Circuit for self-contained
TAPE AMPLIFIER

This publication is based on part of the Mullard book 'Circuits for Tape Recorders' first issued in August 1956. The circuit discussed is the self-contained record/playback tape amplifier, type A, described in that book.

The functions associated with both the recording and playback processes are, in most tape recording equipment, fulfilled by a single amplifier with suitable switching facilities. It is only with the more elaborate and costly equipment that separate recording and playback amplifiers are used.

The circuit to be described in this booklet combines the requirements of both processes, and it can be used with many of the tape decks that are fitted with a combined record/playback head and a separate erase head. With such a deck, the amplifier forms a self-contained recording and reproducing unit which is capable of excellent performance whether using recordings made on the unit, or pre-recorded tapes.

Any tape amplifier must, if an acceptable performance is to be achieved, provide compensation for the unequal response over the audio-frequency range that is inherent in the process of magnetic recording. In keeping with general practice, the treble equalisation is associated with the recording channel and the bass equalisation is incorporated during playback. Because treble attenuation is dependent on the tape speed, it is desirable to provide separate high-frequency correction for the different tape speeds. In this amplifier, equalisation is provided for speeds of $3\frac{3}{4}$ and $7\frac{1}{2}$ inches per second.

In addition to the basic equalisation, some measure of tone control may be desired in a complete recorder. Equalisation is arranged to provide a level overall frequency characteristic. The tone control provided allows for modifications to be made to the playback characteristic so that the response can be given fixed degrees of bass or treble attenuation to suit the demands of the individual listener.

The quality of the performance of the complete equipment is necessarily limited by the output stage of the playback amplifier and the associated loudspeaker system. A higher standard of reproduction can be achieved if a good quality amplifier and pre-amplifier are fed from the low-level output of the playback amplifier.

Excluding the limitations mentioned in the previous paragraph, and the distortion introduced by the tape itself, the major source of distortion in this unit occurs in the recording stage. The voltage required from this stage to provide a recording current of 200μA depends on the series resistance between the anode and the recording head. A low value of this resistance, whilst reducing the output voltage requirements, also increases the distortion of this stage. The total harmonic distortion in the recording stage at the peak level of 20V which has been adopted in this design is not more than 2% at 1kc/s.

Sensitivity

The sensitivity of each amplifier is measured with the volume control set for maximum gain. This, of course, does not apply to the low-level output measurements: the control is not effective until after this point of the circuit.

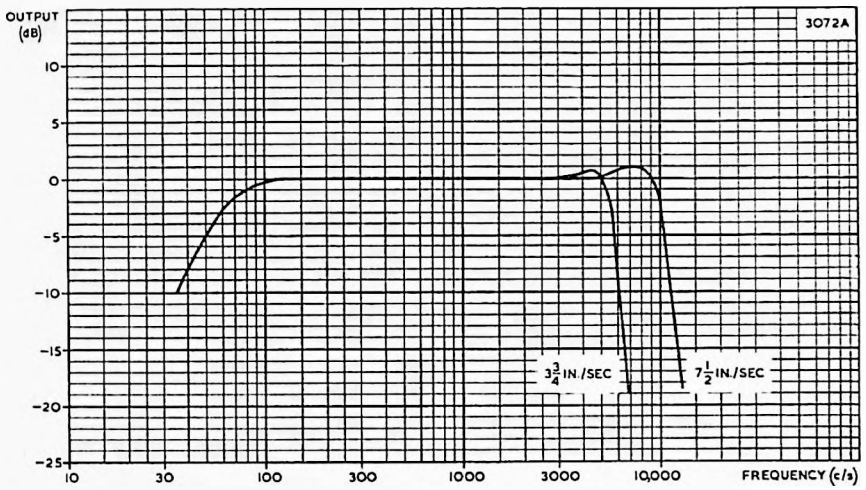


Fig. 1—FREQUENCY RESPONSE CHARACTERISTICS

PERFORMANCE CHARACTERISTICS

Frequency Response

Treble boost is incorporated during recording and bass boost during replay. Separate equalisation is provided for tape speeds of $7\frac{1}{2}$ and $3\frac{3}{4}$ inches per second to give the following attainable overall response:

$7\frac{1}{2}$ in./sec ±2dB (relative to the level at 1kc/s) from 70c/s to 10kc/s

$3\frac{3}{4}$ in./sec ±2dB (relative to the level at 1kc/s) from 70c/s to 5kc/s

The overall response at the higher frequencies depends on the type of head used and on the magnitude of the bias current. The response figures given above and the curves drawn in Fig. 1 will normally be obtained with a bias current of 0·5 to 1·0mA through heads of medium impedance.

The playback characteristic of the amplifier is designed to the specification of the International Radio Consultative Committee (C.C.I.R.), thus permitting excellent reproduction of pre-recorded tapes. The recording characteristic is arranged to give a flat frequency response in conjunction with this replay characteristic.

Recording Sensitivity

(measured at 1kc/s, with recording-head audio current of 200μA)

(*a*) Microphone input: (impedance = 2MΩ) 2·5mV for peak recording level

(*b*) Radio input: (impedance ≃ 700kΩ) 300mV for peak recording level

Playback Sensitivity

(measured at 5kc/s for both tape speeds)

(*a*) $7\frac{1}{2}$ in./sec: 3·5mV for 3W power output or for 110mV low-level output.

(*b*) $3\frac{3}{4}$ in./sec: 2mV for 3W power output or for 110mV low-level output.

CIRCUIT DESCRIPTION

The circuit diagram of the combined record/playback amplifier is given in Fig. 2.

Three stages of the circuit are common to both recording and playback processes. A fourth stage acts as an r.f. oscillator for the biasing and erasing signals when recording, and is used as a power output stage in the playback process. A subsidiary stage of the recording amplifier, which is excluded from the playback circuit, is the recording level indicator stage.

Controls

Four controls are provided in the circuit:

(1) The switch SA sets the amplifier for either the recording or the playback condition.

(2) The switch SB allows for some degree of either bass or treble attenuation during playback. The degree of attenuation introduced by the various positions of the switch is shown in Table I.

(3) The switch SC gives the appropriate equalisation for a tape speed of either $7\frac{1}{2}$ or $3\frac{3}{4}$ inches per second. The switch must be in the correct position during playback as well as when recording.

(4) The gain control RV25 operates during both recording and playback processes. It does not influence the low-level output which is available at the anode of the second stage of the amplifier.

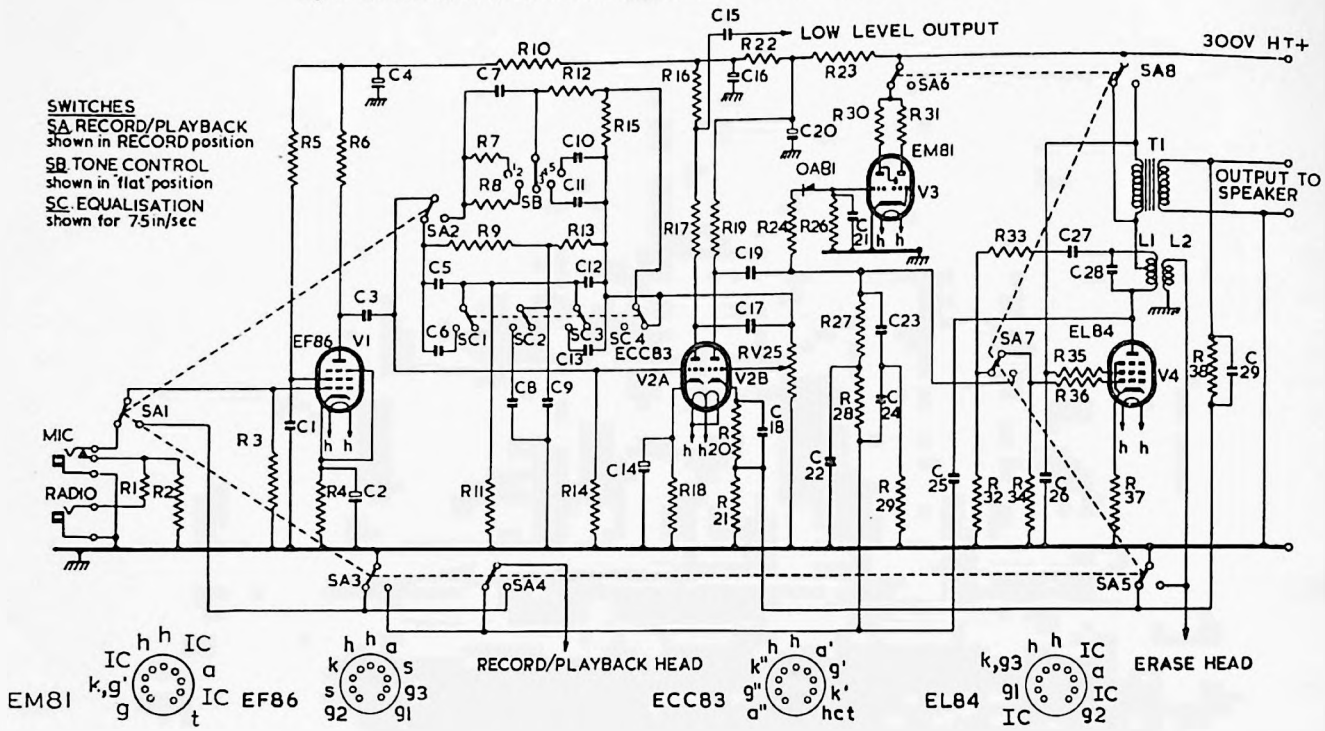
Valve Complement

The amplifier uses four Mullard valves and one Mullard germanium diode. These are:

(*a*) Type EF86, low-noise pentode, used in the input stage for both recording and playback functions.

(*b*) Type ECC83, double triode. The first section of the valve is used in the equaliser stage for recording and playback. The second section is used as the output

Fig. 2—CIRCUIT DIAGRAM OF SELF-CONTAINED AMPLIFIER AND LIST OF COMPONENTS



Resistors

Circuit reference	Value	Tolerance (±%)	Rating (W)
R1	680 kΩ	10	⅛
R2	5·6 kΩ	10	⅛
R3	2·2 MΩ	10	⅛
R4	2·2 kΩ	10	⅛
[1]R5	1·0 MΩ	5	⅛
[1]R6	220 kΩ	5	⅛
R7	1·8 MΩ	10	⅛
R8	4·7 MΩ	10	⅛
R9	220 kΩ	5	⅛
R10	33 kΩ	20	⅛
R11	100 kΩ	5	⅛
R12	270 kΩ	10	⅛
R13	220 kΩ	5	⅛
R14	560 kΩ	20	⅛
R15	270 kΩ	10	⅛
[2]R16	22 kΩ	10	⅛
[2]R17	180 kΩ	10	⅛
R18	4·7 kΩ	10	⅛
R19	100 kΩ	10	⅛
R20	1·5 kΩ	10	⅛
R21	220Ω for 15Ω output; 470Ω for 3·75Ω output	10	⅛
R22	27 kΩ	20	⅛
R23	10 kΩ	20	⅛
R24	470 kΩ	10	⅛
RV25	500kΩ logarithmic potentiometer	10% law	carbon
R26	1·0 MΩ	20	⅛
R27	56 kΩ	10	⅛
R28	56 kΩ	10	⅛
R29	27 kΩ	10	⅛
R30	560 kΩ	10	⅛
R31	100 kΩ	10	⅛
R32	22 kΩ	10	⅛
R33	18 kΩ	10	⅛
R34	680 kΩ	20	⅛
R35	6·8 kΩ	10	½
R36	1·0 kΩ	20	½
R37	150 Ω	10	1
R38	2·2 kΩ	10	½

[1] High stability.

[2] Values may be adjusted to vary output impedance.

Capacitors

Circuit reference	Value	Tolerance (±%)	Description	Rating (V)
C1	0·5 μF		paper	350
C2	50 μF		electrolytic	12
C3	0·1 μF		paper	350
C4	8 μF		electrolytic	350
C5	68 pF	5	silvered mica	
C6	68 pF	5	silvered mica	
C7	270 pF	10	silvered mica	
C8	150 pF	5	silvered mica	
C9	150 pF	5	silvered mica	
C10	330 pF	10	silvered mica	
C11	100 pF	10	silvered mica	
C12	68 pF	5	silvered mica	
C13	68 pF	5	silvered mica	
C14	25 μF		electrolytic	25
C15	0·1 μF		paper	350
C16	8 μF		electrolytic	350
C17	0·1 μF		paper	350
C18	0·02 μF		paper	350
C19	0·1 μF		paper	350
C20	16 μF		electrolytic	350
C21	0·05 μF		paper	150
C22	100 pF	10	silvered mica	
C23	47 pF	10	silvered mica	
C24	47 pF	10	silvered mica	
C25	82 pF	10	silvered mica	350
C26	0·5 μF		paper	350
C27	0·01 μF		paper	350
C28	3300 pF	10	silvered mica	350
C29	1800 pF	10	silvered mica	

Valves and Germanium Diode

V1	Low noise pentode	Mullard type EF86
V2	Double triode	Mullard type ECC83
V3	Tuning indicator	Mullard type EM81
V4	Output pentode	Mullard type EL84
	Germanium diode	Mullard type OA81

Oscillator Coil

Former: Standard Aladdin

Slug: $\frac{1}{4}$ in. dia.; $\frac{1}{2}$ in. winding length
$\frac{3}{16}$ in. dia.; $\frac{1}{4}$ in. long, centred on winding

Primary: 400 turns of 38 s.w.g. wire, tapped at 360 turns

Secondary: 50 turns of 34 s.w.g. wire

Miscellaneous

T1 Output transformer. One of the following commercial types would be suitable:

Manufacturer	Type No.
Colne	35206
Elstone	OT/3
Gilson	WO767
Hinchley	1379
Parmeko	P2641
Partridge	P4073
Wynall	W.1452

Loudspeaker sockets (red and black). Belling Lee L.316

Recessed coaxial output socket. Belling Lee L.734/S

Record / playback head coaxial socket. Belling Lee L.604/S

Erase head coaxial socket. Belling Lee L.604/S

Supply input socket. Elcom PO4

Input jack (radio). Igranic P71

Input jack (microphone). Igranic P72

B9A valveholder (two). McMurdo BM9/U

B9A nylon-loaded valveholder with screening skir (two). McMurdo XM9/AU, skirt 95

Record / playback switch.
Shirley Laboratories, Ltd., 16370/B3
Specialist Switches, SS/567/A
(Note: Contacts 9 and 12 on wafer 2 are not used)

Tone control switch.
Shirley Laboratories, Ltd., 16368/B1
Specialist Switches, SS/567/B

Equaliser switch.
Shirley Laboratories, Ltd., 16369/B1
Specialist Switches, SS/567/C

Five-way tagboard (two), Bulgin C120

Ten-way tagboard (two), Bulgin C125

Ceramic stand-off insulator (may not be required); must be capable of withstanding 350V

stage when recording and as an amplifying stage during playback.

(*c*) Type EL84, output pentode. When recording this is used as the oscillator valve, and in the playback process, it is used in a power output stage to drive the loudspeaker.

(*d*) Type EM81, tuning indicator, used in the recording level stage.

(*e*) Type OA81, germanium diode, used as the indicator-circuit rectifier.

Input Stage

The pentode, type EF86, acts as a voltage amplifier for both recording and playback processes. It is possible to record from either microphone or radio sources. Both inputs are fed to the grid of the valve, the radio input being attenuated to the level of the microphone input. The switching is achieved by inserting the jacks so that only one input may be used at a time.

Equaliser Stage

One section of the double triode, type ECC83, is used in the second or equaliser stage of both processes. The tone control which is operative only during playback, is also located in this stage.

The high-frequency equalising boost is applied during the recording process by means of negative feedback taken through parallel-T networks from the anode of the first section of the ECC83 to its grid. Capacitor values giving the appropriate treble boost for tape speeds of $3\frac{3}{4}$ and $7\frac{1}{2}$ inches per second are arranged on the switch SC. The switch is shown in Fig. 2 in the position for $7\frac{1}{2}$ inches per second. The bass boost is provided during the playback process through the R–C feedback circuit also located between the anode and grid of the first section of the double triode. The section SA2 of the record/playback switch SA includes the parallel-T or series feedback networks in the circuit as is appropriate. In Fig. 2 the switch is in the recording position. The switch SB operates as the tone control for the playback process. The positions of SB introduce either a capacitive shunt across the resistive arm of the series feedback network or a resistive shunt across the capacitive arm of the feedback loop. Thus, either bass or treble attenuation respectively can be obtained.

A low-level output of 150mV, having a source impedance of 20kΩ, can be taken from the anode load of this stage of the amplifier and can be used either during recording for monitoring purposes, or during playback for feeding an external preamplifier and power amplifier.

Recording Output Stage

The output from the anode of the equaliser stage is taken to the grid of the second section of the double triode by way of the gain control RV25. Further high-frequency boost is added to the recording signal by the capacitor C18 in combination with the resistor R20.

The recording signal from the anode of the second section of the ECC83 is taken by way of a parallel-T network to the recording head. The network presents its highest impedance at the biasing frequency. Bias is fed to the recording head immediately after the T-network. This arrangement produces a substantially constant current drive to the recording head and provides efficient rejection of the bias voltage at the anode of the output valve.

H.F. Oscillator (Record) or Power Ontput Stage (Playback)

The output pentode, type EL84, acts as an audio output stage during playback. In the recording process, the EL84 is used to provide the h.f. oscillations for the biasing and erasing signals.

The bias signal is introduced into the recording head through the capacitor C25, the value of which determines the bias current flowing in the head. The bias voltage is obtained from the anode of the EL84. The arrangement of the oscillator circuit and the choice of the oscillator coil will depend on the impedance of the combined record/playback head and the erase head. The details given here are for record/playback heads having an impedance between 15 and 30kΩ, and erase heads having an impedance between 200 and 300Ω. Details for heads with other values of impedance should be obtained from the manufacturer of the tape deck used.

The bias oscillator coil and the primary winding of the output transformer are arranged in series. The latter is by-passed by the switch SA8 when in the recording position.

The presence of the capacitor C26 prevents an abrupt cessation of the oscillations when the amplifier is switched from the recording to the playback position, and thus prevents magnetisation of the record playback head.

The erase head is earthed for the playback process by the switch SA5. On playback, negative feedback is taken from the secondary winding of the output transformer to the cathode of the second section of the double triode. The harmonic distortion in the output stage is not more than 3% at 1kc/s for an output level of 3 watts.

The power output from the playback amplifier is taken by way of the transformer T1 to either a 3·75Ω or a 15Ω speaker.

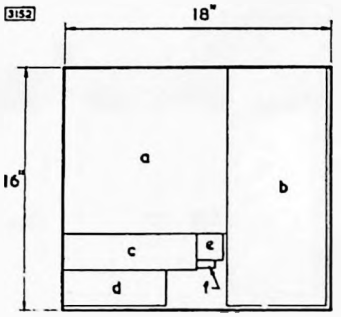


Fig. 3—ALUMINIUM SHEET FOR CHASSIS

Recording Level Indicator

A tuning indicator, type EM81, is fed from the anode of the second section of the ECC83 through a detector circuit using a germanium diode, type OA81.

The value of the resistor R31 in the target anode circuit governs the sensitivity of the indicator, and has been chosen to give a sufficiently high sensitivity to allow a large series resistance R24 to be used between the diode and the second anode of the ECC83. This large resistance minimises the loading effects on the recording output stage.

TABLE I

Switch position	Tape speed = $7\frac{1}{2}$ in. sec		Tape speed = $3\frac{3}{4}$ in. sec	
	Frequency (c/s)	Attenuation (dB)	Frequency (c/s)	Attenuation (dB)
1	100	−8	100	−8
2	100	−4	100	−4
3	—	Flat	—	Flat
4	10,000	−4	5000	−4
5	10,000	−8	5000	−8

The operating conditions of the EM81 are normally chosen so that the target shadow 'closes' for a recording current of 200μA. They can however be chosen so that the shadow 'closes' at lower peak recording levels if reduced peak distortion is desired at the expense of the signal-to-noise ratio.

In the playback position, switch SA6 disconnects the recording-level indicator stage from the h.t. supply, and this serves as a reminder of the position of the record/playback switch SA.

CHASSIS CONSTRUCTION

The chassis is made up of six separate pieces of 16 s.w.g. aluminium sheet. The dimensions (in inches) of these are:

(*a*)	Main chassis	11 × 11
(*b*)	Base	$15\frac{3}{4} \times 6\frac{3}{8}$
(*c*)	Internal screen	$9 \times 2\frac{3}{8}$
(*d*)	Internal screen	$7 \times 2\frac{3}{8}$
(*e*)	EM81 mounting bracket	$1\frac{3}{4} \times 1\frac{3}{4}$
(*f*)	Small bracket	$1\frac{1}{4} \times \frac{1}{2}$

The six pieces can all be cut from one sheet 18 in. long and 16 in. wide if the arrangement shown in Fig. 3 is adopted. There is enough spare metal at the edges to allow for the actual cutting. Each piece should be marked as shown in the chassis drawings of Fig. 27, and the holes indicated should be cut. To ensure that the pieces fit together properly, it is important that, when bending the sheets, the scribed lines should lie exactly along the angles.

The holes for mounting the output transformer on top of the chassis should be drilled in the positions shown in Fig. 27. With some transformers, it may be necessary to cut another hole, 7/16 inches in diameter, to take a rubber grommet through which the leads can pass to the underside of the chassis. The mounting holes should be fitted with self-tapping screws or hank bushes (whichever are required) to give the anchoring points for the output transformer.

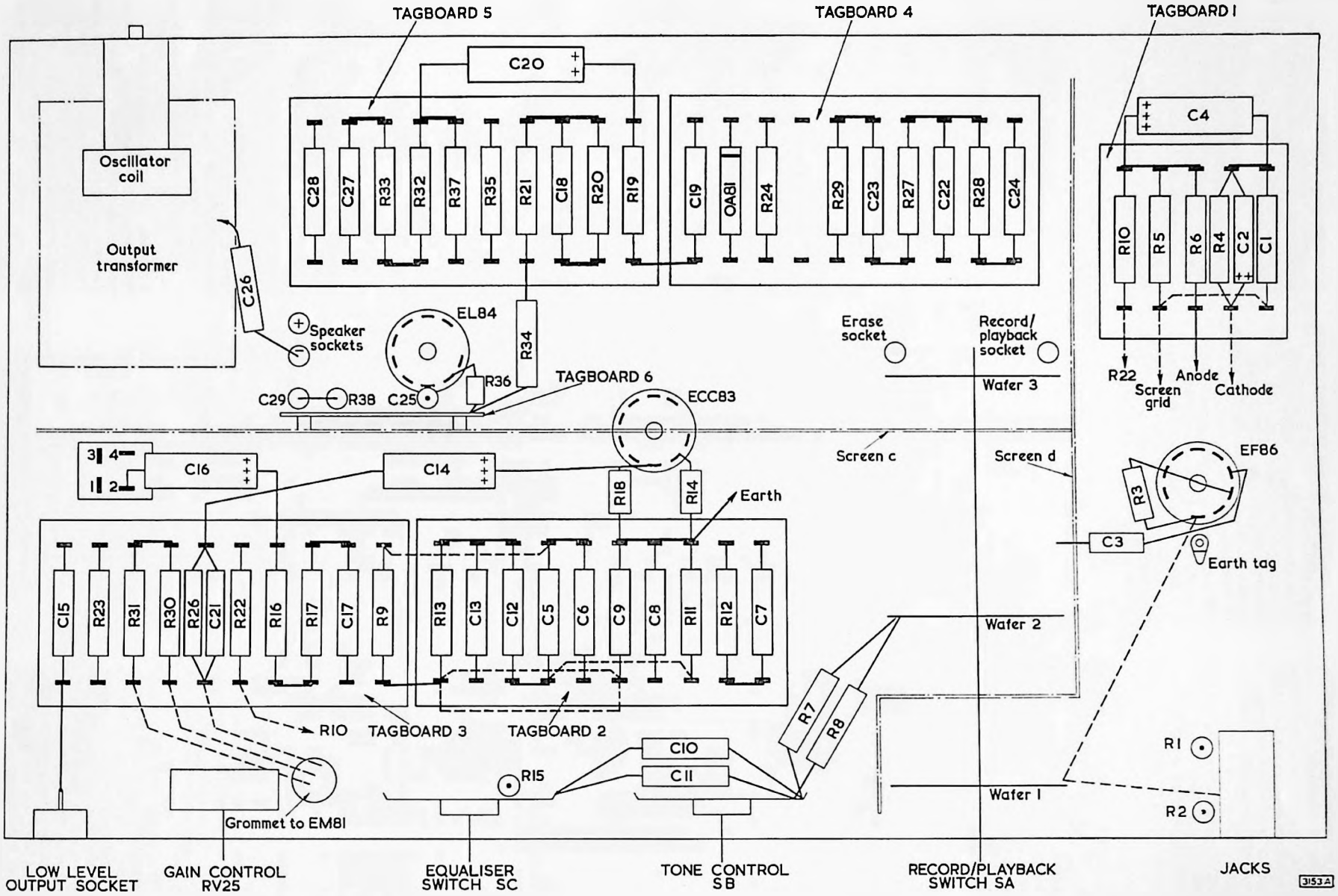
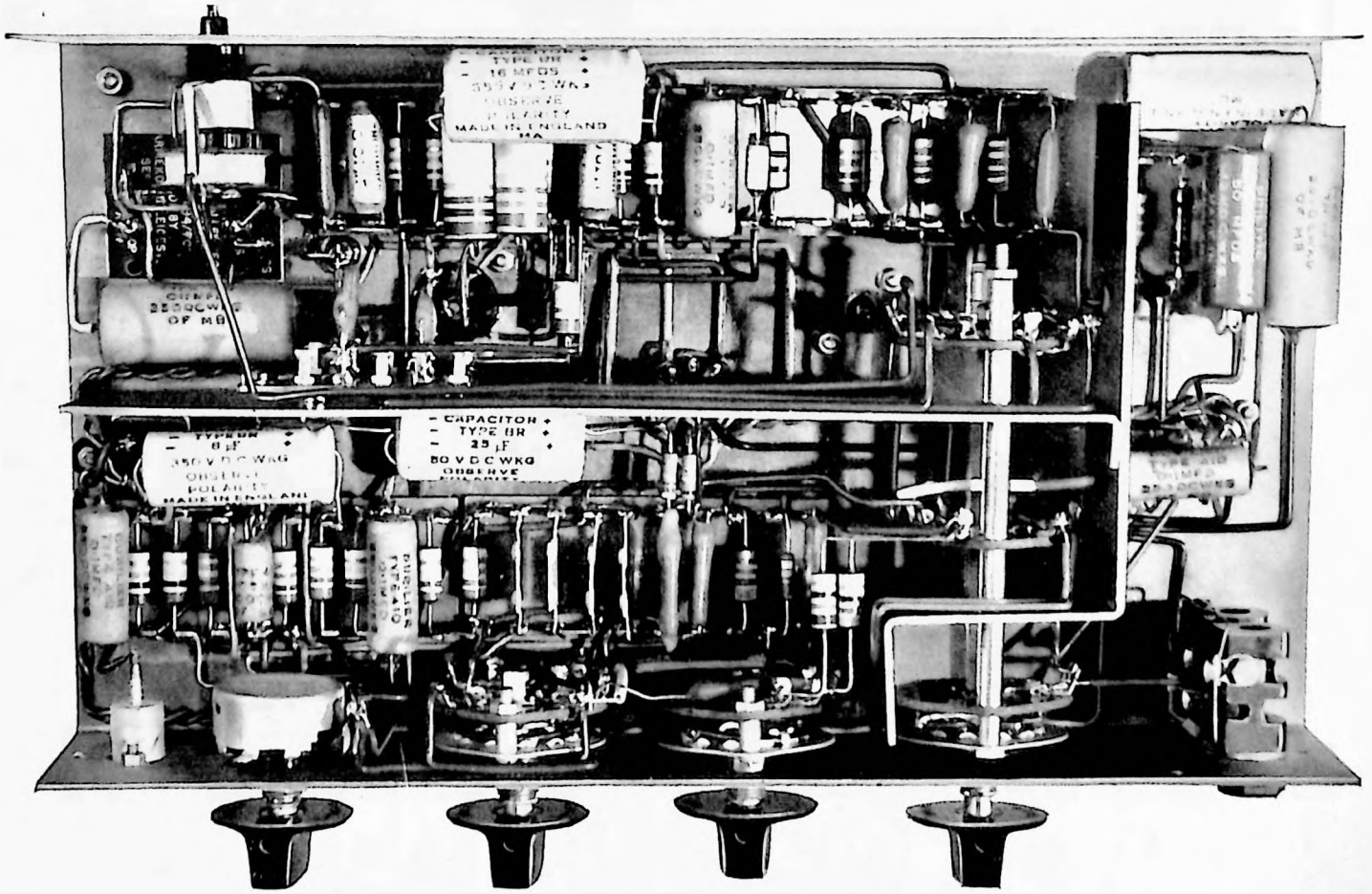


Fig. 4—COMPONENT LAYOUT DIAGRAM (Components which would obscure parts of the layout have not been shown)



PHOTOGRAPH OF UNDERSIDE OF PROTOTYPE AMPLIFIER

ASSEMBLY AND WIRING DETAILS

In this section, all positional references to the amplifier should be interpreted as follows: The chassis is upside down for wiring. The top of the chassis is the surface nearer to the viewer; the bottom is the furthermost surface. The front of the chassis is the panel with the control knobs on it.

Initial Assembly

Before assembling the record/playback switch SA around the screens, it will be found convenient to fix some of the components to the chassis. These components are:

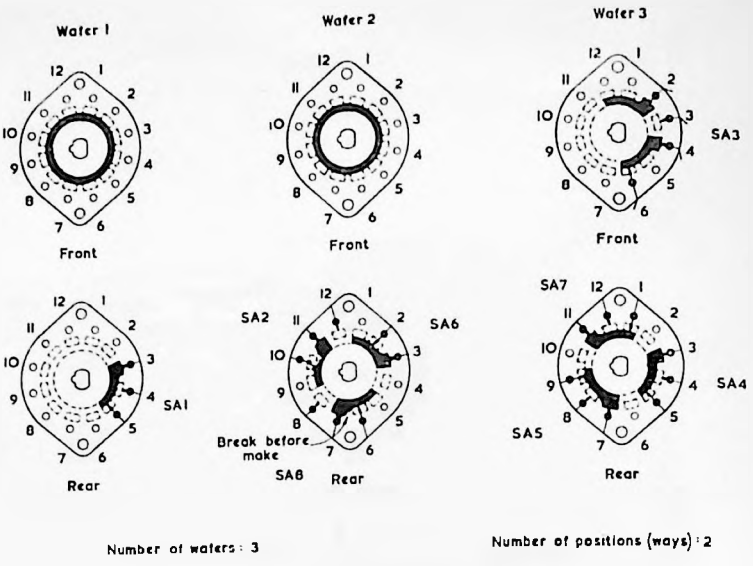
(1) The erase and record/playback coaxial sockets which have to be fitted to the chassis beneath wafer 3 of switch SA.
(2) The nylon-loaded valveholder for the ECC83 complete with the skirt for the screening can. The gap between pins 1 and 9 should face towards the coaxial sockets.
(3) A five-way tag board (Bulgin, type C120). This should be bolted to the internal screen c in the position marked 'Tagboard No. 6' in the screen assembly diagram of Fig. 6.
(4) The small fixing bracket f, which should be bolted to the screen c as indicated in Fig. 6.

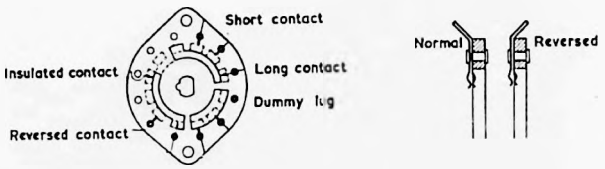
After fixing the components listed above, the construction is continued by assembling wafers 1 and 2 of switch SA around the internal screen d. The wafers should be arranged so that positions 6 and 7 are at the bottom and the face of each wafer described as the 'rear' in the switch diagram (Fig. 5) is farthest from the switch plate. The internal screen c should be added to the assembly, both screens should be bolted together, and wafer 3 should be fitted in position, again with its 'rear' face (Fig. 5) farthest from the switch plate. The general arrangement of the switch wafers and internal screens is shown in Fig. 6. Details of spacers required for the assembly are shown in Fig. 5.

The switch and screens should be fitted to the main chassis, a shakeproof washer being used between the switch plate and the front panel of the chassis. It will be necessary to drill a hole in the main chassis so that the fixing bracket f, attached to the internal screen c, can be bolted down.

The assembling of the unit is best continued by referring to the diagram giving the component layout (Fig. 4). The components that should be fitted at this stage are listed below, and some remarks are made when the exact positioning of the component is perhaps doubtful.

(1) EM81 mounting bracket—The valveholder should be fastened to the bracket so that the solder tags are on the same side as the flange on the bracket. The gap between pins 1 and 9 of the holder should face the flange, to ensure that the tuning eye of the EM81 faces forwards. The level indicator should appear in the centre of the front panel of the equipment, and the bracket should be bolted to the chassis in the correct position for this to be so.
(2) Input jacks—The soldering tags should be on the inside, and the radio jack, which has two contacts only, should be beneath the microphone jack.
(3) EF86 valveholder (this should be a nylon-loaded type with a screening skirt)—The gap between pins 1 and 9 should face forwards, and a soldering tag should be bolted under the front nut.
(4) EL84 valveholder—The gap between pins 1 and 9 should be directed away from the output transformer.





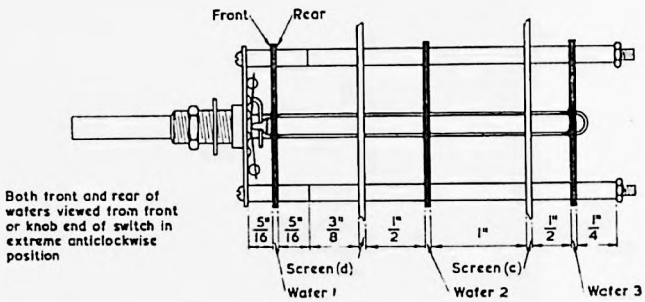


Fig. 5—RECORD/PLAYBACK SWITCH DETAILS

(5) Bias oscillator coil.
(6) Recessed coaxial socket for the low-level output.
(7) Supply input socket—Pins 1 and 3 should be on the outside.
(8) Loudspeaker sockets—The two sockets should be arranged with the black one in front.

Wiring Instructions

With this set of instructions it should be possible to complete the wiring without reference to the circuit diagram. It will be of help, however, to make reference to the diagram, especially if it is intended to use different coloured wires for various sections of the circuit.

It will obviously be more convenient to solder most of the smaller components to the tagboards before the boards are mounted in the amplifier. Several general remarks may be of use in assembling these small components.

The small carbon resistors should be laid across two tags on the board, and the lead wires bent around the tags in the manner shown in Fig. 7. If the tagboard wiring diagrams show that neighbouring tags are to be connected together, the lead wires of

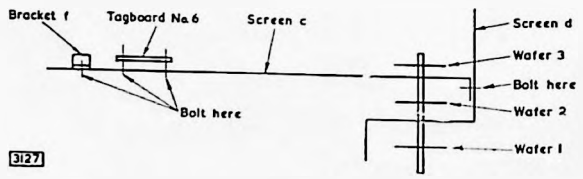


Fig. 6—SCREEN POSITIONS

the appropriate components should be cut to lengths sufficient to allow this.

Waxed capacitors, silvered mica capacitors and high stability resistors will require longer leads so that they are not overheated when they are soldered into position. The leads should be bent as shown in Fig. 8, care being taken in doing so to avoid making sharp bends very close to the ends of the components.

Where dotted lines indicate links between tags, the connections should be made with insulated wire.

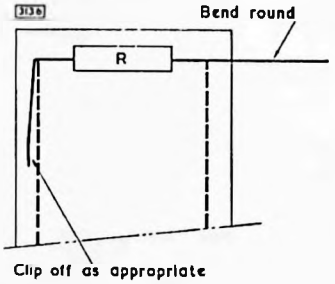


Fig. 7—MOUNTING OF SMALL COMPONENTS

Heater supply

This is the first stage in the wiring of the amplifier. From pins 1 and 3 of the supply input socket (Fig. 9) a pair of twisted wires should be taken to pins 4 and 5 on the EL84 valveholder. From these pins the wires should be taken to the valveholder for the ECC83. This valve has two heater sections: these should be wired in parallel, pins 4 and 5 being strapped together. The heater-supply connection should then be made to this common junction and pin 9.

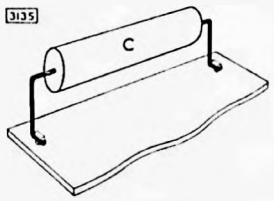


Fig. 8—MOUNTING OF LARGE COMPONENTS

The supply wiring should be continued from the ECC83 to pins 4 and 5 of the EF86 holder on the other side of the internal screen d, the leads passing through the cut-out in the screen. To complete the heater wiring, another pair of leads should be

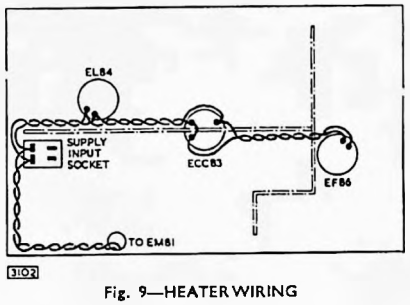


Fig. 9—HEATER WIRING

taken from the supply input plug through the rubber grommet to pins 4 and 5 of the EM81 holder. Sufficient wire should be left in this last connection to allow for Tagboard No. 3 to be fitted.

Input stage (valve V1, type EF86)

The assembly of this stage should be started by wiring Tagboard No. 1, and the components: R10 (33kΩ), R5 (1MΩ), R6 (220kΩ), R4 (2·2kΩ), C1 (0·5μF), C2 (50μF) and C4 (8μF) should be fitted to a small tagboard (Bulgin, type C120) as shown in Fig. 10. It is important that the polarity of the electrolytic capacitors C2 and C4 should be correct. The assembled tagboard should be bolted to the chassis in the position indicated in the layout diagram of Fig. 4.

On the EF86 valveholder shown in Fig. 11, pins 2 and 7 should be strapped to the centre spigot and a wire should be taken from the spigot to the solder tag. (This should be the only earth connection in the amplifier made directly to the chassis: additional connections to the chassis are likely to cause increased mains hum.) The connection between pins 3 and 8 should be made with insulated wire.

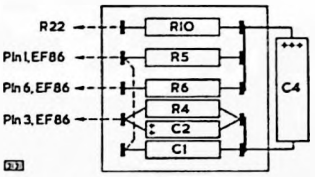


Fig. 10—TAGBOARD No. 1

The grid resistor R3 (2·2MΩ) should be soldered directly across the valveholder between pins 2 and 9. Pin 9 should be connected to position 5 on section SA1 of the record/playback switch with an insulated wire.

The resistors R1 (680kΩ) and R2 (5·6kΩ) should be wired directly across the tags of the input jacks, as shown in Fig. 12. The output from the jacks should be taken to position 3 of switch SA1. Earth connections from the jacks and from the junction of capacitors C1 (0·5μF) and C4 (8μF) should be made to the nearest convenient earth point on the valveholder.

Connections should be made from the cathode resistor R4 (2·2kΩ) on Tagboard No. 1 to pin 3 of the EF86 valveholder, from the screen resistor R5 (1MΩ) to pin 1 and from the anode resistor R6 (220kΩ) to pin 6.

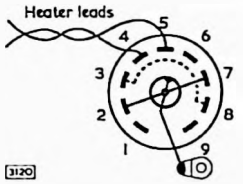


Fig. 11—EF86 VALVEHOLDER

The feed for the next stage is taken from the anode (pin 6) of the EF86 to position 10 on switch SA2. The capacitor C3 (0·1μF) should be wired between these two points, sleeving being used on the bare wires, with the wire passing through the rubber grommet (V in Fig. 27) in the internal screen d. A wire should run through the other grommet (U) in the screen from position 4 on switch SA1 to the double contact in position 4 on sections SA3 and SA4.

The EM81 and first half of the ECC83

This stage incorporates the tone control components and the equalisation networks for tape speeds of 3¾ and 7½ inches per second.

The assembly of this stage should start with the wiring of Tagboard No. 3 (Bulgin, type C125). Reading from top to bottom in Fig. 13, the components to be fitted to the tagboard are: C15 (0·1μF), R23 (10kΩ), R31 (100kΩ), R30 (560kΩ), R26 (1·0MΩ), C21 (0·05μF), R22 (27kΩ), R16 (22kΩ), R17 (180kΩ), C17 (0·1μF) and R9 (220kΩ). The connections should be made as shown in the figure. Components R26 and C21 are mounted between the same tags. When assembled and wired, the tagboard should be bolted to the chassis.

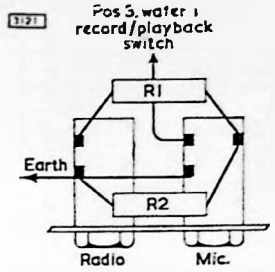


Fig. 12—INPUT-ATTENUATING RESISTORS

The construction should proceed with the wiring of the h.t. supply to the EM81. A wire should be taken from pin 4 of the supply input socket to position 2 of switch SA6 by the path indicated in Fig. 14. A connection should then be made (again along the path indicated in Fig. 14) from position 3 of SA6 to the junction of R30 (560kΩ) and R31 (100kΩ). Wires should be taken from the other end of R30 (560kΩ) by way of the grommet to pin 7 of the EM81 valveholder and from the other end of R31 (100kΩ) through the grommet to pin 9 of the holder. The grid (pin 1) of the EM81 should be joined through the grommet to the nearer of the tags to which both R26 (1MΩ) and C21 (0·05μF) are connected.

A wire for the h.t. supply should be connected to the junction of the resistors R16 (22kΩ) and R22 (27kΩ) on Tagboard No. 3 and taken along the front of the chassis as shown in Fig. 14 to the resistor R10 (33kΩ) on Tagboard No. 1.

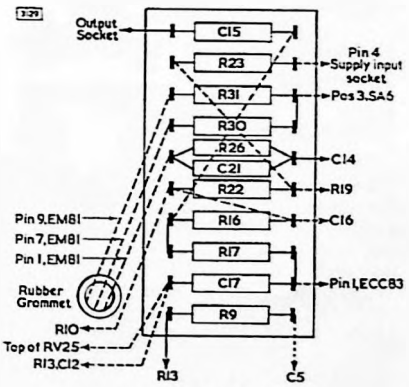


Fig. 13—TAGBOARD No. 3

The components R13 (220kΩ), C13 (68pF), C12 (68pF), C5 (68pF), C6 (68pF), C9 (150pF), C8 (150pF), R11 (100kΩ), R12 (270kΩ) and C7 (270pF) should be arranged on a large tagboard (Bulgin, type C125) as shown in the diagram for Tagboard No. 2 in Fig. 15. The assembled board should be fitted to the chassis, the bolt used for one end of the EM81 bracket being used to hold the board. The connections from Tagboard No. 2 to R9 (220kΩ)

on Tagboard No. 3 should be made as shown in the component layout diagram of Fig. 4.

From position 10 on switch SA2 (the point to which the signal from the EF86 is taken) a lead should be joined directly to pin 2 on the ECC83 valveholder. The grid resistor R14 (560kΩ) should be wired between pin 2 and the junction of C8 (150pF) and R11 (100kΩ), which is an earth point. This earth point should be

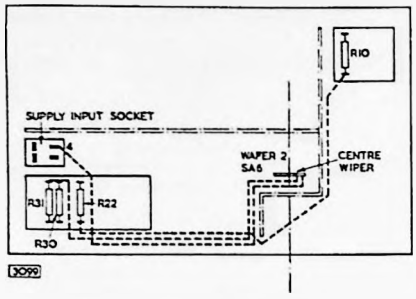


Fig. 14—H.T. SUPPLY FOR EM81

joined to the centre spigot of the ECC83 valveholder and then through the cut-out in the internal screen to the earth tag near the EF86. The cathode resistor R18 (4·7kΩ) should be connected between pin 3 of the ECC83 holder and the earth point at the junction of C8 and R11.

A lead should be taken along the edge of the tagboards from the anode pin (No. 1) of the ECC83 to the junction of R17 (180kΩ) and C17 (0·1μF) (Tagboard No. 3).

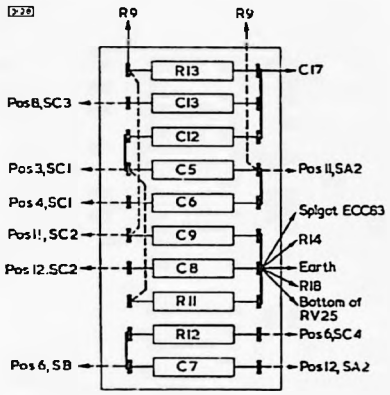


Fig. 15—TAGBOARD No. 2

The resistors R16 (22kΩ) and R17 (180kΩ) together form the anode load of the stage: the low level output of the amplifier is taken from the junction of the two components. The connection between the junction and the blocking capacitor C15 (0·1μF) has already been made, but the other end of the capacitor should now be joined to the output socket immediately above it. The plastic which insulates the output socket is easily melted, so it is recommended that a plug be inserted to hold the centre pin when soldering the capacitor to the socket.

The gain control should be fastened into the chassis with the connecting tags away from the output socket. The lower connecting tag on the control should be joined to the earth point at the junction of C8 (150pF) and R11 (100kΩ) on Tagboard No. 2 and also to the far side of the resistor R26 (1·0MΩ) on Tagboard No. 3, this latter connection being continued to earth at pin 2 on the supply input socket. Also, from the lower connecting tag of the gain control,

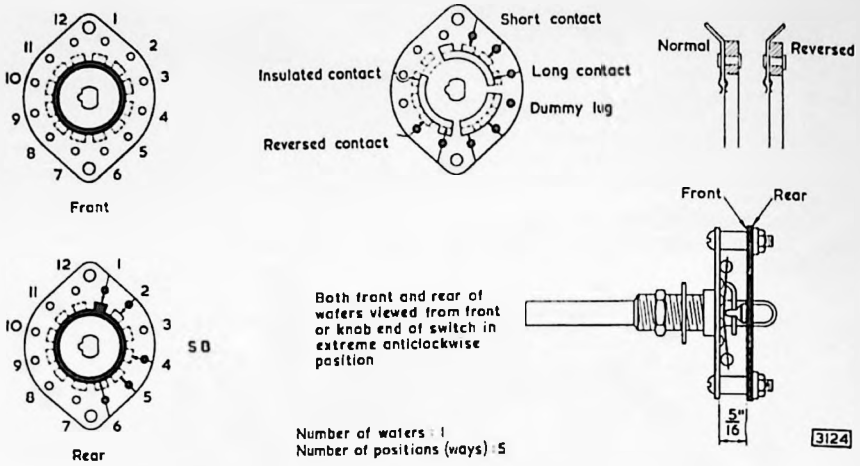


Fig. 16—TONE CONTROL SWITCH DETAILS

another earth lead should be taken through the rubber grommet to pin 2 on the EM81 valveholder.

The top of the gain control is fed from the anode of the first section of the ECC83 through the capacitor C17 (0·1μF) on Tagboard No. 3, and the connection between the capacitor and the control should be made.

The two remaining switches should be fitted as shown in the layout diagram in Fig. 4, with the positions 6 and 7 at the bottom. It is recommended that no washers be used between the switch plate and the chassis, or there will be insufficient room for wiring the switch contacts. The wafer and contact diagrams for the tone control switch SB and the equaliser switch SC are shown in Figs. 16 and 17 respectively.

Feedback is taken from the top of the gain control to the grid of the first section of the ECC83 by two different networks—one for recording, and one for playback. The circuit of Fig. 18 shows the playback feedback network in a rather simpler form than in the complete circuit diagram of the amplifier.

From the top of the gain control a lead should be taken to position 2 on the section SC4 of the equaliser switch SC. (This contact is on the front of the wafer.) The resistor R15 (270kΩ) should be soldered directly across the switch SC4 from positions 6 to 2. From position 6 a lead should be taken across Tagboard No. 2 to the far side of the resistor R12 (270kΩ). The capacitor C7 has already been joined to the near side of R12: this junction should be connected to position 6 of the tone control SB, which is situated immediately above it. The other end of the capacitor C7 (270pF) should be joined to position 12 on switch SA2. In the playback position this will be connected to the first grid of the ECC83.

The components for the tone control should be wired directly between the contacts on the switches as follows:

C10 (330pF)—from position 5 on SB to position 2 on SC4
C11 (100pF)—from position 4 on SB to position 2 on SC4
R8 (4·7MΩ)—from position 2 on SB to position 12 on SA2
R7 (1·8MΩ)—from position 1 on SB to position 12 on SA2

The circuit of Fig. 19 shows, in a simplified form, the record feedback network. The three switches are ganged together, and appear on the rear of the wafer in the equaliser switch SC. In the position for a tape speed of 3¾ inches per second, the contacts are closed, and the value of the capacitance in the network is doubled.

The end of the capacitor C17 (0·1μF) on Tagboard No. 3 which is nearer to the gain control should be connected over the tagboards to the junction of R13 (220kΩ) and C12 (68pF) (Tagboard No. 2). From the junction of R9 (220kΩ) (Tagboard No. 3) and C5 (68pF) (Tagboard No. 2) a connection should be made to position 11 on the switch section SA2, care being taken to keep

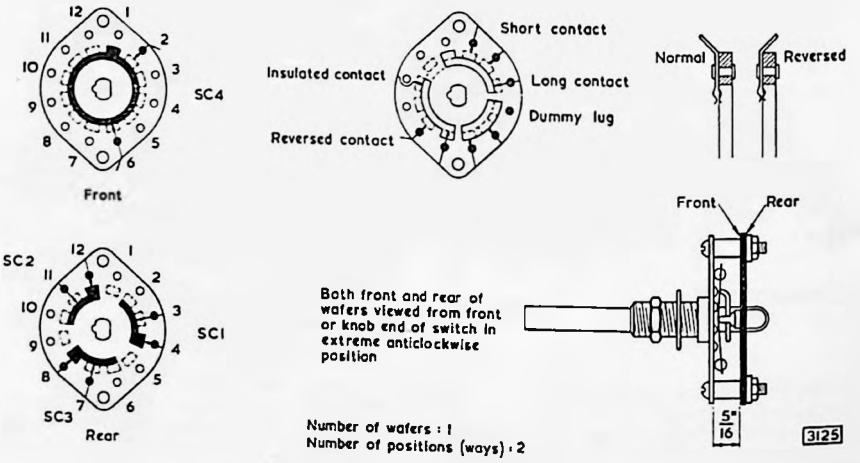


Fig. 17—EQUALISER SWITCH DETAILS

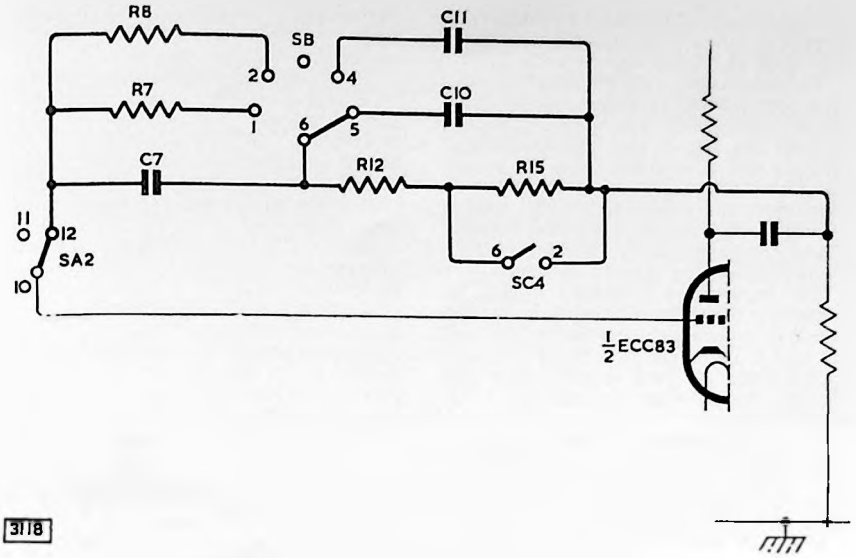


Fig. 18—TONE-CONTROL CIRCUIT

this lead well away from the lead connected to the anode.

On the rear of switch SC, positions 3 and 7 should be joined together, and then from the near ends of the components, the following connections to SC should be made:

C5 (68pF) to position 3
C6 (68pF) to position 4
C8 (150pF) to position 12
C9 (150pF) to position 11
C13 (68pF) to position 8

The signal is taken from the centre tag of the gain control RV25 to the grid of the second section of the double triode ECC83. A lead should be taken from the centre tag down and under the tagboards, through the internal screen c to pin 7 on the ECC83 valveholder.

The second half of the ECC83

The construction of this stage should be started by wiring the following components to a ten-way tagboard (Bulgin, type C125) in the manner shown in Fig. 20: C28 (3300pF), C27 (0·01μF), R33 (18kΩ), R32 (22kΩ), R37 (150Ω), R35 (6·8kΩ), R21 (220 or 470Ω), C18 (0·02μF), R20 (1·5kΩ) and R19 (100kΩ). The assembled board should be bolted to the chassis in the position indicated for Tagboard No. 5 in the layout diagram (Fig. 4). If the output transformer has not already been fitted, it should now be bolted to the chassis.

It will be found convenient to proceed with the construction by wiring the h.t. supply to the EL84. A connection should be made from position 6 on switch SA8 to position 2 on SA6. From position 7 on SA8, a lead should be taken under the internal screen c, past the ECC83 and along the front of Tagboard No. 5 to the primary winding of the output transformer. It is essential that this lead should be kept well away from the grid of the second section of the ECC83. A suitable path for this lead to follow is shown in Fig. 21.

From position 8 on SA8, another lead should be taken to the far side of the resistor R35 (6·8kΩ) on Tagboard No. 5 and thence to the other side of the primary winding of the output transformer. The path for this connection is also shown in Fig. 21. If the transformer is such that connections to it have to be made through a rubber grommet, the lead from R35 (6·8kΩ) should be connected to an insulated tag fitted to some convenient bolt, and then taken from this point to the transformer primary. Fig. 21 should make the arrangement clear.

Pin 6 of the ECC83 holder should be joined to the near side of R19 (100kΩ); pin 8 should be connected to the near side of R20 (1·5kΩ); and the centre spigot of the valveholder should be connected to the nearer end of R21 (220Ω).

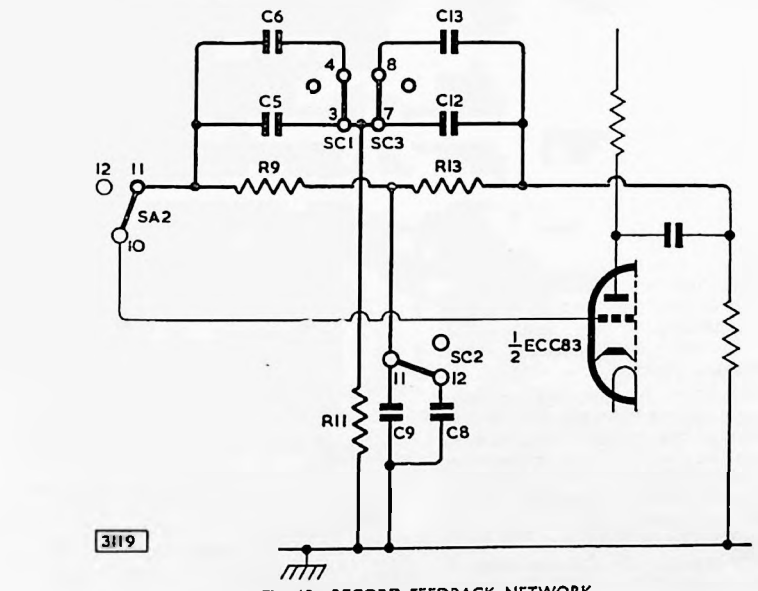


Fig. 19—RECORD FEEDBACK NETWORK

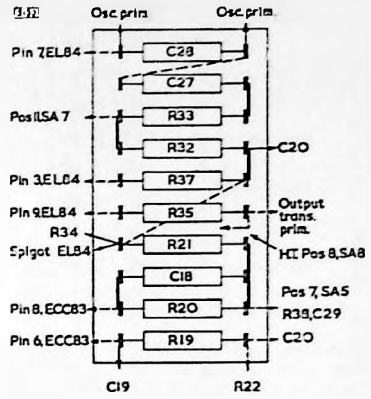


Fig. 20—TAGBOARD No. 5

Components should now be wired to the remaining tagboard (Tagboard No. 4, Bulgin, type C125, shown in Fig. 22). These components, reading from top to bottom, are: C19 (0·1μF), OA81, R24 (470kΩ), R29 (27kΩ), C23 (47pF), R27 (56kΩ), C22 (100pF), R28 (56kΩ) and C24 (47pF). In fitting the OA81, plenty of wire should be left at its ends to prevent any overheating of the diode when it is being soldered in position. Preferably, the leads should be held with pliers, which will act as a heat shunt. The end of the diode with the band printed on it should be connected to the resistor R24 (470kΩ).

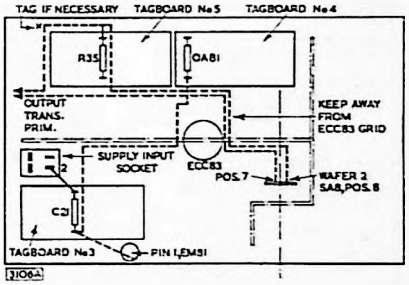


Fig. 21—H.T. SUPPLY FOR EL84

The anode pin has already been connected to the near side of the anode resistor R19 (100kΩ) on Tagboard No. 5 and the coupling capacitor C19 (0·1μF) on Tagboard No. 4 should be connected to this junction.

To connect the OA81 to the grid of the level indicator, a long lead should be taken from the front end of the diode (the end with lettering printed on it) past the ECC83 to the grid junction of C21 (0·05μF) and R26 (1MΩ) (Tagboard No. 3). The connection is shown in Fig. 21.

The junction of R27 (56kΩ) and C23 (47pF) (Tagboard No. 4) should be connected to position 12 on switch SA7. The junction of R28 (56kΩ) and C24 (47pF) should be joined to position 3 of SA3 and SA4, both front and back contacts being connected to this lead.

The record playback and the erase coaxial sockets should be connected to the switch SA, care again being taken when soldering to avoid overheating the plastic insulant. The record playback socket should be joined to position 5 of section SA4, and the erase socket should be wired to position 8 on section SA5.

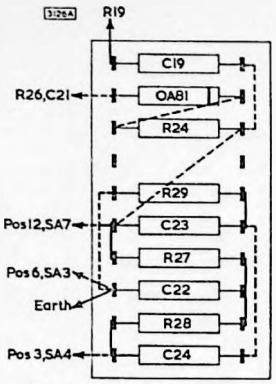


Fig. 22—TAGBOARD No. 4

Positions 6 (SA3), 2 (SA3) and 9 (SA5) on wafer 3 of switch SA should be joined together, and a lead should be taken from position 9 to the centre spigot of the ECC83 valveholder. Position 6 should be joined to the near end of the capacitor C22 (100pF) on Tagboard No. 4. From position 7 on section SA5, a lead should be taken under Tagboard No. 4 to the junction of R20 (1·5kΩ) and R21 (220Ω or 470Ω) on Tagboard No. 5.

The assembly of this stage is completed by wiring the h.t. supply to the valve as in Fig. 23. Pin 4 on the supply input socket should be connected to the resistor R23 (10kΩ) on Tagboard No. 3; the resistor R22 (27kΩ) again on Tagboard No. 3, should be connected to R19 (100kΩ) on Tagboard No. 5 by a lead running along the internal screen c up to the ECC83 holder, and then passing through the screen and continuing to the far side of the tagboard.

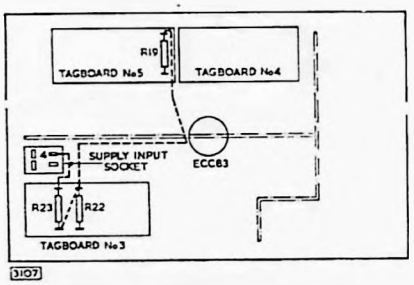


Fig. 23—H.T. SUPPLY FOR ECC83

The EL84 stage

The connections to the EL84 valveholder should be made to the components on Tagboard No. 5 as follows:

Pin 9 (the screen grid) to the near end of the resistor R35 (6·8kΩ);

Pin 3 (the cathode) to the near end of the resistor R37 (150Ω);

Pin 7 (the anode) to the near end of the capacitor C28 (3300pF);

The centre spigot to the earth point at the near end of the resistor R21 (220Ω or 470Ω).

The resistor R36 (1kΩ) should be joined to pin 2 (the grid) of the valveholder and also to the tag situated immediately above pin 2 at the bottom righthand corner of Tagboard No. 6 (see Fig. 24). From this tag, the grid resistor R34 (680kΩ) should be wired directly to the earth point at the near end of R21 (220Ω or 470Ω) (Tagboard No. 5).

The connections from the switch sections SA4, SA5 and SA7 on wafer 3 of the switch SA to Tagboard No. 6 are shown in Fig. 24.

From the tag at the junction of R34 (680kΩ) and R36 (1kΩ) (Fig. 24) a lead should be taken along the path shown to position 1 on section SA7. (This lead is shown as the second of the four parallel dotted lines drawn in Fig. 24 counting from the straight edge of the internal screen c).

The capacitor C25 (82pF) should be soldered to the tagboard, and the lower end should be connected to the anode (pin 7) of the EL84. The upper end should be connected along the path of the first of the parallel, dotted lines to position 3 on switch SA4.

A connection should be made from position 11 on SA7 to the junction of R32 (22kΩ) and R33 (18kΩ) on Tagboard No. 5 by means of a lead following the third dotted line and passing under Tagboard No. 6.

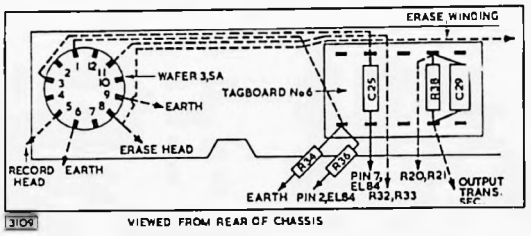


Fig. 24—INTERNAL SCREEN

A wire following the fourth dotted line, and passing along the top of Tagboard No. 6 should be soldered to position 8 on section SA5. The other end of this lead will be taken to the oscillator coil, details of which are given below.

The secondary winding of the output transformer should be connected to the two speaker output sockets. A lead should be taken from the earthed socket to the centre spigot of the EL84 holder.

Feedback is taken from the other end of the secondary winding of the output transformer to the cathode circuit of the second half of the ECC83 by way of a parallel combination of R38 (2·2kΩ) and C29 (1800pF). These two components should be soldered between two tags on Tagboard No. 6 and a lead should be taken to the 'live' speaker output socket from the lower end of the combination. The other end of the combination should be joined to the junction of R20 (1·5kΩ) and R21 (220 or 470Ω) on Tagboard No. 5 with a lead running down and across Tagboard No. 6 and under Tagboard No. 5.

It is essential that the feedback should be of the correct polarity. Negative feedback will reduce distortion; positive feedback will cause oscillation. Obtaining the desired (negative) feedback is a matter of trial and error. If the connections from the output secondary winding to the loudspeaker sockets are incorrect, oscillation will occur and the connections must be reversed.

If it is feared that the oscillation resulting from wrongly-phased feedback will, if prolonged, damage the speaker, then, instead of soldering the feedback lead in position, it should be left free until the completed amplifier can be tested. A momentary connection of the feedback lead to the 'live' speaker socket should then be sufficient to indicate the polarity of the feedback. If oscillation occurs, the transformer connections to the speaker should be reversed, when the feedback lead can safely be soldered to the 'live' socket.

The primary winding of the output transformer already has two leads connected to it. One of these leads is connected directly to position 7 of switch SA8. The h.t. tap on the oscillator coil should be joined to this end of the winding. The other lead from the transformer is connected to R35 (6·8kΩ), perhaps by way of an insulated tag. The capacitor C26 (0·5μF) should be wired between this lead and the earthed output socket.

The near end of C28 (3300pF) is already connected to the anode of the EL84. A connection should be made from this point to the anode end of the oscillator coil primary. The other end of C28 should be connected to the grid end of the coil.

The wire from position 8 on SA5 and the erase head should be connected to the flying lead of the coil. The remaining tag on the oscillator coil should be connected to the nearest convenient earth point.

Capacitors C14, C16 and C20

There are three electrolytic capacitors to be fitted to complete the wiring of the amplifier. It is essential that the polarity of these capacitors agrees with Figs. 25 and 26.

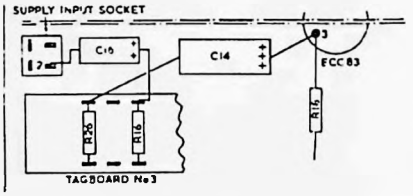


Fig. 25—ELECTROLYTIC CAPACITORS C14 AND C16

The capacitor C16 (8μF) should be connected between earth (pin 2 on the supply input socket) and the nearer end of R16 (22kΩ) on Tagboard No. 3. The cathode decoupling capacitor C14 (25μF) should be connected from pin 3 (cathode) on the ECC83 valveholder to the earth point at the end of R26 (1·0MΩ) on Tagboard No. 3.

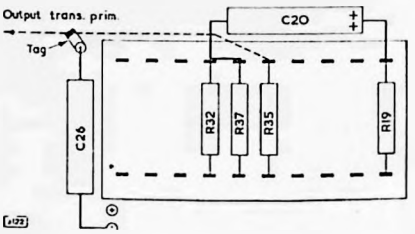
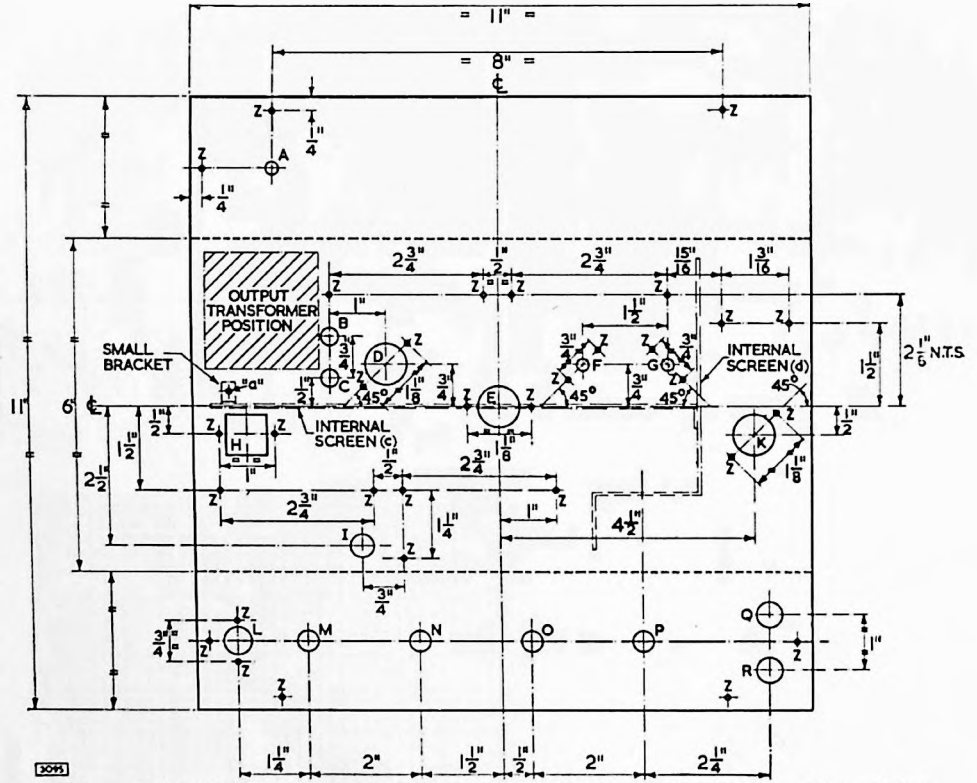
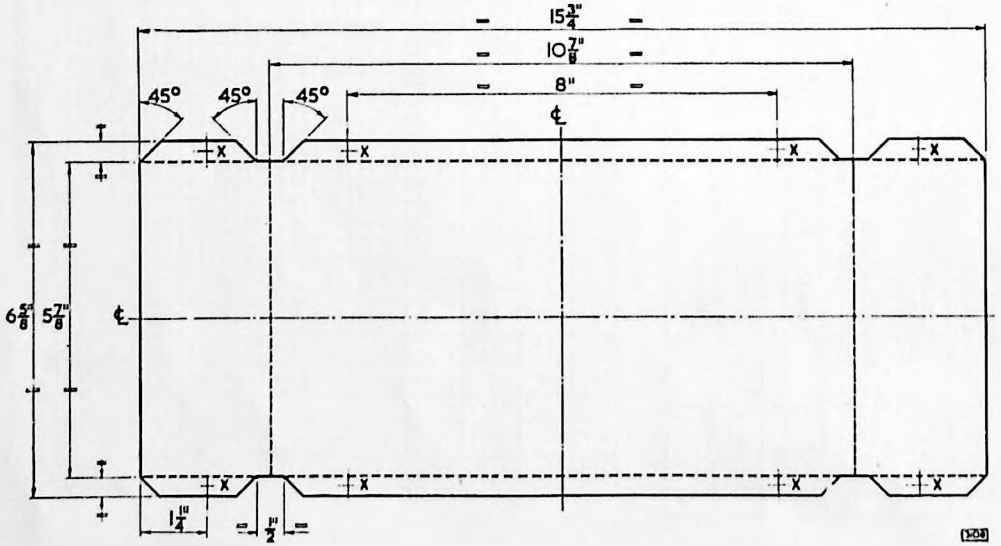


Fig. 26—ELECTROLYTIC CAPACITOR, C20

The capacitor C20 (16μF) should be wired between the end of the resistor R19 (100kΩ) farthermost from the ECC83 to the junction of the resistors R32 (22kΩ) and R37 (150Ω), all three resistors being located on Tagboard No. 5.



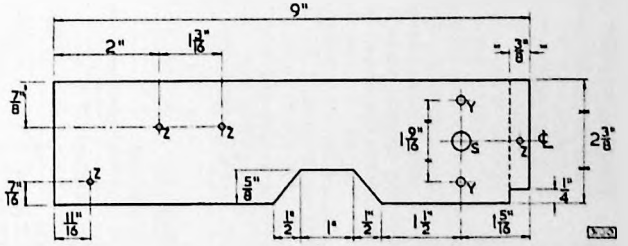
Above—(a) Main Chassis (hole marked 'a' should be made after assembly with No. 34 drill)



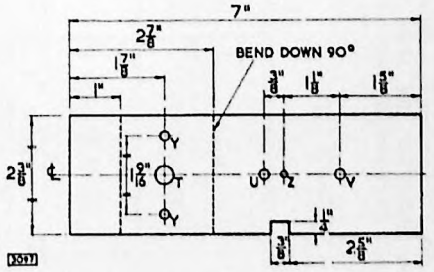
Below—(b) Base

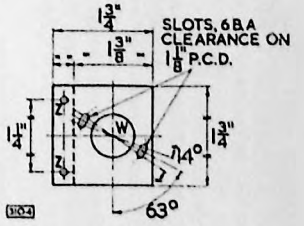
Hole	Dimensions	Use	List No.
A	¼ in. dia.	Oscillator coil	—
B	7/16 in. dia.	Loudspeaker socket, Belling Lee (Red)	L.316
C	7/16 in. dia.	Loudspeaker socket, Belling Lee (Black)	L.316
D	¾ in. dia.	B9A valveholder, McMurdo	BM9/U
E	¾ in. dia.	B9A nylon-loaded valveholder with screening skirt	XM9/AU; Skirt 95
F	¼ in. dia.	Coaxial socket, Belling Lee	L.604/S
G	¼ in. dia.	Coaxial socket, Belling Lee	L.604/S
H	11/16 × 11/16 in.	4-way input supply socket, Elcom	F04
I	7/16 in. dia.	Grommet	—
K	¾ in. dia.	B9A nylon-loaded valveholder with screening skirt	XM9/AU; Skirt 95
L	⅛ in. dia	Coaxial socket, Belling Lee	L.734/S
M	⅜ in. dia.	500kΩ potentiometer (logarithmic)	—
N	⅜ in. dia.	Equaliser switch SC	—
O	⅜ in. dia.	Tone control switch SB	—
P	⅜ in. dia.	Record/playback switch SA	—
Q	7/16 in. dia.	Jack (radio), Igranic	P71
R	7/16 in. dia.	Jack (mic.), Igranic	P72
S	⅜ in. dia.	Record/playback switch SA	—
T	⅜ in. dia.	Record/playback switch SA	—
U	7/16 in. dia.	Rubber grommet	—
V	7/16 in. dia.	Rubber grommet	—
W	¾ in. dia.	B9A valveholder, McMurdo	BM9/U
X	Drill No. 49	Self-tapping screw	⅜ in. × 4
Y	Drill No. 27	4 B.A. clearance hole	—
Z	Drill No. 34	6 B.A.clearance hole	—

Right—(c) Internal Screen



Below—(d) Internal Screen





Above—(e) EM81 Fixing Bracket

Below—(f) Small Bracket

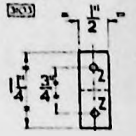


Fig. 27—CHASSIS DETAILS AND KEY TO HOLES. (The chassis sections should be bent up at 90° at all dotted lines except where the contrary is specifically indicated)

TEST INSTRUCTIONS AND PERFORMANCE CHARACTERISTICS

The four tests outlined below are intended as simple, yet quite effective, checks for the combined record/playback amplifier.

The values given in the various tables and figures were obtained from the prototype amplifier, using Brenell record/playback and erase heads. The bias current used throughout was 1·0mA at a frequency of 60kc/s, and the erase-head voltage was about 25V, again at a frequency of 60kc/s.

Test I — D.C. Voltages

The d.c. voltages at points in the equipment should be tested with reference to Table II. The results shown in this table were obtained using an Avometer, Model No. 8.

Test II — Amplifier on Playback

Three pieces of equipment are required for this test:

(1) A signal generator covering a frequency range from 20c/s to 20kc/s;
(2) A valve voltmeter covering a frequency range from 20c/s to 20kc/s;
(3) A load resistor of 15Ω with a 6W rating.

The 15Ω resistor should be connected to the speaker sockets. The record/playback switch SA should be in the playback position, and the tone control SB should be set for the flat response—that is, SB should be set at position 3.

A signal from the generator, having a frequency of 5kc/s, should be applied to the record/playback socket (which normally accommodates the connection plug from the record/playback head). The consequent output signals should be measured on the voltmeter, both at the low-level output socket and across the load resistor.

The input voltage should be adjusted to give an output voltage across the load resistor of 6·7V for both tape speeds, and the input required for this output should be noted. The voltage readings that should be obtained are given in Table III.

With the switch SC set to 7½ inches per second, and the conditions obtaining in the previous paragraph, the gain control should be varied until the output voltage across the load resistor drops to 250mV. The frequency of the signal should then be reduced to 100c/s and the values of boost given in Table IV should be observed at the 15Ω-load output. The switch SC should be changed to 3¾ inches per second, and the boost measurements should again be made.

The bass boost characteristics for both tape speeds are shown in Fig. 28.

The tone control circuit for bass loss should be tested for each tape speed while the 100c/s input signal is applied to the amplifier. Bass cut should be introduced by the switch positions for both tape speeds according to the values in Table V.

The tone controls should now be tested for positions 4 and 5.

TABLE II

D.C. Conditions

	Point of Measurement	Voltages (V) (a) SA in Record position	Voltages (V) (b) SA in Playback position	D.C. Range of Avometer* (V)
	C4	218	218	1000
	C16	240	240	1000
	C20	275	271	1000
	C100	<350	<350	1000
	C101	300	299	1000
EF86	Anode	65	65	1000
	Screen grid	80	80	1000
	Cathode	1·8	1·8	10
ECC83	First anode	160	160	1000
	First cathode	1·5	1·5	10
	Second cathode	170	170	1000
	Second cathode	1·5	1·5	10
EM81	Anode	60	0	1000
	Target	250	0	1000
EL84	Anode	300	260	1000
	Screen grid	240	260	1000
	Cathode	7·5	8·0	100

*Resistance of Avometer:
1000V-range, resistance = 20MΩ;
100V-range, resistance = 2MΩ;
10V-range, resistance = 200kΩ.

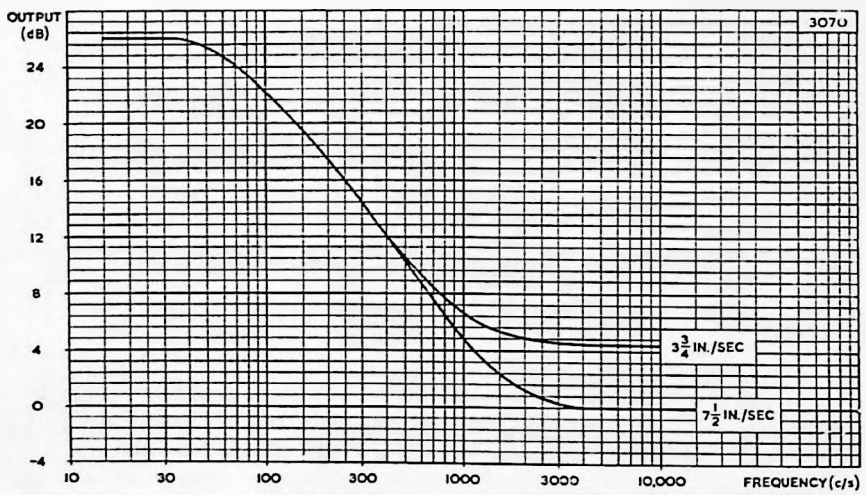


Fig. 28—BASS BOOST CHARACTERISTICS

TABLE III

Playback Sensitivity
(Signal frequency = 5kc/s)

Tape speed (in./sec)	Input (mV)	Output voltages: Low-level (mV)	Output voltages: 15Ω-load (V)
7½	3·5	110	6·7
3¾	2·0	110	6·7

TABLE IV

Bass Boost
Signal frequency = 100c/s
(Output voltage for 5kc/s = 250mV)

Tape speed (in./sec)	Voltmeter reading (V)	Output boost (dB)
7½	3·2	22
3¾	1·6	16

TABLE V

Tone Control — Bass Loss
Signal Frequency = 100c/s
Tape speed = 7½ or 3¾ in./sec

Switch position	Bass loss (dB)	Voltmeter reading (V)
3	0	1·6
2	−4	1·0
1	−8	0·6

For a tape speed of 7½ inches per second, the output voltage should be set to 250mV at a signal frequency of 10kc/s. The treble loss introduced by switch positions 4 and 5 should agree with the values given in Table VI.

For a tape speed of 3¾ inches per second and an output voltage of 250mV at a signal frequency of 5kc/s, the treble loss obtained should again be in accord with the values given in Table VI.

The loss introduced by the various tone-control switch positions is shown graphically in Figs. 29 and 30. The response for, say, position 1 of the switch should read as the curved section of the graph marked 'position' 1 and thereafter it is flat. No two curved sections of the graphs apply at any one time.

Test III — Amplifier on Record

The instruments required for this test are:

(1) A signal generator covering a frequency range from 20c/s to 20kc/s;

(2) A valve voltmeter covering a frequency range from 20c/s to 20kc/s.

For accurate results, two separate pieces of p.v.c. covered wire are recommended for the connections to the valve voltmeter. A coaxial cable may result in considerable errors in the measurements, because of the parallel capacitance which is introduced.

TABLE VI

Tone Control — Treble Loss
(i) Tape speed = 7½ in./sec
Signal frequency = 10kc/s
(ii) Tape speed = 3¾ in./sec
Signal frequency = 5kc/s

Switch position	Treble loss (dB)	Voltmeter reading (mV)
3	0	250
4	−4	150
5	−8	100

TABLE VII

Treble Boost
(Low-level output voltage for 1kc/s = 50mV)

Tape speed (in./sec)	Signal frequency (kc/s)	Voltmeter reading (mV)	Output boost (dB)
7½	10	200	12
3¾	5	252	14

TABLE VIII

Recording Sensitivity

Signal frequency	1	kc/s
Tape Speed	7½ or 3¾	in./sec
Voltage at second anode of ECC83	20	V
Microphone input	2·5	mV
Radio input	300	mV

The record/playback and erase heads should be connected to the appropriate sockets in the amplifier, and the equipment should be switched to the recording condition.

For a tape speed of 7½ inches per second, a signal at 1kc/s should be applied from the generator to the radio input socket. The magnitude of this signal should be such that an output of 50mV is obtained at the low-level output socket.

On switching the signal frequency to 10kc/s, the boost indicated in Table VII should be observed.

With a tape speed of 3¾ inches per second, the input signal at 1kc/s should again be adjusted to give a low level output of 50mV. Changing to an input frequency of 5kc/s should give the treble boost indicated in Table VII.

The treble boost characteristics for both tape speeds are shown in Fig. 31.

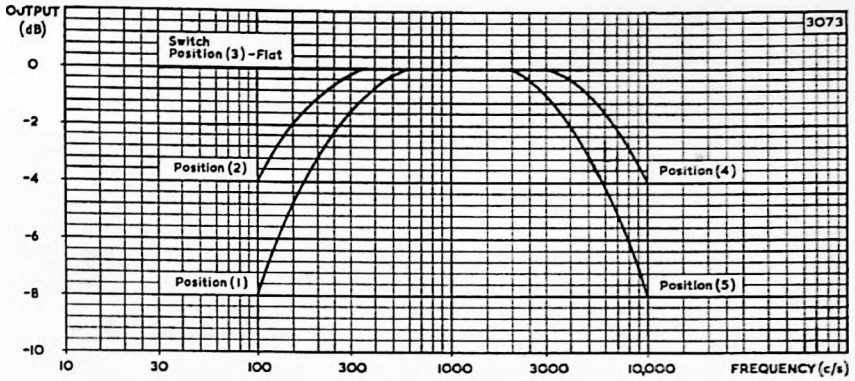


Fig. 29—TONE-CONTROL CHARACTERISTIC; TAPE SPEED = 7½ IN./SEC

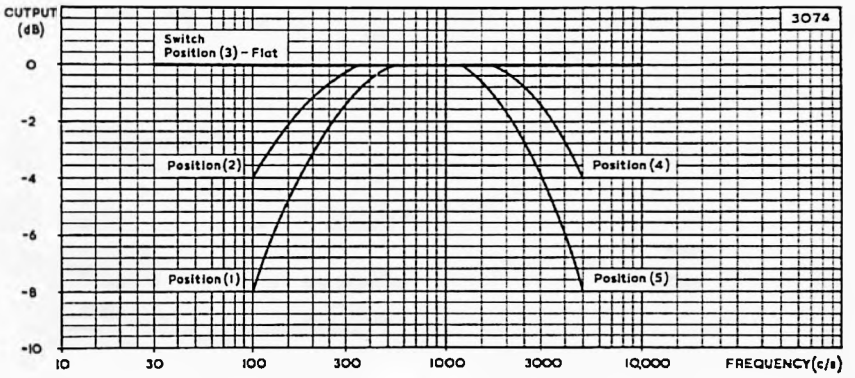


Fig. 30—TONE-CONTROL CHARACTERISTIC; TAPE SPEED = 3¾ IN./SEC

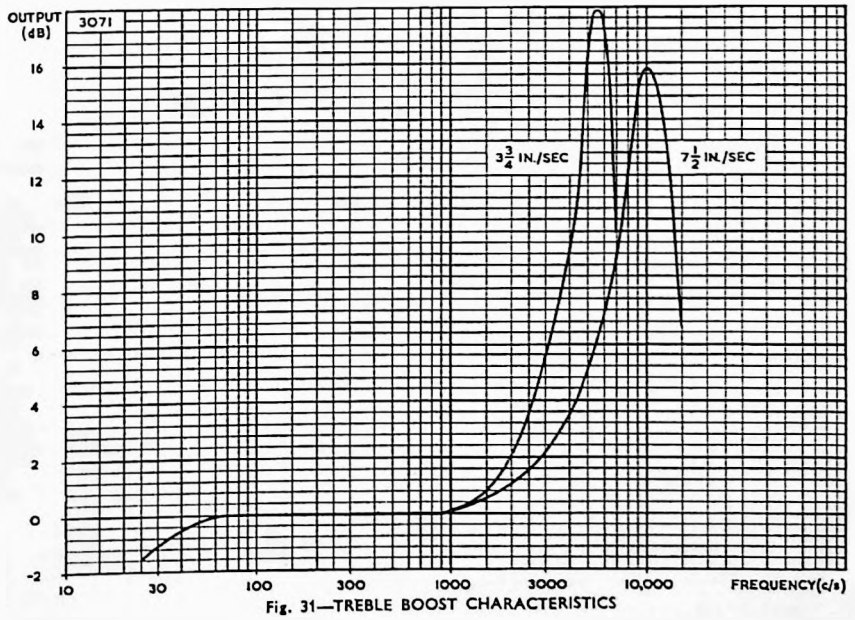


Fig. 31—TREBLE BOOST CHARACTERISTICS

Values for the recording sensitivity for an output voltage measured at the second anode of the ECC83 are given in Table VIII. A test of the recording level indicator should show that the EM81 'closes' with approximately 20V at this anode.

An alternative method of checking the recording amplifier is possible: For either tape speed, the voltage developed across a 50Ω-resistor connected in series with the recording head can be observed for the full range of signal frequencies. The response curve so obtained should agree with the appropriate curve for the prototype amplifier, plotted in Fig. 31. For these observations, it will be necessary to disconnect one end of the resistor R33 (18kΩ), to be found on Tagboard No. 5, otherwise only the bias signal will be measured.

Test IV — Bias Level Test

For this test, two pieces of equipment are required:

(1) A valve voltmeter which will indicate accurately at frequencies of up to 70kc/s;

(2) A resistor of 50Ω.

The resistor should be soldered in series with the earthy end of the record/playback head, and the voltage developed across this resistor, with no input signal, should be measured with the voltmeter.

The voltage developed across the resistor should be 50mV, which corresponds to a bias current of 1·0mA flowing in the 50Ω-resistor.

POWER UNIT

CIRCUIT DESCRIPTION

The circuit diagram for a power unit for use with the self-contained tape amplifier is given in Fig. 32. The requirements of the unit are that it should provide (i) a d.c. voltage of 300V at a current of 50mA, and (ii) an a.c. voltage of 6·3V at a current of 2A.

Any of the mains transformers suggested for use either with the 'low-loading' version of the Mullard 5-valve 10-watt High Quality Amplifier, or with the Mullard '3-3' Quality Amplifier will be suitable for this unit. The specification for this transformer is:

	Voltage tappings	Current rating
Primary	10-0-200-220-240V	
Secondaries	300-0-300V	60mA
	3·15-0-3·15V	2A
	0-6·3V	1A

The choice of rectifier will depend on the tape deck used. Normally, the Mullard full-wave rectifier, type EZ80, will be suitable. However, with tape decks that use electrical braking for the tape transport system, it is essential that the Mullard type EZ81 be used, so that the currents of up to 150mA which are required for the short braking periods can be supplied.

If the EZ80 is used, the series resistance n each anode circuit of the rectifier must

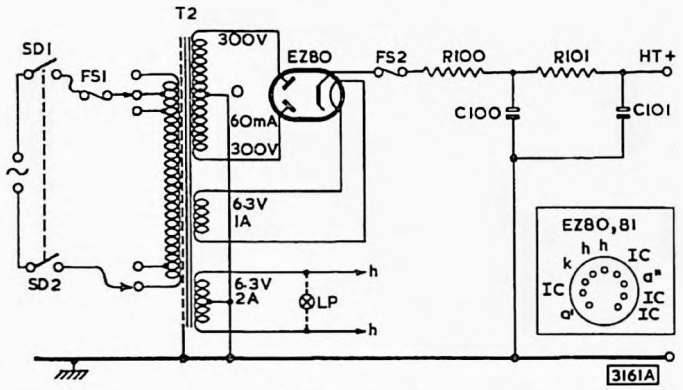


Fig. 32—CIRCUIT OF FOWER UNIT AND LIST OF COMPONENTS

C100 and C101, 50 + 50μF electrolytic capacitor.
Working voltage rating = 350V d.c.;
Min. ripple current rating = 100mA.

R100, Value to give less than 350V across C100. (Unnecessary in prototype).

R101, value to give 300V h.t. across C101. (820Ω, 3W, wire-wound resistor used in prototype).

B9A valveholder McMurdo BM9/U.

Rectifier, Mullard type EZ80 (EZ81).

T2 Mains transformer. One of the following commercial types would be suitable:

Manufacturer	Type No.
Elstone	MT/3M
Gilson	WO839
Hinchley	1442
Parmeko	P2631
Partridge	H300/60
Wynall	W.1547

Input securing clip. Hellerman P clip, 3180/5B.
Output securing clip. Hellerman P clip, 3180/3B.
SD mains switch. Bulgin 2-way, S300.
Fused voltage selector. Clix VSP393/0, P62/1.
Fuseholder. Belling Lee Minifuse L575.
FS1, 1A Fuse.
FS2, 200mA Fuse.
LP, pilot lamp (optional), 6·3V, 0·3A. Bulgin D180/Red.

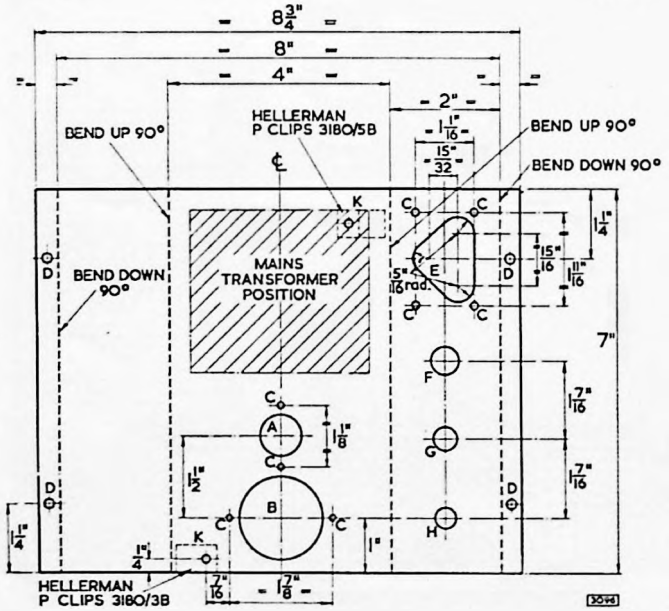


Fig. 33—CHASSIS DRAWINGS AND KEY TO HOLES

Hole	Dimension	Use	List No.
A	¾ in. dia.	B9A valveholder, McMurdo ..	BM9/U
B	1¼ in. dia.	50 + 50μF electrolytic capacitor	—
C	Drill No. 34	6 B.A. clearance hole	—
D	Drill No. 12	No. 6 wood screw	—
E	—	Mains selector switch, Clix ..	VSP393/0 P62/1
F	½ in. dia.	Mains switch, Bulgin 2-way ..	S300
G	7/16 in. dia.	Minifuse holder, Belling Lee ..	L575
H	¾ in. dia.	Pilot lamp, Bulgin	D180/Red
K	Drill No. 27	4 B.A. clearance hole	—

be at least 215Ω; if the EZ81 is used, the minimum series resistance is 200Ω for each anode. Very few transformers meeting the specifications given above will have a total winding resistance less than these minimum requirements, but should it be lower, a series resistance large enough to make up the minimum should be added to each anode circuit.

The amount of series resistance R_t contributed at each anode by the transformer is:

$$R_t = R_s + n^2 R_p ,$$

where R_s = the resistance of half the secondary,

R_p = the resistance of the primary,

and n = the ratio of the number of turns on half the secondary to the number of turns on the whole primary.

If R_{min} is the minimum resistance needed in each anode circuit (215Ω or 200Ω for the EZ80 or EZ81 respectively), the value of the resistance R that it may be necessary to add to each circuit is:

$$R = R_{min} - R_t .$$

The values of the dropper resistors R100 and R101 should be chosen to give a potential of less than 350V across the reservoir capacitor C100 and a potential of 300V across C101 respectively. It may be found that the resistor R100 is not needed in the power unit.

CHASSIS ASSEMBLY AND WIRING DETAILS

The chassis consists of one piece of 16 s.w.g. aluminium sheet, 8¾ in. long, and 7 in. wide. It should be marked as shown in the chassis drawing (Fig. 33) and the holes indicated should be cut. Mounting holes for the mains switch, the fused voltage-selector and the pilot lamp are shown in the figure, but if it so desired, these components may be mounted elsewhere, when, of course, there will be no need to cut the particular holes in this chassis.

The chassis drawing shown in Fig. 33 is for a mains transformer of the inverted mounting type. If a different type is used, it will be necessary to drill grommet holes to enable the leads to be taken through the chassis.

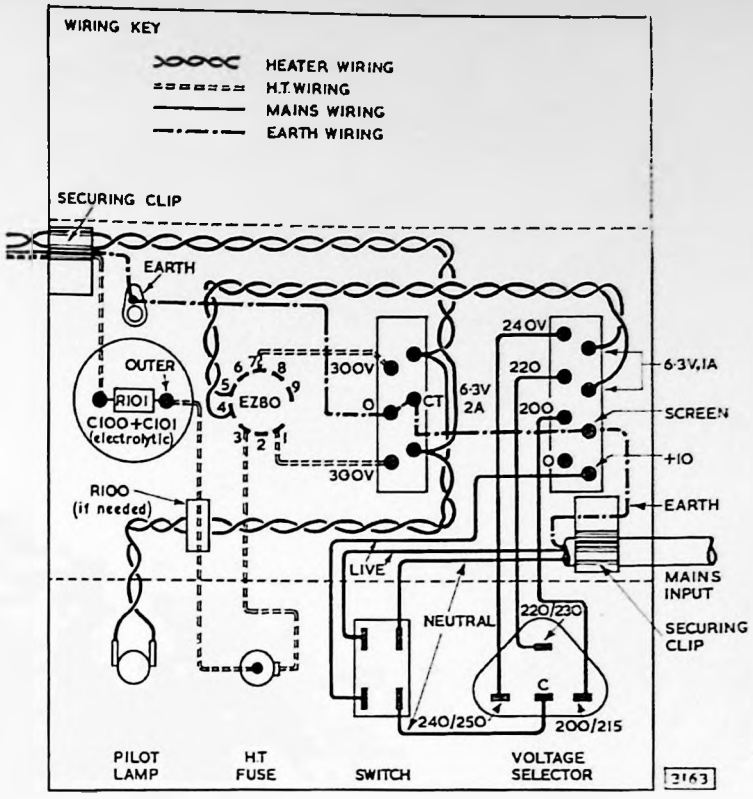
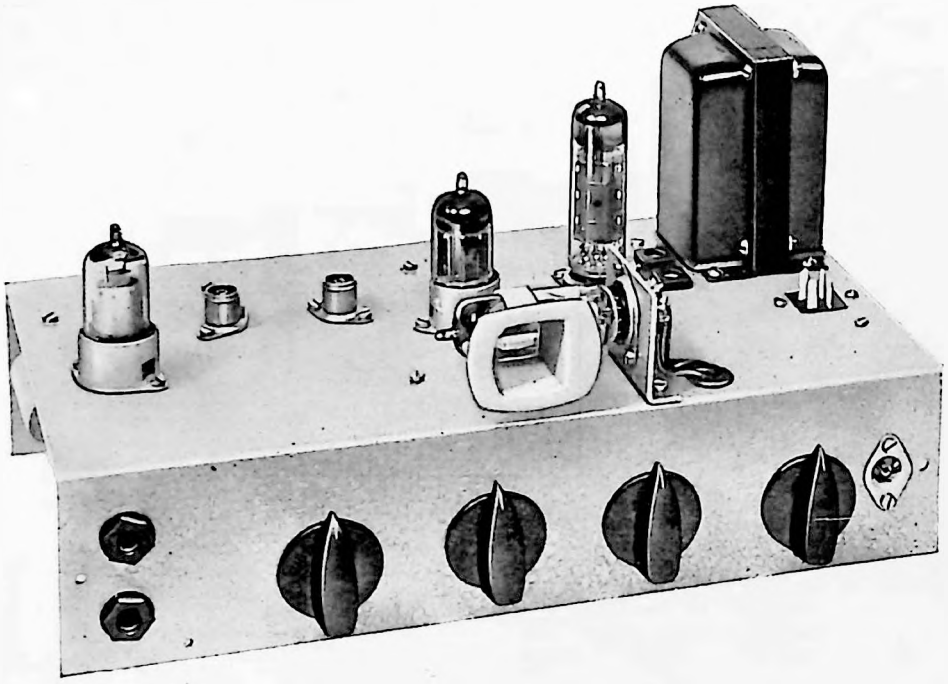


Fig. 34—POWER UNIT ASSEMBLY AND WIRING DETAILS

The wiring of the power unit should be accomplished quite easily by referring to the wiring diagram of Fig. 34. This figure again caters for a transformer of the inverted mounting type.

To avoid unnecessary expense, input and output plugs have not been used: securing clips suffice to anchor the mains and h.t. leads. The pilot lamp is also an optional component.

It is very important when wiring the electrolytic capacitor to ensure that the correct section is used as the reservoir capacitor, C100. The section which is identified as the 'outer', or else marked with a red spot, should be used for this component.



PHOTOGRAPH OF PROTOTYPE TAPE AMPLIFIER

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