TECHNICAL INSTRUCTION
R. 9

Leevers-Rich Transportable Tape Recorder

BRITISH BROADCASTING CORPORATION

ENGINEERING DIVISION

TECHNICAL INSTRUCTION

R.9

Leevers-Rich

Transportable Magnetic Tape Recorders

Part 1 : Battery-operated Recorder

Part 2 : Mains-operated Recorders

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Part 2: *First issue July* 1960

PART 1: BATTERY-OPERATED RECORDER

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LEEVERS-RICH
TRANSPORTABLE MAGNETIC TAPE RECORDERS

PART 1 : BATTERY-OPERATED RECORDER

SECTION 1

INTRODUCTION

The Leevers-Rich d.c. tape recorder used by the BBC is operated from a 12-volt battery and is intended for working at a single tape-speed of 15 in./sec. Three motors are used for tape transport purposes, whilst a small built-in rotary convertor provides the amplifier h.t. supply. Most recorders in service are of the maker's DB2 series, slightly modified to meet BBC requirements. All can be used with quarter-inch tape on spools of up to 10 inches diameter fitted with N.A.B. or European or cine-type centres.

Fig. 1.1. General View of Equipment

The complete equipment comprises two units, a recording machine and an amplifier unit ; these are operated side-by-side, with the amplifier unit on the left as shown in Fig. 1.1. The equipment is connected by three cables. One connects the reproducing head to the reproducing amplifier, a second connects the recording amplifier to the recording head and carries l.t. and h.t. supplies from the machine unit to the amplifiers, and the third connects the battery to the machine.

The recording chain has two separately controlled inputs which can be used either with two microphones of 25 to 50 ohms impedance or with one such microphone and a 600-ohm line. Monitoring is normally carried out on headphones during recording, and facilities are provided for playback either via a 15-ohm or 300-ohm loudspeaker or to a 600-ohm line. A volume-indicating meter is fitted, calibrated in dB and provided with a single-stage amplifier ; neither meter nor amplifier is of the BBC P.P.M: type.

The erase and bias currents are provided by a 60-kc/s oscillator. Two further oscillators supply 100 c/s to a neon stroboscope lamp and 1 kc/s for use as a test tone.

The recording machine and the amplifier unit are housed in two welded light-alloy cases covered in polythene. The front panel of the amplifier unit and the deck of the recording machine carry the main controls, and they are protected during transport by detachable covers fastened by trunk-catches, shown closed in Fig. 1.2.

The current consumption from the battery varies from about 2·5 amps in the standby condition with the h.t. set and all tape transport motors at

rest to 11 amps or more during recording.

The recording machine is 13 in. high, 18 in. wide and 16½ in. from front to back, and weighs 58½ lb. The amplifier unit is 9¼ in. high, 18 in. wide and 9 in. from front to back, and weighs 21 lb. Both units are fitted with carrying handles, and can be lifted by a single person without difficulty, although if the recording machine has to be moved far, the assistance of a second person should be obtained.

The recorder is robust, and performance is good for an easily transportable battery-driven machine. Its main limitation is a slight tendency for the tape-speed to drift as the drive-motor windings become heated in use. This makes it unsuitable for making long continuous recordings of music, since completely unnoticeable speed adjustments during music are difficult to achieve. The same manufacturer also produces a.c.-operated models which overcome this difficulty.

The original design of the Leevers-Rich equipment provided for half-track recording of programme, with a synchronising signal for cinematograph purposes recorded on the other half-track via an additional recording head. This provision has been omitted from equipment supplied to the BBC, and full-track recording and reproducing heads have been fitted.

Fig. 1.2. Amplifier and Machine Unit with Covers Closed

SECTION 2

RECORDING MACHINE

General Description

The three tape transport motors are mounted directly beneath the deck-plate of the machine. One motor is used to drive the tape capstan and the others for take-up and rewind. The capstan-drive motor is shunt wound, with a variable resistance in the field circuit for speed adjustment ; the take-up and rewind motors are series-wound machines.

Fig. 2.1 shows how the tape travels through the machine. During normal forward operation the tape is pulled off the left-hand spool by the drive capstan, against which it is held by a rubber-faced pressure roller, and is wound onto the right-hand spool by the take-up motor, operating under reduced power via a resistance in series with the 12-volt battery supply. The rewind motor is not energised, although the left-hand spool has light braking applied.

A brake is also fitted to the right-hand spool, and the braking applied to each spool is controlled by tape tension via two jockey pulleys. Before the tape reaches the heads, it passes round a further pulley, which bears stroboscopic markings and is attached to a small flywheel beneath the deck-plate. The flywheel (Fig. 2 : 39)* is provided to damp out tape-speed fluctuations caused by the operation of the left-hand brake. Attached to the flywheel is a disk (37) with stroboscopic perforations through which the neon (38) operated from the 100-c/s oscillator is visible through a hole in the deck-plate. (Fig. 1 : 18.)

The principal machine controls are mounted on the deck-plate as illustrated in Fig. 1.

At the back of the deck-plate is a shallow panel, to which are connected the two cables from the amplifier unit and the one from the battery. The connector (1) at the extreme left of the panel terminates the cable which connects the reproducing head to the reproducing amplifier. The connector (2) terminates the cable supplying h.t. and l.t. to the amplifier unit and the audio-frequency recording input to the machine. The extreme right-hand connector (11) terminates the battery cable ; the connector to the left of this, labelled *Aux.*, is wired in parallel but not used. A pre-set control (9), marked *Strobe*, to the left of this is used to adjust the frequency of the 100-c/s stroboscope-lamp oscillator. A further connector, labelled *Pulse*, is not used by the BBC. Details of cables are shown in Figs. 10, 11 and 12 at the end of the Instruction.

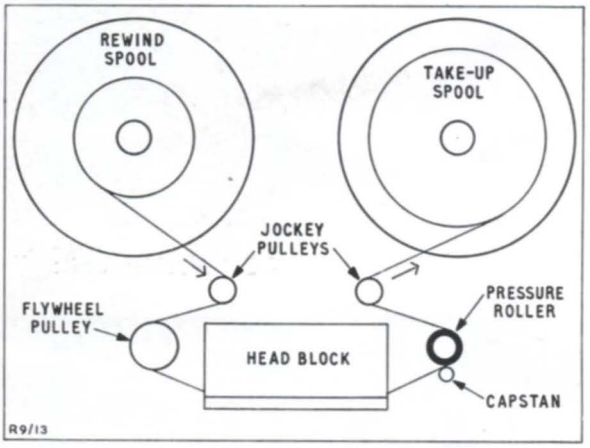

Fig. 2.1. Tape Lacing Diagram

The deck-plate is hinged at the rear (36) below the narrow connector panel, and can be lifted by a handle in front of the head unit if two captive screws (30, 18) at the front left and right-hand corners are undone. Two semicircular latches (Fig. 2) are provided to hold the deck in the raised position.

Beneath the deck-plate is a framework (Fig. 2) supporting a tray-like chassis (Fig. 2.2) which carries the h.t. rotary convertor and the 60-kc/s and 100-c/s oscillators. The main electrical connections with the tray-mounted apparatus are made by means of a 12-pin plug and socket on the left, behind the 60-kc/s oscillator. The wiring to the neon stroboscope lamp and to the pre-set *Strobe* control is conveyed via two single-pin

* *Figs.* 1, 2 *and* 3, *at the back of the Instruction, should be opened out to facilitate cross reference.*

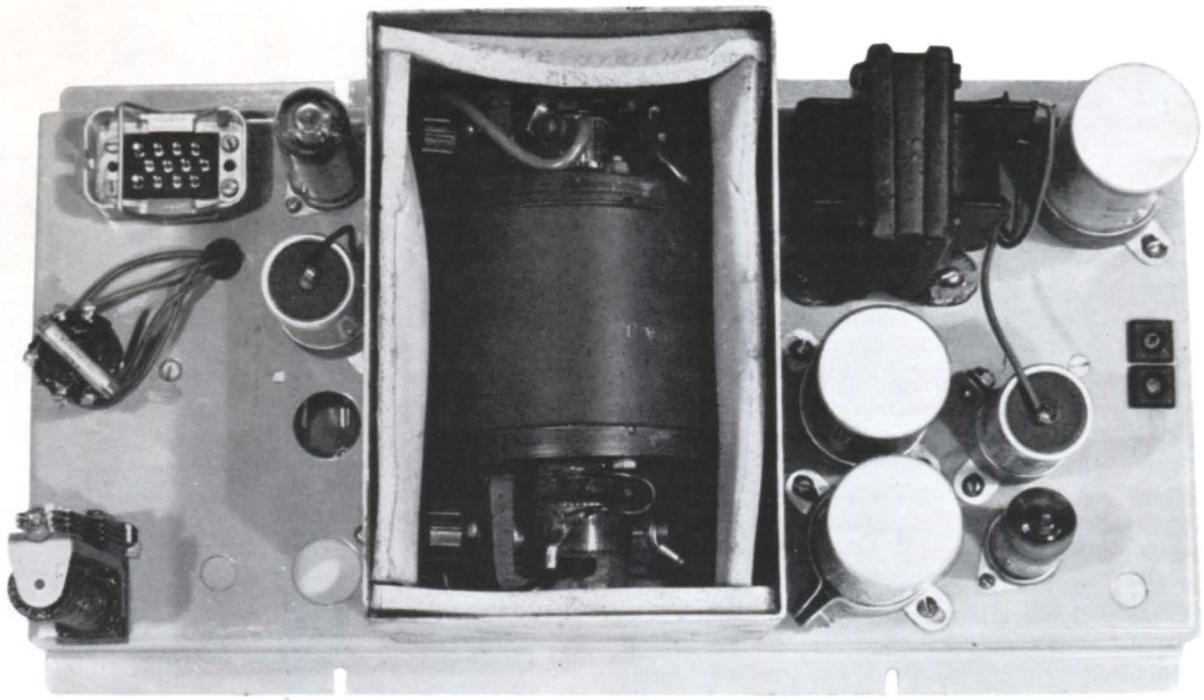

Fig. 2.2. Machine Unit: Tray with H.T. Set and Oscillators

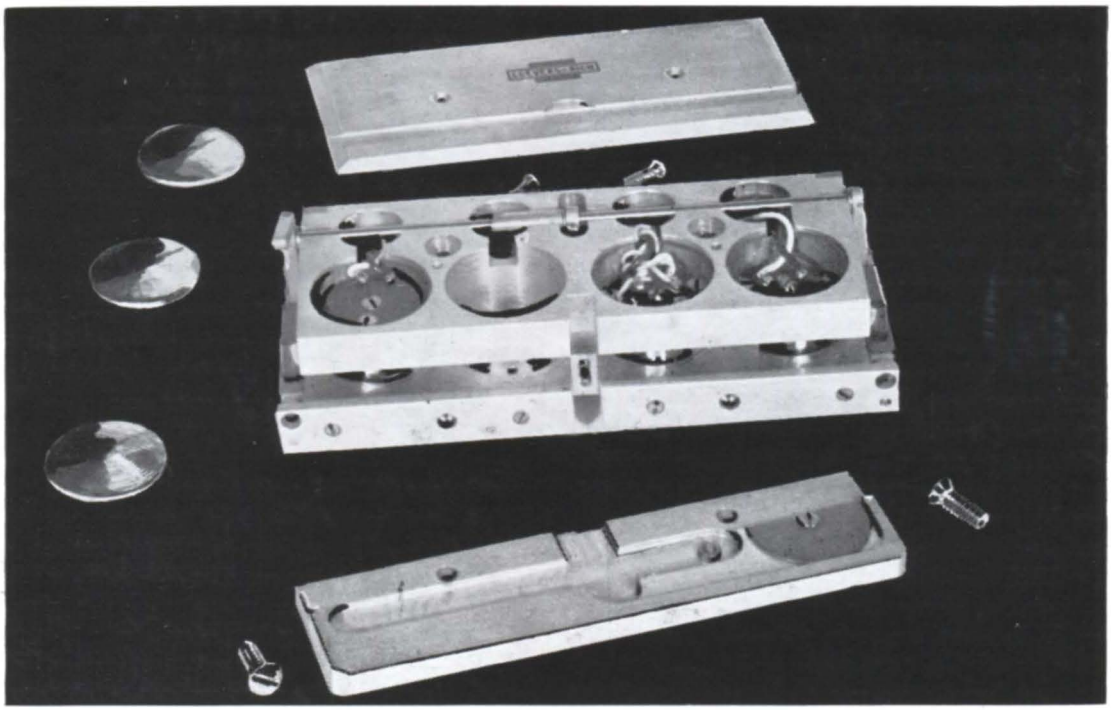

Fig. 2.3. Head Unit with Covers Removed

connectors at the right-hand side of the tray adjacent to the 100-c/s oscillator.

Also beneath the deck-plate, on the capstan shaft, is a further flywheel, and below this, connected via a flexible coupling, is the driving motor. This arrangement acts as a mechanical filter, and thus prevents motor rumble from reaching the tape. The capstan, with its flywheel and motor, together with the pressure roller and arm assembly, are constructed as a separately demountable unit, which is bolted to the deck-plate.

which can be reached with the heads in position except on a few early machines where the screws are underneath the head-block. Electrical connection with the heads is via individual 3-pin plugs let into the deck-plate which engage with corresponding sockets in the underside of the block.

Fig. 2.3 shows the head unit with the top and front covers of the block and the cover disks of the screening cans removed. An additional screen to protect the reproducing head gap is fitted inside the front cover of the block and is visible

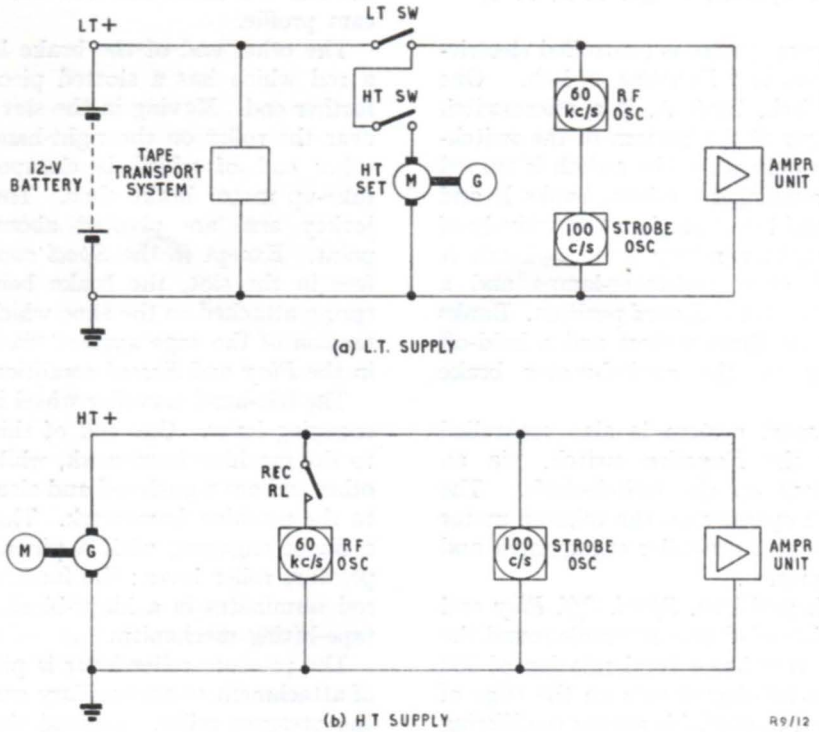

Fig. 2.4. Power Distribution

Head Unit

The head unit is a duralumin block, with cylindrical recesses for the heads and cut-outs to accommodate the mechanism which lifts the tape clear of the heads when the *Function* switch is in the *Spool* or *Off* position. Three screened full-track heads are fitted, one each for erasing, recording and reproducing, taken from left to right in that order, although there is space for a further head between the erasing and recording heads. The recording and reproducing heads are each fitted with two azimuth aligning screws in the photograph. Two long screws (not shown) secure the block to the deck, and are normally hidden by the top cover. Also shown are the cover-fixing screws.

Power Supplies

The routing of power supplies is shown schematically in Fig. 2.4, in which the upper and lower diagrams show the l.t. and h.t. supply circuits respectively. The input from the battery is connected to the tape transport mechanism, which is controlled by the *Function* switch. The

positive side of the battery input is also taken to the l.t. switch on the recorder, which controls the heater supply to all valves. Connected across the valve heater circuits is the l.t. winding of the rotary convertor (Fig. 4) controlled by the h.t. switch. An h.t. supply is delivered by the convertor to the valves in the machine unit and in the amplifier unit, the 60-kc/s oscillator valve in the machine unit receiving its h.t. supply through one of the contacts of a relay which operates when the *Function* switch is on *Record*.

Tape Transport System (Figs. 1, 2, 3, 4)

Function Switch

The tape transport system is controlled electrically by a four-position *Function* switch. One section of the switch, bank A, is a microswitch operated by a finger at the bottom of the switch-shaft and engages only when the switch is turned to *Record*. The remaining sections, banks B and C, are the upper and lower portions respectively of a two-way four-position rotary switch. Bank A controls red and green indicator-lamps and a relay which operates in the *Record* position. Banks B and C control the three motors and a hold-off magnet operating on the rewind-motor brake mechanism.

The tape transport system is also controlled mechanically by the *Function* switch, via an edgewise-acting cam on the switch-shaft. The mechanical system operates on the take-up motor brake, and on the pressure-roller engagement and tape-lifting mechanisms.

The four switch positions, *Spool*, *Off*, *Play* and *Record*, are spaced at 60-degree intervals round the shaft, so that the cam has a total rotation of 180 degrees. The two 180-degree arcs on the edge of the cam which are thus available are cut to differing contours which control the motion of two separate follower wheels. One follower operates the take-up motor brake mechanism; the other acts on the pressure-roller engagement and tape-lifting mechanisms.

Figs. 1, 2 and 3 show the mechanical arrangement of the system, while Figs. 2.5 and 2.6 indicate the method of operation. Fig. 4 shows the electrical arrangement.

Mechanical Control System (Fig. 2.5)

A greatly simplified plan view of the mechanical control system, excluding most of the tape-lifting mechanism, is given in Fig. 2.5. The greater part of the system shown is mounted below the deck level, exceptions being the two brake drums with their shoes and springs, the two jockey rollers, and the pressure roller and drive capstan, together with the gate-pressure pin which forms a part of the tape-lifting mechanism which is described in the next sub-section. All springs shown are in tension.

The outline of the cam appears near the bottom right-hand corner of the diagram. The right-hand traveller wheel is attached to the brake lever. Also attached to the brake lever is a spring the other end of which is fastened to the machine framework. This spring pulls the brake lever to the left and holds the traveller wheel against the cam profile.

The other end of the brake lever is jointed to a rod which has a slotted piece attached to its further end. Moving in the slot is a pin mounted near the roller on the right-hand jockey arm the other end of which is clamped rigidly to the take-up motor brake shoe. The brake shoe and jockey arm are pivoted about their clamping point. Except in the *Spool* condition, the pin is free in the slot, the brake being held on by a spring attached to the shoe which acts against the tension of the tape applied via the jockey pulley in the *Play* and *Record* conditions.

The left-hand traveller wheel is mounted on the engaging lever. One end of this lever is pivoted to the machine framework, while attached to the other end are a push rod and also a spring fastened to the machine framework. The push rod carries a finger engaging with a pin at one end of the pressure roller lever; the further end of the push rod terminates in a hinge-block connected to the tape-lifting mechanism.

The pressure roller lever is pivoted at its point of attachment to an auxiliary curved arm carrying the pressure roller. Beyond the pivot point the arm is pulled by two springs which hold the roller against the drive capstan in order to grip the tape. During forward running the tape is transported from left to right, the capstan motor rotating clockwise and the pressure roller being therefore driven anti-clockwise.

The brake mechanism of the rewind motor (Fig. 2.5) is not controlled by the cam, but is electrically operated. The brake is held on by spring (35), except (i) when the jockey arm is pulled to the left by tape tension, and (ii) when the brake hold-off magnet (61) is energised via the *Function* switch in the *Spool* condition. When the magnet is energised, it attracts armature (60), although its pull is insufficient to overcome the

opposition of spring (35) until the tape tension acting on jockey roller (4) brings the magnet and armature into contact. Once contact is made, however, the brake is held off until the *Function* switch is moved to some other position.

(Fig. 2.6) consists essentially of three gate-pressure pins, one at the middle of the headblock and one at each end. The middle pin emerges through an aperture in the deck-plate, and below deck level is mounted on a bell-crank hinged to the push

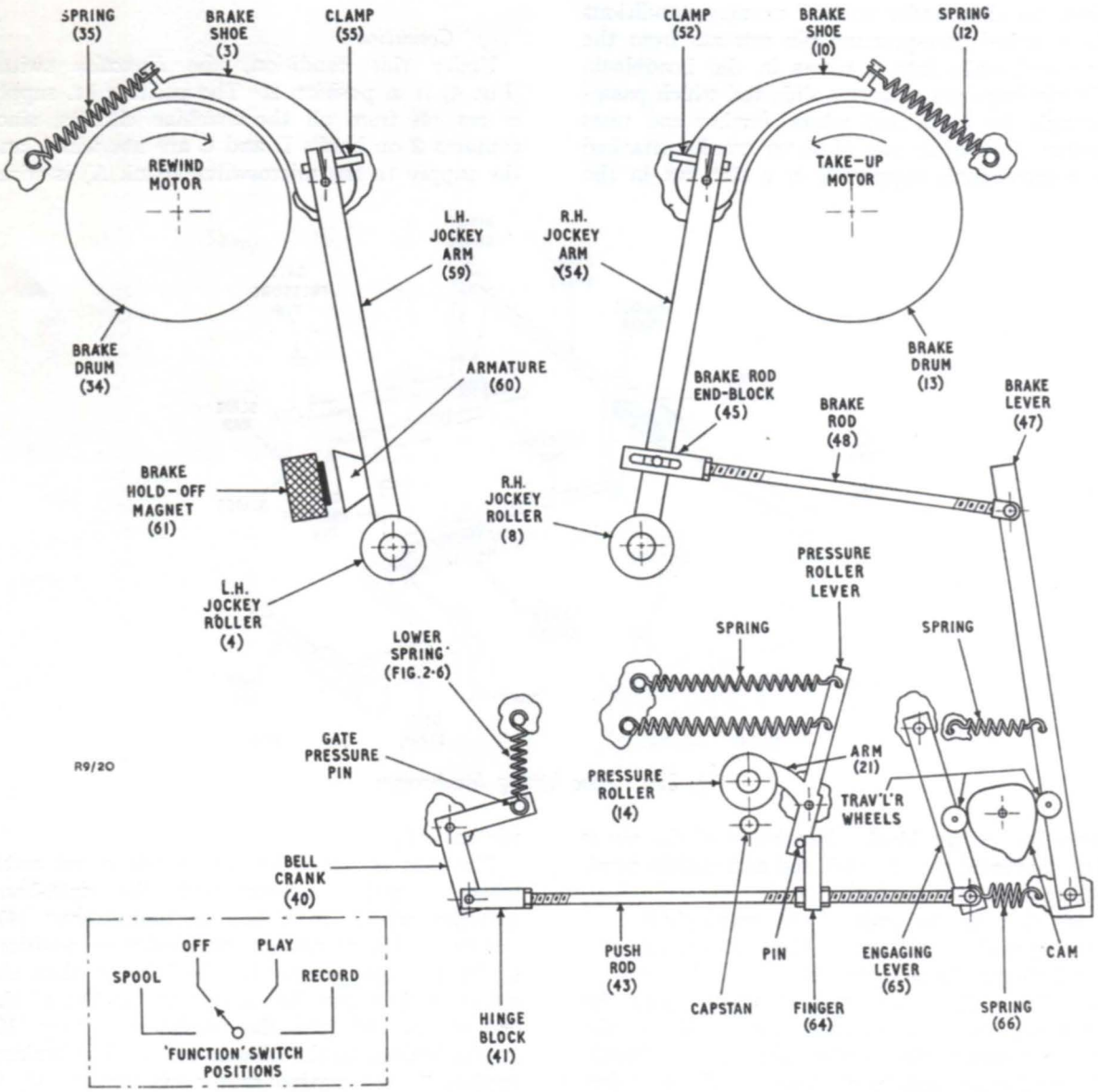

Fig. 2.5. Tape Transport Mechanism

Tape Lifting Mechanism (*Fig. 2.6*)

This mechanism lifts the tape away from the heads in the *Spool* and *Off* conditions to minimise head wear and facilitate loading. The mechanism

rod (Fig. 2.5). The further end of the push rod is attached as already mentioned to the engaging lever, the mechanism being thus controlled by the cam of the *Function* switch.

In the *Play* and *Record* positions of the switch, the profile of the cam is recessed, and the push rod moves to the right under the pull exerted on the bell-crank by the lower spring shown in Fig. 2.6 and the spring (66) shown in Fig. 2.5. The bell-crank itself rotates anticlockwise about its pivot, so that under normal running conditions the attached gate-pressure pin retreats from the tape and sinks into a recess in the headblock. The pin impinges against a slide rod which passes through the block and whose further end rests against the middle one of three cranks attached to a crank-shaft supported in a slot cut in the upper face of the block. Movement of the pin is thus converted via the slide rod and middle crank into rotation of the crank-shaft.

Attached to the ends of the crank-shaft, and rotating with it, are two further cranks, the tips of which rest in slots cut in one of the ends of two sliders the other ends of which carry the remaining two gate-pressure pins. When the middle pressure pin recedes into the headblock, the crank-shaft rotates clockwise, and the sliders carrying the left and right-hand pressure pins fall back on either side of the block.

In the *Spool* and *Off* positions of the *Function* switch, the profile of the cam projects, causing the push rod to move to the left and bring forward the middle pin, which lifts the tape away from the heads at the middle of the block. The upper spring shown in Fig. 2.6 now rotates the crank-shaft anticlockwise, so advancing the left and right-hand gate-pressure pins. A handle is provided on the left-hand crank, so that the two end pins can if necessary be advanced by hand.

'Off' Condition

Under this condition, the *Function* switch (Fig. 4) is in position 2. The positive l.t. supply is cut off from all the machine circuits, since contacts 2 on banks B and C are not wired, and the supply to the microswitch (bank A) is wired via bank C.

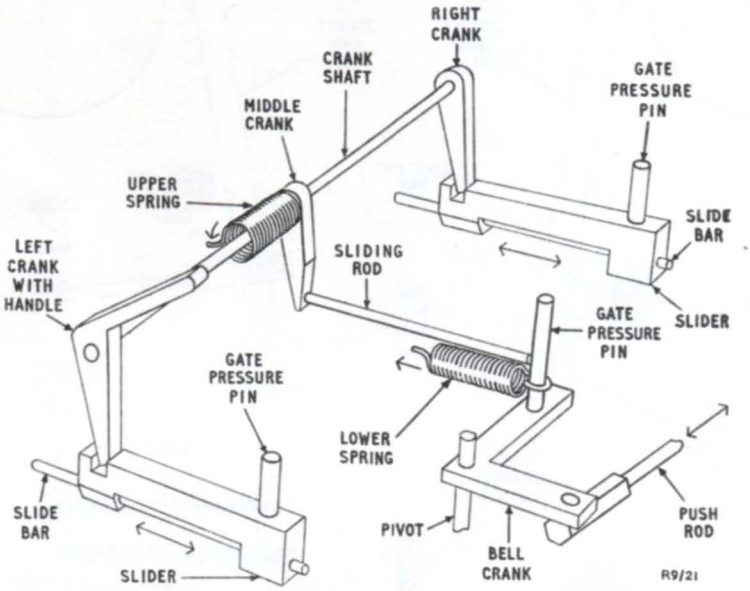

Fig. 2.6. Tape Lifting Mechanism

The cam operated by the switch is cut away where it makes contact with the right-hand traveller wheel, so that the brake lever (47) moves to its maximum anticlockwise position. Brake rod (48) moves to the left, so that the pin on jockey arm (54) is free in the slot at the end of the rod, and the tension in spring (12) applies braking to the take-up motor. The braking applied to the rewind motor via spring (35) is not controlled by the cam.

The sector of the cam in contact with the left-hand traveller wheel projects, so that engaging lever (65) rotates clockwise and push rod (43) moves to the left. The finger (64) attached to the rod presses against the pin at the front end

of the pressure-roller lever, which also rotates clockwise, moving the pressure roller out of contact with the capstan and disengaging the tape drive.

The disengagement of the drive prevents the formation of loops which might otherwise be produced since the capstan motor, although switched off, has no braking applied.

The left-hand end of the push rod moving to the left imparts a clockwise motion to the bell-crank (40) which appears in both Fig. 2.5 and Fig. 2.6. The attached gate-pressure pin advances from its slot in the headblock, allowing the sliding rod to be pushed forward by the middle crank under the action of the upper spring. The movement of the middle crank is conveyed via the crankshaft to the left and right cranks. These in turn advance the slide bars at either end of the headblock which carry the other gate-pressure pins.

The pressure pins lift the tape away from the heads. This lifting action in the *Off* condition serves no purpose, but occurs because the lifting mechanism is controlled by the same sector of the cam as the pressure-roller mechanism, which is required to disengage as already explained.

NOTE :—The *Function* switch must always be left in the *Off* or *Spool* position when the machine is not in use or the rubber facing of the pressure roller will become deformed.

'Play' Condition

Under this condition the *Function* switch (Fig. 4) is in position 3. Bank A of the switch lights the green pilot-lamp from the l.t. supply via bank C. Bank B switches on the take-up motor, which operates under reduced power via a resistor. Bank C switches on the capstan motor.

The active sector of the right-hand side of the cam is cut away as in the *Off* position, so that the take-up motor brake remains on except when released by tape tension acting on the right-hand jockey arm. The left-hand side of the cam is also cut away, so that the push rod moves to the right and the pressure roller engages with the capstan, which commences to drive the tape. The left-hand end of the push rod turns the bell-crank anticlockwise. This makes the gate-pressure pins recede and allows the heads to come into contact with the tape.

Braking continues to be applied to the rewind motor, except when released by tape tension acting on the left-hand jockey arm.

'Record' Condition

The *Function* switch is in position 4. Bank A lights the red pilot-lamp and operates the *Record* relay. This relay applies h.t. to the erase-and-bias oscillator (Fig. 5) and connects the recording head (Fig. 6).

Banks B and C of the *Function* switch have the same effect as under the *Play* condition. The action of the cam-operated mechanisms and the left-hand brake is also the same.

'Spool' Condition

The *Function* switch is in position 1. Bank A is inoperative since the l.t.-positive supply to its traveller is fed via contact 4 of bank C. Bank B energises the rewind-motor brake hold-off magnet, which holds the brake permanently off as soon as the armature on the left-hand jockey arm is brought into contact with the magnet by tape tension. Bank C energises the rewind and take-up motors, which operate in series under reduced power and apply tension in opposite directions to the tape.

The take-up motor brake is held off by the cam mechanism, the profile of the cam projecting where it makes contact with the right-hand follower wheel. The brake lever is thus turned clockwise, pulling the brake rod to the right. The play in the slot at the left-hand end of the rod and the pin on the jockey arm is taken up, and the jockey arm and attached brake shoe turn anticlockwise about their pivoted junction point, leaving the motor free to rotate.

Fast forward or reverse operation of the machine is controlled by the centre-biased *Spool* switch. When this switch is held in the *Wind* position, the take-up motor is connected in parallel with the hold-off magnet across the l.t. supply, the motor operating under full power since its series resistor is by-passed. The rewind motor is short-circuited and acts as a magnetic brake.

When the *Spool* switch is held in the *Rewind* position, the rewind motor now operates under full power, whereas the take-up motor is short-circuited and acts as a brake.

NOTE :—During fast spooling operations the tape must be brought to rest by putting the *Spool* switch into reverse before the *Function* switch is turned to *Off*. If this precaution is neglected tape spillage may occur.

Erase and Bias Oscillator (Fig. 5)

This 60-kc/s oscillator is of the Hartley type, its circuit diagram being given in the upper part of Fig. 5. It receives a smoothed h.t. supply from the rotary convertor. This supply is routed via a contact of the *Record* relay, and is available only when the *Function* switch is in the *Record* position. The 6-volt heater of the single tetrode valve V1 is supplied in series with the heater of the stroboscope oscillator valve V2, also a 6-volt type. A current-equalising resistor is shunted across V1, as shown on the right of the circuit diagram.

The connections between the erase-and-bias oscillator and the head circuits are shown in Fig. 6.

Neon Stroboscope Oscillator (Fig. 5)

The circuit of this 100-c/s oscillator appears in the lower part of Fig. 5. Operation is on the Wien-bridge principle, described in Instruction S.4, Appendix 9.1. The two halves of the double-triode valve V2 form the two stages required, the output to the stroboscope neon being taken from the anode of the second stage. The neon strikes once per cycle on positive-going peaks only, so that the flicker rate is the same as with a 50-c/s a.c. supply. The 100-kilohm resistor R350 in series with the neon prevents the discharge from affecting the frequency-control circuit comprising R341, C341, R342, C342 and the variable element VR302.

To set the frequency of oscillation to 100 c/s, the machine speed is first adjusted under 50-c/s overhead lighting using the stroboscope card on the flywheel with a tape running through the machine. When the pattern on the card appears stationary, the oscillator frequency is adjusted by means of the control VR 302, labelled *Strobe*. When the frequency is correct, the pattern of dots seen while observing the neon lamp through the perforated disk attached to the flywheel beneath the deck should also be stationary.

The stroboscope oscillator receives a 310-volt h.t. supply directly from the rotary convertor. The 6-volt heater is supplied in series with that of V1 in the erase-and-bias oscillator as stated under the previous heading.

Head Circuits (Fig. 6)

The erasing head winding is fed from the 60-kc/s oscillator (Fig. 5) via C313, which tunes the head to the oscillator frequency. The recording head has two windings, for bias and programme respectively. One end of each recording-head winding is commoned to the erasing-head winding, the common connection being taken to frame in the amplifier unit via the power cable.

The 60-kc/s bias for the recording head is obtained from a variable tapping on potential divider VR304-R330 across the erasing head. For bias-current metering the potential divider R325-R326 is connected in series with the head, the meter and its series resistance being applied across R326 when the *Bias* switch is pressed. The a.f. feed to the head from the amplifier unit is routed via the power cable and a contact of the *Record* relay which is open except when the *Function* switch is in the *Record* position. Also in series with the head are two tuned circuits employed for recording equalisation and bias rejection respectively. The recording equaliser is a variable tuned circuit shunted by a resistor and designed to increase the head current around its resonance frequency to obtain a level surface-induction characteristic on the tape. The bias rejector is a variable shunt resonant circuit intended to present a maximum impedance at the bias frequency in order to keep the bias signal out of the amplifier.

The reproducing head is connected to the amplifier unit via the ' play ' cable.

The recording and reproducing amplifier circuits are described in the next Section.

SECTION 3

AMPLIFIER UNIT

General

This unit contains all the necessary amplifying circuits and programme controls for recording and reproduction. The operating controls are mounted on the front panel, while the pre-set controls are inside the case.

Mounted on a chassis at right-angles to the front panel are eight valves with other related components. Access to the chassis is obtained by loosening two captive screws at the top of the front panel. The panel and chassis can then be swung forward on hinge-like supports or lifted completely out of the case with all connectors still attached.

The unit embodies the following sub-amplifiers :

(a) 2 Microphone Amplifiers
(b) Recording Amplifier
(c) Volume Meter Amplifier
(d) Reproducing Amplifier
(e) Loudspeaker Amplifier

Programme Chain (Fig. 3.1)

The programme chain of the equipment comprises recording, reproducing and monitoring circuits, these last two being partially combined. A complete schematic diagram is given in Fig. 3.1.

The recording chain includes :

(a) Two microphone input circuits, each with an amplifying stage, an l.f. attenuator, and a switch and fader for gain control. The inputs to the amplifiers are via transformers designed to accommodate low-level microphones with an impedance of 25 to 50 ohms. The l.f.-attenuator circuits are intended for use when recording speech for motion-picture purposes, and are normally by-passed via the *Att./Level* switches shown. Facilities are provided for converting one of the microphone amplifiers into a 1-kc/s oscillator by means of the switch labelled *Off* and *1 kc/s*.

(b) An input jack intended to accept programme at 0 dB from a 600-ohm line. This input utilises the l.f.-attenuator circuit and gain control of the second microphone amplifier. A repeating-coil and 600-ohm matching network replace the microphone transformer and amplifier, which are disconnected by auxiliary contacts on the line jack as shown.

(c) A recording amplifier which feed the recording head via the *record* relay, recording equaliser and bias rejector in the machine unit.

The reproducing and monitoring chain provides facilities for both visual and aural monitoring, the latter via either headphones or loudspeaker, and for sending programme to line. The chain comprises :

(a) A reproducing amplifier which takes its input from the reproducing head via a transformer and variable equaliser and is followed by a *Reproducing Gain* control.

(b) A monitoring amplifier whose input can be switched either to the reproducing chain or to the recording chain. The input and output of the monitoring amplifier are controlled by the *Monitor* switch.

(c) An output section including a loudspeaker amplifier which can be used either for feeding a loudspeaker or for sending programme to line.

(d) A volume meter and amplifier which can be bridged across the recording or reproducing chain as required.

The reproducing and aural monitoring chain includes two switches, one of which is the *Monitor* switch already mentioned, the other being the *Output* switch. Some explanation of the action of each is required.

The *Monitor* switch has four positions, marked *L.S. Direct, L.S. Rep., Phones Rep.* and *Phones Direct.* In either of the *Direct* positions, the recording amplifier output is selected for monitoring, whereas in either of the *Rep.* positions, the reproducing amplifier output is selected instead. In either of the *Phones* positions the loudspeaker amplifier is disconnected and the programme routed to the *Phones 150 Ω* jack via transformer T5.

In either *L.S.* position of the *Monitor* switch, the programme passes to the loudspeaker amplifier and thence to transformer T4. This transformer has two secondary windings. One feeds a 15-ohm loudspeaker socket direct and the *Phones 150 Ω*

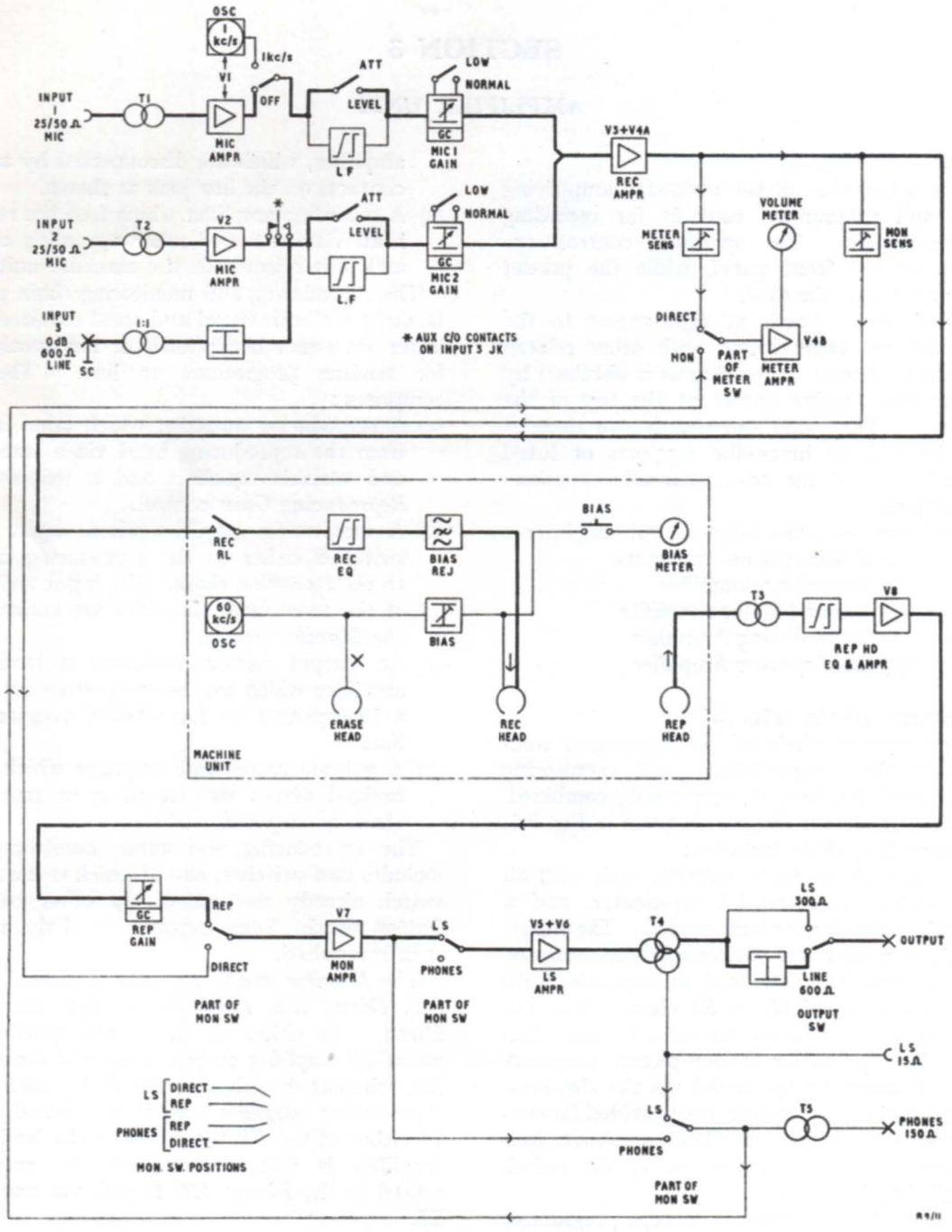

Fig. 3.1. The Programme Chain

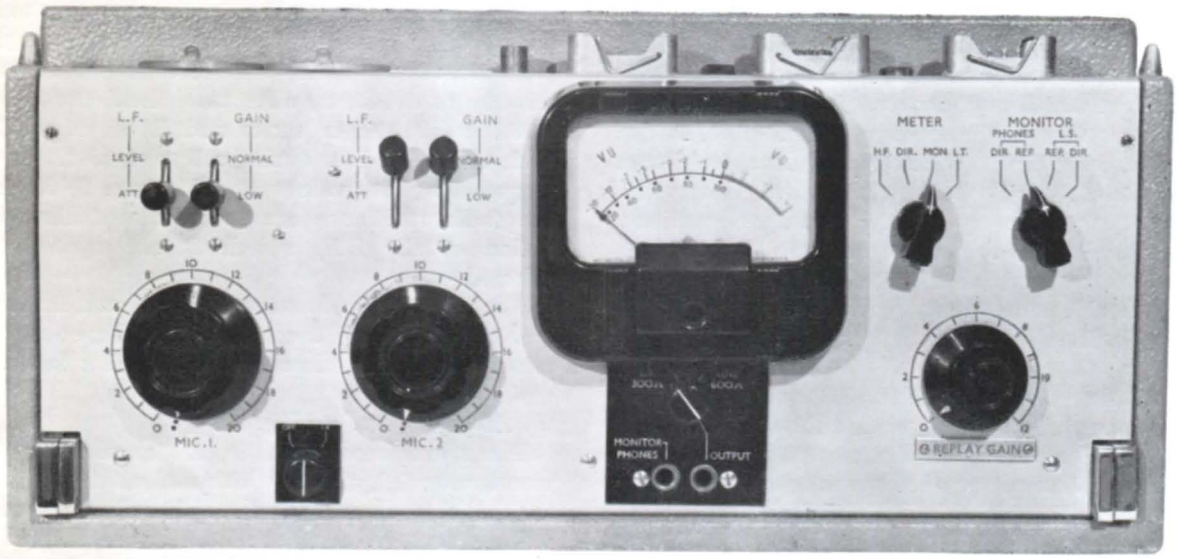

Fig. 3.2. Amplifier Control Panel

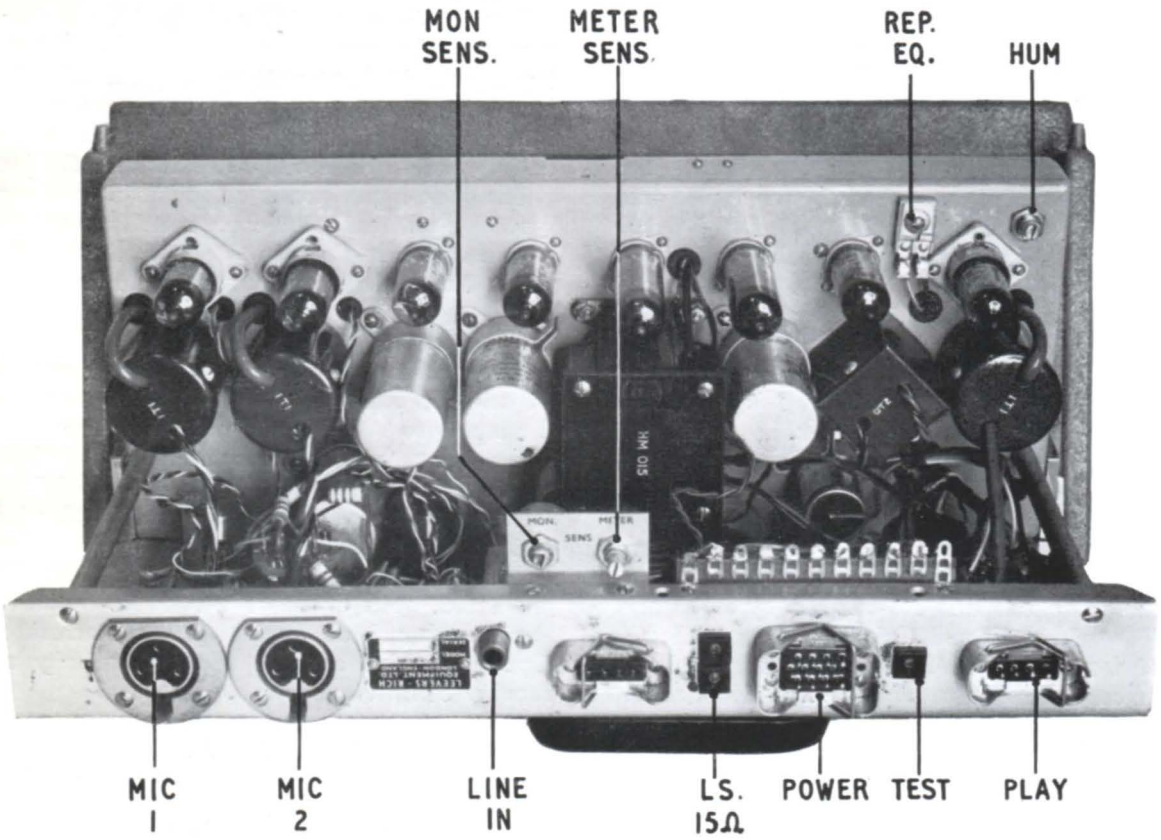

Fig. 3.3. Amplifier Chassis

jack via T5, the other secondary winding feeds the *Output* jack via the *Output* switch. This switch has two positions, marked *L.S. 300 Ω* and *Line 600 Ω* respectively. In the *L.S.* position of the switch, T5 secondary is connected to the *Output* jack direct, while in the *Line* position a matching network is inserted which brings the output impedance up to 600 ohms. By adjustment of the *Reproducing Gain* control, the sending level to line can be set to 0 dB. The *Mon. Sens.* control allows the listening levels to be made the same in the *Direct* and *Rep.* conditions.

Amplifier Controls (Figs. 3.2 and 3.3)

The amplifier control panel is shown in Fig. 3.2. The *H.F.* position of the meter switch is for checking bias current leakage into the recording amplifier when adjusting the bias-rejection circuit (Section 5); the *L.T.* position is used with the lower scale, a reading of 100 per cent representing a new battery fully charged.

The pre-set controls and the cable connectors are shown in Fig. 3.3.

Circuit Description (Fig. 8)

Microphone Amplifiers

(*a*) *Amplifier No. 1 (Fig. 3.4)*

This can be made to function either as an ordinary amplifier or as a line-up oscillator, the change-over being controlled by a double-pole switch with alternative positions labelled *Off* and *1 kc/s*. The microphone input to the amplifier is via step-up transformer T1, the secondary of which is connected to V1 control grid. In the *Off* position of the switch, parallel-connected voltage negative feedback from anode to grid is applied to V1 via C105 and R127. In the *1-kc/s* position, the amount of feedback is reduced by R149, and the connection to V1 grid is made via the phase-reversing network R143-R140, C128-C125. The amplifier becomes an oscillator of similar type to the OS/10 (Instruction S.4), with its frequency adjustable by pre-set capacitor C125.

The valve anode is *RC*-coupled by R103 and C105 to the *L.F.* and *Gain* switches and fader. R149 is short-circuited when V1 is an amplifier, but reduces the output by potential divider action when the valve is an oscillator.

The *L.F.* switch is normally left in the *Level* closed position, but when moved to *Att.* it puts capacitor C106 in series with the output; this introduces a 12-dB loss at 100 c/s (and a 2-dB loss at 1 kc/s).

The *Gain* switch enables the fader setting to be brought to a convenient part of the scale. In the *Normal* position of this switch, C102 is connected directly to the fader, whereas in the *Low* position R152 is inserted in series and R151 in parallel with the fader, introducing a loss of 15 dB at all frequencies; the values of R151 and R152 and the fader resistance are so calculated that the action of the *L.F.* switch is not appreciably affected.

The fader output is taken via C120 and isolating resistor R107 to V3 control grid where it is in parallel with the output from the other fader.

(*b*) *Amplifier No. 2 (Fig. 3.5)*

The microphone input to this amplifier is vi transformer T2, the secondary of which is taken to the control grid of V2. Parallel-connected voltage negative feedback from anode to grid is applied to V2 via C107 and R130, and the valve is *RC*-coupled by R104 and C107 to V3 via the l.f. and gain switches, the microphone fader, C120A and R108.

Inserted between C107 and the l.f. switch are auxiliary changeover contacts on the 600-ohm input jack. With no plug in this jack, V2 output is routed through to V3, but when a plug is inserted the auxiliary contacts disconnect V2 output and substitute the circuit from the jack.

The jack input circuit comprises a one-to-one repeating-coil and 600-ohm matching network with a total loss of about 10 dB. Both repeating-coil and matching network are fitted by the BBC.

Recording Amplifier (Fig. 3.6)

The recording amplifier comprises the pentod V3 and one half (V4A) of the double triode V4, the inputs to V3 grid from the microphone faders being taken via the capacitors and isolating resistors C120-R107 and C120A-R108. V3 and V4A are *RC*-coupled by R111 and C112, whilst series voltage negative feedback to V3 cathode circuit is applied from V4A anode via C118, R133 and R132. The anode of V4A is *RC*-coupled to the recording head circuit (Fig. 6), across the input to which are the *Meter Sensitivity* and *Monitor Sensitivity* controls.

Reproducing Amplifier (Fig. 3.7)

The signal voltage from the reproducing head in the machine unit is conveyed to the amplifier unit via the play cable and applied to V8 control grid via transformer T3. (Fig. 3.7.) Between the

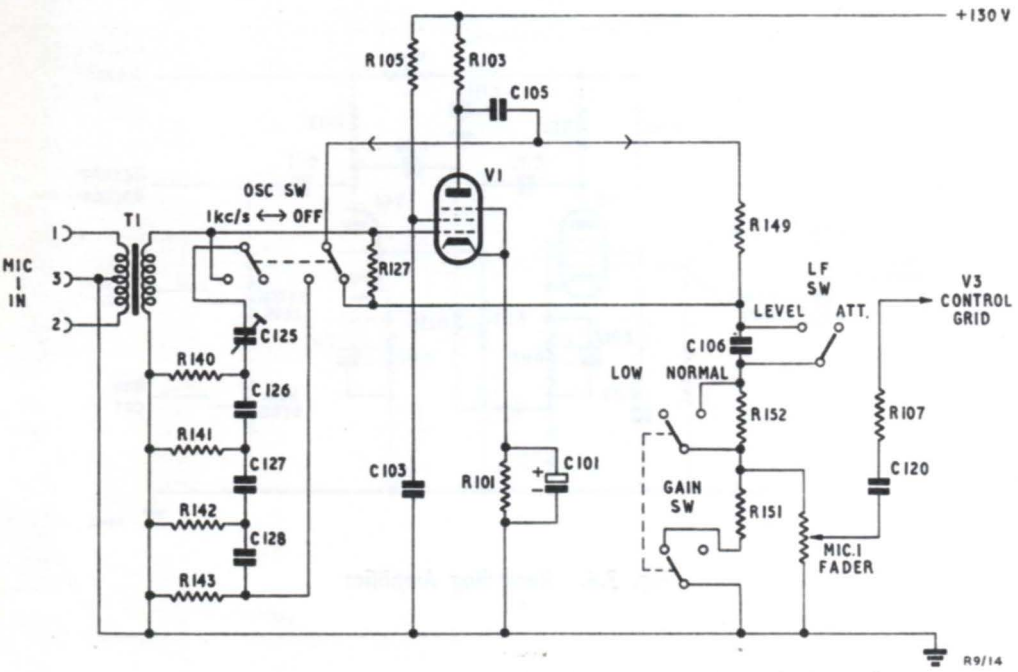

Fig. 3.4. No. 1 Microphone Amplifier (embodying 1-kc/s Oscillator)

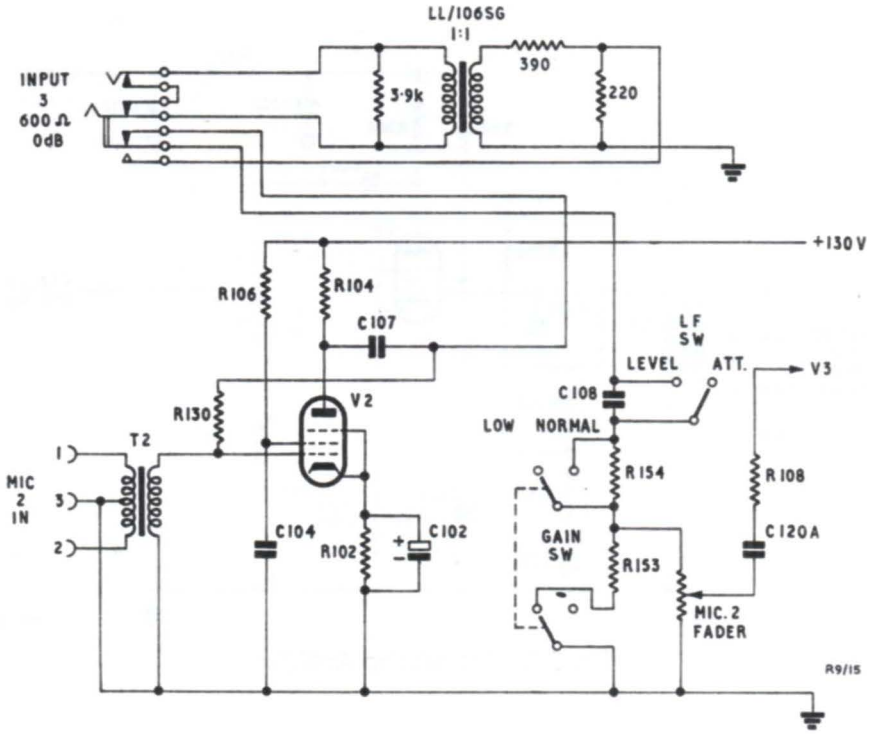

Fig. 3.5. No. 2 Microphone Amplifier and Line Input Circuit

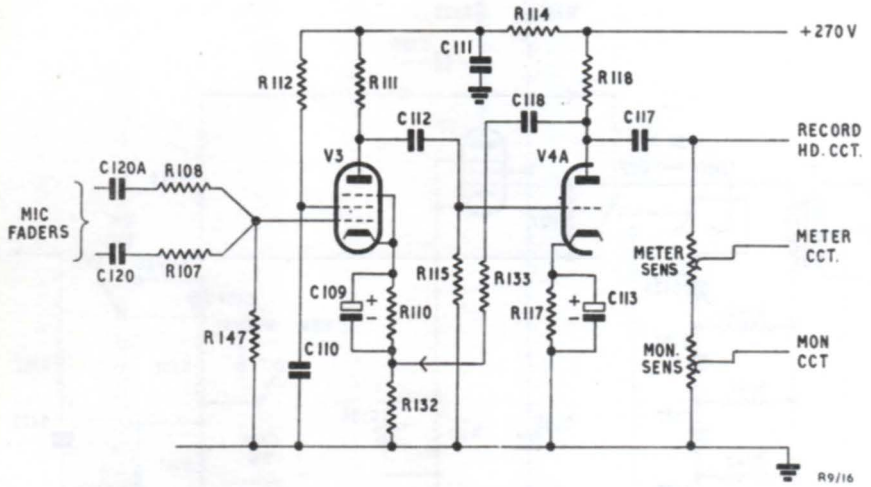

Fig. 3.6. Recording Amplifier

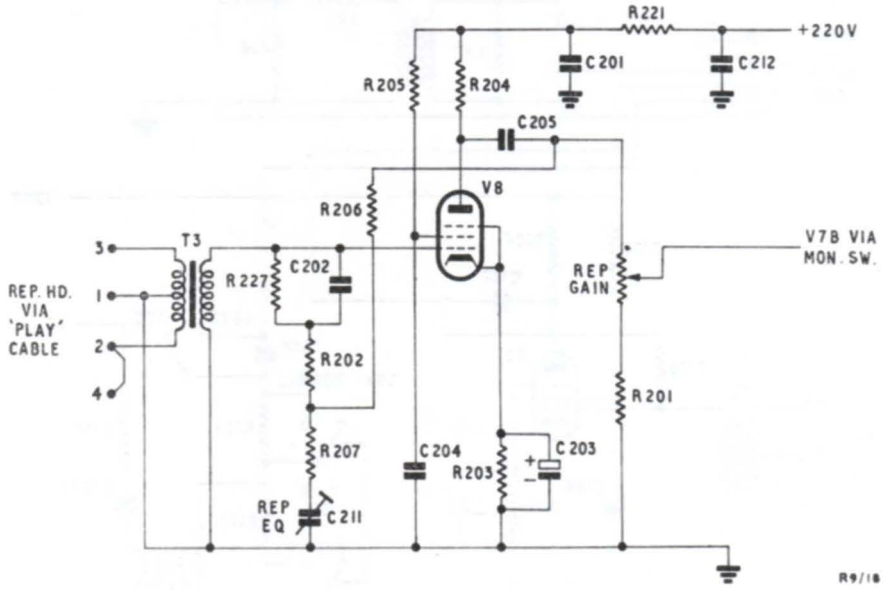

Fig. 3.7. Reproducing Amplifier

grid and earth is an equalising network incorporating parallel-connected voltage negative feedback applied from the anode of the valve via C205 and R206.

The equaliser reduces the effective gain of the amplifier to a minimum at the medium-high frequencies by varying the negative feedback voltage reaching V8 control grid. The method can be more clearly seen from Fig. 3.8, in which the feedback network is rearranged. The voltage from the anode circuit of the valve is injected at the junction of R202 and R207, so that for feedback purposes the network comprises a frequency-discriminating potential divider with two branches having R206 in common.

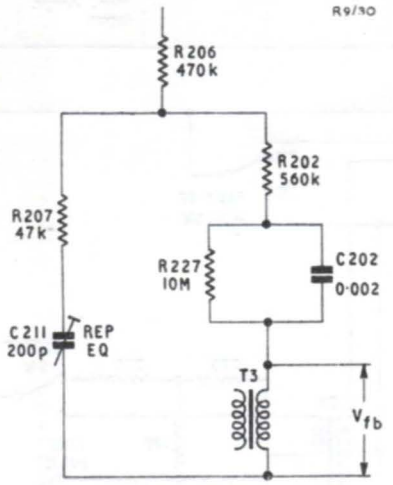

Fig. 3.8. Reproducing Equaliser

The left-hand branch contains pre-set capacitor C211, the *Reproducing Equaliser* control. At all settings of this control the impedance of the branch is too high to affect the behaviour of the circuit below a frequency of 2 kc/s.

The right-hand branch includes R202 and the fixed capacitor C202 as well as T3 secondary winding, the voltage across which is applied between the grid and cathode of the valve. Resistor R227 is included merely to prevent the grid from floating, and as it has a negligible shunting effect on C202, for feedback purposes it can be ignored. Since T3 winding reflects the inductive source impedance of the reproducing head and is also itself inductive, the impedance across the winding rises with frequency, while that across C202 falls, so that the grid-cathode feedback voltage V_{fb} increases fairly rapidly with frequency and correspondingly the output voltage of the amplifier falls to compensate for the normal rising head response to a level tape surface-induction characteristic.

At frequencies above 2 kc/s, the impedance of the left-hand branch of the circuit becomes sufficiently low to have an appreciable shunting effect on the right-hand branch containing the transformer. A greater proportion of the voltage applied from the anode is therefore developed across R206, so that the net feedback voltage increases less steeply, and finally reaches a maximum at a frequency whose exact value is determined by the setting of C211 but is normally in the region of 7 kc/s. Beyond this point the feedback begins to fall off and the gain of the amplifier is thus increased to compensate for reproducing-head losses.

The equalised output voltage from V8 is taken via the *Reproducing Gain* control and *Monitor* switch to the grid of V7B, the first stage of the monitor amplifier. Resistor R201 in series with the *Reproducing Gain* control restricts the maximum attenuation introduced by this control to 41 dB.

Monitor and Loudspeaker Amplifiers (*Fig. 3.9*)

The monitor amplifier uses the two halves of the double-triode valve, V7. It takes its input from either the recording amplifier or the reproducing amplifier as selected by the *Monitor* switch. It has two outputs ; one is balanced and feeds the loudspeaker amplifier ; the other output is unbalanced and feeds the volume-meter circuit via the *Monitor* switch, and the headphone jack via this switch and transformer T5.

The first stage (V7B) of the monitoring amplifier is *RC*-coupled to the second stage (V7A), which is arranged as a phase-splitter with one valve of the loudspeaker amplifier fed from V7A anode and the other fed from the junction of R212 and R213 in the cathode circuit. The headphone output is taken via C209 across R223. Of the resistors mentioned, R212 is the cathode load, R213 provides cathode bias for V7A, and R223 is an anti-click resistor which prevents a charge from building up on coupling capacitor C209 in the *Loudspeaker* position of the *Monitor* switch.

The loudspeaker amplifier, comprising V5 and V6, is fed from V7A via C208 and C210 and antiparasitic resistors R225 and R226. The amplifier operates in push-pull into transformer

T4; this feeds the output jack via a 600-ohm line-matching network which can be short-circuited by the *Output* switch when the line is replaced by a 300-ohm loudspeaker.

A tertiary winding on T4 provides overall voltage negative feedback to V7B by cathode injection, and feeds pin sockets (not used) for a 15-ohm loudspeaker. The headphone jack and meter circuit can also be connected to this winding, via the *Monitor* switch.

The *Monitor* switch controls not merely the programme output circuits, but also the monitor and loudspeaker amplifier h.t. supply. When the switch is set to either *Loudspeaker* position, h.t. is provided to V5 and V6 and T5 is fed from the tertiary of T4. If, however, the switch is moved to either *Phones* position, the h.t. supply is cut off from V5 and V6, and the full voltage connected to the anode of V7A, which becomes a cathode follower working into T5.

Monitor Switch (*Fig. 8*)

The four-position monitor switch (Fig. 8) has four banks, A, B, C and D. The functions of the switch are shown schematically in Figs. 3.1 and 3.9 and are tabulated below.

Position	*Bank A Connections*	*Bank B Connections*	*Bank C Connections*	*Bank D Connections*
1. Phones Direct	Mon. Ampr. output to T5 and to Meter Sw. contact C3	Full H.T. to Mon. Ampr. (also cuts H.T. from L.S. Ampr.)	Rec. Ampr. output to Mon. Ampr. input	None
2. Phones Rep.	As above	As above	Rep. Ampr. output to Mon. Ampr. input	Rec. Ampr. mon. output to earth
3. L.S. Rep.	T4 IIIy to T5 and to Meter Sw. contact C3	H.T. to L.S. Ampr. (also drops Mon. Ampr. H.T.)	As above	As above
4. L.S. Direct	As above	As above	Rec. Ampr. output to Mon. Ampr. input	None

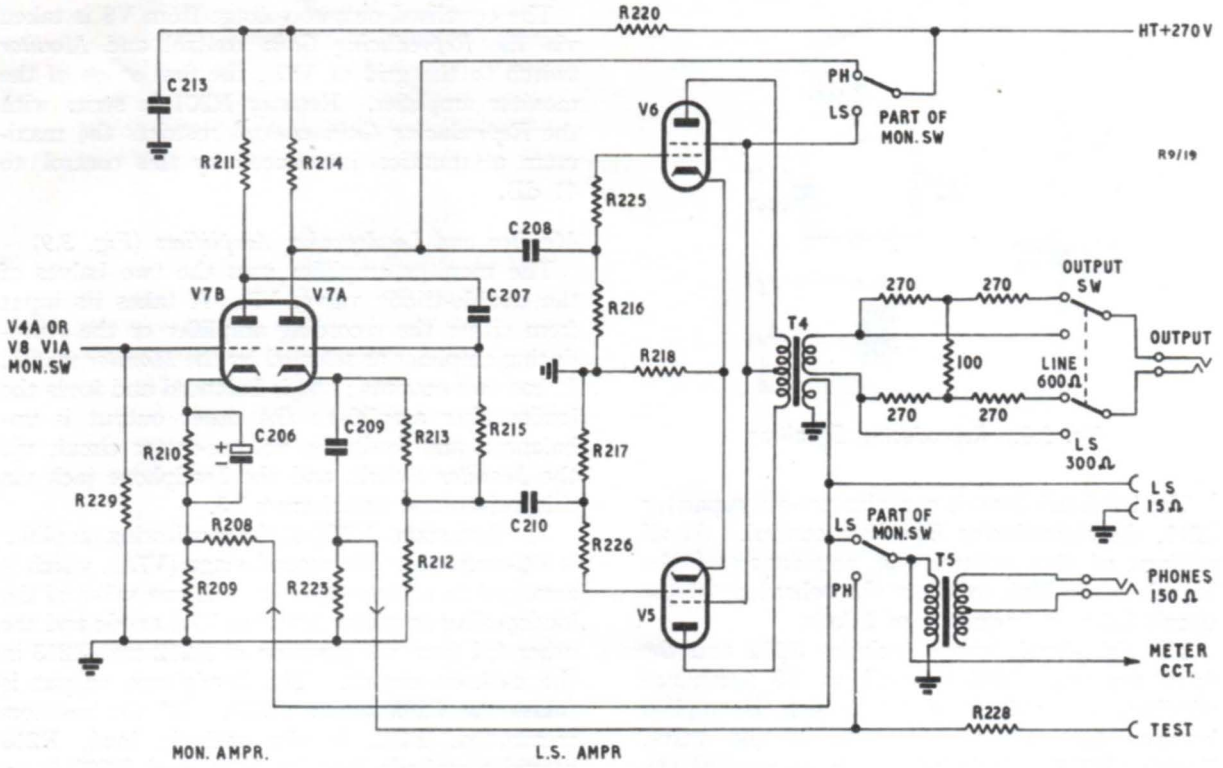

Fig. 3.9. Monitoring and Loudspeaker Amplifiers

Volume-meter Amplifier (*Fig. 3.10*)

This comprises one half, V4B, of a double triode, the other half of which is used for the output stage of the recording amplifier. The circuit takes the form of a cathode follower, and

thus provides an extremely high input impedance for connection to the measuring points, combined with a low output impedance for connection to the meter.

The input to V4B grid is via C130 as shown in Fig. 3.10. R121 is the grid resistor; R119 and R120 provide the cathode load, the output being taken from the cathode end of R119 via C116. Since R121 is connected to the junction of R119 and R120, cathode bias is provided by R119 only.

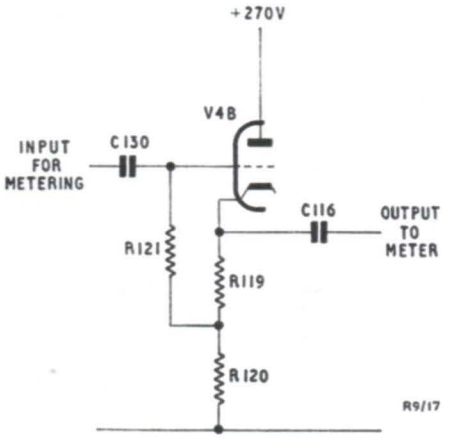

Fig. 3.10. Volume-meter Amplifier

Volume-meter Switch (*Fig. 7*)

The four-position volume-meter switch has three banks, A, B and C. (Fig. 7.) Banks A and B of the switch select the meter connections, whilst bank C, which is shrouded, selects the input to the meter amplifier in the *H.F.*, *Direct* and *Mon.* positions. In the *L.T.* position of the switch the meter-amplifier input is earthed and the battery is connected to the meter via a simple series resistor.

Supplies

H.T. supply, 270 volts from rotary convertor.

L.T. supply, 12 volts, 1·5 amps from battery. Heaters of V1-V2, V3-V8 and V5-V6 are wired in series.

Valve Data

Valve	*Anode Volts*	*Screen Volts*	*Cathode Volts*	*Heater Volts*	*Heater Amps*
Mic. Ampr. 1					
V1 : EF86	39 (34)	55 (47)	(1·2) (1·0)	6	0·2
Mic. Ampr. 2					
V2 : EF86	39 (34)	55 (47)	1·2 (1·0)	6	0·2
Rec. Ampr.					
V3 : EF86	46 (41)	56 (50)	1·7 (1·5)	6	0·2
V4A : ½ECC81	150 (125)		1·6 (1·4)	12	0·15
Meter Ampr.					
V4B : ½ECC81	270 (190)		135 (120)		
L.S. Ampr.					
V5 : EL84	(270)		(8·5)	6	0·75
V6 : EL84	(270)		(8·5)	6	0·75
Mon. Ampr.					
V7A : ½ECC81	270 (120)			12	0·15
V7B : ½ECC81	110 (70)		1·5 (1·0)		
Rep. Ampr.					
V8 : EF86	45 (40)	75 (65)	1·6 (1·5)	6	0·2

NOTE :—Voltages measured between point stated and frame, using Avometer Model 8 on lowest practicable range. Voltages within brackets are with loudspeaker amplifier switched on.

General Data

Impedances

Microphone Connectors
  Normal source $Z = 25\text{-}50\ \Omega$
Line Input Jack
  Normal source $Z = 600\ \Omega$
  Input $Z = 600\ \Omega$
Output Jack
  Output $Z = 300\ \Omega$ or $600\ \Omega$
  Normal load $Z = 300\text{-}\Omega$ L.S. or $600\text{-}\Omega$ line
Headphones Jack
  Normal load $Z = 150\ \Omega$ approx.

SECTION 4

OPERATING PROCEDURE

Setting up the Equipment

(i) Place the two cases horizontally on a flat surface with the amplifier unit on the left.

(ii) Remove both lids by releasing the clips and opening with an upward and backward movement to release the rear dowels.

(iii) Connect the *Power*, *Play* and *Battery* cables as indicated in Fig. 4.1, being careful to observe correct polarity for the battery. (Wiring details of the cables and connectors are given in Figs. 10, 11 and 12.)

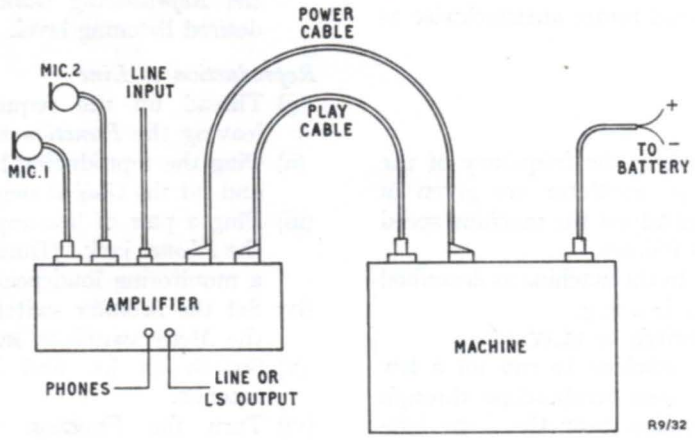

Fig. 4.1. Diagram of Connections

(iv) Connect the required input and output circuits, i.e. microphones, lines, headphones and loudspeaker. (Fig. 4.1.)

Switching on Supplies

(i) Throw the *L.T.** switch on the machine deck to the ON position. This energises all valve heaters in the machine and amplifier units, the heaters reaching their normal operating temperature about 15 seconds after the *L.T.* switch is operated. The switch also controls the lamp for the volume-indicating meter.

(ii) Now set the *H.T.* switch to ON, thus starting the rotary convertor, which runs up to speed immediately. The *H.T.* switch is only operative when the *L.T.* switch is also ON.

(iii) Set the *Meter* switch to L.T., and read the percentage battery voltage. If the voltage falls below 11 volts (approx. 90%) the equipment may not behave satisfactorily. The meter does not indicate polarity, and if the amplifier does not appear to be functioning, the battery polarity should be checked.

(iv) To economise in battery consumption, keep the *H.T.* switch at OFF except when the amplifier unit is actually in use. (The battery current with the *H.T.* switch OFF is about 2·5 amps.)

Notes on Supplies

For continuous operation, a battery of not less than 50 Ah capacity is required.

Where a.c. mains are available, a charger may be used with a battery of this size while the machine is operating without introducing hum, provided that the charger is more than six feet away.

* In early models, the *L.T.* and *H.T.* switches are combined in one rotary-type switch having a *Standby* position for l.t. only and an *On* position for l.t. and h.t.

In emergency only, the equipment may be run from the 12-volt battery of a motor vehicle ignition system, but metal parts of the recorder (also microphone, headphones, etc.,) **must not** be allowed to touch metal parts of the vehicle, since the recorder case is bonded to the *negative* side of the l.t. circuit, whereas in most vehicles the chassis is connected to the *positive* pole of the battery.

Loading the Machine

(i) Place the reel of tape, wound coating inwards, on the left-hand turntable, and clamp the spool in position by means of the knurled knob. Similarly clamp an empty spool on the right-hand turntable.

(ii) With the *Function* switch in the OFF position, lace up the tape as indicated in Fig. 2.1. When correctly threaded, the coated side of the tape should face the heads, and the left-hand spool should rotate anticlockwise as the tape unwinds.

Speed Adjustment

Instructions for adjusting the frequency of the 100-c/s neon stroboscope oscillator are given in Section 2. To check and adjust the machine speed in the field, proceed as follows.

(i) Thread up the tape in the machine as described under the previous heading.

(ii) Set the *Function* switch to PLAY.

(iii) After allowing the machine to run for a few minutes, view the neon stroboscope through the observation window near the front left-hand corner of the deck-plate and adjust the adjacent *Speed* control until the stroboscopic pattern is stationary.

(iv) Keep a watch on the stroboscope all the time the machine is running. If the pattern starts to rotate, the *Speed* control may be adjusted very cautiously whilst speech is being reproduced or recorded, but should not be touched during music.

(v) To avoid speed fluctuations at the beginning and end of a reel, do not record programme on the first or last fifteen seconds of a tape.

(vi) Although the stroboscope oscillator is normally set to produce a stationary pattern at the standard tape speed of 15 in./sec, the *Speed* control itself has a range of 14 to 18 in./sec. Non-standard speeds within these limits can thus be obtained if required.

Rewinding

At the end of fast winding or rewinding operations, always bring the tape to rest by putting the centre-biased switch into reverse, otherwise tape spillage may occur.

Preparing for Reproduction

Loudspeaker Playback

(i) Thread up the required programme tape in the manner already described, leaving the *Function* switch in the OFF position.

(ii) Set the *Output* switch to L.S. 300 Ω and plug a 300-ohm loudspeaker to the *Output* jack.

(iii) Set the *Monitor* switch to L.S. REP., and the *Meter* switch to MON.

(iv) Switch on the l.t. and h.t. supplies. Then wait fifteen seconds for the valve heaters to reach their operating temperatures.

(v) Move the *Function* switch to PLAY, and adjust the *Reproducing Gain* control to give the desired listening level.

Reproduction to Line

(i) Thread up the required programme tape, leaving the *Function* switch at OFF.

(ii) Plug the reproducing line to the *Output* jack, and set the *Output* switch to LINE 600 Ω.

(iii) Plug a pair of low-impedance headphones to the *Phones* jack. (During reproduction to line a monitoring loudspeaker cannot be used.)

(iv) Set the *Monitor* switch to PHONES REP. and the *Meter* switch to MON.

(v) Switch on l.t. and h.t. and wait fifteen seconds.

(vi) Turn the *Function* switch to PLAY and reproduce the band of 1-kc/s tone recorded at the start of the tape, adjusting the *Reproducing Gain* control until the volume meter reads −4 dB. At this setting, tone at zero level is being sent to line. (Do not, subsequently, alter the setting of this control.)

(vii) Henceforward proceed in the standard manner for handling a reproduction.

Preparing for Recording

(i) Set the *Monitor* switch to PHONES REC., switch on l.t. and h.t., wait 15 seconds, then move the *Function* switch to RECORD.

(ii) Press the *Bias* switch and adjust the pre-set *Bias* control until the correct reading on the bias-current meter is obtained. (See Section 5: *Bias-current Adjustment.* Note that if a change is made from high to medium

coercivity tape or vice versa the complete recording circuit must be realigned in the manner described in Section 5.)

(iii) Switch off h.t. and l.t. and restore the *Function* switch to OFF.

(iv) Thread up a clean tape on the machine.

(v) Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT.

(vi) Switch on l.t. and h.t. and wait 15 seconds.

(vii) With the *Function* switch on RECORD, the *Monitor* switch on PHONES REP. and the *Oscillator* switch on 1 KC/S, adjust the *Mic. 1* fader until the volume meter reads —4 dB and record tone for 10 seconds on the start of the tape.

(viii) Restore the *Oscillator* switch to OFF, set the *Monitor* switch to PHONES DIRECT and connect the recording input(s) required. The 600-ohm line input, if used, appears on microphone channel 2, the insertion of a plug into the line jack automatically disconnecting the microphone amplifier. When a line is used, set the *Mic. 2 Gain* switch to LOW in order to bring the *Mic. 2* fader to a convenient point on the scale; if a microphone is used, leave the *Mic. Gain* switch on NORMAL. Whatever the input(s), set the *Mic. L.F.* switches to LEVEL.

(ix) Proceed with the usual programme test and if this is satisfactory carry out the recording in accordance with standard procedure.

(x) Before starting the recording, however, confirm that the *Monitor* switch is on PHONES DIRECT and the *Meter* switch on DIRECT, so as to monitor the incoming programme. As soon as recording begins, move the *Monitor* switch to PHONES REP. and the *Meter* switch to MON. to check what is being recorded. During recording, make an occasional check on the incoming material as necessary. Note that the time constant of the meter is such that with zero programme volume incoming or outgoing it should not read above 0 dB on the scale. Any movement of the pointer into the red portion of the scale to the right of the 0-dB line indicates that the programme is at too high a volume, when appropriate action should be taken to restore conditions to normal.

Transport and Storage

The amplifier controls may be left at any desired setting, but the *Function* switch must be returned to OFF. This prevents damage to the rubber facing of the pressure roller, and also allows tape to be left on the machine without unspooling.

The lids must be fitted rear dowels first, and drawn well forward in closing. The machines are best transported or stored flat. In very damp or dusty conditions the cases should be sealed with adhesive tape round the edges of the lids.

SECTION 5

MAINTENANCE INSTRUCTIONS

Electrical Adjustments

General Notes

Two varieties of recording tapes are in common use, those of high coercivity (e.g., Type H77) and the older medium-coercivity tapes (principally Type H50). The two varieties differ in sensitivity by some 8 dB, although they require approximately the same recording-head currents. For convenience, two corresponding 1-kc/s test-tapes are supplied, as mentioned below.

The recording level to be used with high-coercivity tape is that which gives on reproduction the same 1-kc/s output level as a 'Type-77 1,000-c/s Line-up' test tape. (This *Line-up* tape must not be confused with a 'Type-77 *Standard-level*' tape, which is an unmodulated tape selected for bias-adjustment purposes because its magnetic properties are average for the type.) The recording level required for medium-coercivity tapes is that which gives on reproduction the same 1-kc/s output level as a 'Zero-level 1,000-c/s' test tape. The 'Zero-level 1,000-c/s' tape gives an output 8 dB below that of the 'Type-77 1,000-c/s Line-up' tape, to correspond with the 8-dB sensitivity difference between recording tapes of medium and high coercivity.

The Leevers-Rich volume meter has a fixed sensitivity when switched to reproduction, and should read −4 dB with zero-level tone outgoing to line. When switched to recording (i.e., *Direct*) the sensitivity of the meter is adjustable as described later, and should be set to read −4 dB when 1-kc/s tone is being recorded at Type-77 line-up level on a Type-H77 tape, or at zero level on a Type-H50 tape. In practice, both these conditions can usually be obtained with the same, or nearly the same meter sensitivity setting, except where the sensitivity of the tape in use departs greatly from the average for the type.

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

Volume-meter Sensitivity on Reproduction

(i) Connect a valve-voltmeter or PPM/6 across the output jack, taking care to terminate the jack in 600 ohms.

(ii) Set the *Meter* switch to MON., the *Monitor* switch to L.S. REP.* and the *output* switch to LINE 600 Ω.

(iii) Play any 15-in./sec 1-kc/s line-up tape and adjust the *Reproducing Gain* control until zero output level is indicated on the external meter.

(iv) The Leevers-Rich volume meter should now read −4 dB. If it does not, the value of the meter series resistor R148 (Fig. 7) is incorrect and must be changed.

Reproducing Level

To line up the reproducing chain for transmission, terminate the output jack in 600 ohms, then set the *Meter* switch to MON., the *Monitor* switch to L.S. REP. and the *Output* switch to LINE 600 Ω. Now play the Type-77 1,000-c/s line-up tape or the zero-level 1,000-c/s tape as appropriate and adjust the *Reproducing Gain* control until the volume meter reads −4 dB. Note this setting of the control.

Reproducing-amplifier Frequency Characteristic

(i) Set the *Monitor* switch to L.S. REP. and the *Output* switch to LINE 600 Ω. Connect a valve-voltmeter or PPM/6 across the output jack, taking care to terminate the jack in 600 ohms. Now reproduce the 15-in./sec C.C.I.R. frequency-response test tape, which is recorded at zero level and carries the following frequencies: 1 kc/s; 15, 12, 10, 8, 6, 4, 2 and 1 kc/s; 500, 200, 100, 60 and 40 c/s; also 10 kc/s for head azimuth alignment. (For azimuth alignment instructions, see *Head Unit.*)

(ii) Using the first 1-kc/s band on the tape, adjust the *Reproducing Gain* control until

* The word TAPE is used instead of REP. on some older machines.

zero output level is indicated on the external meter.

(iii) Using the 15-kc/s band on the tape, adjust the pre-set *Reproducing Equaliser* control on the amplifier chassis until zero output level is again obtained. (Note that turning the control anticlockwise raises the turnover frequency, and vice versa.)

(iv) Taking the response at each frequency above 1 kc/s, readjust the *Reproducing Equaliser* until a minimum departure from zero output level at all frequencies is obtained. The nominal tolerance figure is ± 2 dB, but a much closer agreement with the test tape can usually be obtained from 1 kc/s upwards. If there should, however, be any difficulty in obtaining the response required, it is preferable to reduce the response at 15 kc/s slightly rather than to overemphasise the range between 8 and 12 kc/s.

Erasing Current

No adjustment is provided for the erasing current, and this current is barely adequate when the loudspeaker amplifier has h.t. applied. If it is desired to keep the loudspeaker on during recording, it is necessary to use a tape which has already been wiped.

Bias-current Rejector Adjustment

Lift the front of the machine deck on its hinges and latch in the raised position. Set the amplifier *Meter* switch to H.F., and with the Function switch on RECORD adjust the pre-set *Bias Rej.* control located below the deck plate until the meter reading is at a minimum.

Bias-current Adjustment

(i) Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT.

(ii) With the *Function* switch on RECORD, the *Monitor* switch on PHONES REP. and the oscillator switch on 1 KC/S, adjust the *Mic. 1* fader until the volume meter reads —4 dB and record tone.

(iii) Set the *Meter* switch to MON. and vary the bias current by means of the pre-set Bias control until the bias setting giving maximum output level as indicated on the volume meter is found.

(iv) Increase the bias current beyond the point of maximum output until the level falls by 1 dB, press the *Bias* switch and note the reading of the bias-current meter. This value of bias current should now be regarded as standard for the particular type of recording tape in use. If a different type of tape is used the procedure must be repeated and the appropriate bias current ascertained.

NOTE :—The bias current is found to vary with the battery voltage and also according to whether or not the loudspeaker amplifier has h.t. applied. The bias must therefore be adjusted to the correct value, determined in operation (iv), under the conditions applicable at the time of each recording.

Volume-meter Sensitivity on Recording

(i) Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT (to read the recording level).

(ii) Set the oscillator switch to 1 KC/S and adjust the *Mic. 1* fader to make the volume meter read —4 dB.

(iii) With the *Monitor* switch on either of the PHONES positions (to take h.t. off the L.S. amplifier) record a band of tone.

(iv) Set the *Meter* switch to MON., the *Monitor* switch to L.S. REP. and the *Output* switch to LINE 600 Ω.

(v) With the output jack loaded by 600 ohms, reproduce the recorded tone and adjust the *Reproducing Gain* control to make the meter read —4 dB. Now reproduce the Type-77 1,000-c/s line-up tape or the zero-level 1,000-c/s tape as appropriate and note the difference between the meter readings for the recorded tape and the test tape.

(vi) Set the *Meter* switch to DIRECT, compensate on *Mic. 1* fader for the difference above, and repeat operations (iii), (iv) and (v) until a meter reading of —4 dB is obtained with both the recorded tape and the test tape.

(vii) With the *Meter* switch on DIRECT, the oscillator switch on 1 KC/S and the *Function* switch on RECORD, adjust the pre-set *Meter Sensitivity* control located inside the amplifier case to make the meter again read —4 dB.

NOTE :—The recording level, bias and meter sensitivity adjustment are interrelated. It follows, therefore, that if any appreciable change is found to be necessary in the setting of either the *Meter Sensitivity* or the *Bias-current* control, it may then be necessary to readjust both to obtain correct recording conditions.

Recording-amplifier Frequency Characteristic

Record a complete frequency run from 15 kc/s to 40 c/s either at Type-77 1,000-c/s line-up level or at 1,000-c/s zero level, according to whether the type of recording tape in use is of high or medium coercivity. Play back the recorded tape, and compare the output levels at the various frequencies with that at 1 kc/s. If necessary, readjust the pre-set *Recording Equaliser* control and repeat the procedure until a flat characteristic is obtained. The tolerance limits are ± 2 dB, but adjustment to within ± 1 dB or less can usually be made.

If there should be any difficulty in obtaining the required response, it is preferable to reduce the response at 15 kc/s slightly rather than to overemphasise the response between 8 and 12 kc/s.

Recording Level from Line

To adjust the recording level on line-up tone incoming from line, check that the oscillator switch is at OFF, then set the *Meter* switch to DIRECT and the *Monitor* switch to PHONES (DIRECT or REP.), now adjust *Mic. 2* fader until the volume meter reads −4 dB. Note that when recording from line it is generally convenient to have the *Mic. 2 Gain* switch in the LOW position.

Balance of Listening Levels

To balance the headphone listening levels obtained in the *Direct* and *Rep.* positions of the *Monitor* switch, record 1-kc/s tone while moving the *Monitor* switch alternately to the PHONES DIRECT and PHONES REP. positions, and adjust the pre-set *Mon. Sens.* control inside the amplifier case until no change in level can be heard.

A similar technique to that described can be used for balancing the listening levels on loudspeaker, although loudspeaker listening during recording is not standard practice.

Head Unit (Figs. 1 and 2.3)

Cleaning the Pole Faces

To avoid loss of level, especially at high frequencies, the pole faces of the heads must be kept free from tape dust and emulsion by regular cleaning with cotton wool soaked in methylated spirit. To do this it is necessary to undo the two small screws on the front of the headblock and remove the front cover. Loose dust may be removed with a small brush or a wad of cloth on a non-metallic probe; ferrous metal instruments must never be used on or near the pole faces.

Removing the Headblock

The pole faces gradually become worn with use, causing deterioration of the frequency response. When this takes place, the complete headblock should be removed and a new or reconditioned one substituted. To withdraw the block from the deckplate, release the two small screws in the top cover-plate, remove the plate, unscrew the two large recessed screws securing the headblock to the deck, and lift the block vertically upwards to disengage the pins of the head connectors.

Azimuth Alignment

The azimuth adjustments for the recording and reproducing heads on Type-B headblocks are accessible within the individual head compartments. (Fig. 2.3, Section 2.) On the earlier Type-A headblocks the azimuth adjustments are located beneath the heads and are only accessible after removing the block from the machine.

All headblock assemblies are aligned by the manufacturers, and repaired assemblies are realigned in Recording Maintenance Unit workshops before despatch to stations. If realignment on site becomes necessary, proceed with great care. Do not force the adjusting screws, or the head structure will be stressed, with disturbance of the gap and possible fracture. Carry out the adjustments in the following sequence.

(i) *Check reproducing-head azimuth.* To do this, play final 10-kc/s band of frequency-response test-tape, making sure that tape passes squarely through gate and does not foul guides or roller flanges. Turn *Reproducing Gain* control to maximum and switch volume meter to MON. Release lock-nuts of azimuth screws (on either side of reproducing head), adjust screws for maximum meter reading and re-lock. Re-check last reading to ensure that adjustment has not been disturbed in locking.

(ii) *Check recording-head azimuth.* Place a clean tape on machine and record 10-kc/s tone at normal level. Switch volume meter to MON., release lock-nuts and adjust azimuth screws of recording head for maximum reading. Secure locknuts, then re-check last reading to ensure that adjustment has not been disturbed.

(iii) *Demagnetise head assembly.* (See instructions under next sub-heading.)

Head Demagnetisation

Magnetised heads produce a hiss on reproduction. The use of magnetised tools near the pole faces may give rise to this trouble, or a faulty head lead may cause it by shorting to frame or shield and injecting a small earth potential across the coils. In ordinary use there is also a gradual tendency for magnetisation to accumulate.

If the hiss is audible only when the machine is switched to *Record*, either the erasing or the recording head is magnetised; if it disappears when the tape is pressed forward out of contact with the erasing head (by a pencil or other non-magnetic implement), it follows that this head is at fault; if the hiss persists, the fault must be in the recording head. Should the hiss still be evident with the machine switched to *Play* and a new or pre-erased tape in use, the fault is almost certainly in the reproducing head.

When the faulty head has been located, remove the headblock from the machine and examine the wiring for a possible short-circuit and clear this if evident. Then pass the headblock tape-slot downwards a few times across the platform of a 'Leeraser,' afterwards lifting the block slowly to a distance of at least three feet above the platform before switching off. Where a 'Leeraser' is not available for this purpose, the head assembly may be demagnetised using any suitable equipment in the way described in Instruction R.6 on page 24.

Machine Unit: Access for Servicing

Raising the Deck-plate on its Rear Hinges

(i) Place the recorder on a level surface, to prevent overbalancing when the deck-plate is raised.
(ii) Release the two screws marked (18) and (30) in Fig. 1.
(iii) Holding the machine case, to prevent tipping, lift the front of the deck-plate by the plated handle in front of the headblock.
(iv) Secure in the raised position by the rotary catches marked (49) and (47) in Fig. 2.

Removing the Mechanism Completely from the Case

(i) Release screws (18) and (30).
(ii) Remove the vertical screws securing the rear connector panel to the rear hinged bar.
(iii) Grip the rear connectors with one hand and the front handle with the other and lift out the deck-plate and mechanism.

Removing the Machine-unit Tray

(i) Unlatch and withdraw the main cable-connector and subsidiary single-pin plugs.
(ii) Release the four securing screws on the underside of the tray.
(iii) Remove the tray downwards.

Machine Lubrication

Avoid excessive lubrication. After long service, repack the ball-races with H.M.P. grease and re-impregnate the capstan bearings with light machine oil. Wipe off surplus oil round the capstan bearings to prevent it from damaging the rubber tyre of the pressure roller.

Spool Brakes (Figs. 1, 2, 3 and 2.5)

General

The spool brakes (3) and (10), visible in Fig. 1, are of the trailing-shoe type, operating on accurately-turned brake-drums (34) and (13) which are integral with the spool platforms. The brakes perform two distinct functions:

1. When the *Function* switch is at *Off*, they prevent the tape from unspooling and spilling.
2. When the *Function* switch is on *Play* or *Record* they provide a sensibly constant tape tension throughout the duration of the reel.

During normal forward running, the brakes are held on by springs (35) and (12), but a mechanical feedback system comprising jockey rollers (4) and (8) and their associated arms (Fig. 2.5) allows the tape itself to pull off either brake as soon as a predetermined tape tension is reached. This system depends for its efficiency on the maintenance of free movement of the jockey arms, free rotation of the jockey rollers and accurate concentricity of the brake drums.

During fast winding and rewinding, the mechanical brakes are not applied; instead, the trailing motor in each instance is short-circuited and provides magnetic braking.

A further description of the brake system is given in Section 2. See also Appendix A, Items 11 and 12.

Brake Tension Adjustment

The brake linings gradually bed down and wear thin with use, allowing the jockey-roller spindles to foul the slots in the deck-plate before full brake tension is achieved. To readjust:

(i) Remove the three screws holding brake cover-plate and lift off.
(ii) Remove screws securing hinged back-strip to

Recording-amplifier Frequency Characteristic

Record a complete frequency run from 15 kc/s to 40 c/s either at Type-77 1,000-c/s line-up level or at 1,000-c/s zero level, according to whether the type of recording tape in use is of high or medium coercivity. Play back the recorded tape, and compare the output levels at the various frequencies with that at 1 kc/s. If necessary, readjust the pre-set *Recording Equaliser* control and repeat the procedure until a flat characteristic is obtained. The tolerance limits are ± 2 dB, but adjustment to within ± 1 dB or less can usually be made.

If there should be any difficulty in obtaining the required response, it is preferable to reduce the response at 15 kc/s slightly rather than to overemphasise the response between 8 and 12 kc/s.

Recording Level from Line

To adjust the recording level on line-up tone incoming from line, check that the oscillator switch is at OFF, then set the *Meter* switch to DIRECT and the *Monitor* switch to PHONES (DIRECT or REP.), now adjust *Mic. 2* fader until the volume meter reads −4 dB. Note that when recording from line it is generally convenient to have the *Mic. 2 Gain* switch in the LOW position.

Balance of Listening Levels

To balance the headphone listening levels obtained in the *Direct* and *Rep.* positions of the *Monitor* switch, record 1-kc/s tone while moving the *Monitor* switch alternately to the PHONES DIRECT and PHONES REP. positions, and adjust the pre-set *Mon. Sens.* control inside the amplifier case until no change in level can be heard.

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Removing the Headblock

The pole faces gradually become worn with use, causing deterioration of the frequency response. When this takes place, the complete headblock should be removed and a new or reconditioned one substituted. To withdraw the block from the deckplate, release the two small screws in the top cover-plate, remove the plate, unscrew the two large recessed screws securing the headblock to the deck, and lift the block vertically upwards to disengage the pins of the head connectors.

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(i) *Check reproducing-head azimuth.* To do this, play final 10-kc/s band of frequency-response test-tape, making sure that tape passes squarely through gate and does not foul guides or roller flanges. Turn *Reproducing Gain* control to maximum and switch volume meter to MON. Release lock-nuts of azimuth screws (on either side of reproducing head), adjust screws for maximum meter reading and re-lock. Re-check last reading to ensure that adjustment has not been disturbed in locking.

(ii) *Check recording-head azimuth.* Place a clean tape on machine and record 10-kc/s tone at normal level. Switch volume meter to MON., release lock-nuts and adjust azimuth screws of recording head for maximum reading. Secure locknuts, then re-check last reading to ensure that adjustment has not been disturbed.

(iii) *Demagnetise head assembly.* (See instructions under next sub-heading.)

Head Demagnetisation

Magnetised heads produce a hiss on reproduction. The use of magnetised tools near the pole faces may give rise to this trouble, or a faulty head lead may cause it by shorting to frame or shield and injecting a small earth potential across the coils. In ordinary use there is also a gradual tendency for magnetisation to accumulate.

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When the faulty head has been located, remove the headblock from the machine and examine the wiring for a possible short-circuit and clear this if evident. Then pass the headblock tape-slot downwards a few times across the platform of a 'Leeraser,' afterwards lifting the block slowly to a distance of at least three feet above the platform before switching off. Where a 'Leeraser' is not available for this purpose, the head assembly may be demagnetised using any suitable equipment in the way described in Instruction R.6 on page 24.

Machine Unit: Access for Servicing

Raising the Deck-plate on its Rear Hinges

(i) Place the recorder on a level surface, to prevent overbalancing when the deck-plate is raised.
(ii) Release the two screws marked (18) and (30) in Fig. 1.
(iii) Holding the machine case, to prevent tipping, lift the front of the deck-plate by the plated handle in front of the headblock.
(iv) Secure in the raised position by the rotary catches marked (49) and (47) in Fig. 2.

Removing the Mechanism Completely from the Case

(i) Release screws (18) and (30).
(ii) Remove the vertical screws securing the rear connector panel to the rear hinged bar.
(iii) Grip the rear connectors with one hand and the front handle with the other and lift out the deck-plate and mechanism.

Removing the Machine-unit Tray

(i) Unlatch and withdraw the main cable-connector and subsidiary single-pin plugs.
(ii) Release the four securing screws on the underside of the tray.
(iii) Remove the tray downwards.

Machine Lubrication

Avoid excessive lubrication. After long service, repack the ball-races with H.M.P. grease and re-impregnate the capstan bearings with light machine oil. Wipe off surplus oil round the capstan bearings to prevent it from damaging the rubber tyre of the pressure roller.

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General

The spool brakes (3) and (10), visible in Fig. 1, are of the trailing-shoe type, operating on accurately-turned brake-drums (34) and (13) which are integral with the spool platforms. The brakes perform two distinct functions:

1. When the *Function* switch is at *Off*, they prevent the tape from unspooling and spilling.
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During normal forward running, the brakes are held on by springs (35) and (12), but a mechanical feedback system comprising jockey rollers (4) and (8) and their associated arms (Fig. 2.5) allows the tape itself to pull off either brake as soon as a predetermined tape tension is reached. This system depends for its efficiency on the maintenance of free movement of the jockey arms, free rotation of the jockey rollers and accurate concentricity of the brake drums.

During fast winding and rewinding, the mechanical brakes are not applied; instead, the trailing motor in each instance is short-circuited and provides magnetic braking.

A further description of the brake system is given in Section 2. See also Appendix A, Items 11 and 12.

Brake Tension Adjustment

The brake linings gradually bed down and wear thin with use, allowing the jockey-roller spindles to foul the slots in the deck-plate before full brake tension is achieved. To readjust:

(i) Remove the three screws holding brake cover-plate and lift off.
(ii) Remove screws securing hinged back-strip to

deck-plate, then move back-strip outwards and downwards, thus giving access to clamps (55) and (52) of brake pivots (56) and (53), visible in Fig. 2. (Note that in Fig. 2.5 the clamps are drawn above instead of below the brake-shoes for clarity.)

(iii) Slightly slacken small clamping nut of brake pivot to be adjusted.

(iv) Hold brake-shoe firmly against drum and move jockey roller to a point midway in its travel.

(v) Tighten pivot clamping nut and replace back-strip and brake cover.

Right-hand Jockey-arm Adjustment

The right-hand brake jockey arm is shown in Figs. 2 and 2.5. The arm (54) engages via a slot-and-pin link with the brake-rod end-block (45). In the *Off*, *Play* and *Record* conditions, the pin should be free to move in the slot in either direction without checking or binding. In the *Spool* condition, the brake-rod is pushed to the right, causing the pin to make positive engagement with the left-hand end of the slot and pull the brake-shoe out of contact with the brake-drum.

If the pin binds on the sides of the slot, release the lock-nut on the slotted end-block, rotate the block for correct alignment and retighten the lock-nut.

If the end-play on the slot is insufficient in the free condition or the engagement unsatisfactory in the *Spool* condition, alter the effective length of the brake-rod by unfastening end-block (45) and screwing it up or down as required.

Cleaning Drum Surfaces

Dirt on the brake-drums may cause uneven operation. To clean :

(i) Remove brake-spring (35) or (17) from its anchor pin. (See Figs. 2 and 2.5.) Then move brake-shoe (3) or (10) out of contact with drum (34) or (13).

(ii) Apply a soft cloth moistened with methylated spirit to surface of rotating drum. Take care that cleaning fluid does not come in contact with shoe lining.

(iii) Allow cleaning fluid to dry. Then refit spring and release shoe into contact with brake-drum.

Spool Motors

Removal for Servicing

(i) Remove tray.

(ii) Disconnect motor leads.

(iii) Lift brake cover and disconnect brake-spring.

(iv) Unscrew the three brake-drum securing screws and lift off drum.

(v) Undo the four motor screws and withdraw motor carefully downwards.

The commutator of the motor is accessible when the terminal-end cover is removed.

Refitting Brake-drums

(i) On reassembly, tighten the three brake-drum screws carefully and progressively. Do not use undue force, or drum may be distorted out of shape or out of concentricity.

(ii) Check concentricity by gently turning empty spool platform and watching for any movement of jockey roller ; this movement should be negligible if drum is correctly mounted.

(iii) If concentricity is unsatisfactory, step round drum 120 degrees and recheck.

(iv) If still unsatisfactory, step round another 120 degrees.

Push-rod Adjustment (Figs. 2, 2.5, 2.6)

(i) Disconnect supply and move *Function* switch to PLAY.

(ii) Slacken lock-nuts on push-rod (43) and release left-hand hinge-block (41) from bell-crank (40). Then rotate bell-crank so that middle gate-pressure pin just touches end of slot in headblock.

(iii) Secure lock-nut at end of rod.

(iv) Slacken set-screw and move pressure-roller actuating finger (64) to allow 0·05 in. clearance with pin at end of pressure-roller lever.

(v) Tighten actuating-finger lock-nuts and set-screw, taking care that finger does not foul capstan flywheel.

Main Driving Unit (Figs. 1, 2, 2.5)

General

The main driving unit forms a separate complete assembly, which is bolted to the deck-plate of the machine. The unit comprises the ground-steel capstan shaft with flywheel and flexible coupling, the pressure-roller and arm assembly, and the driving motor itself. Before work is undertaken on any item, the complete unit must be removed from the machine.

Removal for Servicing

(i) Take off headblock.

(ii) Release push-rod from its left-hand pivot and swing outwards on right-hand pivot.

(iii) Remove motor connections.
(iv) Release the five bolts holding unit to deck-plate, first slackening lock-nuts if fitted.
(v) Withdraw unit carefully downwards.

Reassembly

On reassembly, if necessary, adjust the position of the pressure-roller actuating finger as follows:

(i) With power supply disconnected, move *Function* switch to PLAY.
(ii) Release lock-nuts and set-screw holding finger in position.
(iii) Move finger so that it makes clearance of 0·05 in. with pin on pressure-roller lever.
(iv) Tighten lock-nuts and set-screw.

Speed Fluctuations

The most clearly audible indication of any unsteadiness in the tape motion is obtained by testing with a frequency of 3 kc/s. It is not always possible to tell whether flutter is due to speed irregularity or to amplitude variations. Speed irregularity can be caused by a warped spool, uneven braking, a damaged pressure-roller tyre, a bent capstan spindle or faulty adjustment of any part of the driving unit. Amplitude variations may arise from poor contact between tape and heads, and sometimes occurs with tape spoilt in storage.

Flywheel Pulley

Adjusting Vertical Alignment

(i) Slacken set-screw one turn in bearing barrel below deck-plate.
(ii) Move whole rotating assembly up or down as required and relock set-screw.
(iii) Check and re-adjust as necessary until tape passes round pulley without plucking at upper or lower flange.

Dismantling

To dismantle the assembly, e.g., for cleaning and repacking ball-races, proceed as follows:

(i) Holding flywheel firmly, unscrew and remove nut below it.
(ii) Release locking pin if fitted.
(iii) Remove flywheel downwards.
(iv) Slacken bearing set-screw and withdraw pulley-shaft and bearing assembly upwards.
(v) Do not try to remove pulley or domed nut above it from shaft, or damage will result.

Rotary Convertor

The rotary convertor is mounted on rubber in a box which provides both acoustic and magnetic screening. The unit has an input rating of 12 volts d.c. and an output rating of 300 volts d.c. at 100 mA. It supplies smoothed h.t. at 270 volts to the amplifiers via the power cable, the cable-connector being so arranged that the convertor and its control switch are inoperative when the connector is withdrawn.

The convertor must be removed from its box for maintenance such as cleaning commutators, replacing brushes or oiling bearings. To obtain access to the unit:

(i) Raise deck-plate on its hinges and remove tray in the way already described.
(ii) Slacken, but do not remove, the four terminal screws in insulated strip beneath box and release connecting leads.
(iii) Unscrew the four fixings securing box to tray and lift box clear.
(iv) Remove the two screws holding lid and lift off to expose commutators.
(v) Remove screws in side of box, thus releasing bridge-piece, and lift unit out of rubber lining.

On re-assembly, take care to replace bonding wire to frame and case.

Commutators

(i) Remove dirt from commutators by rotating in contact with rag moistened with cleaning solvent.
(ii) If segments are burnt or scored, return the rotary convertor to Recording Maintenance Unit, and fit a replacement rotary convertor.

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APPENDIX A

FAULT INDICATIONS

	Symptom	Probable Cause
1.	Amplifiers not working but motors function and meter shows normal battery voltage.	Battery polarity reversed.
2.	Machine erases but does not record, although bias-current reading is normal. Headphone listening to incoming programme and ordinary reproduction also both normal.	(a) Tape wrongly threaded through head block, so that pressure pin fails to guide tape against recording head. (b) Disconnection in recording-head circuit.
3.	Machine neither records nor erases, and bias-current meter gives zero reading. Headphone listening to incoming programme and to ordinary reproduction both normal.	Record relay not closing : (a) contacts damaged or dirty ; (b) relay coil circuit interrupted.
4.	Background of commutator hum audible on microphone input.	Microphone lead too close to battery lead.
5.	Excessive background hiss on reproduction even when pre-erased unmodulated tape is played.	Reproducing head magnetised.
6.	Quiet background when reproducing pre-erased unmodulated tape, but hiss audible when switched to *Record*, although no programme input circuit connected.	Recording head magnetised.
7.	High-frequency response poor.	(a) Tape back-to-front ; (b) Bias excessive ; (c) Pole-faces dirty.
8.	High-frequency response fluctuating.	Pressure pin not entering headblock fully because linkage needs adjusting.
9.	Speed fluctuations at period of rotation of left-hand spool, especially near end of tape.	Left-hand spool-brake dirty or out of adjustment.
10.	Speed fluctuations at period of pressure roller, particularly near beginning of reel.	(a) Pressure-roller tyre out of true ; (b) Actuating finger out of adjustment.
11.	Tape breakage *during* fast rewind.	*Left*-hand spool-brake hold-off magnet inoperative.
12.	Tape breakage at *switching off* fast rewind.	*Right*-hand spool-brake pull-off clearance excessive.

APPENDIX B

STANDARD EQUIPMENT, TOOL KIT AND ACCESSORIES

Standard Equipment

Machine Unit
Amplifier Unit
Battery, 12-volt, 50-Ah
Power, play and battery cables
Post-Office cords
Microphone(s), 25-50 ohms
Moving-coil low-impedance headphones
Loudspeaker, 300 ohms

Tool Kit

Inspection lamp
Screwdriver 2BA
Screwdriver 4BA
Screwdriver 6BA
Terry spanner 2-4-6-BA
Box spanner 4 × 6
Adjustable spanner
Grease
Thin oil
' Dermic ' oiler

Electrical Apparatus

The following should be available for testing and repair work:

Electric soldering iron
Flux cored solder
Insulated wire
Cleaning solvent (methylated spirit)
Relay leaf tool
Relay contact cleaner
Tone source covering 40 c/s to 15 kc/s
Valve-voltmeter or PPM/6
Avometer
One valve each of Types EF86, ECC81 and EL84
Indicator-lamp and lamp for volume meter
Neon lamp for stroboscope
' Leeraser ' or other demagnetiser

Accessories

Canvas covers for machine and amplifier units
Accumulator carrying case

APPENDIX C

PERFORMANCE SPECIFICATION

General Data

Power Supply

12 volts d.c. from 50-Ah battery.

Tape Speed

Adjustable from 14 to 18 in./sec.

Test Input and Output Impedances

600 ohms at line input and output.

Standard Input and Output Levels

0 dB at line input, and at line output loaded with 600 ohms.

Impedances

See page 19.

Test Data

Frequency Response

Response at Type-77 standard level, between 50 c/s and 15 kc/s: ±2 dB referred to 1 kc/s.

Total Harmonic Distortion

Not more than 2½% r.m.s. at 1 kc/s at peak output level (8 dB above Type-77 standard level).

No-signal Noise Level

More than 45 dB unweighted below peak output level, measured with bias and erase on.

Wow and Flutter

Total r.m.s. wow and flutter, measured with 3-kc/s carrier, less than 0·2%.

Fig. 1. Deck-plate Assembly Showing Controls and Brake Mechanisms

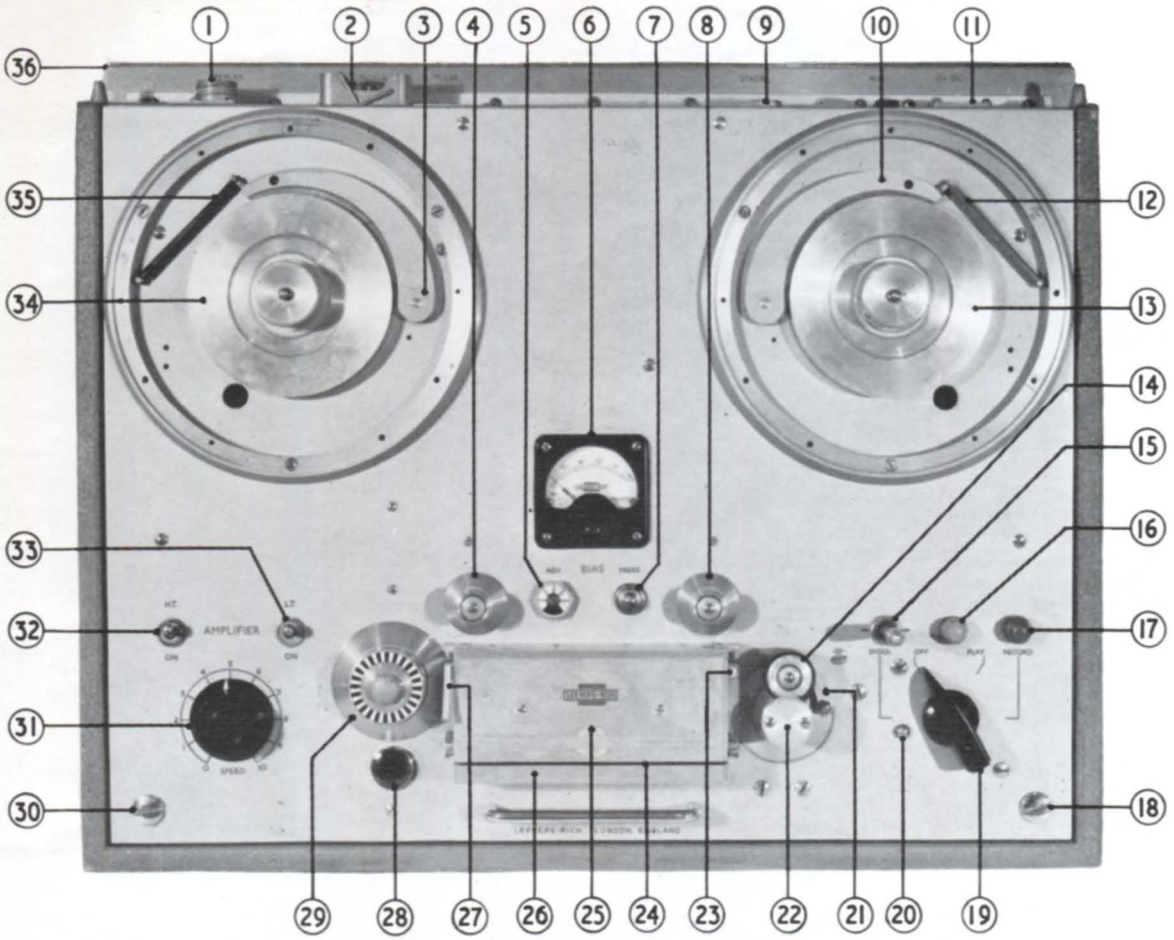


Fig. 1. Deck-plate Assembly Showing Controls and Brake Mechanisms

KEY

1. Replay-cable connector
2. Power-cable connector
3. Brake shoe
4. Jockey roller
5. Bias-current control
6. Bias-current meter
7. Bias-current meter switch
8. Jockey roller
9. Stroboscope oscillator frequency control
10. Brake shoe
11. Battery-cable connector
12. Brake spring
13. Brake drum
14. Pressure roller
15. Spooling switch
16. Green ' Play ' lamp
17. Red ' Record ' lamp
18. Deckplate locking screw
19. Function switch
20. Safety catch
21. Pressure-roller arm
22. Drive capstan housing
23. Gate-pressure crank
24. Tape slot or ' gate '
25. Headblock top cover
26. Headblock front cover
27. Gate-pressure crank with handle
28. Stroboscope window
29. Flywheel pulley
30. Deckplate locking screw
31. Speed control
32. H.T. switch
33. L.T. switch
34. Brake drum
35. Brake spring
36. Deckplate hinge

Fig. 2. Deck-plate Assembly : Underneath View with Tray Removed

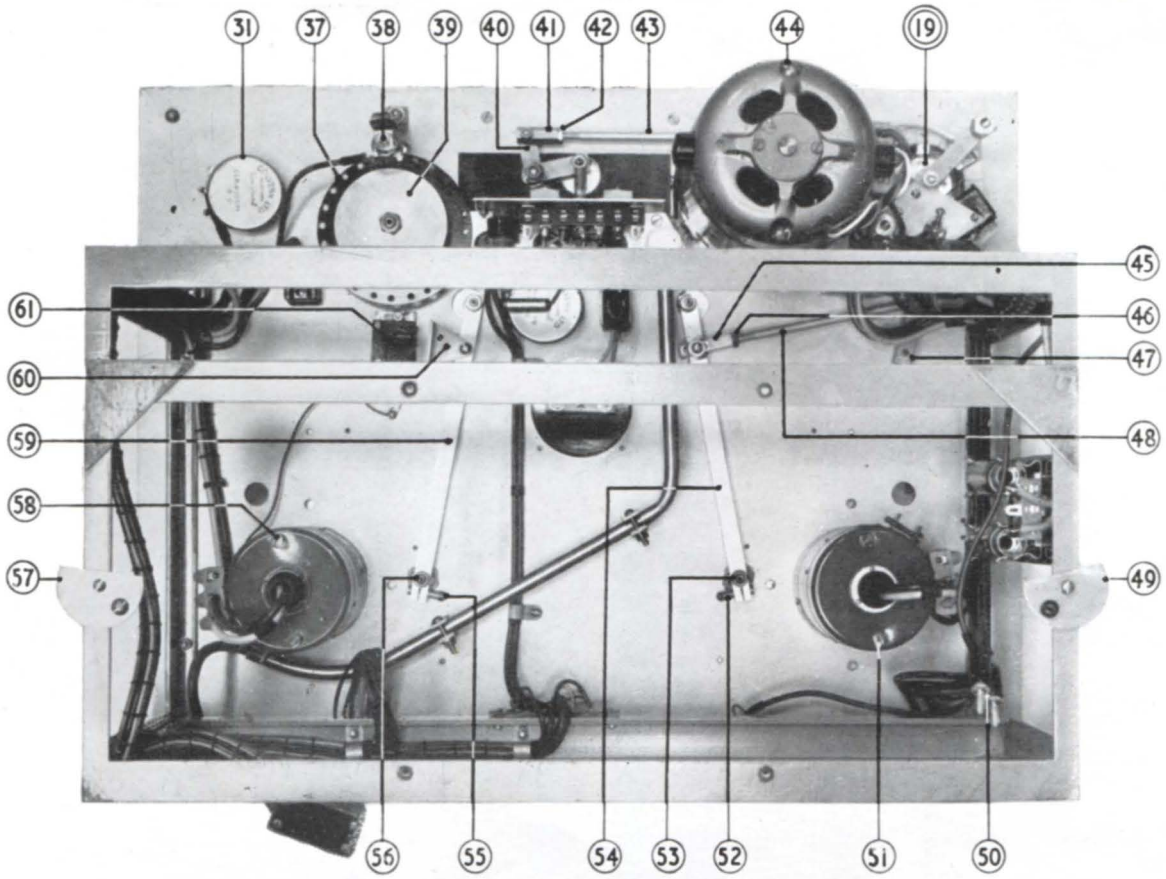


Fig. 2. Deck-plate Assembly: Underneath View with Tray Removed

KEY

19. Function switch
31. Speed control
37. Stroboscope disk
38. Neon stroboscope lamp
39. Flywheel
40. Bell-crank
41. Hinge block
42. Lock-nut
43. Push rod
44. Capstan-drive motor
45. Brake-rod end block
46. Lock-nut
47. Brake lever
48. Brake rod
49. Deckplate supporting latch
50. Stroboscope connectors
51. Take-up motor
52. Jockey-arm clamp
53. Brake-shoe pivot
54. Jockey arm
55. Jockey-arm clamp
56. Brake-shoe pivot
57. Deckplate supporting latch
58. Rewind motor
59. Jockey arm
60. Armature
61. Brake hold-off magnet

Fig. 3. Recording Machine with Deck-plate Raised

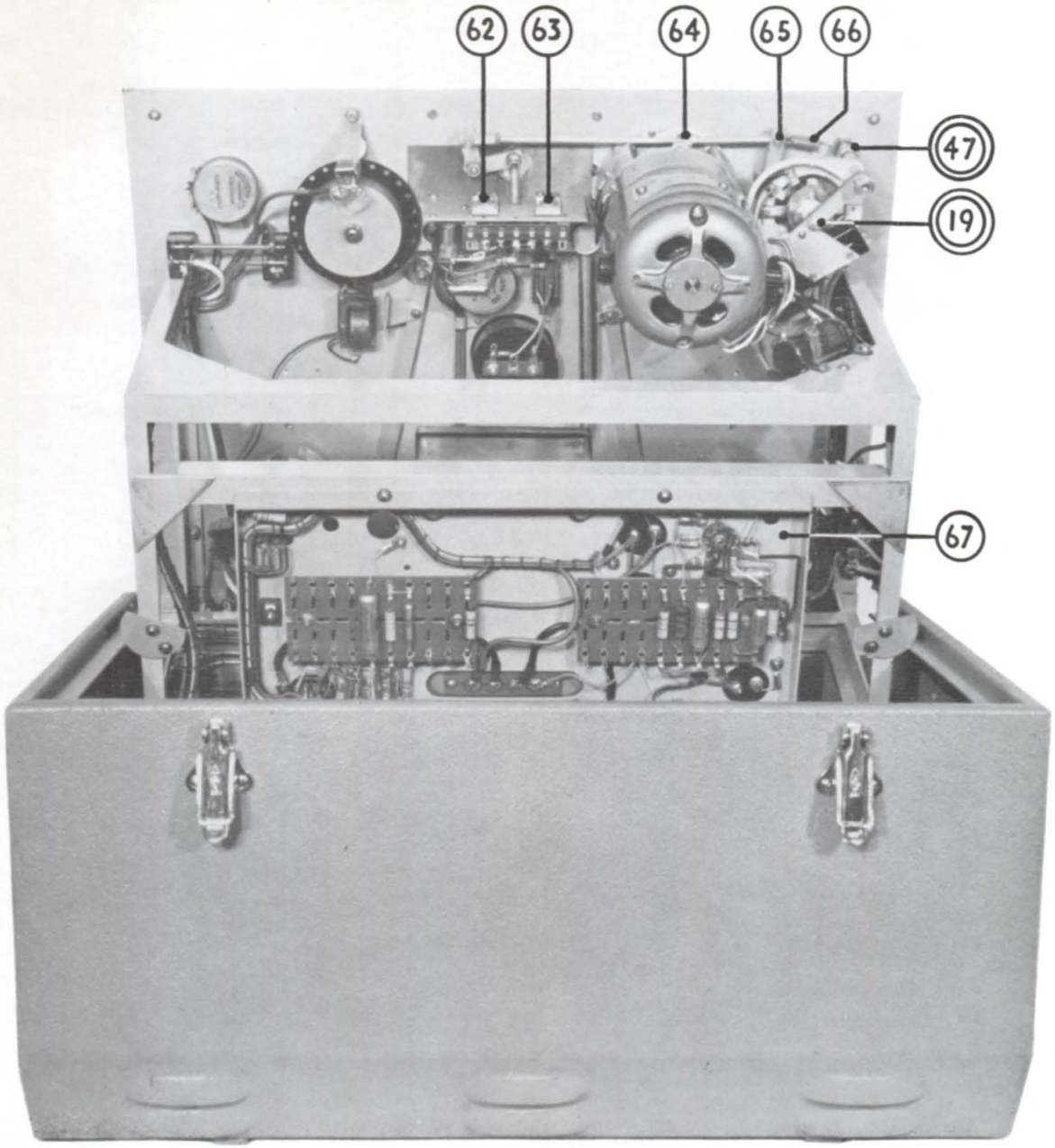
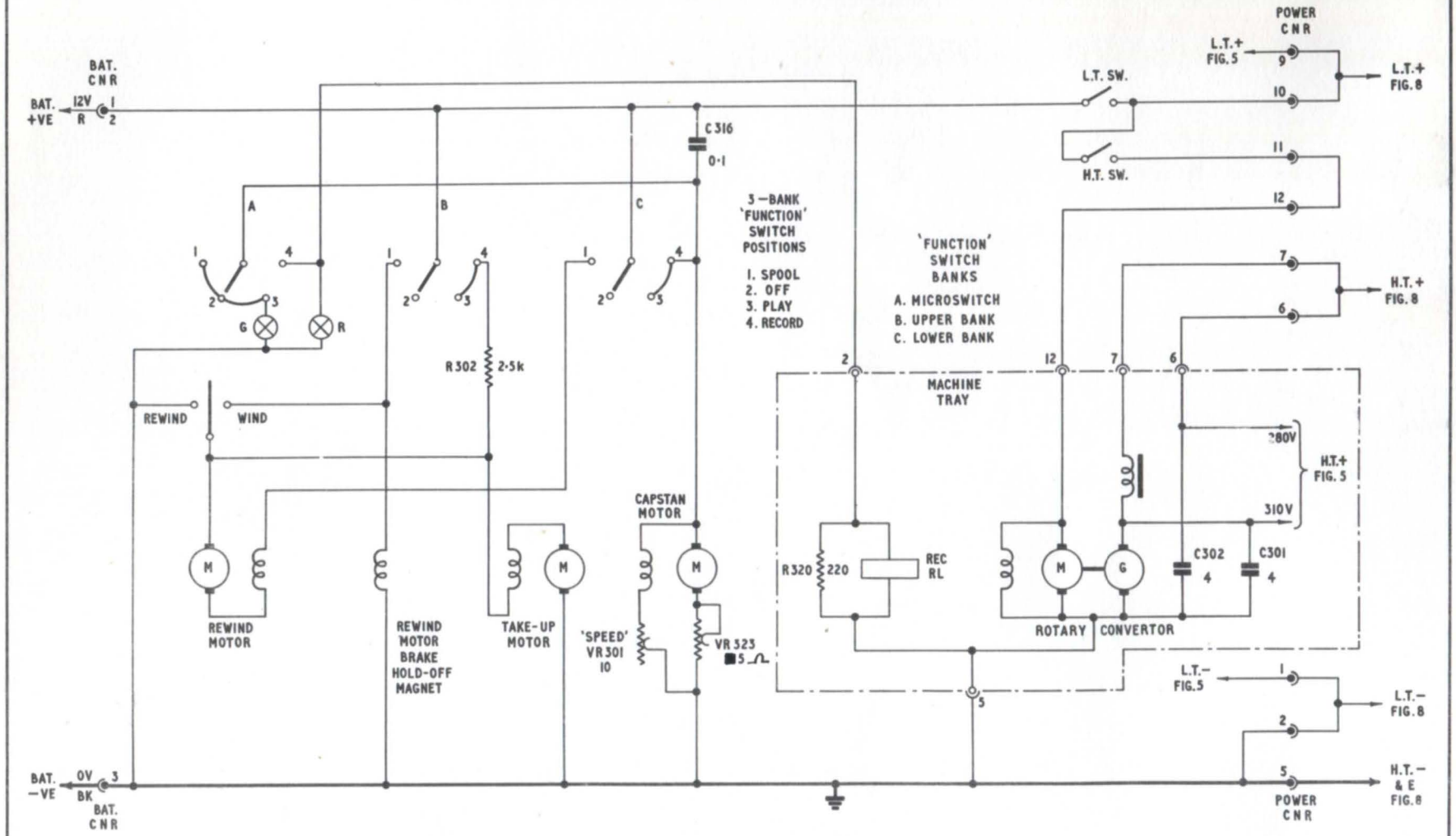


Fig. 3. Recording Machine with Deck-plate Raised

KEY

19. Function switch
47. Brake lever
62. Bias rejection control
63. Recording equaliser control
64. Pressure-roller finger
65. Engaging lever
66. Engaging-lever spring
67. Tray

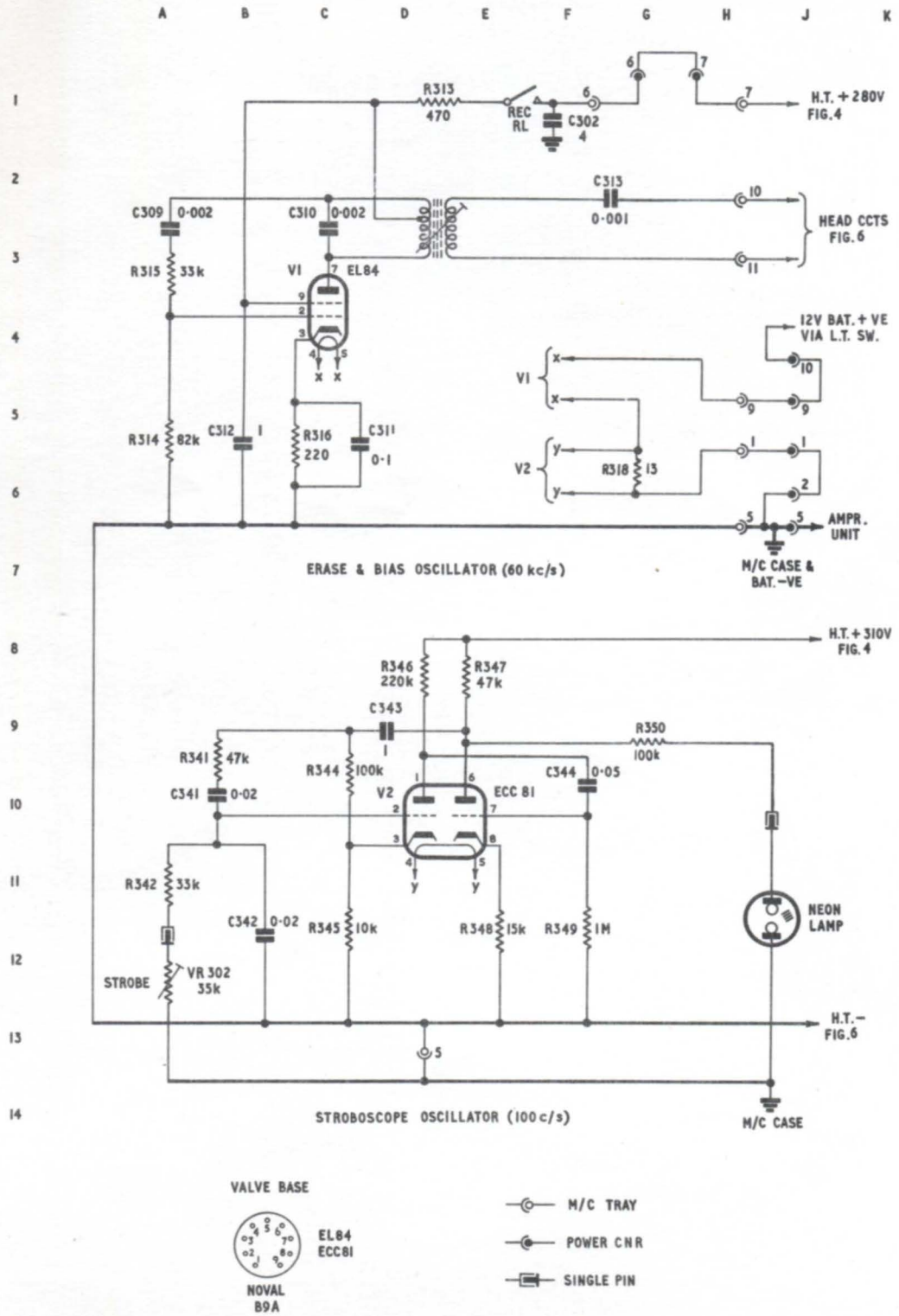


MACHINE UNIT : POWER CIRCUITS

FIG. 4

R.9

FIG.5



VALVE BASE

NOVAL B9A

EL84
ECC81

M/C TRAY

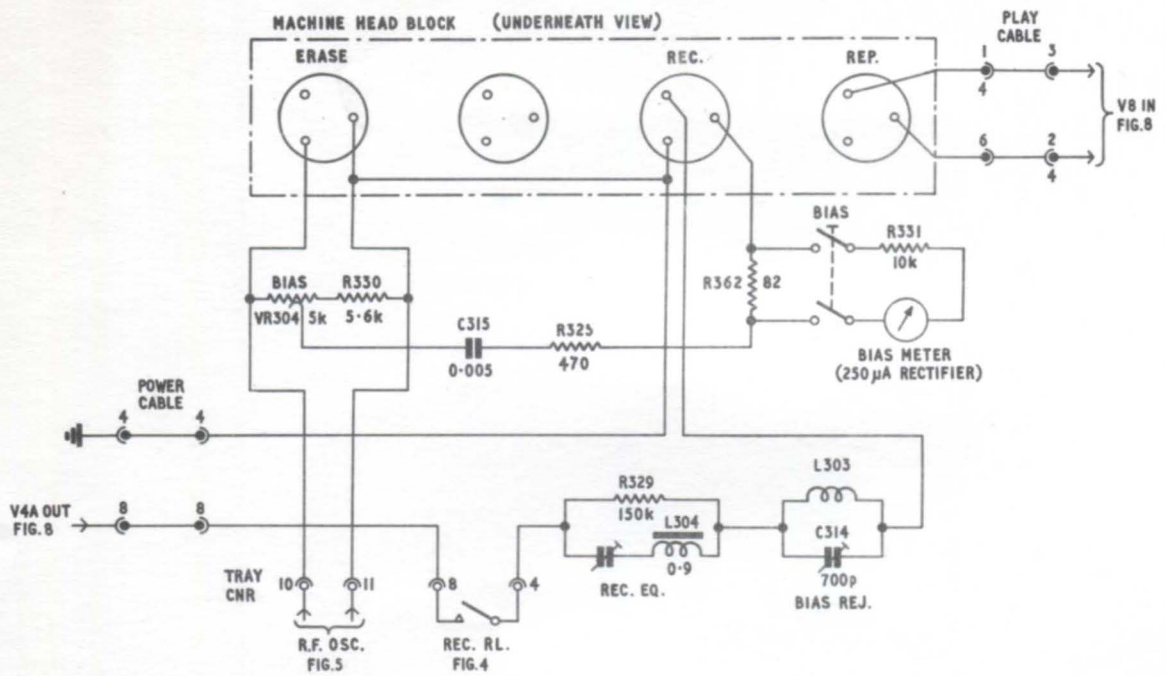
POWER CNR

SINGLE PIN

MACHINE UNIT : OSCILLATOR CIRCUITS

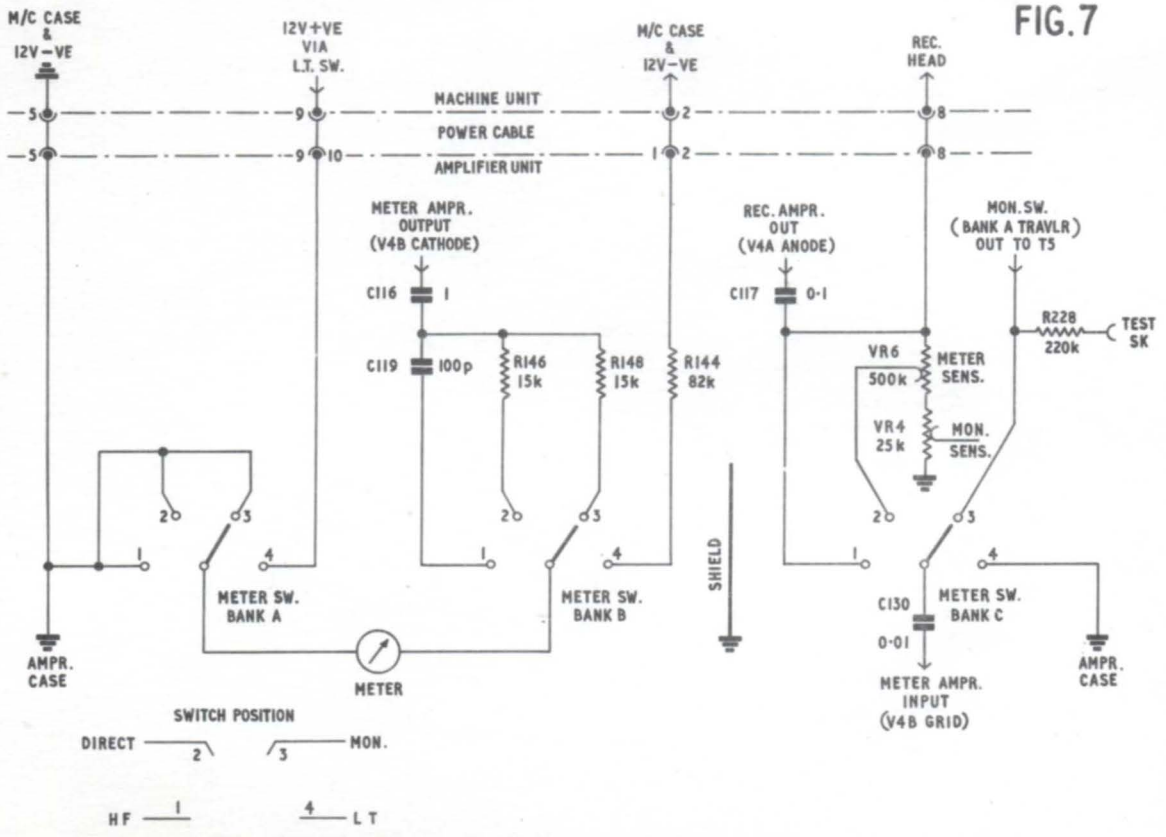
R.9

FIG.6



MACHINE UNIT : HEAD CIRCUITS

FIG.7



AMPLIFIER UNIT : METER SWITCHING CIRCUIT

COMPONENT TABLE: FIG. 8

Comp.	Loc.	Type	Tolerance Per cent
C101	F5	T.C.C. CE31B 12V	
C102	K5	T.C.C. CE31B 12V	
C103	D5	T.C.C. CP37N 350V	
C104	I5	T.C.C. CP37N 350V	
C105	E2	T.C.C. CP32N 350V	
C106	G4	T.C.C. CP30S 500V	
C107	J2	T.C.C. CP32N 350V	
C108	M4	T.C.C. CP30S 500V	
C109	Q5	T.C.C. CE31B 12V	
C110	P5	T.C.C. CP37N 350V	
C111	R1	Hunt WP200 350V	
C112	Q2	T.C.C. CP35N 350V	
C113	S5	T.C.C. CE31B 12V	
C116	R9	T.C.C. CP91N 350V	
C117	T2	T.C.C. CP37N 350V	
C118	S2	T.C.C. CP37N 350V	
C119	N8	T.C.C. SCT2 350V	
C120	N3	T.C.C. CP33N 350V	
C120A	N2	T.C.C. CP33N 350V	
C121	G1	Hunt WP200 350V	
C125	C4	Cyldon TP11	
C126	C4	T.C.C. CP30S 500V	
C127	C5	T.C.C. CP30S 500V	
C128	C6	T.C.C. CP30S 500V	
C130	R10	T.C.C. CP32N 350V	
C201	L13	Hunt WP200 350V	
C202	I15	T.C.C. CP30S	10
C203	L17	T.C.C. CE31B 12V	
C204	J17	T.C.C. CP37N 350V	
C205	L13	T.C.C. CP35N 350V	
C206	Q15	T.C.C. CE31B 12V	
C207	T14	T.C.C. CP33N 350V	
C208	U13	T.C.C. CP35N 350V	
C209	R15	T.C.C. CP91N 350V	
C210	U16	T.C.C. CP35N 350V	
C211	I17	Cyldon	
C212	M13	T.C.C. CP91N 350V	
C213	O13	Hunt WP200 350V	
R101	E5	Morganite T 0·5W	10
R102	V5	Morganite T 0·5W	10
R103	E1	Dubilier R425	5
R104	J1	Dubilier R425	5
R105	E1	Dubilier R425	5
R106	I1	Dubilier R425	5
R107	O3	Morganite T 0·5W	10
R108	O2	Morganite T 0·5W	10
R109	M1	Morganite R 1W	10
R110	Q5	Morganite T 0·5W	10
R111	Q1	Morganite R 1W	10
R112	P1	Morganite T 0·5W	10
R114	S1	Morganite R 1W	10
R115	R1	Morganite T 0·5W	10
R117	S5	Morganite T 0·5W	
R118	T1	Morganite R 1W	
R119	S9	Morganite R 1W	10
R120	S8	Morganite R 1W	10
R121	R9	Morganite T 0·5W	10
R127	D3		
R130	I2	Morganite T 0·5W	10
R132	Q6	Morganite T 0·5W	10
R133	R5	Morganite T 0·5W	10
R140	B4	Morganite T 0·5W	10
R141	B5	Morganite T 0·5W	10
R142	B5	Morganite T 0·5W	10
R143	B6	Morganite T 0·5W	10
R144	F8	Morganite R 1W	10
R146	O8		
R147	O5	Morganite T 0·5W	10
R148	O8	Morganite R 1 W	10
R149	G3	Morganite T 0·5W	10
R151	G6	Morganite T 0·5W	10
R152	G5	Morganite R 1W	10
R153	M6	Morganite T 0·5W	10
R154	M5	Morganite R 1W	10
R201	M17	Morganite T 0·5W	10
R202	I16	Morganite T 0·5W	10
R203	K17	Morganite T 0·5W	10
R204	K13	Dubilier R425	5
R205	J13	Dubilier R425	5
R206	J14	Morganite T 0·5W	10
R207	I16	Morganite T 0·5W	10
R208	Q17	Morganite T 0·5W	10
R209	P17	Morganite T 0·5W	10
R210	P15	Morganite T 0·5W	10
R211	Q13	Morganite R 1W	10
R212	S17	Morganite R 1W	5
R213	S15	Morganite T 0·5W	10
R214	R13	Morganite R 1W	10
R215	T15	Morganite T 0·5W	10
R216	V14	Morganite T 0·5W	10
R217	V15	Morganite T 0·5W	10
R218	W15	Morganite R 1W	10
R220	O12	Morganite R 1W	10
R221	M12	Morganite R 1W	10
R222	N12	Morganite R 1W	10
R223	R17	Morganite T 0·5W	10
R225	V13	Morganite T 0·5W	10
R226	V16	Morganite T 0·5W	10
R227	H15	Morganite T 0·5W	10
R228	V18	Morganite R 1W	10
R229	P17	Morganite T 0·5W	10
T1	A3	Gilson 30CT 50 : 1	
T2	A7	Gilson 30CT 50 : 1	
T3	H15	Gilson 30CT 50 : 1	
T4	X14	Haddon HMO15 A/A 6 K 600Ω C/T BAL 15 Ω FEEDBACK 4W	
T5	Z9	Gilson A 20 K 200 Ω LINE	
VR1	H6	Painton LOG	
VR2	M6	Painton LOG	
VR3	M14	Morganite LH LOG	
VR4	U5	Morganite	
VR5	Y7	Colvern WW 1W	
VR6	U3	Morganite	

58/GH/110/DJE
LEEVERS-RICH
DRWG No 573

R9

FIG.8
ISSUE 2

AMPLIFIER UNIT : CIRCUIT

NOTE:– VOLTAGES SHOWN IN BRACKETS ARE WITH L.S. AMPR. IN USE

MIC.1 IN T1 — OSC.SW. 1kc/s ↔ OFF — FREQ. — R127 10M — R140 150k — C125 750p — R141 150k — C126 0·001 — R142 150k — C127 0·001 — R143 150k — C128 0·001

MIC.2 T2

LL/1065G — INPUT 3 600Ω 0dB — 3·9k — 390 — 220 — 1:1

MIC.1 AMPR. & 1-kc/s OSC.

V1 EF86 — R105 560k — R103 150k — C105 0·01 — 39V (34V) — 55V (47V) — C121 4 — R149 4·7M — L.F SW. LEVEL ATT. — C106 0·001 — LOW NORMAL — R152 390k — GAIN SW. — MIC.1 FADER VR1 500k — R151 100k — C103 0·1 — R101 1·5k — C101 25 — 1·2V (1V)

V2 EF86 — R106 560k — R104 150k — C107 0·01 — R130 10M — 39V (34V) — 55V (47V) — C104 0·1 — R102 1·5k — C102 25 — 1·2V (1V)

MIC.2 AMPR.

130V (120V) — R109 47k — 215V (185V) — R112 1M — R111 220k — 215V (185V) — C111 4 — R114 33k — 270V (190V)

V3 EF86 — 46V (41V) — C112 0·05 — 56V (50V) — C120A 0·02 — R108 470k — C120 0·02 — R107 470k — L.F SW. LEVEL ATT. — C108 0·001 — LOW NORMAL — R154 390k — GAIN SW. — MIC.2 FADER VR2 500k — R153 100k — R147 2·2M — C110 0·1 — 1·7V (1·5V) — C109 25 — R115 1M — R110 1·5k — R132 470 — R133 330k — R117 470 — C113 25 — 1·6V (1·4V)

V4A ECC81 — C118 0·1 — 150V (125V) — C117 0·1 — R118 47k

REC. AMPR.

VR6 500k — METER SENS. — VR4 25k — MON. SENS.

POWER CONNECTOR

HT+ 6 7 — REC. HD. 8 — REC. HD. 4 — M/C E 5

METER LAMP — VR5 200 — R229 220 — HEATERS (L.T. SW.) 9 10 — HEATERS (M/C E) 2

MONITOR SWITCH — T5 — PHONES 150Ω

METER SWITCH — C119 100p — R146 15k — R148 15k — R144 82k — M1

METER AMPR. — R120 74k — R121 1M — R119 470 — 135V (120V) — C116 1 — C130 0·01 — V4B

METER SWITCH: DIRECT H.F. — MON. L.T.

MONITOR SWITCH: PHONES REP. DIRECT — REP. DIRECT — L.S. REP. DIRECT

VALVE BASE — Noval B9A — EF86 ECC81 EL84

T3 — FROM REP. HD. VIA 'PLAY' CABLE — R227 10M — C202 0·002 — R202 560k — R207 47k — REP. EQ. C211 200p — C204 0·1 — R203 1·5k — C203 25 — 75V (65V) — 1·6V (1·5V) — V8 EF86 — R206 470k — C205 0·05 — 45V (40V) — R205 560k — R204 150k — C201 4 — C212 1 — R221 47k — 220V (195V) — R222 47k — R220 47k — C213 4 — VR3 500k — REP. GAIN — R201 4·7k

REP. AMPR.

V7B V7A ECC 81 — R211 100k — R214 51k — 110V (70V) — 270V (120V) — C208 0·05 — C207 0·02 — 1·5V (1V) — R210 1k — C206 25 — C209 1 — R213 1k — R215 1M — C210 0·05 — R229 10M — R209 22 — R208 1·5k — R223 10M — R212 51k

MON. AMPR.

V6 EL84 — R225 47k — R216 220k — 8·5V — R218 220 — R217 220k — R226 47k — V5 EL84

T4 — 270 — 270 — OUTPUT SW — 100 — LINE 600Ω — L.S. 300Ω — OUTPUT

R228 220k — TEST — L.S. 15Ω

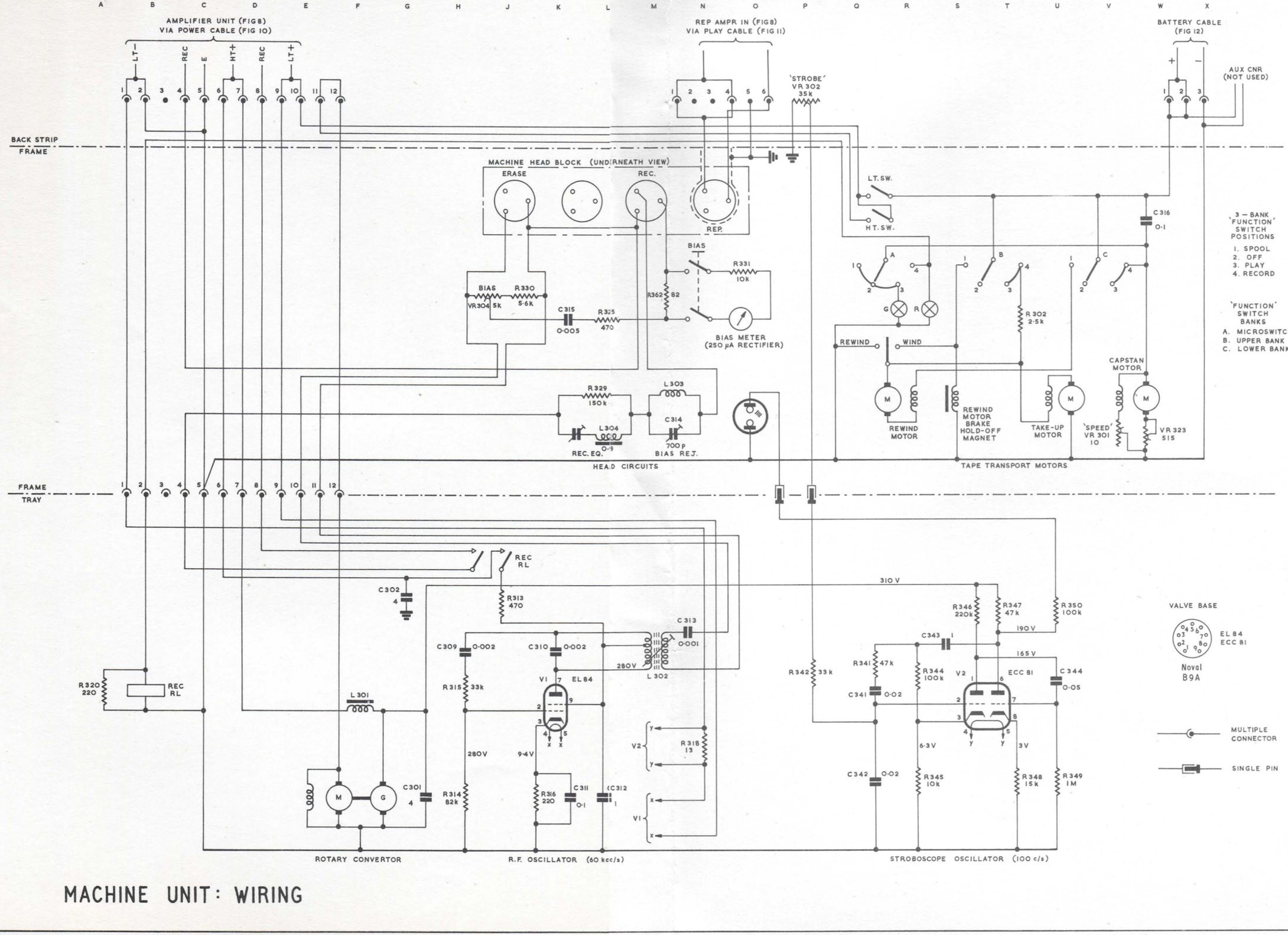
L.S. AMPR.

COMPONENT TABLE: FIG. 9

Comp.	Loc.	Type	Tolerance Per cent	Comp.	Loc.	Type	Tolerance Per cent
C301	G16	Hunt WP200 350V		R315	H14	Morganite R 1W	10
C302	G12	Hunt WP200 350V		R316	K16	Morganite R 1W	10
C309	H13	T.C.C. CP30S 500V		R318	W15	Zenith TG138	5
C310	K13	T.C.C. CP30S 500V		R320	A14	Morganite R 1W	10
C311	K16	T.C.C. CP37N 350V		R325	L6	Morganite T	
C312	L16	T.C.C. CP91N 350V		R329	L8	Morganite T	
C313	N12	T.C.C. CP32N 350V		R330	J6	Morganite T	
C314	M9	Cyldon TP11		R331	O5		
C315	K6	Hunt CP31N		R341	Q13	Morganite R 1W	10
C316	W4	Cyldon TP4		R342	P13	Morganite R 1W	10
C341	Q14	T.C.C. CP33N 350V		R344	R13	Morganite T 0·5W	10
C342	Q15	T.C.C. CP33N 350V		R345	R15	Morganite T 0·5W	10
C343	S13	T.C.C. CP91N 350V		R346	S12	Morganite R 1W	10
C344	U13	T.C.C. CP35N 350V		R347	T12	Morganite R 1W	10
				R348	T15	Morganite T 0·5W	10
L301	F14	Gilson 120mA		R349	U15	Morganite T 0·5W	10
L302	M13	Wearite		R350	U12	Morganite R 1W	10
L303	L9			R362	M6		
L304	L8						
				VR301	V8		
R302	T6	Morganite T 0·5 W	10	VR302	P2	Morganite LH LIN	
R313	J12	Morganite R 1W	10	VR304	J6	Colvern 4201/7S	
R314	H16	Morganite R 1W	10	VR323	W9		

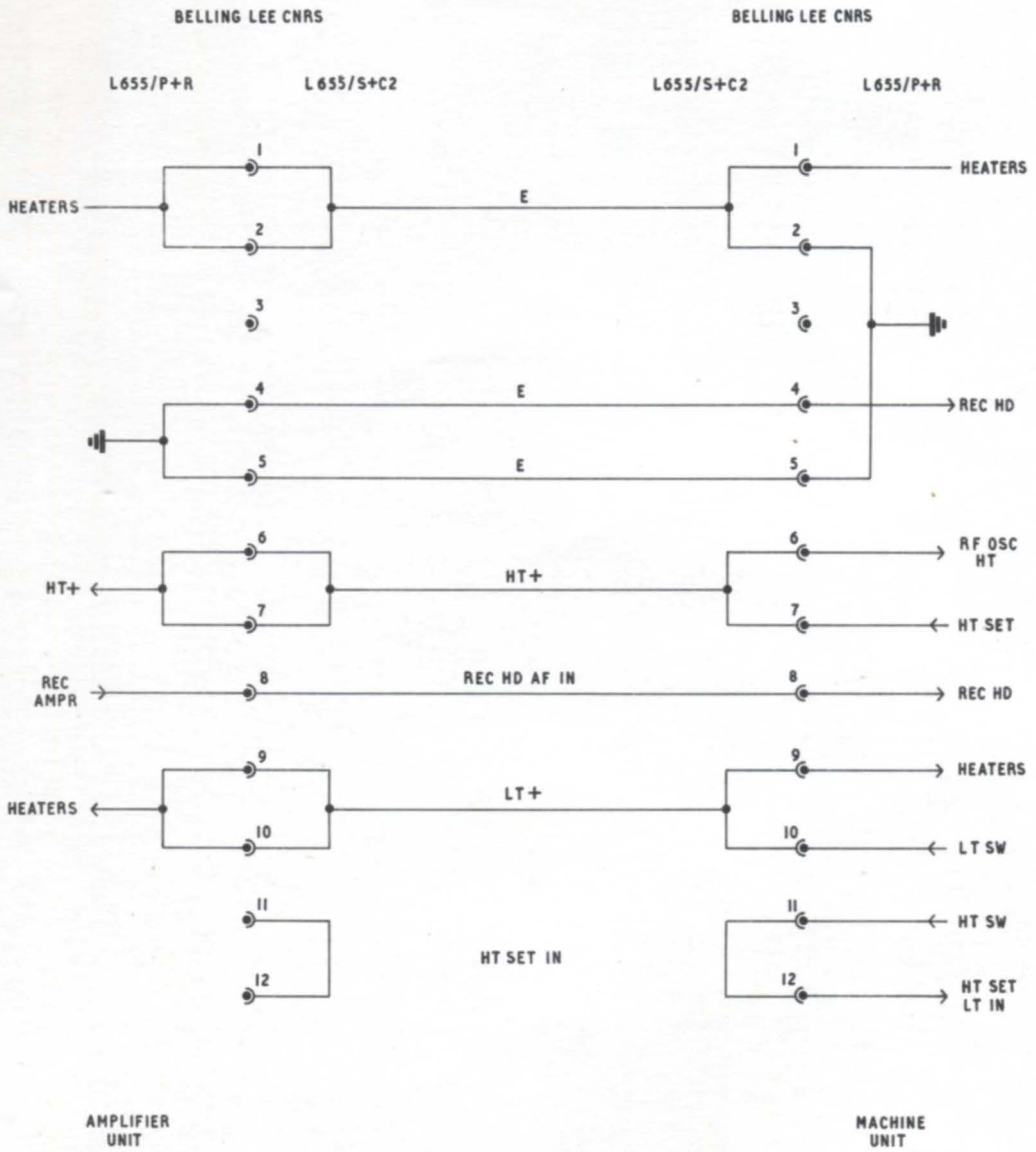
58/GH/111/AP
LEEVERS-RICH
DRWG. No.630

FIG.9 R9



MACHINE UNIT: WIRING

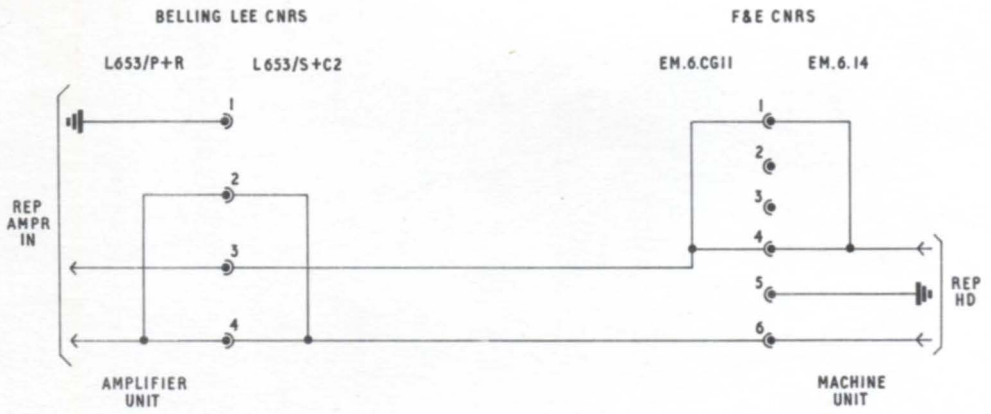
FIG 10



POWER CABLE

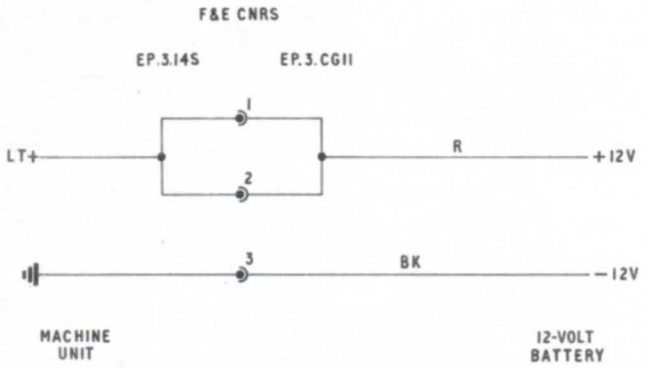
R.9

FIG 11



REPLAY CABLE

FIG 12



BATTERY CABLE

MICROPHONE CABLE

CABLE: EP.3.CG12
AMPR: EP.3.13

MACHINE TRAY

CABLE: L655/S+C2
TRAY: L655/P+R

MICROPHONE & TRAY CONNECTORS

INDEX

PART 2: MAINS-OPERATED RECORDERS

CONTENTS

ILLUSTRATIONS IN TEXT

DIAGRAMS AND PHOTOGRAPHS AT END

LEEVERS-RICH TRANSPORTABLE MAGNETIC TAPE RECORDERS

PART 2: MAINS-OPERATED RECORDERS

SECTION 6

INTRODUCTION

Two different a.c.-mains operated Leevers-Rich tape recorders are used at present by the BBC. These are a transportable model, Type E-121-P, and a console model, Type E-141. Only the transportable model is considered here. The transportable model itself exists in two different versions, and only the earlier version, comprising machines with serial numbers up to 498 and amplifiers with numbers up to 230, is described.

The recorder is designed to operate from 200/250-volt 50-c/s mains at either of two alternative speeds, 15 in./sec and 7½ in./sec, but is otherwise broadly similar to the 12-volt d.c. model described in Part 1. The current taken from the mains is one ampere approximately.

The usual three-motor tape-transport system is adopted, the alternative speeds being obtained by switching the stator windings of the capstan-drive motor. Operation of the speed-switch automatically selects the appropriate equaliser settings. Remote-starting facilities are available.

Standard quarter-inch tape is employed, using the following spool types:

European: up to 11½ inches diameter,
N.A.B.: up to 10½ inches diameter,
Domestic: up to 9½ inches diameter.

The equipment comprises an amplifier unit and recording machine interconnected by two cables. One of these cables connects the reproducing head to the reproducing amplifier; the other connects the recording amplifier to the bias circuit and recording head, and also carries h.t. and l.t. supplies to the amplifiers from the machine unit, which contains the necessary transformer and rectifiers. A third cable is required to connect the machine unit to the mains.

The recording chain has two separately controlled input channels, one suitable for microphones of 300 ohms impedance and the other for microphones of 30 to 50 ohms impedance, but jacks are also provided which by-pass the microphone amplifiers and allow either or both of the inputs to be taken from line. One line jack is intended for use with programme at zero volume, and presents an input impedance of 600 ohms (balanced); the other line jack, intended for bridging purposes, can accept an input of 100 mV and presents an impedance of 500 kilohms (unbalanced).

The reproducing-chain main output is unbalanced and normally delivers zero level into a 600-ohm line. Provision for monitoring includes a socket for use with a 15-ohm loudspeaker, and two jacks of 600 ohms output impedance which may be used with an L.S.U. or with headphones. The 15-ohm socket can be used during recording or playback, but not during transmission, since the loudspeaker speech-coil impedance, which may vary with frequency, is effectively in shunt across the outgoing line. A volume-indicating meter is fitted; this meter works without an amplifier, and its scale is not of the BBC P.P.M. type, although calibrated in dB.

The erase and bias currents are provided by a 60-kc/s push-pull oscillator in the machine unit. A 1-kc/s line-up tone oscillator is fitted in the amplifier unit, and uses the same valve as microphone amplifier 1.

The construction and finish of the equipment resembles that of the d.c. model shown in the photographs on pages 1 and 2 of Part 1. The recording machine is 11½ in. high, 20½ in. wide and measures 16½ in. from front to back. The amplifier unit is 9¼ in. high, 18¼ in. wide and 8¾ in. from front to back. The recording machine weighs 76 lb and the amplifier unit 20 lb.

The amplifier circuits differ only slightly from those of the d.c. model, but the tape-transport mechanism has been partly redesigned, and a timing indicator reading minutes and tenths at 15 in./sec has been supplied. The slight long-term speed variations occurring with the d.c. model are absent on the a.c. machine when mains operated, and consequently full-length music recordings can be made. The use of a battery-and-vibrator power supply is permissible for recording speech, but is not recommended for music.

SECTION 7

RECORDING MACHINE

General Description

The three a.c. motors employed for capstan drive, take-up and rewind purposes respectively are mounted directly beneath the deck-plate of the machine. The capstan-drive motor is of the synchronous hysteresis type and operates at 1,500 r.p.m. when switched to 15 in./sec or at 750 r.p.m. when switched to 7½ in./sec. The take-up and rewind motors are of the variable-speed squirrel-cage type. A flexible coupling is provided between the capstan spindle, which carries a small flywheel, and the drive motor. This arrangement acts as a mechanical filter, and thus prevents motor vibration from reaching the tape.

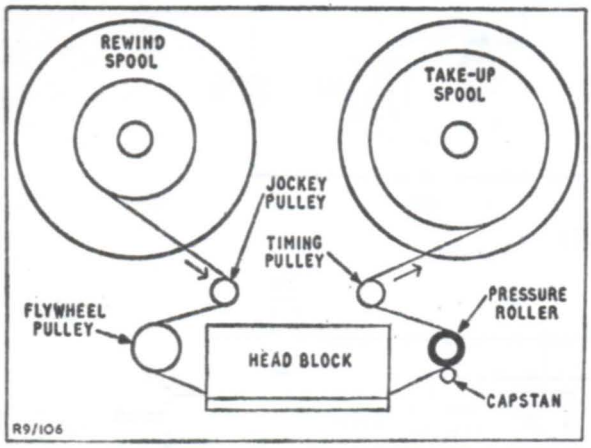


Fig. 7.1. Tape Lacing Diagram

Fig. 7.1 shows how the tape travels through the machine. During normal forward operation the tape is pulled off the left-hand spool by the drive capstan and pressure roller and wound onto the right-hand spool by the take-up motor, operating under reduced power via a resistance in series with the mains supply. The rewind motor is not energised, but has slight braking applied. This braking is controlled by tape tension via a jockey pulley round which the tape passes on leaving the left-hand spool. A correspondingly placed fixed pulley on the take-up side of the machine operates the timing indicator via a gear-train. The tape also passes over a further pulley immediately before it reaches the heads. This pulley bears stroboscopic markings and is attached to a small flywheel beneath the deck-plate. The purpose of the flywheel is to damp out tape-speed fluctuations caused by the operation of the left-hand brake.

At the moment of starting, the pressure roller is brought into engagement with the drive capstan by a solenoid mechanism, while two further solenoids operate to release the take-up and rewind motor ' stop ' brakes, which are independent of the jockey-arm tape-tension brake.

The principal machine controls are mounted on the deck-plate as illustrated in Fig. 13, which also shows the rear connector panel. Details of the replay and power cables connecting with the amplifier unit are shown in Figs. 20 and 21. The deck-plate is hinged at the rear and can be lifted and latched in the raised position as shown in Fig. 14. Extending beneath the rear of the deck-plate is a vertically mounted chassis or ' tray ' which embodies the connector panel at its upper end. This tray carries the 60-kc/s oscillator, a mains transformer and two h.t.-rectifying valves, together with metal rectifiers which provide a direct-current l.t. supply. Connection between the tray and the deck-plate cable-forms is made via a 12-pin plug and socket (the ' tray ' connector) as indicated in Figs. 16 and 17.

Power Supplies (Fig. 16)

The routing of power supplies is shown schematically in Fig. 7.2, in which (a) mains, (b) h.t. and (c) l.t. supply circuits are separately indicated. Further details of the supply circuits are shown in Fig. 16. The incoming a.c. supply is taken to fuses on the machine connector panel, and hence to the tape transport system, which is controlled by the *Function* switch and remote-starting relay RM. The supply is also taken via the *Amplifier* switch on the deck-plate to the mains transformer, the appropriate voltage tapping for which is selected by a U-link on the machine connector panel. The mains transformer has two secondary windings; one of these is centre-tapped

to earth via a 250-milliamp fuse on the connector panel, and feeds the amplifier and oscillator h.t. supply circuits shown at (b) via two separate rectifying valves; the other winding provides the l.t. supply.

The h.t. feed to the amplifiers is routed directly to the amplifier unit via the power cable. The oscillator h.t. is controlled by the *Function* switch, heaters receive a rectified and smoothed 12-volt supply. This d.c. supply is further used to energise the amplifier-unit A relay, which re-sets the reproducing equaliser when the drive-motor speed-switch is moved from 15 to 7½-in./sec. The 'remote' relay, RM, is also energised from this supply when the pins of the remote-starting socket on the machine connector panel are bridged.

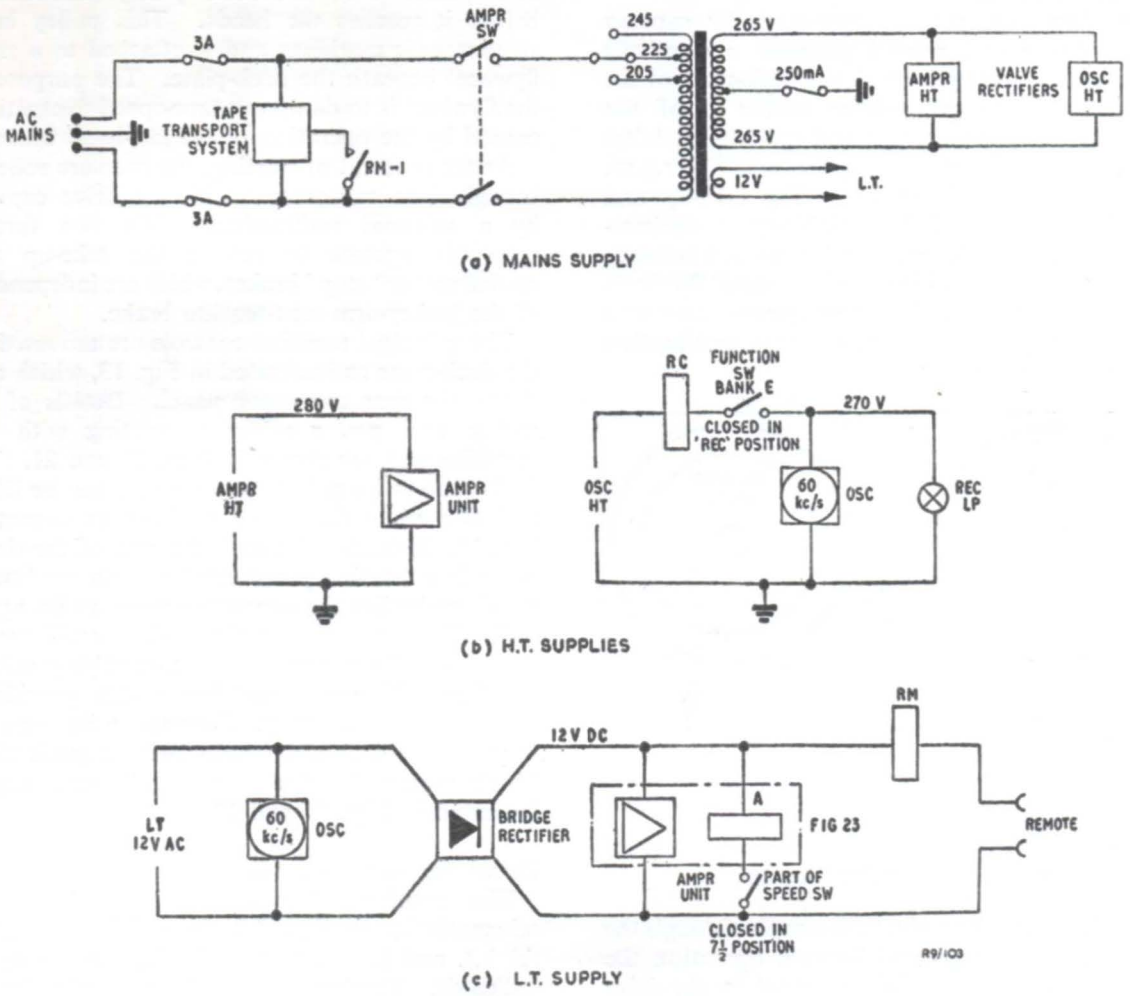


Fig. 7.2. Power Distribution

and is available only when this switch is set to *Record*. In these circumstances a *Record* indicator-lamp adjacent to the switch is fed in parallel with the oscillator, and relay RC controlling the a.f. recording circuit is energised in series.

The l.t. supply from the mains transformer is taken to the circuit shown at (c). The oscillator-valve heaters are a.c.-operated, but the amplifier

Two additional metal rectifiers (Fig. 15) on the underside of the deck-plate are used to operate the drive and brake solenoids. (Fig. 17.)

Tape Transport System (Figs. 13, 14, 15, 17)

Function Switch

The tape transport system is controlled electrically by a five-section *Function* switch with four

positions, *Spool*, *Off*, *Play* and *Record*. Three sections of the switch, banks A, B and C, are portions of a rotary switch; the remaining sections, banks D and E, are microswitches operated by differently positioned fingers on the bottom of the switch-shaft. Banks A to D between them control the motors, the 'stop' brakes and the drive-engagement mechanism. Bank E controls the *Record* lamp and oscillator h.t. supply; the microswitch composing this bank closes in the *Record* position.

The tape transport system is also controlled mechanically by the *Function* switch, via an edgewise-acting cam on the switch-shaft. The four switch positions are spaced at 60-degree intervals round the shaft, which thus has a total rotation of 180 degrees. A corresponding arc on the edge of the cam controls the motion of a small wheel on a pivoted follower arm. The follower is attached to a system of rods and cranks which lift the tape away from the heads and de-operate the tape-tension brake when the *Function* switch is set to *Spool* or *Off*.

Figs. 13, 14 and 15 show the mechanical arrangement of the system, while Fig. 7.3 indicates the method of operation. Fig. 17 shows the electrical arrangement.

Mechanical Control System (*Fig.* 7.3)

A simplified plan of the mechanical control system is given in Fig. 7.3. The profile of the cam on the shaft of the *Function* switch appears near the right-hand lower corner of the diagram. The position of the cam is that assumed with the switch in the *Off* position. The cam follower arm with its small wheel is pivoted at one end and attached at the other to a connecting rod, a tension spring at the further end of which holds the follower wheel in contact with the cam profile.

The connecting rod is hinged at its left-hand end to a double crank, one arm of which carries a glass tape-lift rod. A further single crank with a second tape-lift rod is held in contact with a pin on the connecting rod by a spring between the two crank-arms. Both tape-lift rods are recessed into the headblock in the *Play* and *Record* conditions, but advance due to cam action and lift the tape off the heads in the *Off* and *Spool* conditions. The lack of rigid connection between the right-hand crank and the connecting rod allows the right-hand tape-lift rod to be moved back into the headblock by means of a small handle when it is desired to use the reproducing head during fast-running operations.

The left-hand arm of the double crank is attached to a push-rod which can bear on a sideways-projecting pin on the arm carrying the tape-tension jockey pulley. In the *Off* and *Spool* conditions the push-rod makes contact with the pin and rotates the jockey arm clockwise, so releasing the tape-tension brake from the left-hand brake-drum.

The two 'stop' brakes, one for each spool, and the pressure-roller engagement mechanism are all solenoid-controlled as mentioned earlier. The arrangement of solenoids and links is visible in Fig. 7.3.

'Off' Condition

Under this condition, the *Function* switch (Fig. 17) is in position 2. Power is cut off from all motors and solenoids and from the 60-kc/s oscillator. The pressure-roller engagement mechanism is held off, and the spool 'stop' brakes are held on, by the springs shown in Fig. 7.3.

The cam attached to the switch-shaft has its profile recessed where it makes contact with the follower wheel, so that the follower arm moves to its maximum clockwise position. The connecting rod moves to the left, swinging the tape-lift rods out of the headblock and lifting the tape off the heads. The accompanying clockwise motion of the left-hand (double) crank thrusts the push-rod against the pin on the jockey arm, so that the latter rotating clockwise disengages the tape-tension brake from the left-hand brake-drum.

'Play' Condition

Under this condition the *Function* switch (Fig. 17) is in position 3.

(*a*) *Local Operation.* Bank A of the *Function* switch energises the capstan-drive motor via the *Speed* switch (Fig. 18). Bank B operates the drive-engage solenoid which brings the pressure roller into engagement with the capstan. Bank C operates the motor-brake hold-off solenoids which release the 'stop' brakes; this bank also energises the take-up motor via bank D, the motor operating under reduced power via a 300-ohm resistor. Bank E is not wired on position 3, and the 60-kc/s oscillator therefore remains inoperative, with l.t. only applied.

The active sector of the cam profile (Fig. 7.3) projects, so that the connecting rod moves to the right, thus making the tape-lift rods fall back into the headblock and also applying the tape-tension

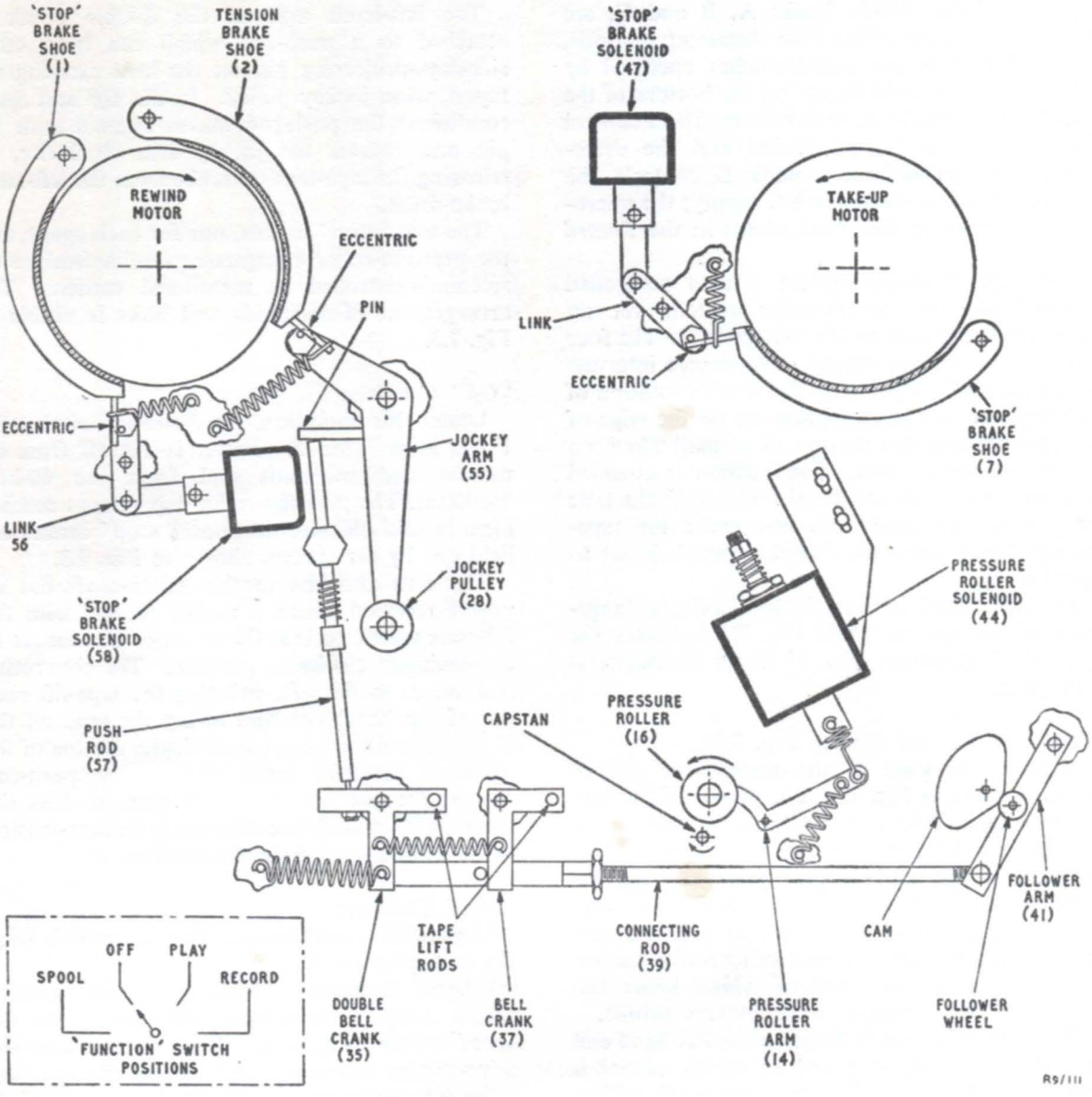


Fig. 7.3. Tape Transport Mechanism

brake; this brake is subsequently controlled by the tape itself via the jockey pulley.

(*b*) *Remote Operation.* When the *Local/Remote* switch (Fig. 17) is in the *Remote* position and the *Function* switch is turned to *Play*, power is not applied to the motors and solenoids until the pins of the *Remote* socket (Fig. 16) are short-circuited. Relay RM is then energised, and RM-1 closing applies power to the *Function* switch via the *Local/Remote* switch as shown in Fig. 17.

'Record' Condition

The *Function* switch is in position 4.

(*a*) *Local Operation.* Banks A to D of the *Function* switch have the same effect as under the *Play* condition. Bank E lights the red pilot-lamp, applies h.t. to the 60-kc/s oscillator (Fig. 16) and energises relay RC. RC-1 closing connects the recording-amplifier output to the recording equaliser and head circuit. RC-2 is not used.

The action of the cam-operated mechanism is the same as for *Play*.

(*b*) *Remote Operation.* The circuit energised via bank E of the *Function* switch is not controlled by the *Local/Remote-switch*. Remote operation with the *Function* switch on *Record* is thus similar to remote operation with the switch on *Play*.

'Spool' Condition

The *Function* switch is in position 1. Bank A provides power to the reverse-drive section of the *Spool* control. Bank B short-circuits the *Local/Remote* switch, thus ensuring exclusively local operation. Bank C operates the solenoids which hold off the motor 'stop' brakes and also applies power to one terminal of the take-up motor, the other terminal of which is connected via bank D to the moving arm of the *Spool* control. Bank E is not wired on position 1.

The cam-operated mechanism holds off the tape-tension brake and advances the tape-lift rods. Since the capstan motor and drive solenoid are not energised, the capstan does not rotate and the pressure-roller does not engage.

When the *Spool* control is in the neutral position, the take-up and rewind motors are energised in series with one another and with a 13-ohm 6-watt resistor; the motors are wired so that they tend to rotate in opposite directions, thus applying tension to the tape. As the control is turned in the forward-drive direction, the rewind motor is progressively short-circuited and its torque thus diminished while that of the take-up motor is increased, so that the tape is wound forward with increasing speed.

When the *Spool* control is moved from neutral to reverse drive, the two motors continue to be energised in series, and as the control is turned further in this direction, the take-up motor is gradually short-circuited, an increasing proportion of the mains voltage being developed across the rewind motor, the torque of which therefore increases; the tape is thus rewound onto the left-hand spool at increasing speed.

NOTE:—The use of maximum fast forward and reverse speeds tends to cause uneven winding of the tape and in normal circumstances should therefore be avoided.

Drive Motor and Speed Switch (*Fig.* 18)

The synchronous hysteresis drive motor is of the split-phase type, operating on the single-phase supply with its auxiliary windings connected via a 4-μF capacitor. Only the motor stator is wound, the rotor being a hollow cylinder of magnetic material which is 'soft' enough to permit induced currents but 'hard' enough to retain magnetism. The torque on starting is due to a combination of the effects of (1) induced currents and (2) induced magnetic poles, each produced in the rotor by the rotating stator field. As the motor gathers speed the induction of poles persists but the rotor current falls, until at synchronism the motor is driven entirely by interaction between the induced poles and the stator field, being locked in step with the mains owing to the remanence of the induced rotor poles.

The drive-motor speed switch is linked mechanically to the recording equaliser switch. The motor switch has eight sections, of which seven are used, as shown in Fig. 18. Section A controls the 'A' relay and reproducing equaliser in the amplifier unit. (Fig. 19.) Sections B to D and F to H control the drive-motor speed. (Section E is not wired.)

With the speed switch in the 7½-in./sec position, the stator windings are connected in delta and have effectively four pairs of poles per phase so that the motor rotates at 750 r.p.m. With the switch in the 15-in./sec position the stator is star-connected with two pairs of poles per phase and the motor rotates at 1,500 r.p.m.

Fig. 18 does not show the magnetic configuration of the motor windings. This is indicated symbolically for a single pair of poles per phase in Fig. 7.4.

With the delta connection, each section (for example that between B and D) can be considered as two electromagnets with current flowing in opposite directions and thus having opposite polarities. With the star connection, the current

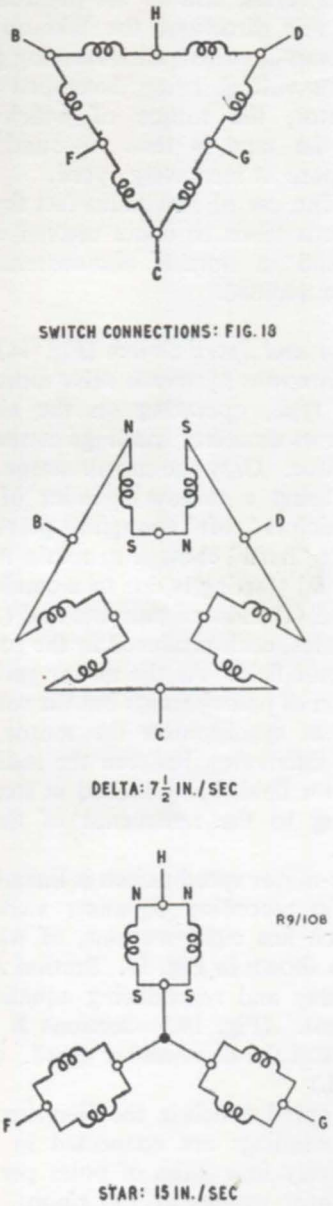


Fig. 7.4. Drive-motor Pole-switching Arrangement

in adjacent electromagnets flows in the same direction, and hence the number of polarity changes is halved. With half the effective number of poles on the stator winding, the rotor speed is multiplied by two.

Erase and Bias Oscillator (Fig. 16)

This 60-kc/s oscillator is of a push-pull Hartley type, using two double-triode valves, V1 and V2, in parallel. It receives a smoothed h.t. supply from V3 via the record relay RC, a 500-ohm 6-watt resistor and bank E of the *Function* switch when this switch is on *Record*. The recording indicator-lamp, a neon type, is supplied in parallel with the oscillator. The 12-volt heater supplies for V1 and V2 are obtained from the mains-transformer l.t. winding.

The connections between the oscillator and the head circuits are shown in Figs. 7.5, 8.1 and 17.

Head Circuits (Fig. 7.5)

The recording and erase head circuit is shown in Fig. 7.5 and a wiring diagram of the recording equaliser panel is given in Fig. 22. The reproducing head circuit is via the machine headblock and coaxial connectors and replay cable (Fig. 20) to the reproducing amplifier (Fig. 19).

The erase head is fed from the 60-kc/s oscillator, which is energised when the *Function* switch is on *Record* as mentioned under the previous heading. The head circuit is tuned to resonance by two capacitors (Fig. 7.5), one of which is adjustable. This arrangement, together with the use of a parallel push-pull oscillator, ensures a head current adequate to provide complete erasure.

The recording head has a single winding fed with bias and programme signals in parallel. The 60-kc/s bias is obtained from the oscillator via a 10-kilohm variable resistor used for bias-current adjustment. The bias-current meter and its series resistor are shunted by an 82-ohm resistor and connected between the variable resistor and the head. The programme feed to the head from the amplifier unit is routed via the power cable and relay contact RC-1; this contact is open except when the *Function* switch is on *Record*. Also in series with the head are two tuned circuits used for recording equalisation and bias rejection respectively. The recording equaliser is a variable tuned circuit shunted by a resistor and is designed to increase the head current around its resonance frequency to obtain a level surface-induction characteristic on the tape; two separate pre-set capacitors are provided in the circuit, selected by a switch linked to that controlling the drive-motor speed. The bias rejector is a variable shunt resonant circuit intended to present a maximum impedance at the bias frequency in order to keep the bias signal out of the amplifier.

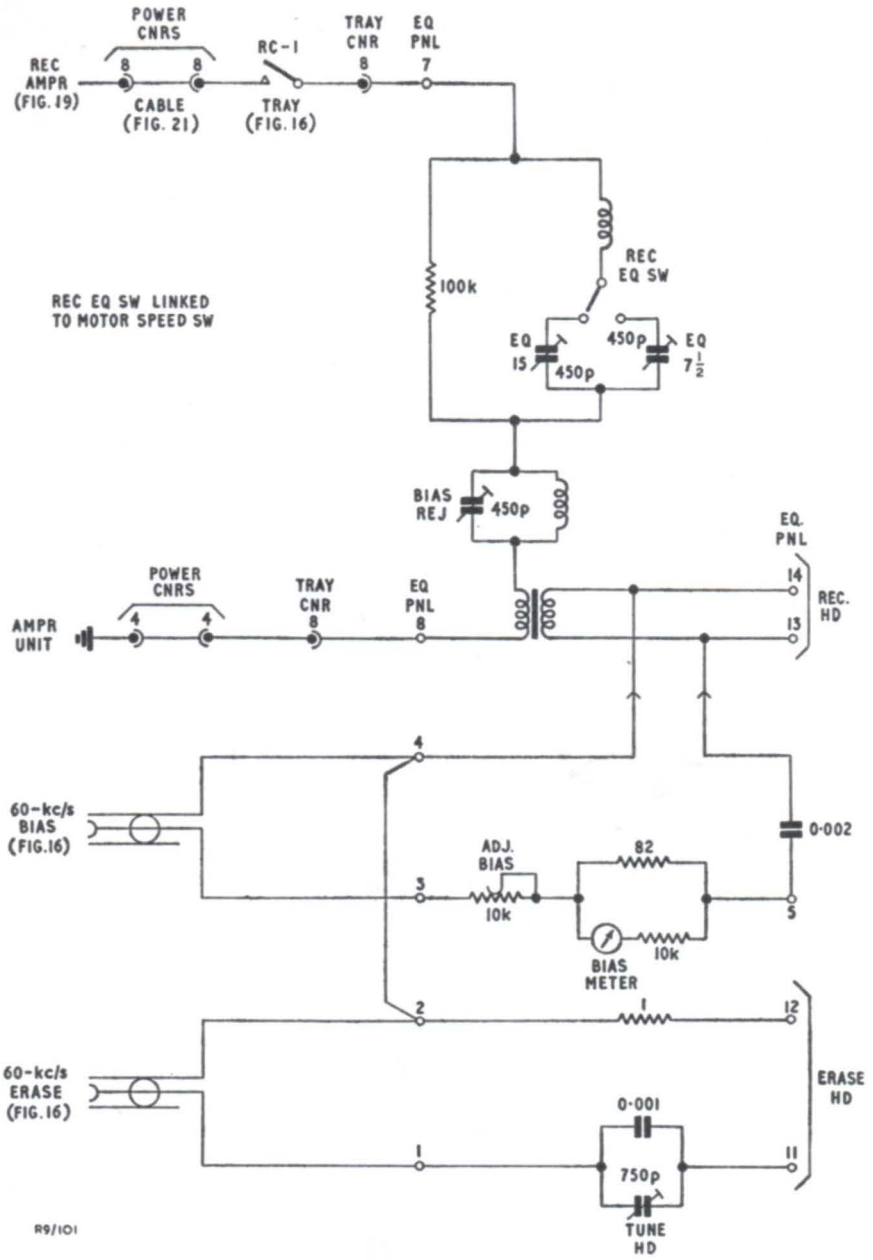


Fig. 7.5. Recording, Bias and Erase Circuits

SECTION 8

AMPLIFIER UNIT

General

This unit is similar to, although not identical with, the amplifier unit described in Section 3. It contains all the amplifying circuits and programme controls. The operating controls are mounted on the front; pre-set controls are inside the case.

The unit has eight valves and embodies the following sub-amplifiers:

(a) 2 Microphone Amplifiers,
(b) Recording Amplifier,
(c) Reproducing Amplifier,
(d) Monitor Amplifier.

Programme Chain (Fig. 8.1)

The programme chain comprises recording, reproducing and monitoring circuits, the last two being partially combined. A schematic is given in Fig. 8.1.

The recording chain includes:

(a) Two microphone input circuits, each with an amplifying stage, an l.f. attenuator, and a switch and fader for gain control. The inputs to the two amplifiers are via transformers designed to take low-level microphones with an impedance respectively of 300 ohms and 30 ohms. In BBC use, the l.f.-attenuator circuits are normally by-passed via the *Att./Level* switches shown. Facilities are provided for converting one of the microphone amplifiers into a 1-kc/s oscillator by means of a switch on the front panel.
(b) An input jack intended to accept signals at a level corresponding to 100 mV minimum into 500 kilohms. This input uses the l.f.-attenuator and gain controls of the first microphone amplifier. The amplifier is wired to the inners of the jack, so that it will become disconnected when the jack is in use.
(c) An input jack intended to accept programme at 0 dB from a 600-ohm line. This input uses the l.f.-attenuator and gain controls of the second microphone amplifier, following a repeating-coil and 600-ohm matching network. Disconnection of the microphone amplifier and transformer is effected by auxiliary contacts on the line jack as shown.
(d) A recording amplifier which feeds the recording head via the record relay, recording equaliser and bias rejector in the machine unit.

The reproducing and monitoring chain provides for visual and aural monitoring, the latter via either headphones or loudspeaker, and for sending programme to line. The chain comprises:

(a) A reproducing amplifier which takes its input from the reproducing head via a transformer and a variable equaliser selected by the speed switch and is followed by a *Reproducing Gain* control.
(b) A monitor amplifier the input of which can be switched either to the reproducing chain or to the recording chain, and the output of which can be used for headphone or loudspeaker monitoring and for sending zero-level programe to line (via an additional bias filter). The input selection and loudspeaker output of the amplifier are controlled by the *Monitor* switch.
(c) A volume meter which can be bridged across the recording or reproducing chain as required, and can also be used as an r.f. indicator for tuning the machine-unit bias rejector.

The *Monitor* switch has four positions, two designated *Direct* and two designated *Rep(lay)*. One of the *Direct* and one of the *Rep.* positions is marked *L.S.* In both *Direct* positions, the recording-amplifier output is switched to the monitor amplifier, whereas in both *Rep.* positions the reproducing-amplifier output is selected instead. In both *L.S.* positions, the 15-ohm *L.S.* pin-sockets are connected to the monitor-amplifier output. The 600-ohm *Line* and *Monitor* outputs are connected at all times.

Circuit Description (Fig. 19)

Microphone Amplifiers

These are similar to the microphone amplifiers described on page 14 except that amplifier No. 1 has a 300-ohm instead of a 30-ohm input and has an additional high-impedance input jack.

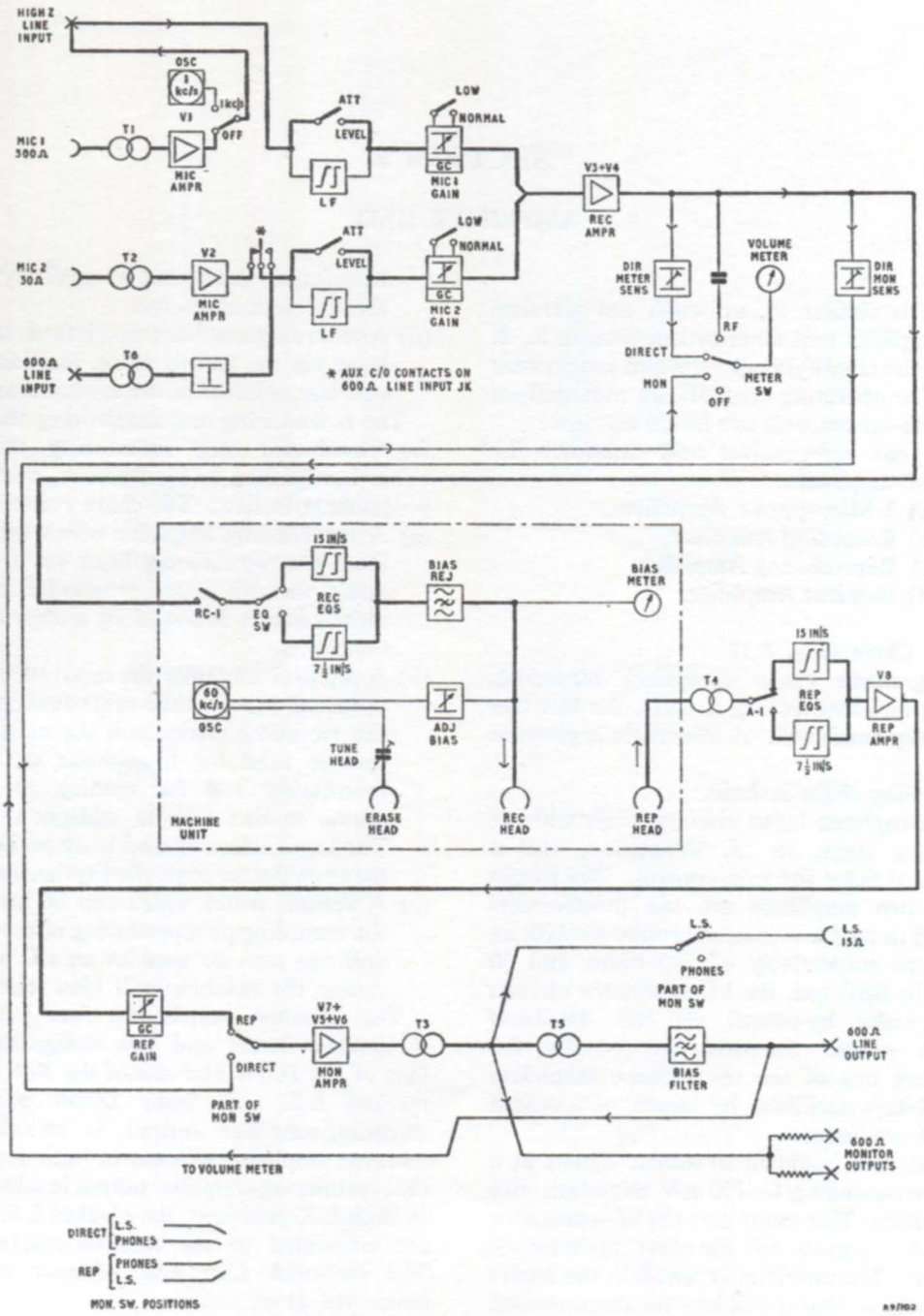


Fig. 8.1. The Programme Chain

Recording Amplifier

The recording amplifier comprises the pentode V3 and both sections of the double-triode V4, instead of the first section only as in the earlier design. The circuits of V3 and V4A are similar to those previously used. The signal from V4A anode is applied to the grid of V4B, which is connected as a cathode follower, and therefore provides a high load impedance for V4A, combined with a low output impedance.

Since V4B is a cathode follower, it has rather less than unity gain. The cathode output is taken to the recording-head circuit shown in Figs. 7.5 and 8.1. Connections are made to the monitoring and metering circuits via the *Direct Mon. Sens.* control VR 4 and the *Direct Meter Sens.* control R156, while a further connection via a 100-pF capacitor to the *R.F.* position of the meter switch allows the recording-circuit bias rejection to be checked. The low output impedance of V4B ensures that monitor switching does not affect the level of the signal fed to the recording head.

Reproducing Amplifier

The signal voltage from the reproducing head in the machine unit is conveyed to the amplifier unit via the 'play' cable and applied to V8 control grid via transformer T4. Between the grid and earth is an equalising network incorporating parallel-connected voltage negative feedback applied from the anode of the valve via C205.

The equaliser reduces the effective gain of the amplifier to a minimum at medium high frequencies by varying the negative feedback voltage reaching V8 control grid. The method can be seen more clearly from Fig. 8.2, in which the equalising network is rearranged. The a.f. signal voltage from the anode circuit of the valve is applied at the junction of C202 and C252. The other end of C202 is taken directly to earth, while C252 is connected to R253, at the lower end of which the network again divides. The left-hand branch contains two alternative series circuits with variable pre-set capacitors, one circuit for each tape-speed. The right-hand branch contains R202 and the secondary winding of T4.

At low frequencies, the branches containing C202, and C211 or C214, present a very high impedance and have a negligible effect on the circuit, but from the lowest frequencies upwards the falling impedance of C252 with rising frequency increases the feedback voltage developed across T4 and applied to the grid of the valve. This increase of feedback gives the amplifier a falling characteristic which compensates for the normal rising head response to a level tape surface-induction characteristic.

At medium frequencies the impedance of C252 becomes too small to exercise much further influence on the amplifier characteristic, but the impedance of the branch containing C211 or C214 is low enough to have an appreciable shunting effect on the branch containing the transformer. A greater proportion of the voltage applied from the anode is therefore developed across R253, so that the net feedback voltage reaches a maximum and begins to fall off at a frequency controlled by the setting of C211 or C214. The amplifier characteristic then starts to rise to compensate for reproducing head losses.

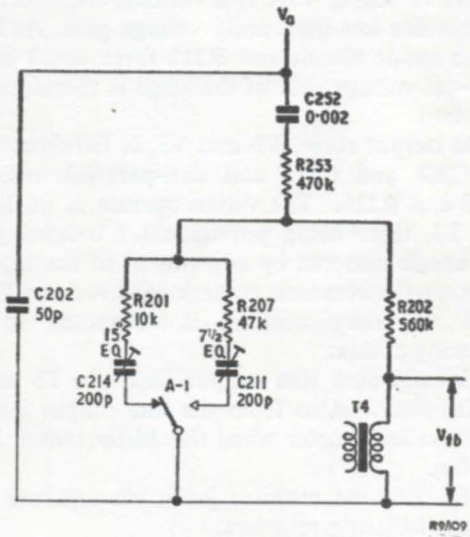


Fig. 8.2. Reproducing Equaliser

The presence of C202 does not have much effect on the audio-frequency characteristic. This capacitor is effectively in parallel with the anode load resistor R204 (Fig. 19) and is intended to reduce the amplifier gain at the bias frequency.

The equalised output voltage from V8 is taken via the *Reproducing Gain* control VR 3 and the *Monitor* switch to the grid of V7B, the first stage of the monitor amplifier.

The *Reproducing Gain* control is a carbon-track type and introduces a maximum attenuation of about 62 dB. When the control is faded out as far as possible, programme is just audible at high listening levels.

Note that a connection is also taken from this control to the test socket which, however, is not normally used by the BBC.

Monitor Amplifier

The monitor amplifier (Fig. 19) uses the two halves of the double-triode valve V7 followed by a push-pull output stage comprising V6 and V5. The input is obtained from either the recording amplifier or the reproducing amplifier as selected by the *Monitor* switch. All the outputs are taken from the final push-pull stage.

The first stage (V7B) provides voltage amplification and is *RC*-coupled to the second stage (V7A), which is arranged as a phase-splitter with V6 fed from V7A anode and V5 fed from the junction of bias resistor R213 and load resistor R212 in the cathode circuit of V7A. Thus, with respect to R212, V7A is a cathode follower, and so provides less than unity voltage gain. As R214 in the anode circuit and R212 form equal loads, the total voltage gain of the stage is therefore less than two.

The output stage, V6 and V5, is fed from V7A via C208 and C210 and anti-parasitic resistors R225 and R226. The valves operate in push-pull into T3, there being provision for balancing the two anode currents by adjustment of the tapping point on the common cathode-bias resistor R252.

T3 secondary winding is connected to the following points:

1. The 600-ohm line output jack via T5 and a bias filter. Also from the line output jack to the volume meter when the *Meter* switch is on *Mon.*
2. The 600-ohm monitor jacks via separate 560-ohm isolating resistors.
3. The 15-ohm loudspeaker pin-sockets when the *Monitor* switch is set to *L.S.*; otherwise to earth via a 14-ohm dummy load.
4. The grid circuit of V7B. This connection provides voltage negative feedback overall.

The bias filter is interposed between T5 and the line output jack to reject any 60-kc/s pick-up which may take place either in the wiring or direct from the recording head to the reproducing head.

The output levels at the line and monitor jacks and the 15-ohm loudspeaker pin-sockets are all adjusted by one control.

When the *Monitor* switch is set to *Rep.*, the output-level adjustment is made by the *Reproducing Gain* control VR 3. Under these circumstances the level delivered from the line jack is normally set to 0 dB into 600 ohms, leaving another 12 dB in hand on the *Reproducing Gain* control. Since the levels at the monitor jacks and 15-ohm loudspeaker pin-sockets are also adjusted by the same control, except for local listening purposes these levels are determined by the requirement of sending the correct level to line.

When the *Monitor* switch is moved to *Direct*, the output levels are controlled by the setting of the *Direct Mon. Sens.* control VR 4, which allows the listening level on incoming material to be adjusted so that during recording there is no level change when the *Monitor* switch is moved between *Direct* and *Rep.* for comprehensive checking.

The 14-ohm dummy load provided by the *Monitor* switch when the 15-ohm loudspeaker pin-sockets are disconnected replaces the impedance of the loudspeaker itself. If the loudspeaker speech-coil impedance/frequency characteristic departs appreciably from the nominal 15-ohm figure, the connection of the loudspeaker may affect the level and frequency response at the line output jack, with which the loudspeaker sockets are effectively in parallel. When no loudspeaker is connected to the pin-sockets, the *Monitor* switch should be set to *Rep.*, and not *L.S.*(*Rep.*), in order to provide a normal load impedance for the amplifier via bank A, contact 3, of the switch. (Fig. 19.)

Monitor Switch

The four-position monitor switch (Fig. 19) has three banks, A, B and C. The functions of the switch are shown schematically in Fig. 8.1 and are tabulated below.

Position	*Bank A Connections*	*Bank B Connections*	*Bank C Connections*
1. L.S. (Direct)	Mon. Ampr. L.S. output to L.S. socket	Rec. Ampr. output to Mon. Ampr. input	None
2. Direct (Phones)	Mon. Ampr. L.S. output to earth via 14 ohms	As above	None
3. Rep. (Phones)	As above	Rep. Ampr. output to Mon. Ampr. input	Rec. Ampr. mon. output to earth
4. L.S. (Rep.)	As Posn. 1	As above	As above

The line and monitor output jacks are permanently connected, as indicated in Fig. 8.1.

Volume-meter Switch

The four-position volume-meter switch has two

banks, A and B (Fig. 19), with the meter connected between their moving arms. In the first two positions of the switch, bank A picks up an earth and bank B picks up the output of the recording amplifier to measure bias leakage in position 1 and audio output in position 2; in the third position, the meter is connected across the line output jack, while the fourth position is not wired. The positions are labelled respectively *R.F.*, *Direct*, *Monitor* and *S./N.* The *S./N.* position was originally intended for signal-to-noise measurements, but in models supplied to the BBC it is equivalent to *Off*.

Valve Data

Valve	*Anode Volts*	*Screen Volts*	*Cathode Volts*	*Heater Volts*	*Heater Amps*
Mic. Ampr. 1 V1: EF86	39	55	1·0	6	0·2
Mic. Ampr. 2 V2: EF86	39	55	1·0	6	0·2
Rec. Ampr. V3: EF86 V4A: ½ECC81 V4B: ½ECC81	45 115 270	67	1·6 1·5 11	6 12	0·2 0·15
Mon. Ampr. V5: EL84 V6: EL84 V7A: ½ECC83 V7B: ½ECC83	260 260 164 100	267 267	9·2 9·2 51 0·3	6 6 12	0·75 0·75 0·15
Rep. Ampr. V8: EF86	55	75	1·5	6	0·2

NOTE:—Voltages measured between point stated and frame, using Avometer Model 8 on lowest practicable range.

Supplies

H.T. supply, 270 volts, 80 mA.

L.T. supply, 12 volts, 1·75 amps d.c., including supplies to meter lamp and relay A. Heaters of V1-V2, V8-V3, and V5-V6 are wired in series. (See Fig. 23.)

General Data

Normal Input and Output Levels

At 600-ohm line input and output jacks:
Normal level, 0 dB.

Impedances

Microphone Connector 1
Normal Source $Z = 300\ \Omega$
Input $Z = 300\ \Omega$

Microphone Connector 2
Normal source $Z = 30\text{-}50\ \Omega$
Input $Z = 30\ \Omega$ nominal

Line Input Jack No. 1
Input $Z = 500\ \text{k}\Omega$ (unbalanced)

Line Input Jack No. 2
Normal source $Z = 600\ \Omega$
Input $Z = 600\ \Omega$ (balanced)

Line Output Jack
Output $Z = 600\ \Omega$ (unbalanced)
Normal load $Z = 600\ \Omega$

Monitor Output Jacks
Output $Z = 600\ \Omega$
Normal load $Z = 100\ \Omega$ upwards

Loudspeaker Socket
Normal load $Z = 15\ \Omega$ nominal

SECTION 9

OPERATING PROCEDURE

Setting up the Equipment

1. Place the two cases on a flat surface with the amplifier unit on the left.
2. Remove both lids by releasing the clips and opening with an upwards and backwards motion to release the rear dowels.
3. Connect the *play*, *power* and *mains* cables as indicated in Fig. 9.1. (Wiring details of the *play* and *power* cables are given in Figs. 20 and 21.)
2. Switch on the power supply at the remote end of the mains cable. The tape transport system is now under the control of the *Function* switch.
3. Set the *Speed* switch to either 15 or 7½ in./sec as required. At both settings the timing indicator reads in minutes and seconds with reference to the higher speed, and the indicated readings should therefore be multiplied by two at 7½ in./sec.
4. Close the *Amplifier* switch. This powers the

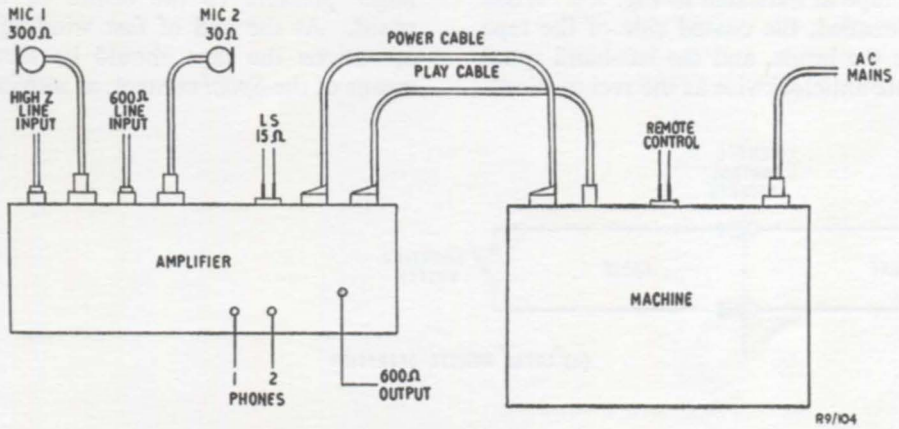


Fig. 9.1. Connecting Diagram

NOTE:—The position of the amplifier unit on the left of the machine unit allows adequate separation between the *play* and *mains* cables. Care should also be taken to keep the equipment away from the influence of stray magnetic fields. The earth pin of the mains connector is the preferred earthing point for the whole equipment; the earth connection should not be duplicated.

4. Connect the required input and output circuits, i.e., microphones, lines, headphones and loudspeaker. (Fig. 9.1.)

Switching on Supplies

1. Insert the mains-transformer U-link at the tapping nearest to the supply voltage, which must be between 200 and 250 volts 50 c/s a.c.

amplifier unit and bias oscillator and also makes supplies available for the three relays. Relay A operates immediately if the speed switch is on 7½ in./sec. The valve heaters reach their normal operating temperature about 15 seconds after switching on.

Operation from Batteries

The a.c. supply for the equipment may be derived from batteries using a convertor of either the rotary or vibrator type. For satisfactory speed and voltage regulation the rating should be at least 250 volt-amps.

Generous filtering should be included to avoid interference pick-up on microphone and head circuits. The recording equipment and its input

and interconnecting cables must be kept well clear of the convertor, battery and battery lead, and it may be necessary to screen and earth these last three items.

The equipment should not be used for recording music when operated from a convertor-and-battery power supply.

Loading the Machine

1. Place the reel of tape, wound coating inwards, on the left-hand spool platform, and clamp the spool in position with the knurled knob. Similarly clamp an empty spool on the right-hand spool platform.
2. With the *Function* switch in the *Off* position, lace up the tape as indicated in Fig. 7.1. When correctly threaded, the coated side of the tape should face the heads, and the left-hand spool should rotate anticlockwise as the reel unwinds.

Spooling

When the *Function* switch is set to *Spool*, the take-up and rewind motors are powered in opposite directions, the speed and direction of tape winding being governed by the voltages applied to the motors via the *Spool* control. By means of this control, the tape speed can be varied from maximum forward to zero and up to maximum reverse speed, the tape being at all times under tension. The control should not, however, be used to hold the tape stationary for long periods as the motors are likely to overheat.

For even winding, it is advisable to use a moderate spooling speed, and it may sometimes be helpful to introduce extra tension by applying finger pressure to the centre of the unwinding spool. At the end of fast winding or rewinding operations the tape should be slowed down by means of the *Spool* control, as moving the *Function* switch to *Off* when the tape is travelling at high speed may cause tape spillage to occur.

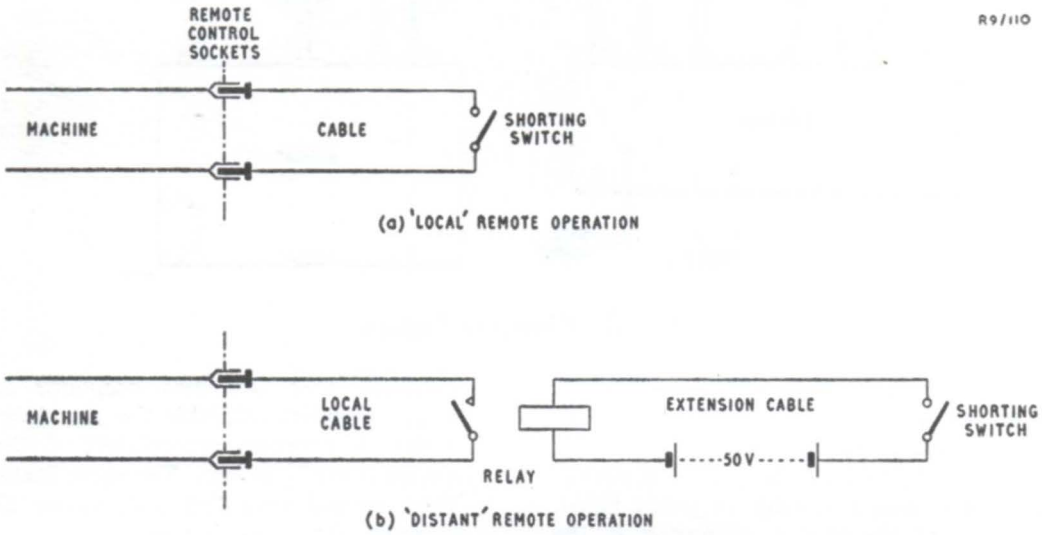


Fig. 9.2. Remote Operating Circuits

NOTE:—Fit domestic-type spools direct to the spool platforms, first removing the small centring adaptors. For European-type spools, fit the small adaptors to the platforms before placing the spools in position. Use the same (small) adaptors for N.A.B. spools and add the large adaptors when the spools are in position, finally locking down with the knurled nuts. Do not use spools with bent flanges or badly worn centre-holes.

Remote Operation

1. Connect a twin-conductor cable to the remote-control pin-sockets on the machine connector panel, with a shorting switch at the further end of the cable. (Fig. 9.2.a.)
2. Set the *Local/Remote* switch to REMOTE and the

Function switch to PLAY or RECORD as required.
3. To start the machine from the remote position, close the shorting switch at the end of the twin-conductor cable.
4. To stop the machine remotely, open the shorting switch.
5. If a very long cable-run is necessary, use a relay at the local end, and insert a battery in series with the shorting switch at the remote end. (Fig. 9.2.b.)

NOTE:—The remote control is inoperative when the *Function* switch is set to *Spool* or *Off*.

Preparing for Reproduction

1. Thread up the required programme tape in the manner already described, leaving the *Function* switch in the OFF position.
2. Set the *Monitor* switch to REP., or to L.S. (REP.) if a loudspeaker is to be used. In the latter circumstances connect a 15-ohm loudspeaker to the pin-sockets. (For reproduction into a transmission, use an L.S.U. fed from one of the 600-ohm monitor jacks. A 15-ohm speech-coil across the output might affect the frequency characteristic of the signal sent to line.)
3. Set the *Meter* switch to MON.
4. Select the tape-speed required.
5. Switch on the power supply at the source end of the mains cable.
6. Close the *Amplifier* switch and wait 15 seconds for the valve heaters to reach their operating temperatures.
7. Plug the reproducing line (if any) to the 600-ohm line output jack.
8. Turn the *Function* switch to PLAY and reproduce the band of 1-kc/s tone recorded at the start of the tape, adjusting the *Reproducing Gain* control until the volume meter reads —4 dB. (At this setting of the control, tone at zero level is being sent to line, and any subsequent variation in the setting will affect the sending level.)
9. Henceforward proceed in the standard manner for handling a reproduction.

Preparing for Recording

1. With the *Function* switch at OFF, make the power supply at the source end of the mains cable and close the *Amplifier* switch.
2. Wait the usual 15 seconds for the valve heaters to reach their operating temperature. Then move the *Function* switch to RECORD.
3. Adjust the pre-set *Bias* control until the correct reading of the bias-current meter is obtained for the grade of recording tape in use. (See Section 10: *Bias-current Adjustment*.)
4. Restore the *Function* switch to OFF, and thread up a clean tape on the machine.
5. Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT.
6. Switch on the built-in 1-kc/s line-up tone oscillator.
7. With the *Function* switch on RECORD, and the *Monitor* switch on REP. or L.S. (REP.), adjust the *Mic. 1* fader until the volume meter reads —4 dB and record tone for 10 seconds on the start of the tape.
8. Switch off the 1-kc/s oscillator, restore the *Monitor* switch to DIRECT or L.S. (DIRECT), and connect the recording input(s) required. When the 600-ohm line input is used, set the *Mic. 2 Gain* switch to LOW in order to bring the *Mic. 2* fader to a convenient point on the scale; if a microphone is used, set the *Mic. Gain* switch to NORMAL. Whatever the input(s), set the *Mic. L.F.* switches to LEVEL.
9. Proceed with the usual programme test and if satisfactory carry out the recording in accordance with standard procedure.
10. Before starting the recording, however, confirm that the *Monitor* switch is on DIRECT or L.S. (DIRECT), and the *Meter* switch on DIRECT, so as to monitor the start of the incoming programme. As soon as recording begins, move the *Monitor* switch to REP. or L.S. (REP.) and the *Meter* switch to MON. to check what is being recorded. During recording, make an occasional check on the incoming material as necessary. Note that the time-constant of the meter is such that with zero programme volume incoming or outgoing it should not read above 0 dB on the scale. Any movement of the pointer into the portion of the scale to the right of the 0-dB line indicates that the programme is at too high a volume, when appropriate action should be taken to restore conditions to normal.

SECTION 10

MAINTENANCE INSTRUCTIONS

Electrical Adjustments

General Note

The electrical tests and adjustments listed in this Section should be carried out in the order given, starting with *Volume-meter Sensitivity on Reproduction.*

Test Tapes Required

1. Type-77 1,000-c/s 15-in./sec Line-up Test Tape.
2. Type-77 Standard-level Tape. This is an unmodulated tape selected for use in bias-adjustment tests because its magnetic properties are average for the type.
3. C.C.I.R. Standard 15-in./sec Frequency-response Test Tape. This is recorded at a level which at 1 kc/s is 8 dB below that of test tape (1), and carries the following frequencies:—1 kc/s; 15, 12, 10, 8, 6, 4, 2 and 1 kc/s; 500, 200, 100, 60 and 40 c/s; also 10 kc/s for head azimuth alignment. (See also under *Routine Test Frequency Runs.*)
4. C.C.I.R. Standard 7½-in./sec Frequency-response Test Tape. This is a 7½-in./sec equivalent of test tape (3), but without the 12 and 15 kc/s frequencies. (See also under *Routine Test Frequency Runs.*)

NOTE:—The old Zero-level 1,000-c/s 15-in./sec Test Tape recorded at a level 8 dB below that of test tape (1) is no longer supplied.

Volume Indicating Meter

The Leevers-Rich volume-indicating meter has a fixed sensitivity when switched to *Mon.* for reproduction, and should read —4 dB with zero-level tone outgoing to line. When switched to *Direct* for recording, the sensitivity of the meter is adjustable as described later, and should be set to obtain a reading of —4 dB when 1-kc/s tone is being recorded at the level on test tape (1), referred to as *Type-77 line-up level*; the recording speed should be 15 in./sec and the recording tape should be Type 77 or another type of similar sensitivity.

Volume-meter Sensitivity on Reproduction

1. Connect a valve-voltmeter, ATM/1, PAD/9 or PPM/6 across the 600-ohm line output jack, taking care to terminate the jack in 600 ohms.
2. Set the *Meter* switch to MON., the *Monitor* switch to REP. (PHONES), and the *Speed* switch to the 15-in./sec position.
3. Play the Type-77 1,000-c/s 15-in./sec line-up test tape and adjust the *Reproducing Gain* control VR 3 (Fig. 19) until zero output level is indicated on the external meter.
4. The Leevers-Rich volume meter should read —4 dB. If it does not, the value of the meter series resistor R268 (Fig. 19) is incorrect and must be changed.

Reproducing Level

To line up the reproducing chain for transmission, terminate the line output jack in 600 ohms, then set the *Meter* switch to MON., the *Monitor* switch to REP. (PHONES) or L.S. (REP.) and the *Speed* switch to either the 15-in./sec or the 7½-in./sec position. Now play the Type-77 1,000-c/s 15-in./sec line-up test tape at the selected speed and adjust the *Reproducing Gain* control until the volume meter reads —4 dB. Note this setting of the control, which should be independent of tape speed, since the smaller e.m.f. induced in the reproducing head at the lower speed is compensated for by a rise in the equalised response of the reproducing amplifier at the lower frequency (500 c/s) reproduced from the tape at this speed.

Reproducing Frequency Characteristic at 15-in./sec

1. Set the *Monitor* switch to REP. (PHONES) and the *Speed* switch to the 15-in./sec position. Connect a valve-voltmeter, ATM/1, PAD/9 or PPM/6 across the line output jack, taking care to terminate the jack in 600 ohms. Now reproduce the 15-in./sec C.C.I.R. frequency-response test tape.
2. Using the first 1-kc/s band on the tape, adjust the *Reproducing Gain* control until zero output level is indicated on the external meter.
3. Using the 15-kc/s band on the tape, adjust the *15-in./sec Reproducing Equaliser* control C214 until zero output level is again obtained. C214 is the right-hand rear one of the three pre-set capacitors mounted on the amplifier chassis

behind the *Reproducing Gain* control. (Note that turning the control anticlockwise raises the turnover frequency, and vice versa.)

4. Taking the response at each frequency above 1 kc/s, readjust the *15-in./sec Reproducing Equaliser* until a minimum departure from zero output level at all frequencies is obtained. The normal tolerance figure is ±2 dB, but unless the reproducing head is worn a much closer agreement with the test tape can usually be obtained. If there should, however, be any difficulty in obtaining the response required, it is preferable to reduce the response at 15 kc/s slightly rather than to over-emphasise it in the range between 8 and 12 kc/s.

Reproducing Frequency Characteristic at 7½-in./sec

Repeat the operations given under the previous heading, but using the 7½-in./sec position of the *Speed* switch and the 7½-in./sec C.C.I.R. frequency response test tape to adjust the *7½-in./sec Reproducing Equaliser* control C211 mounted in front of C214 on the amplifier chassis. The highest frequency recorded on the test tape is 10 kc/s, but the 1-kc/s level is the same as at 15 in./sec.

Recording-circuit Bias-current Rejector

To tune the rejector circuit to the oscillator frequency, first lift the front of the machine deck on its hinges and latch in the raised position. Then set the amplifier *Meter* switch to R.F., and with the *Function* switch on RECORD adjust the pre-set *Bias Rej.* control located below the deck-plate until the meter reading is at a minimum.

Output-circuit Bias Filter

The purpose of this filter is to remove from the output any bias-frequency component, the presence of which would be indicated by a standing reading on the volume meter with the *Meter* switch at *Mon.* The filter is adjustable by means of pre-set capacitor C262 (Fig. 19), which is the left-hand one of three similar components mounted on the amplifier chassis behind the *Reproducing Gain* control. The adjustment procedure is as follows:

1. Set *Function* switch to RECORD.
2. Set *Meter* switch to MON.
3. Fade up *Reproducing Gain* control to maximum.
4. Adjust C262 for minimum reading on volume meter.

Bias-current Adjustment

The optimum value of bias current does not normally alter appreciably with a change of tape speed. To adjust the bias, proceed as follows:

1. Thread up the (unmodulated) Type-77 standard-level tape.
2. Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT.
3. Switch on the built-in 1-kc/s oscillator.
4. Set the *Function* switch to RECORD and the *Monitor* switch to REP. (PHONES), or L.S. (REP.) if a 15-ohm loudspeaker is in use.
5. Adjust the *Mic 1* fader until the volume meter reads −4 dB and record tone.
6. Move the *Meter* switch to MON. and vary the bias current by means of the pre-set *Bias Current* control until the bias setting giving maximum output level as indicated on the volume meter is found.
7. Increase the bias beyond the point of maximum output until the level falls by 1 dB. Note the reading of the bias-current meter and enter this reading on the tablet above the meter.

Volume-meter Sensitivity on Recording

1. Thread up a tape of the grade currently in use.
2. Set the *Mic. 1 Gain* switch to LOW, the *Mic. 1 L.F.* switch to LEVEL and the *Meter* switch to DIRECT (to read the recording level).
3. Switch on the built-in 1-kc/s oscillator, and adjust the *Mic. 1* fader to make the volume meter read −4 dB.
4 Using the 15-in./sec tape speed record a band of tone.
5. Set the *Meter* switch to MON. and the *Monitor* switch to REP. (PHONES).
6. With the output line jack loaded by 600 ohms, reproduce the recorded tone and adjust the *Reproducing Gain* control to make the meter read −4 dB. Now reproduce the Type-77 1,000-c/s 15-in./sec line-up tape and note the difference between the meter readings for the recorded tone and the test tape.
7. Set the *Meter* switch to DIRECT, compensate on *Mic. 1* fader for the difference above, and repeat operations 4, 5 and 6 until a meter reading of −4 dB is obtained with both the recorded tape and the test tape.
8. With the *Meter* switch on DIRECT, adjust the pre-set *Direct Meter Sensitivity* control R156 located on the amplifier face-panel to make the meter again read −4 dB.

NOTE:—The recording level, bias and meter sensitivity adjustment are interrelated. It follows,

therefore, that if any appreciable change is found to be necessary in the setting of either the *Direct Meter Sensitivity* control or the *Bias-current* control, it may then be necessary to adjust both to obtain correct recording conditions.

Recording Frequency Characteristic at 15-*in./sec*

1. Thread up a clean tape on the machine.
2. Set the *Mic. 2 Gain* switch to LOW, the *Mic. 2 L.F.* switch to LEVEL and the *Meter* switch to DIRECT.
3. Connect a variable frequency oscillator to the 600-ohm line input jack, and adjust the *Mic. 2* fader to make the volume meter read —4 dB at 1-kc/s.
4. At constant input voltage, record a complete frequency run from 15 kc/s to 40 c/s.
5. With the Monitor switch on REP. and the *Meter* switch on MON., play back the recorded tape and compare the output levels at the various frequencies with that at 1 kc/s.
6. If necessary, readjust the pre-set 15-*in./sec Recording Equaliser* control mounted beneath the machine deck-plate and repeat operations 4 and 5 until the flattest possible characteristic above 1 kc/s is obtained.

NOTE:—The tolerance limits are ±2 dB, but adjustment to within ±1 dB can usually be made. If there should be any difficulty in obtaining the required response, it is preferable to reduce the response at 15 kc/s slightly rather than to over-emphasise the response between 8 and 12 kc/s.

Recording Frequency Characteristic at 7½ *in./sec*

Repeat the operations listed under the previous heading, using the 7½-in./sec tape speed, and adjust the 7½-*in./sec Recording Equaliser* control. The highest frequency recorded should be 10 kc/s, the reference frequency again being 1 kc/s and the tolerance limits ±2 dB.

Recording Level from Line

To adjust the recording level on line-up tone incoming from line, set the *Meter* switch to DIRECT and adjust *Mic. 2* fader until the volume meter reads —4 dB. Note that for recording from line it is generally convenient to have *Mic. 2 Gain* switch in the LOW position.

Balance of Listening Levels

To balance the listening levels obtained in the *Direct* and *Rep.* positions of the *Monitor* switch, record 1-kc/s tone while moving the *Monitor* switch alternately to the DIRECT and REP. positions, and adjust the pre-set *Direct Monitor Sensitivity* control VR 4 on the amplifier face-panel until no change in level can be heard.

Routine Test Frequency Runs

The C.C.I.R. standard frequency-response test tapes are expensive to produce, and to minimise wear on these a modified procedure should be adopted for routine test frequency runs. This procedure involves the production of test frequency run tapes at both speeds for each machine.

The test frequency run tapes are produced as follows

1. Using the C.C.I.R. standard frequency response test tapes, adjust the reproducing characteristics at both speeds according to the instructions already given.
2. Using a clean tape, similarly adjust the recording characteristics at both speeds.
3. Make test frequency run tapes at both speeds by recording 10-second bands at 60 c/s, 100 c/s, 1 kc/s, 5 kc/s, 10 kc/s and (at 15 in./sec only) 15 kc/s.
4. Reproduce these recorded tapes and note the response at the extreme frequencies of 60 c/s and 15 (or 10) kc/s with respect to the response at 1 kc/s, and add the difference figures so obtained to the ±2 dB tolerances; e.g., —1 dB at 60 c/s would give working tolerances of +1 dB and —3 dB at this frequency.
5. Transfer each tape to a 7-inch spool with N.A.B. hub supplied by C.M.U., and enter the machine identification, the date, the speed and the working tolerances on the label of the box supplied with the spool.

The test frequency run tapes should be used for checking the reproducing characteristics of the machine on which they were recorded, and must not be used on any other machine. When a test frequency run is reproduced on its own machine, if the response at the extreme frequencies of 60 c/s and 15 or 10 kc/s (or at either extreme) falls outside the tolerances marked on the label, the machine should be realigned with the aid of the appropriate C.C.I.R. standard frequency-response test tape and a new test frequency run recorded.

Under no circumstances may any alteration be made to the recording or reproducing equaliser settings with reference to the locally recorded test frequency run tapes.

Whereas the test frequency run tapes may be used by both operational and maintenance staff,

the use of C.C.I.R. standard tapes should in general be restricted to maintenance engineers.

Head Unit

The head unit of the a.c. recorder is similar to that of the d.c. machine as described on page 5, except that the recording head has a single winding, and that a different tape-lifting mechanism (as described in Section 7) is used. The maintenance instructions given on pages 27 and 28 therefore apply. The following additional notes, which except where otherwise stated refer to both types of machine, may be found useful.

Removing the Headblock. In lifting the a.c. machine headblock off its plugs, special care must be taken to avoid damage to the glass tape-lift rods.

Azimuth Alignment. Re-alignment is not normally required during the life of the heads on any model of the Leevers-Rich machine. Disturbance of the maker's alignment is strongly to be deprecated unless absolutely necessary, and must never be regarded as routine maintenance procedure nor undertaken merely as a check that the existing alignment is correct. If re-alignment becomes essential, two screwdrivers should be used simultaneously, one for each azimuth screw, and the screws must be left only finger tight. The screwdrivers should be demagnetised before use. Note that no lock-nuts are fitted to the azimuth adjusting screws on the a.c. machine.

Head Magnetisation. Each head circuit is earthed to frame at one point only, and leakage or shorting to frame at any other point will cause magnetisation. Head-lead continuity must not be checked with the headblock in position, nor may head windings be tested with a d.c. test meter.

Machine Unit: Access for Servicing

Switch off the mains supply and disconnect the mains cable before opening the machine.

Raising the Deck-plate on its Rear Hinges

1. Place the recorder on a level surface, to prevent overbalancing when the deck-plate is raised.
2. Undo the two large-headed captive screws (13) and (23) near the front corners of the deck-plate. (Fig. 13.)
3. Secure a length of cord or thick string to the plated handle in front of the headblock, and use this cord to lift the front of the deck-plate, holding the machine case meanwhile to prevent tipping.
4. Secure the deck-plate in the raised position by the two rotary catches (46) and (50) fitted beneath the side members of the deck assembly. (Fig. 14.)

Removing the Mechanism Completely from the Case

1. Undo the two large-headed screws (13) and (23) near the front of the deck-plate.
2. Remove the six vertical screws securing the rear connector panel from the rear hinged bar.
3. Grip the rear connectors with one hand and the front handle with the other and lift out the deck-plate and mechanism.

Removing the Machine-unit Tray

1. Unlatch and withdraw the connector on the main cable between the deck-plate and the tray.
2. Release the screw holding the coaxial replay-cable connector and withdraw the connector downwards.
3. Remove the *Amplifier* switch knob.
4. Release the four screws securing the tray to the frame.
5. Remove the tray downwards to clear the switch spindle.

Machine Lubrication

Avoid excessive lubrication. After long service, repack the ballraces with H.M.P. grease and re-impregnate the capstan bearings with light machine oil. Wipe off surplus oil round the capstan bearings to prevent it from damaging the rubber tyre of the pressure roller.

Certain oiling points are indicated on the lower sketch in Fig. 15.

Brakes

General

Two separate braking systems are used, one for applying a controlled tension to the tape passing over the head when the machine is recording or reproducing, the other for stopping the spools when the *Function* switch is turned to *Off* and for preventing spool rotation when the machine is stationary.

The tape-tension brake comprises a felt-lined shoe (Fig. 7.3) acting on the left-hand (or rewind) spool platform only. The brake shoe is held against the drum by a spring, and the resultant tension in the tape passing round the jockey pulley is fed back by the jockey arm to offset the spring. This arrangement holds the tension in the tape sensibly constant under all working conditions at

all spool diameters. The shoe is lifted mechanically when the machine is switched to fast spooling or to *Off*. (See Section 7.)

The spool 'stop' brake system comprises two leather-lined shoes, one acting on each spool platform. These spools are held against the platforms by springs, and are arranged to be self-wrapping in opposite directions. Thus adequate braking effort is applied to the left-hand spool to resist anticlockwise rotation. The action of the right brake is in the reverse sense, offering maximum resistance to clockwise rotation. This system ensures that the tape is brought to rest by the self-servo braking effort on whichever spool is paying out tape, and thus prevents spool overrun and tape spillage.

When the *Function* switch is moved away from the *Off* position, both 'stop' brakes are lifted by means of solenoids.

(for stop brakes) or jockey arm (for tension brake) the clearance between brake lining and drum is 1/16 or 1/32 inch respectively.

The clearance increases as the lining wears, causing sluggish operation. The change in the tension of the brake springs during the life of a lining is however small, and accordingly no tension adjustment is provided.

Solenoid Adjustment

The two 'stop' brakes are retracted by a pair of small solenoids supplied from a full-wave metal rectifier with reservoir capacitor. (Fig. 17.) Each solenoid is adjustable for travel and alignment on its mounting bracket, the procedure being as follows:

1. With the brake retracted, ensure that the solenoid core is in line with the link pivot on the actuating lever, and at right-angles with this lever. (Figs. 7.3 and 15.)
2. With a newly lined brake-shoe, and with the brake clearance adjustment set to minimum, loosen the bracket-securing screw and move the solenoid frame forward to accept the core until the latter is within 1/16 inch of the end stop.
3. Tighten the bracket-securing screw.

With this adjustment, when the core is pulled fully into the solenoid the brake will lift by

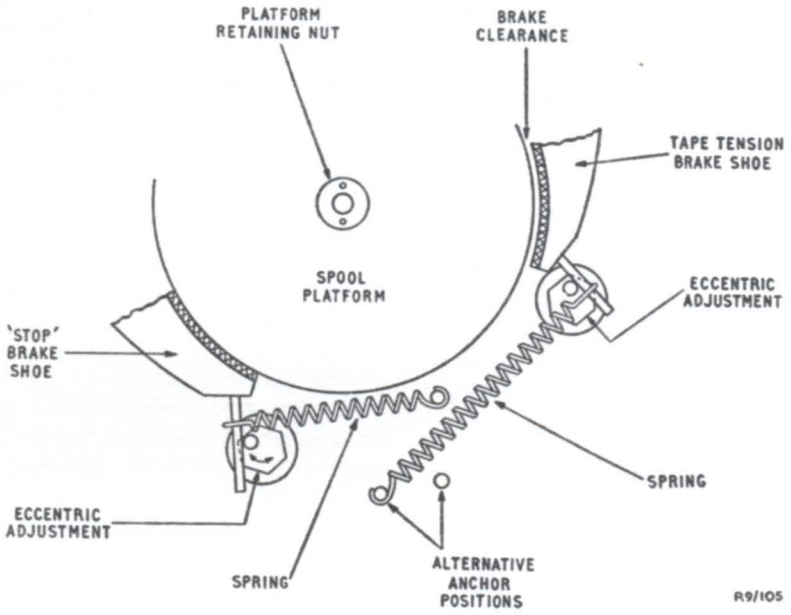


Fig. 10.1. Details of Brake Mechanism

Clearance Adjustment (*Fig.* 10.1)

1. Remove the three screws holding brake cover-plate and lift it off by the use of a fine-pointed probe inserted in one of the screw holes. Do not attempt to lift the cover by inserting the probe into the centre clearance hole or damage to the brakedrum will result.
2. By means of a box spanner, rotate the hexagon eccentric (Fig. 10.1) carrying the brake actuating pin until with the brake lifted by its solenoid

1/16 inch. This clearance will increase as the lining of the shoe wears.

Cleaning Drum Surfaces

1. Release the tension spring from its anchor pin.
2. Holding the tip of the shoe in one hand and the heel in the other, lift the shoe and spacing washer off the pivot.
3. Apply a soft cloth moistened with methylated spirit to surface of rotating drum. Take care that cleaning fluid does not come into contact with shoe lining.
4. Allow cleaning fluid to dry. Then refit shoe, washer and spring.

Spool Motors

Removal for Servicing

1. Remove tray.
2. Disconnect motor leads.
3. Remove brake cover and brake shoe(s).
4. Unscrew spool-platform securing nut, and lift platform off motor spindle.
5. Remove motor-securing screws now exposed, noting the position of any shim washers used between motor pillars and underside of panel.

Refitting

On re-assembly, take care to replace the washers mentioned in operation (5) above in their original position, in order to preserve alignment.

The spool platform is prevented from turning on the motor shaft by a slot in the platform boss which engages a pin through the motor shaft. Carefully align the slot and pin before tightening the platform-securing nut.

Main Driving Unit (Figs. 13, 14 and 15)

General

The main driving unit comprises the capstan and flywheel in its bearing cage, the pressure roller, the flexible coupling, the motor and screen, and a tray carrying the motor speed switch and capacitor. To service any item in this assembly except the pressure roller, it is usually best to remove the whole unit from the machine.

Removal for Servicing

1. Remove headblock.
2. Release switch-connecting screw.
3. Remove capstan-connecting leads.
4. Release solenoid spring link.
5. Remove five capstan-securing screws while holding the unit, which will then be free to be withdrawn downwards.

Capstan Motor

The capstan motor is secured to the case by three conical mounting nuts. These must be kept evenly adjusted to preserve shaft alignment. The resilient shaft coupling is locked by screws to motor and flywheel. These fixings must be checked for tightness periodically as they transmit the starting torque of the motor, and may give rise to speed fluctuation if loose.

The oil-retaining bushes at top and bottom of the capstan shaft and at top and bottom of the motor shaft should have thin machine oil applied periodically, e.g. every six months. After at least one hour has been allowed for the oil to penetrate, the surplus should be wiped off to avoid contamination of the pressure roller.

Pressure Roller

The pressure roller should present an even concentric surface to the drive capstan. The ground neoprene tyre may be cleaned if necessary by running the machine without tape and applying a cloth soaked in trichlorethylene or a similar solvent to the neoprene surface as it revolves.

To remove the pressure roller for servicing:

1. Remove retaining screw and cap in centre of roller.
2. Press pressure-roller arm outwards against its spring to clear capstan top.
3. Lift roller complete with bearings upwards off its shaft.

Pressure-roller Solenoid

The pressure roller is pressed against the capstan by a large solenoid supplied by a full-wave metal rectifier with reservoir capacitor. (Fig. 17.)

The solenoid core is linked to the roller actuating arm by a short tension spring. (Fig. 7.3.) When the solenoid is energised, the core should snap right home, pulling the roller into contact with the capstan and extending the spring by 1/8 inch.

If the core snaps home before the spring is extended by this amount, the pressure between roller and capstan will be insufficient to prevent tape slip and flutter.

If the spring is extended too far when the core is pulled right in, the core may not always snap home and the pressure between roller and capstan may again be insufficient.

The solenoid position may be adjusted to effect correct closure as defined above by moving the solenoid and bracket on its securing screws, so that the solenoid core is in line with the link pivot

on the actuating lever and at right-angles with this lever. The core should then slide smoothly with freedom from lateral stress.

Flywheel Pulley

Adjusting Vertical Alignment

1. Slacken set-screw one turn in bearing barrel below deck-plate.
2. Move whole rotating assembly up or down as required and re-lock setscrew.
3. Check and re-adjust as necessary until tape passes round pulley without plucking at upper or lower flange.

Dismantling

To dismantle the assembly, e.g., for cleaning and repacking ballraces, proceed as follows:

1. Holding flywheel firmly, unscrew and remove nut below it.
2. Remove flywheel downwards. (Do not try to remove pulley or domed nut above it from shaft, or damage will result.)

Timing Counter

The timing counter is of the four-digit type, but is mounted on a plate having an aperture which reveals the first three digits only. The counter is driven by spur gearing from the right-hand tape pulley, the three digits visible representing minutes and tenths at a speed of 15 in./sec.

The tape pulley must be free in rotation or a reading error will occur. To remove the counter for inspection or cleaning, remove the four plate-securing screws and lift the counter upwards clear of the panel. The unit should be replaced with care to ensure that the spur gears mesh correctly and run quite freely.

Tape-lift Rods (Figs. 7.3, 13 and 14)

The tape is held clear of the heads under the *Spool* and *Off* conditions by means of two glass rods (18) and (20) attached to the arm of two cranks (37) and (35) linked to the *Function* switch mechanism by the connecting rod (39). Tape-lift clearances may be adjusted for head or rod wear by releasing the left-hand shackle of the connecting rod, slackening its lock-nut, and rotating it on the threaded rod.

Worn or broken tape-lift rods may be replaced after slackening the nylon securing screws. These screws are self-locking and undue force should not be used in tightening.

G.H. 1/60

APPENDIX D

PERFORMANCE SPECIFICATION

General Data

Power Supply

200-250 volts 50 c/s a.c.; 1 amp approx.

Tape Speeds

15 or 7½ in./sec, selected by switch.

Test Input and Output Impedances

600 ohms at line input and output.

Standard Input and Output Levels

0 dB at line input, and at line output loaded with 600 ohms.

Impedances

See page 45.

Test Data

Frequency Response

Response at Type-77 standard level:
15 in./sec: ±2 dB from 50 c/s to 15 kc/s;
7½ in./sec: ±2 dB from 50 c/s to 10 kc/s.

Total Harmonic Distortion

Not more than 2½% r.m.s. at 1 kc/s at peak output level (8 dB above Type-77 standard level).

No-signal Noise Level

More than 50 dB unweighted below peak output level, measured with bias and erase on.

Wow and Flutter

Total r.m.s. wow and flutter, measured with 3-kc/s carrier, less than 0·15% at 15 in./sec and less than 0·2% at 7½ in./sec.

APPENDIX E

BBC AND MAKER'S CHANGES

The a.c. equipments Model E121-P covered in Part 2 of this Instruction comprise machine units Type E Mark II with serial numbers up to 498 and amplifier units Model 21 Mark IV with serial numbers up to 230. Both the machines and the amplifiers have been modified by the BBC so as to incorporate some of the features of equipments of later type, and these modifications are included in the equipments as described.

More recently manufactured E121-P equipments comprise machine units Type E Mark III with serial numbers from 499 upwards and amplifier units Model 21 Mark V with serial numbers starting at 231. One amplifier-unit change introduced in the Mark V but not incorporated in the earlier equipments is the provision of an output fader; further differences in the output circuit and elsewhere are shown in the circuit diagram in the maker's handbook. The new machine units differ from the old as modified mainly in certain details of the tray wiring.

There is also, as mentioned in Section 6, an a.c. console model, Type E-141, with which this Instruction is not concerned.

Fig. 13 Deck-plate Assembly showing Controls and Brake Mechanisms

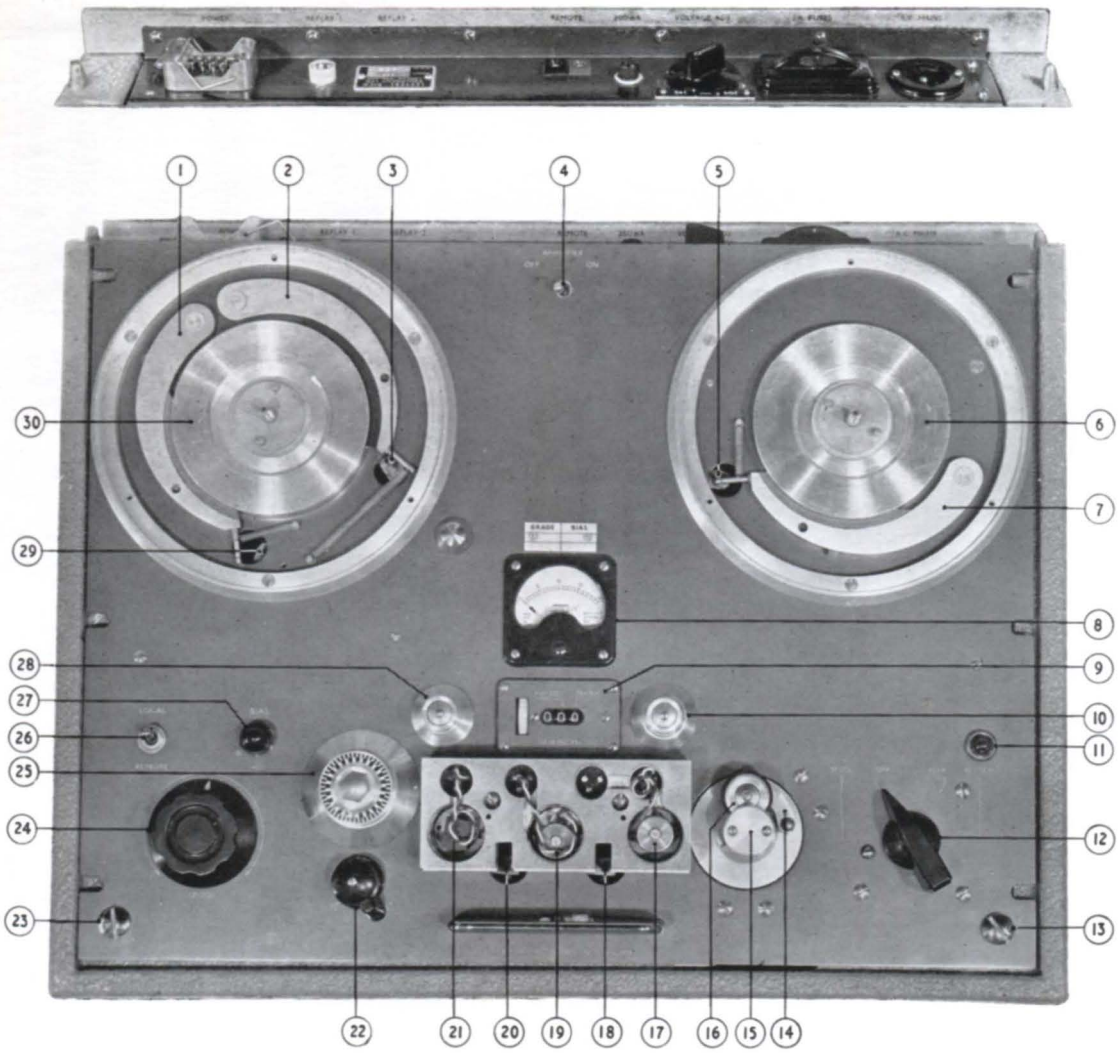


Fig. 13. Deck-plate Assembly showing Controls and Brake Mechanisms

KEY

1. ' Stop ' brake shoe
2. Tension brake shoe
3. Eccentrically mounted pin
4. Amplifier switch
5. Eccentrically mounted pin
6. Spool support plate
7. ' Stop ' brake shoe
8. Bias-current meter
9. Tape timing counter
10. Timing pulley
11. ' Record ' lamp
12. Function switch
13. Deck-plate locking screw
14. Pressure-roller arm
15. Drive-capstan housing
16. Pressure roller
17. Reproducing head
18. Tape-lift rod
19. Recording head
20. Tape-lift rod
21. Erase head
22. Motor speed control
23. Deck-plate locking screw
24. Spooling control
25. Flywheel pulley
26. Local/Remote switch
27. Bias-current control
28. Jockey pulley
29. Eccentrically mounted pin
30. Spool support plate

Fig. 14. Recording Machine with Deck-plate Raised

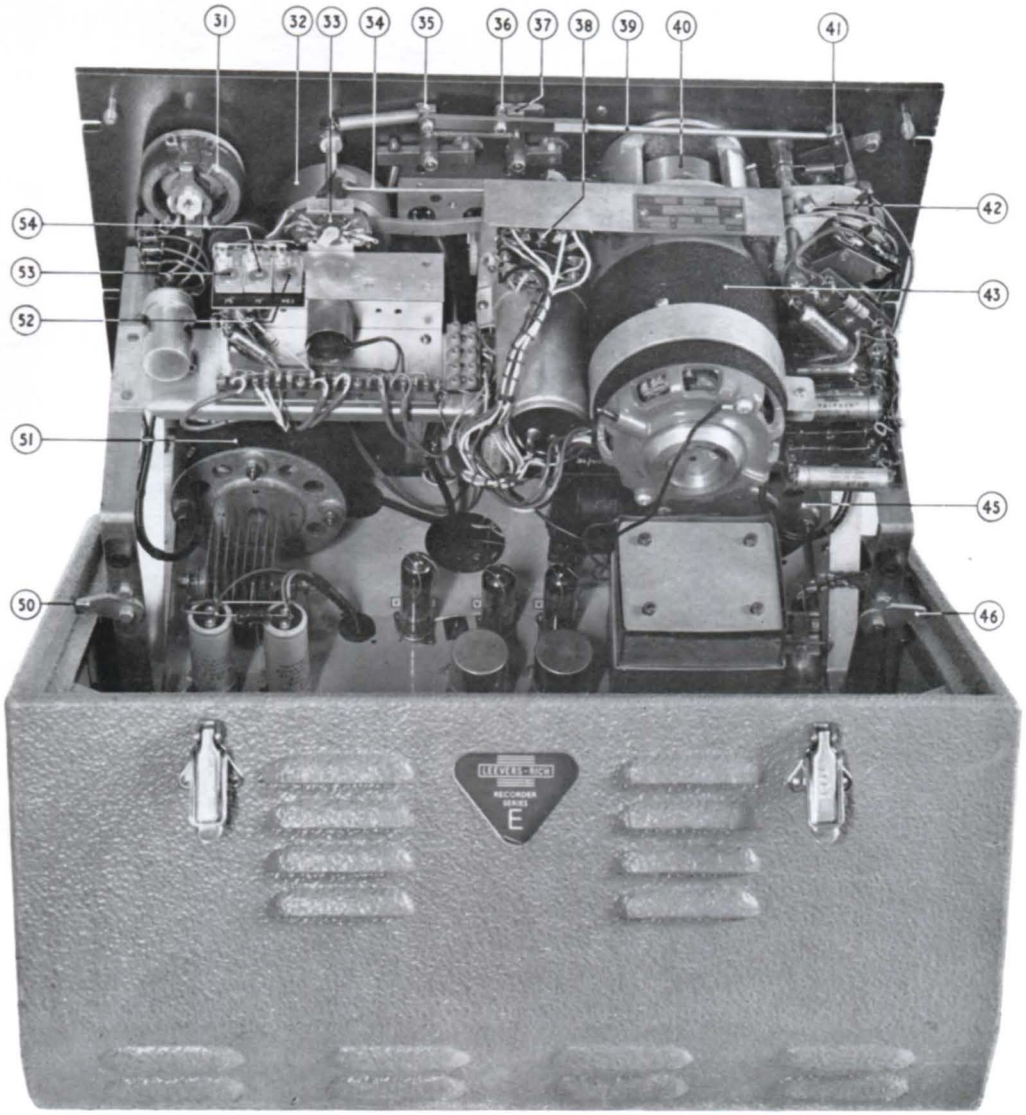


Fig. 14. Recording Machine with Deck-plate Raised

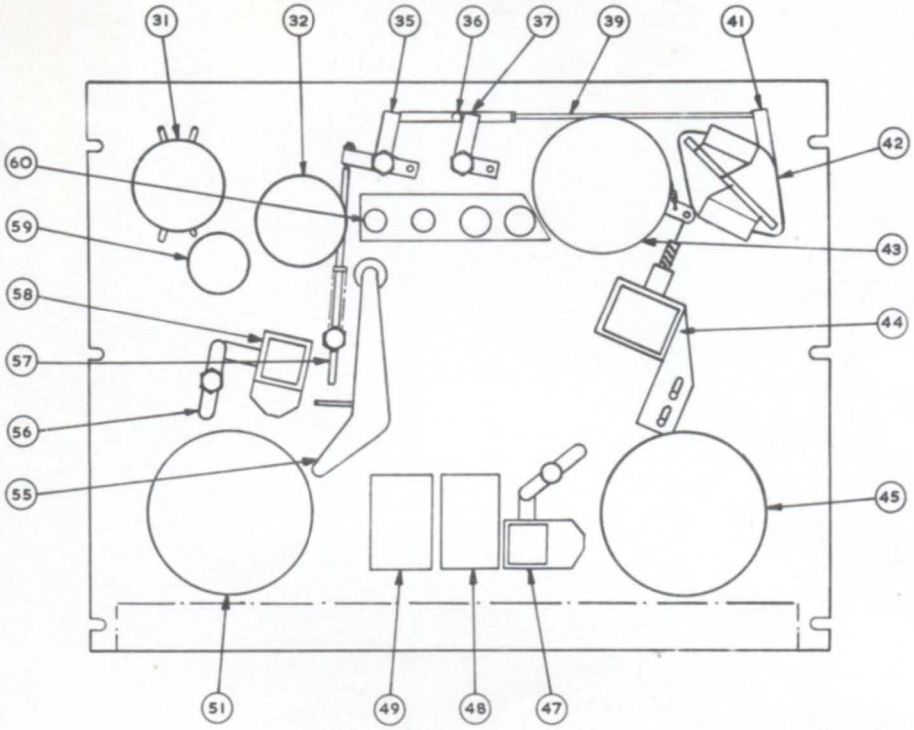
KEY

31. Spooling control resistor
32. Left-hand flywheel
33. Recording equaliser switch
34. Speed-switch link
35. Double bell-crank or ' tape-lift arm '
36. Stud
37. Bell-crank or ' tape-lift arm '
38. Motor speed switch
39. Connecting rod
40. Capstan flywheel
41. Cam follower arm
42. Function switch mechanism
43. Capstan motor
45. Take-up motor
46. Rotary latch
50. Rotary latch
51. Rewind motor
52. Bias rejection control
53. Recording equaliser control ($7\frac{1}{2}$ in./sec)
54. Recording equaliser control (15 in./sec)

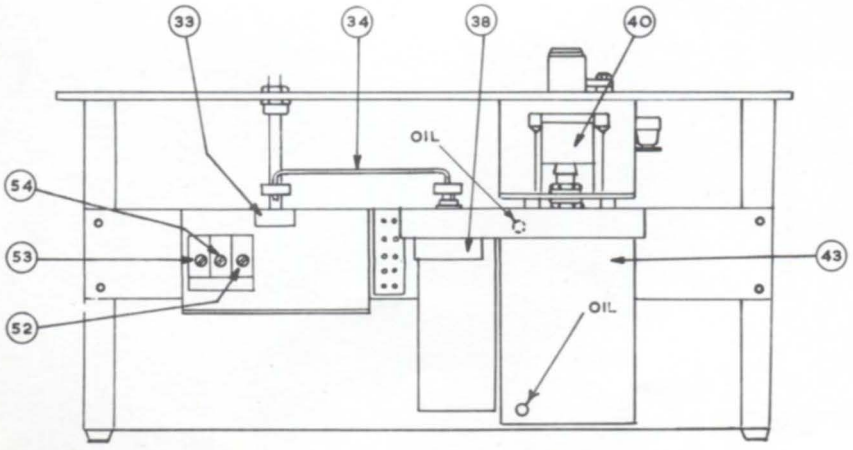
KEY TO FIG. 15

31. Spooling control resistor
32. Left-hand flywheel
33. Recording equaliser switch
34. Speed-switch link
35. Double bell-crank or ' tape-lift arm '
36. Stud
37. Bell-crank or ' tape-lift arm '
38. Motor speed switch
39. Connecting rod
40. Capstan flywheel
41. Cam follower arm
42. Function switch mechanism
43. Capstan motor
44. Pressure-roller solenoid
45. Take-up motor
47. ' Stop ' brake solenoid
48. Pressure-roller solenoid rectifier
49. Brake solenoids rectifier
51. Rewind motor
52. Bias rejection control
53. Recording equaliser control (7½ in./sec)
54. Recording equaliser control (15 in./sec)
55. Jockey arm
56. ' Stop ' brake solenoid link
57. Push rod
58. ' Stop ' brake solenoid
59. Bias control resistor
60. Headblock mount

R9
FIG.15



PLAN VIEW FROM BELOW



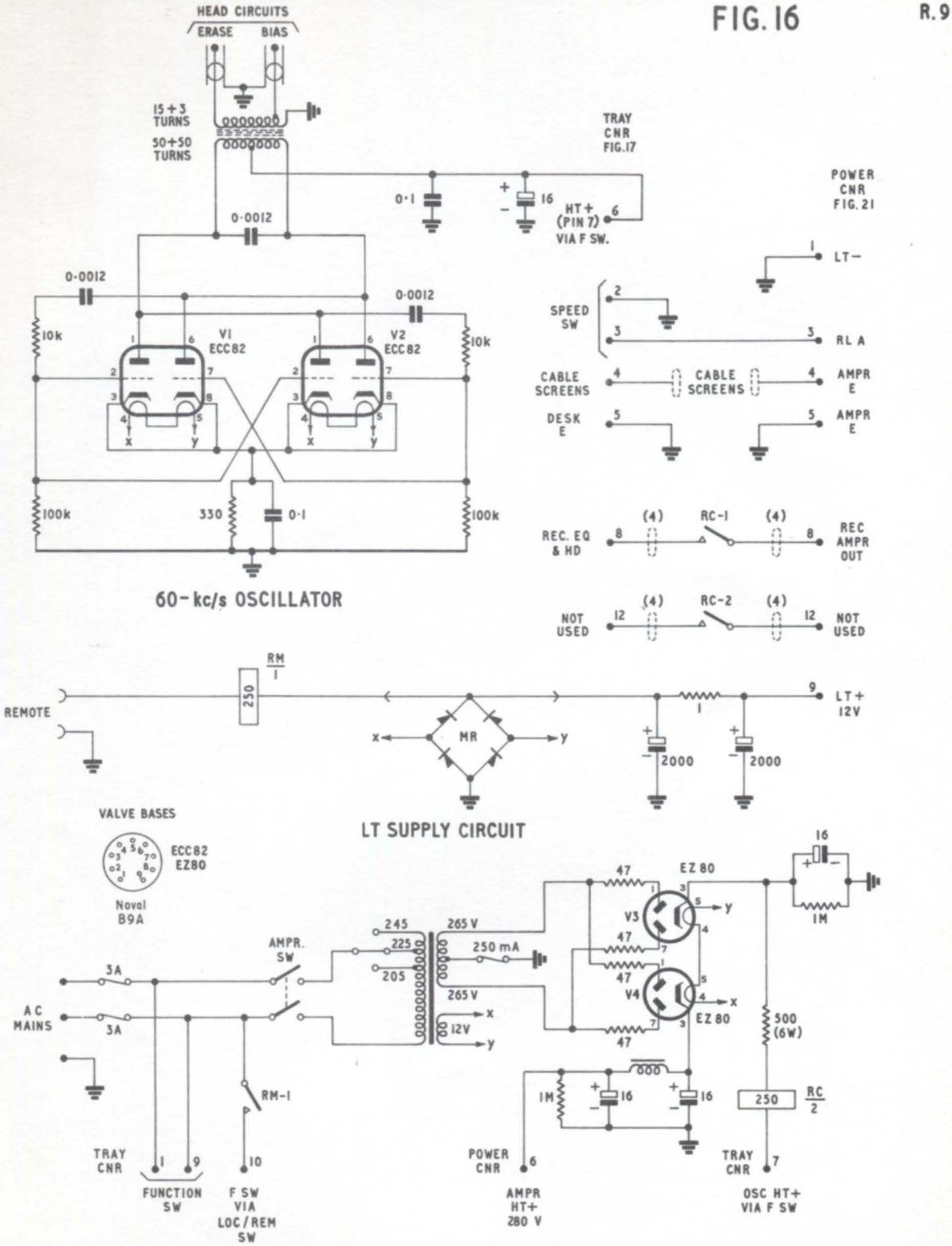
FRONT ELEVATION

DECK-PLATE ASSEMBLY: UNDERNEATH VIEWS

59/GH/102/AP
LEEVERS-RICH
DRWG. No.731

FIG. 16

R.9

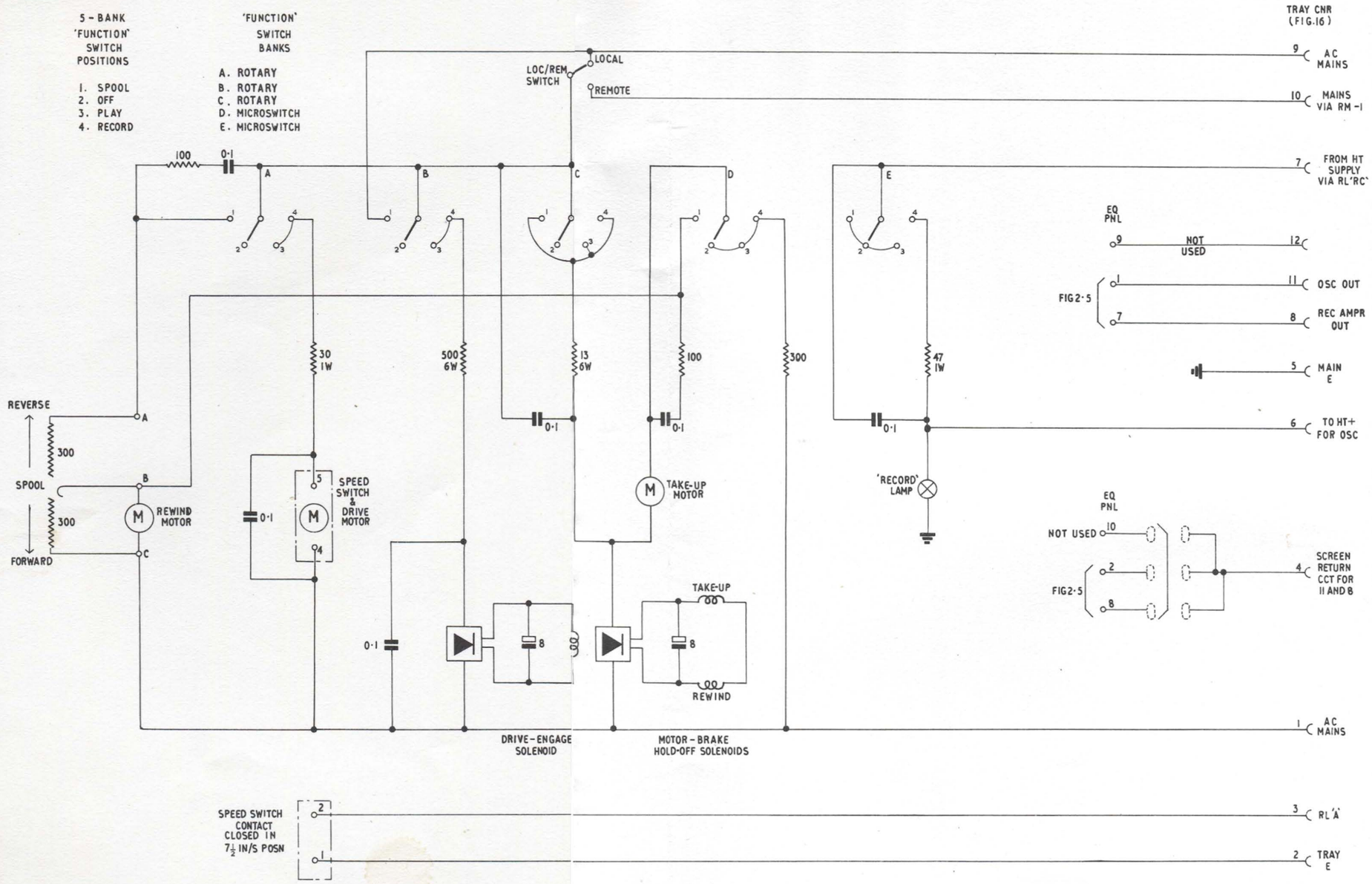


NOTES:- 1. POWER CNR CONNECTS TO AMPR UNIT (FIG 19)
2. TRAY CNR CONNECTS TO DECKPLATE (FIG 17)

MACHINE UNIT : TRAY CIRCUIT

SERIAL NUMBERS UP TO 498

FIG.17



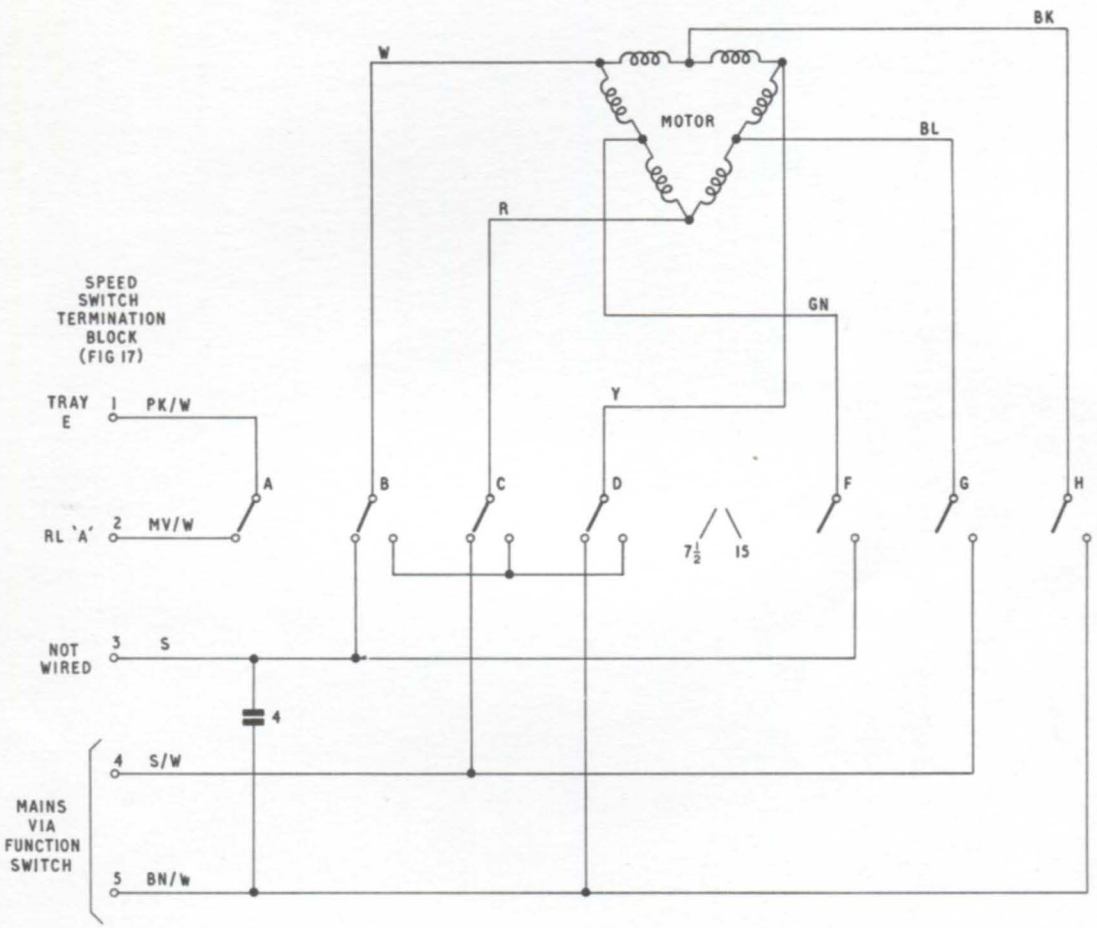
SPEED SWITCH CCT SHOWN IN FIG. 18.

MACHINE UNIT : DECK CIRCUIT

HEAD & BIAS CCTS SHOWN IN FIG. 2·5

59/GH/105/AP
LEEVERS-RICH
DRWG. No.728

FIG.18 R.9



NOTE: SECTIONS A-H OF SPEED SWITCH GANGED & COUPLED TO RECORDING EQUALISER SWITCH (FIG 7.5)

DRIVE MOTOR SPEED SWITCH CIRCUIT

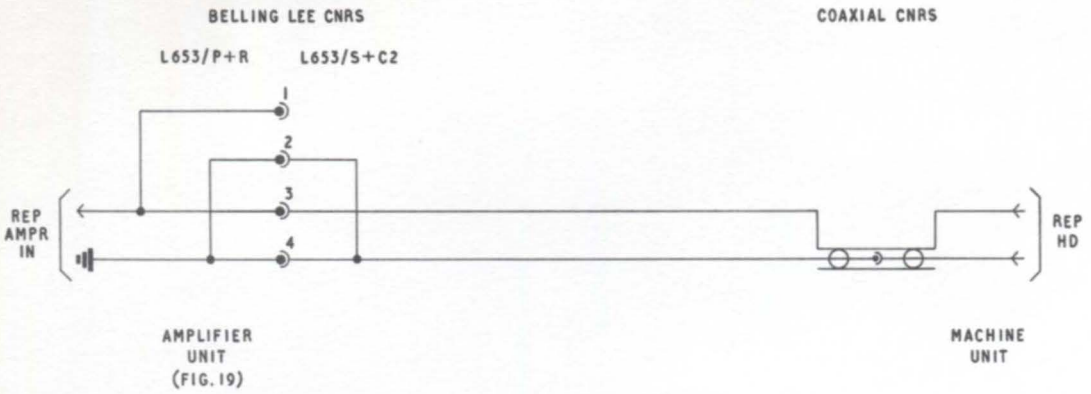
59/GH/101/DJE
LEEVERS-RICH
DRWG No A708

R9

FIG.19

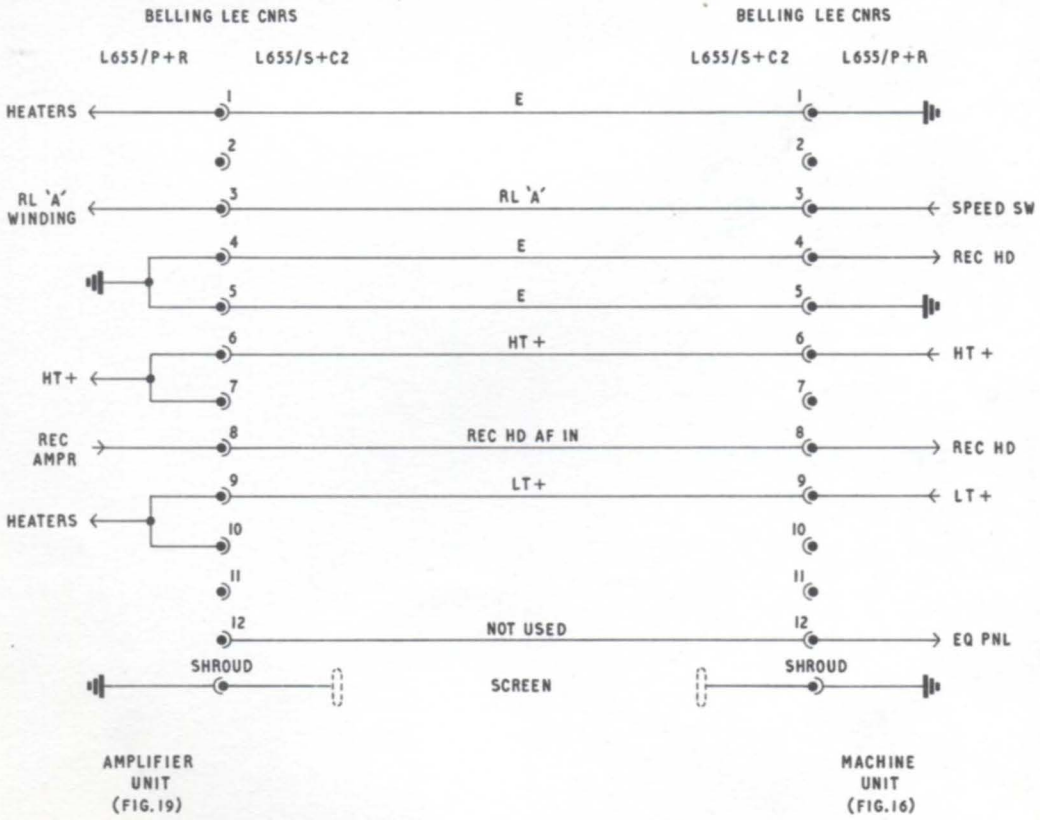
AMPLIFIER UNIT : CIRCUIT
SERIAL NUMBERS UP TO 230

FIG. 20 R.9



REPLAY CABLE

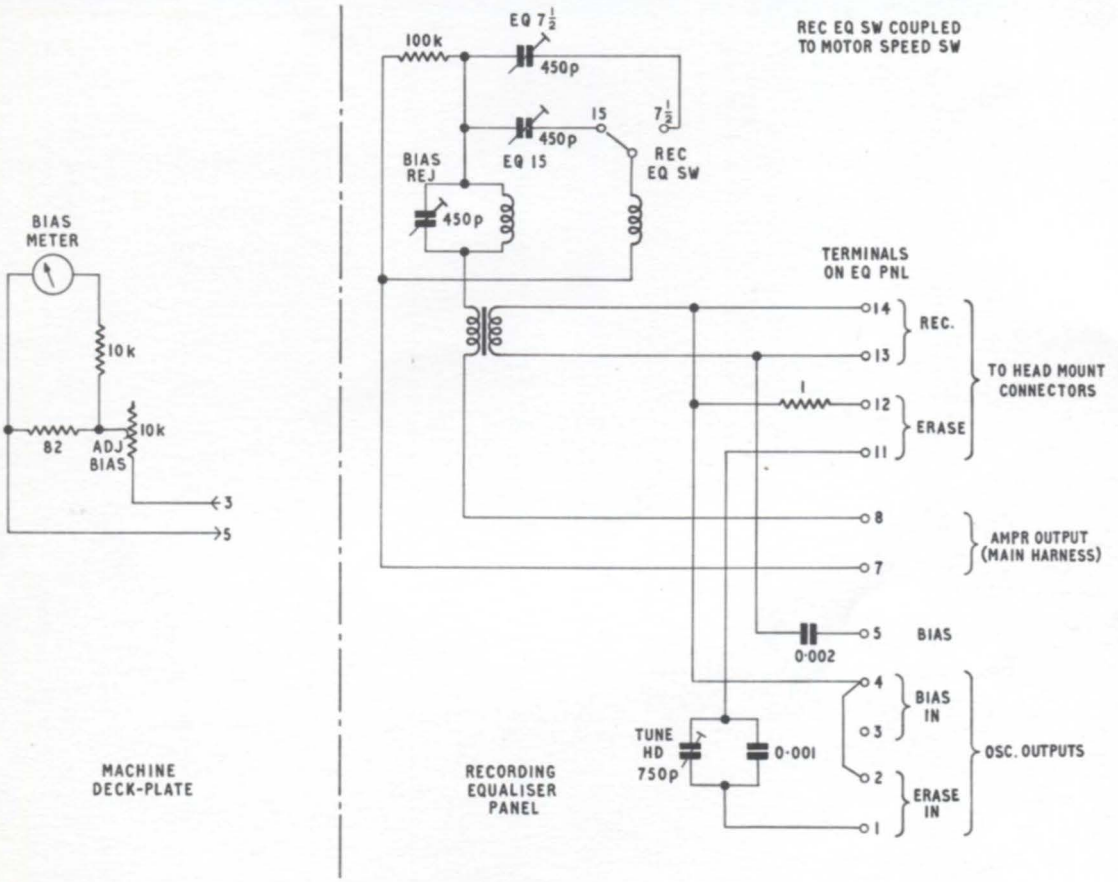
FIG. 21



POWER CABLE

59/GH/107/AP
LEEVERS-RICH
DRWG. No. 727

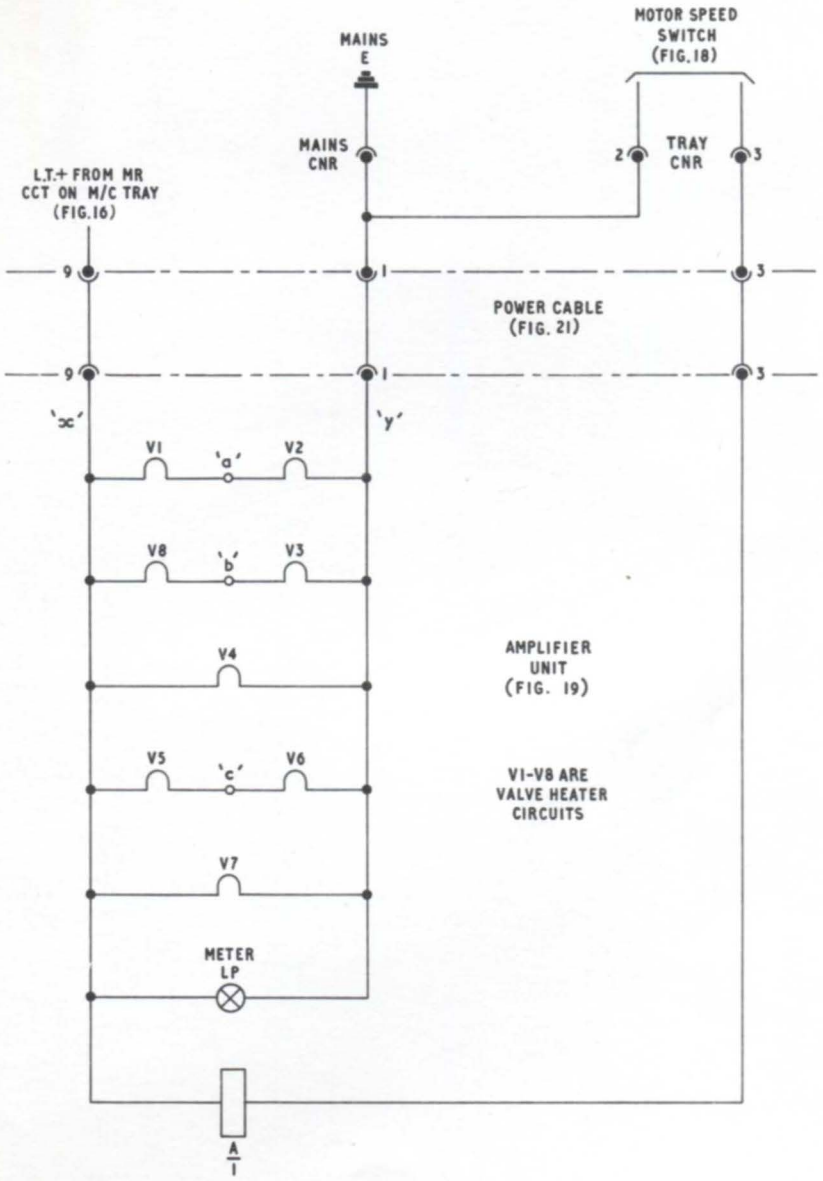
FIG. 22 R.9



NOTE: SEE FIG 2.5 FOR CIRCUIT DIAGRAM

RECORDING EQUALISER PANEL: WIRING

FIG. 23 R9



NOTE: L.T.+ SUPPLY FROM M/C TRAY: 13 V APPROX.
DROP IN POWER CABLE & CNRS: 1V APPROX.
L.T.+ SUPPLY AT AMPR. UNIT: 12V APPROX.

AMPLIFIER UNIT: L.T. SUPPLIES

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