

EAI[®]

ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

**ELECTRONIC
COMPARATOR
MODEL 40.488**

**for use with
TR-48
ANALOG COMPUTER**

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January 1964

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ELECTRONIC COMPARATOR

MODEL 40.488

1. GENERAL DESCRIPTION

The Electronic Comparator, Model 40.488 (Figure 1), is a high-speed analog device that compares two continuously variable signals and operates the electronic equivalent of a form-C relay according to the polarity of the sum of the inputs. The sum of the analog inputs is first digitized, then these digital signals are connected to the control inputs of two electronic switches. External digital signals may alternately be used to operate the switches. In addition, the electronic switches may alternately be connected to provide two independent channels of track and storage (hold) of analog voltages.

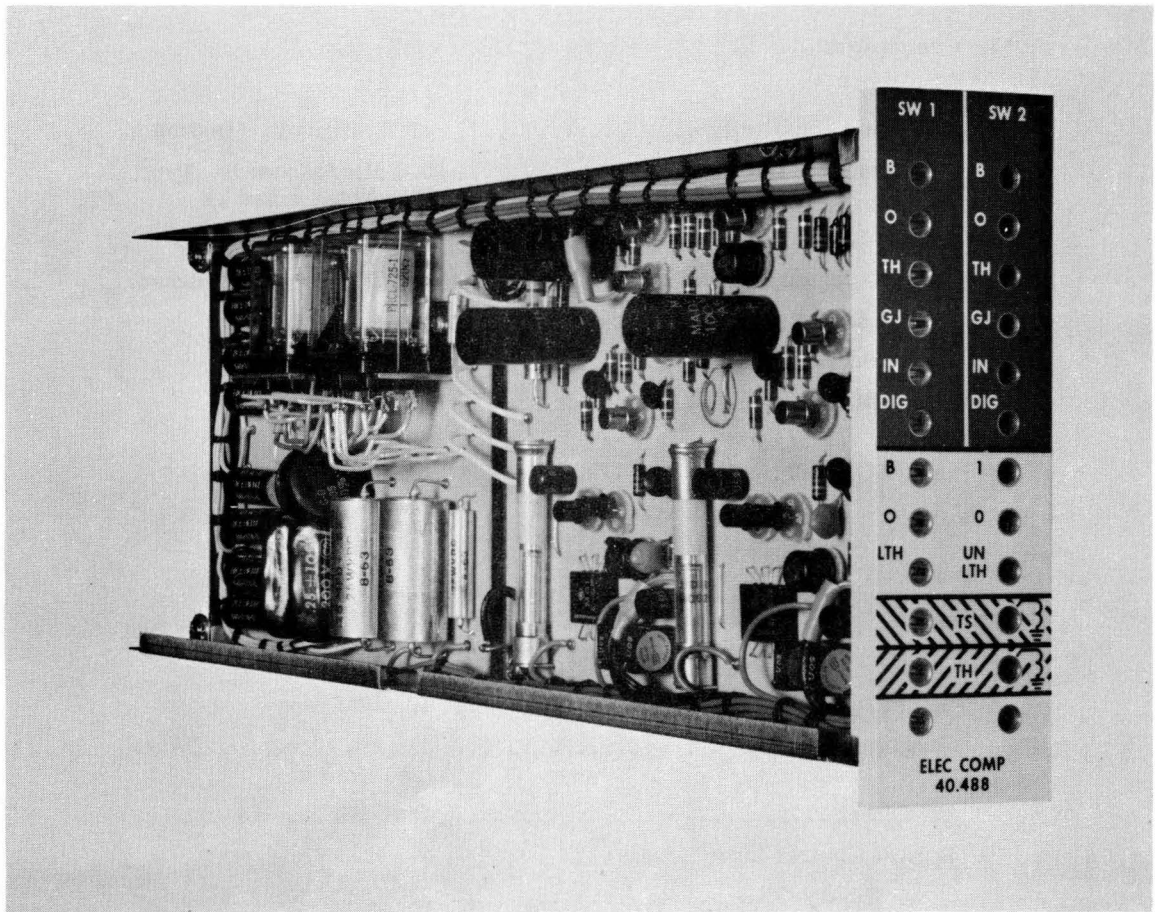


Figure 1. Electronic Comparator 40.488

2. TECHNICAL DATA

a. Power Requirements

+15 VDC @ 16 MA, Nominal
 -15 VDC @ 12 MA, Nominal
 +10 VDC (Reference) @ 2.0 MA
 -10 VDC (Reference) @ 2.0 MA
 -20 VDC, Nominal, @ 80 MA

b. Specifications

(1) *Comparator*

Switching Sensitivity ±1.0 Millivolt, Maximum
 Propagation Time 5.0 Microseconds, Typical
 (See Notes 1 and 2)
 Analog Input Range -10 Volts to +10 Volts
 Latch Input Impedance 100,000 Ohms, Minimum
 Digital Output Levels
 Binary ONE 5.0 VDC, Nominal
 Binary ZERO 0.0 VDC, Nominal

(2) *Electronic Switch*

Signal Input Impedance 10,000 Ohms
 Propagation Time 1.0 Microsecond, Typical
 (See Note 2)
 DC Offset ±500 Microvolts
 Digital Control Input Levels
 Binary ONE 5.0 VDC, Nominal
 Binary ZERO 0.0 VDC, Nominal
 Control Input Impedance 100,000 Ohms, Minimum

NOTES

1. *The propagation time of the comparator is dependent upon the slope of the algebraic sum of the inputs. With a sum of the input signal with a rise time in the order of 1.0 microsecond, the propagation time is typically 5.0 microseconds.*
 2. *The propagation time of the comparator and electronic switch in cascade is typically 5.0 microseconds even though the propagation time of each is 5.0 and 1.0 microseconds respectively.*
-

(3) *Track and Hold*

Digital Control Input Levels

| | |
|-------------------------------|-----------------------|
| Binary ONE | 5.0 VDC, Nominal |
| Binary ZERO | 0.0 VDC, Nominal |
| Control Input Impedance | 100,000 Ohms, Minimum |
| Signal Input Impedance | 2000 Ohms |

Drift in Hold Mode

| | |
|---------------------------|-----------------------|
| Real Time Operation | 2.0 Millivolts/Second |
| Fast Time Operation | 100 Millivolts/Second |

Phase Shift

| | |
|-------------------------------------|----------------|
| Real Time Operation 20V P-P, 10 CPS | |
| Sine Wave Input | 0.06°, Typical |
| Fast Time Operation 20V P-P, 1.0 KC | |
| Sine Wave Input | 0.3°, Typical |

Gain Error

| | |
|-------------------------------------|----------------|
| Real Time Operation 10V P-P, 10 CPS | |
| Sine Wave Input | 0.02%, Typical |
| Fast Time Operation 10V P-P, 1.0 KC | |
| Sine Wave Input | 0.1%, Typical |

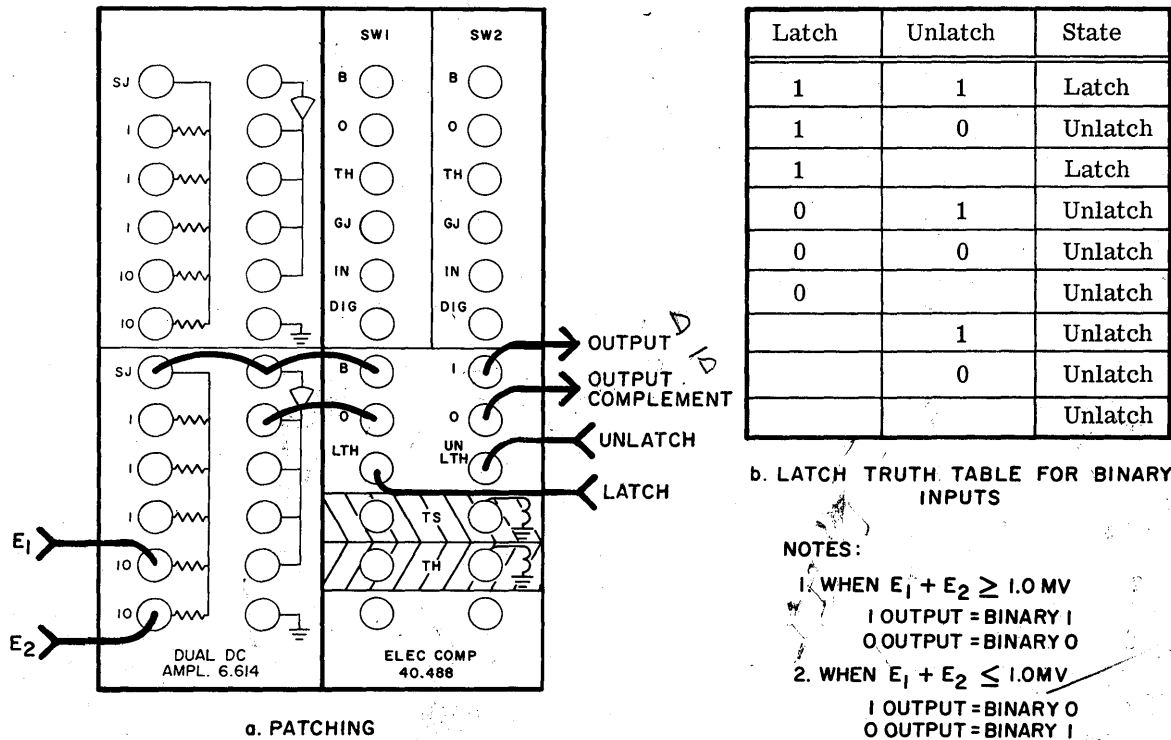


Figure 2. Comparator Mode

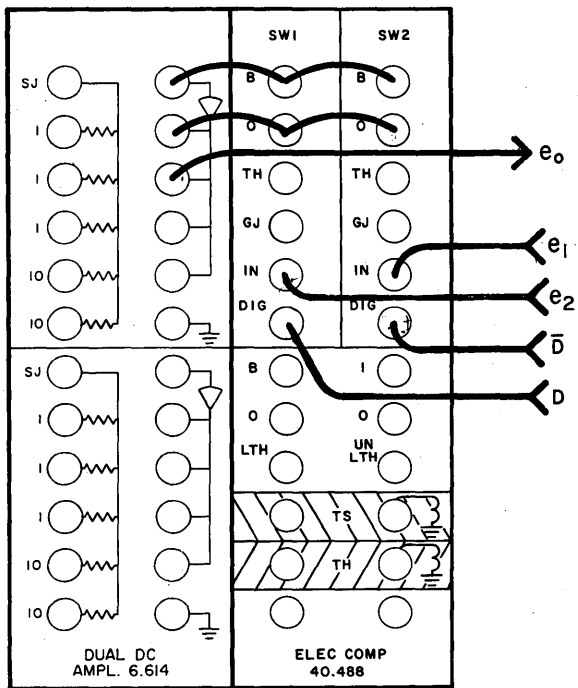
3. OPERATION

The mode of operation of the Electronic Comparator 40.488 is completely controlled by preliminary patching connections. The patching connections for each mode and the input/output terminals are shown in Figures 2 through 4.

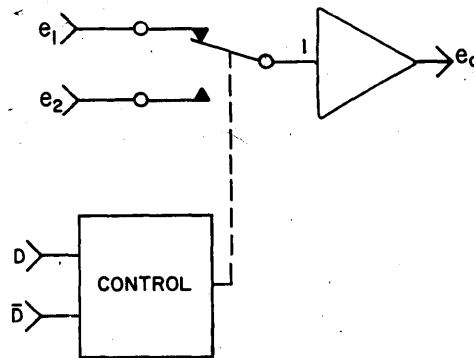
In addition to unity gain switching, the comparator unit may be used for multiplying the switched input by a constant. To multiply the input by a constant, remove the input from the IN terminal and connect it to the GJ (gate junction) terminal through a fixed resistor (R_i). The value of R_i is calculated by the formula

$$R_i = \frac{e_i}{e_o} R_f$$

where $R_f = 10K$.



a. PATCHING

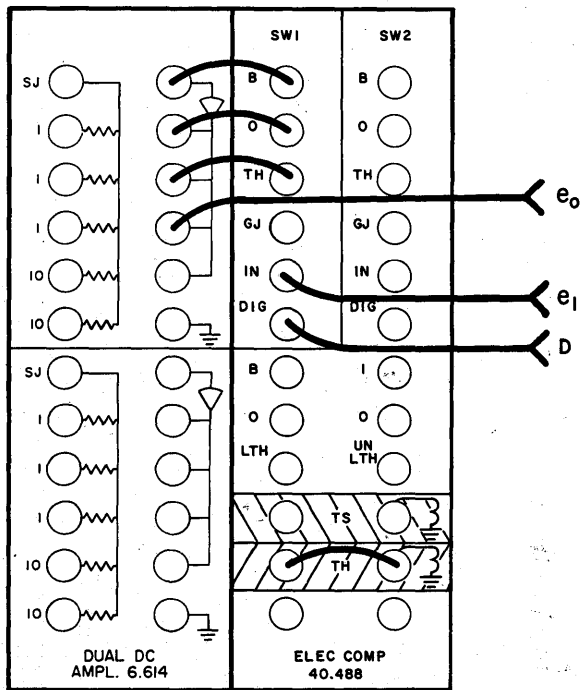


b. EQUIVALENT CIRCUIT

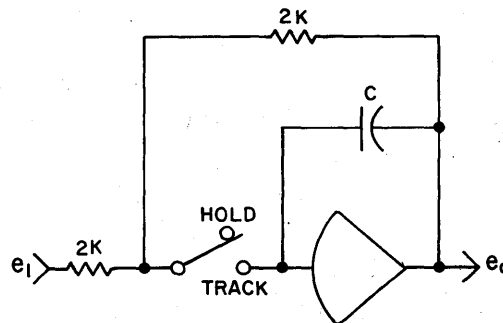
NOTES :

1. WHEN D IS BINARY 1
 $e_o = -e_1$
2. WHEN D IS BINARY 0
 $e_o = -e_2$

Figure 3. Electronic Selector Switch Mode



a. PATCHING



b. EQUIVALENT CIRCUIT

NOTES:

1. TYPICAL, ONE CHANNEL
2. WHEN D IS BINARY 1
AMPLIFIER TRACKS.
3. WHEN D IS BINARY 0
AMPLIFIER HOLDS.
4. FOR REPETITIVE OPERATION
CONNECT BOTTLE PLUG IN
TS AREA.

Figure 4. Track-Hold Mode

4. THEORY OF OPERATION

a. General Information

The theory of operation is first presented in terms of a block diagram analysis for each mode, followed by a circuit description of each section of the comparator.

b. Block Diagram

(1) *Comparator.* The comparator is shown in block diagram form in Figure 5. The input signals are applied to resistors and summed at the junction. This junction is applied to a high gain amplifier, which in turn is applied to a flip-flop. When the sum of the inputs is positive, a negative signal from the amplifier sets the flip-flop with the 1 output to a binary ONE and the 0 output to a binary ZERO. Like wise, when the sum of the inputs is negative, the 1 output is binary ZERO and the 0 output is binary ONE.

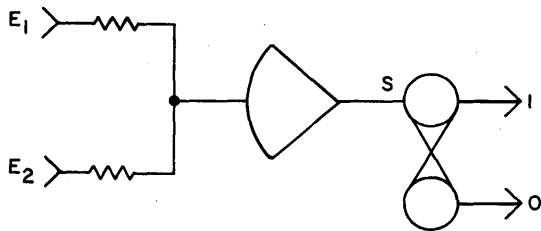


Figure 5. Analog Comparator, Block Diagram

(2) *Electronic Selector Switch.* An electronic selector switch is shown in block diagram form in Figure 6. The complementary control inputs (D , \bar{D}) may be applied from the 1 and 0 outputs of a comparator or external digital equipment. When D is a binary ONE and \bar{D} is a binary ZERO, the upper switch on the drawing is closed and the lower switch is open. This state produces an output of $-e_1$. Likewise, if D is a binary ZERO, the output is $-e_2$.

(3) *Track and Hold.* A typical track and hold network is shown in block diagram form in Figure 7. When D is a binary ONE, the network is in track. When D is a binary ZERO, the network is in hold. The binary inputs may be applied from the output of a comparator or from external digital equipment.

c. Circuit Description

(1) *Comparator.* The analog comparator section of the unit is operated by analog input signals that are applied to inputs of an associated dc amplifier. The outputs are digital logic levels at the 1 and 0 terminals of the comparator.

The circuit configuration is schematically illustrated on Drawing D040 488 0S and Figure 8. Assume that two analog voltages (E_1 and E_2) whose sum is positive are applied to the inputs.

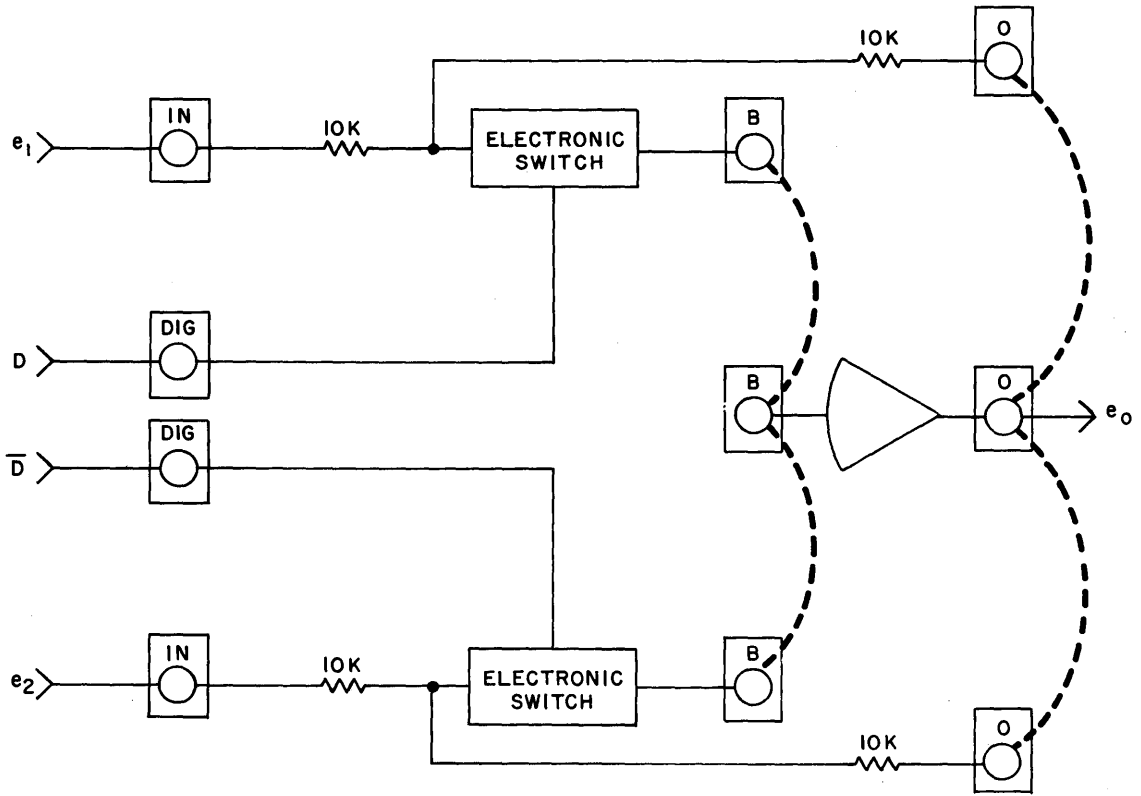


Figure 6. Electronic Selector Switch, Block Diagram

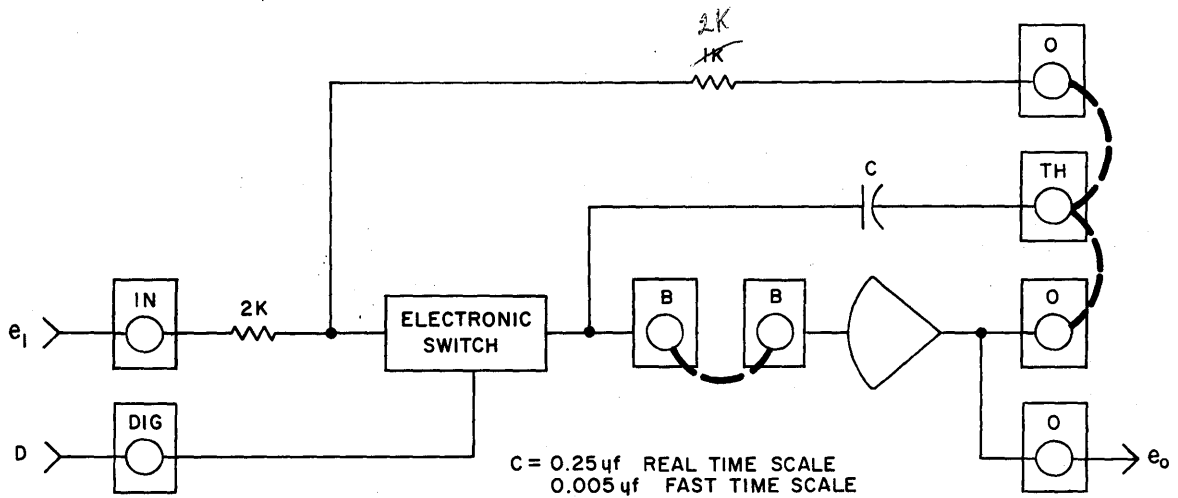


Figure 7. Track-Hold Network, Block Diagram

These signals produce a minus output at the dc amplifier of approximately -0.6 volt. This signal is applied to the emitter of Q1 (PNP) which is forward biased by the -15 volt level through R1 to the base. The negative signal, therefore, appears at the collector of Q1 and is applied to the base of Q3. This signal sets Q3 (NPN) off which in turn sets Q4 (NPN) on. A +5.0 volt level appears at the collector of Q3; zero volt (ground) appears at the collector of Q4. These signals are applied to the 1 and 0 output terminals respectively as a binary ONE and binary ZERO.

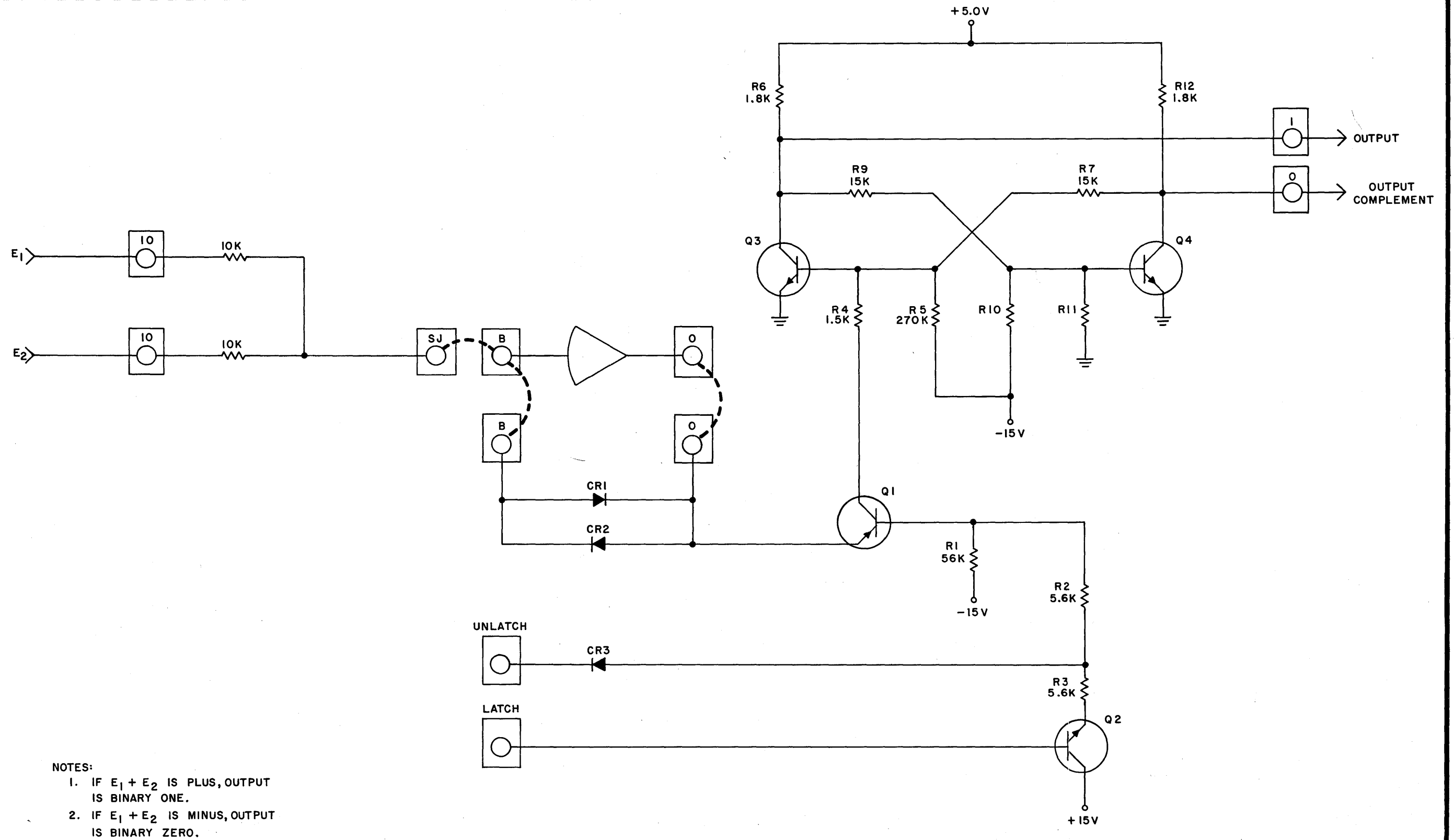
On the other hand, if two analog voltages (E_1 and E_2) whose sum is negative are applied to the inputs, the output of the dc amplifier is approximately +0.6 volt. This signal is applied through Q1 (effective short circuit due to forward bias) to the base of Q3. This signal sets Q3 on which in turn sets Q4 off. Therefore a binary ZERO (ground) appears at the 1 output when the sum of the inputs is negative. Likewise, a binary ONE (+5.0 volts) appears at the 0 output when the sum of the inputs is negative.

The latch circuit permits latching the binary outputs in their existing state. When a binary ONE (+5.0 volts) is applied to the latch input, Q2 (NPN) is forward biased and a positive potential appears at the emitter. This signal is connected to Q1 (PNP) and reverse biases the stage. In this state, signals from the dc amplifier are blocked from the flip-flop Q3, Q4. The outputs remain in their present state due to the bias arrangement of R5, R7, R9, and R11.

If a binary ZERO is applied to the unlatch input, the positive potential from the emitter of Q2 is removed from the base of Q1. Thus, Q1 is forward biased by the -15 volts through R1 and the output of the dc amplifier is coupled to the flip-flop Q3, Q4.

(2) *Electronic Switch.* The electronic switch section of the unit is controlled by digital logic levels that are applied to the input terminal marked DIG on the patch panel and drawings. The input signal to be switched is applied to the input terminal marked IN. The output appears at the output of the associated dc amplifier.

The circuit configuration is schematically illustrated on Drawing D040 488 0S and Figure 9. Assume that a binary ONE (+5.0 volts) is applied to the DIG input control terminal. This signal is blocked by diode CR8 and the Q5-Q6 flip-flop state is determined by the bias arrangement the same as if no input were applied. Transistor Q5 (PNP) is reverse biased by the positive potential from the tap on voltage divider R13, R14, R15. Therefore, a minus potential appears at the collector. The minus voltage from the collector of Q5 reverse biases Q6 (NPN) and a positive voltage appears at the collector. The minus voltage from the collector of Q5 together with the plus voltage from the collector of Q6 are applied to the base of Q8 (NPN) and the base of Q7 (PNP) respectively. These signals reverse bias these transistors.



- NOTES:
1. IF $E_1 + E_2$ IS PLUS, OUTPUT IS BINARY ONE.
 2. IF $E_1 + E_2$ IS MINUS, OUTPUT IS BINARY ZERO.

Figure 8.
Comparator, Simplified Schematic

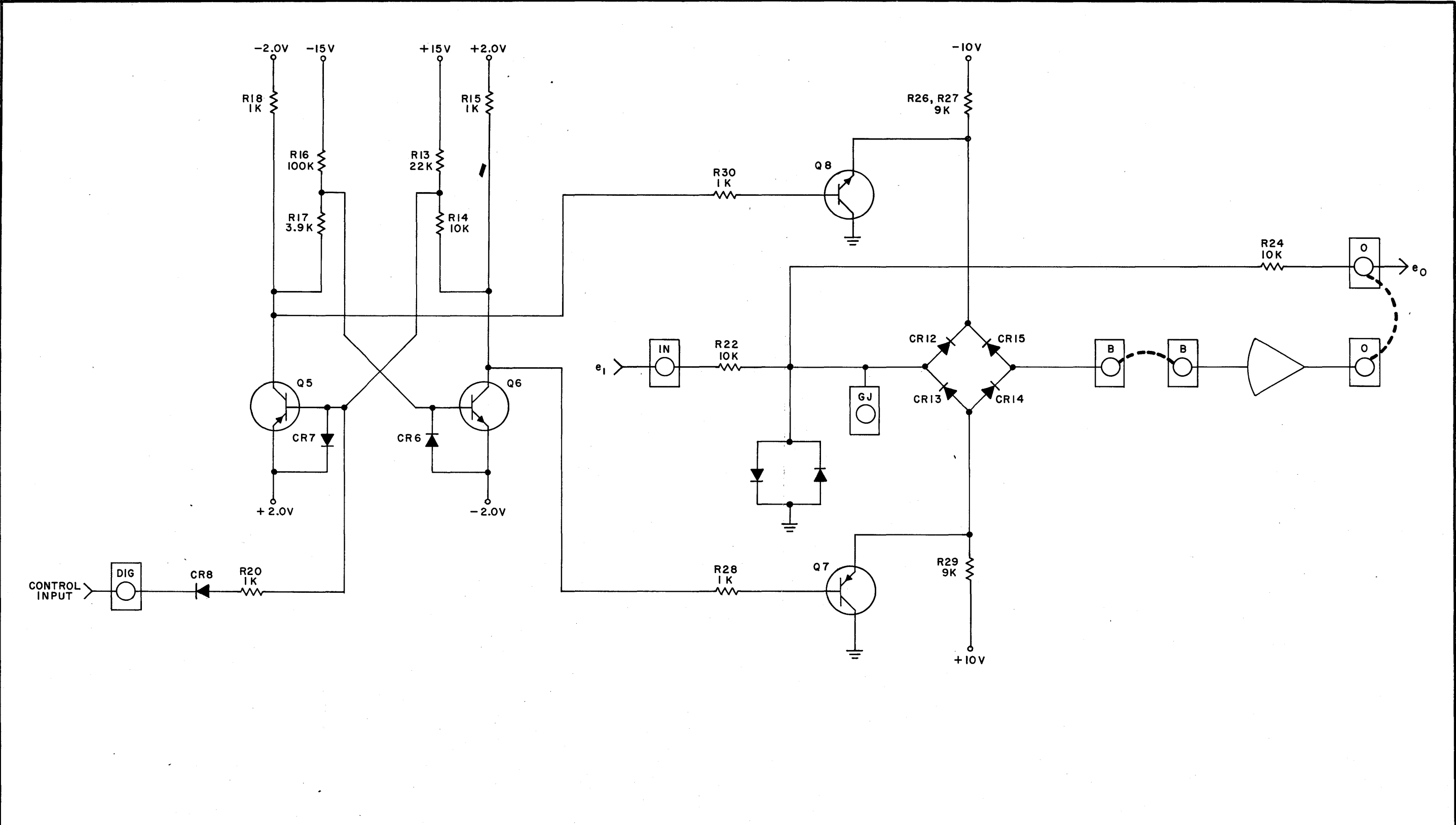


Figure 9.
Electronic Switch, Simplified Schematic

In this state, the diodes (CR12-CR15) in the gate circuit are forward biased and the switch is closed (gate open) permitting an input signal applied to the IN terminal to be applied to the external amplifier which is connected as an inverter.

On the other hand, if a binary ZERO (0.0 volt) is applied to the DIG input control terminal, CR8 is forward biased and R20 and R13 form a voltage divider with the tap connected to the base of Q5. The voltage level at this tap, which biases Q5, is less than the +2.0 volts on the emitter. Therefore, Q5 is forward biased, which in turn reverse biases Q6. The signal from the collectors of Q5 and Q6 forward bias Q7 and Q8. The ground signal from the collectors of Q7 and Q8 reverse bias the diodes in the gate circuit and the switch is open (gate closed).

(3) *Track and Hold.* The track and hold feature is an extension of the electronic switch section of the comparator unit.

The circuit configuration is schematically illustrated on Drawing D040 488 0S. Relay K2 is energized by the bottle plug connection in the TH area. This relay connects 2K input and feedback resistors in the loop instead of the 10K resistors. The input resistor is paralleled with a lead network (C14, R33) to reduce phase shift. The bottle plug connection from TH to 0 provides the connection for the storage capacitor. When the TS bottle plug is installed, the circuit is prepared for repetitive operation. The remainder of the circuit is identical with the electronic switch.

(4) *Power Supplies.* Plus and minus 15 volts operating power is supplied to the unit externally from the computer.

As shown on Drawing D040 488 0S, Zener diodes CR5 and CR18 provide regulated +2.0 and -2.0 volts respectively. De-coupling of the power supplies is provided by L1, L2, R19, C5, R34, C27, and C2.

5. ADJUSTMENTS

The comparator section of the unit does not contain any adjustments. The electronic switch section of the unit contains adjustments for offset. These adjustments are set at the factory for optimum operation. The offset adjustments should be checked periodically and set if necessary. To set these adjustments, proceed as follows:

Before performing an adjustment, let the computer warm up for at least 30 minutes, then balance the dc amplifiers and reference voltage according to the standard procedure.

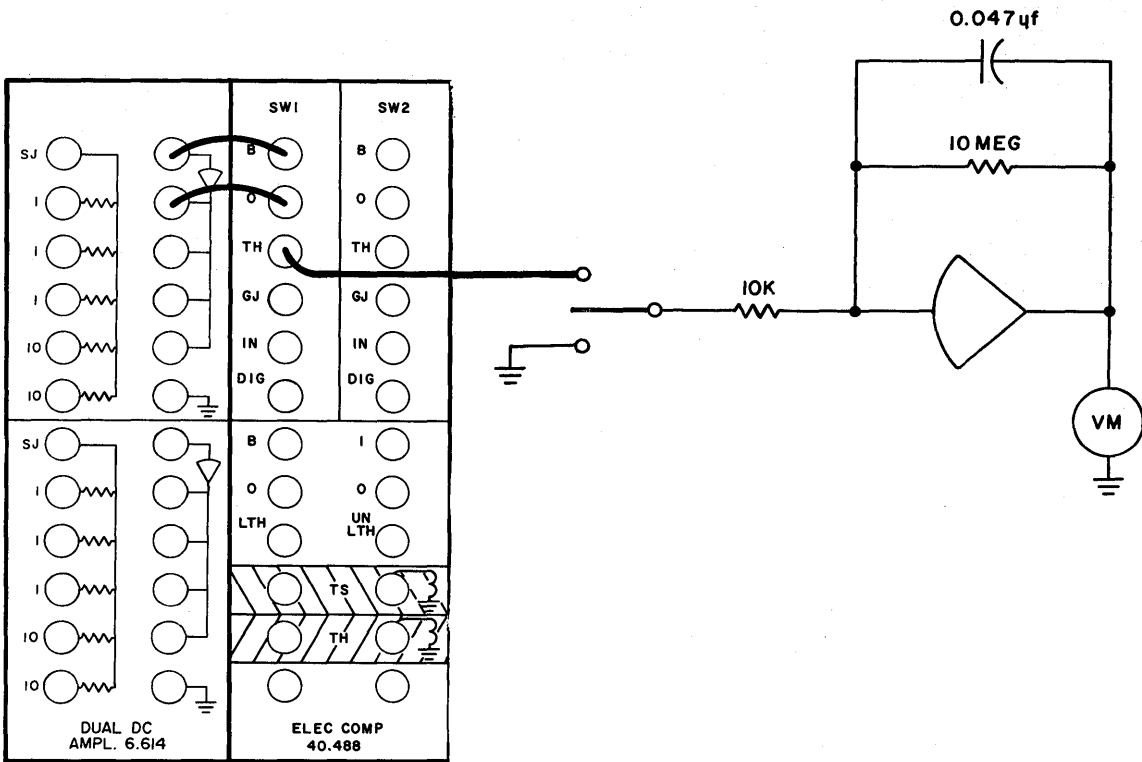


Figure 10. Gate Output Offset, Test Circuit

a. Gate Output Offset

- (1) Connect the circuit shown in Figure 10 with the function switch set to the down position.
- (2) Set the voltmeter to the 1.0 volt range and balance it.
- (3) Set the function switch to the up position and adjust R27-1 for a minimum reading.
- (4) Repeat the procedure for SW2 adjusting R27-2.

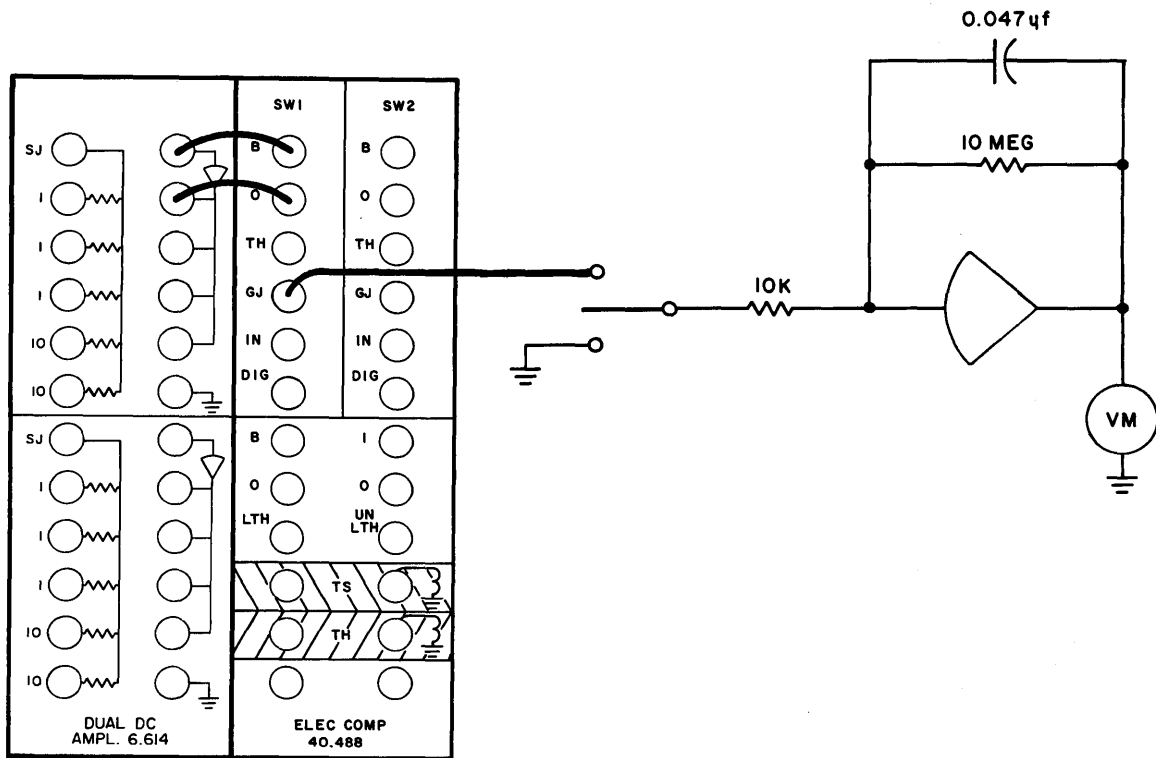


Figure 11. Gate Junction Offset, Test Circuit

b. Gate Function Offset

- (1) Connect the circuit shown in Figure 11 with the function switch set to the down position.
- (2) Set the voltmeter to the 1.0 volt range and balance it.
- (3) Set the function switch to the up position and adjust R31-1 for a minimum reading.
- (4) Repeat the procedure for SW2 and adjust R31-2.

APPENDIX I

REPLACEABLE PARTS LISTS

ELECTRONIC COMPARATOR, MODEL 40.488

This appendix contains a Replaceable Parts List for the equipment described in this manual. In each case, a brief description of the part and a manufacturer's number are listed. Where applicable, a reference symbol (schematic designation) is included. To enable a particular sheet to be readily located, an index precedes the individual spare parts lists.

The category column in the parts list indicates the availability of each listed part so that a replacement part can be obtained as quickly as possible. The components in category A are standard electronic items that are usually available from any commercial electronic supplier. In order to expedite obtaining items of this nature, it is suggested that they be purchased from a local source whenever possible. If necessary these parts may be ordered from EAI.

The components in category B are items that can be obtained from EAI or any of the listed manufacturers. However, in most cases, EAI is in a position to offer the most rapid service on items in this category.

The parts in category C are custom-made components and proprietary items that are available only from EAI. When ordering items of this type, please specify the type number and serial number of the basic unit in which the part is located, as well as the part identification.

Where possible, sufficient information is given for category C items to permit an *electrically-similar* replacement part to be obtained locally. Thus, if desired, a temporary repair may be made while the *exact* replacement is being obtained from EAI. *Note, however, that EAI does not guarantee that the affected unit will operate within specifications when the specified category C part is not used.*

PLEASE NOTE THAT EAI RESERVES THE RIGHT TO MAKE PART SUBSTITUTIONS WHEN REQUIRED. IN ALL CASES EAI GUARANTEES THAT THESE SUBSTITUTIONS ARE ELECTRICALLY AND PHYSICALLY COMPATIBLE WITH THE ORIGINAL COMPONENT.

40.488 ELECTRONIC COMPARATOR

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| 2. 12.959 | RELAY NETWORK CARD | AI-3 |
| 3. 40.493 | ELECTRONIC COMPARATOR CARD | AI-4 |

| ITEM | REF. DESIG. | DESCRIPTION | EAI NO. | *CAT. |
|------|-------------|--|------------|-------|
| 1 | C7 | Capacitor, Fixed, Plastic: .25 UF \pm 5%, 25 VDCW; EAI | B521 291 0 | C |
| 2 | C8 | Capacitor, Fixed, Plastic: .005 UF \pm 5%, 25 VDCW; EAI | B521 292 0 | C |
| 3 | C14 | Capacitor, Fixed, Plastic: .25 UF \pm 10%, 600 VDCW; Cornell-Dubilier DPM52P25 | 521 293 0 | B |
| 4 | C15 | Capacitor, Fixed, Ceramic: 5000 PF \pm 10%, 600 VDCW; Cornell-Dubilier JB6D5 | 515 271 0 | B |
| 5 | C25,26 | Capacitor, Fixed, Ceramic: 220 PF \pm 10%, 600 VDCW; Cornell-Dubilier LA6T22-S3 | 515 020 0 | A |
| 6 | CR16,17 | Diode, Germanium: Clevite CTP462 | | |
| 7 | K1 | Relay, Coil: 20 VDC, 520 ohms, 4 Form C Contacts; Allied Control T-154-4C-520 | 618 171 0 | B |
| 8 | K2 | Relay, Coil: 20 VDC, 520 ohms, 2 Form C Contacts; Allied Control T-154-2C-520 | 618 173 0 | B |
| 9 | R22,24 | Resistor, Fixed, Wirewound, Precision (Matched Pair): per EAI Specifications; 10,000 ohms \pm .1%; Julie Research Labs | B640 077 0 | C |
| 10 | R23,25 | Resistor, Fixed, Wirewound, Precision (Matched Pair): per EAI Specifications; 2000 ohms \pm 1%; Julie Research Labs | B640 078 0 | C |
| 11 | R33 | Resistor, Fixed, Composition: 3.9K ohms \pm 10%, 1/4W; Allen-Bradley CB | 625 392 1 | A |

| | |
|--|--|
| <p>*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS. A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY. B - INDICATES PARTS THAT CAN BE PURCHASED LOCALLY OR FROM EAI. C - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI. THE PROPER EAI PART SHOULD BE INSTALLED FOR CATEGORY C ITEMS. A COMPLETE DESCRIPTION IS GIVEN TO PROVIDE FOR TEMPORARY REPAIRS; HOWEVER, EAI WILL NOT BE RESPONSIBLE IF UNIT IS NOT WITHIN SPECIFICATIONS UNDER THESE CONDITIONS.</p> | <p>UNIT TITLE</p> <p>RELAY NETWORK CARD</p> |
| | <p>MODEL NO.</p> <p>12.959 Sh. 1 of 1 Sh.</p> |

DATE 11 / 18 / 63

| ITEM | REF. DESIG. | DESCRIPTION | EAI NO. | *CAT. |
|------|----------------|--|------------|-------|
| 1 | C2,5,27 | Capacitor, Fixed, Electrolytic: 100 UF, 25 VDCW; P.R. Mallory PET Type | A516 191 0 | B |
| 2 | C3,20 | Capacitor, Fixed, Ceramic: 27 PF $\pm 10\%$, 1000 VDCW; Cornell-Dubilier L10Q27 | 515 016 0 | A |
| 3 | C4 | Capacitor, Fixed, Ceramic: 68 PF $\pm 10\%$, 1000 VDCW; Cornell-Dubilier L10Q68 | 515 018 0 | A |
| 4 | C6,28 | Capacitor, Fixed, Ceramic: 100 PF $\pm 10\%$, 1000 VDCW; Cornell-Dubilier L10T1 | 515 019 0 | A |
| 5 | C11 | Capacitor, Fixed, Ceramic: 470 PF $\pm 10\%$, 500 VDCW; Aerovox IDI | 515 272 0 | A |
| 6 | CR1,2 | Diode, Silicon: Hughes Semiconductors 1N459 | B614 007 0 | B |
| 7 | CR3,6,7,8,9,10 | Diode, Silicon: General Instrument DR837 | A614 043 0 | B |
| 8 | CR4 | Diode, Silicon: Zener, 10V $\pm 1\%$, 1/2W; Dickson Electronics Corp. 1/4-Z10D5 | 614 179 0 | B |
| 9 | CR5,18 | Diode, Silicon: Zener, 13V $\pm 2\%$, 3/4W; Dickson Electronics Corp. 3/4Z13D2 | 614 178 0 | B |
| 10 | CR12,15 | Diode, Silicon: Matched Quad; General Electric 4JF4-MQ2 | 614 203 0 | B |
| 11 | L1,2 | Coil: 240 UH, $\pm 5\%$; J.W. Miller Co. 9210-94 | 538 017 0 | B |
| 12 | Q1,5 | Transistor, Germanium: PNP; Texas Instruments 2N964 | 686 103 0 | B |
| 13 | Q2 | Transistor, Silicon: NPN; General Electric 2N2714 | 686 170 0 | B |
| 14 | Q3,4 | Transistor, Germanium: NPN; Texas Instruments 2N1304 | 686 074 0 | B |
| 15 | Q6 | Transistor, Germanium: NPN; Texas Instruments 2N797 | 686 120 0 | B |
| 16 | Q7 | Transistor, Silicon: PNP; Philco 2N2276 | 686 144 0 | B |
| 17 | Q8 | Transistor, Silicon: NPN; Motorola SM1136 | C686 107 0 | C |
| 18 | R1 | Resistor, Fixed, Composition: 56K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 563 1 | A |

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
A - INDICATES PARTS THAT SHOULD BE PURCHASED LOCALLY.
B - INDICATES PARTS THAT CAN BE PURCHASED LOCALLY OR FROM EAI.
C - INDICATES PARTS THAT SHOULD BE PURCHASED FROM EAI.
THE PROPER EAI PART SHOULD BE INSTALLED FOR CATEGORY C ITEMS. A COMPLETE DESCRIPTION IS GIVEN TO PROVIDE FOR TEMPORARY REPAIRS; HOWEVER, EAI WILL NOT BE RESPONSIBLE IF UNIT IS NOT WITHIN SPECIFICATIONS UNDER THESE CONDITIONS.

UNIT TITLE

ELECTRONIC COMPARATOR CARD

MODEL NO.

40.493

Sh.1 of 2 Sh.

DATE 12 / 10 / 63

| ITEM | REF. DESIG. | DESCRIPTION | EAI NO. | *CAT. |
|------|------------------------|---|------------|-------|
| 19 | R2,3 | Resistor, Fixed, Composition: 5.6K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 562 1 | A |
| 20 | R4 | Resistor, Fixed, Composition: 1.5K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 152 1 | A |
| 21 | R5,10 | Resistor, Fixed, Composition: 270K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 274 1 | A |
| 22 | R6,12 | Resistor, Fixed, Composition: 1.8K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 182 1 | A |
| 23 | R7,9 | Resistor, Fixed, Composition: 15K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 153 1 | A |
| 24 | R11 | Resistor, Fixed, Composition: 2.2K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 222 1 | A |
| 25 | R13 | Resistor, Fixed, Composition: 22K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 223 1 | A |
| 26 | R14 | Resistor, Fixed, Composition: 10K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 103 1 | A |
| 27 | R15,18,19, 20,28,30 | Resistor, Fixed, Composition: 1K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 102 1 | A |
| 28 | R16,35 | Resistor, Fixed, Composition: 100K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 104 1 | A |
| 29 | R17 | Resistor, Fixed, Composition: 3.9K ohms $\pm 10\%$, 1/4W; Allen-Bradley CB | 625 392 1 | A |
| 30 | R26 | Resistor, Fixed, Wirewound, Precision: 8980 ohms $\pm 0.05\%$; Resistance Products Co. PB Type | B638 906 0 | C |
| 31 | R27 | Resistor, Variable, Wirewound: 50 ohms $\pm 5\%$, 1W; Daystrom-Pacific 25500 | 642 591 0 | B |
| 32 | R29 | Resistor, Fixed, Wirewound, Precision: 9000 ohms 0.05% ; Resistance Products Co. PB Type | B638 907 0 | C |
| 33 | R31 | Resistor, Variable, Wirewound: 20 ohms $\pm 5\%$, 1W; Daystrom-Pacific 25500 | 642 592 0 | B |

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
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DATE 12/ 10 / 63

UNIT TITLE

ELECTRONIC COMPARATOR CARD

MODEL NO.

40.493

Sh. 2 of 2 Sh.

APPENDIX II

DRAWINGS

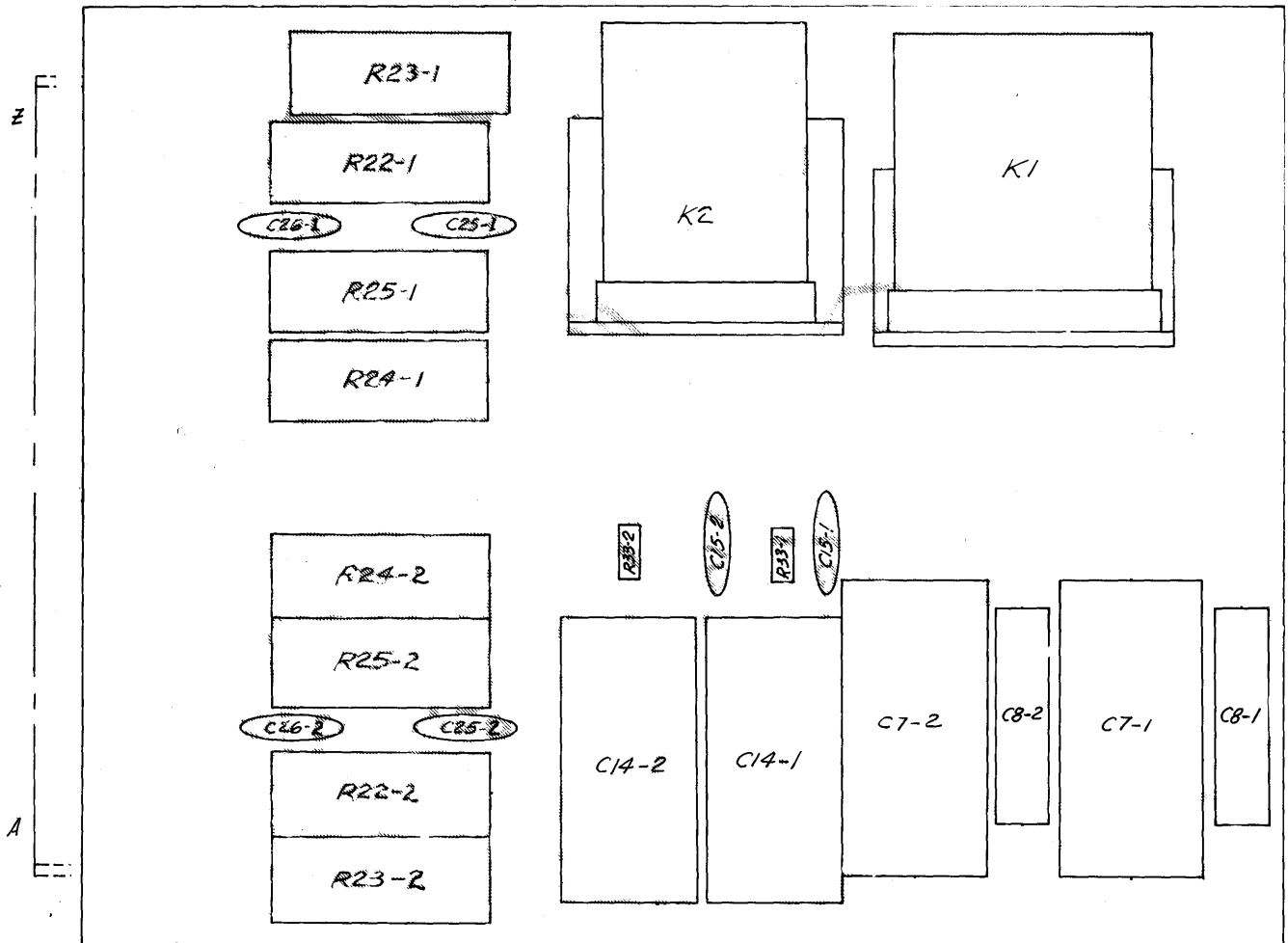
ELECTRONIC COMPARATOR, MODEL 40.488

This appendix contains necessary schematics and wiring diagrams of equipment described in this manual. To facilitate locating a particular sheet, an index is provided that lists the model number of each unit or component, the type of drawings, and the associated drawing number. The drawings are bound into the manual in the order listed under the index Drawing Number column.

EAI drawings are prepared in accordance with standard drafting practices for electro-mechanical and electronic equipment. All symbols are in accordance with current government standards.

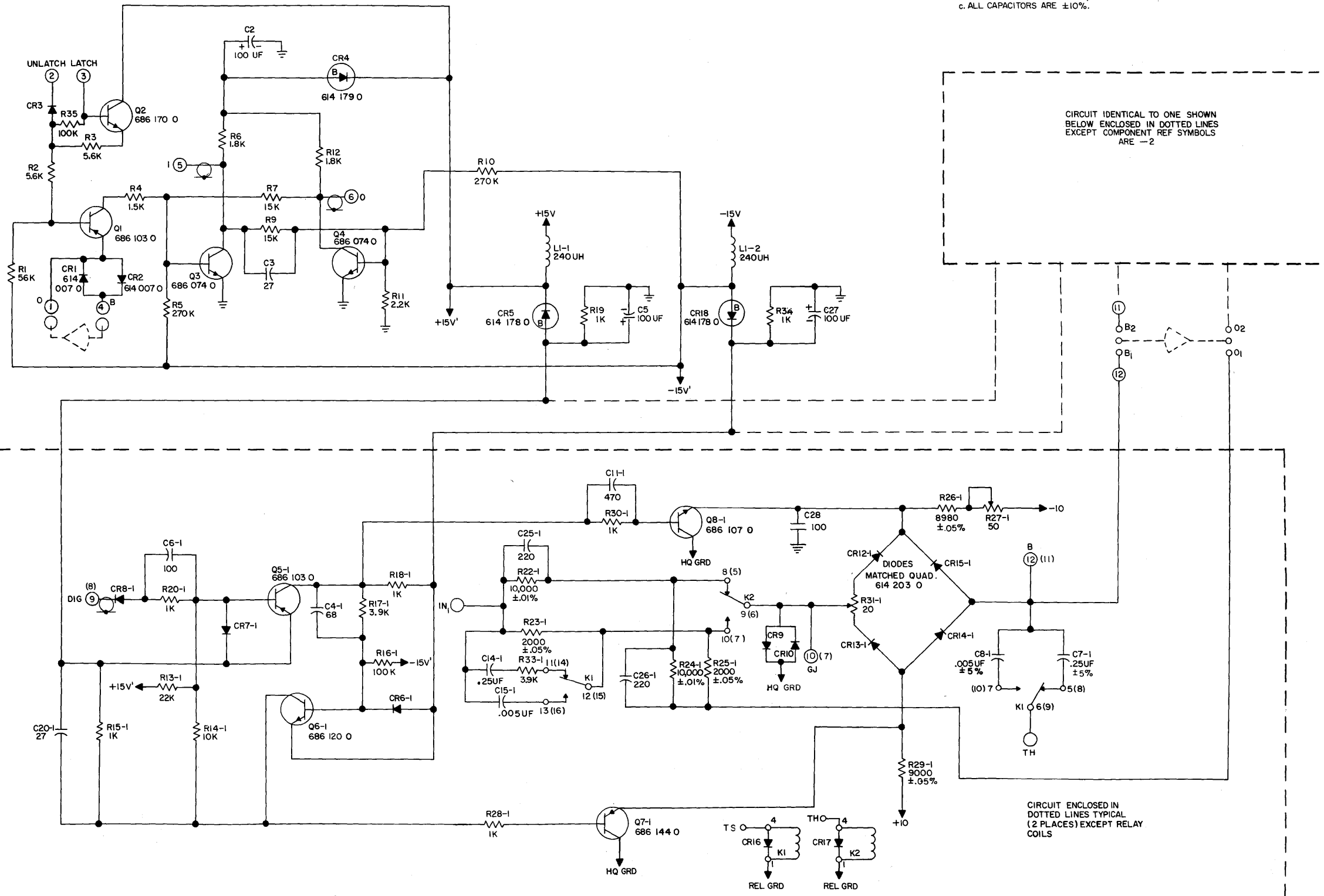
INDEX

| <u>Unit or Component</u> | <u>Type of Drawing</u> | <u>Drawing Number</u> |
|------------------------------|------------------------|----------------------------|
| 40.488 Electronic Comparator | Schematic Wiring | D040 488 0S C040 488 0W |



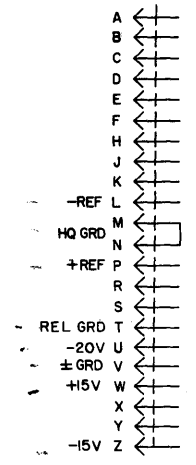
12.959 Relay Network, Component Location Diagram

NOTES:
 1. UNLESS OTHERWISE SPECIFIED:
 a. ALL DIODES ARE 642 043 O.
 b. ALL RESISTORS ARE $\pm 10\%$, 1/4 W.
 c. ALL CAPACITORS ARE $\pm 10\%$.



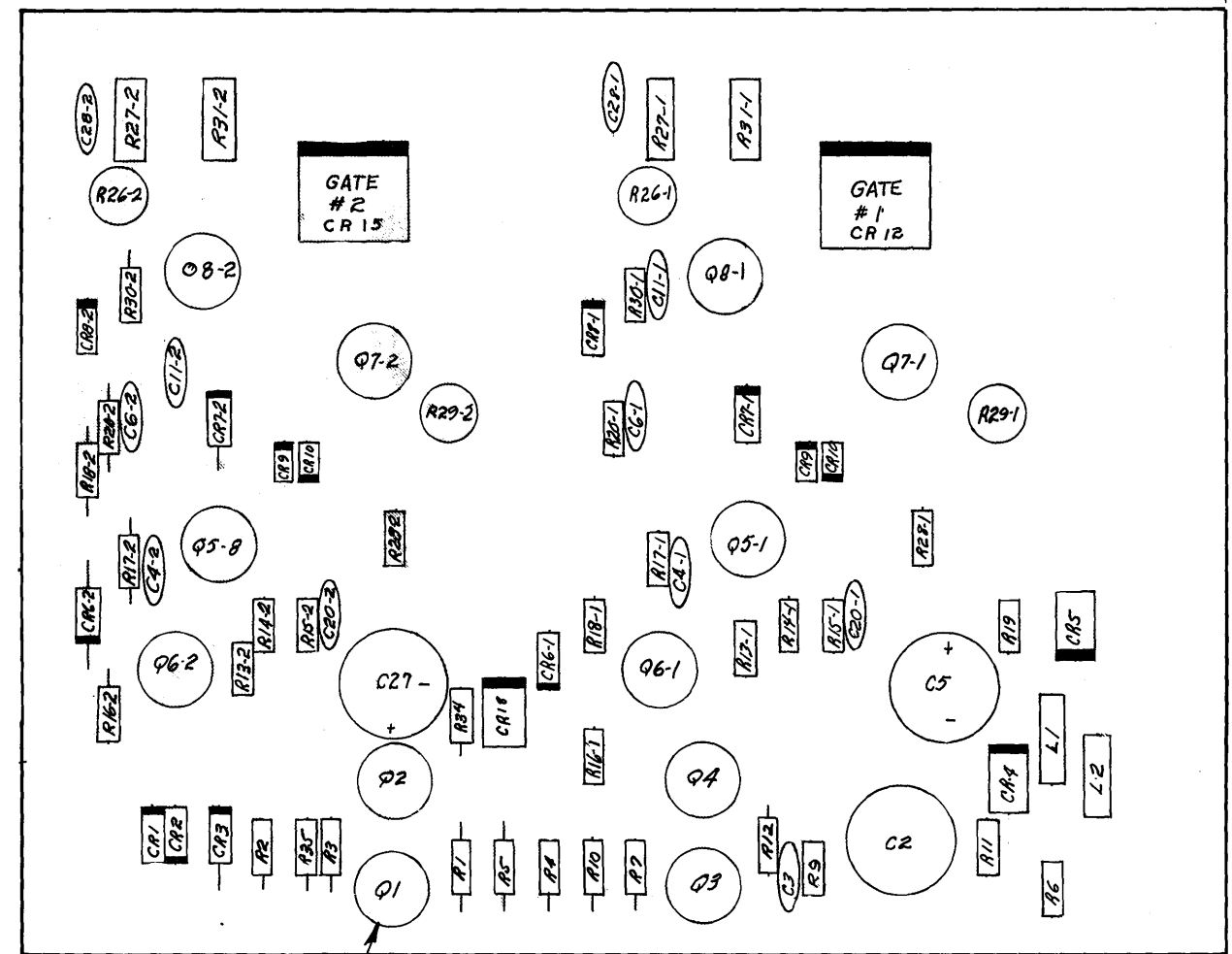
CIRCUIT IDENTICAL TO ONE SHOWN BELOW ENCLOSED IN DOTTED LINES EXCEPT COMPONENT REF SYMBOLS ARE -2

CIRCUIT ENCLOSED IN DOTTED LINES TYPICAL (2 PLACES) EXCEPT RELAY COILS

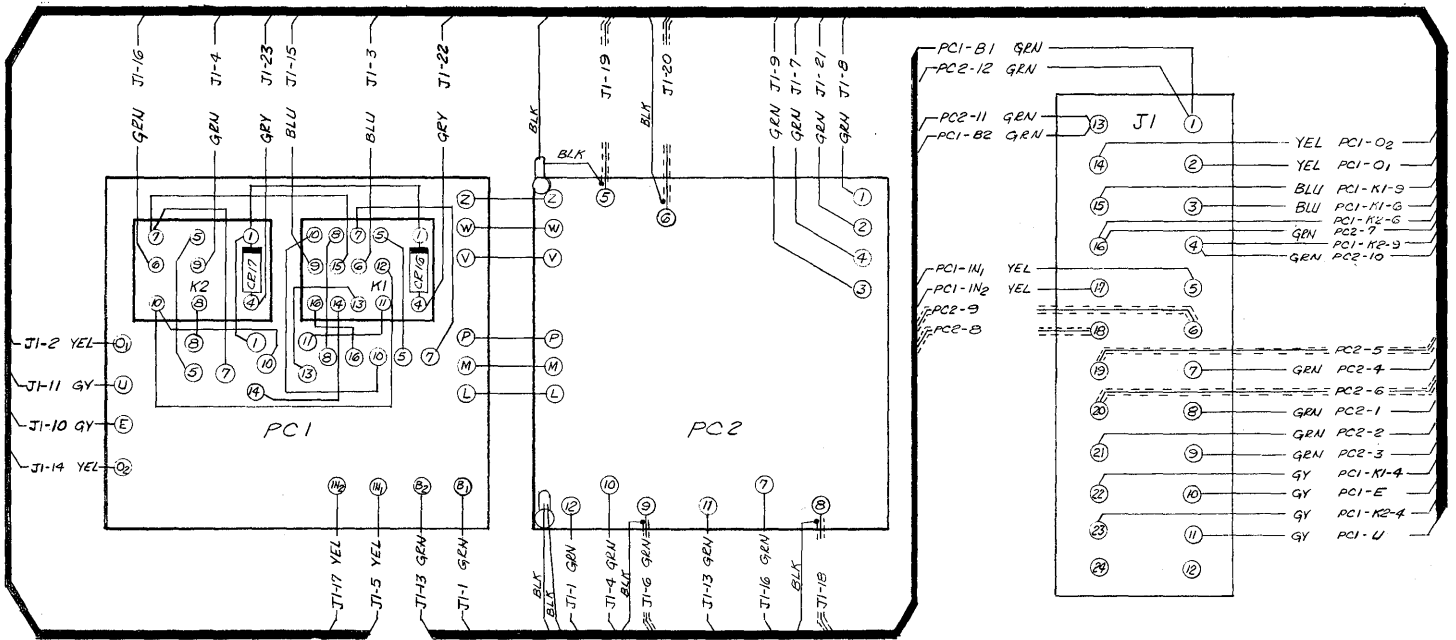


UNLESS OTHERWISE SPECIFIED
 DIMENSIONS ARE IN INCHES
 CAPACITANCE IS IN PF
 RESISTANCE IS IN OHMS
 TOLERANCE ON FRACTIONS DECIMALS ANGLES
 $\pm 1/16$ $\pm .008$ \pm
 *TOL. OF MATERIAL SUPPLIED

| | |
|--|--------------|
| ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY | |
| ELECTRONIC COMPARATOR | |
| SHT. NO. | |
| SIZE | |
| REV. NO. | |
| PROJECT 19008 | DO40 488 O'S |
| SHEET / OF / SHEETS | |



40.493 Electronic Comparator Card, Component Location Diagram



| | |
|--|-------------|
| ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY | |
| WIRING ELECT. COMPARETOR | |
| SHT. NO. | |
| SIZE | |
| REV. NO. | |
| PROJECT | C040 488 OW |
| SHEET / OF / SHEETS | |

APPENDIX III

SERVICING TECHNIQUES

1. INTRODUCTION

Although servicing and troubleshooting procedures applicable to transistor circuits are similar in many ways to the techniques used with vacuum tube circuits, certain differences exist, and several extra precautions are necessary when servicing transistor circuits. The following suggestions and techniques are given to aid maintenance personnel who are not familiar with servicing transistorized equipment.

2. ETCHED-CIRCUIT BOARD SOLDERING

The techniques and precautions employed while soldering any electronic equipment still apply, but there are several additional factors to be considered when working with etched-circuit boards.

a. Wire leads or components fastened to the board by their leads may be replaced using the following procedures:

(1) Grip the lead to be removed with a pair of long-nose pliers, (in cases where this is impossible due to extremely short or hidden leads, the component itself must be carefully grasped). While applying pressure to the lead, touch a well-tinned, small (40 watt or less), soldering iron to the fillet. If the lead does not slip out immediately, remove the soldering iron and recheck to be sure the correct fillet is being heated.

(2) Clear the excess solder from the hole by touching the iron to it briefly and either blowing the excess solder out or carefully pushing it out with a soldering aid (GC Electronics No. 9093 or equivalent).

(3) Bend the leads on the new component or jumper to fit the board connections. Insert the component, but *do not* cut the leads.

(4) With the component or jumper held in place, touch the soldering iron to the lead and allow solder to run down the lead and form a fillet. Heat should be applied to the lead only until the fillet has formed. It is not necessary to fill the hole with solder, and some components such as transistors and diodes may be damaged by prolonged application of the soldering iron.

(5) After both leads have been soldered, use a pair of diagonal cutters to cut the lead off as close to the board as possible. Use the soldering aid to carefully scrape any excess flux or solder off the board.

b. Replacing components such as transistors, relay and chopper sockets, potentiometers, or networks with multiple connections is accomplished in essentially the same manner. Removal of these components is much easier if special tips such as the Ungar Electric Tools No. 856 (5/8" dia. cup) and No. 858 (bar) are used. These tips are used for component *removal* only, and permit all leads to be freed simultaneously.

If the above procedures are strictly adhered to, no trouble with the etched conductor itself should be encountered. If, however, a conductor becomes cracked or broken it may be repaired by carefully soldering a tinned piece of bus wire over it. Again extreme care should be taken not to overheat the strip and cause it to separate from the board.

3. TRANSISTOR SERVICING

Most transistors are mechanically rugged, but they are easily damaged by excessive heat. If it becomes necessary to solder near a socket-mounted transistor, the transistor should be removed to prevent damaging it. When the transistor is soldered to the board, extreme care should be taken to prevent damage to it from overheating. Always use a small, well-tinned soldering iron and work as quickly as possible.

Transistors and small diodes which are soldered directly to the board should be removed only when there is strong reason to believe they are defective, as they are often over-heated while being removed. When soldering transistors or diodes a heat sink should be used, whenever practicable, on each lead as it is soldered. Two common methods of protecting these semi-conductors from overheating while soldering are holding the lead with a pair of long-nose pliers, or clipping an alligator clip, the jaws of which have been filled with solder, on the lead.

Power transistors, which are usually used in power amplifiers and power supplies, are mounted on metal chassis plates which function as heat sinks to dissipate the heat generated during normal operation. The metal case of a power transistor is usually the collector and operates at relatively high potentials. For this reason power transistors must be mounted so that they are electrically insulated from the heat sink. At the same time, heat from the transistor must be transferred easily to the heat sink. A common method of accomplishing this is by using a mica, anodized aluminum, or fiberglass washer coated with silicone grease. The washer provides electrical insulation, and the silicone grease increases the heat conduction. When replacing a power transistor, use only a single washer, and coat both sides with silicone grease (Dow Corning

No. 4 Compound or equivalent). As a final precaution before applying power to the unit, check the resistance between the body of the transistor and the heat sink to ensure that no short or high resistance leakage path exists between these points.

Diodes, electrolytic capacitors, and the transistors themselves used in transistor circuits are easily damaged by voltage overload. For this reason transistors should never be removed or inserted with power applied, and special care must be taken in the selection and use of test equipment. Signal generators commonly used in servicing vacuum tube circuits are often capable of producing enough output to overload and permanently damage the diodes, electrolytic capacitors, and transistors used in transistor circuits. Always start with the minimum output signal and slowly increase it to the desired level.

The meter used for continuity and resistance checks must be carefully chosen. Some ohmmeters use batteries with a higher voltage rating than the transistors and capacitors being checked, and will destroy them. For this reason a meter with a 1-1/2 volt battery (Triplet Model 630A or equivalent) is recommended. In order to prevent damage to the small electrolytic capacitors used in these circuits it is essential to determine the polarity of the ohmmeter leads. This may be done easily by using another meter set to a low dc scale.

4. TRANSISTOR TROUBLESHOOTING

As with any other type of electronic circuit, the first step in troubleshooting transistor circuits is a visual inspection for charred, discolored, or leaky components; broken, shorted, or loose connections; heavily tarnished or broken connectors; and physical damage to the board itself. The next step is to replace any relays, relays, or choppers, which are socket mounted on the board, with units known to be good. This is done not only because it is fairly easy, but also because each contains mechanical moving parts which may fail due to normal wear. If the trouble is not located by either of these steps, the board may be dynamically tested by applying all supply voltages and a signal input and then checking voltages and signals on the board until the trouble is isolated. If dynamic testing is impossible due to the lack of suitable test equipment, or availability of "down time" on the equipment in which it is used, the trouble can usually be located through resistance and continuity checks.

Refer to the schematic when making resistance checks to be sure that meter polarity is correct for any electrolytic capacitors in the circuit and that parallel dc paths are not affecting the readings. When the board is removed many components are naturally isolated by the plug or pin connections. Others are effectively isolated by capacitors in series with them. When it becomes necessary to unsolder and lift one end of a component from the board to isolate it for resistance checks, resistors should be chosen whenever possible as they are the component

least likely to be damaged by the heat. In many cases, by carefully selecting the correct lead to disconnect, several components may be isolated at one time. It is not usually necessary to risk overheating a transistor by unsoldering it to make resistance checks. For example, lifting one end of the collector load resistor and one end of the emitter resistor would effectively isolate the transistor in a normal transistor amplifier stage.

Once a transistor is isolated, it may be checked using the following procedures:

a. Set the ohmmeter to a high range and connect it between the base and the collector leads; reverse the leads and note which connection caused the higher reading. This is the reverse-bias direction.

b. Connect the ohmmeter to reverse-bias the transistor and note the reading. Short the base to the emitter. The reading should decrease. Remove the short.

c. Move the lead on the base to the emitter and note the reading. Re-connect the short. The reading should increase.

This test will indicate a burnt-out transistor but not a weak or high-leakage transistor. If the transistor is still suspected, and no other troubles are found, substitute one known to be good.