

CHAPTER 13

Seven-watt Stereophonic Amplifier

The circuit diagram drawn in Fig. 1 is for a high-quality, dual-channel amplifier designed principally for stereophonic reproduction but also providing facilities for monaural applications. Only one channel of the amplifier is drawn. The circuitry appearing between the dotted lines is for the left-hand channel: it should be duplicated for the right-hand channel. The circuitry drawn outside the dotted lines (the power supply, for example) is common to both channels.

The total complement of valves used in the amplifier consists of one double triode, type ECC83, four triode pentodes, type ECL82, and one full-wave rectifier, type EZ81. The double triode is shared between the two channels, one section of the valve being used in each channel for voltage amplification. Two of the ECL82s are used in each channel. The triode sections of these valves form a phase-splitting stage and the pentode sections are arranged as a push-pull output stage with distributed loading. The EZ81

forms a conventional power supply with resistance-capacitance smoothing, providing the h.t. for both channels.

The rated output-power reserve of each channel is 7W, at which level the total harmonic distortion is always better than 0.5%. The low level of distortion is achieved by using 21dB of negative feedback, the feedback voltage being taken from the secondary winding of the output transformer in each channel to the cathode circuit of the corresponding input stage. The sensitivity of the circuit, even with this high value of feedback, is 100mV, which is ample for use with existing stereophonic crystal pick-up heads.

CIRCUIT DESCRIPTION

Resistors and capacitors appearing in the left-hand channel of the amplifier are numbered 1, 2, 3, etc.; the corresponding components in the right-hand channel are numbered 101, 102, 103, etc.



Prototype of Seven-watt Stereophonic Amplifier

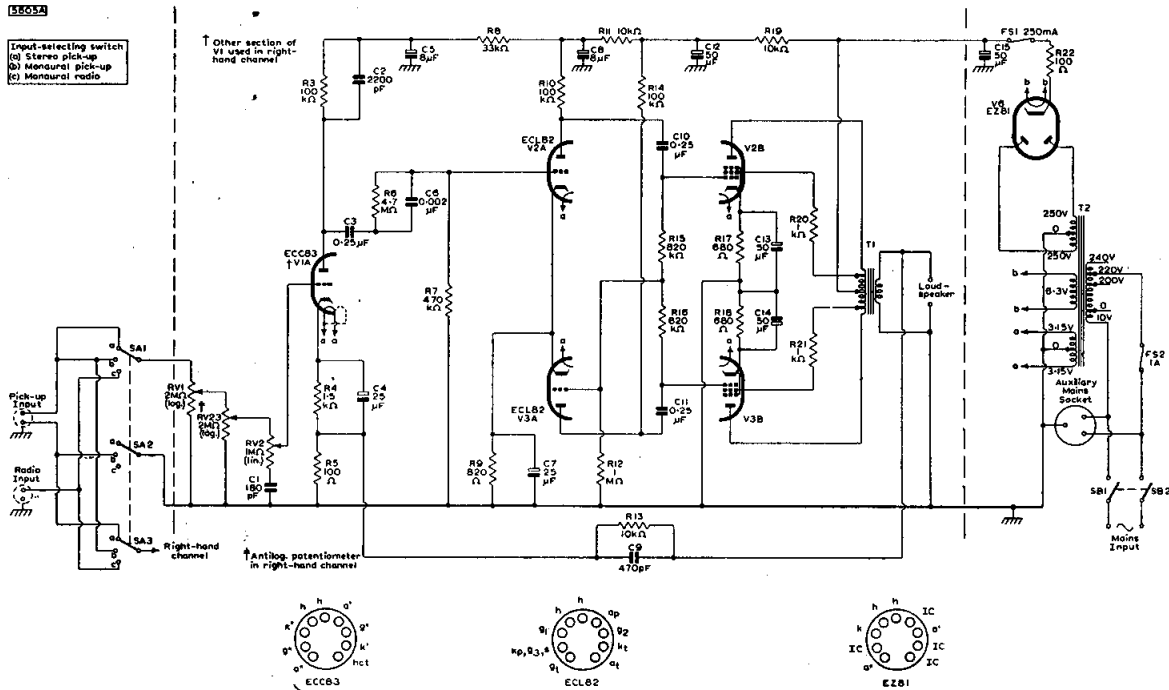


Fig. 1—Circuit diagram of seven-watt stereophonic amplifier (left-hand channel only is shown: circuitry between vertical dotted lines should be repeated in right-hand channel)

Input Selector Switch

The input stages of both channels are connected to the 3-way selector switch SA. The switch positions indicated in Fig. 1 provide the following facilities:

- (a) Stereophonic reproduction from stereophonic crystal pick-up heads.
- (b) Dual-channel monaural reproduction from a monaural pick-up head. In this position, the left-hand pick-up input terminal is 'live', and both channels are connected in parallel at the input. The input terminal for the right-hand channel of a stereophonic pick-up head is earthed at position *b* of SA2. If position *b* of SA3 is earthed instead of being connected to position *b* of SA1, single-channel reproduction is possible.
- (c) Dual-channel monaural reproduction from an f.m. tuner unit. The input socket in Fig. 1 is connected for monaural applications. If position *c* of SA3 is connected to the right-hand input terminal instead of the left-hand terminal, the circuit will be suitable for reproducing stereophonic transmissions. If position *c* of SA3 is earthed instead of being connected to the input socket, the system gives single-channel monaural reproduction from an f.m. tuner unit.

Input Stage

The triode sections of the ECC83 are used for voltage amplification, one section being used in each channel. A simple treble tone-control network consisting of the components RV2 and C1 (RV102 and C101) is incorporated in the grid circuit giving continuously variable treble cut. A volume control RV1 (RV101) is also included in the grid circuit. Dual-ganged potentiometers are used in the prototype for the tone-control components RV2 and RV102 and also for the volume-control components RV1 and RV101, so that equal adjustments can be made simultaneously to both channels. It may be found more convenient to use dual-concentric potentiometers for these controls because adjustments can be made separately to each channel with them.

Instability can result from the large amount of negative feedback introduced to the cathode circuit of each input stage, and the simplest method of ensuring stability is to reduce the loop gain of each channel. To achieve this reduction at high audio frequencies, the capacitor C2 (C102) is connected to bypass the anode load resistor R3 (R103). To reduce the loop gain at bass frequencies, the parallel combination R6 and C6 (R106 and C106) is included in

LIST OF COMPONENTS

Resistors and capacitors in the left-hand channel are numbered 1, 2, 3, etc.; corresponding components in the right-hand channel are numbered 101, 102, 103, etc.

Resistors

Circuit ref.	Value	Tolerance (±%)	Rating (W)	
*RV1 and RV101	2×2 MΩ		logarithmic potentiometer	
*RV2 and RV102	2×1 MΩ		linear potentiometer	
R3, R103	100 kΩ	10	↑ ↑	
R4, R104	1.5kΩ	10		
R5, R105	100 Ω	10		
R6, R106	4.7MΩ	10		
R7, R107	470 kΩ	10		
R8, R108	33 kΩ	10		
R9, R109	820 Ω	10		
R10, R110	100 kΩ	10		
R11, R111	10 kΩ	10		
R12, R112	1 MΩ	10		
R13, R113	10 kΩ	10		
R14, R114	100 kΩ	10		
R15, R115	820 kΩ	5		
R16, R116	820 kΩ	5		
R17, R117	680 Ω	10		
R18, R118	680 Ω	10		
R19, R119	10 kΩ	10		
R20, R120	1 kΩ	10		
R21, R121	1 kΩ	10		
R22	100 Ω	10		
*RV23	2 MΩ			logarithmic potentiometer
*RV123	2 MΩ			antilogarithmic potentiometer

*10% law (See text)

Capacitors

Circuit ref.	Value	Description	Rating (V)
C1, C101	180 pF	silvered mica	
C2, C102	2200 pF	silvered mica	
C3, C103	0.25 μF	paper	275
C4, C104	25 μF	electrolytic	3
C5, C105	8 μF	electrolytic	300
C6, C106	0.002 μF	paper	275
C7, C107	25 μF	electrolytic	3
C8, C108	8 μF	electrolytic	300
C9, C109	470 pF	silvered mica	
C10, C110	0.25 μF	paper	275
C11, C111	0.25 μF	paper	275
†C12, †C112	50 μF	electrolytic	300
C13, C113	50 μF	electrolytic	3
C14, C114	50 μF	electrolytic	3
†C15	50 μF	electrolytic	300

†(50+50+50) μF electrolytic capacitor
Tolerance of silvered mica capacitors is ±10%

Mains Transformer

Primary: 10-0-200-220-240V
 Secondaries: H.T. 250-0-250V, 150mA
 L.T. 3.15-0-3.15V, 4A (for ECC83 and ECL82s)
 0-6.3V, 1A (for EZ81)

Output Transformer

Primary: 9kΩ
 Secondary 3.75, 7.5 and 15Ω

Commercial Components

Manufacturer	Type No.
Colne	03062
Elden	1298
Gardners	AS.7009
Gilson	W.O.1340
Hinchley	1535
Howells	MO10
Parmeko	P2932
Partridge	P4133
Wynall	7914

Manufacturer	Type No.
Colne	04022
Elden	1297
Gardners	RS.3110
Gilson	W.O.741B
	W.O.741A/B
Hinchley	1447
Howells	MM10
Parmeko	P2931
Partridge	P4132
Savage	5D32
Wynall	7915

Valves

Mullard ECC83, ECL82 (four), EZ81

Valveholders

B9A (noval) nylon-loaded with screening skirt (for ECC83)
 McMurdo XM9/AU, skirt 95
 B9A (noval) (five), McMurdo BM9/U

Miscellaneous

Mains input plug, 3-pin, Bulgin, P429
 Mains switch, N.S.F., 8370/B3
 Fused voltage selector, Clix, VSP/393/2
 H.T. supply plug (pre-amplifier) 6-pin, Bulgin, P427
 Fuseholder, Minifuse, Belling Lee, L.575
 Fuse, 250mA
 Lampholder, Bulgin, D675/1/Red
 Pilot lamp, 6.3V, 0.15A., L.E.S.
 Input socket, 3-pin, Belling Lee, L.790/CS
 Output plug, (two) 2-pin, non-reversible, Painton, 313263

7W STEREPHONIC AMPLIFIER

the coupling circuit between the first and second stages of each channel. This manner of coupling results in resistive attenuation at low audio frequencies, so that the phase shift is limited.

Balance Control

To compensate for any differences in acoustical output resulting from unequal outputs from the stereophonic pick-up head or unequal sensitivities of the loudspeakers, a balance control consisting of RV23

and RV123 is incorporated between the volume and tone controls. This is made up of a logarithmic potentiometer connected in reverse in one channel and an antilogarithmic potentiometer connected normally in the other. The characteristics of this control are discussed on page 28 in Chapter 4. If dual-concentric potentiometers are used for the volume control RV1, RV101, balance can be achieved with them, and the potentiometers RV23, RV123 can be omitted.

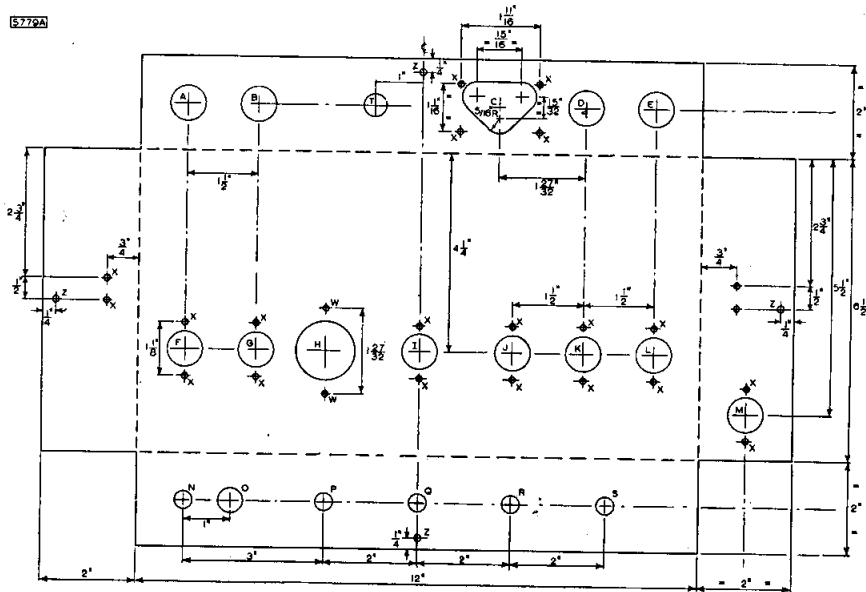
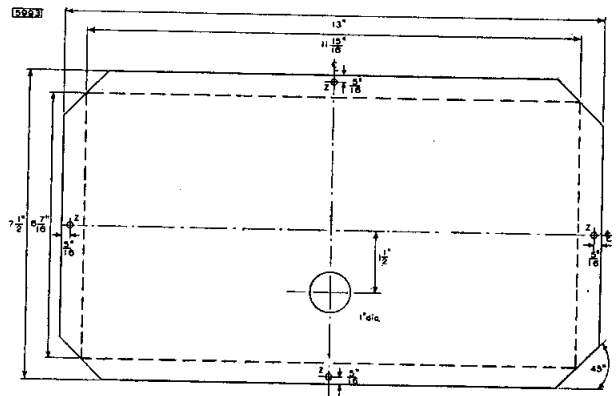
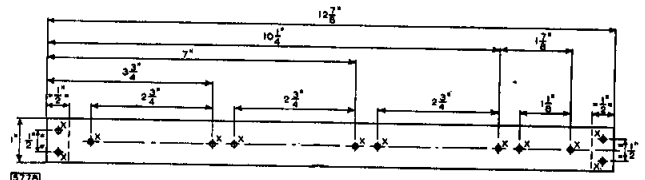


Fig. 2—Chassis details (the pieces should be bent up at 90° at all dotted lines)

- (a) (above) Main chassis
- (b) (right) Tagboard mounting strip
- (c) (bottom right) Cover plate



KEY TO HOLES IN CHASSIS			
Hole	Dimension	Use	Type No.
A	3/8 in. dia.	Output socket, 2-pin, Painton ..	313263
B	in. dia.	Mains input plug, 3-pin, Bulgin ..	P429
C	—	Fused voltage selector, Clix ..	VSP/393/2
D	3/8 in. dia.	H.T. supply plug, 6-pin, Bulgin ..	P427
E	in. dia.	Output socket, 2-pin, Painton ..	313263
F	in. dia.	B9A (noval) valveholder, McMurdo ..	BM9/U
G	in. dia.	B9A (noval) valveholder, McMurdo ..	BM9/U
H	1 1/2 in. dia.	Electrolytic capacitor ..	—
I	3/8 in. dia.	B9A (noval) nylon-loaded valveholder with screening skirt, McMurdo ..	XM9/AU Skirt 95
J	in. dia.	B9A (noval) valveholder, McMurdo ..	BM9/U
K	in. dia.	B9A (noval) valveholder, McMurdo ..	BM9/U
L	in. dia.	B9A (noval) valveholder, McMurdo ..	BM9/U
M	in. dia.	Input socket, 3-pin, Belling Lee ..	L.790/CS
N	in. dia.	Lampholder, Bulgin ..	D675/1/Red
O	in. dia.	Mains switch, N.S.F. ..	8370/B3
P	in. dia.	2 x 1MΩ logarithmic potentiometers ..	—
Q	in. dia.	500kΩ log/antilog potentiometers ..	—
R	in. dia.	2 x 100kΩ logarithmic potentiometers ..	—
S	in. dia.	Selector switch, 3-way, miniature rotary ..	—
T	1/2 in. dia.	Fuseholder, Minifuse, Belling Lee ..	L.575
X	2.9 mm dia.	6 B.A. clearance holes	—
Z	Drill No. 34		

Phase-splitting Stage

The output from the anode of V2A is taken to the grid of V3A by way of the resistors R15 and R12 (R115 and R112). These components also form the grid-leak resistance for the pentode section V2B, and R16 and R12 (R116 and R112) comprise the grid-leak resistance for V3B. Balance between the output voltages from the triodes of the phase-splitter is governed by the values of these three resistors.

Output Stage

The pentode sections of the ECL82s are used in a push-pull output stage. Distributed loading is used, and the primary winding of the output transformer is tapped so that 20% of the winding in each anode circuit also appears in the corresponding screen-grid circuit. (The choice of tapping points is discussed in Chapter 3.)

Negative Feedback

The amount of negative feedback which is used between the secondary winding of the output transformer in each channel to the cathode circuit of the input stage of that channel is 21dB. The output resistance of each channel with this feedback is 0.54Ω measured at the 15Ω output terminal. This gives an adequate damping factor of approximately 28.

Power Supply

A conventional power supply using the Mullard full-wave rectifier, type EZ81, with resistance-capacitance smoothing, provides the h.t. for both channels. Both supply connections are made to the common reservoir capacitor C15, but smoothing is achieved separately in each channel with the components R19, C12 and R119, C112.

The resistor R22 in the cathode circuit of the EZ81 should, with the transformer resistance, provide the minimum limiting resistance quoted for the valve. The choice of value for limiting resistors is discussed on page 28. A total h.t. current of 150mA at 260V is required for the amplifier, and the total heater current needed is 5A at 6.3V.

CONSTRUCTION AND ASSEMBLY

The chassis for the 7W stereophonic amplifier is made from three separate pieces of 16 s.w.g. aluminium sheet. The dimensions (in inches) of these pieces are:

- | | |
|-----------------------------|----------|
| (a) Main chassis | 16 × 10½ |
| (b) Tagboard mounting strip | 12⅞ × 1 |
| (c) Cover plate | 13 × 7½ |

Each piece should be marked as shown in the drawings of Fig. 2, and the holes should be cut as indicated. Where bending is required, it is important that the bends should be made accurately at the lines for the pieces to fit together properly on assembly.

Most of the smaller components should be mounted on tagboards, the wiring of which is shown in Figs. 4 to 7, and the tagboards should be fixed to the mounting strip. The larger components such as switches, valveholders and transformers should be mounted in the chassis in the positions indicated in the layout diagram of Fig. 3. The recommended wiring between these components is also indicated in Fig. 3. It will be seen that the two channels of the amplifier are separate, one channel being in each half of the chassis.

PERFORMANCE

Distortion

The total harmonic distortion was measured in the prototype amplifier with a continuous sine-wave input signal at 400c/s. With 21dB of negative feedback, the distortion for the rated output of 7W per channel

TABLE 1

D.C. Conditions in Each Channel

Point of Measurement		Voltage (V)	Range of D.C. Avometer* (V)
C15 Common to both channels		260	1000
	C12	230	1000
	C8	210	1000
	C5	190	1000
V2, V3 ECL82	Pentode anodes	256	1000
	Pentode screen grids	255	1000
	Pentode cathodes	21	100
	Triode anode V3	130	1000
	Triode anode V2	110	1000
	Triode cathodes	2.0	25
V1 ECC83	Anode	90	100
	Cathode	1.5	25

*Resistance of Avometer:
1000V-range, resistance = 20MΩ
100V-range, resistance = 2MΩ
25V-range, resistance = 500kΩ

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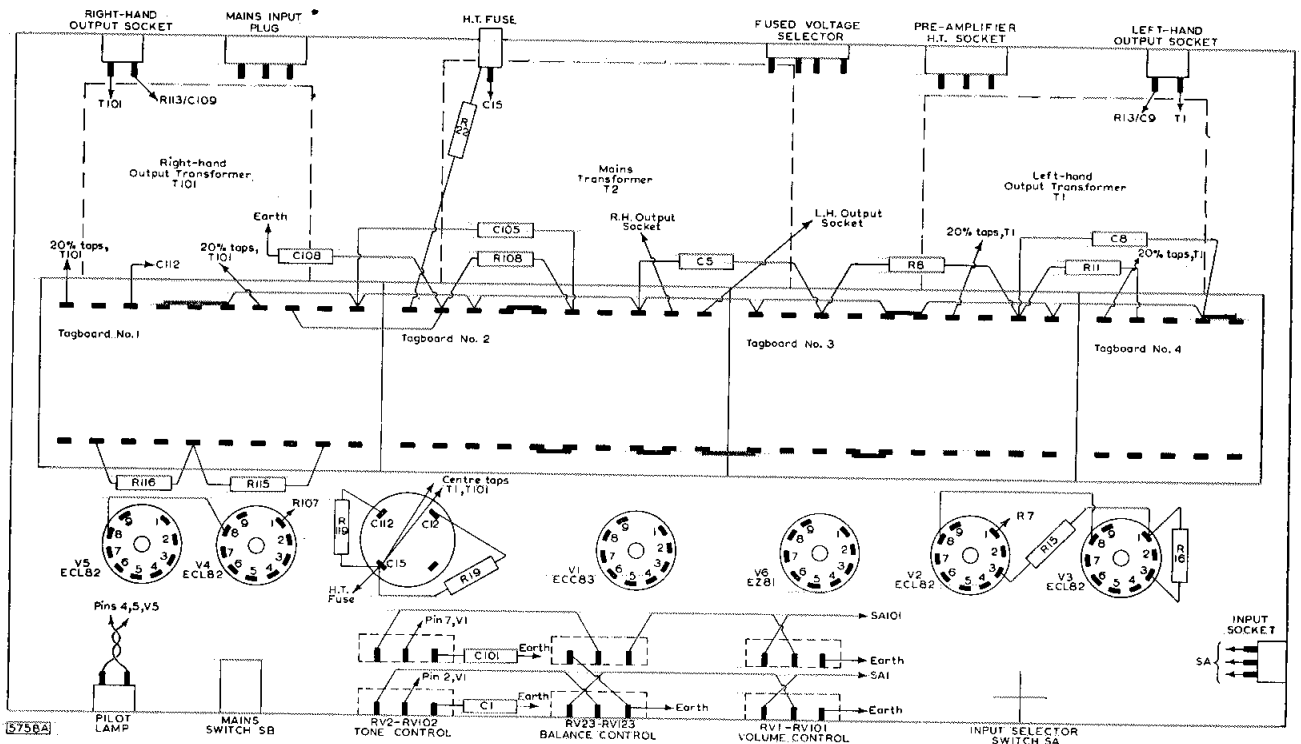
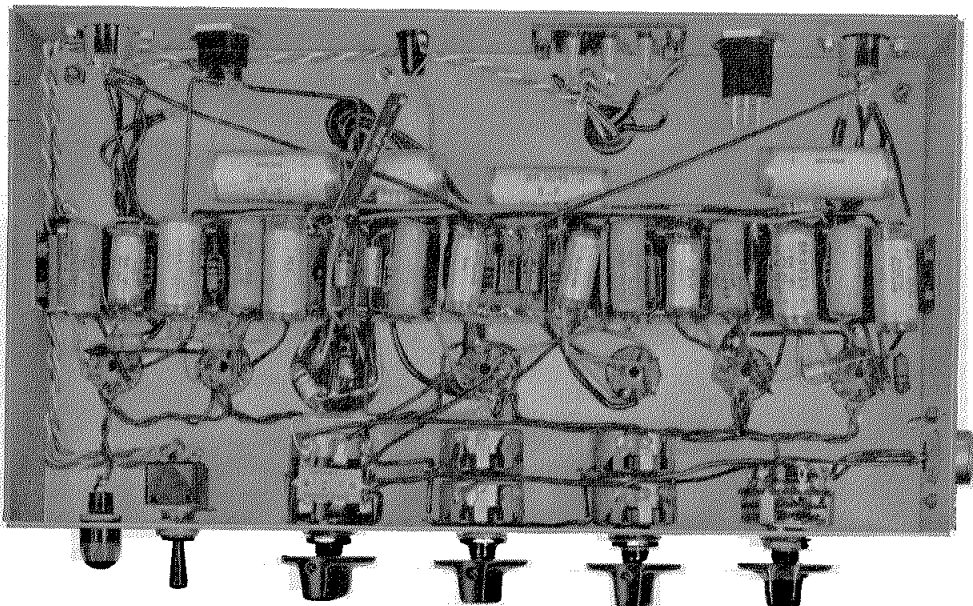
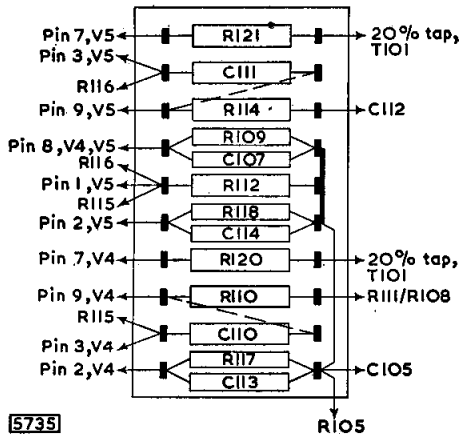


Fig. 3—Suggested layout of components



Underside View of Prototype Amplifier

7W STEREOPHONIC AMPLIFIER



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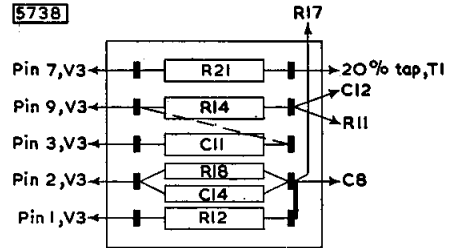
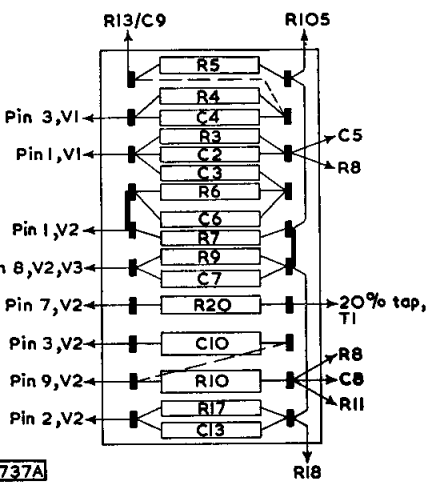
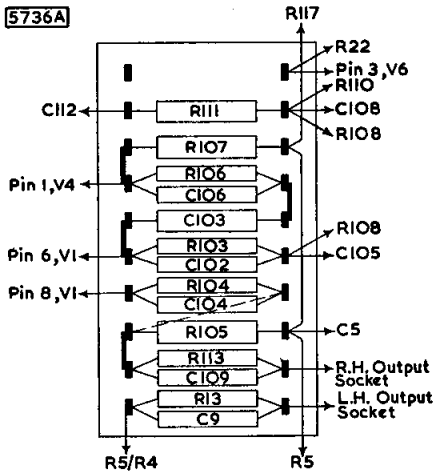


Fig. 4 (top left)—Tagboard No. 1

Fig. 5 (middle left)—Tagboard No. 2

Fig. 6 (bottom left)—Tagboard No. 3

Fig. 7 (above)—Tagboard No. 4



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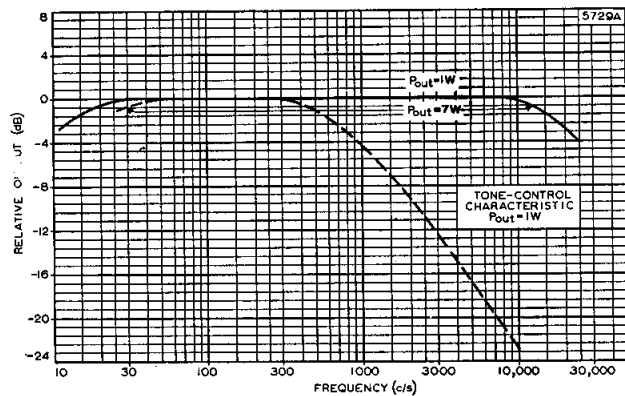


Fig. 8—Frequency-response, power-response and tone-control characteristics

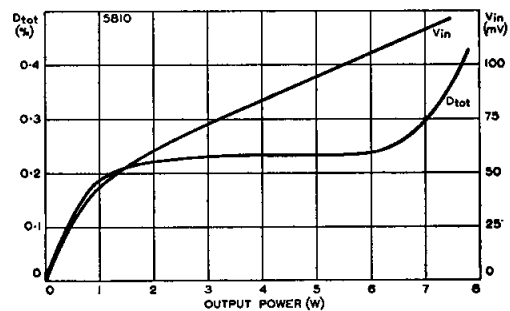


Fig. 9—Variations in harmonic distortion D_{tot} , and input V_{in} with output power

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is always better than 0.5%. The variation of distortion with output power is shown in Fig. 9.

Intermodulation distortion, measured with carrier and modulating frequencies of 10kc/s and 40c/s respectively, is better than 1.5%.

Frequency Response

The frequency-response characteristic of each channel of the prototype amplifier, measured for an output of 1W is shown in Fig. 8. At 20kc/s, the response is 3dB below the level at 1kc/s and at 15c/s it is 1.5dB down. The response at the rated output power of 7W is 3dB down at 15c/s.

Sensitivity

The sensitivity of each channel of the circuit (including the controls) with 21dB of negative feedback is 100mV for the rated output of 7W.

Hum and Noise

The level of hum and noise in each channel of the prototype amplifier is better than 65dB below the rated output.

Tone Controls

A continuously variable treble-cut tone control is included in each channel of the amplifier. The characteristic of this control is shown in Fig. 8, from which it can be seen that full application of the control gives about 23dB of cut at 10kc/s.

D.C. CONDITIONS

The d.c. voltages in each channel should be tested with reference to Table 1. The results shown in this table were obtained with an Avometer No. 8.