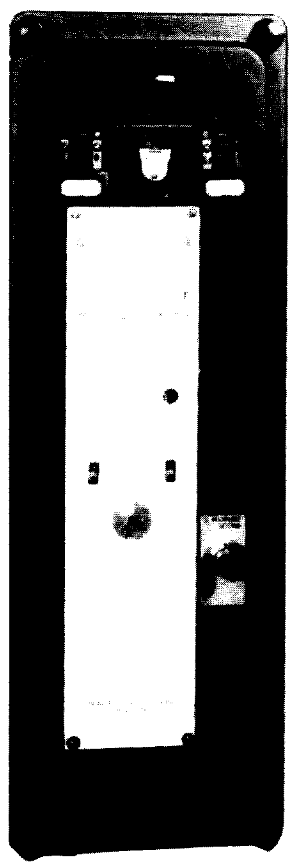
GEK-49862C

INSTRUCTIONS

STATIC, THREE PHASE OFFSET PHASE DISTANCE RELAY

TYPE SLY82A



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TYPE SLY82A

DESCRIPTION

The type SLY82A relay is a three phase, static, phase distance relay and is used as a blocking relay in a blocking relay scheme when SLY81A relays are used for the tripping relays. The SLY82A is available with ratings of 60 hertz, five amperes; 50 hertz, five amperes; and 50 hertz, one ampere. The ohmic reach range of the five ampere rated relay is continuously adjustable from 0.75 to 30 ohms phase to neutral and the range of the one ampere rated relay is continuously adjustable from 3.75 to 30 ohms phase to neutral. DC power supply voltages available are 48, 110, or 125. A 250 volt rating is available with an external pre-regulator. Contact outputs are provided for tripping (one normally open contact with series target), for blocking (one normally closed contact), and a normally open contact connected to positive for auxiliary functions. The relay is mounted in a deep, large size, double-ended drawout (L2D) case.

The SLY82A has a "variable mho" characteristic, which provides optimum accommodation of fault resistance.

The functional block diagram is shown in Fig. 1. The internal connections are shown in Fig. 2 and the external connections are shown in Fig. 3.

APPLICATION

The SLY82 relay utilizes a three input phase angle comparator for the phase distance measurement. The three inputs for the phase A-B measurements are:

(a)	$(I_A - I_B) Z_{R1} - T V_{AB}$	Operating Quantity
(b)	$(V_{AB} + KV_{AB1}) + R(I_A - I_B)Z_{R1}$	Polarizing Quantity
(c)	$(I_A - I_B) Z_{R1}$	Overcurrent Supervision

where

I_A and I_B	are the currents in the faulted phases
Z_{R1}	is the base reach impedance with an impedance angle of 85 degrees
$T V_{AB}$	is the faulted phase-to-phase voltage, multiplied by the restraint setting T
R	is a ratio tap to provide an "offset" equivalent to 0, 0.1, 0.2, or 0.3 of the relay reach
$V_{AB} + KV_{AB1}$	is the faulted phase-to-phase voltage plus K times the positive sequence component of the faulted phase-to-phase voltage. K is a design constant equal to 0.3 per unit.

The use of the positive sequence component of voltage in the polarizing signal results in a relay characteristic of the "variable mho" type; that is, the characteristic expands as the source impedance behind the relay increases, providing an automatic accommodation of increasing arc impedance. The positive sequence component of voltage in the polarizing signal also improves the directional integrity of the distance measurement.

The third input to the comparator provides an overcurrent supervision function.

RATINGS

GENERAL

The Type SLY82A relay is designed for continuous operation in ambient temperatures between -20°C and +55°C per ANSI Standard C37.90-1978. In addition, these relays will not malfunction nor be damaged if operated in an ambient up to 65°C.

The current circuits of the relays which are rated five amperes RMS will carry 10 amperes continuously and will carry 250 amperes for one second. The current circuits of the relays which are rated one ampere RMS will carry two amperes RMS continuously and will carry 50 amperes RMS for one second. The potential circuits are rated 69 volts RMS line-to-neutral and will withstand 110 percent of this value continuously.

The Type SLY82A relay is available with an impedance range as shown in Table I.

TABLE I

AVAILABLE REACHES

Relay Current Circuit Rating Amperes	Base Reach Tap In Positive Sequence Ohms Z_{R1}	Impedance Range In Positive Sequence Ohms Z_R
5	0.75	0.75 to 7.5
5	1.5	1.5 to 15.0
5	3.0	3.0 to 30.0
1	3.75	3.75 to 37.5
1	7.5	7.5 to 75.0
1	15.0	15.0 to150.0

Selection of the desired base reach tap (Z_{R1}) is made by means of the three tap screws at the lower rear of the relay (see Fig. 4). All three tap screws (ØA, ØB, ØC) must be in equal ohmic tap positions.

The relay reach (Z_R) of the relay is continuously adjustable, within the range shown in Table I for a particular tap, by means of a three-gang-precision potentiometer at the lower front of the relay (see Fig. 5). The 10-turn dial of this potentiometer is calibrated in percent restraint setting (T) and is adjustable from 10 percent (fully counterclockwise) to 110 percent (fully clockwise). The maximum recommended setting is 100 percent. An enlarged picture of the dial is shown in Fig. 6.

The relay reach is given by equation (1):

$$\text{Relay Reach} = Z_R = \frac{100 \times Z_{R1}}{T} \qquad (1)$$

where

T = Restraint setting in percent

Z_R = Relay reach in ohms

Z_{R1} = Base reach tap in positive sequence ohms

The relay reach should be within five percent of the value given by equation (1) if the ambient temperature is within the rated range of -20°C to +55°C.

SURGE WITHSTAND CAPABILITY

These relays will withstand ANSI C37.90-1978 surge test without incorrect operation or damage to any component.

POWER SUPPLY

Models are available with ratings of 48 volts DC (38 to 56 volts), 110 volts DC (88 to 120 volts), or 125 volts DC (100 to 140 volts). The power supply contains a DC-to-DC converter to provide isolation between the DC input control power and the solid state circuitry of the relay. On relays with DC control voltage in excess of 125 volts, an external pre-regulator is used. This reduces the control voltage to 125 volts, suitable for input to the relay terminals.

CONTACTS

The trip contacts will make and carry 30 amperes for tripping duty. Their continuous current ratings are limited by the target ratings as listed in Table III.

The interrupting ratings of the contacts are listed in Table II.

TABLE II

INTERRUPTING RATINGS IN AMPERES OF OUTPUT CONTACTS

VOLTAGE	TRIP OUTPUT CONTACTS	
	INDUCTIVE**	NON-INDUCTIVE
115 volts AC	0.75	2.0
230 volts AC	0.5	1.0
48 volts DC	1.0	3.0
125 volts DC	0.5	1.5
250 volts DC	0.25	0.75

**The inductive ratings are based on an L/R ratio of 0.04 second.

TARGET

A target unit with 0.6 and 2 ampere taps is provided for the output contact between terminals 11 and 12. The ratings of this target are given in Table III.

TABLE III

TARGET RATINGS

	0.6 Amp Tap	2.0 Amp Tap
Minimum Operating	0.6 amps	2.0 amps
Carry Continuously	1.2 amps	2.6 amps
Carry 30 Amps for	0.5 sec.	3.5 secs.
Carry 10 Amps for	5 secs.	30 secs.
DC Resistance	0.78 ohm	0.18 ohm
60 Hertz Impedance	6.2 ohms	0.65 ohm

CHARACTERISTICS

OPERATING PRINCIPLES

The SLY82A blocking relay operating principle is selected to provide the optimum coordination with the SLY81A tripping relay located at the remote terminal of the line. The operating quantity of the SLY82A relay is the same as the SLY81A relay. The polarizing quantity in the SLY82A relay, $(V_{AB}+KV_{AB1}) + R(I_A-I_B)\, Z_{R1}$, has a current compensating component in addition to the same polarizing quantity as is used for the SLY81A relay. The purpose of this current compensating component, on a dynamic basis, is to provide a polarizing signal in the blocking relay more nearly in phase with the polarizing voltage in the tripping relay. When load flow causes an angular separation of the voltages at the two ends of the line, the current compensation partially cancels this angular difference.

The characteristic timer in the SLY82A relay has a shorter setting than the characteristic timer in the type SLY81A relays. This gives the SLY82A relay a slightly "tomato-shaped" characteristic, thereby ensuring that the blocking unit will operate first on a through fault.

RELAY REACH

The balance point of the relay is defined as the point at which the operating quantity goes to a null which, for phase AB, is:

$$(I_A - I_B)\, Z_{R1} = \frac{TV_{AB}}{100}$$

or

$$V_{AB} = \frac{100\, Z_{R1}}{T}\,(I_A - I_B)$$

where

T = Restraint setting in percent

Z_{R1} = Base reach tap in positive sequence ohms.

For a phase A to phase B fault where $I_A = -I_B$

$$V_{AB} = \frac{2I_A Z_{R1}}{T} \times 100$$

The reach of the relay is defined as:

$$Z_R = \frac{V_{AB}}{2I_A} = \frac{100Z_{R1}}{T} \quad \text{Relay Reach in Ohms}$$

To set the relay for the desired reach, it is necessary to first select the proper "Base Reach Tap". This tap should be the highest "Base Reach Tap" that is smaller than the desired ohmic reach. The setting of the "Base Reach Tap" is explained under the section titled CONSTRUCTION in this book. After the "Base Reach Tap" is selected the "Percent Restraint Setting" may now be chosen to produce the required relay reach.

SENSITIVITY

Sensitivity is defined as the steady state RMS voltage or current (at the relay terminals) required for a particular quantity to pick up the relay if all quantities are in the optimum phase relationship. The nominal sensitivies for the signal quantities in the SLY82 relay are as follows:

1. Polarizing Sensitivity:

   0.2 volts

2. Overcurrent Supervision Sensitivity:

   The sensitivity is fixed by design as shown in Table IV.

TABLE IV

OVERCURRENT SENSITIVITY

BASE REACH TAP IN OHMS	MINIMUM SENSITIVITY IN ø TO ø AMPERES RMS
0.1	4
0.2	2
0.4	1
0.75	0.52
1.5	0.26
3.0	0.13
0.5	0.8
1.0	0.4
2.0	0.2
3.75	0.11
7.5	0.052
15.0	0.026

3. Operate Circuit Sensitivity:

See Fig. 7 for sensitivity in terms of $V_{LL} \times \frac{(\%T)}{100}$

The current sensitivity for phase pair A-B is given by the relationship:

$$(I_A - I_B)Z_{R1} = \frac{0.032 \times I \text{ rated}}{1-X}$$

where

$$X = \frac{\text{Actual Relay Reach}}{\text{Nominal Relay Reach}}$$

For example, if $X = 0.8$ and $Z_{R1} = 3$ ohms, then:

$$I_A - I_B = \frac{0.16}{3(1-0.8)} = 0.27 \text{ amperes}$$

For a phase to phase fault where $I_A = -I_B$,

$$I_A - I_B = 2I_A = 0.27 \text{ amperes}$$

$$\text{or } I_A = 0.13 \text{ amperes}$$

Similarly for a three phase fault $I_A = \frac{I_A - I_B}{\sqrt{3}}$

$$I_A - I_B = \sqrt{3}\, I_A = 0.27 \text{ amperes}$$

$$\text{or } I_A = 0.15 \text{ amperes}$$

BURDENS

The potential circuit burden per phase at 120 volts RMS is 0.4 volt-amperes, 0.2 watts, 0.35 vars.

The current circuit impendance per circuit measured at rated current is given in Table V below.

TABLE V

CURRENT CIRCUIT BURDENS

Relay Current Rating	5 Amperes	1 Ampere
Current Circuit	Phase	Phase
Impedance, Z, in ohms	0.030	0.210
Resistance, R, in ohms	0.027	0.200
Reactance, X, in ohms	0.002	0.065

The current requirements at the DC control power input (studs 19 and 20) are given in Table VI below.

TABLE VI

DC CONTROL CIRCUIT BURDENS

Relay Rated DC Voltage	Condition of Output Relay K2	Control Circuit Burden in Milliamperes
48	Dropped Out	200
48	Picked Up	315
110	Dropped Out	90
110	Picked Up	175
125	Dropped Out	80
125	Picked Up	155
250	Dropped Out	250*
250	Picked Up	250*

*Input to studs A and C of external pre-regulator.

CIRCUIT DESCRIPTION

The internal connections for type SLY82 are shown in Fig. 2. The terminal numbers at the tops and bottoms of these diagrams represent the external connections to the relays. The external connections can be grouped as shown in Table VII.

TABLE VII

EXTERNAL CONNECTIONS

TERMINAL NUMBERS	DESCRIPTION
1 through 6	AC current inputs
9	Contact (other end connected to #19)
10	Surge ground
11 and 12	Normally open contact with target
13 and 14	Normally closed contact without target
15 through 17	AC potential inputs
19 and 20	DC control power input

The line-to-line input voltages are connected to the primaries of step down potential transforemrs (T_A, T_B and T_C). The secondaries of these potential transformers are connected to the signal processing (SP) card as well as to a three-gang potentiometer. The voltages on the sliders of the potentiometers are also connected as inputs to the SP card.

The input phase currents pass through the primaries of transactors (X_A, X_B and X_C). The transactors produce secondary voltages proportional to their primary currents in magnitude; however, the secondary voltages lead their respective primary currents by a phase angle of 85 degrees. Taps are provided on the primaries of these transactors and the secondary voltages are connected as inputs to the SP card.

The SP card combines the above mentioned quantities to produce various output signals which are then fed as inputs to other cards. Table VIII indicates the types of output signals produced by the SP card and which other cards are fed by each signal.

TABLE VIII

OUTPUTS FROM SP CARD

OUTPUT SIGNAL FROM SP CARD	INPUT TO CARD
V_{AB}, V_{BC}, V_{CA}	Combined Polarizing (CP)
$(I_A-I_B)Z_{R1}$	Coincidence Logic (CL) and Combined Polarizing (CP)
$(I_B-I_C)Z_{R1}$	
$(I_C-I_A)Z_{R1}$	
$(I_A-I_B)Z_{R1} - TV_{AB}$	Operate Signal (OS)
$(I_B-I_C)Z_{R1} - TV_{BC}$	
$(I_C-I_A)Z_{R1} - TV_{CA}$	

The combined polarizing (CP) card produces voltages, $V_{AB} + 0.3\ V_{AB1}$ and $V_{BC} + 0.3\ V_{BC1}$ and $V_{CA} + 0.3\ V_{CA1}$ by algebraic summations of V_{AB}, V_{BC}, and V_{CA}. A current compensating component equal to $R(I_A - I_B)Z_{R1}$ is added to the $V_{AB} + 0.3\ V_{AB1}$ voltage and the other two voltages are similarly compensated. These voltages are then filtered in active bandpass filters with natural frequencies (fo) equal to the system frequency. These three filtered voltages are fed to the CL card as polarizing quantities.

The operate signal (OS) card filters its input signals from the SP card in active bandpass filters with natural frequencies equal to system frequency. Circuitry is also provided to bypass this filtering for (IZ-TV) signals of large magnitudes. The outputs of the OS card are fed to the (CL) card as operating signals.

Each phase of the CL card has three input signals and produces a high logic (+15 volts DC) output signal whenever these signals have the proper instantaneous phase relationship. Table IX shows the various input signals for phase AB and where the signals are obtained. In order for the output of CL to be high, inputs 1 and 3 must have the same polarity and input 2 must have an opposite polarity.

TABLE IX

INPUTS TO CL CARD

INPUT NO.	INPUT SIGNAL	DERIVED FROM
1	Combined Polarizing	CP Card
2	Operate Signal	OS Card
3	$(I_A - I_B)\ Z_{R1}$	SP Card

The CL card outputs are fed to the integrating timer (IT) card which measures the time that each CL output signal is high. If the input signal to the IT card is high for 3.5 milliseconds (50 hertz relays -4.2 milliseconds) on a repetitive basis (or 3.7 milliseconds (50 hertz relays - 4.4 milliseconds) on a single shot basis), the output of the IT card will go to a high logic value which picks up a reed relay (K1) mounted on the power supply (PS) card. A normally open contact on K1 energizes a telephone relay (K2) mounted on the front panel. One normally open contact of K2 is connected in series with the coil of a target to provide the main tripping contact (terminals 11 and 12). In addition, a second normally open contact of K2 is connected between terminals 19 and 9, without a target, for auxiliary functions. A normally closed contact is connected between terminals 13 and 14 for blocking duty.

The input DC control power (48, 110, or 125 volts) is connected to the power supply (PS) card which contains a DC-to-DC converter. The outputs of the DC-to-DC converter are plus and minus 15 volts DC regulated which supply the necessary control power to the other cards. The transformer in the DC-to-DC converter provides isolation between the solid state circuitry of the relay and the input DC control power (i.e., station battery). A yellow LED monitors the output voltage from this internal power supply.

The internal connections and card layouts for each printed circuit card are listed in Table X. The printed circuit cards have test points accessible from the front of the cards. Each test point, except the reference connection, "OV" on the PS card, is buffered by a resistor to prevent a disturbance to the circuitry if a test point is accidentally short circuited. The test points are labeled functionally; i.e., the AB phase input to the integrating timer is labled "AIN". The internal connection drawings show the test points with the same label.

TABLE X

INTERNAL CONNECTIONS FOR CARDS

CARD DESIGNATION	CARD FUNCTION	FIGURE NUMBER OF INTERNAL CONNECTIONS	FIGURE NUMBER OF CARD LAYOUT
SP	Signal Processing	8A	8B
CP	Combined Polarizing	9A & 9B	9C
OS	Operate Signal	10A & 10B	10C
CL	Coincidence Logic	11A	11B
IT	Integrating Timer	12A	12B
PS	Power Supply (125 Volts DC)	13A	13B
PS	Power Supply (48 Volts DC)	14A	14B

CALCULATION OF SETTINGS

The setting of the SLY82A is predicated on the setting of the SLY81A overreaching relay at the remote end of the protected line.

The Z_{R1} settings of the SLY82A relay should be at least equal to, and preferably larger than, the corresponding settings of the SLY81A relay at the remote terminal. In general, the restraint setting should be selected to provide a relay reach between 100 percent to 150 percent of the remote SLY81A reach. A 100 percent setting is appropriate for very long lines, and a 150 percent is appropriate for short-to-intermediate line lengths. If the line is very short, i.e., less than one ohm secondary, a minimum setting of three ohms is desirable when a shorter reach is not required for use of this relay in third zone back-up applications.

The R setting is generally selected such that the "offset" is equal to or less than the line impedance. For two terminal lines, an R tap of 30 percent is usually appropriate. On very short lines, the 10 percent or 20 percent tap may be more appropriate. When considering three terminal lines, the offset should be equal to or less than the impedance to the nearest terminal. If the calculated offset is less than 0.1 times the relay reach, the 10 percent tap may be used without reducing the relay reach.

For example, on a two-terminal, 70-mile line with $Z_{1L} = 4.2\angle 83^{o}$, the remote overreaching SLY81A relay has the following settings:

$$Z_{R1} = 3 \text{ ohms}, \quad T = 40.8 \text{ percent}, \quad Z_R = 7.35 \text{ ohms}$$

The base reach settings for the SLY82A relay will then be $Z_{R1} = Z_{R0} = 3$ ohms.

Since a 70-mile line would be considered to be a relatively long line, a multiplier of 1.2 times the reach of the remote SLY81A relay is appropriate. This gives 1.2 (7.35) = 8.82 ohms for the SLY82A reach setting.

$$\%T = \frac{Z_{R1}}{Z_R}(100) = \frac{3}{8.82}(100) = 34\%$$

Assuming an R tap of 30 percent the offset is 0.3 (8.82) = 2.65 ohms, or 63 percent of the line impedance, and is therefore acceptable.

CONSTRUCTION

The type SLY82A relay is assembled in a deep, large size, double-end (L2D) drawout case having studs at both ends in the rear for external connections. The electrical connections between the relay unit and the case studs are made through stationary molded inner and outer blocks between which nests a removable connecting plug which completes the circuits. The outer blocks attached to the case have the studs for the external connections, and the inner blocks have the terminals for the internal connections.

Every circuit in the drawout case has an auxiliary brush, as shown in Fig. 15, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Fig. 2) and on these circuits, it is especially important that the auxiliary brush make contact as indicated in Fig. 15 with adequate pressure to prevent the opening of important interlocking circuits.

The relay is mounted in a steel framework called the cradle and is a complete unit with all leads terminated at the inner blocks. This cradle is held firmly in the case with a latch at both top and bottom and by a guide pin at the back of the case. The connecting plug, besides making the electrical connections between the respective blocks of the cradle and case, also locks the latch in place. The cover, which is drawn to the case by thumbscrews, holds the connecting plugs in place. The target reset mechanism is a part of the cover assembly.

The relay case is suitable for either semiflush or surface mounting on all panels up to two inches thick and appropriate hardware is available. However, panel thickness must be indicated on the relay order to insure that proper hardware will be included. Outline and panel drilling is shown in Fig. 17. For DC supply voltages greater than 125 volts it is necessary to use an external pre-regulator. The pre-regulator is packaged in a box made from compound plates and perforated steel siding. It can be mounted on the rear of the relay or at a convenient location near the relay. The outline and mounting dimensions for the pre-regulator are shown in Fig. 24.

A separate testing plug can be inserted in place of the connecting plug to test the relay in place on the panel either from its own source of current and voltage, or from other sources. The relay can be drawn out and replaced by another which has been tested in the laboratory.

The potential transformers (TA, TB and TC) and the transactors (XA, XB and XC) are mounted at the rear of the cradle as shown in Fig. 4. The tap block below the transactors is used to set the base reach to the value determined in the CALCULATION OF SETTINGS section of this book. The three leads tagged, A, B, and C, should be connected to the desired ohmic value labeled ØA, ØB, and ØC respectively. For example, Fig. 4 shows a base reach (Z_{R1}) setting of 3.0 ohms and the leads are connected as follows:

lead C ⟶ position 1
lead B ⟶ position 4
lead A ⟶ position 7

A base tap indicator is provided on the nameplate. The knob should be rotated until the number corresponding to the base reach setting is exposed.

Fig. 18 shows a front view of the relay with the nameplate removed. This view shows the targets, the telephone relay and all adjustments other than the base reach tap described above.

The dial of the restraint setting potentiometer (T) is calibrated directly in percent with the number in the window indicating the 10's digit and the two digits on the dial indicating the units and decimal digits. An example is shown in Fig. 6 with a setting of 84 percent. The dial can be adjusted from 10 percent to 100 percent. The lock must be disengaged (by turning the lever counterclockwise) in order to change the restraint setting but should be engaged again after the desired setting is made.

The other adjustments indicated in Fig. 18 are trim potentiometers located on printed circuit cards. Most of these adjustments are set in the factory and should not normally require readjustment. See the ACCEPTANCE TESTS section of this book for the recommended procedures if adjustment is required.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Apparatus Sales Office.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

ACCEPTANCE TESTS

Immediately upon receipt of the relay an INSPECTION AND ACCEPTANCE TEST should be made to insure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed.

These tests may be performed as part of the installation or acceptance test at the discretion of the user.

Since operating companies use many different procedures for acceptance and installation tests, the following section includes applicable tests that may be performed on these relays.

VISUAL INSPECTION

Check the nameplate stamping to insure that the model number and rating of the relay agree with the requisition.

Remove the relay from its case and check that there are no broken or cracked molded parts or other signs of physical damage, and that all screws are tight.

MECHANICAL INSPECTION

Cradle and Case Blocks

Check that the fingers on the cradle and the case agree with the internal connection diagram. Check that the shorting bars are in the correct position. Check that each finger with a shorting bar makes contact with the shorting bar. Deflect each contact finger to insure that there is sufficient contact force available. Check that each auxiliary brush is bent high enough to contact the connecting plug.

TARGET UNIT

The target unit has an operating coil tapped at 0.6 and 2.0 amperes. The relay is shipped from the factory with the tap screw in the higher ampere position. The tap screw is the screw holding the right-hand tap plate. To change the tap setting, first remove one screw from the left-hand plate and place it in the desired tap. Next remove the screw from the undesired tap and place it on the left-hand plate where the first screw was removed. See Fig. 18. Screws should never be left in both taps at the same time.

TABLE XI

TARGET PICKUP CURRENTS

TAP	PICKUP CURRENT IN AMPERES
0.6	0.35-0.6
2.0	1.15-2.0

The backing strip should be so formed that the forked end (front) bears against the molded strip under the armature. Since mechanical adjustments may affect the Seismic Fragility Level, it is advised that no mechanical adjustments be made if seismic capability is of concern.

TELEPHONE RELAY

With telephone relays in the de-energized position all circuit closing contacts should have a gap of at least 0.015 inch and all circuit opening contacts have a wipe of at least 0.005 inch. Gap may be checked by inserting a feeler gage between the contacts and wipe can be checked by observing the amount of deflection on the stationary contact before parting the contacts. The armature should then be operated by hand and the gap and wipe again checked as described above.

ELECTRICAL TESTS-GENERAL

All alternating current operated devices are affected by frequency. Since non-sinusoidal waveforms can be analyzed as a fundamental plus harmonics of the fundamental frequency, it follows that alternating current devices (relays) will be affected by the applied waveform. Therefore, in order to properly test alternating current relays it is essential to use a sine wave source of current or voltage.

DIELECTRIC TESTS

1. Introduction

The surge capacitors (C1-C9 and C15-C20) used in the type SLY relay do not have voltage ratings to withstand AC hipot voltage; therefore, caution must be exercised when hipotting to avoid damaging these capacitors.

It is recommended that hipot tests be performed on a bench with the relay in its case. If the relay is to be hipot tested together with other apparatus in an equipment, all external connections to terminal 10 (surge ground) must be removed.

The hipot test voltage should be 1500 volts RMS, 50 or 60 hertz for new relays or 1125 volts RMS, 50 or 60 hertz for other relays. New relays are defined as those which have not been in service, which are not more than one year old from the date of shipment, and which have been suitably stored to prevent deterioration. The duration of application of the test voltage for both old and new relays should be 60 seconds.

2. Hipot Tests

a) Common Mode Hipot Tests (All terminals to case):

Temporary connections should be made to tie all relay terminals, including terminal 10, together. Hipot voltage can then be applied between this common connection and the relay case.

b) Transverse Mode Hipot Tests (Between circuits):

For hipot tests between circuits of the relay, the surge capacitors must be temporarily disconnected from the surge capacitor buses inside the relay. The relay terminals should be jumpered to provide the four groups of circuits shown in Table XII. Hipot voltage can then be applied between any two groups of circuits.

TABLE XII

CIRCUIT GROUPING FOR TRANSVERSE MODE HIPOT TESTS

CIRCUIT GROUP	JUMPER BETWEEN TERMINAL NUMBERS
AC Current	1,2,3,4,5, and 6
AC Potential	15,16 and 17
DC Control Power	9,19 and 20
Output Contacts	11,12,13 and 14

An alternate test using a 500 volt DC megger can be performed between the circuit groups of Table XII with the surge capacitors connected in their normal manner. While this method does not test the relay to its full dielectric rating, it will detect some cases of degraded insulation.

3. Restoring Relay to Service

After the hipot or megger testing is completed, the surge capacitors should be reconnected to the surge capacitor buses and all external wiring to terminal 10 should be reconnected. The reach tests described under the ACCEPTANCE TESTS section of this book should then be repeated.

DETAILED TESTING INSTRUCTIONS

1. Required Settings

Make certain all the relay settings have been made. These should be in accordance with the setting calculations. The settings are:

a) Base reach (Z_{R1}) is set on the tap block at rear of relay. All three phase settings should be the same.

b) Percent restraint (T) is set on the precision potentiometer on the front of the relay.

c) Offset tap (R) is set on the CP card. Note that R=0 is selected by removing the jumper altogether.

2. Relay Base Reach Angle and Reach Check

The following procedure is recommended to check the base reach angle (Ø) and the relay reach setting (Z_R).

a) Make the test connections shown in Fig. 25 for the particular phase being tested. (The test connections shown in Fig. 19 may also be used.)

b) Adjust the load box until the ammeter indicates the desired test current (I_T). See Table XIII for the recommended test current for a desired reach.

TABLE XIII

RECOMMENDED TEST CURRENT

5 Ampere Rated Relay		1 Ampere Rated Relay	
Base Reach Tap	Recommended Minimum Test Current	Base Reach Tap	Recommended Minimum Test Current
0.75	8	3.75	1.6
1.5	4	7.5	0.8
3	2	15.	0.4

c) Adjust the phase angle for the nominal base reach angle of 85 degrees.

d) Observe the waveform at the following test point (on OS card) with an oscilloscope.

1) "AOUT" for phase pair A-B

2) "BOUT" for phase pair B-C

3) "COUT" for phase pair C-A

e) Lower the voltage V_T to the value given in equation (1) below:

$$\dagger\ V_T = 2 \times I_T \times Z_{R1} \times \frac{100}{T} \qquad (1)$$

where

I_T = test current in amperes RMS

T = restraint voltage setting in percent

V_T = pickup voltage at the base reach angle in volts RMS

Z_{R1} = base reach tap in ohms

† V_T should not be greater than 10% above the relay's rated voltage. If V_T is greater, reduce I_T until V_T is correct.

f) As the voltage is lowered, observe the waveform at the test point designated in step d) above. At the point where the telephone relay (K2) picks up, a slight adjustment of the phase angle and input voltage will cause the waveform to be reduced to a null consisting of only third and fifth harmonics. At this null point, the angle on the phase angle meter is the base reach angle Ø and should be within two degrees of the nominal value of 85 degrees. The voltage V_T at this null condition should be within five percent of the value calculated by equation (1).

NOTE: THE MEASURED PICKUP SHOULD AGREE WITH THE CALCULATED VALUE WITHIN FIVE PERCENT. IF THE VALUES DO NOT AGREE WITHIN THESE LIMITS, IT IS RECOMMENDED THAT THE TEST SETUP AND METER CALIBRATIONS BE CHECKED BEFORE THE FACTORY SETTINGS ON THE RELAY ARE DISTURBED. ONE GOOD METHOD OF CHECKING THE TEST SET-UP AND PROCEDURE IS TO REPEAT THE TESTS ON A DUPLICATE RELAY.

g) If it is desired to readjust the reach so that measured pickup occurs at a value closer to the calculated value, this may be accomplished by means of the trim potentiometers on the SP card. The potentiometer to be adjusted for each phase is shown in Table XIV. These potentiometers should be turned clockwise to increase the reach.

TABLE XIV

REACH ADJUSTMENT LOCATIONS

PHASE UNDER TEST	POTENTIOMETER DESIGNATION
AB	P1
BC	P3
CA	P5

3. Testing Mho Characteristics

The complete mho characteristic can be measured by the same test circuit (Fig. 19) as used for the preceding REACH TESTS. The procedure is similar except that the phase shifter is adjusted until the phase angle meter indicates the angle of interest. Reduce the voltage out of the variac until the relay picks up. The value of V_T at this point should be as shown in Fig. 20 for the particular offset (R) setting.

NOTE: The connections shown in Figure 25 are the recommended test connections for checking the complete mho characteristic. The connections shown in Fig. 19 may also be used; but, if these connections are used, pull back may occur at some angles. The amount of pull back can be kept to a minimum by using the highest value of test current that is practical.

4. Offset (R Setting) Tests

The value of offset must be measured by the test circuit shown in Figure 19. The procedure is similar except that the phase shifter is adjusted until the phase angle meter indicates 265° (180° plus nominal angle of maximum reach). Reduce the voltage of the variac until the relay picks up. The value of VT at this point should be as given by equation (2)

$$\dagger VT = 2 \times IT \left(\frac{ZR1 \times R}{1.15}\right) \quad (2)$$

where
R = offset in per unit

† V_T should not be greater than 10% above the relay's rated voltage. If V_T is greater, reduce I_T until V_T is correct.

5. Alternate Test Method for Reach Tests

An alternate method of testing the relay characteristic is shown in Fig. 21 where the R-X test combination is employed. The circuit uses the test box (102L201), test reactor (6054975) and test resistor (6158546) described in GEI-44236. Since a limited number of resistor-reactor fault impedances are available, only a few points on the relay characteristic can be checked.

6. Integrating Timer Tests

The integrating timer (IT) card has three adjustments as indicated in Table XV.

TABLE XV

TIMER ADJUSTMENT LOCATIONS

POTENTIOMETER DESIGNATION	POTENTIOMETER LOCATION	FUNCTION	60 HZ RELAY FACTORY SETTING MILLISECONDS	50 HZ RELAY FACTORY SETTING MILLISECONDS
P1	Bottom	Transient Pickup Time	3.7	4.44
P2	Top	Steady State Pickup Time	3.5	4.2
P3	Middle	Dropout Time	50	60

These potentiometers have been factory set and should not be adjusted unless a plot of the mho characteristics indicates an improper pickup time setting. The P1 potentiometer, used for transient operation, has been set in co-ordination with the P2 potentiometer at the factory and sealed. All three of these potentiometers increase their time settings when they are turned clockwise.

Note: When checking the setting of the timer using the input for one phase, always connect the inputs for the other two phases to reference.

The test circuit of Fig.25 may be used to check the steady-state pickup time setting. A dual-trace oscilloscope should be used, with channel "1" connected to test point "AIN" on the IT card and channel "2" on test point "OUT" on the IT card. Reduce "V_{IN}" until the relay picks up. The output (channel 2) should go positive 3.5 milliseconds ± 0.2 millisecond after the the input (channel 1) goes positive.

To check the transient pickup time setting, the following procedure should be used:

a) Remove the CL card.

b) Connect the test circuit of Figure 22.

c) With the oscilloscope trigger on positive slope, open the normally closed contact. The channel-2 trace should step positive 3.7 milliseconds ±0.2 millisecond after the channel-1 trace steps positive.

To check the dropout time setting, the following procedure should be used:

a) Remove the CL card.

B) Connect the test circuit of Figure 22.

C) With the oscilloscope trigger on negative slope, close the normally closed contact. The channel-trace should step negative 50 milliseconds (±2.5 milliseconds) after the channel-1 trace steps negative.

INSTALLATION PROCEDURE

INTRODUCTION

The relay should be mounted on a vertical surface. The outline and panel drilling diagram is shown in Fig. 17.

The location should be clean, dry, free from dust or excessive vibration and well lighted to facilitate inspection and testing.

The internal connection diagram for the relay is shown in Fig. 2. Typical external connections are shown in Fig. 3.

SURGE GROUND AND RELAY CASE GROUND CONNECTIONS

One of the mounting studs or screws should be permanently connected to ground by a conductor not less than No. 12 AWG gage copper wire or its equivalent. This connection is made to ground the relay case. In addition, Terminal 10 designated as "surge ground" on the internal connections diagram must be tied to ground for the surge suppression networks in the relay to perform properly. This surge ground lead should be as short as possible to ensure maximum protection from surges (preferably ten inches or less to reach a solid ground connection).

With Terminal 10 connected to ground, "surge ground" is connected electrically to the relay case. The purpose of this connection is to prevent high frequency transient potential differences from entering the solid state circuitry. Therefore, with Terminal 10 connected to ground the surge capacitors are connected between the input terminals and the case. When hipotting the relay, the procedure given in DIELECTRIC TESTS under the ACCEPTANCE TESTS section of this book must be followed.

TEST PLUGS

The relay may be tested without removing it from the panel by using a 12XLA13A test plug. This plug makes connections only with the relay and does not disturb any shorting bars in the case. Of course, the 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it also requires current transformer shorting jumpers and the exercise of greater care since connections are made to both the relay and the external circuitry. Additional information on the XLA test plugs may be obtained from instruction book GEI-25372.

INSTALLATION TESTS

Since operating companies use many different procedures for installation tests, the section under ACCEPTANCE TESTS contains all necessary tests which may be performed as part of the installation procedure at the discretion of the user.

The minimum suggested tests are as follows:

1. VISUAL INSPECTION

   Repeat the items described under ACCEPTANCE TESTS - VISUAL INSPECTION.

2. MECHANICAL INSPECTION AND ADJUSTMENTS

   Repeat the items described under ACCEPTANCE TESTS - MECHANICAL INSPECTION.

3. TARGET UNIT

   Set the target unit tap screw in the desired position. The adjustment will not be disturbed if a screw is first transferred from the left plate to the desired tap position on the right tap plate and then removing the screw in the undesired tap and transferring it to the left plate. Do not leave the relay with two screws in the right tap plate.

4. REACH TESTS

   a) Using the values selected in the CALCULATION OF SETTINGS section of this book, set:

      - Base reach (Z_{R1}) on the back of the relay
      - Percent restraint (T) on the front panel potentiometer
      - Percent offset reach (R) on the "CP" printed circuit card (three plugs).

   b) Measure the relay reach at 85 degrees as described in the ACCEPTANCE TESTS section of this book.

PERIODIC TESTING AND ROUTINE MAINTENANCE

In view of the vital role of protective relays in the operation of a power system it is important that a periodic test program be followed. It is recognized that the interval between periodic checks will vary depending upon environment, type of relay and the user's experience with periodic testing. Until the user has accumulated enough experience to select the test interval best suited to his individual requirements it is suggested that the points listed under INSTALLATION PROCEDURE be checked at an interval of from one to two years.

Check the items described under ACCEPTANCE TESTS - VISUAL INSPECTION AND MECHANICAL INSPECTION. Examine each component for signs of overheating, deterioration or other damage. Check that all connections are tight by observing that the lockwashers are fully collapsed.

CONTACTS

Examine the contacts for pits, arc or burn marks, corrosion, and insulating films. For cleaning contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched-roughened surface resembling, in effect, a superfine file. The polishing action is so delicate that no scratches are left, yet it will clean off any corrosion throughly and rapidly. Its flexibility insures the cleaning of the actual points of contact. Do not use knives, files, abrasive paper or cloth of any kind to clean relay contacts.

ELECTRICAL TESTS

The reach tests described under the ACCEPTANCE TESTS section should be repeated and the results compared against the desired setting. If the measured value is slightly different from that measured at a previous time, this is not necessarily an indication that the relay should be readjusted. The errors of all the test equipment is often additive and the total error of the present setup may be of opposite sign from the error at the previous periodic test. Instead of readjusting the relay it is recommended that, if the apparent error is acceptable, no adjustment be made and that the error be noted on the relay test record. After sufficient test data has accumulated, it will become apparent whether the measured errors in the setting are due to random variations in the test conditions or are due to a one-time drift in the characteristics of the relay.

SERVICING

CAUTION

Remove ALL power from the relay before removing or inserting any of the printed circuit boards. Failure to observe this caution may result in damage to and/or misoperation of the relay.

A recommended troubleshooting procedure is shown in Table XVI.

TABLE XVI

TROUBLESHOOTING PROCEDURE

PROBLEM	PROBABLE CAUSE	TROUBLESHOOTING SEQUENCE
I. Power supply monitor LED is not on.	1. Plus and/or minus 15 VDC missing.	1. Check +15V and -15V test points on PS card. If either or both voltages are not between 14 and 16 volts check that rated DC voltage (48 or 125 VDC) is on PS card pin 40(+) to pin 24(-). If not, check input terminals 19(+) to 20(-).
	2. Defective LED, zener diode CR15 or resistor R15.	2. Replace PS card.
II. Relay will not pick up when it should on any of the three phases but power supply monitor LED is on.	1. Defective telephone relay (K2) or target (T1).	1. Remove PS card and jumper pins 17 and 40 of the PS card. If the relay does not pick up, then K2 or T1 is defective.
	2. Defective reed relay (K1).	2. If the relay picks up with the jumper in the preceding step (1) then remove the jumper and reinsert PS card. Remove the CL card and the relay should pick up. If not, K1 relay is possibly defective. Change the PS card.

PROBLEM	PROBABLE CAUSE	TROUBLESHOOTING SEQUENCE
II. Cont'd	3. Defective IT card.	3. If replacing the PS card in the preceding step (2) does not cause pickup (with the CL card still removed) the IT card is possibly defective. Change the IT card.
III. Relay will not pick up when it should on one phase, but picks up correctly on another phase.	1. Defective card.	1. Change printed circuit cards, one at a time, in the following order: IT, CL, SP, CP, OS.
IV. Out of specification in maximum reach $\pm 30^{\circ}$ tests.	1. Incorrect steady state pickup time on IT card. 2. Defective card.	1. Set steady state pickup time pot and recheck other phases. 2. Change printed circuit cards, one at a time, in the following order: SP, CP, IT, CL, OS.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken or damaged.

Should a printed circuit card become inoperative, it is recommended that this card be replaced with a spare. A special tool (see Fig. 16) is available for removing the printed circuit cards from their sockets and this tool should always be used for removal. In most instances, the user will be anxious to return the equipment to service as soon as possible and the insertion of a spare card represents the most expeditious means of accomplishing this. The faulty card can then be returned to the factory for repair or replacement.

Although it is not generally recommended, it is possible with the proper equipment and trained personnel to repair cards in the field. This means that a troubleshooting program must isolate the specific component on the card which has failed. By referring to the internal connection diagram for the card, it is possible to trace through the card circuit by signal checking and, hence determine which component has failed. This, however, may be time consuming and if the card is being checked in place in its unit, as is recommended, will extend the outage time of the equipment.

CAUTION:

GREAT CARE MUST BE TAKEN IN REPLACING COMPONENTS ON THE CARDS. SPECIAL SOLDERING EQUIPMENT SUITABLE FOR USE ON THE DELICATE SOLID-STATE COMPONENTS MUST BE USED AND, EVEN THEN, CARE MUST BE TAKEN NOT TO CAUSE THERMAL DAMAGE TO THE COMPONENTS, AND NOT TO DAMAGE OR BRIDGE OVER THE PRINTED CIRCUIT BUSES. THE REPAIRED AREA MUST BE RECOATED WITH A SUITABLE HIGH-DI-ELECTRIC PLASTIC COATING TO PREVENT POSSIBLE BREAK-DOWNS ACROSS THE PRINTED CIRCUIT BUSES DUE TO MOISTURE OR DUST.

ADDITIONAL CAUTION:

DUAL IN-LINE INTEGRATED CIRCUITS ARE ESPECIALLY DIFFICULT TO REMOVE AND REPLACE WITHOUT SPECIALIZED EQUIPMENT. FURTHERMORE, MANY OF THESE COMPONENTS ARE USED ON PRINTED CIRCUIT CARDS WHICH HAVE BUS RUNS ON BOTH SIDES. THESE ADDITIONAL COMPLICATIONS REQUIRE VERY SPECIAL SOLDERING EQUIPMENT AND REMOVAL TOOLS AS WELL AS ADDITIONAL SKILLS AND TRAINING WHICH MUST BE CONSIDERED BEFORE FIELD REPAIRS ARE ATTEMPTED.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of the part wanted, and the complete model number of the relay for which the part is required.

APPENDIX I

DEFINITION OF SYMBOLS

I_A	=	total phase A current in relay in amperes rms
I_B	=	total phase B current in relay in amperes rms
I_C	=	total phase C current in relay in amperes rms
I_T	=	relay current during test in amperes rms
R	=	ratio tap to provide offset in per unit
T	=	relay voltage restraint setting in percent
V_{AB}	=	phase A to phase B voltage in volts rms
V_{BC}	=	phase B to phase C voltage in volts rms
V_{CA}	=	phase C to phase A voltage in volts rms
V_{AB1}	=	positive sequence of V_{AB} voltage in volts rms
V_{BC1}	=	positive sequence of V_{BC} voltage in volts rms
V_{CA1}	=	positive sequence of V_{CA} voltage in volts rms
V_T	=	relay voltage during test in volts rms
Z_1	=	system positive sequence phase to neutral impedance in ohms
Z_{1L}	=	line positive sequence phase to neutral impedance in ohms
Z_{1S}	=	source positive sequence phase to neutral impedance in ohms
Z_{2L}	=	line negative sequence phase to neutral impedance in ohms
Z_{2S}	=	source negative sequence phase to neutral impedance in ohms
Z_F	=	system impedance between relay location and fault location in ohms
Z_R	=	relay reach in ohms
Z_{R1}	=	base reach tap in positive sequence ohms
α	=	phase angle meter reading during test in degrees
ϕ	=	relay base reach angle in degrees

LIST OF ILLUSTRATIONS

Since the last edition, changes have been made in the DETAILED TESTING INSTRUCTIONS, 2. Relay Base Reach Angle and Reach Check, step a), 3. Testing Mho Characteristics, and 6. Integrating Timer Tests.
Also, Fig. 17 has been redrawn.

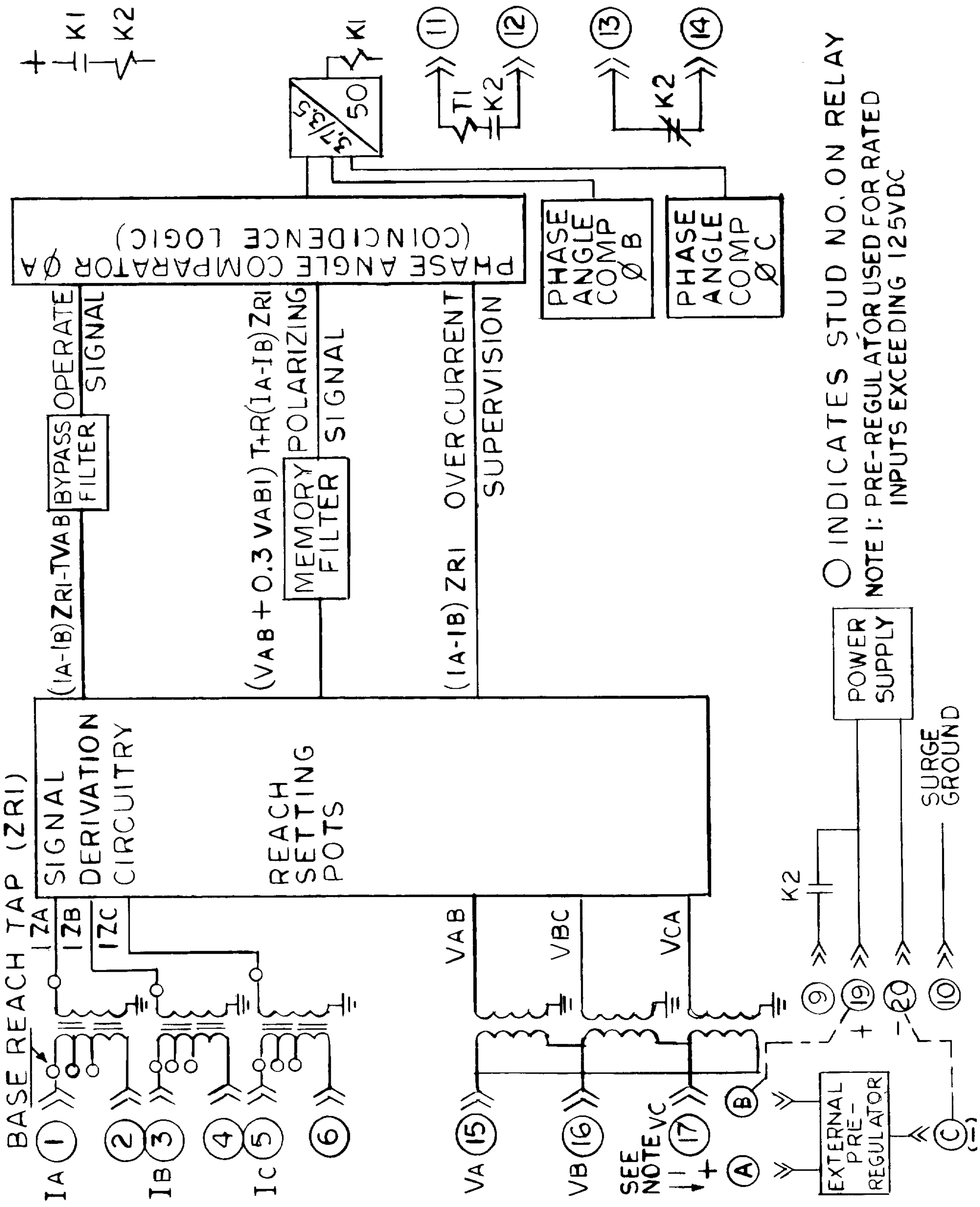


Fig. 1 (0273A9157-1) Functional Block Diagram

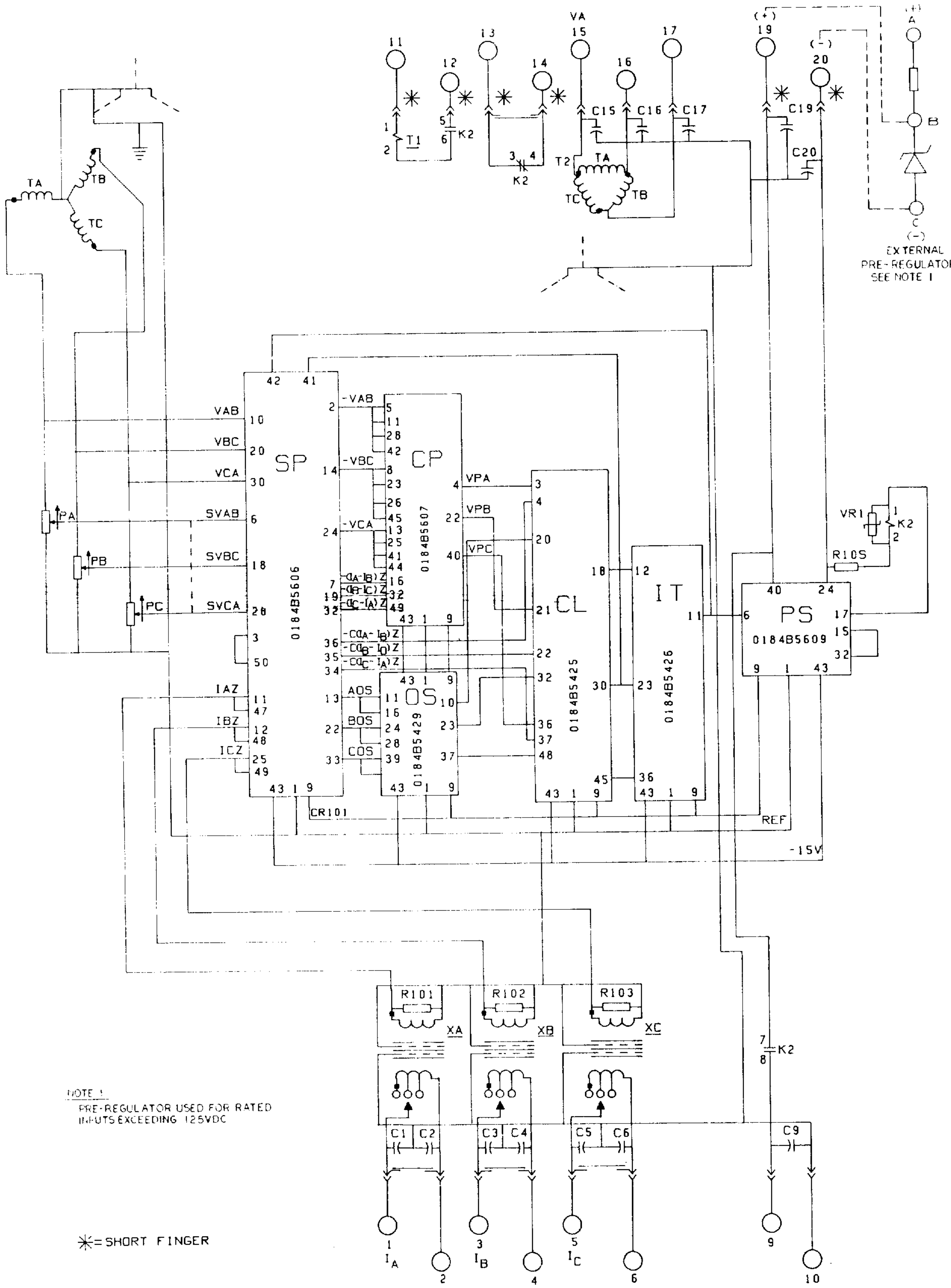


Figure 2 (0152C8462 [3]) Internal Connections

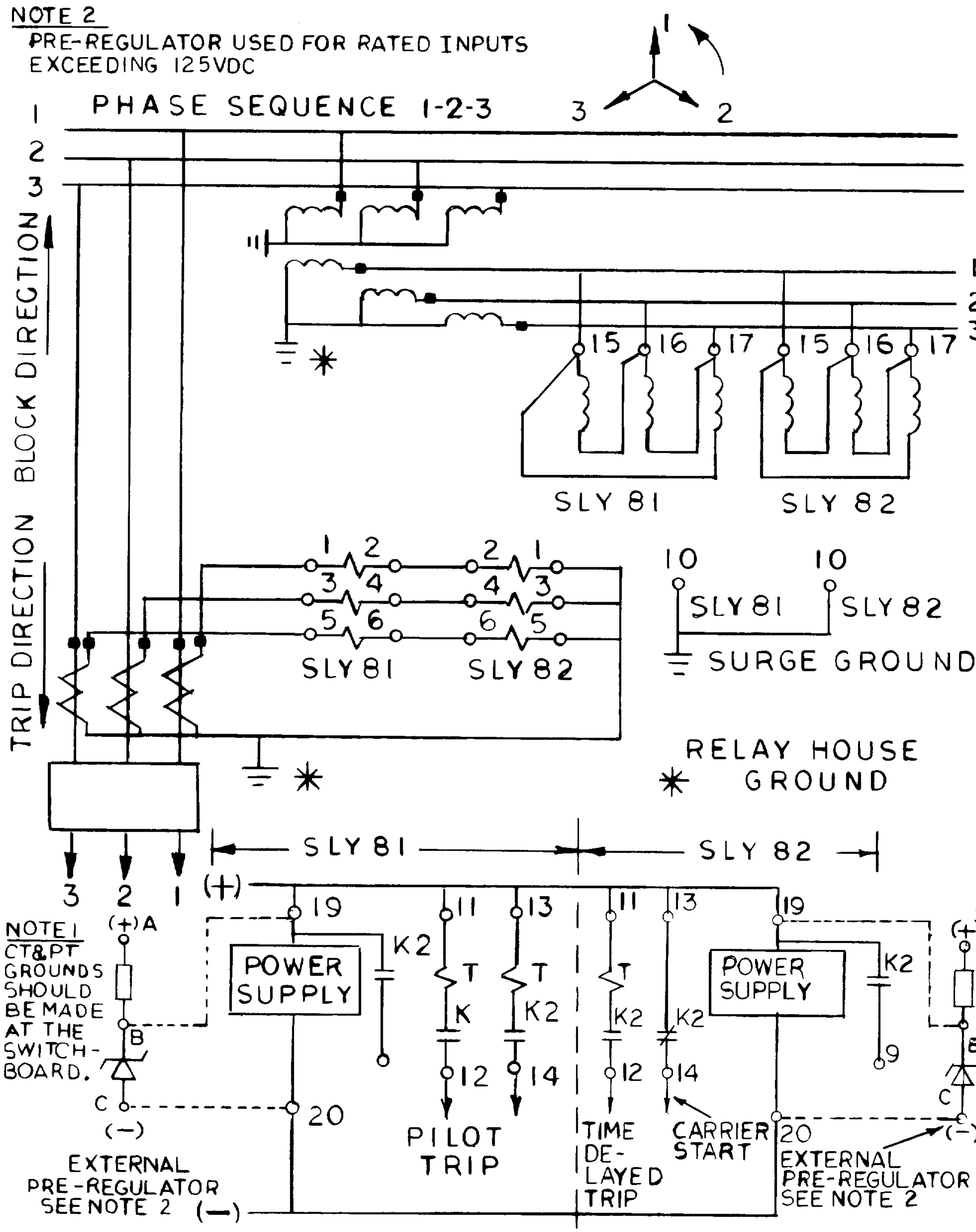


Fig. 3 (0273A9156-1) External Connections

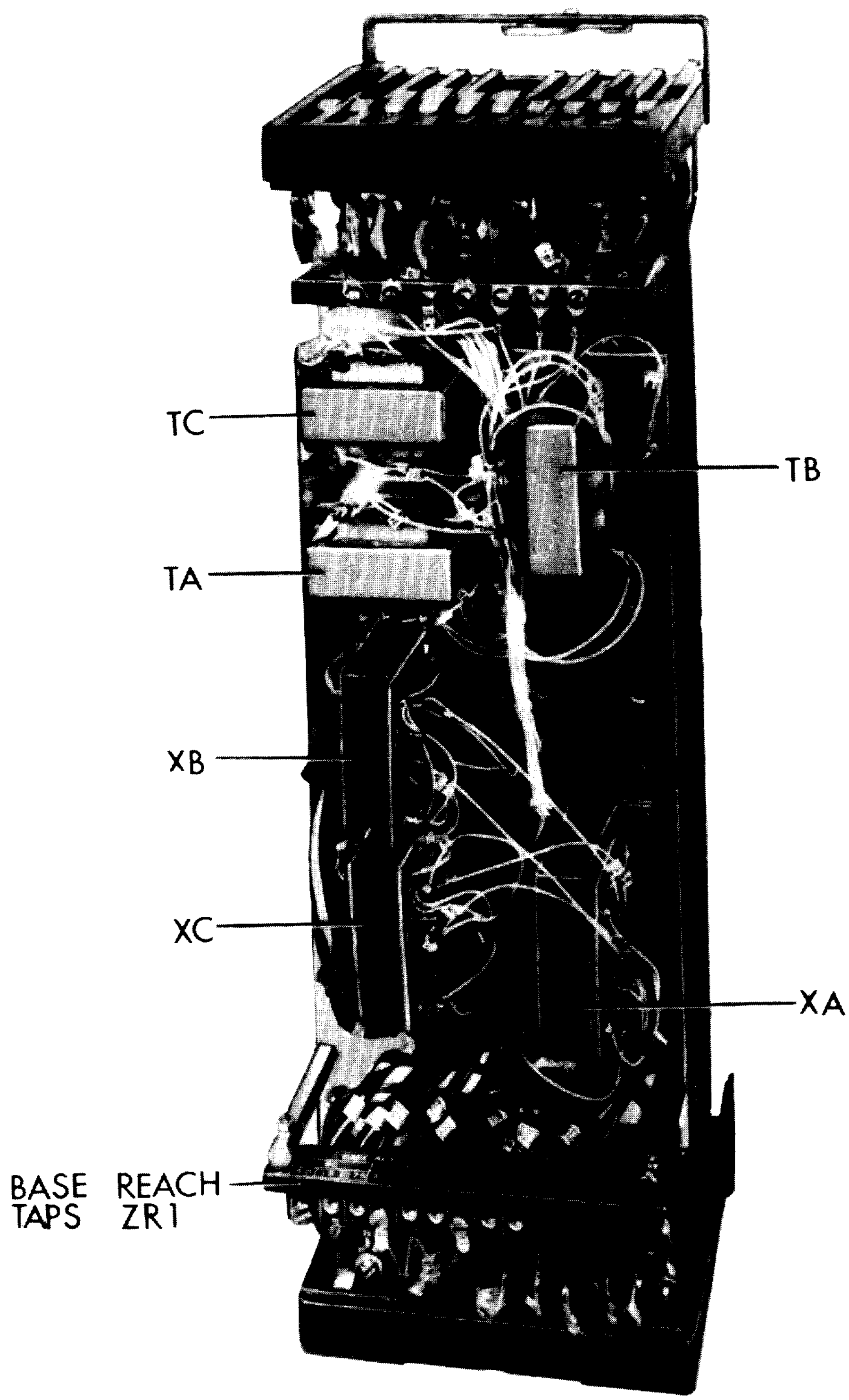


Fig. 4 (8043397) Rear View of Long Reach Model Out of Case

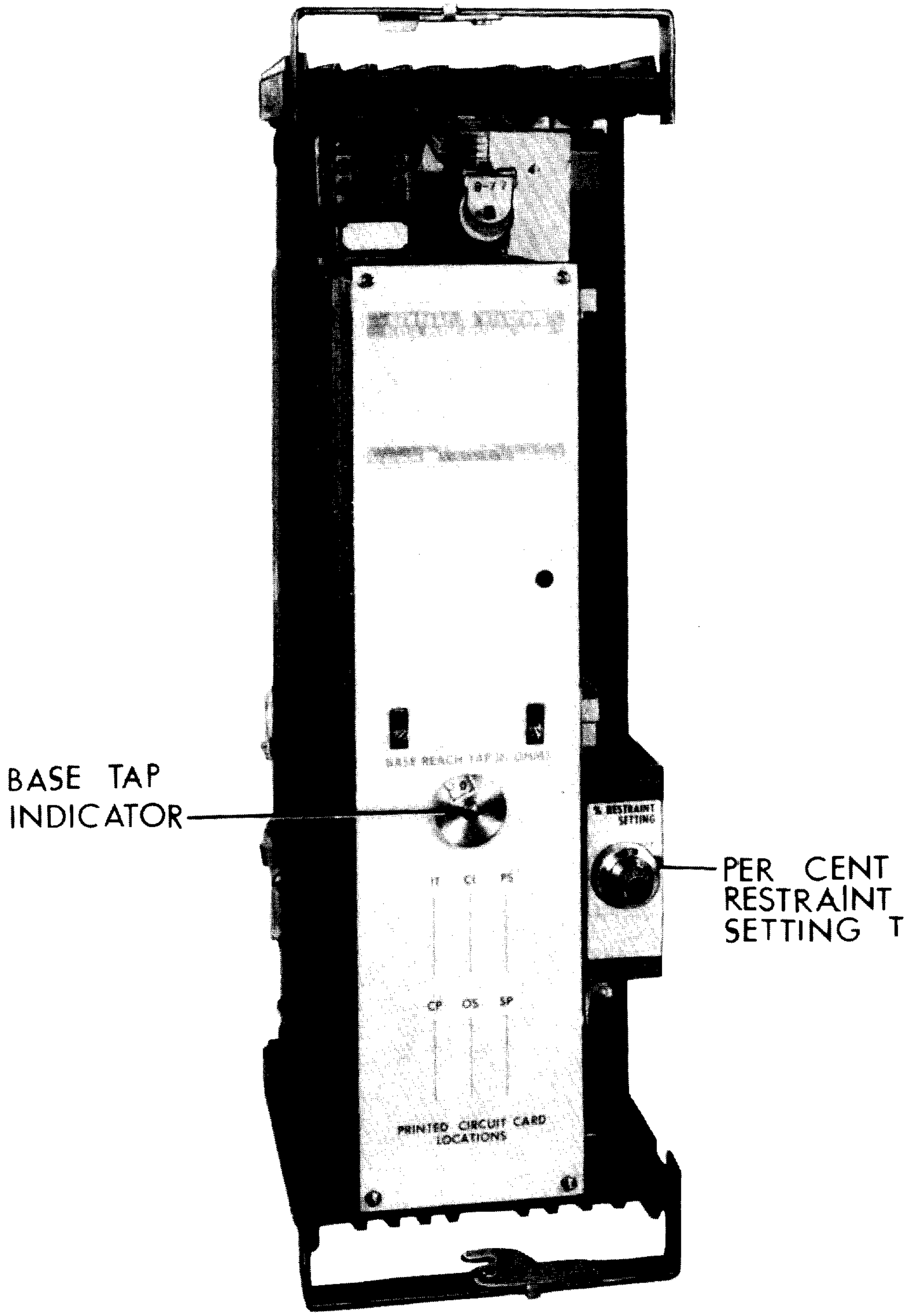


Fig. 5 (8043395) Front View of Relay Out of Case

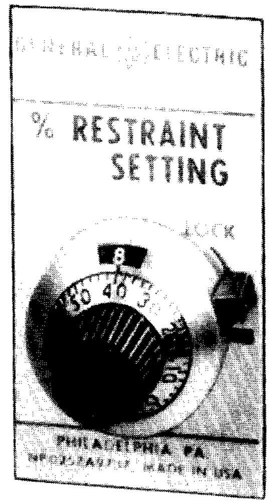


Fig. 6 (8042986) Restraint Setting Dial (Set at 84 Percent)

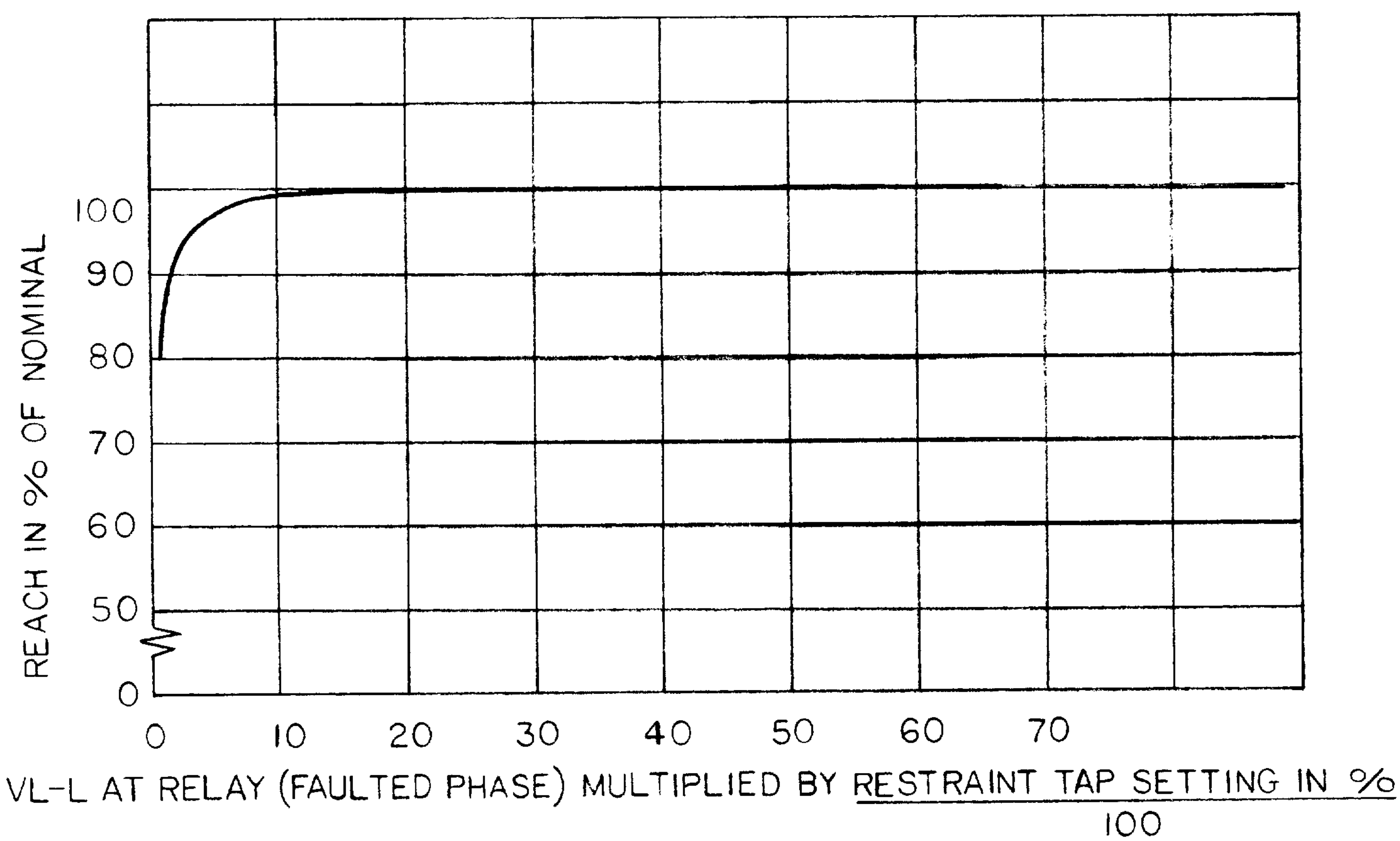


Fig. 7 (0273A9096-0) Reach Versus Faulted Phase Voltage

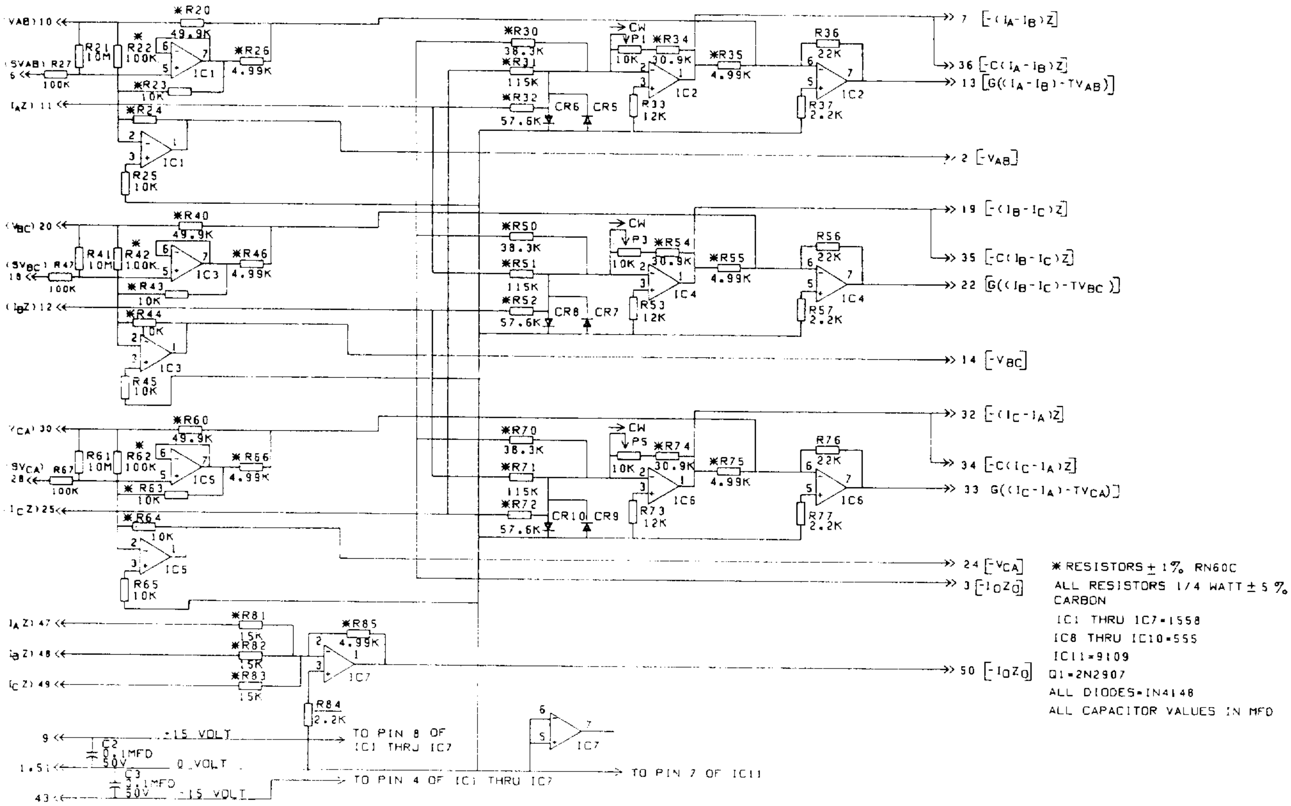


Figure 8A (0152C8463 Sh.2) Internal Connections for Signal Processing Card (SP)

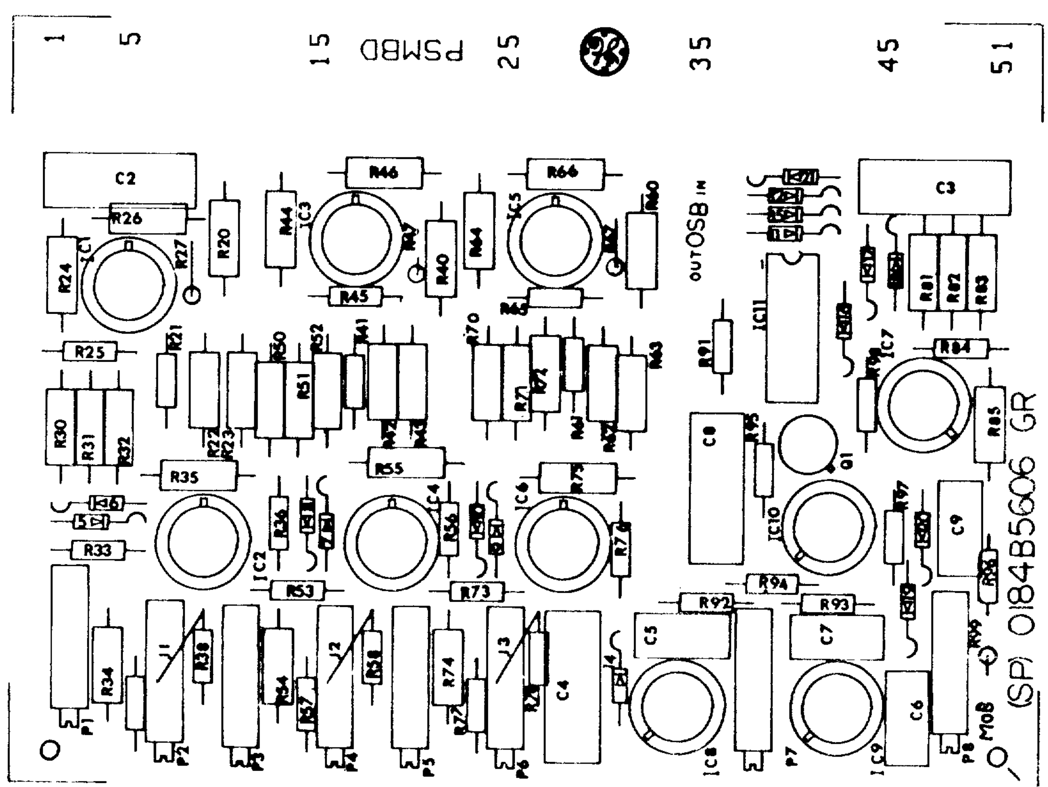


Figure 8B (0171C8706 SS Sh.1 [8]) Card Layout for Signal Processing Card (SP)

NOTES

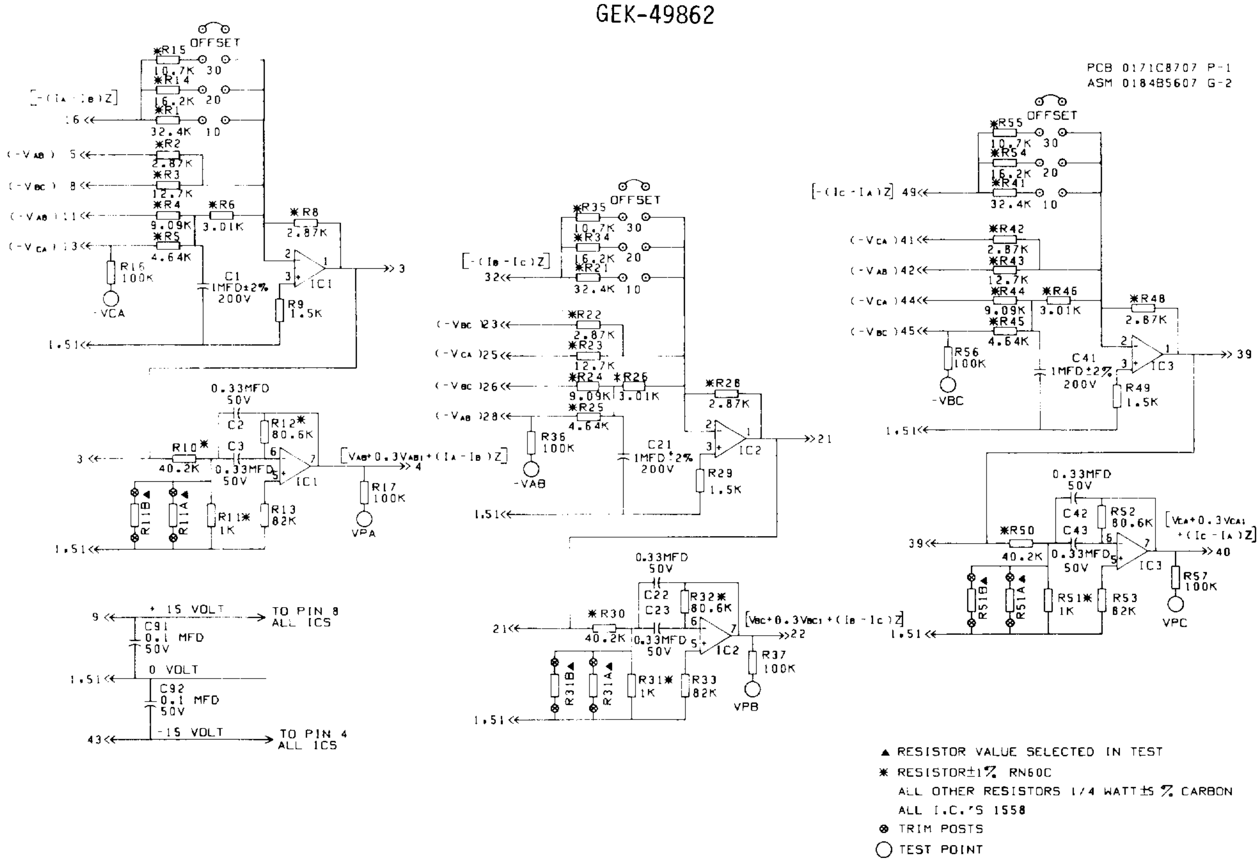


Fig. 9A (0152C8464-0 SH-2) Internal Connections for 60 Hertz Combined Polarizing Card (CP)

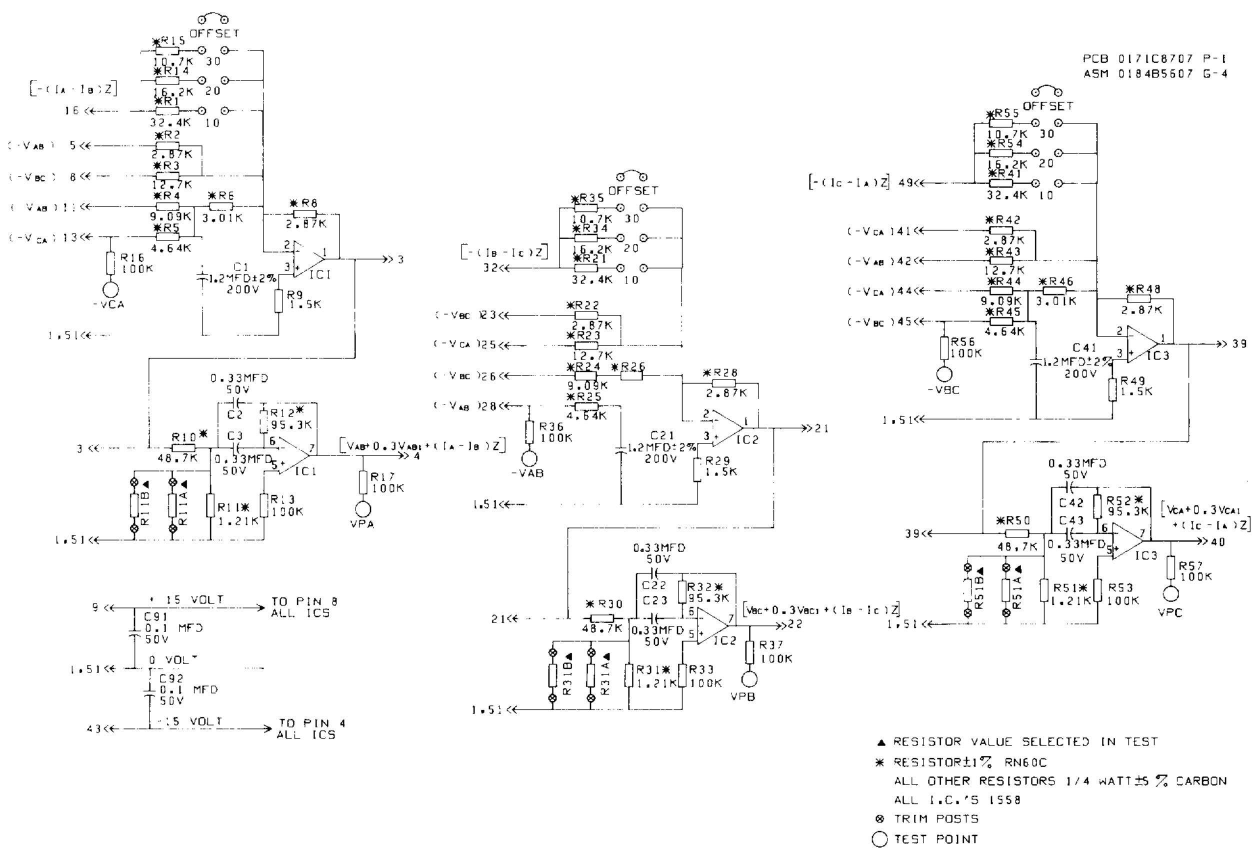


Fig. 9B (0152C8464-0 SH-4) Internal Connections for 50 Hertz Combined Polarizing Card (CP)

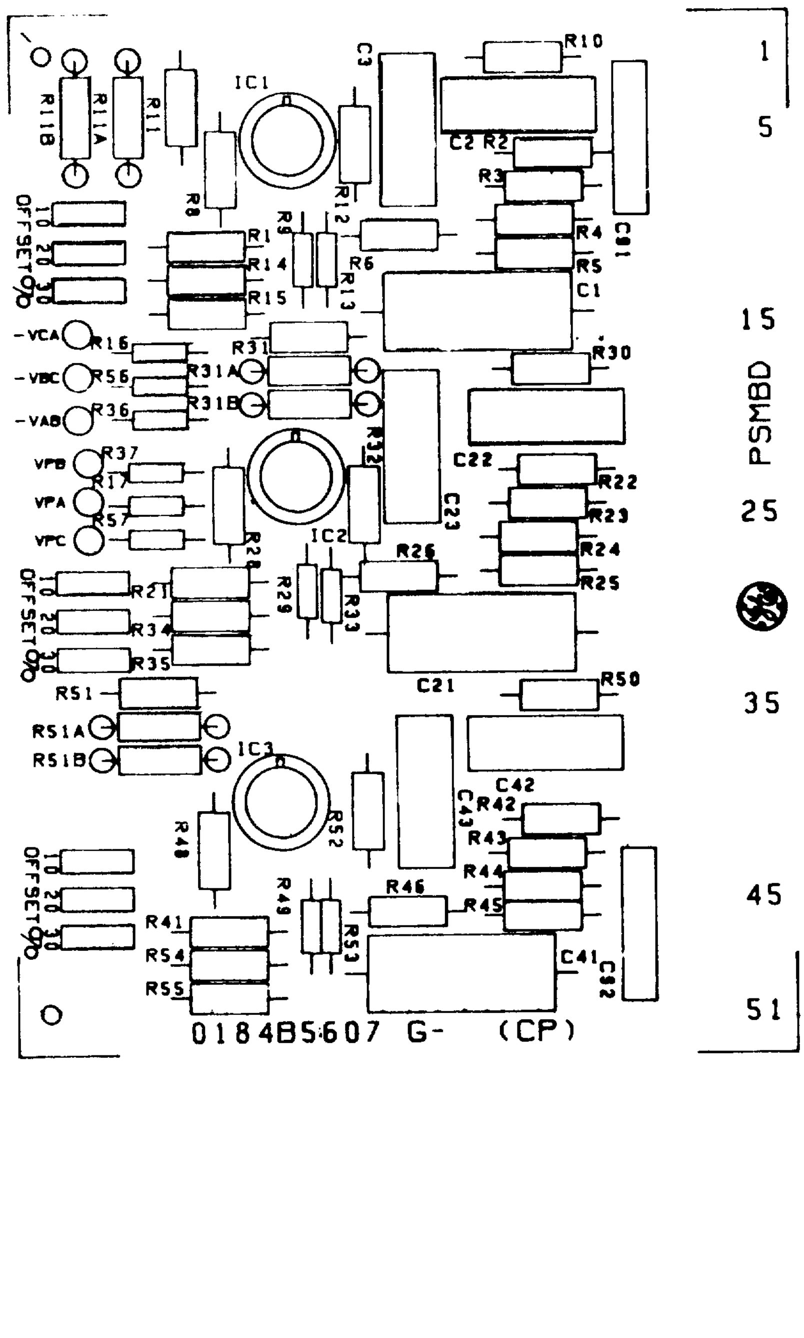


Figure 9C (0171C8707 SS Sh.1) Card Layout for Combined Polarizing Card (CP)

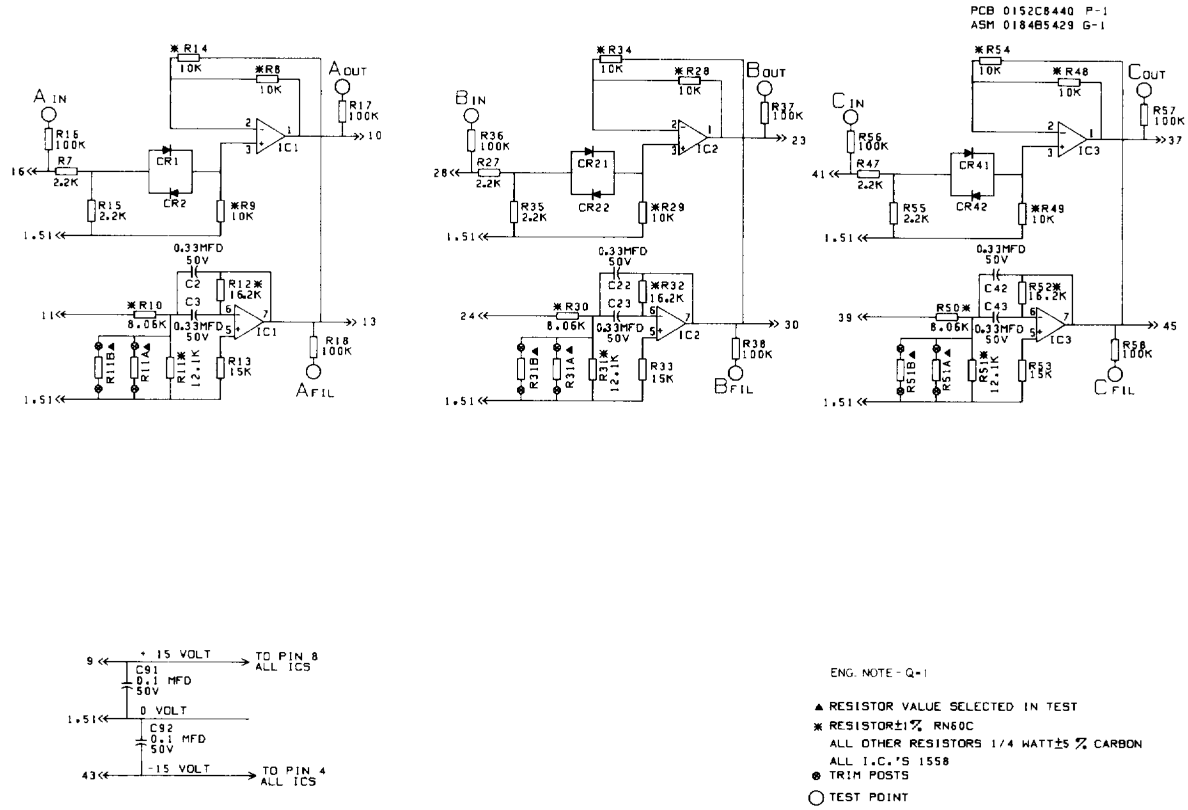


Fig. 10A (0152C9087-2 SH-1) Internal Connections for 60 Hertz Operate Signal Card (OS)

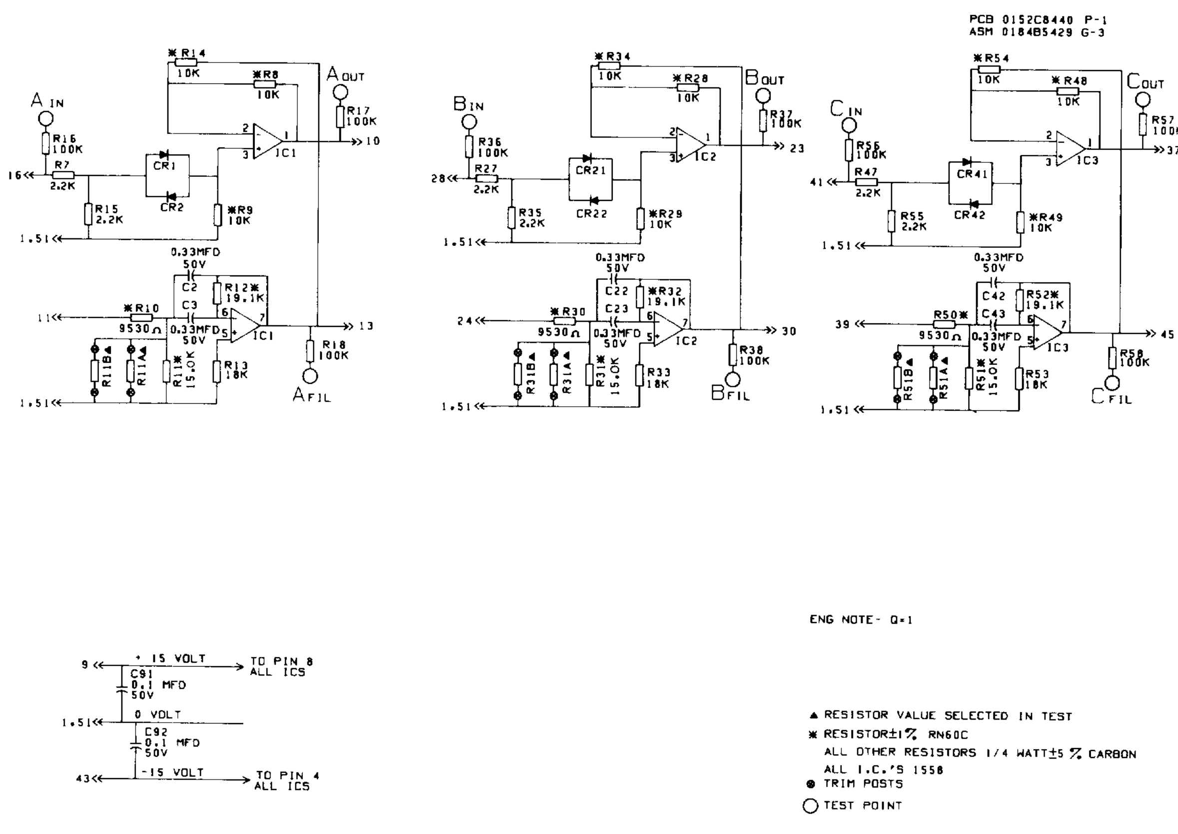


Fig. 10B (0152C9087-1 SH-3) Internal Connections for 50 Hertz Operate Signal Card (OS)

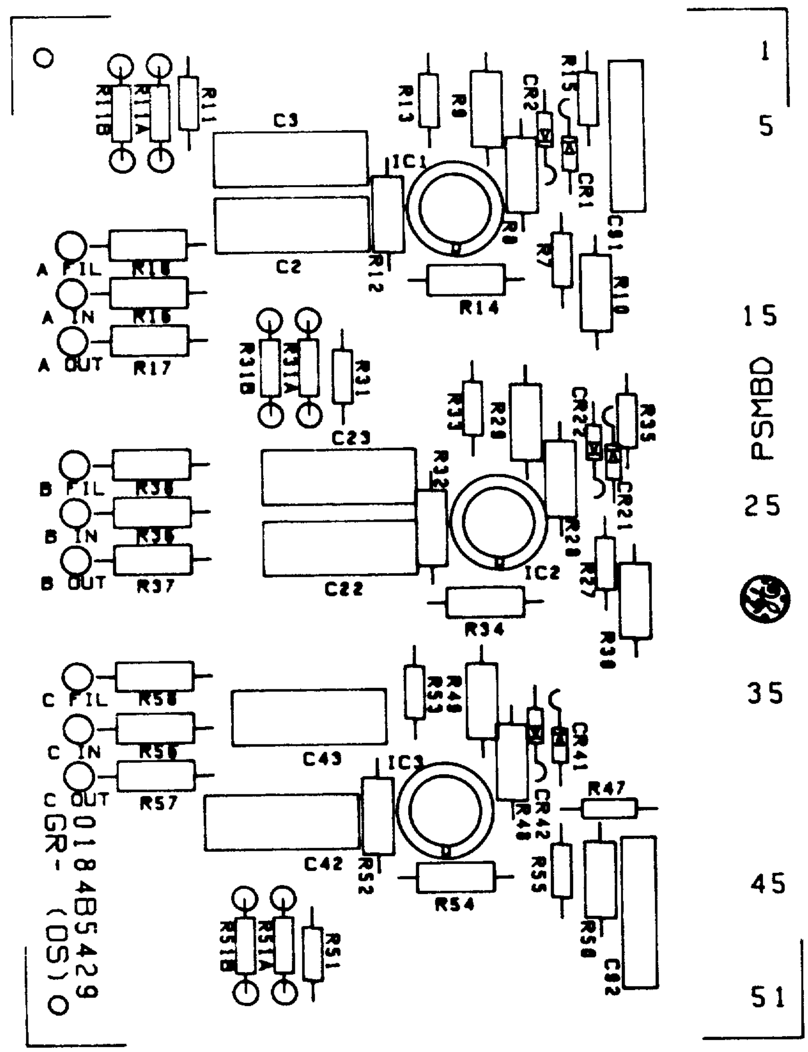


Figure 10C (0152C8440 SS Sh.1 [3]) Card Layout for Operate Signal Card (OS)

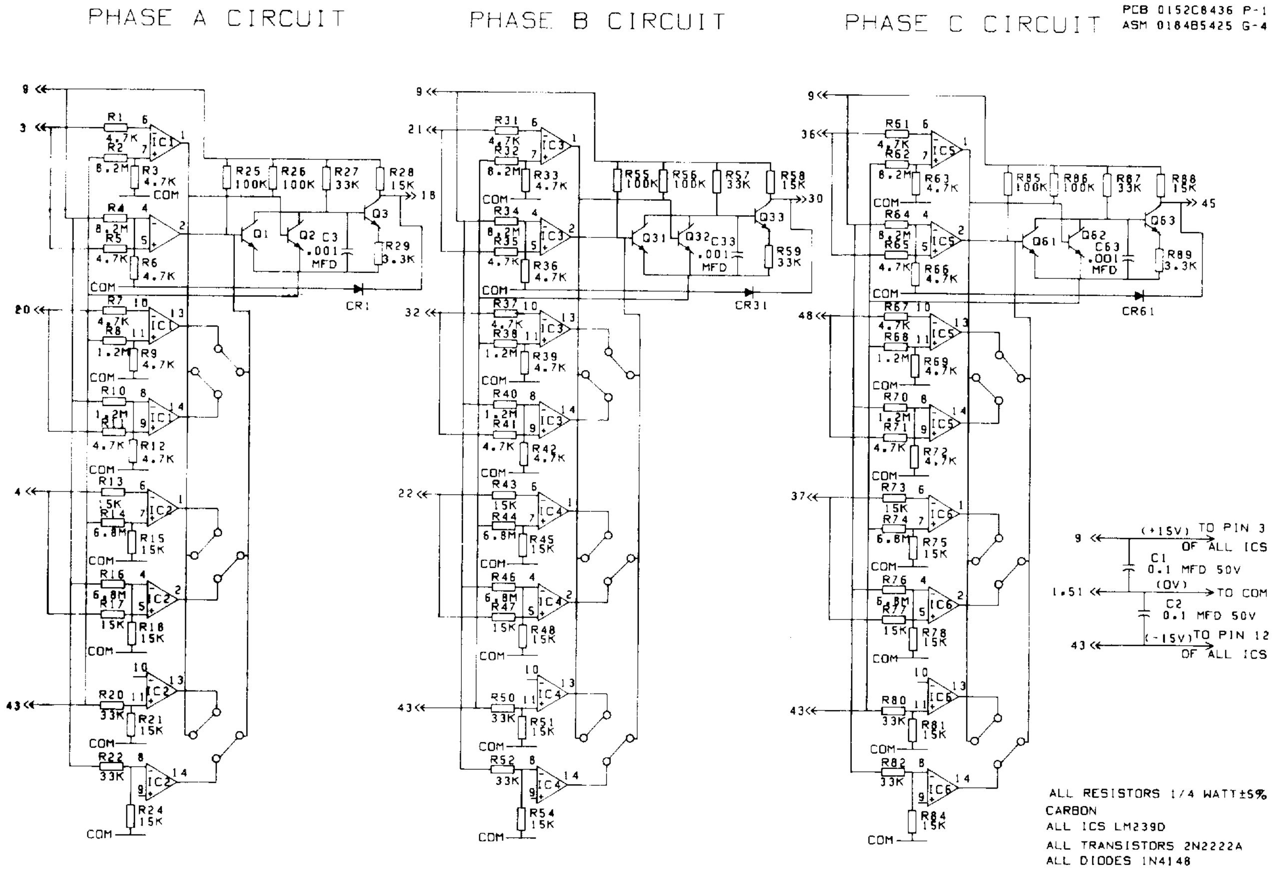


Fig. 11A (0152C9083-0 SH-4) Internal Connections for Coincidence Logic Card (CL)

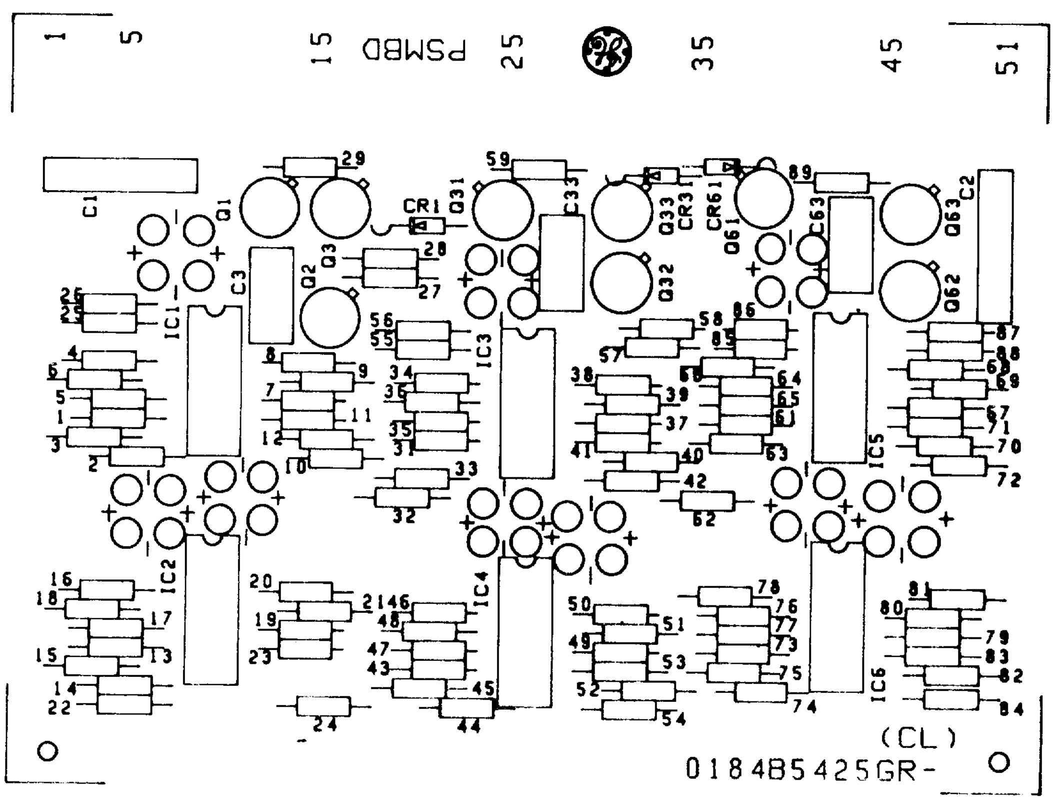


Figure 11B (0152C8436 SS Sh.1 [4]) Card Layout for Coincidence Logic Card (CL)

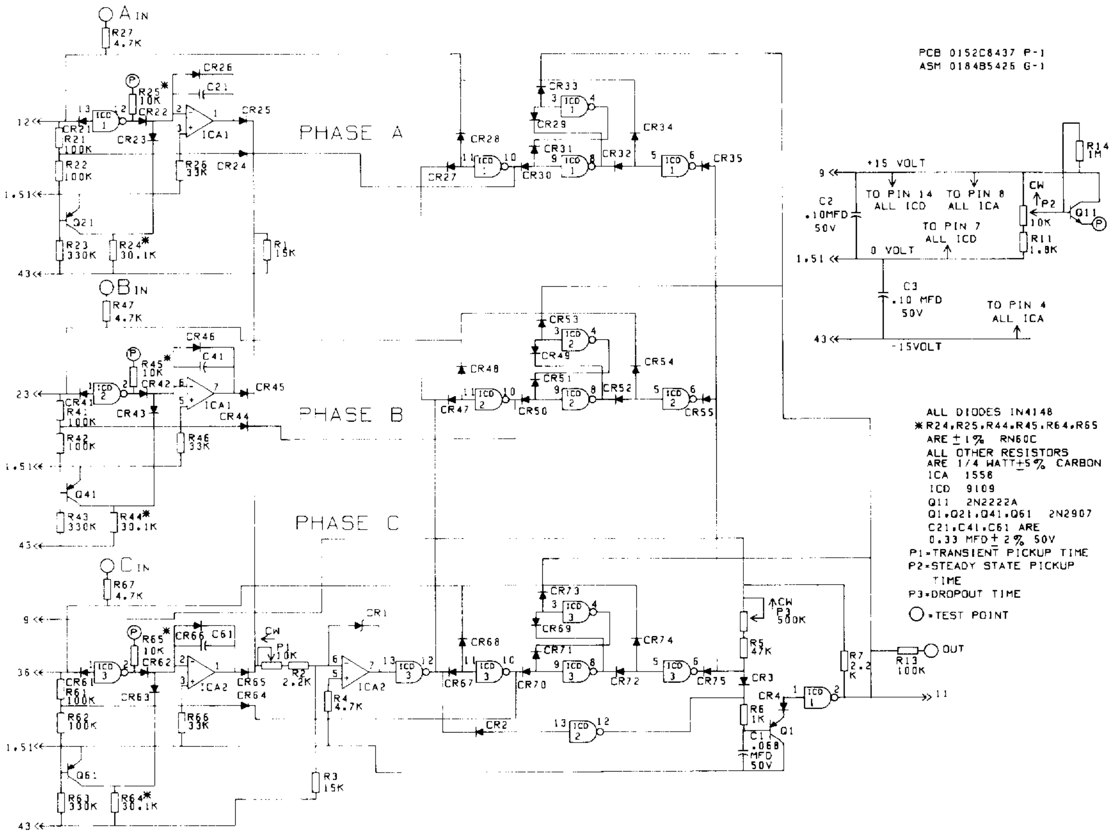


Fig. 12A (0152C9084-2 SH-1) Internal Connections for Integrating Timer Card (IT)

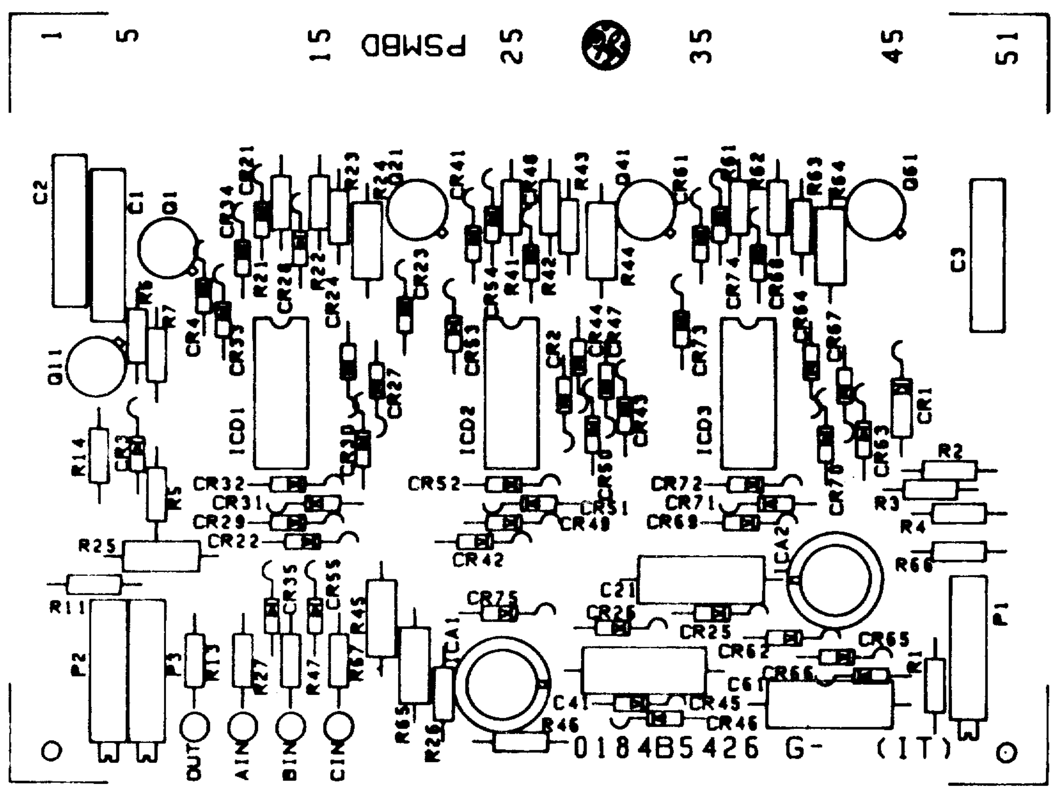


Figure 12B (0152C8437 SS Sh.1 [7]) Card Layout for Integrating Timer Card (IT)

PCB 0171C8709
ASM 0184B5609 G-1

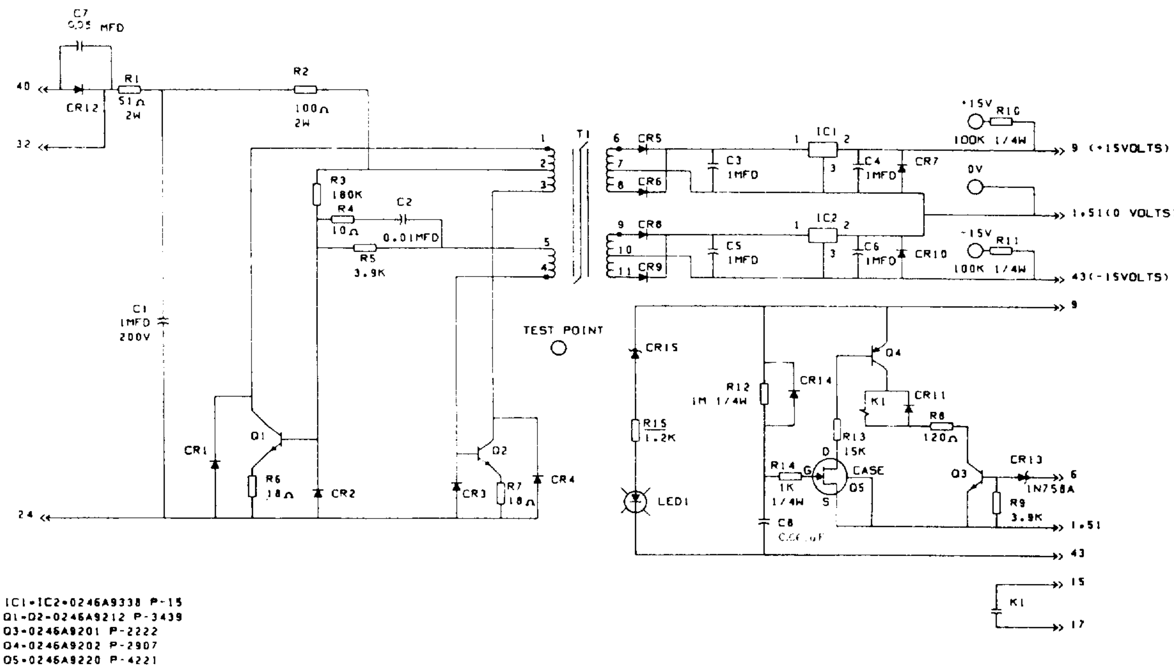


Figure 13A (0152C8465 Sh.1[4]) Internal Connections for 125VDC Rated Input Power Supply Card (PS)

PCB 0171C8709
ASM 0184B5609 G-3

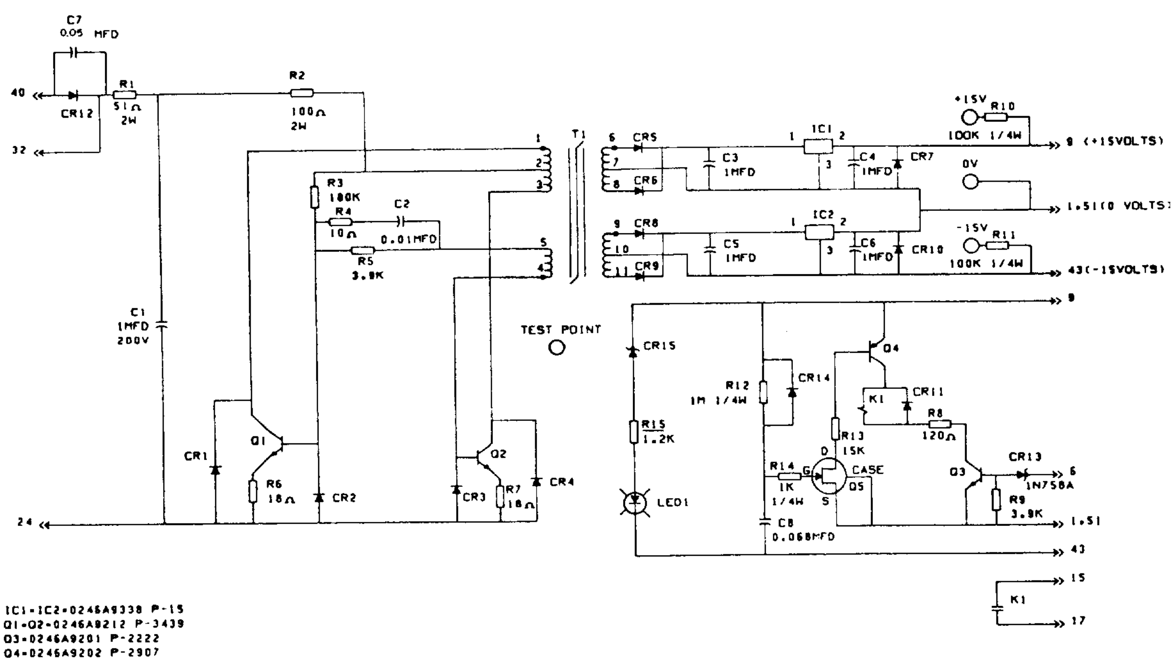


Figure 13B (0152C8465 Sh.3[2]) Internal Connections for 110VDC Rated Input Power Supply Card (PS)

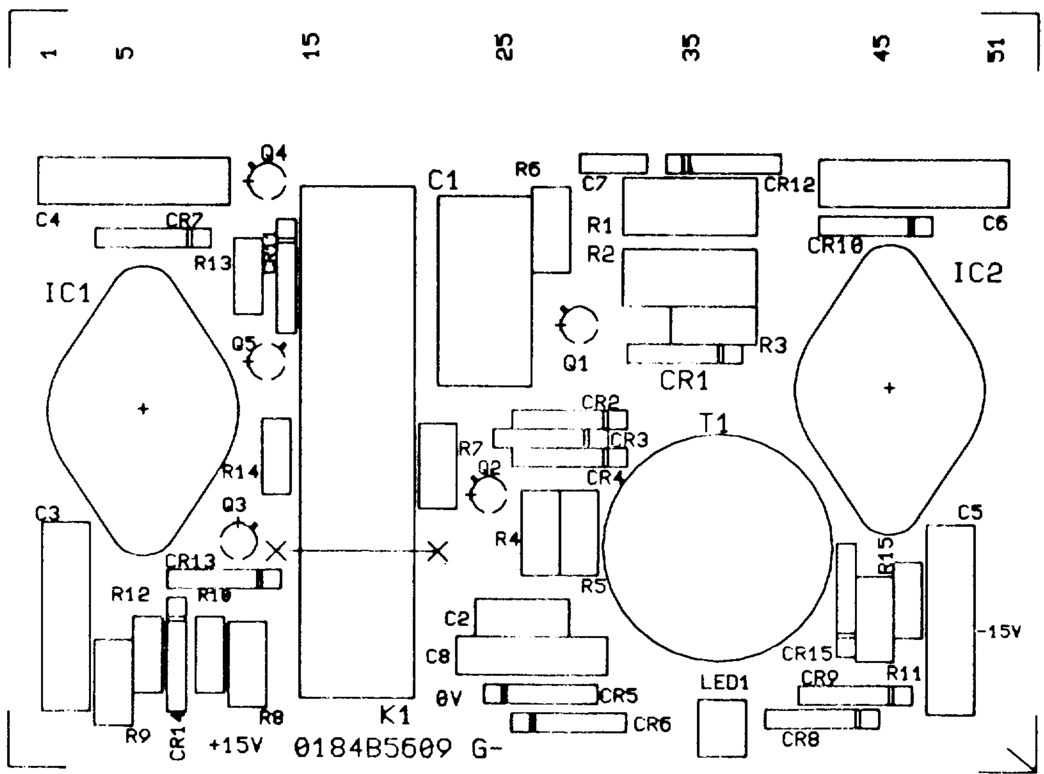


Figure 13C (0171C8709 SS Sh.1[8]) Card Layout for 110VDC & 125VDC Rated Input Power Supply Card (PS

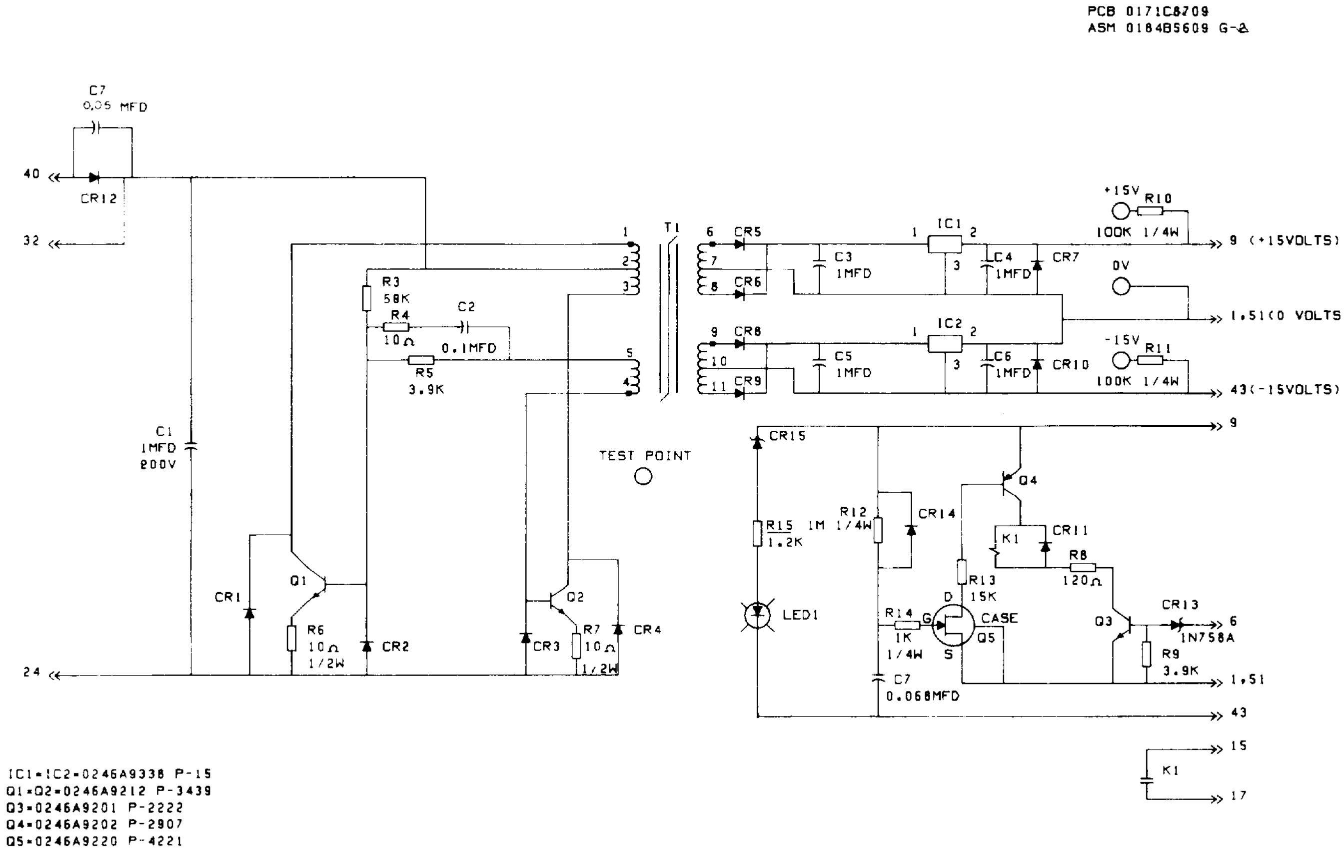


Fig. 14A (0152C8465- 2SH-2) Internal Connections for 48 Volt DC Rated Input Power Supply Card (PS)

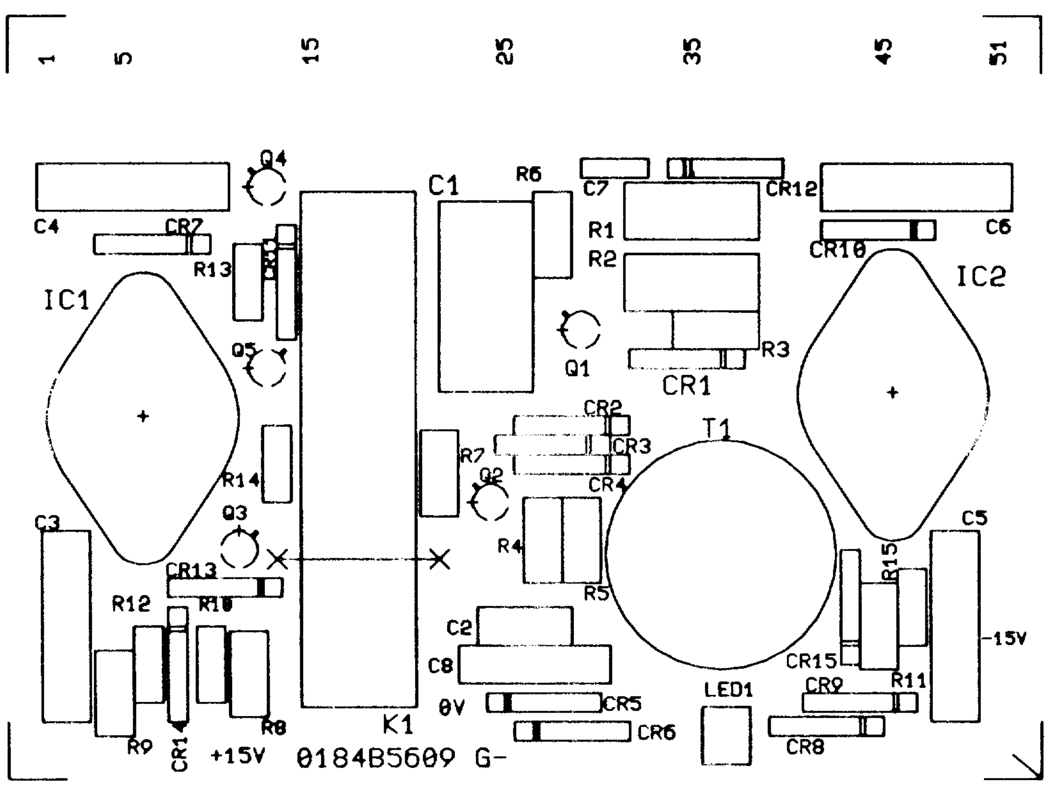
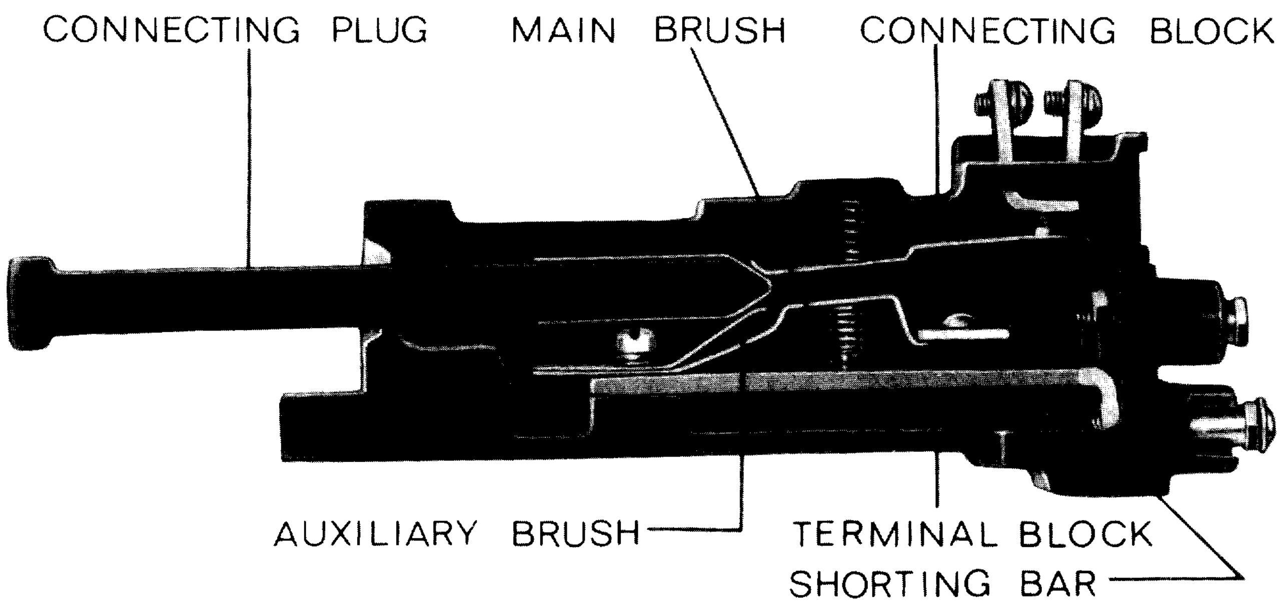


Figure 14B (0171C8709 SS Sh.1[8]) Card Layout for 48 Volt DC Rated Input Power Supply Card (PS)



NOTE: AFTER ENGAGING AUXILIARY BRUSH CONNECTING PLUG TRAVELS 1/4 INCH BEFORE ENGAGING THE MAIN BRUSH ON THE TERMINAL BLOCK

Fig. 15 (8025039) Cradle Block and Terminal Block Cross Section

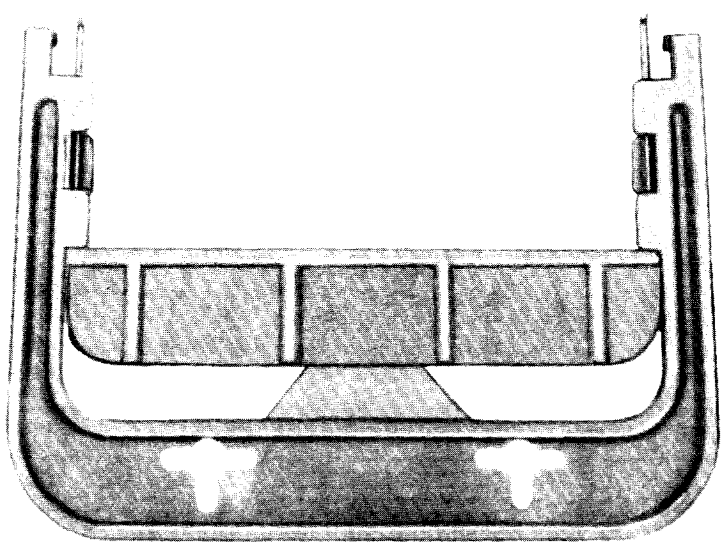


Fig. 16 (8043016) Printed Circuit Card Extracting Tool

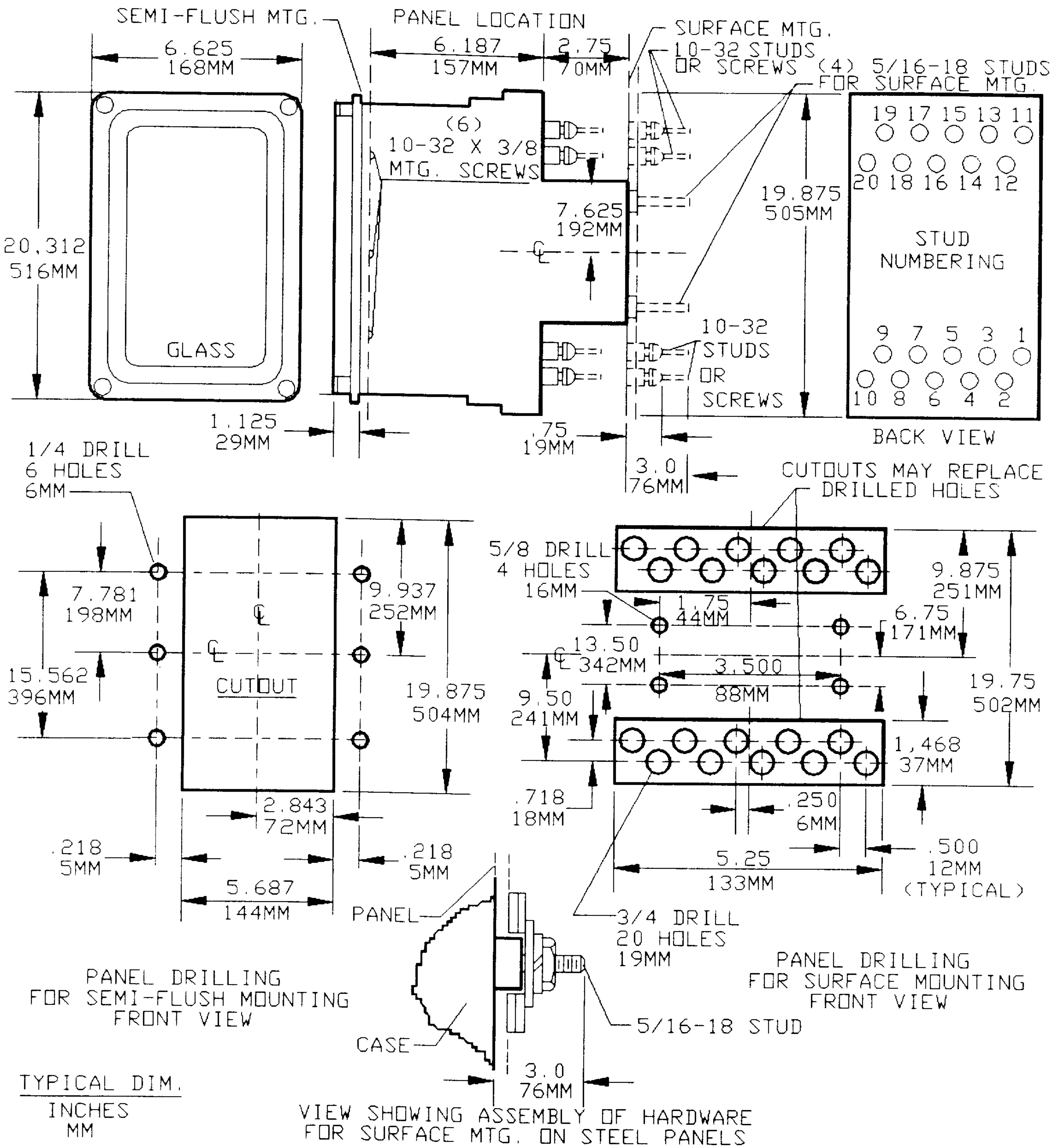


Fig. 17 (0178A7336 [6]) Outline and Panel Drilling for Type SLY82A Relay

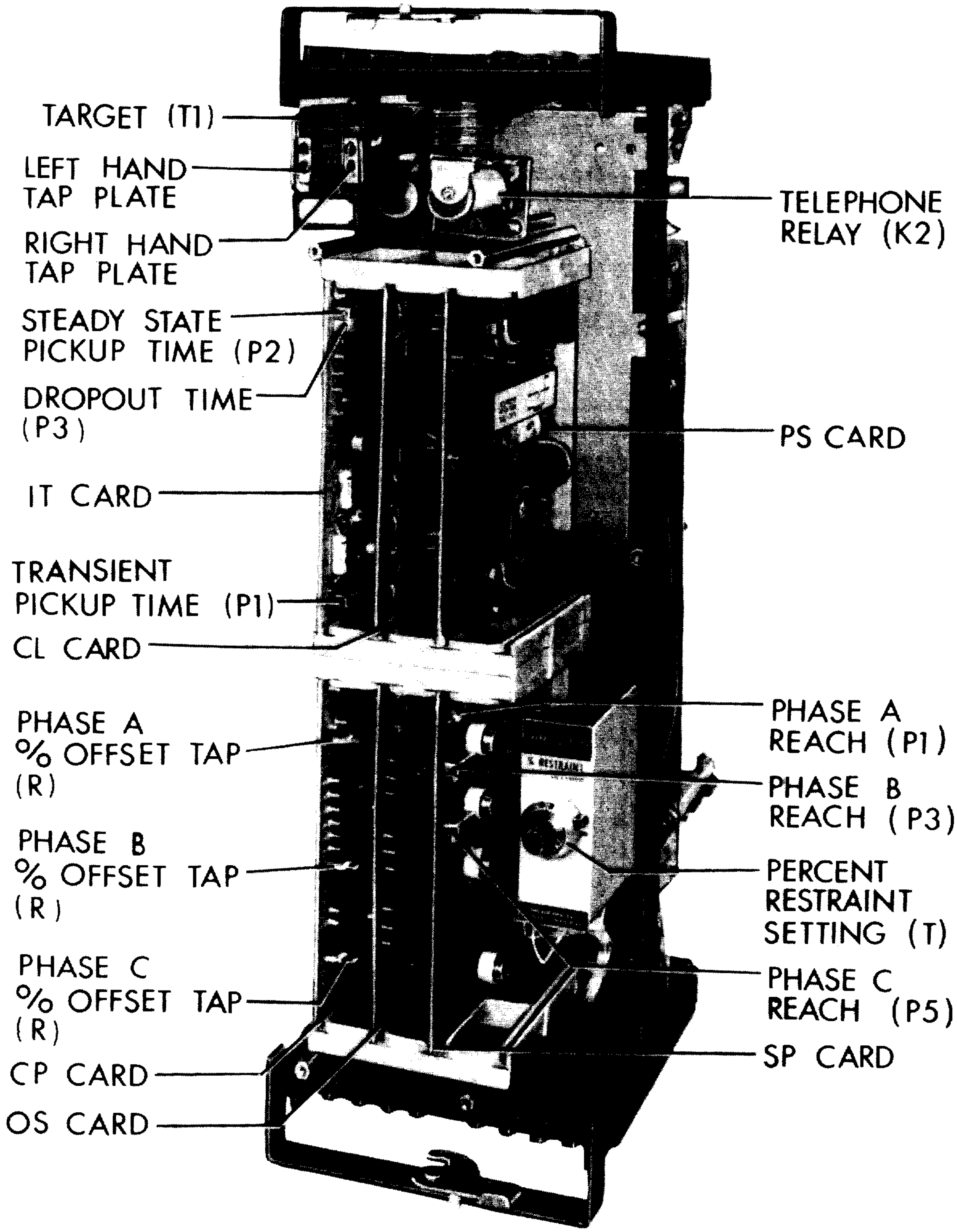


Fig. 18 (8043396) Front View of Relay Out of Case with Nameplate Removed

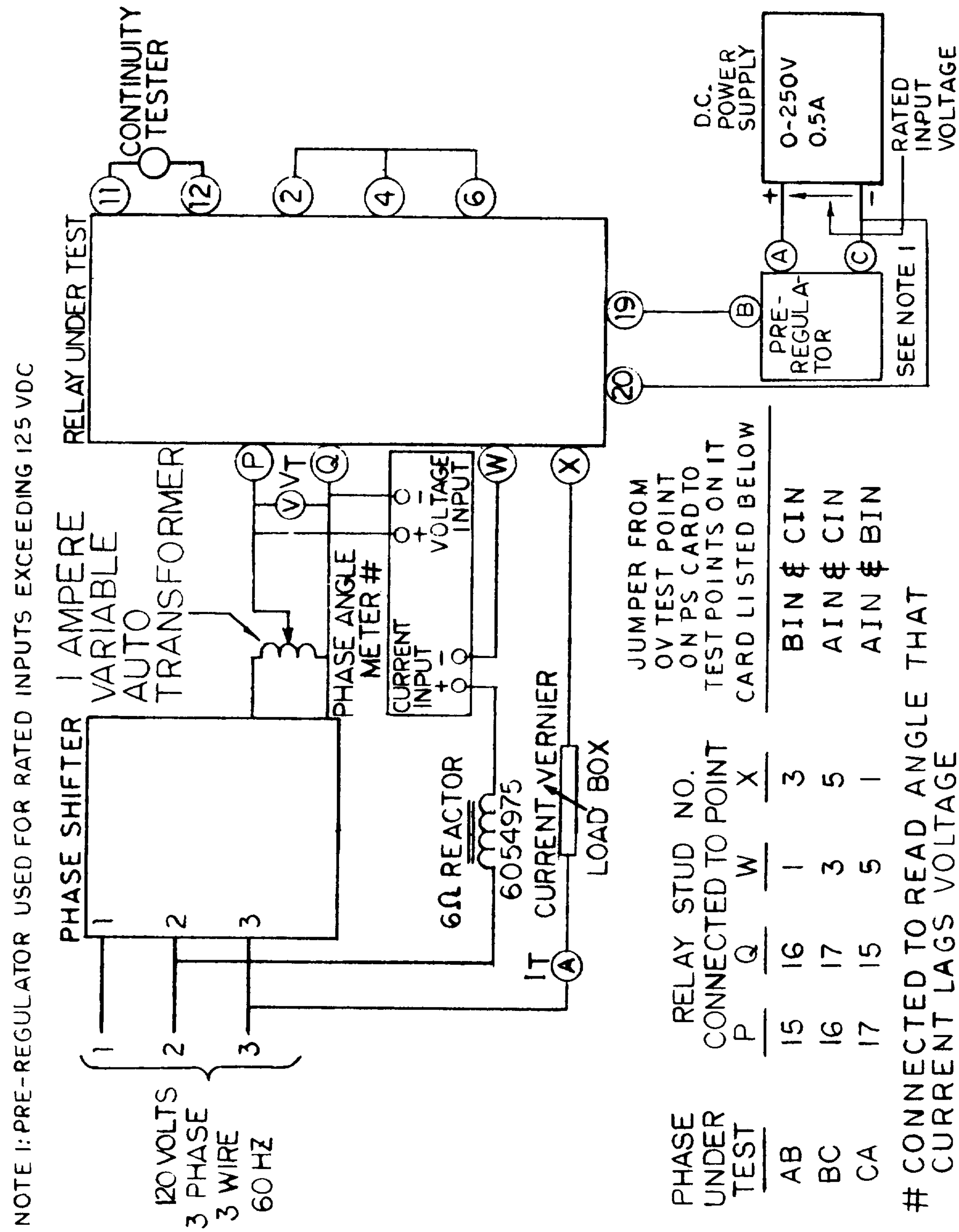


Fig. 19 (0273A9097-1) Test Circuit for Reach Tests

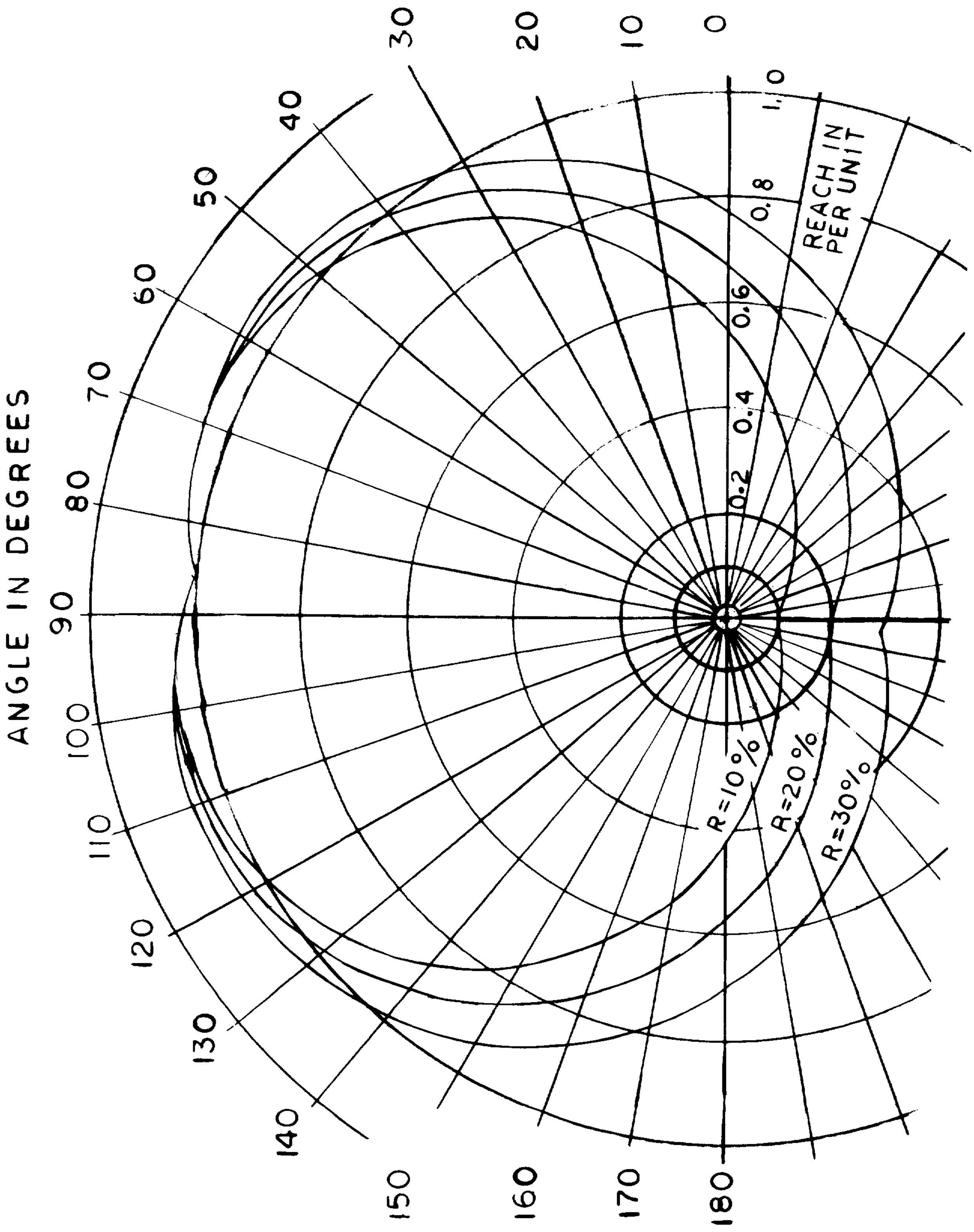


Fig. 20 (0273A9155-0) Mho Characteristic for Timer Setting of 3.5 Milliseconds (60 Hertz Basis)

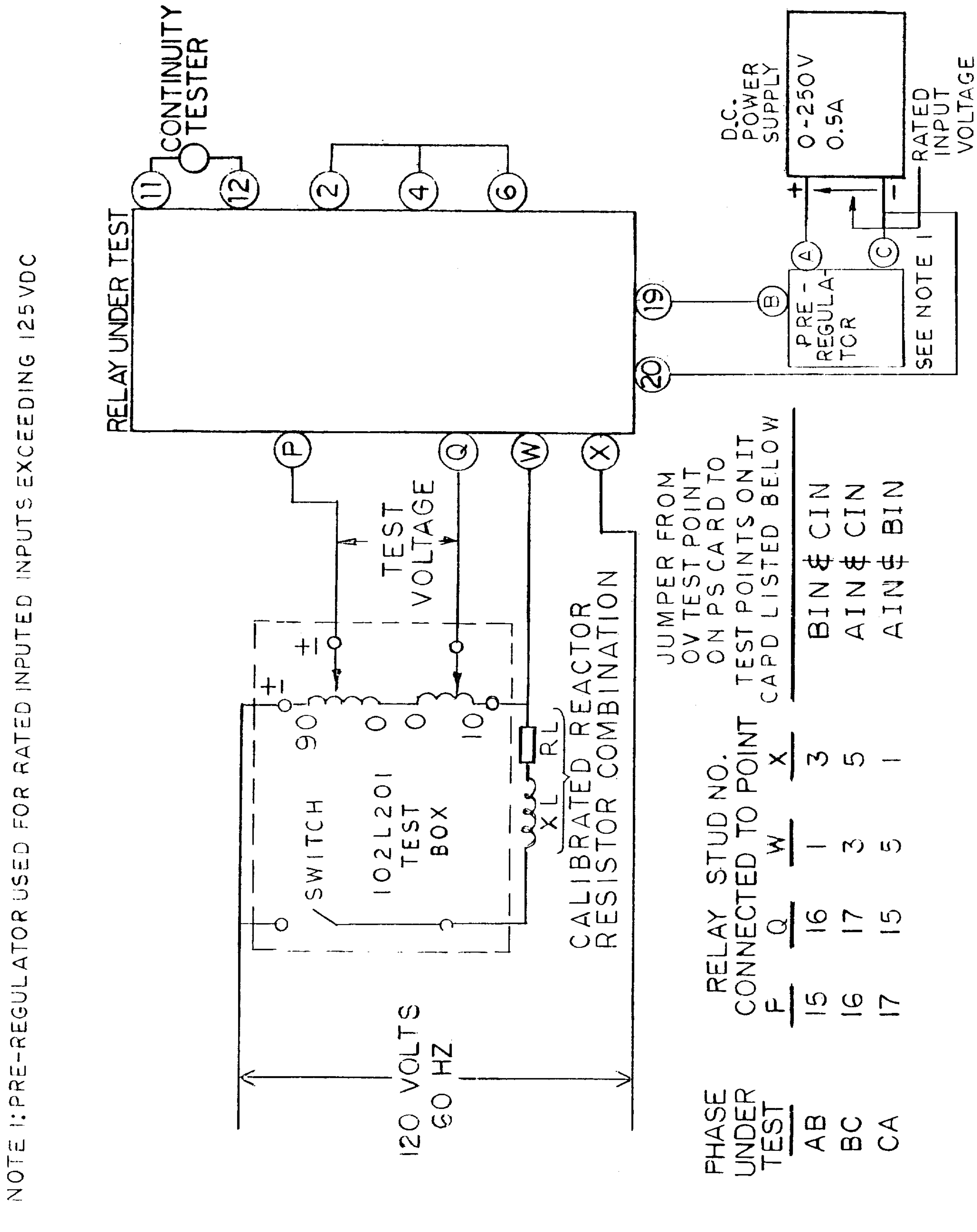
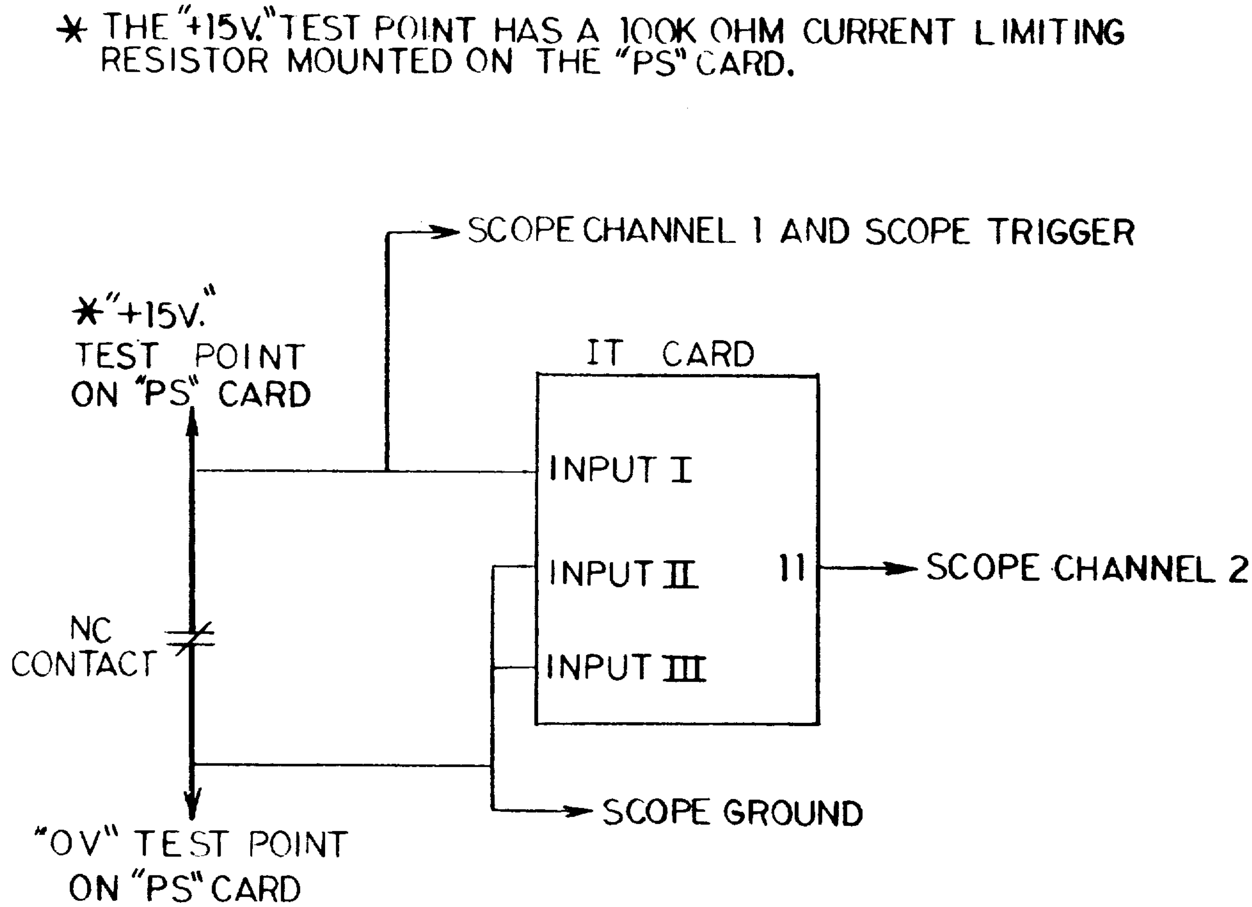
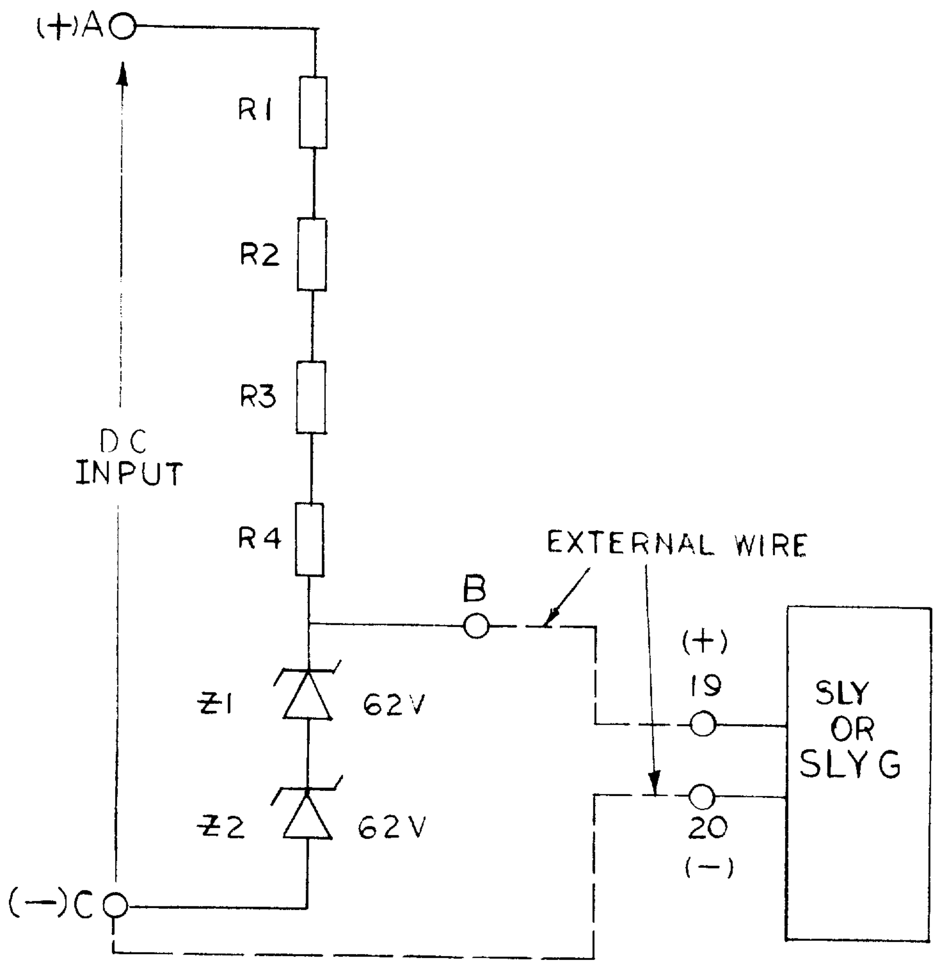


Figure 21 (0273A9098 [1]) Characteristic Test Circuit Using Test Box, Reactor and Resistor



PHASE UNDER TEST	PIN No. OF CARD		
	INPUT I	INPUT II	INPUT III
AB	12	23	36
BC	23	12	36
CA	36	12	23

Fig. 22 (0273A9099-0) Timer Card Test Circuit



DC INPUT	R1	R2	R3	R4
250 VOLTS	150Ω	150Ω	100Ω	100Ω

Fig. 23 (0275A4336-1) Internal Connections Diagram of External Pre-Regulator

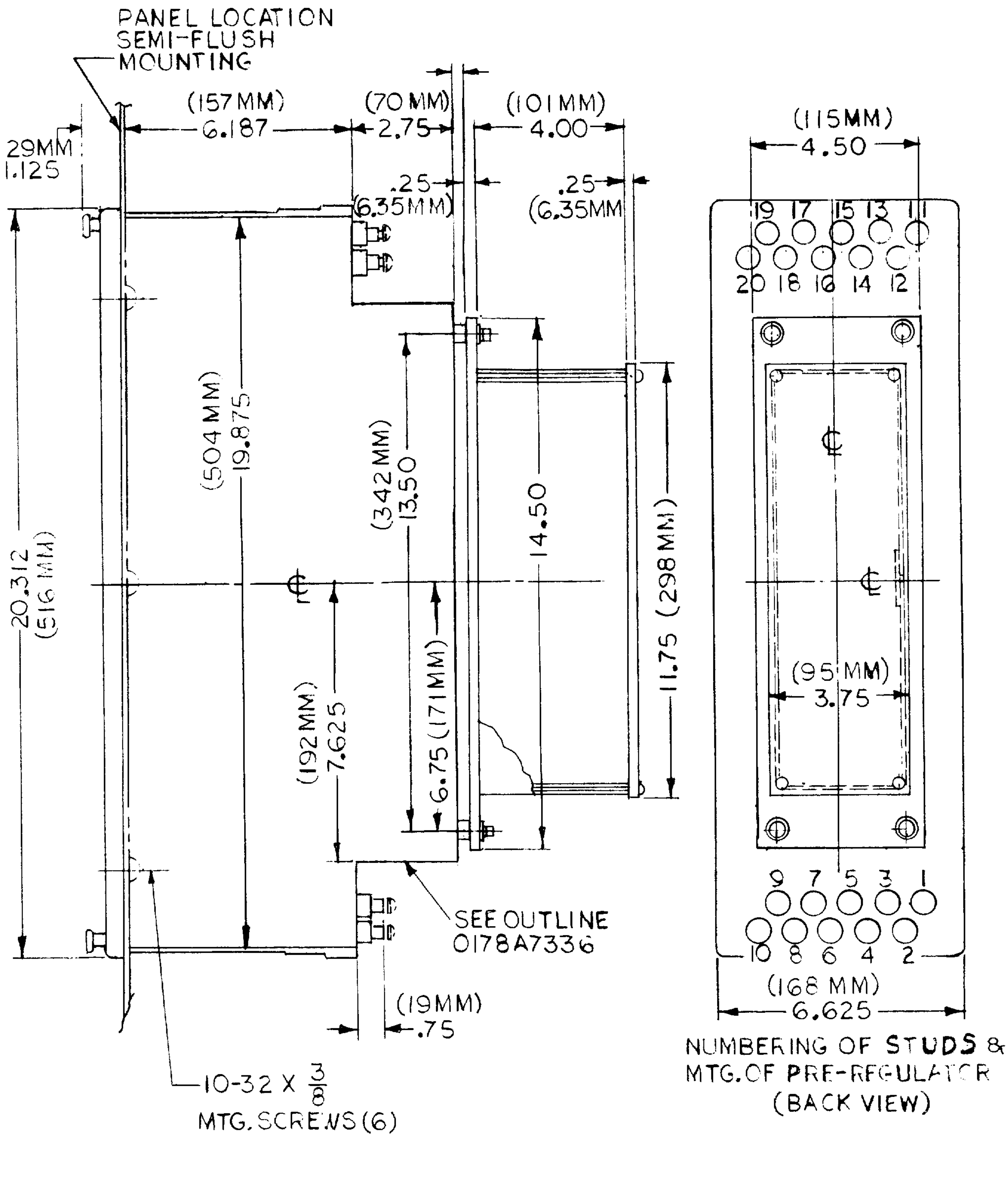


Fig. 24 (0275A4339-0) Outline and Mounting Dimensions of External Pre-Regulator

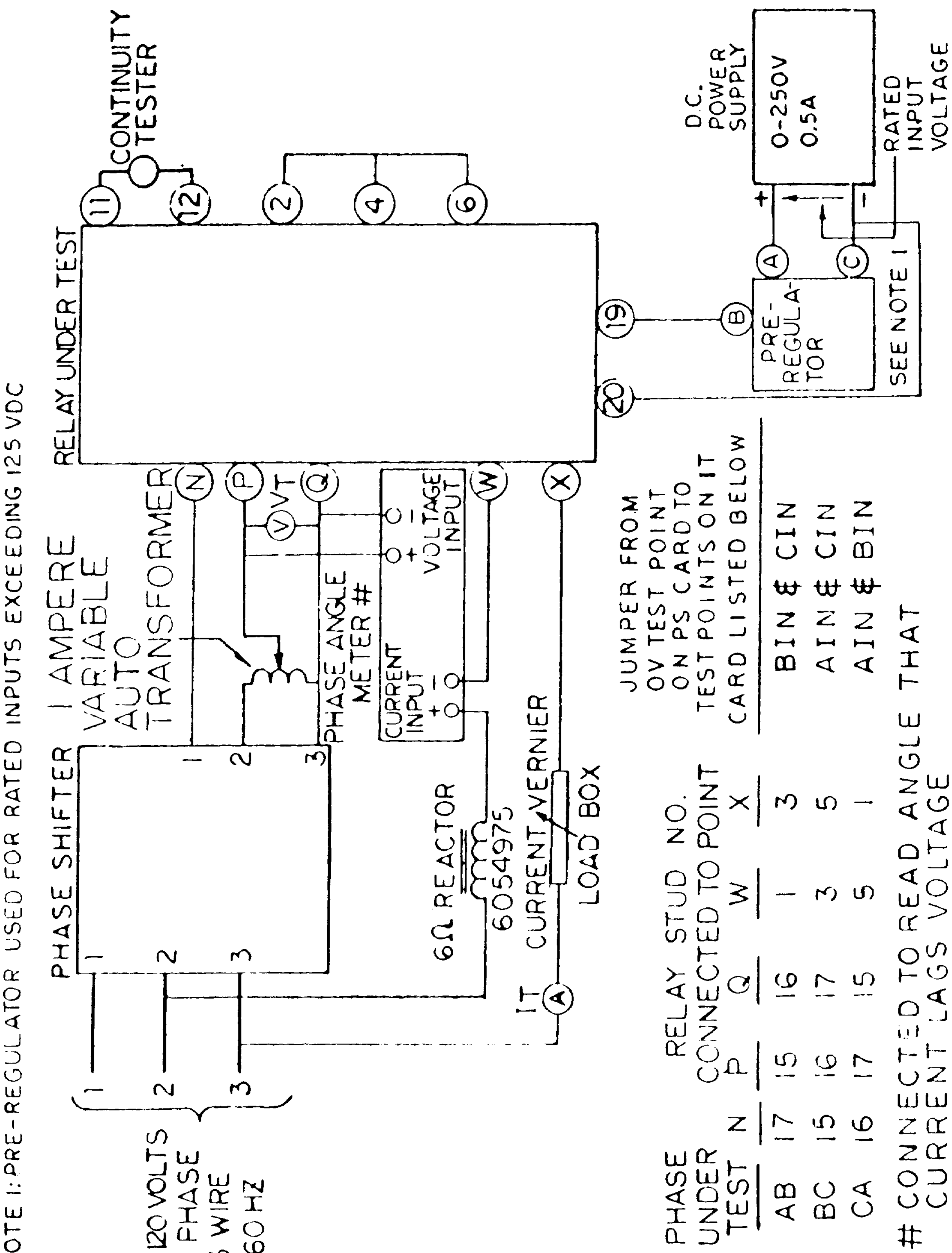


Figure 25 (0285A9951) Test Circuit for Characteristic Tests