INSTRUCTIONS

STATIC DIFFERENTIAL RELAY

FOR

BUS PROTECTION

SBD11B

seal-in unit will make and carry 30 amperes for tripping duty and will make and carry 3 amperes continuously. The interrupting ratings are given in the following table.

The normally-open contact with a target seal-in unit will make and carry 30 amperes for tripping duty and will make and carry 3 amperes continuously. The interrupting ratings are given in the following table:

INTERRUPTING RATINGS

AC Volts	AMPS	
	Inductive**	Non-Inductive
115	0.75	2.0
230	0.5	1.5
DC Volts		
48	1.0	3.0
125	0.5	1.5
250	0.25	1.0

** The inductive rating is based on an L/R ratio of 0.1 second.

The continuous and short-time ratings of the seal-in unit are given in the table below.

CHARACTERISTICS OF SEAL-IN UNIT

	0.2	0.6	1.0	2.0	4.0
DC Resistance ± 10% (Ohms)	7	0.6	0.21	0.13	0.06
Minimum Operating (Amperes)	0.2	0.6	1.0	2.0	4.0
Carry Continuously (Amperes)	0.3	0.9	1.5	3	6
Carry 30 Amperes for (Seconds)	0.03	0.5	1.4	4	7
Carry 10 Amperes for (Seconds)	0.25	4	12	30	60
60 Hz Impedance (Ohms)	52	6	2.1	0.53	0.13
DC Dropout Amperes (Minimum)	0.05	0.15	0.25	0.5	1.0

CHARACTERISTICS

Operation of the SBD relay is initiated as a function of the instantaneous voltage developed across terminals 5 and 6 of the relay, but an output will not be produced unless the total secondary fault current that flows through the relay after the SCRs fire is greater than the pickup current setting; i.e. both voltage and current are required to produce an output. The voltage and current requirements needed to produce an output are determined by the voltage tap setting and the pickup current setting.

VOLTAGE TAP SETTING

The relay is provided with seven discrete taps in 50-volt steps over the range of 50-350 volts rms symmetrical. The SCRs will fire whenever the instantaneous value

of the applied voltage is equal to twice the peak value $\pm$ 4% of an rms symmetrical voltage equal to the voltage tap setting; i.e.,

$$V_R = (2)\ (\sqrt{2})\ V_T \tag{3}$$

where: V_R = instantaneous voltage needed to fire SCRs

V_T = voltage tap setting

Note that this voltage V_R is also equal to the peak voltage of a completely offset voltage wave having an rms symmetrical value equal to the voltage tap setting. In other words, the SCRs will fire whenever an rms symmetrical voltage greater than twice tap setting is applied, or whenever the corresponding peak voltage is exceeded on an instantaneous basis by an applied waveshape. When the SCRs fire, the relay will produce an output, provided the total secondary fault current that flows in the relay is greater than the pickup current setting.

PICKUP CURRENT

Pickup current is defined as the rms value of a symmetrical sinusoidal current that must flow in the primary of T1 (see internal connections, Figure 13) in order to provide a contact output. Two models of SBD relays are available with current pickup settings of 0.5/1.0 and 0.5/2.5 $\pm$ 10% rms amperes.

OPERATING TIMES

Typical operating times are shown in Figure 18. The dropout time is 15 milliseconds or less.

EFFECT OF TEMPERATURE

Voltage Tap Setting may vary an additional 2% over the operating temperature range. **Pickup Current** may vary an additional 20% over the operating temperature range.

BURDENS

DC BURDEN

The relay draws no power from the DC supply unless the output relay is picked up. The burden with the output relay picked up is 0.05 ampere or less at any rated voltage.

AC BURDEN

Tap Setting	Impedance (Ohms)			
50	935 @	-20°	or	880 - j320
100	1600 @	-37°	or	1280 - j960
150	2000 @	-48°	or	1340 - j1480
200	2200 @	-56°	or	1230 - j1830
250	2340 @	-62°	or	1100 - j2060
300	2400 @	-65°	or	1000 - j2200
350	2480 @	-69°	or	880 - j2300

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CALCULATION OF SETTINGS

The SBD11B relay is set on the basis of the maximum possible voltage that can be produced in the differential circuit as the result of a fault external to the zone of protection. Determination of the maximum voltage for this condition is subject to simple calculations, hence the relay setting can be easily determined. The relay is tapped in seven discrete steps of 50 volts per step from 50 to 350 volts rms. Thus, it is first necessary to calculate the maximum voltage that can be produced in the differential circuit for an external fault, after which an appropriate tap can be selected. Next, if a mixture of multi-ratio CTs are involved in the application, or if the CTs are applied on taps other than the full winding, evaluate the application to determine that excessive voltages will not be produced across the full windings of these CTs. Finally, the minimum internal fault for which the relay will just operate is determined.

CALCULATION OF VOLTAGE TAP SETTING, V_T

The minimum acceptable voltage tap setting can be determined using the following equation:

$$V_T = 1.25 \ (R_S + PR_L) \ \frac{I_F}{N} \qquad\qquad (6)$$

where: VT = minimum acceptable voltage tap setting. Since V_T in general will not come out exactly equal to one of the available taps, the next higher tap setting should be used; available voltage taps: 50V, 100V, 150V, 200V, 250V, 300V, or 350V rms

R_S = DC resistance of fault CT secondary windings and leads to housing terminal (at maximum expected operating temperature)

R_L = single conductor DC resistance of CT cable for one-way run from the differential junction point to the fault CT housing terminal (at maximum expected operating temperature)

P = one (1.0) for three-phase faults; two (2.0) for single phase-to-ground faults

I_F = maximum external fault current in fault CT in primary symmetrical rms amperes

N = CT ratio

1.25 = margin factor for safety

The following comments may be made with respect to the evaluation of equation (6).

1.   The calculations need only be made for three phase and single phase-to-ground faults. If the results yield a satisfactory application, the application will also be satisfactory for other multi-phase faults.

2.   For single phase-to-ground faults, the differential circuit is such that the CT secondary fault current will flow through both of the fault CT cables; thus the

multiplier P must be set equal to two. On the other hand, the CT secondary currents during balanced three-phase faults result in 0 current in the return cable; thus only the one-way cable resistance is involved, and P is set equal to one.

3.   If the single phase-to-ground fault current at a given location is greater than or equal to the three-phase fault current, the calculations need only be made for single phase-to-ground faults.

4.   The resistance of the CTs and connecting cables will increase with increasing temperature; therefore, if adequate margin is to be maintained at all times, equation (6) should be evaluated using resistance values corresponding to the maximum expected operating temperature.

The methods to be used in calculating the voltage tap setting using equation (6) will to some extent be dependent on the type of application. The following comments are made with respect to the different areas in which the SBD11B relay may be applied.

1.   <u>Bus Protection</u> - Two methods will be outlined for evaluating equation (6) in order to determine an appropriate relay voltage tap setting.

The first method offers a simplified conservative approach to the problem and requires that equation (6) be evaluated only once. With this method, it is assumed that a single phase-to-ground fault with a current magnitude equal to the maximum interrupting rating of the breaker occurs on the feeder associated with the CT having the longest cable run from the differential junction point. Under these assumptions, the effect of the fault current, I_F, is maximized, and so is the effect of cable resistance, because the highest value of resistance is used and P is set equal to 2. Thus, the highest possible value of V_T will be obtained.

The second method offers an exact approach but requires that equation (6) be evaluated a number of times in order to obtain the maximum V_T. With this method, calculations must be made for the maximum single phase-to-ground fault and the maximum three-phase fault just off each of the n feeders on the bus. Therefore, equation (6) must be evaluated 2n times, using the associated value of cable resistance and P = 1 or P = 2, as required.

In general, Method II will produce a lower voltage tap setting than Method I, but Method I is simpler to utilize. The user should begin with Method I. If the voltage tap setting resulting from the use of this method results in adequate sensitivity, a unique advantage is realized since the setting does not require recalculation following future changes in the power system configuration that result in higher fault current magnitudes. If the sensitivity resulting from the use of Method I does not prove adequate, then Method II should be used.

Each of the methods are outlined below:

<u>Method I</u> (Simplified Conservative Approach):

a.   Use the maximum interrupting rating of the circuit breaker as the maximum external single phase-to-ground symmetrical fault current (I_F).

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b. R_L is based on the distance from the differential junction point to the most distant CT.

c. Calculate V_T substituting the values of current and resistance from a and b and set P = 2.

d. Select the highest available voltage tap (V_T) that just accommodates the voltage calculated in c above.

Method II (Exact Approach):

a. Determine the maximum three-phase and single phase-to-ground fault currents for faults just off each of the n breakers on the bus.

b. R_L is the one-way DC resistance of the cable from the associated CT to the differential junction point.

c. For each breaker in turn, calculate V_T separately, utilizing the associated maximum external three-phase symmetrical fault current in the fault CT, with P = 1 and the maximum external single phase-to-ground symmetrical fault current in the fault CT, with P = 2.

d. Use the highest of the 2n values of V_T so obtained, and select the next higher available tap setting that accommodates this value.

2. Shunt Reactor Protection - Depending on the type of protection required, shunt reactors may be protected by the SBD11B relay in one of two ways. See Figures 3 and 4. Since the shunt reactors contribute no current to an external fault, equation (6) should be evaluated using the highest magnitude of current that can possibly flow in the reactor under any system condition, exclusive of a fault in the reactor. If the differential junction point is located near the reactors, the resistance of the CT connecting cables can probably be ignored, and equation (6) need only be evaluated using the CT resistance and the maximum expected current. If the cable resistance cannot be ignored, use the maximum expected reactor current and P = 2. After a value of V_T has been calculated, select the next higher available voltage tap that just accommodates this voltage.

APPLICATIONS WITH MIXED MULTI-RATIO CT'S

Where CTs are to be used on other than their full windings, the application should be evaluated after a voltage tap has been selected, to determine that excessive voltages are not developed across the full windings of these CTs as a result of autotransformer action. It is desirable to limit the peak value of the voltage to less than the insulation breakdown of the connected equipment. It has been shown in the section under **OPERATING PRINCIPLES** that the peak voltage across the full winding can be calculated as follows:

$$V_F = \frac{(2.83)(V_T)(N1)}{N2} \qquad (4)$$

where: V_T =   SBD11B relay voltage tap setting

         N1 =   Number of turns in full CT winding

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N2 = Number of turns in CT tap used

2.83 = $2\sqrt{2}$ (peak value of fully offset wave)

V_F = Peak voltage across full winding

See Figure 8 for an illustration of the above terms. If V_F is less than the insulation breakdown, and if the current rating of the CT is not exceeded, the application is permissible. Equation (4) should be evaluated for the CT having the highest N1/N2 ratio. If the condition of equation (4) is met for this CT, then it will also be met for the remaining CTs.

MINIMUM FAULT TO TRIP

After the voltage tap setting has been established for an application, a check should be made to determine the minimum internal fault current that will just cause the relay to operate. The following expression can be used to determine the minimum internal fault current required for a particular tap setting:

$$I_{min.} = \frac{n}{\sum_{X=1}^{n} (I)_X + I_R} \quad n \tag{7}$$

Where: $I_{min.}$ = Minimum rms symmetrical internal fault current required to operate the SBD11B relay

   n = Number of CTs (number of circuits)

   I = Secondary excitation current of individual CT at a voltage equal to $2\sqrt{2} \times V_T$

   I_R = Current in the SBD11B at pickup setting

   N = CT ratio on tap used

The excitation currents $(I)_1$, $(I)_2$,....$(I)_n$ will be a function of the peak voltages that can be produced in the secondaries of the respective CTs. It is possible to determine the currents with the aid of the secondary excitation characteristic for the respective CT, but it is first necessary to modify the characteristics so that they are plotted as a function of the peak voltages that can be produced. The modifications are easily made; the procedure for doing so is as follows:

1.   Determine the knee point coordinates of the standard excitation curve (E_S and I_e). These points will be indicated on the given characteristic, or they can be found graphically by determining the point where a 45° line is tangent to the knee of the excitation curve.

2.   Calculate and plot the following point on the same sheet with the excitation curve.

$$V = (7)(E_S) \tag{8}$$
$$I = (5)(I_e)$$

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3. Draw a line having a slope of 1/2 through the point (V,I) calculated and plotted in 2. above. A slope of 1/2 corresponds to one log cycle on the vertical axis (voltage) and two log cycles on the horizontal axis (current). See line A-B in Figure 7.

4. Extend the lower part of the excitation curve in a straight line until it intersects the line A-B drawn in 3. above. See line C-D in Figure 7.

The curve (CPB) so formed by these two lines now represents the modified excitation characteristics as a function of the peak voltages that can be produced. After the curve has been drawn, calculate the following corresponding excitation current I.

$$V_S = 2(\sqrt{2})(V_T) \tag{9}$$

Where V_S = Voltage coordinate for determining I

V_T = Voltage tap setting on SBD relay

Note that the first term in equation (7) reduces to nI if all the CTs have the same characteristics.

The second term in equation (7) represents the current (I_R) drawn by the relay just at the operating point. It can be calculated as follows:

$$I_R = \frac{(2)(V_T)}{2500} \tag{10}$$

SAMPLE CALCULATION

The various steps for determining the setting of the SBD11B relay in a typical bus application will be demonstrated with the aid of a worked example. Assume the protected zone includes five breakers, all rated at 69kV, 1500mva, 1200 amperes, with a maximum interrupting rating of 12,500 amperes. The excitation curve for the 1200/5 bushing CTs in these breakers is shown in Figure 7.

The 0.5 ampere sensitivity setting will be used. The voltage tap setting will be determined by using Method I as described in the preceding section. The value of R_S from Figure 7 is (0.0019)(240)+2(0.0347) = 0.524 ohms. It is assumed that this resistance corresponds to the maximum expected operating temperature. It is further assumed that the longest CT cable run is 442 feet and that number 10 copper wire is used. The one-way cable resistance at 25°C is 0.450 ohms. The resistance value of wire at 25°C or at any temperature T1 may be corrected to any temperature T2 by means of the following equation.

$$R_{T2} = [1 = \rho_1 (T2-T1)]R_{T1}$$

Where: R_{T2} = Resistance in ohms at T2, °C

R_{T1} = Resistance in ohms at T1, °C

ρ_1 = Temperature coefficient of resistance at T1

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For standard annealed copper, $\rho_1 = 0.00385$ at T1 = 25°C. If the maximum expected operating temperature is assumed to be 50°C, then

$$R_L = [1 + 0.00385(50-25)]0.450$$
$$= (1.096)(0.450) = 0.493 \text{ ohms}$$

Substituting the various quantities in equation (6) yields:

$$V_T = 1.25 [0.524 + 2(0.493)]\frac{12500}{240}$$

$$= 98.31 \text{ volts}$$

Since $V_T = 98.31$ volts is not exactly equal to one of the available taps, select the next higher available tap, which is 100 volts.

$$V_T = 100 \text{ volts}$$

Since the CTs are all used on the full winding, there is no need to check that excessive voltages will be produced in the CT circuits.

Now that a tap has been selected, the sensitivity may be calculated following the procedure outlined in the section under MINIMUM FAULT TO TRIP.

From Figure 7, the knee point coordinates, E_S and I_e, are 290 volts and 0.06 ampere. From equation (8):

$$V = (7)(E_S) = (7)(290) = 203 \text{ volts}$$
$$I = (5)(I_e) = (5)(0.06) = 0.30 \text{ ampere}$$

Plot this point (V,I) on the graph of Figure 7 and draw the lines A-B and C-D. This gives the modified secondary excitation characteristics. Calculate the voltage V_S using equation (9):

$$V_S = (2)(\sqrt{2})V_T = 283 \text{ volts}$$

From the modified curve, the current I_e corresponding to $V_S = 283$ volts is 0.05 ampere.

The relay current from equation (10) is:

$$I_R = \frac{(2)(V_T)}{2500} = \frac{(2)(100)}{2500} = 0.08 \text{ ampere}$$

The sensitivity of the relay, or the minimum fault to trip from equation (7) is:

$$I_{min.} = [(5)(0.05) + 0.08](240)$$
$$= 80 \text{ amperes}$$

With the relay set at 0.5 ampere, 120 amperes of primary current are required to produce 0.5 ampere secondary from the 1200/5 CTs. Since the calculated value is less than 120 amperes, the sensitivity will be 120 amperes. If a higher minimum basic current sensitivity is used on the relay, the minimum current required for pickup will be correspondingly higher.

CONSTRUCTION

The Type SBD relays are assembled in the small size double-ended (S2) drawout case with studs at both ends in the rear of the case for external connections. The electrical connections between the relay and the case studs are through stationary molded inner and outer blocks, between which nests a removable connecting plug. The outer blocks have the terminals for the internal connections.

Every circuit in the drawout case has an auxiliary brush, as shown in Figure 9, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Figure 13), and on those circuits it is especially important that the auxiliary brush make contact as indicated in Figure 9 with adequate pressure to prevent the opening of the important interlocking circuits.

The relay mechanism 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 ensure that proper hardware will be included. Outline and panel drilling are shown in Figure 22.

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. Or the relay can be drawn out and replaced by another which has been tested in the laboratory.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as 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

VISUAL INSPECTION

When the relay is received, check the nameplate stamping to ensure that the model number and rating of the relay received 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

Case and Cradle Blocks

Check that the fingers on the cradle and the case agree with the internal connection diagram. Each cradle finger should be flush or project above the between-finger barriers. Check that there is a coil spring under each finger. The case fingers, if not held down by a shorting bar, should come within 1/16 inch of touching a straight-edge bridging the case block from side to side. If the finger is held down by a shorting bar, opening the electrical circuit between the finger and the shorting bar should require at least one pound (450 grms.) of force. See Figure 9. Check that each auxiliary brush extends above the between-finger barrier.

Telephone Relay Unit (R_T)

Operate the telephone relay unit manually by pushing on the armature. Check that the movement is free of binding or roughness. Check that the normally-closed stationary contacts follow the moving contacts before they open. The normally-closed contact at the top of the stack should open last. All contacts, when in the open position, should have 0.015 inch or more gap. The normally-open contacts should have at least 0.005 inch travel after closing. This can be checked by putting a 0.005 inch shim between the armature and the pole piece, closing the armature by hand, and checking that each normally-open contact still closes. As the normally-closed contacts cannot be tested using a shim, they may be checked by measuring the force applied to the stationary contact which is required to open the contact. This should be at least 10 grams.

Target Seal-in Unit

Pick up the armature by hand. The orange target should appear. When the armature is released, the target should remain in view. Push in on the reset arm. The target should drop from view.

Hold the armature up by hand. The target should not be at the end of its travel. Verify this by reaching in one of the windows of the target with a sharp instrument such as a scribe or knife and pushing upward. The target should move definitely upward (at least 1/64 inch). Release the armature; the target should fall visibly downward (at least 0.010 inch) before the target is caught by the latch.

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ELECTRICAL TESTS

CAUTION

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

Drawout Relays, General

Since all drawout relays in service operate in their cases, it is recommended that they be tested in their cases or an equivalent steel case. In this way any magnetic effects of the enclosure will be accurately duplicated during testing. A 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 CT shorting jumpers and the exercise of greater care, since connections are made to both the relay and the external circuitry.

Power Requirements, General

All alternating current operated devices are affected by frequency. Since non-sinusoidal waveforms can be analyzed as a fundamental frequency 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 of current and/or voltage. The purity of the sine wave (i.e., its freedom from harmonics) cannot be expressed as a finite number for any particular relay; however, any relay using tuned circuits, RL or RC networks, or saturating electromagnets (such as time overcurrent relays), would be essentially affected by non-sinusoidal waveforms.

Similarly, relays requiring DC control power should be tested using DC and not full wave rectified power. Unless the rectified supply is well filtered, many relays will not operate properly due to the dips in the rectified power. Zener diodes, for example, can turn off during these dips. As a general rule, the DC source should not contain more than 5% ripple.

CAUTION

When performing the following electrical tests it is very important to adhere to the length of time that voltage and/or current is applied to the relay. The SBD relay is designed to perform satisfactorily during in-service operation when applied per the APPLICATION section and within the limits called for in the RATINGS section. The relay is not rated for continuous operation, with some of the voltages and currents applied, when performing all the following electrical tests.

Voltage Pickup

Set the SBD relay to the 50 volt tap setting (which is the equivalent of 100 volts rms symmetrical pickup as tested) located on the front of the relay, and connect the relay per the test diagram in Figure 11.

CAUTION

Do not apply voltage to the SBD relay for longer than 10 seconds and do not re-apply voltage more often than once every 2 minutes.

With S2 open and S1 closed, pre-set the voltage as read on the AC voltmeter for 95 volts. Open S1, then close S2, in that order. The relay is now ready to be tested. Close S1 and increase the voltage until the SCRs fire, as indicated by a drop in the voltmeter reading and an indication in the ammeter reading. The voltage reached prior to the voltmeter drop is the pickup voltage. If necessary, adjust the rheostat located on the front of the relay to obtain 100 ± 4 volts pickup.

Tap Voltage Test

This test is to check the calibration of the 100, 150, 200, 250, 300, and 350 volt tap settings, which are obtained by a movable lead, on a tap block located in the front of the SBD relay. Tap settings are a function of a voltage divider circuit consisting of precision resistors mounted on the printed circuit card.

Connect the relay per Figure 12. Set the relay to the tap setting that is to be tested. Apply 10% of tap voltage to the relay, as read on the AC voltmeter connected between terminals 5 and 6. The AC voltmeter connected between terminals 16 and 5 should read 5 volts $\pm$ 2%. (The voltmeter should have an input impedance of at least 5000 ohms/volt for this test.)

Pickup Current and Output Test

Set the relay to the minimum voltage tap setting. Set the pickup current link located on the front of the SBD relay to the desired current pickup setting. Connect the relay per the test diagram shown in Figure 16. Increase the current until the telephone relay (RT) operates and the lamp lights. This is the actual pickup current, and must be within 10% of the current pickup setting (either 0.5 or 1.0).

Full Voltage Test (Optional)

The previous tests are sufficient to verify the proper operation and calibration of the SBD relay.

CAUTION

The full voltage test, because of the high power requirements and the potential danger due to high voltages, with the possibility of damage to the SBD relay due to improper test procedure, is an optional test and left to the discretion of the user.

This test applies full voltage, current and power to the relay in order to duplicate conditions during a fault.

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This optional test requires a source of adjustable AC voltage, with an excellent waveform, capable of providing more than twice the voltage of the tap to be tested, and enough current availability for pickup, determined by the pickup sensitivity setting. An HEA type lockout relay is required, with a coil rated for the DC control voltage of the SBD relay and having an operating time of approximately 16 milliseconds, and capable of interrupting the test voltage and current. The auxiliary relay shown in Figure 17 with two normally-closed contacts must open its contacts not more than 100 milliseconds after being energized.

When a voltage greater than twice the tap setting is applied, and enough current flows in the relay, the SBD will provide a contact closure, picking up the HEA, which will remove the AC source from the SBD relay. The auxiliary relay shown in Figure 17 provides the removal of the AC voltage should a malfunction occur. Note that, even though the applied voltage exceeds the voltage tap setting, if the required pickup current does not flow, the SBD relay will not operate and consequently the auxiliary relay will operate, protecting the SBD relay, and indicate a malfunction.

Observe the relay's short time ratings when performing this test. An oscilloscope or high speed oscillograph may be used to observe the operation of the relay.

OBSERVE ALL SAFETY PRECAUTIONS when performing the full voltage test. Carefully connect the SBD relay as shown in the test diagram of Figure 17. With S2 open and S1 closed, set the voltage, as read on the rms voltmeter, greater than two times the tap setting selected to be tested. Open S1 and close S2, in that order. The relay is now ready to be tested. Note that R (current limiting resistor) in Figure 17 is to be selected, to limit the current in SBD relay to two times the pickup current. Apply rated DC control voltage, then close S1. The SBD relay should operate, and the full voltage test will duplicate fault conditions.

High Potential Testing (Insulation Testing)

CAUTION

When high-potential testing this relay, the surge ground connection to stud 4 must be removed and all studs shorted together to avoid damage to the surge capacitors in the relay.

INSTALLATION PROCEDURE

LOCATION AND MOUNTING

The relay should be mounted on a vertical surface in a location reasonably free from excessive heat, moisture, dust and vibration. The relay case may be grounded, if desired, using at least #12 B&S gage copper wire. The outline and panel drilling diagram for the Type SBD relays is shown in Figure 22.

CONNECTIONS

The internal connection diagram for the Type SBD is shown in Figure 13. The external connection diagrams are shown in Figures 1 through 4.

Stud 4, the relay surge ground, should be connected to the station ground bus, using the shortest and most direct route.

The voltage tap plug and the current tap plug should be moved to the desired settings.

TARGET/SEAL-IN UNIT

Set the target/seal-in unit tap screw in the desired position. The contact adjustment will not be disturbed if a screw is first transferred from the left contact to the desired tap position on the right contact, and the screw in the undesired tap is then removed and transferred to the left contact.

HIPOT

See High Potential Testing section under ACCEPTANCE TESTS.

PERIODIC CHECKS 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. 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 ACCEPTANCE TESTS be checked at an interval of from one to two years.

CONTACT CLEANING

For cleaning relay contacts, a flexible burnishing tool should be used. This is a flexible strip of metal with an etch-roughened surface, which in effect resembles a superfine file. The polishing action of this file is so delicate that no scratches are left on the contacts, yet it cleans off any corrosion thoroughly and rapidly. The flexibility of the tool ensures the cleaning of the actual points of contact. Relay contacts should never be cleaned with knives, files, or abrasive paper or cloth.

RENEWAL PARTS

Sufficient quantities of renewal parts should be kept in stock for the prompt replacement of any that are worn, broken or damaged.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company. Specify the name of the part wanted, quantity required, and complete nameplate data, including the serial number, of the relay for which the part is required.
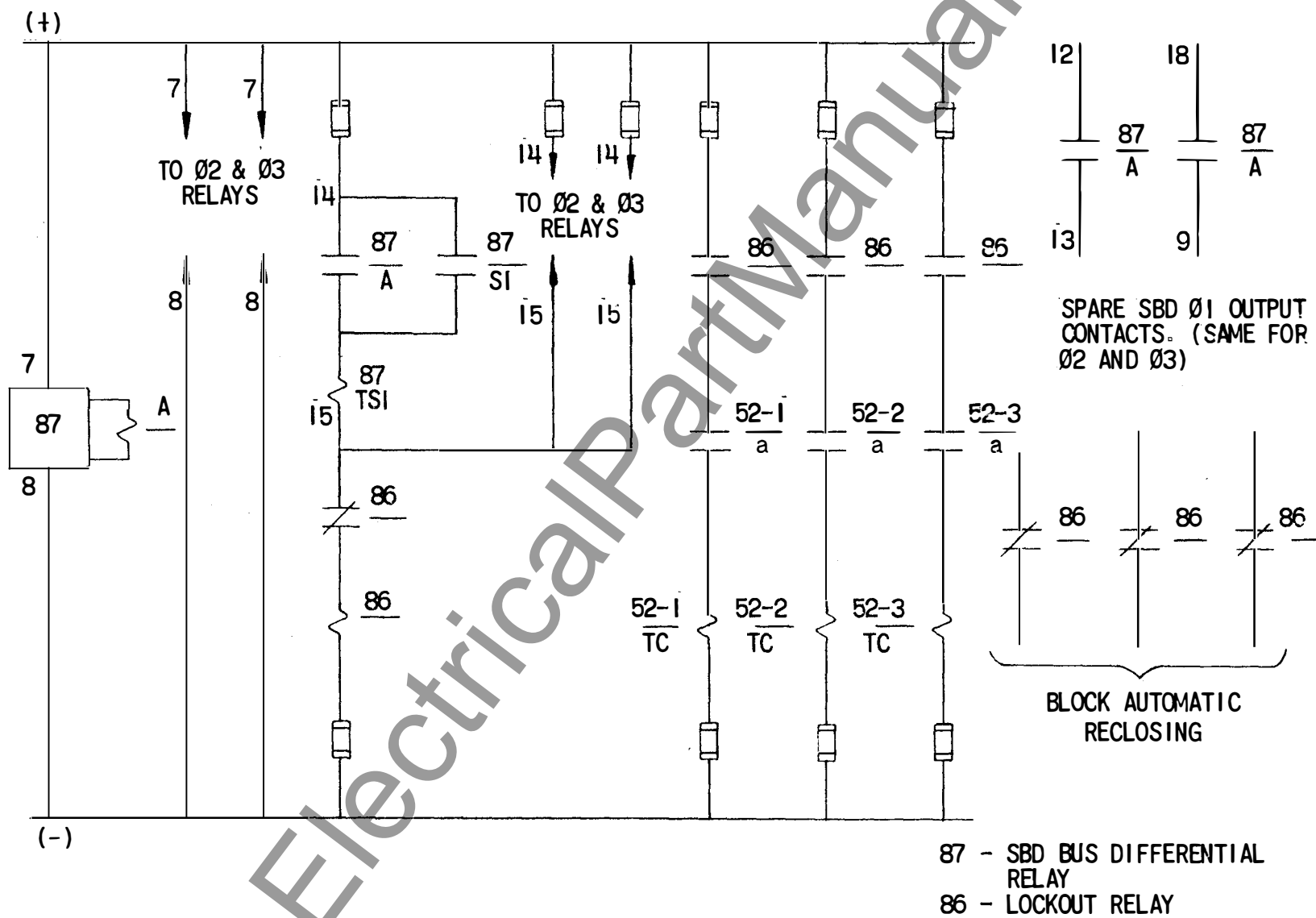
Since the last edition, changes have been made on pages 7 and 8 in the OPERATING PRINCIPLES section, on p.9 in the VOLTAGE RATING paragraph, in the CONNECTIONS section on p.23, and in Figure 22.

Figure 1 (0246A6980-2) External AC Connections to SBD11B Relay for Bus Protection

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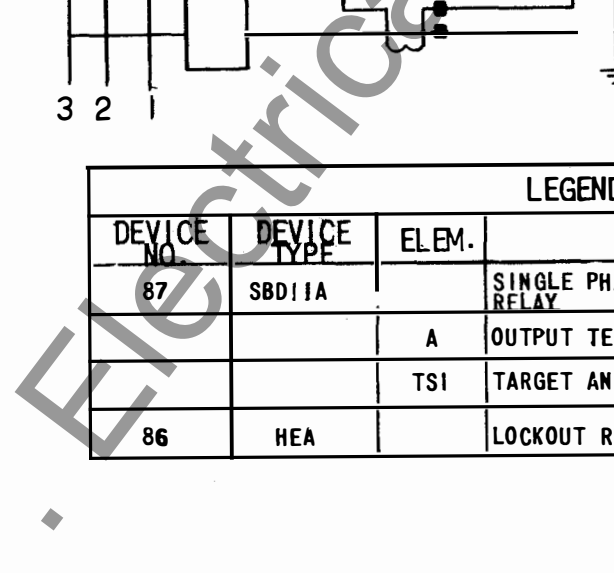
LEGEND			
DEVICE NO.	DEVICE TYPE	ELEM.	DESCRIPTION
87	SBD11A		SINGLE PHASE HIGH IMPEDANCE DIFFERENTIAL RELAY
		A	OUTPUT TELEPHONE RELAY
		TS1	TARGET AND SEAL-IN UNIT
86	HEA		LOCKOUT RELAY

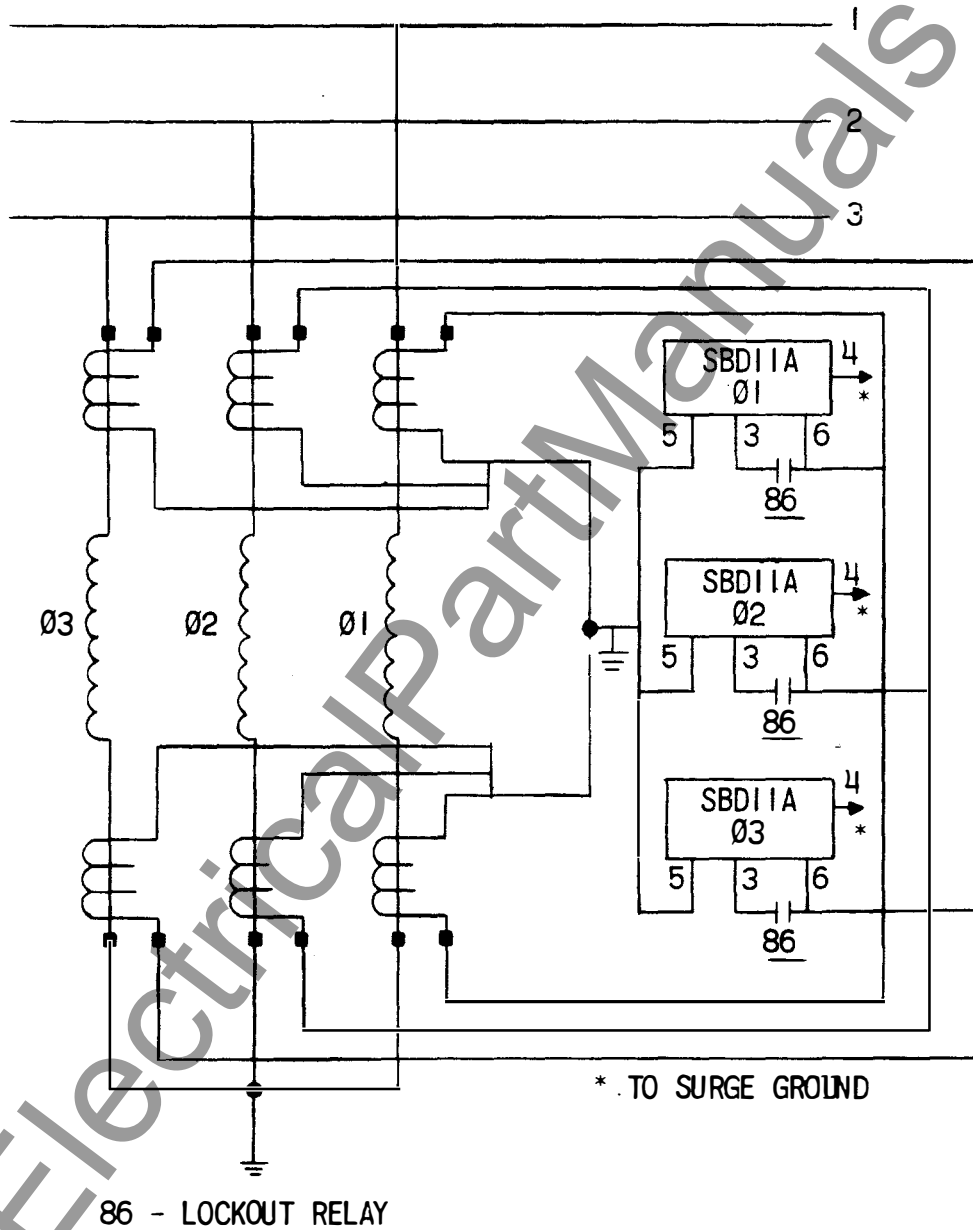Figure 2 (0246A6979-2) External DC Connections to SBD11B Relay for Bus Protection

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87 — SBD BUS DIFFERENTIAL RELAY
86 — LOCKOUT RELAY

SPARE SBD Ø1 OUTPUT CONTACTS. (SAME FOR Ø2 AND Ø3)

BLOCK AUTOMATIC RECLOSING

TO Ø2 & Ø3 RELAYS

TO Ø2 & Ø3 RELAYS

Figure 3 (0246A6981-2) External AC Connections to SBD11B for Shunt Reactor Protection
for Multi-Phase and Line-to-Ground Faults
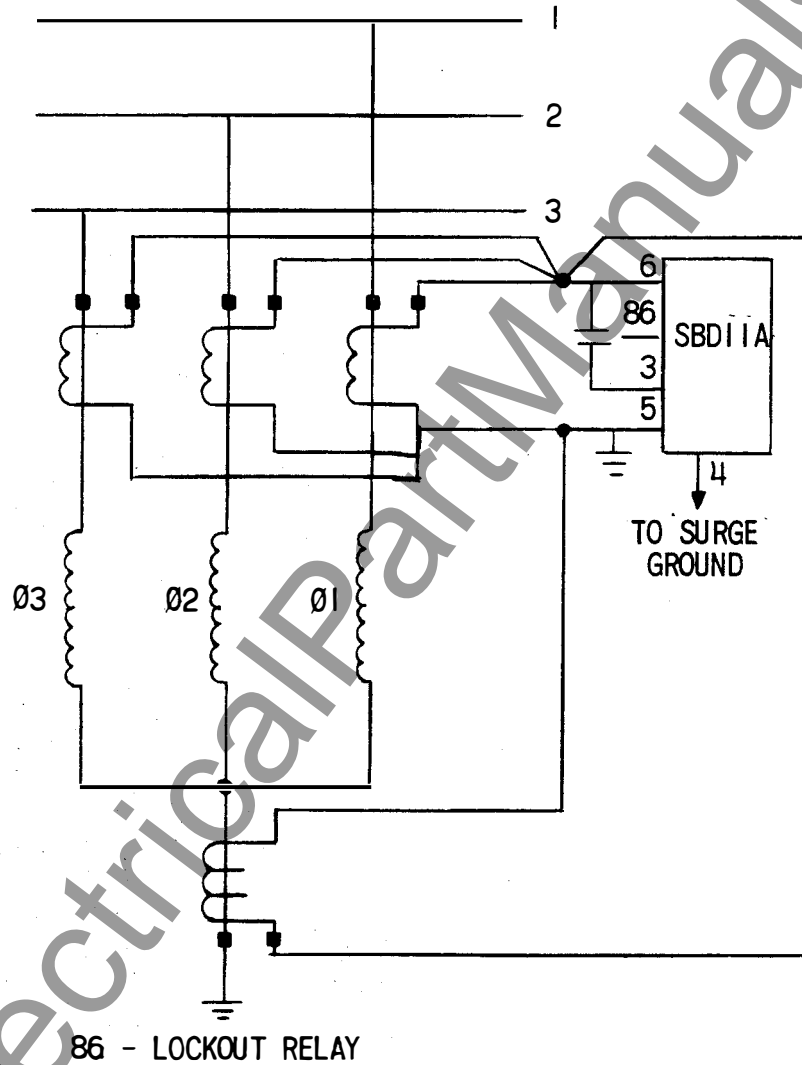
Figure 4 (0246A6982-2) External AC Connections to SBD11B Relay
for Shunt Reactor Protection for Ground Faults
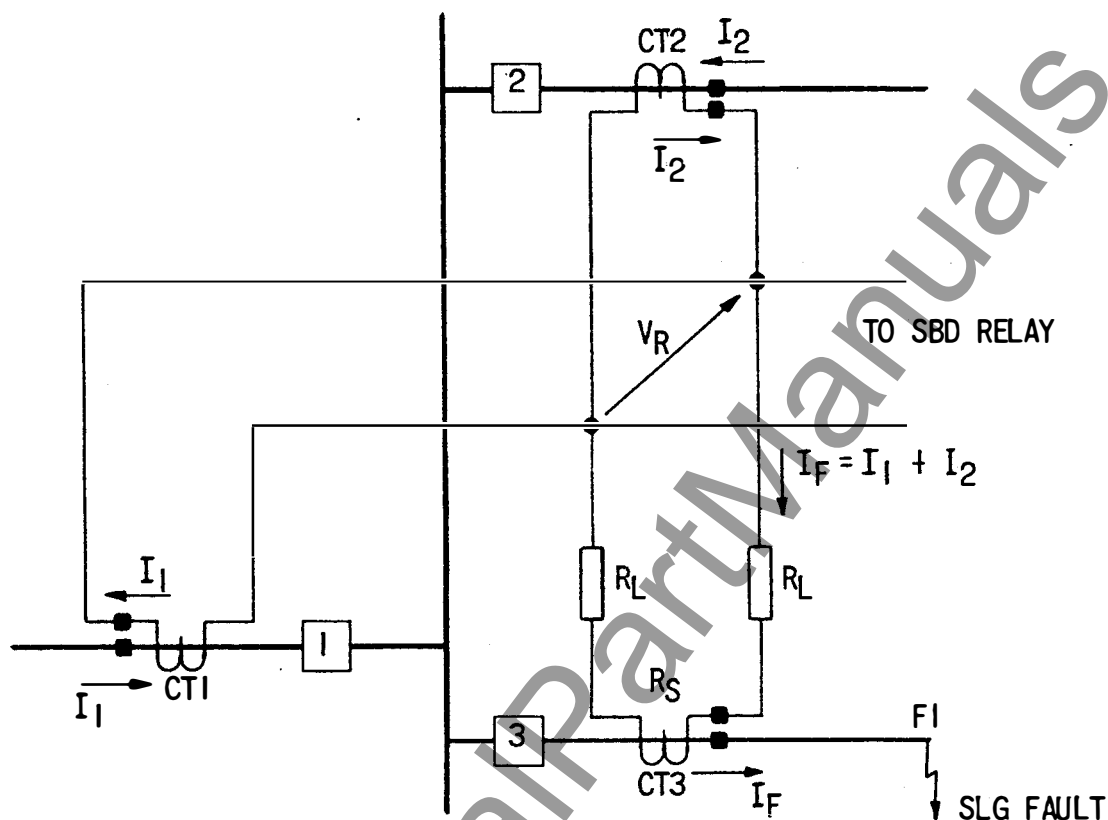
NOTE: CT3 ASSUMED TO BE COMPLETELY SATURATED

R_S CT SECONDARY WINDING RESISTANCE PLUS ANY LEAD
RESISTANCE (AT HIGHEST EXPECTED OPERATING TEMPERATURE)

R_L CABLE RESISTANCE FROM JUNCTION POINT TO CT (AT
HIGHEST EXPECTED OPERATING TEMPERATURE)

I_F RMS VALUE OF THE CURRENT IN THE PRIMARY OF CT3
DIVIDED BY THE SECONDARY TURNS.

V_R VOLTAGE ACROSS SBD

Figure 5 (0246A6976-0) Simplified Circuit Illustrating Effect
of Single Line-to-Ground Fault at Location F1
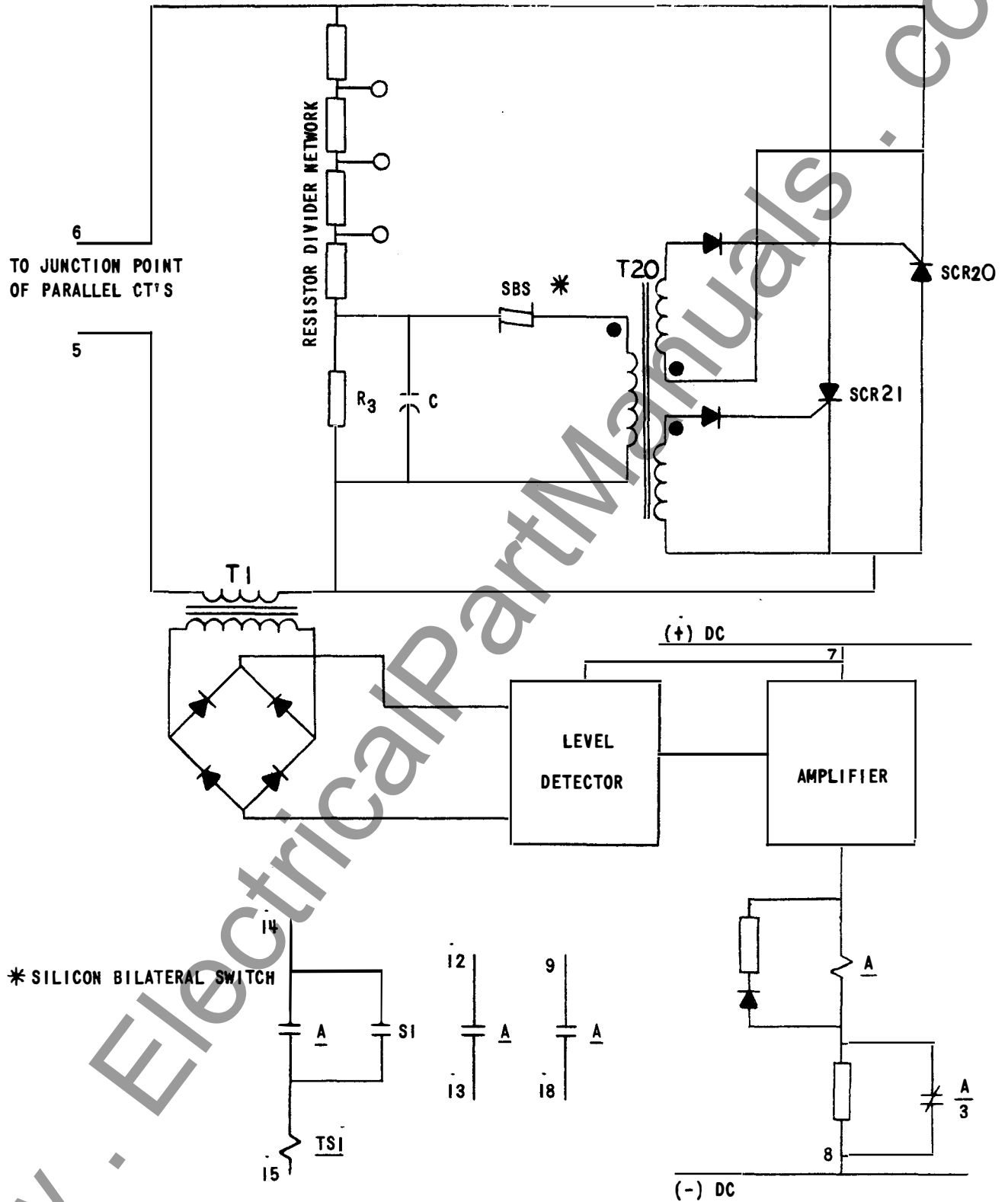
Figure 6 (0246A6977-3) Simplified Internal Connection Diagram for SBD11B Relay
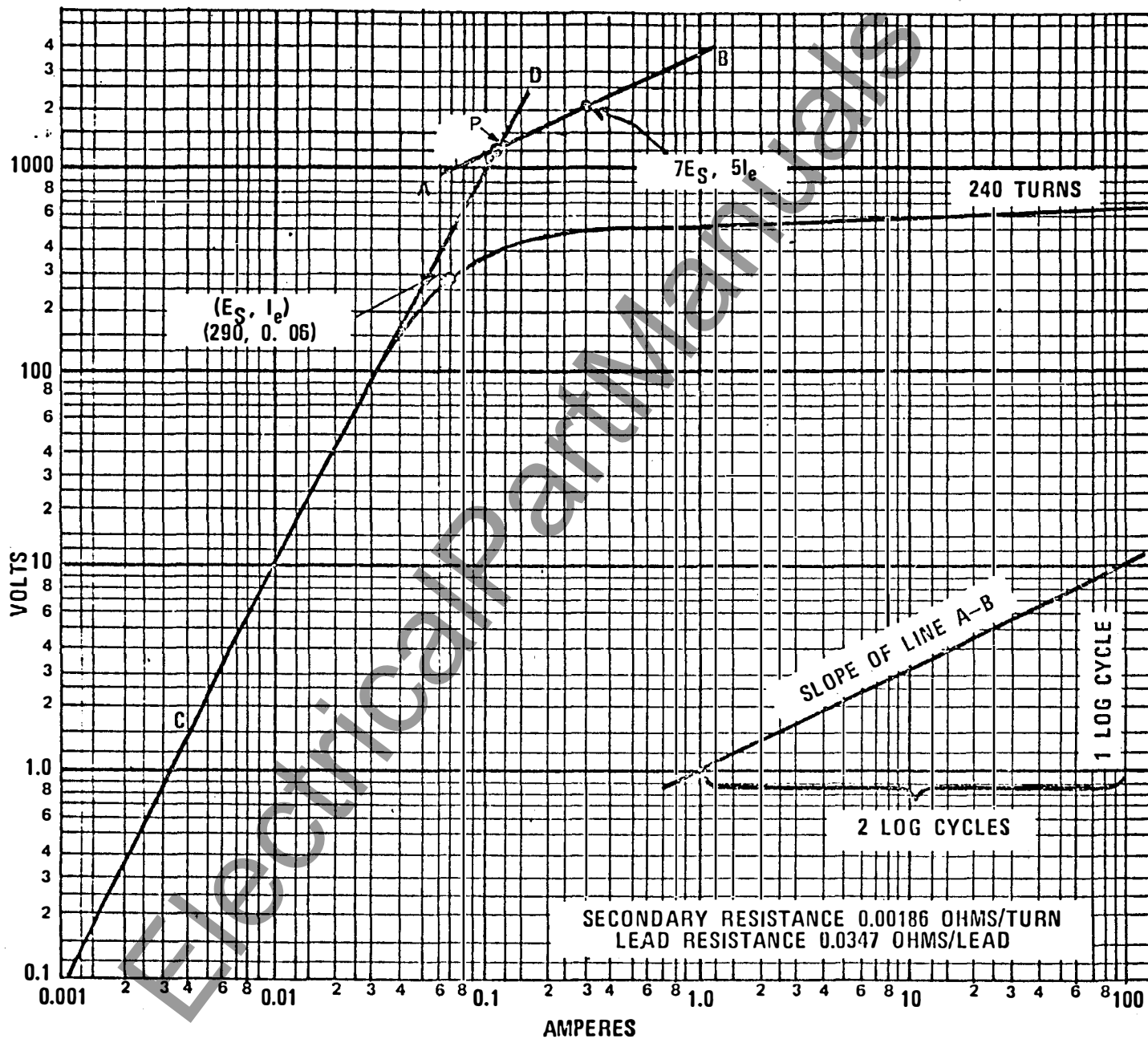
Figure 7 (0246A7082-3) Typical Secondary Excitation for 1200/5 Bushing Current Transformer
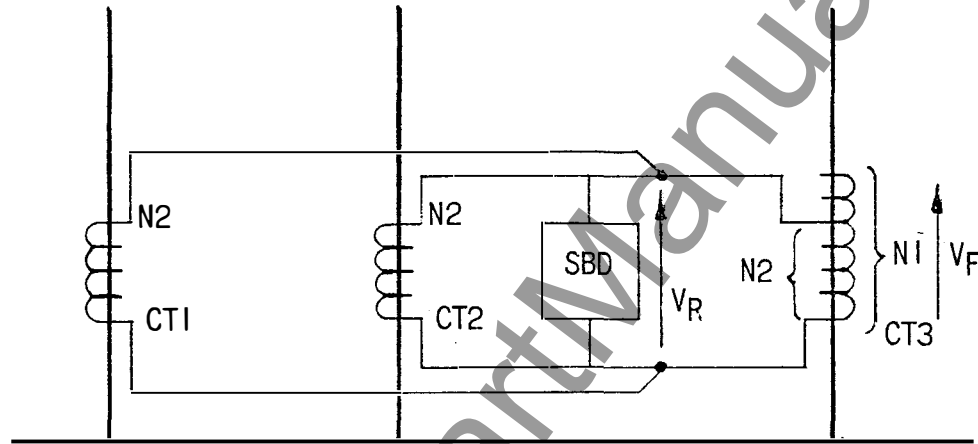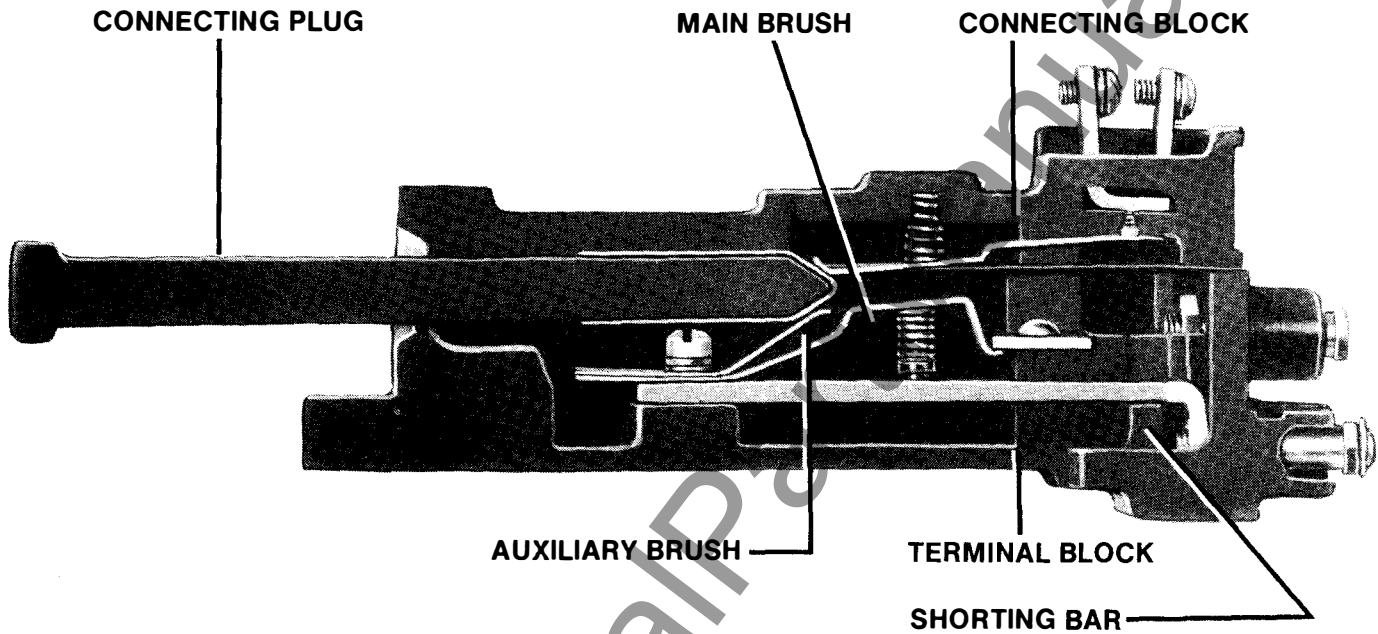
$$V_F = \frac{NI}{N2} \, V_R$$

V_F = VOLTAGE DEVELOPED ACROSS FULL WINDING

V_R = MAXIMUM INSTANTANEOUS VOLTAGE

NI = TOTAL NUMBER OF CT TURNS

$N2$ = NUMBER OF CT TURNS USED (TAP SETTING)

Figure 8 (0246A6978-2) Voltage Appearing Across Full Winding
of a CT Used on Tap Other than Full Winding

CONNECTING PLUG **MAIN BRUSH** **CONNECTING BLOCK**

AUXILIARY BRUSH **TERMINAL BLOCK**

SHORTING BAR

**NOTE: AFTER ENGAGING AUXILIARY BRUSH CONNECTING PLUG TRAVELS ¼ INCH
BEFORE ENGAGING THE MAIN BRUSH ON THE TERMINAL BLOCK.**

Figure 9   (8025039)   Cross Section of Drawout Case
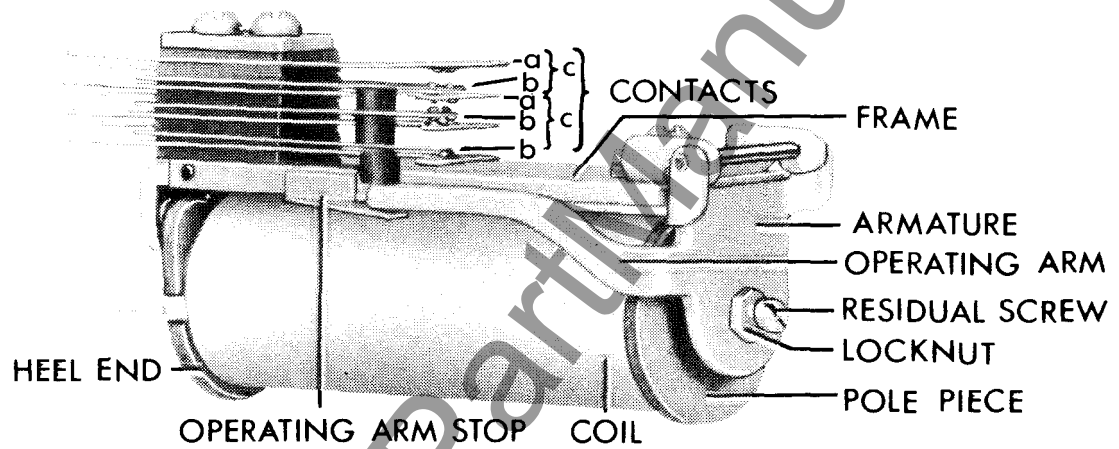Showing Position of Auxiliary Brush and Shorting Bar

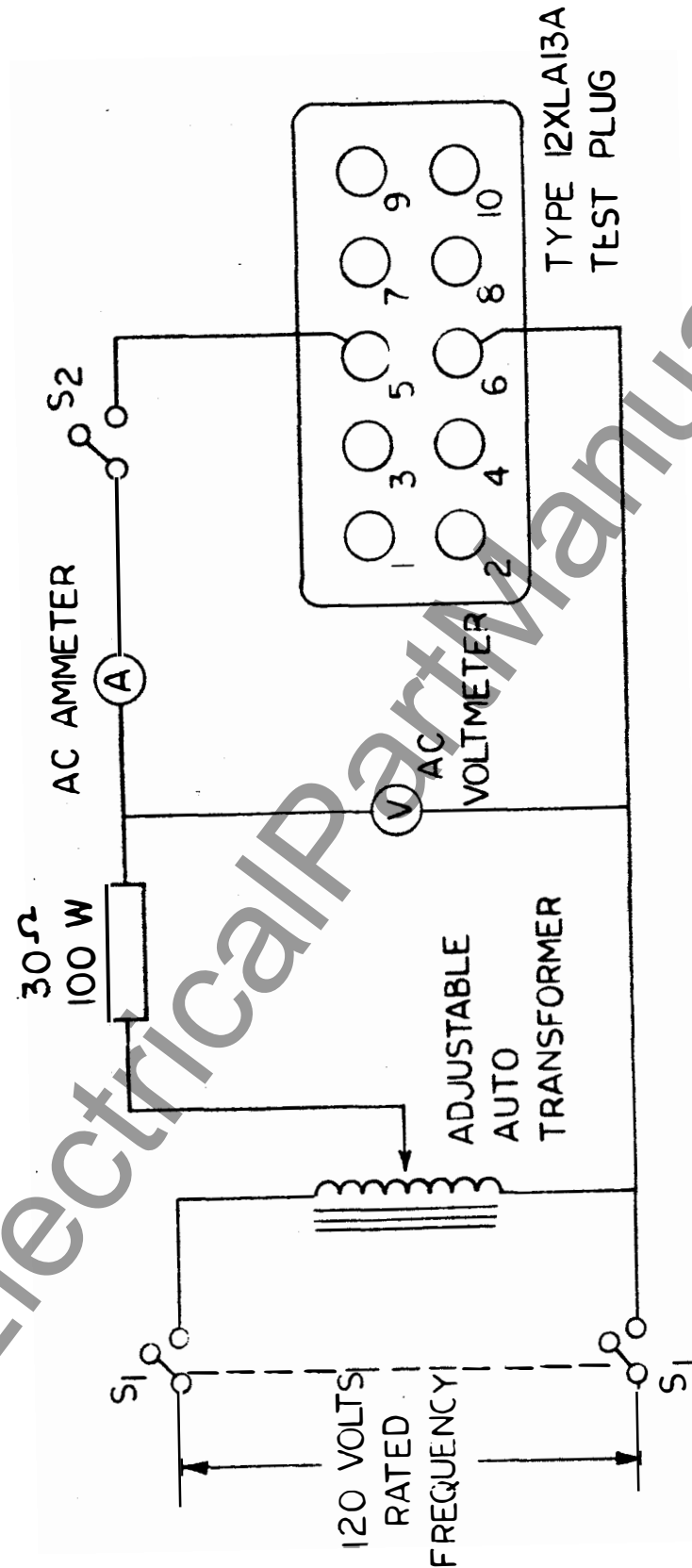Figure 10 (8012106) Typical Telephone-Type Relay Unit

Figure 11 (0246A6990-1)   Voltage Pickup Test Connection Diagram for the SBD11B Relay
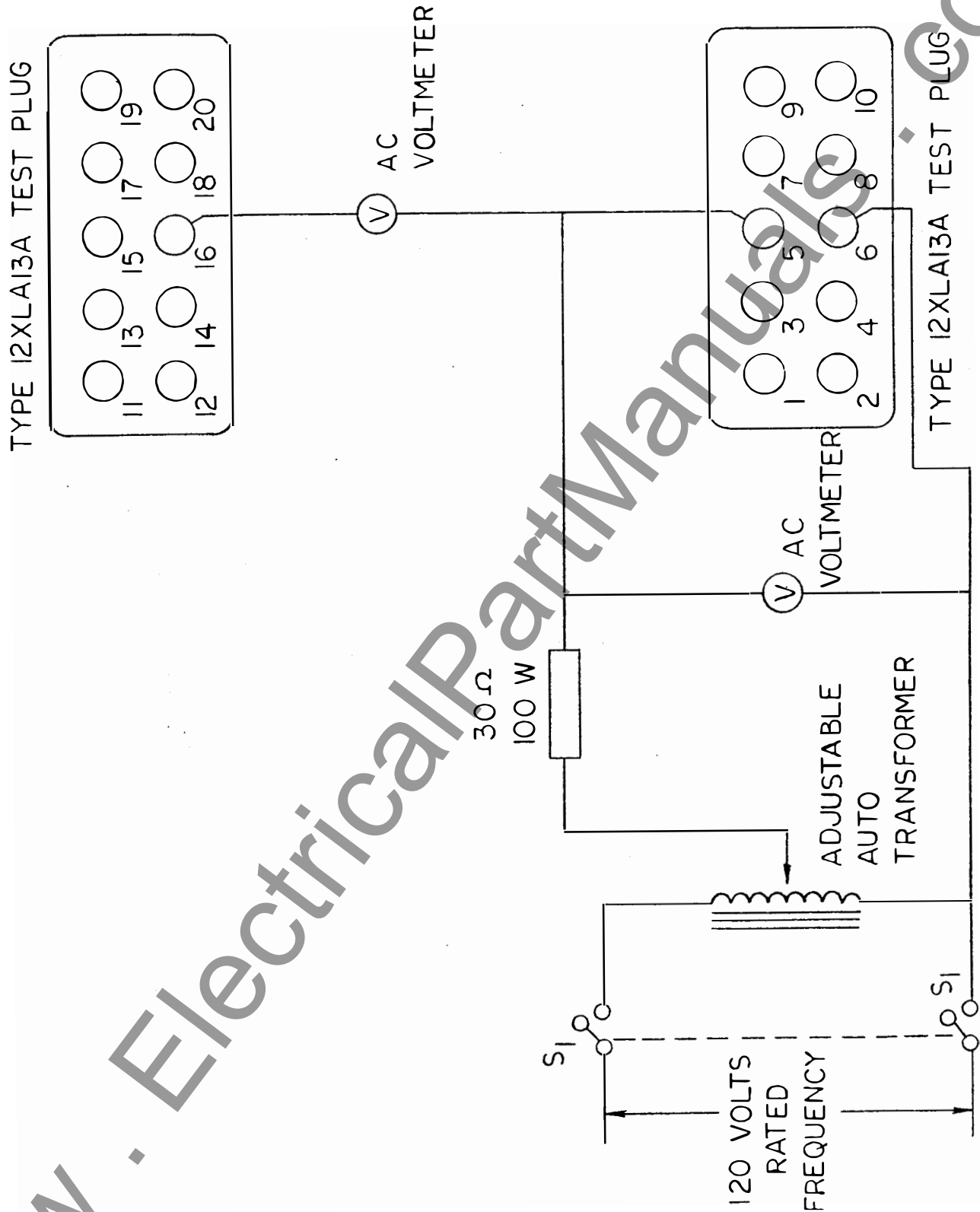
Figure 12 (0257A3208-0) Tap Voltage Test Connection Diagram for the SBD11B Relay
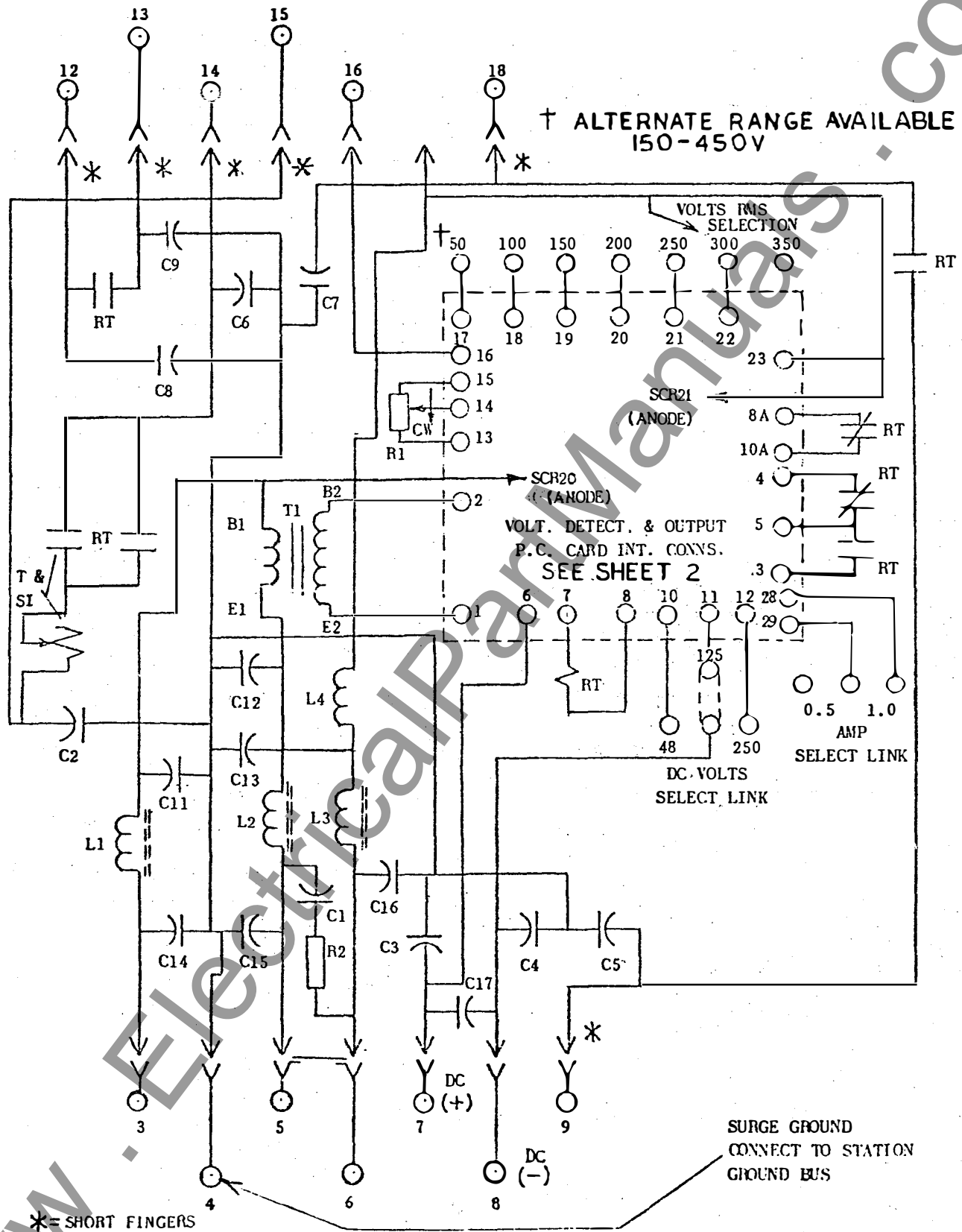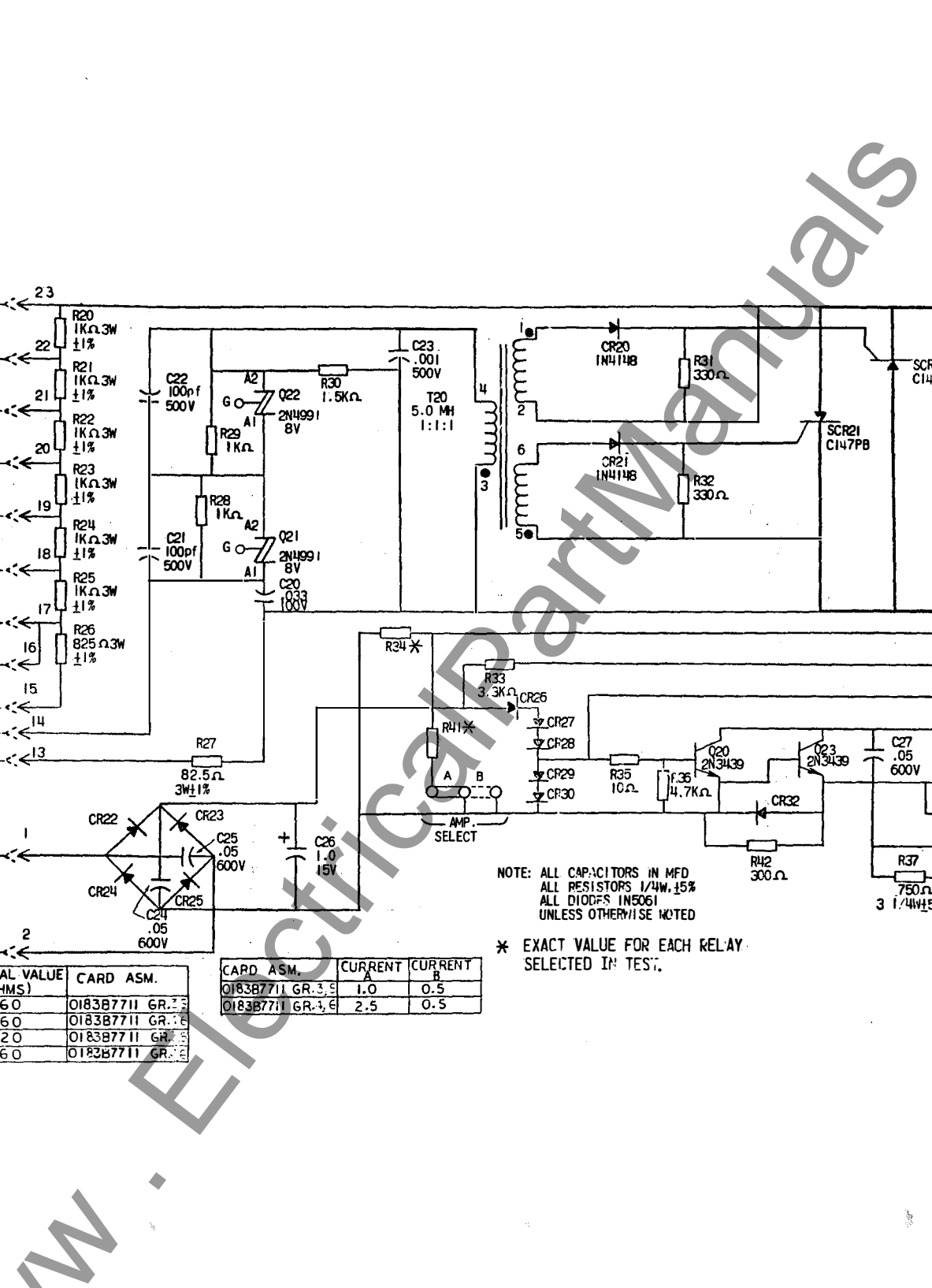
Figure 13A   (0257A9612 Sh.1 |1|)   Internal Connections Diagram for The Type SBD11B Relay

MODEL	FORM
12SBD11B	1 THRU 4
VOLTS AC	100
FREQUENCY	50/60 HZ
COMPONENT VALUES	
R1	100 Ω 12.5W
R2	24 Ω 2W
RT RELAY COIL	300 Ω
C2,C3,C4,C5,C6,C7,C8,C9,C17	.05uf 600V
C11,C12,C13,C14,C15,C16	.025uf 1.2KV
C1	1.0uf - 1KV

P.C. CARD INTERNAL CONNS.	
GROUP	DRAWING
1,2,3,	0108B8932
4	0183B4471

Figure 13B (0257A9612 Sh.2 |2|)   Internal Connections Diagram for The Type SBD11B Relay

Figure 14 (0108B8932 [2]) Internal Connections Diagram for the Printed Circuit Board

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HIGH CURRENT CIRCUIT WIRE LEADS

350V — 23 — R20 1KΩ3W ±1%
300V — 22 — R21 1KΩ3W ±1%
250V — 21 — R22 1KΩ3W ±1%
200V — 20 — R23 1KΩ3W ±1%
150V — 19 — R24 1KΩ3W ±1%
100V — 18 — R25 1KΩ3W ±1%
50V — 17 — R26 825Ω3W ±1%
TERM 16 (TEST) — 16
15
R1 POT 100Ω — 14
CW — 13

C22 100pf 500V
C21 100pf 500V
A2 Q22 2N4991 8V G A1
R29 1KΩ
R28 1KΩ
A2 Q21 2N4991 8V G A1
R30 1.5KΩ
C23 .001 500V
C20 .033 100V

T20 5.0 MH 1:1:1

CR20 1N4148
R31 330Ω
CR21 1N4148
R32 330Ω

SCR20 C147PB
SCR21 C147PB

R27 82.5Ω 3W±1%

CR22 CR23
C25 .05 600V
CR24 CR25
C24 .05 600V

E2
T1
E2

C26 1.0 15V

R34 ✱
R33 3.3KΩ CR26
R41 ✱
A B
AMP. SELECT
CR27
CR28
CR29
CR30

R35 10Ω
R36 4.7KΩ
Q20 2N3439
Q23 2N3439
CR32
R42 300Ω

C27 .05 600V
CR31
R40 1KΩ
R37 750Ω 3 1/4W±5%
R39 1.8KΩ 3 1/4W±5%
R38 3KΩ 5W±5%

4 RT
3
5 RT
6 — TERM 7 (+DC)
7 RT
8
8A
10A RT
10 — TO TERM 8 (-DC)
48
11 125
12 250
DC SELECT LINK

NOTE: ALL CAPACITORS IN MFD
ALL RESISTORS 1/4W, ±5%
ALL DIODES 1N5061
UNLESS OTHERWISE NOTED

✱ EXACT VALUE FOR EACH RELAY SELECTED IN TEST.

RESISTOR	NOMINAL VALUE (OHMS)	CARD ASM.
R34	360	0183B7711 GR.
R34	360	0183B7711 GR.
R41	220	0183B7711 GR.
R41	60	0183B7711 GR.

CARD ASM.	CURRENT A	CURRENT B
0183B7711 GR. 3,5	1.0	0.5
0183B7711 GR. 4,6	2.5	0.5

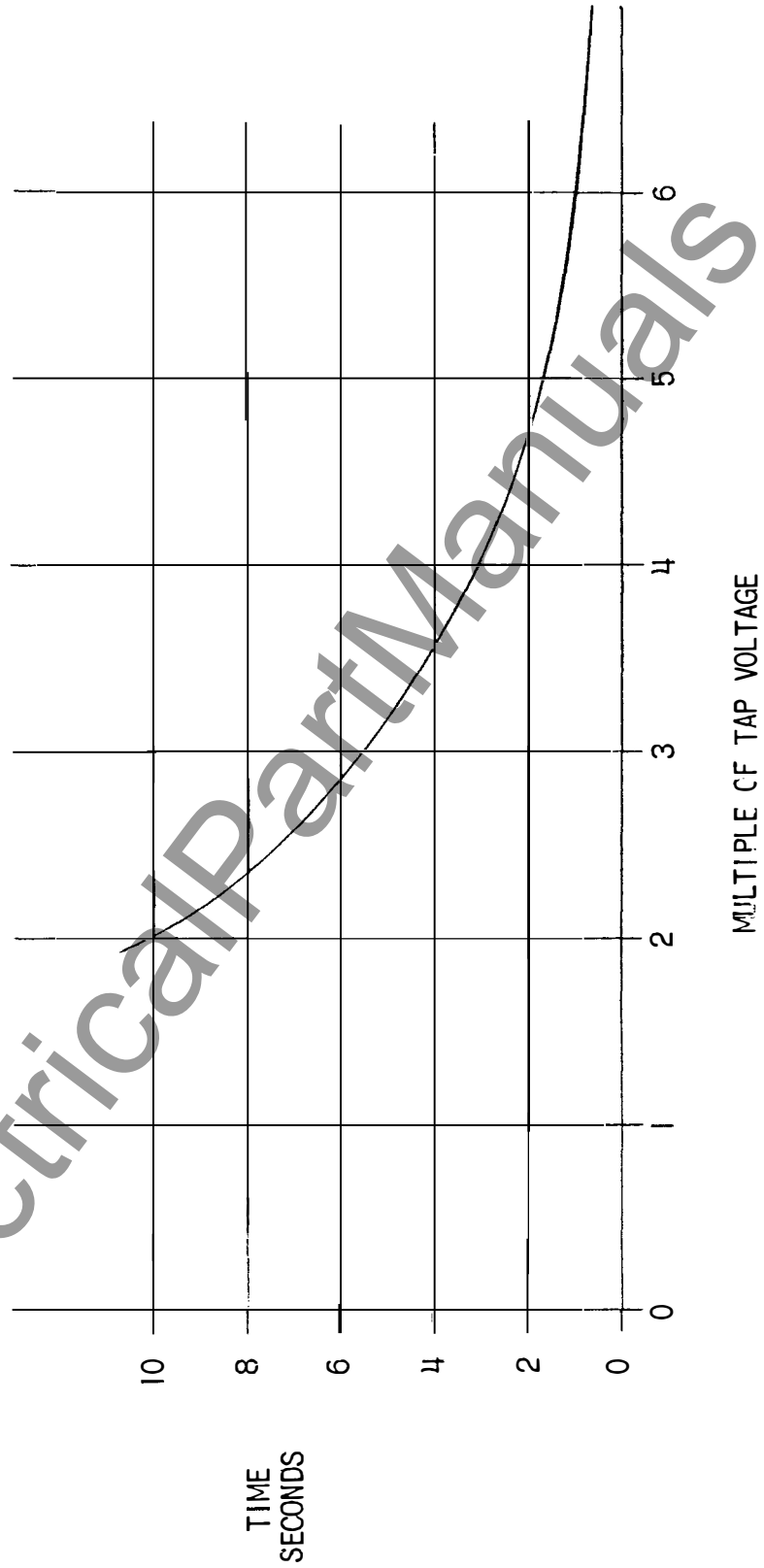TYPE SBD RELAY
SHORT TIME OVERVOLTAGE RATING

Figure 15 (0246A7091-0) Short-Time Rating Graph for the SBD11B Relay
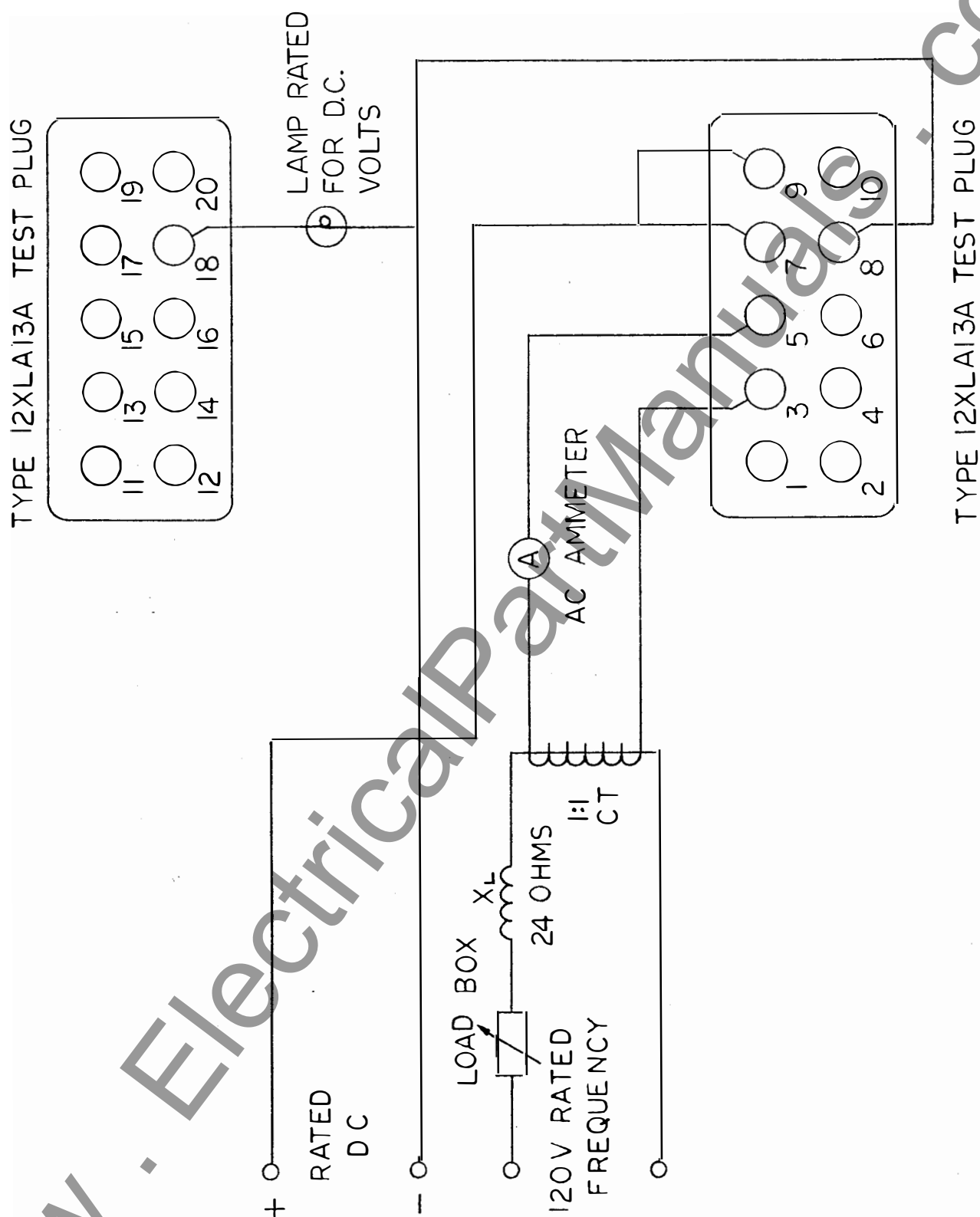
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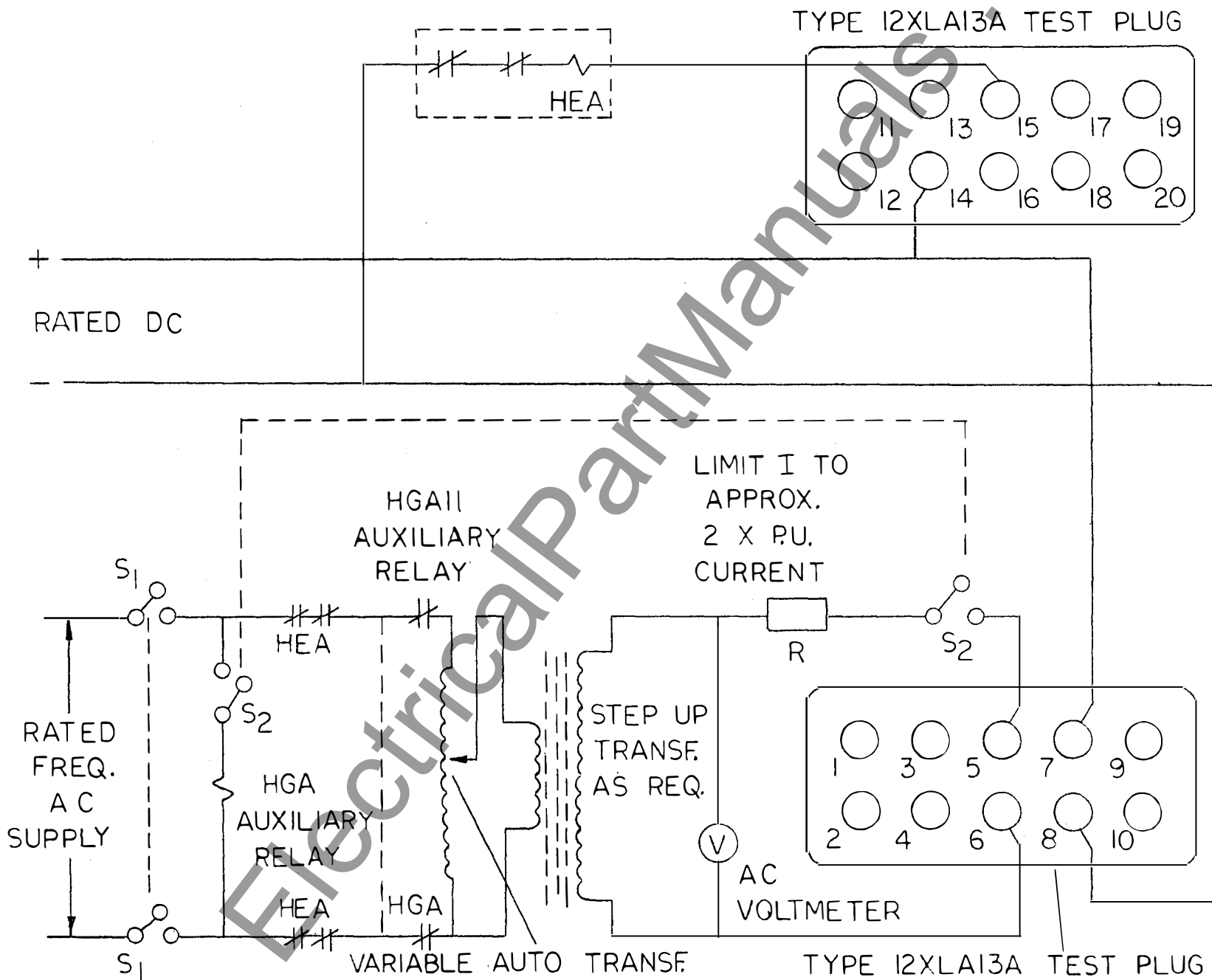Figure 16 (0257A3207-1) Pickup Current Test Connections for the SBD11B Relay

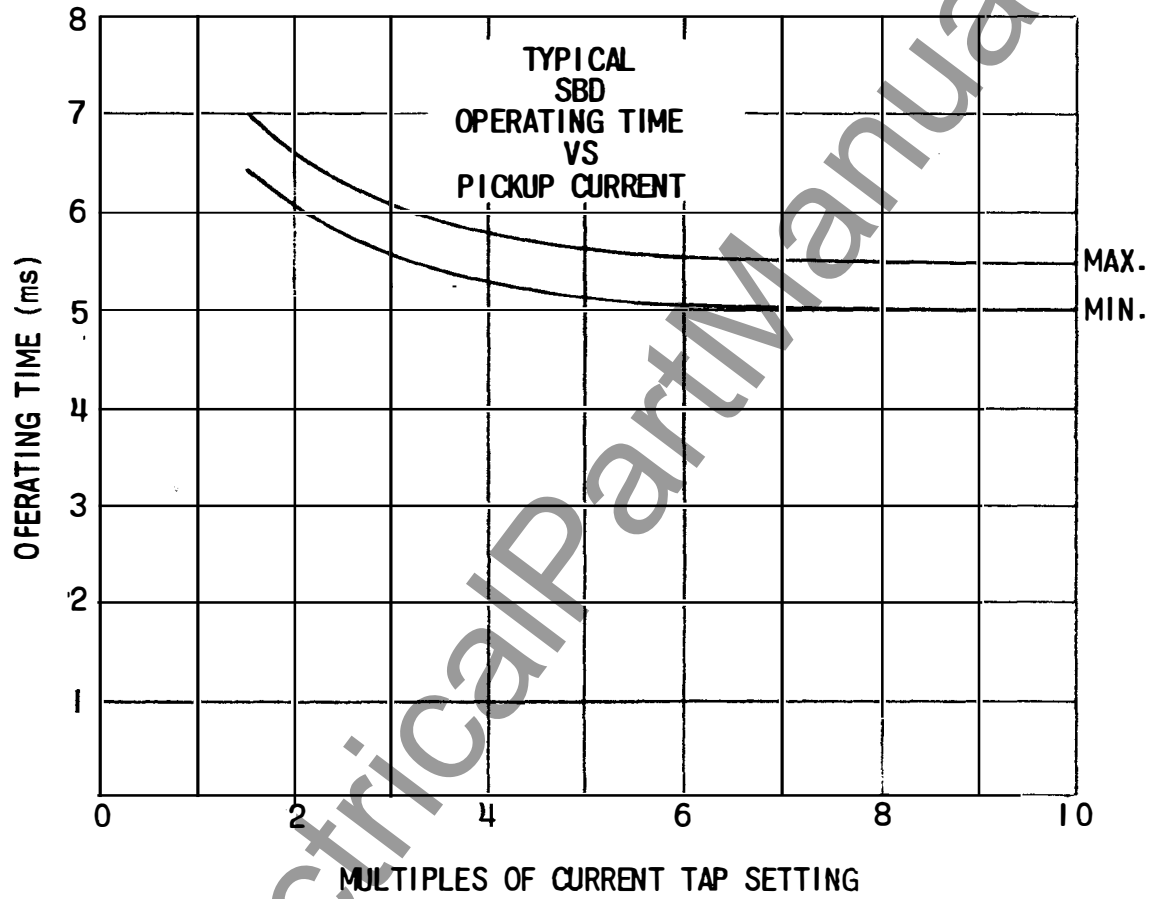Figure 17 (0246A6991-2) Full Voltage Test Connection Diagram for the SBD11B Relay

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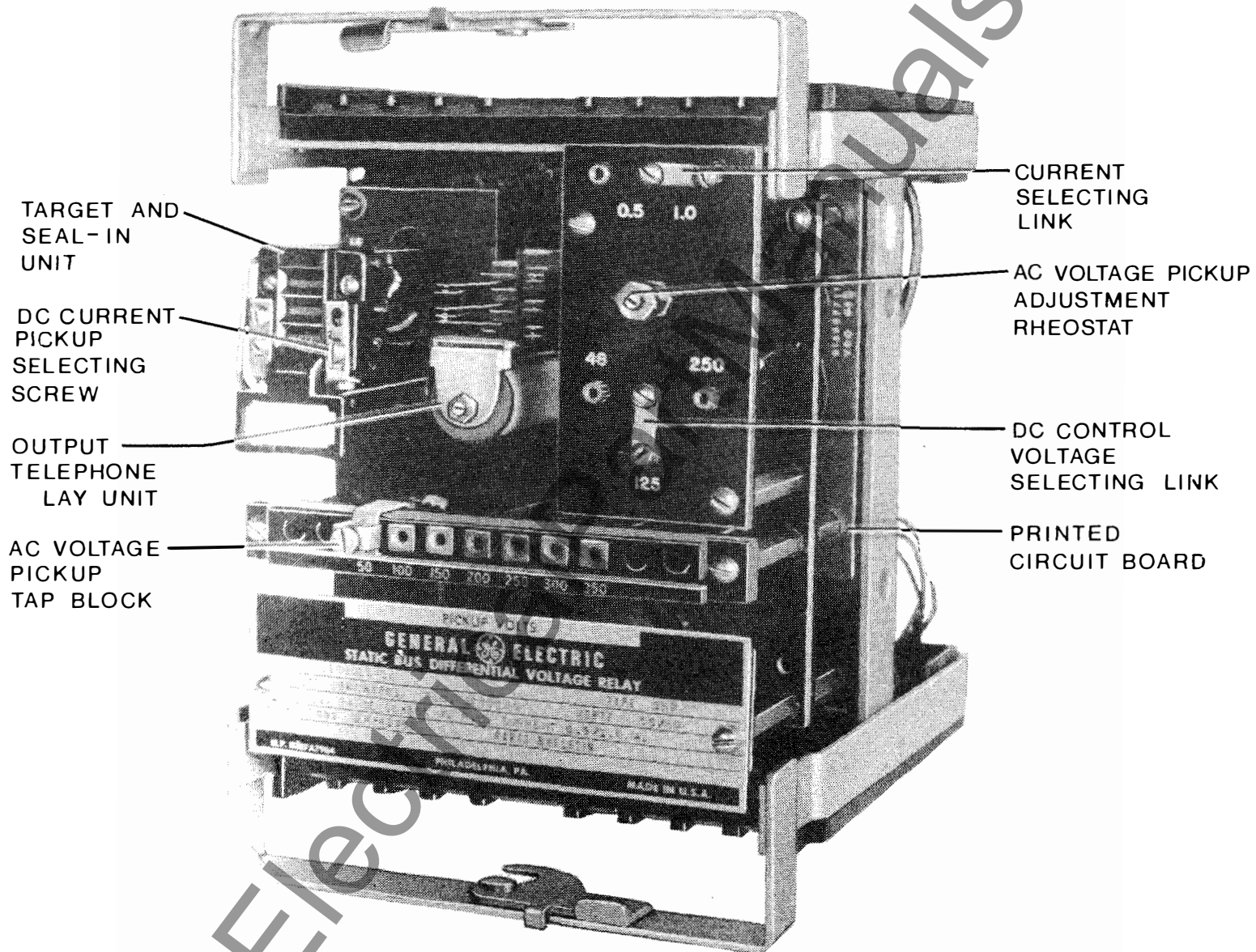Figure 18 (0208A8696-0) Typical SBD11B Operating Times

TARGET AND
SEAL-IN
UNIT

DC CURRENT
PICKUP
SELECTING
SCREW

OUTPUT
TELEPHONE
LAY UNIT

AC VOLTAGE
PICKUP
TAP BLOCK

CURRENT
SELECTING
LINK

AC VOLTAGE PICKUP
ADJUSTMENT
RHEOSTAT

DC CONTROL
VOLTAGE
SELECTING LINK

PRINTED
CIRCUIT BOARD

Figure 19   (8042393)   Type SBD11B Relay Out of Case, 3/4 Front View
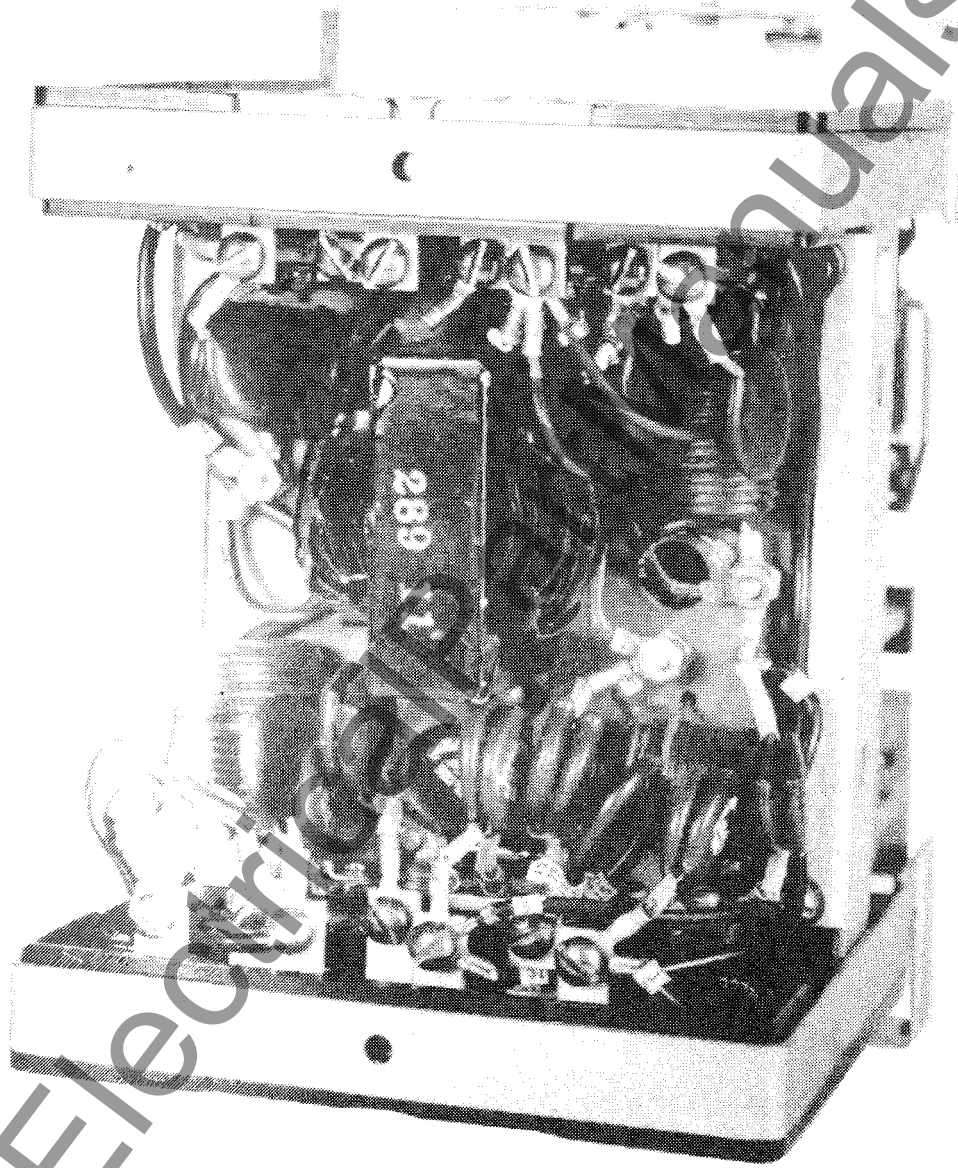
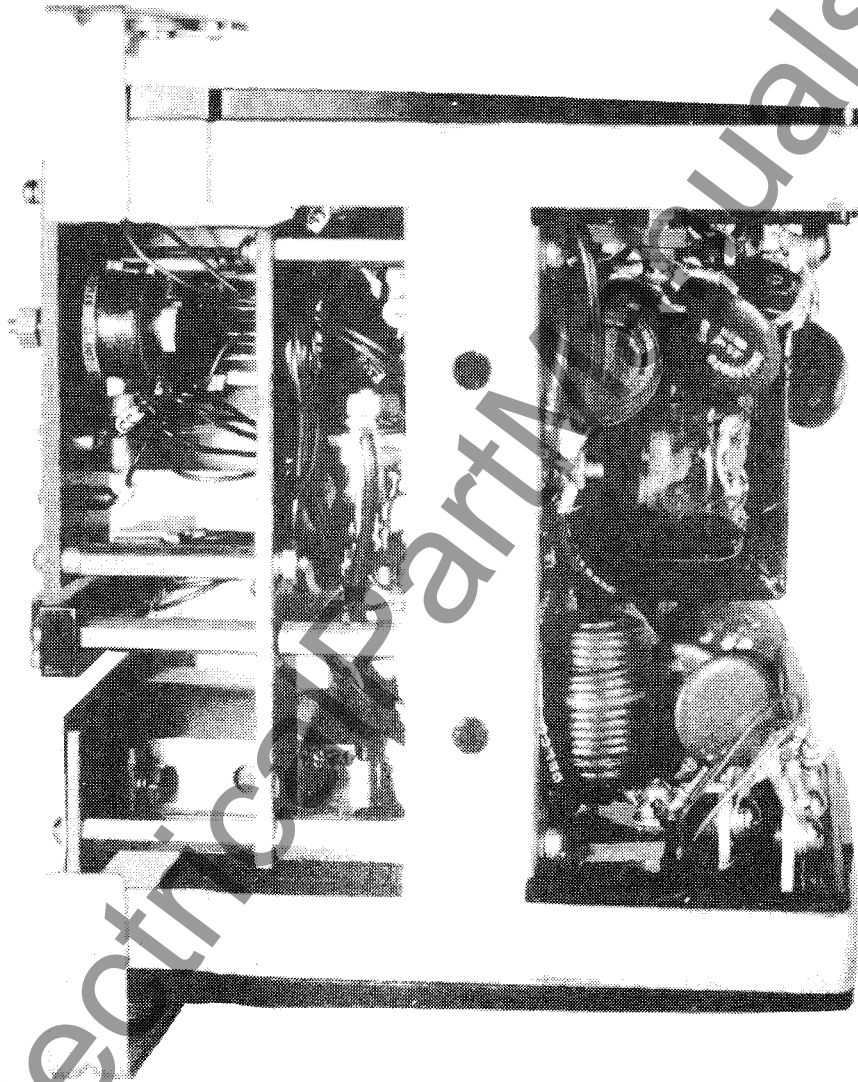Figure 20   (8042391)   Type SBD11B Relay Out of Case, Back View

Figure 21 (8042390) Type SBD11B Relay Out of Case, Left Side View
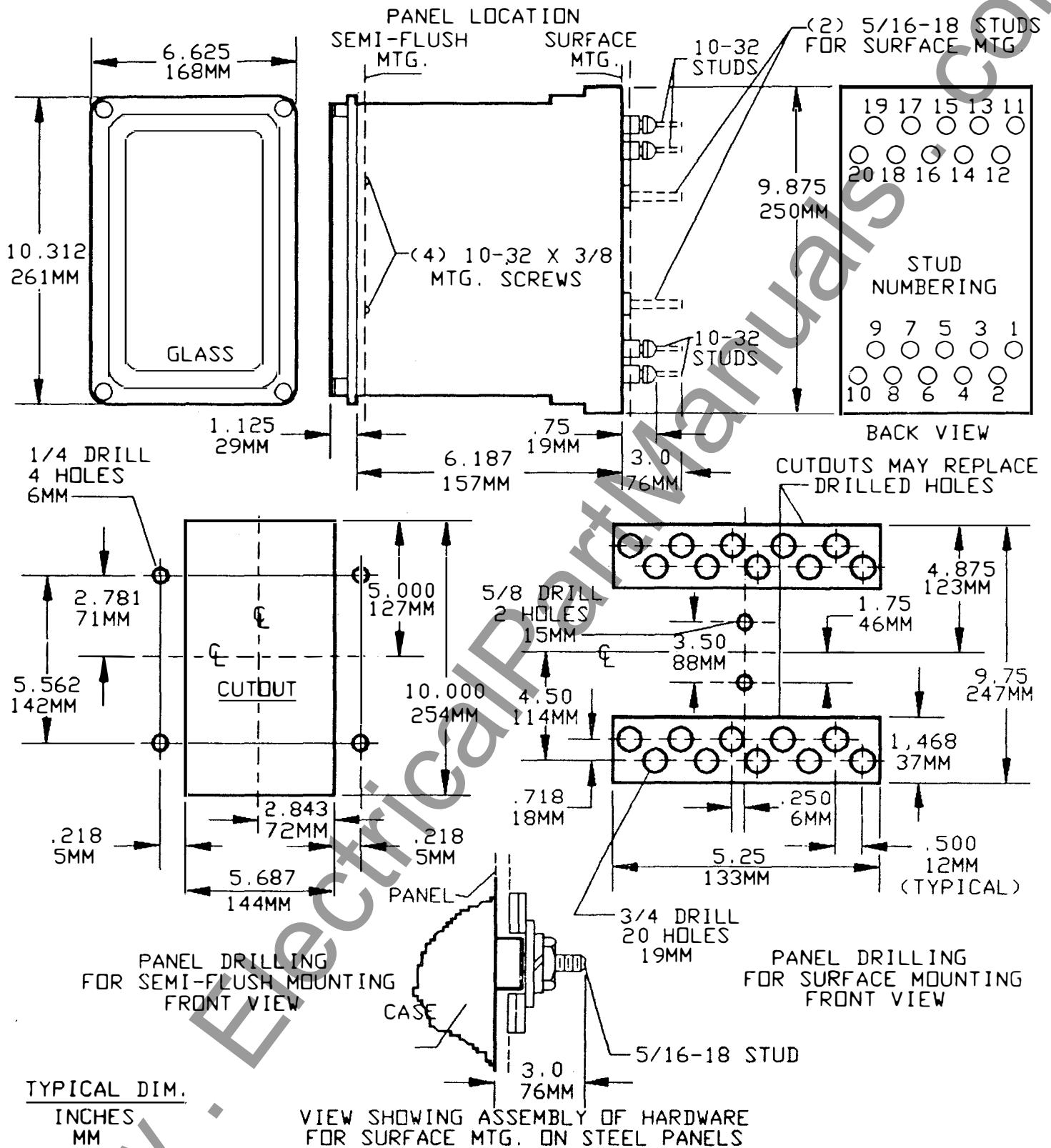
Figure 22 (6209272-7)   Outline and Panel Drilling Dimensions for the S2 Size Case

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