CHAPTER 12
Tape Pre-amplifier

The tape-recording pre-amplifier described in this chapter is intended to be used in conjunction with a high-quality pre-amplifier and power amplifier. The unit combines the function of both recording and playback amplification, although, for the playback operation, it acts only as an equalising stage, giving sufficient output voltage to drive the high-quality amplifying system.

The general principle of the design has been to preserve simplicity as far as is compatible with high-quality performance. The distortion introduced in the recording channel has been reduced to such an extent that it is probable that the quality of performance will be limited only by the magnetic tape itself, provided, of course, that the tape deck used is of satisfactory performance. The level of total harmonic distortion in the recording process should not be greater than 0·5% with a recording current of 150μA through the head.

Equalisation to correct for head and tape characteristics is provided for each of the tape speeds: $3\frac{3}{4}$, $7\frac{1}{2}$, and 15 inches per second. The high-frequency equalisation is applied during the recording process and the low-frequency correction during playback.

Treble equalisation is achieved by using a wound Ferroxcube pot-core inductor, Mullard type WF1932, in a resonant circuit between the first and second stages of the amplifier. The frequency at which maximum treble boost occurs is determined by the tuning capacitance which is adjusted by the switch SB3. The value of resistance in the feedback network to give bass equalisation during playback is selected for each tape speed by the switch SB1.

There is no provision for tone control in this pre-amplifier. It is anticipated that such control will be available with the associated amplifying equipment.

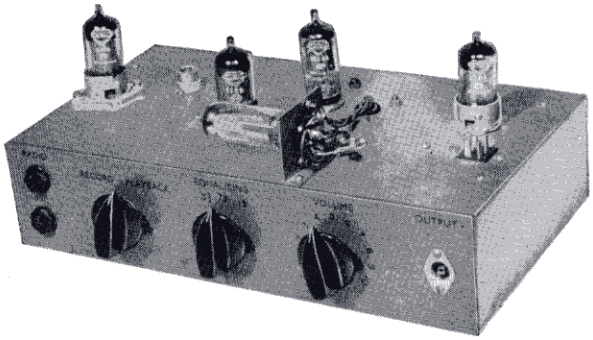
CIRCUIT DESCRIPTION

The circuit diagram of the combined record-playback pre-amplifier is given in Fig. 2. The record-playback switch SA is shown in the position for recording and the equaliser switch SB is set for equalisation at a tape speed of $7\frac{1}{2}$ inches per second. The playback output is taken from the anode of the second EF86, and the remaining stages are used only for the recording operation.

Controls

Two switch banks are used in the pre-amplifier. Switch SA provides the change from the recording to the playback process, and switch SB provides the equalisation appropriate to one of the tape speeds: $3\frac{3}{4}$, $7\frac{1}{2}$ and 15 inches per second.

The gain control RV13 is the only other control in the pre-amplifier.



Prototype of the Tape Pre-amplifier

Valve Complement

The complete pre-amplifier uses five Mullard valves and one Mullard germanium diode. These are:

(*a*) Type EF86, low-noise pentode, used in the input stage.

(*b*) Type EF86, used in the second stage.

(*c*) Type EF86, used in the output stage for recording.

(*d*) Type ECC82, double triode, used as a push-pull oscillator for the bias and erase signals.

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

(*f*) 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, the radio input also being convenient for recording from crystal pick-ups. Both inputs are fed to the grid of the valve, the radio input being attenuated to the level of the microphone input. Switching is achieved by inserting the jacks, so that only one input may be used at a time.

Equaliser Stage

As was stated above, no tone control is incorporated in this stage. The output is taken during playback from across part (R10) of the anode load of the second EF86. The output supplied is 250mV at a source impedance of 15kΩ. A rearrangement of the anode load resistance (that is, R10 and R11) can be made, if required, to give an output of, for instance, 1V at a source impedance of 60kΩ.

The output of the second stage of the amplifier is fed during the recording process from the anode of the EF86 by way of the gain control RV13 to the grid of the following EF86.

A resonant circuit containing a wound Ferroxcube pot-core inductor L3 (Type WF1932) is used to provide treble equalisation. The value of tuning capacitance in the resonant circuit is selected by the switch SB3 to give the maximum treble boost at frequencies appropriate to the tape speed used. The extent of treble boost is controlled by the resistor R30 and the damping resistors R34 and R35 connected in parallel with the capacitors C26 and C25. The steep rise in boost which occurs below the resonant frequency is modified by damping the inductance, and by partially shunting the resistor R30 at the appropriate frequency.

The treble boost obtained will be correct for many combinations of tape and head, but it may be too great for others. If this is so, the damping on L3 should be increased by connecting a resistor in parallel with C27 and reducing the values of R34 and R35. The optimum values should be determined by listening tests.

The values of the resistors R31, R32 and R33 arranged on switch SB1 have been chosen to give appropriate feedback for bass equalisation during playback. To avoid capacitive coupling, this section of the equaliser switch is arranged on the front of the switch wafer.

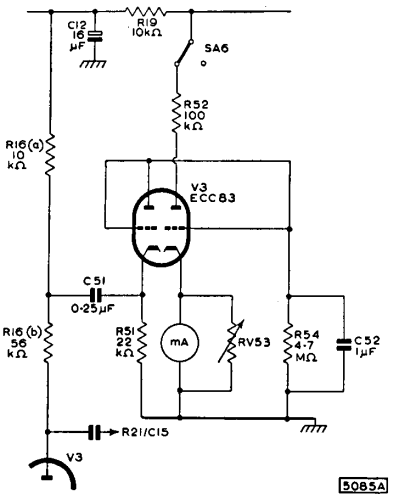


Fig. 1—Circuit for metering the recording level

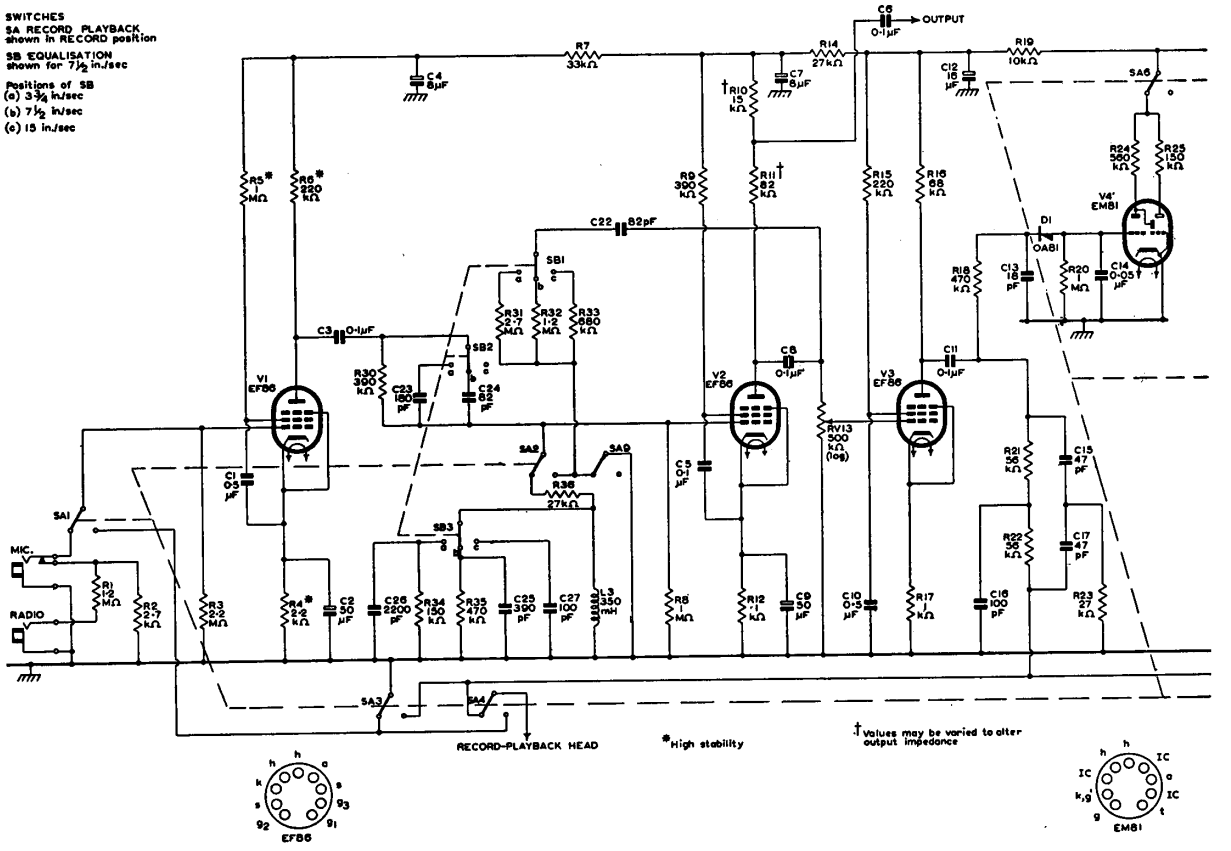
Recording Output Stage

The third stage of the unit, operative only during the recording process, uses another EF86, the grid of which is fed from the volume control RV13. The stage is designed to give low harmonic distortion at peak levels of recording current, and the distortion should not exceed 0·5% for a recording current of 150μA.

The recording current is fed to the recording head by way of a parallel-T network, which acts primarily as a bias-voltage rejector circuit. The series resistance of the network is needed in this stage to ensure a constant drive to the head, and its inclusion is also desirable to preserve a satisfactory a.c./d.c. load ratio for the EF86 of the third stage.

H.F. Oscillator Stage

The halves of the double triode are arranged as a push-pull oscillator. The stage is designed so that the ECC82 draws approximately the same h.t. current during playback, when it is inoperative, as it does under its oscillatory conditions during recording. In



LIST OF

Resistors

Circuit ref.	Value	Tolerance (±%)	Rating (W)
R1	1·2MΩ	20	¼
R2	2·7kΩ	20	¼
R3	2·2MΩ	20	¼
[1]R4	2·2kΩ	10	½
[1]R5	1 MΩ	10	½
[1]R6	220 kΩ	10	½
R7	33 kΩ	20	¼
R8	1 MΩ	20	¼
R9	390 kΩ	10	¼
[2]R10	15 kΩ	10	½
[2]R11	82 kΩ	10	¼
R12	1 kΩ	10	¼
RV13	500 kΩ	logarithmic potentiometer	
R14	27 kΩ	20	¼
R15	220 kΩ	10	¼
R16	68 kΩ	10	¼
R17	1 kΩ	10	¼
R18	470 kΩ	20	¼
R19	10 kΩ	20	¼
R20	1 MΩ	20	¼
R21	56 kΩ	10	¼
R22	56 kΩ	10	¼
R23	27 kΩ	10	¼
R24	560 kΩ	20	¼
R25	150 kΩ	20	¼
R26	4·7kΩ	20	¼
R27	22 kΩ	10	¼
R28	4·7kΩ	20	¼
R29	22 kΩ	10	¼
R30	390 kΩ	10	¼
R31	2·7MΩ	10	¼
R32	1·2MΩ	10	¼
R33	680 kΩ	10	¼
R34	150 kΩ	10	¼
R35	470 kΩ	10	¼
R36	27 kΩ	10	¼
R37	680 Ω	10	1

1. High stability, cracked carbon
2. Values may be adjusted to vary output impedance

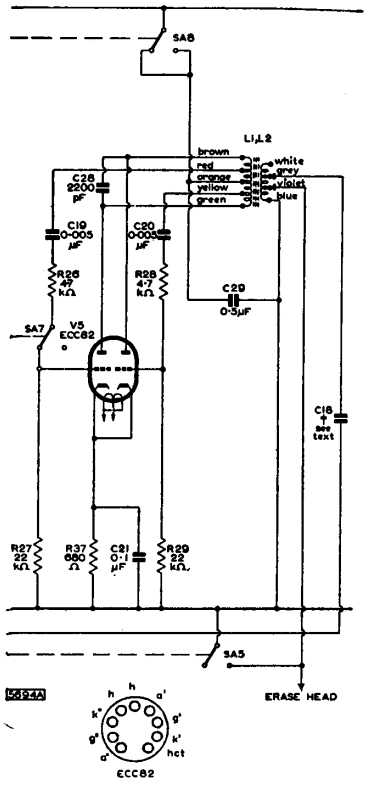


Fig. 2—*Circuit diagram of tape pre-amplifier*

COMPONENTS

Valves and Germanium Diode

V1	Low noise pentode,	Mullard type EF86
V2	Low noise pentode,	Mullard type EF86
V3	Low noise pentode,	Mullard type EF86
V4	Tuning indicator,	Mullard type EM81
V5	Double triode,	Mullard type ECC82
D1	Germanium diode,	Mullard type OA81

Valveholders

B9A valveholder (two). McMurdo, BM9/U
B9A nylon-loaded valveholder with screening skirt (two). McMurdo, XM9/UC.1
B9A nylon-loaded valveholder with screening skirt and flexible mounting. McMurdo, XM9/UXG.1

Inductors

Equalisation coil: Wound Ferroxcube pot-core inductor. Mullard, WF1932
Oscillator coil: Wound Ferroxcube pot-core inductor. Mullard, WF1738

Capacitors

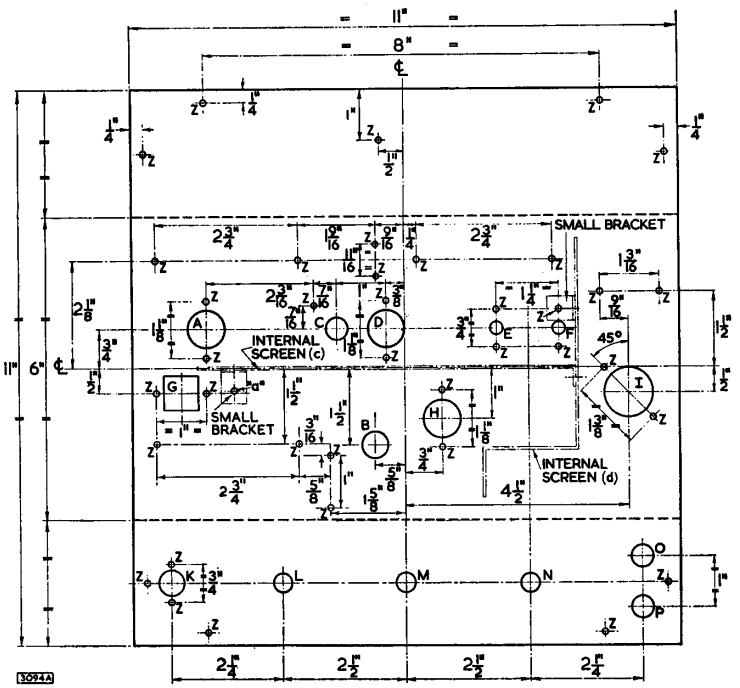
Circuit ref.	Value	Description	Rating (V)
C1	0·5 µF	paper	350
C2	50 µF	electrolytic	12
C3	0·1 µF	paper	350
C4	8 µF	electrolytic	350
C5	0·1 µF	paper	350
C6	0·1 µF	paper	350
C7	8 µF	electrolytic	350
C8	0·1 µF	paper	350
C9	50 µF	electrolytic	12
C10	0·5 µF	paper	350
C11	0·1 µF	paper	350
C12	16 µF	electrolytic	350
C13	18 pF	silvered mica	
C14	0·05 µF	paper	150
C15	47 pF	silvered mica	
C16	100 pF	silvered mica	
C17	47 pF	silvered mica	
C18	*	silvered mica	
C19	0·005µF	paper	350
C20	0·005µF	paper	350
C21	0·1 µF	paper	350
C22	82 pF	silvered mica	
C23	180 pF	silvered mica	
C24	82 pF	silvered mica	
C25	390 pF	silvered mica	
C26	2200 pF	silvered mica	
C27	100 pF	silvered mica	
C28	2200 pF	silvered mica	
C29	0·5 µF	paper	350

Tolerance of all silvered mica capacitors is ±10%

*C18: 56pF for Brenell or Collaro decks
47pF for Lane deck
120pF for Motek deck
180pF for Truvox deck

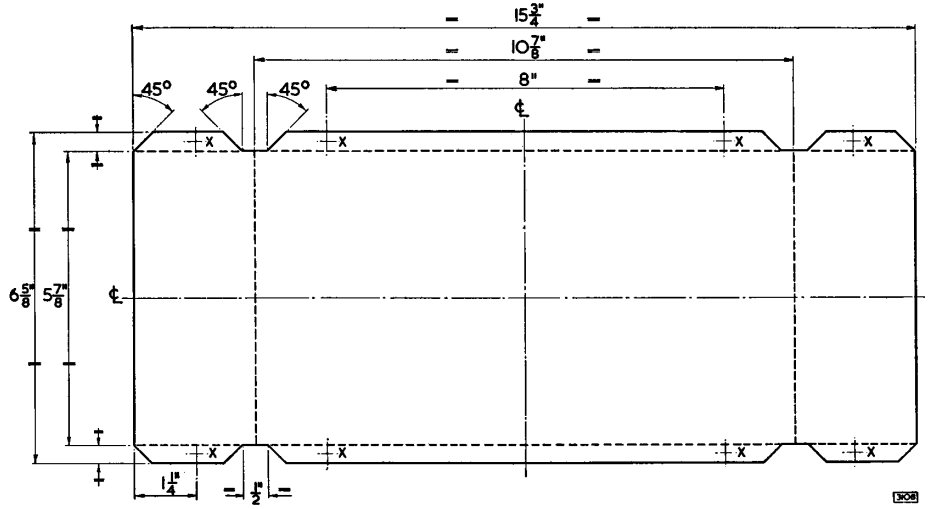
Miscellaneous

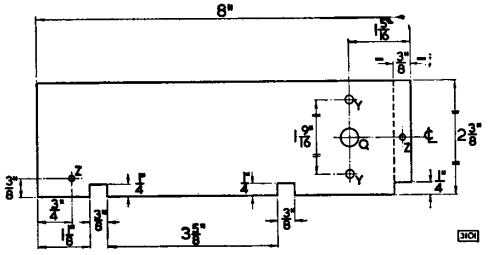
Output socket, recessed coaxial. Belling Lee, L.734/S
Record-playback head coaxial socket. Belling Lee, L.604/S
Erase head coaxial socket. Belling Lee, L.604/S
Supply input plug, 4-pin. Elcom, P04
Input jack (radio). Igranic, P.71
Input jack (microphone). Igranic, P.72
Record-playback switch SA:
Shirley Laboratories Ltd., 16370/B3
Specialist Switches, SS/567/A
Tele-Radio, TR8
(Note: Details of proprietary switches may not be identical with those given in the diagrams.)
Equaliser switch SB, 3-pole, 3-way
Tele-Radio, TR9
Five-way tagboard (one). Bulgin, C.120. Denco
Ten-way tagboard (three). Bulgin, C.125. Denco
Ceramic stand-off insulator (two)
Stand-off insulator, 2-tag
Pointer knob (three). Bulgin, K.370



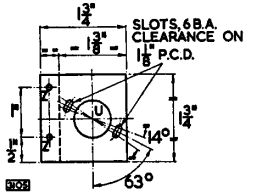
(a) (above) Main chassis (hole marked 'a' should be made after assembly with No. 34 drill)

(b) (below) Base

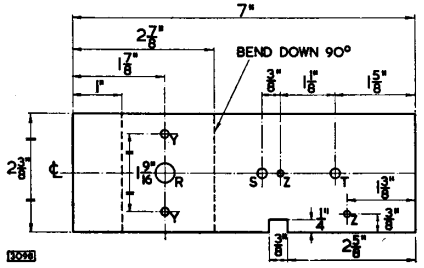




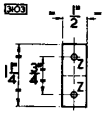
(c) (above) Internal screen



(e) (above) EM81 fixing bracket



(d) (left) Internal screen



(f) (above) Small bracket

Fig. 3—*Chassis details. (The chassis should be bent up at 90° at all dotted lines except where the contrary is specifically indicated.)*

KEY TO HOLES IN CHASSIS DRAWINGS

Hole	Dimension	Use	List No.
A	¾ in. dia.	B9A nylon-loaded valveholder with screening skirt, McMurdo	XM9/UC1
B	5/16 in. dia.	Equalisation coil, wound Ferroxcube pot-core, Mullard	WF1932
C	7/16 in. dia.	Rubber grommet	—
D	¾ in. dia.	B9A valveholder, McMurdo	BM9/U
E	¼ in. dia.	Coaxial socket, Belling Lee	L.604/S
F	¼ in. dia.	Coaxial socket, Belling Lee	L.604/S
G	¾ × ¾ in.	Supply input plug, Elcom	P04
H	¾ in. dia.	B9A nylon-loaded valveholder with screening skirt, McMurdo	XM9/UC1
I	1 in. dia.	B9A nylon-loaded valveholder with skirt and flexible mounting, McMurdo	XM9/UXG1
K	¼ in. dia.	Coaxial socket, Belling Lee	L.734/S
L	⅜ in. dia.	500kΩ potentiometer (logarithmic)	—
M	⅜ in. dia.	Equaliser switch, 3-pole, 3-way	—
N	⅜ in. dia.	Record-playback switch	—
O	7/16 in. dia.	Jack (radio), Igranic	P71
P	7/16 in. dia.	Jack (mic.), Igranic	P72
Q	⅜ in. dia.	Record-playback switch	—
R	⅜ in. dia.	Record-playback switch	—
S	3/16 in. dia.	Rubber grommet	—
T	3/16 in. dia.	Rubber grommet	—
U	¾ in. dia.	B9A valveholder, McMurdo	BM9/U
X	Drill No. 49	Self-tapping screw	—
Y	Drill No. 27	4 B.A. clearance hole	—
Z	Drill No. 34	6 B.A. clearance hole	—

this way, the total current drain for either the recording or the playback process does not alter greatly, and the design of the power supply is consequently simplified.

The oscillator coil consists of a wound Ferroxcube pot-core, type WF1738, in which the secondary windings are tapped so that the coil can be used with most of the commercially available tape decks. The value of the coupling capacitor C18 will vary with the type of record-playback head used, and a list of appropriate values is given in Table 1.

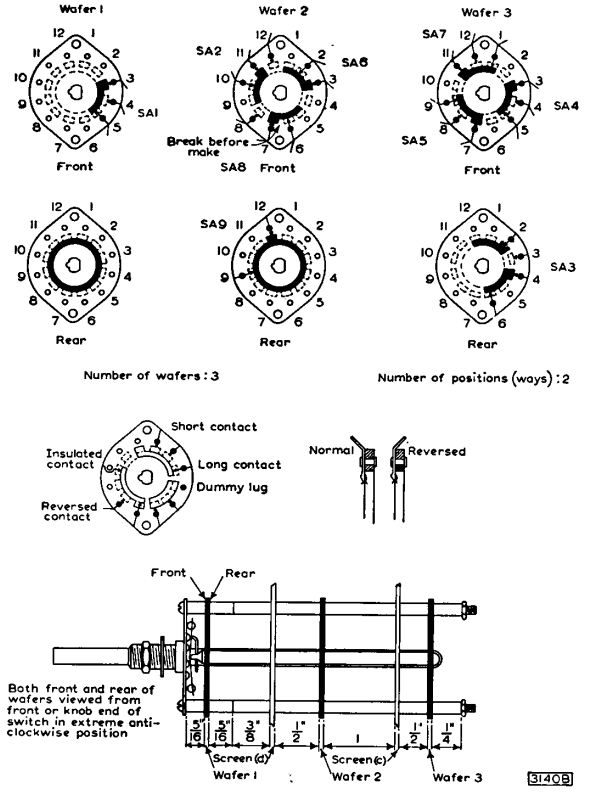


Fig. 4—Record-playback switch details

Recording Level Indicator

The tuning indicator, type EM81, used in this stage is fed from the anode of the recording stage. The large series resistance R18 is used to minimise the loading of the recording stage. If a meter indication of the recording level is required, the circuit given in Fig. 1 can be used in place of the EM81. This alternative arrangement is similar to that suggested on page 92 for the 3W tape amplifier.

Power Supply

The unit described in Chapter 11 is suitable for use with the pre-amplifier circuit. The heater-current requirements of the two tape circuits are similar; allowance for the difference in h.t. currents is made by a suitable choice of value for R101.

CONSTRUCTION AND ASSEMBLY

The chassis for the tape pre-amplifier is made up of seven separate pieces of 16 s.w.g. aluminium sheet. The dimensions (in inches) of these are:

(*a*) Main chassis	11×11
(*b*) Base	$15\frac{3}{4} \times 6\frac{5}{8}$
(*c*) Internal screen	$8 \times 2\frac{3}{8}$
(*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 (two)	$1\frac{1}{4} \times \frac{1}{2}$

Each piece should be marked as shown in the chassis drawings of Fig. 3, and the holes should be cut as indicated. It is important that, when bending the sheet, the scribed lines should be exactly along the angles. This ensures that the pieces will fit together properly when assembled.

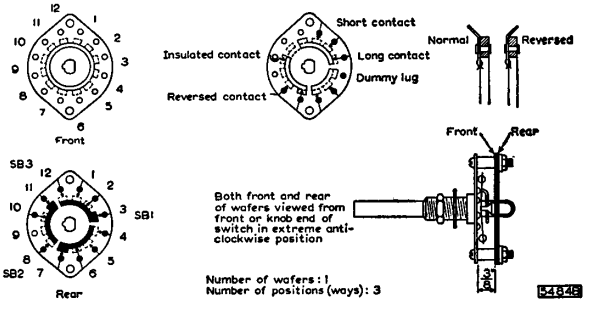


Fig. 5—Equaliser switch details

Details of the record-playback switch SA are given in Fig. 4. Before assembling this switch around the screens, it will probably be found convenient to fix the following components to the chassis:

(1) The erase and record-playback coaxial sockets which have to be fitted to the chassis beneath wafer 3 of the switch.

(2) All the valveholders. Only the three EF86 valves should be skirted, and the holders for these valves should be nylon-loaded. The holder for the input valve V1 (EF86) should be of an anti-microphonic type – that is, having a flexible mounting.

(3) The two small brackets (f) which should be bolted

to the internal screens (c) and (d) as shown in the layout diagram in Fig. 10.

The construction is best continued after the above components have been fitted by assembling wafers 1 and 2 around the internal screens. The wafers should be arranged so that positions 6 and 7 are nearest the chassis and the face of each wafer described as 'rear' in the switch diagram (Fig. 4) 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 farthest from the switch plate. The general arrangement of the switch wafers and internal screens is shown in Fig. 10. The use of a shake-proof washer is recommended between the switch plate and the front panel when the switch and screens are fitted to the main chassis. The arrangement of the smaller components on tagboards is shown in Figs. 6 to 9, and a suitable layout of these boards and the other components in the chassis is shown in Fig. 10. In fitting the 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 on the holder should face the flange to ensure that the tuning eye of the EM81 faces forward. The 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. The valveholder can be fixed in the main chassis, as described in Chapter 11, if it is required to mount the EM81 at the end of extension leads. An extra hole with a diameter of $\frac{3}{4}$ in. will have to be drilled for the valveholder, in place of the grommet hole C shown in Fig. 3(a).

Identification of the coil winding suitable for the erase heads of various decks can be made by referring to Table 1. The appropriate value of C18 is also given in this table. The bias capacitor is connected to the *grey* lead from the secondary winding for all the makes of deck indicated. The connections in the diagram for the primary winding of the coil and for the blue (earth) lead from the secondary winding are also the same for the decks listed.

TABLE 1

Circuit Arrangement for Various Tape Decks

Tape Deck	Erase Lead	C18 (pF)
Brenell	violet	56
Collaro	violet	56
Lane	grey	47
Motek	grey	120
Truvox	white	180

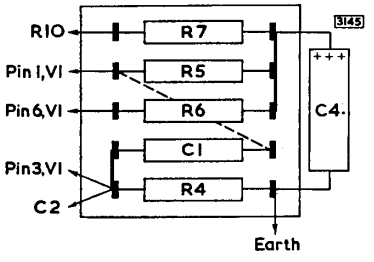


Fig. 6—Tagboard No. 1

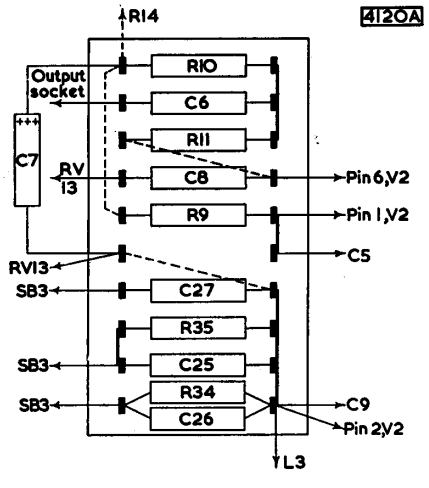


Fig. 7—Tagboard No. 2

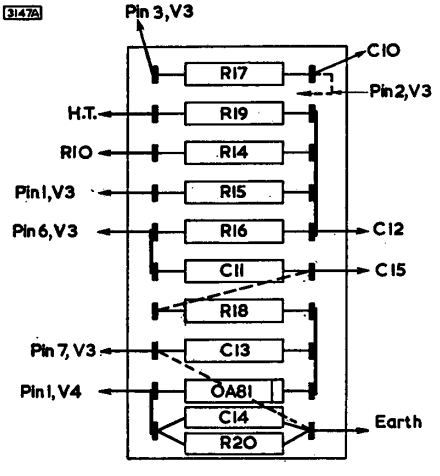


Fig. 8—Tagboard No. 3

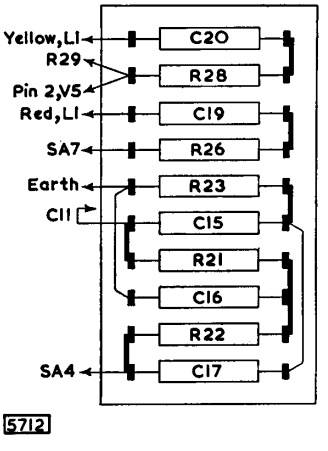
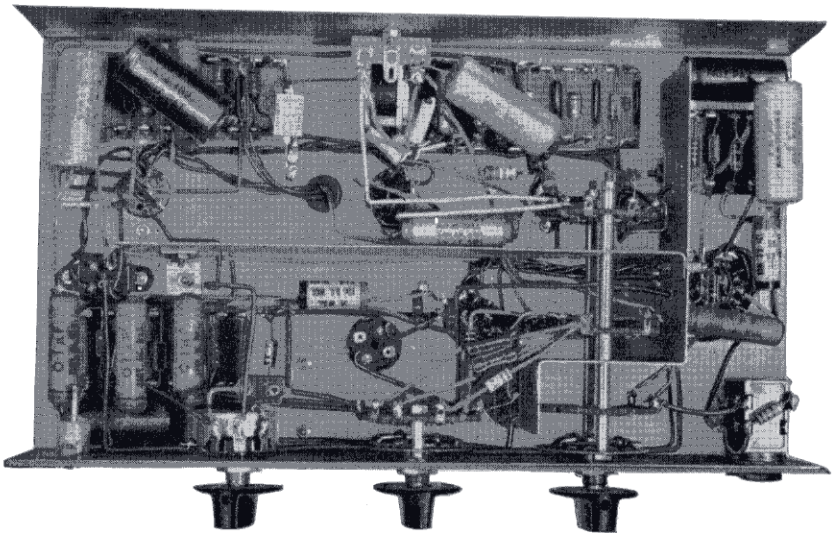


Fig. 9—Tagboard No. 4



Underside View of Prototype Pre-amplifier

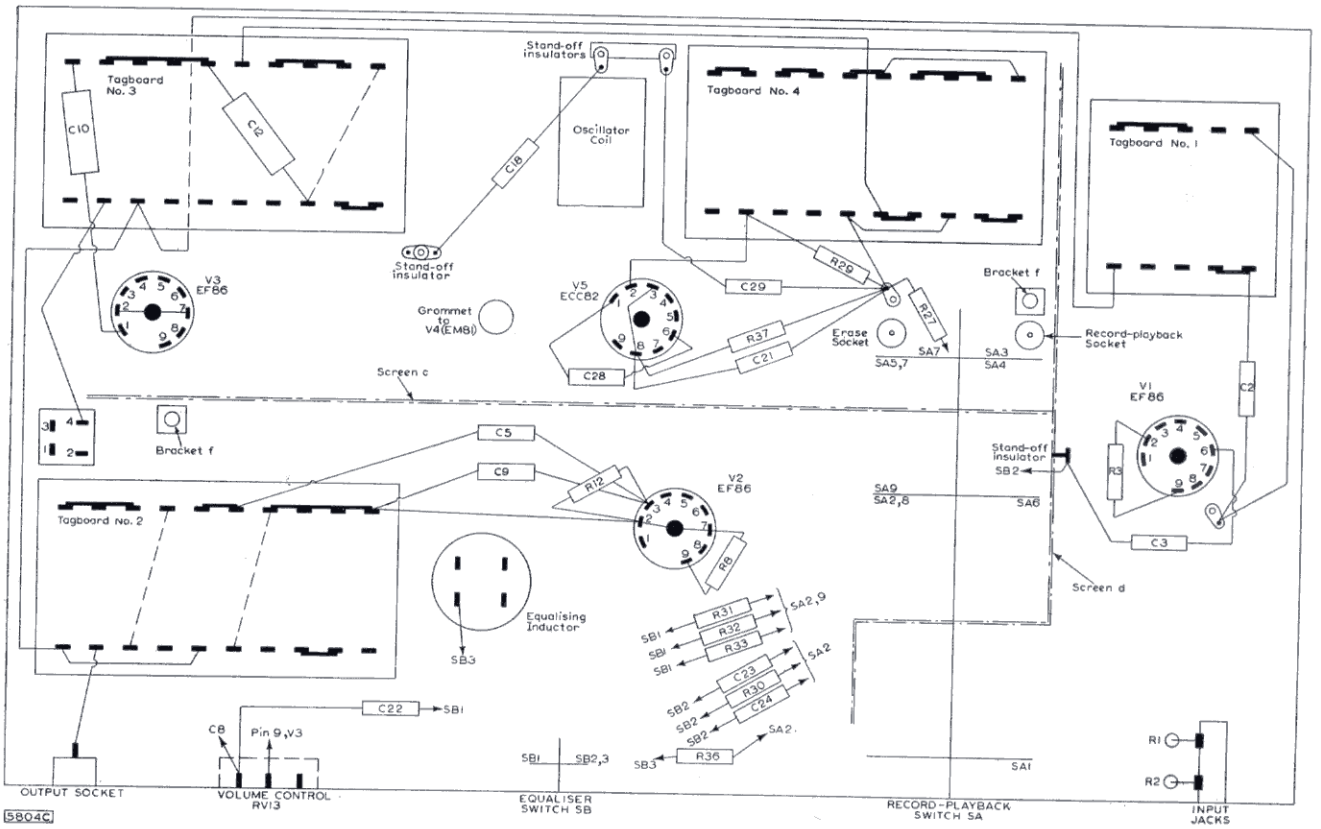


Fig. 10—Suggested layout of components

PERFORMANCE

Frequency Response

The overall response of the recorder depends on the type of head used, the magnitude of the bias current, and, to some extent, on the tape employed. The low-frequency response depends on the amplifier used rather than on the type of head, and in this design, it will not be more than 3dB down at 50c/s. The high-frequency response depends on the tape speed and the gap width of the head. With heads having a gap width of 0·0005 in., the following performance figures (relative to the level at 1kc/s) can be obtained:

15 in./sec: ±3dB from 35c/s to 17kc/s

7½ in./sec: ±3dB from 50c/s to 13kc/s

3¾ in./sec: ±3dB from 50c/s to 6kc/s

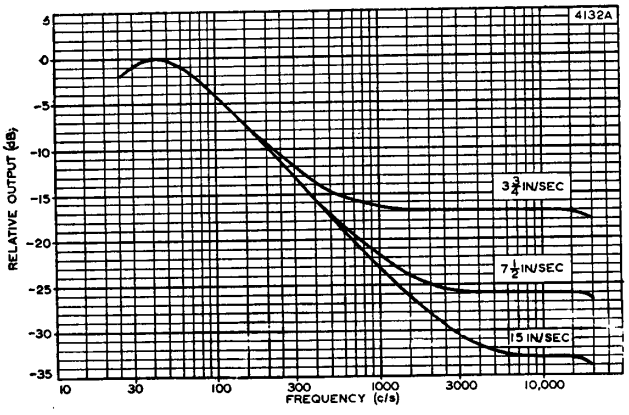


Fig. 11—Bass-boost characteristics

Flexibility has been achieved in the treble-boost circuits of the pre-amplifier. Consequently good control of the complete response of the pre-amplifier is possible and equalisation to reasonably high frequencies is practicable. However, the degrees of control and equalisation depend on the individual adjustments of component values to suit the head and tape being used. *The component values given in this chapter apply only to the pre-amplifier when it is used with Scotch recording tape and a Collaro tape deck.*

Ferroxcube pot-core inductors are adequately screened to prevent excessive hum or stray bias being picked up, and they do not appear to cause more circuit-ringing than RC networks which produce the same treble boost.

The playback characteristic of the pre-amplifier conforms to the C.C.I.R. specification, thus permitting excellent reproduction of pre-recorded tapes. The recording characteristic is arranged to give a flat frequency response in conjunction with this playback characteristic. Additional head losses occurring during playback will normally be capable of correction by the tone controls in the associated amplifying systems.

Sensitivity

The sensitivity of the recording process is measured with the control RV13 set for maximum gain. This does not apply to the playback sensitivity because the gain control is not operative at the point from which the output is taken for the associated equipment.

Recording Sensitivity

(measured at 1kc/s, with recording-head audio current of 150μA)

(*a*) Microphone input: (impedance = 2MΩ)	0·5mV for peak recording level
(*b*) Radio input: (impedance = 1·2MΩ)	250mV for peak recording level

Playback Sensitivity

(measured at 5kc/s for each tape speed for output of 250mV)

(*a*) 15 in./sec:	5·5mV
(*b*) 7½ in./sec:	2·4mV
(*c*) 3¾ in./sec:	1·0mV

TEST PROCEDURE

The four tests outlined below are intended as simple, yet quite effective, checks for the pre-amplifier.

The values given in the various tables and figures were obtained from the prototype pre-amplifier, using Collaro 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 2. The results shown in this table were obtained using an Avometer No. 8.

Test II—Amplifier on Playback

Two 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.

TABLE 2

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)
	H.T.	300	300	1000
	C12	250	250	1000
	C7	190	190	1000
	C4	163	163	1000
V5 (ECC82)	2nd Anode	290	290	1000
	1st Anode	290	290	1000
	1st Cathode	14	12	1000
V4 (EM81)	Anode	40	0	1000
	Target	145	0	1000
V3 (EF86)	Anode	110	110	1000
	Screen grid	140	140	1000
	Cathode	2·6	2·6	10
V2 (EF86)	Anode	60	60	1000
	Screen grid	90	90	1000
	Cathode	1·5	1·5	10
V1 (EF86)	Anode	50	50	1000
	Screen grid	60	60	1000
	Cathode	1·4	1·4	10

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

TABLE 3

Playback Sensitivity

(Signal frequency = 5kc/s)

Tape Speed (in./sec)	Input (mV)	Output (mV)
15	5·5	250
$7\frac{1}{2}$	2·4	250
$3\frac{3}{4}$	1·0	250

The record-playback switch SA should be in the playback position. A signal from the generator, having a frequency of 5kc/s, should be applied to the record-playback socket (which normally accommodates the connecting plug from the record-playback head). The consequent output signal should be measured on the voltmeter at the output socket.

The input voltage should be adjusted to give an output voltage at the output socket of 250mV for each tape speed, and the input required for this output should be noted. The voltage readings that should be obtained are given in Table 3.

For operation at such high sensitivities, great care should be taken to ensure that the signal measured is not composed mostly of hum. It is advisable, therefore (*a*) to use screening cans on the three EF86, (*b*) to screw on firmly the base of the amplifier, and (*c*) to use coaxial cables for the connections to the measuring equipment.

The input voltage at 5kc/s should be varied until the output voltage drops to 50mV. The frequency of the signal should then be reduced to 40c/s and the values of boost listed in Table 4 should be observed at the output socket.

The bass-boost characteristics for the three tape speeds are shown in Fig. 11.

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[1] covering a frequency range from 20c/s to 20kc/s.

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

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 15mV is obtained at the output socket.

The boost indicated in Table 5 should be obtained at the appropriate tape speed when the signal frequency is altered to the value shown in the table.

The treble-boost characteristics for the three tape speeds are shown in Fig. 12. *These characteristics will be suitable for many combinations of tape and head,*

[1]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.

but the peaks may occur at too low a frequency and may indicate too much boost for other combinations. If this is so, modification of the equalisation network (that is the component connected to switch SB3) may prove beneficial (see page 103). Any alteration to the treble-boost characteristics will, of course, cause changes in the overall frequency-response characteristics of the pre-amplifier.

Values for the recording sensitivity for an output voltage measured at the anode of V3 (EF86) are given in Table 6. A test of the recording-level indicator should show that the EM81 'closes' for each tape speed with approximately 15V at the anode of the recording-output valve.

An alternative method of checking the recording amplifier is possible: for each 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 figures so obtained should agree with the values obtained with the prototype pre-amplifier and listed on page 110. For these observations, it will be necessary to disconnect one end of the resistor R26, otherwise only the bias signal will be measured.

Test IV—Bias Level

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 the 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.

TABLE 4

Bass Boost

Signal frequency = 40c/s

(Output voltage for 5kc/s = 50mV)

Tape speed (in./sec)	Voltmeter reading (V)	Output boost (dB)
15	2·3	33
7½	1·0	26
3¾	0·36	17

TABLE 5

Treble Boost

(Output voltage for 1kc/s = 15mV)

Tape speed (in./sec)	Signal frequency (kc/s)	Voltmeter reading (mV)	Output boost (dB)
15	17	84	15
7½	12	150	20
3¾	5·5	100	16·8

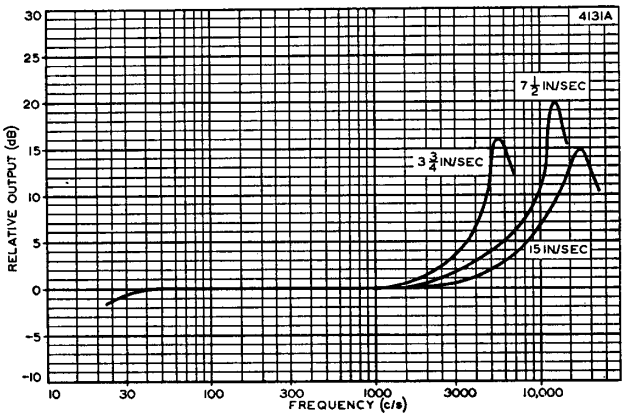


Fig. 12—Treble-boost characteristics

TABLE 6

Recording Sensitivity

Signal frequency	1	kc/s
Tape speed	15, 7½ or 3¾	in./sec
Voltage at anode of V3	15	V
Microphone input	0·5	mV
Radio input	250	mV