INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE SKBU-21 PHASE COMPARISON RELAY FOR TYPE TA-2 FREQUENCY SHIFT TONE 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 system.

If the SKBU-21 is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The type SKBU-21 is a high-speed relay used in conjunction with frequency shift type channels. Simultaneous tripping of the relays at each line terminal is obtained in less than 32 milliseconds for all internal faults within the limits of the relay settings.

The system is applicable to a voice-grade pilot-wire or microwave channel.

In contrast to the carrier blocking scheme, this is a transfer-trip system; accordingly, the blocking-start function is not required.

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These instructions apply to SKBU-21 relays for application to the following relaying systems.

1. All distance supervision

2. Distance phase comparison

CONSTRUCTION

The type SKBU-21 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, 8-3/4 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-21 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-21 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, and the arming board varies 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 position in slotted guides at the top and bottom of each compartment and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block is keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the relay.

1. Fault Detector Board

The fault detector board contains a resistor-Zener diode combination, a phase splitting network, a solid-state fault detector, and a frequency verifier circuit. The controls for setting pickup (S1) and dropout (S2) of the fault detector are mounted on a plate in the front of the assembly. This unit operates when the fault current exceeds a definite value.

The location of components on the board is shown in Fig. 3 and the schematic of the board is shown in Fig. 4.

2. Arming Board

The arming board connects the outputs of the supervision board and the fault detector board to the final output of the relay. This board contains logic circuits that will arm the trip output, set up the time delay of the trip output, and start transient blocking on external faults.

The components of this board vary with the relaying system. The schematic of the board for the distance phase comparison system is shown in Fig. 6 and the schematic of the board for the all-distance supervision system is shown in Fig. 7. The difference in the two boards is that the distance phase comparison board has an additional resistor and diode on the board. The location of components is shown in Fig. 5.

3. Amplifier and Keying Board

The amplifier and keying board contains two local squaring amplifiers, a transmitter keying circuit, two remote squaring amplifiers, and a signal squelch circuit for each line terminal. The amplifier circuits produce the pulses that are compared by the AND circuits of the arming board to determine if the fault is external or internal.

The location of components on the board is shown in Fig. 8 and the schematic of the board is shown in Fig. 9.

4. Output Board

The output board contains a 4-millisecond pickup instantaneous dropout timer circuit, trip "AND" (flip-flop circuit), trip amplifier, transient blocking and unblocking circuits. The trip AND operates when all the inputs to the AND inputs of the arming board are of the correct polarity and the fault detector has operated. The transient blocking circuit operates after a time delay on external faults, and the transient unblock circuit operates after a time delay on a sequential fault (external fault followed by an internal fault). The following figures apply to this board: Fig. 10 Component Location; Fig. 11 Schematic of the board.

5. Relay Board

The relay board contains the phase delay circuit for shifting the local signals with reference to the remote signals. It also contains a low-pass filter, and a Zener clipper-resistor combination for protection of the solid-state circuits on the relay board.

The following figures apply to this board: Fig. 12 Component Location, and Fig. 13 for the schematic of the board.

6. Supervision Board

The circuits on this board vary with the relaying system. For all applications a 150 millisecond pickup and 15 millisecond dropout alarm timer circuit and a 2.5 second alarm circuit for fault detector operation are provided on this board. The circuits on the board are utilized to lockout the SKBU-21 relay for channel failure on the channel equipment. For tone channels a noise circuit is provided to lock out the SKBU-21 relay from information supplied by the tone equipment.

Because the board varies with the noise circuit of the channel equipment, the following figures apply to the board.

Type Channel	Location of Components	Schematic of Board
TA-2 with AM Squelch	Fig. 14	Fig. 15
TA-2 with TA-3 Noise Supervision	Fig. 16	Fig. 17

7. Protective Relay Board

The protective relay board contains logic circuits to connect the distance fault detectors, and squelch relays into the phase comparison portion of the relaying system. This board contains AND circuits, circuit buffer and OR circuits to connect the relays into the system.

For a distance phase comparison system Fig. 18 shows the component location of the board and Fig. 19 shows the schematic of the board. For an all-distance supervision system, Fig. 20 shows the component location of the board and Fig. 21 shows the schematic of the board.

Card Extender

A card extender (Style No. 644B315G02) is available for facilitating circuit voltage measurements of major adjustments. After withdrawing anyone of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all components and test points on the board are readily accessible.

Test Points

Test ponts are located on each printed circuit board for the major components on the board. Complete circuit test points are wired to the front of the relay for convenience in adjusting and testing the relay.

OPERATION

A. System

In phase comparison relaying, the phase positions of fault currents at the ends of a transmission line are compared over a pilot channel to determine if the fault is internal or external to the line section. When a frequency shift channel is used as the pilot channel, a dual comparison transfer-trip system can be utilized. This means that the system can trip on either half-cycle of power system frequency as contrasted to a blocking scheme where tripping occurs on alternate half-cycles during the absence of a carrier signal.

The three-phase line currents energize a sequence network in the SKBU-21 relay which produces two single-phase output voltages which are proportional to either the positive sequence current or the negative sequence current. The single-phase voltages are applied to saturating transformers one which energizes the fault detector circuit and the other energizes the keying circuit of the SKBU-21 relay. This circuit shifts the frequency of the transmitter from a space frequency to a mark frequency on alternate half-cycles of the power frequency current. These frequencies are transmitted over the pilot channel to the receiver which converts the mark and space frequencies to two D.C. output voltages, a space output that corresponds to the space frequency and a mark output that corresponds to the mark frequency. Thus, on each half-cycle of power system frequency either a space or mark output is obtained from the receiver and applied as pulses to the remote squaring amplifiers of the SKBU-21 relay. Each of these half-cycle pulses are compared with the phase positions of each half-cycle of the sine wave voltage from the sequence network of the SKBU-21 relay at the receiver terminal. The space pulse is compared to one half-cycle of the voltage and the mark pulse to the other half-cycle. If the local and remote half-cycle pulses are of the correct phase positions for an internal fault, after a fault detector operation, 4 milli-second tripping will be initiated through operation of the trip "AND" and trip amplifier circuits.

Current transformer connections to the sequence networks at the two line terminals are such that the space and mark pulses are in phase with their respective local pulses during an internal fault to allow tripping. However, if the fault is external to the protected line section, the space and mark pulses are out-of-phase with their respective local pulses and tripping does not occur.

The four-millisecond delay previously mentioned is added to allow for differences in current transformer performance at opposite line terminals and relay coordination.

B. Relay

With reference to the logic diagram that applies to the particular relay, the three-phase line currents energize a sequence filter that produces two single-phase voltages: One voltage proportional to the positive sequence current, and the second voltage proportional to the negative sequence current. These voltages are applied to two mixing transformers which have zero sequence windings on them. The output of the two transformers are applied to two separate board:

1. Output from one transformer to the fault detector board.

2. Output from the second transformer to the relay board.

These transformers and a Zener clipper connected across their secondaries are used to limit the voltage impressed on the solid state circuits, thus providing a small range of voltage for a large variation of fault currents.

With reference to the schematic Dwg. of Fig. 4, the A.C. voltage from one mixing transformer is applied to a phase-splitting network (C52, R52, R53) and a polyphase rectifier (diodes D51 to D56). The D.C. voltages so obtained are applied to the fault detector circuit which operates when the D.C. input "signal" exceeds a predetermined value.

Fault Detector

Under normal conditions, transistor Q51, has no base "signal" and is turned off. The collector of Q51 is at a high enough positive potential to provide base drive for transistor Q52, driving it to full conduction. With Q52 fully conducting there is no base drive to transistor Q53 and Q53 is turned off. With no Q53 collector current, the base of transistor Q54 is supplied from the 20-volt source. Thus the Q54 emitter is normally at a slightly lower potential than its base. This condition keeps transistor Q54 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 Z52, a positive bias is applied to Q51 base causing it to conduct. In turn, Q52 stops conducting, and capacitor C54 charges, giving a few milliseconds time delay before Q53 and Q54 are switched to full conduction, thus "closing" the fault detector. When the fault detector operates, a positive output is applied to the arming board at terminal 12. Resistors R66 and S2 increase the voltage to Z52 to allow the fault detector to drop out at a high dropout ratio when the A.C. current is reduced.

<u>Frequency Verifier</u>

During certain switching conditions, such as energization of a transmission line, residual currents and voltages may exist of higher frequencies than 60 cycles per second. The frequency verifier prevents fault detector operation when frequencies 120 cycles or higher are encountered during the switching conditions. The frequency cerfier circuit consists of two functional parts: Zero-crossing and commutator circuits. With reference to Fig. 4, the zero-crossing circuit consists of Q55, Q56, Q57, and Q58. The commutator circuit consists of Q59, Q60, C9, C59 and Q61.

During the positive or negative half-cycles of the output voltage from the saturating transformer, Q55 or Q57 transistors are driven into saturation by the output of the FV transformer. Transistors Q56 or Q58 conduct until capacitors C56 or C57 respectively are fully charged. While either capacitor charges a voltage output in the form of very narrow pulse is developed across R76 and R78 resistors during the start of each half-cycle. This pulse triggers Q59 control switch. When transistors Q55 or Q57 are not conducting,C56 and C57 capacitors discharge respectively through D66 or D62 and the parallel combination of R73 and R74 or R69 and R70.

While Q59 is "on" its anode is only about 0.7 volts above negative, thus turning off transistor Q62 to allow capacitor C60 to start charging. However, a shorter time delay (consisting of R84, the capacitor C59 and the reference Zener diode Z54) or 4.3 milliseconds is also started. After 4.3 milliseconds of delay, the control switch Q60 fires applying the voltage of capacitor C88 across Q59 turning it off. This raises the potential of the Q59 anode to turn on Q62 to discharge C60 before the charge reaches a value to break down Z55 to turn on Q63. After the next zero-crossing pulse Q59 switch is turned on again, and the Q60 switch is turned off by capacitor C58. Transistor Q61 when turned on by the same voltage that fires the gate of Q59, discharges timing capacitor C59, thus starting the timing cycle with close to zero charge on the capacitor. If the zero-crossing period of the FV voltage is less than 4.3 milliseconds, the Q61 transistor discharges the timing capacitor thus preventing the turning off of Q60 switch. This keeps Z59 switch on to allow C60 to charge to a value to break over Zener diode Z55 to turn on Q63. Turning Q63 prevents Q53 of the fault detector from turning on thereby preventing Q54 from turning on to prevent an output from the fault detector.

2. Relay Board

With reference to Fig. 13, the A.C. voltage from the second mixing transformer is applied to the phase delay circuit through a low pass filter of the relay board. The low pass filter (C201, L201, C202) removes the harmonics from this voltage and applies a voltage that is essentially sinusoidal in waveform to R202 and R203 of the phase delay circuit. By means of capacitor C203 and variable resistor S5, the voltage across terminal 4 and 2 can be made to lag the voltage across terminal 10 and 11 by a definite amount depending on the setting of S5. Each of these two voltages are applied to separate isolating transformers.

1. Undelayed voltages to a keying transformer (T1)

2. Delayed voltages to a local transformer (T2)

A. Keying Circuit

With no A.C. output (Ref. Fig. 9) voltage from the sequence network, base current does not flow into transistor Q103. The collector of Q103 is at positive potential which allows base current to flow from positive 20 volts D.C. through the base of Q104 through R111 and R112 to negative. This applies negative potential to the collector of Q104 to prevent base current from flowing to Q105. Since Q104 is conducting, transistor Q105 does not conduct and the collector of Q105 is held at positive potential.

When a sinusoidal voltage is applied to the keying transformer (T1), the transformer steps up the voltage applied to terminals 9 and 8 of the amplifier and keying board. On the positive half-cycle of voltage, terminal 8 is more negative than terminal 9 and transistor Q103 does not conduct. In turn, Q104 remains conducting and Q105 does not turn on. On the negative half-cycle of sine wave voltage from the keying transformer, terminal 9 is more positive than terminal 8 and base current flows into Q103. This turns Q103 on which applies negative potential to the collector of Q103. Base current to transistor Q104 is stopped and Q104 stops conducting, and its collector goes to positive potential. Positive potential is thus applied to the base of Q105 through R114 and R115 to turn on Q105. When Q105 conducts, its collector is connected to negative potential. Thus on alternate half-cycles of the 60-cycle voltage from the low pass filter, Q105 turns on. By connecting Q105 through the proper interface to the channel transmitter, turning on Q105 keys the transmitter to a mark condition.

B. Local Squaring Amplifiers (1 and 2)

There are two identical local squaring amplifiers in the SKBU-21. One is turned on and off by the positive half-cycle of voltage from the local transformer (T2) while the other one is turned on and off by the negative half-cycle of voltage from the transformer. The square wave output voltages are, therefore, functions of the A.C. voltage input to the amplifiers. The polarity of the outputs of the two amplifiers are such that one amplifier has an output when the other one does not when A.C. voltage is applied to the squaring transformer.

With reference to amplifier number 1 of Fig. 9 with no A.C. input voltage, Q106 is not conducting and the collector of Q106 is at positive potential. This applies base current to transistor Q107 through R120 and R121 such that Q107 is turned on. This applies negative potential to the collector of Q107 to allow base current to flow in Q108. Q108 turns on to apply positive potential across R125.

With the application of a sine wave voltage to terminal 6 and 19 of the amplifier and keying board, on the positive half-cycle of the voltage, the base of transistor Q106 is more positive than the emitter and Q106 (amplifier 1) conducts, and Q110 (amplifier 2) is turned off. On the negative half-cycle of the a.c. voltage, Q106 is turned off and Q110 is turned on. Therefore, Q106 is conducting on the positive half-cycle of voltage and Q110 is conducting on the negative half-cycle of A.C. voltage. Turning Q106 on, puts negative potential on the collector of Q106 and turns off transistor Q107. Transistor Q107 stops conducting and its potential goes to a positive potential which turns off Q108 to place its collector at a negative potential. Thus the output of the squaring amplifiers square wave voltages ranging from 0 volts D.C. to 20 volts D.C. depending upon the polarity of the voltage from the phase delay circuit.

Amplifier 2 is the same as amplifier number 1 except it is supplied by the opposite polarity of sine wave voltage from the local transformer (T2) at terminals 19 and 6 of the amplifier and keying board. The output voltage from the amplifier appears across R138. By applying the same analysis of amplifier 1 to amplifier 2, the output voltage across R138 is a square wave voltage of the reversed polarity than that across R125.

C. Remote Squaring Amplifiers

As shown in Fig. 9, there are two remote squaring amplifiers in the SKBU-21. One amplifier is to connect the space output of the receiver to the SKBU-21 while the other is to connect the mark output of the receiver to the SKBU-21 relay. The space squaring amplifier consists of transistor Q109 on the amplifier and keying board in conjunction with an interface circuit of Q167 on the supervision board. The mark remote squaring amplifier consists of Q113 on the amplifier and keying board and interface transistor Q165 on the supervision board.

The remote squaring amplifiers are in one of three states:

1. Loss-of-channel state
2. Receiving space frequency only
3. Receiving alternate half-cycles of space and mark frequency.

For a loss of a tone channel, the receiver clamps its output to a mark condition. The space output from the receiver is zero with respect to the positive source. This means that transistor Q167 (on the supervision board) is not conducting. Base drive to transistor Q109 is provided from positive source through R131 to negative. Q109 is turned on to provide a positive 20 volts across R129. When the channel is in service and the receiver is in a space condition, transistor Q167 is turned on. This applies source voltage through R130 and diode D106 to R131. The potential of the base of transistor Q109 is raised higher than its emitter; hence, transistor Q109 stops conducting and the voltage across R129 is -20 volts. For the condition where the receiver is receiving pulses, transistor Q167 (on supervision board) turns on and off for the same half-cycle and the voltage across R129 is a square wave voltage varying from zero volts to a -20 volts D.C.

For either internal or external fault conditions the outputs of both remote squaring amplifiers are square wave voltages. Both voltages vary from zero volts to approximately -20 volts D.C. and are out of phase with each other; i.e., when one voltage is at zero volts the other voltage is at -20 volts.

3. Arming Board

The phase relationship of the outputs of the local and remote squaring amplifiers are compared by the two AND circuits of the Arming Board. One AND circuit (number 1) compares the space signal with the output from local squaring amplifier number 1. The second AND circuit (number 2) compares the mark signal with the output of local squaring amplifier number 2. Since the local signals are always 180 degrees out-of-phase with each other, and the remote signals are always 180 degrees out-of-phase with each other, a change in phase angle of one signal with respect to the other 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 and Amplifier 2 such that their outputs are in phase with the remote signals. This means that AND 1 has a half-cycle of negative voltage and that AND 2 has a half-cycle of negative voltage (not the same half-cycle). The period of each negative voltage will be 180 degrees out-of-phase with reference to each other and a negative voltage will be produced out of the OR circuit of the arming board. 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 the OR circuit. The second condition to activate the AND is provided by arming the SKBU-21.

In either Fig. 22 or 23, for a distance phase comparison system, arming occurs through either the operation of the distance fault detectors or the operation of the SKBU-21 fault detector. 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 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-21 relay. For an all-distance supervision system, arming occurs through operation of the distance fault detectors only. As shown in either Fig. 24 or 25, the operation of the distance fault detector applies the voltage to the ARM logic of the arming board to activate AND 3.

B. <u>External Fault</u>

Under external fault conditions, the square wave voltages from the remote squaring amplifiers and the square wave voltages from the local squaring amplifiers are out-of-phase such that zero input is being received on the AND circuits of the arming board. The output from local 1 and remote 3 are out-of-phase to prevent tripping on AND 1 and the outputs from local 2 and remote 4 are out-of-phase to prevent tripping on AND 2. As a result, the outputs of these AND circuits 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 negative input from the 0/100 timer the three conditions of transient block are fulfilled--not a negative voltage from the TRIP AND; 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 AND 1 and AND 2 of the arming board will reverse such that a negative output is obtained from these AND circuits. This output energizes the OR circuit which negates the signal to a negative signal. The negative signal...

1. Provides a second input to AND 3, and the 4/0 timer times out to apply a negative input to the TRIP AND.

2. Applies a negative input to the AND of the transient unblock circuit to fulfill the requirements to obtain an output from the transient unblock circuit.

As a result, a negative input is applied to the unblock timer. Eighteen milliseconds later, the unblock timer will operate 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-21 relay.

D. Protective Relay Operation

The SKBU-21 relay is armed by the distance fault detectors through a 6/0 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-21 relay, and they vary with the application of the relay and the type of equipment used as a pilot channel. In general, though, this board contains a low signal clamp timer and an arming timer.

A. Low Signal Clamp (.5/150 Timer)

With a serviceable channel either a space frequency or an alternate space-mark frequency is received from the channel equipment. With reference to Fig. 15 or 17, Q167 of the supervision board is either turned on or is turned off. With Q169 turned on, base current is supplied to transistor Q158 and Q158 conducts. The collector of Q158 is thus at negative potential and capacitor C155 cannot charge.

If the channel is not serviceable, the tone receiver is clamped into a mark condition and the space output is zero. Transistor Q167 does not conduct and transistor Q158 is turned off. Positive potential is applied to capacitor C155 through resistor R177. After a 150 millisecond time delay, capacitor C155 charges sufficiently to break down Zener diode Z154. When Z154 conducts, base drive is supplied to transistor Q159 and Q159 turns on. This connects the collector of Q159 to negative potential which allows base current to flow in transistor Q160 through R181. This turns on transistor Q160 to apply positive voltage to R183. This voltage is then applied to AND 2 of the arming board and to an alarm output. Applying the voltage to

AND 2 blocks tripping.

Under the conditions of alternate mark and space outputs from the tone receiver, transistor Q158 is turned on and off every 8.3 milliseconds (half-cycle of power system frequency). Every half-cycle, capacitor C155 starts to charge but on the next half-cycle Q158 turns on to discharge capacitor C155. Since the charging time is not sufficient to allow capacitor C155 to break down Z152, transistor Q159 will not turn on to block tripping.

B. Loss-of-Potential Alarm (2500 Timer)

When arming occurs on the SKBU-21, negative potential is removed from terminal 18 of the supervision board. This applies positive potential to capacitor C152. Two-and-a-half seconds later, the potential on C152 breaks down the Zener diode Z152 to allow base current to flow into Q154. This turns on Q154 which turns off Q155. Turning Q155 off applies positive potential to the base of Q156 and Q156 turns off. This removes positive potential from R170 and an external alarm is energized.

C. Arming Delay by Distance Fault Detectors (6/0 Timer)

The distance supervision arming is delayed by 6 milliseconds to allow time for the circuits feeding AND 1 and AND 2 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 when positive potential is applied to capacitor C151. Six milliseconds later the voltage on C151 reaches a value to break down Zener diode A151. 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.

D. Noise Supervision for a TA-2 Tone Channel with AM Squelch

The noise supervision interface of the SKBU-21 relay for a TA-2 tone channel with AM squelch consists of transistors Q166, Q161, Q162, and associated components. Under normal conditions, the output from the noise circuit of the tone channel is zero volts. As a result, transistor Q166 is not conducting and base current is not supplied to transistor Q161. Transistor Q161 is turned off and its collector is held at positive potential to prevent base current from flowing in transistor Q162 and negative voltage (across R158) is applied to AND 1 and AND 2 of the arming board.

Under noise conditions the noise circuit of the tone equipment provides a negative output with respect to positive 48 volts D.C. This negative voltage allows transistor Q166 to turn on and provides base current to Q161 through resistor, R187. Transistor Q161 turns on, and its collector is connected to negative potential. Base current then flows in transistor Q162 through resistor, R188, and Q162 turns on. Positive potential is applied to resistor, R190 and to terminal 5 and 1 of the supervision board. From terminal 5, the voltage is applied to AND 1 and AND 2 of the arming board to block tripping. The voltage on terminal 1 is applied to an external alarm.

The noise supervision interface of the SKBU-21 relay for a TA-2 tone channel with a TA-3 noise supervision is the same as above except Q166 is omitted.

CHARACTERISTICS

The type SKBU-21 relay is available for a frequency shift tone channel. Taps are available to set different sensitivities of the fault detector 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 positive sequence response of the fault detector is greater than 7 amperes.

The operating time of the fault detector is shown in Fig. 24. 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 25 shows the operating times for different points on the fault wave for fault current at five amperes.

The keying response of the SKBU-21 relay is independent of the tap setting. Figure 26 shows typical lengths of keying pulses with reference to a 60-cycle base of the SKBU-21 relay for different values of positive, negative, and zero sequence current.

Operating time	15 to 32 Milliseconds
Alarm Times	2.5 seconds for FD Operation 150 Milliseconds Loss-of-Channel
Transient Block Time	18 to 20 Milliseconds
Transient Unblock Time	25 to 30 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 a fault detector has operated	100 Milliseconds
2. When Unblock time is Utilized	Instantaneous

ENERGY REQUIREMENTS

Burdens atbalanced three-phase currents 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 VA	Phase A Angle	Phase B VA	Phase B Angle	Phase C VA	Phase C Angle
C-H	11.7	2.1°	9.7	1.8°	44.	2.2°
B-H	11.4	2.1°	10.3	1.8°	46	2.2°
A-H	11.1	2.0°	11.2	1.8°	48	2.2°
C-G	8.8	2.0°	7.0	1.8°	42	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	2.2°
C-F	6.7	2.0°	7.5	1.8°	42	2.2°
B-F	6.5	2.0°	7.2	1.8°	42	2.2°
A-F	5.8	2.0°	6.6	1.8°	43	2.2°

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

SETTINGS

The SKBU-21 relay has separate tap plates for adjustment of the zero and negative sequence sensitivity of the fault detector. The fault-detector tap markings and pickup 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 one 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 and 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 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	I2 Tap	I0 Tap
1	C	F
2	B	F
3	B	H
4	B	G

INSTALLATION

The SKBU-21 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-21 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-21 relay is not a part of a relaying system, the following procedure can be followed to verify that the circuits of the SKBU-21 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 points.

ACCEPTANCE TEST

Connect the relay to the test circuit of Fig. 27 which represents the tone 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 $\pm$ 5%.

2. FD 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_{22} and X_4 (neg.)

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

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

3. Check of Local Squaring Amplifiers

a. With all switches of test circuit open, apply 0.6 to 0.8 amperes A.C. to terminals 3 and 5 of the relay.

b. Place scope probe across X12 and X4 (grd). A square wave of voltage should appear across X12 and X4 as shown in Table I.

c. Place scope probe across X15 and X4 (grd). A square wave of voltage should appear across X15 and X4 as shown in Table I.

d. If scope has two traces, connect one probe to X12 and second probe to X15. Connect grd. of scope to X4. The phase relationship of Table I should be observed.

4. Check of Keying Circuit

a. With all switches of test circuit open and 0.6 to 0.8 amperes A.C. applied to terminal 3 and 5 of the relay, with scope check voltage across X14 and X4 (grd).

b. Waveform shown in Table I should be observed.

5. Check of Remote Squaring Amplifiers

a. Close switches A, B, and C of test fixture.

b. Apply 0.6 to 0.8 amperes A.C. to terminals 3 and 5 of the SKBU-21 relay.

c. Using scope with grd. lead on X4, check waveshape of voltage across X9 and then X16. Waveforms of Table I should be observed.

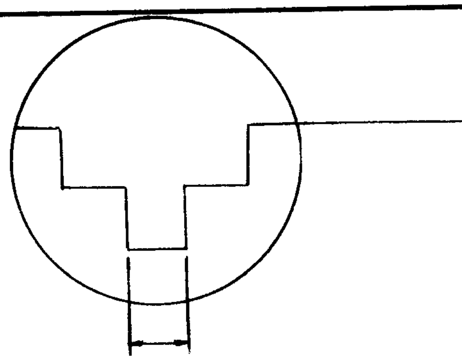
d. If scope has two traces, connect one probe to X9 and the other on X16. Connect grd. to X4. With scope set on chopped, the phase relationship of Table I should be observed.

6. Setting of S5 and S6

a. Set S5 to minimum resistance and S6 to maximum resistance (fully clockwise).

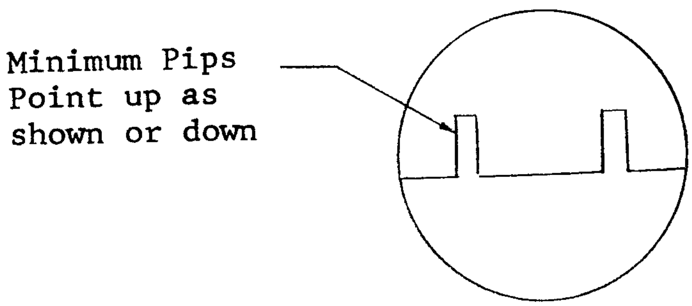
b. Set switch L to external fault and close switches A, B, and C of the test circuit. Apply 0.6 to 0.8 amperes A.C. to terminals 3 and 5 of the SKBU-21 relay.

c. Connect scope across X10 and X2 (grd). Adjust S5 until following waveform appears on scope.



d. Adjust S6 until the relay trips as determined by an increase in voltage across X_{11} to X_4 from zero to approximately 20 volts. This sets the triggering of the flip-flop after a 4 millisecond delay.

e. Slowly increase S5 to obtain the following waveform. This will be with S5 at or near minimum resistance.



7. Transient Blocking Delay (18/0 and 0/100 Timer)

a. Connect electronic timer stop to X7 and X4 (grd). Set timer stop on negative going pulse.

b. Connect timer start to X22. Set timer start to positive going pulse.

c. Apply 0.6 to 0.8 amperes A.C. to terminals 3 and 5 of the SKBU-21 relay. Measure time for voltage to drop from 20 volts to approximately zero volts. This should be between 16 and 20 milliseconds.

d. Set timer start on a negative pulse and timer stop on a positive pulse.

e. De-energize relay. Timer should start and should stop after a time delay of 80 to 135 milliseconds.

8. Check of Transient Unblocking Circuit

a. With electronic timer stop connected to X7 and X4 (grd), set timer stop on positive going pulse.

b. Connect timer start to timer start contacts of switch L. Set L on external fault, and close other switches of test circuit.

c. Apply 0.6 to 0.8 amperes A.C. into terminal 3 & 5 of the SKBU-21 relay.

d. Close switch L to internal fault, timer should start and should stop after a time delay. Time should be 16 to 20 milliseconds.

9. Loss of Channel Timer (.5/150)

a. With electronic timer stop connected to X19 and X4 (grd), set timer stop on positive pulse.

b. Connect timer start to start contacts fo switch C. Set time start to break.

c. Close switch C.

d. Open switch C. Timer should start and should stop after 130 to 170 milliseconds.

10. Alarm on Relay Operation (2.5 Seconds)

a. With electronic timer stop connected to X20 and X4 (grd), set timer stop on negative going pulse.

b. Connect timer start to X22. Set timer start on negative pulse.

c. Apply 0.6 to 0.8 amperes A.C. to terminals 3 & 5 of SKBU-21 relay.

d. Timer will start and should stop after 2.3 to 2.7 seconds.

11. Signal Squelch Time (10/150)

a. Connect timer stop to X14 and X4 (grd). Connect a jumper from TP102 to terminal 8 of the amplifier and keying board. This turns off Q104 to turn on Q105.

b. Connect timer start to switch 28. Set timer start on positive pulse. Connect timer stop on positive pulse.

c. Close switch 28. Timer will start and will stop after a 8 to 12 millisecond delay.

d. Set timer stop on negative pulse, and timer start to negative pulse.

e. Open switch 28. Timer should start and stop after a time delay of 125 to 185 milliseconds.

12. Check of Noise Circuit

a. Connect D.C. voltmeter to X17 and X4 (grd). Voltage must read zero.

b. Close switch D. Voltage must rise to 20 volts.

13. Check of Frequency Verifier

a. Open all switches of test circuit.

b. Connect scope across TP60 and terminal 8 of the FD board.

c. Apply 0.6 to 0.8 amperes to terminal 3 & 5 of SKBU-21 relay.

d. Wave form of Fig. 29 should be observed.

TROUBLE SHOOTING PROCEDURE

To trouble shoot the equipment, the logic diagram voltages of Table I should be used to isolate the circuit that is not performing correctly. The schematic of the individual board, and the voltages of Table II should then be used to isolate the faulty component.

TABLE II

VOLTAGE MEASUREMENTS ON PRINTED CIRCUIT BOARDS

1) 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.)
Terminal 5-6	0	15 volts a.c. (Approx.)
TP 57	18 volts	Pulses see Table II for Waveform
TP 58	18 volts	
TP 59	less than 1	
TP 60	20 volts	
TP 61	18 volts	
TP 62	less than 1	

2. Supervision Board

Test Point	Normal Condition	Abnormal Condition
Term 16	12	less than 1 with DFD Operation
TP151	less than 1	7 " " "
TP152	20	less than 1 " " "
Term 13	less than 1	20
Term 18	less than 1	15 with arming
TP153	15	less than 1 " "
TP154	less than 1	20 " "
Term 19	20	less than 1 " "
Term 17	*48 VDC(receiving space)	less than 1 with loss of channel
TP155	*less than 1 (receiving space)	18 with loss of channel

Supervision Board (Cont'd.)

Test Point	Normal Condition	Abnormal Condition
TP156	20(receiving space)	less than 1 with loss of channel
Term 11	less than 1	20
TP157	less than 1	46 with noise clamp
TP158	20	less than 1 with noise clamp
Term 1	less than 1	20 with noise clamp
Term 15	*less than 1	46 with loss of channel

* Normal condition could be square wave pulses

Amplifier and Keying

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

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 the repair work. When ordering parts, always give the complete nameplate data. For components mounted on the printed circuit board, give the circuit symbol and the electrical value (ohms, mfd, etc.) and component style number.

ELECTRICAL PARTS LIST

Fault Detector Board Style 5312D13G01

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
	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

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE STYLE NUMBER
	Resistors	
R51	50 Ohms, 5W	185A209H06
R52-R68-R71	2.7K Ohms 1/2W	629A531H42
R53 (POT)	2.5K Ohms 1/2W	629A430H03
R54-R55-R58-R62 R64-R66-R84-R89-R92	10K Ohms 1/2W	629A531H56
R56-R60	100K Ohms 1/2W	184A763H75
R57	47K Ohms 1/2W	629A531H72
R59	56K Ohms 1/2W	1 4A763H69
R61-R87	22K Ohms 1/2W	629A531H64
R63	6.8K Ohms 1/2W	629A531H52
R65	27K Ohms 1/2W	629A531H66
R67	150K Ohms 3W	762A679H01
R69-R73	68K Ohms 1/2W	629A531H76
R70-R74-R88	39K Ohms 1/2W	629A531H70
R72-R75-R80	2K Ohms 1/2W	836A503H33
R76-R78-R90	1K Ohms 1/2W	629A531H32
R77	5.6K Ohms 1/2W	629A531H50
R81	20K Ohms 1/2W	629A531H63
R82	1.5K Ohms 1/2W	836A503H30
R83-R91	470 Ohms 1/2W	629A531H24
R85	4.7K Ohms 1/2W	629A531H48
	Zener Diodes	
Z51	1N1832C, 62V	184A617H06
Z52-Z55	1N957B, 6.8V	186A797H06
Z53	1N3688A, 24V	862A288H01
Z54	1N759A, 12V	837A693H01

Supervision Board Style 5315D33G01

CIRCUIT SYMBOL	DESCRIPTION			WESTINGHOUSE STYLE NUMBER
	Capacitor			
C151-C153-C157	0.47	Mfd		188A669H01
C152	68	Mfd		187A508H02
C154-C156-C158	1.5	Mfd		187A508H09
C155	6.8	Mfd		184A661H10
	Diodes			
D151-D153-D158-to D162	1N457A			184A855H07
D152-D154-D155	1N645A			837A692H03
	Transistors			
Q151-Q152-A154-A155 Q158-Q159-A161	2N3417			848A851H02
Q153-A156-Q160-Q162	2N3645			849A441H01
Q165-Q166-Q167	2N4356			849A441H02
	Resistors			
R151-R158-R168-R177 R181-R188	6.8K	Ohms	1/2W	629A531H52
R152-R153-R157-R159-R164-R165-R167-R169-R176-R180-R182-R186 R189-R200	10K	Ohms	1/2W	629A531H56
R154	470	Ohms	1/2W	184A763H19
R155-R166-R197-R201	22K	Ohms	1/2W	184A763H59
R156-R161-R178	1K	Ohms	1/2W	184A763H27
R160-R170-R183-R190	82K	Ohms	1/2W	629A531H78
R162	33K	Ohms	1/2W	184A763H63
R163	56K	Ohms	1/2W	184A763H69
R171-R184-R191	150K	Ohms	1/2W	762A679H01
R175-R187	47K	Ohms	1/2W	184A763H67
R179	39K	Ohms	1/2W	629A531H70
R198-R202	2K	Ohms	1/2W	184A763H34
	Zener Diode			
Z151-Z152-Z154	1N957B,	6.8V		186A797H07
Z153-Z155-Z157-Z159	1N3688,	24V		862A288H01
Z158	UZ5875,	75V		837A693H04

Amplifier & Keying Board Style 5314D78G01

CIRCUIT SYMBOL	DESCRIPTION			WESTINGHOUSE STYLE NUMBER
	Capacitor			
C101	6.8	Mfd		184A661H21
C102	1.5	Mfd		187A508A09
	Diodes			
D101-D106-D110	1N457A			184A855H07
D102 to D105-D107-D109	1N645A			837A692H03
	Transistors			
Q101 to Q104-Q106 Q107-Q110-Q111	2N3417			848A851H02
Q105	2N699			184A638H19
Q108-Q109-Q112-Q113	2N3645			849A441H01
	Resistors			
R101-R117	6.8K	Ohms	1/2W	629A531H52
R102-R106	470	Ohms	1/2W	184A763H19
R103	39K	Ohms	1/2W	184A763H65
R104-R108	1K	"	"	184A763H27
R105-R109-R112-R113- R115-R116-R121-R122- R124-R134-R135-R137	10K	"	"	184A763H51
R107-R127-R130-R141	15K	"	"	629A531H60
R110	82K	"	"	629A531H78
R111-R120-R133	33K	"	"	184A763H63
R114-R123-R136	22K	"	"	184A763H59
R118	220K	"	"	184A763H83
R119-R132	68K	"	"	629A531H76
R125-R129-R138-R139	4.7K	"	"	184A763H43
R126-R128	470K	"	"	184A763H91
R127-R130-R141	47K	"	"	184A763H67
R131-R140	56K	"	"	184A763H69
	Zener Diodes			
Z101-Z102	1N957B,	6.8V		186A797H06
Z103	UZ5875,	75V		837A693H04

Arming Board Style 201C174G01 - 201C172G01

Diodes

D251 to D257-D260-D261 to D265 - D267	1N457A	184A855H07

Transistors

Q251-Q252-Q253-Q256 Q258-Q259	2N3417	848A851H02
Q257	2N3645	849A441H01

Resistors

R251 to R257-R259-R261 R262-R263-R265-R274 R277-R278-R280-R281 R287-R288	22K Ohms 1/2W	184A763H59
R258-R260-R264-R275 R276-R282-R284-R285	10K Ohms 1/2W	184A763H51
R279	27K Ohms 1/2W	629A531H66
R283-R289	12K Ohms 1/2W	184A763H53

Zener Diodes

Z251	1N3688A, 24V	862A288H01

Protective Relay Board Style 201C166G01 - 201C148G01

Capacitors

C1 to C5	.047 Mfd	849A437H04

Diodes

D1 to D5	1N645A	837A692H03
D6 to D10	1N457A	184A855H07

Transistors

Q1 to Q7-Q9	2N3417	848A851H02
Q8	2N3645	849A441H01

CIRCUIT SYMBOL	DESCRIPTION		WESTINGHOUSE STYLE NUMBER
	Resistors		
R1 (125 volt input)	68K	1W	187A643H71
R1 (48 volt input)			
R6-R21-R30=R39	27K	1/2W	184A763H01
R2-R3-R4-R8-R9			
R13-R14-R122-R23			
R31-R32-R33	4.7K	1/2W	629A531H48
R5-R10-R15-R24-R34-R38	82K	1/2W	629A531H78
R7-R11-R16-R25-R35	10K	1/2W	629A531H56
R12-R17-R26-R37	6.8K	1/2W	629A531H52
R18-R19-R27-R28	22K	1/2W	184A763H59
R20-R29-R36-R40	10K	1/2W	184A763H51
	Zener Diode		
Z1-Z3-Z5-Z7-Z9	1N3686B	20V	185A212H06
Z2-Z4-Z6-Z8-Z10	1N957B	6.8V	186A797H06

Output Board Style 201C025G01

CIRCUIT SYMBOL	DESCRIPTION		WESTINGHOUSE STYLE NUMBER
	Capacitors		
C301-C304-C305	4.7	Mfd	184A661H12
C302-C303-C306-C309	0.22	Mfd	762A703H01
C307-C308	0.047	Mfd	849A437H04
C310	0.10	Mfd	188A669H03
C311	1.5	Mfd	187A508H09
	Diodes		
D301 to D306-D308	1N457A		184A855H07
D307	1N645A		837A692H03
	Transistors		
Q301-Q305-Q306-Q307			
Q308	2N3645		849A441H01
Q302-Q303-Q304-Q308	2N3417		848A851H02

CIRCUIT SYMBOL	DESCRIPTION			WESTINGHOUSE STYLE NUMBER
	Resistors			
R301-R303-R304-R306 R310-R311-R315 R320-R323-R324 R326-R330-R335	10K	Ohms	1/2W	184A763H51
R302	2.2M	Ohms	1/2W	187A290H26
R305	47K	Ohms	1/2W	187A290H17
R307-R314-R319-R321 R325-R328	22K	"	"	184A763H59
R309-R317	1K	"	"	184A763H27
R312	470K	"	"	184A763H19
R313	470K	"	"	184A763H91
R316	15K	"	"	629A430H08
R318-R322	4.7K	"	"	184A763H43
R327	6.8K	"	"	184A763H47
R329	18K	"	"	184A763H57
R331	10K	"	"	629A531H56
R332	6.8K	"	"	629A531H52
R333	27K	"	"	629A531H66
R334	150K	"	3W	762A679H01
	Zener Diodes			
Z301-Z303-Z304-Z305	1N957B			186A797H06
Z306	1N3688A			862A288H01

Relay Board Style 5312D78G01

CIRCUIT SYMBOL	DESCRIPTION		WESTINGHOUSE STYLE NUMBER
	Capacitors		
C201-C202-C203	0.25	Mfd	187A624H02
	Resistors		
R201	50 Ohms	5W	185A209H06
R202-R203	3.3K Ohms	1/2W	629A531H44
	Filter Choke		
L201	8.5Hy	450 Ohms	188A460H01
	Zener Diodes		
Z201	1N1828C	43V	629A798H14

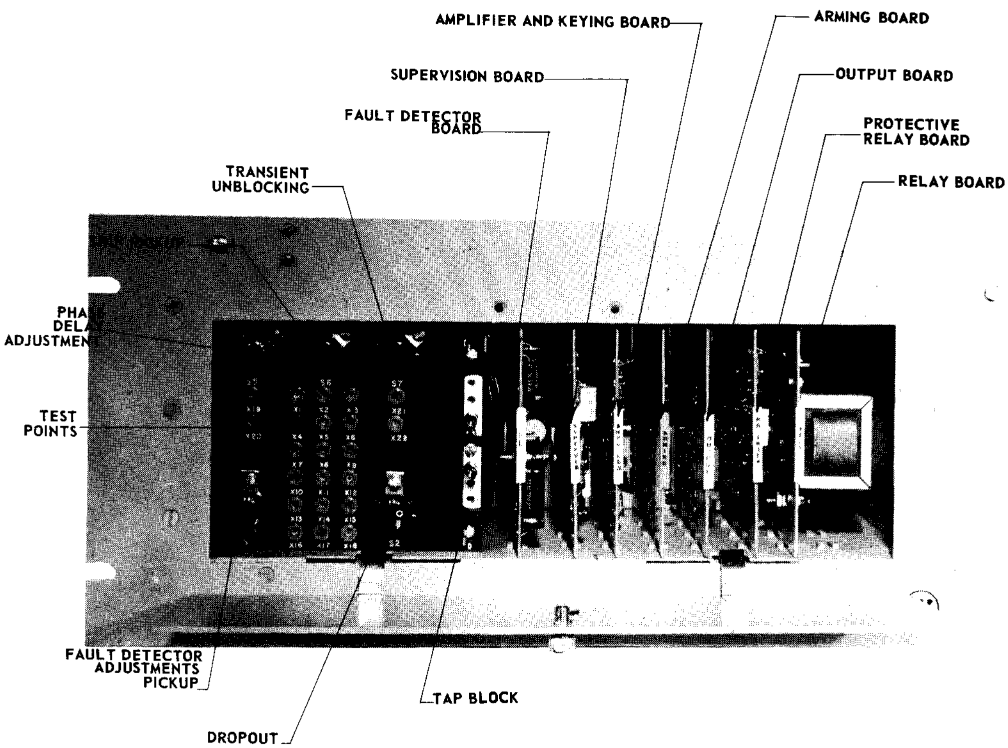


Fig. 1 Type SKBU-21 Relay (Front View)

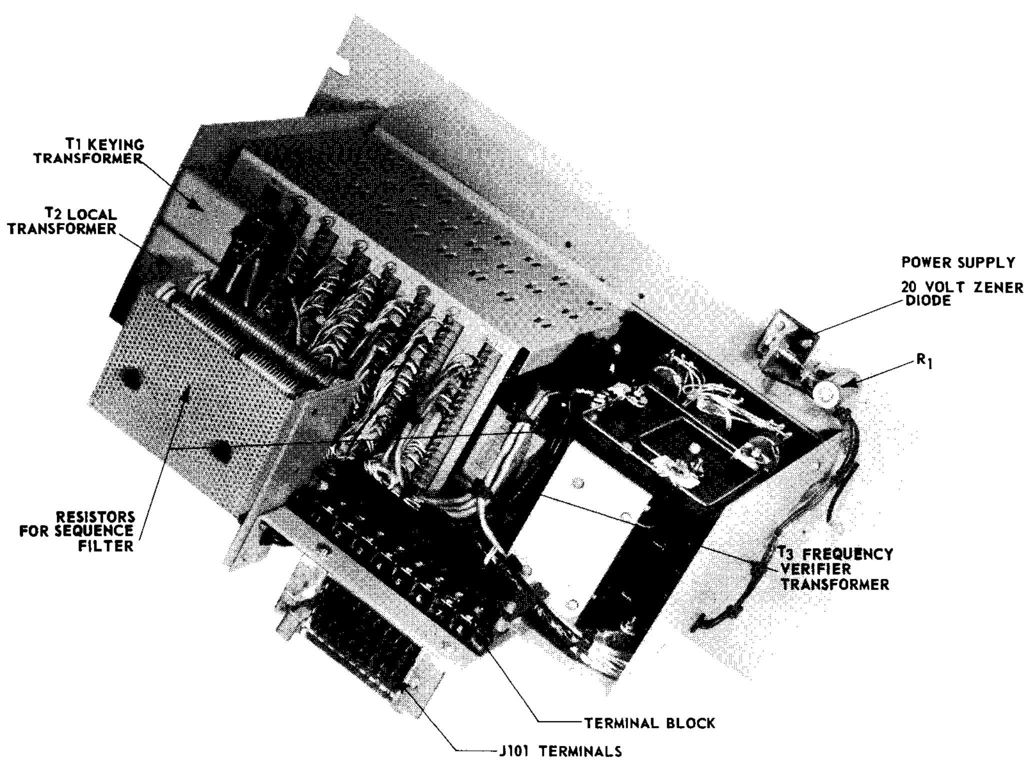


Fig. 2 Type SKBU-21 Relay (Rear View)

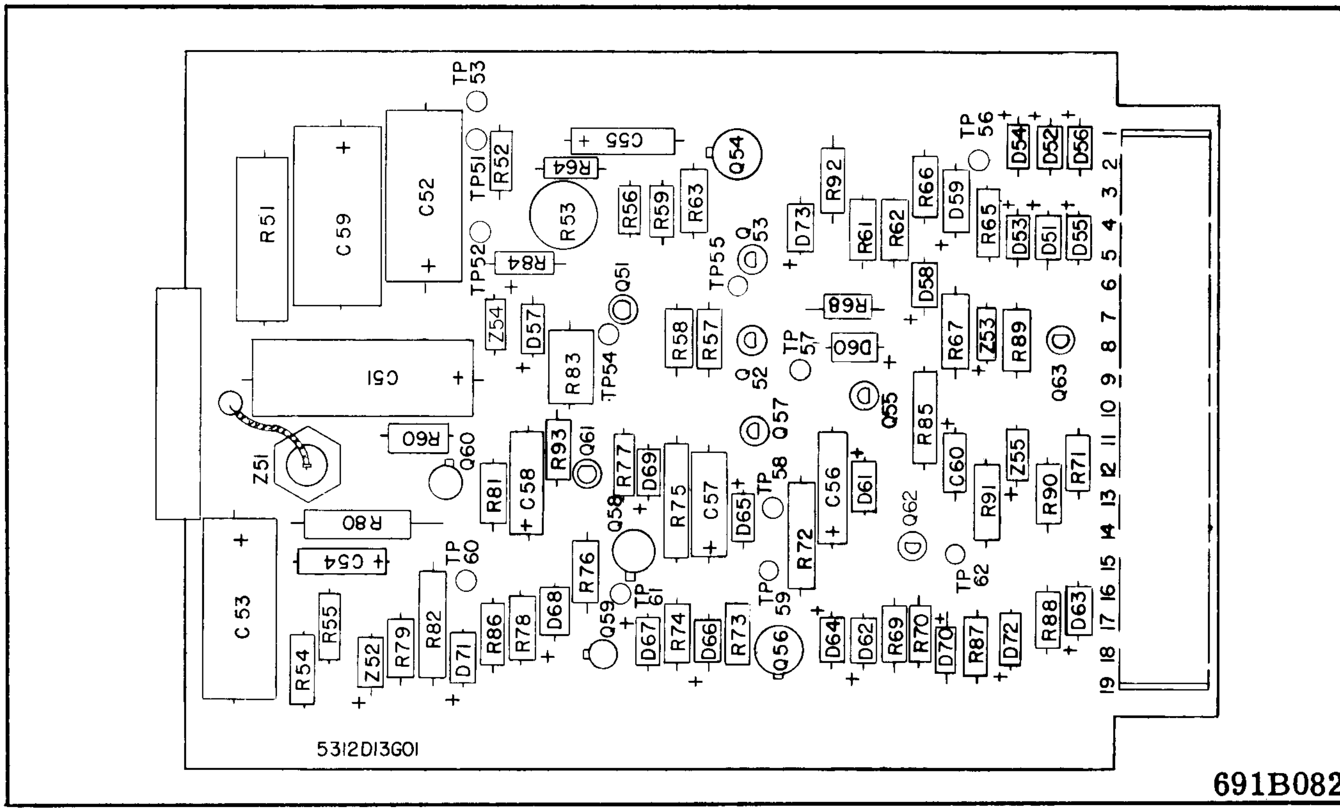


Fig. 3 Location of Components on Fault Detector Board.

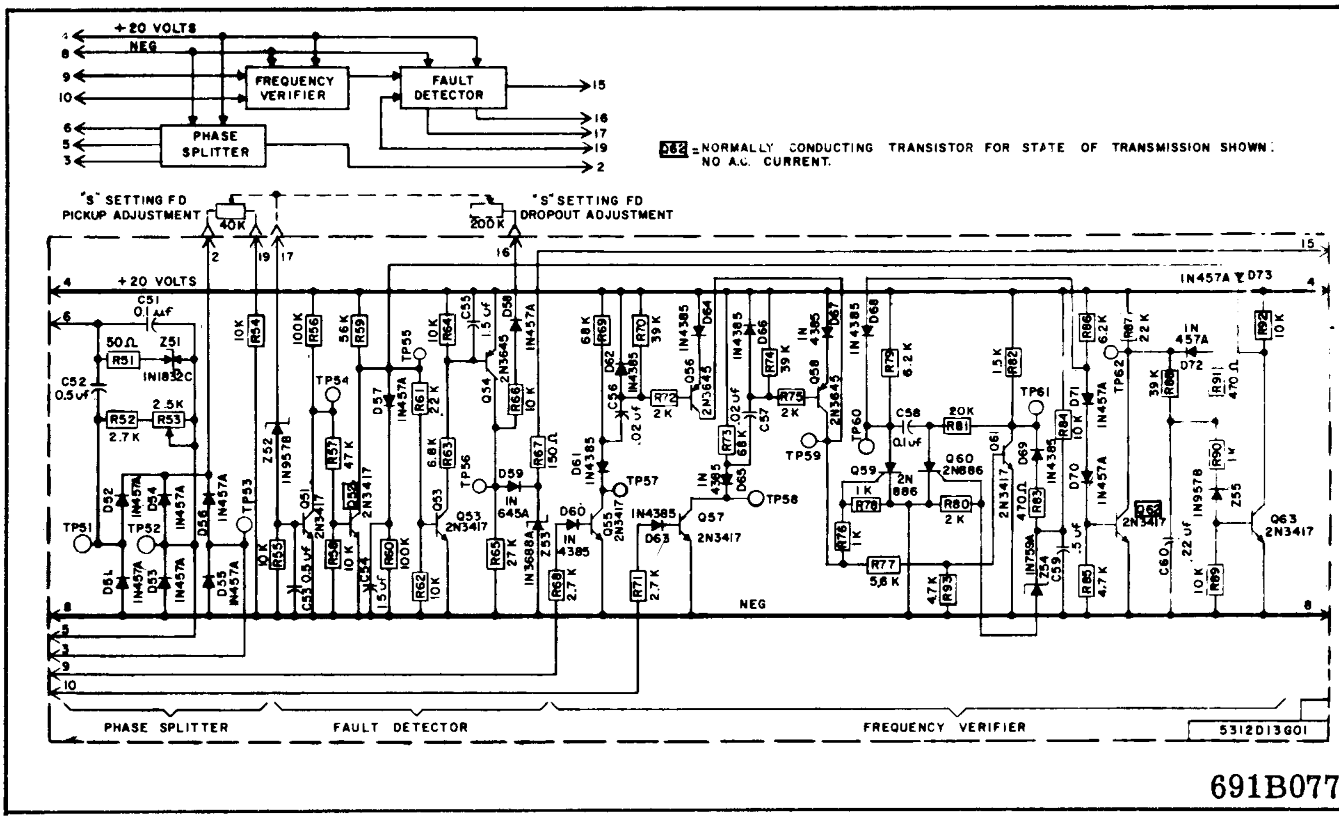


Fig. 4 Schematic of Fault Detector Board .

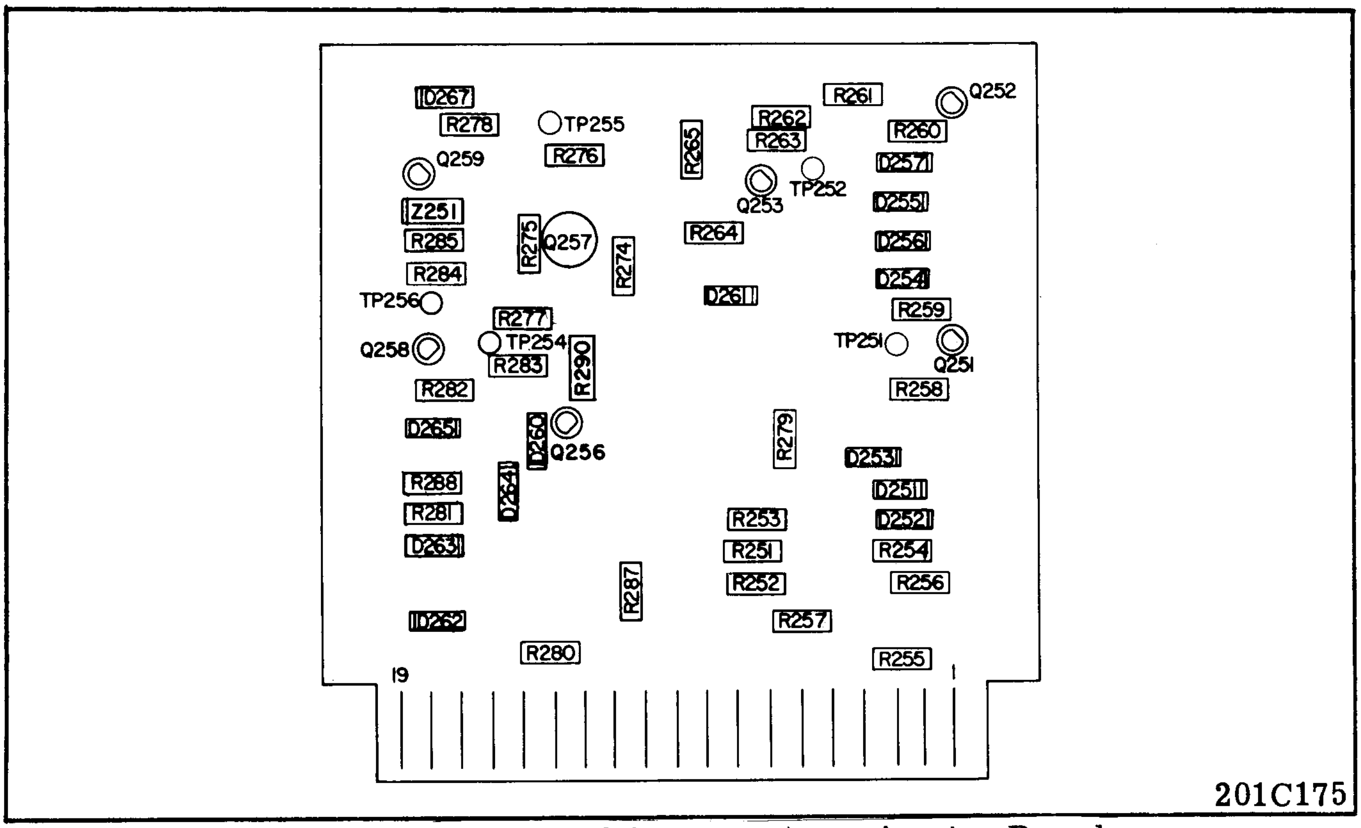


Fig. 5 Location of Components on Arming Board.

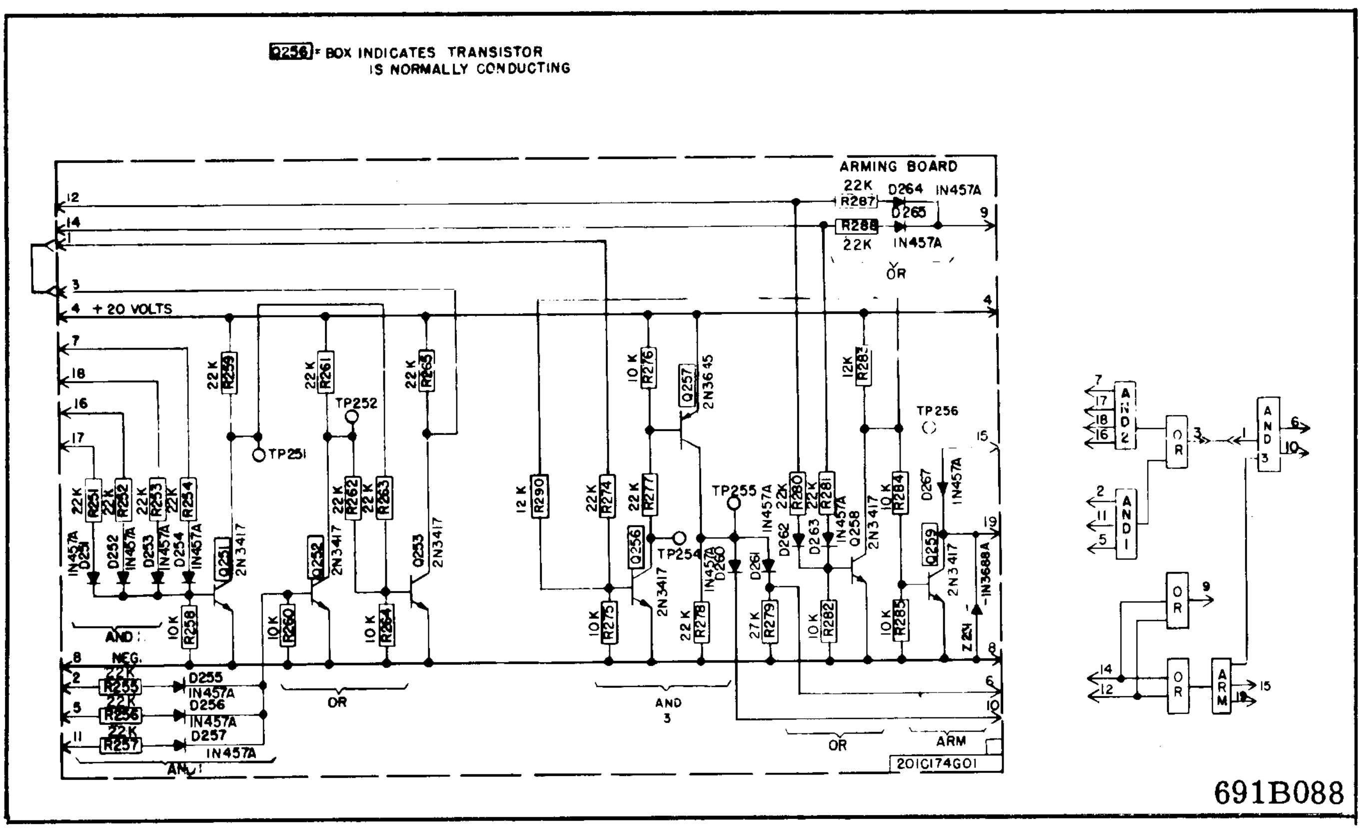


Fig. 6 Schematic of Arming Board for Distance Phase Comparison System.

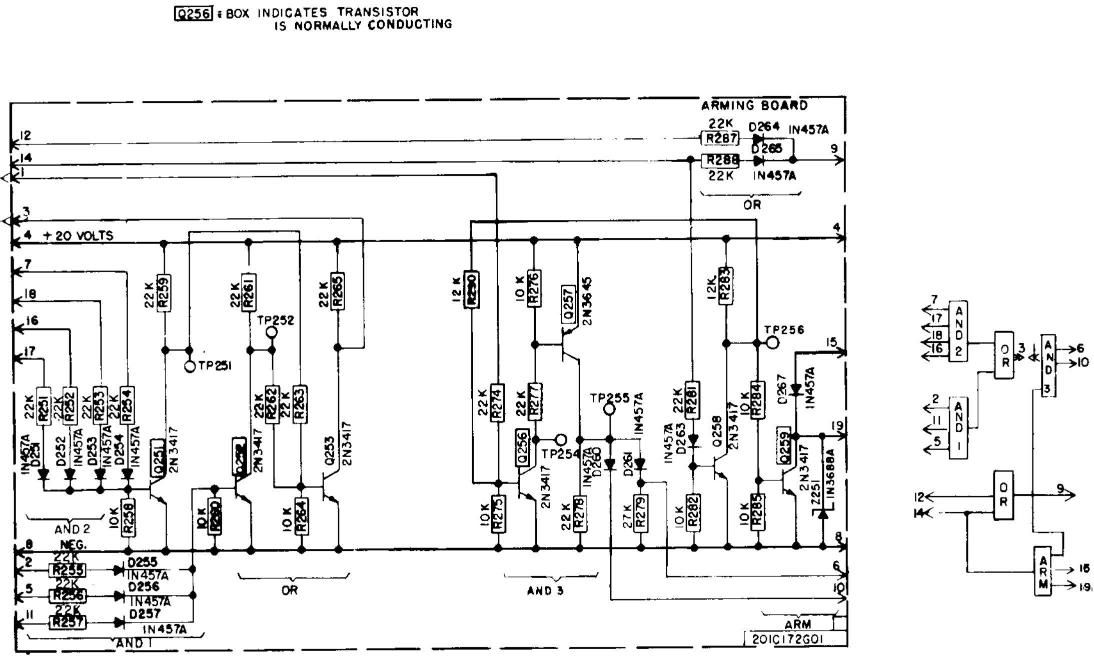


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Fig. 7 Schematic of Arming Board for All Distance Supervision System.

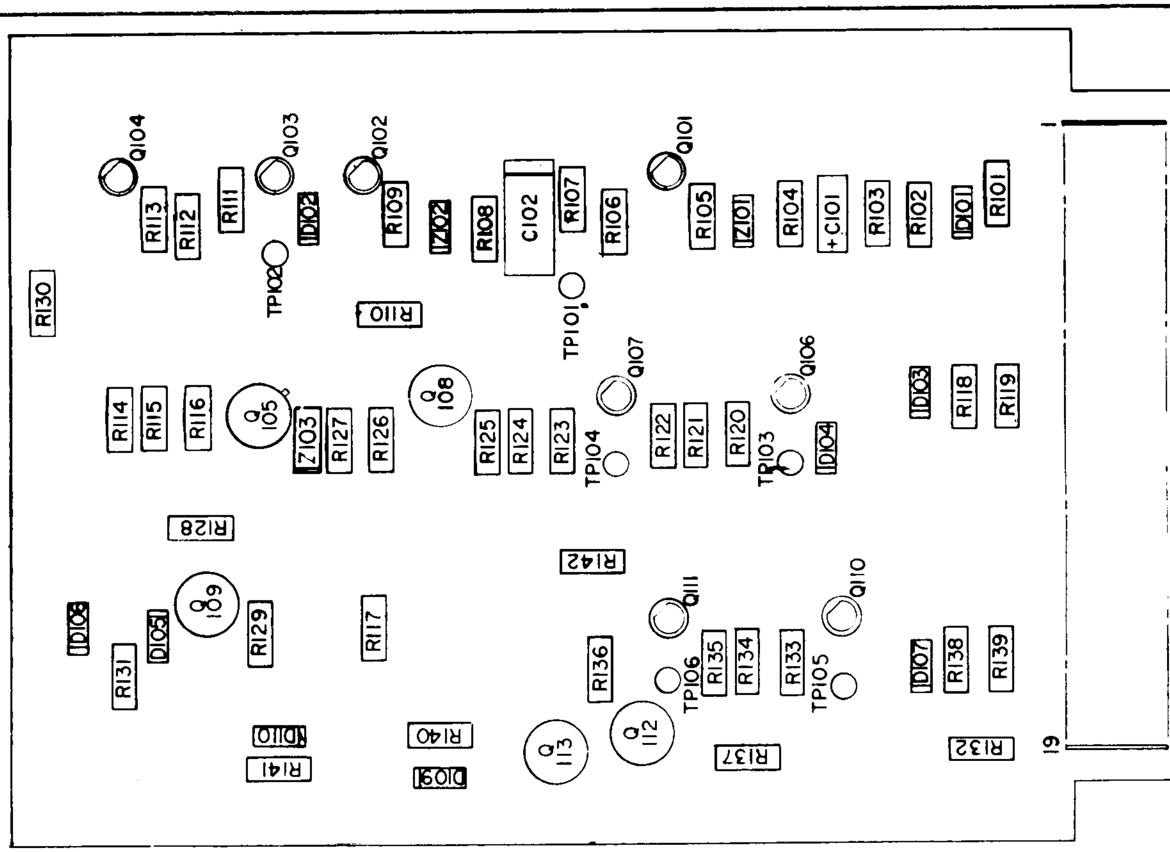

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Fig. 8 Location of Components on Amplifier and Keying Board.

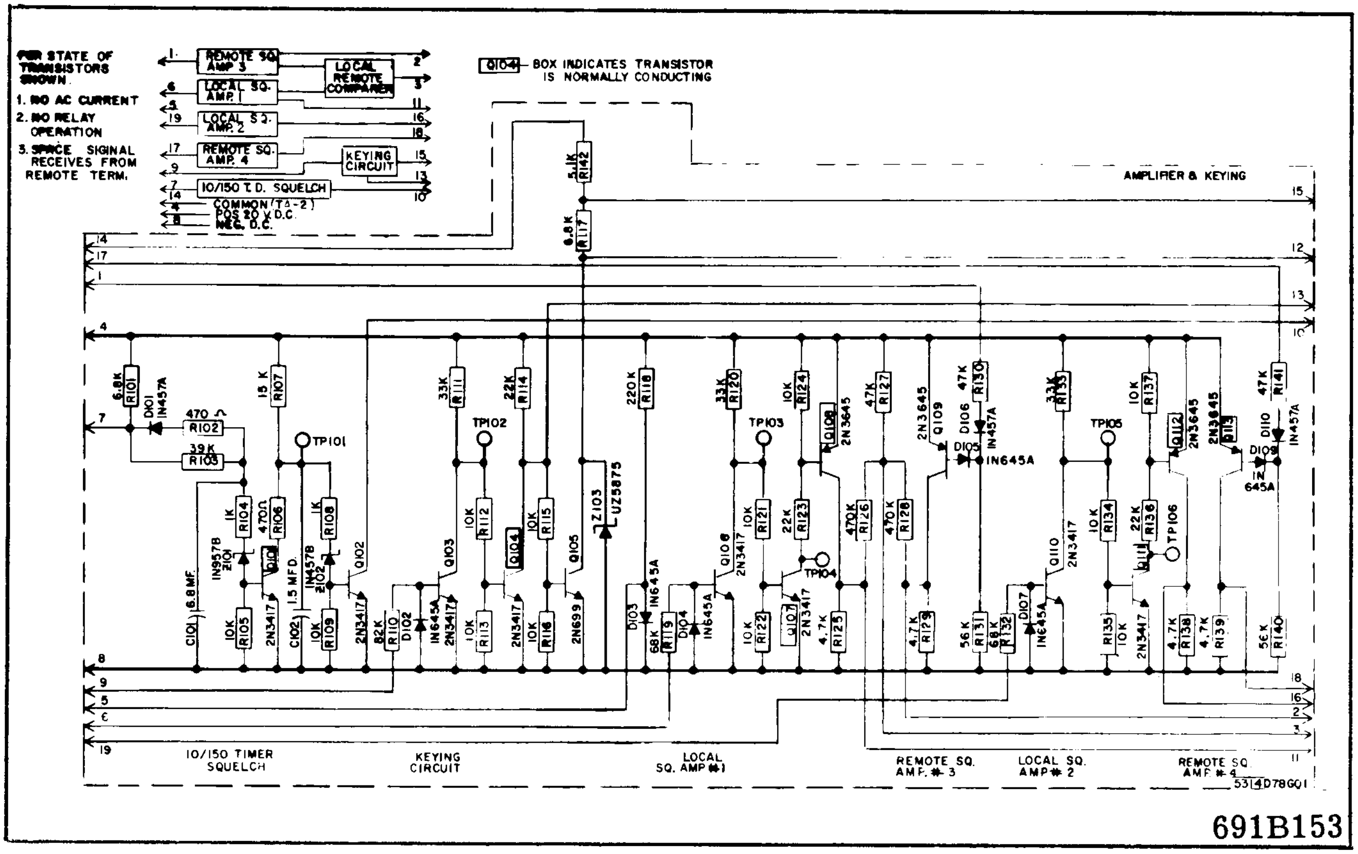

Fig. 9 Schematic of Amplifier and Keying Board.

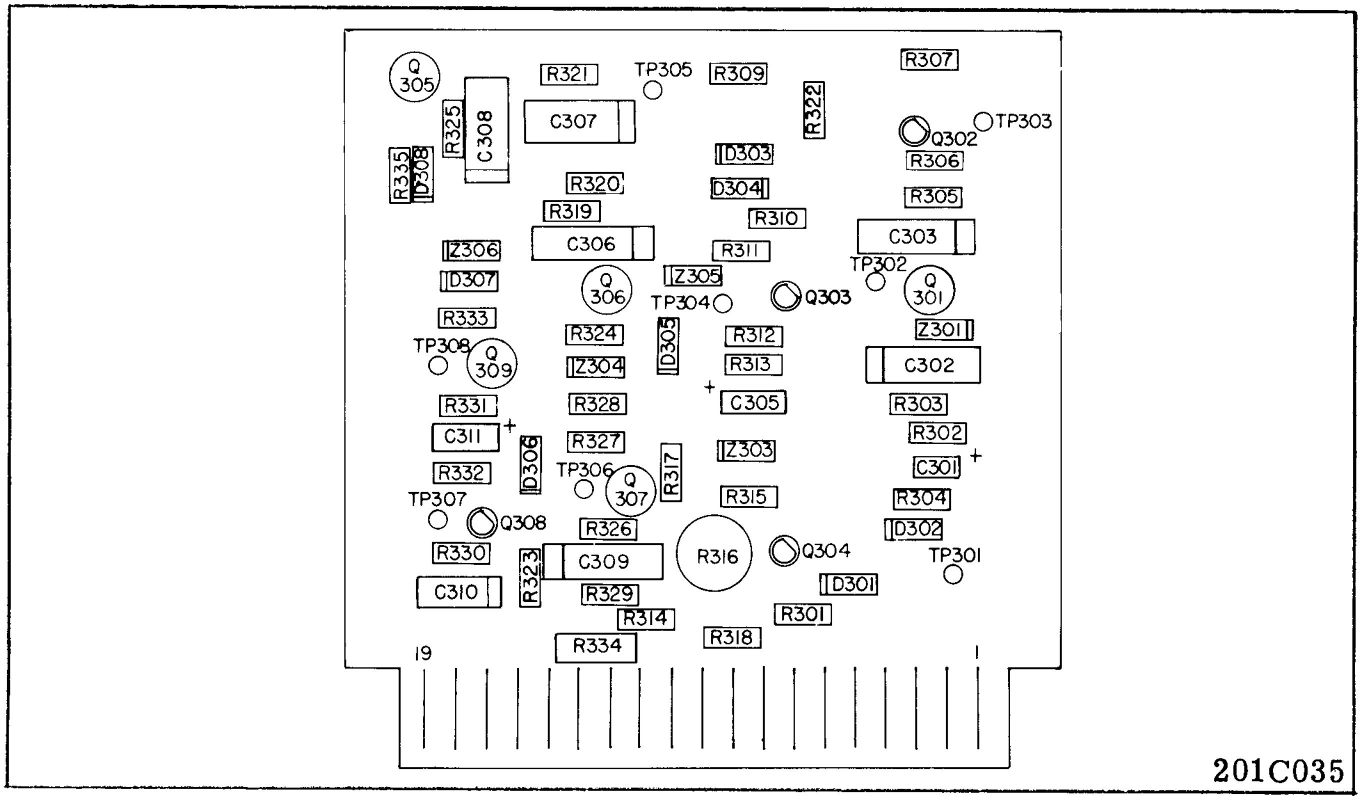

Fig. 10 Location of Components on Output Board .

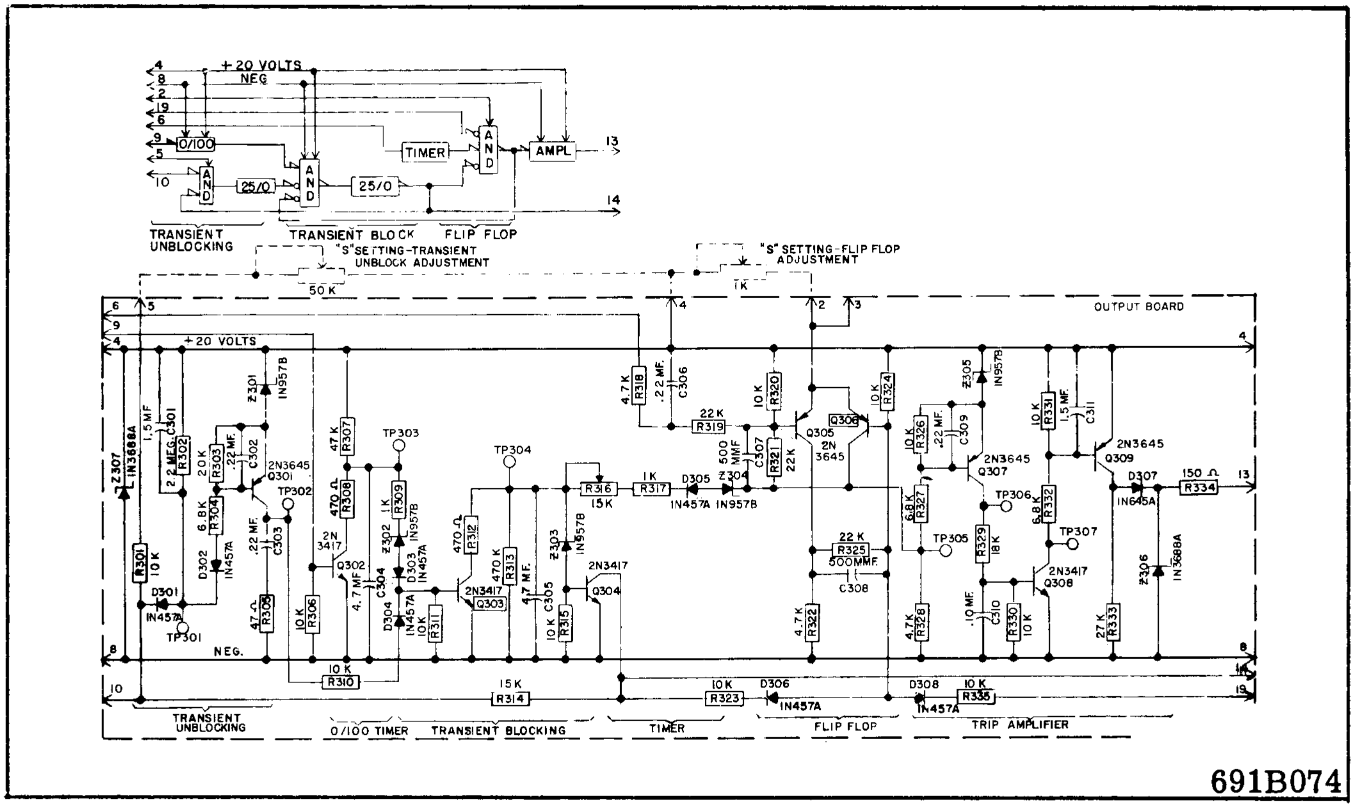

Fig. 11 Schematic of Output Board.

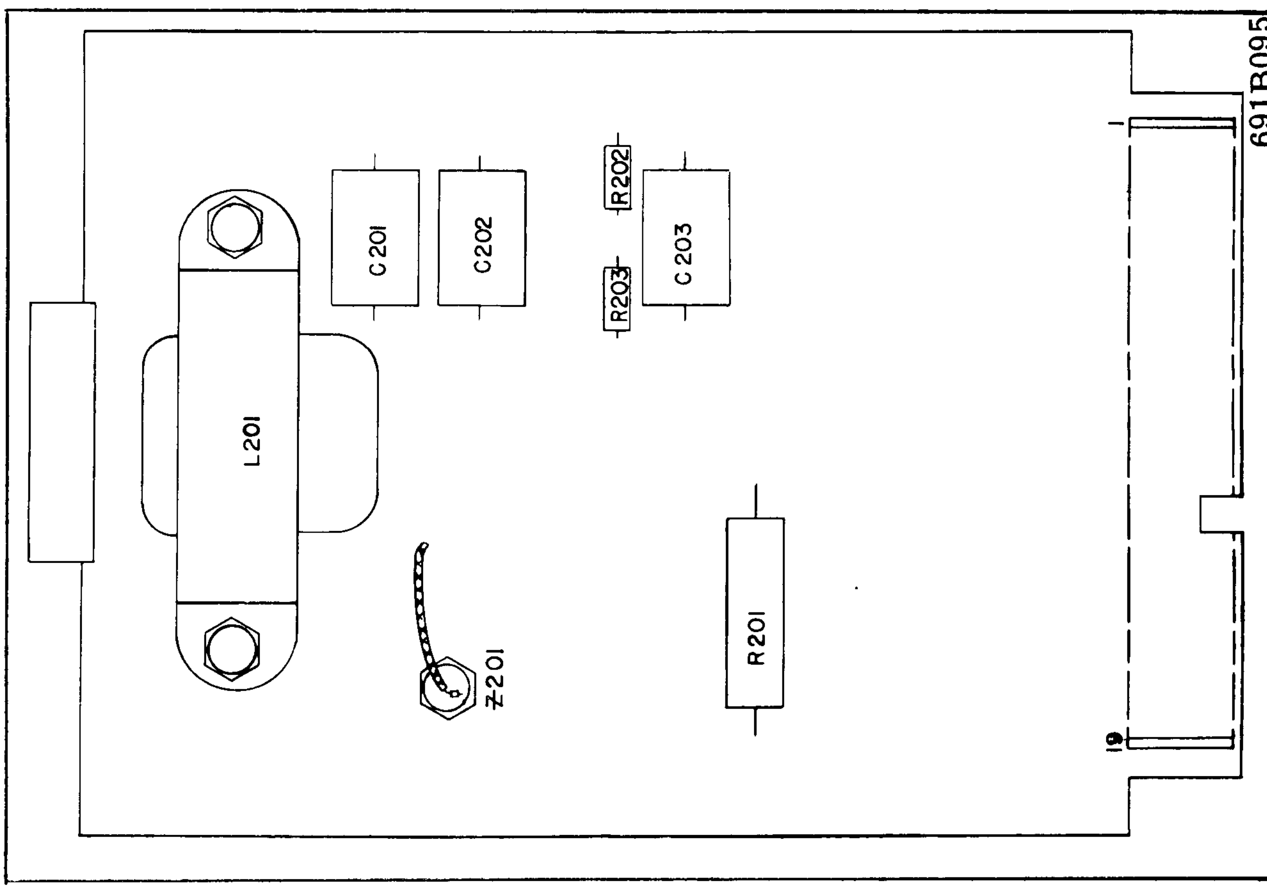

Fig. 12 Location of Components on Relay Board.

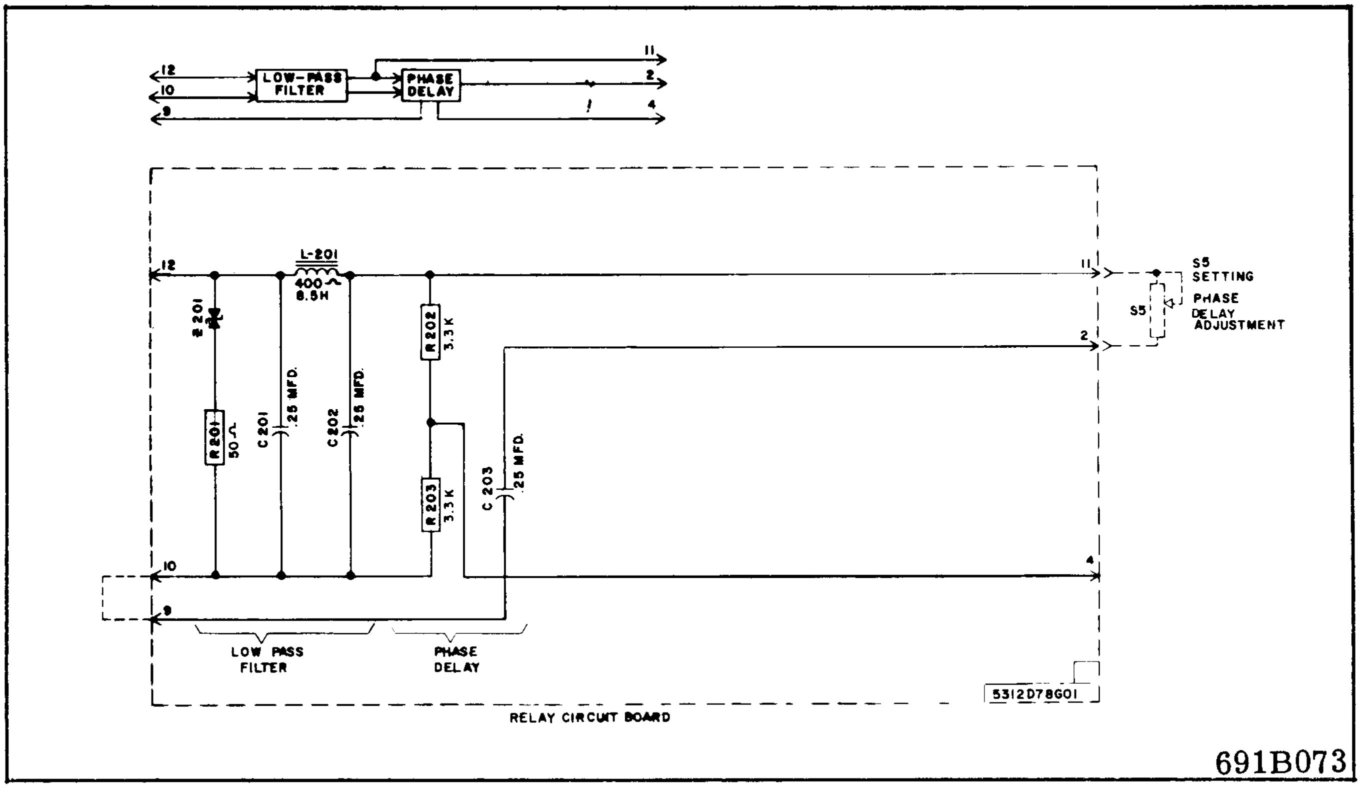

Fig. 13 Schematic of Relay Board.

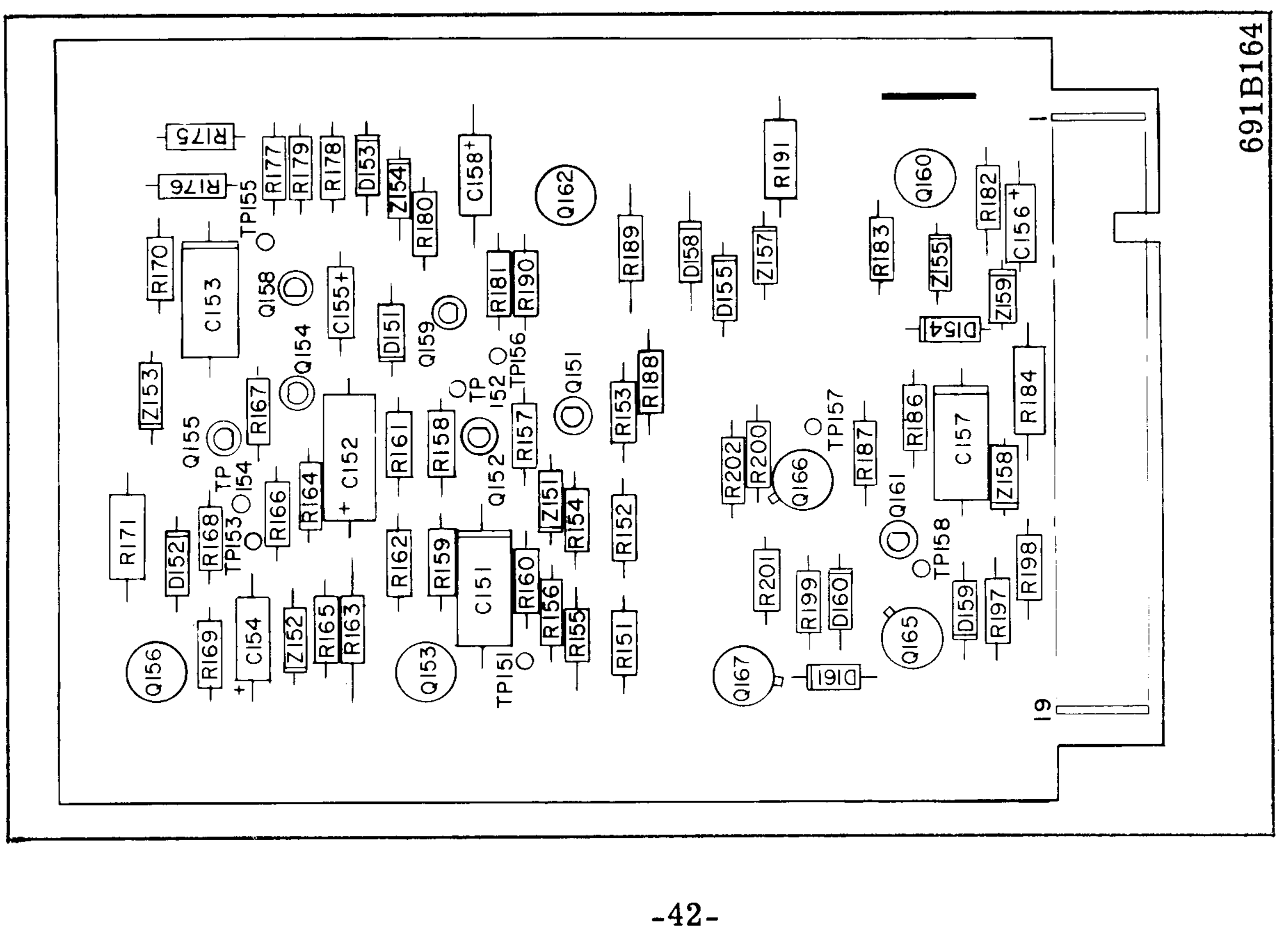

Fig. 14 Location of Components on Supervision Board for TA-2 Tone Channel with AM Squelch.

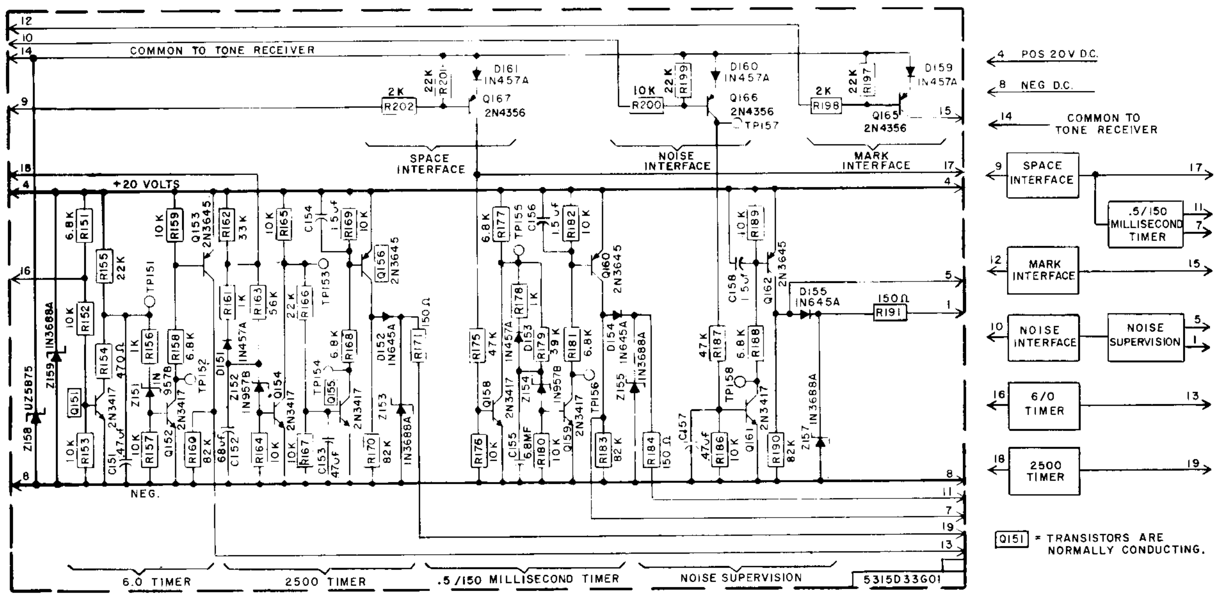

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Fig. 15 Schematic of Supervision Board for TA-2 Tone Channel with AM Squelch.

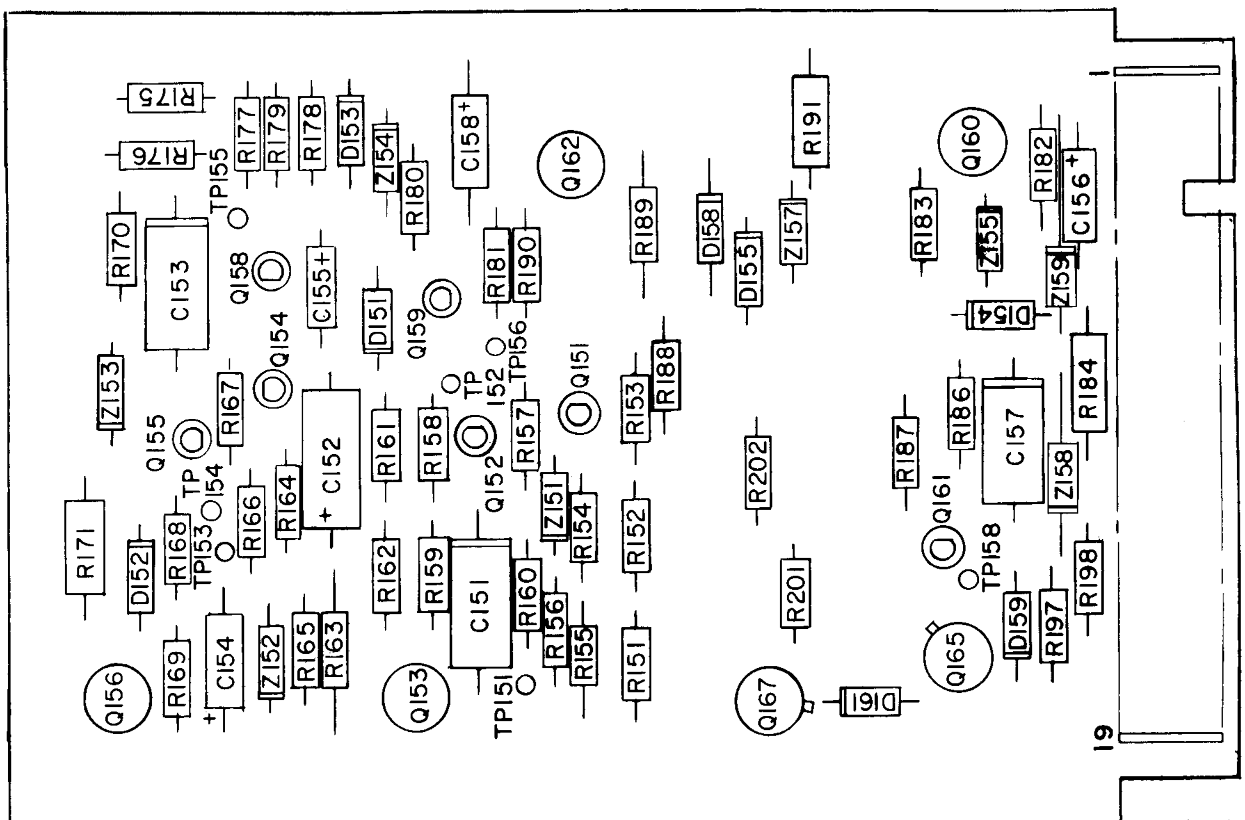

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Fig. 16 Location of Components on Supervision Board for TA-2 Tone Channel with TA-3 Noise Supervision.

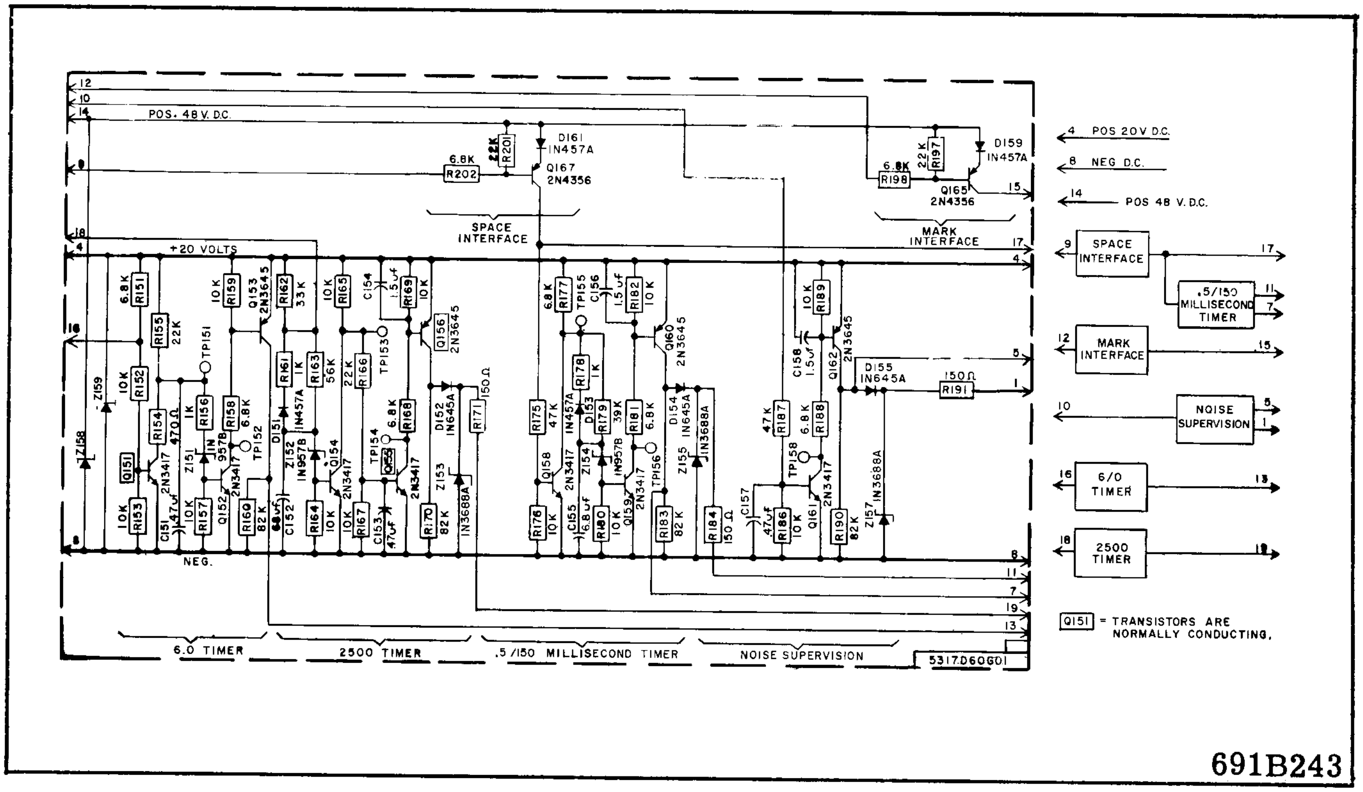


Fig. 17 Schematic of Supervision Board for TA-2 Tone Channel with TA-3 Noise Supervision.

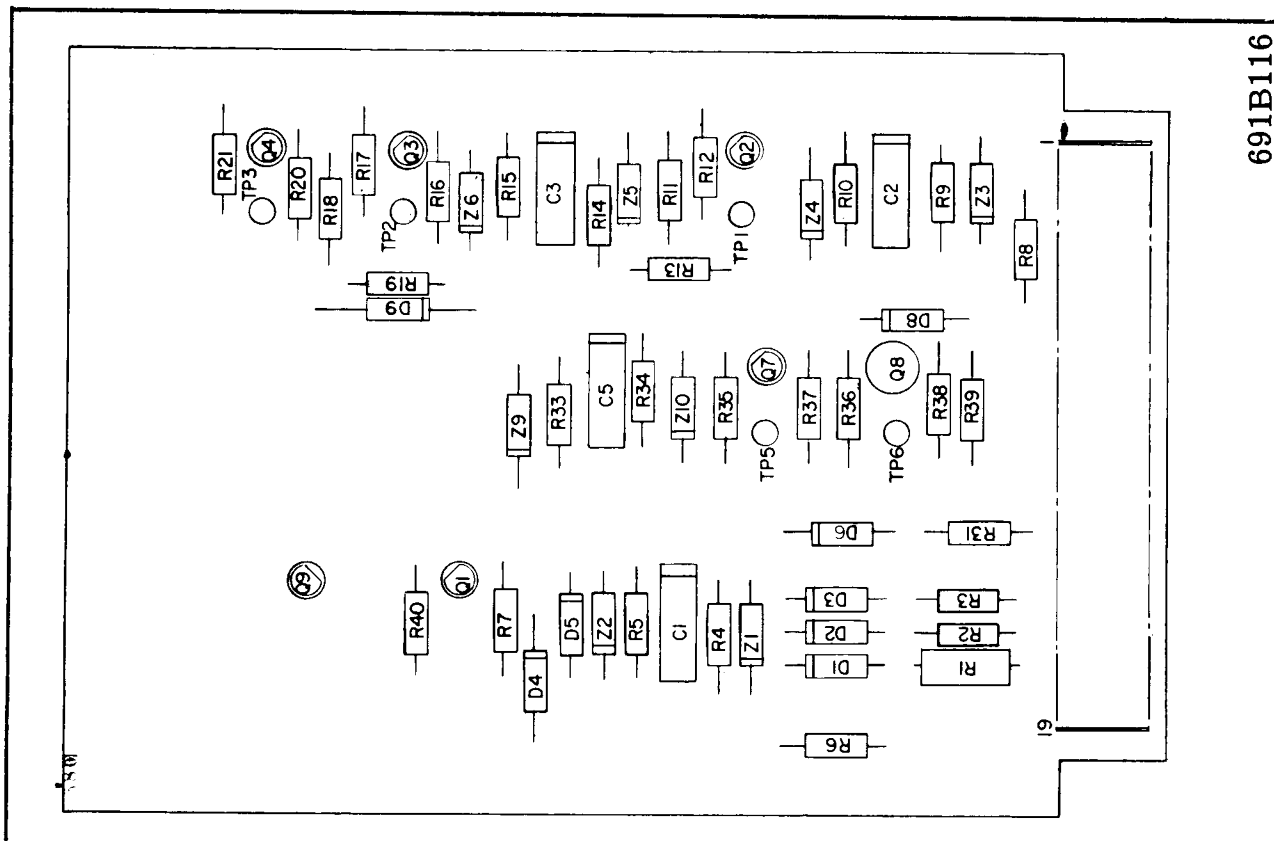


Fig. 18 Location of Components on Protective Relay Board for Distance Phase Comparison.

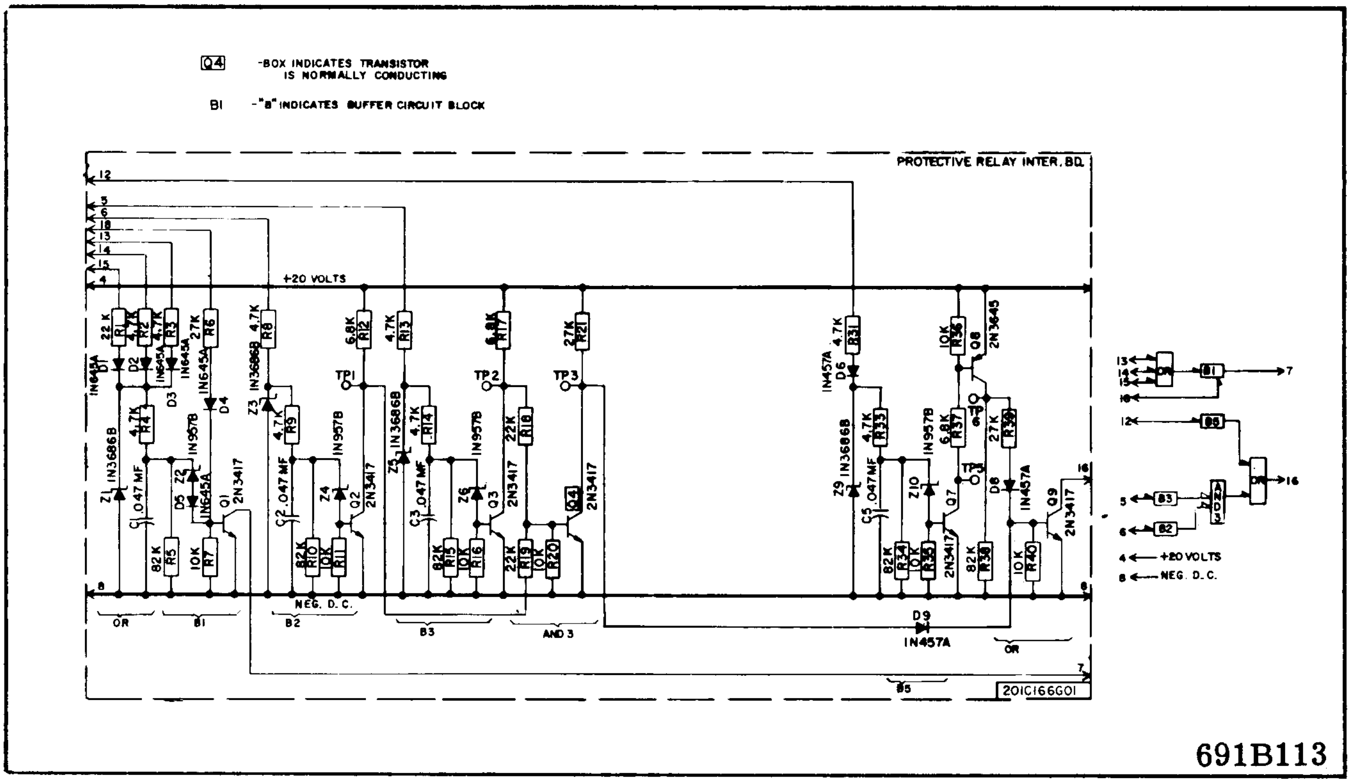


Fig. 19 Schematic of Protective Relay Board for Distance Phase Comparison System.

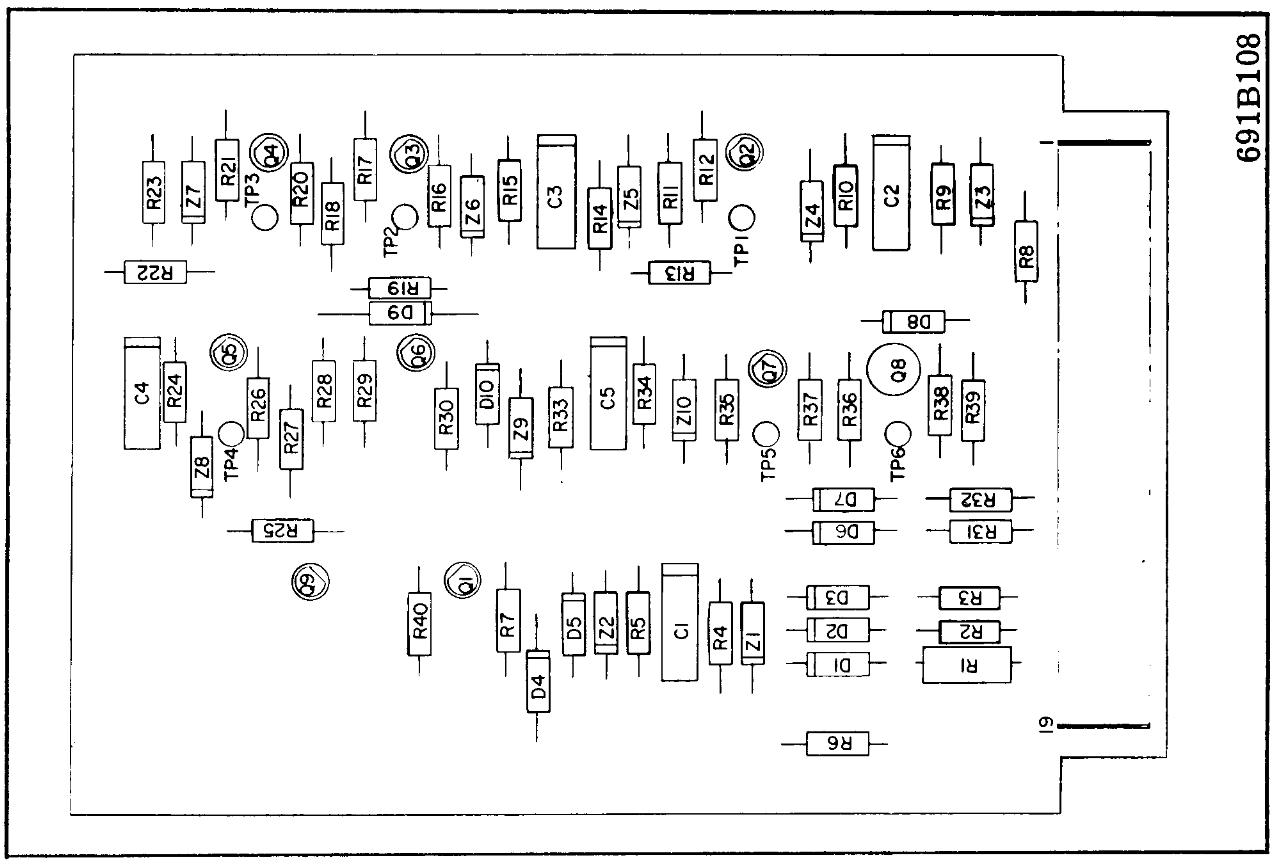


Fig. 20 Location of Components on Protective Relay Board for All Distance. Supervision System.

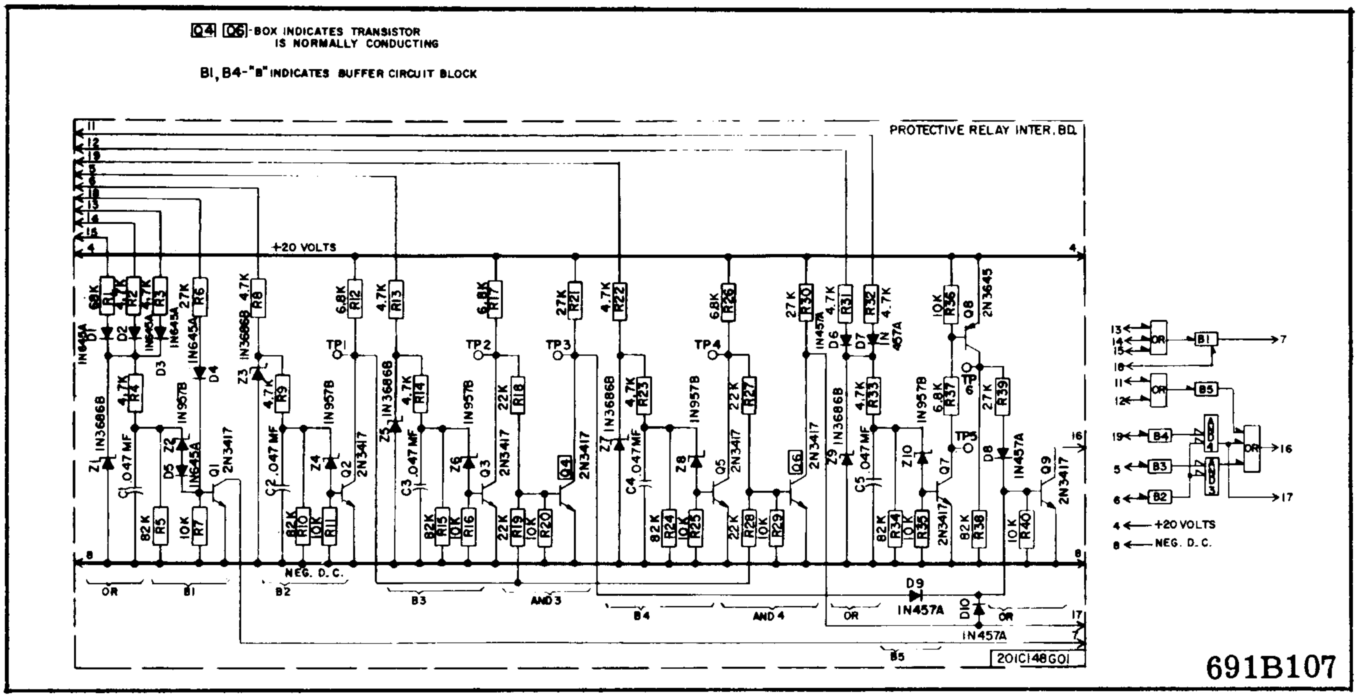


Fig. 21 Schematic of Protective Relay Board for All Distance Supervision System.

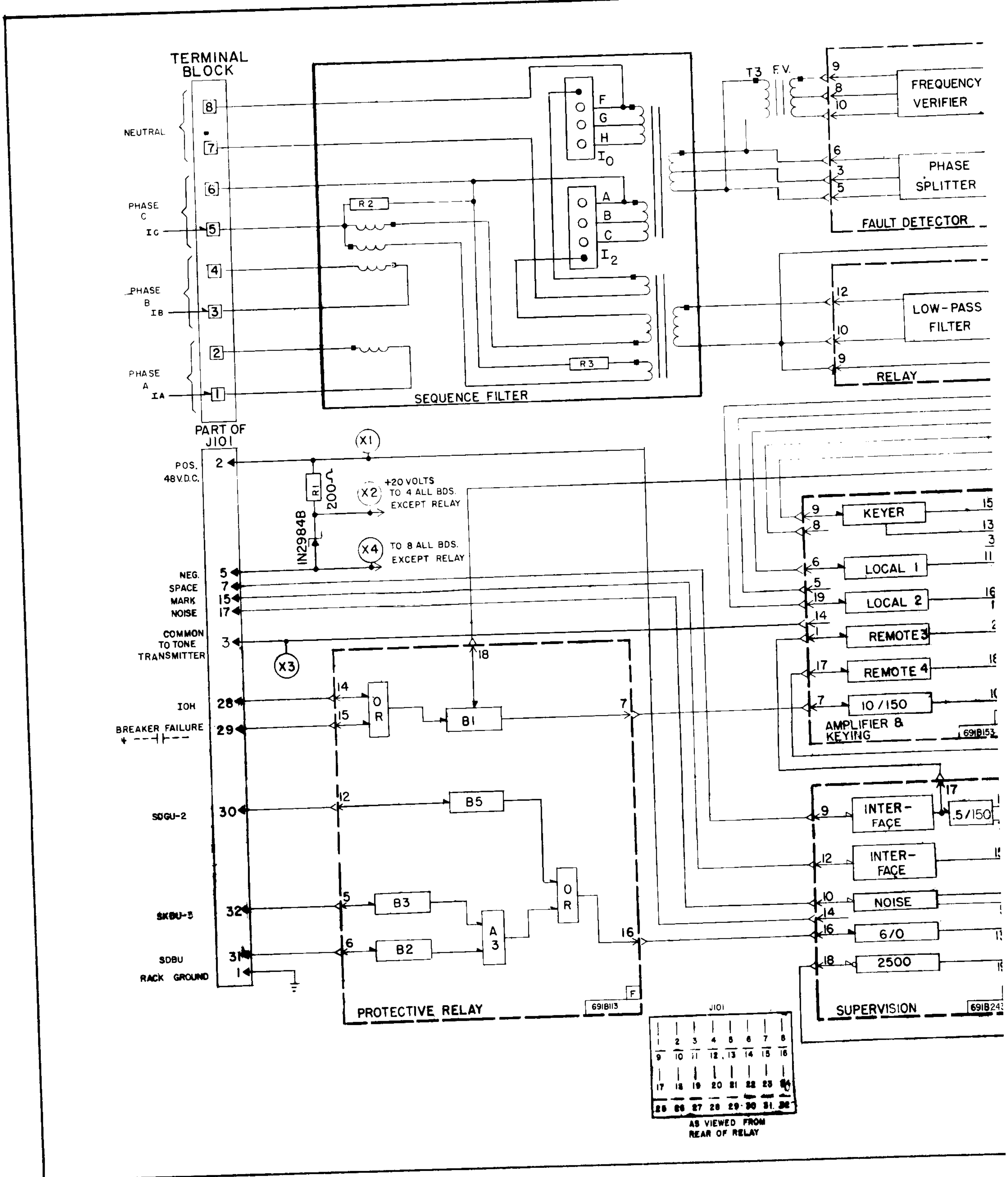
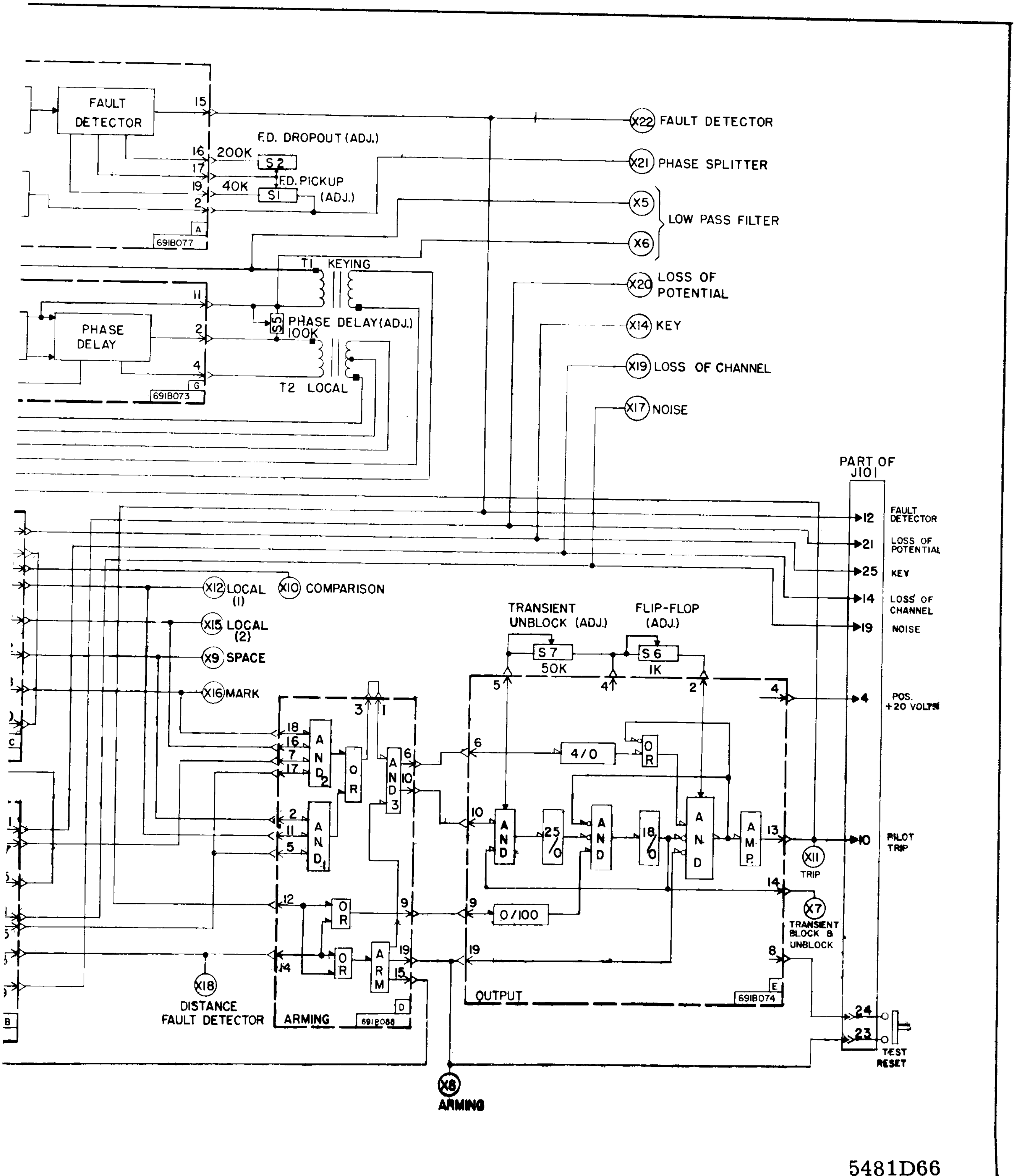


Fig. 23 Logic Diagram of SKBU-21 for Distar



ce Phase Comparison System with TA-3 Noise Supervision.

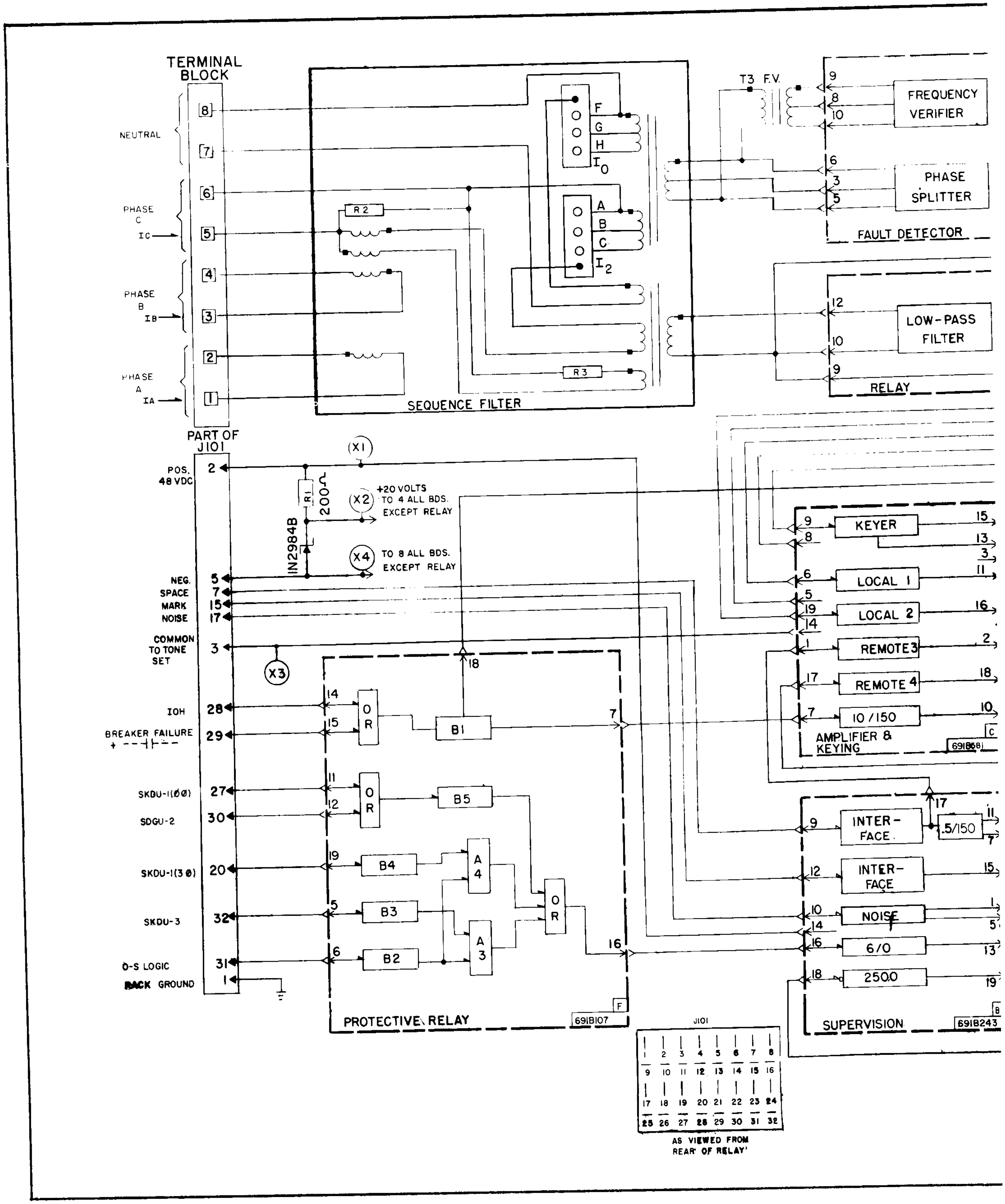
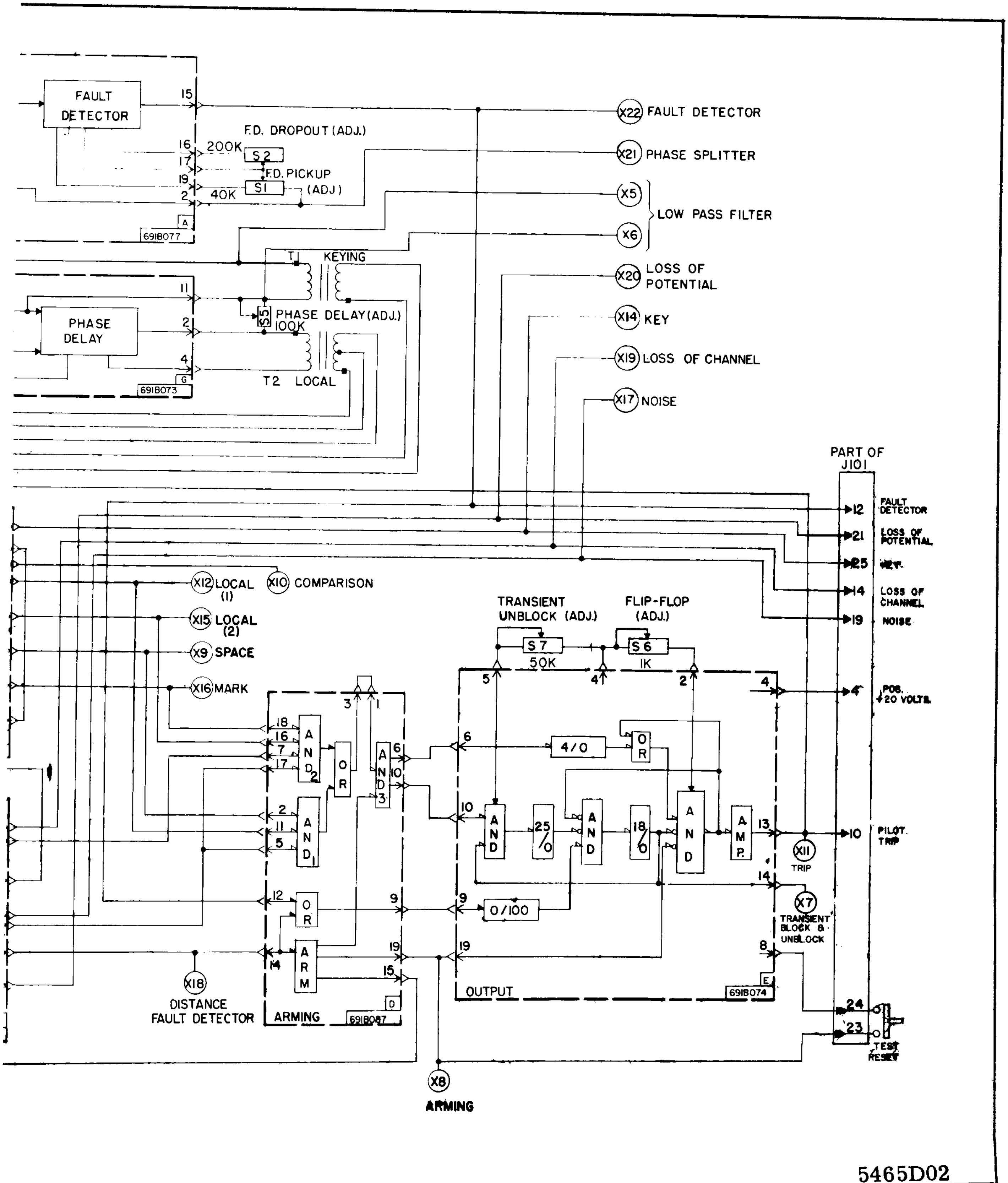


Fig. 25 Logic Diagram of SKBU-21 Relay for All Dist



ance Supervision System with TA-3 Noise Supervision.

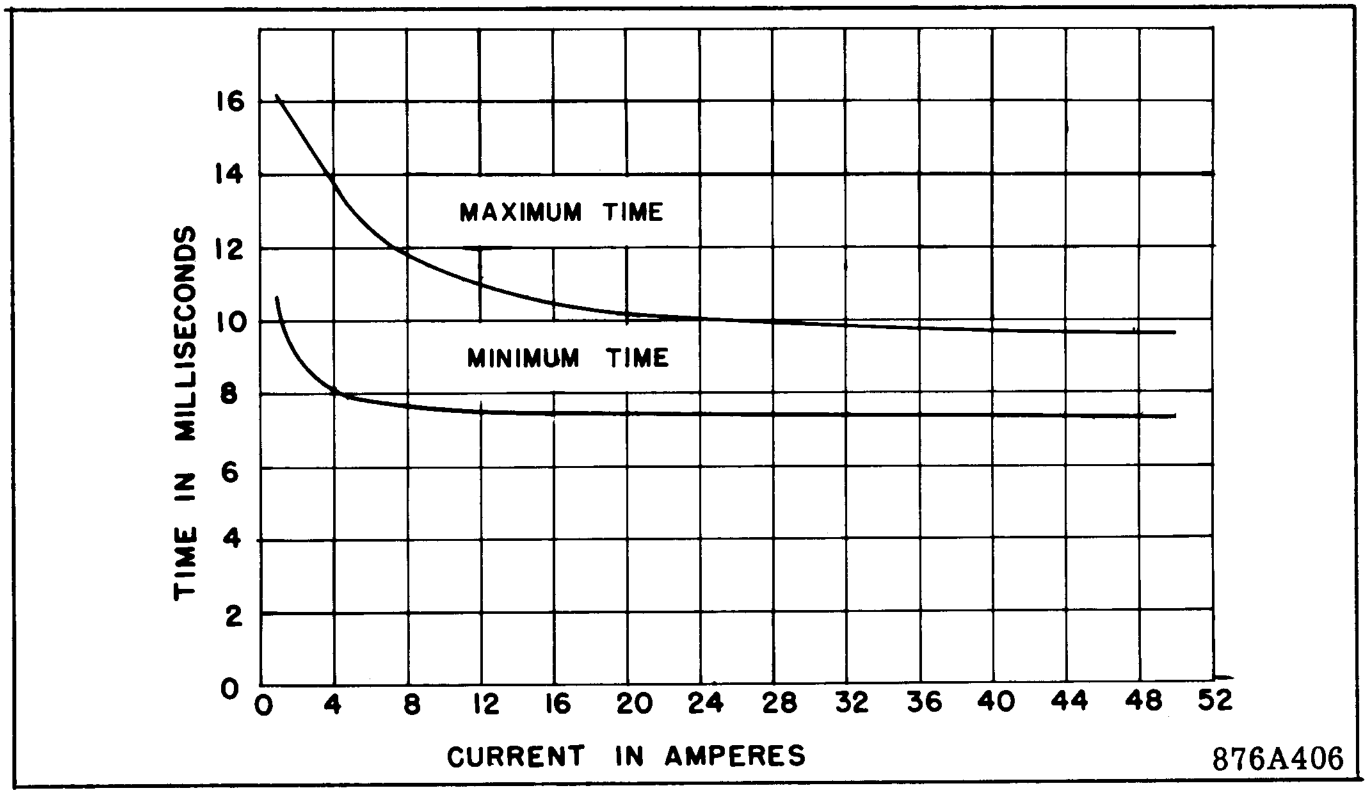


Fig. 26 Operating Times of Fault Detector of SKBU-21 Relay.

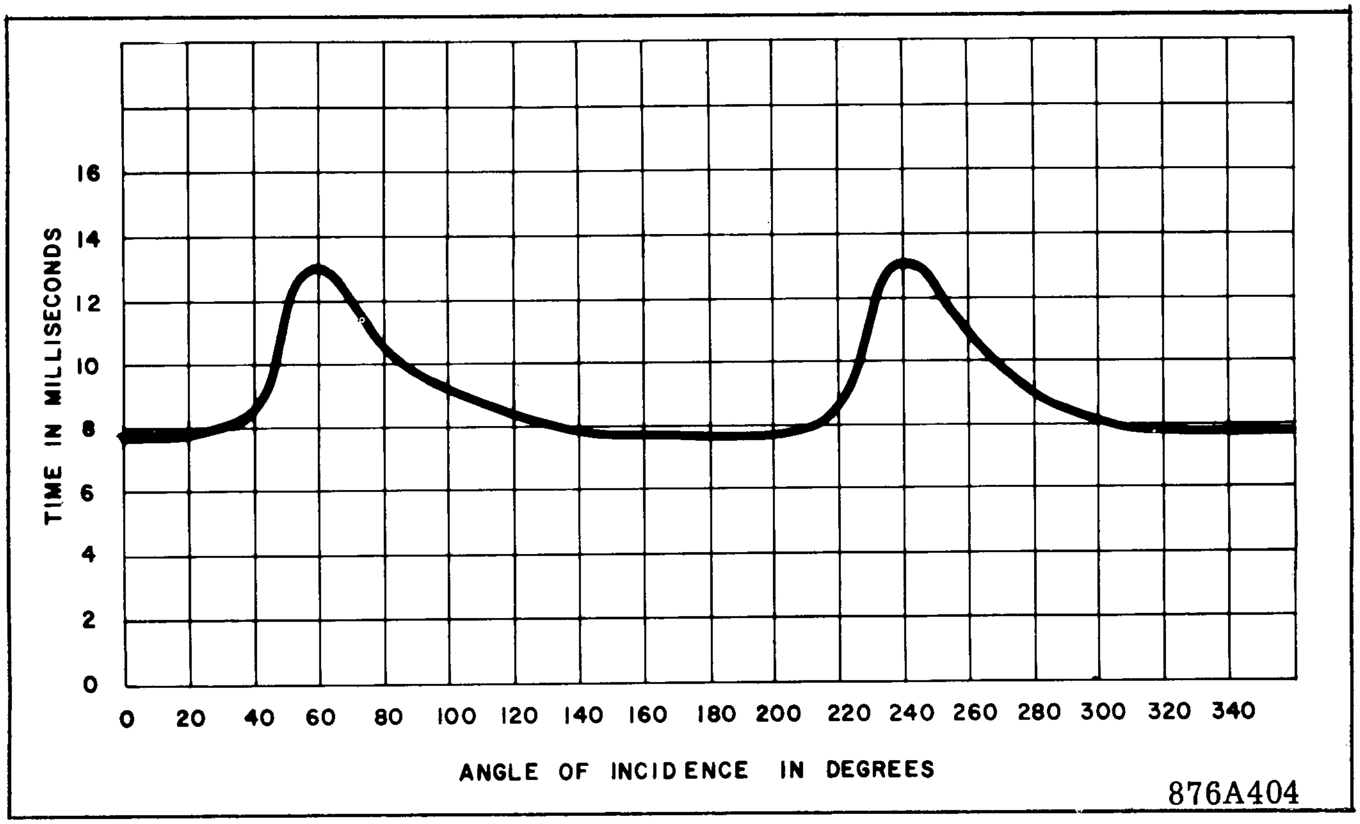


Fig. 27 Operating Times for Fault Detector of SKBU-21 Relay as A Function of Fault Incidence Angle at 5 Amperes.

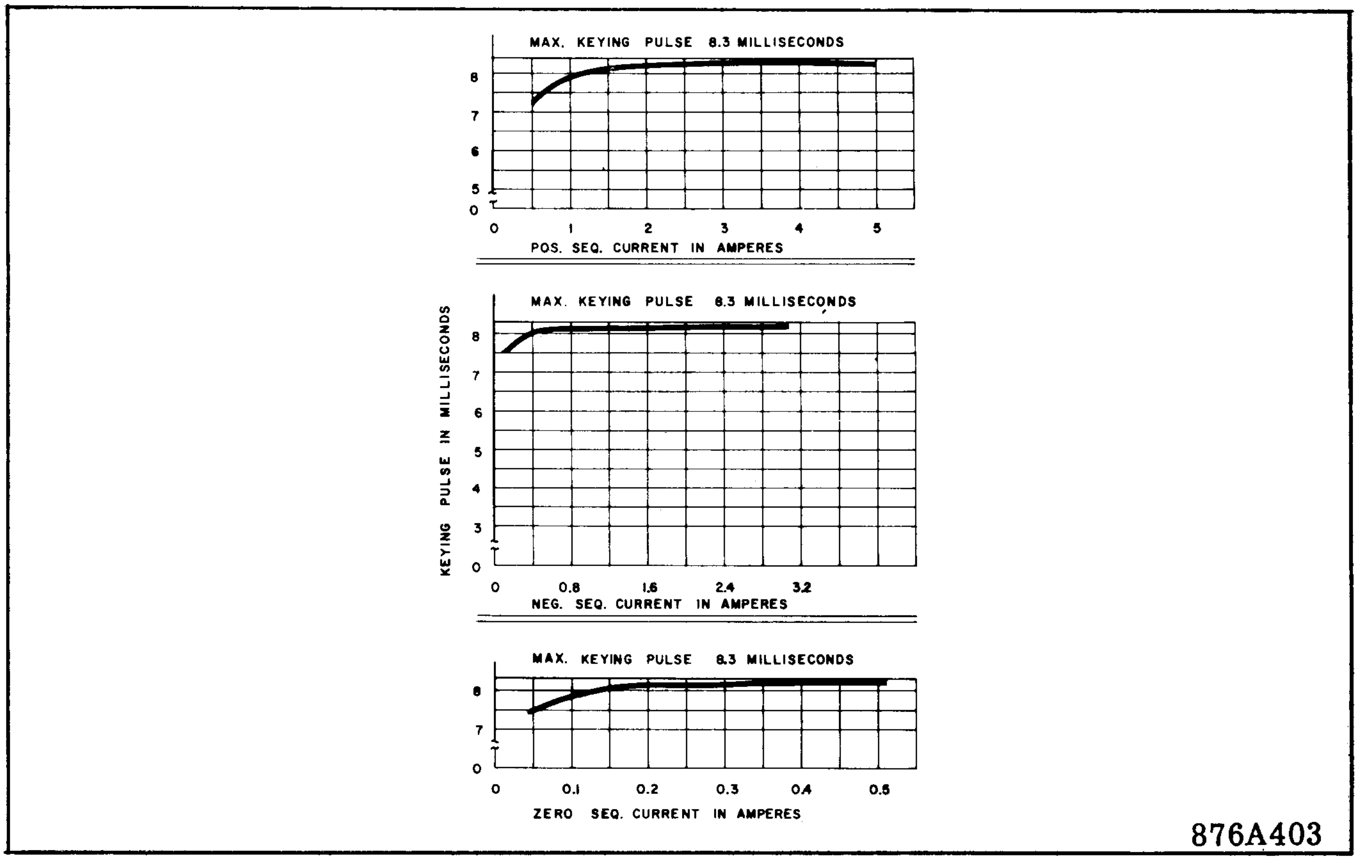


Fig. 28 Width of Keying Pulses at Different Current Levels of SKBU-21 Relay.

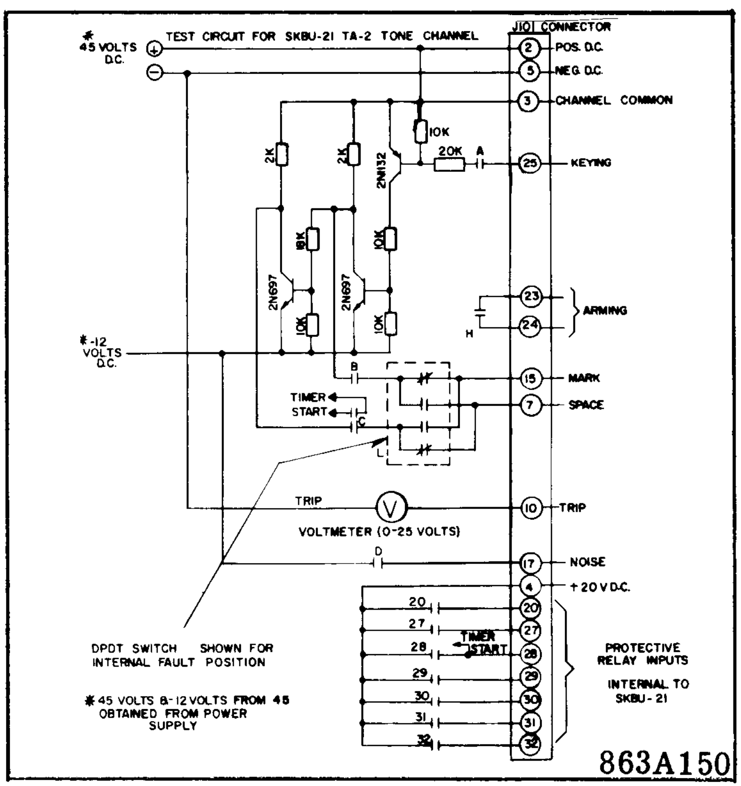


Fig. 29 Test Circuit of SKBU-21 Relay for TA-2 Tone Channel.

TEST POINT	CIRCUIT	VOLTAGE TO X4
X1	D.C. INPUT VOLTAGE	48 VOLTS D.C.
X2	REGULATED D.C.	20 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
X17	NOISE	NORMAL 0 VOLTS OPERATE 20 VOLTS
X18	DISTANCE FAULT DETECTOR OPERATION	NORMAL 0 VOLTS OPERATE 20 VOLTS
X19	LOSS OF SIGNAL CLAMP	NORMAL 0 VOLTS OPERATE 20 VOLTS
X20	LOSS OF POTENTIAL	NORMAL 20 VOLTS OPERATE 0 VOLTS
X22	FAULT DETECTOR	NORMAL 0 VOLTS OPERATE 20 VOLTS
X5 TO X6(GND)	LOW PASS FILTER	I LOAD 5 AMPS 3Ø — 16.7 MS — 14 TO 16 VOLTS
X14	KEYING	45 — SPACE; 36 — MARK
X12	LOCAL # 1	20 — BLOCK; 0 — UNBLOCK
X9	SPACE REMOTE # 3	20 — BLOCK; 0 — UNBLOCK; CHANNEL DELAY
X15	LOCAL # 2	20 — BLOCK; 0 — UNBLOCK
X16	MARK REMOTE # 4	20 — BLOCK; 0 — UNBLOCK

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Fig. 30 Table I Test Point Voltages.

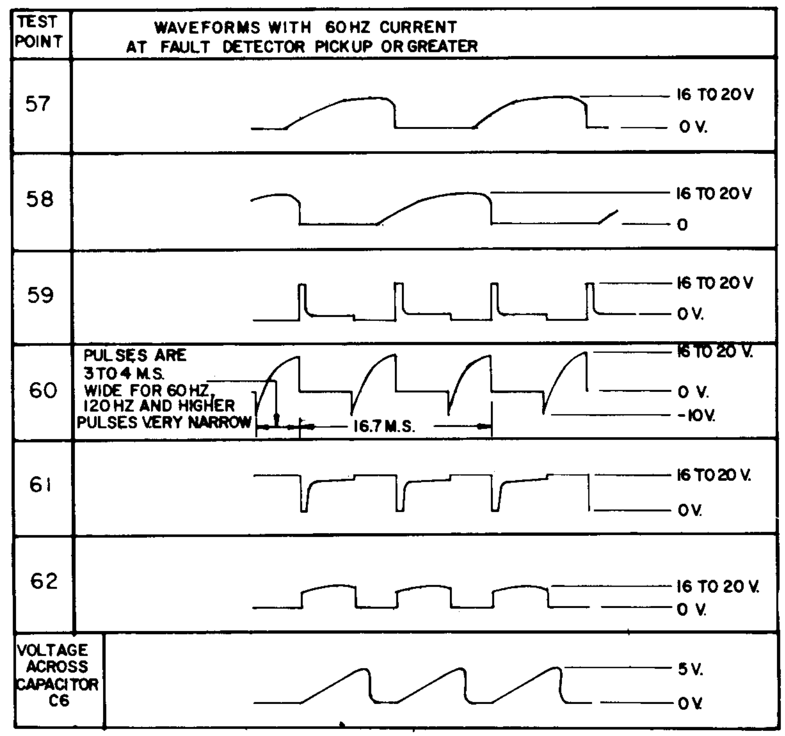

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Fig. 31 Table III frequency Verifier Waveforms at $60H_z$.

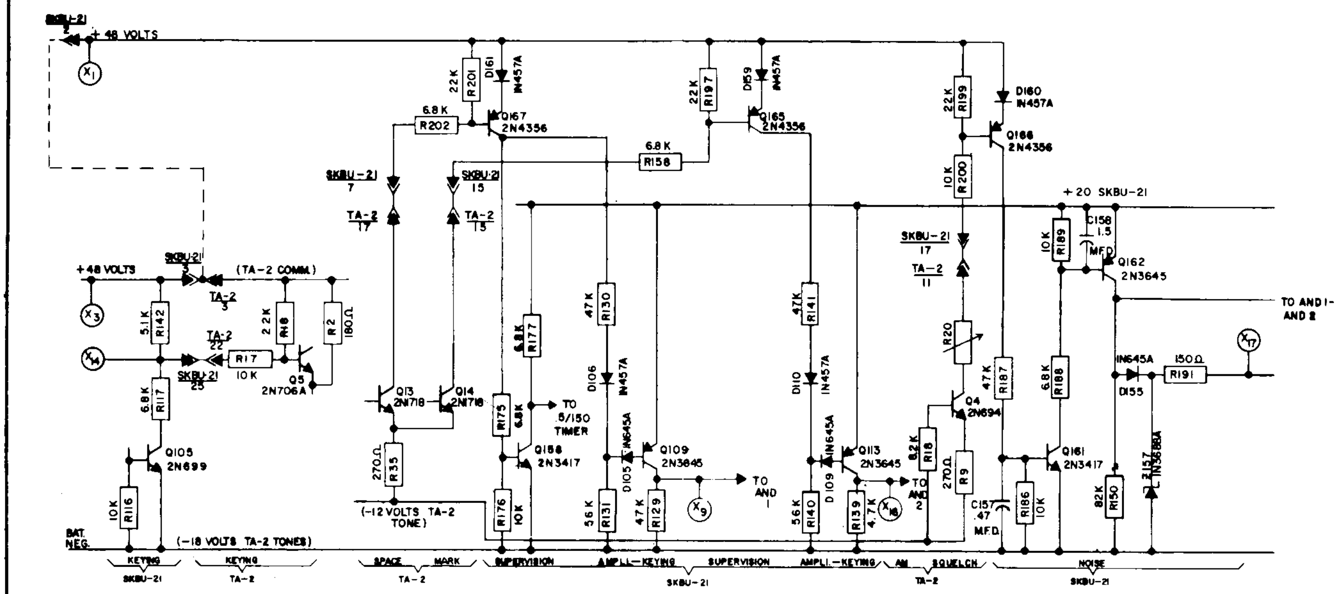

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Fig. 32 Elementary Connections for SKBU-21 Relay with TA-2 Tone Channel with AM Squelch.

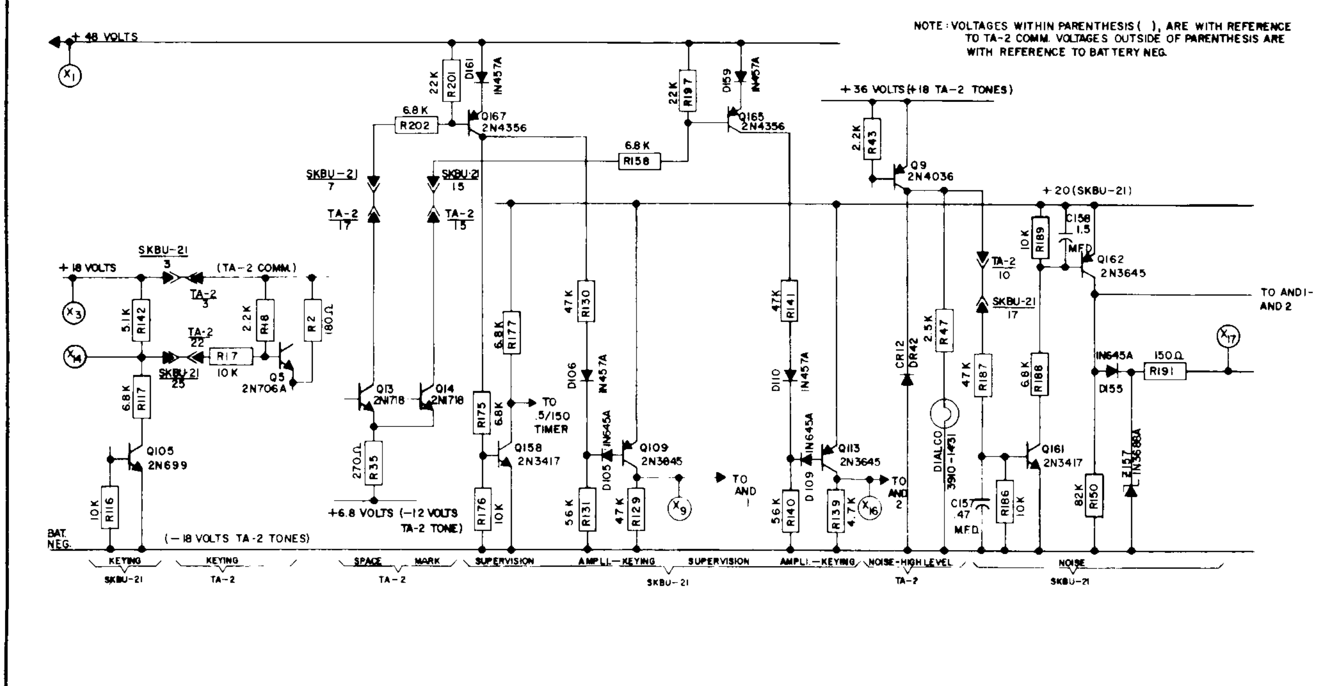

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Fig. 33 Elementary Connections of SKBU-21 Relay with TA-2 Tone Channel with TA-3 Noise Supervision.

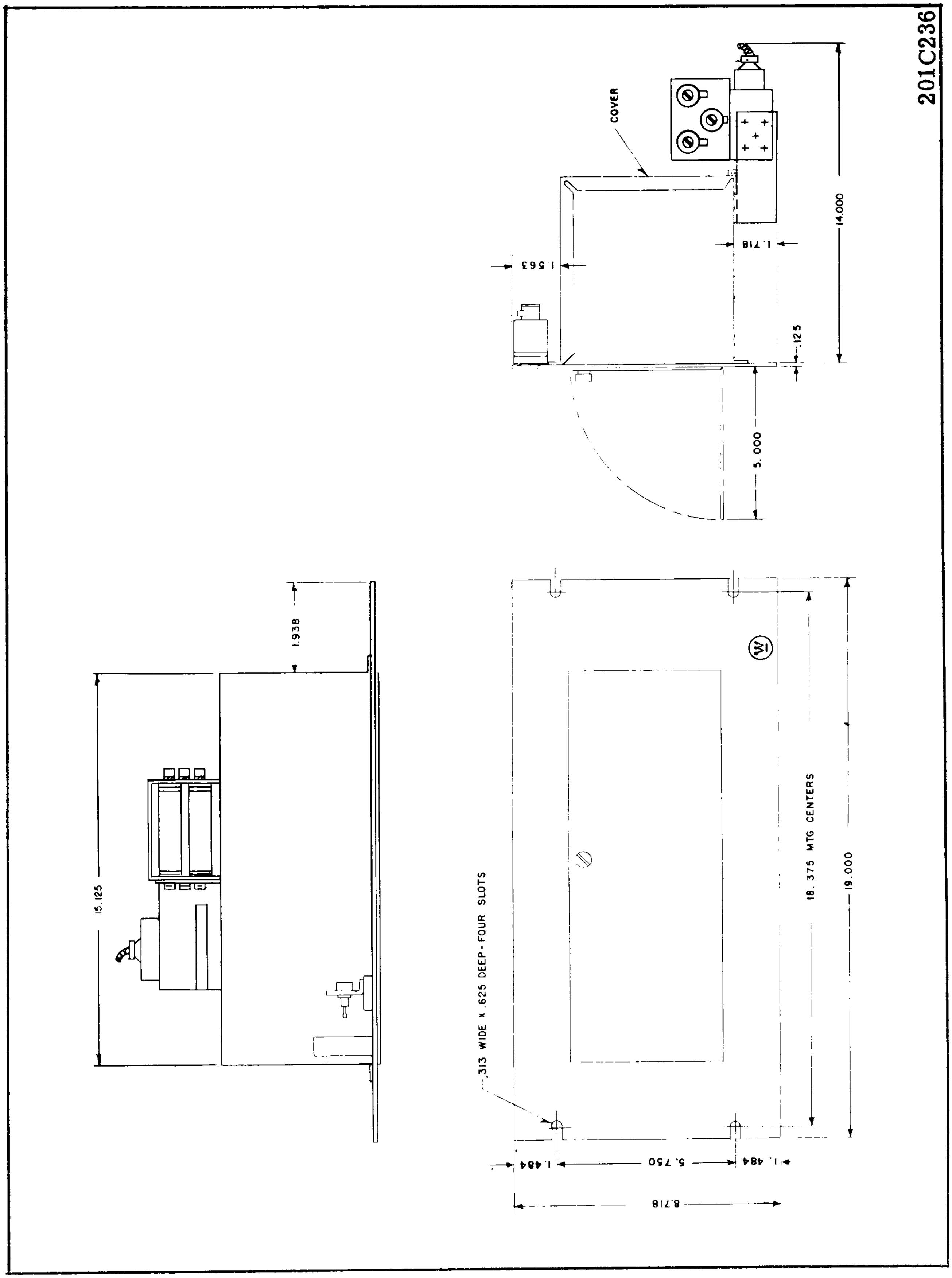

Fig. 34 Outline for the Type SKBU-21 Relay.

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

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