TECHNICAL INSTRUCTION

R.10

Transistorised Magnetic Tape Recorders

RD4/1 and RD4/501

Electrical Maintenance Instruction

First issued December 1959

AMENDMENT RECORD

Amendment Sheet No.	*Initials*	*Date*	*Amendment Sheet No.*	*Initials*	*Date*
R.10— 1					
R.10— 2					
R.10— 3					
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R.10— 5					
R.10— 6					
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DIAGRAMS AT THE END

TRANSISTORISED MAGNETIC TAPE RECORDERS RD4/1 AND RD4/501

ELECTRICAL MAINTENANCE INSTRUCTION

SECTION 1

INTRODUCTION

This Instruction gives information for the electrical adjustment and maintenance of Magnetic Recorders RD4/1 and RD4/501. Both these recorders are basically the E.M.I. Lightweight Battery-operated Tape Recorder Model L2B which has been modified to utilise transistorised circuits instead of valve circuits in order to reduce the number of batteries and to provide additional facilities. The transistorised units are constructed on printed-wiring cards.

The RD4/501 is similar to the RD4/1 except that it is provided with double-track heads and facilities for recording synchronising signals when used with an Arriflex film camera, has a line input jack for recording zero level signals and is fitted with a loudspeaker volume control.

Fig. 1.1. Recorder RD4/1: General View

A description of the tape mechanism and mechanical tests and adjustments for the original L2B recorder is given in the Instruction Manual issued by the makers of the Model L2B recorder.

Transistors and their applications are described in Engineering Training Supplement No. 12.

SECTION 2

GENERAL DESCRIPTION

2.1 General Design

Both the RD4/1 and the RD4/501 utilise the tape deck and case of the E.M.I. Model L2B magnetic recorder with certain modifications to guides, etc., as described in Designs Department Technical Memorandum No. 1.21(58). Both operate at a tape speed of 7½ in./sec. The electrical circuits employ transistors instead of valves, and the transistorised units are constructed on printed-wiring cards and consist of a record amplifier, a replay amplifier, a bias oscillator and a loudspeaker amplifier which feeds a small internal loudspeaker for listening to playback.

The record and replay amplifier cards are carried on two pillars and can be removed easily for replacement or special service. The loudspeaker amplifier card is mounted on a hinged plate to which is fixed a 3½-inch loudspeaker. The bias oscillator card is fixed to a new panel at the right-hand end of the chassis; this card also carries a transistor battery-smoothing circuit for reducing the transfer of motor commutator interference to the signal circuits by the common impedance of the 12-volt battery. This battery provides all the supplies to both the motor and the transistors, the need for the original h.t. and l.t. batteries for valve supplies having been eliminated.

2.2 Facilities Provided

The *record amplifier* of the RD4/501 is provided with inputs for both a low-impedance (30-ohm) microphone and zero-level line, a bass cut, a recording gain control and a simple modulation meter which is also used to check h.f. bias current and battery voltage. In the RD4/1 provision for a line input has been omitted, but the facilities are otherwise the same.

Incoming modulation and bias can be checked for level on the meter without the drive motor running and hence without using up any tape. A *Test Modulation* button switch applies power to the amplifiers and oscillator only for this purpose.

The separate *replay amplifier* has no gain control and feeds zero-level programme either to line or to headphones from a tape recorded with the levels normally used with Type-77 Emitape.

The *loudspeaker amplifier* is fed with programme only when replaying a tape and cannot be used when there is a plug in the *Phones/Line Out* jack. A volume control is provided in the RD4/501 only.

In the RD4/501, which is fitted with double-track heads for recording and reproducing synchronising signals in addition to the programme, a 'star' indicator is provided which shows four white sectors only when synchronising tone is arriving from the film camera and thus indicates that the camera is turning over. Provision is also made for recording on the audio or upper track a 730-800 c/s 'slating' signal when the camera operator presses a button which simultaneously marks the film by means of a lamp inside the camera. The oscillator which provides this signal, and the generator which provides the 50-c/s synchronising signal when the camera is turning, are fitted on the Arriflex camera and are described in Technical Instruction F.2.

2.3 Controls

The controls are grouped in three positions: on the original panel at the left-hand end of the case, on the tape deck, and on a new panel at the right-hand end of the case.

The left-hand panel on both the RD4/1 and RD4/501 carries a 600-ohm *Phones/Line Out* jack, a socket for a 30-ohm microphone, an *On/Off* switch, and, under a hinged flap, a record gain control, a bass-cut switch and a three-position meter switch.

The tape deck carries a latch lever which, when engaged to the right, moves the tape into contact with the heads and operates a switch. When disengaged (to the left), the tape is free and all power is cut off. Also on the tape deck are the *Record/Replay* switch, the modulation meter, the *Test Modulation* button and, in the RD4/501, the 'star' indicator.

The new panel on the right-hand end of the case of the RD4/501 carries the 'bridging' *Line In* jack, the loudspeaker volume control, and the 4-pin *Sync* socket which receives the cable bringing the synchronising tone and the 'slating' signal from the film camera. Also on this panel, in both the RD4/1 and RD4/501, are the h.f. bias pre-set control and the 100-mA miniature fuse. Both of these are accessible only when the recorder is removed from its case.

SECTION 3

CIRCUIT DESCRIPTION

3.1 Supply Circuit (Figs. 1 and 2)

An internal 12-volt battery supplies both the motor and the signal circuits. *It is most important that its polarity is correct otherwise damage may be done to some parts of the apparatus.* The method of checking this is described in the Section on Maintenance Tests.

A simplified block schematic of the supply circuits is given in Fig. 3.1 and details of the circuits are shown in Figs. 1 and 2 for the RD4/1 and RD4/501 respectively.

The motor supply from the battery passes through the two poles of the *Latch Lever* switch and two poles of the *On/Off* switch. The supply

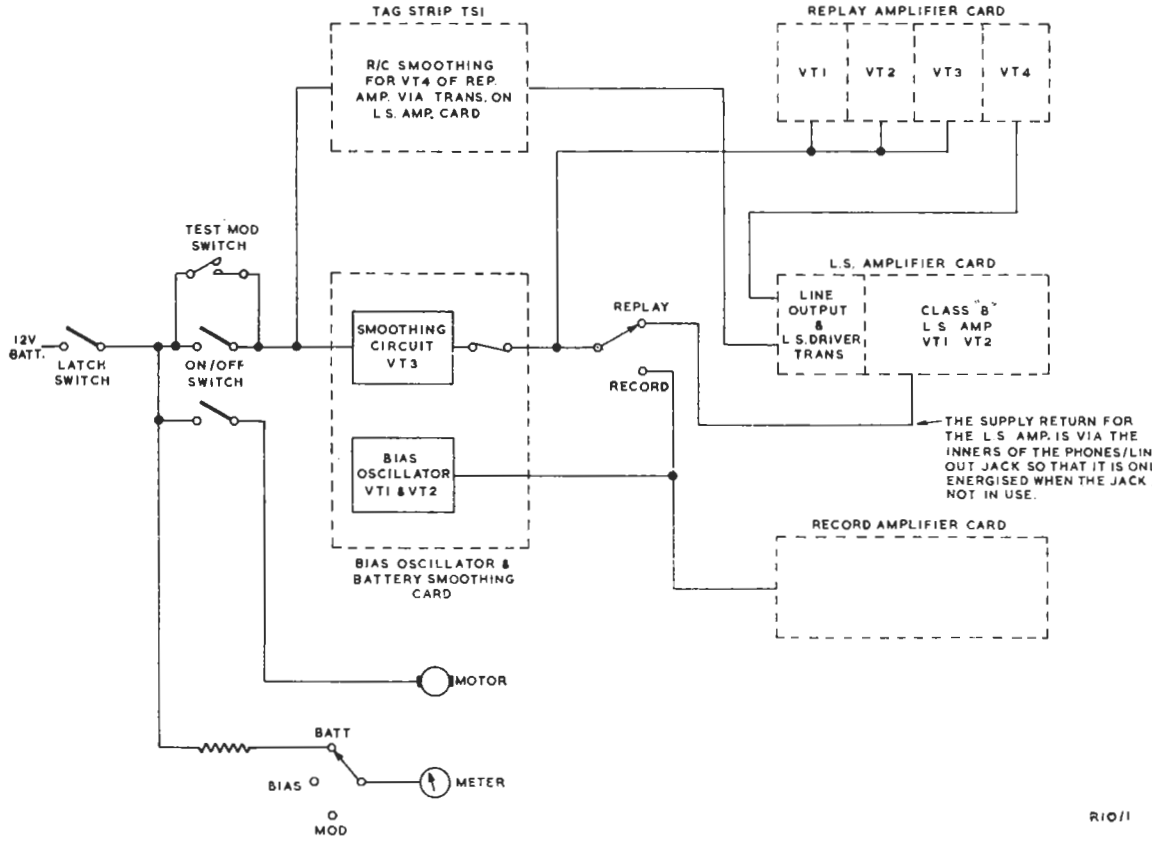

Fig. 3.1. RD4/1 and RD4/501: Supply Schematic

The positive terminal of the battery is at earth or chassis potential, and it is very important to note that it is connected to chassis at only one point, namely, on one supporting pillar of the record-amplifier card.

for the signal circuits also passes through the two poles of the *Latch Lever* switch but here the common path with the motor supply ends. The 12-volt negative is passed through a third pole on the *On/Off* switch and taken to Tag Strip TS1,

terminal 2, and terminal *Batt.*— on the bias-oscillator and smoothing card.

The 12-volt positive for the signal circuits is taken from the motor *On/Off* switch pole (*Latch* switch connection) to Tag Strip TS1, terminal 5, and to terminal V+ of the bias-oscillator and smoothing card. Across the third pole of the *On/Off* switch is connected the *Test Mod* micro-switch.

The 12-volt negative from TS1, after passing through an RC network is connected to terminal 1 of transformer AL/52S (on the loudspeaker-amplifier card) which supplies the output transistor (VT4) of the replay amplifier. (See Section 3.2.1.)

The 12-volt negative from terminal *Batt.*— on the bias-oscillator and smoothing card passes through a transistor circuit, the output of which is labelled V—. (This corresponds to h.t.+ in valve circuits.) The transistor circuit filters motor ripple from the amplifier V— supply.

The transistor (VT3) is a Mullard OC72, a pnp junction type, and is connected in series with the supply A potential divider R5 R6 across the supply provides the base with appropriate d.c. bias, while a.c. decoupling at motor ripple frequencies is provided by C4.

The amplifiers are in the emitter circuit in parallel with C5, and the filtering action is due to the relatively flat collector-current/collector-voltage characteristic of the transistor for a given base current as determined by the battery voltage, R5 and R6. This flat characteristic makes the effective collector-emitter resistance much higher to the small-amplitude superimposed ripple than to d.c.

The transistor can also be considered as an emitter-follower, although only for direct current owing to the presence of C4 and C5. A d.c. emitter-follower, like a d.c. cathode-follower, has a very low output resistance to d.c. This property provides good regulation of the V— supply, which is required to handle varying demands from the class-B loudspeaker amplifier. The V— supply circuit is decoupled from the transistor output impedance with respect to alternating current by C5.

Terminal V— on the bias-oscillator and smoothing card is connected to the traveller of the *Rec/Rep* switch to give the following facilities:

(a) Replay amplifier has V— in both positions of the switch.

(b) In the *Rec* position of the switch, the record amplifier and bias-oscillator, but not the loudspeaker amplifier, have V—.

(c) In the *Rep* position of the switch the loudspeaker amplifier, but not the record amplifier or the bias oscillator, has V—. The V+ return of the emitters of the transistors of the loudspeaker amplifier passes via the inners of the *Phones/Line Out* jack so that this amplifier can only be energised if the jack is not in use.

The smoothing-circuit transistor VT3 is protected against accidental short-circuit (i.e., V— to V+) by a 100-mA miniature fuse fitted between the emitter and the load. The fuse is mounted on the panel on the right-hand end of the case but is only accessible when the recorder is removed from the case.

3.2 Signal Circuits (Figs. 1 and 2)

The signal circuits of the RD4/1 and RD4/501 are shown in Figs. 1 and 2 respectively, and simplified block schematics of the replay and record circuits are given in Figs. 3.2 and 3.3. All signal circuits are common-emitter connected and use junction transistors of the pnp type.

Push-pull class-B operation is used in the loudspeaker amplifier and bias oscillator to keep down battery demands. All other stages are single-sided and therefore operate in class A.

Base biasing and stabilisation against thermal runaway of collector current are in general effected by the method described in *Engineering Training Supplement No. 12* on page 17. Briefly, the base potential is held steady by a potential divider across the supply, while a resistor in the emitter circuit applies negative current feedback which varies the emitter voltage in opposition to thermal or other changes in collector current. The addition of a by-pass capacitor across the emitter resistor where necessary restricts the negative-feedback action to d.c.

It is very important to note that the V+ of each recorder is connected to chassis at one point only (see also under *Supply Circuits*), and that the screens of screened wires and components are connected as shown. This ensures an absence of earth loops and hence freedom from undesirable motor-interference circulating currents.

3.2.1. Replay Amplifier

The replay amplifier uses four transistors, the first three being Mullard Type OC71 which are supplied with power from V— via the lead to the *Rec/Rep* switch traveller and not through the switch. The fourth transistor is a Mullard OC72 which is supplied directly from the *Batt.*— supply

via an RC network. The four stages are resistance-capacitance coupled and the amplifier is equalised to C.C.I.R. limits, most of the equalisation being effected in the feedback loop between the first two stages, although that between the last two stages also provides some bass equalisation. A resistor fitted between the first two and last two stages is adjusted on test to give the required overall gain.

The signal from the reproducing head is applied to the first-stage transistor VT1 via a step-up transformer and the coupling capacitor C1. The head impedance is 25 ohms at 1 kc/s but rises with frequency, and VT1 input impedance is about 3 kilohms. A transformer impedance ratio of 1 to 20 has been chosen as giving the best possible signal/noise ratio consistent with satisfactory frequency response, the corresponding voltage step-up being 4·5. Resistors R1 R2 are base-biasing components, R3 determines the mean collector voltage, and R4 stabilises collector current in the way already described. (Note that in all the remaining stages corresponding resistors are used.)

The signal from VT1 collector is applied to VT2 base via coupling capacitor C2, the collector load of VT1 being effectively the input impedance of VT2. C8 in VT2 emitter circuit is a decoupling capacitor preventing current feedback across R12, a similar arrangement being also used in the emitter circuit of VT4.

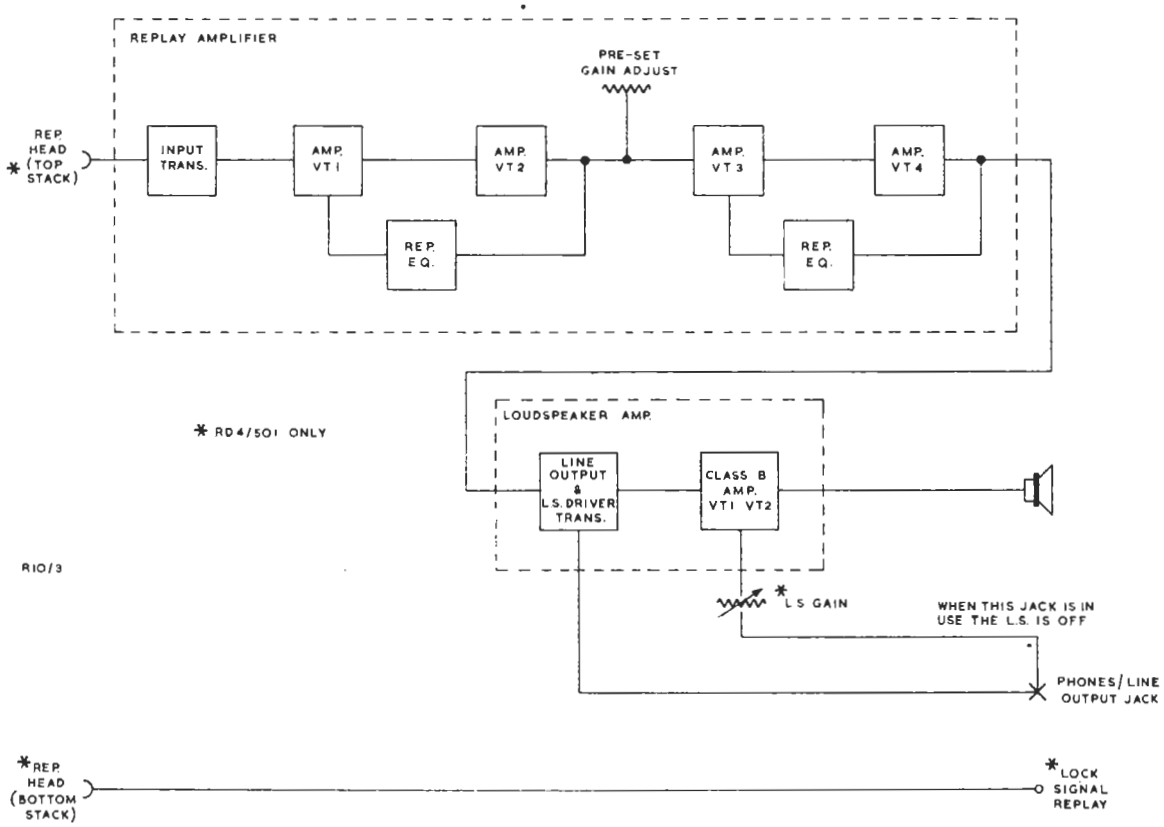

Fig. 3.2. RD4/1 and RD4/501: Replay Schematic

Negative feedback from VT2 collector is applied to VT1 emitter via C3 R5, R6 C4, and C5 R7. Components C3 R5 provide current feedback which is virtually independent of frequency. C5 R7 provide voltage feedback which increases gradually over the middle and upper audio frequencies and hence produces a falling gain characteristic over this range. C4 and R5 in parallel reduce the feedback at the higher frequencies, making the amplifier response flatten off in the upper range to an extent limited by R6.

As all the feedback is of the series type, it increases the input impedance of the first stage.

The output from VT2 is taken to VT3 via R13, which together with R15 in parallel with R14 and the transistor input impedance forms a potential divider feeding VT3 base. The value of R13 is adjusted on test to obtain the required overall amplifier gain.

VT3 is coupled via C10 to VT4, the output stage. Between VT4 collector and VT3 base a second feedback loop provides an effective bass-lift to supplement the action of the loop between VT2 and VT1.

The collector circuit of the output stage feeds a transformer which is fitted on the loudspeaker-amplifier card and has two secondary windings, one providing a line or headphone output and the other driving the loudspeaker-amplifier stage.

The signal from VT4 collector is applied to the lower end of the transformer primary winding, the upper end of which is connected to the junction of R3 and C3 (not on the card), which are in series across the battery and filter motor ripple from VT4 collector negative supply. C13 between collector and V— provides high-frequency correction required mainly to offset the effect of the rising load impedance presented by the driver transformer, which is outside the feedback loop.

3.2.2 Loudspeaker Amplifier

The loudspeaker amplifier uses two Mullard Type-OC72 transistors in a class-B push-pull stage directly coupled to a centre-tapped 120-ohm speech-coil loudspeaker. In the RD4/501 but not in the RD4/1 a gain control in the common emitter lead reduces the gain by about 15 dB.

The amplifier is energised in the replay condition of the recorder but only if the *Phones/Line Out* jack is not in use.

The base inputs of the two transistors VT1 and VT2 are taken from the centre-tapped secondary winding of the input transformer, which has a base-to-base voltage-step-down ratio of 1·5 to 1. R1 and R2 are common biasing components for VT1 and VT2, while R5 and R6 provide a small amount of negative current feedback to minimise cross-over distortion effects. Each collector has an a.c. load comprising one half of the centre-tapped loudspeaker speech-coil, the V— connection to the collectors being made via R4 and the centre-tap of the coil. R4 is provided to limit collector dissipation at high battery voltages; this resistor is not in the a.c. circuit, as it is by-passed to earth by C2. The network C1 R3 in combination with the loadspeaker speech-coil impedance keeps the load on the stage reasonably constant at all frequencies. (A comparable arrangement is used in the C/8 amplifier. See Instruction S.3, Appendix to Section 18.)

3.2.3 Record Amplifier

The record amplifier uses three transistors, the first two being Mullard Type OC71 and the output stage a Mullard Type OC72. A fourth transistor (Type OC71) used with the modulation meter is also mounted on this card. The supplies for these transistors are from V— via the *Rec* position of the *Rec/Rep* switch.

An input transformer is fitted and gives a step-up of 30 ohms to 3 kilohms for use with 30-ohm microphones. Resistor R5 in VT1 base circuit provides series current feedback which increases the transistor input impedance to 3 kilohms to match the source.

Immediately preceding the first transistor is a switchable bass-cut circuit embodying C1. This gives a loss of about 10 dB at 100 c/s relative to 1 kc/s.

Between the first and second stages a record gain control R1 is connected and provides a 30-dB variation in gain. At this point also in the RD4/501 a line-input jack is provided, via a 47-kilohm hold-off resistor, for line levels of from −20 dB to +10 dB.

Between the second and third stages is a feedback circuit which supplies the major part of the equalisation. Into this feedback circuit in the RD4/501 the 'slating' signal from the associated film camera is injected via the tag marked *Sync.* The complete amplifier is equalised to the C.C.I.R. characteristic. (See Section 4.3.2.)

The output is fed to the modulation-meter stage and via the bias-oscillator card to the low-impedance record head. The output to the record head is required to rise by 11·5 dB at 10 kc/s relative to 1 kc/s in order to maintain the C.C.I.R. surface-induction characteristic on the tape, but at maximum recording level the output transistor VT3 is not capable of supplying the necessary current. This difficulty is overcome by tuning the head with a capacitor, the resultant circulating current in the head circuit giving the characteristic required. In the RD4/1 a 0·03-μF capacitor C12 is used, mounted on the recording-amplifier card, while on the RD4/501 a 0·02-μF capacitor C3 is fitted on the oscillator card; these two values give

the correct circulating current at 10 kc/s under the slightly different head-circuit operating conditions. The capacitor C12 or C3 also provides a return path for the bias current, which is thus largely prevented from passing through the record amplifier.

3.2.4 Modulation Meter Circuit

The single-stage amplifier carried on the record-amplifier card feeds the 50-μA moving-coil meter via a 1-mA bridge rectifier and the meter switch. The meter amplifier includes de-emphasis circuits to offset the rising record-amplifier response; the high-frequency response is controlled by capacitors C13 and C16 and the low-frequency response by C14 C17. The resistor R21 is adjusted on test to give a meter-pointer indication on the leading edge of the green band on the meter scale when zero-level tone is being recorded on Type-77 Emitape.

3.2.5 Bias Oscillator

The bias oscillator operates in a transformer-coupled class-B push-pull circuit, using Mullard Type-OC72 transistors, at a frequency of about 50 kc/s. The transformer has five mutually coupled windings on a ferrite core and (neglecting capacitor C6) the oscillator is basically of the saturable reactor type. The advantage of this design is that it produces a waveform with no even-order harmonics, the presence of which in the recording bias current would greatly increase tape noise. To obtain the required frequency, however, the saturable reactor principle of operation has had to be modified.

In a saturable reactor oscillator, the frequency is controlled by the magnetic saturation characteristics of the transformer, and in this mode the circuit used would oscillate at about 16 kc/s. If the circuit is to work as desired at a higher frequency, oscillation must be controlled by the

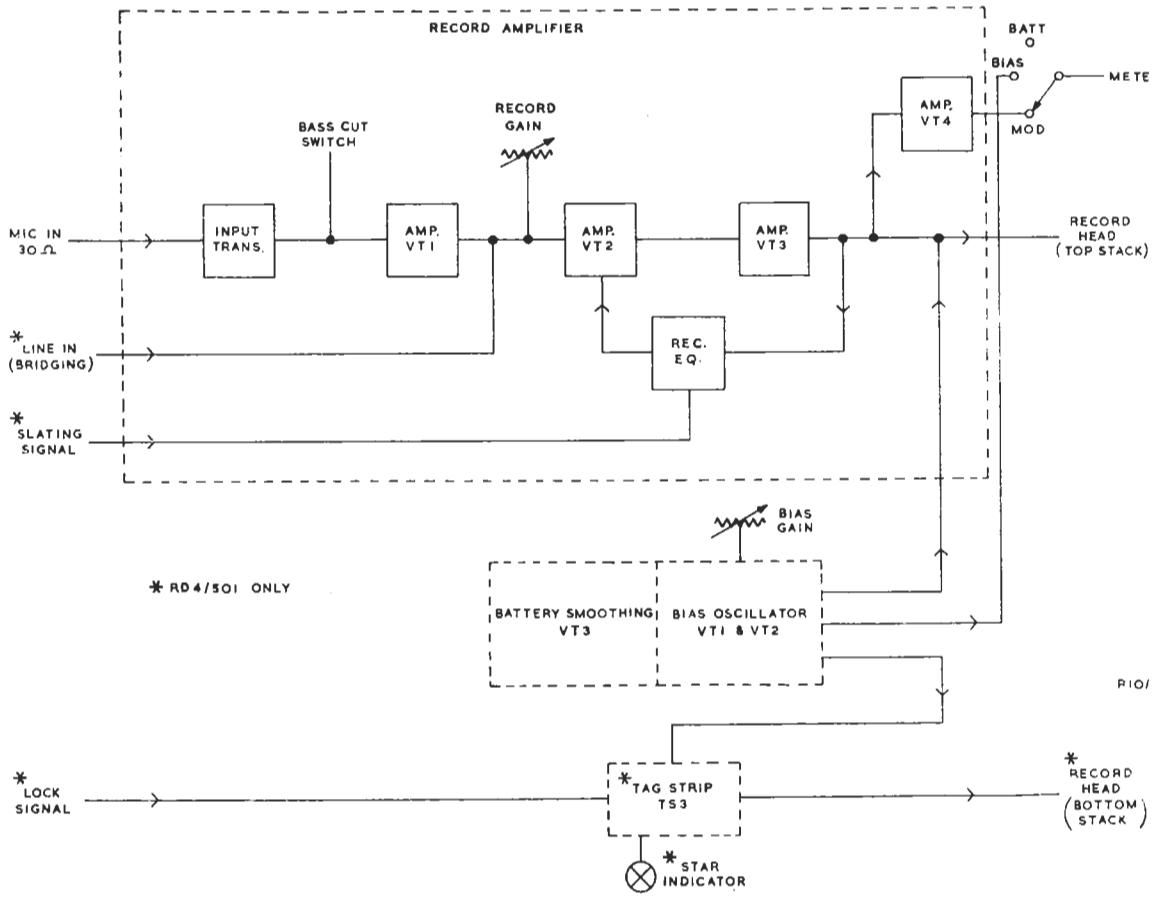

Fig. 3.3. RD4/1 and RD4/501: Record Schematic

transistors, and the frequency is then critically dependent on transistor parameters, battery voltage and load impedance.

Frequency variations due to differing transistor parameters can be minimised by careful selection, and the load can be made constant by suitable circuit design. Other considerations limit the permissible range of battery voltage to from 12 to 8·5 volts, the corresponding range of frequency variation being from 40 kc/s to 60 kc/s. However, the frequency variation with the given battery-voltage limits is reduced, and transistor tolerance requirements relaxed, by the addition of capacitor C6 to tune the transformer.

The supply is connected across the resistors R1 and R2, which bias and stabilise the transistor bases, C2 decoupling R2 with respect to a.c. The supply is taken in parallel to the *Bias Gain* control resistor (not on the card), which is decoupled by C1. This resistor, also designated R2, determines collector voltage and hence the oscillation amplitude; the resistor is a pre-set type mounted on the right-hand control panel and is accessible only when the recorder is removed from its case.

The circuit used to combine the audio and bias currents in the single-track recording head of the RD4/1 is shown in Fig. 1 and that for the double-track head of the RD4/501 is shown in Fig. 2.

In the RD4/1 (Fig. 1) the 50-kc/s bias is injected in series with the audio output signal and the recording head. In the RD4/501 (Fig. 2) the bias is similarly injected in series with the audio output to record head stack 1, using only part of the oscillator coupling coil, the rest of the coil being used to supply bias in parallel with the sync lock signal from the camera to record head stack 2. Components C4 and R6 in the sync circuit prevent the bias from reaching sync connector pins 2 and 3, while C5 keeps the locking signal out of the bias winding.

The record-head bias-current indication on the meter in both models is derived via a half-wave rectifier MR 1 from the junction of resistors R3 and R4. R3 is adjusted on test to make the meter pointer indicate at the lower edge of the green sector for a current of 7 mA for the RD4/1, and 5 mA for the RD4/501, with a battery voltage in each instance of 10 volts.

SECTION 4

MAINTENANCE

4.1 Supply Currents and Voltages

4.1.1 Battery: Meter Indication

The meter is used to check battery polarity as well as battery voltage. Polarity must be checked before the *On/Off* switch is moved from *Off* by engaging the latch lever and putting the meter switch to *Batt.*, when the meter should read 'on scale' and will indicate the open-circuit battery voltage. *It is most important that polarity is correct otherwise damage may be done to some parts of the apparatus.* Subsequently the battery voltage may be checked on load after the *On/Off* switch has been operated.

The recorder signal circuits will operate satisfactorily down to 8·5 volts, at which voltage the meter has been adjusted to read at the lower edge of the green sector.

4.1.2 Replay Amplifier

Connect a meter in the lead to terminal 1 of Tag Strip TS2. Unsolder the V— connection from the *Rec/Rep* switch (on the *Rep* side) to the L.S. Amplifier.

Rec/Rep switch to REP
On/Off switch to OFF.
Latch lever engaged.

Press *Test Mod.* button; meter gives total Replay Amplifier current.

If the meter is now connected in the V— lead from the *Rec/Rep* switch traveller to the Replay Amplifier card and the *Test Mod.* button pressed, the meter will read the current to the first three stages of the Replay Amplifier. Subtract this reading from the first and the output stage current is obtained.

	V_{BATT} (volts)	V— (volts)	I_{TOTAL} (mA)	$I_{VT\ 1,2,3}$ (mA)	$I_{VT\ 4}$ (mA)
	11·5	10	9·7	2·3	7·4
	10	8·8	8·4	2·0	6·4
	8·5	7·5	7·1	1·7	5·4
Point of Measurement	Tag Strip TS2, Term. 1, 2	Rec/Rep Sw. Trav./V+	Tag Strip TS2, Term. 1	Rec/Rep Sw. Trav.	Col. 3 minus Col. 4

4.1.3 Loudspeaker Amplifier

Connect the meter in the V— lead from the *Rec/Rep* switch to the L.S. Amplifier card.

Rec/Rep switch to REP.
On/Off switch to OFF.
Phones/Line Out jack not in use.
Latch lever engaged.

Press *Test Mod.* button; with no audio-frequency input signal, the meter reading gives the quiescent current of the l.s.-amplifier class-B push-pull stage.

On inserting any plug in the *Phones/Line Out* jack, the meter reading gives the bias current for the transistors.

	V_{BATT} (volts)	V— (volts)	$I_{Quiescent}$ (mA)	I_{BIAS} (mA)
	11·5	10	2·5	1·5
	10	8·8	1·9	1·3
	8·5	7·5	1·5	1·1
Point of Measurement	Tag Strip TS2, Term. 1, 2	Rec/Rep Sw. Trav./V+	Rec/Rep Sw., Rep side (Phones/ Line Out jack unused)	Rec/Rep Sw., Rep side (Phones/ Line Out jack in use)

4.1.4 Record Amplifier

Connect the meter in the V— lead from the *Rec/Rep* switch to the Record Amplifier card.

Rec/Rep switch to REC.
On/Off switch to OFF.
Latch lever engaged.
Press *Test Mod.* button.

	V_{BATT} (volts)	V— (volts)	I (mA)
	11	9·2	10·2
	9·7	8·1	8·8
	8·3	6·9	7·3
Point of Measurement	Tag Strip TS2, Term. 1, 2	Rec/Rep Sw. Trav./V+	Rec/Rep Sw., Rec. side

4.1.5 Bias Oscillator

Connect the meter in the V— lead from the *Rec/Rep* switch to the Bias Oscillator card.

Rec/Rep switch to REC.
On/Off switch to OFF.
Latch lever engaged.
Press *Test Mod.* button.

For the purpose of measuring the supply currents only and not for recording purposes, adjust the *Bias* pre-set control to give 5 mA a.c. in the Record Head circuit for the RD4/501 and 10 mA a.c. for the RD4/1 for the maximum value of V_{BATT}. (See Section 4.2.6.)

	V_{BATT} (volts)	V— (volts)	I (mA)
RD4/501	11	9·2	17
	9·7	8·1	14
	8·3	6·9	11
Point of Measurement	Tag Strip TS2, Term. 1, 2	Rec/Rep Sw. Trav./V+	Rec/Rep Sw., Rec side (5 mA a.c. in Rec Hd. circuit for V_{BATT} = 11)
RD4/1	11·3	8·5	24
	10	7·5	20
	8·5	6·5	16
Point of Measurement	Tag Strip TS2, Term. 1, 2	Rec/Rep Sw. Trav./V+	Rec/Rep Sw., Rec side (10 mA a.c. in Rec Hd. circuit for V_{BATT} = 11·3)

4.1.6 Smoothing Circuit

To test the smoothing circuit measure voltages at Tags *Batt.*— and V—. The difference in values will depend on the load current. A range of 1·1 to 2·2 volts should be expected. If this range is exceeded it is probable that the transistor VT3 has been damaged and should be changed. This can be verified by noise measurements. (See 4.3.1.)

4.1.7 Motor

To measure motor current, the meter should be connected in either of the leads to terminals 4 or 5 of Tag Strip TS2. The currents given below are for the Elliott motor; other motors will give different results.

	V_{BATT} (volts)	I (mA)
	10·3	275
	8·0	265
	7·7	260
Point of Measurement	Tag Strip TS2, Term. 1, 2	Tag Strip TS2, Term. 4 or 5

4.2 Static Tests on Signal Circuits (Figs. 1 and 2)

4.2.1. Replay Amplifier

The lead from the replay head to V+ on the Replay Amplifier card should be unsoldered and a 1-ohm resistor inserted as shown in Fig. 4.1. A

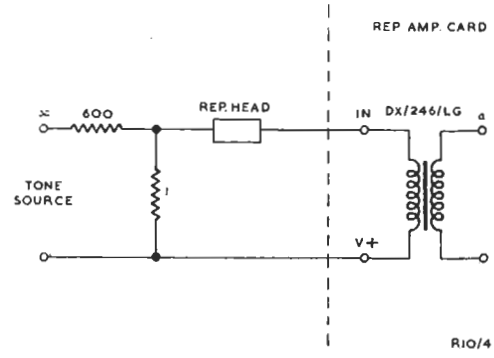

Fig. 4.1. RD4/1 and RD4/501: Test Conditions for Replay Amplifier

tone source can then be connected to this resistor via 600 ohms. The *Phones/Line Out* jack should be loaded with a 600-ohm amplifier detector.

Gain Measurements (1 kc/s)

	V— (volts)	Output Level into 600 Ω (dB)	Level at 'x' (dB)	Level at 'a' (dB)	Level at 'm'* (dB)
RD4/501	10	0	−18·0 ±1	−64·7	−27
RD4/1	10	0	−14·7 ±1	−59·2	−23

* 'm' is the junction between C7 and R13.

Frequency Characteristic

Measure as in Fig. 4.1 with $V_{BATT} = 11{\cdot}5$ volts. To avoid overload the 1-kc/s output level should be about −20 dB.

	Frequency	*Relative Output Level (dB)*	*Relative Level at 'm' (dB)*
	c/s		
	60	+16·5	+16
	100	+15	+14
	200	+10	+10
	500	+3·5	+3·5
RD4/501	*kc/s*		
	1	0	0
	2	−1·5	−1·5
	4	−1·0	−1·0
	6	−0·7	−0·7
	8	−0·5	−0·5
	10	+1·0	+1·0
	c/s		
	60	−21	+19
	100	−17	+16·5
	200	+11	−10·8
	500	+4	+4
RD4/1	*kc/s*		
	1	0	0
	2	−1·5	−1·5
	4	−1·0	−1·0
	6	−0·5	−0·5
	8	+0·5	+0·5
	10	+1·0	+1·0

Tolerance: ±2 dB.

Noise

Measured as in Fig. 4.1 with $V_{BATT} = 11.5$ volts.

Measuring Point	*Level (dB)*
Output	−44 to −38
Point 'm'	−65 to −59

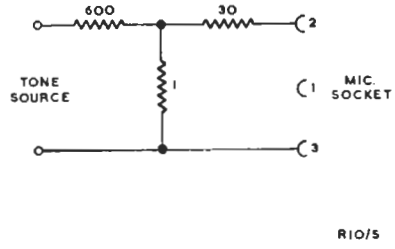

Fig. 4.2. RD4/1 and RD4/501: Input Test Conditions for Record Amplifier

4.2.2 Loudspeaker Amplifier

Connect an a.c. voltmeter across the 120-ohm speech coil. With the circuit of Fig. 4.1 apply 1-kc/s tone at the input and adjust the input level to get 0·775 volt at the *Phones/Line Out* jack loaded with 600 ohms. Remove the 600-ohm load and keeping the input level constant measure the a.c. volts across the loudspeaker speech coil.

Output Measurements (1 kc/s)

V_{BATT}	I_{dc} (mA) No drive	I_{dc} (mA) 0 dB level to line	V_{ac} (volts)	*Tolerance*
11·5	2·5	16	1·6	V_{ac} min = 1·23 V
10	1·9	15	1·5	—
8·5	1·5	13	1·35	—

NOTE:—Column 2 gives quiescent conditions of direct current. Column 3 gives direct current for a 1-kc/s signal from the Replay Amplifier which produces 0·775 volt across the 600-ohms loaded *Phones/Line Out* jack after removing the 600-ohm load.

Frequency Characteristic

Frequency	*Relative Output Level (dB)*
60 c/s	−0·5
100 c/s	0
*200 c/s	*±4
500 c/s	±1
1 kc/s	0
2 kc/s	±1·5
4 kc/s	±1·0
6 kc/s	±1·0
8 kc/s	±1·0
10 kc/s	+1·0

Tolerance: ±2 dB from 100 c/s to 10 kc/s.

* The resonance frequency of the loudspeaker is at approximately 200 c/s.

4.2.3 Record Amplifier (RD4/501)

The test conditions for the record amplifier in the RD4/501 are shown in Figs. 4.2 and 4.3. For the output measurements a 1-ohm resistor must be connected between the violet lead of transformer F157 on the Bias Oscillator card and V+; the slate-coloured lead must be disconnected from

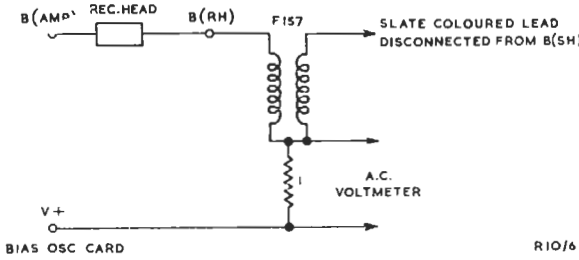

Fig. 4.3. RD4/501: Output Test Conditions for Record Amplifier

tag B (SH) and the V— supply to the bias oscillator removed.

Gain Measurements (1 kc/s)

V— (*volts*)	*Input Tone Source Level Fig. 4.2* (*dB*)	*Output across 1 Ω Fig. 4.3* (*mV*)	*Level at points shown in Fig 2* (*dB*)			
			p	*o*	*i*	*a*
10·2	−22	1 (−57·8 dB)	−6	−36	−40	−66

Tolerance: ±2 dB for an input of −22 dB to give 1 mV across the 1-ohm resistor in the output circuit.

Frequency Characteristic

Conditions	(1)	(2)	(3)
Gain Control	Max.	5	5
Bass Cut	Out	Out	In
Output Across 1 Ω at 1 kc/s	0·7 mV	0·7 mV	0·7 mV (−60·9 dB)

Frequency	(1) *Relative Output across 1 Ω* (*dB*)	(2) *Relative Output across 1 Ω* (*dB*)	(3) *Relative Output across 1 Ω* (*dB*)
c/s			
60	−3	−3·3	−17·5
100	−1	−1·3	−10
200	−0·5	−0·5	− 4
500	−0·5	−0·5	− 0·5
kc/s			
1	0 (0 dB)	0 (−17 dB)	0 (−17·2 dB)
2	+ 1·5	− 1·5	− 1·6
4	+ 4·5	− 4·6	− 4·6
6	+ 7·0	− 7·3	− 7·3
8	+ 9	− 9·5	− 9·5
10	+11	−11·5	−11·5

Tolerance: ±2 dB.

Line Input Measurements

Input Impedance: 50 kΩ

Gain Control Setting	*Line Input Level* (*dB*)	*Output Level Across 1Ω* (*Fig. 4.3*)
Max.	−11·5	1 mV
Min.	+20	1 mV

4.2.4 Record Amplifier (RD4/1)

The test conditions for the record amplifier in the RD4/1 are shown in Figs. 4.2 and 4.4. The V— supply to the bias oscillator must be removed.

Gain Measurements (1 kc/s)

V— (*volts*)	*Input Tone Source Level Fig. 4.2* (*dB*)	*Output across 1 Ω Fig. 4.4* (*mV*)	*Level at points shown in Fig. 1* (*dB*)			
			p	*o*	*i*	*IN*
10·2	−19	1·5 (−54·3 dB)	−4	−32	−36	−60

Tolerance: ±2 dB for an input of −19 dB to give 1·5 mV across the 1-ohm resistor in the output circuit.

Frequency Characteristic

Conditions:	(1)	(2)	(3)
Gain Control	Max.	2	Max.
Bass cut	Out	Out	In
Output across 1 Ω at 1 kc/s	1 mV	1 mV	1 mV (−57·8 dB)

Frequency	(1) *Relative Output across 1 Ω* (*dB*)	(2) *Relative Output across 1 Ω* (*dB*)	(3) *Relative Output across 1 Ω* (*dB*)
c/s			
60	−2	−2	−14·5
100	−0·5	−0·5	− 9
200	−0·3	−0·3	− 4·5
500	−0·2	−0·2	− 1·0
kc/s			
1	0 (0 dB)	0 (−23 dB)	0 (−0·5 dB)
2	1·2	1·2	1·2
4	3·6	3·6	3·6
6	5·8	5·8	5·8
8	7·0	8·2	7·0
10	6·8	9·7	6·8

Tolerance: ±2 dB.

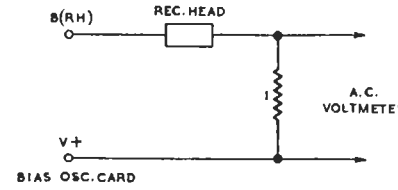

Fig. 4.4. RD4/1:
Output Test Conditions for Record Amplifier

4.2.5 Modulation Meter Indication

At 1 kc/s in the RD4/501 an output level of −11 dB with reference to 1 mV across the 1-ohm resistor of Fig. 4.3 should give a meter pointer indication on the lower edge of the green sector. This level should record zero-level tone on Type-77 Emitape. (See Section 4.3.2.)

At 1 kc/s in the RD4/1 an output level of −8 dB with reference to 1·5 mV across the 1-ohm resistor of Fig. 4.4 should give a meter pointer indication on the lower edge of the green sector. This level should record zero level on Type-77 Emitape. (See Section 4.3.2.)

If the indication is out in either case by more than ±1 dB, adjust by resistor R21. (See Section 3.2.4.)

The frequency response should be within ±2 dB over the range 100 c/s to 10 kc/s.

4.2.6 Bias Oscillator

Fig. 4.5 shows the test circuits for measuring bias currents in the record and sync heads of the RD4/501, and the table below gives the test figures for maximum and minimum settings of the pre-set control. The violet lead of transformer F157 is the centre-tap of the output winding and consists of two wires; they should be separated and 1-ohm resistors connected from each wire to V+. The alternating voltages measured across these resistors give the required values of current.

V_{BATT} (volts)	I_{dc} (mA)	f (kc/s)	Record Head		Sync Head	
			I_{ac} (max.) (mA)	I_{ac} (min.) (mA)	I_{ac} (max.) (mA)	I_{ac} (min.) (mA)
11·3	23·5	46	8·3	—	9·4	—
11·3	8·8	53	—	2·4	—	2·9
10	19·3	51	6·8	—	7·9	—
10	7·3	65	—	2·0	—	2·5
8·5	15·3	59	5·4	—	6 5	—
8·5	6·0	82	—	1·63	—	2·2

Tolerances: Battery range, 12—8·5 V.
Biasing current (min.), 5 mA.
Frequency range, 40—60 kc/s.

As there is no sync head in the RD4/1 the test circuit requires a single 1-ohm resistor only and this is connected in the lead between the record head and V+ as shown in Fig. 4.4. The test results are given below for the two extreme settings of the bias current pre-set control.

V_{BATT} (volts)	I_{dc} (mA)	Maximum		Minimum	
		I_{ac} (mA)	f (kc/s)	I_{ac} (mA)	f (kc/s)
11·3	35	15	49	—	—
11·3	15	—	—	5·4	56
10	29	12	54	—	—
10	12	—	—	4·5	66
8·5	23	10	62	—	—
8·5	10	—	—	3·7	82

Tolerances: Battery range, 12—8·5 V.
Biasing current (min.), 7 mA.
Frequency range, 40—60 kc/s.

Bias Current Meter Indication

With the bias control of RD4/501 adjusted to give 5 mA of bias current in the recording head audio signal circuit, as measured in Fig. 4.5, the

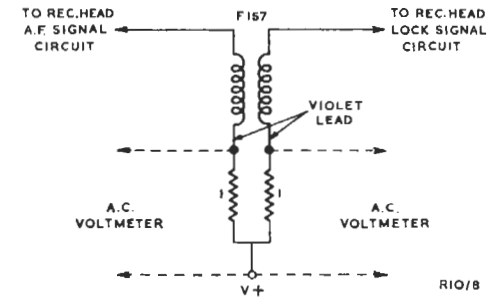

Fig. 4.5. RD4/501: Test Conditions for Measuring Bias Current in Record Head (Audio Signal) and Record Head (Lock Signal)

meter pointer should give a reading at the lower edge of the green sector of the meter. With the RD4/1, a bias current of 7 mA should give a reading at the lower edge of the green sector. Resistors R3 or R4 should be used for adjustment if necessary. The battery voltage for these adjustments should be 10 volts.

4.2.7 Lock and Slating Signals (RD4/501 only)

The 50-c/s lock signal supplied to the RD4/501 from the generator on the associated Arriflex camera should give a voltage level at pins 2 and 3 of the *Sync Input* 4-pin plug (see Fig. 2) of about 1·7 volts (+7 dB above 0·775 volt).

The 730-800 c/s slating signal supplied to the record amplifier of the RD4/501 from the oscillator mounted on the camera should give a level of 3 volts peak/peak when measured on a cathode ray oscilloscope at the *Sync* tag of the record amplifier. Test data for the lock generator and slating oscillator are given in Technical Instruction F.2.

4.3 Dynamic Tests

4.3.1 Replay

(*a*) *Azimuth Adjustment*

Load the recorder with a BBC/CCIR 7½-in./sec test tape.

Rec/Rep switch to REP.
Phones/Line Out jack plugged to a 600-Ω Amp. Det.
Latch lever ENGAGED.
On/Off switch to ON.

Replay the 10-kc/s head-alignment band and adjust the azimuth control for maximum output.

(*b*) *Gain Adjustment*

Replay the 1-kc/s band on the test tape with the set-up for azimuth adjustment. The output level should be −8 dB. The static tests described in 4.2.1 should ensure this level but if it is not obtained, because of variations in head sensitivity, the level can be adjusted by altering R13.

The replay chain is now set for use with Type-77 Emitape.

(*c*) *Frequency Response*

Replay the complete test tape. The results should be as follows:

±3 dB 100 c/s—10 kc/s

(*d*) *Noise Test*

Remove the test tape from the machine and load with a clean spool of Type-77 Emitape.

Replay this clean tape. The noise level as measured on the Amp. Det. should not exceed −38 dB.

4.3.2 Record: Audio Track

(*a*) *Azimuth Adjustment*

Load the recorder with Type-77 Emitape.

Rec/Rep switch to REC.
Bass Cut switch to OUT.
Phones/Line Out jack plugged to a 600-Ω Amp. Det.
Latch lever ENGAGED.
On/Off switch to ON.

Connect a tone source to the *Mic.* input of the recorder as in Fig. 4.2.

Rec Gain at maximum.
Meter switch to MOD.

With a 10-kc/s input, adjust the record-head azimuth control to give maximum output as measured on the Amp. Det.

(*b*) *Bias Adjustment*

With the set-up as for azimuth adjustment apply an input of 1 kc/s from the tone source, at a level of −33 dB for the RD4/501 and of −23 dB for the RD4/1. As the bias control is turned clockwise from its minimum setting, the output from the reproducing chain, as measured on the Amp. Det., will be seen to increase to a maximum and then, as the bias control is turned up more, to decrease again. The correct setting for the bias is when the output, having passed its maximum level, has decreased by 1 dB from that level. The following conditions should then exist:

(i) The Amp. Det. should read zero level. This assumes normal recording-head and tape sensitivities and correct gains for the record amplifier and replay system.
(ii) The meter switch when switched to *Mod* should give a meter indication at the lower edge of the green sector. (See Section 3.2.4.)
(iii) The meter switch when switched to *Bias* should give a meter indication within the green sector. This assumes the use of a new battery. For an average recording head the above settings of bias correspond to bias current values of 5 mA and 7 mA for the RD4/501 and RD4/1 respectively. It is recommended that the bias control should be adjusted to give these values of current when the battery voltage is 10 volts and that the meter should then indicate at the lower edge of the green sector. (See Sections 3.2.5 and 4.2.6.) This gives the optimum bias setting for the useful life of the battery.

(*c*) *Frequency Response*

With the set-up as for azimuth adjustment record a frequency run. The response over the frequency range 60 c/s—10 kc/s should fall within ±3 dB limits when the tape is replayed on the machine itself and corrected for the replay response of the machine.

(*d*) *Noise Tests*

The set-up as for azimuth adjustment (Fig. 4.2)

should be used for this test except that the tone-source should be removed.

Run the machine for, say, 10 seconds, which records the maximum noise of the system on the tape.

Now mark the tape, reduce the *Rec Gain* setting to mark 5, which is an average working point, and run the machine for another 10 seconds.

When these two bands are replayed on the machine the Amp. Det. readings should not exceed −32 dB and −36 dB respectively, which corresponds to signal/noise ratios of 40 dB and 44 dB.

If this tape is replayed on a standard Type BTR/2 machine the signal/noise ratio figures should not be worse than 42 dB and 49 dB respectively.

(*e*) *Programme Recording*

When recording programme the pointer of the modulation meter should enter the green sector occasionally. If during the recording the pointer stays in the green sector all the time, the level recorded will be excessive.

4.3.3 Record: Lock Track (RD4/501 only)

Having completed the tests on the audio track of the RD4/501, connect the machine to its associated camera, and record, on Type-77 Emitape, a lock signal.

Reverse the tape so that the lock track becomes the top track and is replayed by the audio replay head. The output level as measured on the Amp. Det. connected to the *Phones/Line Out* jack should be +8 dB above the replay amplifier response at 50 c/s as obtained from the test tape measurements of frequency response.

To test for cross-talk replay the tape in its normal position, that is, lock signal on bottom track. The output level as measured on the Amp. Det. should be at least −30 dB assuming no audio signal on the top track.

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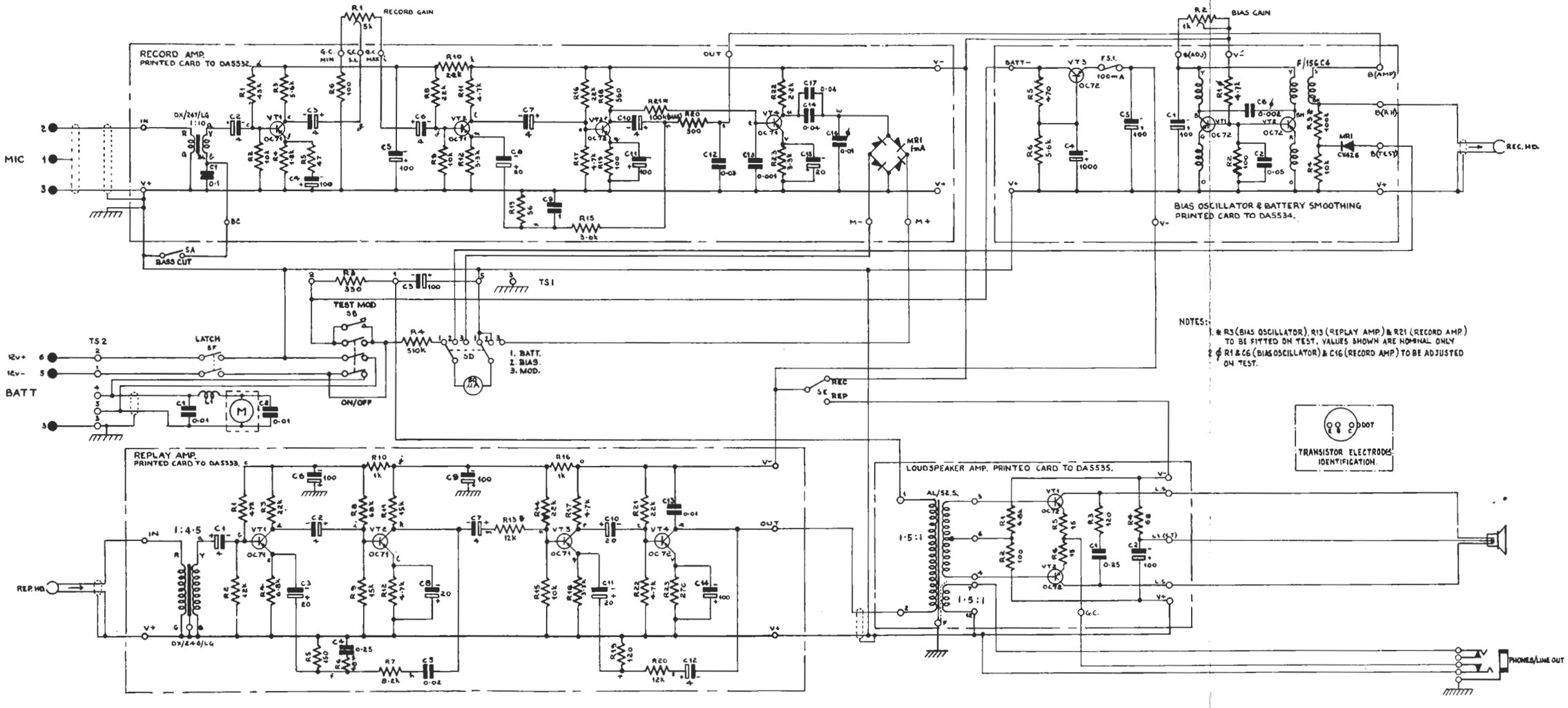
FIG. 1

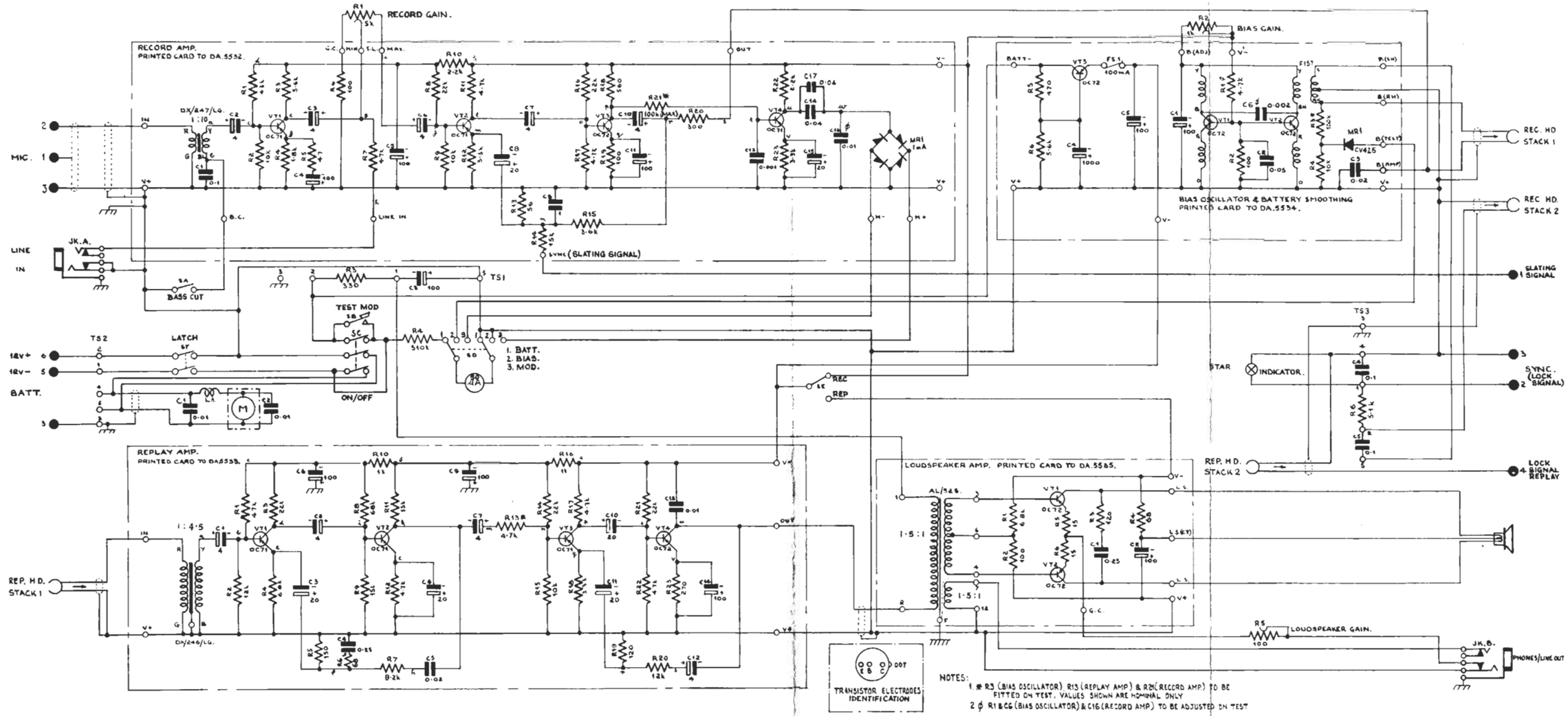


NOTES:

1. * R3 (BIAS OSCILLATOR), R13 (REPLAY AMP.) & R21 (RECORD AMP.) TO BE FITTED ON TEST. VALUES SHOWN ARE NOMINAL ONLY.
2. ϕ R1 & C6 (BIAS OSCILLATOR) & C16 (RECORD AMP.) TO BE ADJUSTED ON TEST.

MAGNETIC RECORDER RD4/1 : CIRCUIT

FIG.2



MAGNETIC RECORDER RD4/501 : CIRCUIT

AMENDMENT RECORD SHEET

Amendment No.	Instruction No.	Date Entered	Amendment No.	Instruction No.	Date Entered