INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted in the FT32 Flexitest case. The static equivalents of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY	Integrating time delay, (adjustable) 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

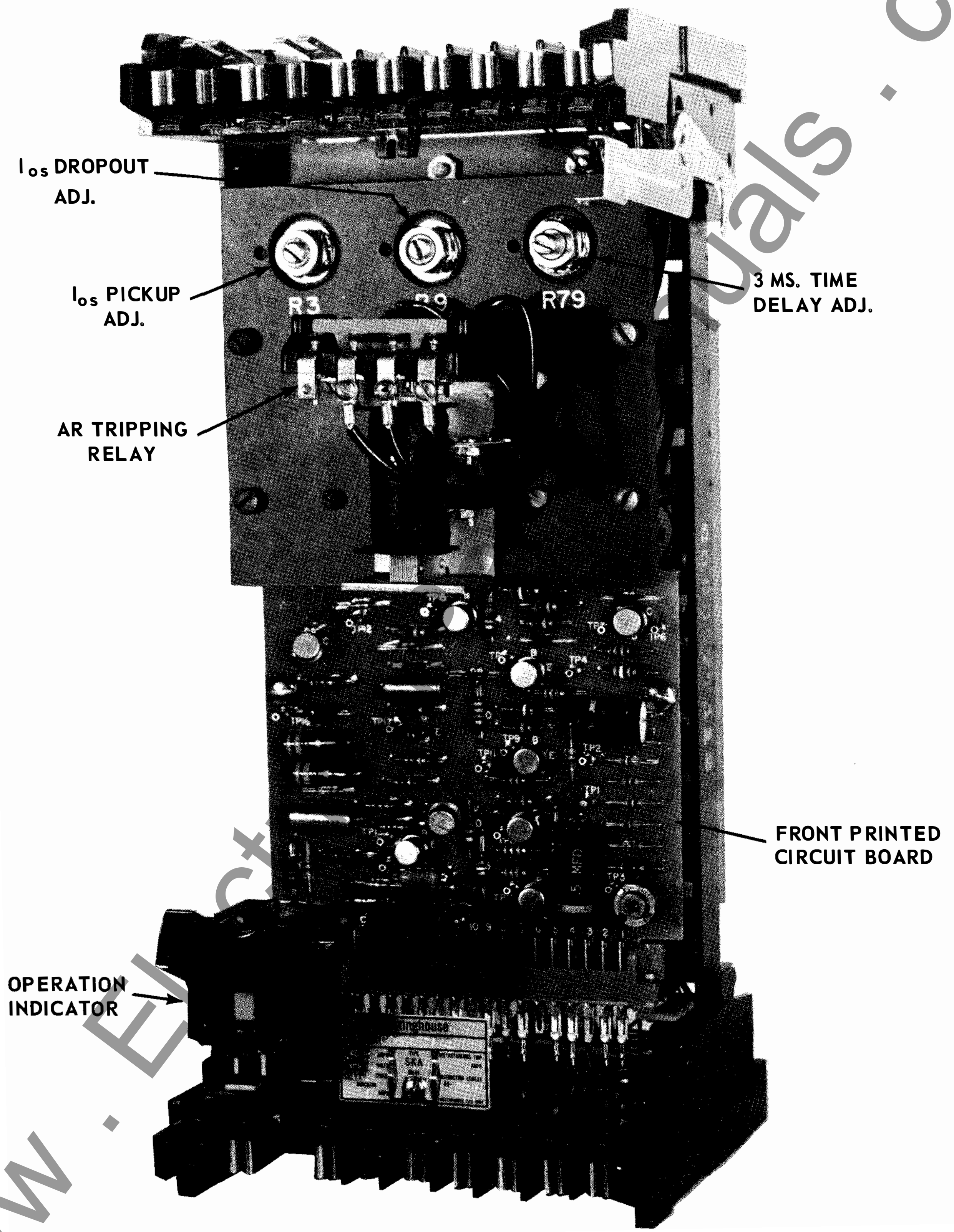


Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).

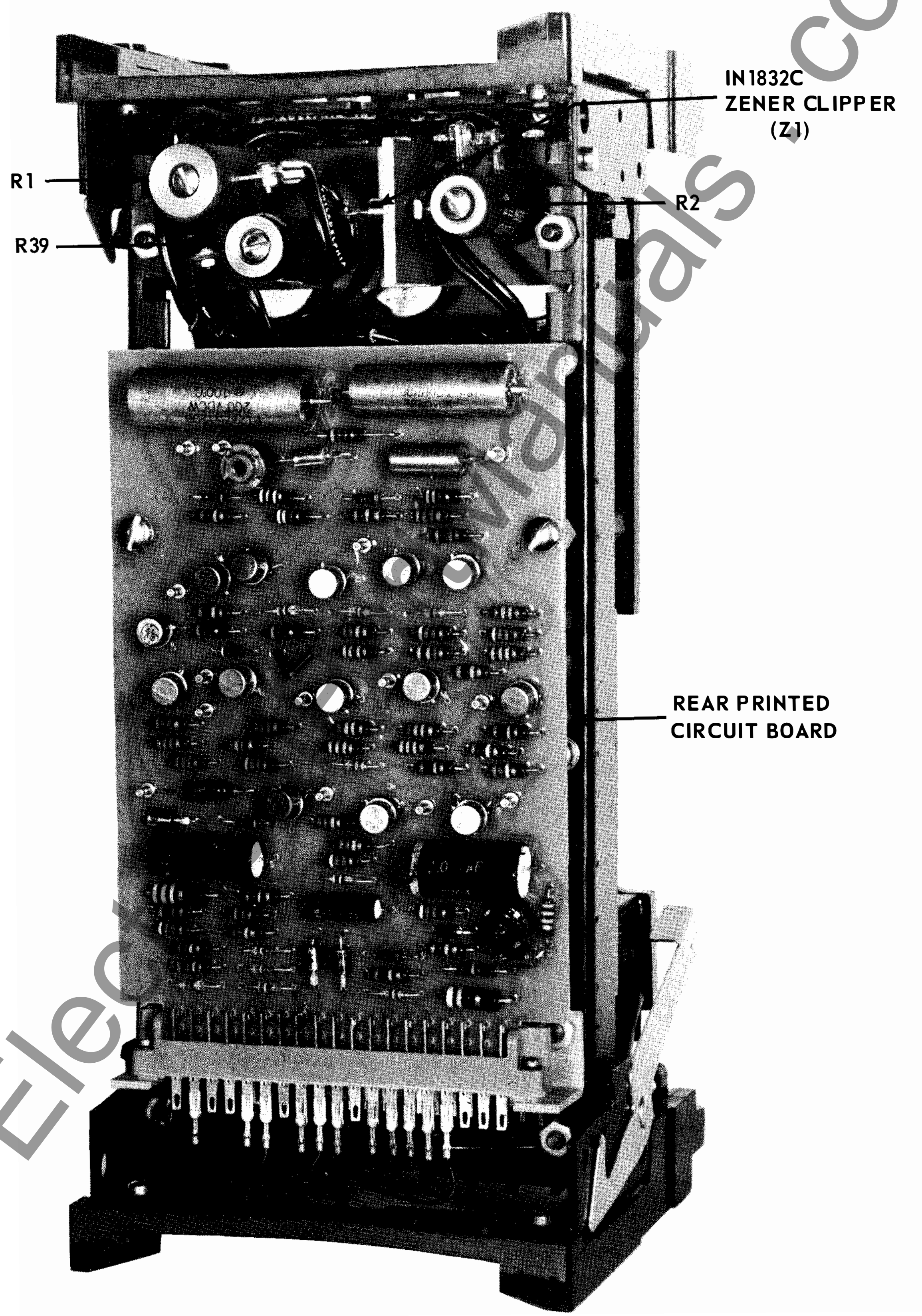


Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows (adjustable) 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals. Provision is made for external initiation of squelch by applying positive d-c to relay terminal 6.
M	Ios and O+T.D. 30-50	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function. No intentional pickup (0+) and 30-50 ms. dropout time when energized from Ios AMP.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

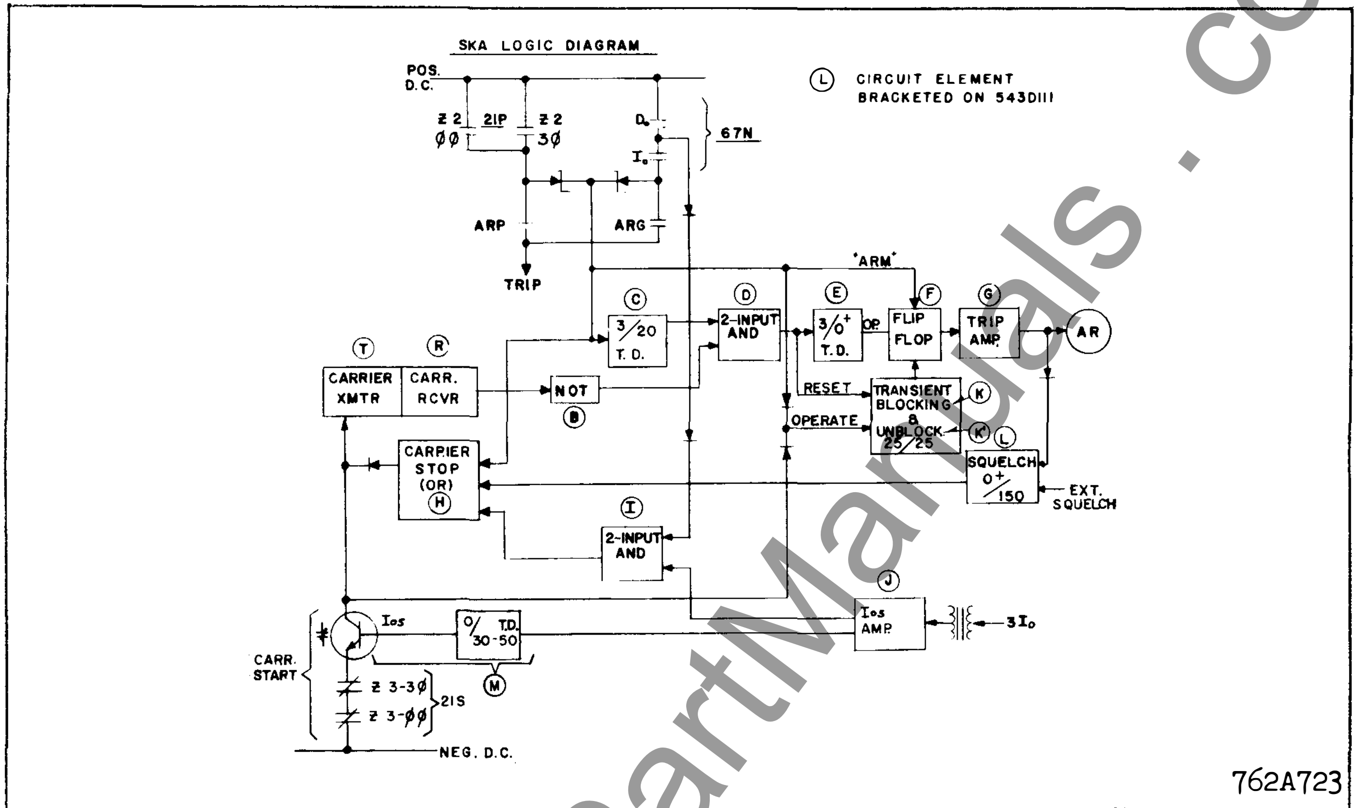


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The complete detailed relay circuit is shown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

C-3/20 MS (ADJUSTABLE) TIME DELAY:

D-TWO-INPUT AND

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

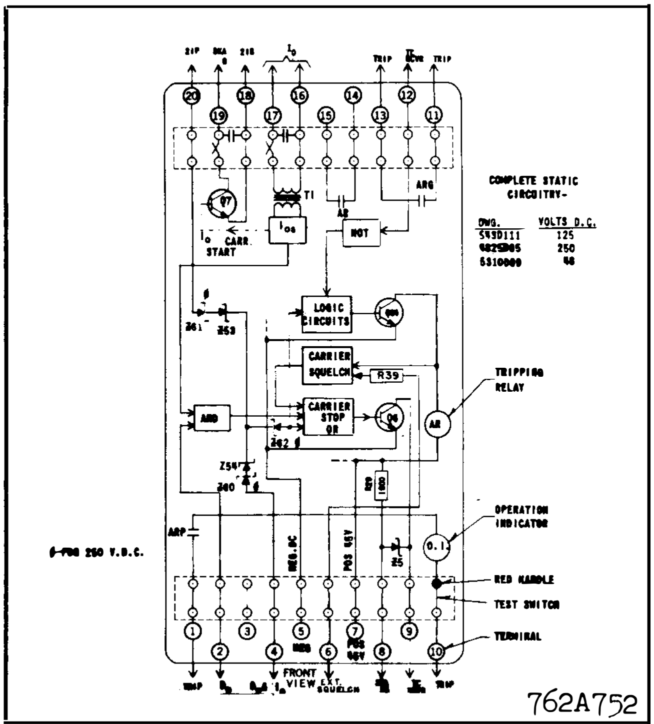


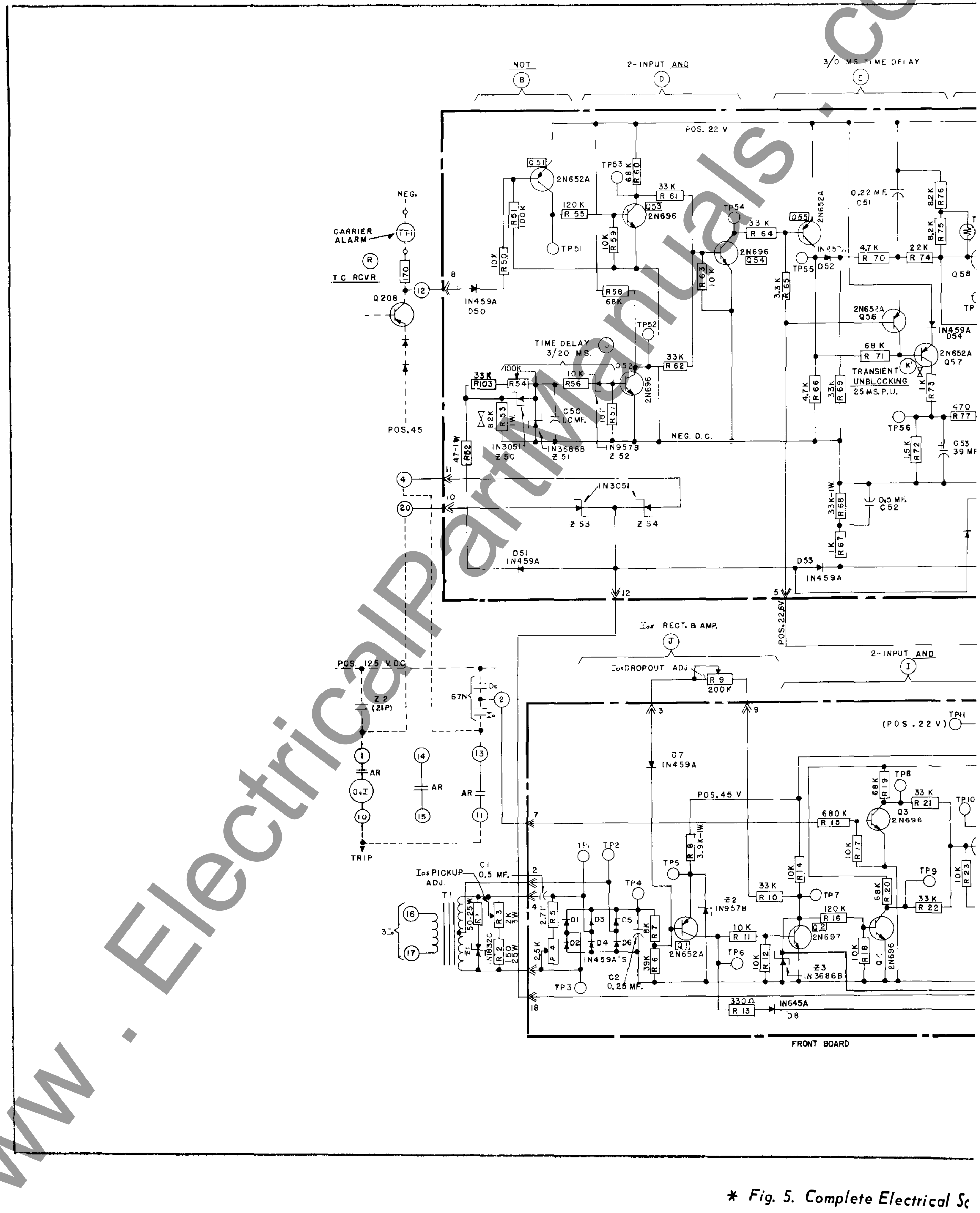
Fig. 4. Internal Schematic for the Type SKA Relay in the FT32 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capacitor C50 starts to charge thru resistors R52, R103 and R54. After a time delay of approximately 3 milliseconds (adjustable), the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

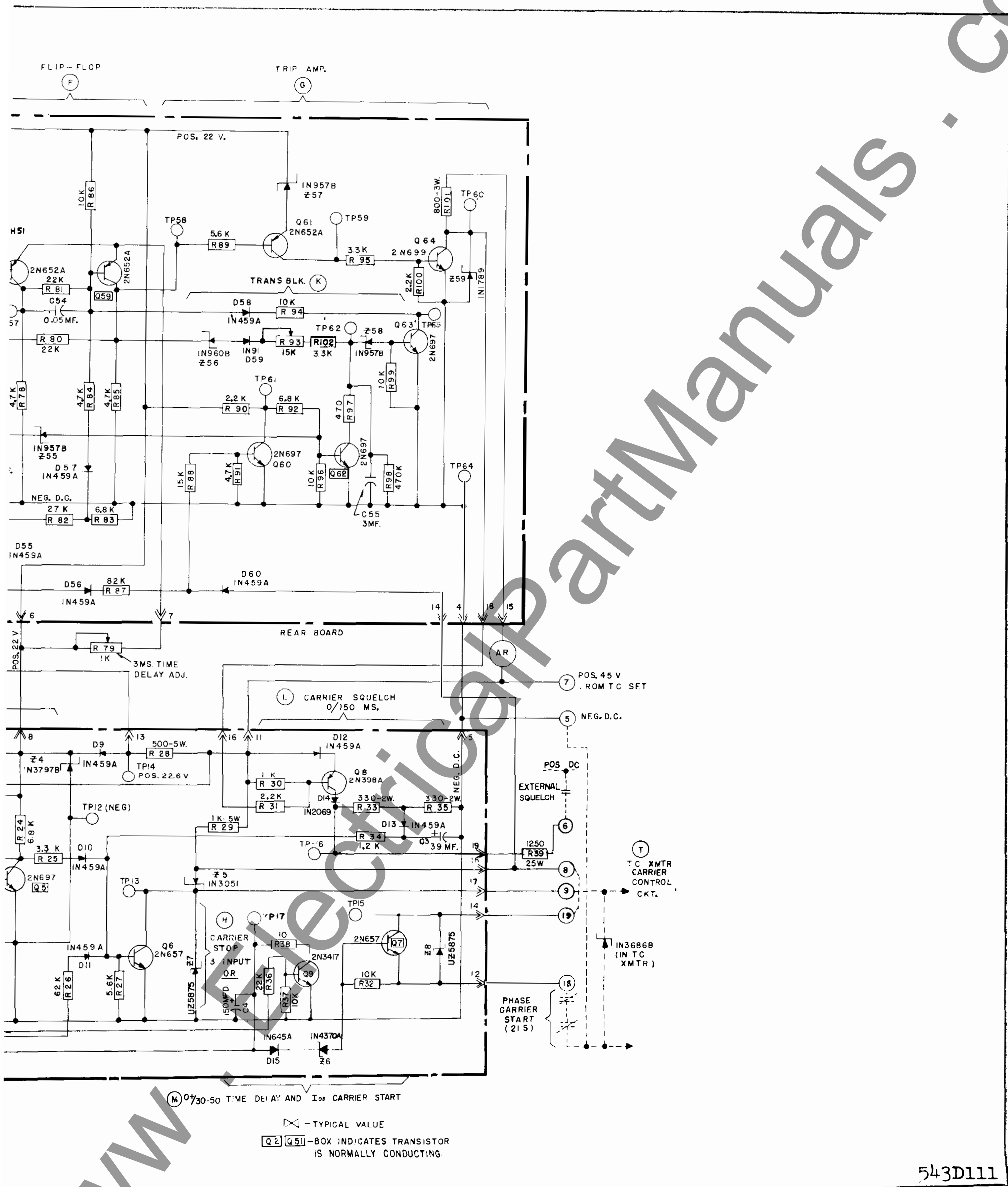
E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 or Z54, plus diode D55 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer



* *Fig. 5. Complete Electrical Sc*



hematic for the Type SKA Relay.

detail in the previous section (M) and by dotted lines to the right of terminals 8, 9, 19, and 18 of the SKA relay (Fig. 3), so that when it conducts it stops the transmission of carrier. This is the carrier stop circuit section H. The combination of operation of the directional unit D_0 in the carrier ground relay 67N and the presence of ground fault current comprises one condition for stopping carrier. This combination is necessary to handle fault current values below the pickup of the I_0 tripping unit of the 67N relay.

If the ground fault current is high enough for the operation of both D_0 and I_0 of the carrier ground relay, this will apply a positive potential to SKA relay terminal 4. Thru the circuit starting from relay terminal 4 thru Zener diode Z54, resistor R26, and diode D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L – CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning on of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitor C3 thru diode D12, transistor Q8, diode D14, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q6. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current. Provision is made for external initiation of carrier squelch by applying positive d-c to relay terminal 6. This allows a path for rapidly charging capacitor C3 through resistors R39 and R33 and diode D12 as above.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

* The AR relay operate time is 3.5 milliseconds.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

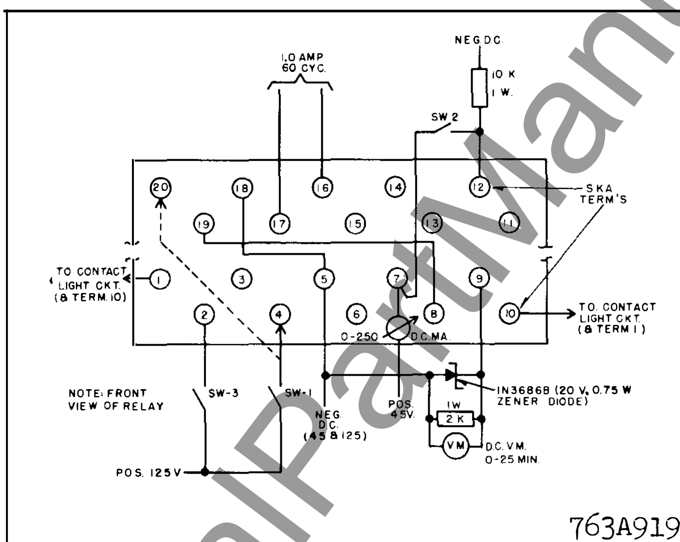


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	* Do and Io trip and Ios

0 = open
C1 = close
α = or 2 x pickup
ϕ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE**: Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit: To test this portion of the relay, use the connections shown below.

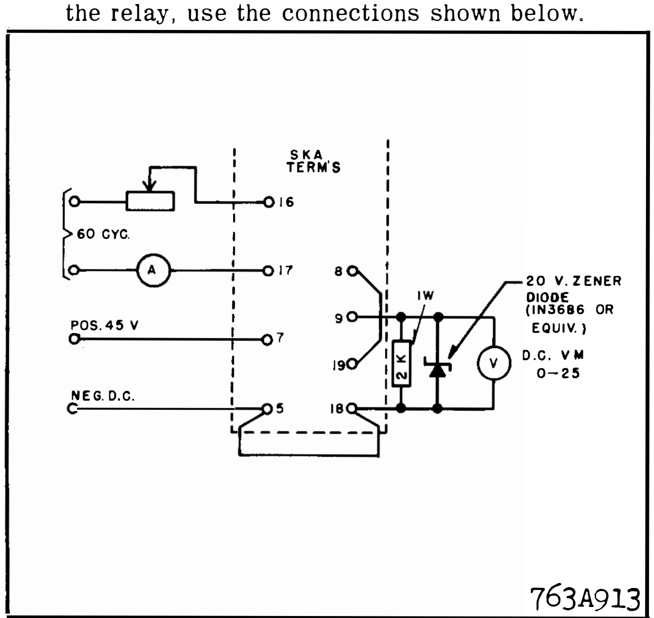


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

4. Time Delays in Logic Circuits. There are six time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits
* separately. Note: The notation "3/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

   1. Make the connections shown in Fig. 9.

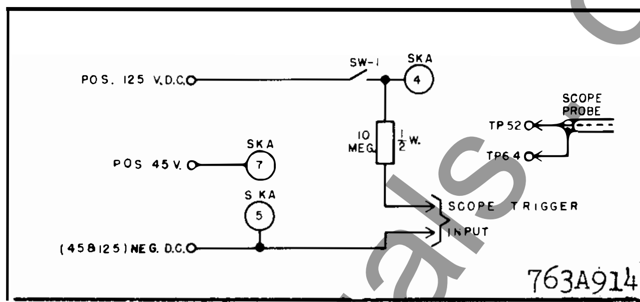


Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.

   2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

   3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP52 (+) to TP64 (-) will drop from 7 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. This time is factory set between 2.7 and 3.3 ms., but may be lowered to less than 2.0 ms. by moving potentiometer R54 counterclockwise, and increased to 7.0 ms. by moving R54 clockwise.

   4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

   1. Make the connections shown in Fig. 10.

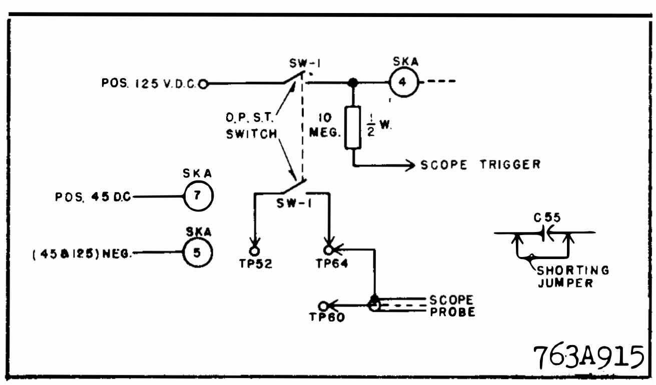


Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

6. This time delay can be adjusted by R79 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

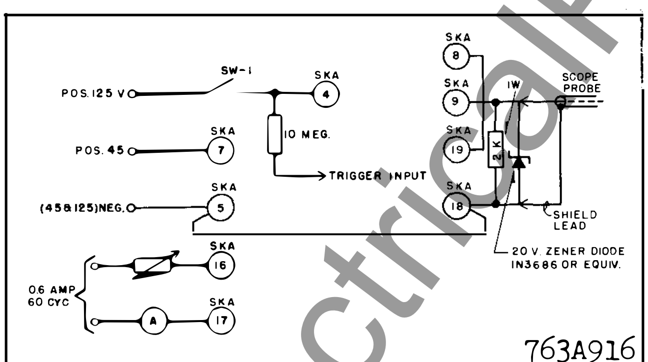


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (–) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

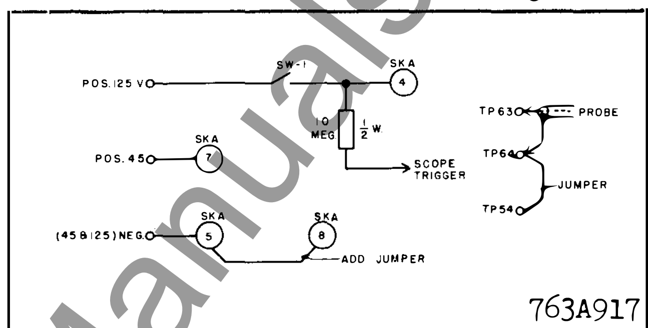


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

4. This time delay may be increased by moving potentiometer R93 clockwise and decreased by moving R93 counterclockwise.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.

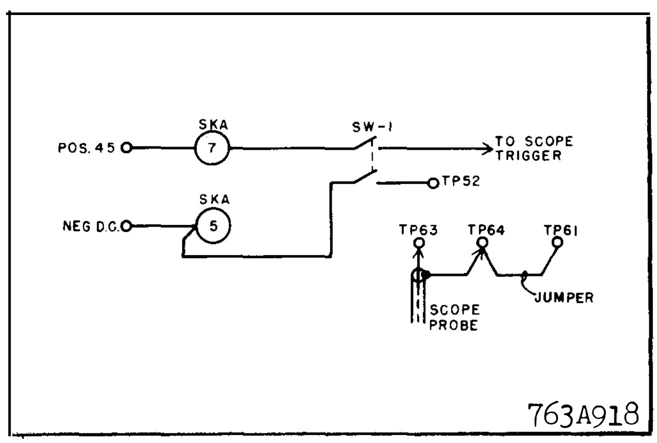


Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.

* TABLE II

Test Point Voltages
(to negative d.c. – TP12- Front Bd., TP64- Rear Bd.)

Test Point	Test Condition (From Table I and Fig. 6)					
	1	2	3	4	5	6
D.C. Ma (Fig. 7)	90	240	115	90	105	250
TP-4	6.5	6.5	6.5	20	20.5	20.5
5	6.7	6.7	6.7	6.7	6.7	6.8
6	6.6	6.6	6.6	<0.5	<0.5	<0.5
7	<0.5	<0.5	<0.5	19.0	19.0	19.0
8	7.6	7.6	7.6	7.6	<0.5	<0.5
9	7.5	7.5	7.5	<0.5	<0.5	<0.5
10	<0.5	<0.5	<0.5	<0.5	11.6	11.6
11	21.6	21.0	21.5	21.5	22.0	21.5
12	–	–	–	–	–	–
13	<0.5	<0.5	<0.5	19.8	0.25	0.15
14	22.5	22.5	22.5	22.5	22.5	22.0
15	<0.5	<0.5	<0.5	21.0	1.05	0.9
16	0	45	0	0	0	45
17	3.5	3.5	3.5	<0.5	<0.5	<0.5
51	21.5	21.5	<0.5	21.5	21.5	21.5
52	7.4	<0.5	<0.5	7.4	7.4	<0.5
53	<0.5	<0.5	7.3	<0.5	<0.5	<0.5
54	<0.5	21.8	<0.5	<0.5	<0.5	22.0
55	21.5	1.3	21.5	21.5	21.5	1.3
56	0	9.2	0	0	0	9.2
57	3.5	20	3.6	3.5	3.5	20
58	20.0	7.8	20.0	20.0	20.0	7.8
59	0	14.5	0	0	0	14.5
60	45.0	<0.5	45	45	45	<0.5
61	18	<0.5	<0.5	<0.5	17.0	<0.5
62	0.6	<0.5	7.4	7.4	0.65	<0.5
63	21.6	20.5	<0.5	<0.5	20.5	20.5
64	0	0	0	0	0	0

<Not a relay test point (D.C. Ma)

Note: <0.5 means "less than 0.5"

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date. The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

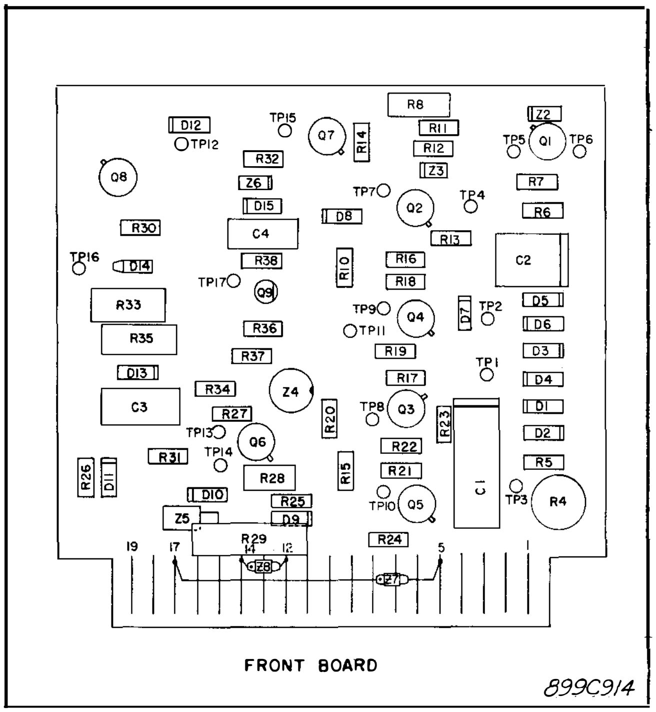
The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16

Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.



* *Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.*

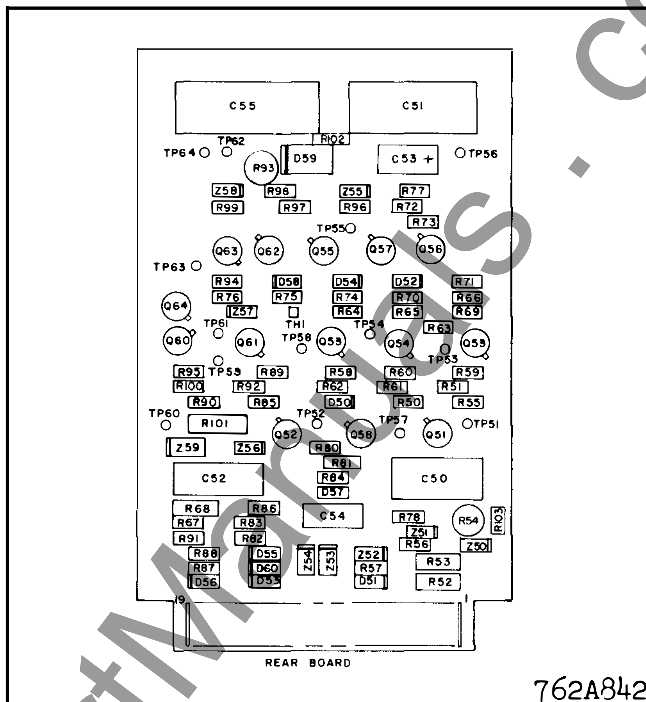


Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.

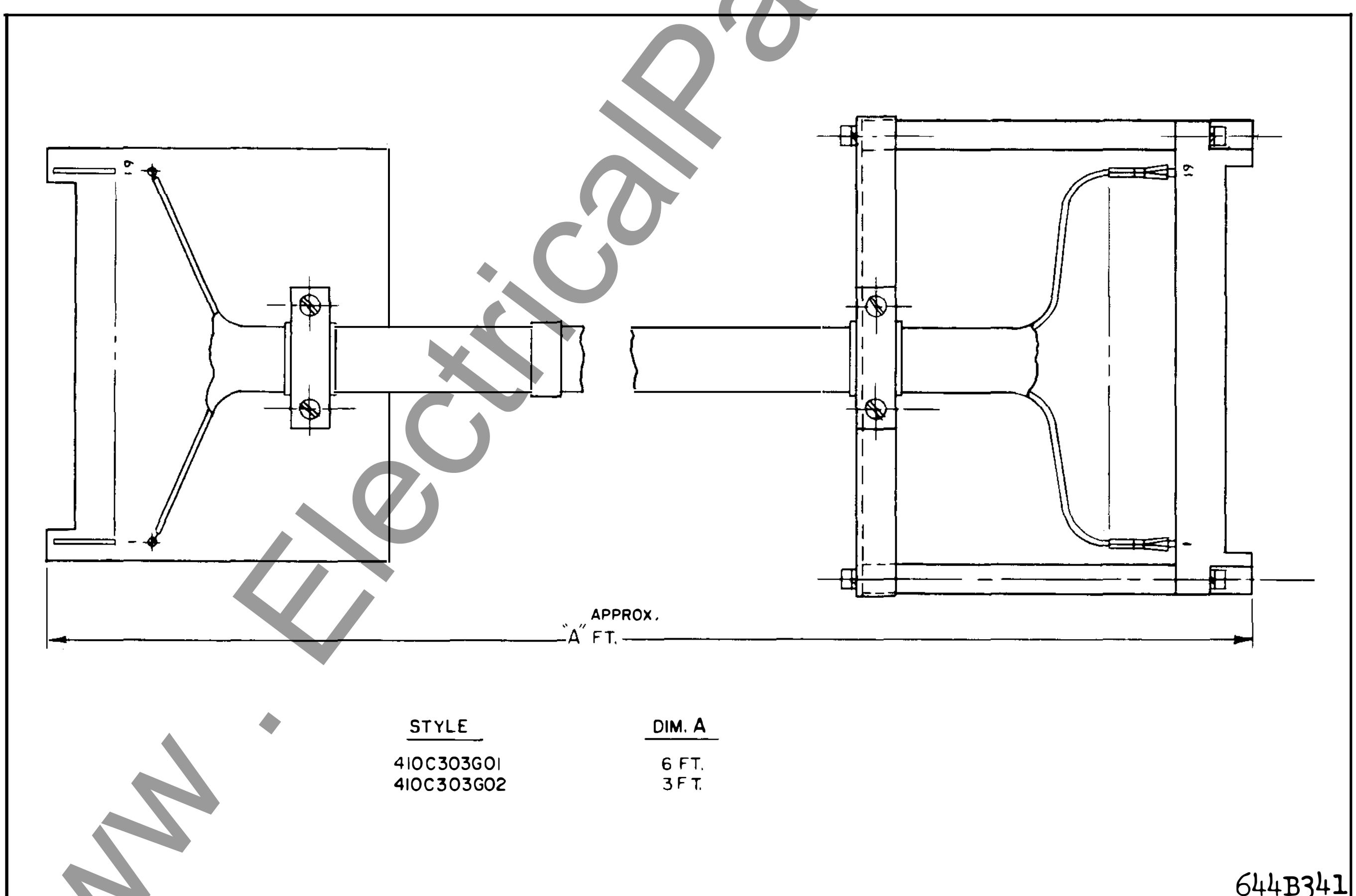


Fig. 16. 19 Terminal Printed Circuit Board Test Harness Outline.

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

Unless Otherwise Noted, All Resistors Are 0.5-Watt, ± 5% Tol.

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
AR	Tripping Relay	408C845G01
	CAPACITORS	
C1	0.5 mfd., 200 V.D.C.	187A624H03
C2	0.25 mfd., 200 V.D.C.	187A624H02
C3	39 mfd., 35 V.D.C.	187A508H04
C4	150 mfd., 6 V.D.C.	184A661H08
C50	1.0 mfd., 200 V.D.C.	187A624H04
C51	0.22 mfd., 400 V.D.C.	188A293H02
C52	0.5 mfd., 200 V.D.C.	187A624H03
C53	39 mfd., 35 V.D.C.	187A508H04
C54	.05 mfd., 200 V.D.C.	187A624H08
C55	3.0 mfd., 200 V.D.C.	188A293H06
	DIODES	
D 1 to D 7 * D 9 to D13	IN459 A	184A855H08
D14	IN2069 (CER-69)	188A342H06
D 8 – D15	IN645A	837A692H03
* D50 to D58	IN459A	184A855H08
D59	IN91	182A881H04
D60	IN459A	184A855H08
	TRANSISTORS	
Q1	2N652A	184A638H16
Q2	2N697	184A638H18
Q3	2N696	762A585H01
Q4	2N696	762A585H01
Q5	2N697	184A638H18
* Q6	2N657	184A638H15
* Q7	2N657	184A638H15
Q8	2N398A	184A638H12
Q9	2N3417	848A851H02
Q51	2N652A	184A638H16
Q52	2N696	762A585H01
Q53	2N696	762A585H01
Q54	2N696	762A585H01
Q55 – Q59	2N652A	184A638H16
Q60	2N697	184A638H18
Q61	2N652A	184A638H16
Q62	2N697	184A638H18
Q63	2N697	184A638H18
Q64	2N699	184A638H19

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS	
R1	50 ohms, 25W, 5%	1340388
R2	150 ohms, 25W, 5%	1267272
R3	2.0K ohms, 3W, Pot.	185A067H17
R4	2.5K ohms, .25W, Pot.	629A430H03
R5	2.7K ohms	184A763H37
R6	39K ohms	184A763H65
R7	18K ohms	184A763H57
R8	3.9K ohms, 1.W, 5%	187A643H41
R9	200K ohms, 2W, Pot.	185A067H14
R10	33K ohms	184A763H63
R11	10K ohms	184A763H51
R12	10K ohms	184A763H51
R13	330 ohms	184A763H15
R14	10K ohms	184A763H51
R15	680K ohms	184A763H95
R16	120K ohms	184A763H77
R17	10K ohms	184A763H51
R18	10K ohms	184A763H51
R19	68K ohms	184A763H71
R20	68K ohms	184A763H71
R21	33K ohms	184A763H63
R22	33K ohms	184A763H63
R23	10K ohms	184A763H51
* R24	6.8K ohms	184A763H47
R25	3.3K ohms	184A763H39
R26	62K ohms	184A763H70
R27	5.6K ohms	184A763H45
* R28	500 ohms, 5W, 5%	762A679H04
R29	1K ohms, 5W, 5%	184A859H10
R30	1K ohms	184A763H27
R31	2.2K ohms	184A763H35
R32	10K ohms	184A763H51
R33	330 ohms, 2W, 5%	185A207H15
R34	1.2K ohms	184A763H29
R35	330K ohms, 2W, 5%	185A207H15
R36	22K ohms	184A763H59
R37	10K ohms	184A763H51
R38	10 ohms	187A290H01
* R39	300 ohms, 25W For 48V	1202847
	1250 ohms, 25W For 125V	1202589
	3000 ohms, 25W For 250V	1202954
R50	10K ohms	184A763H51
R51	100K ohms	184A763H75
R52	47 ohms, 1W, 10%	184A859H09
R53	82K ohms, 1W, 5%	187A643H73

ELECTRICAL PARTS LIST (Continued)

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R54	* 100K, .25W, Pot.	629A430H04
R55	120K ohms	184A763H77
R56	10K ohms	184A763H51
R57	10K ohms	184A763H51
R58	68K ohms	184A763H71
R59	10K ohms	184A763H51
R60	68K ohms	184A763H71
R61	33K ohms	184A763H63
R62	33K ohms	184A763H63
R63	10K ohms	184A763H51
R64	33K ohms	184A763H63
R65	3.3K ohms	184A763H39
R66	4.7K ohms	184A763H43
R67	1K ohms	184A763H27
R68	33K ohms, 1W, 5%	187A643H63
R69	47K ohms	184A763H67
R70	4.7K ohms	184A763H43
R71	68K ohms	184A763H71
R72	1.5K ohms	184A763H31
R73	* 1K ohms.	184A763H27
R74	22K ohms	184A763H59
R75	8.2K ohms	184A763H49
R76	8.2K ohms	184A763H49
R77	470 ohms	184A763H19
R78	4.7K ohms	184A763H43
R79	1K ohms, 2W, Pot.	185A067H09
R80	22K ohms	184A763H59
R81	22K ohms	184A763H59
R82	27K ohms	184A763H61
R83	6.8K ohms	184A763H47
R84	4.7K ohms	184A763H43
R85	4.7K ohms	184A763H43
R86	10K ohms	184A763H51
R87	82K ohms	184A763H73
R88	15K ohms	184A763H55
R89	5.6K ohms	184A763H45
R90	2.2K ohms	184A763H35

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R91	4.7K ohms	184A763H43
R92	6.8K ohms	184A763H47
R93	*15K ohms, .25W, Pot.	629A430H08
R94	10K ohms	184A763H51
R95	* 3.3K ohms	184A763H39
R96	10K ohms	184A763H51
R97	470 ohms	184A763H19
R98	470 ohms	184A763H19
R99	10K ohms	184A763H51
R100	2.2K ohms	184A763H35
R101	800 ohms, 3W, 5%	184A859H06
R102	* 3.3K ohms	184A763H39
R103	33K ohms	184A763H63
TH51	Thermistor, 10K at 25°C	185A211H04
	TRANSFORMER	
T1	Saturating Transformer	606B519G03
	*** ZENER DIODES**	
Z1	IN1832C, 62V.	184A617H06
Z2	IN957B. 6.8V.	186A797H06
Z3	IN3686B, 20V.	185A212H06
Z4	IN3797B, 22V.	185A089H09
Z5	IN3051, 200V.	187A936H01
Z6	IN4370A, 2.4V.	184A639H12
Z7-Z8	UZ5875, 75V.	837A693H04
Z50	IN3051, 200V.	187A936H01
Z51	IN3686B, 20V.	185A212H06
Z52	IN957B, 6.8V.	186A797H06
Z53	IN3051, 200V.	187A936H01
Z54	IN3051, 200V.	187A936H01
Z55	IN957B, 6.8V.	186A797H06
Z56	IN960B, 9.1V.	186A797H10
Z57	IN957B, 6.8V.	186A797H06
Z58	IN957B, 6.8V.	186A797H06
Z59	IN1789, 56V.	584C434H08

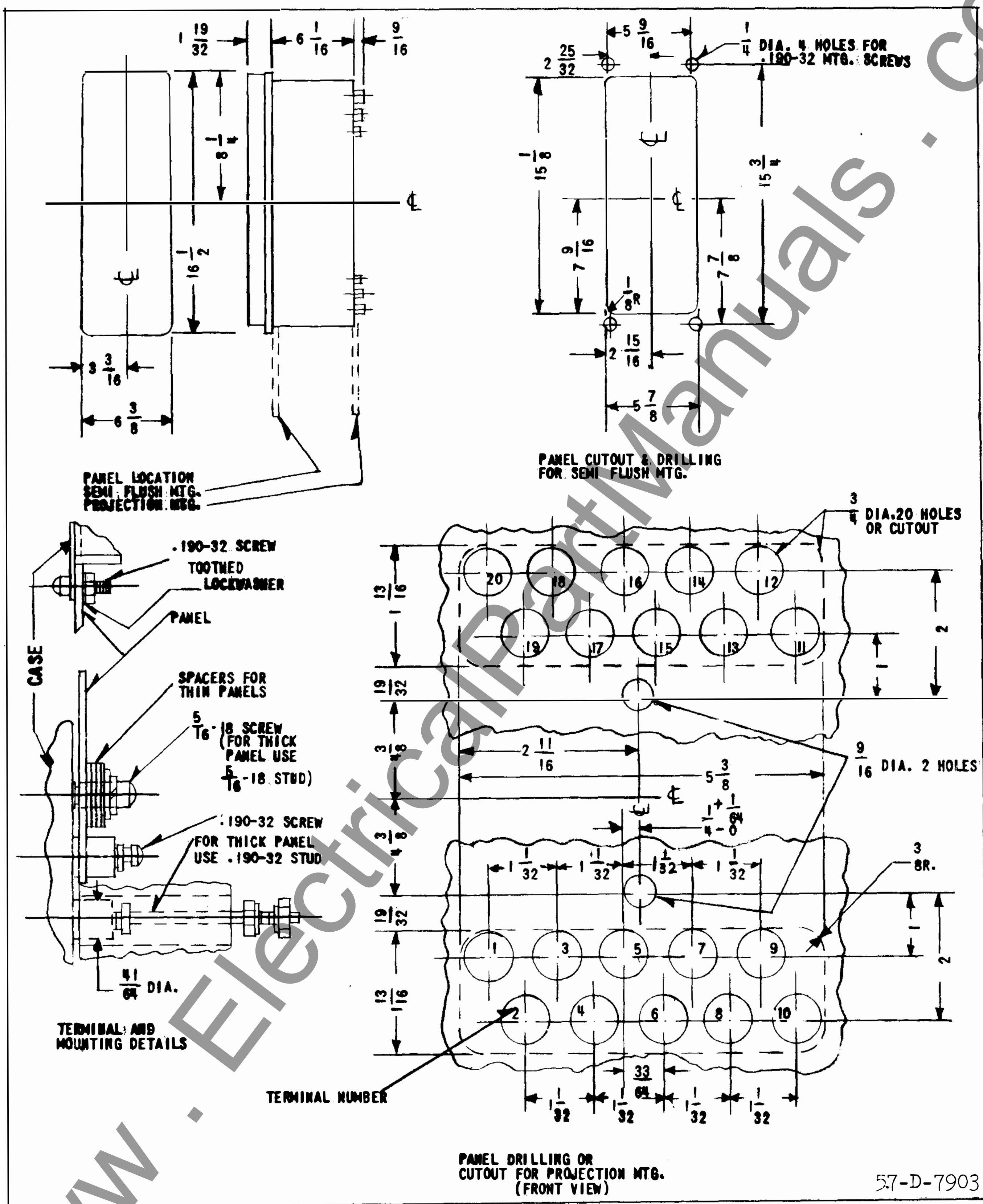


Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted in the FT32 Flexitest case. The static equivalents of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY *	Integrating time delay, (adjustable) 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

SUPERSEDES I.L. 41-923.5A
*Denotes change from superseded issue.

EFFECTIVE OCTOBER 1967

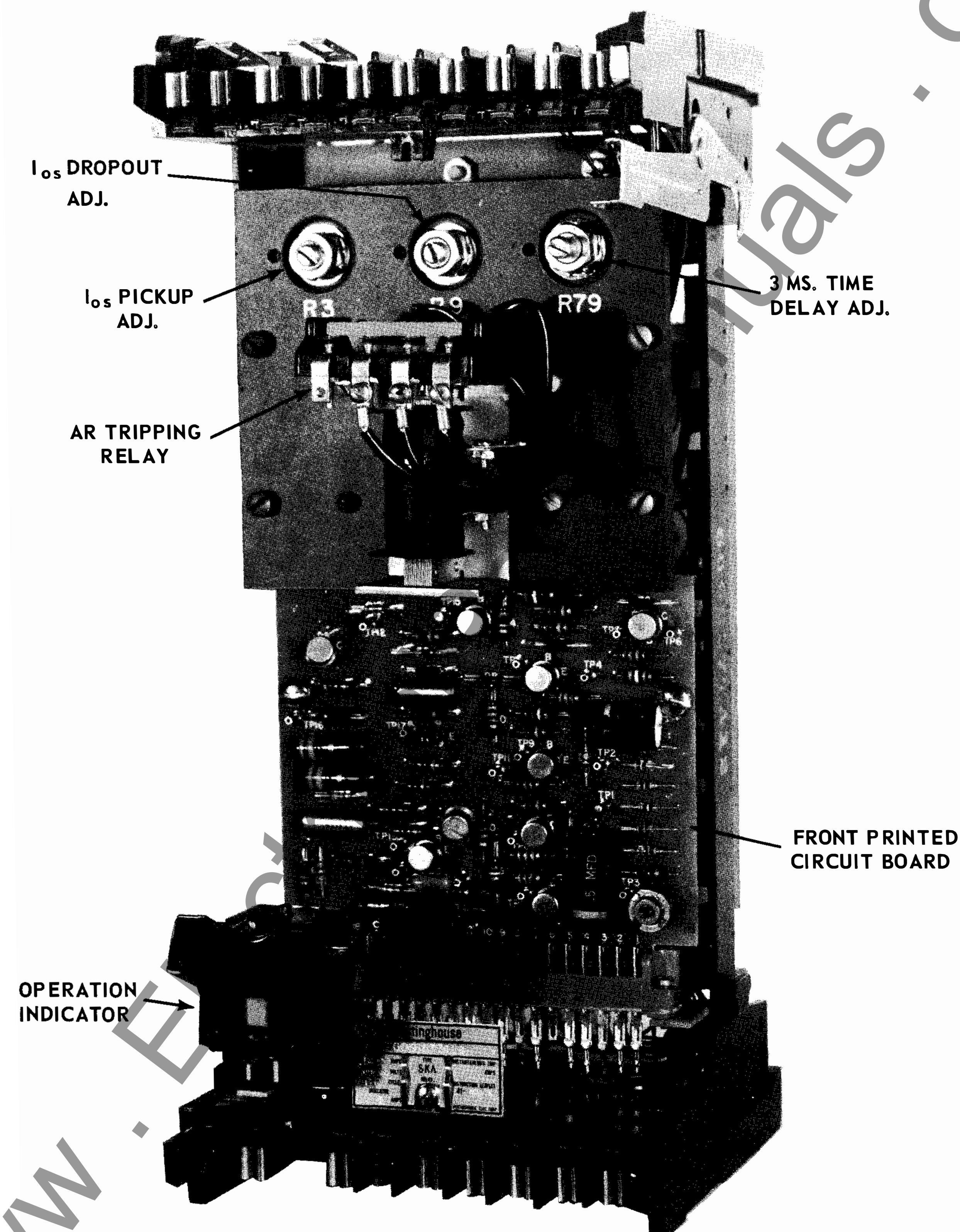


Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).

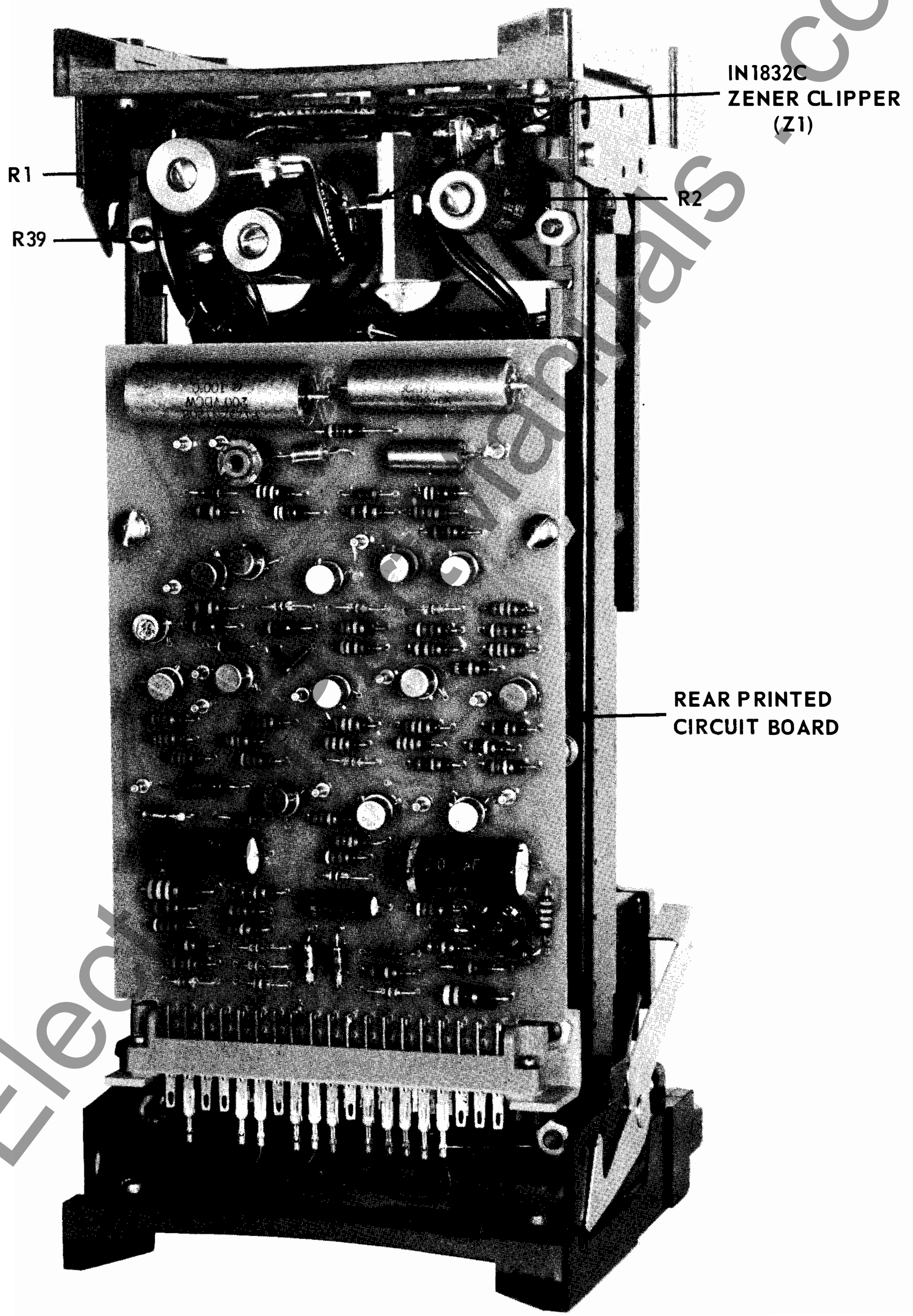


Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

			The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
	F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
	G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
	H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
	I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
	J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
*	K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows (adjustable) 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
*	L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals. Provision is made for external initiation of squelch by applying positive d-c to relay terminal 6.
*	M	Ios and O+T.D. 30-50	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function. No intentional pickup (0+) and 30-50 ms. dropout time when energized from Ios AMP.
	R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
	T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

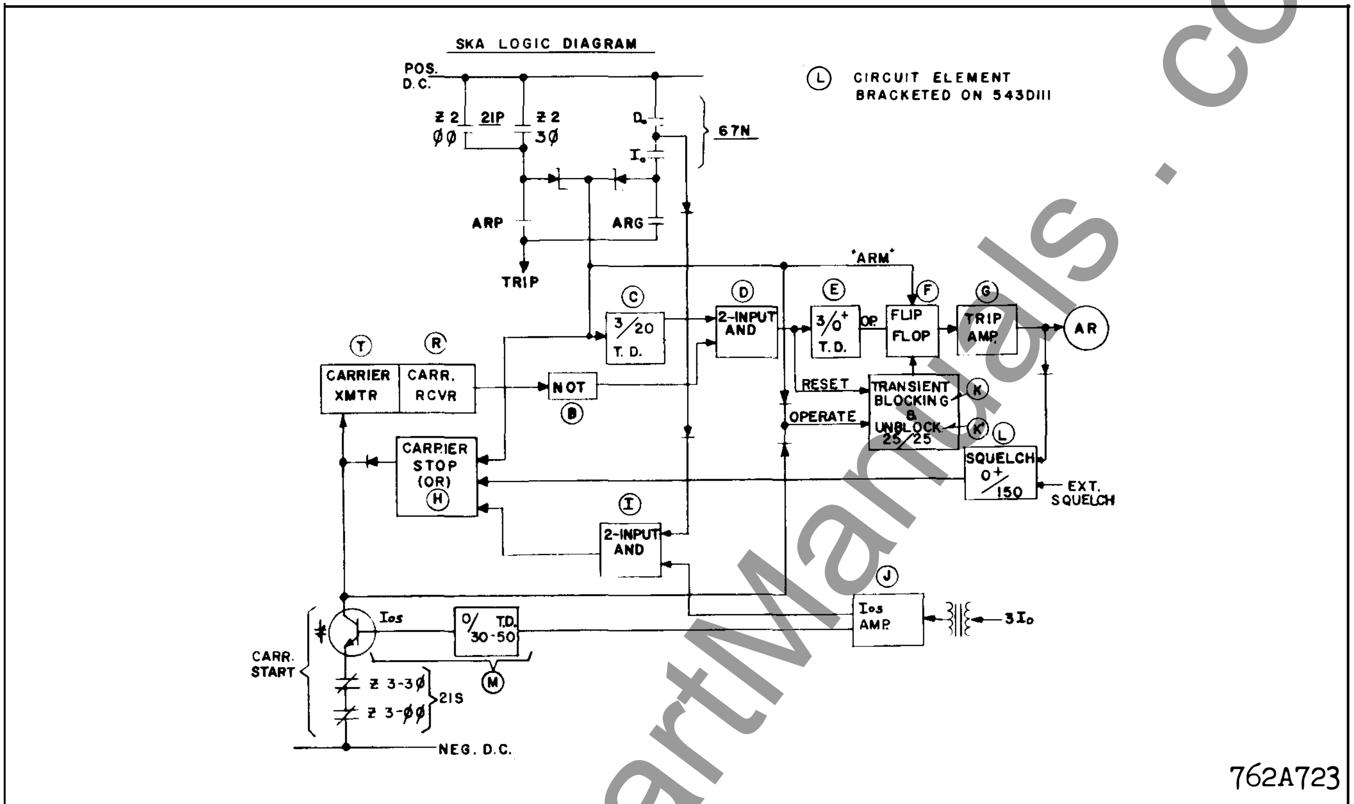


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The * complete detailed relay circuit is shown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

* C-3/20 MS (ADJUSTABLE) TIME DELAY: D-TWO-INPUT AND

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

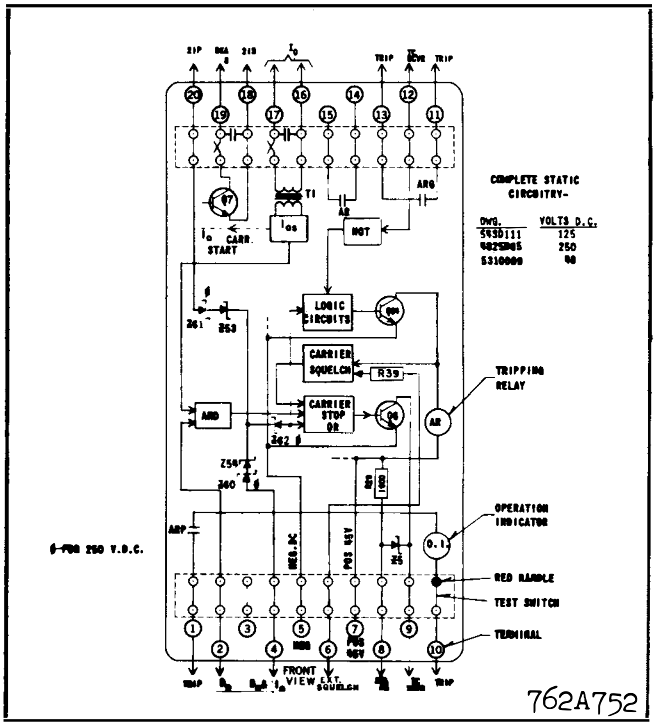


Fig. 4. Internal Schematic for the Type SKA Relay in the FT32 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capa-
* citor C50 starts to charge thru resistors R52, R103 and R54. After a time delay of approximately 3 milliseconds (adjustable), the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53
* or Z54, plus diode D55 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer

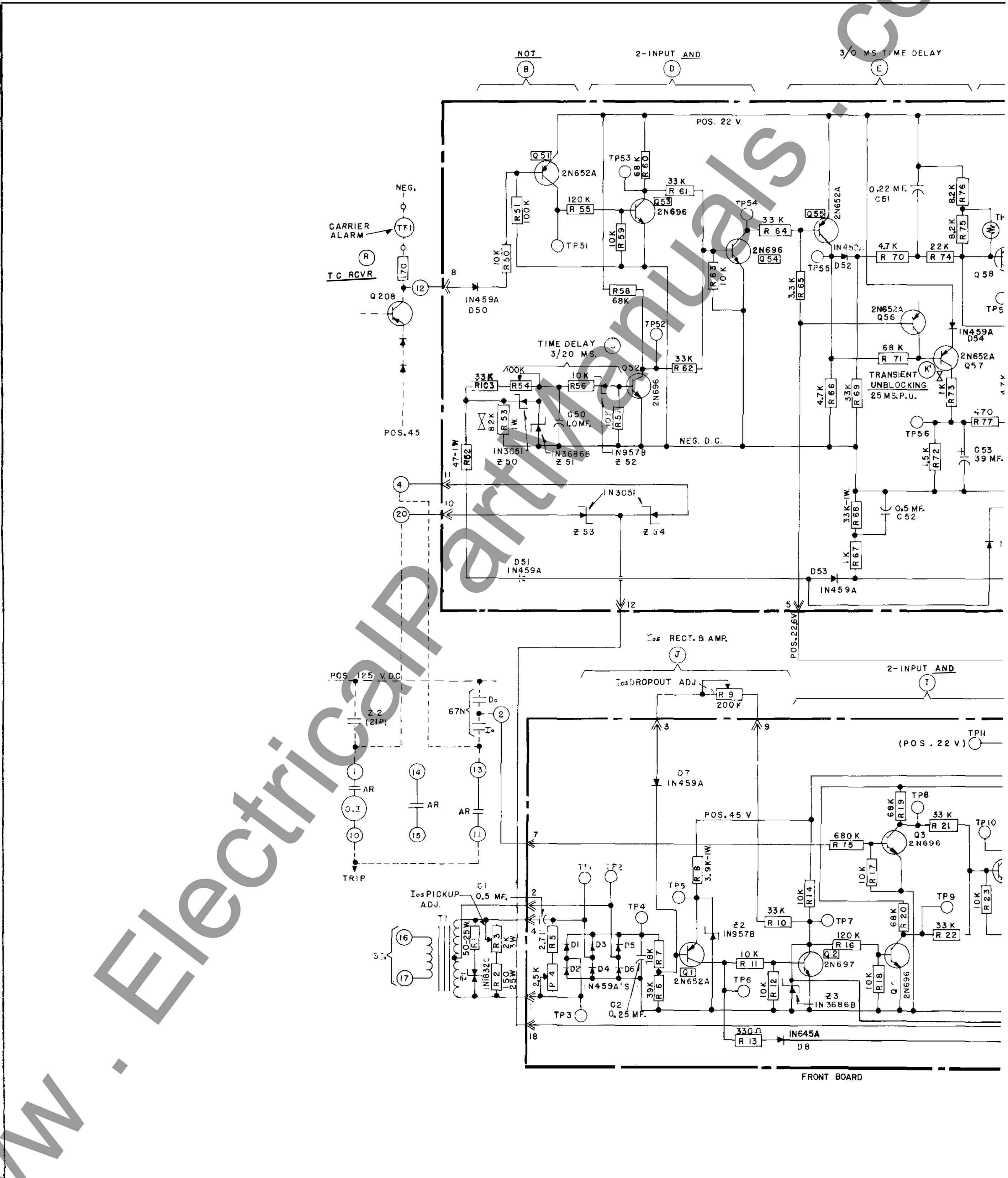
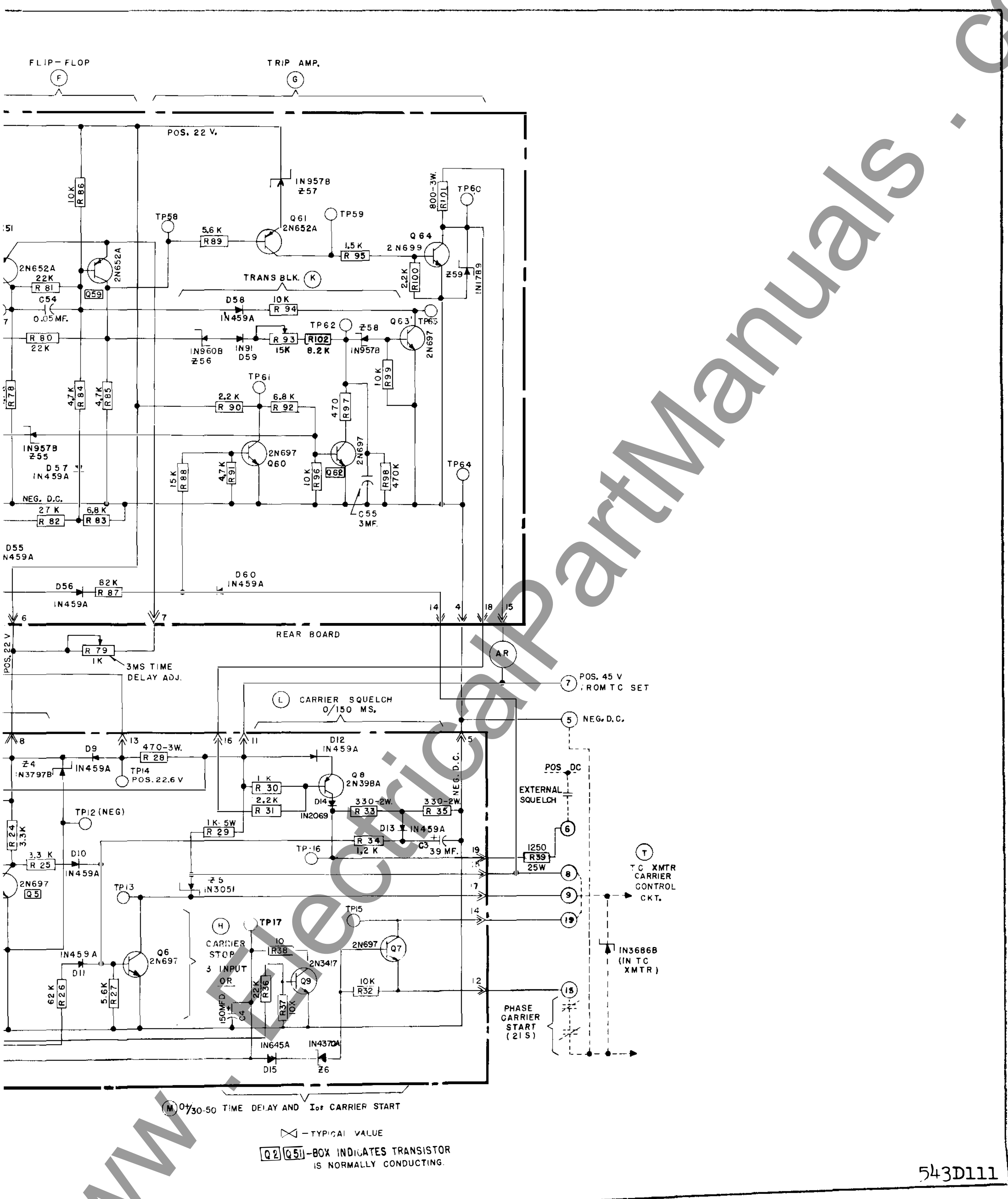


Fig. 5. Complete Electrical Sc



...hematic for the Type SKA Relay.

detail in the previous section (M) and by dotted lines to the right of terminals 8, 9, 19, and 18 of the SKA relay (Fig. 3), so that when it conducts it stops the transmission of carrier. This is the carrier stop circuit section H. The combination of operation of the directional unit D_O in the carrier ground relay 67N and the presence of ground fault current comprises one condition for stopping carrier. This combination is necessary to handle fault current values below the pickup of the I_O tripping unit of the 67N relay.

If the ground fault current is high enough for the operation of both D_O and I_O of the carrier ground relay, this will apply a positive potential to SKA relay terminal 4. Thru the circuit starting from relay terminal 4 thru Zener diode Z54, resistor R26, and diode D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L – CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning on of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitor C3 thru diode D12, transistor Q8, diode D14, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q6. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current. Provision is made for external initiation of carrier squelch by applying positive d-c to relay terminal 6. This allows a path for rapidly charging capacitor C3 through resistors R39 and R33 and diode D12 as above.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

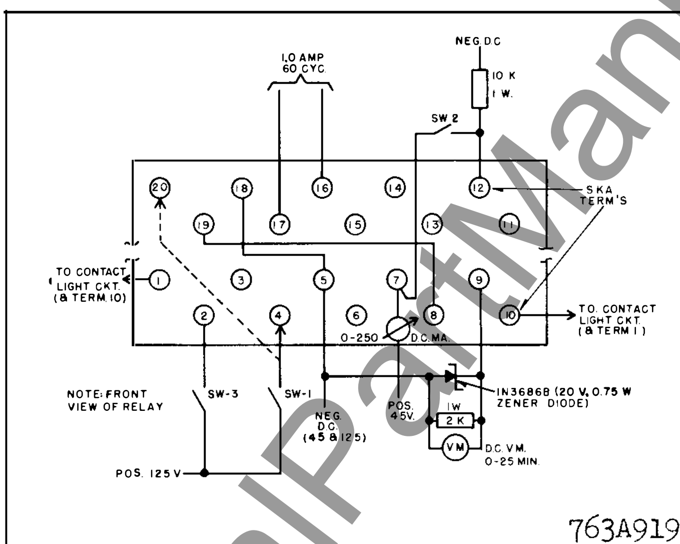


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ɸ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	* Do and Io trip and Ios

0 = open
C1 = close
α = or 2 x pickup
ɸ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit: To test this portion of the relay, use the connections shown below.

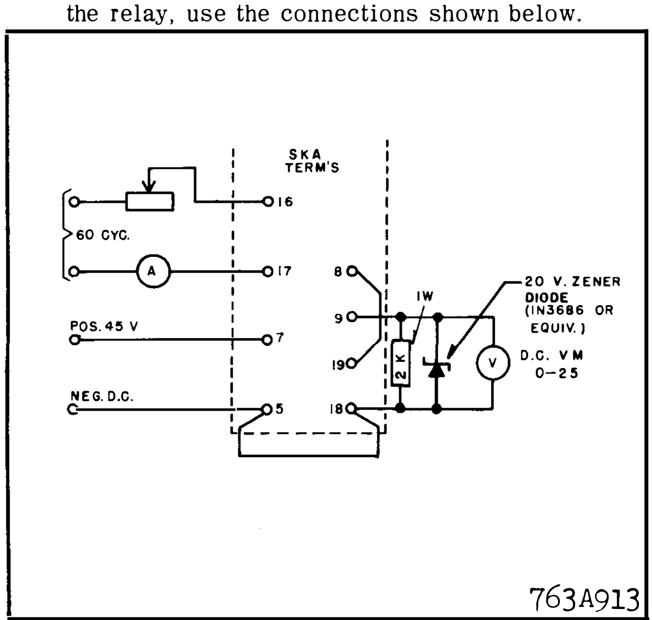


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

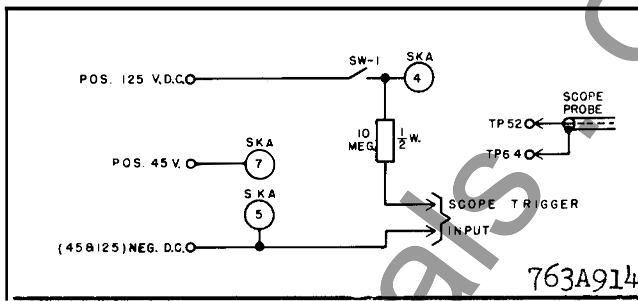
3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

* 4. Time Delays in Logic Circuits. There are six time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. Note: The rotation "30/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

      1. Make the connections shown in Fig. 9.



* *Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.*

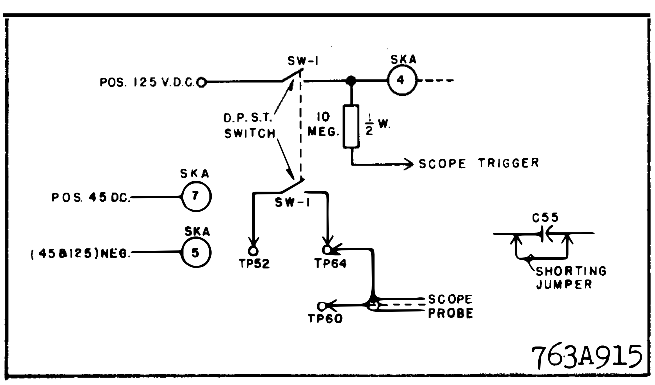
      2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

*   3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP52 (+) to TP64 (-) will drop from 7 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. This time is factory set between 2.7 and 3.3 ms., but may be lowered to less than 2.0 ms. by moving potentiometer R54 counterclockwise, and increased to 7.0 ms. by moving R54 clockwise.

      4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

      1. Make the connections shown in Fig. 10.



* *Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.*

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

* 6. This time delay can be adjusted by R79 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

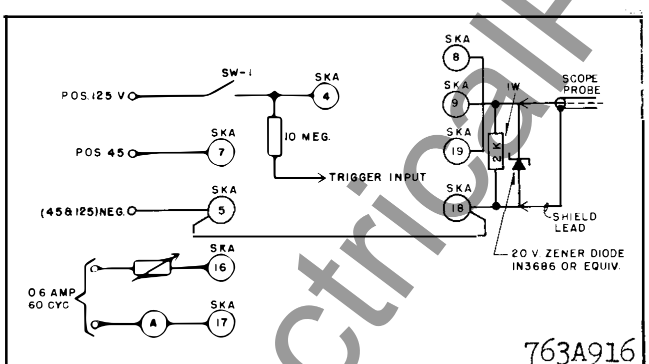


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (-) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

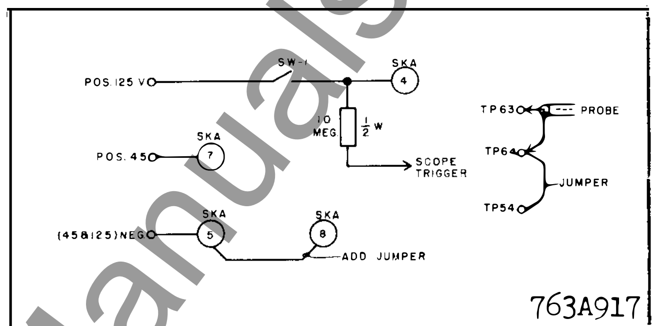


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

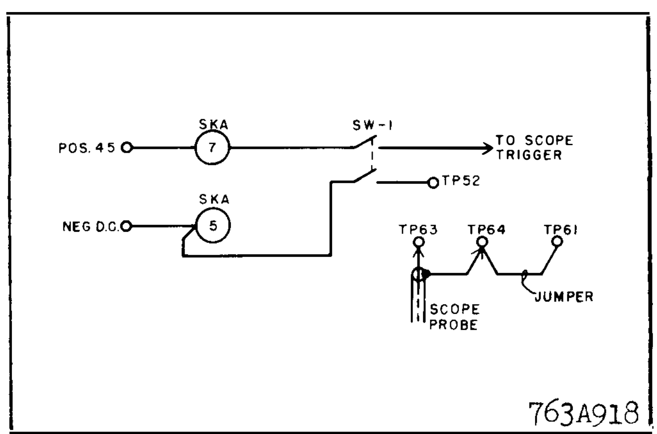
3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

* 4. This time delay may be increased by moving potentiometer R93 clockwise and decreased by moving R93 counterclockwise.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.



* *Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.*

* TABLE II

Test Point Voltages (to negative d.c.)

Test Point	Test Condition (From Table I and Fig. 6) 1	2	3	4	5	6
D.C. Ma (Fig. 7)	90	240	115	90	105	250
TP-4	6.5	6.5	6.5	20	20.5	20.5
5	6.7	6.7	6.7	6.7	6.7	6.8
6	6.6	6.6	6.6	< 0.5	< 0.5	< 0.5
7	< 0.5	< 0.5	< 0.5	19.0	19.0	19.0
8	7.6	7.6	7.6	7.6	< 0.5	< 0.5
9	7.5	7.5	7.5	< 0.5	< 0.5	< 0.5
10	< 0.5	< 0.5	< 0.5	< 0.5	11.6	11.6
11	21.6	21.0	21.5	21.5	22.0	21.5
12	—	—	—	—	—	—
13	< 0.5	< 0.5	< 0.5	19.8	0.25	0.15
14	22.5	22.5	22.5	22.5	22.5	22.0
15	< 0.5	< 0.5	< 0.5	21.0	1.05	0.9
16	0	45	0	0	0	45
17	3.5	3.5	3.5	< 0.5	< 0.5	< 0.5
51	21.5	21.5	< 0.5	21.5	21.5	21.5
52	7.4	< 0.5	< 0.5	7.4	7.4	< 0.5
53	< 0.5	< 0.5	7.3	< 0.5	< 0.5	< 0.5
54	< 0.5	21.8	< 0.5	< 0.5	< 0.5	22.0
55	21.5	1.3	21.5	21.5	21.5	1.3
56	0	9.2	0	0	0	9.2
57	3.5	20	3.6	3.5	3.5	20
58	20.0	7.8	20.0	20.0	20.0	7.8
59	0	14.5	0	0	0	14.5
60	45.0	< 0.5	45	45	45	< 0.5
61	18	< 0.5	< 0.5	< 0.5	17.0	< 0.5
62	0.6	< 0.5	7.4	7.4	0.65	< 0.5
63	21	20.5	< 0.5	< 0.5	20.5	20.5

- TP-4: Not a relay test point. TP-12 is neg. d.c. on front printed circuit board.
- 13: Neg. d.c.
- 51: Type-64 is neg. d.c. on rear printed circuit board.

Note: < 0.5 means "less than 0.5"

2. Set scope sweep-speed as for previous section.
3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.
4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date. The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

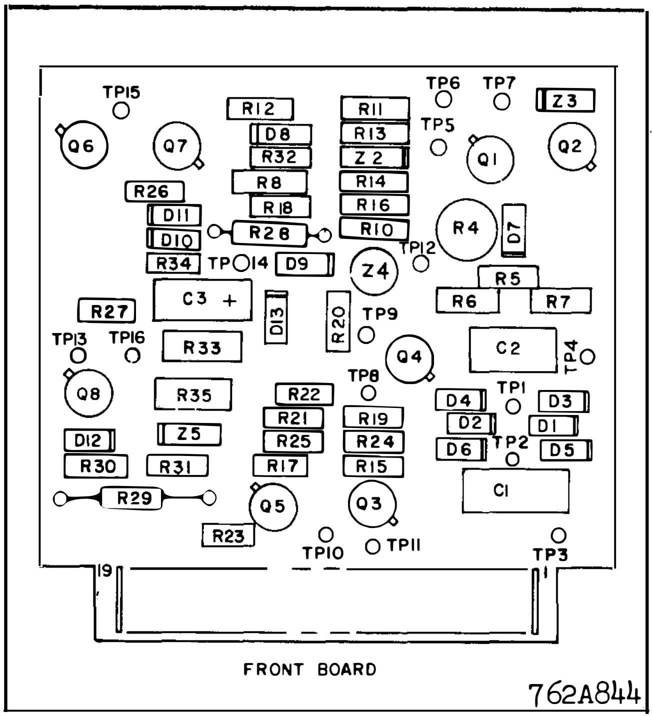
The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

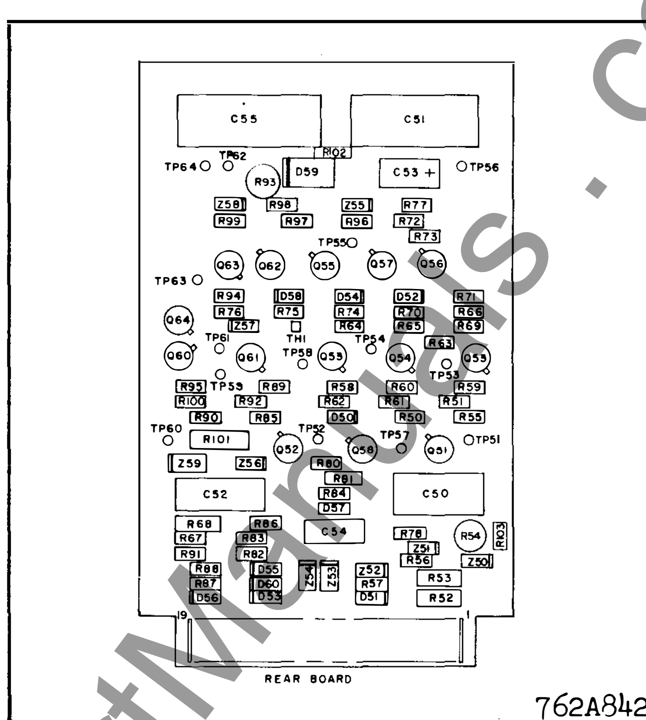
Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

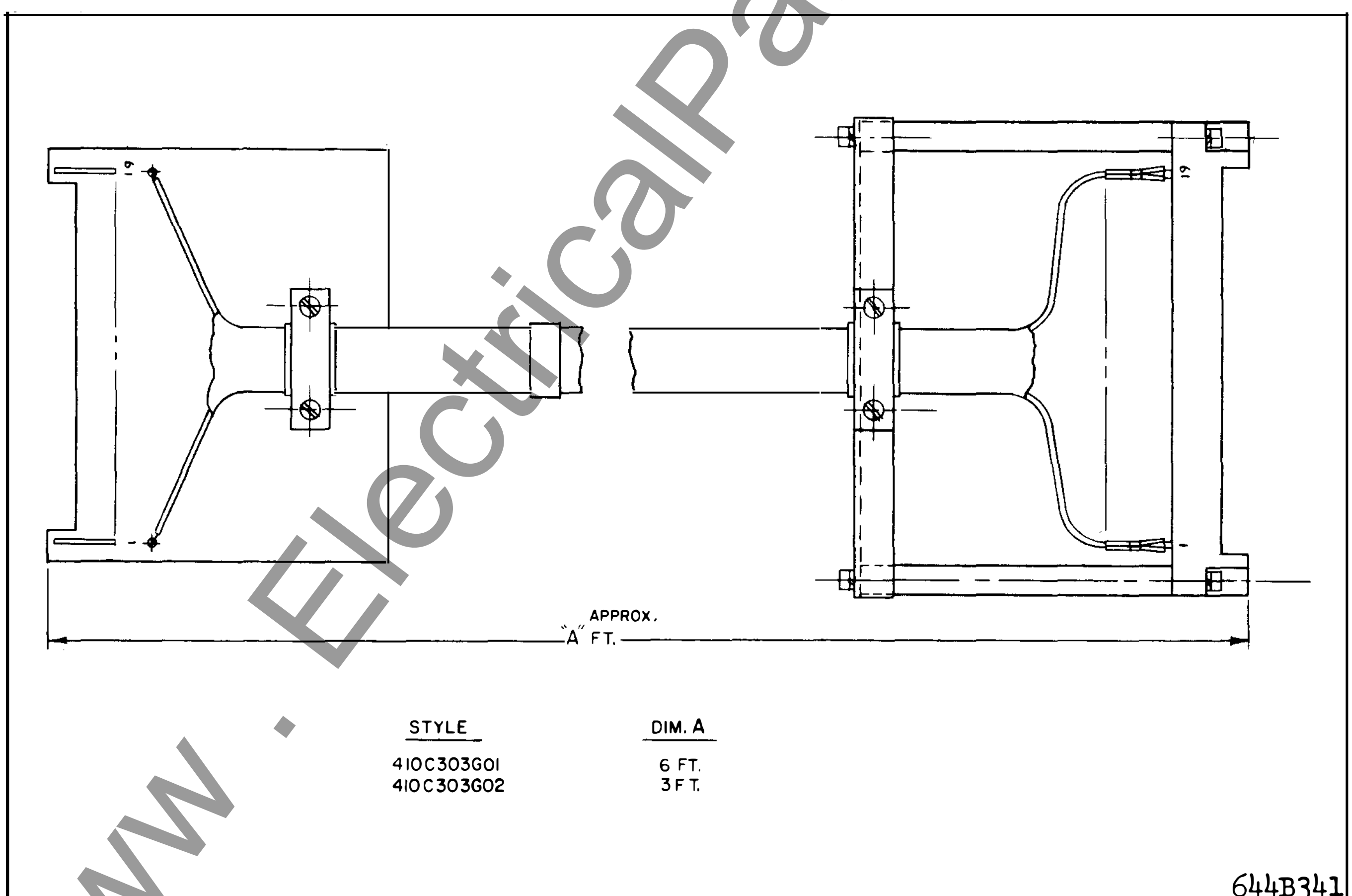
TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.



* *Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.*



* *Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.*



* *Fig. 16. 19 Terminal Printed Circuit Board Test Harness Outline.*

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

Unless Otherwise Noted, All Resistors Are 0.5-Watt, ± 5% Tol.

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
AR	Tripping Relay	408C845G01
	CAPACITORS	
C1	0.5 mfd., 200 V.D.C.	187A624H03
C2	0.25 mfd., 200 V.D.C.	187A624H02
C3	39 mfd., 35 V.D.C.	187A508H04
C4	150 mfd., 6 V.D.C.	184A661H08
C50	1.0 mfd., 200 V.D.C.	187A624H04
C51	0.22 mfd., 400 V.D.C.	188A293H02
C52	0.5 mfd., 200 V.D.C.	187A624H03
C53	39 mfd., 35 V.D.C.	187A508H04
C54	.05 mfd., 200 V.D.C.	187A624H08
C55	3.0 mfd., 200 V.D.C.	188A293H06
	DIODES	
D 1 – D 7 D 8 – D13	IN459A	184A855H08
D14	IN2069 (CER-69)	188A342H06
D 8 – D15	IN645A	837A692H03
D50 – D58	IN459A	184A855H08
D59	IN91	182A881H04
D60	IN459A	184A855H08
	TRANSISTORS	
Q1	2N652A	184A638H16
Q2	2N697	184A638H18
Q3	2N696	762A585H01
Q4	2N696	762A585H01
Q5	2N697	184A638H18
Q6	2N697	184A638H18
Q7	2N697	184A638H18
Q8	2N398A	184A638H12
Q9	2N3417	848A851H02
Q51	2N652A	184A638H16
Q52	2N696	762A585H01
Q53	2N696	762A585H01
Q54	2N696	762A585H01
Q55 – Q59	2N652A	184A638H16
Q60	2N697	184A638H18
Q61	2N652A	184A638H16
Q62	2N697	184A638H18
Q63	2N697	184A638H18
Q64	2N699	184A638H19

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS	
R1	50 ohms, 25W, 5%	1340388
R2	150 ohms, 25W, 5%	1267272
R3	2.0K ohms, 3W, Pot.	185A067H17
R4	2.5K ohms, .25W, Pot.	629A430H03
R5	2.7K ohms	184A763H37
R6	39K ohms	184A763H65
R7	18K ohms	184A763H57
R8	3.9K ohms, 1 W, 5%	187A643H41
R9	200K ohms, 2W, Pot.	185A067H14
R10	33K ohms	184A763H63
R11	10K ohms	184A763H51
R12	10K ohms	184A763H51
R13	330 ohms	184A763H15
R14	10K ohms	184A763H51
R15	680K ohms	184A763H95
R16	120K ohms	184A763H77
R17	10K ohms	184A763H51
R18	10K ohms	184A763H51
R19	68K ohms	184A763H71
R20	68K ohms	184A763H71
R21	33K ohms	184A763H63
R22	33K ohms	184A763H63
R23	10K ohms	184A763H51
R24	3.3K ohms	184A763H39
R25	3.3K ohms	184A763H39
R26	62K ohms	184A763H70
R27	5.6K ohms	184A763H45
R28	470 ohms, 3.W, 5%	184A636H20
R29	1K ohms, 5W, 5%	184A859H10
R30	1K ohms	184A763H27
R31	2.2K ohms	184A763H35
R32	10K ohms	184A763H51
R33	330 ohms, 2W, 5%	185A207H15
R34	1.2K ohms	184A763H29
R35	330K ohms, 2W, 5%	185A207H15
R36	22K ohms	184A763H59
R37	10K ohms	184A763H51
R38	10 ohms	187A290H01
R39	300 Ω, 25W For 48V	1202847
	1250Ω, 25W For 125V	1202589
	3000Ω, 25W For 250V	1202954
R50	10K ohms	184A763H51
R51	100K ohms	184A763H75
R52	47 ohms, 1W, 10%	184A859H09
R53	82K ohms, 1W, 5%	187A643H73

ELECTRICAL PARTS LIST (Continued)

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R54	100K Pot.	629A430H04
R55	120K ohms	184A763H77
R56	10K ohms	184A763H51
R57	10K ohms	184A763H51
R58	68K ohms	184A763H71
R59	10K ohms	184A763H51
R60	68K ohms	184A763H71
R61	33K ohms	184A763H63
R62	33K ohms	184A763H63
R63	10K ohms	184A763H51
R64	33K ohms	184A763H63
R65	3.3K ohms	184A763H39
R66	4.7K ohms	184A763H43
R67	1K ohms	184A763H27
R68	33K ohms, 1W, 5%	187A643H63
R69	47K ohms	184A763H67
R70	4.7K ohms	184A763H43
R71	68K ohms	184A763H71
R72	1.5K ohms	184A763H31
R73	1K ohms, ½W ± 5%	184A763H27
R74	22K ohms	184A763H59
R75	8.2K ohms	184A763H49
R76	8.2K ohms	184A763H49
R77	470 ohms	184A763H19
R78	4.7K ohms	184A763H43
R79	1K ohms, 2W, Pot.	185A067H09
R80	22K ohms	184A763H59
R81	22K ohms	184A763H59
R82	27K ohms	184A763H61
R83	6.8K ohms	184A763H47
R84	4.7K ohms	184A763H43
R85	4.7K ohms	184A763H43
R86	10K ohms	184A763H51
R87	82K ohms	184A763H73
R88	15K ohms	184A763H55
R89	5.6K ohms	184A763H45
R90	2.2K ohms	184A763H35

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R91	4.7K ohms	184A763H43
R92	6.8K ohms	184A763H47
R93	15K Pot.	629A430H08
R94	10K ohms	184A763H51
R95	1.5K ohms	184A763H31
R96	10K ohms	184A763H51
R97	470 ohms	184A763H19
R98	470 ohms	184A763H19
R99	10K ohms	184A763H51
R100	2.2K ohms	184A763H35
R101	800 ohms, 3W, 5%	184A859H06
R102	8.2K, ½W ± 5%	184A763H49
R103	33K ohms	184A763H63
TH51	Thermistor, 10K at 25°C	185A211H04
	TRANSFORMER	
T1	Saturating Transformer	606B519G03
	ZENER DIODES	
Z1	IN1832C, 62V.	184A617H06
Z2	IN957B. 6.8V.	186A797H06
Z3	IN3686B, 20V.	185A212H06
Z4	IN3797B, 22V.	185A089H09
Z5	IN3051, 200V.	187A936H01
Z6	IN4370	184A639H12
Z50	IN3051, 200V.	187A936H01
Z51	IN3686B, 20V.	185A212H06
Z52	IN957B, 6.8V.	186A797H06
Z53	IN3051, 200V.	187A936H01
Z54	IN3051, 200V.	187A936H01
Z55	IN957B, 6.8V.	186A797H06
Z56	IN960B, 9.1V.	186A797H10
Z57	IN957B, 6.8V.	186A797H06
Z58	IN957B, 6.8V.	186A797H06
Z59	IN1789, 56V.	584C434H08

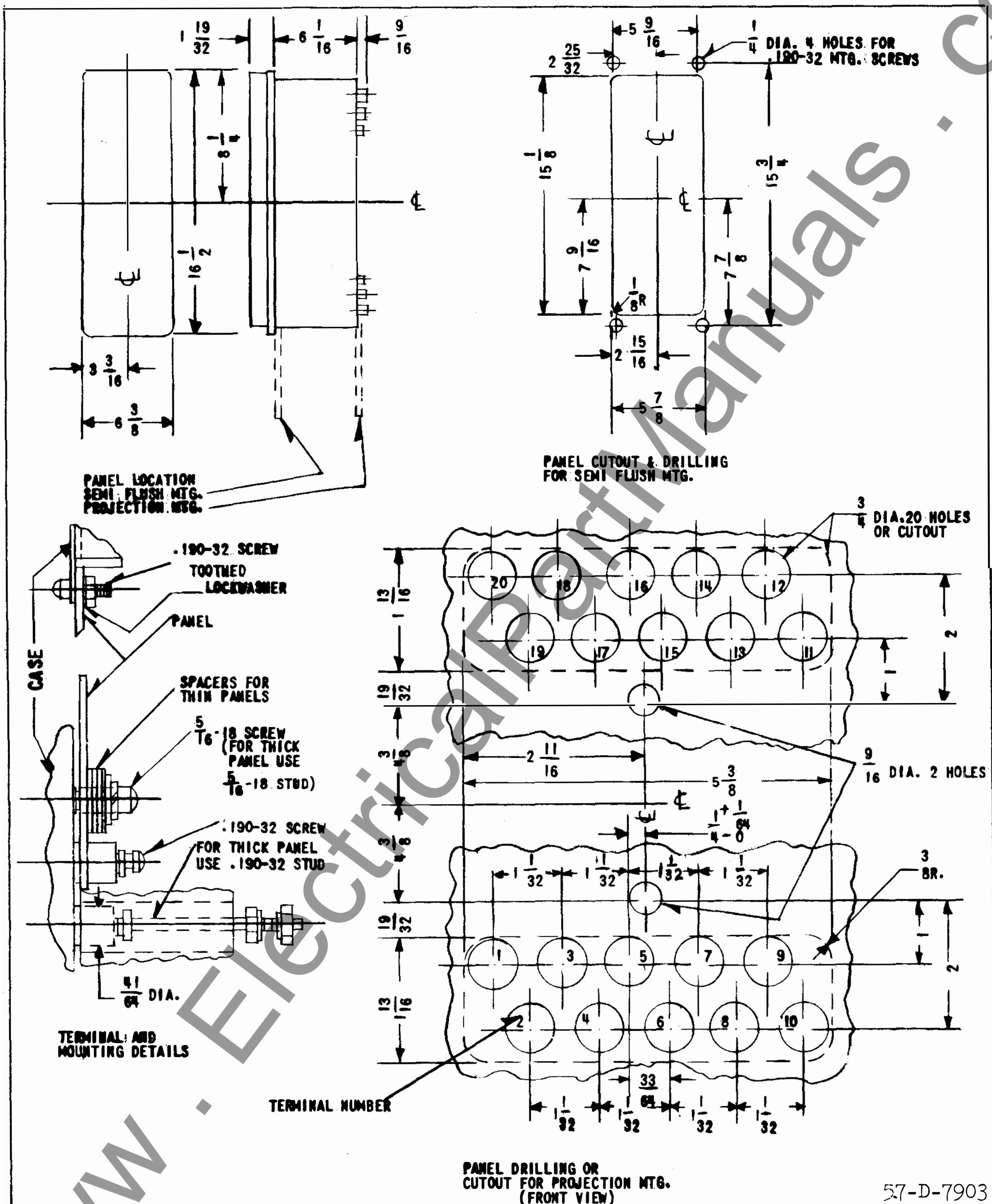


*Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted in the FT32 Flexitest case. The static equivalents of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY *	Integrating time delay, (adjustable) 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

SUPERSEDES I.L. 41-923.5A
*Denotes change from superseded issue.

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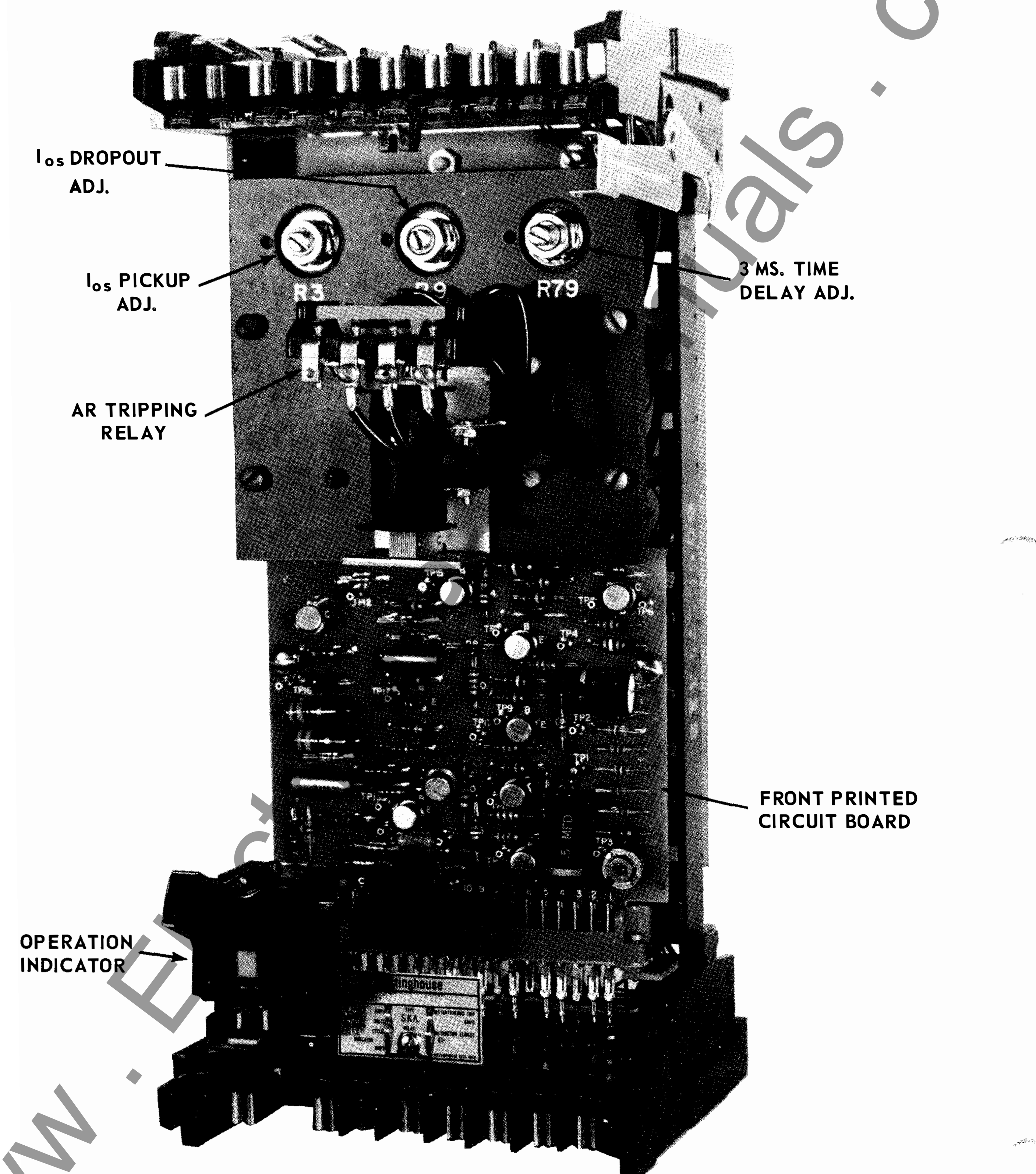


**Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).*

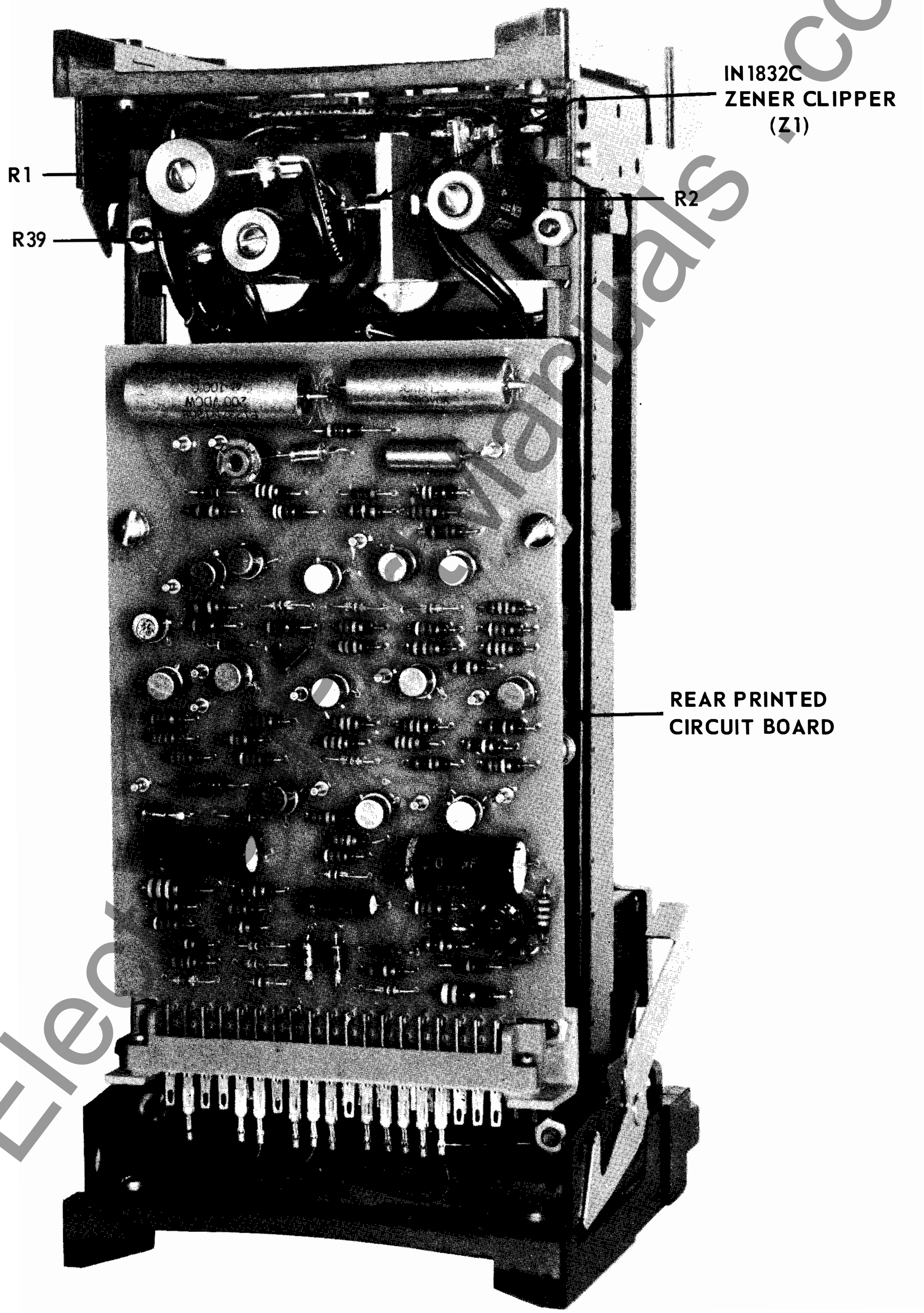


*Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
* K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows (adjustable) 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
* L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals. Provision is made for external initiation of squelch by applying positive d-c to relay terminal 6.
* M	Ios and O+T.D. 30-50	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function. No intentional pickup (0+) and 30-50 ms. dropout time when energized from Ios AMP.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

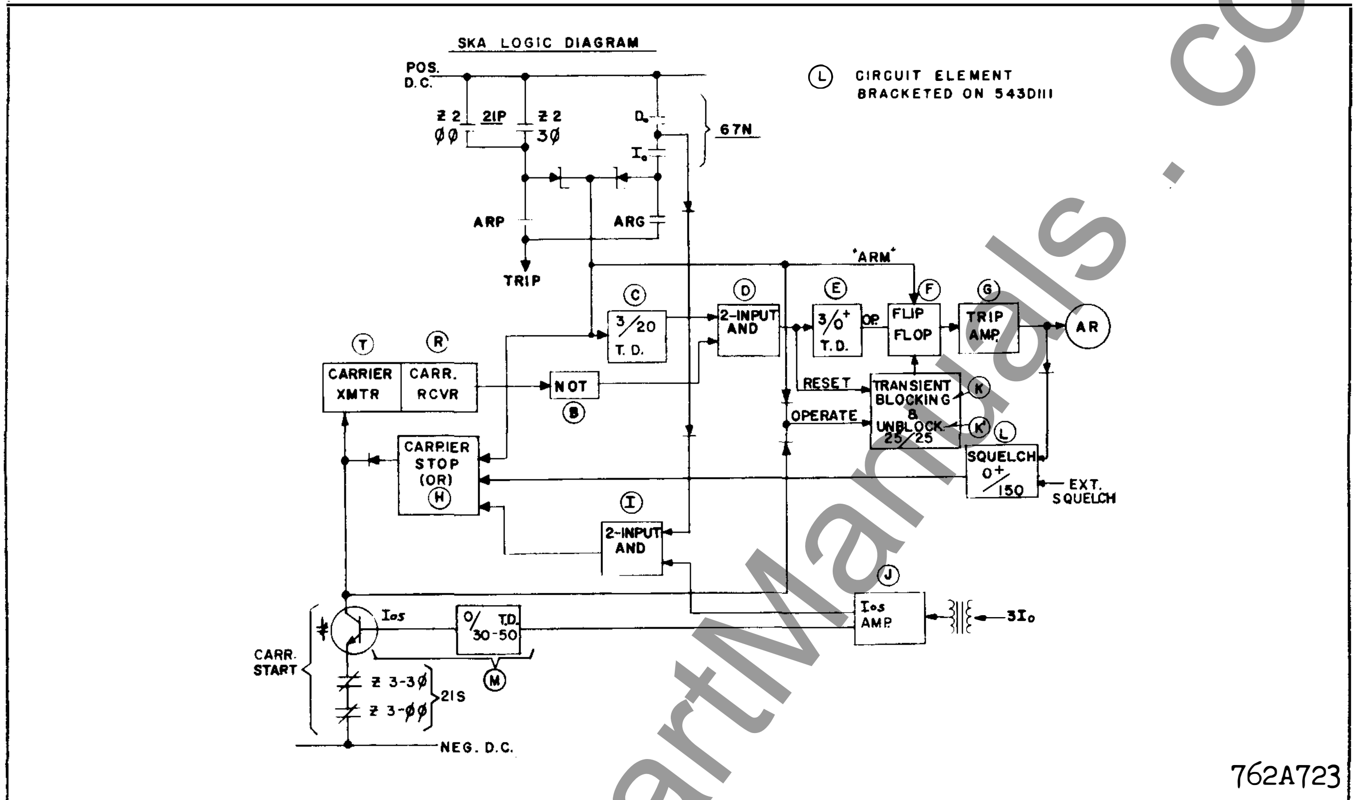
1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).



* *Fig. 3. Logic Diagram for the Type SKA Relay.*

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The * complete detailed relay circuit is shown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

* C-3/20 MS (ADJUSTABLE) TIME DELAY: D-TWO-INPUT AND

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

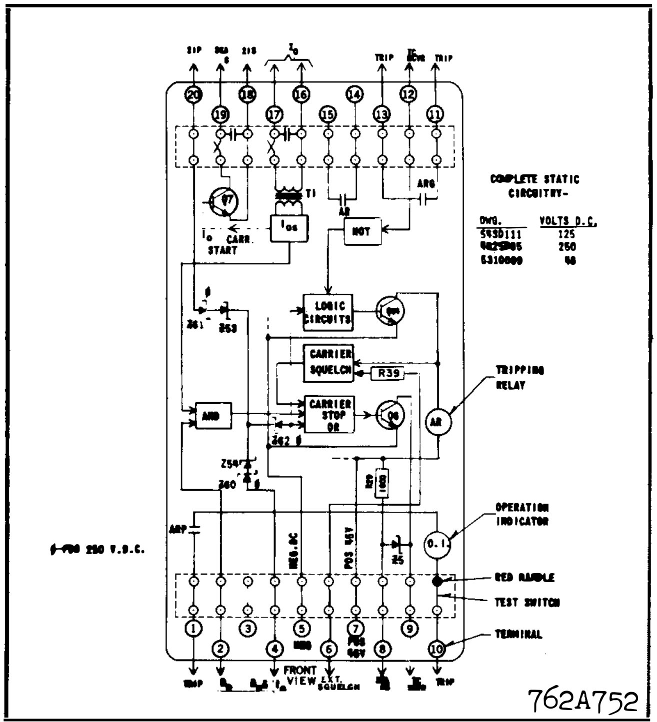


Fig. 4. Internal Schematic for the Type SKA Relay in the FT32 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capa- * citor C50 starts to charge thru resistors R52, R103 and R54. After a time delay of approximately 3 milliseconds (adjustable), the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 * or Z54, plus diode D55 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer

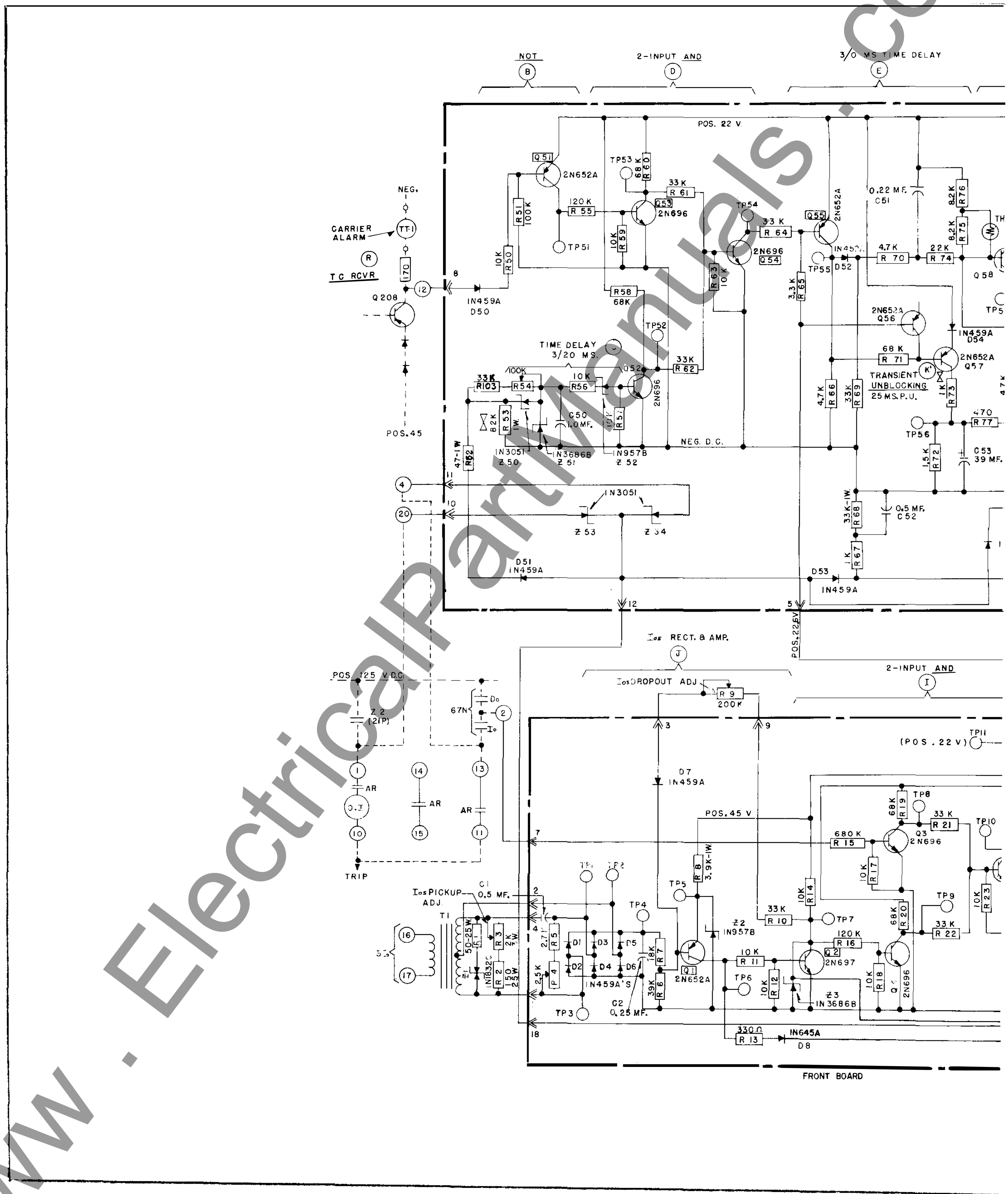
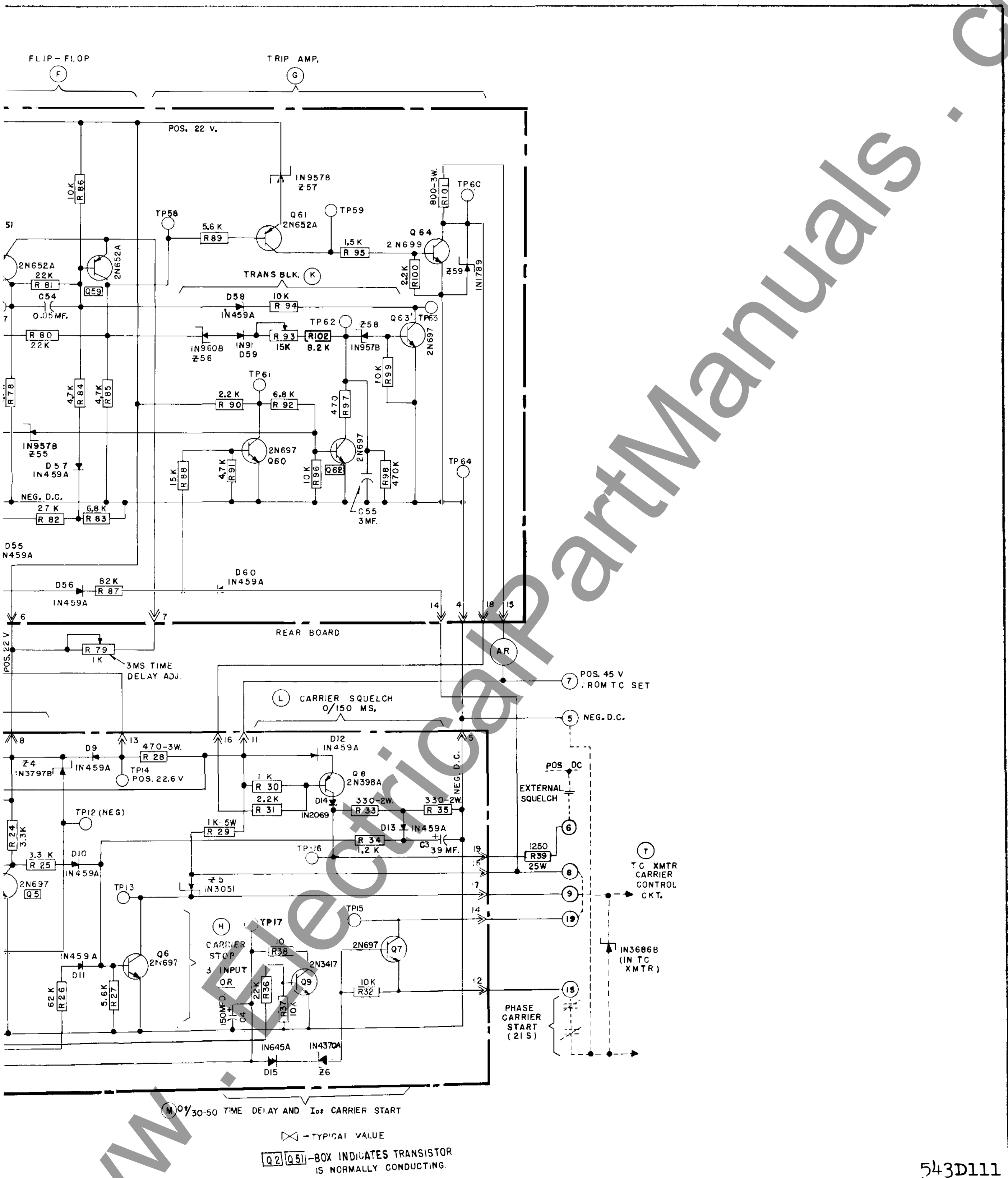


Fig. 5. Complete Electrical Sc



...hematic for the Type SKA Relay.

detail in the previous section (M) and by dotted lines to the right of terminals 8, 9, 19, and 18 of the SKA relay (Fig. 3), so that when it conducts it stops the transmission of carrier. This is the carrier stop circuit section H. The combination of operation of the directional unit D_O in the carrier ground relay 67N and the presence of ground fault current comprises one condition for stopping carrier. This combination is necessary to handle fault current values below the pickup of the I_O tripping unit of the 67N relay.

If the ground fault current is high enough for the operation of both D_O and I_O of the carrier ground relay, this will apply a positive potential to SKA relay terminal 4. Thru the circuit starting from relay terminal 4 thru Zener diode Z54, resistor R26, and diode D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L – CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning on of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitor C3 thru diode D12, transistor Q8, diode D14, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q6. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current. Provision is made for external initiation of carrier squelch by applying positive d-c to relay terminal 6. This allows a path for rapidly charging capacitor C3 through resistors R39 and R33 and diode D12 as above.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

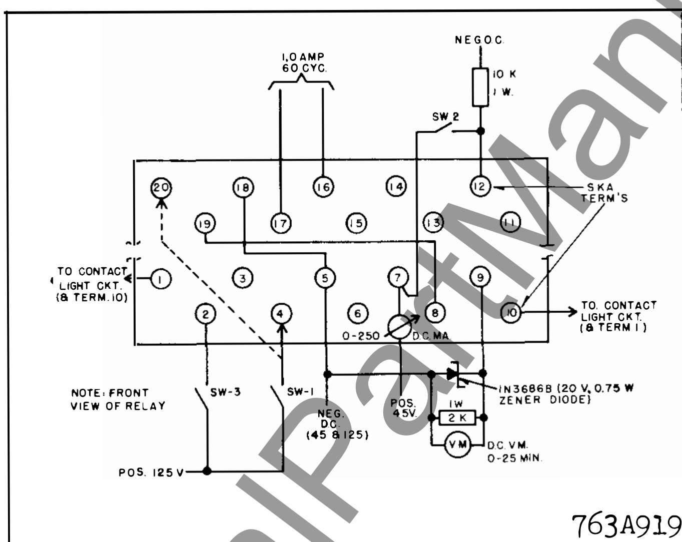


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	* Do and Io trip and Ios

0 = open
C1 = close
α = or 2 x pickup
ϕ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit: To test this portion of the relay, use the connections shown below.

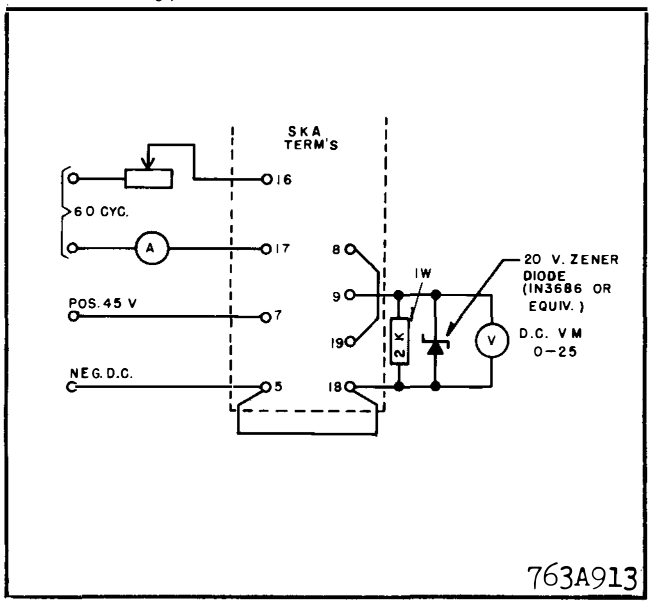


Fig. 8. Test Connections for the I_{OS} Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

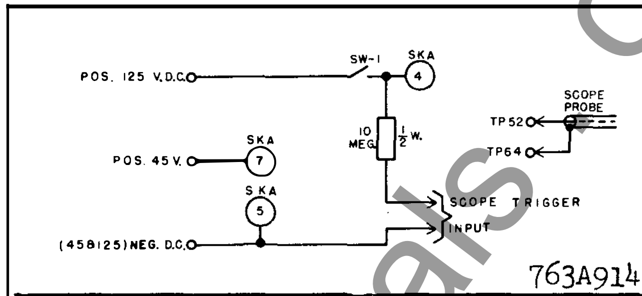
3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

* 4. Time Delays in Logic Circuits. There are six time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. Note: The rotation "30/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

   1. Make the connections shown in Fig. 9.



* *Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.*

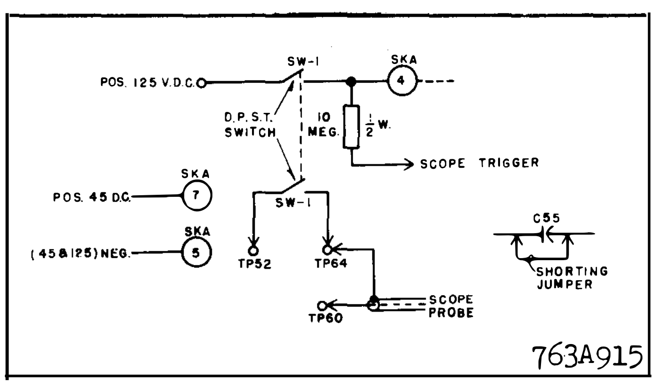
   2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

* 3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP52 (+) to TP64 (-) will drop from 7 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. This time is factory set between 2.7 and 3.3 ms., but may be lowered to less than 2.0 ms. by moving potentiometer R54 counterclockwise, and increased to 7.0 ms. by moving R54 clockwise.

   4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

   1. Make the connections shown in Fig. 10.



* *Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.*

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

* 6. This time delay can be adjusted by R79 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

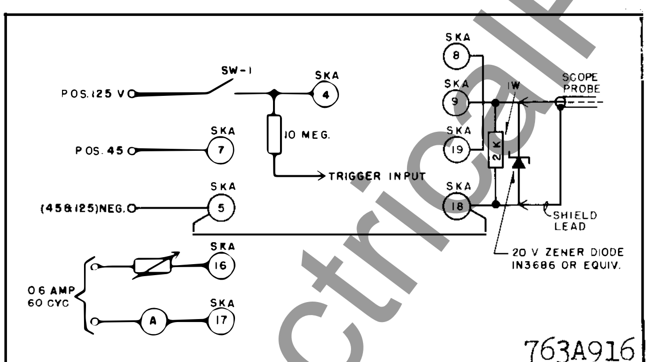


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (-) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

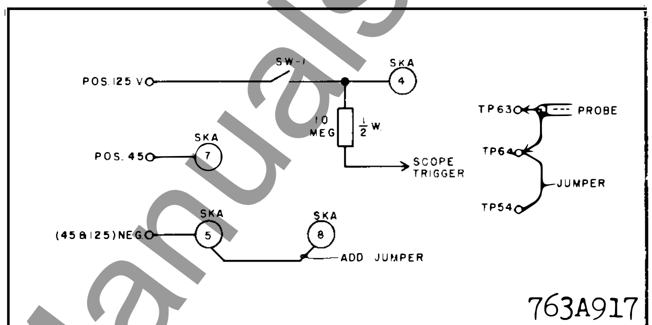


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

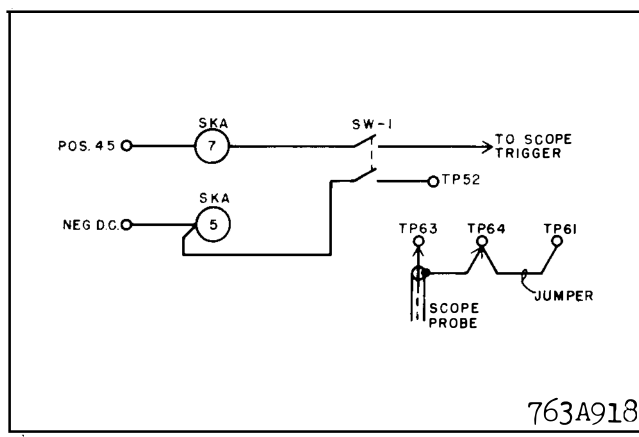
3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

* 4. This time delay may be increased by moving potentiometer R93 clockwise and decreased by moving R93 counterclockwise.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.



* *Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.*

* TABLE II

Test Point Voltages (to negative d.c.)

Test Point	Test Condition (From Table I and Fig. 6)					
	1	2	3	4	5	6
D.C. Ma (Fig. 7)	90	240	115	90	105	250
TP-4	6.5	6.5	6.5	20	20.5	20.5
5	6.7	6.7	6.7	6.7	6.7	6.8
6	6.6	6.6	6.6	< 0.5	< 0.5	< 0.5
7	< 0.5	< 0.5	< 0.5	19.0	19.0	19.0
8	7.6	7.6	7.6	7.6	< 0.5	< 0.5
9	7.5	7.5	7.5	< 0.5	< 0.5	< 0.5
10	< 0.5	< 0.5	< 0.5	< 0.5	11.6	11.6
11	21.6	21.0	21.5	21.5	22.0	21.5
12	—	—	—	—	—	—
13	< 0.5	< 0.5	< 0.5	19.8	0.25	0.15
14	22.5	22.5	22.5	22.5	22.5	22.0
15	< 0.5	< 0.5	< 0.5	21.0	1.05	0.9
16	0	45	0	0	0	45
17	3.5	3.5	3.5	< 0.5	< 0.5	< 0.5
51	21.5	21.5	< 0.5	21.5	21.5	21.5
52	7.4	< 0.5	< 0.5	7.4	7.4	< 0.5
53	< 0.5	< 0.5	7.3	< 0.5	< 0.5	< 0.5
54	< 0.5	21.8	< 0.5	< 0.5	< 0.5	22.0
55	21.5	1.3	21.5	21.5	21.5	1.3
56	0	9.2	0	0	0	9.2
57	3.5	20	3.6	3.5	3.5	20
58	20.0	7.8	20.0	20.0	20.0	7.8
59	0	14.5	0	0	0	14.5
60	45.0	< 0.5	45	45	45	< 0.5
61	18	< 0.5	< 0.5	< 0.5	17.0	< 0.5
62	0.6	< 0.5	7.4	7.4	0.65	< 0.5
63	21	20.5	< 0.5	< 0.5	20.5	20.5

TP-4: Not a relay test point. TP-12 is neg. d.c. on front printed circuit board.

TP-13: Neg. d.c.

TP-51: Type-64 is neg. d.c. on rear printed circuit board.

Note: < 0.5 means "less than 0.5"

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date. The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

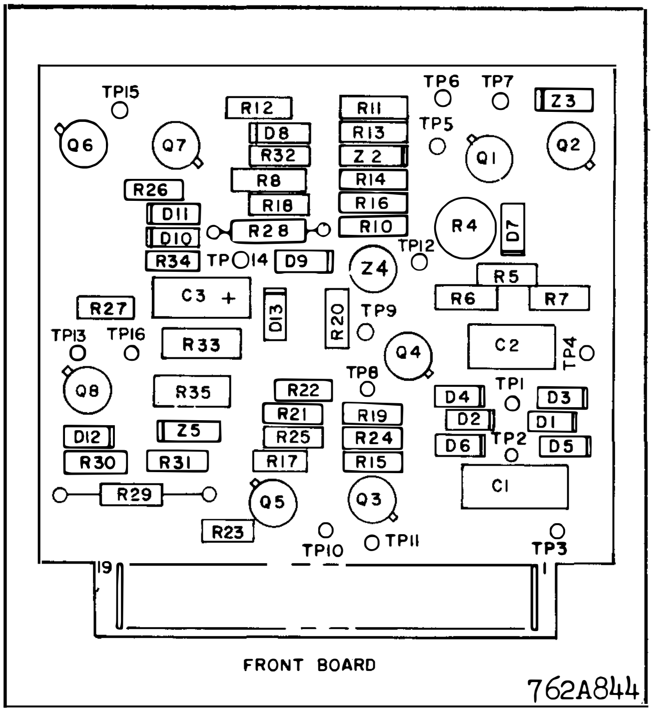
The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

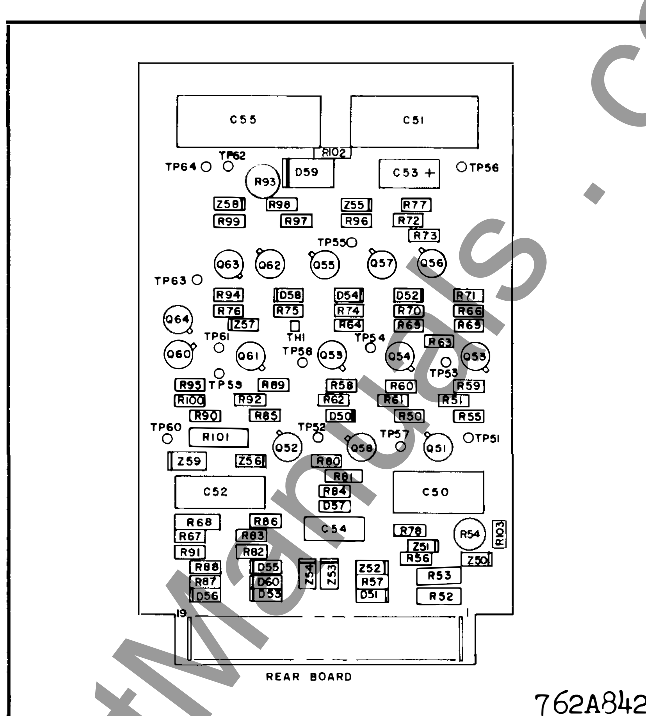
Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

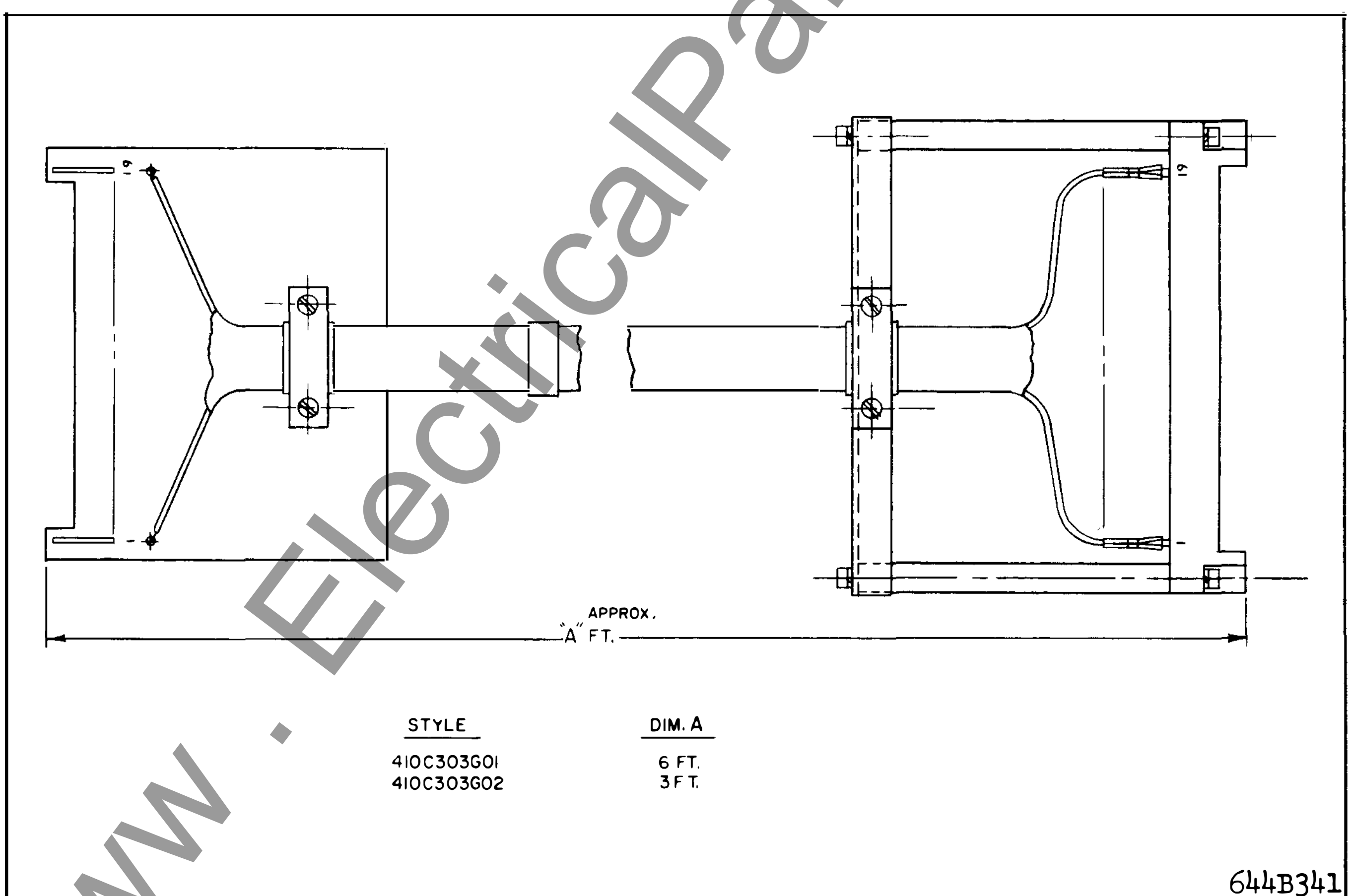
TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.



* *Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.*



* *Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.*



* *Fig. 16. 19 Terminal Printed Circuit Board Test Harness Outline.*

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

Unless Otherwise Noted, All Resistors Are 0.5-Watt, ± 5% Tol.

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
AR	Tripping Relay	408C845G01
	CAPACITORS	
C1	0.5 mfd., 200 V.D.C.	187A624H03
C2	0.25 mfd., 200 V.D.C.	187A624H02
C3	39 mfd., 35 V.D.C.	187A508H04
C4	150 mfd., 6 V.D.C.	184A661H08
C50	1.0 mfd., 200 V.D.C.	187A624H04
C51	0.22 mfd., 400 V.D.C.	188A293H02
C52	0.5 mfd., 200 V.D.C.	187A624H03
C53	39 mfd., 35 V.D.C.	187A508H04
C54	.05 mfd., 200 V.D.C.	187A624H08
C55	3.0 mfd., 200 V.D.C.	188A293H06
	DIODES	
D 1 – D 7 D 8 – D13	IN459A	184A855H08
D14	IN2069 (CER-69)	188A342H06
D 8 – D15	IN645A	837A692H03
D50 – D58	IN459A	184A855H08
D59	IN91	182A881H04
D60	IN459A	184A855H08
	TRANSISTORS	
Q1	2N652A	184A638H16
Q2	2N697	184A638H18
Q3	2N696	762A585H01
Q4	2N696	762A585H01
Q5	2N697	184A638H18
Q6	2N697	184A638H18
Q7	2N697	184A638H18
Q8	2N398A	184A638H12
Q9	2N3417	848A851H02
Q51	2N652A	184A638H16
Q52	2N696	762A585H01
Q53	2N696	762A585H01
Q54	2N696	762A585H01
Q55 – Q59	2N652A	184A638H16
Q60	2N697	184A638H18
Q61	2N652A	184A638H16
Q62	2N697	184A638H18
Q63	2N697	184A638H18
Q64	2N699	184A638H19

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS	
R1	50 ohms, 25W, 5%	1340388
R2	150 ohms, 25W, 5%	1267272
R3	2.0K ohms, 3W, Pot.	185A067H17
R4	2.5K ohms, .25W, Pot.	629A430H03
R5	2.7K ohms	184A763H37
R6	39K ohms	184A763H65
R7	18K ohms	184A763H57
R8	3.9K ohms, 1 W, 5%	187A643H41
R9	200K ohms, 2W, Pot.	185A067H14
R10	33K ohms	184A763H63
R11	10K ohms	184A763H51
R12	10K ohms	184A763H51
R13	330 ohms	184A763H15
R14	10K ohms	184A763H51
R15	680K ohms	184A763H95
R16	120K ohms	184A763H77
R17	10K ohms	184A763H51
R18	10K ohms	184A763H51
R19	68K ohms	184A763H71
R20	68K ohms	184A763H71
R21	33K ohms	184A763H63
R22	33K ohms	184A763H63
R23	10K ohms	184A763H51
R24	3.3K ohms	184A763H39
R25	3.3K ohms	184A763H39
R26	62K ohms	184A763H70
R27	5.6K ohms	184A763H45
R28	470 ohms, 3.W, 5%	184A636H20
R29	1K ohms, 5W, 5%	184A859H10
R30	1K ohms	184A763H27
R31	2.2K ohms	184A763H35
R32	10K ohms	184A763H51
R33	330 ohms, 2W, 5%	185A207H15
R34	1.2K ohms	184A763H29
R35	330K ohms, 2W, 5%	185A207H15
R36	22K ohms	184A763H59
R37	10K ohms	184A763H51
R38	10 ohms	187A290H01
R39	300 Ω, 25W For 48V	1202847
	1250Ω, 25W For 125V	1202589
	3000Ω, 25W For 250V	1202954
R50	10K ohms	184A763H51
R51	100K ohms	184A763H75
R52	47 ohms, 1W, 10%	184A859H09
R53	82K ohms, 1W, 5%	187A643H73

ELECTRICAL PARTS LIST (Continued)

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R54	100K Pot.	629A430H04
R55	120K ohms	184A763H77
R56	10K ohms	184A763H51
R57	10K ohms	184A763H51
R58	68K ohms	184A763H71
R59	10K ohms	184A763H51
R60	68K ohms	184A763H71
R61	33K ohms	184A763H63
R62	33K ohms	184A763H63
R63	10K ohms	184A763H51
R64	33K ohms	184A763H63
R65	3.3K ohms	184A763H39
R66	4.7K ohms	184A763H43
R67	1K ohms	184A763H27
R68	33K ohms, 1W, 5%	187A643H63
R69	47K ohms	184A763H67
R70	4.7K ohms	184A763H43
R71	68K ohms	184A763H71
R72	1.5K ohms	184A763H31
R73	1K ohms, ½W ± 5%	184A763H27
R74	22K ohms	184A763H59
R75	8.2K ohms	184A763H49
R76	8.2K ohms	184A763H49
R77	470 ohms	184A763H19
R78	4.7K ohms	184A763H43
R79	1K ohms, 2W, Pot.	185A067H09
R80	22K ohms	184A763H59
R81	22K ohms	184A763H59
R82	27K ohms	184A763H61
R83	6.8K ohms	184A763H47
R84	4.7K ohms	184A763H43
R85	4.7K ohms	184A763H43
R86	10K ohms	184A763H51
R87	82K ohms	184A763H73
R88	15K ohms	184A763H55
R89	5.6K ohms	184A763H45
R90	2.2K ohms	184A763H35

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R91	4.7K ohms	184A763H43
R92	6.8K ohms	184A763H47
R93	15K Pot.	629A430H08
R94	10K ohms	184A763H51
R95	1.5K ohms	184A763H31
R96	10K ohms	184A763H51
R97	470 ohms	184A763H19
R98	470 ohms	184A763H19
R99	10K ohms	184A763H51
R100	2.2K ohms	184A763H35
R101	800 ohms, 3W, 5%	184A859H06
R102	8.2K, ½W ± 5%	184A763H49
R103	33K ohms	184A763H63
TH51	Thermistor, 10K at 25°C	185A211H04
	TRANSFORMER	
T1	Saturating Transformer	606B519G03
	ZENER DIODES	
Z1	IN1832C, 62V.	184A617H06
Z2	IN957B. 6.8V.	186A797H06
Z3	IN3686B, 20V.	185A212H06
Z4	IN3797B, 22V.	185A989H09
Z5	IN3051, 200V.	187A936H01
Z6	IN4370	184A639H12
Z50	IN3051, 200V.	187A936H01
Z51	IN3686B, 20V.	185A212H06
Z52	IN957B, 6.8V.	186A797H06
Z53	IN3051, 200V.	187A936H01
Z54	IN3051, 200V.	187A936H01
Z55	IN957B, 6.8V.	186A797H06
Z56	IN960B, 9.1V.	186A797H10
Z57	IN957B, 6.8V.	186A797H06
Z58	IN957B, 6.8V.	186A797H06
Z59	IN1789, 56V.	584C434H08

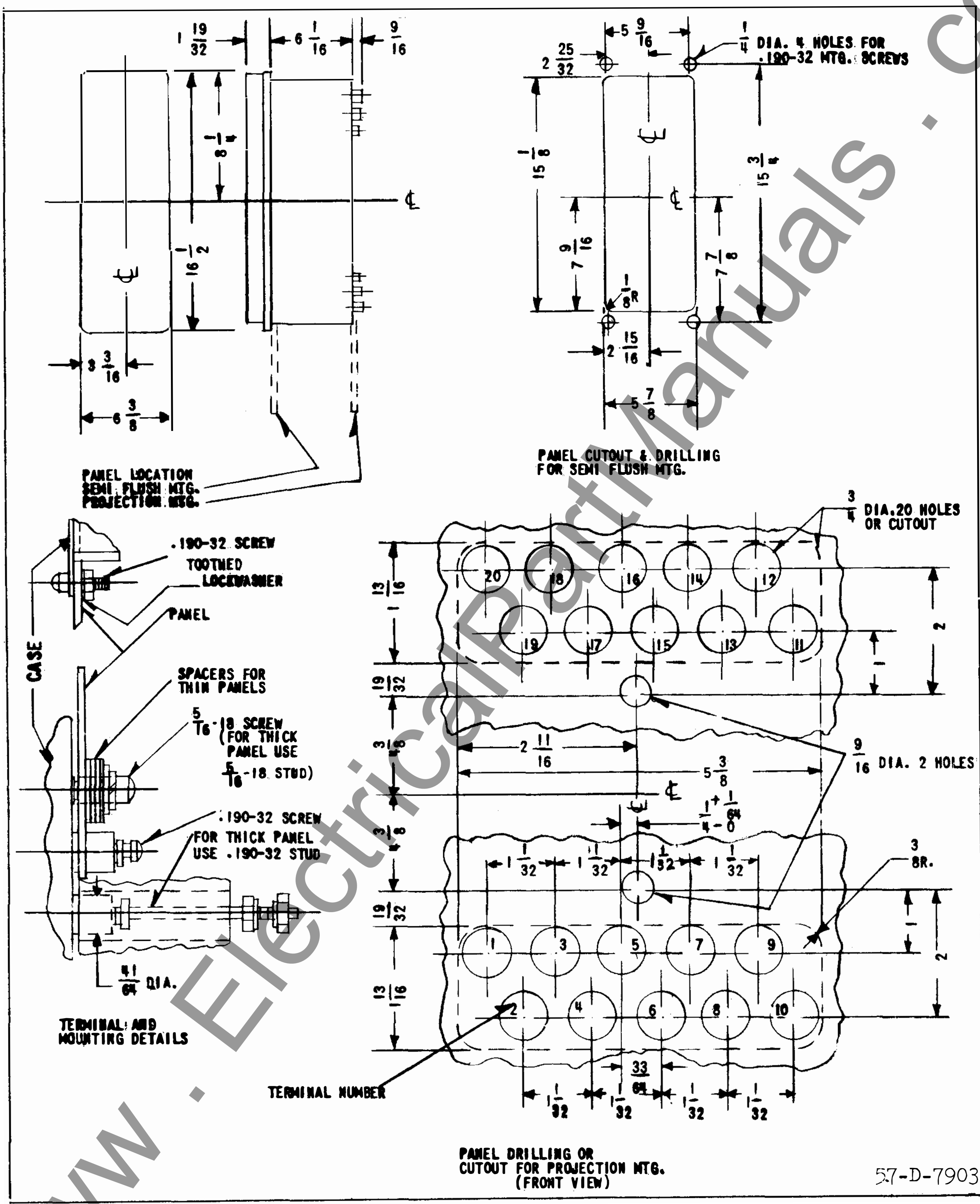


*Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying * system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted * in the FT32 Flexitest case. The static equivalents * of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY	Integrating time delay, 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

SUPERSEDES I.L. 41-923.5
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1965

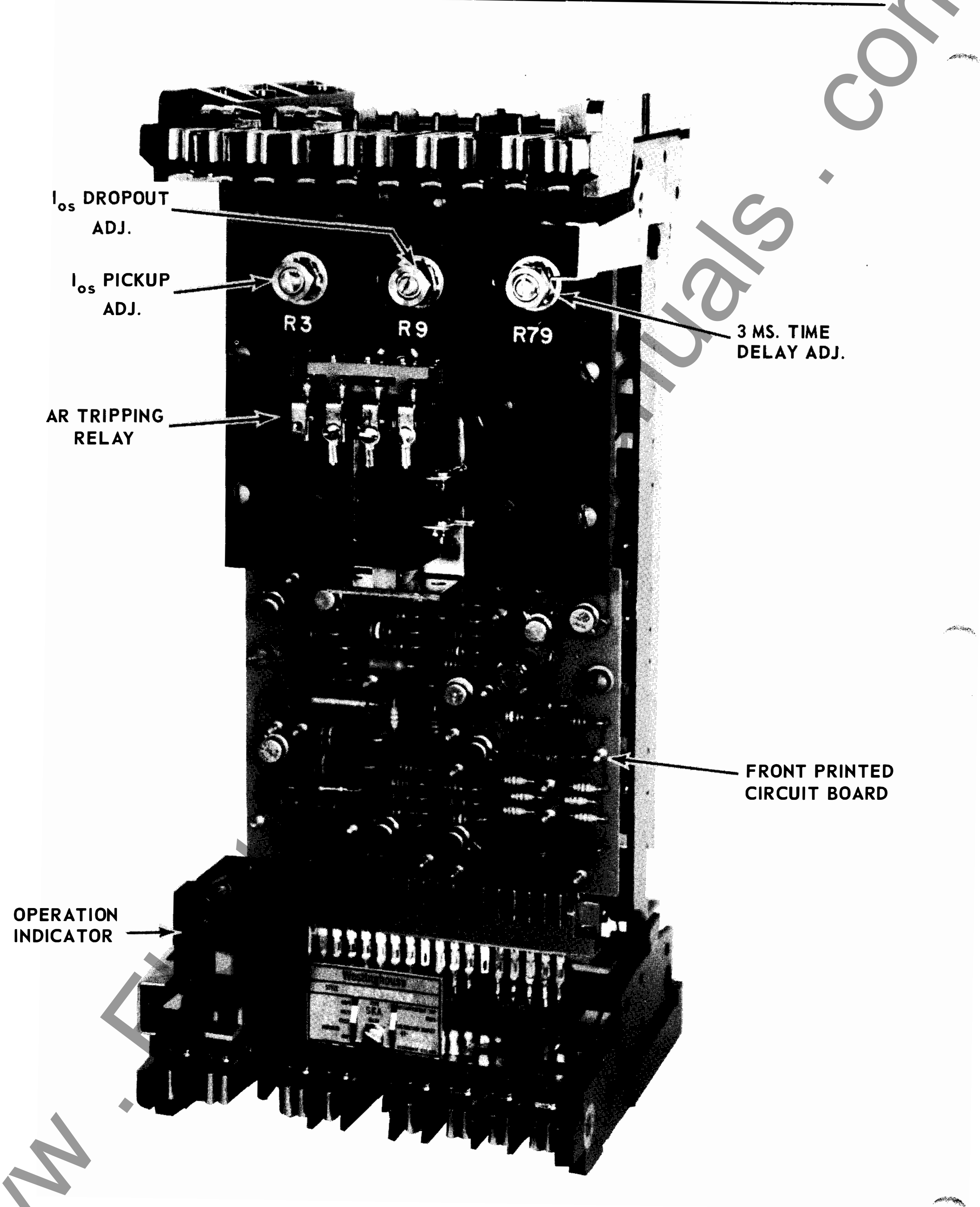


**Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).*

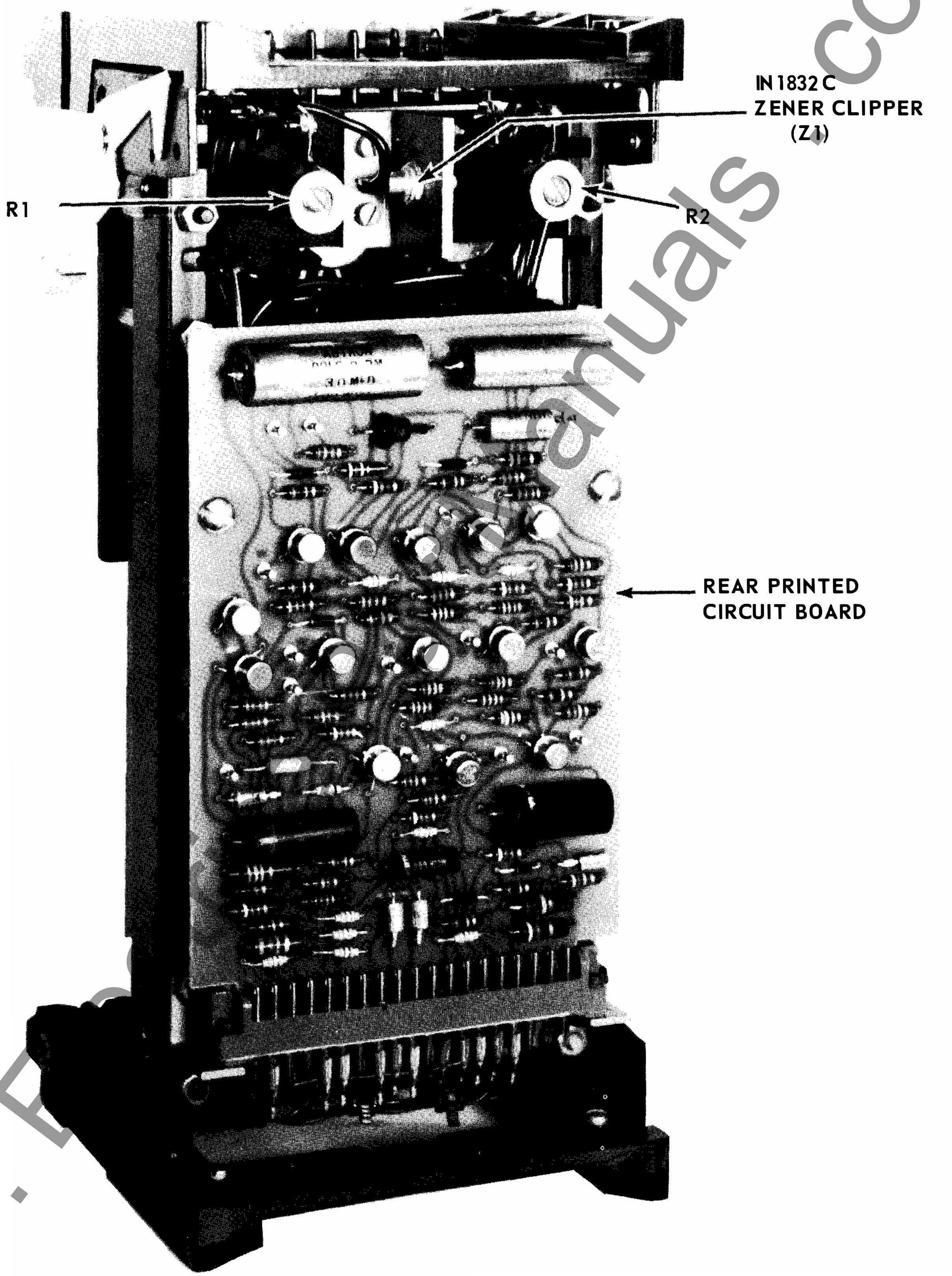


*Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals.
M	Ios	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

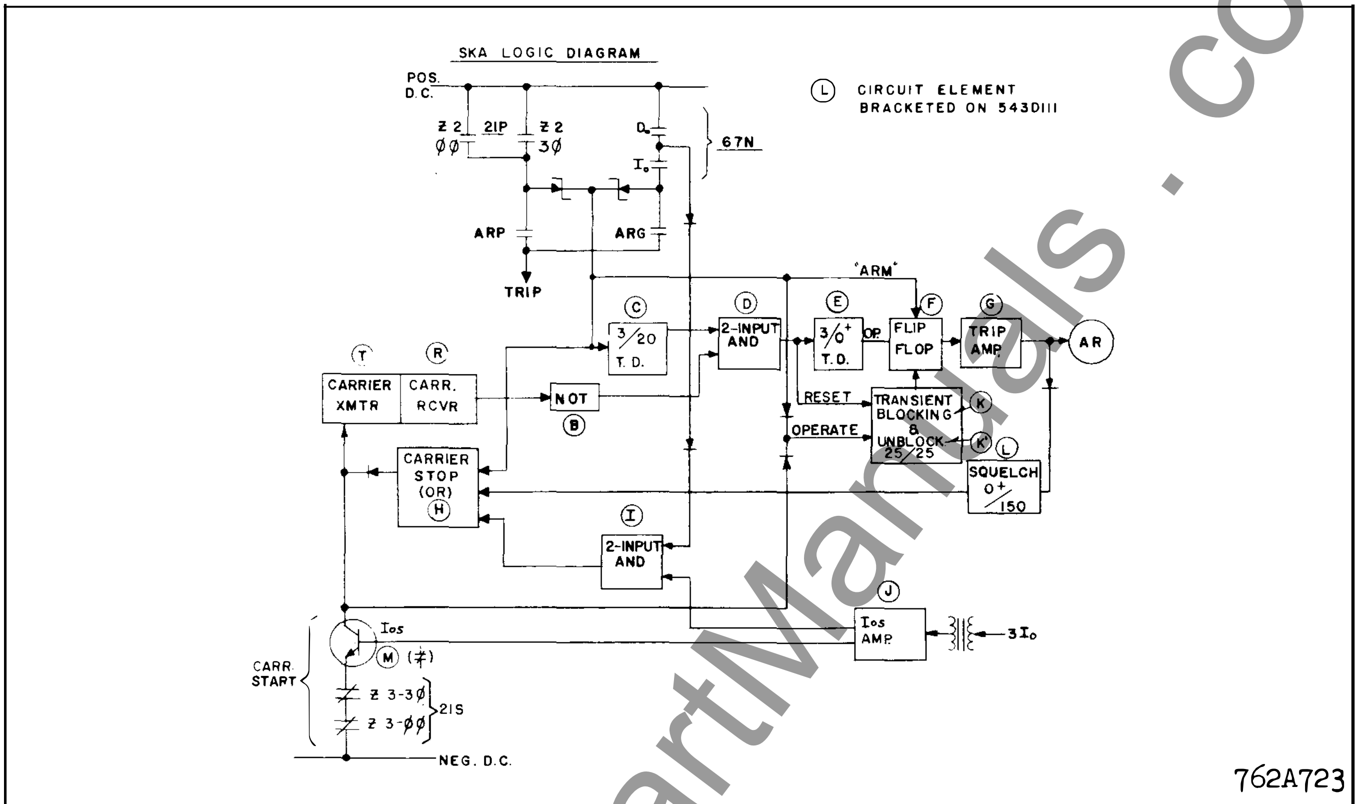


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The complete detailed relay circuit is chown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22**V.**), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

C-3/20 MS TIME DELAY: D-TWO-INPUT AND.

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

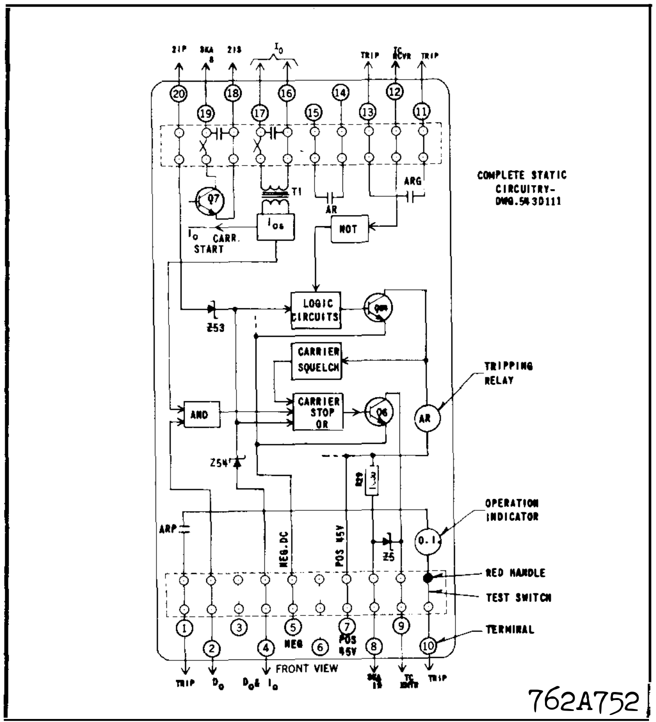


***Fig. 4. Internal Schematic for the Type SKA Relay in the FT32 Case.**

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capacitor C50 starts to charge thru resistors R52 and R-54. After a time delay of approximately 3 milliseconds, the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 or Z54, plus diode D53 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer conducting,

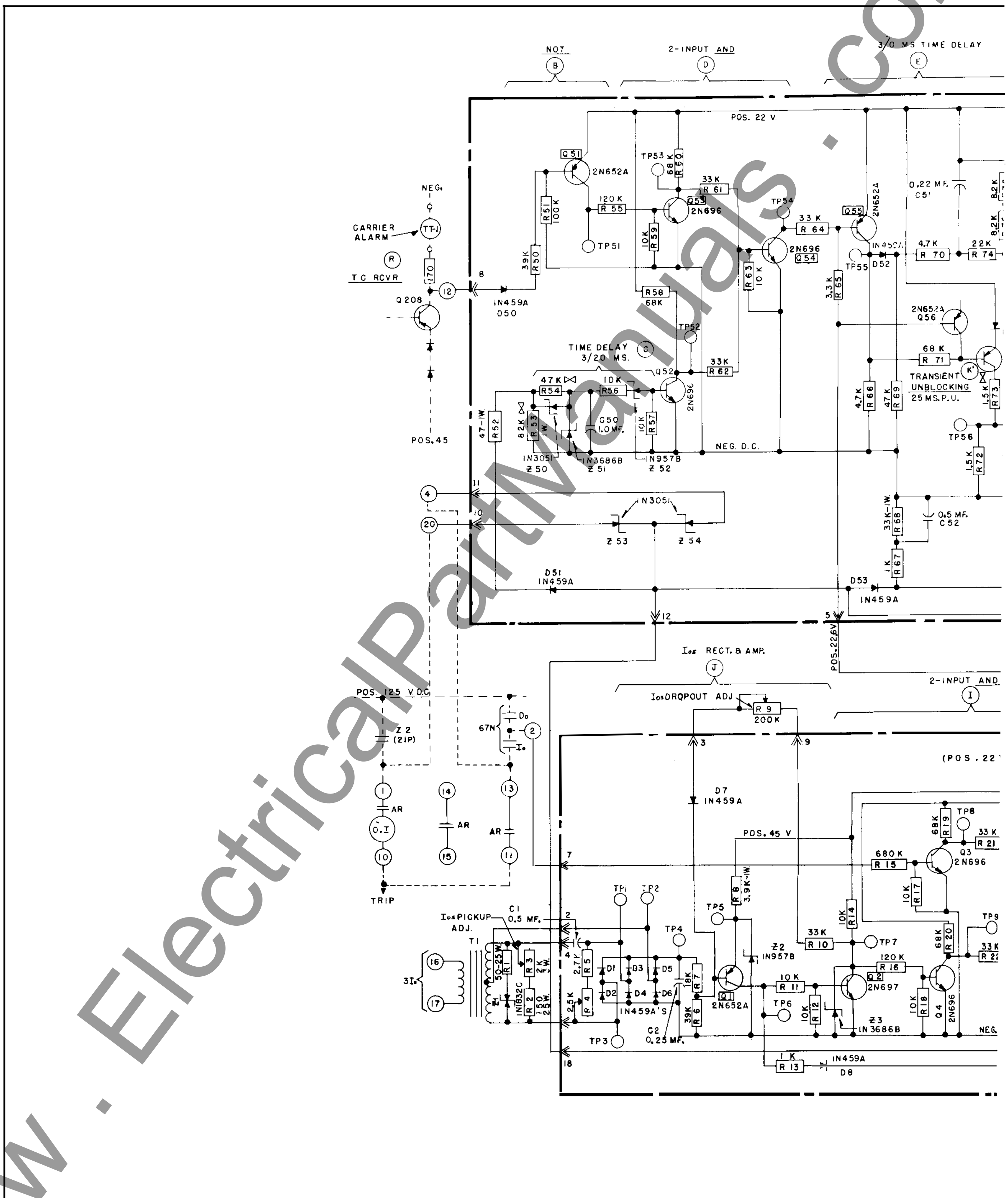
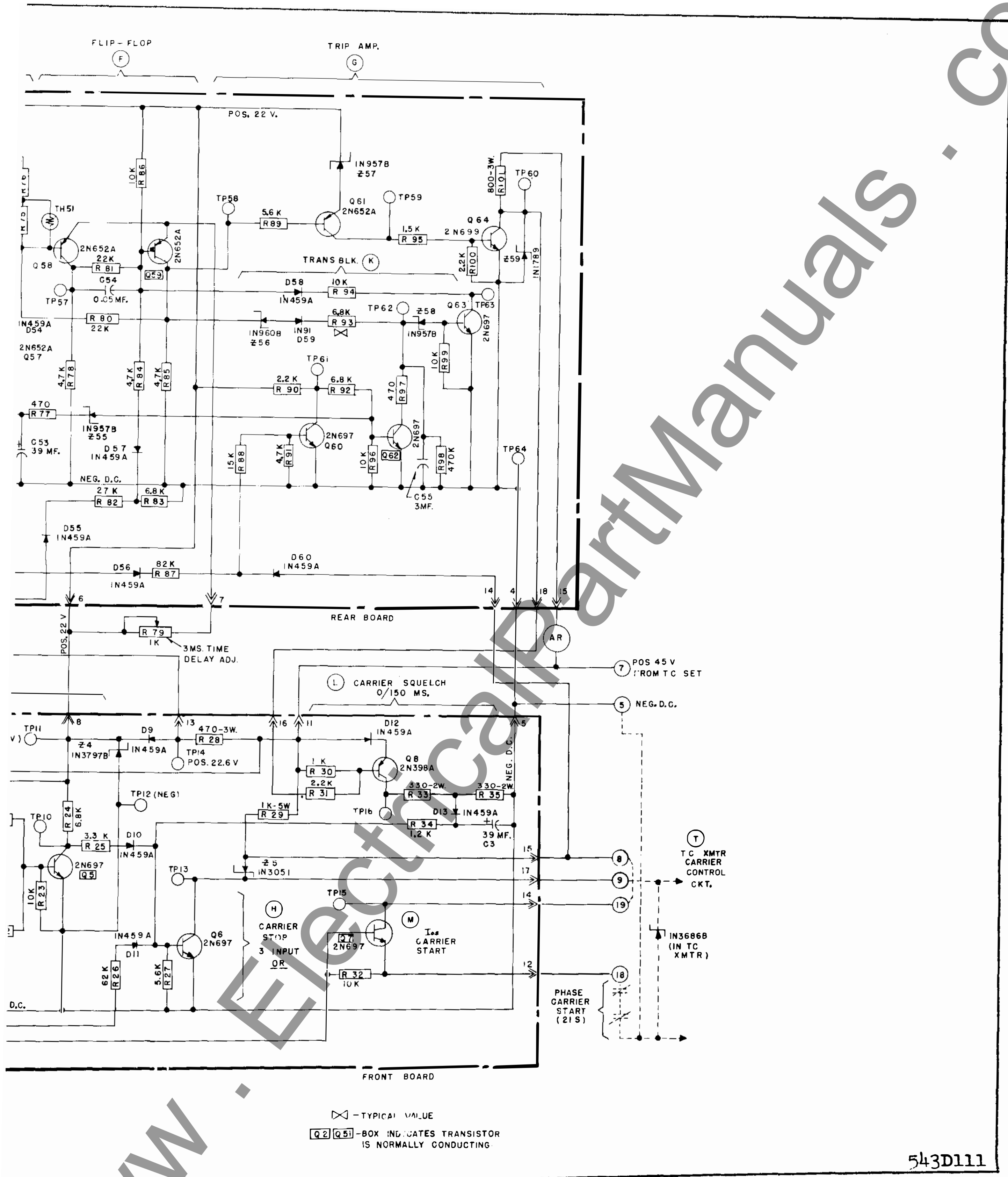


Fig. 5. Complete Electrical S



chematic for the Type SKA Relay.

D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L - CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitors C3 thru diode D12, transistor Q8, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q64. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

*The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay

or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

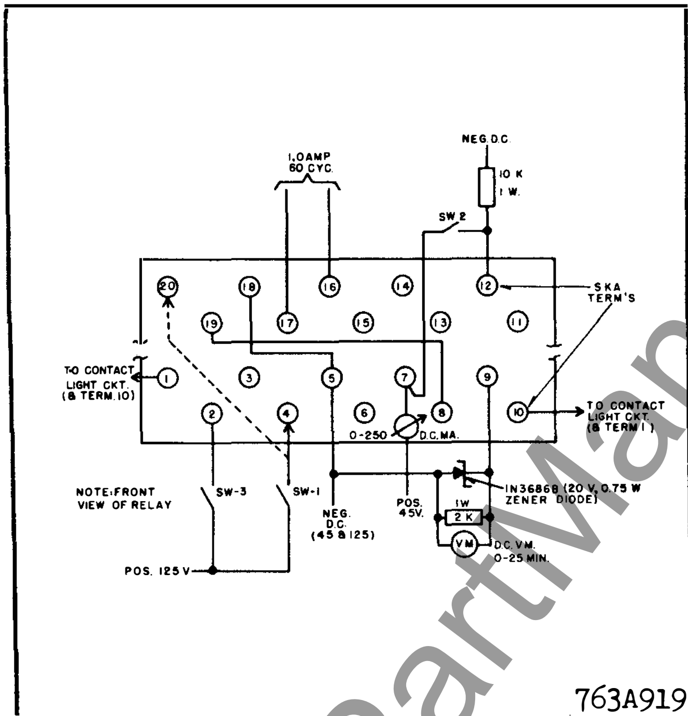


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	Do and Io trib. and Ios

0 = open
C1 = close
α = or 2 x pickup
ϕ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit. To test this portion of the relay, use the connections shown below.

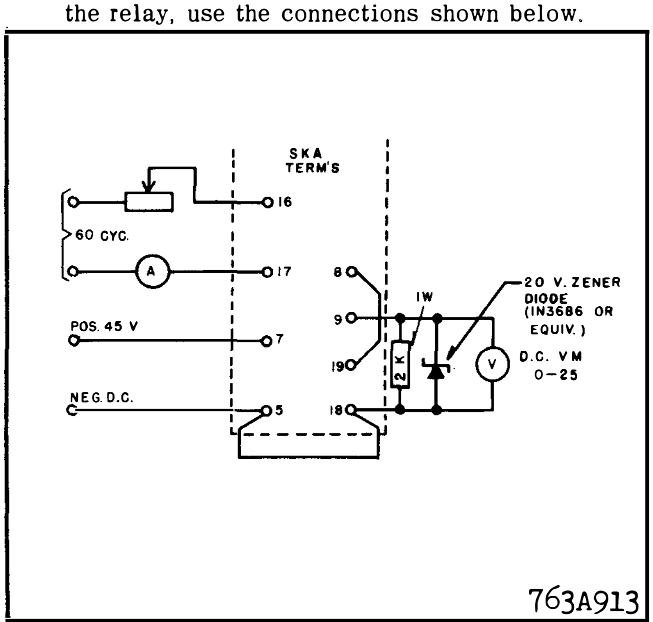


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

4. Time Delays in Logic Circuits. There are five time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. Note: The rotation "3/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

   1. Make the connections shown in Fig. 9.

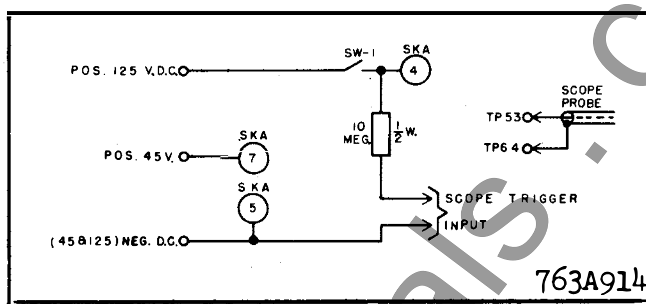


Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.

   2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

   3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP53 (+) to TP64 (−) will drop from 22 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. The time should be between 2.7 and 3.3 ms. Variations in circuit constance may give values slightly outside these limits. If the time is over 3.5 ms., reduce R54. Conversely, if the time is under 2.5 ms., increase R54.

   4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

   1. Make the connections shown in Fig. 10.

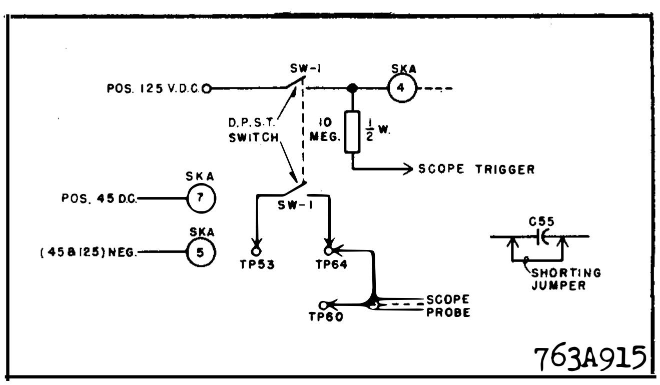


Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

6. This time delay can be adjusted by R73 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

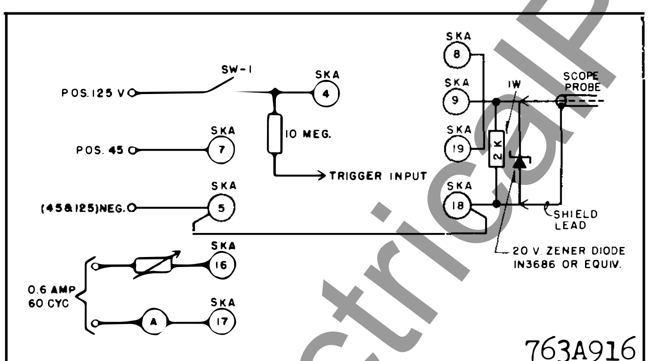


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (−) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

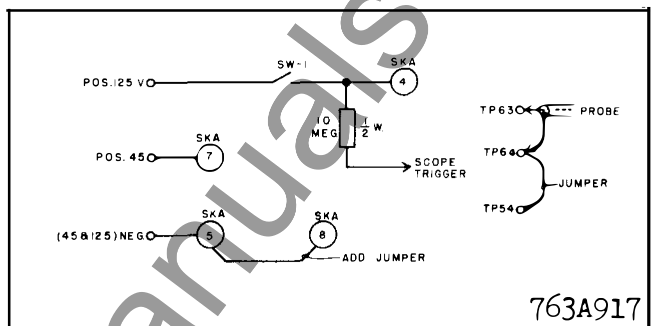


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

4. Check several times. If time exceeds 30 ms., R93 may be replaced with a resistor as low as 4.7 K. If time interval is too short, R93 may be increased to as high as 10K.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.

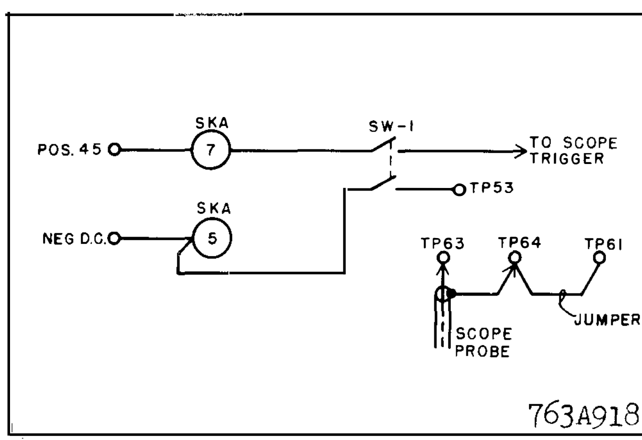


Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.

TABLE II

Test Point Voltages (to negative d.c.)

	Test Condition (From Table I and Fig. 6)						
Test Point	1	2	3	4	5	6	
D.C. Ma (Fig. 7)	90	240	115	90	105	250	Not a relay test point
TP–4	6.5	6.5	6.5	20	20.5	20.5	TP-12 is neg. d.c. on front printed circuit board.
5	6.7	6.7	6.7	6.7	6.7	6.8	
6	6.6	6.6	6.6	0.05	0.05	0.05	
7	0.1	0.1	0.1	19.0	19.0	19.0	
8	7.6	7.6	7.6	7.6	0.1	0.1	
9	7.5	7.5	7.5	0.1	0.1	0.1	
10	0.1	0.1	0.1	0.1	8.3	8.1	
11	21.6	21.0	21.5	21.5	22.0	21.5	
12	—	—	—	—	—	—	Neg. d.c.
13	19.8	0.15	0.28	19.8	0.25	0.15	
14	22.5	22.5	22.5	22.5	22.5	22.0	
15	0.05	0.05	0.05	21.0	0.1	0.1	
16	0	45	0	0	0	45	

51	21.5	21.5	0.32	21.5	21.5	21.5	Type-64 is neg. d.c. on rear printed circuit board.
52	7.4	0.05	0.05	7.4	7.4	0.05	
53	0.05	0.05	7.3	0.05	0.05	0.05	
54	0.1	21.8	0.1	0.1	0.1	22.0	
55	21.5	1.3	21.5	21.5	21.5	1.3	
56	0	9.2	0	0	0	9.2	
57	3.5	20	3.6	3.5	3.5	20	
58	20.0	7.8	20.0	20.0	20.0	7.8	
59	0	14.5	0	0	0	14.5	
60	45.0	0.42	45	45	45	0.4	
61	0.1	0.1	0.1	0.1	17.0	0.1	
62	7.4	0.05	7.4	7.4	0.65	0.05	
63	0.06	20.5	0.05	0.05	20.5	20.5	

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date: The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number (Q2) means that the transistor is normally conducting.

TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.

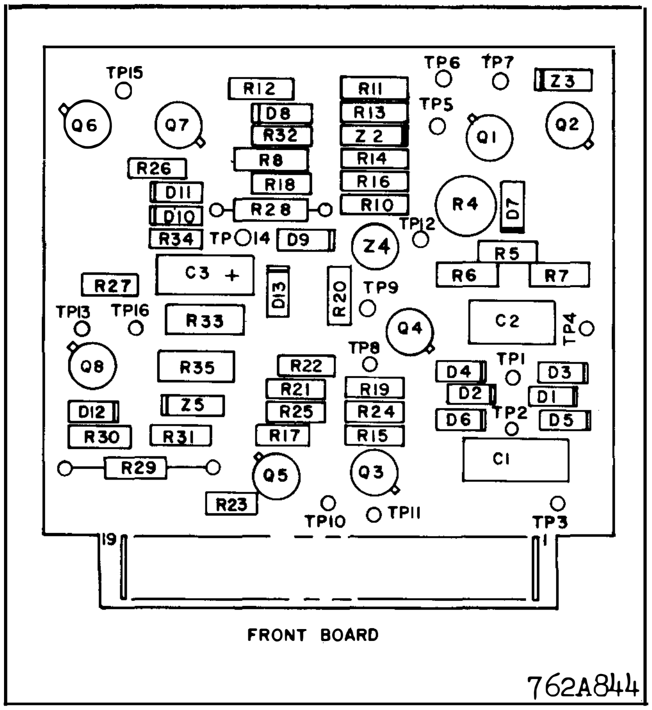


Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.

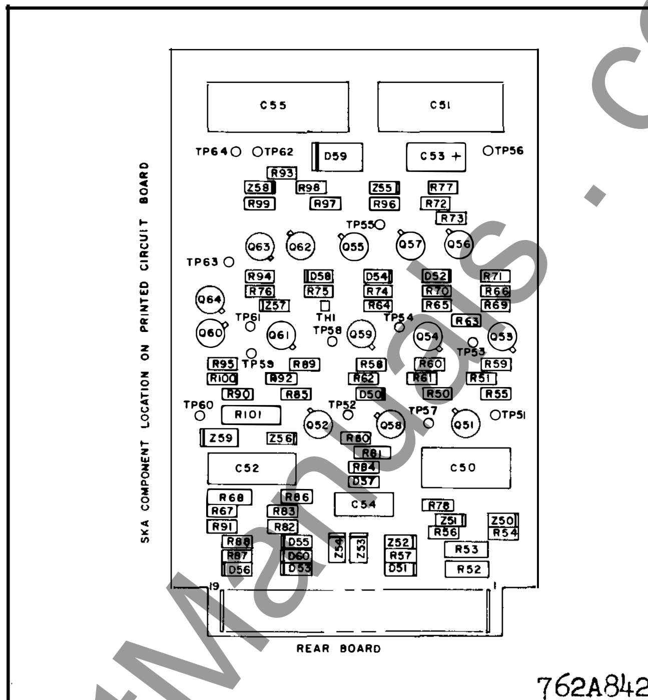


Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.

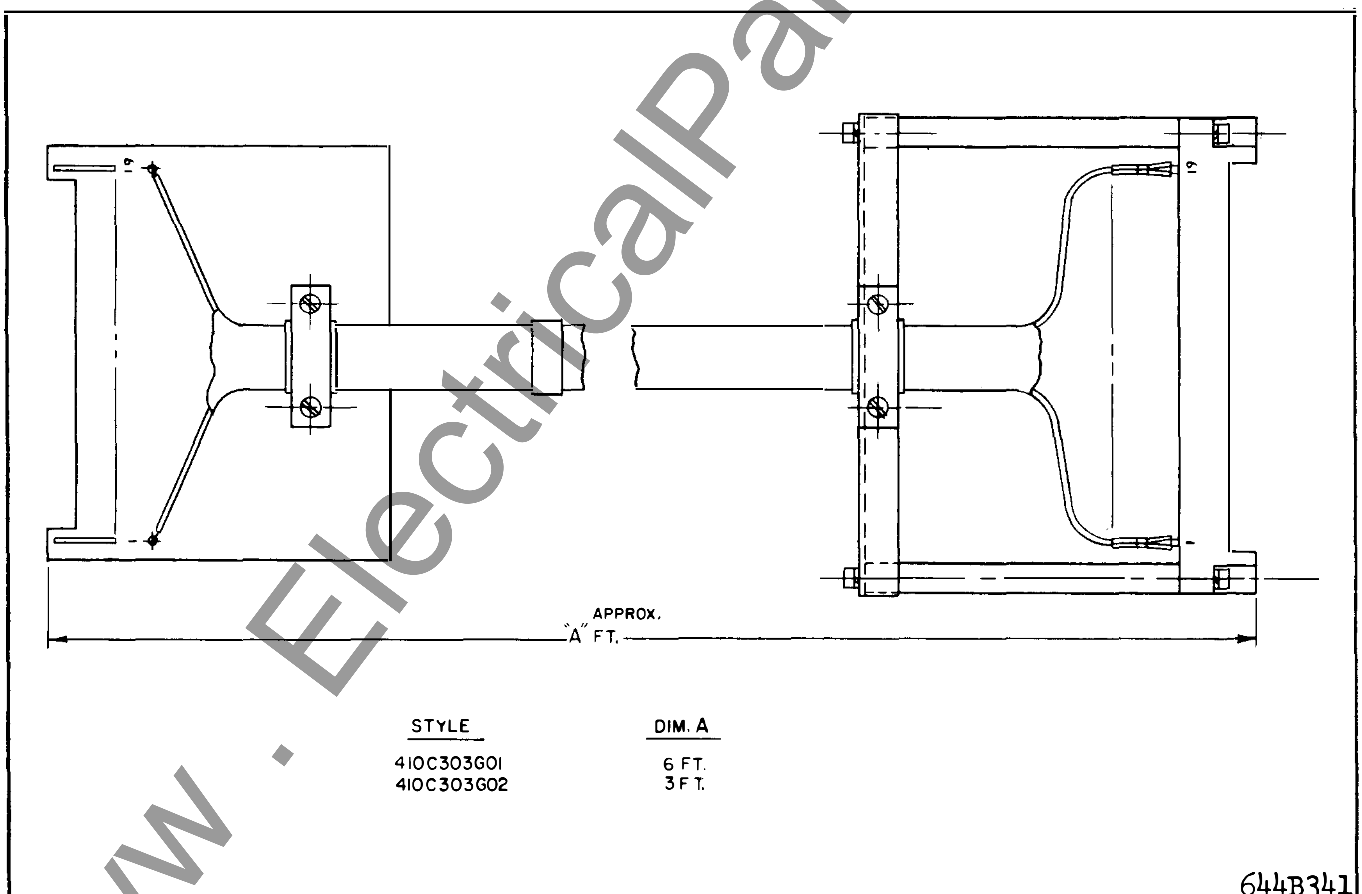


Fig. 16. Test Harness Outline

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

All capacitors 200 v.d.c. rating, minimum, unless otherwise noted.

All resistors ± 5% tolerance, 0.5-watt, unless otherwise noted.

Type	Voltage	Material
IN91	100 v.d.c.	Ge
IN459A	175 v.d.c.	Si

Ratings of Zener diodes in SKA relay:

Type	Volts	± Tol. %	Watts
IN957B	6.8	5	0.4
IN960b	9.1	5	0.4
IN1789	56	10	1
IN1832C	62	10	10 (Clipper)
IN3051	200	20	1
IN3686B	20	5	1.5
IN3797B	22	5	1.5

Other components:

T1	Saturating transformer S# 606B519G03
T51	Type 1D101 Thermistor – 10K at 25°C S# 185A211H04
C3,C53	39 mfd, 35 v. tantalum capacitors S# 187A508H04

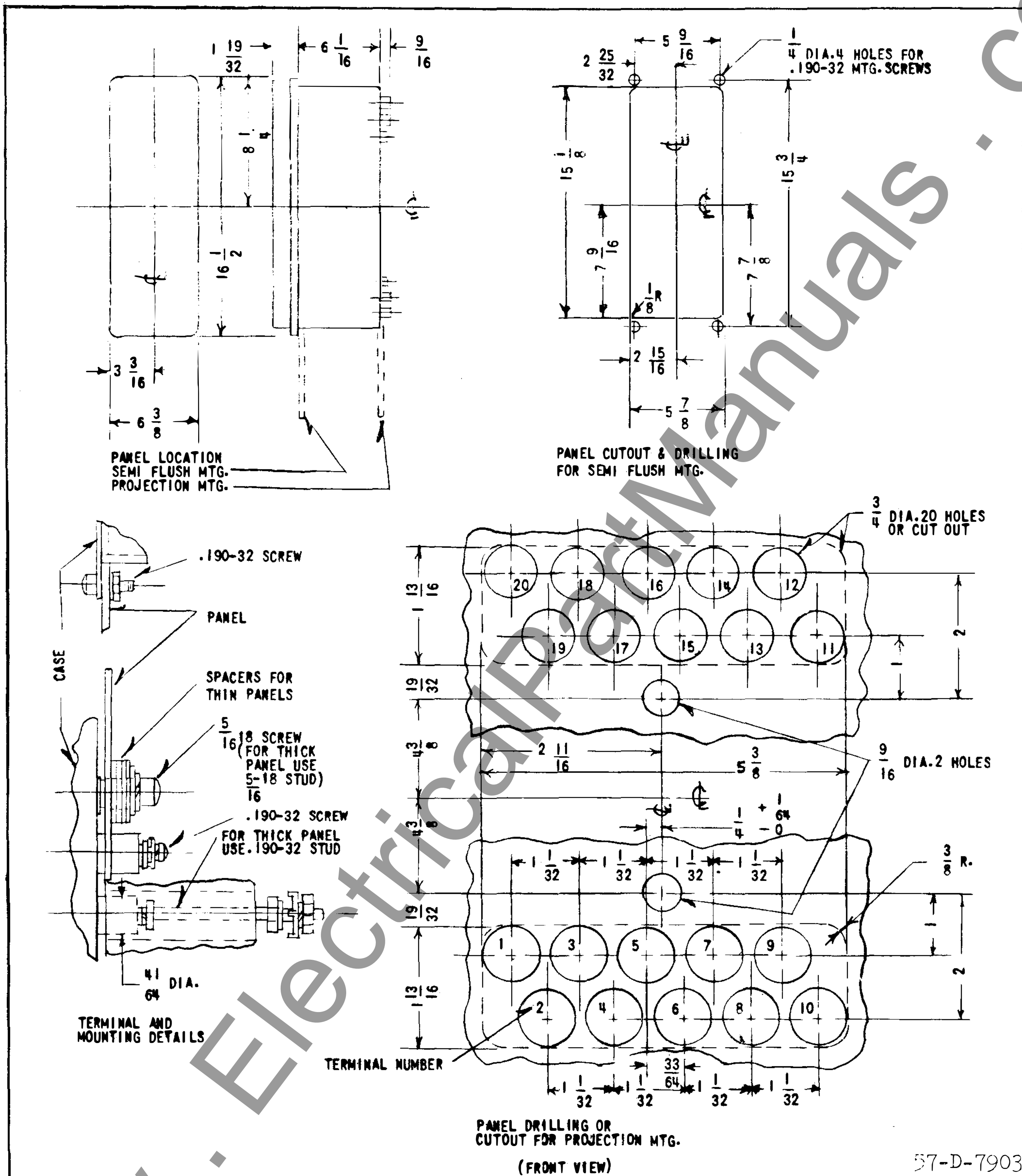


**Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying * system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mount- * ed in the FT32 Flexitest case. The static equivalents * of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY	Integrating time delay, 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

SUPERSEDES I.L. 41-923.5
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1965

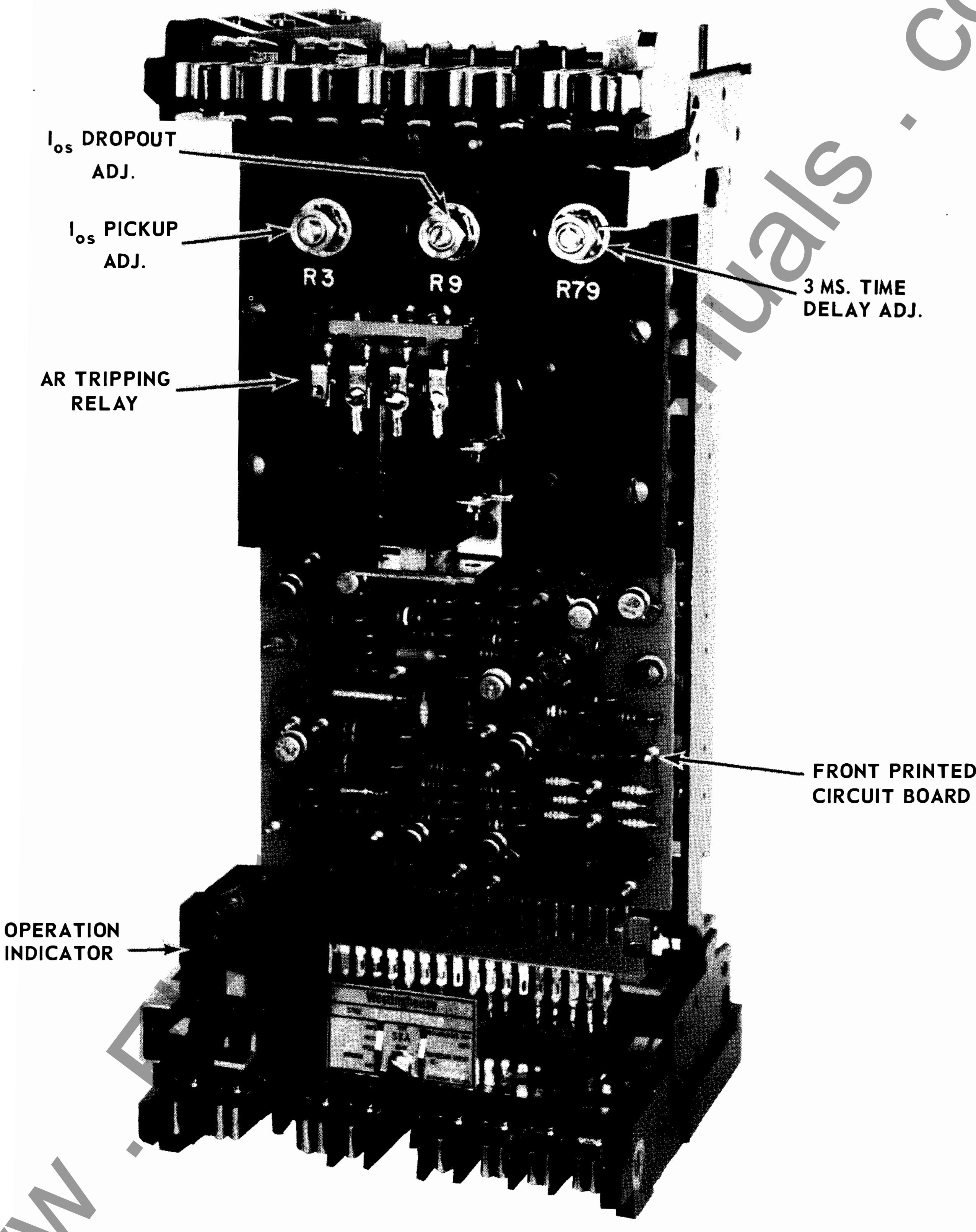


**Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).*

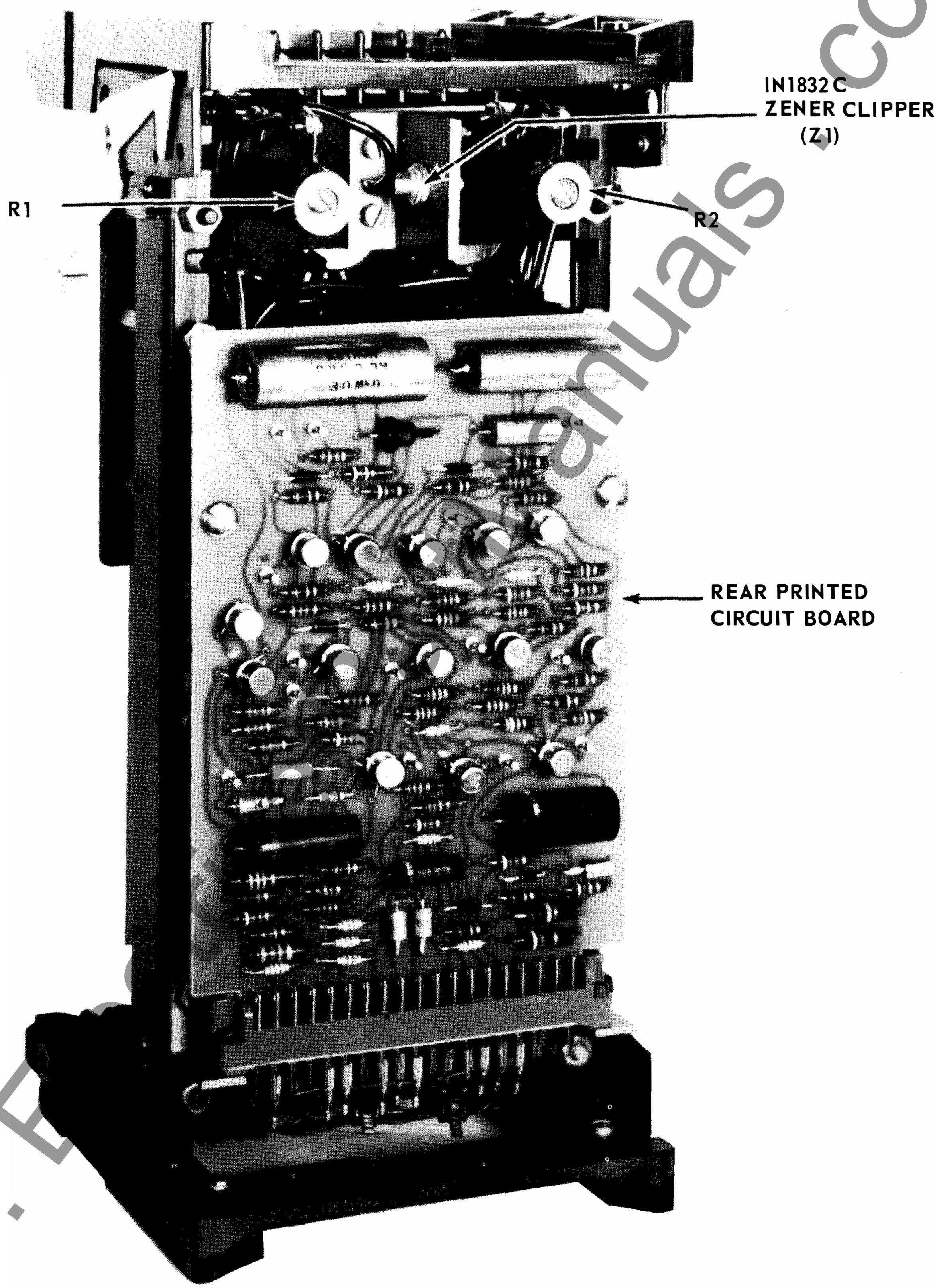


Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals.
M	Ios	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

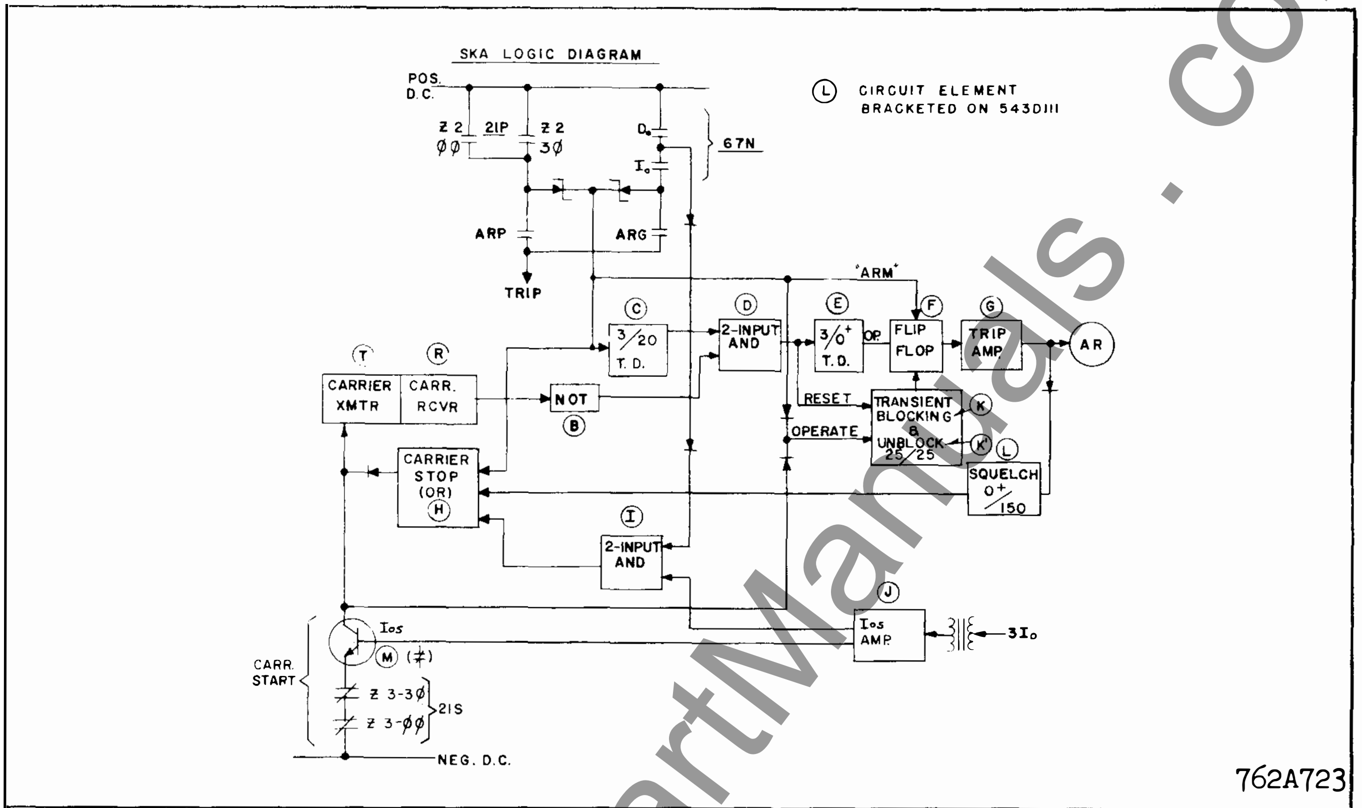


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The complete detailed relay circuit is chown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

C-3/20 MS TIME DELAY: D-TWO-INPUT AND.

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

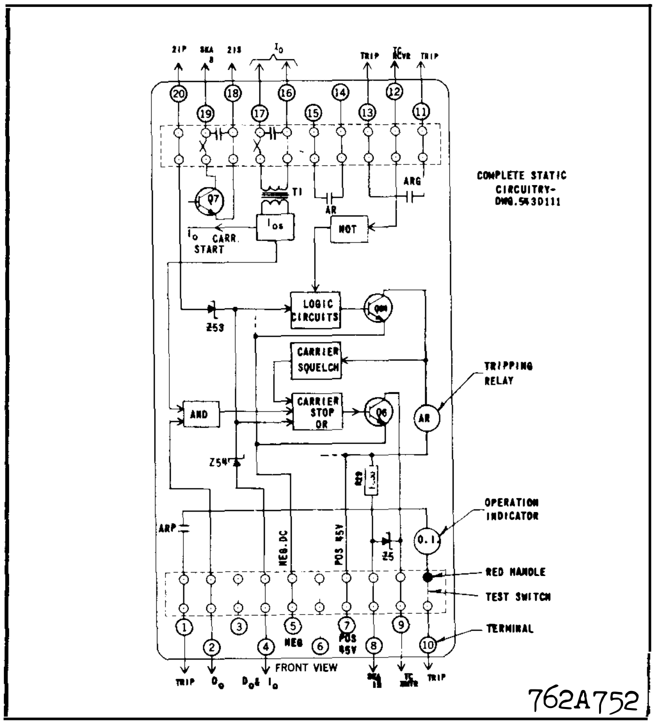


Fig. 4. *Internal Schematic for the Type SKA Relay in the FT32 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capacitor C50 starts to charge thru resistors R52 and R-54. After a time delay of approximately 3 milliseconds, the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 or Z54, plus diode D53 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer conducting,

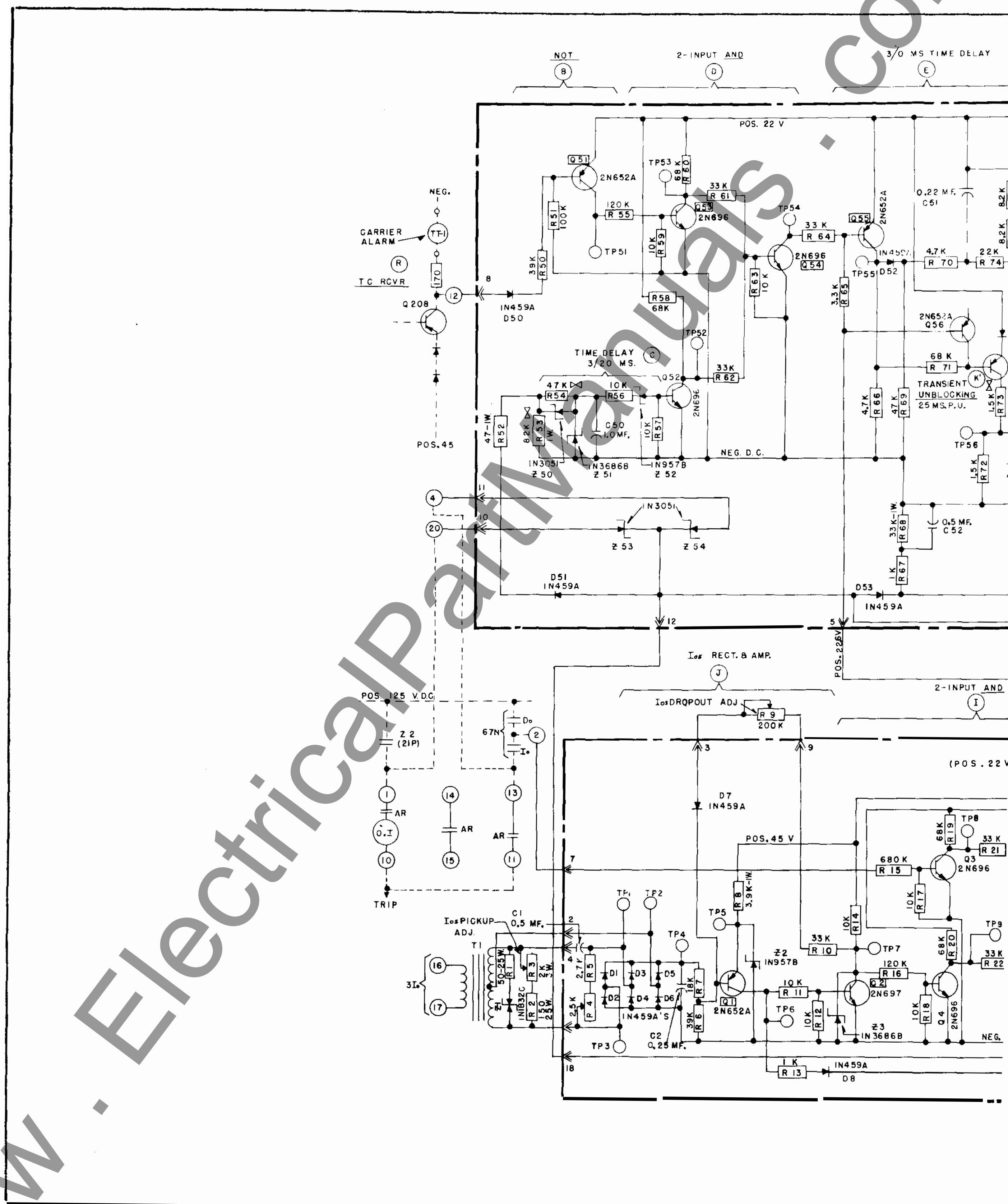
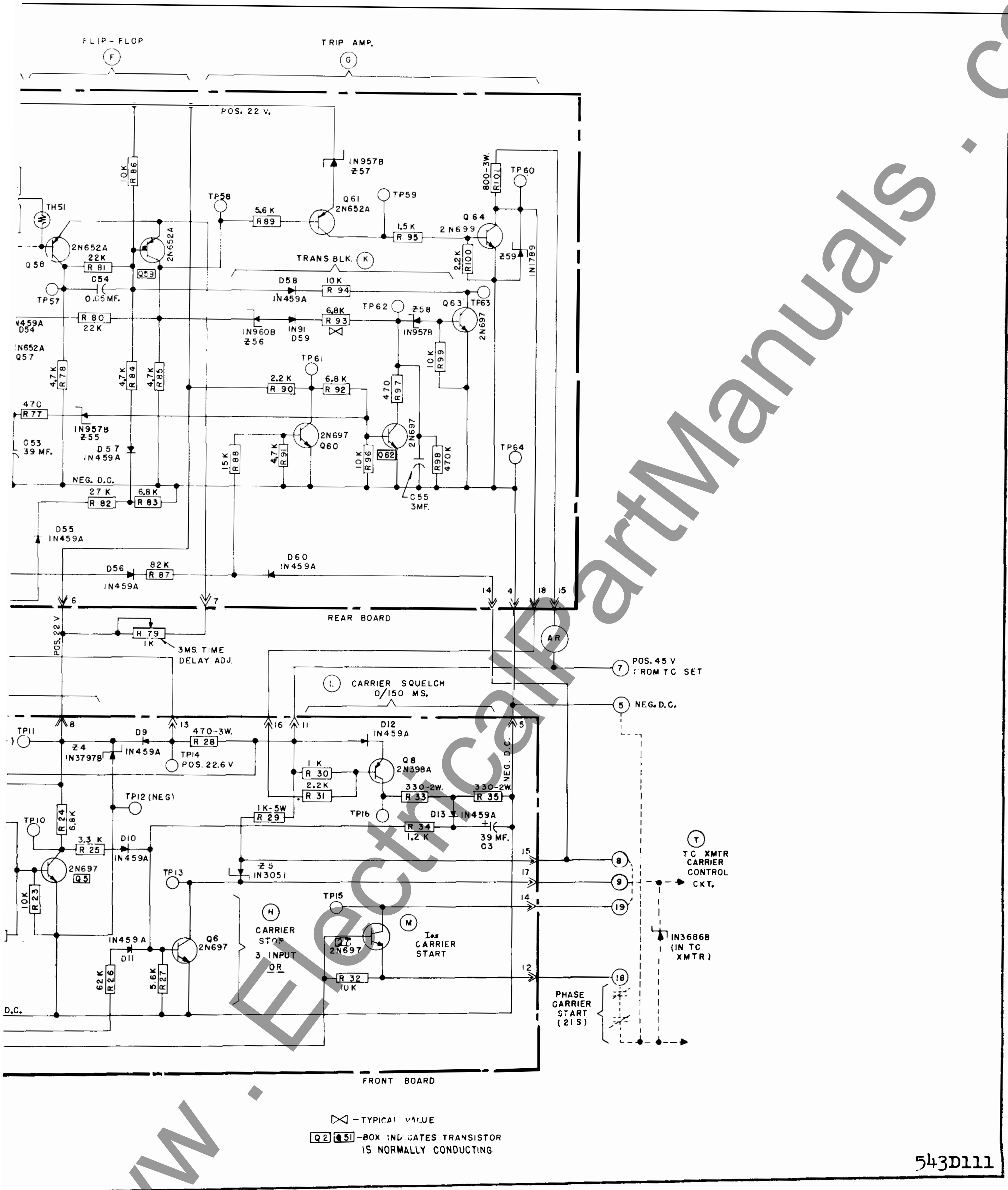


Fig. 5. Complete Electrical S



chematic for the Type SKA Relay.

D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L - CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitors C3 thru diode D12, transistor Q8, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q64. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

*The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay

or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

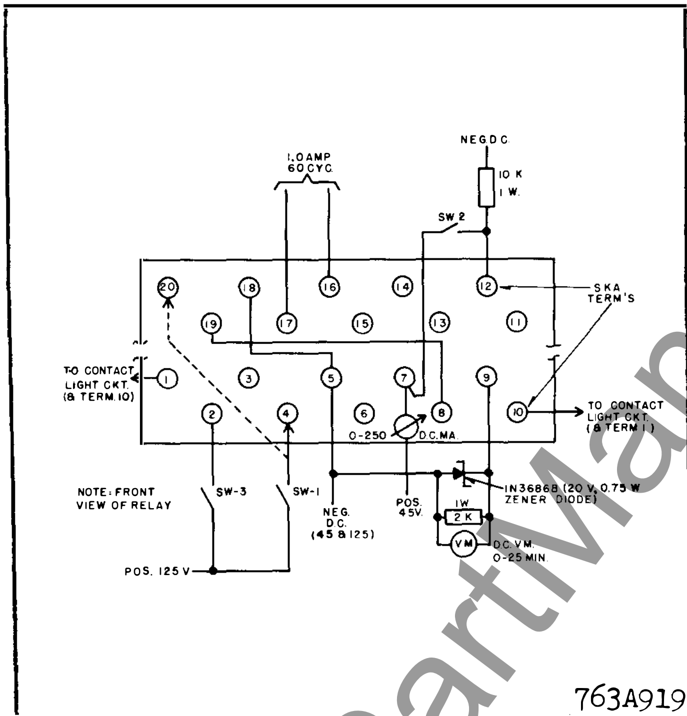


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	☒1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	Do and Io trib. and Ios

0 = open
C1 = close
☒ = or 2 x pickup
ϕ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit. To test this portion of the relay, use the connections shown below.

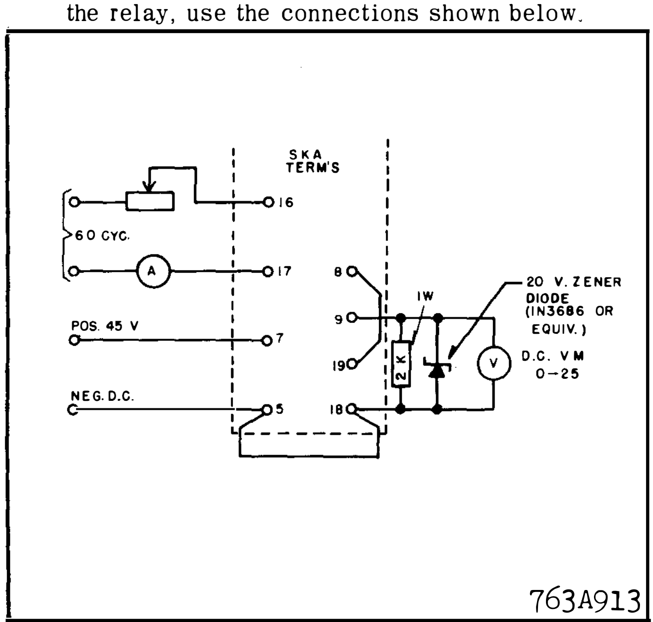


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn tne shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

4. Time Delays in Logic Circuits. There are five time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. Note: The rotation "3/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

   1. Make the connections shown in Fig. 9.

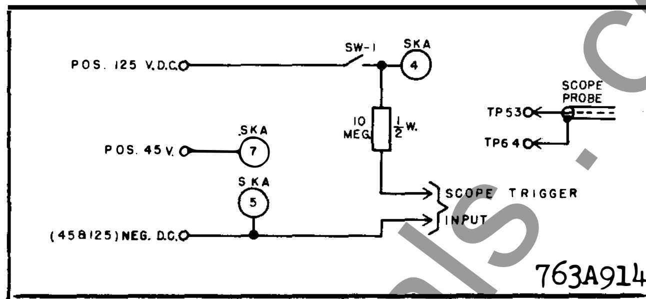


Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.

   2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

   3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP53 (+) to TP64 (-) will drop from 22 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. The time should be between 2.7 and 3.3 ms. Variations in circuit constance may give values slightly outside these limits. If the time is over 3.5 ms., reduce R54. Conversely, if the time is under 2.5 ms., increase R54.

   4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

   1. Make the connections shown in Fig. 10.

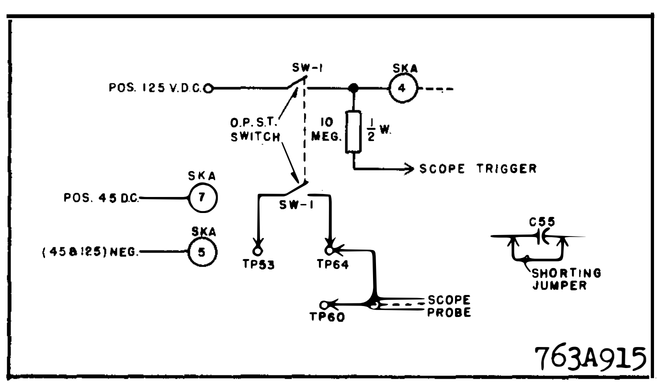


Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

6. This time delay can be adjusted by R73 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

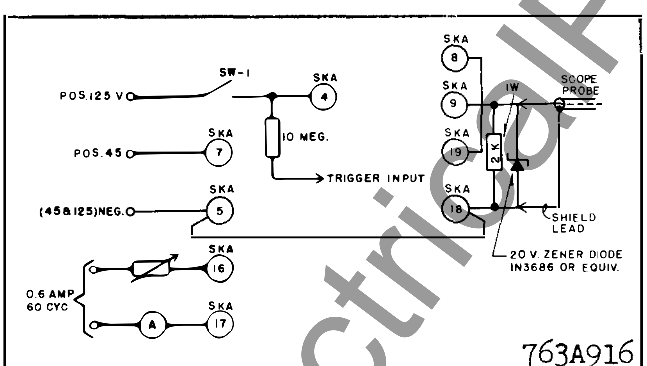


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c., then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (-) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

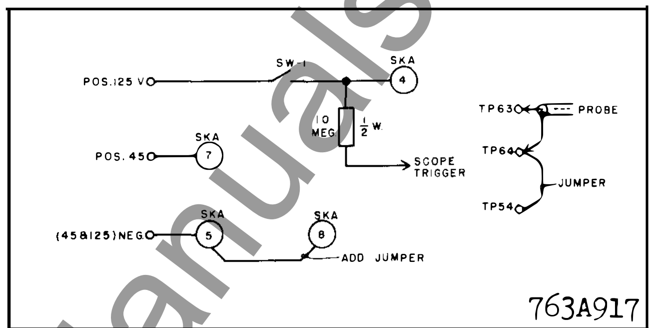


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

4. Check several times. If time exceeds 30 ms., R93 may be replaced with a resistor as low as 4.7 K. If time interval is too short, R93 may be increased to as high as 10K.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.

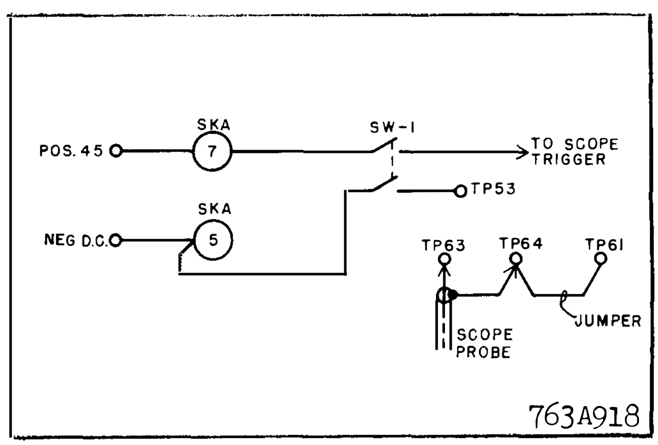


Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.

TABLE II

Test Point Voltages (to negative d.c.)

Test Point	Test Condition (From Table I and Fig. 6) 1	2	3	4	5	6	Note
D.C. Ma (Fig. 7)	90	240	115	90	105	250	Not a relay test point
TP-4	6.5	6.5	6.5	20	20.5	20.5	TP-12 is neg. d.c. on front printed circuit board.
5	6.7	6.7	6.7	6.7	6.7	6.8	
6	6.6	6.6	6.6	0.05	0.05	0.05	
7	0.1	0.1	0.1	19.0	19.0	19.0	
8	7.6	7.6	7.6	7.6	0.1	0.1	
9	7.5	7.5	7.5	0.1	0.1	0.1	
10	0.1	0.1	0.1	0.1	8.3	8.1	
11	21.6	21.0	21.5	21.5	22.0	21.5	
12	—	—	—	—	—	—	Neg. d.c.
13	19.8	0.15	0.28	19.8	0.25	0.15	
14	22.5	22.5	22.5	22.5	22.5	22.0	
15	0.05	0.05	0.05	21.0	0.1	0.1	
16	0	45	0	0	0	45	
51	21.5	21.5	0.32	21.5	21.5	21.5	Type-64 is neg. d.c. on rear printed circuit board.
52	7.4	0.05	0.05	7.4	7.4	0.05	
53	0.05	0.05	7.3	0.05	0.05	0.05	
54	0.1	21.8	0.1	0.1	0.1	22.0	
55	21.5	1.3	21.5	21.5	21.5	1.3	
56	0	9.2	0	0	0	9.2	
57	3.5	20	3.6	3.5	3.5	20	
58	20.0	7.8	20.0	20.0	20.0	7.8	
59	0	14.5	0	0	0	14.5	
60	45.0	0.42	45	45	45	0.4	
61	0.1	0.1	0.1	0.1	17.0	0.1	
62	7.4	0.05	7.4	7.4	0.65	0.05	
63	0.06	20.5	0.05	0.05	20.5	20.5	

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date: The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.

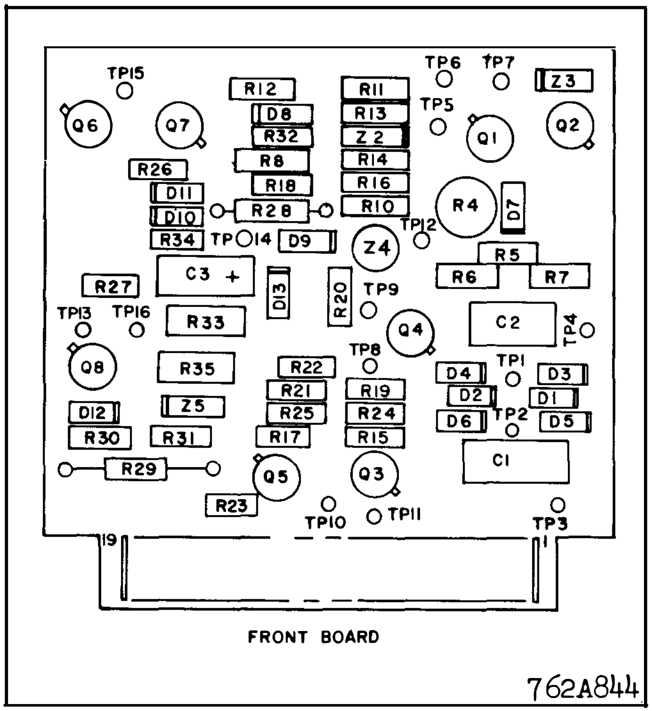


Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.

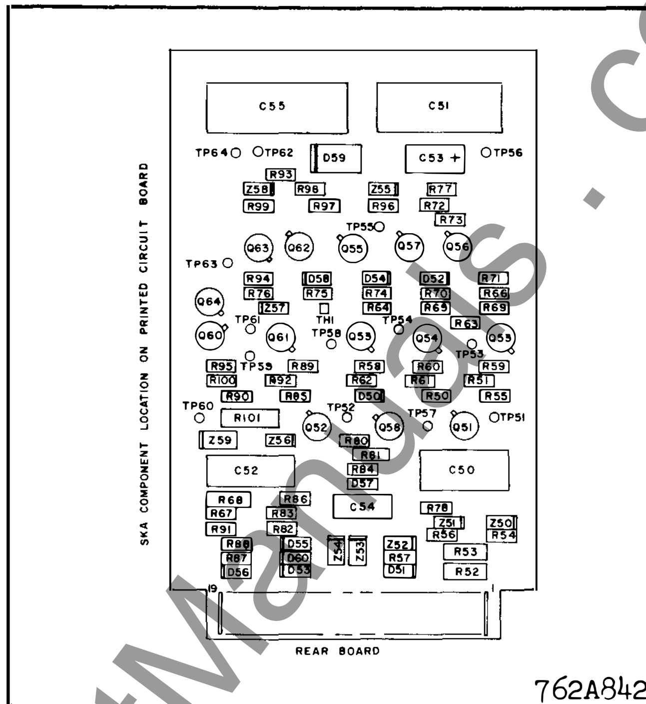


Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.

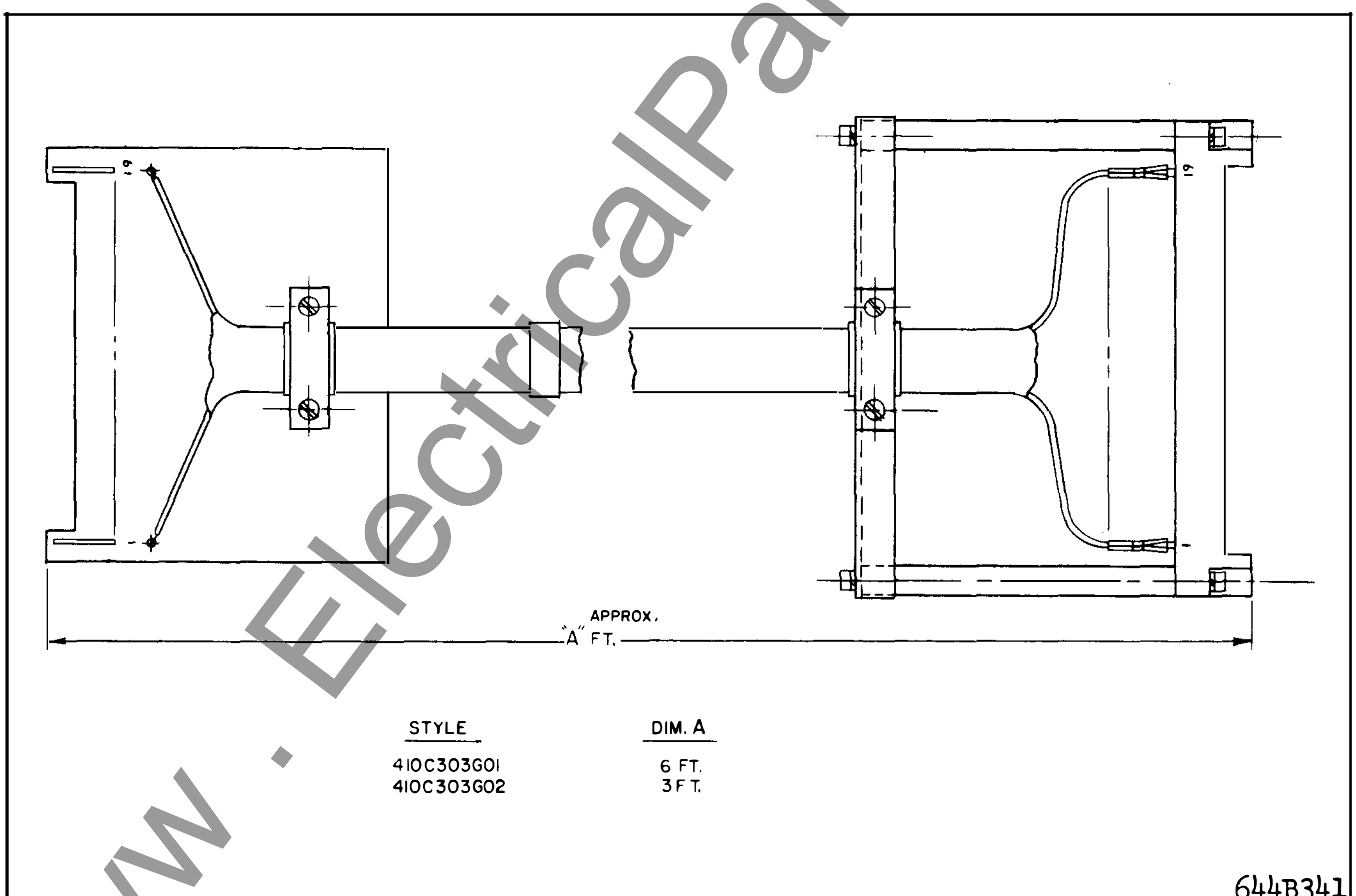


Fig. 16. Test Harness Outline

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

All capacitors 200 v.d.c. rating, minimum, unless otherwise noted.

All resistors ± 5% tolerance, 0.5-watt, unless otherwise noted.

Type	Voltage	Material
IN91	100 v.d.c.	Ge
IN459A	175 v.d.c.	Si

Ratings of Zener diodes in SKA relay:

Type	Volts	± Tol. %	Watts
IN957B	6.8	5	0.4
IN960b	9.1	5	0.4
IN1789	56	10	1
IN1832C	62	10	10 (Clipper)
IN3051	200	20	1
IN3686B	20	5	1.5
IN3797B	22	5	1.5

Other components:

T1	Saturating transformer	S# 606B519G03
T51	Type 1D101 Thermistor −10K at 25°C	S# 185A211H04
C3,C53	39 mfd, 35 v. tantalum capacitors	S# 187A508H04

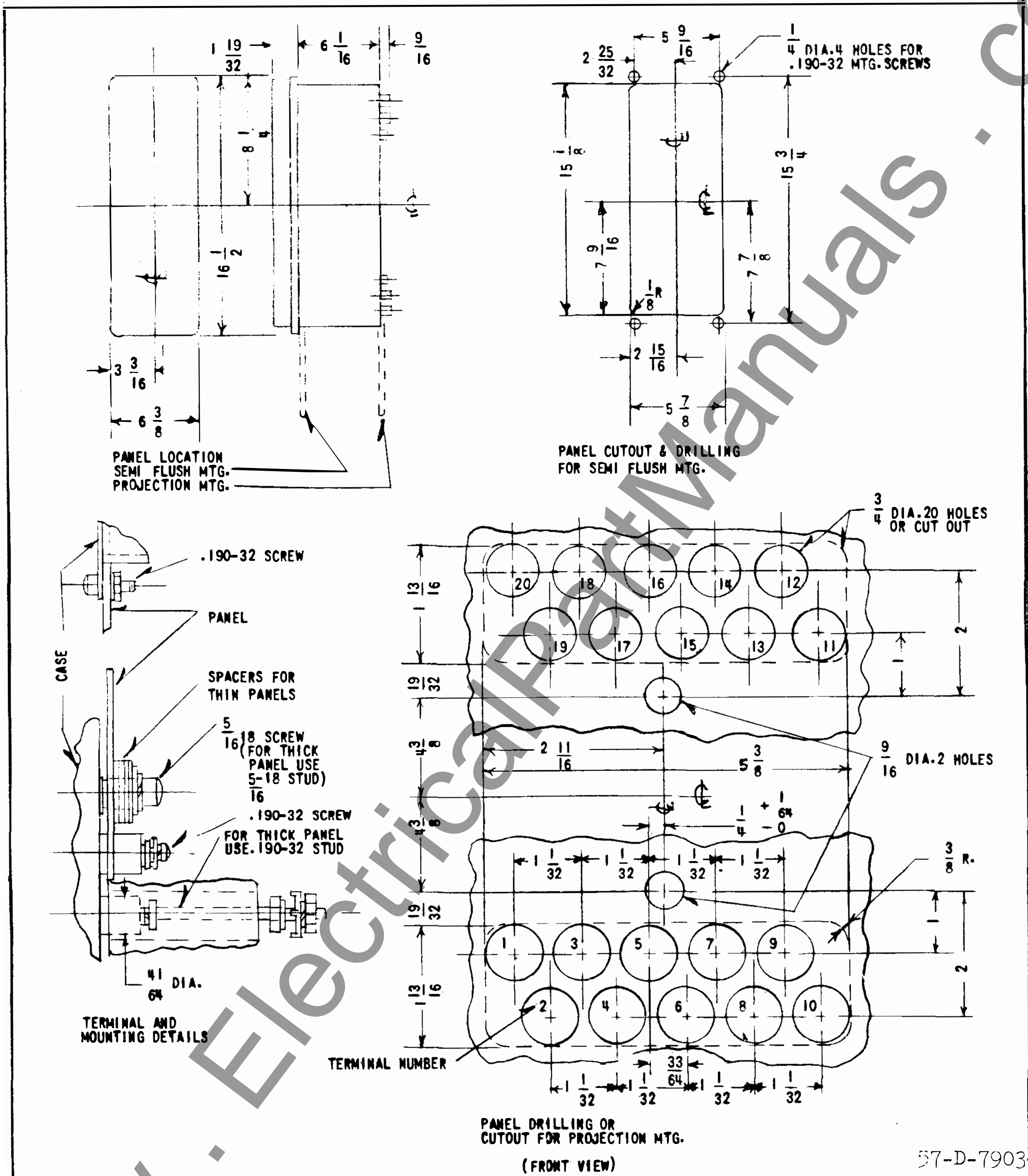


**Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying system to block or prevent instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted in the FT42 Flexitest case. The static equivalents of the receiver relay, the directional auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY	Integrating time delay, 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

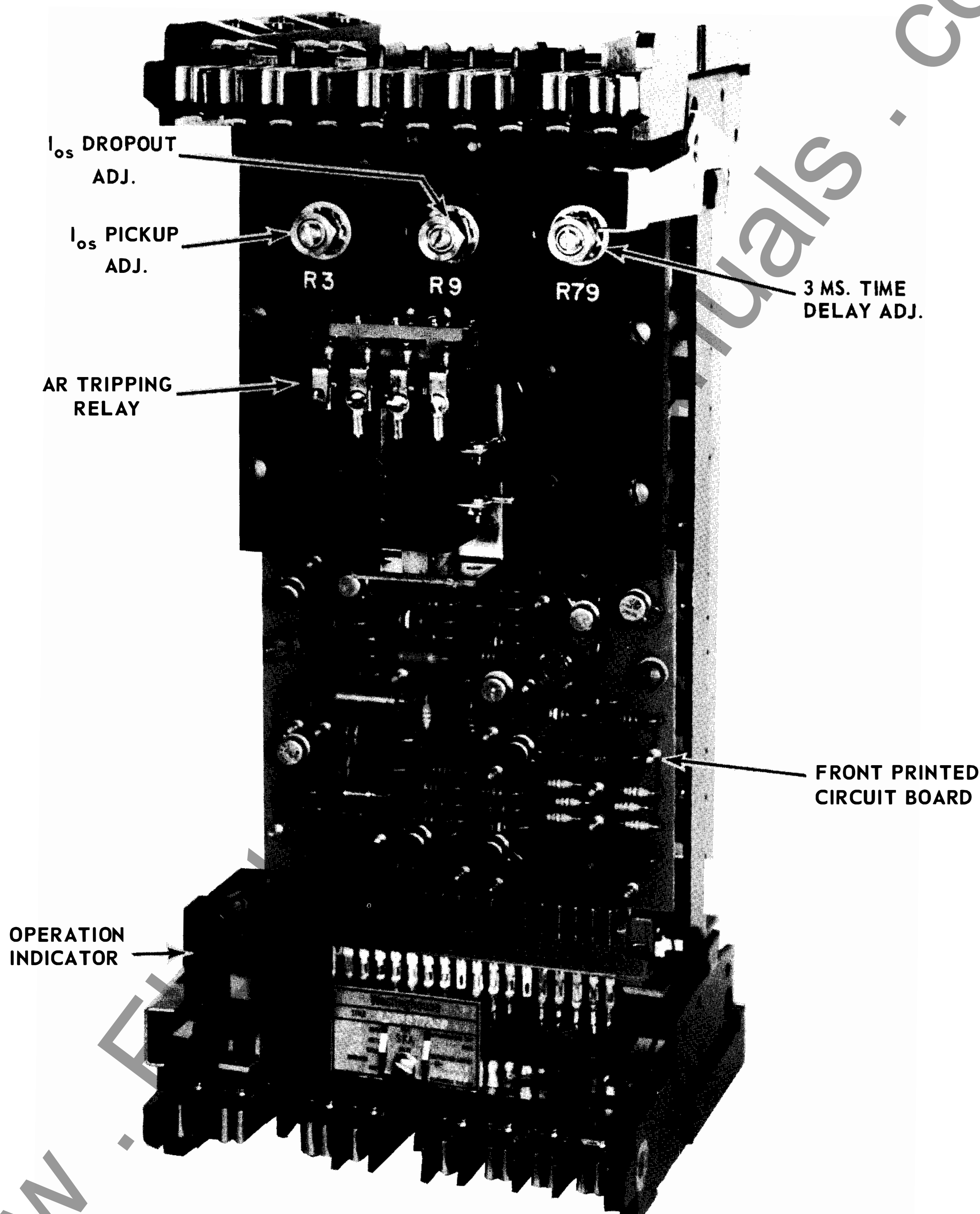


Fig. 1. Type SKA Carrier Auxiliary Relay in FT42 Case (Front View).

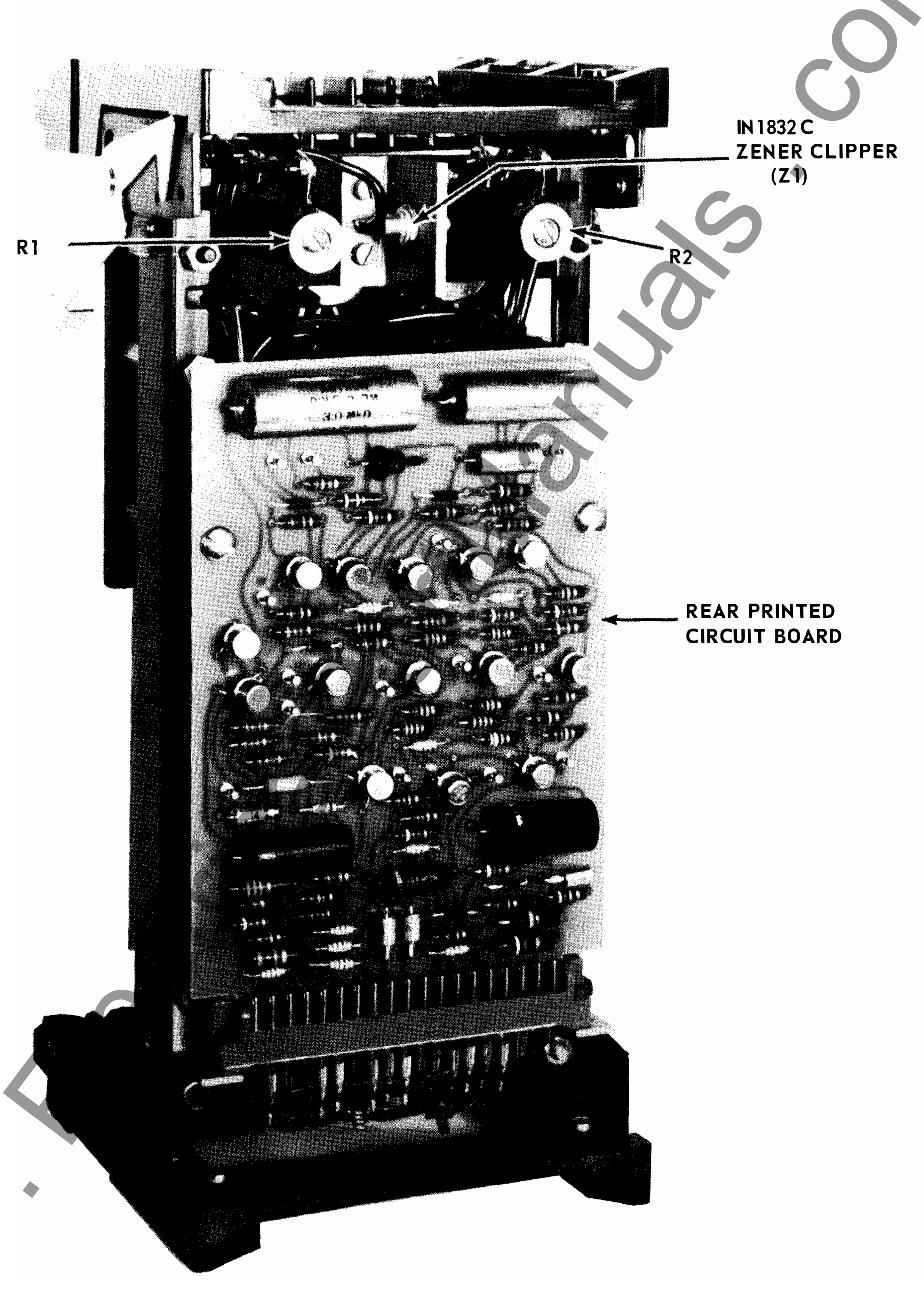


Fig. 2. Type SKA Carrier Auxiliary Relay in FT42 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals.
M	Ios	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

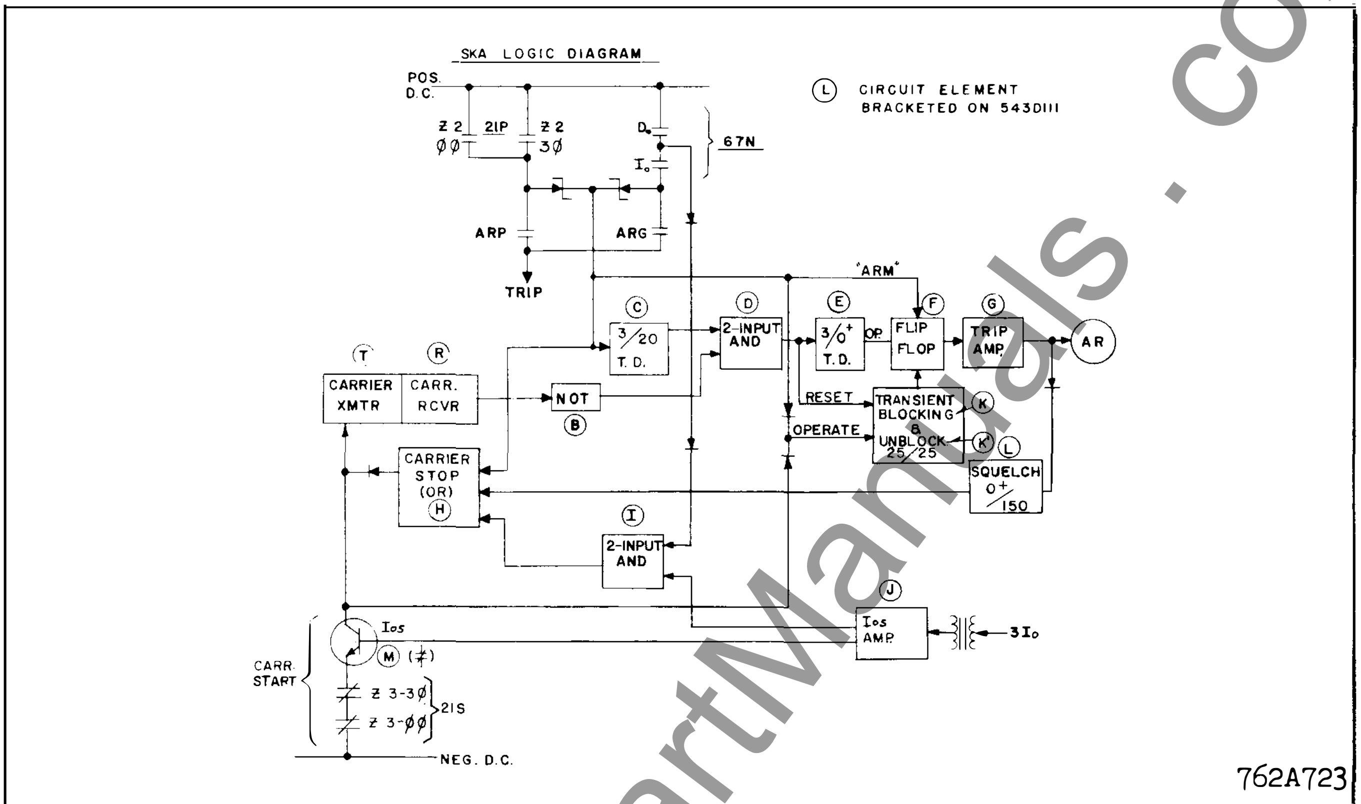


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The complete detailed relay circuit is chown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

C-3/20 MS TIME DELAY: D-TWO-INPUT AND.

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

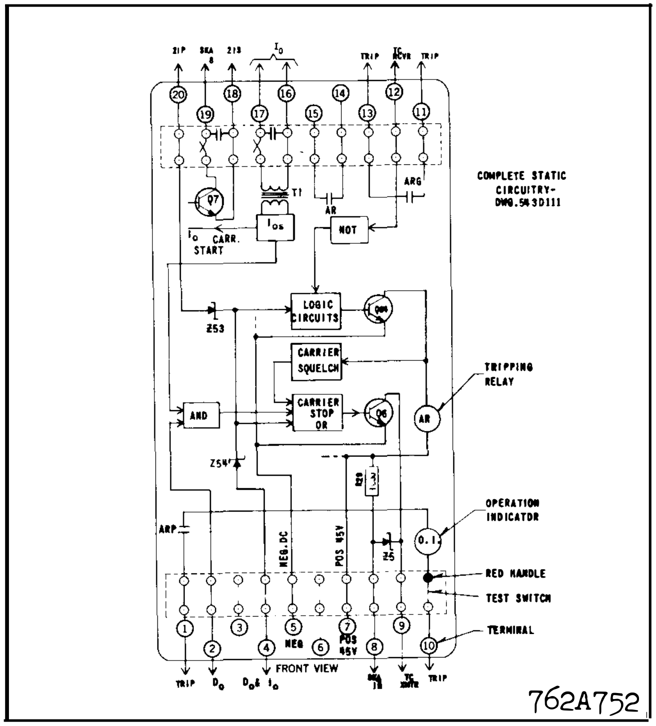


Fig. 4. Internal Schematic for the Type SKA Relay in the FT42 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capacitor C50 starts to charge thru resistors R52 and R-54. After a time delay of approximately 3 milliseconds, the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 or Z54, plus diode D53 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer conducting,

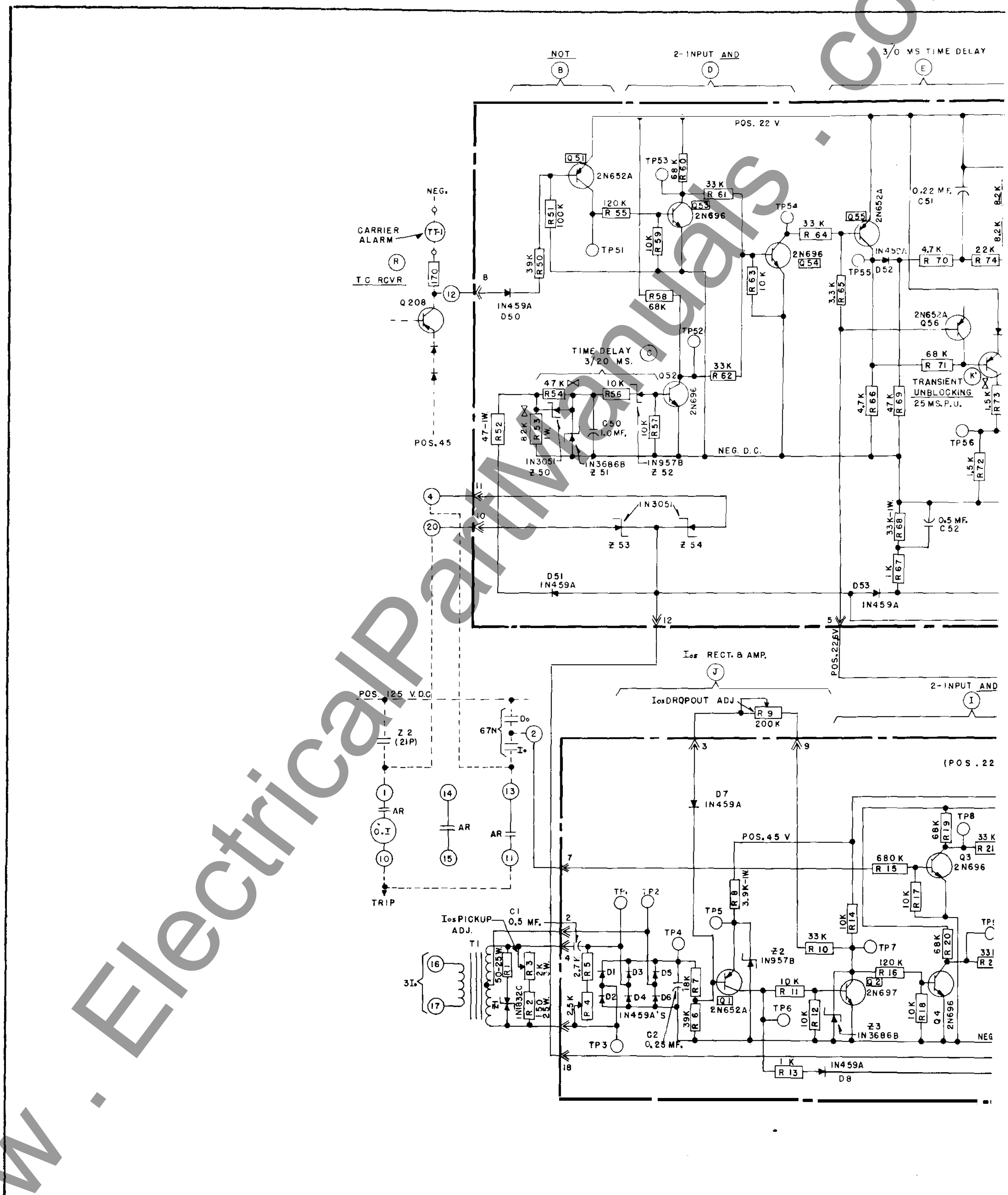
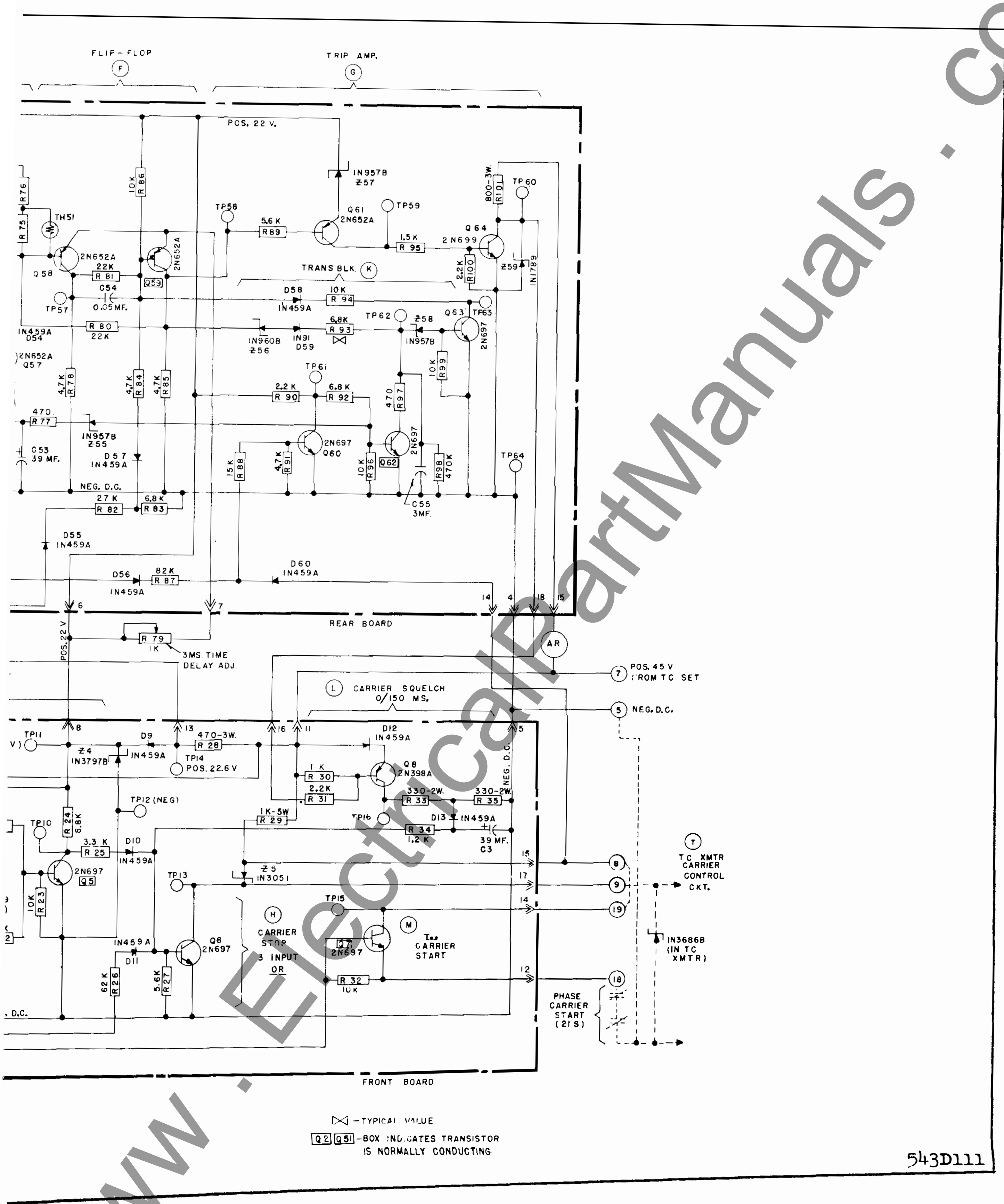


Fig. 5. Complete Electrical [cut off at page edge]



ichematic for the Type SKA Relay.

D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L - CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitors C3 thru diode D12, transistor Q8, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q64. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

The outline and drilling plan of the type SKA relay in the FT-42 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay

or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

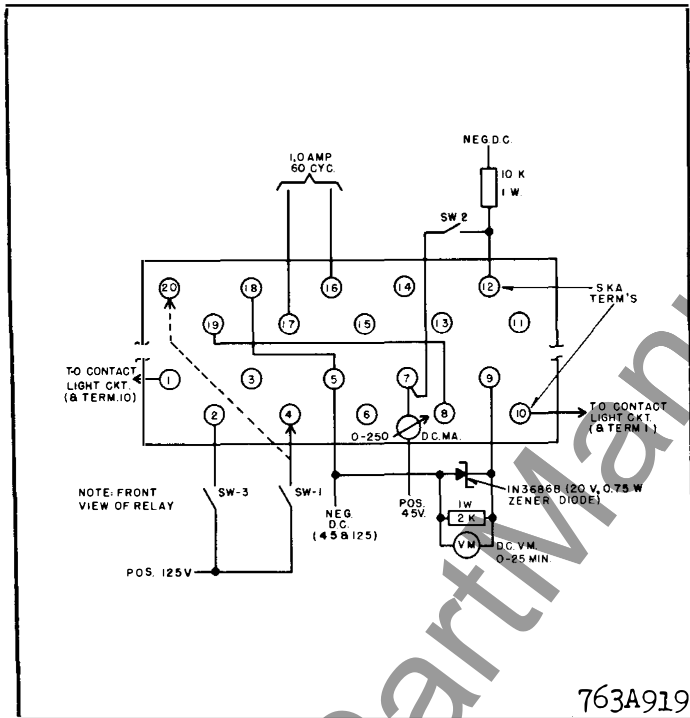


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	Do and Io trib. and Ios

0 = open
C1 = close
α = or 2 x pickup
ϕ = close SW-2, then SW-1
* = close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit. To test this portion of the relay, use the connections shown below.

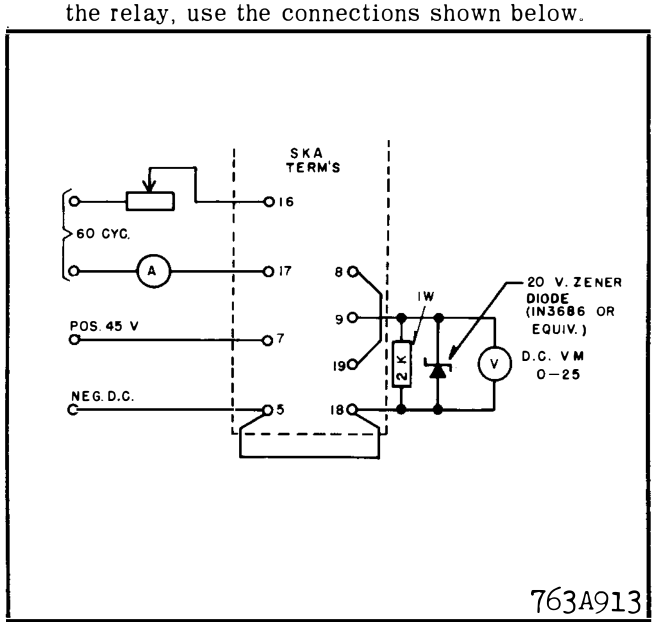


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

4. Time Delays in Logic Circuits. There are five time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. Note: The rotation "3/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

   1. Make the connections shown in Fig. 9.

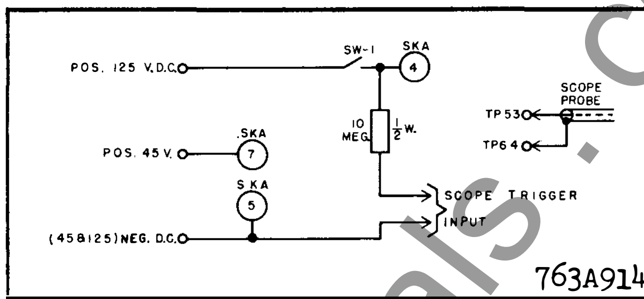


Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.

   2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

   3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP53 (+) to TP64 (−) will drop from 22 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. The time should be between 2.7 and 3.3 ms. Variations in circuit constance may give values slightly outside these limits. If the time is over 3.5 ms., reduce R54. Conversely, if the time is under 2.5 ms., increase R54.

   4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

   1. Make the connections shown in Fig. 10.

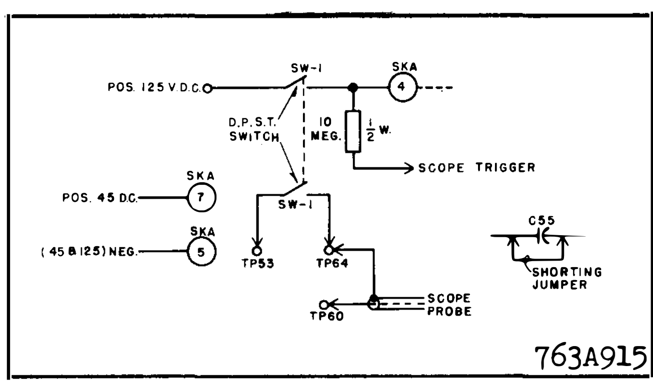


Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

6. This time delay can be adjusted by R73 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

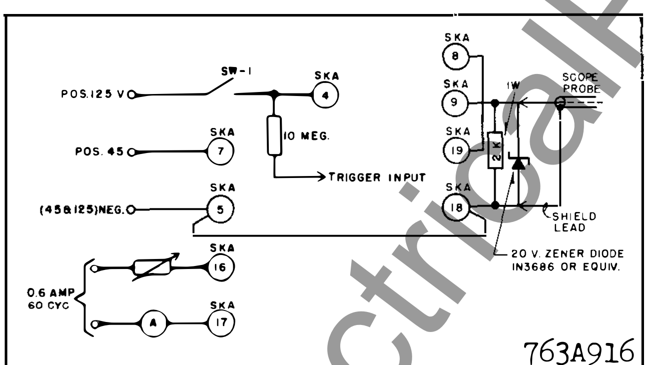


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (−) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

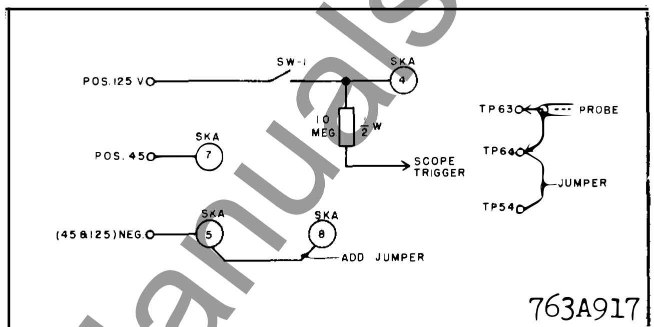


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

4. Check several times. If time exceeds 30 ms., R93 may be replaced with a resistor as low as 4.7 K. If time interval is too short, R93 may be increased to as high as 10K.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.

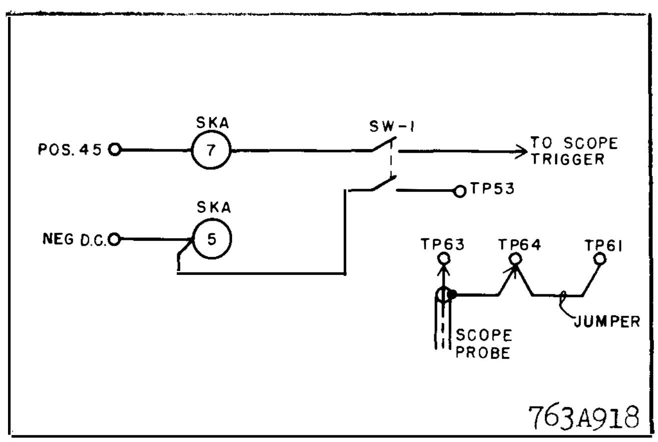


Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.

TABLE II

Test Point Voltages (to negative d.c.)

	Test Condition (From Table I and Fig. 6)						
Test Point	**1**	**2**	**3**	**4**	**5**	**6**	
D.C. Ma (Fig. 7)	90	240	115	90	105	250	Not a relay test point
TP–4	6.5	6.5	6.5	20	20.5	20.5	TP-12 is neg. d.c. on front printed circuit board.
5	6.7	6.7	6.7	6.7	6.7	6.8	
6	6.6	6.6	6.6	0.05	0.05	0.05	
7	0.1	0.1	0.1	19.0	19.0	19.0	
8	7.6	7.6	7.6	7.6	0.1	0.1	
9	7.5	7.5	7.5	0.1	0.1	0.1	
10	0.1	0.1	0.1	0.1	8.3	8.1	
11	21.6	21.0	21.5	21.5	22.0	21.5	
12	—	—	—	—	—	—	Neg. d.c.
13	19.8	0.15	0.28	19.8	0.25	0.15	
14	22.5	22.5	22.5	22.5	22.5	22.0	
15	0.05	0.05	0.05	21.0	0.1	0.1	
16	0	45	0	0	0	45	
51	21.5	21.5	0.32	21.5	21.5	21.5	Type-64 is neg. d.c. on rear printed circuit board.
52	7.4	0.05	0.05	7.4	7.4	0.05	
53	0.05	0.05	7.3	0.05	0.05	0.05	
54	0.1	21.8	0.1	0.1	0.1	22.0	
55	21.5	1.3	21.5	21.5	21.5	1.3	
56	0	9.2	0	0	0	9.2	
57	3.5	20	3.6	3.5	3.5	20	
58	20.0	7.8	20.0	20.0	20.0	7.8	
59	0	14.5	0	0	0	14.5	
60	45.0	0.42	45	45	45	0.4	
61	0.1	0.1	0.1	0.1	17.0	0.1	
62	7.4	0.05	7.4	7.4	0.65	0.05	
63	0.06	20.5	0.05	0.05	20.5	20.5	

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date. The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.

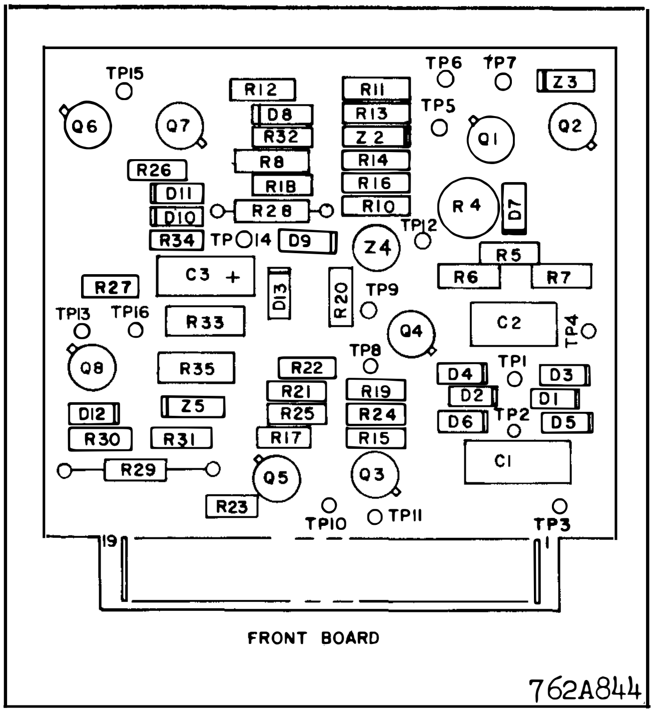


Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.

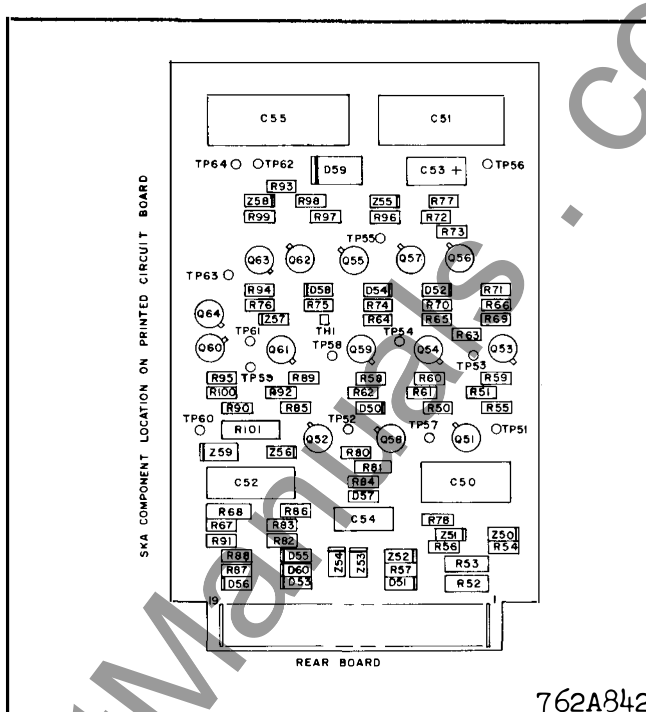


Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.

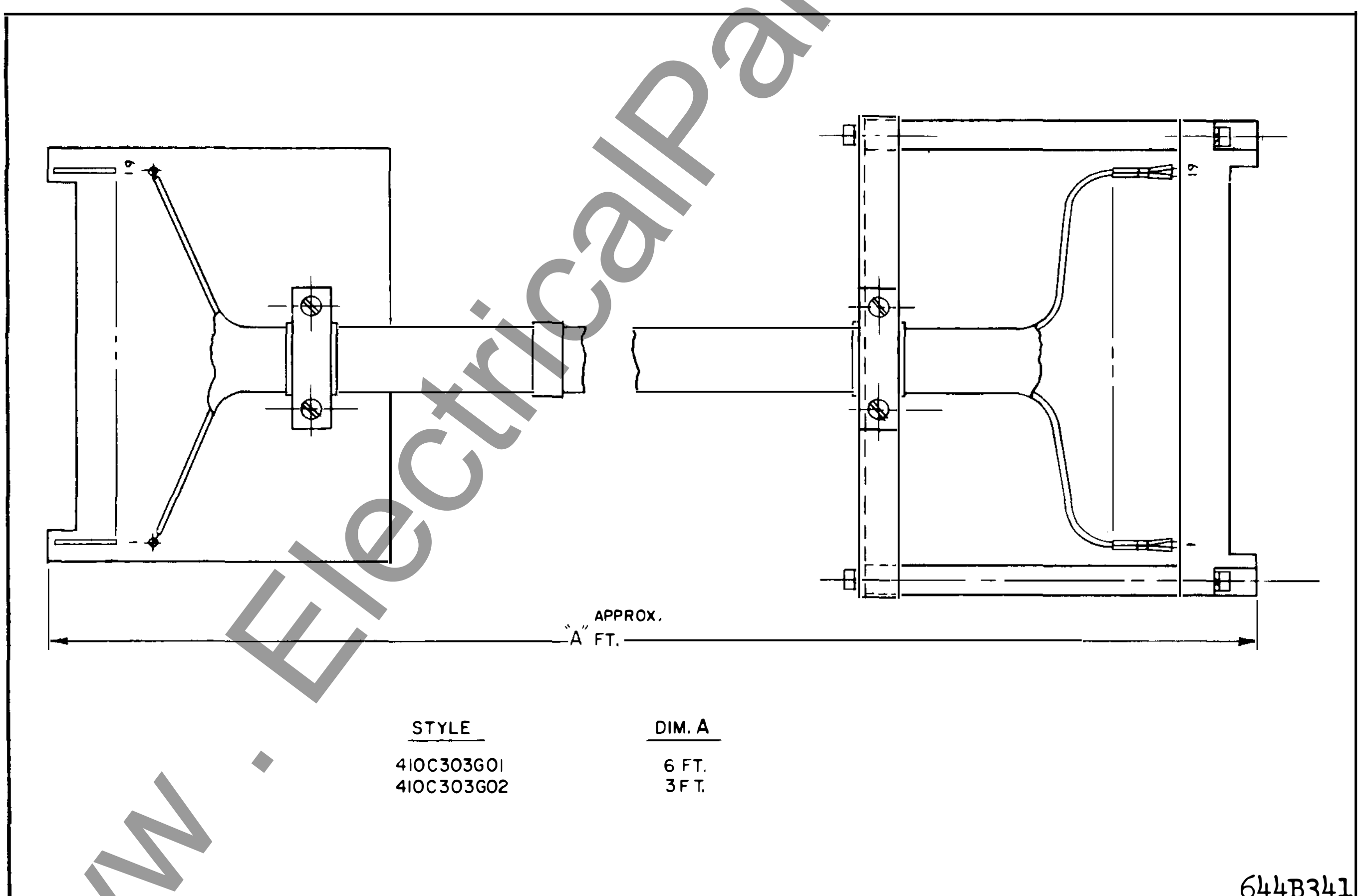


Fig. 16. Test Harness Outline

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

All capacitors 200 v.d.c. rating, minimum, unless otherwise noted.

All resistors ± 5% tolerance, 0.5-watt, unless otherwise noted.

Type	Voltage	Material
IN91	100 v.d.c.	Ge
IN459A	175 v.d.c.	Si

Ratings of Zener diodes in SKA relay:

Type	Volts	± Tol. %	Watts
IN957B	6.8	5	0.4
IN960b	9.1	5	0.4
IN1789	56	10	1
IN1832C	62	10	10 (Clipper)
IN3051	200	20	1
IN3686B	20	5	1.5
IN3797B	22	5	1.5

Other components:

T1	Saturating transformer S# 606B519G03
T51	Type 1D101 Thermistor −10K at 25°C S# 185A211H04
C3,C53	39 mfd, 35 v. tantalum capacitors S# 187A508H04

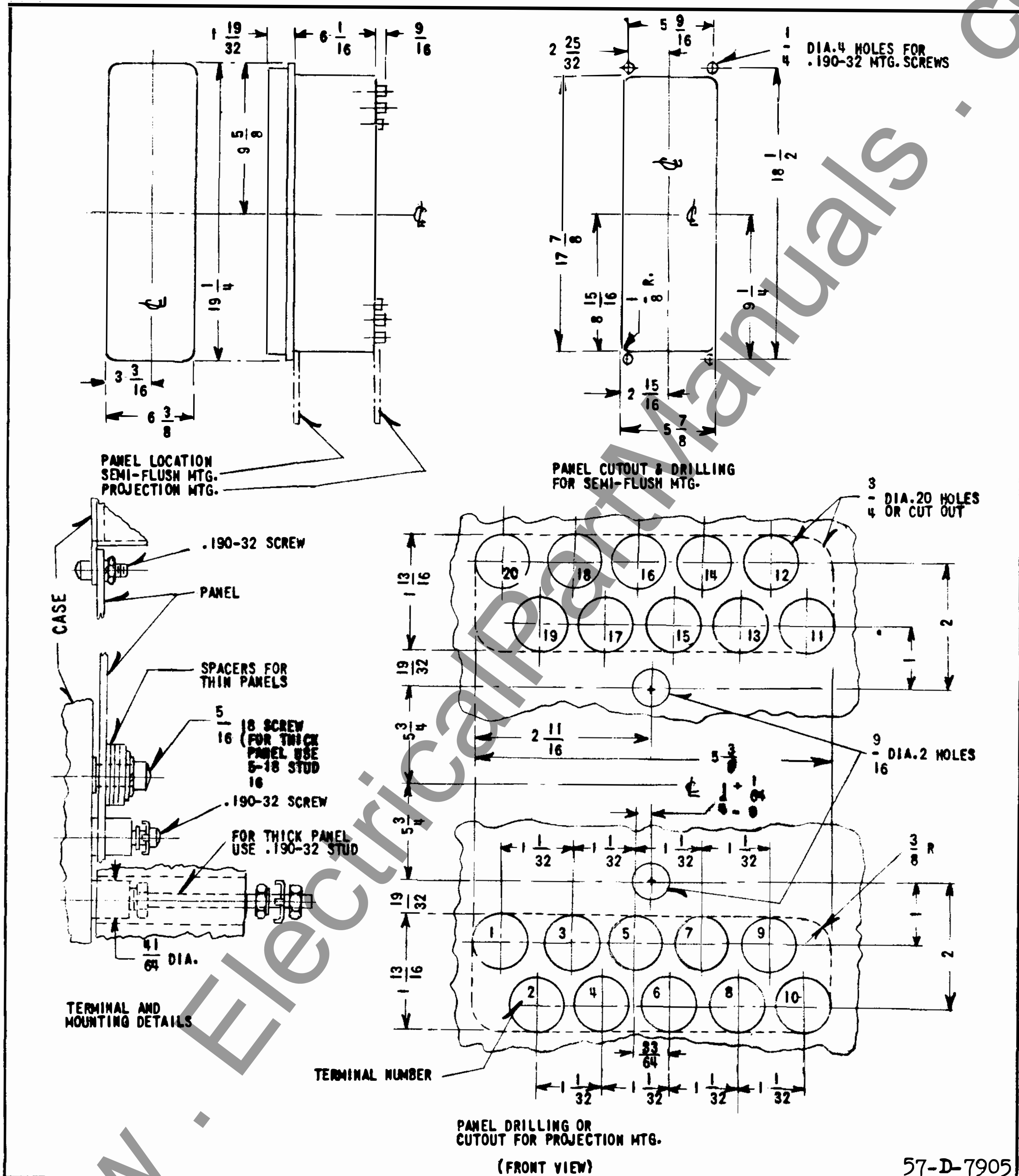


Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT42 Case.

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKA CARRIER AUXILIARY RELAY

INSTRUCTIONS

CAUTION: Before putting relays into service, 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 type SKA relay is the static carrier auxiliary relay used in the K-Dar distance carrier relaying system to block instantaneous tripping for faults external to the line section to which it is applied, and to permit instantaneous simultaneous tripping for internal faults. The relay is arranged to respond to indications of fault power and direction provided by the phase and ground relays, thereby controlling the transmission of the carrier signals, or the initiation of high-speed tripping for internal faults.

CONSTRUCTION

The components of the type SKA relay are mounted in the FT32 Flexitest case. The static equivalents of the receiver relay, the carrier stop auxiliary relay units, and the carrier-start ground over-current unit Ios are mounted on plug-in printed circuit boards. In addition, the static components for the transient blocking and carrier squelch functions are similarly mounted. Two printed circuit boards are used, one mounted on the front of the relay chassis, and the one at the rear of the chassis.

There is only one electromechanical relay unit in the SKA relay: a high-speed auxiliary tripping relay unit (AR) connected to the output of the decision-making static circuitry. This relay unit operates in approximately 3 milliseconds for internal faults cleared through the SKA relay. The tripping has a d-c electromagnet and an attracted magnetic armature. An insulated member fastened to the armature pulls four movable contact springs until they touch the stationary contacts when the relay coil is energized. Only three of the contacts are used, but all four must be in adjustment for proper operation of the relay.

The alarm function is handled by a separate type TT-1 alarm relay mounted in an SC-type semi-flush case. The TT-1 alarm relay uses a telephone-type relay unit with a single normally-open contact. The coil circuit is shunted by a small vitreous resistor to give the desired calibration.

The phase carrier relay target or operation indicator is a d-c operated clapper-type device which drops an orange target when trip current flows through its coil circuit.

OPERATION

LOGIC ELEMENTS

The operation of the SKA relay during internal and external faults can best be understood by reference to Fig. 3 which is a circuit logic diagram. In Fig. 3, the lettered logic blocks serve the following functions:

SYMBOL	TITLE	FUNCTION
B	NOT	Delivers a tripping output when carrier is not received. Energized from output of carrier receiver.
C	3/20 TIME DELAY	Integrating time delay, (adjustable) 3 ms. pickup time, 20 ms. dropout time, energized from 21P (phase) or 67N (ground) protective relay.
D	2-INPUT AND.	Provides an output trip signal only when 21P or 67N operates (longer than 3ms.) and carrier is not received.
E	3/0+T.D.	Co-ordinating time delay, 3 ms. pickup time, no intentional dropout delay (0+).

SUPERSEDES I.L. 41-923.5B
*Denotes change from superseded issue.

EFFECTIVE JANUARY 1969

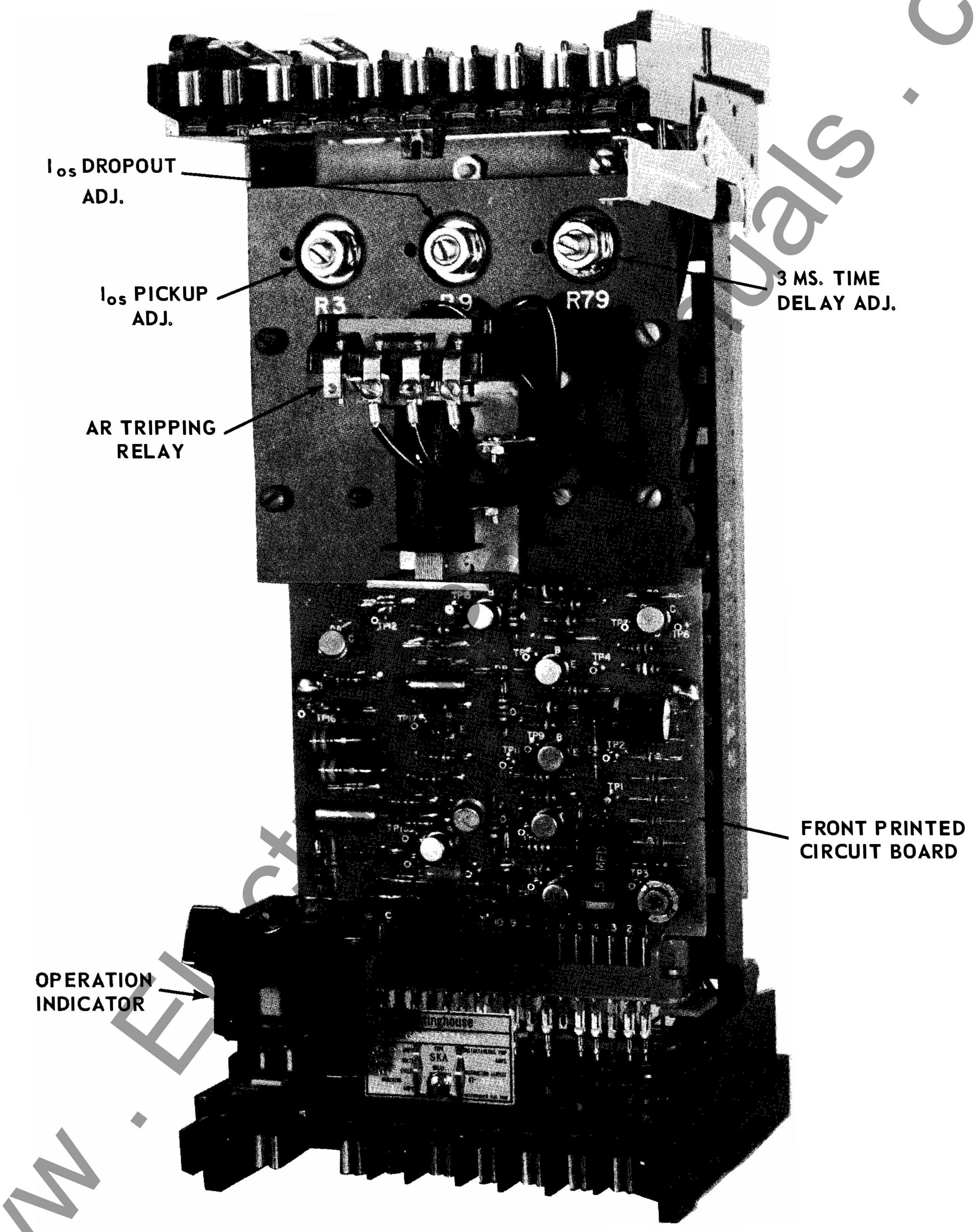


Fig. 1. Type SKA Carrier Auxiliary Relay in FT32 Case (Front View).

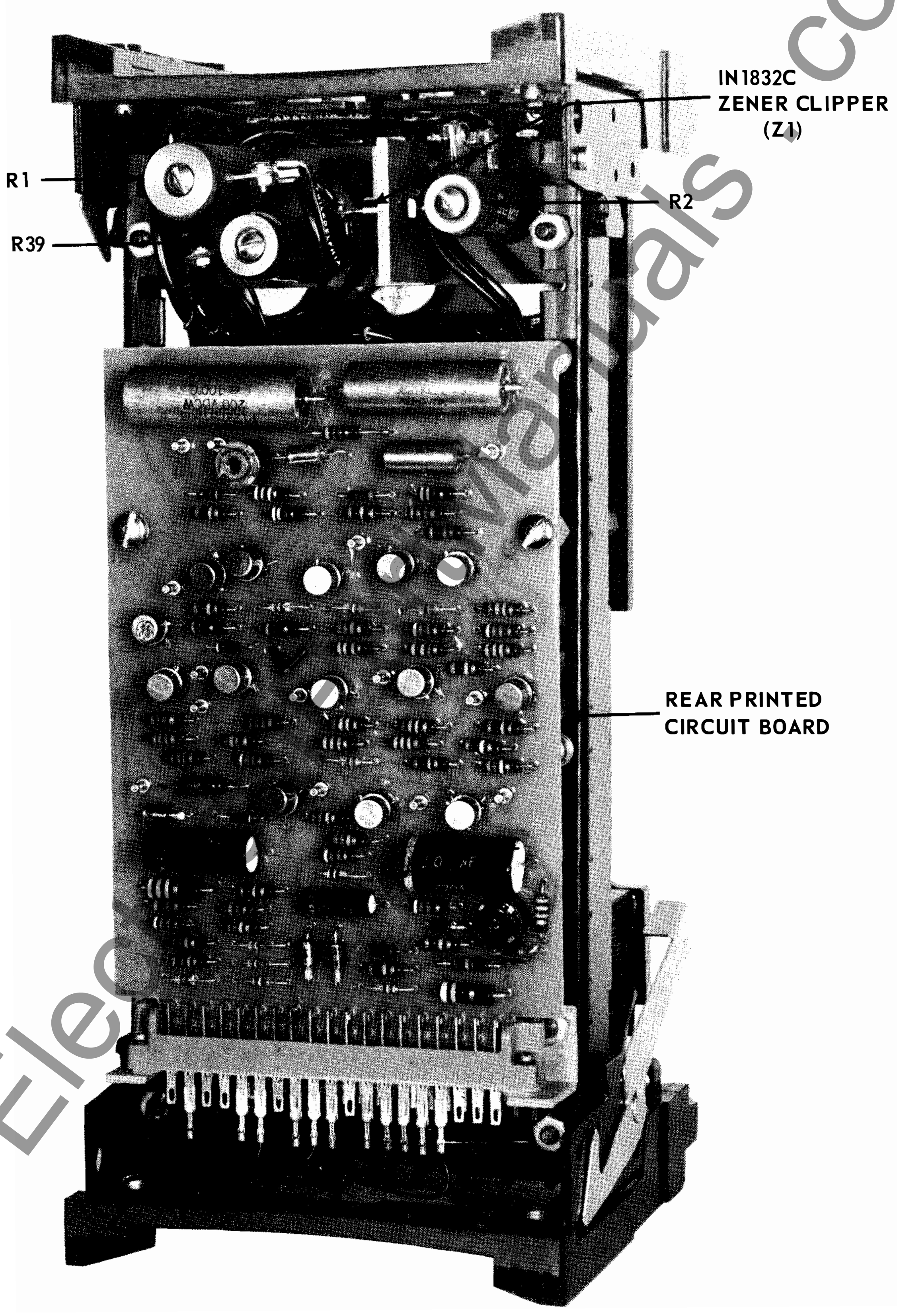


Fig. 2. Type SKA Carrier Auxiliary Relay in FT32 Case (Rear View).

		The 3-ms. pickup delay allows for momentary interruptions of carrier during external faults without incorrect tripping.
F	FLIP-FLOP	Provides positive and steady tripping output when logic circuits determine presence of internal fault.
G	TRIP AMP	D.C. amplifier energized from FLIP-FLOP. Provides adequate energy to AR tripping relay.
H	CARRIER STOP (OR)	Stops carrier transmission on signal from 21P, 67N, carrier squelch, or from 2-input AND at I.
I	2-INPUT AND	Provides an output to carrier-stop OR (H) on operation of both Do (in 67N) and carrier-start Ios units.
J	Ios AMP	Includes phase splitter, rectifier, and level detector for static ground carrier-start over-current unit.
K	TRANSIENT BLOCKING AND UN-BLOCKING 25/25	Allows (adjustable) 25 ms. for normal tripping after operation of 21P, 67N, or Ios, then blocks flip-flop to prevent incorrect tripping during clearing of external fault. If internal fault develops before clearing of external fault, the unblocking feature allows tripping after 25 ms. delay.
L	SQUELCH 0+/150	Energizes carrier-stop circuit when AR trip relay is energized (no intentional delay), and holds carrier off for about 150 ms. to allow sequential tripping of other terminals. Provision is made for external initiation of squelch by applying positive d-c to relay terminal 6.
M	Ios and O + T.D. 30-50	Switching transistor (energized from output of Ios AMP) which serves as normally-closed contact for ground carrier-start function. No intentional pickup (0+) and 30-50 ms. dropout time when energized from Ios AMP.
R	--	Carrier receiver to provide blocking signal to logic circuits from remote transmitter.
T	--	Carrier transmitter to send blocking signal to remote station.

INTERNAL FAULT

The operation of 21P (phase) or 67N (ground) relay for an internal fault performs the following:

1. Energizes the carrier-stop circuit (H).
2. Starts the 3-ms. timing circuit (C). The longer dropout time of 20 ms. is to minimize any additional delay caused by contact bounce of the electromechanical protective relays.
3. "Arms" the flip-flop (F), or puts it in a "ready" condition by removing a blocking bias voltage.
4. Energizes the transient blocking circuit (K).

In the absence of received carrier, the NOT circuit B has an output which is fed into the AND circuit D. After 3 ms., the output of time delay C is also fed into D. If both these inputs continue for another 3 ms., the output of E operates the flip-flop F, and in turn the trip amplifier G which energizes the tripping relay AR to complete the trip circuit through AR relay contacts ARP or ARG. This operation will be completed before the transient blocking becomes effective.

The function of the CARRIER-SQUELCH block L is to hold carrier off (for about 150 milliseconds) after the trip circuit is completed for an internal fault. This is to prevent undesirable blocking where sequential relay operation may occur at the terminals of a protected line section for an internal fault with widely different fault currents at the two terminals.

EXTERNAL FAULT

If carrier is received from the remote terminal when 21P or 67N operates (as for an external fault), there will be no tripping output from the NOT circuit B into the AND circuit D. Thus the conditions will not be set up for tripping. The "carrier-stop" block H functions (when 21P or 67N operates) to stop carrier transmission on those internal faults for which carrier may be started by 21S phase relay (ØØ or 3 Ø) or Ios (at M). For those internal ground faults which may not operate the 67N Io contact, operation of Do of 67N and Ios (thru Ios AMP at J) energizes a second AND circuit (at I) to stop carrier (at H).

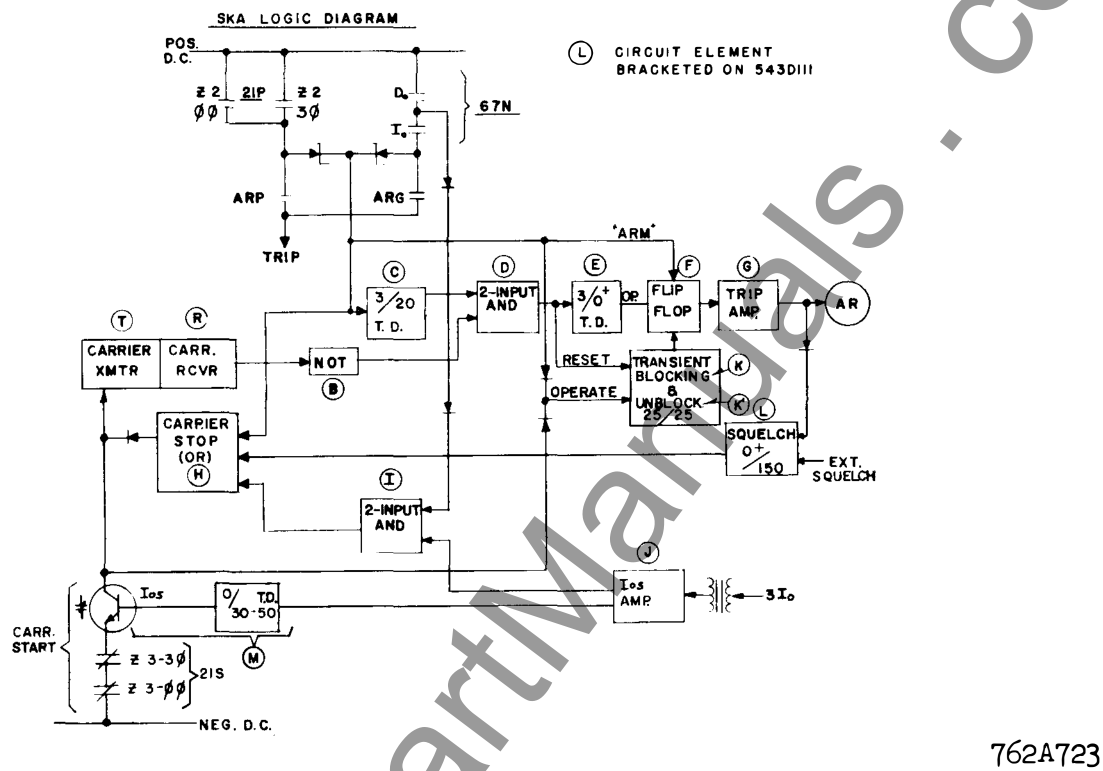


Fig. 3. Logic Diagram for the Type SKA Relay.

If tripping does not take place within 25 ms. after the protective relays operate, a TRANSIENT BLOCKING circuit at K is energized which de-sensitizes the FLIP-FLOP to prevent possible undesired tripping during transients occurring at the clearing (elsewhere) of an external fault.

SEQUENTIAL FAULTS

Occasionally an external fault will be followed by an internal fault before the former is cleared. In order to prevent a long delay in clearing such a internal fault, a "transient unblocking" feature is included at K'. Although transient blocking has been set up by the initial external fault, the presence of an internal fault will cause an output from the AND at D. This output will energize the transient unblocking circuit which, after 25 ms., will allow the flip-flop to operate, and complete the trip circuit by energizing the AR relay through the trip amplifier G.

RELAY CIRCUITRY

The connections of the logic elements to the relay terminals are shown on the internal schematic, Fig. 4. This diagram also indicates the major external circuit connections to the relay terminals. The complete detailed relay circuit is shown in Fig. 5. The components enclosed by the heavy broken lines in this diagram are mounted on the two printed circuit boards of the SKA relay. The operation of the individual circuit components is explained in the following paragraphs. The letters identifying the logic elements in Fig. 3 are also used to identify the corresponding portion of the circuit in Fig. 5.

B - NOT circuit

In the absence of received carrier, transistor Q51 is normally conducting. Under this condition, transistor Q51 has a tripping output. When carrier is received, transistor Q208 in the carrier receiver conducts, raising the potential of SKA relay terminal 12 to approximately +45 volts. This raises the base of Q51 above its emitter potential (+22V.), thus cutting off collector current. Thus, when carrier is received, there is no positive tripping output from the NOT circuit B.

C-3/20 MS (ADJUSTABLE) TIME DELAY:

D-TWO-INPUT AND

Under normal conditions, transistor Q52 is not conducting; thus the positive potential of the collector of transistor Q52 is not a tripping condition. When relay terminal 4 or 20 is made positive by the opera-

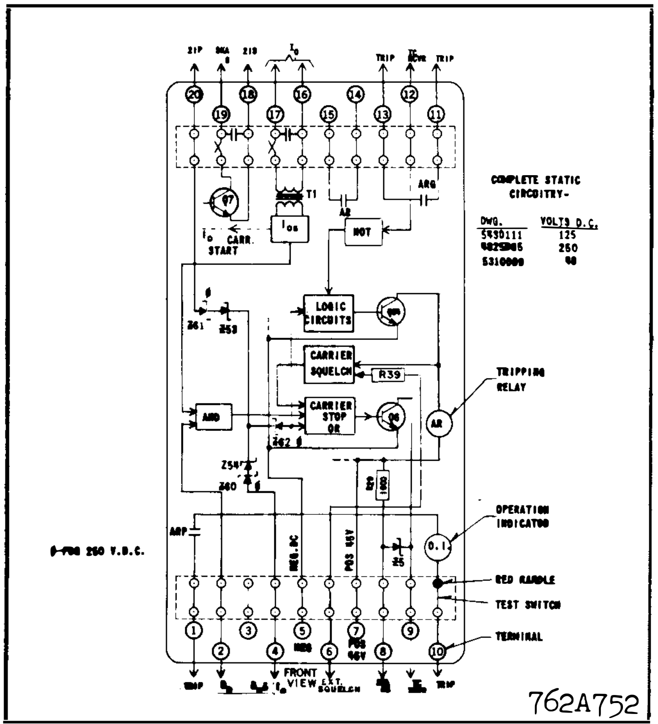


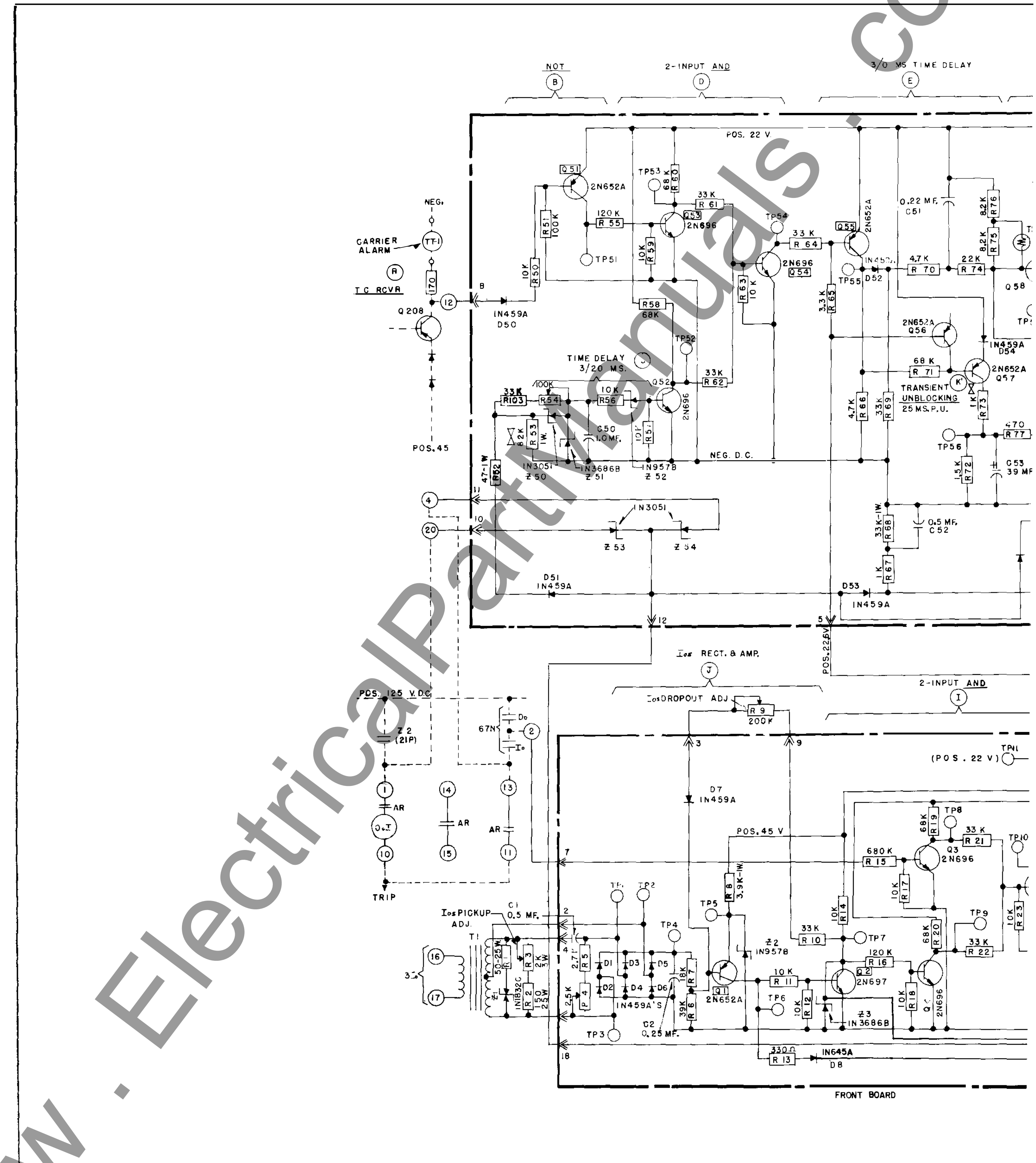
Fig. 4. Internal Schematic for the Type SKA Relay in the FT32 Case.

tion of a protective relay, this positive potential is applied thru Zener diode Z53 or Z54 and diode D51 to the time delay circuit C. When this occurs, capacitor C50 starts to charge thru resistors R52, R103 and R54. After a time delay of approximately 3 milliseconds (adjustable), the voltage on C50 is sufficient to cause Zener diode Z52 to conduct, thus making the base of Q52 positive. Under this condition, transistor Q52 is switched on and its collector potential drops to a very low value. Thus, for an operation of 21P or 67N and with no carrier received, transistors Q52 and Q53 of the 2-input AND at D will both be in a conducting condition. This combination will remove the positive potential from the base of transistor Q54, thus cutting off its collector current, and represents a tripping condition. If, however, carrier is received at the same time that 21P or 67N operates, the reception of carrier will cause Q51 and Q53 to turn off, raising the potential of Q53 collector and Q54 base, thus keeping Q54 conducting. The output of Q54 under this condition represents a blocking or non-tripping condition.

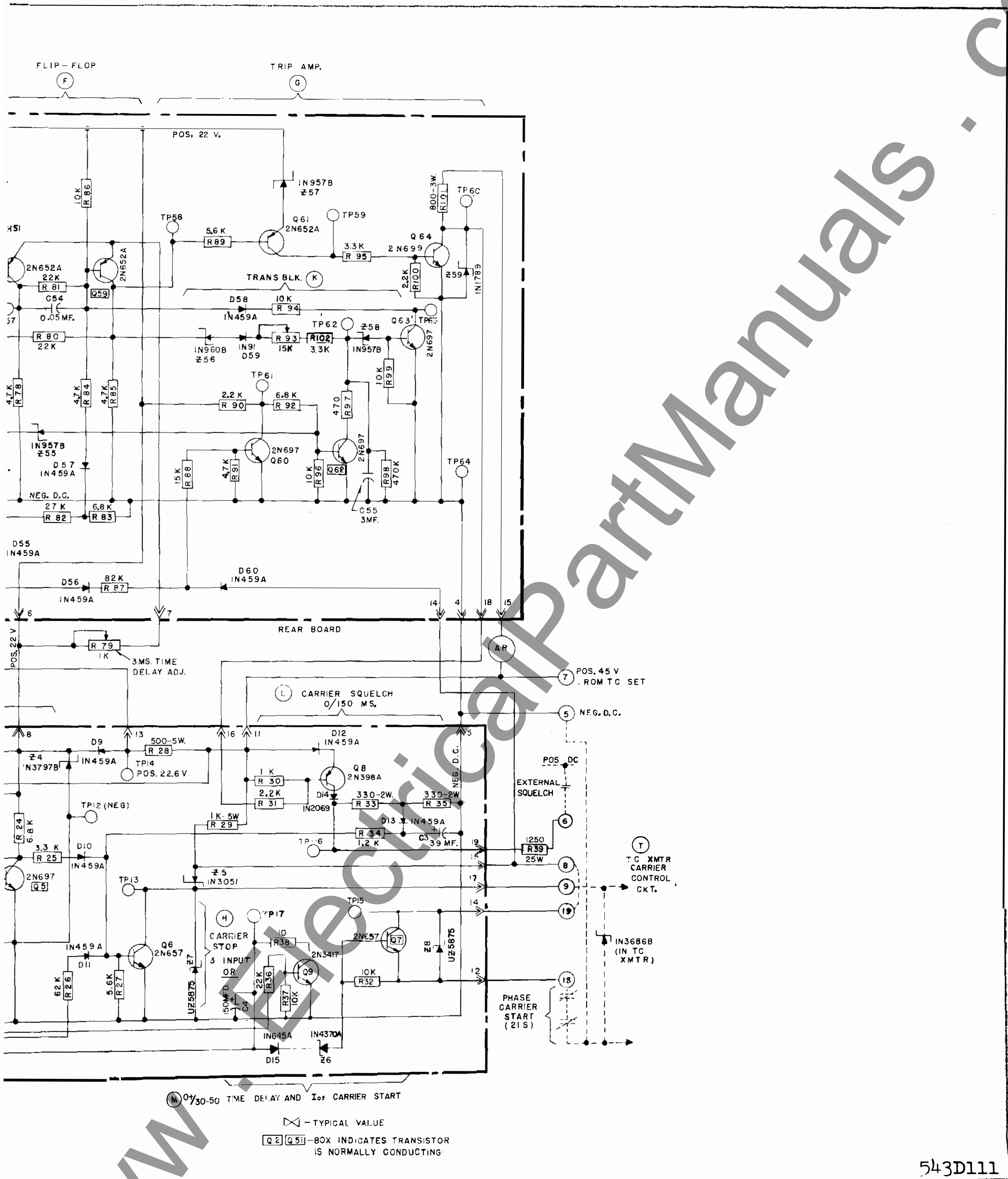
E - 3/0 ms TIME DELAY. Under normal conditions, Q54 is in a conducting state. This provides a path for current to flow from the emitter to the base of transistor Q55 and then thru the collector circuit of Q54, keeping Q55 turned on. Under this condition, transistor Q55 short circuits or bypasses capacitor C51, preventing it from charging up. Under the condition for tripping explained in the previous section, transistor Q55 is turned off, allowing C51 to charge thru resistors R70 and R69. After a calibrated time delay of 3 milliseconds, the voltage across capacitor C51, which is applied to the base-emitter circuit of transistor Q58 in the flip-flop circuit, is sufficient to cause operation of the flip-flop. The time delay circuit E has no intentional reset time delay. If a tripping condition is indicated for 1 or 2 milliseconds such as during a reversal of fault power flow, as soon as transistor Q55 again conducts. The capacitor C51 is rapidly discharged thru Q55, diode D52, and resistor R70. The rapid resetting of the time delay circuit E prevents possible notching up of the charge on capacitor C51 during momentary intermittent interruptions of the carrier blocking signal. This time delay in conjunction with that provided in circuit C are ample to provide coordination of the carrier-start and tripping protective relays at the two ends of a line circuit during fault conditions.

F - FLIP-FLOP CIRCUIT. The flip-flop circuit consists of transistors Q58 and Q59 and associated components. Under normal conditions, transistor Q58 is in a non-conducting, and transistor 59 is fully conducting. The base of transistor Q59 is held well below its emitter potential by means of the voltage divider consisting of resistors R86, R84, diode D57, and resistor R83. With this bias, transistor Q59 is held in saturation, and the flip-flop is desensitized so that even if a tripping voltage were applied to transistor Q58, transistor Q59 would not turn off. This desensitizing circuit is an arrangement to prevent inadvertant operation of the flip-flop caused by surges on the dc system. As long as Q59 is conducting, its collector is at a high enough positive potential that transistor Q61 in the tripping amplifier cannot turn on.

Upon the occurence of an internal fault, positive 125 volts dc is supplied to either terminal 4 or 20 of the SKA relay. Through the Zener diodes Z53 or Z54, plus diode D55 and resistors R82 and R83, the desensitizing bias is removed from transistor Q59. This is accomplished by making the potential of the junction of resistors R82 and R83 higher than the positive 22 volt supply for the flip-flop circuit. When this occurs, there is no current flow through resistor R84 and diode D57, and the flip-flop is now "armed", or in a ready condition for a tripping operation. After the three-millisecond time delays of circuits C and E have elapsed, the potential across capacitor C51 is sufficient to cause Q58 to conduct. This immediately causes operation of the flip-flop, turning off transistor Q59. When Q59 is no longer



* *Fig. 5. Complete Electrical Sc*



...hematic for the Type SKA Relay.

detail in the previous section (M) and by dotted lines to the right of terminals 8, 9, 19, and 18 of the SKA relay (Fig. 3), so that when it conducts it stops the transmission of carrier. This is the carrier stop circuit section H. The combination of operation of the directional unit D_O in the carrier ground relay 67N and the presence of ground fault current comprises one condition for stopping carrier. This combination is necessary to handle fault current values below the pickup of the I_O tripping unit of the 67N relay.

If the ground fault current is high enough for the operation of both D_O and I_O of the carrier ground relay, this will apply a positive potential to SKA relay terminal 4. Thru the circuit starting from relay terminal 4 thru Zener diode Z54, resistor R26, and diode D11 in the carrier stop relay circuit H, the application of positive potential to the base of transistor Q6 turns it on and stops carrier by applying a low resistance path from relay terminal 9 to negative thus effectively shorting the Zener diode 1N3686B in the TC transmitter (shown dotted at the right of the relay terminals). Similarly, for phase faults, the closing of 21P (Z2) applies positive to SKA relay terminal 20, through diode Z53, resistor R26, and diode D11 to the base of Q6, turning it on to stop carrier. The operation of 67N or 21P directly energize the second input to the 3-input OR. The third input is from the carrier squelch circuit, as described in the next section.

L – CARRIER SQUELCH. When the trip amplifier G is energized as a result of an internal fault, the turning on of transistor Q64 drops its collector voltage to a very low value. The collector circuit of Q64 is also connected from the rear board terminal 18 to the front board terminal 16, the resistor R31 and the base of transistor Q8. Applying a negative potential from Q64 to this circuit allows transistor Q8 to turn on, thus providing a path for rapidly charging capacitor C3 thru diode D12, transistor Q8, diode D14, resistor R33, and diode D13. This positive potential on capacitor C3 is applied, through R34, to the base input circuit of the carrier-stop transistor Q6. Thus when a tripping operation occurs, the carrier-stop circuit is energized for a period of 120 to 160 milliseconds to hold carrier in the "off" condition at that terminal to allow the tripping of other terminals which may have to operate sequentially because of the distribution of fault current. Provision is made for external initiation of carrier squelch by applying positive d-c to relay terminal 6. This allows a path for rapidly charging capacitor C3 through resistors R39 and R33 and diode D12 as above.

It will be noted that an output of the carrier control circuit at relay terminal 8 is also connected to the rear printed circuit and through diode D60 to the transient blocking circuit. This circuit is provided so that for an external fault, where the directional element remains open and only the overcurrent unit operates, this will still allow energizing the transient blocking circuit. Operation of the transient blocking circuit by the carrier-start overcurrent unit alone is desirable so that the transient blocking will be acting if a power reversal occurs during the clearing of an external fault. However, the flip-flop is not "armed" by the operation of the ground overcurrent carrier-start relay alone since this relay unit does not set up tripping.

CHARACTERISTICS

The type SKA relay is shipped with the carrier-start overcurrent unit set for 0.5-ampere pickup and 0.4-ampere dropout current. This setting is satisfactory for most applications. The range of pickup adjustment of this unit is 0.5 to 2.0 amperes. The dropout is 80 percent of pickup.

* The AR relay operate time is 3.5 milliseconds.

The pickup and dropout characteristics of the various time-delay circuits of the relay logic are given in the OPERATION sections.

Burden of overcurrent unit:

At 0.5-amp. pickup setting: 0.2 v.a. at 0.5 a, 60 cycles
7.8 v.a. at 5.0 a, 60 cycles

SETTINGS

Normally, there are no settings to be made on the SKA relay. The 0.5-ampere pickup of the ground overcurrent carrier-start unit (Ios) and the various time delay circuits are factory adjustments. For most applications, a pickup current of 0.5 ampere for the Ios unit is satisfactory. If conditions require, the pickup can be changed to any value between 0.5 and 2.0 amperes, as explained under Calibration in the Adjustment and Maintenance section.

INSTALLATION

The relay should be mounted on a switchboard panel or its equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of four mounting holes on the flange for semi-flush mounting or by means of the rear mounting 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.

The outline and drilling plan of the type SKA relay in the FT-32 case is shown in Fig. 17.

ADJUSTMENT AND MAINTENANCE

A. Acceptance Test

The operation of the SKA relay can be checked by connecting it in accordance with Fig. 7. Operate the switches 1, 2, and 3, and apply 1 ampere, 60 cycles as indicated for the six test conditions in Table I. The operation of the type AR tripping relay or the presence of carrier control voltage (20 volts dc) as listed in the columns of Table I will check the performance of the logic circuits and other components of the complete relay. The right-hand column of Table I indicates the protective relay operation represented by the six test conditions.

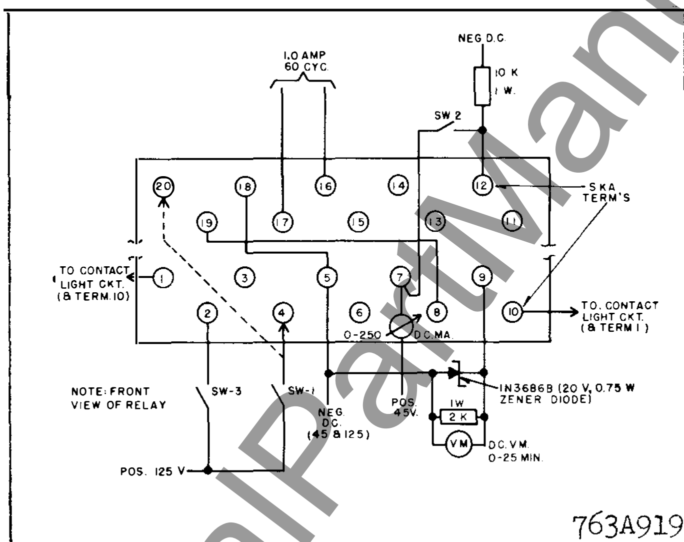


Fig. 7. Test Diagram for Type SKA Relay.

TABLE I

Test	SETTINGS				RESPONSE		
	SW-1	SW-2	SW-3	Cur. at Term. 16-17	AR Relay	D.C. Volts Term. 9-5	Operating Condition Represented
1	0	0	0	Zero	open	Zero	Normal
2	C1#	0	0	Zero	closed	Zero	21P or 67N operation
3	close 2nd	close 1st ϕ	0	Zero	open	Zero	21P and received carrier
4	0	0	0	α1.0 amp	open	20V	Ios carrier-start
5	0	0	C1	1.0	open	Zero	Do and Ios operation
6	C1	0	C1	1.0	closed	Zero	* Do and Io trip and Ios

0 = open
C1 = close
α = or 2 x pickup
ϕ = close SW-2, then SW-1
= close SW-1 with lead connected first to term. 4 then to term. 20.

B. Calibration Check

The pickup and dropout current values for the carrier-start overcurrent ground relay (I_{OS}) can be checked using the same test connections shown in Fig. 7. With switches 1, 2, 3 all open, apply a 60-cycle current to terminals 16 and 17 of the SKA relay. Increase this current gradually. At a current level of approximately 0.5 ampere, the d-c voltmeter reading will suddenly increase from 0 to approximately 20 volts. This is the pickup point of the overcurrent relay. Now reduce the current applied to terminal 16 and 17. At approximately 0.4 ampere (80% of the pickup value), the d-c voltage will drop to zero. The zero value of d-c voltage may be a few tenths of a volt rather than exactly zero. The low value of voltage is the drop across the transistor Q7 when it is fully conducting.

The overall operating time of the SKA relay can be checked using test condition #2. Arrange to start a timer, or the single sweep of a cathode-ray oscilloscope provided with this operating feature, when switch SW-1 is closed. The timer can be stopped by the closing of the relay trip circuit between terminals 1 and 10, or by applying a d-c voltage from an external source thru the relay trip circuit to the timer or to the vertical deflection input of the oscilloscope. The time from the closing of SW-1 until the trip circuit is completed should be in the order of 9 to 12 milliseconds. If a double-pole, single-throw switch is used to energize the relay and start the timing device, be sure that both poles of the switch close within a millisecond of each other.

The performance of the operation indicator can be checked while the circuit of Fig. 7 is set up by connecting the relay trip circuit (terminals 1 and 10) to an external source of approximately 1.5 amperes dc, using external current-limiting resistance. When switch SW-1 is closed, the indicator should drop its target. **NOTE:** Do not try to interrupt the 1.5-ampere direct current by opening SW-1 as the AR tripping relay will not interrupt this current. Instead, open the trip circuit external to the SKA relay, then open SW-1.

C. Recommended Routine Maintenance

The contacts of the type AR tripping relay should be periodically cleaned. A contact burnisher such as S#182A836H01 is recommended for this purpose. Be careful not to distort the moving contact spring fingers during burnishing operation. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact performance.

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. If the adjustments have been changed, or components have been replaced which may affect the calibration, or if it is desired to check the adjustments at regular maintenance periods, the instructions in the calibration section should be followed.

D. Calibration

1. Tripping Relay (AR). The type AR tripping relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.
   a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
   b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
   c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.
2. Static Overcurrent Unit: To test this portion of the relay, use the connections shown below.

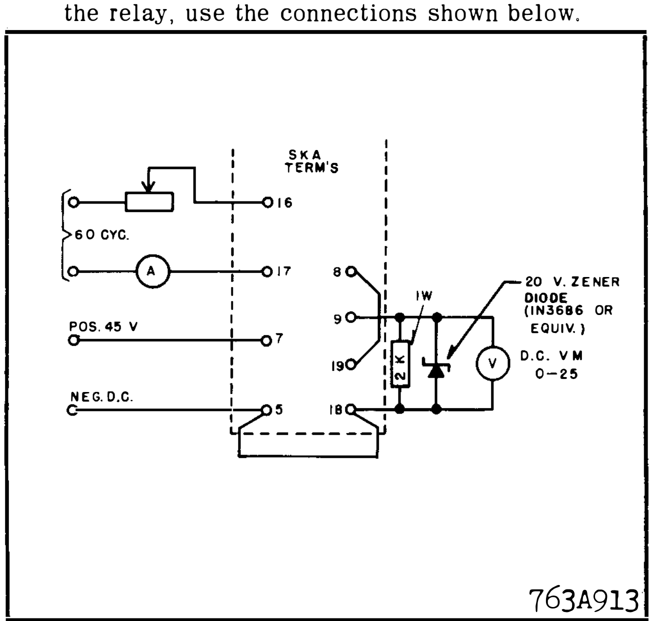


Fig. 8. Test Connections for the Ios Unit of the Type SKA Relay.

With the 45 volts d.c. applied, the d-c voltmeter will initially read zero (perhaps as much as 0.3-volt dc.). Slowly increase the 60-cycle current applied to terminals 16 and 17. At a current of 0.5 ampere a.c., the voltmeter reading should suddenly increase to approximately 20 volts. Loosen the lock-nut for adjusting R3, and again lock it after any adjustments have been made. If it is necessary to adjust the pickup, turning the slotted shaft of potentiometer R3 in a clockwise direction will increase the pickup current. Conversely, if a lower pickup current is desired, turn the shaft counterclockwise. The range of pickup adjustment is 0.5 to 2.0 amperes, 60 cycles. After the relay has picked up, slowly reduce the 60-cycle current. At 80 percent of pickup (0.4 amp. for a 0.5-amp.), the relay should drop out as pickup indicated by the voltmeter reading dropping to zero. If this point needs adjustment, loosen the lock-nut on the resistor R9 and turn the shaft of R9 clockwise to increase the dropout current or counterwise to reduce the dropout current. After this point has been set, tighten the lock-nut and make a final check of the dropout current value. Do not try to set the dropout below 80 percent as the relay may not reset at all.

3. Operation Indicator. The operation indicator should pick up and drop the indicator target when the current is between 1 and 1.2 amperes d-c. To increase the pick-up current, remove the molded cover and bend the springs out or away from the cover. To decrease the pick-up current, bend the springs in toward the cover.

   Make sure that the target drops freely when the unit operates.

4. Time Delays in Logic Circuits. There are six time-delay circuits in the SKA relay. These can be checked most easily using a cathode-ray oscilloscope having provision for a single sweep and an external trigger source. The scope should preferably have a calibrated horizontal sweep which can be read in milliseconds directly from the grid on the screen of the scope. The following paragraphs will explain the procedure to be used and the connections necessary for checking or recalibrating each of the time delay circuits separately. * Note: The notation "3/20 MS" on the logic diagram and on the internal schematic means 3 milliseconds pickup time, 20 milliseconds dropout time. The figure "0+" means no intentional time delay.

   a. 3/20 ms. time delay (section C of circuit)

      1. Make the connections shown in Fig. 9.

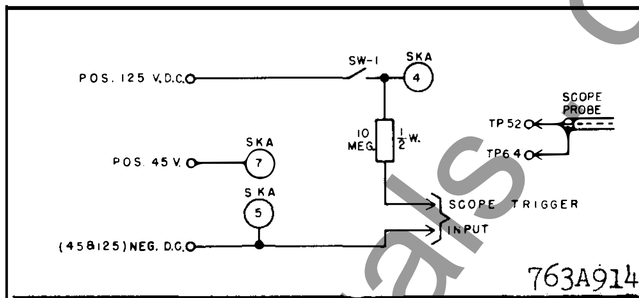


Fig. 9. Test Connections for the 3/20 MS Time Delay Unit of the Type SKA Relay.

      2. Set the scope sweep-speed for around 5 milliseconds time to make one sweep.

      3. Approximately 3 ms. after SW-1 is closed, the d-c voltage across TP52 (+) to TP64 (-) will drop from 7 volts to nearly zero. The sudden drop in vertical position of the trace will indicate completion of the time delay. This time is factory set between 2.7 and 3.3 ms., but may be lowered to less than 2.0 ms. by moving potentiometer R54 counterclockwise, and increased to 7.0 ms. by moving R54 clockwise.

      4. Reset scope and change sweep speed to measure 20 ms. Open SW-1 and note dropout time. The time should be in the range of 17 to 23 milliseconds. If time is appreciably outside this range, change R53. Increasing R53 will increase dropout time; decreasing it will reduce dropout time.

   b. 3/0+ time delay of flip-flop (sections E and F of circuit).

      1. Make the connections shown in Fig. 10.

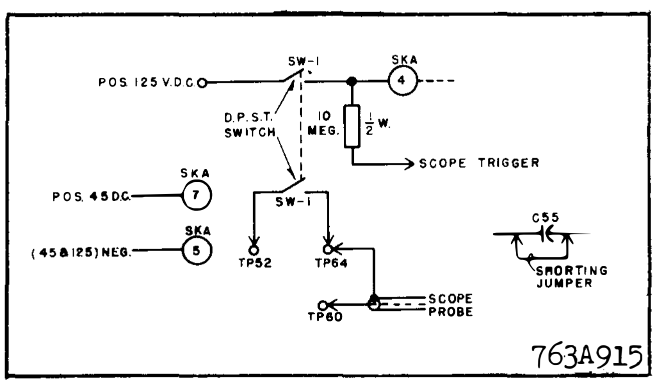


Fig. 10. Test Connections for the 3/0 MS Time Delay Unit and the Flip-Flop of the Type SKA Relay.

2. Start with SW-1 open. Note: Both poles of SW-1 must close simultaneously - well within one millisecond of each other.

3. Temporarily short out C55 with a short clip lead.

4. Set R79 on SKA sub panel to 90 percent of full counterclockwise - only if setting has been previously disturbed. If timing is just being checked, do not initially change setting.

5. Close SW-1. (AR relay will pick up). Note time delay indication on scope trace. It should be 2.7 to 3.3 ms.

6. This time delay can be adjusted by R79 on relay subpanel. Loosen lock-nut. Turn shaft clockwise to increase time delay. Adjust if necessary to 3 ms. ± 10 percent.

7. Opening SW-1 resets 3-ms. time delay circuit with no intentional dropout or reset delay.

8. When calibration is satisfactory, tighten locknut and remove C55 jumper.

c. Carrier Squelch (section L of circuit).

1. Make the connections shown in Fig. 11.

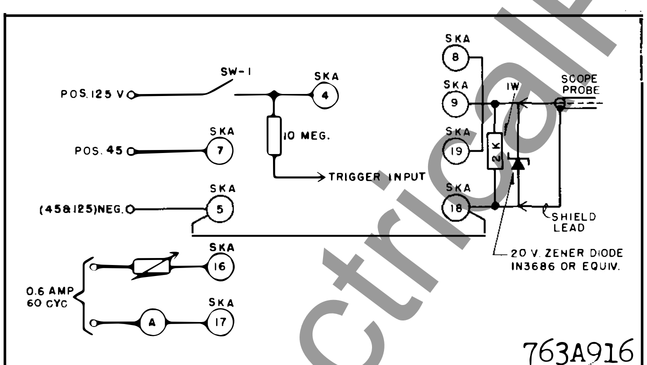


Fig. 11. Test Connections for the Carrier Squelch Unit of the Type SKA Relay.

2. Apply d.c.; then 0.6 amp., 60 cycles (or 120 percent of pickup); then close SW-1, and reset scope trigger. (It may be necessary to set scope for negative sweep-triggering voltage). Set range to around 200 ms. Note: Voltage across SKA terminals 18 (-) 9 (+) will jump from zero to 20 volts d.c. when a-c is applied, then back to zero when SW-1 is closed.

3. Open SW-1 to start carrier-squelch timing. After about 120 ms., scope trace will rise to 20-volt value. Rise will not be sudden, but will start at about 120 ms., and may take to 160-200 ms., to reach final value. No adjustment, since the carrier-squelch time is not critical.

d. Transient Blocking (part of section K of circuit).

1. Make the connections shown in Fig. 12.

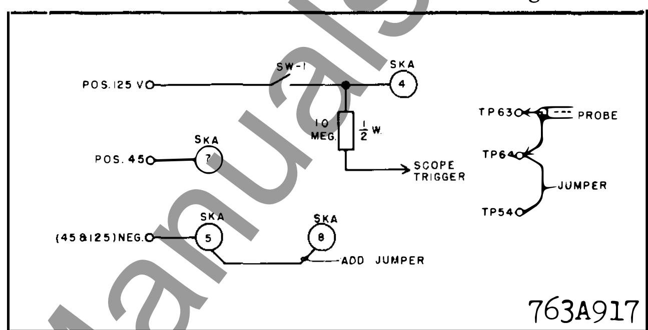


Fig. 12. Test Connections for the Transient Blocking Unit of the Type SKA Relay.

2. Set scope sweep-speed to measure about 30-40 ms. max.

3. With d.c. applied, close SW-1. After 20 to 30 ms., the scope trace will suddenly drop from about 20 volts to zero. Open SW-1 and reset scope.

4. This time delay may be increased by moving potentiometer R93 clockwise and decreased by moving R93 counterclockwise.

5. Remove test jumper.

e. Transient Unblocking (part of section K of circuit)

1. Make the connections shown in Fig. 13.

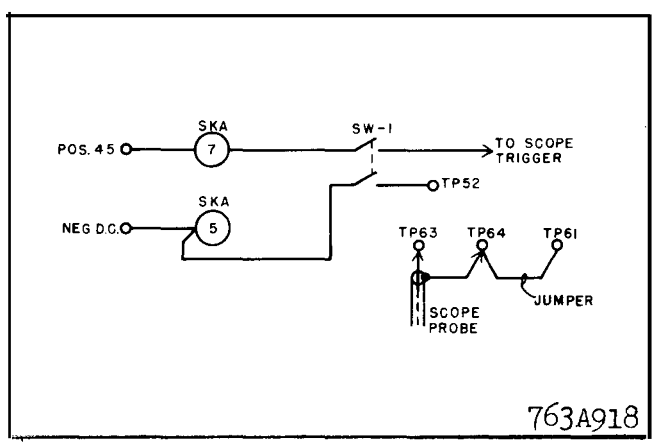


Fig. 13. Test Connections for the Transient Unblocking of the Type SKA Relay.

*TABLE II

Test Point Voltages
(to negative d.c. – TP12- Front Bd., TP64- Rear Bd.)

Test Point	Test Condition (From Table I and Fig. 6)					
	1	2	3	4	5	6
D.C. Ma (Fig. 7)	90	240	115	90	105	250
TP-4	6.5	6.5	6.5	20	20.5	20.5
5	6.7	6.7	6.7	6.7	6.7	6.8
6	6.6	6.6	6.6	<0.5	<0.5	<0.5
7	<0.5	<0.5	<0.5	19.0	19.0	19.0
8	7.6	7.6	7.6	7.6	<0.5	<0.5
9	7.5	7.5	7.5	<0.5	<0.5	<0.5
10	<0.5	<0.5	<0.5	<0.5	11.6	11.6
11	21.6	21.0	21.5	21.5	22.0	21.5
12	—	—	—	—	—	—
13	<0.5	<0.5	<0.5	19.8	0.25	0.15
14	22.5	22.5	22.5	22.5	22.5	22.0
15	<0.5	<0.5	<0.5	21.0	1.05	0.9
16	0	45	0	0	0	45
17	3.5	3.5	3.5	<0.5	<0.5	<0.5
51	21.5	21.5	<0.5	21.5	21.5	21.5
52	7.4	<0.5	<0.5	7.4	7.4	<0.5
53	<0.5	<0.5	7.3	<0.5	<0.5	<0.5
54	<0.5	21.8	<0.5	<0.5	<0.5	22.0
55	21.5	1.3	21.5	21.5	21.5	1.3
56	0	9.2	0	0	0	9.2
57	3.5	20	3.6	3.5	3.5	20
58	20.0	7.8	20.0	20.0	20.0	7.8
59	0	14.5	0	0	0	14.5
60	45.0	<0.5	45	45	45	<0.5
61	18	<0.5	<0.5	<0.5	17.0	<0.5
62	0.6	<0.5	7.4	7.4	0.65	<0.5
63	21.6	20.5	<0.5	<0.5	20.5	20.5
64	0	0	0	0	0	0

D.C. Ma: Not a relay test point

Note: <0.5 means "less than 0.5"

2. Set scope sweep-speed as for previous section.

3. Apply d.c., then close SW-1. (Both poles must close simultaneously.) After 20 to 30 ms., the scope trace will suddenly rise from zero to about 20 volts. If time is outside 20-30 ms. limits, reduce R73 to shorter time, or increase R73 to lengthen time.

4. Remove jumper.

This completes the calibration checks of the various time delay circuits.

E. Electrical Checkpoints

With the SKA relay connected as shown in Fig. 7, the d-c voltages at the test points on the two printed circuit boards are listed in the following table for the six test conditions tabulated in Table I. These values can be checked on a new relay, then kept for a reference if trouble shooting becomes necessary at a later date. The exact values will vary from one relay to another, but in general will be within ± 20 percent between relays.

Return to TEST 4 except pass just pickup current (0.5 amp., 60 cycles unless relay has been recalibrated)

through terminals 16 and 17. Check the a-c voltages tabulated below, using a vacuum-tube voltmeter:

Test Points	Voltage
TP1 to TP2	3.5 v.a.c.
TP1 to TP3	3.5 v.a.c.

NOTE: The above two voltage readings should not differ by more than 5 percent, although the actual value will vary from one relay to another.

F. Trouble-shooting

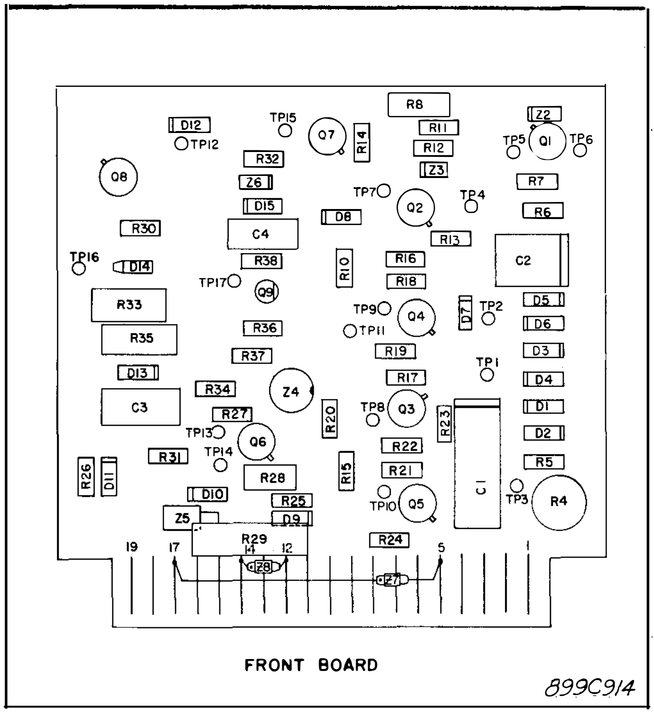
The components of the SKA relay are operated well within their ratings, and under normal conditions should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the following procedure is suggested for trouble-shooting:

If it is desired to check the SKA relay in position on the switchboard, a test cable is available for bringing the rear printed circuit board to an accessible position outside the relay. In use, the relay chassis is first removed from its case, then the rear printed circuit board is removed. In its place is inserted a connector board provided with 3 ft. or 6 ft. of 19-conductor "ribbon" cable, and a similar receptacle for the removed SKA circuit board at the other end. The relay chassis is now re-inserted in its case, and both the front and rear boards are accessible for maintenance. The test cable is shown in Fig. 16.

Under standby conditions, the test point voltages should essentially agree with the values listed in Table II under Test Condition 1 (first column of voltages). If these values are correct, the relay should then be checked per Fig. 7 and Table I, as explained in ADJUSTMENT AND MAINTENANCE, Section A, Acceptance Test. Following is a tabulation of some symptoms, and the sections of the SKA relay which may be at fault.

In locating trouble with no specific component failure indicated, proceed as with any electronic device. Start at the input and gradually work through to the output circuit. For the SKA relay printed circuit boards, start at the left side (circuit-wise, per Fig. 5), checking voltages at each stage. Note that a box around a transistor number ([Q2]) means that the transistor is normally conducting.

TEST	SYMPTOM	POSSIBLE CAUSE
1	No 22-volt supply	1. Z4 shorted (22-volt zener) 2. R28 open 3. D9 open
1	Incorrect test point voltage	1. Failure of nearest associated transistor or diode.
2	AR relay does not operate	1. Defect in some circuit on rear printed circuit board
3	AR relay does operate	1. Shorted Q51, or Q52 2. Defect in associated circuit
4	No 20 v.d.c. at SKA terms 9 and 5	Trouble in front printed circuit board: 1. Ios overcurrent relay not operating 2. Transistor Q6, Q7, or Q8 shorted or held in conducting condition. 3. Other component failure
5	20 volts d.c. does appear at SKA term's 9 and 5	1. I_{OS} portion of front p.c. bd. not operating, or 2. 2-input AND (I) not functioning
6	AR relay does not operate	1. As for test 2, defect in some circuit on rear p.c. bd.



* Fig. 14. Component Location for the Front Printed Circuit Board of the Type SKA Relay.

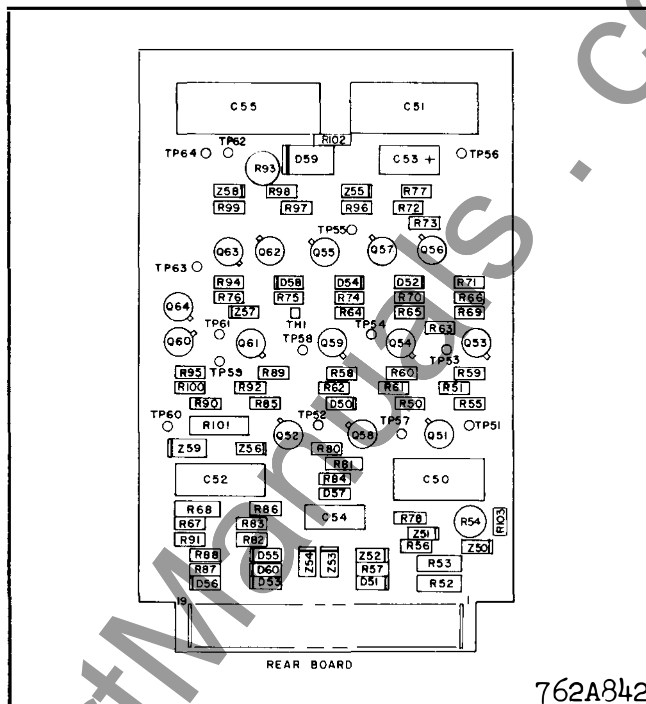


Fig. 15. Component Location for the Rear Printed Circuit Board of the Type SKA Relay.

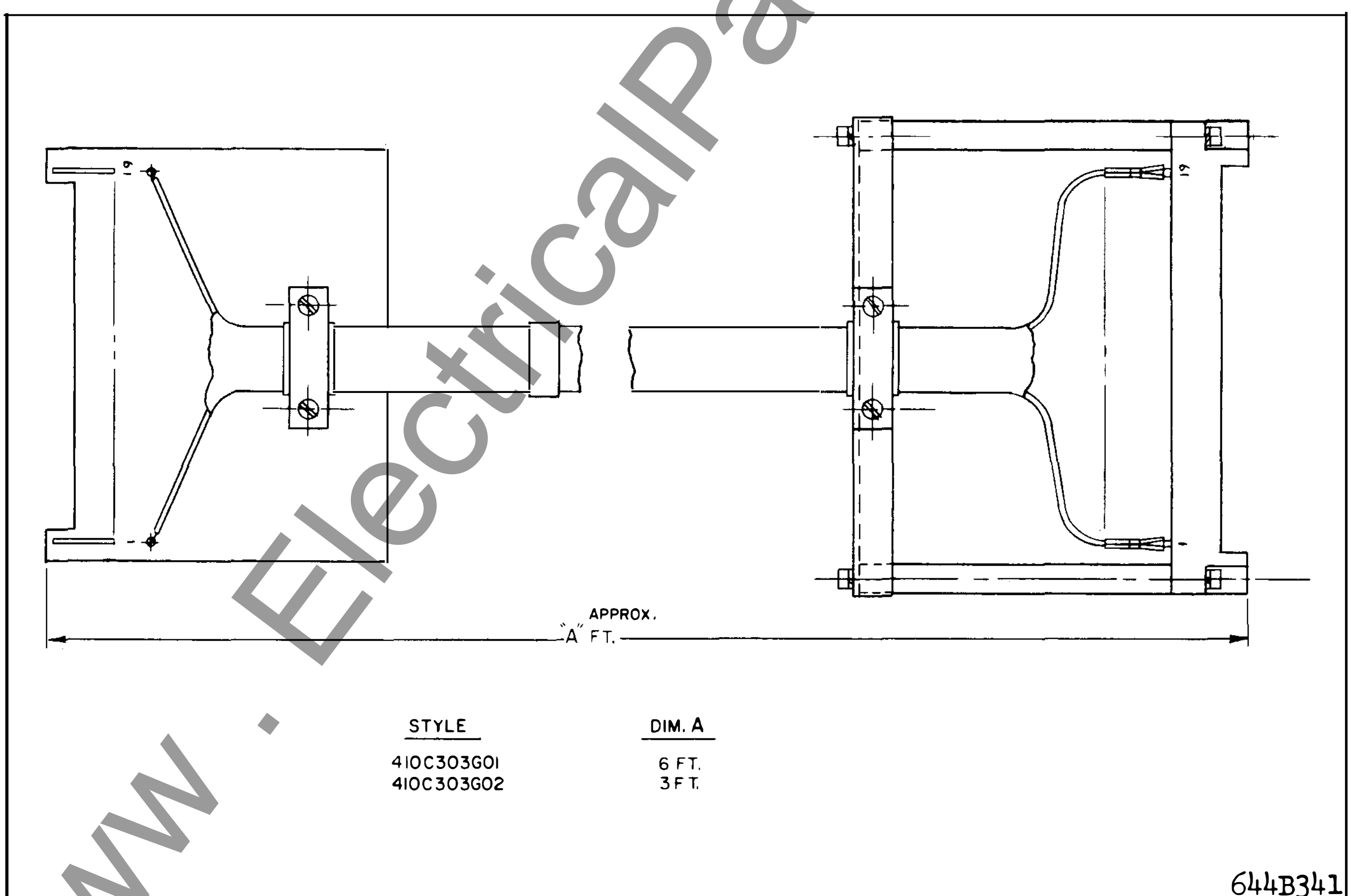


Fig. 16. 19 Terminal Printed Circuit Board Test Harness Outline.

G. Replacement of printed-circuit board components.

When a defective resistor, capacitor, or diode is found, cut it out of the circuit by first clipping off its leads on the component side of the printed circuit board. Then turn the board over, melt the solder holding the remaining lead to the printed pad, and remove the lead with tweezers. NOTE: For such work, a 60-watt iron with a small, well-tinned tip is recommended. Use a 60-40 (tin-lead) rosin-core solder. Do not hold the iron against the printed-circuit board any longer than necessary to remove and replace the the component. If the terminal hole in the board closes up with solder, use the iron to melt it, then open up the hole with fine awl or similar tool.

Where transistors are mounted on small plastic pads, the leads cannot be clipped off. In such a case, melt the solder on one connection at a time, while gently tilting back that section of the transistor. Because of the small flexible leads, the transistor will gradually separate from the board.

Wherever possible, use a heat-sink (such as an alligator clip) on any transistor or diode being soldered. As an alternate, use a long-nosed pliers to the lead (being soldered) between the devices and the point of soldering.

H. Test Equipment

1. Vacuum-tube voltmeter for a-c and d-c measurements.
2. Cathode-ray oscilloscope with provision for calibrated single sweep.

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.

ELECTRICAL PARTS LIST

Unless Otherwise Noted, All Resistors Are 0.5-Watt, ± 5% Tol.

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
AR	Tripping Relay	408C845G01
	CAPACITORS	
C1	0.5 mfd., 200 V.D.C.	187A624H03
C2	0.25 mfd., 200 V.D.C.	187A624H02
C3	39 mfd., 35 V.D.C.	187A508H04
C4	150 mfd., 6 V.D.C.	184A661H08
C50	1.0 mfd., 200 V.D.C.	187A624H04
C51	0.22 mfd., 400 V.D.C.	188A293H02
C52	0.5 mfd., 200 V.D.C.	187A624H03
C53	39 mfd., 35 V.D.C.	187A508H04
C54	.05 mfd., 200 V.D.C.	187A624H08
C55	3.0 mfd., 200 V.D.C.	188A293H06
	DIODES	
D 1 to D 7 * D 9 to D13	IN459A	184A855H08
D14	IN2069 (CER-69)	188A342H06
D 8 – D15	IN645A	837A692H03
* D50 to D58	IN459A	184A855H08
D59	IN91	182A881H04
D60	IN459A	184A855H08
	TRANSISTORS	
Q1	2N652A	184A638H16
Q2	2N697	184A638H18
Q3	2N696	762A585H01
Q4	2N696	762A585H01
Q5	2N697	184A638H18
* Q6	2N657	184A638H15
* Q7	2N657	184A638H15
Q8	2N398A	184A638H12
Q9	2N3417	848A851H02
Q51	2N652A	184A638H16
Q52	2N696	762A585H01
Q53	2N696	762A585H01
Q54	2N696	762A585H01
Q55 – Q59	2N652A	184A638H16
Q60	2N697	184A638H18
Q61	2N652A	184A638H16
Q62	2N697	184A638H18
Q63	2N697	184A638H18
Q64	2N699	184A638H19

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS	
R1	50 ohms, 25W, 5%	1340388
R2	150 ohms, 25W, 5%	1267272
R3	2.0K ohms, 3W, Pot.	185A067H17
R4	2.5K ohms, .25W, Pot.	629A430H03
R5	2.7K ohms	184A763H37
R6	39K ohms	184A763H65
R7	18K ohms	184A763H57
R8	3.9K ohms, 1.W, 5%	187A643H41
R9	200K ohms, 2W, Pot.	185A067H14
R10	33K ohms	184A763H63
R11	10K ohms	184A763H51
R12	10K ohms	184A763H51
R13	330 ohms	184A763H15
R14	10K ohms	184A763H51
R15	680K ohms	184A763H95
R16	120K ohms	184A763H77
R17	10K ohms	184A763H51
R18	10K ohms	184A763H51
R19	68K ohms	184A763H71
R20	68K ohms	184A763H71
R21	33K ohms	184A763H63
R22	33K ohms	184A763H63
R23	10K ohms	184A763H51
* R24	6.8K ohms	184A763H47
R25	3.3K ohms	184A763H39
R26	62K ohms	184A763H70
R27	5.6K ohms	184A763H45
* R28	500 ohms, 5W, 5%	762A679H04
R29	1K ohms, 5W, 5%	184A859H10
R30	1K ohms	184A763H27
R31	2.2K ohms	184A763H35
R32	10K ohms	184A763H51
R33	330 ohms, 2W, 5%	185A207H15
R34	1.2K ohms	184A763H29
R35	330K ohms, 2W, 5%	185A207H15
R36	22K ohms	184A763H59
R37	10K ohms	184A763H51
R38	10 ohms	187A290H01
* R39	300 ohms, 25W For 48V	1202847
	1250 ohms, 25W For 125V	1202589
	3000 ohms, 25W For 250V	1202954
R50	10K ohms	184A763H51
R51	100K ohms	184A763H75
R52	47 ohms, 1W, 10%	184A859H09
R53	82K ohms, 1W, 5%	187A643H73

ELECTRICAL PARTS LIST (Continued)

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R54	* 100K, .25W, Pot.	629A430H04
R55	120K ohms	184A763H77
R56	10K ohms	184A763H51
R57	10K ohms	184A763H51
R58	68K ohms	184A763H71
R59	10K ohms	184A763H51
R60	68K ohms	184A763H71
R61	33K ohms	184A763H63
R62	33K ohms	184A763H63
R63	10K ohms	184A763H51
R64	33K ohms	184A763H63
R65	3.3K ohms	184A763H39
R66	4.7K ohms	184A763H43
R67	1K ohms	184A763H27
R68	33K ohms, 1W, 5%	187A643H63
R69	47K ohms	184A763H67
R70	4.7K ohms	184A763H43
R71	68K ohms	184A763H71
R72	1.5K ohms	184A763H31
R73	* 1K ohms.	184A763H27
R74	22K ohms	184A763H59
R75	8.2K ohms	184A763H49
R76	8.2K ohms	184A763H49
R77	470 ohms	184A763H19
R78	4.7K ohms	184A763H43
R79	1K ohms, 2W, Pot.	185A067H09
R80	22K ohms	184A763H59
R81	22K ohms	184A763H59
R82	27K ohms	184A763H61
R83	6.8K ohms	184A763H47
R84	4.7K ohms	184A763H43
R85	4.7K ohms	184A763H43
R86	10K ohms	184A763H51
R87	82K ohms	184A763H73
R88	15K ohms	184A763H55
R89	5.6K ohms	184A763H45
R90	2.2K ohms	184A763H35

CIRCUIT SYMBOL	DESCRIPTION	STYLE NO.
	RESISTORS (Cont.)	
R91	4.7K ohms	184A763H43
R92	6.8K ohms	184A763H47
R93	*15K ohms, .25W, Pot.	629A430H08
R94	10K ohms	184A763H51
R95	* 3.3K ohms	184A763H39
R96	10K ohms	184A763H51
R97	470 ohms	184A763H19
R98	470 ohms	184A763H19
R99	10K ohms	184A763H51
R100	2.2K ohms	184A763H35
R101	800 ohms, 3W, 5%	184A859H06
R102	* 3.3K ohms	184A763H39
R103	33K ohms	184A763H63
TH51	Thermistor, 10K at 25°C	185A211H04
	TRANSFORMER	
T1	Saturating Transformer	606B519G03
	*** ZENER DIODES**	
Z1	IN1832C, 62V.	184A617H06
Z2	IN957B. 6.8V.	186A797H06
Z3	IN3686B, 20V	185A212H06
Z4	IN3797B, 22V.	185A089H09
Z5	IN3051, 200V.	187A936H01
Z6	IN4370A, 2.4V.	184A639H12
Z7-Z8	UZ5875, 75V.	837A693H04
Z50	IN3051, 200V.	187A936H01
Z51	IN3686B, 20V.	185A212H06
Z52	IN957B, 6.8V.	186A797H06
Z53	IN3051, 200V.	187A936H01
Z54	IN3051, 200V.	187A936H01
Z55	IN957B, 6.8V.	186A797H06
Z56	IN960B, 9.1V.	186A797H10
Z57	IN957B, 6.8V.	186A797H06
Z58	IN957B, 6.8V.	186A797H06
Z59	IN1789, 56V.	584C434H08

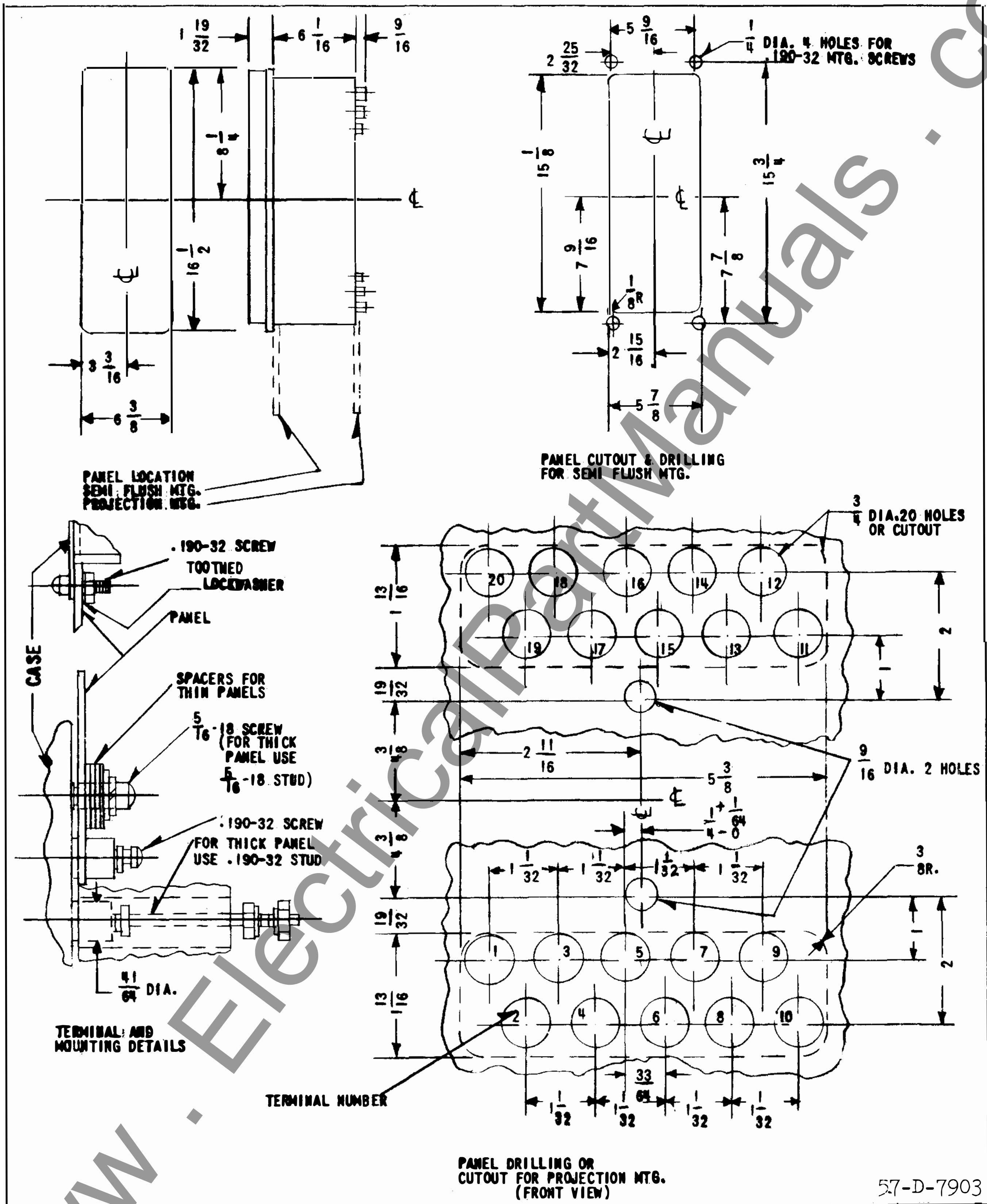


Fig. 16. Outline and Drilling Plan for the Type SKA Relay in the FT32 Case.