TECHNICAL INSTRUCTION

R2

BBC Disk Recording Head

Type B

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ILLUSTRATIONS

BBC DISK RECORDING HEAD TYPE B

SECTION A

PRINCIPLES OF DESIGN OF A RECORDING HEAD FOR DIRECT-RECORDING DISKS

Introduction

This Instruction deals with the design of a moving-iron recording head for use with existing disk-recording machines. The housing is constructed in two different forms in order to simplify fitting on specific machines, but the basic design is the same for both.

Referring to the photograph, Fig. 1, Type-B1/A head is constructed for use with Presto recording machines and Type B1/B with the BBC disk recorder Type D.

The use of modern magnetic materials has enabled the designers to produce a recording head having small physical dimensions, and the incorporation of feedback within the head has contributed towards an improved performance, both as regards frequency response and harmonic distortion. The construction is such that maintenance is simplified and the laborious operation of renewing damping material, common with most recording heads, has been eliminated.

General Problems of Design

For the past few years, progress in the technique of sound recording on cellulose disks has been handicapped by limitations in the performance of recording heads. The M.S.S. moving-iron recording-head, used by the BBC for a number of years, usually gave a good performance on initial installation but was subject to inconsistencies due to the damping material varying with age and temperature. These inconsistencies frequently caused the head to become unsatisfactory after a few weeks' service.

The BBC Type-A recording head, designed for use with mobile recorders, is more stable than the M.S.S. head, but its restricted frequency range and its susceptibility to overload renders this head unsatisfactory for general use.

The problem of designing a recording head for use on cellulose-coated disks, as distinct from wax blanks, is complicated by the wide variations in resistance to cutting offered by disks under varying service conditions. Where wax blanks are used as the recording medium, precautions are taken to ensure that they are maintained at a constant temperature. This precaution could conceivably be applied to direct-recording disks on fixed recording channels but is by no means practicable on mobile recorders. Apart from this, there is considerable difference between the coatings of disks of different makes and often between individual disks of the same make. The ideal recording head must give consistent results under these rather variable conditions of loading.

The first essential principle of design is that the deflection of the cutter point should be independent of the load on the tip. This may be obtained by using an operating system having considerable stiffness over the working frequency range, or by the use of feedback directly controlled by the motion of the cutter. The first alternative may be obtained by using a moving-iron, piezo-electric or magneto-striction system, while the second is most conveniently achieved by a moving-coil device. The latter has greater technical advantages, but, because of the very intense magnetic field required for satisfactory operation, the size of the magnetic system would preclude its use on existing recording machines. Because of its mechanical simplicity and robustness, the moving-iron is probably the most suitable of the remaining systems, but it has rather low efficiency. In common with all recording heads, internal stiffness disappears at the resonant frequency of the armature system.

Ignoring, for the moment, the question of efficiency, the main requirement, from the point of view of frequency response, is that the armature resonance shall be damped or made to occur outside the working frequency range. For a given inertia of the moving parts, this resonant frequency can be increased by increasing the stiffness of the armature.

Now if, with a given inertia of the moving parts, the stiffness is steadily increased, the frequency of resonance will increase. But if the stiffness is increased too much, the increased flux density required to produce the desired deflection of the armature will cause magnetic saturation at low frequencies, thereby introducing non-linearity.

The problem then is to find a form of armature which will just record the required amplitude at the bass frequencies without distortion and which, at the same time, will have its mechanical resonance at the highest frequency possible.

In a moving-iron system, copper or I^2R-loss is appreciable below 2,000 c/s and increases as the frequency decreases. In order to maintain efficiency, it is therefore important that as much copper as possible should be used in the operating coil. This is referred to again on page 3. Efficiency may also be increased by reducing the mechanical stiffness of the armature system or by increasing the length of the cutter. The employment of either of these methods will lower the frequency of mechanical resonance.

Type of Armature

In choosing the type of armature most likely to meet the requirements outlined above, it is necessary to consider the moving system as a whole, made up of the armature proper and the cutter.

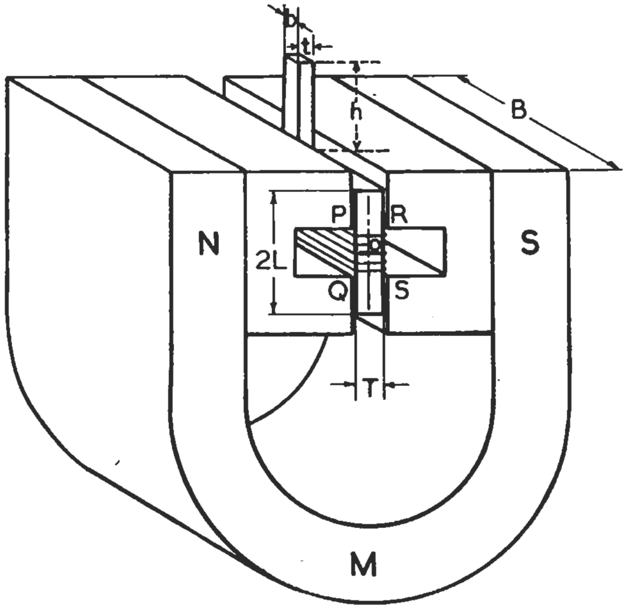

Fig. A.1. Typical Balanced-armature movement

A symmetrical balanced magnetic system was considered the most likely to give the required linearity, and this offered a choice of three types of armature; the cantilever, the half-rocker and the balanced armature. With a thin uniform cantilever, the effective mass may be represented by 0·24 times its total mass lumped at the free edge, whereas for the half-rocker or the balanced armature it is 0·33 times its total mass. Because of its lower effective mass, the cantilever appears to be the more suitable form, but it has two disadvantages. Firstly, it is difficult to arrange for a detachable cutter without the securing screw adding to the effective moving mass, and, secondly, less space is available for the operating coil than with the equivalent balanced armature. The balanced armature is equivalent to two half-rockers on opposite sides of the axis of rotation. The same effect could be produced by a single half-rocker of twice the breadth; other considerations, however, limit the breadth, and for this reason, the balanced armature was finally adopted as the most suitable form.

Principles of Armature Design

A typical balanced armature movement is shown in Fig. A.1. The armature, of length 2L, breadth B, thickness T, lies symmetrically at right-angles to the strong magnetic field provided by the permanent magnet M. The cutter is represented by an extension to the armature of length h, breadth b and thickness t. The armature is pivoted about the front-to-back axis through its centre point O and is maintained in stable equilibrium midway between the pole-piece tips P, Q, R, S, by the restoring force of the torsion bars, which acts like a spring.

The armature and its extension may be represented by a lumped mass at the juncture of the two, and the mechanical resonance of the system is determined by the relation of this mass to the stiffness of the spring.

Suppose that a given extension increases the total effective mass n times. Then for a given resonant frequency the stiffness must be increased n times, but this will allow only $1/n$ times the previous maximum deflection at the edge of the armature proper, so the extension will be advantageous only so long as it gives a mechanical magnification greater than n. (Formulae for calculating the gain are given in Research Report C.044.)

The effect of efficiency of changing the ratio of the length of the extension h to the length of the armature L is shown in Fig. A.2, where the percentage of efficiency obtainable under conditions of maximum gain is plotted against the percentage of optimum h/L ratio for the armature of a Type-B head. From this it is seen that the variation in efficiency with variation in h/L ratio is fairly small near the optimum, consequently, there is some latitude available to meet other stylus conditions.

As shown in Research Report C.044, the greater the ratio of the mass per unit length of the armature to that of the extension, the greater the mechanical magnification which can be used with advantage.

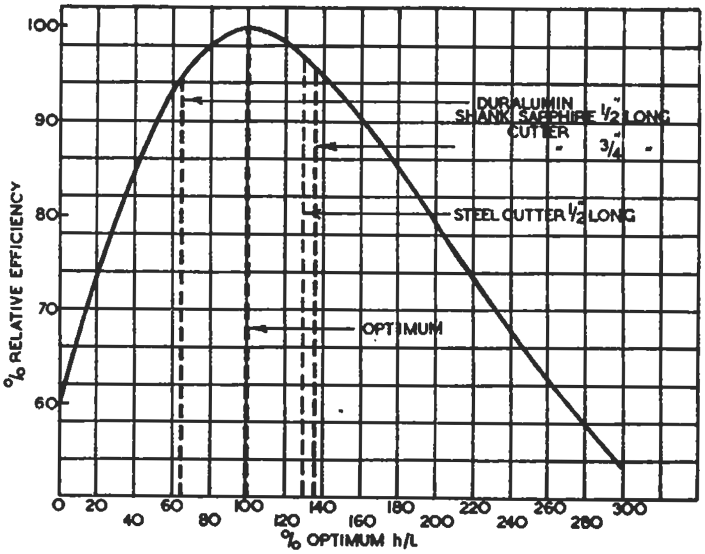

Fig. A.2. Curve showing effect on efficiency of changes in the ratio h/L

The factors which limit this ratio are as follows:

(i) *the natural period of vibration of the extension, relative to the armature, must be above the upper limit of the working frequency range.* This limits the length of extension which may be employed. Some idea of the limitation may be obtained from the fact that a $\frac{1}{16}$-in. diameter steel rod resonates at 10,000 c/s when its length is 0·42 inch. A $\frac{1}{16}$-inch square rod resonates at the same frequency when its length is 0·45 inch. (For the general formula see Appendix 1 of Research Report C.044.)

(ii) *the lowest natural period of transverse vibration of the armature, considered as a beam supported at its ends, must also lie outside the working frequency range.* In practice, this factor is the most troublesome, causing a sharp dip in the frequency characteristic. This, however, may be removed from the working range by the reduction of the breadth of the armature and its supports.

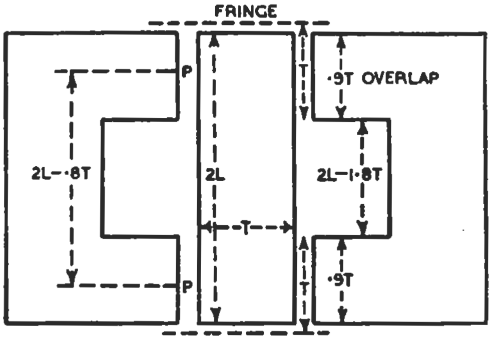

Fig. A.3. Theoretical Armature Dimensions

(iii) *the ratio of armature thickness to length,* T/2L. If this becomes too large, the electro-mechanical conversion efficiency falls. This fall in efficiency appears to be due to two causes: the reduction in the mechanical advantage of the magnetic deflecting forces acting on the armature, and the increase in copper loss due to a reduction in coil space. These two factors determine the minimum length of armature which can be used with a given thickness.

Referring to Fig. A.3, two pole-piece tips face each side of the armature. It was found by experiment that, with an armature of uniform cross-section, each tip should overlap the armature vertically by at least 0·9T and should extend beyond the armature by about 0·5T (to avoid confusion the extension is not shown in Fig. A.3); if this extension is not given there will be a loss of about 10 per cent in efficiency. With a reduced overlap and no extension, the loss in efficiency would exceed 10 per cent.

When the minimum overlap of 0·9T is used (assuming no extension), it would appear that about 10 per cent of the magnetic-induction flare from each pole tip to the armature occurs as a fringe beyond the ends of the armature, Fig. A.3. Thus the flare behaves as if each pole tip were lengthened by 0·1T, the effective overlap of each pole becoming equal to T. As a first approximation, it may therefore be assumed that the deflecting couple acting on the armature, due to a current in the coil, consists of two forces whose effective points of application, P (the centres of the effective pole-piece overlap), are separated by a distance of 2L−0·8T. Also, the maximum space available for the operating coil is 2L−1·8T. Thus, with a given value of 2L, the smaller that T can be made, the greater will be the space available for the coil, and the farther apart will be the forces of the deflecting couple. The actual value of these forces decreases linearly with T, but so does the effective mass of the armature. The effective mass also decreases with L.

From the above, it would appear that the thickness T of the armature should be kept at a minimum and that the length 2L of the armature should be reduced until the advantages gained by the reduction in mass is off-set by the disadvantages mentioned, conditions which are most conveniently found by experiment.

SECTION B

DETAILS OF DESIGN OF BBC RECORDING HEAD, TYPE B

General Construction

A recording head designed on the principles outlined in Section A is shown in Fig. B.1.

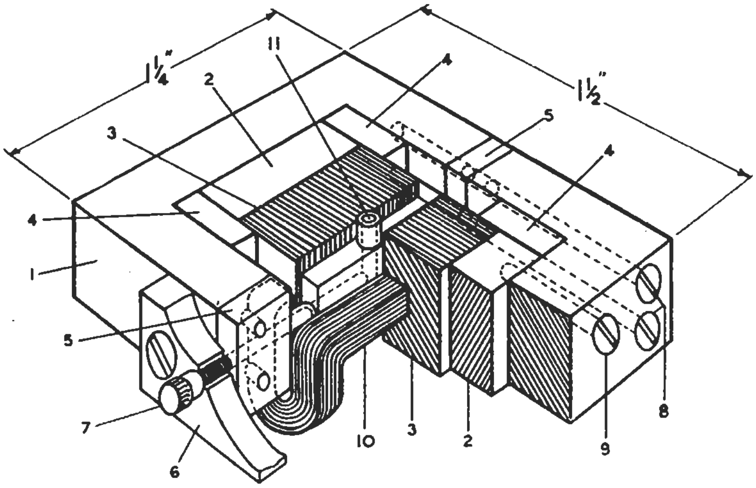

Fig. B.1. Cut-away view of Recording Head (Inverted)

The assembly consists of a pair of yokes (1) forming the main frame, the armature (5) being tightly clamped between the two yokes by means of the screws (8). The laminated pole-pieces (3) are riveted to the brass spacers (4), which in turn are fastened to the yokes by screws (9). The Ticonal magnet blocks (2) are clamped between the pole-pieces and the yokes. The coil (10) surrounding the armature passes through a tunnel in the pole-pieces, the ends being bent up to pass round the torsion bars. (The figure is upside down to show the cutter-holder.) A cylindrical extension to the armature (11) forms the cutter-holder, the cutter-clamping screw (7) passing through one end of the armature. A clearer picture of the respective components is shown in the photograph, Fig. 3.

Magnet System

Magnets

The design of a light, flat recording head having the low centre of gravity required for the Type-D recording machine was made possible by the efficient use of the new permanent magnet alloy Ticonal 42/50, the energy content of which is three times greater than that of the best magnetic materials known to exist before its discovery.

Ticonal magnets can be made in three grades, defined by the manufacturers as high-remanence, high-coercivity and average magnets and all were tried during initial experiment. Those with high-remanence or retentivity were found to be unsuitable because, while they produced a higher flux density in the pole-piece gap, the sensitivity was lower than that of the other two grades.

High-coercivity magnets were finally chosen because, besides producing the required sensitivity, they allow larger variations in the demagnetising forces over a given range of flux density because of the relative flatness of their *B*/*H* curve.

Two small blocks of Ticonal 42/50 are placed as near as possible to the magnetic reluctance they have to overcome in the air gaps, thus reducing the proportion of useless stray field. These magnets can actually give more energy than is required.

Pole-pieces

In choosing material for pole-pieces, three main factors had to be taken into account: sensitivity, distortion and availability of supplies. Tests were carried out with 0·014-inch Lohys iron, 0·007-inch and 0·014-inch stalloy, 0·015-inch radiometal, 0·010-inch Permendur, and solid soft iron. Sensitivity and distortion at line-up and peak levels were measured. The Permendur showed an increase of 2 db and the solid soft iron a decrease of 1 db in sensitivity compared with the remainder.

The Permendur produced least distortion, followed in order by 0·007-inch and 0·014-inch stalloy, 0·014-inch Lohys, solid soft iron and 0·015-inch radiometal. There were only slight differences between the 0·007-inch and 0·014-inch stalloy and the 0·014-inch Lohys, but the solid soft iron and radiometal showed considerable distortion.

It is of interest that the type of distortion obtained with soft iron was different from that caused by radiometal. The distortion with soft iron was approximately constant for varying levels, while for radiometal the distortion increased rapidly above a certain level, and therefore it would appear that the latter distortion was due to saturation, while the former may have been due to hysteresis effect.

It was decided to use 0·007-inch stalloy in preference to 0·010-inch Permendur, owing to the availability of supplies, and to the fact that it does not require heat treatment, after stamping, to restore its magnetic properties.

Initial tests with these pole-pieces disclosed considerable non-uniformity in manufacture. This affected the damping to such an extent that the variation in frequency response between different heads was too great. The trouble was traced to varying tightness of the laminations in the pole-pieces. To overcome this difficulty, the manufacturers vacuum-impregnated the stampings with a bakelised varnish, and stoved them.

Air Gap

To determine the best air gap to use, tests were carried out with direct current through the coil. The deflection of a pointer, attached to the armature and viewed through a microscope was plotted against current through the coil, and the smallest air gap which would give linear results was chosen. Too large an air gap reduced the sensitivity and the maximum deflection available. The value chosen was 0·005 inch.

Design of Armature

It was desirable that the armature should be designed to use a detachable cutter of steel, or of duralumin with a sapphire tip, $\frac{1}{2}$ inch long and fitting into a $\frac{1}{16}$-inch hole. The armature had, therefore, to accommodate a $\frac{1}{16}$-inch diameter hole and some means of clamping the cutter. This was achieved by making the armature 0·082 inch thick and by providing a clamping screw through the axis of rotation. The maximum distance of the cutter-tip from the centre of the armature was fixed at $\frac{1}{2}$ inch less half the diameter of the cutter, i.e. $\frac{15}{32}$ inch.

The armature is held in position by a pair of symmetrical torsion bars, which also provide the restoring force. One of these is drilled to receive the cutter-clamping screw (Fig. B.1), while the other has a blind hole. To avoid trouble from lateral vibration, the length of these bars must be kept to a minimum, but if they are too short, the maximum shear stress at the surface may exceed the elastic limit of the material, resulting in a permanent deformation.

The design procedure adopted in this case was to decide on the minimum permissible thickness of armature, and to find by trial the maximum breadth that could be used. The length of armature was chosen to give the best mechanical magnification using the cutter as the extension. The moment of inertia of the armature and cutter was then calculated and the torsion bars designed to give the required frequency of resonance. Their length was determined by the space needed to accommodate the coil. (See Fig. B.1.) The calculation of the moment of inertia of the armature and cutter is given in Appendix 2 of Research Report C.044.

When the maximum usable breadth had been found, several different armatures were tried in order to find the best length. There was no measurable difference in sensitivity between armatures 0·3 inch and 0·33 inch long, but those shorter than 0·3 inch were definitely worse. A length of 0·33 inch was chosen so that the addition of a sleeve, to guide the entry of the cutter and to provide a dust seal, would have the least effect upon the performance of the armature and at the same time leave the internal mechanical impedance as high as possible. Any further increase in length has the disadvantage that to maintain the same resonant frequency involves an increase in the diameter of the torsion bars, thereby increasing their maximum stress.

The armature was made of mild steel, distortion and sensitivity tests having failed to reveal any advantage in using soft iron. An improvement was obtained, however, by chamfering the ends of the armature (see Fig. 3), which did not reduce the maximum deflection, but raised the resonant frequency slightly.

Torsion Bars

These bars must provide the required stiffness without excessive stress at full deflection. It was calculated that for a torsional vibration frequency of 10,000 c/s, the conditions of design are satisfied when maximum stress at full deflection of the armature is equivalent to 7·3 tons per sq. in. This figure allows for considerable latitude and is only reached under conditions of severe overload. (The method of calculation is shown in Research Report C.044.)

Cutter-clamping Screw

The clamping screw (7), Fig. B.1, consists of a knurled head followed by a short screwed portion which screws into the detachable nut (6). Beyond this there is a long thin shank, which fits through one of the hollow torsion bars on the axis of rotation of the armature. This shank secures the cutter in the holder and also ensures that the cross-section of the magnetic path is not reduced. The use of a detachable nut facilitates renewal should the thread become damaged and prevents the head of the screw from vibrating with the armature. The shank of the screw, due to its length, has very little torsional stiffness and at its inner end moves with the cutter.

Armature Damping

In most recording heads, damping is unreliable and generally unsatisfactory. The design of the Type-B head had to be based upon the use of a standard BBC detachable cutter. The mass of this cutter made it impossible to get the resonant frequency above 10,000 c/s, so a simple form of damping was necessary.

This consists of a piece of thin paper (8, Fig. 3) wrapped round the armature and occupying some of the air-gap between it and the magnet poles. The inside of the recording head is liberally soaked in damping oil. The effect of the oil takes a few days to become stabilised, but after this it remains consistent for two or three months. The type of paper is important and that used is a bank paper of a substance similar to that used for the Engineering Data Sheet No. 16.

The effectiveness of the damping was checked by recording a square wave of 1,000 c/s repetition frequency. Under these conditions, any undamped resonances tend to ring, and when reproduced may be observed on an oscilloscope. Such observations indicated that the damping was not perfect but that the amount of " ring " was of small amplitude and lasted for about one complete cycle at a frequency of 10,000 c/s.

A non-metallic cover-plate (9, Fig. 3) with a blotting-paper washer is fitted over the underside of the recording head to keep the oil in and dirt out.

In the Type-B1/A head, the upper side of the recording head is covered by the terminal block which forms the protective housing for the bent-up ends of the coil. (See Figs. 2 and 3.) It is desirable to retain as much oil as possible in the cavity enclosed by the block, but a breather-hole is provided so that oil is not pumped out by changes in atmospheric pressure.

Feedback in the Recording Head

Advantages of Feedback

One of the most interesting features of the Type-B head is the successful application of negative feedback to the operating coil, the feedback controlling the operating flux. The chief advantage of feedback is that it tends to improve the linearity at low frequencies and materially increases the maximum amplitude which may be accommodated without distortion.

Distortion in a Moving-iron Recording Head

Before discussing the effects of the application of feedback, it is necessary to consider the types of distortion present in a moving-iron head. There appear to be two major forms of distortion, one occurring at large amplitude and the other at small amplitude.

The term *large-amplitude distortion* implies the amplitude distortion which occurs at low frequencies when the magnetic system becomes saturated before the required maximum deflection of the armature is obtained. It is serious in effect, since the low-frequency component modulates the remaining components of a signal at the instant of overloading.

Small-amplitude distortion is more obscure. It is not normally noticeable on an original recording, but increases with each subsequent re-recording.

Tests carried out on a Type-B head having solid pole-pieces proved conclusively that most of the distortion could be eliminated by the use of feedback. With feedback the head had a good performance and could be used for re-recording without introducing serious distortion. Without feedback, the performance was not good on an original recording and poor on re-recording.

Further tests showed that by using laminated pole-pieces, small-amplitude distortion could be eliminated without using feedback and that by using laminated pole-pieces together with feedback, both large and small amplitude distortion were materially reduced, and the maximum available amplitude was increased.

Feedback and Impedance

The development of the application of feedback to a moving-iron recording head was greatly encouraged by some experiments carried out on a Presto head. A small coil was wound round the armature and connected to the amplifier of an oscilloscope. The recording head was then operated alternately from a very high and a very low impedance source. The flux wave-form shown on the oscilloscope under the two conditions proved beyond doubt that to minimise distortion the head should be fed from a source of as low an impedance as possible. With feedback, this impedance is maintained at a very low value which tends to neutralise the resistive voltage drop in the coil.

Method of Application

The method of applying feedback to the Type-B head is as follows: the required number of turns of fine wire is wound as close to the armature as possible, with the main operating winding wound on top.

The system follows normal feedback practice in that a portion of the amplifier output voltage is fed back to a previous stage in anti-phase. A method commonly employed is for the feedback voltage to be taken from an additional winding on the output transformer, but in this case the feedback winding is incorporated within the recording head. A theoretical circuit of the arrangement is shown in Fig. B.2 and a detailed explanation in Research Report C.044.

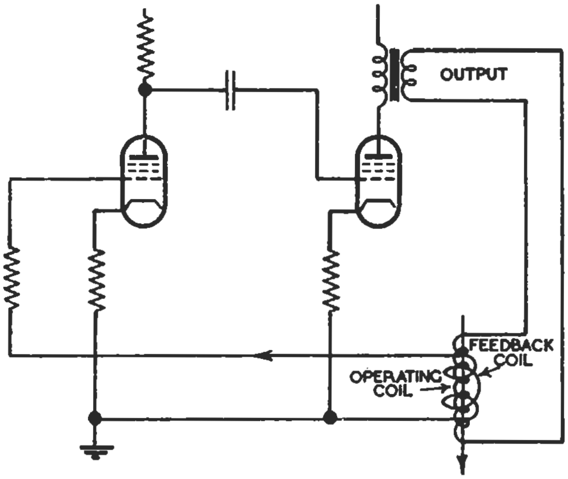

Fig. B.2. Method of Feedback Application

In the case of the Presto equipment, the amplifier was first modified to give more feedback than that originally used, about 28 db feedback at 1,000 c/s being obtained from a 15-ohm winding on the output transformer. The recording head operating coil was then wound to suit the 15-ohm output of the amplifier and the feedback coil used to provide the same degree of negative feedback at 1,000 c/s. (See [redacted] page[redacted].)
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Effects of Feedback

When no feedback is employed it is usually found that with constant voltage applied to the head, the cutter velocity tends to fall off below about 1,000 c/s, and usually still more rapidly below about 200 c/s. This effect is sometimes used to provide the required recording characteristic. The application of feedback alters this entirely, giving a good approximation to a constant-velocity characteristic down to quite low frequencies where, of course, the amplitude must be limited. It would appear that the fall in characteristic in the bass without feedback is entirely due to the fact that the decrease in reactance of the operating coil with the fall in frequency is modified by the d.c. resistance of the coil, whereas at the higher frequencies, resistance is negligible, compared with the reactance. Hence, the current in the operating coil does not increase in proportion to the fall in frequency.

When feedback is applied, the feedback voltage, which is derived from the operating coil, does not remain constant but falls as the frequency is decreased. This results in an increasing amplifier gain, which tends to maintain the operating flux at a constant value.

Some idea of the operating conditions with feedback may be obtained from the fact that the feedback through the recording head when using a Presto amplifier was 29·5 db at 3,000 c/s, 28·5 db at 1,000 c/s, falling to 10·5 db at 50 c/s.

SECTION C

PERFORMANCE OF TYPE-B RECORDING HEADS

Frequency Characteristics

Effect of Damping

The information contained in this Section is based on data obtained from tests carried out over a relatively long period, during which Type-B recording heads have been in use on an experimental basis.

The method used for obtaining the frequency response of the Type-B recording head was similar to that outlined in Instruction R4, page 33. Measurements were first taken of a number of undamped heads using sapphire-tipped cutters, Type SB/8, the recorded disks being reproduced by a modified E.M.I. Type-12 reproducing head using a sapphire-tipped reproducing needle, Type RS/8. The result of these tests is shown in Fig. C.1, which indicates the maximum variation in the overall characteristics of the six heads tested. The voltage across the main winding of the recording head during the frequency run is shown in Fig. C.2 and the frequency response of the reproducing chain when replaying Test Record XTR.311, in Fig. C.3.

Damping was applied to the same set of heads and fresh measurements taken under similar conditions. Fig. C.4 shows the limits of variation obtained from these heads after damping. If the curve in Fig. C.3 be subtracted from the mean of those in Fig. C.4, it will be seen that the frequency response of the average damped head is sensibly flat between 100 and 10,000 c/s.

Amplitude Linearity

In order to ensure that low-frequency amplitude distortion would not occur at relatively high recording levels a series of tests was carried out by recording a 100-c/s tone at levels varying between line-up and 10 db above line-up. The maximum departure from linearity in no case exceeded 0·5 db.

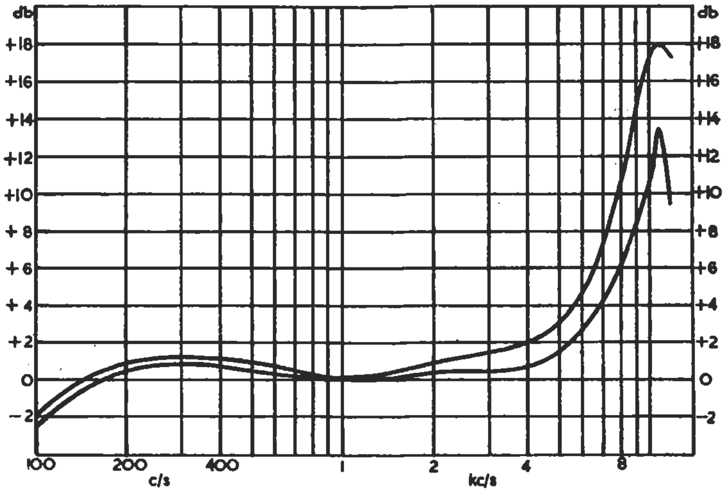


Fig. C.1. Maximum Variation in Frequency Response for Undamped Heads

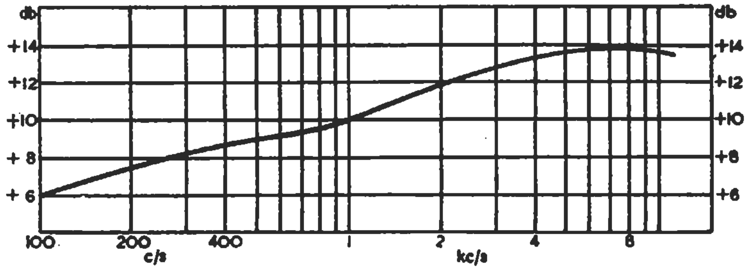


Fig. C.2. Voltage across Recording Head

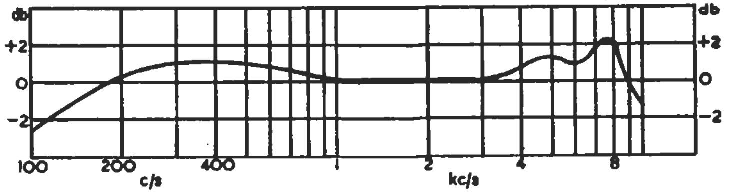


Fig. C.3. Frequency Response of Reproducing Chain

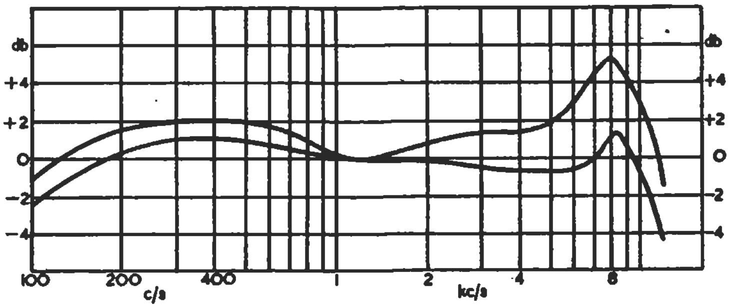


Fig. C.4. Maximum Variation in Frequency Response for Damped Heads

Effect of Temperature Variation

The effect of variation in temperature on the frequency characteristic is shown in Fig. C.5. Ideally, the characteristic would remain constant with changes in temperature and whilst this ideal is not fully achieved, Fig. C.5 indicates that under normal operating conditions, the present variations are not excessive, for there is little likelihood of temperature variation as great as 64° F. to 120° F. being encountered.

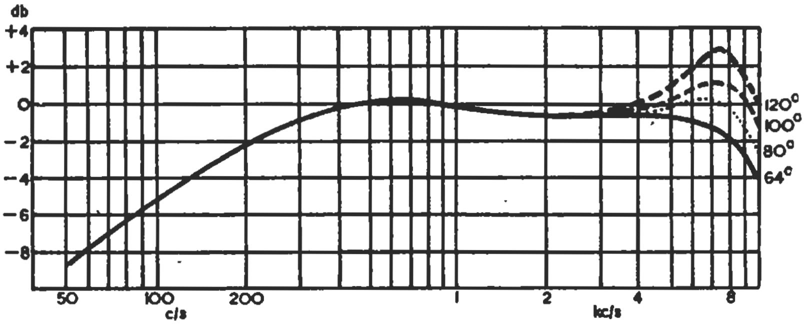


Fig. C.5. ~~Effort~~ Effect of Temperature Variations on Frequency Response

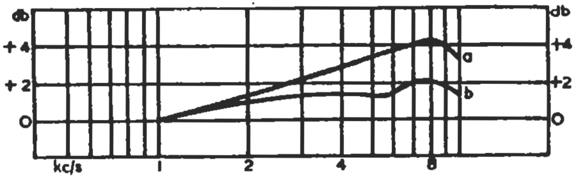


Fig. C.6. Effect of Different Lacquers on Frequency Response

Effect of Cutter-point Loading

It has been found that, for a given head and cutter, the frequency response may vary with different types of disk. This is because of the variation in elasticity of the plastics forming the cutting medium which causes variation in the loading on the cutter-point, the load increasing with the toughness of the material. This is shown in Fig. C.6, the curves indicating the response obtained from the same recording head for a soft disk, *a*, and a hard disk, *b*. The soft disk was cut at 120 grooves per inch and the hard disk at 104. As the same groove-to-land ratio was maintained in both cases, the cut on the soft disk was not so deep, thus accentuating the difference in loading between the two disks.

These conditions produced the maximum difference in loading (resulting from different disk material) likely to be met in practice and the results indicate that the variation in frequency response is not serious.

It should be understood that Fig. C.6 represents the conditions obtaining at the time the tests were taken. Development of new disk materials is progressive and variation in cutter-point loading is likely to be experienced with each new type of disk. Where different types of disks are used concurrently, the difference in loading for a given diameter may be compensated for by a suitable variable correction circuit in the amplifier. (See page 11.)

The difference in loading resulting from different disk radii can only be corrected by radius compensation.

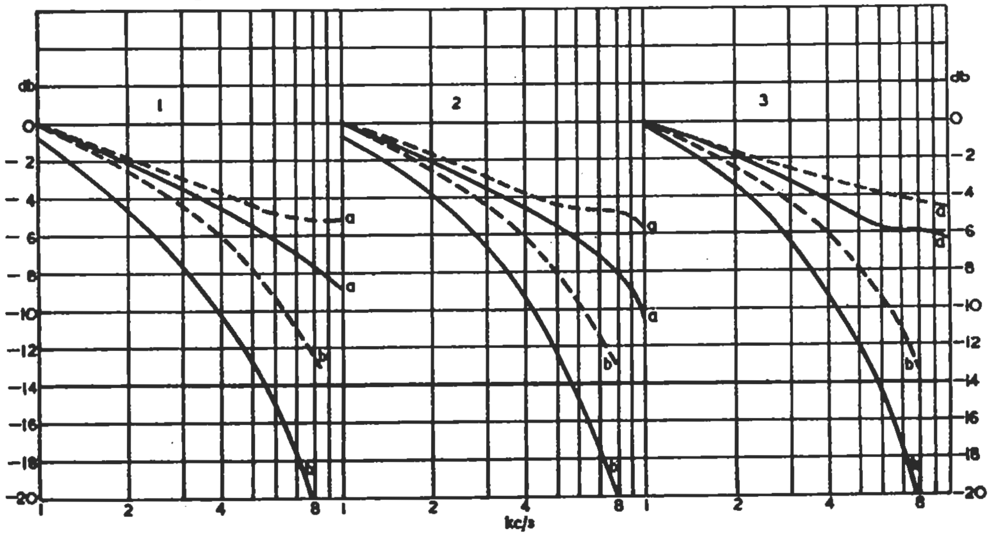


Fig. C.7. Variations in Frequency Response with different Cutters

Variations Due to Cutters

The influence of the cutter on the design of the recording head has already been discussed in Section B. As the Type-B recording head was designed to use a cutter of the size and mass of the SB/8, tests were carried out before putting it into service to determine the average frequency characteristic which would be obtained with SB/8 cutters. Some typical results obtained from three SB/8 and three Presto cutters for 78 and 33⅓ r.p.m. are shown in Fig. C.7. In each set of curves, *a* represents results at 78 r.p.m., the full curve for SB/8 and dotted curve for Presto cutters; *b* shows corresponding results for the same cutters at 33⅓ r.p.m. It is clear that greater high-frequency loss occurs with the SB/8 cutters. Since these tests were made, however, considerable improvements have been effected in the production of SB/8 cutters, resulting in reduced high-frequency loss.

Effect of Radius Compensation

An interesting curve, demonstrating tracing loss as a function of groove radius, obtained with a sharp cutter and a reproducing needle of 0·002 inch tip radius is given in Fig. C.8. Results are shown for 78 and 33⅓ r.p.m. and the radius scale (B) for 33⅓ r.p.m. has been adjusted to that of 78 r.p.m. (A) so that the same curves are applicable for both turntable speeds. For example, at a radius of 8 inches at 33⅓ r.p.m., the wavelength at a given frequency is the same as that for a radius of 3¾ inches at 78 r.p.m. Consequently, with a 78-r.p.m. disk, less high-frequency loss has to be allowed for in the correction circuits at a maximum radius of 5½ inches than for a 33⅓-r.p.m. disk, at a maximum radius of 8 inches. Thus, at 4,000 c/s, the values are respectively 1·0 db and 2·7 db, and at 8,000 c/s, 3·5 db and 7·8 db. At the inside of a disk there is a loss of 7·5 db at 4,000 c/s at 78 r.p.m. at a radius of 2½ inches and 12·8 db at 33⅓ r.p.m. at a radius of 3¾ inches, while at 8,000 c/s the losses are respectively greater than 17·4 db and 30 db. Attempts to apply correction in the form of radius compensation for high-frequency losses experienced on the inside of a disk recorded at 33⅓ r.p.m. have been found impracticable for frequencies above 5,000 c/s because of the prohibitive amount of distortion thereby introduced.

The figures given in the preceding paragraphs were obtained by using sharp cutters. Actual values of tracing loss may vary considerably with different types of cutters, but the principles outlined above apply to all.

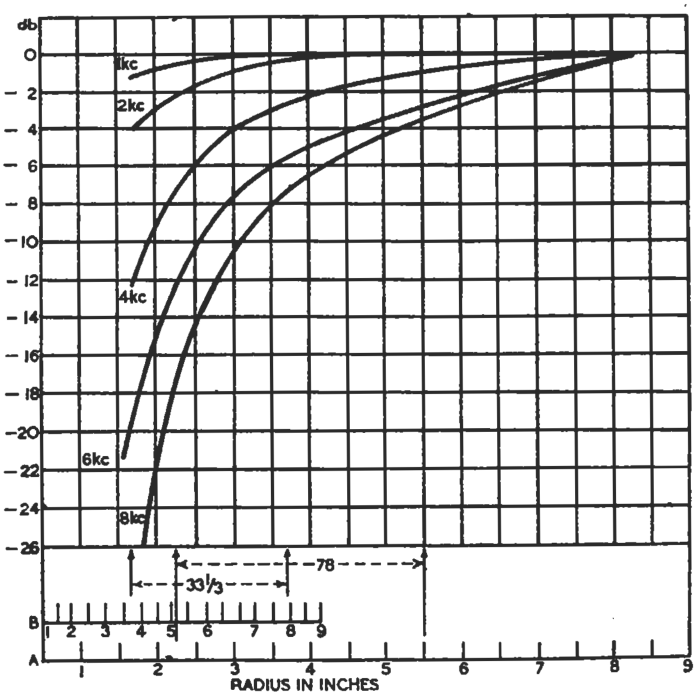


Fig. C.8. Curves demonstrating Tracing Loss as a function of Groove Radius

SECTION D

MODIFICATION OF PRESTO RECORDERS TO ACCOMMODATE BBC TYPE-B RECORDING HEADS

The modifications necessary to permit the use of BBC Type-B recording heads with Presto recording equipment ~~have been dealt with in the appendices of Instruction RC.8 and~~ are summarised here for convenience, together with some explanatory matter. ~~not included in RC.3.~~

Radius Compensation. Fig. 4

Modification for 33⅓ r.p.m.

The original radius-compensation circuits of the Presto equipment do not meet the requirements indicated in Section C, especially with regard to 33⅓-r.p.m. recording. In particular, the original circuit provided no compensation at the outside of a large-diameter disk, whereas it has been shown that such compensation is necessary in order to correct for the difference in frequency response resulting from the reduced linear speed of the disk when recording at 33⅓ r.p.m. To meet this requirement, a circuit consisting of a 0·1-μF capacitor shunted by a 500-ohm resistor has been incorporated in the equaliser panel on the amplifier bay. This raises the response at the higher frequencies. The circuit is so arranged that by setting the equaliser switch to the position marked 33⅓ *r.p.m.*, the capacitor is in circuit. In all other positions of this switch, the capacitor is open-circuited.

Reduction of Ringing in Resonant Circuit

The resonant circuit in the equaliser was subject to ringing when energised by transients. To control this and to reduce the amplitude at the resonant frequency, a 100-ohm resistor is shunted across the inductance when the equaliser switch is in the 78-*r.p.m.* position. The resistor is permanently connected so that it remains in circuit across part of the inductance when the switch is in the 33⅓-*r.p.m.* position.

Input-circuit Impedance

In order to maintain a constant load on the output circuit of the limiter 41A, and hence on the input to the radius compensator, the arrangement of the recording-chain attenuator has been modified. This attenuator, referred to in RC.3 as the *Recorder Fader*, is placed in circuit between the recording change-over switch and the input to the radius compensator. The side of the network marked *In*, which carries the variable arm, is now connected to the radius compensator, and the side marked *Out*, carrying the fixed arm, to the repeating coil, the ratio of which has been changed to 1 : 1. The fixed arm is padded out by a 500-ohm resistance to help maintain a constant-impedance load on the repeating coil whatever the position of the fader. A 2,000-ohm resistor is wired in parallel with the input of each radius-compensation circuit to maintain the same source impedance as before the change. With these modifications, the input impedance of either recording chain is 900 ohms. When the change-over switch is in the central position, these impedances are paralleled, so that the effective input impedance is 450 ohms. With the change-over switch in position 1 or 2, a 900-ohm resistance is shunted across the input circuit, so that, under all conditions, the input impedance remains at 450 ohms.

Modification to Amplifiers

Recording Amplifier 88AB, Fig. 5

The Presto recording amplifier 88A, when modified for use with Type-B heads, is designated 88AB. Details of these modifications are given in RC.3, Appendix F, page 23. Instead of repeating these, a brief circuit description of the modified amplifier will be given.

The amplifier, Fig. 5, comprises two voltage-amplifying stages, V1, V2, resistance-capacitance coupled, followed by a phase-splitting stage V3, which feeds into the parallel push-pull output stage comprising V4-V7.

Voltage feedback from V2 is applied through [illegible], C22 R7, to the cathode circuit of V1 by means of R31 and is controlled by the shunt circuit comprising C10, R41, R39, R40. The effect of this is to reduce the feedback at high frequencies by an amount varying with the setting of the variable resistance R40. The purpose of this variable setting is to permit some control over the frequency response and thus enable compensation to be made for varying conditions of recording, such as different types of disk, varying temperature conditions and variation between different heads. (See page 9.)

The output of V2 is coupled to the phase-splitter V3 through C20, C4. The 0·0013-μF capacitor C20 is included to attenuate low frequencies to the BBC recording characteristic.

The circuits associated with the double triode

V3 are so arranged that the output voltages of the two anodes are 180° out of phase. The anode of the driver stage is connected to the grid of the phase-splitter through R10, C5, the values of which are calculated so that the voltages applied to the respective grids of the two halves of the push-pull output stage are equal in value but opposite in phase.

The secondary winding of the output transformer T2 is split and the 250-ohm tappings of one section are connected to the output meter, the meter being arranged to read zero db when the level at the recording head is + 10 db. The 15-ohm winding is connected to the recording head main winding. The recording head main and feedback windings are connected to a 4-pin plug, the feedback voltage being injected between the two cathodes of the phase-splitter V3.

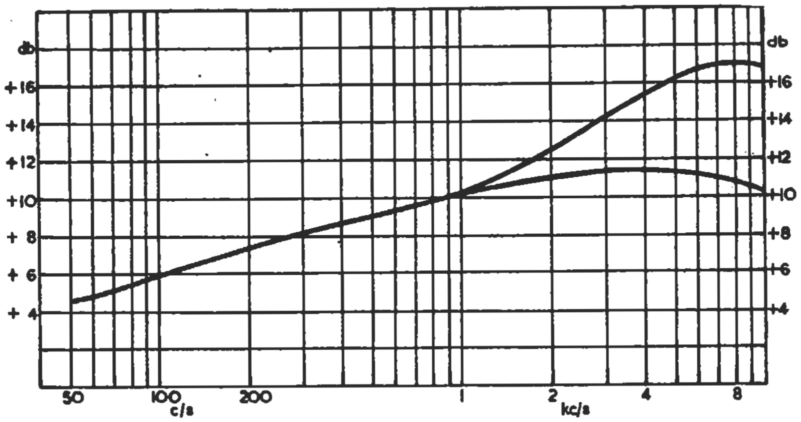


Fig. D.1. Frequency Response of Amplifier with Recording-head Windings connected normally

Fig. D.1 shows the frequency response of the amplifier measured across the recording-head winding with main and feedback windings connected normally. The figure indicates the maximum and minimum high-frequency response at the two extreme settings of R40, Fig. 5.

Fig. D.2 shows the corresponding frequency response when measured across the 250-ohm meter winding of the output transformer with a 600-ohm load, the recording head being disconnected. In this case, the 15-ohm winding is used for internal feedback by strapping the socket terminals, 13 to 15, 14 to 16 (Fig. 5).

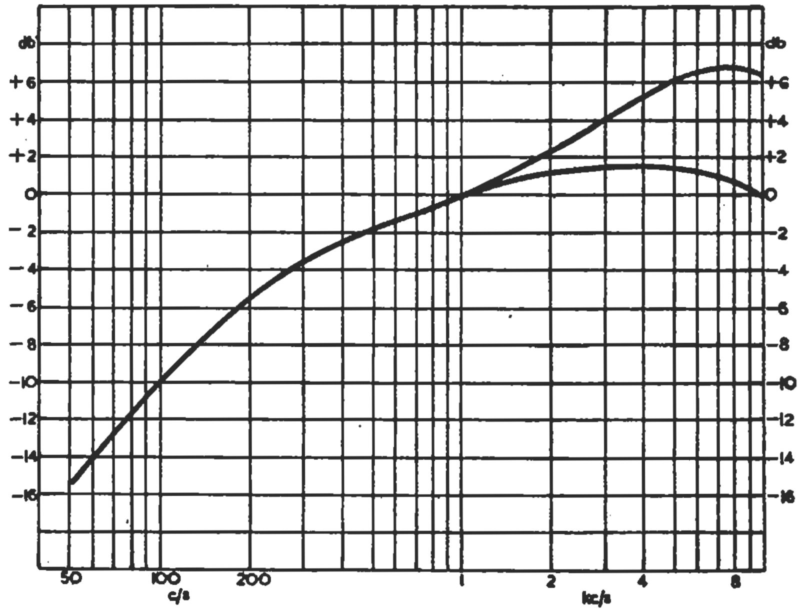


Fig. D.2. Frequency Response of Amplifier with Recording Head disconnected

Limiter 41*A*

The modifications to this amplifier are described in R[redacted] page[redacted]. These modifications were not directly connected with the change over from Presto to Type-B heads and need not be repeated here.

Characteristics of the Recording Chain

The characteristics of a Presto recording chain when using a Type-B head are shown in Fig. D.3, which indicates the voltages across the recording head for frequencies above 1,000 c/s at various disk radii, the equaliser switch being set at 78 r.p.m. Fig. D.4 gives corresponding curves with the equaliser switch set at 33⅓ r.p.m. These figures show the effect of the radius-compensating circuit upon the recording-head voltages. In both cases, the level at 1,000 c/s has been set at the same datum value for each curve.

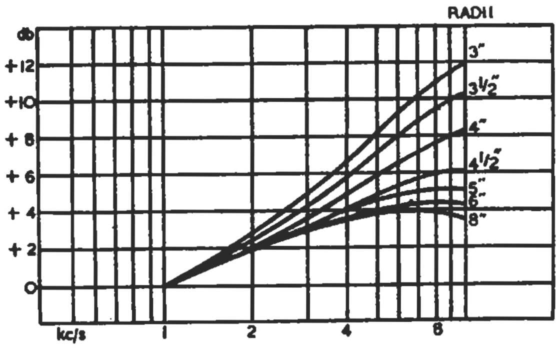
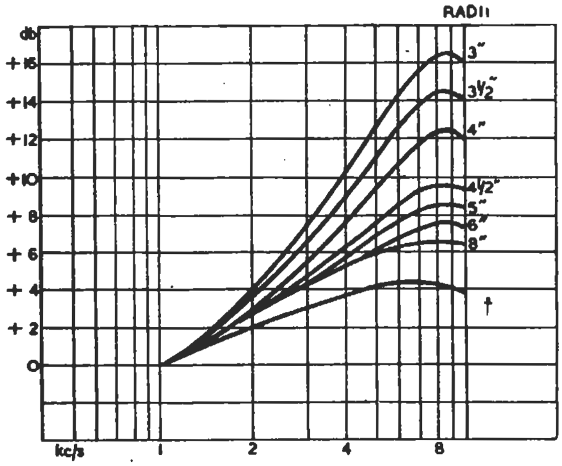


Fig. D.3. Characteristics of Presto Chain with Type-B Heads (78 r.p.m.)



† 8" *without initial* 33⅓ *r.p.m. radius compensation.*

Fig. D.4. Characteristics of Presto Chain with Type-B Heads (33⅓ r.p.m.)

APPENDIX 1

RE-DAMPING OF TYPE-B1/A RECORDING HEADS

The practice of returning all recording heads to Recording Maintenance Unit for re-damping is not necessary in the case of BBC Type-B1/A recording heads, as these can be re-damped by the local station staff. (WARNING: No maintenance work other than re-damping must be attempted by local staff.)

Tolerance curves at 78 r.p.m. for the Presto recording chain when using the Type-B1/A recording head are shown on Fig. 1.1 and Fig. [redacted]19

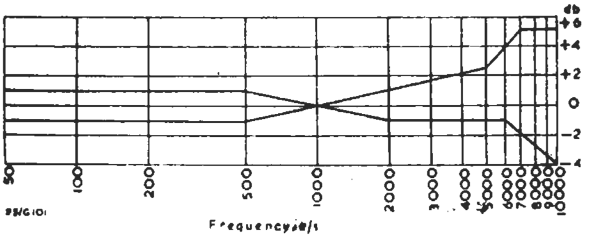


Fig. 1.1. Tolerance Curves for Presto Chain with Type-B1/A Head (78 r.p.m.) & DOM·85

R4 [redacted]. When the characteristic is outside the upper tolerance limit, the head should be re-damped using the following procedure:—

The oil to be used is Price's recording-head oil, Type BA, provided in a medical drop bottle which has a glass pipette attached to the stopper.

Remove the recording head from the traversing assembly, invert it and stand it on the turntable with the cutter-holder (Fig. B.1, item 11) upwards.

Remove the four countersunk screws which secure the tufnol or ebonite cover-plate, and carefully lift the cover-plate from the recording head together with its paper seal, taking care not to damage the paper seal. Part of the armature and pole-pieces will now be exposed, including the 0·005-inch air gaps between the armature and the pole-pieces, in which can be seen the oil retaining paper stirrup.

Fill the glass pipette with oil and apply three or four drops of oil to the 0·005-inch air gaps between the armature and pole-pieces. Immediately apply 1,000 c/s tone at zero level to the recording head for a period of 5 seconds.

Remove all surplus oil from the pole-pieces, armature and cover-plate with clean blotting paper, and press the paper seal between sheets of clean blotting paper.

Carefully replace the paper seal and cover-plate, and secure them in position with the four countersunk screws, taking care that the cutter-holder is concentric with the hole in the cover-plate.

Refit the recording head to the traversing assembly and check the frequency response of the recording chain at 78 r.p.m., as laid down in Instruction R4 [redacted], page 33 [redacted]. If the response at the upper end of the frequency range is still outside the upper limit of the tolerance curve, the damping operation should be repeated.

Great care should be taken that no foreign matter, such as dust or iron filings, enters the recording head, and on no account should a screwdriver or similar instrument be allowed to touch the armature or pole-pieces.

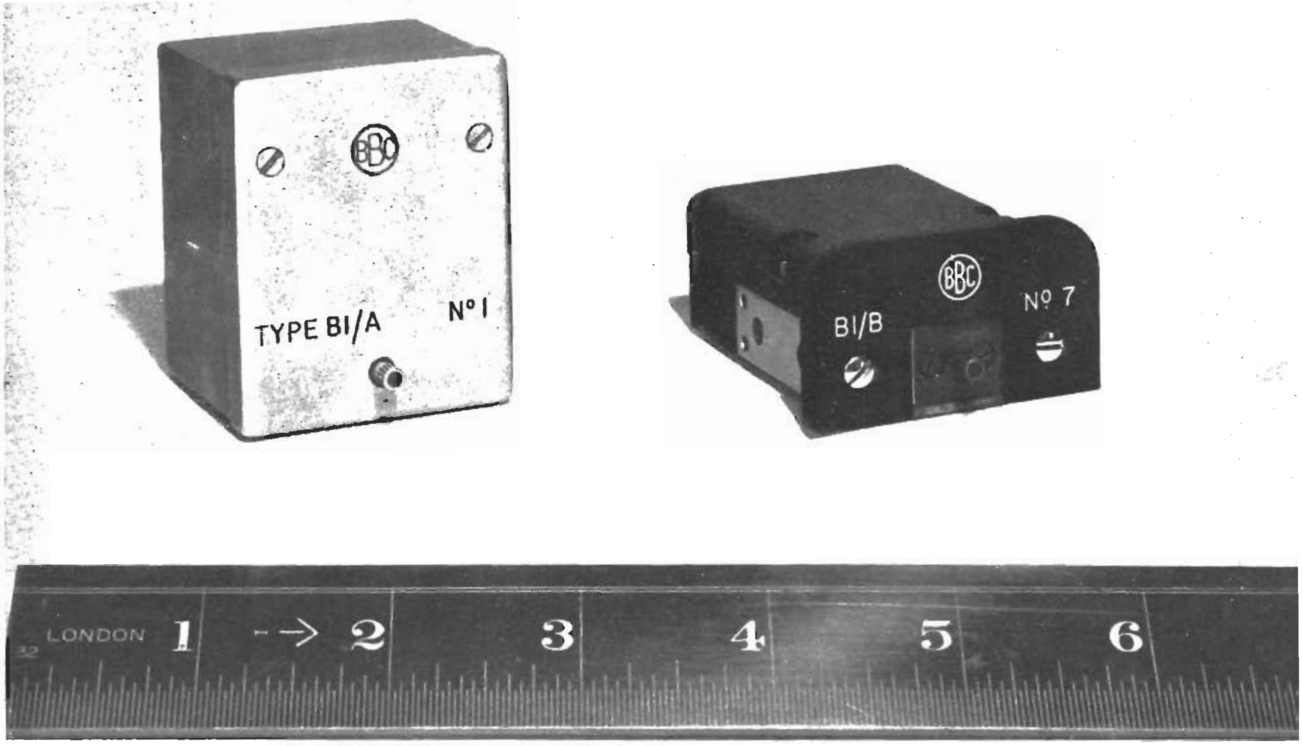


Fig. 1. BBC Moving-iron Recording Head Type B.
Type B1 A for Presto Recorders.
,, B1 B ,, BBC Type D Recorders

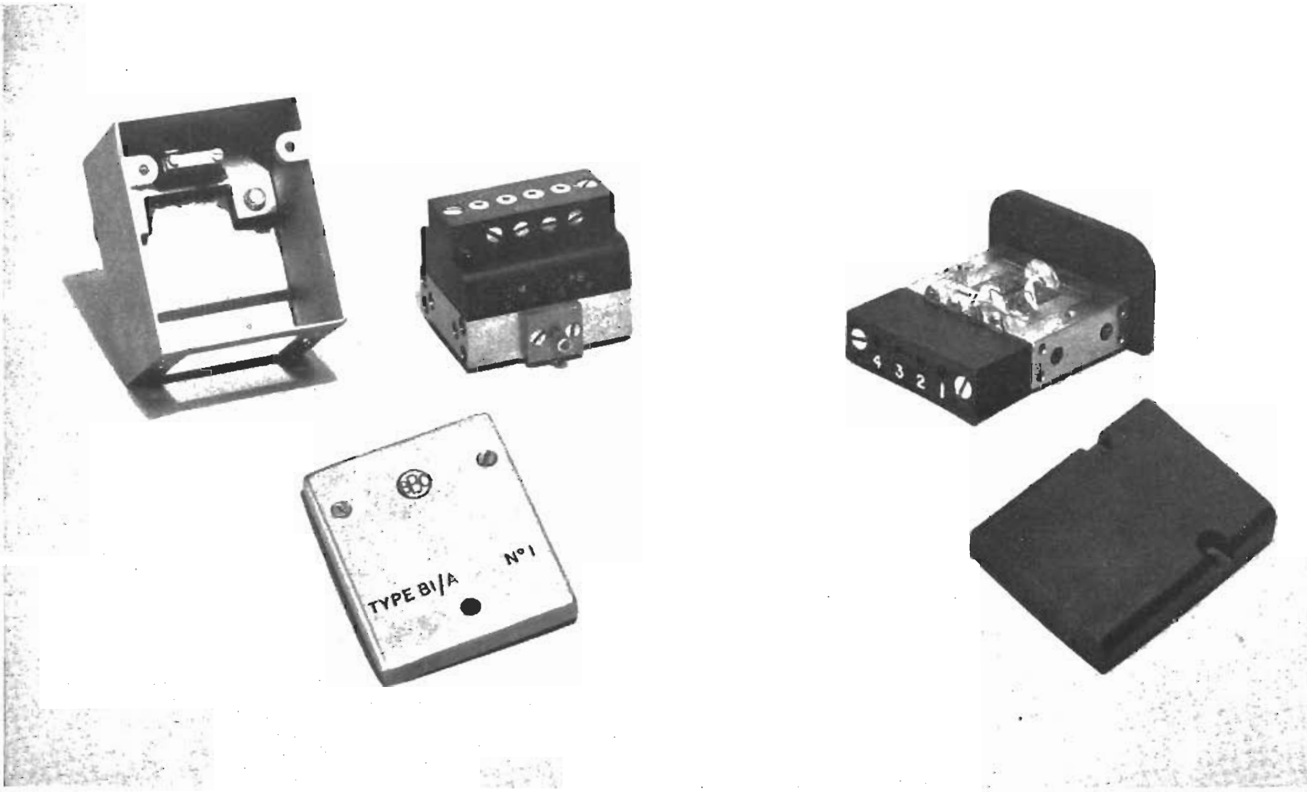


Fig. 2. BBC Moving-iron Recording Head Type B.
Covers Removed.

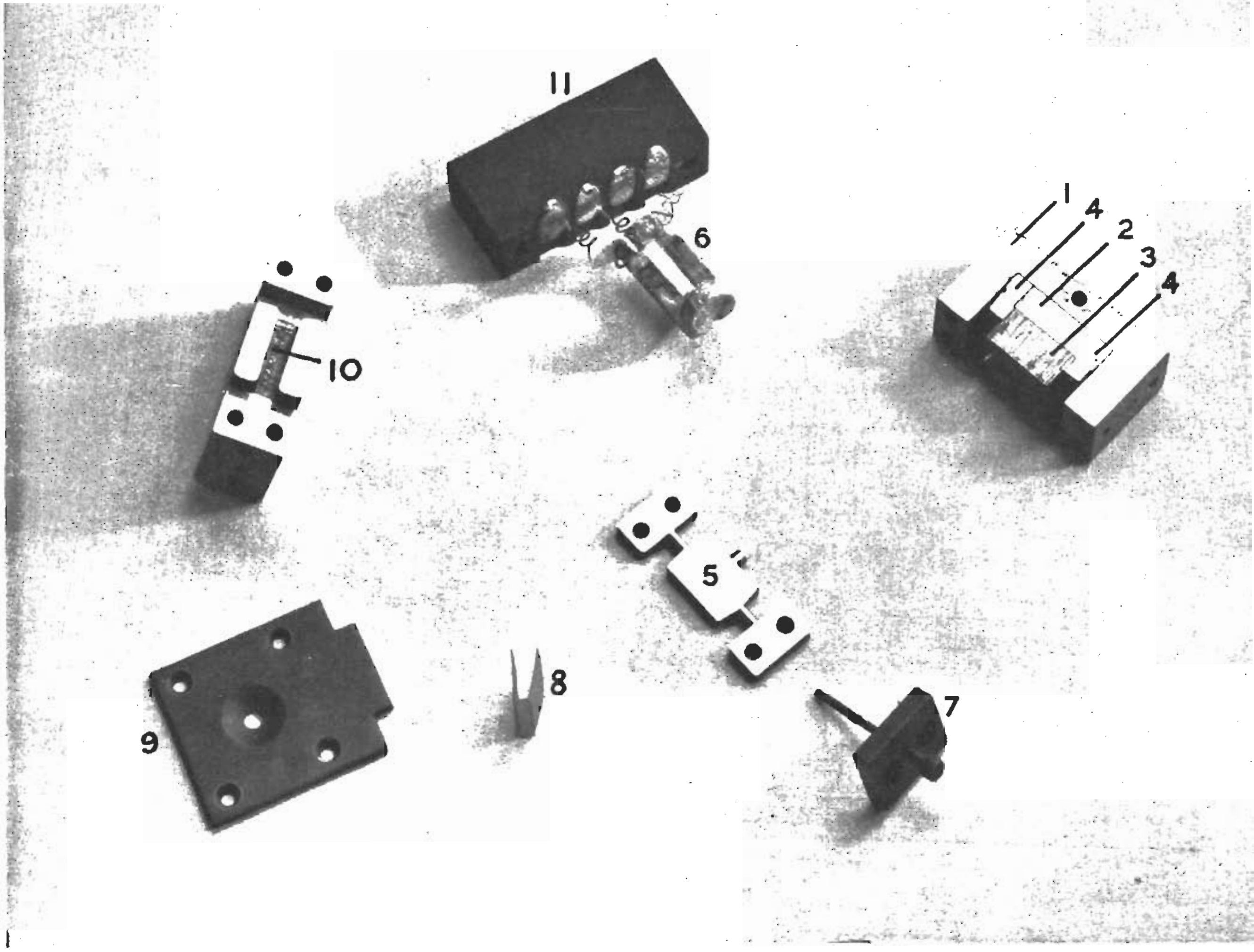
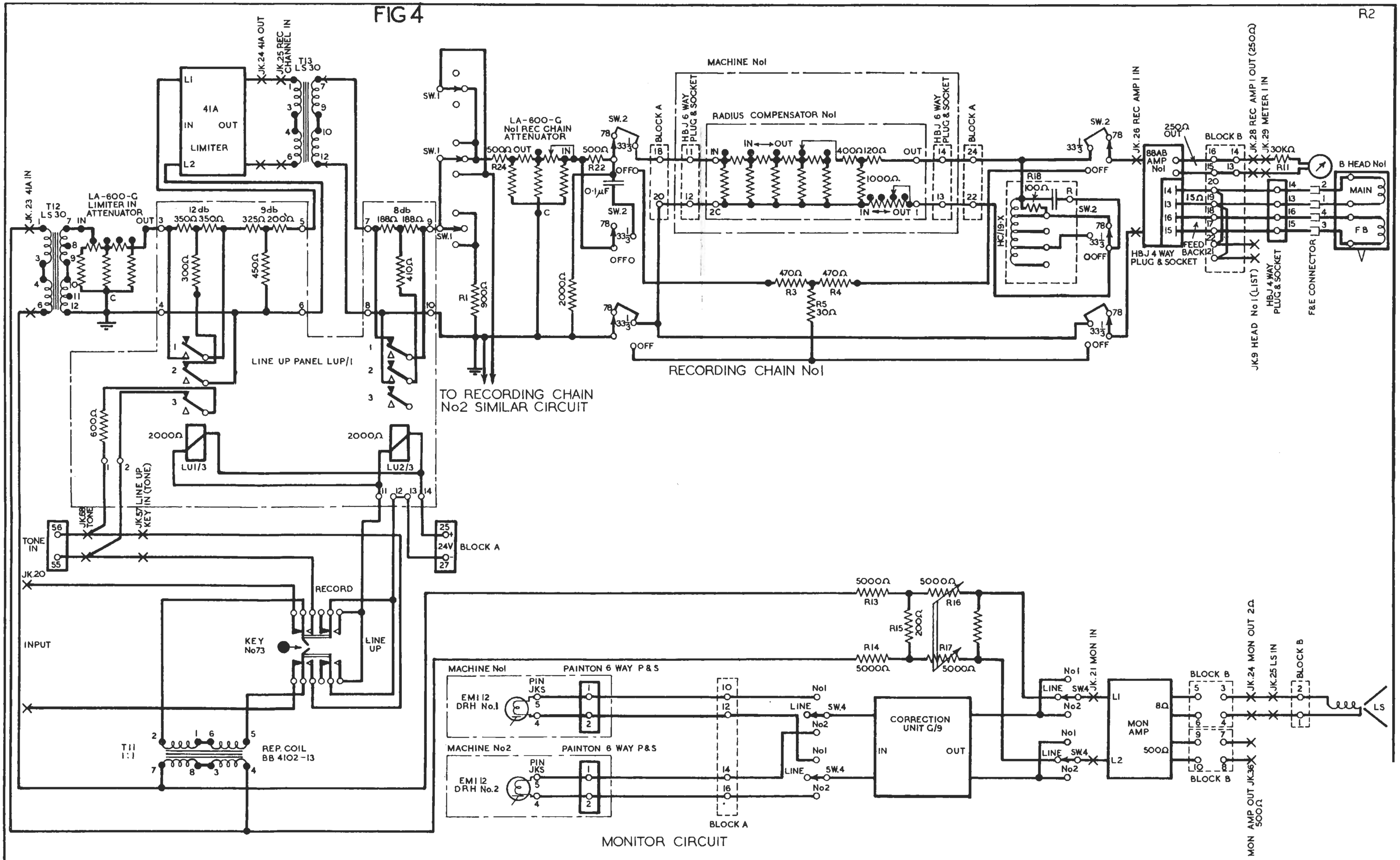


Fig. 3. BBC Moving-iron Recording Head Type B1/B Components.

REFERENCES

1. Yoke.
2. Magnet.
3. Pole-piece.
4. Separators.
5. Armature.
6. Coil.
7. Cutter-clamping Screw Assembly.
8. Paper Damping-oil Retainer.
9. Bottom Cover Plate.
10. Coil Space.
11. Terminal Block.

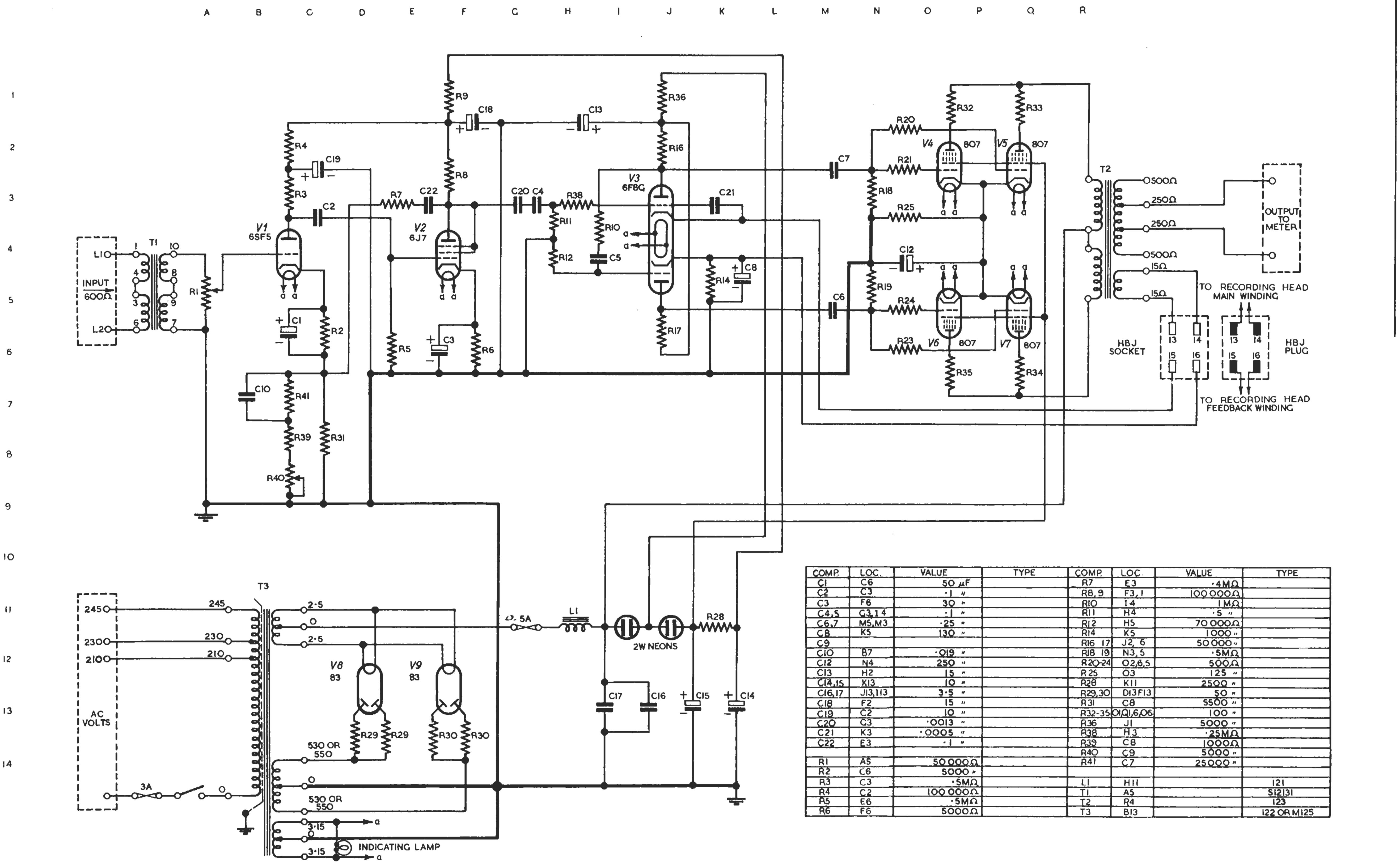
FIG 4



PRESTO RECORDING CHANNEL TYPE JB

54016/R2/DJE

FIG.5



PRESTO RECORDING AMPLIFIER 88AB

COMP.	LOC.	VALUE	TYPE	COMP.	LOC.	VALUE	TYPE
C1	C6	50 μF		R7	E3	·4MΩ	
C2	C3	·1 "		R8, 9	F3, 1	100 000Ω	
C3	F6	30 "		R10	I4	1MΩ	
C4,5	G3,I4	·1 "		R11	H4	·5 "	
C6,7	M5,M3	·25 "		R12	H5	70 000Ω	
C8	K5	130 "		R14	K5	1000 "	
C9				R16 17	J2, 6	50 000 "	
C10	B7	·019 "		R18 19	N3, 5	·5MΩ	
C12	N4	250 "		R20-24	O2,6,5	500Ω	
C13	H2	15 "		R25	O3	125 "	
C14,15	K13	10 "		R28	K11	2500 "	
C16,17	J13,I13	3·5 "		R29,30	D13F13	50 "	
C18	F2	15 "		R31	C8	5500 "	
C19	C2	10 "		R32-35	O1,Q1,6,O6	100 "	
C20	G3	·0013 "		R36	J1	5000 "	
C21	K3	·0005 "		R38	H3	·25MΩ	
C22	E3	·1 "		R39	C8	1000Ω	
				R40	C9	5000 "	
R1	A5	50 000Ω		R41	C7	25000 "	
R2	C6	5000 "					
R3	C3	·5MΩ		L1	H11		121
R4	C2	100 000Ω		T1	A5		S12131
R5	E6	·5MΩ		T2	R4		123
R6	F6	5000Ω		T3	B13		122 OR M125

54074/R2 /DJE

NOTES

NOTES

INDEX

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