TECHNICAL INSTRUCTION
R.6

R.G.D. Transportable Magnetic Tape Recorder

BRITISH BROADCASTING CORPORATION

ENGINEERING DIVISION

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R.G.D. TRANSPORTABLE MAGNETIC TAPE RECORDER

SECTION A

GENERAL DESCRIPTION

The R.G.D. magnetic tape recorder is a transportable equipment providing alternative tape speeds of 15 and 30 in./sec. It is intended for use with a 200/250-volt single-phase 50-c/s a.c. supply obtained either from the mains or from a battery and vibrator. The recorder was designed by the Radio Gramophone Development Company, but incorporates modifications requested by the BBC.

The complete apparatus consists of two units, a recording machine and an amplifier unit, the latter built to form a plinth on which the recording machine can stand. The recording machine itself (Fig. 1) is of conventional design, being generally similar to the German Magnetophon and the E.M.I. recorder described in Chapter 6 of the *Recording Training Manual.* The recording amplifier chain is arranged to take its input either at low level direct from a microphone or at zero level from a normal line; the reproducing amplifier is capable of delivering zero-level output into a 600-ohm load. A peak programme meter is fitted similar to that used by the BBC.

The recording machine and amplifier assembly are housed in two light-alloy sheet-metal cases, each consisting of a framework with removable panels. The panels on the fronts of the units have cut-outs giving access to the main controls, and both the front and rear panels are secured by 'Oddie' quick-release fasteners. When the equipment is set up for operation, rubber feet beneath the machine fit into indentations in the top of the amplifier case, making a rigid assembly. For operation, the units are interconnected by three detachable cables, terminating in plugs and sockets of different types. (See Appendix 1.) Provision is made for remote control, but this facility is not used by the BBC.

Except for a difference in height, the dimensions of both units are the same: 28½ in. wide, and 18 in. from front to back to which an extra 2½ in. must be added to allow for projecting cable connectors. The height of the recording machine is 13½ in., and that of the amplifier assembly 9¾ in. Their weights are 90 lb and 87 lb respectively. Either unit alone can be lifted easily by two people, by means of carrying handles at the sides.

The consumption of the complete equipment from the power supply is about 330 volt-amps, the current taken under normal running conditions from a 230-volt supply being 0·7 amp for the recording machine and a further 0·7 amp approximately for the amplifiers.

A tape-timing indicator is fitted to the recorder, coupled to the left-hand idler pulley through a worm drive. This indicator has two pointers showing the running time in minutes and seconds, with provision for re-setting. It had not been fitted at the time the photograph was taken for Fig. 1.

SECTION B

HEAD UNIT

General Description (Fig. 2)

The erasing, recording and reproducing heads are embodied in an interchangeable plug-in-type unit (Fig. 2) protected by a non-magnetic cast-alloy housing. The head unit is mounted on the deck of the recording machine, and is held in position by two knurled-headed screws and two dowel pins on its underside which fit into locating holes in the deck-plate. The unit incorporates a three-position tape-lifting device which holds the tape away from the heads not in use, to minimise wear. The tape is guided past the heads by a channel cut in the leading edge of the housing, and an adjustable slotted plate screwed to the trailing edge.

The erasing head is magnetically unscreened. The recording and reproducing heads are enclosed in single mu-metal screens, that of the reproducing head having a hinged cover behind which the tape is threaded. Each head is secured to the plug-in unit by a single central bolt. To permit gap azimuth alignment, the bolt is fitted with a rubber ring located between the head and the fixing plate, and two set-screws are provided, bearing in slots in the head at either side of the bolt.

Head Construction

The heads are of the normal laminated gapped-ring type, made up of two symmetrical stacks of semi-circular stampings separated by non-magnetic spacers and with a winding on each stack. The erasing and recording heads have each two gaps: a relatively narrow working gap in front, and a wider gap at the rear to minimise head magnetisation. The reproducing head has no appreciable rear gap.

Erasing Head

An intense magnetic field is produced across the erasing-head working gap by the passage of a 90-mA 50-kc/s current through the windings; this ensures magnetic saturation of the tape by the erasing flux. The gap is made wide enough to subject the tape to a large number of flux cycles; the amplitude of these falls away gradually as the tape leaves the gap, so that it emerges completely demagnetised.

Recording Head

To localise the field of the recording head, the working gap is made only about 0·001 in. wide. The head carries both an audio current and a biasing current, the latter being of somewhat higher value than the former. The biasing current is of the same frequency and obtained from the same oscillator as that used for erasing.

Reproducing Head

The width of the working gap of the reproducing head is about 0·0005 in.; this small dimension is necessary to minimise scanning loss. The rear gap consists merely of a butt joint between the two stacks of laminations, and is of negligible width as already stated.

SECTION C

RECORDING MACHINE

General Description

The recording machine is powered by three motors, slung below a three-sixteenth inch steel motor plate which is in turn suspended from a one-sixteenth inch steel deck-plate. One motor runs at constant speed and drives the tape capstan; the others are variable-speed motors for take-up and rewind. To minimise vibration, rubber bushes are inserted at the points of attachment of the motor suspensions to the motor plate. A flexible coupling is provided between the capstan spindle, which carries a small flywheel, and the shaft of the constant-speed motor, this arrangement tending to reduce flutter.

The three motors are squirrel-cage induction machines of the split-phase type, intermittently rated, and operating on the single-phase supply with their auxiliary windings capacitively connected. The stators are wound with two pairs of poles per phase, and the capstan motor has flats on its rotor designed to bring it up to the synchronous speed of 1,500 r.p.m. The rated speed of the take-up and rewind motors is 1,400 r.p.m.

The tape-drive capstan is machined to the correct diameter for a tape-speed of 15 in./sec, a sleeve being fitted when a speed of 30 in./sec. is required. During normal forward operation the tape is held in contact with the capstan by a rubber-faced pressure roller, two different rollers being provided, one for each speed. (The sleeve and pressure rollers should not be interchanged between machines.) A solenoid-operated mechanism engages the pressure roller and capstan, and a similar mechanism holds off the band-brakes, fitted to all three motors, against adjustable tensioning springs.

On the front of the machine unit (Fig. 3) are a small recessed sloping panel holding the peak-programme-meter instrument, and a larger central panel (Fig. C.2) carrying the machine controls. The P.P.M. is illuminated by a lamp, and is connected by a screened cord circuit to a small h.t.-metering type jack on a panel at the rear of the amplifier cabinet. (Figs. 4 and D.3.) At the rear of the machine unit (Fig. 4) is a panel on which are terminated cables from sockets 3AU, 8AU and 9AU (Fig. 10) on the amplifier cabinet. The first of these cables carries a.c. and d.c. supplies, and also accommodates circuits for remote control; the second cable connects the reproducing head to the reproducing amplifier, and earths the framework of the machine unit via its screen; the third cable connects the erasing and recording heads to the recording amplifier, and includes further circuits for measuring the currents taken by these heads.

Deck-plate Assembly (Fig. 1)

The deck of the recording machine, with a tape set up ready for use, is illustrated in Fig. 1. The tape on the left-hand spool is wound in an anti-clockwise spiral, with the magnetic coating inwards; it is given a half twist to make the coating face towards the heads. During forward operation it is pulled off the spool and taken to the right of a spring-tensioned arm (41) which is mounted on the motor plate (Fig. 5) and projects through a slot in the deck plate. The tape is subsequently looped to the left round a guide pulley (42) before being drawn past the head assembly at a constant speed by the drive capstan (1), against which it is held by the pressure roller (2), the latter being forced by a spring against the capstan with a definite pressure controlled by the setting of a stop. The tape is then looped round a second guide pulley and passes to the left of a further spring-tensioned arm before reaching the take-up spool, on which it is wound in a clockwise-increasing spiral with the magnetic coating outwards.

The tape deck is provided with a hinged and countersprung dust cover, fitted with a transparent plastic window through which the operation of the machine may be observed when the cover is closed.

Power Supplies

The routing of power supplies is shown schematically in Fig. C.1.

The input from the mains or vibrator is taken to an on-off switch and fuses in the control unit (Fig. 11). This unit is housed in the amplifier cabinet, and is described later. One output from the control unit is taken to a power-supply unit (Fig. 7). This unit, also housed in the amplifier cabinet, provides supplies at 50 volts d.c. and at 230 volts, 170 volts and 110 volts a.c. for the recording machine.

These values are shown on the recording-machine power-circuit diagram, Fig. 9.

Control Panel and Relays

General

On the machine-control panel (Fig. C.2) are four non-locking push-button keys marked *Stop*, *Play*, *Wind* and *Record*. Below these is the *Tape Wind* control; this is brought into circuit by the *Wind* button, and provides a variable speed for spooling in either direction.

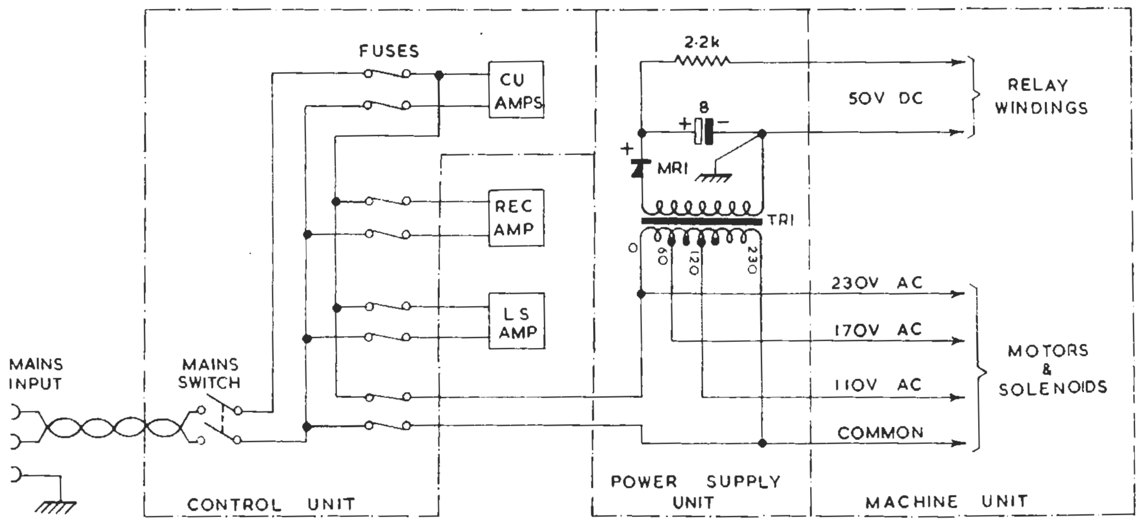

Fig. C.1. Power Distribution

The connections between units are made via H. B. Jones connectors, as shown in Figs. 7, 8, 9 and 10. The power plug on the recording machine is mounted on a connector panel at the rear, and is wired to a soldered tag-strip, known as the *Relays Distributor Panel*, mounted adjacent to three relays inside the machine. The 50-volt d.c. supply is used to energise the relays, and the a.c. supplies pass via the relay contacts to a Grelco screw-terminal block, from which further wiring is taken to the motors and solenoids.

With reference to the power-supply unit, it will be noticed from Fig. C.1 that the connections to TR 1 primary winding are unusual, in that the terminal marked '0' on the transformer tag-block is used to provide a 230-volt a.c. supply only, whereas the terminal marked '230' is common to all three a.c. supplies. The marking of intermediate tappings on TR 1 is also misleading. The actual voltages of the a.c. supplies reaching the recording machine as measured from the common lead are:

230 volts,
230 − 60 = 170 volts, and
230 − 120 = 110 volts.

Fig. C.2. Machine-control Panel

The four push-button keys operate in conjunction with four 50-volt relays. The three relays already mentioned, controlling the power supplies to motors and solenoids, are mounted beneath the tape deck near the front of the machine, and are visible in Fig. 3. The fourth relay, mounted on the recording amplifier, is used to prevent this amplifier (including the incorporated oscillator section) from functioning except when the machine is recording.

Only the relays on the recording machine are energised from the power-supply unit. These relays are coded RLF, RLR, and RLFF, and are connected as shown in Figs. 8 and 9. The remaining relay, coded RL1, is energised from the recording-amplifier h.t. supply, and is connected as shown in Figs. 8, 13 and 15.

Operating Sequences

The *Stop* key should cause the machine to stop whenever it is pressed. The key must, however, be pressed firmly and held momentarily in the operated position; when stopping from the *Wind* position, if the key is released too soon, there is a possibility that the direction of tape travel may reverse. The *Play* key starts the machine for reproduction, and can be operated only from the *Stop* condition. The *Record* key brings the recording amplifier into use, provided that the *Play* key is pressed at the same time. The *Wind* key cancels both the *Play* and the *Record* conditions, and can thus be used either when the machine is stationary or when it is already running.

'Stop' Condition

On the operation of the *Stop* key (Fig. 8), the 50-volt d.c. supply is short-circuited, the source impedance of this supply being deliberately made high in the manner shown in Fig. 7. All the relays now de-operate, thereby cutting off the a.c. supplies to the motors and solenoids (Fig. 9), and switching the recording amplifier (Fig. 13) to the quiescent condition. The pressure roller releases, and the spring-operated brakes stop the three motors. To prevent clicks from getting on to a recording when the d.c. supply is short-circuited, a spark-suppression circuit comprising 0·1 microfarads in series with 47 ohms is connected permanently across this supply.

'Play' Condition

The *Play* key is effective only when the machine is initially at rest. When this key is operated by itself, the machine runs at normal speed in the forward direction, but can be used only for reproduction. The feeds to the erasing and recording heads are suppressed, since RL1 does not operate.

On depressing the key, relay RLF (Fig. 8) is energised via RLR-1 and RLFF-2, all relays being at first in the *Stop* or de-energised condition shown in the diagram.

When RLF operates, RLF-1 closes, preparing a circuit to RL1 winding through the *Record* key. RLF-2 also closes; this contact holds in RLF after the *Play* key is released, as it connects the relay winding directly to the 50-volt positive supply. RLF-3 closes and short-circuits the winding of RLR; this connection controls the switching sequence produced by operating the *Wind* button from the *Play* condition, as explained later on. RLF-4, RLF-5 and RLF-6 (Fig. 9) also close. Relays RLFF and RLR remain in the non-operated condition.

Referring to Fig. 9, the drive motor and the brakes solenoid are now supplied at 230 volts through RLF-5, and the pressure-roller solenoid through RLF-5, RLFF-6 and RLR-3. The take-up motor is supplied at 170 volts through RLR-5 and RLF-6, and the rewind motor at 110 volts through RLFF-5 and RLF-4. The two solenoids operate, removing the brakes and engaging the tape with the synchronous drive. The take-up motor, under normal power, winds the tape on to the right-hand spool, whereas the rewind motor exerts only sufficient torque to tension the tape.

If the running winding of the drive motor were connected directly to the 230-volt supply, the reproducing head might pick up hum from the motor's stray field, and for this reason the current taken by the winding is limited by a 500-ohm series resistor, the current in the other winding being controlled by the value of the starting capacitor. Spark-suppression circuits are connected across the a.c. contacts of the relays as shown.

'Wind' Condition

The switching operations produced by pressing the *Wind* key vary according to whether or not the tape is in motion when the key is pressed. If the machine is already switched to *Play* or *Record*, so that RLF is made, the first result of pressing the *Wind* key is to short-circuit the 50-volt supply over the closed contact RLF-3 (Fig. 8), thus de-energising RLF and momentarily producing the same conditions as when the *Stop* key is pressed.

RLF-3 having opened, RLR and RLFF operate while the machine is coming to rest. RLR-1 opens, locking out RLF, and rendering subsequent operation of the *Play* key ineffective. RLR-2 closes, holding in RLR. RLFF-2 changes over, holding in RLFF.

RLR-6 (Fig. 9) closes, and the remaining contacts of RLR and RLFF change over. The drive motor and brakes solenoid are connected to the 230-volt supply via RLFF-5. One terminal of the take-up motor is connected to the 170-volt supply via RLFF-6, and the corresponding terminal of the rewind motor to the 110-volt supply via RLR-6; the further ends of the windings of these motors are joined together through the *Tape Wind* control, which is a wire-wound resistor with its slider returned to the 'common' lead through RLR-3 and RLR-5.

Under these conditions, although the drive motor rotates, the pressure roller remains disengaged, since its solenoid mechanism is not energised. Movement of the tape is thus controlled by the relative strengths of the opposing torques exerted by the take-up and rewind motors, according to the voltages applied to their windings through the *Tape Wind* control.

NOTE.—To ensure correct relay operation, the *Wind* key must be pressed firmly and held momentarily in the operated position.

'Record' Condition

To carry out a recording, the *Play* and *Record* keys must be pressed simultaneously. The *Play* key brings up RLF and switches the machine to normal forward running as before. The *Record* key brings up RL1; the operation of this relay will now be described.

The winding and the contact assemblies of RL1 appear in Fig. 13. The connections between the *Record* key and the relay are shown in Fig. 8, and for greater clarity these connections are also illustrated in Fig. 15. One end of the relay winding is connected to h.t. positive on the recording amplifier through a 50-kilohm resistor, and as the negative side of the h.t. supply is earthed, the relay can thus be energised by earthing the other end of its winding.

Two alternative earth paths are provided, one to operate the relay initially, and the other to hold it in through its own contacts. The 'operate' path is through normally-open contacts on the *Play* and *Record* keys, and normally-closed contacts on the *Wind* key, to the earthed side of the 50-volt d.c. supply. The 'hold-in' path is through RL1-4 to the chassis of the recording amplifier. Both paths are completed through RLF-1.

With the *Play* and *Record* keys closed and RLF operated, RL1 winding is earthed through RLF-1 and the keys. When RL1 operates, RL1-1 changes over, taking an earth off the secondary winding of the recording-amplifier output transformer, and, at the same time, earthing the cathode of the recording-amplifier oscillator valve, which except in the *Record* condition, is biased back to suppress oscillation. RL1-2 opens, removing a short-circuit from the previously earthed transformer secondary winding. RL1-3 changes over, bringing up a red *Record* lamp on the amplifier-control panel in place of the green *Reproduce* lamp previously appearing. RL1-4 closes and holds in RL1 by putting a local earth on its winding.

If, now, either the *Stop* key or the *Wind* key is pressed, RLF falls out, and RLF-1 opening interrupts the holding circuit of RL1. This relay also falls out and the recording amplifier returns to the quiescent condition.

To provide for the addition of remote control, by means of an auxiliary unit at the end of a cable, the wiring between RLF-1 and RL1-4 is broken at socket 2AU on the amplifier cabinet (Fig. 10), the circuit being completed via a dummy plug connecting pins 8 and 12 when remote control is not required. As the remote control facilities are not used, no description of the auxiliary remote-control unit is given in this Instruction.

SECTION D

AMPLIFIER ASSEMBLY

General Description

The amplifier assembly comprises four separate units, housed together in a single cabinet. Taken from left to right, the units are as follows:

(a) Loudspeaker Amplifier,
(b) Control Unit,
(c) Recording Amplifier,
(d) Power-supply Unit.

The first three units, comprising the amplifiers and associated controls, are of drawer-type construction, and are fitted with pins sliding in guide slots. They are connected via H. B. Jones sockets on the rear of each unit to plugs fixed at the back of the cabinet. (A wiring diagram of the cabinet is given in Fig. 10.) The power-supply unit chassis is screwed down on to the main chassis, and is fitted with a similar socket connecting to a plug attached to a flexible extension of the cabinet main cable-form. The unit is accessible when the right-hand side-panel of the cabinet is removed.

The loudspeaker amplifier is intended to be used in conjunction with a loudspeaker or headphones for local listening and checking purposes. The control unit is so termed because it contains all the more important circuit controls, mounted on two panels, one at the front of the unit, and the other at the rear; it also incorporates five switchable amplifying sections as follows:

(a) Microphone Amplifier,
(b) Incoming-line Isolating Amplifier,
(c) P.P.M. Amplifier,
(d) Head-current-meter Amplifier,
(e) Reproducing Amplifier.

The recording amplifier embodies a 50-kc/s oscillator providing erasing and biasing currents for the heads. The power-supply unit has already been described in connection with the recording-machine a.c. and d.c. supplies.

All the amplifiers use valves with a 6·3-volt heater and a B8A base, and each main amplifier has its own h.t. and l.t. supply. Facilities for feed-current measurements are not provided. Access to components beneath the amplifiers can be obtained by removing the bottom panel of the cabinet; similarly, the upper components on any amplifier chassis may be inspected after removing the top panel. For some maintenance work an amplifier may have to be withdrawn, and as it then becomes disconnected, extension cables must be fitted if testing is required. These extension cables are not interchangeable, since different pins of their connectors must be earthed to the cable screens.

External Connections

A narrow vertical panel at the extreme left on the front of the amplifier cabinet (Fig. 3) carries *Speaker* and *Headphone* jacks, and two further similar panels are situated at the rear (Fig. 4). These latter panels carry ten cable-connectors of various kinds, and as most of the terminations are engraved with a number only, additional details are given below.

Left-hand Rear Panel:

(1) H. B. Jones 4-pin connector to 2·5-ohm or 15-ohm loudspeaker. Not used by BBC.

(2) H. B. Jones 12-pin connector to remote-control unit. Not used by BBC, but must be bridged by plug with pins 8 and 12 strapped.

(3) H. B. Jones 12-pin connector for cable carrying a.c. and d.c. supplies to corresponding connector at rear of recording machine.

Unnumbered 3-pin 2-amp socket providing spare mains outlet. Not normally used by BBC.

(4) Bulgin 3-pin plug for a.c. input from mains supply.

Right-hand Rear Panel:

(5) Jack, labelled *Rep. 600 Ω.*

(6) Cannon 3-pin connector, labelled *Mic. 30Ω.*

(7) Jack, labelled *Rec. 1200 Ω.*

(8) Miniature-cannon 3-pin connector for cable carrying reproducing-head output from similar connector on panel at rear of recording machine. *The machine framework is earthed solely via the screen of this cable.*

(9) Miniature-cannon 6-pin connector for cable

to erasing and recording heads and from associated 50-kc/s head-current-meter rectifiers, via 6-pin connector at rear of recording machine.

Programme Chain (Fig. D.1)

The programme chain of the equipment comprises recording, reproducing and monitoring sections, and is shown schematically in Fig. D.1.

The recording chain includes:

(a) Two alternative input circuits with key selection, one circuit being for use with a line and the other, introducing an additional amplifier, for use with a microphone. The input-selector key has also an *Off* position.

(b) A line-isolating voltage amplifier, preceded by a potentiometer for recording-level control.

(c) A recording amplifier embodying an oscillator providing supersonic erasing and biasing currents, both of the same frequency.

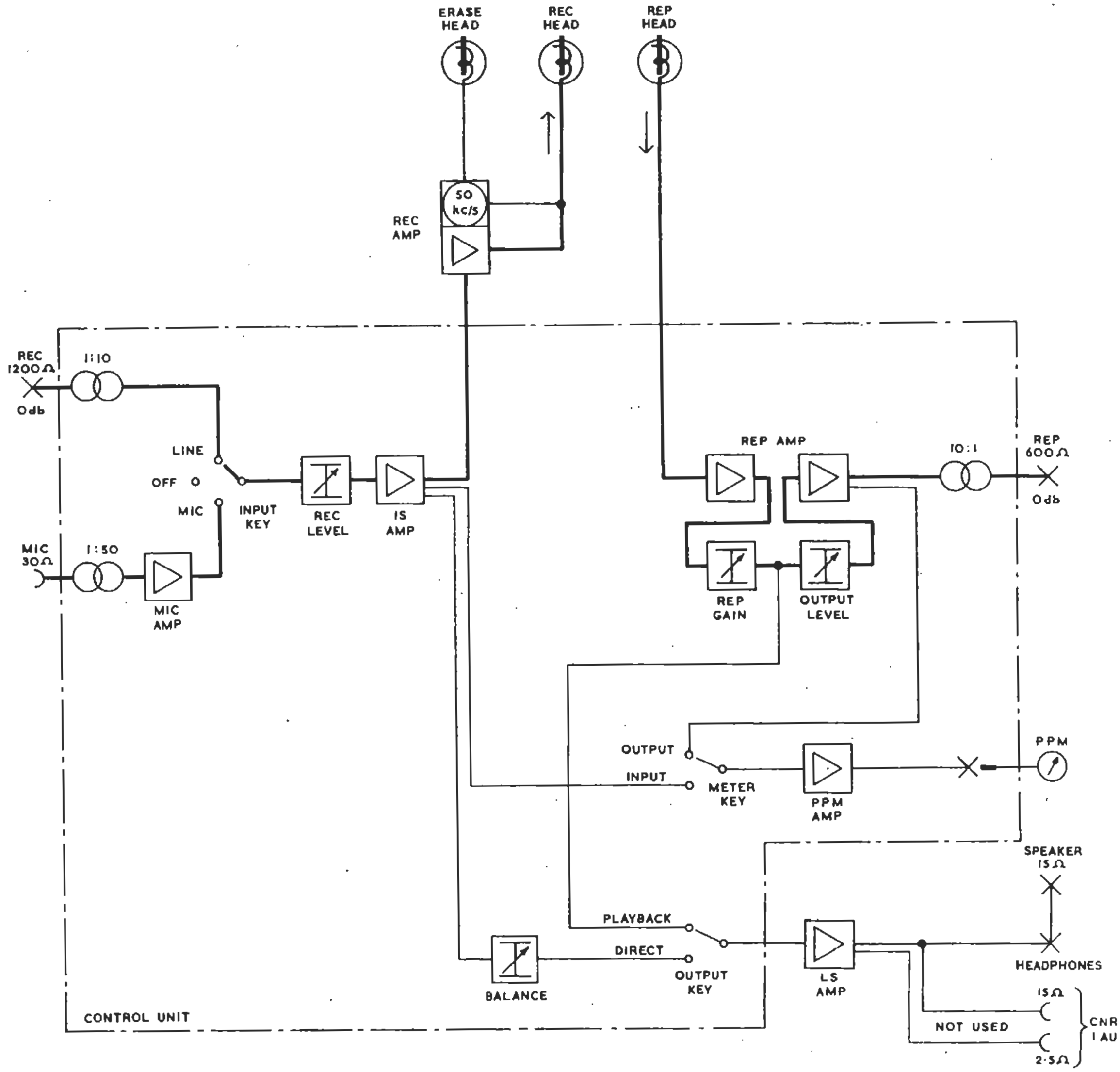

Fig. D.1. The Programme Chain

The reproducing chain consists of a three-stage amplifier incorporating the main output-level control and capable of feeding zero level to line.

Visual and aural monitoring facilities are provided by a peak-programme meter and amplifier and a loudspeaker amplifier, either of which can be switched to the input of the recording amplifier or across the reproducing amplifier.

Referring to Fig. D.1, the line input jack, marked *Rec. 1200 Ω*, is intended for connection to a balanced line carrying programme at zero volume, and the *Mic. 30 Ω* input socket is intended for a balanced 30-ohm source at microphone level, the actual input impedance being 60 ohms. In the *Line* position of the input selector, a suitable resistive termination for the incoming line is provided by the use of a balanced-L pad between the line jack and the isolating-amplifier input transformer, and by correct loading of this transformer. The positioning of the *Record Level* potentiometer prior to the isolating amplifier allows the necessary control of input volume without risk of overloading either the isolating amplifier or the recording amplifier.

All volume controls and switches are in high-impedance circuits; the volume controls provided are of the ordinary variable-impedance type.

The *Speaker* jack is wired to the inners of the *Headphones* jack. The loudspeaker amplifier provides an output of 8 watts into a 15-ohm loudspeaker, using the *Speaker* jack, or into a 15-ohm or 2·5-ohm loudspeaker using connector No. 1 at the rear. No provision is made for connecting either the loudspeaker amplifier or peak-programme-meter amplifier directly across the incoming or outgoing line.

Control Unit

General

The control unit is housed in the middle drawer of the amplifier cabinet. It has an amplifier-control panel on the front and a fuse-and-meter panel at the rear. Inside the unit are the microphone amplifier, isolating amplifier, peak-programme-meter amplifier, head-current-meter amplifier and reproducing amplifier previously mentioned.

Amplifier-control Panel (Fig. D.2)

This panel carries operational controls comprising the *Input-selector, Output* and *Meter* keys and *Record-level* and *Output-level* controls shown in Fig. D.1, in addition to a mains on-off switch, and three indicator lamps which are arranged together near the top of the panel. Of these, a red *Mains* pilot lamp is centrally placed; the two outer lamps, one green and the other red, marked *Reproduce* and *Record* respectively, are controlled by the *Record* key via relay RL1 in the recording amplifier. Along the bottom of the front panel, and normally hidden by a cover, are five pre-set controls, four appertaining to the reproducing amplifier and the other a pre-set loudspeaker *Balance* control. These controls are not normally used in operation, and once correctly set should be left undisturbed save for occasional checking.

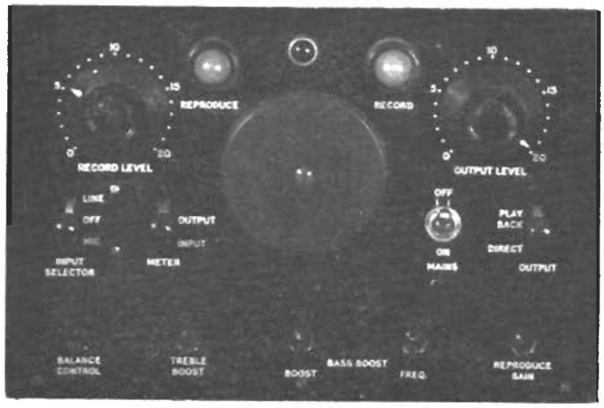

Fig. D.2. Amplifier-control Panel

Fuse-and-meter Panel (Fig. D.3)

Mounted on this panel are four pairs of 2-amp fuses. The panel also carries the head-current meter and controls, the P.P.M. jack and P.P.M. pre-set controls, and the reproducing amplifier hum-cancellation controls. The arrangement of the pairs of fuses is:

(1) Power-supply Unit (labelled 'Motors'),
(2) Loudspeaker Amplifier (labelled 'Power Amp.'),
(3) Recording Amplifier,
(4) Control-unit Sub-amplifiers.

One leg of each of the first three fuseways listed is supplied via a leg of the control-unit amplifier fuseway, which is at the bottom of the panel. The circuit arrangement is shown in Figs. C.1 and 11.

The head-current meter, in the centre of the panel, has mechanical and electrical zero adjustments. A *Head Current Meter Selector* is fitted, and has three positions: *Bias*, *Audio* and *Wipe*. The meter employs a 100-μA movement, but is calibrated in milliamps with three differently-coloured scales corresponding to the three positions of the key.

The P.P.M. jack, which is unlabelled, is situated above the head-current meter. Pre-set controls for the P.P.M.-amplifier *Zero*, *Law* and *Sensitivity* adjustments are arranged down the right-hand side of the panel, the labels referring in each instance to *Level Meter* controls. No *Zero Balance* control is provided.

Microphone Amplifier

The input to the microphone amplifier, V1, is taken through the hum-bucking coil and the 1 : 50 voltage-step-up transformer TR 1 direct to the grid of the valve, the input impedance on the primary side of TR 1 being approximately 60 ohms. A 300-pF capacitor C28 is shunted across the 100-kilohm anode-load resistor R3; this introduces a loss at frequencies above about 3 kc/s to compensate for the slightly rising response of the following stage. (This rising response is introduced to compensate for deficiencies of the

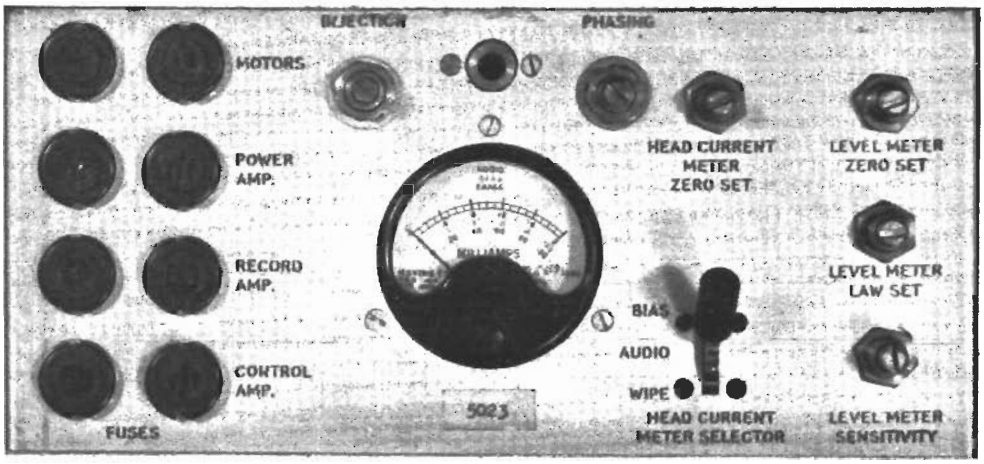

Fig. D.3. Fuse-and-meter Panel

line-input transformer TR 2, and is not required when the microphone amplifier is used, since TR 2 is not then in circuit.) The output of V1 via C4 is taken to the *Mic.* position of *Input Selector* SW 1, and to earth through the 1-megohm anti-click resistor R13.

Located on either side of the P.P.M. jack are the reproducing-amplifier hum-cancellation circuit *Injection* and *Phasing* controls.

Sub-amplifiers (*Fig.* 11)

The various sub-amplifiers of the control unit are indicated on the circuit diagram, Fig. 11. Briefly, the microphone amplifier comprises V1, together with input transformer TR1 and a hum-bucking coil. The incoming-line-isolating amplifier comprises V2 with transformer TR2. The peak-programme-meter amplifier includes V3, V4 and V5, together with the neon stabiliser V11 and signal-rectifier transformer TR 4. The reproducing amplifier embodies V7, V8 and V9, with output transformer TR 3. The head-current meter is operated by V10, also stabilised by V11. The h.t.-rectifier V6 is fed from mains transformer TR 5, further windings on which supply the valve heaters and various lamps.

Incoming-line Isolating Amplifier

The line-input transformer TR 2 is connected to the grid of the isolating amplifier V2 via the *Line* position of *Input Selector* SW 1 and the main *Record Level* control R14. Transformer TR 2 is designed for a 600-ohm source impedance, and is padded out for 1,200-ohm working. In the *Mic.* and *Off* positions of SW 1, when R14 is disconnected from TR 2, the required loading of the transformer secondary winding is maintained by the substitution of R62. In the *Off* position of the selector, break-through to V2 from either input is prevented by earthing R14 at the grid end.

A moderate amount of voltage negative feedback is applied to V2 through a double potentiometer comprising R6, R40, in the anode circuit of the valve and R53, R8 and part of R14 in the grid circuit, the purpose of R8 being to prevent the amount of feedback applied from being influenced by the setting of R14. The capacitor C32 between the high-potential end of R53 and earth reduces the feedback fraction and increases the gain at the higher frequencies, to compensate for deficiencies of the input transformer TR 2, and its associated circuit.

The main output of V2 is fed to the recording amplifier via pin 11 of connector 2CU ; additional outputs are taken to the P.P.M. amplifier via the *Meter* key SW 2, and to the loudspeaker amplifier via the *Balance* control R15 and *Output Selector* SW 3.

P.P.M. Amplifier

The circuit of this amplifier resembles that of peak-programme meter amplifier PPM/2 described in Technical Instruction S4, the main differences being that different valve types are employed and that there is no *Zero Balance* control.

At the input to the amplifier is the *Meter* key already mentioned. This has two positions, marked *Input* and *Output* respectively. In the *Input* position of the key the P.P.M. amplifier is bridged across the output of the isolating amplifier and the input of the recording amplifier, and with a correct line-up the P.P.M. then indicates the incoming programme volume. In the *Output* position of the key the P.P.M. amplifier is connected across part of the anode load in the final stage of the reproducing amplifier, and with the same line-up as before the P.P.M. now indicates the programme volume sent to line.

Following the meter key is the *Sensitivity* control R16, and a cathode-follower stage consisting of the triode section of the double-diode-triode V3 and the transformer TR 4 feeding the diode rectifier V4. The cathode follower presents a low source impedance to V4, thus minimising meter errors due to waveform distortion.

The rectifier V4 charges the 0·3-microfarad capacitor C12, shunted by the 4·7-megohm discharge resistor R18. The voltage developed across C12 is applied to the grid of the variable-mu pentode V5, the screen and cathode potentials of which are stabilised by the neon V11, and can be adjusted by the *Zero* and *Law* controls R21, R19. An h.t.-metering type jack for the peak-programme meter instrument is connected between the anode of V5 and the h.t.-positive line.

Instructions for lining up the amplifier are given in section F.

Head-current-meter Amplifier

The erasing, biasing and a.f.-recording currents supplied to the heads from the recording amplifier are passed through resistors of suitable values, and the voltages developed across these are applied after rectification and smoothing to a 3-position *Head-current Meter Selector* switch, SW 5. (Further details of the circuit preceding this switch are given in the description of the recording amplifier.)

The positions of SW 5 are labelled *Bias*, *Audio* and *Wipe*, and the output of the switch is taken to the grid of one section of the double-triode V10. The head-current meter is connected between the two anodes of this valve, and the anodes are also connected through two equal-value resistors R50, R51, to the ends of a tapped resistor R49, the *Head-current Meter Zero Set* control. A stabilised voltage (approximately 100 volts) from the neon V11 is applied to the slider of this control.

In the no-signal condition of the circuit, when the recording amplifier is not in use and no voltage is passed to V10 from SW 5, both grids of the valve are held at earth potential through their grid leaks R46, R48, a negative grid bias with respect to cathode being provided by the common cathode resistor R47. The slider of R49 is adjusted so that the meter reads zero, making the voltages of the two anodes the same. (This adjustment is equivalent to balancing a bridge in which the anode d.c. resistances of the valve sections constitute two arms.)

When an input is applied, a positive voltage proportional to the head current selected by SW 5 is applied to one grid of V10, increasing the anode current and reducing the anode voltage of the corresponding triode section to an extent modified by the negative feedback action of R47. The feedback has also the effect of increasing the negative bias applied to the other grid of the valve, reducing the anode current and increasing the anode voltage of the quiescent section. The alteration in the voltages of the two anodes produces a potential difference between the terminals of the head-current meter, and a current flows through this instrument, deflecting the pointer over scales calibrated to correspond to the three positions of SW 5.

Reproducing Amplifier

The signal voltage from the reproducing head and an associated hum-bucking coil in the machine unit is brought into the amplifier through connector 1CU, and is applied via C14 and R59 to the grid of V7, the first valve in the reproducing chain. The purpose of C14, which is in a screened compartment with R25, R59 and the input connector, is to prevent any grid current passed by V7 from flowing through the winding of the reproducing head, and magnetising the laminations. R25 is the grid-leak resistor, and R59 is a grid stopper. R31 is inserted to isolate the anode-load impedance of V7 from the grid-input impedance of V8.

To assist in the neutralisation of hum pick-up, a 50-c/s voltage is applied to the screen grid of V7 from the mains-transformer heater winding through the *Phasing* and *Injection* controls. The ends of the winding, which is centre-tapped to earth, are connected to the *Phasing* control R57 through two equal-value hold-off resistors R55 and R56. By adjusting R57, the instantaneous polarity of the injected voltage can be reversed, and the amplitude of this voltage can at the same time be varied within limits dependent upon the setting of the *Injection* potentiometer, R58, which acts as a coarse control.

The second stage of the amplifier, V8, incorporates controls for adjusting the frequency characteristic by means of a variable network included in its feedback loop. A potential divider, comprising the parallel combination C18-C20 and C27, in series with the potentiometer R30 and with R29, is connected between the anode of V8 and earth, and voltage negative feedback is applied from the slider of R30 to the grid of the valve through a bridged parallel-T network*, equivalent to a variable-selectivity rejector circuit tuned to 11 kc/s.

The variable elements of the potential divider are used to control the low-frequency gain. The frequency below which the feedback fraction begins to fall off is controlled by the *Bass Boost* '*Frequency*' switch SW 6, which alters the number of parallel-connected capacitors. As capacitances in parallel are additive, the greater the number of capacitors, the lower the frequency at which the bass boost begins, since any increase in feedback reduces the gain. The feedback at medium and high frequencies is adjusted by means of the *Bass Boost* '*Boost*' control R30; any increase in this feedback reduces the overall gain and results in an apparent increase by contrast in the gain at low frequencies.

At high frequencies a separate means of varying the amount of feedback is provided by the *Treble Boost* control, R32. This resistor bridges across the sharply-tuned rejector circuit formed by the parallel-T network, and increasing its resistance therefore reduces the feedback at high frequencies and increases the high-frequency gain.

It will be appreciated that the treble and bass controls are not independent, since the effect produced for a given setting of R32 is governed by the overall feedback fraction controlled by the positions of SW 6 and R30 slider. In practice, however, only the treble control is varied, the bass-control settings being standardised as follows:

Bass Boost '*Frequency*':—One step back from the fully-clockwise position, i.e., with C20 and C27 in circuit.

Bass Boost '*Boost*':—Fully clockwise, i.e., at maximum.

The anode of V8 is connected to the grid of V9 via the pre-set *Reproduce Gain* control R39 and the main ***Output Level*** control R43, a stud-type wirewound potentiometer. Between R39 and R43 is a connection to the *Output Selector* key SW 6, selecting the source of the programme fed to the loudspeaker amplifier. In the *Direct* position of this key the input of the recording amplifier is selected, taken via R71 and the loudspeaker *Balance* control R15, whereas in the *Playback* position the output of V8 is selected, taken via R39 and R70. The source not connected to the loudspeaker amplifier is taken to earth through the 50-kilohm resistor R72, which replaces the loudspeaker-amplifier input impedance; the impedance seen by either source looking into SW 3 is built out to 520 kilohms in both positions of the key by R70 and R71.

The final valve V9 has negative feedback from the anode to the grid via R44, R54 and part of R43.

*See Hillan, A. B. 'The Parallel-T Bridge Amplifier.' *Journal I.E.E.*, Vol. 94, Part III, No. 27 (Jan., 1947), pp. 42-51.

The shunt-fed output transformer has a 10 : 1 turns ratio, and presents a source impedance of about 130 ohms to the load. The design of the output circuit is such that maximum gain with minimum distortion is obtained when feeding into a 600-ohm line.

A connection to the *Output* contact of the P.P.M. *Meter* key is taken via C10 from the junction of R52 and R60 in the anode-load circuit of V9; only about half the output signal from this valve is needed by the P.P.M., which has to be made sufficiently sensitive to operate in its alternative position across the input of the recording amplifier.

Power-supply Circuits

The control unit serves as the distribution point for the mains supply incoming to the recorder via cable-connector 4 at the rear of the amplifier cabinet, which is wired to pins 11 and 12 of the plug engaging with socket 3CU. From this point the supply passes through the *Mains On-Off* switch SW 7 before being connected through fuses to individual supplies.

The power supply for the control unit itself is taken to appropriate voltage tappings on transformer TR 5, the primary winding of which can be used as an auto-transformer to feed the remaining units at 230 volts when the mains supply is at some other voltage between 200 and 250 volts.

The h.t. winding of TR 5 is connected to the full-wave rectifying valve, V6, which is indirectly heated from the common l.t. supply. H.T. smoothing is provided by two resistance-capacitance networks, the elimination of a choke minimising hum pick-up in low-level inductive circuits. To reduce the danger of instability in the reproducing amplifier due to back coupling between V9 and V7 through the h.t. supply, separate smoothing is provided for V9.

A voltage tapped down from the 6·3-volt heater winding is applied to the screen grid of V7 for the purpose of hum cancellation, as mentioned elsewhere, and a further winding on the transformer provides a 5-volt indicator-lamp supply.

A lamp for lighting the peak-programme-meter instrument on the front of the recording machine is also fed from the 5-volt winding of TR 5. The lamp circuit is insulated throughout from the machine framework; a wiring diagram is given in Fig. 16. The P.P.M. lamp has a centre-contact miniature-bayonet cap, in contrast to the indicator-lamps, which are of the M.E.S. type.

Valve Data

Valve	Anode Volts	Screen Volts	Cathode Volts	Heater Volts	Heater Amps
Mic. Amp.					
V1 : EF40	60	55	1·2	6·3	0·2
Isol. Amp.					
V2 : EF42	55	110	0·7	6·3	0·33
P.P.M. Amp.					
V3 : EBC41	225		2·3	6·3	0·23
V4 : EZ41			0	6·3	0·4
V5 : EF41	225	*40	*0·5	6·3	0·2
Rectifier					
V6 : EZ41			320	6·3	0·4
Rep. Amp.					
V7 : EF40	30	40	1·5	6·3	0·2
V8 : EF40	30	40	1·5	6·3	0·2
V9 : EF42	90	290	3·0	6·3	0·33
Head-current-meter Amp.					
V10 : ECC40	90		2·0	6·3	0·6
Neon					
V11 : 7475	100				

*These voltages vary with settings of P.P.M. controls.

Supplies

Mains input, 200-250 volts, 50 c/s a.c.

H.T. supply: H.T. 1 (unsmoothed), 320 volts.
H.T. 2 (smoothed), 225 volts.

L.T. supply, 6·3 volts, 3·1 amps, a.c.

Lamps, 5 volts, 1 amp, a.c.

NOTE.—All voltages measured to frame, using Avometer Model 7. Lower voltages may be obtained with a battery-and-vibrator power supply.

General Data

Impedances

Mic. 30 Ω Socket
Normal source Z = 30 Ω
Input Z = 60 Ω

Rec. 1,200 Ω Jack
Normal source Z variable (balanced)
Input Z = 1,200 Ω

Rep. 600 Ω Jack
Output Z = 130 Ω (balanced)
Normal load Z = 600 Ω (balanced).

Recording Amplifier (Fig. 13)

General

The recording amplifier consists of a voltage-amplifying stage V1 and an audio-output stage V2, both with negative feedback, and a 50-kc/s oscillator V3, supplying the current for erasing and biasing. A frequency-discriminating network in the feedback loop of the first valve includes variable elements used as treble boost controls.

Amplifying Stages

The input to V1, a high-slope r.f. pentode, is taken from the output of the isolating amplifier in the control unit, and is applied to the grid of the valve via R11, the *Record Gain* control. Voltage feedback from anode to grid is applied through a parallel-T network, which acts as a sharply-tuned rejector circuit, and includes three banks of capacitors controlled by the ganged switches SW 1, SW 2 and SW 3. By means of these switches, which together constitute the *Treble Boost 'kc'* control, the frequency of rejection can be set to 6, 7·5, 8, 9 or 11 kc/s. At the selected frequency the feedback is reduced, and the gain of V1 thereby increased, by an amount which is dependent upon the sharpness of the tuning and is controlled by the *Treble Boost 'db'* control R35, bridging across the parallel-T. In the minimum-boost position of R35 the series arms of the parallel-T are shorted out, and the grids of V1 and V2 are then separated by the resistors R9 and R17. R12 is inserted between R11 slider and V1 grid to prevent the feedback circuit from being affected by the setting of the *Record Gain* control.

The anode of V1 is connected to the grid of V2, a high-slope output pentode, via C18 and R17. The anode circuit of V2 contains the a.f.-output transformer TR 1; this has a turns ratio of 2 : 1, and in series with its secondary winding are two resistors R24 and R25 having values of 4·7 kilohms and 560 ohms respectively. Current negative feedback applied to the valve from these resistors increases the output impedance of the stage, making it large at all frequencies compared with the impedance of the recording head; the amplifier thus behaves to the head as a 'constant-current' source.

Head-current Metering

The voltage developed across R25 shunted by the 0·1-microfarad capacitor C34 is applied to a germanium rectifier MR 1, the output from which is smoothed by C26, R26, C27, and then taken to the *Audio* contacts of the *Head-current-meter Selector* SW 5 on the control unit. (Fig. 11.) The effect of C34 is to attenuate any voltage produced across R25 by 50-kc/s current getting through from the oscillator circuit and thus to prevent a false indication of the audio current from being given by the meter.

Rectified and smoothed voltages corresponding to the erasing and biasing currents are obtained in a similar manner from a circuit in the machine unit. The details are shown in Fig. 12.

Output to Recording Head

The output from TR 1 to the recording head passes through the 50-kc/s rejector circuit L1, C24, which isolates the audio amplifier from the oscillator. The biasing current is supplied from the anode of V3 through a d.c.-blocking capacitor C25 and a variable resistor R23, the pre-set *Bias* control. The audio and bias currents are brought out together to pin 6 on the connector at the rear of the amplifier. From this point they are conveyed through the amplifier cabinet main cableform to cable-connector 9, and hence via an external cable to the corresponding cable-connector on the machine-unit rear panel; this is wired to the 4-pin head-unit connector let into the deck of the machine.

Oscillator Stage

V3 is another high-slope output pentode, connected as a Hartley oscillator, in which the anode and grid voltages swing in opposite directions about the earthed cathode. The a.c. circuit between the valve electrodes consists essentially of a tapped inductor TR 2 in parallel with a capacitor C28, the values of these components being such that resonance occurs at the desired frequency. The ends of the parallel combination are connected to the anode and grid of the valve, the tapping point on the inductor being taken to the cathode (which is earthed by RL1-1) via h.t. positive and the smoothing capacitor C33.

Until relay RL1 is energised, the oscillation is suppressed owing to negative biasing of V3 grid by R30 shunted by C31 and the open relay contact RL1-1. When, however, the *Record* key is pressed, RL1 operates, closing RL1-1. Oscillations in the tuned circuit TR 2, C28, due to shock excitation caused by any slight disturbance of the electrode potentials, are now reinforced by V3. The energy stored in the fields of TR 2 and C28 circulates backwards and forwards as the fields alternately collapse and build up again in the reverse direction. The ends of the inductor to which the anode and grid are tied thus undergo cyclic reversals in polarity, the loss in the resistance of TR 2 being made good by energy supplied from the valve.

The amplitude of oscillation is limited in practice by grid-current biasing across R28, the grid-cathode circuit acting as a shunt-fed diode coupled through C29; the values of R28 and C29 are important, as they control the time constant of the grid circuit, and hence the biasing voltage. To avoid waveform distortion due to overdriving, the oscillatory voltage applied between the grid and cathode is reduced by using a suitable tapping on TR 2. R27 is a grid stopper inserted to prevent parasitic oscillations from occurring in other modes above the desired operating frequency.

Output to Erasing Head

The 50-kc/s feed from V3 anode to the erasing head is brought out via a screened lead to pin 5 of the amplifier connector via the d.c.-blocking capacitor C32 and the series resistor R31; this resistor limits the erasing current to 90 milliamps, approximately.

Power-supply Circuits

The power supply to the amplifier is controlled by the *Mains On-Off* switch on the control unit, and is routed through a pair of 2-amp fuses (Fig. 11) protecting the mains transformer TR 3 (Fig. 13). The h.t. supply is provided by the full-wave rectifier V4, with smoothing components L2 and C33. The supply to valve heaters, including that of the rectifier, is obtained from a 6·3-volt winding on TR 3.

'Record' Relay RL1

This relay is energised from the recording-amplifier h.t. supply when the *Play* and *Record* push-buttons on the machine are pressed simultaneously. When the relay operates, contact RL1-1 changes over, short-circuiting R30 and C31 as previously explained, and at the same time taking an earth off the secondary winding of the audio-output transformer TR 1. Contact RL1-2 opens, removing a short-circuit from the previously earthed secondary winding. RL1-3 is a lamp change-over contact and RL1-4 a holding contact; their operation is explained in Section C under the heading *'Record' Condition* and is shown in Figs. 8, 13 and 15.

Supplies

Mains input, 110-250 volts, 50 c/s a.c. (from control unit).

H.T. supply, 440 volts at output of L2.

L.T. supply, 6·3 volts, 2·3 amps, a.c.

Relay winding, 6 mA approx. supplied by h.t.

NOTE.—All voltages measured to frame, using Avometer Model 7. Lower voltages may be obtained with a battery-and-vibrator power supply.

Valve Data

Valve	Anode Volts	Screen Volts	Cathode Volts	Heater Volts	Heater Amps
Stage 1 EF42	115	90	2·0	6·3	0·33
Stage 2 EL41	380	380	16	6·3	0·7
Oscillator EL41	440	435	*50	6·3	0·7
Rectifier EZ40			452	6·3	0·6

*Cathode-bias voltage removed in operated position of *Record* relay RL 1.

Loudspeaker Amplifier (Fig. 14)

This is a three-stage power amplifier with an unbalanced high-impedance input, and push-pull output feeding into a loudspeaker-matching transformer the secondary winding of which is earthed at one end and is tapped for speech-coil impedances of 15 and 2·5 ohms. The signal from the control-unit *Output Selector* appears at pin 8 of connector 1CU (Fig. 11) and is conveyed through the cable-form at the rear of the amplifier cabinet (Fig. 10) and pin 11 of connector MN (Fig. 14) to the *Monitor Gain* control R2 at the input to the amplifier.

The first valve, V1, is a voltage-amplifying stage. Current feedback is developed across R6, R7, in the cathode circuit, and overall voltage feedback from the output-transformer secondary winding is applied through the potential divider R19, R8, R7, to the earthy end of R6.

The phase-splitter, V2, driving the push-pull output stage, is of a type referred to on page 57 of Engineering Training Supplement No. 3. The load resistance of the valve is equally divided between R11 in the anode circuit and R13 in the cathode circuit, the cathode-bias voltage being obtained from R12. The signal voltages developed across the load resistors are applied to the output valves, V3 and V4, via C4 and C5 and the grid stoppers R16 and R17. With respect to R13, V2 behaves as a cathode follower, and has therefore rather less than unity gain. Since the valve is triode-connected, the same current flows through R11 as through R13, and the voltages applied to V3 and V4, although of opposite polarity, are equal. As the waveforms of the output valves are additive, the overall stage gain of V2 is thus a little under two.

V3 and V4 have common cathode bias supplied by R18 by-passed by C6, and have the centre-tapped primary winding of TR 1 connected between their anodes, the tapping point on the transformer being taken to the h.t.-positive supply. Shunted across the two halves of the winding are C9, R24, and C10, R25, together acting as a by-pass circuit to frequencies above the audible range. These components were fitted because the earth capacitance of the output leads was found to cause instability.

The mains input to the amplifier is taken from fuses marked 'Power amp.' on the rear panel of the control unit. The h.t. and l.t. supply circuits are of the conventional type, except that the rectifier heater is connected to the common l.t. winding of the mains transformer. Resistance-capacitance smoothing is employed.

Valve Data

Valve	Anode Volts	Screen Volts	Cathode Volts	Heater Volts	Heater Amps
Stage 1 EF40	80	65	2·2	6·3	0·2
Stage 2 EBC41	205		42	6·3	0·23
Stage 3 2 EL41's	300	310	10	6·3	0·7
Rectifier EZ40			385	6·3	0·6

Supplies

Mains input, 110-250 volts, 50 c/s a.c.
H.T. supply, 310 volts.
L.T. supply, 6·3 volts, 1·7 amps, a.c.

NOTE.—All voltages measured to frame, using Avometer Model 7. Lower voltages may be obtained with a battery-and-vibrator power supply.

SECTION E

OPERATING PROCEDURE

Installation on Site

Setting up the Equipment

It is usually most convenient to place the recording machine on top of the amplifier cabinet, the rubber feet on the machine then locating firmly in recesses on the cabinet; with this arrangement the two units can be mounted on a specially designed trolley which brings the tape-deck up to normal operating height. The length of the connecting cables is, however, sufficient to allow the units to be placed side by side.

Cable Connections (*Fig.* 10)

(i) Insert the loudspeaker plug in the *Speaker 15 Ω* jack on the front of the cabinet.

(ii) Ignoring socket 1 (1AU in Fig. 10), insert the dummy 12-pin Jones plug in socket 2 (2AU) to bridge out the remote-control circuit.

(iii) Taking the machine-power cable, which is terminated at both ends in 12-pin Jones connectors, insert one end in socket 3 and connect the other to the Jones plug on the panel at the rear of the recording machine.

(iv) If reproduction to line is required, plug the *Rep. 600 Ω* jack 5 to the outgoing line.

(v) Make the programme-input connection, either by inserting the 3-pin cannon plug on the microphone cable into the *Mic. 30 Ω* socket 6, or by plugging the incoming line to the *Rec. 1200 Ω* jack 7.

(vi) Take the reproducing-head cable, which is terminated at both ends by 3-pin miniature-cannon plugs, and connect one end to socket 8 and the other to the 3-pin socket at the rear of the machine.

(vii) Connect the recording cable to the 6-pin miniature-cannon socket 9 and to the corresponding miniature-cannon socket on the machine.

(viii) Plug the P.P.M. cord to the jack at the top of the fuse-and-meter panel.

(ix) Take the mains-input cable, which has a Bulgin 3-pin socket on one end and a mains plug on the other, and connect one end to the Bulgin 3-pin recessed plug 4. Before completing the mains connection, check that the supply switch is at *Off*.

Switching on Supplies

(i) Switch on the power supply at the remote end of the mains cable.

(ii) Operate the *Mains* toggle-switch on the front control panel to *On*. The presence of a supply should now be indicated by the illumination of the central red pilot-lamp on the panel, and also of the P.P.M. lamp.

Preparing for Reproduction

(i) Remove both spools; rotate the *Tape Wind* control either fully clockwise or fully anti-clockwise, thus preventing over-heating of the wire-wound resistor during operation (ii).

(ii) Operate the *Wind* key, and allow the machine to run for some time to free the bearings of the main-drive motor. This motor usually runs slow when cold, and the time elapsing before it locks into synchronism varies with ambient temperature and also with individual machines. The warming-up process may frequently occupy some 15 minutes or more.

(iii) Continue to run the machine for about 5 minutes after hunting of the main-drive motor ceases to be audible, then operate the *Stop* key and replace the spool plates. Note that although the motor may behave satisfactorily on no-load, it can sometimes run slow under operating conditions with a tape on the machine, and for this reason further speed-tests mentioned later are required.

(iv) Set the *Meter* key to *Output*, and check that the P.P.M. shows a zero reading. This check should not be performed until operations (i) to (iii) have been completed, as the valve-feed currents do not attain stability until some minutes after the amplifiers have been switched on.

(v) Place the 1-kc/s line-up tape on the left-hand spool-supporting plate, and lock in position by lifting the spool clamp and turning it through 90 degrees. Turn the tape-lifting lever on the head unit to the right, and thread up the tape as shown in Fig. 1 and described in Section C under the heading *Deck-plate Assembly*. After checking that the tape runs correctly over the head guides, return the tape-lifting lever to the central position. The tape should now be held clear of the erasing and recording heads, thus preventing unnecessary wear.

(vi) Operate the *Play* key, thus starting the machine for reproduction. When the tape is in motion, observe the behaviour of the left-hand spring-loaded tape-guide, which will oscillate if the main-drive motor is not running in synchronism, thus indicating that a further warming-up period is required.

(vii) Increase the setting of the *Output Level* control to maximum. The P.P.M. should now read 4 to within a quarter of a division either way (i.e., to within ± 1 db).

(viii) Now listen to the output on a loudspeaker, as a final check for wow.

(ix) For mobile recording, if necessary adjust the loudspeaker volume, using the pre-set *Monitor Gain* control on the front of the loudspeaker amplifier. (When the cover panels are in position, this control will be found behind a small disk marked *V*.) The same control also adjusts the headphone level.

(x) When adjustments (vii) to (ix) have been completed, press the *Wind* key and turn the *Tape Wind* control anti-clockwise to rewind the test-tape. To avoid unnecessary wear on the reproducing head during this operation, turn the tape-lifting lever fully to the right.

Preparing for Recording

(i) First check the equipment for reproduction according to the procedure already described.

(ii) Now connect a source of 1-kc/s line-up tone at zero level to the *Rec. 1200 Ω* jack.

(iii) Switch the *Input Selector* to *Line* and the *Meter* key to *Input.*

(iv) Place a ' clean ' reel of tape on the left-hand spool plate. Then turn the tape-lifting lever to the right and thread up the tape as for reproducing. After checking that the tape runs correctly over the head guides, return the tape-lifting lever to the left-hand position.

(v) Fade up the *Record Level* control until the P.P.M. reads 4.

(vi) Operate the *Play* and *Record* keys simultaneously, thus starting the machine and bringing the recording amplifier into use.

(vii) Switch the *Meter* key to the *Output* position. The P.P.M. should now read 4, with a tolerance of plus and minus a quarter of a division to allow for variations in the sensitivity of the tape.

(viii) With the *Input-selector* key in the appropriate position, i.e. *Line* or *Mic.*, replace the 1-kc/s line-up tone by a source of programme and, by operating the *Meter* key, check the *Input* and *Output* volumes on the P.P.M.

(ix) The *Output* key may be switched between the *Playback* and *Direct* positions for comprehensive checking. It should be noted, however, that as the connection from the reproducing amplifier to the loudspeaker amplifier precedes the main output level control, the fact that a programme may be heard on the loudspeaker is not necessarily an indication that it is being sent to line. (In this respect it is safer to rely on the reading of the P.P.M., since the P.P.M. amplifier is fed from the anode of the final valve in the reproducing amplifier.)

Changing Speeds

The equipment as supplied is correctly adjusted for operation at 15 in./sec, giving a playing time of 32 minutes with an N.A.B.-standard double-sided 10-in. spool containing 2,400 ft of tape, or nearly 43 minutes with the earlier 3,200-ft European-type reel such as can be accommodated on an 11½-in. backing plate.

To change to 30 in./sec, giving a playing time of 16 or just over 21 minutes, proceed as follows :—

(i) Remove the 15-in./sec pressure roller, which is retained by means of a screw and disk. Do not remove any spacing washers from the pressure-roller spindle.

(ii) Fit the smaller 30-in./sec pressure roller and replace the retaining disk.

(iii) Fit the 30 in./sec sleeve over the existing capstan, taking care that the slot locates over the step, and secure firmly by means of the special screw provided. (The sleeve supplied with each recorder is correctly dimensioned to fit the corresponding capstan, and the sleeves must not therefore be interchanged between machines.) This completes the mechanical adjustments.

In practice it will normally be necessary to operate the recorder at 30 in./sec for reproduction only. It is agreed internationally that the same equalisation shall be used for reproduction at both speeds, the necessary adjustment being made to the frequency characteristic of the recording. So far as normal use of the recorder is concerned, therefore, the 15 in./sec line-up remains correct at 30 in./sec.

Mobile Work

Auxiliary Equipment

The auxiliary equipment used for mobile work is broadly the same as that supplied with the Type-C disk recorder, as described in Instruction R3, Section D.

The Wharfedale loudspeaker associated with the Type-C equipment is modified by the addition of a listen jack across the speech-coil, thus allowing connection to the *Speaker 15 Ω* jack on the R.G.D. amplifier unit, with adequate loudspeaker level.

When more than one microphone is necessary, the microphone outputs are taken as usual to a three-channel mixer MX/24. Since this unit has an output impedance of 300 ohms, a matching transformer must then be inserted between the mixer output and the *Mic. 30 Ω* socket on the R.G.D. recorder. A suitable-ratio transformer, Type LL/101SA, is supplied for this purpose mounted in an HV/7 box and provided with 3-pin Cannon connectors, a socket for the input and a plug for the output.

Earthing

If the power supply is provided by a battery and vibrator, particular care must be taken to connect the recorder supply-cable earth to the vibrator casing, because the recorder is not earthed at any other point.

SECTION F

MAINTENANCE INSTRUCTIONS

Amplifiers

The following tests and adjustments should be carried out at weekly intervals in the order given.

Peak Programme Meter

The programme meter is intended to read 4 with tone incoming or outgoing at zero level, i.e., for an input or output power corresponding to 0·755 volt across 600 ohms.

To check the calibration, proceed as follows:

(a) *Zero Setting*

(i) By means of the *Level Meter Zero Set* control, bring the instrument pointer to zero under no-signal conditions.

(b) *Sensitivity Adjustment*

(ii) Connect a valve-voltmeter or PPM/6 across the *Rep. 600 Ω* output jack, taking care that the jack is terminated in 600 ohms.

(iii) Throw the *Meter* key to *Output*, and rotate the *Output Level* control as far as possible clockwise, so that it is in the maximum-output position.

(iv) Play the 1-kc/s line-up tape and adjust the pre-set *Reproduce Gain* control until zero output level is indicated on the external meter.

(v) Now bring the reading of the R.G.D. programme meter to 4 by means of the *Level Meter Sensitivity* control.

The R.G.D. peak-programme meter differs from corresponding instruments of BBC design in that for some positions of the *Sensitivity* control it may be impossible to obtain a satisfactory *Law* adjustment. Moreover, when the *Zero* and *Law* controls are adjusted to correct the law, the *Sensitivity* control may require readjustment. Further, the reproducing amplifier has relatively little gain in hand, and when playing the 1-kc/s line-up tape the meter reading cannot in general be increased to 6, as required for checking the law, by the apparently obvious method of fading up the *Reproduce Gain* control. The *Law* adjustment is correctly set before the equipment is supplied, and as re-calibration may be difficult it should not be attempted unnecessarily. After replacement of a neon stabiliser or EF 41, however this calibration must always be checked and adjusted.

(c) *Law Adjustment*

(vi) Remove the 1-kc/s line-up tape and replace by a clean tape of the type normally used.

(vii) Plug a source of zero-level 1-kc/s tone to the *Rec. 1200 Ω* input jack, and operate the machine for recording.

(viii) Adjust the *Record Level* control until the external meter indicates zero level. If operation (v) has been correctly performed, the R.G.D. meter should now read 4.

(ix) By means of the *Record Level* control vary the recording level, and hence the output voltage as indicated on the external meter, above and below zero in steps of 4 db at a time, taking care not to leave high-level tone on the heads for longer than necessary. (The *Record Level* control has 2 db between studs over the upper part of its range, and 6 db between studs over the lower part; for this reason it may sometimes be impossible to proceed in 4-db steps below an output level of zero using this control alone. The solution is either to use a variable-level tone-source, such as a PTS/9, or to judge the accuracy of the *Law*, while carrying out the next operation, by interpolating between the marked divisions on the P.P.M. scale.)

(x) Note the readings of the P.P.M. on the recorder, and set the instrument *Law* in the manner described for the PPM/2 in Section H of Instruction S4, readjusting the *Zero* control, and also the *Sensitivity* control if necessary. During this operation do not disturb the settings of the *Reproduce Gain* and *Output Level* controls.

Reproducing Level

To line-up the reproducing amplifier, play the 1-kc/s line-up tape, set the *Output Level* control to maximum and with the *Meter* key in the *Output* position, adjust the pre-set *Reproduce Gain* control until a P.P.M. reading of 4 is obtained.

Head-current Meter

With the *Head-current-meter Selector* key at *Audio*, and no signal incoming, adjust the meter to zero by means of the pre-set *Head-current-meter Zero Set* control.

Erasing Current

No adjustment is provided for the erasing current. It should, however, be checked periodically and should be greater than 90 mA, as indicated on the head-current meter when switched to the *Wipe* position, and with the *Play* and *Record* buttons operated as for recording.

Bias Current

To adjust the bias current, record 1-kc/s line-up tone, and switch the head-current meter to read the bias, which should be 8 mA approximately. Now adjust the pre-set *Bias* control until the maximum possible output level is obtained from the tape, as indicated on the P.P.M. Then listen to the output, and increase the bias, thus reducing both recording level and modulation noise. The modulation noise falls more rapidly than the recording level, and the bias should be adjusted until the optimum signal-to-noise ratio is obtained. This will generally be when the level has been reduced by some 2 or 3 db.

Recording Level

To set the recording level, switch the *Meter* key to *Input* and record 1-kc/s line-up tone with the *Record Level* control adjusted so that the P.P.M. reads 4. Switch the *Meter* key to *Output* and if necessary adjust the *Record Gain* pre-set control until the P.P.M. again reads 4. Now switch the head-current meter to *Audio* and check that a recording current of roughly 0·4 mA is obtained.

Direct/Playback Balance

To balance the listening levels for monitoring in the *Direct* and *Playback* positions of the *Output* key, record 1-kc/s line-up tone as described in the previous paragraph. Set the *Output* key to *Direct* and adjust the *Balance* control until no change in level is audible on the loudspeaker when the key is switched between *Direct* and *Playback* alternately. Adjust the *Monitor Gain* control to the required listening level.

Reproducing-amplifier Frequency Characteristic

Play the 15-in./sec frequency-response test-tape supplied by Recording Maintenance Unit, and with the *Meter* key at *Output* observe the readings of the P.P.M. The tape is recorded at line-up level and the output levels with respect to zero (i.e., a P.P.M. reading of 4) should be as follows:

8 kc/s	... ...	± 2 db
6 kc/s	... ...	± 1 db
4 kc/s	... ...	± 1 db
2 kc/s	... ...	± 1 db
1 kc/s	... ...	0 db
100 c/s	... ...	− 2 db

If necessary, adjust the pre-set *Treble Boost* control on the front of the control unit to align the characteristic. Do not alter the bass-control settings from the positions shown on Fig. 11, i.e., *Bass Boost* '*Boost*' fully clockwise, and *Bass Boost* '*Frequency*' one stop back from the fully-clockwise position.

Recording-amplifier Frequency Characteristic

Record a complete frequency run from 50 c/s to 10 kc/s at line-up level. Play back the recorded tape, and compare the reproducing level at spot frequencies with that on the test tape. Then adjust the recording-amplifier *kc* and *db* pre-set *Treble Boost* controls, and repeat the procedure until a characteristic similar to that of the test-tape is obtained.

NOTE.—During this test the reproducing levels at the various frequencies must not be measured while recording, or errors may be introduced due to cross-talk between the recording and reproducing chains. When seeking the best positions for the controls, it is usually satisfactory to leave the *kc* control on 11 and vary the *db* control.

Microphone-amplifier Hum-bucking Coil

This hum-bucking coil is inserted at the input to the control-unit microphone amplifier, between connector 2CU and transformer TR 1. (Fig. 11.) The coil consists of a single loop of wire in each leg, suitably made up from a twisted pair. Its purpose is to cancel hum induced in the low-level input circuit by mains transformers and similar components of amplifiers.

To adjust for minimum hum, the following apparatus is necessary:

(a) Valve-voltmeter.

(b) Loudspeaker preceded by amplifier with high-impedance input.

(c) Cannon 3-pin plug to fit socket 6AU. Pins 1 and 2 on plug to be connected together through 30 ohms.

(d) Miniature-cannon 6-pin plug to fit socket 9AU. This should have pins 1 and 2 bridged by 600 ohms, and also brought out separately. Pins 5 and 6 are to be joined and brought out together.

Proceed as follows:

(i) Withdraw the recording amplifier from the cabinet. Insert a slip of paper between the 'break' block-spring contact and the lever-spring of contact-group RL1-2, and similarly for RL1-3; these remove the short-circuit and earth from TR 1 secondary winding, so allowing the audio amplifier to be used while RL1 is de-operated, i.e., without the oscillator.

(ii) Insert the previously prepared 30-ohm dummy plug in socket 6AU (labelled *Mic. 30 Ω*) at the rear of the amplifier cabinet, thus providing a suitable input termination for the microphone amplifier.

(iii) Insert the 6-pin plug in socket 9AU to provide an output termination for the recording amplifier. Connect the leads from pins 1 and 2 to the valve-voltmeter and loudspeaker-amplifier (mentioned under *a* and *b*) in parallel. The lead from pins 5 and 6 is to be earthed to chassis.

(iv) Set the *Head-current-meter Selector* to either *Bias* or *Wipe*. This earths the grid of the head-current-meter amplifier valve via the meter rectifiers and prevents the grid from floating during the test.

The monitoring chain now set up comprises V1 and V2 on the control unit, in cascade with V1 and V2 on the recording amplifier, and terminated by visual and aural monitoring equipment comprising the valve-voltmeter and the loudspeaker and amplifier.

(v) Invert the amplifier cabinet, and remove the bottom panel thus exposed, to obtain access to the hum-bucking coil.

(vi) Apply power to the amplifiers (via connector 4AU) and to the external test equipment. The recording machine is not required, and should be left unconnected.

(vii) Adjust the position and orientation of the coil until minimum hum is indicated by the valve-voltmeter and loudspeaker.

Take care not to disturb the coil if the control unit is later removed from the cabinet for servicing.

Reproducing-amplifier Hum Level

The hum level in the reproducing amplifier may often be reduced by injecting a small voltage at mains frequency into the circuit. For optimum results, the pre-set *Injection* and *Phasing* controls should be adjusted with the motors stationary and the hinged cover of the reproducing-head screen closed, while the level of the hum from the reproducing amplifier is measured on a sensitive valve-voltmeter. The hum level is usually of the order of —35 db, but may in some instances be as high as —25 db.

To carry out the adjustments, proceed as follows: Note the hum level across the *Rep. 600 Ω* output with the *Injection* control in the minimum position. Inject a small hum voltage into the amplifier by fading up *Injection*. Adjust *Phasing* until a minimum reading is obtained on the valve-voltmeter. Inject more hum and readjust the *Phasing*. Continue to increase the *Injection* and readjust the *Phasing* control until a minimum hum-level reading is obtained.

When making the adjustments, it is important that the setting of the *Injection* control be increased only a little at a time. With too high a setting of the control, the final adjustment is liable to be critical, a slight movement of either control increasing the hum level rapidly. Note that the controls may require readjustment if valves or head unit are changed.

A hum-bucking coil in series with the reproducing head is also provided. This coil consists merely of two self-supported turns of 18-gauge brass wire inside the machine unit, and care must be taken that it is not accidentally disturbed. The orientation of the coil can be adjusted by hand for maximum hum neutralisation, and when the adjustment is correct the hum level with the motors running should be better than —38 db.

Head Unit

Head Azimuth Alignment

The azimuth alignment of the recording and reproducing heads is checked and adjusted by Recording Maintenance Unit before the head assembly is supplied. If later there is reason to suspect that either head is out of adjustment, a spare head assembly should be fitted, and the faulty unit returned to R.M.U. for attention.

Tape Guide-plate

A movable slotted guide-plate is attached to the right-hand side of the head unit (Figs. 1 and 2). The purpose of this plate is to hold the tape at the correct height relative to the heads, in spite of any tendency to rise or fall which may result from a possible slight misalignment of the drive-capstan or pressure-roller axis. The guide-plate is held in position by two screws provided with washers and passing through elongated holes in the plate.

For correct adjustment the tape should run level with the heads, the plate projecting only just sufficiently beyond the housing to steady the tape. Care must be taken that the plate does not project too far, as with incorrect adjustment it is possible to lift the tape out of contact with the reproducing head, with consequent loss of top.

Head Demagnetisation

If it is necessary for any reason to remove the head assembly from the machine, it is of the utmost importance that the equipment should first be switched off. If this precaution is not observed, the heads may become magnetised. Magnetised heads increase the background noise from the tape, and may also damage an existing recording. If there is reason to suspect that magnetisation of any head has occurred, operations in progress on the machine should be stopped as soon as possible, and the heads demagnetised.

Demagnetisation is best carried out with the head unit removed from the machine. The unit is held in position by two knurled-headed screws, one near either end, and two dowel-pins and two Jones plugs underneath which locate in sockets let into the deck-plate.

After unplugging the head unit, rotate the tape-lifting lever until the tape-lifting plates withdraw into the casting. Then bring the demagnetiser carefully into contact with the erasing head, and slowly withdraw. Repeat with the recording head. Open the hinged cover plate of the reproducing-head screen, and demagnetise the reproducing head. The demagnetiser must be held firmly, and not allowed to 'jump' or vibrate as it approaches the head unit, or the heads may become misaligned. As the demagnetiser is not continuously rated, it must be switched off as soon as possible after use.

Since the equipment is also liable to become magnetised gradually with normal use, the heads and screens together with other steel parts (including the capstan) should be demagnetised periodically.

Tape Drive System

Machine Speed Constancy

Lack of speed constancy in the recording machine, manifested by variations in the instantaneous rate of travel of the tape, may give rise to pitch fluctuations which on sustained notes have a seriously disturbing effect. Where the rate of pitch variation is relatively slow, e.g., below 20 c/s, this phenomenon is termed *wow*, whereas a higher-speed pitch fluctuation is generally referred to as *flutter*.

To test for these faults, switch the *Output* key to *Playback* and reproduce the 1-kc/s line-up tape on a loudspeaker.

If wow is present, it may be caused by incorrect adjustment of the relative heights of the spools and tape-guides, in conjunction with slip caused by inadequate pressure between the tape capstan and the pressure roller. Wow may also occur if the pressure roller is eccentric or has faulty bearings.

A higher speed pitch fluctuation, in the form of a 25-c/s flutter, can be produced by an eccentric capstan-drive spindle or by play in the spindle bearings. The flutter-frequency of 25 c/s corresponds to the 1,500-r.p.m. synchronous speed of the main-driving motor.

A further possible source of trouble is a warped spool-plate rubbing against the tape or against the heads of screws projecting above the deck-plate.

NOTE.—Tests carried out with the aid of a wow-meter* on a carefully adjusted machine indicate that, when a mains power supply is used, the r.m.s. values of medium-frequency wow (3-20 c/s) and flutter (above 20 c/s) respectively are of the order of 0·05 and 0·1 per cent. For the wow component below 3c/s, the instrument used gave a peak to-peak reading instead of an r.m.s. reading, the value obtained being about plus and minus 0·05 per cent.

*For a description of a wow-meter, see *Recording Training Manual,* Appendix G.

With a vibrator-and-battery power supply, the r.m.s. wow and flutter are only negligibly worse, but there may be periodic ' flicks ' reaching a peak-to-peak value of plus and minus 0·2 per cent. These, however, should not seriously affect the quality of reproduction.

Capstan Drive

The tape-drive capstan is integral with the upper end of the shaft carrying the drive-motor brake-drum, this drum being also a flywheel. The underside of the drum is driven through a polyvinyl-chloride disk by a flanged coupling on the upper end of the separate motor shaft below. The p.v.c. disk minimises the effect of misalignment between shafts, and also absorbs motor vibration. Positive transmission of the drive between the two shafts is secured by the use of six cheese-headed screws on a uniform radius at 60-degree spacing; the heads of three screws spaced at 120 degrees project below the brake drum and engage with holes in the disk, while the heads of three other screws project above the flanged coupling and engage with further holes, staggered 60 degrees from the first to prevent the upper and lower screw-heads from touching.

The flanged coupling is secured on the end of the motor shaft by two Allen screws, and when these are loosened it is free to slide up and down. The positioning of the coupling is critical, correct adjustment requiring care. To find the optimum position, the height of the coupling should first be set so that solid contact is barely established with the p.v.c. disk, tone should then be recorded, and the height subsequently readjusted slightly if either flutter or wow is heard. In general, any appreciable compression of the p.v.c. disk is liable to cause flutter, due to transmission of vibration from the motor when solidly coupled to the capstan drive, whereas if the p.v.c. disk is floating, torsional oscillation of the capstan and flywheel with respect to the motor shaft may be set up by a slight departure of the pressure roller from concentricity; this oscillation takes place at a relatively slow speed, and is audible as wow. The adjustment of the coupling should be continued as necessary until the optimum position is attained.

If the drive capstan itself is eccentric, or if the capstan or its shaft becomes bent or play develops in the bearings, a noticeable 25-c/s flutter will be produced. In this event the complete recording machine should be returned to R.M.U. for repair.

Pressure Roller

The large-diameter pressure roller is used for operation at a tape-speed of 15 in./sec, and the smaller-diameter roller at 30 in./sec. The rubber tyre on the roller in use should be examined from time to time and, if wear is apparent, a new roller should be fitted and the faulty one returned to R.M.U. for re-tyring. The pressure of the roller against the capstan should be sufficient to drive the tape without slipping; either inadequate or excessive pressure produces incorrect speed, and can also cause wow.

The deck of the recording machine, with the drive capstan and pressure roller, is shown in Fig. 1. Part of the operating mechanism for the roller is mounted beneath the deck, on top of the motor plate, and is visible in Fig. 5, in which the motor plate is seen from above, the deck plate having been removed. The remaining portion of the mechanism is beneath the motor plate, and is partly visible in Fig. 6. Since, however, the component mounting on the underside of the motor plate is somewhat congested, this part of the mechanism has been drawn out more clearly in Fig. F.1. Components numbered in the following text appear in Figs. 1, 5 or 6. Unnumbered components are shown in Fig. F.1, where they are labelled in full. **(For Fig. F.1, see p. 29.)**

The pressure roller (2) is free to rotate on a spindle (3) at the end of a crank-arm (4). The other end of the crank-arm is mounted eccentrically on a crank-shaft (5) which passes through the motor plate, the crank-arm boss being locked on the shaft by a one-sixteenth inch Allen screw. Attached to and wound round the crank-shaft (5) below the motor plate is a retracting spring (not visible in the illustrations) which, in the non-operated condition of the mechanism, holds the crank (4) and pressure roller (2) away from the drive capstan (1) and against a roller-ended cam (6). The tension of this spring is adjustable, and may be varied by loosening a set-screw in a collar (10) on the bottom of the crank-shaft.

The roller-ended cam (6) has a split boss which is bolted on to the cam-shaft (7). The cam-shaft also projects below the motor plate, and its lower end carries a second crank (11) which is hinged at (18) to a threaded rod (13) forming an extension to the pressure-roller operating rod (12), the armature of the solenoid mechanism (14) being fastened to the other end of this rod through a heavy-gauge helical spring (15).

When the *Play* button is pressed, the solenoid is energised. The armature (16) is then pulled into the solenoid by a fixed electromagnet (17), and a motion is transmitted through the helical spring (15), the operating rods (12) and (13), the lower crank (11) and the cam-shaft (7) to the cam (6) above the motor plate. The cam bears against the side of the crank-arm (4) carrying the pressure roller (2), pushing the roller into the capstan (1) and gripping the tape. The rotation of the crank-arm (4), and hence the movement of the roller, is limited by a stud (8) screwed horizontally through a fixed bracket (9) to form an adjustable stop.

The armature (16) has a fixed length of travel and, when the solenoid is operated, part of its motion is used to bring the pressure-roller crank-arm (4) against the screw stop (8), and the remainder is taken up by extension of the helical spring (15). The spring tension is adjustable by loosening a lock-nut on the threaded extension rod (13) and screwing this rod into or out of the operating rod (12) ; the tension should not normally be altered, however, as any adjustment of rod (13) may affect the action of cam (6).

The portion of the mechanism above the motor plate is accessible for adjustment through cut-outs in the deck-plate, visible when two cover-plates screwed to the deck are removed. The pressure of the roller (2) against the capstan (1) is adjustable by rotating the crank-shaft (5) on which the crank-arm (4) is mounted eccentrically. This adjustment is facilitated by the provision of a slot, cut in the end of the shaft and allowing the shaft to be rotated with a screwdriver when the miniature Allen screw in the crank-arm boss is undone. Adjust the pressure of the roller so that the rubber tyre is slightly compressed. Maintenance of the correct pressure helps to prevent the tape from riding up or dropping down relative to the level of the heads as it is drawn through the machine. The result of unsuitable pressure is incorrect speed, with possible wow.

When the pressure of roller (2) is correct, and spindle (3) is in line with capstan (1) and crank-shaft (5), advance the limit stud (8) until it touches the crank-arm (4). (The stud-mounting bracket (9) is split on one side, so that the upper portion, resting on the thread of stud (8), forms a saddle which can be tightened down to clamp the stud in position by means of a screw securing the bracket to the motor plate.) Now tighten the Allen screw securing the boss of crank-arm (4) on eccentric shaft (5). Loosen the set-screw in collar (10) at the lower end of the shaft, and by rotating this collar adjust the tension of the roller-retracting spring, until with the mechanism de-operated the spring pulls the roller firmly away from the capstan, thereby releasing the tape. Do not increase the retracting-spring tension too much, or the solenoid will not be able to operate against it. Note that rotation of eccentric shaft (5) relative to crank-arm (4) affects the spring tension.

With the solenoid operated, cam (6) should be nearly at right angles to crank-arm (4), and the roller end of the cam should force the crank-arm against limit stud (8). Cam (6) is not visible through the cut-outs in the deck-plate, and the removal of the deck-plate itself is a major operation which should not be carried out at stations. To vary the operated position of the cam without removing the deck-plate, loosen the lock-nut on rod (13) and screw this rod into or out of rod (12). The correct position of the cam can be judged from the behaviour of crank-arm (4), which in the operated condition should be held in definite contact with limit stud (8). Further, if the cam rotates beyond the position where it makes an angle of 90 degrees with the crank-arm, it may lock in and hold the pressure roller permanently against the capstan, due to the spring-like action of the pressure-roller tyre when compressed. When the adjustment is correct, tighten the lock-nut on rod (13) against the end of rod (12). Note that adjustment of rod (13) also affects the tension of spring (15), and that the required setting for the cam itself depends on the position of eccentric shaft (5). The lower crank (11) is made in two parts, each with a split end-clamp (not shown in Fig. F.1) secured on cam-shaft (7) by a nut and bolt, and by loosening these, both parts of crank (11) may be rotated relative to shaft (7), so allowing the position of the cam to be altered without affecting spring (15) ; this and further possible adjustments, however, are better left to R.M.U.

In the de-operated condition of the mechanism, the armature is held away from the fixed electromagnet within the solenoid by a light-gauge helical spring, attached at one end to the lower crank (11) and at the other to a short threaded rod which passes through a hole drilled in a fixed pillar and is secured by a knurled nut. The tension in this spring may be varied by rotating the knurled nut, and should be sufficient to ensure that the armature is withdrawn rapidly from the solenoid when the latter is de-energised. Too much tension in this spring retards the engagement of the pressure roller when the solenoid is operated, causing the machine to run up with a wow if the tape is set for a quick start, with the beginning of the programme close to the heads. Too little tension, on the other hand, retards disengagement of the roller, and may cause a slack loop of tape to form at the right of the machine when stopping from the *Play* condition.

The relative diameters of the two pressure rollers employed for alternative tape speeds, and of the capstan and sleeve, are so arranged that no adjustment of eccentric (5) or limit stud (8) is required on replacing a roller when changing speeds. Replacement rollers are re-tyred to the correct diameters, and rollers with ground-down tyres are not normally supplied.

Spool Height Adjustment (*Fig.* 5)

Referring to Fig. 5, the take-up and rewind spools are supported by small circular plates (21) projecting slightly above the deck of the machine. The plates are mounted on extension shafts (23) which fit inside the hubs of the brake-drums (22) and are secured by Allen screws. The motor spindles themselves are not visible in Fig. 5, but the upper ends of these also fit inside the brake-drum hubs, to which they are secured by further Allen screws. When these latter screws are loosened, the brake-drums (carrying the extension shafts and plates) are free to slide up and down on their respective motor spindles, thus permitting adjustment of the brake-drum heights. Similarly, loosening the upper screws allows the extension shafts to slide inside the upper parts of the brake-drum hubs, thereby providing a height adjustment for the spool-supporting plates. To carry out the adjustments, the height of each brake-drum should first be set correctly in relation to its band-brake, and the extension shafts should then be raised or lowered as required to align the spools and the tape with the heads and guides. The adjustments are, however, correctly set before the machine is supplied, and normally subsequent alteration will not be necessary.

The upper end of each extension shaft (23) is drilled and threaded internally to take a large flat-headed screw (24) securing the spool-clamp (25). The end of the shaft is slotted, and fits inside the centre hole of the supporting plate (21). When the screw (24) is tightened firmly, the end of the shaft expands like a collet, holding the supporting plate in position. This arrangement provides a means of adjusting the height of the spool-supporting plate relative to the spool-clamp, so ensuring proper clearance between them. To facilitate this somewhat critical adjustment, the plate is packed up to approximately the correct height by a rubber grommet (26) and metal spacing washers. The plate is intended to be set with the grommet slightly compressed, so that it springs up proud of the deck-plate when the screw (24) is released, and can easily be lifted off the shaft (23). This adjustment also affects the spool height.

Lubrication

Accessible extension-tube oilers are provided for the top and bottom bearings of the three motors, and the bearings should be lubricated at monthly intervals by applying two or three drops of a thin machine oil to the open oil-feed holes at the projecting ends of the tubes. Regular oiling is important, as no provision is made for taking up play in the event of wear.

The bearings of the guide-pulleys, pressure roller and capstan-drive spindle should also be lubricated sparingly with thin oil.

Brake System (Fig. F.2)

General Description

The brake system is located beneath the motor plate, and is difficult to show in photographs, as it is hidden by the plate when the machine is viewed from above (Fig. 5), and by sub-panels and wiring when the machine is viewed from below (Fig. 6). The simplified sketch, Fig. F.2, shows the system as it would appear if it could be seen through the motor plate.

Each motor is fitted with a felt-lined steel band-brake, acting under spring tension on a drum attached to the motor shaft. The brakes of all three motors are controlled by the same solenoid mechanism through a system of levers. The solenoid is enclosed in a magnetic screen, and is mounted immediately beneath the motor plate in a central position at the rear of the machine.

Fig. F.2 shows the mechanism as it appears when the machine is at rest. The brakes are held on by their springs, the solenoid being de-energised.

This condition obtains when the power supply to the recorder is cut off, or the *Stop* button on the machine-control panel is operated.

When the incoming supply is connected, and the control-unit *Mains* switch is thrown to *On*, the brakes solenoid is energised as soon as the *Play* or *Wind* button is depressed. In this condition, the armature is attracted to the fixed electromagnet, pulling the armature bar in the direction marked by arrows on the diagram (i.e., towards the rear of the machine). A crossbar clamped rigidly to the armature bar carries two studs which bear on the ends of the take-up and rewind motor brake levers. Each lever is pivoted near the centre, and its further end, carrying a bar which is attached to the brake band and slides in a slot, is pulled away from the motor against the tension spring, thereby relieving the pressure of the brake band on its drum, and freeing the motor.

At the same time a third lever, hinged at one end to the armature bar and pivoted at the other, is pulled towards the rear of the machine. This lever carries a stud which engages with the bent-up end of a bell-crank pivoted as snown in the sketch. The further end of the bell-crank moves against the drive-motor brake-band tension spring, relieving the pressure between the brake band and drum, and freeing the drive motor.

The three tension springs are attached to short threaded rods which pass through holes in fixed members and are held by knurled nuts. By rotating these nuts the spring tensions and hence the braking torques may be varied.

The photograph, Fig. 5, shows the rewind-motor brake-drum (22) together with part of the band-brake (31). The armature bar (32), the three studs (33), and part of the drive-motor brake lever (34) and bell-crank (35) are visible through a cut-out in the motor plate.

Brake Operation

The moment the brakes are applied, the pressure roller disengages, and the capstan motor ceases to drive the tape. A finite time then elapses before the motor comes to rest, but the duration of this braking period is not usually very important.

Control of the take-up and rewind motor stopping times is, however, essential, as these affect the behaviour of the tape. The time each motor takes to stop depends on its brake-torque and its kinetic energy, this latter being a function of inertia and speed. The total inertia of a motor and tape-spool increases with the diameter of the tape wound on to the spool, but the effect on the kinetic energy of the resulting change in inertia is to some extent offset by a compensating change in rotational speed.

Unless the brakes of the take-up and rewind motors are correctly adjusted, when the machine is stopped, the tape may either stretch or form a slack loop between one of the spools and the heads. The usual reason for tape-stretch is over-fierce brake operation, whereas a loop is generally caused either by the spool on the trailing side continuing to unwind after the leading-side spool has stopped rotating, or by the pressure roller disengaging too slowly. The danger in slack tape being left between the spools after stopping is that the tape may stretch or part as it tightens up again when the machine is re-started.

The directions in which the motors tend to rotate under power are indicated on Fig. F.2 by arrows, the direction of rotation of either spool when trailing being the opposite to that shown. When the brake is applied to the motor on the trailing side, the brake-torque resulting from friction under spring tension is magnified by added tension produced in the brake band by the friction itself. This self-servo action is essential for correct brake operation, because it ensures that the braking effect is greater on the trailing spool than on the leading spool, both when the machine is running forwards, and when it is rewinding. The servo action is not fully effective, however, when the felt brake-lining material is new, and until the action is well established, slackness in the tape may be produced on stopping the machine; this slackness must always be taken up by hand before the machine is started again.

Adjustment Procedure

(1) *Checking Spring Tensions of Take-up and Rewind Motor Brakes*

(a) Thread up a tape on the machine, leaving the tape-lifting lever in the right-hand position.

(b) Operate the *Wind* key and *Tape Wind* control to obtain maximum speed under each of the four test conditions specified below:

(i) Running *forwards*, with a full reel of tape on the left-hand side of the machine and a few turns only on the right.

(ii) Running *backwards*, with the remaining conditions as in (i).
(iii) Running *backwards*, with a full reel of tape on the right and a few turns only on the left.
(iv) Running *forwards*, with remaining conditions as in (iii).

(c) During each test, operate the *Stop* key, and vary the take-up and rewind motor brake-spring tensions until the formation of slack loops of tape between the spools when the machine is stopped has been reduced to a minimum.

Under test condition (i) the left-hand brake is servo-assisted. If on stopping the machine a slack loop forms at the left, increase the rewind-motor braking torque slightly by rotating the knurled nut on the threaded rod attached to the brake-band spring. Do not increase the braking too much, or a loop may form at the right of the machine under test (ii), although the adjustment allows some latitude because under test (ii) the take-up motor brake in turn is servo-assisted. If the take-up motor brake is initially slack, a slight increase in its tension may be necessary to satisfy test (ii).

Under test condition (iii), the right-hand brake again is servo-assisted. If a tape-loop forms at the right, increase the take-up motor braking slightly. Repeat test (iii) as a check that the loop has been eliminated, and proceed to test (iv). If the take-up motor braking has been increased too much, a loop will now form at the left-hand side of the machine. After the final adjustments have been made, as a further check, repeat all four tests.

When the felt brake linings are worn in, and self-servo action is well established, a minimum of brake-spring tension should suffice, although with new linings entirely satisfactory operation may not always be attainable. In the latter circumstances it should, however, be possible to effect a reasonable compromise by increasing the tensions slightly. If this procedure is necessary the tensions must be checked again after a period of use, and reduced to their lowest practicable values; this readjustment is essential, because if the brakes are too powerful there is a danger of stretching the tape.

(2) *Checking Disengagement of Tape-drive*

If the pressure-roller retracting spring is inadequately tensioned, the roller may not be pulled away from the capstan when the machine is stopped, the existence of this fault being a possible source of difficulty in operation. For satisfactory functioning, when the *Stop* key is operated the drive must disengage not merely completely, but also rapidly, since otherwise the capstan may continue to feed tape to the right-hand side of the machine after the take-up motor has stopped. To check this point, repeat tests (i) and (iv), but this time operate the *Play* key instead of the *Wind* key. Should a slack loop of tape form between the capstan and the take-up spool, try to eliminate it by slightly increasing the tension in the springs of the pressure-roller mechanism, as described earlier in the Section. If this is unsuccessful, increase the capstan-motor brake-spring tension.

(3) *Checking Stud Clearances*

The stud clearances will normally only require adjustment after a new brake band has been fitted. The clearances should then be checked and adjusted as follows:

(a) With the brake-bar in the position assumed when the machine is switched to *Stop*, loosen the lock-nuts on the studs which bear on the rewind and take-up motor brake levers and screw the studs away from the levers until about a tenth of an inch clearance is visible. (The presence of this clearance when the brakes are on indicates that the studs are not limiting the braking torque, which should be governed solely by the spring tension. The clearance also allows scope for the differential servo action.) Do not increase the clearance unnecessarily or the brakes will remain permanently on. When a satisfactory clearance has been obtained, tighten the lock-nuts to hold the studs in position.

(b) If a clearance cannot be obtained by adjusting the studs, slacken off the nut on the bolt clamping the crossbar to the armature bar. This bolt moves in a slot, and the position of the crossbar should be adjusted so that the studs are well separated from the brake levers. After tightening the nut and bolt firmly to prevent the crossbar from slipping, repeat operation (a).

(c) Loosen the lock-nut of the stud on the drive-motor brake lever, and withdraw the stud until slight play can be felt between the armature and its backstop when the armature bar is moved backwards and forwards by hand. Advance the stud gradually until the play is only just appreciable. Check that when the armature bar is held in the running position the brake band does not buckle back on to the drum after contact with one of the motor supporting pillars. If it does, withdraw the stud gradually until the drum is free. Then tighten the lock-nut.

(d) Finally, check and if necessary readjust the spring tensions as described under (1) and (2).

Note that snatching of the tape on starting is a trouble which can sometimes be traced to the brake system, wrong adjustment of the crossbar studs causing the take-up or rewind motor brake to remain partially on while the machine is running. Unfortunately, at the 30 in./sec tape speed, the recorder has an inherent slight tendency to snatch, caused by the take up motor driving torque being insufficient when starting at this speed.

Dismantling Procedure

Withdrawing the Amplifiers

(i) Remove the front and rear covers of the amplifier cabinet, first releasing the 'Oddie' fasteners by turning the slots in their heads to the vertical.

(ii) Remove the two bent up clamps in front of the amplifiers, and push each unit out from behind. (When the amplifiers are re-inserted, some slight manipulation may be necessary to engage the H. B. Jones connectors.)

Removing the Power-supply Unit

(i) Unscrew and remove the panel on the right-hand side of the amplifier cabinet.

(ii) Withdraw the H. B. Jones plug on the power-supply unit now exposed.

(iii) Undo the bolts securing the unit to the main chassis, and lift the unit out of the cabinet.

Recording Machine

No attempt at dismantling the recording machine itself should be made at stations. If a serious fault develops, a spare unit must be obtained, and the defective one returned to Recording Maintenance Unit for repair.

G.H. 535

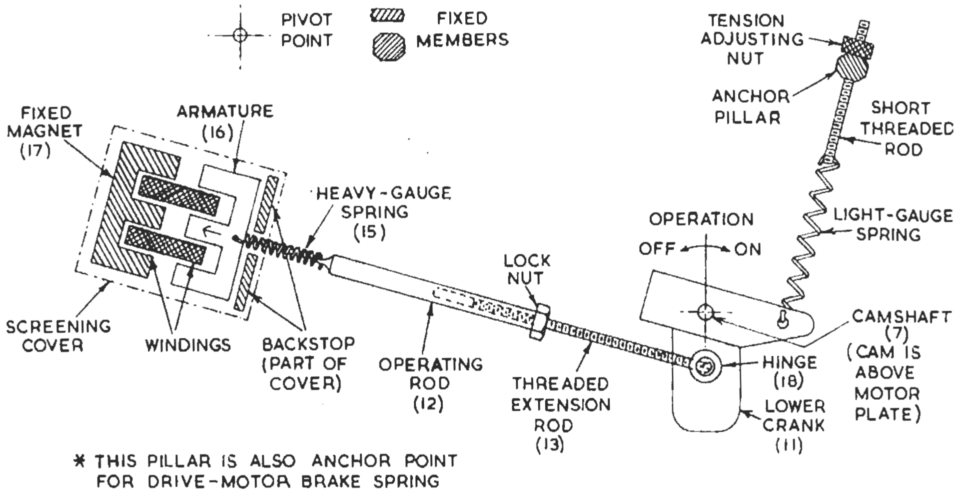

Fig. F.1. Pressure-roller Mechanism

Simplified View from Above of Portion below Motor Plate

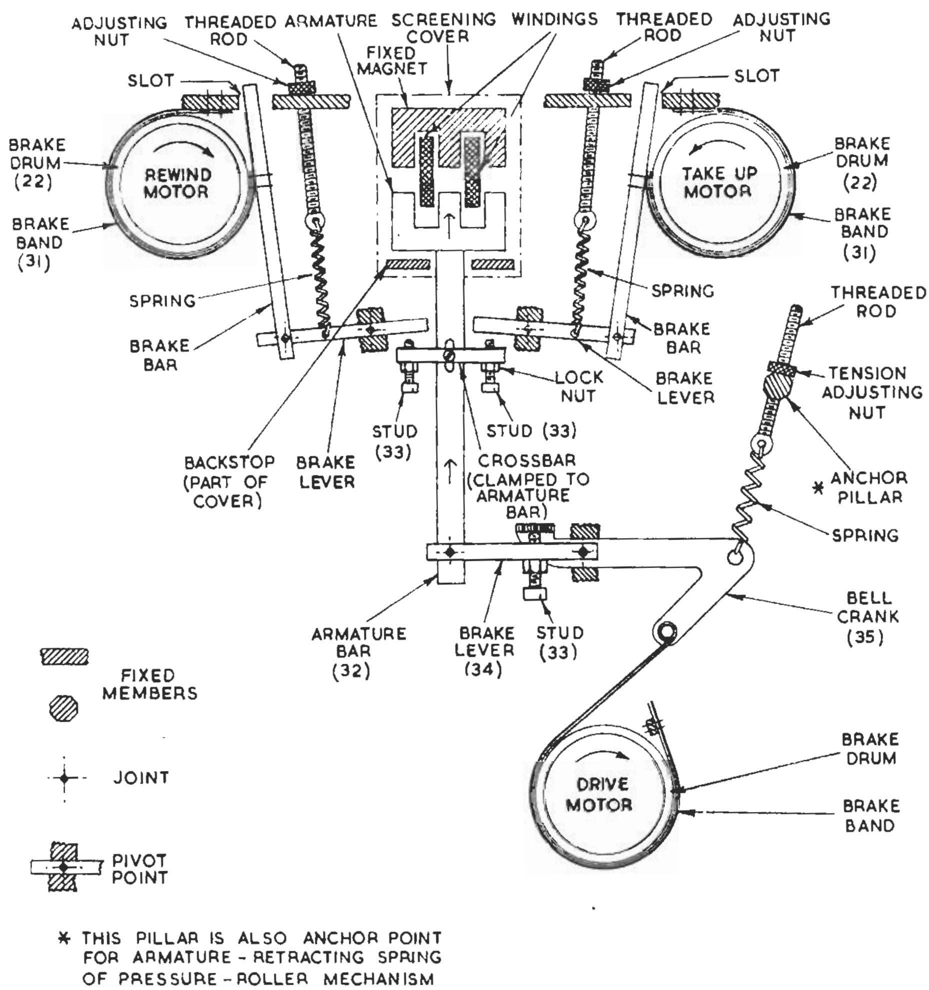

Fig. F.2. Brake System

Simplified View from Above

APPENDIX 1

CODING OF CONNECTORS

This Appendix gives the circuit symbol employed in the text and drawings for each connector. To facilitate the ordering of replacements, the maker's coding is also listed.

Amplifier Cabinet

Unit	*Purpose*	*Circuit Symbol*	*Maker's Coding*	*Remarks*
Cabinet	L.S. 2·5 Ω and 15 Ω	1AU	JSM.4.AB	Not used
Cable	,, ,,	—	JPM.4.CCE	Not supplied
Cabinet	Remote control	2AU	JSM.12.AB	
Dummy	,, ,,	,,	JPM.12.CCE	See text
Cabinet	Machine supplies	3AU	JSM.12.AB	
Cable	,, ,,	,,	JPM.12.CCE	
Cabinet	Mains outlet socket	—	Crabtree C2544 3-pin 250 V 2 A	Not used, and less cover plate
Cabinet	Mains input	4AU	Bulgin P.73	Male half
Cable	,, ,,	,,	,, ,,	Female half
Cabinet	Machine supplies	PS	JPM.8.CCE	
P.S.U.	,, ,,	,,	JSM.8.AB	
Cabinet		RC	JP.12.AB	
Rec. amp.		,,	JS.12.AB	
Cabinet	C.U. Power circuits	3CU	JP.12.AB	
C.U.	,, ,,	,,	J.S.12.AB	
Cabinet	C.U. Rep. head cct.	1CU	JPM.2.AB	
C.U.	,, ,,	,,	JSM.2.AB	
Cabinet	C.U. Programme ccts.	2CU	JP.12.AB	
C.U.	,, ,, ,,	,,	JS.12.AB	
Cabinet		MN	JP.12.AB	
L.S. amp.		,,	JS.12.AB	
Cabinet	Mic. 30 Ω	6AU	EP.3.13	
Cable	,, ,,	,,	EP.3.CG12	
Cabinet	Rep. head cct.	8AU	EM.3.13	
Cable	,, ,,	,,	EM.3.CG12	
Cabinet	Rec. and erase ccts.	9AU	EM.6.13	
Cable	,, ,,	,,	EM.6.CG12	

Recording Machine

Position	*Purpose*	*Maker's Coding*	*Remarks*
Rear panel	Machine supplies	JPM.12.AB	
Cable	,, ,,	JSM.12.CCE	From 4AU
Rear panel	Rep head cct.	EM.3.13	
Cable	,, ,,	EM.3.CG12	From 8AU
Rear panel	Rec. and erase ccts.	EM.6.13	
Cable	,, ,,	E.M.6.CG12	From 9AU
Deckplate	Rep. head	JSM.2.AB	
Head unit	,, ,,	JPM.2.AB	
Deckplate	Rec. and erase heads	JSM.4.AB	
Head unit	,, ,, ,,	JPM.4.AB	

APPENDIX 2

OPERATIONAL AND PRE-SET CONTROLS

The rather large number of controls may be classified under two headings: (i) those used for normal operation, and (ii) pre-set controls. To avoid confusion complete lists covering both are given below.

Pre-set Controls

These controls are used for lining up the recording and reproducing circuits. The alignment procedure is somewhat complicated, and at static recording centres will generally be carried out by the maintenance staff. Re-alignment should not be attempted in the field or, in normal circumstances, by static operating engineers.

(1) *On Recording Machine*:
- (l) Reproducing-head hum-bucking coil (orientation adjustment).

(2) *On Front of Control Unit*:
- (m) *Reproduce Gain* control (in series with and preceding output-level control).
- (n) *Balance* control for adjusting loudspeaker level in *Direct* position of *Output Selector*.
- (o) *Treble Boost*, *Bass Boost* and *Bass-boost Frequency* controls for the reproducing amplifier.

(3) *At Rear of Control Unit*:
- (p) P.P.M. (*Level Meter*) *Zero Set*, *Law Set* and *Sensitivity* controls.
- (q) Reproducing-amplifier hum-cancellation *Injection* and *Phasing* controls.
- (r) *Head-current-meter Zero Set* control.

(4) *Beneath Chassis of Control Unit*:
- (s) Microphone-amplifier hum-bucking coil (orientation adjustment).

(5) *On Front of Loudspeaker Amplifier*:
- (t) *Monitor Gain* control.

(6) *On Front of Recording Amplifier*:
- (u) *Record Gain* control.

(7) *At Rear of Recording Amplifier*:
- (v) Recording-head *Bias* current control.
- (w) Two *Treble Boost* recording pre-emphasis controls, one (marked *db*) controlling the amount of equalisation, the other (marked *kc*) selecting the resonant frequency of the equaliser circuit.

Operational Controls

(1) *On Recording Machine*:
- (a) Tape-lifting lever.
- (b) *Stop*, *Play*, *Wind*, and *Record* keys.
- (c) *Tape Wind* control.

(2) *On Front of Control Unit*:
- (d) Mains on-off switch with central red pilot-lamp.
- (e) Red *Record* and green *Reproduce* pilot-lamps controlled by *Record* key on machine.
- (f) *Input-selector* key with three positions: *Line*, *Off*, and *Mic*.
- (g) *Record Level* control.
- (h) *Output Level* control for adjusting programme volume sent to line.
- (i) *Output* key for comprehensive checking (can be operated with *Output Level* control faded out, i.e. as pre-fade).
- (j) *Meter* key for P.P.M.

(3) *At Rear of Control Unit*:
- (k) *Head-current-meter Selector* key, with three positions: *Bias*, *Audio* and *Wipe*.

APPENDIX 3

RESPONSE OF A SYSTEM USING GAPPED-RING HEADS

General Considerations

The use of gapped-ring heads, in conjunction with a coated tape and supersonic erasing and biasing currents, has advantages in respect of frequency response and signal-to-noise ratio over the earlier steel-tape system using high-reluctance heads and d.c. bias. Disadvantages are a tendency to ' print ' between layers when the tape is wound on a spool, and if a high-coercivity tape is used, a possible difficulty in erasing.

With the a.c. bias system, the intensity of remanent magnetisation in the tape is roughly proportional to audio recording current over the greater part of the working frequency range, although, at the higher frequencies, some falling off occurs. This is influenced by (amongst other things) the speed of travel and magnetic properties of the tape, which together control tape self-demagnetisation.

If the reproducing head were free from losses, its output e.m.f. would be proportional to the tape surface induction, i.e., to the number of flux lines leaving or entering the tape through unit surface area. (For a constant intensity of remanent magnetisation, the surface induction, and consequently the reproducing-head e.m.f., is directly proportional to frequency.) In practice a reduction in output, accompanied by irregularities in response, may occur at low frequencies where the length of the recorded wave is comparable with that of the arc of contact between the head laminations and the tape; at the higher frequencies some scanning loss is unavoidable, owing to the finite width of the reproducing gap. (Cf. *Recording Training Manual*, Appendix F.) Further reproducing losses are caused by eddy currents induced in the head laminations, and by imperfect contact between the head and the tape. (At a frequency of 10 kc/s, the gap and eddy-current losses together amount to some 3 or 4 db.)

Equalisation

General

For an unequalised system, the overall response with a constant recording current rises from the bass, at first rapidly and then more gradually, to a ' turn-over ' point of the order of 3-6 kc/s; beyond this point the fall-off increases, and eventually becomes rapid.

Equalisation is divided between the recording and reproducing chains, and with any given heads the nature and amount of equalisation required for optimum results depends on linear recording speed and on tape properties.

To enable recordings made on one equipment to be reproduced satisfactorily on another, some means of standardising the surface-induction/frequency characteristic of the tape is required. The proposed international standard characteristic is defined in terms of two concepts:

(1) An *Ideal Reproducing Head*, the e.m.f. of which is proportional to the tape surface induction.

(2) A *Standard Reproducing Chain*, incorporating an *Ideal Reproducing Head*, followed by an amplifier with a prescribed frequency-response characteristic.

The frequency response of any actual reproducing chain can be standardised if allowance is made for reproducing-head losses. The requirement of a linear output then effectively defines the frequency characteristic of tape surface induction, and for a given recording head and tape the frequency-response characteristic required in the recording chain at a given linear speed is similarly fixed.

Ideal Reproducing Head

An ' Ideal Reproducing Head ' is defined simply as a reproducing head with negligible losses.

Normally, this means that the gap is short and the arc of contact with the tape long, compared to the relevant wavelengths, and that the losses in the material of the head are small. With a constant surface induction from the tape, the e.m.f. of an ideal head is the same at all frequencies. For constant-current recording, it can be shown that, neglecting all losses, the surface induction and therefore the output e.m.f. increase at 6 db per octave.

Standard Reproducing Chain

The International Radio Consultative Committee (C.C.I.R.) proposes* ' that for recording on magnetic tape at speeds of 30 in./sec and 15 in./sec, a " Standard Reproducing Chain " be defined as one having the same response as an " Ideal Reproducing Head " the e.m.f. of which is amplified in an amplifier with a response curve that results from the superposition of a curve that falls at the rate of 6 db per octave and a curve that rises with increase of frequency in conformity with the admittance of a parallel combination of a capacitance and a resistance with a time constant of 35 microseconds.'

With normal reproducing heads, an equalisation to compensate for the head losses must be added to the reproducing amplifier, as mentioned. With well-designed heads the losses are nearly the same at both tape speeds, and a mean value of equalisation may be used.

Calibration

The relative surface inductions at different frequencies on a coated tape can be measured,* and from such measurements the departure of any actual reproducing head from the ideal can be deduced. Consequently, a ' Standard Reproducing Chain ' can be established as a primary standard. Test tapes can then be made which can serve as secondary standards for use in normal operation.

*' Draft Recommendations of C.C.I.R. Study Group X, Geneva 1952.' *Sound Recording and Reproduction (The Official Journal of the British Sound Recording Association)*, Vol. 4, No. 1 (Dec., 1952), pp. 12-16.

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*This Manual is also published by Iliffe under the title ' Sound Recording and Reproduction.'

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in **Instruction**

Station .... *Date* .... *Signature* ....

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in **Instruction**

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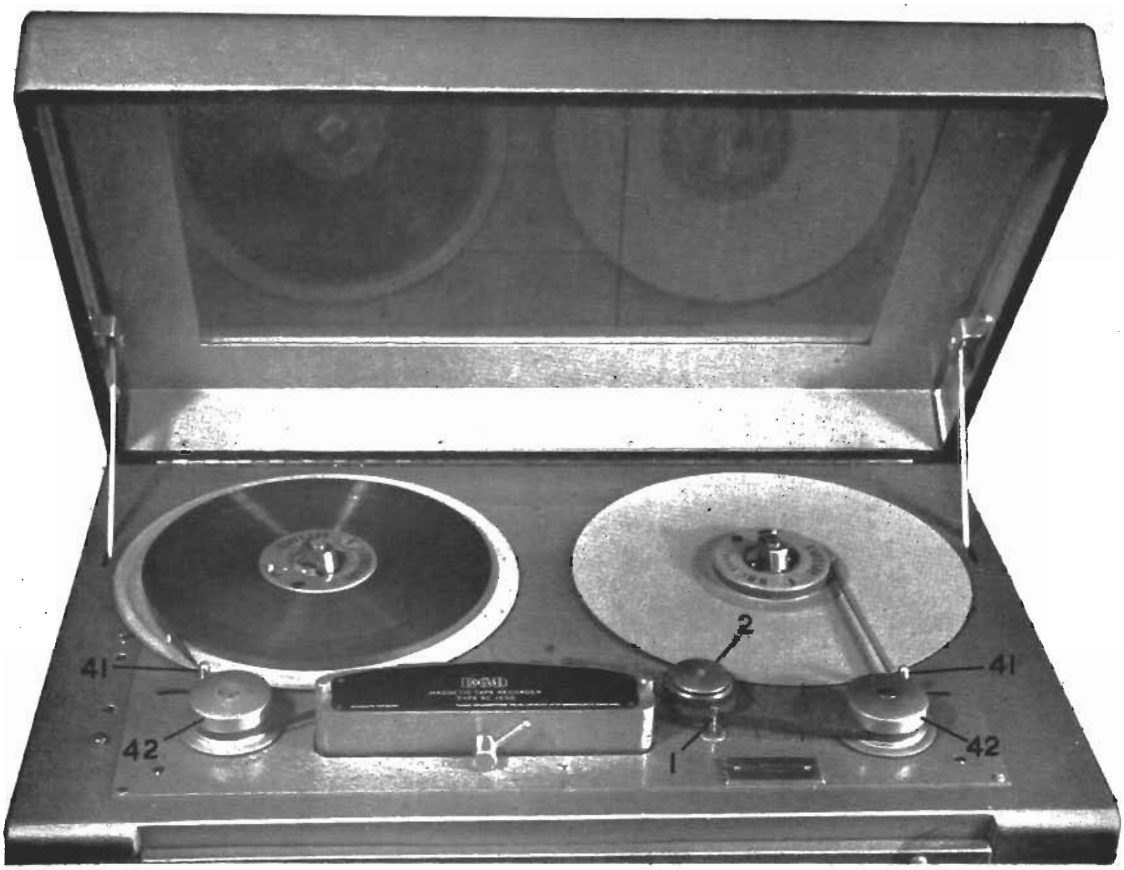


Fig. 1. Deck-plate Assembly

1. Tape-drive capstan
2. Pressure roller
41. Spring-tensioned tape-guide arms
42. Tape-guide pulleys

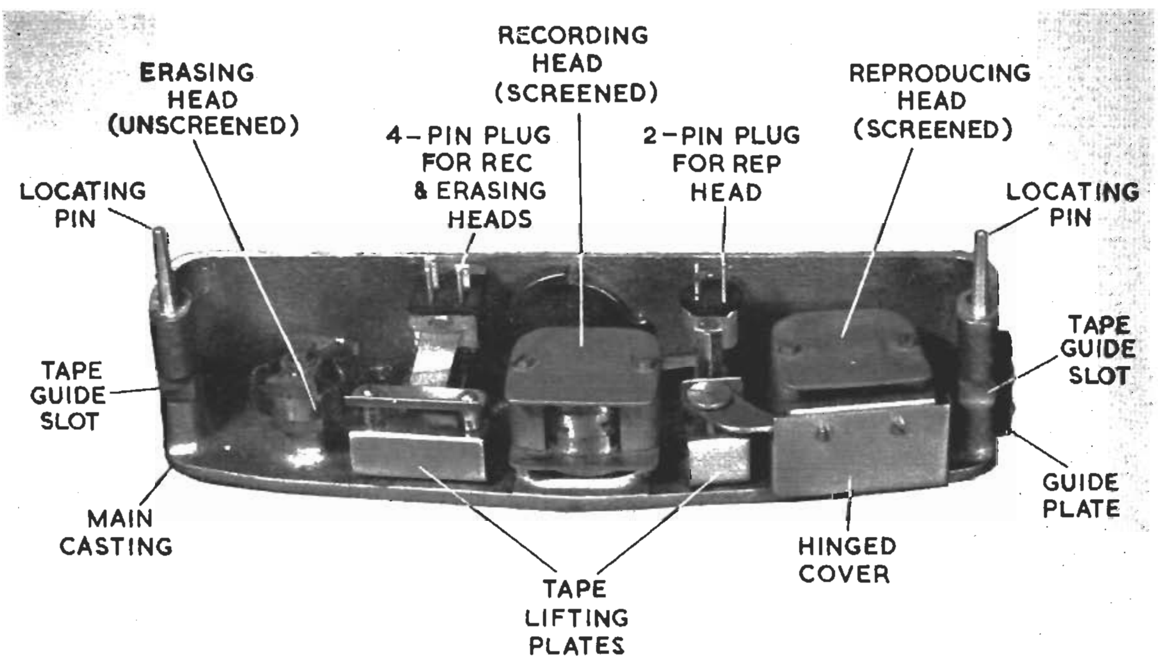


Fig. 2. Head Unit

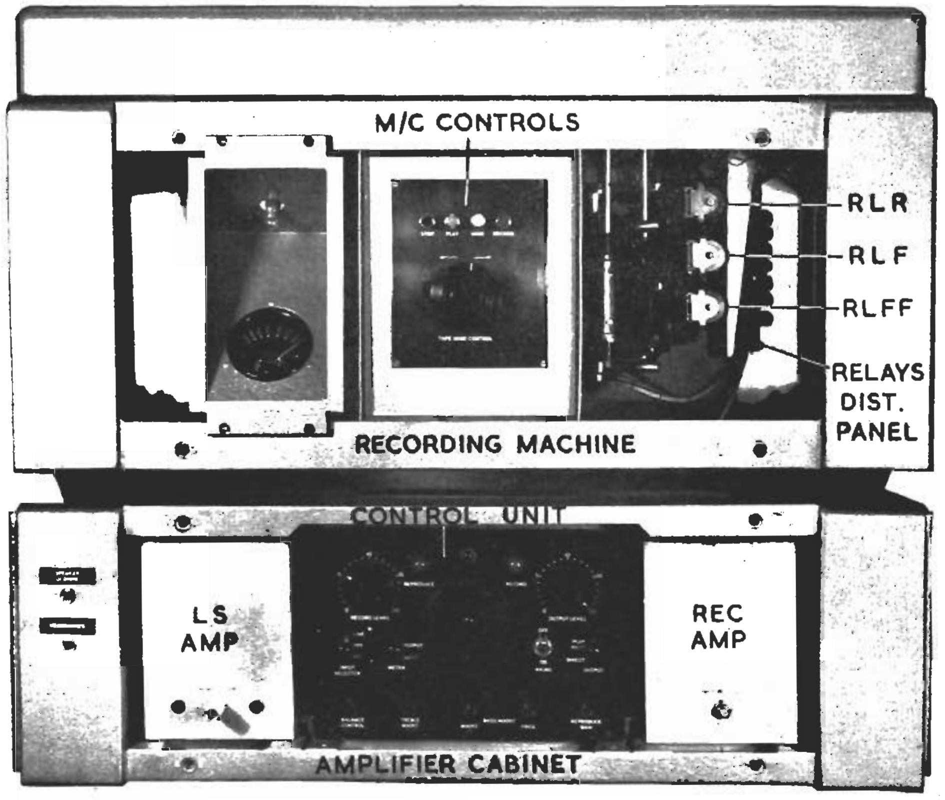


Fig. 3. Front View of Equipment

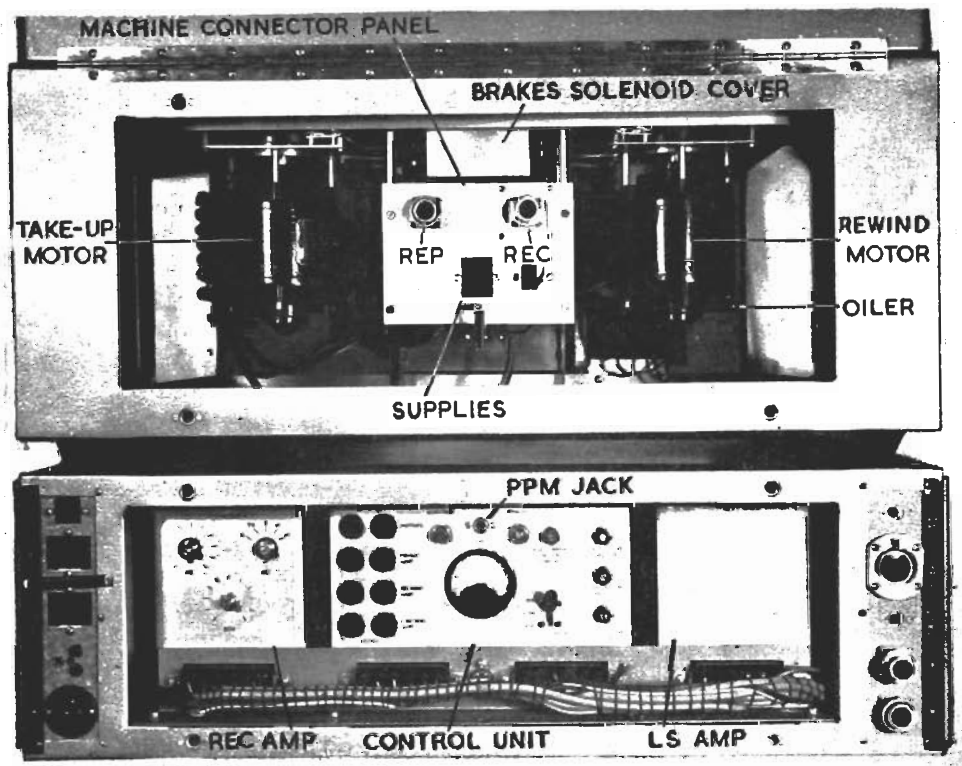


Fig. 4. Rear View of Equipment

KEYS TO FIGS. 5 & 6

1. Tape-drive capstan
2. Pressure roller
3. Pressure-roller spindle
4. Pressure-roller spindle crank-arm
5. Pressure-roller spindle eccentric crank-shaft
6. Pressure-roller cam
7. Pressure-roller cam-shaft
8. Limit stud for 4
9. Limit-stud bracket
10. Collar at lower end of 5
11. Crank at lower end of 7
12. Pressure-roller operating rod
13. Threaded extension rod
14. Pressure-roller solenoid mechanism
15. Spring between 12 and 14
16. Armature of 14
17. Fixed electromagnet of 14
18. Hinge between 11 and 13
21. Spool supporting plate
22. Brake drum (rewind motor)
23. Rewind-motor extension shaft
24. Spool-clamp securing screw
25. Spool clamp
26. Grommet on shaft 23
31. Band brake
32. Brake-mechanism armature bar
33. Brake-adjusting studs
34. Drive-motor brake lever
35. Drive-motor brake bell-crank

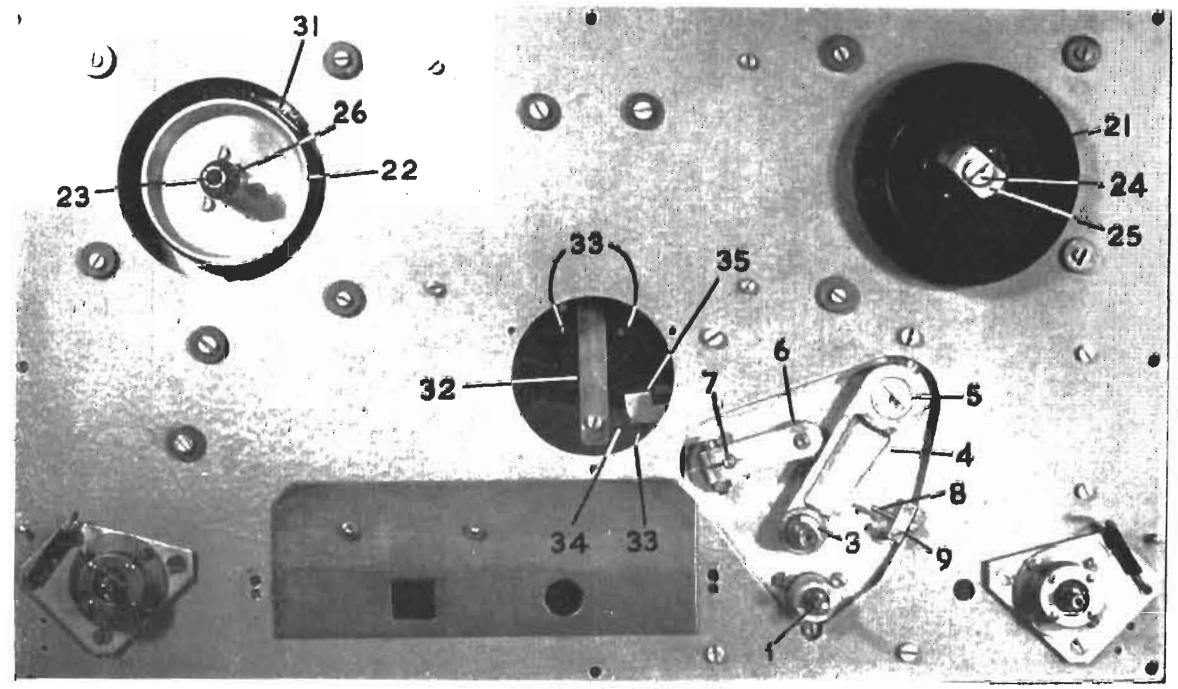


Fig. 5. Motor Plate

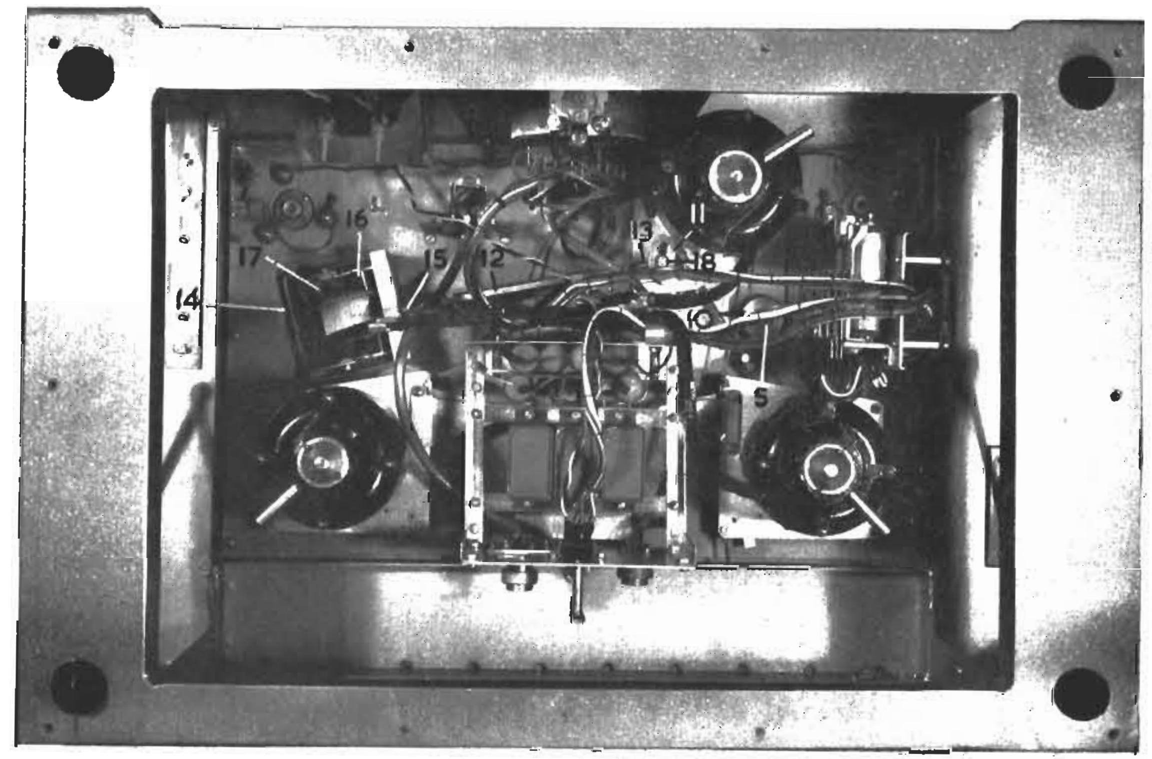
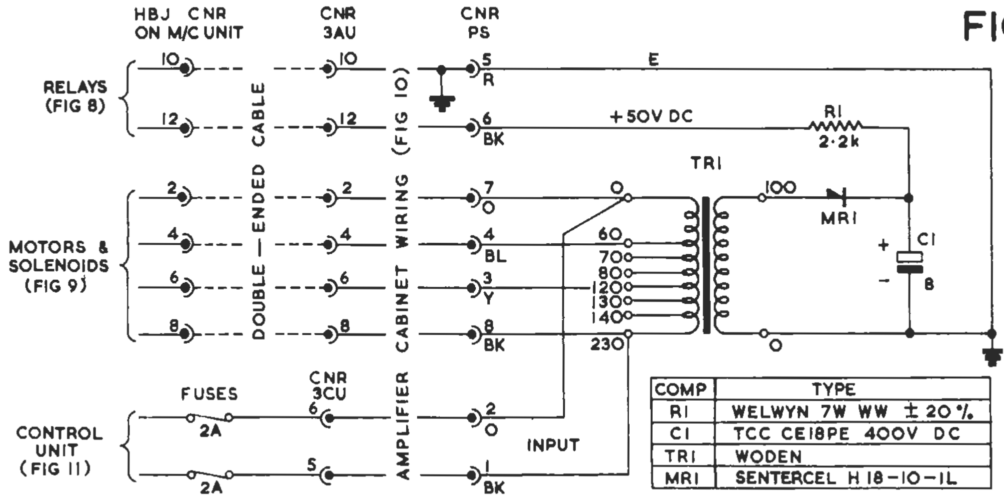


Fig. 6. Underside of Machine

FIG7

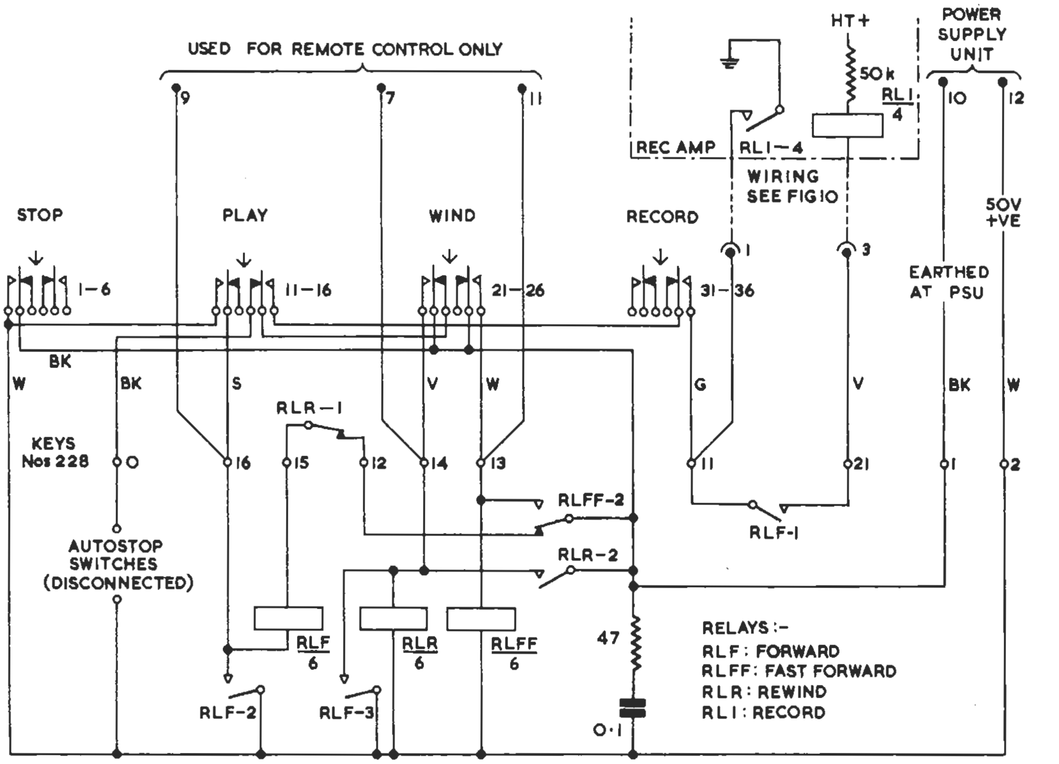


COMP	TYPE
R1	WELWYN 7W WW ± 20 %.
C1	TCC CE18PE 400V DC
TR1	WODEN
MR1	SENTERCEL H 18–10–1L

NOTE:– POWER SUPPLY UNIT BOLTED DOWN INSIDE AMPLIFIER CABINET

POWER SUPPLY UNIT CIRCUIT & INTERCONNECTIONS

FIG8



TERMINALS:–

12 ON HBJ PLUG ON REAR CONNECTOR PANEL

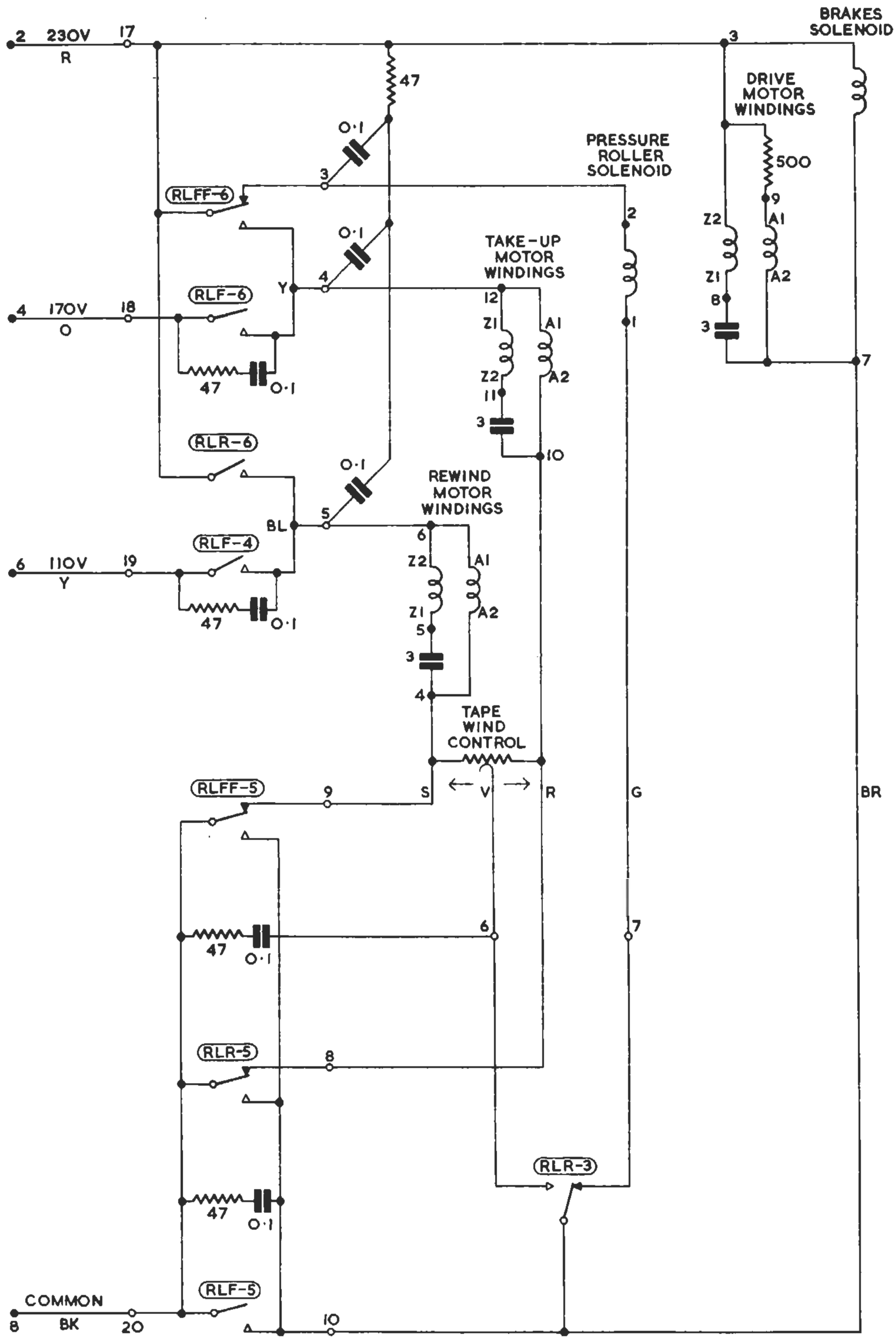
12 ON RELAYS DISTRIBUTOR PANEL

RELAY CONTACT UNITS RLFF 1-3-4 & RLR-4 NOT USED. AC–SWITCHING CONTACTS SHOWN IN FIG 9. 'RECORD' RELAY RL1 SHOWN IN FIGS 13 & 15

MACHINE UNIT : CONTROL CIRCUIT

52/GWH/136/DJE
RGD/990139
& 990154

FIG9



NOTES:- 1 MOTOR CAPACITORS ARE 2+(2×0·5)μF
2 FOR RELAY WINDINGS SEE FIG 8
3 TERMINALS: 4 HBJ PLUG REAR CONNECTOR PANEL
4 RELAYS DISTRIBUTOR PANEL
4 GRELCO BLOCK

MACHINE UNIT: POWER CIRCUIT

52/GWH/139/NIB
RGD/SK/10309

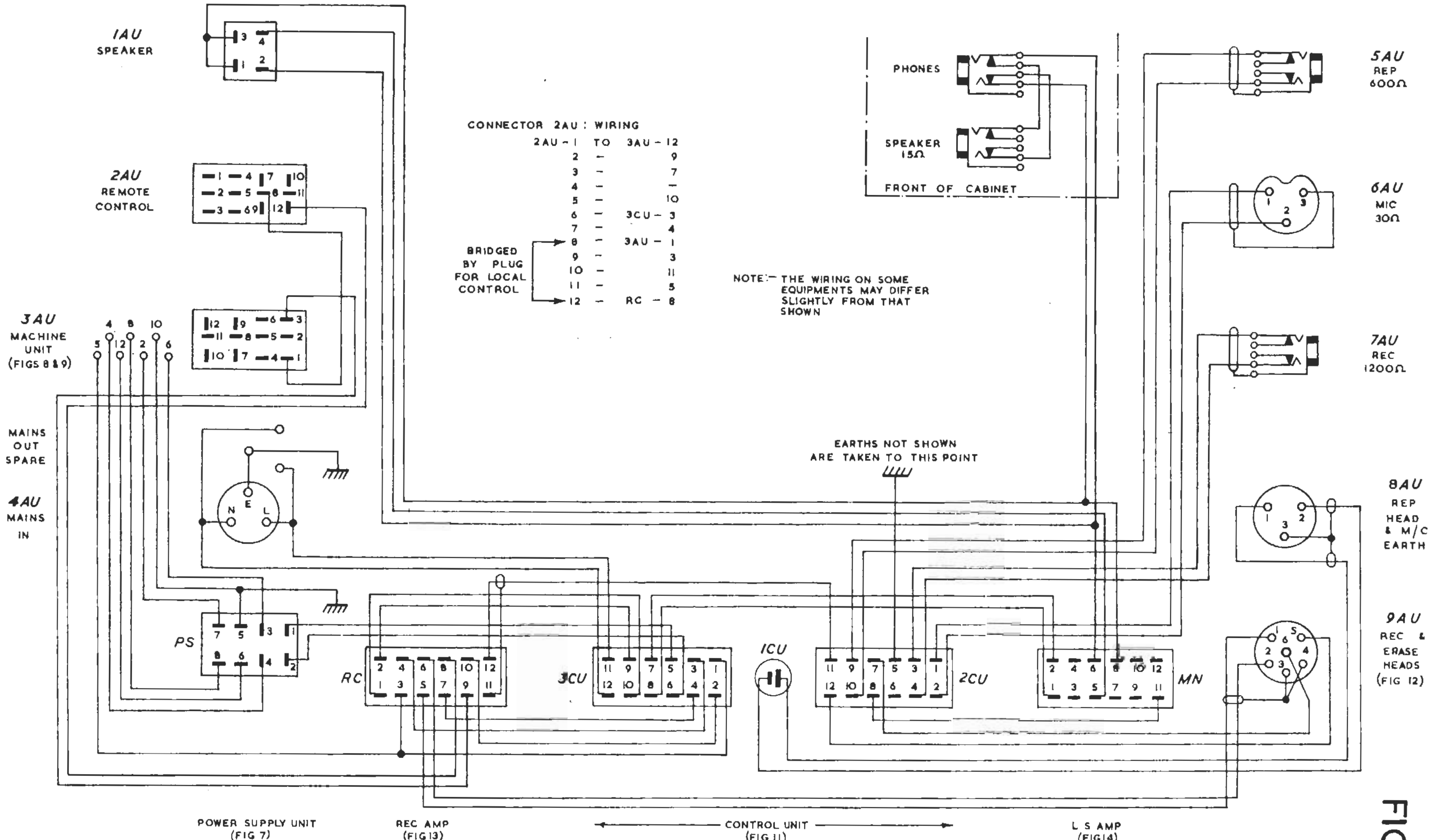


FIG10

AMPLIFIER CABINET : WIRING

COMPONENT TABLE: FIG. 11

Comp.	*Loc.*	*Type*
C1	D2, M11	T.C.C. CE37P
C2	E7	T.C.C. CE303
C3	D5	250 V Dubilier 412
C4	E3	350 V Sprague
C5	J7	T.C.C. CE18L
C6	K7	12 V T.C.C. CE30B
C7	K3	350 V Sprague
C8	K2	350 V T.C.C. CE11L
C9	K15	350 V T.C.C. CP47N
C10	W10	350 V T.C.C.
C11	P7	12 V T.C.C. CE30B
C12	S7	T.C.C. CP45N (Three in parallel)
C13	F10	T.C.C. CE37P
C14	H15	250 V Dubilier 412
C15	L15	12 V T.C.C. CE30B
C16	L16	250 V Dubilier 412
C17	M12	350 V Sprague
C18	S13	T.C.C. 401 SMP ± 2%
C19	S13	T.C.C. 101 SMP ± 2%
C20	R13	T.C.C. 101 SMP ± 2%
C21	N13	T.C.C. 401 SMP ± 2%
C22	O13	T.C.C. 401 SMP ± 2%
C23	N15	T.C.C. 425 SMP ± 2%
C24	R12	350 V Sprague
C25	P16	250 V Dubilier 412
C26	Q15	12 V T.C.C. CE30B
C27	R14	T.C.C. 101 SMP ± 2%
C28	E2	± 20%
C29	Q11, Y11	T.C.C. CE37P
C30	W12	350 V T.C.C. CP47N
C31	W15	12 V T.C.C. CE 30B
C32	J7	± 10%
R1	L10	½ W Erie ± 20%
R2	E1	½ W Erie ± 20%
R3	E3	½ W Erie ± 20%
R4	D3	½ W Erie ± 20%
R5	J3	½ W Erie ± 20%
R6	L5	½ W Erie ± 5%
R7	E7	¼ W Erie ± 20%
R8	H4	¼ W Erie ± 20%
R9	C5	¼ W Erie ± 20%
R10	K7	¼ W Erie ± 5%
R11	K2	½ W Erie ± 20%
R12	K3	½ W Erie ± 20%
R13	F7	¼ W Erie ± 20%
R14	H5	Electronics
R15	L7	LHNAR 50450
R16	Q5	LHNAR 50450
R17	Q7	¼ W Erie ± 20%
R18	R7	¼ W Erie ± 5%
R19	U7	LHNAP 10250
R20	U5	¼ W Erie ± 5%
R21	U4	LHNAP 50350
R22	T5	½ W Erie ± 20%

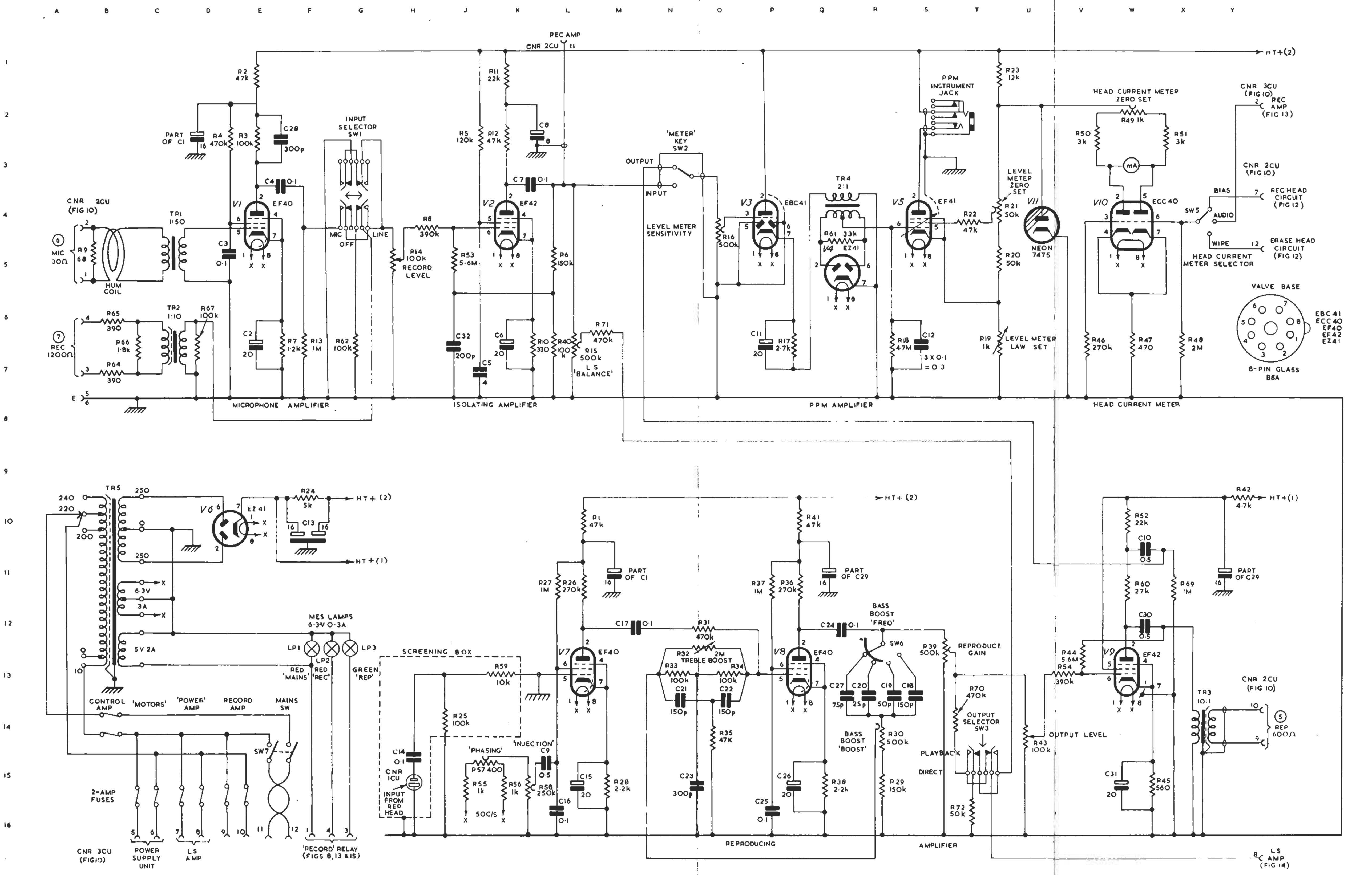
Comp.	*Loc.*	*Type*
R23	U1	½ W Erie ± 20%
R24	F10	7 W Painton W.W. P301
R25	J14	¼ W Erie ± 20%
R26	L11	½ W Erie ± 20%
R27	K11	½ W Erie ± 20%
R28	M15	¼ W Erie ± 20%
R29	R15	¼ W Erie ± 5%
R30	R14	LHNAP 50450
R31	O12	¼ W Erie ± 5%
R32	O13	LHNAP 20550
R33	N13	¼ W Erie ± 5%
R34	O13	¼ W Erie ± 5%
*R35	O14	¼ W Erie ± 5%
R36	P11	½ W Erie ± 20%
R37	P11	½ W Erie ± 20%
R38	Q15	¼ W Erie ± 20%
R39	S13	LHNAR 50450
R40	L7	¼ W Erie ± 5%
R41	P10	½ W Erie ± 20%
R42	V10	½ W Erie ± 20%
R43	V14	Electronics
R44	V13	½ W Erie ± 20%
R45	W15	½ W Erie ± 5%
R46	V7	¼ W Erie ± 20%
R47	W7	¼ W Erie ± 5%
R48	X7	½ W Erie ± 5%
R49	W2	LHNAP 10250
R50	V2	½ W Erie ± 5%
R51	X2	½ W Erie ± 5%
R52	W10	½ W Erie ± 10%
R53	J5	½ W Erie ± 20%
R54	V13	¼ W Erie ± 5%
R55	J15	½ W Erie ± 20%
R56	K15	½ W Erie ± 20%
R57	J15	Wirewound
R58	K15	LHNAR 25450
R59	K13	¼ W Erie ± 20%
R60	W11	½ W Erie ± 10%
R61	Q5	¼ W Erie
R62	G7	¼ W Erie
R63	—	
R64	B7	¼ W Erie ± 5%
R65	B6	¼ W Erie ± 5%
R66	C7	¼ W Erie ± 5%
R67	D7	¼ W Erie
R68	—	
R69	X11	¼ W Erie ± 20%
R70	T14	¼ W Erie
R71	M6	¼ W Erie
R72	T16	¼ W Erie
TR1	C5	R.G.D.
TR2	C7	Parmeko
TR3	Y14	Parmeko
TR4	Q4	Woden
TR5	B10	Woden

*R35 is adjusted on test so that filter tunes at 11 kc/s.

52/GWH/133/NIB
RGD/990165

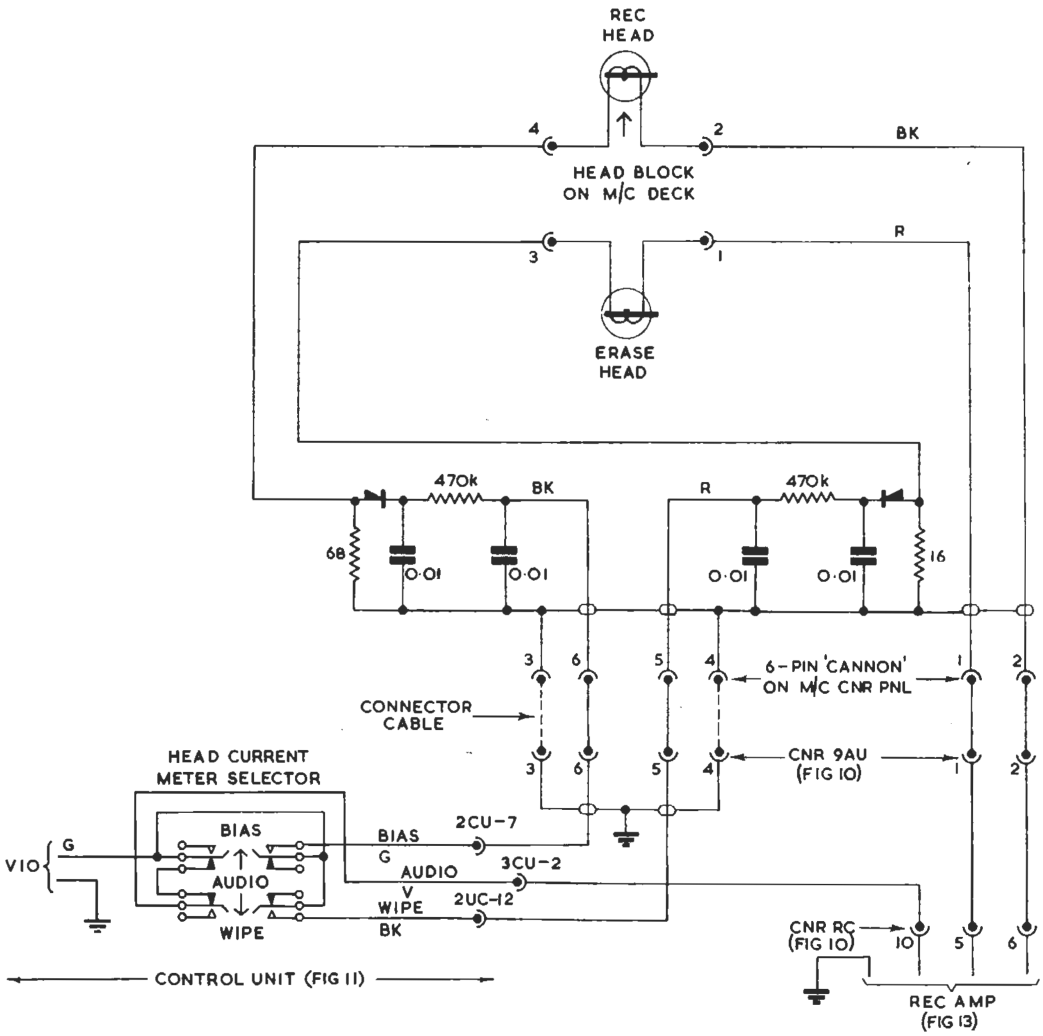
FIG 11

R6



CONTROL UNIT: CIRCUIT

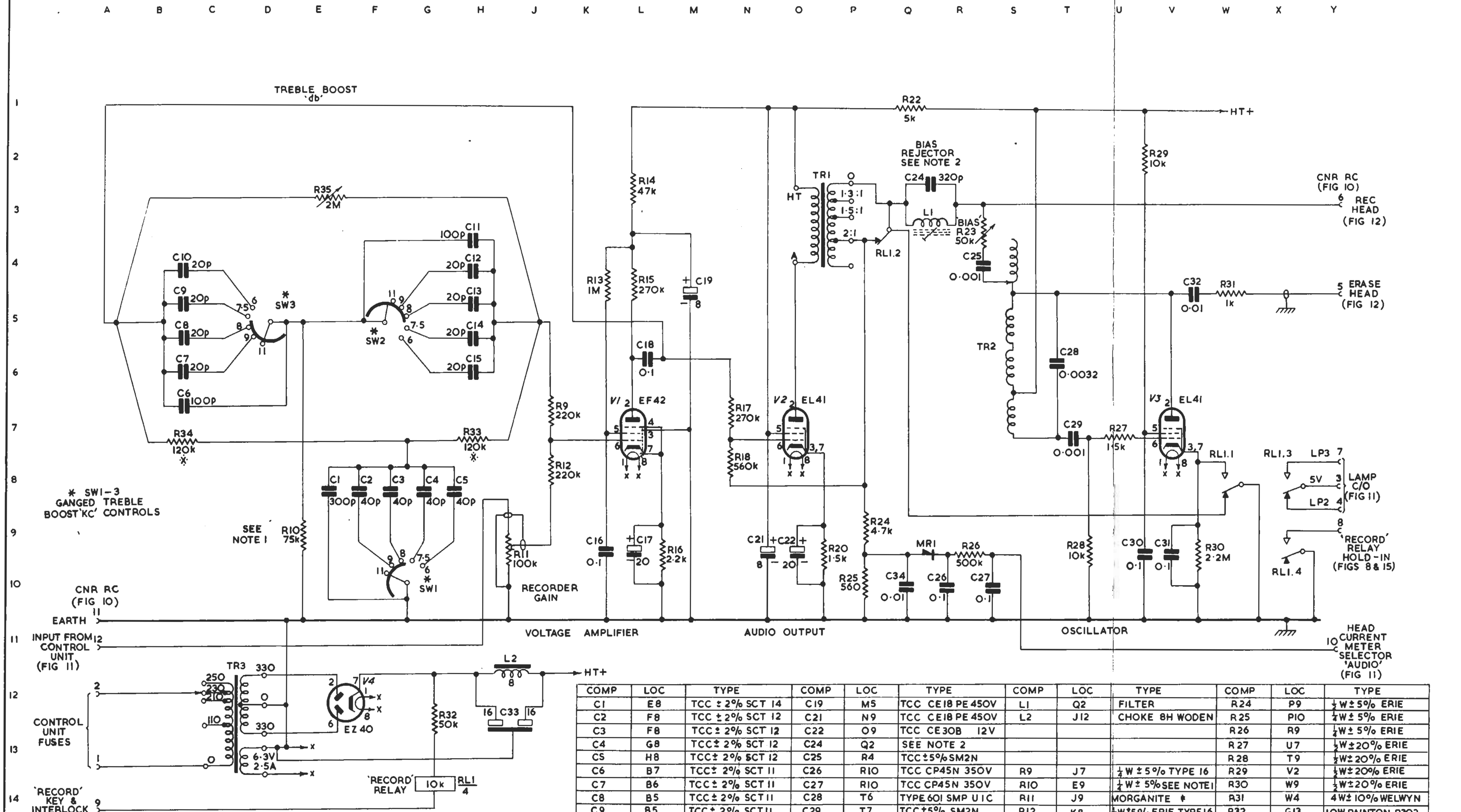
FIG12 R6



HEAD-CURRENT METER: INPUT CIRCUIT

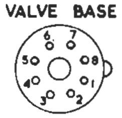
52/GWH/132/AJP
RGD/990164

FIG 13 R6



NOTES:- 1 R10 ADJUSTED ON TEST SO THAT FILTER TUNES AT 11 kc/s
2 C24 ADJUSTED ON TEST SO THAT FILTER REJECTS 50 kc/s BIAS

VALVE BASE



B8A

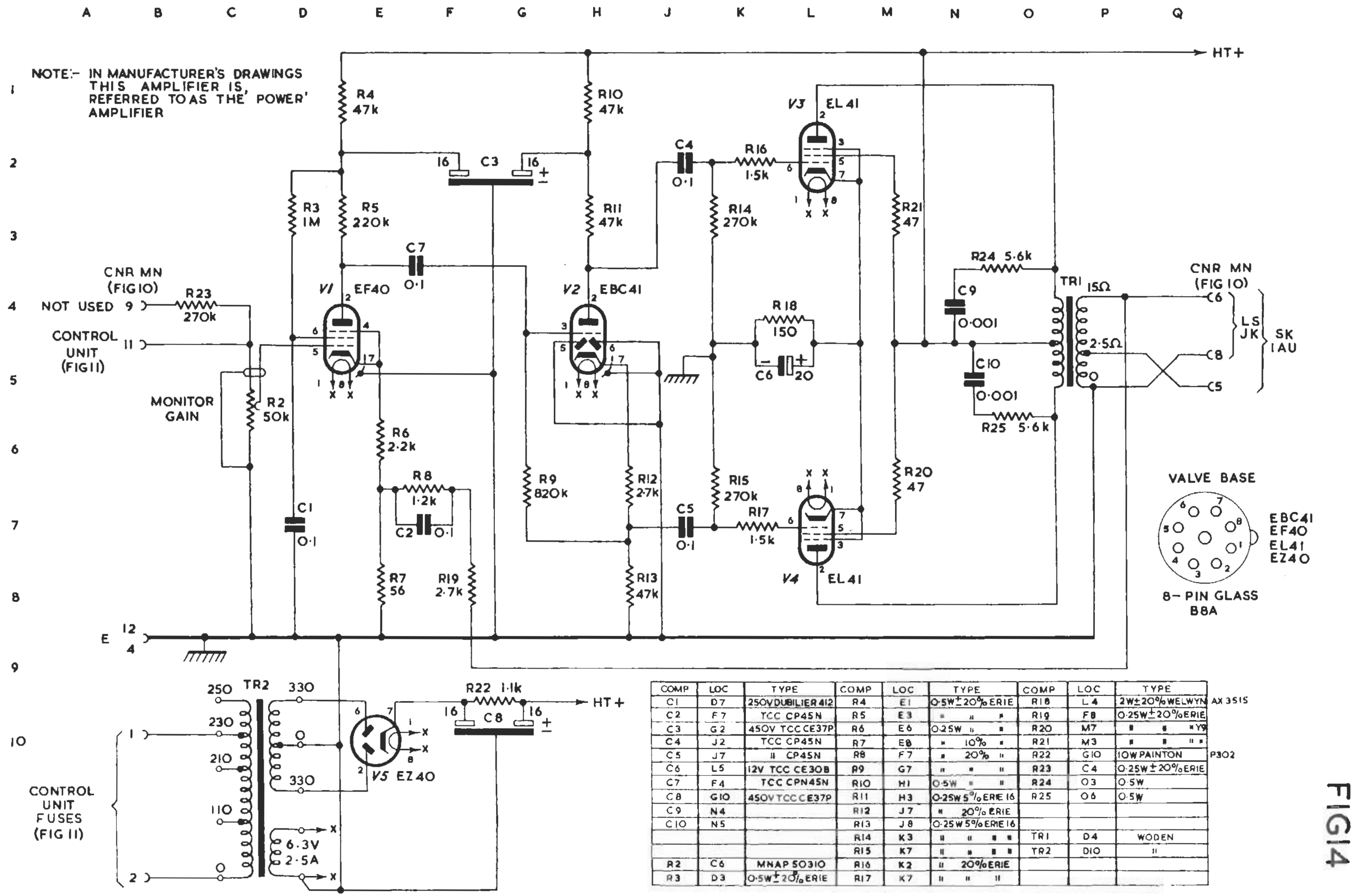
* LHNAR 10450

⁂ TWO RESISTORS IN PARALLEL

COMP	LOC	TYPE	COMP	LOC	TYPE	COMP	LOC	TYPE	COMP	LOC	TYPE
C1	E8	TCC ± 2% SCT 14	C19	M5	TCC CE18 PE 450V	L1	Q2	FILTER	R24	P9	½W ± 5% ERIE
C2	F8	TCC ± 2% SCT 12	C21	N9	TCC CE18 PE 450V	L2	J12	CHOKE 8H WODEN	R25	P10	¼W ± 5% ERIE
C3	F8	TCC ± 2% SCT 12	C22	O9	TCC CE30B 12V				R26	R9	¼W ± 5% ERIE
C4	G8	TCC ± 2% SCT 12	C24	Q2	SEE NOTE 2				R27	U7	½W ± 20% ERIE
C5	H8	TCC ± 2% SCT 12	C25	R4	TCC ± 5% SM2N				R28	T9	½W ± 20% ERIE
C6	B7	TCC ± 2% SCT 11	C26	R10	TCC CP45N 350V	R9	J7	¼W ± 5% TYPE 16	R29	V2	½W ± 20% ERIE
C7	B6	TCC ± 2% SCT 11	C27	R10	TCC CP45N 350V	R10	E9	¼W ± 5% SEE NOTE 1	R30	W9	½W ± 20% ERIE
C8	B5	TCC ± 2% SCT 11	C28	T6	TYPE 601 SMP U1C	R11	J9	MORGANITE *	R31	W4	4W ± 10% WELWYN
C9	B5	TCC ± 2% SCT 11	C29	T7	TCC ± 5% SM2N	R12	K8	½W ± 5% ERIE TYPE 16	R32	G13	10W PAINTON P302
C10	B4	TCC ± 2% SCT 13	C30	U9	TCC CP46S 500V	R13	K4	½W ± 20% ERIE TYPE 16	R33	H7	½W ± 5%
C11	H3	TCC ± 2% SCT 13	C31	V9	TCC CP45N 350V	R14	L3	½W ± 20% ERIE TYPE 16	R34	B7	½W ± 5%
C12	H4	TCC ± 2% SCT 11	C32	V4	TCC METALMITE	R15	L4	½W ± 20% ERIE TYPE 16	R35	E3	
C13	H5	TCC ± 2% SCT 11	C33	J12	CE37P 450V	R16	L9	¼W ± 20% ERIE TYPE 16			
C14	H5	TCC ± 2% SCT 11	C34	Q9	TCC METALMITE	R17	M7	½W ± 5% ERIE TYPE 16	TR1	O3	WODEN
C15	H6	TCC ± 2% SCT 11				R18	N9	¼W ± 5% ERIE TYPE 16	TR2	S5	RGD
C16	K9	DUBILIER 412 250V				R20	P9	½W ± 20% ERIE	TR3	C12	WODEN
C17	L9	TCC CE30B 12V				R22	Q1	⁂ ½W ± 20% EACH			
C18	L6	TCC CP45N 350V	MR1	Q9	GERMANIUM	R23	S3	5W POT RELIANCE WW			

RECORDING AMPLIFIER : CIRCUIT

52/GWH/13U/NIB
RGD/990163



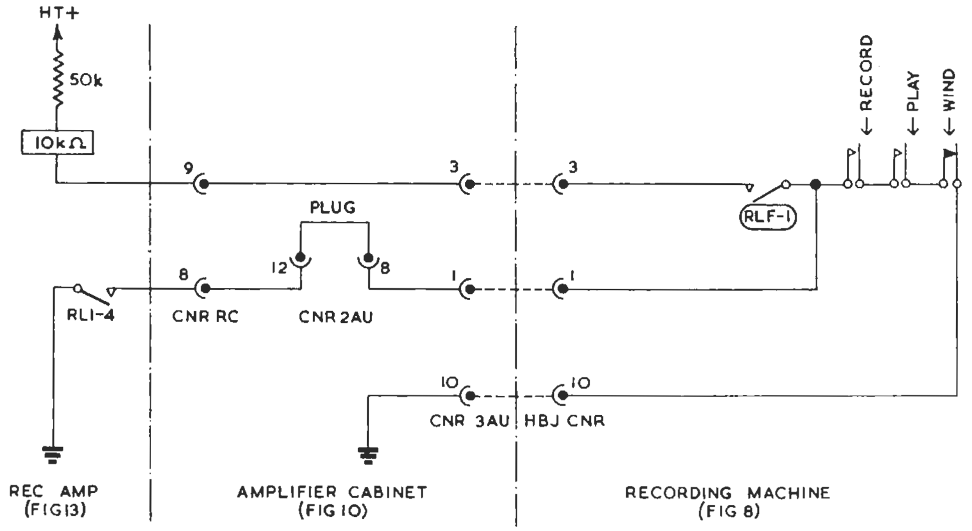
COMP	LOC	TYPE	COMP	LOC	TYPE	COMP	LOC	TYPE
C1	D7	250V DUBILIER 412	R4	E1	0·5W ± 20% ERIE	R18	L4	2W ± 20% WELWYN AX 3515
C2	F7	TCC CP45N	R5	E3	" " "	R19	F8	0·25W ± 20% ERIE
C3	G2	450V TCC CE37P	R6	E6	0·25W " "	R20	M7	" " " Y9
C4	J2	TCC CP45N	R7	E8	" 10% "	R21	M3	" " " "
C5	J7	" CP45N	R8	F7	" 20% "	R22	G10	10W PAINTON P302
C6	L5	12V TCC CE30B	R9	G7	" " "	R23	C4	0·25W ± 20% ERIE
C7	F4	TCC CPN45N	R10	H1	0·5W " "	R24	O3	0·5W
C8	G10	450V TCC CE37P	R11	H3	0·25W 5% ERIE 16	R25	O6	0·5W
C9	N4		R12	J7	" 20% ERIE			
C10	N5		R13	J8	0·25W 5% ERIE 16			
			R14	K3	" " " "	TR1	D4	WODEN
			R15	K7	" " " "	TR2	D10	"
R2	C6	MNAP 50310	R16	K2	" 20% ERIE			
R3	D3	0·5W ± 20% ERIE	R17	K7	" " "			

FIG 14

LOUDSPEAKER AMPLIFIER : CIRCUIT

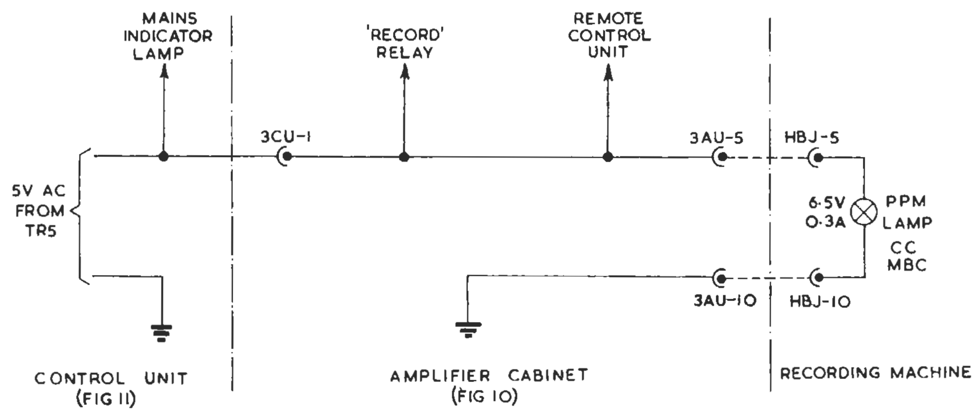
R6

FIG15



RECORD RELAY: 'OPERATE' & 'HOLD-IN' CIRCUITS

FIG16



PPM LAMP CIRCUIT

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