INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES SI AND SI-1 OVERCURRENT RELAYS

CAUTION: Before putting relay into service, operate the relay to check the electrical connections. Close output switches last when placing relay in service. Open output switches first when removing relay from service.

APPLICATION

These overcurrent relays are static devices that produce a d.c. output voltage when the input current in them exceeds a given value. This output voltage is used as the input to other devices that trip a breaker.

The number of inputs and outputs varies with the type of relay. Generally, these are as follows:

Type SI relay-three inputs, one or two outputs.

Type SI-1 relay-one input, one output.

CONSTRUCTION

The type SI-1 relay consists of an input transformer, a setting circuit, a phase splitter circuit, a sensing circuit, an amplifier circuit, a voltage regulator circuit, a feedback circuit and a transistor output. An operational indicator is an optional unit. The type SI relay in addition to these components has two input transformers, two phase splitter circuits, and either a single output or a dual output transistor circuit.

The components are connected as shown in Figs. 1 to 4.

Input Transformer – The input transformer is a two winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the setting circuit and from a fixed tap to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat connected in parallel with a resistor and Zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, resistor, potentiometer and a three-phase rectifier bridge. This circuit converts the single phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

Sensing Circuit – The sensing circuit consists of three resistors, a transistor and a Zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, a reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be greater than the reference voltage.

Amplifier Circuit – The amplifier circuit consists of a normally conducting transistor, Zener diode, three resistors and a diode. This circuit is the final output stage of the relay.

Feedback Circuit – The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit – The voltage regulator circuit consists of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt Zener diode mounted on an aluminum heat sink. The series resistor is a 3-½ inch resistor and is used to reduce the supply voltage to the Zener voltage.

Operational Indicator – The operational indicator consists of a silicon control rectifier, lamp, microswitch, Zener diode, and three resistors. This circuit is triggered by a signal from the output of the relay.

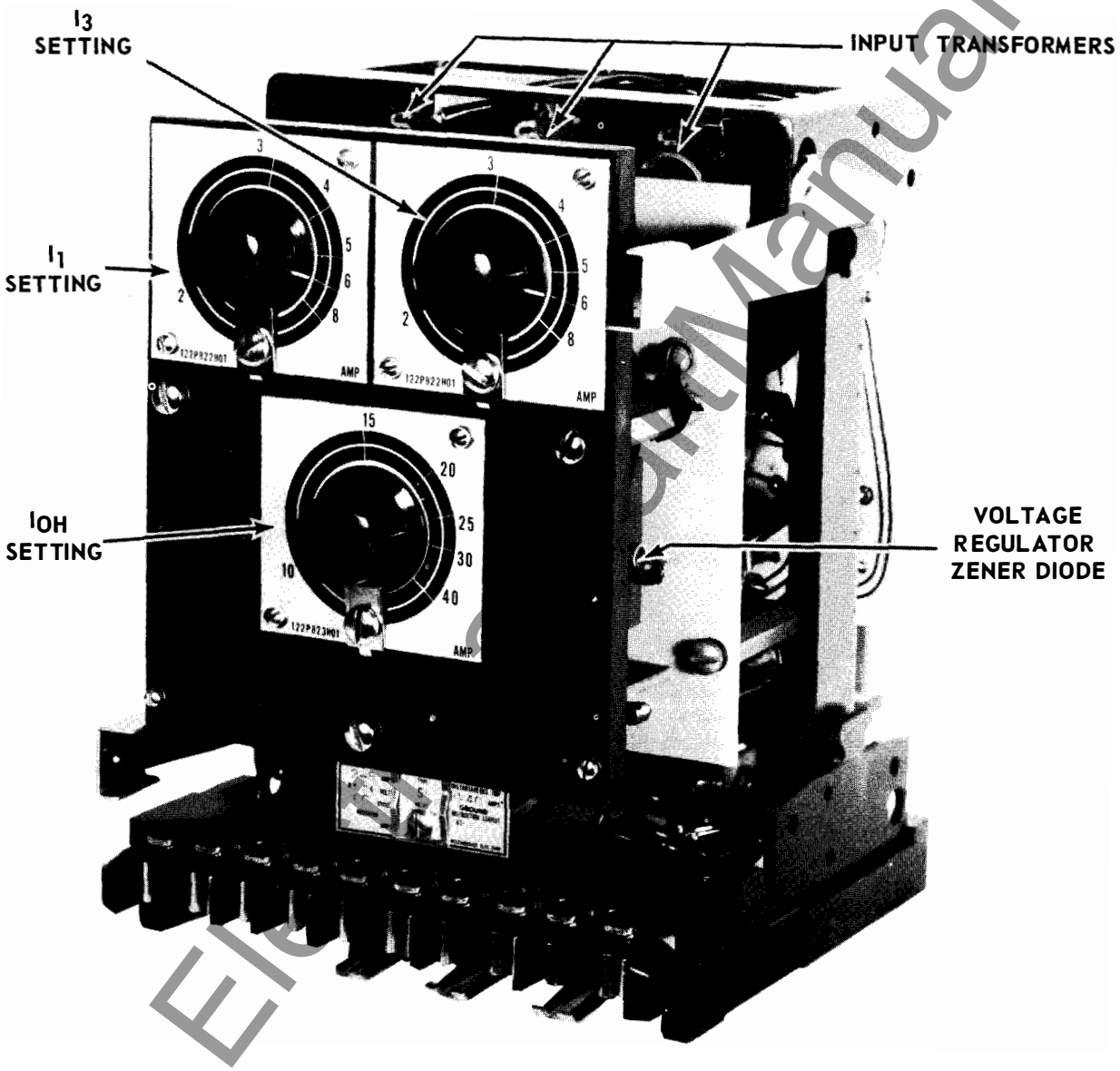


Fig. 1 Type SI Relay in an FT-21 case (front view).

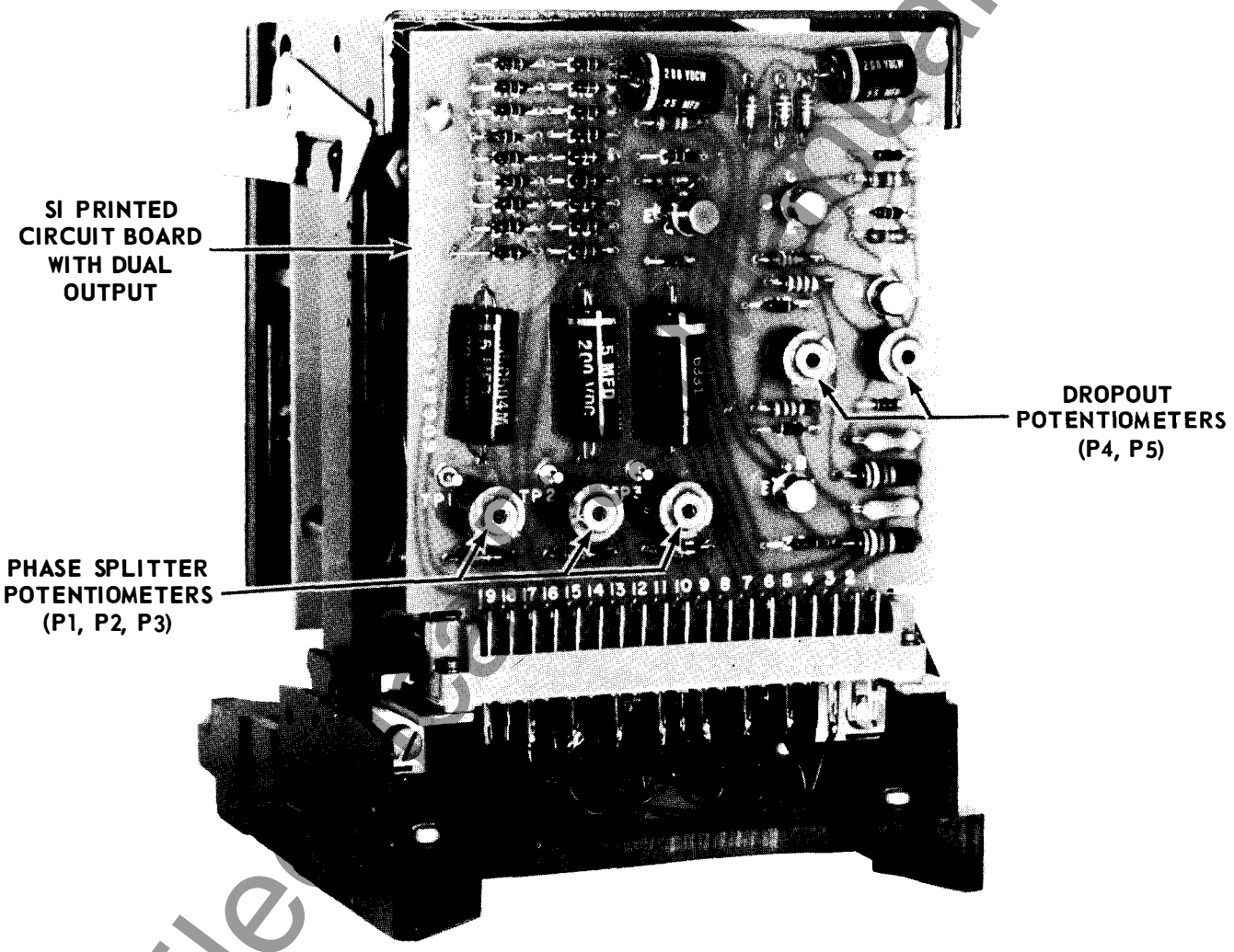


Fig. 2 Type SI Relay in an FT-21 case (rear view).

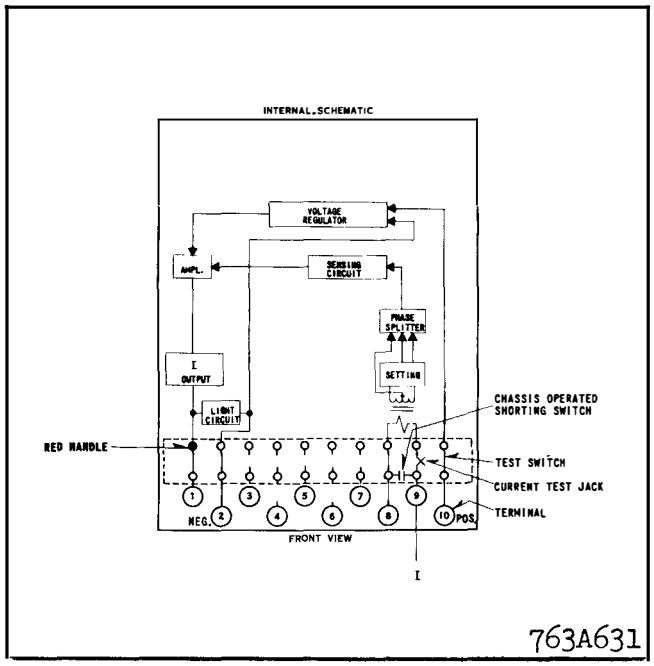


Fig. 3 Block diagram of the Type SI-1 Relay in FT-11 case (diagram of SI-1 without the operation indicator is 763A630).

OPERATION

The components of the SI-1 relay are connected as shown in Fig. 5. With no input to the relay, all transistors (Q_1 and Q_2) are conducting and a very small output is obtained from the relay. Zener diode (Z_2) of the sensing circuit establishes the reference voltage from the emitter of Q_1 to negative and allows a base current to flow in Q_1 through R_5 to negative.

When a.c. current is applied to the primary of the transformer (T), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (S1). This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor R_5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, Q_1 turns off to allow Q_2 to turn off which produces an output.

When Q_2 turns off, positive voltage is applied to the feedback circuit such that a voltage is applied to the base of Q_1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of pickup.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the voltage applied to the electronic components from becoming excessive.

The operation of the type SI relay is similar to the SI-1, except that the SI has three overcurrent inputs. These three inputs are applied through seperate phase splitting and setting circuits to a common sensing circuit which operates on the maximum voltage applied to it.

Figs. 6, 7, and 8 show the connections of the SI-1, SI with single output with the SI with a dual output.

CHARACTERISTICS

The SI-1 relay is available in the current ranges shown in Table I.

TABLE I

Range	Scale Marking					
.25 – 1 ampere	.25	.4	.5	.6	.8	1.0
.5 – 2 amperes	.5	.75	1.0	1.25	1.5	2.0
1 – 4 amperes	1.0	1.5	2.0	2.5	3.0	4.0
2 – 8 amperes	2	3	4	5	6	8
4 – 16 amperes	4	6	8	10	12	16
10 – 40 amperes	10	15	20	25	30	40

The setting of the relay is the minimum current required to produce an output. Settings between the scale markings can be obtained by applying the desired current to the relay and setting the rheostat at the desired point.

The SI relay is available with any combination of three of the above ranges. In the usual application, two inputs are the same range with an output. The third input is of a different range and can be of a different output than the other two.

The operating time of the relay is shown in Fig. 9. As shown in the figure, there is a maximum and minimum operating time of the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Figure 10 shows the operate times for different points on the fault wave for fault currents at twice pickup.

TABLE II
ENERGY REQUIREMENTS

Ampere Range	Setting	VA at Setting	P.F. Angle	VA at 5 amps.	P.F. Angle
.25 – 1	.25	0.17	7.5	23	51°
	.4	0.31	15	22.8	50
	.5	0.42	21	22.7	48
	.6	0.54	25	22.6	48
	.8	0.81	30	22.2	48
	1.0	1.20	35	21.8	48
.5 – 2	.5	0.17	7.5	8.80	32
	.75	0.31	15	8.50	32
	1.0	0.42	21	8.10	33
	1.25	0.54	25	7.80	34
	1.5	0.81	30	7.60	36
	2.0	1.20	35	7.10	37
1 – 4	1	0.17	7.5	3.15	16
	1.5	0.31	15	2.95	19
	2	0.42	21	2.65	21
	2.5	0.54	25	2.35	25
	3	0.81	20	2.21	28
	4	1.20	35	2.0	30
2 – 8	2	0.22	7.5	1.4	13
	3	0.39	15	1.1	15
	4	0.60	21	0.95	21
	5	0.85	25	0.85	25
	6	1.17	30	0.80	30
	8	1.94	35	0.73	35
4 – 16	4	0.26	8.5	0.41	8.5
	6	0.49	13	0.34	13
	8	0.80	15	0.3	15
	10	1.15	16.5	0.29	16.5
	12	1.57	17.5	0.28	17.5
	16	2.56	19	0.25	19.0
10 – 40	10	1.0	3	0.25	3
	15	2.1	4	0.23	4
	20	3.6	5	0.21	5
	25	5.9	6	0.21	6
	30	8.1	6	0.20	6
	40	14.4	6	0.20	6

TABLE III
CURRENT RATINGS
Rating of the Overcurrent Units

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.25 – 1	6	185
.5 – 2	8	350
1 – 4	10	400
2 – 8	12	400
4 – 16	15	400
10 – 40	20	460

TABLE IV

Battery Drain at 125 Volts D.C.

SI-1 Relay	65 Milliamperes
SI-1 Relay with Indicator	100 Milliamperes
SI- Relay Single Output	65 Milliamperes
SI Relay Dual Output	105 Milliamperes

SETTING

The pickup of the relay is selected by adjusting the rheostat, S, in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

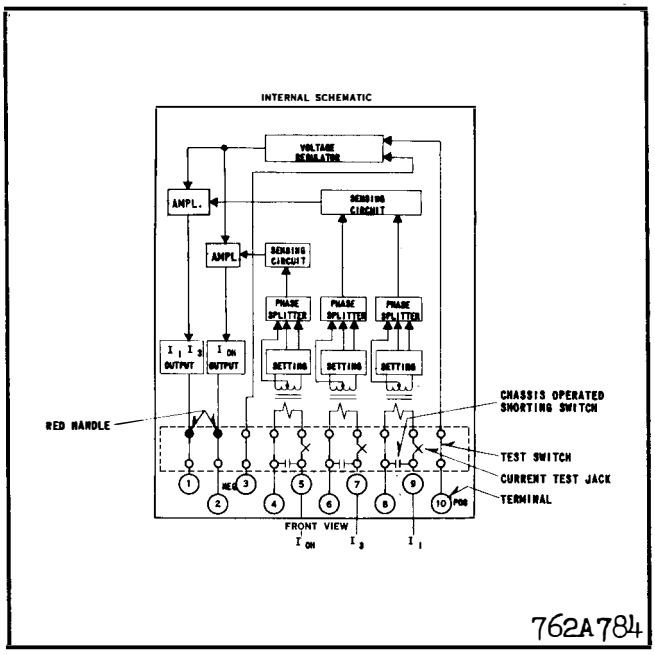


Fig. 4 Block diagram of the Type SI Relay in FT-21 case (for SI with single output omit the circuits connected to terminal 2; dwg. no. 763A629.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. All checks can best be performed by connecting the relay per the test circuit of Fig. 11. Refer to fig. 4 and make similar connections for the test of the SI relay.

1. Minimum trip current – Check pickup at the minimum and maximum setting. This is accomplished by applying the specified current and checking that the voltmeter reads approximately 20 volts when the current is within 3% of the setting.

2. Dropout – After checking pickup, the dropout should be checked to be approximately 97% of the pickup when the a.c. current is gradually reduced.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

Calibration

Use the following procedure for calibrating the SI-1 relay if the relay adjustments have been distributed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs on the type SI relay.

Splitter Adjustments

1. Turn rheostat (S) on front of relay to extreme counter-clockwise position.

2. Apply minimum S current to the proper relay terminals.

3. With a high resistance voltmeter (a.c.) adjust phase splitter potentiometer such that three voltages approximately equal to each other are obtained across TP 1, printed circuit board terminal 12 and printed circuit board terminal 18 or 14.

Dial Calibration (S)

1. Apply 125 volts d.c. to relay terminals 10 and 2. Terminal 10 is positive.

2. Connect a high resistance d.c. voltmeter across terminals 1 and 2. Terminal 1 is positive.

3. Apply desired S current to terminal 8 and 9.

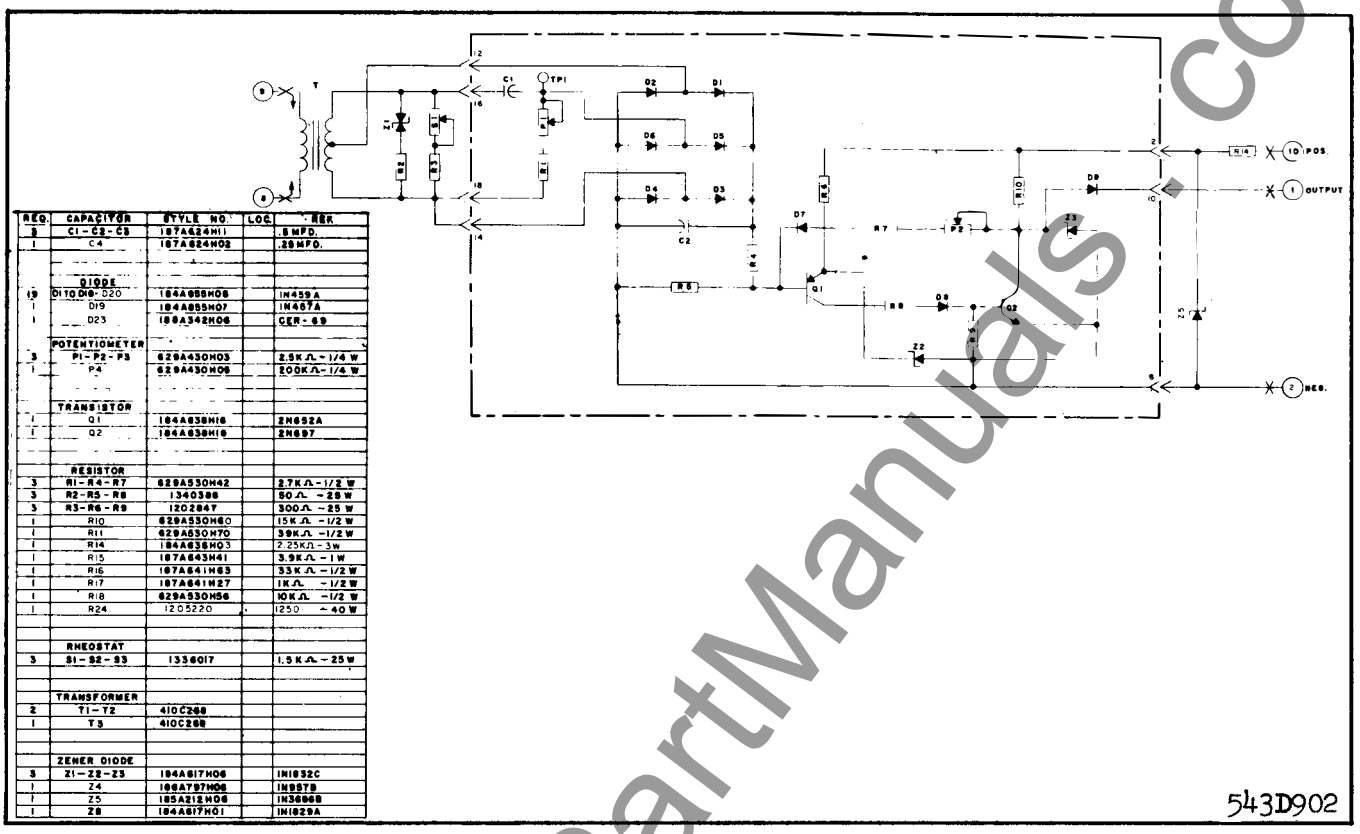
4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on meter.

Dropout (P)

1. Set S on desired point and apply S amperes to relay to make it operate.

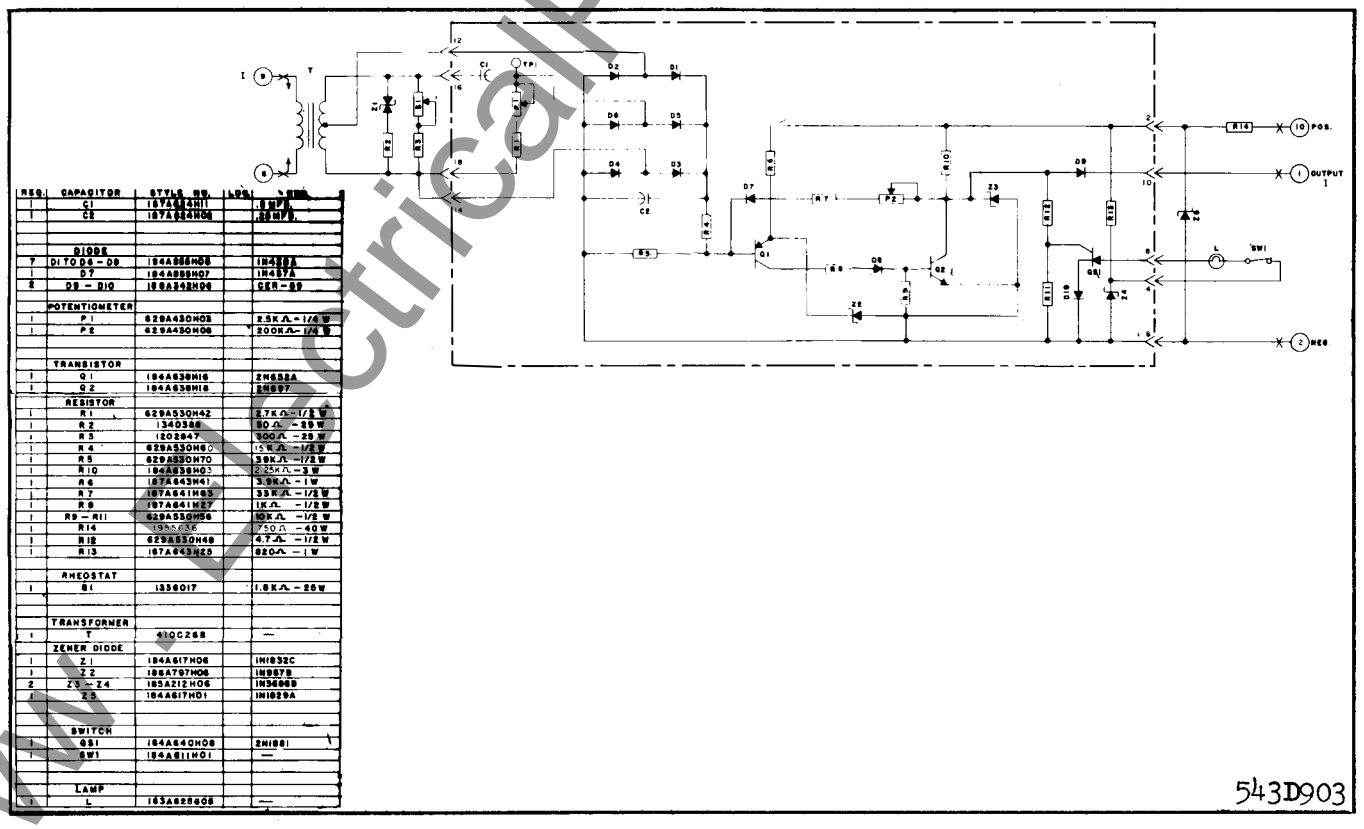
2. Lower S amperes to desired droput value and adjust P potentiometer until voltmeter drops to approximately zero.

3. Verify dropout and pickup several times by raising a.c. current until relay operates and then lowering the a.c. current until relay dropouts.



REQ.	CAPACITOR	STYLE NO.	LOC.	RER.
2	C1-C2-C3	187A624H11		.5 MFD.
1	C4	187A624H02		.25 MFD.
	DIODE			
9	D1 TO D6-D20	184A855H08		IN459A
1	D19	184A855H07		IN457A
1	D23	188A342H06		GER-69
	POTENTIOMETER			
3	P1-P2-P3	629A430H03		2.5K Ω - 1/4 W
1	P4	629A430H06		200K Ω - 1/4 W
	TRANSISTOR			
1	Q1	184A638H16		2N652A
1	Q2	184A638H18		2N697
	RESISTOR			
3	R1-R4-R7	629A530H42		2.7K Ω - 1/2 W
3	R2-R5-R8	1340386		50 Ω - 25 W
3	R3-R6-R9	1202847		300 Ω - 25 W
1	R10	629A530H80		15K Ω - 1/2 W
1	R11	629A530H70		39K Ω - 1/2 W
1	R14	184A636H03		2.25KΩ - 3W
1	R15	187A643H41		3.9K Ω - 1W
1	R16	187A641H63		33K Ω - 1/2 W
1	R17	187A641H27		1K Ω - 1/2 W
1	R18	629A530H56		10K Ω - 1/2 W
1	R24	1205220		1250 - 40 W
	RHEOSTAT			
3	R1-R2-R3	1336017		1.5K Ω - 25 W
	TRANSFORMER			
2	T1-T2	410C268		
1	T3	410C268		
	ZENER DIODE			
3	Z1-Z2-Z3	184A817H06		IN1832C
1	Z4	188A797H06		IN957B
1	Z5	185A212H06		IN3686B
1	Z6	184A817H01		IN1829A

Fig. 5 Internal Schematic for the type SI-1 Relay.



REQ.	CAPACITOR	STYLE NO.	LOC.	RER.
1	C1	187A624H11		.5 MFD.
1	C2	187A624H06		.25 MFD.
	DIODE			
7	D1 TO D6 - D8	184A855H08		IN459A
1	D7	184A855H07		IN457A
2	D9 - D10	188A342H04		GER-69
	POTENTIOMETER			
1	P1	629A430H05		2.5K Ω - 1/4 W
1	P2	629A430H06		200K Ω - 1/4 W
	TRANSISTOR			
1	Q1	184A638H16		2N652A
1	Q2	184A638H18		2N697
	RESISTOR			
1	R1	629A530H42		2.7K Ω - 1/2 W
1	R2	1340386		50 Ω - 25 W
1	R3	1202847		300 Ω - 25 W
1	R4	629A530H80		15K Ω - 1/2 W
1	R5	629A530H70		39K Ω - 1/2 W
1	R10	184A636H03		2.25K Ω - 3 W
1	R6	187A643H41		3.9K Ω - 1W
1	R7	187A641H63		33K Ω - 1/2 W
1	R8	187A641H27		1K Ω - 1/2 W
1	R9 - R11	629A530H56		10K Ω - 1/2 W
1	R14	1205220		1250 Ω - 40 W
1	R12	629A530H48		4.7 Ω - 1/2 W
1	R13	187A643H25		820 Ω - 1 W
	RHEOSTAT			
1	R1	1336017		1.5K Ω - 25 W
	TRANSFORMER			
1	T	410C268		—
	ZENER DIODE			
1	Z1	184A817H06		IN1832C
1	Z2	188A797H06		IN957B
2	Z3 - Z4	185A212H06		IN3686B
1	Z5	184A817H01		IN1829A
	SWITCH			
1	GS1	184A640H08		2N1881
1	SW1	194A811H01		—
	LAMP			
1	L	183A625H08		—

Fig. 6 Internal Schematic for the type SI-1 Relay with an operation indicator.

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the SI-1 relay or the SI relay is not operating correctly.

1. Inspect all wires and connections, paying particular attention to printed circuit terminals.
2. Check resistances as listed on the internal schematic of the relays.
3. Check voltages as listed on the electrical checkpoints.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ELECTRICAL CHECKPOINTS

Connect relay per test circuit of Fig. 11. All voltage readings should be made with a high resistance voltmeter. Refer to Fig. 12, 13 or 14 for printed circuit board points. For some readings it is necessary to scrape varnish from the components to make a connection at the point.

I No. A.C. Current Input 125 volts d.c.

Component	Negative terminal	Approximate d.c. voltage
Z_2	2	7
Z_3	2	less than .6 volts
Z_5	2	45 volts

II Minimum Trip A.C. current applied

Circuit	Terminals	Voltage
Phase	TP_1 to board 18	7.5 volts a.c.
Splitter	TP_1 to board 12	7.5 volts a.c.
	Board 12 to board 18	7.5 volts a.c.
Setting	Board 16 to board 18	15 volts a.c.
Output	Terminal 1(+) and 2	18 to 22 volts D.C.

The above terminals are for the SI-1 relay. For corresponding terminals for the SI relay, refer to the relay.

ELECTRICAL PARTS LIST

TYPE SI

Circuit Symbol	Description
CAPACITORS	
CI-C2-C3	.5 MFD.
C4-C5 ††	.25 MFD.
DIODES	
D1 TO D18-D20-D22 ††	IN459A
D19-D21 ††	IN457A
POTENTIOMETERS	
P1-P2-P3	2.5K Ω — 1/4W
P4-P5 ††	200K Ω — 1/4W
TRANSISTORS	
Q1-Q3 ††	2N652A
Q2-Q4 ††	2N697
RESISTORS	
R1-R4-R7	2.7 K Ω — 1/2W
R2-R5-R8	50 Ω — 25 W
R3-R6-R9	300 Ω — 25 W
R10-R12 ††	15 K Ω — 1/2 W
R11-R13 ††	39 K Ω — 1/2 W
R14-R19 ††	1 K Ω — 3 W
R15-R21 ††	3.9 K Ω — 1 W
R16-R20 ††	33 K Ω — 1/2 W
R17-R22 ††	1 K Ω — 1/2 W
R18-R23 ††	10 K Ω — 1/2 W
R24	500 Ω — 40 W
RHEOSTAT	
S1-S2-S3	1.5K Ω — 25 W
TRANSFORMER	
T1-T2	S# 410C268
T3	S#410C268
ZENER DIODES	
Z1-Z2-Z3	INI832C
Z4-Z6 ††	IN957B
Z5-Z7 ††	IN368B
Z8	INI829A

†† Used only in relay with double output.

TYPE SI-1

Circuit Symbol	Description
CAPACITORS	
C1	.5 MFD.
C2	.25 MFD.
DIODES	
D1 TO D6-D8	IN459A
D7	IN457A
D9 - D10 †	CER - 69
POTENTIOMETERS	
P 1	2.5K Ω — 1/4 W
P 2	200 K Ω — 1/4 W
TRANSISTORS	
Q 1	2N652A
Q 2	2N697
RESISTORS	
R 1	2.7 K Ω — 1/2 W
R 2	50 Ω — 25 W
R 3	300 Ω — 25 W
R 4	15 K Ω — 1/2 W
R 5	39 K Ω — 1/2 W
R 10	1K Ω — 3 W
R 6	3.9 K Ω — 1 W
T 7	33 K Ω — 1/2 W
R 8	1 K Ω — 1/2 W
R 9 — R 11 †	10 K Ω — 1/2 W
R 14	500 Ω — 40 W
R 12 †	4.7 Ω — 1/2 W
R 13 †	820 Ω — 1 W
RHEOSTAT	
S 1	1.5 K Ω — 25 W
TRANSFORMER	
T	S # 410C268
ZENER DIODES	
Z 1	INI832C
Z 2	IN957B
Z 3 - Z 4 †	IN3686B
Z 5	INI829A
SWITCHES	
QS 1 †	2N1881
SW 1 †	S# 184A611H01
LAMP	
L †	S# 183A825G05

† Used only in relay with operation indicator

REQ.		STYLE NO.	LOC.
1	C1	1874824H11	8 MFD
1	C2	1874824H02	25 MFD
	DIODE		
7	DIODE - D8	1N4589A	
1	D7	1N4855N07	1N437A
1	D9	1883432H06	CER-89
	POTENTIOMETER		
1	P1	8294490H03	2.5K Ω - 1/4 W
1	P2	8294490H05	200K Ω - 1/4 W
	TRANSISTOR		
1	Q1	1844638H16	2N652A
1	Q2	1844638H16	2N697
	RESISTOR		
1	R1	8294530H42	8.7K Ω - 1/2 W
1	R2	1340388	30 Ω - 25 W
1	R3	1340367	150 Ω - 25 W
1	R4	8294530H60	1.5K Ω - 1/2 W
1	R5	8294530H70	3.8K Ω - 1/2 W
1	R10	1844636H03	2.25 Ω - 3 W
1	R6	1874643H41	5.9K Ω - 1 W
1	R7	1874641H63	33K Ω - 1/2 W
1	R8	1874641H27	1K Ω - 1/2 W
1	R9	8294530H56	10K Ω - 1/2 W
1	R14	(2222)	12500 Ω - 40 W
	RHEOSTAT		
1	S1	1336017	1.5K Ω - 25 W
	TRANSFORMER		
1	T	410C288	—
	ZENER DIODE		
1	Z1	1844617H08	1N832C
1	Z2	1884797H08	1N957B
1	Z3	1853212H06	1N5086B
1	Z5	1844617H01	1N1298A

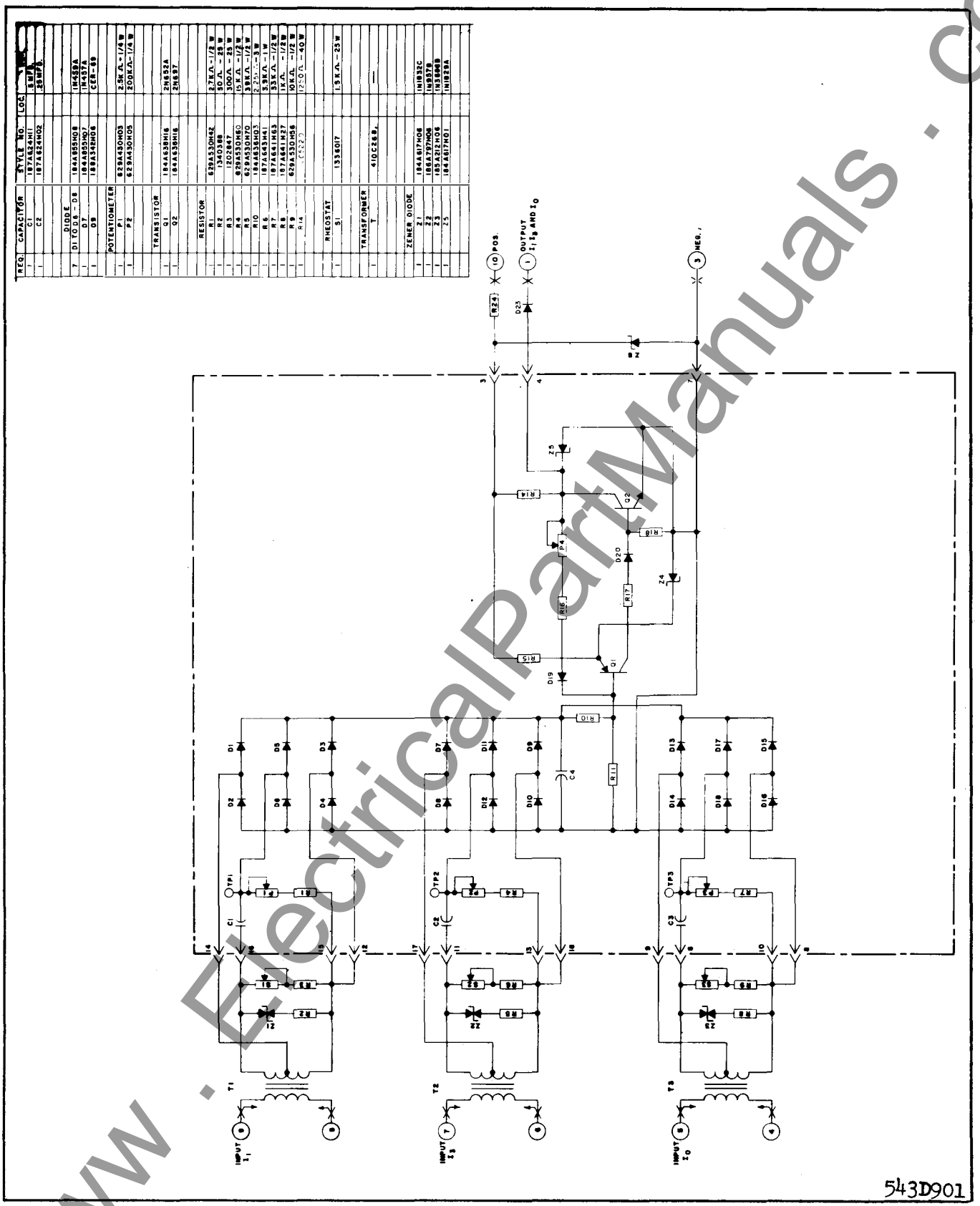


Fig. 7 Internal Schematic for the type SI Relay with a single output.

REQ.	CAPACITOR	STYLE NO.	LOC.	REF.
3	C1-C2-C3	187A824H11		.5 MFD.
2	C4-C5	187A824H02		.25 MFD.
	DIODE			
20	D1 TO D18-D20-D22	1844B95H08		1N459A
2	D19-D21	1844B55H07		1N457A
	POTENTIOMETER			
3	P1-P2-P3	629A430H03		2.5K Ω. - 1/4 W
2	P4-P5	629A430H05		200K Ω. - 1/4 W
	TRANSISTOR			
2	Q1-Q3	1844A638H16		2N652A
2	Q2-Q4	1844A638H18		2N697
	RESISTOR			
3	R1-R4-R7	629A530H42		2.7K Ω. - 1/2 W
3	R2-R5-R8	1340388		50 Ω. - 2 W
3	R3-R6-R9	1340387		15 Ω. - 2 W
2	R10-R12	629A530H80		15K Ω. - 1/2 W
2	R11-R13	629A530H70		39K Ω. - 1/2 W
2	R14-R19	1844A636H03		2.2 MΩ - 3 W
2	R15-R21	187A643H41		3.9K Ω. - 1 W
2	R16-R20	187A641H83		33K Ω. - 1/2 W
2	R17-R22	187A641W27		1K Ω. - 1/2 W
2	R18-R23	629A530H58		10K Ω. - 1/2 W
1	R24	1955836		T60 Ω. - 40 W
	RHEOSTAT			
3	S1-S2-S3	1336017		1.5 K Ω. - 25 W
	TRANSFORMER			
2	T1-T2	410C288		
1	T3	410C288		
	ZENER DIODE			
3	Z1-Z2-Z3	1844B17H06		1N832C
3	Z4-Z6-Z7	1844A97H06		1N829B
2	Z5-Z7	1854A212H08		1N3686B
1	Z8	1844B17H01		1N829A

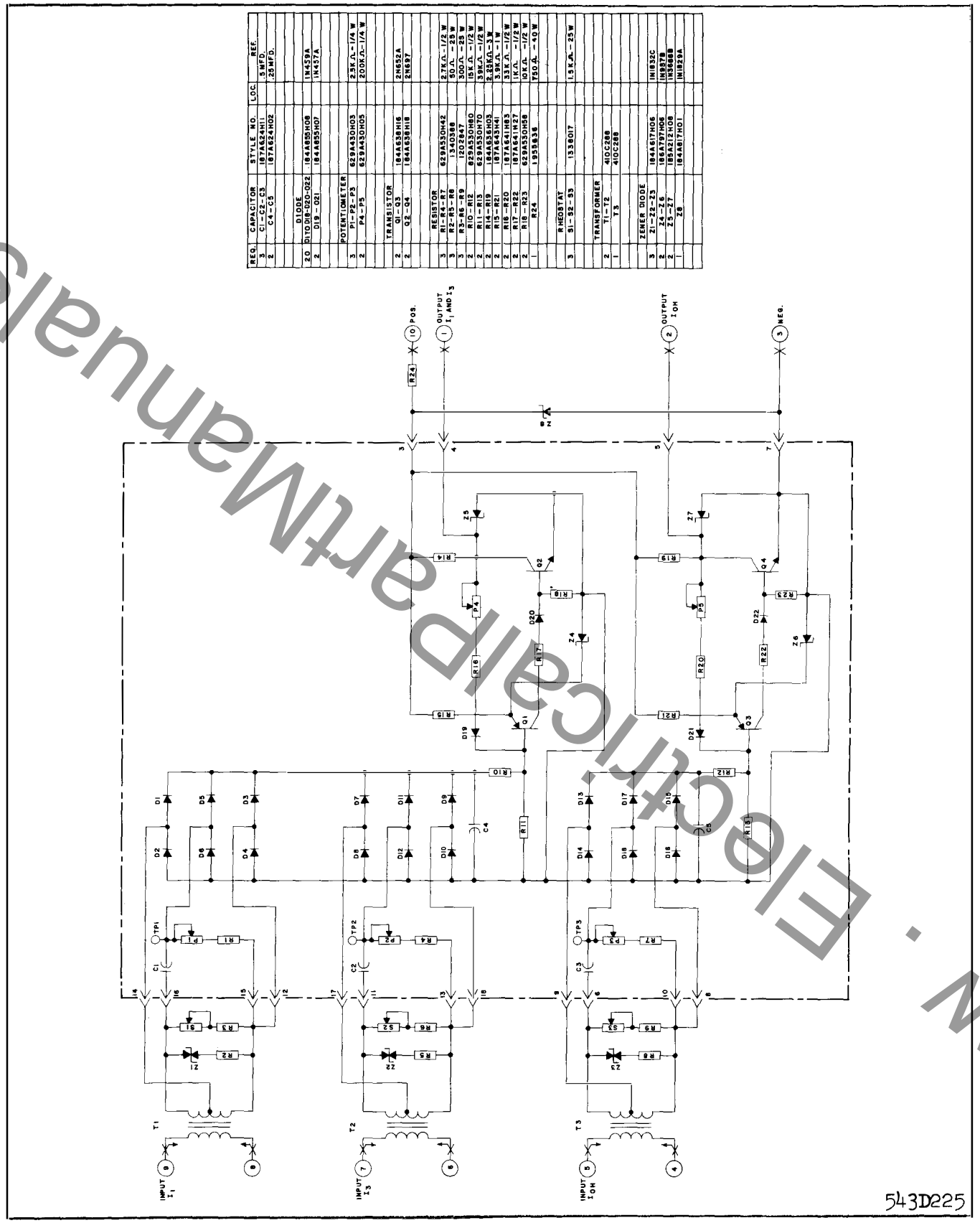


Fig. 8 Internal Schematic of the type SI Relay with a double output.

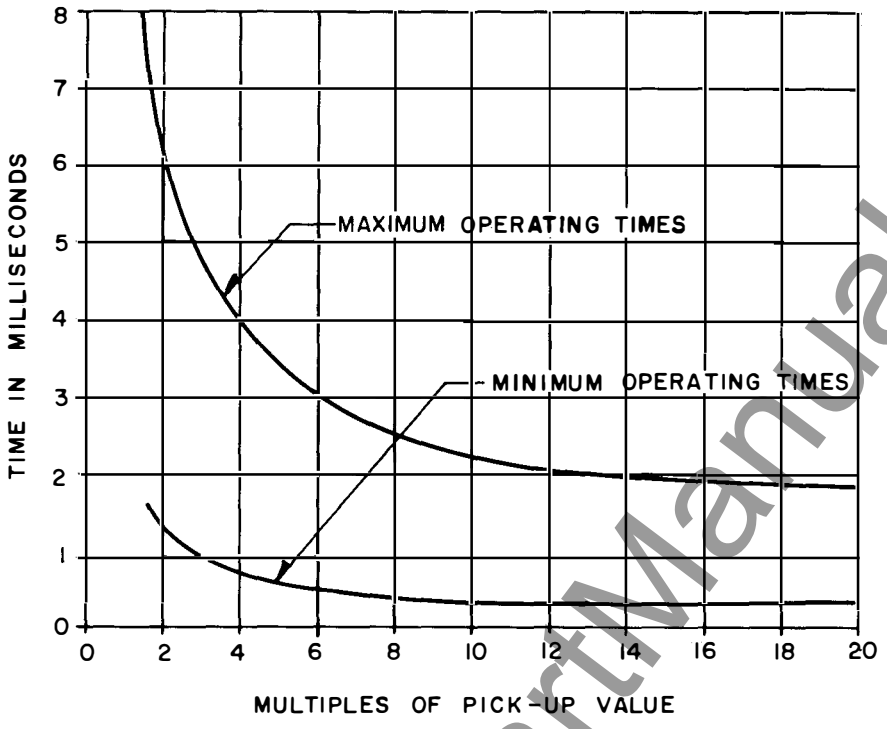


Fig. 9 Operating time for the type SI and SI-1 Relays.

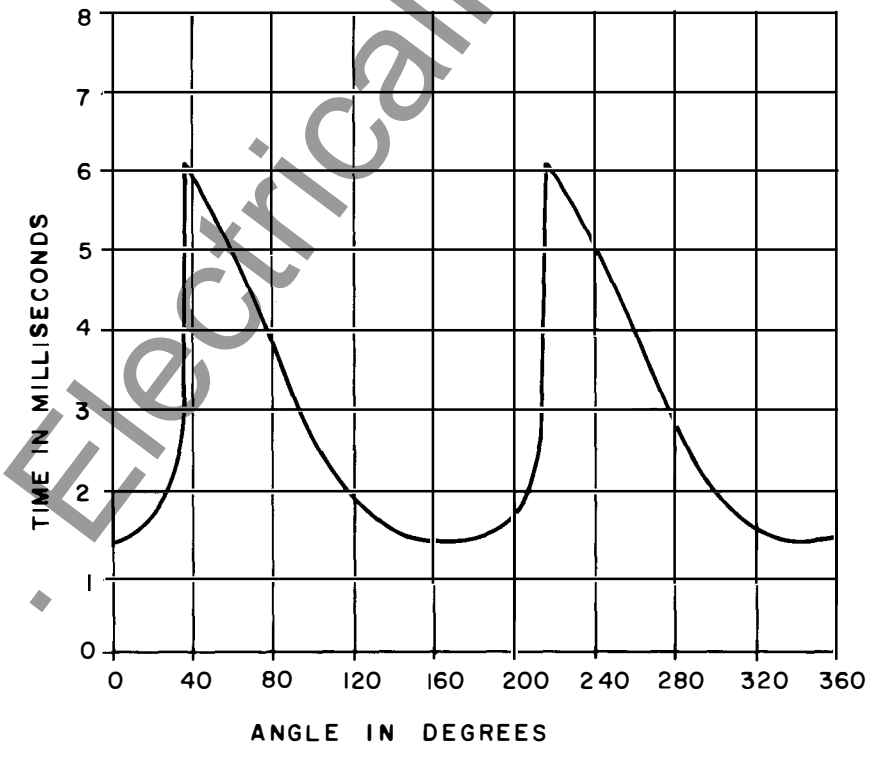


Fig. 10 Operating time for the type SI and SI-1 Relays as a function of fault incidence angle at twice minimum trip.

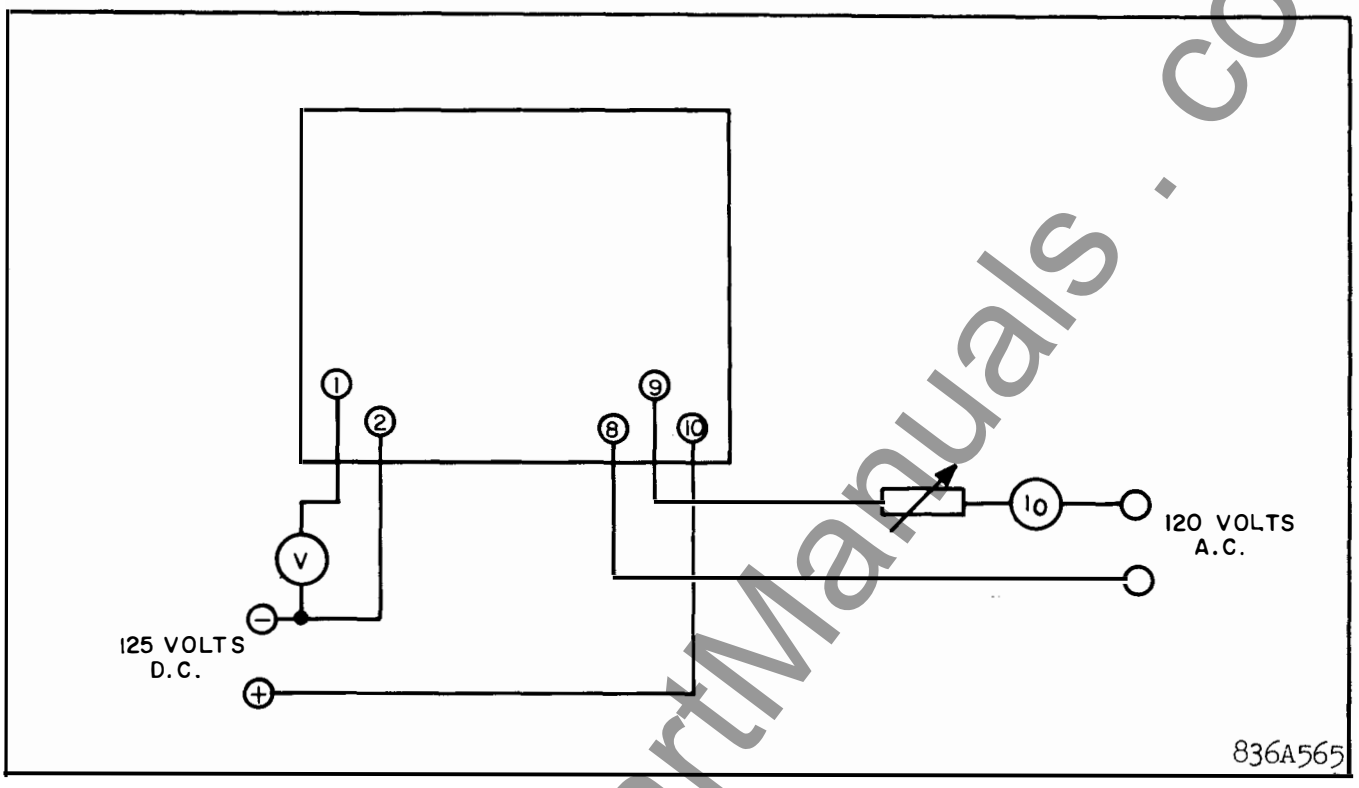


Fig. 11 Test circuit for the type SI-1 Relay.

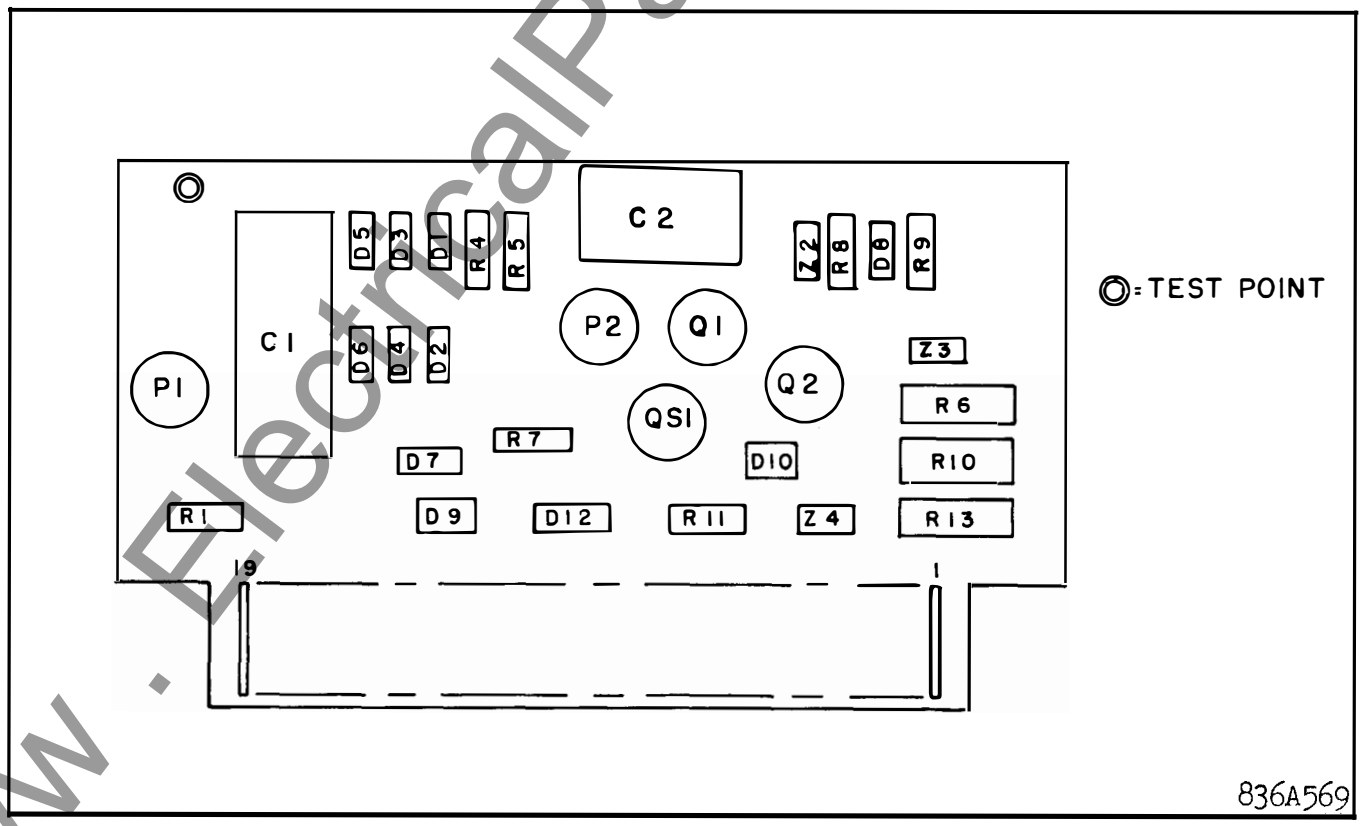


Fig. 12 Component location on printed circuit board for the type SI-1 Relay.

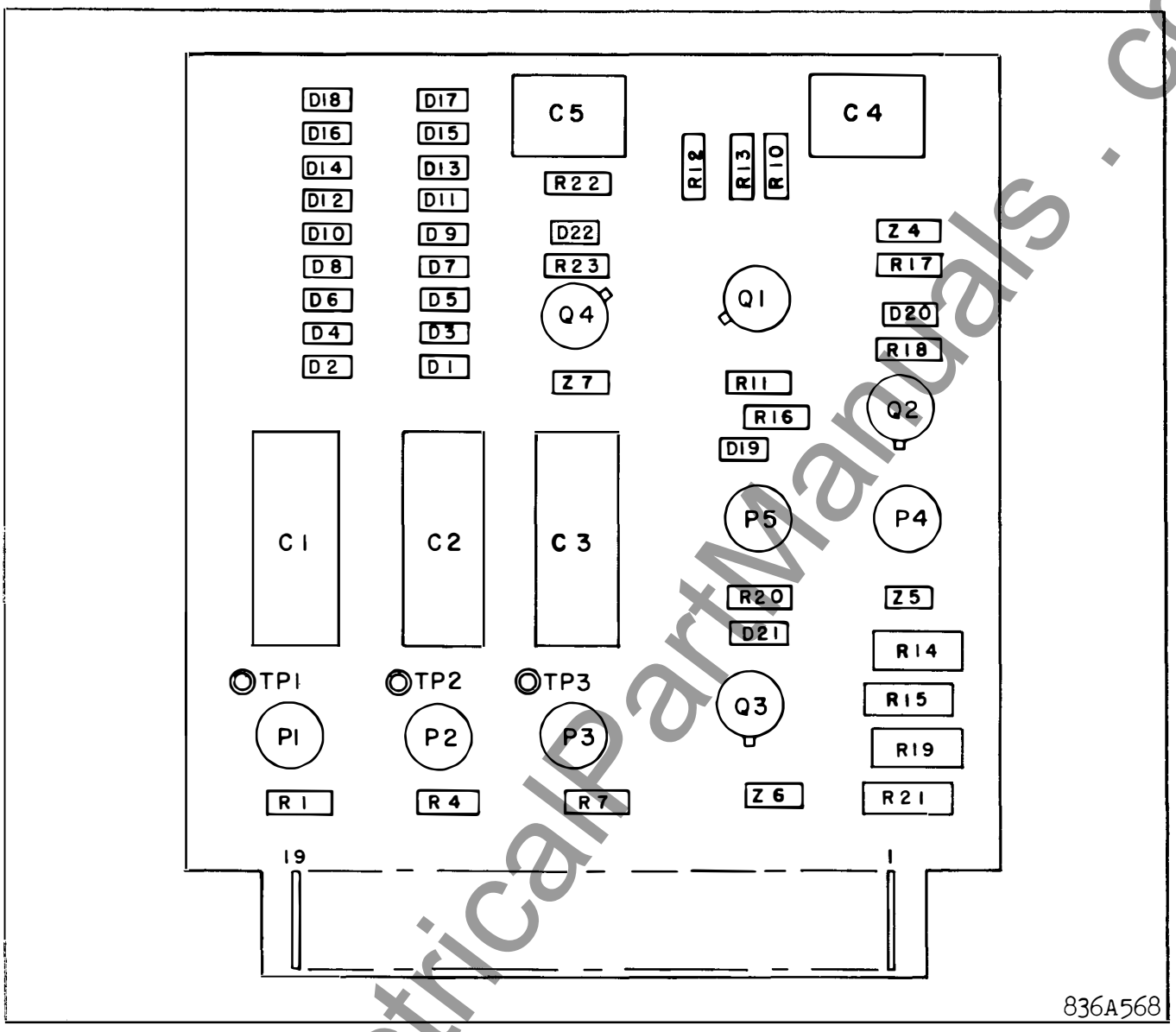


Fig. 13 Component location on printed circuit board for the type SI Relay.

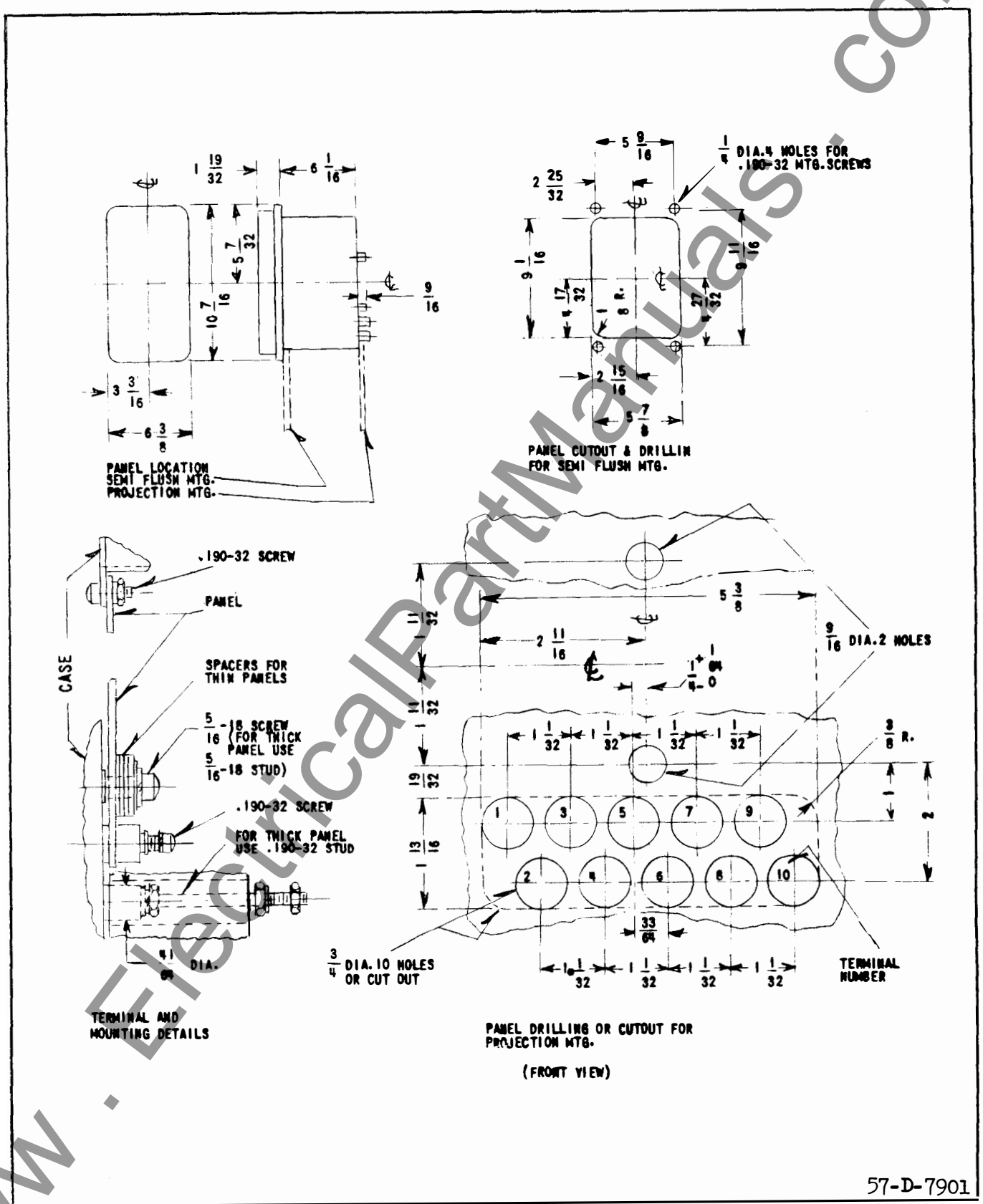


Fig. 14 Outline and drilling plan for the type SI Relay in the FT-21 case.

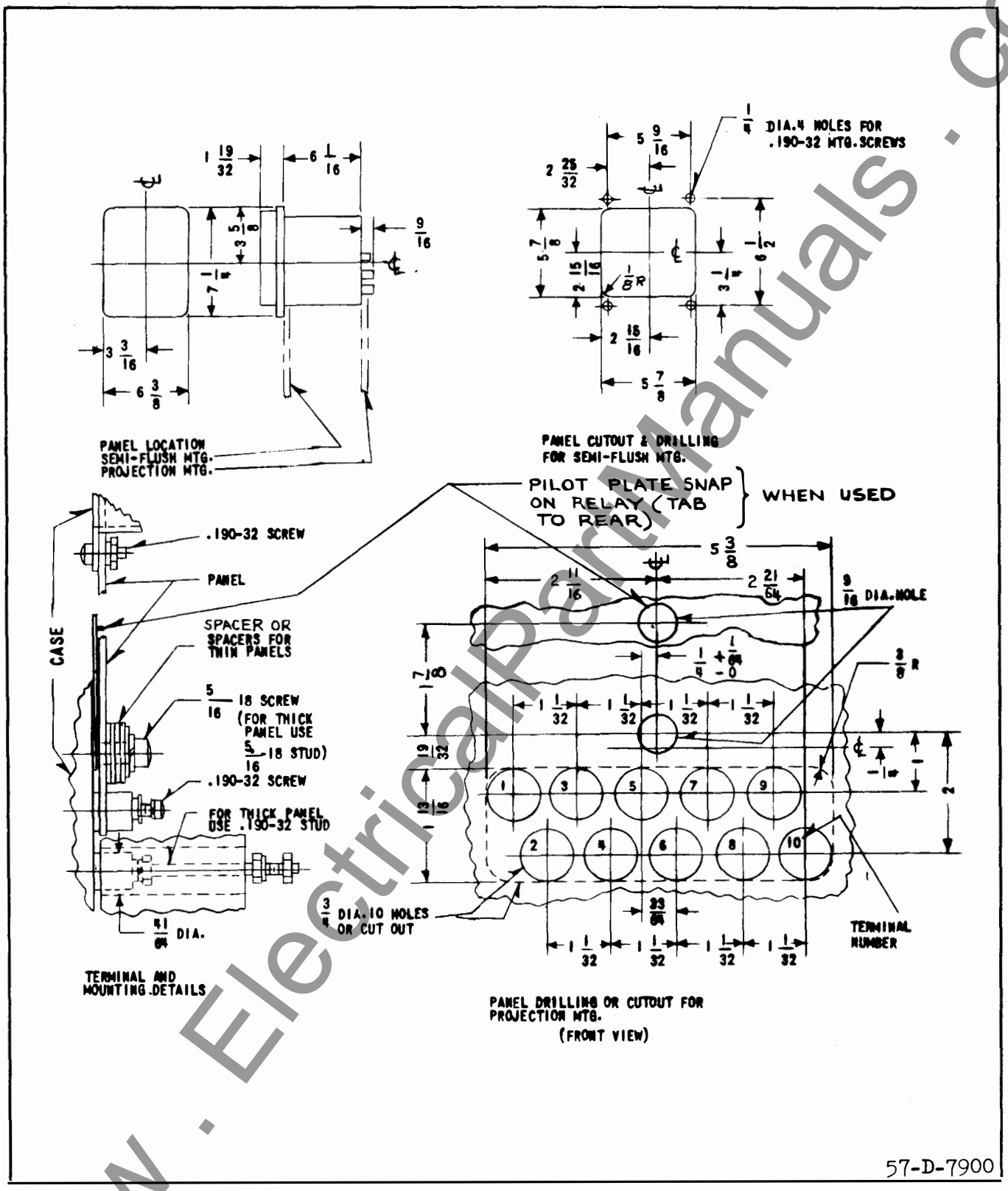


Fig. 15 Outline and drilling plan for the type SI-1 Relay in the FT-11 case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES SI AND SI-1 OVERCURRENT RELAYS

CAUTION: Before putting relay into service, operate the relay to check the electrical connections. Close output switches last when placing relay in service. Open output switches first when removing relay from service.

APPLICATION

These overcurrent relays are static devices that produce a d.c. output voltage when the input current in them exceeds a given value. This output voltage is used as the input to other devices that trip a breaker.

The number of inputs and outputs varies with the type of relay. Generally, these are as follows:

Type SI relay-three inputs, one or two outputs.

Type SI-1 relay-one input, one output.

CONSTRUCTION

The type SI-1 relay consists of an input transformer, a setting circuit, a phase splitter circuit, a sensing circuit, an amplifier circuit, a voltage regulator circuit, a feedback circuit and a transistor output. An operational indicator is an optional unit. The type SI relay in addition to these components has two input transformers, two phase splitter circuits, and either a single output or a dual output transistor circuit.

The components are connected as shown in Figs. 1 to 4.

Input Transformer – The input transformer is a two winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the setting circuit and from a fixed tap to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat connected in parallel with a resistor and Zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, resistor, potentiometer and a three-phase rectifier bridge. This circuit converts the single phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

Sensing Circuit – The sensing circuit consists of three resistors, a transistor and a Zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, a reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be greater than the reference voltage.

Amplifier Circuit – The amplifier circuit consists of a normally conducting transistor, Zener diode, three resistors and a diode. This circuit is the final output stage of the relay.

Feedback Circuit – The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit – The voltage regulator circuit consists of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt Zener diode mounted on an aluminum heat sink. The series resistor is a 3-½ inch resistor and is used to reduce the supply voltage to the Zener voltage.

Operational Indicator – The operational indicator consists of a silicon control rectifier, lamp, microswitch, Zener diode, and three resistors. This circuit is triggered by a signal from the output of the relay.

SUPERSEDES I.L. 41-777
*Denotes change from superseded issue.

EFFECTIVE APRIL 1966

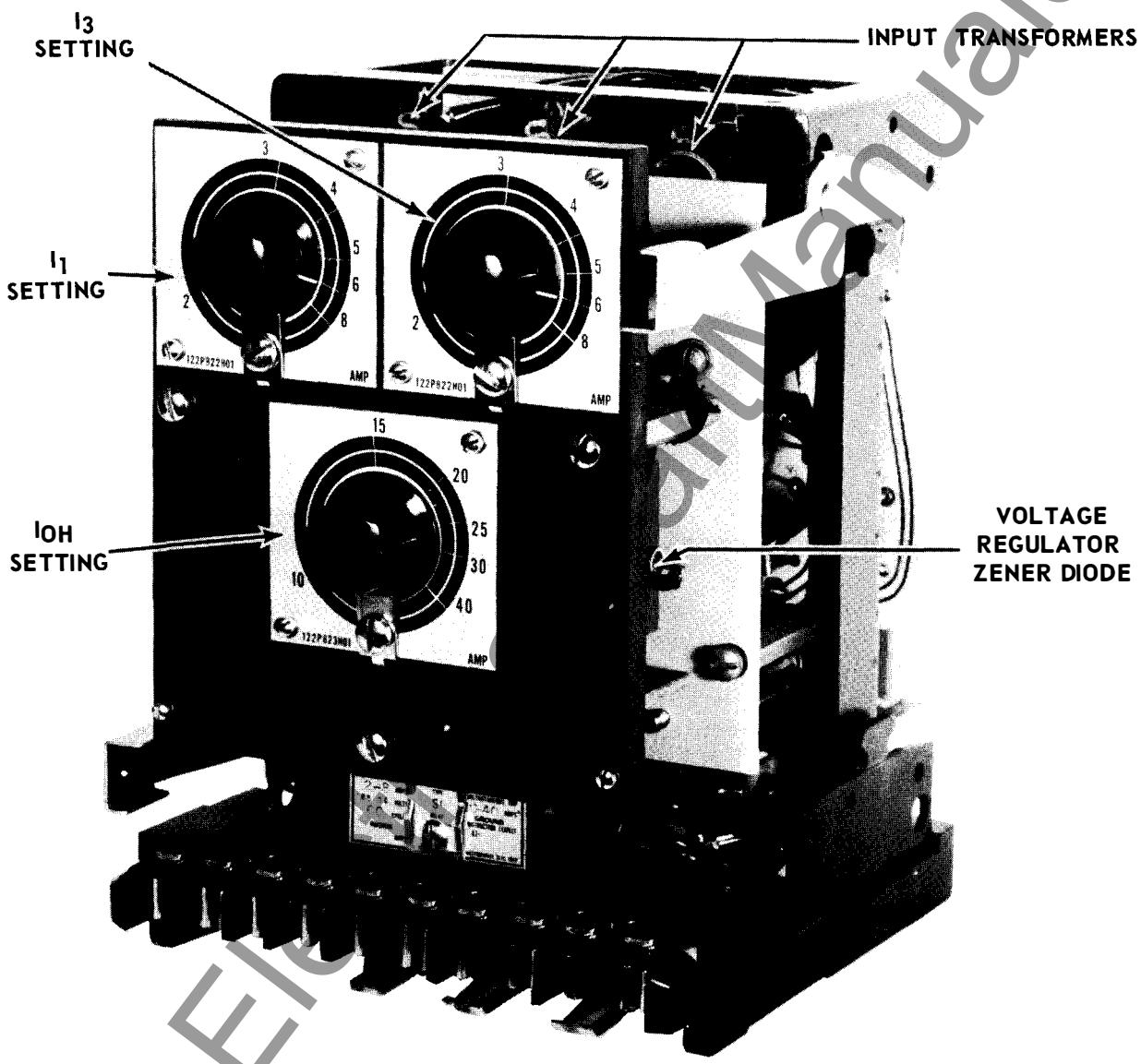


Fig. 1 Type SI Relay in an FT-21 case (front view).

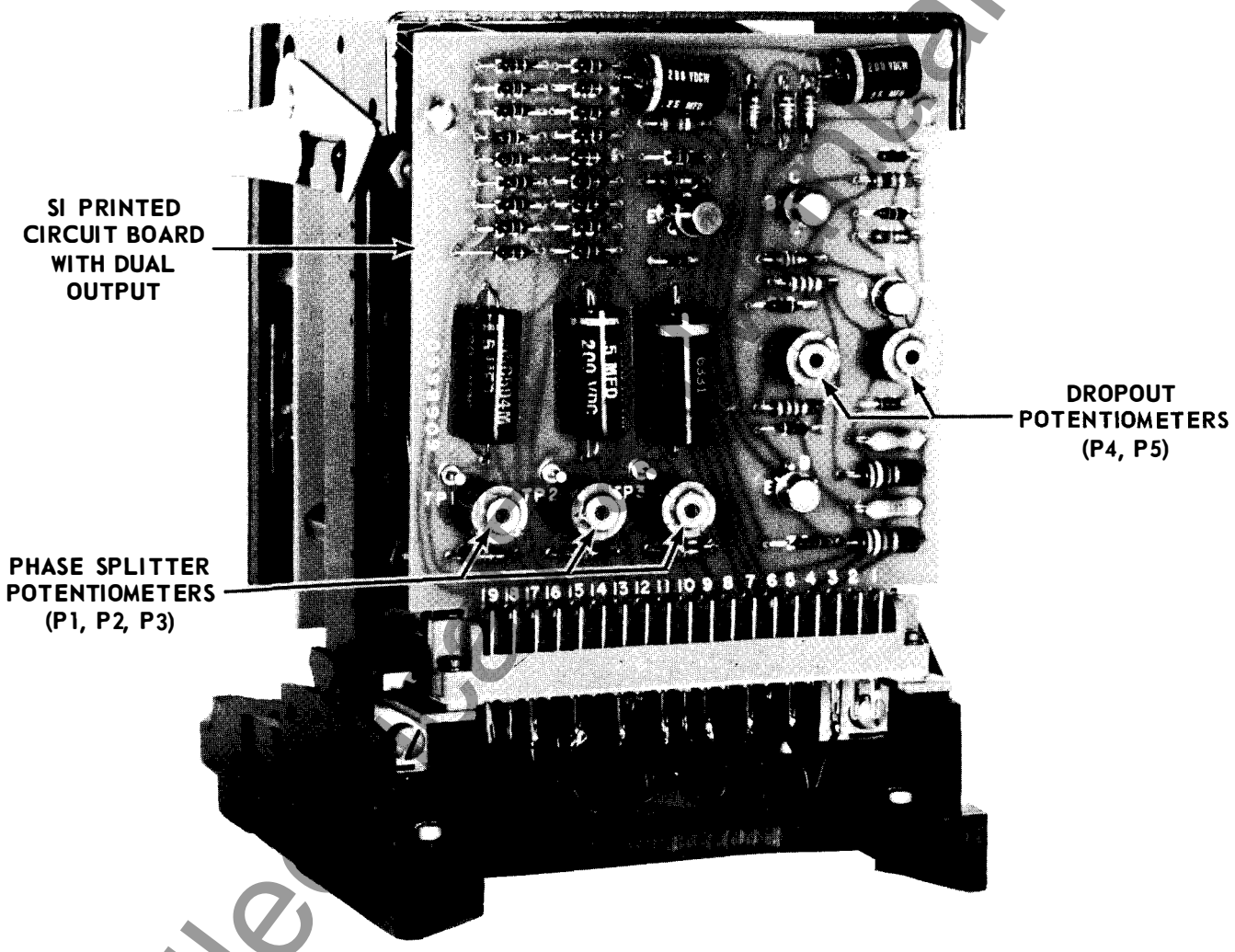


Fig. 2 Type SI Relay in an FT-21 case (rear view).

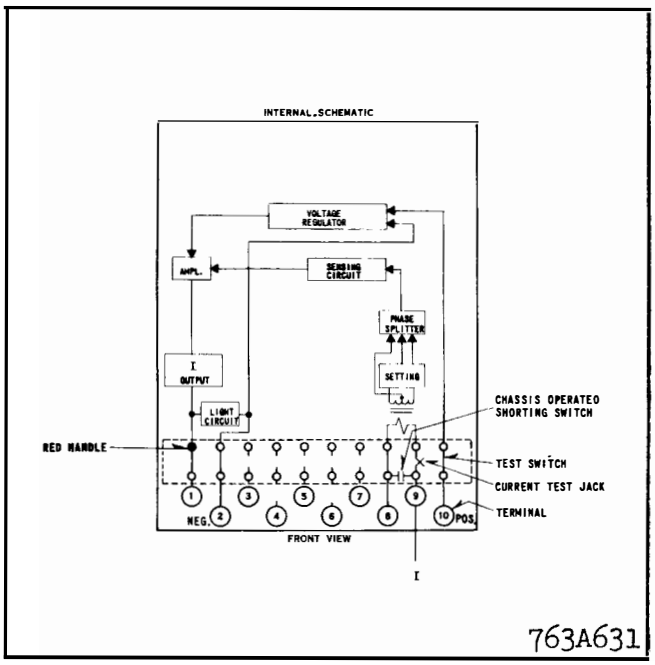


Fig. 3 Block diagram of the Type SI-1 Relay in FT-11 case (diagram of SI-1 without the operation indicator is 763A630).

OPERATION

The components of the SI-1 relay are connected as shown in Fig. 5. With no input to the relay, all transistors (Q_1 and Q_2) are conducting and a very small output is obtained from the relay. Zener diode (Z_2) of the sensing circuit establishes the reference voltage from the emitter of Q_1 to negative and allows a base current to flow in Q_1 through R_5 to negative.

When a.c. current is applied to the primary of the transformer (T), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (S1). This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor R_5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, Q_1 turns off to allow Q_2 to turn off which produces an output.

When Q_2 turns off, positive voltage is applied to the feedback circuit such that a voltage is applied to the base of Q_1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of pickup.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the voltage applied to the electronic components from becoming excessive.

The operation of the type SI relay is similar to the SI-1, except that the SI has three overcurrent inputs. These three inputs are applied through seperate phase splitting and setting circuits to a common sensing circuit which operates on the maximum voltage applied to it.

Figs. 6, 7, and 8 show the connections of the SI-1, SI with single output with the SI with a dual output.

CHARACTERISTICS

The SI-1 relay is available in the current ranges shown in Table I.

TABLE I

Range	Scale Marking					
.25 – 1 ampere	.25	.4	.5	.6	.8	1.0
.5 – 2 amperes	.5	.75	1.0	1.25	1.5	2.0
1 – 4 amperes	1.0	1.5	2.0	2.5	3.0	4.0
2 – 8 amperes	2	3	4	5	6	8
4 – 16 amperes	4	6	8	10	12	16
10 – 40 amperes	10	15	20	25	30	40

The setting of the relay is the minimum current required to produce an output. Settings between the scale markings can be obtained by applying the desired current to the relay and setting the rheostat at the desired point.

The SI relay is available with any combination of three of the above ranges. In the usual application, two inputs are the same range with an output. The third input is of a different range and can be of a different output than the other two.

The operating time of the relay is shown in Fig. 9. As shown in the figure, there is a maximum and minimum operating time of the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Figure 10 shows the operate times for different points on the fault wave for fault currents at twice pickup.

TABLE II
ENERGY REQUIREMENTS

Ampere Range	Setting	VA at Setting	P.F. Angle	VA at 5 amps.	P.F. Angle
.25 – 1	.25	0.17	7.5	23	51°
	.4	0.31	15	22.8	50
	.5	0.42	21	22.7	48
	.6	0.54	25	22.6	48
	.8	0.81	30	22.2	48
	1.0	1.20	35	21.8	48
.5 – 2	.5	0.17	7.5	8.80	32
	.75	0.31	15	8.50	32
	1.0	0.42	21	8.10	33
	1.25	0.54	25	7.80	34
	1.5	0.81	30	7.60	36
	2.0	1.20	35	7.10	37
1 – 4	1	0.17	7.5	3.15	16
	1.5	0.31	15	2.95	19
	2	0.42	21	2.65	21
	2.5	0.54	25	2.35	25
	3	0.81	20	2.21	28
	4	1.20	35	2.0	30
2 – 8	2	0.22	7.5	1.4	13
	3	0.39	15	1.1	15
	4	0.60	21	0.95	21
	5	0.85	25	0.85	25
	6	1.17	30	0.80	30
	8	1.94	35	0.73	35
4 – 16	4	0.26	8.5	0.41	8.5
	6	0.49	13	0.34	13
	8	0.80	15	0.3	15
	10	1.15	16.5	0.29	16.5
	12	1.57	17.5	0.28	17.5
	16	2.56	19	0.25	19.0
10 – 40	10	1.0	3	0.25	3
	15	2.1	4	0.23	4
	20	3.6	5	0.21	5
	25	5.9	6	0.21	6
	30	8.1	6	0.20	6
	40	14.4	6	0.20	6

TABLE III
CURRENT RATINGS
Rating of the Overcurrent Units

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.25 – 1	6	185
.5 – 2	8	350
1 – 4	10	400
2 – 8	12	400
4 – 16	15	400
10 – 40	20	460

TABLE IV

Battery Drain at 125 Volts D.C.

SI-1 Relay	65 Milliamperes
SI-1 Relay with Indicator	100 Milliamperes
SI-Relay Single Output	65 Milliamperes
SI Relay Dual Output	105 Milliamperes

SETTING

The pickup of the relay is selected by adjusting the rheostat, S, in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

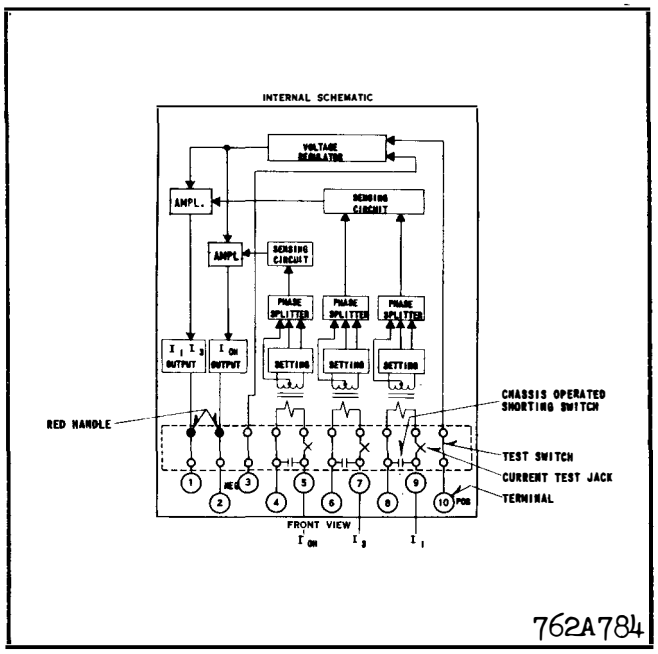


Fig. 4 Block diagram of the Type SI Relay in FT-21 case (for SI with single output omit the circuits connected to terminal 2; dwg. no. 763A629.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. All checks can best be performed by connecting the relay per the test circuit of Fig. 11. Refer to fig. 4 and make similar connections for the test of the SI relay.

1. Minimum trip current — Check pickup at the minimum and maximum setting. This is accomplished by applying the specified current and checking that the voltmeter reads approximately 20 volts when the current is within 3% of the setting.

2. Dropout — After checking pickup, the dropout should be checked to be approximately 97% of the pickup when the a.c. current is gradually reduced.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

Calibration

Use the following procedure for calibrating the SI-1 relay if the relay adjustments have been distributed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs on the type SI relay.

Splitter Adjustments

1. Turn rheostat (S) on front of relay to extreme counter-clockwise position.

2. Apply minimum S current to the proper relay terminals.

3. With a high resistance voltmeter (a.c.) adjust phase splitter potentiometer such that three voltages approximately equal to each other are obtained across TP 1, printed circuit board terminal 12 and printed circuit board terminal 18 or 14.

Dial Calibration (S)

1. Apply 125 volts d.c. to relay terminals 10 and 2. Terminal 10 is positive.

2. Connect a high resistance d.c. voltmeter across terminals 1 and 2. Terminal 1 is positive.

3. Apply desired S current to terminal 8 and 9.

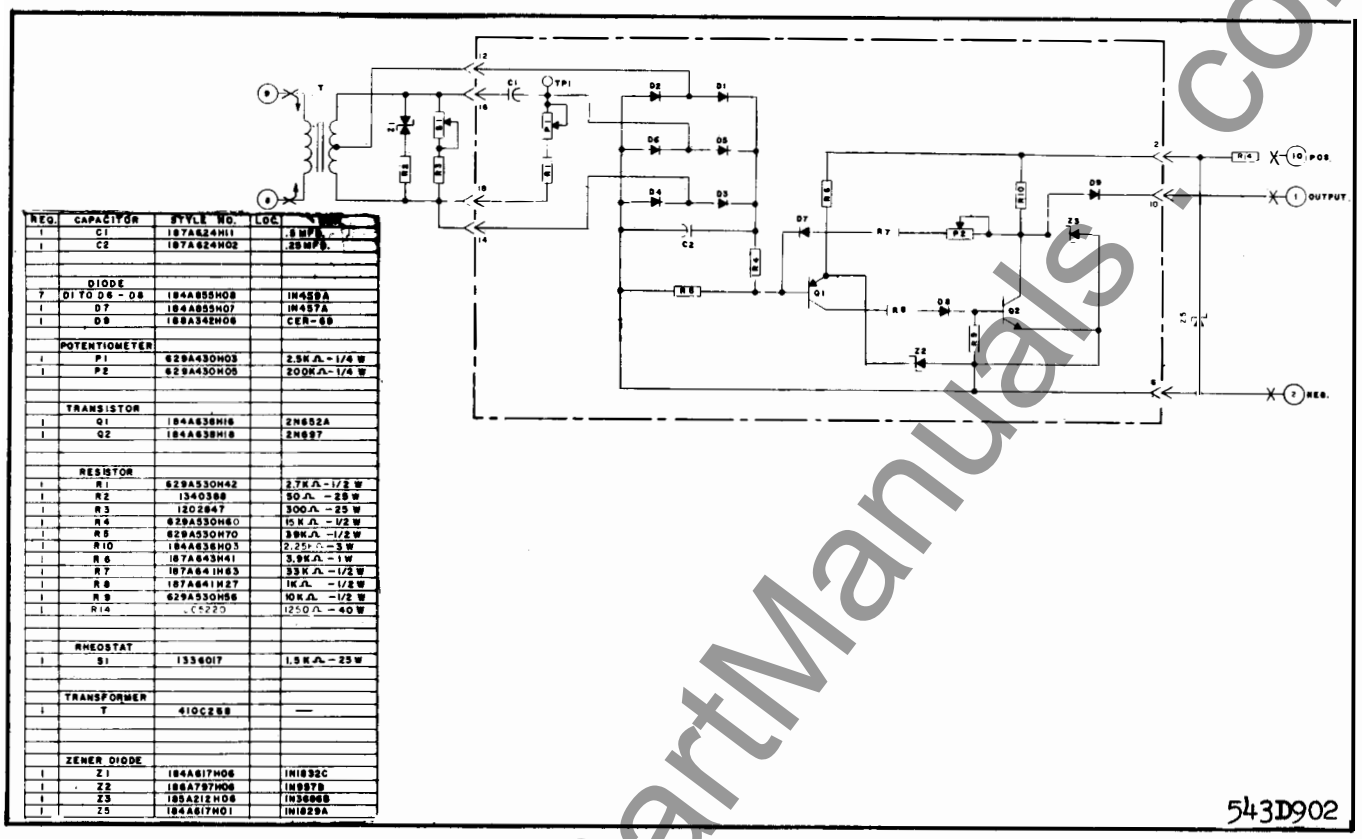
4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on meter.

Dropout (P)

1. Set S on desired point and apply S amperes to relay to make it operate.

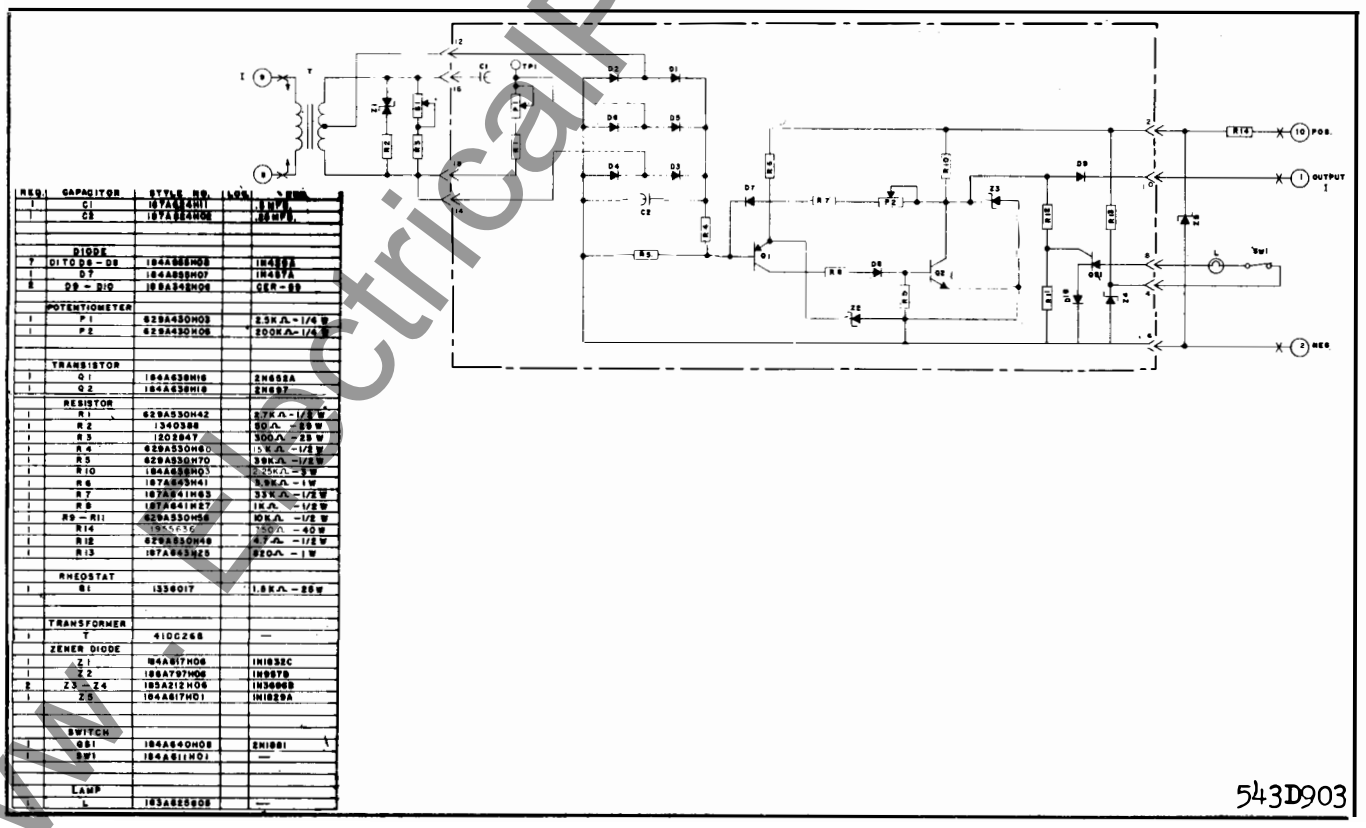
2. Lower S amperes to desired droput value and adjust P potentiometer until voltmeter drops to approximately zero.

3. Verify dropout and pickup several times by raising a.c. current until relay operates and then lowering the a.c. current until relay dropouts.



REQ.	CAPACITOR	STYLE NO.	LOC.
1	C1	187A624H11	.5 MF.
1	C2	187A624H02	.25MFD.
	DIODE		
7	D1 TO D6 - D8	184A855H08	IN459A
1	D7	184A855H07	IN457A
1	D9	188A342H06	CER-88
	POTENTIOMETER		
1	P1	629A430H03	2.5K Ω - 1/4 W
1	P2	629A430H05	200K Ω - 1/4 W
	TRANSISTOR		
1	Q1	184A638H16	2N652A
1	Q2	184A638H18	2N697
	RESISTOR		
1	R1	629A530H42	2.7K Ω - 1/2 W
1	R2	1340388	50 Ω - 25 W
1	R3	1202847	300 Ω - 25 W
1	R4	629A530H60	15 K Ω - 1/2 W
1	R5	629A530H70	39K Ω - 1/2 W
1	R10	184A638H03	2.25K Ω - 3 W
1	R6	187A643H41	3.9K Ω - 1 W
1	R7	187A641H63	33 K Ω - 1/2 W
1	R8	187A641H27	1K Ω - 1/2 W
1	R9	629A530H56	10K Ω - 1/2 W
1	R14	1955F36	1250 Ω - 40 W
	RHEOSTAT		
1	S1	1336017	1.5 K Ω - 25 W
	TRANSFORMER		
1	T	410C268	—
	ZENER DIODE		
1	Z1	184A617H06	IN1832C
1	Z2	188A797H06	IN957B
1	Z3	185A212H06	IN3006B
1	Z5	184A617H01	IN1829A

* *Fig. 5 Internal Schematic for the type SI-1 Relay.*



REQ.	CAPACITOR	STYLE NO.	LOC.
1	C1	187A624H11	.5 MF.
1	C2	187A624H02	.25MFD.
	DIODE		
7	D1 TO D6 - D8	184A855H08	IN459A
1	D7	184A855H07	IN457A
2	D9 - D10	188A342H06	CER-88
	POTENTIOMETER		
1	P1	629A430H03	2.5K Ω - 1/4 W
1	P2	629A430H05	200K Ω - 1/4 W
	TRANSISTOR		
1	Q1	184A638H16	2N652A
1	Q2	184A638H18	2N697
	RESISTOR		
1	R1	629A530H42	2.7K Ω - 1/2 W
1	R2	1340388	50 Ω - 25 W
1	R3	1202847	300 Ω - 25 W
1	R4	629A530H60	15 K Ω - 1/2 W
1	R5	629A530H70	39K Ω - 1/2 W
1	R10	184A638H03	2.25K Ω - 3 W
1	R6	187A643H41	3.9K Ω - 1 W
1	R7	187A641H63	33 K Ω - 1/2 W
1	R8	187A641H27	1K Ω - 1/2 W
1	R9 - R11	629A530H56	10K Ω - 1/2 W
1	R14	1955F36	1250 Ω - 40 W
1	R12	629A530H48	4.7 Ω - 1/2 W
1	R13	187A643H29	820 Ω - 1 W
	RHEOSTAT		
1	S1	1336017	1.5 K Ω - 25 W
	TRANSFORMER		
1	T	410C268	—
	ZENER DIODE		
1	Z1	184A617H06	IN1832C
1	Z2	188A797H06	IN957B
2	Z3 - Z4	185A212H06	IN3006B
1	Z5	184A617H01	IN1829A
	SWITCH		
1	QS1	184A640H08	2N1881
1	SW1	184A811H01	—
	LAMP		
1	L	183A825H08	—

Fig. 6 Internal Schematic for the type SI-1 Relay with an operation indicator.

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the SI-1 relay or the SI relay is not operating correctly.

1. Inspect all wires and connections, paying particular attention to printed circuit terminals.
2. Check resistances as listed on the internal schematic of the relays.
3. Check voltages as listed on the electrical checkpoints.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ELECTRICAL CHECKPOINTS

Connect relay per test circuit of Fig. 11. All voltage readings should be made with a high resistance voltmeter. Refer to Fig. 12, 13 or 14 for printed circuit board points. For some readings it is necessary to scrape varnish from the components to make a connection at the point.

I No. A.C. Current Input 125 volts d.c.

Component	Negative terminal	Approximate d.c. voltage
Z_2	2	7
Z_3	2	less than .6 volts
Z_5	2	45 volts

II Minimum Trip A.C. current applied

Circuit	Terminals	Voltage
Phase	TP_1 to board 18	7.5 volts a.c.
Splitter	TP_1 to board 12	7.5 volts a.c.
	Board 12 to board 18	7.5 volts a.c.
Setting	Board 16 to board 18	15 volts a.c.
Output	Terminal 1(+) and 2	18 to 22 volts D.C.

The above terminals are for the SI-1 relay. For corresponding terminals for the SI relay, refer to the relay.

ELECTRICAL PARTS LIST

TYPE SI

Circuit Symbol	Description
CAPACITORS	
CI-C2-C3	.5 MFD.
C4-C5 ††	.25 MFD.
DIODES	
D1 TO D18-D20-D22 ††	IN459A
D19-D21 ††	IN457A
POTENTIOMETERS	
P1-P2-P3	2.5K Ω — 1/4W
P4-P5 ††	200K Ω — 1/4W
TRANSISTORS	
Q1-Q3 ††	2N652A
Q2-Q4 ††	2N697
RESISTORS	
R1-R4-R7	2.7 K Ω — 1/2W
R2-R5-R8	50 Ω — 25 W
R3-R6-R9	300 Ω — 25 W
R10-R12 ††	15K Ω — 1/2 W
R11-R13 ††	39 K Ω — 1/2 W
R14-R19 ††	1K Ω — 3 W
R15-R21 ††	3.9 K Ω — 1 W
R16-R20 ††	33 K Ω — 1/2 W
R17-R22 ††	1 K Ω — 1/2 W
R18-R23 ††	10 K Ω — 1/2 W
R24	500 Ω — 40 W
RHEOSTAT	
S1-S2-S3	1.5K Ω — 25 W
TRANSFORMER	
T1-T2	S# 410C268
T3	S#410C268
ZENER DIODES	
Z1-Z2-Z3	INI832C
Z4-Z6 ††	IN957B
Z5-Z7 ††	IN368B
Z8	INI829A

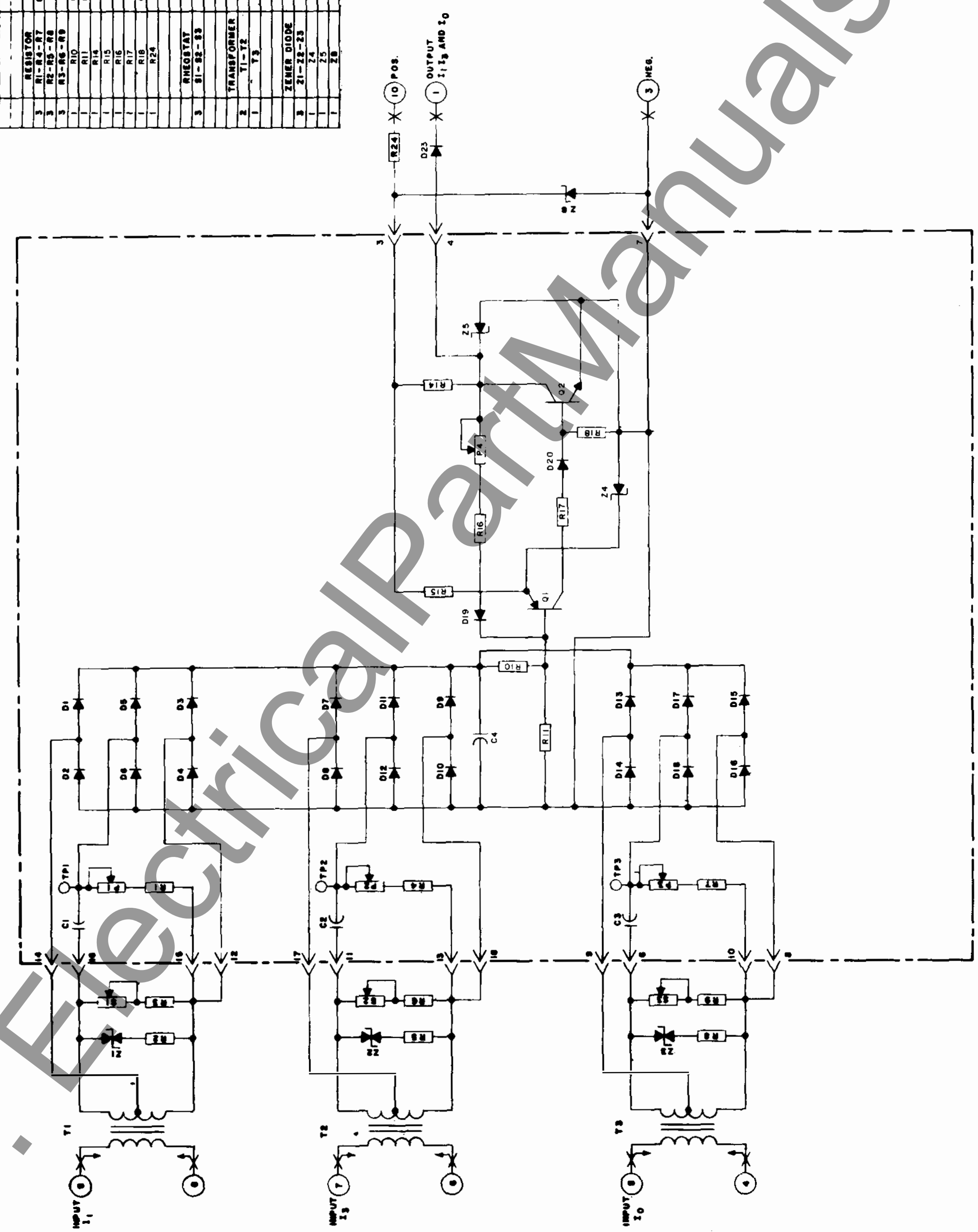
†† Used only in relay with double output.

TYPE SI-1

Circuit Symbol	Description
CAPACITORS	
C1	.5 MFD.
C2	.25 MFD.
DIODES	
D1 TO D6-D8	IN459A
D7	IN457A
D9-D10 †	CER-69
POTENTIOMETERS	
P 1	2.5K Ω — 1/4 W
P 2	200 K Ω — 1/4 W
TRANSISTORS	
Q 1	2N652A
Q 2	2N697
RESISTORS	
R 1	2.7 K Ω — 1/2 W
R 2	50 Ω — 25 W
R 3	300 Ω — 25 W
R 4	15 K Ω — 1/2 W
R 5	39 K Ω — 1/2 W
R 10	1K Ω — 3 W
R 6	3.9 K Ω — 1 W
T 7	33 K Ω — 1/2 W
R 8	1 K Ω — 1/2 W
R 9 — R 11 †	10 K Ω — 1/2 W
R 14	500 Ω — 40 W
R 12 †	4.7 Ω — 1/2 W
R 13 †	820 Ω — 1 W
RHEOSTAT	
S 1	1.5 K Ω — 25 W
TRANSFORMER	
T	S # 410C268
ZENER DIODES	
Z 1	INI832C
Z 2	IN957B
Z 3 — Z 4 †	IN3686B
Z 5	INI829A
SWITCHES	
QS 1 †	2N1881
SW 1 †	S# 184A611H01
LAMP	
L †	S# 183A825G05

† Used only in relay with operation indicator

REQ.	CAPACITOR	STYLE NO.	LOC.	REF.
3	C1-C2-C3	187A624H11		.5 MFD.
1	C4	187A624H02		.25 MFD.
	DIODE			
19	D1 TO D18-D20	184A855H08		1N459A
1	D19	184A855H07		1N457A
1	D23	188A342H06		CER-69
	POTENTIOMETER			
3	P1-P2-P3	629A430H03		2.5K Ω - 1/4 W
1	P4	629A430H06		200K Ω - 1/4 W
	TRANSISTOR			
1	Q1	184A638H16		2N652A
1	Q2	184A638H18		2N697
	RESISTOR			
3	R1-R4-R7	629A530H42		2.7K Ω - 1/2 W
3	R2-R5-R8	1340388		80 Ω - 25 W
3	R3-R6-R9	1202847		300 Ω - 25 W
1	R10	629A530H60		15K Ω - 1/2 W
1	R11	629A530H70		39K Ω - 1/2 W
1	R14	184A636H03		2.25K Ω - 3W
1	R15	187A643H41		3.9K Ω - 1 W
1	R16	187A641H63		33K Ω - 1/2 W
1	R17	187A641H27		1K Ω - 1/2 W
1	R18	629A530H86		10K Ω - 1/2 W
1	R24	1205220		1250 Ω - 40 W
	RHEOSTAT			
3	S1-S2-S3	1336017		1.5K Ω - 25 W
	TRANSFORMER			
2	T1-T2	410C268		
1	T3	410C268		
	ZENER DIODE			
3	Z1-Z2-Z3	184A617H06		1N1832C
1	Z4	188A797H06		1N957B
1	Z5	185A212H06		1N3686B
1	Z6	184A617H01		1N1829A



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* *Fig. 7 Internal Schematic for the type SI Relay with a single output.*

REQ.		CAPACITOR	STYLE NO.	LOC.	REF.
	3	C1-C2-C3	187A624H11		5 MFD.
	2	C4-C5	187A624H02		25 MFD.
		DIODE			
	20	D1TOD18-D20-D22	184A855H08		IN459A
	2	D19-D21	184A855H07		IN457A
		POTENTIOMETER			
	3	P1-P2-P3	629A430H03		2.5K Ω - 1/4 W
	2	P4-P5	629A430H05		200K Ω - 1/4 W
		TRANSISTOR			
	2	Q1-Q3	184A638H16		2N652A
	2	Q2-Q4	184A638H18		2N697
		RESISTOR			
	3	R1-R4-R7	629A530H42		2.7K Ω - 1/2 W
	3	R2-R5-R8	1340588		50 Ω - 25 W
	3	R3-R6-R9	1202847		300Ω - 25 W
	2	R10-R12	629A530H40		15K Ω - 1/2 W
	2	R11-R13	629A530H60		33K Ω - 1/2 W
	2	R14-R19	184A836H03		2.25KΩ - 3W
	2	R15-R21	187A643H41		3.9K Ω - 1 W
	2	R16-R20	187A641H83		33K Ω - 1/2 W
	2	R17-R22	187A641H27		1K Ω - 1/2 W
	2	R18-R23	629A530H56		10K Ω - 1/2 W
	1	R24	1958638		750 Ω - 40 W
		RHEOSTAT			
	3	S1-S2-S3	1338017		L5K Ω - 25 W
		TRANSFORMER			
	2	T1-T2	410C288		
	1	T3	410C288		
		ZENER DIODE			
	3	Z1-Z2-Z3	184A617H08		1N1852C
	2	Z4-Z6	184A727H08		1N1499B
	2	Z5-Z7	184A727H05		1N1358B
	1	Z8	184A617H01		1N1829A

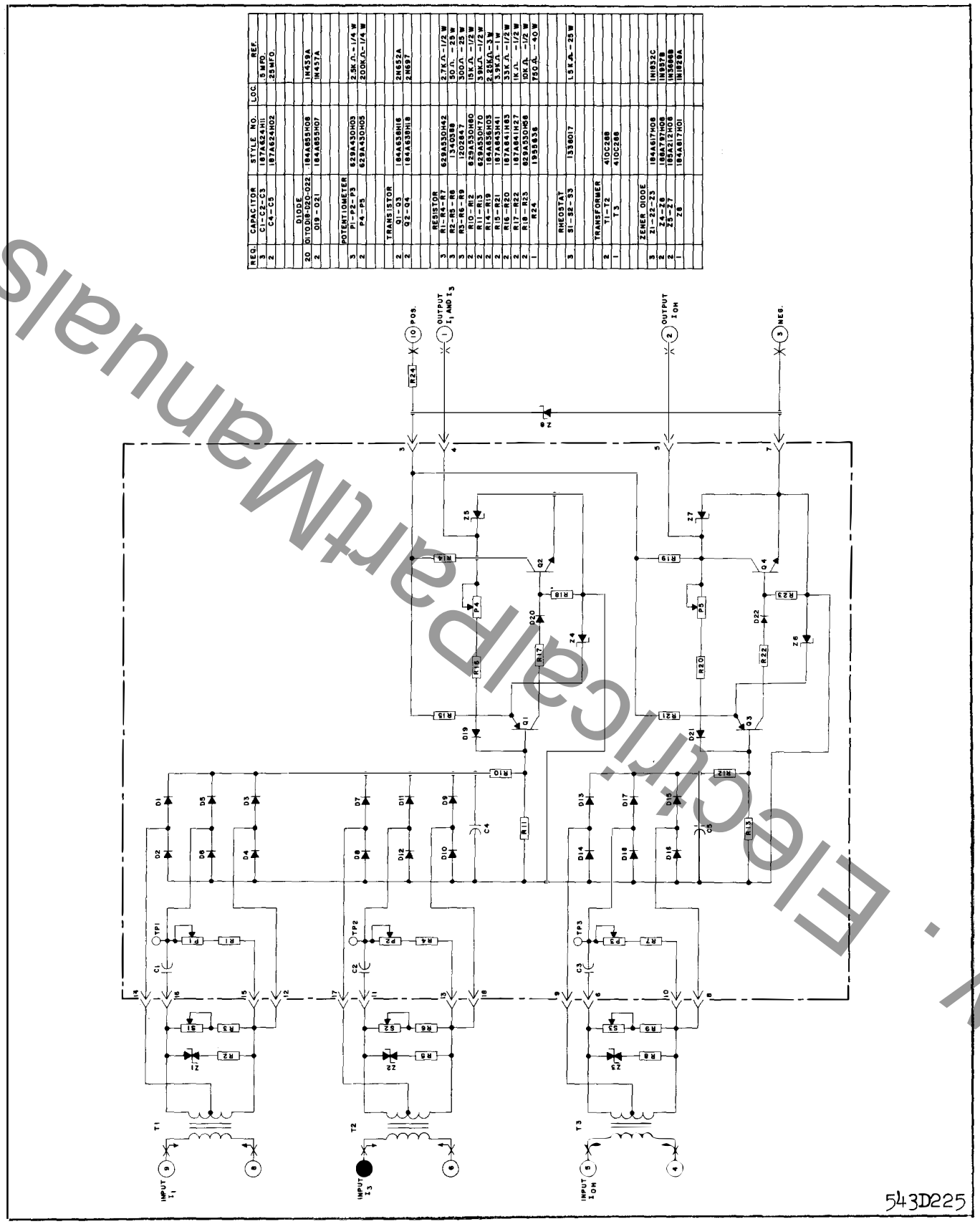


Fig. 8 Internal Schematic of the type SI Relay with a double output.

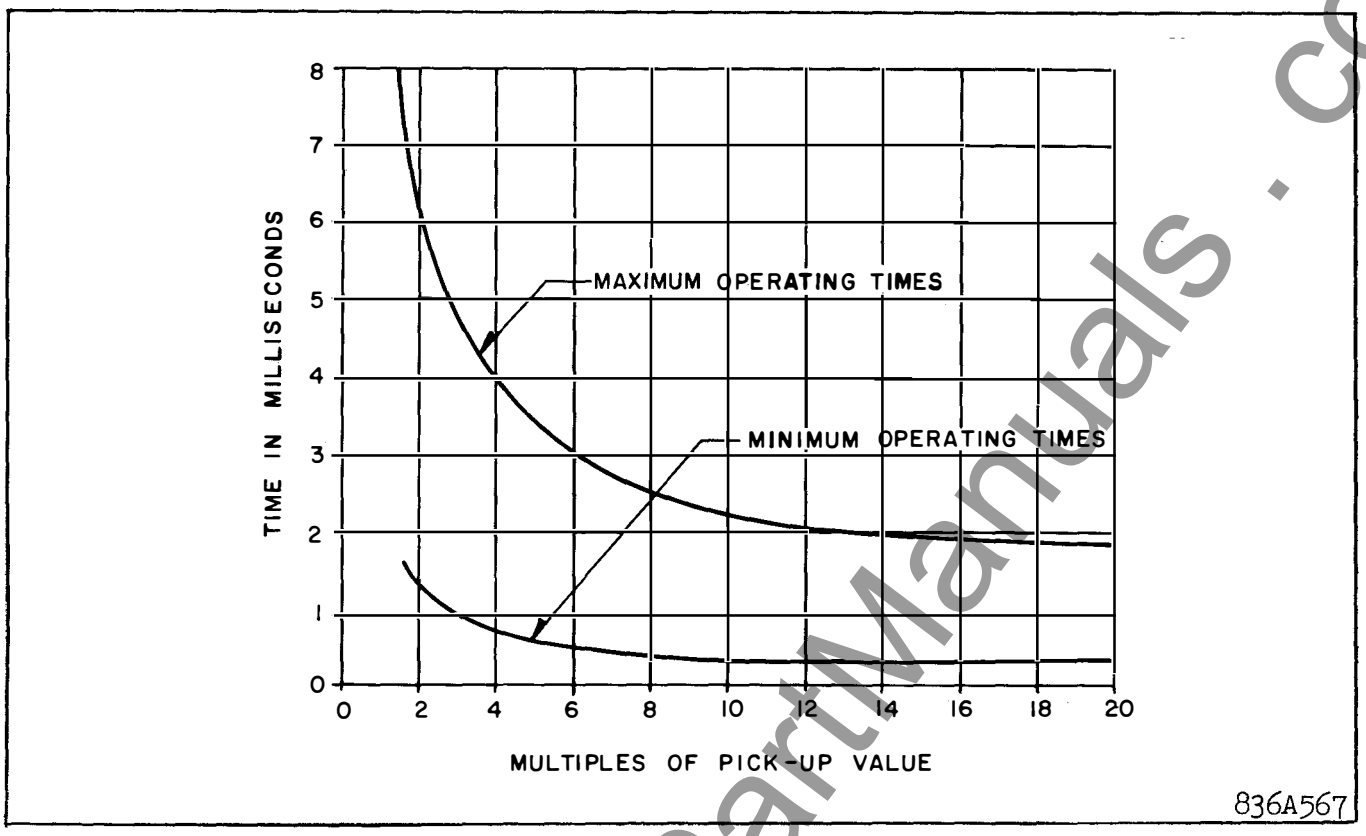


Fig. 9 Operating time for the type SI and SI-1 Relays.

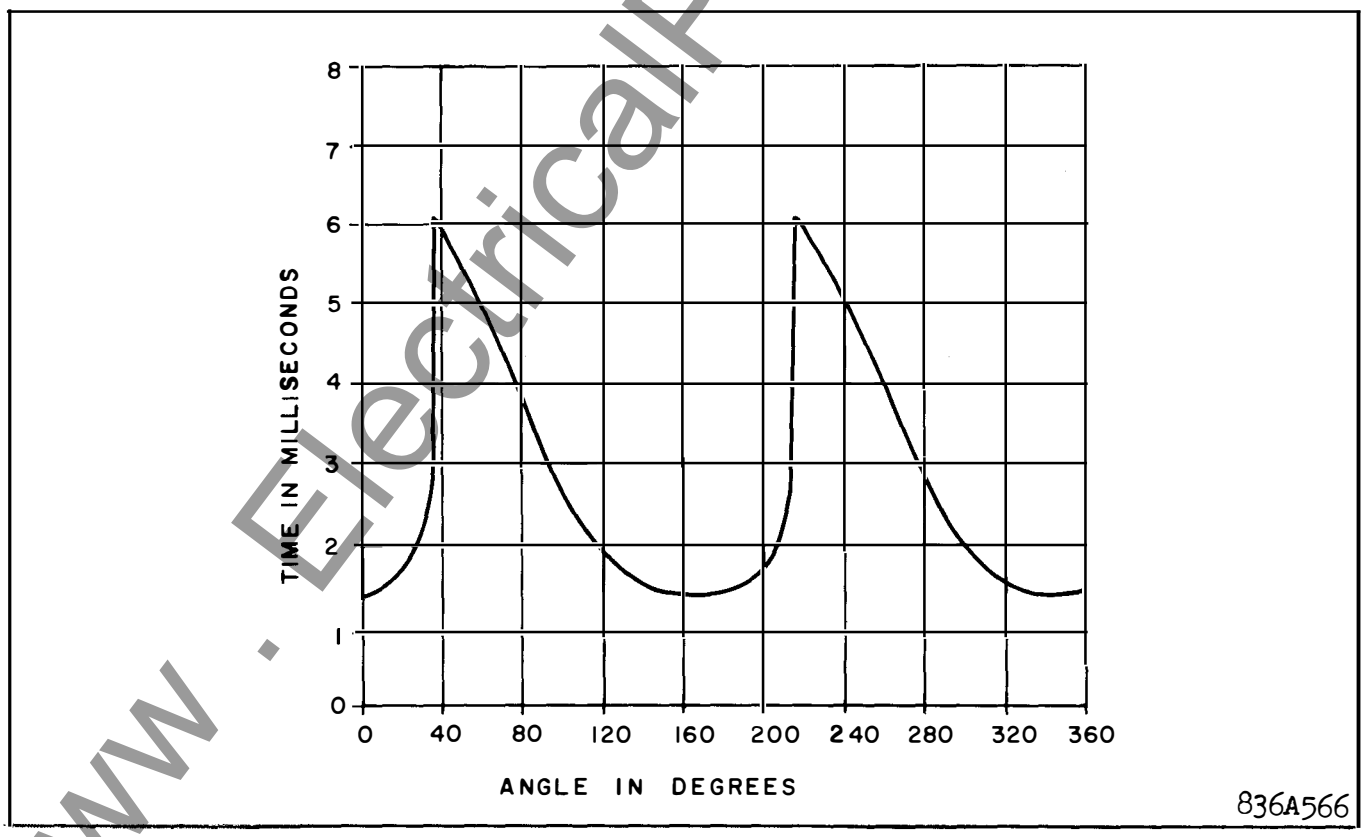


Fig. 10 Operating time for the type SI and SI-1 Relays as a function of fault incidence angle at twice minimum trip.

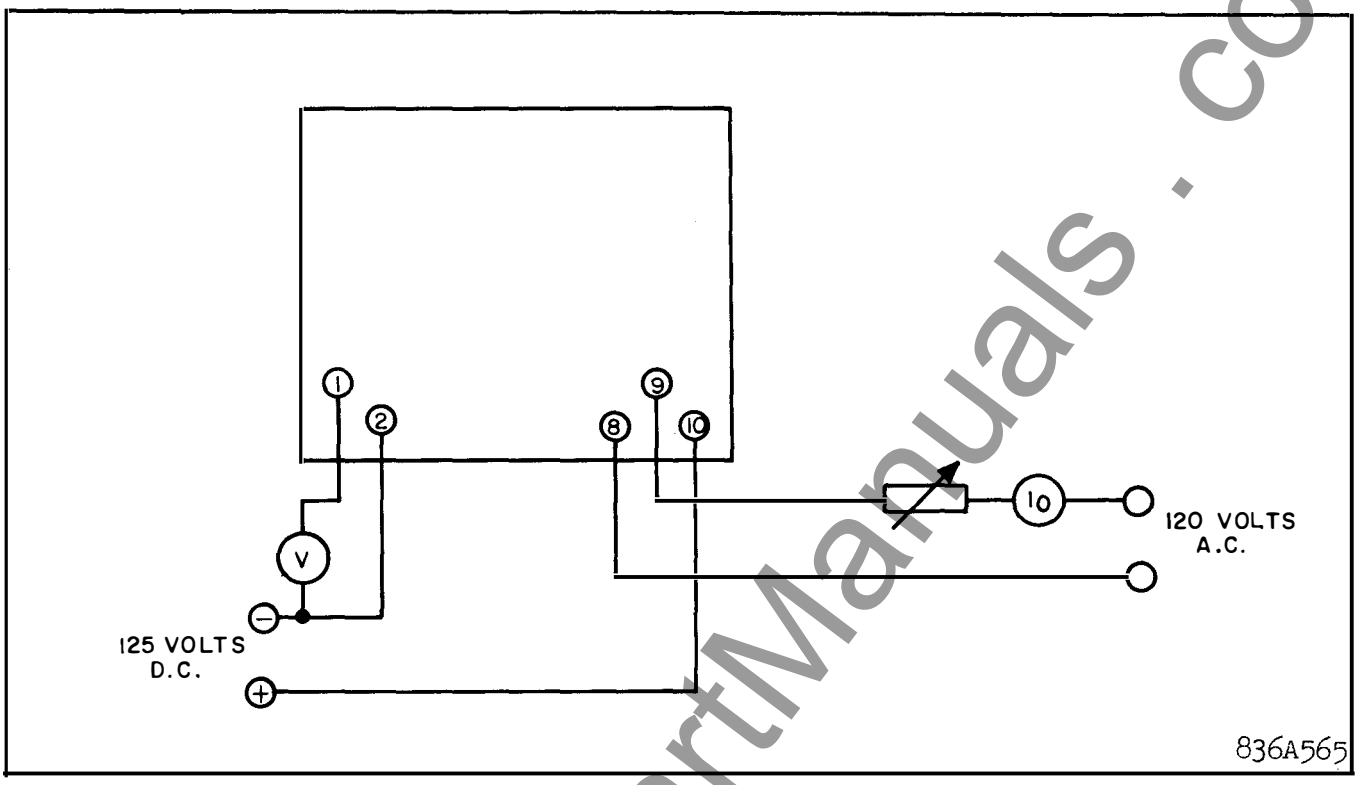


Fig. 11 Test circuit for the type SI-1 Relay.

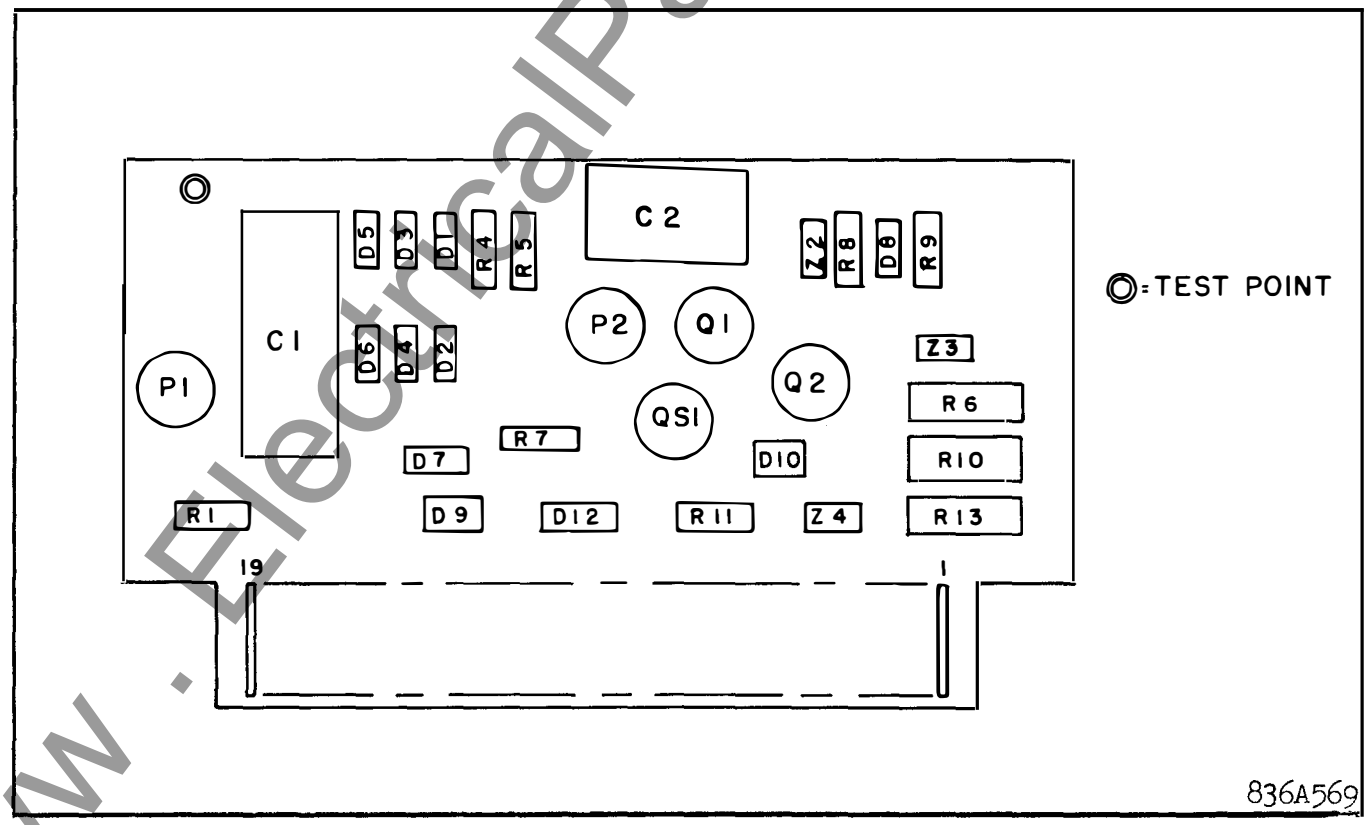


Fig. 12 Component location on printed circuit board for the type SI-1 Relay.

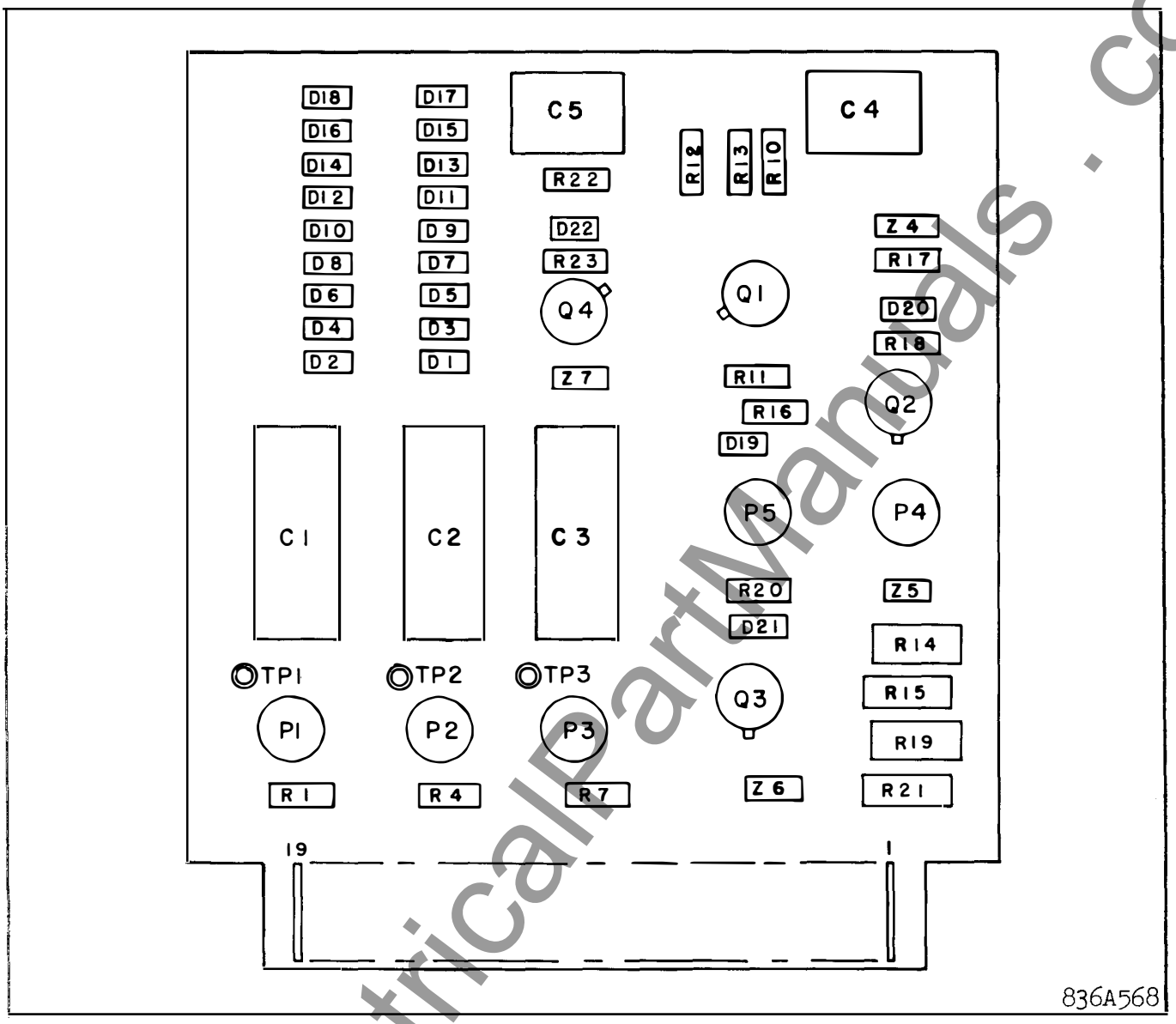


Fig. 13 Component location on printed circuit board for the type SI Relay.

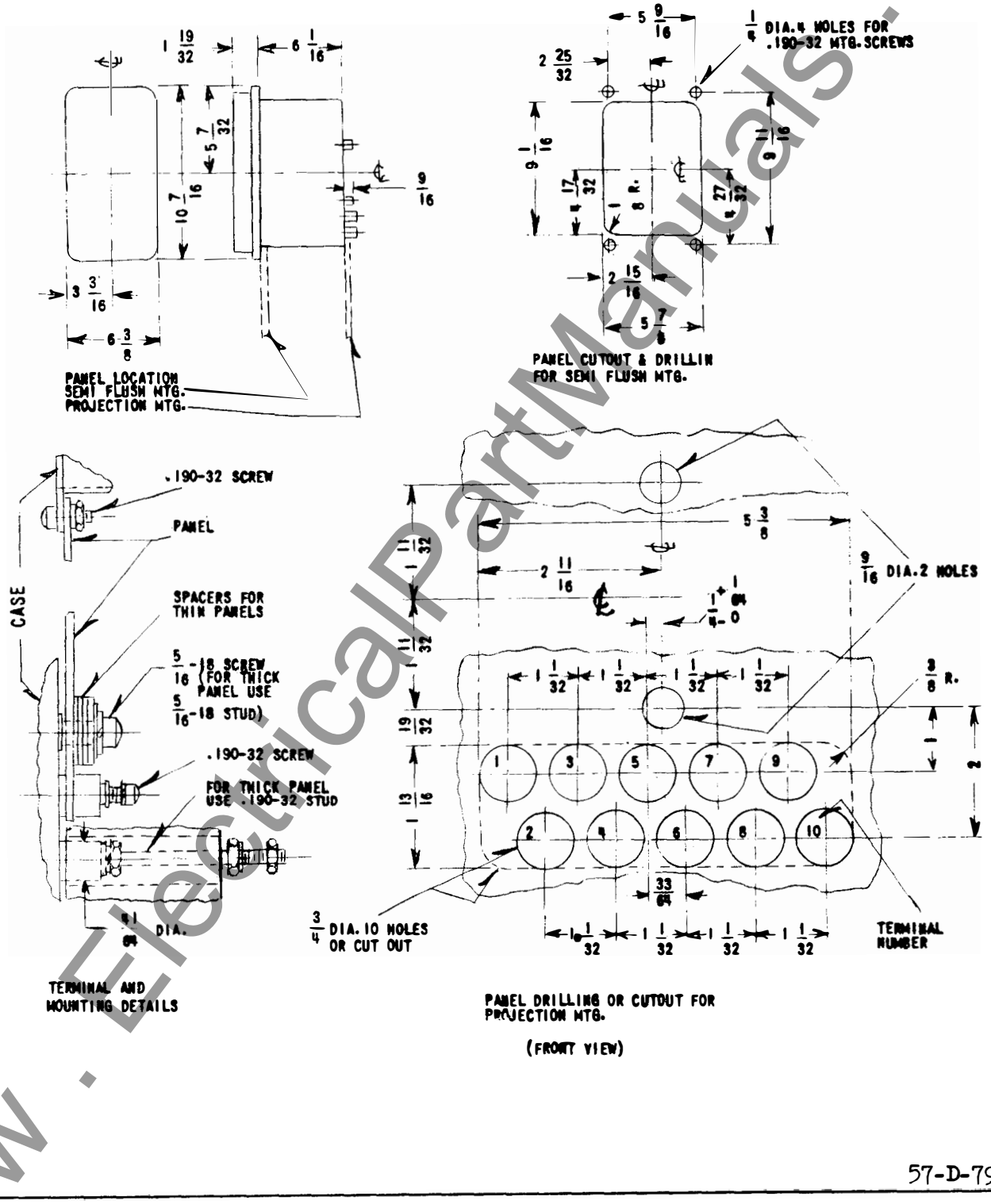


Fig. 14 Outline and drilling plan for the type SI Relay in the FT-21 case.

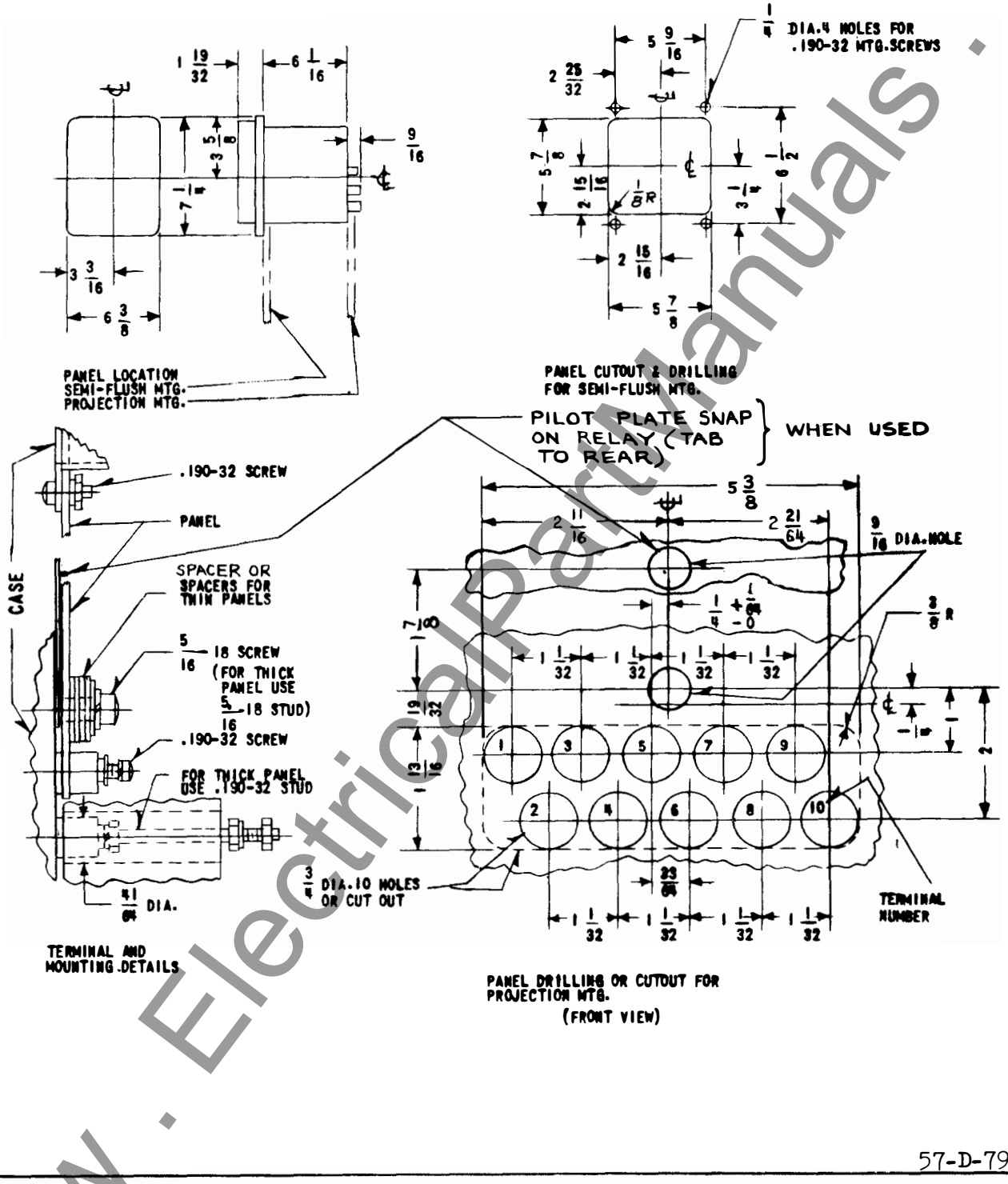


Fig. 15 Outline and drilling plan for the type SI-1 Relay in the FT-11 case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES SI AND SI-1 OVERCURRENT RELAYS

CAUTION: Before putting relay into service, operate the relay to check the electrical connections. Close output switches last when placing relay in service. Open output switches first when removing relay from service.

APPLICATION

These overcurrent relays are static devices that produce a d.c. output voltage when the input current in them exceeds a given value. This output voltage is used as the input to other devices that trip a breaker.

The number of inputs and outputs varies with the type of relay. Generally, these are as follows:

Type SI relay-three inputs, one or two outputs.

Type SI-1 relay-one input, one output.

CONSTRUCTION

The type SI-1 relay consists of an input transformer, a setting circuit, a phase splitter circuit, a sensing circuit, an amplifier circuit, a voltage regulator circuit, a feedback circuit and a transistor output. An operational indicator is an optional unit. The type SI relay in addition to these components has two input transformers, two phase splitter circuits, and either a single output or a dual output transistor circuit.

The components are connected as shown in Figs. 1 to 4.

Input Transformer – The input transformer is a two winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the setting circuit and from a fixed tap to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat connected in parallel with a resistor and Zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, resistor, potentiometer and a three-phase rectifier bridge. This circuit converts the single phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

Sensing Circuit – The sensing circuit consists of three resistors, a transistor and a Zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, a reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be greater than the reference voltage.

Amplifier Circuit – The amplifier circuit consists of a normally conducting transistor, Zener diode, three resistors and a diode. This circuit is the final output stage of the relay.

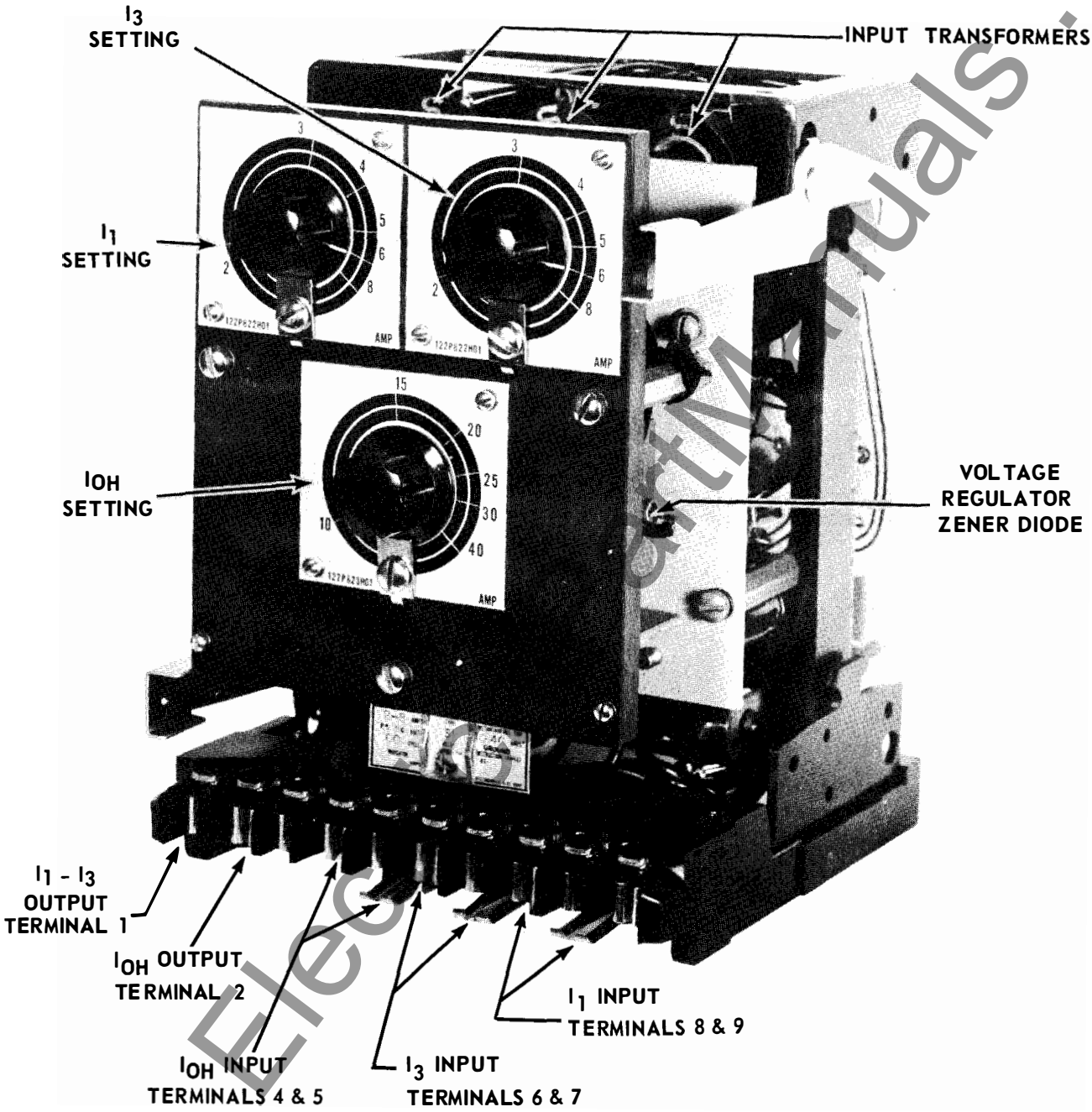
Feedback Circuit – The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit – The voltage regulator circuit consists of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt Zener diode mounted on an aluminum heat sink. The series resistor is a 3-½ inch resistor and is used to reduce the supply voltage to the Zener voltage.

Operational Indicator – The operational indicator consists of a silicon control rectifier, lamp, microswitch, Zener diode, and three resistors. This circuit is triggered by a signal from the output of the relay.

SUPERSEDES I.L. 41-777A
*Denotes change from superseded issue.

EFFECTIVE JANUARY 1967



* *Fig. 1 Type SI Relay in an FT-21 case (front view).*

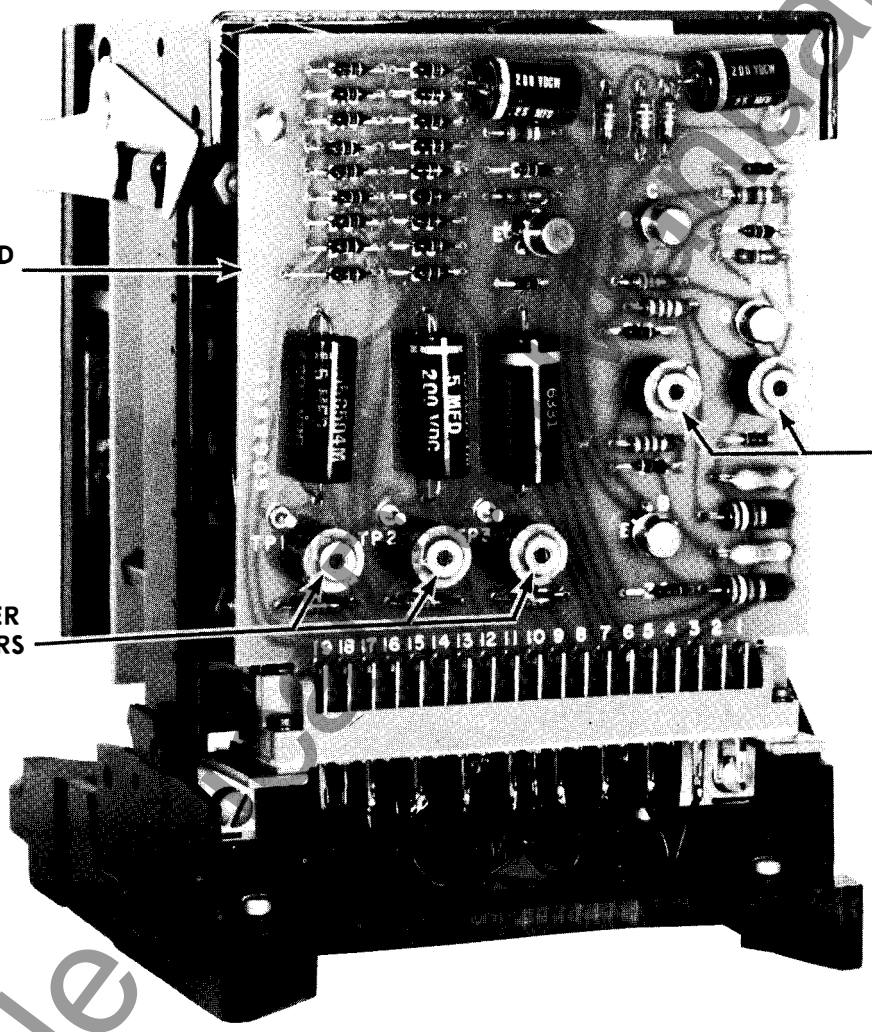


Fig. 2 Type SI Relay in an FT-21 case (rear view).

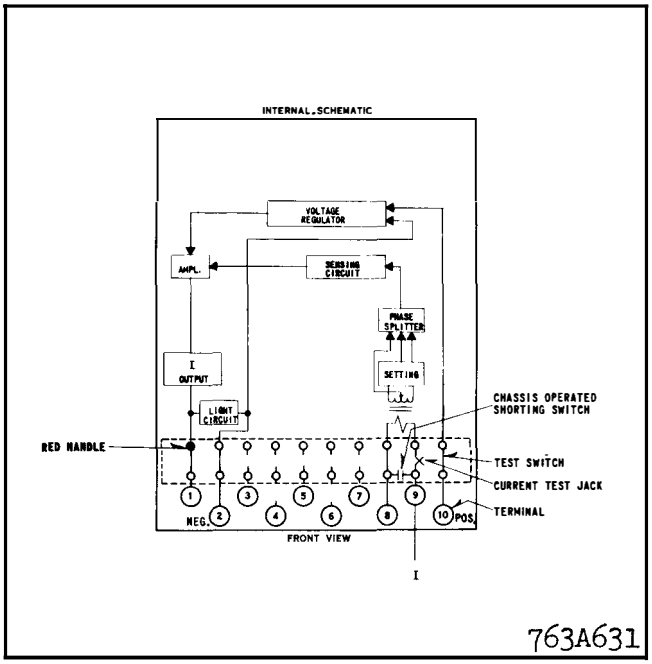


Fig. 3 Block diagram of the Type SI-1 Relay in FT-11 case (diagram of SI-1 without the operation indicator is 763A630).

OPERATION

The components of the SI-1 relay are connected as shown in Fig. 5. With no input to the relay, all transistors (Q_1 and Q_2) are conducting and a very small output is obtained from the relay. Zener diode (Z_2) of the sensing circuit establishes the reference voltage from the emitter of Q_1 to negative and allows a base current to flow in Q_1 through R_5 to negative.

When a.c. current is applied to the primary of the transformer (T), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (S1). This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor R_5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, Q_1 turns off to allow Q_2 to turn off which produces an output.

When Q_2 turns off, positive voltage is applied to the feedback circuit such that a voltage is applied to the base of Q_1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of pickup.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the voltage applied to the electronic components from becoming excessive.

The operation of the type SI relay is similar to the SI-1, except that the SI has three overcurrent inputs. These three inputs are applied through seperate phase splitting and setting circuits to a common sensing circuit which operates on the maximum voltage applied to it.

Figs. 6, 7, and 8 show the connections of the * SI-1, SI with single output and the SI with a dual output.

CHARACTERISTICS

The SI-1 relay is available in the current ranges shown in Table I.

TABLE I

Range	Scale Marking					
.25 – 1 ampere	.25	.4	.5	.6	.8	1.0
.5 – 2 amperes	.5	.75	1.0	1.25	1.5	2.0
1 – 4 amperes	1.0	1.5	2.0	2.5	3.0	4.0
2 – 8 amperes	2	3	4	5	6	8
4 – 16 amperes	4	6	8	10	12	16
10 – 40 amperes	10	15	20	25	30	40

The setting of the relay is the minimum current required to produce an output. Settings between the scale markings can be obtained by applying the desired current to the relay and setting the rheostat at the desired point.

The SI relay is available with any combination of three of the above ranges. In the usual application, two inputs are the same range with an output. The third input is of a different range and can be of a different output than the other two.

The operating time of the relay is shown in Fig. 9. As shown in the figure, there is a maximum and minimum operating time of the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Figure 10 shows the operate times for different points on the fault wave for fault currents at twice pickup.

TABLE II
ENERGY REQUIREMENTS

Ampere Range	Setting	VA at Setting	P.F. Angle	VA at 5 amps.	P.F. Angle
.25 – 1	.25	0.17	7.5	23	51°
	.4	0.31	15	22.8	50
	.5	0.42	21	22.7	48
	.6	0.54	25	22.6	48
	.8	0.81	30	22.2	48
	1.0	1.20	35	21.8	48
.5 – 2	.5	0.17	7.5	8.80	32
	.75	0.31	15	8.50	32
	1.0	0.42	21	8.10	33
	1.25	0.54	25	7.80	34
	1.5	0.81	30	7.60	36
	2.0	1.20	35	7.10	37
1 – 4	1	0.17	7.5	3.15	16
	1.5	0.31	15	2.95	19
	2	0.42	21	2.65	21
	2.5	0.54	25	2.35	25
	3	0.81	20	2.21	28
	4	1.20	35	2.0	30
2 – 8	2	0.22	7.5	1.4	13
	3	0.39	15	1.1	15
	4	0.60	21	0.95	21
	5	0.85	25	0.85	25
	6	1.17	30	0.80	30
	8	1.94	35	0.73	35
4 – 16	4	0.26	8.5	0.41	8.5
	6	0.49	13	0.34	13
	8	0.80	15	0.3	15
	10	1.15	16.5	0.29	16.5
	12	1.57	17.5	0.28	17.5
	16	2.56	19	0.25	19.0
10 – 40	10	1.0	3	0.25	3
	15	2.1	4	0.23	4
	20	3.6	5	0.21	5
	25	5.9	6	0.21	6
	30	8.1	6	0.20	6
	40	14.4	6	0.20	6

TABLE III
CURRENT RATINGS
Rating of the Overcurrent Units

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.25 – 1	6	185
.5 – 2	8	350
1 – 4	10	400
2 – 8	12	400
4 – 16	15	400
10 – 40	20	460

TABLE IV
Battery Drain

*	48 Volts D.C.	125 Volts D.C.
SI-1 Relay	32MA	65 MA
SI-1 Relay with Indicator	65MA	100 MA
SI-Relay Single Output	32MA	65 MA
SI Relay Dual Output	65MA	105 MA
Maximum Output	20 MA at 20 Volts D.C.	

SETTING

The pickup of the relay is selected by adjusting the rheostat, S, in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

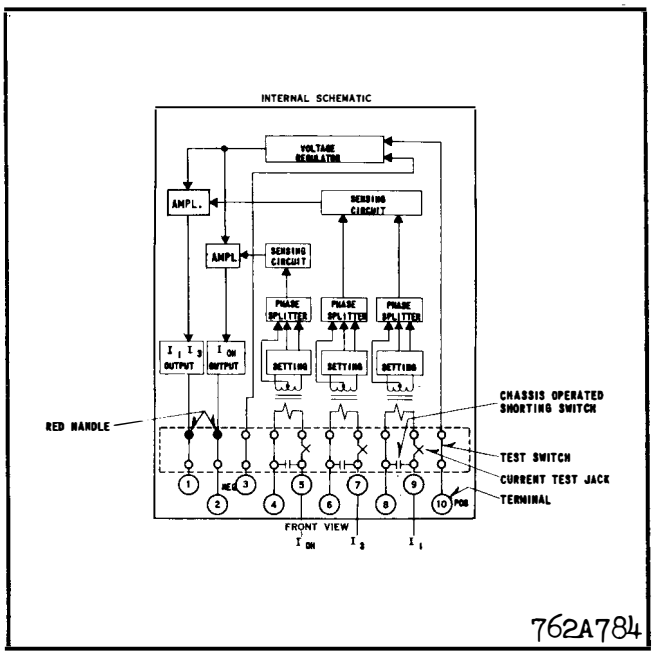


Fig. 4 Block diagram of the Type SI Relay in FT-21 case (for SI with single output omit the circuits connected to terminal 2; dwg. no. 763A629.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. All checks can best be performed by connecting the relay per the test circuit of Fig. 11. Refer to fig. 4 and make similar connections for the test of the SI relay.

1. Minimum trip current — Check pickup at the minimum and maximum setting. This is accomplished by applying the specified current and checking that the voltmeter reads approximately 20 volts when the current is within 3% of the setting.

2. Dropout — After checking pickup, the dropout should be checked to be approximately 97% of the pickup when the a.c. current is gradually reduced.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

Calibration

Use the following procedure for calibrating the SI-1 relay if the relay adjustments have been distributed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs on the type SI relay.

Splitter Adjustments

1. Turn rheostat (S) on front of relay to extreme counter-clockwise position.

2. Apply minimum S current to the proper relay terminals.

3. With a high resistance voltmeter (a.c.) adjust phase splitter potentiometer such that three voltages approximately equal to each other are obtained across TP 1, printed circuit board terminal 12 and printed circuit board terminal 18 or 14.

Dial Calibration (S)

1. Apply 125 volts d.c. to relay terminals 10 and 2. Terminal 10 is positive.

2. Connect a high resistance d.c. voltmeter across terminals 1 and 2. Terminal 1 is positive.

3. Apply desired S current to terminal 8 and 9.

4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on meter.

Dropout (P)

1. Set S on desired point and apply S amperes to relay to make it operate.

2. Lower S amperes to desired droput value and adjust P potentiometer until voltmeter drops to approximately zero.

3. Verify dropout and pickup several times by raising a.c. current until relay operates and then lowering the a.c. current until relay dropouts.

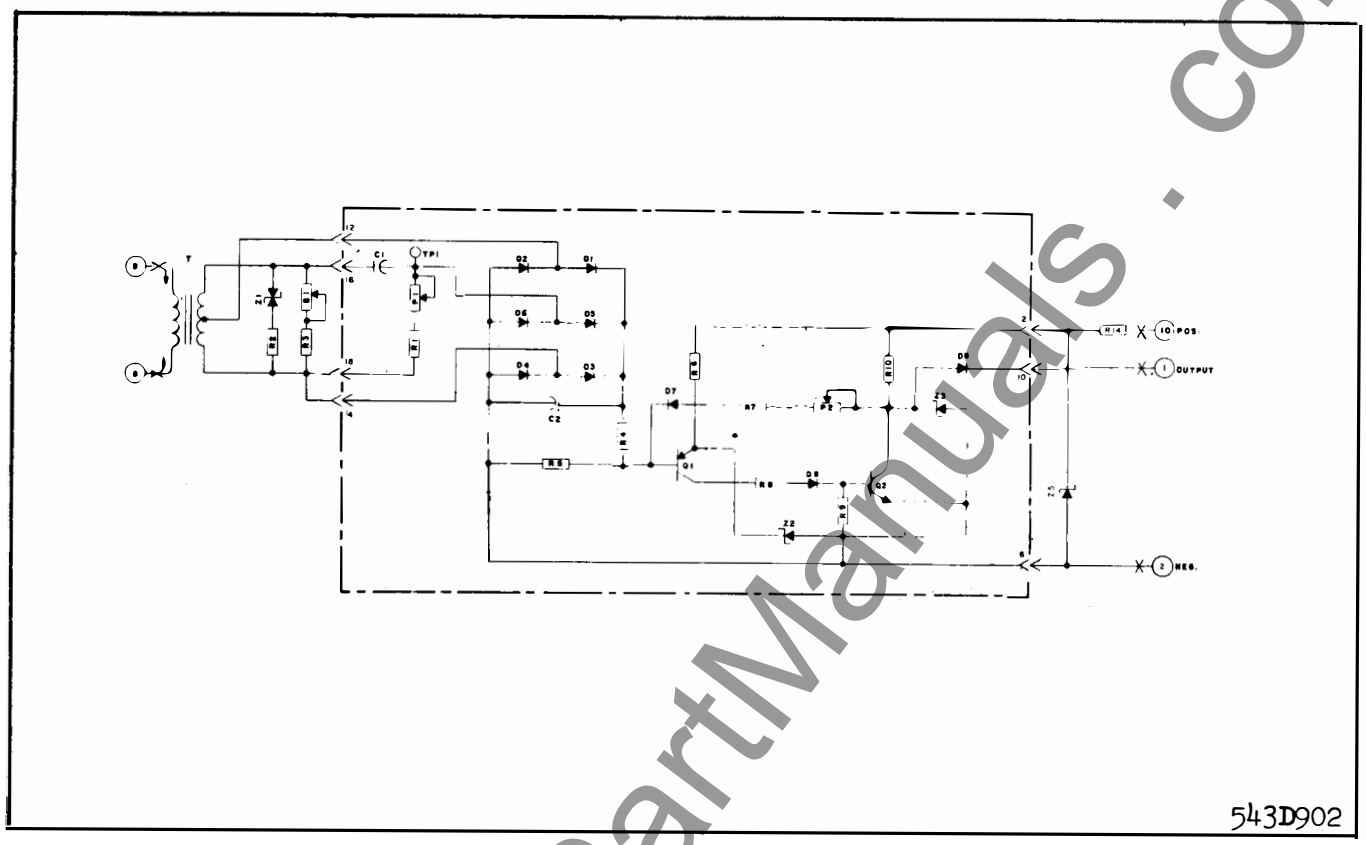
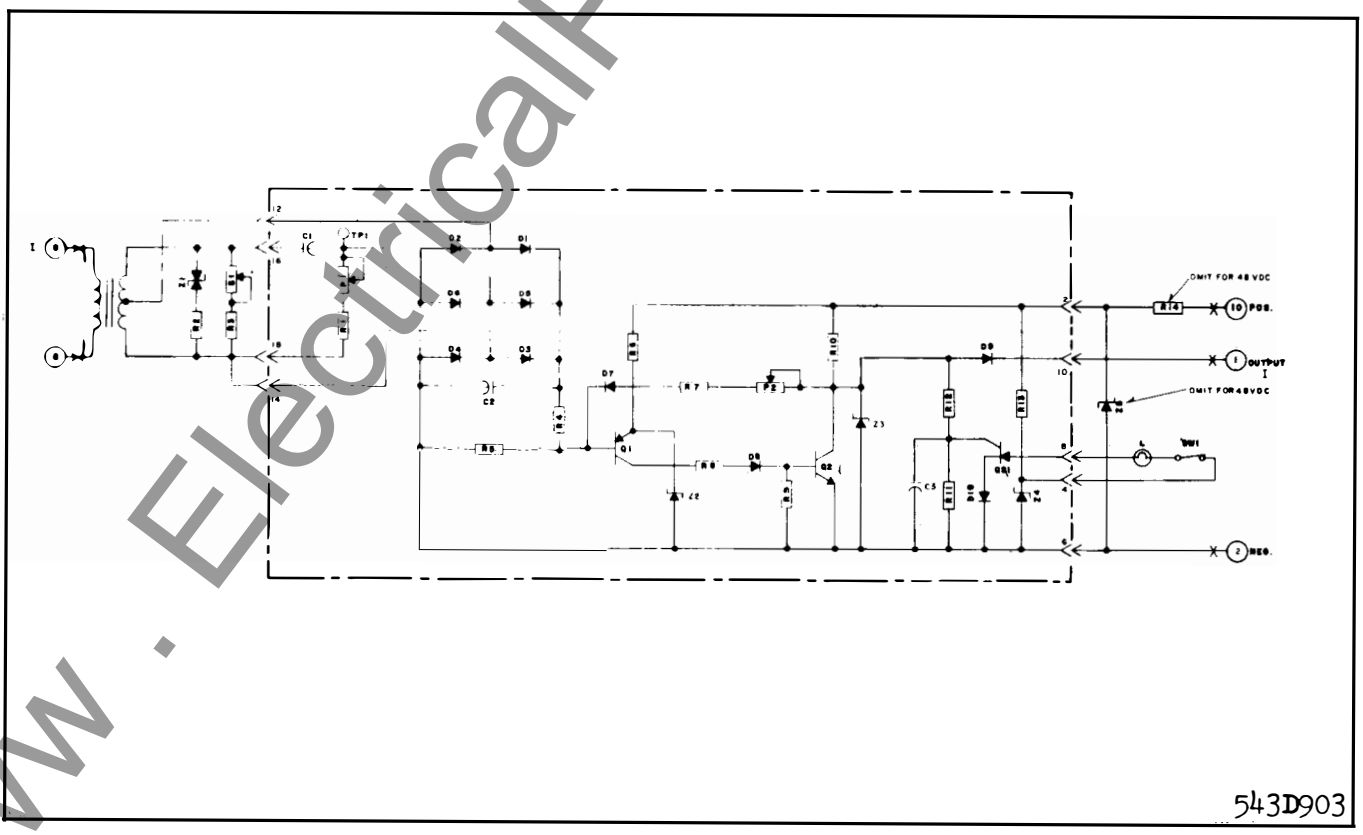


Fig. 5 Internal Schematic for the type SI-1 Relay.



* *Fig. 6 Internal Schematic for the type SI-1 Relay with an operation indicator.*

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the SI-1 relay or the SI relay is not operating correctly.

1. Inspect all wires and connections, paying particular attention to printed circuit terminals.
2. Check resistances as listed on the internal schematic of the relays.
3. Check voltages as listed on the electrical checkpoints.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ELECTRICAL CHECKPOINTS

Connect relay per test circuit of Fig. 11. All voltage readings should be made with a high resistance voltmeter. Refer to Fig. 12, 13 or 14 for printed circuit board points. For some readings it is necessary to scrape varnish from the components to make a connection at the point.

I No. A.C. Current Input 125 volts d.c.

Component	Negative terminal	Approximate d.c. voltage
Z_2	2	7
Z_3	2	less than .6 volts
Z_5	2	45 volts

II Minimum Trip A.C. current applied

Circuit	Terminals	Voltage
Phase	TP_1 to board 18	7.5 volts a.c.
Splitter	TP_1 to board 12	7.5 volts a.c.
	Board 12 to board 18	7.5 volts a.c.
Setting	Board 16 to board 18	15 volts a.c.
Output	Terminal 1(+) and 2	18 to 22 volts D.C.

The above terminals are for the SI-1 relay. For corresponding terminals for the SI relay, refer to the relay.

ELECTRICAL PARTS LIST

TYPE SI

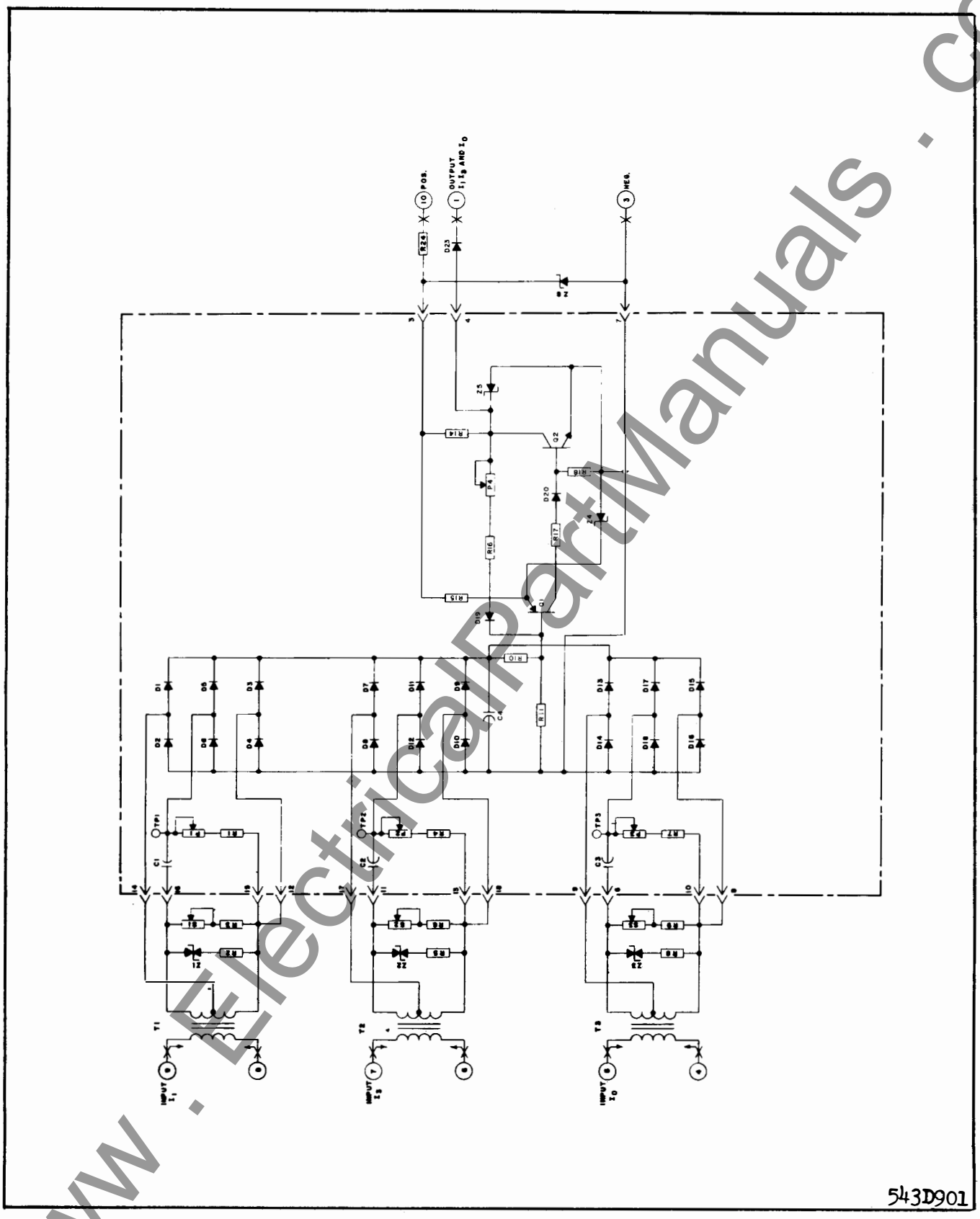
Circuit Symbol	Description
CAPACITORS	
CI-C2-C3	.5 MFD.
C4-C5 ††	.25 MFD.
DIODES	
D18-D20-D22 ††	IN459A
D19-D21 ††	IN457A
POTENTIOMETERS	
P1-P2-P3	2.5K Ω – 1/4W
P4-P5 ††	200K Ω – 1/4W
TRANSISTORS	
Q1-Q3 ††	2N652A
Q2-Q4 ††	2N697
RESISTORS	
R1-R4-R7	2.7 K Ω – 1/2W
R2-R5-R8	50 Ω – 25 W
R3-R6-R9	300 Ω – 25 W
R10-R12 ††	15K Ω – 1/2 W
R11-R13 ††	39 K Ω – 1/2 W
R14-R19 ††	* 2.25K Ω – 3 W
R15-R21 ††	3.9 K Ω – 1 W
R16-R20 ††	33 K Ω – 1/2 W
R17-R22 ††	1 K Ω – 1/2 W
R18-R23 ††	10 K Ω – 1/2 W
R24	500 Ω – 40 W
RHEOSTAT	
S1-S2-S3	1.5K Ω – 25 W
TRANSFORMER	
T1-T2	S# 410C268
T3	S#410C268
ZENER DIODES	
Z1-Z2-Z3	INI832C
Z4-Z6 ††	IN957B
Z5-Z7 ††	IN368B
Z8	INI829A

†† Used only in relay with double output.

TYPE SI-1

Circuit Symbol	Description
CAPACITORS	
C1	.5 MFD
C2	.25 MFD
*C3†	6.8 MFD
DIODES	
D1 TO D6-D8	IN459A
D7	IN457A
D9-D10 †	CER-69
POTENTIOMETERS	
P 1	2.5K Ω – 1/4 W
P 2	200 K Ω – 1/4 W
TRANSISTORS	
Q 1	2N652A
Q 2	2N697
RESISTORS	
R 1	2.7K Ω – 1/2 W
R 2	50 Ω – 25W
R 3	300 Ω – 25 W
R 4	15 K Ω – 1/2 W
R 5	39K Ω – 1/2 W
R 10	* 2.25K Ω – 3 W
R 6	3.9 K Ω – 1 W
T 7	33 K Ω – 1/2 W
R 8	1 K Ω – 1/2 W
R 9	10 K Ω – 1/2 W
R 14	500 Ω – 40 W
R 12 †	* 4.7K Ω – 1/2 W
R 13 †	820 Ω – 1 W
*R 11 †	3.9K Ω – 1/2 W
RHEOSTAT	
S 1	1.5 K Ω – 25 W
TRANSFORMER	
T	S # 410C268
ZENER DIODES	
Z 1	INI832C
* Z 2 – Z6 †	IN957B
Z 3 – Z4 †	IN3686B
Z 5	INI829A
SWITCHES	
QS 1 †	2N1881
SW 1 †	S # 184A611H01
LAMP	
L †	S # 183A825G05

† Used only in relay with operation indicator



* *Fig. 7 Internal Schematic for the type SI Relay with a single output.*

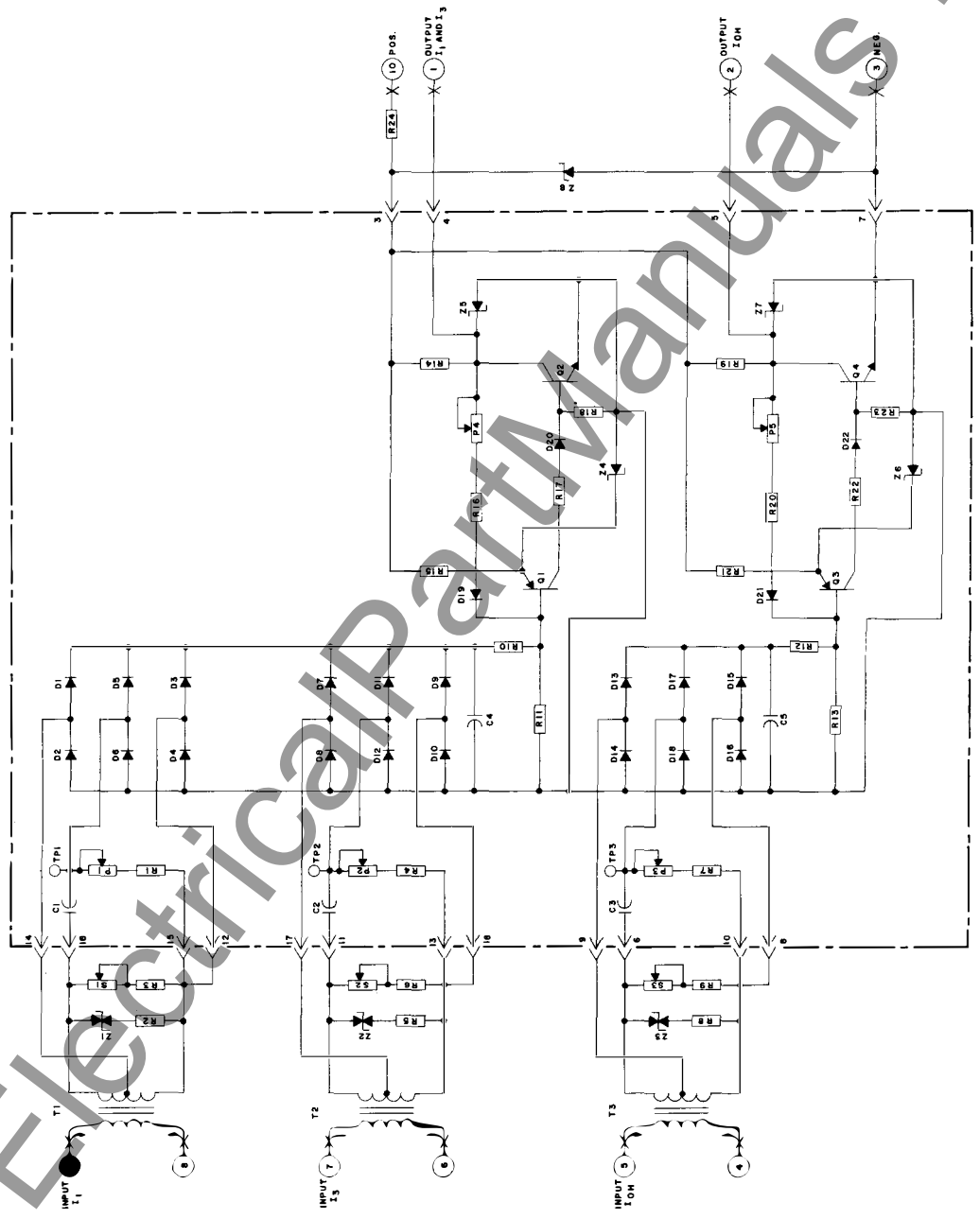


Fig. 8 Internal Schematic of the type SI Relay with a double output.

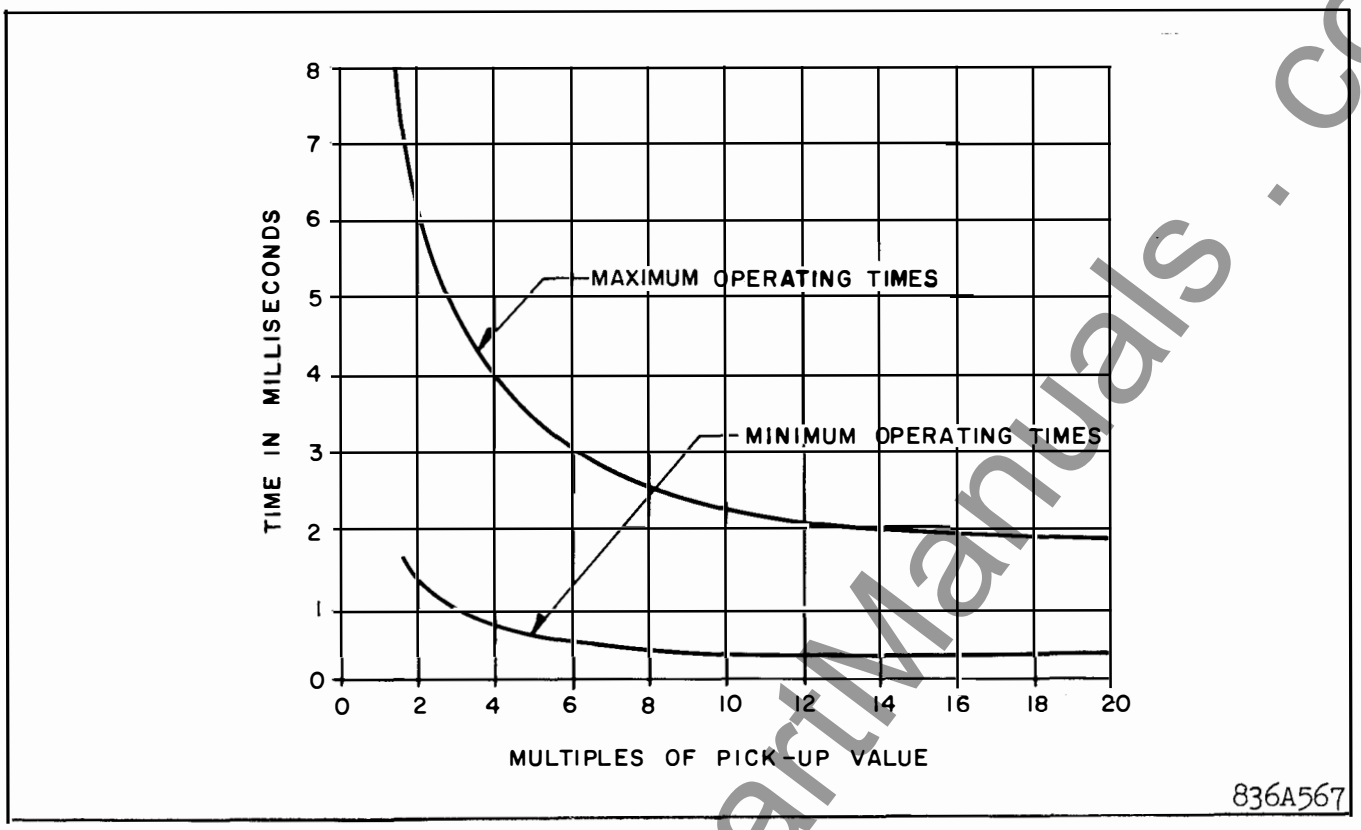


Fig. 9 Operating time for the type SI and SI-1 Relays.

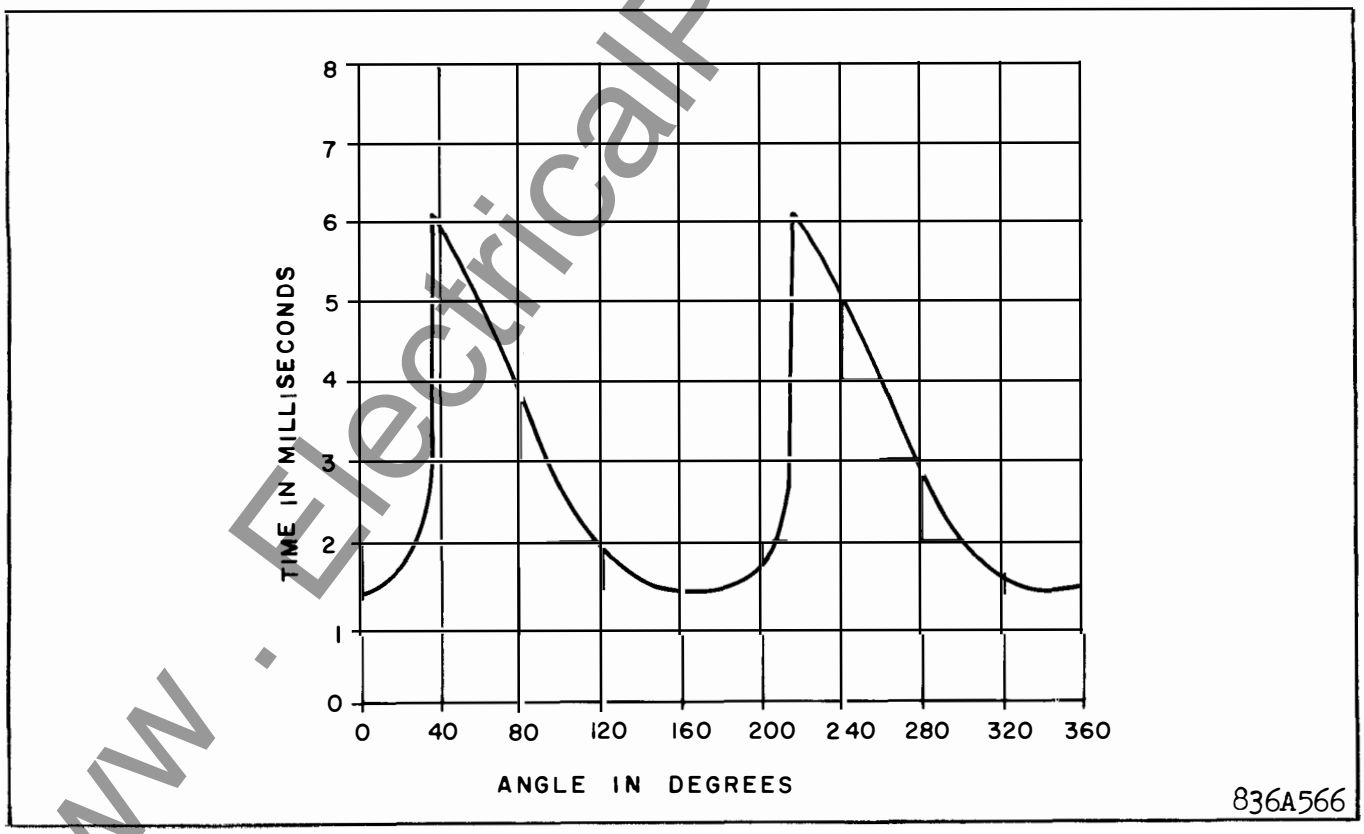


Fig. 10 Operating time for the type SI and SI-1 Relays as a function of fault incidence angle at twice minimum trip.

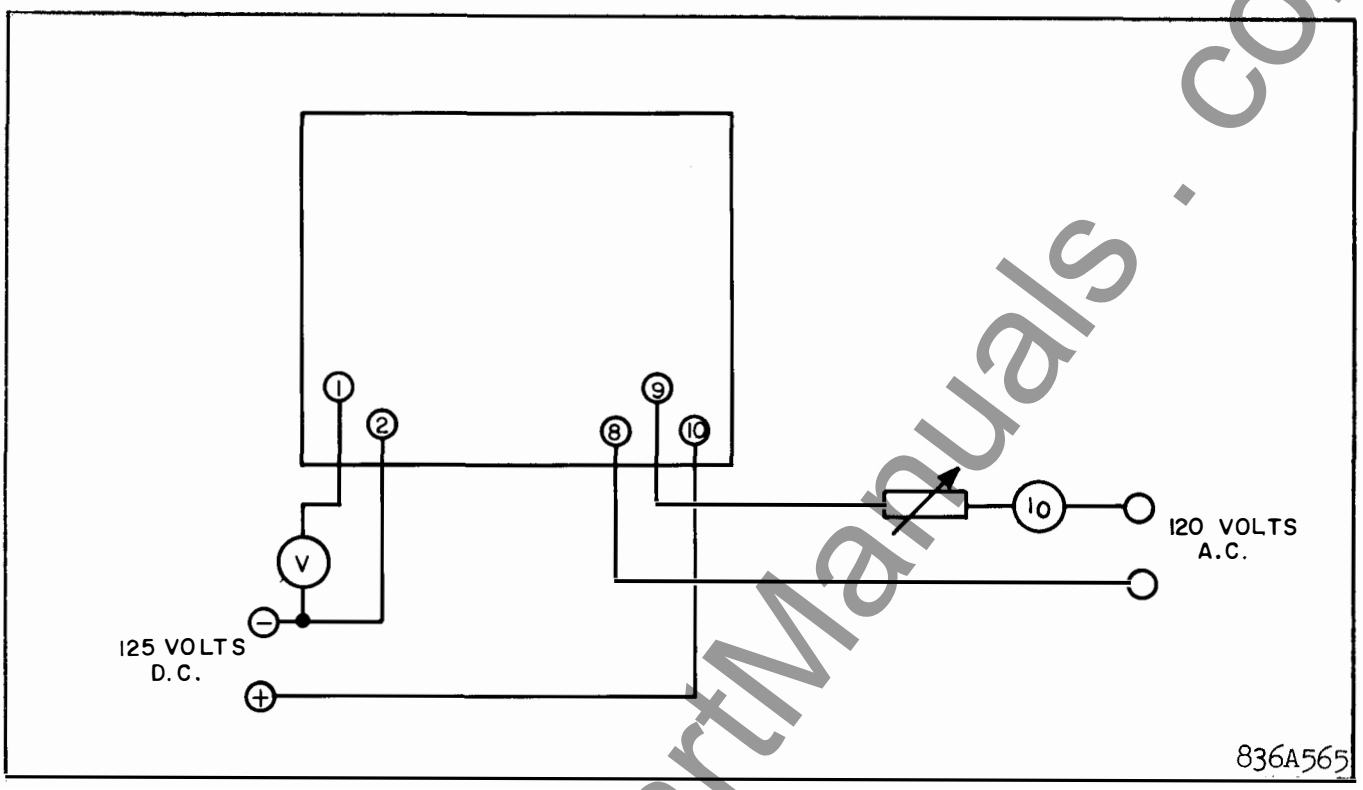
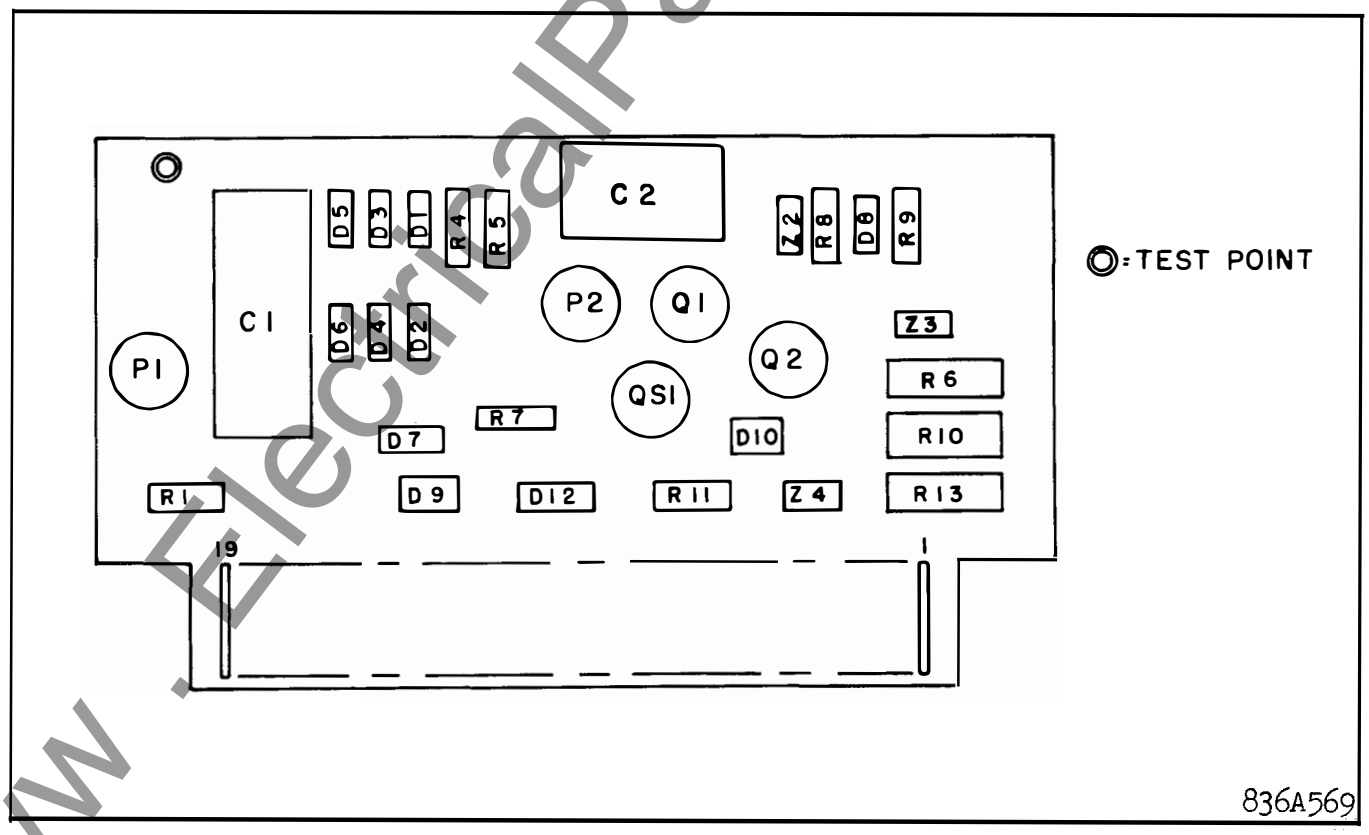


Fig. 11 Test circuit for the type SI-1 Relay.



* *Fig. 12 Component location on printed circuit board for the type SI-1 Relay.*

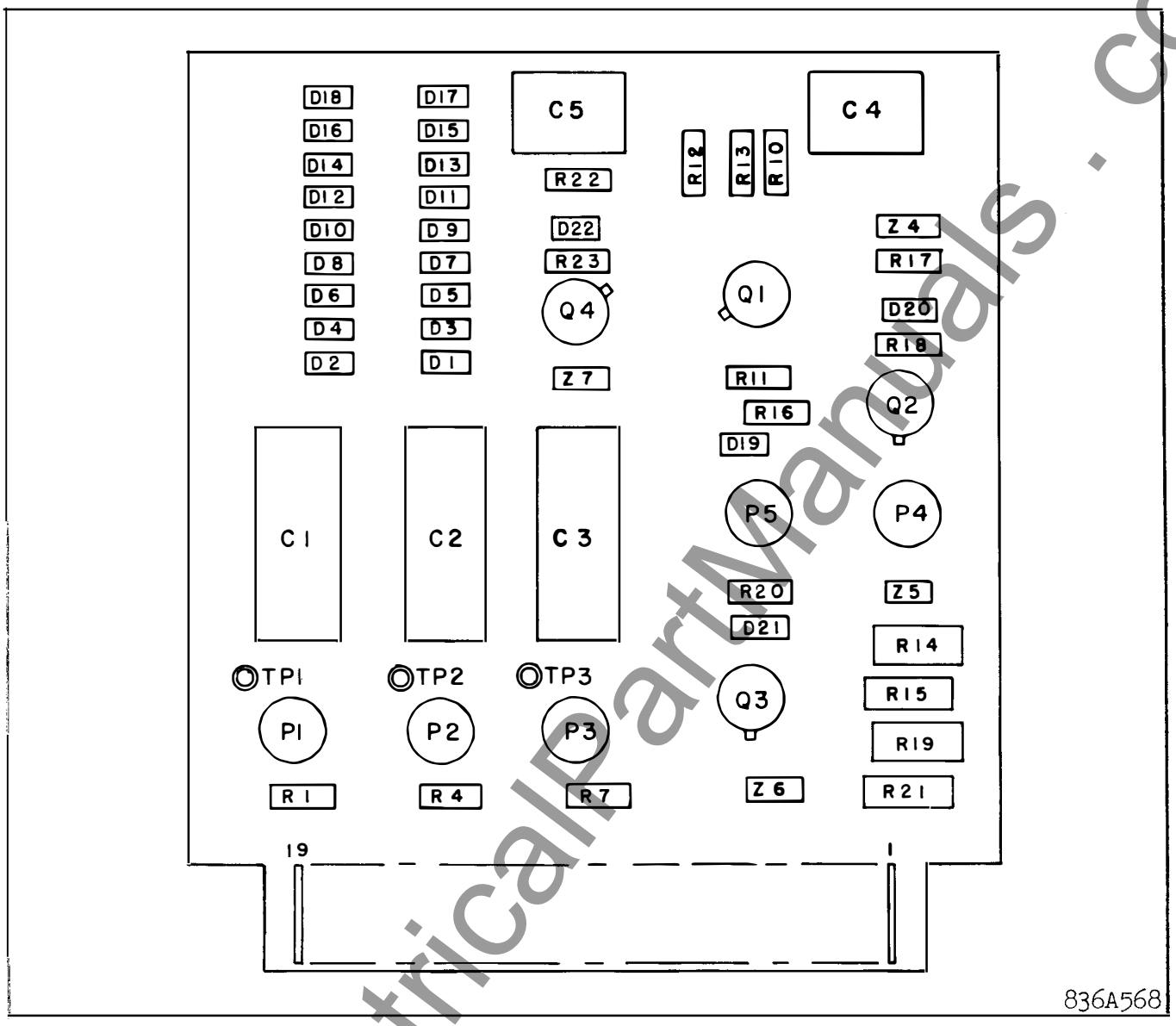


Fig. 13 Component location on printed circuit board for the type SI Relay.

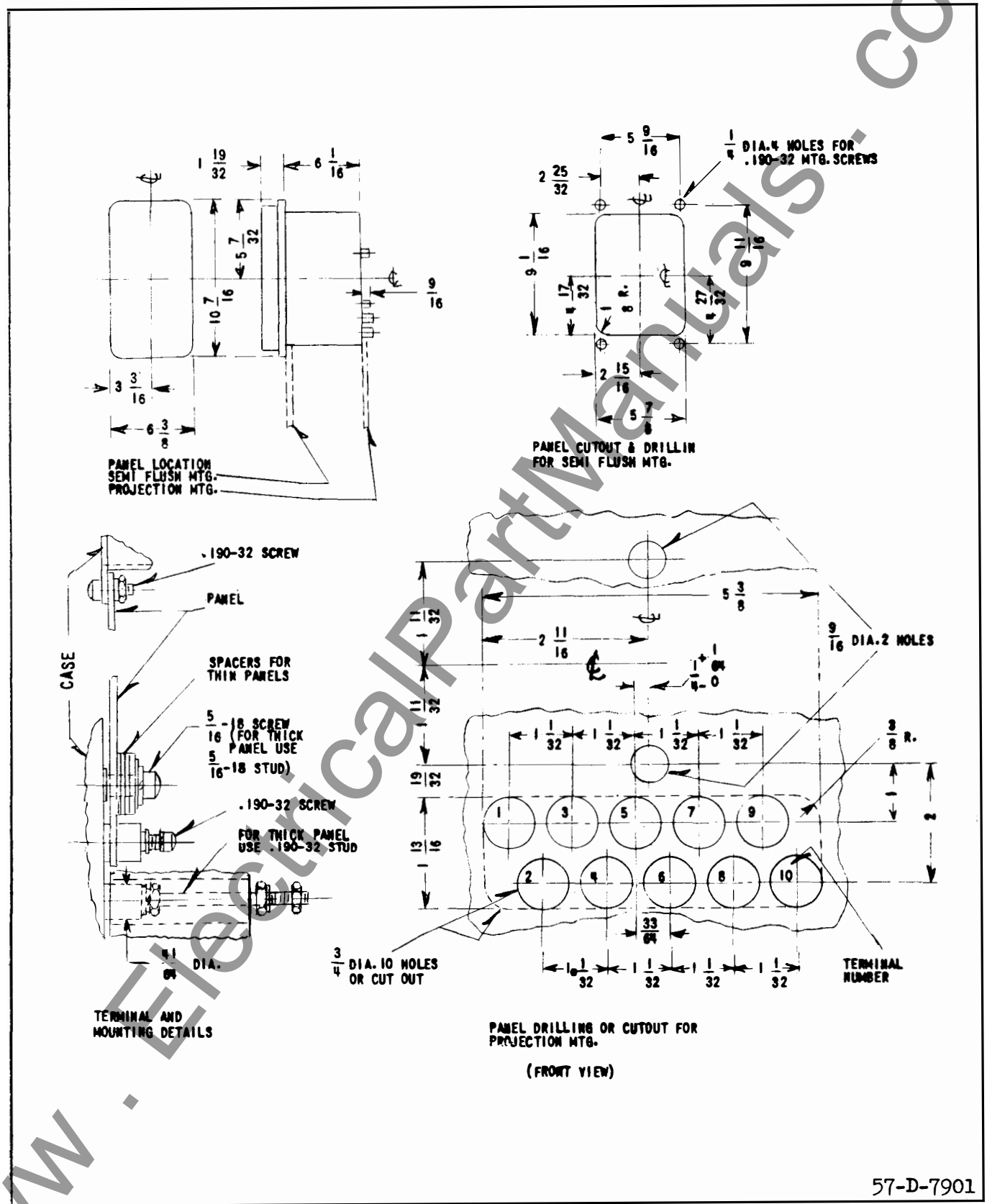


Fig. 14 Outline and drilling plan for the type SI Relay in the FT-21 case.

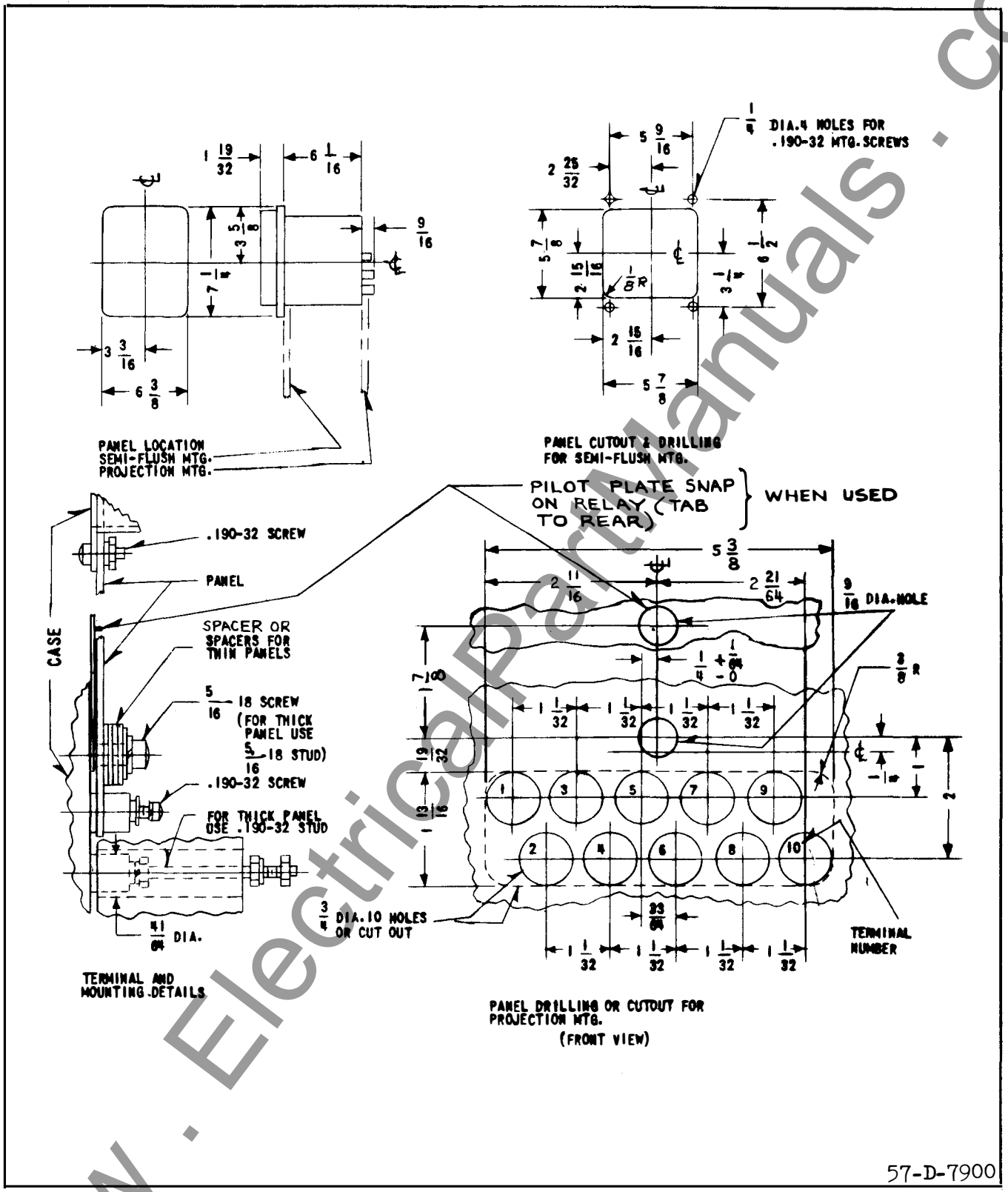


Fig. 15 Outline and drilling plan for the type SI-1 Relay in the FT-11 case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES SI AND SI-1 OVERCURRENT RELAYS

CAUTION: Before putting relay into service, operate the relay to check the electrical connections. Close output switches last when placing relay in service. Open output switches first when removing relay from service.

APPLICATION

These overcurrent relays are static devices that produce a d.c. output voltage when the input current in them exceeds a given value. This output voltage is used as the input to other devices that trip a breaker.

The number of inputs and outputs varies with the type of relay. Generally, these are as follows:

Type SI relay-three inputs, one or two outputs.

Type SI-1 relay-one input, one output.

CONSTRUCTION

The type SI-1 relay consists of an input transformer, a setting circuit, a phase splitter circuit, a sensing circuit, an amplifier circuit, a voltage regulator circuit, a feedback circuit and a transistor output. An operational indicator is an optional unit. The type SI relay in addition to these components has two input transformers, two phase splitter circuits, and either a single output or a dual output transistor circuit.

The components are connected as shown in Figs. 1 to 4.

Input Transformer – The input transformer is a two winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the setting circuit and from a fixed tap to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat connected in parallel with a resistor and Zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, resistor, potentiometer and a three-phase rectifier bridge. This circuit converts the single phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

Sensing Circuit – The sensing circuit consists of three resistors, a transistor and a Zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, a reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be greater than the reference voltage.

Amplifier Circuit – The amplifier circuit consists of a normally conducting transistor, Zener diode, three resistors and a diode. This circuit is the final output stage of the relay.

Feedback Circuit – The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit – The voltage regulator circuit consists of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt Zener diode mounted on an aluminum heat sink. The series resistor is a 3-½ inch resistor and is used to reduce the supply voltage to the Zener voltage.

Operational Indicator – The operational indicator consists of a silicon control rectifier, lamp, microswitch, Zener diode, and three resistors. This circuit is triggered by a signal from the output of the relay.

SUPERSEDES I.L. 41-777B
*Denotes change from superseded issue.

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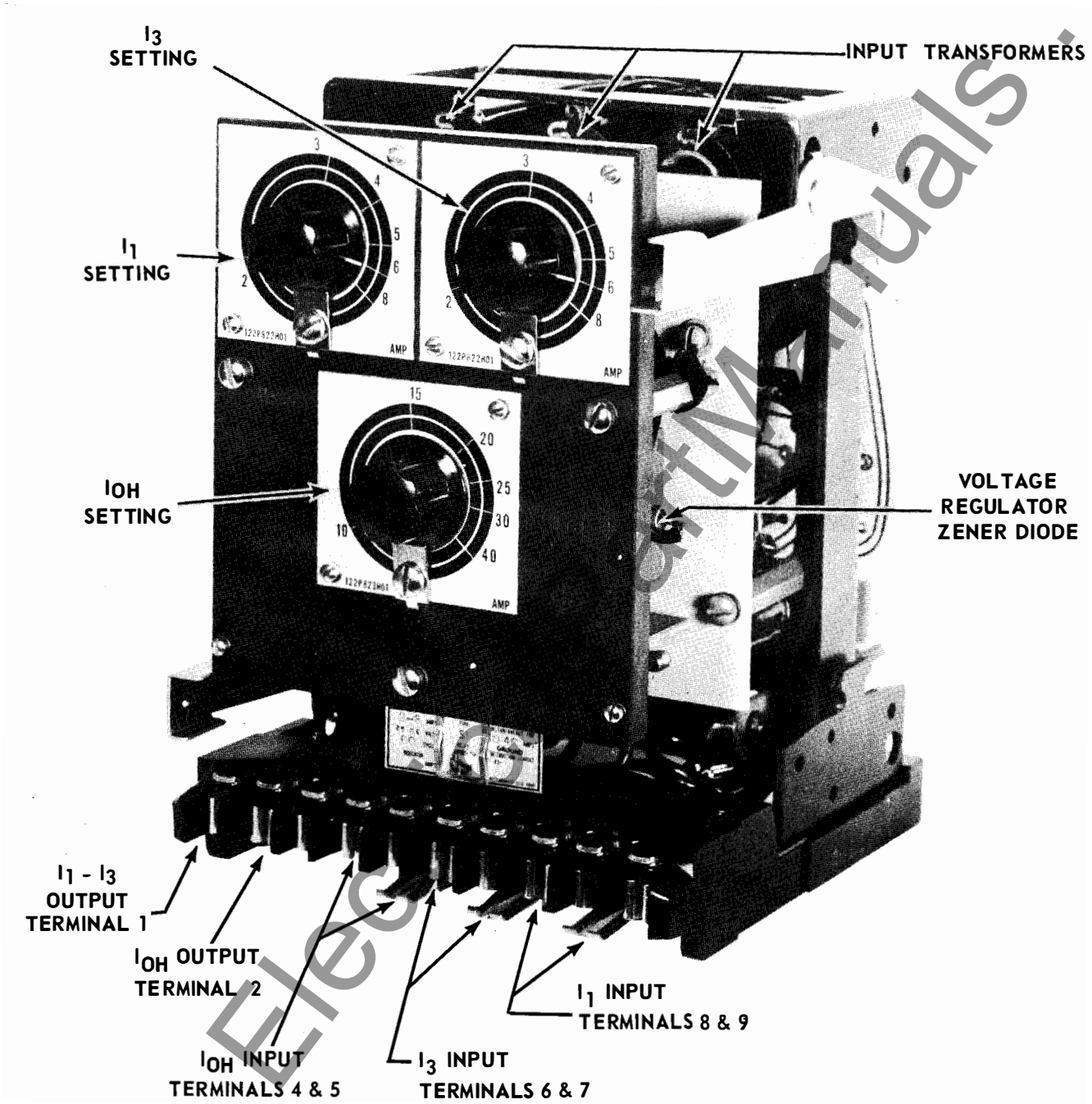


Fig. 1 Type SI Relay in an FT-21 case (front view).

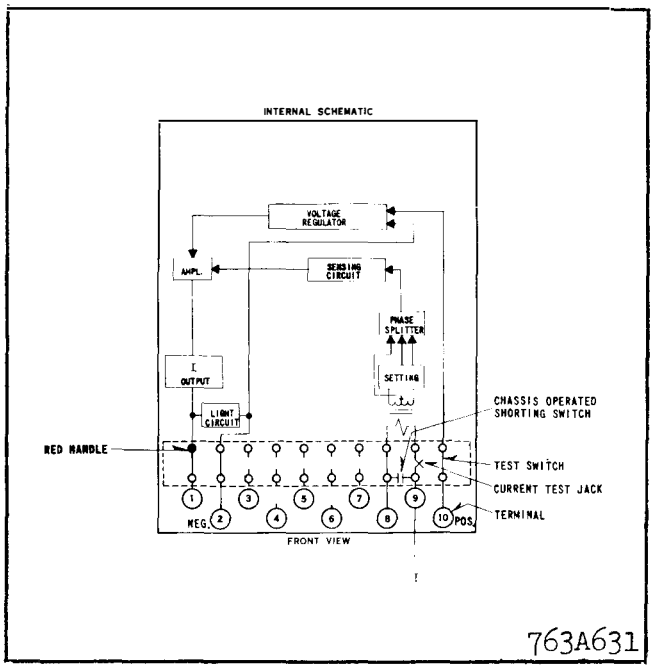


Fig. 2 Block diagram of the Type SI-1 Relay in FT-11 case (diagram of SI-1 without the operation indicator is 763A630).

OPERATION

The components of the SI-1 relay are connected as shown in Fig. 5. With no input to the relay, all transistors (Q_1 and Q_2) are conducting and a very small output is obtained from the relay. Zener diode (Z_2) of the sensing circuit establishes the reference voltage from the emitter of Q_1 to negative and allows a base current to flow in Q_1 through R_5 to negative.

When a.c. current is applied to the primary of the transformer (T), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (S1). This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor R_5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, Q_1 turns off to allow Q_2 to turn off which produces an output.

When Q_2 turns off, positive voltage is applied to the feedback circuit such that a voltage is applied to the base of Q_1. By varying the magnitude of this voltage, the dropout of the relay can be regulated from approximately 98% to 0% of pickup.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the voltage applied to the electronic components from becoming excessive.

The operation of the type SI relay is similar to the SI-1, except that the SI has three overcurrent inputs. These three inputs are applied through seperate phase splitting and setting circuits to a common sensing circuit which operates on the maximum voltage applied to it.

Figs. 6, 7, and 8 show the connections of the SI-1, SI with single output and the SI with a dual output.

CHARACTERISTICS

The SI-1 relay is available in the current ranges shown in Table I.

TABLE I

Range	Scale Marking					
.25 – 1 ampere	.25	.4	.5	.6	.8	1.0
.5 – 2 amperes	.5	.75	1.0	1.25	1.5	2.0
1 – 4 amperes	1.0	1.5	2.0	2.5	3.0	4.0
2 – 8 amperes	2	3	4	5	6	8
4 – 16 amperes	4	6	8	10	12	16
10 – 40 amperes	10	15	20	25	30	40

The setting of the relay is the minimum current required to produce an output. Settings between the scale markings can be obtained by applying the desired current to the relay and setting the rheostat at the desired point.

The SI relay is available with any combination of three of the above ranges. In the usual application, two inputs are the same range with an output. The third input is of a different range and can be of a different output than the other two.

The operating time of the relay is shown in Fig. 9. As shown in the figure, there is a maximum and minimum operating time of the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Figure 10 shows the operate times for different points on the fault wave for fault currents at twice pickup.

TABLE II
ENERGY REQUIREMENTS

Ampere Range	Setting	VA at Setting	P.F. Angle	VA at 5 amps.	P.F. Angle
.25 – 1	.25	0.17	7.5	23	51°
	.4	0.31	15	22.8	50
	.5	0.42	21	22.7	48
	.6	0.54	25	22.6	48
	.8	0.81	30	22.2	48
	1.0	1.20	35	21.8	48
.5 – 2	.5	0.17	7.5	8.80	32
	.75	0.31	15	8.50	32
	1.0	0.42	21	8.10	33
	1.25	0.54	25	7.80	34
	1.5	0.81	30	7.60	36
	2.0	1.20	35	7.10	37
1 – 4	1	0.17	7.5	3.15	16
	1.5	0.31	15	2.95	19
	2	0.42	21	2.65	21
	2.5	0.54	25	2.35	25
	3	0.81	20	2.21	28
	4	1.20	35	2.0	30
2 – 8	2	0.22	7.5	1.4	13
	3	0.39	15	1.1	15
	4	0.60	21	0.95	21
	5	0.85	25	0.85	25
	6	1.17	30	0.80	30
	8	1.94	35	0.73	35
4 – 16	4	0.26	8.5	0.41	8.5
	6	0.49	13	0.34	13
	8	0.80	15	0.3	15
	10	1.15	16.5	0.29	16.5
	12	1.57	17.5	0.28	17.5
	16	2.56	19	0.25	19.0
10 – 40	10	1.0	3	0.25	3
	15	2.1	4	0.23	4
	20	3.6	5	0.21	5
	25	5.9	6	0.21	6
	30	8.1	6	0.20	6
	40	14.4	6	0.20	6

TABLE III
CURRENT RATINGS
Rating of the Overcurrent Units

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.25 – 1	6	185
.5 – 2	8	350
1 – 4	10	400
2 – 8	12	400
4 – 16	15	400
10 – 40	20	460

TABLE IV
Battery Drain

	48 Volts D.C.	125 Volts D.C.
SI-1 Relay	32MA	65 MA
SI-1 Relay with Indicator	65MA	100 MA
SI-Relay Single Output	32MA	65 MA
SI Relay Dual Output	65MA	105 MA
Maximum Output	20 MA at 20 Volts D.C.	

SETTING

The pickup of the relay is selected by adjusting the rheostat, S, in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

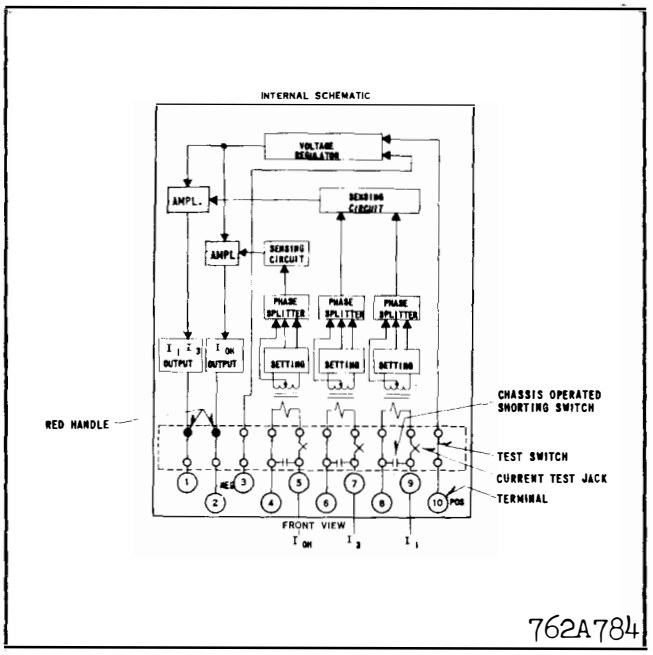


Fig. 3 Block diagram of the Type SI Relay in FT-21 case (for SI with single output omit the circuits connected to terminal 2; dwg. no. 763A629.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

The following check is recommended to insure that the relay is in proper working order. All checks can best be performed by connecting the relay per the test circuit of Fig. 11. Refer to fig. 4 and make similar connections for the test of the SI relay.

1. Minimum trip current – Check pickup at the minimum and maximum setting. This is accomplished by applying the specified current and checking that the voltmeter reads approximately 20 volts when the current is within 3% of the setting.

2. Dropout – After checking pickup, the dropout should be checked to be approximately 97% of the pickup when the a.c. current is gradually reduced.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

Calibration

Use the following procedure for calibrating the SI-1 relay if the relay adjustments have been distributed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs on the type SI relay.

Splitter Adjustments

1. Turn rheostat (S) on front of relay to extreme counter-clockwise position.

2. Apply minimum S current to the proper relay terminals.

3. With a high resistance voltmeter (a.c.) adjust phase splitter potentiometer such that three voltages approximately equal to each other are obtained across TP 1, printed circuit board terminal 12 and printed circuit board terminal 18 or 14.

Dial Calibration (S)

1. Apply 125 volts d.c. to relay terminals 10 and 2. Terminal 10 is positive.

2. Connect a high resistance d.c. voltmeter across terminals 1 and 2. Terminal 1 is positive.

3. Apply desired S current to terminal 8 and 9.

4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on meter.

Dropout (P)

1. Set S on desired point and apply S amperes to relay to make it operate.

2. Lower S amperes to desired droput value and adjust P potentiometer until voltmeter drops to approximately zero.

3. Verify dropout and pickup several times by raising a.c. current until relay operates and then lowering the a.c. current until relay dropouts.

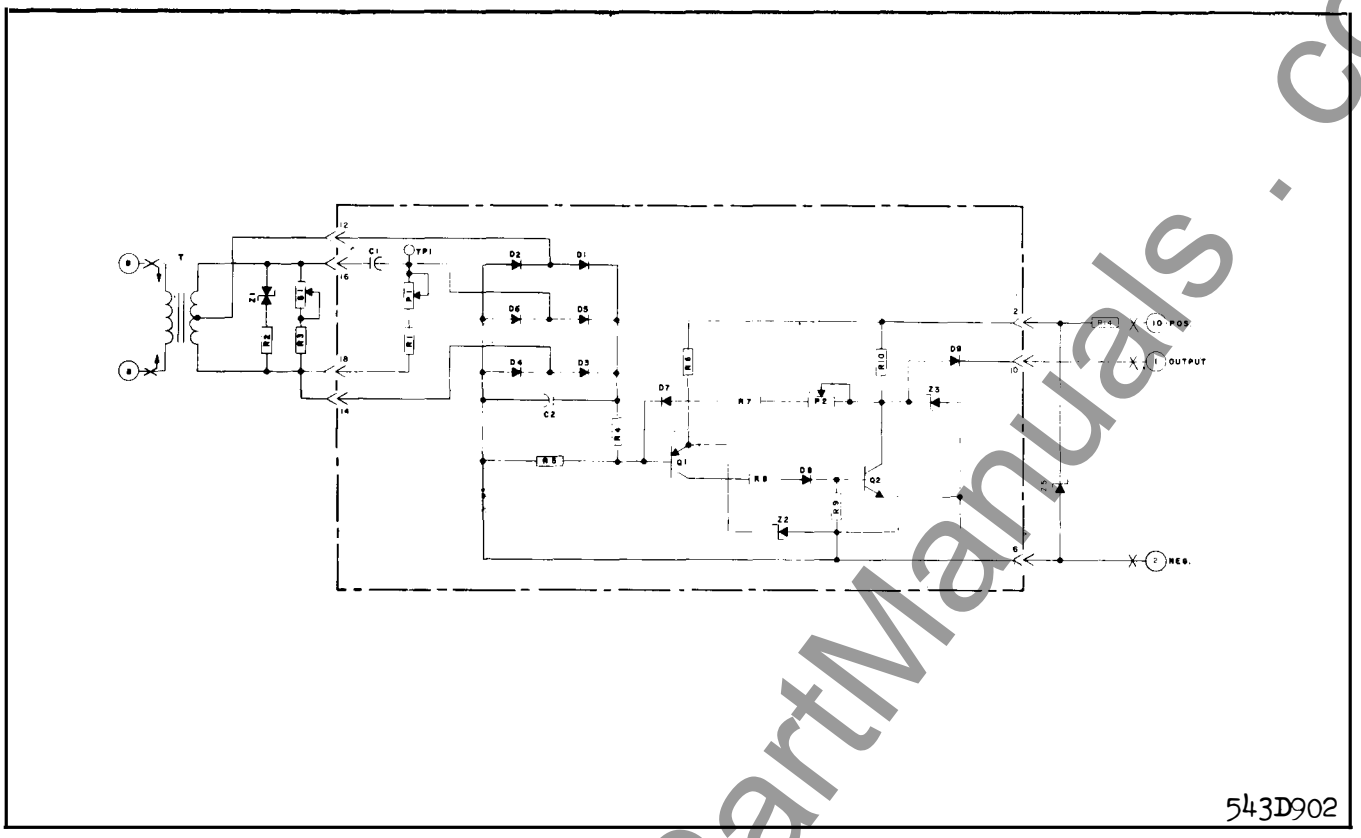
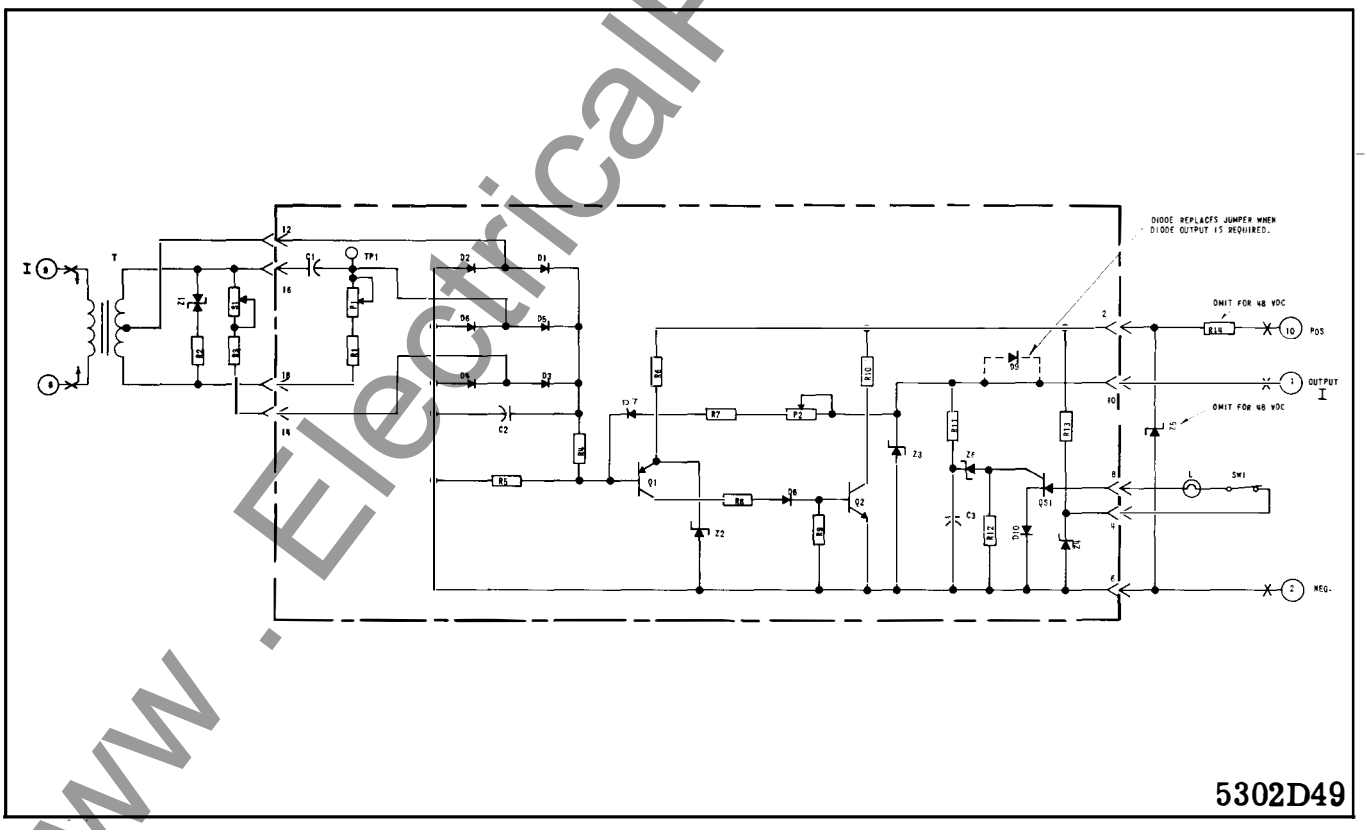


Fig. 4 Internal Schematic for the type SI-1 Relay.



* *Fig. 5 Internal Schematic for the type SI-1 Relay with an operation indicator.*

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the SI-1 relay or the SI relay is not operating correctly.

1. Inspect all wires and connections, paying particular attention to printed circuit terminals.
2. Check resistances as listed on the internal schematic of the relays.
3. Check voltages as listed on the electrical checkpoints.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ELECTRICAL CHECKPOINTS

Connect relay per test circuit of Fig. 11. All voltage readings should be made with a high resistance voltmeter. Refer to Fig. 12, 13 or 14 for printed circuit board points. For some readings it is necessary to scrape varnish from the components to make a connection at the point.

I No. A.C. Current Input 125 volts d.c.

Component	Negative terminal	Approximate d.c. voltage
Z_2	2	7
Z_3	2	less than .6 volts
Z_5	2	45 volts

II Minimum Trip A.C. current applied

Circuit	Terminals	Voltage
Phase	TP_1 to board 18	7.5 volts a.c.
Splitter	TP_1 to board 12	7.5 volts a.c.
	Board 12 to board 18	7.5 volts a.c.
Setting	Board 16 to board 18	15 volts a.c.
Output	Terminal 1(+) and 2	18 to 22 volts D.C.

The above terminals are for the SI-1 relay. For corresponding terminals for the SI relay, refer to the relay.

ELECTRICAL PARTS LIST

TYPE SI

Circuit Symbol	Description
CAPACITORS	
CI-C2-C3	.5 MFD.
C4-C5 ††	.25 MFD.
DIODES	
D18-D20-D22 ††	IN459A
D19-D21 ††	IN457A
POTENTIOMETERS	
P1-P2-P3	2.5K Ω – 1/4W
P4-P5 ††	200K Ω – 1/4W
TRANSISTORS	
Q1-Q3 ††	2N652A
Q2-Q4 ††	2N697
RESISTORS	
R1-R4-R7	2.7 K Ω – 1/2W
R2-R5-R8	50 Ω – 25 W
R3-R6-R9	300 Ω – 25 W
R10-R12 ††	15K Ω – 1/2 W
R11-R13 ††	39 K Ω – 1/2 W
R14-R19 ††	* 2.7K Ω – 5 W
R15-R21 ††	3.9 K Ω – 2 W
R16-R20 ††	33 K Ω – 1/2 W
R17-R22 ††	1 K Ω – 1/2 W
R18-R23 ††	10 K Ω – 1/2 W
R24	500 Ω – 40 W
RHEOSTAT	
S1-S2-S3	1.5K Ω – 25 W
TRANSFORMER	
T1-T2	S# 410C268
T3	S#410C268
ZENER DIODES	
Z1-Z2-Z3	INI832C
Z4-Z6 ††	IN957B
Z5-Z7 ††	IN368B
Z8	INI829A

†† Used only in relay with double output.

TYPE SI-1

Circuit Symbol	Description
CAPACITORS	
C1	.5 MFD
C2	.25 MFD
C3†	6.8 MFD
DIODES	
D1 TO D6-D8	IN459A
D7	IN457A
D9 - D10 †	CER - 69
POTENTIOMETERS	
P 1	2.5K Ω – 1/4 W
P 2	200 K Ω – 1/4 W
TRANSISTORS	
Q 1	2N652A
Q 2	2N697
RESISTORS	
R 1	2.7 K Ω – 1/2 W
R 2	50 Ω – 25W
R 3	300 Ω – 25 W
R 4	15 K Ω – 1/2 W
R 5	39K Ω – 1/2 W
R 10	* 2.7K Ω – 5 W
R 6	3.9 K Ω – 2 W
T 7	33 K Ω – 1/2 W
R 8	1 K Ω – 1/2 W
R 9	10 K Ω – 1/2 W
R 14	500 Ω – 40 W
R 12 †	4.7 K Ω – 1/2 W
R 13 †	820 Ω – 1 W
R 11 †	3.9K Ω – 1/2 W
RHEOSTAT	
S 1	1.5 K Ω – 25 W
TRANSFORMER	
T	S # 410C268
ZENER DIODES	
Z 1	INI832C
Z 2 - Z6 †	IN957B
Z 3 - Z4 †	IN3686B
Z 5	INI829A
SWITCHES	
QS 1 †	2N1881
SW 1 †	S # 184A611H01
LAMP	
L †	S# 183A825G05

† Used only in relay with operation indicator

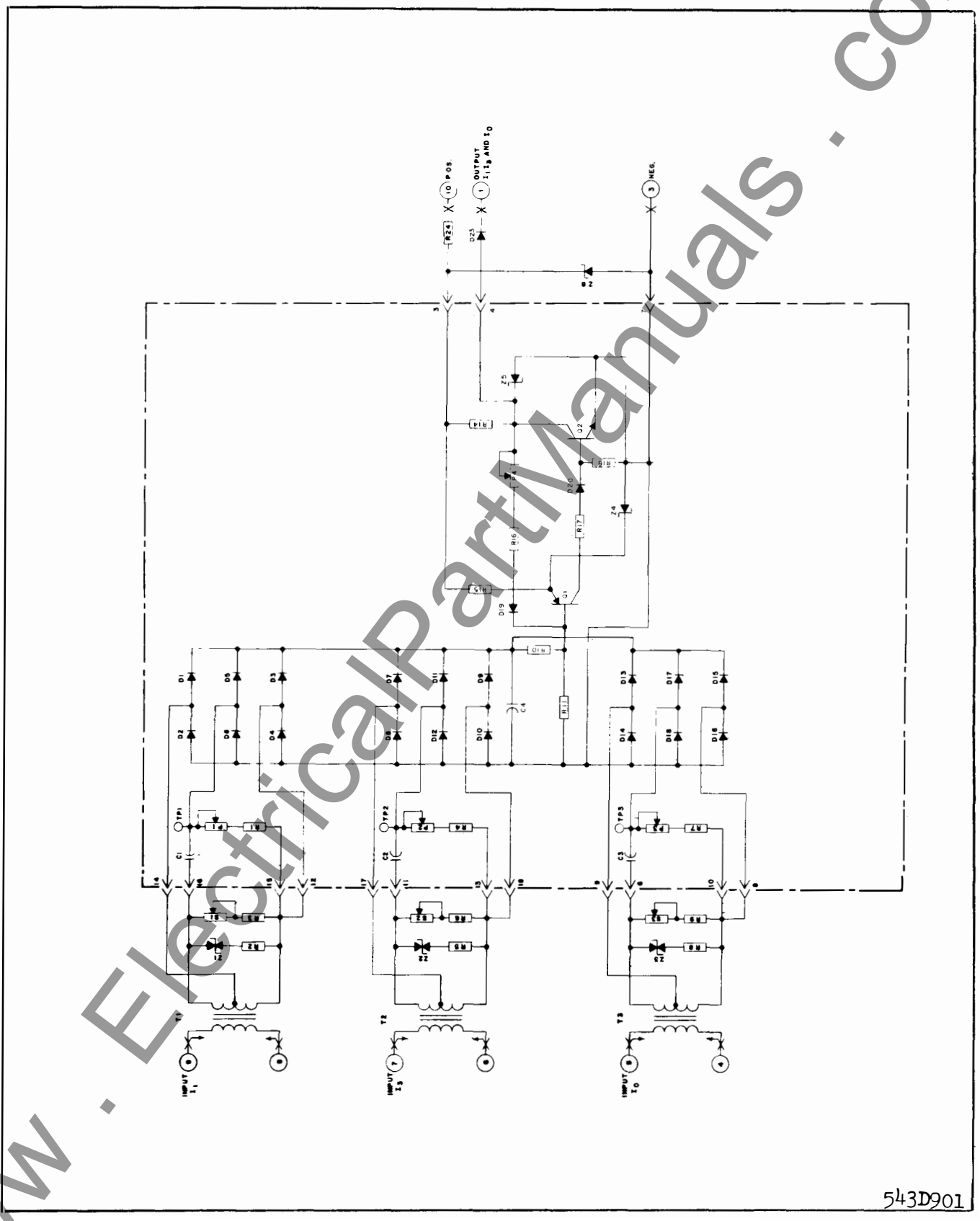


Fig. 6 Internal Schematic for the type SI Relay with a single output.

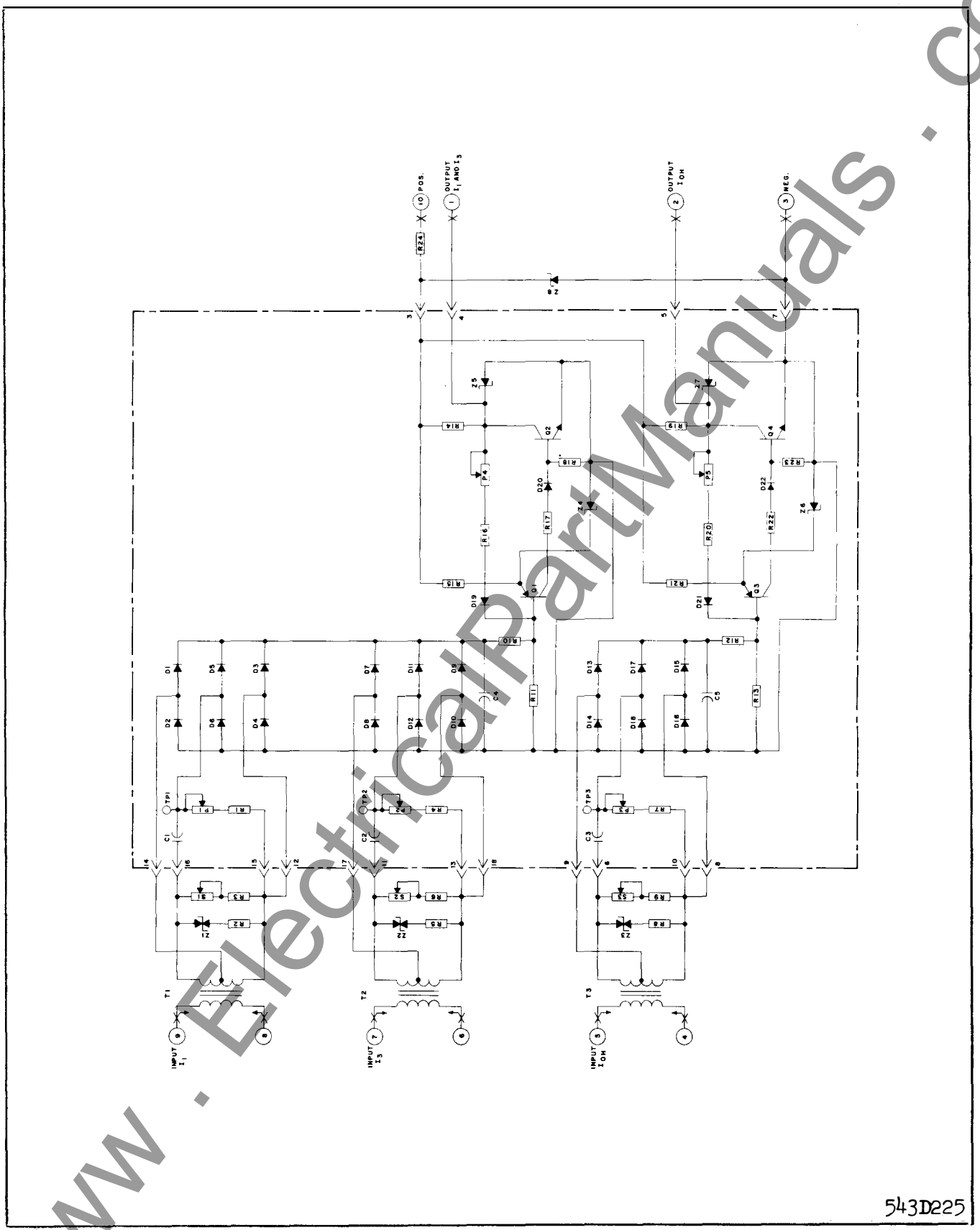


Fig. 7 Internal Schematic of the type SI Relay with a double output.

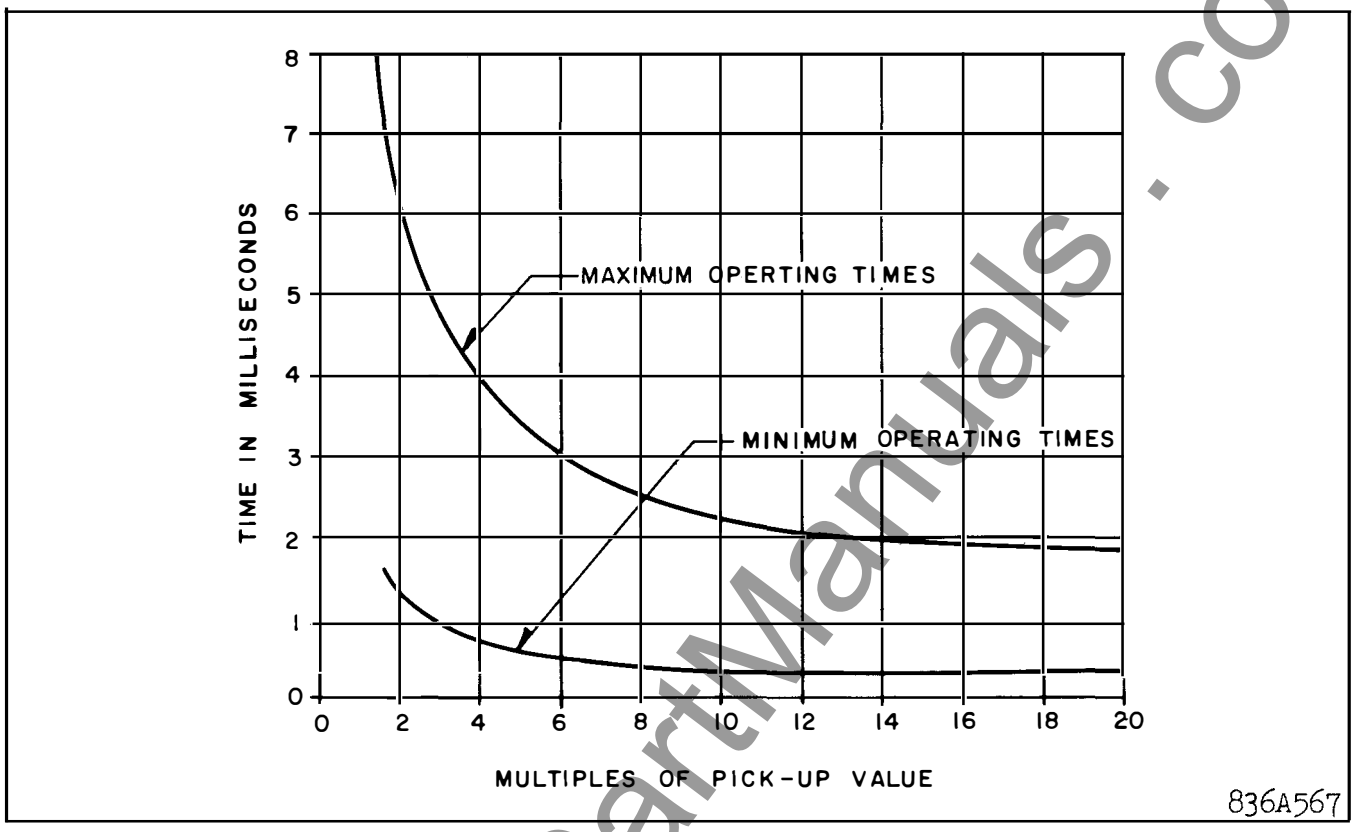


Fig. 8 Operating time for the type SI and SI-1 Relays.

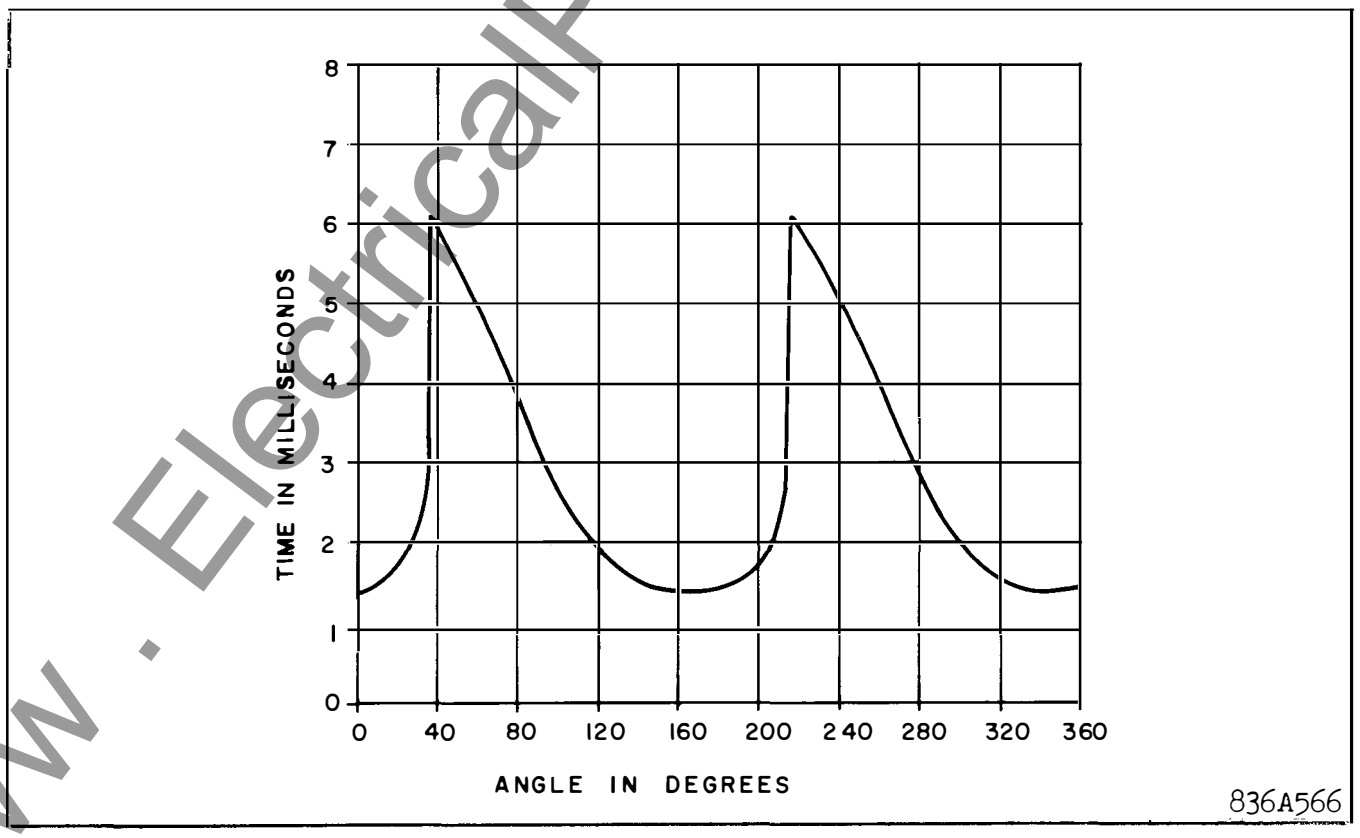


Fig. 9 Operating time for the type SI and SI-1 Relays as a function of fault incidence angle at twice minimum trip.

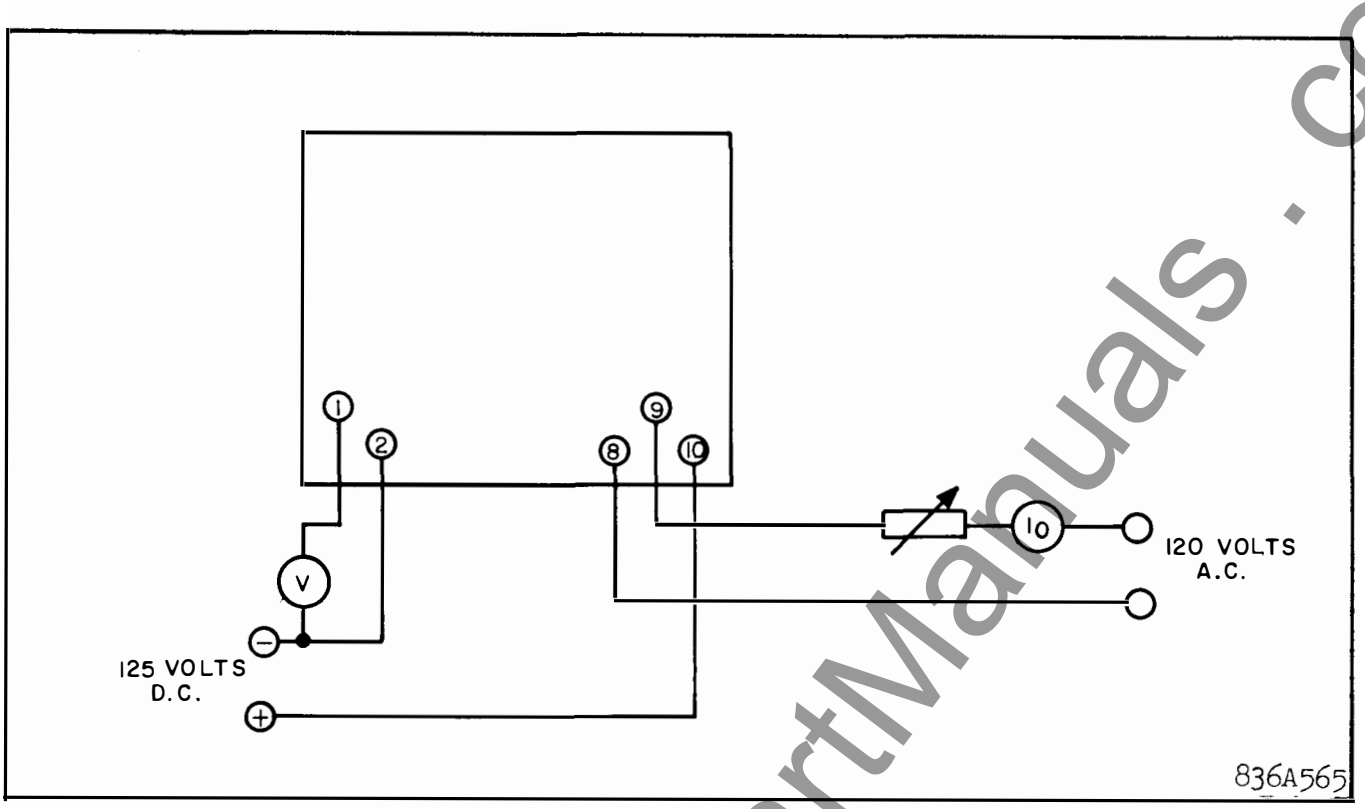


Fig. 10 Test circuit for the type SI-1 Relay.

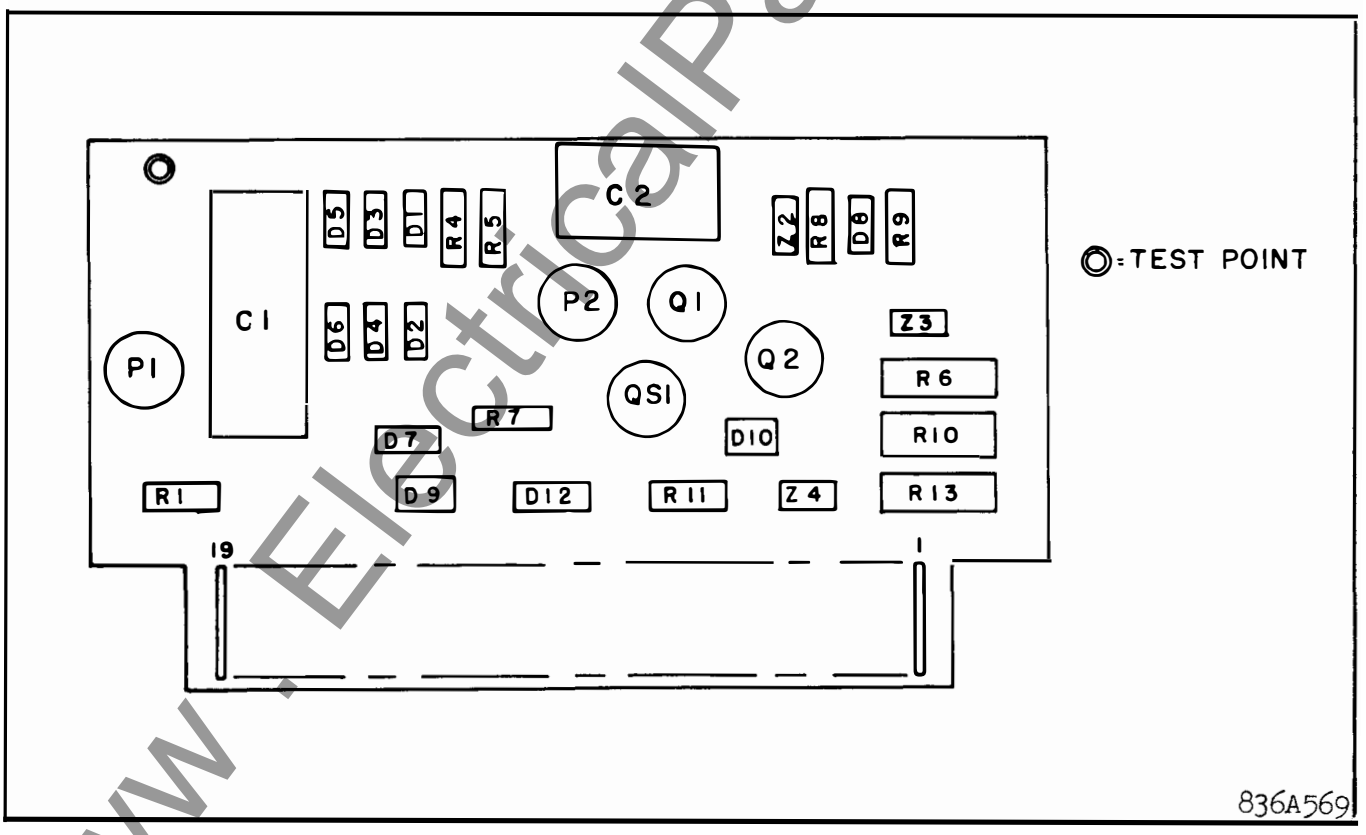
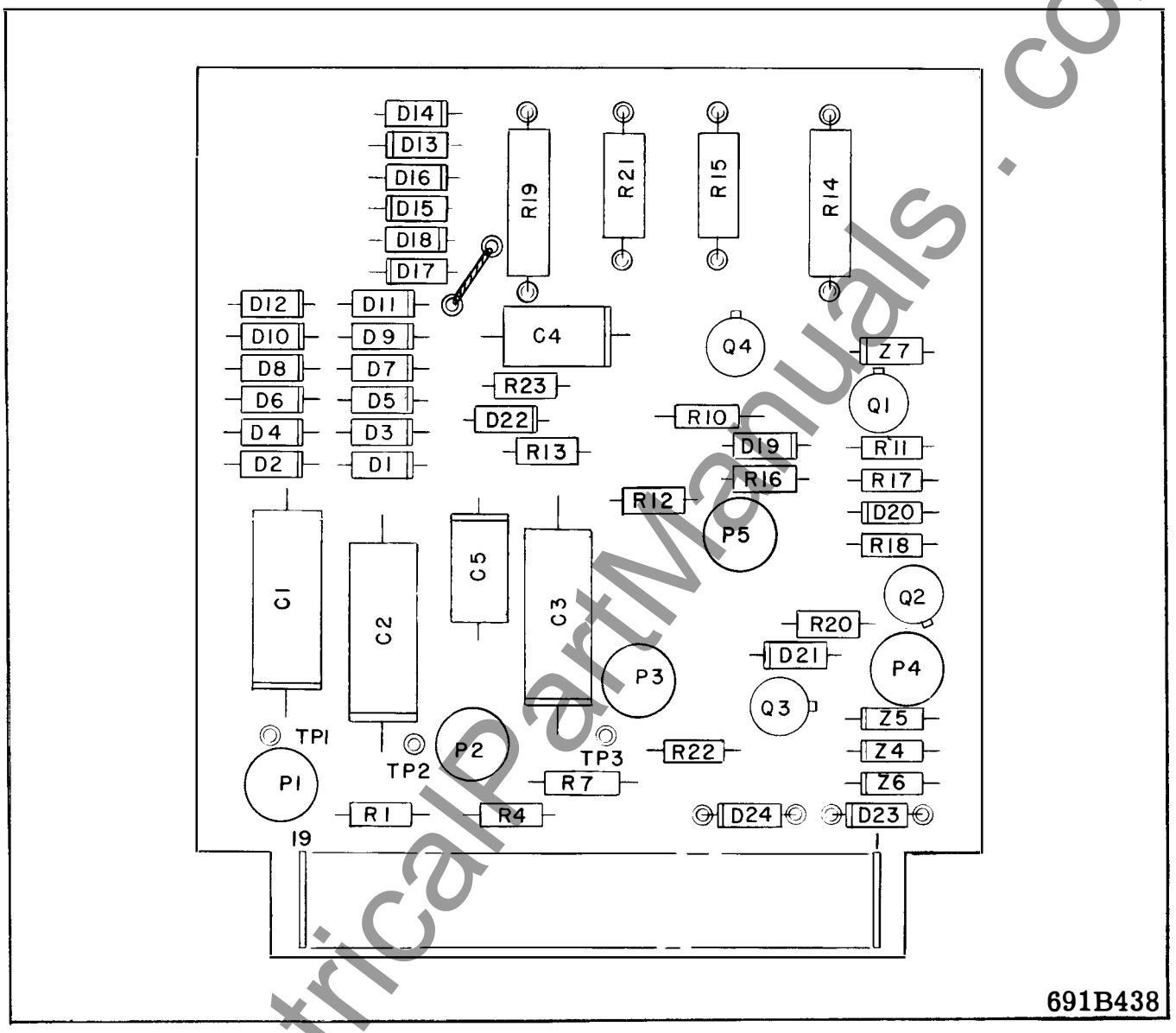


Fig. 11 Component location on printed circuit board for the type SI-1 Relay.



* *Fig. 12 Component location on printed circuit board for the type SI Relay.*

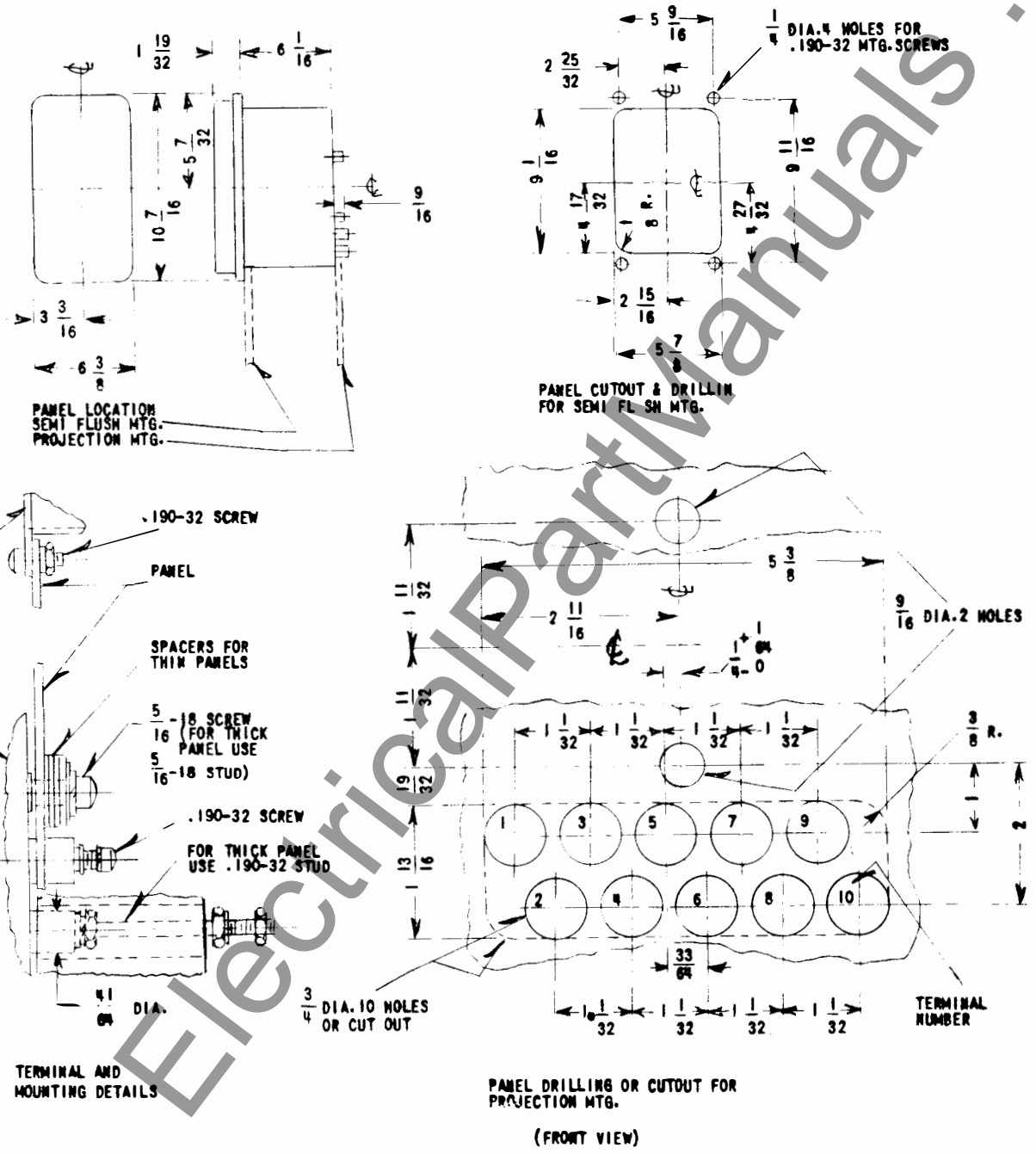


Fig. 13 Outline and drilling plan for the type SI Relay in the FT-21 case.

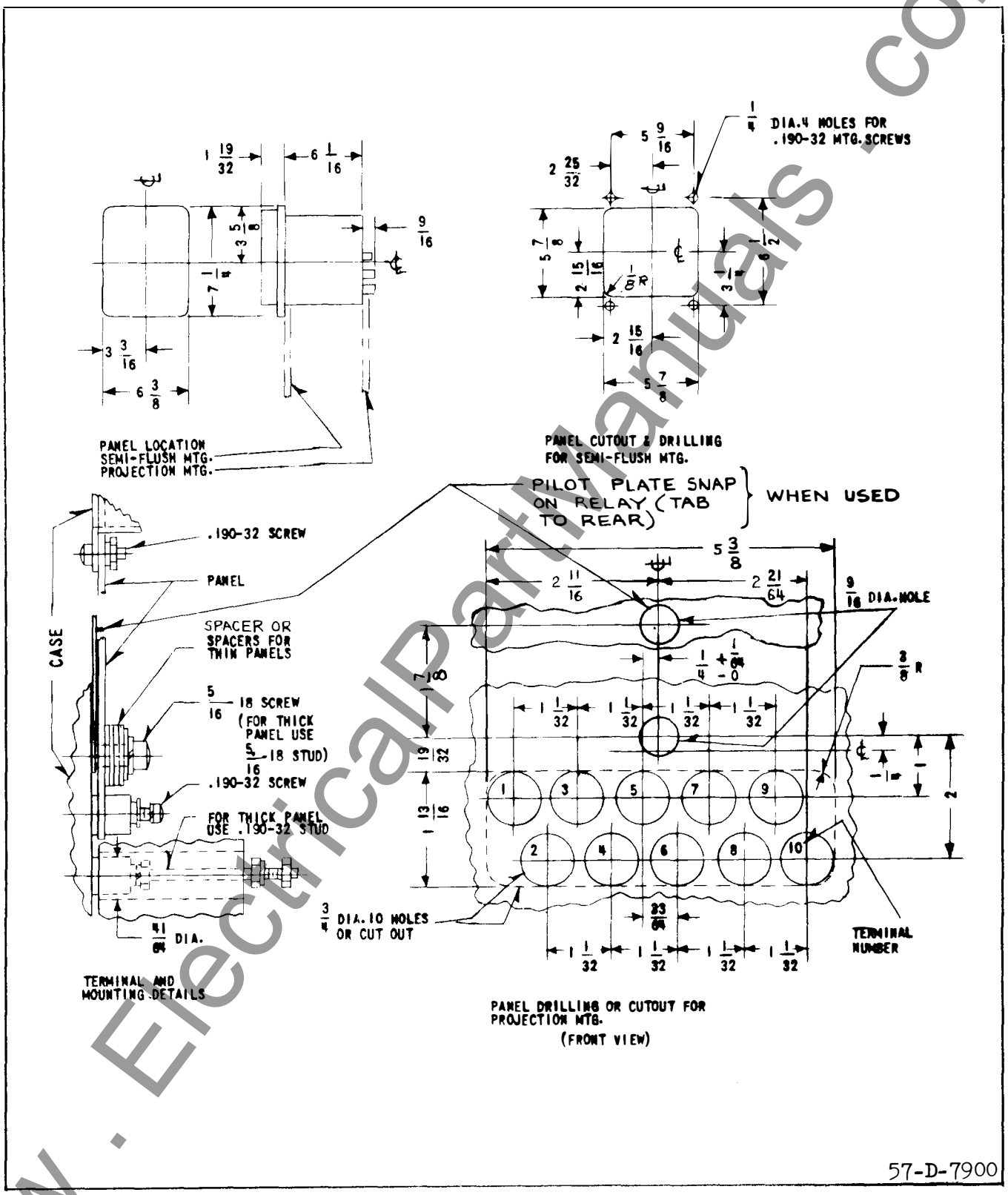
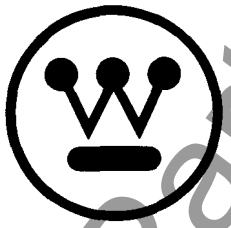


Fig. 14 Outline and drilling plan for the type SI-1 Relay in the FT-11 case.



WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES SI AND SI-1 OVERCURRENT RELAYS

CAUTION: Before putting relay into service, operate the relay to check the electrical connections. Close output switches last when placing relay in service. Open output switches first when removing relay from service.

APPLICATION

These overcurrent relays are static devices that produce a d.c. output voltage when the input current in them exceeds a given value. This output voltage is used as the input to other devices that trip a breaker.

The number of inputs and outputs varies with the type of relay. Generally, these are as follows:

Type SI relay-three inputs, one or two outputs.

Type SI-1 relay-one input, one output.

CONSTRUCTION

The type SI-1 relay consists of an input transformer, a setting circuit, a phase splitter circuit, a sensing circuit, an amplifier circuit, a voltage regulator circuit, a feedback circuit and a transistor output. An operational indicator is an optional unit. The type SI relay in addition to these components has two input transformers, two phase splitter circuits, and either a single output or a dual output transistor circuit.

* The components are connected as shown in Fig. 4 to 7.

Input Transformer – The input transformer is a two winding type with a non-tapped primary winding and a tapped secondary winding. The secondary is connected to the setting circuit and from a fixed tap to the phase splitter circuit.

Setting Circuit – The setting circuit is connected across the secondary winding of the input transformer and consists of two branches, a resistor and a rheostat connected in parallel with a resistor and Zener diode. This circuit loads the transformer and produces a secondary voltage proportional to the input current. The rheostat has a locking feature to minimize accidental change of current setting.

Phase Splitter Circuit – The phase splitter circuit consists of two capacitors, resistor, potentiometer and a three-phase rectifier bridge. This circuit converts the single phase a.c. voltage from the output of the transformer to a three-phase voltage and rectifies this voltage to d.c.

Sensing Circuit – The sensing circuit consists of three resistors, a transistor and a Zener diode. This circuit is connected between the output of the phase splitter circuit and the amplifier circuit. In this circuit, a reference voltage is established which turns the transistor on. To turn the transistor off, the output voltage from the phase splitter must be greater than the reference voltage.

Amplifier Circuit – The amplifier circuit consists of a normally conducting transistor, Zener diode, three resistors and a diode. This circuit is the final output stage of the relay.

Feedback Circuit – The feedback circuit consists of a resistor, potentiometer, and diode. This circuit controls the dropout current of the relay.

Voltage Regulator Circuit – The voltage regulator circuit consists of a silicon power regulator and a series resistor. The silicon power regulator is a 10 watt Zener diode mounted on an aluminum heat sink. The series resistor is a 3-½ inch resistor and is used to reduce the supply voltage to the Zener voltage.

Operational Indicator – The operational indicator consists of a silicon control rectifier, lamp, microswitch, Zener diode, and three resistors. This circuit is triggered by a signal from the output of the relay.

SUPERSEDES I.L. 41-777C and L-SPEC. 835945B
*Denotes change from superseded issue.

EFFECTIVE APRIL 1971

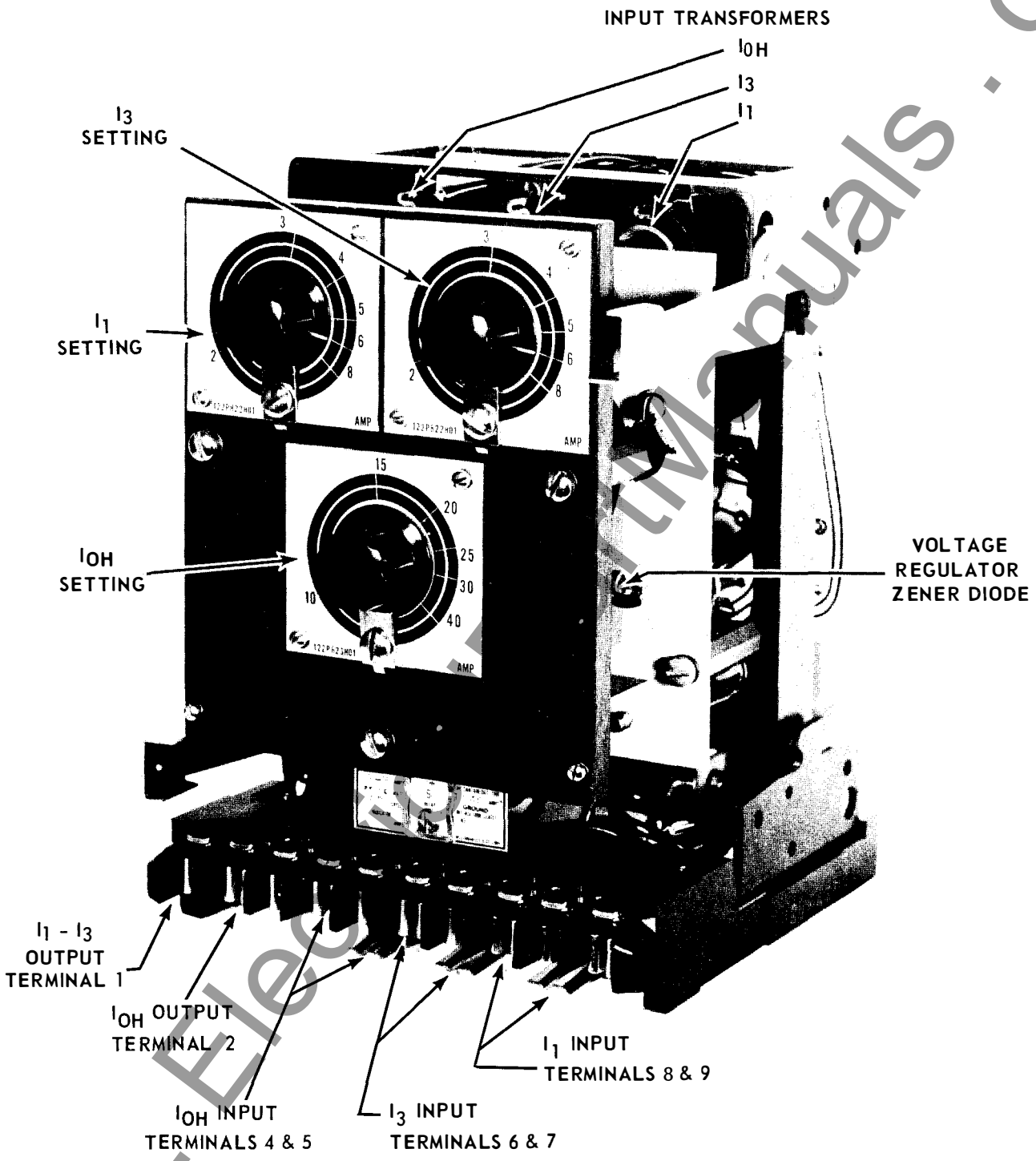


Fig. 1 Type SI Relay in an FT-21 case (front view).

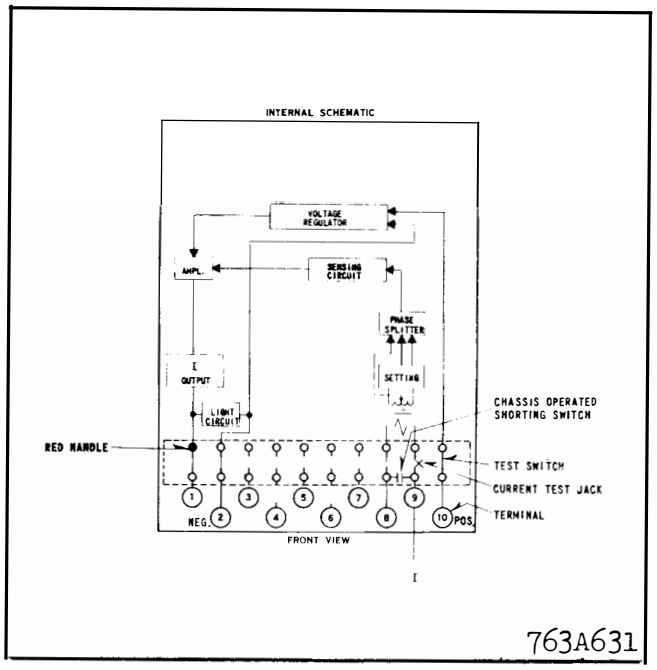


Fig. 2 Block diagram of the Type SI-1 Relay in FT-11 case

OPERATION

* The components of the SI-1 relay are connected as shown in Fig. 4 and Fig. 5. With no input to the relay, all transistors (Q_1 and Q_2) are conducting and a very small output is obtained from the relay. Zener diode (Z_2) of the sensing circuit establishes the reference voltage from the emitter of Q_1 to negative and allows a base current to flow in Q_1 through R_5 to negative.

When a.c. current is applied to the primary of the transformer (T), a voltage is produced on the secondary side that is proportional to the amount of resistance in the rheostat (S1). This single phase voltage is applied to the phase splitter circuit where a three phase voltage is produced, rectified, and applied to resistor R_5 of the sensing circuit. If the voltage from the rectifier is greater than the reference voltage across the sensing circuit, Q_1 turns off to allow Q_2 to turn off which produces an output.

* When Q_2 turns off, positive voltage is applied to the feedback circuit such that a voltage is applied to the base of Q_1 on relays where feedback resistor "P" is used, the dropout of the relay can be regulated from approximately 98% to 85% of pickup by varying the magnitude of this voltage. On those relays without adj. feedback resistor, the magnitude of feedback voltage is set to give the proper dropout ratio.

When large currents are applied to the primary of the input transformer, the Zener clipper on the secondary prevents the voltage applied to the electronic components from becoming excessive.

* The operation of the type SI relay is similar to the SI-1 except that the SI has three overcurrent inputs. These three inputs are applied through separate phase splitting and setting circuits to a common sensing circuit which operates on the maximum voltage applied to it.

* Figs. 6 and 7 show the connections of the SI with single output and the SI with a dual output.

CHARACTERISTICS

The SI-1 relay is available in the current ranges shown in Table I.

TABLE I

Range	Scale Marking					
.25 – 1 ampere	.25	.4	.5	.6	.8	1.0
.5 – 2 amperes	.5	.75	1.0	1.25	1.5	2.0
1 – 4 amperes	1.0	1.5	2.0	2.5	3.0	4.0
2 – 8 amperes	2	3	4	55	6	8
4 – 16 amperes	4	6	8	10	12	16
10 – 40 amperes	10	15	20	25	30	40

The setting of the relay is the minimum current required to produce an output. Settings between the scale markings can be obtained by applying the desired current to the relay and setting the rheostat at the desired point.

The SI relay is available with any combination of three of the above ranges. In the usual application, two inputs are the same range with an output. The third input is of a different range and can be of a different output than the other two.

* The operating time of the relay is shown in Fig. 8. As shown in the figure, there is a maximum and minimum operating time of the relay for each multiple of pickup. This difference in time is due to the point on the current wave that the fault current is applied. Figure 9 shows the operate times for different points on the fault wave for fault currents at twice pickup.

* For breaker failure applications, the SI relay is modified to obtain a fast reset characteristic. With reference to Fig. 6, the filtering capacitor, C_4, is removed and the dropout ratio is set at 90% of pickup. This lower dropout ratio allows a snapped pickup without the filtering capacitor. The reset curves of the relay is shown in Fig. 13 and Fig. 14. The external schematic of the relay in a breaker failure application is shown in Fig. 15.

TABLE II
ENERGY REQUIREMENTS

Ampere Range	Setting	VA at Setting	P.F. Angle	VA at 5 amps.	P.F. Angle
.25 – 1	.25	0.17	7.5	23	51°
	.4	0.31	15	22.8	50
	.5	0.42	21	22.7	48
	.6	0.54	25	22.6	48
	.8	0.81	30	22.2	48
	1.0	1.20	35	21.8	48
.5 – 2	.5	0.17	7.5	8.80	32
	.75	0.31	15	8.50	32
	1.0	0.42	21	8.10	33
	1.25	0.54	25	7.80	34
	1.5	0.81	30	7.60	36
	2.0	1.20	35	7.10	37
1 – 4	1	0.17	7.5	3.15	16
	1.5	0.31	15	2.95	19
	2	0.42	21	2.65	21
	2.5	0.54	25	2.35	25
	3	0.81	20	2.21	28
	4	1.20	35	2.0	30
2 – 8	2	0.22	7.5	1.4	13
	3	0.39	15	1.1	15
	4	0.60	21	0.95	21
	5	0.85	25	0.85	25
	6	1.17	30	0.80	30
	8	1.94	35	0.73	35
4 – 16	4	0.26	8.5	0.41	8.5
	6	0.49	13	0.34	13
	8	0.80	15	0.3	15
	10	1.15	16.5	0.29	16.5
	12	1.57	17.5	0.28	17.5
	16	2.56	19	0.25	19.0
10 – 40	10	1.0	3	0.25	3
	15	2.1	4	0.23	4
	20	3.6	5	0.21	5
	25	5.9	6	0.21	6
	30	8.1	6	0.20	6
	40	14.4	6	0.20	6

TABLE III
CURRENT RATINGS
Rating of the Overcurrent Units

Range	Continuous Rating (Amperes)	One Second Rating (Amperes)
.25 – 1	6	185
.5 – 2	8	350
1 – 4	10	400
2 – 8	12	400
4 – 16	15	400
10 – 40	20	460

TABLE IV
Battery Drain

	48 Volts D.C.	125 Volts D.C.
SI-1 Relay	32MA	65 MA
SI-1 Relay with Indicator	65MA	100 MA
SI-Relay Single Output	32MA	65 MA
SI Relay Dual Output	65MA	105 MA
Maximum Output	20 MA at 20 Volts D.C.	

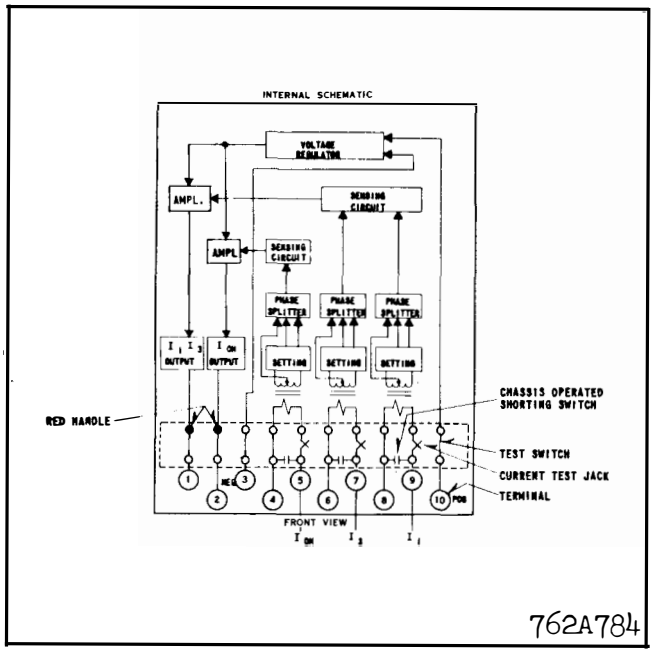
SETTING

The pickup of the relay is selected by adjusting the rheostat, S, in the front of the relay. Setting in between the scale marking can be made by applying the desired current and adjusting the rheostat until an output is obtained.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.



* *Fig. 3 Block diagram of the Type SI Relay in FT-21 case (for SI with single output omit the circuits connected to terminal 2).*

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer.

Acceptance Tests

* The following check is recommended to insure that the relay is in proper working order. All checks can best be performed by connecting the relay per the test circuit of Fig. 10. Refer to fig. 6 or fig. 7 and make similar connections for the test of the SI relay.

1. Minimum trip current — Check pickup at the minimum and maximum setting. This is accomplished by applying the specified current and checking that the voltmeter reads approximately 20 volts when the current is within 3% of the setting.

* 2. Dropout — After checking pickup, the dropout should be checked to be 96 to 98% of the pickup when the a.c. current is gradually reduced. For relay with fast reset characteristics, the dropout ratio should be 89 to 92%.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

Calibration

Use the following procedure for calibrating the SI-1 relay if the relay adjustments have been distributed. This procedure should not be used until it is apparent that the relay is not in proper working order. A new scale plate may be necessary when parts are changed. This procedure must be repeated for the other two inputs on the type SI relay.

Splitter Adjustments

1. Turn rheostat (S) on front of relay to extreme counter-clockwise position.
2. Apply minimum S current to the proper relay terminals.
3. With a high resistance voltmeter (a.c.) adjust phase splitter potentiometer such that three voltages approximately equal to each other are obtained across TP 1, printed circuit board terminal 12 and printed circuit board terminal 18 or 14.

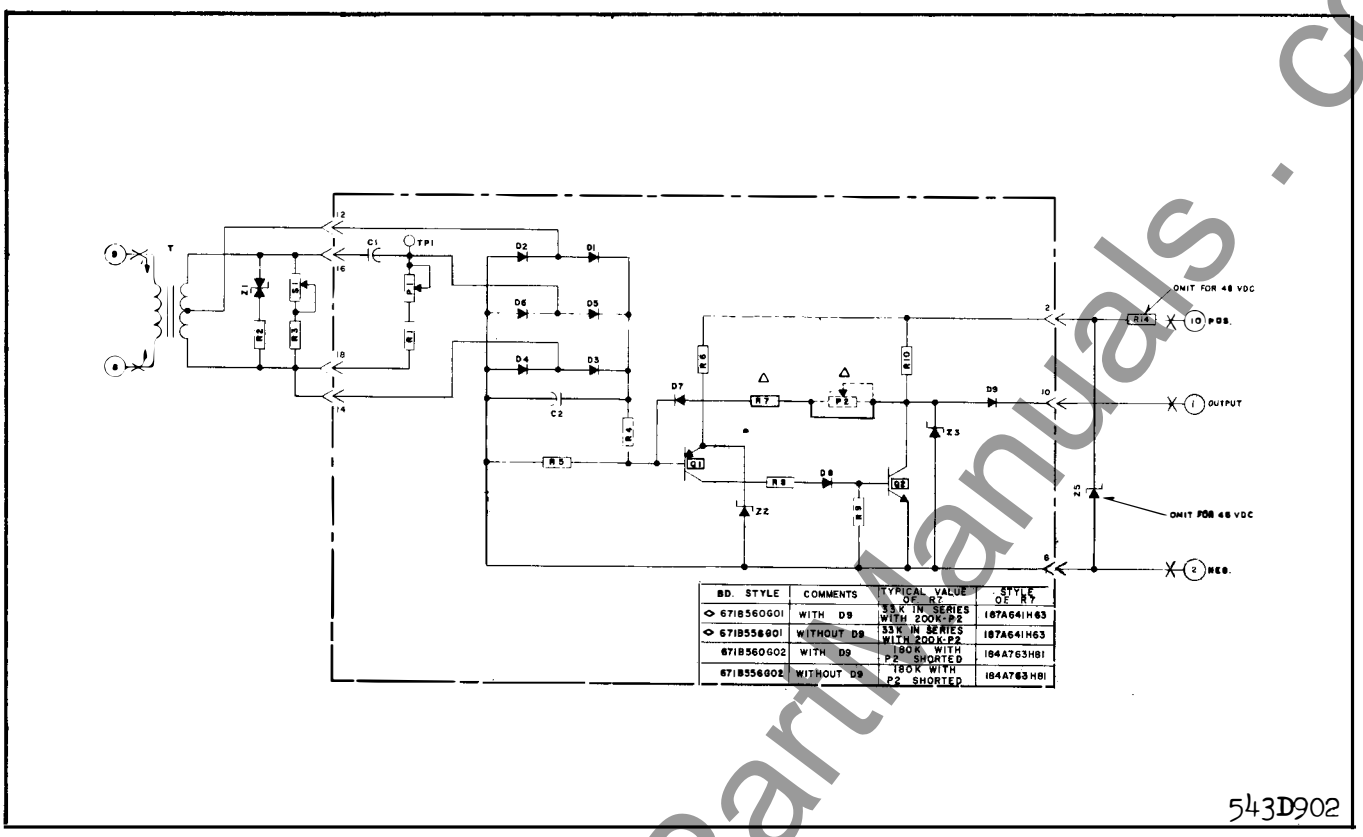
Dial Calibration (S)

1. Apply 125 volts d.c. to relay terminals 10 and 2. Terminal 10 is positive.
2. Connect a high resistance d.c. voltmeter across terminals 1 and 2. Terminal 1 is positive.
3. Apply desired S current to terminal 8 and 9.
4. Turn S rheostat until the relay operates as indicated by a sudden reading of approximately 20 volts d.c. on meter.

* Drouput (P) (Where Used)

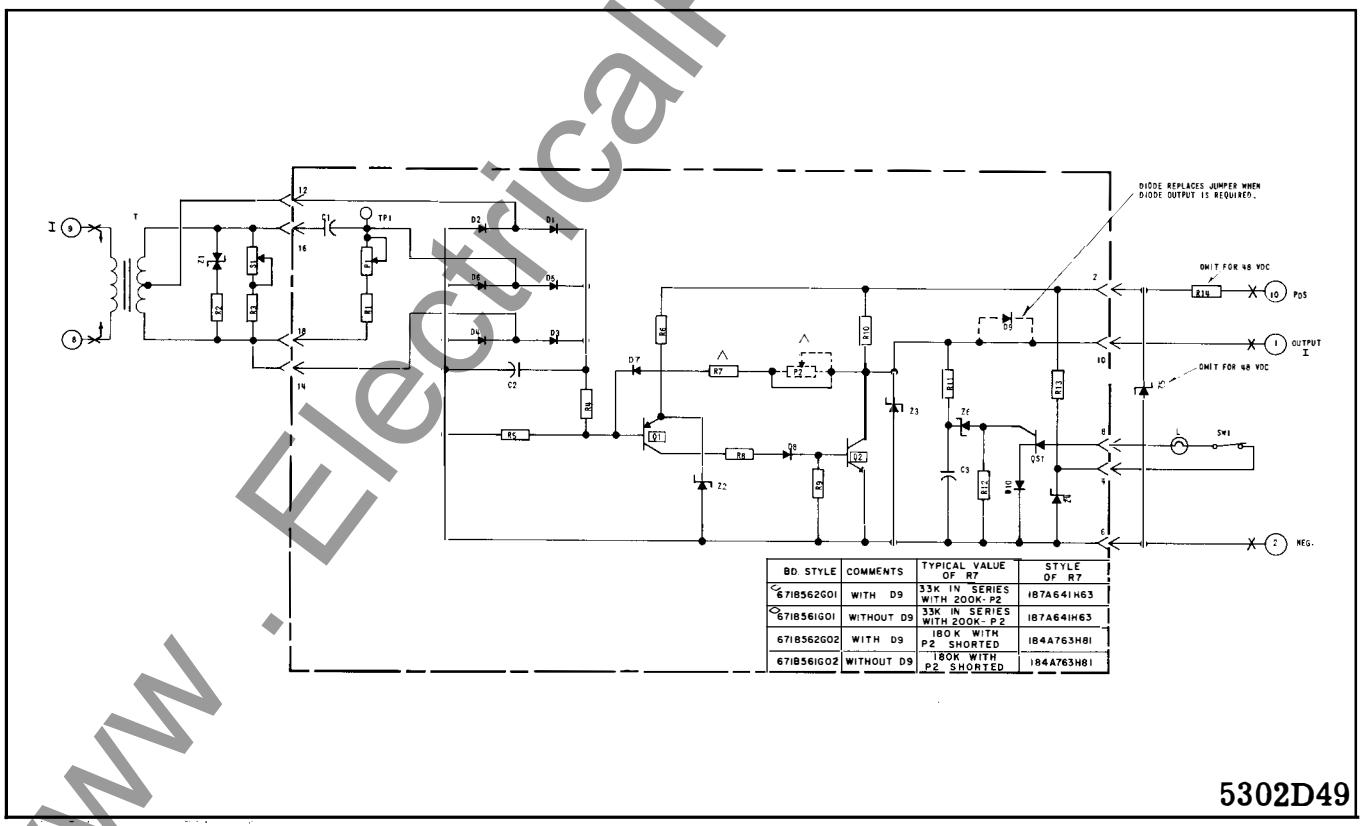
1. Set S on desired point and apply S amperes to relay to make it operate.
2. Lower S amperes to desired droput value and adjust P potentiometer until voltmeter drops to approximately zero.
3. Verify dropout and pickup several times by raising a.c. current until relay operates and then lowering the a.c. current until relay dropouts.

* On those relays, where dropout adjustment P is not used, the dropout ratio will be 96 to 98% of pickup on the standard relay and 89 to 92% on the fast reset relay.



BD. STYLE	COMMENTS	TYPICAL VALUE OF R7	STYLE OF R7
◇ 671B560G01	WITH D9	33K IN SERIES WITH 200K-P2	187A641H63
◇ 671B556G01	WITHOUT D9	33K IN SERIES WITH 200K-P2	187A641H63
671B560G02	WITH D9	180K WITH P2 SHORTED	184A763H81
671B556G02	WITHOUT D9	180K WITH P2 SHORTED	184A763H81

* *Fig. 4 Internal Schematic for the type SI-1 Relay.*



BD. STYLE	COMMENTS	TYPICAL VALUE OF R7	STYLE OF R7
◇ 671B562G01	WITH D9	33K IN SERIES WITH 200K-P2	187A641H63
◇ 671B561G01	WITHOUT D9	33K IN SERIES WITH 200K-P2	187A641H63
671B562G02	WITH D9	180K WITH P2 SHORTED	184A763H81
671B561G02	WITHOUT D9	180K WITH P2 SHORTED	184A763H81

* *Fig. 5 Internal Schematic for the type SI-1 Relay with an operation indicator.*

Trouble Shooting Procedure

Use the following procedure to locate the source of trouble if the SI-1 relay or the SI relay is not operating correctly.

1. Inspect all wires and connections, paying particular attention to printed circuit terminals.
2. Check resistances as listed on the internal schematic of the relays.
3. Check voltages as listed on the electrical checkpoints.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ELECTRICAL CHECKPOINTS

* Connect relay per test circuit of Fig. 10. All voltage readings should be made with a high resistance voltmeter. Refer to Fig. 11 or 12 for printed circuit board points. For some readings it is necessary to scrape varnish from the components to make a connection at the point.

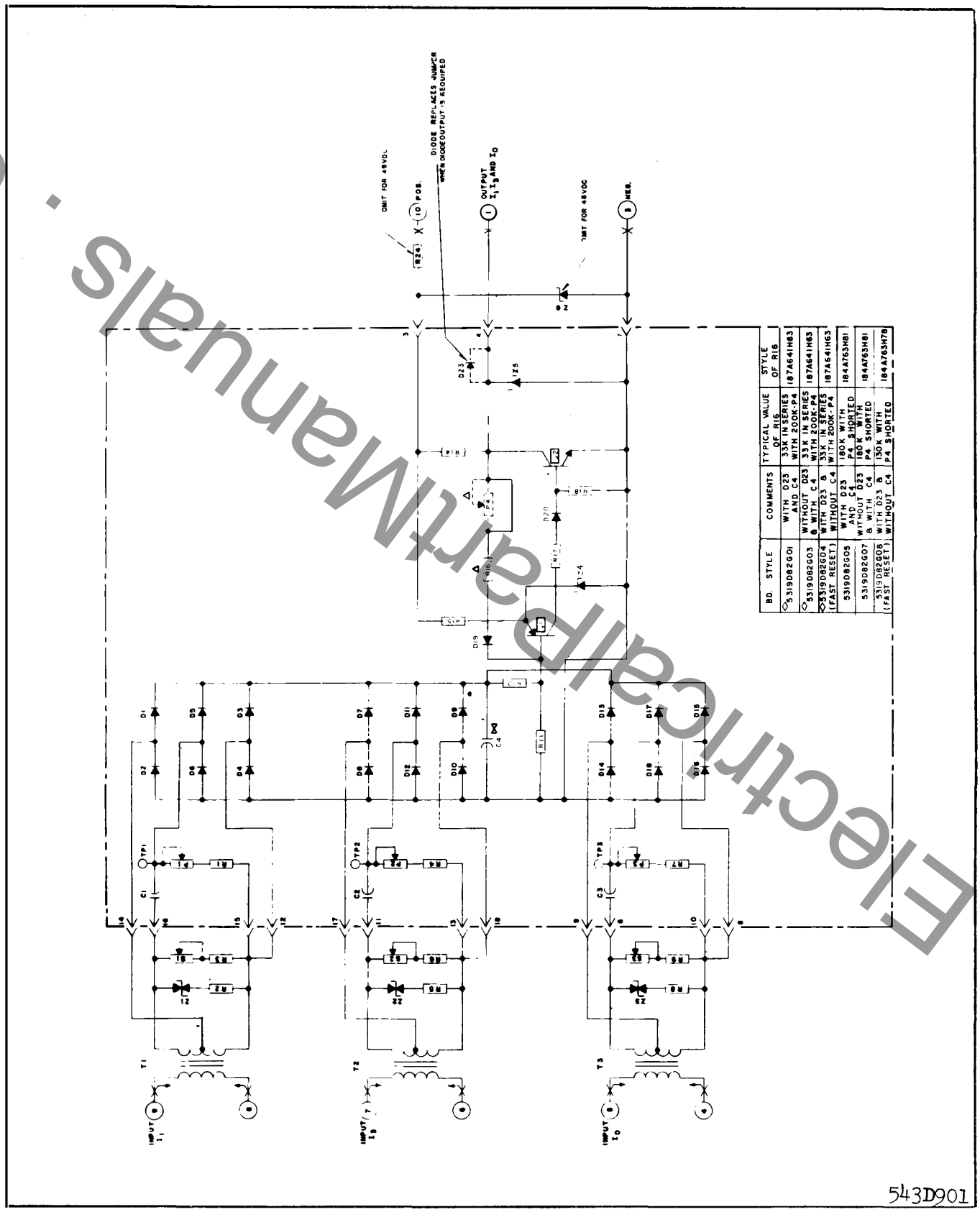
I No. A.C. Current Input 125 volts d.c.

Component	Negative terminal	Approximate d.c. voltage
Z_2	2	7
Z_3	2	less than .6 volts
Z_5	2	45 volts

II Minimum Trip A.C. current applied

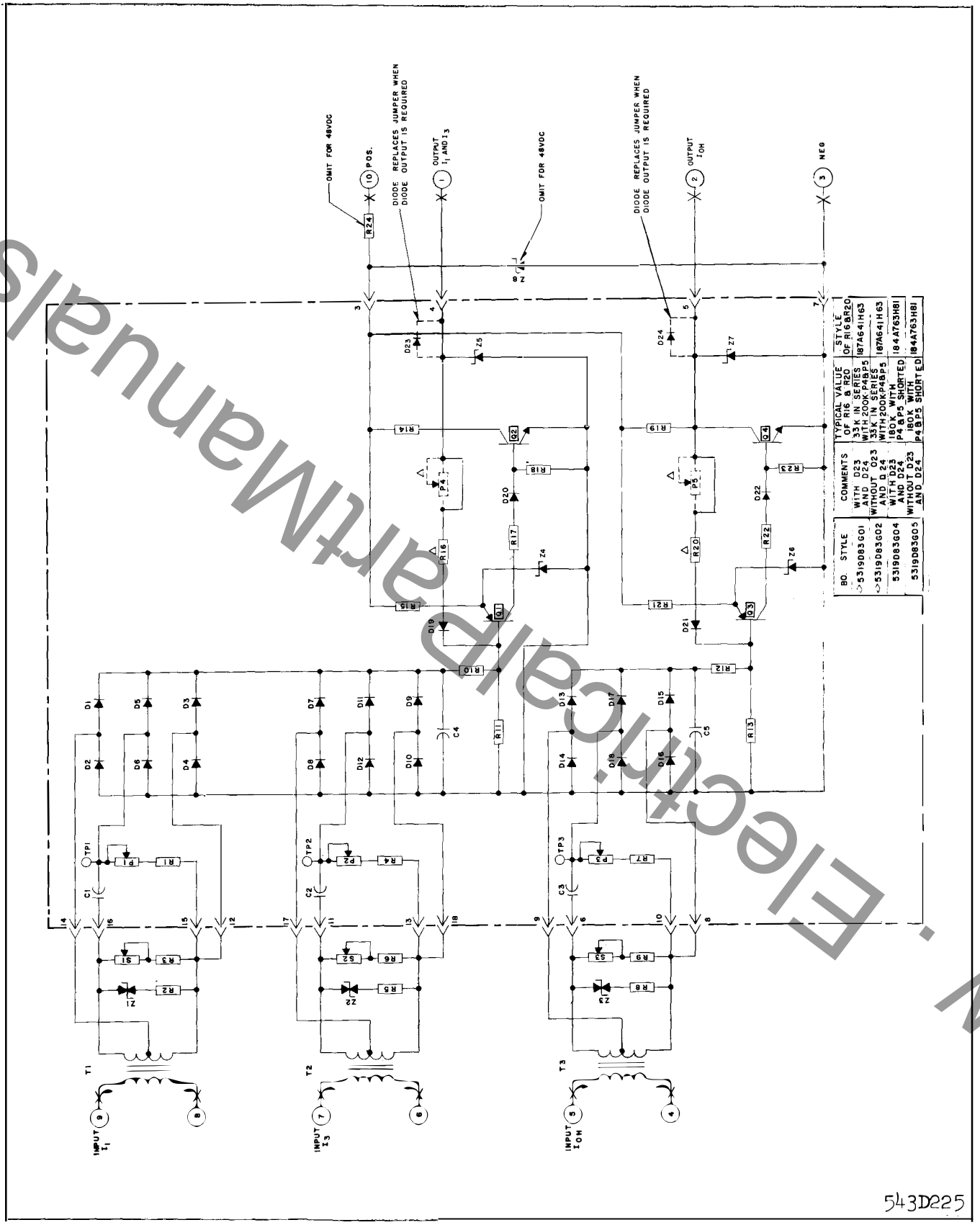
Circuit	Terminals	Voltage
Phase	TP_1 to board 18	7.5 volts a.c.
Splitter	TP_1 to board 12	7.5 volts a.c.
	Board 12 to board 18	7.5 volts a.c.
Setting	Board 16 to board 18	15 volts a.c.
Output	Terminal 1(+) and 2	18 to 22 volts D.C.

The above terminals are for the SI-1 relay. For corresponding terminals for the SI relay, refer to the relay.

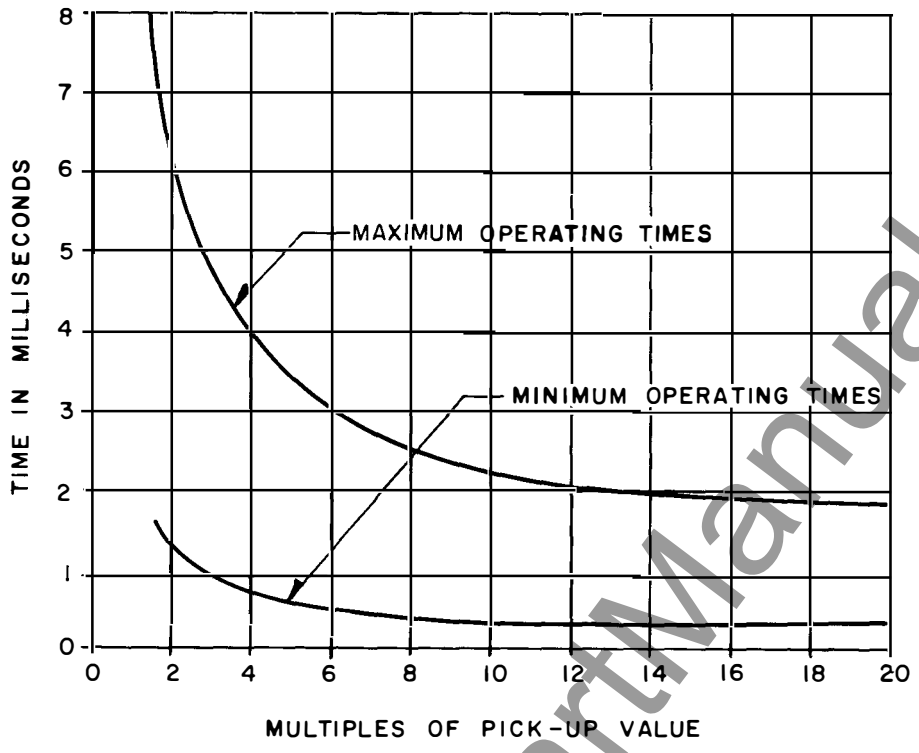


BD. STYLE	COMMENTS	TYPICAL VALUE OF R16	STYLE OF R16
◇ 53190826O1	WITH D23 AND C4	33K IN SERIES WITH 200K-P4	187A641H63
◇ 53190826O3	WITHOUT D23 & WITH C4	33K IN SERIES WITH 200K-P4	187A641H63
◇ 53190826O4 (FAST RESET)	WITH D23 & WITHOUT C4	33K IN SERIES WITH 200K-P4	187A641H63
53190826O5	WITH D23 AND C4	180K WITH P4 SHORTED	184A763H81
53190826O7	WITHOUT D23 & WITH C4	180K WITH P4 SHORTED	184A763H81
53190826O8 (FAST RESET)	WITH D23 & WITHOUT C4	150K WITH P4 SHORTED	184A763H78

* *Fig. 6 Internal Schematic for the type SI Relay with a single output.*



* *Fig. 7 Internal Schematic of the type SI Relay with a double output.*



* *Fig. 8 Operating time for the type SI and SI-1 Relays.*

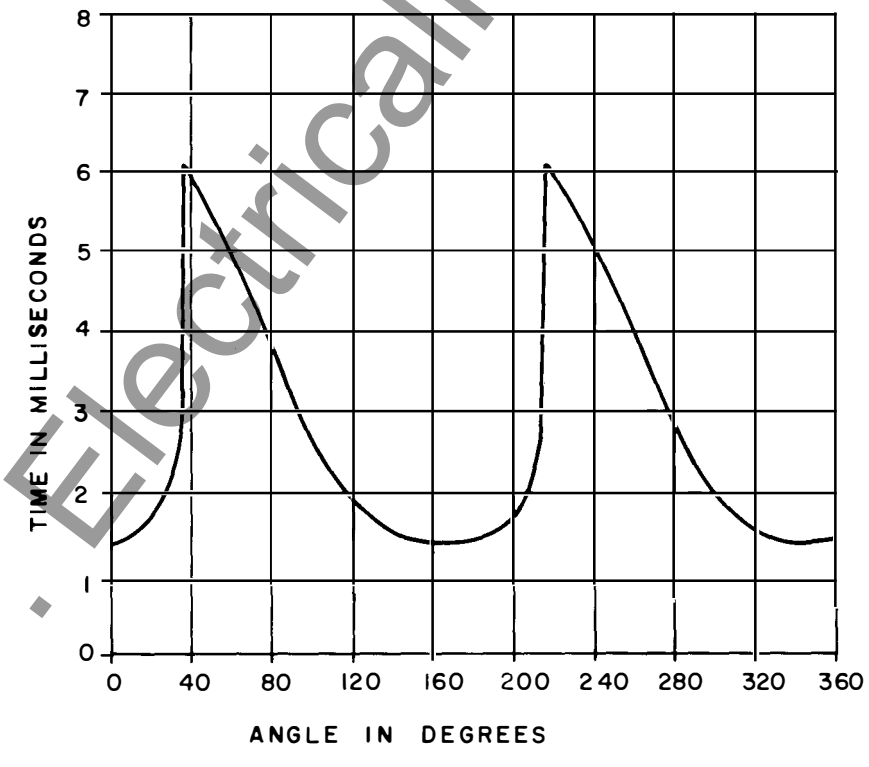


Fig. 9 Operating time for the type SI and SI-1 Relays as a function of fault incidence angle at twice minimum trip.

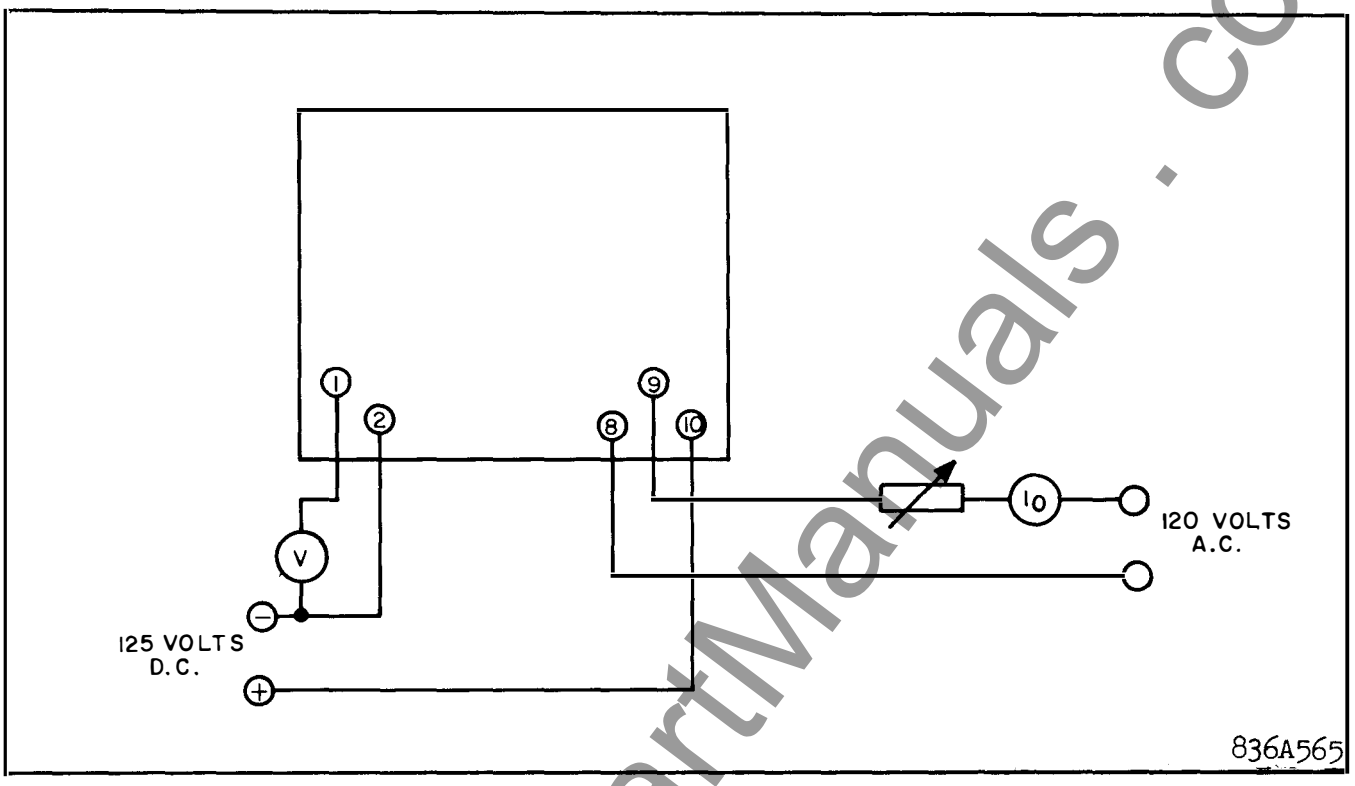
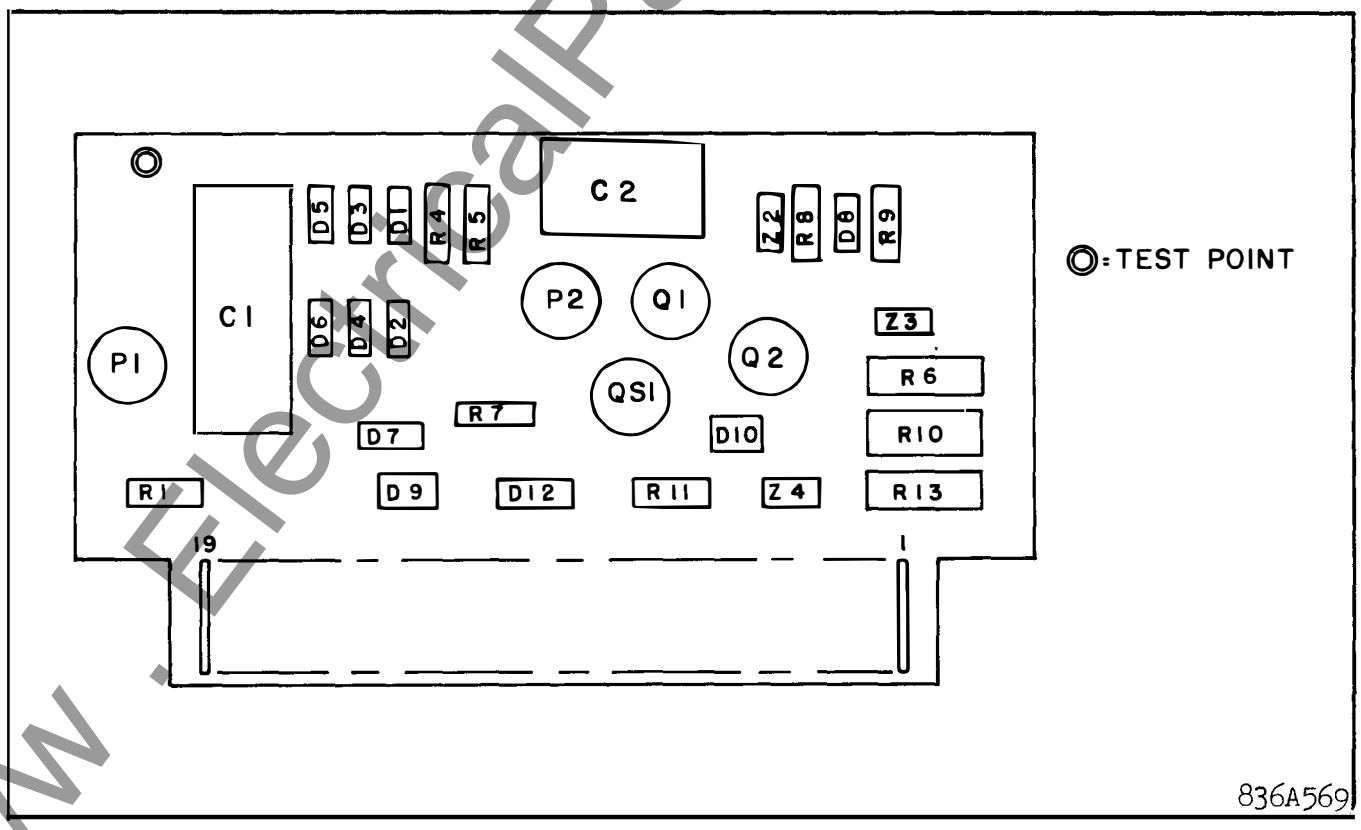
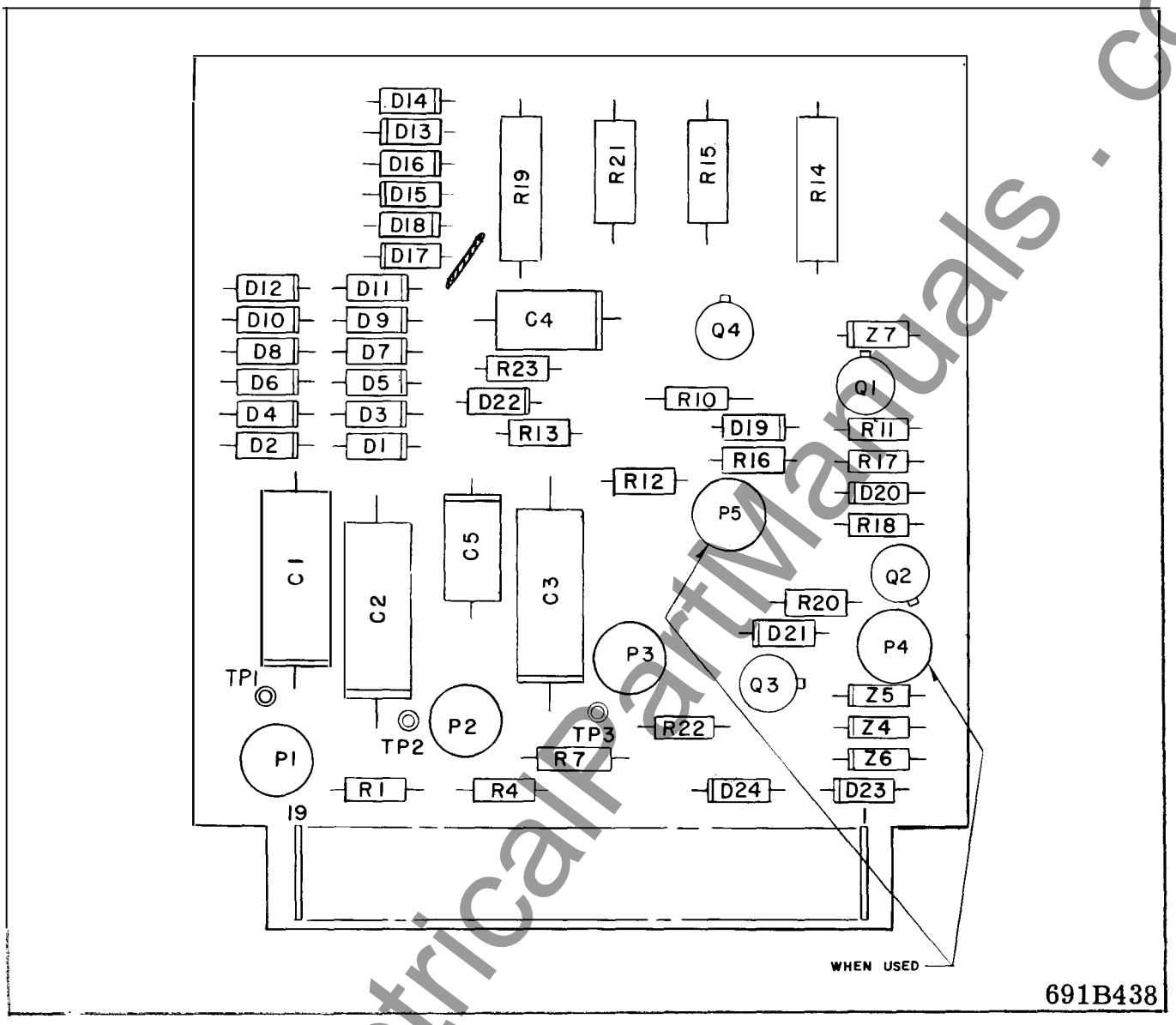


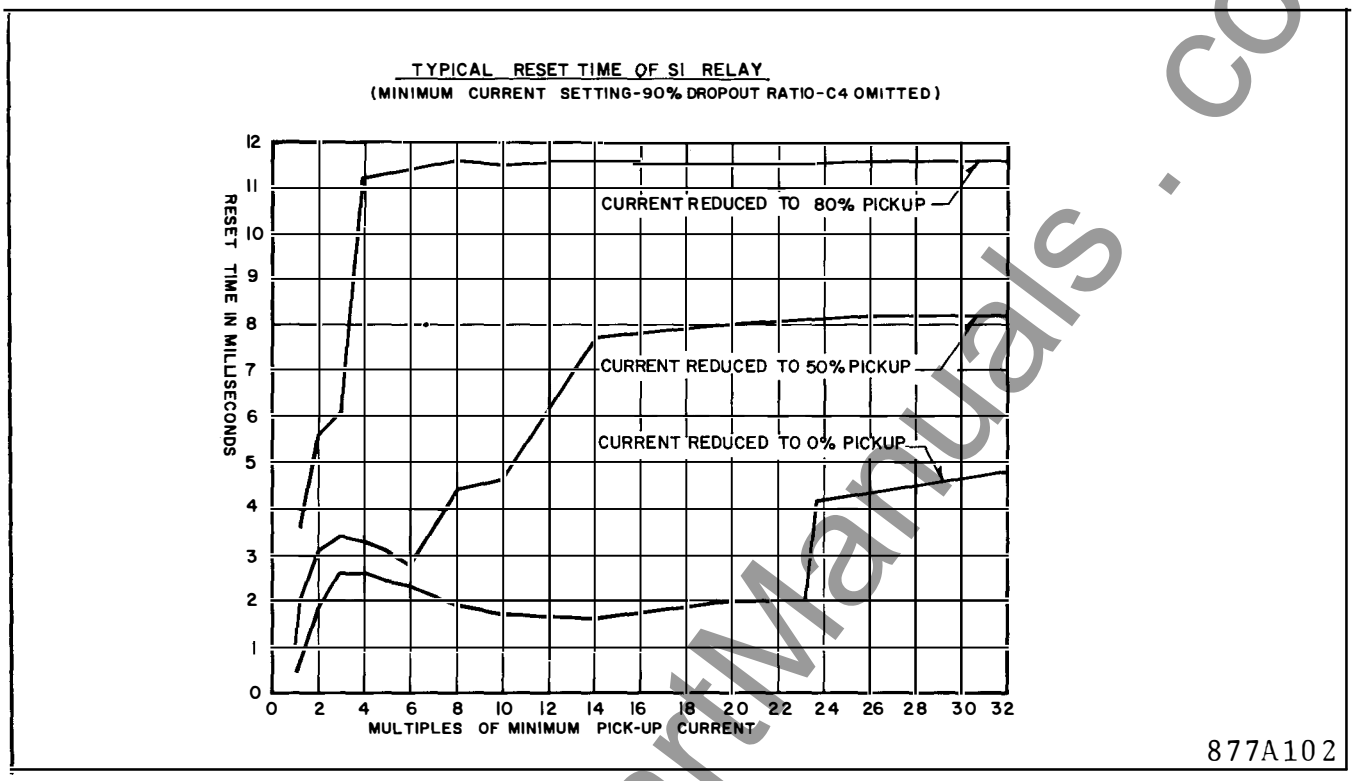
Fig. 10 Test circuit for the type SI-1 Relay.



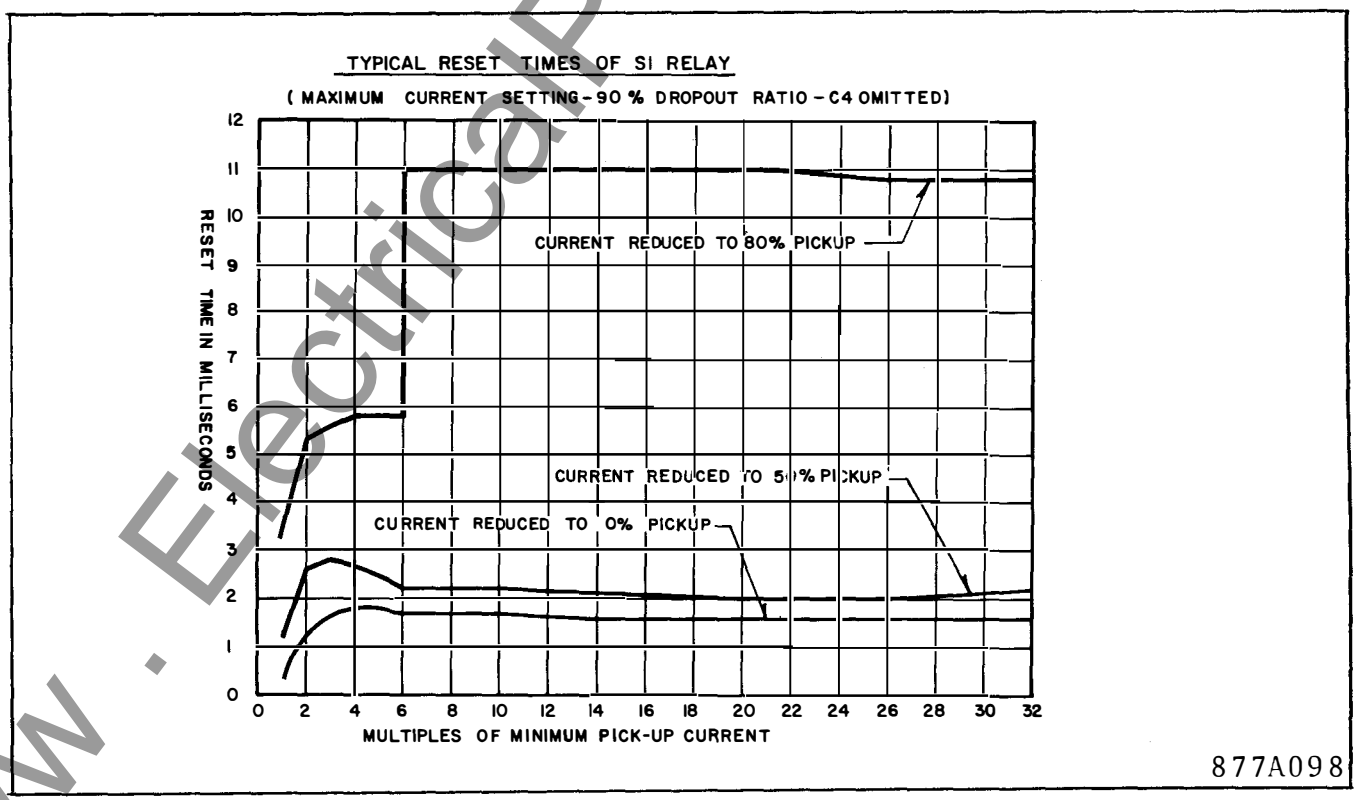
* *Fig. 11 Component location on printed circuit board for the type SI-1 Relay.*



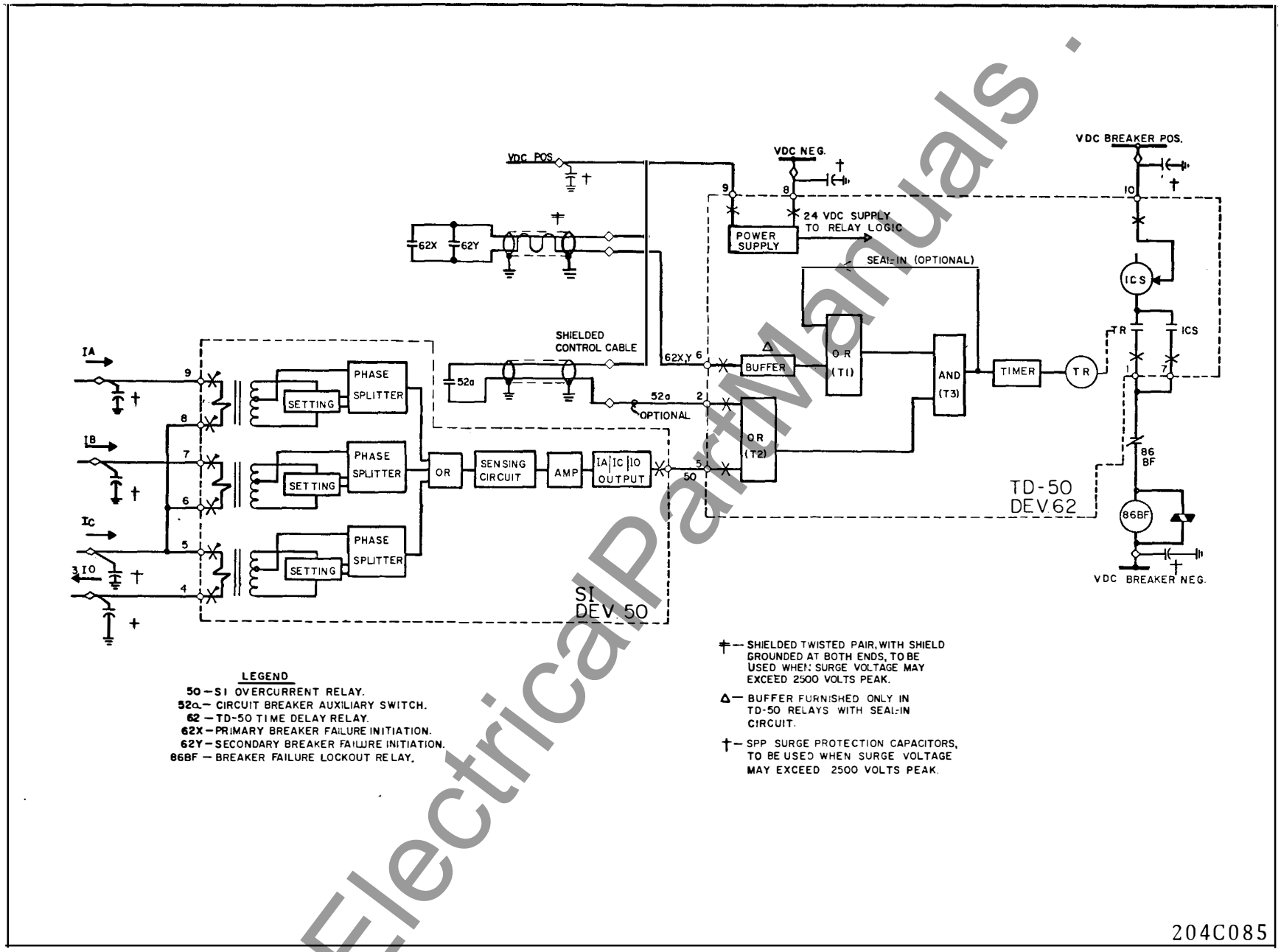
* *Fig. 12 Component location on printed circuit board for the type SI Relay.*



* *Fig. 13 Reset time of SI Relay with C4 removed at minimum setting*



* *Fig. 14 Reset time of SI Relay with C4 removed at maximum setting.*



** Fig. 15 External schematic of SI-TD-50 Breaker Failure System.*

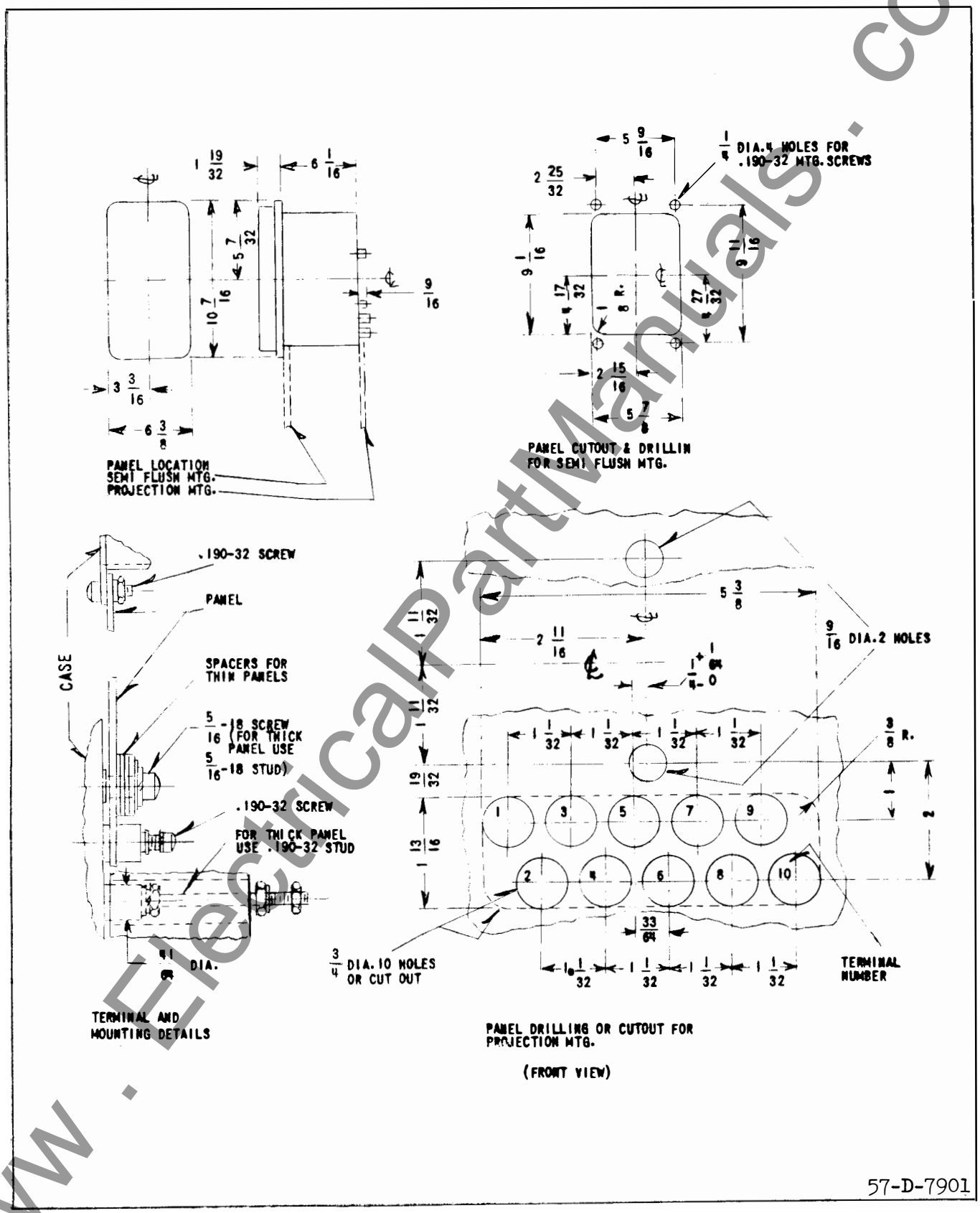


Fig. 16 Outline and drilling plan for the type SI Relay in the FT-21 case.

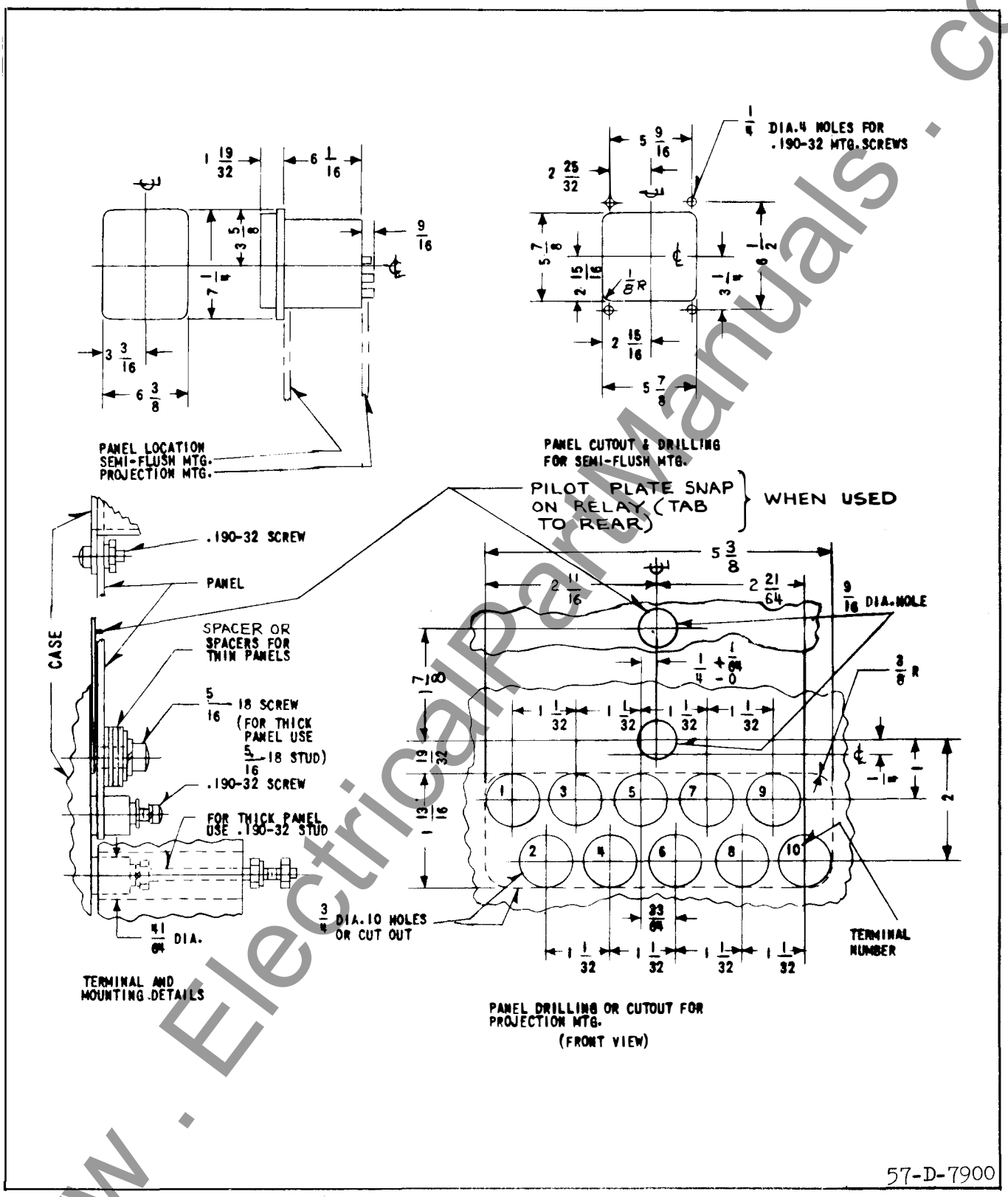


Fig. 17 Outline and drilling plan for the type SI-1 Relay in the FT-11 case.