Mullard

CIRCUITS FOR TAPE RECORDERS

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MULLARD LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2 August 1956, TP430

FOREWORD

The techniques and equipments for magnetic recording have progressed and improved markedly in the last few years, and tape recorders are becoming increasingly popular, both in the business world and in the various fields of entertainment.

Possibly the greatest fascination of the tape recorder is that the amateur can be his own recording director and star performer. To this appeal can be added the opportunity of listening to the works of leading composers and artistes now available on pre-recorded tapes. The *soirée musicale* can be interspersed with recordings of some budding Billy Daniels or baby's first words.

In 1954, Mullard introduced with great success their 'Five-Ten' high-quality amplifier. During 1955, improvements to this equipment were suggested, pre-amplifier designs were offered and a twenty-watt amplifier was displayed. In keeping with this policy of producing circuits of first-class audio equipments for the home constructor, Mullard engineers have designed two amplifiers for use with the various tape decks available on the commercial market, and this booklet has been devised to enable the home constructor to build these equipments himself.

In an introductory section of the booklet, an endeavour has been made to give a simple account of the rudiments of magnetic recording. No claim is made that this section is comprehensive: its object is solely to point out the requirements of the amplifiers discussed in subsequent pages.

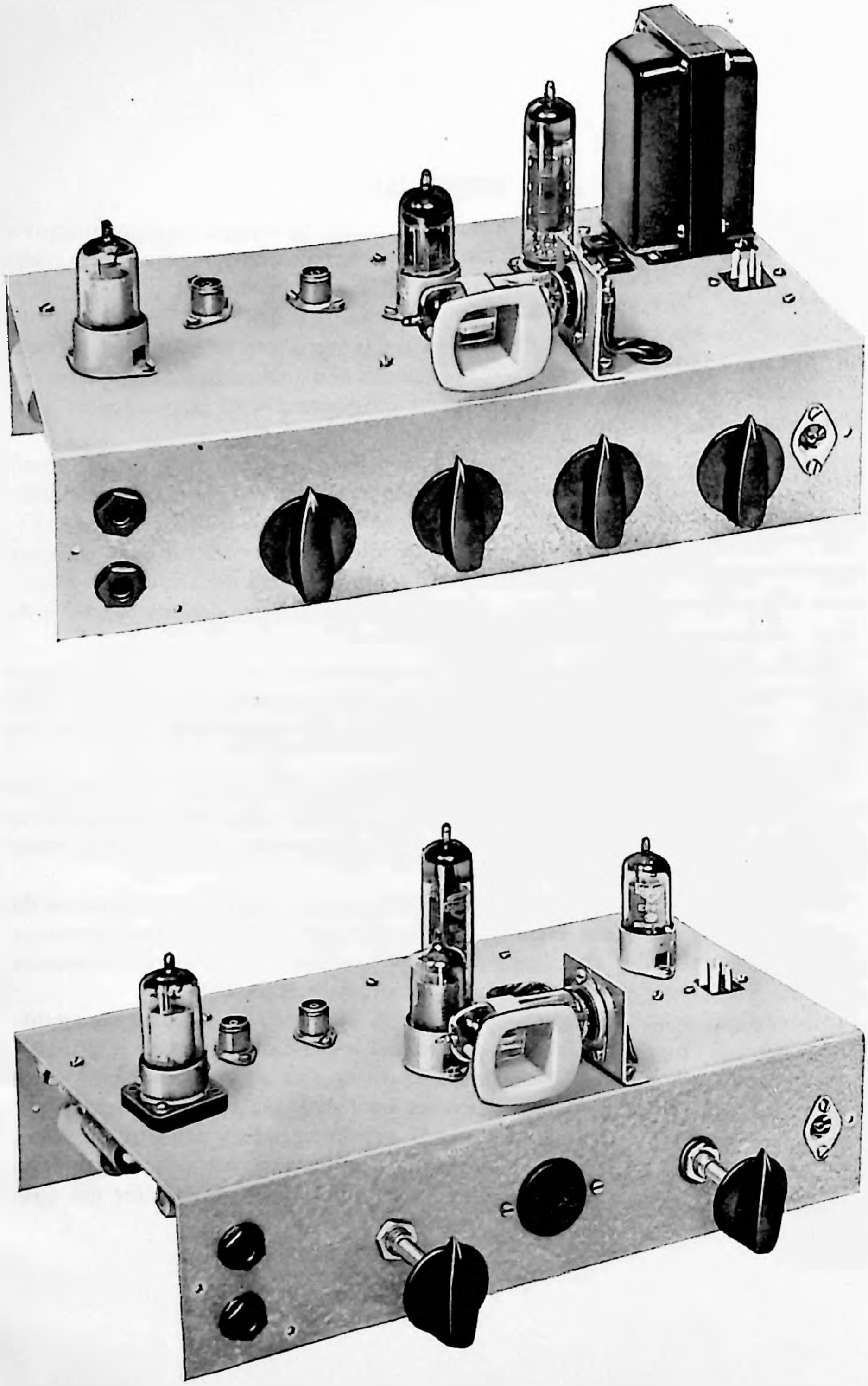
The design of the two amplifiers is discussed in full in the next two sections of the booklet. The Type A amplifier is a self-contained unit which gives an output power of three watts, while the Type B amplifier is intended to drive a high-quality audio amplifier, such as the Mullard 'Five-Ten'.

Circuit descriptions are given for both types of amplifier, performance figures of the prototypes are presented, and test procedures are described. Complete chassis drawings, instructions on assembly and wiring details are included, and numerous schematic wiring diagrams are given to help with the construction of the units.

Lists of components for the amplifiers are included in each section, and the modifications necessary for the several types of tape deck are discussed for both amplifiers.

Finally, a circuit, assembly instructions and wiring details for a power unit which can be used with either amplifier are described in a fourth section of the booklet.

It should be noted that, while the circuits were designed by Mullard engineers, Mullard Ltd. do not manufacture or market the equipments. Also, the information contained in this publication does not imply any authority or licence for the utilisation of any patented feature.



PHOTOGRAPHS OF PROTOTYPE TAPE AMPLIFIERS
TYPE A (TOP) AND TYPE B

RUDIMENTS

OF

MAGNETIC RECORDING

INTRODUCTION

Sound impinging on a microphone will give rise to a current in the microphone circuit. This signal current can be amplified and used to activate an electromagnet (the recording head) and the variations in the magnetic field so produced will be dependent on the original sound.

If a magnetic material, in the form of a tape for example, is drawn with uniform speed through the magnetic field, it will be magnetised, and the degree of residual magnetism induced in the tape will again be some function of the original sound. In other words, the sound will be recorded in terms of the intensity of magnetisation of the tape.

To reconvert this magnetic recording into sound, a process, which is virtually the reverse of the recording procedure, has to be adopted. The tape, with its pattern of magnetism, is drawn past the pole pieces of an electromagnet (the playback head). The moving magnetic field associated with the tape induces voltages in the coils of the head which depend mainly on the degree of magnetisation of that part of the tape closest to the pole pieces. This voltage can be amplified and then used to energise a loud-speaker. The sound emanating from the speaker is, in essence, a reproduction of the original sound.

The previous paragraphs contain a simple and, of course, a largely incomplete account of the processes of magnetic recording, giving only the principles and ignoring all other aspects which will be met in practice. These other aspects cannot, in fact, be ignored: phenomena inherent in this method of sound recording would result in a reproduction which would be a travesty of the original sound unless several corrective stages were introduced to the process. .

The two main corrections to be applied result from (*a*) the non-linear relationship between the amount of residual magnetism induced in the tape and the magnetic field, and (*b*) the dependence of the response of the equipment on the frequency of the signal. Rectification of the first fault is achieved by the application of a high-frequency biasing current to the recording head simultaneously with the audio current. A brief account of this is given later. The equalisation of the frequency response is achieved partly in the recording amplifier and partly in the playback amplifier. This again is treated more fully on subsequent pages.

Basically, a magnetic tape recording equipment can be illustrated by the schematic diagrams of Fig. 1.

The two inputs of the recording system allow for the use of either a microphone or a radio source. The auxiliary or input stage is necessary with the former to give added boost to the weaker signals derived from the microphone. The radio input is shown in Fig. 1 to bypass the input stage. If suitable attenuation is provided, however, the radio signals may be introduced into this stage.

The erasing stage ensures that the tape is unmagnetised before passing the recording head. The h.f. oscillator is used to supply both the biasing and erasing currents. The recording level indicator shows the extent of the amplified audio current being fed into the recording head.

The Recording and Playback Head

Generally speaking, all decks (with perhaps the exception of some of those used with the so-called 'professional' equipments) combine the duties of recording and reproduction in a common head. The requirements of the recording and the playback heads are fundamentally the same and, as they are not required simultaneously, economy is served by combining them.

Modern heads are usually constructed of two semi-circular stacks of high-permeability laminations of about a half to one inch in diameter. The stacks are assembled symmetrically with a 'head gap' (against which the tape passes) of about five ten-thousandths of an inch, and an auxiliary gap, diametrically opposite the head gap, of about ten times that thickness. Both gaps are filled with non-magnetic, metallic 'shims' to prevent any accumulation in the gaps of magnetic material which may be rubbed off the tape by friction, and to maintain a linear relationship between the flux at the gaps and the current through the exciting coils of the head.

The impedance of these coils, which are placed symmetrically about each core, should, for recording, be low compared with the source impedance. This ensures, as far as is possible, a current which is independent of the frequency of the signal. For

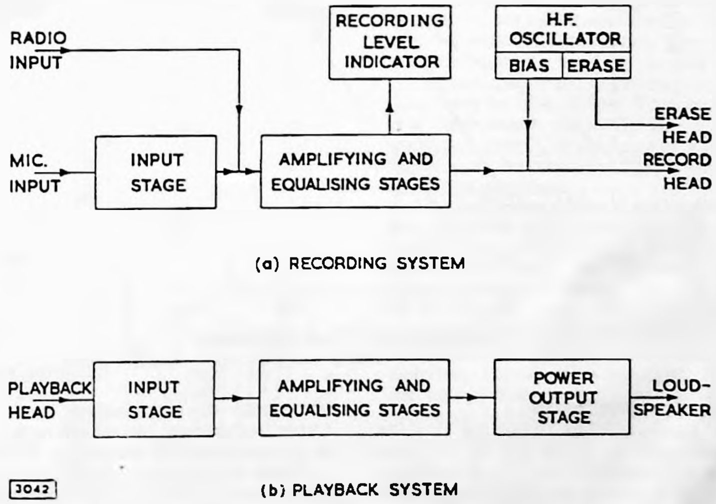


FIG. 1

THE TAPE DECK AND THE TAPE

The object of this publication is the design and construction of the circuitry which is needed for a tape recording unit. The tape-deck and tape are as essential to the unit as the turntable and disc are to the normal record-player, but the mechanics of their construction cannot be discussed here. Only those aspects which have a direct bearing on the principles of magnetic recording or the design of the associated circuits will be considered.

the playback process however maximum output voltages are to be gained from high impedance windings. Any conflict between these requirements can be resolved by feeding the output from low impedance coils into a step-up transformer.

The Erase Head
Although similarities exist between the erase head and the recording head, they differ in construction in two principal respects: Firstly, appreciable power (about 2 to 4W) is required for efficient erasure, while that necessary for the recording head is usually about 1mW. Hence the core of the erase head must be of a material having a higher point of magnetic saturation than the material in the recording head. Secondly, the longer the tape is under the influence of the erasing field, the more complete will be the cleaning. Thus the gap in the erase-head core should be considerably larger than in the core of the combined head. The erase gap is usually about fifteen thousandths of an inch wide. Normally there is no auxiliary gap in the core of the erase head.

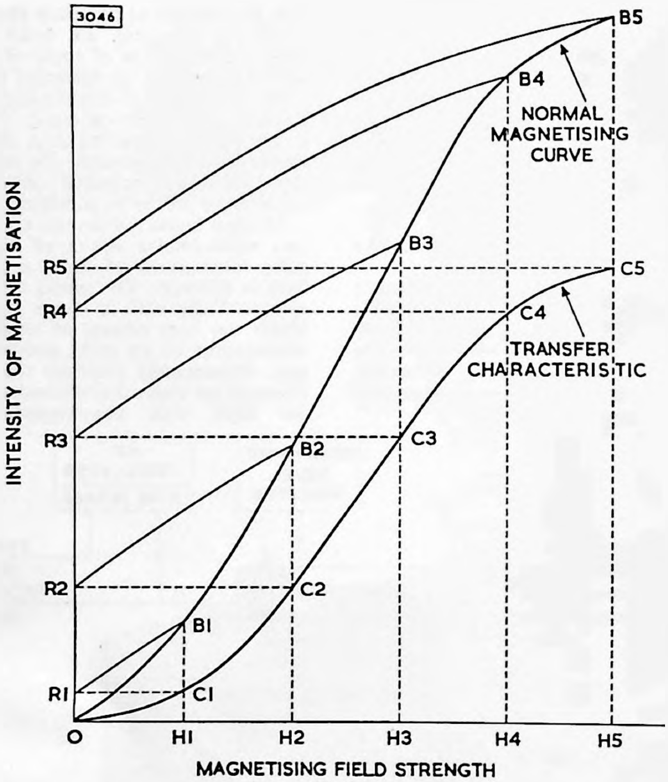


FIG. 2

The Tape Transport System
It is not fundamentally important that the spool and capstan drives can be obtained from either separate motors or a common one; fast wind-on and re-wind arrangements are only refinements to the transport mechanism; the braking system, whether mechanical or electrical, is necessary, but is incidental to the object of this publication. The basic requirement of the transport system is that a steady speed be imparted to the tape. Momentary changes in this speed result in audio effects variously termed 'wow' or 'flutter'. ('Wow' results from slow variations; 'flutter' results from fast fluctuations; the dividing line is arbitrary.)

The actual speed of transport has a considerable bearing on the performance of the recording apparatus. The higher the speed, the better the performance at the higher frequencies. This is closely allied to the size of the gap in the recording head. But, of course, economically, great speeds are a disadvantage: the playing time of the tape is obviously reduced. Most transport systems are standardised for playing speeds of either 3¾, 7½ or 15 inches of tape per second, with, possibly, a choice of speeds.

The Tape
Modern magnetic tapes consist, generally, of a non-magnetic base (paper, cellulose acetate or p.v.c., for example) coated with a magnetic material. The base obviously needs to have strength and suppleness. The magnetic material (often red or black iron oxides) is a very finely divided powder mixed in some binding substance (lacquer, for instance), and the coating applied to the base material has to be very smooth. Unevenness in the surface of the tape will tend to cause broken contact with the heads, and consequently an undulating level of recording. The magnetic material needs a high coercivity to prevent, in particular, very large demagnetisation losses at the treble frequencies, and a high remanence to give a good level of recording.

Tapes are usually supplied in 5- or 7-inch reels, giving playing times, depending on the transport speed, of between about 10 and 60 minutes. The standard width of the tape is a quarter of an inch, and this width normally allows for two adjacent recording paths.

AMPLITUDE DISTORTION
The non-linear relationship between the residual magnetism and the magnetic field inducing it, will cause considerable amplitude distortion in the recording.

The curve OB_3B_5 in Fig. 2 shows a typical relationship between the magnetisation produced in a magnetic material and the *increasing* magnetic field producing it. A field strength of H_2 units, for example, would produce a degree of magnetisation corresponding to the point B_2, provided the material was unmagnetised initially, and also provided the field strength was not, at any time during its general increase from zero to H_2, caused to diminish. The levels of magnetisation corresponding to B_1, B_2, etc., are those obtaining when the field strengths are actually H_1, H_2, etc. These do not represent residual magnetism. If the fields are reduced from H_1, H_2, etc., to zero, the induced magnetism decreases along the paths B_1R_1, B_2R_2, etc., respectively, and the points R_1, R_2, etc., denote the degree of residual magnetisation, or remanence, induced in the magnetic material by maximum applied field strengths of H_1, H_2, etc.

The curve OC_3C_5 plotted in Fig. 2 gives a typical 'transfer' characteristic for a magnetic material; that is, it shows the intensity of residual magnetism (R_1, R_2, etc.) resulting from any given maximum magnetising field (H_1, H_2, etc.). Complete transfer characteristics for positive and negative magnetising fields are shown in both Figs. 3 and 4.

It is obvious from these characteristic curves that the degree of residual magnetism is not a linear function of the maximum magnetising field. Because of this non-linearity, any signal applied to the microphone would, on recording, suffer distortion. All signals (for example, the 'unbiased' sine wave shown in Fig. 3) would suffer 'bottom-bend' distortion resulting in even harmonics of the fundamental appearing in the recording. Large signals would be further distorted by the magnetic saturation depicted by the flattening of upper sections of the characteristics, and the 'clipped' reproduction would contain a high percentage of odd harmonics of the original.

The middle sections of the arms of the transfer characteristics are, however, approximately linear, and if the variations in the magnetic field strengths are confined to these portions, then the recording will be a relatively undistorted replica of the original sound. If a constant current is fed into the recording head together with the signal current, the effect is to 'lift' the variations in the magnetising field above the lower curvature of the characteristic (Fig. 3). The d.c. bias induces a constant degree of magnetisation in the tape on which the audio variations are superimposed. Only the variations of the residual magnetism will appear on replaying the recording, so that the bias will not be translated into sound (in fact, some noise does result from the biasing remanence). But because of the limitation imposed by the saturation curvature of the characteristic, the fact that the bias magnetism is added to the audio magnetism means that the amplitude of the signal must be restricted quite considerably. The signal-to-noise ratio is thus lowered when d.c. bias is used.

A.C. Biasing
The method of preventing amplitude distortion by introducing a constant biasing current into the recording head together with the signal current has been superseded by a method in which the direct current is replaced by a high-frequency, alternating current. The result is a recording relatively free from harmonic distortion in which the signal-to-noise ratio is maintained. No complete explanation of the mechanism of a.c. biasing has yet been accepted generally, but some idea of the process can be obtained from Fig. 4.

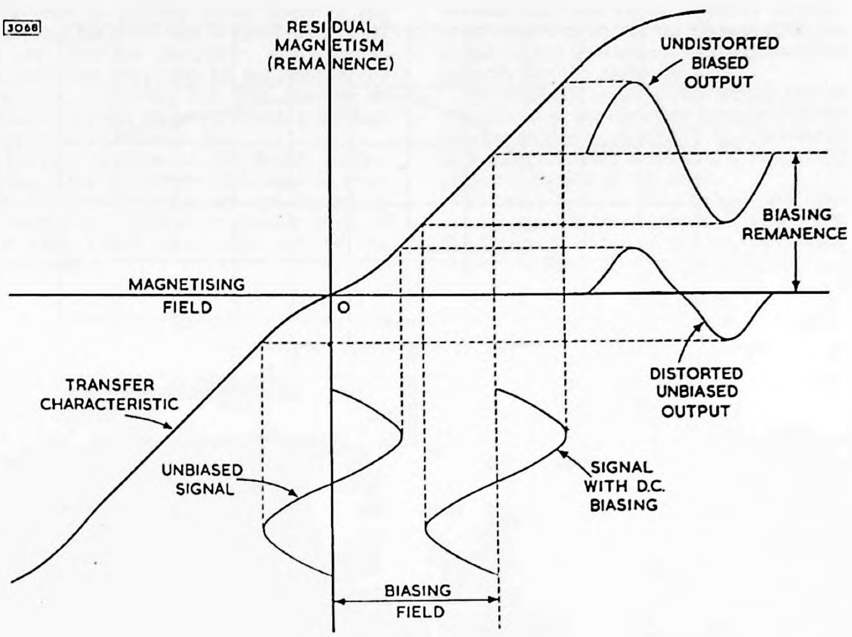


FIG. 3

A feature of this method of biasing is the fact that no residual magnetism is induced in the tape by the a.c. signal, provided, of course, that these oscillations are free from even harmonic distortion. As any point on the tape passes the gap in the recording head, it is subjected to a rapidly alternating magnetic field, the strength of which increases as the point approaches the gap and dies away as the point recedes. Such a process causes no remanence in the tape. Only the audio variations, which are superimposed on the a.c. field, cause any residual magnetism, and, because of the bias, this magnetism depends linearly on the audio signal. Thus, the tape is not loaded with any 'wasted' remanence as it is when d.c. biasing is used. In addition to this, it will be seen from Fig. 4 that both linear sections of the transfer characteristic can be used. It follows then that the limitations imposed by d.c. biasing on the strength of the audio signal can be relaxed considerably without increasing the danger of approaching the saturation level of the tape. A.C. bias, therefore, reduces 'bottom bend' distortion and, compared with d.c. biasing, gives an improved signal-to-noise ratio.

Initially, an increase in the a.c. biasing current for a given signal strength lessens the distortion of the recorded signal and increases the level of recording. But too much bias will cause 'top bend' distortion and will also cause a lessening in the output, especially for treble signals. (The bias acts very much in the manner of the erase signal —see below.) A typical variation of output with bias current is shown in Fig. 5.

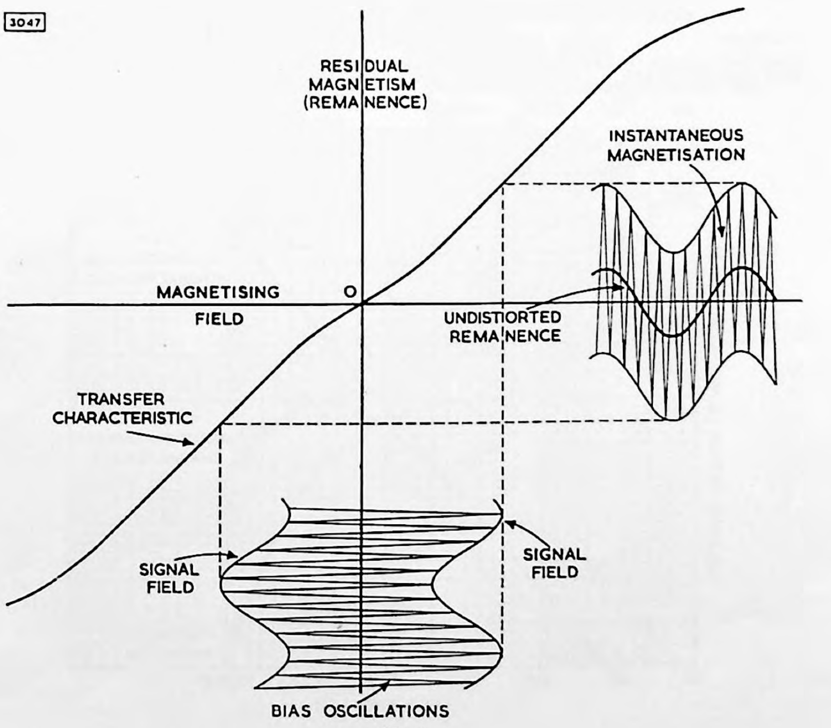


FIG. 4

Erasing

It was stated in the previous section that the field associated with the a.c. biasing signal did not cause any residual magnetism in a tape passing through the field. If the tape is unmagnetised when the signal is applied, it will be unmagnetised when it has passed through the field. If the initial amplitude of the a.c. signal is sufficient to saturate the tape, then even if the tape is not unmagnetised originally, it will be so when it has travelled through the field.

This fact is used in the erase heads of most magnetic recording equipments. The tape is drawn through the strong local magnetic field arising from a high-frequency alternating current in the erase head. As each point of the tape travels into the field, it is saturated, and as each point recedes, it is subjected to a field strength which diminishes to zero some distance from the head. By this process it is cleaned of all previous magnetisation.

THE OSCILLATOR

High frequency signals are required at two stages in the process of magnetic recording: for a.c. biasing, and for erasing.

The bias oscillator should generate a sine wave with negligible harmonic distortion to keep noise to a minimum. Symmetry in the waveform is essential. An asymmetrical sine wave has, in effect, a d.c. component made up of the difference between the positive and negative amplitudes of the sine wave. This will introduce noise in the recording and impart some 'wasted' remanence to the tape.

It is usual for the oscillator valve to provide both bias and erase currents. In most of the commercial tape decks, the combined record/playback head is usually of high impedance, while the impedance of the erase head may be high or low. To accommodate low impedance erase heads, a separate oscillator output, in the form of a secondary winding to the oscillator coil, is required for matching purposes.

The frequency of the signal generated by the oscillator must obviously be outside the audio range. Furthermore, it must be high enough to avoid any possibility of beat effects between it and the treble frequencies of the audio signal. But the higher the frequency, the more marked is the tendency for the biasing signal to cause demagnetisation (see below). The oscillator frequency for equipments to be used for recording music should be between 50 and 100kc/s.

It is important, in considering the h.t. supply for the oscillator, that, when the power is switched off, the oscillations should die away smoothly. A rapid decay of the oscillations can cause permanent magnetisation of the heads. The decay is often retarded by placing a large capacitor between the supply line and earth.

FREQUENCY RESPONSE

Ideally, any sound-reproducing equipment should provide a balanced response over the entire a.f. range. In the method for magnetic recording outlined above, the processes are intrinsically incapable, as they stand, of giving such a balanced response.

The degree of magnetisation of the tape which results from recording with a current through the head which is constant at all frequencies is of the form shown by the curve ABC of Fig. 6. The reduced intensity in the treble region is attributable in the main to the self-demagnetisation of the tape.

To recapitulate the recording process briefly—the tape is drawn steadily past the recording head, and the field produced by the signal current in the head induces some degree of residual magnetism in the section of the tape nearest to the head. The amplitude of the signal governs the amount of magnetism, and the sense (whether positive or negative) controls the direction of the magnetism in each section.

Assuming the molecular theory of magnetism, the 'molecular magnets' in the tape are aligned by the magnetising field: the strength of the field governs how many of these magnets are brought into line; the direction of the field dictates whether the alignment is with north or south poles leading.

The field set up by a sinusoidal signal current in the head would change direction regularly, so that the pattern of magnetism induced in the tape would have adjacent sections of the tape with north and south poles leading alternately (see Fig. 7). Thus, the poles of each section of the tape would be adjacent to the like poles of the neighbouring sections.

The length of these sectional magnets in the tape depends on the speed at which the tape passes the head, and on the frequency at which the magnetising field changes direction. For a constant transport speed, the length varies inversely as the frequency of the signal. For low frequency signals, the magnets are comparatively long, but for high frequencies they are short.

The ability of the tape to resist demagnetisation depends, in part, on the length of these sectional magnets. If they are short, the opposing fields set up by the neighbouring like poles will cause mis-alignment more readily than if they are long. Hence the demagnetising effect is greater at the higher frequencies than at the lower ones, and consequently there will be less residual magnetism at the higher frequencies even if the signal amplitudes are constant throughout the frequency range.

For the playback process, the magnetised tape is drawn past the playback head at a constant speed, and the magnetic fields associated with the sections of the tape move and cut the coils of the head, thereby setting up voltages in the coils. The *rate of change* of the flux cutting the coils governs the voltage generated. Thus, the rapidly changing fields set up by the sections of the tape on which high-frequency sounds have been recorded must of necessity give rise to larger voltages than the sections containing low frequency impressions. This is so, even if the impressions at both high and low frequencies have the same intensity of magnetisation. The actual speed of the tape has no bearing on the relative levels of the output at the various frequencies. An increase in the transport speed simply multiplies all levels by the same amount.

The rate at which the playback voltage rises with frequency is equivalent to 6dB per octave. In Fig. 6, the line DEF indicates the frequency response of the playback head only. (A tape which has been ideally magnetised is assumed for this response curve.) The response curve for the recording head alone will depend on various practical considerations. For example, a tape made of a magnetic material of high coercivity is difficult to demagnetise, and if one is used, then the demagnetisation losses at high frequencies will be less than if a low-

FIG. 5

coercivity tape is used. The use of a high coercivity tape, of course, makes intentional erasing more difficult.

The response for the complete apparatus, that is, the response combining both recording and playback deviations is indicated by the curve DEGH of Fig. 6. To obtain an equalised output from this response curve it is necessary to introduce boost at both ends of the frequency range. For ideal equalisation, the compensating curve must be a mirror image of the curve DEGH, that is, the equalising response curve needs to be the curve IGJ.

There will be, in fact, further high-frequency losses encountered in tape recording. The tendency of the a.c. bias signal to act as an erasing signal during the recording process is more pronounced at high frequencies because the remanence is less deeply seated at these frequencies. Also, the physical dimensions of the gap in the playback head cause losses when the size of the sectional magnets and the gap are commensurate. (This is usually referred to as 'gap effect'.) These combine to produce a more accentuated drop in the response curve in the treble region.

Unfortunately, equalisation is not simply a matter of compensating for bass and treble deviations. Several performance requirements are in conflict, and a compromise is the best that can be achieved. A wide frequency response, low distortion or a high signal-to-noise ratio can each be obtained only at the expense of the others. Over a restricted range, an increase in the bias current, for example, lessens distortion, but causes treble attenuation and tends to lessen the signal-to-noise ratio.

One 'non-electrical' method of resolving the conflict of these requirements should, perhaps, be mentioned. The treble attenuation is mainly some function of the length of the sectional magnets in the tape. These lengths are increased, and thus the demagnetisation is reduced, if the transport speed of the tape is increased. But, of course, the transport mechanism is the concern of the tape-deck manufacturers. The home constructor must work on the assumption of pre-ordained tape speeds, and must seek the means of equalisation elsewhere.

AMPLIFYING AND EQUALISING CIRCUITS

Generally speaking, the design of both amplifying units will follow normal a.f. practice, although attention must be paid to certain requirements of the equipment. Precautions will be required to minimise hum pick-up, and the overall signal-to-noise ratio should be at least 40dB.

The attenuation of the bass response in a tape recorder takes place mainly in the playback head. The treble response suffers its greatest losses in the recording process. Thus, in order to load the tape more or less evenly,

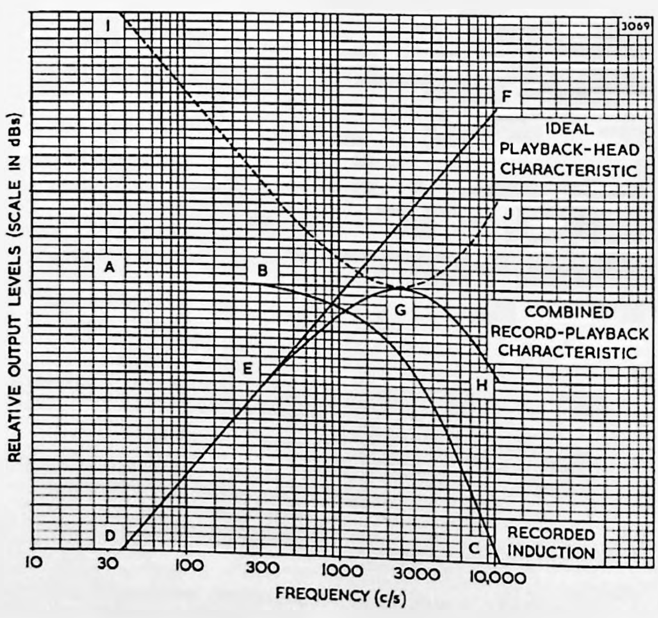


FIG. 6

it is best to provide treble boost in the recording amplifier and to apply bass boost in the playback amplifier. Some treble accentuation may also be required in the playback amplifier, but this has to be limited in order to avoid much amplification of background noise.

Except, perhaps, in the larger, professional types of recorder, it is usual to combine both amplifiers in one unit. Switching arrangements include or exclude parts of the unit which serve only one of the applications.

derived from this source. Another arrangement would be to use the three amplifying stages, and to introduce a signal attenuation network for the radio input.

Pre-emphasis of the treble signals can be introduced in the equaliser stage, the boost being provided by parallel-T, R–C networks in a feedback loop between the anode and grid of the valve of this stage.

The bass boost in the playback amplifier can be supplied by a series R–C network in the feedback circuit of the equaliser stage of the amplifier.

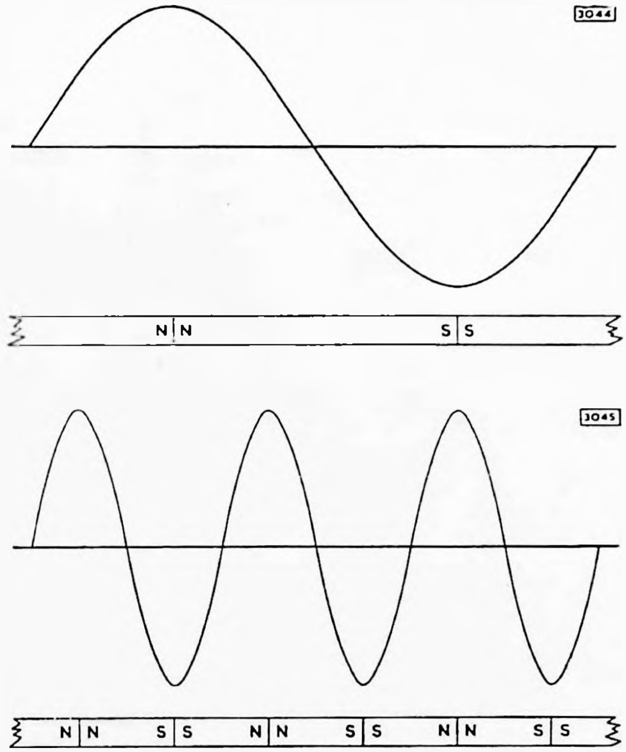


Fig. 7—LENGTHS OF SECTIONAL MAGNETS CORRESPONDING TO LOW AND HIGH FREQUENCY SIGNALS

The recording amplifier unit is often made up of three stages. Two of these stages —the equaliser and the recording output stages—are used with both types of input. A third or auxiliary input stage is normally required with microphone excitation to give extra amplification to the weaker signals

In a 'self-contained' tape amplifier unit it is obviously economical to use all the valves of the recording channel for the playback process. The oscillator valve of the recording amplifier, for instance, should be arranged as a power output stage for the playback amplifier. But, of course, if the unit is designed so that a low-level output is taken from a point early in the playback amplifier to drive subsidiary high-quality amplifying equipment, this does not apply, and some valves will be idle during playback.

Switching arrangements must bring in the recording head as the output termination of the recording unit, and the loudspeaker for the output of the playback amplifier. The microphone or radio source is the input to the recording amplifier and the playback head provides the signal for the reproduction amplifier. In designing the changeover switching devices, screening precautions must be taken to avoid undesirable parasitic oscillations.

RECORDING LEVEL INDICATOR

In order to obtain the optimum signal-to-noise ratio, the level of recording on the tape should be the maximum that is consistent with saturation of the magnetic material of the tape. If the magnetising signal is too low, the gain of the playback amplifier will have to be increased to give a satisfactory output, and consequently the background noise will be increased. If the signal is too high, the output will be heavily distorted. Thus, some means of indicating the level of recording is essential.

A satisfactory indicator makes use of a 'magic eye' tuning indicator valve. The sensitivity of the level indicator is adjusted to show visually the relative level of the recording current.

POWER SUPPLY

The power unit can follow any standard design, but there are three aspects worthy of especial note:

(1) The mains transformer should be of good quality. Saturation of the core can produce intense magnetic fields which interact with the heads of the tape deck, resulting in hum.

(2) The final h.t. supply should be adequately smoothed. It is preferable to use resistance smoothing: a gapped-choke in the h.t. line following the rectifier will produce a heavy external magnetic field.

(3) The output from the h.f. oscillator stage should die away smoothly when the power supply is switched off. A large capacitor should be placed between the supply line and earth.

Because of the stray magnetic fields associated with any power unit, it is advisable to separate the unit from the body of the recorder.

TAPE AMPLIFIER TYPE A

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

The unit to be described in this section 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 equipment which is capable of an excellent performance, whether it is reproducing recordings made on the same unit, or whether pre-recorded tapes are used.

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 in the Type A unit and the bass equalisation is incorporated during playback.

It has been pointed out in the previous section of this booklet that the extent of treble attenuation is dependent on the tape speed. It is thus 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 control RV25 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.

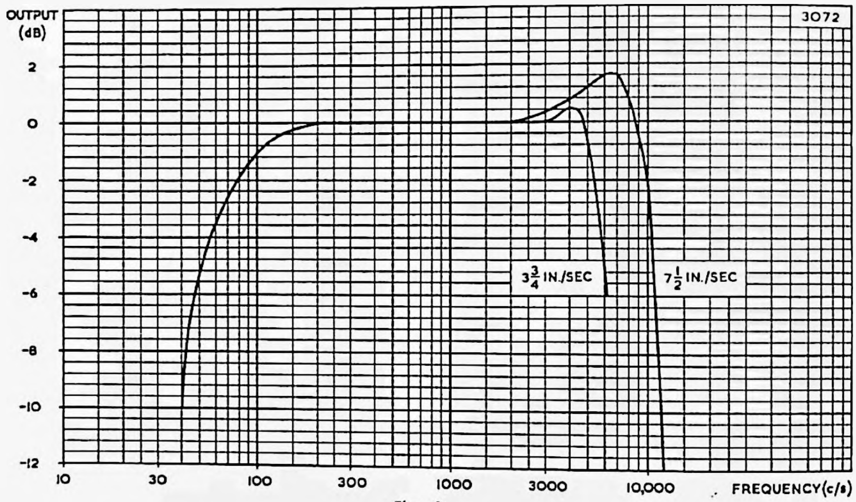


FIG. 8

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. 8 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. 9.

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.

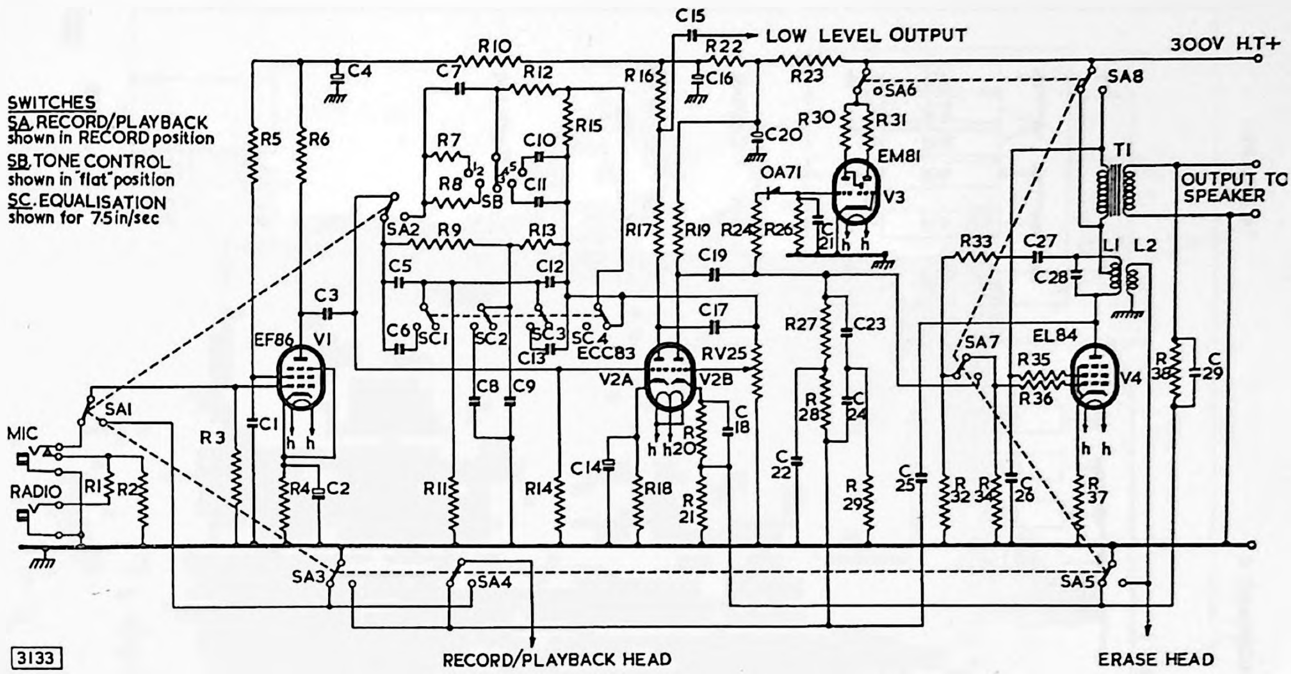


Fig. 9—TYPE A TAPE AMPLIFIER

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 7½ or 3¾ 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 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 OA71, 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: thus 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 3¾ and 7½ inches per second are arranged on the switch SC. The switch is shown in Fig. 9 in the position for 7½ 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. 9 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 pre-amplifier 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

TABLE 1

Switch position	Tape speed = 7½ in./sec		Tape speed = 3¾ 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

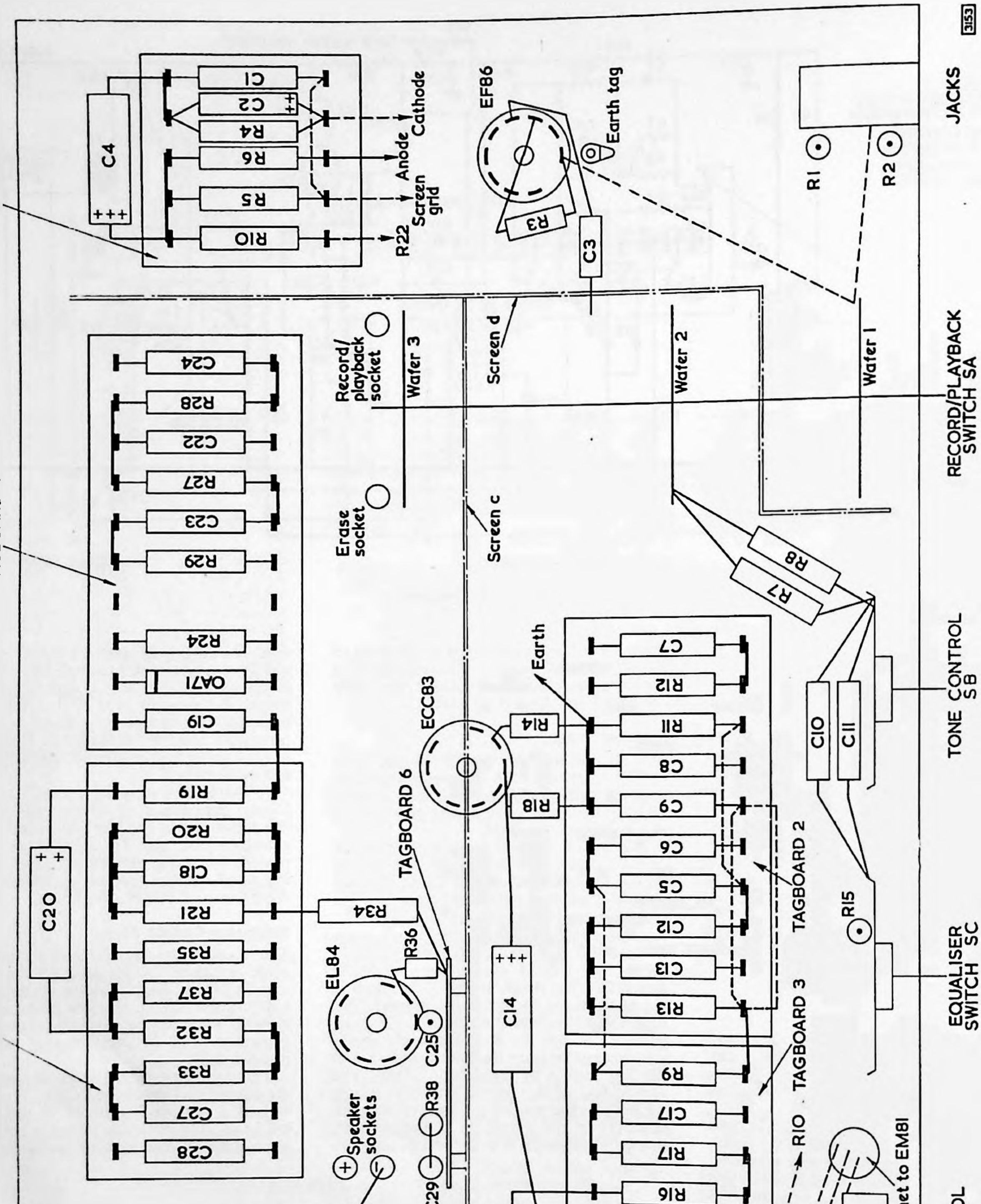
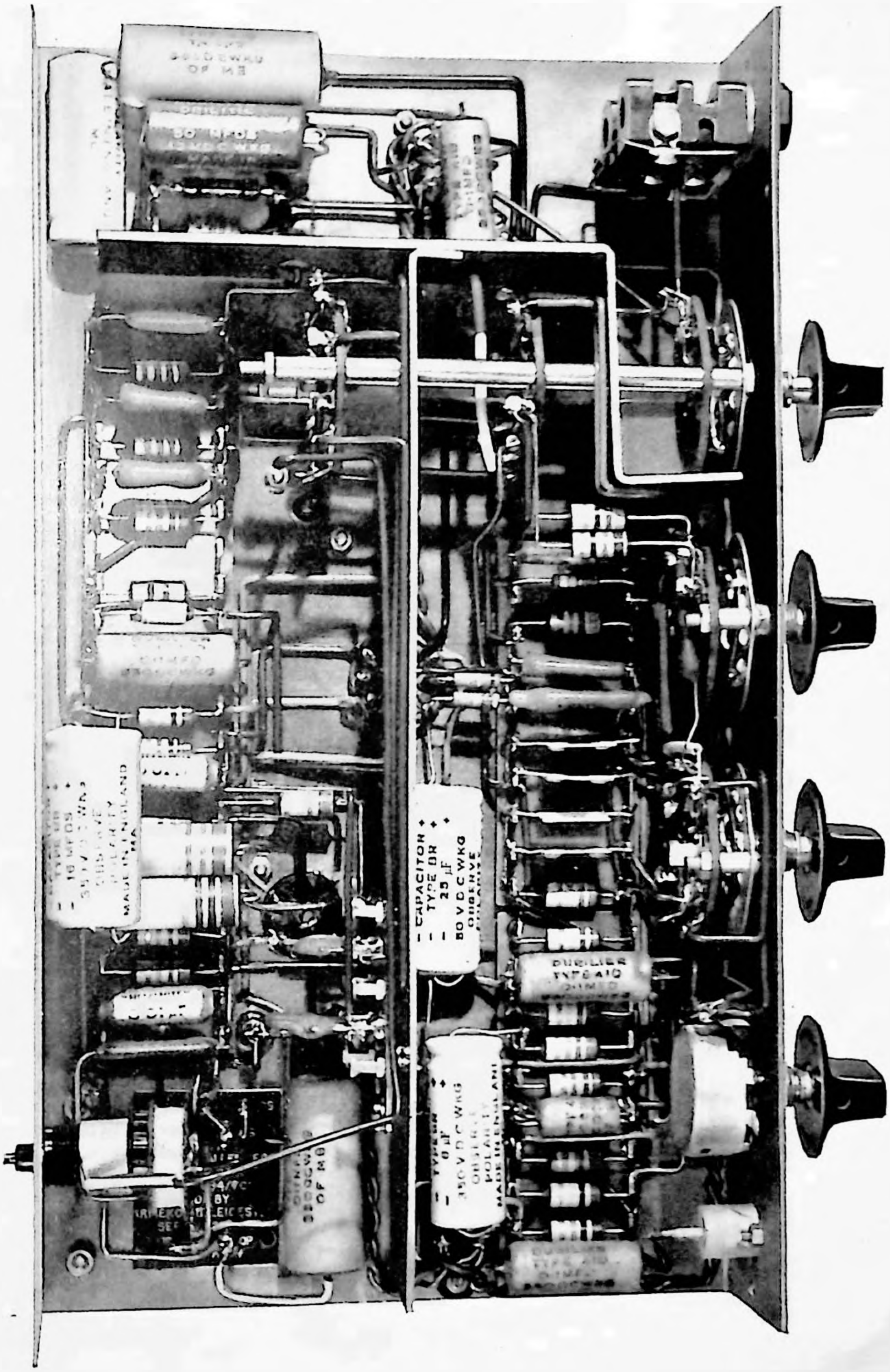


Fig. 10—COMPONENT LAYOUT DIAGRAM (Components which would obscure parts of the layout have not been shown)



PHOTOGRAPH OF UNDERSIDE OF PROTOTYPE AMPLIFIER TYPE A 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 Output 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 the 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. It is likely that the coils specified by the various tape-deck manufacturers can be used satisfactorily. Details of the use of some proprietary coils are included later.

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.

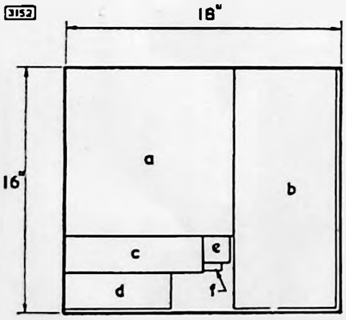


FIG. 11

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 OA71.

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.

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	15¾ × 6⅝
(*c*)	Internal screen	9 × 2⅜
(*d*)	Internal screen	7 × 2⅝
(*e*)	EM81 mounting bracket	1¾ × 1¾
(*f*)	Small bracket	1¼ × ½

The six pieces can all be cut from one sheet 18 in. long and 16 in. wide if the arrangement shown in Fig. 11 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. 42, 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. 42. 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.

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.

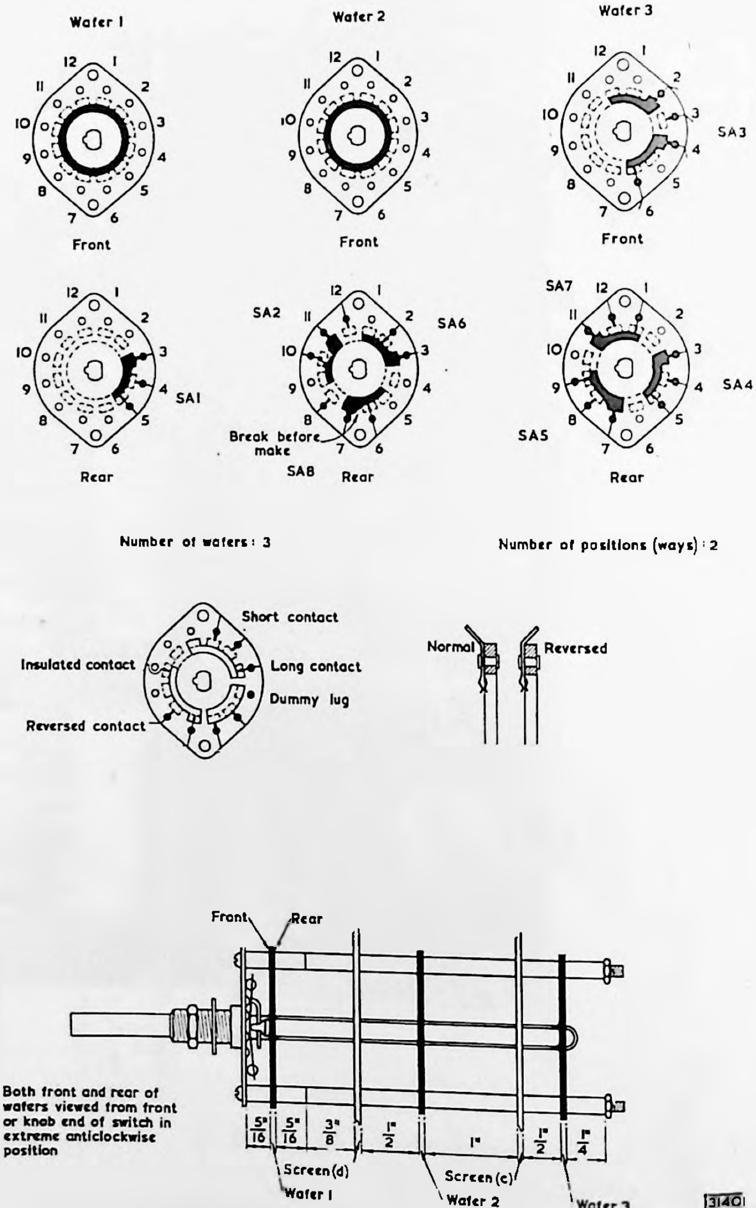


Fig. 12—RECORD/PLAYBACK SWITCH DETAILS

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. 13.
(4) The small fixing bracket f, which should be bolted to the screen c as indicated in Fig. 13.

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. 12) 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. 12) farthest from the switch plate. The general arrangement of the switch wafers and internal screens is shown in Fig. 13. Details of spacers required for the assembly are shown in Fig. 12.

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.

(4) EL84 valveholder—The gap between pins 1 and 9 should be directed away from the output transformer.
(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.

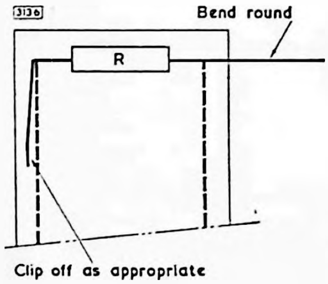


FIG. 14

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. 14. If the tagboard wiring diagrams show that neighbouring tags are to be connected together, the lead wires of 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. 15, 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.

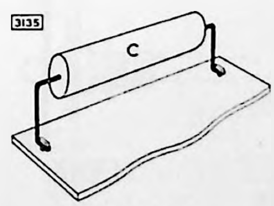


FIG. 15

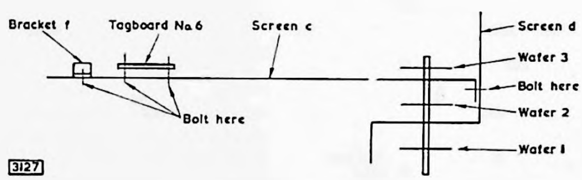


FIG. 13

The assembling of the unit is best continued by referring to the diagram giving the component layout (Fig. 10). 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.

Heater Supply

This is the first stage in the wiring of the amplifier. From pins 1 and 3 of the supply input socket (Fig. 16) 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.

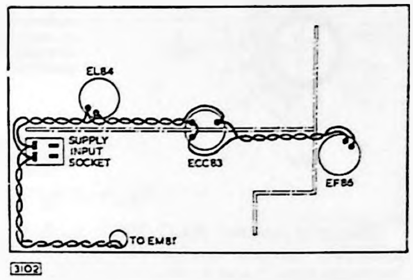


FIG. 16

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 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.

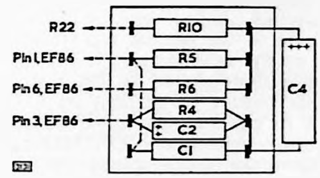


Fig. 17—TAGBOARD No. 1

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. 17. 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. 10.

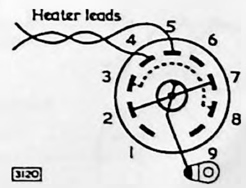


FIG. 18

On the EF86 valveholder shown in Fig. 18, 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.

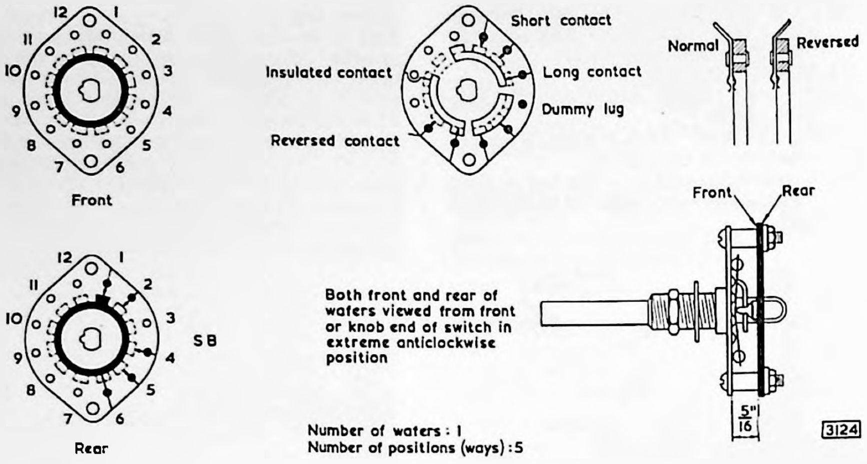


Fig. 19—TONE CONTROL SWITCH DETAILS

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. 21. 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.

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. 42) 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. 22, 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.

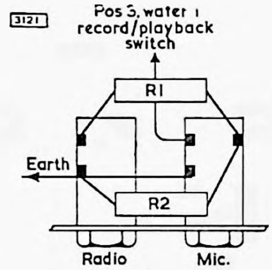


FIG.21

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. 23. A connection should then be made (again along the path indicated in Fig. 23) 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. 23 to the resistor R10 (33kΩ) on Tagboard No. 1.

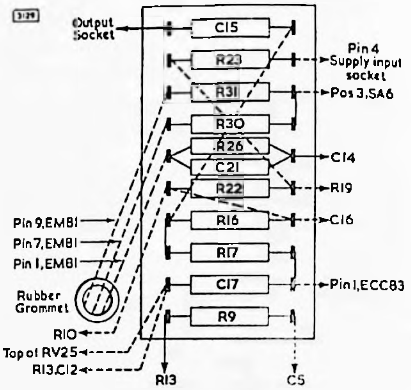


Fig. 22—TAGBOARD NO. 3

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. 24. 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. 10.

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

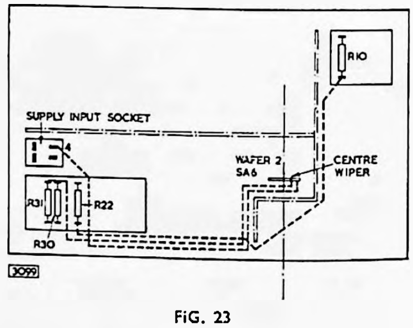


FIG. 23

between pin 2 and the junction of C8 (150pF) and R11 (100kΩ), which is an earth point. This earth point should be joined to the centre spigot of the ECC83 valveholder and then through the cut-out in the internal screened 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).

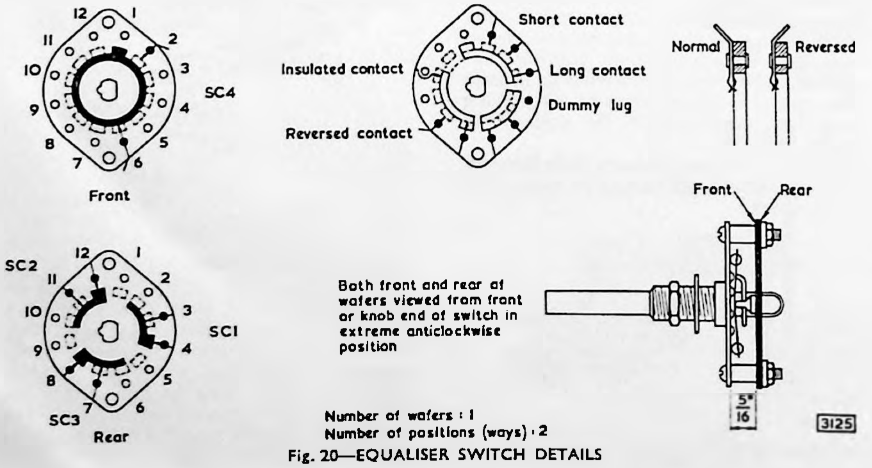


Fig. 20—EQUALISER SWITCH DETAILS

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

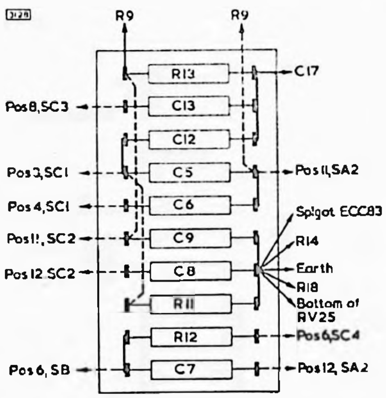


Fig. 24—TAGBOARD No. 2

The top of the gain control is fed from the anode of the first section of the ECC81 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. 10, 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. 19 and 20 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. 25 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.

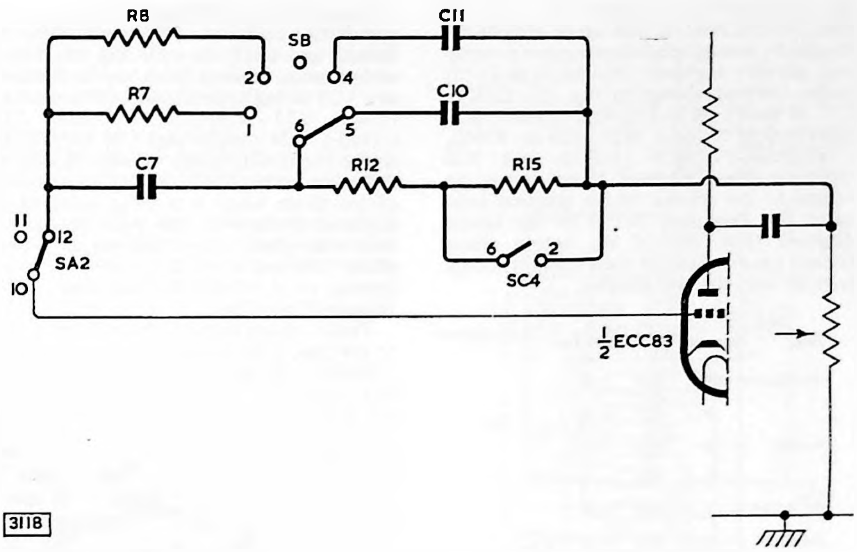


FIG. 25

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. 26 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 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.

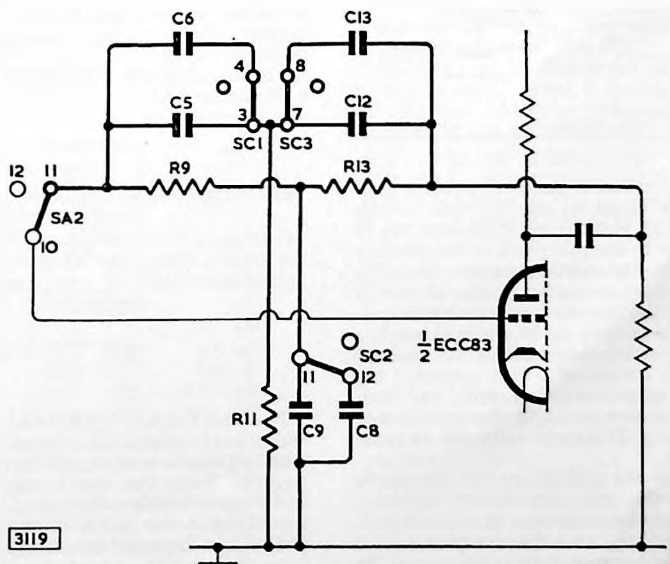


FIG. 26

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. 27: C28(*), C27 (0·01μF), R33 (*), 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. 10). If the output transformer has not already been fitted, it should now be bolted to the chassis.

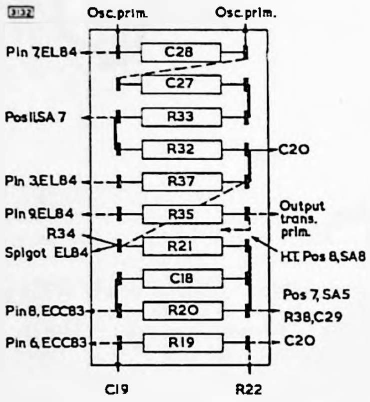


Fig. 27—TAGBOARD No. 5

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. 28.

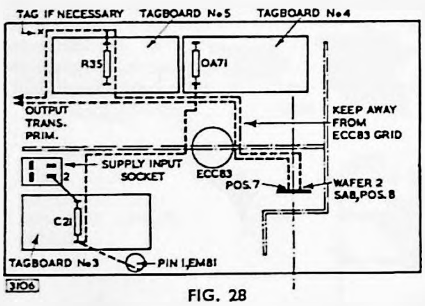


FIG. 28

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. 28. 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. 28 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).

Components should now be wired to the remaining tagboard (Tagboard No. 4, Bulgin, type C125, shown in Fig. 29). These components, reading from top to bottom, are: C19 (0·1μF), OA71, R24 (470kΩ), R29 (27kΩ), C23 (47pF), R27 (56kΩ), C22 (100pF), R28 (56kΩ) and C24 (47pF). In fitting the OA71, 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).

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 OA71 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. 28.

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.

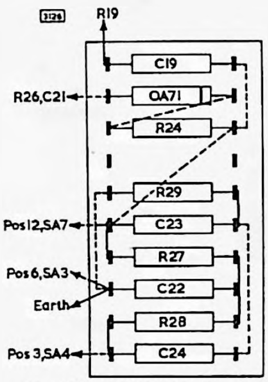


Fig. 29—TAGBOARD No. 4

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.

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. 30. 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.

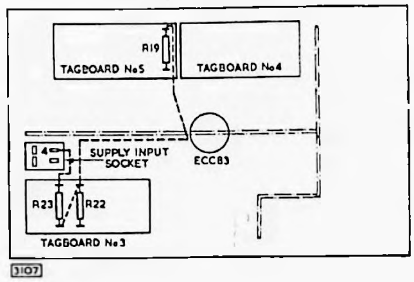


FIG. 30

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 (*);
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. 31). 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. 31.

From the tag at the junction of R34 (680kΩ) and R36 (1kΩ) (Fig. 31) 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. 31 counting from the straight edge of the internal screen c).

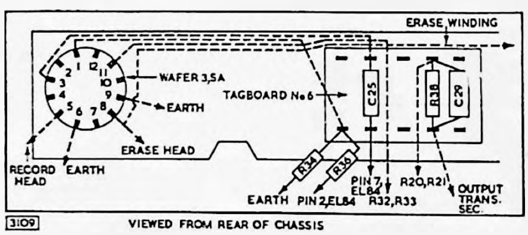


FIG.31

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

The capacitor C25 (*) 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.

*Values dependent on type of oscillator coil used. See section on oscillator coils and components list.

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

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 Oscillator Coil

The full instructions given in this section apply only to the wiring of the oscillator coil suitable for use with Brenell or Collaro tape decks. This was the type of coil used in the prototype amplifier.

Abbreviated assembly details for this coil, and similar details for oscillator coils provided by the makers of Lane and Truvox tape decks, are given after the full instructions.

Full wiring instructions for the prototype oscillator coil

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 (blue) 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 (yellow) of the oscillator coil primary. The other end of C28 should be connected to the grid end (red) 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 (black) on the oscillator coil should be connected to the nearest convenient earth point.

Abbreviated wiring details

A—For the Brenell oscillator coil which is suitable for use with Brenell or Collaro tape decks.

The circuit for the oscillator stage when this type of oscillator coil is used is given in Fig. 32. The values of the components appearing in this figure are:

R32 = 22 kΩ	C25 = 82 pF
R33 = 18 kΩ	C26 = 0·5 μF
R35 = 6·8kΩ	C27 = 0·01μF
R36 = 1·0kΩ	C28 = 3300 pF
R37 = 150 Ω	

The coil connections should be made as follows (all references are to Fig. 32):

Yellow, marked 1, to the anode of the EL84 (i.e. to the anode end of C28);
Blue, marked 2, to the h.t. supply (i.e. to the end of the output transformer primary winding already connected to position 7 of SA8);
Red, marked 3, to the junction of C27 and C28 (i.e. to the grid circuit of the EL84);
Black, marked 4, to the nearest earth point;
The Flying Lead, marked 5, to the erase head, (i.e. to position 8 of switch SA5).

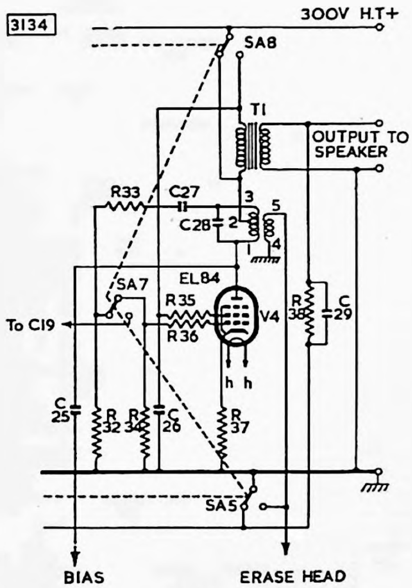


FIG. 32

B—For the Lane oscillator coil suitable for use with a Lane tape deck.

The circuit for the oscillator stage when this type of oscillator coil is used is given in Fig. 33. The values for the components appearing in this figure are:

R32 = 22 kΩ	C25 = 56 pF
R33 = 56 kΩ	C26 = 0·5 μF
R35 = 6·8kΩ	C27 = 0·01μF
R36 = 1·0kΩ	C28 = 680 pF
R37 = 150 Ω	C50 = 180 pF

The coil connections should be made as follows (all references are to Fig. 33):

Blue, marked 1, to the anode of the EL84 (i.e. to the anode end of C28.) The other end of C28 should be connected to the green tag of the oscillator coil, and not to C27.
Green, marked 2, to the h.t. supply (i.e.

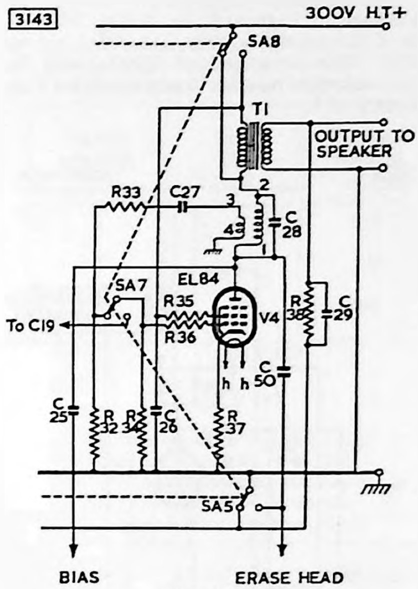
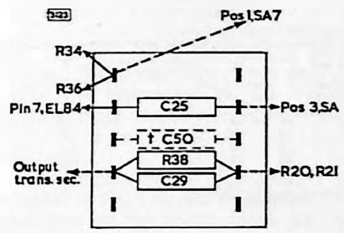


FIG. 33

to the end of the output transformer primary winding already connected to position 7 of SA8);
White, marked 3, to the near end of C27 (i.e. to the grid circuit of the EL84).
Red, marked 4, to the nearest earth point.

The capacitor C50 (180pF) should be soldered to Tagboard No. 6 (Fig. 34) next to C25, and the bottom end connected to C25. The other end of C50 should be connected to the erase head at position 8 on switch SA5.



† see text

Fig. 34—TAGBOARD No. 6

C—For the Truvox oscillator coil suitable for use with a Truvox tape deck.

The circuit for the oscillator stage when this type of oscillator coil is used is given in Fig. 35. The values for the components appearing in this figure are:

R32 = 22 kΩ	C25 = 120 pF
R33 = 150 kΩ	C26 = 0·5 μF
R35 = 6·8kΩ	C27 = 0·01μF
R36 = 1·0kΩ	C28 = 1200 pF
R37 = 150 Ω	C50 = 82 pF

The coil connections should be made as follows (all references are to Fig. 35, and the position numbers of the coil are obtained by counting in a clockwise direction from the gap, the coil being viewed from the top):

Position 1, marked 1, to the h.t. supply (i.e. to the end of the output transformer primary winding already connected to position 7 of SA8);
Position 2, no connection;
Position 3, marked 3, to the anode of the EL84 (i.e. to the anode end of C28);
Position 4, marked 4, to the junction of C27 and C28 (i.e. to the grid circuit of the EL84).

The capacitor C50 (82pF) should be soldered to Tagboard No. 6 (Fig. 34) next to C25, and the bottom end connected to C25. The other end of C50 should be connected to the erase head at position 8 on switch SA5.

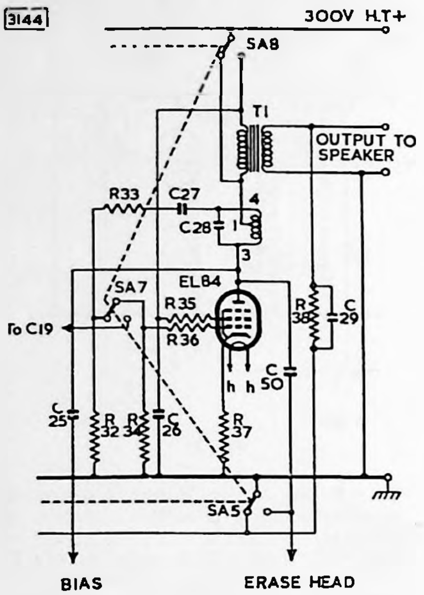


FIG. 35

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. 36 and 37.

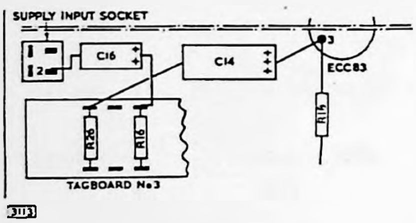


FIG. 36

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.

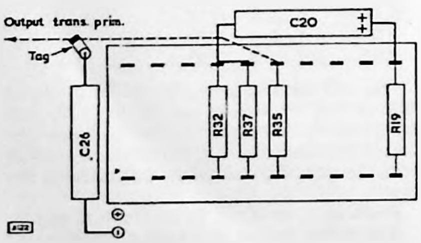


FIG. 37

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.

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 60 kc/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 20 c/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

TABLE II

	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
	C30	<350	<350	1000
	C31	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 anode	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.

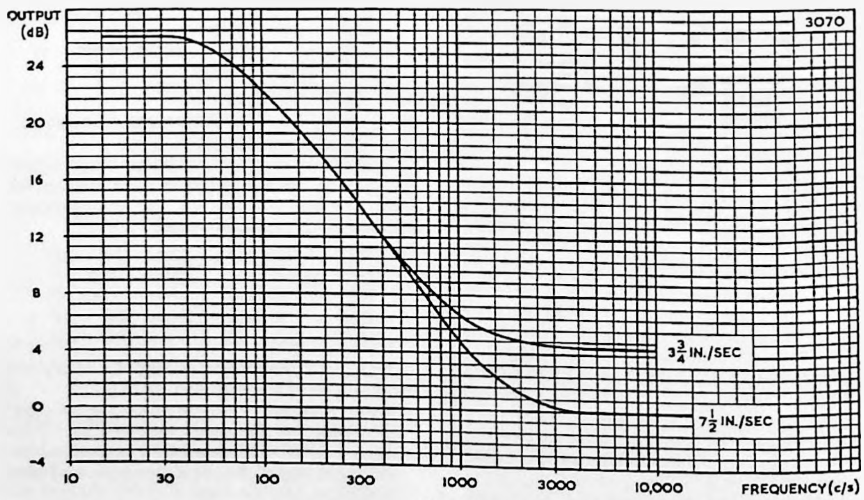


FIG. 38

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 measurement should again be made.

The bass boost characteristics for both tape speeds are shown in Fig. 38.

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.

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 TableVI.

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. 39 and 40. 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.

TABLE III

Playback Sensitivity
(Signal frequency = 5kc/s)

Tape speed (in./sec)	Input (mV)	Output voltages	
		Low-level (mV)	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

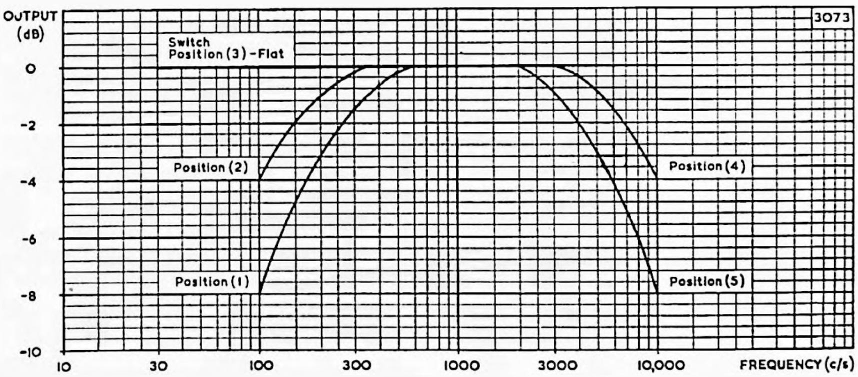


Fig. 39—TONE CONTROL CHARACTERISTIC; TAPE SPEED = 7½ IN./SEC

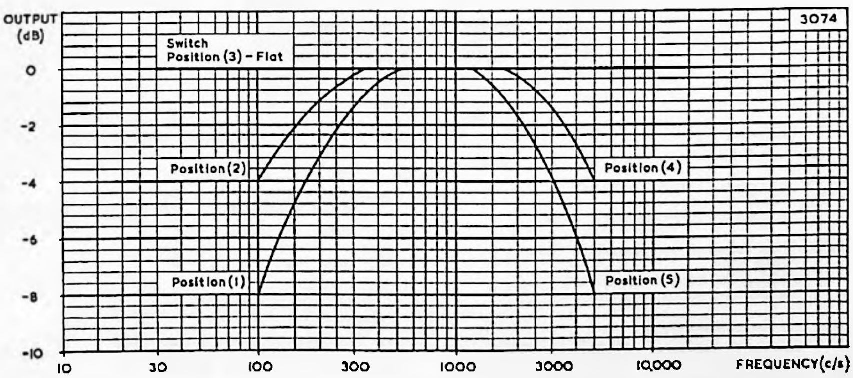


Fig. 40—TONE CONTROL CHARACTERISTIC; TAPE SPEED = 3¾ IN./SEC

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

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

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 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. 41.

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

[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.

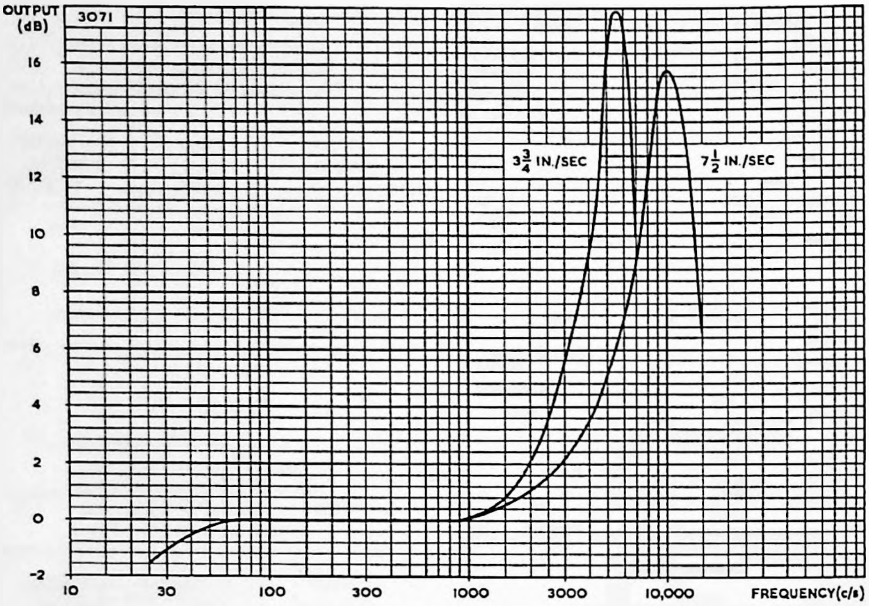


FIG. 41

curve so obtained should agree with the appropriate curve for the prototype amplifier, plotted in Fig. 8. For these observations, it will be necessary to disconnect one end of the resistor R33 (22kΩ), 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.

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

LIST OF COMPONENT VALUES FOR TYPE A AMPLIFIER

Resistors

Circuit reference	Value	Tolerance (±%)	Rating (W)
R1	680 kΩ	10	¼
R2	5·6 kΩ	10	¼
R3	2·2 MΩ	10	¼
R4	2·2 kΩ	10	¼
[1]R5	1·0 MΩ	5	½
[1]R6	220 kΩ	5	½
R7	1·8 MΩ	10	¼
R8	4·7 MΩ	10	¼
R9	220 kΩ	5	¼
R10	33 kΩ	20	¼
R11	100 kΩ	5	¼
R12	270 kΩ	10	¼
R13	220 kΩ	5	¼
R14	560 kΩ	20	¼
R15	270 kΩ	10	¼
[2]R16	22 kΩ	10	¼
[2]R17	180 kΩ	10	¼
R18	4·7 kΩ	10	¼
R19	100 kΩ	10	¼
R20	1·5 kΩ	10	¼
R21	220Ω for 15Ω output / 470Ω for 3·75Ω output	10	¼
R22	27 kΩ	20	¼
R23	10 kΩ	20	¼
R24	470 kΩ	10	¼
RV25	500kΩ logarithmic 10% law; carbon potentiometer		
R26	1·0 MΩ	20	¼
R27	56 kΩ	10	¼
R28	56 kΩ	10	¼
R29	27 kΩ	10	¼
R30	560 kΩ	10	¼
R31	100 kΩ	10	¼
R32	22 kΩ	10	¼
R33	*	10	¼
R34	680 kΩ	20	¼
R35	6·8 kΩ	10	1
R36	1·0 kΩ	20	¼
R37	150 Ω	10	1
R38	2·2 kΩ	10	¼

*R33: 18kΩ for Brenell or Collaro oscillator coil
56kΩ for Lane oscillator coil
150kΩ for Truvox oscillator coil

[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	0·02μF		paper	350
C19	0·1 μF		paper	350
C20	16 μF		electrolytic	350
C21	0·05μF		paper	150
C22	100 pF	10	silvered mica	
C23	47 pF	10	silvered mica	
C24	47 pF	10	silvered mica	
C25	*	10	silvered mica	350
C26	0·5 μF		paper	350
C27	0·01μF		paper	350
C28	**	10	silvered mica	350
C29	1800 pF	10	silvered mica	
C50	***	10	silvered mica	350

*C25: 82pF for Brenell or Collaro oscillator coil
56pF for Lane oscillator coil
120pF for Truvox oscillator coil

**C28: 3300pF for Brenell or Collaro oscillator coil
680pF for Lane oscillator coil
1200pF for Truvox oscillator coil

***C50: Not required for Brenell or Collaro oscillator coils
180pF for Lane oscillator coil
82pF for Truvox oscillator coil

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
MR	Germanium diode	Mullard type OA71

Oscillator Coils

Choice depends on tape deck used. Coils are normally provided by manufacturers for their proprietary decks.

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	VP2641
Partridge	SVO/1
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 skirt (two). McMurdo XM9/UD1, skirt 811

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

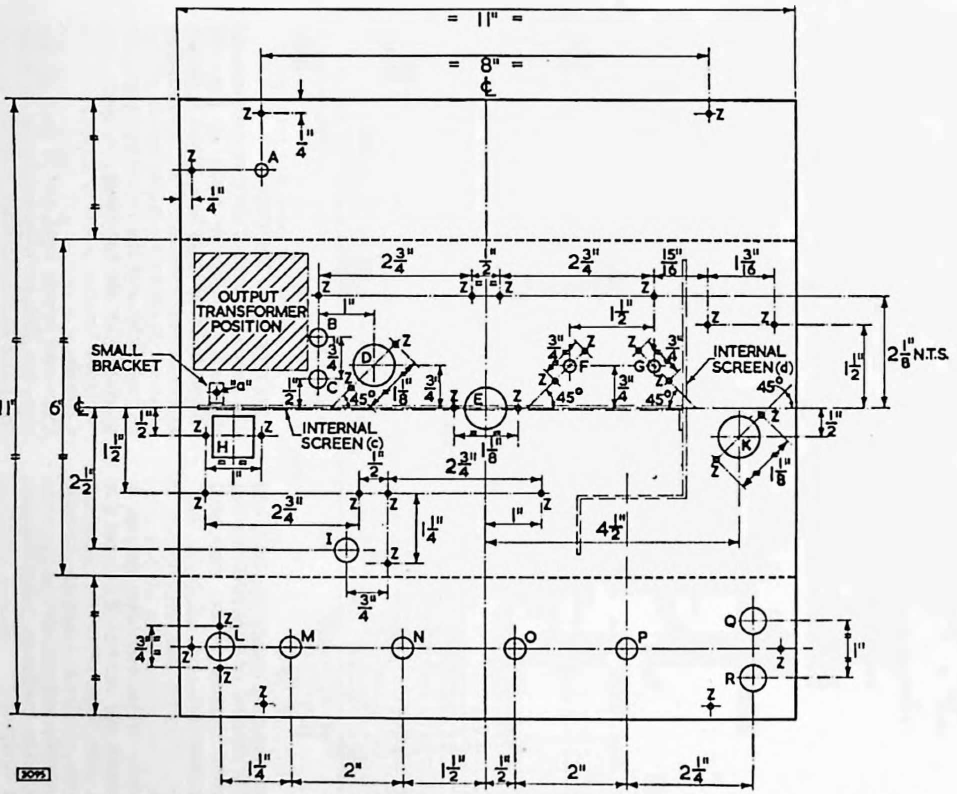
Tone Control switch.
Shirley Laboratories, Ltd., 16368/B1
Specialist Switches, SS/567/B

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

Five-way tagboard (two), Bulgin C120

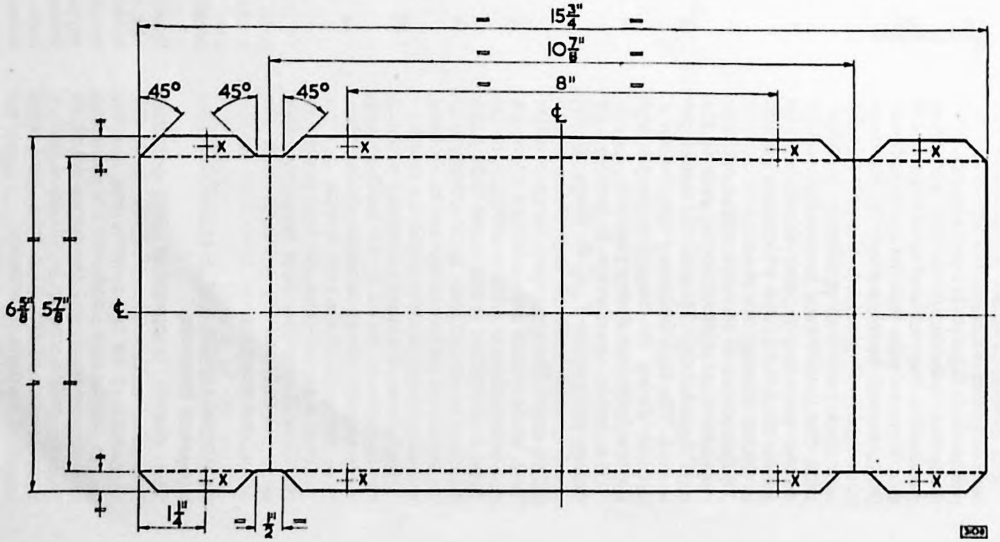
Ten-way tagboard (two), Bulgin C125

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

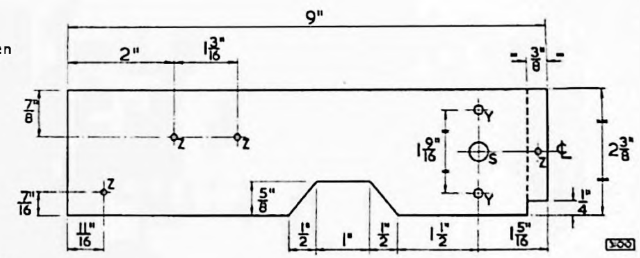


Above—(a) Main Chassis (hole marked 'a' should be made after assembly with No. 34 drill)

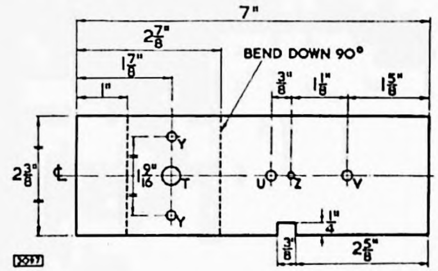
Below—(b) Base

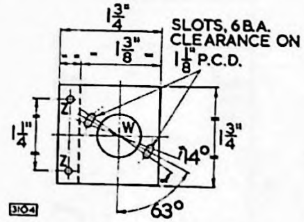


Right—(c) Internal Screen



Below—(d) Internal Screen





Above—(e) EM81 Fixing Bracket

Below—(f) Small Bracket

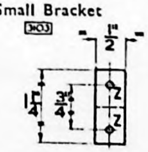


Fig. 42—TYPE A TAPE AMPLIFIER CHASSIS DETAILS (The chassis sections should be bent up at 90° at all dotted lines except where the contrary is specifically indicated)

KEY TO HOLES IN CHASSIS DRAWINGS

Hole	Dimension	Use	List No.
A	¼ in. dia.	Oscillator coil	—
B	5/16 in. dia.	Loudspeaker socket, Belling Lee (Red)	L/316
C	5/16 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/UD1; Skirt 811
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	P04
I	7/16 in. dia.	Grommet	—
K	¾ in. dia.	B9A nylon-loaded valveholder with screening skirt	XM9/UD1; Skirt 811
L	¼ 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	3/16 in. dia.	Rubber grommet	—
V	3/16 in. dia.	Rubber grommet	—
W	¾ in. dia.	B9A valveholder, McMurdo	BM9/U
X	Drill No. 49	Self-tapping screw	⅜ × 4 in.
Y	Drill No. 27	4 B.A. clearance hole	—
Z	Drill No. 34	6 B.A. clearance hole	—

TAPE AMPLIFIER TYPE B

There has been a very great demand for a design for a tape-recording amplifier which can be used in conjunction with a high-quality pre-amplifier and power amplifier. The design described in this section is intended to meet this demand.

The unit combines the function of both recording and playback amplification, although, in the playback operation, it acts only as an equalising stage, giving sufficient output to drive the high-quality 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 200μA through the head.

Equalisation to correct for head and tape characteristics is provided for each of the tape speeds: 3¾, 7½ and 15 inches per second. The high-frequency equalisation is applied during the recording process and the low-frequency during playback.

The treble equalisation is provided by means of parallel-T, C-R filters in the anode-to-grid feedback loop of the second EF86 stage. The capacitive elements which have to be varied for each tape speed are not arranged on a selector switch as in the Type A Amplifier: it was found to be more satisfactory to arrange these components on octal-base plug-in units, one unit holding the components for one particular speed.

Each base also carries a resistor which is the component varied in the feedback network to give bass equalisation during playback for each of the tape speeds.

There is no provision for tone control in the Type B amplifier. It is anticipated that such control will be available with the associated amplifier.

PERFORMANCE CHARACTERISTICS

Frequency Response

The overall response of the amplifier depends on the type of head used, the magnitude of the bias current, and, to some extent, on the tape employed. The following overall responses, and the curves drawn in Fig. 43, will normally be obtained with a bias current of 0·5 to 1·0mA used with heads of medium impedance.

15 in./sec ±2dB (relative to the level at 1kc/s) from 50c/s to 16kc/s
7½ in./sec ±2dB (relative to the level at 1kc/s) from 50 c/s to 11kc/s
3¾ in./sec ±2dB (relative to the level at 1kc/s) from 50 c/s to 5kc/s

The playback characteristic of the amplifier conforms 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 playback characteristic. Additional head losses occurring during playback will normally be capable of correction by the tone controls situated in the associated amplifying systems.

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

(*a*) Microphone input: 1·4mV for peak
(impedance = 2MΩ) recording level
(*b*) Radio input: 152mV for peak
(impedance ≃ 700kΩ) recording level

Playback Sensitivity
(measured at 5kc/s for each tape speed for output of 300mV)

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

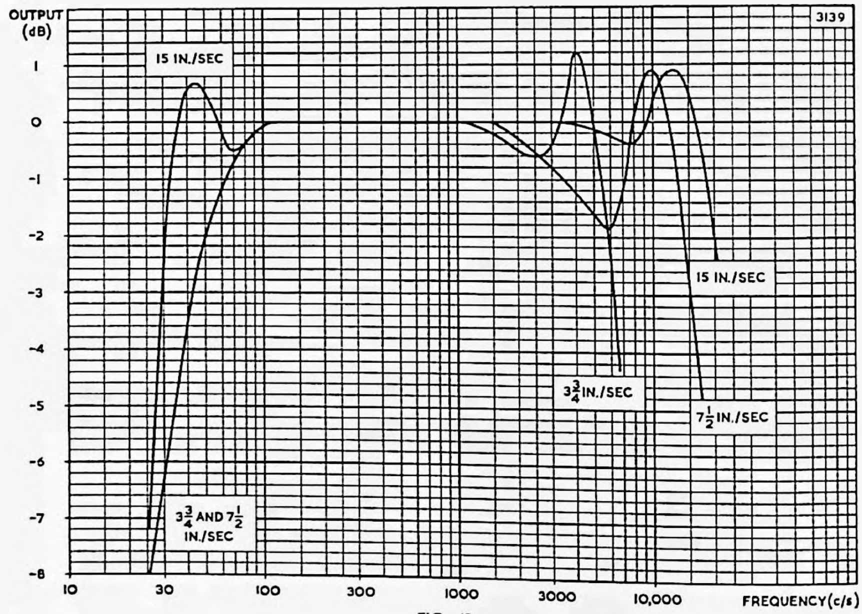


FIG. 43

Sensitivity

The sensitivity of the recording process is measured with the control RV13 set for maximum gain. This, of course, 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.

CIRCUIT DESCRIPTION

The circuit diagram of the combined record/playback amplifier is given in Fig. 44, where the record/playback switch is shown in the 'record' position. The output during playback is taken from the anode of the second EF86, and the remaining stages are used only for the recording operation.

Controls

Only one switch bank (S) is used in the amplifier. This provides the change from the recording to the playback process.

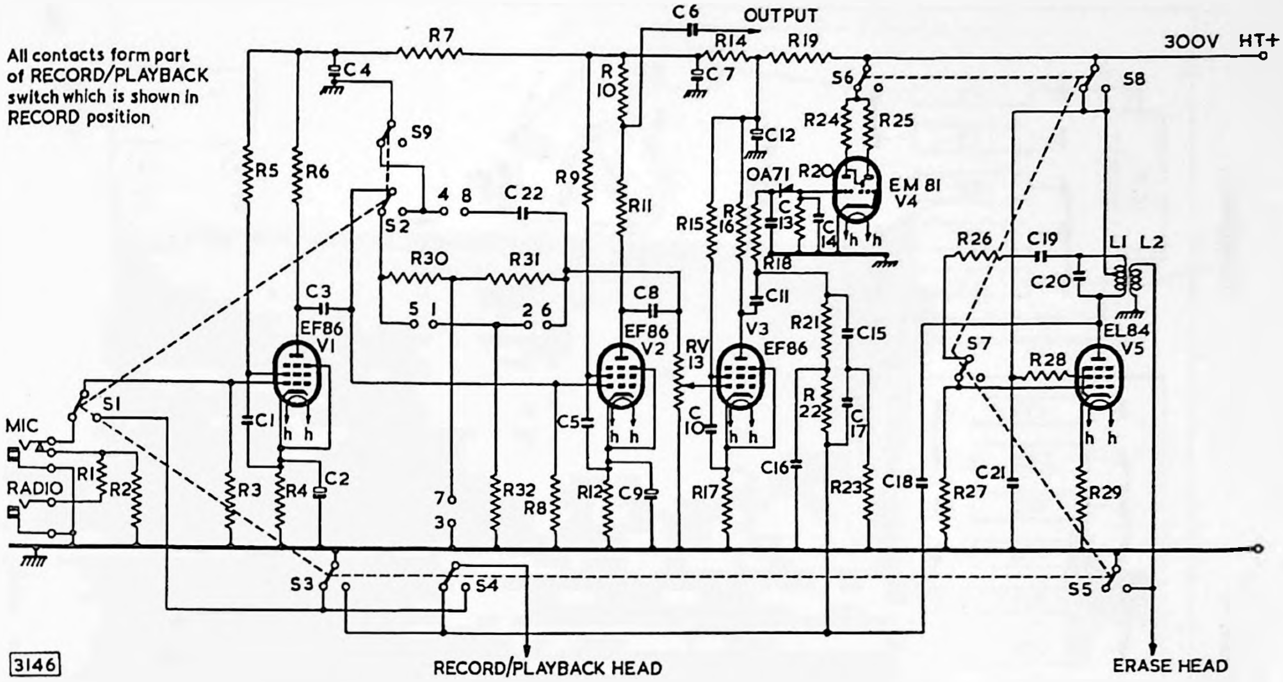


Fig. 44—TYPE B TAPE AMPLIFIER

The adaption of the equipment for different tape speeds is effected by means of plug-in units. The arrangement of the components on the octal-base plugs is shown in Fig. 45.

The gain control RV13 affects only the output of the recording process, because the output during playback is taken earlier in the circuit.

Valve Complement

The complete 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 EL84, output pentode, used as an oscillator for the bias and erase signals.
(*e*) Type EM81, tuning indicator, used in the recording level stage.
(*f*) Type OA71, 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: thus only one input may be used at a time.

Equaliser Stage

By using an EF86 for this stage of the amplifier instead of half of the double triode as in the Type A circuit, greater flexibility is achieved in the design.

No tone control is incorporated in this stage, as it is anticipated that such control will be available in the associated amplifier and preamplifier. The output is taken during playback from across part (R10) of the anode load of the EF86. The output supplied is 300mV at a source impedance of 20kΩ. A rearrangement of the anode load resistance can be made, if required, to give an output of, for instance, about 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 EF86 by way of the gain control RV13 to the grid of the following EF86.

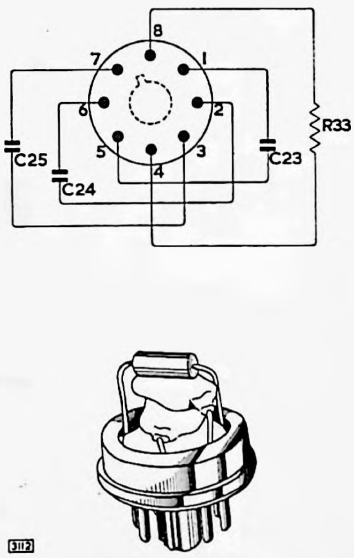


Fig. 45—OCTAL PLUG-IN UNIT

As previously explained, different values of components are arranged on plug-in units, and the appropriate unit is introduced to the circuit for each speed to form a feedback loop between the anode and grid of the second EF86. The components for both treble and bass equalisation are arranged on the plug-in units, the record/playback switch S selecting those needed for the particular process.

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 gain 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 200µA.

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 current drive to the head, and its inclusion is also desirable to preserve a satisfactory a.c./d.c. load ratio for the EF86.

H.F. Oscillator Stage

This stage differs from the oscillator of the Type A amplifier in that no provision has to be made for the valve to serve as a power output stage in the playback process.

The stage is designed so that the EL84 draws approximately the same current during playback, when it is inoperative, as it does under its oscillatory conditions during recording. In 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 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. It is likely that the coils specified by the various tape-deck manufacturers can be used satisfactorily. Details of the use of some proprietary coils are included later.

Recording Level Indicator

The design of this stage is similar to that of the corresponding stage in the Type A equipment. The tuning indicator, type EM81, is fed from the anode of the recording stage through a large series resistance R18 to minimise the loading of the recording stage.

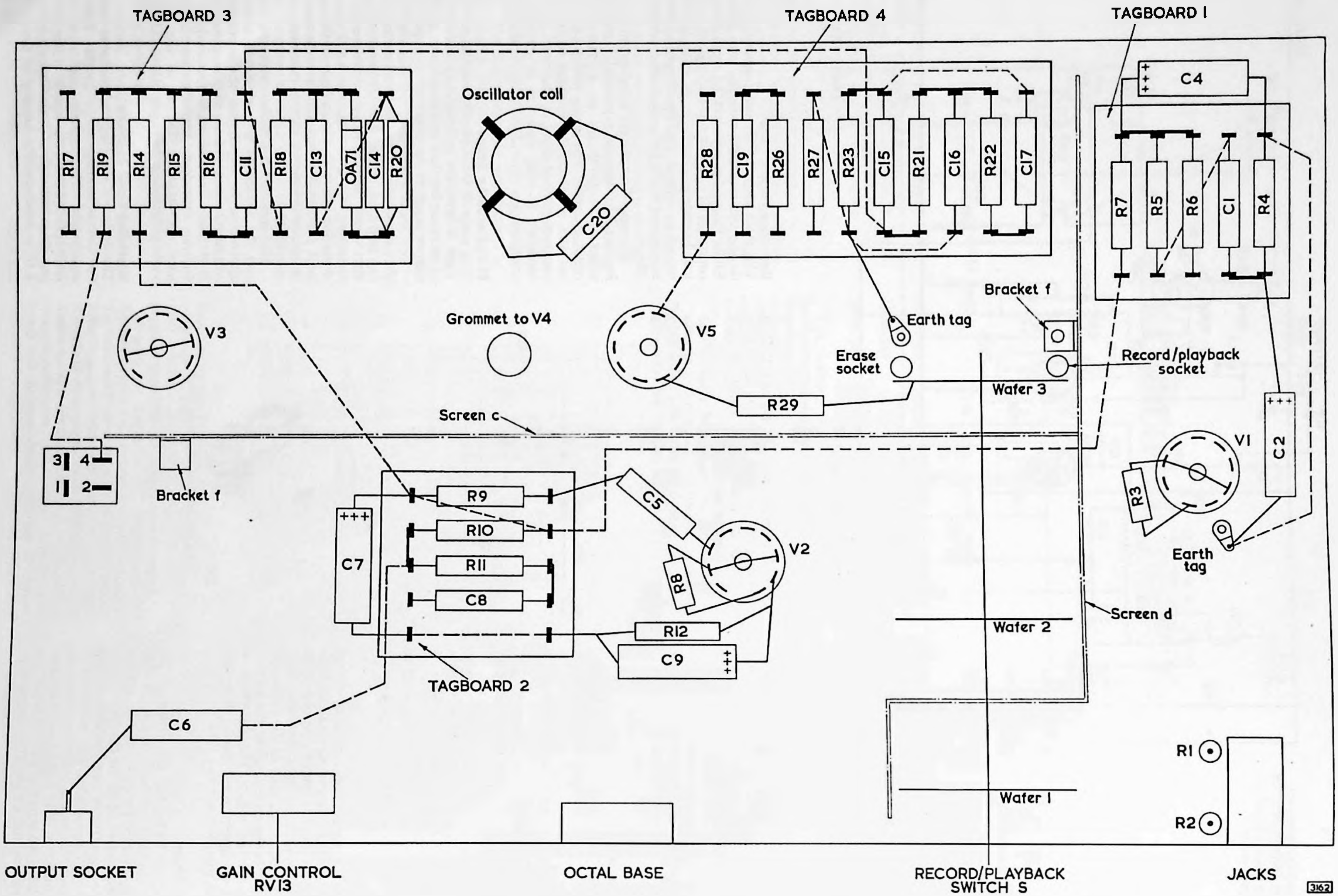
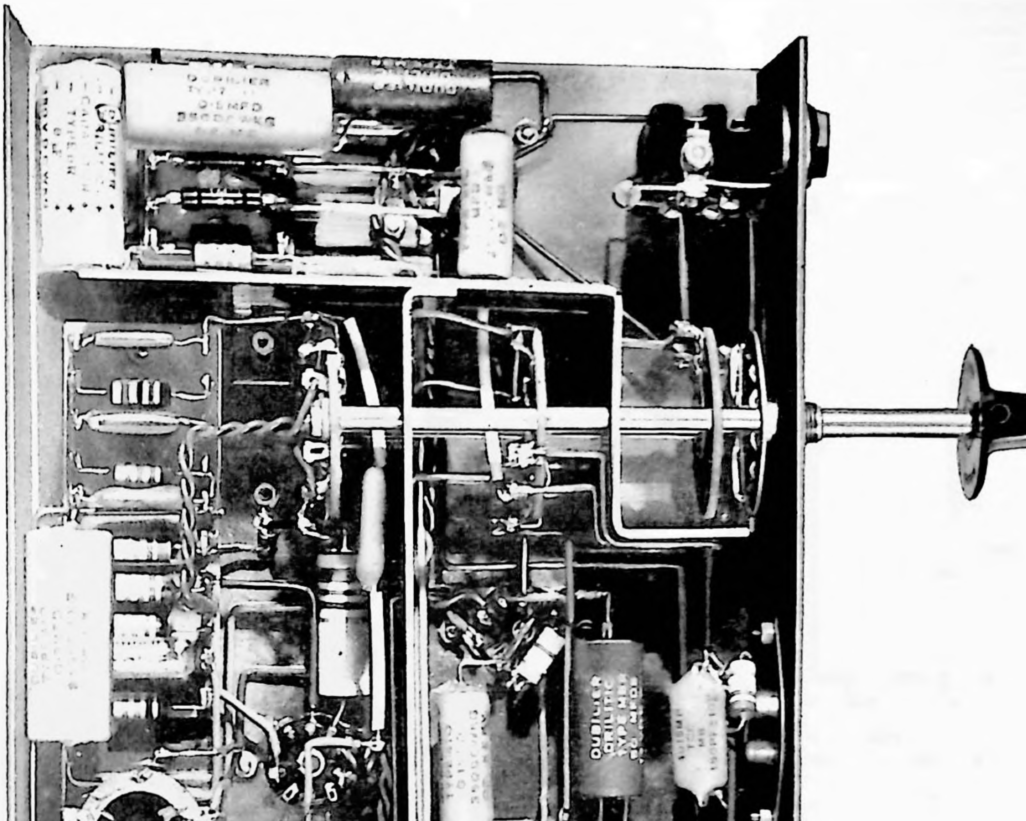


Fig. 46—COMPONENT LAYOUT DIAGRAM (Components which would obscure parts of the layout have not been shown



PHOTOGRAPH OF UNDERSIDE OF PROTOTYPE AMPLIFIER TYPE B

CHASSIS CONSTRUCTION

The chassis 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	$7 \times 2\frac{3}{4}$
(*e*)	EM81 mounting bracket	$1\frac{3}{4} \times 1\frac{3}{4}$
(*f*)	Two small brackets, each	$1\frac{1}{4} \times \frac{1}{4}$

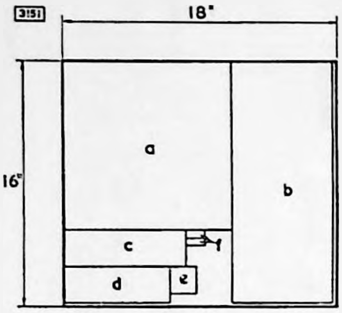


FIG. 47

The seven pieces can all be cut conveniently from one sheet 18 in. long and 16 in. wide if the arrangement shown in Fig. 47 is adopted. There is enough spare metal indicated at the edges to allow for the actual cutting. Each piece should be marked as shown in the chassis drawings of Fig. 64, and the holes indicated should be cut. It is important that, when bending the sheet, the scribed lines should lie exactly along the angles. This ensures that the pieces will fit together properly when assembled.

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 farthermost surface. The front of the chassis is the panel with the control knobs on it.

Initial Assembly

Before assembling the record/playback switch S 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 the change-over switch S.

(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 antimicrophonic 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 Fig. 48.

The construction is continued after the above components have been fitted by assembling wafers 1 and 2 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 'rear' in the switch diagram (Fig. 49) 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. 49) farthest from the switch plate. The general arrangements of the switch wafers and internal screens, is shown in Fig. 48. Details of the spacers required for the assembly are shown in Fig. 49.

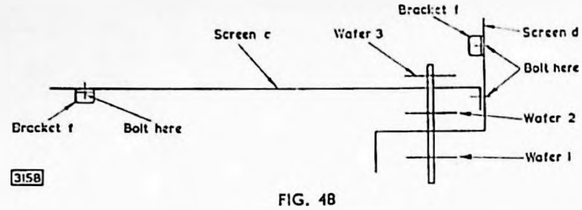


FIG. 48

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 chassis so that one of the small fixing brackets, attached to the internal screen c, can be bolted down. The other small bracket should be fixed by one of the screws holding the record/playback coaxial socket.

The assembling of the unit is best continued by referring to the diagram giving the component layout (Fig. 46). 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 on 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

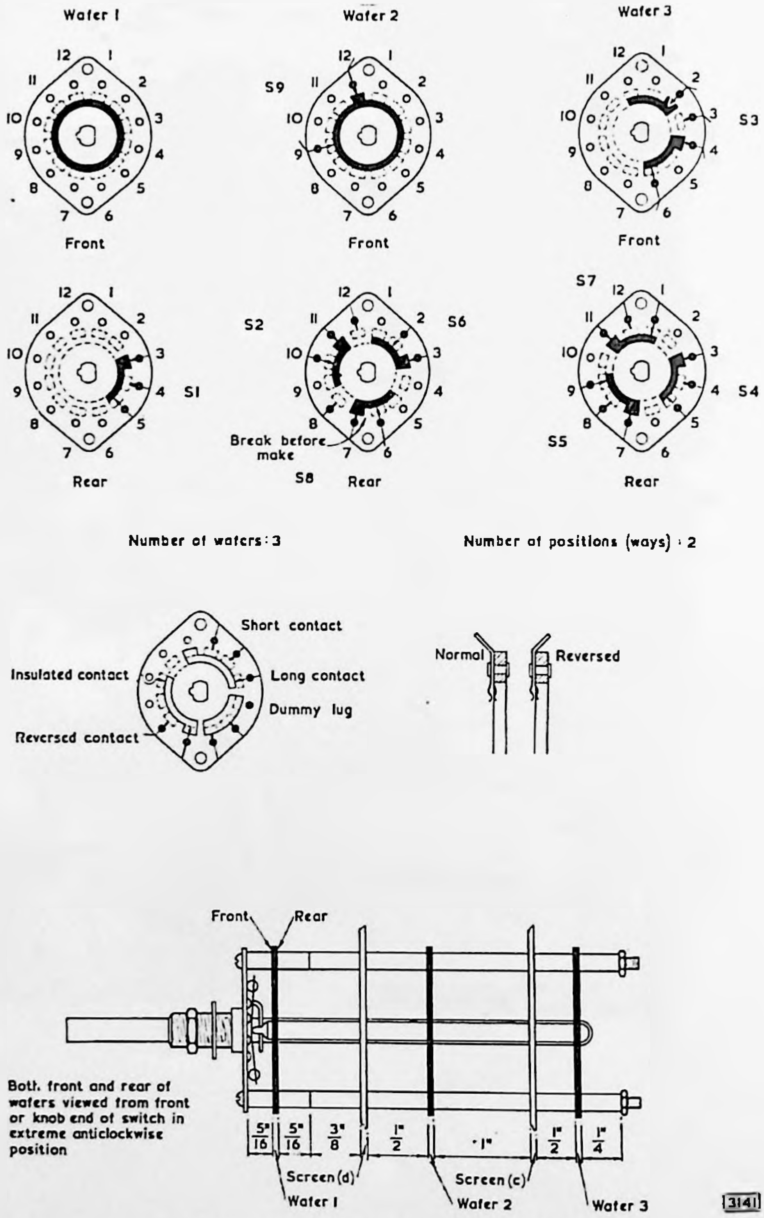


Fig. 49—RECORD/PLAYBACK SWITCH DETAILS

be on the inside, and the radio jack, which has two contacts only, should be beneath the microphone jack.
(3) Recessed coaxial socket for the output.
(4) Supply input plug—Pins 1 and 3 should be on the outside.

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.

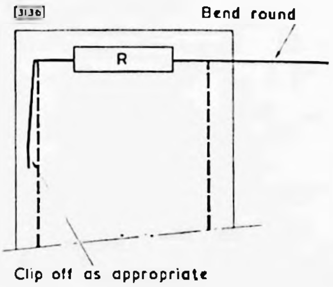


FIG. 50

It will obviously be more convenient to solder most of the smaller components to the tagboards before they 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. 50. If the tagboard wiring diagrams show that the neighbouring tags are to be connected together, the lead wires of the appropriate components should be cut to lengths to allow this.

Waxed capacitors, silvered-mica capacitors and high-stability resistors will require longer leads so that they will not be overheated when they are soldered into position. The leads should be bent as shown in Fig. 51, care being taken in doing so to avoid 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.

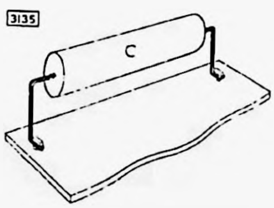


FIG. 51

Heater Supply

This is the first stage in the wiring of the amplifier. From pins 1 and 3 of the supply input socket (Fig. 52) a pair of twisted wires should be taken to pins 4 and 5 on the valveholder for valve V3. From these pins the wires should be taken to pins 4 and 5 on the valveholder for V5 (the EL84). Two sets of heater leads should be taken from V5. One set should pass through the rubber grommet to pins 4 and 5 on the holder for the EM81, and the other set should be connected to pins 4 and 5 on the holder for V2.

From V2, the heater leads should be taken to pins 4 and 5 on the holder for V1 to complete the heater wiring of the amplifier.

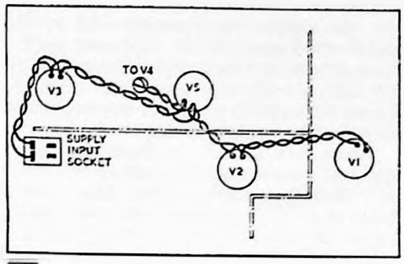


FIG. 52

The Input Stage (Valve V1, Type EF86)

The construction of this stage should be started by wiring Tagboard No. 1. The components: R7 (33kΩ), R5 (1MΩ), R6 (220kΩ), C1 (0·5μF), R4 (2·2kΩ) and C4 (8μF) should be soldered to a small tagboard (Bulgin, type C120) as shown in Fig. 53. It is important that the polarity of the electrolytic capacitor C4 should be correct. The assembled tagboard should be bolted to the chassis in the position indicated in the layout diagram (Fig. 46).

On the V1 valveholder, 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 one of only two earth connections in the amplifier made directly to the chassis; additional connections to the chassis are likely to cause increased mains hum.)

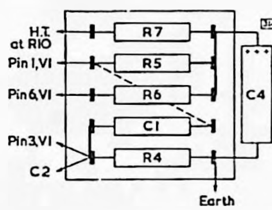


Fig. 53—TAGBOARD No. 1

The grid resistor R3 (2·2MΩ) should be soldered directly across the valveholder between pins 2 and 9. Pin 9 should be joined to position 5 on section S1 of the record/playback switch S.

The resistors R1 (680kΩ) and R2 (5·6kΩ) should be wired directly across the tags of the input jacks as shown in Fig. 54. The output from the jacks is taken to position 3 on the switch section S1. Earth connections from the jacks and from the junction of C4 (8μF) and R4 (2·2kΩ) should be made to the solder tag near the valveholder.

The positive pole of the capacitor C2 (50μF) should be connected to the junction of C1 (0·5μF) and R4 (2·2kΩ) on Tagboard No. 1, and the negative pole of C2 should be wired to the earth point near the valveholder.

The screen resistor R5 (1MΩ) on the tagboard should be connected to pin 1 of the

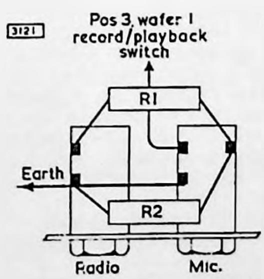


FIG. 54

valveholder, and the anode resistor R6 (220kΩ) should be joined to pin 6. Pins 3 and 8 should be joined together with insulated wire, and a connection taken to the cathode resistor R4 (2·2kΩ).

The feed for the next stage is taken from the anode (pin 6) of V1 to position 10 on switch S2. 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 (T in Fig. 64) in the internal screen d. A wire should run through the other grommet (S) in the screen from position 4 on switch S1 to the double contact in position 4 on sections S3 and S4.

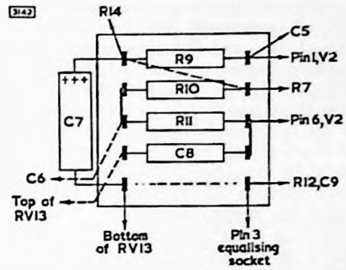


Fig. 55—TAGBOARD No. 2

The Equaliser Stage (Valve V2, Type EF86)

The assembly of this stage should start with the wiring of Tagboard No. 2. The components: C7 (8μF), R9 (390kΩ), R10 (18kΩ), R11 (82kΩ) and C8 (0·1μF), should be fitted to a small tagboard (Bulgin, type C120) and the connections should be made as illustrated in Fig. 55. When assembled and wired, the tagboard should be bolted to the chassis as shown in Fig. 46.

The octal holder which is to be used as a socket for the equalisation plug-in units, should be wired in the manner shown in Fig. 56. The connections should be as follows:

R30 (220kΩ)—between pins 5 and 7
R31 (220kΩ)—between pins 6 and 7
R32 (100kΩ)—between pins 1 and 3
C22 (180pF)—between pins 6 and 8
Connect pins 1 and 2

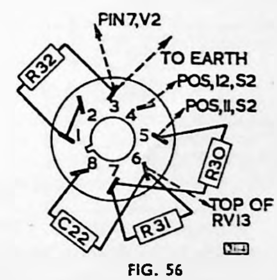


FIG. 56

When wired, the octal base should be bolted to the chassis with the spigot towards the gain control.

On the holder for V2, pins 2 and 7 should be joined to the spigot, and the spigot should be connected to the earth tag near the holder for V1. Pins 3 and 8 should be strapped together.

A wire for the h.t. supply should be connected to the junction of resistors R9 (390kΩ) and R10 (18kΩ) on Tagboard No. 2 and taken along the front of the internal screen c, through the cut-out in screen d, to the free end of resistor R7 (33kΩ) on Tagboard No. 1. Pin 4 on the supply input plug should be joined to position 6 on switch S8. From this point the connection should be taken to position 2 on section S6.

The ends of the resistors R9 (390kΩ) and R11 (82kΩ) on Tagboard No. 2 nearer the valveholder for V2 should be connected to pins 1 and 6 respectively on the holder.

The components R12 (1kΩ) and C9 (50μF) should be soldered between the earth tag on Tagboard No. 2 and pin 8 on the valveholder, the positive pole of the capacitor being joined to the valve pin.

The capacitor C5 (0·1μF) should be connected between pin 3 of the valveholder and the end of resistor R9 (390kΩ) which is nearer the holder. The resistor R8 (470kΩ) should be joined between pins 2 and 9 on the valveholder, and a direct connection should be made between pin 9 and position 10 on switch S2.

A lead should be taken from the earth point on Tagboard No. 2 to pin 3 on the octal socket, and the connection should be continued from pin 3 on the socket to pin 7 on the holder for V2. Two wires should be taken from pin 7, one to the earth tag near the V1 valveholder, and the other to position 9 on switch S9. Pin 4 on the octal base should be connected to position 12 on the switch section S2, and pin 5 on the base should be joined to position 11 on S2. Position 11 on S2 should be connected directly to position 12 on S9.

One end of the capacitor C6 (0·1μF) should be joined to the junction of resistors R10 (18kΩ) and R11 (82kΩ), and the other end of C6 should be taken to the output socket.

The gain control RV13 (500kΩ logarithmic) should be mounted in the chassis at this stage, with its tags facing the octal socket. The top tag of the control should be connected to pin 6 on the octal socket and also to the free end of C8 (0·1μF) on Tagboard No. 2. The bottom tag of the control should be joined to the earth tag on Tagboard No. 2.

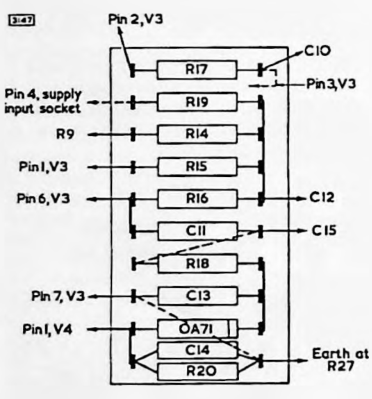


Fig. 57—TAGBOARD No. 3

Recording Output Stage (V3 Type EF86)

The following components should be fitted and wired to Tagboard No. 3 (Bulgin, type C125) as shown in Fig. 57: R17 (1kΩ), R19 (10kΩ), R14 (27kΩ), R15 (220kΩ), R16 (68kΩ), C11 (0·1μF), R18 (470kΩ), C13 (18pF), OA71, C14 (0·05μF) and R20 (1·0MΩ). In fitting the germanium diode type OA71, plenty of wire should be left at its ends to prevent overheating when it is soldered in position. Preferably, the wires should be held with pliers, which act as a heat shunt. The end with the band on it should be connected to R18 (470kΩ). When assembled, the tagboard should be bolted to the chassis in the position indicated in Fig. 46.

Pins 2 and 7 on the valveholder for V3 should be connected to the centre spigot. From pin 2, leads should be taken to pin 2 on the supply input socket and to R17 (1kΩ) on Tagboard No. 3. From pin 7, a lead should be connected to the nearer end of C13 (18pF) and continued from this point through the grommet to pin 2 on the valveholder for V4 (EM81).

From R14 (27kΩ) on Tagboard No. 3, a connection should be made to the end of R9 (390kΩ) on Tagboard No. 2 farthermost from the V2 valveholder, the wire passing under the internal screen c. The end of R17 (1kΩ) farthest from the V3 holder should be connected to pin 3 on the holder, and the connection should be continued to pin 8. The near end of R15 (220kΩ) should be connected to pin 1 and C10 (0·5μF) should be connected between pin 1 and the remote end of R17.

The junction of R16 (68kΩ) and C11 (0·1μF) should be joined to pin 6 of the V3 holder. The end of the OA71 with the lettering on it should be connected through the rubber grommet to pin 1 of the EM81 valveholder.

The capacitor C12 (16μF) should be connected between the junction of R19 (10kΩ) and R16 (68kΩ) on Tagboard No. 3 and pin 7 on the holder for V4. The positive end of C12 should be joined to the junction of the resistors. The other end of R19 should be connected to pin 4 on the supply input socket.

To complete the assembly of this stage, pin 9 on the valveholder should be connected to the centre tag of the volume control RV13, the wire passing under the internal screen c.

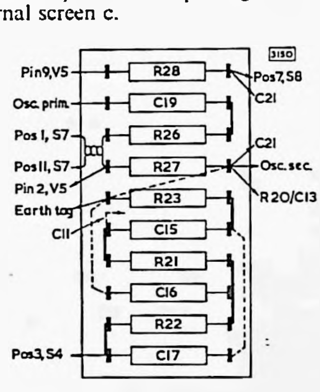


Fig. 58—TAGBOARD No. 4

The EL84 Stage

Tagboard No. 4 should be assembled, the following components being fitted as shown in Fig. 58: R28 (10kΩ), C19 (0·01μF), R26 (*), R27 (22kΩ), R23 (27kΩ), C15 (47pF), R21 (56kΩ), C16 (100pF), R22 (56kΩ), C17 (47pF). The completed tagboard should be bolted to the chassis in the position indicated in the layout diagram.

The record/playback and the erase co-axial sockets should be connected to the record/playback switch S, care being taken when soldering to avoid overheating the plastic insulant. The record/playback socket should be joined to position 5 of the section S4 and the erase socket should be wired to position 8 on S5. The near end of R28 (10kΩ) on Tagboard No. 4 should be connected to pin 9 of the EL84 valveholder.

On wafer 3 of the record/playback switch S, position 6 should be connected to position 2, and the connection continued to position 9. Position 9 should be earthed at the tag at the erase-head socket.

The resistor R29 (220Ω) should be wired between pin 3 on the EL84 valveholder and position 9 on switch S5. Pin 2 on the valveholder should be connected to the near end of R27 (22kΩ) on Tagboard No. 4, and this end of R27 should be joined to position 11 of switch section S7. A wire should also be taken from position 1 on S7 to the near end of R26 on Tagboard No. 4.

The far end of R27 should be connected to the junction of R20 (1·0MΩ) and C14 (0·05μF) on Tagboard No. 3, and an earth connection should be made from the near end of R23 (27kΩ) on Tagboard No. 4 to the earth tag (the second direct connection to the chassis) at the erase-head socket.

The end of C15 (47pF) on Tagboard No. 4 nearer to the erase-head socket should be connected along the path indicated in Fig. 46 to the end of C11 (0·1μF) on Tagboard No. 3 farthermost from the V3 valveholder.

The junction of C17 (47pF) and R22 (56kΩ) on Tagboard No. 4 should be connected to position 3 of switch section S4. The capacitor C21 (0·5μF) should be connected between the ends of the resistors R27 (22kΩ) and R28 (10kΩ) on Tagboard No. 4 farthermost from the EL84 valveholder. From the junction of R28 and C21, a lead should be taken to position 7 of switch S8.

The Oscillator Coil

The full instructions given in this section apply only to the wiring of the Brenell oscillator coil suitable for use with Brenell or Collaro tape decks. This was the type of coil used in the prototype amplifier.

Abbreviated assembly details for this coil, and similar details for oscillator coils provided by the makers of Lane and Truvox tape decks, are given after the full instructions.

Full wiring instructions for the prototype oscillator coil

The anode end (yellow) of the oscillator coil should be connected to pin 7 of the EL84 valveholder which should, in turn, be connected through C18 (82pF) to both contacts in position 3 of switches S3 and S4.

The h.t. tap (blue) of the coil should be connected to position 7 of switch S8 by a wire which passes under the internal screen c. Position 7 should be joined directly to position 8 on this switch.

The grid end (red) of the coil should be connected to the end of the capacitor C19 (0·01μF) which is nearer the EL84 holder. The capacitor C20 (3300pF) should be joined directly across the primary of the coil between the red and yellow tags.

The end of the secondary winding (black) should be earthed at the far side of R27 (22kΩ) on Tagboard No. 4. The flying lead should be wired directly to the erase-head socket.

Abbreviated wiring details

A—For the Brenell oscillator coil which is suitable for use with Brenell or Collaro tape decks.

The circuit for the oscillator stage when this type of oscillator coil is used is given in Fig. 59. The values of the components appearing in this figure are:

R26 =	18kΩ	C18 =	82 pF
R27 =	22kΩ	C19 =	0·01μF
R28 =	10kΩ	C20 =	3300 pF
R29 =	220 Ω	C21 =	0·5 μF

The coil connections should be made as follows (all references are to Fig. 59):

Yellow, marked 1, to the anode of the EL84 (i.e. to pin 7 of the EL84 holder);

*Value dependent on the type of oscillator coil used. See section on oscillator coils and components list.

Blue, marked 2, to the h.t. supply (i.e. to positions 7 and 8 of switch S8);
Red, marked 3, to the near end of C19 (i.e. to the grid circuit of the EL84); C20 should be joined between the yellow and red coil connections;
Black, marked 4, to the nearest earth point;
The Flying Lead, marked 5, to the erase head socket.

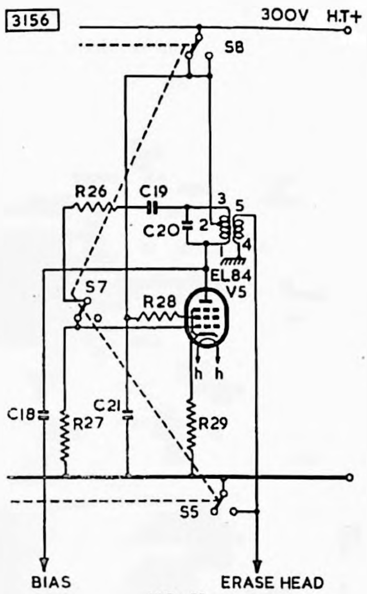


FIG. 59

B—For the Lane oscillator coil suitable for use with a Lane tape deck.

The circuit for the oscillator stage when this type of oscillator coil is used is given in

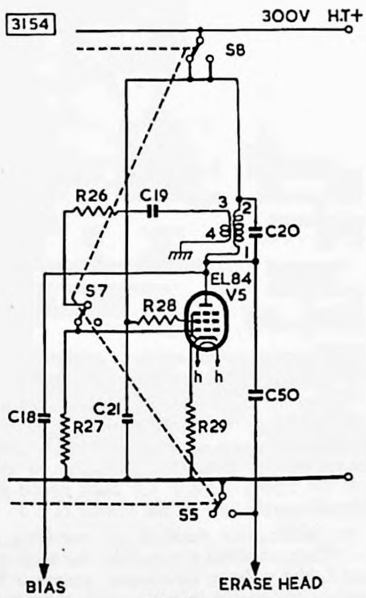


FIG. 60

Fig. 60. The values for the components appearing in this figure are:

R26 = 39kΩ	C18 = 56 pF
R27 = 22kΩ	C19 = 0·01µF
R28 = 10kΩ	C20 = 1000 pF
R29 = 220 Ω	C21 = 0·5 µF
	C50 = 0·01µF

The coil connections should be made as follows (all references are to Fig. 60):
Blue, marked 1, to the anode of the EL84 (i.e. to pin 7 of the EL84 valveholder);
Green, marked 2, to the h.t. supply (i.e. to positions 7 and 8 of S8); C20 should be joined between the blue and green coil connections;
White, marked 3, to the near end of C19 (i.e. to the grid circuit of the EL84);
Red, marked 4, to the nearest earth point.

The capacitor C50 (0·01µF) should be connected between the anode (pin 7) of the EL84 and position 8 of S5.

C—For the Truvox oscillator coil suitable for use with a Truvox tape deck.

The circuit for the oscillator stage when this type of oscillator coil is used is given in Fig. 61. The values for the components appearing in this figure are:

R26 = 150kΩ	C18 = 180 pF
R27 = 22kΩ	C19 = 0·01µF
R28 = 10kΩ	C20 = 1200 pF
R29 = 220 Ω	C21 = 0·5 µF
	C50 = 0·01µF

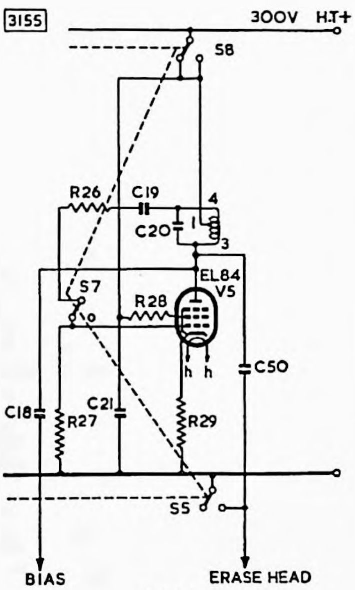


FIG. 61

The coil connections should be made as follows (all references are to Fig. 61, and the position numbers of the coil are obtained by counting in a clockwise direction from the gap, the coil being viewed from the top):
Position 1, marked 1, to the h.t. supply (i.e. to positions 7 and 8 of S8);
Position 2, no connection;
Position 3, marked 3, to the anode of the EL84 (i.e. to pin 7 of the EL84 valveholder);
Position 4, marked 4, to the near end of C19 (i.e. to the grid circuit of the EL84); C20 should be joined between coil connections 3 and 4.

The capacitor C50 (0·01µF) should be connected between the anode (pin 7) of the EL84 and position 8 of S5.

The EM81 Stage

The resistor R25 (150kΩ) should be connected between pins 6 and 9 of the EM81 valveholder. R24 (560kΩ) should be joined between pins 6 and 7, and a lead taken from pin 6 through the rubber grommet, under the internal screen c to position 3 on switch S6.

The Octal Base

The plug-in units used to hold the components for equalisation at various tape speeds are McMurdo octal plugs, type L8/USP, fitted with covers. They are numbered in exactly the same way as a conventional octal valve base.

The components should be fitted in layers (see Fig. 45), with the leads soldered to appropriate tags. To ensure a good connection, it is best to allow the component leads to protrude from the base pins and then to solder them. After soldering, the ends of the leads should be cut off level with the ends of the base pins.

The bottom component should be fitted as low in the holder as possible, to allow enough room for the other components. In Table IX, the pin connections for the components are given for the units for each of the tape speeds. The first component in each list should be fitted at the bottom of the holder, the second, next, and so on. The connections are also given in Fig. 45.

TABLE IX

Pin connections	Circuit reference	Component values (pF or kΩ) for three tape speeds (in./sec)		
		3¾	7½	15
1 to 5	C23	150	68	39
2 to 6	C24	150	68	39
3 to 7	C25	270	150	82
4 to 8	R33	1500	680	330

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 X. The results shown in this table were obtained using an Avometer, Model 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.

The record/playback switch S 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 connection 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 300mV 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 XI.

TABLE X

	Point of Measurement	Voltages (V) (a) S in Record position	Voltages (V) (b) S in Playback position	D.C. Range of Avometer* (V)
	C4 C12 C16 C25 C26	150 170 220 300 <350	150 170 220 300 <350	1000 1000 1000 1000 1000
V1 (EF86)	Anode Screen grid Cathode	50 55 1·2	50 55 1·2	1000 1000 10
V2 (EF86)	Anode Screen grid Cathode	50 80 1·3	50 80 1·3	1000 1000 10
V3 (EF86)	Anode Screen grid Cathode	90 135 2·4	90 135 2·4	1000 1000 10
V4 (EM81)	Anode Target	50 150	0 0	1000 1000
V5 (EL84)	Anode Screen grid Cathode	300 250 8·0	300 270 9·0	1000 1000 100

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

For operations 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 EF86s, (*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 XII should be observed at the output socket.

The bass boost characteristics for the three tape speeds are shown in Fig. 62.

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 amplifier, and the equipment should be switched to the recording condition.

[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.

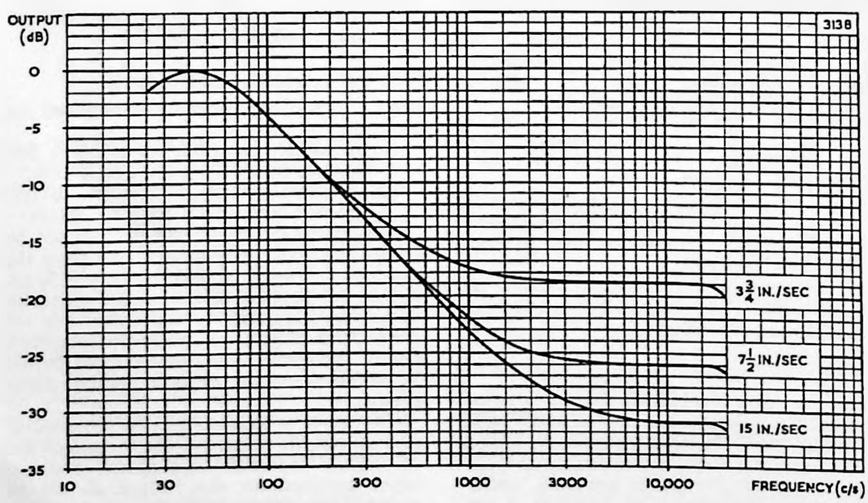


FIG. 62

TABLE XI

Playback Sensitivity
(Signal frequency = 5kc/s)

Tape speed (in./sec)	Input (mV)	Output (mV)
15	4·5	300
7½	2·4	300
3¾	1·2	300

TABLE XII

Bass Boost
Signal frequency = 40c/s
(Output voltage for 5kc/s = 50mV)

Tape speed (in./sec)	Voltmeter reading (V)	Output boost (dB)
15	1·7	30·8
7½	1·0	26·5
3¾	0·45	19·5

TABLE XIII

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

Tape speed (in./sec)	Signal frequency (kc/s)	Voltmeter reading (mV)	Output boost (dB)
15	17	52	14·5
7½	10	120	18
3¾	5	95	16

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 XIII 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. 63.

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

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 curve so obtained should agree with the appropriate curve for the prototype amplifier, plotted in Fig. 43. For these observations, it will be necessary to disconnect one end of the resistor R26 (22kΩ), to be found on Tagboard No. 4, otherwise only the bias signal will be measured.

TABLE XIV

Recording Sensitivity

Signal frequency = 1kc/s;
Tape speed = 15, 7½ or 3¾ in./sec;
Voltage at anode of V3 = 15V;
Microphone input = 1·4mV;
Radio input = 170mV.

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 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.

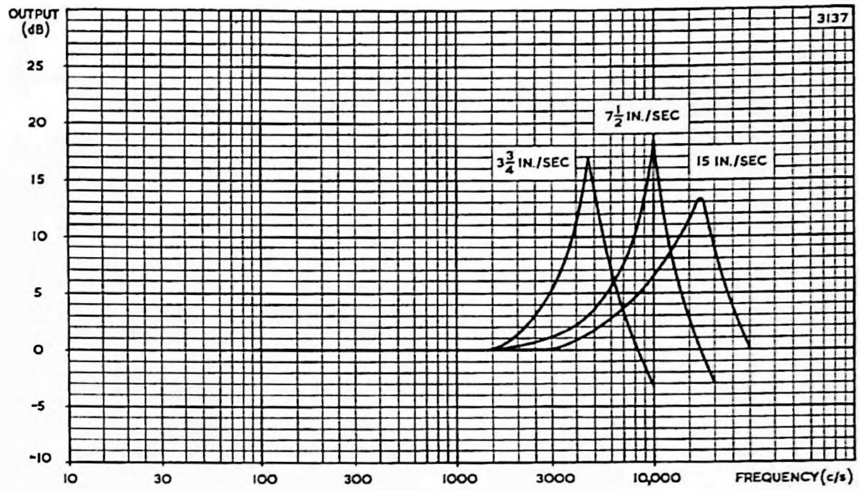


FIG. 63

LIST OF COMPONENT VALUES FOR TYPE B AMPLIFIER

Resistors

Circuit reference	Value	Tolerance (±%)	Rating (W)
R1	680 kΩ	10	¼
R2	5·6 kΩ	10	¼
R3	2·2 MΩ	10	¼
[1]R4	2·2 kΩ	5	½
[1]R5	1·0 MΩ	5	½
[1]R6	220 kΩ	5	½
R7	33 kΩ	10	¼
R8	470 kΩ	10	¼
R9	390 kΩ	10	¼
[1]R10	18 kΩ	10	½
[2]R11	82 kΩ	10	¼
R12	1·0 kΩ	10	¼
RV13	500kΩ logarithmic 10% law; carbon potentiometer		
R14	27 kΩ	10	¼
R15	220 kΩ	10	¼
R16	68 kΩ	10	¼
R17	1·0 kΩ	10	¼
R18	470 kΩ	10	¼
R19	10 kΩ	10	¼
R20	1·0 MΩ	10	¼
R21	56 kΩ	10	¼
R22	56 kΩ	10	¼
R23	27 kΩ	10	¼
R24	560 kΩ	10	¼
R25	150 kΩ	10	¼
R26	•	10	¼
R27	22 kΩ	10	¼
R28	10 kΩ	10	½
R29	220 Ω	10	1
R30	220 kΩ	5	¼
R31	220 kΩ	5	¼
R32	100 kΩ	5	¼
R33	See below	5	¼

• R26: 18kΩ for Brenell or Collaro oscillator coil
39kΩ for Lane oscillator coil
150kΩ for Truvox oscillator coil

[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	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	10	silvered mica	
C14	0·05μF		paper	150 (Min.)
C15	47 pF	10	silvered mica	
C16	100 pF	10	silvered mica	
C17	47 pF	10	silvered mica	
C18	•	10	silvered mica	350
C19	0·01μF		paper	350
C20	••	10	silvered mica	350
C21	0·5 μF		paper	350
C22	180 pF	10	silvered mica	
C23	See below	5	silvered mica	
C24	See below	5	silvered mica	
C25	See below	5	silvered mica	
C50	•••		paper	350

• C18: 82pF for Brenell or Collaro oscillator coil
56pF for Lane oscillator coil
180pF for Truvox oscillator coil

•• C20: 3300pF for Brennell or Collaro oscillator coil
1000pF for Lane oscillator coil
1200pF for Truvox oscillator coil

••• C50: Not required for Brenell or Collaro oscillator coil
0·01μF for Lane oscillator coil
0·01μF for Truvox oscillator coil

Oscillator Coils

Choice depends on tape deck used. Coils normally provided by manufacturers for their proprietary decks.

Components for Plug-in Units

Circuit reference	Component values for each tape speed 3¾ in./sec	7½ in./sec	15 in./sec
C23	150	68	39
C24	150	68	39
C25	270	150	82
R33	1500	680	330

Capacitor values in pF
Resistor values in kΩ
All components in the ±5% tolerance range.

Valves and Germanium Diode

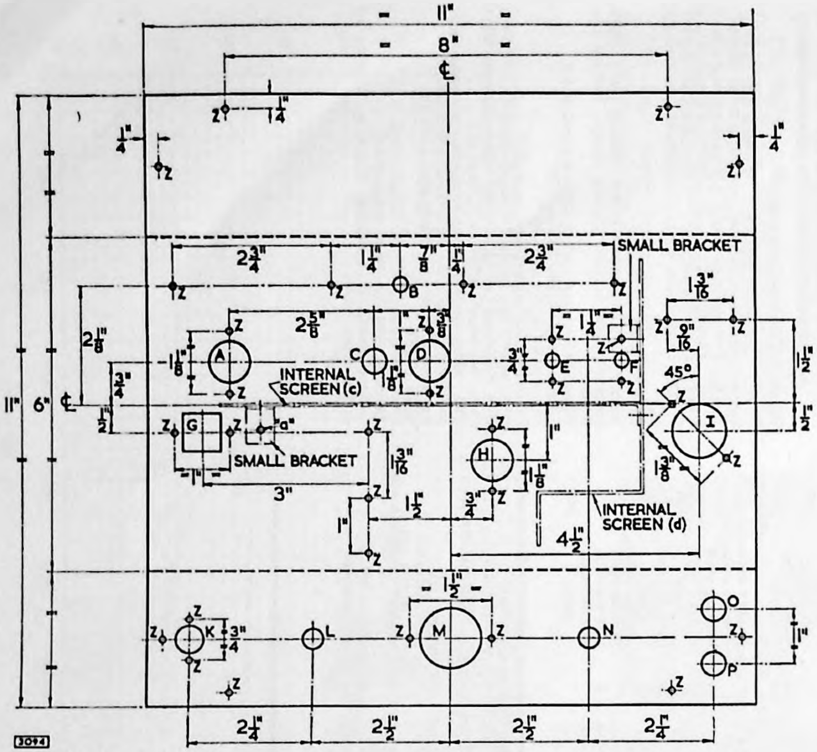
V1	Low noise pentode,	Mullard type EF86
V2	Low noise pentode,	Mullard type EF86
V3	Low noise pentode,	Mullard type EF86
V4	Tuning indicator,	Mullard type EM81
V5	Output pentode,	Mullard type EL84
MR	Germanium diode,	Mullard type OA71

Miscellaneous

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 skirt (two). McMurdo XM9/UD1, skirt 811
B9A nylon-loaded valveholder with screening skirt and flexible mounting. McMurdo XM9/U61
Equaliser plug-in unit. McMurdo L8/USP
Octal socket
Five-way tagboard (two). Bulgin C120
Ten-way tagboard (two). Bulgin C125
Ceramic stand-off insulator. Must be capable of withstanding 350V

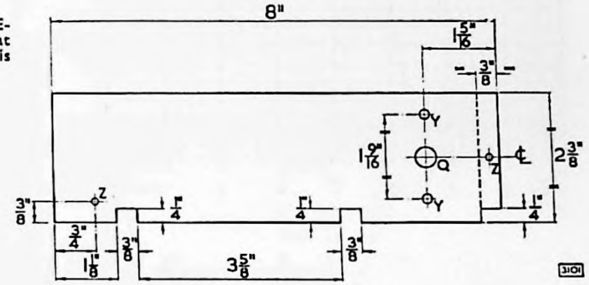
KEY TO HOLES IN CHASSIS DRAWINGS

Hole	Dimension	Use	List No.
A	$\frac{3}{4}$ in. dia.	B9A nylon-loaded valveholder with screening skirt, McMurdo	XM9/UD1; Skirt 811
B	$\frac{1}{4}$ in. dia.	Oscillator coil	—
C	$\frac{7}{16}$ in. dia.	Rubber grommet	—
D	$\frac{3}{4}$ in. dia.	B9A valveholder, McMurdo	BM9/U
E	$\frac{1}{4}$ in. dia.	Coaxial socket, Belling Lee	L/604/S
F	$\frac{1}{4}$ in. dia.	Coaxial socket, Belling Lee	L/604/S
G	$\frac{11}{16}\times\frac{11}{16}$ in.	4-Way Input supply socket, Elcom	P04
H	$\frac{3}{4}$ in. dia.	B9A nylon-loaded valveholder with screening skirt, McMurdo	XM9/UD1; Skirt 811
I	1 in. dia.	B9A nylon-loaded valveholder with screening skirt and flexible mounting	XM9/U61
K	$\frac{1}{2}$ in. dia.	Coaxial socket, Belling Lee	L/734/S
L	$\frac{3}{8}$ in. dia.	500kΩ potentiometer (logarithmic)	—
M	$1\frac{1}{8}$ in. dia.	Octal socket	—
N	$\frac{3}{8}$ in. dia.	Record/playback switch	—
O	$\frac{7}{16}$ in. dia.	Jack (radio), Igranic	P71
P	$\frac{7}{16}$ in. dia.	Jack (mic.), Igranic	P72
Q	$\frac{3}{8}$ in. dia.	Record/playback switch	—
R	$\frac{3}{8}$ in. dia.	Record/Playback switch	—
S	$\frac{3}{16}$ in. dia.	Rubber grommet	—
T	$\frac{3}{16}$ in. dia.	Rubber grommet	—
U	$\frac{3}{4}$ in. dia.	B9A valveholder, McMurdo	BM9/U
X	Drill No. 49	Self-tapping screw	$\frac{3}{8}\times 4$ in.
Y	Drill No. 27	4 B.A. clearance hole	—
Z	Drill No. 34	6 B.A. clearance hole	—

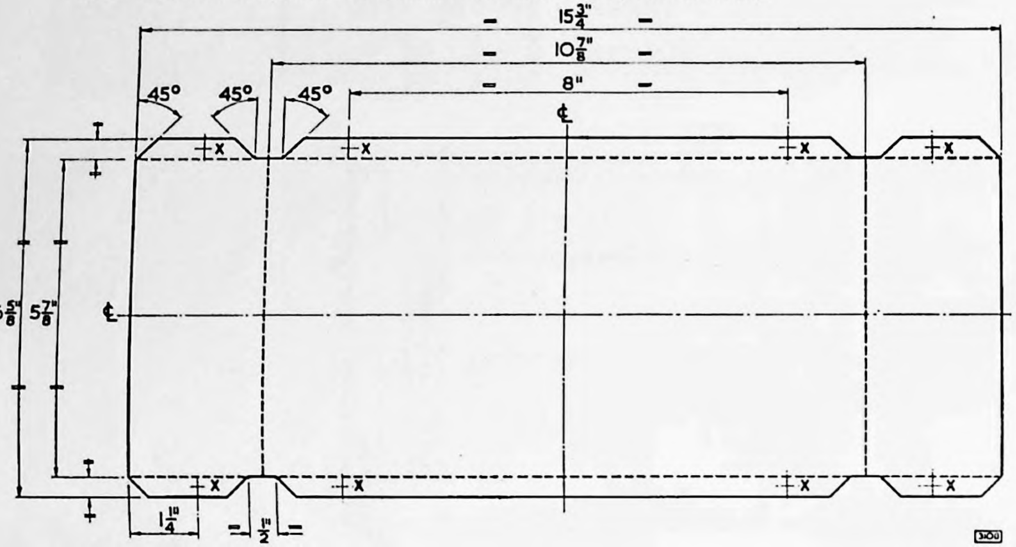


Above—(a) Main Chassis (hole marked 'a' should be made after assembly with No. 34 drill)

Fig. 64—TYPE B TAPE AMPLIFIER CHASSIS DETAILS (The chassis sections should be bent up at 90° at all dotted lines except when the contrary is specifically indicated)

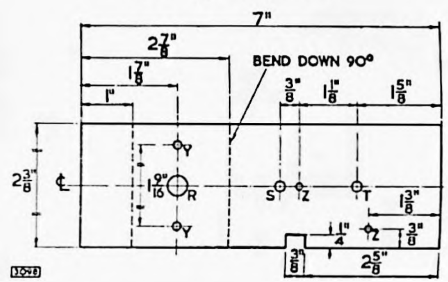


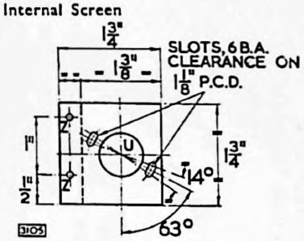
Above—(c) Internal Screen



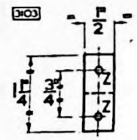
Left—
(b) Base

Below—(d) Internal Screen





Above—(e) EM81 Fixing Bracket



Right—(f) Small Bracket

POWER UNIT
FOR
TAPE AMPLIFIERS

CIRCUIT DESCRIPTION

The circuit diagram for a power unit suitable for use with either the Type A or the Type B tape amplifier is given in Fig. 65. 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.

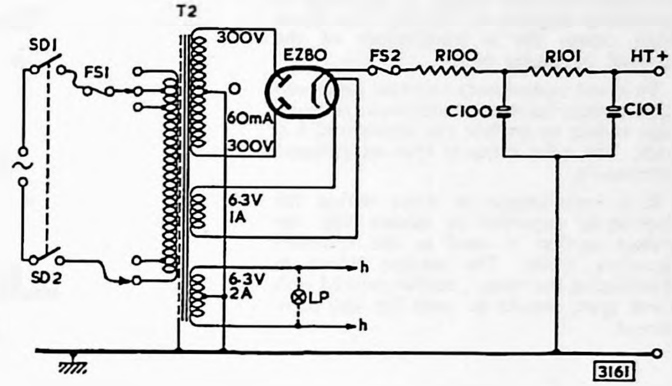
Any of the mains transformers suggested for use either with the 'low-loading' version of the Mullard 5-valve 10-watt High Quality Amplifier, or with the Mullard '3-3' Quality Amplifier will be suitable for this unit. The specification for this transformer is:

	Voltage tappings	Current rating
Primary	10–0–200–220–240	
Secondaries	300–0–300	60mA
	3·15–0–3·15	2A
	0–6·3	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—the Truvox, for example—it is essential that the Mullard type EZ81 be used, so that the current of 150mA which is required for the short braking periods can be supplied.

If the EZ80 is used, the series resistance in each anode circuit of the rectifier must be at least 215Ω; if the EZ81 is used, the minimum series resistance is 200Ω for each anode. Very few transformers meeting the specification 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.

Fig. 65—POWER UNIT 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,

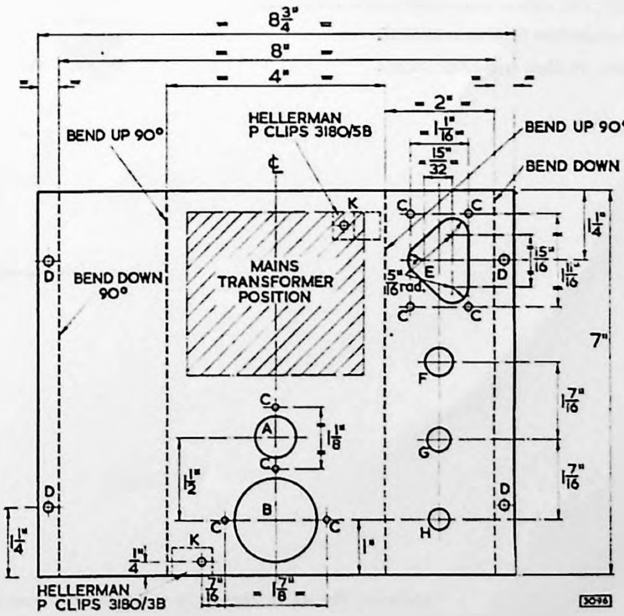
and n = the ratio of the number of turns on half the secondary to the number of turns on the primary.

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.

Fig. 66—POWER UNIT CHASSIS DETAILS



KEY TO HOLES IN CHASSIS DRAWING

Hole	Dimension	Use	List No.
A	$\frac{3}{4}$ in. dia.	B9A valveholder, McMurdo ...	BM9/U
B	$1\frac{1}{8}$ 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	$\frac{1}{2}$ in. dia.	Mains switch, Bulgin 2-way ...	S310
G	$\frac{7}{16}$ in. dia.	Minifuse holder, Belling Lee ...	L575
H	$\frac{3}{8}$ in. dia.	Pilot lamp, Bulgin	D180/Red
K	Drill No. 27	4 B.A. clearance hole	—

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. 66) 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 is 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. 66 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.

The wiring of the power unit should be accomplished quite easily by referring to the wiring diagram of Fig. 67. 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.

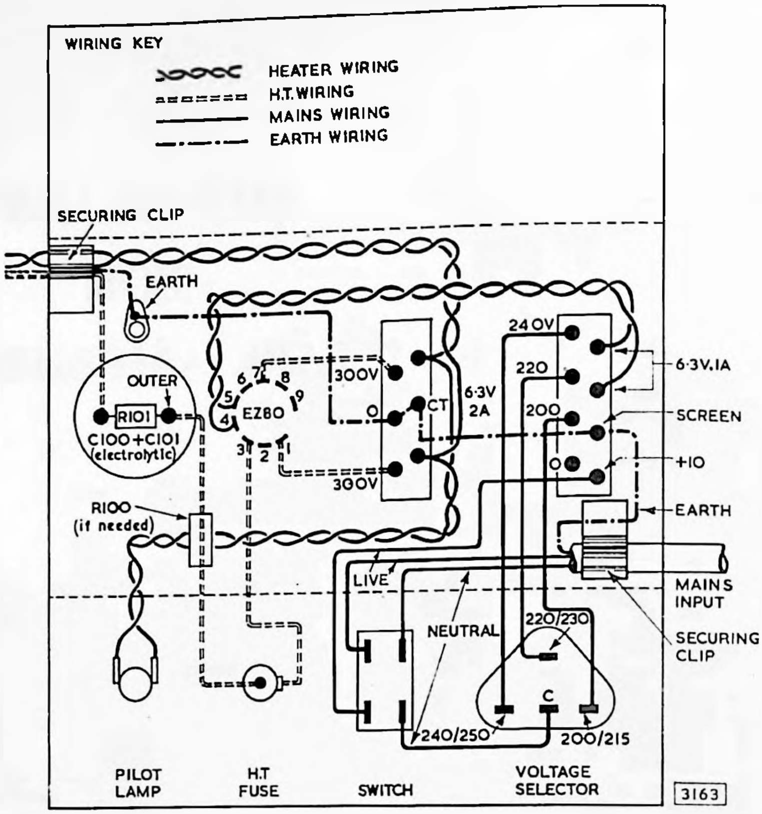


Fig. 67—POWER UNIT ASSEMBLY AND WIRING DETAILS

COMPONENTS LIST FOR THE POWER UNIT

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.

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.

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Mullard