INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKBU-11 PHASE COMPARISON RELAY FOR TC CARRIER CHANNEL

CAUTION: It is recommended that the user of this equipment become acquainted with the information in either this instruction leaflet or the system instruction leaflet before energizing the relay system. If the SKBU-11 relay is mounted in a cabinet, the cabinet must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tripping over.

APPLICATION

The type SKBU-11 relay is a high speed carrier relay used in conjunction with a type TC power line carrier set to provide complete phase and ground fault protection of a two terminal transmission line. Simultaneous tripping of the relays at each line terminal is obtained in less than twenty-five milliseconds for all internal faults within the limits of the relay settings. The relay operates on line current only, and no source of a-c line potential is required. Consequently, the relays will not trip during a swing or out-of-step conditions. The carrier equipment operates directly from the station battery.

CONSTRUCTION

The type SKBU-11 relay consists of a composite positive and negative sequence current network, two mixing transformers, three isolating transformers, a 20-volt power supply, and printed circuit boards mounted on a standard 19-inch wide panel, 8¾ inches high (5 rack units). Edge slots are provided for mounting the rack on a standard relay rack.

Sequence Network

The sequence filter consists of a three-legged iron core reactor and a resistor. The reactor is a four-winding reactor with two primary windings and two secondary windings. The secondary windings are connected to the resistor which consists of three tube resistors and a small formed resistor. One secondary winding and the resistor is a negative sequence current filter while the other secondary winding and the resistor is a positive sequence filter.

Mixing Transformer

The voltage from the sequence network is fed into two mixing transformers. One transformer supplies the fault detector circuit and the other transformer supplies the keying circuit. These transformers and Zener clippers (mounted on printed circuit boards) connected across their secondary are used to limit the voltage impressed on the solid-state circuits, thus providing a small range of voltage for a large variation of maximum to minimum fault currents. This provides high operating energy for light fault, and limits the operating energy for heavy faults to a reasonable value.

Isolating Transformer

Three isolating transformers are provided in the relay to isolate the D.C. voltages from the A.C. voltages. Two of the transformers are also used to energize solid-state circuit on alternate half-cycle of the power system frequency.

Power Supply

The solid-state circuits of the SKBU-11 are regulated from a 20-volt supply on the relay panel. This voltage is taken from a Zener diode mounted on a heat sink. A voltage dropping resistor is provided between the source D.C. supply and the 20-volt regulated supply.

Printed Circuit Boards

Seven printed circuit boards are used in the SKBU-11 relay: A fault detector board, protective relay interface board, supervision board, amplifier and keying board, arming board, output board, and a relay board. The circuits of the protective relay board vary with the relaying system.

All of the circuitry that is suitable for mounting on printed boards is contained in an enclosure that projects from the rear of the front panel and is accessible by opening a hinged door on the front of the panel. The printed circuit boards slide in posi-

local and remote squaring amplifiers are compared by an AND circuit of the Arming Board. If the local and remote signals are out of phase with respect to each other, the AND circuit will provide one input to AND number 3 which will activate the 4/0 timer.

A. Internal Fault Conditions

With reference to the logic drawing that applies to the relay, the output voltages from one terminal of the sequence filter is 180 degrees out-of-phase with respect to its load current condition. This changes the polarity of Amplifier #1 such that its output is in phase with the remote signal. This means that the AND has a half-cycle of negative voltage. The negative voltage is applied to AND 3 of the arming board. One condition for activating this AND is thereby set up – negative voltage from AND circuit. The second condition to activate the AND is provided by arming the SKBU-11.

In either Fig. 19 or 20, arming occurs through either the operation of the distance fault detectors or the operation of the SKBU -11 fault detector (FD2). The operation of either fault detector will apply a voltage to the ARM logic of the arming board. The output voltage from the ARM logic removes negative potential from the trip AND applies a negative signal into AND 3 of the arming board. AND 3 is activated and starts the 4/0 timer. Four milliseconds later, a negative input is applied to the trip AND of the output board. Since the three conditions of trip (a negative input from the 4/0 timer, not a negative input from the ARM logic, and not a negative signal from the 18/0 timer) is fulfilled, a trip output is obtained from the SKBU-11 relay.

B. External Fault

Under external fault conditions, the square wave voltage from the remote squaring amplifier and the square wave voltage from the from the local squaring amplifier are out-of-phase such that zero input is being received on the AND circuit of the arming board. As a result, the output of the AND circuit are zero, and AND 3 cannot be activated. This blocks AND 3 and the 4/0 timer is not energized.

With fault detector operation, an input is applied to the ARM logic of the arming board. A positive input will be applied to the trip AND but tripping will not occur since the 4/0 timer is not providing a negative input to the Trip AND. Operation of the fault detector will provide an input to a 1/100 timer on the Output Board. The timer negates the signal to provide a negative input to the transient block AND. With the application of the input from the 0/100 timer the three conditions of transient block are fulfilled – not a negative voltage from the Transient UNBLOCK Circuit; and a negative input from the 0/100 timer. Eighteen milliseconds later the 18/0 timer of the transient block circuit times out to provide a negative input to the TRIP AND. The TRIP AND is thus desensitized to prevent undesirable operation during transients associated with power reversals on the protective line or at the clearing of an external fault.

C. Sequential Faults

If the above external fault is followed by an internal fault before the external fault is cleared, the transient unblock circuit is set up to remove the transient blocking input to the TRIP AND. For the internal fault, the square wave pulses on the AND circuit of the arming board will reverse such that a square-wave output is obtained from the AND circuit. On the negative half cycle this output energizes AND 3 which negates the signal to a negative signal. The negative signal....

1. Provides an input to the 4/0 timer which times out to apply a negative input to the TRIP AND.

2. Applies a square wave input every other half cycle to the AND of the transient unblock circuit to fulfill the requirements to obtain an output from the transient unblock circuit on every other half cycle.

As a result, a negative input is applied to the unblock timer every other half cycle. Twenty-five milliseconds later, capacitor C301 will charge such that the unblock timer will operate on the negative to remove the

negative voltage from the block AND circuit. This resets the 18/0 block timer, and removes the negative input to the AND of the unblock timer to reset the unblock. The required three inputs are thus applied to the trip AND and a trip output is obtained from the SKBU-11 relay.

D. Protective Relay Operation

The SKBU-21 relay is armed by the distance fault detectors through a 8/0 timer on the supervision board. The operation of the distance fault detectors applies negative potential to terminal 16 of the supervision board. This removes current to transistor Q157 and allows C151 to charge. Six milliseconds later the voltage on C157 reaches the breakdown of Zener diode, Z151, and base current flows into transistor Q152 to turn Q152 on. This turns on Q153 to apply a positive potential to terminal 14 of the arming board.

4. Supervision Board

The circuits on the supervision board include the auxiliary functions of the SKBU-11 relay, and they include a detector (FD-1), carrier control circuit and timer circuit.

A. Fault Detector 1 (FD-1)

Under normal conditions, transistor Q161, has no base "signal" and is turned off. The collector of Q161 is at positive potential and no collector current flows. With no Q161 collector current flows. With no Q161 collector current, the base of transistor Q162 is supplied from the 20-volt source. Thus the Q162 emitter is normally at a slightly lower potential than its base. This condition keeps transistor Q162 in a non-conducting state, equivalent to an open circuit.

When a fault causes the D.C. input voltage from the polyphase rectifier to exceed the 6.8 volt rating of Zener diode Z156, a positive bias is applied to Q161 base causing it to conduct. In turn, Q162 is switched to full conduction, thus "closing" the fault detector. When the fault detector operates, a positive output is applied to the carrier control circuit. Resistors R191 and S2 increase the voltage to Z156 to allow the fault detector to drop out at a high dropout ratio when the A.C. current is reduced.

B. Carrier Control Circuit

Under normal conditions Q163 is not conducting and base drive is supplied to Q164. As shown in Fig. 18, the emitter of Q164 is connected to negative D.C. The collector of Q174 is connected to positive 45 volts D.C. of the TC set through R142 of the amplifier and keying board. Normally Q164 is conducting. When either FD1 or the distance fault detector operate, base drive is supplied to Q163. Q163 turns on and shorts the base of Q164 to negative. Q164 turns off to raise the potential of point A of Fig. 18. This starts the transmission of carrier.

C. Arming Delay By Distance Fault Detectors (8/0 Timer)

The distance supervision arming is delayed by 8 milliseconds to allow time for the AND of the arming board to respond at fault inception. Operation of the distance fault detectors will apply negative potential to terminal 16 of the supervision board. This removes the base current to transistor Q151. Q151 turns off once positive potential is applied to capacitor C151. Eight milliseconds later the voltage on C151 reaches a value to break down Zener diode Z151. This turns on Q152, which connects the base of Q153 to negative through resistor, R158. Q153 turns on to apply positive potential to resistor, R160 and terminal 13. From terminal 13 the voltage is applied to the arming board.

CHARACTERISTICS

Taps are available in the SKBU-11 relay to set different sensitivities of the fault detector (FD-1) to zero and negative sequence currents. These taps are as follows:

NEGATIVE SEQUENCE TAPS (I_2)

Tap Setting	Negative Sequence Sensitivity
A	None
B	0.4 Amperes
C	0.25 Amperes

ZERO SEQUENCE TAPS (I_0)

Tap Setting	Zero Sequence Sensitivity
F	None
G	0.2 Amperes
H	0.1 Amperes

The second fault detector unit (FD-2) which supervises arming is adjusted to pick up at a current 25 per cent greater than FD-1. By means of the S_1 adjustment the pick up of FD-2 can be increased to 100 per cent greater than FD-1.

The positive sequence response of the fault detector is greater than 7 amperes.

The operating time of the fault detectors is shown in Fig. 21. As shown in the figure, the operating curve has a maximum and minimum value. This is due to the point on the current wave that fault current is applied. Figure 22 shows the operating times for different points on the fault wave for fault wave for fault current at five amperes.

The keying response of the SKBU-11 relay is independent of the tap setting. Figure 23 shows typical lengths of keying pulses with reference to a 60-cycle base of the SKBU-11 relay for different values of positive, negative, and zero sequence current.

Typical logic drawings are shown in Fig. 19 and in Fig. 20.

Operating Time:	15 to 32 Milliseconds
Alarm Time:	2.5 Seconds for FD Operation
Transient Block Time:	18 to 20 Milliseconds
Transient Unblock Time:	22 to 28 Milliseconds
Ambient Temperature Range:	−20°C to 55°C
D.C. Drain:	0.14 Amps. at 48 Volts D.C.
Reset Time of Transient Block:	1. After Fault Detector has operated: 100 Milliseconds 2. When Unblock time is Utilized: Instantaneous

ENERGY REQUIREMENTS

Burdens at balanced three-phase current of five amperes. (Independent of tap setting).

Phase A		Phase B		Phase C	
VA	Angle	VA	Angle	VA	Angle
8.3	106°	2.2	50°	46	0°

Burden at five amperes (single-phase to neutral current).

Relay Taps	Phase A		Phase B		Phase C	
	VA	Angle	VA	Angle	VA	Angle
C-H	11.7	2.1°	9.7	1.8°	44.0	2.2°
B-H	11.4	2.1°	10.3	1.8°	46.0	2.2°
A-H	11.1	2.0°	11.2	1.8°	48.0	2.2°
C-G	8.8	2.0°	7.0	1.8°	42.0	2.2°
B-G	8.7	2.0°	7.5	1.8°	43.5	2.2°
A-G	7.8	2.0°	8.5	1.8°	45.0	2.2°
C-F	6.7	2.0°	7.5	1.8°	42.0	2.2°
B-F	6.5	2.0°	7.2	1.8°	42.0	2.2°
A-F	5.8	2.0°	6.6	1.8°	43.0	2.2°

The angles above are the degrees by which the current lags its respective voltage.

SETTINGS

The SKBU-11 relay has separate tap plates for adjustment of the zero and negative sequence sensitivity of fault detector (FD1). The tap markings and pickup for FD-1 are:

Negative Sequence Sensitivity (I_2)

A. None
B. 0.4 Amperes
C. 0.25 Amperes

Zero Sequence Sensitivity (I_0)

F. None
G. 0.2 Amperes
H. 0.1 Amperes

Two tap plates are provided: one for I_2 and the other for I_0.

Tap A should not be used in service since this would prevent fault detector operation for phase-to-phase faults. However, tap F may be used with either B or C since negative sequence current flows for both phase-to-phase and ground faults.

The recommended settings are tap B or C as needed for the required sensitivity, and tap F. Taps

G and H have been provided for applications where the negative-sequence load flow due to series impedance unbalance may be high enough to operate FD-1 with a tap C setting. In this case set in tap B and in tap G or H. It is not intended that taps C and H be used simultaneously due to the possibility of cancellation of the negative-and zero-sequence effects on ground faults. With a tap B setting, a tap H setting is preferred.

To summarize, the recommended setting combinations in the order of preference are:

Combination	I_2 Tap	I_0 Tap
1	C	F
2	B	F
3	B	H
4	B	G

For a long two-terminal line, FD2 should be set at 200 per cent of FD-1. As shipped from factory, FD2 is set to pick up at 125 per cent of FD1.

The SKBU-11 relay is generally supplied in a cabinet or on a relay rack as part of a complete assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum temperature around the chassis must not exceed 55°C.

ADJUSTMENTS AND MAINTENANCE

NOTE: The SKBU-11 relay is normally supplied as part of a relaying system, and its calibration should be checked after the system has been installed and interconnected. Details are given in the instructions of the assembly. The assembly instructions and not the following instruction should be followed when the relay is received as an integral part of the relaying system.

In those cases where the SKBU-11 relay is not a part of a relaying system, the following procedure can be followed to verify that the circuits of the SKBU-11 are functioning properly.

TEST EQUIPMENT

1. Oscilloscope
2. A.C. Current Source
3. Electronic Timer ⊀
4. A.C. Voltmeter
5. D.C. Voltmeter

⊀ Scope may be used for timing, by connecting scope probe to timer stop points, and external trigger of scope to timer start.

ACCEPTENCE TEST

Connect the relay to the test circuit of Fig. 24 which represents the carrier channel for test purposes.

Open all test switches of the test circuit and connect a 60-cycle test current between terminals 3 and 5 of the relay. Connect terminal 2, 4, 6 and 8 of the terminal block together. Set taps I_2-C and I_0-H.

1. Filter Output

a. Connect a high resistance a-c voltmeter across X6 and X5 of the relay.

b. Pass 10 amperes, 60 cycles into terminal 5 and out terminal 3. Voltmeter should read 20 volts ± 5%.

2. FD-1 Pickup and Dropout

a. Set relay on taps I_2-C and I_0-H.

b. Connect a high resistance D.C. voltmeter across X_{16} and X_4 (neg.).

c. Connect a 60 cycle test current to terminal 5 3 of the relay. Gradually increase the current until the voltmeter changes reading from approximately 20 volts. This is the operating current of FD and should be 0.433 ± 5% amperes.

d. Gradually lower A.C. test current until the D.C. voltmeter drops to approximately zero volts. This is the dropout current of FD and occur at 0.35 ± 5% amperes of the pickup current.

3. FD-2 Pickup and Dropout

a. With relay set on taps I_2 = C, I_0 = H, connect a high resistance voltmeter to X_{13} and X_4 (neg.).

b. With a 60 cycle test current connected to terminal 5 and 3 of the relay, gradually increase the current until the voltmeter charges reading from approximately zero volts to approximately 20 volts. This is the operating

TABLE II

VOLTAGE MEASUREMENTS ON PRINTED CIRCUIT BOARDS

FAULT DETECTOR BOARD

Test Point	$I_{a.c.}$ = 0	$I_{a.c.}$ = Pickup of FD
54	6.5 V. d.c.	less than 1
55	less than 1	4.5 V. d.c.
56	less than 1	18 to 20 V. d.c.
Term. 2	less than 1	8.6 V. d.c.
51-52	0	7.4 volts a.c. (Approx.)
52-53	0	7.5 volts a.c. (Approx.)
53-51	0	7.4 volts a.c. (Approx.)
Term. 5-6	0	15 volts a.c. (Approx.)
TP 57	18 volts	
TP 58	18 volts	
TP 59	less than 1	Pulses See Table III For
TP 60	20 volts	Waveform
TP 61	18 volts	
TP 62	less than 1	

SUPERVISION BOARD

Test Point	Normal Condition	Abnormal Condition
Term. 16	12	less than 1 with DFD Operation
TP151	less than 1	7 with DFD Operation
TP152	20	less than 1 with DFD Operation
Term. 13	less than 1	20
Term. 18	less than 1	15 with arming
TP153	15	less than 1 with arming
TP154	less than 1	20 with arming
Term. 19	20	less than 1 with arming
Term. 10	less than 1	6.8 volts d.c.
TP158	20	less than 1
Term. 1	less than 1	20
Term. 159	6	20
Term. 6	less than 1	20

AMPLIFIER AND KEYING

Test Point	Normal ($I_{a.c.}$ = 0)	Serviceable Channel: Abnormal or I_{AC} = Pickup of FD
Term. 7	18	less than 1 breaker failure on trip
TP101	less than 1	8.5 breaker failure on trip
Term. 10	less than 1	less than 1 breaker failure on trip
TP102	5 Vdc	4.3 V pulses
Term. 13	less than 1	⊀ 6 volt pulses
Term. 12	48 Vdc	⊀ 48 volt pulses

AMPLIFIER AND KEYING (Continued)

Test Point	Normal ($I_{a.c.}$ = 0)	Serviceable Channel: Abnormal or I_{AC} = Pickup of FD
TP103	5 Vdc	5 volt pulses
TP104	less than 1	16 volt pulses
Term. 11	20 Vdc	20 volt pulses
Term. 2	20 V pulses	200 with loss of channel
TP105	5 Vdc	5 volt pulses
TP106	less than 1	16 volt pulses
Term. 16	20 Vdc	20 volt pulses
Term. 18	20 volt pulses	20 with loss of channel

⊀ Non-squelch condition

ARMING BOARD

Test Point	Normal	Internal Fault	Loss of Channel
TP251	⊀ less than 1	10 V pulses	less than 1
TP252	⊀ less than 1	10 V pulses	less than 1
Term. 3	⊀ 10 volts	⊀ less than 1	10 volts
TP254	⊀ less than 1	17 volts D.C.	less than 1
TP255	⊀ 20 volts	# less than 1	20 volts
TP256	6.5 volts	less than 1	when armed
Term. 19	less than 1	18 volts	when armed

⊀ Very narrow pulses would be observed on scope.

20 volts pulses with signal squelch from remote terminal.

OUTPUT BOARD

Test Point	Normal	Trip	Blocking
301	20	Applies to Sequential Fault	
302	0	Applies to Sequential Fault	
303	2.2	12.5	less than 1
304	less than 1	less than 10	7
Board 14	20	20	less than 1
305	18.5	7	18.5
306	0	13.5	0
307	20	less than 1	20
308	0	20	0

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
FAULT DETECTOR BOARD Style 5312D13G01		
Capacitors		
C51	0.1 Mfd	1544920
C52-C53-C59	0.5 Mfd	187A624A11
C54-C55	1.5 Mfd	187A508H09
C56-C57	0.02 Mfd	187A624H09
C58	0.1 Mfd	187A624H01
C60	0.22 Mfd	762A703H01
Diodes		
D51 to D58-D70 to D73	1N457A	184A855H07
D59	1N645A	837A692H03
D60 to D69	1N4385	184A855H14
Transistors		
Q51-Q52-Q53-Q55-Q57-Q61-Q62-Q63	2N3417	848A851H02
Q54-Q56-Q58	2N3645	849A441H01
Switches		
Q59-Q60	2N886	185A517H03
Resistors		
R51	50 Ohms, 5W	185A209H06
R52-R68-R71	2.7K Ohms ½W	629A531H42
R53 (POT)	2.5K Ohms ½W	629A430H03
R54-R55-R58-R62-R64-R66-R84-R89-R92	10K Ohms ½W	629A531H56
R56-R60	100K Ohms ½W	184A763H75
R57	47K Ohms ½W	629A531H72
R59	56K Ohms ½W	184A763H69
R61-R87	22K Ohms ½W	629A531H64
R63	6.8K Ohms ½W	629A531H52
R65	27K Ohms ½W	629A531H66
R67	150K Ohms 3W	762A679H01
R69-R73	68K Ohms ½W	629A531H76
R70-R74-R88	39K Ohms ½W	629A531H70
R72-R75-R80	2K Ohms ½W	836A503H33
R76-R78-R90	1K Ohms ½W	629A531H32
R77	5.6 Ohms ½W	629A531H50
R81	20K Ohms ½W	629A531H63
R82	1.5K Ohms ½W	836A503H30
R83-R91	470 Ohms ½W	629A531H24
R85	4.7K Ohms ½W	629A531H48

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
FAULT DETECTOR BOARD (Continued)		
Zener Diodes		
Z51	1N1832C, 62V	184A617H06
Z52-Z55	1N957B, 6.8V	186A797H06
Z53	1N3688A, 24V	862A288H01
Z54	1N759A, 12V	837A693H01
SUPERVISION BOARD Style 5315D34G01		
Capacitor		
C151-C153-C157	0.47 Mfd	188A669H01
C152	68 Mfd	187A508H02
C154-C158	1.5 Mfd	187A508H09
Diodes		
D151-D156-D157-D162	1N457A	184A855H07
D152-D155	1N645A	837A692H03
Transistors		
Q151-Q152-Q154-Q555-Q161-Q163-Q164	2N3417	848A851H02
Q153-Q156-Q162	2N3645	849A441H01
Resistors		
R151-R158-R168-R188-R194	6.8K Ohms ½W	629A531H52
R152-R153-R157-R159-R164-R165-R167-R169-R186	10K Ohms ½W	629A531H56
R189-R191-R193-R196-R154	470 Ohms ½W	184A763H19
R155-R166-R192	22K Ohms ½W	184A763H59
R156-R161	1K Ohms ½W	184A763H27
R160-R170-R190	82K Ohms ½W	629A531H78
R162	33K Ohms ½W	184A763H63
R163	56K Ohms ½W	184A763H69
R171	150K Ohms 3W	762A679H01
R195	2.7K Ohms ½W	184A763H37
Zener Diode		
Z151-Z152-Z156	1N957B, Y.8V	186A797H07
Z153	1N3668, 24V	862A288H01
Z158	UZ5875, 75V	837A693H04

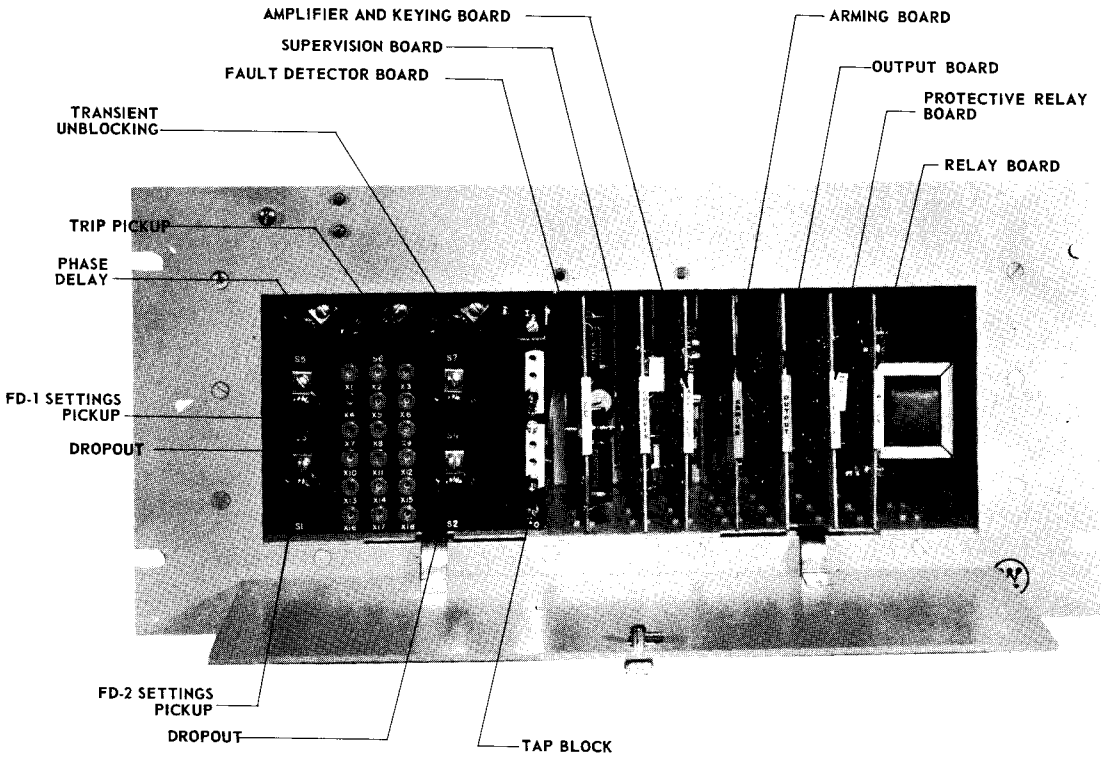


Fig. 1. Photograph (Front View)

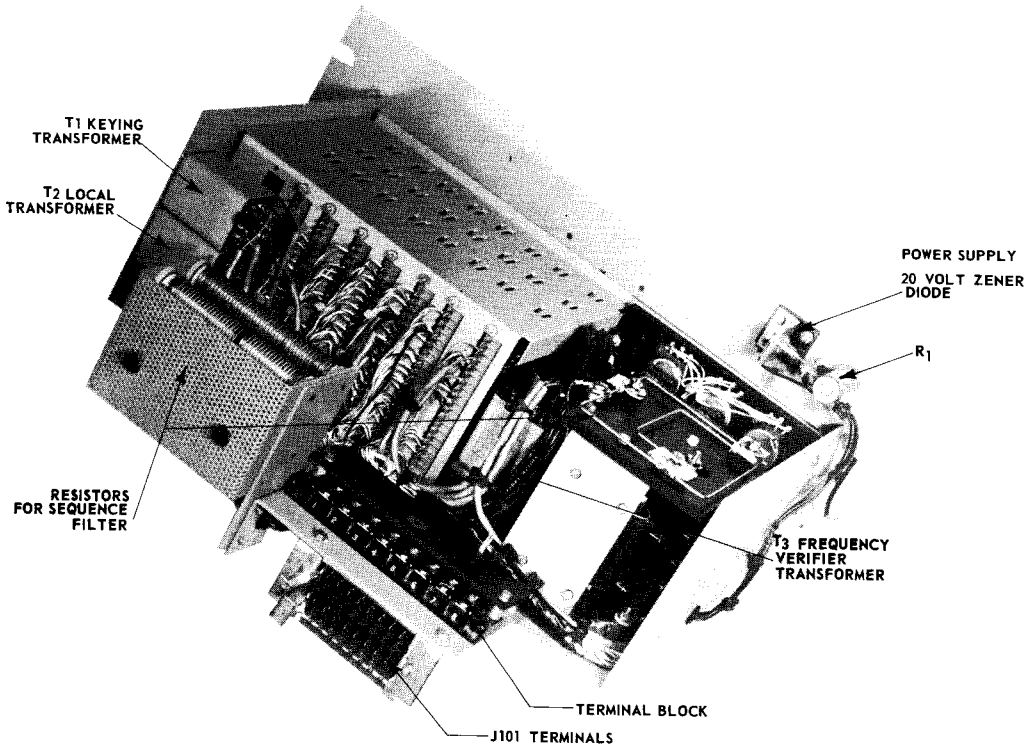


Fig. 2. Photograph (Rear View)

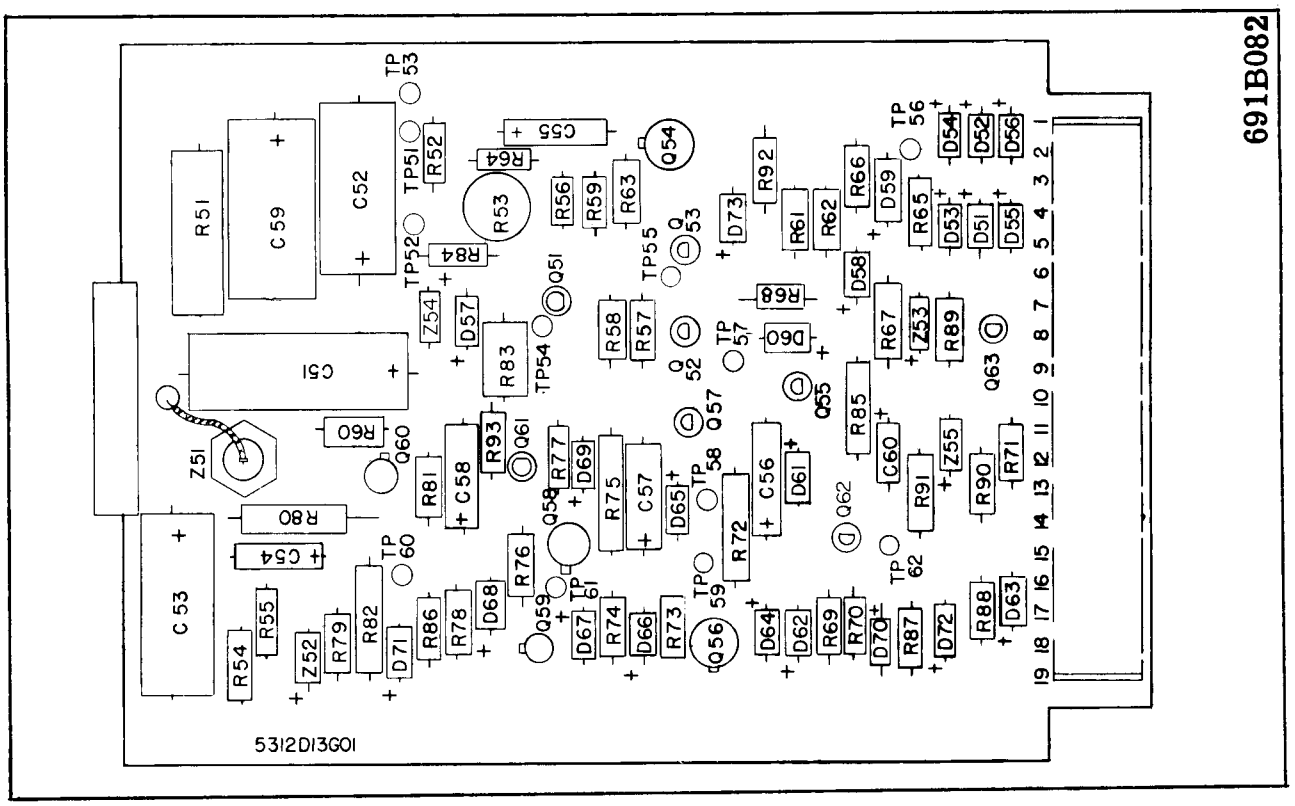


Fig. 3. Location of Components on Fault Detector Board.

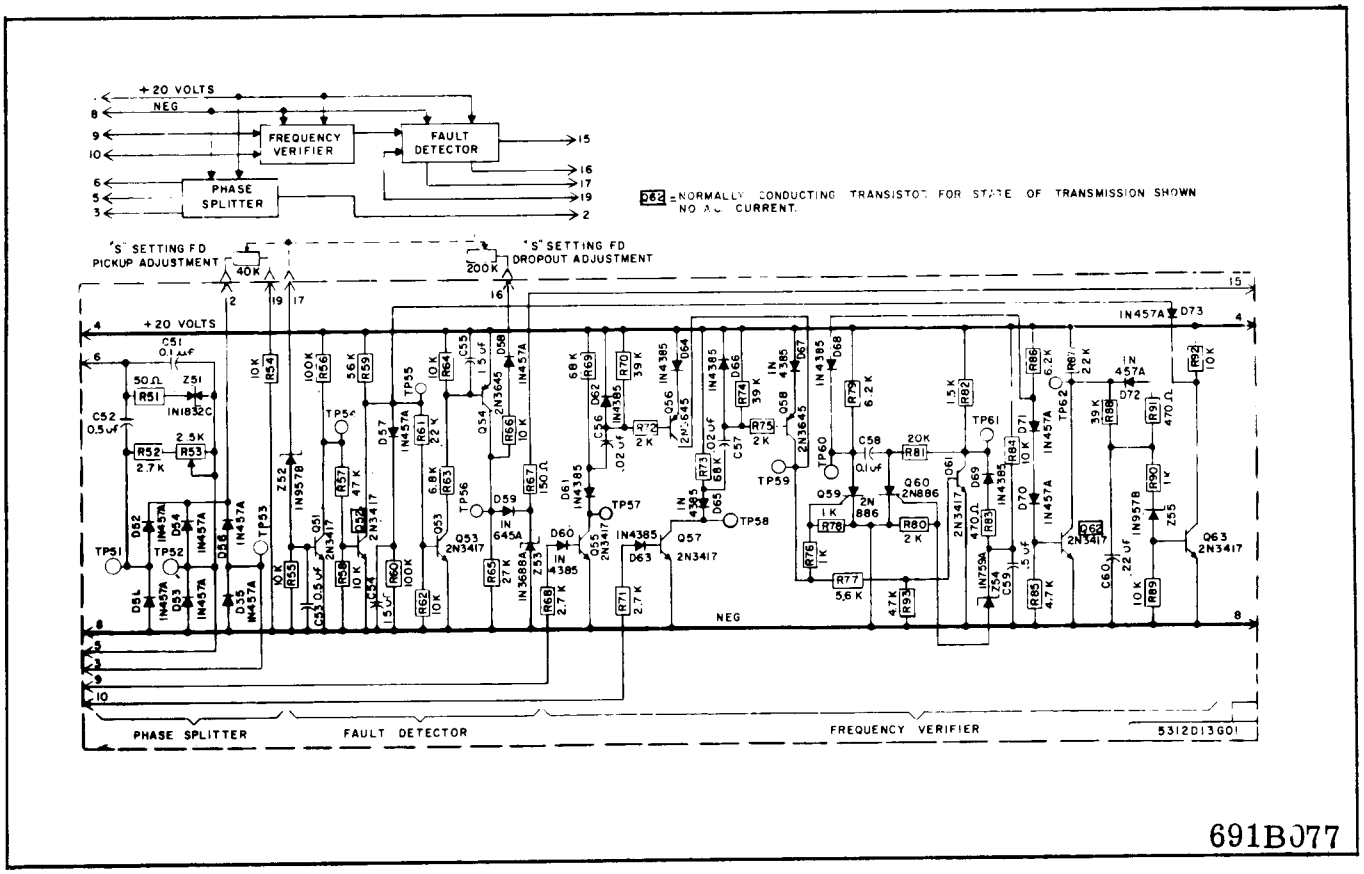


Fig. 4. Schematic of Fault Detector Board.

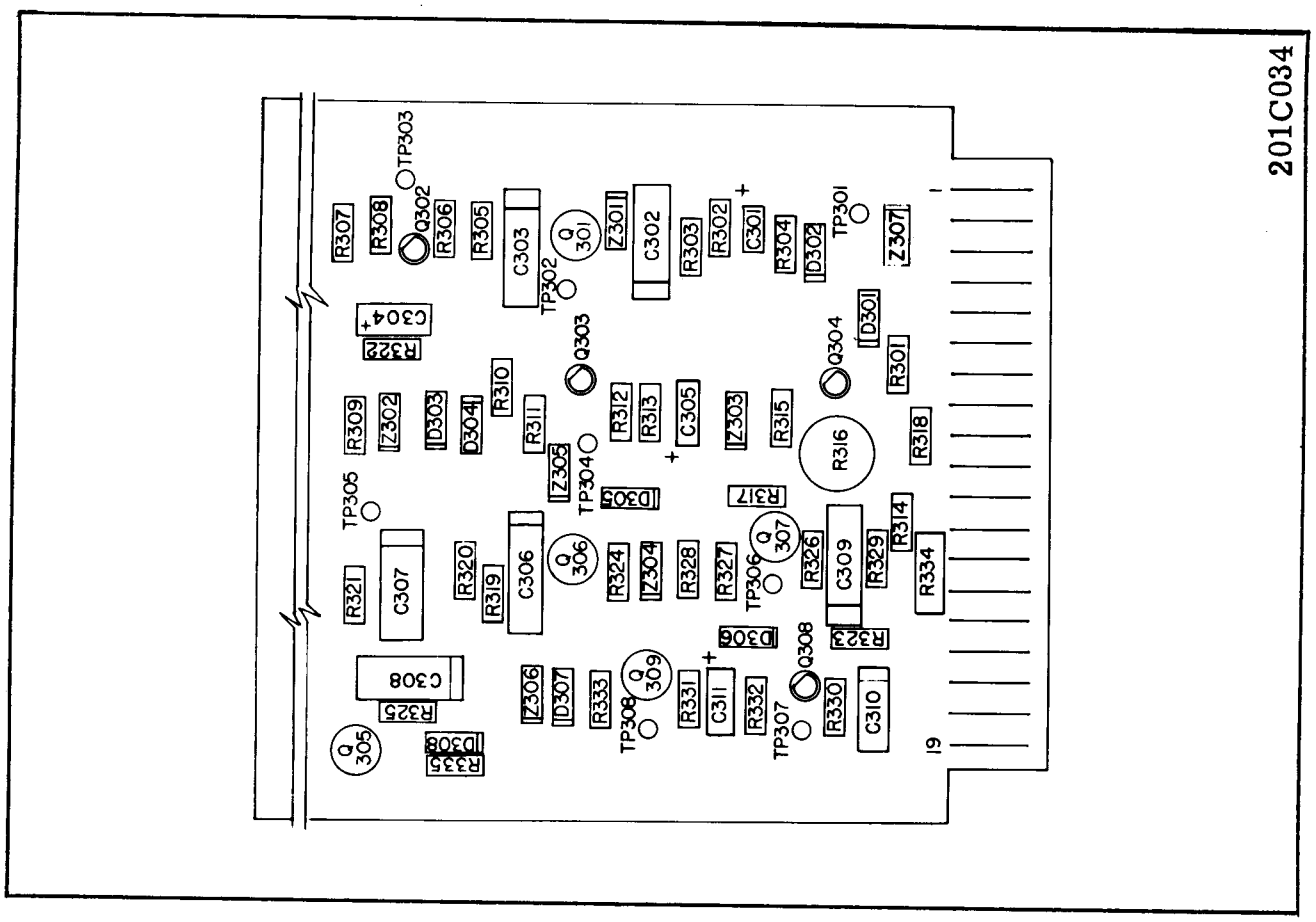


Fig. 9. Location of Components on Output Board.

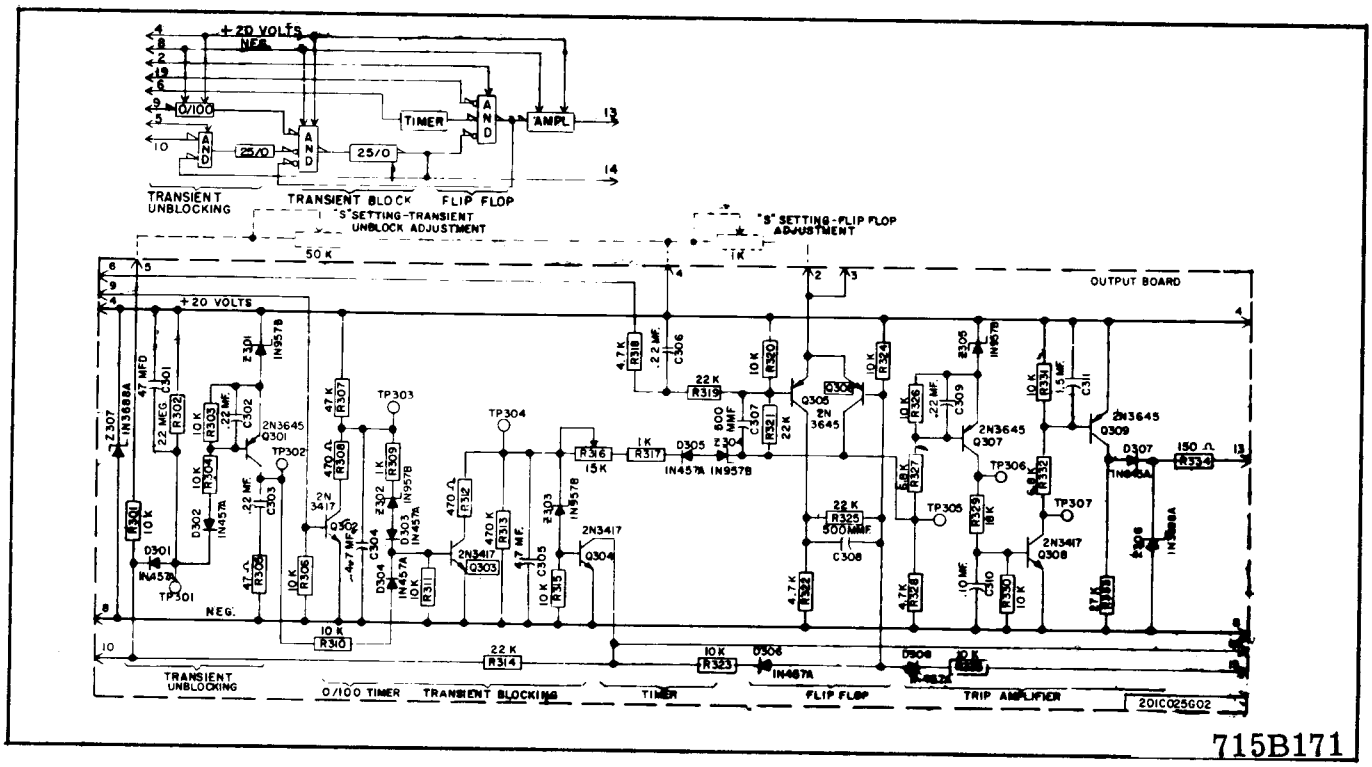


Fig. 10. Schematic of Output Board.

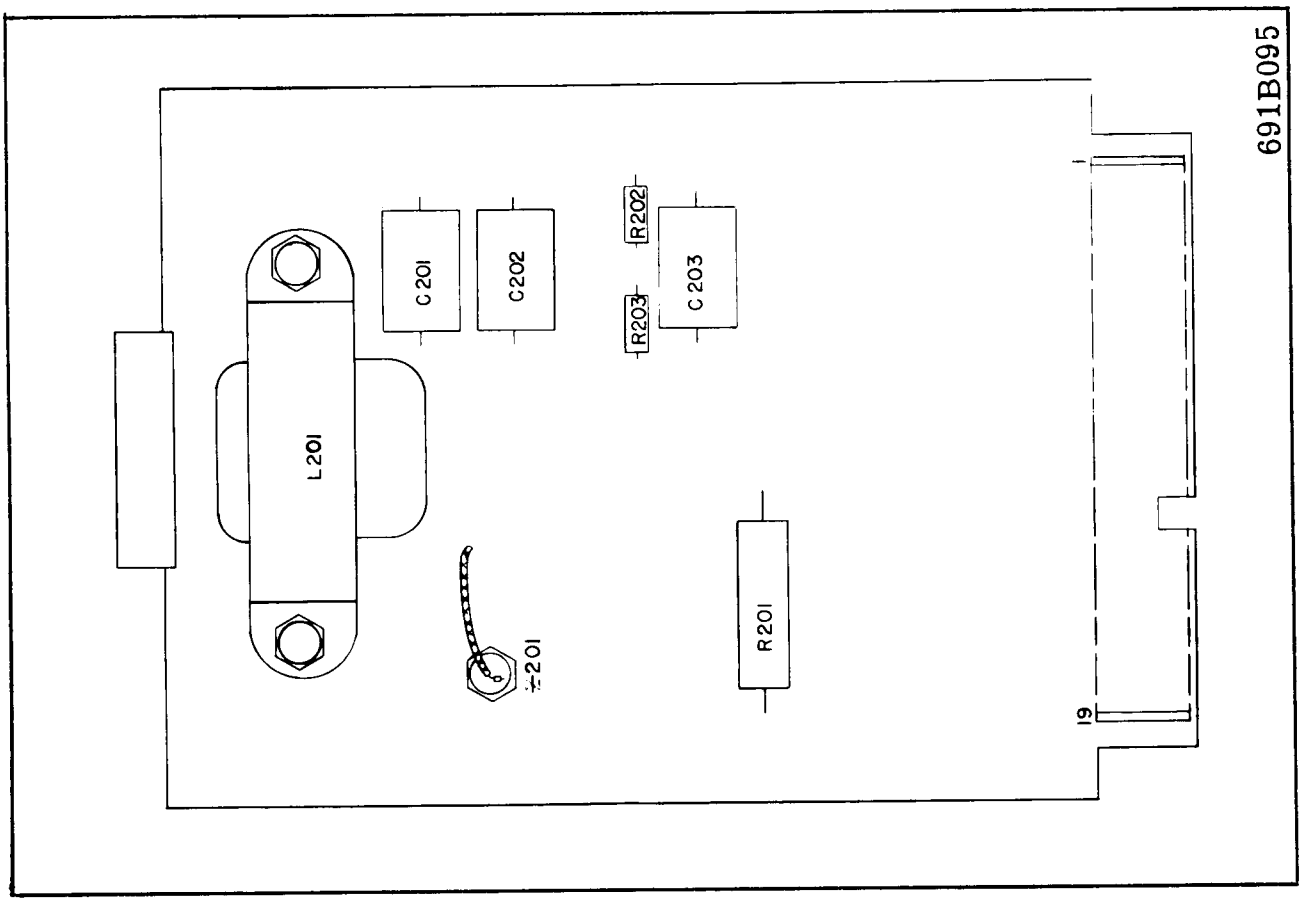


Fig. 11. Location of Components on Relay Board.

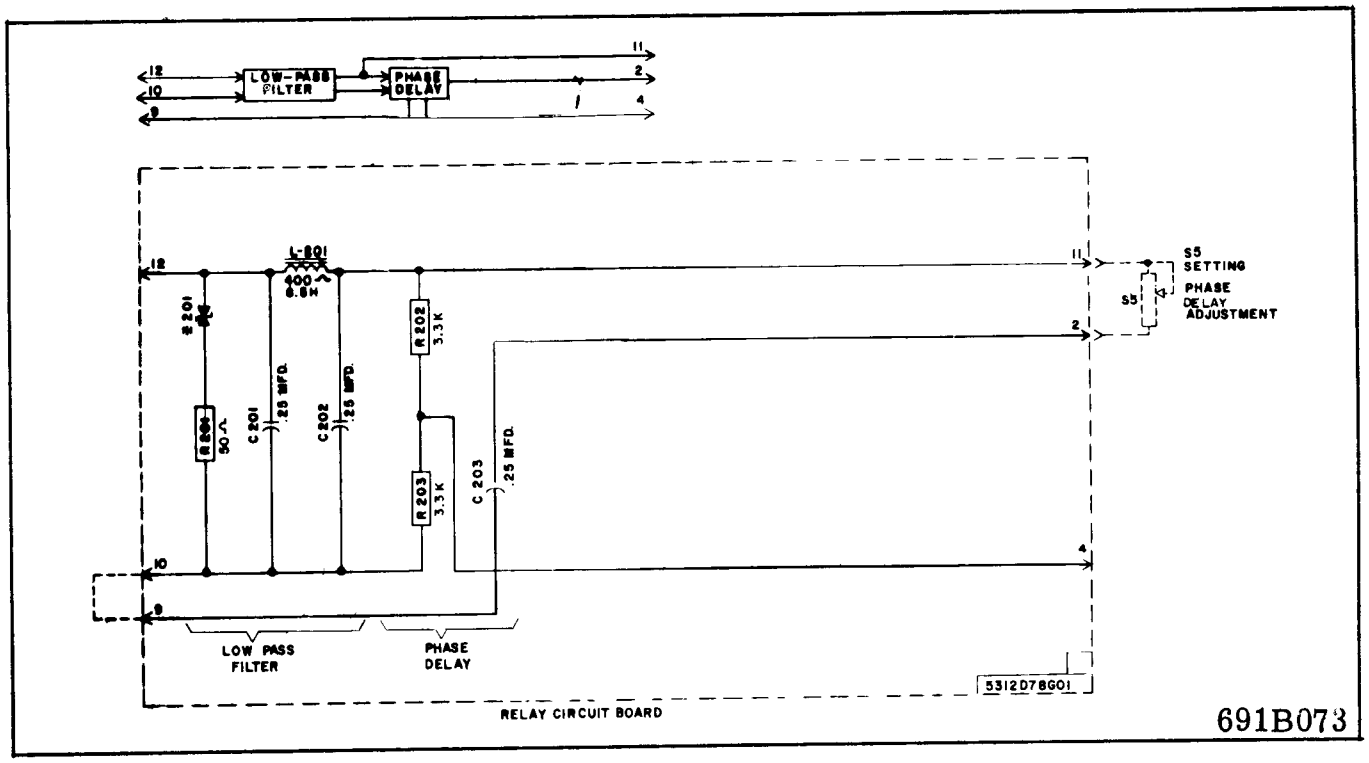


Fig. 12. Schematic of Relay Board.

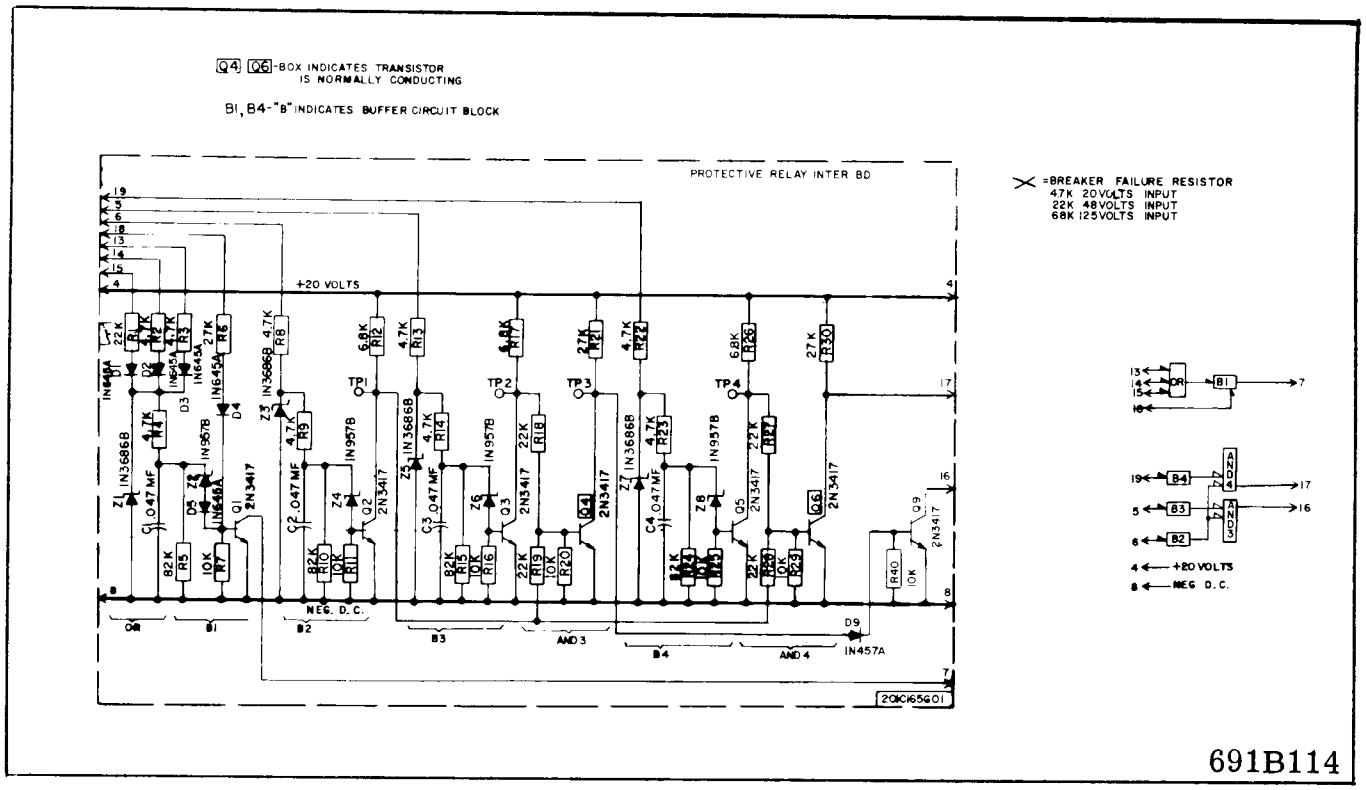


Fig. 17. Schematic of Protective Relay Board for Distance Phase Comparison System with Blinder Control.

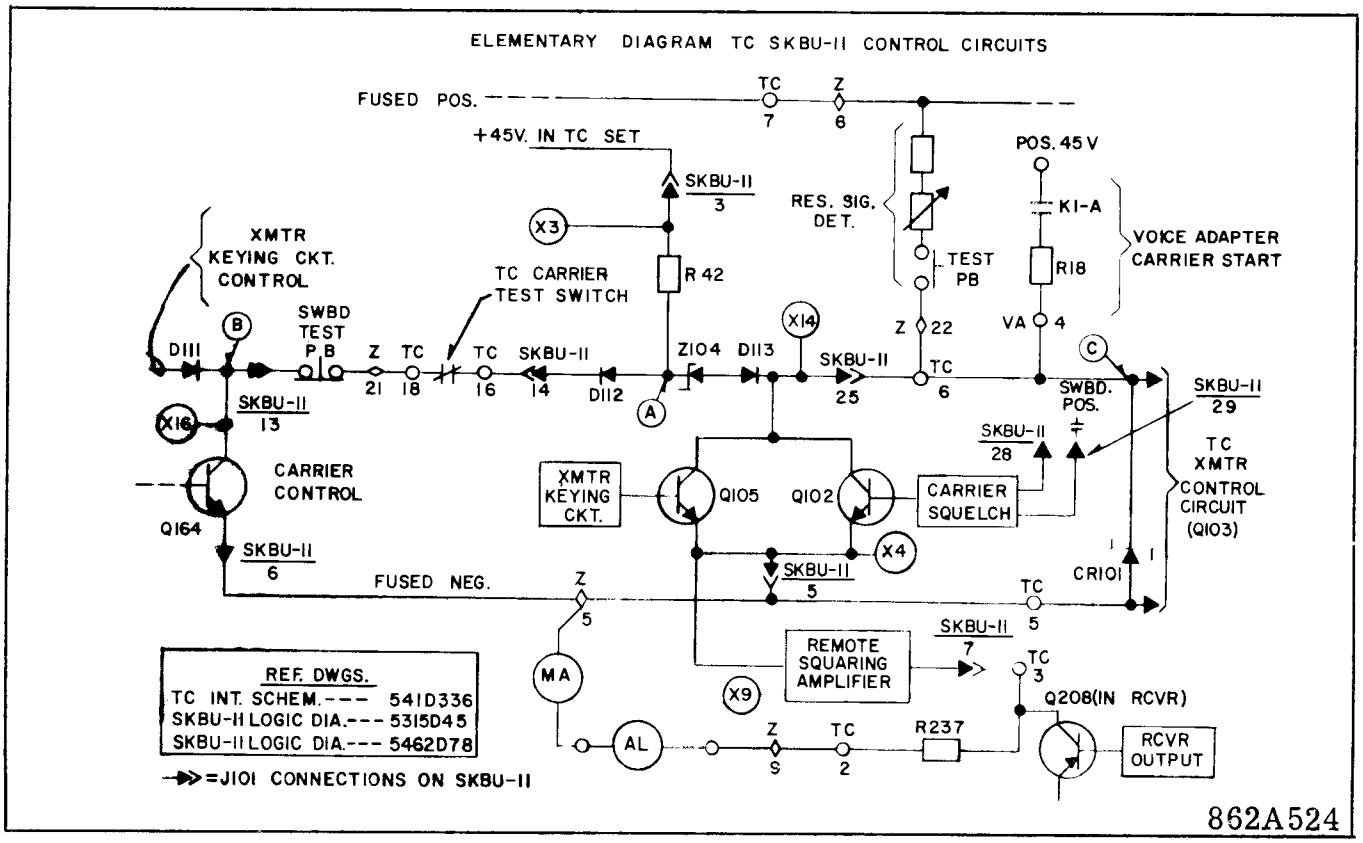


Fig. 18. Elementary Connection of TC SKBU-11.

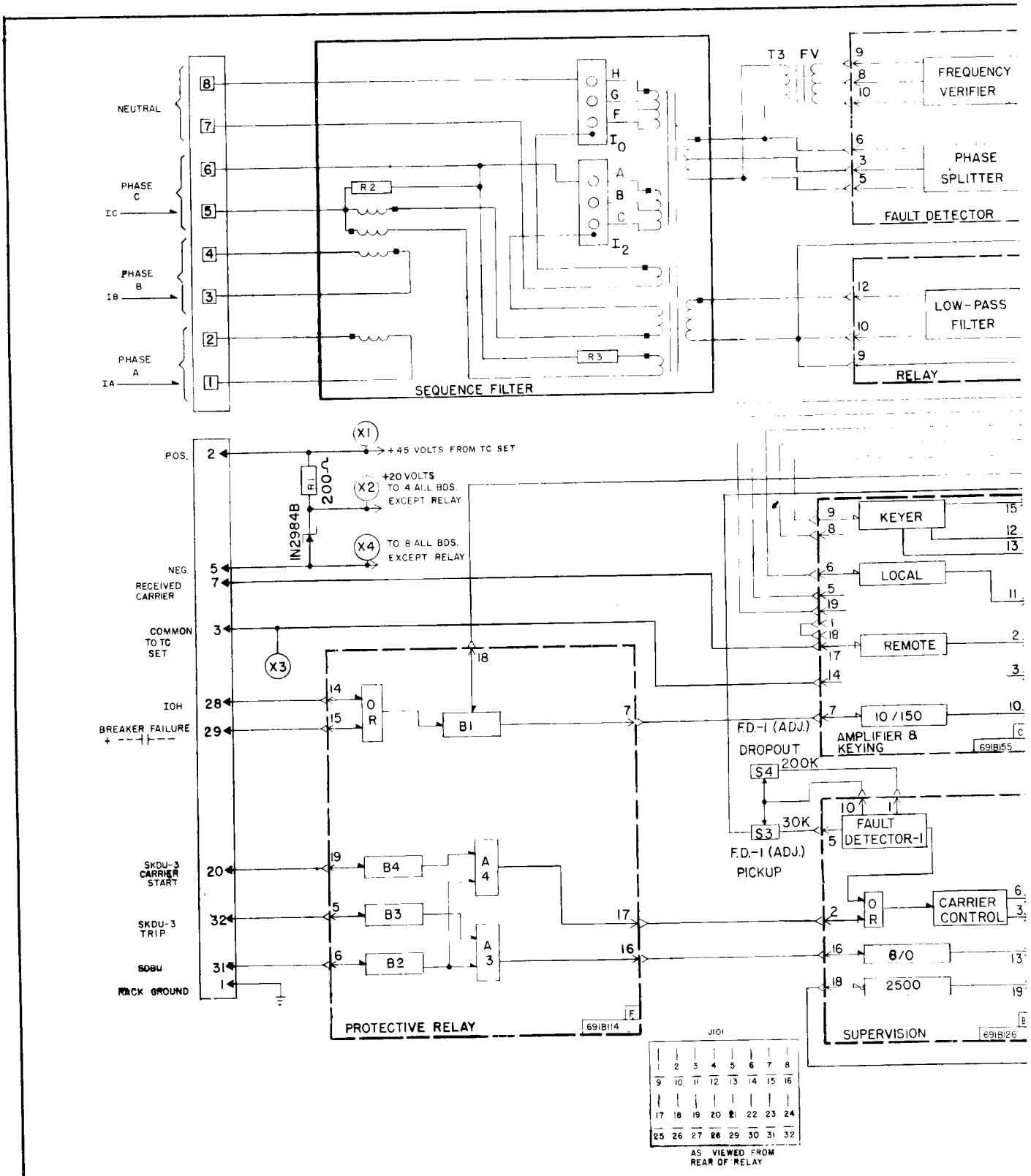
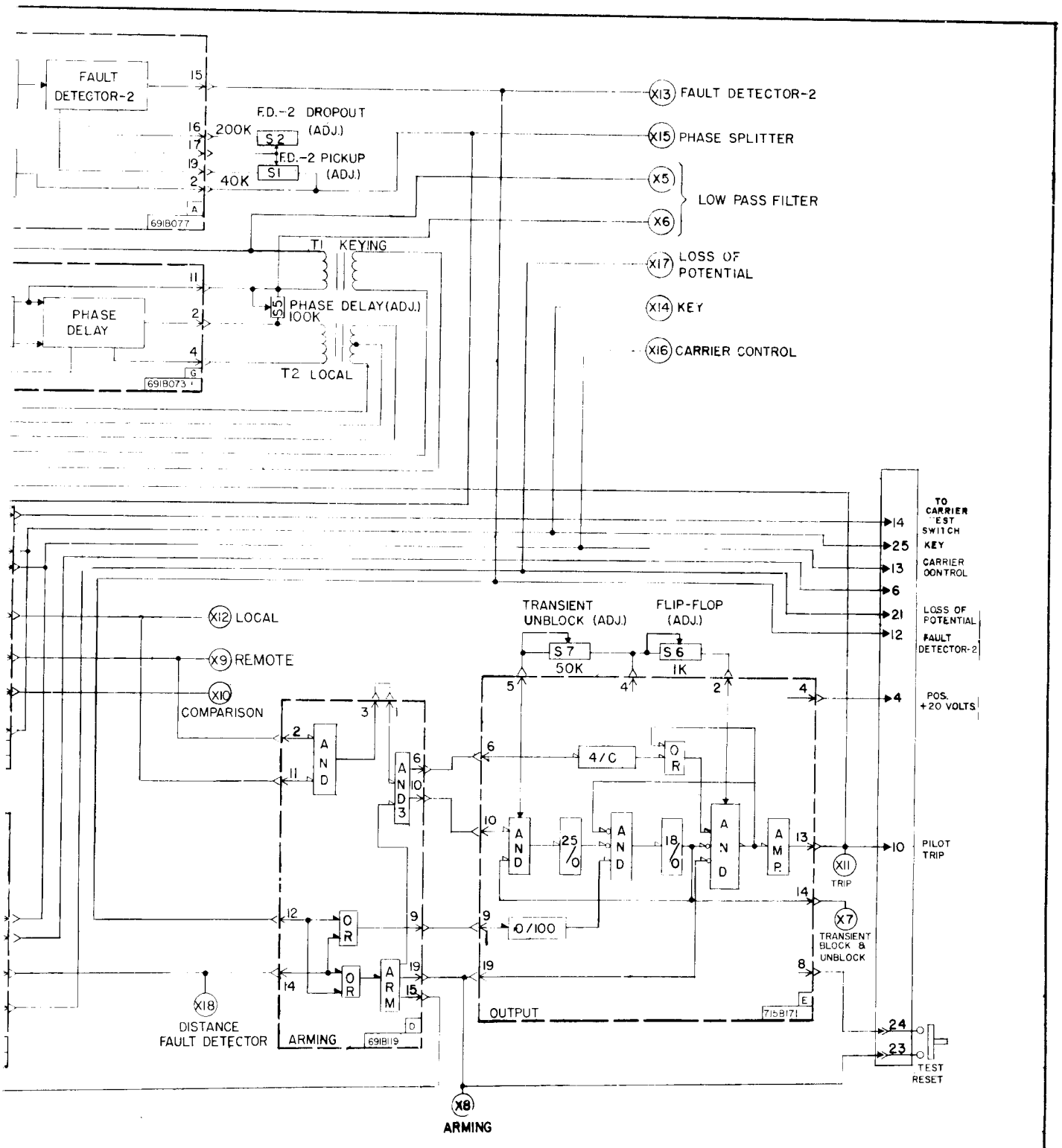


Fig. 20. Logic Diagram of SKBU-11 Relay fo



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Distance Phase Comparison System with Blinder Control.

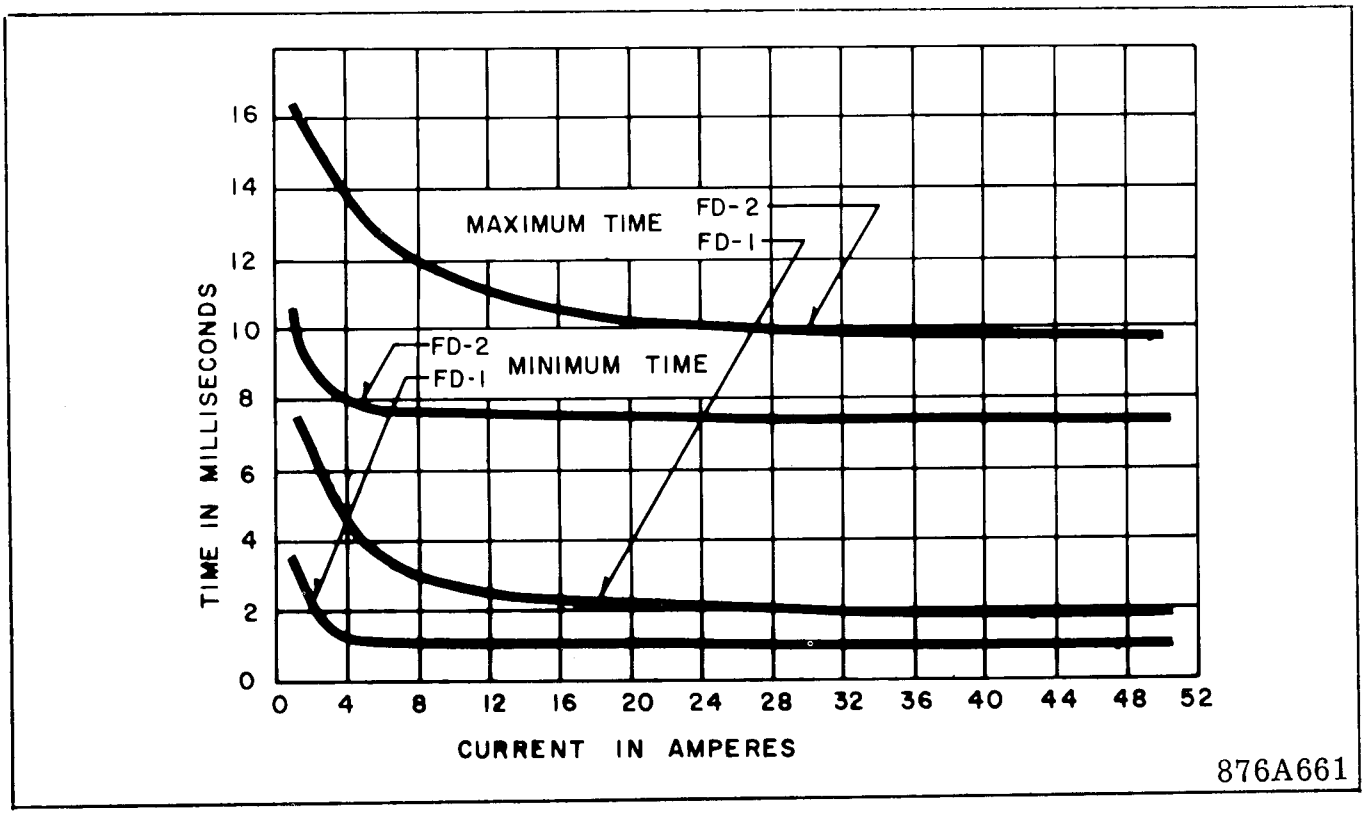


Fig. 21. Operating Times of Fault Detectors of SKBU-11 Relay.

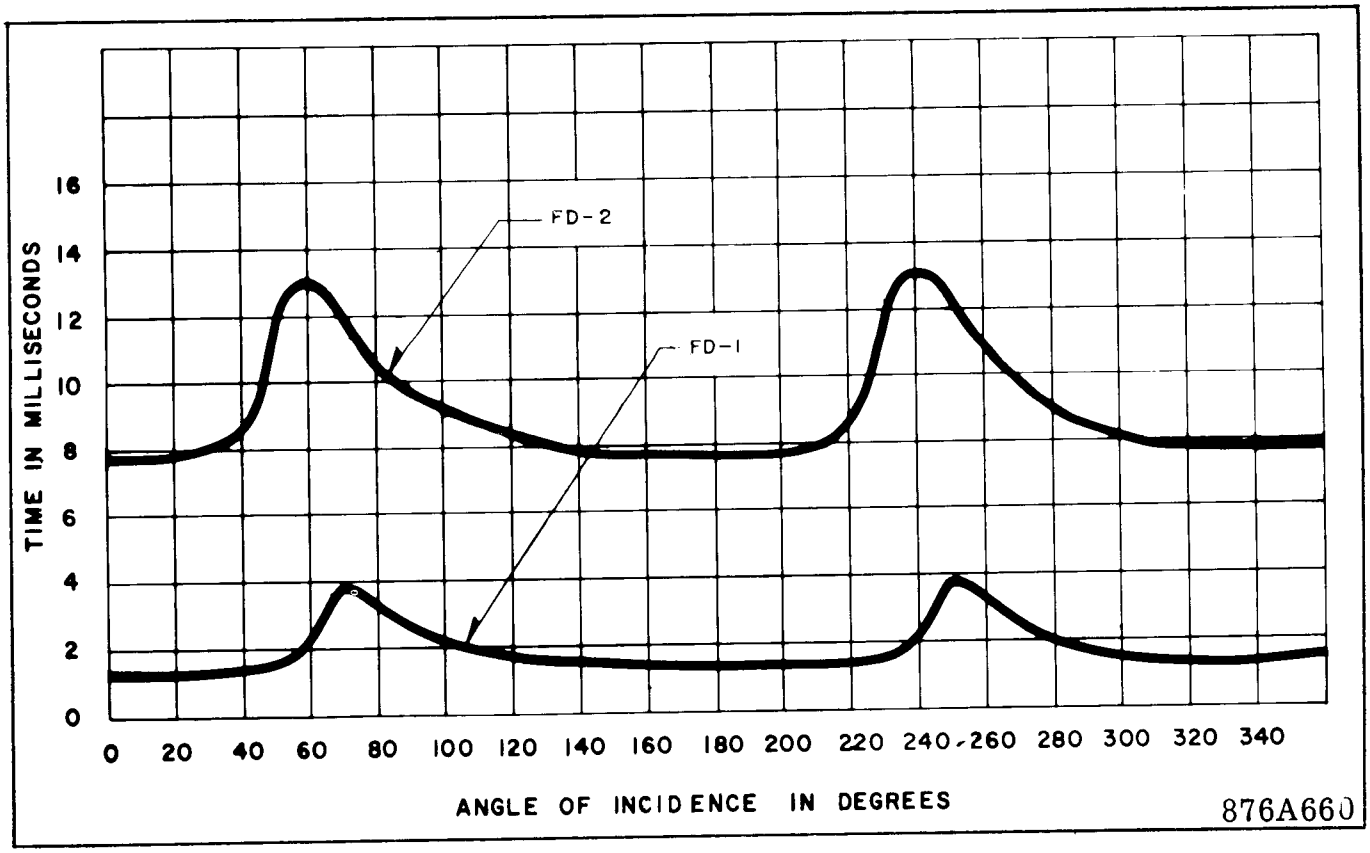


Fig. 22. Operating Time of Fault Detector of SKBU-11 Relay as a function of Fault Incidence Angle at 5 Amperes.

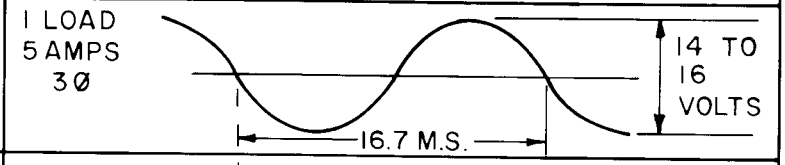
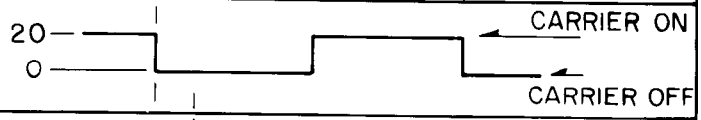
TEST POINT	CIRCUIT	VOLTAGE TO X4
X1	D.C. INPUT VOLTAGE	48 VOLTS D.C.
X2	REGULATED D.C.	20 VOLTS D.C.
X3	COMMON T.C.	45 VOLTS D.C.
X4	BATTERY NEGATIVE	———
X7	TRANSIENT BLOCK	NORMAL 20 VOLTS OPERATE 0 VOLTS
X8	ARMING	NORMAL 20 VOLTS OPERATE 0 VOLTS
X11	PILOT TRIP	NORMAL 0 VOLTS OPERATE 20 VOLTS
X13	FAULT DETECTOR	NORMAL 0 VOLTS OPERATE 20 VOLTS
X17	LOSS OF POTENTIAL	NORMAL 20 VOLTS OPERATE 0 VOLTS
X18	DISTANCE FAULT DETECTOR OPERATION	NORMAL 0 VOLTS OPERATE 20 VOLTS
X5 TO X6(GND)	LOW PASS FILTER	
X14	KEYING	
X12	LOCAL	
X9	REMOTE	
X16	CARRIER CONTROL	

Fig. 25. Table I Test Point Voltages.

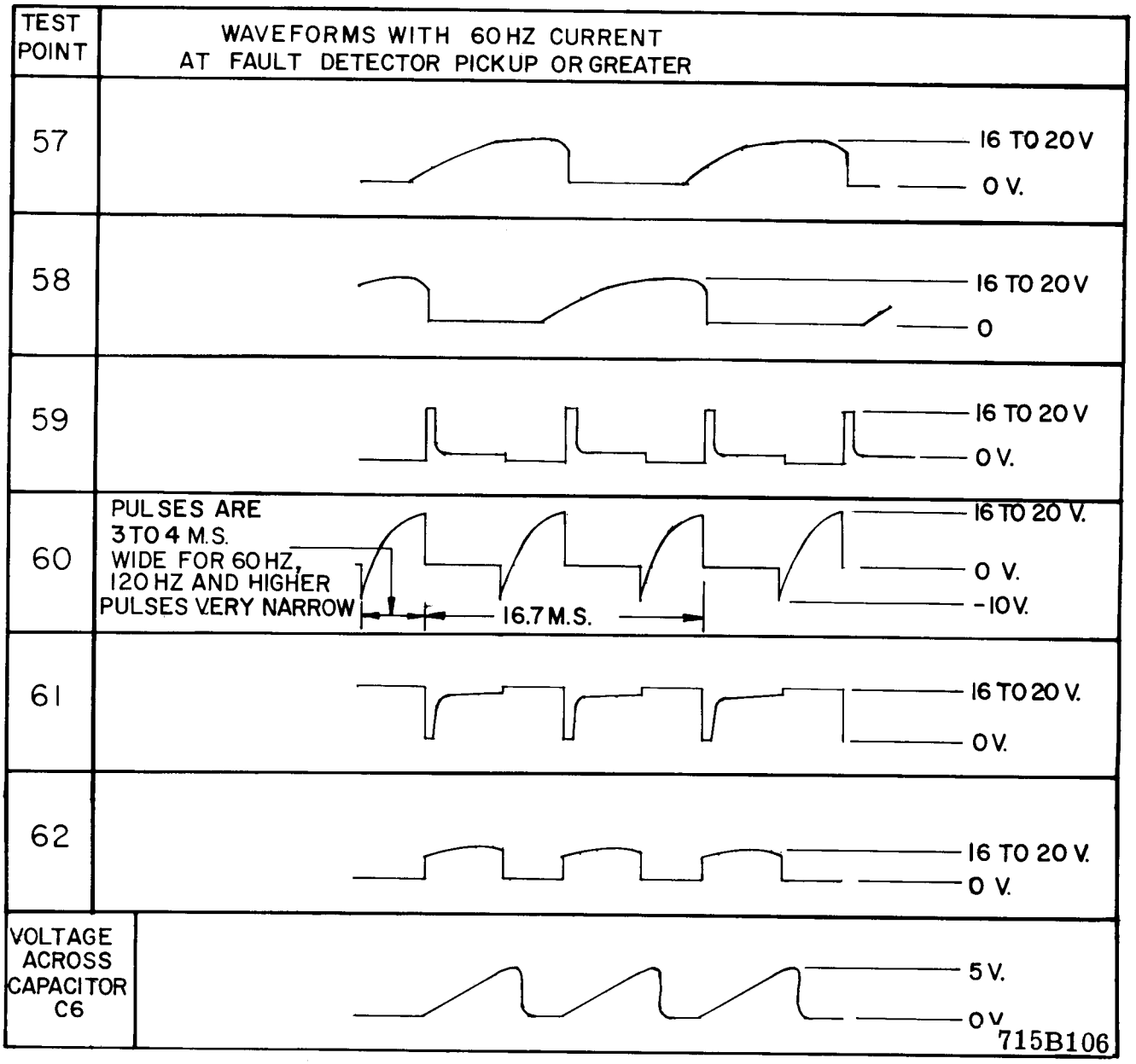


Fig. 26. Table III Frequency Verifier Waveforms at 60 Hz.

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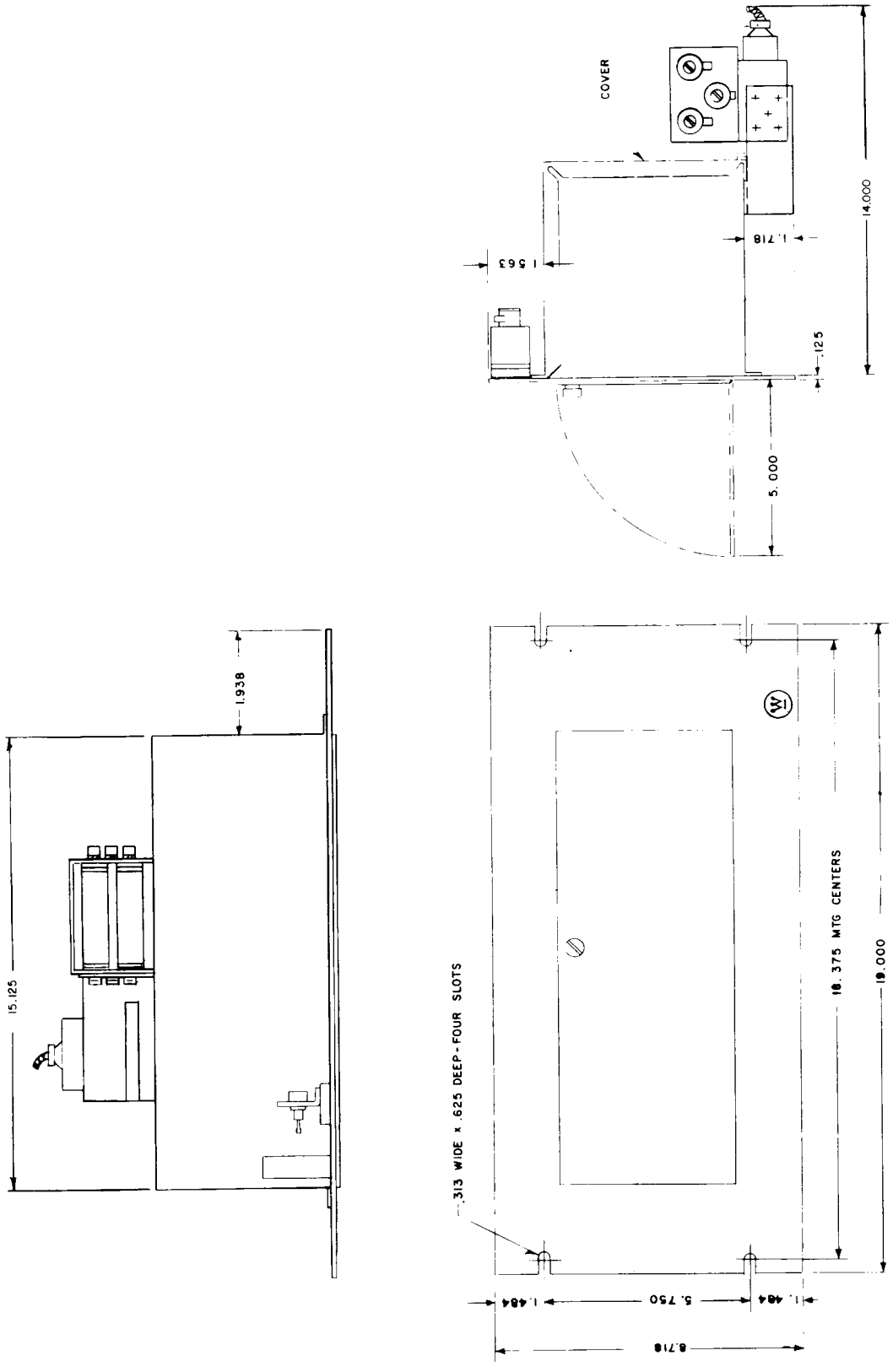

Fig. 27. Outline for Type SKBU-11 Relay.