducer-Voltage,0-800vdc In,0-1ma Out                                  | SMC              | 1     |
|            | FU5-6       | D100RB010V   | Fuse-1000VDC,10A  | Ferraz           | 2     |
|            | FU5-6,9-10  | PSI20X127PRE | Fuse Holder   | Ferraz           | 4     |

# Installation/Maintenance Instructions

## DC Low-Voltage Power Circuit Breakers

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*Type FBK-S Semi-High Speed, Model 01  
1600 through 6000 Amperes*

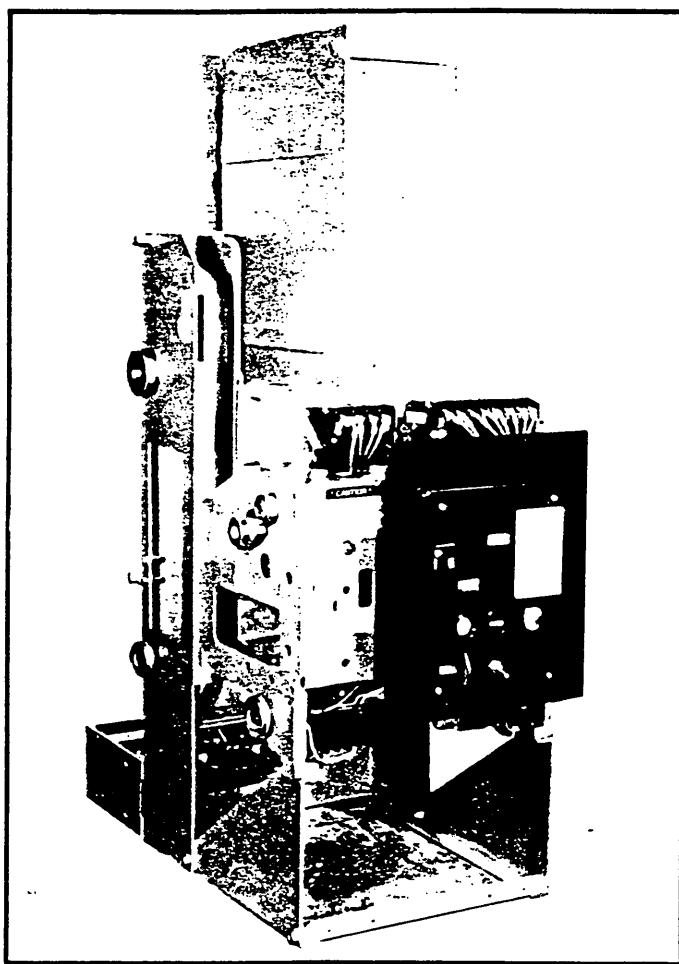


ABB Power Distribution, Inc.  
Circuit Breaker Division

**ABB**  
ASEA BROWN BOVERI

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These instructions do not purport to cover all details or variations nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the nearest District Office.

## INTRODUCTION

These instructions apply to the semi-high speed versions of ABB's direct current circuit breakers with continuous currents of 1600 through 6000 amperes; the type FBK-S-1600 through FBK-S-6000. They may be applied on systems with voltages of 300, 800, or 1000 volts DC. The circuit breakers are available as single pole breakers with electro-mechanical or solid state tripping. Also available is a negative disconnect withdrawal unit. The mechanisms are electrically operated and mechanically latched with provision for manual close, trip and maintenance slow closing. These circuit breakers are available in stationary and drawout forms.

A drawout type FBK-H 4000, single pole, is shown in Figure 1, with a typical schematic diagram shown in Figures 11 and 12.

These instructions should be read thoroughly before handling, installing and/or operating the circuit breaker.

## RECEIVING AND STORAGE

Immediately upon receipt of the circuit breakers, examine the shipping crate to determine if any damage or loss was sustained during transit. If breakage or rough handling is evident, file a damage claim at once with the carrier and promptly notify the nearest ABB District Office representative. Asea Brown Boveri is not responsible for damage of goods after delivery to the carrier. However, we will lend assistance if notified of claims.

Unpack circuit breakers as soon as possible after receipt. If unpacking is delayed, difficulty may be experienced in making a claim for damages not evident upon receipt. Use care in unpacking in order to avoid damaging any circuit breaker parts. Check the contents of each crate against the packing list before discarding any packing material. If any discrepancy is discovered, promptly notify the company representative. Information specifying the purchase order number, carton number and part number of damaged or missing parts should accompany the claim.

Circuit breakers should be installed in their permanent locations as soon as possible. (See Basic Handling section.) If possible, a drawout circuit breaker should be stored and locked in the "DISCONNECTED" position in its compartment with the door closed. Both the primary and control separable contacts are disconnected in this position. If the breaker cannot be installed in its compartment, it should be kept in a clean and dry location or covered and sealed to prevent infiltration of dirt. Where conditions of high humidity prevail, the use of heaters is recommended, regardless of the method of storage selected.

## BASIC HANDLING INSTRUCTIONS

Once the circuit breaker has been removed from its shipping crate, it should be kept in the upright position and placed on a flat surface to avoid damage to breaker parts. For safety, all handling in this position should utilize a lifting yoke (Figure 1, Item 20): CAUTION CAUTION Do not push against or lift the circuit breaker by its arc chute.

## CIRCUIT BREAKER OPERATION

### Circuit Breaker Rating

The continuous current rating is the maximum current that can be carried without exceeding rated temperature rise. There is no overload rating.

Exceeding the current rating may raise the temperature of the breaker beyond its design limit and, thus, affect the life of the circuit breaker.

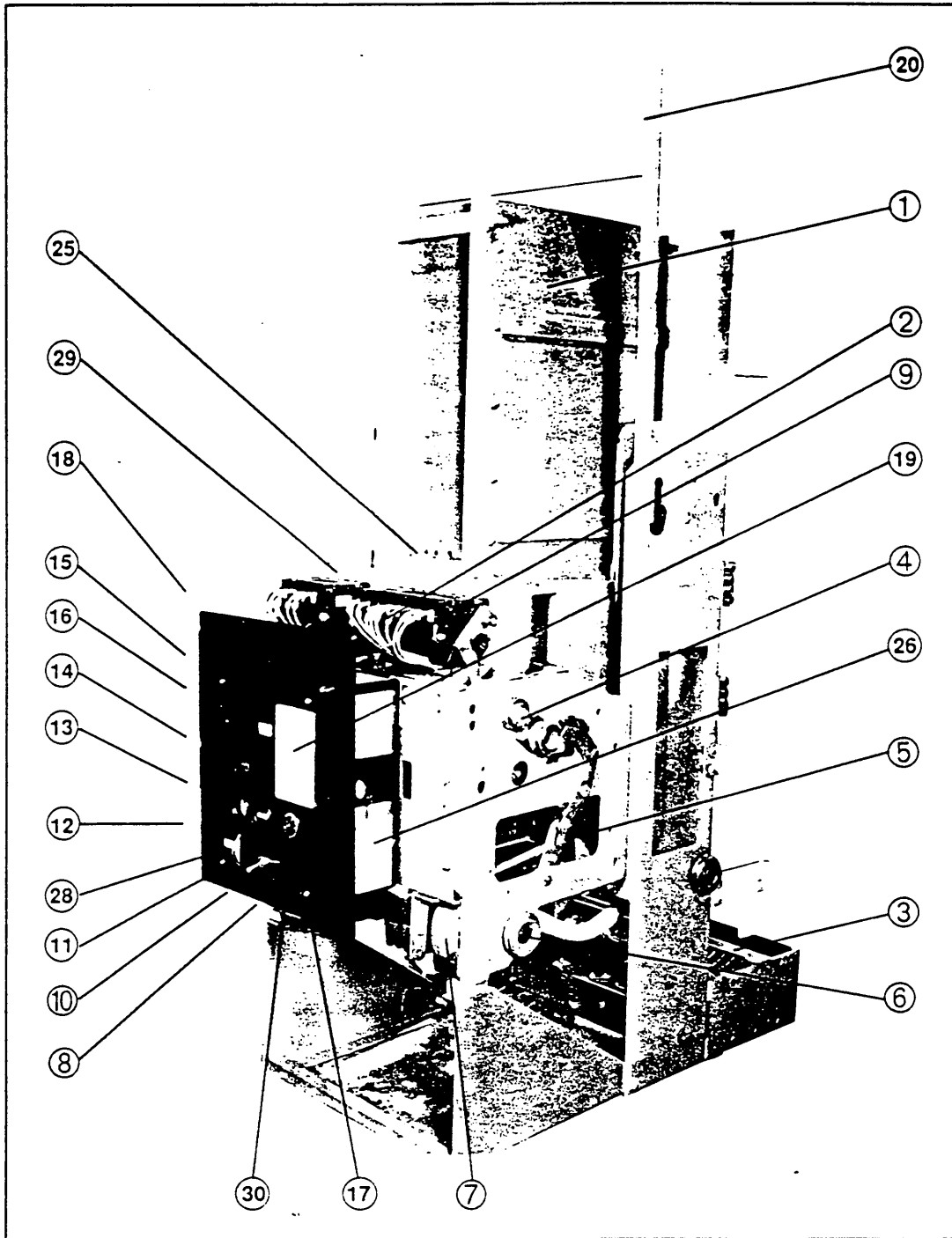
### Basic Circuit Breaker Operating Scheme

Refer to the specific schematic diagrams, electrical operating sequences and any other operational information furnished with the order. See also, Fig. 11 or 12.

With the circuit breaker open, the closing springs discharged, the control power source energized, and the motor disconnect switch (MDS) closed, operation occurs as follows:

1. Immediately upon application of control power, the spring charging motor is energized, which in turn charges the closing springs. When the closing springs are charged, limit switch contacts "LS/1" and "LS/3" are opened, and limit switch contact "LS/2" is closed.
2. Operation of the remote close control switch or local electrical close pushbutton (when supplied) energizes the close latch release coil (X) through the circuit breaker auxiliary switch "L/b" contact, the normally closed lockout relay contact "Y/2", and the limit switch contact "LS/2". The close latch release coil (X) releases the latch and the springs then discharge to close the circuit breaker.
3. When the springs discharge, limit switch contacts "LS/1" and "LS/3" close and limit switch contact "LS/2" opens.
4. When the circuit breaker closes, all auxiliary switch "b" contacts open and all auxiliary switch "a" contacts close.
5. When the limit switch contacts "LS/3" close, the lockout relay coil (Y) is energized and opens lockout contact "Y/2" which de-energizes the close latch release coil (X). Lockout contact "Y1" closes which seals in the lockout relay coil (Y) as long as the "close" signal is maintained. The purpose of the lockout coil (Y) is to prevent pumping of the closing mechanism when closing against a faulted circuit.
6. The circuit breaker can be tripped by operation of the remote trip control switch which energizes the circuit breaker trip coil (TC) through the auxiliary switch "L/a" contact.
7. The closing springs recharge after the circuit breaker closes.





- |  |                                       |  |
|--|---------------------------------------|--|
| 1. Arc Chute   | 11. Locking Hasp                      | 22. Removable Maintenance Handle (Not Shown) |
| 2. Auxiliary Switch  | 12. Electrical Close Push button      | 23. Track (not shown)                        |
| 3. Secondary Separable Contacts                                  | 13. Manual Trip Button                | 24. Latch (not shown)                        |
| 4. Racking Cam Assembly  | 14. "OPEN" or "CLOSED" Indicator      | 25. Arc Chute Retaining Nuts                 |
| 5. Overcurrent Trip Device (Electro-mechanical, Semi-High Speed) | 15. Racking Shutter                   | 26. Position Indicator                       |
| 6. Positioning Wheels  | 16. Closing Spring Charge Indicator   | 27. Cradle (not shown)                       |
| 7. Closing Spring Charging Motor                                 | 17. Electrical Trip Button (Optional) | 28. Operation Counter                        |
| 8. Escutcheon Assembly   | 18. Self-Aligning Dust Plate          | 29. Arc Chute Shelf                          |
| 9. Arc Chute Return Connections<br>Motor Disconnect Switch       | 19. Nameplate                         | 30. Automatic Trip Indicator (Not Shown)     |
|  | 20. Lifting Yoke                      |  |
|  | 21. Racking Crank (Not Shown)         |  |

Figure 1 - 4000 AMPERE FBK SEMI-HIGH SPEED BREAKER  
 MODEL 01 WITH ELECTRO-MECHANICAL TRIPPING

## Closing Spring Operation

The two closing springs supply the power that closes the circuit breaker contacts and also charge the opening springs during the closing operation. The closing springs are charged by a motor, storing energy for the next close operation. For safety, the closing springs are automatically discharged when drawout circuit breakers are racked from the disconnected to the withdrawn position.

## ESCUTCHEON FEATURES

### Summary of Features

All FBK circuit breakers are provided with an escutcheon which extends through its enclosure door. All indicators and controls necessary to open, close, or rack the circuit breaker are grouped on this escutcheon.

The controls and indicators (Figure 1) included on the escutcheon face plate are (19) nameplate giving the rating assigned to the particular circuit breaker, (13) manual trip button, (12) electrical close push button switch, (10) motor disconnect switch, (14) "OPEN" and "CLOSED" position indicator, (11) means for padlocking the circuit breaker in the "CONNECTED", "TEST", or "DISCONNECTED" position and (16) closing spring charge indicator. A maintenance handle (22) is inserted for manual spring charging and maintenance slow closing. An operation counter (28) is furnished on all FBK breakers.

All drawout circuit breakers have the racking shutter (15) that must be raised to allow inserting of the racking crank (21).

A self-aligning dust plate (18) immediately behind the escutcheon face plate is issued to exclude dust from the circuit breaker compartment. On drawout type circuit breakers, the escutcheon face will protrude through the front door of the compartment when the circuit breaker is in the "TEST" and "DISCONNECTED" positions. In these positions, the dust plate adjusts its position to still function as a dust shield.

### Circuit Breaker Nameplate (Figure 1, Item 19)

The circuit breaker nameplate contains information regarding (1) the manufacturer's name and address, (2) type of circuit breaker, (3) serial number, (4) continuous current rating, (5) short circuit current rating at rated voltages and (6) momentary current rating.

### Circuit Breaker "Open" or "Closed" Indicator (Figure 1, Item 14)

This indicator shows the physical position of the circuit breaker contacts.

### Manual Trip Button (Figure 1, Item 13)

This button, when pushed, mechanically trips the circuit breaker to "OPEN".

### Padlocking Device (Figure 1, Item 11)

All FBK circuit breakers have provisions for padlocking the mechanism in the trip-free position. When the padlocking hasp is pulled out, it can be secured with up to three padlocks.

To use the Padlocking Device, first push the manual trip button to trip the circuit breaker (if it is closed) and to unlatch the padlock hasp. Pull out the padlock hasp and affix the padlock(s) through it. In this position, the mechanism is held trip-free; the main contacts cannot be closed even though the closing springs can be charged and discharged.

On circuit breakers equipped with a drawout mechanism, the Padlocking Device will also lock the circuit breaker in any of its three basic drawout positions of "CONNECTED", "TEST", or "DISCONNECTED".

### Closing Spring Charge Indicator (Figure 1, Item 16)

The closing springs on a FBK circuit breaker are automatically charged as soon as control power is applied and immediately after each closing operation when the Motor Disconnect Switch is on. The Closing Spring Charge Indicator shows the status of the closing springs by showing "SPRINGS CHARGED" or "SPRINGS DISCHARGED" through an escutcheon window.

### Auto-Trip Indicator (Optional) (Figure 1, Item 30)

This white pushbutton, engraved "RESET", is located on the lower right corner of the escutcheon when furnished. In its normal position, it is almost flush with the circuit breaker escutcheon. The following conditions cause it to pop out:

- Operation of the direct acting semi-high speed electro-mechanical overcurrent trip device. (Optional)
- Operation of the direct acting undervoltage trip device.

Depress the button before reclosing the circuit breaker.

### Motor Disconnect Switch (Figure 1, Item 10)

The motor disconnect switch is a double pole, single throw toggle type switch connected in series with the charging motor circuit and is used to disconnect the motor from the voltage source. This cut-off switch is used:

- When it is desirable to prevent automatic recharging of the closing springs just prior to taking the circuit breaker out of service.
- To prevent automatic recharging when racking in the circuit breaker.
- For control wiring dielectric tests. The motor must be disconnected for the control wiring dielectric test and tested at voltages recommended by the latest revision of ANSI C37.14. Note that

Lower dielectric test voltages are allowed for breakers that have been in service.

#### Electrical Close Push Button (Figure 1, Item 12)

The electrical close push button is used to electrically close the breaker from the escutcheon. This contact is connected in series with the latch release coil (X). Energizing the latch release coil allows the charged springs to close the circuit breaker.

#### Operation Counter (Figure 1, Item 30)

The operation counter is used to count each opening of the circuit breaker contacts. The counter is nonresetable and gives only progressive adding indication. It is frequently used as a reference to schedule maintenance intervals.

#### Racking Mechanism (Drawout Breaker)

The racking mechanism is used to move the circuit breaker to any one of its three positions ("CONNECTED", "TEST", or "DISCONNECTED"). All of these positions are attainable with the cubicle door closed. The racking shutter (15, Fig. 1), which must be lifted to gain access to the racking mechanism, is interlocked with the circuit breaker so that the circuit breaker contacts must be open before the shutter can be lifted to rack the circuit breaker to another position. The circuit breaker cannot be closed when the shutter is open. The circuit breaker may be padlocked open by means of the locking hasp. This automatically locks the racking mechanism.

There are two sets of arrows and indicating lines to show the circuit breaker position within the compartment. One set, located on the dust cover, is utilized with the compartment door closed and one set, located on the cradle, is utilized with the door open.

#### Control Device (Fig. 8)

This device is mounted below and to the left of the mechanism. The control device contains three electrical components, the limit switch (LS), the lockout relay (Y), and the latch release relay (X). The schematic diagram of the control circuit (Fig. 2) illustrates the function of this device. In addition to its electrical functions, the base of the device provides a terminal block for the circuit breaker wiring. A close latch release plunger is available for manual close and spring discharge operation. On circuit breakers with solid state tripping, metal oxide varistors are secured to the outside of the control device.

The lockout relay (Y) in the control device is energized with the latch release relay (X) and serves as an anti-pump device. Without this device, a maintained close signal would then allow the FBK circuit breaker to close, recharge its springs, discharge, recharge and so on until the close signal is released. The lockout relay requires that the close signal be removed before the close signal can be re-energized. Because some control systems require maintained close signals, the lockout relay is designed for continuous operation.

#### Auxiliary Switches (Figure 1, Item 2)

The auxiliary switches, available for customer use, are mounted on the upper right-hand side of the circuit breaker and are wired to its secondary disconnects. Two types of contacts are provided: "a" contacts which are closed when the circuit breaker main contacts are closed, and "b" contacts which are open when the circuit breaker mains are closed. Driven by the same mechanical operator as the main contacts, the auxiliary contacts are available in four and eight pole forms. Two "a" contacts and two "b" contacts are supplied on four pole forms with four "a" and four "b" on eight pole forms. These switches can be field converted to meet various control needs.—

### AVAILABLE TRIP DEVICES

#### Semi-High Speed Solid State Overcurrent Trip System

The optional semi-high-speed solid state overcurrent trip system is a multi-component system consisting of sensor(s) and an electronic control assembly. The system can be equipped with normally open contacts to be used with the circuit breaker shunt trip or normally closed contacts for use with the breaker undervoltage device.

The sensor(s), supplied in several ratings, provides a signal in direct response to the direction and level of the current (I) through the circuit breaker. This signal initiates the tripping operation. By proper selection of sensor ratings and connections, forward and/or reverse tripping functions are provided at selected settings.

The Hall device, integral in the sensor, produces an output voltage signal proportional to the current (I) through the circuit breaker and in the same polarity. When a fault occurs, this output voltage exceeds the level-detector threshold voltage value; and the detector initiates a contact change of state to either energize the shunt trip or open the undervoltage control circuit.

A current-measuring sensor (Hall effect), that is mounted on either the lower or the upper breaker terminal supplies an input signal to the 76 device. The devices are interconnected by a 4-conductor cable, with a plug at the sensor end and wire lugs at the relay terminal. Interchange of two cable leads at the relay is used to change the trip direction. Auxiliary switching by the 76 device is by both a contact and solid state switching. The contact is used for alarm and the solid state for shunt trip operation. Both devices close at the moment of threshold but open after tripping or return to normal operating conditions before end of time delay. Available functions, trip settings and sensor ratings are shown in Table 4. The 76 relay requires a control power source as shown in Table 5.

Refer to IB-7.5.1.7-1 for further information on the sensor-operated 76 DC Overcurrent Relay.

### Rate-of-Rise Fault Detector 76R/R (Optional)

For transit application, the rate-of-rise fault detector (R-R) functions to discriminate between normal train starting currents and actual track fault currents. The circuit is based on a true rate-of-rise principle. Upon detection of the track fault, the breaker will trip within a preset time limit. This device has adjustable time delay. This adjustment provides fault detection "reach" based on the parameters of the system. Inherent with this device is a push button operated test circuit for periodic maintenance checks. The test circuit simulates a track fault signal which checks the integrity of the R-R detector and trip system. **NOTE:** Where automatic reclosing circuitry is provided, the above test should only be made when the breaker is in the TEST position or if the reclosing circuit is disconnected during the test.

### Direct-Acting Overcurrent Trip Devices (Fig. 9)(Table 6) (Optional) (Semi-High Speed) ( Bi-directional)

The following electro-mechanical trip devices are available:

- a. ODFBK - 3A - Long time and high-set instantaneous
- b. ODFBK - 3B - Long time and low-set instantaneous
- c. ODFBK - 4A - Long time and short time
- d. ODFBK - 7A - Instantaneous
- e. ODFBK - 8A - Low-set instantaneous
- f. ODFBK - 10A - Short time

The adjustments for pick up or time delay as applicable are made by adjustment screws on the bottom of the trip device. These devices have been calibrated at the factory prior to shipment; the settings of the trip devices should be made by qualified personnel based on the application conditions prior to installation in the switchgear.

ODFBK trip units are located on the lower terminal of the single pole breakers.

### Direct Acting Undervoltage Trip Device (Optional)

The electrically reset undervoltage trip device automatically trips the circuit breaker when its control voltage decreases to 30 to 60 percent of the rated voltage. This device may be furnished for either instantaneous or adjustable time delay (0-15 seconds) tripping.

See Table 3 for electrical characteristics.

### Other Trip Devices

Other trip devices such as shunt trip, undervoltage or electro-mechanical overcurrent trip devices act directly on the latch bar (10), causing roller (8), latch (7) and the jackshaft to move as a unit in opening the circuit breaker.

## INSTALLATION, INITIAL TESTING AND REMOVAL (Drawout & Stationary)

### CAUTION CAUTION CAUTION CAUTION

When installing or removing stationary breakers, the supply for primary and control circuits must be de-energized at all times. Testing of stationary circuit breakers should be done with the primary supply circuit DE-ENERGIZED.

For initial installation of drawout breakers in the "CONNECTED" position, the supply for the primary circuit should be de-energized. Testing of the drawout breaker should be done in the "TEST" position.

**NOTE:** When the circuit breaker has an overcurrent device with long-time delay (OD FBK-3), the following procedure must be performed prior to inserting the circuit breaker into the switchboard. With the breaker in the upright position, exercise the long-time armature (1" wide armature) several times until resistance to motion has increased, indicating that the oil dashpot is functioning properly. Improper operation can result if the circuit breaker is shipped or stored on its back. This causes the oil in the dashpot to be displaced and an air bubble can be trapped under the piston. The exercise described above removes the air to permit proper operation.

### Installation (Stationary Type) (Refer to Fig 1)

Lifting yoke (20, Fig. 1) can be used to move the breaker to the installation location.

### Installation (Drawout Type) (Refer to Fig. 1)

To insert the circuit breaker into its compartment, proceed as described below:

1. The circuit breaker must be in the "OPEN" position, the racking crank turned in the counterclockwise direction fully against its stop, and the motor disconnect switch (10) in the "OFF" position.
2. Open the compartment door and pull out the right-hand and left-hand tracks (23) to the fully extended and latched position.
3. Using a lifting yoke (20), lower the circuit breaker so that the positioning wheels (6) (two on each side of circuit breaker) rest in the cut-out sections of each track (23).
4. Remove the lifting yoke and push the circuit breaker toward the compartment. The circuit breaker will slide in the cut-out sections of the tracks until the positioning wheels reach the end of the cut-outs. While holding the two latches (24, one on each side of the circuit breaker) down, push the circuit breaker toward the compartment until the racking cams (4) stop against their guides on the cradle (28). Release hold on latches.

Lift shutter (15) covering the racking opening, insert racking crank, and turn crank clockwise, pass through the "DISCONNECTED" position, until the position indicator on the cradle (left side) shows "TEST" position. Remove racking crank. The shutter should close if the breaker is in the proper position. In the "TEST" position, the primary disconnects are not engaged in the cradle, but the control power disconnects are engaged.

#### Checking Circuit Breaker Operation in "TEST" Position (Drawout Type) Control Power on (Refer to Fig. 1)

1. Turn motor disconnect switch (10) to "ON" position and closing springs will automatically charge.

2. Close circuit breaker by local close button and trip by local trip button.

**NOTE:** All breakers have a manual trip button. A local electrical trip button is optional.

3. Close and trip circuit breaker by means of remote control switch (when used), if the control scheme allows this with the breaker in the "TEST" position.

4. Check each auxiliary device for proper operation.

5. Close the circuit breaker and check that the shutter (15) cannot be opened to allow insertion of the racking crank. This demonstrates that the circuit breaker could not be racked while closed in the test position.

#### Checking Circuit Breaker Operation in "CONNECTED" Position (Drawout Type) Control Power On (Refer to Fig. 1)

Primary supply circuit must be DE-ENERGIZED with the circuit breaker in the "OPEN" position and the motor disconnect switch (10) in the "OFF" position, insert the racking crank and turn clockwise until the position indicator on the cradle shows "CONNECTED" position. Test the circuit breaker as it was tested in the "TEST" position above.

#### Check Circuit Breaker Operation (Stationary Type)

Follow the same procedure as for the drawout circuit breaker, remembering that the breaker is bolted to its line and load. Therefore ALL TESTS MUST BE PERFORMED WITH THE PRIMARY SUPPLY CIRCUIT DE-ENERGIZED.

#### Emergency operation (Refer to Fig. 3)

Circuit breakers may be charged manually by a removable maintenance handle (4) for emergency operation.

The removable maintenance handle (4) is first positioned in two positions in the pawl carrier (2). The handle is then raised and lowered in a pumping motion until the pawl carrier (2) no longer rotates the ratchet wheel (1). The breaker closing springs are now fully charged and ready for a closing operation.

**NOTE:** The motor crank arm (3) may occasionally stop in such a position as to prevent charging the springs with the handle. Should this happen, the motor crank arm must be rotated manually by using a screwdriver or similar tool to rotate the crank arm a quarter turn so that the springs may be charged with the handle as described above.

#### Circuit Breaker Removal (Drawout Type)

(Refer to Fig. 1)

To move the circuit breaker to the "TEST" position or to remove it from the compartment, proceed as follows:

1. With the compartment door closed, trip the circuit breaker by means of the remote control switch (when used) or manual "TRIP" button (13) on the escutcheon.

2. Lift racking shutter (15), insert racking crank and turn counterclockwise until position indicator (27) on the right-hand side of the escutcheon shows "TEST" position.

3. Continue turning the racking crank counterclockwise until the position indicator (27) on the right-hand side of the escutcheon shows "DISCONNECTED" position. Remove the racking crank.

4. Open compartment door. Place motor disconnect switch (10) in the "OFF" position.

5. Insert racking crank and turn counterclockwise as far as the stops will allow. Check that the automatic spring discharge device will discharge the closing springs near the end of the racking operation.

6. Pull circuit breaker forward on tracks (23) to the fully extended and latched position.

7. With a positive pull, release positioning wheels from cut-out sections of the tracks.

8. Remove circuit breaker from tracks by means of lifting yoke and crane.

9. Release latch (24) on each track, push tracks into the compartment, and close compartment door.

## MAINTENANCE

### CAUTION CAUTION CAUTION CAUTION

De-energize both primary and control circuits before making any inspections, adjustments, or replacements of parts. Make certain that the circuit breaker is open and that the closing springs are discharged by observing their indicators on the front escutcheon (14 and 16, Figure 1).

When it is necessary that the charging springs be charged, or the circuit breaker be closed, make sure to stay clear of operating parts.

Stationary breakers should be checked for operation with the control circuit energized and the primary power de-energized. Drawout breakers should be withdrawn to "TEST" position for checking the breaker operation. For further inspection, adjustments, cleaning or replacement of parts, the drawout circuit breaker should be withdrawn and moved to a suitable area. Stationary breakers should likewise be removed, but, if removal is not possible, then the primary and control circuit sources MUST BE DE-ENERGIZED.

### Periodic Maintenance Inspection

The safety and successful functioning of the connected apparatus depends upon the proper operation of the circuit breaker. Therefore, it is recommended that a maintenance program be established that will provide for a periodic inspection of the circuit breaker after a given number of operations as follows:

FBK - 1600 through 6000 - 1 pole      500 Operations

The above inspection periods apply to either no-load or current switching operations. If the listed number of operations are not completed in the first year of service, the circuit breakers should be inspected, regardless.

When a circuit breaker is known to have interrupted close-in, high current faults or highly inductive track faults in transit applications, it should be inspected after the series of faults regardless of any time period or number of operations.

If, after the initial inspection period, there is no indication of any problem, actual operating experience can then determine the inspection cycle.

Where unusual service conditions exist, as covered by ANSI C37.14, it must be assumed that these conditions were considered at the time of order; that the equipment supplied was designed for the special applications; and that an appropriate supplemental maintenance program has been developed. These maintenance instructions only cover circuit breakers used under the standard usual service conditions described in ANSI C37.14.

The inspection should include opening and closing the circuit breaker electrically and manually. The unit should be visually inspected for loose or damaged parts. Arc chutes, contacts and insulation structure should be inspected as described below. All accessible bolts, nuts and screws should be checked to insure that they are tight.

### Arc Chute (Refer to Figure 2)

#### Removal

1. Remove the two nuts and washers which secure the return connections (9, Fig. 1) to the arc chute.
2. Pull the return connections off the studs projecting from each side of the arc chute and position them back away from these studs. Replace the washers and nuts to prevent loss and hold the studs in place.
3. Remove the two bolts and washers that secure the front of the arc chute to the frame of the circuit breaker.
4. Using a 1/4-inch Allen wrench on a long extension, loosen the two Allen screws at the bottom rear of the arc chute. Do not remove these screws; leave them in place loosened so that they are removed when the arc chute is lifted from the circuit breaker.
5. Lifting STRAIGHT UP, remove the arc chute (with its rear screws in place) from the circuit breaker. The arc chute is much heavier than it looks; some assistance will be necessary to remove it.

#### Examination

Examine the arc chute for damage. Discoloration or slight eroding of the arc plates, runners or liners is normal and does not signify damage.

The cooling plates of the arc chute feature a special light blue epoxy paint. Take care to avoid chipping or scratching this paint; chips in the paint can compromise the performance of the arc chute. If chips are noted, a repair kit is available from Asea Brown Boveri, Circuit Breaker Division.

The sides of the arc chute have insulating strips which cover the staked ends of the cooling plates. (See Fig. 2.) These four strips must be securely in place to maintain arc chute integrity.

If a crust has formed on the liner plates at the base of the arc chute, lightly remove it with a carborundum stone or scraper. Remove all dirt by blowing out the arc chute with DRY compressed air. DO NOT USE SOLVENTS OF ANY KIND TO CLEAN ANY PART OF THE ARC CHUTE.

If any of the following conditions exist, the arc chute should be replaced:

1. Arc runners or cooling plates that are badly burned or liner plates with large cracks.
2. A hole 1/4" in diameter or larger burnt in the rear steel arc plate.
3. Broken or cracked polyester side plates.

## Installation

The arc chute is installed by reversing the removal sequence. Make sure to tighten the hardware at each end of the return connection.

## Contacts

Remove dirt and/or grease on contacts with a clean, lintless cloth. **DO NOT USE SOLVENTS OF ANY KIND TO CLEAN THE CONTACTS. SOME SOLVENTS CAN DAMAGE THE CIRCUIT BREAKER INSULATION STRUCTURES.** Pitting or discoloration of the contacts is normal and is only detrimental when it interferes with proper contact adjustment. Oxidation of contact surfaces can be removed by several no-load operations every two weeks.

Small burrs on the arcing contact can be removed with non-metallic abrasive pads (like Scotch-Brite, a 3M Company product). Larger burrs can be removed by filing along the contour of the contacts.

**CAUTION:** Before cleaning the contacts, cover the puffer nozzle. Do not allow debris removed from the contacts to fall into the breaker mechanism. Use DRY compressed air to blow out stray debris after cleaning the contacts.

Contacts should be replaced if any of the following conditions exist:

1. Less than 50% of the original contact material thickness is left.
2. The tips of the arcing contacts are eroded away.
3. Any contact is broken or cracked.

When the contacts are filed or replaced, the contact pressure must be checked and adjusted if necessary.

## Insulation Structure

Insulated parts, such as the push rod and the lead support structure, should be checked for cracks or other damage. Dust and dirt can be removed by DRY compressed air or wiped clean with a lintless cloth. **DO NOT USE SOLVENTS OF ANY KIND AS THEY MAY DAMAGE THE SURFACE FINISH OF THE INSULATION STRUCTURE.**

## Puffer

The puffer helps push the arc up into the arc chute with a blast of air. Its performance can easily be checked during the maintenance interval. Charge and close the circuit breaker with the arc chute removed. Keeping clear of moving parts, place a hand above the arcing contact and open the circuit breaker. A moderate blast of air should be felt. If the puffer has low or no puffing action, do not put the circuit breaker in service. Check the puffer nozzle for blockage, the puffer tube for cracks or breaks, and the puffer piston seals and adjustment. Replace any of these parts if found defective. See below for puffer adjustments.

## WARNING WARNING WARNING WARNING

KEEP CLEAR OF ALL MOVING PARTS WHEN MAKING ADJUSTMENTS.

## ADJUSTMENTS

**NOTE:** The operating mechanism must be operated slowly, as described in section SLOW CLOSE PROCEDURE, when performing any adjustment requiring contact movement.

In order to charge the closing springs and to close and open the circuit breaker, the racking mechanism must be turned to a position such that the racking shutter (15, Fig. 1) closes when the racking crank (21, Fig. 1) is removed.

Only one basic adjustment is normally required and that is contact adjustment. This should be checked to the dimensional values required as described in paragraph "Contacts". Other adjustments are required only when operational check indicates a need.

### Slow Close Procedure

**NOTE:** The charging cranks must be reset (see steps 8, 9 and 10 below) after the last slow close operation, or future electrical operation will be impossible.

Refer to Figure 4 unless otherwise noted.

1. The closing springs must be charged; check spring charge indicator (16, Fig. 1).
2. Insert a screwdriver or rod through the hole in the escutcheon box (4) (right-hand side when facing the front of the circuit breaker) and depress the close block lever pin (5) at "A".
3. Push up on close latch release rod (5, Fig. 8) to manually close the circuit breaker. The close block lever pin (5, Fig. 4) will now remain in the down position. Remove screwdriver or rod.
4. Insert the maintenance handle in the ratchet carrier and operate the handle to slowly close the contacts (See Fig. 3 and "Emergency Operation".)

To repeat the slow-close operation, continue with the following steps:

5. Insert the maintenance handle and continue the charging operation until the indicator (16, Fig. 1) shows "SPRINGS CHARGED".
6. Push manual "TRIP" button (13, Fig. 1) to open the contacts.
7. Repeat steps 2, 3 and 4 above for the slow-close operation. To reset the charging cranks for normal electrical operation, proceed as follows:

8. Repeat steps 5 and 6 above.

9. Push up on close latch release rod (5, Fig. 8) to manually close the circuit breaker.

10. Push the manual "TRIP" button (13, Fig. 1) to open the contacts.

The circuit breaker is now ready for normal service operation with the charging cranks reset and the closing springs discharged.

#### Contacts (Refer to Figure 5)

Perform this adjustment with breaker out of switchgear with its arc chute removed:

1. The hex portion of the adjusting stud (1) should be centered within 1/16 inch, between the yoke (2) and the insulator (3).
2. Turning the adjusting stud (1) counterclockwise when viewed from the insulated push rod (3) will increase the contact pressure.
3. If stationary arcing contact is removed for any reason, be sure to reinstall the contact with its keeper plate.
4. The initial contact adjustment, 5.62 (+.03, -.00), is to be made with the circuit breaker in the open position.

#### Tripper Bar Load (Refer to Figure 6)

The tripper bar load is measured by use of a spring scale (4) positioned as shown. With the circuit breaker in the "CLOSED" position, the push required to trip the circuit breaker must be between 40 and 60 ounces for a one pole unit and 48 to 80 ounces for a two pole unit.

#### Shunt Trip Device (Refer to Figure 7)

After tripper bar has been checked per the above, proceed with the following:

1. Charge springs (electrically or manually).
2. Turn trip rod (1, Fig. 7) up until a .105 gauge fits between head of trip rod (1) and trip extension (5).
3. Remove gauge and close breaker.
4. Try .105" gauge; it should still fit. If it doesn't, turn up trip rod until gauge can be inserted.
5. Try .156" gauge - it should not fit.
6. Push up slowly with screwdriver or small rod at position "A" to make sure the breaker trips mechanically.

#### Control Device (Refer to Figure 8)

The control device is adjusted before leaving the factory. No attempt should be made to adjust the internal relays and contacts of this device in the field. If replacement of the control device is required, the close latch release rod (5) overtravel may require adjustment as described below.

#### Close Latch Release Rod

1. Back off on the close latch release rod (5) and check that the circuit breaker will not close by attempting to close it electrically or manually pushing up on the close latch release rod (5) to the full extent of its travel.

2. Charge the closing springs. Push up on the close latch release rod (5) to the full extent of its travel. While holding this rod up, turn it in until the closing springs are released, closing the breaker. Turn the close latch release rod (5) up an additional 1-1/2 turns.

#### OD-Overcurrent Device Adjustments (Refer to Figure 9)

##### Pick-up Setting Adjustments

Pick-up settings may be changed by turning the appropriate adjusting screw until the moving indicator lines up with the desired pick-up point line.

**NOTE:** The top line corresponds to the top printed pick-up value, the second line from the top corresponds to the second printed pick-up value from the top, etc.

##### Armature Trip Travel Adjustment

### CAUTION CAUTION CAUTION CAUTION

KEEP HANDS CLEAR OF ALL MOVING PARTS. THE CIRCUIT BREAKER WILL TRIP TO THE "OPEN" POSITION WHILE CHECKING OR ADJUSTING THE ARMATURE TRIP TRAVEL.

The overload device trip travel is set at the factory; however, if trip travel readjustment is required due to replacement of overloads or other parts, then readjust as follows:

1. Back out on the two trip adjusting screws (2 & 3) until the screws are engaging the nut by approximately two turns.
2. Charge springs and close circuit breaker.
3. Using a 1-foot long (approx.) rod, push up on long time armature (thick armature) at point "A", and hold it tight against the magnet. Turn in screw (3) until the breaker just trips. Continue to turn the screw in an additional 1-1/2 turns.



Charge springs and close the circuit breaker. Push up on the thin armature and adjust screw (2) using the same procedure as "3" above.

## LUBRICATION

Only two lubricants are approved for use in the FBK circuit breaker. Lubricated during final assembly, the FBK circuit breaker may not require additional lubrication during its service life when applied in accordance with ANSI C37.14. If, however, the breaker is applied in unusual situations defined by ANSI C37.14, has lubricant contaminated with dirt and debris, or has had parts replaced, relubrication should be performed as follows:

1. Apply NO-OX-ID special Grade "A" grease from Dearborn Chemical Company to all mating surfaces of moving current carrying joints. DO NOT APPLY NO-OX-ID GREASE ON ANY MAIN OR ARCING CONTACT SURFACE. Primary disconnects should be maintained by reapplying NO-OX-ID during maintenance periods. NO-OX-ID is available from ASEA Brown Boveri in one pint cans, number 713222-A.
2. Apply Anderol 757 synthetic grease manufactured by Huls, America, Inc. to mechanism parts, bearing and pins. DO NOT APPLY GREASE TO LATCH OR ROLLER SURFACES. Anderol 757 is available from Asea Brown Boveri in four-ounce tubes, part number 712994-A.
3. DO NOT APPLY light machine oil, or thin spray lubricants to lubricate any mechanism part.
4. DO NOT attempt to relubricate the spring charging motor gearbox. It is sealed and should not require repacking.
5. NEVER LUBRICATE THE OD-TYPE ELECTRO-MECHANICAL OVERCURRENT TRIP DEVICE.
6. Do not lubricate the circuit breaker using only Anderol 732 spray lube. Although useful as a solvent for removing old lubricant, Anderol 732 is not a substitute for Anderol 757.

## DIELECTRIC TEST

If the insulation has become contaminated, or routine tests are required, the test voltages to be applied for one minute to test the ability of the insulation to withstand overvoltages are as shown in Table 1.

### CAUTION CAUTION CAUTION CAUTION

**NOTE:** Disconnect the charging motor by means of the motor disconnect switch (10, Fig. 1) to avoid motor damage.

Before any dielectric tests are made on the control circuit, the semi-high speed overcurrent relay should be withdrawn from its enclosure so that the printed circuit card is not plugged in. No dielectric tests should be made on the semi-high speed trip system.

It is not recommended that the motor be dielectric tested, but if desired, then test at 600V ac. Motors that have been in service for a long period time may fail dielectric due to the normal accumulation of debris from the brushes and commutator. Cleaning the motor will restore dielectric integrity.

## ELECTRICAL CHARACTERISTICS OF CONTROL DEVICES

For closing and tripping currents, voltages and ranges, refer to Table 2.

For undervoltage trip devices, standard voltages and operating data, refer to Table 3.

Current values are average steady state values. Momentary inrush currents for all charging motors and ac coils are approximately 6-8 times these values.

## RENEWAL PARTS

Asea Brown Boveri recommends only those renewal parts be stocked that will be required to insure proper and timely maintenance of the breaker.

Refer to renewal parts bulletin RP-4.2.1.8 for complete ordering information and parts list.

The minimum quantities of assemblies recommended in the Renewal Parts Bulletin are based on ABB's own tests and statistical information on customer operating experience. The replacement of total assemblies is recommended in the field so that the circuit breaker can be returned to service as quickly as possible. The faulty assemblies can then be returned to ABB for reconditioning when that is possible.

The ABB service organization and factory personnel can be reached by calling:

Service 1-215-699-8887  
 Factory 1-803-665-4144

## REFERENCES

Additional reference material available:

IB 18.5.7-2 - Instructions for Circuit-Shield Solid State DC Overcurrent Relay Type ITE-76

TD-6691 - OD-FBK-3 Time Current Characteristic Curves

**TABLE 1**  
**TEST VOLTAGES TO BE APPLIED FOR ONE MINUTE**  
**TO TEST THE ABILITY OF THE INSULATION TO WITHSTAND OVERVOLTAGES**

|  | <b>Breaker Oper:</b>   | <b>Breaker Closed</b>   | <b>Breaker Open or Closed</b>   |
|--|--|---|---|
| <b>Breaker in Service or After Storage</b> | 3150V. A.C.<br>a. Between line and load terminals and metal parts normally grounded.<br>b. Between line and load terminals | 3150V. A.C.<br>a. Between terminals and metal parts normally grounded.<br>b. Between phases | 1125V. A.C.<br>a. Between control circuit and metal parts normally grounded.<br><br>NOTE: Motor & semi-high-speed trip assy. must be disconnected from control circuit for this test. |
| <b>After Short Circuit</b>                 | 2520V. A.C.<br>a. and b. as above.   | 2520V. A.C.<br>a. and b. as above.  | 900V. A.C.<br>a. as above and note.   |

**TABLE 2**  
**ELECTRICAL CHARACTERISTICS OF CONTROL DEVICES**  
**CLOSING AND TRIPPING CURRENTS, VOLTAGES AND RANGES**

| Nominal Control Voltage | Average Closing Motor Current Amperes | Shunt Trip Current Amperes | Control Device Current Amperes |             | Closing Circuit Voltage Range | Shunt Trip Circuit Voltage Range | FBK Semi-High Speed Trip Device Voltage Range | FBK-Mech Recommended Control Fuse Size * |
|-------------------------|---------------------------------------|----------------------------|--------------------------------|-------------|-------------------------------|----------------------------------|---|--|
|                         |                                       |                            | (X) Anti-Pump                  | (Y) Release |                               |                                  |   |  |
| 120 V ac 60 cycle       | 10.                                   | 6.5                        | .4                             | 1.5         | 104-127                       | 104-127                          | 104-127                                       | 10A                                      |
| 125 V dc                | 10.                                   | 1.3                        | .06                            | .7          | 106-140                       | 70-140                           | 70-140  | 10A                                      |
| 250 V dc                | 5.                                    | .65                        | .03                            | .3          | 210-280                       | 140-280                          | 140-280                                       | 10A                                      |

**TABLE 3**  
**UNDERVOLTAGE TRIP DEVICE**  
**STANDARD VOLTAGE AND OPERATING DATA**

| Service Voltage  | Current At Rated Volts | Maximum Pickup Voltage | Dropout Voltage Range |
|------------------|------------------------|------------------------|-----------------------|
| 120V ac 60 cycle | 0.4                    | 92                     | 36-72                 |
| 125V dc          | 0.2                    | 100                    | 38-75                 |
| 250V dc          | 0.1                    | 200                    | 75-150                |

**TABLE 4**  
**CHARACTERISTICS OF 76 DEVICE\* AND SENSOR RATINGS**

| Characteristics       |                           |                                     | Sensor Ratings (Amps) |
|-----------------------|---------------------------|-------------------------------------|-----------------------|
| Features              | Unit                      | Selectable Settings **              |                       |
| Instantaneous         | Pickup in Amperes         | 1, 2, 3 & 4 X Sensor Rating         | 500                   |
| Long Time             | Pickup in Amperes         | .5, .75, 1.0 & 1.25 X Sensor Rating | 1600                  |
|                       | Time-Delay in Seconds     | 5, 10, 15 & 20                      | 2500                  |
| Rate-of-Rise Detector | Rise-Rate in Amperes/Sec. | .2 to 4.0 X Sensor Rating           | 4000                  |
|                       | Time in Seconds           | .05 to .40                          | 6000                  |

\* Actual Pickup and Rise-Rate values for 8,000 and 10,000 ampere breakers are twice the setting of the overcurrent device.

\*\* Supplied with sensor-to-76 Relay Cable (609970-K1).

**TABLE 5**  
**CONTROL POWER OF 76 RELAY DEVICES**

| Nominal Voltage | Control           |               |
|-----------------|-------------------|---------------|
|                 | Current (Amperes) | Voltage Range |
| 125 V dc        | .05               | 90-140 *      |

\* Voltage range for tripping function is 70-140 volts.

**TABLE 6**  
**AVAILABLE SETTINGS FOR ODFBK TRIP DEVICES**

| Device      | Long Time            | Short Time | High - Set Inst. | Low - Set Inst.             | Time Current Curve          |
|-------------|----------------------|------------|------------------|-----------------------------|-----------------------------|
| ODFBK - 3A  | .5X, .65X, .8X, 1.0X |            | 1X, 2X, 3X, 4X   |                             | TD - 6691                   |
| ODFBK - 3B  | .5X, .65X, .8X, 1.0X |            |                  | 1X, 1.5X, 2.0X, 2.5X        | TD - 6691                   |
| ODFBK - 4A  | .5X, .65X, .8X, 1.0X | 2X, 3X, 4X |                  |                             | TD - 6690                   |
| ODFBK - 7A  |                      |            | 1X, 2X, 3X, 4X   |                             | TD - 7498                   |
| ODFBK - 8A  |                      |            |                  | .8X, 1.0X, 1.5X, 2.0X, 2.5X | TD - 6691 (Inst. Only)      |
| ODFBK - 10A |                      | 2X, 3X, 4X |                  |                             | TD - 6690 (Short Time Only) |

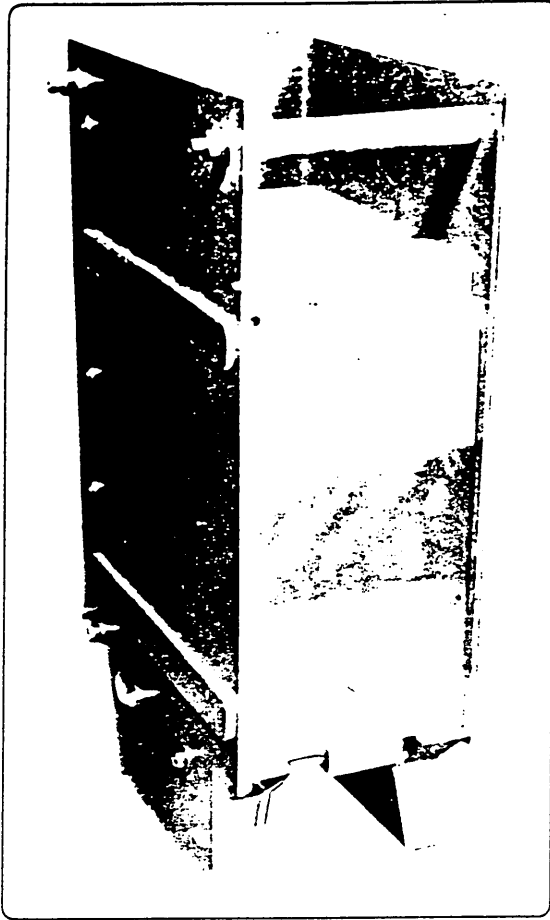


Figure 2 - ARC CHUTE

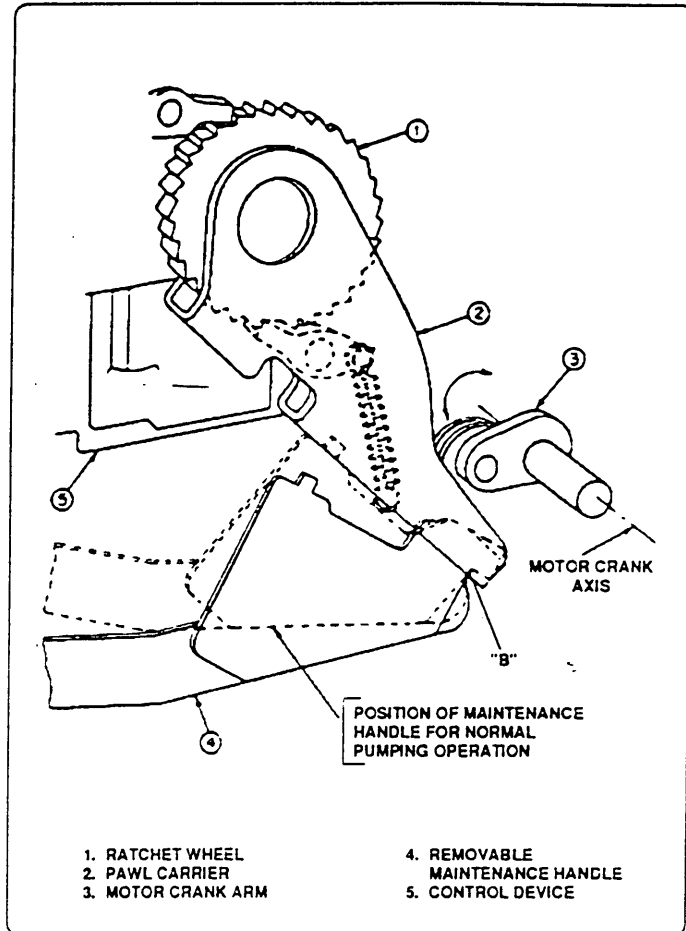


Figure 3 - METHOD OF APPLYING MAINTENANCE HANDLE FOR CHARGING CLOSING SPRINGS

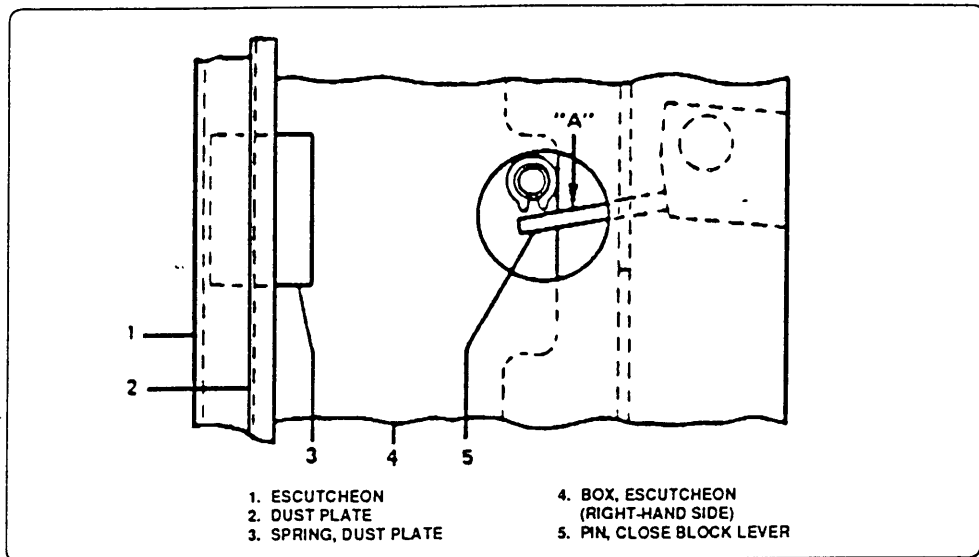


Figure 4 - PARTIAL VIEW OF ESCUTCHEON ASSEMBLY (RIGHT-HAND SIDE) SHOWING SLOW CLOSE LEVER FOR ELECTRICALLY OPERATED CIRCUIT BREAKERS

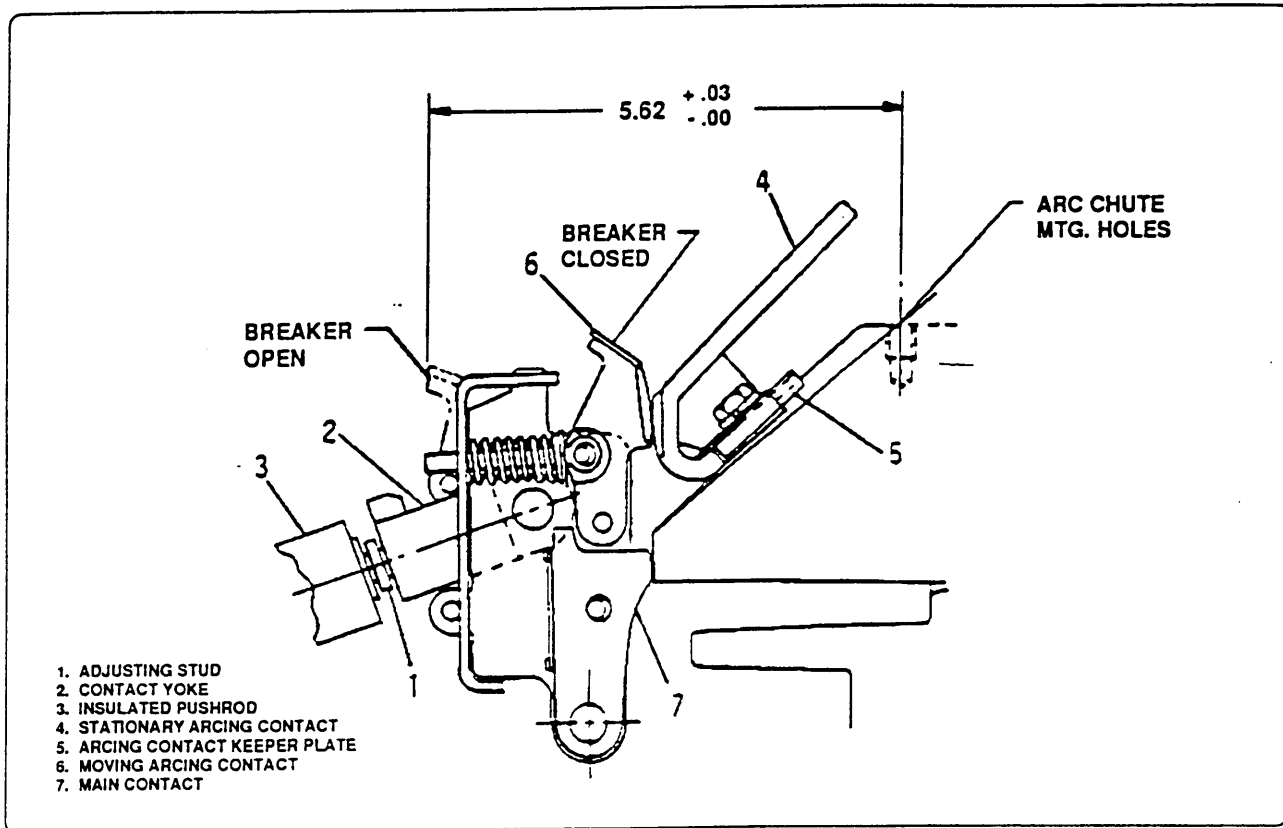


Figure 5 - CONTACTS

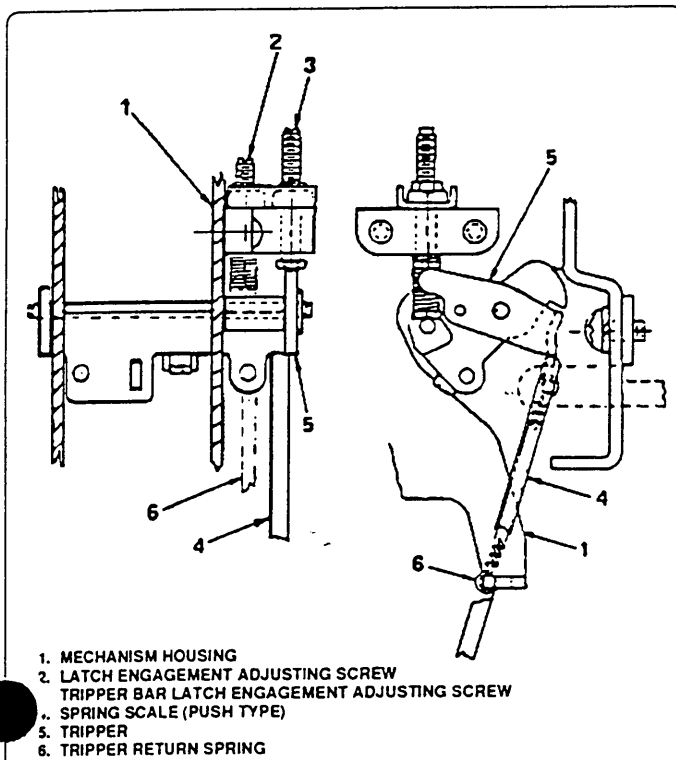


Figure 6 - TRIP LATCH

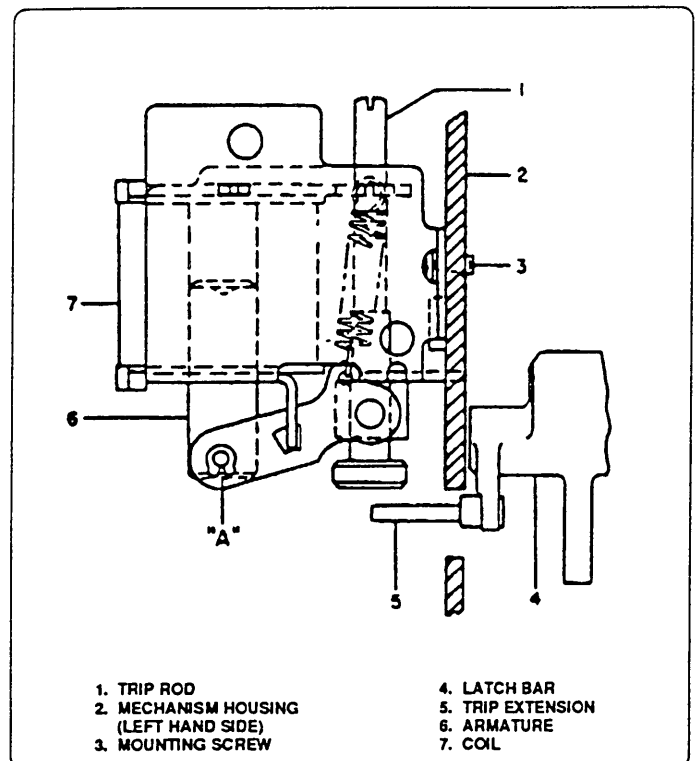


Figure 7 - SHUNT TRIP DEVICE ADJUSTMENT

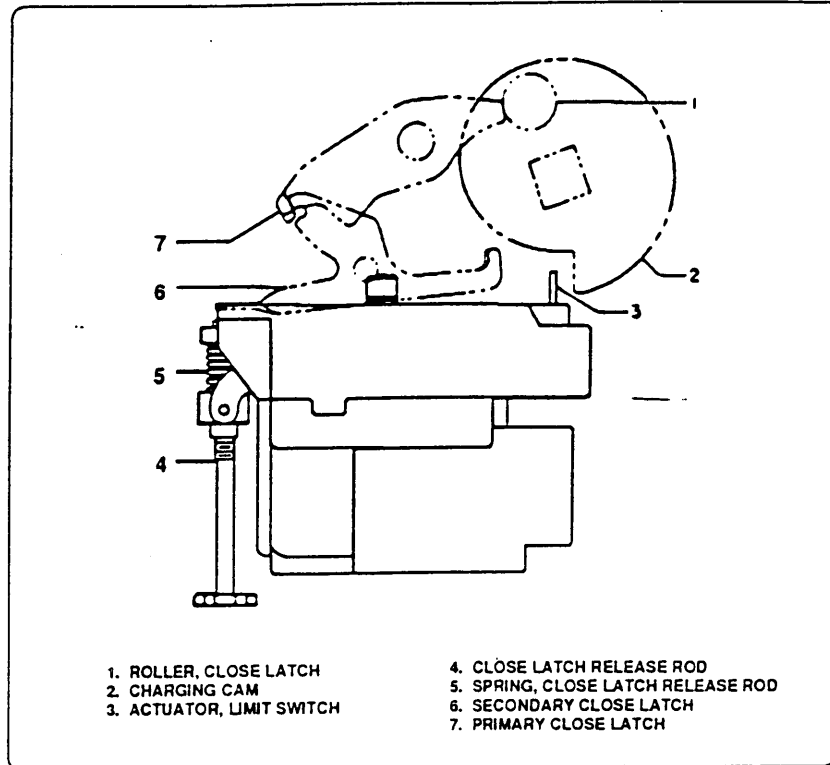


Figure 8 - CONTROL DEVICE ADJUSTMENT

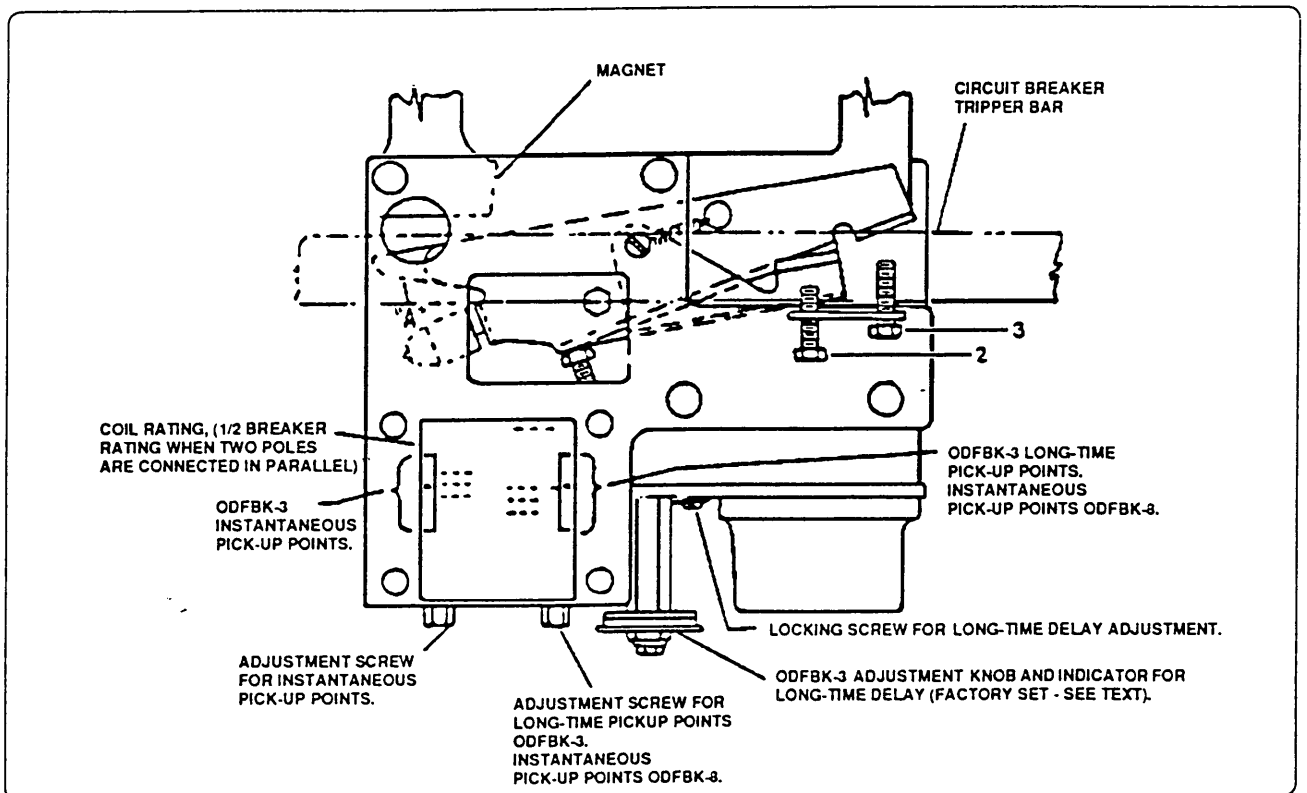


Figure 9 - DIRECT-ACTING OVERCURRENT TRIP DEVICE

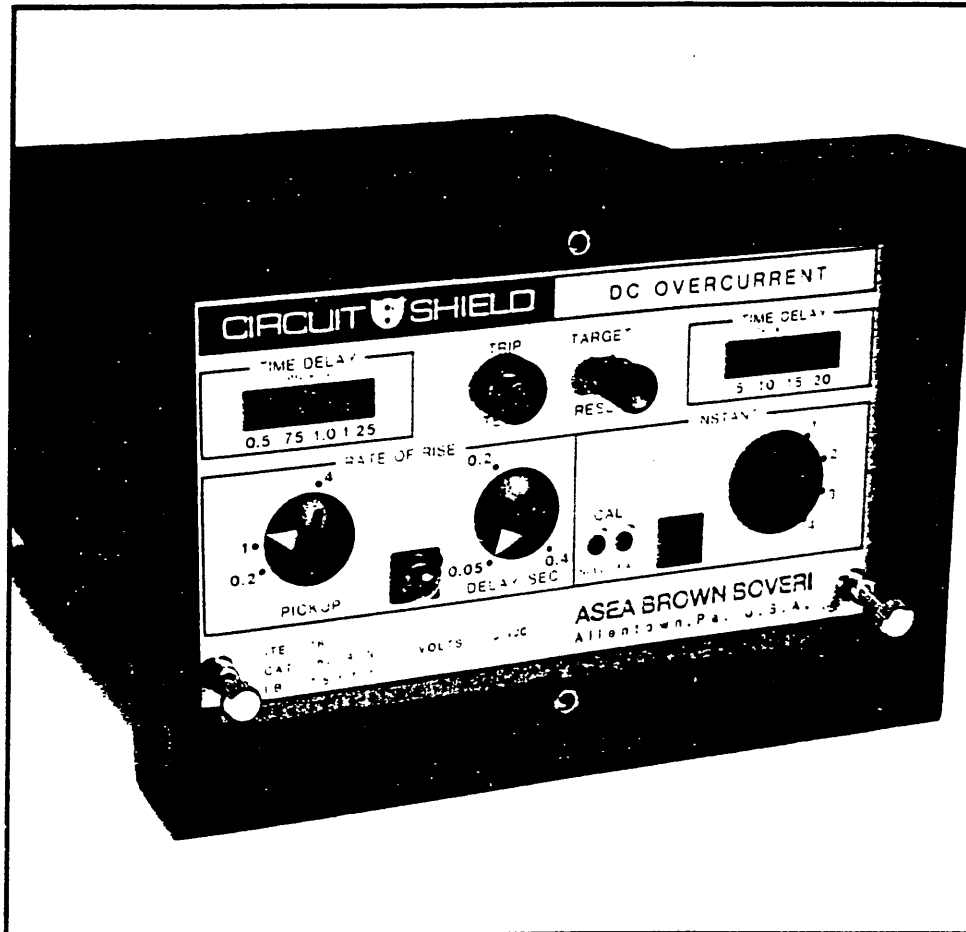
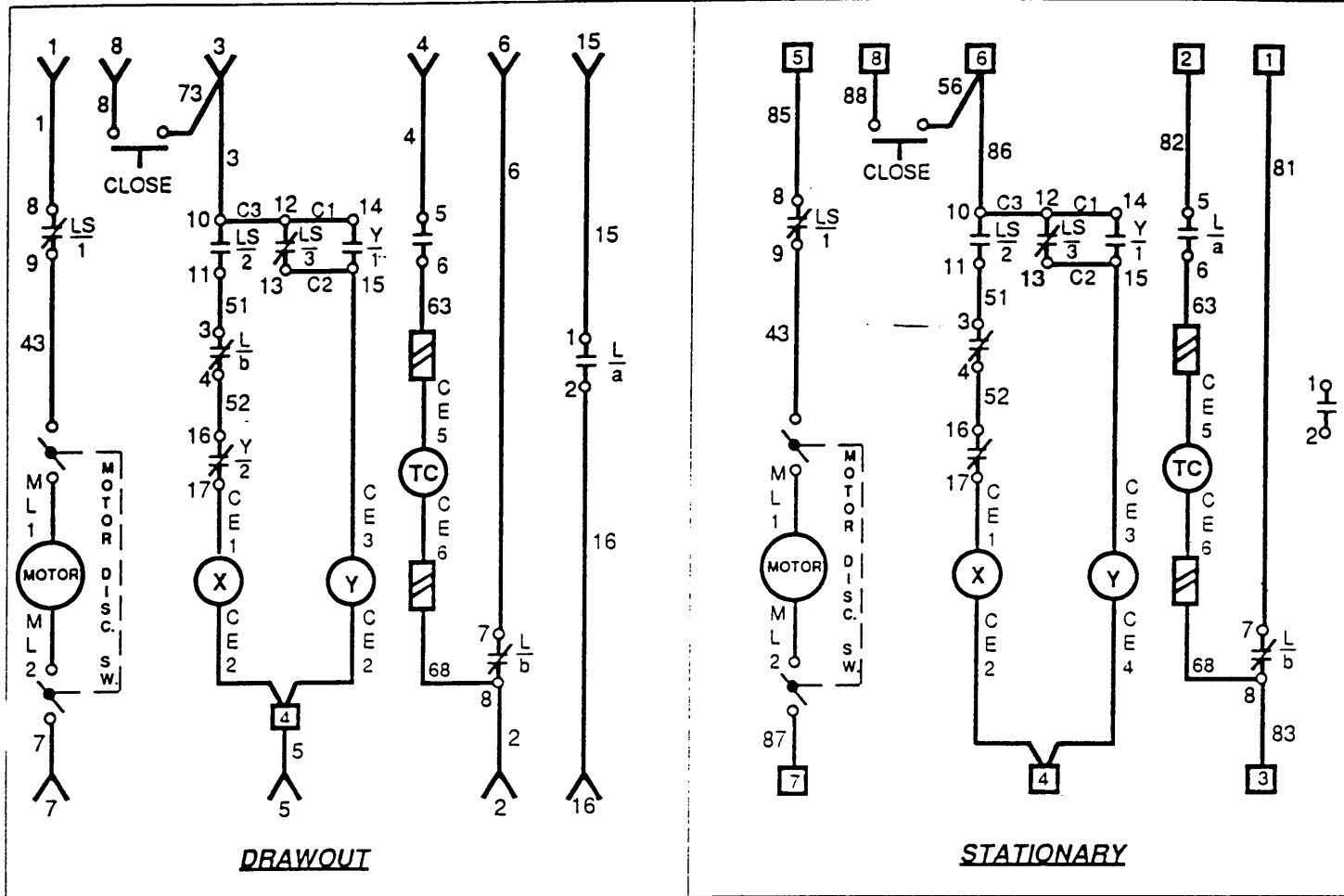


Figure 10 - TYPE 76 UNI-DIRECTIONAL SOLID-STATE  
OVERCURRENT RELAY

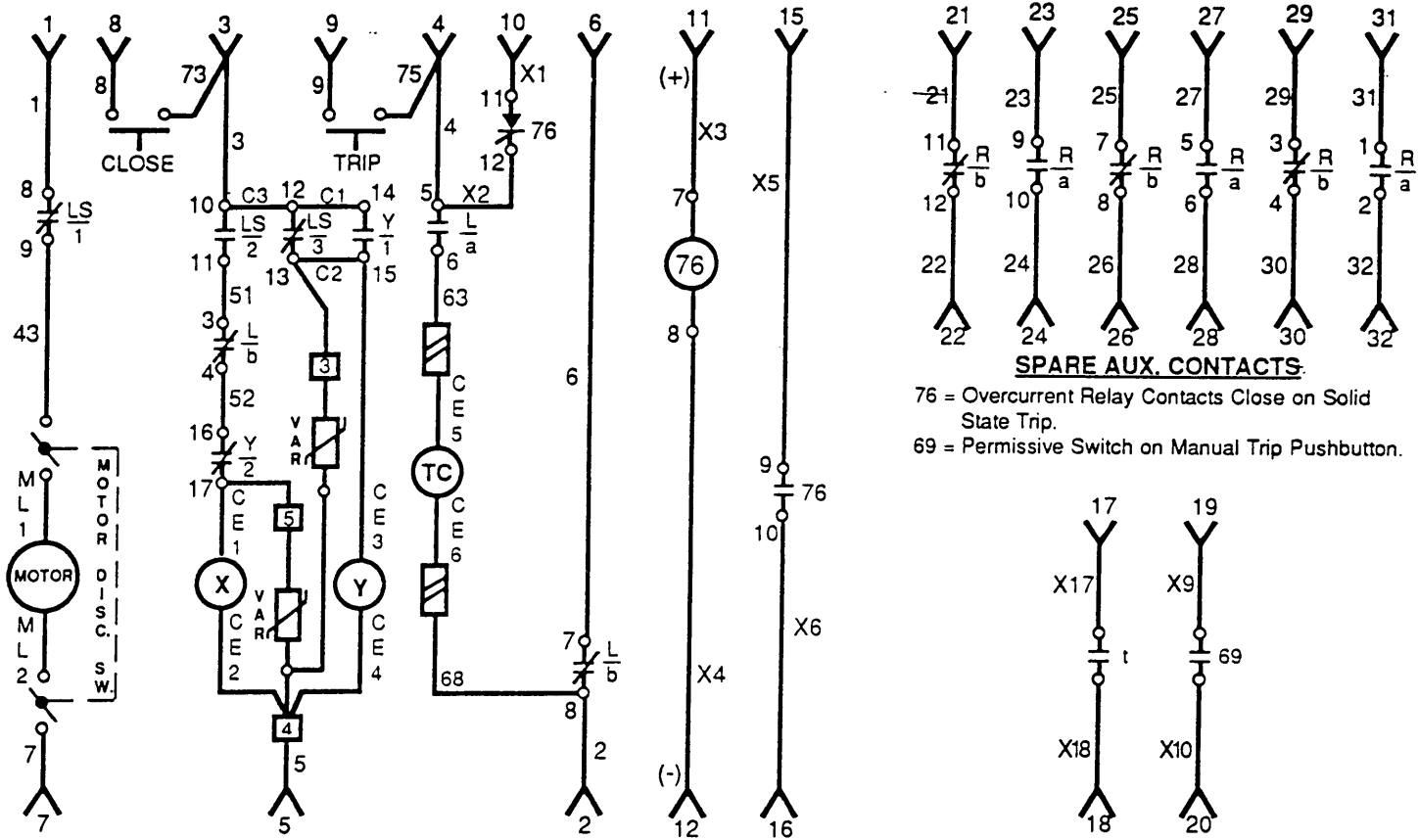


**LEGEND**

| SYMBOL      | DESCRIPTION   |
|-------------|---|
| a           | AUXILIARY SWITCH CONTACT OPEN WHEN BREAKER IS OPEN.                                       |
| b           | AUXILIARY SWITCH CONTACT CLOSED WHEN BREAKER IS OPEN.                                     |
| bp          | BYPASS SWITCH CONTACTS CLOSED WHEN DRAWOUT BREAKER IS WITHDRAWN.                          |
| CE          | COIL LEAD.  |
| L           | AUXILIARY SWITCH MOUNTED ON LEFT HAND SIDE.   |
| LS/2        | LIMIT SWITCH CONTACT OPEN WHEN SPRINGS ARE DISCHARGED, CLOSED WHEN SPRINGS ARE CHARGED.   |
| LS/1 & LS/3 | LIMIT SWITCH CONTACT CLOSED WHEN SPRINGS ARE DISCHARGED, OPEN WHEN SPRINGS ARE CHARGED.   |
| ML          | MOTOR LEAD.   |
| PB          | LOCAL PUSH BUTTON RECOMMENDED OPERATION IN TEST POSITION ONLY.                            |
| r           | ALARM CONTACT CLOSING ON OVERCURRENT TRIP. MANUALLY RESET.                                |
| s           | ALARM CONTACT OPENS ON OVERCURRENT TRIP. MANUALLY RESET.                                  |
| R           | AUXILIARY SWITCH MOUNTED ON RIGHT HAND SIDE.  |
| TB          | TERMINAL BLOCK POINT.   |
| TC          | SHUNT TRIP COIL.  |
| UV          | UNDERVOLTAGE DEVICE (TRIP OR LOCK OPEN).  |
| UV/b        | UNDERVOLTAGE CONTACT CLOSED WHEN UV COIL IS DE-ENERGIZED, OPEN WHEN UV COIL IS ENERGIZED. |
| X           | CLOSING LATCH RELEASE COIL.   |
| Y           | CONTROL RELAY LOCKOUT COIL.   |
| Y/1         | NORMALLY OPEN CONTROL RELAY CONTACT.  |
| Y/2         | NORMALLY CLOSED CONTROL RELAY CONTACT.  |
| LC          | LATCH CHECK SWITCH; CLOSED WHEN PRIMARY TRIP LATCH IS RESET.                              |
| MDS         | MOTOR DISCONNECT SWITCH.  |
| CD          | CONTROL DEVICE.   |
| CLOSE       | LOCAL ELECTRICAL CLOSE PUSH BUTTON.   |
| TRIP        | LOCAL ELECTRICAL TRIP PUSH BUTTON.  |
| □           | TERMINAL BLOCK.   |
| ▧           | KNIFE BLADE WIRE DISCONNECTS.   |
| ▨           | MOVABLE SECONDARY DISCONNECT CONTACT.   |
| ⊏           | DISCONNECT PLUG PIN AND RECEPTACLE.   |
| ▩           | VARIATOR.   |

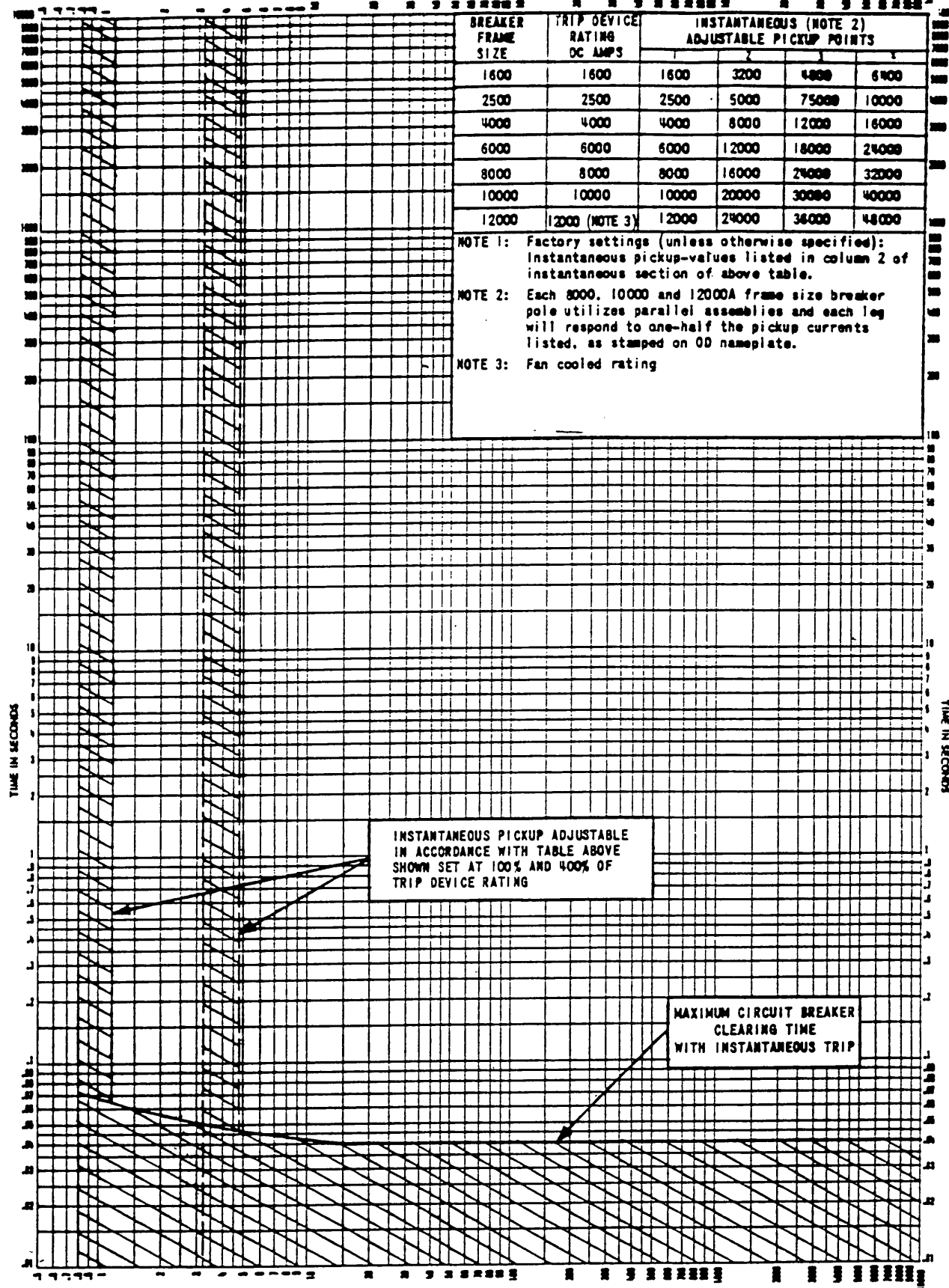
Figure 11 - TYPICAL SCHEMATIC DIAGRAM OF CONTROL CIRCUIT WITH ELECTRO-MECHANICAL TRIP DEVICE





- NOTES:**
1. Spare Aux. Contacts are convertible. Std. arrangement shown, if special list on sales order. (Typical for Figures 11 and 12).
  2. Refer to Legend in Figure 11.

Figure 12 - TYPICAL SCHEMATIC DIAGRAM OF CONTROL CIRCUIT WITH CIRCUIT-SHIELD SOLID STATE DC OVERCURRENT RELAY (DRAW-OUT BREAKER SHOWN)



| BREAKER FRAME SIZE | TRIP DEVICE RATING DC AMPS | INSTANTANEOUS (NOTE 2) ADJUSTABLE PICKUP POINTS |       |       |       |
|--------------------|----------------------------|---|-------|-------|-------|
|                    |                            | 1   | 2     | 3     | 4     |
| 1600               | 1600                       | 1600  | 3200  | 4800  | 6400  |
| 2500               | 2500                       | 2500  | 5000  | 7500  | 10000 |
| 4000               | 4000                       | 4000  | 8000  | 12000 | 16000 |
| 6000               | 6000                       | 6000  | 12000 | 18000 | 24000 |
| 8000               | 8000                       | 8000  | 16000 | 24000 | 32000 |
| 10000              | 10000                      | 10000   | 20000 | 30000 | 40000 |
| 12000              | 12000 (NOTE 3)             | 12000   | 24000 | 36000 | 48000 |

NOTE 1: Factory settings (unless otherwise specified); Instantaneous pickup-values listed in column 2 of instantaneous section of above table.

NOTE 2: Each 8000, 10000 and 12000A frame size breaker pole utilizes parallel assemblies and each leg will respond to one-half the pickup currents listed, as stamped on OD nameplate.

NOTE 3: Fan cooled rating

INSTANTANEOUS PICKUP ADJUSTABLE IN ACCORDANCE WITH TABLE ABOVE SHOWN SET AT 100% AND 400% OF TRIP DEVICE RATING

MAXIMUM CIRCUIT BREAKER CLEARING TIME WITH INSTANTANEOUS TRIP

RATIO OF ACTUAL CURRENT TO TRIP DEVICE RATING

|   |   |
|---|---|
| TIME-CURRENT CHARACTERISTIC CURVES I-T-E TYPE OD FBK-7A<br>HIGH INSTANTANEOUS DIRECT-ACTING TRIP DEVICE | ORDER NO. _____<br>TEST NO. _____ FILE NO. _____<br>DWG. BY R. DEWITTE DATE 11-6-74<br>NO. _____ TD-7498 REV. 1 |
|---|---|



# Installation/Maintenance Instructions

## I-T-E D-C Low-Voltage Power Circuit Breakers

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### Type FBK-H High Speed

1600 thru 10,000 Amperes  
800 Volts

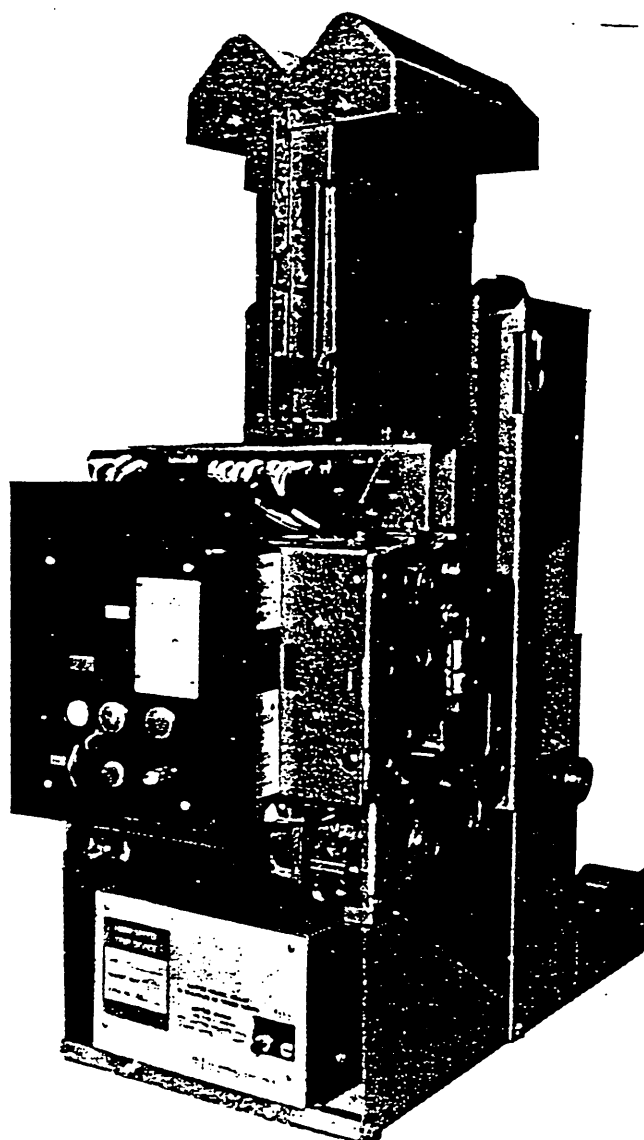


ABB Power Distribution, Inc.  
Circuit Breaker Division

**ABB**  
ASEA BROWN BOVERI

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## INSTRUCTIONS FOR FBK-H CIRCUIT BREAKER

Stationary and Drawout Mounted

### INTRODUCTION

These instructions apply to the type FBK-H 1600 through FBK-H 10,000 circuit breakers; 1600 through 10,000 ampere D.C. continuous current rating respectively at any voltage up to 800V. D.C. These high-speed circuit breakers will limit the magnitude and duration of fault currents to values significantly less than the circuit's available peak current. The circuit breakers are available as one or two pole breakers with high-speed trip in forward and/or reverse direction. Also available, is a negative disconnect withdrawal unit. The mechanisms are electrically operated and mechanically latched with provision for manual close, trip and maintenance slow closing.

A drawout type FBK-H 4000, single pole, is shown in Figure 1, with a typical schematic diagram shown in Figure 2.

These instructions should be read thoroughly before handling, installing and/or operating the circuit breaker.

### RECEIVING AND STORAGE

Immediately upon receipt of the circuit breakers, examine the cartons to determine if any damage or loss was sustained during transit. If injury or rough handling is evident, file a damage claim at once with the carrier and promptly notify the nearest District Office representative. Brown Boveri Electric is not responsible for damage of goods after delivery to the carrier. However, we will lend assistance if notified of claims.

Unpack circuit breakers as soon as possible after receipt. If unpacking is delayed, difficulty may be experienced in making a claim for damages not evident upon receipt. Use care in unpacking in order to avoid damaging any circuit breakers parts. Check the contents of each carton against the packing list before discarding any packing material. If any discrepancy is discovered, promptly notify the company representative. Information specifying the purchase order number, carton number and part numbers of damaged or missing parts should accompany the claim.

Circuit breakers should be installed in their permanent locations as soon as possible. (See Basic Handling section.) If possible, a drawout circuit breaker should be stored and locked in the "DISCONNECTED" position in its compartment with the door closed. Both the primary and control separable contacts are disconnected in this position. If the breaker cannot be installed in its compartment, it should be kept in a clean and dry location or covered and sealed to prevent infiltration of dirt. Where conditions of high humidity prevail, the use of heaters is recommended, regardless of the method of storage selected.

### BASIC HANDLING INSTRUCTIONS

Once the circuit breaker has been removed from its shipping crate, it should be kept in the upright position and

placed on a flat surface to avoid damage to breaker parts. For safety, all handling in this position should utilize a lifting yoke (Figure 1, Item 20).

### CIRCUIT BREAKER OPERATION

#### CIRCUIT BREAKER RATING

The continuous current rating is the maximum current that can be carried without exceeding rated temperature rise. There is no overload rating.

Exceeding the current rating may raise the temperature of the breaker beyond its design limit and thus affect the life of the circuit breaker.

#### BASIC CIRCUIT BREAKER OPERATION (See Fig. 2)

(Refer to the specific schematic diagrams, electrical operating sequences and any other operational information furnished with the order.)

With the circuit breaker open, the closing springs discharged, the control power source energized, and the motor disconnect switch (MDS) closed, operation occurs as follows:

1. Immediately upon availability of control power, the spring charging motor is energized, which in turn charges the closing springs. When the closing springs are charged, limit switch contacts "LS/1" and "LS/3" are opened, and limit switch contact "LS/2" is closed.

2. Operation of the remote close control switch or local electrical close pushbutton (when supplied) energizes the close latch release coil (X) through the circuit breaker auxiliary switch "L/b" contact, the normally closed lockout relay contact "Y/2," the 76 HS1 contact and the limit switch contact "LS/2." The close latch release coil (X) releases the latch and the springs then discharge to close the circuit breaker.

3. When the springs discharge, limit switch contacts "LS/1" and "LS/3" close and limit switch contact "LS/2" opens.

4. When the circuit breaker closes, all auxiliary switch "b" contacts open and all auxiliary switch "a" contacts close.

5. When the limit switch contacts "LS/3" close, the lockout relay coil (Y) is energized and opens lockout contact "Y/2" which de-energizes the close latch release coil (X). Lockout contact "Y/1" closes which seals in the lockout relay coil (Y) as long as the "close" contact is maintained. The purpose of the lockout coil (Y) is to prevent pumping of the closing mechanism when closing against a faulted circuit.

6. The circuit breaker can be tripped by operation of the remote trip control switch which energizes the circuit breaker trip coil (TC) through the auxiliary switch "L/a" contact.

7. The closing springs recharge when the breaker is in the closed position.

## CLOSING SPRING OPERATION

The two closing springs supply the power that closes the circuit breaker and also charge the opening springs during the closing operation. The closing springs are charged by a motor. The spring energy is available to close the circuit breaker, thus referred to as "stored energy". For safety, the closing springs are automatically discharged when drawout circuit breakers are racked from the disconnected to the withdrawn position.

## ESCUTCHEON OPERATING FEATURES

FBK-H circuit breakers are provided with an extendible escutcheon face plate. This escutcheon provides a central area for the controls and indicators which are mounted directly on the circuit breaker.

The controls and indicators (Figure 1) included on the escutcheon face plate are: (19) nameplate giving the rating assigned to the particular circuit breaker, (13) manual trip button, (12) electrical close push button switch, (10) motor disconnect switch, (14) "OPEN" and "CLOSED" position indicator, (11) means for padlocking the circuit breaker in the "CONNECTED", "TEST", or "DISCONNECTED" position and (16) closing spring charge indicator. Maintenance handle (22) is inserted for manual spring charging and maintenance slow closing.

All drawout circuit breakers have the racking shutter (15) that must be raised to allow inserting of the racking crank (21).

A self-aligning dust plate (18) immediately behind the escutcheon face plate is used to exclude dust from the circuit breaker compartment. On drawout type circuit breakers, the escutcheon face will protrude through the front door of the compartment when the circuit breaker is in the "TEST" and "DISCONNECTED" positions. In these positions, the dust plate adjusts its position to still function as a dust shield.

### Circuit Breaker Nameplate (Figure 1, Item 19)

The circuit breaker nameplate contains information regarding (1) the manufacturer's name and address, (2) type of circuit breaker, (3) serial number, (4) continuous current rating, (5) short circuit current rating at rated voltages and (6) momentary current rating.

### Circuit Breaker "Open" or "Closed" Indicator (Figure 1, Item 14)

This indicator shows the physical position of the circuit breaker contacts.

### Manual Trip Button (Figure 1, Item 13)

This button, when pushed, mechanically trips the circuit breaker to "OPEN".

### Padlocking Device (Figure 1, Item 11)

All FBK-H circuit breakers are equipped with means for padlocking the circuit breaker mechanism in a trip-free position. This is accomplished by the use of a locking plate to maintain the manual trip button in a tripped position when the locking plate is held forward by one or more padlocks. To obtain the condition for padlocking the circuit breaker in the open position, the manual trip button

is pushed inward (tripped position). Then the padlock plate is pulled out and the padlock inserted into the vertical slot. In this position, the mechanism is maintained trip free and the contact arm cannot be moved to the closed position.

On circuit breakers equipped with drawout mechanism, the padlocking device is also associated with the drawout interlocking mechanism so that the circuit breaker cannot be moved from any of its three basic drawout positions of "CONNECTED", "TEST", or "DISCONNECTED" when padlocked.

### Closing Spring Charge Indicator (Figure 1, Item 16)

Under normal operating conditions, the closing springs are automatically charged after each closing operation. However, there are occasions when the springs will be in a discharged state. Therefore, it is desirable that means be available to indicate the charged or uncharged condition of the closing springs. This is accomplished by a visual indicator seen through an aperture in the escutcheon plate. The indicator is marked "SPRINGS CHARGED" and "SPRINGS DISCHARGED".

### Auto-Trip Indicator (Optional) (Figure 1, Item 17)

This button, engraved RESET, is located on the breaker escutcheon, when furnished. Its normal position is depressed flush with the escutcheon. It can be arranged to pop out if the breaker trips automatically due to:

- A. Operation of the Direct Acting Overcurrent Trip Device (Optional)
- B. Operation of the Direct Acting Undervoltage Trip Device (Optional)

Depress the button before reclosing the circuit breaker.

### Motor Disconnect Switch (Figure 1, Item 10)

The motor disconnect switch is a double pole, single throw toggle type switch connected in series with the charging motor circuit and is used to disconnect the motor from the voltage source. This cut-off switch is used (1), when it is desirable to prevent automatic recharging of the closing springs just prior to taking the circuit breaker out of service for maintenance and (2), for control wiring dielectric test. The motor must be disconnected for the control wiring dielectric test and subsequently tested at 540 volts.

### Electrical Close Push Button (Figure 1, Item 12)

The electrical close push button is used to electrically close the breaker from the escutcheon. This contact is connected in series with the latch release coil (X). Energizing the latch release coil allows the charged springs to close the circuit breaker.

### Racking Mechanism (Drawout Breaker)

The racking mechanism is used to move the circuit breaker to any one of its three positions ("CONNECTED", "TEST" or "DISCONNECTED"). All of these positions are attainable with the cubicle door closed. The racking shutter (15, Fig. 1), which must be lifted to gain access to the racking mechanism, is interlocked with the circuit breaker so that the circuit breaker contacts must be open before the shutter can be lifted to rack the circuit breaker to another

position. The circuit breaker cannot be closed when the shutter is open. The circuit breaker may be padlocked open by means of the locking hasp. This automatically locks the racking mechanism.

With "TRIP" button (13, Fig. 1) depressed, the locking hasp (11, Fig. 1) may be pulled outward, accommodating from one to three padlocks, when the shutter is closed and the circuit breaker is tripped. The shutter cannot be lifted and the breaker contacts cannot be closed when the locking hasp is restrained by one or more padlocks.

There are two sets of arrows and indicating lines to show the circuit breaker position within the compartment. One set, located on the dust cover, is utilized with the compartment door closed and one set, located on the cradle, is utilized with the door open.

## OPERATION OF DEVICES

### Circuit Breakers Rated over 6000 Amperes Continuous

Circuit breakers with these ratings consist of two (2) main contact assemblies with the upper terminals connected in parallel and the lower terminals connected in parallel. The electro-mechanical trip devices and high speed trip devices are calibrated for the current that passes through one main contact assembly and is equal to one-half the current passing through the circuit breaker.

#### Two-Pole Circuit Breakers

Two-pole circuit breakers with a continuous current rating less than 8000 amperes are assembled on one (1) circuit breaker frame. Two-pole circuit breakers with continuous current ratings of 8000 amperes and above consists of two (2) circuit breaker frames with the breakers being electrically interlocked.

The normal overcurrent trip device arrangement is to provide the high speed function(s) on the left hand pole and the direct acting overcurrent trip function (when ordered) also on the left hand pole.

#### Single-Pole Circuit Breakers with Negative Disconnect

Single-pole/negative disconnect circuit breakers rated up to and including 6000 amperes are on one (1) circuit breaker frame. Single-pole / negative disconnect circuit breakers rated in excess of 6000 amperes consists of two (2) frames, the circuit breaker on one (1) frame and the disconnect on the other.

#### High-Speed Overcurrent Trip System (Electrical Operation)

The high-speed overcurrent trip system is a multi-component system consisting of sensor(s), a high-speed trip control assembly (76HS), and the impulse trip coil. The system is represented by block diagram (see Figure 11).

The sensor(s), supplied in several ratings, provides a signal in direct response to the direction and level of the current (I) through the circuit breaker. This signal initiates the tripping operation. By proper selection of sensor ratings and connections, forward and/or reverse tripping functions are provided at selected settings.

The Hall device, integral in the sensor, produces an output voltage signal proportional to the current (I) through the circuit breaker and in the same polarity. When a fault occurs, this output voltage exceeds the level-detector threshold voltage value; (pickup) and the detector initiates a firing pulse to energize the impulse trip coil, which opens the circuit breaker. This high-speed tripping operation causes the circuit breaker contacts to part in approximately 3 milliseconds after the fault level reaches the selected pickup value.

Pickup settings are provided that are 1.0, 2.0, 3.0 and 4.0 times the selected sensor rating and a tap block with plug is mounted on the front panel of the assembly for selecting the pickup setting required.

Monitoring: The high-speed control assembly is designed to monitor the trip system and to provide automatic interlocking in the event of low or unavailable control power. If control power is unavailable or the voltage is low, 76HS1 contact opens the close latch release coil circuit (Fig. 2). If the breaker is open, it cannot be closed electrically. 76HS3 contacts also opens. This contact is available to customer and is rated 15VA non-inductive, 1 Amp maximum.

After a high-speed tripping operation, interlocking will not allow the breaker to close until the tripping capacitor is fully recharged. Refer to Table 4 for capacitor charging time.

#### High-Speed Test Trip

Another feature provided is a test push button which provides a means of simulating a sensor output signal above the pickup level. Pressing this button with the breaker closed will cause the breaker to trip open. This test should only be made with the circuit breaker in the test position when automatic reclosing equipment is provided, unless such equipment is disconnected for the test period.

#### High-Speed Trip (Mechanical Operation) (Refer to Figure 7)

As described in the electrical operation, above, the impulse trip coil (6) is energized when the current level through the circuit breaker reaches a predetermined value or when the high-speed test pushbutton (31, Fig. 1) is pushed. The impulse trip armature (2) acts on the high-speed trip latch (7) that releases the roller (8) connected to the main contact assembly. This sequence constitutes the high-speed trip operation.

When the latch (7) moves to release roller (8), it also causes the actuator (9) to strike the mechanism trip screw (4) that initiates the movement of the mechanism to the open position.

#### Other Trip Devices

Other trip devices such as shunt trip, undervoltage or electro-mechanical overcurrent trip devices act directly on the latch bar (10) causing roller (8), latch (7) and the jack-shaft to move as a unit in opening the circuit breaker. The operating trip times of these devices are not as fast as the high-speed overcurrent trip system.

### Rate-of-Rise Fault Detector 76HS-RR (Optional)

For transit application the rate-of-rise fault detector (R-R) functions to discriminate between normal train starting currents and actual track fault currents. The circuit is based on a true rate-of-rise principle. Upon detection of the track fault, the breaker will trip within a preset time limit. This device has adjustable time delay. This adjustment provides fault detection "reach" based on the parameters of the system. Inherent with this device is a push button operated test circuit for periodic maintenance checks. The test circuit simulates a track fault signal which checks the integrity of the R-R detector and trip system. NOTE: Where automatic reclosing circuitry is provided, the above test should only be made when the breaker is in the TEST position or if the reclosing circuit is disconnected during the test.

### Control Device (Fig. 9)

This device is mounted below and to the left of the mechanism. The control device contains three electrical components, the limit switch (LS), the lockout relay (Y), and the latch release relay (X). The schematic diagram of the control circuit (Fig. 2) illustrates the function of this device. In addition to its electrical functions, the base of the device provides a terminal block for the circuit breaker wiring. A close latch release plunger is available for manual close and spring discharge operation.

The purpose of the lockout relay (Y) is to require that, if the remote or local close contacts are closed, resulting in the charging springs discharging, the close contacts must first be released (opened) before the breaker can be reclosed. This prevents closing the circuit breaker more than one time unless the close contacts are first released (anti-pump). The operating coil of lockout relay (Y) is designed for continuous duty. Consequently, the close signal can be a maintained contact.

### Auxiliary Switches (Figure 1, Item 2)

The auxiliary switches contain the "a" and "b" contacts (Fig. 2) and are furnished in 4 or 8 contact arrangements. They are mechanically interconnected with the main circuit breaker contacts such that, with the circuit breaker closed, the "a" contacts are closed. With the circuit breaker open, the "b" contacts are closed.

### Direct Acting Undervoltage Trip Device (Optional)

The electrically reset undervoltage trip device automatically trips the circuit breaker when the line voltage decreases to 30 to 60 percent of the rated voltage. This device may be furnished for either instantaneous or adjustable time delay (0-15 seconds) tripping.

See Table 3 for electrical characteristics.

NOTE: If no means are provided to trip the circuit breaker on loss of control power, a remote indication may be obtained by paralleling the 76HS3 contact with an auxiliary switch "b" contact. A closed circuit indicates a good power supply or an open breaker. An open circuit indicates a closed breaker with no high-speed trip capability.

### Direct-Acting Overcurrent Trip Devices (Fig. 10) (Optional) (Semi-High Speed) (Bi-directional)

- A. Type ODFBK-8 Overcurrent Trip Device. This device provides semi-high-speed instantaneous tripping normally adjustable from .8X to 2.5X the circuit breaker continuous current rating. A screw on the bottom of the device provides adjustment for the instantaneous pickup. The instantaneous setting is indicated on the device nameplate.
- B. Type ODFBK-3 Dual Overcurrent Trip Device. This trip device, for general purpose applications, provides long-time delay tripping on moderate overcurrents which are above the long-time pickup settings; and instantaneous (semi-high-speed) tripping on fault currents above the instantaneous trip setting. Three adjustment screws on the bottom of the device provide independent control of the long-time delay.\* The setting of these adjustments and the range of settings which are available are indicated on the device nameplate. The long-time pickup is adjustable from 0.5X to 1.0X the circuit breaker continuous current rating. The instantaneous pickup is adjustable from 1.0X to 4.0X the circuit breaker continuous current rating. The time-current characteristics of this device are shown on Dwg. TD-6991 (copies available upon request).

\*The long-time delay adjusting screw is factory set and is not to be disturbed.

## INSTALLATION, INITIAL TESTING AND REMOVAL

(Drawout & Stationary)

**FOR SAFETY:** When installing or removing stationary breakers, the supply for primary and control circuits must be de-energized at all times. Testing of stationary circuit breakers should be done with the primary supply circuit de-energized.

For initial installation of drawout breakers in the "CONNECTED" position, the supply for the primary circuit should be de-energized. Testing of the drawout breaker should be done in the "TEST" position.

NOTE: If the circuit breaker has an overcurrent device with long-time delay (OD FBK-3), then, prior to inserting the circuit breaker into the switchboard and with the breaker in the upright position, exercise the longtime armature (1" wide armature) several times until resistance to motion has increased, indicating that the oil dashpot is functioning properly. Improper operation can result if the circuit breaker is shipped or stored on its back. This causes the oil in the dashpot to be displaced and an air bubble can be trapped under the piston. The exercise removes the air to permit proper operation.

### INSTALLATION (Stationary Type) (Refer to Fig. 1)

Lifting yoke (20, Fig. 1) can be used to move the breaker to the installation location.

### INSTALLATION (Drawout Type) (Refer to Fig. 1)

To insert the circuit breaker into its compartment, proceed as described below:



1. The circuit breaker must be in the "OPEN" position, the racking crank turned in the counter clockwise direction fully against its stop, and the motor disconnect switch (10) in the "OFF" position.

2. Open the compartment door and pull out the right-hand and left-hand tracks (23) to the fully extended and latched position.

3. Using a lifting yoke (20) lower the circuit breaker so that the positioning wheels (6) (two on each side of circuit breaker) rest in the cut-out sections of each track (23).

4. Remove the lifting yoke and push the circuit breaker toward the compartment. The circuit breaker will slide in the cut-out sections of the tracks until the positioning wheels reach the end of the cut-outs. While holding down, push the circuit breaker toward the compartment until the racking cams (4) stop against their guides on the cradle (28). Release hold on latches.

5. Lift shutter (15) covering the racking opening, insert racking crank, and turn crank clockwise, pass through the "DISCONNECTED" position, until the position indicator on the cradle (left side) shows "TEST" position. Remove racking crank. The shutter should close if the breaker is in the proper position.

**CHECKING CIRCUIT BREAKER OPERATION IN "TEST" POSITION (DRAWOUT TYPE)**

CONTROL POWER ON (Refer to Fig. 1)

1. Turn motor disconnect switch (10) to "ON" position and closing springs will automatically charge.

2. Close circuit breaker by local close button and trip by local trip button.

NOTE: All breakers have a manual trip button. A local electrical trip button is optional.

3. Close and trip circuit breaker by means of remote control switch (when used) if the control scheme allows this with the breaker in the "TEST" position.

4. Check each auxiliary device for proper operation.

5. Close the circuit breaker and check that the shutter (15) cannot be lifted to allow insertion of the racking crank. This demonstrates that the circuit breaker could not be racked while closed in the test position.

6. With the circuit breaker closed, push the high-speed test push button (31). The circuit breaker should trip, indicating that simulated sensor output signal will trip the circuit breaker. Note that a delay is required before the circuit breaker can be reclosed. The delay time is shown in Table 4: and parts. Do not use.

7. With the circuit breaker closed, de-energize the control circuit and note that the circuit breaker will open.

**CHECKING CIRCUIT BREAKER OPERATION IN "CONNECTED" POSITION (DRAWOUT TYPE)**  
CONTROL POWER ON (Refer to Fig. 1)

Primary supply circuit must be de-energized with the circuit breaker in the "OPEN" position and the motor disconnect switch (10) in the "OFF" position. Insert the

racking crank and turn clockwise until the position indicator on the cradle shows "CONNECTED" position. Proceed per "TEST" position operation above.

**CHECK CIRCUIT BREAKER OPERATION (Stationary Type)**

Follow the same procedure as for the drawout circuit breaker, except the circuit breaker will be in the "CONNECTED" position. Primary supply circuit must be de-energized.

**EMERGENCY OPERATION (Refer to Fig. 3)**

Circuit breakers may be charged manually by a removable maintenance handle (4) for emergency operation.

The removable maintenance handle (4) is first positioned in two slots in the pawl carrier (2). The handle is then raised and lowered in a pumping motion until the pawl carrier (2) no longer rotates the ratchet wheel (1). The breaker closing springs are now fully charged and ready for a closing operation.

NOTE: The motor crank arm (3) may occasionally stop in such a position as to prevent charging the springs with the handle. Should this happen, the motor crank arm must be rotated manually by using a screwdriver or similar tool to rotate the crank arm a sufficient amount so that the springs may be charged with the handle as described above.

**CIRCUIT BREAKER REMOVAL (Drawout Type)**  
(Refer to Fig. 1)

To move the circuit breaker to the "TEST" position or to remove it from the compartment, proceed as follows:

1. With the compartment door closed, trip the circuit breaker by means of the remote control switch (when used) or manual "TRIP" button (13) on the escutcheon.

2. Lift racking shutter (15), insert racking crank and turn counter-clockwise until position indicator (27) on the right-hand side of the escutcheon shows "TEST" position. (NOTE: the circuit breaker may be tested in this position—primary contacts are disconnected and the control contacts are connected.)

3. Continue turning the racking crank counterclockwise until the position indicator (27) on the right-hand side of the escutcheon shows "DISCONNECTED" position. Remove the racking crank.

4. Open compartment door. Place motor disconnect switch (10) in the "OFF" position.

5. Insert racking crank and turn counterclockwise as far as the stops will allow. Check that the automatic spring discharge device will discharge the closing springs near the end of the racking operation.

6. Pull circuit breaker forward on tracks (23) to the fully extended and latched position.

7. With a positive pull, release positioning wheels from cut-out sections of the tracks.

8. Remove circuit breaker from tracks by means of lifting yoke and crane.

9. Release latch (24) on each track, push tracks into the compartment, and close compartment door.

FOR SAFETY: Keep clear of all moving parts.

Optional Feature

## MAINTENANCE

### SAFETY NOTES

De-energize both primary and control circuits before making any inspections, adjustments or replacements of parts. Make certain the circuit breaker is open by observing indicator (14, Fig. 1), and closing springs are not charged by observing indicator (16, Fig. 1).

When it is necessary that the charging springs be charged, or the circuit breaker be closed, make sure to stay clear of operating parts.

Stationary breakers should be checked for operation with the control circuit energized and the primary power de-energized. Drawout breakers should be withdrawn to "TEST" position for checking the breaker operation. For further inspection, adjustments, cleaning or replacement of parts, the drawout circuit breaker should be withdrawn and moved to a suitable area.

Stationary breakers should likewise be removed, but, if removal is not possible, then the primary and control circuit sources **MUST BE DE-ENERGIZED**.

### PERIODIC MAINTENANCE INSPECTION

The safety and successful functioning of the connected apparatus depends upon the proper operation of the circuit breaker. Therefore, it is recommended that a maintenance program be established that will provide for a periodic inspection of the circuit breaker after a given number of operations as follows:

|                                   |                |
|-----------------------------------|----------------|
| FBK-1600-6000-1 pole              | 500 Operations |
| FBK-8000 and 10000 and all 2 pole | 250 Operations |

The above inspection periods apply for no load or load current switching. If the listed number of operations are not completed in the first year of service, the circuit breakers should be inspected regardless. The circuit breaker should also be inspected after a short-circuit or severe overload interruption, regardless of time period or number of operations.

Where unusual service conditions exist, as covered by ANSI C37.14, it must be assumed that these conditions were considered at the time of order; that the equipment supplied was designed for the special application; and that an appropriate supplemental maintenance program has been developed. These maintenance instructions only cover circuit breakers used under the standard usual service conditions.

The inspection should include opening and closing the circuit breaker electrically and manually. The unit should be visually inspected for loose or damaged parts. Arc chutes, contacts and insulation structure should be inspected as described below. All accessible bolts, nuts and screws should be checked to insure that they are tight.

### ARC CHUTE (Refer to Fig. 1)

#### Removal

1. Remove the hardware fastening the two return connections (9) to the arc chute.
2. Remove 2 bolts and washers (25).
3. Lift the arc chute straight up to remove.

#### Examination

Examine the arc chute for damage. Discoloration or slight eroding is not harmful. Arc runners or cooling plates that are badly burned or liner plates with large cracks require that the arc chute be replaced. If a crust has formed on the liner plates, due to short circuit interruption or current switching, it should be removed by using a carborundum stone or scraper. Remove all dirt by blowing out the arc chute with dry compressed air.

#### Installation

The arc chute is installed by reversing the removal sequence. Make sure to tighten the hardware at each end of the return connection.

On breakers equipped with two (2) arc chutes, there is a tie-rod located between the chutes. This rod ties the arc chute shelf (32, Fig. 1) to the rear breaker frame, if at any time this rod is disturbed or replaced, readjust as follows: (The breaker must be open and the arc chutes installed.) Insert the rod through both holes in the shelf and the hole in the rear frame. Install a nut on both ends of the rod equalizing the thread on each end. Before tightening fully, insert a .010 shim under either nut, continue tightening the nuts until pressure is felt on the shim. Do not tighten further. Remove the shim.

### CONTACTS

1. Remove dirt or grease on contacts with a clean lintless cloth.
2. Pitting or discoloration is not detrimental unless it interferes with proper contact adjustment.
3. Small burrs on the arcing contacts can be removed by filing along contour of the contact. Do not let filings fall into the mechanism or puffer nozzle.
4. Replacement of contacts need only be considered when: after repeated dressing of any contacts, less than 50% of the original contact material thickness is left; the tips of the arcing contacts have been eroded away; any contact has been broken or cracked.
5. If contacts are replaced or filed, then it is necessary to check the contact adjustment.

**NOTE:** Several operations at two-week intervals will remove the effects of oxidation.

### INSULATION STRUCTURE

Insulated parts should be checked for damage. Dust and dirt should be removed by air or wiped with a clean lintless cloth. Do not use any oil base solvents.

### PUFFERS

The performance of the puffers can be readily checked during a maintenance interval. Each puffer, 1 for each contact assembly, should provide a moderate blast of air at the breaker contacts on opening of the circuit breaker. This can be detected by holding the hands or arm over the top of the contacts and opening the circuit breaker. If all puffers do not have puffing action, the circuit breaker must not be placed in service.

**FOR SAFETY:** Keep clear of all moving parts.

## ADJUSTMENTS

**NOTE:** The operating mechanism must be operated slowly, as described in section SLOW CLOSE PROCEDURE, when performing any adjustment requiring contact movement.

In order to charge the closing springs and to close and open the circuit breaker, the racking mechanism must be turned to a position such that the racking shutter (15, Fig. 1) closes when the racking crank (21, Fig. 1) is removed.

### SLOW CLOSE PROCEDURE

**NOTE:** The charging cranks must be reset (see steps 8, 9 and 10 below) after the last slow close operation, or future electrical operation will be impossible.

Refer to Figure 4 unless otherwise noted.

1. The closing springs must be charged; check spring charge indicator (16, Fig. 1).

2. Insert a screwdriver or rod through the hole in the escutcheon box (4) (right-hand side when facing the front of the circuit breaker) and depress the close block lever pin (5) at "A".

3. Push up on close latch release rod (5, Fig. 9) to manually close the circuit breaker. The close block lever pin (5, Fig. 4) will now remain in the down position. Remove screw driver or rod.

4. Insert the maintenance handle in the ratchet carrier and operate the handle to slowly close the contacts. (See Fig. 3 and "Emergency Operation.")

To repeat the slow-close operation, continue with the following steps:

5. Insert the maintenance handle and continue the charging operation until the indicator (16, Fig. 1) shows "SPRINGS CHARGED."

6. Push manual "TRIP" button (13, Fig. 1) to open the contacts.

7. Repeat steps 2, 3 and 4 above for the slow-close operation.

To reset the charging cranks for normal electrical operation, proceed as follows:

8. Repeat steps 5 and 6 above.

9. Push up on close latch release rod (5, Fig. 9) to manually close the circuit breaker.

10. Push the manual "TRIP" button (13, Fig. 1) to open the contacts.

The circuit breaker is now ready for normal service operation with the charging cranks reset and the closing springs discharged.

### CONTACTS (Refer to Figure 5)

1. The hex portion of the adjusting stud (1) must be centered within 1/16 inch, between the yoke (2) and the insulator (3).

**NOTE:** In the following steps 2 and 3 turning the adjusting stud (1) counter-clockwise when viewed from the insulator (3) will increase the contact pressure and dimension "A".

2. The contact adjustment is to be made with the circuit breaker in the closed position. The self-locking

adjusting stud (1) is to be turned to provide contact pressure such that the dimension at point "A" is 15/32". After making this adjustment in contact pressure, open and close the circuit breaker. Recheck the 15/32 dimension. Readjust if necessary.

3. On two-pole circuit breakers or where two contact assemblies constitute one pole, open the circuit breaker and slow close the contacts until the leading arcing contacts (4) of one pole or contact assembly just touches. The remaining contact assembly should be advanced by turning adjusting stud (1) so that the arcing contact of the other contact assembly just touches.

### HIGH-SPEED TRIP

#### Impulse Coil Trip Adjustment (High-Speed Trip) (Refer to Figure 7)

1. With the circuit breaker closed, turn the adjusting screw (1) for dimension "A" of .025/.035 inch. When making this measurement make certain the striker pin (2) is seated on the plunger (3).

#### Mechanism Trip Adjustment (Initiated by H-S Trip) (Refer to Figure 7)

1. Back out on trip screw (4) so that when the high-speed trip test button (31, Fig. 1) is actuated to trip the breaker, the main contacts open but the breaker mechanism remains closed as shown by the indicator (14, Fig. 1).

2. Reset the jackshaft and mechanism by depressing the manual trip button. Close the breaker. Turn trip screw (4) in slowly until the mechanism and jackshaft just trip. Try closing twice; the breaker should not close. Back out trip screw (4) by half turns until the breaker will close. Trip the breaker. Turn trip screw (4) out two additional turns.

### MECHANISM

#### Latch Engagement (Bite) (Refer to Figure 6)

The latch engagement adjusting screw (2) is located to the right of the right-hand mechanism housing (1).

To adjust the latch engagement, proceed as follows:

1. Back off adjusting screw (2) to assure excessive latch engagement.

2. Close the circuit breaker.

3. Turn adjusting screw (2) down slowly until the latch just releases, tripping the circuit breaker.

4. Back off the adjusting screw (2) two turns.

#### Tripper Bar Latch Engagement (Refer to Figure 6)

The tripper bar latch engagement adjusting screw (3) is located adjacent to the latch engagement adjusting screw (2).

To adjust the tripper bar latch engagement, proceed as follows:

1. Back off adjusting screw (3) to assure excessive tripper bar travel.

2. Close the circuit breaker.

3. Turn adjusting screw (3) down slowly until the latch just releases tripping the circuit breaker.

4. Back off the adjusting screw (3) 3½ turns.

#### Tripper Bar Load (Refer to Figure 6)

The tripper bar load is measured by use of a spring scale (4) positioned as shown. With the circuit breaker in the "CLOSED" position, the push required to trip the circuit breaker must be between 40 and 60 ounces for a one pole unit and 48 to 80 ounces for a two pole unit.

#### SHUNT TRIP DEVICE (Refer to Figure 8)

After latch bite and tripper bar are set per "MECHANISM", proceed with the following:

1. Charge springs (electrically or manually).
2. Turn trip rod (1, Fig. 8) up until a .105 gauge fits between head of trip rod (1) and trip extension (5).
3. Remove gauge and close breaker.
4. Try .105" gauge, it should still fit, if it doesn't turn up trip rod until gauge can be inserted.
5. Try .156" gauge—it should not fit.
6. Push up slowly with screw driver or small rod at position "A" to make sure the breaker trips mechanically.

#### CONTROL DEVICE (Refer to Figure 9)

The control device is adjusted before leaving the factory. It is recommended that no attempt be made to adjust the internal relays and contacts of this device in the field. If replacement of the control device is required, the close latch release rod (5) overtravel may be adjusted as described below.

#### Trip Rod Overtravel

1. Back off on the close latch release rod (5) and check that the circuit breaker will not close by attempting to close it electrically or manually pushing up on the close latch release rod (5) to the full extent of its travel.
2. Charge the closing springs. Push up on the close latch release rod (5) to the full extent of its travel. While holding this rod up, turn it in until the closing springs are released, closing the breaker. Turn the close latch release rod (5) up an additional 1-1/2 turns.

#### OD-OVERCURRENT DEVICE ADJUSTMENTS (Refer to Figure 10)

##### Pick-up Setting Adjustments

Pick-up settings may be changed by turning the appropriate adjusting screw until the moving indicator lines up with the desired pickup point line.

**NOTE:** The top line corresponds to the top printed pick-up value, the second line from the top corresponds to the second printed pick-up value from the top, etc.

##### Armature Trip Travel Adjustment

**CAUTION:** Keep hands clear of all moving parts. The circuit breaker will trip to the "OPEN" position while checking or adjusting the armature trip travel.

The overload device trip travel is set at the factory; however, if trip travel readjustment is required due to replacement of overloads or other parts, then readjust as follows:

1. Back out on the two trip adjusting screws (2 & 3) until the screws are engaging the nut by approximately two turns.
2. Charge springs and close circuit breaker.
3. Using a 1-foot long (approx.) rod, push up on long time armature, thick armature at point "A", and hold it tight against the magnet. Turn in screw (3) until the breaker just trips. Continue to turn the screw in an additional 1-1/2 turns.
4. Charge springs and close the circuit breaker. Push up on the thin armature and adjust screw (2) using the same procedure as "3" above.

#### HIGH-SPEED TRIP PICKUP SETTING

The pickup current for high-speed trip operation is set to multiples of the sensor rating by locating the selector plug (26, Fig. 1A) in the desired tap block slot. If the selector plug is accidentally left out, the trip setting automatically reverts to the minimum setting.

#### LUBRICATION

The FBK circuit breakers are lubricated during factory assembly as follows:

1. All mating surfaces of moving current-carrying joints have been lubricated with NO-OX-ID special Grade "A" grease manufactured by Dearborn Chemical Company.
2. All other mechanism parts, bearings, pins, etc. have been lubricated with Anderol L757 synthetic grease, manufactured by Tenneco Chemical Inc., Intermediate Division.

The circuit breaker requires no lubrication during its normal service life. However, if the grease should become contaminated or if parts are replaced, any relubrication should be done with NO-OX-ID or Anderol L757 grease as applicable.

#### NOTES:

1. Do not use NO-OX-ID grease on any main and arcing contact surfaces.
2. It is recommended that the primary disconnects be maintained by renewing the NO-OX-ID grease during maintenance periods.
3. Do not use light oil to lubricate any mechanism parts.
4. Do not allow grease to be deposited on any latch roller surface during relubrication.
5. The charging motor is sealed and does not require lubrication.
6. DO NOT LUBRICATE OVERCURRENT TRIP DEVICES.

#### DIELECTRIC TEST

If the insulation has become contaminated, or routine tests are required, the test voltages to be applied for one minute to test the ability of the insulation to withstand overvoltages are as shown in Table 1. **NOTE:** Disconnect

the charging motor by means of the motor disconnect switch (10, Fig. 1).

Before any dielectric tests are made on the control circuit, the plug connections at the rear of the circuit breaker connecting the circuit breaker and high speed trip assembly should be disconnected. No dielectric tests should be made on the high speed trip assembly parts.

It is not recommended that the motor be dielectric tested, but if desired, then test at 540V ac.

### ELECTRICAL CHARACTERISTICS OF CONTROL DEVICES

For closing and tripping currents, voltages and ranges, refer to Table 2.

For undervoltage trip devices, standard voltages and operating data, refer to Table 3.

Current values are average steady state values. Momentary inrush currents for all charging motors and ac coils are approximately 6-8 times these values.

### RENEWAL PARTS

Brown Boveri Electric recommends only those renewal

parts be stocked that will be required to insure proper and timely maintenance of the breaker.

Refer to renewal parts bulletin RP-16.4.1.8-1 for complete ordering information and parts list.

The minimum quantity of assemblies and items recommended in the bulletin are predicated on infrequent replacement of parts based on accumulated tests and operating experience. Total assemblies are recommended for fast replacement, when necessary, to return the breaker to service as quickly as possible. Then certain replaced assemblies, such as the stationary upper terminals, high speed trip control, etc. can be returned to the factory for reconditioning or replacement.

### REFERENCES

Additional reference material available.

- IB-16.4.1.7-2 – Instructions for High-Speed Trip Control Assembly
- IB-16.4.1.7-3 – Instruction Supplement for High-Speed Trip Control Assembly with Optional Monitoring Accessories
- TD-6691 – OD-FBK-3 Time Current Characteristic Curves

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the nearest District Office.

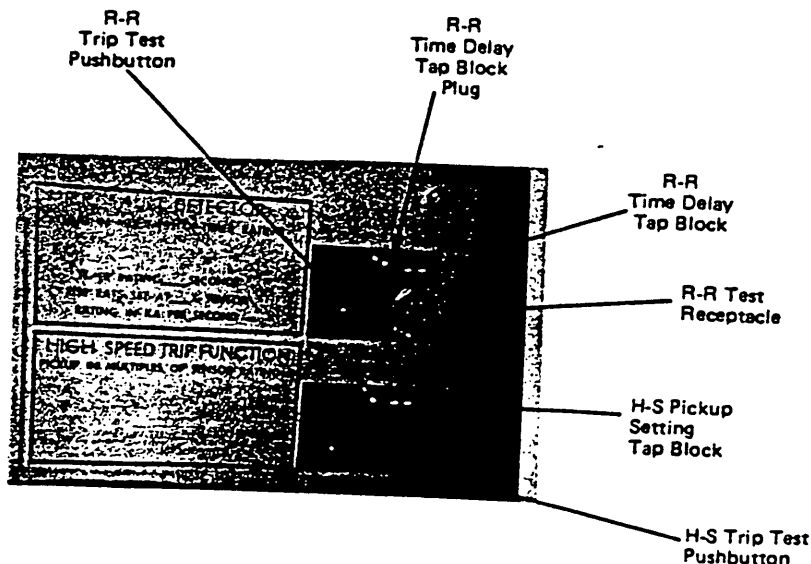


Fig. 1A—High-Speed Trip Control Assembly With R-R Fault Detector (Optional)

- |  |                                     |   |
|--|-------------------------------------|---|
| 1. Arc Chute                                 | 11. Locking Hasp                    | 23. Track                                     |
| 2. Auxiliary Switch                          | 12. Electrical Close Push Button    | 24. Latch                                     |
| 3. Secondary Separable Contacts              | 13. Manual Trip Button              | 25. Retaining Screws                          |
| 4. Racking Cam Assembly                      | 14. "OPEN" or "CLOSED" Indicator    | 26. High-Speed Trip Calibration Selector Plug |
| 5. Overcurrent Trip Device (Semi-High Speed) | 15. Racking Shutter                 | 27. Position Indicator                        |
| 6. Positioning Wheels                        | 16. Closing Spring Charge Indicator | 28. Cradle                                    |
| 7. Closing Spring Charging Motor             | 17. Auto Trip Indicator             | 29. High-Speed Trip Control Assy. (76HS)      |
| 8. Escutcheon Assembly                       | 18. Self-Aligning Dust Plate        | 30. Operation Counter                         |
| 9. Arc Chute Return Connections (Not Shown)  | 19. Nameplate                       | 31. High-Speed Trip Test Button               |
| 10. Motor Disconnect Switch                  | 20. Lifting Yoke                    | 32. Arc Chute Shelf                           |
|  | 21. Racking Crank                   | 33. Sensor Nameplate                          |
|  | 22. Removable Maintenance Handle    |   |

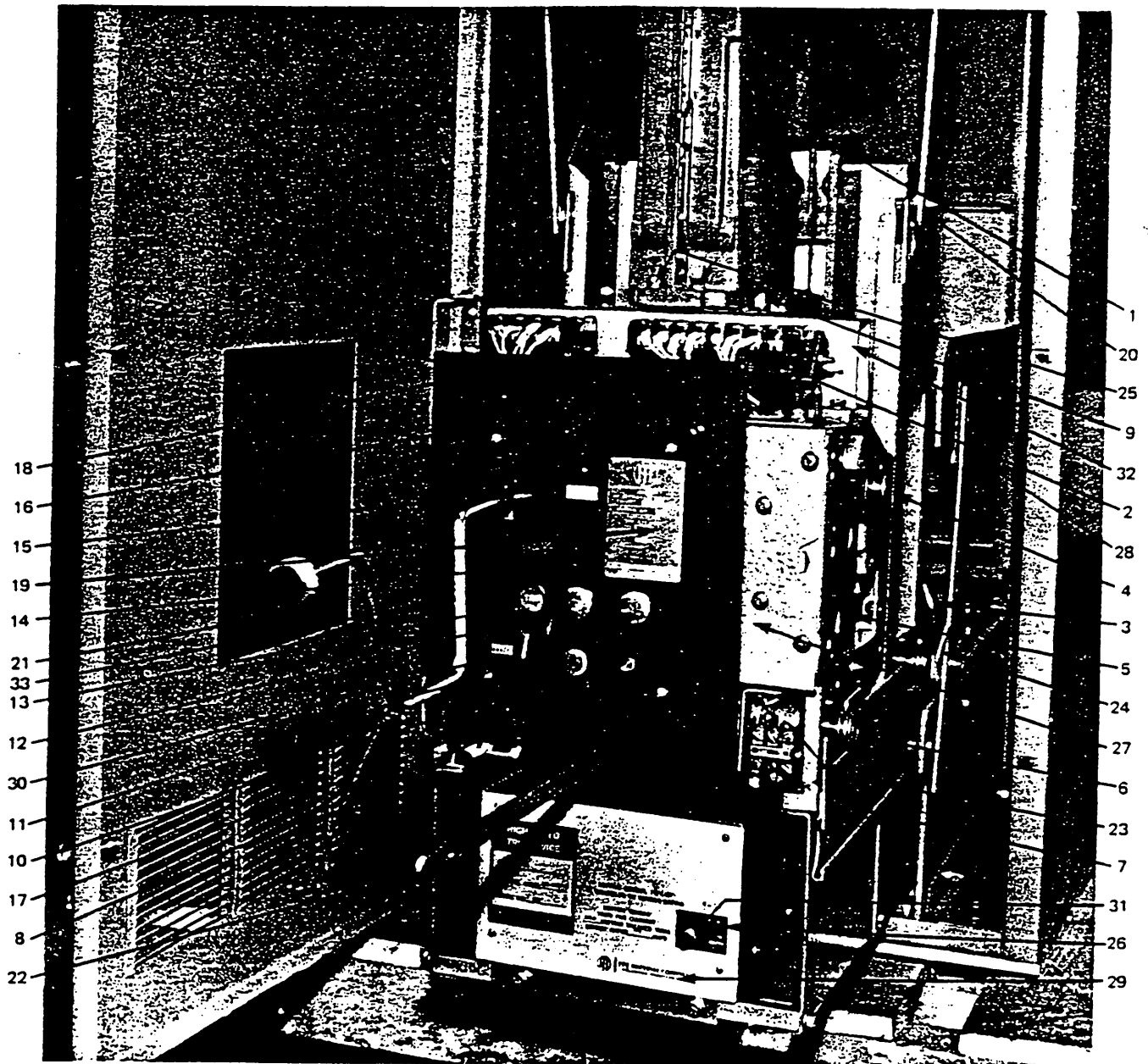
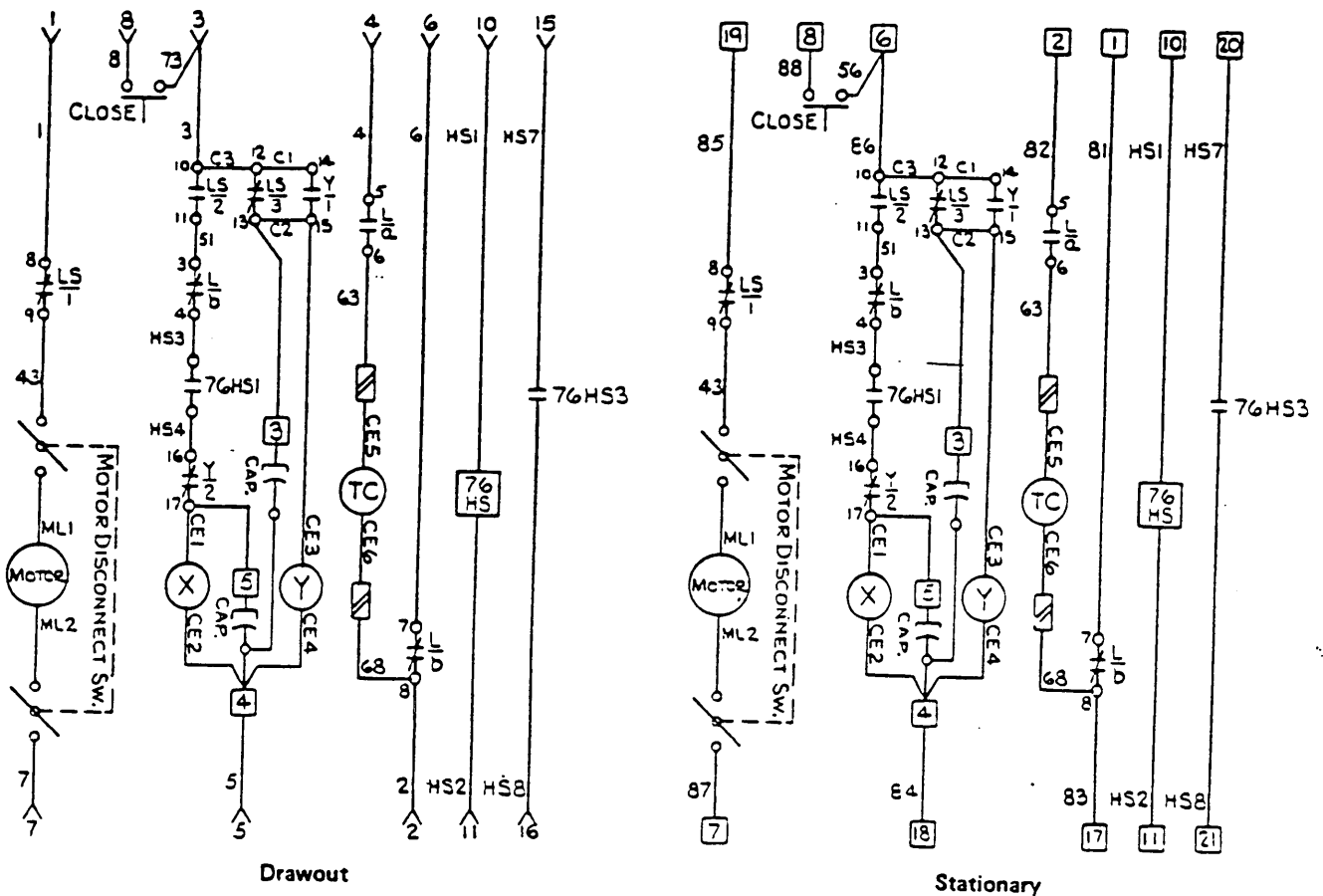
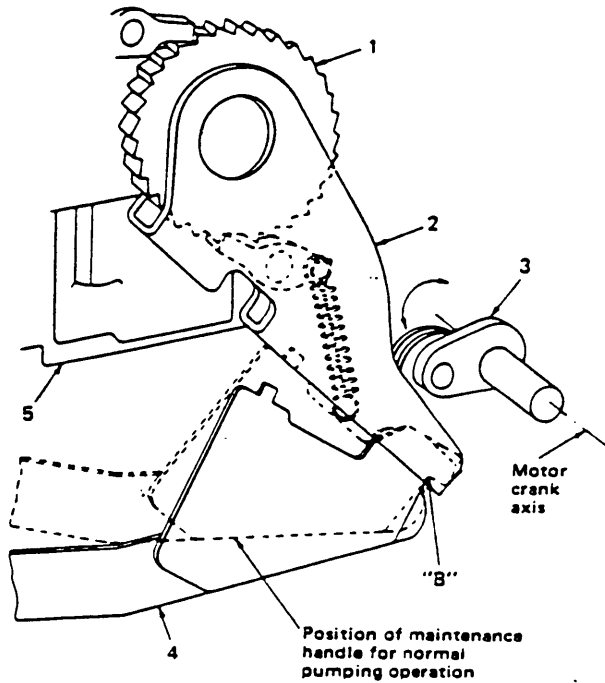


Fig. 1—FBK-H Drawout D-C Circuit Breaker—  
Major Components



| Symbol                     | Description  |
|----------------------------|--|
| a                          | AUXILIARY SWITCH CONTACT OPEN WHEN BREAKER IS OPEN.  |
| b                          | AUXILIARY SWITCH CONTACT CLOSED WHEN BREAKER IS OPEN.  |
| bp                         | BYPASS SWITCH CONTACTS CLOSED WHEN DRAWOUT BREAKER IS WITHDRAWN.   |
| CE                         | COIL LEAD.   |
| L                          | AUXILIARY SWITCH MOUNTED ON LEFT HAND SIDE.  |
| LS                         | LIMIT SWITCH CONTACT OPEN WHEN SPRINGS ARE DISCHARGED, CLOSED WHEN SPRINGS ARE CHARGED.  |
| LS/2                       | LIMIT SWITCH CONTACT CLOSED WHEN SPRINGS ARE DISCHARGED, OPEN WHEN SPRINGS ARE CHARGED.  |
| LS/1 & LS/3                | LIMIT SWITCH CONTACT CLOSED WHEN SPRINGS ARE DISCHARGED, OPEN WHEN SPRINGS ARE CHARGED.  |
| ML                         | MOTOR LEAD.  |
| PB                         | LOCAL PUSH BUTTON RECOMMENDED OPERATION IN TEST POSITION ONLY.   |
| r                          | ALARM CONTACT CLOSING ON OVERCURRENT TRIP, MANUALLY RESET.   |
| R                          | ALARM CONTACT OPENING ON OVERCURRENT TRIP, MANUALLY RESET.   |
| R                          | AUXILIARY SWITCH MOUNTED ON RIGHT HAND SIDE.   |
| TB                         | TERMINAL BLOCK POINT.  |
| TC                         | SHUNT TRIP COIL.   |
| UV                         | UNDERVOLTAGE TRIP DEVICE.  |
| UV/b                       | UNDERVOLTAGE CONTACT CLOSED WHEN UV COIL IS DE-ENERGIZED, OPEN WHEN UV COIL IS ENERGIZED.                                      |
| X                          | CLOSING LATCH RELEASE COIL.  |
| Y                          | CONTROL RELAY LOCKOUT COIL.  |
| Y/1                        | NORMALLY OPEN CONTROL RELAY CONTACT.   |
| Y/2                        | NORMALLY CLOSED CONTROL RELAY CONTACT.   |
|                            | MOVABLE SECONDARY DISCONNECT CONTACT.  |
|                            | KNIFE BLADE WIRE DISCONNECTS.  |
| LC                         | LATCH CHECK SWITCH: CLOSED WHEN PRIMARY TRIP LATCH IS RESET.   |
| 76HS-1 & 76HS-2            | HIGH SPEED CONTROL MONITORING INTERLOCK CONTACTS; OPEN IF HIGH SPEED TRIP FUNCTION IS INOPERATIVE, OR LOSS OF CONTROL VOLTAGE. |
| 76HS-J                     | HIGH SPEED CONTROL ASSEMBLY  |
| 76HS                       | DISCONNECT PLUG PIN AND RECEPTACLE   |
| MDS                        | MOTOR DISCONNECT SWITCH  |
| CD                         | CONTROL DEVICE   |
| K701                       | AUX. RELAY IN HIGH SPEED CONTROL ASSEMBLY  |
| K701/M                     | NORMALLY OPEN AUX. RELAY CONTACT   |
| K702                       | AUX. RELAY IN HIGH SPEED CONTROL ASSEMBLY  |
| K702/21, K702/22 & K732/23 | NORMALLY OPEN AUX. RELAY CONTACTS  |
| LOR                        | LATCH TYPE RELAY FURNISHED BY OTHERS   |
| LOR/b1 & LOR/b2            | NORMALLY CLOSED LATCH TYPE RELAY CONTACTS  |

Fig. 2—Typical Control Circuit Schematic Diagrams



- 1. Ratchet Wheel
- 2. Pawl Carrier
- 3. Motor Crank Arm
- 4. Removable Maintenance Handle
- 5. Control Device

Fig. 3—Method of Applying Maintenance Handle for Charging Closing Springs

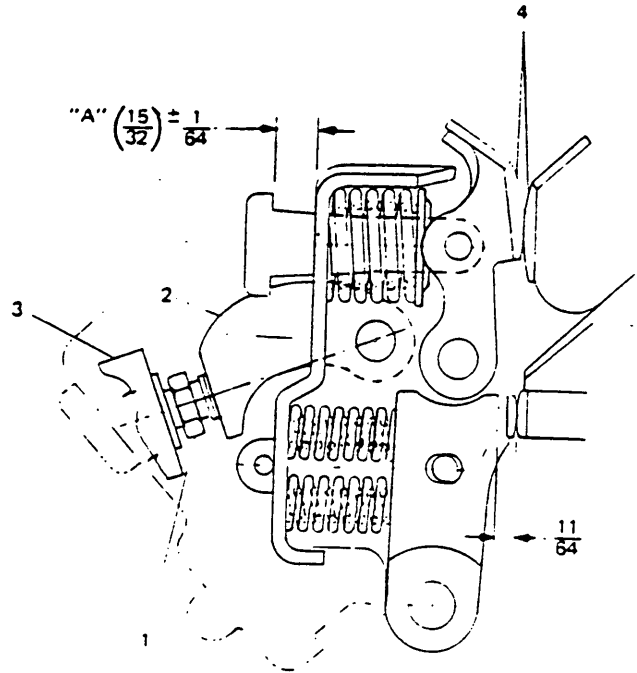
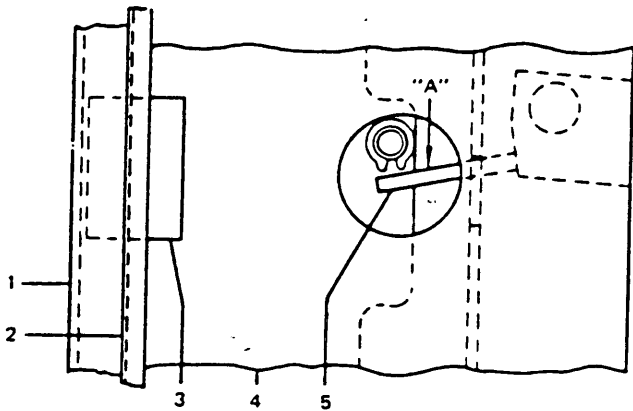
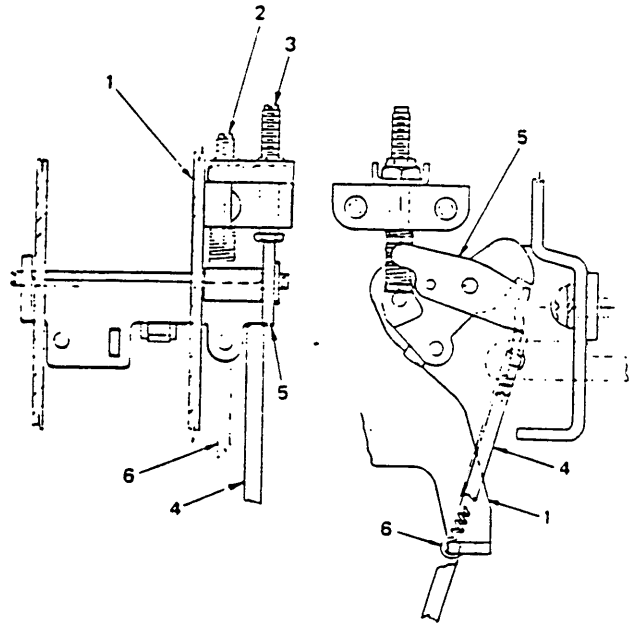


Fig. 5—Contacts



- 1. Escutcheon
- 2. Dust Plate
- 3. Spring, Dust Plate
- 4. Box, Escutcheon (Right-Hand Side)
- 5. Pin, Close Block Lever

Fig. 4—Partial View of Escutcheon Assembly (Right-Hand Side) Showing Slow Close Lever for Electrically Operated Circuit Breakers



- 1. Mechanism Housing
- 2. Latch Engagement Adjusting Screw
- 3. Tripper Bar Latch Engagement Adjusting Screw
- 4. Spring Scale (Push Type)
- 5. Tripper
- 6. Tripper Return Spring

Fig. 6—Trip Latch



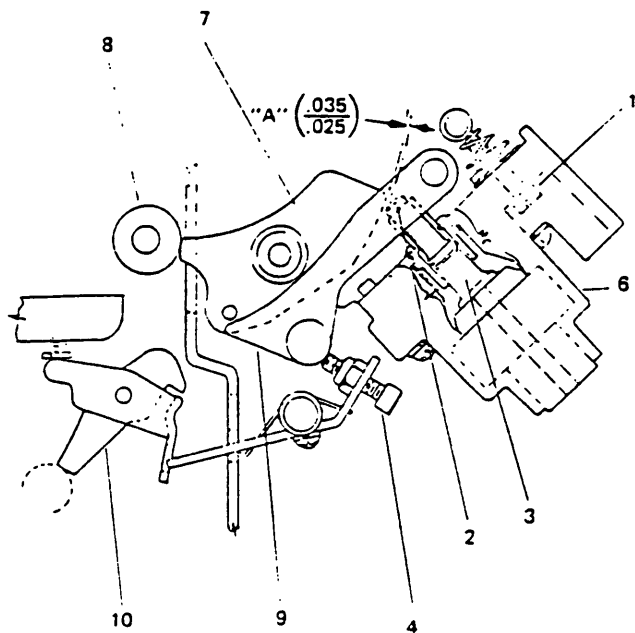
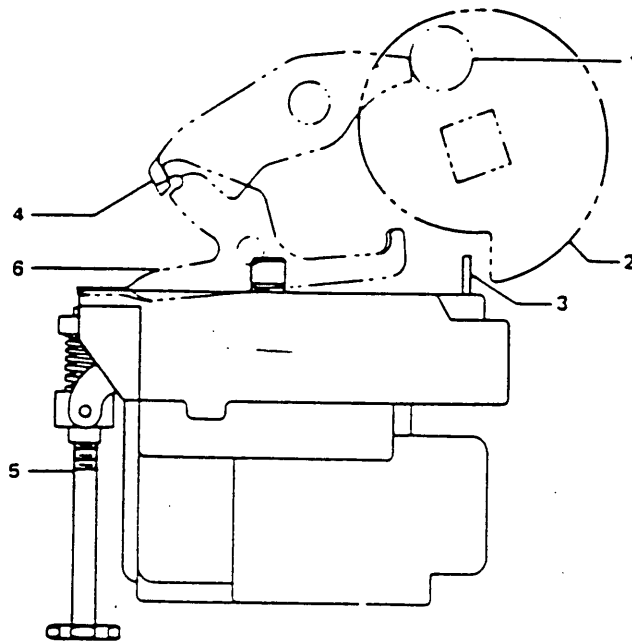
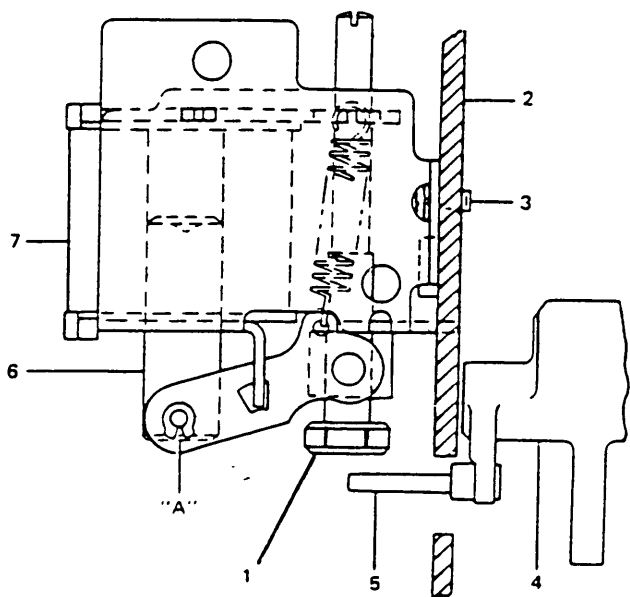


Fig. 7—High Speed Trip



- |                           |                            |
|---------------------------|----------------------------|
| 1. Roller, Close Latch    | 4. Primary Close Latch     |
| 2. Charging Cam           | 5. Close Latch Release Rod |
| 3. Actuator, Limit Switch | 6. Secondary Close Latch   |

Fig. 9—Control Device Adjustment



- |                                       |                   |
|---------------------------------------|-------------------|
| 1. Trip Rod                           | 4. Latch Bar      |
| 2. Mechanism Housing (Left-Hand Side) | 5. Trip Extension |
| 3. Mounting Screw                     | 6. Armature       |
|                                       | 7. Coil           |

Fig. 8—Shunt Trip Device Adjustment

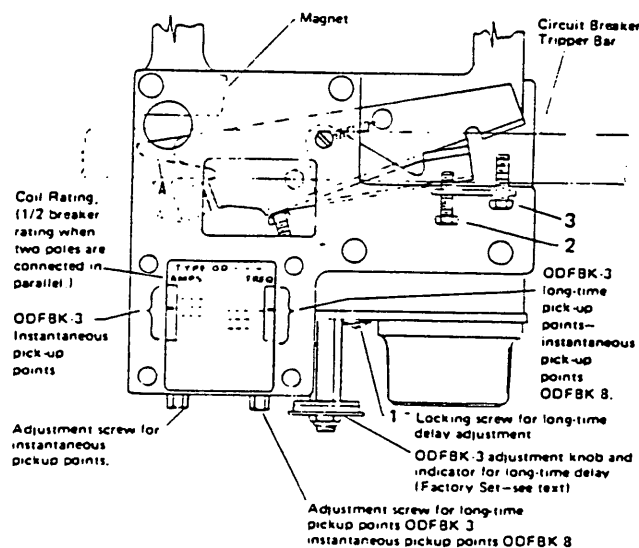


Fig. 10—Direct-Acting Overcurrent Trip Device

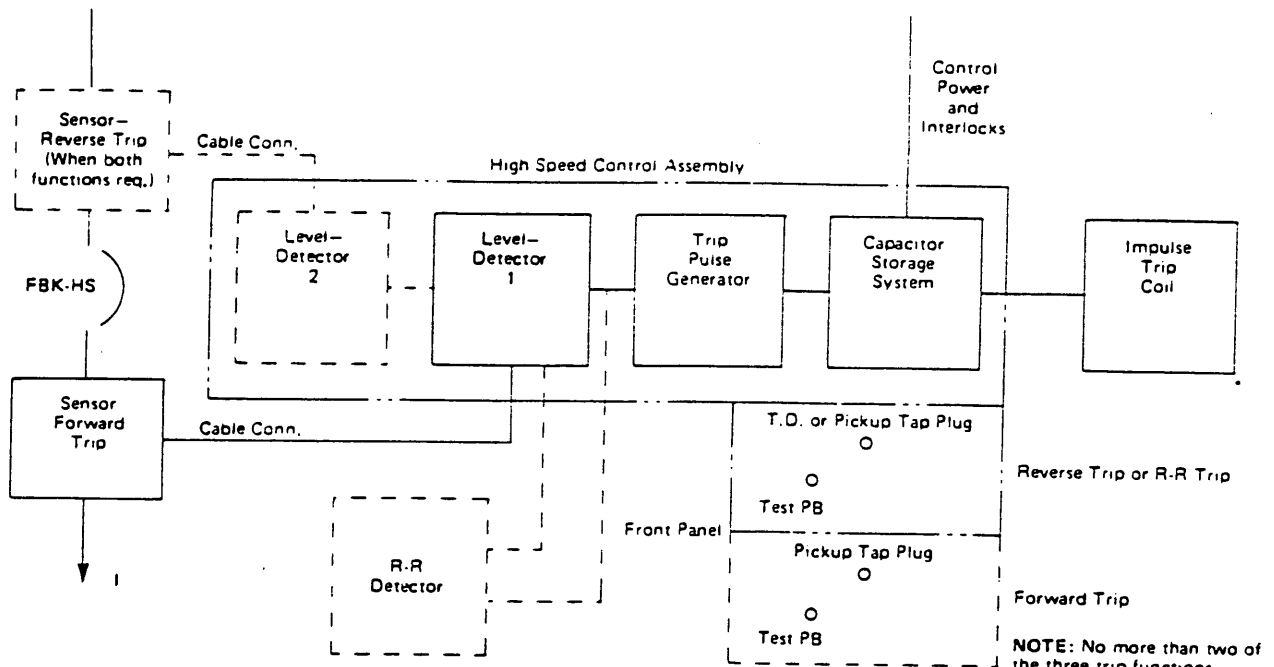


Fig. 11—High Speed Trip Control Assembly  
Block Diagram

NOTE: No more than two of the three trip functions (forward, reverse & R-R) can be supplied on one FBK-H breaker.

**TABLE 1**  
**TEST VOLTAGES TO BE APPLIED FOR ONE MINUTE**  
**TO TEST THE ABILITY OF THE INSULATION TO WITHSTAND OVERVOLTAGES**

|                                     | Breaker Open   | Breaker Closed   | Breaker Open or Closed   |
|-------------------------------------|--|--|--|
| Breaker in Service or After Storage | 3150V. A.C.<br>a. Between line and load terminals and metal parts normally grounded.<br>b. Between line and load terminals | 3150V. A.C.<br>a. Between terminals and metal parts normally grounded.<br>b. Between phases. | 1125V. A.C.<br>a. Between control circuit and metal parts normally grounded.<br><br>NOTE: Motor & high-speed trip assy. must be disconnected from control circuit for this test. |
| After Short Circuit                 | 2520V. A.C.<br>a. and b. as above  | 2520V. A.C.<br>a. and b. as above  | 900V. A.C.<br>a. as above and note   |

**TABLE 2**  
**ELECTRICAL CHARACTERISTICS OF CONTROL DEVICES**  
**CLOSING AND TRIPPING CURRENTS, VOLTAGES AND RANGES**

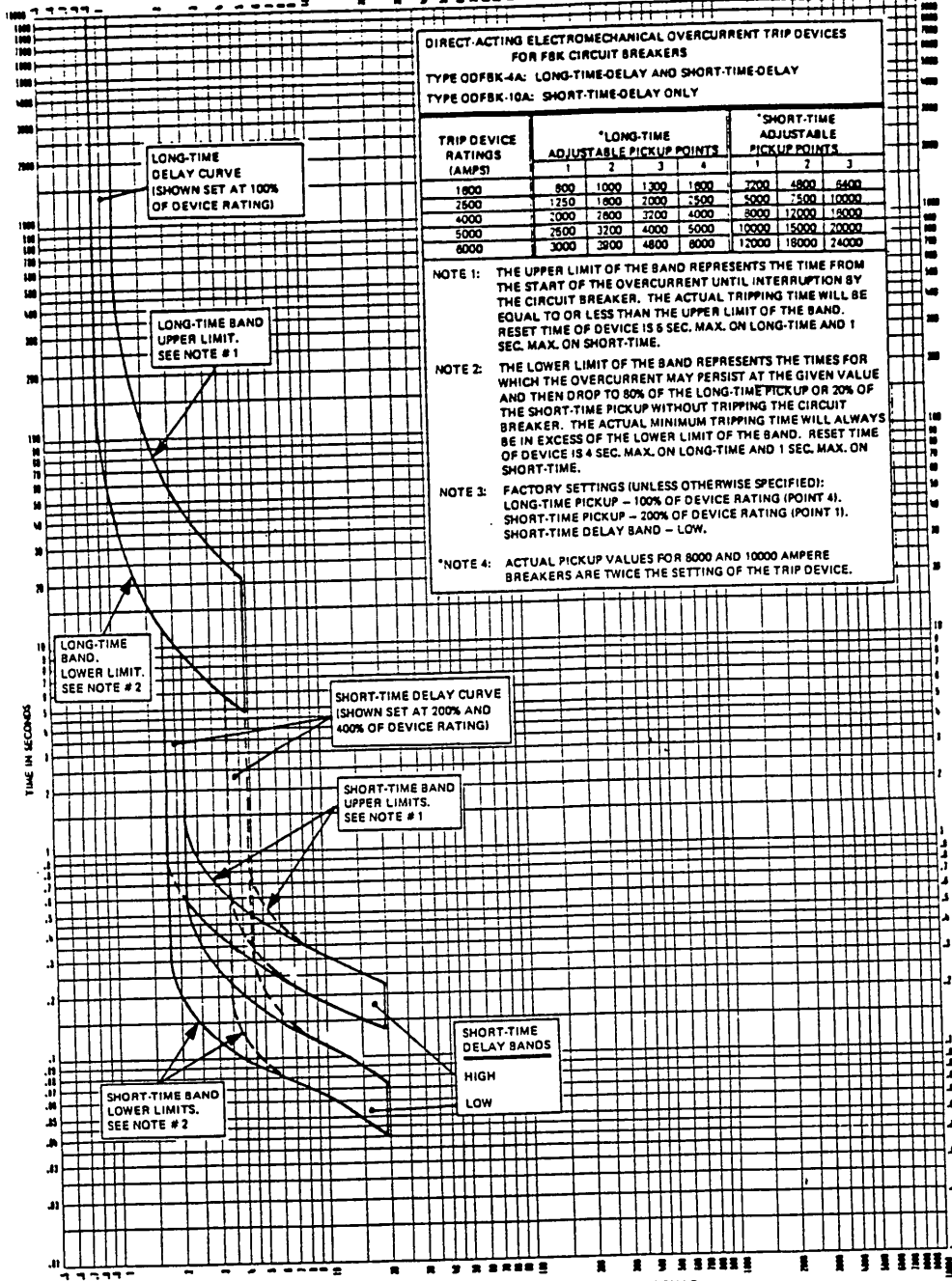
| Nominal Control Voltage | Average Closing Motor Current Amperes | Shunt Trip Current Amperes | CONTROL DEVICE Current Amperes |             | Closing Circuit Voltage Range | Shunt Trip Circuit Voltage Range | FBK-H High Speed Trip Device Voltage Range | Recommended Control Fuse Size |
|-------------------------|---------------------------------------|----------------------------|--------------------------------|-------------|-------------------------------|----------------------------------|--|-------------------------------|
|                         |                                       |                            | (X) Anti-Pump                  | (Y) Release |                               |                                  |  |                               |
| 120 ac 60 cycle         | 10.                                   | 6.5                        | .4                             | 1.5         | 104-127                       | 104-127                          | 104-127                                    | 10 A                          |
| 125V dc                 | 10.                                   | 1.3                        | .06                            | .7          | 106-140                       | 70-140                           | 70-140                                     | 10 A                          |
| 250V dc                 | 5.                                    | .65                        | .03                            | .3          | 210-280                       | 140-280                          | 140-280                                    | 10 A                          |

**TABLE 3**  
**UNDervOLTAGE TRIP DEVICE**  
**STANDARD VOLTAGE AND OPERATING DATA**

| Service Voltage  | Current at Rated Volts | Maximum Pickup Voltage | Dropout Voltage Range |
|------------------|------------------------|------------------------|-----------------------|
| 120V ac 60 cycle | 0.4                    | 92                     | 36-72                 |
| 125V dc          | 0.2                    | 100                    | 38-75                 |
| 250V dc          | 0.1                    | 200                    | 75-150                |

**TABLE 4**  
**MINIMUM RECLOSÉ TIME—SECONDS**  
**(TRIP CAPACITOR CHARGING TIME)**

| Service Voltage | Frame Size |              |
|-----------------|------------|--------------|
|                 | 1600-6000A | 8000-10,000A |
| 120V 60HZ (NOM) | 4          | 8            |
| 104V 60HZ (MIN) | 7          | 14           |
| 125V DC (NOM)   | 4          | 8            |
| 106V DC (MIN)   | 7          | 14           |
| 250V DC (NOM)   | 12         | 24           |
| 210V DC (MIN)   | 20         | 40           |



**DIRECT-ACTING ELECTROMECHANICAL OVERCURRENT TRIP DEVICES  
FOR FBK CIRCUIT BREAKERS**  
 TYPE ODFBK-4A: LONG-TIME-DELAY AND SHORT-TIME-DELAY  
 TYPE ODFBK-10A: SHORT-TIME-DELAY ONLY

| TRIP DEVICE RATINGS (AMPS) | *LONG-TIME ADJUSTABLE PICKUP POINTS |      |      |      | *SHORT-TIME ADJUSTABLE PICKUP POINTS |       |       |
|----------------------------|-------------------------------------|------|------|------|--------------------------------------|-------|-------|
|                            | 1                                   | 2    | 3    | 4    | 1                                    | 2     | 3     |
| 1800                       | 800                                 | 1000 | 1300 | 1600 | 7200                                 | 4800  | 6400  |
| 2500                       | 1250                                | 1600 | 2000 | 2500 | 5000                                 | 7500  | 10000 |
| 4000                       | 2000                                | 2800 | 3200 | 4000 | 8000                                 | 12000 | 18000 |
| 5000                       | 2500                                | 3200 | 4000 | 5000 | 10000                                | 15000 | 20000 |
| 8000                       | 3000                                | 3900 | 4800 | 6000 | 12000                                | 18000 | 24000 |

- NOTE 1: THE UPPER LIMIT OF THE BAND REPRESENTS THE TIME FROM THE START OF THE OVERCURRENT UNTIL INTERRUPTION BY THE CIRCUIT BREAKER. THE ACTUAL TRIPPING TIME WILL BE EQUAL TO OR LESS THAN THE UPPER LIMIT OF THE BAND. RESET TIME OF DEVICE IS 6 SEC. MAX. ON LONG-TIME AND 1 SEC. MAX. ON SHORT-TIME.
- NOTE 2: THE LOWER LIMIT OF THE BAND REPRESENTS THE TIMES FOR WHICH THE OVERCURRENT MAY PERSIST AT THE GIVEN VALUE AND THEN DROP TO 80% OF THE LONG-TIME PICKUP OR 20% OF THE SHORT-TIME PICKUP WITHOUT TRIPPING THE CIRCUIT BREAKER. THE ACTUAL MINIMUM TRIPPING TIME WILL ALWAYS BE IN EXCESS OF THE LOWER LIMIT OF THE BAND. RESET TIME OF DEVICE IS 4 SEC. MAX. ON LONG-TIME AND 1 SEC. MAX. ON SHORT-TIME.
- NOTE 3: FACTORY SETTINGS (UNLESS OTHERWISE SPECIFIED):  
 LONG-TIME PICKUP - 100% OF DEVICE RATING (POINT 4).  
 SHORT-TIME PICKUP - 200% OF DEVICE RATING (POINT 1).  
 SHORT-TIME DELAY BAND - LOW.
- \*NOTE 4: ACTUAL PICKUP VALUES FOR 8000 AND 10000 AMPERE BREAKERS ARE TWICE THE SETTING OF THE TRIP DEVICE.

TIME-CURRENT CHARACTERISTIC CURVES  
 FOR I-T-E TYPE FBK CIRCUIT BREAKERS WITH TYPE ODFBK-4A OR  
 ODFBK-10A DIRECT ACTING TRIP DEVICE

**ABB**

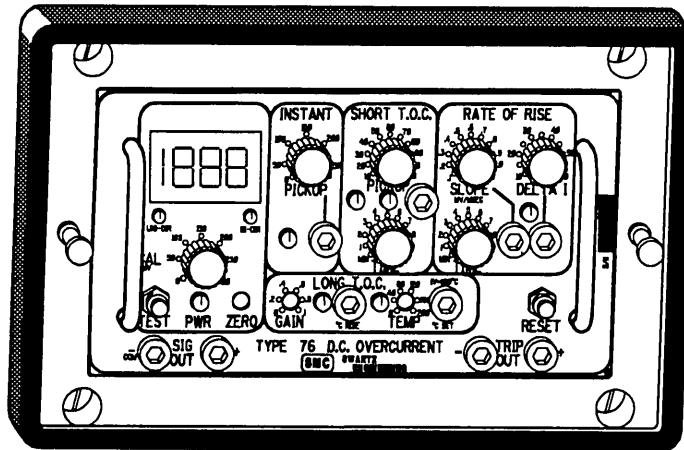
DWN. BY WJ DATE 6-21-78

NO. TD-6690 REV. 12

# SWARTZ® D.C. OVERCURRENT RELAY

260-02-00

Date: 3/21/97



MODEL C4280-508

## GENERAL

The **SWARTZ** Type 76 DC Overcurrent Relay from SMC is the most widely accepted protective overcurrent device used in the transit industry today, having been successfully used in every major transit system. The overcurrent relay provides maximum protection for trolley wires, third rails, feeder and substations from intermediate or remote overload conditions such as bolted faults, arcing faults and severe overloads. The solid state design and rugged construction ensure dependable low maintenance operation under adverse conditions.

## FEATURES

- Uni-Bi directional: mode indicating, field switchable
- LED Meter - Accurate, easy to read
- Draw out construction
- Detector channels include:
  - instant overcurrent: range 10 to 300 mv
  - short-time overcurrent: range 10 to 110 mv
  - long-time overcurrent
  - rate of rise
- Internal Power Supply operates on and auto-compensates for a wide range of DC inputs
- Calibration controls: allows preset threshold and time delays on all protective channels
- Use with any shunt
- For use with positive & negative conductors in DC Networks
- Field Calibration

## DESCRIPTION

The Type 76 DC Overcurrent Relay is an isolated current monitor and overcurrent relay that may be used for either the positive or negative conductors in DC power distribution networks. The device is designed as a stand-alone relay or may be used in conjunction with a Type 82 automatic recloser relay. In combination with a recloser relay, it will automatically interrupt a fault and then reclose to continue service. SMC's unique rate of rise channel detects arcing faults on systems too far removed to be detected by the instantaneous overcurrent channel. The Type 76 DC Overcurrent Relay front panel controls are calibrated in millivolts so that the relay is compatible with any type of shunt. The built-in calibration components allow accurate field calibration of each channel and feeder current settings.

## SPECIFICATION

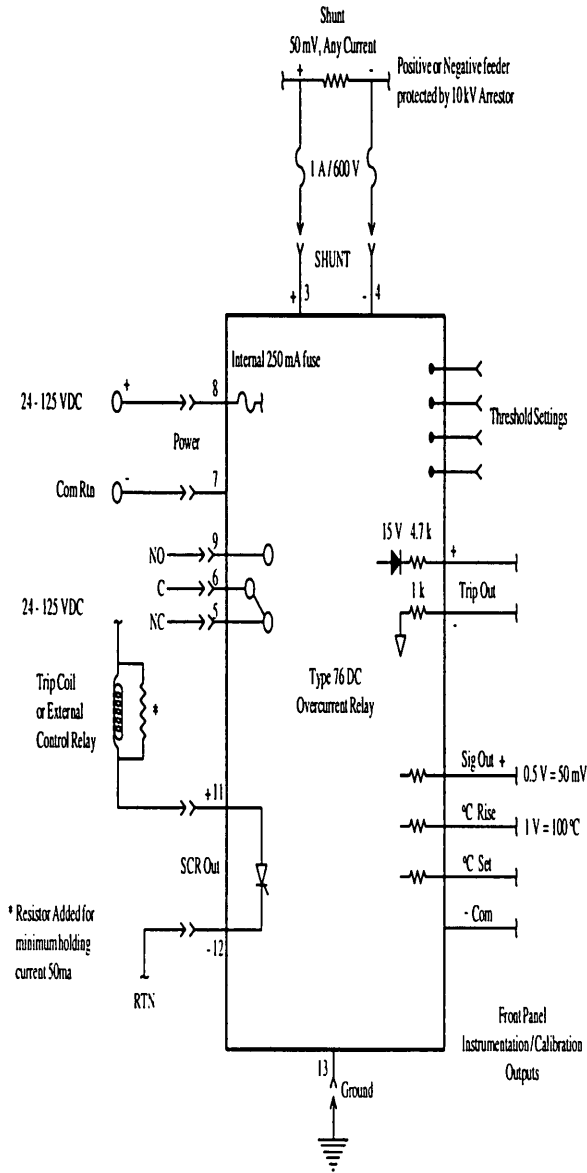
- |                         |                          |                            |                        |
|-------------------------|--------------------------|----------------------------|------------------------|
| • Input Power:          | Operates on 24 - 125 VDC | • Threshold Setting Error: | ± .5 mV                |
| • Supply Current:       | 40 mA at 125 VDC         | • Isolation Error:         | ± 1 mV                 |
|                         | 200 mA at 24 VDC         | • SCR Output:              | 100 mA to 6 A (1 sec.) |
| • Ambient Temperature:  | -20°C to +55°C           |                            | 200 V                  |
| • Design Test:          | SWC ANSI/IEEE C37.90     | • Annunciation:            | Reed Relay 100 VA, 2A, |
| • Isolation Dielectric: | 5400 V, 60 Hz, 1 min.    |                            | 500 VDC                |

TYPE 76 OVERCURRENT RELAY

COMPONENTS OPERATION • P.O. Box 880, Barboursville, WV 25504 • Phone: (304) 736-8933 • Fax (304) 529-1406

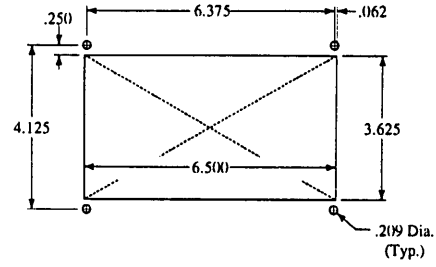
**SMC**  
ELECTRICAL PRODUCTS

# INTERFACE DIAGRAM

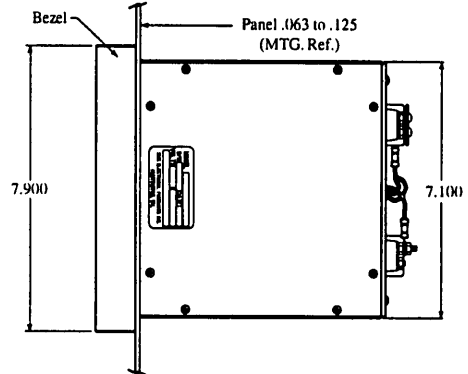


# RELAY CASE DIMENSIONS

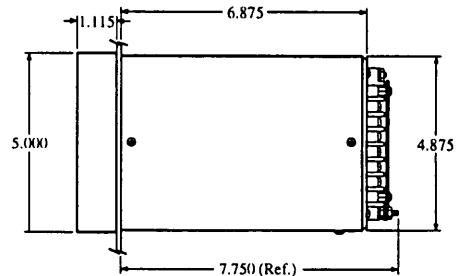
## PANEL MOUNTING CUT OUT



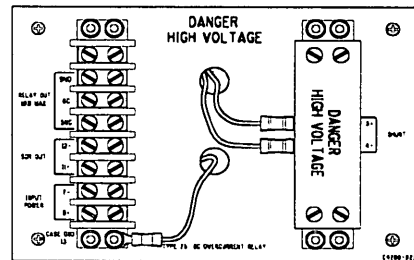
## TOP VIEW



## SIDE VIEW



## REAR VIEW



# SMC ELECTRICAL PRODUCTS, INC.

**Mailing Address**  
 PO Box 880  
 Barboursville, WV 25504

**Components Operation**

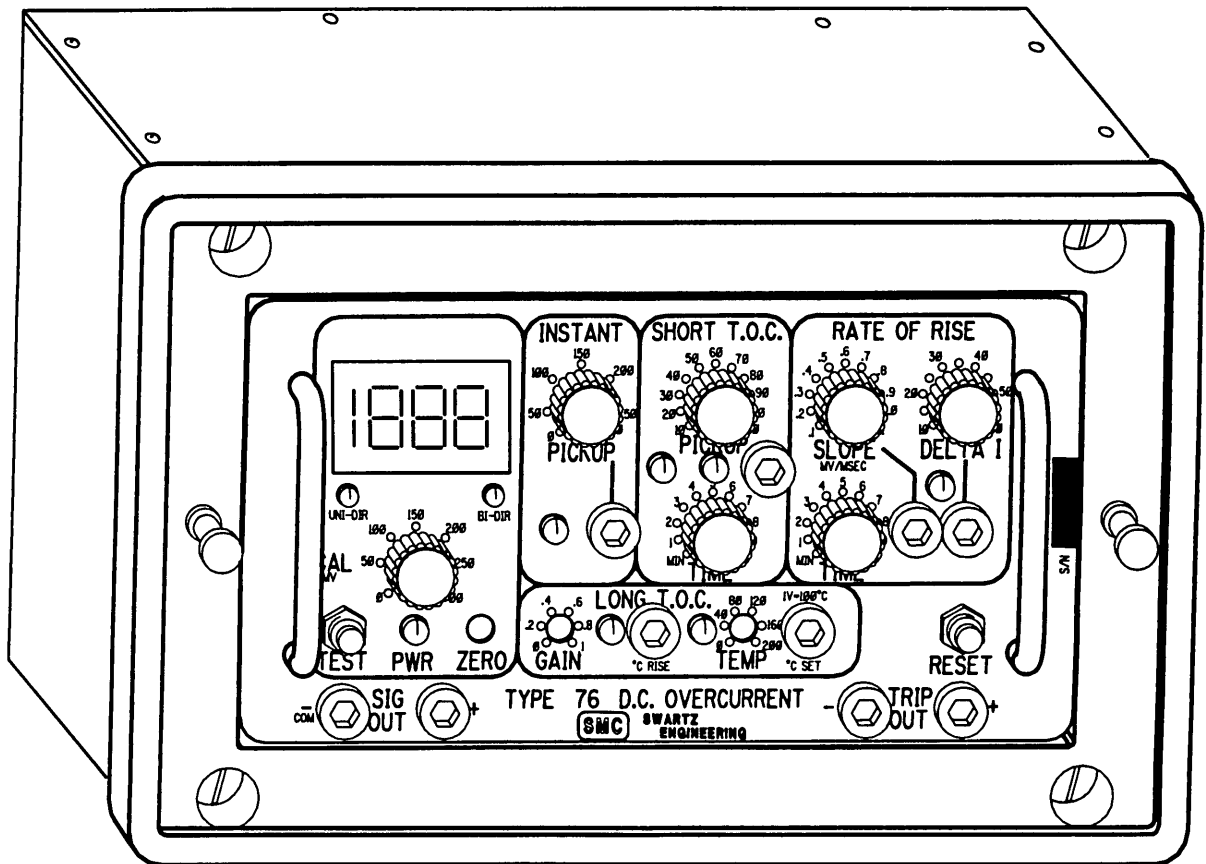
Phone: (304) 736-8933 Fax: (304) 529-1406

**Shipping Address**  
 5950 Ohio River Road  
 Huntington, WV 25702



**SWARTZ  
ENGINEERING**

## TYPE 76 DC OVERCURRENT RELAY



## OPERATION AND CALIBRATION MANUAL

The information contained within is intended to assist operating personnel by providing information on the general characteristics of equipment of this type. It does not relieve the user of responsibility to use sound engineering practices in the installation, application, operation and maintenance of the particular equipment purchased.

These instructions do not purport to cover all details or variation in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to SMC.

If drawings or other supplementary instructions for specific applications are forwarded with this manual or separately, they take precedence over any conflicting or incomplete information in this manual.

**SMC Electrical Products, Inc. *Components Operation* Phone (304) 736-8933 Fax (304) 529-1406**



# TYPE 76 DC OVERCURRENT RELAY

## OPERATION AND CALIBRATION MANUAL

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\*Your Type 76 Overcurrent Relay may not contain all of the features noted. Refer to the Appendix and to the sections that apply.

## 1.0 SAFETY PRECAUTIONS

### INTRODUCTION

This section of the manual is to familiarize the operating and maintenance personnel with the hazards and the necessary precautions to follow when either operating or maintaining the Type 76 Relay. Although all the hazards or possible hazardous conditions which may arise during the operation of the Type 76 Relay may not be foreseen, this section of the manual is a guideline so as to prevent personnel injury, equipment damage, or limit equipment damage should a fault occur.

### SYSTEM HAZARDS AND PRECAUTIONS

Below are listed the safety hazards associated with the Type 76 Relay followed by a list of safety precautions. Prior to the energization of the equipment or prior to commencement of any maintenance, the appropriate personnel should review these hazards and precautions to become readily familiar with them.

### SAFETY HAZARDS

a. Electrical Shock or Current Flow

Current Flow through chest or head area may cause cardiac arrest, stoppage of breathing, and ventricular fibrillation.

b. Electrical Arcs

May cause equipment explosion, flash burn to eyes, ultraviolet burning of skin tissue.

c. Direct Burns

May occur when in direct contact with overheated electrical equipment.

### SAFETY PRECAUTIONS

- a. Prior to any maintenance or entry into electrical switchgear, remove all metallic objects from person. (Such items as wristwatches, rings, metal badges, belt buckle, metal pins, rules, flashlights, keys, and key chains).
- b. Do not wear loose fitting clothing when in and around equipment.
- c. Work from an insulating mat whenever possible.
- d. All hand tools should be insulated to the fullest extent possible.
- e. Portable powered hand tools should be of a 3 wire grounded design.
- f. Do not use aluminum or metallic ladders while in and around electrical switchgear.

### OPERATIONAL SAFETY SUMMARY

Follow the manufacturer's start-up and shut-down procedures.

Never operate equipment which has been tagged "Out of Service" or "Do Not Operate". Never override any electrical or mechanical interlocks unless the over-riding of such devices is called for in the special or emergency operating procedures. Become familiar with the substation functional operation prior to operating the substation. Prior to any maintenance ensure that equipment has been tagged out of service following the appropriate tag out procedures. Familiarize oneself with the manufacturer's maintenance procedure prior to conducting any maintenance. Never perform maintenance in an isolated location by oneself.

## 2.0 INTRODUCTION

The Swartz Type 76 D.C. Overcurrent Relay is an isolated current monitor which is applicable to either the positive or negative conductors in D.C. power distribution networks. The relay can be made to operate in either unidirectional or bidirectional mode. The primary function of the detector is to protect trolley wire, feeders, and substations from a variety of overload conditions including bolted faults, arcing faults, and heavy over-loads either near the substation or remote from it. The detector is designed to work in conjunction with an automatic recloser to automatically interrupt a fault and then reclose to continue service. Detector channels include instant overcurrent, short time overcurrent, long time overcurrent, and rate of rise. All front panel controls are calibrated in millivolts so that the detector can be used with any shunt. Current is referred to as equivalent "millivolts" in this manual. Each channel and its calibration is described below.

## 3.0 FRONT PANEL CALIBRATION AND CONTROLS

Refer to Figure 1a (Front Panel Layout), Figure 1b (Uni/Bidir Mode), Figure 2 (Interface Diagram).

### Test

A built-in calibration control (CAL) with variable settings from 0 to 300 mV and a momentary pushbutton switch (TEST) allow functional check of both thresholds and time delays of all current detector channels. Test current can be read on the meter or at "SIG OUT" test jacks where 0.5mV equals 50mV.

Accuracy precaution : Test current adds to any current already present at shunt leads.

### Meter

The digital LED meter reads from 0 to 300mV to continuously monitor current. The signal is sampled and updated approximately every 300ms and is accurate to within 1mV.

### Power

The green LED indicates that the detector has power and is operational. If this LED is off, either input power is off or the internal fuse is blown. In either case, the output is fail safe and should cause breaker to trip.

### Zero

This adjustment compensates for slight offsets in the high voltage isolator and should only require adjustment when the overcurrent unit is initially installed in the substation. With zero shunt current (DC breaker open or zero loads) measure "SIG OUT" voltage with a Fluke 8024A digital voltmeter or equal. Adjust zero for  $.000 \pm .002$  volts. For best results, a five minute or greater warm-up period should be allowed. Note that offset varies slightly depending on installation. For example, offset will change by up to 1mV when the detector is bench tested outside of its enclosure.

### Uni-dir/Bi-dir

These LEDs indicate the mode in which the unit is sensing current, either in a single direction (positive) or in both positive and negative directions. The mode can be changed in the field by setting the slide switch located at the back of the motherboard to the desired position as marked on the board. Note that one of the LEDs should be on at all times.

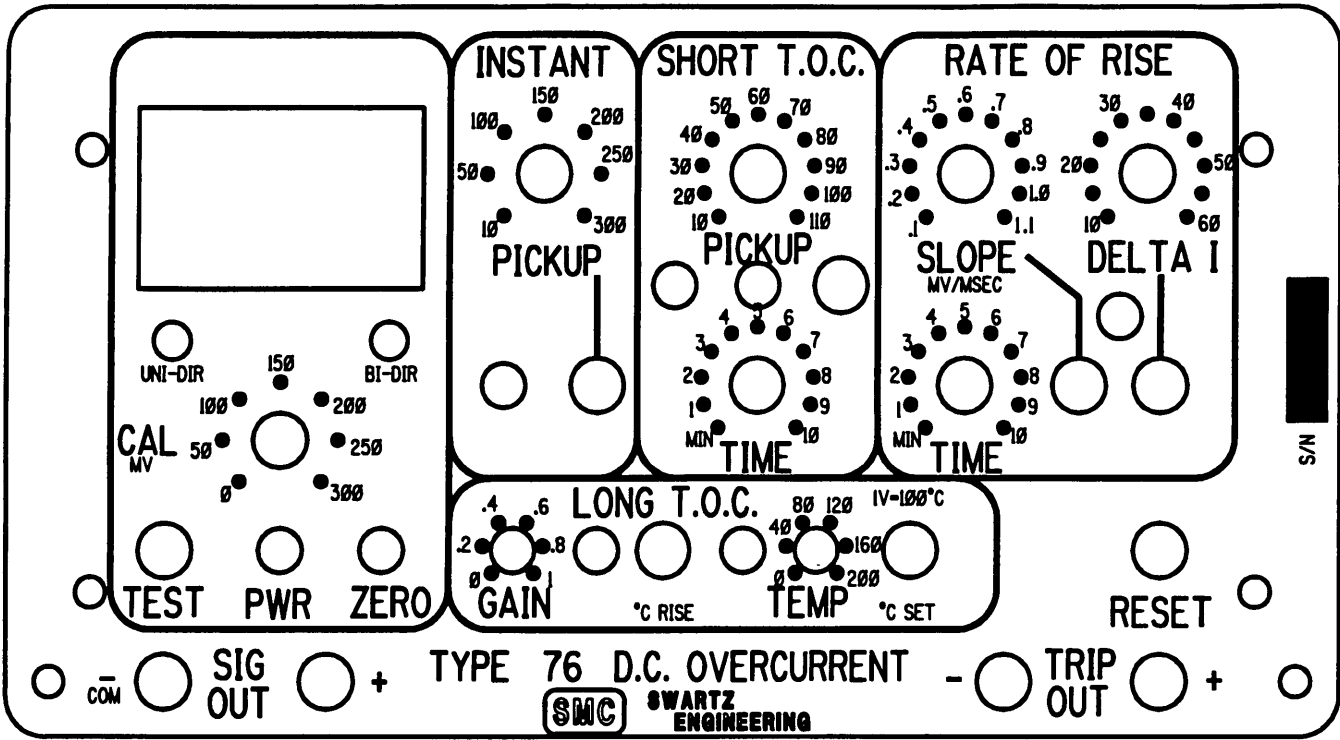


Figure 1a Front Panel Layout

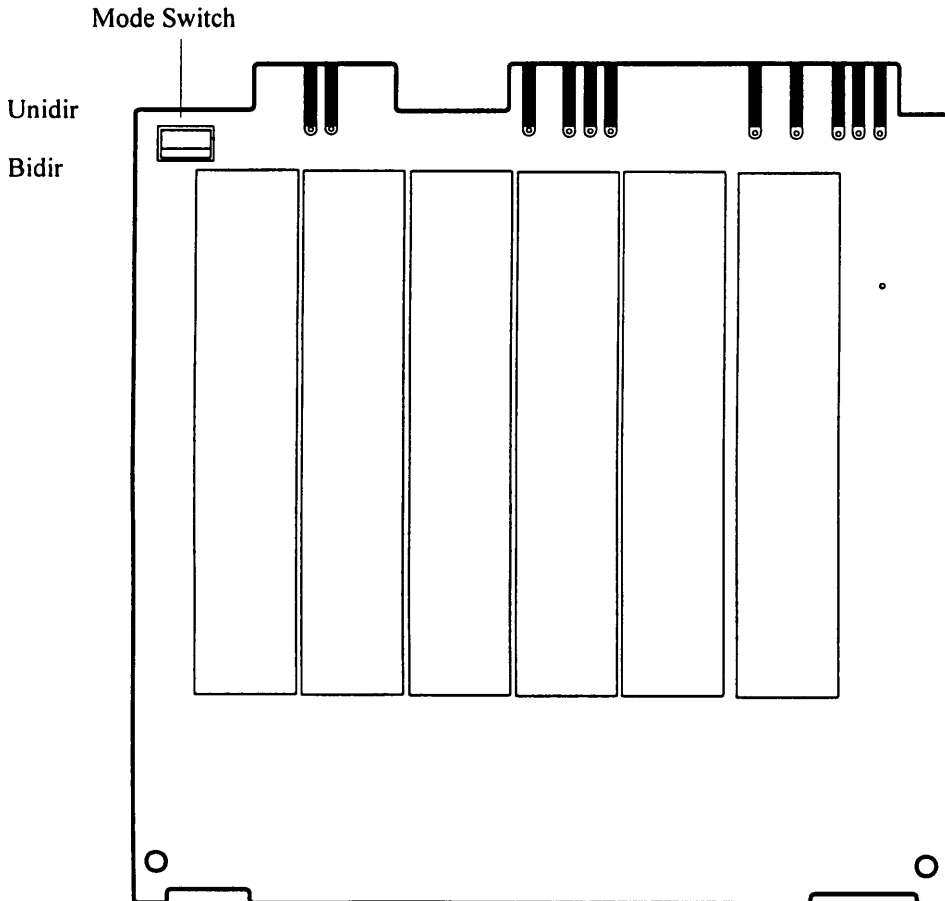


Figure 1b Setting Unidirectional/Bidirectional Modes

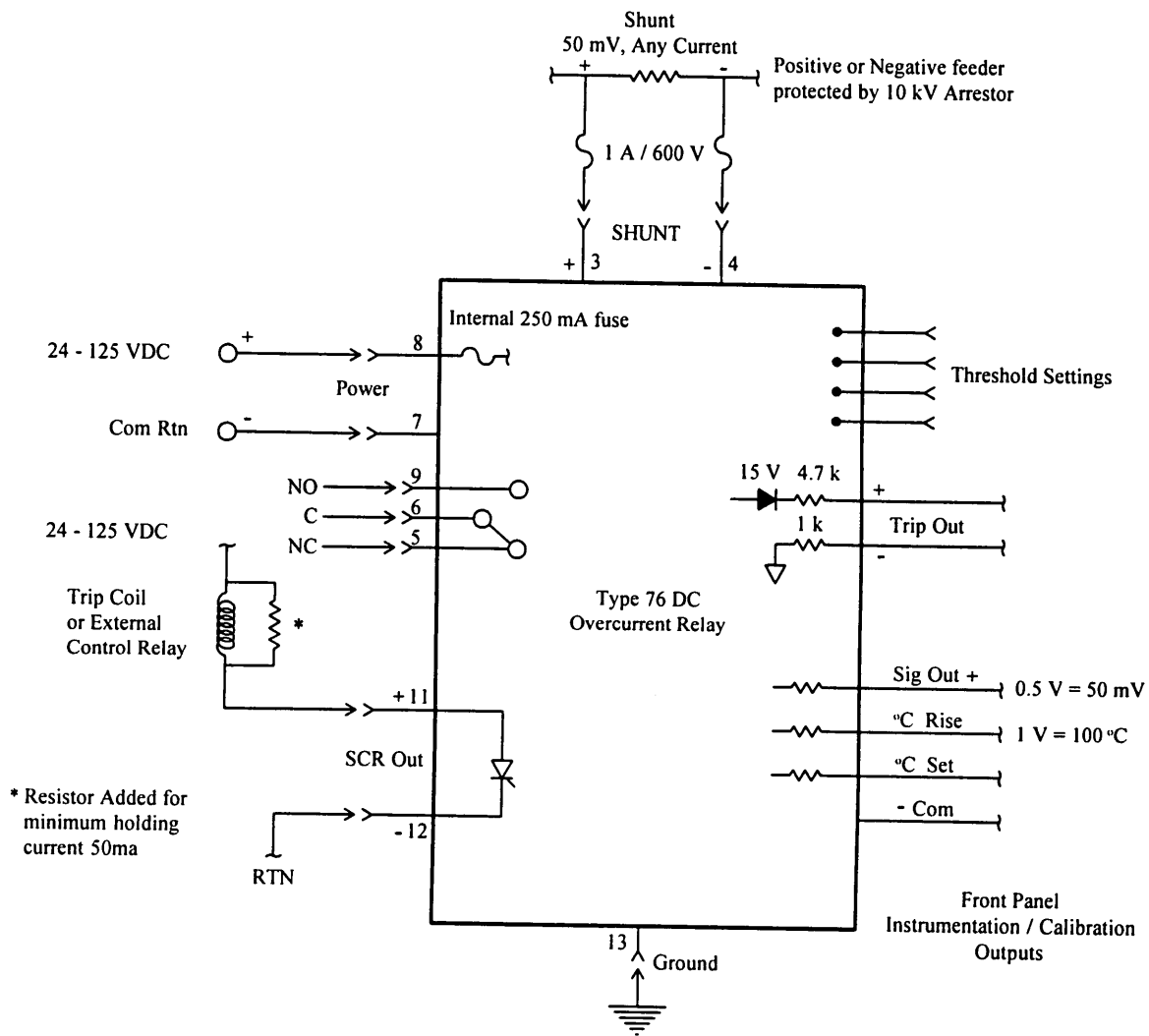


Figure 2 Interface Diagram

#### **4.0 INSTANT OVERCURRENT CHANNEL**

This channel responds to "instantaneous" high current levels between 10 and 300mV as set by the control. Input from the isolator is RC filtered for all channels so that current spikes or noise are suppressed to prevent nuisance tripping. A buffered test jack is provided for highly accurate adjustment of trip threshold with a digital voltmeter. A red LED latches on to indicate that a trip has occurred. Note that loss of shunt continuity will trip either this channel or the rate-of-rise channel if the latter's delay is set short.

##### **Setting "Pickup" Threshold**

Connect digital voltmeter's common lead to "SIG OUT-COM". Connect positive lead (+) to instant test jack. Adjust pickup control for desired trip level. Note that knob calibration for this control as well as all other front panel controls is only approximate ( $\pm 10\%$ ). As an alternate method of setting this control, apply trip level to shunt leads or by using "CAL/TEST" controls. While pressing RESET switch to prevent LED from latching, adjust PICKUP knob until instant LED is just turned on.

#### **5.0 SHORT - TIME OVERCURRENT CHANNEL (Short T.O.C.)**

This time overcurrent channel is a thermal overload protection for trolley wire and especially works well in protecting against an arcing fault which does not draw enough current to trip other channels. Trip threshold and time delay are settable from the front panel. Time delay is inversely proportional to current above the threshold. Delay adjustment is marked 1 thru 10 which represents a family of time delay curves, (See Figure 3). Threshold control is marked 10 thru 110mV and is also provided with a test jack. A non-latching yellow LED indicates that current is above threshold. A red LED latches on to indicate trip. When current falls below threshold, a fast reset occurs so that trip is not sustained.

##### **Setting Short T.O.C. "Pickup" Threshold**

This threshold is set in the same way as instant threshold except that yellow LED is monitored, (See above).

##### **Setting "Time" Delay**

Time delay can be set, approximately, according to family of curves in Figure 3. For more accuracy, using a stop watch, interval timer, or calibrated oscilloscope, time can be measured for any given set of trip conditions. Adjust PICKUP to desired threshold. Set "CAL" control to input current above the threshold. Apply simulated step input current by pressing TEST switch and measure the time interval between closing TEST switch and the red STOC trip LED coming on.

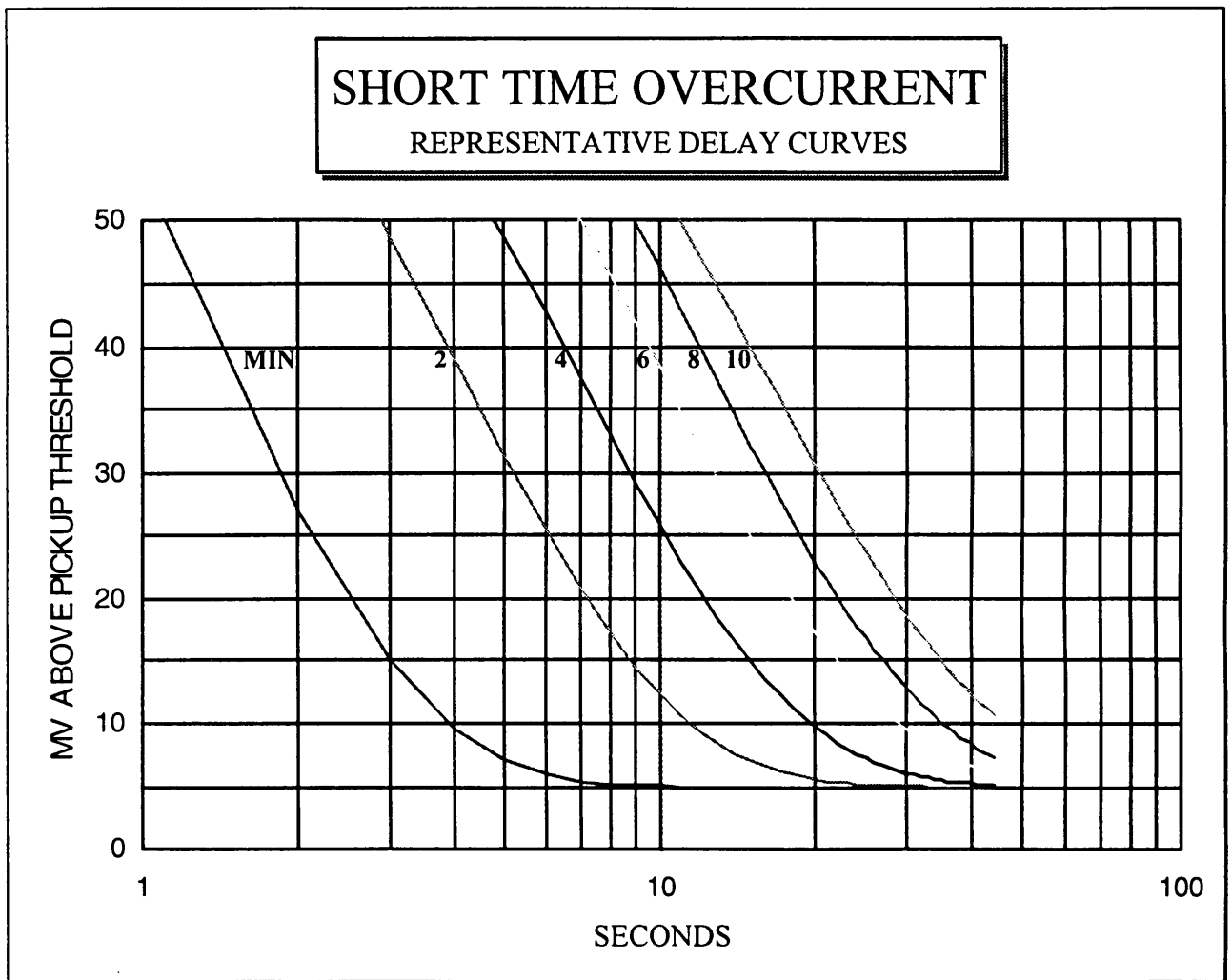
#### **6.0 LONG - TIME OVERCURRENT CHANNEL (T.O.C.)**

This channel thermally protects the trolley or feeder to prevent annealing of the wire during sustained heavy overloads. Wire temperature is continuously simulated within the detector by a current squaring circuit and an exponential time delay circuit with a time constant of 9.5 minutes both during wire heat up and cool down. In operation, this control is set, say to 80 °C, then a total wire current corresponding to this wire temperature is applied with the calibration control. Then, the gain control is adjusted until the yellow LED comes on. In this manner, different wire sizes and substation configurations can be accommodated. A red LED indicates trip. Test jacks are provided to monitor simulated wire temperature and trip temperature settings. A trip of this circuit, if properly adjusted, indicates a serious overheating of feeders and / or conductors. Because of this, the circuit was designed with trip hysteresis which causes a long reset time and a substation lockout.

**NOTE:** For minimum sensitivity of short reset time during a relay check, turn gain control fully counter clockwise (CCW) and temperature setting to 200°. Remember to return to normal settings for proper protection.

**Setting TEMP Control**

Wire temperature rise in °C is set by adjusting TEMP control while monitoring "°C Set" Test jack, (1 volt equals 100 °C). Allowable rise varies with conductor type, but a typical setting for hard drawn copper wire might be 50 °C which is 0.5V at test jack.



**FIGURE 3**

**SHORT TIME OVERCURRENT DELAY CURVES**  
(FOR REFERENCE ONLY; INDIVIDUAL UNITS WILL VARY. SEE TEXT.)

### Setting GAIN Control

Refer to wire charts showing allowable current versus absolute wire temperature, Factors such as maximum ambient temperature, wear of wire running surface, and wire configuration should be considered. Set CAL / TEST controls to selected current. Then adjust gain control until yellow LED just comes on.

### Degree Rise Test Jack

This test jack can be connected to an oscillograph or recorder for long-term monitoring of simulated wire temperature. (1V equals 100 °C rise)

## 7.0 RATE OF RISE CHANNEL

This is the most complex channel and a valuable feature of the overcurrent relay. This channel responds to bolted or arcing faults on the distribution system which are too far away to trip the instant channel. Three independent controls are used which closely characterize a fault as could be seen on an oscillograph, (See Figure 4). These are initial slope ( $di/dt$ ), peak current (DELTA I), and time duration. Unless the current pulse is steep enough, high enough, and long enough, it will be rejected and will not cause a nuisance trip. Typical settings are 0.3mV/msec slope, 20mV DELTA I, and 70 msec time. SLOPE and DELTA I have test jacks for calibration as well as calibrated knob settings. For slope setting, 10mV equals 1.0mV/msec. Disregard negative polarity. A red LED indicates trip. Time delay is adjusted according to curve in Figure 5.

- A. Slope Detection
- B. Delta I Detection
- C. Time Duration. Time interval starts at point B

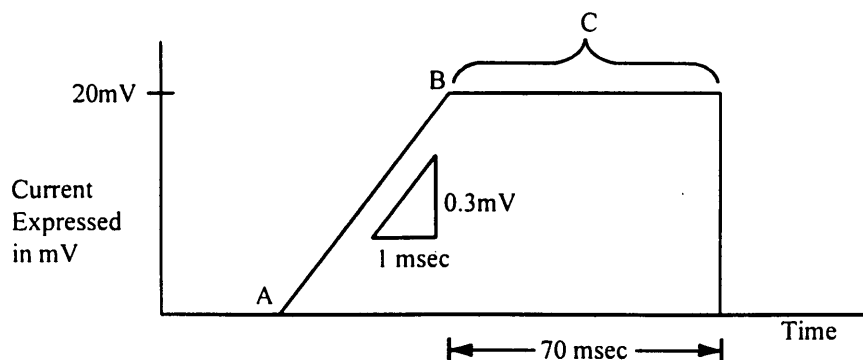


Figure 4. Rate of Rise, Typical Waveform



### **Setting Delta I**

Set DELTA I control to desired current step by measuring at associated test jack. This current should be slightly greater than the maximum current drawn by a single vehicle. Although the three Rate of Rise controls are as independent as possible, there is a slight interaction between SLOPE and DELTA I. If DELTA I setting is checked by applying waveform at shunt leads, waveform should be trapezoidal rather than a step function. (Type 76 D.C. Overcurrent Relay Simulator provides trapezoidal pulses as well as other inputs useful in calibration and testing overcurrent detectors).

### **Setting SLOPE**

SLOPE is set by measuring voltage at SLOPE test jack. 10mV equals 1mV / msec so that easy adjustments can be made using a standard 3 1/2 digit voltmeter. Note that SLOPE trip occurs at the initial portion of the rise time.

### **Setting TIME**

Refer to Figure 5 for time delay vs. knob setting. The most accurate time setting can be achieved by applying a step pulse waveform to shunt leads with the desired pulse width. Adjust SLOPE and DELTA I to minimums, while pressing reset switch until a pulsed output on the LED is observed. Measure precaution: If trapezoidal waveform is used, note that TIME is measured along the top of the waveform after the DELTA I trip has occurred as shown in Figure 4.

## **8.0 OUTPUTS**

### **SCR Output**

SCR output for substation control is available on rear terminal strip of detector. This 6 amp, 200 volt SCR is optically isolated and floating for connection anywhere in a relay control ladder. An external load of 50mA or more should be provided, at least part of which is resistive, i.e., a 25k Ohm relay coil paralleled with a 2.5k Ohm, 5 watt resistor will provide minimum SCR latching and holding currents. (This example is for a system with a 125 VDC supply power).

### **Form C Output**

Momentary output contacts for annunciation, etc. are 100 vA, 2 A & 500 VDC.

### **Signal Output (SIG OUT)**

Front panel jacks are provided for analog output current, (0.5V at test jacks equals 50mV at shunt). This output is not floating, but is tied to internal power supplies so that when connected to external instrumentation, differential amplifiers should be used.

### **Trip Output (TRIP OUT)**

A current limited trip output 15V / 6k Ohm is provided to directly drive a galvanometer event marker while making oscillograph recordings.

### **Wire Temperature Output (°C Rise)**

This output is available from the long T.O.C. section, (1V equals 100 °C rise). As in the Signal output (SIG OUT) above, a differential amplifier should be used when this output is connected to a recorder.

## **9.0 INTERNAL CALIBRATION**

Internal adjustments should be infrequent. Most are made by selected fixed resistors and are only necessary when sensitive components have been replaced.

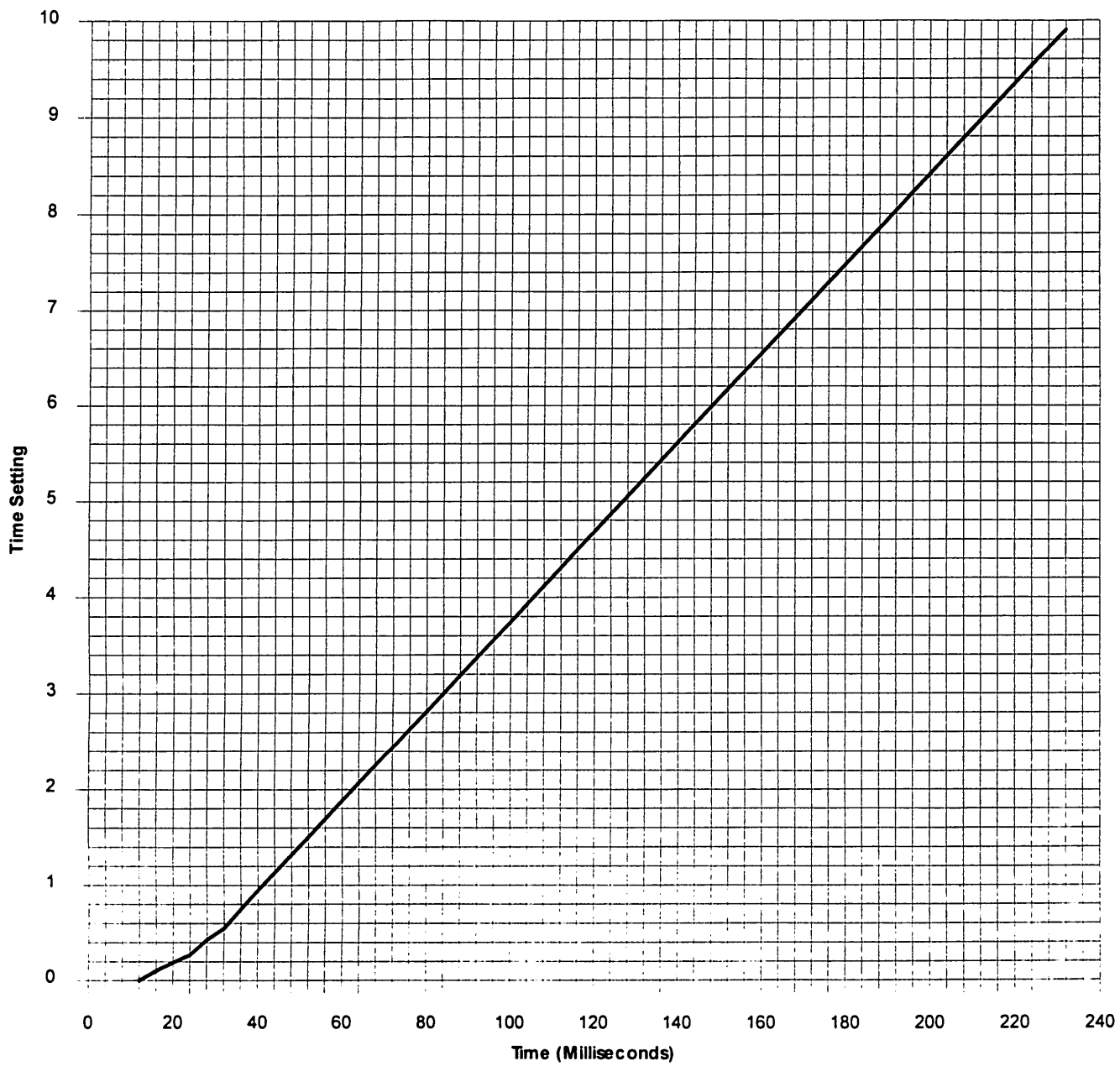
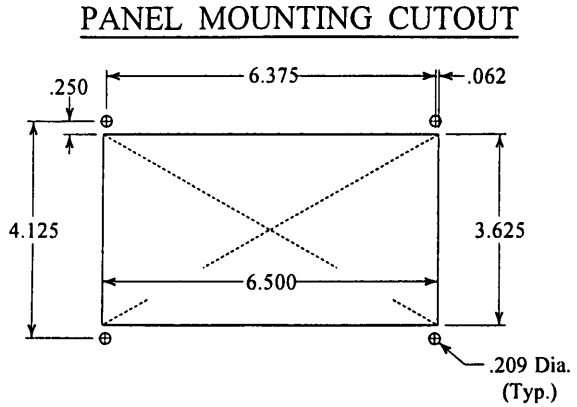
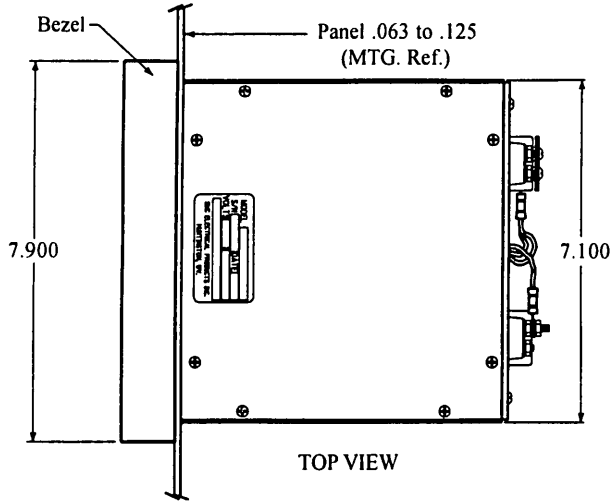


Figure 5.  
 Rate of Rise Timer  
 Time Delay Curve  
 Typical Waveform

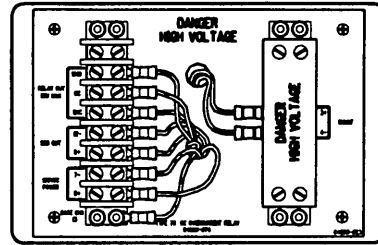
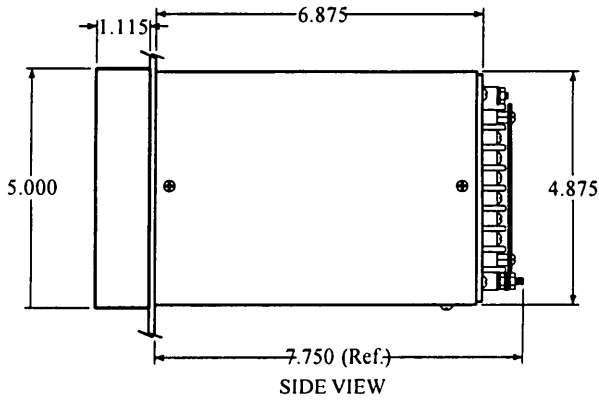
## SPECIFICATIONS

| <b>PARAMETER</b>                     | <b>PERFORMANCE</b>                       |
|--------------------------------------|--|
| Isolator Error .....                 | $\pm 1\text{mV}$                         |
| Isolator Dielectric Capability ..... | 5400V, 60Hz, 1min.                       |
| Ambient Temperature .....            | -20 to +55 °C                            |
| Threshold Setting Error .....        | $\pm 0.5\text{mV}$ inst. and time pickup |
| Supply Voltage (Nominal) .....       | 24 - 125V DC                             |
| Supply Voltage Range .....           | 20-140V DC                               |
| Supply Current .....                 | 200mA @ 24VDC - 40mA @ 125VDC            |

# Type 76 DC Overcurrent Relay Case Dimensions



NOTE: Degauss steel panel before mounting case



REAR VIEW  
With Protective Cover Removed  
#6 Screw Terminals

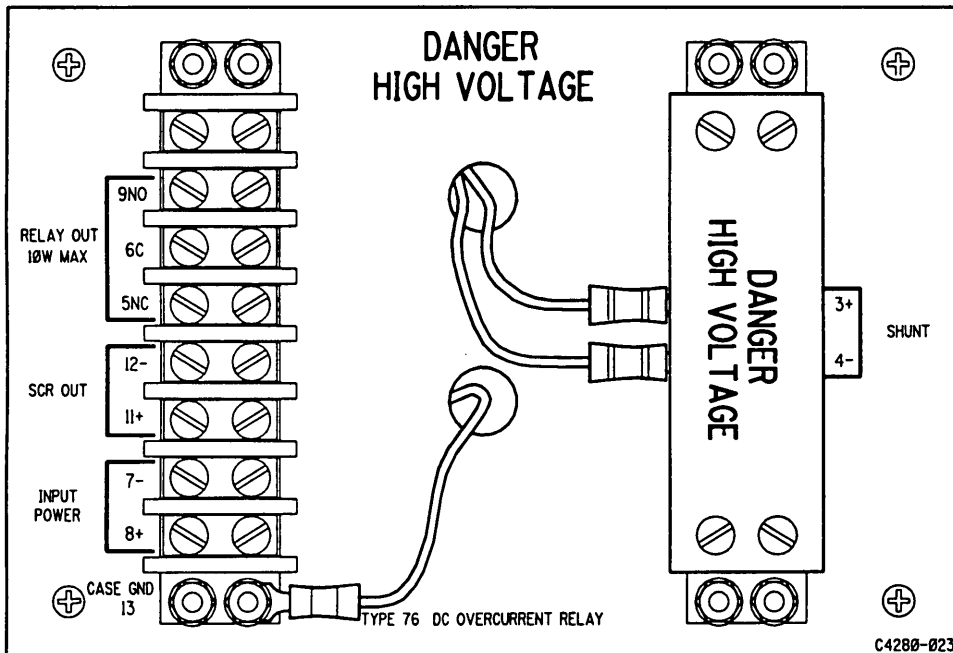


Figure 6.

## **APPENDIX A: TYPE 76 INSTANTANEOUS RELAY**

Refer to Section 4.0 - Instant Overcurrent Channel for the 76 Instantaneous Relay. Sections 5.0, 6.0, and 7.0 do not apply to this specific purpose relay. All other sections do apply.

## **APPENDIX B: TYPE 76 RATE OF RISE RELAY**

Refer to Section 7.0 - Rate of Rise Channel for the Type 76 Rate of Rise Relay. Sections 4.0, 5.0, and 6.0 do not apply to this specific purpose relay. All other sections do apply.

August 1, 1994

## SMC WARRANTY STATEMENT

The purchaser has a reasonable time to ascertain whether the apparatus is as represented. Any test required by the purchaser to determine any conformance to representation must be made within 60 days from date of shipment. SMC reserves the right to review and mutually agree on condition of tests and to be represented at any tests. SMC electric products are warranted for a period of one year from the date of shipment to be free from any defect in materials or workmanship. SMC will repair or replace F.O.B. factory, with regular UPS shipment allowed, any part which under normal and proper use proves defective in workmanship or material within the effective warranty period.

The correction of such defects by repair or replacement at SMC's sole discretion, shall constitute fulfillment of all of the SMC obligations with respect to the apparatus sold hereunder. (RMA Procedures for return are outlined below).

- 1) Obtain verbal or written approval from SMC as outlined in the return procedure.
- 2) Issue a purchase order to SMC Electrical Product, Inc for replacement of defective products, full credit will be issued when the part is received and evaluated by SMC of the and is determined to be under warranty.
- 3) Warranty replacements are quoted F.O.B. factory with regular UPS shipping charges allowed. Any special shipping charges will be billed to the customer.
- 4) Return Material - No material may be returned without an RMA (Return Material Authorization) authorized by SMC. Proper RMA identification and packaging of returned goods will only be accepted. Contact an SMC Components Division sales representative for authorization at telephone number (304) 736-8933 or fax (304) 529-1406.

Such warranty shall not apply to any product or component; (A) repaired or altered by anyone other than SMC or an authorized service center without SMC's prior written approval; (B) tampered with or altered in any way or subject to misuse, negligence or accidents; (C) which has the serial number altered, defaced or removed; or (D) which has been improperly connected, installed or adjusted other than in accordance with SMC instructions.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF QUALITY WHETHER WRITTEN, ORAL, OR IMPLIED. INCLUDING BUT NOT LIMITED TO ANY WARRANTY OR FITNESS FOR A PARTICULAR PURPOSE.

### SMC Electrical Products, Inc.

Mailing Address

PO Box 880  
Barboursville, WV 25504

*Components Operation*

Phone: (304) 736-8933 Fax: (304) 529-1406

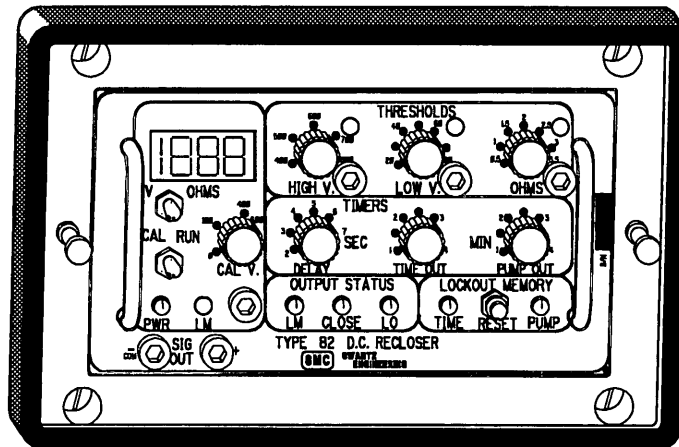
Shipping Address

5950 Ohio River Road  
Huntington, WV 25702

# SWARTZ® DC RECLOSING RELAY

260-02-00

Date: 3/21/97



MODEL C4280-560

## GENERAL

The **SWARTZ** Type 82 DC Reclosing Relay from SMC is part of a solid state reclosing system that prevents the closing of a DC breaker on a faulted line. After a fault or overcurrent trip occurs, the relay provides load side fault verification before the breaker can close and will automatically reclose the breaker on a clear line. The Type 82 Relay is designed to be used on light and heavy rail systems.

## FEATURES

- Draw-out construction
- LED Meter - Accurate, easy to read
- "Load Measure" memory
- Bi-Directional Load Measuring
- Voltage Compensating
- Internal Power Supply operates on and auto-compensates for a range of DC inputs
- Fault Annunciation
- Built-in Calibration
- Modular Construction

## DESCRIPTION

The reclosing system consists of two units: the **SWARTZ** DC Reclosing Relay and a **SWARTZ** solid state transducer. The transducer is a self powered unit that sends converted, properly scaled bus voltages to the relay. The relay can be remotely mounted from the transducer to eliminate exposure to traction voltage. The relay responds to the input and performs the functions of voltage measurements, load measurements, sequencing and indication. The relay measures voltage on the load side of the breaker and picks up if the voltage is above its pre-set values to close the breaker on a clear line. The relay will maintain pre-existing line voltage measurements and measure the differential voltage when load measuring is applied. If the differential voltage is above the pre-set value, it will close the breaker. The set value for the relay is the voltage produced by the load measuring current at the minimum feeder resistance. Adjustments include time for each step of the sequence, number of attempts and levels for voltage and dead load pick-up.

## SPECIFICATION

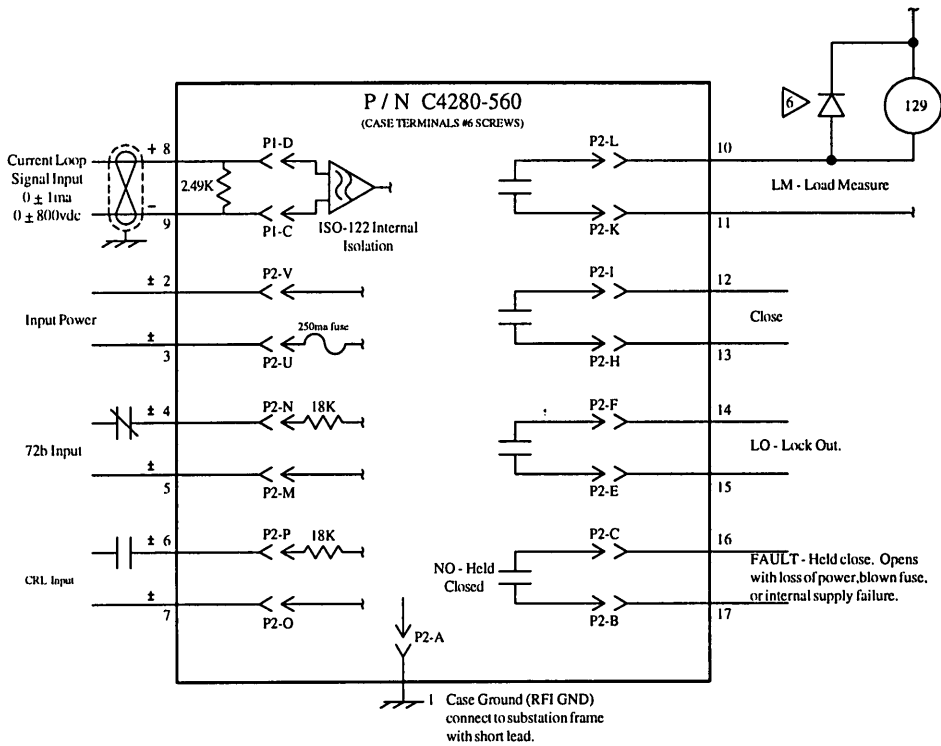
- |                        |                                    |                            |   |
|------------------------|------------------------------------|----------------------------|---|
| • Input Power:         | Operates on 24 - 125 VDC           | • Load Measuring Resistor: | 15 to 100 ohm   |
| • Supply Current:      | 40 mA at 125 VDC                   | • Close Attempts:          | 1 to 5  |
|                        | 200 mA at 24 VDC                   | • Pump Attempts:           | 1 to 5  |
| • Ambient Temperature: | -20°C to +55°C                     | • Cycles Per Close:        | 1 to 3  |
| • Design Test:         | SWC ANSI/IEEE C37.90               | • Outputs:                 | Fault, Load Measuring,<br>Close, Lockout (2A/500 VDC,<br>100 VA max.) |
| • Thresholds:          | High and Low Voltage, Load<br>ohms | • Meters:                  | 0 to 800 V, 0-10 ohms   |
| • Current Loop:        | 0-1 mA/2.49K ohm                   |                            |   |

TYPE 82 DC RECLOSING RELAY

COMPONENTS OPERATION • P.O. Box 880, Barboursville, WV 25504 • 5950 Ohio River Road • Phone: (304) 736-8933 • Fax: (304) 529-1406

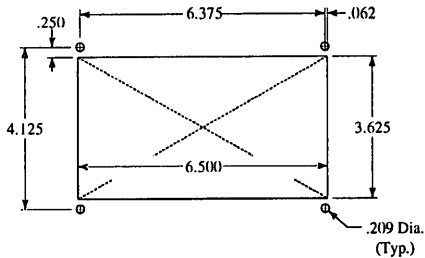


# TYPE 82 DC RECLOSING RELAY INTERFACE DIAGRAM

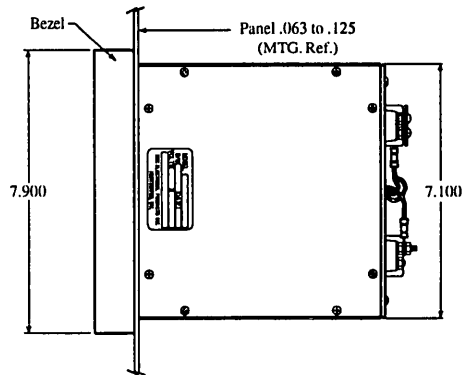


## RELAY CASE DIMENSIONS

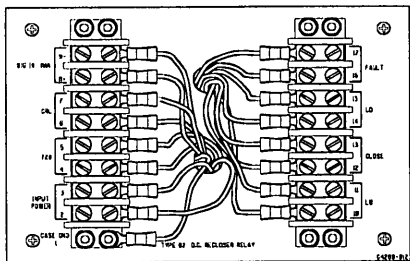
PANEL MOUNTING CUT OUT



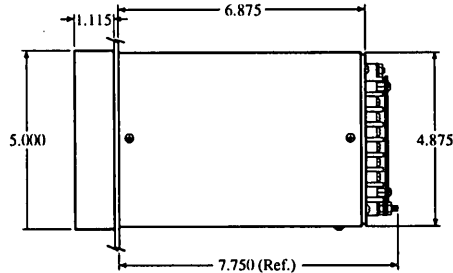
TOP VIEW



REAR VIEW



SIDE VIEW



## SMC ELECTRICAL PRODUCTS, INC.

Mailing Address

PO Box 880  
Barboursville, WV 25504

Components Operation

Phone: (304) 736-8933 Fax: (304) 529-1406

Shipping Address

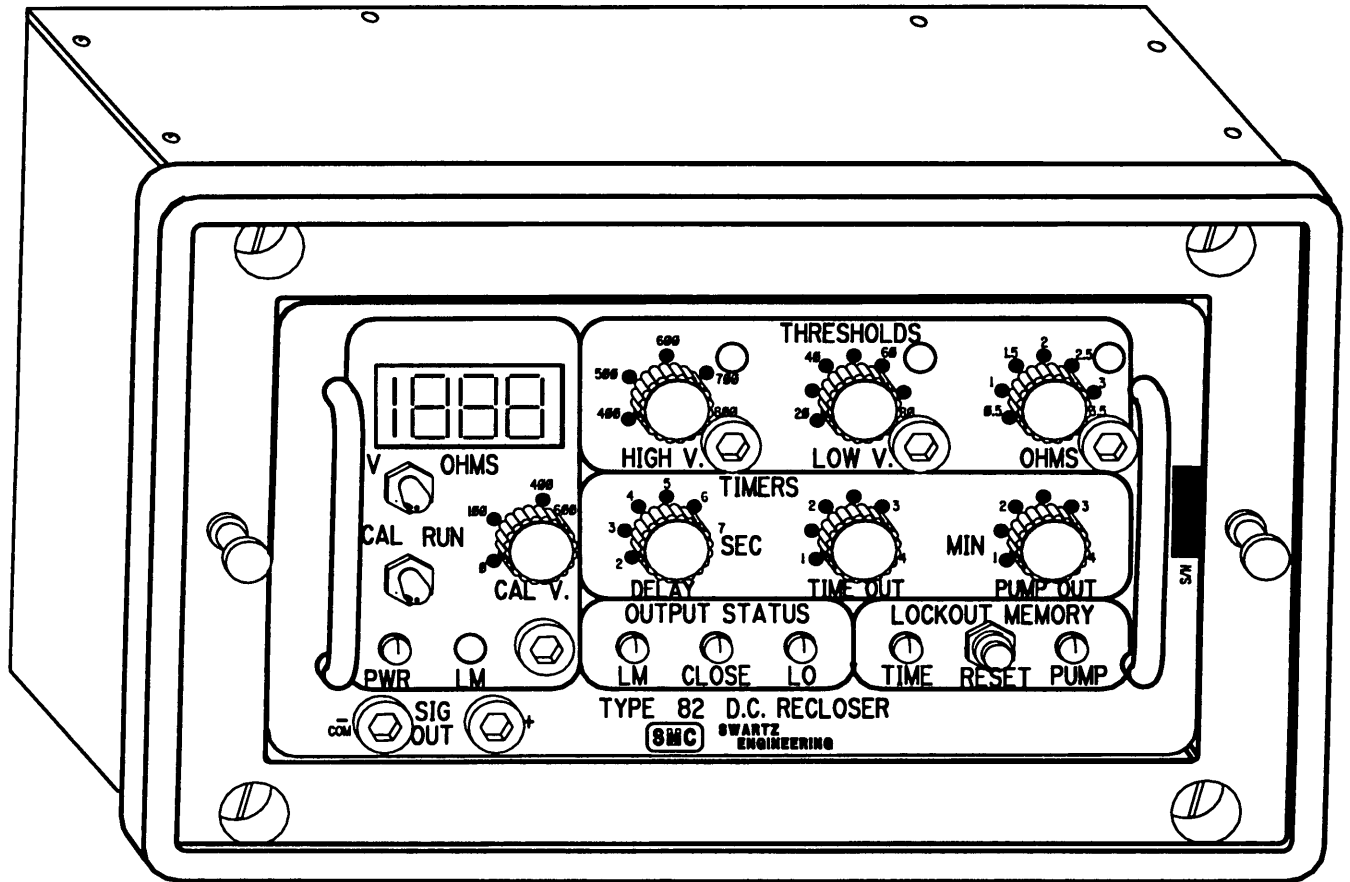
5950 Ohio River Road  
Huntington, WV 25702





**SWARTZ  
ENGINEERING**

## TYPE 82 SOLID STATE DC RECLOSING RELAY



## OPERATION AND CALIBRATION MANUAL

The information contained within is intended to assist operating personnel by providing information on the general characteristics of equipment of this type. It does not relieve the user of responsibility to use sound engineering practices in the installation, application, operation and maintenance of the particular equipment purchased.

These instructions do not purport to cover all details or variation in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to SMC.

If drawings or other supplementary instructions for specific applications are forwarded with this manual or separately, they take precedence over any conflicting or incomplete information in this manual.

**SMC Electrical Products, Inc. *Components Operation* Phone (304) 736-8933 Fax (304) 529-1406**

# TYPE 82 SOLID STATE DC RECLOSNG RELAY

## OPERATION AND CALIBRATION MANUAL

### TABLE OF CONTENTS

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| 2.0 | Introduction .....                           | 5  |
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| 5.0 | Typical Applications and System Design ..... | 13 |
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## 1.0 SAFETY PRECAUTIONS

This section of the manual is to familiarize the operating and maintenance personnel with the hazards and the necessary precautions to follow when either operating or maintaining the Type 82 Relay. Although all the hazards or possible hazardous conditions which may arise during the operation of the Type 82 Relay may not be foreseen, this section of the manual is a guideline so as to prevent personnel injury, equipment damage, or limit equipment damage should a fault occur.

### SYSTEM HAZARDS AND PRECAUTIONS

Below are listed the safety hazards associated with the Type 82 Relay followed by a list of safety precautions. Prior to the energization of the equipment or prior to commencement of any maintenance, the appropriate personnel should review these hazards and precautions to become readily familiar with them.

#### SAFETY HAZARDS

a. Electrical Shock or Current Flow

Current Flow through chest or head area may cause cardiac arrest, stoppage of breathing, and ventricular fibrillation.

b. Electrical Arcs

May cause equipment explosion, flash burn to eyes, ultraviolet burning of skin tissue.

c. Direct Burns

May occur when in direct contact with overheated electrical equipment.

#### SAFETY PRECAUTIONS

- a. Prior to any maintenance or entry into electrical switchgear, remove all metallic objects from person. (Such items as wristwatches, rings, metal badges, belt buckle, metal pins, rules, flashlights, keys, and key chains).
- b. Do not wear loose fitting clothing when in and around equipment.
- c. Work from an insulating mat whenever possible.
- d. All hand tools should be insulated to the fullest extent possible.
- e. Portable powered hand tools should be of a 3 wire grounded design.
- f. Do not use aluminum or metallic ladders while in and around electrical switchgear.

#### OPERATIONAL SAFETY SUMMARY

Follow the manufacturer's start-up and shut-down procedures.

Never operate equipment which has been tagged "Out of Service" or "Do Not Operate". Never override any electrical or mechanical interlocks unless the over-riding of such devices is called for in the special or emergency operating procedures. Become familiar with the substation functional operation prior to operating the substation. Prior to any maintenance ensure that equipment has been tagged out of service following the appropriate tag out procedures. Familiarize oneself with the manufacturer's maintenance procedure prior to conducting any maintenance. Never perform maintenance in an isolated location by oneself.

## 2.0 INTRODUCTION

The Type 82 Solid State DC reclosing relay provides all logic and control in a small draw out unit for load measure and auto reclose of circuit breakers on D.C. power distribution feeders for third rail or trolley electric transit systems. By monitoring and measuring the voltage and impedance on the system circuit, the 82 relay determines whether to allow a manual close operation or initiate an automatic reclose.

Positive or negative dead line voltage is stored in a sample and hold circuit for comparison to voltage during load measure. Dead line voltage can be either polarity in a network of substations depending on IR drop in negative line, grounding of system, and nature of positive feeder/line fault or open circuit resistance to ground. The Type 82 Relay system uses a bidirectional transducer and bidirectional input to the recloser to track both polarities and accurately compensate this dead line voltage.

The relay can be set to require 1, 2, or 3 successful load measuring cycles before close. Coupled with a special lead / follow circuit, several reclosers can be set up in a network such that simultaneous load measures by 2 or 3 reclosers will not cause a close onto a low resistance fault. This is a selectable feature that can be deleted in a single feed application or in case availability of service is deemed more important than protection of equipment.

Annunciation occurs when the relay is pulled out, power fails, or relay fails such that the internal supply fuse blows.

This manual contains helpful information for installing, calibrating and operating the recloser.

## 3.0 CONTROLS AND INDICATORS

### **CAL RUN Switch**

Spring loaded switch when held in CAL position injects D.C. level from CAL V. pot for setting LM GAIN and THRESHOLDS. Outputs are disabled in CAL mode. CAL Switch also resets relay.

### **V / OHMS Switch**

Selects meter function. In Volts mode, meter displays line voltage. In Ohms mode, meter displays track load during load measure cycle and will hold the last- read value until the unit is reset by switching to CAL mode or until the next load measure cycle. For best operation, the 82 recloser should be set to allow adequate time for the track signal to stabilize, providing a more accurate Ohms measurement; see section 7, "TIMING".

### **CAL V Pot**

Injects simulated line voltage between 0 and +800V in CAL mode (0 to 1600V for high voltage model).

### **PWR LED**

Indicates presence of supply power and that relay is functional. LED blinks when relay is in active reclosing mode. LED blinks at a rate proportional to each step in sequence counter. If master oscillator pot (front, top board) is set full CCW for fast cycle, one period of LED will be about 1/2 Second. For slowest setting (full CW) LED period will be about 4 seconds.

### **LM ADJUST Trimpot**

Used to adjust relay internal ohm-meter to read correctly for different substation LM resistors (10-100 ohms) and nominal feeder voltage (550-700VDC) see section 5.0 for detailed calibration instruction. Once set for a given transit system, LM ADJUST may be sealed. This adjustment may be factory set, if desired.

### **LM ADJUST Test Jack**

Used for LM adjustment.

Note: Scale factor:  $1V = 1 \text{ Ohm}$ .

Note: This and all other test jacks are buffered with series resistance. High impedance DVM's must be used for all measurements.

### **Panel Meter**

High accuracy digital LED meter displays line voltage (-70V to 850V); When set to Ohms mode, meter displays dead load during load measure cycle and holds the value until the next cycle.

### **SIG OUT Test Jacks**

Scale factor is 1 volt = 100 line volts. SIG OUT tracks both positive and negative feeder voltages. SIG OUT (-) is common for all other test jacks. SIG OUT (+) is buffered with 10k ohm so that high impedance DVM such as fluke 77 must be used. SIG OUT can be connected to an external recorder. Keep common mode voltage to substation structure less than 100 volts and take into account the internal 10K ohm buffer.

## **THRESHOLDS**

### **High Voltage**

Each control has an associated LED and Test Jack. LED's on indicates a good condition for reclose. Test Jack scale factors are 1 volt = 100 v and 1 v = 1 ohm. If feeder voltage is above High Voltage setting, recloser will close after initial delay but without going through load measure cycle. Feeder voltage, for example above 500 volts on a 600v System, says that trolley line or third rail is already being fed from other end and its ok to close immediately.

### **Low Voltage**

If feeder voltage is below setting, recloser will go into load measure cycle. If feeder voltage is between low voltage and high voltage settings, relay will neither reclose nor load measure and will eventually reach a time out lock out.

### **Ohms**

This is the permissible load in ohms for reclose on an unenergized line. Loads include rolling stock and any insulation leakage. Relay will not close on lower ohms or onto a short circuit. LED is only meaningful during load measure interval as indicated by output status "LM" LED.

## **TIMERS**

### **Delay**

Sets minimum time delay for reclose after breaker opens on overcurrent. Time delay (2 to 8 seconds) allows ionized air in breaker arc chute to dissipate.

### **Time Out**

Overall timer causes relay to go into lock out if a successful load measure and reclose is not made within the set time period (1 to 4 minutes). Note that this timer is reset every time breaker closes.

## Pump Out

Pump Out limits cycling of breaker within set time limit (1 to 4 minutes). Number of pump cycles is set by "pump attempt" internal dip switch (right side, top board). Setting is 1 to 5 cycles. Timer automatically resets at end of time period for additional cycles. Excess cycling due to faulted line on breaker failure leads to a "pump" lockout.

## OUTPUT STATUS

**LM - (Yellow LED).....** On during load measure period.

**CLOSE - (Red LED) ....** On during command to close breakers.

**LO - (Green LED) .....** On when recloser is locked out.

## LOCKOUT MEMORY

### Time (Red LED)

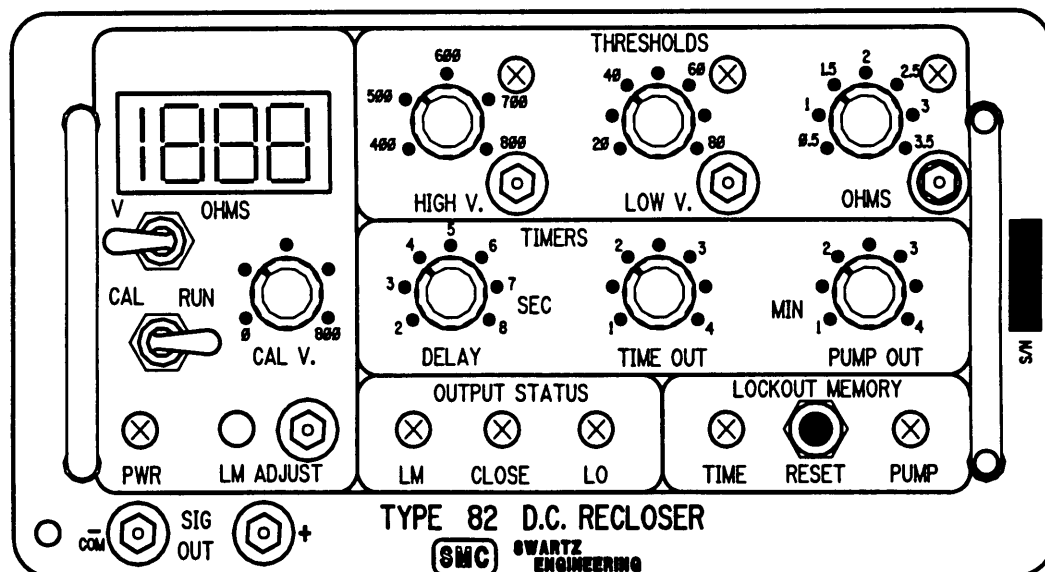
On when time out has expired without successful close.

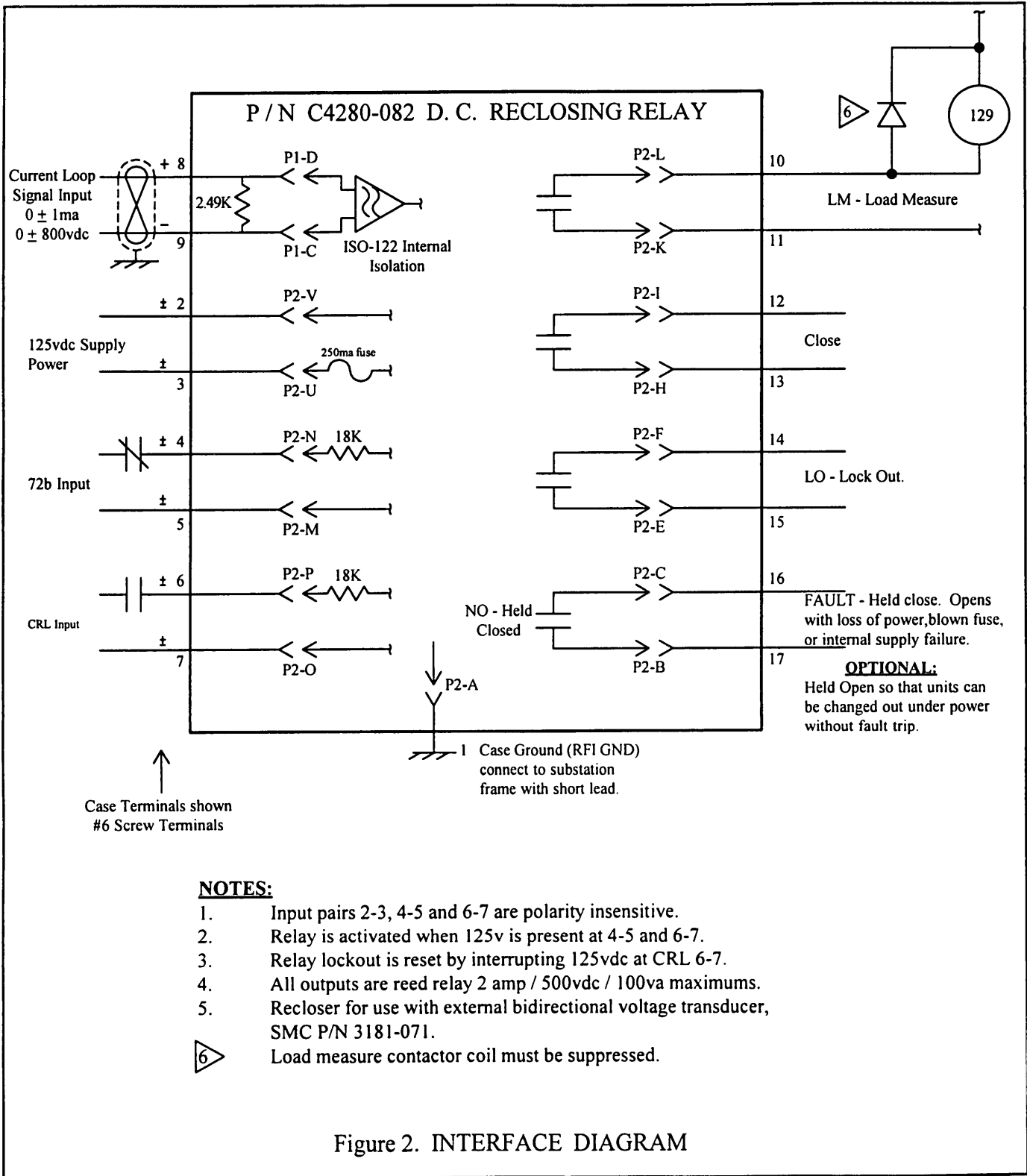
### Pump (Red LED)

On when breaker has cycled too many times within pump out time interval.

### Both LED's on

Recloser has attempted to close breaker but has not received feedback via 72b - faulty breaker or wiring or auxiliary switch. Cycle limit is set by internal dip switch on top board marked "Close Attempt" with selection from 1 to 5. This dip switch should always be set higher than pump attempt dip switch.







## 4.0 ADJUSTMENTS AND CALIBRATION

### TRIM POT SETTINGS

#### **Offset and Gain trimpots**

These trimpots adjust the ISO 122. input isolation amplifier. Scale factor is 1ma into 2.49K (located on edge connector of relay case) equals 8 volts at SIG OUT equals 800 VDC. Adjust offset for 0.00v out at zero input, then adjust Gain at 1 ma input. Repeat if necessary.

#### **MTR - Meter Calibration**

With meter on volts scale, using either current loop source or CAL V Pot, set for 5.00 volts at SIG OUT, adjust MTR trimpot (located at top left of front panel, beside digital meter) for desired reading.

#### **OSC trimpots**

Sets cycle speed of load measure sequencer. Full counter-clock-wise is approximately 1/2 second per sequence step. Full clock-wise is approximately 4 seconds per step. For most applications, this control is set full counter-clock-wise.

### DIP SWITCH SETTINGS

*Note for all dip switches: ON or SET is always toward the board, or down.*

#### **Sequence LNF - Lead, Normal, Follow**

This dip switch adds or subtracts sequence steps and therefore, overall cycle time in order for 2 or 3 reclosers to function simultaneously in a network configuration without load measure overlap. Sequence is, left to right when viewed from front, Lead (subtract steps), Normal, Follow (add steps). Refer to section 7 on timing for more detail.

#### **LM Cycle per Close Dip Switch**

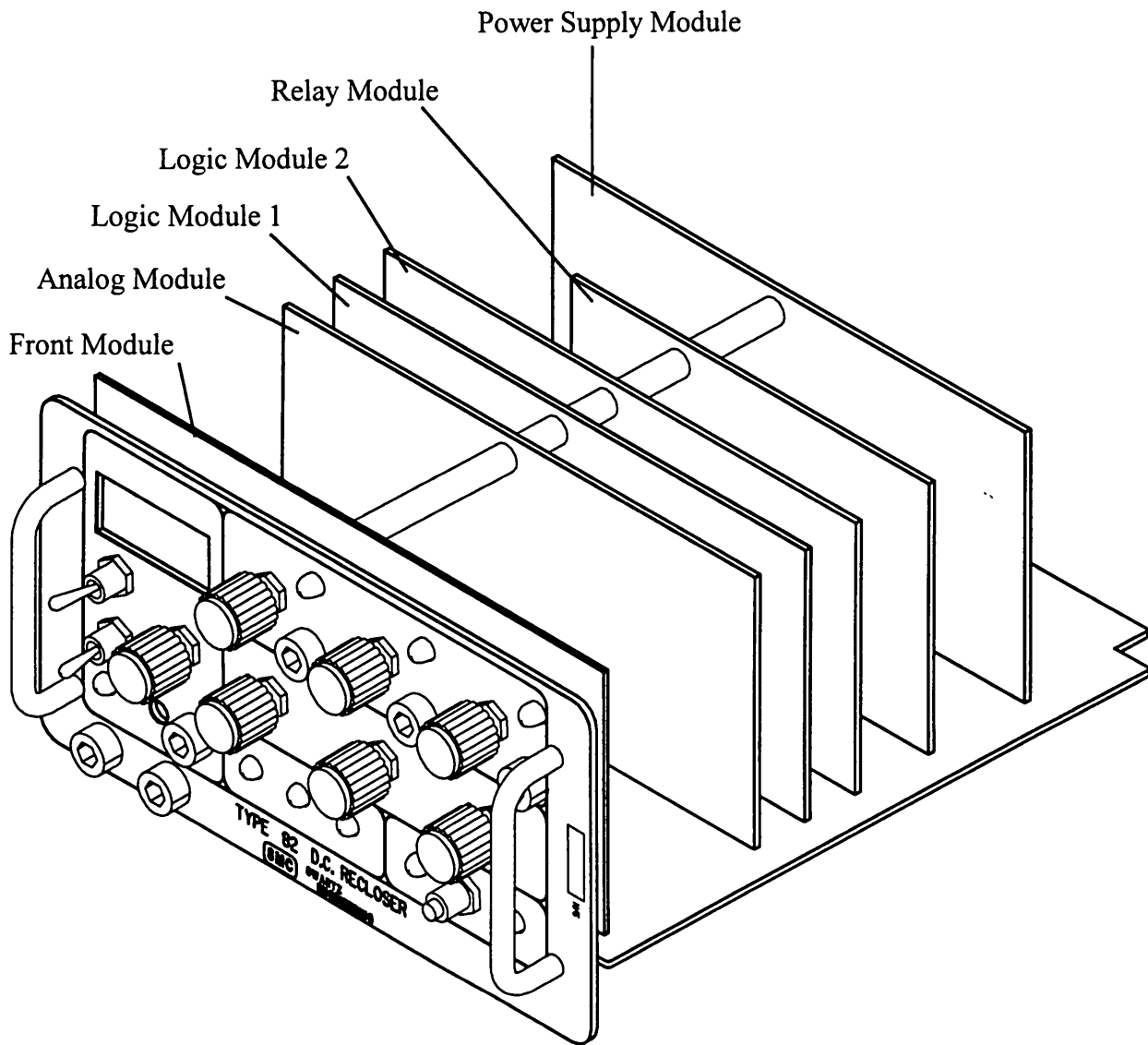
Set for 1, 2 or 3 successful load measure cycles before close output. Again, with a 2 or 3 setting, this control prevents simultaneous load measure from causing a closure on a heavy overload or near short. If, however, power system availability and minimal delay is most important, set this switch to 1 (left-most rocker).

#### **Pump Attempt Dip Switch**

Sets allowable breaker cycles within pump timer time interval. This is the top-most switch bank on the Logic 2 module; settings run 1-5 attempts, bottom rocker to top rocker, respectively.

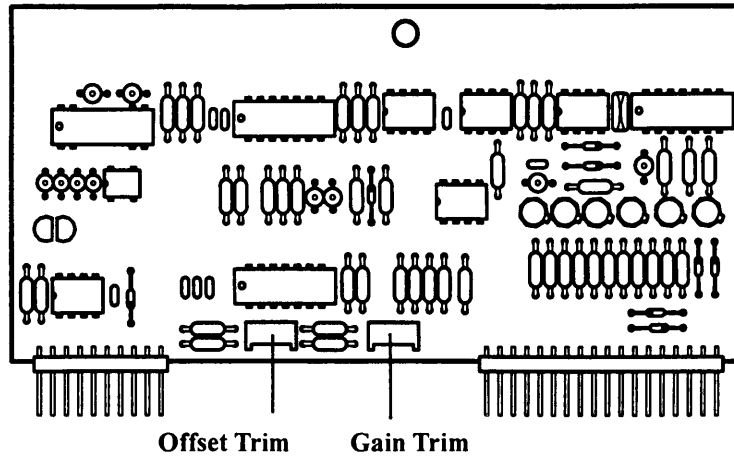
#### **Close Attempt Dip Switch**

Set allowable close outputs from relay within pump timer time interval. This is a watchdog internal loop which looks for equipment failure. Set higher than Pump Attempt Dip Switch. The Close attempt dip switch is the bottom-most switch bank on the Logic 2 module; settings run 1-5 close attempts, bottom rocker to top rocker, respectively.

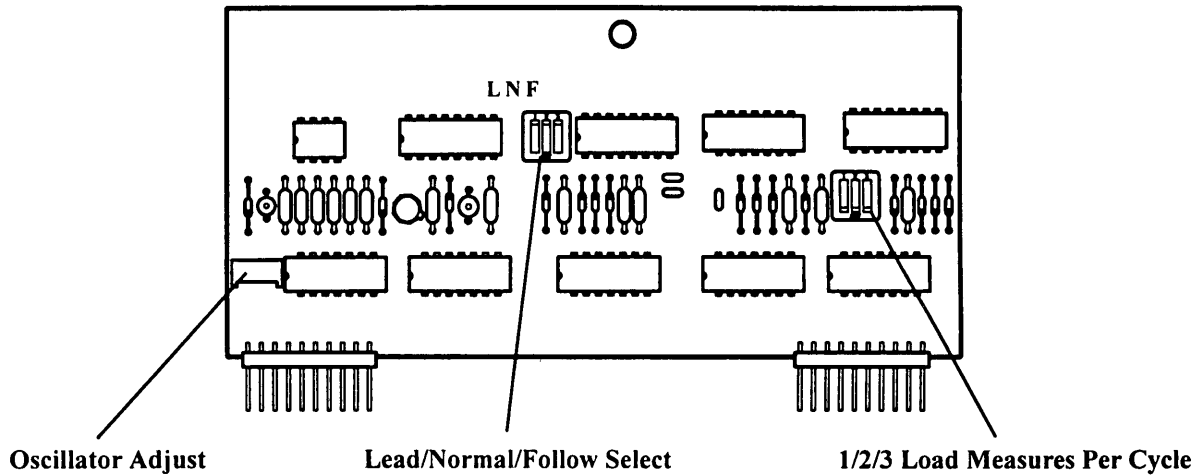


**Figure 3a Type 82 Module Locations**

### Analog Module



### Logic Module 1



### Logic Module 2

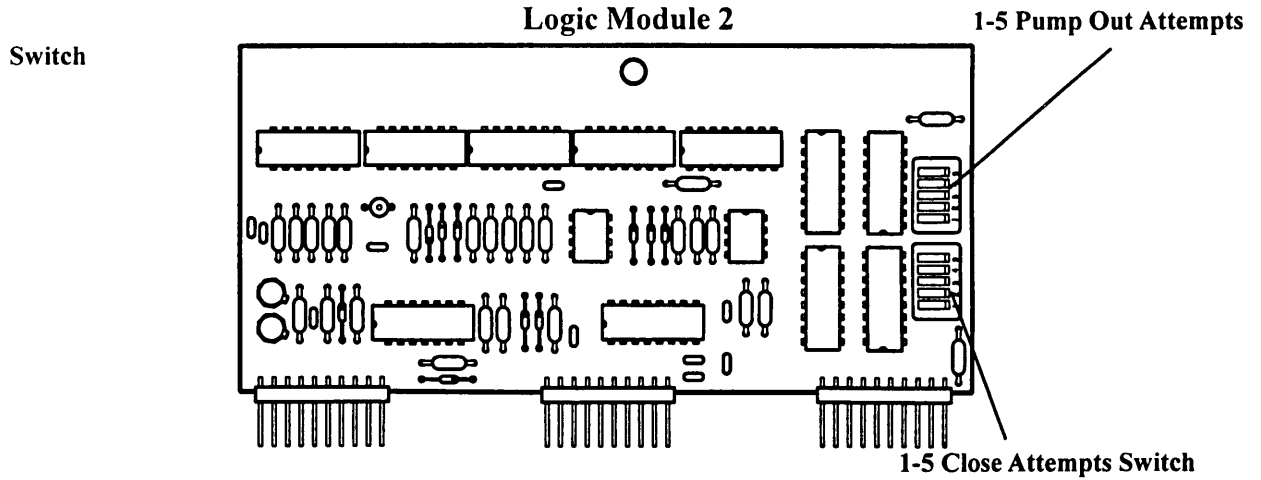


Figure 3b Internal Settings

## CALIBRATION OF LM GAIN

This is a one time calibration that makes the ohm meter portion of the recloser read correctly when the unit is used with various external load measure resistors (10 to 100 ohm) and system voltages (550 to 700 VDC). When calibrating recloser, note that 1v = 100 feeder volts and 1v = 1 ohm at pin jacks. Use only high impedance DVM's. Refer to Figure 4.

1. Calculate load measure current *assuming* a 1 Ohm load:

$$I_{LM} = \frac{\text{nominal system voltage}}{R_{LM} + 1}$$

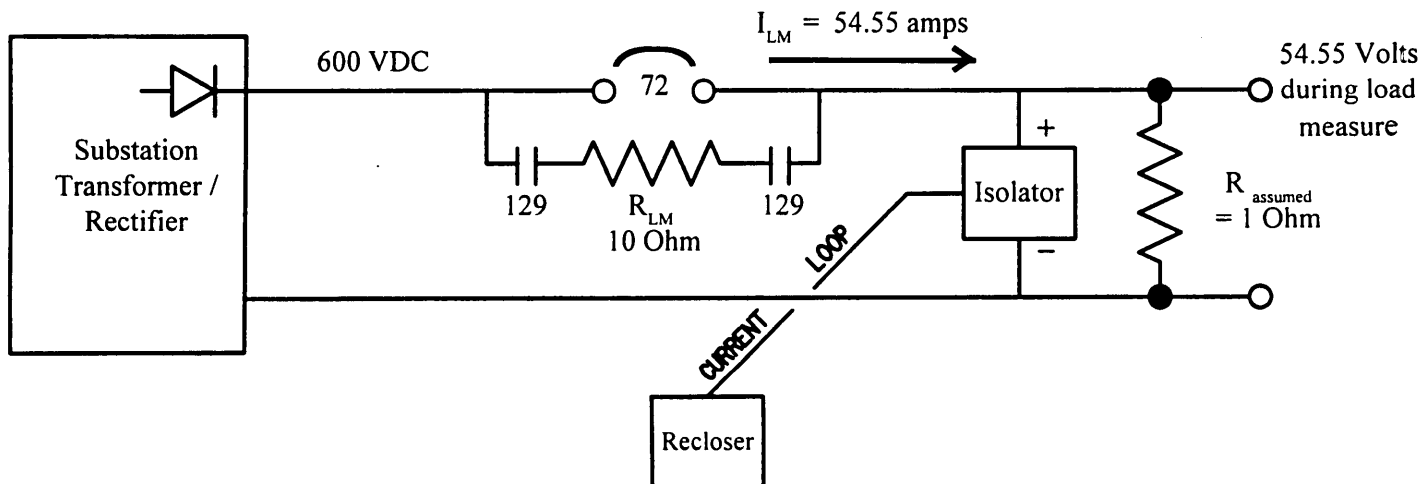
2. Calculate voltage fed back to relay during ohms load measure:

$$V = I_{LM} \times 1$$

3. Using "CAL V" pot, inject this voltage into recloser (as measured at SIG OUT).
4. Adjust LM Gain until "Ohms" at LM GAIN test jack equals 1.00.

Note: For best accuracy, calibrate at expected recloser ohms threshold.

For easier calibration, when using low LM current, multiply both Voltage and assumed load in step 2 by a factor of 10, then adjust per step 4 using these higher values.



1.  $I_{LM} = \frac{600 \text{ Volts}}{10 \text{ Ohm} + 1} = 54.55 \text{ amps}$
2.  $V = 54.55 \text{ amps} \times 1 \text{ Ohm} = 54.55 \text{ volts}$
3. Inject 54.55 volts using "CAL V" pot (.5455v at SIG OUT)
4. Adjust LM ADJUST for 1 Ohm (1 volt at LM GAIN jack)

**Figure 4 Load measure schematic / example**

## 5.0 Typical Applications And System Design

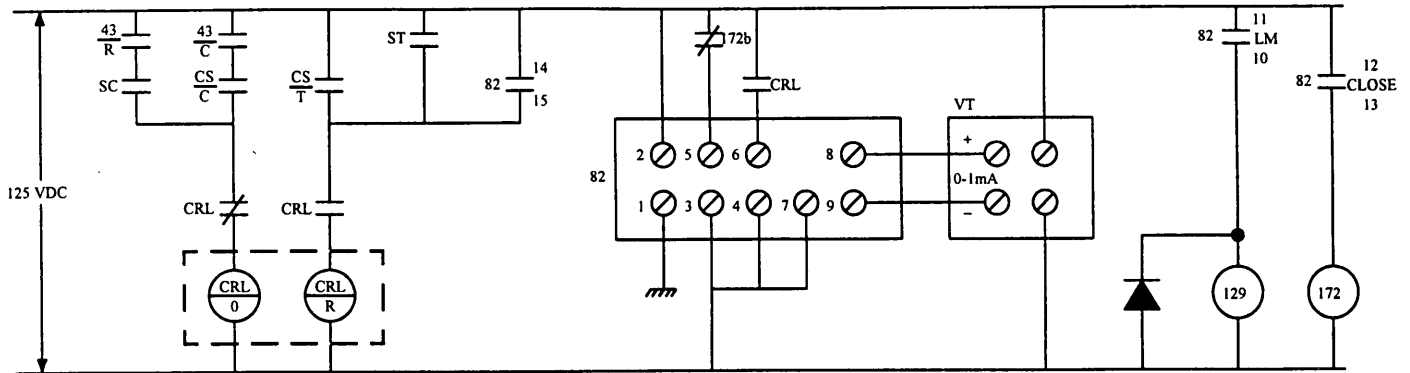


Figure 7 Type 82 Recloser Control Scheme

## TRADE STUDY

Load measure resistance, Low vs. High  
(600 volt system, 1 Ohm dead load threshold)

| <b>Low</b> 15 Ohm Load Measure Resistor<br>Test current 37.5 amps  | (maximum for 600-700v system)<br><b>High</b> 100 Ohm Load Measure Resistor<br>Test current 5.94 amps   |
|--|--|
| <p><u>Pro</u></p> <ul style="list-style-type: none"> <li>Overcomes diode bridges, carbon brush drops and other nonlinear load resistance.</li> <li>High enough energy to heat up carbon tracks?</li> <li>Blow away or melt nuisance shorts?</li> </ul> <p><u>Con</u></p> <ul style="list-style-type: none"> <li>Higher cost LM Resistor and 129 Relay</li> <li>Higher heat dissipation / Size</li> </ul> | <p><u>Pro</u></p> <ul style="list-style-type: none"> <li>Lower cost LM Resistor and 129 Relay</li> </ul> <p><u>Con</u></p> <ul style="list-style-type: none"> <li>Requires better resolution, noise immunity accuracy of recloser circuits.<br/> <math>\Delta 5.94</math> volts go / no go<br/>                     vs.<br/>                     37.5 volts for 15 Ohm LM resistor</li> <li>More susceptible to being fooled by negative rail voltage fluctuations.</li> </ul> |

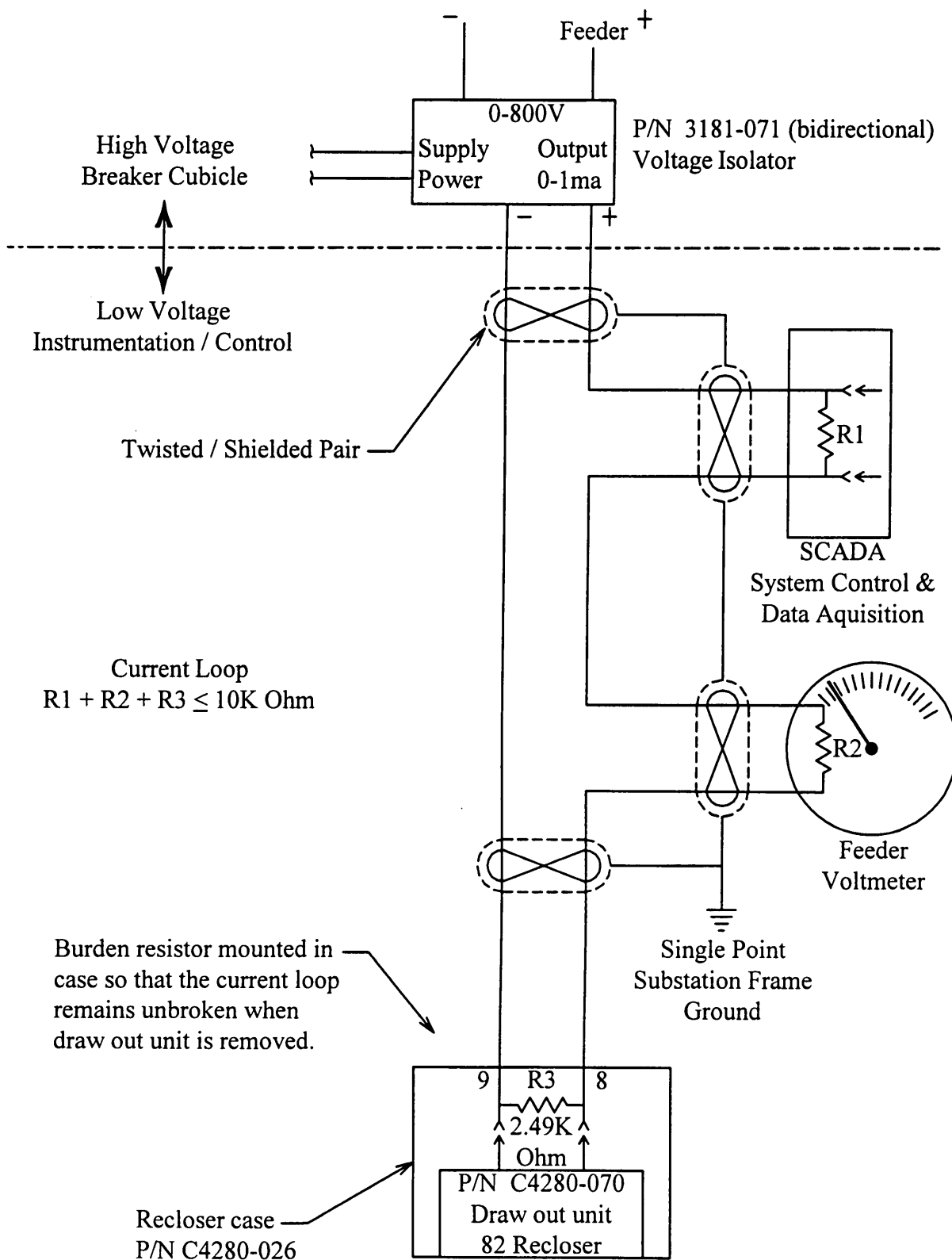


Figure 6 Typical hookup - Voltage Isolator / Recloser Current Loop

## 6.0 TIMING

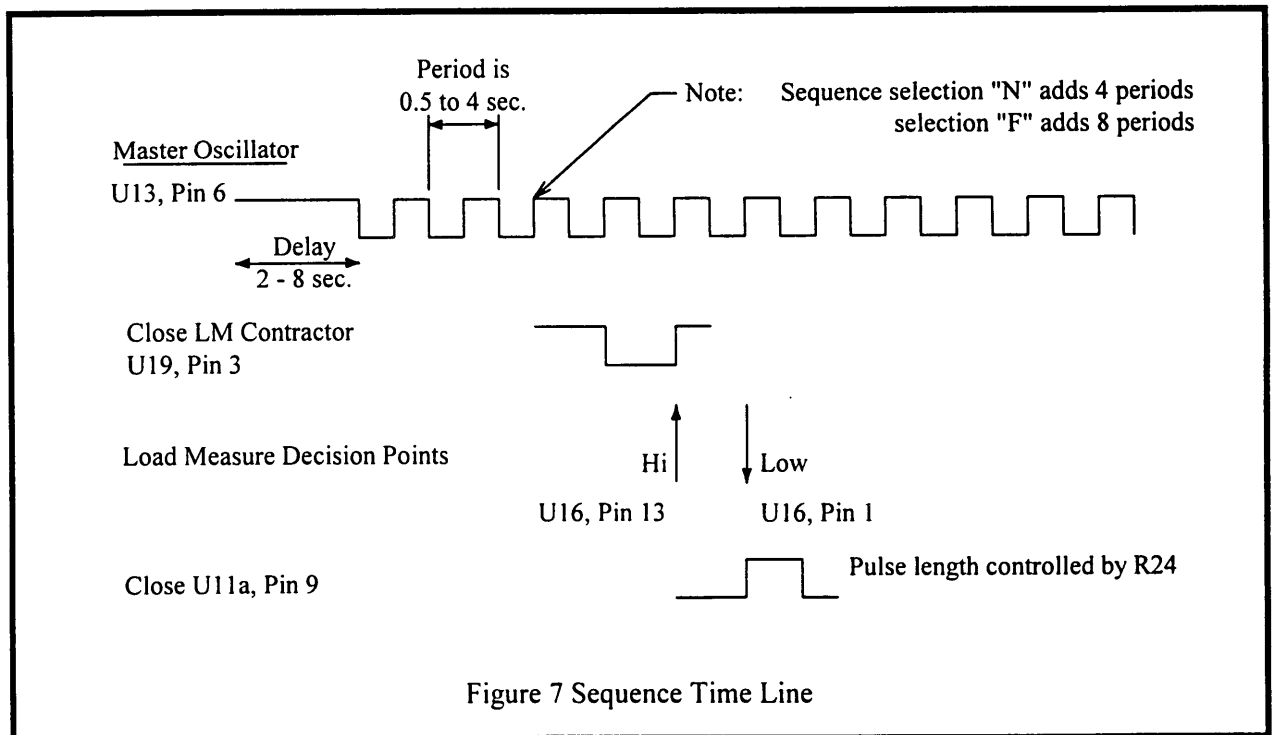
Time required for a reclose can vary widely depending on OSC Trimpot setting and selection of LNF and LM Cycle selections. Recloser can be set up for as little as 1 or up to 40 load measures and close opportunities in a four minute period. Timing requirements are a function of application. On a trolley bus system for example, time should be allowed for driver to exit bus and remove poles from overhead lines before recloser goes into lockout. The following tables are typical time to close for various set ups.

1. **Shortest time** - Delay set to 2 seconds  
(Seconds) OSC full CCW

| Sequence | LM Cycles per close |    |    |
|----------|---------------------|----|----|
|          | 1                   | 2  | 3  |
| L        | 5                   | 10 | 15 |
| N        | 7                   | 14 | 21 |
| F        | 9                   | 18 | 27 |

2. **Longest time** - Delay set to 8 seconds  
(Seconds) OSC full CW

| Sequence | LM Cycles per close |     |     |
|----------|---------------------|-----|-----|
|          | 1                   | 2   | 3   |
| L        | 32                  | 72  | 112 |
| N        | 48                  | 104 | 160 |
| F        | 64                  | 136 | 208 |



### CAUTION

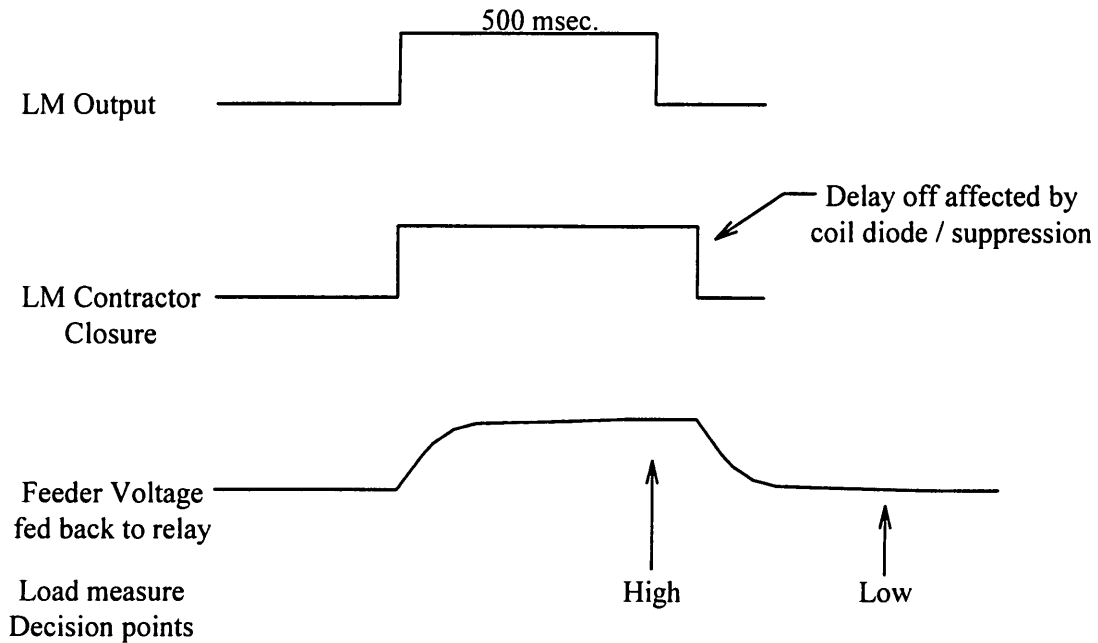
Close pulse length is approximately 250 msec and is controlled by value of fixed resistor, R24. This reclosing relay is set up to close a breaker (172) which has the following safety circuits:

1. 72 trip control overrides 72 close control
2. Breaker has an anti-pump circuit.

If the breaker does not have these safety circuits, consult SMC Electrical Products, Inc. before using this recloser.

## Load Measure Period (Refer to Figure 8 and Trade Study)

Load measure contactor will be closed for one period of sequence. Time interval is therefore adjustable from 0.5 to 4 seconds. Note that all other sequence times are affected. Normally, a fast cycle is adequate. The following shows critical timing parameters for load measure period.



Load measure period should be much longer than L/R time constant for charging line, as-well-as the recloser signal input filter which has a 50 msec. time constant.

Figure 8 Critical Timing Parameters

## TRADE STUDY

### Short vs. Long load measure period

| Short Load Measure Period 0.5 seconds  | Long Load Measure Period 4 seconds  |
|--|---|
| <p><u>Pro</u></p> <ul style="list-style-type: none"> <li>• Low duty cycle on Load Measure Resistor</li> <li>• Lower shock hazard.</li> </ul> | <p><u>Pro</u></p> <ul style="list-style-type: none"> <li>• Plenty of time to reach equilibrium</li> </ul>   |
| <p><u>Con</u></p> <ul style="list-style-type: none"> <li>• Must charge feeder and load capacitance</li> </ul>                                | <p><u>Con</u></p> <ul style="list-style-type: none"> <li>• Bigger window for fluctuations in negative rail voltage to influence LM decision.</li> </ul> |



## 7.0 THEORY OF OPERATION

By monitoring status of the breaker "72b" switch and the control relay "CRL" (reset by manual close command) and by measuring the voltage and impedance on the system circuit, the situations for breaker closing are described as follows:

**High Voltage** - If the incoming feeder is at or near normal voltage, i.e. hot from another station, then it is assumed that conditions are normal and the breaker can be closed by hand or remotely or can close automatically without human intervention if there has not been a pre-set time out period or a pre-set pump out.

High voltage is normally set with a DVM for threshold pickup of 400 volts and above for reclose (front panel measurement and adjust). The voltage is measured with an 800 volt transducer connected to the incoming cable through a fuse. This transducer also supplies a current output to the panel meter and SCADA. This voltage can be read on the upper scale of the 82 meter in "v" position.

If the transducer measures a voltage on the line between 30 volts and 400 volts, reclosing is not allowed. The time out timer begins counting after the "b" closes and will produce a lockout signal after a preset time of between 1 minute and 4 minutes. Low voltage threshold is adjustable from 20 - 80 volts and is typically set with a DVM for 30 volts pickup as measured and adjusted on front panel using DVM.

If less than threshold for low voltage is sensed by the transducer on the incoming line (0 - 30 volts) then, after the initial delay time, a load measure operation is called for which measures the resistance between positive and negative of the overhead wire and feeders. A value which is very low, typically an ohm or less, indicates that a short circuit is on the line and reclosing either by hand or automatically is not allowed.

If a measurement is greater than an ohm or two, it is assumed that this is a coach load or maybe no load at all and reclosing is allowed. This front panel adjust is accomplished with a Digital Voltmeter.

### **Load Measuring has several special features...**

A Load Measure output pulse from the 82 relay causes the 129 relay to close which inserts resistance in series with the 600 vdc bus and the feeder positive cables. This effectively places a reduced voltage on the line which the 82 relay can measure and convert to ohms of loading or perhaps, a short circuit.

Because nearly all overhead circuits are fed from more than one end, and because Load Measuring is likely to be initiated at each station, it is necessary to avoid overlapping measuring attempts which will give false readings. The 82 relay can be preset to lead / follow to normal with respect to the other end. This setting is performed by DIP switch on top of the relay. The setting will depend on the type of load measuring equipment at the remote station or other parallel source. The initial delay setting, interval time set , and the L/N/F switch must all be coordinated to reasonably avoid an overlap between adjacent stations. (see enclosed information for details). The L/N/F switch will be generally more effective for two Type 82 relays talking to each other. There can be anywhere from a few seconds difference between lead and lag at minimum setting up to 2 or more minutes difference at maximum.

The Load Measure output is pulsed onto the line at intervals which are set on the pot on top of upper PC board from 5 - 208 seconds. The pulse itself is short (0.5 - 4 seconds) and is a percentage of the preset interval. The output pulse may be observed by the yellow LM front panel light.

The close attempt counter is set (DIP switch) from 1 - 5 attempts (pulses) to close. When this count out occurs, it will then produce a lockout signal for the 82 relay. The close attempt counter is intended to cover the situation when there is a malfunction in the breaker and the "b" switch is not available or indicates incorrectly. The indication of this happening is both a pump out light and a time out light. Typically set this at 5 on the Close Attempt DIP switch.

The pump out counter measures the number of operations of the "b" switch in the breaker. This pump out counter is preset from 1 - 5 breaker operations by DIP switch, typically at 3. This close attempt counter should always be set more than the pump out counter because otherwise it may be possible to end up with a closed breaker under a lockout condition. The pump out counter latches a manually reset light on the front panel of the 82 relay.

The close time out counter measures the length of time from a relay trip until the breaker recloses automatically. If it does not close the 82 relay locks out and the breaker will not close until a manual or SCADA close action resets CRL. This is adjustable from 1 - 4 minutes on the front panel. Typically set for 2 minutes.

The pump out timer will provide a reset to the close attempt and pump out counters after the amount of time preset on the front panel (1 - 4 minutes). Resetting these counters back to zero is necessary if the breaker successfully recloses after a breaker overcurrent trip. Otherwise there would be an unwanted lockout signal generated after a few legitimate breaker operations. This timer would typically be set at somewhat more than the total Load Measure period x pump count setting. Typically set for 1 minute.

To minimize false Load Measure readings, the relay can be preset via DIP switch to make an additional 1 or 2 successful measurements before allowing a close operation. Typically set LM cycles to "2".

**Other 82 Relay features include:**

Initial Delay Timer - This timer delays any reclose until arcing, etc. is complete and is adjustable on the front panel from 2 - 8 seconds.

Front panel meter - Measures incoming line voltage directly in volts position. Measures ohms on line during Load Measuring interval pulse. The ohms range is adjustable by DIP switch at full scale of 2 or 5 or 10 ohms.

The CAL/Run test switch is used to adjust the sig out value to the calculated value unique to the particular station. Using a digital voltmeter, with the switch held in CAL, adjust CAL V to calculated "V". The LM Gain can now be adjusted with the switch in "cal" to pickup load "L" (usually about 1.4 ohms) as read in volts on the DVM.

A lockout is generated for several reasons. In review they are from pump out, time out, pump out window and close attempts. When a lockout signal is generated, a NO relay contact will close which acts to disable breaker closing and bring in various alarms. The lockout light on the front panel does not seal-in and does not require a reset but a control switch or SCADA close operation is required to reset the CRL lockout relay.

The RESET Switch on the front panel will unlatch time and pump out memory LED's.

An 82 failure alarm output will occur for various internal failure modes in the 82 relay and this is brought out to the annunciator and SCADA.

## Type 82 Solid State D.C. Reclosing Relay Specifications

### Supply

Voltage: ..... 24 to 125vdc operating range

Current: ..... 30ma @125v, 200ma @24v, standby

### Inputs

Signal Input: ..... 0-1ma current loop, scale factor 0 to 800vdc

Impedance: ..... approximately 2.4k ohm

Isolation: ..... 5.6kv line to loop at external voltage transducer  
2.0kv loop to internal recloser circuits (Burr Brown ISO 122)

External Isolator: ..... To be used with P/N 3181-071 Voltage Transducer or Equiv.  
0 to  $\pm 1$  ma up to 10k ohm load. Isolator must be bidirectional.

Digital Inputs: ..... CRL input - requires 125vdc / 7ma polarity insensitive  
72B input - requires 125vdc / 7ma polarity insensitive

### Outputs

Fault ..... NO held closed - All outputs 2a / 500vdc / 100va max (optional NC held open)

Load measure ..... NO

Closed ..... NO

Lockout ..... NO

### Thresholds, Front Panel

High voltage ..... 400vdc to 800vdc (direct close); 200vdc to 600vdc available

Low voltage ..... 20vdc to 80 vdc

Load ohms ..... 0.5 to 3.5 ohms; 0.15 to 0.45 ohms available

### Timers, Front Panel

Initial Delay ..... 2 to 8 seconds (deionizing time)

Overall time to close ..... 1 to 4 minutes

pump window ..... 1 to 4 minutes

### Internal Settings

Close attempts: ..... 1 to 5

Pump attempts: ..... 1 to 5

Lead/follow dip switch: .. Lead / Neutral / Follow

Cycles per close attempt: 1 to 3

Signal input gain and offset pots

Meter Cal.

Meter range dip switch: ... 2 / 5 / 10 ohms full scale

OSC: ..... 0.25 Hz (clock-wise) to 2 Hz (counter-clock-wise)

### Miscellaneous Specs

Load Measure Cycle: ..... 1 to 12 per minute

Ext LM resistance: ..... 15 to 100 ohms (600vdc system)

Ext LM current: ..... 6 to 40 amps (600vdc system)

### Environment Qualification Testing

SWC Fast transient test per ANSI / IEEE 37.90.1-1989

SWC Oscillatory test per ANSI / IEEE 37.90.1-1989

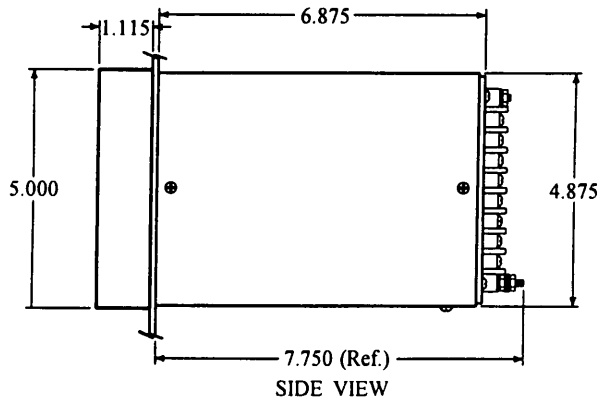
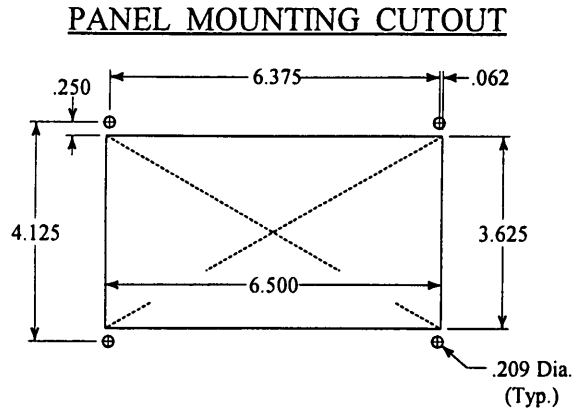
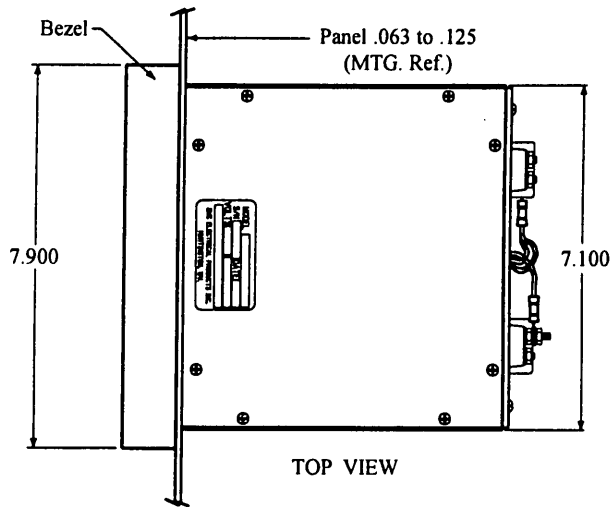
Temperature -24°C to +55°C

RF Suscept. qualitative at 150mhz and 440mhz

Input Power Range  $\pm 15\%$

Polyurethane conformal coat / low resistance timing circuits, Hermetic IC's wherever possible.

# Type 82 Reclosing Relay Case Dimensions



## REAR VIEW

#6 Screw Terminals

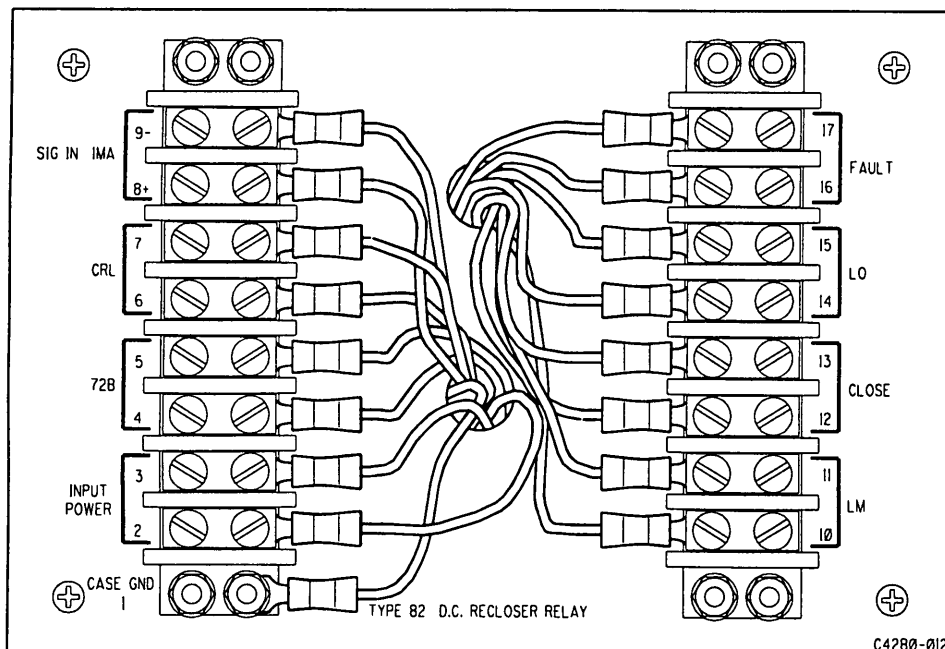


Figure 3

August 1, 1994

## SMC WARRANTY STATEMENT

The purchaser has a reasonable time to ascertain whether the apparatus is as represented. Any test required by the purchaser to determine any conformance to representation must be made within 60 days from date of shipment. SMC reserves the right to review and mutually agree on condition of tests and to be represented at any tests. SMC electric products are warranted for a period of one year from the date of shipment to be free from any defect in materials or workmanship. SMC will repair or replace F.O.B. factory, with regular UPS shipment allowed, any part which under normal and proper use proves defective in workmanship or material within the effective warranty period.

The correction of such defects by repair or replacement at SMC's sole discretion, shall constitute fulfillment of all of the SMC obligations with respect to the apparatus sold hereunder. (RMA Procedures for return are outlined below).

- 1) Obtain verbal or written approval from SMC as outlined in the return procedure.
- 2) Issue a purchase order to SMC Electrical Product, Inc for replacement of defective products, full credit will be issued when the part is received and evaluated by SMC and is determined to be under warranty.
- 3) Warranty replacements are quoted F.O.B. factory with regular UPS shipping charges allowed. Any special shipping charges will be billed to the customer.
- 4) Return Material - No material may be returned without an RMA (Return Material Authorization) authorized by SMC. Proper RMA identification and packaging of returned goods will only be accepted. Contact an SMC Components Division sales representative for authorization at telephone number (304) 736-8933 or fax (304) 529-1406.

Such warranty shall not apply to any product or component; (A) repaired or altered by anyone other than SMC or an authorized service center without SMC's prior written approval; (B) tampered with or altered in any way or subject to misuse, negligence or accidents; (C) which has the serial number altered, defaced or removed; or (D) which has been improperly connected, installed or adjusted other than in accordance with SMC instructions.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF QUALITY WHETHER WRITTEN, ORAL, OR IMPLIED. INCLUDING BUT NOT LIMITED TO ANY WARRANTY OR FITNESS FOR A PARTICULAR PURPOSE.

### SMC Electrical Products, Inc.

#### *Components Operation*

Mailing Address

PO Box 880  
Barboursville, WV 25504

Shipping Address

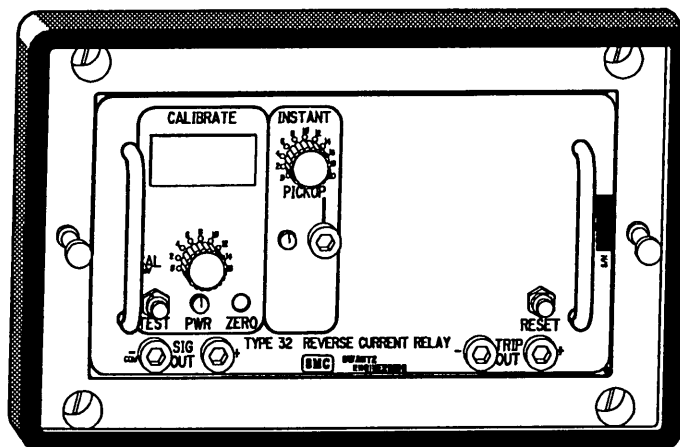
5950 Ohio River Road  
Huntington, WV 25702

Phone: (304) 736-8933 Fax: (304) 529-1406

# SWARTZ® REVERSE CURRENT RELAY

260-02-00

Date: 3/21/97



MODEL C4280-555

## GENERAL

The SWARTZ® Type 32 Reverse Current Relay from SMC is designed for the protection of rectifiers in transit or industrial applications. The relay protects the rectifier from back-feeds in the power system, should there be an internal fault. The solid state design and rugged construction ensure dependable, low maintenance operation under adverse conditions.

## FEATURES

- Draw-out construction
- LED Meter - Accurate, easy to read
- Instant Reverse Current Channel - 0 to 20 mV
- Use with any Shunt
- Uni-Directional
- Internal Power Supply operates on and auto-compensates for a wide range of DC inputs
- Calibration Controls Allow Preset Threshold and Test
- Field Adjustable

## DESCRIPTION

The Type 32 relay detects reverse current flow onto the rectifier. It is recommended where there is no cathode breaker or when supplementary protection is required. The front panel controls are calibrated in millivolts so the relay is compatible with any type of shunt. The built-in calibration components allow accurate field calibration of the current setting. The relay incorporates a signal-out jack that gives voltage output equal to the line current.

## SPECIFICATION

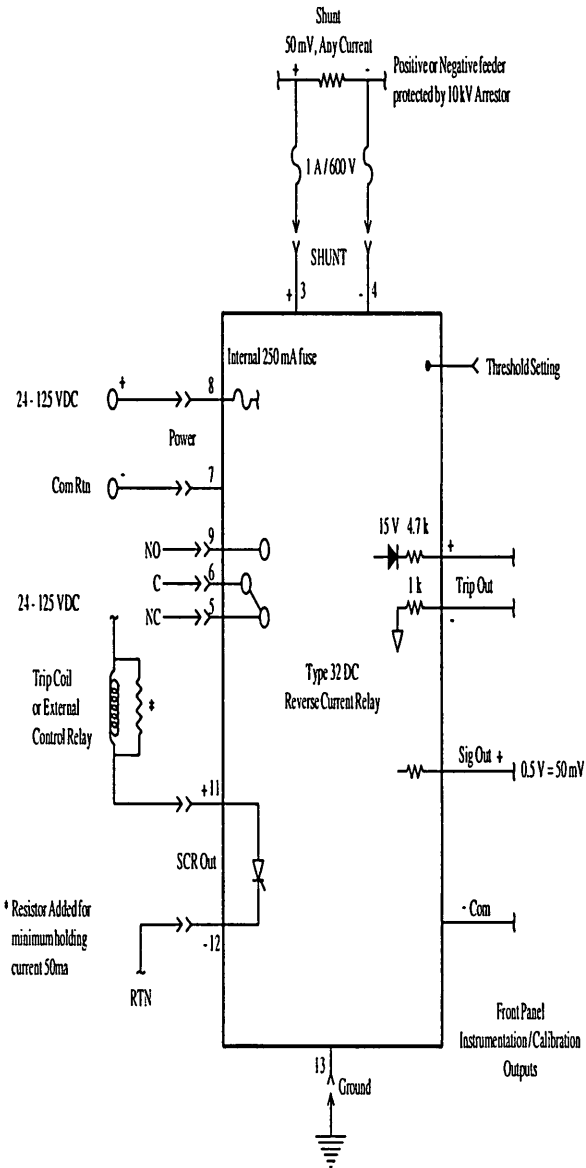
- |                        |                          |                            |                                 |
|------------------------|--------------------------|----------------------------|---------------------------------|
| • Input Power:         | Operates on 24 - 125 VDC | • Isolation Dielectric:    | 5400 V, 60 Hz, 1 min.           |
| • Supply Current:      | 40 mA at 125 VDC         | • SCR Output:              | 100 mA to 6 A(1 sec.) 200 V     |
|                        | 200 mA at 24 VDC         | • Annunciation:            | Reed Relay 100 VA, 2 A, 500 VDC |
| • Ambient Temperature: | -20°C to +55°C           | • Threshold Setting Error: | ± .5 mV                         |
| • Design Test:         | SWC ANSI/IEEE C37.90     | • Isolation Error:         | ± 1 mV                          |

## TYPE 32 REVERSE CURRENT RELAY

COMPONENTS OPERATION • P.O. Box 880, Barboursville, WV 25504 • 5950 Ohio River Road • Phone: (304) 736-8933 • Fax: (304) 529-1406

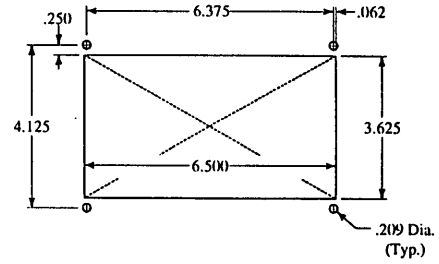
**SMC**  
ELECTRICAL PRODUCTS

# INTERFACE DIAGRAM

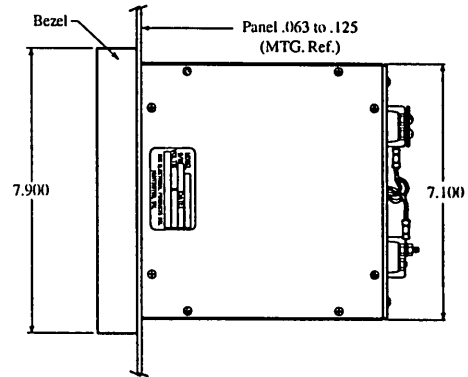


# RELAY CASE DIMENSIONS

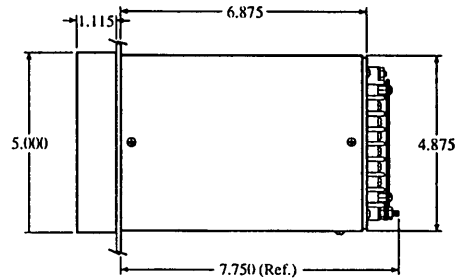
## PANEL MOUNTING CUT OUT



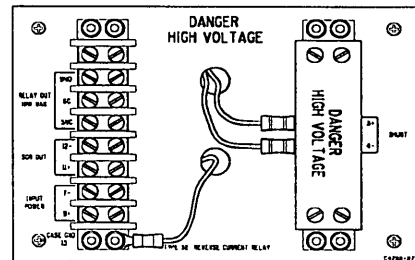
## TOP VIEW



## SIDE VIEW



## REAR VIEW



# SMC ELECTRICAL PRODUCTS, INC.

**Mailing Address**  
PO Box 880  
Barboursville, WV 25504

**Components Operation**

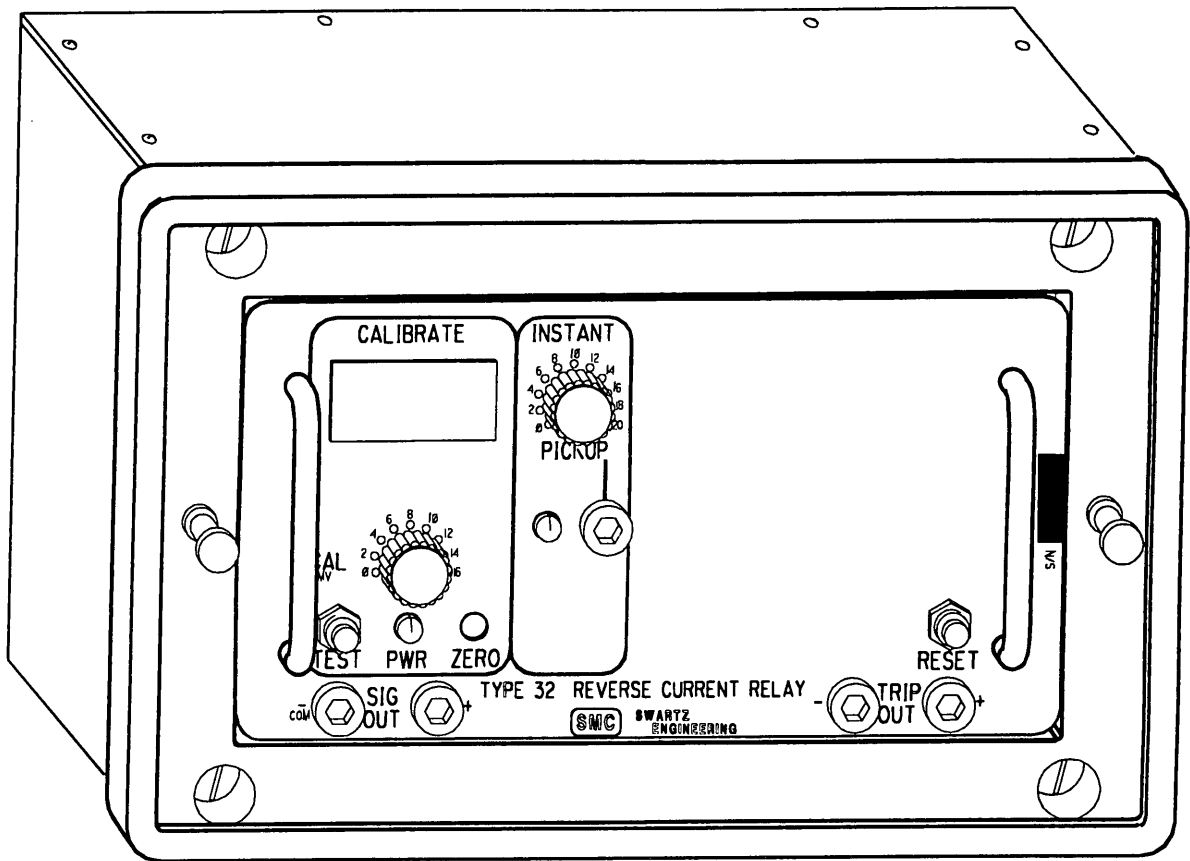
Phone: (304) 736-8933 Fax: (304) 529-1406

**Shipping Address**  
5950 Ohio River Road  
Huntington, WV 25702



**SWARTZ®  
ENGINEERING**

## TYPE 32 REVERSE CURRENT RELAY



## OPERATION AND CALIBRATION MANUAL



The information contained within is intended to assist operating personnel by providing information on the general characteristics of equipment of this type. It does not relieve the user of responsibility to use sound engineering practices in the installation, application, operation and maintenance of the particular equipment purchased.

These instructions do not purport to cover all details or variation in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to SMC.

If drawings or other supplementary instructions for specific applications are forwarded with this manual or separately, they take precedence over any conflicting or incomplete information in this manual.

**SMC Electrical Products, Inc. *Components Operation* Phone (304) 736-8933 Fax (304) 529-1406**

# TYPE 32 REVERSE CURRENT RELAY

## OPERATION AND CALIBRATION MANUAL

### TABLE OF CONTENTS

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## 1.0 SAFETY PRECAUTIONS

### INTRODUCTION

This section of the manual is to familiarize the operating and maintenance personnel with the hazards and the necessary precautions to follow when either operating or maintaining the Type 32 Reverse Current Relay. Although all the hazards or possible hazardous conditions which may arise during the operation of the Type 32 Reverse Current Relay may not be foreseen, this section of the manual is a guideline so as to prevent personnel injury, equipment damage, or limit equipment damage should a fault occur:

### SYSTEM HAZARDS AND PRECAUTIONS

Below are listed the safety hazards associated with the Type 32 Reverse Current Relay followed by a list of safety precautions. Prior to the energization of the equipment or prior to commencement of any maintenance, the appropriate personnel should review these hazards and precautions to become readily familiar with them.

### SAFETY HAZARDS

a. Electrical Shock or Current Flow

Current Flow through chest or head area may cause cardiac arrest, stoppage of breathing, and ventricular fibrillation.

b. Electrical Arcs

May cause equipment explosion, flash burn to eyes, ultraviolet burning of skin tissue.

c. Direct Burns

May occur when in direct contact with overheated electrical equipment.

### GENERAL SAFETY PRECAUTIONS

- a. Prior to any maintenance or entry into electrical switchgear, remove all metallic objects from person. (Such items as wristwatches, rings, metal badges, belt buckle, metal pins, rules, flashlights, keys, and key chains).
- b. Do not wear loose fitting clothing when in and around equipment.
- c. Work from an insulating mat whenever possible.
- d. All hand tools should be insulated to the fullest extent possible.
- e. Portable powered hand tools should be of a 3 wire grounded design.
- f. Do not use aluminum or metallic ladders while in and around electrical switchgear.

### SPECIAL SAFETY PRECAUTIONS

- a. **Voltage Hazard** 2000V may be present at case terminal strip, internal case connectors and portions of relay.
- b. **Grounding Relay** case 13 should be grounded to the equipment frame for voltage safety and to reduce susceptibility to RF interference.
- c. **Dielectric Testing** Remove relay from case when dielectric testing of substation wiring is performed.
- d. **Fusing** One amp fuses are recommended in shunt leads and power supply leads.

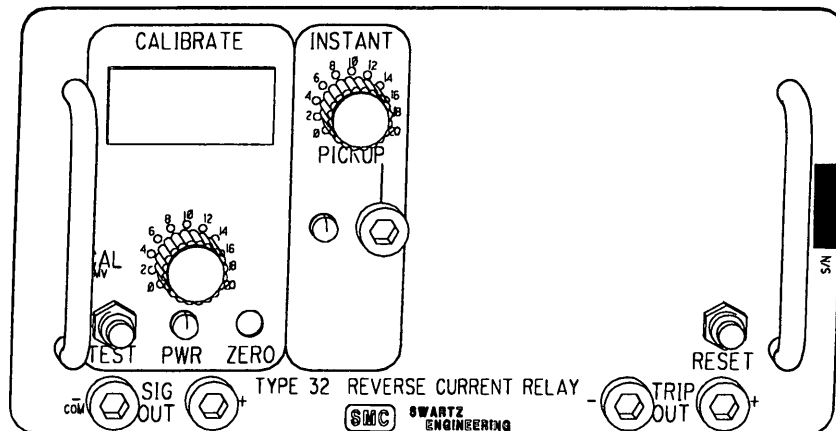
## OPERATIONAL SAFETY SUMMARY

Follow the manufacturer's start-up and shut-down procedures.

Never operate equipment which has been tagged "Out of Service" or "Do Not Operate". Never override any electrical or mechanical interlocks unless the over-riding of such devices is called for in the special or emergency operating procedures. Become familiar with the substation functional operation prior to operating the substation. Prior to any maintenance ensure that equipment has been tagged out of service following the appropriate tag out procedures. Familiarize oneself with the manufacturer's maintenance procedure prior to conducting any maintenance. Never perform maintenance in an isolated location by oneself.

### 2.0 INTRODUCTION

The Swartz Type 32 Reverse Current Relay is an isolated current monitor which is used with either the positive or negative conductors in D.C. power distribution networks. The primary function of the detector is to monitor low levels of reverse feeder current. All front panel controls are calibrated in millivolts so that the detector can be used with any shunt. Current is referred to as equivalent "millivolts" in this manual.



Front Panel Layout

### 3.0 FRONT PANEL CALIBRATION AND CONTROLS

#### Test

A built-in calibration control (CAL) with variable settings from 0 to 20 mV and a momentary pushbutton switch (TEST) allow functional check of reverse threshold. Test current can be read on the meter or at "SIG OUT" test jacks where 0.5V at test jacks equals 50mV at shunt.

Accuracy precaution : Test current adds to any current already present at shunt leads.

#### Digital Meter

The ameter reads from 0 to 20mV.

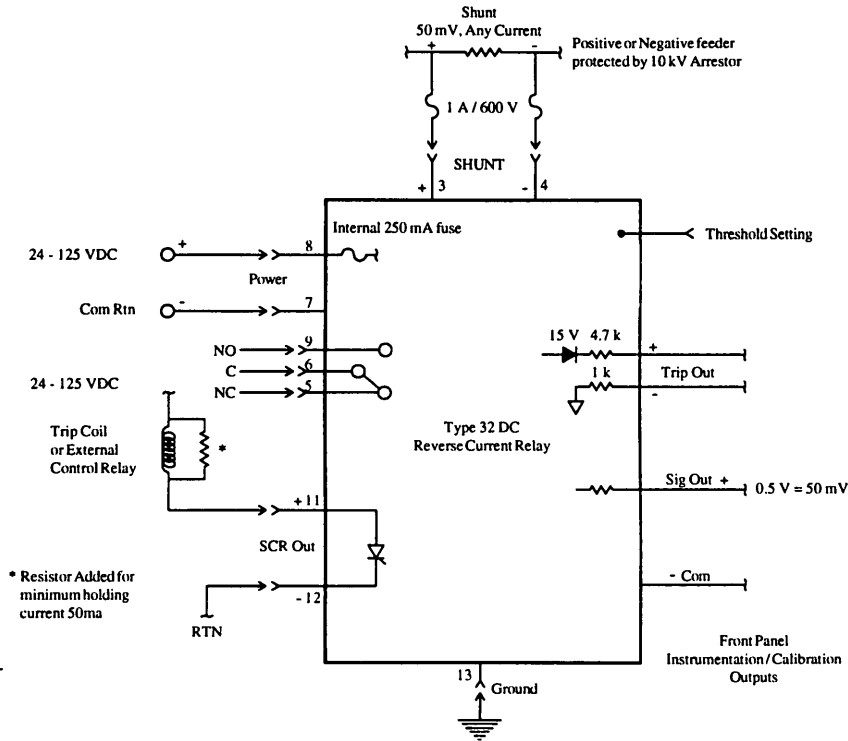
#### Power

The green light emitting diode (LED) indicates that the detector has power and is operational. If this LED is off, either input power is off or internal 1 A fuse is blown. In either case, the output is fail

safe and should cause substation trip.

### Zero

This adjustment compensates for slight offsets in the high voltage isolator and should only require adjustment when the overcurrent unit is initially installed in the substation. With zero shunt current (DC breaker open or zero loads) measure "SIG OUT" voltage with a Fluke 8024A digital voltmeter or equal. Adjust zero for  $.000 \pm .002$  volts. For best results, a five minute or greater warm-up period should be allowed. Note that offset varies slightly depending on installation. For example, offset will change by up to 1mV when the detector is bench tested outside of its enclosure.



Interface Connection Block Diagram

#### 4.0 INSTANT OVERCURRENT CHANNEL

This channel responds to reverse "instantaneous" current levels between 0 and 20mV as set by the control. Input from the isolator is RC filtered so that current spikes or noise are suppressed to prevent nuisance tripping. A buffered test jack is provide for highly accurate adjustment of trip threshold with a digital voltmeter. A red LED latches on to indicate that a trip has occurred.

#### Setting "Pickup" Threshold

Connect digital voltmeter common lead to "SIG OUT-comm". Connect positive lead (+) to instant test jack. Using the 200mV range on the DVM, adjust pickup control for desired trip level. Note that knob calibration for this control is only approximate ( $\pm 10\%$ ). As an alternate method of setting this control, apply trip level to shunt leads or by using "CAL/TEST" controls. While pressing RESET switch to prevent LED from latching, adjust PICKUP knob until instant LED is just turned on.

#### 5.0 OUTPUTS

##### SCR Output

SCR output for substation control is available on rear terminal strip of detector. This 6 amp, 200 volt SCR is optically isolated and floating for connection anywhere in a relay control ladder. An external load of 50mA or more should be provided, at least part of which is resistive, i.e., a 5k Ohm relay coil

paralleled with a 5k Ohm, 5 watt resistor will provide minimum SCR latching and holding currents.

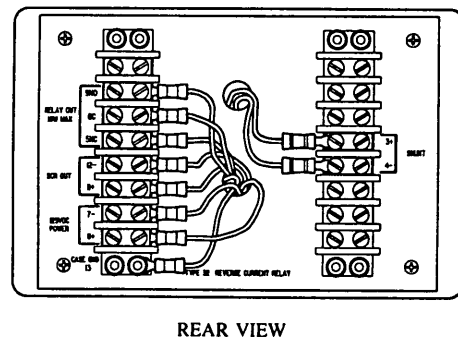
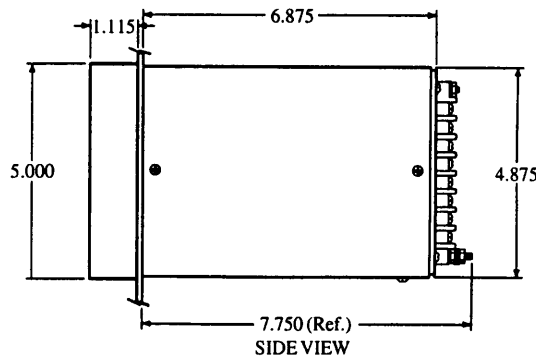
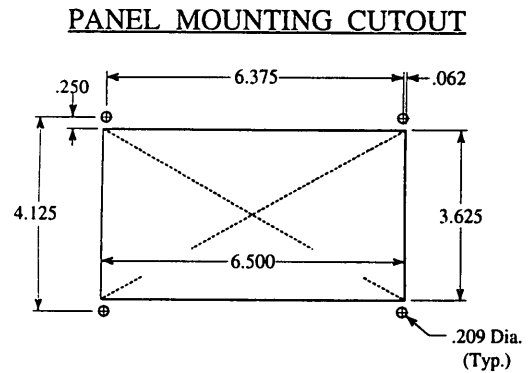
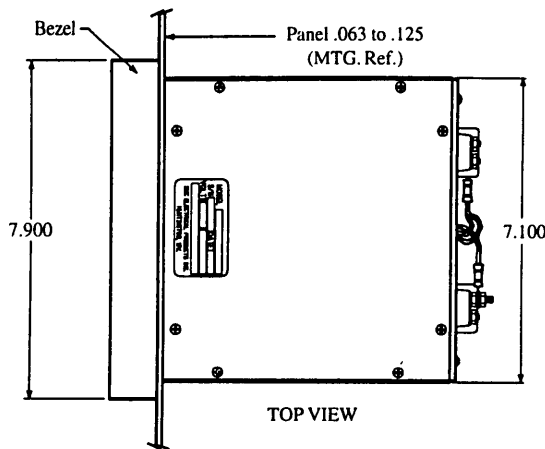
**Signal Output (SIG OUT)**

Front panel jacks are provided for analog output current, (0.5V equals 50mV). This output is not floating, but is tied to internal power supplies so that when connected to external instrumentation, differential amplifiers should be used.

**Trip Output (TRIP OUT)**

A current limited trip output 15V / 6k Ohm is provided to directly drive a galvanometer event marker while making oscillograph recordings.

**Type 32 REVERSE CURRENT RELAY CASE**



**SPECIFICATIONS**

|                                      |                              |
|--------------------------------------|------------------------------|
| Isolator Error .....                 | ±1mV                         |
| Isolator Dielectric Capability ..... | 5400V, 60Hz, 1min.           |
| Ambient Temperature .....            | -20 to +55 °C                |
| Threshold Setting Error .....        | ±0.5mV                       |
| Supply Voltage Range .....           | 24-125 V DC ± 15%            |
| Supply Current .....                 | 200mA @ 24V    30mA @ 125VDC |

August 1, 1994

## SMC WARRANTY STATEMENT

The purchaser has a reasonable time to ascertain whether the apparatus is as represented. Any test required by the purchaser to determine any conformance to representation must be made within 60 days from date of shipment. SMC reserves the right to review and mutually agree on condition of tests and to be represented at any tests. SMC electric products are warranted for a period of one year from the date of shipment to be free from any defect in materials or workmanship. SMC will repair or replace F.O.B. factory, with regular UPS shipment allowed, any part which under normal and proper use proves defective in workmanship or material within the effective warranty period.

The correction of such defects by repair or replacement at SMC's sole discretion, shall constitute fulfillment of all of the SMC obligations with respect to the apparatus sold hereunder. (RMA Procedures for return are outlined below).

- 1) Obtain verbal or written approval from SMC as outlined in the return procedure.
- 2) Issue a purchase order to SMC Electrical Product, Inc for replacement of defective products, full credit will be issued when the part is received and evaluated by SMC and is determined to be under warranty.
- 3) Warranty replacements are quoted F.O.B. factory with regular UPS shipping charges allowed. Any special shipping charges will be billed to the customer.
- 4) Return Material - No material may be returned without an RMA (Return Material Authorization) authorized by SMC. Proper RMA identification and packaging of returned goods will only be accepted. Contact an SMC Components Division sales representative for authorization at telephone number (304) 736-8933 or fax (304) 529-1406.

Such warranty shall not apply to any product or component; (A) repaired or altered by anyone other than SMC or an authorized service center without SMC's prior written approval; (B) tampered with or altered in any way or subject to misuse, negligence or accidents; (C) which has the serial number altered, defaced or removed; or (D) which has been improperly connected, installed or adjusted other than in accordance with SMC instructions.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF QUALITY WHETHER WRITTEN, ORAL, OR IMPLIED. INCLUDING BUT NOT LIMITED TO ANY WARRANTY OR FITNESS FOR A PARTICULAR PURPOSE.

### SMC Electrical Products, Inc.

*Components Operation*

Mailing Address

PO Box 880  
Barboursville, WV 25504

Shipping Address

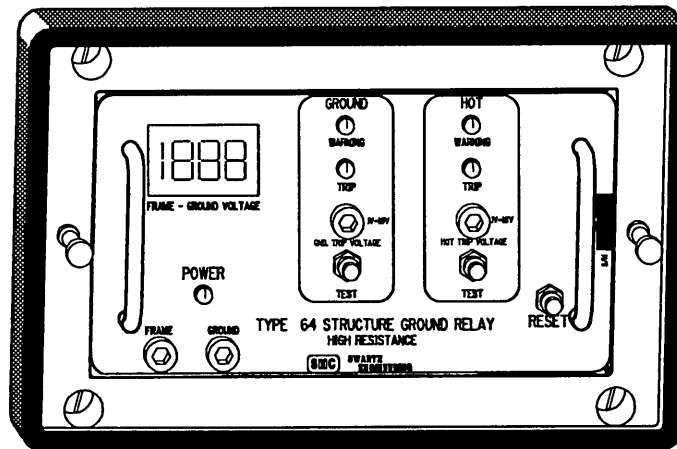
5950 Ohio River Road  
Huntington, WV 25702

Phone: (304) 736-8933 Fax: (304) 529-1406

# SWARTZ® STRUCTURE GROUND RELAY - HIGH RESISTANCE

260-02-00

Date: 3/21/97



MODEL C4280-600

## GENERAL

The **SWARTZ** Type 64 Structure Ground Relay from SMC provides dual functions for high resistance grounded DC switchgear. The relay is designed to protect equipment enclosures and alert personnel to "ground" and "hot" fault conditions in DC switchgear and rectifiers. These high resistance relays provide superior performance and operational reliability through solid state components, rugged construction and self-diagnostic features.

## FEATURES

- Draw-out construction
- LED Meter - Accurate, easy to read
- Transient Surge Protection
- Detects AC or DC "hot structure" faults
- Internal Power Supply operates on and auto-compensates for a wide range of DC inputs
- Internal Time Delays to prevent nuisance tripping

## DESCRIPTION

The **SWARTZ** Type 64 High Resistance Structure Ground Relays alert personnel visually and through alarm output contacts when a DC switchgear structure or rectifier becomes grounded through a breach in the insulation. Annunciation occurs when the voltage sensing trip system has been by-passed by grounding or when the relay's self-diagnostic feature determines that an internal failure has occurred. The relay also alerts personnel when a leakage or fault occurs between the bus and structure ("hot structure"). Normally, the output is connected to a lockout relay to automatically de-energize the entire station. The hot structure function detects both AC and DC leakages and faults. Setpoints for ground structure annunciation and hot structure trip are adjustable. Test buttons for both ground structure annunciation and hot structure tripping are provided on the front panel. In the event of a fault and a lockout condition does not occur, the Structure Ground Relay will provide continuous operation if voltage does not exceed 800 VDC or 700 VDC with 600 VAC superimposed (rectifier faults).

## SPECIFICATION

- |                        |                                      |                              |                                     |
|------------------------|--------------------------------------|------------------------------|-------------------------------------|
| • Input Power:         | Operates on 24 - 125 VDC or 120 VAC  | • Structure Applied Voltage: | 25 VDC                              |
| • Supply Current:      | 40 mA at 125 VDC<br>200 mA at 24 VDC | • Output Rating-Gnd:         | Form C; 2A, 500V, 100VA             |
| • Ambient Temperature: | -20°C to +55°C                       | • Output Rating-Hot:         | Transistor; 350V, 10A,<br>60A Surge |
| • Design Test:         | SWC ANSI/IEEE C37.90                 | • Trip Setting - Hot:        | 30-45 VDC                           |
|                        |                                      | • Trip Setting - Ground:     | 5 V - 20 VDC                        |

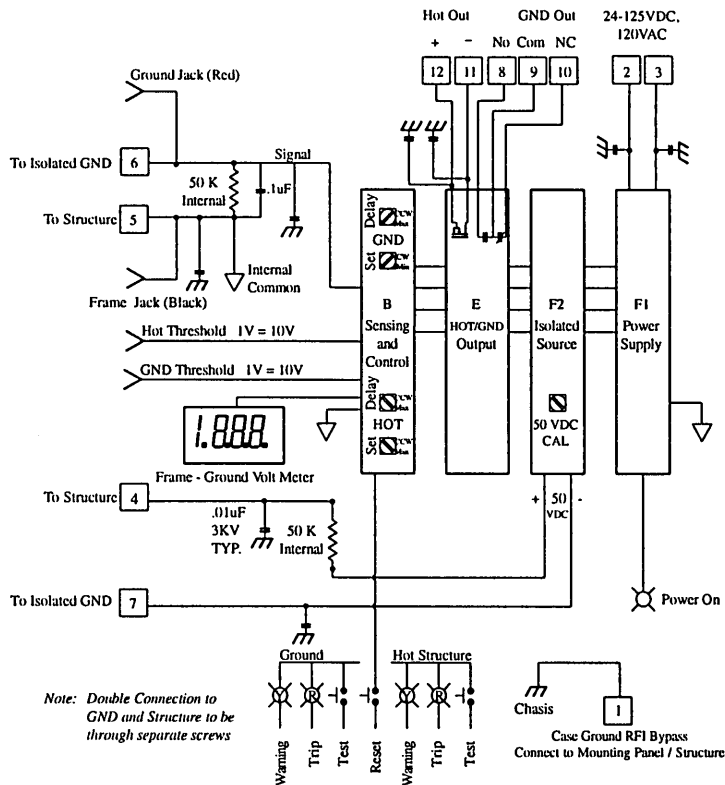
TYPE 64 STRUCTURE GROUND RELAY - HIGH RESISTANCE

COMPONENTS OPERATION • P.O. Box 880, Barboursville, WV 25504 • 5950 Ohio River Road • Phone: (304) 736-8933 • Fax (304) 529-1406



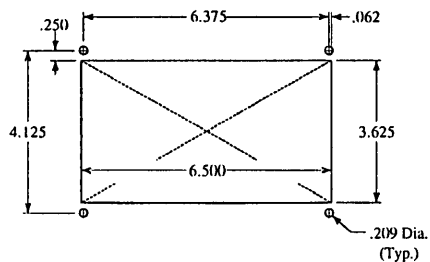


# TYPE 64 HIGH RESISTANCE GROUND STRUCTURE RELAY BLOCK DIAGRAM

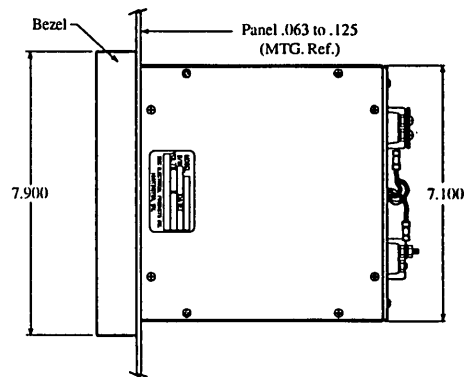


## RELAY CASE DIMENSIONS

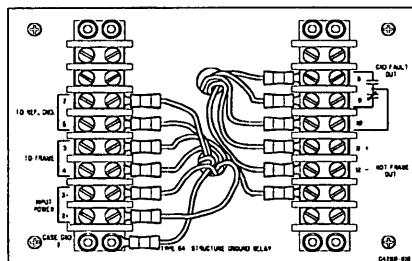
PANEL MOUNTING CUT OUT



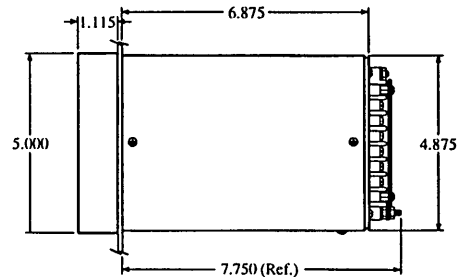
TOP VIEW



REAR VIEW



SIDE VIEW



## SMC ELECTRICAL PRODUCTS, INC.

Mailing Address  
PO Box 880  
Barboursville, WV 25504

Components Operation

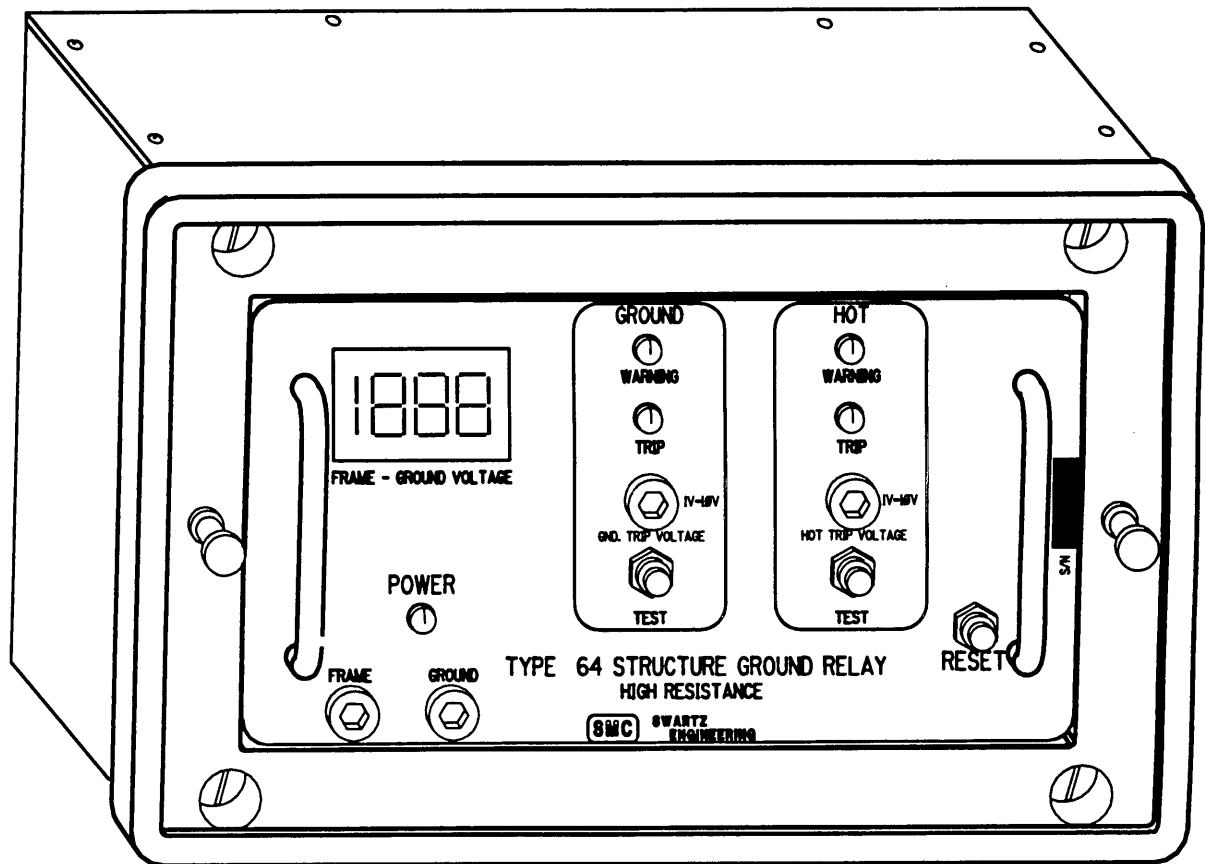
Phone: (304) 736-8933 Fax: (304) 529-1406

Shipping Address  
5950 Ohio River Road  
Huntington, WV 25702



**SWARTZ®  
ENGINEERING**

## TYPE 64 STRUCTURE GROUND RELAY HIGH RESISTANCE MODEL



### OPERATION AND CALIBRATION MANUAL

The information contained within is intended to assist operating personnel by providing information on the general characteristics of equipment of this type. It does not relieve the user of responsibility to use sound engineering practices in the installation, application, operation and maintenance of the particular equipment purchased.

These instructions do not purport to cover all details or variation in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to SMC.

If drawings or other supplementary instructions for specific applications are forwarded with this manual or separately, they take precedence over any conflicting or incomplete information in this manual.

**SMC Electrical Products, Inc. *Components Operation* Phone (304) 736-8933 Fax (304) 529-1406**

# TYPE 64 GROUND STRUCTURE RELAY

## OPERATION AND CALIBRATION MANUAL

### TABLE OF CONTENTS

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## 1.0 SAFETY PRECAUTIONS

### INTRODUCTION

This section of the manual is to familiarize the operating and maintenance personnel with the hazards and the necessary precautions to follow when either operating or maintaining the Type 64 Relay. Although all the hazards or possible hazardous conditions which may arise during the operation of the Type 64 Relay may not be foreseen, this section of the manual is a guideline so as to prevent personnel injury, equipment damage, or limit equipment damage should a fault occur.

### SYSTEM HAZARDS AND PRECAUTIONS

Below are listed the safety hazards associated with the Type 64 Relay followed by a list of safety precautions. Prior to the energization of the equipment or prior to commencement of any maintenance, the appropriate personnel should review these hazards and precautions to become readily familiar with them.

### SAFETY HAZARDS

- a. Electrical Shock or Current Flow  
Current Flow through chest or head area may cause cardiac arrest, stoppage of breathing, and ventricular fibrillation.
- b. Electrical Arcs  
May cause equipment explosion, flash burn to eyes, ultraviolet burning of skin tissue.
- c. Direct Burns  
May occur when in direct contact with overheated electrical equipment.

### GENERAL SAFETY PRECAUTIONS

- a. Prior to any maintenance or entry into electrical switchgear, remove all metallic objects from person. (Such items as wristwatches, rings, metal badges, belt buckle, metal pins, rules, flashlights, keys, and key chains).
- b. Do not wear loose fitting clothing when in and around equipment.
- c. Work from an insulating mat whenever possible.
- d. All hand tools should be insulated to the fullest extent possible.
- e. Portable powered hand tools should be of a 3 wire grounded design.
- f. Do not use aluminum or metallic ladders while in and around electrical switchgear.

### SPECIAL SAFETY PRECAUTIONS

- a. Voltage Hazard.  
High voltage may be present at the external terminal strip, at internal connections, and in portions of the relay.
- b. Grounding.  
The relay case should be grounded to substation frame via case ground at terminal 1 for voltage safety and to reduce susceptibility to R.F. interference.
- c. Dielectric Testing.  
Remove relay from case when dielectric testing of substation wiring is performed.

## **OPERATIONAL SAFETY SUMMARY**

Follow the manufacturer's start-up and shut-down procedures.

Never operate equipment which has been tagged "Out of Service" or "Do Not Operate". Never override any electrical or mechanical interlocks unless the over-riding of such devices is called for in the special or emergency operating procedures. Become familiar with the substation functional operation prior to operating the substation. Prior to any maintenance ensure that equipment has been tagged out of service following the appropriate tag out procedures. Familiarize oneself with the manufacturer's maintenance procedure prior to conducting any maintenance. Never perform maintenance in an isolated location by oneself.

### **2.0 INTRODUCTION**

The unit operates from 24 - 125 VDC or 120VAC supply as a dual function structure ground relay for high-resistance-grounded D.C. switchgear and rectifier enclosure systems. The first function is "grounded structure" annunciation, activated by breaching the insulation system between the structure being monitored and earth ground. This annunciation indicates that the voltage-sensing system has been bypassed (by grounding) or that a failure within the relay has occurred. The second function is "hot structure" detection, activated by a fault or leakage (AC or DC) between the bus and structure. Normally, this output is connected to a lockout relay to de-energize the entire station. The unit imposes a test voltage on the switchgear structure being monitored, and has adjustable thresholds for annunciation and trip functions.

### **3.0 FRONT PANEL INDICATION AND CONTROLS**

#### **Power**

The green light emitting diode (LED) indicates that the relay has power applied. If this LED is off, either input power is off or the internal 1A fuse (located on rear right of motherboard) is blown. In either case, ground annunciation will occur.

#### **METER**

The LED digital meter displays the voltage read between frame and ground. It is nominally 25V. This can be checked with a DVM at the jacks provided labeled "GROUND" (red) and "FRAME" (black). Ground-to-frame voltage will read -25V nominal (polarity only reflects frame vs. earth ground point of reference).

#### **Ground**

The ground section consists of a nonlatching yellow warning LED, a latching red trip LED, a test jack, and a test button. When the imposed structure voltage drops below the preset level (5-20 volts) and remains for the set time (10-250 ms), the "Ground" output relay closes (de-energizes) and the red LED latches. This output may be connected to the annunciator (local and/or remote) to indicate that the structure is grounded. Note that both normally closed and normally open contacts are provided for a variety of applications (500V, 2A, 100VA continuous contact rating). Leakage which brings the structure voltage between the set point and nominal will light the yellow LED, but no output or latch will occur. Loss of power will also cause a ground fault output.

The test jack is provided to check the threshold at which the ground trip will occur. The measurement is made with reference to the frame (black jack); one volt as read on a DVM is equivalent to ten volts actual.

A test button is also supplied for the ground channel. Pressing this button simulates a grounded structure condition, closing the output contacts, and latching the red LED (reset by pressing "RE-SET" button.)

## Hot Structure

The Hot Structure Section consists of a nonlatching yellow warning LED, a latching red trip LED, a test jack, and a test button. When the imposed structure voltage rises above the preset trip level (30-45 volts) and remains for the set time (10-100 ms), the "Hot Structure" output transistor fires and the red LED latches. This output is normally connected to a lockout relay which trips all station breakers. Voltage between the normal 25 volts and the trip preset point will light the yellow LED, but no output or latch will occur.

The test jack is provided to check the threshold at which the hot trip will occur. The measurement is made with reference to the frame (black jack); one volt as read on a DVM is equivalent to ten volts actual.

A test button is also supplied for the hot channel. Pressing this button simulates a hot structure condition, latching the output transistor on and latching the red LED. The relay is reset by pressing "RESET".

The output transistor rating is 350V, 10A continuous, 60A surge.

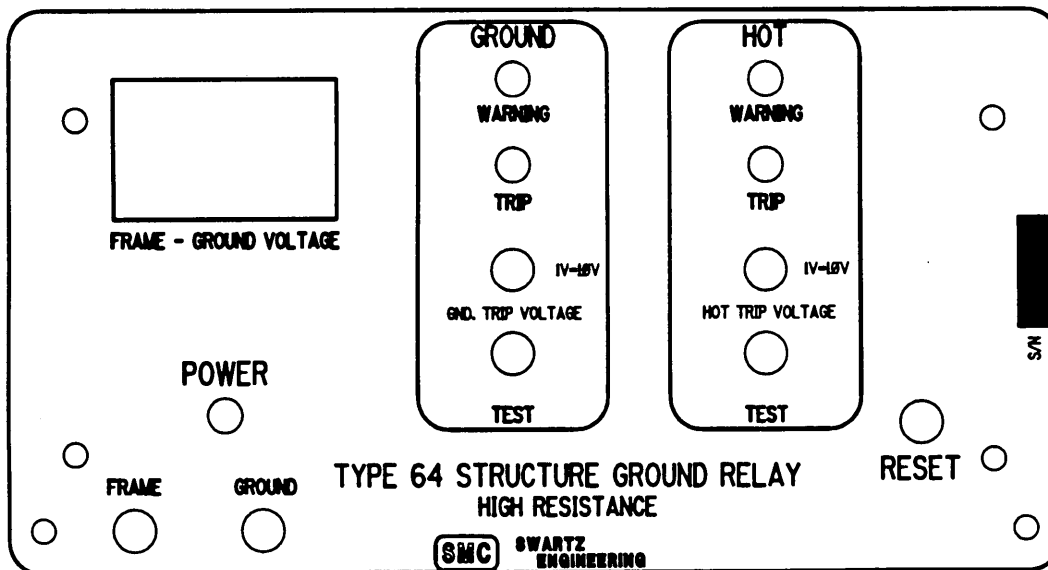
## OUTPUT OPTIONS

The type 64 relay's outputs are configured from the factory as follows:

Hot output      LATCHING (model 600) or NONLATCHING (model 601)

Transistor FIRES on hot trip

Ground output    Form C relay coil DE-ENERGIZES on ground fault, ie, fail-safe operation



Note: Relay has clear front cover with access hole for reset only

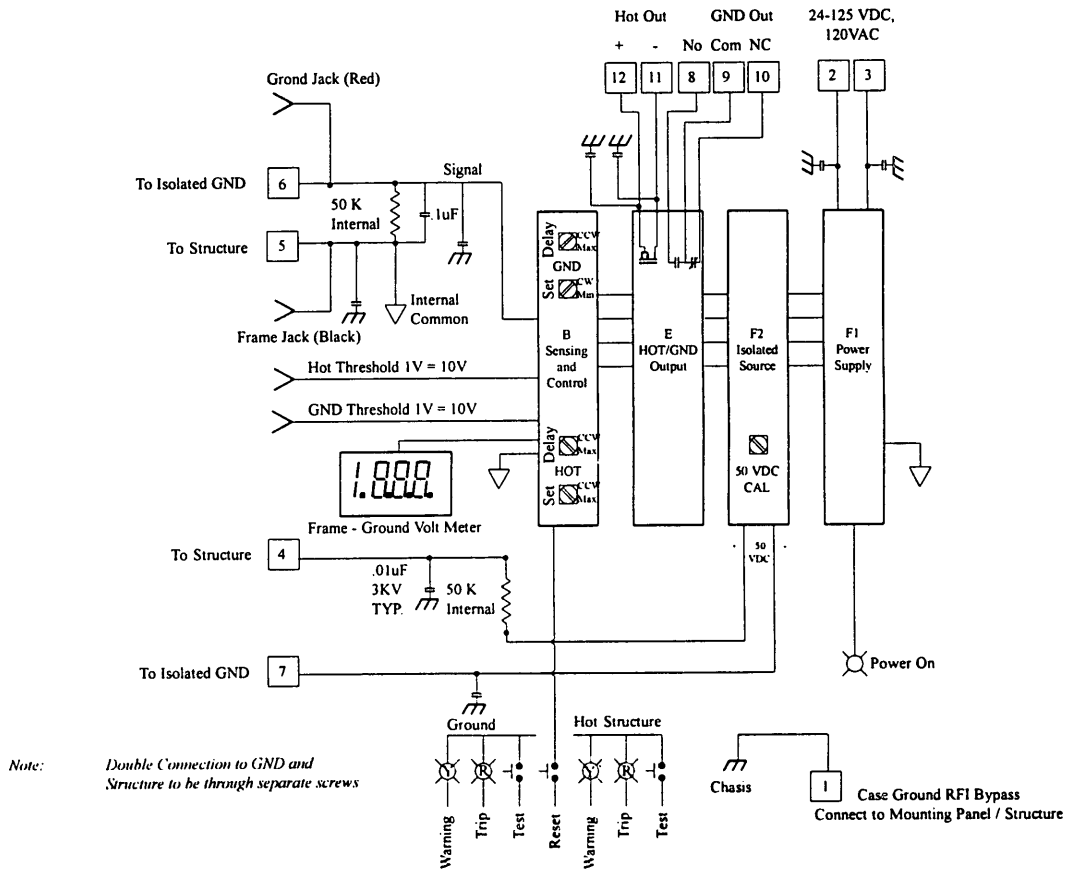
## Front Panel

## 4.0 SETTINGS

During fault clearing, lightning storms, etc., transients are induced into feeders of switchgear systems which capacitively couple to the structure. The time delay functions of this relay are designed to tolerate such "normal" structure voltages while suppressing outputs. Maximum setting of "Hot Structure" will trip at approximately 0.8 ma of leakage current, while maximum setting of the ground would trip at approximately 6.25K ohm resistance from structure to ground. The warning lights are designed to give warning of a developing situation in time to react before a dangerous condition exists.

| The relay's ranges      | Full CCW        | Full CW        |
|-------------------------|-----------------|----------------|
| Ground Time Delay ..... | 250 ms delay*   | 10ms delay     |
| Ground Set .....        | 20 V threshold  | 5 V threshold* |
| Hot Time Delay .....    | 100 ms delay*   | 10ms delay     |
| Hot Set .....           | 45 V threshold* | 30 V threshold |

\* FACTORY SETTINGS



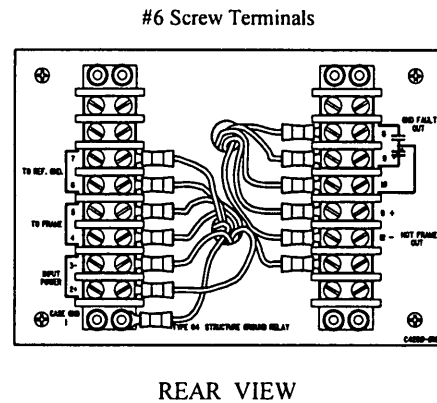
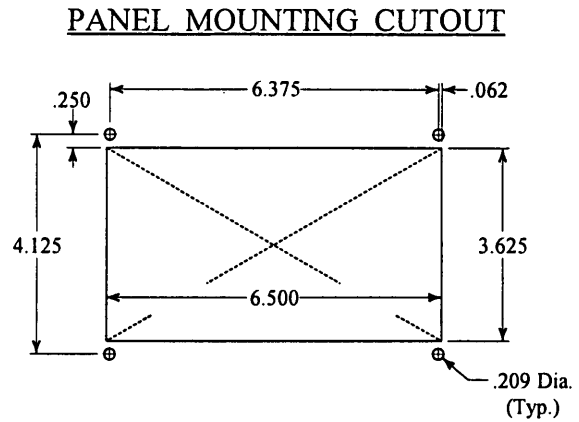
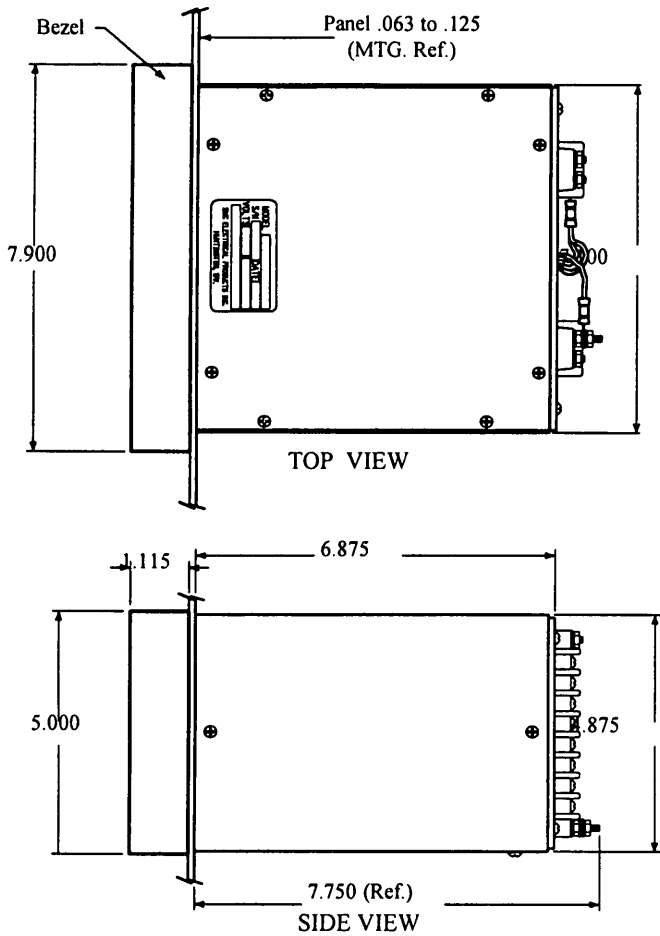
## Block Diagram Type 64 High Resistance Structure Ground Relay

## 5.0 CALIBRATION OF 50 VDC POWER SUPPLY

Connect terminals 4 and 5 together and 6 and 7 together and isolate at least one pair from structure or ground so that no external load exists. Adjust trimpot on module F2 for 25.0 VDC as indicated with high impedance DVM connected between GROUND and FRAME jacks. This should not need adjustment unless F2 module is replaced or repaired.



# Type 64 Ground Structure Relay Case Dimensions



## SPECIFICATIONS

### Specifications

|                                   |                        |
|-----------------------------------|------------------------|
| Input voltage (nom.) .....        | 24-125 VDC, 120VAC     |
| Input voltage range .....         | ± 15%                  |
| Supply current .....              | 40mA @125V, 200mA @24V |
| Ambient temperature .....         | -20 to + 55 °C         |
| Structure applied voltage .....   | 25 VDC                 |
| Ground trip setting (GTS).....    | 5V-20 VDC              |
| Ground warning .....              | 25-1/2 (25V - GTS)     |
| Hot trip setting (HTS).....       | 30-45 VDC              |
| Hot trip warning.....             | 25 + 1/2 (HTS -25)     |
| Time delay setting - ground ..... | 10 - 250 ms            |
| Time delay setting - hot .....    | 10 - 100 ms            |
| Output rating - ground* .....     | 2A, 500V, 100VA        |
| Output rating - hot** .....       | 350V, 10A, 60A surge   |

\* Mercury-wetted relay

\*\* Transistor

August 1, 1994

## SMC WARRANTY STATEMENT

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