INSTRUCTIONS

GEI-68701

SUPERSEDES GEI-50262

Attachment GEI-100070

COMBINED PHASE AND DIRECTIONAL COMPARISON CARRIER-PILOT RELAYS

Types

EDD12J and EDD12K

LOW VOLTAGE SWITCHGEAR DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

COMBINED PHASE & DIRECTIONAL COMPARISON CARRIER-PILOT RELAYS

TYPE EDD

INTRODUCTION

Panel Mounted: EDD12J
Cabinet Mounted: EDD12K

These instructions are a supplement to Instruction Book GEI-44070A which is included in this book. The combination of the two forms instructions for the type EDD12J and EDD12K relays.

These relays differ in the following from the standard EDD12D and EDD12E relays:

1. The internal and external connections are modified to make the relays suitable for combined-phase and directional comparison relaying.

2. The A-C test circuit is changed to provide phase-to-ground instead of phase-to-phase test current.

APPLICATION

The combined Phase and Directional Comparison Relaying is usually employed in medium and longer length transmission lines where mutual induction between transmission lines can cause false operation of directional comparison relaying for ground faults, but where phase comparison relaying is not sensitive enough for phase faults. In this application, the phase comparison relay is selected for ground faults, and the distance type or directional relays are used for phase faults. By combining the applicable portions of both equipments, (Phase Comparison and Directional Relays), reliable high speed protection is provided under all circumstances.

BASIC OPERATION

The method of control is shown in the schematic diagram of Fig. (1). Operation of any one of the carrier-starting phase units OM takes control away from the phase-comparison network and causes the transmission of continuous carrier. The operation of the carrier stopping phase relay $\frac{21Y}{MX}$ also takes control away from the phase comparison network (from any other carrier-starting means) preventing the transmission of carrier. Operation of $\frac{21Y}{MX}$ also applies a positive voltage to the screen grid of the comparer tube which will conduct and cause operation of the trip relay if not blocked by a negative voltage, derived from the received carrier, on the control grid. Note that the phase-comparison "comparer" acts as the "receiver relay" of directional comparison.

DETAILED OVERALL OPERATION

In the following reference will be made to elementary diagram No. 245D424, sheets #5 and #6, or (114R154, sheets #4 and #5), and Figs. #1 and #2 of this book.

A. SINGLE-PHASE-TO-GROUND FAULT
   a. External and Internal
      (No Phase Relay Operation)

The phase-comparison network relay is connected to be energized by CT residual current only and on a phase-to-ground fault T-201 and T-202 will be energized causing the voltage amplifier tube V201 to conduct. The rectified output of V201 is fed to the grids of the fault detector tube V202 and acts as the control voltage. The non-rectified output of V201 is used to drive the power amplifier tubes V203 and V204.

As soon as the fault detector tube V202 conducts sufficient current, the fault detector-low (FD-L) telephone relay picks up and opens its "b" contact, thus removing the negative potential from the screen grids of the EDD power amplifier tubes V203 and V204. At the same time an "a" contact of the FD-L closes and shorts out resistor R-239 applying a modulating signal from the secondary winding 1 to 2 of transformer T-203 to the screens of the carrier transmitter tubes. The transmitter now sends a blocking signal to the opposite end to prevent tripping.

If the fault current is sufficiently high the fault detector tube V202 will conduct enough current to

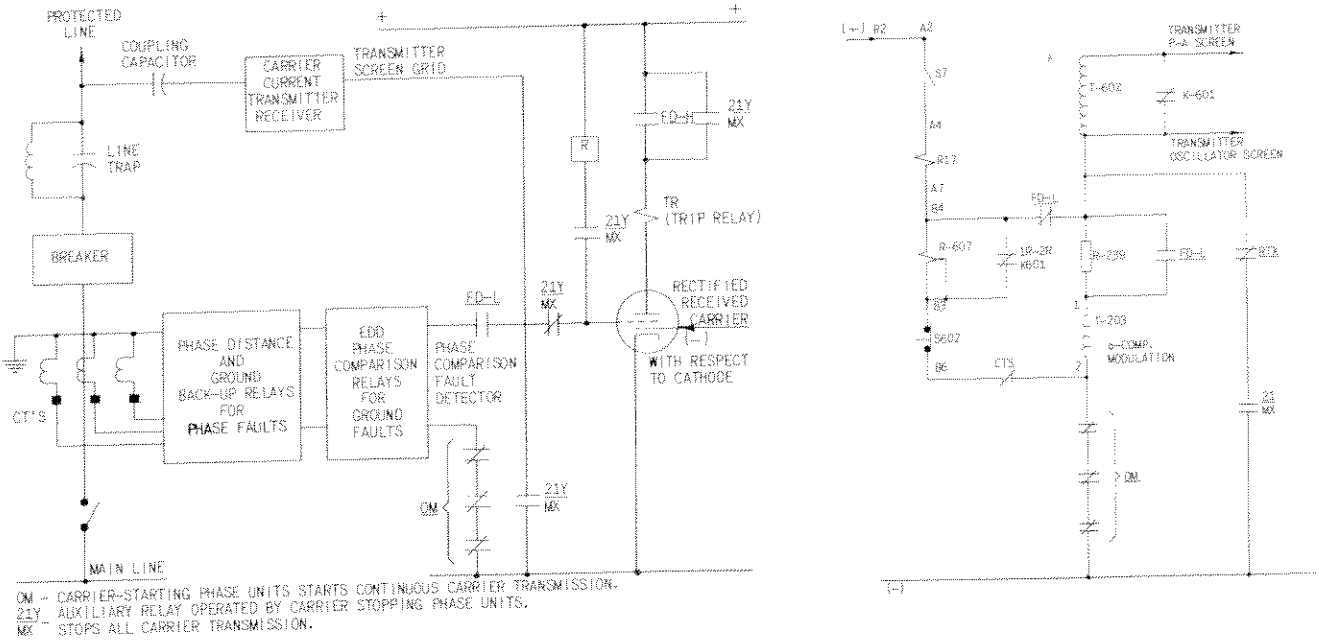


Fig. 1 Functional Diagram For Combined Phase And Directional Comparison Relaying

pick up the fault detector-high (FD-H) telephone relay. The normal setting of FD-H is 50 per cent above FD-L to give a 50 per cent safety margin between the blocking and tripping function of the relay.

The other secondary winding, 6 to 7 of transformer T-203, provides a signal 180 degrees out of phase with that which was supplied to modulate the carrier transmitter. This signal is fed to the screen grid of the comparer tube through a phase-shifting network.

The phase-shifting network, consisting of C-211, C-212, C-213, R-251, R-252 and R-253, introduces a time delay between the power amplifier signal to the comparer tube screen grid and the signal applied to modulate the transmitter. The time delay compensates for the time of propagation between terminals of long transmission lines.

The secondary winding 1 to 2 of transformer T-203 at the remote station modulates the remote transmitter. This signal is received and applied to the control grid of the local comparer tube.

During an external fault, the received carrier swings the comparer control grid negative for the half-cycle when the local relay voltage swings the screen grid positive. Thus, the control grid blocks plate current and no tripping occurs.

During an internal fault, the half-cycle signals received from the opposite terminal swing the comparer control grid negative for the same half cycle that the local relay voltage swings the screen grid negative. There is no incoming signal during the half cycles when the screen grid is positive. The comparer plate current, therefore, increases and picks up the tripping relay TR through the FD-H contact which completes the breaker trip circuit. (For more details on phase comparison operation, refer to pages 29 to 35 of the included instruction book GEI-44070A).

When FD-H picks up, the transient blocking relay (RB) is energized. If the fault is internal, TR will pick up and deenergize RB before RB picks up. The relay permits tripping without time delays for about 4 cycles after the inception of the internal fault. But thereafter, it introduces a delay in tripping sufficient to outlast transients associated with circuit-breaker arcing, CT trapped flux, etc., which may occur when an external fault is cleared.

The seal-in unit, SI, is picked up by trip coil current when TR picks up. The SI contacts close around TR and RB contacts and prevent opening of trip coil current by the relay contacts. A hand-reset target is exposed when the seal-in element picks up indicating that the EDD equipment has operated.

b. Internal Single-Phase-to-Ground Fault
(With operation of a phase-tripping unit)

Sometimes it is possible for a phase distance unit to operate during a single-phase-to-ground fault. If carrier stopping phase units 21Y/MX operate at both line terminals during an internal fault, all carrier transmission will be stopped and tripping will take place through the comparer tube at each end. Each comparer tube conducts continuously since no blocking signal is received to provide restraint. At each end the TR element of the

Fig. 1 (418A996) Right

Fig. 1 (418A984) Left

phase comparison tripping unit will pick up through the $\frac{21Y}{MX}$ contact, and cause clearing of the faulted line.

If any one carrier-stopping phase unit operates, at only one terminal of the transmission line, tripping will be by directional comparison at that terminal and by phase comparison at the other terminal. For example, assume that a carrier-stopping phase unit operates at terminal A for a single-phase-to-ground fault at (x) of Fig. 2. All carrier transmission will be stopped at terminal A when the $\frac{21Y}{MX}$ contact closes and connects the carrier transmitter screen to the negative bus. The other $\frac{21Y}{MX}$ contacts connect both the comparer screen and plate to the positive bus. The comparer tube will now conduct if continuous carrier is not received from B. At B the phase comparison FD-L and FD-H will pick up (providing the fault current is sufficient) and terminal B will transmit half-cycle pulses. Since no blocking signal is received at B from A, a phase-comparison trip will occur at B.

The TR relay in the phase comparison tripping unit at terminal B will pick up through the FD-H contact and will cause tripping of circuit breakers at terminal B. Since no carrier is transmitted at A, there is no local restraint voltage at A to keep the comparer tube from conducting except for the half-cycle restraint pulses received from B. The TR relay at terminal A will pick up through the $\frac{21Y}{MX}$ contact and it will cause tripping of the associated circuit breakers.

B. FAULTS INVOLVING MORE THAN ONE PHASE

a. Internal Faults (First Zone)

The MHO and the OHM units of the GCX relay will operate and close $\frac{21\text{-}1}{M}$, -2, or -3 contacts and the $\frac{21\text{-}1}{O}$, -2, or -3 contacts respectively. The auxiliary tripping relay 94 will pick up and trip the circuit breakers. (Refer to GEI-25363D for more details on directional comparison relaying).

b. Internal Faults (End Zone)

The MHO unit of the GCX relay picks up closing $\frac{21\text{-}1}{M}$, -2, or -3 contacts, but since it is a second zone fault the $\frac{21}{O}$ contacts do not pick up. $\frac{21X\text{-}1}{TX}$ picks up and starts timer $\frac{21X\text{-}1}{TU}$. However, while this is taking place, the $\frac{21Y}{MX}$ picks up and closes an "a" contact (6-7) which applies (+) potential to the comparer screen grid. This will cause the comparer tube to conduct unless it is blocked by a negative voltage derived from the carrier signal received on the control grid of the comparer tube. Since it

Fig. 2 Internal Fault for Type EDD Relay

is an internal fault, carrier will not be transmitted from either end unless the fault is close to either end of the line; in which case carrier may be started by the $\frac{21B}{CM}$ contacts of the local CEB13 relay, but will be stopped as soon as $\frac{21Y}{MX}$ picks up and closes an "a" contact (15-16), connecting the transmitter screen to the (-) bus. Since no carrier is received either from the local transmitter or from the remote transmitter, the comparer tube will conduct continuously and the $\frac{87T}{TR}$ will pick up through a $\frac{21Y}{MX}$ contact. The auxiliary trip relay is then picked up and the associated circuit breakers are tripped.

C. EXTERNAL FAULTS

On faults external to the protected line, the CEB13 relay will pick up and open the 21B/OM contacts. The opening of these contacts removes the negative potential from the transmitter screen and a continuous carrier will be transmitted from one end of the line blocking tripping at both ends; however, should the breakers on the faulted line fail to trip, then the back-up relays of the protected line section will operate to clear the external fault.

A-C TEST SOURCE

During tests and adjustments, the load imposed by the A-C test source can vary from 0.38 to 1.38 amperes, approximately. The A-C test circuit rheostats are rated at 100 watts.

Fig. 2 (41A985)

INSTALLATION TEST AND ADJUSTMENTS: (SECTION E)

The following has been put in an abbreviated form to facilitate its use. For a detailed explanation of the relay operation see "Principles of Operation" (Section G of GEI-44070A). Refer to "Relay Settings" (Section H of GEI-44070A) for limiting conditions and a method for calculating the ground current tap setting.

1. Make all tests on the transmitter-receiver unit insofar as possible.

NOTE: Disconnect the wires from terminals 11T and 12T of the tripping unit.

E_1 D-C POLARITY (CHECK)

1. Cabinet mounting terminals K14(+) and K3(-) and J18(-).

2. Panel mounting terminals 14T(+) and 20T(-), 13N(-) and 13T(-).

E_2 TARGET TAP (SET)

TABLE I

TRIP COIL CURRENT (MIN. CONTROL VOLTAGE)	TAP SETTING
.2 to 2 amp.	0.2
2 to 30 amp.	2.0

NOTE: Tighten a screw in the desired tap before removing the screw from the other tap. Spare screws may be obtained from the left hand stationary contact.

E_3 TRIP CIRCUIT (CHECK)

1. Turn the RTS (Relay Test Switch) to "NOR" position. For cabinet mounted equipment, momentarily jumper terminals J7 and J9, then J7 and J10. Battery voltage should appear across terminals J8 and J9, then J8 and J10, respectively. (Breaker should trip, if trip coil is connected to J9 or J10. For panel mounted relay, jumper terminals 1T and 11T, then 1T and 12T on the tripping unit. Voltage should appear across 11T and 20T, then 12T and 20T.

2. Simultaneously, manually operate the FD-H and TR units and observe the same results.

E_4 ALARM CIRCUIT (CHECK) (IF USED)

1. Turn relay test switch to "TCO" position at both ends of the line.

2. Remove carrier fuses, then see that contacts of the signal alarm element (SA) ring the proper alarm. The white indicating lamp should light. Replace carrier fuses.

3. If desired, disconnect alarm leads at the relay for remainder of installation tests.

E_5 TEST SOURCE CURRENT (SET)

E_6 TYPE EDD-403A211 RELAY (PANEL MOUNTED)

1. Place an external ammeter in series with the a-c test source.

2. Turn the relay test switch to the "OUT" position. Holding the voltmeter at 100 volts by means of the tap switch (S-203) and the rheostat (R-216), adjust rheostats (R-204D) and (R-204C) to obtain the desired FD-L test setting. To insure positive pickup, this value should be a little greater than the FD-L pickup setting. (About 10% greater than the desired FD-L pickup.)

3. Turn the relay test switch to the "IN" position. Holding the voltmeter at 100 volts by means of the tap switch (S-203) and the rheostat (R-216), adjust rheostat (R-204B) to obtain the desired FD-H test setting. To insure positive pickup, this value should be set about 10% higher than the desired FD-H trip setting.

4. Return the switch to the off position.

RANGE OF A-C TEST CIRCUIT

E_7 TYPE EDD-403A244 (Cabinet Mounted)

The a-c network unit in this relay has been preadjusted at the factory to draw the same current as the Type EDD-403A211 relay, when the voltmeter is set at 100 volts by means of the trip switch and rheostat as outlined for the Type EDD-403A211 relay.

The factory adjustment is for two-terminal lines with FD-L setting of 2 amps and FD-H setting of 3 amps. The factory equivalent FD-L setting for ground excitation will be 0.33 to 1.33 amps depending on the ground current tap setting, and the FD-H setting will be 0.5 to 2.0 again depending on the ground current tap setting.

E_8 PHASE FAULT DETECTORS

In the Combined Phase and Directional Relaying application, the phase fault detectors (FD-1, FD-2 and FD-3) are not used. (If used refer to GEI-44070A section E for test and adjustment instructions.)

E_9 HEATER ADJUSTMENTS NETWORK UNIT (SET)

1. Plug the test cord into the milliammeter jack and into the network unit jack. Turn the selector switch in the unit to "HEATER".

2. Remove the coverplate from R-230, then move slider of R-230 to give 552 to 562 milliamperes with 129 (or 258) volts on the battery. With 250 volt equipment, adjust the external cage type resistor 214A to give 128-130 volts across stud 14T and stud 20T of the tripping unit. Make these two adjustments alternately until both current and voltage are correct. Check R231 external connections if heater current is too high.

E_{10} HEATER ADJUSTMENTS, TRIPPING UNIT (SET)

1. Plug the test cord into the milliammeter jack and into the tripping unit jack. Turn the selector switch in the tripping unit to "HEATER" and adjust the slider on R-232 until the current reads 1/2 of the value read on the network unit heater. This value should be from 276 to 281 milliamperes. It may be necessary to repeat the adjustment under SECTION E_9 and then SECTION E_{10} to obtain the correct values of heater current in both the network unit and tripping unit.

E_{11} POWER AMPLIFIER PLATE CURRENT (CHECK)

1. Plug the test cord into the milliammeter and tripping unit. Turn the selector switch to V-203. No signal current should be supplied to the network unit.
2. The milliammeter should read 35 to 50 milliamperes when FD-L is picked up by hand at 129 volts d-c bus potential.
3. Repeat for V-204 and record both readings for future comparison.

E_{12} SIGNAL ALARM AND COMPARER PLATE CURRENT (SET)

All installation tests and adjustments on both carrier transmitters should be completed before proceeding with the following tests.

1. Close grounding switch on carrier transmitter.
2. Adjust battery voltage within 2 per cent normal.
3. Set carrier test switch to "RECEIVE" and relay test switch to "OFF" position.
4. Plug test cord into milliammeter and tripping unit and set selector switch to "Signal Alarm". The following adjustments are made on the Transmitter-Receiver.
5. Set S10 to its left-hand position.
6. Adjust R47 fully counterclockwise.
7. Adjust R38 until signal alarm current is just below 0.5 milliampere.
8. Set S10 to right-hand position.
9. Turn R47 fully clockwise and then adjust counterclockwise until a point is found where signal-alarm current just begins to drop.
10. Open grounding switch on carrier transmitter.
11. An increase of comparer tube current to a value between 5 and 6 milliamperes may be achieved by a slight adjustment of R38 when the two relay terminals are in a simulated trip condition. When the relays are operated to produce a blocking signal a reduction of signal alarm current to less than 0.5 milliampere on receipt of steady carrier must be maintained by re-adjustment of R47, if necessary.

E_{13} SIGNAL ALARM CURRENT (CHECK)

1. Turn local carrier test switch to "SEND" and relay test switch to "OFF".
2. Plug test cord into milliammeter and tripping unit and set selector switch to "SIGNAL ALARM".
3. Milliammeter reading should be 0.5 milliampere, or less.
4. Turn local carrier test switch to "RECEIVE" and have remote carrier test switch set on "SEND".
5. Milliammeter should read 0.5 milliampere, or less.

E_{14} RESERVE SIGNAL (SET)

1. Have both relay test switches in the "OFF" or "NORMAL" position.
2. Have remote carrier test switch turned to "SEND".
3. Perform the following operations on the transmitter-receiver unit: Depress button S-11 (or turn local carrier test switch to "TEST") and adjust R29 to give a. current of 1 to 3 milliamperes, measured at the signal alarm current jack (J12). Record the current reading and resistor setting for future comparison.
4. Note that this setting should be made only when transmission conditions are normal. Current will increase as transmission efficiency is decreased by such things as sleet.

E_{15} PHASING OF TEST SOURCES (CHECK)

1. If a cathode ray oscilloscope is available, connect its vertical input between the ground and line terminal of the transmitter receiver.

2. Turn relay test switches at both ends of the line to "IN". Oscilloscope should indicate approximately 0 degree phase displacement between the local and remote signals. Refer to oscilloscope pattern #1. (Oscilloscope patterns appear on pages 21 and 22 of GEI-44070A).

3. Turn relay test switch at one end of line to "OUT", other end to "IN". Oscilloscope should indicate approximately 180 degrees displacement. Refer to oscilloscope pattern #2.

4. If oscilloscope patterns are considerably different from 0 and 180 degrees, the voltages at the two ends are from different phases. In this case, substitute either of the other two phases of the a-c test source at one end of the line at terminals M5 and M6. Repeat phasing tests. Refer to oscilloscope patterns #3 and #4.

5. If an oscilloscope is not available, plug the test cord into the milliammeter and tripping unit, and turn switch to "COMPARER".

6. Milliammeter should read approximately 6 milliamperes with the relay test switches in like positions, or 0 to 0.5 milliamperes when the switches are in opposite positions.

7. If the difference between the two readings is less than 4 milliamperes, the test voltages, at the two ends are from different phases. In this case, proceed as indicated in 4 above.

E_{16} PHASE SHIFTER (SET)

NOTE: For lines of length up to 50 miles the phase shifter may be set at 0 degrees (extreme counterclockwise rotation).

1. Determine degrees of lag of carrier-current signal due to the time of propagation from one line end to the other. The approximate lag per 100 miles of open line is 12 degrees

2. Turn both relay test switches to "IN".

3. Turn phase shifter to 0 degree phase shift (extreme counterclockwise position).

4. Use calibrated phase shifter to supply a signal of about 125 V. a-c between P9 and P10, or A10 and A11, after first blocking the "a" contacts of FD-H open.

5. Adjust the shop calibrated phase shifter for minimum comparer plate current.

6. From the point found in 5, turn the shop phase shifter, in a lagging direction, the number of degrees calculated in 1.

7. Adjust the phase shifter of tripping unit for minimum comparer tube plate current. Lock the phase shifter control in place by means of the locking nut.

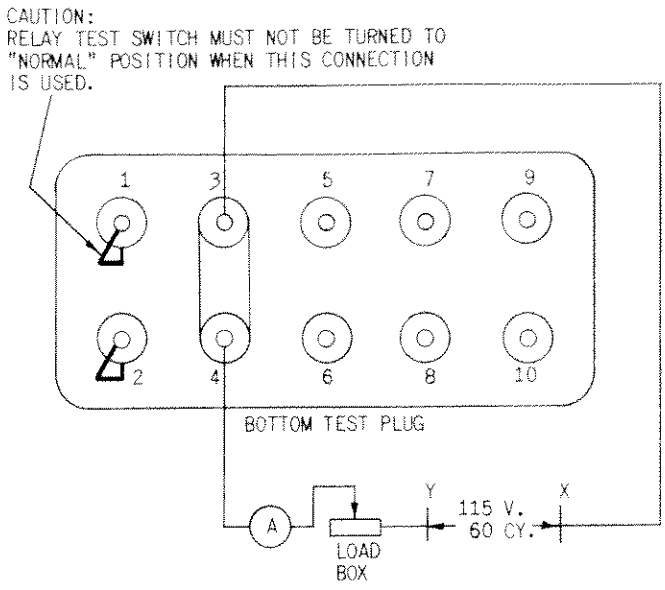


Fig. 3 (418A983)

Fig. 3 Drawout Test Plug Connections For Ground Pickup Check For Type EDD Relay

E_{17} COMPARER PLATE CURRENT (CHECK)

1. Record the comparer plate current with the relay test switches at the two ends of the line in the same position ("IN" or "OUT") (Approximately 6 ma. See SECTION E_{16}-6) of GEI-44070.

2. Repeat with the switches in opposite positions (0 to 0.5 ma.).

3. Repeat with the local relay test switch on "IN" and the remote relay test switch on "OFF". The plate current should be approximately 6 milliamperes.

NOTE: Comparer-plate current will vary with power transfer on a long line. For this reason, it is advisable to graph comparer-plate current under various killowatt loads and use this graph whenever checks are made on comparer-plate current.

E_{18} GROUND CURRENT BLOCKING POINT (CHECK) (FD-L)

1. With the relay test switches in the "OFF" position, apply 60 cycles current to the network unit through a drawout test plug connected according to Fig. (3).

2. Turn the local relay test switch to the position "IN". Gradually decrease the test resistance and note the current at which FD-L picks up.

3. If the pick-up current is incorrect, or a different value is required, adjust the FD-L rheostat R-209 and R-210. The FD-L pickup should be 2/3 of FD-H pick-up current to provide a definite margin between blocking and tripping.

4. Record the pick-up current and FD-L current.

E_{19} GROUND CURRENT TRIP POINT (CHECK) (FD-H)

1. Insert a drawout test plug, connected as shown in Fig. 3, in the bottom network unit. Turn the local test switch to "IN". Gradually decrease the test resistance and note the current at which the amber test lamp lights.

2. If the pick-up current is incorrect, adjust the FD-H rheostat, R-221.

3. Record the pick-up current and the FD-H plate current.

RENEWAL PARTS

In Table II, which supplements L_2 in instruction book GEI-44070A, additional parts are listed for reference to assist in identifying part numbers that appear on the internal connection and elementary diagrams.

TABLE II

REFERENCE COMPONENT VALUES

RESISTOR	OHMS
R204A	50
R204B	50
R204C	100
R204D	50
R216	50

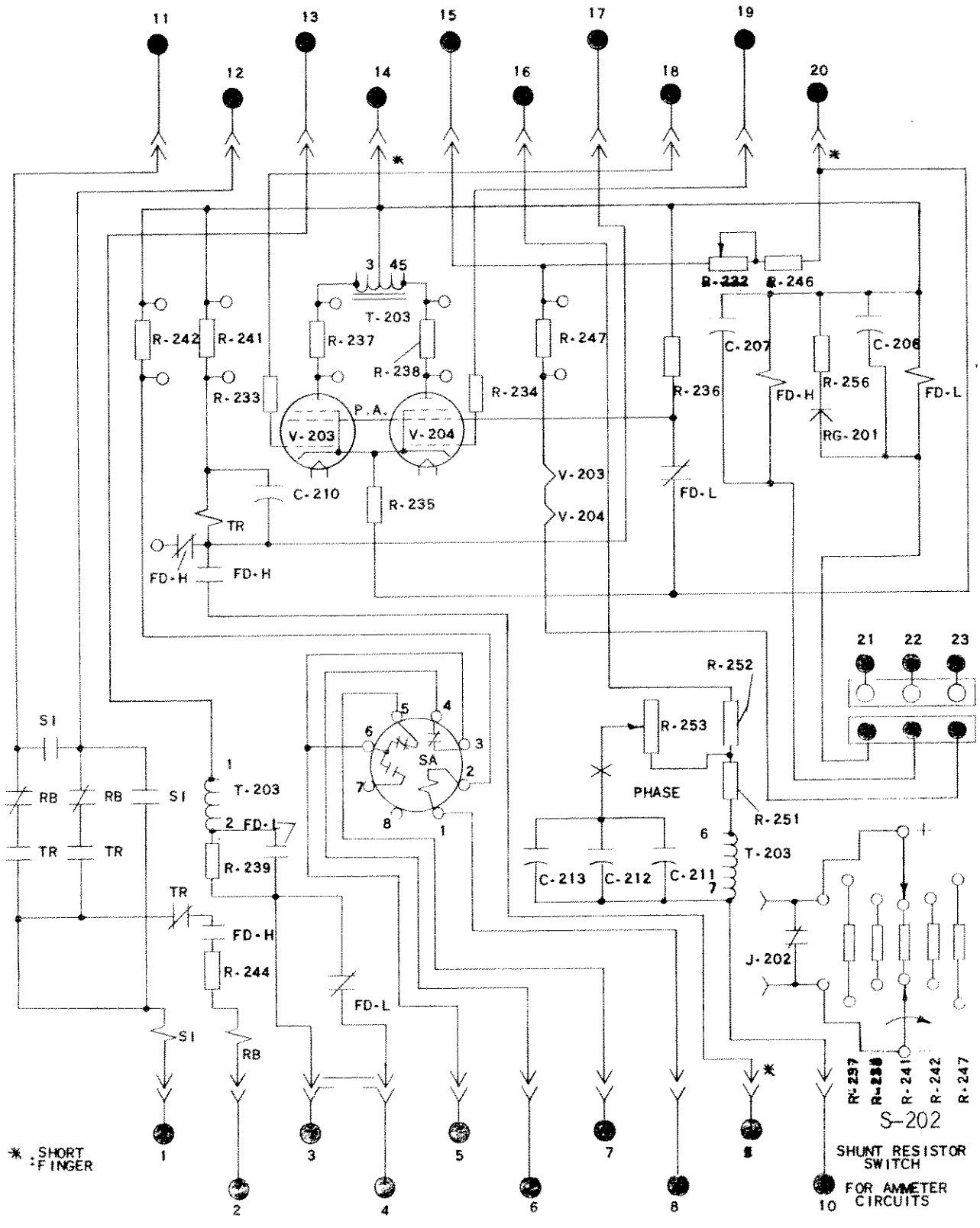


Fig. 4 (403A192)

Fig. 4 Internal Connections For Type EDD Relay (Tripping Unit)

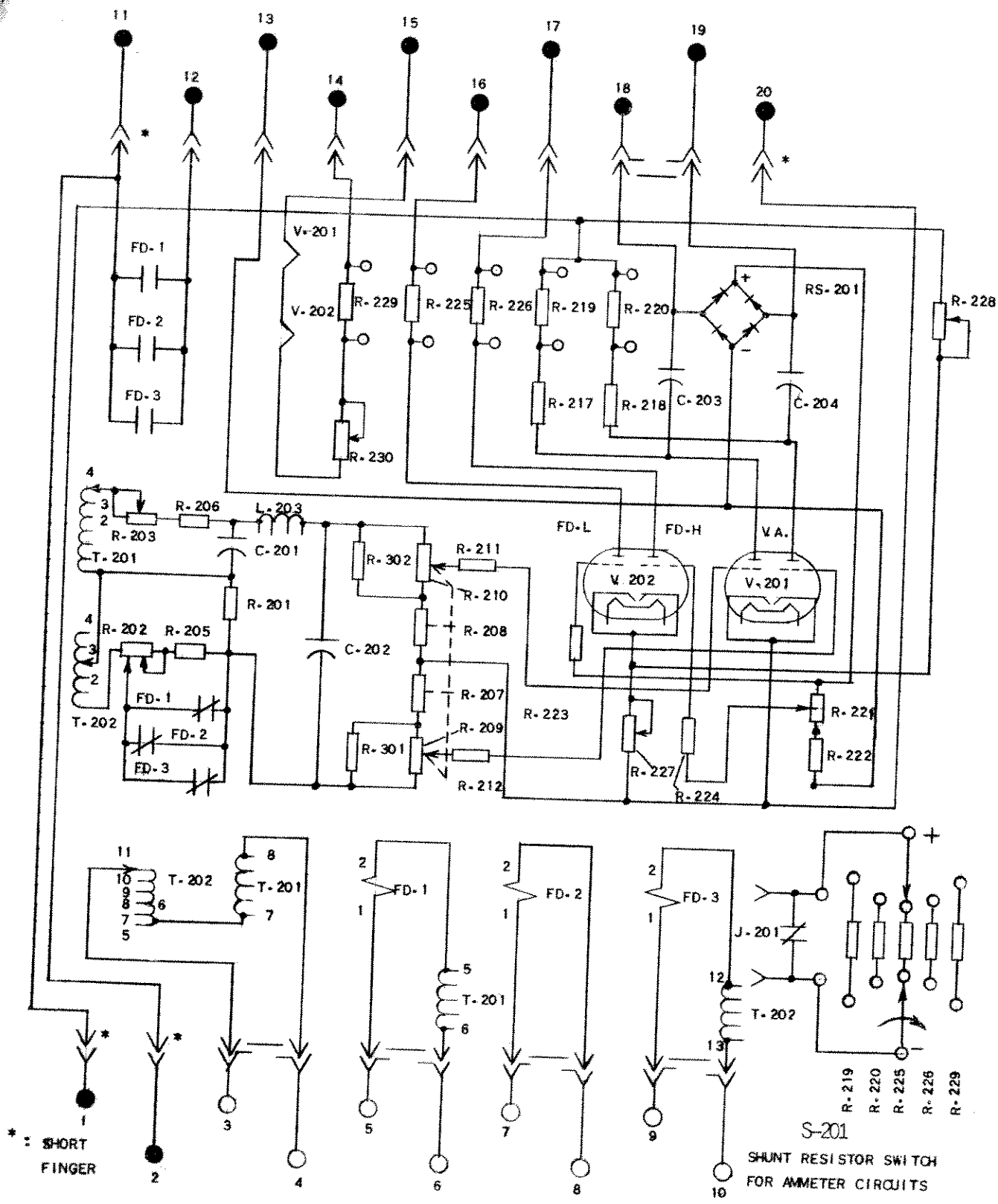
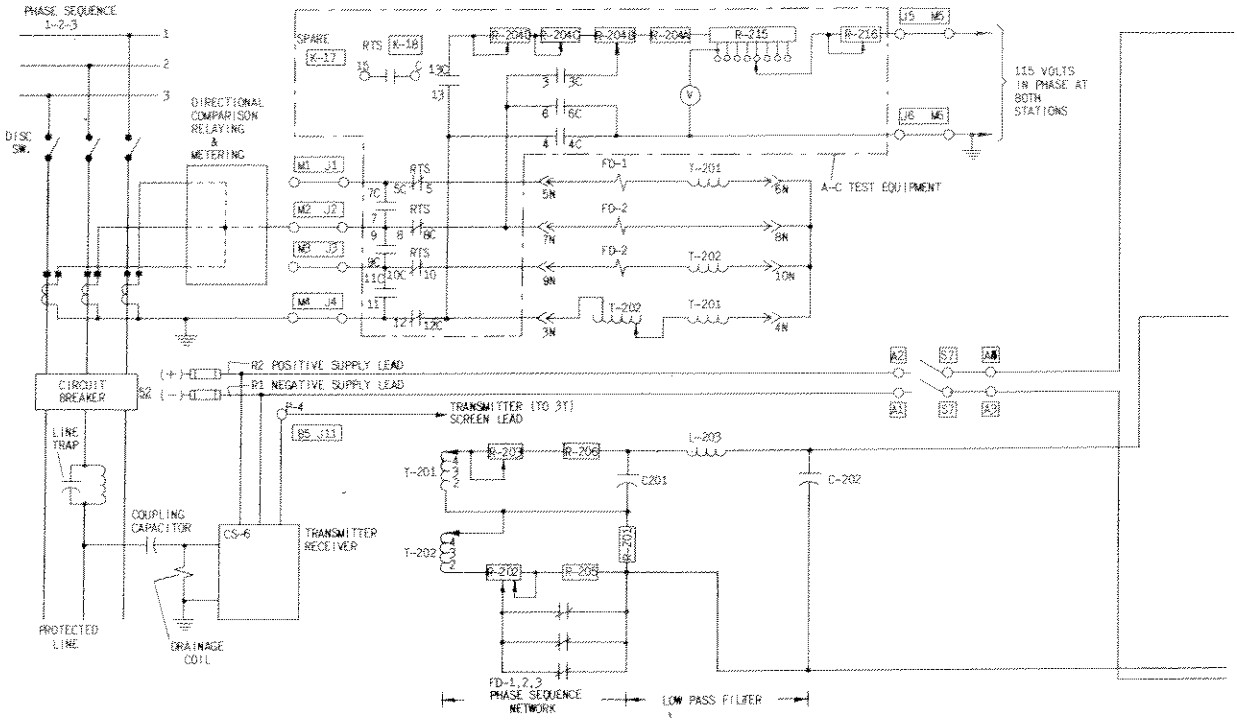


Fig. 5 (389A743)

Fig. 5 Internal Connections For Type EDD Relay (Network Unit)



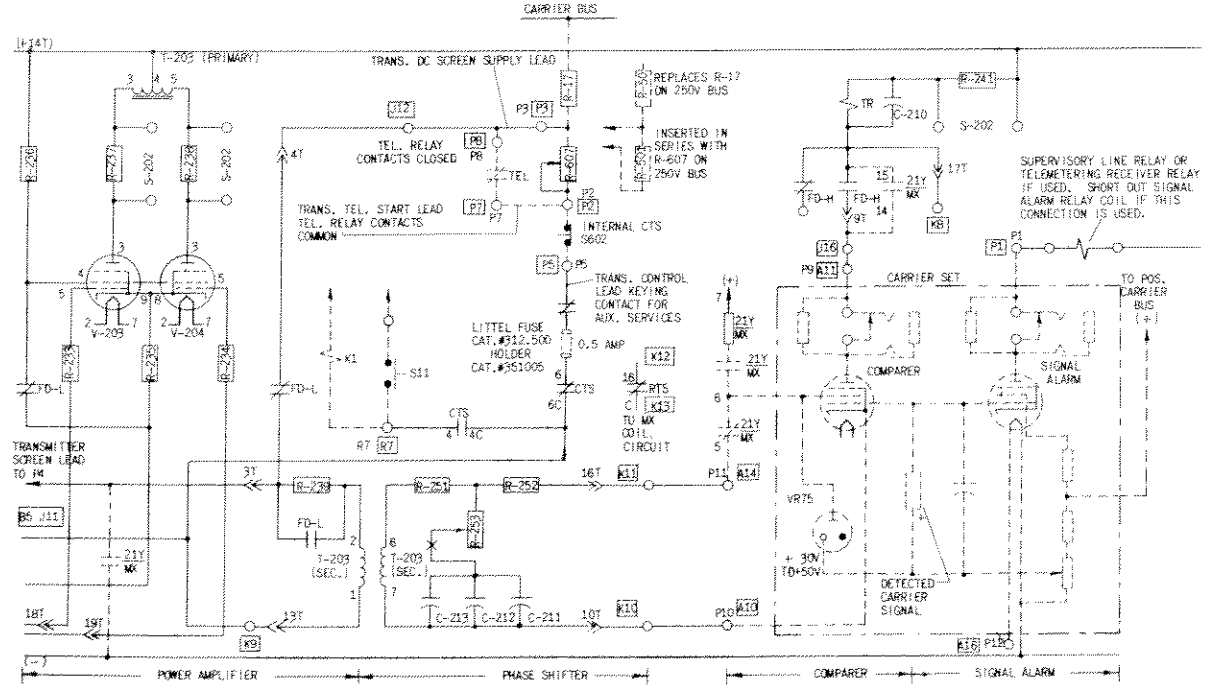


Fig. 6 Elementary Diagram For Phase Comparison Pilot Relaying

Fig. 6 (7021B88)

Fig. 6 (7021B88)

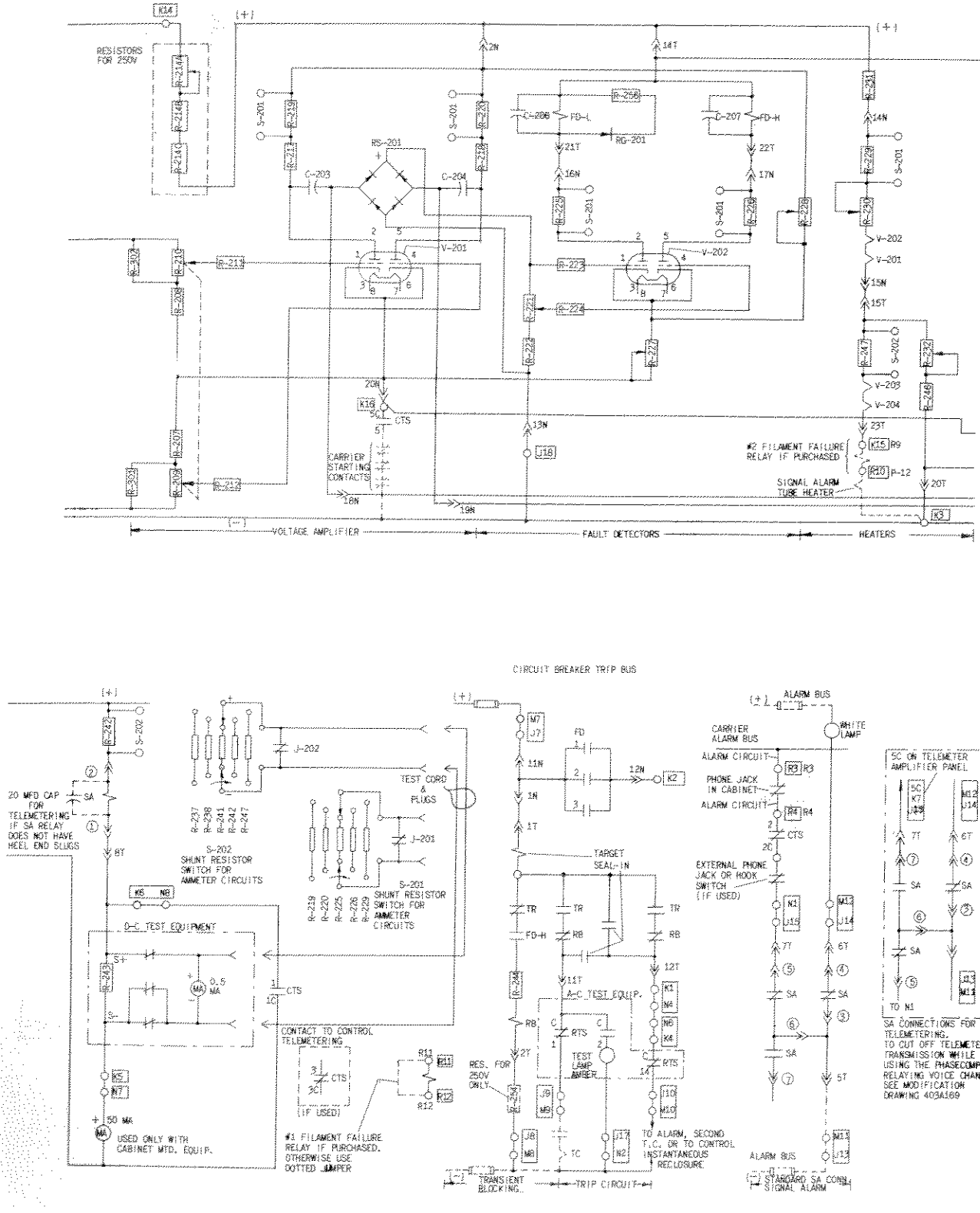
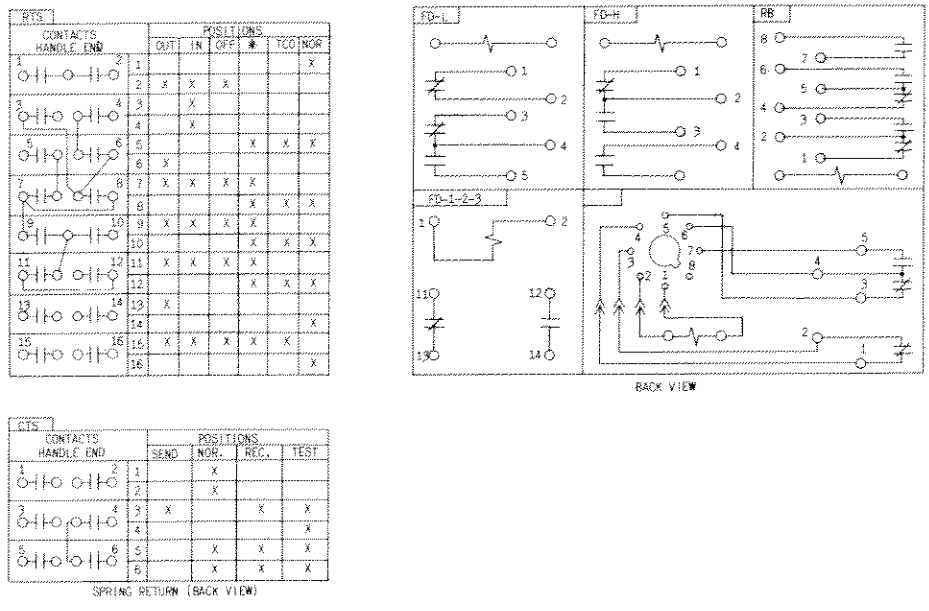


Fig. 6 (Cont'd.) Elementary Diagram for Phase Comparison Pilot Relaying



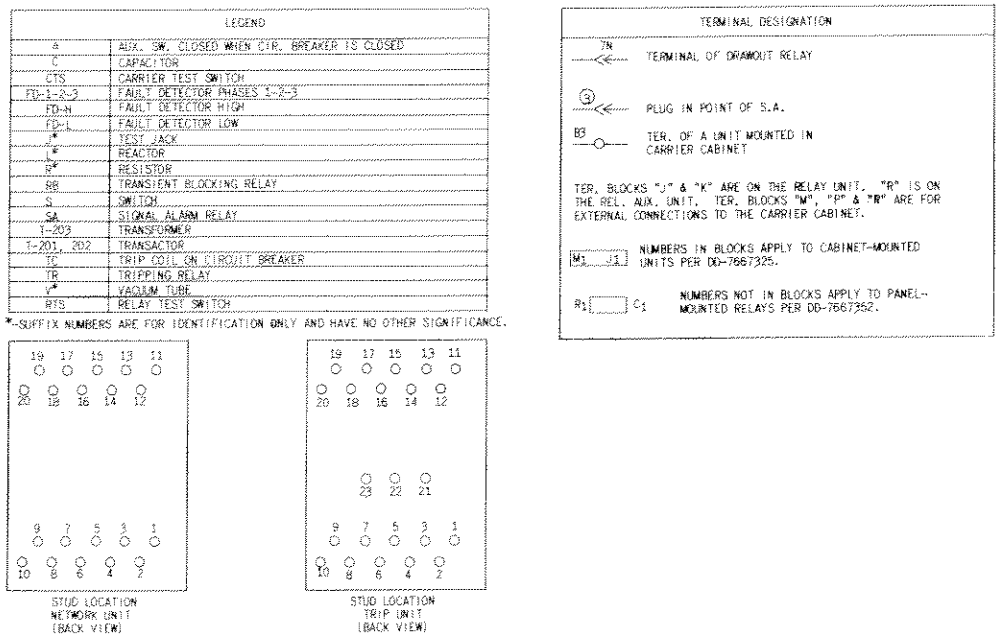


Fig. 6 (Cont'd.) Elementary Diagram for Phase Comparison Pilot Relaying

Fig. 6 (7021B88)

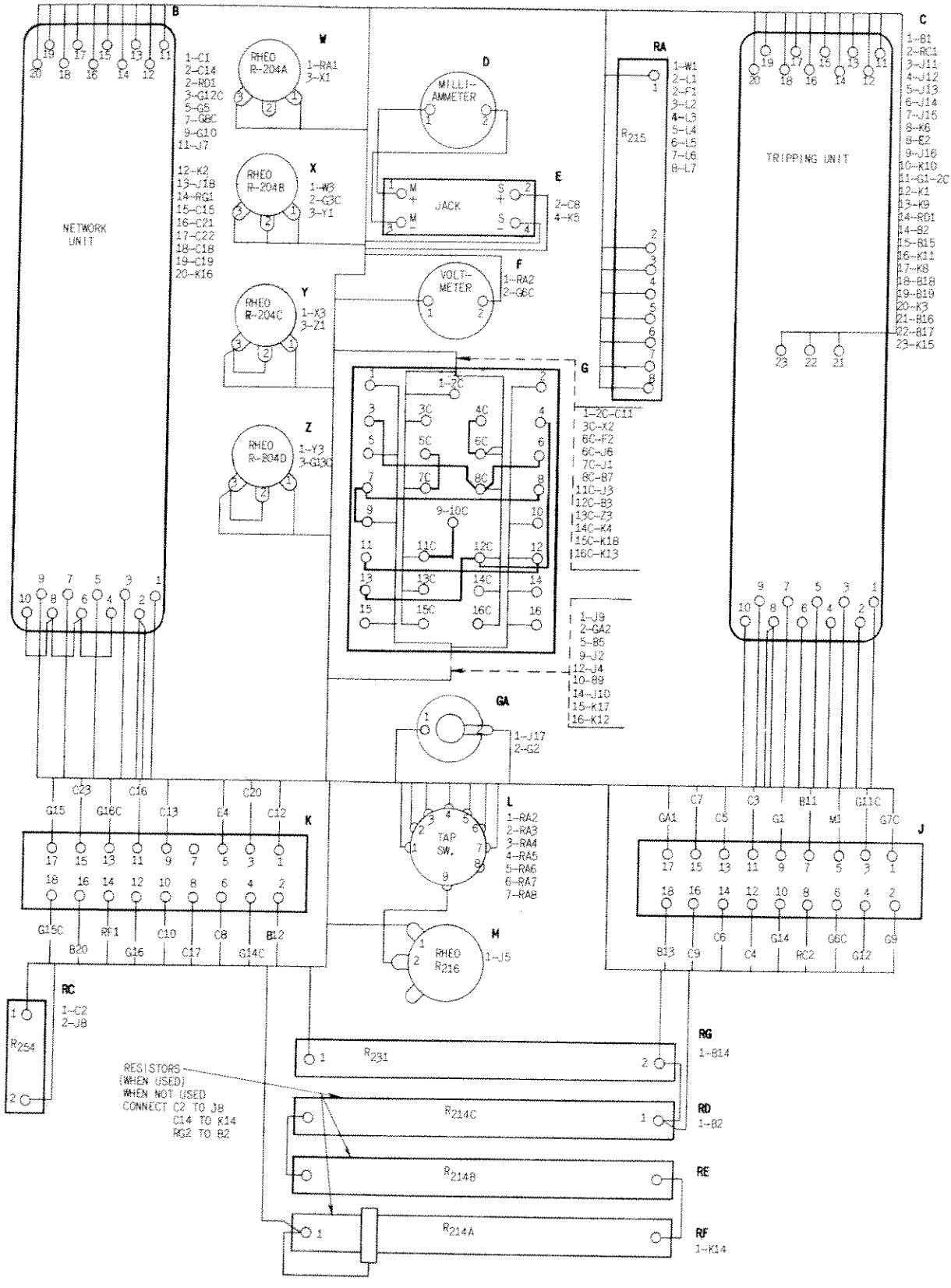


Fig. 7 (2370735)

Fig. 7 Internal Connections for Type EDD Relay (Sub Panel) (Back View)

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