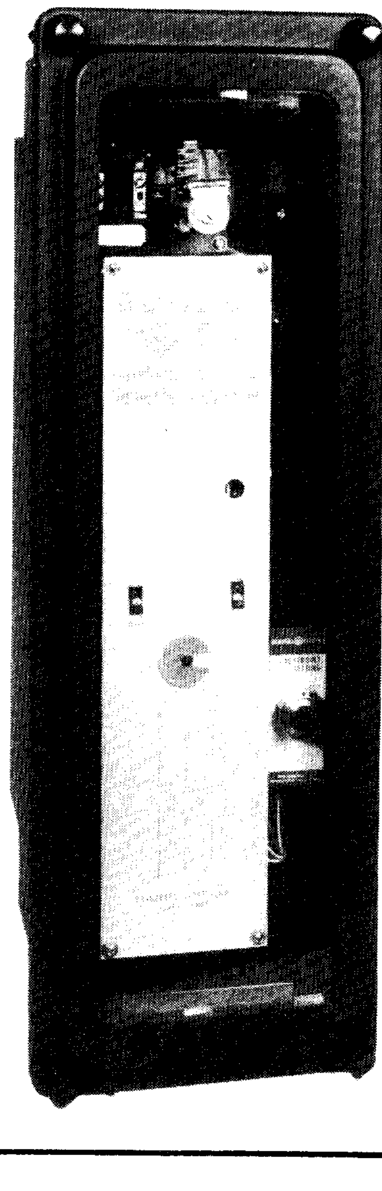
INSTRUCTIONS

GEK-49814C
Supersedes GEK-49814B

STATIC, THREE-PHASE OFFSET GROUND DISTANCE RELAY

TYPE SLYG82A



GENERAL ELECTRIC

CONTENTS

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TYPE SLYG82A

DESCRIPTION

The type SLYG82A relay is a three-phase, static, ground distance relay and is used as a blocking relay in a blocking-relay scheme when SLYG81A relays are used for the tripping relays. The SLYG82A is available with ratings of 60 hertz, 5 amperes; and 50 hertz, 1 ampere. The 5 ampere relays have a continuously adjustable ohmic range of 0.75 to 30 ohms phase-to-neutral and the 1 ampere relays have a continuously adjustable ohmic range of 3.75 to 150 ohms phase-to-neutral. DC-power-supply voltages available are 48, 110, and 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-sized, double-ended, drawout (L2D) case.

The SLYG82A has a "variable mho" characteristic, which provides optimum accommodation of fault resistance.

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

APPLICATION

The SLYG82A utlizes a four-input phase-angle comparator for ground-distance measurement for each phase. The four inputs for the phase-A-to-ground measurement are:

(a) $(I_A - I_0)\ Z_{R1} + K_0 I_0\ Z_{R0} - T\ V_{AG}$..................Operating Quantity

(b) $\frac{T}{\sqrt{3}} V_{BC}\ \underline{/90^\circ} + R\ [(I_A - I_0)\ Z_{R1} + I_0 K_0\ Z_{R0}]$ ....#1 Polarizing Quantity

(c) $-V_0$..#2 Polarizing Quantity

(d) $I_0\ Z_{R0}$...Overcurrent Supervision

where

I_A is the faulted phase current

I_0 is the zero-sequence component of current

Z_{R1} is the phase (positive and negative sequence) base reach tap with an impedance angle of 85°

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 General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

Z_{R0} is the neutral (zero-sequence) base reach tap with an impedance angle of 75°

$T\ V_{AG}$ is the "Tapped" phase-to-ground restraint voltage

$V_{BC}\underline{/90^{\circ}}$ is the "quadrature" voltage shifted 90° leading

K_0 is a ratio tap to compensate for the magnitude ratio between the zero- and positive-sequence line impedance

R is a ratio tap to provide an "offset" equivalent to 0.1, 0.2, or 0.3 of the relay reach

V_0 is the zero-sequence voltage at the relay

The use of a four-input comparator produces many advantages over previous designs in simplifying the application of a ground-distance relay.

The first and second inputs to the comparator produce a characteristic similar to the well known quadrature-polarized ground-distance unit with a "variable mho" characteristic. The "variable mho" characteristic increases in size as the source impedance increases to accommodate increasing fault resistance. The current compensation in the Number 1 polarizing signal provides a remembered polarizing signal that is close in phase to the equivalent polarizing signal in the tripping relay at the remote end of the line, when there is heavy load transfer over the line.

The fourth input provides overcurrent supervision to prevent operation on potential failure or on the line-de-energizing transients that are associated with lines having shunt reactors. The line-de-energizing transients would present a problem if the relay were to operate on the transient voltages existing prior to a high-speed reclosure.

In addition, the third and fourth inputs act as a zero-sequence directional unit, thereby providing excellent directional integrity.

RATINGS

GENERAL

The Type SLYG82A relay is designed for use in an environment where the air temperature outside the relay case is between $-20^{\circ}C$ and $+55^{\circ}C$ per ANSI standard C37.90-1978. In addition, these relays will not malfunction nor be damaged if operated in an ambient up to $65^{\circ}C$.

The current circuits of the Type SLYG82A relays that are rated 5 amperes will carry 10 amperes rms continuously and will carry 250 amperes rms for 1 second. The relays rated 1 ampere have current circuits that will carry 2 amperes rms continuously and will carry 50 amperes rms for 1 second. The potential circuits are rated 69 volts rms line-to-neutral and can withstand 110% of this value continuously.

The Type SLYG82A relay is available with an impedance range as shown in Table I.

TABLE I

TYPE	Z_{R1} BASE REACH TAP IN POSITIVE-SEQUENCE OHMS	Z_R IMPEDANCE RANGE IN POSITIVE-SEQUENCE OHMS
5 AMPERE RATING	0.75	0.75 to 7.5
	1.5	1.5 to 15
	3.0	3.0 to 30
1 AMPERE RATING	3.75	3.75 to 37.5
	7.5	7.5 to 75
	15	15 to 150

Selection of the desired base-reach taps (Z_{R1} and Z_{R0}) is made by means of the four tap screws at the lower rear of the relay (see Figure 4). All four tap screws (ØA, ØB, ØC and Neutral) should normally be in equal ohmic tap positions.

The actual reach (Z_R) of the relay is continuously adjustable, within the range shown in Table I for a particular tap, by means of the three-gang precision potentiometer at the lower right front of the relay (see Figure 5). The 10-turn dial on this potentiometer is calibrated in percent restraint setting (T) and the relay reach is given by equation 1:

$$\text{relay reach} = Z_R = \frac{100 \times Z_{R1}}{T}$$

T = Restraint setting in percent
Z_{R1} = Base reach tap in positive-sequence ohms

The range of restraint setting (T) is from 10% (fully counterclockwise) to 110% (fully clockwise). The maximum recommended setting is 100%. An enlarged picture of the dial is shown in Figure 10.

The relay reach should be within 5% of the value given by equation (1) if the ambient temperature is within the rated range of $-20^{o}C$ to $+55^{o}C$.

SURGE-WITHSTAND CAPABILITY

These relays will withstand the 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

All three of the output contacts of the Type SLYG82A will make and carry 30 amperes for tripping duty and will carry 3 amperes continuously. The continuous-current ratings of the contact with a target are further limited by the target ratings, as listed in Table III. The interrupting ratings are given in Table II.

TABLE II

INTERRUPTING RATINGS OF OUTPUT CONTACTS

AC VOLTS	AMPS	
	INDUCTIVE+	NON-INDUCTIVE
115	0.75	2.0
230	0.5	1.0
DC VOLTS		
48	1.0	3.0
125	0.5	1.5
250	0.25	0.75

+The inductive rating is based on an L/R ratio of 0.04 seconds

TARGETS

A target having 0.6 and 2.0 ampere taps is provided for the output contacts between studs 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 SLYG82A blocking-relay operating principle is selected to provide the optimum coordination with the SLYG81A tripping relay location at the remote terminal of the line. The operating quantity of the SLYG82A relay is the same as the SLYG81A relay. The number 1 polarizing quantity in the SLYG82A relay, $(\frac{T}{\sqrt{3}} V_{BC} \angle 90^{o} + R, [(I_A - I_0) Z_{R1} + I_0 K_0 Z_{R0}])$ has a current-compensating component in addition to the same Number 1 polarizing quantity as is used for the SLYG81A relay. The purpose of this current-compensating component, on a dynamic basis, is to provide a polarized 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 Number 2 polarizing quantity in the SLYG82A relay uses only $(-V_0)$ rather than $(-V_0 + C\ K_0 I_0\ Z_{R0})$, which is used in the SLYG81A tripping relay. The current-compensating signal is omitted for the blocking function, since it might cause the total Number 2 polarizing quantity to reverse polarity for close-in faults on the protected line section. The current-compensating signal is not required in the blocking relay since, for external faults for which operation is desired, $-V_0$ will be equal to the zero-sequence voltage drop in the line plus the remote-source impedance, and will be suitably large in magnitude and correct in phase.

The characteristic timer in the SLYG82A relay has a shorter setting than the characteristic timer in the SLYG81A relay. This gives the SLYG82A relay a slightly "tomato-shaped" characteristic, thereby ensuring that the blocking unit will operate first on a through fault.

If the 100% restraint setting is used and K_0 is set equal to Z_0'/Z_1', the phase-to-neutral reach of the realy at the angle of maximum reach is equal to the Z_{R1} base reach chosen. If a restraint setting other than 100% is used, reach is increased in inverse proportion to the restaint setting. For example, if restaint is set at 50%, relay operation will occur at twice the terminal voltage required at 100% setting; therefore, the relay reach is twice as great.

Relay reach at the angle of maximum reach can be calculated from the expression:

$$Z_R = \frac{Z_{R1}}{T} x\ 100$$

where:

T = restraint setting in percent
Z_{R1} = base-reach tap settings in positive-sequence ohms
Z_R = relay reach in positive-sequence ohms

To set the relay for the desired reach, it is necessary first to 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 sensitivities at the input terminals of the relay for the signal quantities in the SLYG82A relay are as follows:

1. Polarizing #1 Sensitivity (Quadrature Polarizing)
   Sensitivity is 0.1 volt

2. Polarizing #2 Sensitivity
   Sensitivity is 0.33 volt ($-V_0$)

3. Overcurrent Supervision Sensitivity I_0 Z_{R0}
   $3I_0 \geq \frac{0.6}{Z_{R1}}$ in amperes For Z_{R1} = 3 ohms, $3I_0$ = 0.2 ohms

4. Operate Circuit Sensitivity
   See Figure 6 for sensitivity in terms of $V_{LG} \frac{(\%T)}{100}$

To determine current sensitivity the ratio of I_0 to I_{phase} must be known or assumed; the ratio of Z_{0L} to Z_{1L} must be known. The current sensitivity can then be determined from the formula

$$(I_\phi - I_0)\ Z_{R1} + I_0 K_0 Z_{R0} = \frac{0.16}{1-X}$$

where

$$X = \frac{\text{actual reach}}{\text{nominal reach}}$$

for example if $I_\phi = 3I_0$, and $K_0 Z_{R0} = 3Z_{R1}$

then $\frac{2}{3} I_{\phi} Z_{R1} + I_{\phi} Z_{R1} = \frac{0.16}{1-X}$

if X = 0.8 $\frac{5}{3} I_{\phi} Z_{R1} = \frac{0.16}{1-0.8} = 0.8$

$I_{\phi} = \frac{0.48}{Z_{R1}}$ For Z_{R1} = 3 ohms, I_{ϕ} = 0.16 amperes

BURDENS

The potential-circuit burden per phase at 69 volts rms line-to-neutral is 0.2 volt-amperes, 0.17 watts, 0.10 vars.

The current-circuit impedance per circuit, measured at rated current, is given in Table IV.

TABLE IV

CURRENT-CIRCUIT BURDENS

RELAY CURRENT RATING	5 AMPERES		1 AMPERE	
CURRENT CIRCUIT	PHASE	GROUND	PHASE	GROUND
Impedance, Z, in ohms	0.030	0.018	0.210	0.160
Resistance, R, in ohms	0.027	0.018	0.200	0.150
Reactance, X, in ohms	0.013	0.002	0.065	0.050

The current requirements at the DC control power input (Studs 19 and 20) are given in Table V.

TABLE V

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	252+
250	Picked Up	252+

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

CIRCUIT DESCRIPTION

The internal connections for the Type SLYG82A relay are shown in Figure 2. The terminal numbers at the top and bottom of this diagram represent the external connections to the relay. The external connections can be grouped as shown in Table VI.

TABLE VI

EXTERNAL CONNECTIONS

TERMINAL NUMBERS	DESCRIPTIONS
1 through 8	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 18	AC Potential Inputs
19 and 20	DC Control-Power Input

The phase-to-ground input voltages are connected to the primaries of 10:1 step-down potential transformers TA, TB, and TC. On secondary of these potenial transformers is connected to the signal-processing card (SP) as well as to a three-gang precision potentiometer. The voltages on the sliders of the potentiometer are also connected as inputs to the SP card.

A second set of secondaries on these potential transformers is connected in broken delta to derive the V_O signal required as an input to the SP card.

The input phase currents pass through the primaries of transactors XA, XB, and XC. These transactors produce secondary voltages proportional to their primary currents in magnitude, and the secondary voltages lead their respective primary currents by a phase angle of 85°. The input zero-sequence current passes through the primary of transactor XO, which is similar to XA, XB, and XC, except that the secondary voltage of XO leads its primary current by 75°. The secondary voltages of all four transactors are connected to the SP card.

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

TABLE VII

OUTPUTS FROM SP CARD

OUTPUT SIGNAL FROM SP CARD	INPUT SIGNAL TO CARD
V_{AG}, V_{BG}, V_{CG}, $-V_{AG}$, $-V_{BG}$, $-V_{CG}$	Quadrature Polarizing (QP)
$(I_A-I_O)\ Z_{R1} + I_O K_O Z_{RO}$	Quadrature Polarizing (QP)
$(I_B-I_O)\ Z_{R1} + I_O K_O Z_{RO}$	Quadrature Polarizing (QP)
$(I_C-I_O)\ Z_{R1} + I_O K_O Z_{RO}$	Quadrature Polarizing (QP)
$-V_O$	Coincidence Logic (CL)
$(IA-I_O)\ Z_{R1} + K_O I_O Z_{RO} -TV_{AG}$	Operate Signal (OS)
$(I_B-I_O)\ Z_{R1} + K_O I_O Z_{RO} -TV_{BG}$	Operate Signal (OS)
$(I_C-I_O)\ Z_{RO} + K_O I_O Z_{RO} -TV_{CG}$	Operate Signal (OS)

The quadrature polarizing card (QP) produces a voltage $V_{BC} \angle +90°$ ($j\ V_{BC}$) by algebraic summations of V_{BN} and V_{CG}. This $j\ V_{BC}$ voltage is then filtered in an active bandpass filter with a natural frequency equal to system frequency. Similarly filtered jV_{CA} and jV_{AB} voltages are also produced in the QP card, and all three outputs are fed to the CL card as the main polarizing voltages. A current-compensating component equal to $R[(I_A - I_O)\ Z_{R1} + I_O K_O Z_{RO}]$ is added to the "jV_{BC}" signal before filtering, and jV_{CA} and jV_{AB} are similary compensated.

The operate signal card (OS) filters the 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 four input signals, and circuitry that produces a high logic (+15 volts DC) output signal whenever these signals have the proper instanteous phase relationship. Table VIII shows the various input signals for one phase and the source of the signals. In order for the output of CL to be high, inputs 1, 3 and 4 must have the same polarity and input 2 must have the opposite polarity.

TABLE VIII

INPUTS TO CL CARD

INPUT NO.	INPUT SIGNAL	DERIVED FROM
1	Quadrature Polarizing	QP Card
2	Operate Signal	OS Card
3	$-V_0$	SP Card
4	I_0Z_{R0}	X_0 Transactor

The output of the CL card has a high logic value if any one, or more, of its phases has the proper phase relationship between its input signals.

The CL card output is fed to the integrating timer (IT) card, which measures the time that the 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 reception basis or 3.7 milliseconds (50 hertz relays - 4.45 milliseconds) on a single shot basis, the output of the IT card will go to a high logic value. This output picks up reed relay K1 mounted on the power supply card (PS). A normally-open contact on K1 energizes telephone relay K2 mounted on the front panel. One normally-open contact of K_2 is connected in series with the coil of a target to provide the main tripping contact (terminal numbers 11 and 12). In addition, a second normally-closed 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 + 15 and - 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., stationary 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 IX. 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 labled 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 IX

INTERNAL CONNECTIONS FOR CARDS

CARD DESIGNATION	CARD FUNCTION	FIGURE NUMBER OF INTERNAL CONNECTIONS	FIGURE NUMBER OF CARD LAYOUT
SP	Signal Processing	11A	11B
QP	Quadrature Polarizing	12A & 12B	12C
OS	Operate Signal	13A & 13B	13C
CL	Coincidence Logic	14A	14B
IT	Integrating Timer	15A	15B
PS	Power Supply (110-125 Volts DC)	16A	16B
PS	Power Supply (48 Volts DC)	17A	17B

CALCULATIONS OF SETTINGS

The setting of the SLYG82A is predicated on the setting of the SLYG81A overreaching relay at the remote end of the protected line.

The Z_{R1}, K_0 and Z_{R0} settings of the SLYG82A relay should be at least equal to, and preferably larger than, the corresponding settings of the SLYG81A relay at the remote terminal. In general, the restraint setting should be selected to provide a relay reach between 100% and 150% of the remote SLYG81A reach. A 100% setting is appropriate for very long lines, and 150% is appropriate for short-to-intermediate line lengths. If the line is very short, i.e., less than 1 ohm secondary, a minimum setting of 3 ohms is desirable when a shorter reach is not required for use of this relay in third-zone backup applications.

The R setting is generally selected such that the "offset" is equal to or less than ($\leq$) the line impedance. For two-terminal lines, an R tap of 0.3 per unit is usually appropriate. Onvery short lines, the 10% or 20% 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% tap may be used without reducing the relay reach.

For example, on a two-terminal, 70-mile line with $Z_{1L} = 4.2 \angle 83^\circ$ and $Z_{0L} = 13 \angle 78^\circ$ ohms secondary, the remote overreaching SLYG81A relay has the following settings:

$$Z_{R1} = Z_{R0} = 3 \text{ ohms},\ K_0 = 3 \quad T = 40.8\%,\ Z_R = 7.35 \text{ ohms}$$

The base reach settings for the SLYG82A relay will then be $Z_{R1} = Z_{R0} = 3$ ohms and $K_0 = 3$.

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 SLYG81A relay is appropriate. This gives 1.2 (7.35) = 8.82 ohms for the SLYG82A reach setting.

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

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

CONSTRUCTION

The Type SLYG82A relay is assembled in a deep, large-sized, 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 that completes the circuits. The outer blocks attached to the case have 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 Figure 7, to provide adequate overlap when the connecting plug is withdrawn or inserted. Current circuits are equipped with shorting bars (see internal connections in Figure 2), and on these circuits, it is especially important that the auxiliary brush make contact, as indicated in Figure 7, with adequate pressure to prevent the opening of the associated CT secondary.

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 (2") thick. Panel thickness must be indicated on the relay order to ensure that appropriate hardware will be included with the relay. Outline and panel drilling is shown in Figure 8. For DC supply voltages greater than 125 volts it is necessary to use an external pre-regulator. The pre-regulator is packed 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 outside and mounting dimensions for the pre-regulator are shown in Figure 25.

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 from the case and replaced by another that has been tested in the laboratory.

The potential transformers, TA, TB, and TC, and the transactors, XA, XB, XC, and XO, are mounted at the rear of the cradle as shown in Figure 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 four leads tagged A, B, C and N should be connected to the desired ohmic value labled ØA, ØB, ØC and NEUT resoectively. For example, Figure 4 shows a base reach Z_{R1}, Z_{R0} setting of 15.0 ohms and the leads are connected as follows:

lead C ⟶ position 1
lead B ⟶ position 4
lead A ⟶ position 7
lead N ⟶ position 10

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.

Figure 9 shows a front view of the relay with the nameplate removed. This view shows the target, 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 Figure 10 with a setting of 84%. The dial can be adjusted from 10% to 110%. The lock must be disengaged (by turning the lever counterclockwise) in order to change the restraint setting, but should be engaged again after desired setting is made.

The value of "K_0" select in the **CALCULATION OF SETTINGS** section is set by means of the K_0 plug indicated in Figure 9. This plug should connect the horizonal jacks labled "2.5", "3.0", "3.5", "4.0" or "4.5" on the SP card to obtain a K_0 value of 2.5, 3.0, 3.5, 4.0 or 4.5 respectively.

The other adjustments indicated in Figure 9 are trim potentiometers located on printed circuit cards. 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 readjustment 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 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 make sure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed.

Since operating companies use many different procedures for acceptance tests and for installation tests, the following section includes several applicable tests that may be performed on these relays as part of the installation or acceptance test, at the discretion of the user.

VISUAL INSPECTION

Check the nameplate stamping to make sure 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 having a shorting bar makes contact with the shorting bar. Deflect each contact finger to make sure that there is sufficient contact force availble. Check that each auxiliary brush is bent high enough to contact the connection plug approximately 1/4 inch of plug travel before contacting the main finger.

HIGH-SEISMIC 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 higer ampere position. The tap screw is the screw holding the right-hand tap plate. To change the tap setting without disturbing the adjustment, 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 Figure 9. Screws should **never** be left in **both** taps at the same time.

TABLE X

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.

NOTE: 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. If adjustments are made, the armature should be operated by hand and the gap and wipe again checked as described above.

ELECTRICAL TESTS - GENERAL

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

DIELECTRIC TESTS

1. Introduction

The surge capacitors used in the Type SLYG relay do not have voltage ratings to withstand AC high-potential voltage; therefore, caution must be exercised when hipotting to avoid damaging these capacitors.

It is recommened 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 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 that have not been in service, that are not more than one year old from the date of shipment, and that have been suitably stored to prevent deterioration. The duration of application of the test voltage 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 XI. Hipot voltage can then be applied between any two groups of circuits.

TABLE XI

CIRCUIT GROUPING FOR TRANSVERSE-MODE HIPOT TESTS

CIRCUIT GROUP	JUMPER BETWEEN TERMINAL NUMBERS
AC Current	1, 2, 3, 4, 5, 6, 7, and 8
AC Potenial	15, 16, 17, and 18
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 circuit groups of Table XI 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 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 in the **ACCEPTANCE TESTS** section of this book should 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} and Z_{R0} are set on the tap block at the rear of relay. All three phases and the neutral should be set to the same value.

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

c) Zero-sequence current compensation (K_0) is set by means of the K_0 plug on printed-circuit card "SP".

d) Percent offset (R) is set by means of three (3) plugs on the "QP" printed-circuit card. For TESTING MHO CHARACTERISTICS (test three that follows) and for ALTERNATE TEST METHOD FOR REACH TESTS (test five that follows), the plugs should be removed to give a zero-offset setting. For other tests, the plugs should be in the positions determined in the **CALCULATION OF SETTINGS** section of this book.

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 sure the test connections shown in Figure 21 for the particular phase being tested,

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

TABLE XII

RECOMMENDED TEST CURRENT

BASE-REACH TAP Z_{R1} IN OHMS	RELAY RATED CURRENT IN AMPERES	RECOMMENDED MINIMUM TEST CURRENT, I_T IN AMPERES RMS
0.75	5	8
1.5	5	4
3.0	5	2
3.75	1	1.6
7.5	1	0.8
15	1	0.4

c) Adjust the phase angle for the nominal base-reach angle of 80°.

d) Observe the waveform at the following test point (on OS card) with an oscilloscope.
   1) "AOUT" for phase A
   2) "BOUT" for phase B
   3) "COUT" for phase C

e) Lower the voltage V_T to the value given in equation (2) below:

* +

$$V_T = \frac{2 + K_0}{3} \frac{I_T Z_{R1}}{T} (100)$$

where

I_T = test current in amperes rms

K_0 = Zero-sequence current-compensation tap setting (plug on SP card)

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 less than 10%.

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 2° of the nominal value of 80°. The voltage V_T at this null condition should be within 5% of the value calculated by equation (2).

NOTE: THE MEASURED PICKUP SHOULD AGREE WITH THE CALCULATED VALUE WITHIN PLUS OR MINUS FIVE PERCENT (± 5%). IF THE VALUES DO NOT AGREE WITHIN THESE LIMITS, IT IS RECOMMENDED THAT THE TEST SETUP AND METER CALIBRATIONS BE CHECKED <u>BEFORE</u> THE FACTORY SETTINGS ON THE RELAY ARE DISTURBED. ONE GOOD METHOD OF CHECKING THE TEST SETUP AND PROCEDURE IS TO REPEAT THE TEST ON A DUPLICATE RELAY.

h) 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 XIII. These potentiometers should be turned clockwise to increase the reach.

*Revised since last issue

TABLE XIII

REACH ADJUSTMENT LOCATIONS

PHASE UNDER TEST	POTENTIOMETER DESIGNATION	POTENTIOMETER LOCATION
A	P1	Top
B	P2	Middle
C	P3	Bottom

3. Testing Mho Characteristics

The complete mho characteristic can be measured by the same test circuit (Figure 18) 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 variable auto transformer until the relay picks up. The value of V_{IN} at this point should be as shown in Figure 19.

4. Offset (R Setting) Tests

a) Make the test connections shown in Figure 20 for the particular phase being tested. This will energize the voltage circuit of the phase under test at rated volts.
b) Adjust the voltages from the variacs so that $V_W = V_X$ = the value shown in Table XIV.
c) Adjust the phase shifter until the phase-angle meter indicates that the current lags voltage by $260^o \pm 1^o$.
d) Adjust the load box until the continuity tester indicates a closed circuit between relay studs 11 and 12. Record the value of current I_T for this condition as "pickup". This value should be between 3.6 and 4.4 amperes rms for 5 ampere rated relays and 0.72 and 0.88 for 1 ampere rated relays.

TABLE XIV

TEST VOLTAGES FOR OFFSET TESTS

R IN PERCENT	$V_W = V_X$ VOLTAGE IN VOLTS RMS
10	2
20	4
30	6

NOTE: OFFSET CAN NOT BE SHOWN ON R-X DIAGRAM BECAUSE IT IS NOT A REAL IMPEDANCE FOR QUADRATURE-VOLTAGE POLARIZED RELAYS. QUADRATURE VOLTAGE IS NOT RELATED IN MAGNITUDE TO THE FAULTED PHASE VOLTAGE DURING SYSTEM FAULTS.

5. Alternate Test Method for Reach Tests

An alternate method of testing the relay characteristic is shown in Figure 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. The value of percent offset, R, must be made zero (0) for this test, by temporarily removing the three plugs on the QP printed-circuit card.

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	MILLISECONDS	
			60 Hz RELAY FACTORY SETTING	50 Hz RELAY FACTORY SETTING
P1	Bottom	Transient Pickup Time	3.7	4.4
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.

The test circuit of Figure 18 may be used to check the steady-state pickup-time setting. A dual-trace oscilloscope should be used, with Channel One connected to test point "AIN" on the IT card and Channel Two on test point "OUT" on the IT card. * Connect unused inputs "AIN", "BIN", or "CIN" on the IT card to the "OV" test point on PS card. Reduce "V_{IN}" until the relay picks up. The output (Channel Two) should go positive 3.5 milliseconds (50 hertz relays - 4.2 milliseconds) after the input (Channel One) goes positive.

*Revised since last issue

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 Two trace should step positive 3.7 milliseconds (50 Hz relays - 4.44 milliseconds) ± 0.1 millisecond after the Channel One trace steps positive.

To check the drop out 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 Two trace should step negative 50 milliseconds (50 Hz relays - 60 milliseconds) ±1 milliseconds after the Channel One trace steps negative.

INSTALLATION PROCEDURE

INTRODUCTION

The relay should be mounted on a vertical surface. The outline and panel-drilling diagram is shown in Figure 8.

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 Figure 2 and typical external connections are shown in Figure 3.

NOTE: PHASE SEQUENCE IS CRITICAL FOR THE PROPER OPERATION OF THE TYPE SLYG82A RELAY. PHASE SEQUENCE SHOULD BE CHECKED AT THE STUDS TO MAKE SURE THAT IT IS 1-2-3 AT RELAY STUDS 15-16-17 RESPECTIVELY.

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 copper wire or its equivalent. This connection is made to ground the relay case. In addition, the terminal 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 (10) 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 procedures given in DIELECTRIC TESTS under the **ACCEPTANCE TESTS** section of this book **must** be followed.

TEST PLUGS

The relay may be used 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. The 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it requires CT 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 the screw in the undesired tap is removed and transferred to the left plate.

REACH TESTS

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

- Base reach (Z_{R1} and Z_{R0}) on the back of the relay
- Percent restraint (T) on the front-panel potentiometer
- Zero-sequence current compensation (K_0) on printed-circuit card "SP", the lower right-hand card
- Percent offset reach (R) on the "QP" printed-circuit card (three plugs).

b) Measure the relay reach at 80° 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 below 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 any corrosion is thoroughly and rapidly cleaned. The flexibility ensures the cleaning of the actual points of contact. Do not use knives, files, abrasives 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. The measured value being slightly different from that measured at a previous time is **not** necessarily an indication that the relay should be readjusted. The errors of all the test equipment are often additive and the total error of the present setup may be of opposite sign from the error of 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 randim variations in the test conditions or are due to a continuing drift in the cahracteristics of the relay.

TROUBLESHOOTING PROCEDURE

A recommended troubleshooting procedure is shown in Table XVI.

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.**

*Revised since last issue

TABLE XVI

TROUBLESHOOTING PROCEDURE

PROBLEM	PROBABLE CAUSE	TROUBLESHOOTING SEQUENCE
I. Relay picks up when it should not.	1. Voltage missing or wrong phase sequence.	1. Set balanced input voltage: V_{AN} = 69 V_{BN} = 69 /-120 V_{CN} = 69 /+120 Check voltages at -V_{AN}, -V_{BN} and -V_{CN} on the QP card test points, which should be balanced at 6.9 volts and phase sequence V_{AN}, V_{BN}, V_{CN}.
	2. Defective CL card.	2. Change CL card.
	3. Defective reed relay (K1).	3. Change PS card.
II. Relay will not pick up when it should on any of the three phases.	1. Plus and/or minus 15 (+15 and/or -15) VDC is missing.	1. Check +15V and -15V test points on PS card. If either or both voltages are not between 14 and 16 volts, check following: a. 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 telephone relay (K2) or target (T1).	2. Remove PS card and jumper pins 17 and 40 of the PS card. If the relay does not pick up, then K2 or or T1 is defective.
	3. Defective reed relay (K1).	3. If the relay picks up with the jumper in the preceding step (2), 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
	4. Defective IT card.	4. If replacing the PS card in the preceding step (3) 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. 2. Incorrect wiring and/or defective card.	1. Change printed-circuit cards, one at a time, in the following order; IT, CL, SP, QP, OS. 2. Check wiring from all magnetics to the SP card. Check wiring between all PC cards. If an error in wiring is found and corrected and the relay still does not pick up, return to preceding step (1) to find defective PC card.
IV. Out of specification in maximum reach $\pm 30^{o}$ tests.	1. Incorrect steady-state pickup time on IT card. 2. Defective card.	1. Set steady-state pickup time potentiometer and recheck other phases. 2. Change printed-circuit cards, one at a time, in the following order; SP QP, 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 (see CAUTION under TROUBLE SHOOTING). A special tool (see Figure 23) is available for removing the printed-circuit cards from their sockets. 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 trouble-shooting program must isolate the specific component on the card that 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 coated with a suitable high dielectric plastic coating to prevent possible breakdowns 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 component are used on printed-circuit cards that 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

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_0 = total zero-sequence current in relay in amperes rms

I_T = relay current during test in amperes rms

R = ratio tap to provide "offset"

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_{AG} = phase A to ground voltage in volts rms

V_{BG} = phase B to ground voltage in volts rms

V_{CG} = phase C to ground 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

Z_{R0} = base-reach tap in zero-sequence ohms

= phase-angle meter reading during test in degrees

$\emptyset$ = relay base-reach angle in degrees

LIST OF ILLUSTRATIONS

*Revised since last issue

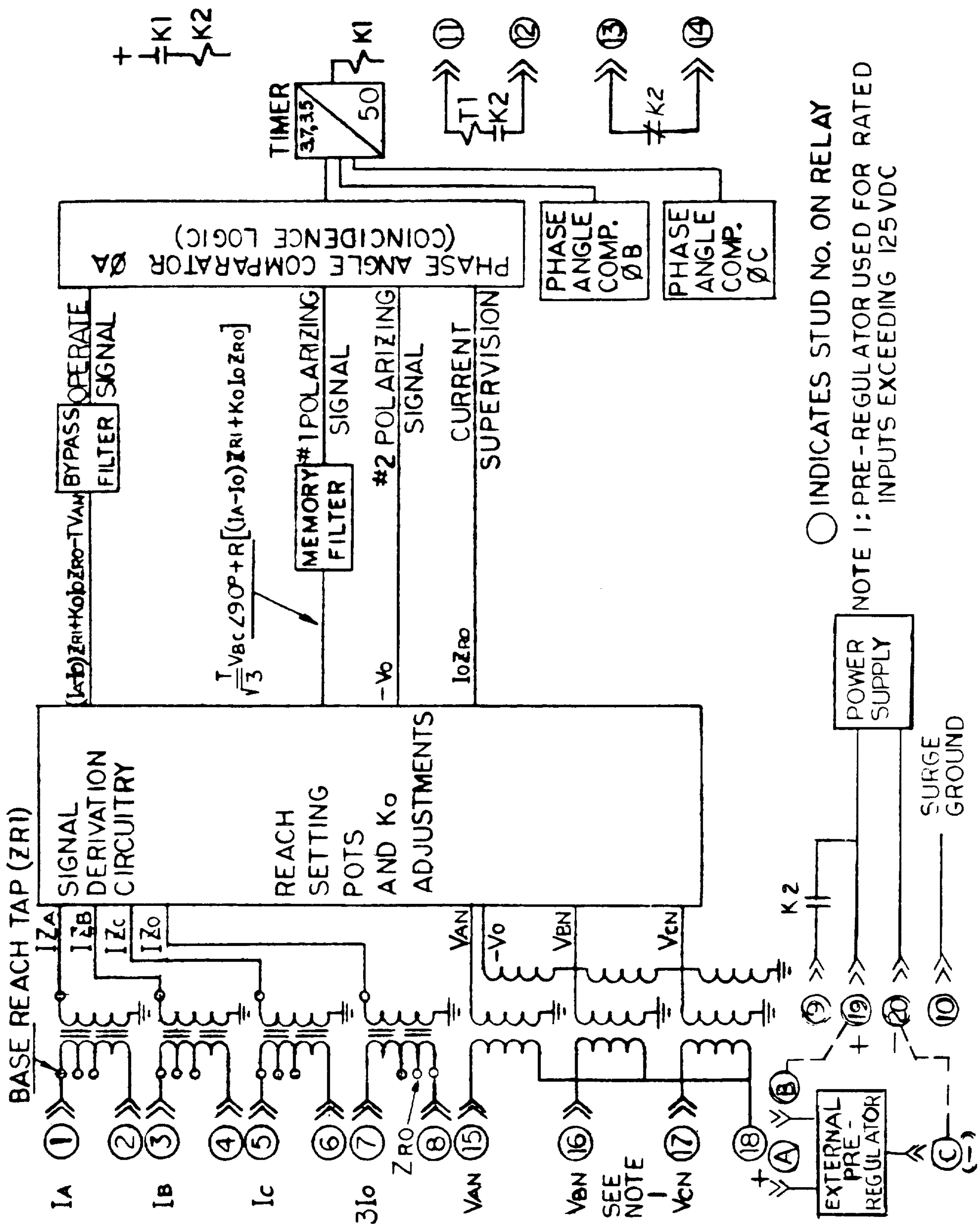


FIGURE 1 (0257A6178-2) FUNCTIONAL BLOCK DIAGRAM

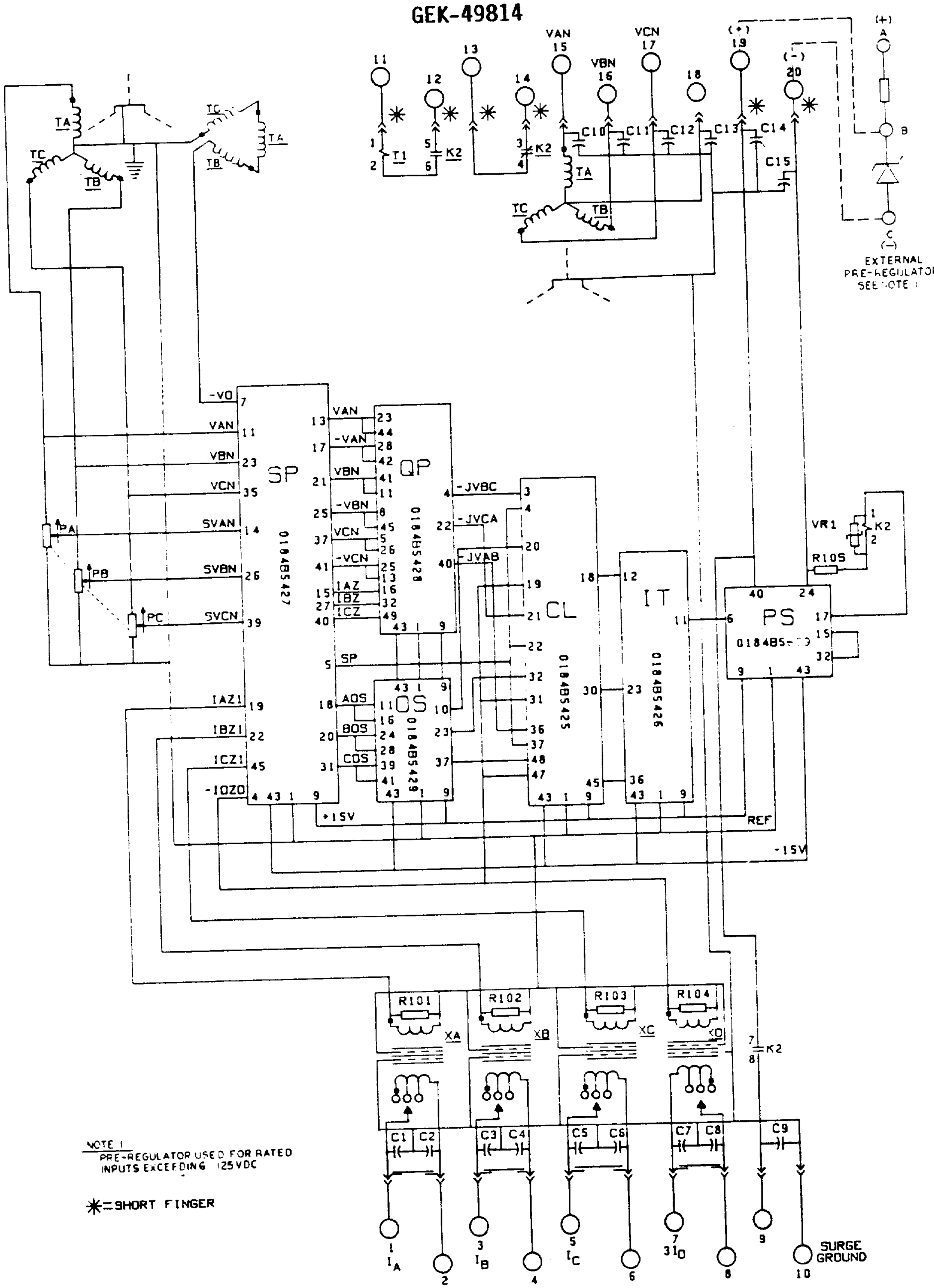


FIGURE 2 (0171C8415-3) INTERNAL CONNECTIONS

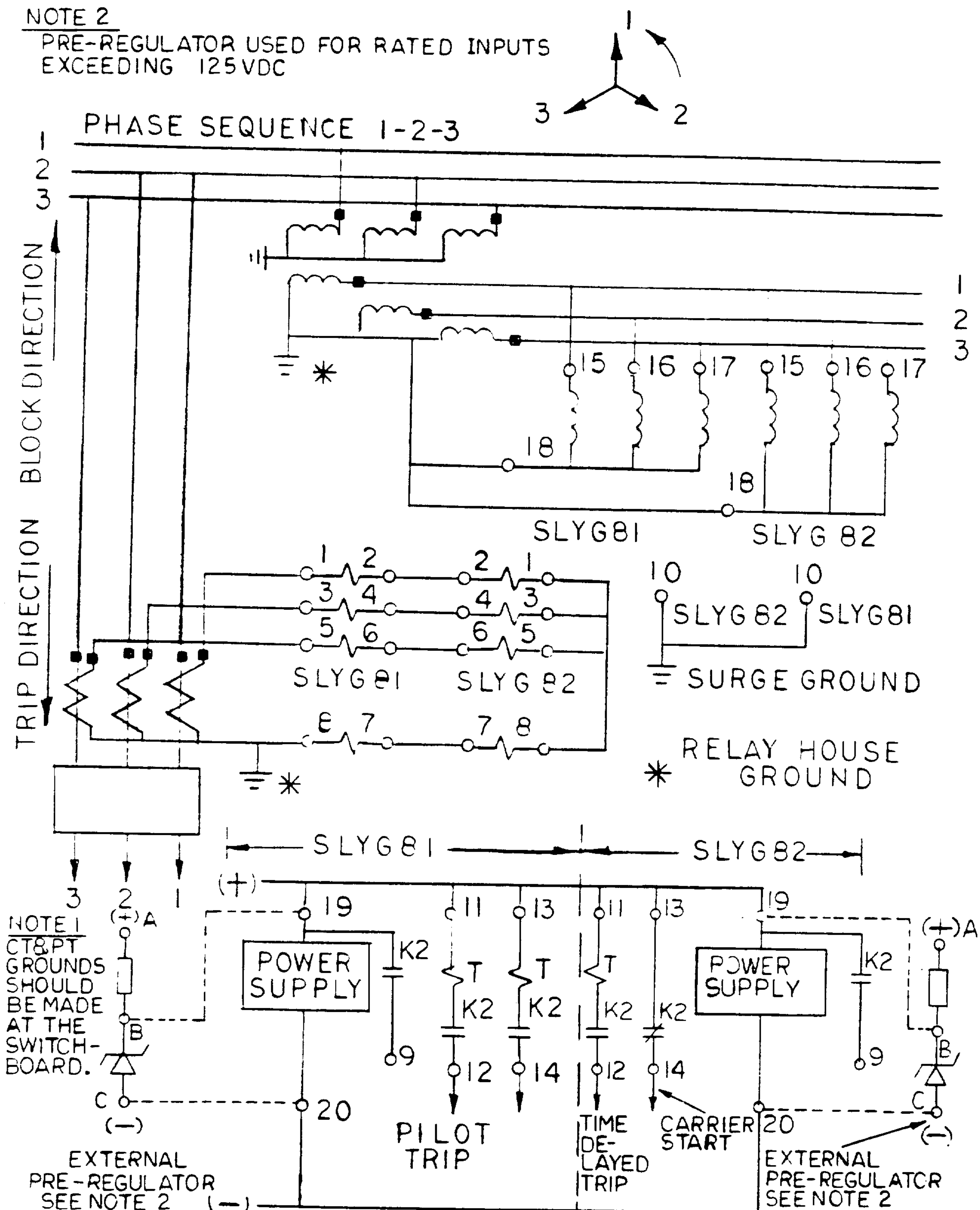


FIGURE 3 (0257A6186-1) EXTERNAL CONNECTIONS

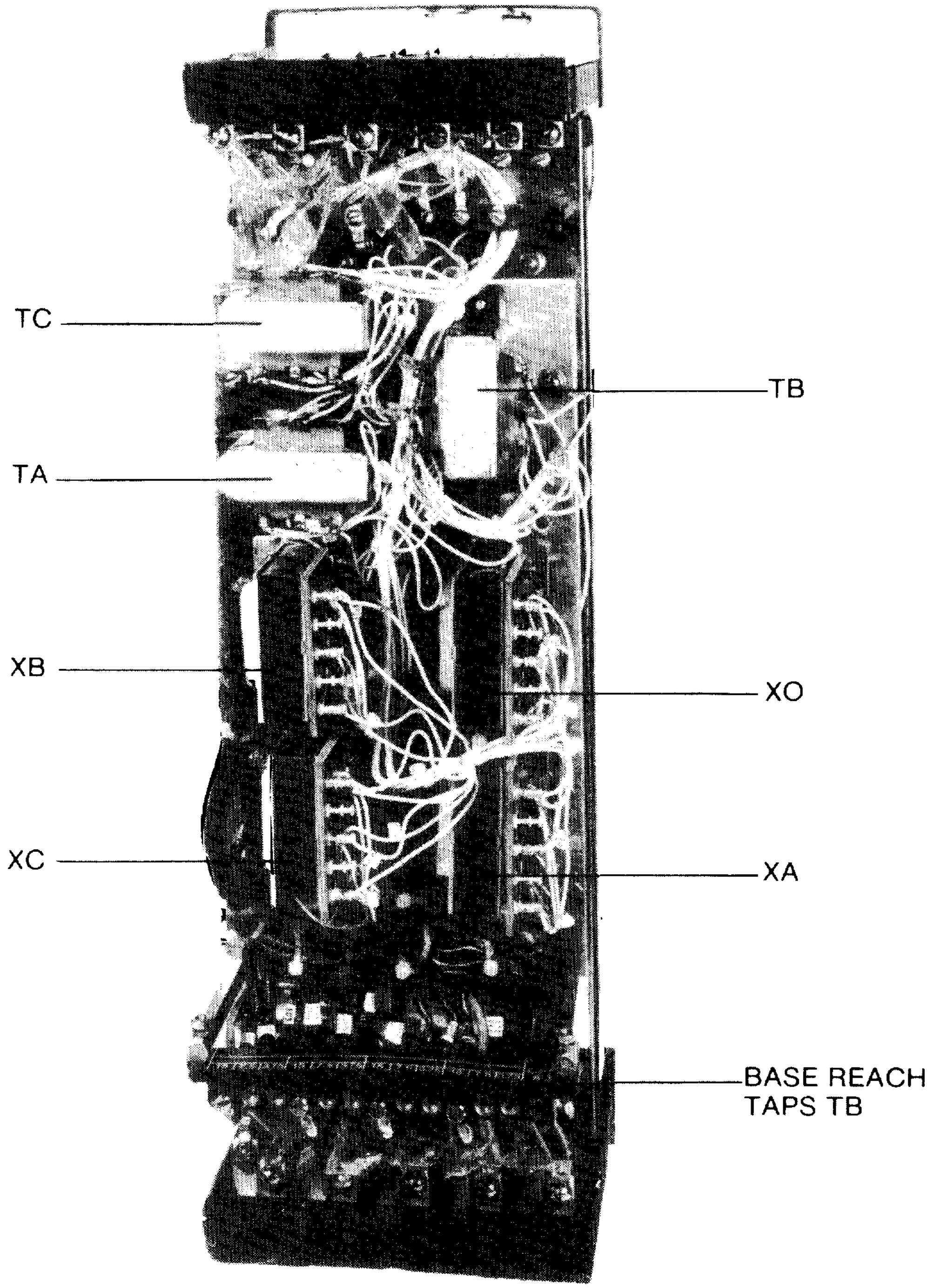


FIGURE 4 (8043550) REAR VIEW OF RELAY OUT OF CASE

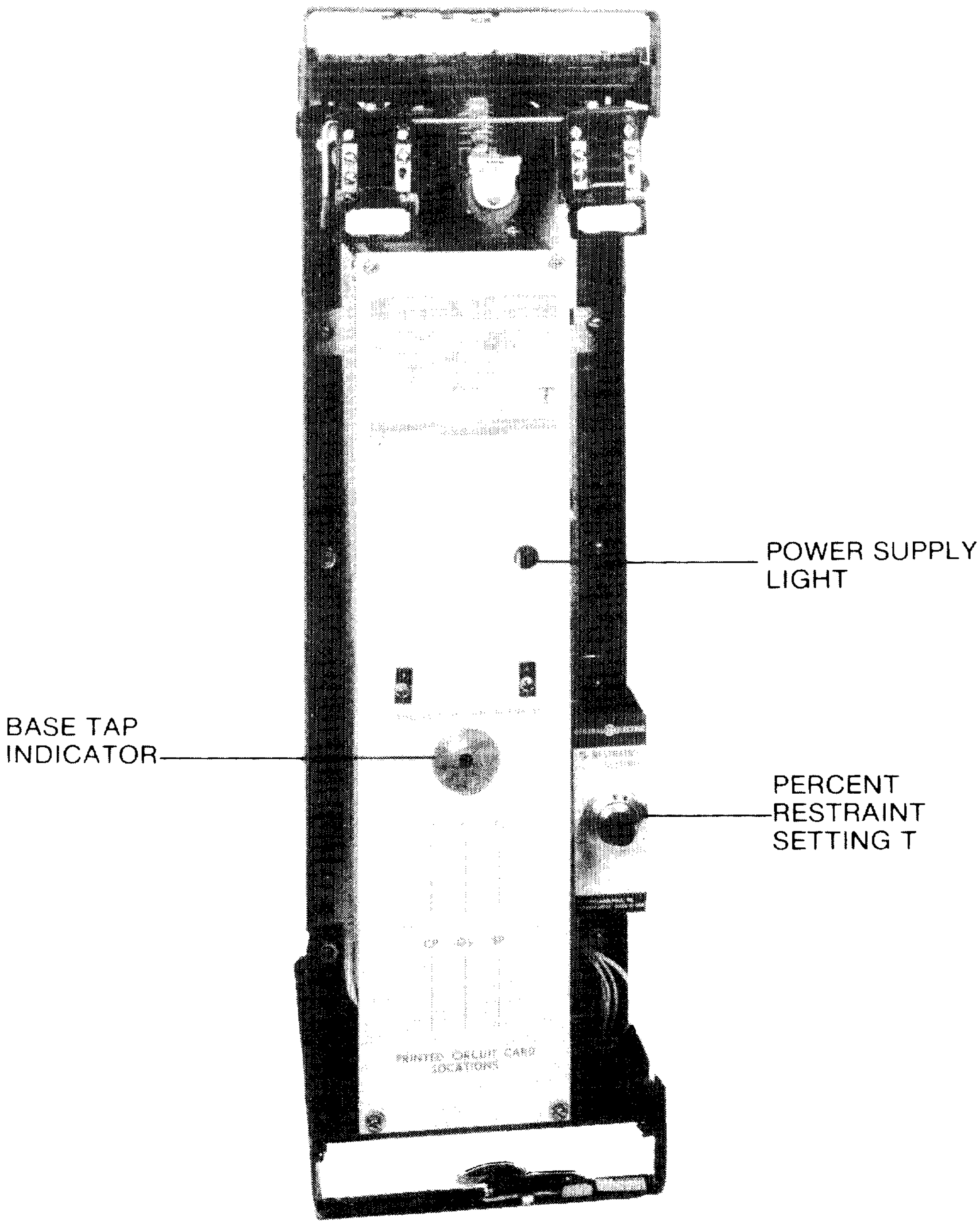


FIGURE 5 (8043548) FRONT VIEW OF RELAY OUT OF CASE

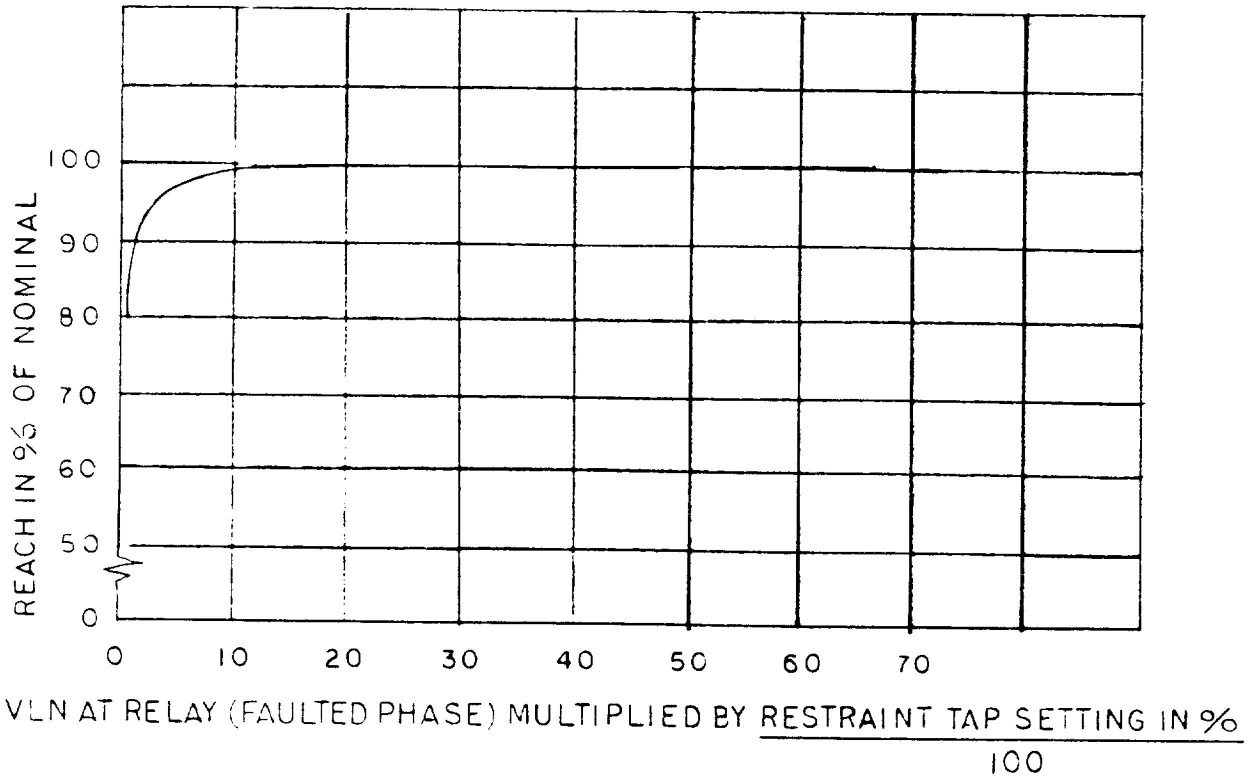
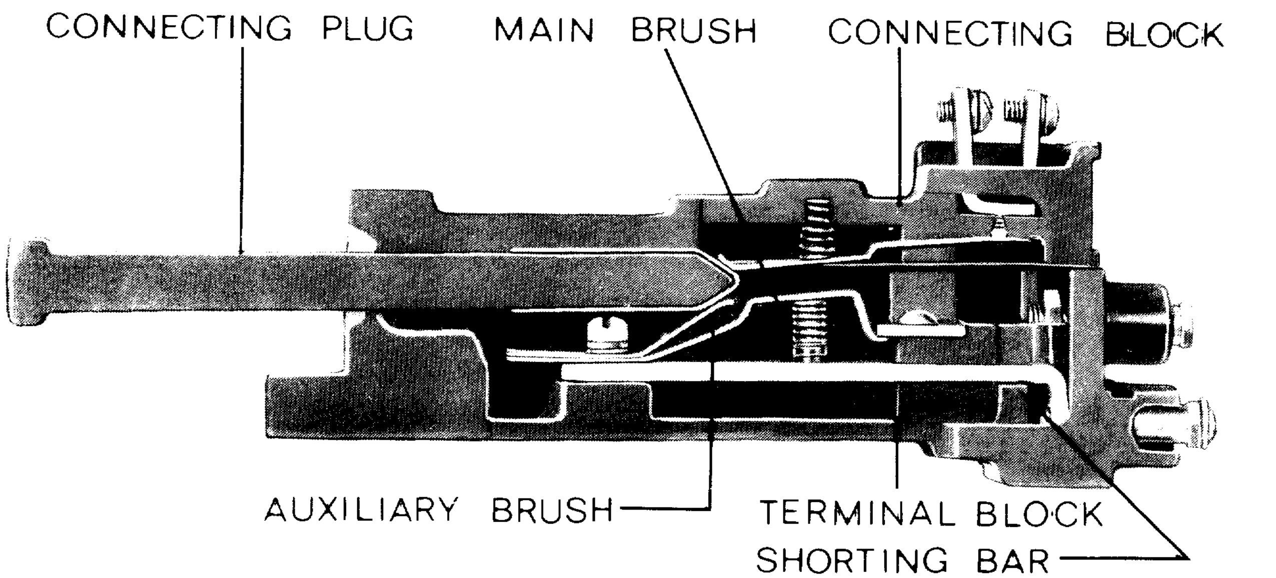


FIGURE 6 (0257A6177) REACH VERSUS FAULTED PHASE VOLTAGE



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

FIGURE 7 (8025039) CRADLE BLOCK AND TERMINAL BLOCK CROSS SECTION

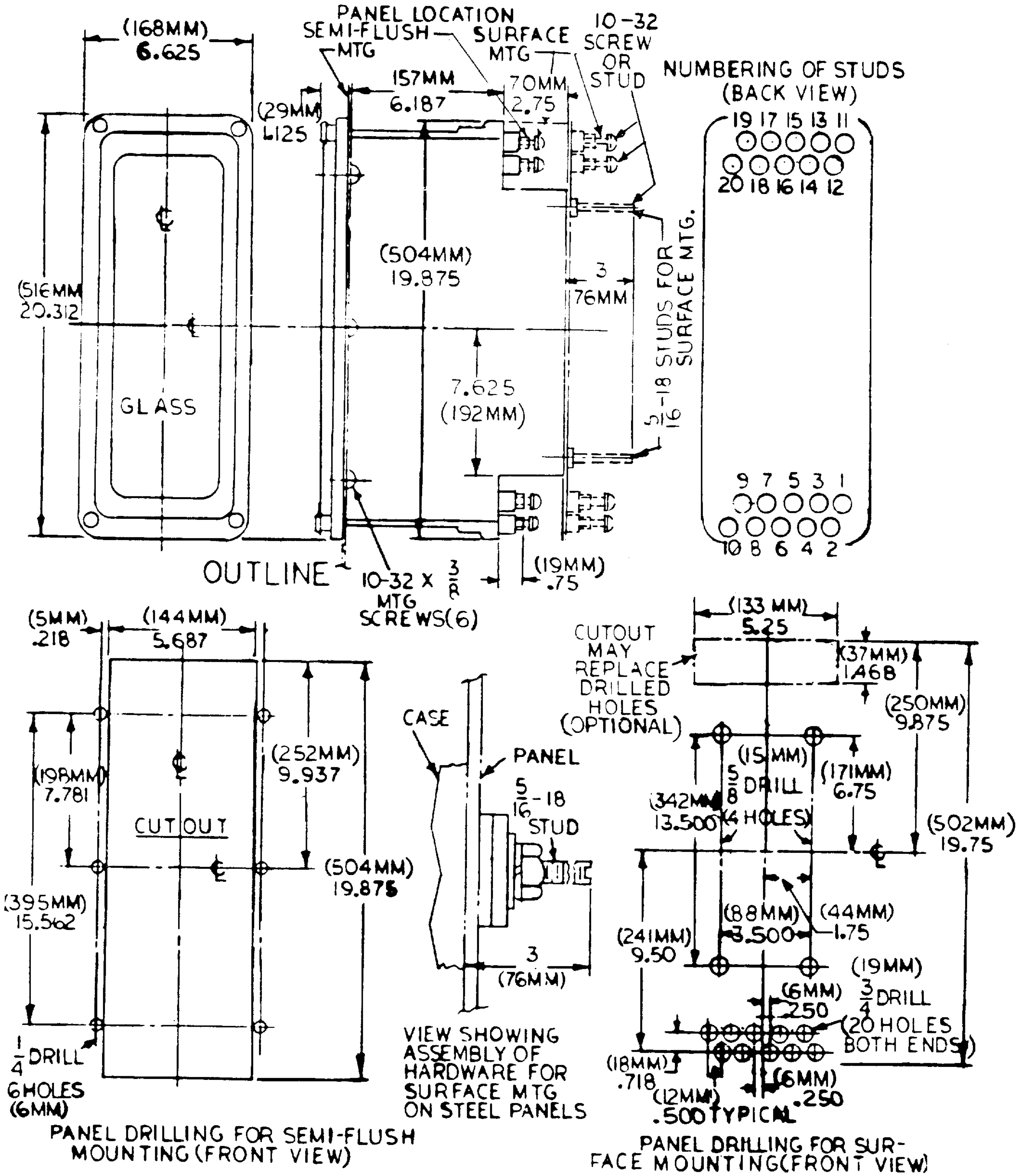


FIGURE 8 (0178A7336-4) OUTLINE AND PANEL DRILLING FOR TYPE SLYG82A RELAY

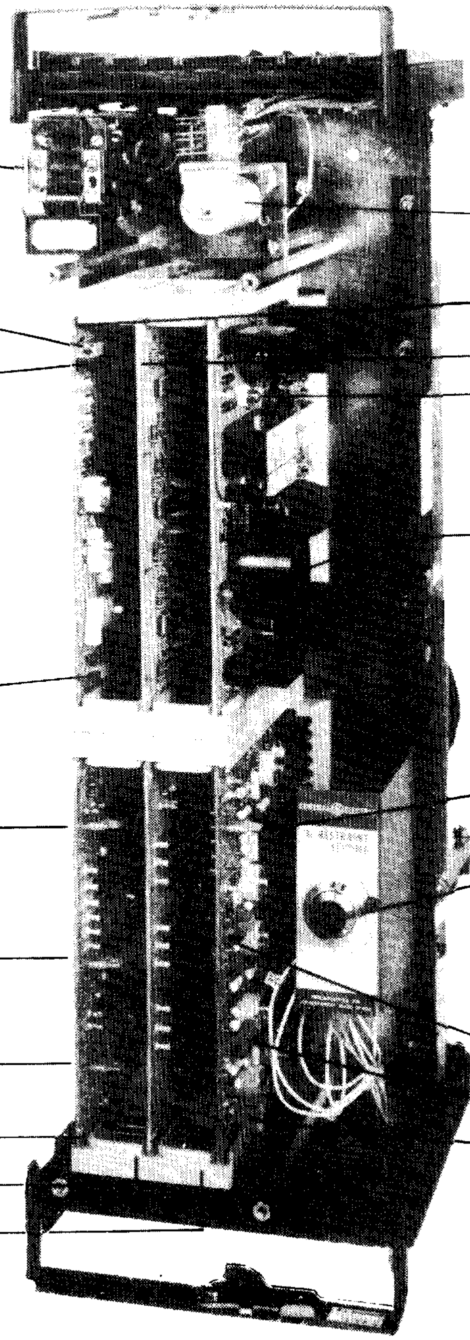


FIGURE 9 (8043549) FRONT VIEW OF RELAY OUT OF CASE WITH NAMEPLATE REMOVED

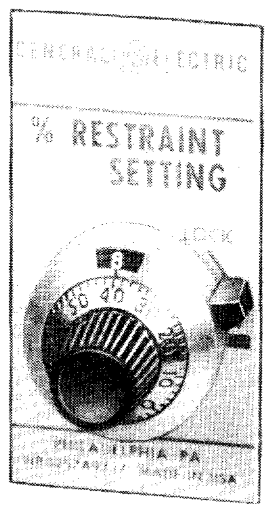


FIGURE 10 (8042986) RESTRAINT SETTING DIAL (SET AT 84%)

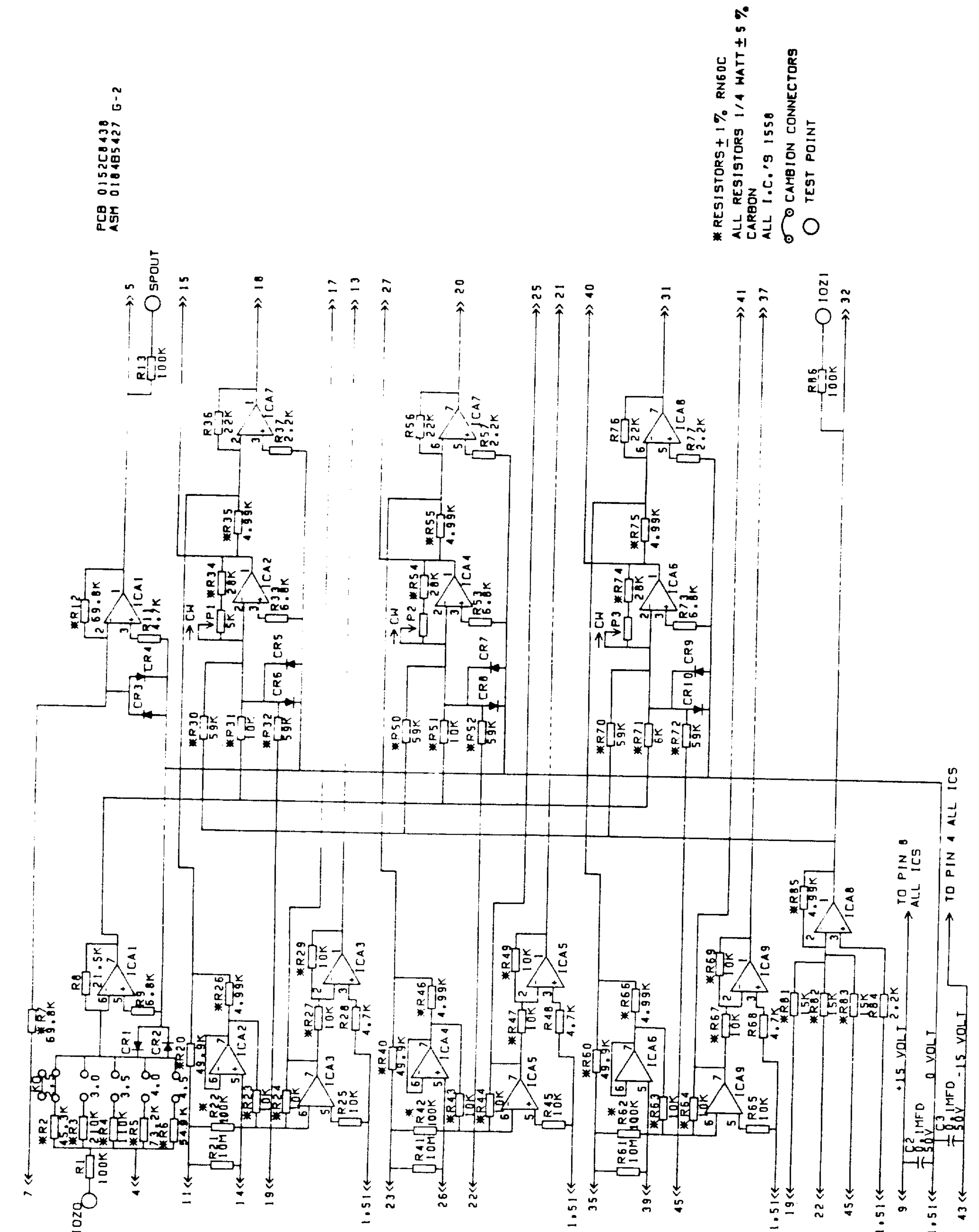


FIGURE 11A (0152C9085 SH.2 1) INTERNAL CONNECTIONS FOR SIGNAL PROCESSING CARD (SP)

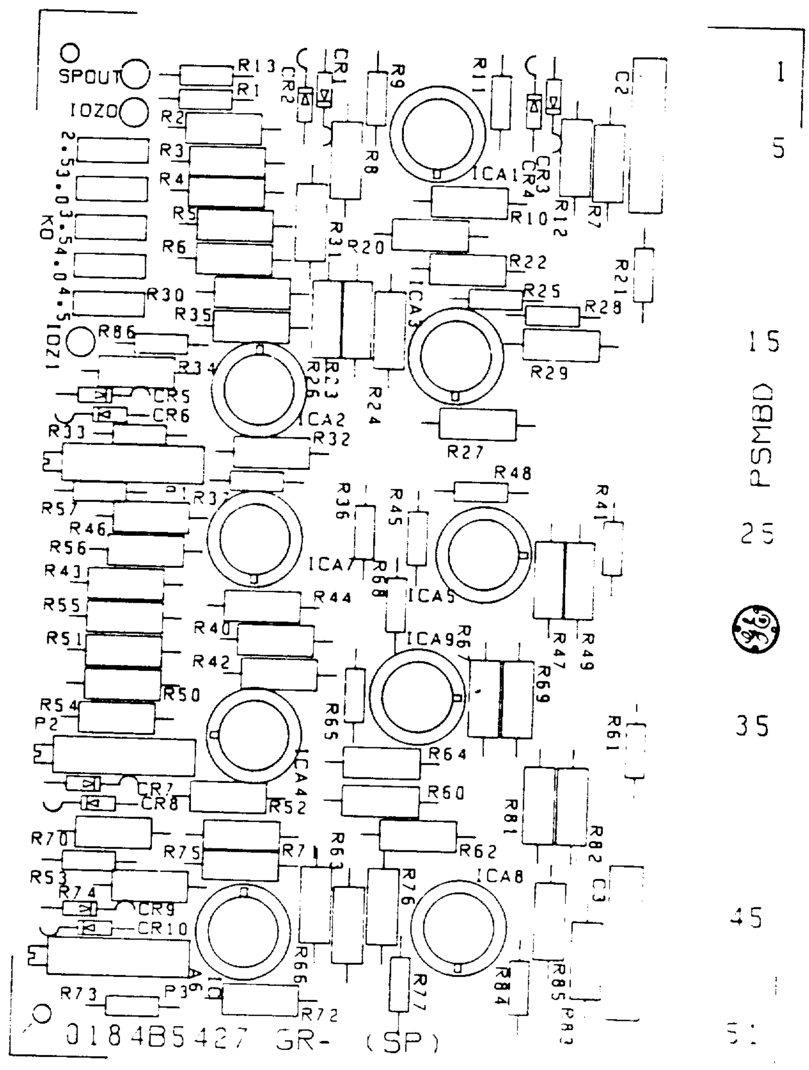


FIGURE 11B (0152C8438 SH.1 3) CARD LAYOUT FOR SIGNAL PROCESSING CARD (SP)

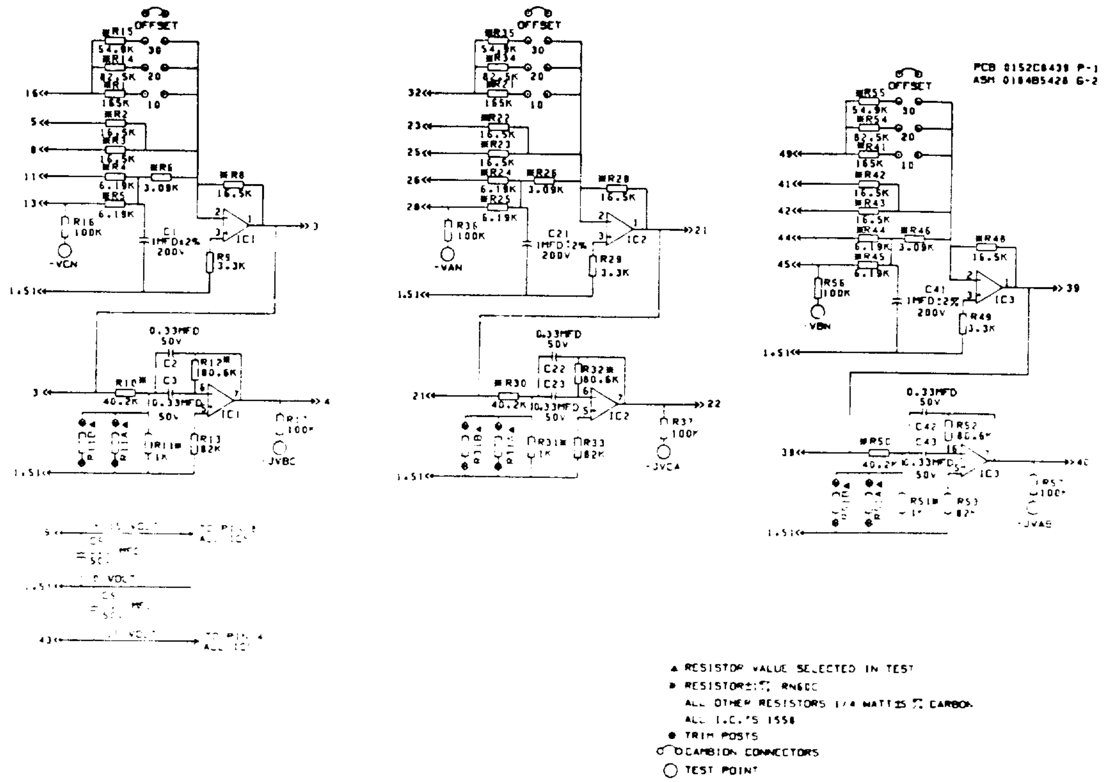


FIGURE 12A (0152C9086 SH.2 1) INTERNAL CONNECTIONS FOR 60 HERTZ QUADRATURE POLARIZING CARD (QP)

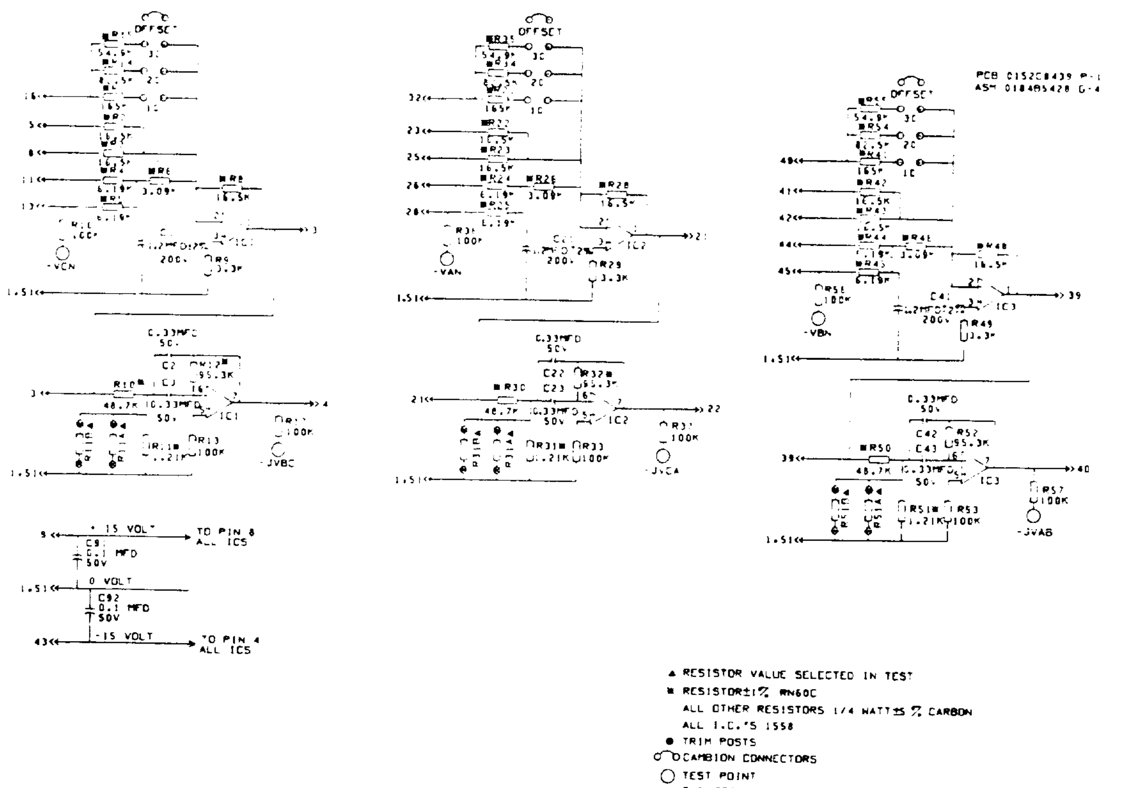


FIGURE 12B (0152C9086 SH.4) INTERNAL CONNECTIONS FOR 50 HERTZ QUADRATURE POLARIZING CARD (QP)

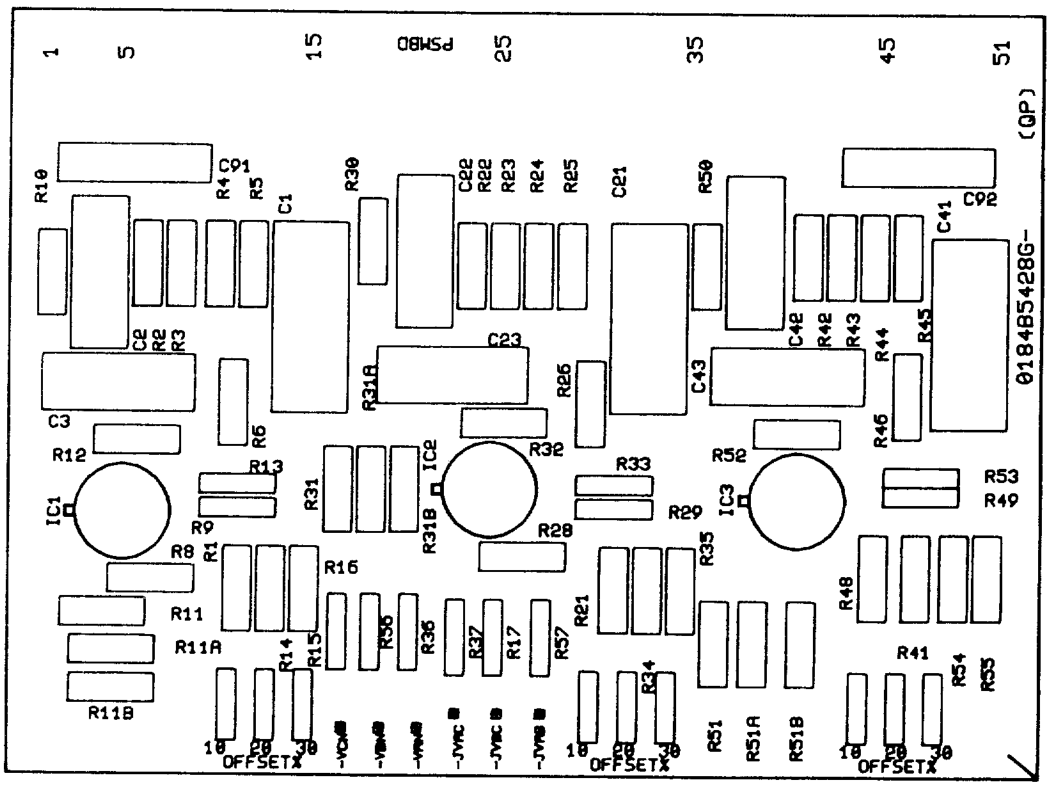


FIGURE 12C (0184B5428) SH.1 [3]) CARD LAYOUT FOR QUADRATURE POLARIZING CARD (QP)

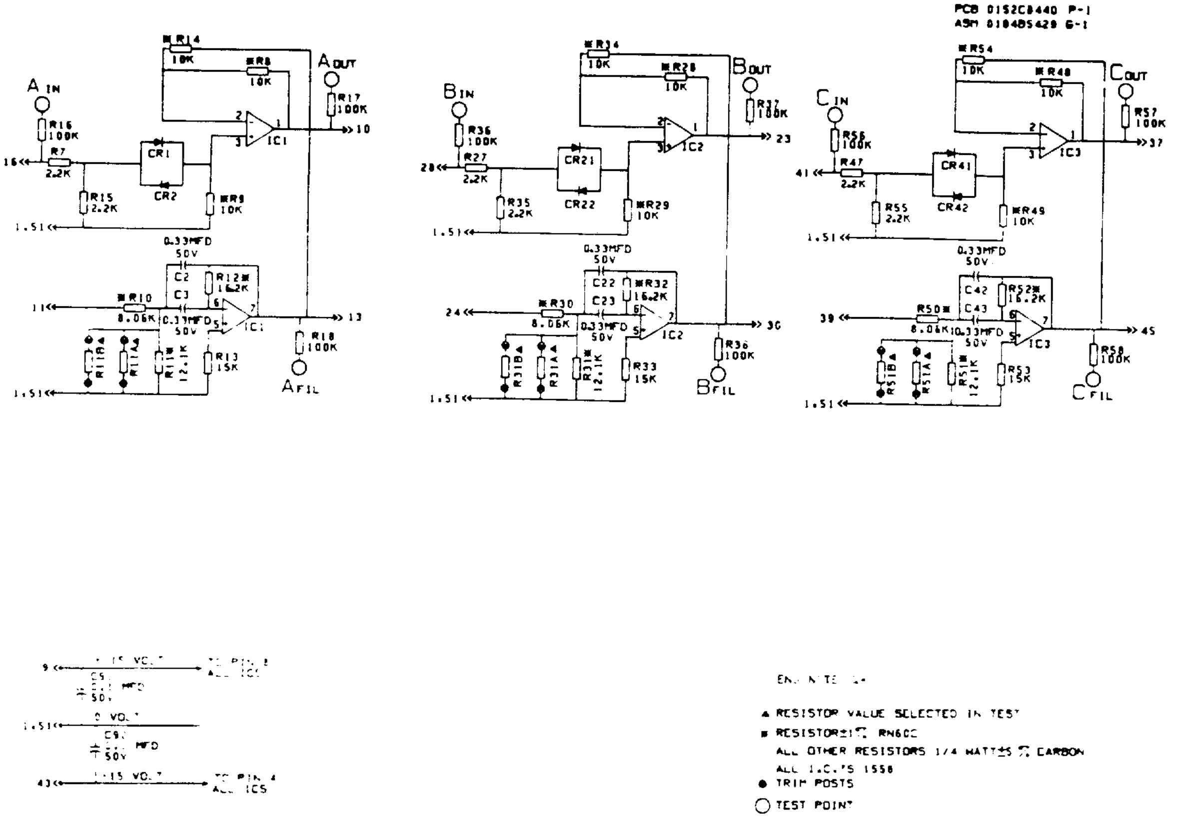


FIGURE 13A (0152C9087 SH.1 2) INTERNAL CONNECTIONS FOR 60 HERTZ OPERATE SIGNAL CARD (OS)

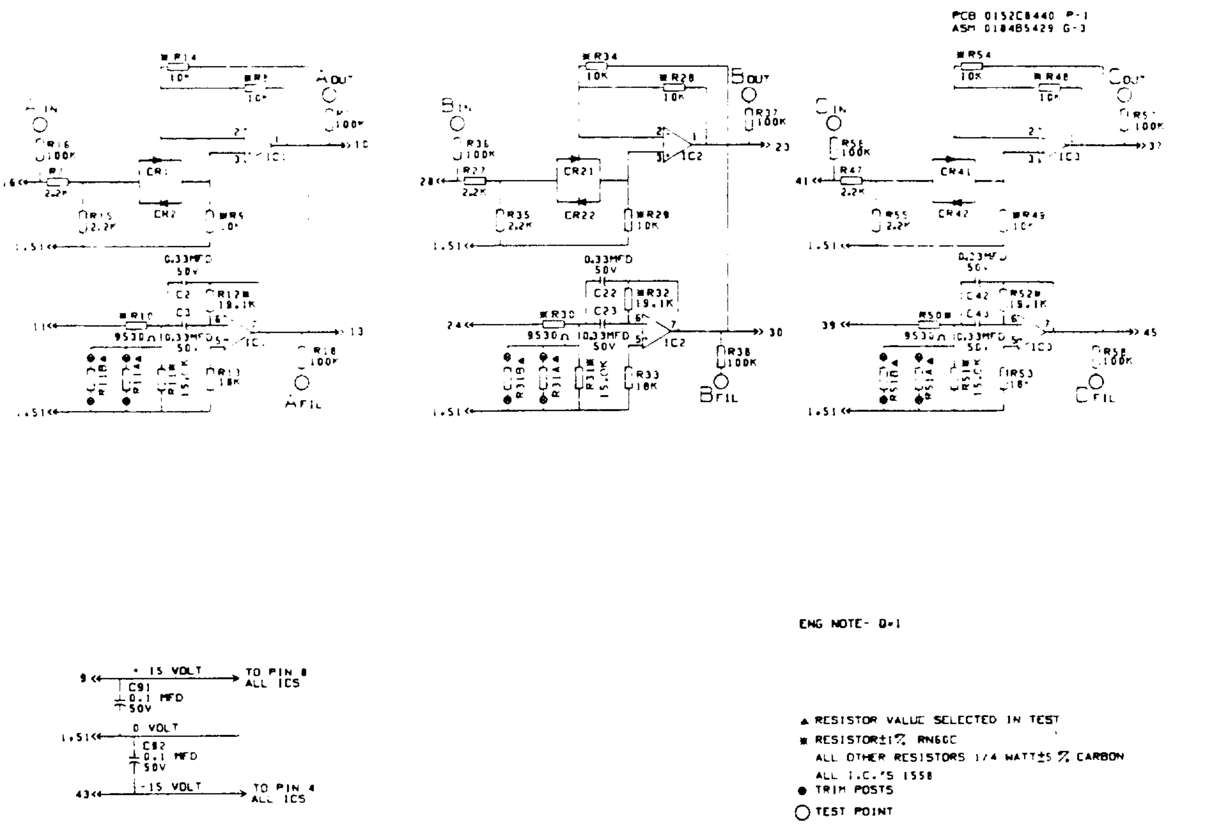
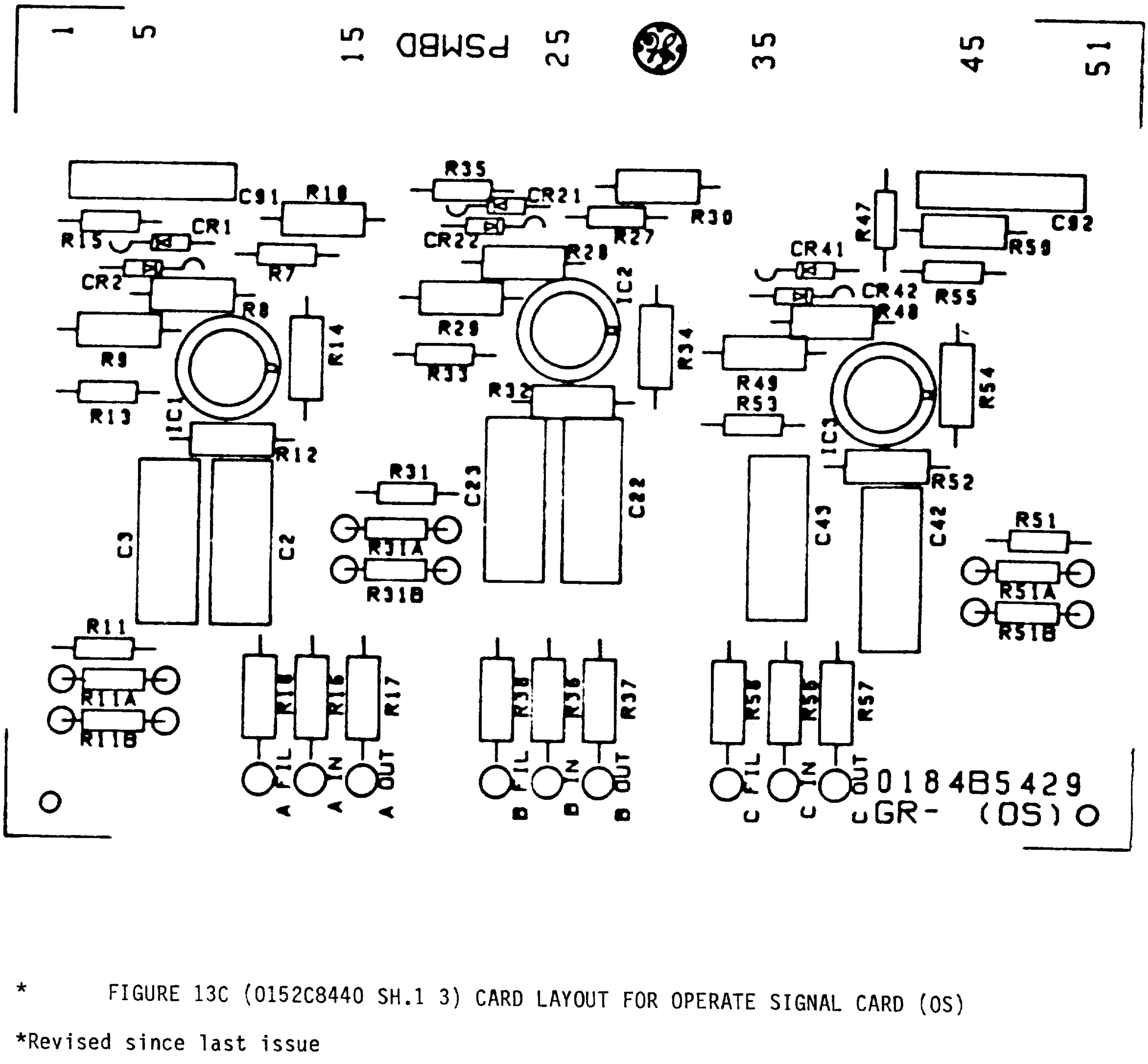


FIGURE 13B (0152C9087 SH.3 1) INTERNAL CONNECTIONS FOR 50 HERTZ OPERATE SIGNAL CARD (OS)



* FIGURE 13C (0152C8440 SH.1 3) CARD LAYOUT FOR OPERATE SIGNAL CARD (OS)

*Revised since last issue

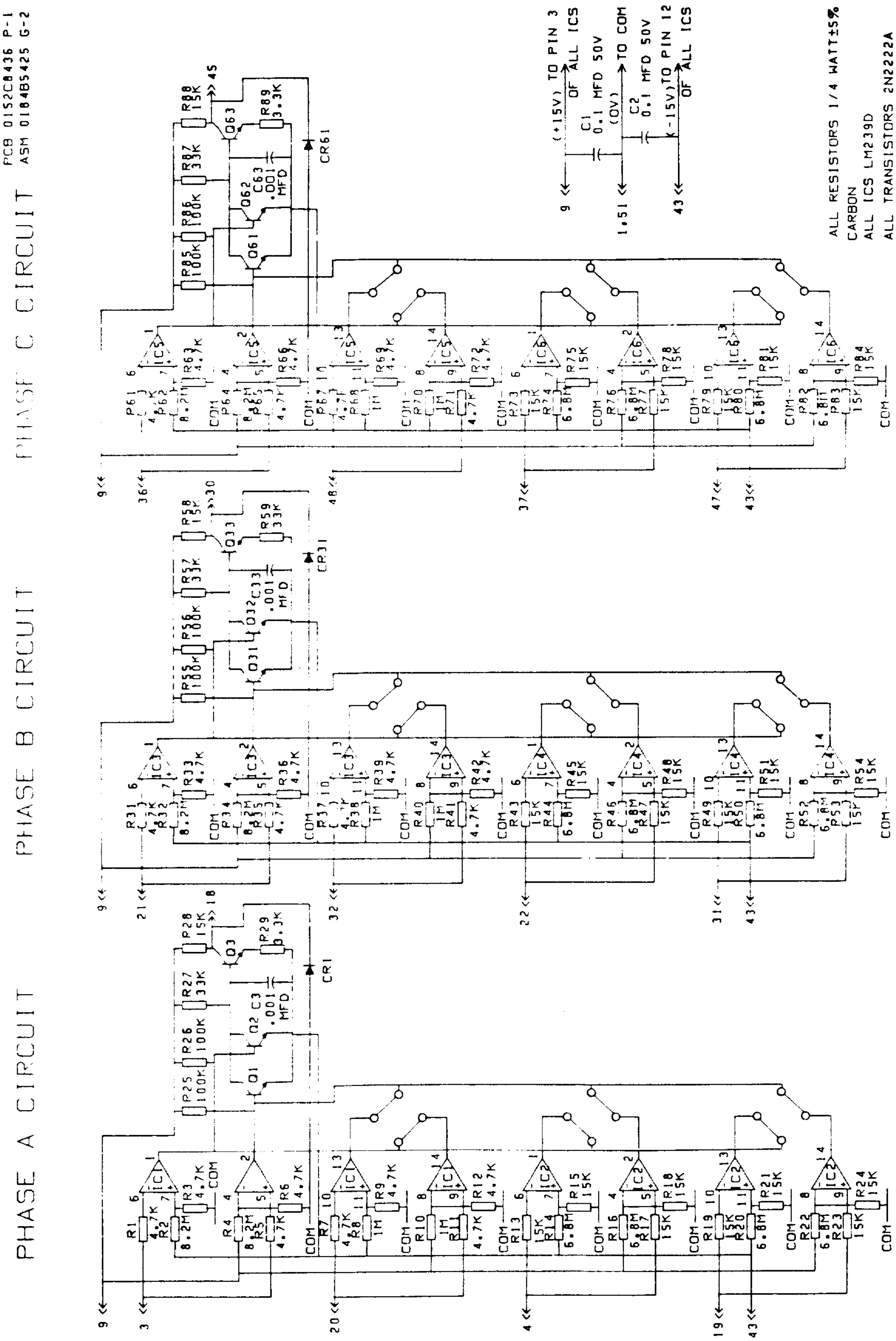


FIGURE 14A (0152C9083 SH.2 1) INTERNAL CONNECTIONS FOR COINCIDENCE LOGIC CARD (CL)

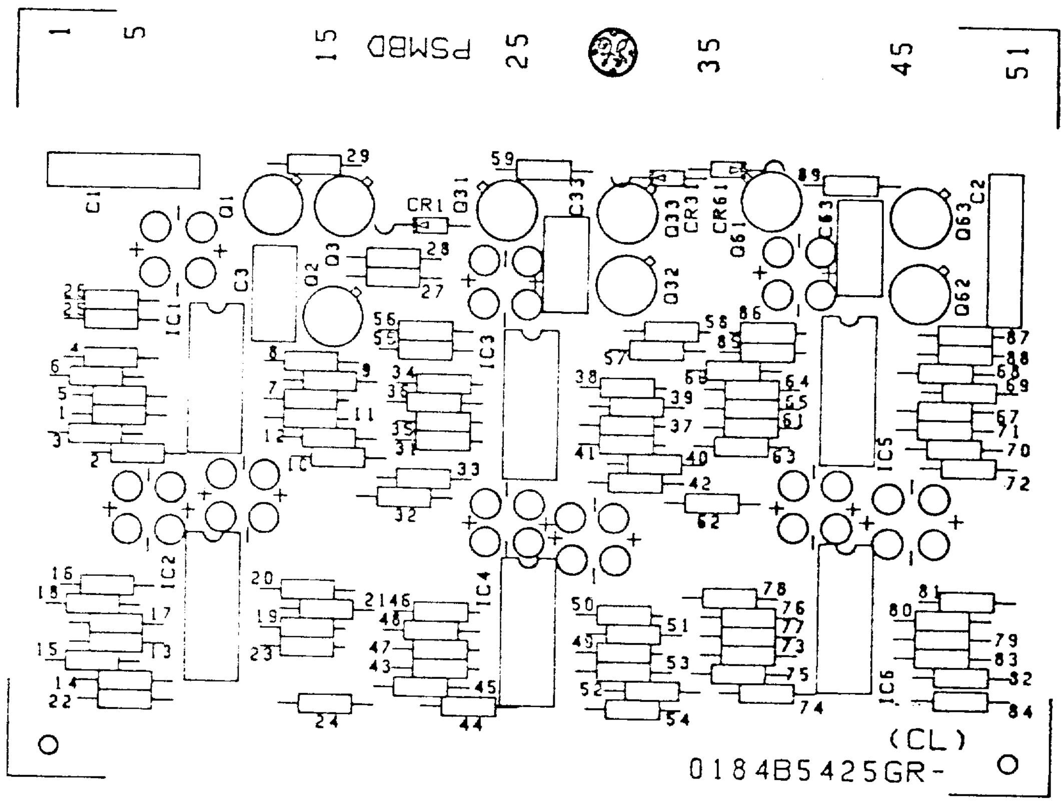


FIGURE 14B (0152C8436 SH.1 4) CARD LAYOUT FOR COINCIDENCE LOGIC CARD (CL)

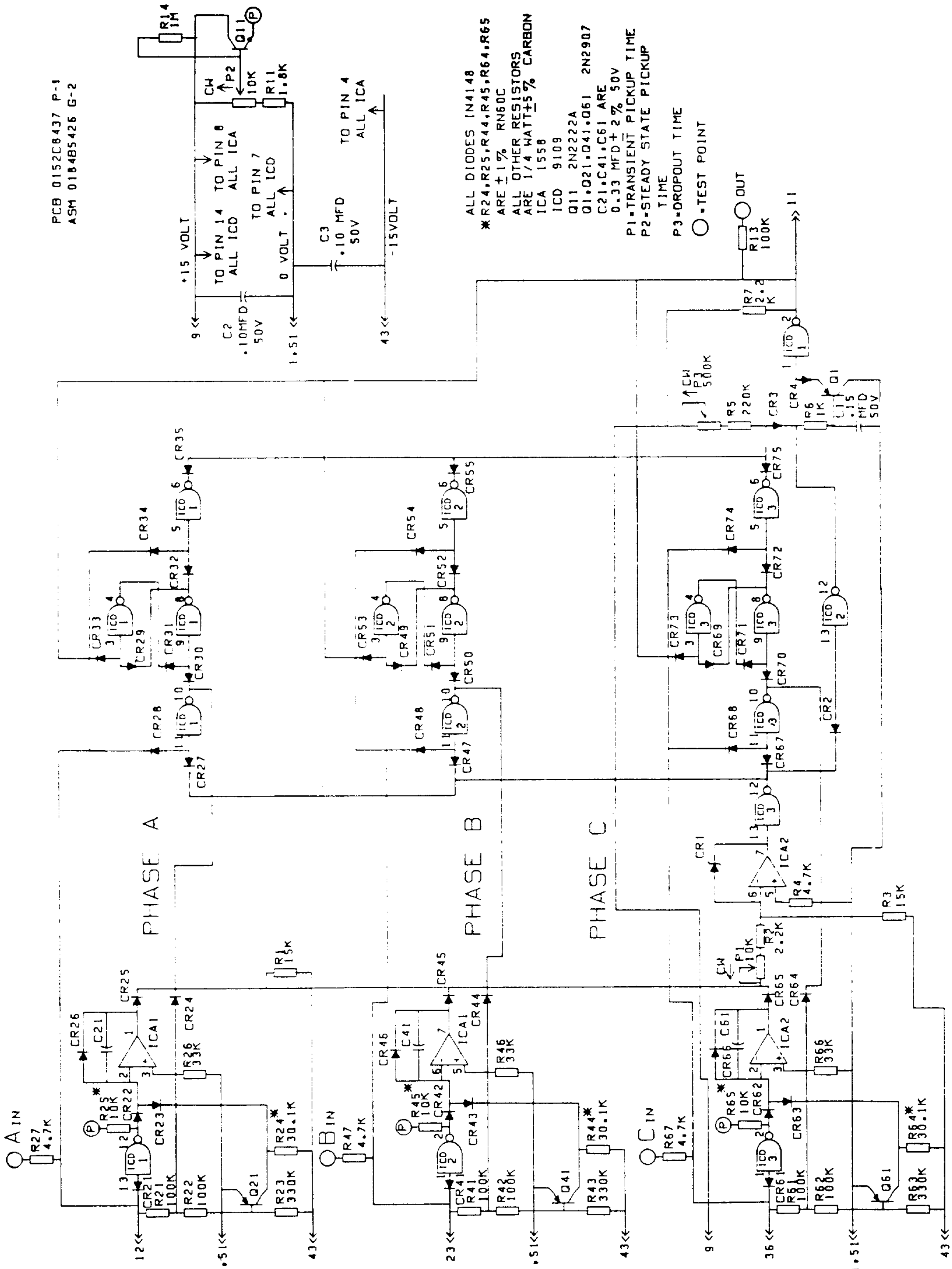
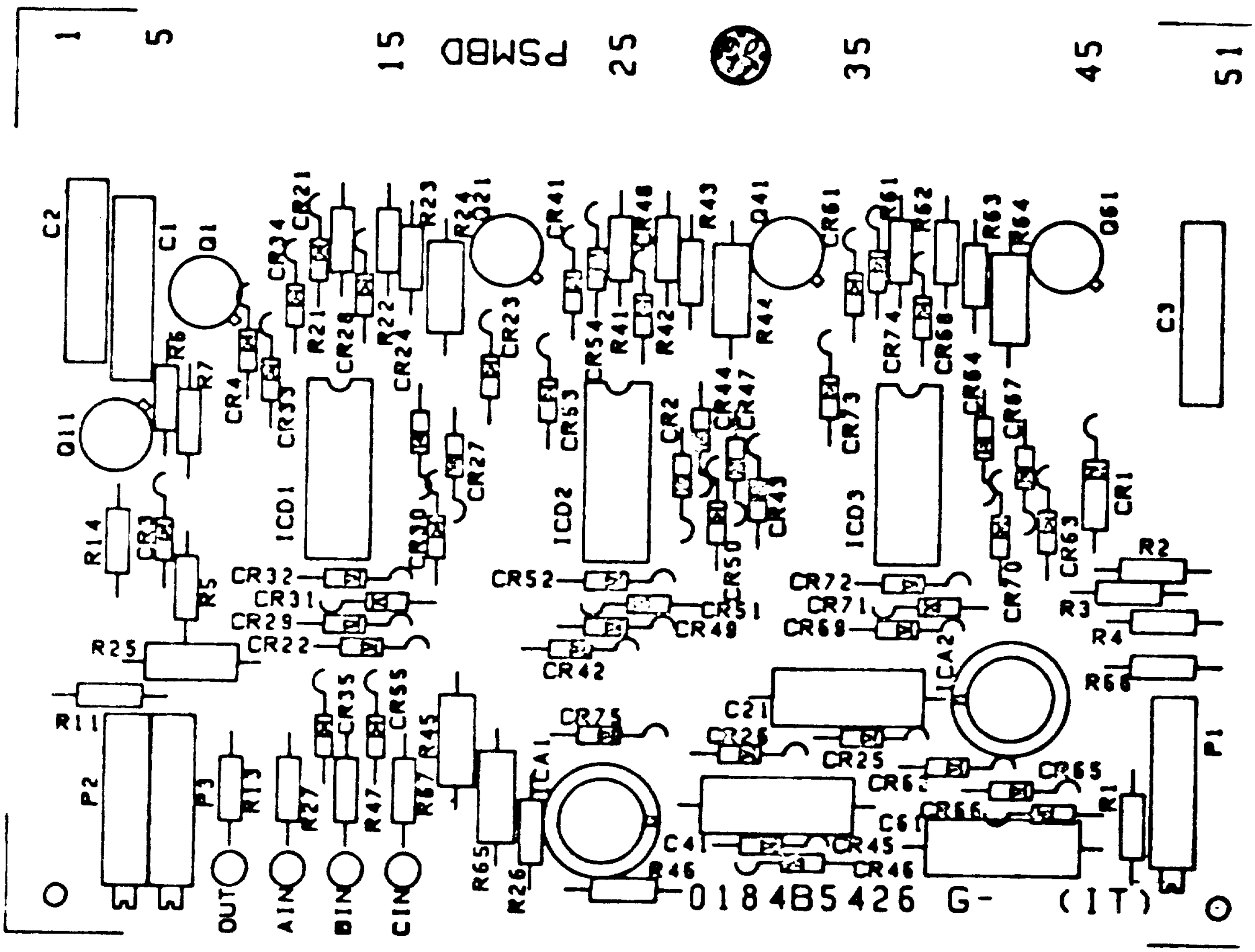
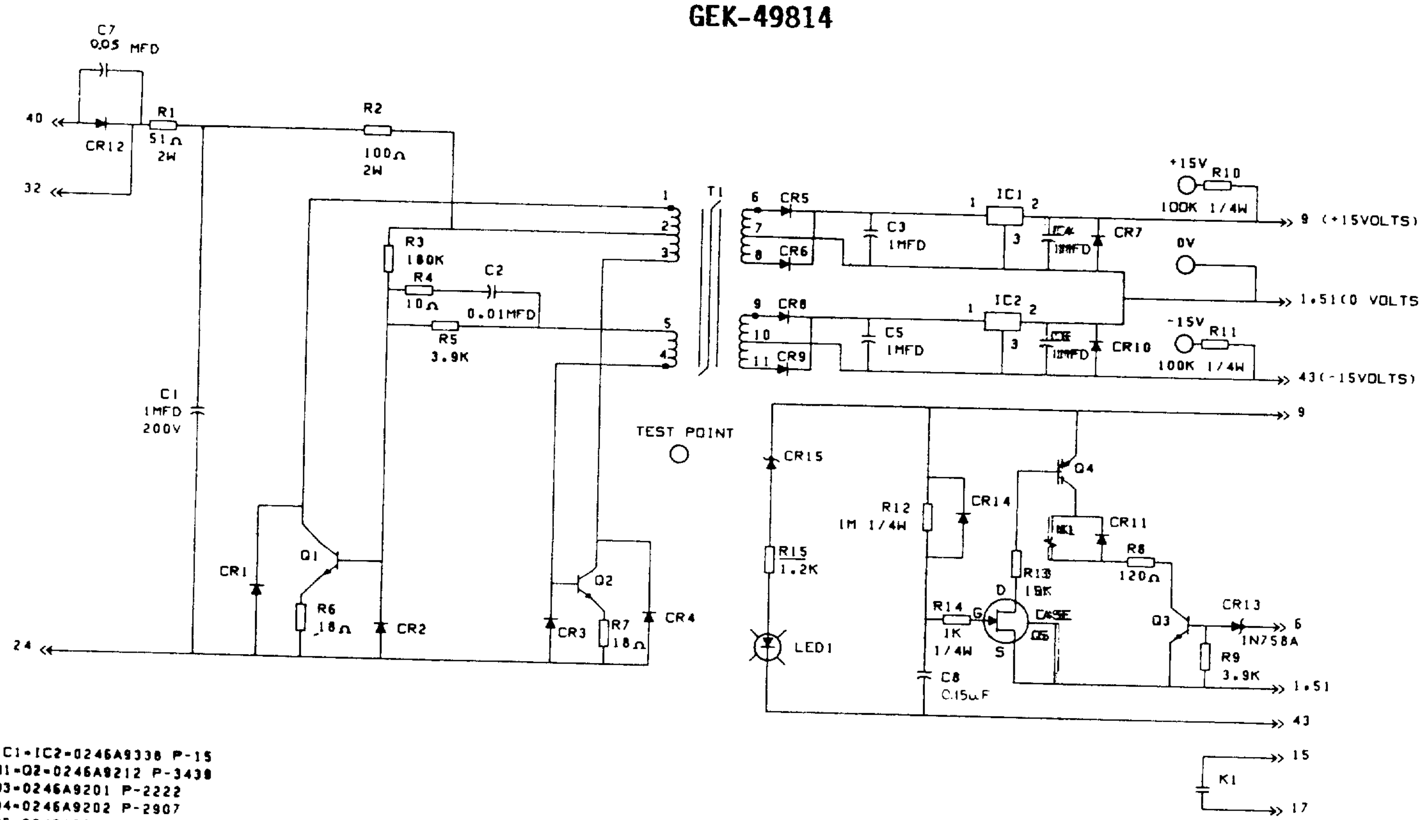


FIGURE 15A (0152C9084 SH.2 3) INTERNAL CONNECTIONS FOR INTEGRATING TIMER CARD (IT)



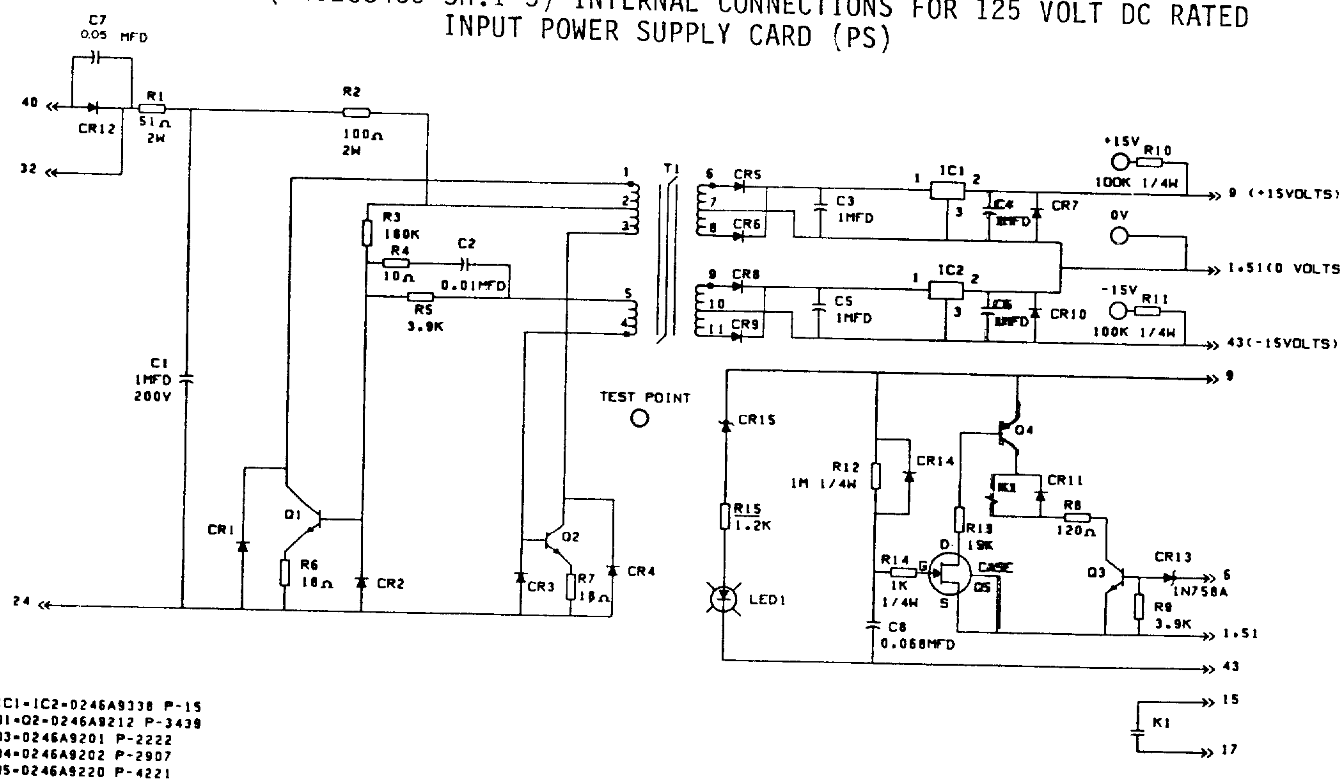
* FIGURE 15B (0152C8437 SH.1 5) CARD LAYOUT FOR INTEGRATING TIMER CARD (IT)

*Revised since last issue



IC1-IC2-0246A9338 P-15
Q1-Q2-0246A9212 P-3439
Q3-0246A9201 P-2222
Q4-0246A9202 P-2907
Q5-0246A9220 P-4221

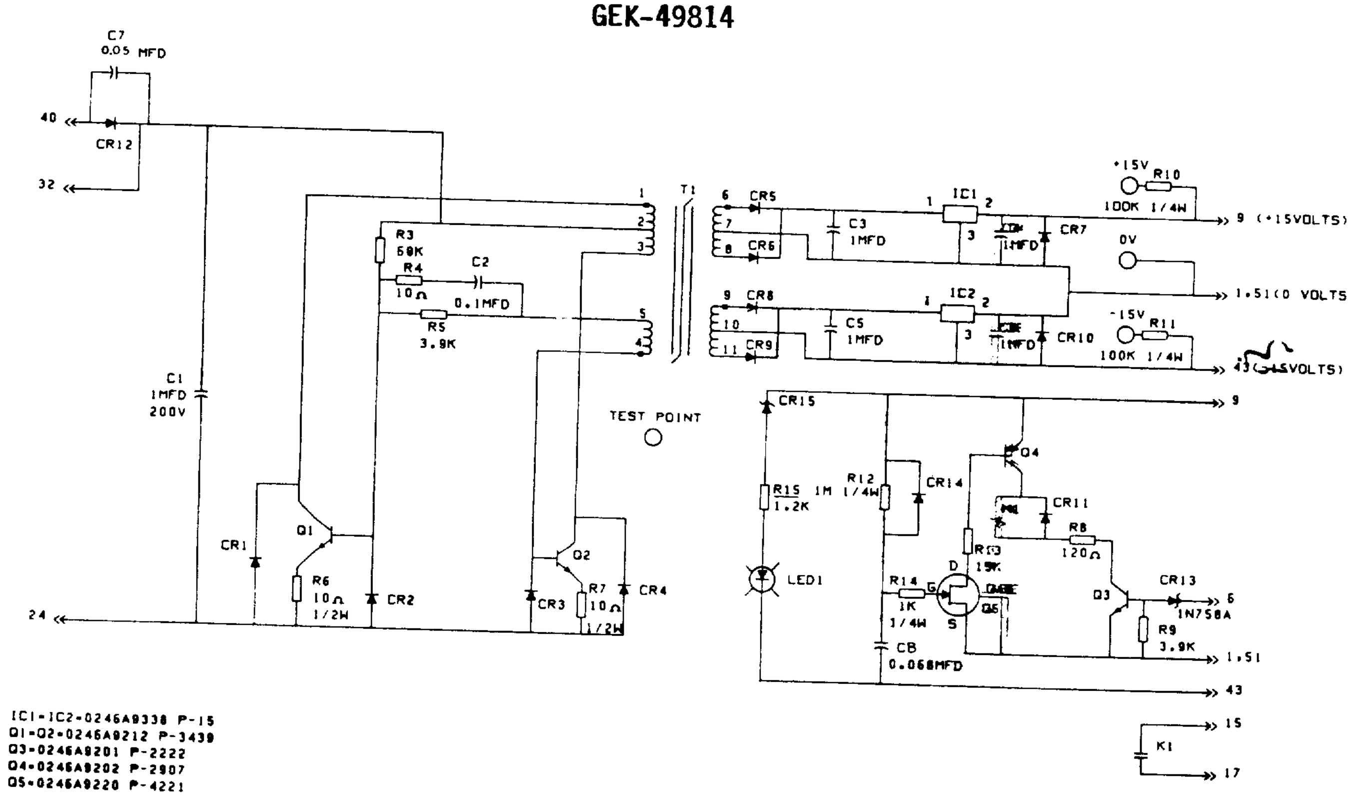
* FIGURE 16A (0152C8465 SH.1 3) INTERNAL CONNECTIONS FOR 125 VOLT DC RATED INPUT POWER SUPPLY CARD (PS)



IC1-IC2-0246A9338 P-15
Q1-Q2-0246A9212 P-3439
Q3-0246A9201 P-2222
Q4-0246A9202 P-2907
Q5-0246A9220 P-4221

* FIGURE 16B (0152C8465 SH.3 2) INTERNAL CONNECTIONS FOR 110 VOLT DC RATED INPUT POWER SUPPLY CARD (PS)

*Revised since last issue



* FIGURE 16C (0152C8465 SH.2 2) INTERNAL CONNECTIONS FOR 48 VOLT DC RATED INPUT POWER SUPPLY CARD (PS)

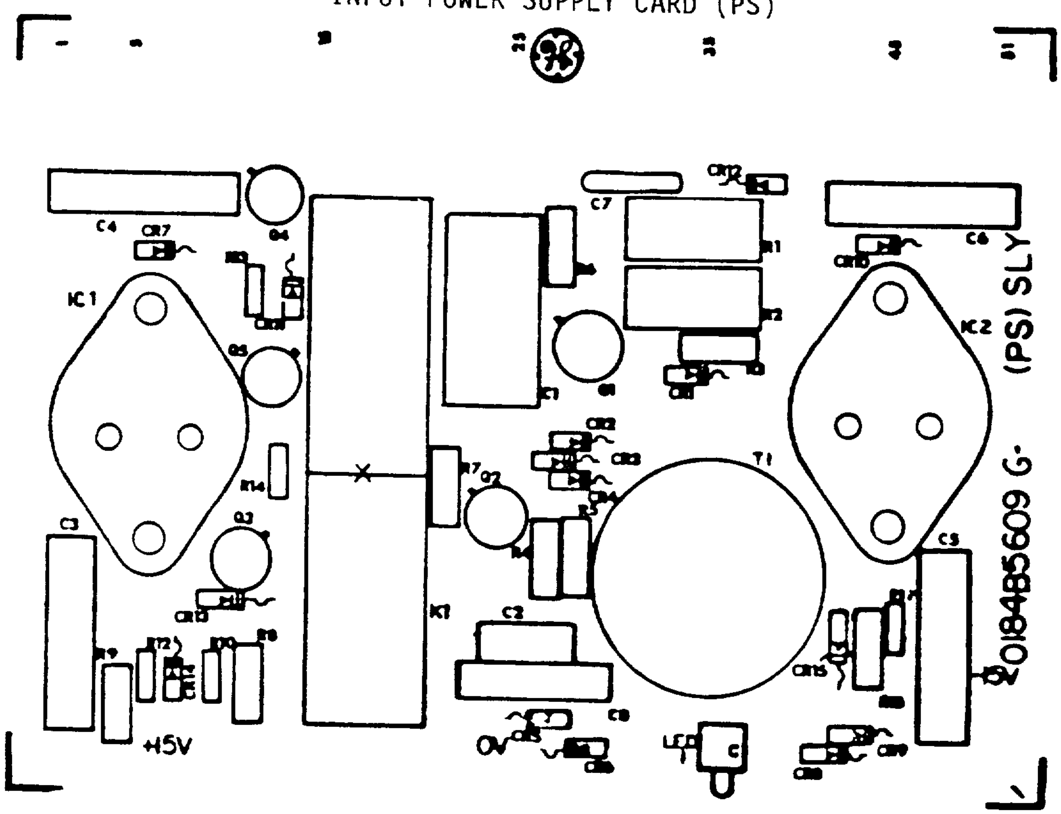


FIGURE 17 (0171C8709 SH.1 4) CARD LAYOUT FOR POWER SUPPLY CARD

*Revised since last issue

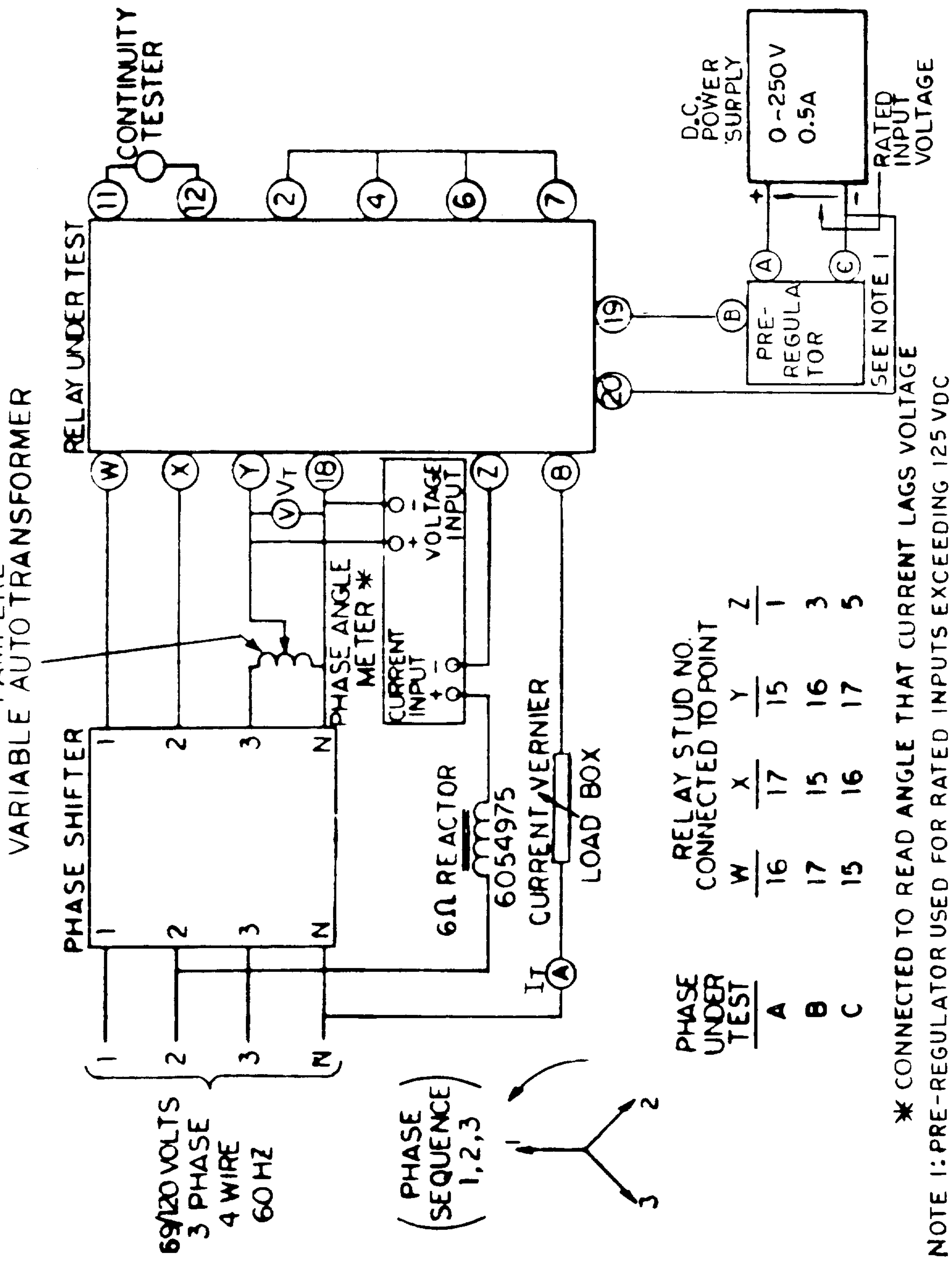


FIGURE 18 (0257A6181-3) TEST CIRCUIT FOR REACH TESTS

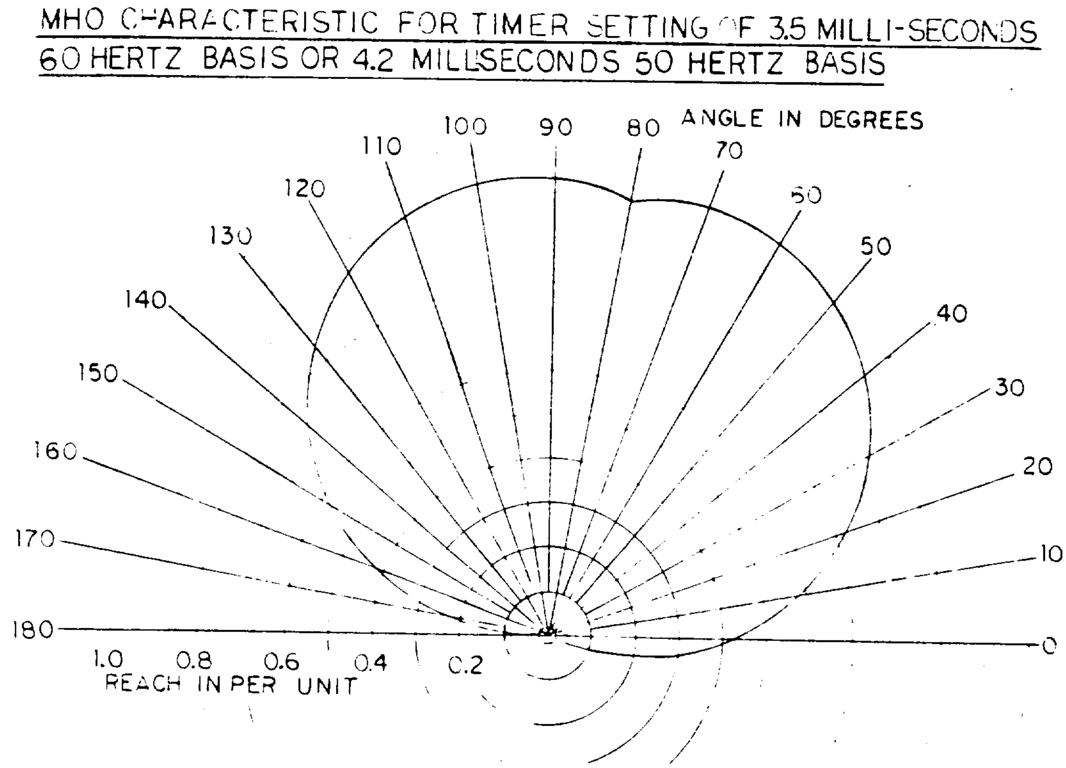


FIGURE 19 (0257A6188-1) MHO CHARACTERISTIC FOR TIMER SETTING OF 3.5 MILLISECONDS (60 HERTZ) OR 4.2 MILLISECONDS (50 HERTZ)

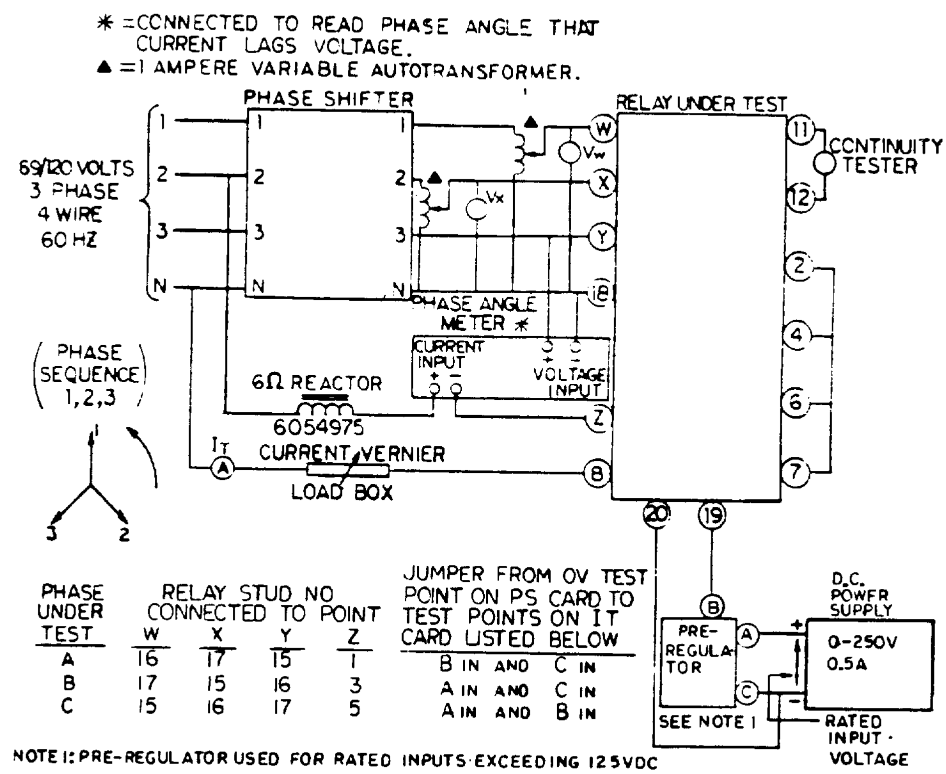
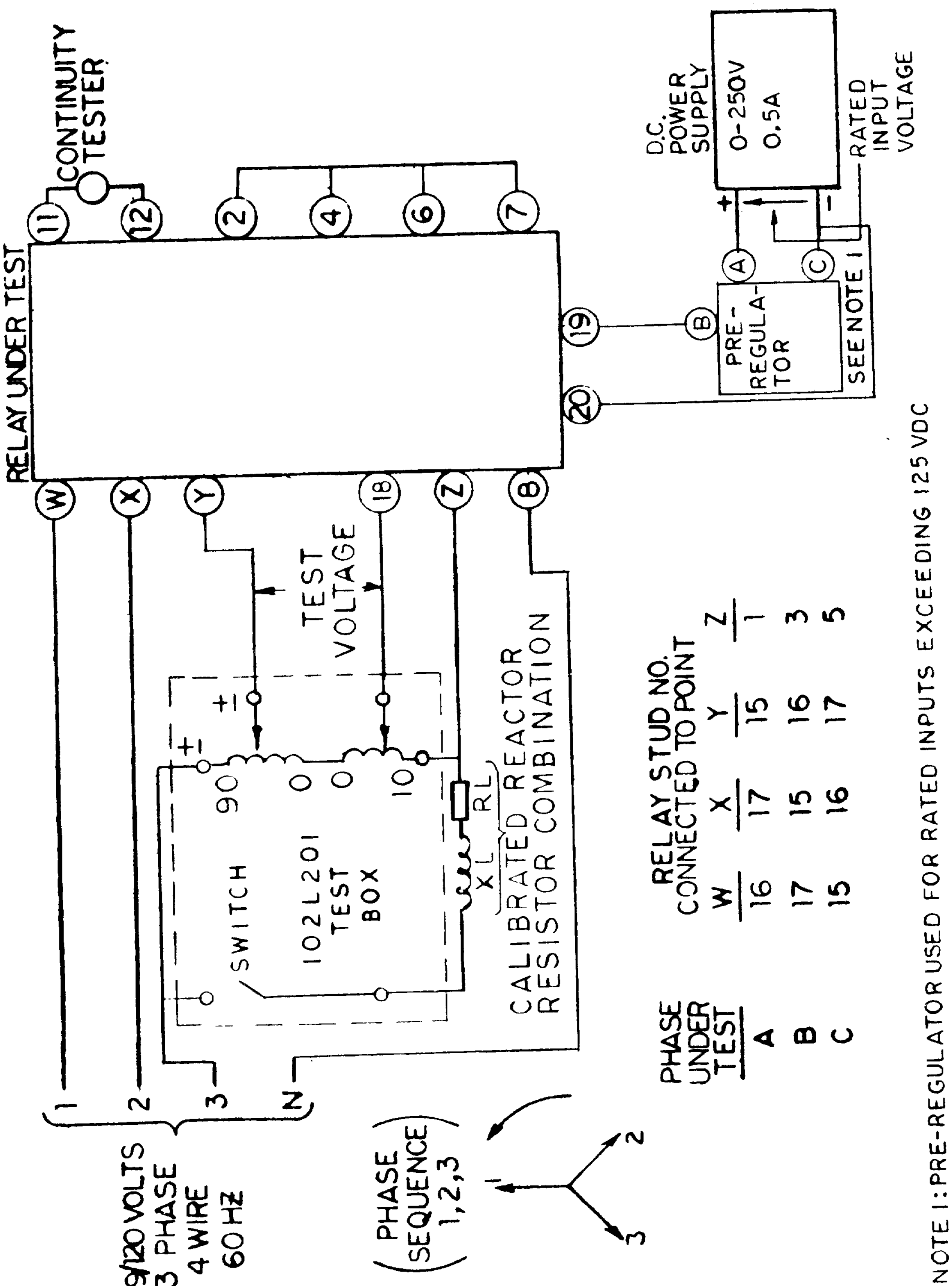


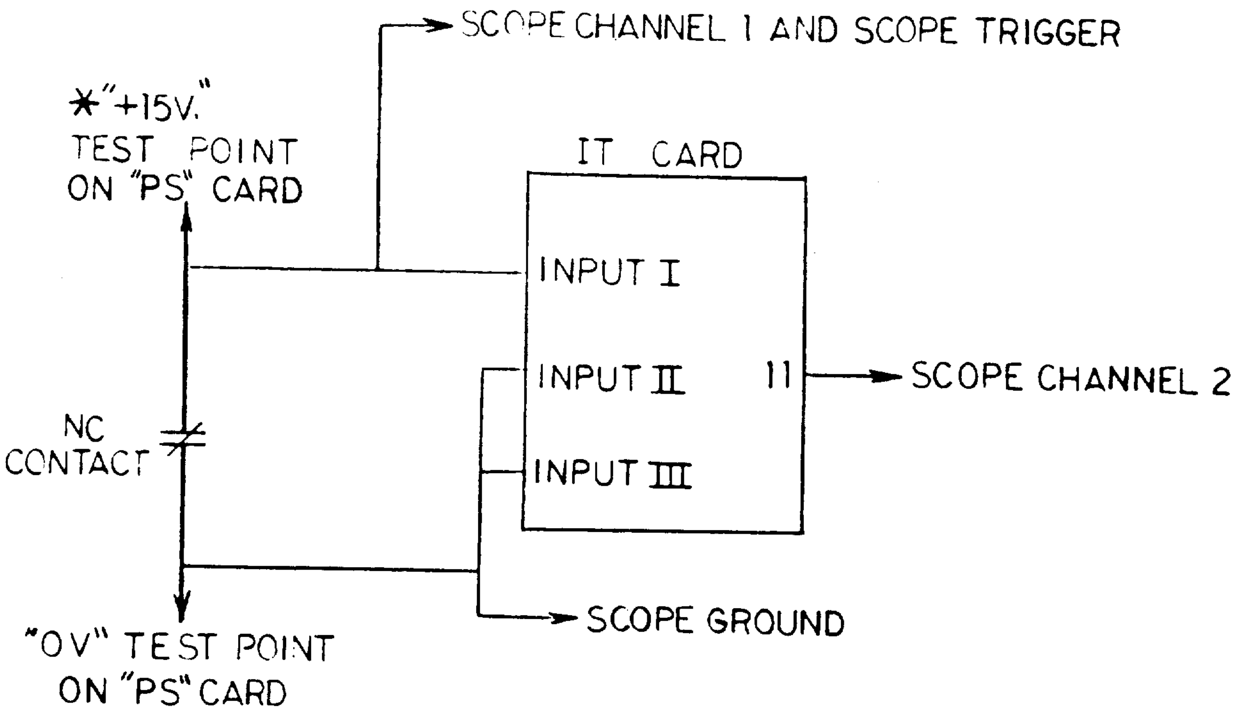
FIGURE 20 (0257A6182-3) TEST CIRCUIT FOR OFFSET TEST



* FIGURE 21 (0257A6187-1) TEST CIRCUIT FOR ALTERNATE REACH TESTS

*Revised since last issue

* THE "+15V." TEST POINT HAS A 100K OHM CURRENT LIMITING RESISTOR MOUNTED ON THE "PS" CARD.



PHASE UNDER TEST	PIN No. OF CARD		
	INPUT I	INPUT II	INPUT III
A	12	23	36
B	23	12	36
C	36	12	23

FIGURE 22 (0257A6185) TIMER CARD TEST CIRCUIT

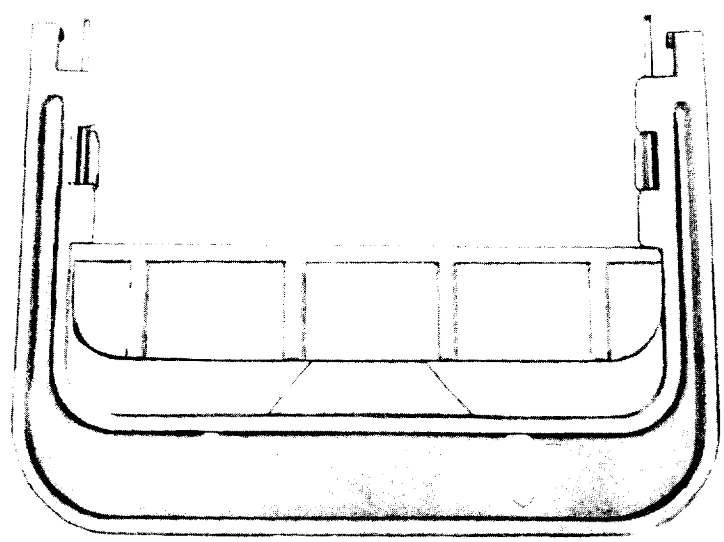
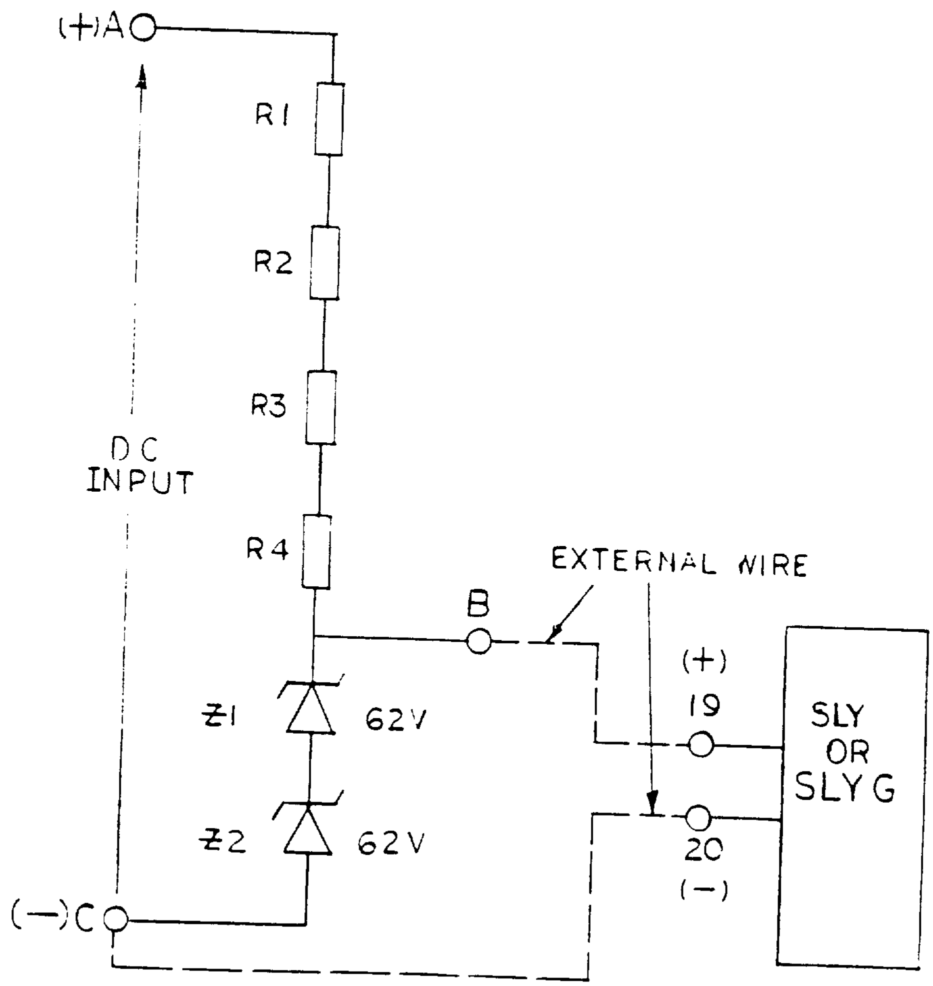


FIGURE 23 (8043016) PRINTED-CIRCUIT-CARD EXTRACTING TOOL



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

FIGURE 24 (0275A4336-1) INTERNAL CONNECTIONS DIAGRAM OF EXTERNAL PRE-REGULATOR

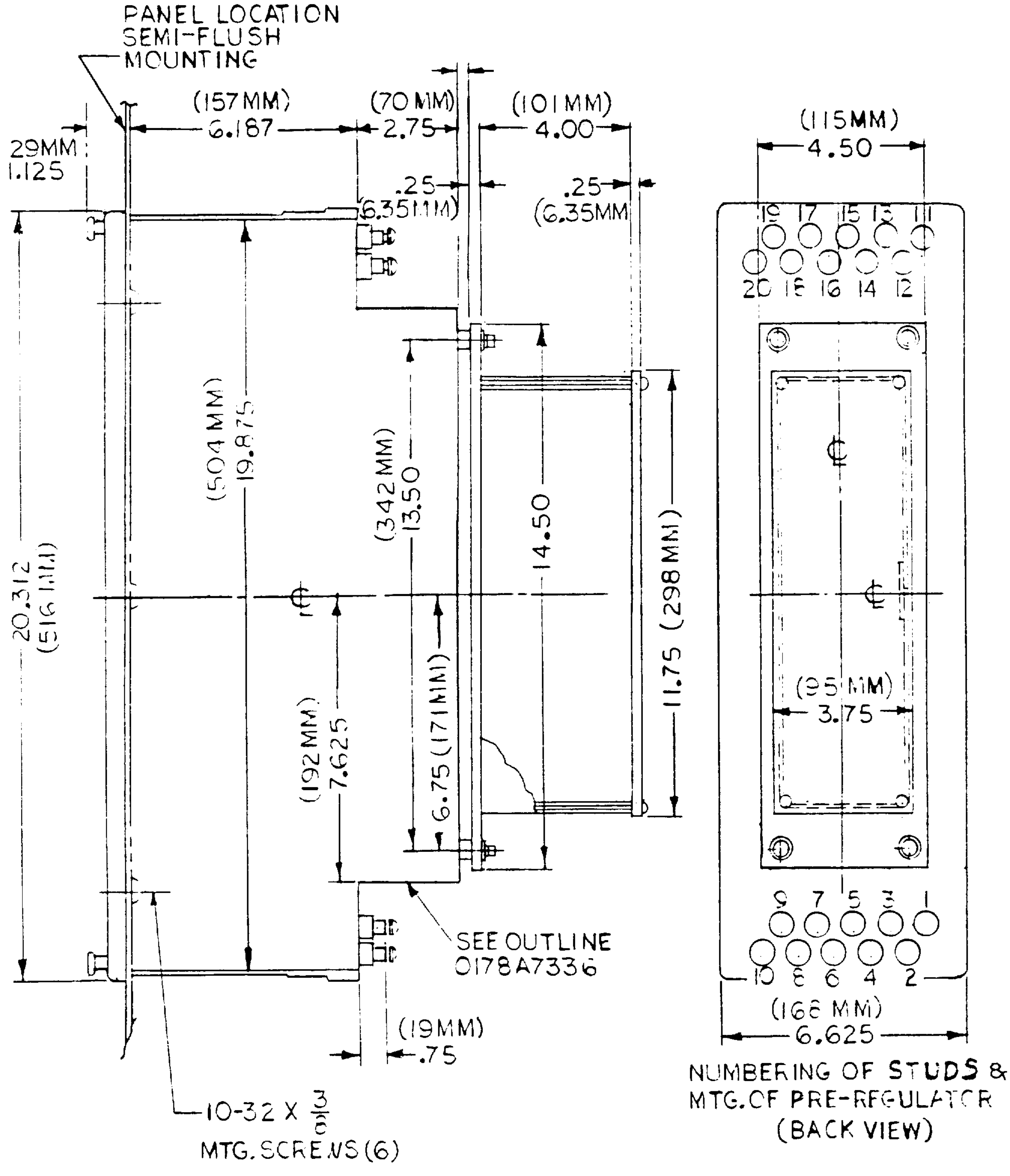


FIGURE 25 (0275A4339) OUTLINE AND MOUNTING DIMENSIONS OF EXTERNAL PRE-REGULATOR

GE Power Management

215 Anderson Avenue
Markham, Ontario
Canada L6E 1B3
Tel: (905) 294-6222
Fax: (905) 201-2098
www.ge.com/indsys/pm