Type KRT Directional Ground and Timer Relay

Effective: November 1984
Supersedes I.L 41497A Dated February 1977
O Denotes Changed since previous issue

CAUTION

Before putting protective 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

The KRT relay is a dual polarized high speed, directional ground relay with a static two step timer. It is used in the KDXG ground reactance switched zone scheme. It provides directional supervision of all tripping and controls the switching of the KDXG from its zone 1 setting to zone 2 and finally to zone 3.

CONSTRUCTION

KRT relays consist of a **single cylinder** type directional unit, a current-voltage polarizing bridge network, two timing circuits, three telephone relays, one voltage regulator, 3 blocking diodes, one pulsing transformer, three operational zone indicators, and one contactor switch.

DIRECTIONAL UNIT (D)

The directional unit is a product type induction cylinder unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the directional unit is composed of four basic components; a die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The electro-magnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, a contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp. With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

POLARIZING NETWORK

The polarizing network is designed so that a polarizing voltage and a polarizing current may both be applied to the operating unit either independently or simultaneously without one affecting the other. Energy from the current polarizing source is introduced by means of an air gap transformer while the energy from the voltage polarizing circuit is applied directly to the voltage circuit. Associate capacitors, reactors, and resistors serve as impedance balancing elements of a bridge type network.

TIMING CIRCUITS

Each of the two timing units is an encapsulated module that consists of an R-C timing circuit, a zener diode for voltage sensing, and a transistorized amplifying circuit.

VOLTAGE REGULATOR

Voltage regulator is a silicon zener type diode. It provides a constant voltage reference for timing circuits.

TELEPHONE RELAYS

The telephone relay units T1, TA2, TA3, are fast operate types. In these relays an electromagnet attracts a right angle iron bracket which in turn operates a set of make and break contacts.

PULSING TRANSFORMER

Pulsing transformer is designed to operate on the impulse from the initial build up of current in the tripping circuit. The low resistance primary winding of the transformer is connected in series with tripping circuit. The secondary of transformer is connected to the operation indicators for Zone 1, 2, and 3. Selection of the proper operation indicator is controlled by timer contacts TA2 and TA3.

BLOCKING DIODES

Diode D1, is a medium power silicon type rectifier. Diode D1 is connected across the coil of the T1 relay. Its function is to provide a path for dissipation of the transient energy released by the coil after any of the contacts controlling its operation opens. Diodes D2 and D3 function in a similar manner across the telephone relays T2X and T3X, located in the KDXG relays. Diodes D2 and D3 are zener type diodes.

OPERATION INDICATOR UNITS (OI)

Three operation indicator units are used to indicate in which zone of protection the fault occurred. Z1 indicator is located in the upper left-hand corner, Z2 in the lower left-hand corner, and Z3 in the lower right hand corner. The operation indicator unit is a small dc operated clapper type device. A magnetic armature is attracted to the magnetic core upon energization of the unit. During this operation, two fingers on the armature deflect a spring located on the front of the unit which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

CONTACT SWITCH UNIT (CS)

The dc contactor switch is a small clapper-type device similar in appearance to the operation indicators and is located in the upper right hand corner. A magnetic armature, to which leaf-spring mounted contacts are attached, 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 to seal in around the contacts of the operating units in the system and to release them from carrying all of the current. The front spring provides restraint for the armature and thus controls the pickup of the switch.

OPERATION

The relay is connected and applied to the system as shown in Fig. 2. The directional unit closes its contacts to permit tripping for ground faults in the direction of the protected line and opens its contacts to block tripping for ground faults located behind the relay and for all phase faults not involving ground. Upon occurrence of a single line to ground fault on the protected line, the ratio discriminator in the KDXG relay (RD) and the directional units (D) close their contacts to operate the TI telephone relay which starts the timer operation. If the single phase to ground fault is located in Zone 1, the reactance unit operation completes the tripping circuit and the build up of tripping current through the primary of the pulsing transfomer will operate the operation indicator for Zone 1. If the fault is located in the second or third zones, after preset time delays, the telephone relays, TA2 and TA3 will switch the reach of the reactance unit to a Z2-reach and later to a Z3-reach respectively. Simultaneously with switching the reach, TA2 and TA3 set up the Zone 2 and Zone 3 operation indicators for proper indication.

TIME UNIT OPERATION

There are two RC timing circuits, one for each zone.

The RC timing circuit in Fig. 3 delivers an increasing voltage to the sensing zener diode (DZ_2). DZ_2 breaks down at approximately 63% of the reference voltage which is supplied by the voltage regulating zener diode DZ, the rate of voltage rise is determined by the resistance (RH2 or RH3) in series with timing capacitor. Therefore, the rheostat setting of T2 or T3 directly determines the total time delay for Z2 and Z3 respectively as shown in Fig. 4.

When capacitor C charges to the voltage value E, DZ_2 breaks down to provide base drive for transistor TR_2 causing it to conduct. Emitter current of TR_2 provides base drive for transistor TR_1. Transistor TR_1 conducts, energizing the output relay. Resetting of the timer is initiated by the resetting of either the ratio discriminator or directional unit.

CHARACTERISTICS

The KRT relay is available in 48, 125, and 250 Vdc rating.

DIRECTIONAL UNIT

The directional unit is designed so that for current polarization only, maximum torque occurs when the operating current and the polarizing current are in phase. The minimum pickup has been set by the spring restraint to be 0.60 amperes when the current circuits are connected in series.

For potential polarization, the maximum torque occurs when the operating current lags the polarizing voltage by 60 degrees.

The voltage circuit has a rating of 345 Vac for 10 seconds, 208 volts a-c for 30 seconds and 120 volts a-c continuous. The short time rating of the current polarizing circuit is maximum 100 amperes. The operating winding has one second rating of 150 amperes operating time of the directional unit is shown on Figs. 4 and 5.

ENERGY REQUIREMENTS 60 HERTZ

OPERATING CURRENT CIRCUIT

At 5 amperes current 2.3 VA – 36° current lag.

CURRENT POLARIZED CIRCUIT

At 5 amperes current 2.8 VA – 27° current lag.

VOLTAGE POLARIZED CIRCUIT

At 120 Vac 17.2 VA at 20° current lag.

TIMER UNIT

Time Delay Range

Zone 2	0.1 sec. – 1.0 sec.
Zone 3	0.5 sec. – 3.0 sec.

Reset Time

TA2 and TA3 Dropout Time	0.1 sec. or less
TI – Dropout Time	0.06 sec. or less
Timing Capacitor	Discharges to less than 1% of full voltage in 0.015 sec.

BATTERY DRAIN

	48 Vdc	125 Vdc	250 Vdc
Non-operating Condition	0	0	0
Operating Condition Timing Circuit and			
DZ1	53 mA	48 mA	35 mA
T1	64 mA	64 mA	64 mA
TXZ3	117 mA	117 mA	117 mA

Accuracy – Overall accuracy of the timer depends upon the repetition rate of consecutive timings, the supply voltage variation, and ambient temperature changes.

1. Nominal Setting

The first time delay, as measured with the test circuit shown in Fig. 6 taken at 25°C, and rated voltage (48, 125, or 250 Vdc), will be within ± 3%.

2. Consecutive Timings

If consecutive time checks are made at any given setting, the readings decrease. This change of time delay is due to the "voltage recovery" of the timing capacitor. Voltage recovery is a characteristic which all capacitors possess; it has been minimized by the selection of the timing capacitor in the module. The amount of change in time delay depends upon the pause, or duration of capacitor discharge between timings. If a pause of at least 3 seconds is observed between readings, the timing will repeat consistently, so that the total spread between the highest and lowest readings will be no more than 2% of the setting. If timings are repeated, the decrease in time delays will be between 3% and 4% in most cases. In no case will this decrease be more than 5% of the setting.

3. Supply Voltage

Changes on supply voltage, between 80% and 110% of nominal, cause time delay variations of no more than ± 5 milliseconds for settings of 0.5 seconds or less, and no more than ± 1% for settings above 0.5 seconds.

4. Ambient Temperature

Changes in ambient temperature cause changes in time delay. This variation in time delay is a direct function of capacitance change with temperature. Typical variation of time delay with temperature is shown in Fig. 7.

TIMER CHARACTERISTICS

The characteristics of various elements of the timer are as follows:

	48 Volts DC	125 Volts DC	250 Volts DC
TA3 and TA2 Relay Units	2000 ohm	2000 ohm	2000 ohm
TI Relay Unit	750 ohm	750 ohm	750 ohm
RT Resistor	350 ohm	2000 ohm	6300 ohm
RT1 Resistor	0 ohm	1180 ohm	3000 ohm
DZ1 Zener Diode	30 volts breakdown 10 watt		
RH2 Rheostat	Adjustable 0-40,000 ohms		
RH3 Rheostat	Adjustable 0-100,000 ohms		

BLOCKING DIODES D1, D2, D3

The diode D1 is type 1N539. It is a low power silicon rectifier. It has 0.75 amperes maximum current rating at 50°C, maximum reverse current at rated peak inverse voltage of 300 volts is 10 microamperes at 50°C. Forward voltage drop at 1 amp instantaneous at 25°C volts is less than 1 volt. The diodes D2 and D3 are zener type 1N3501. (250 Vdc relays: Have 2 1N3051 Diodes connected in series for every diode used on 48 and 125 Vdc rated relays.)

TRIPPING CIRCUIT

The contactor switch has a nominal rating of 1 ampere. The burden of the tripping circuit consists of the d-c resistance of the contactor switch and the primary of the pulsing transformer, and is equal to 0.64 ohm d-c resistance. Since operation of the pulsing transformer depends on the rate of change of current which depends on inductance of the tripping path, it is recommended that the inductance of the tripping path for circuits with 4 amperes of final current should not exceed 2.8 Henrys. For larger final currents, the inductance limiting value is much higher. Usually the inductance of a typical tripping coil varies between 0.028 and 0.250 Henrys. The tripping circuit of the KRT relay should not be shunted by less than 100 ohms of d-c resistance.

SETTINGS

DIRECTIONAL UNIT

There are no settings to be made on the directional unit.

TIMER

Timing for zone 2 and zone 3 tripping is established by the setting of RH2 and RH3 rheostats. The zone 2 timer must coordinate with adjacent line zone 1 tripping including breaker time. This is typically chosen to be 0.25 seconds. The zone 3 timer must coordinate with adjacent line zone 2 tripping including breaker time. 0.5 seconds is typically chosen for this setting.

RH3 should never be set for less than RH2 because operation of TA3 prior to TA2 will cause the autotransformer and T3X contacts in the KDXG to be overloaded momentarily and may shorten the life of both.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from moisture. Mount the relay vertically by means of 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 for steel 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.

ADJUSTMENT AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. Do not remove the knobs on the RH2 and RH3 rheostats unless the rheostats are to be replaced as this will upset the relay calibration.

ACCEPTANCE TESTS

DIRECTIONAL UNIT

Using test circuit shown on Fig. 8, make following test:

1. Contact Gap

The gap between stationary and moving contacts with relay in the de-energized position should be approximately 0.093".

2. Sensitivity

Setting voltage to zero, pass 0.60 amp through terminals 6, 7, 9, 8. Directional unit contacts should just close. Set voltage to 1.5 volt, current for 3 amp a-c, 60° lagging the voltage through terminals 9 and 8. Directional unit contacts should just close.

3. Spurious Torque

Setting voltage to zero, pass 60 amperes of a-c current through terminals 9, 8. There should be no spurious closing torque.

TIMER UNIT

A timing check at various settings is recommended using test circuit of Fig. 6.

CONTACTOR SWITCH

Energize the contactor switch between terminals 1 and 10 with sufficient current to pick up the contactor switch. It should occur between the 1.0 and 1.2 amp d-c.

OPERATION INDICATOR TEST

Energize the pulsing transformer between terminals 1 and 10 with 0.7 amperes of d-c current suddenly applied. The operation indicator marked "1" should operate after closing the reset switch. It will not operate when current is increased gradually. Close armature of TA2 relay manually, and operate reset switch, operation indicator marked "2" should operate. Operate TA2 and TA3 relay closed - operation indicator marked "3" should operate.

ROUTINE MAINTENANCE

All contacts should be cleaned periodically. A contact burnisher S#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 have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order (see "Acceptance Check").

DIRECTIONAL UNIT

A. Shaft Clearance Adjustment

The upper bearing screw should be screwed down until there is approximately 0.025 clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.

B. Contact Gap Adjustment

The spring type pressure clamp holding the stationary contact in position should not be loosened to make necessary gap adjustments. With moving contact in the opened position, i.e., against right hand stop on bridge, screw in stationary contact until both contacts just make. Then screw the stationary contact away from the moving contact 3 turns for a contact gap of 0.093".

C. Bridge Adjustment

Screw out both magnetic plugs located in the front part of the electromagnet as far as possible. Short out terminals 4 and 5. Apply 5 amps to terminals 6 and 7 and measure with high resistance voltmeter (at least 2,000 ohm/volt) voltage across the two terminals of the reactor (located on the right hand side rear view). Adjust the resistor (located next to the upper terminals and mounted across the relay frame) until voltmeter reading is minimum. It should be below 3.0 volts.

D. Sensitivity Adjustment

Jumper terminals 7 and 9 and pass 0.58 amperes of a-c current in terminal 6 out terminal 8. Adjust the spiral spring by rotating the spring adjuster which is located on the underside of the bridge until the contacts just close. The spring type clamp holding the spring adjuster should not be loosened to make the adjustment. Recheck pickup 4 times to see that the contact closes within 0.55 - 0.65 amperes and no friction is present.

E. Adjustable Reactor Adjustment

Energize relay with 120 volts a-c across terminals 4 and 5 and with 5 amperes of a-c current through terminals 9 and 8 observing polarity as per internal schematic.

The current should lead voltage by 30°. Adjust the adjustable reactor, located in the front just above the cylinder unit, until the contacts just close. Set current for 3.0 amps 60° lagging the voltage, reduce voltage to 1.5 volts, the cylinder unit contacts should remain closed. (This is the maximum torque angle setting). Contacts should open between 0 and 1.5 volts.

F. Core Adjustment (If Supplied)

Apply 120 Vac to terminals 4 and 5. Contacts should remain open. If not, readjust core at bottom of cylinder unit by means of a screwdriver until the contact remains open. Recheck sensitivity D and E.

G. Plug Adjustment

1. Screw in both plugs as far as possible.

2. Short out voltage input terminals 4 and 5.

3. Momentarily pass 40 amps of a-c current through terminals 8 and 9 only and observe the contacts. The cylinder unit need not be cooled during initial rough adjustment, but the unit should not be hot when final adjustment is made.
4. When relay contacts close to the left, screw out the right hand plug until spurious torque is reversed.
5. When spurious torque is in the contact opening direction (to the right) so that contacts remain open, screw out the left hand plug until spurious torque is in the contact closing direction, then screw the left hand plug in until the spurious torque just opens the contacts.

CS TEST (RIGHT HAND TOP)

Check contact gap. It should be 5/64" + 0 - 1/64". Pickup must not be less than 1.0 amp d-c nor greater than 1.2 amperes suddenly applied. To increase pickup current, bend the springs out, or away from the cover. To decrease the pickup current, bend the springs toward the cover.

OPERATION INDICATOR TEST

1. Energize CS with 0.5 amp d-c current through a S.P.S.T. switch. After switch is closed the top left hand unit with target marked "1" should operate. To increase or decrease O.I. pickup, adjust the spring the same way as for C.S. described above. Repeat the pickup check of the indicator five times.
2. Block telephone relay TA2 closed. Energize CS again through the switch. The lower left hand unit marked "2" should operate. Adjust spring if necessary for correct pickup.
3. Block telephone relays TA2 and TA3 closed. Energize CS again through the switch. The lower right hand unit marked "3" should operate. Adjust spring if necessary for correct pickup.

It should be noted that if polarity of the d-c supply has been reversed on the first try operation indicator may operate on much lower current. Hence, operate the operational indicators several times before making final adjustment. The same may be true if the operational indicator has not been operated for a long time – on the first try it may pickup at much lower current. Try pickup several times.

TIMER UNITS

TROUBLESHOOTING PROCEDURES

Use the following procedure to locate the source of trouble if the timer is not operating properly:

1. Apply rated voltage between relay terminals 14 and 15 and check TI contact operation.
2. Check reference voltage circuit. This is done by measuring voltage across zener diode DZ1 mounted in the front on a large metal bracket between CS and 01-Zone 1 units. This voltage should be zero before T1 operates, and between 27 and 32 volts d-c after T1 has operated.
3. Check rheostats RH-2 and RH-3, and TA2 and TA3 relays with an ohmmeter. The RH-2 should measure from 0 to 40,000 ohms and the RH-3 should measure 0-100,000 ohms.
4. If the above checks do not determine the source of the trouble, either the wiring or the module, M, is faulty.

CALIBRATION

Use the following procedure for calibrating the timer if the relay adjustments have been disturbed. This procedure should not be used until it is apparent that the timer is not in proper working order. Before calibrating, follow the Troubleshooting Procedure to locate the source of trouble.

1. Telephone Relay Adjustment

Adjust the armature gap on the three telephone type relays to be approximately 0.004" with the armature closed. This is done with the armature set-screw and lock-nut. Also, adjust contact leaf springs to obtain at least 0.015" gap on all contacts and at least .005" follow on all normally closed contacts.

2. **Rheostat Knob Adjustment, Same Scale Plate**

If it is necessary to replace the RH-2 or RH-3 rheostats the relay may be recalibrated with the same scale plate. This is done by rotating the shaft, without knob until a 1.0 second delay is measured for RH-2 or a 0.5 second delay is measured by RH-3. Then, align the knob for this delay and tighten the knob set-screw securely. There should be a pause of several seconds between readings for all time delays above 0.5 seconds. See section under Accuracy for discussion of this.

3. **Scale Plate Calibration, New Scale Plate**

If it is necessary to replace the silicon power regulator (DZ1), or the modules (M), the relay should be recalibrated with a new scale plate. The first step should be to insure that the knob is approximately vertical for the midscale time delay (0.550 seconds for T2 and 1.75 for T3). This will locate the calibration lines symmetrically around the scale plate. After centering and securely locking the knob on the rheostat shaft, new calibration lines may be marked on the scale plate. When scribing calibration lines may be marked on the scale plate. When scribing calibration lines for delays above 0.5 seconds, there should be a pause of at least 3 seconds between readings. See section under Accuracy for discussion of this.

DIODES D2, D3 TEST

Forward Voltage Drop

Pass 0.2 amp d-c through D2 and D3 diodes with positive connected to terminal 16 and negative on 13 for D2 and negative on 11 for D3.

Measure voltage drop across 16-13 for D2 and across 16-11 for D3. It should not be more than 1.5 volts.

Breakdown Voltage for 48/125 Vdc

Apply d-c voltage source with 10,000 ohm resistor in series with terminals 11 and 16 with positive on 11. Measure the leakage current with a d-c milliammeter. Start with 100 volts d-c and increase voltage until current exceeds 0.25 milliamps and starts to increase rapidly. Do not exceed 3 mA. The voltage at which current exceeds 0.25 mA should be between 60 and 240 volts. Repeat the same test for terminals 13 and 16, except connect positive to terminal 13.

Leakage Current for 250 Vdc Relays

The same test as above except breakdown voltage should be between 320 and 480 volts.

RENEWAL PARTS

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

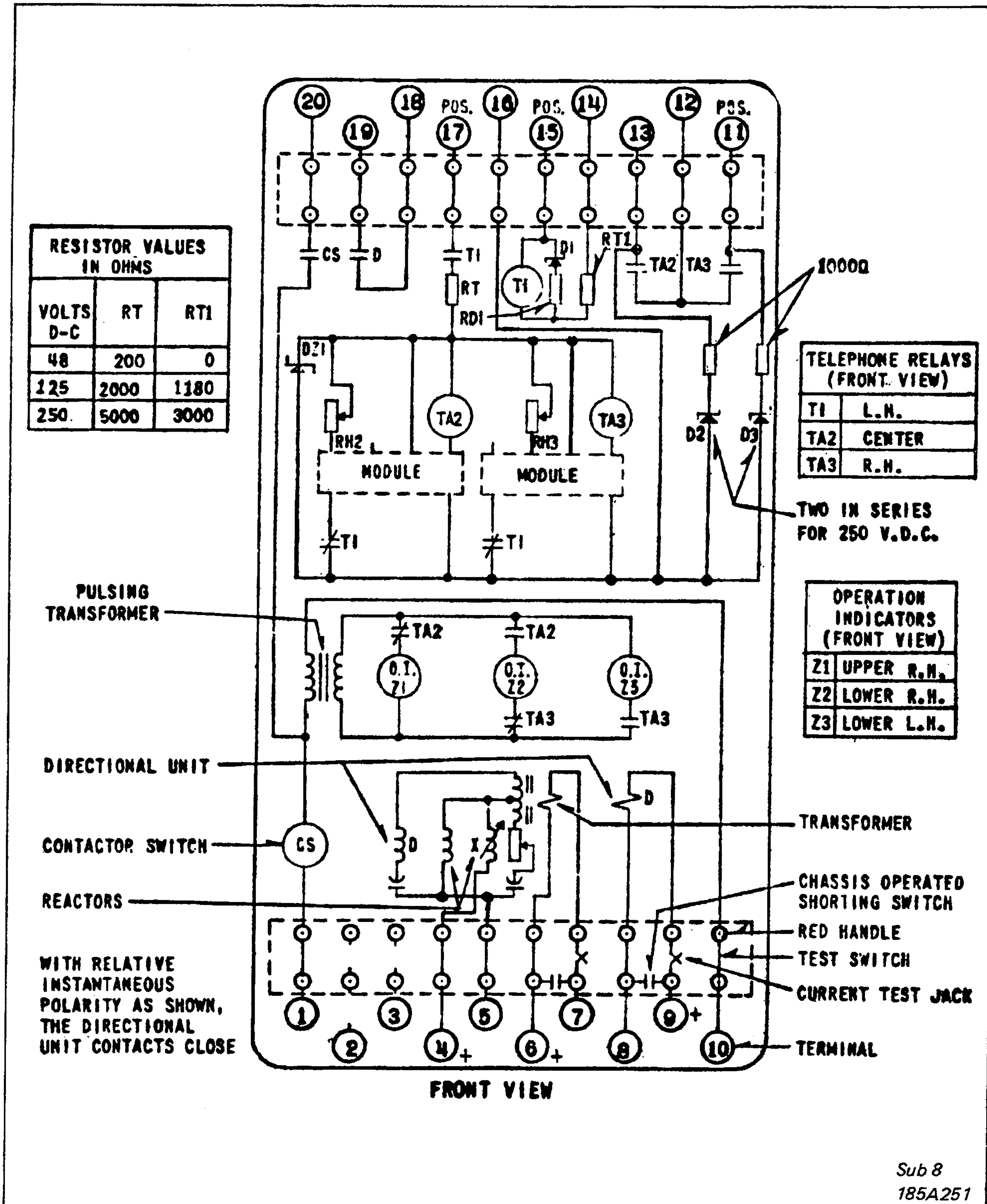


Fig. 1. Internal Schematic

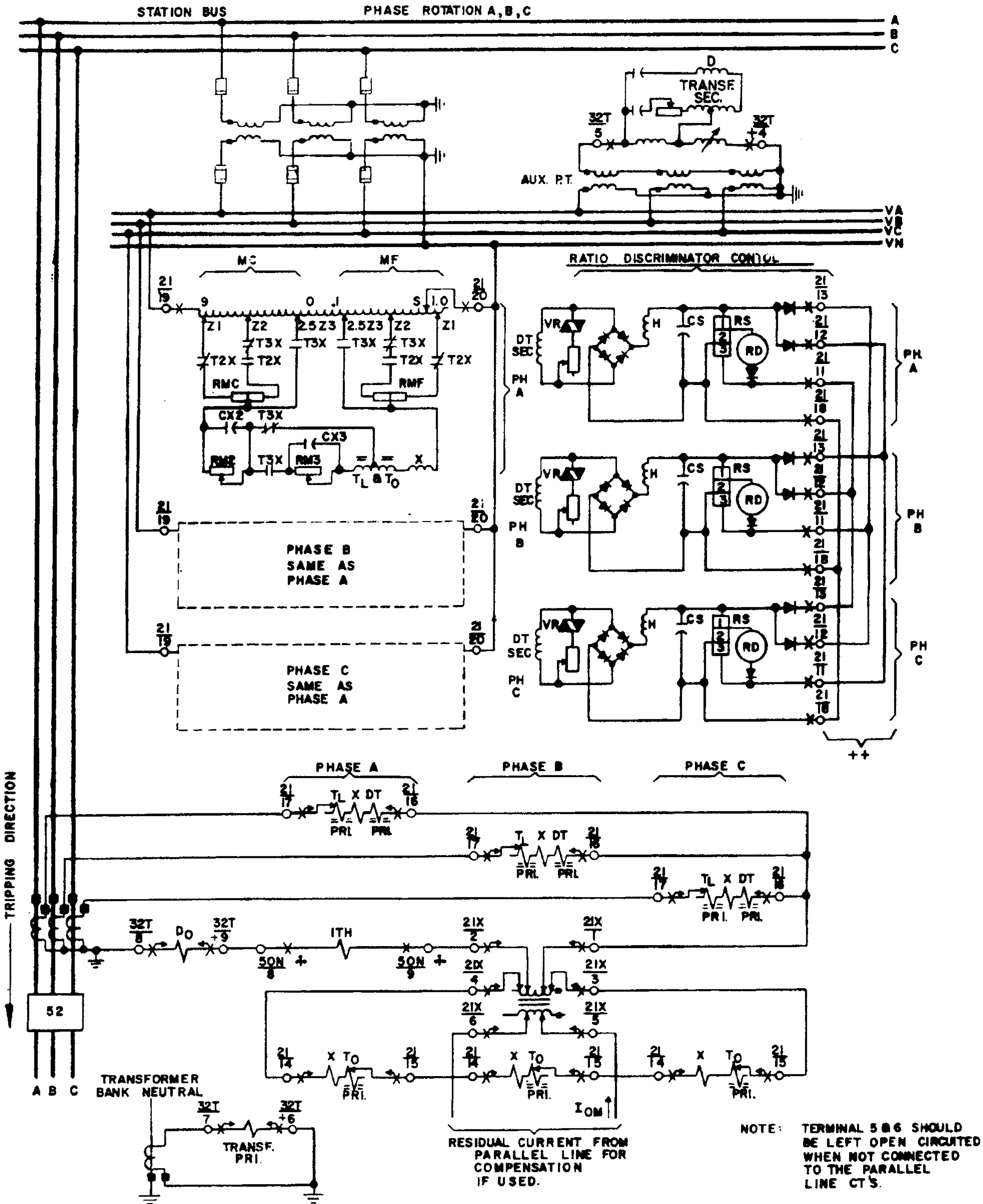
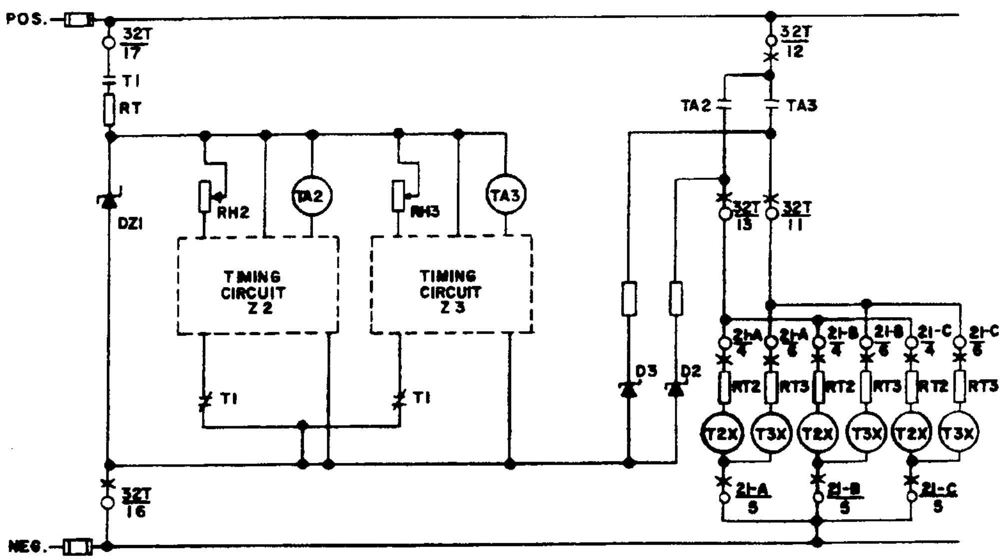
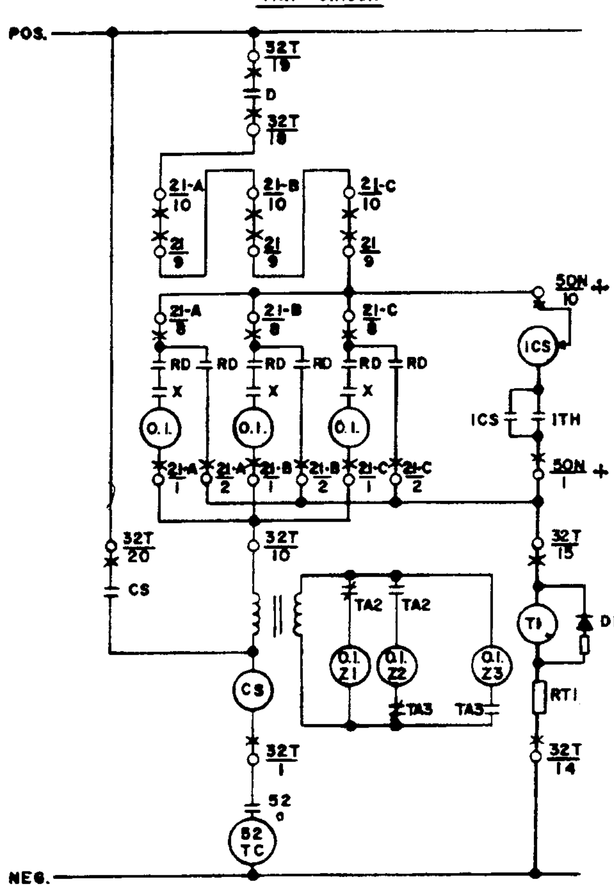


Fig. 2. External Schemat

CONTROL CIRCUIT



TRIP CIRCUIT



DEVICE NUMBERS	
DEVICE NO.	DEVICE
21	TYPE KDXG RELAY
21X	AUX. CURRENT TRANSFORMER
32T	TYPE KRT RELAY
✝ 50N	TYPE ITH RELAY
52	CIRCUIT BREAKER
52 a	BREAKER AUX. CONTACT
52 TC	BREAKER TRIP COIL

✝= OPTIONAL — FOR SUPPLEMENTING, RATIO DISCRIMINATOR.

++= NOTE THESE EXTERNAL CONNECTIONS BETWEEN RELAYS.

Sub 14
407C602

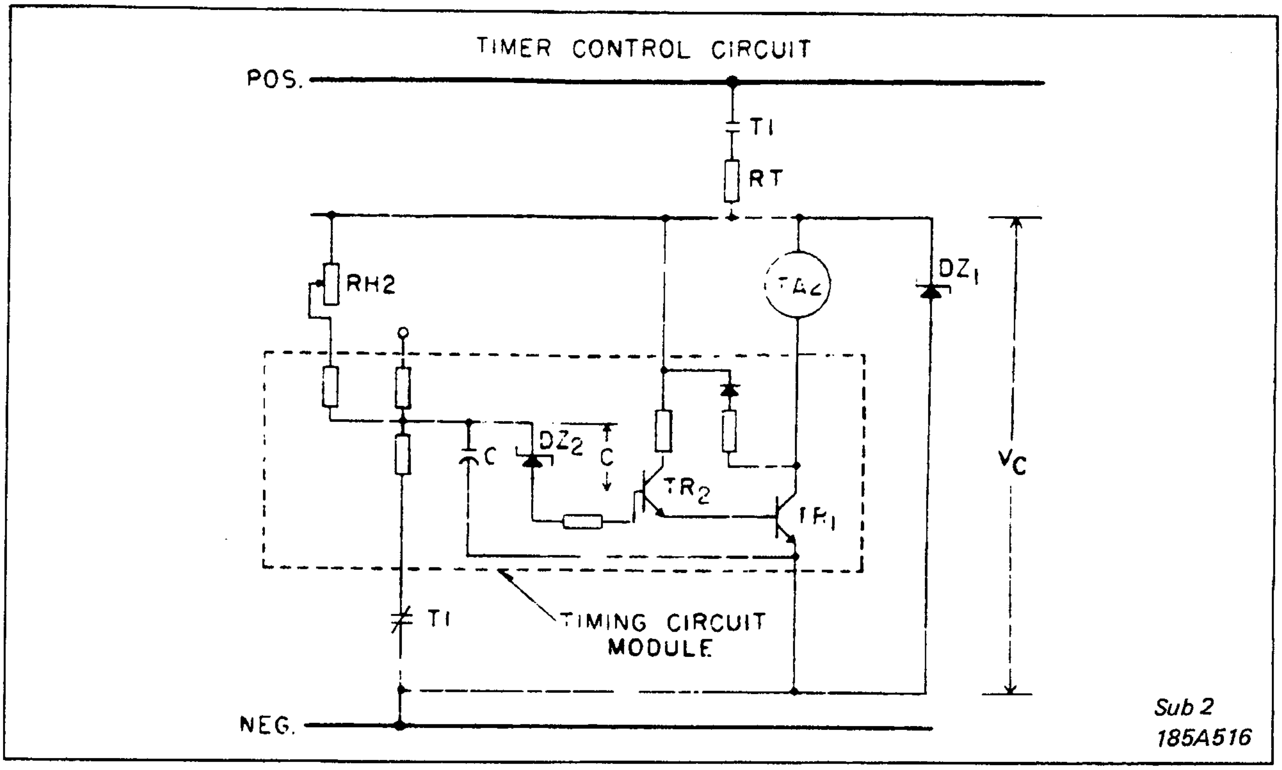


Fig. 3. Module Schematic

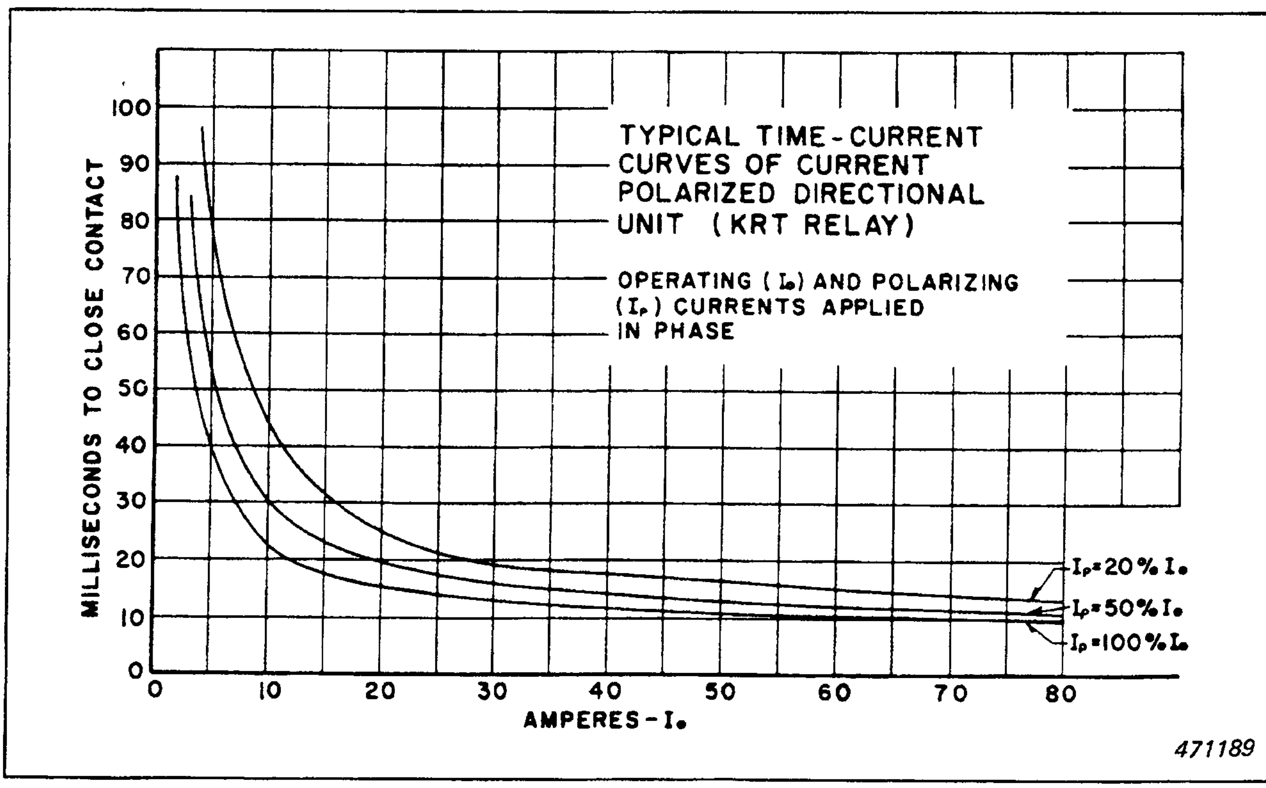


Fig. 4. Time Curve for Current Polarized Operation

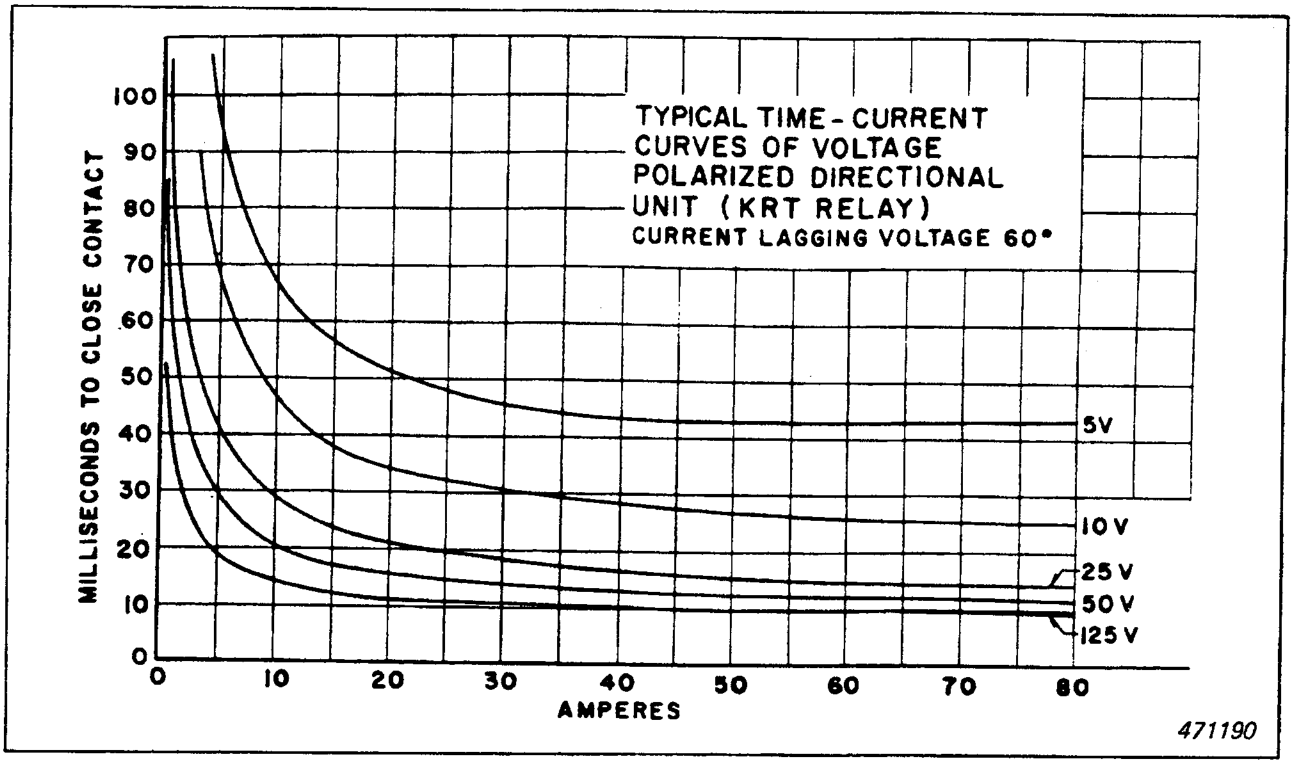


Fig. 5. Time Curve for Voltage Polarized Operation

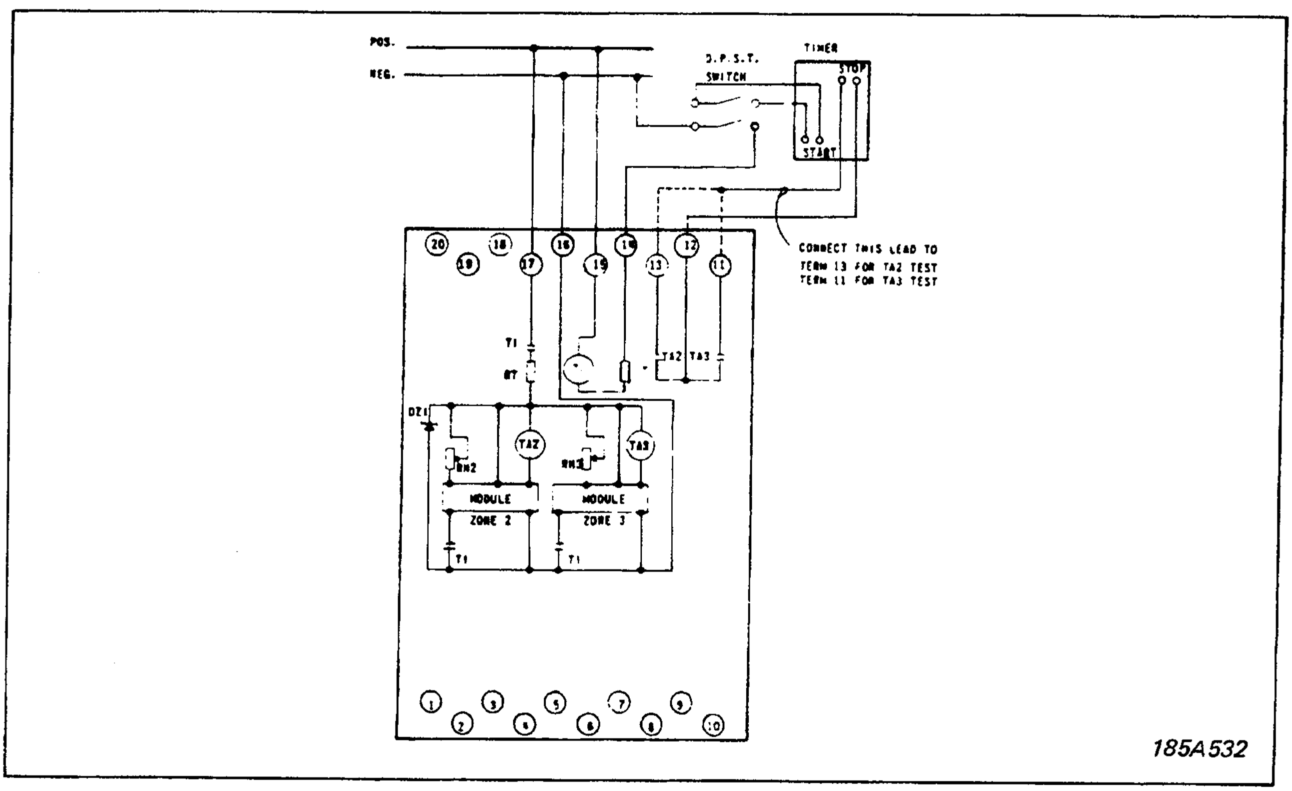


Fig. 6. Timer Test Circuit

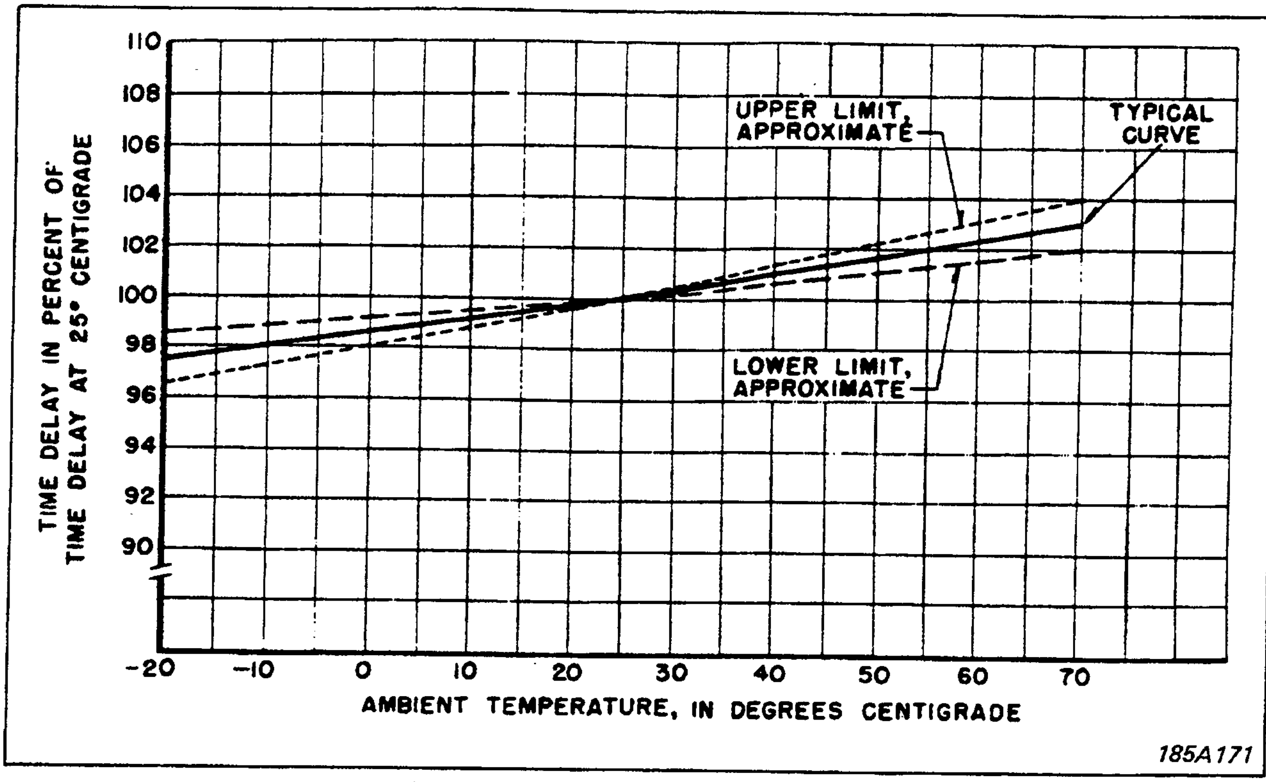


Fig. 7. Timing Variation with Temperature

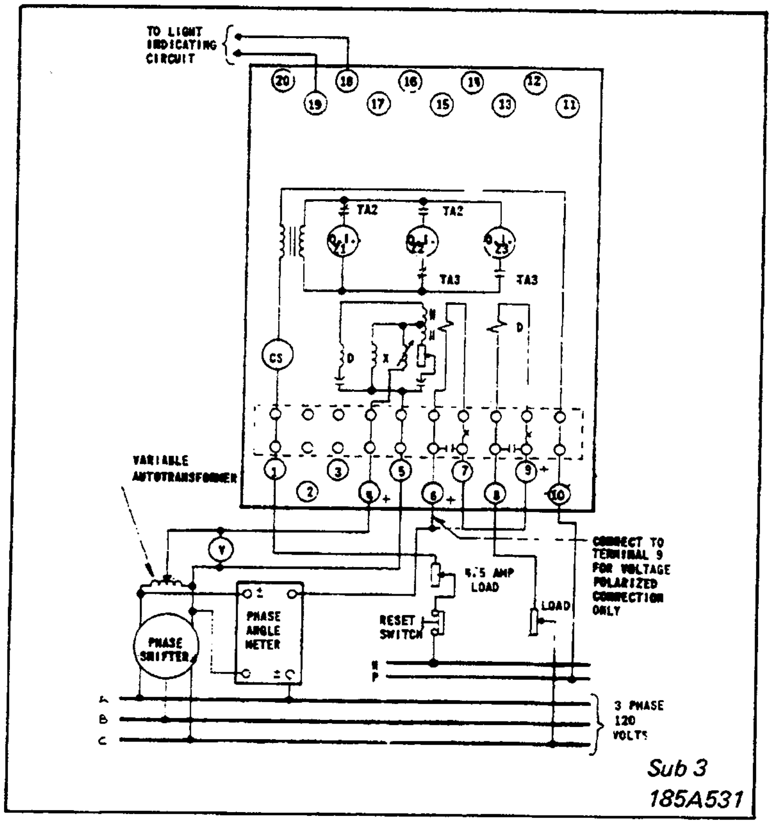


Fig. 8. Directional Unit Test Circuit

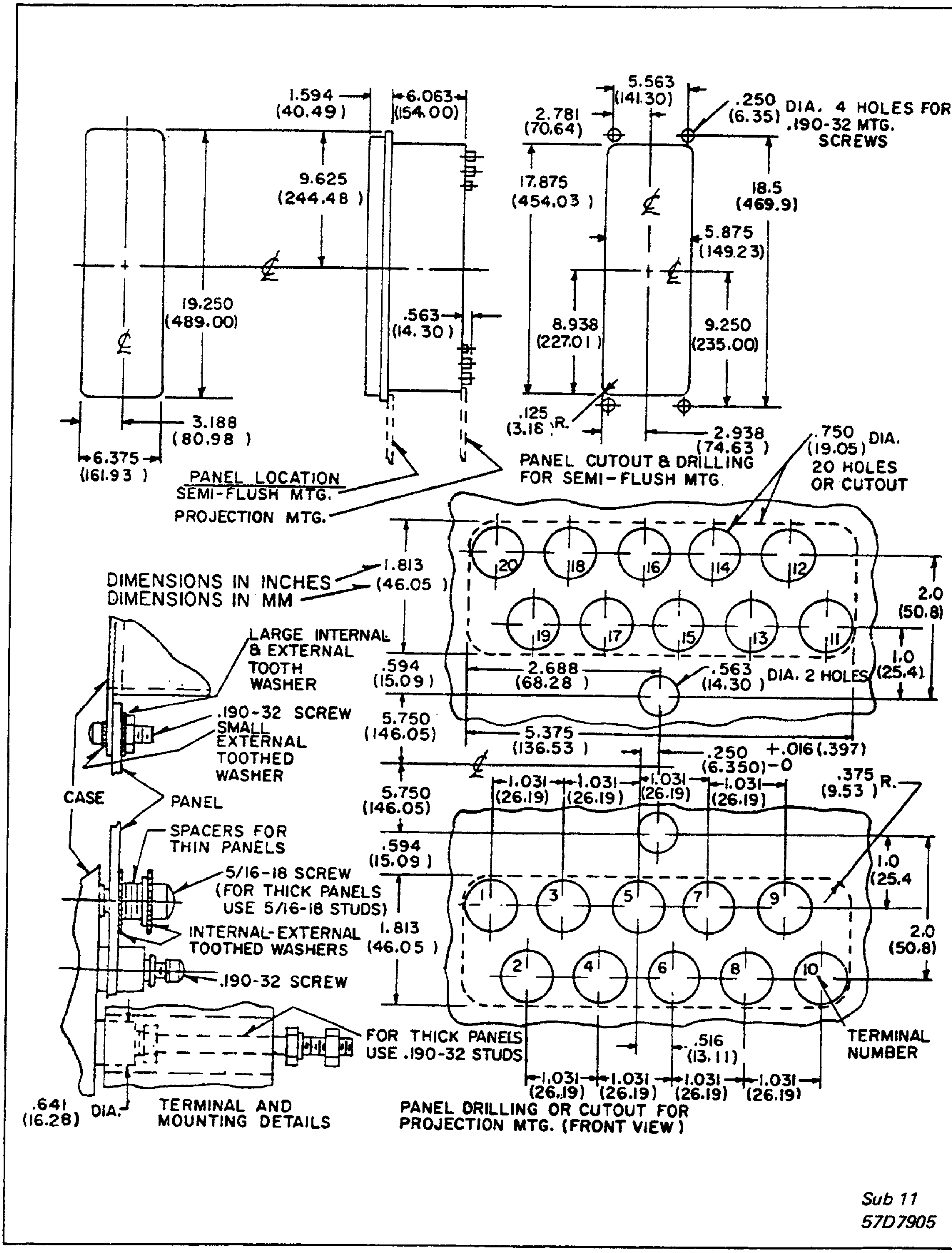


Fig. 9. FT-42 Case Outline

IL 41-497 - Revision B

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