INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE COD
CURRENT SENSING RELAY

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These relays are used to initiate switching or control operations when the line current rises above a preset value, or falls below a preset value. Thus the relay is a current sensing device with high and low current settings.

CONSTRUCTION

The relay consists of an induction disc type current sensing unit.

Current Sensing Unit

The electromagnet is an "E" type laminated structure with a current coil, which may be tapped, mounted on the center leg that produces a flux which divides and returns through the outer legs. A shading coil on the right leg, front view, causes the flux to lag the main pole flux. The out-of-phase fluxes, thus produced in the air gap cause torque on the disc.

When the current sensing unit contact closes to the right this indicates that the line current is at or above the value of current desired. Conversely when the current sensing unit contact closes to the left this indicates that the line current is at or below value of current desired.

* Indicating Contactor Switch Unit (ICS) (Optional)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attracted, is attracted to the magnetic core upon energization of the switch. When the switch closes the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop.

* The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

CHARACTERISTICS

The type COD current sensing relay has adjustable high and low current contacts that can be set around a 150° arc which is calibrated in amperes on non-tapped relays, or in percent of tap value current on tapped relays. These values represent the tripping position of the moving contacts when that value of current is applied to the relay. For the tapped relays the percent scale markings are 80, 85, 90, 95, 100, 105 and 110.

The relays are available in the following ranges:

* Range	Taps						
.5 – 2.5	0.5	0.6	0.8	1.0	1.5	2.0	2.5
2 – 6	2	2.5	3	3.5	4	5	6
4 – 12	4	5	6	7	8	10	12
.2 – .8				none			
.5 – 2				none			
1.5 – 6				none			

The moving contacts will assume a position corresponding to the current applied to the relay and will stay in that position until the current changes. If the current changes either gradually or suddenly, the contact will assume a new position corresponding to the change unless the travel is limited by the setting of the adjustable contacts. If the contacts are set to close for a particular value of current, and if a current of that exact amount is applied, then the relay is operating at its minimum trip point and the times on repeated operations are not repetitive within close tolerances. However, currents appreciably greater than the overcurrent setting, or appreciably less than the undercurrent setting, result in relay timing operations which are consistent for repeated trials.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-112A
*Denotes change from superseded issue.

EFFECTIVE MAY 1971

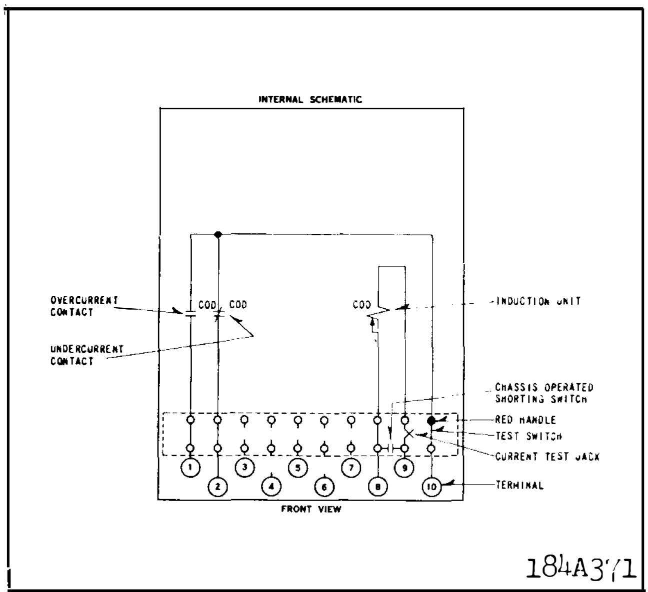


Fig. 1 Internal Schematic of the Tapped Type COD Relay in the Type FT 11 Case.

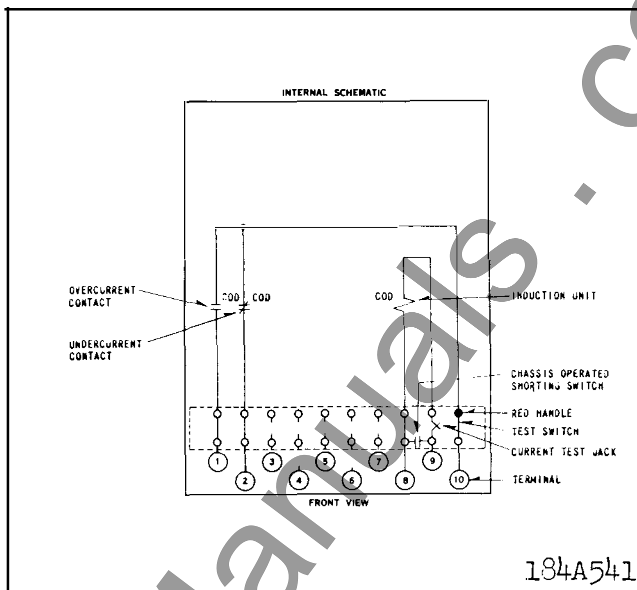


Fig. 2 Internal Schematic of the Non-Tapped Type COD Relay in the Type FT 11 Case.

The induction unit has inverse timing; that is, the greater the change in current the faster the relay contact will travel.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. 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. See Fig. 4 for outline & drilling plan.

SETTINGS

The current sensing unit settings can be defined either by contact settings or tap setting. The high and low current contact settings are described under "Characteristics".

Relays which are tapped have a connector screw on the terminal plate above the scale which makes connections to various turns on the operating coil. The tap setting is made by placing this screw in the desired tap as marked on the terminal plate.

Caution

Since the tap block connector screw carries operating current, be sure that the screw is turned tight. In order to avoid opening the current transformer circuits when changing taps under load, connect the spare connector screw in the desired tap position before removing the other tap screw from the original tap position.

* **Indicating Contactor Switch (ICS) (Optional)**

The only setting required on the ICS unit, is the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

ADJUSTMENTS AND MAINTENANCE

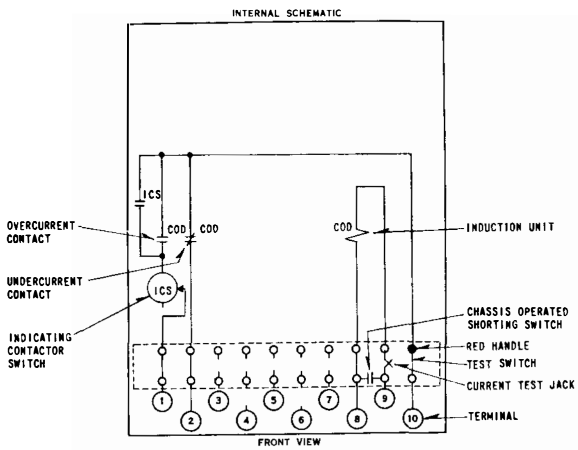
The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay no customer adjustments, other than those covered under "SETTING" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

A. Current Sensing Unit

1. Contact Adjustment Check — Set the left-hand contact in the center of the scale and adjust the current until the moving contact just makes. Move the left-hand contact out of the way and bring the right-hand contact up until the contacts just make. The right pointer should be within ± 1/32" of where the left-hand pointer was.



185A430

Fig. 3 Internal Schematic of the Non-Tapped Type COD Relay with ICS Unit in overcurrent circuit in the Type FT-11 case.

2. Calibration Check — Check the scale markings by setting either of the two contacts at a value marked on the scale, then alternately apply this current plus 0.1 amp and minus 0.1 amp for non-tapped relays, and plus and minus 3% for tapped relays. The undercurrent contact should make at the lower current and break at the higher current. For the overcurrent contact check, the contact will make for the higher current and break at the lower current.

* **B. Indicating Contactor Switch (ICS) (Optional)**

Close the main relay contacts in over current circuit and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

Routine Maintenance

All relays should be inspected periodically and the time of operation should be checked at least once every year or at such other time intervals as may be dicatated by experience to be suitable to the particular application. The use of phantom loads, in testing induction-type relays, should be avoided, since the resulting distorted current wave form will produce an error in operation.

All contacts should be periodically cleaned. A contact burnisher #182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

A. Current Sensing Unit

1. Contacts — Apply sufficient current to the relay, to make the disc float in the center of its travel. Move both of the adjustable contacts until they just make with the moving contact. If the two contact pointers do not meet at the same point on the scale (± 1/32"), adjust the follow on both adjustable contacts. Approximately the same follow should be in each of the adjustable stationary contacts.

2. **Calibration Check** — The adjustment of the spring tension in calibrating the relay is most conveniently made with the damping magnet removed.

Set either of the adjustable stationary contacts in the center of its travel and apply this current to the relay. Wind up the spiral spring by means of the spring adjuster until the stationary contact and moving contact just make.

Check the other markings by setting the adjustable contact on these markings and applying the corresponding current to the relay. The contacts should make within plus or minus .1 amp of contact setting for non-tapped relays and plus or minus 3% of contact setting for tapped relays.

* **B. Indicating Contactor Switch (ICS) (Optional)**

Close the main relay contacts in overcurrent circuit and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

* The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

The 60 cycle burdens for the COD relay are as follows:

Tapped Relays

AMPERE RANGE	TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING* (AMPERES)	POWER FACTOR ANGLE ɸ	VOLT AMPERES** AT TAP VALUE CURRENT	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
	(0.5	2.7	88	72	2.38	21	132	350
	(0.6	3.1	88	71	2.38	21	134	365
	(0.8	3.7	88	69	2.40	21.1	142	400
0.5/2.5	(1.0	4.1	88	67	2.42	21.2	150	440
	(1.5	5.7	88	62	2.51	22	170	530
	(2.0	6.8	88	57	2.65	23.5	200	675
	(2.5	7.7	88	53	2.74	24.8	228	800
	(2	8	230	70	2.38	21	136	360
	(2.5	8.8	230	66	2.40	21.1	142	395
	(3	9.7	230	64	2.42	21.5	149	430
2/6	(3.5	10.4	230	62	2.48	22	157	470
	(4	11.2	230	60	2.53	22.7	164	500
	(5	12.5	230	58	2.64	24	180	580
	(6	13.7	230	56	2.75	25.2	198	660
	(4	16	460	68	2.38	21.3	146	420
	(5	18.8	460	63	2.46	21.8	158	480
	(6	19.3	460	60	2.54	22.6	172	550
4/12	(7	20.8	460	57	2.62	23.6	190	620
	(8	22.5	460	54	2.73	24.8	207	700
	(10	25	460	48	3.00	27.8	248	850
	(12	28	460	45	3.46	31.4	292	1020

Non-Tapped Relays

AMPERE RANGE	CONTINUOUS RATING (AMPERES)	POWER FACTOR ANGLE ɸ	VOLT AMPERES** AT MINIMUM SETTING	AT MAXIMUM SETTING	AT 5 AMPERES
.5/2	5	76	0.48	7.6	42.5
1.5/6	12	74	0.48	7.6	4.7

**Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.*

ɸDegrees current lags voltage at tap value current.

***Voltages taken with Rectox type voltmeter.*

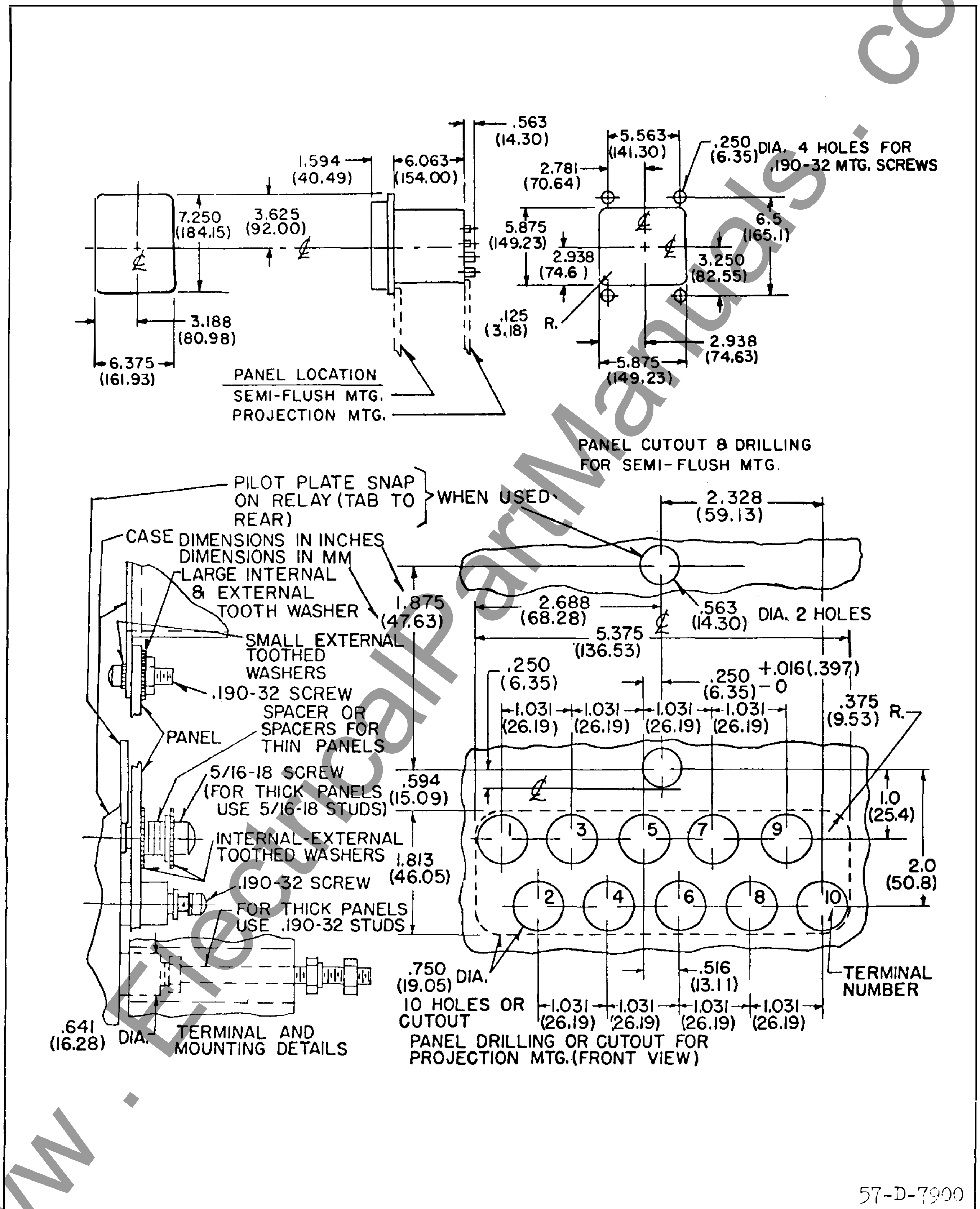


Fig. 4 Outline and Drilling Plan for the Type COD Relay in the Type FT 11 Case.

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SCO-T SOLID STATE SINGLE PHASE OVERCURRENT RELAY

CAUTION: It is recommended that the user become acquainted with the information in this instruction leaflet before energizing the equipment. Failure to observe this precaution may result in damage to the equipment.

APPLICATION

The SCO-T relay is a single phase solid state non-directional time over-current device. It is used to sense current level above the setting and normally is used to trip a circuit breaker to clear faults. A wide range of characteristics permit applications involving coordination with fuses, reclosers, cold load pickup, motor starting, or essentially fixed time applications.

The following describes typical applications of the SCO-T Relay:

RELAY TYPE	CURVE MODULE	TIME CURVE	TYPICAL APPLICATIONS
SCO-2T	A02	Short	1) Differential protection where saturation of current transformers is not expected, or where delayed tripping is permissible. 2) Overcurrent protection, phase or ground, where coordination with downstream devices is not involved and 2 to 60 cycle tripping is allowable.
SCO-5T	A05	Long	Motor locked rotor protection where allowable locked rotor time is approximately between 10 and 70 seconds.
SCO-6T	A06	Definite	Overcurrent protection where coordination with downstream devices is not involved and SCO-2T is too fast. The operating time of this relay does not vary greatly as current level varies.
SCO-7T	A07	Moderately Inverse	1) Overcurrent protection where coordination with other devices is required, and generation varies.
SCO-8T	A08	Inverse	2) Backup protection for relays on other circuits.
SCO-9T	A09	Very Inverse	
SCO-11T	A11	Extremely Inverse	1) Motor protection where allowable locked rotor time is less than 10 sec. 2) Overcurrent protection where coordination with fuses and reclosers is involved, or where cold load pickup or transformer inrush are factors.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-111B DATED JULY 1982
✪ DENOTES CHANGED SINCE PREVIOUS ISSUE
EFFECTIVE APRIL 1984

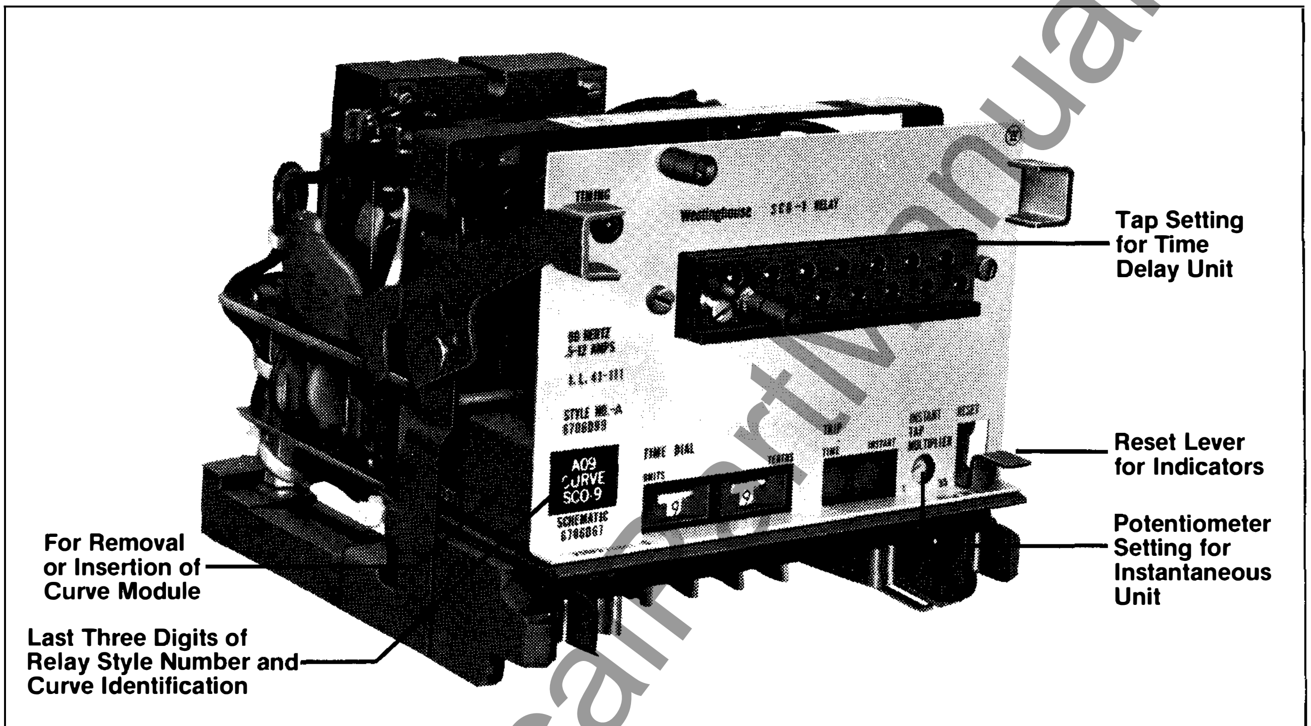


Fig. 1. Type SCO-T Relay—Front Left Side View

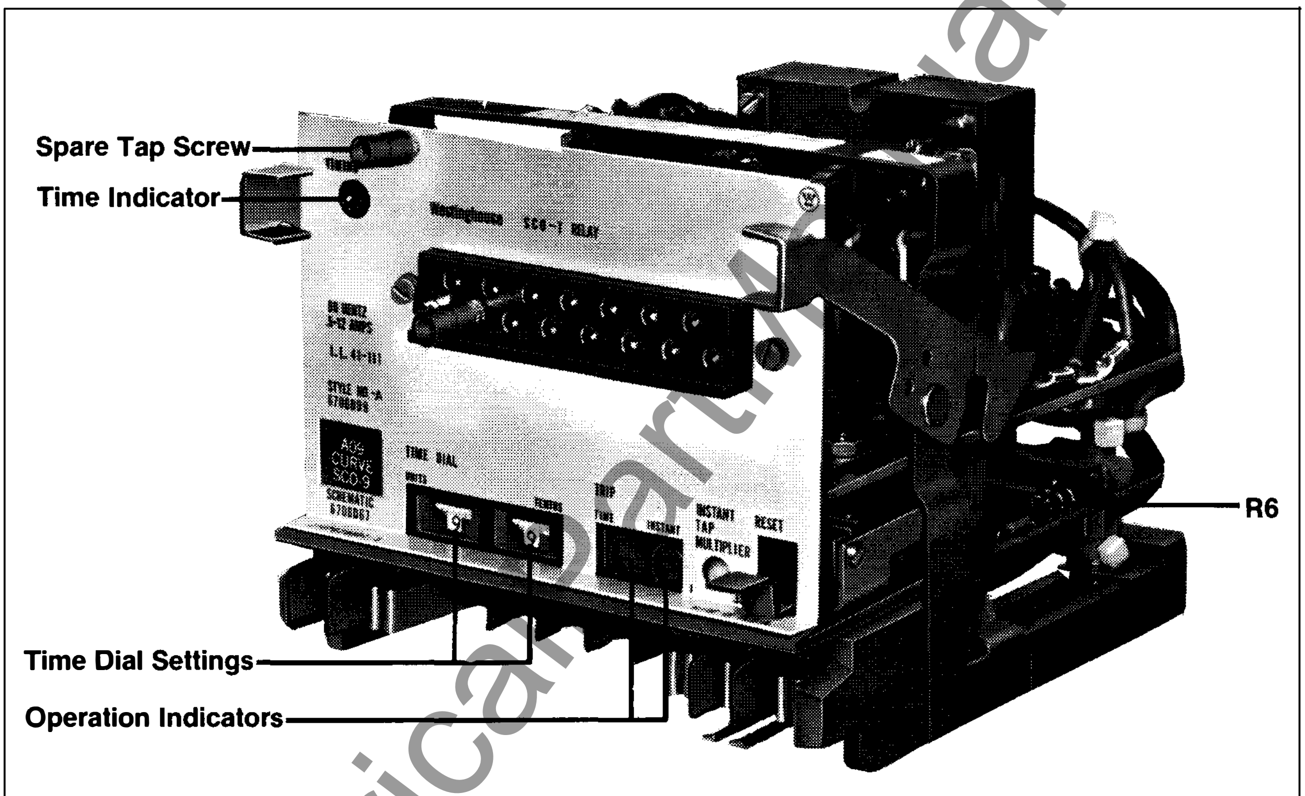


Fig. 2. Type SCO-T Relay—Front Right Side View

The SCO-T relay is equipped with an instantaneous trip feature with separate trip output to provide high speed tripping for high current faults.

Instantaneous trip units can be applied effectively where wide variations in fault currents occur for different fault locations, but have limited applications where wide variations in fault currents occur for a fixed fault location. It responds to total current and must be set to include the effect of dc current and to override the conditions that should be ignored such as transformer inrush, motor locked rotor, and faults outside of the desired trip zone.

Independent contact trip outputs and separate indication are provided for the instantaneous and time delay trip outputs. No indication occurs unless there is current flow in the trip circuit. Indicator reset is accomplished manually.

The relay is self contained in that the power supply for the solid state logic is derived from the current transformer. There is no continuous drain on the tripping battery.

See SETTINGS Section for further application data.

CONSTRUCTION

The SCO-T relay is a static relay consisting of 2 printed circuit modules, a time curve plug-in module, and a front panel assembly, packaged in a FT-11 case. For detailed information on the flexitest case, referred to I.L. 41-076.

The photographs in Figures 1 and 2 show the front left and front right view of the SCO-T reay removed from the case.

All of the circuitry suitable for mounting on printed circuit boards is contained on the two modules horizontally mounted on posts behind the front panel. The top module contains the transformer and "front-end" circuitry and the trip output relays for the SCO-T while the bottom module contains the power supply, information sensing, curve shaping, tripping and indication circuitry, as well as the plug-in curve module. Terminals for current input and trip output are located on the rear of the case, and all inputs and outputs pass through the FT switchjaws on the lower front part of the relay, below the front panel. The front panel, in addition to showing all pertinent style and setting information, has the minimum pickup indicator located on the upper left-hand side.

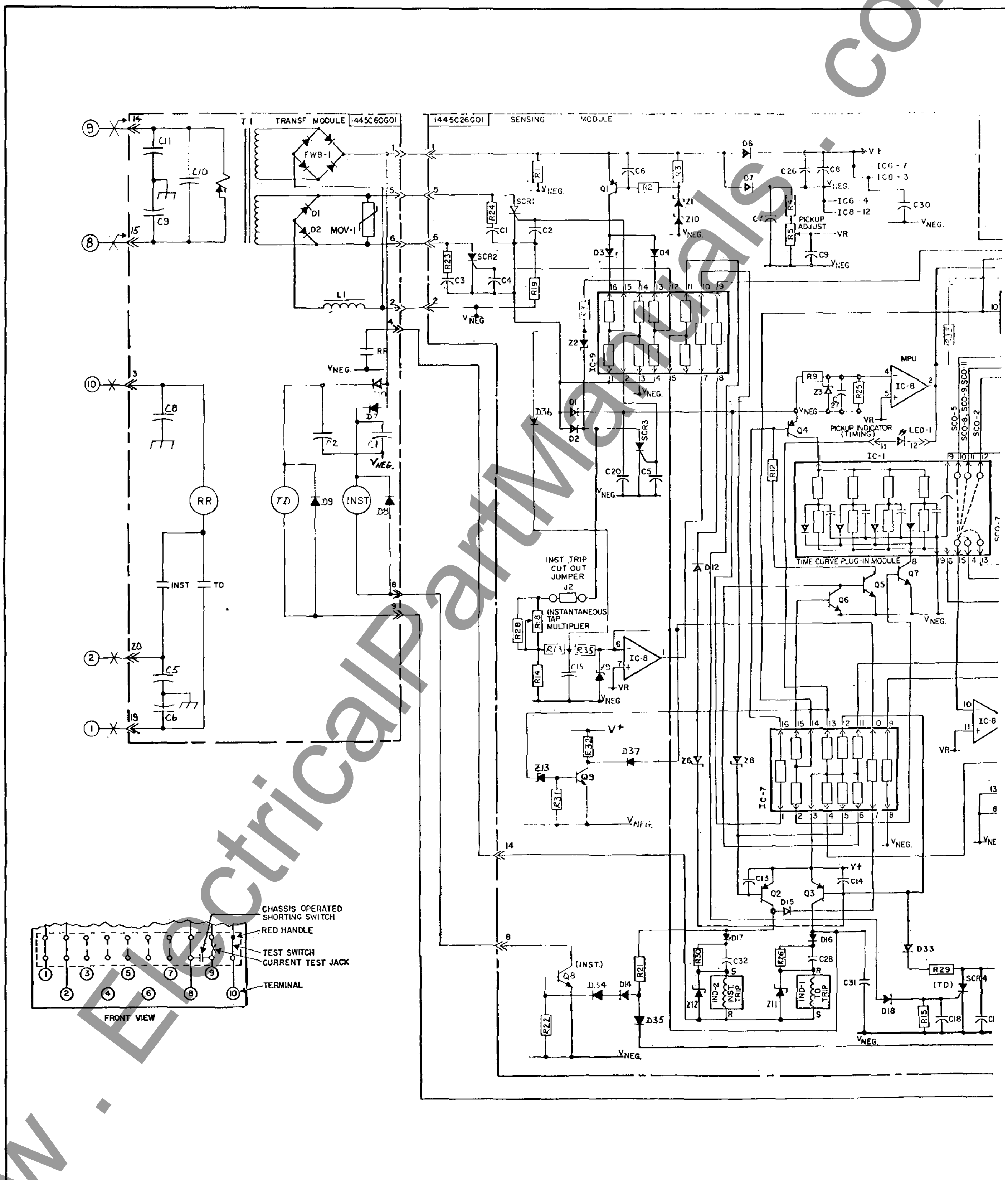
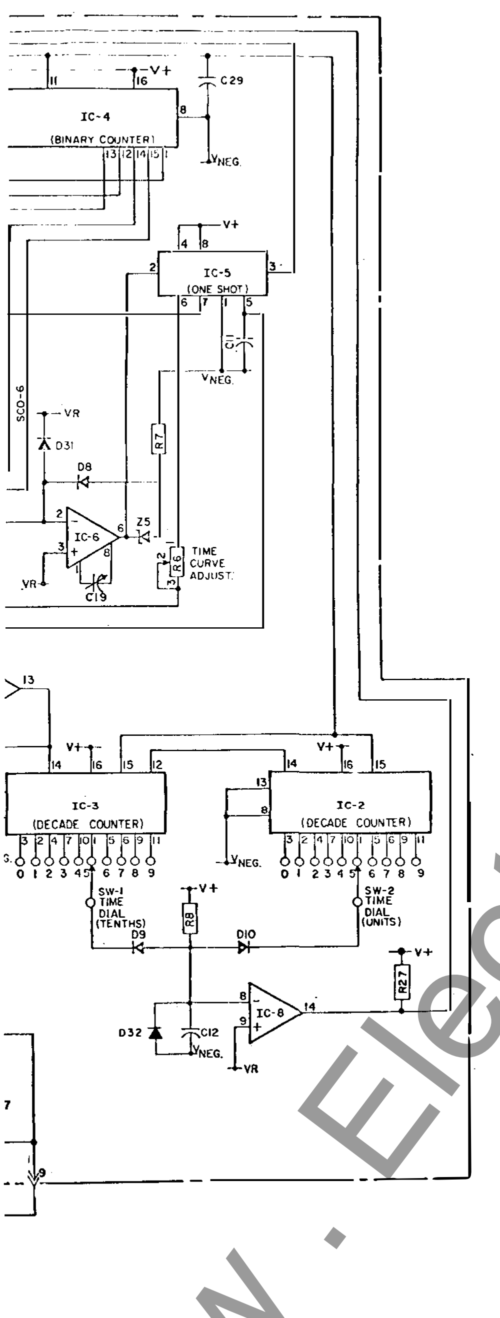


Fig. 3. SCO-T Interr



1445C26G01 SCO 1 PHASE

COMPONENT		DESCRIPTION		STYLE NO.
C32	CAPACITOR	22 UF	15 V	184A661H13
C1	CAPACITOR	.050UF	500V	879A211H13
C2	CAPACITOR	1000.000PF	100V	3509A34H01
C3	CAPACITOR	.050UF	500V	879A211H13
C4	CAPACITOR	1000.000PF	100V	3509A34H01
C5	CAPACITOR	1000.000PF	100V	3509A34H01
C6	CAPACITOR	.010UF	50V	3509A34H02
C7	CAPACITOR	22.000UF	16V	3509A32H01
C8	CAPACITOR	220.000UF	16V	3509A32H02
C9	CAPACITOR	470.000PF	1000V	879A211H10
C11	CAPACITOR	.010UF	50V	3509A34H02
C12	CAPACITOR	150.000PF	100V	3509A34H04
C13	CAPACITOR	.100UF	50V	3509A34H03
C14	CAPACITOR	.100UF	50V	3509A34H03
C15	CAPACITOR	.100UF	50V	717B624H07
C18	CAPACITOR	1000.000PF	100V	3509A34H01
C19	CAPACITOR	5.5-30PF	50V	3516A79H01
C20	CAPACITOR	2.000UF	200V	3509A33H01
~~C24~~	~~CAPACITOR~~	~~1000.000PF~~	~~100V~~	~~3509A34H01~~
C17	CAPACITOR	.02 MFD	500V	762A680H01
~~C25~~	~~CAPACITOR~~	~~.02 MFD~~	~~500V~~	~~762A680H01~~
C26	CAPACITOR	.470 UF	50 V	762A680H04
C27	CAPACITOR	[illegible] UF	[illegible] V	[illegible]
C28	CAPACITOR	22 UF	15 V	184A661H13
C29	CAPACITOR	.010 UF	500V	879A911H12
C30	CAPACITOR	.470 UF	50V	762A680H04
C31	CAPACITOR	22.000UF	16V	3509A32H01
D1	DIODE	1N4822		188A342H11
D2	DIODE	1N5406		188A342H21
D3	DIODE	1N4818		188A342H06
D4	DIODE	1N4818		188A342H06
D6	DIODE	1N4818		188A342H06
D7	DIODE	1N4818		188A342H06
D8	DIODE	1N4148		836A928H06
D9	DIODE	1N4148		836A928H06
D10	DIODE	1N4148		836A928H06
D12	DIODE	1N4148		836A928H06
D14	DIODE	1N4148		836A928H06
D15	DIODE	1N4148		836A928H06
D16	DIODE	1N4818		188A342H06
D17	DIODE	1N4818		188A342H06
D18	DIODE	1N4148		836A928H06
~~D19~~	~~DIODE~~	~~1N4822~~		~~188A342H11~~
~~D20~~	~~DIODE~~	~~1N4822~~		~~188A342H11~~
D31	DIODE	1N4148		836A928H06
D32	DIODE	1N4148		836A928H05
D33	DIODE	1N4148		836A928H06
IC2	INT CKT	4017AE		3494A01H15
IC3	INT CKT	4017AE		3494A01H15
IC4	INT CKT	4040AE		3494A01H14
IC5	INT CKT	SE555CV		774B956H01
IC6	INT CKT	LM301AN		775B061H01
IC8	INT CKT	MC3302P		775B062H01
IC7	INT CKT			775B106H01
IC9	INT CKT			775B107H01
J1	JUMPER	0 OHM RESISTOR		862A478H01
J2	JUMPER	0 OHM RESISTOR		862A478H01
J3	JUMPER	0 OHM RESISTOR		862A478H01
R5	POT	50.0K	.75W	880A826H06
R6	POT	10.0K	.75W	880A826H05
R18	POT	500K	.75W	3512A37H01
R1	RESISTOR	3.0K	.50W 2%	629A531H43
R2	RESISTOR	1000.0	.25W 5%	836A908H63
R3	RESISTOR	150.0	.50W 2%	629A531H12

COMPONENT		DESCRIPTION		STYLE NO.
R4	RESISTOR	51.0K	.50W 2%	629A531H73
R7	RESISTOR	300.0K	.25W 5%	836A909H23
R8	RESISTOR	100.0K	.50W 2%	629A531H80
R9	RESISTOR	100.0K	.50W 2%	629A531H80
R12	RESISTOR	24.3K	.50W 1%	862A377H39
R13	RESISTOR	30.0K	.50W 2%	629A531H67
R14	RESISTOR	7.5K	.50W 1%	862A376H35
R15	RESISTOR	200.0	.25W 5%	836A903H46
R19	RESISTOR	50.0	5.00W 1%	763A130H37
R21	RESISTOR	1000.0	.50W 1%	848A819H48
R22	RESISTOR	10.0K	.50W 2%	629A531H56
R23	RESISTOR	100.0	.50W 2%	629A531H08
R24	RESISTOR	100.0	.50W 2%	629A531H08
R25	RESISTOR	1.0 MEG	.50W 1%	848A822H39
R26	RESISTOR	1000.0	.50W 1%	848A819H48
R27	RESISTOR	51.0K	.50W 2%	629A531H73
R28	RESISTOR	2.2M	.50W 5%	187A290H26
R29	RESISTOR	10.0K	.50W 2%	629A531H56
R30	RESISTOR	1000.0	.50W 1%	848A819H48
Q1	TRANSISTOR	2N2907A		762A672H17
Q2	TRANSISTOR	2N2907A		762A672H17
Q3	TRANSISTOR	2N2907A		762A672H17
Q4	TRANSISTOR	2N5401		3509A35H01
Q5	TRANSISTOR	2N5551		3509A35H02
Q6	TRANSISTOR	2N2222A		762A672H15
Q7	TRANSISTOR	2N2222A		762A672H15
Z1	ZENER	1N752A	5.6V	186A797H12
Z2	ZENER		.0V	
Z3	ZENER	1N5235B	6.8V	862A288H07
Z5	ZENER	1N750A	4.7V	837A398H03
Z6	ZENER	1N5235B	6.8V	862A288H07
Z8	ZENER	1N5235B	6.8V	862A288H07
Z9	ZENER	1N959	8.2V	837A398H12
Z10	ZENER	1N752A	5.6V	186A797H12
SCR-1	RECTIFIER	S4003LS2		3509A50H01
SCR-2	RECTIFIER	S4003LS2		3509A50H01
~~SCR-3~~	~~RECTIFIER~~	~~S4003LS2~~		~~3509A50H01~~
SCR-4	RECTIFIER	S4003LS2		3509A50H01
SCR-8	RECTIFIER	S4003LS2		3509A50H01
IC1	CURVE MOD.	SCO-2		1442C29G02
		SCO-5		" 5
		SCO-6		" 6
		SCO-7		" 7
		SCO-8		" 8
		SCO-9		" 9
		SCO-11		" 11
SW-1,2	SWITCH	2A21600IG		3509A52H01
IND-1, IND-2	INDICATOR			3513A71G01
Z11	ZENER	1N752A	5.6 V	186A797H12
Z12	ZENER	1N752A	5.6 V	186A797H12
Z13	ZENER	1N5235	6 8 V	862A288H07
R31	RESISTOR	10K	.50W 2%	629A531H56
R32	RESISTOR	51K	.50W 2%	629A531H73
R33	RESISTOR	51.0K	.50W 2%	629A531H73
R34	RESISTOR	2.7K	.50W 2%	629A531H[illegible]
R35	RESISTOR	200K	.50W 2%	629A531H63
D34	DIODE	1N4148		836A928H06
D35	DIODE	1N4148		836A928H06
D36	DIODE	1N4818		188A342H06
D37	DIODE	1N4148		836A928H06
Q8	TRANSISTOR	2N2222A		762A672H15
Q9	TRANSISTOR	2N2222A		762A672H15

[illegible] SCO 1 PHASE

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	100 PF	184A661H19
C2	CAPACITOR	100 PF	184A661H19
D1	DIODE	1N4822	188A342H11
D2	DIODE	1N4822	188A342H11
D3	DIODE	1N4822	188A342H11
D4	DIODE	1N4822	188A342H11
D5	DIODE	1N4822	188A342H11
D6	DIODE	1N4822	188A342H11
D7	DIODE	1N4822	188A342H11
R1	RESISTOR	2000 5W 5%	~~763A129H32~~
R2	RESISTOR	680 3W 5%	~~763A127H18~~
R3	RESISTOR	680 3W 5%	~~763A127H18~~
Z1	ZENER	1N5352B 15V	862A288H04
L1	INDUCTOR	150 µH	3516A48G01
T1	TRANSFORMER		1440C18G04
FWB-1	RECTIFIER	VM48	3511A90H01
T O	RELAY		1445C27H01
INST	RELAY		1445C27H01
R.R.	RELAY		1442C62G01
MOV-1	VARISTOR	ERZ-C10DK-471	3509A31H02
C5	CAPACITOR	.004 UF	3516A36H02
C6	CAPACITOR	.004 UF	3516A36H02
~~C7~~	~~CAPACITOR~~	~~.004 UF~~	~~3516A36H02~~
C8	CAPACITOR	.004 UF	3516A36H02
C9	CAPACITOR	.004 UF	3516A36H02
C10	CAPACITOR	0.01 UF	3516A36H01
C11	CAPACITOR	.004 UF	3516A36H02
D8	DIODE	1N4822	188A342H11
D9	DIODE	1N4822	188A342H11
D10	DIODE	1N4822	188A342H11
~~D11~~	~~DIODE~~	~~1N4822~~	~~188A342H11~~
	MOUNTED ON FRONT PANEL		
LED	LAMP		879A774H02
~~SW-3~~	~~SWITCH~~		~~3510A06H01~~

Sub 13

6706D67

al Schematic

PRINTED CIRCUIT MODULES

Following is a description of the printed circuit modules used in the SCO-T relay. Refer to the internal schematic shown in Figure 3. This schematic contains a detailed scheme for understanding of the circuitry and a complete list and description of the components for renewal parts.

For those users not generally acquainted with circuit notation or with device symbols of those components used in the SCO-T drawings, it is recommended that a copy of Westinghouse instruction leaflet I.L. 41-000.1 entitled "Symbols for Solid State Protective Relaying" be consulted.

TRANSFORMER MODULE

Component Location Figure 5.

The transformer module, mounted at the top of the relay, contains the current transformer for obtaining the line current information and also supplies the power to operate the electronic circuits. A tap block with 14 taps covering the range of 0.5-12 amperes, is contained at the front of the module and extends through the front panel. A full-wave-bridge for the power supply winding and two diodes for the information winding of the transformer are also mounted on this circuit module to minimize wiring between the two modules. The two trip output relays and the reed relay for indicator pickup are also located on this module.

SENSING & TRIP MODULE

Component location Figure 6.

The sensing and trip module is mounted at the bottom of the relay, beneath the transformer module. It contains the circuitry for power supply voltages V+ and V_R, information sensing, curve shaping, tripping and indication. It also contains two decade thumb wheel switches for setting the time-dial, the potentiometer for setting the instantaneous trip, the instantaneous trip cut-out jumper, the reset lever assembly for resetting the time delay and instantaneous trip indicators, and the socket for the plug-in curve module. It also contains the two multi-turn trimpot calibration controls for setting minimum pickup and calibrating the curve.

TIME CURVE MODULE (IC-1)

The time curve module is a 24 pin plug-in module containing the specific circuitry and components for each particular curve style. There are seven different curve module styles corresponding to the SCO-2, SCO-5, SCO-6, SCO-7, SCO-8, SCO-9 and SCO-11 curves. This module plugs into the 24 pin socket on the sensing-trip module and is visible to the front of the relay through a window in the front panel. There the front label on the module completes the last 3 digits of the style of the relay (printed on the front panel), and also shows which curve the relay is set for i.e. "SCO-2 curve". See Figure 1 front photograph and Figure 6 for exact location. For further information on time curve modules see Plug-in Curve Modules section in Renewal Parts of this instruction leaflet and also I.L. 41-110.2 instruction leaflet for Type SCO Time Curve Plug-in Modules.

FRONT PANEL

The front panel, which is attached to the two tap block brackets on the transformer module, shows all pertinent style and setting information. It also has the minimum pick-up indicator mounted on the upper left hand side. See Figure 1 for exact location.

MINIMUM PICKUP INDICATOR TIMING

The minimum pickup indicator is mounted on the upper left-hand corner of the front panel. It consists of a light-emitting diode which is dimly lit at 99% of pickup value current and fully energized when current exceeds the minimum pickup value. It is visible from the front of the relay which facilitates monitoring and testing. See Figure 1 for exact location.

THEORY OF OPERATION

The basic operation of the SCO-T relay will be described with the aid of Figure 3 internal schematic 6706D67, and Figure 4 external scheme.

The SCO-T relay derives both its power and its sensing information from a single transformer. The type of transformer used is of the linear current transformer design consisting of a tapped primary winding and two secondary windings. The tapped primary winding allows 14 different pickup current settings from 0.5 to 12 amperes. One of the two secondary windings is a high current power supply winding (low number of turns) and the

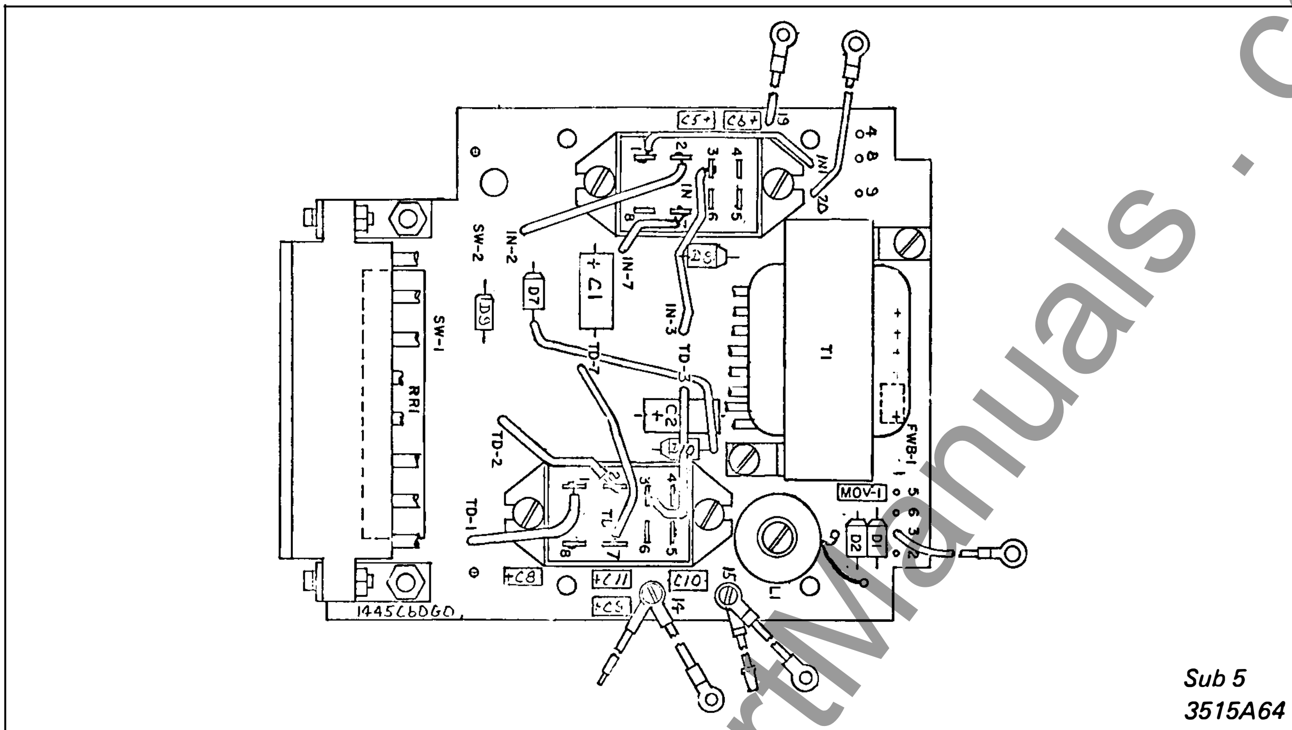


Fig. 5. Transformer Module Component Location Single Phase

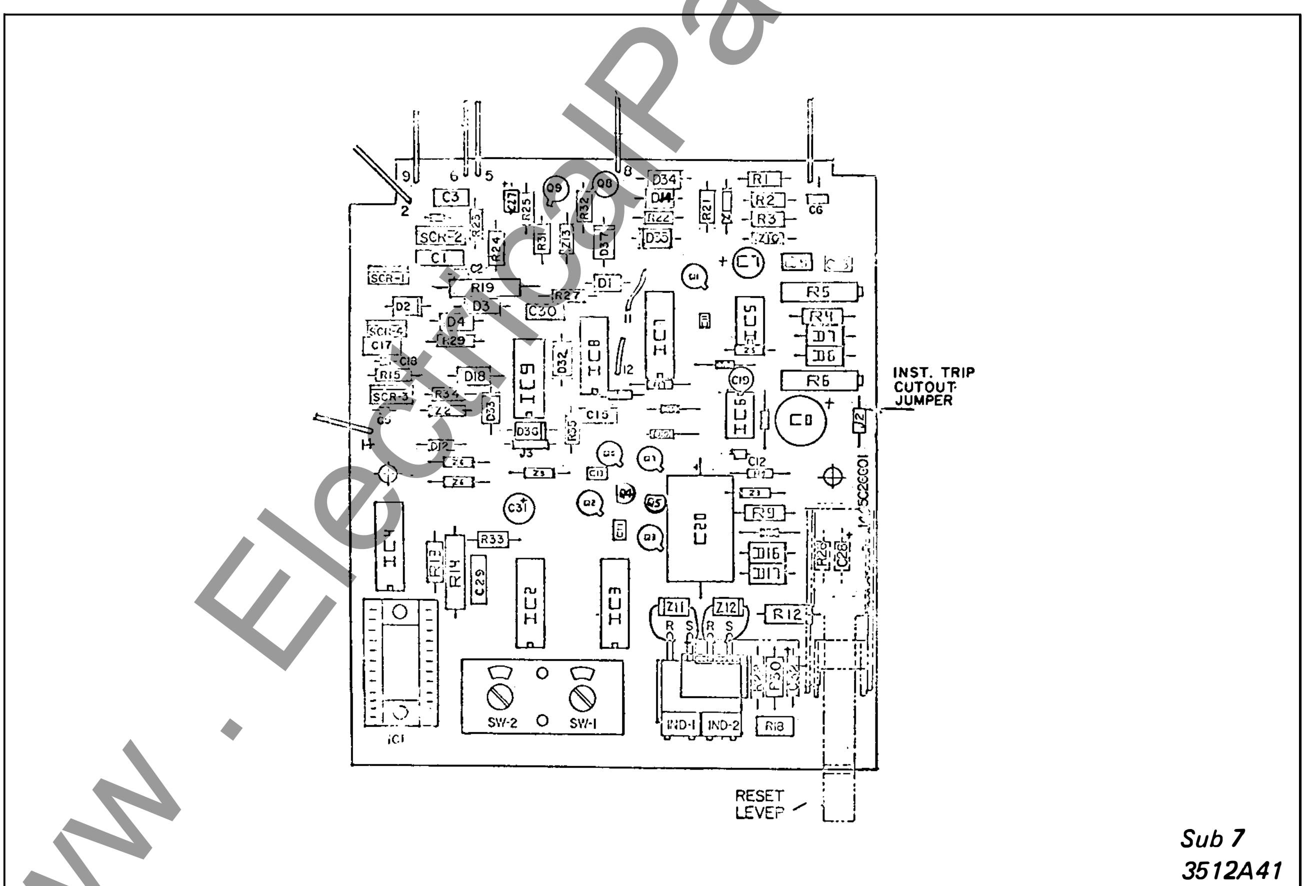


Fig. 6. Sensing-Trip Module Component Location Single Phase

other one is a low current information winding (high number of turns). The circuit operation is based on the transformer ampere-turns balance principle between the primary and the secondary. Following each zero crossing of the line current, balancing of the primary ampere-turns is first achieved by the high current winding. During this time thyristors SCR-1 and SCR-2 are both off and the power supply regulator circuit is the only load imposed at the transformer's secondary. When the regulator reaches the specified regulated voltage based on zener diodes Z1 and Z10, transistor Q1 generates a signal to turn SCR-1 and SCR-2 on. Since these thyristors form a full wave bridge with diodes D1 and D2 on the transformer module, only the respective forward-biased thyristor will fire. Upon firing, an instant voltage drop is seen at the power supply winding output.

This action forces the diode bridge FWB-1 into a back-biased condition cutting off the power supply winding current flow. Balancing of the primary ampere-turns is, therefore, carried out in the low current, or information winding circuit. From this switching point the next zero crossing, the line current represented in voltage form is obtained across the burden resistor R19. When the line current experiences the next zero-crossing the thyristor is turned off automatically, again allowing the current flow in the power supply winding to charge the regulator circuit. The transformer is designed to allow a large enough current flow in the power supply winding at the pickup level so that the regulated voltage can be established very quickly. Once the regulated supply voltage is obtained, the subsequent replenishment uses only the very initial portion of each half cycle of the current. Therefore, the flux build-up due to the power supply replenishment is very low and the design is capable of providing a linear current information transfer up to 40 times pickup current.

The line current information obtained across burden resistor R19 in voltage form is then utilized using the technique of RC approximation and digital time multiplication for time-current curve sensing. The time current curves generated by this design are closely matched to the ones presently obtained from the electromechanical induction disc type relays. This technique utilizes a short, precision time-constant network for time-current curve shaping, and then uses digital counting and decoding techniques to provide time multiplication and precision time dial section. This has an advantage over a straight RC approximation scheme since long delay times are required at low multiples of pickup current. Component leakage and other design factors that make the straight RC network type of timing unattractive and complicated are not considered a problem in this digital approach. Thus, the information across resistor R19 is fed through transistor Q4 to this precision multi-branch RC network housed in the plug-in curve module IC-1. Depending upon the degree of inverseness of the desired time-current curve, the number of RC branches may vary from 2 to 4 branches. Each RC branch contains a first order RC circuit with a time-constant different from other branches. The branches are then combined to give a common weighted output. The weighted RC output is then compared with the reference V_R by IC-6. This operational amplifier maintains a closed-loop operation through Z5 and D8 before the equivalent voltage of the RC network reaches the reference level V_R. This reference level is set at the minimum pickup condition through the comparator IC-8 (pin 2 output) and potentiometer R5. Once this V_R reference level is exceeded, IC-6 outputs a negative-going signal which triggers the one-shot circuit (IC-5). The one-shot signal, which has a pulse width adjusted to supply the proper definite delay time (poteniometer R6), resets the multi-branch RC network by turning transistor Q4 off, through Q5 and Q6, and by turning Q7 on to discharge the RC capacitors.

The one-shot signal also advances the binary counter circuit IC-4. This counter, which is enabled (logic 0 on pin 11) when the input current is above the minimum pickup level and reset or kept inactive when below minimum pickup level (MPU IC-8 pin 2), counts the negative going signals from the one-shot output. When the correct count is attained, up to 2^{12} power or 4096 counts, depending upon which binary output is used per respective curve connection in IC-1, the counter output is inverted by comparator IC-9 (pin 13) and then drives the two time-dial decade counter/decorder circuits, IC-3 and IC-2. These two counters, one for tenth time-dial positions and one for unit time-dial positions, are connected to a dual decade thumbwheel switch to provide ninety-nine distinct time-dial settings, which means up to 99 count outputs from the binary counter IC-4. Thus, for example, if the 2^{10}(1024) output of IC-4 is used, up to 2^{10}X time dial setting (from 1 to 99) actual counts of the RC network takes place before generation of a trip signal. These decade counters, as in the previous case of the binary counter IC-4, are kept inoperative and reset whenever the minimum pickup signal on pin 15 of IC-3 and IC-2 goes to a logic 1, indicating that the input current dropped below pickup level.

Thus, when the set time dial count has elapsed, a positive output occurs from both the decade counters. These are applied through the time dial switches to the cathode ends of D9 and D10, reverse biasing them. This allows the signal present on pin 8 of comparator IC-8 to now become a logic 1 (through R8) generating a trip signal (IC-8 pin 14). Prior to this, the signal on pin 8 of comparator IC-8 was kept at a logic 0 level by the shorting of this input, in accordance with the logic 0 outputs of IC-3 and IC-2, through either or both of diodes D9 and D10.

This trip signal is then applied through IC-9 D12 and Z6 to the base of Q3, turning it on. This, in turn, applies 2 distinct branch signals; one is through IC-9 and D18 to gate thyristor SCR-4, the second is through D16, C28 and R26 to IND-1, the time-delay trip indicator. With the turn on of SCR-4 the T.D. relay on the top module is energized and a trip output occurs between terminals 1 and 10 of the SCO-T relay. The turn-on of SCR-4 also forces the turn off of the INST unit by short circuiting the current through diode D35 that would otherwise flow into the base of Q8 and cause the INST unit to be energized. The turn on of the indicator can only occur when the reed relay RR picks up, concurrent with the flow of trip coil current. This happens when the normally open RR contact closes completing the path to, and allowing the indicator current to thereby flow to, power supply negative.

The trip of the breaker will interrupt the current input, and total reset of the relay circuitry occurs within 50 milliseconds plus an additional 15 to 20 milliseconds dropout time of the trip relay. Reset of the indicator is accomplished manually through use of the reset lever actuated from the outside of the case. This lever magnetically flips the indicator back to its reset state.

The instantaneous trip circuitry also derives its information from the voltage across resistor R19. This information is taken from the cathode side of diode D2, through the instantaneous trip cutout link jumper, J2, to the level control and filter circuitry on the input of the instantaneous trip comparator, IC-8 (pin 6). This input is then compared with the minimum pickup reference level V_R by IC-8. The potentiometer R18 allows a continuous range of setting from 1.3 to 35 times the minimum pickup tap setting of the relay. Once the V_R reference level is exceeded, IC-8 (pin 1) outputs a negative-going instantaneous trip signal. This signal is then applied through IC-9 and Z8 to the base of Q2, turning it on. This, in turn, applies 3 distinct branch signals; one is through D15 and IC-7 to immediately seal-in the instantaneous input on IC-8 pin 6, the second is through R21, D14 and D34 to the base of Q8 and thereby energizing the INST. relay, and the third is through D17, C32 and R30, and the IND-2, the instantaneous trip indicator.

With the energization of the INST. relay a trip output occurs through similar paths as previously described when initiated by the time delay circuit. If the fault current magnitude is made to drop below tap value before the breaker is tripped, transistor Q9 and its associated components force IC8-1 and Q2 to turn off (reset) and allow INST to drop out.

Similarly to the time delay trip indicator, turn on of the instantaneous trip indicator can only occur when the reed relay RR turns on, and is concurrent with the flow of trip coil current.

CHARACTERISTICS

RANGE

The SCO-T has taps covering the range of 0.5 to 12 amperes. The tap values are: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4, 5, 6, 7, 8, 10 and 12 amperes.

Tap values are based on the sensing circuit having an operate threshold which is a constant ampere-turns (AT). In some cases the tap value will have a 1 or 2 percent error resulting from rounding off the ampere value as compared to the actual value. The actual value is obtained by dividing AT by the coil turns (T). This error is normally insignificant, however, when checking the operate time at "2X TAP value" in some relays, a 2 percent error in the true threshold current will be reflected as a 5 percent error in time delay.

Table III shows correction factors which apply to each tap based on standard calibration using the 1 ampere tap.

Pickup accuracy ±5 percent of tap value for all taps.

✪ The instantaneous circuit has a range of 1.3 to 35 times the tap value selection with a continuous adjustable pickup. Settings of less than 1.3 times tap value may not produce an indicator target when the unit trips.

TIME-OVERCURRENT CHARACTERISTICS

The time vs. current characteristics are shown in Figures 7 to 13. These characteristics give the trip time for the various time dial settings when the indicated multiples of tap value current are applied to the relay. 8 milliseconds T.D. relay pickup time delay must be added to these curves for total operate time of the SCO-T relay.

Timing accuracy ±10% of the characteristics curve for any combination of time dial setting and tap value. Operating time repeatability ±2% at 25°C. for any given time dial and tap setting.

NOTE: A higher percentage value may occur on the 0.1 time dial position when the SCO-T relay is suddenly energized due to angle of incidence and delay in power supply turn-on.

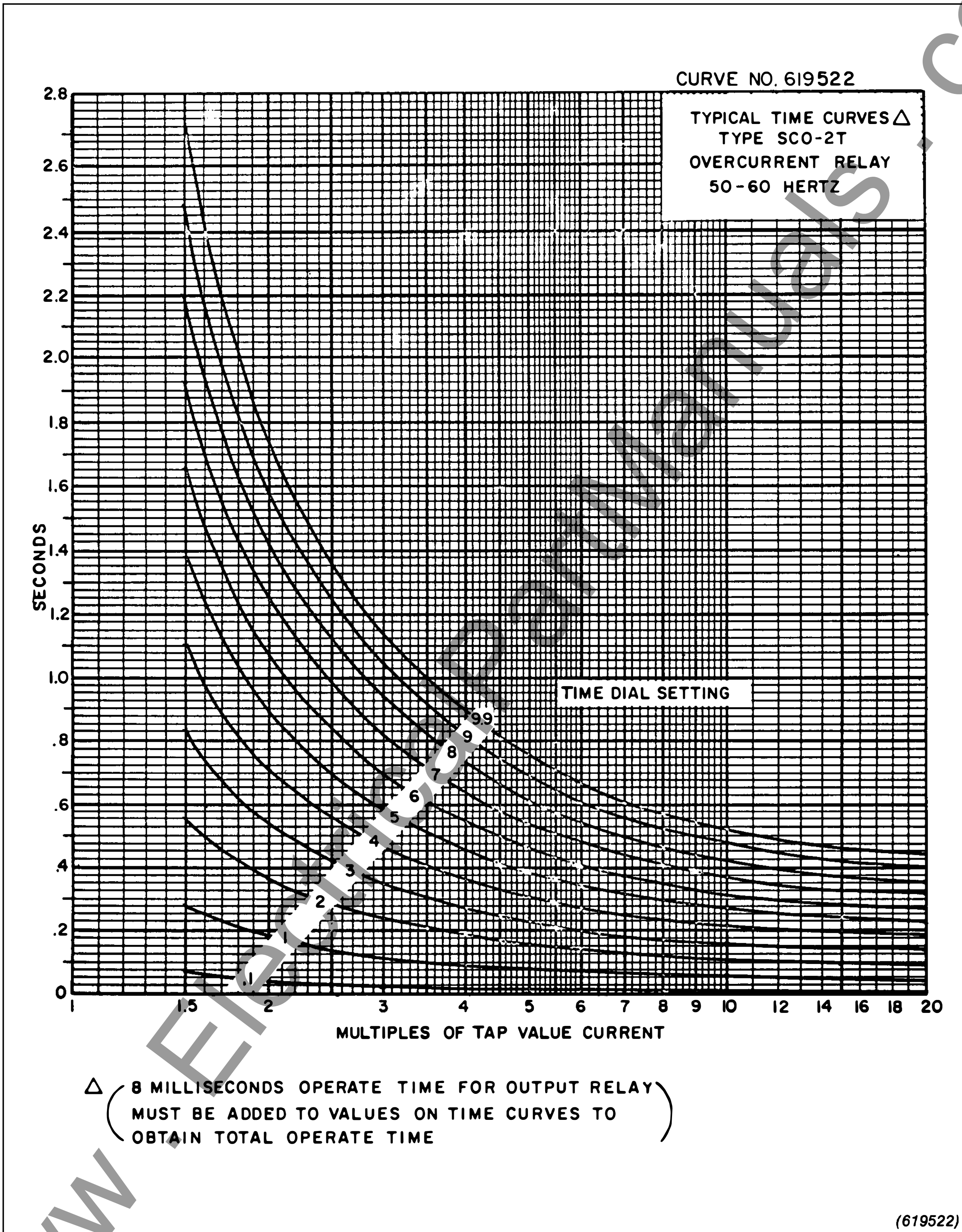


Fig. 7. Typical Time Curves of the Type SCO-2T Relay

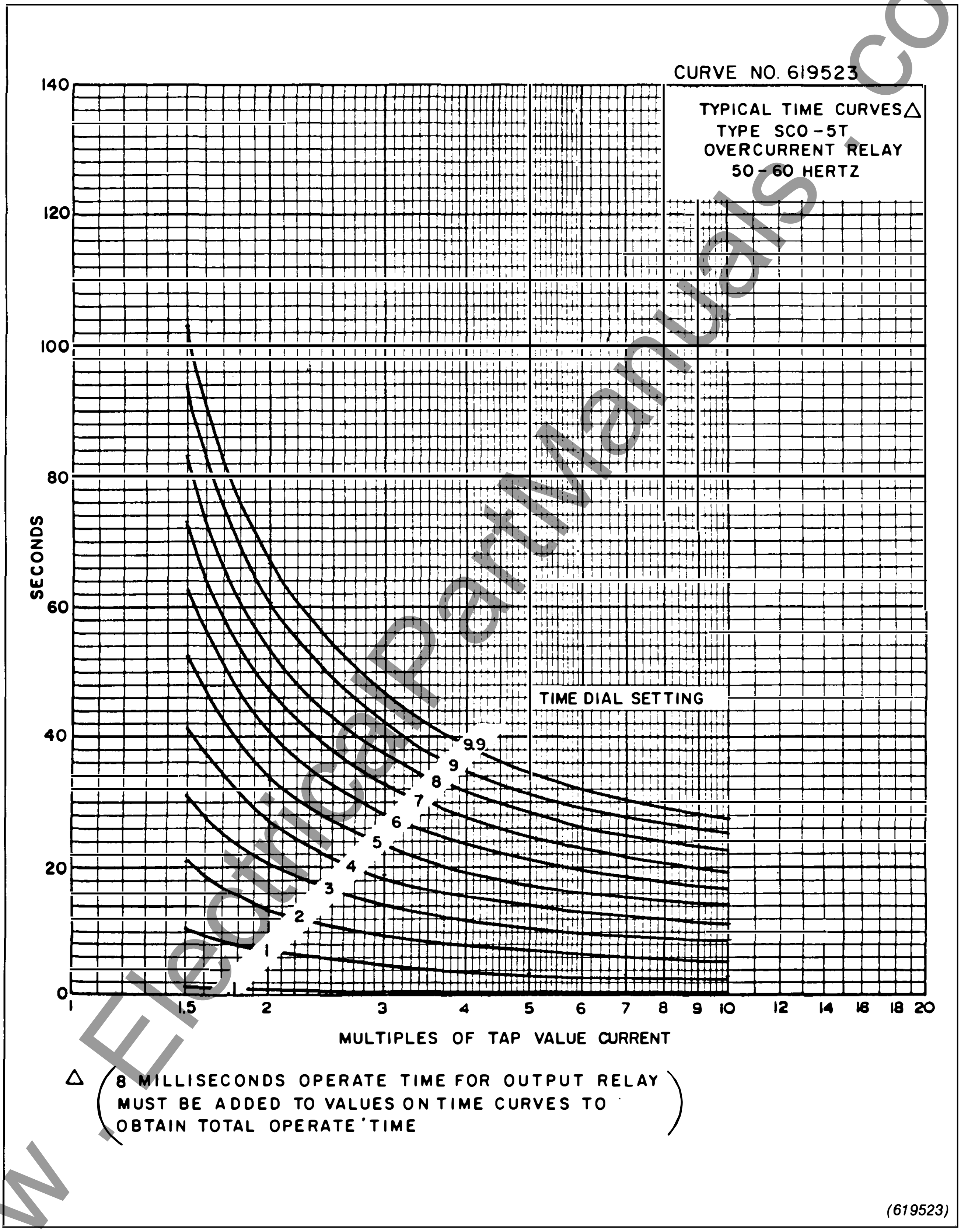
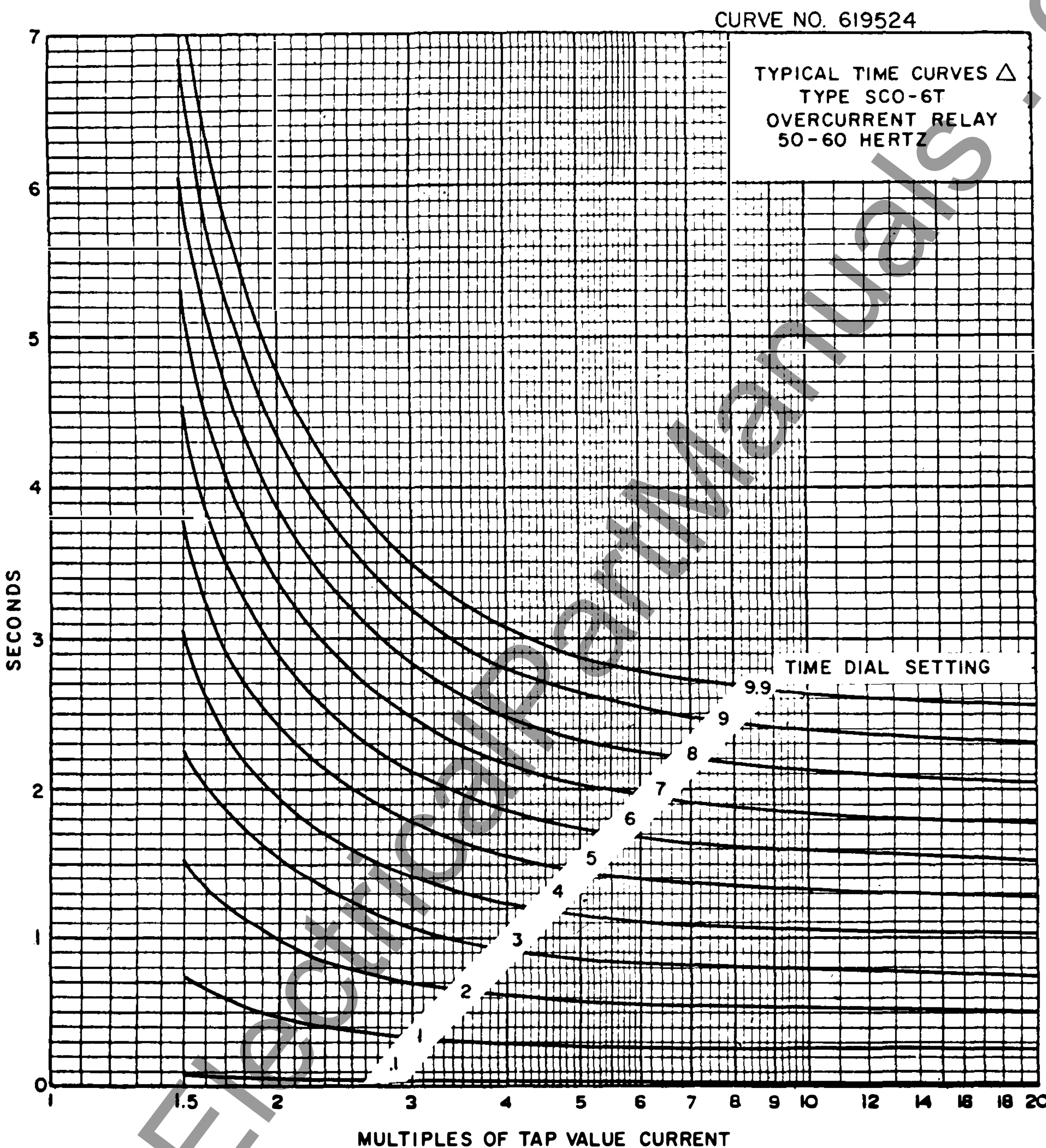


Fig. 8. Typical Time Curves of the Type SCO-5T Relay



△ (8 MILLISECONDS OPERATE TIME FOR OUTPUT RELAY MUST BE ADDED TO VALUES ON TIME CURVES TO OBTAIN TOTAL OPERATE TIME.)

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Fig. 9. Typical Time Curves of the Type SCO-6T Relay

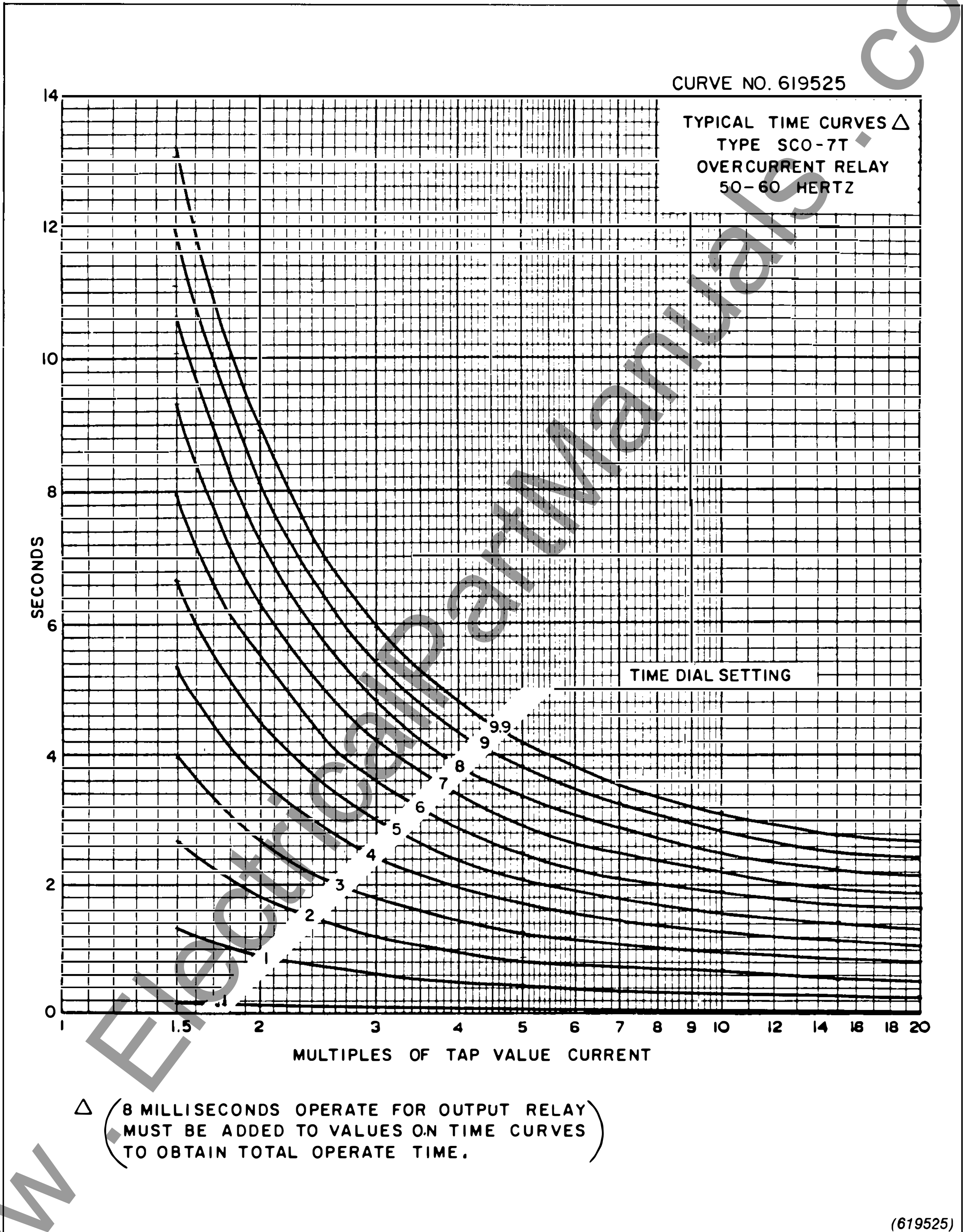

Fig. 10. Typical Time Curves of the Type SCO-7T Relay

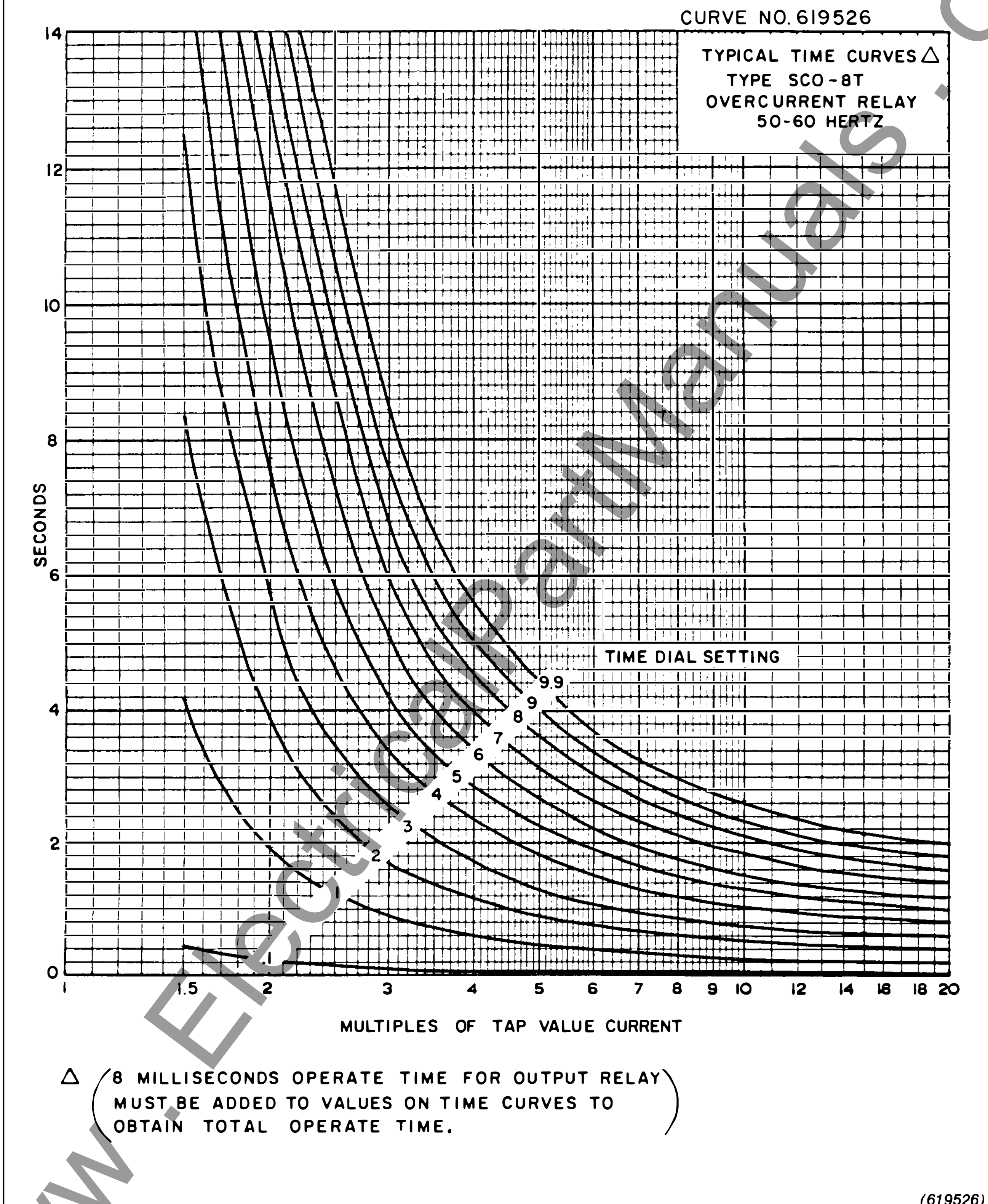

Fig. 11. Typical Time Curves of the Type SCO-8T Relay

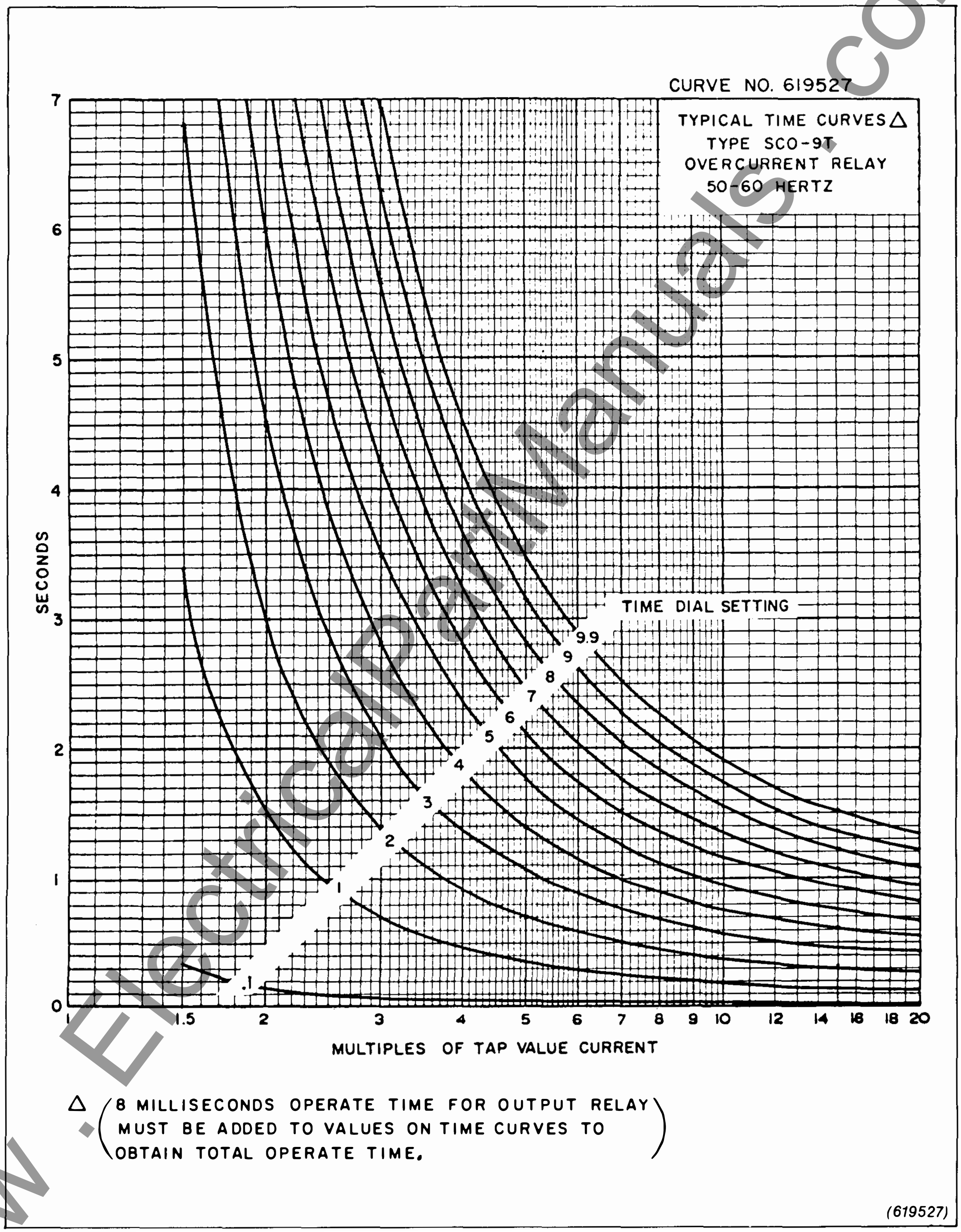

Fig. 12. Typical Time Curves of the Type SCO-9T Relay

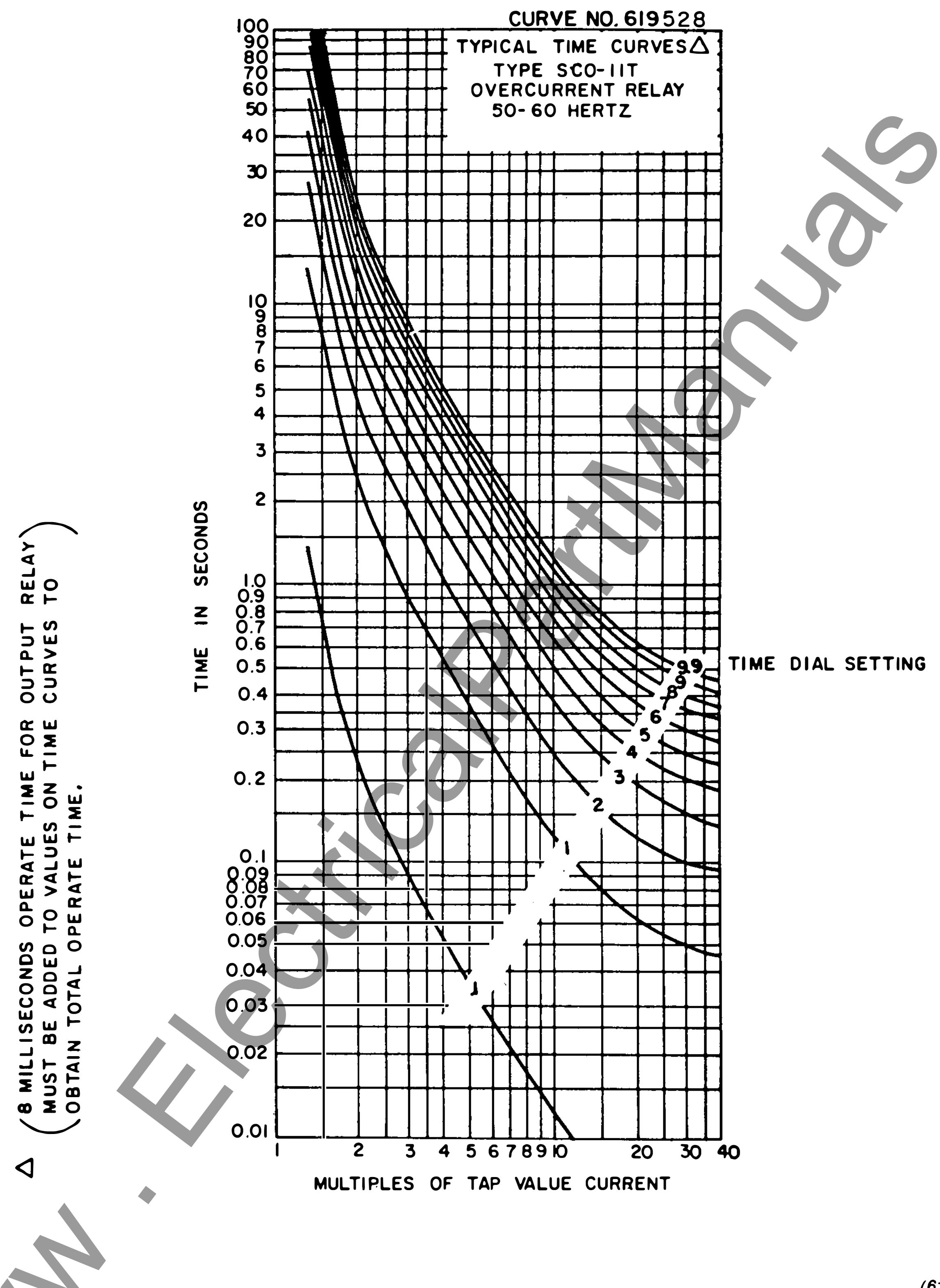

Fig. 13. Typical Time Curves of the Type SCO-11T Relay

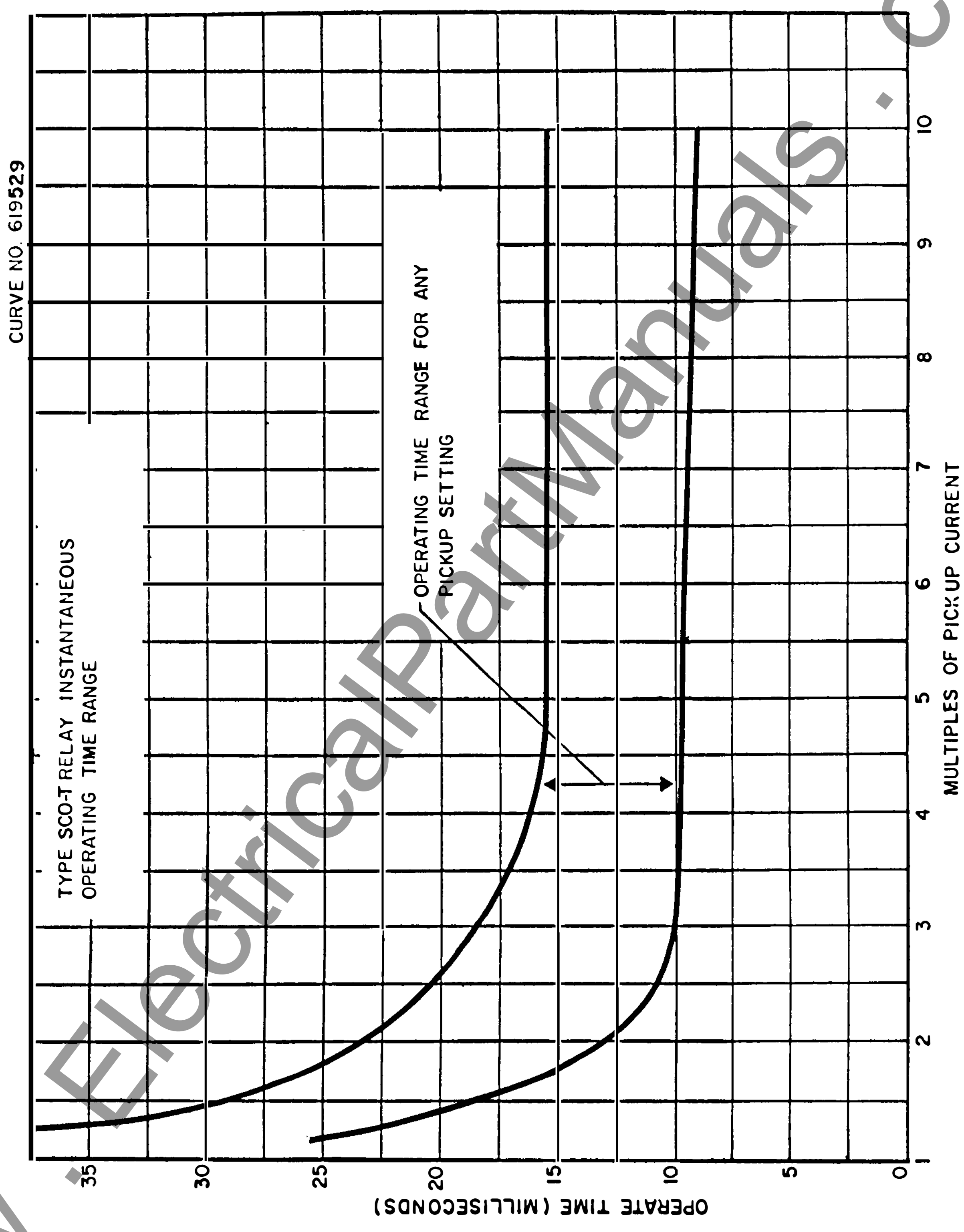

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Fig. 14. Typical Time Curves of Type SCO-T Relay Instantaneous

INSTANTANEOUS CHARACTERISTICS

The time vs. current characteristics are shown in Figure 14. These characteristics give the trip time when the indicated multiples of instantaneous pickup current are applied to the relay. 8 milliseconds inst. relay pickup time must be added to this curve for total time of the SCO-T instantaneous.

TRIP CIRCUIT

The SCO-T relay energizes the breaker trip coil by means of an output contact. This contact will safely carry 30 amperes on a 250 dc system, or less, long enough to trip a circuit breaker (10 cycles). If the trip current requirement exceeds 30 amperes an auxiliary relay should be used and connected so that tripping current is not conducted through the output contact. A 52a contact, or similar contact, should be used to interrupt the trip coil current. Refer to the external scheme Figure 4 for proper trip connections.

Resistance of the RR relay coil, shown in the circuit between terminal 10 and terminals 1 or 2 is not greater than 0.1 ohms. At least 0.5 amp trip current is required to produce a target.

SURGE WITHSTAND CAPABILITY

Withstand SWC test per ANSI Standard C37.90A.

DIMENSIONS

See Figure 18 for outline dimensions.

WEIGHT

Single Phase SCO-T Approximately 8 lbs. 6 ozs. (3.8 kilograms).

TEMPERATURE RANGE

−20°C to +55°C chassis ambient (outside the relay case) without departure from the +25°C operating accuracy by more than ±5%.

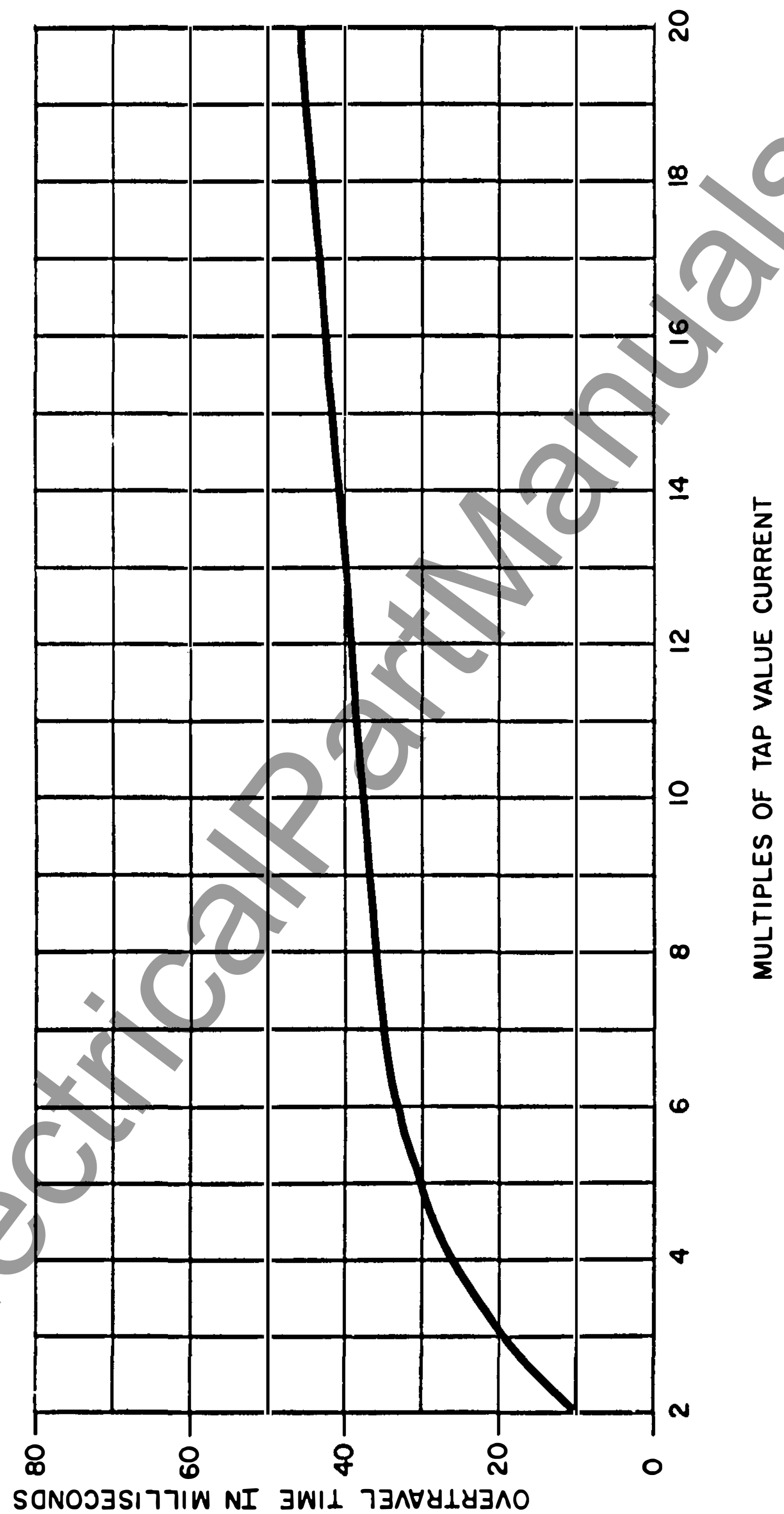
−30°C to +70°C chassis ambient (outside the the relay case) without failure and with no more than 5% additional timing departure. Continuous current ratings must be derated at temperatures above +55°C.

RESET TIME

The reset time of the SCO-T relay circuitry is less than 50 milliseconds, and the reset of the output relays is approx. 25 milliseconds for a total reset time at 75 milliseconds max.

OVERTRAVEL TIME

The typical overtravel characteristics of the SCO-T relay is shown in Figure 15.



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✪ *Fig. 15. Typical Overtravel Time of the Type SCO-T Relay*

TABLE I
ENERGY REQUIREMENTS (60 HERTZ)[1]

TYPE SCO-T RELAY WITH INSTANTANEOUS TRIP CIRCUITRY

TAP	CON-TINUOUS RATING (AMPERES)	ONE SECOND RATING[2] (AMPERES)	BURDENS AT TAP VALUE CURRENT			BURDENS IN OHMS[1]		
			R OHMS	X OHMS	Z OHMS	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5	1.6	44	12.4	0	12.4	3.78	2.32	2.08
1.0	3.3	44	3.0	0	3.0	0.96	0.62	0.58
1.5	4.9	185	1.29	0	1.29	0.41	0.27	0.26
2.0	6.5	185	0.73	0	0.73	0.25	0.17	0.17
2.5	8.1	185	0.48	0	0.48	0.17	0.12	0.12
3.0	9.8	185	0.32	0	0.32	0.12	0.09	0.08
3.5	11.4	185	0.25	0	0.25	0.09	0.06	0.06
4.0	13.0	185	0.19	0	0.19	0.07	0.05	0.05
5.0	16.3	460	0.13	0	0.13	0.05	0.04	0.04
6.0	19.5	460	0.09	0	0.09	0.04	0.03	0.03
7.0	22.8	460	0.08	0	0.08	0.04	0.03	0.03
8.0	25.0	460	0.06	0	0.06	0.03	0.03	0.03
10	29.0	460	0.05	0	0.05	0.03	0.03	0.03
12	29.0	460	0.04	0	0.04	0.02	0.02	0.02

[1] Burdens are approximately 10% lower at 50 hertz.

[2] Thermal capacities for short times other than 1 second may be calculated on the basis of time being inversely proportional to the square of the current (i.e. $K = I^2t$)

SETTINGS

TIME DELAY

The overcurrent time delay settings can be defined either by tap setting and time dial setting or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2.6 time dial setting or 4 tap setting, 0.6 seconds at 6 times tap value current).

The connector screw on the terminal plate of the tap block makes connections to various turns on the input current transformer. By placing this screw in the various terminal plate holes, the tap desired can be set and the relay will respond to multiples of tap value currents in accordance with the various typical time-current curves.

CAUTION

Since the tap block connector screw carries operating current, be sure that the screw is turned tight. In order to avoid opening the current transformer circuits when changing taps under load, connect the spare connector screw in the desired tap position before removing the other tap screw from the original tap position.

The time dial should be set to the desired setting on the two decade time dial thumbwheel switches on the front panel in accordance with the various typical time-current curves.

The time delay must be set to overide the normal conditions to which the relay can be subjected, such as motor starting current, cold load pickup, emergency circuit load and transformer inrush.

1. Differential protection

   For small transformers and less important buses the SCO-T differential scheme can be used. A pickup setting above maximum load of any circuit connected to the bus, and a time delay setting for maximum fault current in excess of three times the primary circuit dc time constant, will generally prove to be suitable.

2. Motor protection

   For locked rotor protection, the pickup of the SCO-T is typically set at one half locked rotor current, and the time delay is set to allow the motor to start without exceeding the allowable locked rotor time for the particular motor.

3. Circuit protection

   A pickup setting of two times maximum circuit loading is typical for the phase relay. The circuit load may reach 5 times normal when reenergized after a long time. It may not drop below 2 times normal for approximately 7 seconds. The relay should not trip for this condition. This is the cold load pickup phenomenon and varies widely with the type of load.

   Devices farther away from the source than the SCO-T and located between the SCO-T and a fault should be allowed to clear the fault. For all currents seen by both devices, the SCO-T curve should be approximately 0.3 seconds above the total clearing time of the remote device. Where consideration to ct performance, fault current variation and relay accuracy a coordinating time equal to or less than 0.2 second plus breaker clearing time may be used. Ground relay pickup must be above the maximum residual load unbalance, including the effect of switching single phase laterals. A pickup setting corresponding to 0.4 of maximum phase load current is typical. The time curve must be above that of all devices farther away from the source than the SCO-T. This includes fuses and recloses even though they may respond to phase current only. 0.3 second coordinating time is adequate. Lower coordinating times may be used as described above.

   Similar SCO characteristics curve shapes at a given system voltage level can generally be more efficiently co-ordinated than dissimilar curve shapes.

INSTANTANEOUS TRIP

The instantaneous circuit should be set to the desired setting on the instantaneous tap multiplier potentiometer on the front panel (see CALIBRATION section). CAUTION: This potentiometer requires only light finger pressure with a thin blade screw driver which fits into the slot. Excessive pressure might damage both the potentiometer mounting as well as the end-of-travel stops. This section is in multiples of tap setting (e.g. with a tap setting of 4 amps. and an instantaneous multiple setting at

20 times, the instantaneous pickup setting will be 80 amps). The relay will respond to currents above this setting per typical time curve Figure 14.

The instantaneous unit is responsive to total current including dc component, and an allowance must be made in the setting to avoid overtripping. Normally a setting of 1.25 times the maximum symmetrical current for which the unit should not trip will provide an adequate margin to prevent undesired tripping due to dc offset.

If an instantaneous trip is not desired in a style relay where it is included, it can be removed from service by cutting out the instantaneous trip cutout jumper J2 located on the right side of the circuit module.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, corrosive fumes and heat. The maximum temperature outside the relay case should not exceed +55°C for normal operation (See CHARACTERISTICS for temperature range specifications).

Mount the relay vertically by means of the four mounting holes on the flanges for semi-flush mounting or by means of the rear stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection between the relay case, its mounting screws or studs, and the relay panel. Ground wires are affixed to the mounting screws or studs as required for poorly grounded or insulating panels. Other electrical connections may be made directly to the terminals by means of screws for steel panel mounting or 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. See Figure 18 for Outline and Drilling Plan. For detailed FT case information refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

✪ PERFORMANCE CHECK

It is recommended that a performance check be applied to the SCO-T relay to verify that the circuits are functioning properly. The SCO-T test ✪ diagram shown in Figure 16 aids in test of the relay. Proper energization of the relay is also shown in this figure.

A. Minimum Trip Current

Set the time dial at 0.1, the tap block at 1 amp and the instantaneous trip potentiometer at maximum setting (35X). Apply current to the relay, starting with a current below the set pickup, and very gradually increase the current applied to 5% below pickup value. The relay should not trip (See characteristic curves for approximate timing). Increase current 5% above pickup value and the relay should trip. The timing indicator (light emitting diode) begins to light in a dim manner at approximately 1% below the pickup point and attains full brightness at the actual minimum pickup level (tap block setting). This same procedure may be used to check the minimum trip current at other tap block settings.

If a more accurate check is desired, an oscilloscope may be used to view the minimum pickup signal. This signal is present on terminal 12 of the sensing-trip module, and is also easily accessible on the top lead of the TIMING light emitting diode by pulling back the insulated sleeving and attaching the scope probe to this point. The current where this signal becomes a solid logic 0 (complete absence of any positive pulses) is the actual minimum pickup point.

B. Time Curve

The time curve calibration points for the various types of relays are shown in Table II. With the time dial set to the indicated position, apply the currents specified by Table II (e.g. for the SCO-8T, 2 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table II plus or minus 10%.

C. Instantaneous Trip

Connect a jumper across resistor R15 to block the turn on of SCR-4 which operates to turn off the instantaneous unit. Exercise care when adjusting the "INSTANT TAP MULTIPLIER" potentiometer, to use a thin-blade screwdriver which fits into the slot and use only light finger pressure. High multiples of current may be involved in the following test, therefore, caution should be taken not to exceed the thermal limits specified under CHARACTERISTICS.

Starting with the instantaneous trip potentiometer set at minimum, a procedure of raising the potentiometer and applying the desired pickup current should be tried until the instantaneous unit does not operate with the desired current applied. The instantaneous unit setting should then be "backed down and tried" until it does operate with the desired current applied (instantaneous trip indicator operates). The instantaneous will then respond to currents above this setting per the typical time curve Figure 14.

Make sure the jumper is removed from across R15 when the check or setting of the instantaneous unit is completed.

D. Trip Indication

The time trip indicator should operate (orange) on time curve trip and be resettable (black) with the reset lever. The instantaneous trip indicator should operate (orange) on instantaneous trip and be resettable (black) with the reset lever.

At completion of the performance check return all settings to desired position.

ROUTINE MAINTENANCE

All relays should be inspected periodically and all settings and times of operation should be checked at least once every year or at such other intervals as may be indicated by experience to be suitable to the particular application.

TABLE II

		LOW CURRENT TESTS		HIGH CURRENT TESTS	
RELAY TYPE	TIME DIAL POSITION	CURRENT APPLIED TIMES TAP VALUE	OPERATING TIME IN SECONDS	CURRENT APPLIED TIMES TAP VALUE	OPERATING TIME IN SECONDS
SCO-2T	5.0	2X	.888	20X	.222
SCO-5T	5.0	2X	33.5	10X	14.0
SCO-6T	5.0	2X	2.42	20X	1.28
SCO-7T	5.0	2X	4.50	20X	1.36
SCO-8T	5.0	2X	9.66	20X	1.00
SCO-9T	5.0	2X	7.50	20X	.675
SCO-11T	5.0	2X	10.5	20X	.310

Note: 8 milliseconds pickup time for the T.D. relay must be added to the above operate times for total operate time of the SCO-T relay.

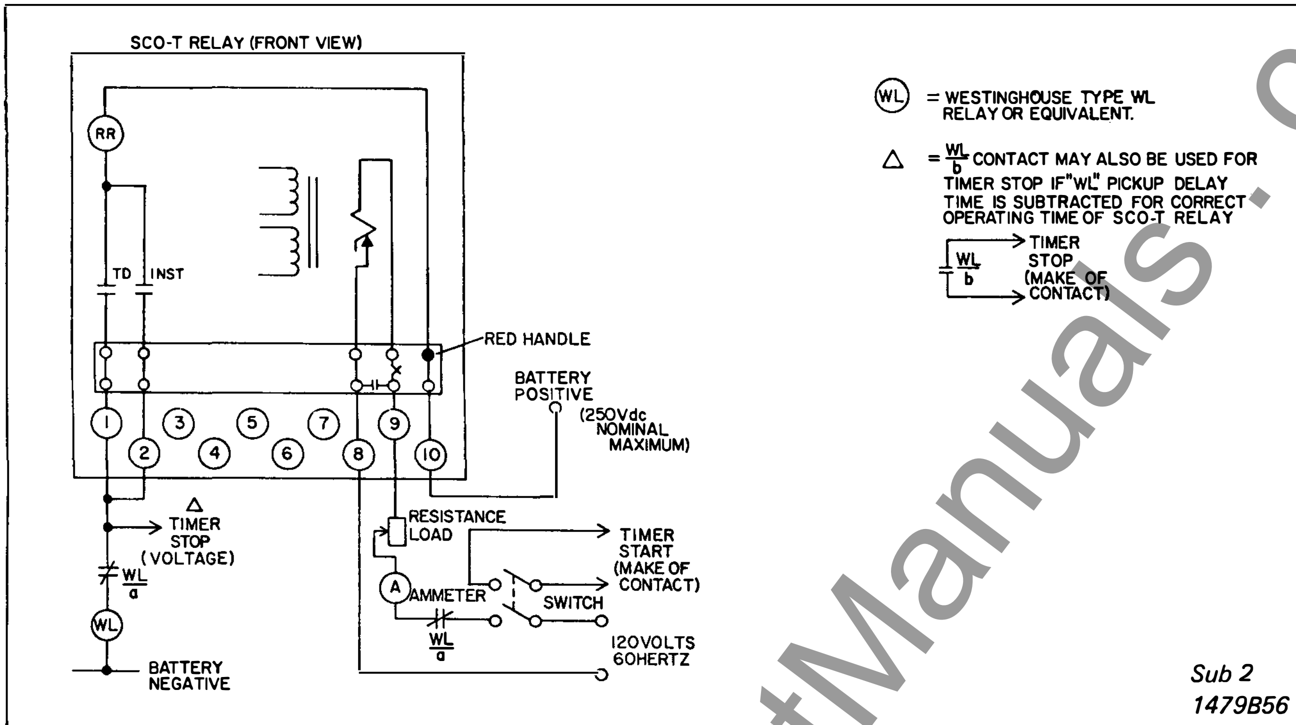


Fig. 16. Diagram of Test Connections for Type SCO-T Relay

CALIBRATION

The proper adjustments to insure correct operation of the relay have been made at the factory and should not be disturbed after receipt by the customer. However, recalibration may be required if the adjustments or any components have been changed or SCO-T curve plug-in modules interchanged. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Performance Check"). The SCO-T test diagram shown in Figure 16 aids in test of the relay. Proper energization of the relay is also shown in this figure.

A. Minimum Trip Curve

Multi-turn trimpot R5 serves two functions. It establishes the minimum pickup point and also affects the time curve calibration point for 2X pickup. Use the following procedure for making a preliminary setting of R5.

Set the time dial at 0.1 setting, the tap block at a 1 amp. setting, and the instantaneous trip potentiometer at maximum setting (35X). Apply minimum current (1 amp.) to the relay (terminals 8 and 9). Adjust multi-turn trimpot R5 so that the relay will trip at tap value +3% and not trip at tap value -1%. Counterclockwise rotation of trimpot R5 increases the pickup point, (increases V_R) and clockwise rotation of trimpot R5 decreases it. See Figure 2, front photograph, and Figure 6, module component location, for exact location of trimpot R5.

TABLE III
Tap Value Correction Factors

Tap Value	Calculated Value
.5	0.50
1.	1.00
1.5	1.48
2.	1.96
2.5	2.45
3.	3.06
3.5	3.50
4.	4.08
5.	4.90
6.	6.13
7.	7.00
8.	8.17
10.	9.80
12.	12.25

Note that the TIMING indicator (light emitting diode) begins to light in a dim manner at approximately 1% below the pickup and attains full brightness at the actual minimum pickup level.

An oscilloscope may be used to view the minimum pickup signal. This signal is present on terminal 12 of the sensing and trip module, and is also easily accessible on the top lead of the TIMING light emitting diode by pulling back the insulated sleeving and attaching the scope probe to this point. The current where this signal becomes solid logic 0 (complete absence of any positive pulses) is the actual minimum pickup point. This method is recommended to avoid overadjusting the trimpot during the timing delay.

B. Time Curve

Set the tap block at a 1 amp. setting, and set the instantaneous trip at maximum or above 20 times setting so it will not interfere with the time curve trip.

The time curve calibration points for the various types of relays are shown in Table II. Apply current per Table II for 10X or 20X pickup and adjust multi-turn trimpot R6 for the appropriate operating time ± 5%. Clockwise rotation of trimpot R6 increases the trip time and counterclockwise rotation decreases it. See Figure 2, front photograph, and Figure 6, module component location, for exact location of trimpot R6. Apply current per Table II for 2X pickup and check for appropriate operating time ± 10%. Adjust trimpot R5 if necessary to get this operating time to fall within these limits.

Check the Minimum Trip level after readjusting R5 to make sure the relay will trip at tap value +5% and will not trip at tap value –1%. Note that a change in R5 will also affect the 10X or 20X test point and the R6 adjustment should be rechecked. Likewise, a change in the R6 adjustment has a small affect on the 2X operating time so it may be necessary to make a slight additional adjustment to R5.

Caution should be taken at these higher multiples of current not to exceed the thermal limits of the relay specified under CHARACTERISTICS. A contact to interrupt the input current upon trip of the relay is recommended in testing the SCO-T relay.

Note: Trimmer capacitor C19 has been factory set for correct operation of IC-6 and should *not* be readjusted. However, if IC-6 is ever replaced, capacitor C19 and trimpot R6 must both be adjusted with a SCO-11 curve module plugged in the relay to obtain correct compensation for IC-6 and correct SCO-11 curve 20X timing value.

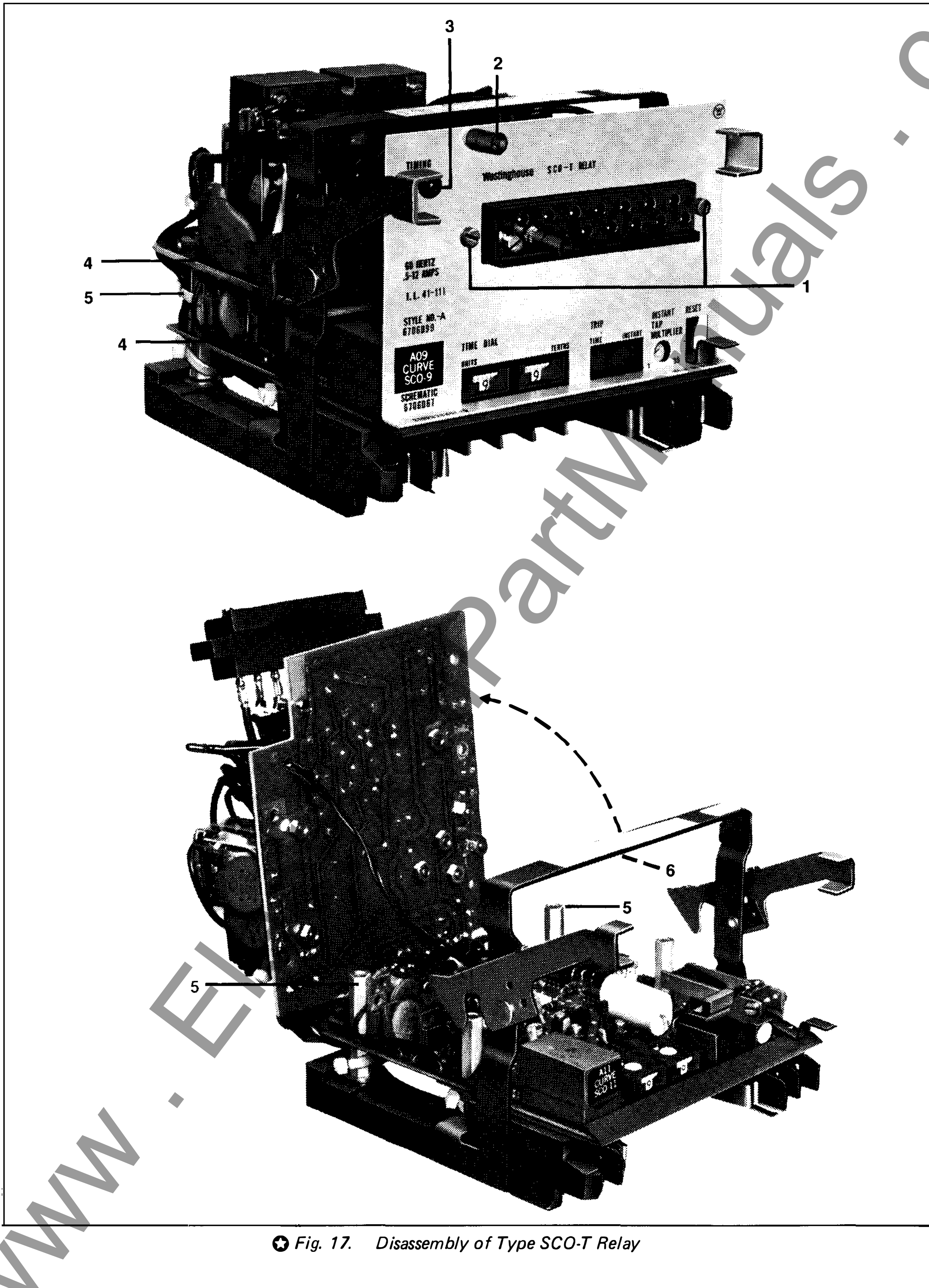
C. Instantaneous Trip

Connect a jumper across resistor R15 to block turn on of SCR-4 which operates to turn off the instantaneous unit.

Exercise care, when adjusting the "INSTANT TAP MULTIPLIER" potentiometer, to use a thin blade screwdriver which fits into the slot and use only light finger pressure. High multiples of current may be involved in the following test, therefore, caution should be taken not to exceed the thermal limits specified under CHARACTERISTICS.

Starting with the instantaneous trip potentiometer R18 set at minimum, (fully counterclockwise) a procedure of raising the potentiometer and applying the desired pickup current should be tried until the instantaneous unit does not operate with the desired current applied. The instantaneous unit setting should then be "backed down and tried" until it does operate with the desired current applied. (Instantaneous trip indicator operates). The instantaneous unit will then respond to currents above this setting per the typical time curve Figure 14.

Make sure the jumper is removed from across R15 when the check or setting of the instantaneous unit is completed. No other calibration is necessary other than desired changes in settings.



✪ *Fig. 17. Disassembly of Type SCO-T Relay*

TROUBLESHOOTING

The components in the SCO-T relay are operated well within their ratings and normally will give long and trouble-free service. However, if a relay has given indication of trouble in service or during routine checks, then using the internal schematic Figure 3, component location Figures 5 and 6, and the theory of operation the faulty component, connection, or circuit can be identified.

Voltage levels for "0" and "1" logic states in the theory of operation are:

Logic "0" is equivalent to less than 1 Vdc positive.
Logic "1" is equivalent to 5 to 11 Vdc positive.

For those users not generally acquainted with circuit notation or with device symbols of those components used in the SCO-T drawings, it is recommended that a copy of Westinghouse Instruction Leaflet I.L. 41-000.1 entitled, "Symbols for Solid State Protective Relaying" be consulted.

The SCO-T relay can easily be disassembled to gain accessibility to all components for ease in troubleshooting. The following procedure should be followed to mechanically detach and slide back the top transformer module when accessibility to components on the bottom module is desired (reference Figure 17):

1. Remove the two nameplate screws.
2. Remove both the tap block screw and spare tap screw.
3. Slide back rear retaining ring on TIMING light emitting diode snap bushing (onto wires), and push light emitting diode back through panel.
4. Remove the four screws holding the top module to posts.
5. Cut the wire ties which holds the leads in the rear to the rear post.
6. Slide the top module backwards for accessibility to components on bottom module.

Reassembly of the relay is accomplished by reassembling everything disassembled in steps 1 through 7 above in reverse order (7 through 1). Reposition intermodule connecting lead wires in rear of relay back to original routing.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. Internal Schematic Figure 3 contains a complete list and description of the components for renewal parts. When ordering parts, always give complete nameplate data and appropriate Westinghouse style numbers.

PLUG-IN CURVE MODULES (IC-1)

Plug-in curve modules are available to change the particular style and time-overcurrent characteristic curve of the relay. The time curve module is a 24 pin plug-in module containing the specific circuitry and components for each particular curve style. There are seven different curve module styles corresponding to the SCO-2, SCO-5, SCO-6, SCO-7, SCO-8, SCO-9 and SCO-11 curves. This module plugs into the 24 pin socket on the sensing-trip module and is visible to the front of the relay through a window in the front panel. There the front label on the module completes the last three digits of the style of the relay (printed on the front panel), and also shows which curve the relay is set for i.e. "SCO-2 curve". Thus, changing this module automatically changes the style of the relay.

When changing plug-in curve modules, the relay should be recalibrated for minimum pickup and time curve specifications per the Calibration Section of this instruction leaflet.

The following are the style numbers of the plug-in curve modules available:

Relay Type	Curve Module	Time Curve	Curve Module Plug-In Style
SCO-2T	A02	Short	1442C29G02
SCO-5T	A05	Long	1442C29G05
SCO-6T	A06	Definite	1442C29G06
SCO-7T	A07	Moderately Inverse	1442C29G07
SCO-8T	A08	Inverse	1442C29G08
SCO-9T	A09	Very Inverse	1442C29G09
SCO-11T	A11	Extremely Inverse	1442C29G11

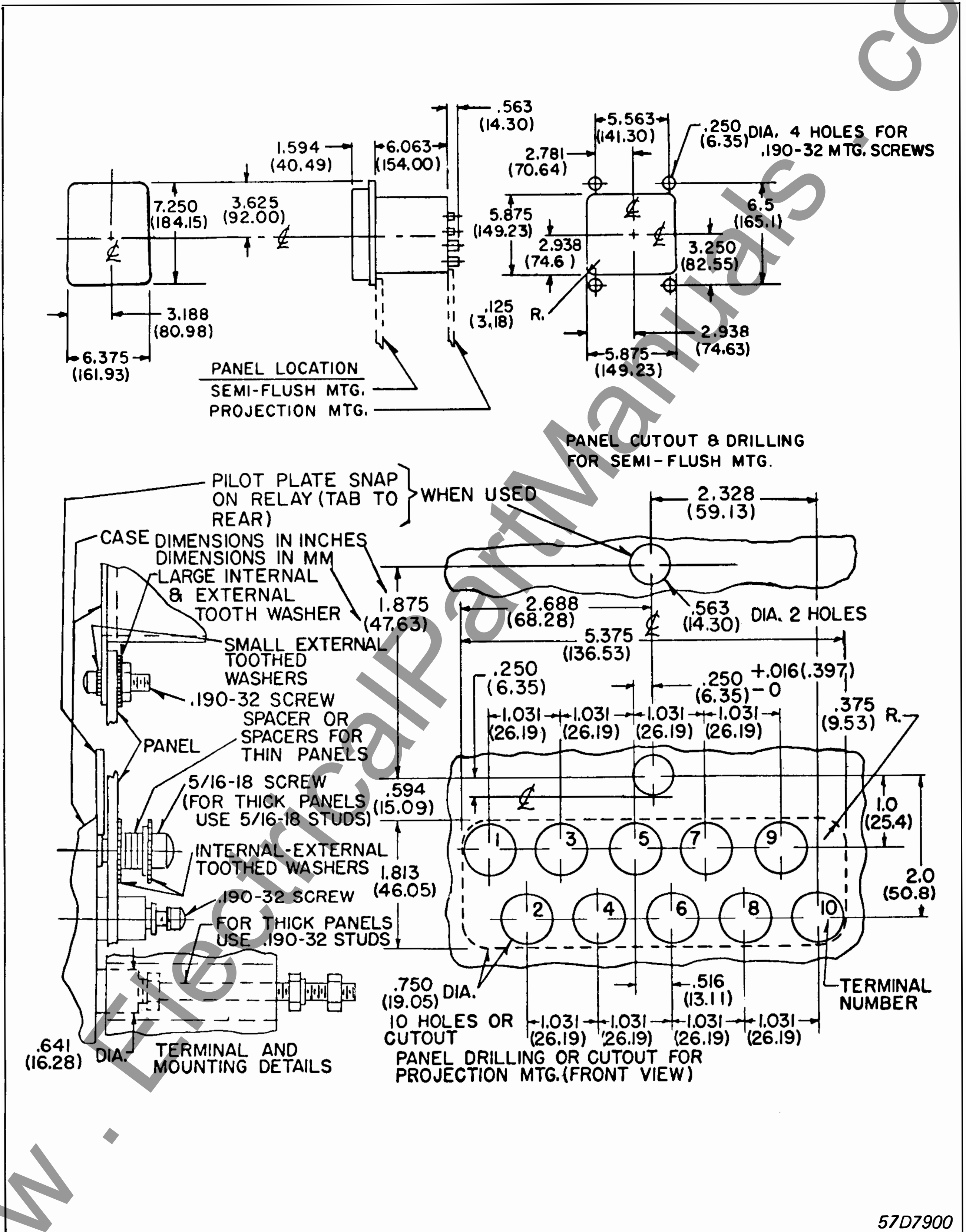


Fig. 18. *Outline and Drilling Plan for Type SCO-T Relay Single Phase in FT-11 Case*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
CORAL SPRINGS, FL 33065
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SCO-T SOLID STATE SINGLE PHASE OVERCURRENT RELAY

CAUTION: It is recommended that the user become acquainted with the information in this instruction leaflet before energizing the equipment. Failure to observe this precaution may result in damage to the equipment.

APPLICATION

The SCO-T relay is a single phase solid state non-directional time over-current device. It is used to sense current level above the setting and normally is used to trip a circuit breaker to clear faults. A wide range of characteristics permit applications involving coordination with fuses, reclosers, cold load pickup, motor starting, or essentially fixed time applications.

The following describes typical applications of the SCO-T Relay:

RELAY TYPE	CURVE MODULE	TIME CURVE	TYPICAL APPLICATIONS
SCO-2T	A02	Short	1) Differential protection where saturation of current transformers is not expected, or where delayed tripping is permissible. 2) Overcurrent protection, phase or ground, where coordination with downstream devices is not involved and 2 to 60 cycle tripping is allowable.
SCO-5T	A05	Long	Motor locked rotor protection where allowable locked rotor time is approximately between 10 and 70 seconds.
SCO-6T	A06	Definite	Overcurrent protection where coordination with downstream devices is not involved and SCO-2T is too fast. The operating time of this relay does not vary greatly as current level varies.
SCO-7T	A07	Moderately Inverse	1) Overcurrent protection where coordination with other devices is required, and generation varies.
SCO-8T	A08	Inverse	2) Backup protection for relays on other circuits.
SCO-9T	A09	Very Inverse	
SCO-11T	A11	Extremely Inverse	1) Motor protection where allowable locked rotor time is less than 10 sec. 2) Overcurrent protection where coordination with fuses and reclosers is involved, or where cold load pickup or transformer inrush are factors.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

Supersedes I.L. 41-111, dated July 1978 and addendum to I.L. 41-111 dated December 1978
✪ Changes since previous issue.

EFFECTIVE SEPTEMBER 1979

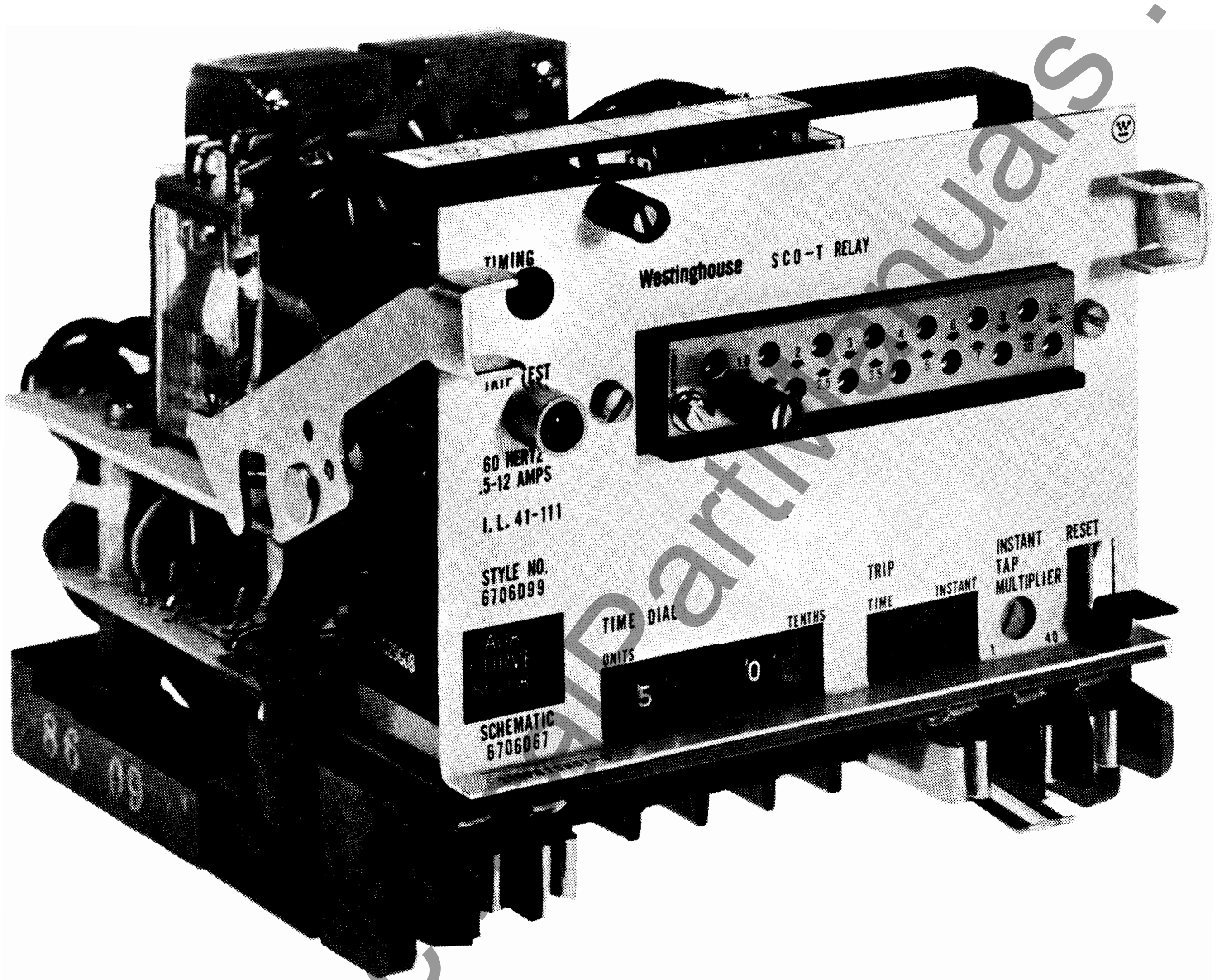


Fig. 1. Type SCO-T Relay—Front Left Side View

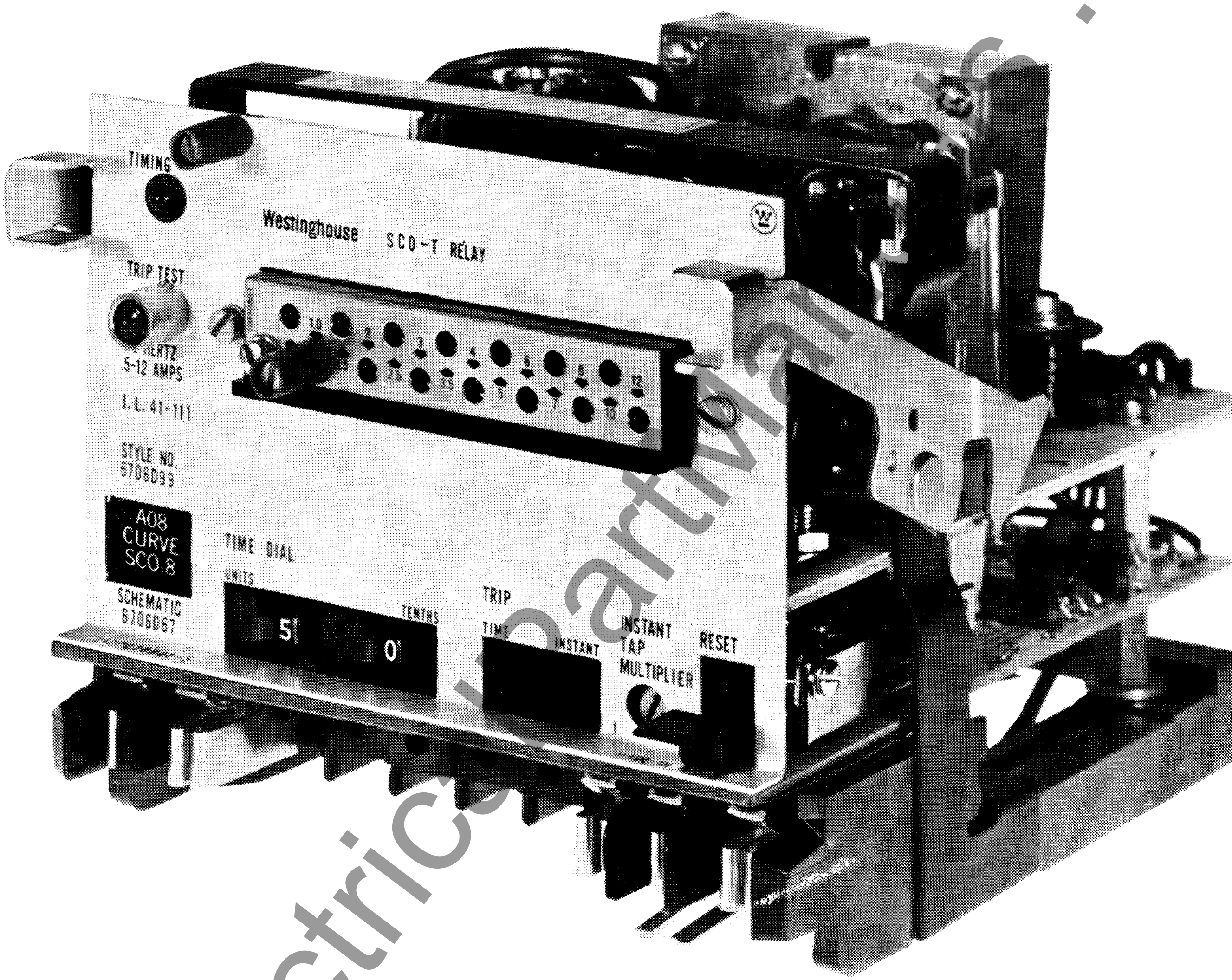


Fig. 2. Type SCO-T Relay—Front Right Side View

The SCO-T relay is equipped with an instantaneous trip feature with separate trip output to provide high speed tripping for high current faults.

Instantaneous trip units can be applied effectively where wide variations in fault currents occur for different fault locations, but have limited applications where wide variations in fault currents occur for a fixed fault location. It responds to total current and must be set to include the effect of dc current and to override the conditions that should be ignored such as transformer inrush, motor locked rotor, and faults outside of the desired trip zone.

Independant contact trip outputs and separate indication are provided for the instantaneous and time delay tirp outputs. No indication occurs unless there is current flow in the trip circuit. Indicator reset is accomplished manually.

The relay is self contained in that the power supply for the solid state logic is derived from the current transformer. There is no continuous drain on the tripping battery.

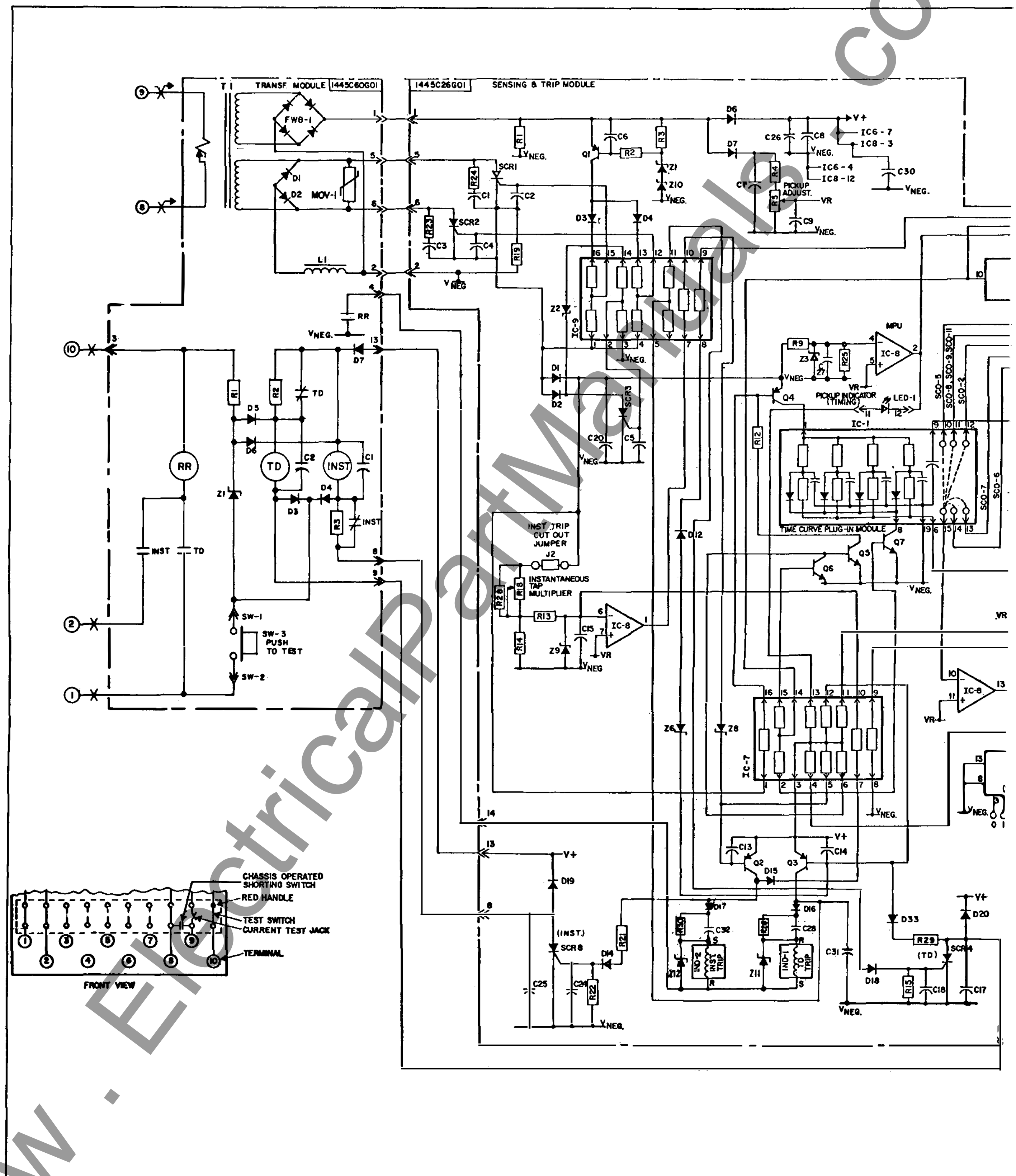
See SETTINGS Section for further application data.

CONSTRUCTION

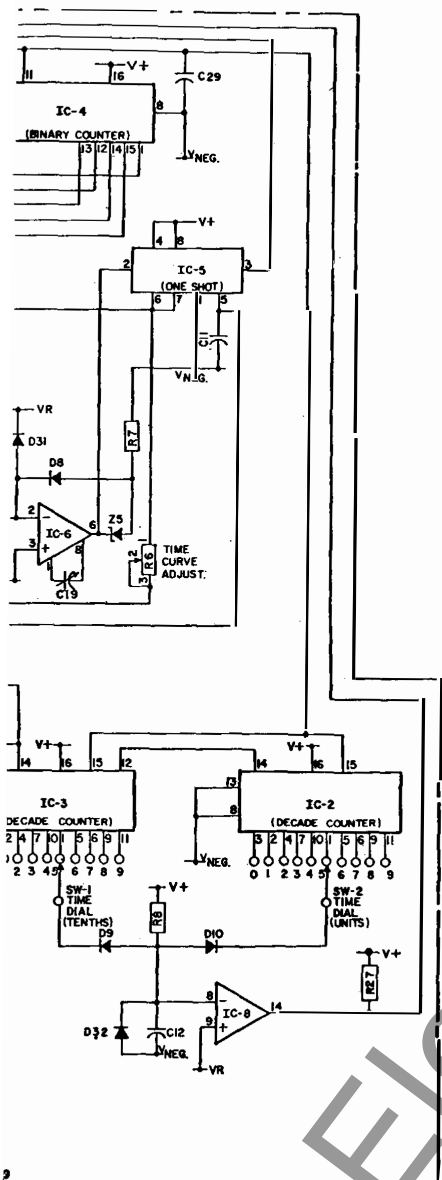
The SCO-T relay is a static relay consisting of 2 printed circuit modules, a time curve plug-in module, and a front panel assembly, packaged in a FT-11 case. For detailed information on the flexitest case, referred to I.L. 41-076.

The photographs in Figures 1 and 2 show the front left and front right view of the SCO-T reay removed from the case.

All of the circuitry suitable for mounting on printed circuit boards is contained on the two modules horizontally mounted on posts behind the front panel. The top module contains the transformer and "front-end" circuitry and the trip output relays for the SCO-T while the bottom module contains the power supply, information sensing, curve shaping, tripping and indication circuitry, as well as the plug-in curve module. Terminals for current input and trip output are located on the rear of the case, and all inputs and outputs pass through the FT switchjaws on the lower front part of the relay, below the front panel. The front panel, in addition to showing all pertinent style and setting information, has the minimum pickup indicator and the trip test switch located on the upper left-hand side.



✪ *Fig. 3. SCO-T Inte*



1445C26G01 SCO 1 PHASE

COMPONENT		DESCRIPTION	STYLE NO.
C32	CAPACITOR	22UF 15V	184A661H18
C1	CAPACITOR	.050UF 500V	879A911H13
C2	CAPACITOR	1000.000PF 100V	3509A34H01
C3	CAPACITOR	.050UF 500V	879A911H13
C4	CAPACITOR	1000.000PF 100V	3509A34H01
C5	CAPACITOR	1000.000PF 100V	3509A34H01
C6	CAPACITOR	.010UF 50V	3509A34H02
C7	CAPACITOR	22.000UF 16V	3509A32H01
C8	CAPACITOR	220.000UF 16V	3509A32H02
C9	CAPACITOR	470.000PF 1000V	879A911H10
C11	CAPACITOR	.010UF 50V	3509A34H02
C12	CAPACITOR	150.000PF 100V	3509A34H04
C13	CAPACITOR	.100UF 50V	3509A34H03
C14	CAPACITOR	.100UF 50V	3509A34H03
C15	CAPACITOR	.100UF 50V	717B694H07
C18	CAPACITOR	1000.000PF 100V	3509A34H01
C19	CAPACITOR	5.5-30PF 50V	3516A79H01
C20	CAPACITOR	2.000UF 200V	3509A33H01
C24	CAPACITOR	1000.000PF 100V	3509A34H01
C17	CAPACITOR	.02MFD 500V	762A680H01
C25	CAPACITOR	.02 MFD 500V	762A680H01
C26	CAPACITOR	.470UF 50 V	762A680H04
C27	CAPACITOR	.470UF 35 V	837A241H21
C28	CAPACITOR	22 UF 15 V	[illegible]
C29	CAPACITOR	.010 UF 500V	879A911H12
C30	CAPACITOR	.470 UF 50V	762A680H04
C31	CAPACITOR	22.000 UF 16V	3509A32H01
D1	DIODE	1N4822	188A342H11
D2	DIODE	1N5406	188A342H21
D3	DIODE	1N4818	188A342H06
D4	DIODE	1N4818	188A342H06
D6	DIODE	1N4818	188A342H06
D7	DIODE	1N4818	188A342H06
D8	DIODE	1N4148	836A928H06
D9	DIODE	1N4148	836A928H06
D10	DIODE	1N4148	836A928H06
D12	DIODE	1N4148	836A928H06
D14	DIODE	1N4822	188A342H11
D15	DIODE	1N4148	836A928H06
D16	DIODE	1N4818	188A342H06
D17	DIODE	1N4818	188A342H06
D18	DIODE	1N4822	188A342H11
D19	DIODE	1N4822	188A342H11
D20	DIODE	1N4822	188A342H11
D31	DIODE	1N4148	836A928H06
D32	DIODE	1N4148	836A928H06
D33	DIODE	1N4148	836A928H06
IC2	INT CKT	4017AE	3494A01H15
IC3	INT CKT	4017AE	3494A01H15
IC4	INT CKT	4040AE	3494A01H14
IC5	INT CKT	SE555CV	774B956H01
IC6	INT CKT	LM301AN	775B061H01
IC8	INT CKT	MC3302P	775B062H01
IC7	INT CKT		775B106H01
IC9	INT CKT		775B107H01

COMPONENT		DESCRIPTION	STYLE NO.
J1	JUMPER	0 OHM RESISTOR	862A478H01
J2	JUMPER	0 OHM RESISTOR	862A478H01
J3	JUMPER	0 OHM RESISTOR	862A478H01
R5	POT	50.0K .75W	880A826H06
R6	POT	10.0K .75W	880A826H05
R18	POT	500K .75W	3512A37H01
R1	RESISTOR	3.0K .50W 2%	629A531H43
R2	RESISTOR	1000.0 .25W 5%	836A908H63
R3	RESISTOR	150.0 .50W 2%	629A531H12
R4	RESISTOR	51.0K .50W 2%	629A531H73
R7	RESISTOR	300.0K .25W 5%	836A909H23
R8	RESISTOR	100.0K .50W 2%	629A531H80
R9	RESISTOR	100.0K .50W 2%	629A531H80
R12	RESISTOR	24.3K .50W 1%	862A377H38
R13	RESISTOR	100.0K .50W 2%	629A531H80
R14	RESISTOR	7.5K .50W 1%	862A376H85
R15	RESISTOR	200.0 .25W 5%	836A908H46
R19	RESISTOR	50.0 5.00W 1%	763A130H37
R21	RESISTOR	1000.0 .50W 1%	[illegible]
R22	RESISTOR	470.0 .50W 2%	[illegible]
R23	RESISTOR	100.0 .50W 2%	629A531H08
R24	RESISTOR	100.0 .50W 2%	629A531H08
R25	RESISTOR	1.0 MEG .50W 1%	848A822H39
R26	RESISTOR	1000.0 .50W 1%	848A819H48
R27	RESISTOR	51.0K .50W 2%	629A531H73
R28	RESISTOR	2.2M .50W 5%	187A290H26
R29	RESISTOR	10.0K .50W 2%	629A531H56
R30	RESISTOR	1000.0 .50W 1%	848A819H48
Q1	TRANSISTOR	2N2907A	762A672H17
Q2	TRANSISTOR	2N2907A	762A672H17
Q3	TRANSISTOR	2N2907A	762A672H17
Q4	TRANSISTOR	2N5401	3509A35H01
Q5	TRANSISTOR	2N5551	3509A35H02
Q6	TRANSISTOR	2N2222A	762A672H15
Q7	TRANSISTOR	2N2222A	762A672H15
Z1	ZENER	1N752A 5.6V	186A797H12
Z2	ZENER	UZ8120 200.0V	837A693H16
Z3	ZENER	1N5235B 6.8V	862A288H07
Z5	ZENER	1N750A 4.7V	837A398H03
Z6	ZENER	1N5235B 6.8V	862A288H07
Z8	ZENER	1N5235B 6.8V	862A288H07
Z9	ZENER	1N959 8.2V	837A398H12
Z10	ZENER	1N752A 5.6V	186A797H12
SCR-1	RECTIFIER	S4003LS2	3509A50H01
SCR-2	RECTIFIER	S4003LS2	3509A50H01
SCR-3	RECTIFIER	S4003LS2	3509A50H01
SCR-4	RECTIFIER	S4003LS2	3509A50H01
SCR-8	RECTIFIER	S4003LS2	3509A50H01
IC1	CURVE MOD.	SCO-2	1442C29G02
		SCO-5	" 5
		SCO-6	" 6
		SCO-7	" 7
		SCO-8	" 8
		SCO-9	" 9
		SCO-11	" 11
SW-1,2	SWITCH	2A216001G	3509A52H01
IND-1, IND-2	INDICATOR		3513A71G01
Z11	ZENER	1N752A 5.6V	186A797H12
Z12	ZENER	1N752A 5.6V	186A797H12

1445C60G01 SCO 1 PHASE

COMPONENT		DESCRIPTION	STYLE NO.
C1	CAPACITOR	220UF 16V	3509A32H02
C2	CAPACITOR	220UF 16V	3509A32H02
D1	DIODE	IN4822	188A342H11
D2	DIODE	IN4822	188A342H11
D3	DIODE	IN4822	188A342H11
D4	DIODE	IN4822	188A342H11
D5	DIODE	IN4822	188A342H11
D6	DIODE	IN4822	188A342H11
D7	DIODE	IN4822	188A342H11
R1	RESISTOR	200.0 5W 5%	763A129H32
R2	RESISTOR	68.0 3W 5%	763A127H18
R3	RESISTOR	68.0 3W 5%	763A127H18
Z1	ZENER	IN5352B 15V	[illegible]
L1	INDUCTOR	150 µH	3516A48G01
T1	TRANSFORMER		1440C18G04
FWB-1	RECTIFIER	VM48	3511A90H01
T.D.	RELAY		1445C27H01
INST.	RELAY		1445C27H01
R.R.	RELAY		1442C62G01
MOV-1	VARISTOR	ERZ-C10DK-471	3509A31H02
	MOUNTED ON FRONT PANEL		
LED	LAMP		879A774H02
SW-3	SWITCH		3510A06H01

Sub.10
6706D67

...rnal Schematic

PRINTED CIRCUIT MODULES

Following is a description of the printed circuit modules used in the SCO-T relay. Refer to the internal schematic shown in Figure 3. This schematic contains a detailed scheme for understanding of the circuitry and a complete list and description of the components for renewal parts.

For those users not generally acquainted with circuit notation or with device symbols of those components used in the SCO-T drawings, it is recommended that a copy of Westinghouse instruction leaflet I.L. 41-000.1 entitled "Symbols for Solid State Protective Relaying" be consulted.

TRANSFORMER MODULE

Component Location Figure 5.

The transformer module, mounted at the top of the relay, contains the current transformer for obtaining the line current information and also supplies the power to operate the electronic circuits. A tap block with 14 taps covering the range of 0.5-12 amperes, is contained at the front of the module and extends through the front panel. A full-wave-bridge for the power supply winding and two diodes for the information winding of the transformer are also mounted on this circuit module to minimize wiring between the two modules. The two trip output relays and the reed relay for indicator pickup are also located on this module.

SENSING & TRIP MODULE

Component location Figure 6.

The sensing and trip module is mounted at the bottom of the relay, beneath the transformer module. It contains the circuitry for power supply voltages $V+$ and V_R, information sensing, curve shaping, tripping and indication. It also contains two decade thumb wheel switches for setting the time-dial, the potentiometer for setting the instantaneous trip, the instantaneous trip cut-out jumper, the reset lever assembly for resetting the time delay and instantaneous trip indicators, and the socket for the plug-in curve module. It also contains the two multi-turn trimpot calibration controls for setting minimum pickup and calibrating the curve.

TIME CURVE MODULE (IC-1)

The time curve module is a 24 pin plug-in module containing the specific circuitry and components for each particular curve style. There are seven different curve module styles corresponding to the SCO-2, SCO-5, SCO-6, SCO-7, SCO-8, SCO-9 and SCO-11 curves. This module plugs into the 24 pin socket on the sensing-trip module and is visible to the front of the relay through a window in the front panel. There the front label on the module completes the last 3 digits of the style of the relay (printed on the front panel), and also shows which curve the relay is set for i.e. "SCO-2 curve". See Figure 1 front photograph and Figure 6 for exact location. For further information on time curve modules see Plug-in Curve Modules section in Renewal Parts of this instruction leaflet and also I.L. 41-110.2 instruction leaflet for Type SCO Time Curve Plug-in Modules.

FRONT PANEL

The front panel, which is attached to the two tap block brackets on the transformer module, shows all pertinent style and setting information. It also has the minimum pick-up indicator and the trip test switch mounted on the upper left hand side. See Figure 1 for exact location.

MINIMUM PICKUP INDICATOR TIMING

The minimum pickup indicator is mounted on the upper left-hand corner of the front panel. It consists of a light-emitting diode which is dimly lit at 99% tap value current and fully energized when current exceeds the minimum tap value. It is visible from the front of the relay which facilitates monitoring and testing. See Figure 1 for exact location.

TRIP TEST SWITCH

The trip test switch is mounted on the upper left-hand side of the front panel. It consists of a push-to-test switch protected from accidental activation by a shield guard which requires a definite depression of the switch by some device that fits inside the guard, i.e. pencil, slender rod, etc. See Figure 1 for exact location. The trip test function derives its power from the station battery to pickup both the time delay and instantaneous trip relays simultaneously. Battery positive must be present on terminal 10 and a return path to battery negative must be provided from terminal 1 (through a trip coil with at least .5 amp loading).

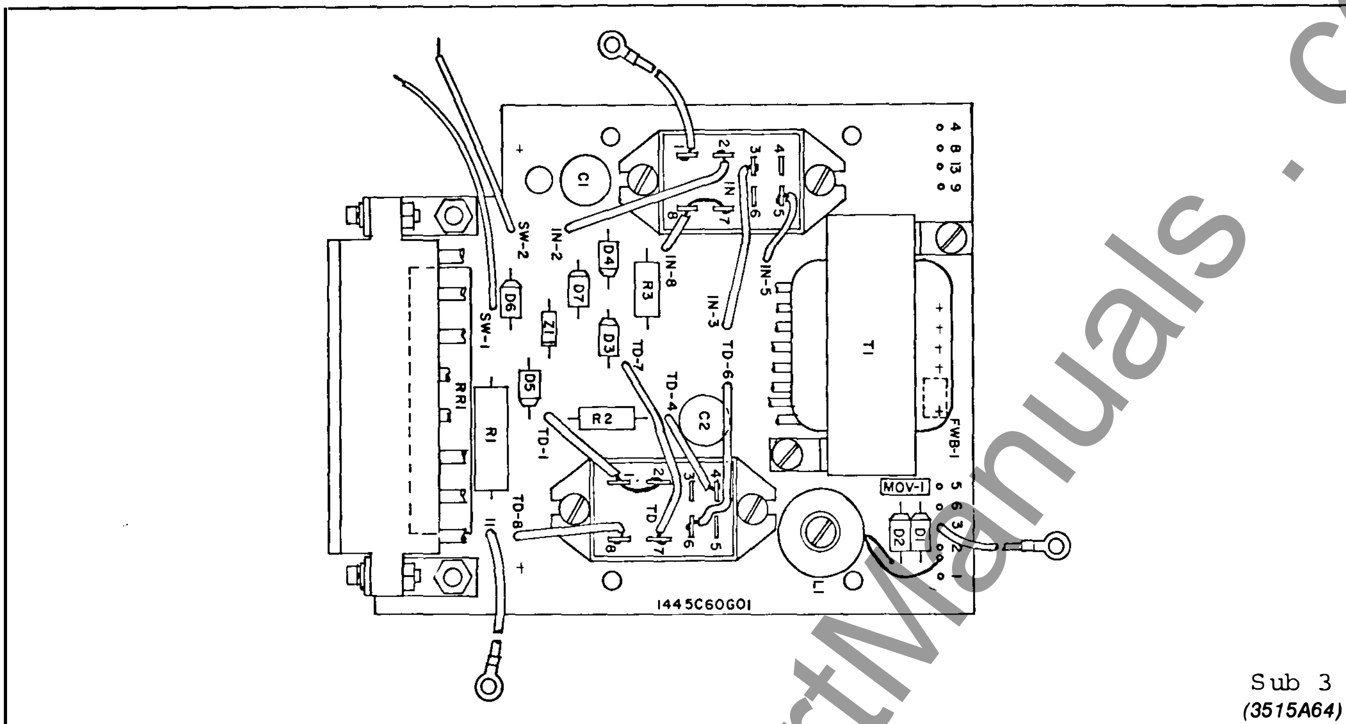


Fig. 5. Transformer Module Component Location Single Phase

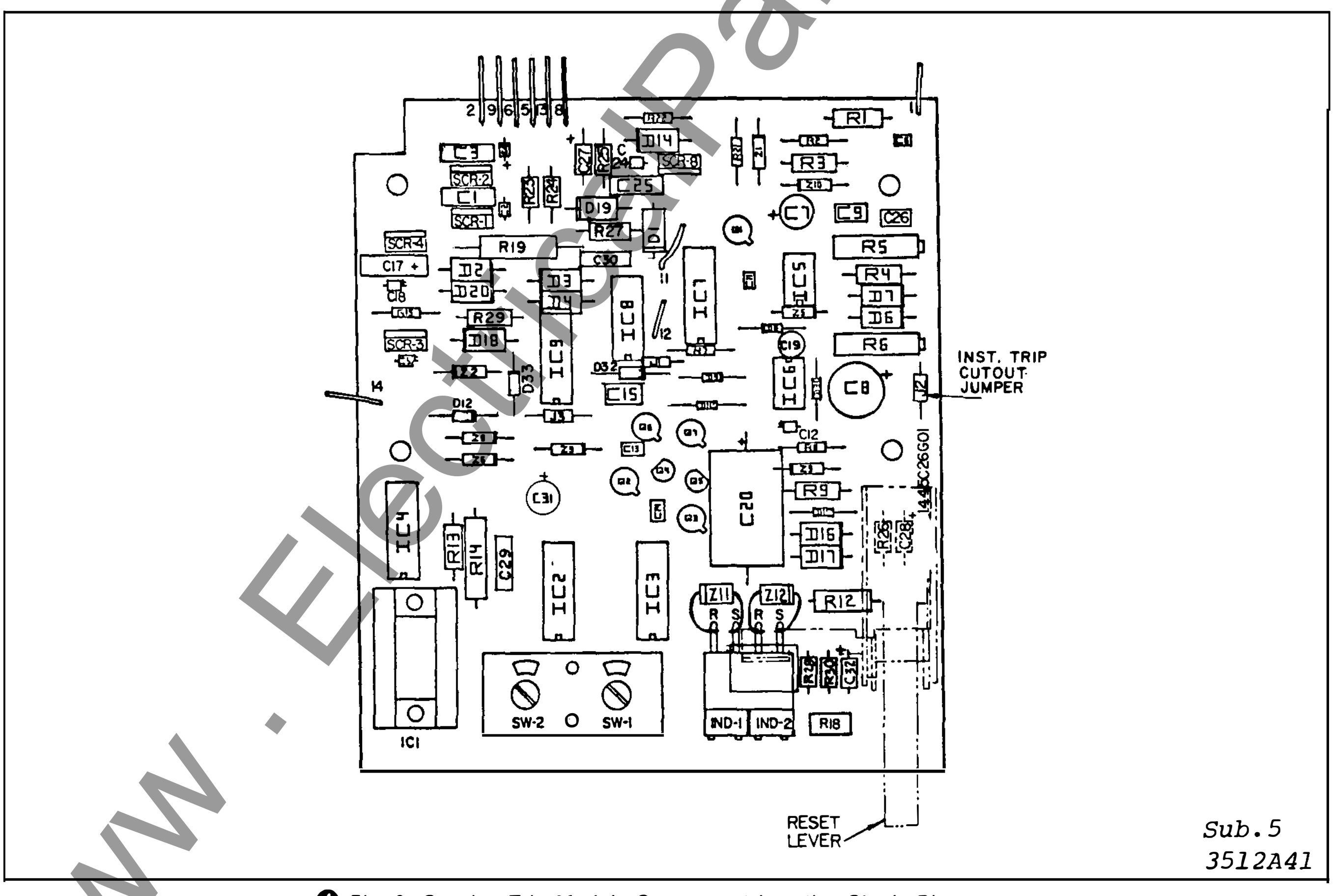


Fig. 6. Sensing-Trip Module Component Location Single Phase

THEORY OF OPERATION

The basic operation of the SCO-T relay will be described with the aid of Figure 3 internal schematic 6706D67, and Figure 4 external scheme.

The SCO-T relay derives both its power and its sensing information from a single transformer. The type of transformer used is of the linear current transformer design consisting of a tapped primary winding and two secondary windings. The tapped primary winding allows 14 different pickup current settings from 0.5 to 12 amperes. One of the two secondary windings is a high current power supply winding (low number of turns) and the other one is a low current information winding (high number of turns). The circuit operation is based on the transformer ampere-turns balance principle between the primary and the secondary. Following each zero crossing of the line current, balancing of the primary ampere-turns is first achieved by the high current winding. During this time thyristors SCR-1 and SCR-2 are both off and the power supply regulator circuit is the only load imposed at the transformer's secondary. When the regulator reaches the specified regulated voltage based on zener diodes Z1 and Z10, transistor Q1 generates a signal to turn SCR-1 and SCR-2 on. Since these thyristors form a full wave bridge with diodes D1 and D2 on the transformer module, only the respective forward-biased thyristor will fire. Upon firing, an instant voltage drop is seen at the power supply winding output.

This action forces the diode bridge FWB-1 into a back-biased condition cutting off the power supply winding current flow. Balancing of the primary ampere-turns is, therefore, carried out in the low current, or information winding circuit. From this switching point the next zero crossing, the line current represented in voltage form is obtained across the burden resistor R19. When the line current experiences the next zero-crossing the thyristor is turned off automatically, again allowing the current flow in the power supply winding to charge the regulator circuit. The transformer is designed to allow a large enough current flow in the power supply winding at the pickup level so that the regulated voltage can be established very quickly. Once the regulated supply voltage is obtained, the subsequent replenishment uses only the very initial portion of each half cycle of the current. Therefore, the flux build-up due to the power supply replenishment is very low and the design is capable of providing a linear current information transfer up to 40 times pickup current.

The line current information obtained across burden resistor R19 in voltage form is then utilized using the technique of RC approximation and digital time multiplication for time-current curve sensing. The time current curves generated by this design are closely matched to the ones presently obtained from the electromechanical induction disc type relays. This technique utilizes a short, precision time-constant network for time-current curve shaping, and then uses digital counting and decoding techniques to provide time multiplication and precision time dial section. This has an advantage over a straight RC approximation scheme since long delay times are required at low multiples of pickup current. Component leakage and other design factors that make the straight RC network type of timing unattractive and complicated are not considered a problem in this digital approach. Thus, the information across resistor R19 is fed through transistor Q4 to this precision multi-branch RC network housed in the plug-in curve module IC-1. Depending upon the degree of inverseness of the desired time-current curve, the number of RC branches may vary from 2 to 4 branches. Each RC branch contains a first order RC circuit with a time-constant different from other branches. The branches are then combined to give a common weighted output. The weighted RC output is then compared with the reference V_R by IC-6. This operational amplifier maintains a closed-loop operation through Z5 and D8 before the equivalent voltage of the RC network reaches the reference level V_R. This reference level is set at the minimum pickup condition through the comparator IC-8 (pin 2 output) and potentiometer R5. Once this V_R reference level is exceeded, IC-6 outputs a negative-going signal which triggers the one-shot circuit (IC-5). The one-shot signal, which has a pulse width adjusted to supply the proper definite delay time (poteniometer R6), resets the multi-branch RC network by turning transistor Q4 off, through Q5 and Q6, and by turning Q7 on to discharge the RC capacitors.

The one-shot signal also advances the binary counter circuit IC-4. This counter, which is enabled (logic 0 on pin 11) when the input current is above the minimum pickup level and reset or kept inactive when below minimum pickup level (MPU IC-8 pin 2), counts the negative going signals from the one-shot output. When the correct count is attained, up to 2^{12} power or 4096 counts, depending upon which binary output is used per respective curve connection in IC-1, the counter output is inverted by comparator IC-9 (pin 13) and then drives the two time-dial decade counter/decorder circuits, IC-3 and IC-2. These two counters, one for tenth time-dial positions and one for unit time-dial positions, are connected to a dual decade thumbwheel switch to provide ninety-nine distinct time-dial settings, which means up to 99 count outputs from the binary counter IC-4. Thus, for example, if the 2^{10}(1024) output of IC-4 is used, up to 2^{10}X time dial setting (from 1 to 99) actual counts of the RC network takes place before generation of a trip signal. These decade counters, as in the previous case of the binary counter IC-4, are kept inoperative and reset whenever the minimum pickup signal on pin 15 of IC-3 and IC-2 goes to a logic 1, indicating that the input current dropped below pickup level.

Thus, when the set time dial count has elapsed, a positive output occurs from both the decade counters. These are applied through the time dial switches to the cathode ends of D9 and D10, reverse biasing them. This allows the signal present on pin 8 of comparator IC-8 to now become a logic 1 (through R8) generating a trip signal (IC-8 pin 14). Prior to this, the signal on pin 8 of comparator IC-8 was kept at a logic 0 level by the shorting of this input, in accordance with the logic 0 outputs of IC-3 and IC-2, through either or both of diodes D9 and D10.

This trip signal is then applied through IC-9 D12 and Z6 to the base of Q3, turning it on. This, in turn, applies 2 distinct branch signals; one is through IC-9 and D18 to gate thyristor SCR-4, the second is through D16, C28 and R26 to IND-1, the time-delay trip indicator. Thus, with the turn on of SCR-4 the T.D. relay on the top module is energized and a trip output occurs between terminals 1 and 10 of the SCO-T relay. The turn on of the indicator can only occur when the reed relay RR picks up, concurrent with the flow of trip coil current. This happens when the normally open RR contact closes completing the path to, and allowing the indicator current to thereby flow to, power supply negative.

The trip of the breaker will interrupt the current input, and total reset of the relay circuitry occurs within 50 milliseconds plus an additional 15 to 20 milliseconds dropout time of the trip relay. Reset of the indicator is accomplished manually through use of the reset lever actuated from the outside of the case. This lever magnetically flips the indicator back to its reset state.

The instantaneous trip circuitry also derives its information from the voltage across resistor R19. This information is taken from the cathode side of diode D1, through the instantaneous trip cutout link jumper, to the level control and filter circuitry on the input of the instantaneous trip comparator, IC-8 (pin 6). This input is then compared with the minimum pickup reference level V_R by IC-8. The potentiometer R18 allows a continuous range of setting from 1 to 40 times the minimum pickup tap setting of the relay. Once the V_R reference level is exceeded, IC-8 (pin 1) outputs a negative-going instantaneous trip signal. This signal is then applied through IC-9 and Z8 to the base of Q2, turning it on. This, in turn, applies 3 distinct branch signals; one is through D15 and IC-7 to immediately seal-in the instantaneous input on IC-8 pin 6, the second is through R21 and D14 to gate thyristor SCR-8, thereby energizing the INST. relay, and the third is through D17 the IND-2, the instantaneous trip indicator. With the energization of the INST. relay a trip output occurs through similar paths as previously described when initiated by the time delay circuit.

Similarly to the time delay trip indicator, turn on of the instantaneous trip indicator can only occur when the reed relay RR turns on, and is concurrent with the flow of trip coil current.

CHARACTERISTICS

RANGE

The SCO-T has taps covering the range of 0.5 to 12 amperes. The tap values are: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4, 5, 6, 7, 8, 10 and 12 amperes.

Pickup accuracy ±5 percent of tap value for all taps.

The instantaneous circuit has a range of 1 to 40 times the tap value selection with a continuously adjustable pickup.

TIME-OVERCURRENT CHARACTERISTICS

The time vs. current characteristics are shown in Figures 7 to 13. These characteristics give the trip time for the various time dial settings when the indicated multiples of tap value current are applied to the relay. 8 milliseconds T.D. relay pickup time delay must be added to these curves for total operate time of the SCO-T relay.

Timing accuracy ±10% of the characteristics curve for any combination of time dial setting and tap value. Operating time repeatability ±2% at 25°C. for any given time dial and tap setting.

NOTE: A higher percentage value may occur on the 0.1 time dial position when the SCO-T relay is suddenly energized due to angle of incidence and delay in power supply turn-on.

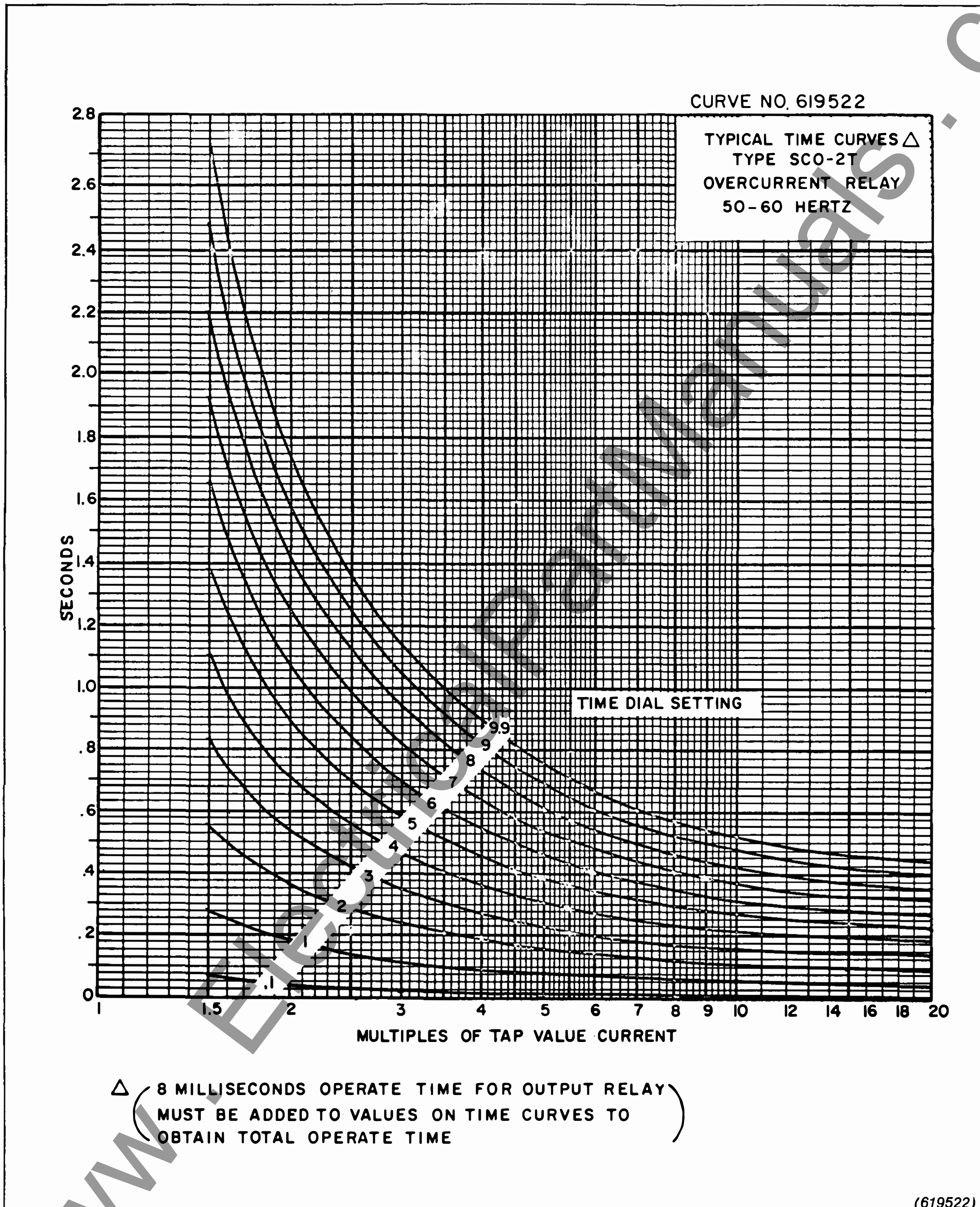


Fig. 7. Typical Time Curves of the Type SCO-2T Relay

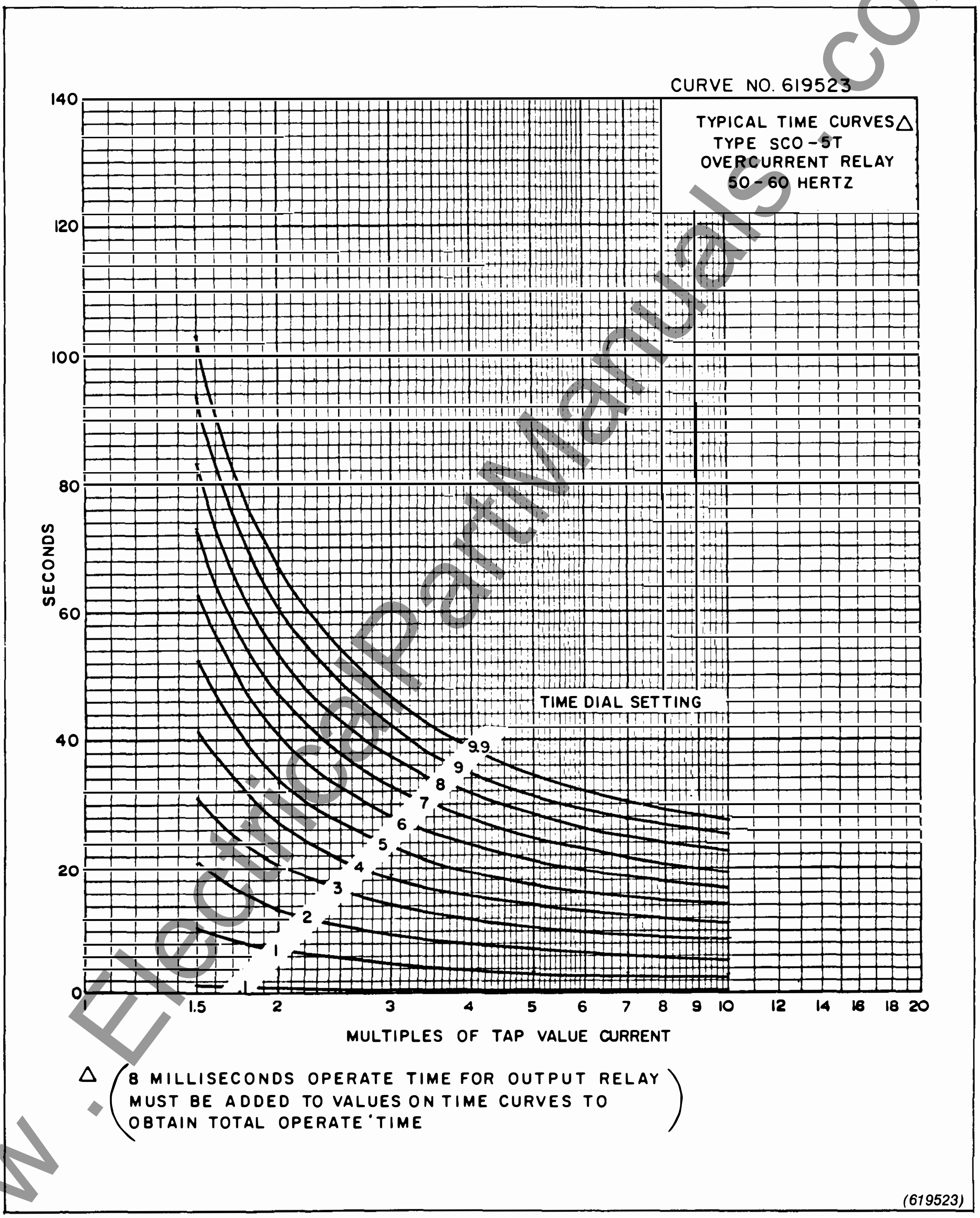


Fig. 8. Typical Time Curves of the Type SCO-5T Relay

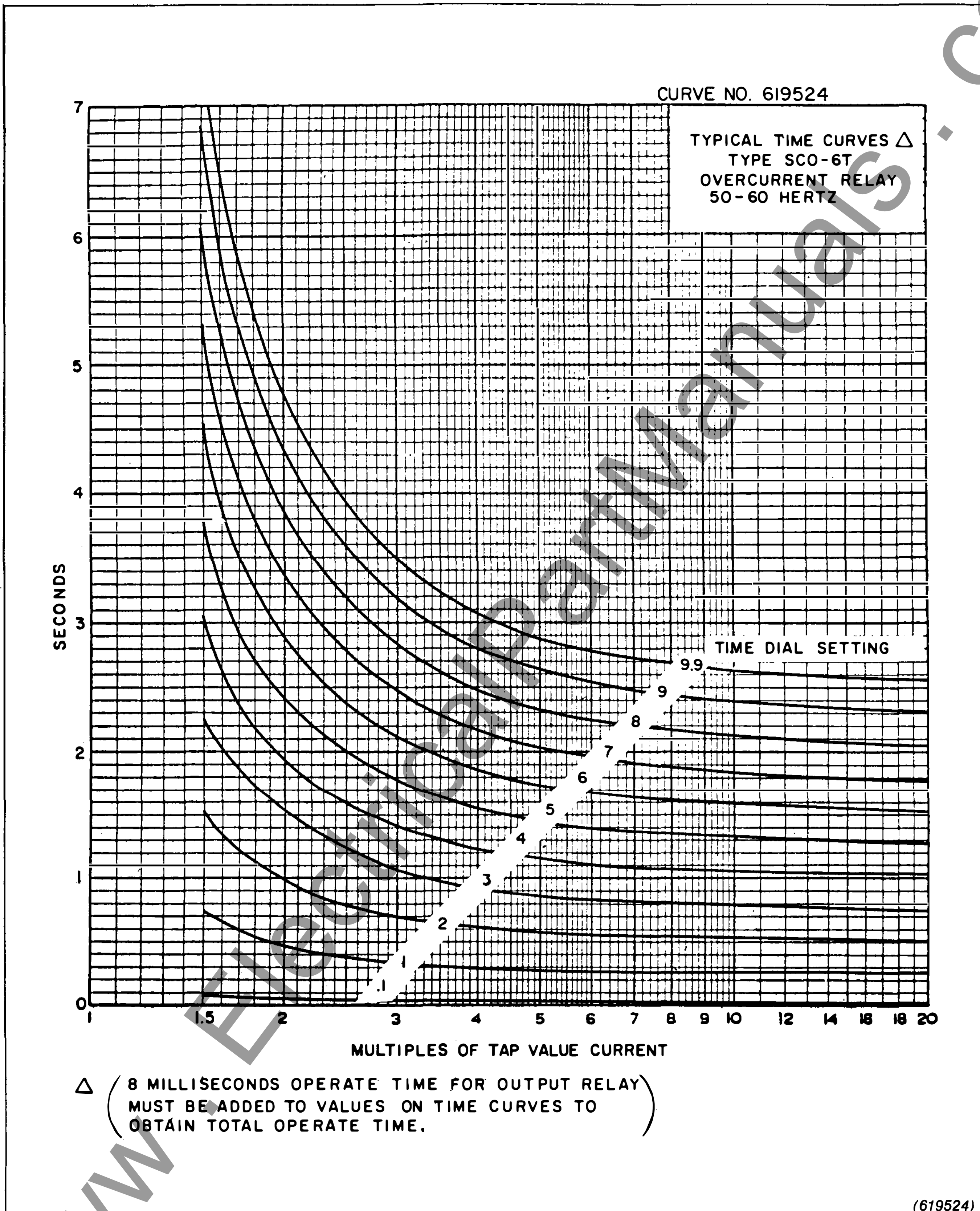


Fig. 9. Typical Time Curves of the Type SCO-6T Relay

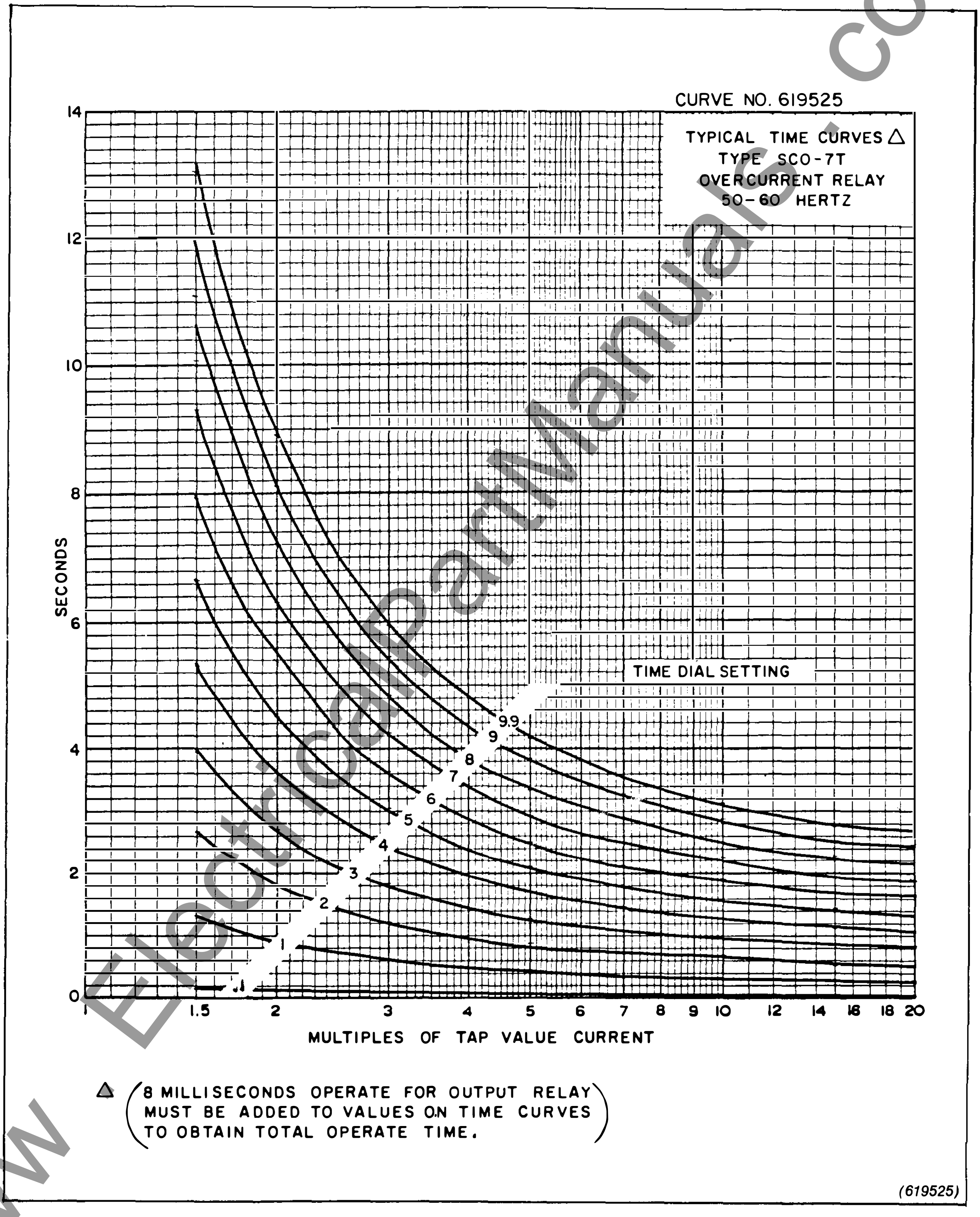


Fig. 10. Typical Time Curves of the Type SCO-7T Relay

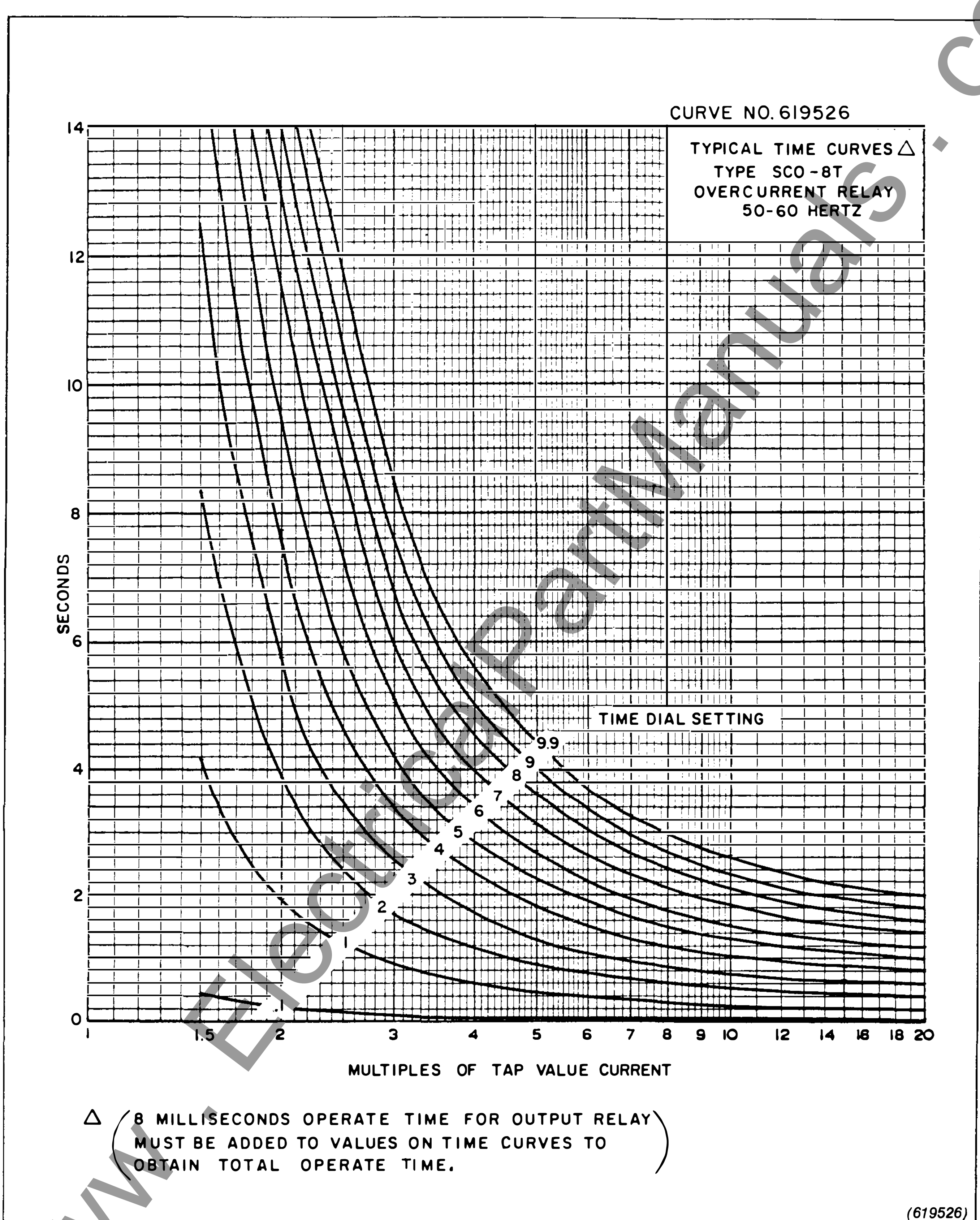
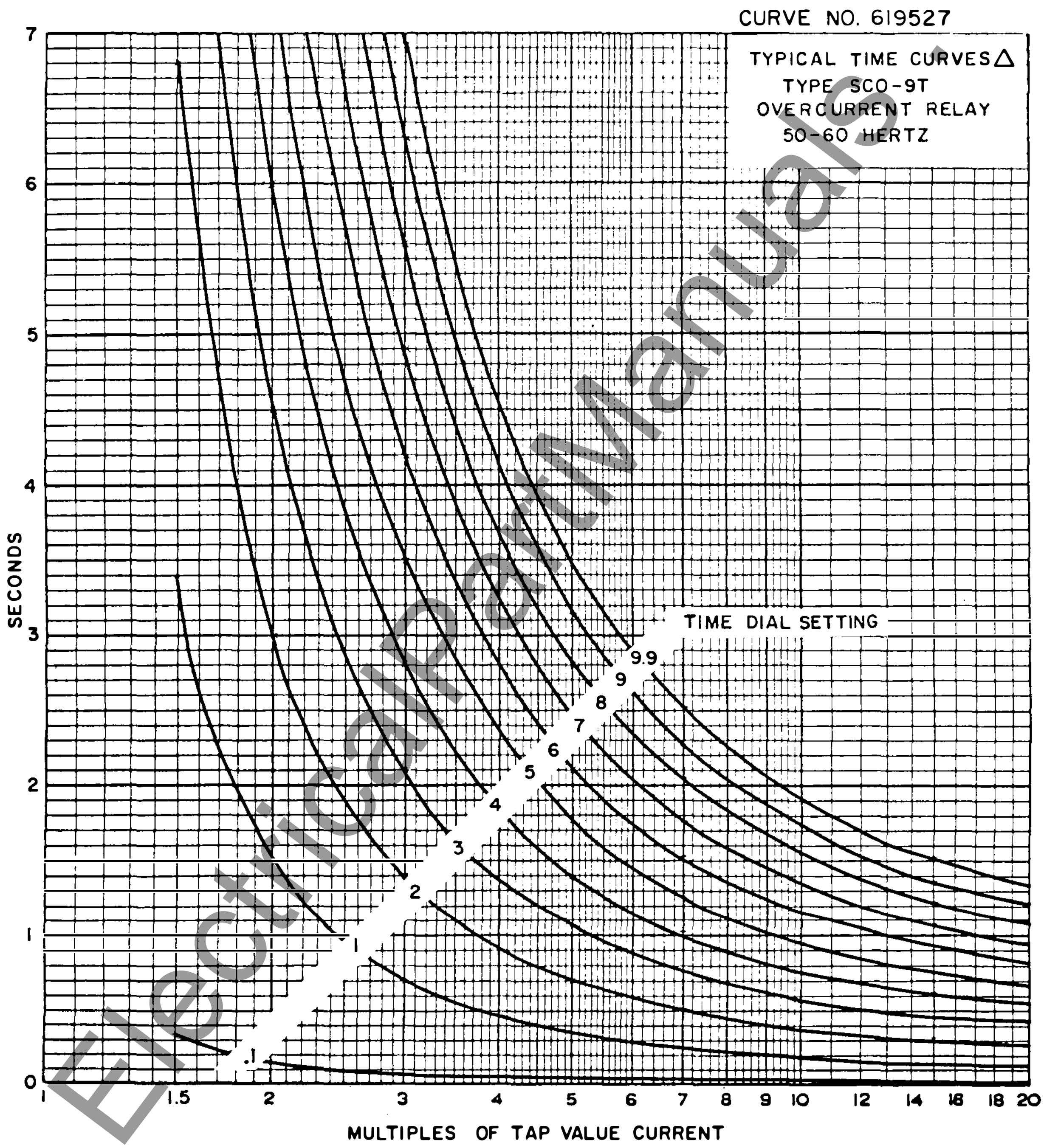


Fig. 11. Typical Time Curves of the Type SCO-8T Relay



△ (8 MILLISECONDS OPERATE TIME FOR OUTPUT RELAY MUST BE ADDED TO VALUES ON TIME CURVES TO OBTAIN TOTAL OPERATE TIME.)

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Fig. 12. Typical Time Curves of the Type SCO-9T Relay

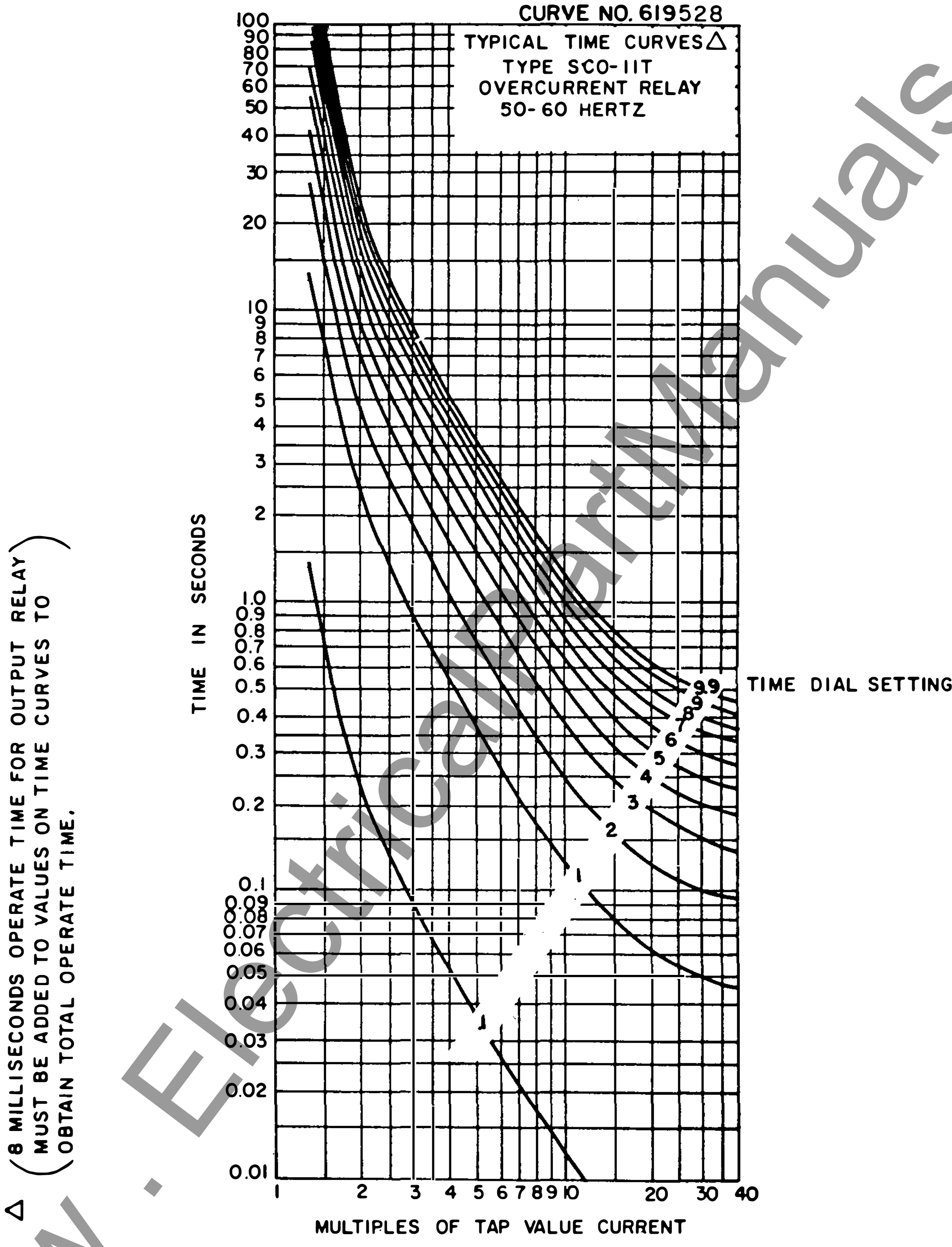

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Fig. 13. Typical Time Curves of the Type SCO-11T Relay

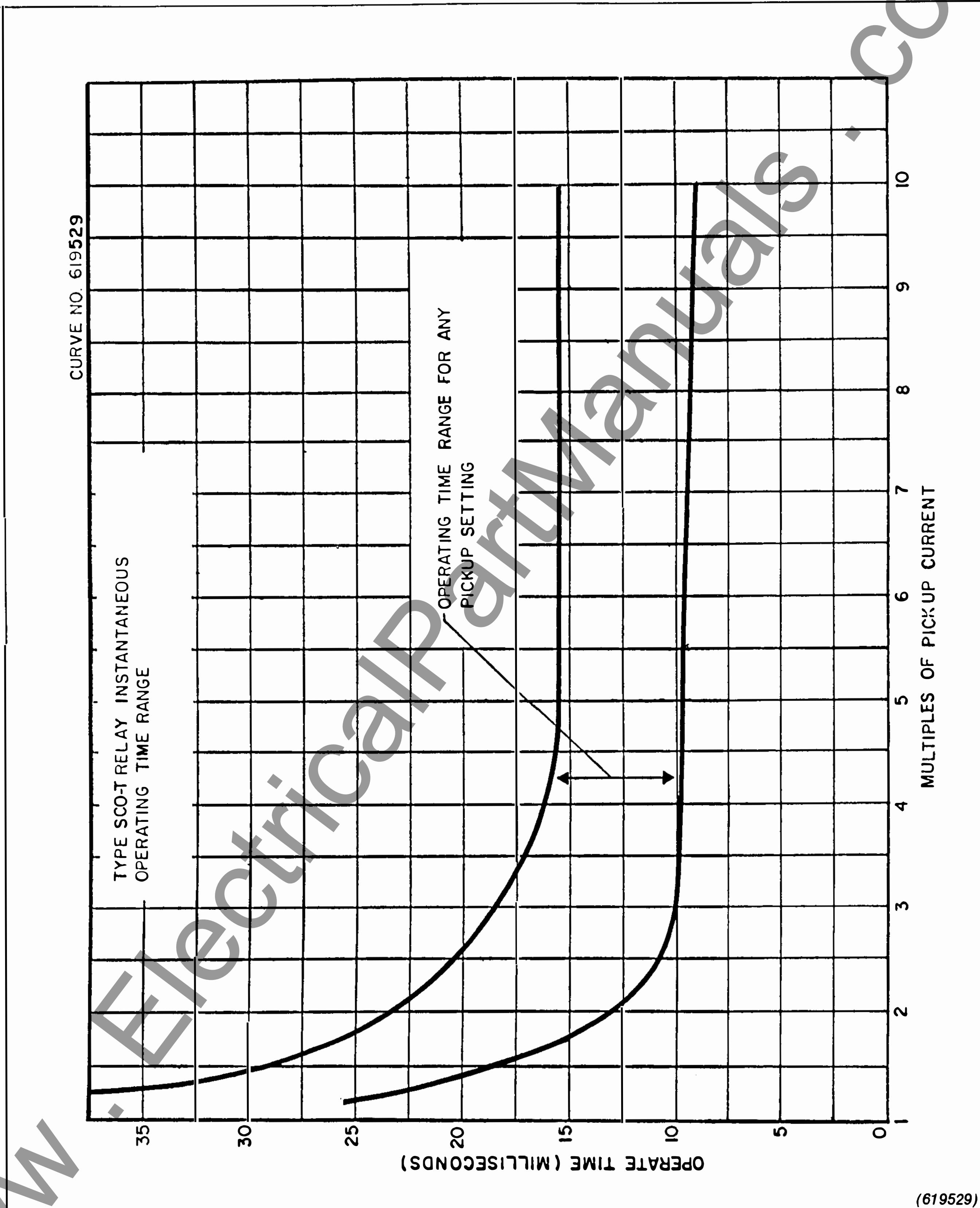

Fig. 14. Typical Time Curves of Type SCO-T Relay Instantaneous

INSTANTANEOUS CHARACTERISTICS

The time vs. current characteristics are shown in Figure 14. These characteristics give the trip time when the indicated multiples of instantaneous pickup current are applied to the relay. 8 milliseconds inst. relay pickup time must be added to this curve for total time of the SCO-T instantaneous.

TRIP CIRCUIT

The SCO-T relay energizes the breaker trip coil by means of an output contact. This contact will safely carry 30 amperes on a 250 dc system, or less, long enough to trip a circuit breaker (10 cycles). If the trip current requirement exceeds 30 amperes an auxiliary relay should be used and connected so that tripping current is not conducted through the output contact. A 52a contact, or similar contact, should be used to interrupt the trip coil current. Refer to the external scheme Figure 4 for proper trip connections.

SURGE WITHSTAND CAPABILITY

Withstand SWC test per ANSI Standard C37.90A.

DIMENSIONS

See Figure 20 for outline dimensions.

WEIGHT

Single Phase SCO-T Approximately 8 lbs. 6 ozs. (3.8 kilograms).

TEMPERATURE RANGE

−20°C to +55°C chassis ambient (outside the relay case) without departure from the +25°C operating accuracy by more than ±5%.

−30°C to +70°C chassis ambient (outside the the relay case) without failure and with no more than 5% additional timing departure. Continuous current ratings must be derated at temperatures above +55°C.

FREQUENCY

The typical frequency characteristics of the SCO-T relay are shown in Figure 15.

HARMONIC RESPONSE

The typical response of the SCO-T relay to harmonics is shown in Figure 16.

RESET TIME

The reset time of the SCO-T relay circuitry is less than 50 milliseconds, and the reset of the output relays is approx. 25 milliseconds for a total reset time at 75 milliseconds max.

OVERTRAVEL TIME

The typical overtravel characteristics of the SCO-T relay is shown in Figure 17.

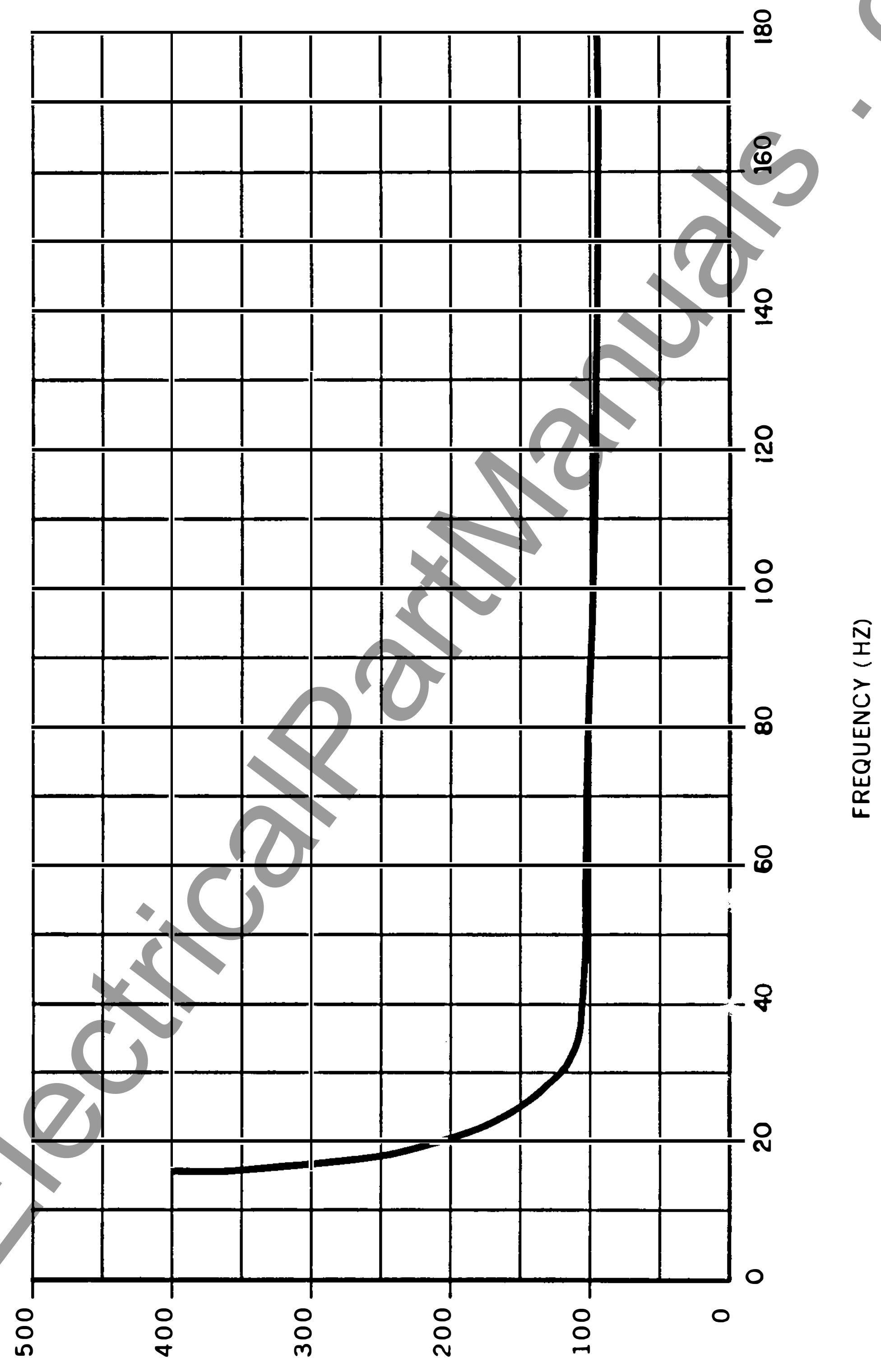

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Fig. 15. Typical Frequency Characteristic of the Type SCO-T Relay

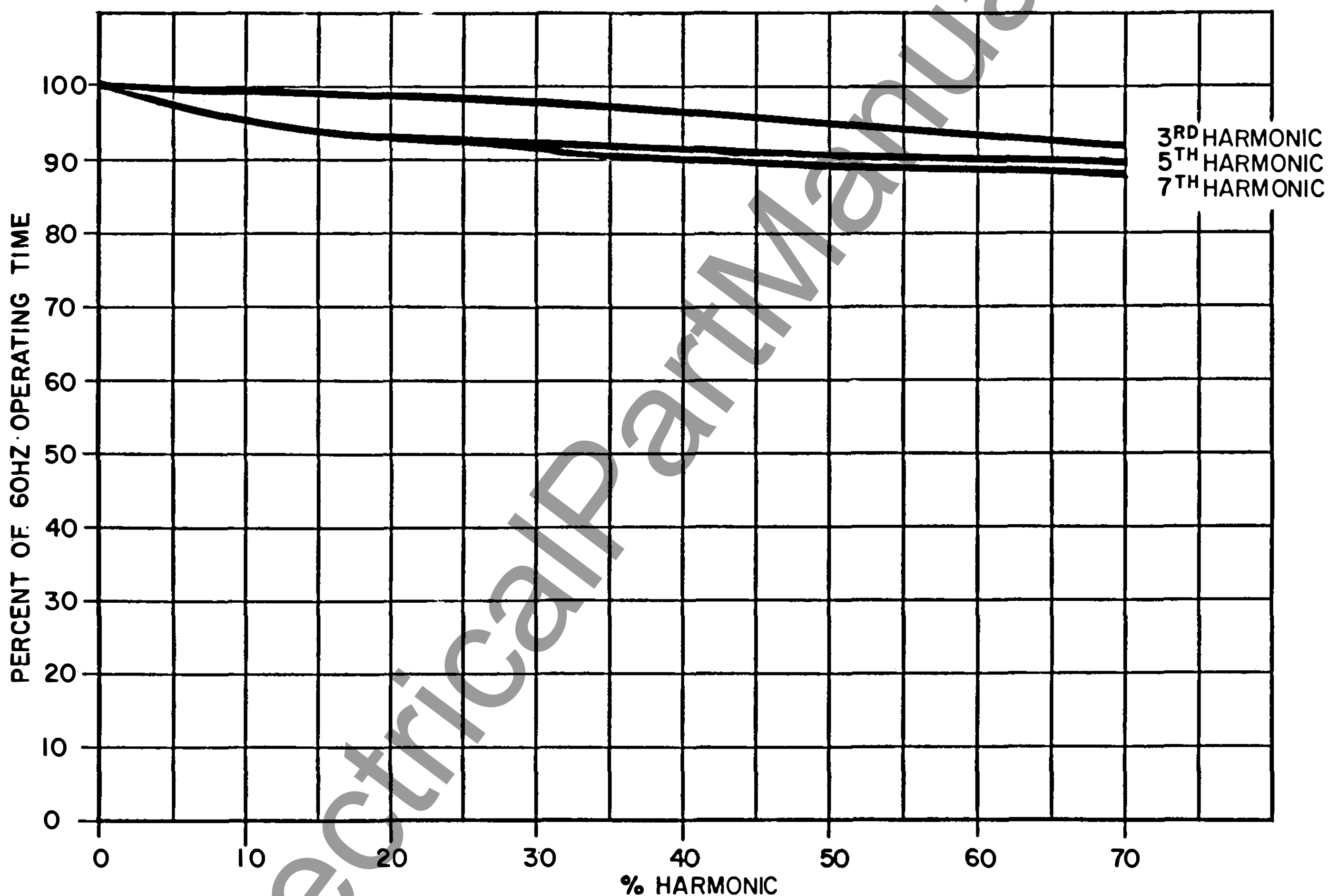

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Fig. 16. Typical Harmonic Response of the Type SCO-T Relay

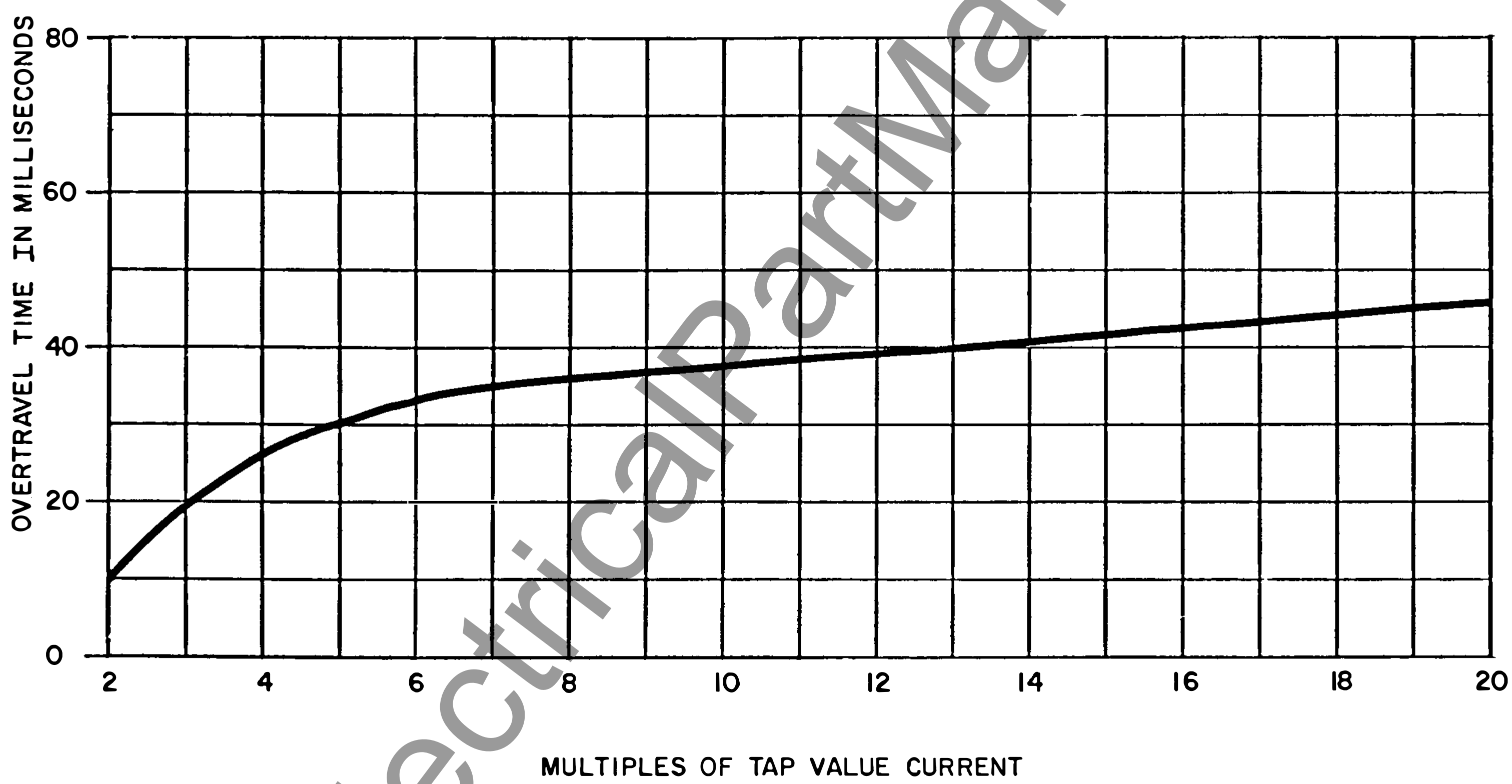

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Fig. 17. Typical Overtravel Time of the Type SCO-T Relay

TABLE I
ENERGY REQUIREMENTS (60 HERTZ)[1]

TYPE SCO-T RELAY WITH INSTANTANEOUS TRIP CIRCUITRY

TAP	CONTINUOUS RATING (AMPERES)	ONE SECOND RATING[2] (AMPERES)	BURDENS AT TAP VALUE CURRENT			BURDENS IN OHMS[1]		
			R OHMS	X OHMS	Z OHMS	AT 3 TIMES TAP VALUE CURRENT	AT 10 TIMES TAP VALUE CURRENT	AT 20 TIMES TAP VALUE CURRENT
0.5	1.6	44	12.4	0	12.4	3.78	2.32	2.08
1.0	3.3	44	3.0	0	3.0	0.96	0.62	0.58
1.5	4.9	185	1.29	0	1.29	0.41	0.27	0.26
2.0	6.5	185	0.73	0	0.73	0.25	0.17	0.17
2.5	8.1	185	0.48	0	0.48	0.17	0.12	0.12
3.0	9.8	185	0.32	0	0.32	0.12	0.09	0.08
3.5	11.4	185	0.25	0	0.25	0.09	0.06	0.06
4.0	13.0	185	0.19	0	0.19	0.07	0.05	0.05
5.0	16.3	460	0.13	0	0.13	0.05	0.04	0.04
6.0	19.5	460	0.09	0	0.09	0.04	0.03	0.03
7.0	22.8	460	0.08	0	0.08	0.04	0.03	0.03
8.0	25.0	460	0.06	0	0.06	0.03	0.03	0.03
10	29.0	460	0.05	0	0.05	0.03	0.03	0.03
12	29.0	460	0.04	0	0.04	0.02	0.02	0.02

[1] Burdens are approximately 10% lower at 50 hertz.

[2] Thermal capacities for short times other than 1 second may be calculated on the basis of time being inversely proportional to the square of the current (i.e. $K = I^2t$)

SETTINGS

TIME DELAY

The overcurrent time delay settings can be defined either by tap setting and time dial setting or by tap setting and a specific time of operation at some current multiple of the tap setting (e.g. 4 tap setting, 2.6 time dial setting or 4 tap setting, 0.6 seconds at 6 times tap value current).

The connector screw on the terminal plate of the tap block makes connections to various turns on the input current transformer. By placing this screw in the various terminal plate holes, the tap desired can be set and the relay will respond to multiples of tap value currents in accordance with the various typical time-current curves.

CAUTION

Since the tap block connector screw carries operating current, be sure that the screw is turned tight. In order to avoid opening the current transformer circuits when changing taps under load, connect the spare connector screw in the desired tap position before removing the other tap screw from the original tap position.

The time dial should be set to the desired setting on the two decade time dial thumbwheel switches on the front panel in accordance with the various typical time-current curves.

The time delay must be set to overide the normal conditions to which the relay can be subjected, such as motor starting current, cold load pickup, emergency circuit load and transformer inrush.

1. Differential protection

   For small transformers and less important buses the SCO-T differential scheme can be used. A pickup setting above maximum load of any circuit connected to the bus, and a time delay setting for maximum fault current in excess of three times the primary circuit dc time constant, will generally prove to be suitable.

2. Motor protection

   For locked rotor protection, the pickup of the SCO-T is typically set at one half locked rotor current, and the time delay is set to allow the motor to start without exceeding the allowable locked rotor time for the particular motor.

3. Circuit protection

   A pickup setting of two times maximum circuit loading is typical for the phase relay. The circuit load may reach 5 times normal when reenergized after a long time. It may not drop below 2 times normal for approximately 7 seconds. The relay should not trip for this condition. This is the cold load pickup phenomenon and varies widely with the type of load.

   Devices farther away from the source than the SCO-T and located between the SCO-T and a fault should be allowed to clear the fault. For all currents seen by both devices, the SCO-T curve should be approximately 0.3 seconds above the total clearing time of the remote device. Where consideration to ct performance, fault current variation and relay accuracy a coordinating time equal to or less than 0.2 second plus breaker clearing time may be used.

   Ground relay pickup must be above the maximum residual load unbalance, including the effect of switching single phase laterals. A pickup setting corresponding to 0.4 of maximum phase load current is typical. The time curve must be above that of all devices farther away from the source than the SCO-T. This includes fuses and recloses even though they may respond to phase current only. 0.3 second coordinating time is adequate. Lower coordinating times may be used as described above.

   Similar SCO characteristics curve shapes at a given system voltage level can generally be more efficiently co-ordinated than dissimilar curve shapes.

INSTANTANEOUS TRIP

The instantaneous circuit should be set to the desired setting on the instantaneous tap multiplier potentiometer on the front panel (see CALIBRATION section). This section is in multiples of tap setting (e.g. with a tap setting of 4 amps. and an instantaneous multiple setting at 20 times, the instantaneous pickup setting will be 80 amps). The relay will respond to currents above this setting per typical time curve Figure 14.

The instantaneous unit is responsive to total current including dc component, and an allowance must be made in the setting to avoid overtripping. Normally a setting of 1.25 times the maximum symmetrical current for which the unit should not trip will provide an adequate margin to prevent undesired tripping due to dc offset.

If an instantaneous trip is not desired in a style relay where it is included, it can be removed from service by cutting out the instantaneous trip cutout jumper J2 located on the right side of the circuit module.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, corrosive fumes and heat. The maximum temperature outside the relay case should not exceed +55°C for normal operation (See CHARACTERISTICS for temperature range specifications).

Mount the relay vertically by means of the four mounting holes on the flanges for semi-flush mounting or by means of the rear stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection between the relay case, its mounting screws or studs, and the relay panel. Ground wires are affixed to the mounting screws or studs as required for poorly grounded or insulating panels. Other electrical connections may be made directly to the terminals by means of screws for steel panel mounting or 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. See Figure 20 for Outline and Drilling Plan. For detailed FT case information refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this realy have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

ACCEPTANCE CHECK

It is recommended that an acceptance check be applied to the SCO-T relay to verify that the circuits are functioning properly. The SCO-T test diagram shown in Figure 18 aids in test of the relay. Proper energization of the relay is also shown in this figure.

A. **Minimum Trip Current**

Set the time dial at 0.1, the tap block at 1 amp. and the instantaneous trip potentiometer at maximum setting (40X). Apply current to the relay, starting with a current below the set pickup, and very gradually increase the current applied to 5% below pickup value. The relay should not trip (See characteristic curves for approximate timing). Increase current 5% above pickup value and the relay should trip. The timing indicator (light emitting diode) begins to light in a dim manner at approximately 1% below the pickup point and attains full brightness at the actual minimum pickup level (tap block setting). This same procedure may be used to check the minimum trip current at other tap block settings.

If a more accurate check is desired, an oscilloscope may be used to view the minimum pickup signal. This signal is present on terminal 12 of the sensing-trip module, and is also easily accessible on the top lead of the TIMING light emitting diode by pulling back the insulated sleeving and attaching the scope probe to this point. The current where this signal becomes a solid logic 0 (complete absence of any positive pulses) is the actual minimum pickup point.

B. **Time Curve**

The time curve calibration points for the various types of relays are shown in Table II. With the time dial set to the indicated position, apply the currents specified by Table II (e.g. for the SCO-8T, 2 and 20 times tap value current) and measure the operating time of the relay. The operating times should equal those of Table II plus or minus 10%.

C. **Instantaneous Trip**

High multiples of current may be involved in the following test, therefore, caution should be taken not to exceed the thermal limits specified under CHARACTERISTICS. Starting with the instantaneous trip potentiometer set at minimum, a procedure of raising the potentiometer and applying the desired pickup current should be tried until the instantaneous unit does not operate with the desired current applied (time delay trip may operate). The instantaneous unit setting should then be "backed down and tried" until it does operate with the desired current applied (instantaneous trip indicator operates). The instantaneous will then respond to currents above this setting per the typical time curve Figure 14. If testing the instantaneous trip at higher multiples of pickup where the instantaneous and time delay curves may overlap, the time dial setting should be raised to the 9.9 setting to give maximum time delay time.

D. **Trip Indication**

The time trip indicator should operate (orange) on time curve trip and be resettable (black) with the reset lever. The instantaneous trip indicator should operate (orange) on instantaneous trip and be resettable (black) with the reset lever.

E. **Test Trip Switch**

The trip test switch, when pushed, should trip the breaker. (Note: No indication occurs on this trip). Note that connection through terminal (1) to Battery Negative through a trip coil must be provided for the trip test to operate.

At completion of the acceptance test return all settings to desired position.

TABLE II

		LOW CURRENT TESTS		HIGH CURRENT TESTS	
RELAY TYPE	TIME DIAL POSITION	CURRENT APPLIED TIMES TAP VALUE	OPERATING TIME IN SECONDS	CURRENT APPLIED TIMES TAP VALUE	OPERATING TIME IN SECONDS
SCO-2T	5.0	2X	.888	20X	.222
SCO-5T	5.0	2X	33.5	10X	14.0
SCO-6T	5.0	2X	2.42	20X	1.28
SCO-7T	5.0	2X	4.50	20X	1.36
SCO-8T	5.0	2X	9.66	20X	1.00
SCO-9T	5.0	2X	7.50	20X	.675
SCO-11T	5.0	2X	10.5	20X	.310

(Note: 8 milliseconds pickup time for the T.D. relay must be added to the above operate times for total operate time of the SCO-T relay).

ROUTINE MAINTENANCE

All relays should be inspected periodically and all settings and times of operation should be checked at least once every year or at such other intervals as may be indicated by experience to be suitable to the particular application.

CALIBRATION

The proper adjustments to insure correct operation of the relay have been made at the factory and should not be disturbed after receipt by the customer. However, recalibration may be required if the adjustments or any components have

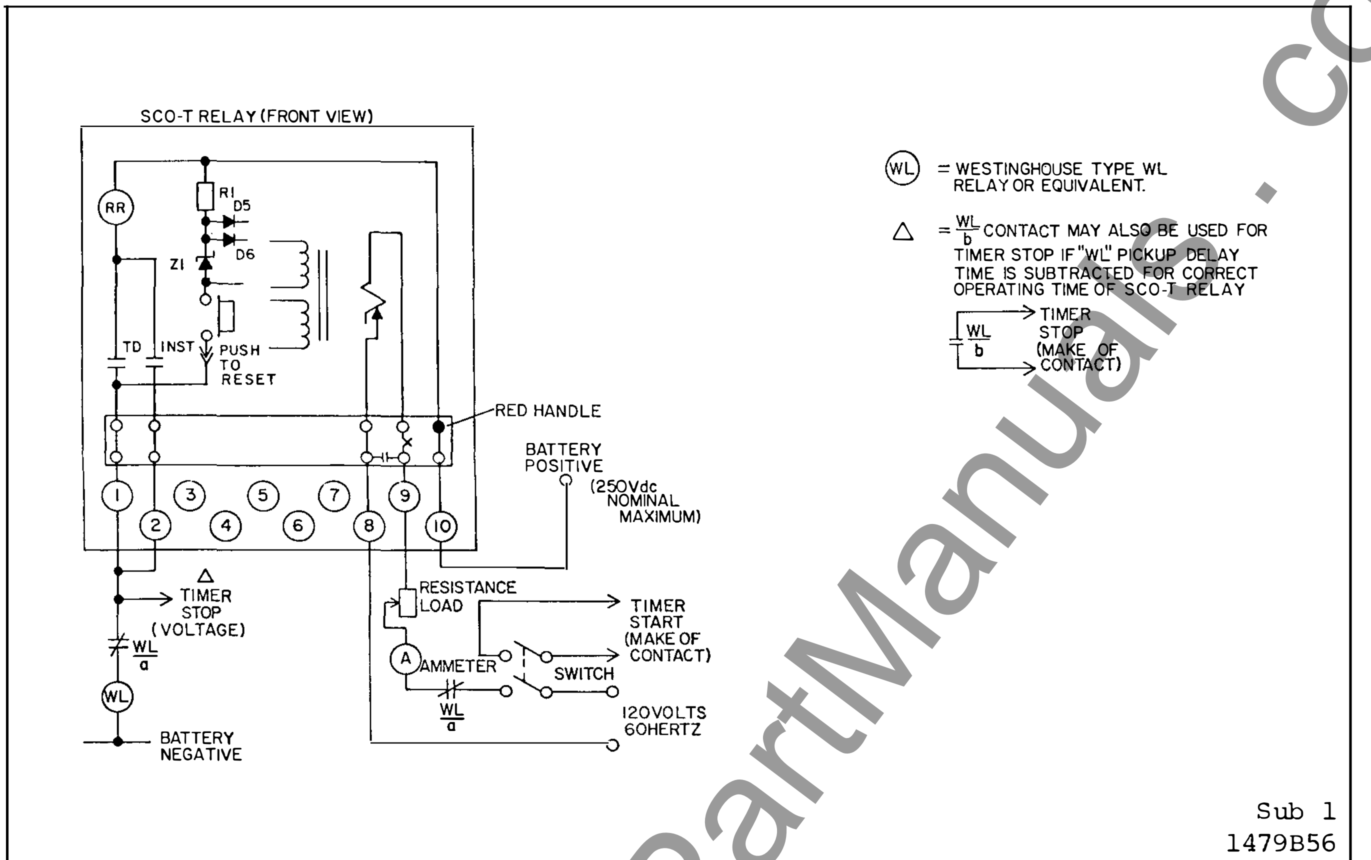

Fig. 18. Diagram of Test Connections for Type SCO-T Relay

been changed or SCO-T curve plug-in modules interchanged. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Acceptance Check"). The SCO-T test diagram shown in Figure 18 aids in test of the relay. Proper energization of the relay is also shown in this figure.

A. **Minimum Trip Curve**

Set the time dial at 0.1 setting, the tap block at a 1 amp. setting, and the instantaneous trip potentiometer at maximum setting (40X). Apply minimum current (1 amp.) to the relay (terminals 8 and 9). Adjust multi-turn trimpot R5 so that the relay will trip at tap value +1% and not trip at tap value −1%. Counterclockwise rotation of trimpot R5 increases the pickup point, (increases V_R) and clockwise rotation of trimpot R5 decreases it. See Figure 2, front photograph, and Figure 6, module component location, for exact location of trimpot R5.

Note that the TIMING indicator (light emitting diode) begins to light in a dim manner at approximately 1% below the pickup and attains full brightness at the actual minimum pickup level.

An oscilloscope may be used to view the minimum pickup signal. This signal is present on terminal 12 of the sensing and trip module, and is also easily accessible on the top lead of the TIMING light emitting diode by pulling back the insulated sleeving and attaching the scope probe to this point. The current where this signal becomes solid logic 0 (complete absence of any positive pulses) is the actual minimum pickup point. This method is recommended for type SCO-5T and SCO-11T relays which have appreciable trip delays at pickup value.

B. **Time Curve**

Set the tap block at a 1 amp. setting, and set the instantaneous trip at maximum or above 20 times setting so it will not interfere with the time curve trip.

The time curve calibration points for the various types of relays are shown in Table II. Apply current per Table II for 10X or 20X pickup and adjust multi-turn trimpot R6 for the appropriate operating time ±2%. Clockwise rotation of trimpot R6 increases the trip time and counterclockwise rotation decreases it. See Figure 2, front photograph, and Figure 6, module component location, for exact location of trimpot R6. Apply current per Table II for 2X pickup and check for appropriate operating time ±7%. Caution should be taken at these higher multiples of current not to exceed the thermal limits of the relay specified under CHARACTERISTICS. A contact to interrupt the input current upon trip of the relay is recommended in testing the SCO-T relay.

Note: Trimmer capacitor C19 has been factory set for correct operation of IC-6 and should *not* be readjusted. However, if IC-6 is ever replaced, capacitor C19 and trimpot R6 must both be adjusted with a SCO-11 curve module plugged in the relay to obtain correct compensation for IC-6 and correct SCO-11 curve 20X timing value.

C. **Instantaneous Trip**

High multiples of current may be involved in the following test, therefore, caution should be taken not to exceed the thermal limits specified under CHARACTERISTICS. Starting with the instantaneous trip potentiometer R18 set at minimum, (fully counterclockwise) a procedure of raising the potentiometer and applying the desired pickup current should be tried until the instantaneous unit does not operate with the desired current applied (Time delay trip may operate). The instantaneous unit setting should then be "backed down and tried" until it does operate with the desired current applied. (Instantaneous trip indicator operates). The instantaneous unit will then respond to currents above this setting per the typical time curve Figure 14. If testing the instantaneous trip at higher multiples of pickup where the instantaneous and time delay curves may overlap, the time dial setting should be raised to the 9.9 setting to give a maximum time delay time.

No other calibration is necessary other than desired changes in settings.

TROUBLE SHOOTING

The components in the SCO-T relay are operated well within their ratings and normally will give long and trouble free service. However, if a relay has given indication of trouble in service or during routine checks, then using the internal schematic Figure 3, component location Figures 5 and 6, and the theory of operation the faulty component, connection, or circuit can be identified.

Voltage levels for "0" and "1" logic states in the theory of operation are:

Logic "0" is equivalent to less than 1 Vdc positive.

Logic "1" is equivalent to 5 to 11 Vdc positive.

For those users not generally acquainted with circuit notation or with device symbols of those components used in the SCO-T drawings, it is recommended that a copy of Westinghouse Instruction Leaflet I.L. 41-000.1 entitled, "Symbols for Solid State Protective Relaying" be consulted.

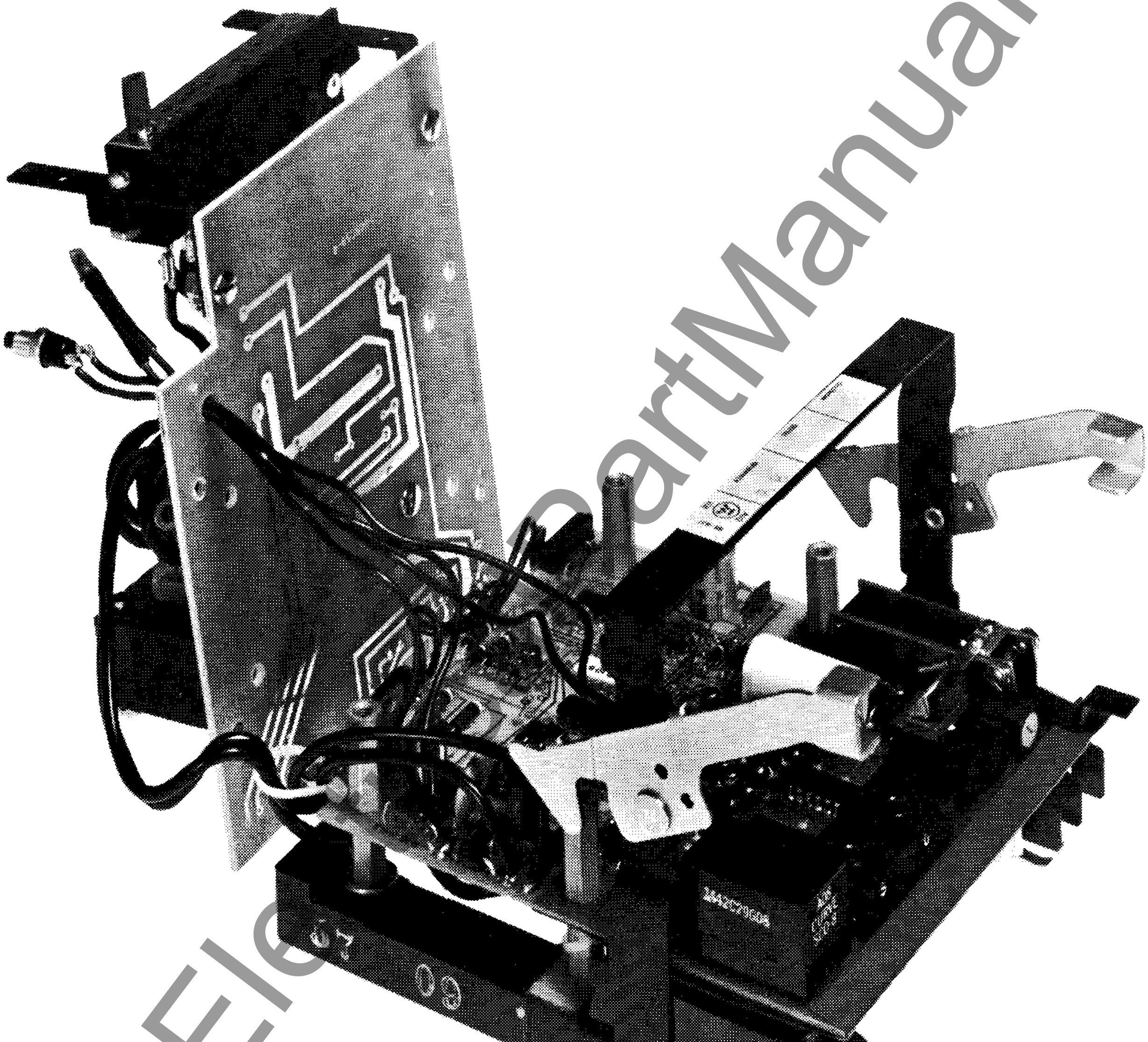

Fig. 19. Disassembly of Type SCO-T Relay

The SCO-T relay can easily be disassembled to gain accessibility to all components for ease in trouble shooting. The following procedure should be followed to mechanically detach and slide back the top transformer module when accessibility to components on the bottom module is desired (reference Figure 19):

1. Remove the two nameplate screws.

2. Remove both the tap block screw and spare tap screw.

3. Slide back rear retaining ring on TIMING light emitting diode snap bushing (onto wires), and push light emitting diode back through panel.

4. Unscrew shield guard from trip test switch (counterclockwise rotation). Front panel is now free to remove.

5. Remove the four screws holding the top module to posts.

6. Slip the wire tie, which holds the leads in the rear, up over the left rear post.

7. Slide the top module backwards for accessibility to components on bottom module.

Reassembly of the relay is accomplished by reassembling everything disassembled in steps 1 through 7 above in reverse order (7 through 1). Reposition intermodule connecting lead wires in rear of relay back to original routing.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. Internal Schematic Figure 3 contains a complete list and description of the components for renewal parts. When ordering parts, always give complete nameplate data and appropriate Westinghouse style numbers.

PLUG-IN CURVE MODULES (IC-1)

Plug-in curve modules are available to change the particular style and time-overcurrent characteristic curve of the relay. The time curve module is a 24 pin plug-in module containing the specific circuitry and components for each particular curve style. There are seven different curve module styles corresponding to the SCO-2, SCO-5, SCO-6, SCO-7, SCO-8, SCO-9 and SCO-11 curves. This module plugs into the 24 pin socket on the sensing-trip module and is visible to the front of the relay through a window in the front panel. There the front label on the module completes the last three digits of the style of the relay (printed on the front panel), and also shows which curve the relay is set for i.e. "SCO-2 curve". Thus, changing this module automatically changes the style of the relay.

When changing plug-in curve modules, the relay should be recalibrated for minimum pickup and time curve specifications per the Calibration Section of this instruction leaflet.

The following are the style numbers of the plug-in curve modules available:

Relay Type	Curve Module	Time Curve	Curve Module Plug-In Style
SCO-2T	A02	Short	1442C29G02
SCO-5T	A05	Long	1442C29G05
SCO-6T	A06	Definite	1442C29G06
SCO-7T	A07	Moderately Inverse	1442C29G07
SCO-8T	A08	Inverse	1442C29G08
SCO-9T	A09	Very Inverse	1442C29G09
SCO-11T	A11	Extremely Inverse	1442C29G11

Consult Type SCO Time Curve Plug-in Modules Instruction Leaflet I.L. 41-110.2 for further information on SCO-T plug-in curve modules.

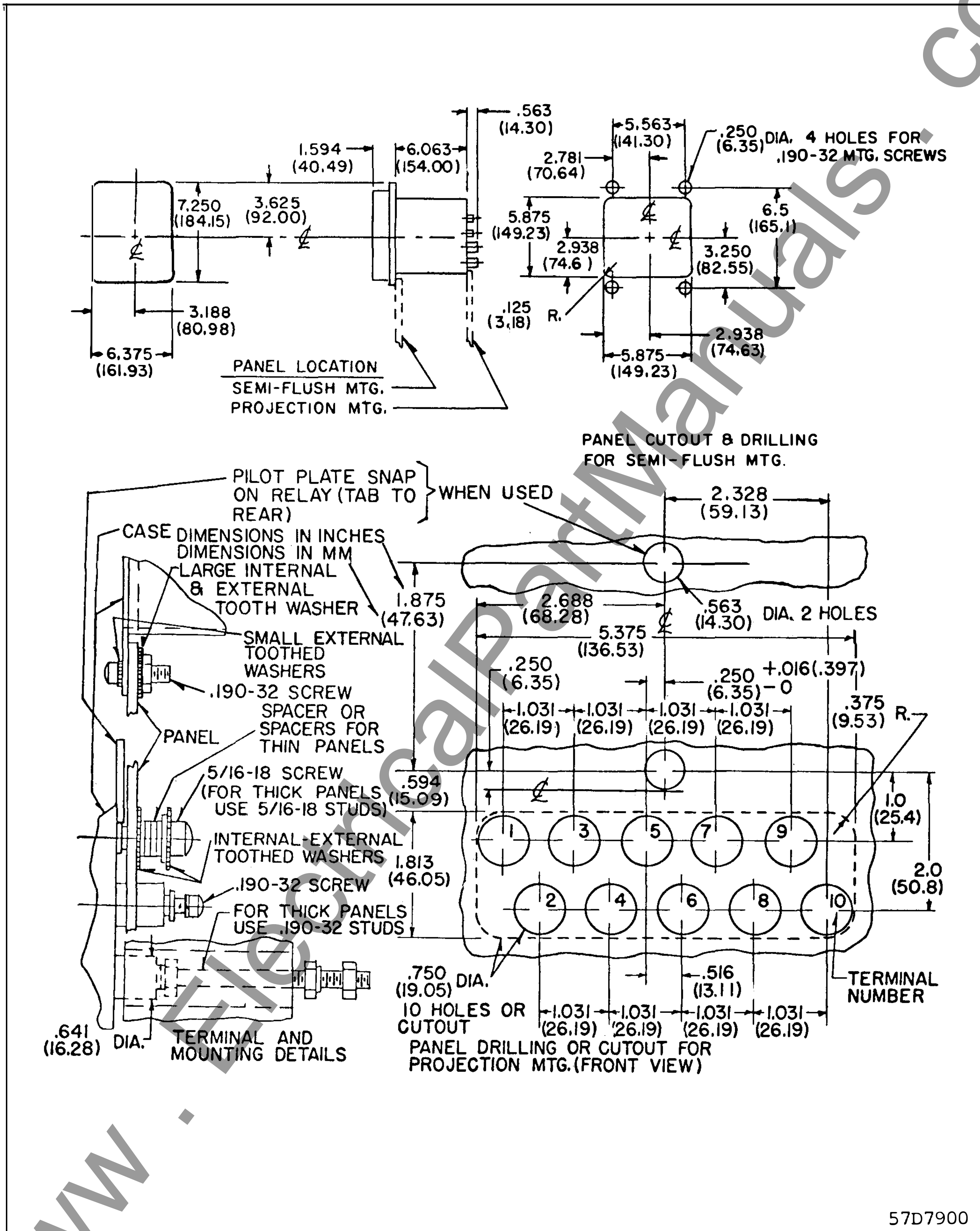

Fig. 20. Outline and Drilling Plan for Type SCO-T Relay Single Phase in FT-11 Case