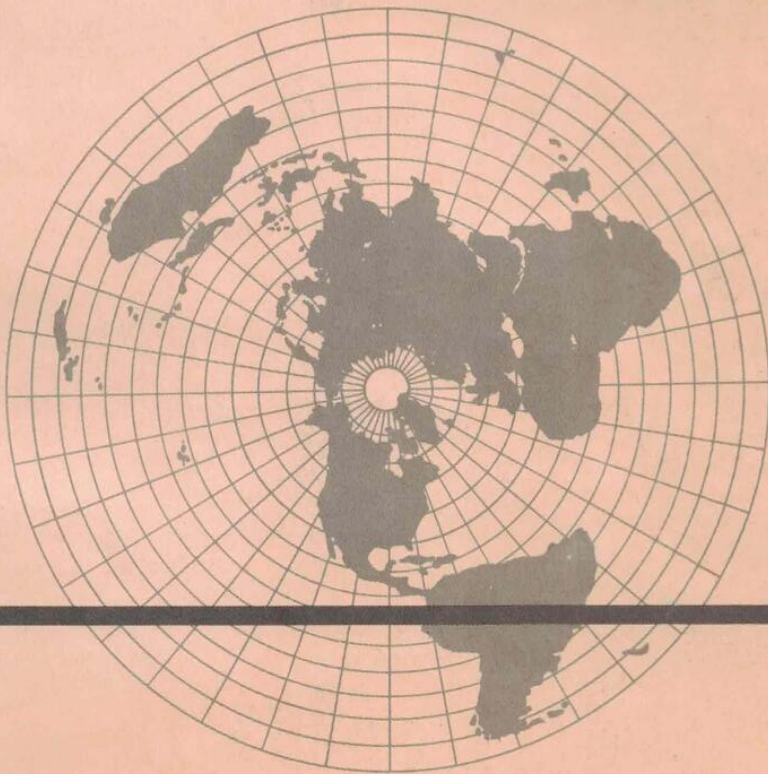


W REC

**DUAL DC AMPLIFIER
MODEL 6.282**



EAI

EAI

ELECTRONIC ASSOCIATES, INC. ■ LONG BRANCH, NEW JERSEY

**DUAL DC AMPLIFIER
MODEL 6.282**

REVISED 8/17/62

PRINTED IN U.S.A.

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In order to enable us to process your requests for spare parts and replacement items quickly and efficiently, we request your conformance with the following procedure:

1. Please specify the type number and serial number of the basic unit as well as the identification of the part when inquiring about replacement items as potentiometer assemblies or cups, relays, transformers, precision resistors, etc.
2. When inquiring about items as servo multipliers, resolvers, networks, cables, potentiometer expansions, etc., please specify the serial numbers of the major equipment with which the units are to be used, such as: Console Type 16-31R, serial #000, or Amplifier Group Type 16-31C, serial #000, etc. If at all possible, please include the purchase order or the EAI project number under which the equipment was originally procured.

Your cooperation in supplying the required information will facilitate the processing of your requests and aid in assuring that the correct items are supplied.

It is the policy of Electronic Associates, Inc. to supply equipment patterned as closely as possible to the individual requirements of the individual customer. This is accomplished, without incurring the prohibitive costs of custom design, by substituting new components, modifying old components, etc., wherever necessary to expedite conformance with requirements. As a result, this instruction manual, which has basically been written to cover standard equipment, may not entirely concur in its content with the equipment supplied. It is felt, however, that a technically qualified person will find the manual a fully adequate guide in understanding, operating, and maintaining the equipment actually supplied.

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NOTICE

Page AI-2 Item 7. Change description of C7 and C16 as follows:

Capacitor, Fixed, Electrolytic:
4.7 MFD $\pm 20\%$, 35V; Cornell Dublier
TYL3BF4R7M (EAI A516 266 0).

Item 15. Change description of Q4 and Q12 as follows:

Transistor, Germanium: PNP; General Electric
2N1925 (EAI 686 091 0).

Page AI-3 Item 19. Change description of R1, R27 as follows:

Resistor, Fixed, Composition: 1.3 Megohms
 $\pm 10\%$, 1/2W; Allen-Bradley EB

Drawing: D006 282 OS. Change EAI number of Q4 and Q12 to EAI 686 091 0
Change value of R1 and R27 to 1.3 Megohms
Change value of C7 and C16 to 4.7 MFD

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DUAL D-C AMPLIFIER 6.282

1. GENERAL.

The Dual D-C Amplifier consists of two independent amplifiers mounted in a single container. These amplifiers are transistorized and chopper-stabilized for low drift and high accuracy. The front panel of the container provides four input terminations (labeled S for summing junction) and four output terminations (labeled O) for each amplifier. (See figure 1.)

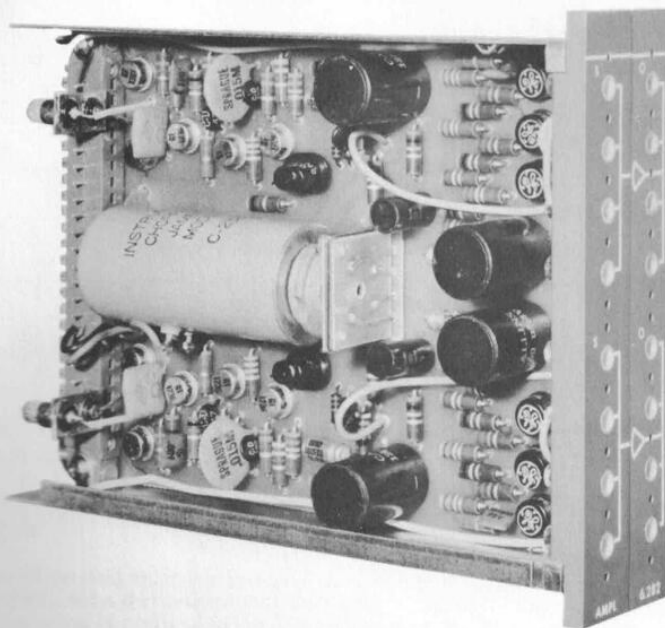


Figure 1. Dual D-C Amplifier 6.282

2. TECHNICAL DATA.

The following data was obtained with the amplifier connected in a standard inverter configuration (10K input and feedback resistors) after the amplifiers were balanced in accordance with the recommended procedures:

Supply voltage	Value of supply current for three inputs with 500-ohm load (output to ground)*		
	0V	+10V	-10V
-15V	20.2 ma	20.4 ma	40.1 ma
+15V	3.0 ma	27.0 ma	0.4 ma
+30V	4.4 ma	4.4 ma	4.4 ma
6.3V ac	53.0 ma	53.0 ma	53.0 ma

2. TECHNICAL DATA. (cont)

Output voltage range

0 to $\pm 10V$ minimum

Power output (minor derating may be required at high ambient temperatures)

See figure 2.

Cutoff frequency** (3db down)

350kc typical

200kc minimum

Phase shift** (at 1kc)

.05° typical

.1° maximum

Dynamic amplitude error** (at 1kc 10V p-p)

.06% typical

.1% maximum

Undistorted output frequency** (maximum for 0.1% total error; 10V p-p)

2kc typical

1kc minimum

Noise and ripple (p-p total from dc to .5 mc)

200 micro volt typical

400 micro volt maximum

Offset voltage

5 micro volt typical

20 micro volt maximum

*Current given for d-c voltages are for a single channel; current given for a-c voltage is for both channels. All currents have a $\pm 10\%$ tolerance.

**Does not include gain error due to input and feedback resistor variations.

3. PATCHING.

The input and output terminations are arranged so that each unit may be used for a variety of functions, depending on the patching arrangement. Thus each d-c amplifier may be used as a high gain amplifier, a summer, an integrator, or an inverter.

The d-c amplifiers are rated for a maximum output of 10 volts. This means that any patching arrangement (regardless of application) should be such that the amplifier output does not rise above this level. (The amplifier is capable of a larger output to allow for minor programming discrepancies.)

To patch an amplifier as a unity-gain inverter, connect a 10K feedback resistor between any S and O termination, and a 10K input resistor to an adjacent S termination.

For a tenth-gain (0.1) inverter, use a 100K input resistor in place of the 10K resistor. A gain-of-ten inverter is provided by connecting a 100K resistor between any S and O termination and connecting a 10K input resistor to an adjacent S termination.

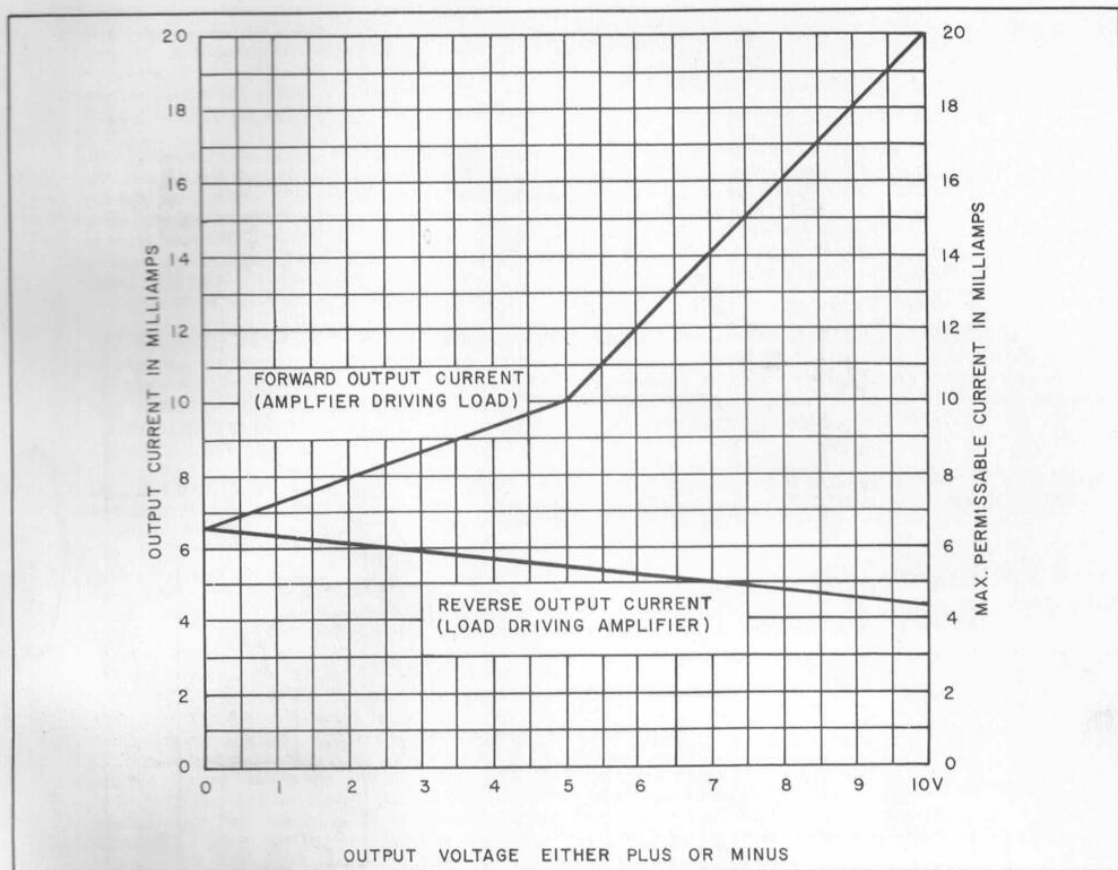


Figure 2. Power Output Curve

4. CIRCUIT DESCRIPTION.

The circuit configuration of the dual amplifier is shown on drawing D006 282 0S. Each amplifier consists of a six-transistor d-c amplifier, and a three-transistor stabilizing amplifier. Since all of the dual amplifiers are identical, the circuit description is confined to the section shown on the upper half of the schematic. Figure 3 is a simplified schematic to be used with the following text.

Input signals are applied to the S terminal. A-c components of these signals are applied to the base of transistor Q17 through resistor R10 (4.7K) and capacitors C1 and C21 (10 mfd and 12 mmf, respectively). They are also coupled to the stabilizer input through R14 (10K). The two reverse-connected diodes (CR1 and CR2) are connected from input to ground so that capacitor C1 cannot be charged to a high value during momentary overload conditions. This allows the amplifier to recover quickly should an overload occur.

Transistors Q17 and Q1 comprise the amplifier input stage. Q1 is connected in a common-emitter configuration with R53, providing self-bias. Q17 (NPN) is connected in a common-collector configuration and it is unique in that it uses the voltage-drop (0.3 volts) across the base-emitter diode of Q1 as its operating voltage. The base-emitter resistance of Q1 serves as the load of Q17 and with this configuration the input impedance to the amplifier becomes quite high (approximately 10K).

The base circuit of Q17 is completed through R55, R1, terminal R and the external balance potentiometer. These components form a voltage divider between -15 volts and +30 volts. Adjusting the balance potentiometer actually sets the optimum operating point for Q17. In practice, the balance potentiometer is adjusted for zero output from the stabilizer; a feedback resistor must be patched into the amplifier before the balancing procedure can be accomplished.

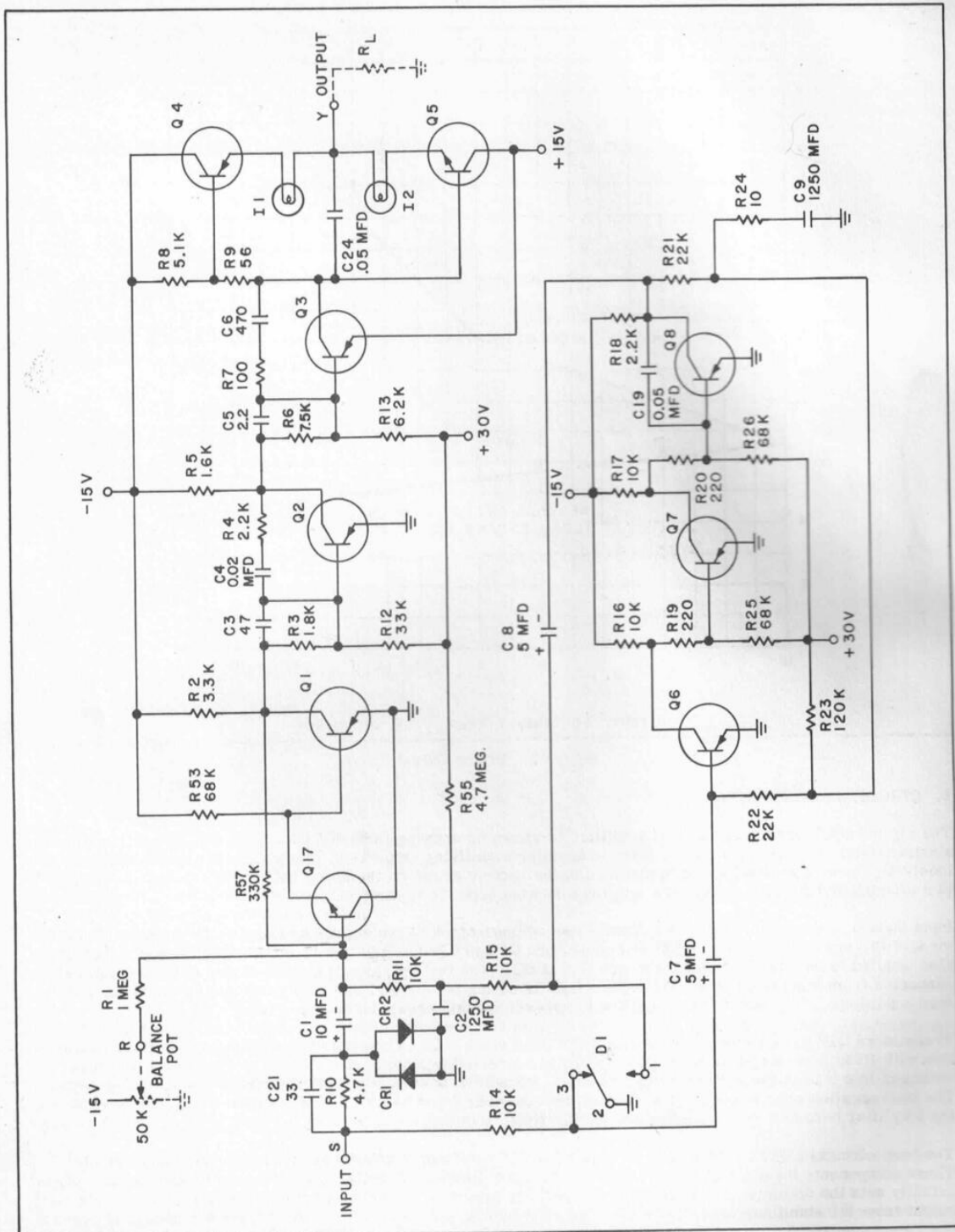


Figure 3. D-C Amplifier, Simplified Schematic

The output at the collector of Q1 is directly coupled to the base of Q2 which is also connected in the common-emitter configuration. Bias is supplied from the voltage divider R3, R12 which is connected between the collector of Q1 and the +30 volt supply. The high-frequency rolloff of the Q2 stage is controlled by the series combination of R4 and C4 which provides an increasing amount of negative feedback at higher frequencies. Capacitors C3, C5 and C24 provide correct phasing of higher input frequencies.

Q3 functions as the driver for the output amplifier. The circuit arrangement of this stage is similar to that of Q2, except that the emitter is returned to +15 volts, instead of ground, to establish the correct operating point for Q3, Q4 and Q5. The output stage of the d-c amplifier consists of Q4 and Q5, each connected in a common-collector (emitter-follower) arrangement. Q4 is a PNP-type transistor and Q5 an NPN-type with similar characteristics. The circuit employs the advantages of the complementary symmetry of the two types to provide push-pull operation with single-ended input. A phase-inverter is not required to drive a stage of this kind. The NPN transistor (Q5) conducts when the output of Q3 goes positive, and the PNP transistor (Q4) conducts when the output of Q3 goes negative.

With no signal, the forward bias across resistor R9 causes a small current flow from the negative supply through Q4, I1, I2, and Q5 to the positive supply. Because the transistors are similar, the voltage drop is the same across each one and the circuit is similar to a balanced bridge; no current flows through the load. Any input to the amplifier causes one of the output transistors to conduct more heavily than the other (unbalancing the bridge) and current flows through the external load. The output voltage appears between terminals Y (the common-emitter point) and ground.

Incandescent lamps (I1 and I2) are connected in series with each emitter. Since the resistance of each lamp increases with increasing current (higher temperature), the lamps serve to stabilize and protect the output stage by limiting the maximum current flow through each transistor.

If the d-c level at the input rises, it cannot pass directly to the base of Q17. Instead, it is converted to a square wave by the action of the chopper D1 and amplified in the stabilizer section. The a-c output of the stabilizer is rectified by D1 and filtered by R15, C2 and R11; then applied to the base of Q17. Therefore, a d-c signal is amplified by a factor equal to the gain of the d-c section, multiplied by that of the stabilizer.

The stabilizer section of the d-c amplifier consists of a three-stage, direct-coupled amplifier (Q6, Q7 and Q8), and a 60-cycle vibrator, D1. The function of the stabilizer is to pre-amplify the d-c and low-frequency components of an input signal before the signal is applied to the d-c section of the amplifier. Any d-c or low frequency a-c voltage appearing at the summing junction is blocked by C1 and, because of the action of vibrator D1, is applied to the stabilizer input as a 60-cycle square wave. This signal is amplified by the stabilizer section and fed back to the base of Q17 as a d-c voltage. (D-c restoration is accomplished by contacts 1 and 2 of D1.) This signal is passed through the d-c section of the amplifier and applied as negative feedback to the summing junction through an external feedback resistor connected between the amplifier output and input terminals. Thus, the action of the cascaded stabilizer-amplifier combination is to reduce the summing junction voltage to zero.

5. WIRING.

The following table provides the necessary data for wiring amplifier connectors:

<u>PIN</u>	<u>FUNCTION</u>
A	-15V
B	OUTPUT
C	OUTPUT
D	+15V
E	±GROUND
F	6.3VAC CHOPPER DRIVE
H	6.3VAC CHOPPER DRIVE
J	+30V
K	BALANCE POTENTIOMETER
L	STABILIZER INPUT

5. WIRING (cont)

<u>PIN (cont)</u>	<u>FUNCTION (cont)</u>
M	HIGH QUALITY GROUND
N	HIGH QUALITY GROUND
P	STABILIZER INPUT
R	BALANCE POTENTIOMETER
S	+30V
V	±GROUND
W	+15V
X	OUTPUT
Y	OUTPUT
Z	-15V

6. ADJUSTMENTS AND TEST PROCEDURES.

a. General

The amplifiers should be balanced periodically to assure computer accuracy. All other tests need be conducted only when an amplifier is suspected of being faulty. During all tests, unused amplifiers in the computer should have 10K feedback resistors placed across them.

b. Balance Procedure

To balance an amplifier, insert a 10K feedback resistor between the S and O termination. Switch the METER SELECT switch to the BAL position, and the AMPL SELECT switch to the amplifier that is to be balanced. Adjust the proper BALANCE control for zero reading on the meter.

c. Amplifier Output Current

Patch the amplifier under test into the circuit shown in figure 4a. Place the METER SELECT switch in the AMPL OUT position and set the AMPL SELECT switch to the amplifier under test. Connect +10 volts to the circuit and observe the meter reading; then connect -10 volts to the circuit and observe the meter reading. The voltmeter should read +10 volts with a negative input to the amplifier and -10 volts with a positive input to the amplifier. If the amplifier is not supplying 20 ma of output current (minimum for reliable operation) the voltmeter reading will be less than 10 volts.

d. Amplifier Dynamic Error

After balancing the amplifier to be tested, patch the circuit shown in figure 4b. Set the horizontal gain of the oscilloscope until the 6.3 volt RMS input gives approximately full scale horizontal deflection. Set the vertical gain to 10 millivolts/cm and adjust R2 for minimum resistance.

Adjust R1 until the diagonal pattern on the scope remains the same when leads A and B are interchanged. (Resistor R3 and R4 may have to be switched in order to accomplish this.) After R1 has been adjusted the resultant pattern on the scope indicates the amplifier dynamic error in combination with R5 and R6.

In order to eliminate R5 and R6 as possible sources of error, adjust R2 until the diagonal pattern on the scope remains the same when leads C and D are interchanged. (Resistors R5 and R6 may have to be switched in order to accomplish this.) After R2 has been adjusted the resultant pattern on the scope indicates the amplifier dynamic error multiplied by a factor of 10. The extent that the horizontal line is tilted (peak-to-peak) represents ten times the amount of amplifier error. A typical amplifier will cause approximately 25 millivolts of vertical deflection. The maximum permissible reading on the oscilloscope is 60 millivolts.

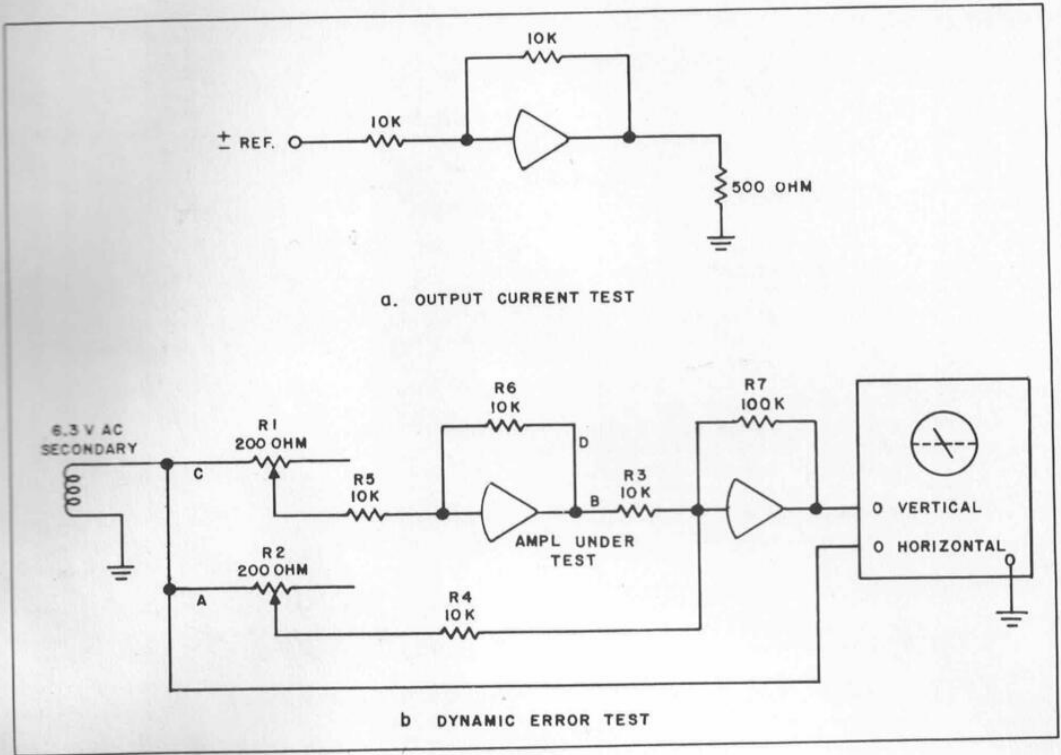


Figure 4. Amplifier Test Circuits

Error of other amplifiers may be tested simply by moving the input (S) and output (O) leads to the next amplifier without further adjustment of R1 and R2.

APPENDIX I

REPLACEABLE PARTS LISTS

This appendix lists all replaceable parts in the Dual D-C Amplifier, Model 6.282. 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.

PARTS LIST INDEX

DUAL D-C AMPLIFIER, MODEL 6.282

<u>Model Number</u>	<u>Component</u>	<u>Page</u>
1. 6.282	Dual DC Amplifier	AI-2

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,10	Capacitor, Fixed, Electrolytic: 10UF $\pm 20\%$, 50V; Sprague Elec. Co. 109D106X0050G2	516 206 0	A
2	C2,9,11,18	Capacitor, Fixed, Electrolytic: 1,250UF, 3V Callins Industries PSS Type	A516 184 0	C
3	C3,12	Capacitor, Fixed, Ceramic: 47PF $\pm 10\%$, 1000V; Cornell-Dubilier L10Q47	515 017 0	A
4	C4,13	Capacitor, Fixed, Ceramic: .02UF $\pm 10\%$, 75V; Glenco MIN-M-.02-K	515 182 0	B
5	C5,14	Capacitor, Fixed, Ceramic: 2.2PF $\pm .5$ PF, 1,000V; Cornell-Dubilier CVOV22C	515 069 0	A
6	C6,15	Capacitor, Fixed, Ceramic: 470PF $\pm 10\%$, 500V; Erie Resistor, Corp. GP2K-470-47	515 046 0	A
7	C7,16	Capacitor, Fixed, Electrolytic: 5UF $+20\%$ -15% ; Sprague Elec. Co. 109D505C2050G2	516 186 0	A
8	C8, 17	Capacitor, Fixed, Electrolytic: 5UF $+100\%$ -10% 25V; Callins Industries PSS Type	A516 182 0	C
9	C21,22	Capacitor, Fixed, Ceramic: 33PF $\pm 5\%$, 500V; Solar CD16C-330J	515 155 0	A
10	C19,20,23,24	Capacitor, Fixed, Ceramic: .05UF $+100\%$ -20% , 30V; Centralab DA-503	515 183 0	A
11	CR1-4	Rectifier, Silicon: Hughes Semiconductors HR10212	614 034 0	B
12	D1	Chopper: 6.3V 60 cps Coil, DPDT BBM; James Electronics C2335	530 042 0	C
13	I1-4	Lamp, Incandescent: Hudson Lamp Co. 2310	578 047 0	B
14	Q1-3,9-11	Transistor, Germanium: PNP; General Transistor Corp. GT1236	B686 028 0	C
15	Q4,12	Transistor, Germanium: PNP; General Transistor Corp. GT1361	686 029 0	C
16	Q5,13	Transistor, Germanium: NPN; General Transistor Corp. GT1442	B686 039 0	B
17	Q6-8,14-16	Transistor, Germanium: PNP, Industro	B686 032 0	C
18	Q17,18	Transistor, Germanium: NPN; Gen. Elec. 2N169A	686 036 0	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.

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UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.282

Sh. 1 of 3

8/21/62

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
19	R1,27	Resistor, Fixed, Composition: 1 Megohm $\pm 10\%$, 1/2W; Allen-Bradley EB	626 105 1	A
20	R2,28	Resistor, Fixed, Composition: 3.3K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 332 1	A
21	R3,35	Resistor, Fixed, Composition: 1.8K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 182 1	A
22	R4,18,36,50	Resistor, Fixed, Composition: 2.2K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 222 1	A
23	R5,29	Resistor, Fixed, Composition: 1.6K ohms $\pm 5\%$, 1/2W; Allen-Bradley EB	626 162 0	A
24	R6,37	Resistor, Fixed, Composition: 7.5K ohms $\pm 5\%$, 1/2W; Allen-Bradley EB	626 752 0	A
25	R7,30	Resistor, Fixed, Composition: 100 ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 101 1	A
26	R8,31	Resistor, Fixed, Composition: 5.1K ohms $\pm 5\%$, 1/2W; Allen-Bradley EB	626 512 0	A
27	R9,32	Resistor, Fixed, Composition: 56 ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 560 1	A
28	R10,33	Resistor, Fixed, Composition: 4.7K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 472 1	A
29	R11,14-17, 34,38,39, 46,48	Resistor, Fixed, Composition: 10K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 103 1	A
30	R12,40	Resistor, Fixed, Composition: 33K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 333 1	A
31	R13,41	Resistor, Fixed, Composition: 6.2K ohms $\pm 5\%$, 1/2W; Allen-Bradley EB	626 622 0	A
32	R19,20,47 49	Resistor, Fixed, Composition: 240 ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 221 1	A
33	R21,22,42, 43	Resistor, Fixed, Composition: 22K ohms $\pm 10\%$, 1/2W; Allen-Bradley	626 223 1	A
34	R23,45	Resistor, Fixed, Composition: 120K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 124 1	A

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UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.282

Sh. 2 Of 3

8/21/62

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
35	R24,44	Resistor, Fixed, Composition: 10 ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 100 1	A
36	R25,26,51- 54	Resistor, Fixed, Composition: 68K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 683 1	A
37	R55,56	Resistor, Fixed, Composition: 4.7 Megohms $\pm 10\%$; 1/2W; Allen-Bradley EB	626 475 1	A
38	R57,58	Resistor, Fixed, Composition: 330K ohms $\pm 10\%$, 1/2W; Allen-Bradley EB	626 334 1	A

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UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.282 Sh. 3 of 3

APPENDIX II

DRAWINGS

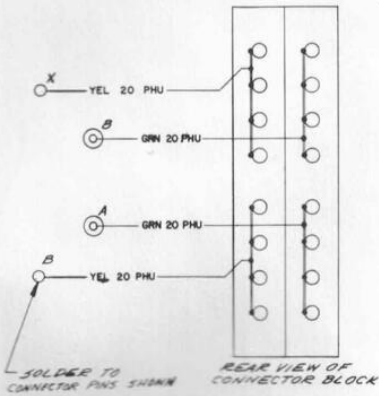
This appendix contains necessary schematic and wiring diagrams for the Dual D-C Amplifier, Model 6.282. To facilitate locating a particular sheet, an index is provided that lists the model number of each unit or component, the type of drawings, and the associated drawing number. The drawings are bound 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. Unless otherwise specified all resistance values are given in ohms and capacitance values in micro-micro farads (mmf).

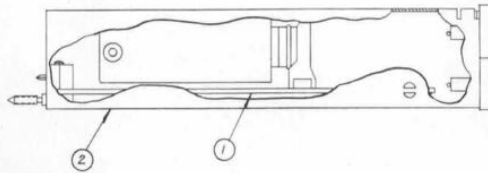
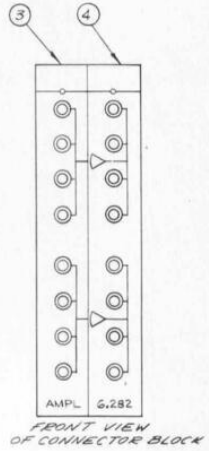
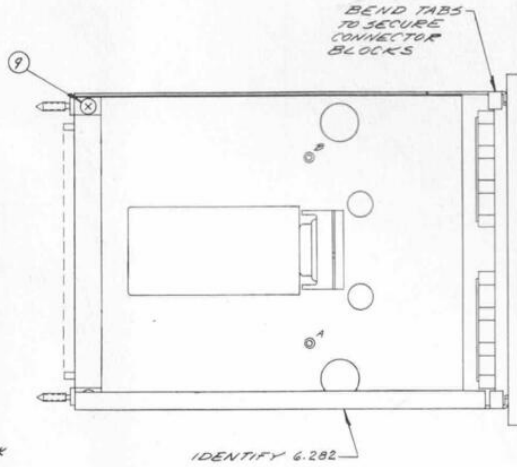
INDEX

<u>Unit or Component</u>	<u>Type of Drawing</u>	<u>Drawing Number</u>
6.282 Dual D. C. Amplifier	Assembly	C006 282 0A
6.282 Dual D. C. Amplifier	Schematic	D006 282 0S

NOTES:
 1. JUMPER TO BE 20 SD-BUS.

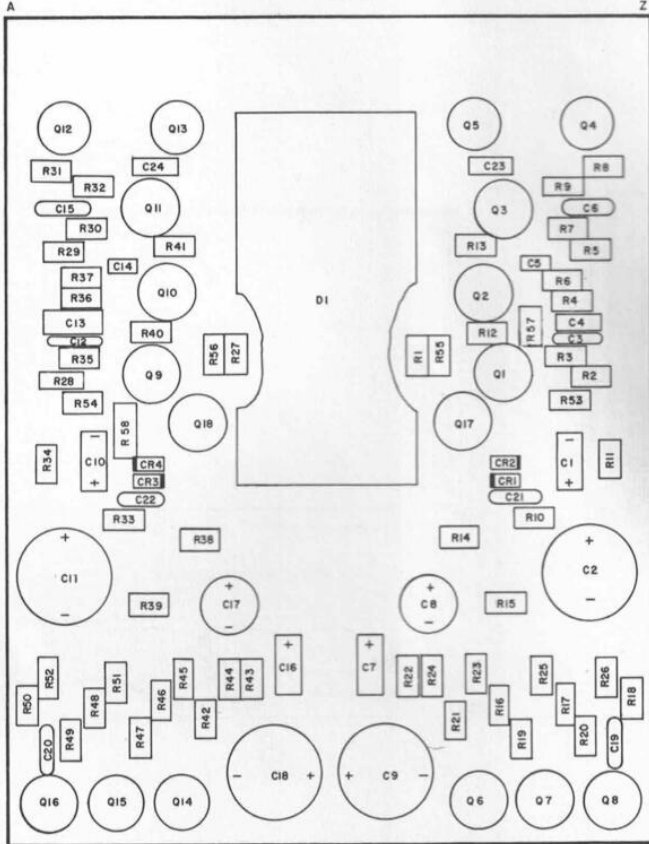


WIRING

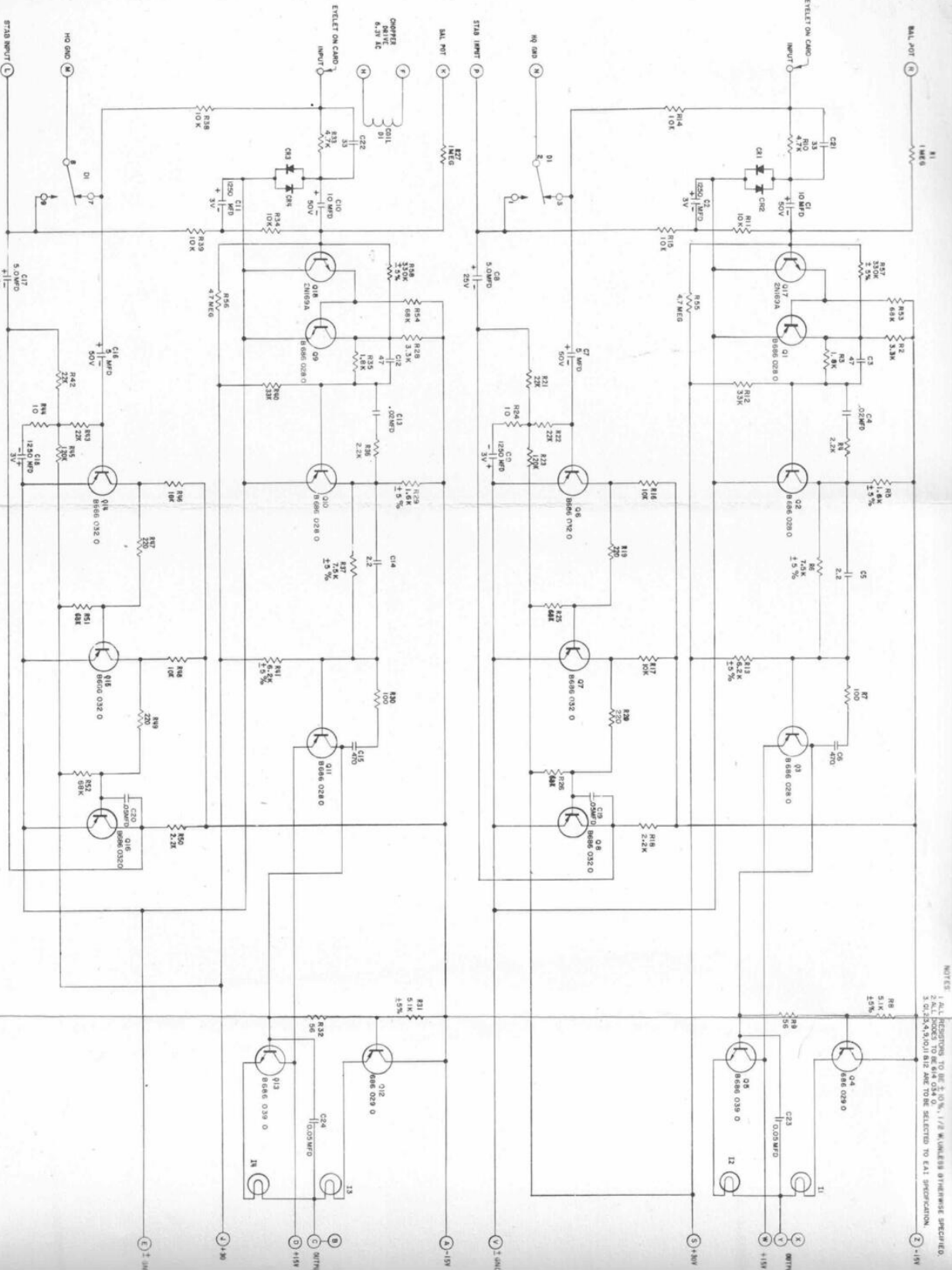


ELECTRONIC ASSOCIATES, INC. LONG BRANCH, NEW JERSEY	
ASSEMBLY DUAL DC. AMPLIFIER	
SHT. NO.	
SIZE	
REV. NO.	
PROJECT 1991	C 006 282 0A
SHEET	OF SHEETS

PLUG-IN END OF CARD



Dual D. C. Amplifier 6.282



NOTE:
 1. ALL RESISTORS TO BE ± 10% 1/2 W UNLESS OTHERWISE SPECIFIED.
 2. 0.003μF, 0.01μF, 0.02μF AND 0.05μF TO BE SELECTED TO O.A.I. SPECIFICATION.