INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE STU-9 DUAL CHANNEL TRANSFER - TRIP RELAY

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

## APPLICATION

The type STU-9 relay is a static auxiliary relay used in transfer-trip relaying, such as would be used to trip a remote breaker for a transformer fault at a station where no high voltage breaker is used. It is used in conjunction with dual channel frequency-shift equipment, either audio tone or power line carrier frequencies.

## CONSTRUCTION

The type STU-9 relay consists of printed circuit boards, power supply, fuses, a pilot light, power switch, two channel monitoring lights, and adjustable controls 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.

### Printed Circuit Boards

The number of boards varies with the type channel used, but in general the STU-9 relay consists of five printed circuit boards; two channel interface boards, two transfer boards and a trip board. For TCF frequency shift power line carrier channels, the interface board is a part of the TCF receiver.

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

The interface board is the connecting link between the channel equipment and the transfer logic and consists of interface circuits, a lockout circuit, and the channel trip NAND. Each of the circuits performs designated functions with reference to the channel equipment. The interface circuits connect the lockout circuit and the channel trip NAND to the tone channel. In the normal state the trip NAND produces an output voltage due to the tone trip input being held at negative potential. This prevents base current from flowing into the transistor of the NAND and keeps the transistor turned off. As long as one of the three inputs is held at negative potential, a voltage output is obtained from the NAND. This voltage will exist until all inputs into the NAND are positive. Base current will then be applied to the NAND transistor and the transistor will turn on. This shorts the output of the NAND to negative potential. If the channel is lost, or if noise exists for extended periods of time, after 150 millisecond the lockout input will short the input of the NAND and hold the output in a non-operative condition. Also noise output from the tone channel will short the input of the NAND and hold the output in a non-operative condition.

This board will vary depending upon the make of frequency shift equipment used as the channel. In the case of TCF Frequency Shift Carrier equipment, the interface board is the logic board contained in the TCF receiver.

### 2. Transfer Logic Board

The transfer logic board contains the necessary

SUPERSEDES I.L. 41-959.2B & L-779959
*Denotes Change From Superseded Issue.

EFFECTIVE JUNE 1969

logic to alarm on loss of channel, to transfer to a single channel operation, and to invert the trip output of the interface logic to the proper polarity for the trip board. This logic will start transferring the STU-9 relay to a single channel mode of operation upon receipt of a positive voltage from the NOT Lockout circuit of the interface board.

Additional circuitry is included in the module for the connection of two external mounted switchboard lights (one for each channel). The lights are used to monitor the trips of the individual channels and should be connected between the regulated 45-volt d.c. (terminal 2) of the STU-9 and terminal 21 (channel 1) and terminal 9 (channel 2). The style switchboard light used is either style 1589193 or 1589181 with bulb style 1124156.

### 3. Trip Board

The trip board contains the final output of the STU-9 relay and consists of an AND circuit and an AR type relay. Under normal channel conditions, the two inputs from the trip of the transfer * logic are held at negative potential. The third input to the trip AND is a voltage from the transfer circuits of the transfer board. As a result the output transistor is not conducting and the AR relay does not pick up. In order for the final transistor to operate, all inputs to the AND must be above negative potential. This occurs when the AND receives a trip input from both transfer logics.

* For a loss of one channel, the trip input from the transfer logic of that channel removes its shorted input to negative, leaving the trip AND shorted to negative from the trip input of the remaining transfer logic. If both channels are lost, the trip inputs to the AND puts a positive voltage into the AND. However, the transfer input to the AND is put at negative potential to short the Input of the AND. A time delay is inserted in the transfer logic so that the transfer input to the AND is shorted to negative before the trip input switches to a positive output.

### Other Circuits (when used)

As shown in Figure 1, the trip output may contain other circuits. An additional transistor may be connected to obtain a voltage output from the trip NAND. This voltage output is used to drive an externally connected SAR relay. The transistor will apply 45 volts to the input of the SAR when the STU-9 relay operates.

D256 and D258 are used where it is not desirable to use the switching mode of the STU-9 relay. By connecting these diodes with a jumper to the lockout terminals of the interface board (terminal 18) of the STU-9 relay, the STU-9 relay will lockout on a single channel failure and not switch to a single channel mode of operation. With this connection the STU-9 relay will be operated as an AND circuit with reference to the channel and not as an OR.

The style numbers of the different boards with reference to the assembly is as follows:

| Style Number | Components |
|---|---|
| * 898C235G01 | AR output 3 NO-1NC, D256 and D258 omitted as well as transsistor Q254 and associated resistors. |
| * 898C235G02 | AR output 3 NO-1NC, D256 and D258 in the circuit but transistor Q254 and associated resistors omitted. |
| 898C235G03 | AR output 4 NO, D256 and D258 omitted, transistor Q254 included. |
| 898C235G04 | AR output 2NO-2NC, transistor Q254 and associated resistors included. |

### Power Supply

The STU-9 relay operates from a regulated 45 V.D.C. supply. This voltage is taken from a Zener diode mounted on a heat sink. Variation of the resistance values between the positive side of the unregulated D.C. supply and the 45 volt Zener diode adapt the receiver for operation on 48 or 125 volts d.c.

### Card Extender

A card extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one 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 circuit connections, and all components and test points on the board are readily accessible.

## OPERATION

The signal to which the STU-9 relay responds is received from the receiver of the channel equipment. If both channels are serviceable both channel receivers must receive a trip signal from the remote terminal for the STU-9 relay to operate. If one channel fails, the STU-9 relay will lock this channel out (after an adjustable time delay) and switch into a single channel mode of operation. The system will then trip upon receipt of a trip signal from the remote terminal on the remaining channel. If both channels fail, the STU-9 locks out the trip circuit until one or both channels are restored to service. Circuits are included in the relay to alarm on the loss of a channel.

The signals from the channel receivers are applied to the STU-9 relay at the input terminals of the interface board. This signal is transmitted to the transfer board to either apply a trip signal to the trip board, to prevent the transmission of this signal, or to transmit a transfer signal to a single channel.

When the frequency shift channel equipment is transmitting a guard signal, the signals to the STU-9 relay are as shown in the logic diagram of Figure 1. The number "1" indicates that a voltage is obtained at that point while a "0" indicates that the voltage is approximately zero. As seen in the logic diagram, the STU-9 relay requires a "1" from the low signal clamp and "0" from the trip and noise clamps of the tone channels to indicate nominal operating conditions.

For the condition shown, the amber lights are on and the alarm relay is picked up. Also the input to the trip "AND" is shorted to negative through the "OR" circuits of the transfer logic.

### Trip Sequence

If both channels are shifted to trip, the "0" from the tone channel changes to a "1". The trip interface of the STU-9 relay sees this change and puts a "1" into the channel trip "NAND". The output of the "NAND" goes to a "0" and the following occurs:

1. One input of the amber light AND is "0" and the light turns off.

2. The output of the NOT of the transfer logic changes to a "1" and applies a "1" to the trip AND through the OR of the transfer logic. Since all inputs to the trip AND are "1", an output is obtained to allow the AR to operate. Also the output transistor (where used) is turned on to give an output of approximately 45 volts. This voltage can be used to fire an external SAR relay to trip two breakers through Trinistor controlled rectifiers.

### Loss of Signal

With reference to the logic diagram of Fig. 1, the channel equipment recognizes a loss of channel and its low signal output changes to a "0". The output of the low signal interface of the STU-9 then changes to a "1". Upon application of the "1" to the NOR circuit, a time delay is energized. If the loss of signal exists for 150 millisecond, the output of the NOR circuit changes to a "0" and the following occurs:

1. The input to the channel trip NAND is clamped to negative which locks the NAND output to a "1" state (non-trip).

2. One input to the amber light AND drops to zero and the amber light turns off.

3. The output of the NOT Lo changes to a "1", which energizes a timer. After a time delay of .5 to 2.5 sec., as determined by the timer setting, the timer times out and its output changes to a "0". The following then occurs:

   a. Alarm relay drops out to close its contacts.

   b. The output of the NOT changes to a 1 and energizes a 10-millisecond time delay circuit. After 10 milliseconds the input to the AND circuit is energized through the OR circuit.

4. Two voltages are applied to the trip "AND". The third input is clamped to negative by the output of the OR circuit on the good channel. The circuits of the STU-9 are set up for single channel operation and the system will operate if a trip signal is received from the output of the good channel.

### Loss of Second Channel

If the second channel is lost while the STU-9 is set up in a single channel mode of operation, the following occurs:

1. The output of the low signal interface of the second channel changes to a 1.

2. The channel trip NAND is clamped to a "1". (non-trip).

3. The input to the amber light AND is de-energized and the amber light turns off.

4. The output of the NOT Lo changes to a 1, and the 2.5 second timer times out, and the following occurs:

   a. The alarm unit drops out to close its contacts.

   b. The input to the trip AND through terminal 11 drops to "0" instantaneously.

   c. The output of the NOT changes to a "1" and energizes a 10 millisecond delay.

   d. At the end of 10 milliseconds the input to the trip AND (through terminal 10) AND changes to a "1". Tripping cannot occur because the AND was clamped previously to negative through terminal 11.

For the condition where both channels are out of service and one or both channels are restored to service, the following occurs:

The time delay in the base of transistor Q251 in the trip logic is energized. This time delay maintains the "0" on the trip AND through diode D252, for ½ millisecond after the voltage from either D253 or D251 drops to "0" from a "1" condition.

## Noise

If an output is obtained from the noise clamp of the channel equipment, the input to the noise interface changes to a "1", and energizes a NOT and a NOR circuit. The output of the NOT changes to a "0" and shorts the input to the channel trip NAND to negative. This puts the NAND in a non-operating condition. If the noise condition exists for 150 milliseconds, the STU-9 relay will recognize the condition as a loss of channel and switch into a single channel mode of operation.

## CHARACTERISTICS

The type STU-9 relay is available for frequency shift channels, either tone, carrier, or a combination of both. The schematic and logic diagram for frequency-shift tone channels is shown in Figure 1.

If TCF frequency shift carrier is used as the channel equipment, the logic diagram and schematic diagram of Figures 2 and 3 apply. This logic is the same as that of Fig. 1, except that the interface board is omitted. The lockout, not lockout, and trip inputs the STU-9 transfer boards are obtained from the logic board of the TCF receiver. These quantities are the same as received from the interface logic Fig. 1.

When the STU-9 relay is used with both TCF frequency shift Carrier and frequency shift tone channels, the relay is connected as shown in Figure 4.

* For the STU-9 for use with frequency shift tone channels and an SRU output package, refer to figures 5 and 6. For these relays the trip output is a voltage.

| | |
|---|---|
| Lockout time | 150 milliseconds |
| Transfer time | 0.5 to 2.5 seconds |
| Operating time | 3 milliseconds with AR – 75 microseconds to obtain voltage contact. |
| Voltage Output Relay (when used) Maximum Output | 60 milliamperes, 45 V. d.c. |
| * Ambient temperature range | –20°C to 55°C |

Battery Voltage Variations

| Rated Voltage | Allowance Variation |
|---|---|
| 48 V.D.C. | 42 - 56 V.D.C. |
| 125 V.D.C. | 105 - 140 V.D.C. |

| | |
|---|---|
| Battery Drain | 235 milliamperes-48 V.D.C.<br>275 milliamperes - 125 V.D.C. |
| Dimensions | Panel Height — 8¾ inch or 5 rack units.<br>Panel Width-19 inches |

## SETTING

The only setting required is the setting of the timer for transfering to a single channel mode of operation upon a loss of one channel. This setting is made by means of the timer knobs on the front panel of the relay. The knob should be locked after the setting is made.

## INSTALLATION

The STU-9 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.

### Routine Maintenance

Periodic checks of the relaying system as described in the assembly instructions are desirable to indicate impending failure so that the equipment can be taken out of service for correction.

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

### Trouble-Shooting

The components of the STU-9 are operated well within their ratings, and under normal conditions they should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the voltages tabulated in TABLE I should be checked to determine the faulty circuit. The test point and component location on the boards are given in Figures 7, 8, 9, 10, * and 11. Refer to electrical parts list for the proper component location.

**TABLE I**

Test point voltages to negative except where specified to positive 45 volts D.C.

| BOARD | TEST POINT | NORMAL CHANNEL | WITH NOISE ONLY | WITH LOSS OF CHANNEL ONLY | | WITH TRIP ONLY |
|---|---|---|---|---|---|---|
| CHANNEL INTERFACE | term 16 to pos | -16 | - 16 | - 2 | | - 16 |
| | TP151 | 0.05 | 0.05 | 15 | | 0.05 |
| | term 17 to pos | 0 | —16 | 0 | | 0 |
| | TP153 | 15 | 0.05 | 15 | | 15 |
| | TP154 | 0.05 | 15 | 0.05 | | 0.05 |
| | TP155 | 15 | 0.05 | 0.05 | | 15 |
| | TP156 | 0.05 | 21 | 21 | | 0.05 |
| | term 18 | 10 | 0.10 | 0.10 | | 10 |
| | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 15 to pos | 0 | 0 | 0 | | -16 |
| | term 11 | 15 | 15 | 15 | | 0.05 |
| | term 10 | 0.05 | 0.05 | 0.05 | | 15 |
| | term 6 | 15 | 15 | 15 | | 0.2 |
| TRANSFER | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 16 | 0.05 | 45 | 45 | | 45 |
| | TP201 | 0.05 | 0.05 | 0.05 | | 10 |
| | TP202 | 9 | 0.1 | 0.1 | | 9 |
| | TP203 | 0.05 | 20 | 20 | | 0.05 |
| | TP204 | 13 | 0.05 | 0.05 | | 0.05 |
| | term 10 | 0.15 | 10 | 10 | | 10 |
| | term 11 | 0.7 | 0.7 | 0.7 | | 0.7 |
| | term 7 | 45 | 0.3 | 0.3 | | 0.3 |
| | | | | Single CH | Both CH | |
| TRIP | TP251 | 0.05 | 0.05 | 0.05 | 15 | 0.05 |
| | TP252 | 15 | 15 | 15 | 0.07 | 15 |
| | term 10 | 0.15 | 10 | 10 | 10 | 10 |
| | term 11 | 0.15 | 10 | 10 | 10 | 10 |
| | term 19 | 0.05 | 0.05 | 0.05 | 0.05 | 43 |

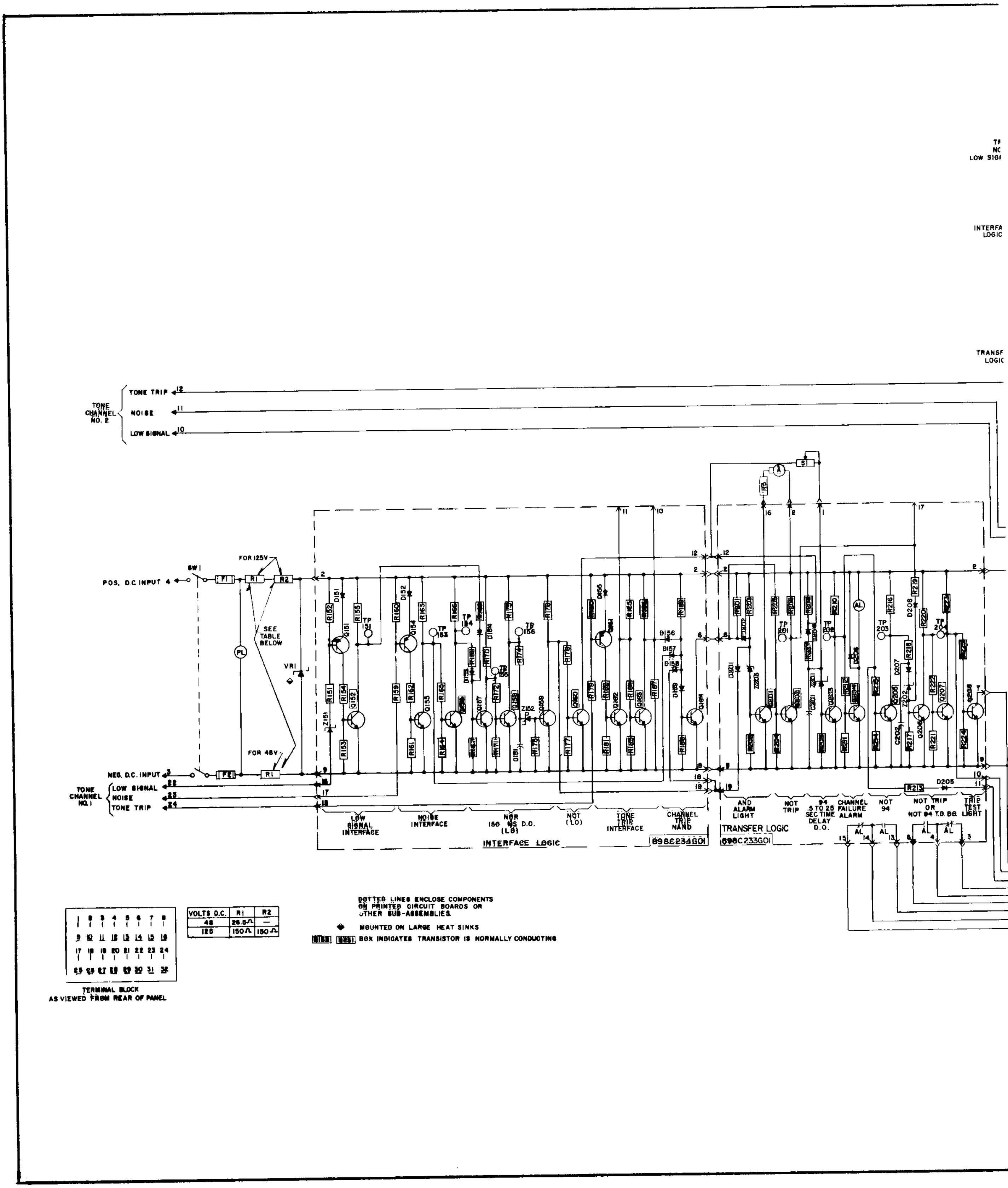
## Renewal Part

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, and component style No. given in the electrical parts list.

## *ELECTRICAL PARTS LIST

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| **PANEL MOUNTED COMPONENTS** | | |
| **Power Supply** | | |
| SW1 | Switch | 183A856H01 |
| PL | Pilot Light 125 V.D.C. | 183A825G01 |
| | Pilot Light 48 V.D.C. | 183A825G04 |
| F1—F2 | 1.5 Ampere Fuse | 11D9195H26 |
| R1 | 26.5 Ω 40w. 48 V.D.C. | 04D1299H44 |
| R1—R2 | 150 Ω 40 w. 125 V.D.C. | 1201499 |
| VR1 | Zener Diode, IN2828B, 50W. | 184A854H06 |
| **Alarm** | | |
| A | Amber Light | 183A825G08 |
| R3—R4 | 330 Ω 3W. | 185A207H15 |
| **Potentiometer** | | |
| S1—S2 | 50 K Ω | 185A086H22 |
| **CHANNEL INTERFACE BOARD (898C234G01) Component Location – Fig. 7** | | |
| **Capacitor** | | |
| C 151 | 6.8MFD 35 V.D.C. | 184A661H25 |
| **Diodes** | | |
| D151 | IN457A | 184A855H07 |
| **Transistors** | | |
| Q151-Q154-Q161 Q152-Q155-Q156 Q157-Q158-Q162 | 2N2043 | 184A638H21 |
| Q163 | 2N696 | 762A585H01 |
| Q159 | 2N697 | 184A638H18 |
| Q160-Q164 | 2N699 | 184A638H19 |
| **Resistors** | | |
| R151-R159-R179 | 6.8KΩ—½W. | 184A763H47 |
| R152-R160-R174 R180 | 1K Ω—½W. | 184A763H27 |
| R153-R161-R164 R167-R171 | 10K Ω—½W. | 184A763H51 |

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| **Resistors (Cont.)** | | |
| R175-R177-R181- R183-R188-R154- R162-R182-R189 | 100KΩ—½W. | 184A763H75 |
| R155-R163-R166- R170-R185-R186 | 68KΩ—½W. | 184A763H71 |
| R165-R168-R169- R172-R184-R187 | 33KΩ—½W. | 184A763H63 |
| R173 | 39KΩ—½W. | 184A763H65 |
| R176 | 12KΩ—½W. | 184A763H53 |
| R178 | 3.3KΩ—½W. | 184A763H39 |
| **Zener Diodes** | | |
| Z151 | IN957B 6.7V | 186A797H06 |
| Z152 | IN3686B 20V | 185A212H06 |
| **TRANSFER BOARD (898C233G01) Component location – Fig. 8** | | |
| **Capacitors** | | |
| C201 | 68MFD 35 V.D.C. | 187A508H02 |
| C202 | 0.5MFD | 187A624H11 |
| **Diodes** | | |
| D201, D202 D204 to D208 | IN457A | 184A638H07 |
| **Transistors** | | |
| Q201-Q202-Q204- Q208 | 2N699 | 184A638H19 |
| Q203-Q207 | 2N697 | 184A638H18 |
| Q205-Q206 | 2N696 | 762A585H01 |
| **Resistors** | | |
| R201-R206-R216- R220 | 68KΩ—½W. | 184A763H71 |
| R202-R204-R208- R209-R211-R214- R217-R221-R224 | 10KΩ—½W. | 184A763H51 |
| R203 | 10KΩ—1W. | 187A643H51 |
| R205-218-R219- R222 | 33KΩ—½W. | 184A763H63 |
| R207 | 1KΩ—½W. | 184A763H27 |
| R210-R223 | 12KΩ—½W. | 184A763H53 |
| R212-R225 | 3.3KΩ—½W. | 184A763H39 |
| R213-R215 | 22KΩ—½W. | 184A763H59 |



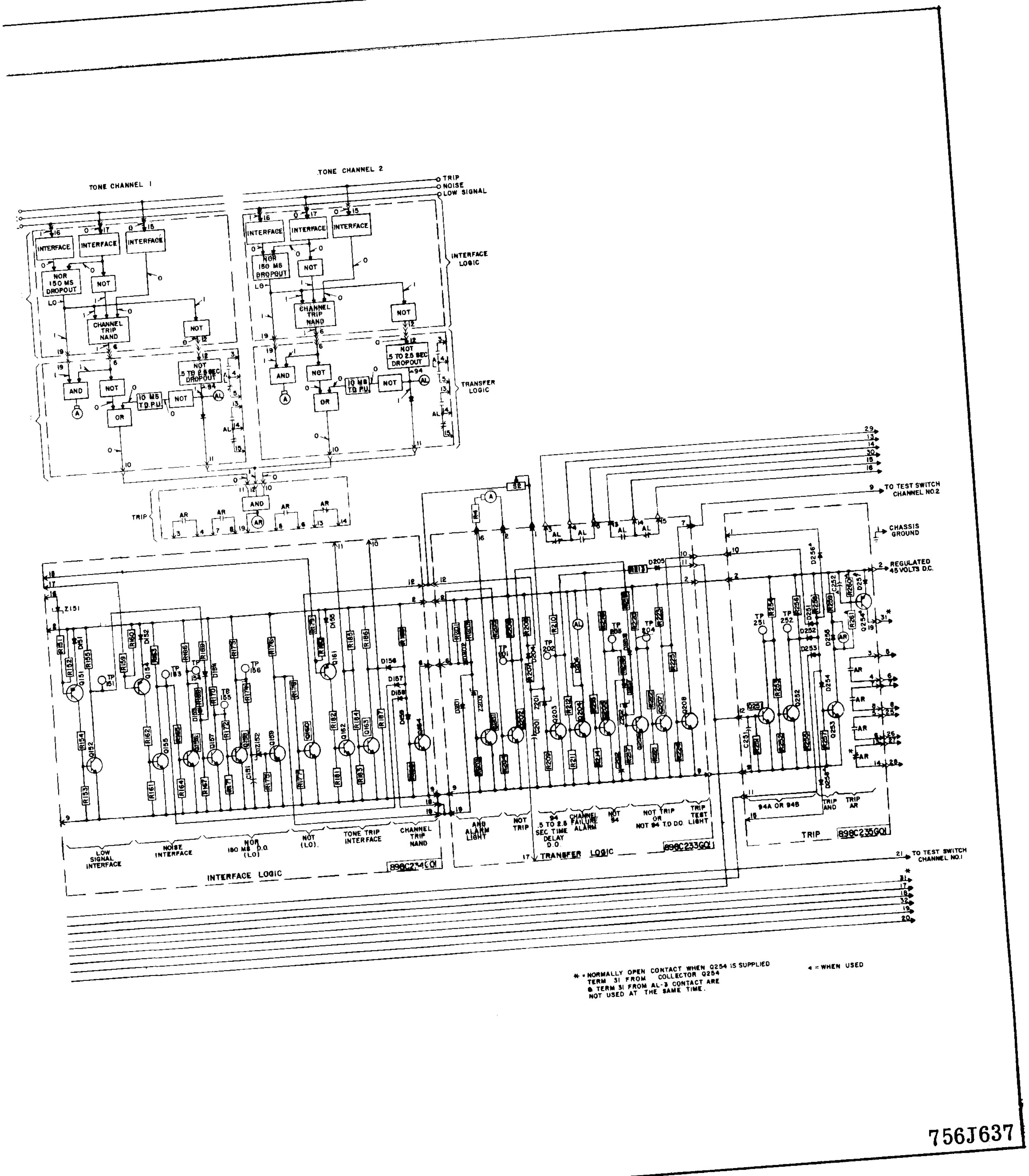

| VOLTS D.C. | R1 | R2 |
|---|---|---|
| 48 | 26.5Ω | — |
| 125 | 150Ω | 150Ω |

** Fig. 1. Internal Schematic of Type STU-9 Rela*

# *ELECTRICAL PARTS LIST (Continued)

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| **TRANSFER BOARD (898C233G01) (Cont.)** | | |
| **Zener Diodes** | | |
| Z201 | IN3686B 20V | 185A212H06 |
| Z202, Z203 | IN957B 6.8V | 186A797H06 |
| **Alarm Unit** | | |
| AL | Telephone Relay | 408C062H07 |
| **TRANSFER BOARD (899C712G01) Component location – Fig. 9** | | |
| **Capacitors** | | |
| C201 | 68 mfd, 35 Vdc | 187A508H02 |
| C202 | 0.5 mfd | 187A624H11 |
| **Diodes** | | |
| D201, D202, D204-D208 | 1N475A | 184A638H07 |
| **Transistors** | | |
| Q201-Q202-Q204-Q208 | 2N699 | 184A638H19 |
| Q203-Q207 | 2N697 | 184A638H18 |
| Q205-Q206 | 2N696 | 762A585H01 |
| **Resistors** | | |
| R201-R206-R216-R220 | 68 K-Ω,½W. | 184A763H71 |
| R202-R204-R208-R209-R211-R214-R217-R221-R224 | 10 K-Ω,½W. | 184A763H51 |
| R203 | 10 K-Ω,1W. | 187A643H51 |
| R205-R218-R219-R222 | 33 K-Ω,½W. | 184A763H63 |
| R207 | 1 K-Ω, ½W. | 184A763H27 |
| R210-R212 | 22 K-Ω,½W. | 184A763H59 |
| R213-R215 | 22 K-Ω,½W. | 184A763H59 |
| R223 | 12 K-Ω,½W. | 184A763H53 |
| R225 | 3.3 K-Ω,½W. | 184A763H39 |
| **Zener Diodes** | | |
| Z201 | 1N3686B,20V | 185A212H06 |
| Z202,Z203 | 1N957B, 6.8V | 186A797H06 |
| **TRIP BOARD (898C235G01) Component location – Fig. 10** | | |
| **Capacitors** | | |
| C251-C252 | .25 uf | 187A624H02 |

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| **Diodes** | | |
| D251 to D255 | IN457A | 184A855H07 |
| D252 to D253 (when used) | IN457A | 184A855H07 |
| **Transistors** | | |
| Q251-Q252 | 2N696 | 762A585H01 |
| Q253 | 2N699 | 184A638H19 |
| Q254 (when used) | 2N2043 | 184A638H21 |
| **Resistors** | | |
| R251-R252-R257 | 10K Ω –½W. | 184A763H51 |
| R253-R255 | 33K Ω –½W. | 184A763H63 |
| R254-R256 | 68K Ω –½W. | 184A763H71 |
| R258 | 10K Ω –1W. | 184A643H51 |
| R259 | 800 Ω –3W. | 184A859H06 |
| R260 (when used) | 1K Ω –½W. | 184A763H27 |
| R261 (when used) | 10K Ω –½W. | 184A763H51 |
| **AR Unit** | | |
| AR (when used) | 3NO–INC contacts | 408C845G23 |
| AR (when used) | 4NO-contacts | 408C845G13 |
| AR (when used) | 2NO-2NC contacts | 408C845G09 |
| **TRIP BOARD (899C700G01) Component location – Fig. 11** | | |
| **Capacitor** | | |
| C251-C252 | 0.25 UF | 187A624H02 |
| D251 to D255-D258-D260 | 1N475A | 184A855H07 |
| D256-D257-D259-D261 | CER-69 | 188A342H06 |
| **Transistors** | | |
| Q251-Q252 | 2N696 | 762A585H01 |
| Q253 | 2N699 | 184A638H19 |
| Q254-Q255-Q256 | 2N4356 | 849A441H02 |
| **Resistors** | | |
| R251-R252-R257-R259-R263-R266 | 10K, ½W. | 184A763H51 |
| R253-R255 | 33K, ½W. | 184A763H63 |
| R254-R256 | 68K, ½W. | 184A763H71 |
| R258 | 100K, ½W. | 184A763H75 |
| R261-R264-R267 | 2.25K, 3W. | 184A636H03 |
| R260-R262-R265 | 1K, ½W. | 184A763H27 |
| **Zener Diodes** | | |
| Z251 | 1N3686B | 185A212H06 |



TONE CHANNEL 1
TONE CHANNEL 2
TRIP
NOISE
LOW SIGNAL
INTERFACE LOGIC
TRANSFER LOGIC
TO TEST SWITCH CHANNEL NO.2
CHASSIS GROUND
REGULATED 45 VOLTS D.C.
LOW SIGNAL INTERFACE
NOISE INTERFACE
NOR 150 MS D.O. (LO)
NOT (LO)
TONE TRIP INTERFACE
CHANNEL TRIP NAND
AND ALARM LIGHT
NOT TRIP
94 .5 TO 2.5 SEC TIME DELAY D.O.
CHANNEL FAILURE ALARM
NOT 94
NOT TRIP OR NOT 94 T.D DO
TRIP TEST LIGHT
94A OR 94B
TRIP AND
TRIP AR
898C234G01
898C233G01
898C235G01
TO TEST SWITCH CHANNEL NO.1
* NORMALLY OPEN CONTACT WHEN Q254 IS SUPPLIED TERM 31 FROM COLLECTOR Q254
& TERM 31 FROM AL-3 CONTACT ARE NOT USED AT THE SAME TIME.
▲ = WHEN USED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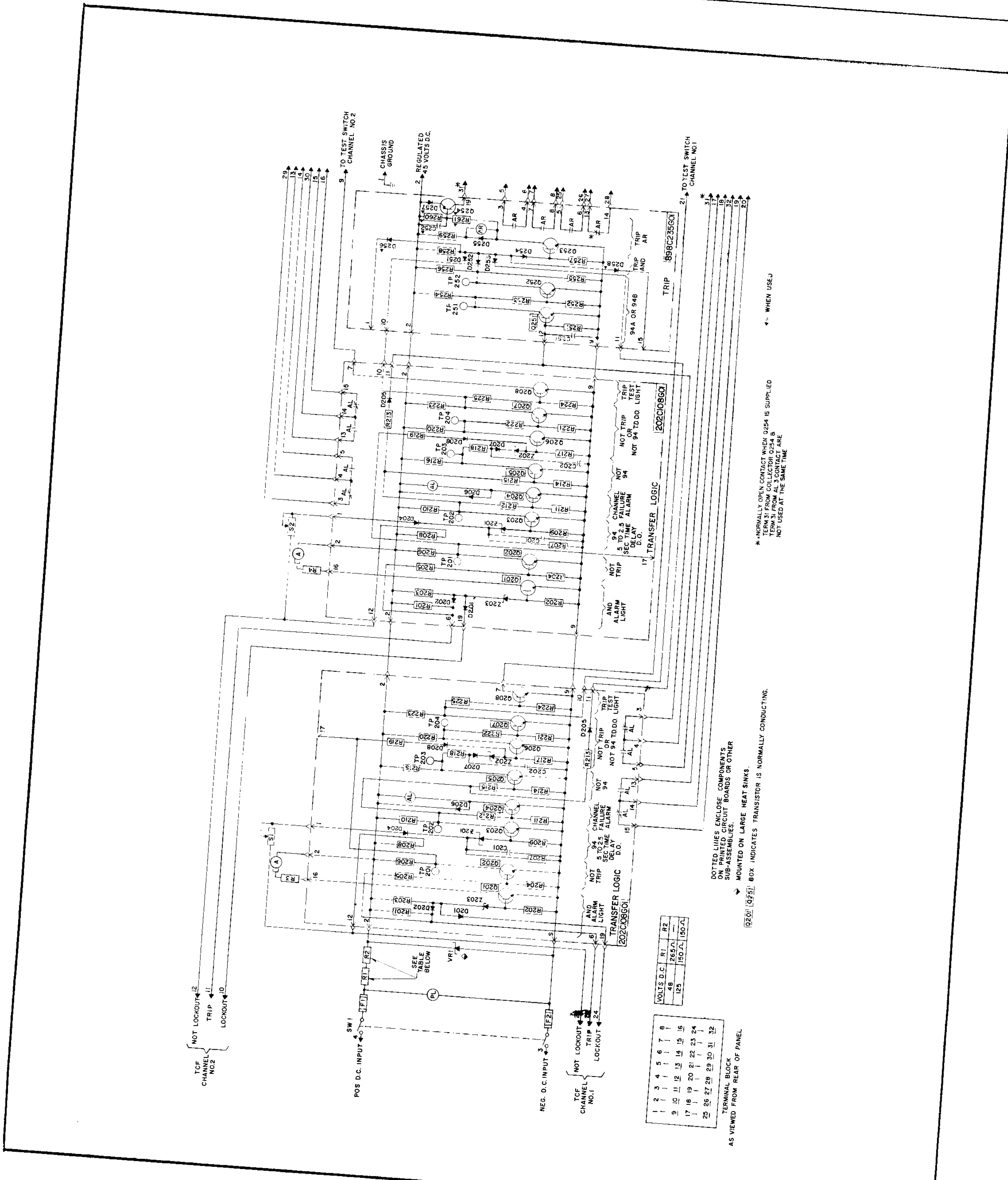



* Fig. 2. Internal Schematic of Type STU-9 Relay for TCF Frequency Shift Carrier Channel

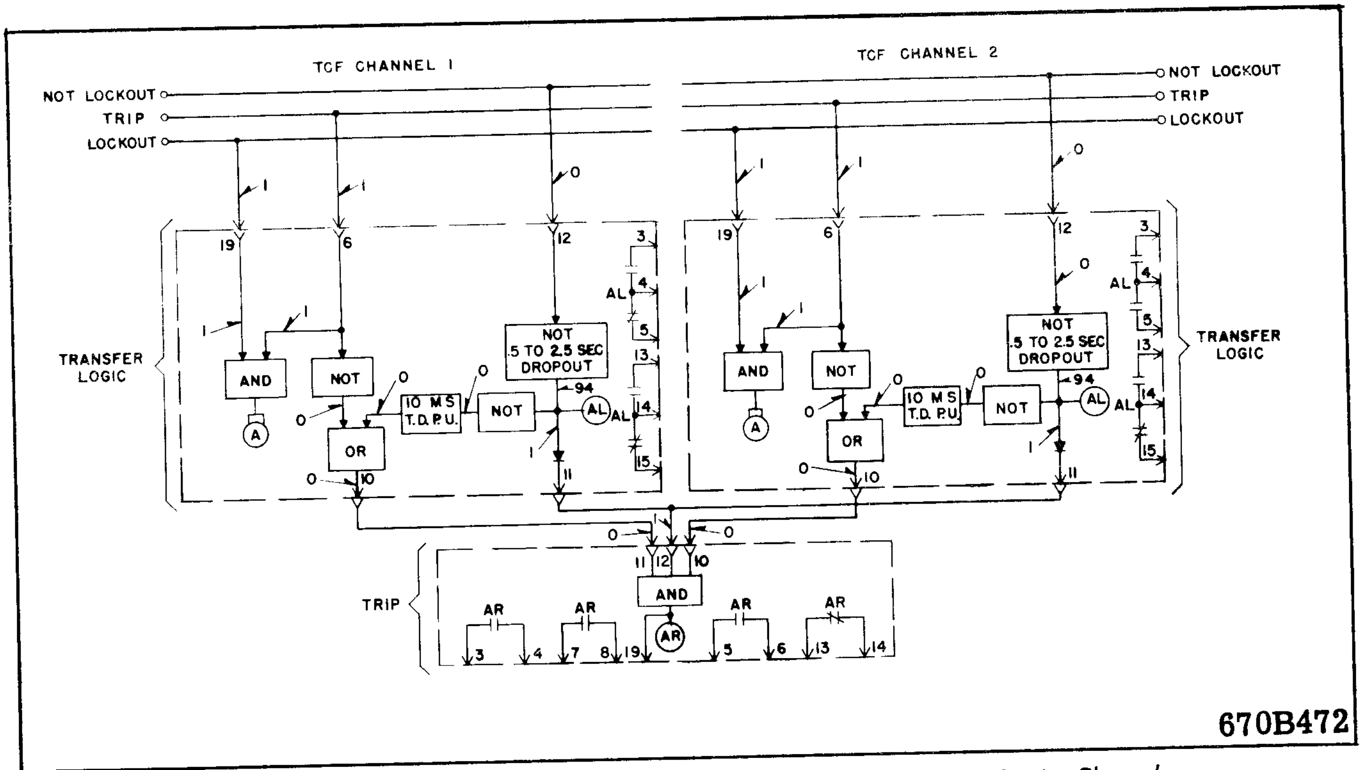
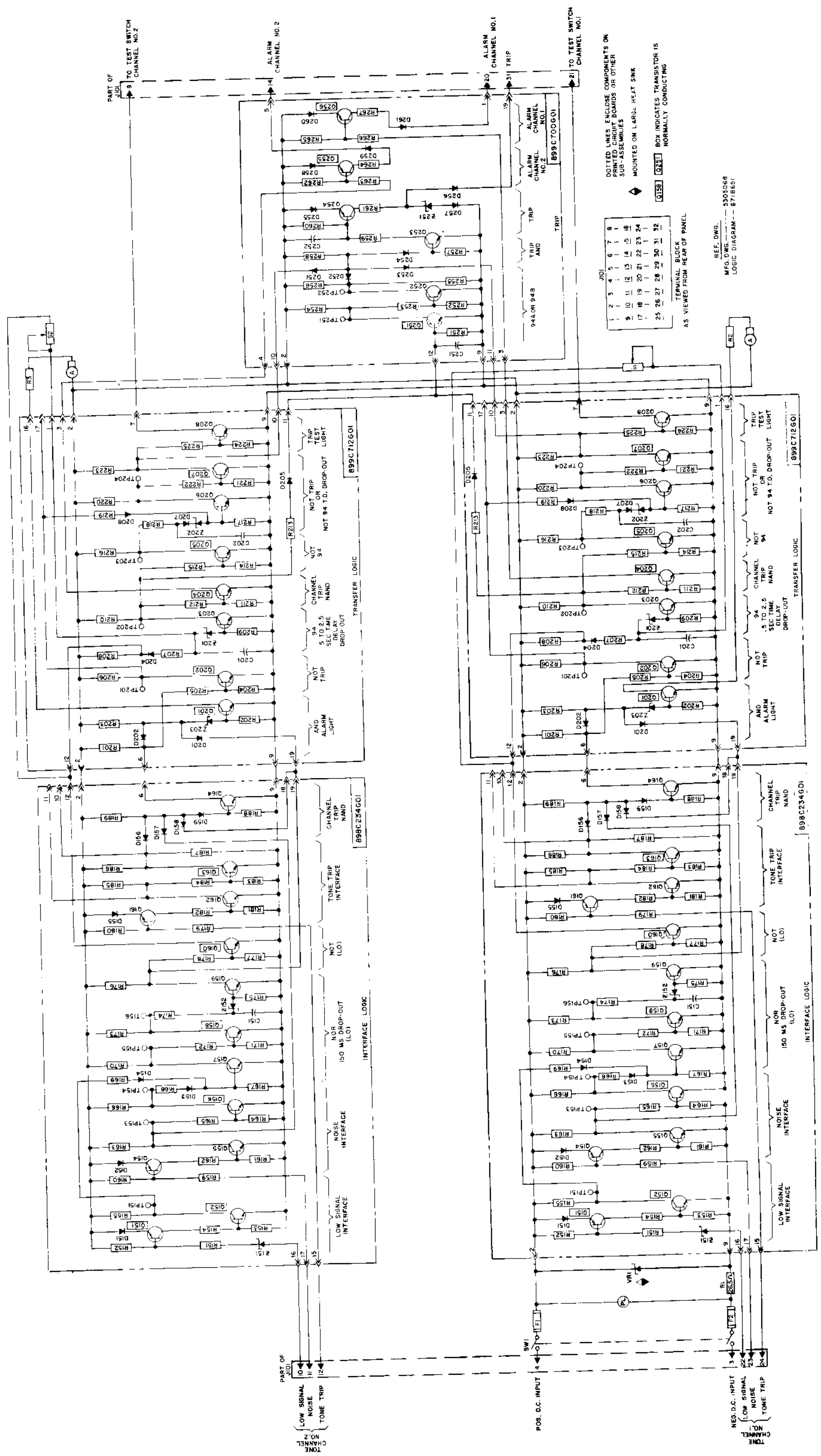



*Fig. 3. Logic Diagram of Type STU-9 Relay for TCF Frequency Shift Carrier Channel*



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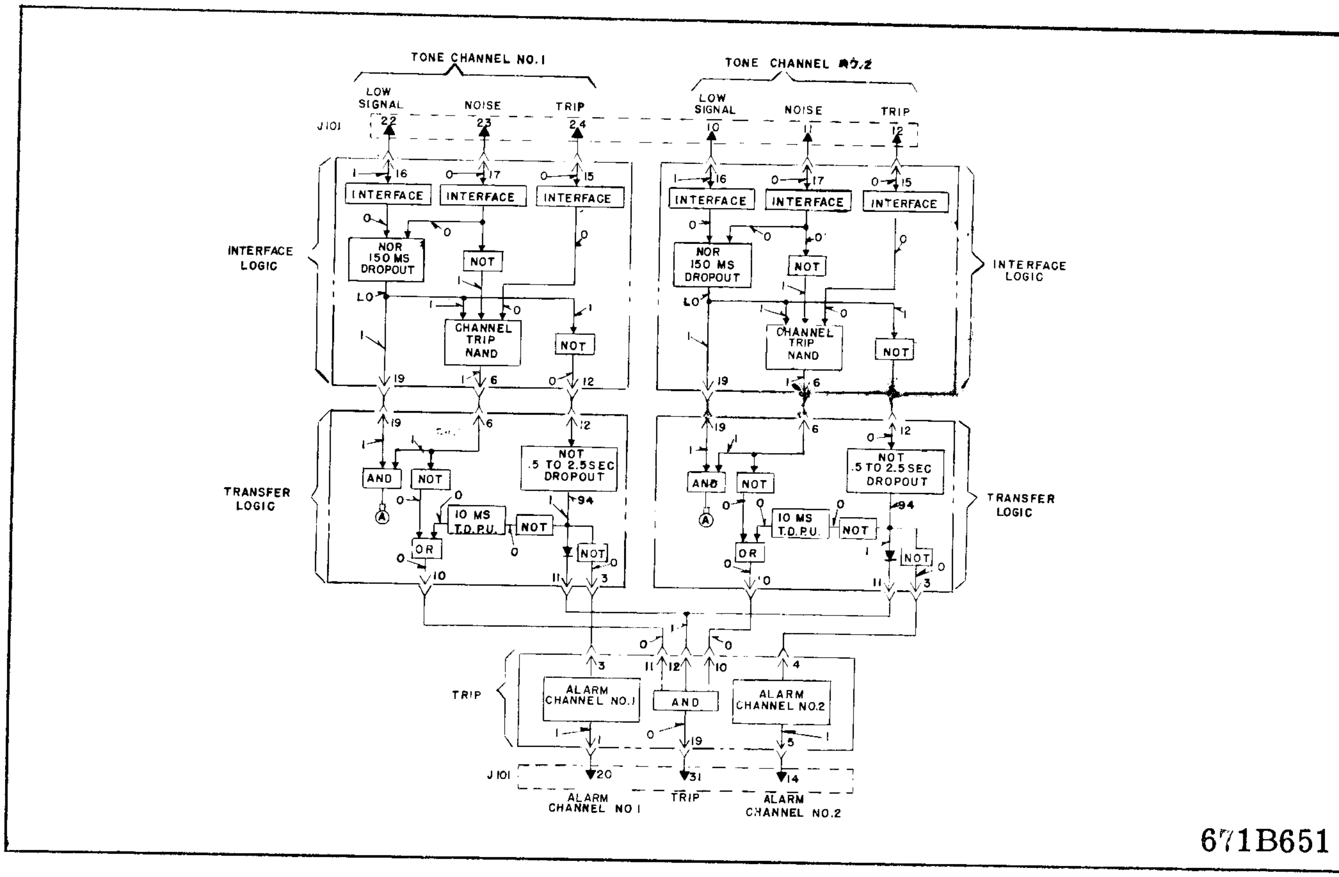
* *Fig. 5.*




* *Fig. 6.*

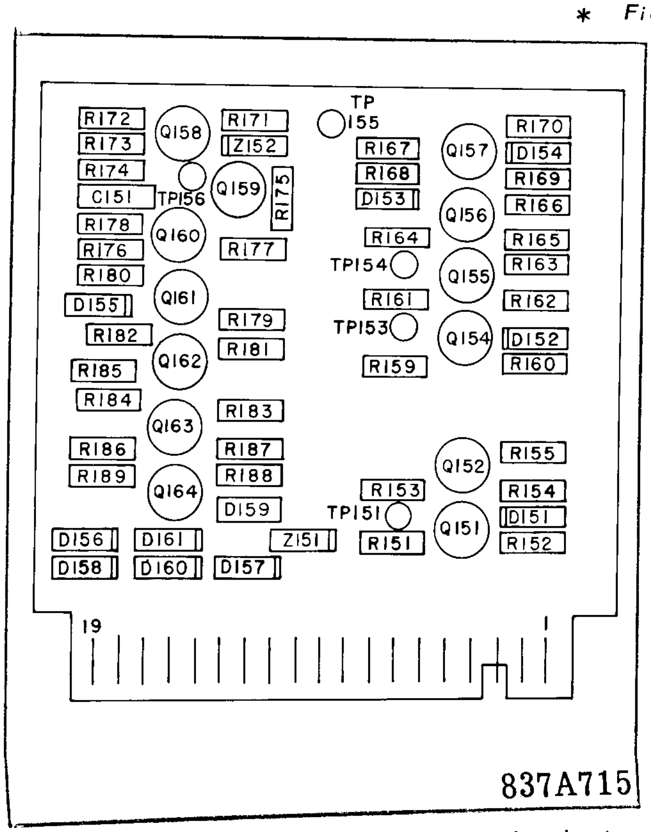
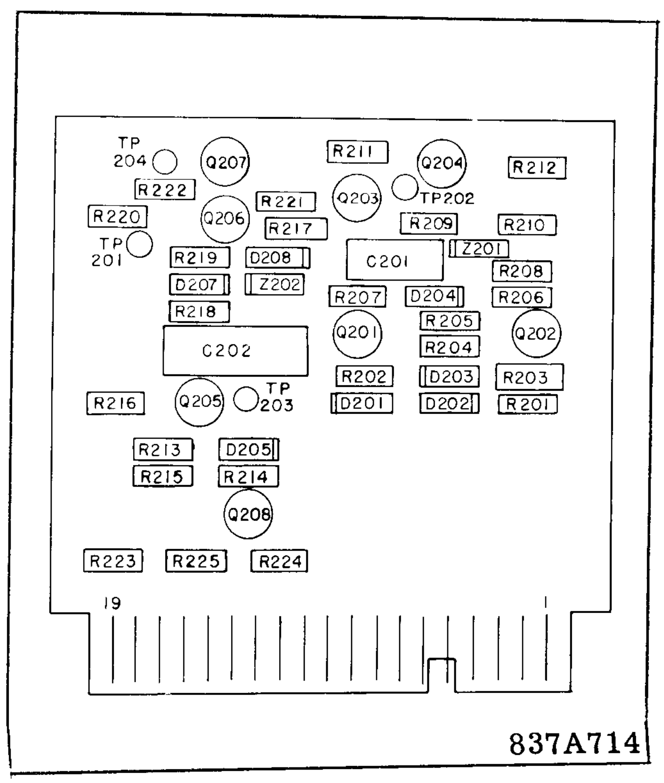
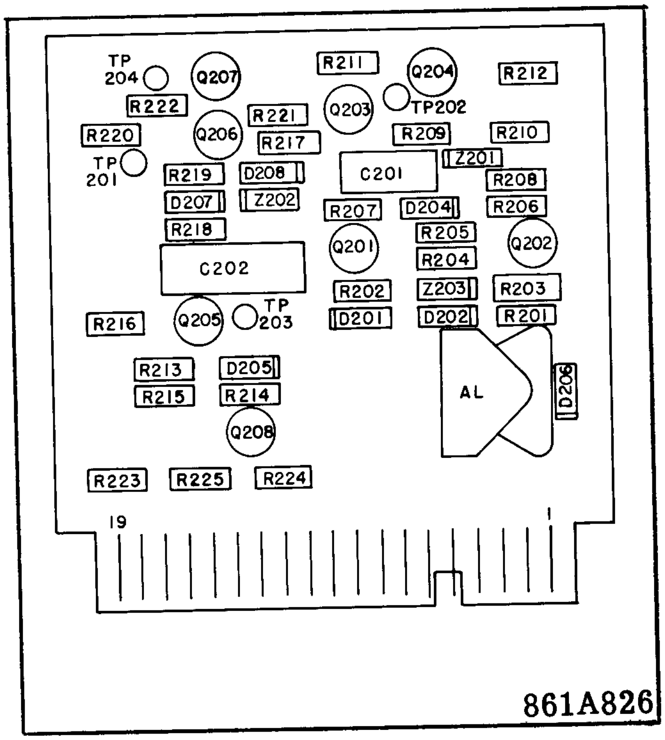



Fig. 7. Component Locations on the Interface Logic Board




* Fig. 8. Component Location on the Transfer Logic Board




* Fig. 9.

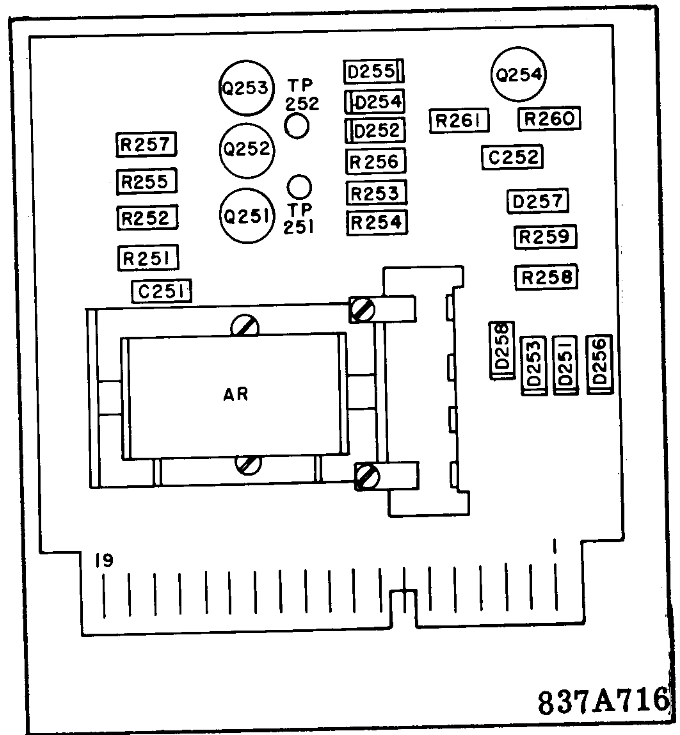
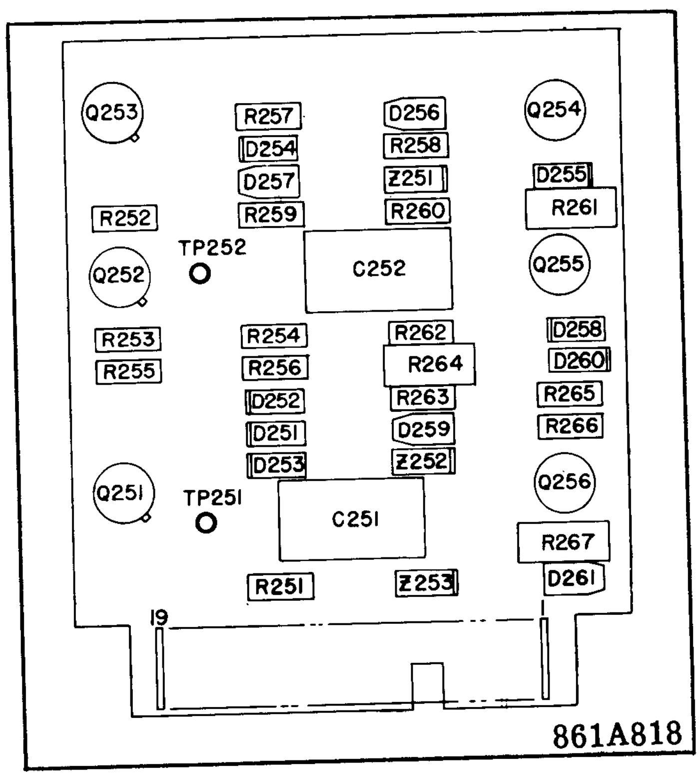
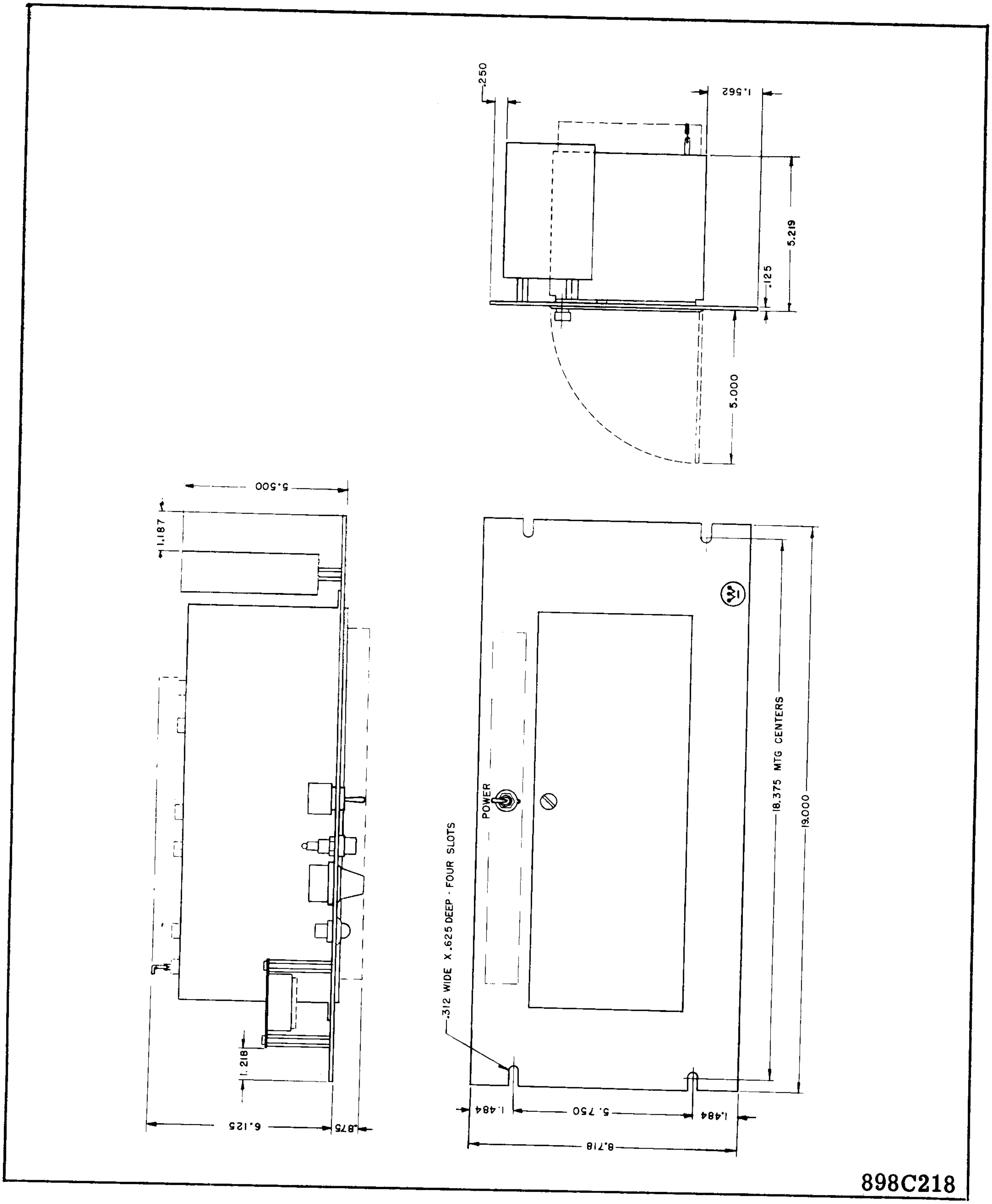



Fig. 10. Component Location on the Trip Board




* Fig. 11.




* *Fig. 12. Outline and Drilling Plan for the Type STU-9 Relay*

**WESTINGHOUSE ELECTRIC CORPORATION**
**RELAY-INSTRUMENT DIVISION**
**NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE STU-9 DUAL CHANNEL TRANSFER - TRIP RELAY

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

## APPLICATION

The type STU-9 relay is a static auxiliary relay used in transfer-trip relaying, such as would be used to trip a remote breaker for a transformer fault at a station where no high voltage breaker is used. It is used in conjunction with dual channel frequency-shift equipment, either audio tone or power line carrier frequencies.

## CONSTRUCTION

The type STU-9 relay consists of printed circuit boards, power supply, fuses, a pilot light, power switch, two channel monitoring lights, and adjustable controls 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. The components are connected as shown in Fig. 1.

### Printed Circuit Boards

The number of boards varies with the type channel used, but in general the STU-9 relay consists of five printed circuit boards; two channel interface boards, two transfer boards and a trip board. For TCF frequency shift power line carrier channels, the interface board is a part of the TCF receiver.

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

The interface board is the connecting link between the channel equipment and the transfer logic and consists of interface circuits, a lockout circuit, and the channel trip NAND. Each of the circuits performs designated functions with reference to the channel equipment. The interface circuits connect the lockout circuit and the channel trip NAND to the tone channel. In the normal state the trip NAND produces an output voltage due to the tone trip input being held at negative potential. This prevents base current from flowing into the transistor of the NAND and keeps the transistor turned off. As long as one of the three inputs is held at negative potential, a voltage output is obtained from the NAND. This voltage will exist until all inputs into the NAND are positive. Base current will then be applied to the NAND transistor and the transistor will turn on. This shorts the output of the NAND to negative potential. If the channel is lost, or if noise exists for extended periods of time, after 150 millisecond the lockout input will short the input of the NAND and hold the output in a non-operative condition. Also noise output from the tone channel will short the input of the NAND and hold the output in a non-operative condition.

This board will vary depending upon the make of frequency shift equipment used as the channel. In the case of TCF Frequency Shift Carrier equipment, the interface board is the logic board contained in the TCF receiver.

### 2. Transfer Logic Board

The transfer logic board contains the necessary

SUPERSEDES I.L. 41-959.2A
*Denotes Change From Superseded Issue.

EFFECTIVE JULY 1968

logic to alarm on loss of channel, to transfer to a single channel operation, and to invert the trip output of the interface logic to the proper polarity for the trip board. This logic will start transferring the STU-9 relay to a single channel mode of operation upon receipt of a positive voltage from the NOT Lockout circuit of the interface board.

Additional circuitry is included in the module for the connection of two external mounted switchboard lights (one for each channel). The lights are used to monitor the trips of the individual channels and should be connected between the regulated 45-volt d.c. (terminal 2) of the STU-9 and terminal 21 (channel 1) and terminal 9 (channel 2). The style switchboard light used is either style 1589193 or 1589181 with bulb style 1124156.

### 3. Trip Board

The trip board contains the final output of the STU-9 relay and consists of an AND circuit and an AR type relay. Under normal channel conditions, the two inputs from the trip of the transfer logic is held at negative potential. The third input to the trip AND is a voltage from the transfer circuits of the transfer board. As a result the output transistor is not conducting and the AR relay does not pick up. In order for the final transistor to operate, all inputs to the AND must be above negative potential. This occurs when the AND receives a trip input from both transfer logics.

For a lost of one channel, the trip input from the transfer logic of that channel removes its shorted input to negative, leaving the trip AND shorted to negative from the trip input of the remaining transfer logic. If both channels are lost, the trip inputs to the AND puts a positive voltage into the AND. However, the transfer input to the AND is put at negative potential to short the Input of the AND. A time delay is inserted in the transfer logic so that the transfer input to the AND is shorted to negative before the trip input switches to a positive output.

### Other Circuits (when used)

As shown in Figure 1, the trip output may contain other circuits. An additional transistor may be connected to obtain a voltage output from the trip NAND. This voltage output is used to drive an externally connected SAR relay. The transistor will apply 45 volts to the input of the SAR when the STU-9 relay operates.

D256 and D258 are used where it is not desirable to use the switching mode of the STU-9 relay. By connecting these diodes with a jumper to the lockout terminals of the interface board (terminal 18) of the STU-9 relay, the STU-9 relay will lockout on a single channel failure and not switch to a single channel mode of operation. With this connection the STU-9 relay will be operated as an AND circuit with reference to the channel and not as an OR.

The style numbers of the different boards with reference to the assembly is as follows:

| Style Number | Components |
|---|---|
| 898C235G01 | AR output 3 NO-INC, D256 and D258 omitted as well as transsistor Q254 and associated resistors. |
| 898C235G02 | AR output 3 NO-INC, D256 and D258 in the circuit but transistor Q254 and associated resistors omitted. |
| 898C235G03 | AR output 4 NO, D256 and D258 omitted, transistor Q254 included. |
| 898C235G04 | AR output 2NO-2NC, transistor Q254 and associated resistors included. |

### Power Supply

The STU-9 relay operates from a regulated 45 V.D.C. supply. This voltage is taken from a Zener diode mounted on a heat sink. Variation of the resistance values between the positive side of the unregulated D.C. supply and the 45 volt Zener diode adapt the receiver for operation on 48 or 125 volts d.c.

### Card Extender

A card extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one 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 circuit connections, and all components and test points on the board are readily accessible.

## OPERATION

The signal to which the STU-9 relay responds is received from the receiver of the channel equipment. If both channels are serviceable both channel receivers must receive a trip signal from the remote terminal for the STU-9 relay to operate. If one channel fails, the STU-9 relay will lock this channel out (after an adjustable time delay) and switch into a single channel mode of operation. The system will then trip upon receipt of a trip signal from the remote terminal on the remaining channel. If both channels fail, the STU-9 locks out the trip circuit until one or both channels are restored to service. Circuits are included in the relay to alarm on the loss of a channel.

The signals from the channel receivers are applied to the STU-9 relay at the input terminals of the interface board. This signal is transmitted to the transfer board to either apply a trip signal to the trip board, to prevent the transmission of this signal, or to transmit a transfer signal to a single channel.

When the frequency shift channel equipment is transmitting a guard signal, the signals to the STU-9 relay are as shown in the logic diagram of Figure 1. The number "1" indicates that a voltage is obtained at that point while a "0" indicates that the voltage is approximately zero. As seen in the logic diagram, the STU-9 relay requires a "1" from the low signal clamp and "0" from the trip and noise clamps of the tone channels to indicate nominal operating conditions.

For the condition shown, the amber lights are on and the alarm relay is picked up. Also the input to the trip "AND" is shorted to negative through the "OR" circuits of the transfer logic.

### Trip Sequence

If both channels are shifted to trip, the "0" from the tone channel changes to a "1". The trip interface of the STU-9 relay sees this change and puts a "1" into the channel trip "NAND". The output of the "NAND" goes to a "0" and the following occurs:

1. One input of the amber light AND is "0" and the light turns off.

2. The output of the NOT of the transfer logic changes to a "1" and applies a "1" to the trip AND through the OR of the transfer logic. Since all inputs to the trip AND are "1", an output is obtained to allow the AR to operate. Also the output transistor (where used) is turned on to give an output of approximately 45 volts. This voltage can be used to fire an external SAR relay to trip two breakers through Trinistor controlled rectifiers.

### Loss of Signal

With reference to the logic diagram of Fig. 1, the channel equipment recognizes a loss of channel and its low signal output changes to a "0". The output of the low signal interface of the STU-9 then changes to a "1". Upon application of the "1" to the NOR circuit, a time delay is energized. If the loss of signal exists for 150 millisecond, the output of the NOR circuit changes to a "0" and the following occurs:

1. The input to the channel trip NAND is clamped to negative which locks the NAND output to a "1" state (non-trip).

2. One input to the amber light AND drops to zero and the amber light turns off.

3. The output of the NOT $L_O$ changes to a "1", which energizes a timer. After a time delay of .5 to 2.5 sec., as determined by the timer setting, the timer times out and its output changes to a "0". The following then occurs:

   a. Alarm relay drops out to close its contacts.

   b. The output of the NOT changes to a 1 and energizes a 10-millisecond time delay circuit. After 10 milliseconds the input to the AND circuit is energized through the OR circuit.

4. Two voltages are applied to the trip "AND". The third input is clamped to negative by the output of the OR circuit on the good channel. The circuits of the STU-9 are set up for single channel operation and the system will operate if a trip signal is received from the output of the good channel.

### Loss of Second Channel

If the second channel is lost while the STU-9 is set up in a single channel mode of operation, the following occurs:

1. The output of the low signal interface of the second channel changes to a 1.

2. The channel trip NAND is clamped to a "1". (non-trip).

3. The input to the amber light AND is de-energized and the amber light turns off.

4. The output of the NOT Lo changes to a 1, and the 2.5 second timer times out, and the following occurs:

   a. The alarm unit drops out to close its contacts.

   b. The input to the trip AND through terminal 11 drops to "0" instantaneously.

   c. The output of the NOT changes to a "1" and energizes a 10 millisecond delay.

   d. At the end of 10 milliseconds the input to the trip AND (through terminal 10) AND changes to a "1". Tripping cannot occur because the AND was clamped previously to negative through terminal 11.

For the condition where both channels are out of service and one or both channels are restored to service, the following occurs:

The time delay in the base of transistor Q251 in the trip logic is energized. This time delay maintains the "0" on the trip AND through diode D252, for ½ millisecond after the voltage from either D253 or D251 drops to "0" from a "1" condition.

## Noise

If an output is obtained from the noise clamp of the channel equipment, the input to the noise interface changes to a "1", and energizes a NOT and a NOR circuit. The output of the NOT changes to a "0" and shorts the input to the channel trip NAND to negative. This puts the NAND in a non-operating condition. If the noise condition exists for 150 milliseconds, the STU-9 relay will recognize the condition as a loss of channel and switch into a single channel mode of operation.

# CHARACTERISTICS

The type STU-9 relay is available for frequency shift channels, either tone, carrier, or a combination of both. The schematic and logic diagram for frequency-shift tone channels is shown in Figure 1.

If TCF frequency shift carrier is used as the channel equipment, the logic diagram and schematic diagram of Figures 2 and 3 apply. This logic is the same as that of Fig. 1, except that the interface board is omitted. The lockout, not lockout, and trip inputs the STU-9 transfer boards are obtained from the logic board of the TCF receiver. These quantities are the same as received from the interface logic Fig. 1.

When the STU-9 relay is used with both TCF frequency shift Carrier and frequency shift tone channels, the relay is connected as shown in Figure 4.

| | |
|---|---|
| Lockout time | 150 milliseconds |
| Transfer time | 0.5 to 2.5 seconds |
| Operating time | 3 milliseconds with AR — 75 microseconds to obtain voltage contact. |
| Voltage Output Relay (when used) Maximum Output | 60 milliamperes, 45 V. d.c. |
| Ambient temperature range | -20 °C to +60 °C |

Battery Voltage Variations

| Rated Voltage | Allowance Variation |
|---|---|
| 48 V.D.C. | 42 - 56 V.D.C. |
| 125 V.D.C. | 105 - 140 V.D.C. |

| | |
|---|---|
| Battery Drain | 235 milliamperes-48 V.D.C.<br>275 milliamperes - 125 V.D.C. |
| Dimensions | Panel Height — 8¾ inch or 5 rack units.<br>Panel Width-19 inches |

# SETTING

The only setting required is the setting of the timer for transfering to a single channel mode of operation upon a loss of one channel. This setting is made by means of the timer knobs on the front panel of the relay. The knob should be locked after the setting is made.

## INSTALLATION

The STU-9 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 60 °C.

### Routine Maintenance

Periodic checks of the relaying system as described in the assembly instructions are desirable to indicate impending failure so that the equipment can be taken out of service for correction.

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

### Trouble-Shooting

The components of the STU-9 are operated well within their ratings, and under normal conditions they should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the voltages tabulated in TABLE I should be checked to determine the faulty circuit. The test point and component location on the boards are given in Figures 5, 6, and 7.

**TABLE I**

Test point voltages to negative except where specified to positive 45 volts D.C.

| BOARD | TEST POINT | NORMAL CHANNEL | WITH NOISE ONLY | WITH LOSS OF CHANNEL ONLY | | WITH TRIP ONLY |
|---|---|---|---|---|---|---|
| CHANNEL INTERFACE | term 16 to pos | -16 | -16 | -2 | | -16 |
| | TP151 | 0.05 | 0.05 | 15 | | 0.05 |
| | term 17 to pos | 0 | -16 | 0 | | 0 |
| | TP153 | 15 | 0.05 | 15 | | 15 |
| | TP154 | 0.05 | 15 | 0.05 | | 0.05 |
| | TP155 | 15 | 0.05 | 0.05 | | 15 |
| | TP156 | 0.05 | 21 | 21 | | 0.05 |
| | term 18 | 10 | 0.10 | 0.10 | | 10 |
| | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 15 to pos | 0 | 0 | 0 | | -16 |
| | term 11 | 15 | 15 | 15 | | 0.05 |
| | term 10 | 0.05 | 0.05 | 0.05 | | 15 |
| | term 6 | 15 | 15 | 15 | | 0.2 |
| TRANSFER | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 16 | 0.05 | 45 | 45 | | 45 |
| | TP201 | 0.05 | 0.05 | 0.05 | | 10 |
| | TP202 | 9 | 0.1 | 0.1 | | 9 |
| | TP203 | 0.05 | 20 | 20 | | 0.05 |
| | TP204 | 13 | 0.05 | 0.05 | | 0.05 |
| | term 10 | 0.15 | 10 | 10 | | 10 |
| | term 11 | 0.7 | 0.7 | 0.7 | | 0.7 |
| | term 7 | 45 | 0.3 | 0.3 | | 0.3 |
| | | | | Single CH | Both CH | |
| TRIP | TP251 | 0.05 | 0.05 | 0.05 | 15 | 0.05 |
| | TP252 | 15 | 15 | 15 | 0.07 | 15 |
| | term 10 | 0.15 | 10 | 10 | 10 | 10 |
| | term 11 | 0.15 | 10 | 10 | 10 | 10 |
| | term 19 | 0.05 | 0.05 | 0.05 | 0.05 | 43 |

**Renewal Part**

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, and component style No. given in the electrical parts list.

ELECTRICAL PARTS LIST

PANEL MOUNTED COMPONENTS

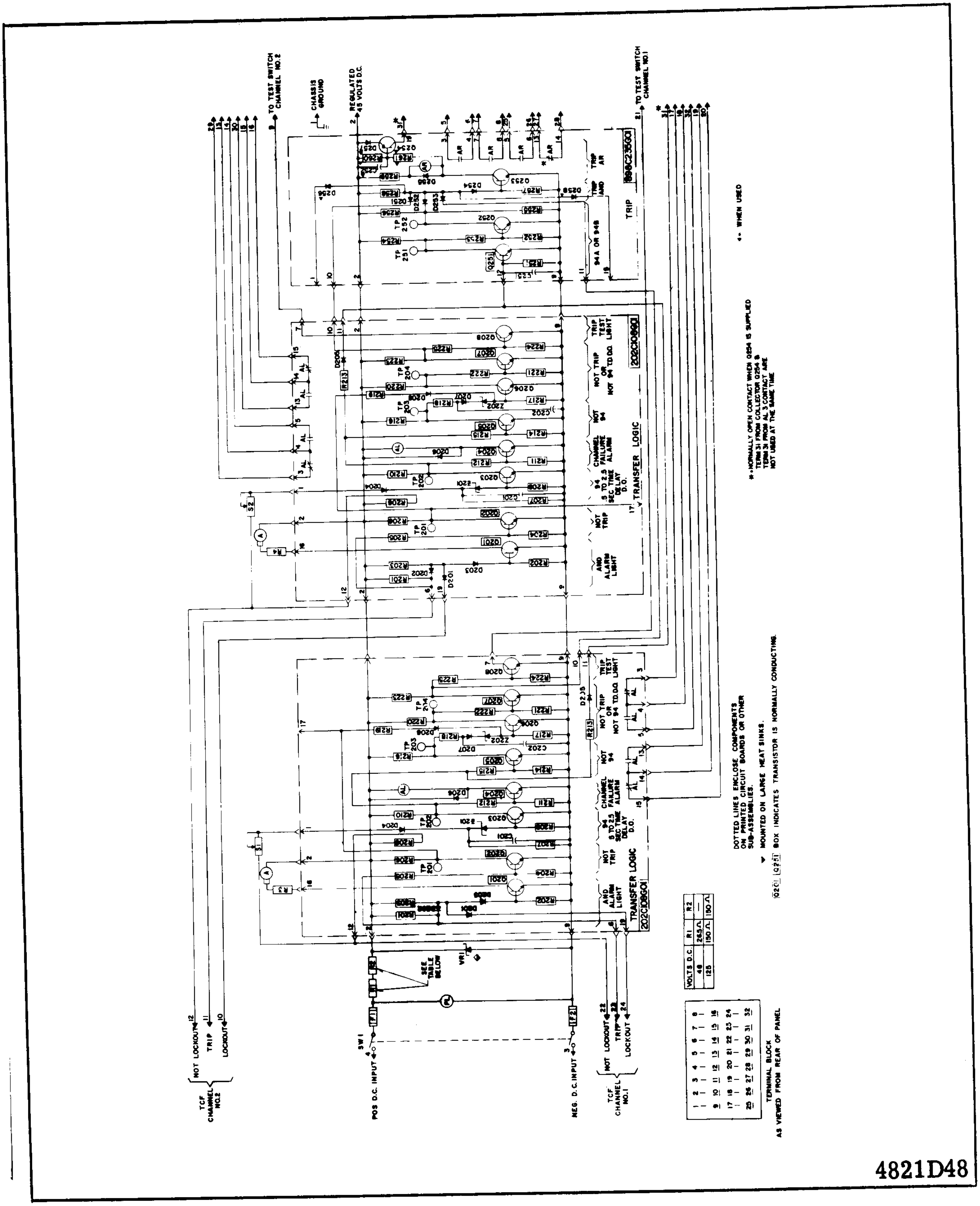
| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | Power Supply | |
| SW1 | Switch | 183A856H01 |
| PL | Pilot Light 125 V.D.C. | 183A825G01 |
| | Pilot Light 48 V.D.C. | 183A825G04 |
| F1-F2 | 1.5 Ampere Fuse | 11D9195H26 |
| R1 | 26.5 Ω 40w. 48 V.D.C. | 04D1299H44 |
| R1-R2 | 150 Ω 40 w. 125 V.D.C. | 1201499 |
| VR1 | Zener Diode, IN2828B, 50W. | 184A854H06 |
| | Alarm | |
| A | Amber Light | 183A825G08 |
| R3-R4 | 330 Ω 3W. | 185A207H15 |
| | Potentiometer | |
| S1-S2 | 50 K Ω | 185A086H22 |

CHANNEL INTERFACE BOARD

| | | |
|---|---|---|
| | Capacitor | |
| C151 | 6.8MFD 35 V.D.C. | 184A661H25 |
| | Diodes | |
| D151 | IN457A | 184A855H07 |
| | Transistors | |
| Q151-Q154-Q161 Q152-Q155-Q156 Q157-Q158-Q162 | 2N2043 | 184A638H21 |
| Q163 | 2N696 | 762A585H01 |
| Q159 | 2N697 | 184A638H18 |
| Q160-Q164 | 2N699 | 184A638H19 |
| | Resistors | |
| R151-R159-R179 | 6.8K Ω -½W | 184A763H47 |
| R152-R160-R174 R180 | 1K Ω -½W. | 184A763H27 |
| R153-R161-R164 R167-R171 | 10K Ω -½W. | 184A763H51 |
| R175-R177-R181- R183-R188-R154- R162-R182-R189 | 100K Ω-½W. | 184A763H75 |
| R155-R163-R166- R170-R185-R186 | 68K Ω -½W. | 184A763H71 |
| R165-R168-R169- R172-R184-R187 | 33K Ω -½W. | 184A763H63 |
| R173 | 39K Ω -½W. | 184A763H65 |
| R176 | 12K Ω -½W. | 184A763H53 |
| R178 | 3.3K Ω-½W. | 184A763H39 |
| | Zener Diodes | |
| Z151 | IN957B 6.7V | 186A797H06 |
| Z152 | IN3686B 20V | 185A212H06 |

TRANSFER BOARD

| | | |
|---|---|---|
| | Capacitors | |
| C201 | 68MFD 35 V.D.C. | 187A508H02 |
| C202 | 0.5MFD | 187A624H11 |
| | Diodes | |
| D201 to D208 | IN457A | 184A638H07 |
| | Transistors | |
| Q201-Q202-Q204- Q208 | 2N699 | 184A638H19 |
| Q203-Q207 | 2N697 | 184A638H18 |
| Q205-Q206 | 2N696 | 762A585H01 |
| | Resistors | |
| R201-R206-R216- R220 | 68K Ω -½W. | 184A763H71 |
| R202-R204-R208- R209-R211-R214- R217-R221-R224 | 10K Ω -½W. | 184A763H51 |
| R203 | 10K Ω - 1W | 187A643H51 |
| R205-R218-R219- R222 | 33K Ω -½W. | 184A763H63 |
| R207 | 1K Ω -½W. | 184A763H27 |




* *Fig. 2. Internal Schematic of Type STU-9 Relay for TCF Frequency Shift Carrier Channel*

| | | |
|---|---|---|
| R210 - R223 | 12K Ω -½W. | 184A763H53 |
| R212 - R225 | 3.3K Ω-½W. | 184A763H39 |
| R213 - R215 | 22K Ω -½W. | 184A763H59 |
| | **Zener Diodes** | |
| Z201 | IN3686B 20V | 185A212H06 |
| Z202 | IN957B 6.8V | 186A797H06 |
| | **Alarm Unit** | |
| AL | Telephone Relay | 408C062H07 |

TRIP BOARD

| | | |
|---|---|---|
| | **Capacitors** | |
| C251 - C252 | .25 uf | 187A624H02 |
| | **Diodes** | |
| D251 to D255 | IN457A | 184A855H07 |
| D252 to D253 (when used) | IN457A | 184A855H07 |

| | | |
|---|---|---|
| | **Transistors** | |
| Q251 - Q252 | 2N696 | 762A585H01 |
| Q253 | 2N699 | 184A638H19 |
| Q254 (when used) | 2N2043 | 184A638H21 |
| | **Resistors** | |
| R251 - R252 - R257 | 10K Ω -½W. | 184A763H51 |
| R253 - R255 | 33K Ω -½W. | 184A763H63 |
| R254 - R256 | 68K Ω -½W. | 184A763H71 |
| R258 | 10K Ω -1W. | 184A643H51 |
| R259 | 800 Ω -3W. | 184A859H06 |
| R260 (when used) | 1K Ω -½W. | 184A763H27 |
| R261 (when used) | 10K Ω -½W. | 184A763H51 |
| | **AR Unit** | |
| AR (when used) | 3NO - INC contacts | 408C845G23 |
| AR (when used) | 4NO - contacts | 408C845G13 |
| AR (when used) | 2NO - 2NC contacts | 408C845G09 |

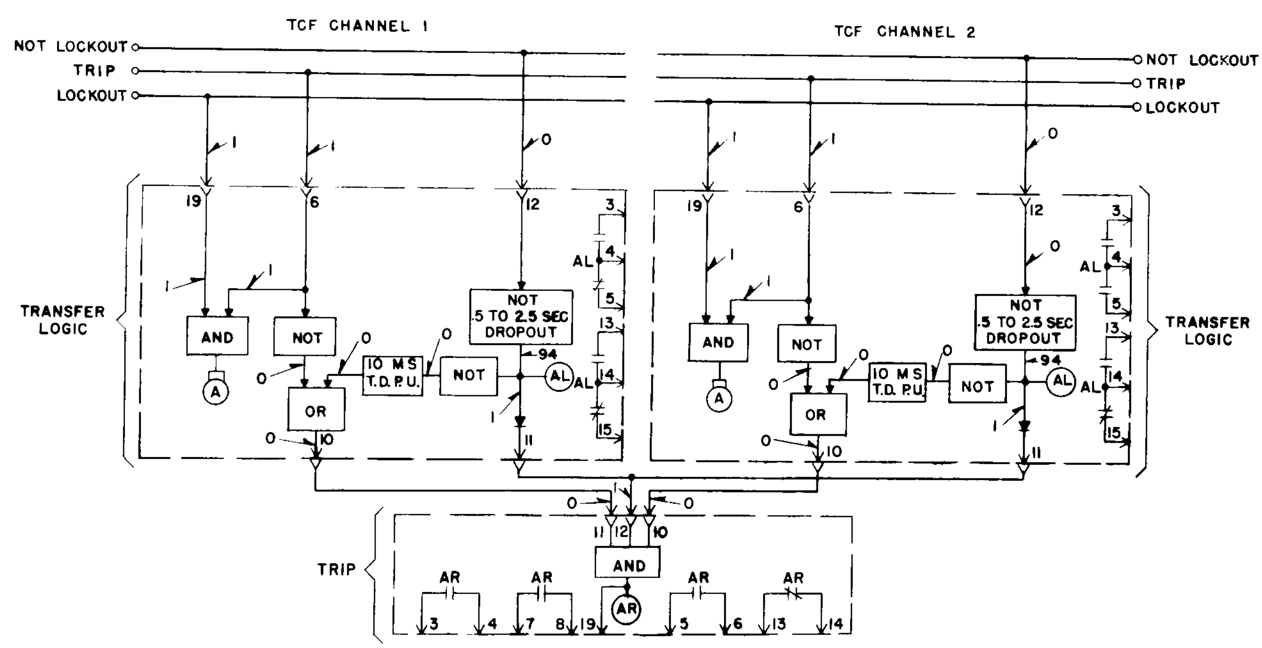



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Fig. 3. Logic Diagram of Type STU-9 Relay for TCF Frequency Shift Carrier Channel

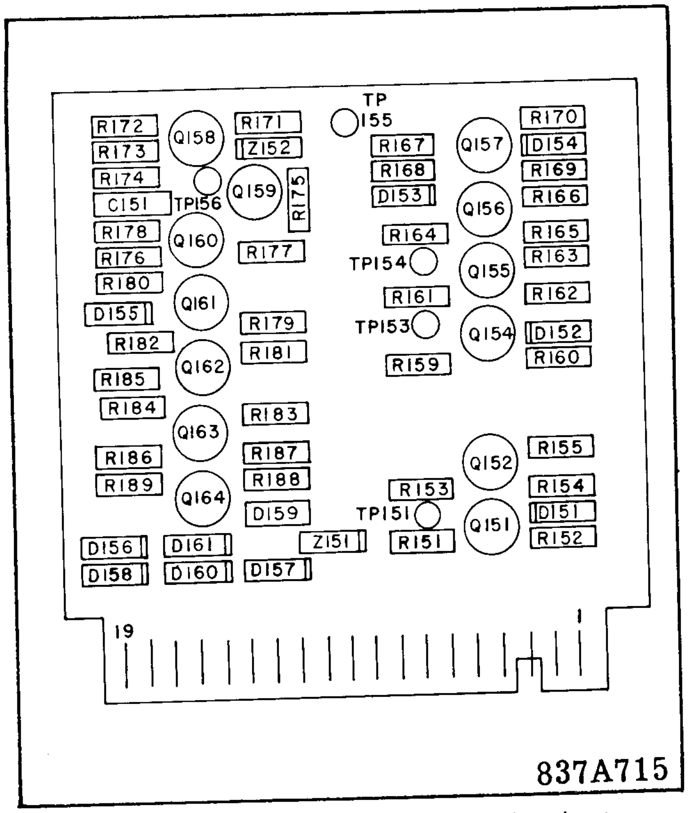


*Fig. 5 Component Locations on the Interface Logic Board*

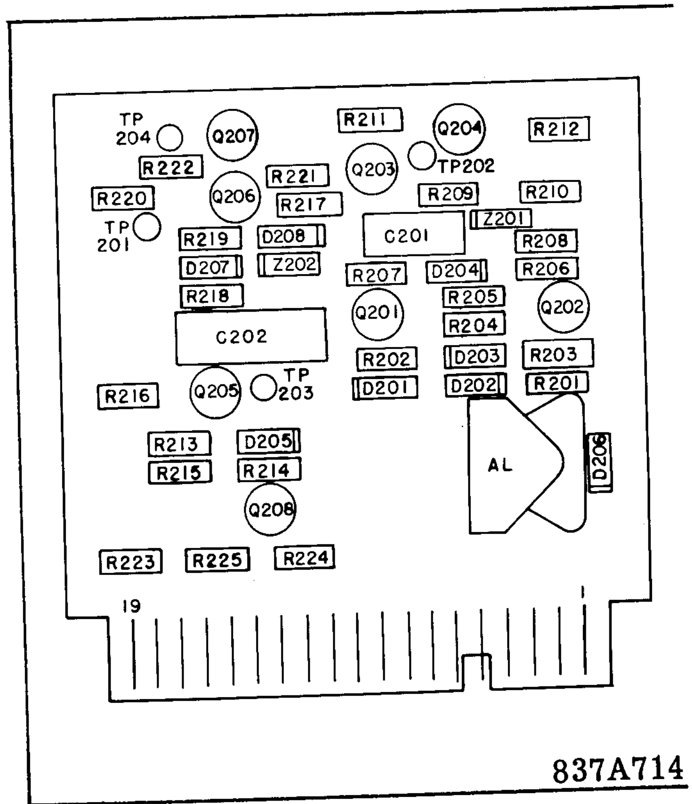


*Fig. 6. Component Location on the Transfer Logic Board*

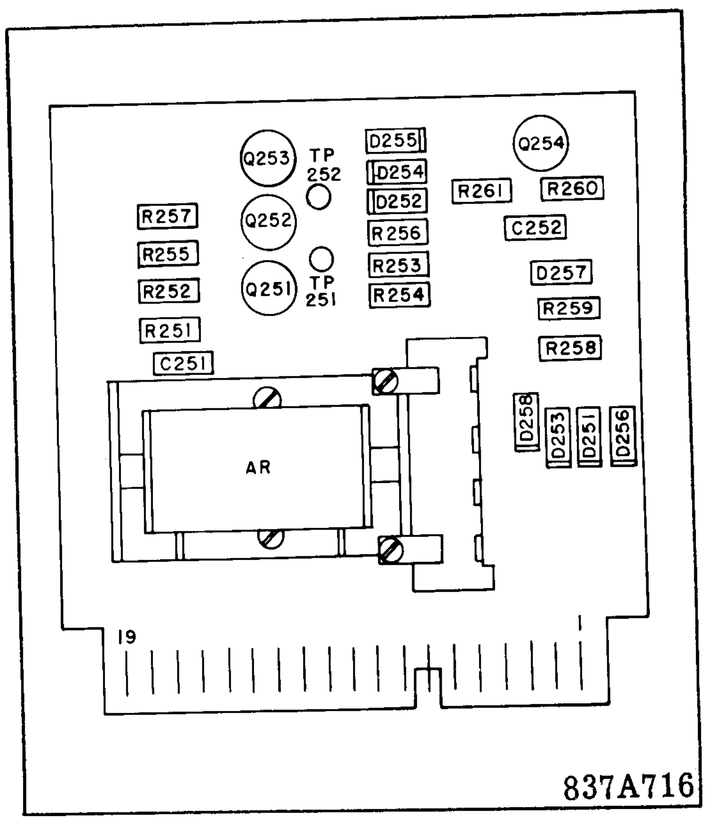


*Fig. 7. Component Location on the Trip Board*

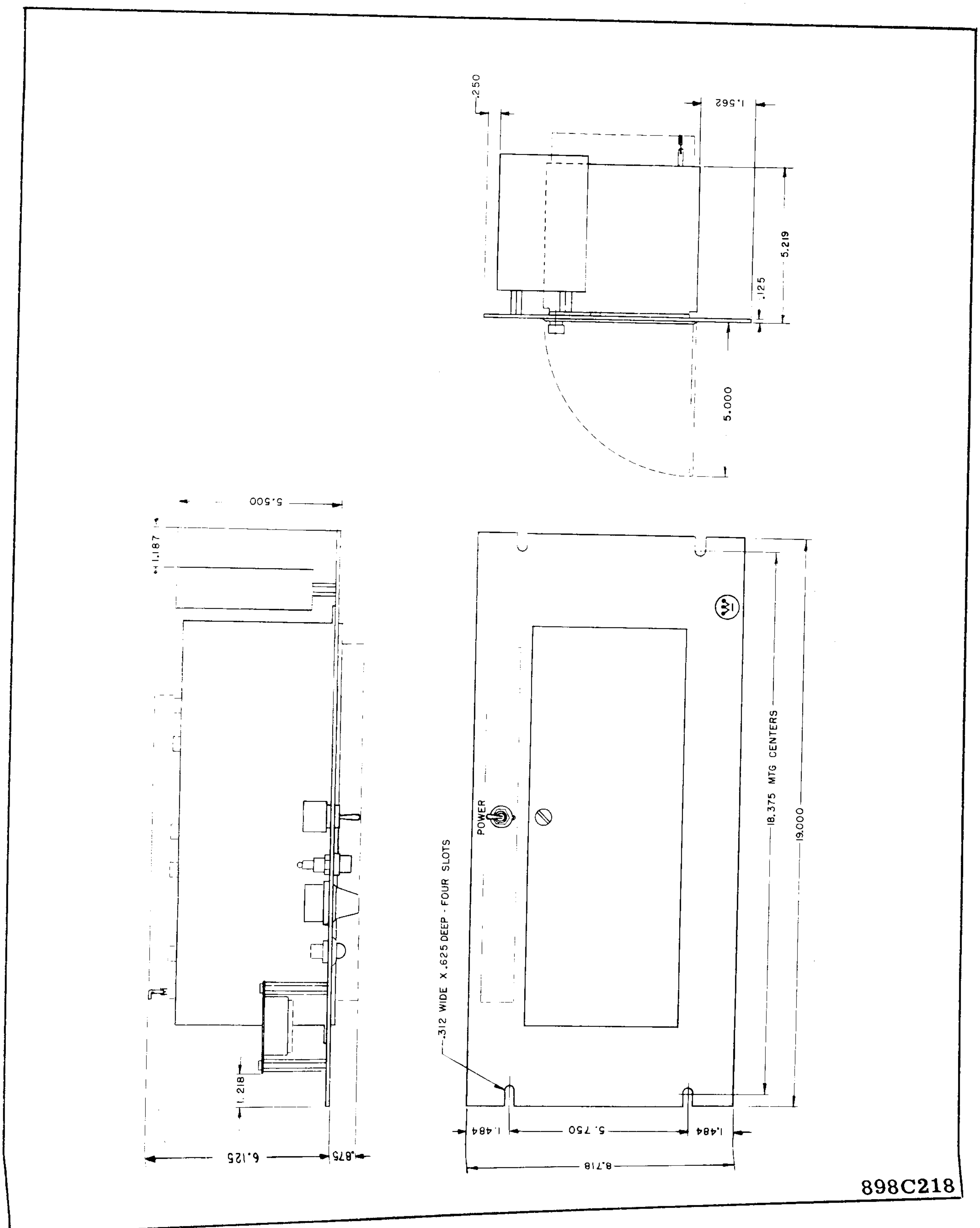


Fig. 8. Outline and Drilling Plan for the Type STU-9 Relay

**WESTINGHOUSE ELECTRIC CORPORATION**

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE STU-9 DUAL CHANNEL TRANSFER - TRIP RELAY

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

## APPLICATION

The type STU-9 relay is a static auxiliary relay used in transfer-trip relaying, such as would be used to trip a remote breaker for a transformer fault at a station where no high voltage breaker is used. It is used in conjunction with dual channel frequency-shift equipment, either audio tone or power line carrier frequencies.

## CONSTRUCTION

The type STU-9 relay consists of printed circuit boards, power supply, fuses, a pilot light, power switch, two channel monitoring lights, and adjustable controls 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. The components are connected as shown in Fig. 1.

### Printed Circuit Boards

The number of boards varies with the type channel used, but in general the STU-9 relay consists of five printed circuit boards; two channel interface boards, two transfer boards and a trip board. For TCF frequency shift power line carrier channels, the interface board is a part of the TCF receiver.

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

The interface board is the connecting link between the channel equipment and the transfer logic and consists of interface circuits, a lockout circuit, and the channel trip NAND. Each of the circuits performs designated functions with reference to the channel equipment. The interface circuits connect the lockout circuit and the channel trip NAND to the tone channel. In the normal state the trip NAND produces an output voltage due to the tone trip input being held at negative potential. This prevents base current from flowing into the transistor of the NAND and keeps the transistor turned off. As long as one of the three inputs is held at negative potential, a voltage output is obtained from the NAND. This voltage will exist until all inputs into the NAND are positive. Base current will then be applied to the NAND transistor and the transistor will turn on. This shorts the output of the NAND to negative potential. If the channel is lost, or if noise exists for extended periods of time, after 150 millisecond the lockout input will short the input of the NAND and hold the output in a non-operative condition. Also noise output from the tone channel will short the input of the NAND and hold the output in a non-operative condition.

This board will vary depending upon the make of frequency shift equipment used as the channel. In the case of TCF Frequency Shift Carrier equipment, the interface board is the logic board contained in the TCF receiver.

### 2. Transfer Logic Board

The transfer logic board contains the necessary

logic to alarm on loss of channel, to transfer to a single channel operation, and to invert the trip output of the interface logic to the proper polarity for the trip board. This logic will start transferring the STU-9 relay to a single channel mode of operation upon receipt of a positive voltage from the NOT Lockout circuit of the interface board.

Additional circuitry is included in the module for the connection of two external mounted switchboard lights (one for each channel). The lights are used to monitor the trips of the individual channels and should be connected between the regulated 45-volt d.c. (terminal 2) of the STU-9 and terminal 21 (channel 1) and terminal 9 (channel 2). The style switchboard light used is either style 1589193 or 1589181 with bulb style 1124156.

### 3. Trip Board

The trip board contains the final output of the STU-9 relay and consists of an AND circuit and an AR type relay. Under normal channel conditions, the two inputs from the trip of the transfer logic is held at negative potential. The third input to the trip AND is a voltage from the transfer circuits of the transfer board. As a result the output transistor is not conducting and the AR relay does not pick up. In order for the final transistor to operate, all inputs to the AND must be above negative potential. This occurs when the AND receives a trip input from both transfer logics.

For a lost of one channel, the trip input from the transfer logic of that channel removes its shorted input to negative, leaving the trip AND shorted to negative from the trip input of the remaining transfer logic. If both channels are lost, the trip inputs to the AND puts a positive voltage into the AND. However, the transfer input to the AND is put at negative potential to short the Input of the AND. A time delay is inserted in the transfer logic so that the transfer input to the AND is shorted to negative before the trip input switches to a positive output.

### Other Circuits (when used)

As shown in Figure 1, the trip output may contain other circuits. An additional transistor may be connected to obtain a voltage output from the trip NAND. This voltage output is used to drive an externally connected SAR relay. The transistor will apply 45 volts to the input of the SAR when the STU-9 relay operates.

D256 and D258 are used where it is not desirable to use the switching mode of the STU-9 relay. By connecting these diodes with a jumper to the lockout terminals of the interface board (terminal 18) of the STU-9 relay, the STU-9 relay will lockout on a single channel failure and not switch to a single channel mode of operation. With this connection the STU-9 relay will be operated as an AND circuit with reference to the channel and not as an OR.

The style numbers of the different boards with reference to the assembly is as follows:

| Style Number | Components |
|---|---|
| 898C235G01 | AR output 3 NO-INC, D256 and D258 omitted as well as transsistor Q254 and associated resistors. |
| 898C235G02 | AR output 3 NO-INC, D256 and D258 in the circuit but transistor Q254 and associated resistors omitted. |
| 898C235G03 | AR output 4 NO, D256 and D258 omitted, transistor Q254 included. |
| 898C235G04 | AR output 2NO-2NC, transistor Q254 and associated resistors included. |

### Power Supply

The STU-9 relay operates from a regulated 45 V.D.C. supply. This voltage is taken from a Zener diode mounted on a heat sink. Variation of the resistance values between the positive side of the unregulated D.C. supply and the 45 volt Zener diode adapt the receiver for operation on 48 or 125 volts d.c.

### Card Extender

A card extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one 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 circuit connections, and all components and test points on the board are readily accessible.

## OPERATION

The signal to which the STU-9 relay responds is received from the receiver of the channel equipment. If both channels are serviceable both channel receivers must receive a trip signal from the remote terminal for the STU-9 relay to operate. If one channel fails, the STU-9 relay will lock this channel out (after an adjustable time delay) and switch into a single channel mode of operation. The system will then trip upon receipt of a trip signal from the remote terminal on the remaining channel. If both channels fail, the STU-9 locks out the trip circuit until one or both channels are restored to service. Circuits are included in the relay to alarm on the loss of a channel.

The signals from the channel receivers are applied to the STU-9 relay at the input terminals of the interface board. This signal is transmitted to the transfer board to either apply a trip signal to the trip board, to prevent the transmission of this signal, or to transmit a transfer signal to a single channel.

When the frequency shift channel equipment is transmitting a guard signal, the signals to the STU-9 relay are as shown in the logic diagram of Figure 1. The number "1" indicates that a voltage is obtained at that point while a "0" indicates that the voltage is approximately zero. As seen in the logic diagram, the STU-9 relay requires a "1" from the low signal clamp and "0" from the trip and noise clamps of the tone channels to indicate nominal operating conditions.

For the condition shown, the amber lights are on and the alarm relay is picked up. Also the input to the trip "AND" is shorted to negative through the "OR" circuits of the transfer logic.

### Trip Sequence

If both channels are shifted to trip, the "0" from the tone channel changes to a "1". The trip interface of the STU-9 relay sees this change and puts a "1" into the channel trip "NAND". The output of the "NAND" goes to a "0" and the following occurs:

1. One input of the amber light AND is "0" and the light turns off.

2. The output of the NOT of the transfer logic changes to a "1" and applies a "1" to the trip AND through the OR of the transfer logic. Since all inputs to the trip AND are "1", an output is obtained to allow the AR to operate. Also the output transistor (where used) is turned on to give an output of approximately 45 volts. This voltage can be used to fire an external SAR relay to trip two breakers through Trinistor controlled rectifiers.

### Loss of Signal

With reference to the logic diagram of Fig. 1, the channel equipment recognizes a loss of channel and its low signal output changes to a "0". The output of the low signal interface of the STU-9 then changes to a "1". Upon application of the "1" to the NOR circuit, a time delay is energized. If the loss of signal exists for 150 millisecond, the output of the NOR circuit changes to a "0" and the following occurs:

1. The input to the channel trip NAND is clamped to negative which locks the NAND output to a "1" state (non-trip).

2. One input to the amber light AND drops to zero and the amber light turns off.

3. The output of the NOT $L_O$ changes to a "1", which energizes a timer. After a time delay of .5 to 2.5 sec., as determined by the timer setting, the timer times out and its output changes to a "0". The following then occurs:

   a. Alarm relay drops out to close its contacts.

   b. The output of the NOT changes to a 1 and energizes a 10-millisecond time delay circuit. After 10 milliseconds the input to the AND circuit is energized through the OR circuit.

4. Two voltages are applied to the trip "AND". The third input is clamped to negative by the output of the OR circuit on the good channel. The circuits of the STU-9 are set up for single channel operation and the system will operate if a trip signal is received from the output of the good channel.

### Loss of Second Channel

If the second channel is lost while the STU-9 is set up in a single channel mode of operation, the following occurs:

1. The output of the low signal interface of the second channel changes to a 1.

2. The channel trip NAND is clamped to a "1". (non-trip).

3. The input to the amber light AND is de-energized and the amber light turns off.

4. The output of the NOT Lo changes to a 1, and the 2.5 second timer times out, and the following occurs:

   a. The alarm unit drops out to close its contacts.

   b. The input to the trip AND through terminal 11 drops to "0" instantaneously.

   c. The output of the NOT changes to a "1" and energizes a 10 millisecond delay.

   d. At the end of 10 milliseconds the input to the trip AND (through terminal 10) AND changes to a "1". Tripping cannot occur because the AND was clamped previously to negative through terminal 11.

For the condition where both channels are out of service and one or both channels are restored to service, the following occurs:

> The time delay in the base of transistor Q251 in the trip logic is energized. This time delay maintains the "0" on the trip AND through diode D252, for ½ millisecond after the voltage from either D253 or D251 drops to "0" from a "1" condition.

### Noise

If an output is obtained from the noise clamp of the channel equipment, the input to the noise interface changes to a "1", and energizes a NOT and a NOR circuit. The output of the NOT changes to a "0" and shorts the input to the channel trip NAND to negative. This puts the NAND in a non-operating condition. If the noise condition exists for 150 milliseconds, the STU-9 relay will recognize the condition as a loss of channel and switch into a single channel mode of operation.

## CHARACTERISTICS

The type STU-9 relay is available for frequency shift channels, either tone, carrier, or a combination of both. The schematic and logic diagram for frequency-shift tone channels is shown in Figure 1.

If TCF frequency shift carrier is used as the channel equipment, the logic diagram and schematic diagram of Figures 2 and 3 apply. This logic is the same as that of Fig. 1, except that the interface board is omitted. The lockout, not lockout, and trip inputs the STU-9 transfer boards are obtained from the logic board of the TCF receiver. These quantities are the same as received from the interface logic Fig. 1.

When the STU-9 relay is used with both TCF frequency shift Carrier and frequency shift tone channels, the relay is connected as shown in Figure 4.

| | |
|---|---|
| Lockout time | 150 milliseconds |
| Transfer time | 0.5 to 2.5 seconds |
| Operating time | 3 milliseconds with AR — 75 microseconds to obtain voltage contact. |
| Voltage Output Relay (when used) Maximum Output | 60 milliamperes, 45 V. d.c. |
| Ambient temperature range | -20 °C to +60 °C |

Battery Voltage Variations

| Rated Voltage | Allowance Variation |
|---|---|
| 48 V.D.C. | 42 - 56 V.D.C. |
| 125 V.D.C. | 105 - 140 V.D.C. |

| | |
|---|---|
| Battery Drain | 235 milliamperes-48 V.D.C.<br>275 milliamperes - 125 V.D.C. |
| Dimensions | Panel Height — 8¾ inch or 5 rack units.<br>Panel Width-19 inches |

## SETTING

The only setting required is the setting of the timer for transfering to a single channel mode of operation upon a loss of one channel. This setting is made by means of the timer knobs on the front panel of the relay. The knob should be locked after the setting is made.

## INSTALLATION

The STU-9 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 60 °C.

### Routine Maintenance

Periodic checks of the relaying system as described in the assembly instructions are desirable to indicate impending failure so that the equipment can be taken out of service for correction.

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

### Trouble-Shooting

The components of the STU-9 are operated well within their ratings, and under normal conditions they should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the voltages tabulated in TABLE I should be checked to determine the faulty circuit. The test point and component location on the boards are given in Figures 5, 6, and 7.

### TABLE I

Test point voltages to negative except where specified to positive 45 volts D.C.

| BOARD | TEST POINT | NORMAL CHANNEL | WITH NOISE ONLY | WITH LOSS OF CHANNEL ONLY | | WITH TRIP ONLY |
|---|---|---|---|---|---|---|
| CHANNEL INTERFACE | term 16 to pos | -16 | - 16 | - 2 | | - 16 |
| | TP151 | 0.05 | 0.05 | 15 | | 0.05 |
| | term 17 to pos | 0 | —16 | 0 | | 0 |
| | TP153 | 15 | 0.05 | 15 | | 15 |
| | TP154 | 0.05 | 15 | 0.05 | | 0.05 |
| | TP155 | 15 | 0.05 | 0.05 | | 15 |
| | TP156 | 0.05 | 21 | 21 | | 0.05 |
| | term 18 | 10 | 0.10 | 0.10 | | 10 |
| | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 15 to pos | 0 | 0 | 0 | | -16 |
| | term 11 | 15 | 15 | 15 | | 0.05 |
| | term 10 | 0.05 | 0.05 | 0.05 | | 15 |
| | term 6 | 15 | 15 | 15 | | 0.2 |
| TRANSFER | term 12 | 0.05 | 4 | (with max. setting 4) | | 0.05 |
| | term 16 | 0.05 | 45 | 45 | | 45 |
| | TP201 | 0.05 | 0.05 | 0.05 | | 10 |
| | TP202 | 9 | 0.1 | 0.1 | | 9 |
| | TP203 | 0.05 | 20 | 20 | | 0.05 |
| | TP204 | 13 | 0.05 | 0.05 | | 0.05 |
| | term 10 | 0.15 | 10 | 10 | | 10 |
| | term 11 | 0.7 | 0.7 | 0.7 | | 0.7 |
| | term 7 | 45 | 0.3 | 0.3 | | 0.3 |
| | | | | Single CH | Both CH | |
| TRIP | TP251 | 0.05 | 0.05 | 0.05 | 15 | 0.05 |
| | TP252 | 15 | 15 | 15 | 0.07 | 15 |
| | term 10 | 0.15 | 10 | 10 | 10 | 10 |
| | term 11 | 0.15 | 10 | 10 | 10 | 10 |
| | term 19 | 0.05 | 0.05 | 0.05 | 0.05 | 43 |

## Renewal Part

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, and component style No. given in the electrical parts list.

### ELECTRICAL PARTS LIST

#### PANEL MOUNTED COMPONENTS

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | Power Supply | |
| SW1 | Switch | 183A856H01 |
| PL | Pilot Light 125 V.D.C. | 183A825G01 |
| | Pilot Light 48 V.D.C. | 183A825G04 |
| F1-F2 | 1.5 Ampere Fuse | 11D9195H26 |
| R1 | 26.5 Ω 40w. 48 V.D.C. | 04D1299H44 |
| R1-R2 | 150 Ω 40 w. 125 V.D.C. | 1201499 |
| VR1 | Zener Diode, IN2828B, 50W. | 184A854H06 |
| | Alarm | |
| A | Amber Light | 183A825G08 |
| R3-R4 | 330 Ω 3W. | 185A207H15 |
| | Potentiometer | |
| S1-S2 | 50 K Ω | 185A086H22 |

#### CHANNEL INTERFACE BOARD

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | Capacitor | |
| C151 | 6.8MFD 35 V.D.C. | 184A661H25 |
| | Diodes | |
| D151 | IN457A | 184A855H07 |
| | Transistors | |
| Q151-Q154-Q161 Q152-Q155-Q156 Q157-Q158-Q162 | 2N2043 | 184A638H21 |
| Q163 | 2N696 | 762A585H01 |
| Q159 | 2N697 | 184A638H18 |
| Q160-Q164 | 2N699 | 184A638H19 |
| | Resistors | |
| R151-R159-R179 | 6.8K Ω -½W | 184A763H47 |
| R152-R160-R174 R180 | 1K Ω -½W. | 184A763H27 |
| R153-R161-R164 R167-R171 | 10K Ω -½W. | 184A763H51 |
| R175-R177-R181-R183-R188-R154-R162-R182-R189 | 100K Ω-½W. | 184A763H75 |
| R155-R163-R166-R170-R185-R186 | 68K Ω -½W. | 184A763H71 |
| R165-R168-R169-R172-R184-R187 | 33K Ω -½W. | 184A763H63 |
| R173 | 39K Ω -½W. | 184A763H65 |
| R176 | 12K Ω -½W. | 184A763H53 |
| R178 | 3.3K Ω-½W. | 184A763H39 |
| | Zener Diodes | |
| Z151 | IN957B 6.7V | 186A797H06 |
| Z152 | IN3686B 20V | 185A212H06 |

#### TRANSFER BOARD

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | Capacitors | |
| C201 | 68MFD 35 V.D.C. | 187A508H02 |
| C202 | 0.5MFD | 187A624H11 |
| | Diodes | |
| D201 to D208 | IN457A | 184A638H07 |
| | Transistors | |
| Q201-Q202-Q204-Q208 | 2N699 | 184A638H19 |
| Q203-Q207 | 2N697 | 184A638H18 |
| Q205-Q206 | 2N696 | 762A585H01 |
| | Resistors | |
| R201-R206-R216-R220 | 68K Ω -½W. | 184A763H71 |
| R202-R204-R208-R209-R211-R214-R217-R221-R224 | 10K Ω -½W. | 184A763H51 |
| R203 | 10K Ω -1W | 187A643H51 |
| R205-R218-R219-R222 | 33K Ω -½W. | 184A763H63 |
| R207 | 1K Ω -½W. | 184A763H27 |

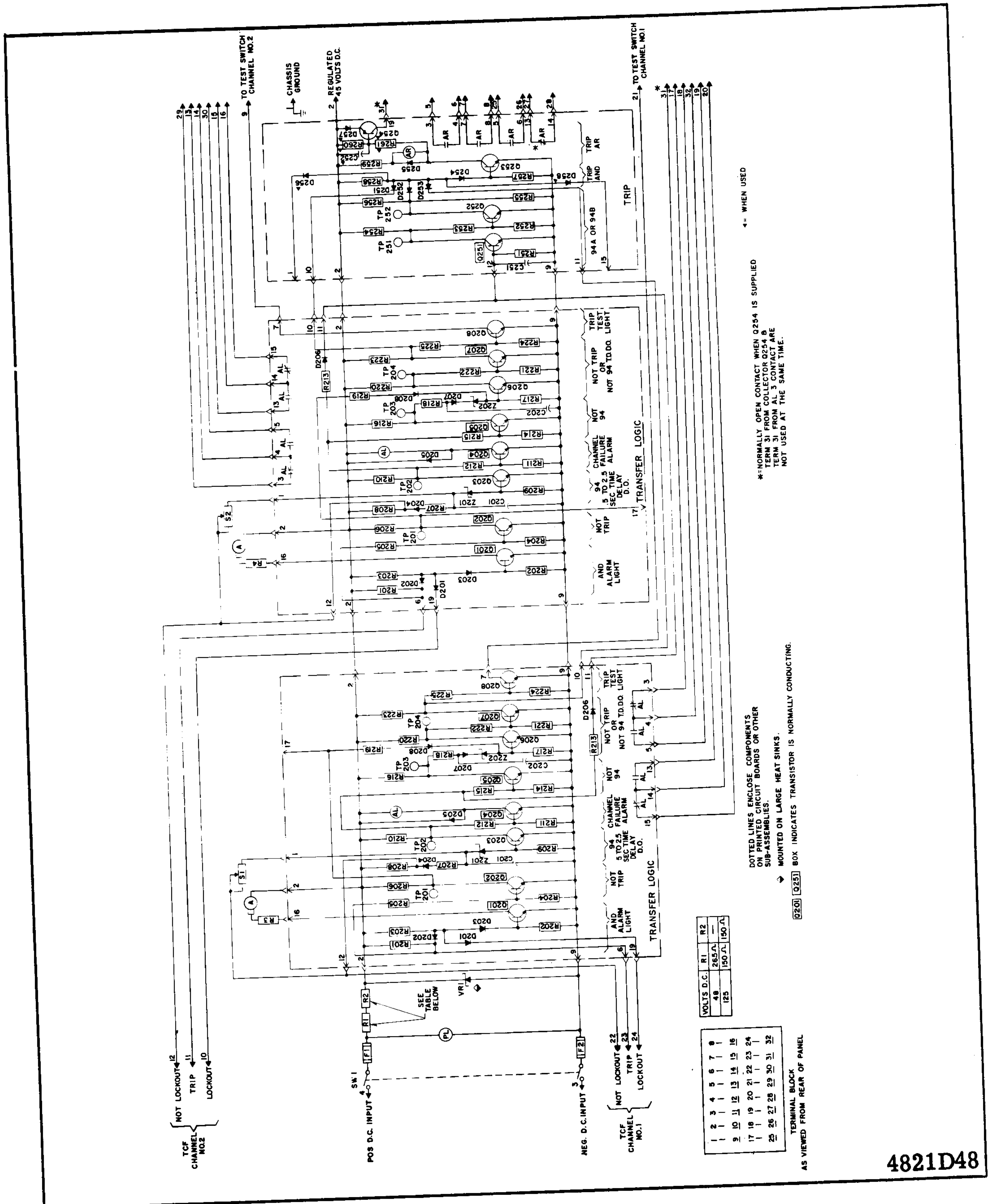


*Fig. 2. Internal Schematic of Type STU-9 Relay for TCF Frequency Shift Carrier Channel*

| | | |
|---|---|---|
| R210 - R223 | 12K Ω -½W. | 184A763H53 |
| R212 - R225 | 3.3K Ω-½W. | 184A763H39 |
| R213 - R215 | 22K Ω -½W. | 184A763H59 |
| | Zener Diodes | |
| Z201 | IN3686B 20V | 185A212H06 |
| Z202 | IN957B 6.8V | 186A797H06 |
| | Alarm Unit | |
| AL | Telephone Relay | 408C062H07 |
| TRIP BOARD | | |
| | Capacitors | |
| C251 - C252 | .25 uf | 187A624H02 |
| | Diodes | |
| D251 to D255 | IN457A | 184A855H07 |
| D252 to D253 (when used) | IN457A | 184A855H07 |

| | | |
|---|---|---|
| | Transistors | |
| Q251 - Q252 | 2N696 | 762A585H01 |
| Q253 | 2N699 | 184A638H19 |
| Q254 (when used) | 2N2043 | 184A638H21 |
| | Resistors | |
| R251 - R252 - R257 | 10K Ω -½W. | 184A763H51 |
| R253 - R255 | 33K Ω -½W. | 184A763H63 |
| R254 - R256 | 68K Ω -½W. | 184A763H71 |
| R258 | 10K Ω - 1W. | 184A643H51 |
| R259 | 800 Ω - 3W. | 184A859H06 |
| R260 (when used) | 1K Ω -½W. | 184A763H27 |
| R261 (when used) | 10K Ω -½W. | 184A763H51 |
| | AR Unit | |
| AR (when used) | 3NO - INC contacts | 408C845G23 |
| AR (when used) | 4NO - contacts | 408C845G13 |
| AR (when used) | 2NO - 2NC contacts | 408C845G09 |

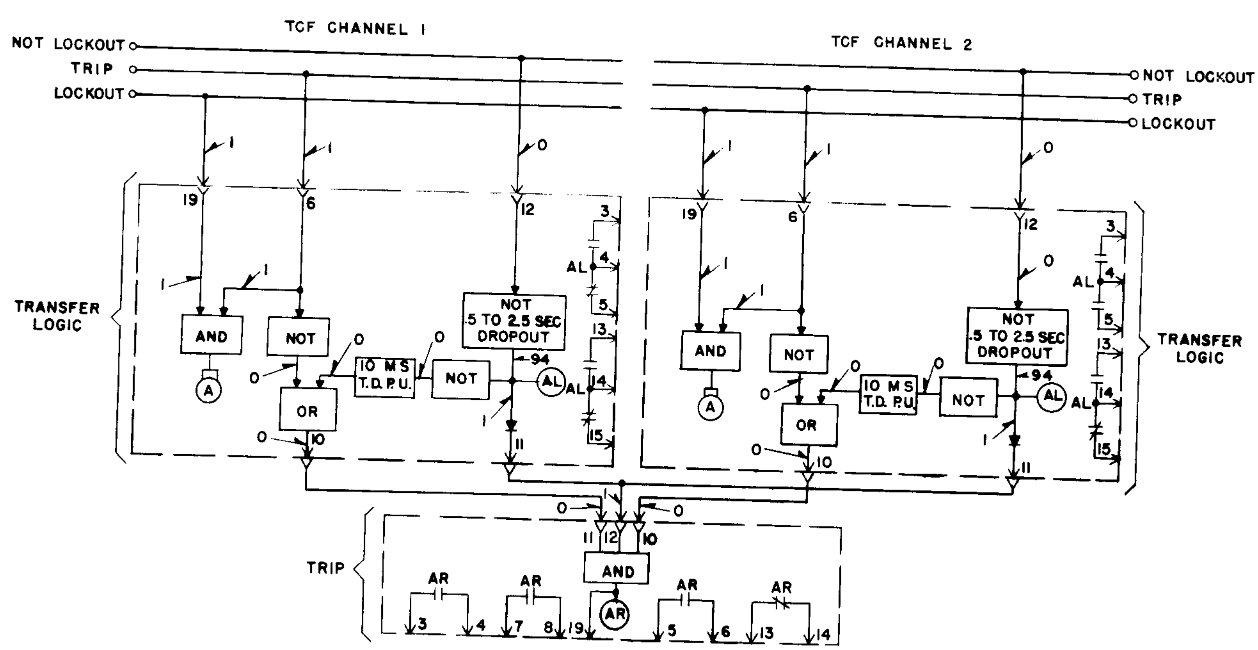


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*Fig. 3. Logic Diagram of Type STU-9 Relay for TCF Frequency Shift Carrier Channel*

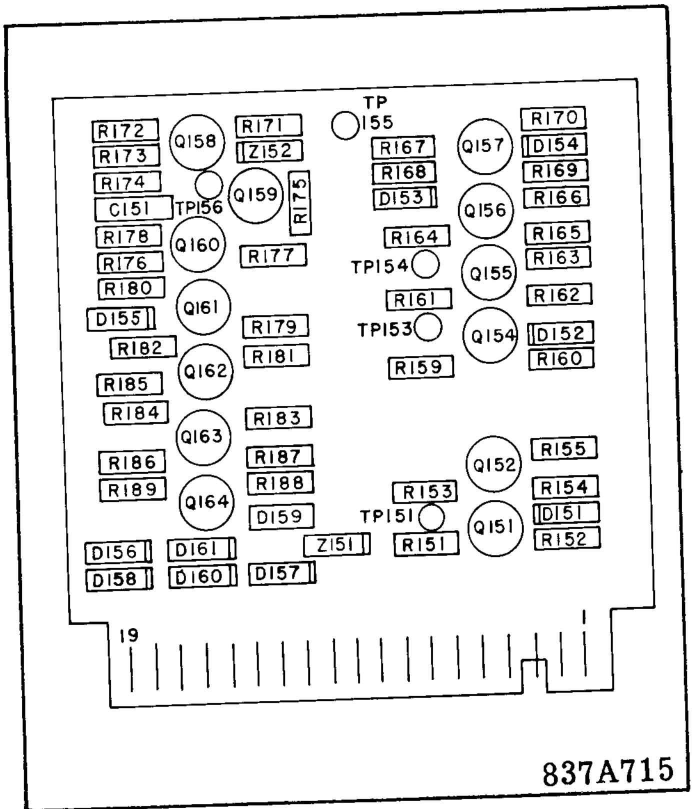


Fig. 5 Component Locations on the Interface Logic Board

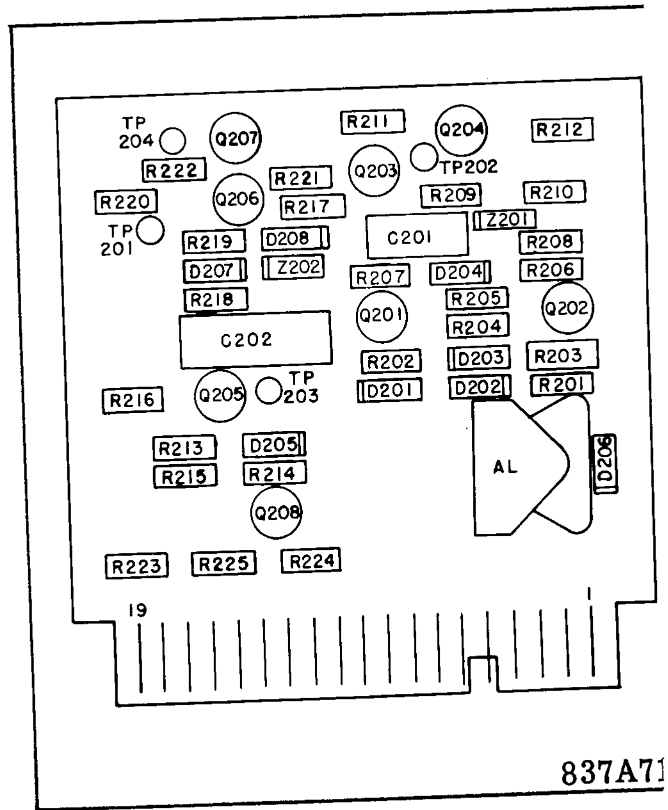


Fig. 6. Component Location on the Transfer Logic Board

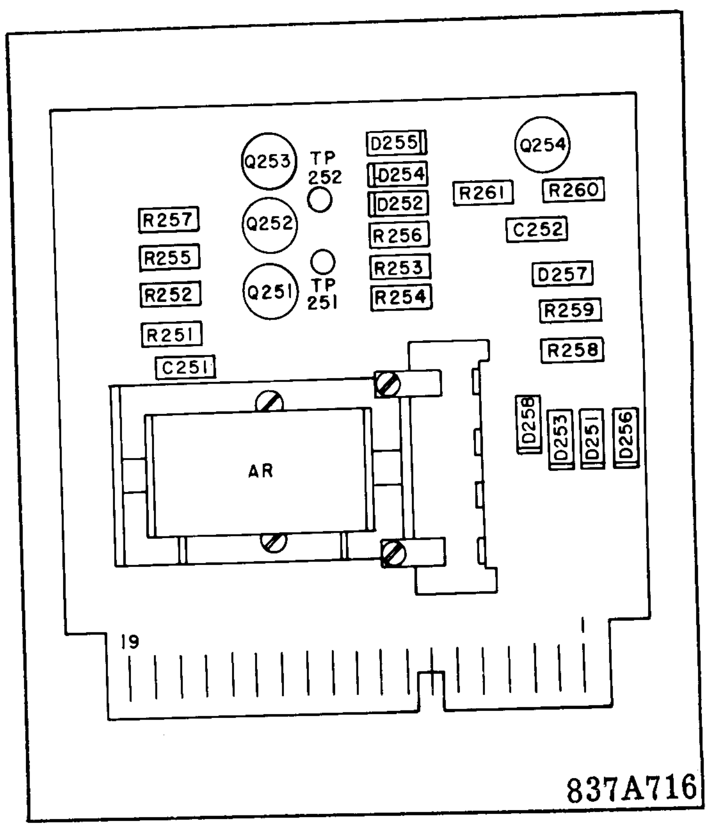


Fig. 7. Component Location on the Trip Board

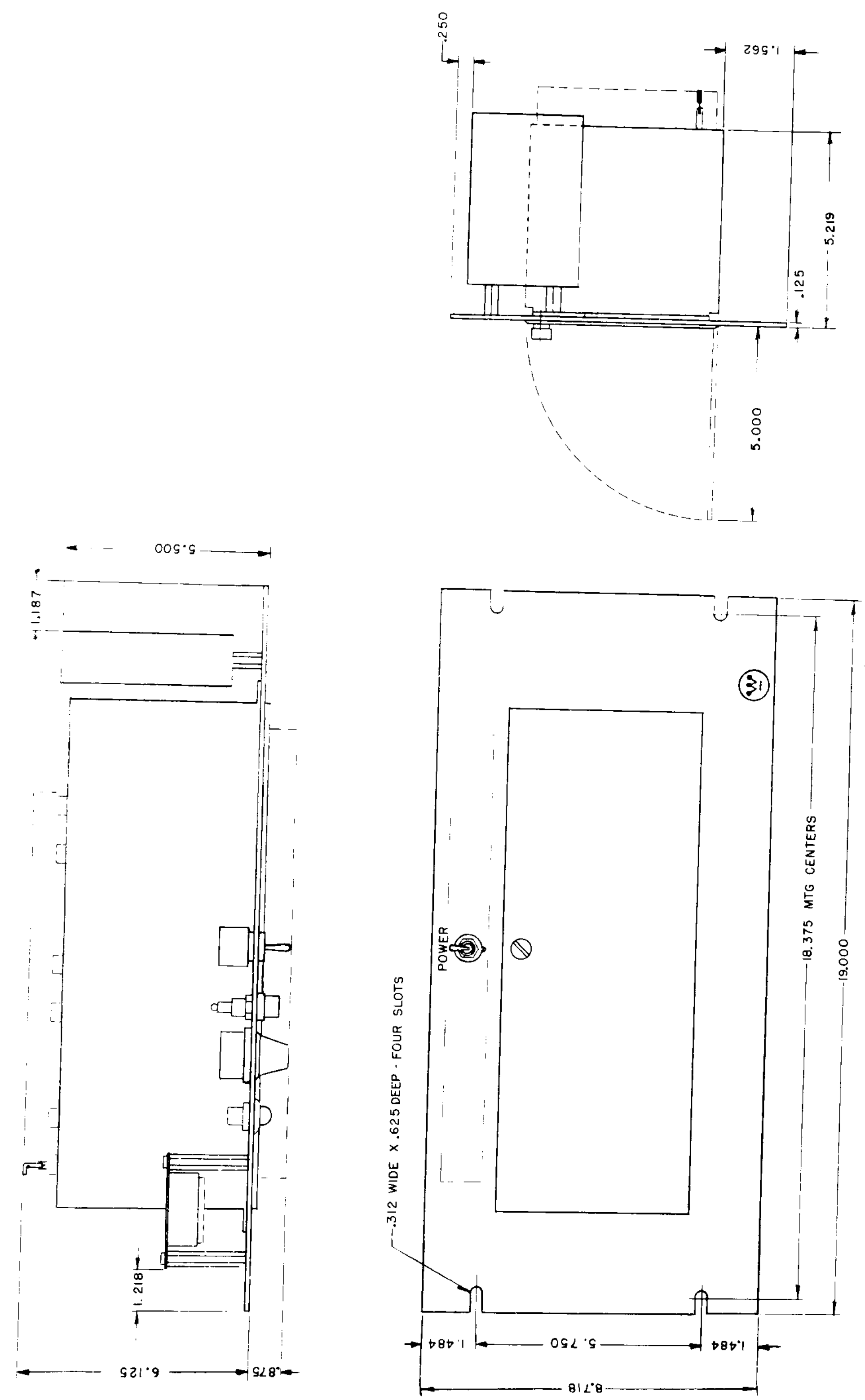


Fig. 8. Outline and Drilling Plan for the Type STU-9 Relay

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The type STU-9 relay is a static auxiliary relay used in transfer-trip relaying, such as would be used to trip a remote breaker for a transformer fault at a station where no high voltage breaker is used. It is used in conjunction with dual channel frequency-shift equipment, either audio tone or power line carrier frequencies.

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### Printed Circuit Boards

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This board will vary depending upon the make of frequency shift equipment used as the channel. In the case of TCF Frequency Shift Carrier equipment, the interface board is the logic board contained in the TCF receiver.

### 2. Transfer Logic Board

The transfer logic board contains the necessary

logic to alarm on loss of channel, to transfer to a single channel operation, and to invert the trip output of the interface logic to the proper polarity for the trip board. This logic will start transferring the STU-9 relay to a single channel mode of operation upon receipt of a positive voltage from the NOT Lockout circuit of the interface board.

Additional circuitry is included in the module for the connection of two external mounted switchboard lights (one for each channel). The lights are used to monitor the trips of the individual channels and should be connected between the regulated 45-volt d.c. (terminal 2) of the STU-9 and terminal 21 (channel 1) and terminal 9 (channel 2). The style switchboard light used is either style 1589193 or 1589181 with bulb style 1124156.

### 3. Trip Board

The trip board contains the final output of the STU-9 relay and consists of an AND circuit and an AR type relay. Under normal channel conditions, the two inputs from the trip of the transfer logic is held at negative potential. The third input to the trip AND is a voltage from the transfer circuits of the transfer board. As a result the output transistor is not conducting and the AR relay does not pick up. In order for the final transistor to operate, all inputs to the AND must be above negative potential. This occurs when the AND receives a trip input from both transfer logics.

For a lost of one channel, the trip input from the transfer logic of that channel removes its shorted input to negative, leaving the trip AND shorted to negative from the trip input of the remaining transfer logic. If both channels are lost, the trip inputs to the AND puts a positive voltage into the AND. However, the transfer input to the AND is put at negative potential to short the Input of the AND. A time delay is inserted in the transfer logic so that the transfer input to the AND is shorted to negative before the trip input switches to a positive output.

### Other Circuits (when used)

As shown in Figure 1, the trip output may contain other circuits. An additional transistor may be connected to obtain a voltage output from the trip NAND. This voltage output is used to drive an externally connected SAR relay. The transistor will apply 45 volts to the input of the SAR when the STU-9 relay operates.

D256 and D258 are used where it is not desirable to use the switching mode of the STU-9 relay. By connecting these diodes with a jumper to the lockout terminals of the interface board (terminal 18) of the STU-9 relay, the STU-9 relay will lockout on a single channel failure and not switch to a single channel mode of operation. With this connection the STU-9 relay will be operated as an AND circuit with reference to the channel and not as an OR.

The style numbers of the different boards with reference to the assembly is as follows:

| Style Number | Components |
|---|---|
| 898C235G01 | AR output 3 NO-INC, D256 and D258 omitted as well as transsistor Q254 and associated resistors. |
| 898C235G02 | AR output 3 NO-INC, D256 and D258 in the circuit but transistor Q254 and associated resistors omitted. |
| 898C235G03 | AR output 4 NO, D256 and D258 omitted, transistor Q254 included. |
| 898C235G04 | AR output 2NO-2NC, transistor Q254 and associated resistors included. |

### Power Supply

The STU-9 relay operates from a regulated 45 V.D.C. supply. This voltage is taken from a Zener diode mounted on a heat sink. Variation of the resistance values between the positive side of the unregulated D.C. supply and the 45 volt Zener diode adapt the receiver for operation on 48 or 125 volts d.c.

### Card Extender

A card extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one 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 circuit connections, and all components and test points on the board are readily accessible.

## OPERATION

The signal to which the STU-9 relay responds is received from the receiver of the channel equipment. If both channels are serviceable both channel receivers must receive a trip signal from the remote terminal for the STU-9 relay to operate. If one channel fails, the STU-9 relay will lock this channel out (after an adjustable time delay) and switch into a single channel mode of operation. The system will then trip upon receipt of a trip signal from the remote terminal on the remaining channel. If both channels fail, the STU-9 locks out the trip circuit until one or both channels are restored to service. Circuits are included in the relay to alarm on the loss of a channel.

The signals from the channel receivers are applied to the STU-9 relay at the input terminals of the interface board. This signal is transmitted to the transfer board to either apply a trip signal to the trip board, to prevent the transmission of this signal, or to transmit a transfer signal to a single channel.

When the frequency shift channel equipment is transmitting a guard signal, the signals to the STU-9 relay are as shown in the logic diagram of Figure 1. The number "1" indicates that a voltage is obtained at that point while a "0" indicates that the voltage is approximately zero. As seen in the logic diagram, the STU-9 relay requires a "1" from the low signal clamp and "0" from the trip and noise clamps of the tone channels to indicate nominal operating conditions.

For the condition shown, the amber lights are on and the alarm relay is picked up. Also the input to the trip "AND" is shorted to negative through the "OR" circuits of the transfer logic.

### Trip Sequence

If both channels are shifted to trip, the "0" from the tone channel changes to a "1". The trip interface of the STU-9 relay sees this change and puts a "1" into the channel trip "NAND". The output of the "NAND" goes to a "0" and the following occurs:

1. One input of the amber light AND is "0" and the light turns off.

2. The output of the NOT of the transfer logic changes to a "1" and applies a "1" to the trip AND through the OR of the transfer logic. Since all inputs to the trip AND are "1", an output is obtained to allow the AR to operate. Also the output transistor (where used) is turned on to give an output of approximately 45 volts. This voltage can be used to fire an external SAR relay to trip two breakers through Trinistor controlled rectifiers.

### Loss of Signal

With reference to the logic diagram of Fig. 1, the channel equipment recognizes a loss of channel and its low signal output changes to a "0". The output of the low signal interface of the STU-9 then changes to a "1". Upon application of the "1" to the NOR circuit, a time delay is energized. If the loss of signal exists for 150 millisecond, the output of the NOR circuit changes to a "0" and the following occurs:

1. The input to the channel trip NAND is clamped to negative which locks the NAND output to a "1" state (non-trip).

2. One input to the amber light AND drops to zero and the amber light turns off.

3. The output of the NOT $L_O$ changes to a "1", which energizes a timer. After a time delay of .5 to 2.5 sec., as determined by the timer setting, the timer times out and its output changes to a "0". The following then occurs:

   a. Alarm relay drops out to close its contacts.

   b. The output of the NOT changes to a 1 and energizes a 10-millisecond time delay circuit. After 10 milliseconds the input to the AND circuit is energized through the OR circuit.

4. Two voltages are applied to the trip "AND". The third input is clamped to negative by the output of the OR circuit on the good channel. The circuits of the STU-9 are set up for single channel operation and the system will operate if a trip signal is received from the output of the good channel.

### Loss of Second Channel

If the second channel is lost while the STU-9 is set up in a single channel mode of operation, the following occurs:

1. The output of the low signal interface of the second channel changes to a 1.

2. The channel trip NAND is clamped to a "1". (non-trip).

3. The input to the amber light AND is de-energized and the amber light turns off.

4. The output of the NOT Lo changes to a 1, and the 2.5 second timer times out, and the following occurs:

   a. The alarm unit drops out to close its contacts.

   b. The input to the trip AND through terminal 11 drops to "0" instantaneously.

   c. The output of the NOT changes to a "1" and energizes a 10 millisecond delay.

   d. At the end of 10 milliseconds the input to the trip AND (through terminal 10) AND changes to a "1". Tripping cannot occur because the AND was clamped previously to negative through terminal 11.

For the condition where both channels are out of service and one or both channels are restored to service, the following occurs:

The time delay in the base of transistor Q251 in the trip logic is energized. This time delay maintains the "0" on the trip AND through diode D252, for ½ millisecond after the voltage from either D253 or D251 drops to "0" from a "1" condition.

**Noise**

If an output is obtained from the noise clamp of the channel equipment, the input to the noise interface changes to a "1", and energizes a NOT and a NOR circuit. The output of the NOT changes to a "0" and shorts the input to the channel trip NAND to negative. This puts the NAND in a non-operating condition. If the noise condition exists for 150 milliseconds, the STU-9 relay will recognize the condition as a loss of channel and switch into a single channel mode of operation.

# CHARACTERISTICS

The type STU-9 relay is available for frequency shift channels, either tone, carrier, or a combination of both. The schematic and logic diagram for frequency-shift tone channels is shown in Figure 1.

If TCF frequency shift carrier is used as the channel equipment, the logic diagram and schematic diagram of Figures 2 and 3 apply. This logic is the same as that of Fig. 1, except that the interface board is omitted. The lockout, not lockout, and trip inputs the STU-9 transfer boards are obtained from the logic board of the TCF receiver. These quantities are the same as received from the interface logic Fig. 1.

When the STU-9 relay is used with both TCF frequency shift Carrier and frequency shift tone channels, the relay is connected as shown in Figure 4.

| | |
|---|---|
| Lockout time | 150 milliseconds |
| Transfer time | 0.5 to 2.5 seconds |
| Operating time | 3 milliseconds with AR – 75 microseconds to obtain voltage contact. |
| Voltage Output Relay (when used) Maximum Output | 60 milliamperes, 45 V. d.c. |
| Ambient temperature range | -20 °C to +60 °C |

Battery Voltage Variations

| Rated Voltage | Allowance Variation |
|---|---|
| 48 V.D.C. | 42 - 56 V.D.C. |
| 125 V.D.C. | 105 - 140 V.D.C. |

| | |
|---|---|
| Battery Drain | 235 milliamperes-48 V.D.C.<br>275 milliamperes - 125 V.D.C. |
| Dimensions | Panel Height — 8¾ inch or 5 rack units.<br>Panel Width-19 inches |

# SETTING

The only setting required is the setting of the timer for transfering to a single channel mode of operation upon a loss of one channel. This setting is made by means of the timer knobs on the front panel of the relay. The knob should be locked after the setting is made.

## INSTALLATION

The STU-9 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 60 °C.

### Routine Maintenance

Periodic checks of the relaying system as described in the assembly instructions are desirable to indicate impending failure so that the equipment can be taken out of service for correction.

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

### Trouble-Shooting

The components of the STU-9 are operated well within their ratings, and under normal conditions they should give long, trouble-free service. However, if a relay has given an indication of trouble in service or during routine checks, the voltages tabulated in TABLE I should be checked to determine the faulty circuit. The test point and component location on the boards are given in Figures 5, 6, and 7.

**TABLE I**

Test point voltages to negative except where specified to positive 45 volts D.C.

<table>
<tr><th>BOARD</th><th>TEST POINT</th><th>NORMAL CHANNEL</th><th>WITH NOISE ONLY</th><th colspan="2">WITH LOSS OF CHANNEL ONLY</th><th>WITH TRIP ONLY</th></tr>
<tr><td rowspan="13">CHANNEL INTERFACE</td><td>term 16 to pos</td><td>-16</td><td>-16</td><td colspan="2">-2</td><td>-16</td></tr>
<tr><td>TP151</td><td>0.05</td><td>0.05</td><td colspan="2">15</td><td>0.05</td></tr>
<tr><td>term 17 to pos</td><td>0</td><td>-16</td><td colspan="2">0</td><td>0</td></tr>
<tr><td>TP153</td><td>15</td><td>0.05</td><td colspan="2">15</td><td>15</td></tr>
<tr><td>TP154</td><td>0.05</td><td>15</td><td colspan="2">0.05</td><td>0.05</td></tr>
<tr><td>TP155</td><td>15</td><td>0.05</td><td colspan="2">0.05</td><td>15</td></tr>
<tr><td>TP156</td><td>0.05</td><td>21</td><td colspan="2">21</td><td>0.05</td></tr>
<tr><td>term 18</td><td>10</td><td>0.10</td><td colspan="2">0.10</td><td>10</td></tr>
<tr><td>term 12</td><td>0.05</td><td>4</td><td colspan="2">(with max. setting 4)</td><td>0.05</td></tr>
<tr><td>term 15 to pos</td><td>0</td><td>0</td><td colspan="2">0</td><td>-16</td></tr>
<tr><td>term 11</td><td>15</td><td>15</td><td colspan="2">15</td><td>0.05</td></tr>
<tr><td>term 10</td><td>0.05</td><td>0.05</td><td colspan="2">0.05</td><td>15</td></tr>
<tr><td>term 6</td><td>15</td><td>15</td><td colspan="2">15</td><td>0.2</td></tr>
<tr><td rowspan="9">TRANSFER</td><td>term 12</td><td>0.05</td><td>4</td><td colspan="2">(with max. setting 4)</td><td>0.05</td></tr>
<tr><td>term 16</td><td>0.05</td><td>45</td><td colspan="2">45</td><td>45</td></tr>
<tr><td>TP201</td><td>0.05</td><td>0.05</td><td colspan="2">0.05</td><td>10</td></tr>
<tr><td>TP202</td><td>9</td><td>0.1</td><td colspan="2">0.1</td><td>9</td></tr>
<tr><td>TP203</td><td>0.05</td><td>20</td><td colspan="2">20</td><td>0.05</td></tr>
<tr><td>TP204</td><td>13</td><td>0.05</td><td colspan="2">0.05</td><td>0.05</td></tr>
<tr><td>term 10</td><td>0.15</td><td>10</td><td colspan="2">10</td><td>10</td></tr>
<tr><td>term 11</td><td>0.7</td><td>0.7</td><td colspan="2">0.7</td><td>0.7</td></tr>
<tr><td>term 7</td><td>45</td><td>0.3</td><td colspan="2">0.3</td><td>0.3</td></tr>
<tr><td rowspan="6">TRIP</td><td></td><td></td><td></td><td>Single CH</td><td>Both CH</td><td></td></tr>
<tr><td>TP251</td><td>0.05</td><td>0.05</td><td>0.05</td><td>15</td><td>0.05</td></tr>
<tr><td>TP252</td><td>15</td><td>15</td><td>15</td><td>0.07</td><td>15</td></tr>
<tr><td>term 10</td><td>0.15</td><td>10</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>term 11</td><td>0.15</td><td>10</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>term 19</td><td>0.05</td><td>0.05</td><td>0.05</td><td>0.05</td><td>43</td></tr>
</table>

## Renewal Part

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, and component style No. given in the electrical parts list.

### ELECTRICAL PARTS LIST

#### PANEL MOUNTED COMPONENTS

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | **Power Supply** | |
| SW1 | Switch | 183A856H01 |
| PL | Pilot Light 125 V.D.C. | 183A825G01 |
| | Pilot Light 48 V.D.C. | 183A825G04 |
| F1 - F2 | 1.5 Ampere Fuse | 11D9195H26 |
| R1 | 26.5 Ω 40w. 48 V.D.C. | 04D1299H44 |
| R1 - R2 | 150 Ω 40 w. 125 V.D.C. | 1201499 |
| VR1 | Zener Diode, IN2828B, 50W. | 184A854H06 |
| | **Alarm** | |
| A | Amber Light | 183A825G08 |
| R3 - R4 | 330 Ω 3W. | 185A207H15 |
| | **Potentiometer** | |
| S1 - S2 | 50 K Ω | 185A086H22 |

#### CHANNEL INTERFACE BOARD

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | **Capacitor** | |
| C 151 | 6.8MFD 35 V.D.C. | 184A661H25 |
| | **Diodes** | |
| D151 | IN457A | 184A855H07 |
| | **Transistors** | |
| Q151 - Q154 - Q161 Q152 - Q155 - Q156 Q157 - Q158 - Q162 | 2N2043 | 184A638H21 |
| Q163 | 2N696 | 762A585H01 |
| Q159 | 2N697 | 184A638H18 |
| Q160 - Q164 | 2N699 | 184A638H19 |
| | **Resistors** | |
| R151 - R159 - R179 | 6.8K Ω -½W | 184A763H47 |
| R152 - R160 - R174 R180 | 1K Ω -½W. | 184A763H27 |
| R153 - R161 - R164 R167 - R171 | 10K Ω -½W. | 184A763H51 |
| R175 - R177 - R181- R183 - R188 - R154- R162 - R182 - R189 | 100K Ω-½W. | 184A763H75 |
| R155 - R163 - R166- R170 - R185 - R186 | 68K Ω -½W. | 184A763H71 |
| R165 - R168 - R169- R172 - R184 - R187 | 33K Ω -½W. | 184A763H63 |
| R173 | 39K Ω -½W. | 184A763H65 |
| R176 | 12K Ω -½W. | 184A763H53 |
| R178 | 3.3K Ω-½W. | 184A763H39 |
| | **Zener Diodes** | |
| Z151 | IN957B 6.7V | 186A797H06 |
| Z152 | IN3686B 20V | 185A212H06 |

#### TRANSFER BOARD

| Circuit Symbol | Description | (W) Style No. |
|---|---|---|
| | **Capacitors** | |
| C201 | 68MFD 35 V.D.C. | 187A508H02 |
| C202 | 0.5MFD | 187A624H11 |
| | **Diodes** | |
| D201 to D208 | IN457A | 184A638H07 |
| | **Transistors** | |
| Q 201 - Q202 - Q204- Q208 | 2N699 | 184A638H19 |
| Q203 - Q207 | 2N697 | 184A638H18 |
| Q205 - Q206 | 2N696 | 762A585H01 |
| | **Resistors** | |
| R201 - R206 - R216- R220 | 68K Ω -½W. | 184A763H71 |
| R202 - R204 - R208- R209 - R211 - R214- R217 - R221 - R224 | 10K Ω -½W. | 184A763H51 |
| R203 | 10K Ω - 1W | 187A643H51 |
| R205 - R218 - R219- R222 | 33K Ω -½W. | 184A763H63 |
| R207 | 1K Ω -½W. | 184A763H27 |

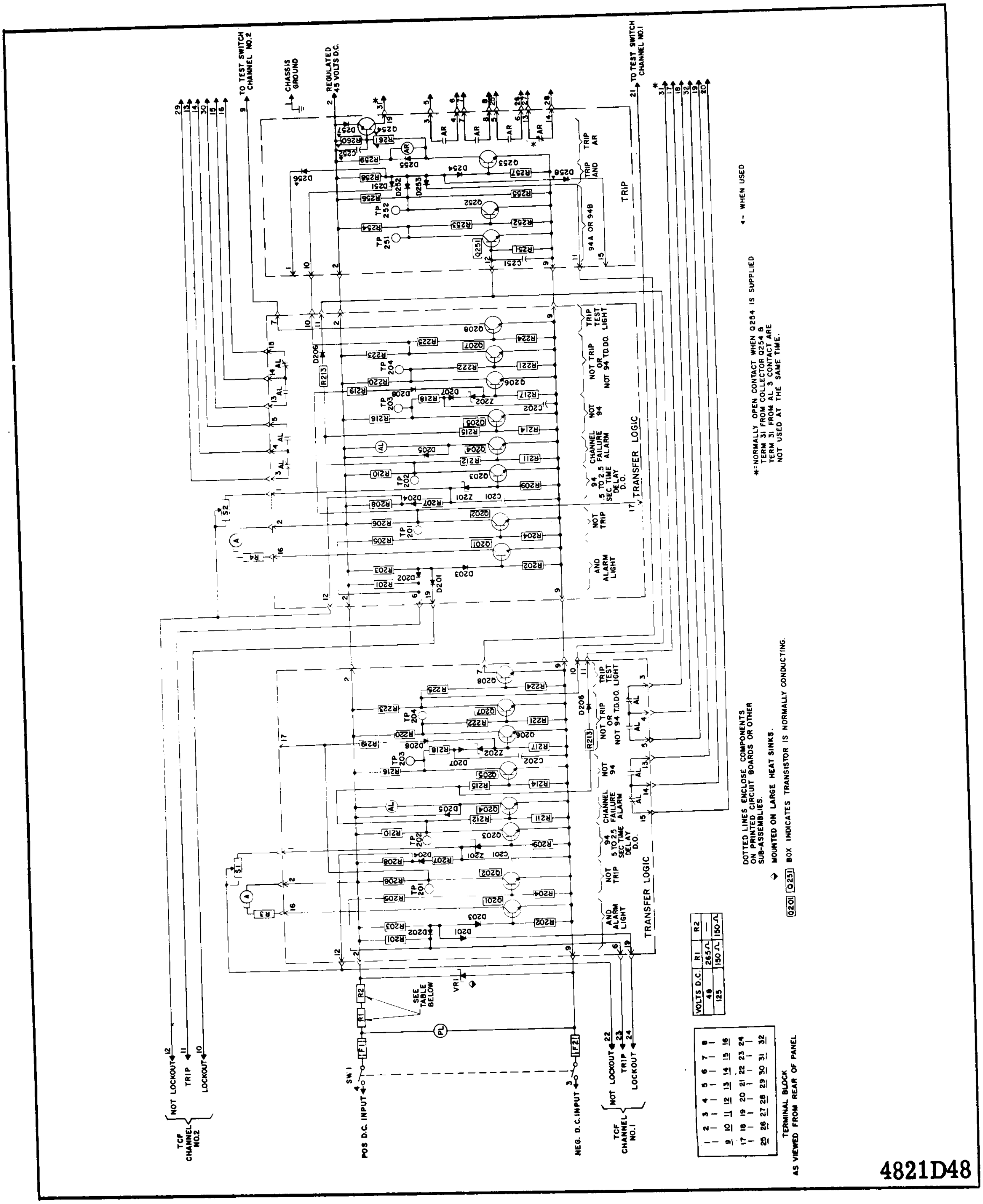


*Fig. 2. Internal Schematic of Type STU-9 Relay for TCF Frequency Shift Carrier Channel*

| | | |
|---|---|---|
| R210 - R223 | 12K Ω -½W. | 184A763H53 |
| R212 - R225 | 3.3K Ω-½W. | 184A763H39 |
| R213 - R215 | 22K Ω -½W. | 184A763H59 |
| | **Zener Diodes** | |
| Z201 | IN3686B 20V | 185A212H06 |
| Z202 | IN957B 6.8V | 186A797H06 |
| | **Alarm Unit** | |
| AL | Telephone Relay | 408C062H07 |

**TRIP BOARD**

| | | |
|---|---|---|
| | **Capacitors** | |
| C251 - C252 | .25 uf | 187A624H02 |
| | **Diodes** | |
| D251 to D255 | IN457A | 184A855H07 |
| D252 to D253 (when used) | IN457A | 184A855H07 |
| | **Transistors** | |
| Q251 - Q252 | 2N696 | 762A585H01 |
| Q253 | 2N699 | 184A638H19 |
| Q254 (when used) | 2N2043 | 184A638H21 |
| | **Resistors** | |
| R251 - R252 - R257 | 10K Ω -½W. | 184A763H51 |
| R253 - R255 | 33K Ω -½W. | 184A763H63 |
| R254 - R256 | 68K Ω -½W. | 184A763H71 |
| R258 | 10K Ω -1W. | 184A643H51 |
| R259 | 800 Ω -3W. | 184A859H06 |
| R260 (when used) | 1K Ω -½W. | 184A763H27 |
| R261 (when used) | 10K Ω -½W. | 184A763H51 |
| | **AR Unit** | |
| AR (when used) | 3NO - INC contacts | 408C845G23 |
| AR (when used) | 4NO - contacts | 408C845G13 |
| AR (when used) | 2NO - 2NC contacts | 408C845G09 |

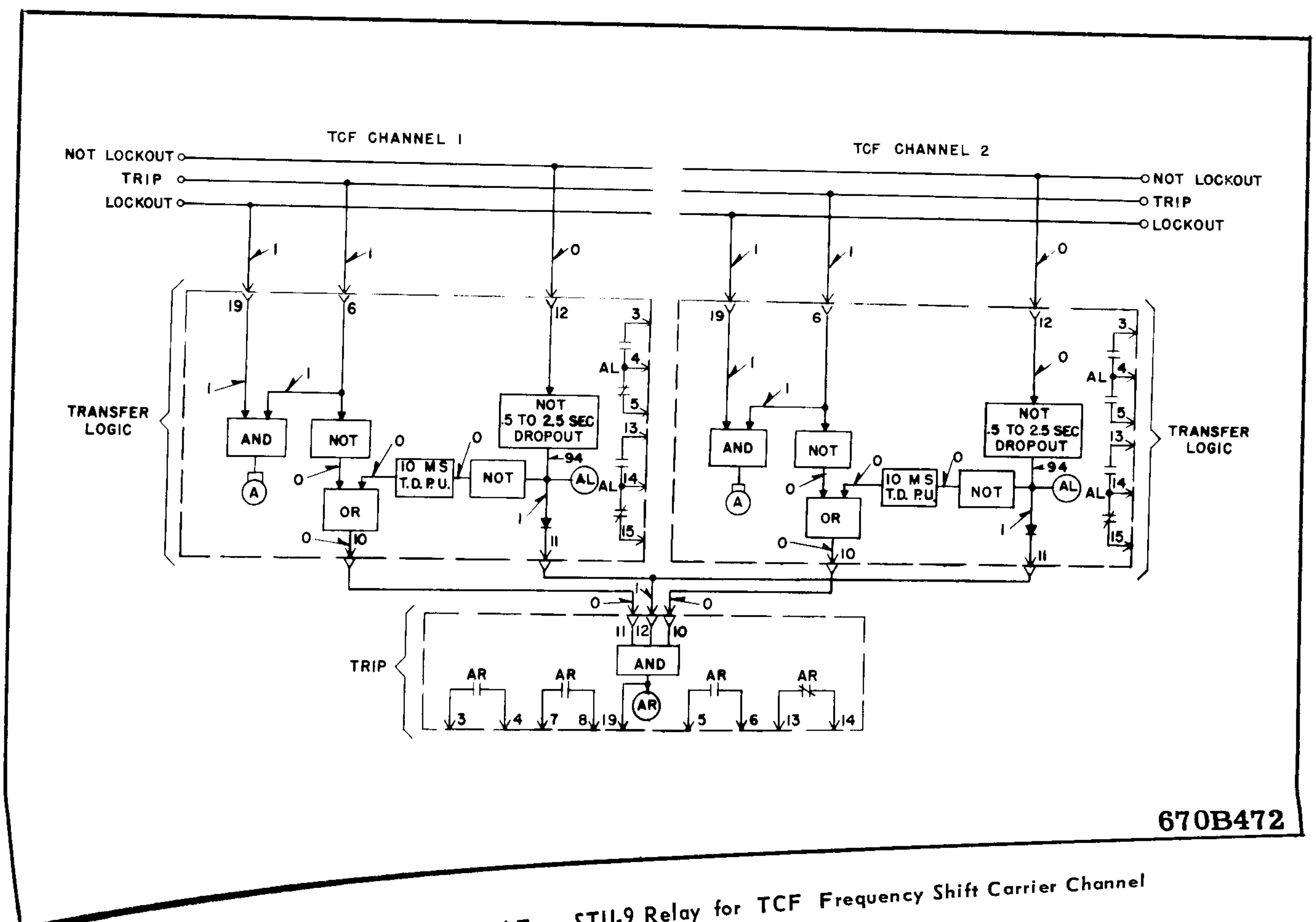


Fig. 3. Logic Diagram of Type STU-9 Relay for TCF Frequency Shift Carrier Channel

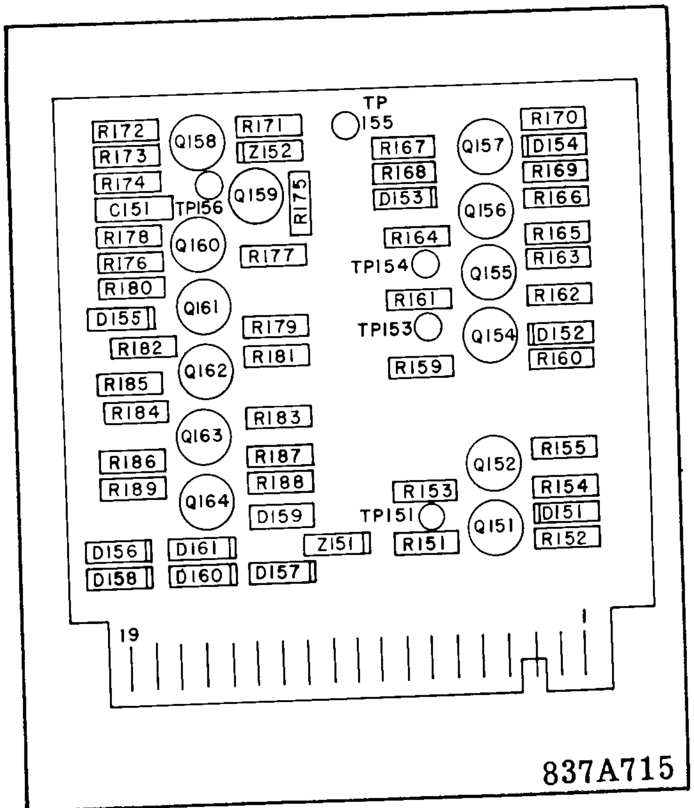


Fig. 5 Component Locations on the Interface Logic Board

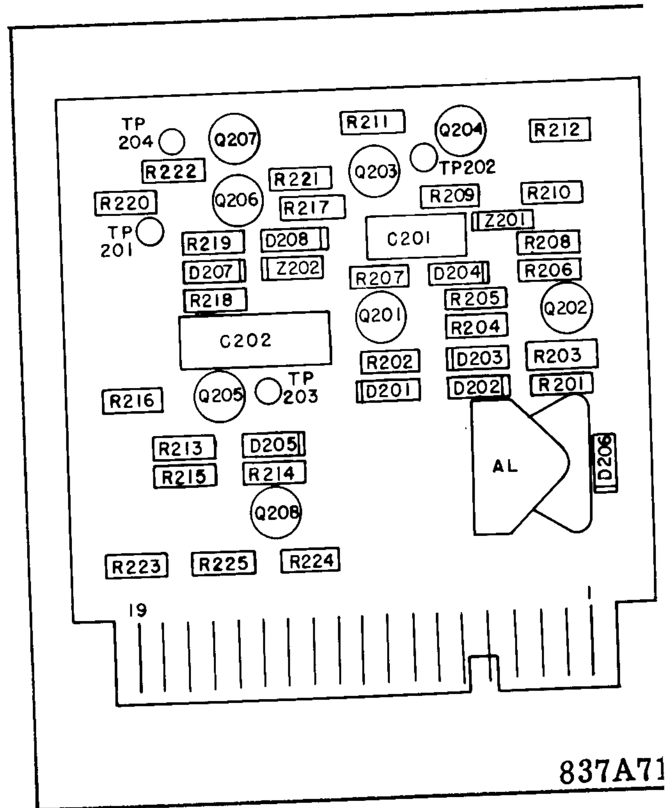


Fig. 6. Component Location on the Transfer Logic Board

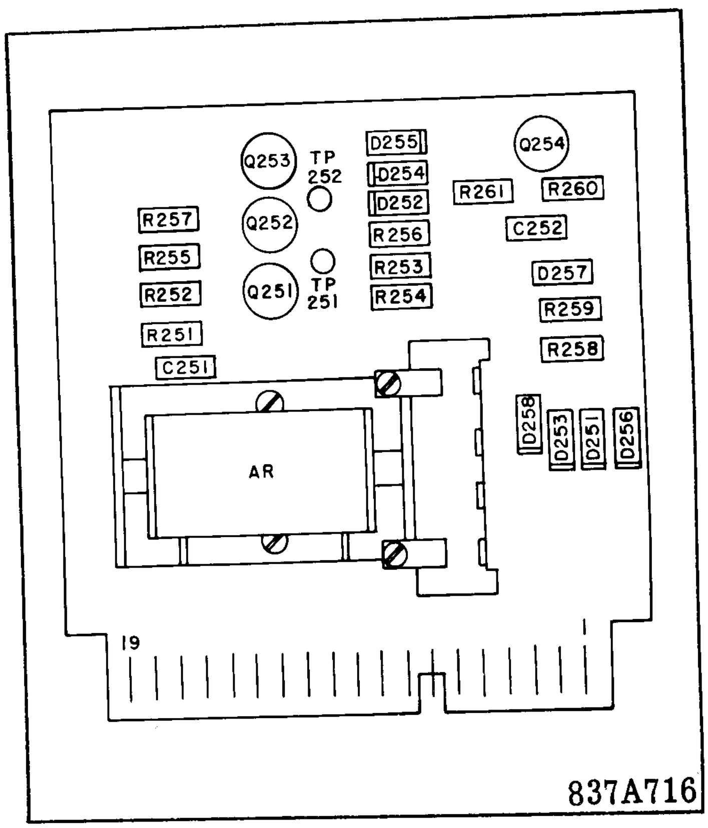


Fig. 7. Component Location on the Trip Board

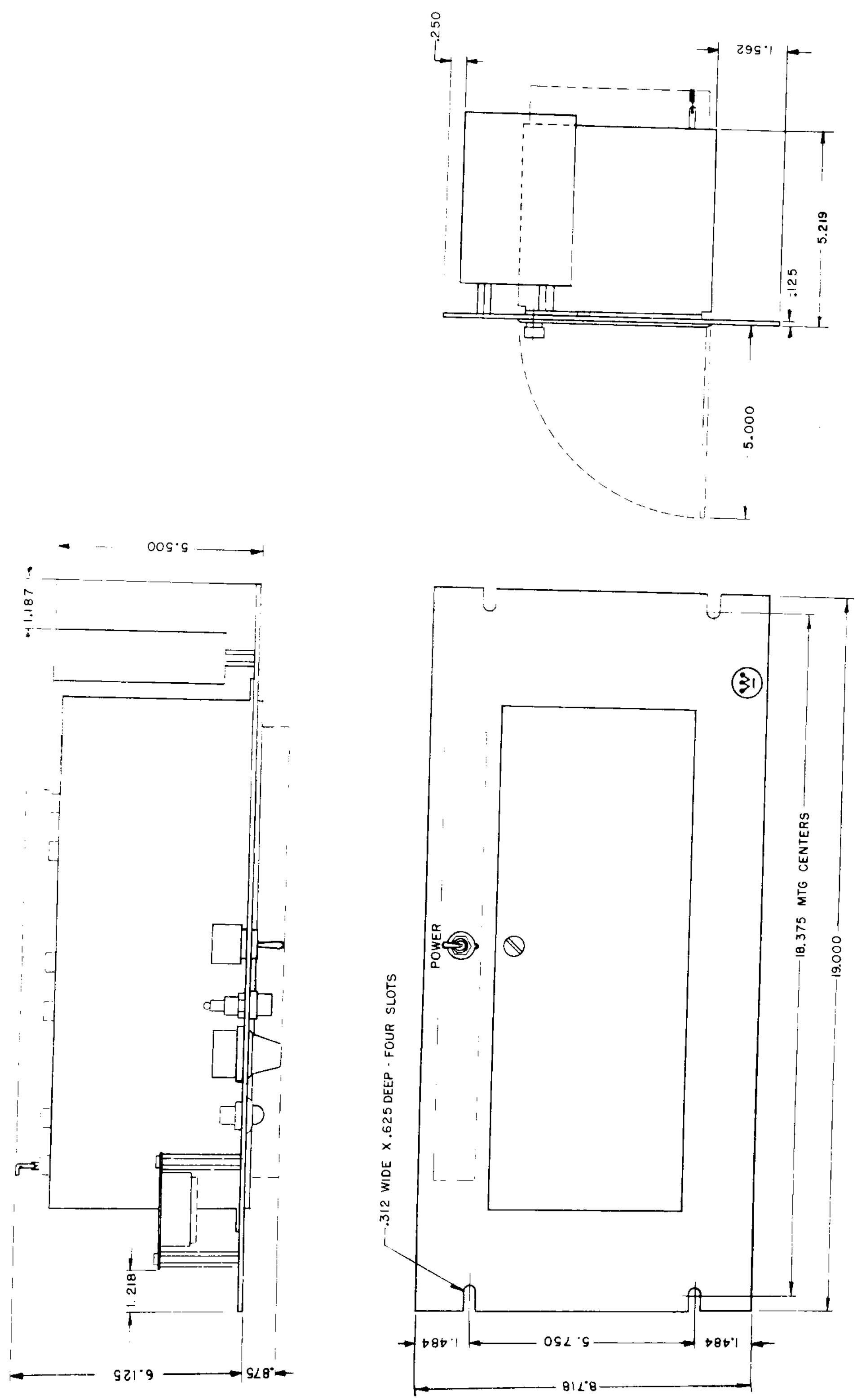


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Fig. 8. Outline and Drilling Plan for the Type STU-9 Relay

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