THE MANUAL

OF THE

"FERROGRAPH"

SERIES 6

Ferrograph

FERROGRAPH
MODELS 632, 634 & 632H

SUPPLEMENTARY NOTES

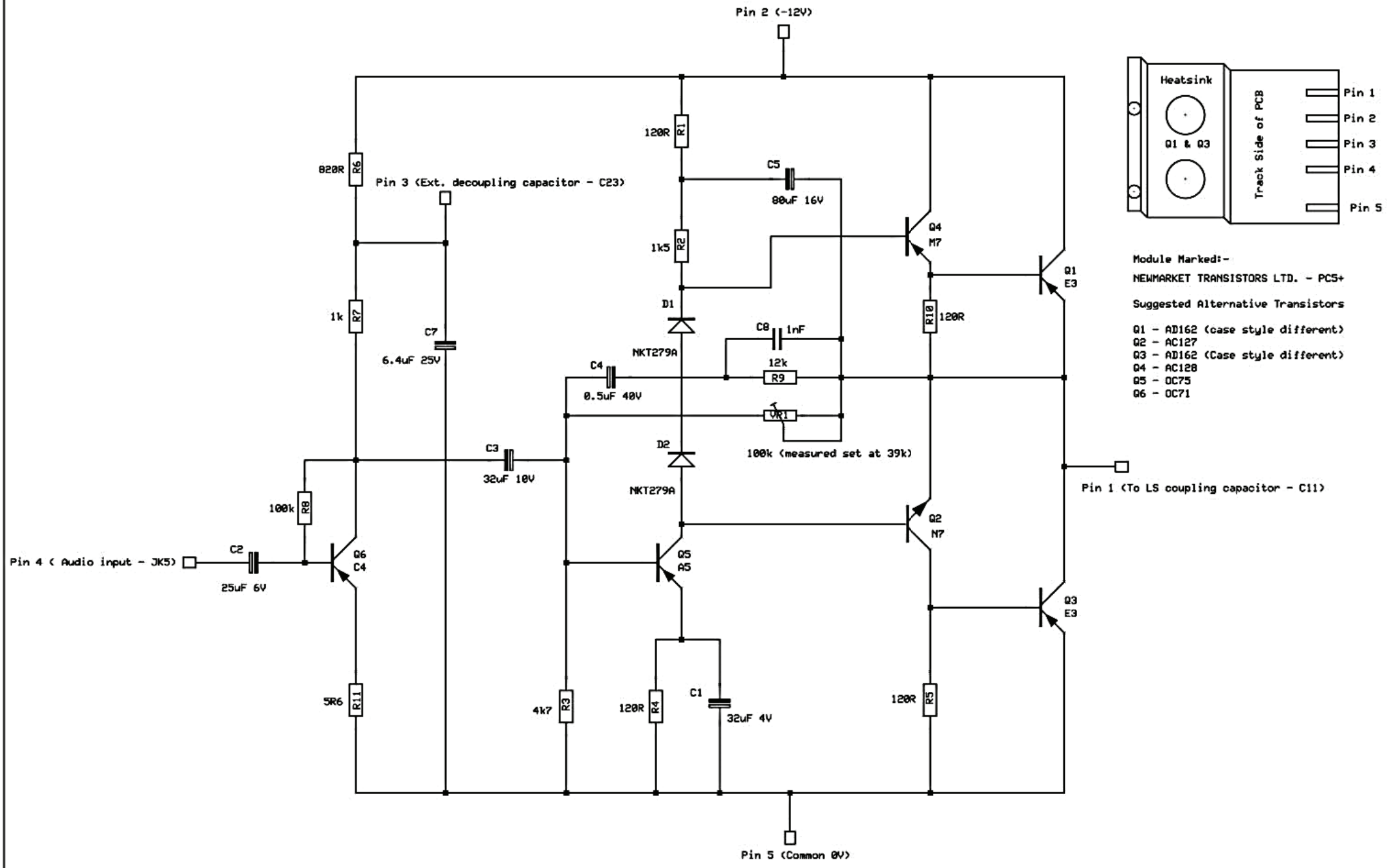
with

Revised Circuit Details

Serial No. 6/50,000 onwards

FERROGRAPH MODELS 632 & 634

Schematic Diagram of 'O.S.U.1' Power Amplifier Module (Ferrograph Series 6)



Module Marked:-

NEWMARKET TRANSISTORS LTD. - PC5+

Suggested Alternative Transistors

Q1 - AD162 (case style different)
Q2 - AC127
Q3 - AD162 (Case style different)
Q4 - AC128
Q5 - OC75
Q6 - OC71

CONTENTS

LIST OF DIAGRAMS AND PLATES

IMPORTANT NOTICE

To achieve the lowest noise levels from tape recording equipment, it is essential that the recording and reproducing heads be free from residual magnetism. In other words, the heads should not be allowed to become polarised.

Normally, under conventional operating conditions, it is difficult to bring about this state of polarisation, and in any case in the "Ferrograph" means are provided for automatically demagnetising the head after recording. This is done by arranging for the supersonic oscillator current to die away gradually in the head as the main selector switch is turned from the "record" to the "wind-back" position.

To take the fullest advantage of this feature, it is necessary that the main selector switch be turned slowly and deliberately between these two positions. If it is turned quickly there will be insufficient time for the demagnetisation process to be completed, in which case any permanent magnetism which has been introduced will not be removed.

By careful operation of the recorder it is possible to ensure that conditions favourable to the retention of permanent magnetism cannot possibly arise. For instance, NEVER OPERATE THE RECORD SWITCH (KNOB 7, FIG. 3) WITH THE MAIN DECK SWITCH ON "RECORD" AS THIS WILL VERY LIKELY POLARISE THE RECORD HEAD, WHICH WOULD THEN NEED DEMAGNETISING.

The above will avoid most of the switching surges likely to cause polarisation, but nevertheless, if it does occur and manifest itself by an increased hiss, irregular thumping noises in the background, and some distortion, the quickest and most convenient method of demagnetising the record/playback head is by using the Wearite Defluxer. It is only necessary to hold the pole tip against the working face of the head for one or two seconds, then slowly withdraw it well clear before releasing the energising button.

"FERROGRAPH"
MAGNETIC TAPE RECORDERS
SERIES 6

FOREWORD

The "Ferrograph" is a very versatile instrument—its applications range far and wide over the fields of science, education, entertainment and industry. Moreover, its simplicity of operation, together with its high standard of performance, commends it equally to the technically unskilled for whom the recording may be an end in itself, as to the engineer or professional recordist for whom it may be a very important link in a complicated system.

This booklet in consequence must have regard to the widely differing outlooks of all these users, if its object — to enable each to derive the maximum possible benefit from the instrument in his chosen field — is to be fulfilled. Much technical information is therefore unavoidable. At the same time explanations in simple terms are necessary for the benefit of those who have no great knowledge of electronics.

In all cases, however, the contents of the succeeding pages will repay careful study as they deal not only with the possibilities of the "Ferrograph" but also with its limitations. As in any well ordered scheme of things, a full understanding of the one is as important as the other.

THE FERROGRAPH COMPANY LTD.
84, BLACKFRIARS ROAD · LONDON S. E. 1.

Due to constant efforts to improve performance and consequent modifications, it may be found that minor differences exist between the actual instrument and that described in this manual. It is therefore essential to quote the serial number of the recorder when ordering any replacement parts.

FERROGRAPH MODELS 632 & 634

GENERAL SPECIFICATION

RECORDING MEDIUM	Standard or Long Play ¼" plastic coated tape, on reels up to a maximum of 8½" diameter (coating inside).
RECORD & PLAYBACK TRACK WIDTH (See Figs. 15 & 16)	632—half track — 0·083 in. 634—quarter track — 0·043 in.
PLAYING TIME PER TRACK (Standard Play Tape) ..	Large Reel 1,750 ft. — 45 min. at 7½ in./sec. 90 min. at 3¾ in./sec. 180 min. at 1⅞ in./sec.
FAST WIND TIME	Less than 1 min. for 1,200 ft. tape (either direction).
FREQUENCY RESPONSE	7½ in./sec. 30—15,000 c./s. ± 3 dB. 3¾ in./sec. 40—10,000 c./s. ± 3 dB. 1⅞ in./sec. 50— 5,000 c./s. within 8 dB.
RECORD/PLAYBACK CHARACTERISTIC	CCIR— 70 microseconds at 7½ in./sec. 140 microseconds at 3¾ in./sec. *Note :*—632A, 634A also supplied to NAB characteristic.
"WOW" & "FLUTTER"	Less than 0·16% at 7½ in./sec.
ERASE & BIAS FREQUENCY ..	Approx. 68 Kc./s.
INPUT LEVELS (minimum signal for full depth recording)	Input 1—2mV RMS at 1 Megohm. Input 2—35mV RMS at 0·5 Megohm.
OUTPUT (Maximum per track) ..	1 Volt RMS (impedance 1000 ohm approx.)
OUTPUT STAGE	1 Watt approx. into 3 ohm, 5 in. internal speaker.
SIGNAL/NOISE RATIO	Unweighted, including hum, 52dB.
TRACK SEPARATION (Stereo) ..	Approx. 40 dB.
LOWER TRACK REJECTION ..	In "Mono" application, equal to or greater than 65 dB at 400 c./s.
MAINS SUPPLY	Suffix U — 240 V 50 c./s. Suffix E — 110 V 50 c./s. Suffix A — 117 V 60 c./s.
POWER CONSUMPTION	115 Watts.
OVERALL DIMENSIONS	17½" wide x 18½" deep x 9⅝" high, with lid.
WEIGHT	47 lbs.

THE "FERROGRAPH" MODELS 632 & 634

GENERAL DESCRIPTION

The suffix U, E or A refers to the mains supply which should be fed to the recorder, the two basic models being 632 and 634. These are identical in performance, operation and construction except for their head arrangements. Both have stacked stereo erase, record and playback heads, but while those on the 632 are half track, those on the 634 are quarter track (Figs. 14 & 15). To enable the latter to playback half track tapes in addition to quarter track, the playback head is fitted in a special mounting which enables it to be lowered to locate at the centre of a half track recording. As this is the only operational difference, the text in this manual applies equally to both except where special notes for the model 634 are added.

The 632 and 634 Ferrographs have facilities for erasing and recording on two tracks of the tape simultaneously (stereo) or individually (mono), and also for playback whilst recording for off-the-tape monitoring of both tracks. For stereo playback two external amplifiers and loudspeakers are required, but as the recorder has a small internal amplifier and monitor loudspeaker, for mono no ancillary equipment is necessary, and if required stereo tapes can be played into this amplifier resulting in both signals being heard simultaneously on the internal speaker. Headphones may be used on either or both tracks without any external amplifiers, and as the playback head gaps are "in-line", the standard "stacked" stereo pre-recorded tapes can be replayed.

Features of the 632 and 634 Ferrographs are :—

Three tape speeds of 7½, 3¾ and 1⅞ in/sec.

Three-motor tape transport, giving fast wind on or wind back of the tape, with the possibility of shuttling from one to the other (without stopping the tape) using the main selector switch.

Gear driven turns counter with positive drive from the take-up motor for accurate cueing and place location on the tape.

Pause control giving instantaneous stop and start of tape transit, and which can be locked in the "stop" position.

Automatic stop on Record and Playback which will switch off the motors at the end of a reel or in the rare event of tape breakage or stopping of the take-up reel.

Record lock device to avoid clicks on the tape due to accidentally turning to Record.

Four pre-amplifiers, two recording and two playback with 1000 ohm output jacks.

1 Watt output stage with 5 in. internal loudspeaker.

Two inputs per track for recording, with independent gain controls for mixing the high level signal (greater than 35 mV) with the low level signal (2 mV to 150 mV).

Illuminated recording level meter, switchable to either track.

Panel switch for instantaneous comparison of signal being recorded and signal "off-the tape".

All input and output jacks are on a panel at the rear of the recorder suitable for permanent connection, if required, using standard jack plugs.

OPERATING INSTRUCTIONS

1. CONNECTING UP

The power lead requires a plug appropriate to the house installation, having due regard to the green earth wire.

ENSURE THAT THE POSITION OF THE VOLTAGE SELECTOR KNOB ON THE REAR PANEL CORRESPONDS WITH THE SUPPLY VOLTAGE (205-245v models only).

Instrument is energised by switch 12 (Fig. 3) on front panel, meter illumination will come on immediately.

While a monitor loudspeaker and output stage are built into the Ferrograph, if required the signal can be heard using headphones or an external amplifier and loudspeaker. Plugging into the output socket automatically disconnects the internal speaker from that track.

The sensitivity of this amplifier can be quite low, as the output from the Ferrograph is approximately 1 volt from a normal recording, *i.e.*, the "pick-up" terminals on the usual AC MAINS ONLY radio set could be used. Ordinary flex can be used for the connection between Ferrograph and external amplifier, and no loading resistor need be used. Indeed, to maintain the full output and the best possible frequency response, it is desirable that the input impedance of the external amplifier should be not less than 20,000 ohms. This of course, is

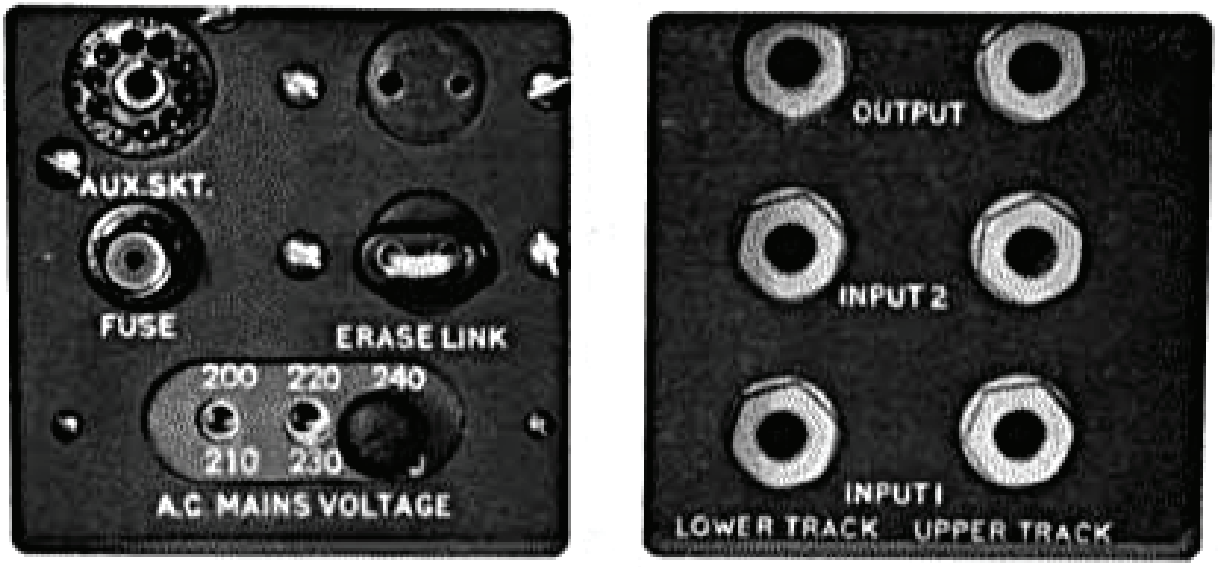


FIG. 1. REAR PANELS

well below the usual figure for practically all amplifiers likely to be encountered. If headphones are used however, these may well be below 20,000 ohms, but due to their basically limited frequency response, the foregoing may be disregarded. Use only one mains "earth" lead for both equipments, to avoid the possibility of hum due to an "earth loop".

2. TO LOAD

Main function switch knob (E, Fig 2) must be in one of the "fast wind" positions. Open the head cover (K), drop tape between heads, pressure pads and capstan, and position over left hand guide and between right hand guide and auto stop arm as shown in Fig. 2.

Fasten the free end of the tape in the empty spool by depressing the red locking lever at the hub and inserting the tape in the opening between the green and grey sections. Take up any slack by rotating the reels, close the head cover and turn the main functions switch to the operation desired.

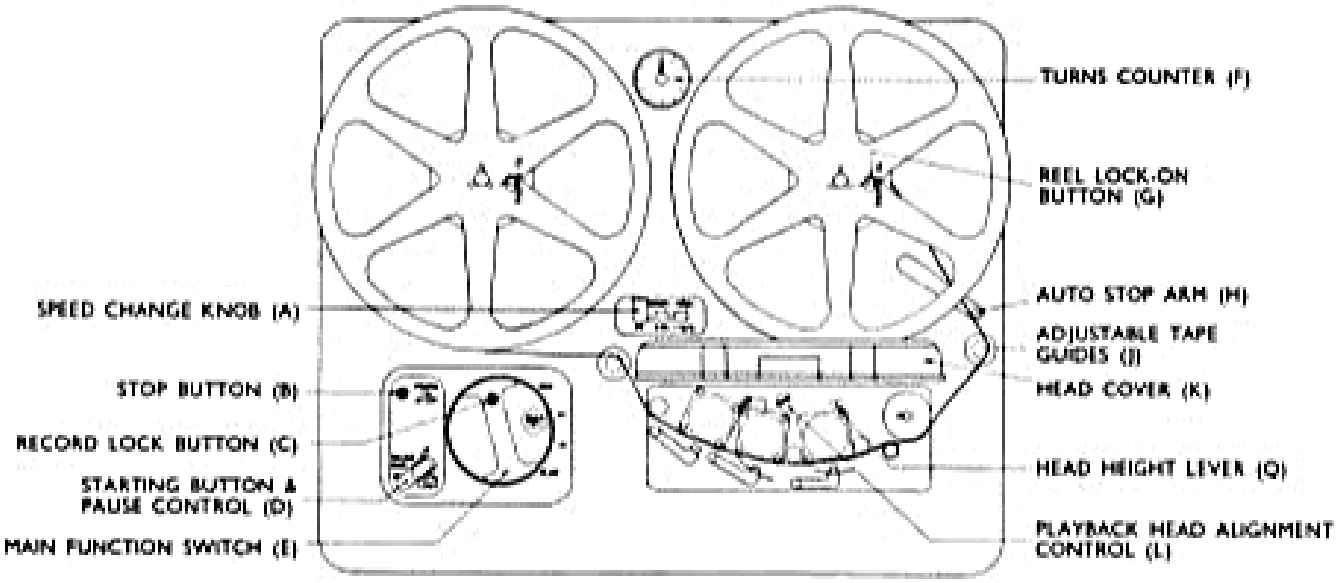


FIG. 2.

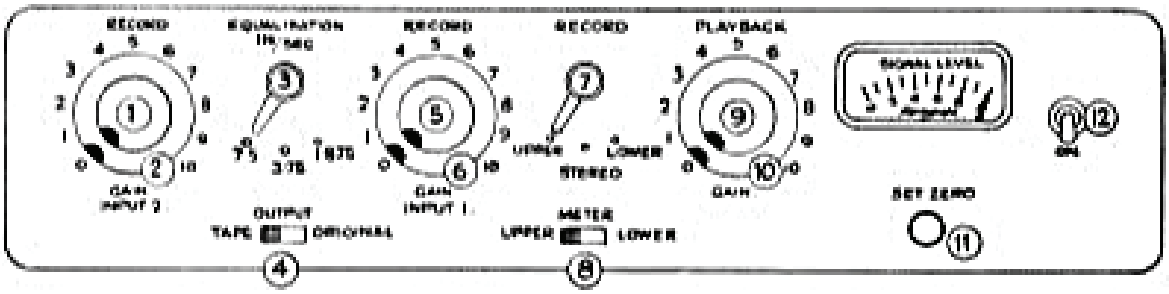


FIG. 3.

3. TO RUN

Select the operating speed required, by the lever knob (A) on the tape deck, check that knob 3 on the front panel (Fig. 3) is set to the same speed otherwise the starting button (D) will not "hold in" when pulled towards the bottom left hand corner of the control panel.

Pull knob D towards the bottom of its slot, (where it will lock in), to start. Stop by momentarily depressing the button on the control panel marked "PRESS STOP" (B).

DO NOT ATTEMPT TO CHANGE THE TAPE SPEED WHEN RUNNING AND NOTE THAT, ALTHOUGH THE MAIN FUNCTION KNOB MAY BE TURNED FROM WIND ON TO WIND BACK OR VICE VERSA WITHOUT STOPPING, THE TAPE MUST BE STOPPED TO SWITCH TO RECORD OR PLAYBACK.

If the tape is catching either reel cheek it can be adjusted to run clear by moving the bobbin guides up or down. Unlock them by twisting top anticlockwise, screw up or down spindle as desired and relock by screwing top and bottom together.

4. TO PLAY BACK

4.1. Single channel upper track (standard)

Check that the front panel controls are as follows.

Knobs 1, 2, 5, 6 and 10 fully anticlockwise, *i.e.*, at zero. Knob 9 advanced to say 5 on scale.

Switch 3 to desired tape speed and equalisation.

Switch 4 to "TAPE".

Switches 7, 8 and knob 11 are only effective when recording, and can be in any position when only playback is envisaged.

On starting the tape transport, sound should be heard from the internal loudspeaker, and knob 9 should be adjusted to give the desired listening level.

If required, an external amplifier could be plugged into the upper track output jack at the rear of the Ferrograph, and knob 9 adjusted in conjunction with the external amplifier gain control.

4.2. Single channel lower track

Except for special applications it will probably be only on rare occasions that this facility by itself is required ; however it is only necessary to observe the same procedure as for upper track playback, except that knob 9 will be turned to zero and knob 10 advanced. If required, the lead to the external amplifier should be transferred to the lower track output jack.

NOTE :—On half track recorded tapes made on a standard recorder such as the Ferrograph model 631, the lower track will be heard backwards if it is attempted to replay it as above. The correct procedure is to invert the reels and replay it through the upper track channel as is done on a standard instrument.

4.3. Simultaneous twin channel recordings, e.g., Stereo

For this of course external amplifiers and loudspeakers will be required and should be connected (without mains earths of their own) to the upper and lower track output jacks.

Taking first a pre-recorded half track stereo tape.

Arrange the loudspeakers at the recommended spacing given by the tape manufacturers. (If none is mentioned, 7 to 10 feet apart is the usual distance).

On the model 634, check that the monitor head lever, (Q in Fig. 2), is fully forward, *i.e.*, head is in "down" position.

Check panel controls.

Knobs 1, 2, 5, 6, at zero.

Knobs 9 and 10 advanced to say 5.

Switch 4 to "TAPE" position.

Run the tape, and adjust knobs 9 and 10, together with the external amplifier gain controls, to the desired output level. If no external amplifiers are connected, both signals will be heard "monaurally" on the internal loudspeaker.

NOTE :—If the external amplifiers have exactly the same amplification, a balanced output should be obtained if knobs 9 and 10 are set to the same dial reading. This will apply over most of the scale but slight individual adjustments may be necessary for optimum balance.

4.4. Model 634 Only

For playback of half track stereophonic tapes as above, the playback head should be in the "down" position (head lever Q forward).

For the replay of quarter track tapes the operation and the control settings will be identical but the playback head should be in its "up" position (head lever Q back). At the end of a quarter track stereo recording the tape is reversed and played back (as is normally done with half track mono tapes). For monaural quarter track recordings, the normal playback sequence of the four tracks will be the same as the recording sequence, the usual order being given in Section 6.6.1.

5. TO REWIND

Set the main function switch to the wind back position, next to record. The automatic stop arm will retract from the tape and is therefore inoperative when fast winding, so that it is advisable to remain in the immediate vicinity of the instrument during this short operation.

Start the mechanism in the usual way when the tape will be rewound at high speed. If the playback gain controls (knobs 9 and 10) have been left advanced, a high speed garbled sound will result as the tape passes over the monitor head ; this is often useful for cueing or place location on the tape, but if undesired one or both knobs should be returned to zero.

The indicator clock will slowly return to the reading it had at the commencement of recording or playback and at this point the rewind may be stopped by depressing button (B).

If the initial point is overrun the direction of the tape run may be reversed without pressing button (B). Simply turn the main function knob to the other wind position when the tape will slow down and reverse direction.

6. TO RECORD

A characteristic common to all recording is that the erasing head on the instrument will be operating throughout this particular process. It is not necessary to load with virgin tape—any reel containing unwanted recordings can be used. The old recording, on the track in operation, will be removed as the new programme material is applied, but the other track will be left unaffected.

6.1. Single channel upper track (microphone)

Model 634 only. Head lever (Q) in back (head up) position (APPLIES FOR ALL RECORDING).

Plug microphone into input 1, UPPER TRACK, jack on rear panel.

Check that the front panel controls are as follows :—

Knobs 1, 2, 5, 6, 9, 10, are at zero. These settings pre-suppose no monitoring of the signal as in general, it is only possible to monitor microphone recording off the tape with headphones. If the internal amplifier and speaker are used, acoustic feedback occurs in the form of a continuous howl. If headphone monitoring is desired a pair of headphones (impedance—any value 300—4,000 Ω) should be plugged into the Upper Track output socket. Knob 9 should then be advanced to approximately "8" on its scale.

Knob 3 to speed desired.

Switch 4 to "TAPE".

Knob 7 and switch 8 to "UPPER" (IMPORTANT :—NEVER OPERATE SWITCH 7 WITH THE MAIN DECK SWITCH ON "RECORD", OTHERWISE THE RECORD HEAD WILL VERY LIKELY BE POLARISED, NECESSITATING THE USE OF A HEAD DEFLUXER.)

Press the record lock button (C in Fig. 2) at the same time turning the main function switch to RECORD and set needle of peak level meter to zero by knob 11.

It is useful at this juncture to set also the turns counter (F. Fig. 2) to zero by means of its centre knob, so that the tape can be wound back to this point after recording.

With the microphone working (speech or music, etc., played into it at the level which will be used), advance knob 5 until the meter needle is swinging up to 8 on its scale.

Start the tape transport.

Adjust the monitor headphone level (if used) by knob 9.

After recording, stop, reconnect the external amplifier if necessary, wind back, and turn main function switch to playback.

6.2. Single channel lower track (microphone)

Plug microphone into input 1 LOWER TRACK, jack on rear panel.

Check that the front panel controls are as follows :—

Knobs 1, 2, 5, 6, 9, 10, are at zero. For monitoring, plug headphones into OUTPUT LOWER TRACK on rear panel and advance knob 10 to, say, 8 on its scale.

Knob 3 to speed desired.

Switch 4 to "TAPE".

Knob 7 and switch 8 to "LOWER".

The procedure then follows that for upper track microphone recording except that knob 6 is used to set the recording level.

When playing back, regulate gain by knob 10.

6.3. Single channel upper track (radio or gramophone)

NOTE :—The following instructions relate to radios and gramophones made to work on AC MAINS ONLY. In general, AC/DC apparatus must be approached with care, as either extra capacitors in the leads, or an isolating transformer, are usually required, and the unskilled are advised to leave this to a qualified technician.

Most radio sets have extension speaker sockets brought out at the rear which provide a useful take-off point for a signal. The connections from these can be made by a length of twisted flex to an unscreened jack plug.

Check that if one of the external sockets is connected to chassis, the lead from it connects to the body of the jack plug. (The longer connection blade under the jack cover). A better method, but one involving some knowledge of radio set circuitry, is to take the output for injection into the "Ferrograph", immediately after the receiver's detector stage. This avoids using the receiver's output stages, which are unnecessary so far as the Ferrograph is concerned, and avoids the distortion and hum sometimes associated with such stages.

Here, the signal will normally be of lower level, and may be taken into the INPUT 1 socket of the recorder if adequate gain is not provided at INPUT 2. This might also apply in the case where a tuner unit is used instead of a complete set, the main criterion being that if knob 1 is turned to a scale reading of 10 and peak level is not attained on the meter, it is necessary to change the lead over to INPUT 1, reset knob 1 to zero and advance knob 5.

Similar considerations apply to recording from gramophones, and it is always better to take the signal from an associated amplifier or pre-amplifier (because of the tone controls provided) rather than direct from the pick-up, and it should be noted that although many crystal pick-ups may be connected via a series resistance of approximately 680 K Ω to input 2 on the Ferrograph, magnetic types will always require frequency response correction, as recommended by the pick-up manufacturer.

For either radio or gramophone recording therefore, the procedure is :—

Connect to input 2, UPPER TRACK.

Check that the front panel controls are as follows :—

Knobs 2, 5, 6, 10, are at zero.

Knob 3 to speed desired.

Knob 7 and switch 8 to "UPPER".

Press the record lock button (C) at the same time turning the main function switch to "RECORD" and set the needle of the peak level meter to zero by knob 11.

With the radio or gramophone working, advance knob 1 until the needle is swinging to 8 on its scale. If now, knob 9 is advanced and switch 4 set to "ORIGINAL", the signal will be heard before recording. Note counter (F) reading. Start the tape running, and change switch 4 to "TAPE", when the signal will be heard off the tape. In this way a check can be made of the quality of the original and recorded sound.

After the recording, stop, wind back to the original counter reading, and turn the main function switch to playback.

For LOWER TRACK recording the same procedure would apply except that the panel knob settings would be :

Knobs 1, 5, 6, 9 at zero.

Knob 3 to speed required.

Knob 7 and switch 8 to "LOWER".

Adjust recording level with knob 2 and monitor level with knob 10.

Plug signal into input 2 and if necessary change over external amplifier to output LOWER TRACK.

6.4. Stereo (both channels together)

It should be noted that, when they are recorded simultaneously, the "crosstalk" between channels is of the order of 40 dB. This is adequate for stereo, but if it is attempted to record two *entirely different* signals at the same time, some breakthrough between the tracks might be audible. Recording the same signals one at a time, (knob 7 on "upper" or "lower"), gives negligible crosstalk because no bias is then present on the track not being recorded.

6.4.1. Stereo recording (microphone)

This requires two separate microphones or a special two unit stereo microphone. With the former, results will vary with the separation and angle of the individual microphone heads (if ribbon type), and usually some experimenting will be necessary. With the stereo microphone, the only variable is the positioning of it relative to the sound to be recorded, the other factors being pre-determined.

To make a recording, the procedure is similar to that described for single channel working, except that both tracks will be working together.

If headphone monitoring is envisaged, each earphone should be connected separately to each output jack on the rear panel.

The panel controls should be set initially as follows :

Knobs 1, 2 at zero (also 9, and 10, if no monitoring).

Knob 3 to speed desired.

Switch 4 to "TAPE".

Knob 7 to "STEREO".

Press the record lock button (C) at the same time turning the main function switch to "RECORD" and set peak level meter to zero (check with switch 8 on UPPER and LOWER).

With the microphone working, and switch 8 on "UPPER", advance knob 5 until the meter is swinging to 8 on its scale.

Set switch to LOWER and advance knob 6 for the same result. Note counter (F) reading and start tape running.

6.4.2. Stereo recording from disc

Once again, most of the notes concerning disc recording on single channel apply, use two external amplifiers and speakers for monitoring, and SWITCH 4 will compare "ORIGINAL" and "RECORDING" on both channels. If no external amplifiers and loudspeakers are used, both signals will be heard "monaurally" on the internal loudspeaker.

6.5. Special Applications

It is recommended that the preceding pages are studied before any of the following applications are attempted, as in general, they are combinations or simple variants of standard recording techniques.

6.5.1. Recording two signals simultaneously on one track (mixing)

The first important thing is to note that one signal must be 35 mV (or more) and the other between 2 and 150 mV.

Once suitable signals are available it is simply a matter of injecting the larger into INPUT 2 and the smaller into INPUT 1.

Considering the upper track, set the recording levels of each signal independently by means of knobs 5 and 1, turning one gain control to zero while determining the setting of the other. Finally turn both to their pre-determined setting and proceed with the recording in the usual way.

6.5.2. Playing back on one track and recording on the other

This is done by combining the instructions for single channel playback and recording on different tracks, and it is possible to copy a recording from one track to the other by linking its output with the input 2 jack of the other track by a double-ended jack plug lead. (can be ordinary flex).

This can be applied to para. 6.5.1. using one previously recorded track as one signal and say a microphone as the other.

6.5.3. Echo effect

An echo effect may be obtained by connecting, say, the upper track OUTPUT to the upper track INPUT 2. The signal source *e.g.* a microphone, would then be plugged in INPUT 1. It is of great assistance in setting the controls if a pair of headphones be also connected across the OUTPUT, *i.e.*, in parallel with the lead to INPUT 2. Now proceed as for a normal single channel recording with headphone monitoring (Para. 6.1.) but slowly advance knob 1, which will bring in the echo. It will be found that a careful adjustment is required to avoid multiple echoes or even feedback instability which occur with too great a setting of knob 1.

Changing to the slower speeds will give a greater delay in the echo.

6.6. Model 634 Only

As stated above, for monitoring off the tape while recording on the Model 634, the playback head should be in the "up" position (head lever Q back). The operation and the control settings will be the same as outlined for the Model 632 above.

6.6.1. Mono

Controls and operation are as outlined for monaural recording above, but attention should be paid to the sequence of the four tracks on the tape. They are numbered from the top — 1, 2, 3 and 4 — and the universally accepted recording sequence is 1 - 4 - 3 - 2.

This is obtained by recording on UPPER on Side A of the reel (Track 1). At the end of the reel reverse the tape and record on UPPER on Side B (Track 4). Again at the end reverse the tape so that it is now back to Side A and record on LOWER (Track 3). Finally reverse the tape and record on LOWER on Side B (Track 2). This arrangement is shown in Fig. 4.

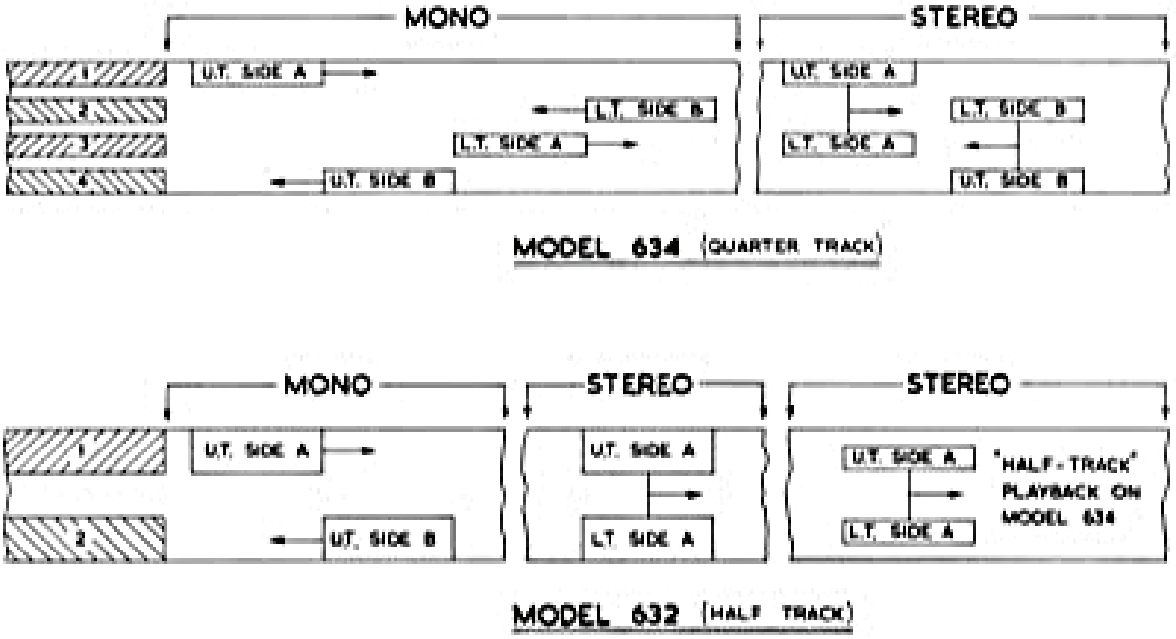


FIG. 4. TRACK DISPOSITIONS

6.6.2. Stereo

At the end of the reel, recording tracks 1 and 3 on Side A, the tape should be reversed and tracks 2 and 4 recorded on Side B.

6.6.3. Special Applications

The special effects of the Model 632 can all be done on the Model 634 provided that the playback head is in the "up" position.

Should it be required to make a monaural tape on the Model 634 *for playback on a Model* 632 *or other half track recorder*, the recording should be made on tracks 1 and /or 4, then the tape run through on record with all gain controls at zero, erasing track 3 and /or similarly erasing track 2 (if track 1 is recorded on stereo with lower track controls at zero, track 3 could be erased at the same time, and then track 2 erased when recording track 4). If this is not done, on playing track 1 any signal on track 2 will also be heard and on track 4, track 3 would also be heard.

7. ERASE LINK

At the rear panel of the instrument will be found a small shorting plug in a socket marked "ERASE LINK". This has a two-fold purpose.

Firstly, by the removal of the plug, it ensures that the recording cannot be accidentally erased. This it does by severing the connection between the erasing oscillator output and the deck. It will be found of great value where the recorder is to be used by the relatively unskilled, for the purpose of repetitive playback only of valuable recordings.

The second function of this link is to provide a means of interjecting spoken commentaries into existing recordings without the clicks and sudden discontinuities which usually occur when this is attempted by merely turning to "Record", interjecting and switching back to "Playback".

The object of the present system is to provide a gradual but complete fade out of the previously recorded material, a smooth insertion of the new material, followed by a gradual restoration of the original. This is achieved by plugging into the erase link socket a new plug which is connected by twin leads to a wirewound, approximately 2,000 ohm rheostat of 4 watts dissipation and with a logarithmic characteristic. (Available from the Company on request).

Having carefully noted by time interval or scale marking, the positions at which the interjection is required, this variable resistor is set to the maximum resistance position and the instrument turned to "Record". The new recording level is set and the tape started, but running in this way no erasure or recording takes place.

As soon as the appropriate point is reached, the variable resistor is slowly rotated to its zero resistance position. At this point, both the erase and the bias will be fully operative, the old material will have been faded out and the new can be inserted. When finished, the resistor should be slowly rotated once more to its maximum position.

By leaving the gain control at zero this method can be used to erase unwanted portions of a recording in an unobtrusive manner, or to remove any "clicks" which have occurred at either end of a recording.

8. PAUSE CONTROL

If during a recording it is found necessary to stop and start the tape several times, it may be noticed that unless the gain control is returned to zero each time, a slight click is put on the tape at each stop and start. Normally this is of little consequence and can be ignored, but if necessary it can be eliminated by the pause control action of the start knob. With the starter bar held on electrically, pushing the start knob towards its off position also moves the pinch roller out of engagement with the capstan and thus stops the tape drive. If at the same time this knob is moved to the right, it will lock in position. It will spring back if moved to the left, or if accidentally left on when the starter bar is released.

9. ENDLESS LOOPS

The "Ferrograph" finds many applications in science and industry where special problems present themselves. Some of these do not require long recording sequences in the normal way but instead, an endless band of tape for continuous presentation of data or for continuous recording. A loop of a few minutes duration is usually adequate in such circumstances and the cassette attachment about to be described (which is an optional extra) caters for a maximum of 4 minutes at 7·5 in./sec. or 8 mins. at 3·75 in./sec. Under the continuous recording conditions referred to above, any activity capable of translation into an electrical phenomenon within the frequency and phase shift limitations can be monitored, so that the last few minutes are always on record. In this way the instrument can be made to act as a memory loop and if necessary,

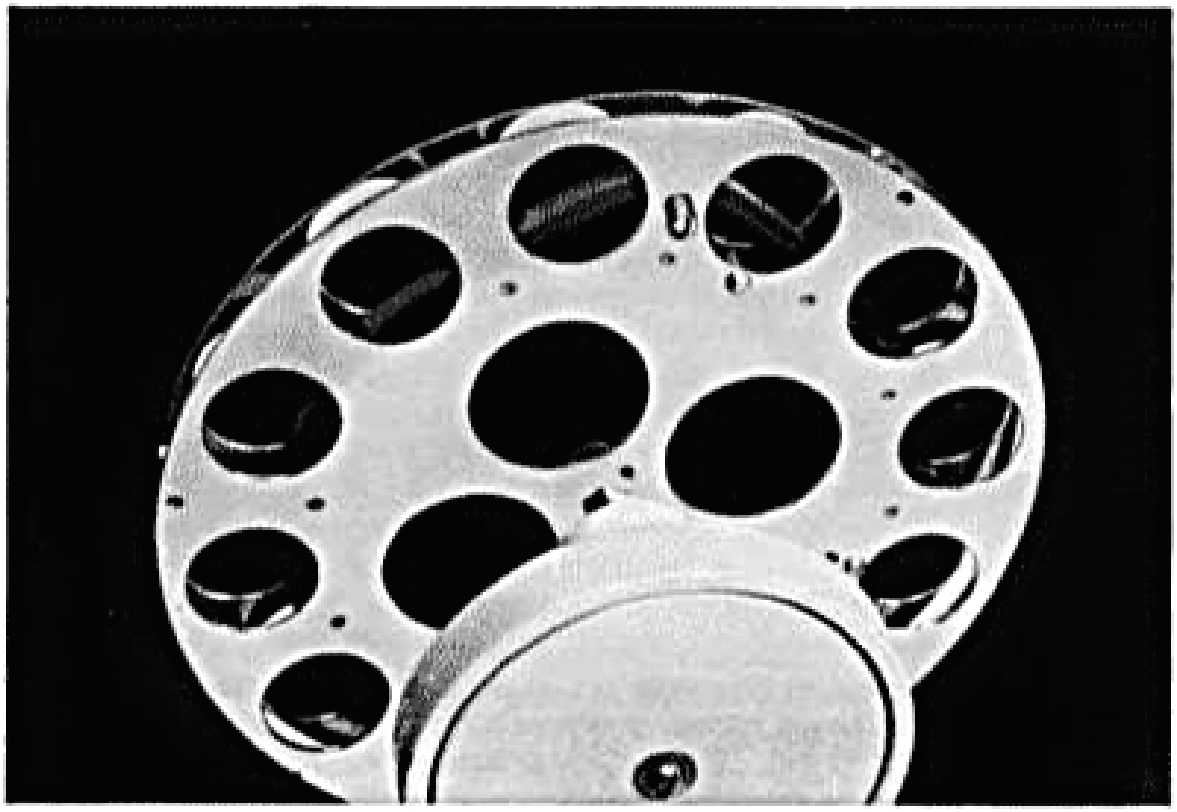


FIG. 5. LOADING OF LOOP CASSETTE

its memory can be shortened to a matter of a few seconds. Monitoring for fault conditions is an obvious application of the facility, as immediately a fault occurs it can be arranged that either manually or automatically the deck is shut down so that afterwards on playback, the conditions leading up to the establishment of the fault can readily be traced.

When making the conversion to endless loop operation, the take-up and magazine motors must be disconnected so that they do not revolve. This can be done by breaking the link between the tags marked 0 & 5 on the rear tagboard of the deck behind the take-up motor.

Before fitting to the deck it will be necessary to load the cassette with the required amount of tape. It is not wise to exceed the maximum running time so, bearing in mind that at 7½ in./sec. the tape velocity is 37½ ft./min. and at 3¾ in./sec. 18¾ ft./min., the appropriate length should be cut from a reel of well aged ACETATE BASED tape. On no account should tapes with either PVC or POLYESTER (MYLAR) backing be used, otherwise sticking and binding between the turns in the cassette will occur.

The three screws and their spacers around the periphery of the cassette should be removed and the small peg inserted in the way shown in Fig. 5. The start of the tape should be passed from the outside through to the inside of the cassette over the fourth roller counted in a counter-clockwise direction from the peg, and the winding should proceed in a conventional "coating inside" manner over the peg, the purpose of which is to ensure that when it is removed, the tape is left very loosely wound. It must of course be removed before any attempt is made to operate the equipment and the peripheral spacers should also be replaced. The illustration

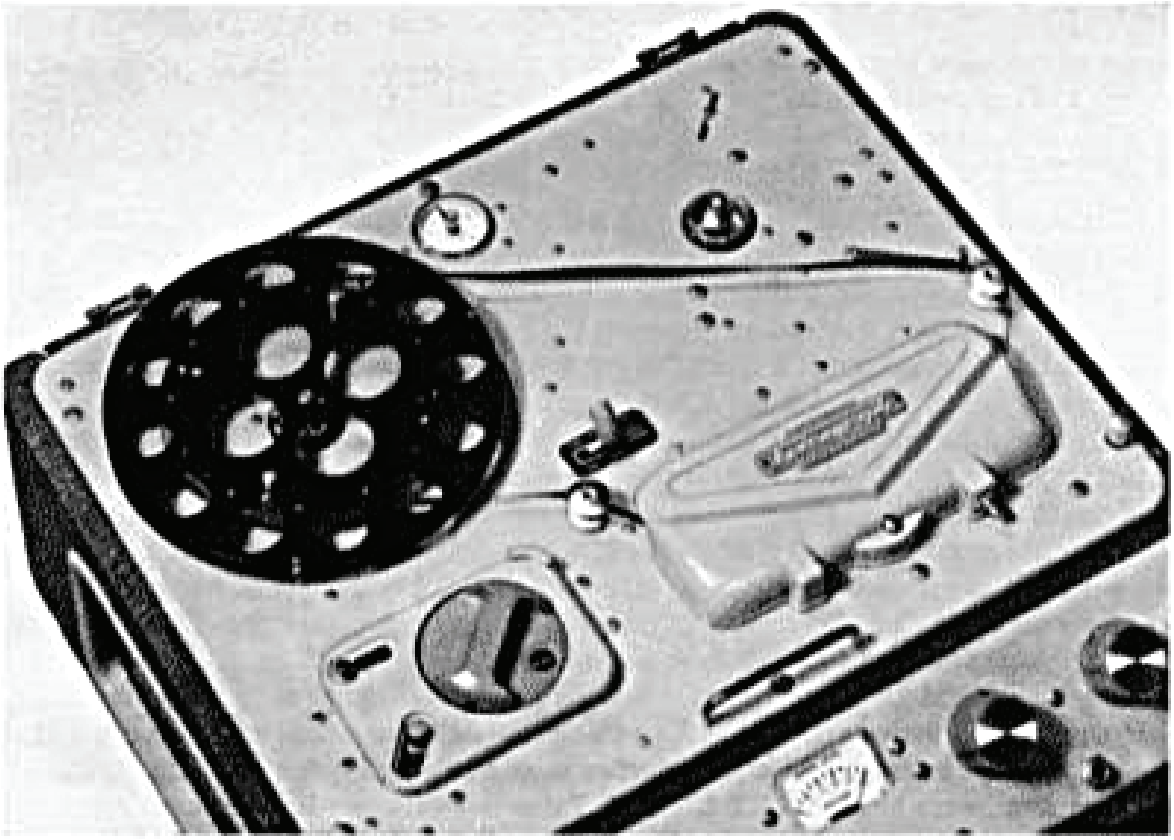


FIG. 6. TAPE DECK CONVERTED TO LOOP OPERATION

shows the cassette being wound on a conventional cine-film winding attachment which provides a convenient means of carrying out the operation. After winding, the ends of the tape should be spliced together, leaving a loop of approximately 18 inches.

In operation the tape will be pulled out of the inside of the cassette and by virtue of the inter-turn friction, the whole mass of tape will revolve easily on the anodised surface and the rollers, and wind itself again on the outside.

The cassette is attached by means of captive screws to the hank bushes rivetted to the deck under the magazine reel. Fig. 6 shows it in position. As there should be little or no tape tension between the capstan and the cassette when the endless loop is running, the auto stop cannot be used. To stop it swinging back and preventing the start button holding in, a small elastic band ($\frac{1}{4}$ inch) should be looped under the lower cheek of the right hand bobbin tape guide (*i.e.* between it and the deck) and over the post on the end of the arm.

When first run after loading on to the instrument, the winding tension will adjust itself automatically to the correct inter-turn friction and the length of the free loop will vary accordingly. Normally it will increase in length as the tape tightens up and after the tape has been running for some few minutes, the tape can then be re-spliced at the original join to bring the free loop within the confines of the deck. It must not be made too small as otherwise the tape may bind in the cassette. Fig. 6 shows a typical loop in operation.

Where the loop is being loaded with previously recorded material, obviously the length cannot be shortened haphazardly and therefore to take up the loop length, the splice must be undone and further turns taken round the cassette before re-joining.

10. CARE AND MAINTENANCE

Little actual maintenance is necessary with the "Ferrograph" beyond the periodic removal of dust and dirt from the head assembly. After a time a deposit from the tape will form on the working surface of the heads and unless removed, may impair the frequency response. To reach the heads it is only necessary to open the head cover box. A small brush is provided for the cleaning operation and it should be gently used. It is best applied while the pressure pads are deflected to their full extent with the fingers, the gate mechanism of course being open.

The record and reproducing heads are very vital parts and their working faces should be treated with great care. After a time they will acquire a high polish, and this is a very desirable condition to be maintained. Never allow any abrasives to come into contact with the head faces and never approach them with steel tools which may have become magnetised. Furthermore never attempt to remove the cylindrical cans of the heads themselves, as the gap setting or the alignment of the head faces may be upset with serious results.

The capstan also requires great care to see that its surface remains undamaged. Here too tape coating material and dirt may accumulate causing "wow", or the tape to pull but weakly. New tape quickly leaves a fine deposit so that periodically, or whenever it is suspected of causing poor tape transport, the capstan surface should be wiped with a dry cloth. If allowed to accumulate for too long, a VERY LIGHTLY damped cloth may be necessary.

Do not carry out this operation with the capstan running as there is grave danger of the cloth becoming caught and causing damage to the capstan.

All rotating parts of the tape deck are fitted either with self oiling bronze bearings or grease packed ball races. The latter require no regular attention and the former should run for approximately 1,000 hours before any oil need be applied. To do this, a few drops of Shell Tellus Oil 27 should be introduced into the top and bottom bearings of each reel motor with a suitable 'dropper', taking great care not to splash either the brake shoes or the idler wheels. If difficulty is experienced in obtaining this particular oil, it can be supplied in a small container as an accessory.

NOTE :—As hinging up the deck causes the rear to be lowered into the cabinet, the deck should not be raised when using reels with an outside diameter of greater than 6 inches.

If necessary due to excessive noise or stiffness, a trace of oil can be applied from time to time to the sliding members of the gate mechanism and the pinch roller bearing, but under no circumstances should oil or grease be allowed to come into contact with the neoprene face of the capstan.

Adjusters have been fitted to the reel brake shoes so that any unbalance in the reel braking can be compensated. The brakes are self wrapping in one direction and are arranged so that this is the direction in which the reel is unwound. Consequently this reel has the greater braking torque applied and tape spillage is prevented. Should there be any overrun, or should the reels take an undue time to come to rest, the screw of the appropriate adjuster should be undone and moved away from the reel spindle to increase braking torque, or towards it to reduce it.

TECHNICAL SECTION

TECHNICAL SECTION

The following pages are entirely technical in nature and devoted to a description of the main design features together with test and alignment procedures in case of need.

11. DESIGN DETAILS

11.1. The mechanical unit

The mechanical unit is wholly contained on the hinged top deck of the instrument. Three motors are employed. One, running counterclockwise when energized, takes up the tape after having passed through the capstan assembly; the second, running clockwise when energized, rewinds the tape after recording. During the record and playback functions this motor is partly energized to maintain a small back tension on the tape. The sole function of the third motor is to drive the capstan and flywheel assembly. It is a split phase capacitor type induction motor which after reaching its synchronous speed is insensitive to small changes of applied voltage or load, and its speed therefore, within certain limits, is controlled only by the frequency of the mains supply.

This motor, running clockwise viewed from its spindle end, carries a stepped pulley, against each step of which a neoprene rimmed idler wheel drives a heavy flywheel. Rigidly coupled to this flywheel is the capstan proper which has a brass bush to which is bonded the loaded neoprene traction surface. No regular lubrication is necessary for this assembly and the capstan motor as both use grease packed ball races, those on the latter being seated in special neoprene mounts.

Three separate heads are used on the models 632 and 634, being the stereo erase head X4, the stereo record head X5 and the stereo playback or monitor head X6. On the model 632 these are all half track, on the model 634 they are quarter track (See Figs. 15 and 16).

The erase head is mounted rigidly on the base plate but small shims are usually employed underneath for exact adjustment of its height.

The record head is screwed to a small plate which pivots on two cone pointed screws on its centre line, one at the front and the other at the rear. These screws fit into tapped holes in the plate and are fixed by 6 BA locknuts; they are used to determine the height setting of the record head. The plate and head may be rocked over a small angle by a screw in the front right corner. This is to ensure that the gaps in the upper and lower track sections of the head are exactly at right angles to the tape path, thus falling into line with other instruments, and guaranteeing that recordings made with it can be played back without any loss of the high frequencies which would occur if the gaps in the record and playback heads were at different angles.

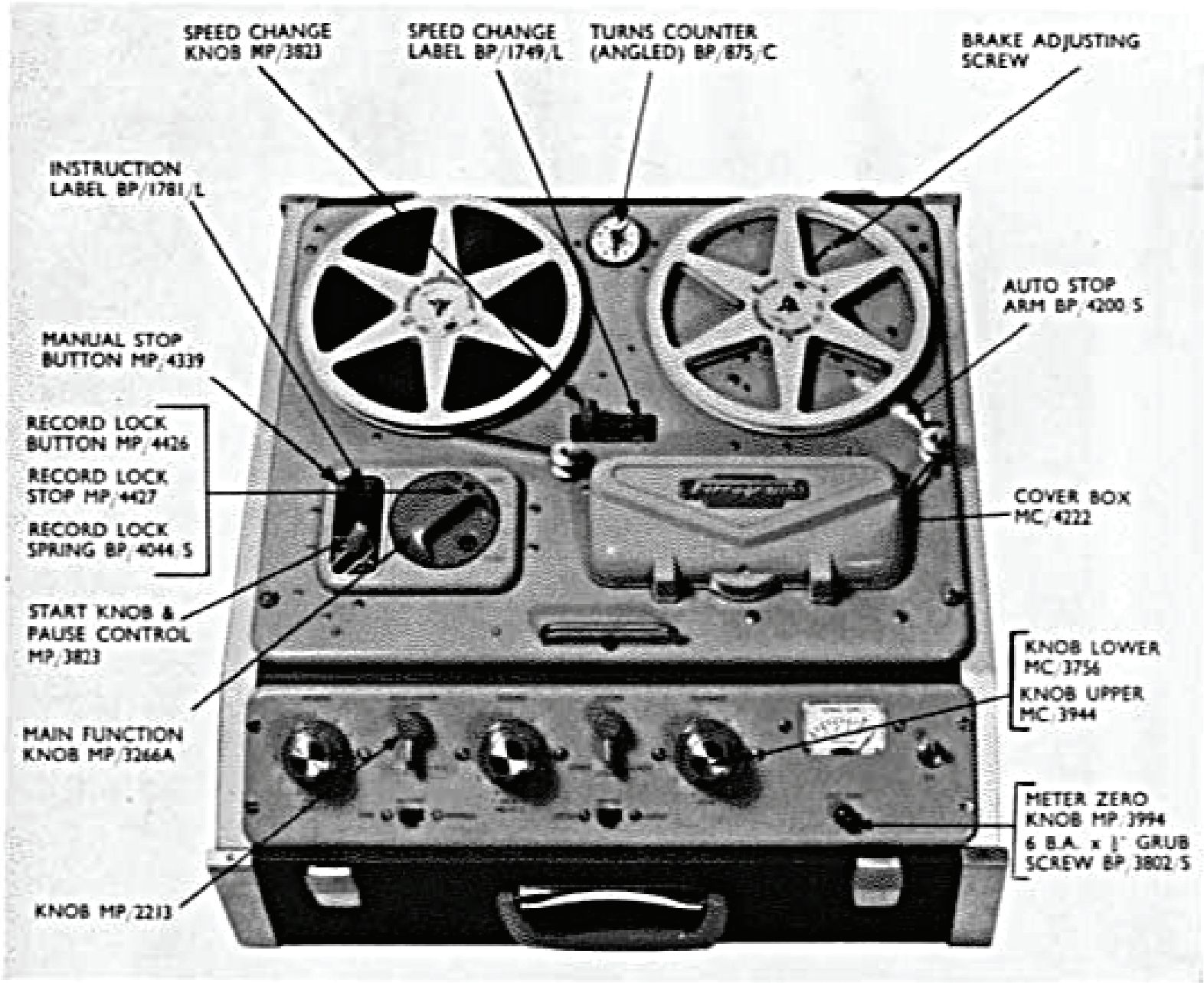


FIG. 7. GENERAL VIEW

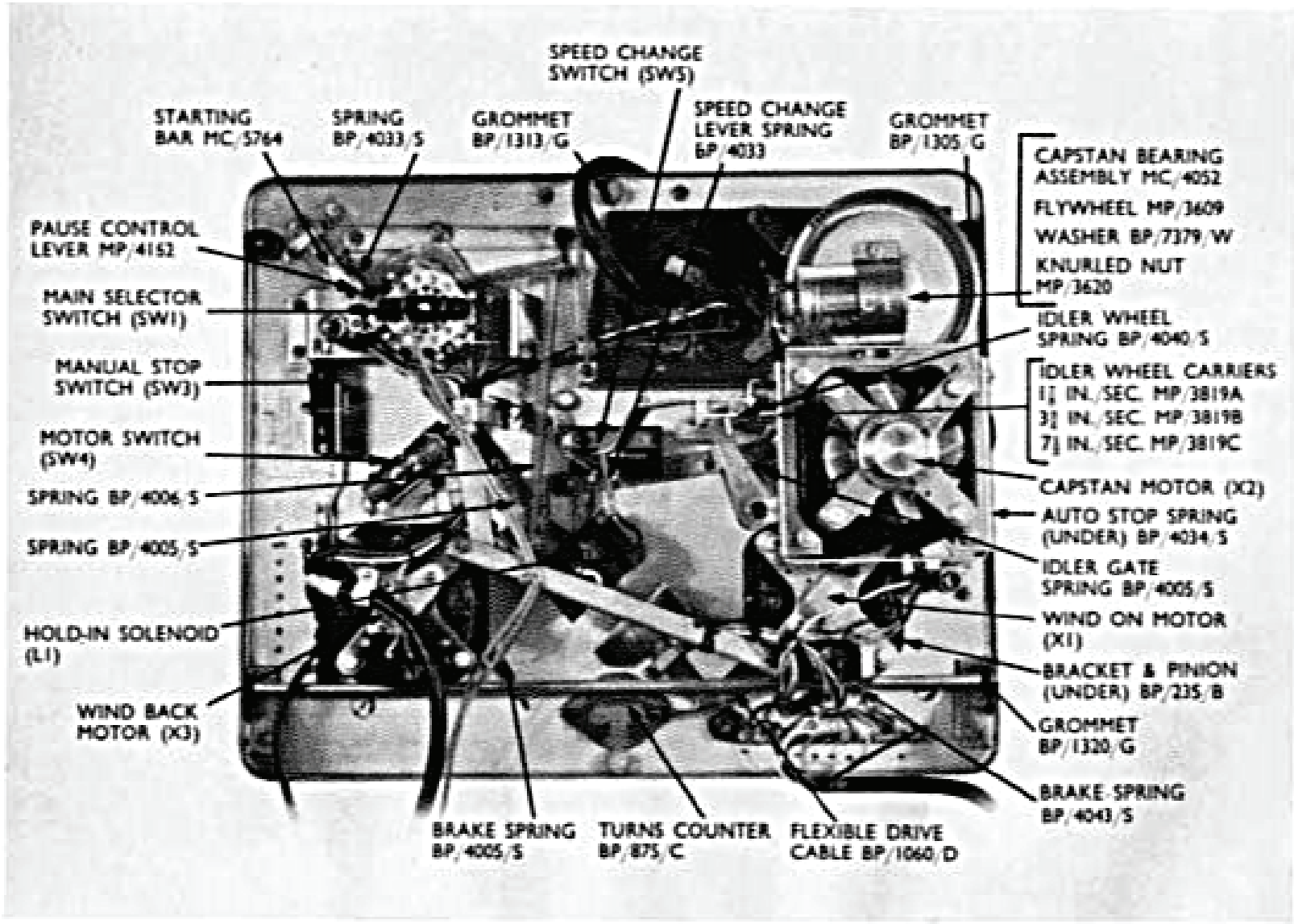


FIG. 8. UNDERSIDE OF TAPE DECK

The playback head X6 is mounted on a diecast body which is also pivoted to permit its gap alignment with the tape. The relevant adjusting screw has a large knurled knob and is located to the left and rear of the head. On the model 632, the playback head height is fixed by shims fitted underneath. On the model 634, a special mounting is used fitted with a lever, and by moving this lever forward, the head may be lowered by approximately 0·035" to align (in the horizontal sense) with half track pre-recorded tapes, the vertical gap alignment remaining unchanged. The relative positions of the heads and the track dispositions are shown in Figures 15 and 16 and it should be noted that while the model 632 will erase both half and quarter track tapes, the model 634 will erase only part of a half track tape at one operation (See Section 6.6.3.).

To the right and rear of the head assembly is pivoted the arm of the automatic stop switch ; at the end this has a short vertical rod which rests lightly across the tape between the right hand bobbin guide and the reel centre. When the supply reel is empty and the end of the tape comes off, or if the tape were to break or the take up motor stop, this arm swings over under light spring tension and by means of a simple switch under the deck shorts out the solenoid (L1).

During the fast winding operations the arm of the auto stop is automatically pulled clear of the tape and is therefore inoperative, but as winding on and back are of short duration and invariably under supervision the action of the auto stop is then unimportant.

Starting and stopping of tape transit is accomplished through the main operating bar (Fig. 7) the knob of which protrudes through the small panel at the lower left of the deck. Pulling this arm diagonally towards the front of the equipment operates the main motor switch (SW4), across which is a capacitor (C2) for interference suppression, and at the same time pulls the brakes off the reel brake drums. This arm is held in the "on" position by the hold-in solenoid (L1) which is energized by rectified current from the special valve heater supply from the mains transformer. To stop the tape transport this solenoid is shorted by the push switch (SW3), or by the contacts of the auto stop switch previously referred to, thus allowing the arm to return under its spring tension. This switches off the motors and applies the brakes to the reel drums. The speed change switch on the tape deck and the equalisation switch on the amplifier panel are also connected across the solenoid in such a manner that unless the same speed is set on each, the solenoid will be shorted and this prevents making a recording with the wrong pre-emphasis (equalisation). The brakes are so arranged as to have self wrapping properties, that is to say that they have their maximum effect on the reel which is being pulled and very little on that which is energized. During rewind therefore a much greater braking torque is applied to the take up reel so that spillage of tape is avoided, and similarly during "wind on" and normal running to the magazine reel.

The main operating arm is also linked with the capstan pinch roller and the idler wheel of the flywheel drive, so that these are only brought into engagement with their respective rotating parts when the mechanism is "on". This has been done to provide an instantaneous start and stop of tape transit, and also to prevent the temporary appearance

of indentations in the neoprene parts which may be caused if these members are left in engagement under spring tension for prolonged periods. On switching off, these members are knocked out of engagement.

The change of connections of the heads and motors necessary during the various operations is carried out by the ceramic wafer switch (SW1). One wafer of this looks after the motor supplies whilst the lower controls the oscillator HT supply and the feeds to the record head. Linked to this switch by a cam arrangement is a lever which deflects the pressure pads from the heads, and the pinch roller even further from the capstan, during the fast wind operations. The cam itself is interlocked with the main operating bar so that the main function knob cannot be turned when the tape is running on record or playback. It can be turned however between rewind and wind on without stopping the tape. As the pressure arms and pinch roller are withdrawn in the "wind" positions of the main function knob, it is then that loading the tape should be carried out. A record locking device is incorporated into the knob such that a small, spring loaded catch engages with a recess in the knob, stopping it from rotating past Wind Back. By pressing the button, this catch is depressed and the knob will rotate. The catch has a sloping rear face so that it is not necessary to press the button when turning from Record.

Most of the connections from the deck are taken down through a pair of multiway cables ending in octal plugs and sockets which engage with similar plugs and sockets on the amplifier and power unit. The exceptions are the two leads from the stereo playback head (coded green for lower track and red for upper), the two leads for the stereo record head (coded yellow for lower track and black for upper) and a lead carrying bias supplies which plugs into the power unit chassis.

11.2. Power supplies

A full theoretical circuit is given in Fig. 17. With regard to the actual wiring, all models are the same except for the primaries of the mains transformers TR3 and TR4 but due to the different mains voltages for the various types, the motors and associated capacitor and resistor have different designations.

As will be seen from the circuit diagram, valves in the first, *i.e.* low level, stages of both playback and record pre-amplifiers, (V1, 2, 4, 6, 8) have their heaters fed with DC to reduce possible hum generation to a minimum. Valves associated with the oscillator, peak level meter and output stages, being less critical in this respect, have AC heater supplies. Direct current for the valve heaters is obtained from a pair of silicon rectifiers MR2, MR3 in an orthodox full wave circuit and smoothed by R82 and C50, ending at 12·6 volts which can be applied directly to the double triodes.

The tape deck solenoid, in series with a 100 ohm resistor (R77), is also connected across this DC supply with one end of the solenoid connected to chassis. When the stop button on the tape deck, or the auto stop is operated, the solenoid is shorted out and R77 prevents a short circuit of the DC power supply.

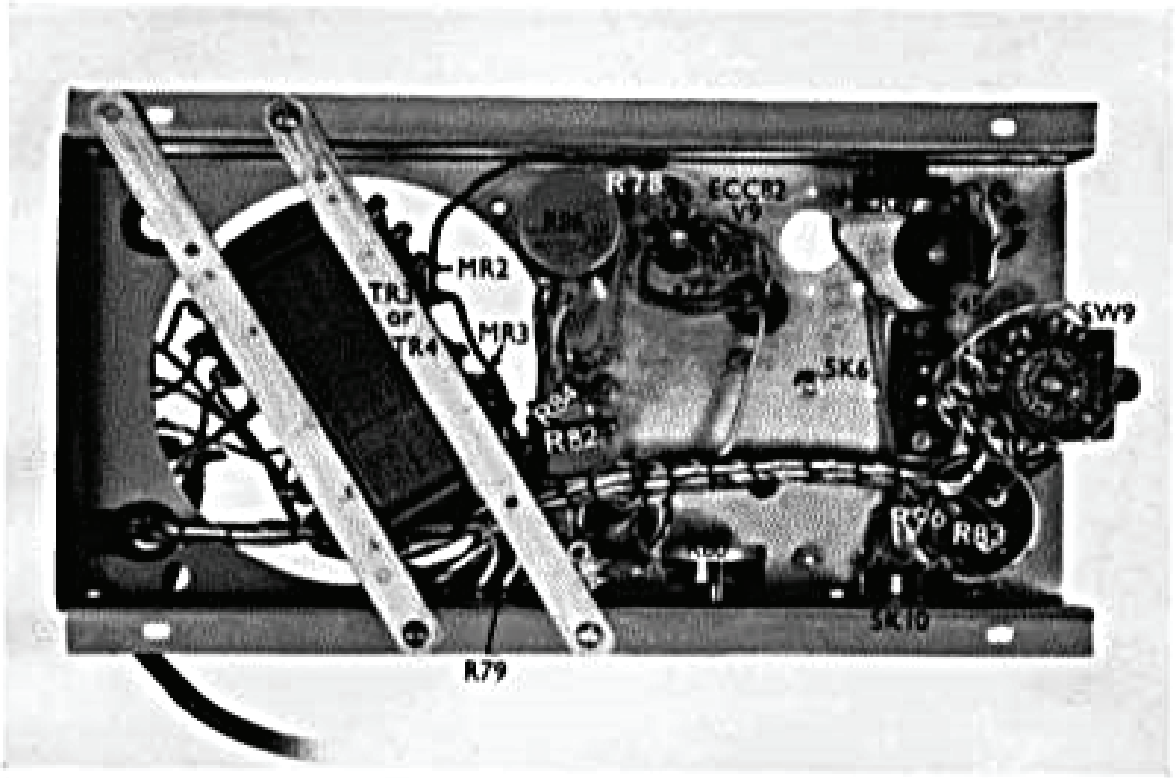


FIG. 9. POWER UNIT UNDERSIDE VIEW

The valves V3, V5 and V7 have their heaters (6·3V connection) wired in series across one half of the 19-0-19 volt AC secondary, whilst V9 plus a series resistor R84, and the two meter illuminating lamps LP1 and LP2 plus their series resistor R90, are across the other half.

The 250 volts DC for the pre-amplifiers is supplied by a solid state rectifier (MR4) in a bridge circuit across the HT secondary winding of the mains transformer. It is smoothed by resistors R83 and R96 and capacitors C12, C51 and C49. The HT supply for the oscillator and meter valves is taken off before the smoothing resistor.

11.3. Erase and Bias supplies, Oscillator

The bias and erase voltage is generated by a double triode V9 located on the power unit chassis. The circuit is that of a conventional push pull oscillator with the primary of the coil L4 tuned by capacitors C54, C46, C53 in series. One side of the secondary of L4 is connected to chassis and the other (output) side goes via the "erase link" SK7 to the track selection switch SW9. The pole of the switch section to which it goes also has connected to it a variable resistor R86 marked "bias equalise". The other end of this resistor goes to another switch section which connects it to chassis in the upper or lower track (mono), but not in the stereo, position of the switch. The function of R86 therefore is to

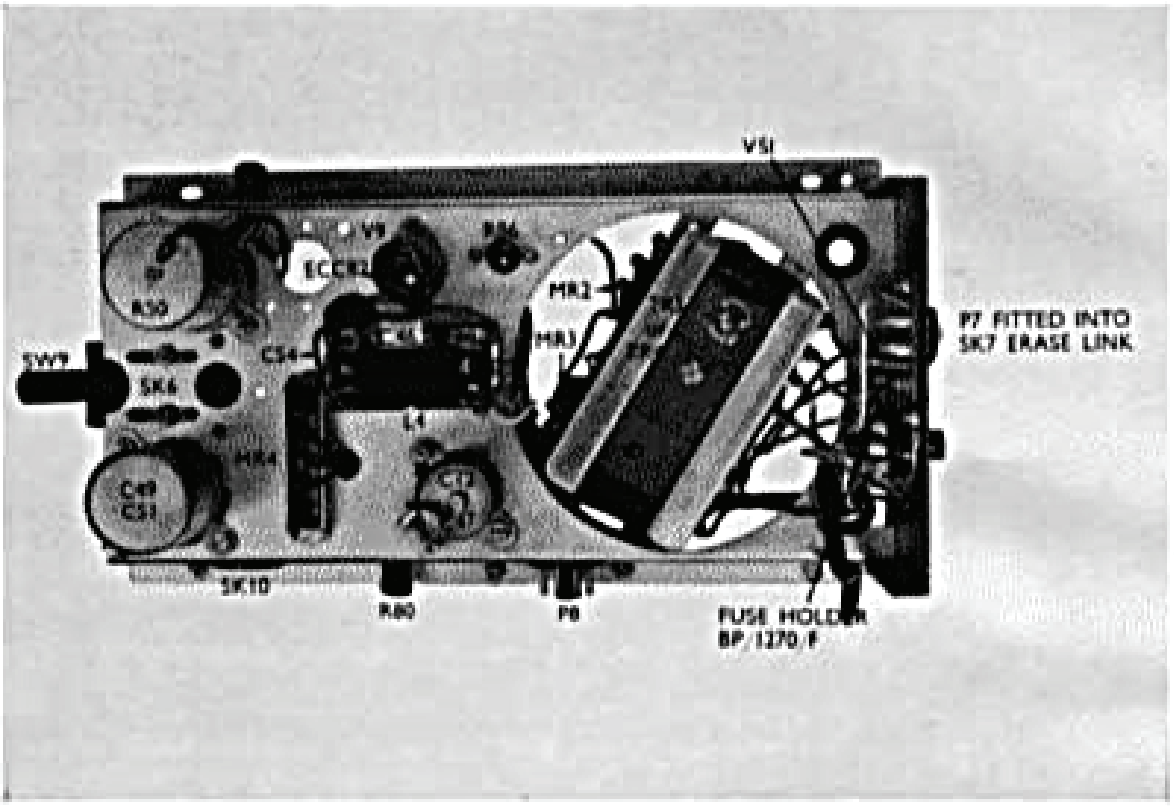


FIG. 10. POWER UNIT TOP VIEW

compensate for the reduced load on the oscillator and maintain the bias voltage at its correct value when each track is recorded independently.

In order to avoid circulating currents leading to some degree of cross coupling, both leads to the unused section of the erase head X4 are disconnected when recording single track. It was found necessary though to disconnect only one lead of the bias supply to the unused track of the record head X5.

To assist in tracing the bias and erase feeds, it may be stated briefly that the upper track bias supply is from SW9 via R80 and pin 4 on P8 and SK8 then through tag 3 on the deck, C4 and to the UT winding on X5, the other end of this head winding being permanently connected to ground.

The upper track erase head section is supplied via C44 and pin 5 (P8 and SK8) then from tag 2 on the deck to X4. The other side of the winding is led via deck tag 1, pin 8 on SK8 and P8 to SW9, where it is switched to chassis in the upper track and stereo, but left disconnected on the lower track, positions.

The lower track bias supply is via R87, SK6 and P6, deck tag F and C3 to the LT winding on X5.

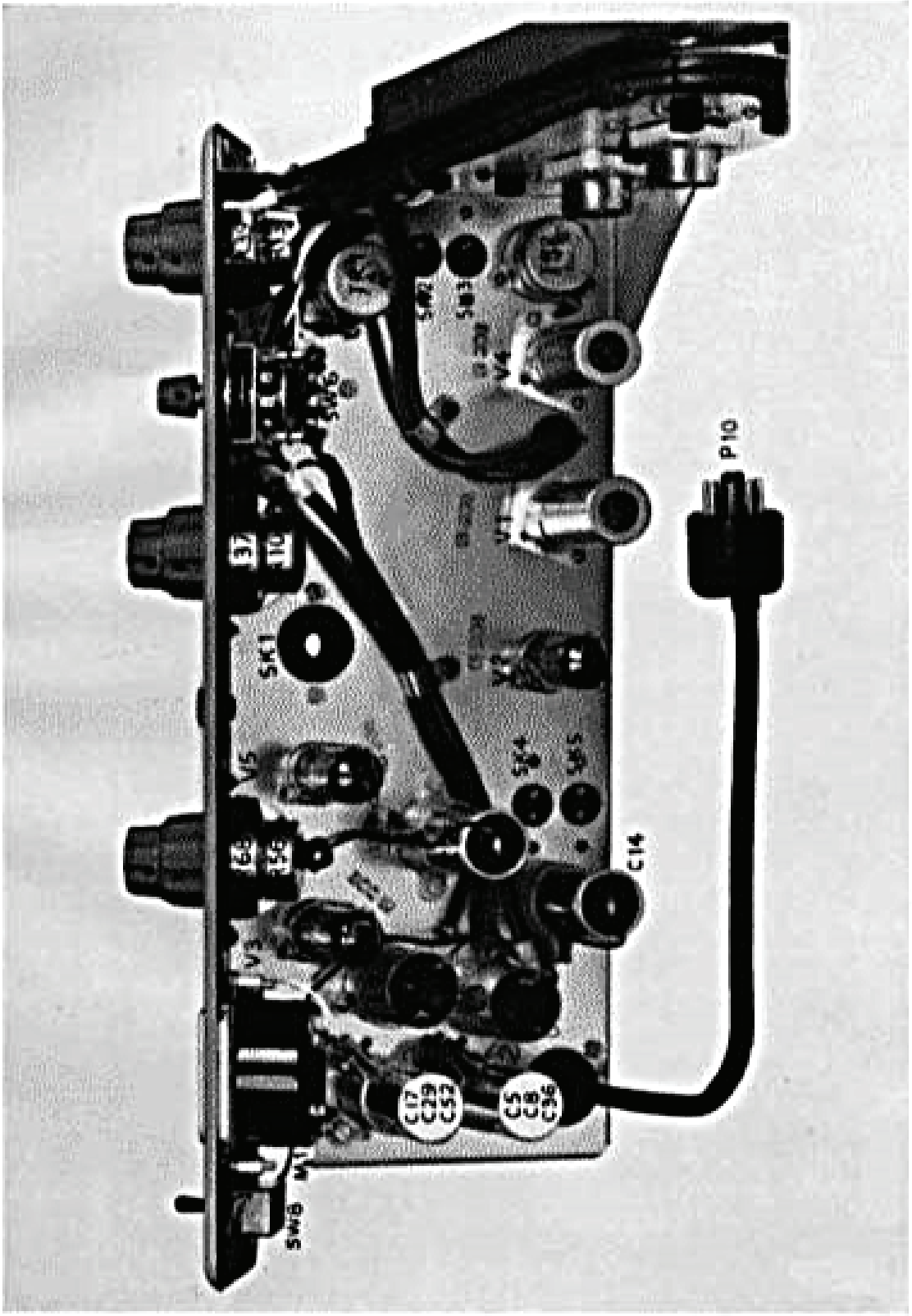


FIG. 11. RECORD AMPLIFIER CHASSIS TOP VIEW

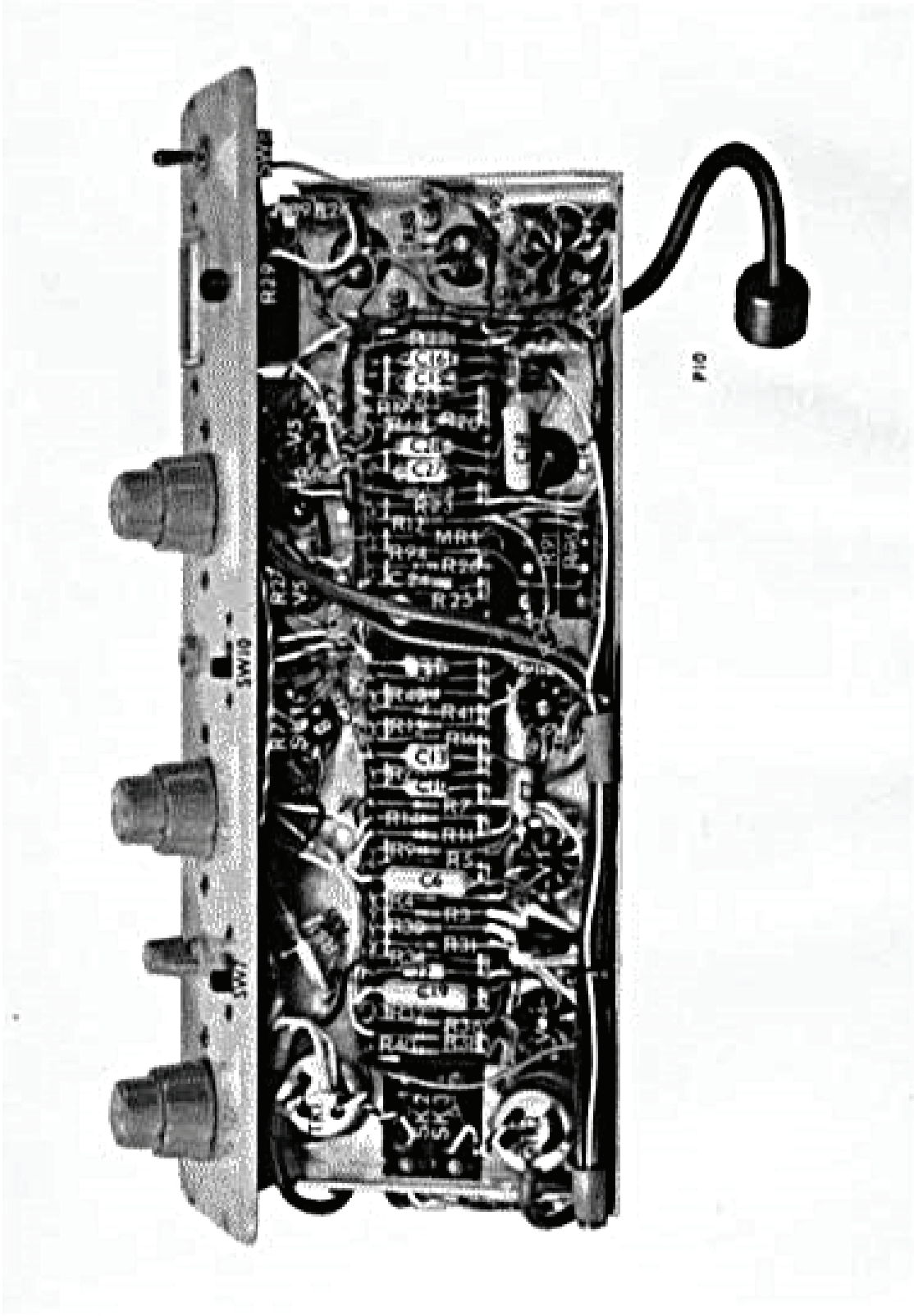


FIG. 12. RECORD AMPLIFIER CHASSIS UNDERSIDE VIEW

The lower track erase supply goes again via SK6 and P6 and deck tag E to one end of the winding, then from the other via deck tag 7 pin 3 on SK8 and P8 to a section on SW9 where it is connected to chassis on every switch position except upper track record.

11.4. Record amplifiers

The two record pre-amplifiers are situated on the front amplifier chassis, *i.e.* below the control panel, and they are of identical construction for upper and lower tracks.

Referring again to the circuit diagram and dealing with the upper track record pre-amplifier, jack JK1 (or input 1) is connected directly to the grid of one triode section of V1 and has an impedance of 1 megohm.

The first triode section of V1a is RC coupled to the second section V1b via C6 and the input 1 gain control R10. R11 prevents the grid of V1b being at chassis potential when R10 is in its minimum position, and R14 performs the same function with respect to the input 2 gain control R13, which is also connected to the grid of V1b. This ensures that signals into inputs 1 or 2 are virtually unaffected (maximum variation 2 db) by the relative positions of the gain controls, wherever these may be. R8 and C10 from the anode of V2a to the cathode of V1b provide approximately 3 dB of bass boost, and the anode load of V2a is in two parts R15 and R16. This is to provide a tap to feed a certain amount of the signal via C9 into the grid of the playback pre-amplifier output valve for the purpose of comparison with the signal off the tape (tape /original switch).

The H.T. supply to V2a and the corresponding lower track valve V2b is decoupled via R12 and C8.

From the anode of V2a the signal passes to the recording output valve V3a and also via the meter switch to the meter valve V5. Treble boost during recording is provided by the resonant circuit L2, C16 across the cathode resistors of V3a. This is changed by a switch to a different value for each tape speed. The signal is conducted to the head via C14 and SK4. From P4 the signal is led via a section of the main function switch to the upper track section of the record head X5.

11.5. Meter circuit

Considering the meter circuit, the signal arrives, via R25 and C24, at the grid of the first section of V5 which is connected as a cathode follower to provide a low impedance source for charging C18. R25 is included so that, in conjunction with R26, the meter sensitivity can be set correctly. From the cathode of V5a the signal is rectified by MR1 and charges the reservoir capacitor C18, the resultant voltage (negative with respect to chassis) being applied to the grid of V5b. The peak level meter proper M1 is a 1mA DC full scale deflection backward reading milliameter *i.e.* the pointer is at the right hand side

for zero current and deflects from right to left. V5b is cathode biased by the resistor network R24, R29 and R89 so that at zero signal input 1 mA is passed through M1, and the pointer deflects full scale which is marked as zero. Exact adjustment to this zero mark can be made by R29, the meter zero potentiometer on the front panel. The arrival of a signal at the input to V5 causes a negative voltage to appear at V5b grid, reduces the anode current and deflects the meter pointer. An advantage of this method is that the meter cannot be damaged by an excessive signal as the effect is to reduce the current through it to zero for apparent full scale. The meter scale, although having 10 arbitary divisions, is substantially linear from zero to nine, and "8", designated additionally by a triangle, corresponds to peak recording level. The meter is illuminated by two miniature bulbs which also serve as an indication that the equipment is switched on, the meter itself however only operates on the "record" position of the main switch, this is done by switching its HT supply on at the same time as that for the oscillator.

11.6. Playback pre-amplifiers

As both playback pre-amplifiers are of identical construction, the following description of the upper track will serve for both.

The signal from the monitoring head X6 arrives via P2 and SK2 at the primary of the input transformer TR1, the secondary of which is connected to the grid of the first section of the double triode V6. This triode section is RC coupled (R50, C32 and R53) to the other, and between the two is the playback equalisation network. This works on the negative feedback principle *i.e.* part of the signal is fed back over C33, R54, R92 and R52 to the cathode resistor R49 of the first triode.

A section of SW6 is used to vary the resistance in the feedback line to compensate for the different recording characteristics of each tape speed.

Using the cathode of V6a tapped into the junction of R51 and R49 provides adequate bias with a moderate value of R49.

It may be noted at this point that there is a minor difference in the upper and lower track amplifiers in that the latter has an extra capacitor C55, this is a compensating feature for the extra capacitance of longer screened leads (due to the different location of each amplifier).

The series resistors R1 and R74 between the cathodes of V6a and V8a are for the purpose of cancelling spurious induced signals between the sections of the stereo monitor head (crosstalk reduction).

Following again the path of the equalised signal in the upper track playback pre-amplifier, it passes through C34, and if SW7 is in the "tape" position, to the playback gain control R56. From there it goes to the grid of the cathode follower output triode V7a (half of V7). The actual output is taken from the cathode resistor R59 through C35 to the output jack.

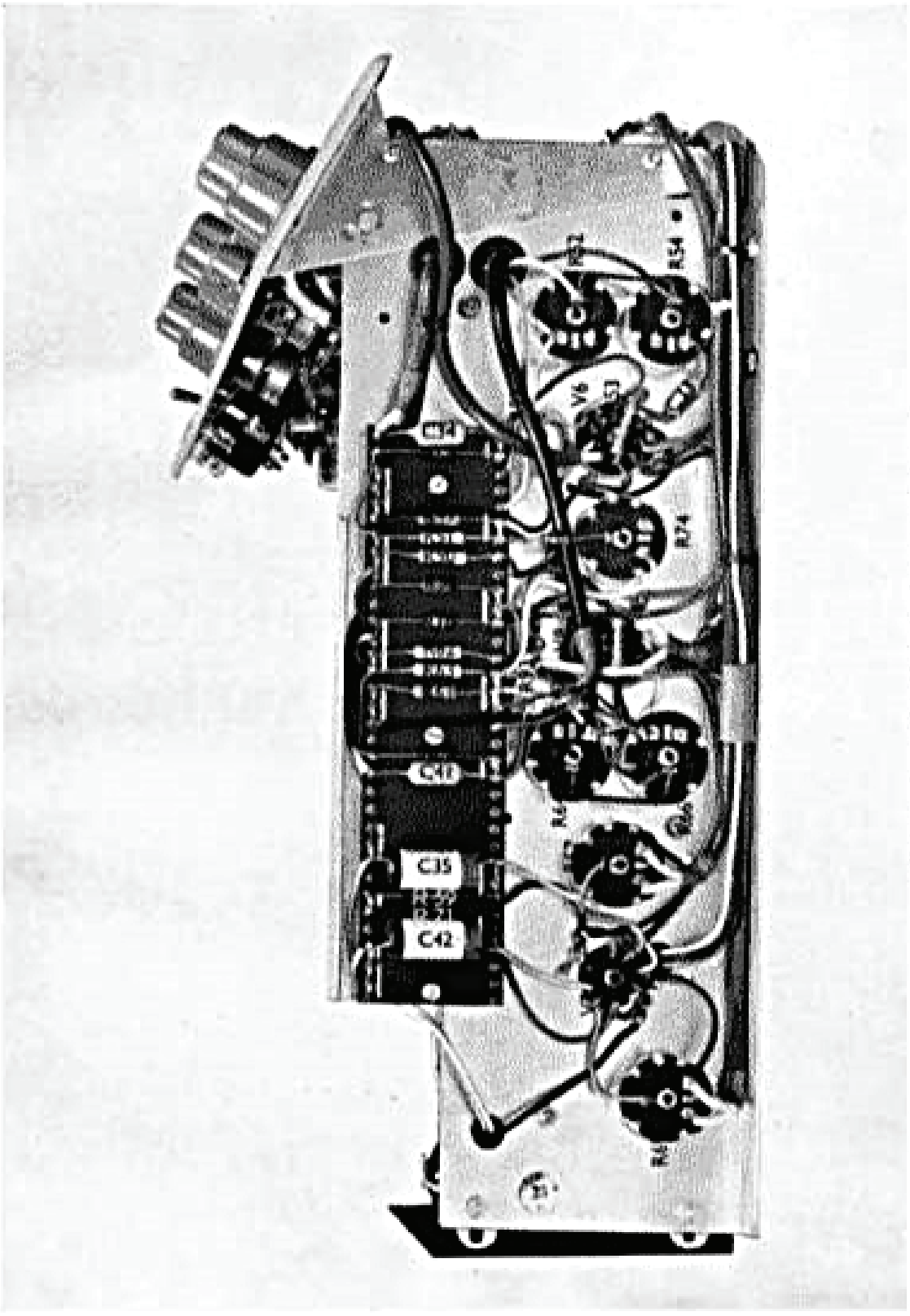


FIG. 13. PLAYBACK PRE-AMPLIFIERS UNDERSIDE VIEW

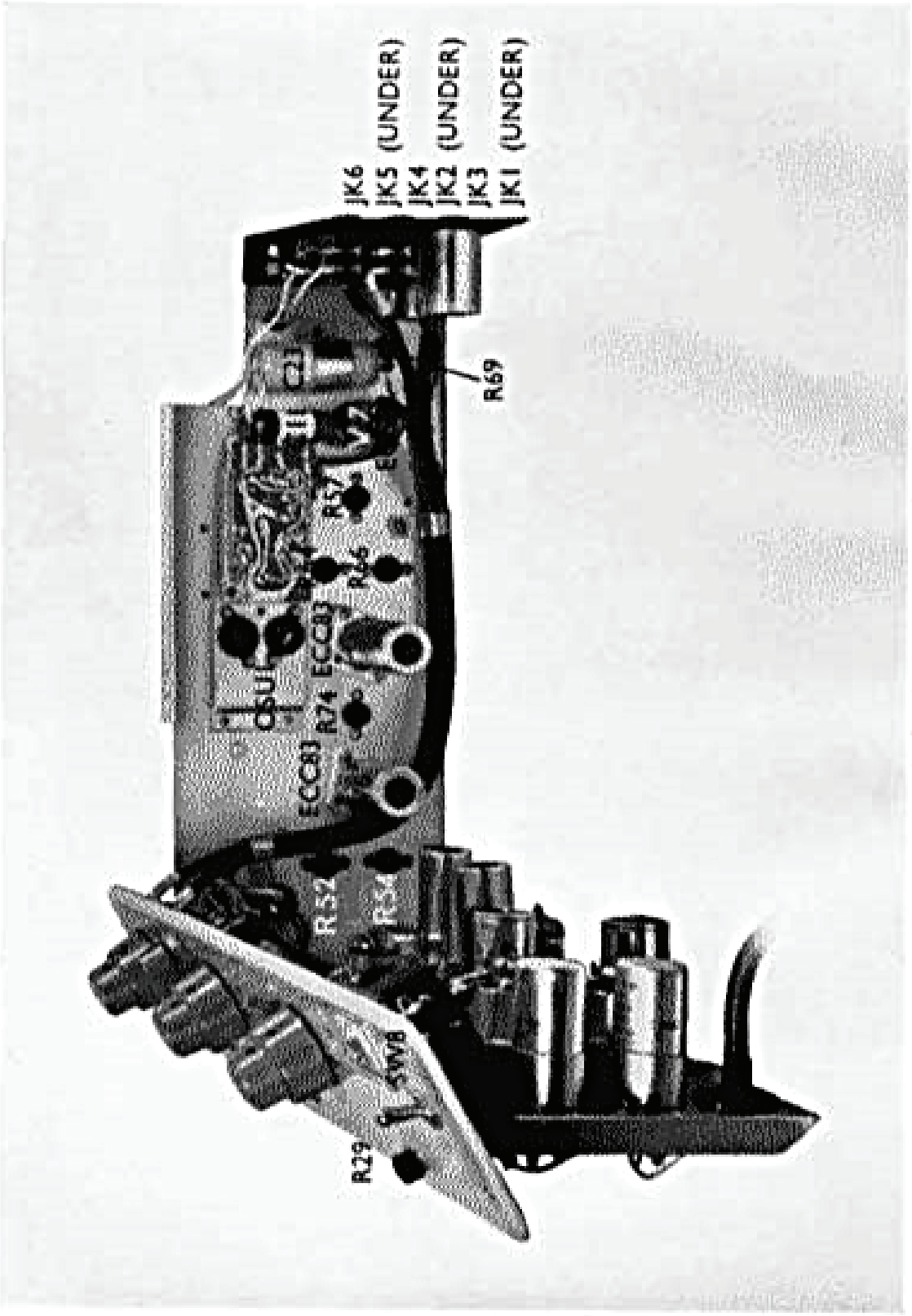


FIG. 14. PLAYBACK PRE-AMPLIFIER1 TOP VIEW

The internal 3 ohm loudspeaker is fed via C11 from the transformerless output stage of the miniature transistorised amplifier (OSU1) which is entirely self contained and normally has its input connected to both tracks. However, inserting a jack plug into each of the output jacks on the rear panel will automatically disconnect that particular track. The amplifier is powered from the negative 12 Volt supply, smoothed by C23, and will provide approximately 1 Watt output from a full depth recording. Under no circumstances should the output be shorted while the recorder is switched on.

12. TESTING AND ALIGNMENT

Where a major component has been replaced it may be necessary to carry out certain re-alignment of the pre-amplifier networks. This section is consequently included for the benefit of the Service Engineer. It details the whole testing and setting procedure.

It cannot be too strongly emphasised however that indiscriminate readjustments should not be made against these instructions without cause, as prior to leaving the factory the "Ferrograph" will have been carefully set up with a great deal of specialised equipment. The fact that there may be slight discrepancies between the readings obtained and those shown below does not mean that adjustments are necessarily called for.

Removal of Amplifier from Cabinet

This involves prising off the metal cover of the handle hinge on the front of the cabinet and removing the four screws and handle complete. The four screws at each corner of the amplifier panel should be undone, and also the two screws on each side of the case holding the cross strap behind this panel. The two deck holding bolts should be loosened and the deck raised, when the two screws and spacers holding the input panel to the aperture frame at the rear of the cabinet should be removed. The mechanical linkage between the track selector knob on the panel and the actual switch on the power unit should be removed by loosening the upper grub screw (4BA) on the collar near the switch and removing the knob and spindle. The amplifier and cross strap can now be moved. The clip holding the lead to the power unit should be loosened and the amplifier undersides can be exposed. To remove it entirely from the cabinet the various connections should be unplugged and the lead to the internal loudspeaker unsoldered.

To refit, the parts should be replaced in reverse order, but the screws should not be tightened until those holding the carrying handle and amplifier have been secured, and the record switch spindle should be reconnected last of all.

12.1. Voltages

AC Heater Voltage (P10 on circuit diagram between Pins 2 & 7) .. 19V RMS

DC Heater Voltage (P10 on circuit diagram between Pins 3 & 7) .. 12·6V

DC Voltage across Tape Deck Solenoid .. .. .. 6·4V

DC Voltages Associated with Valves (Record position)

Valve No.	Anode 1 (Pin 1)	Anode 2 (Pin 6)	Cathode 1 (Pin 3)	Cathode 2 (Pin 8)
V1	84	137	0·6	1·1
V2	130	130	1·1	1·1
V3	136	136	32	32
V4	137	84	1·1	0·6
V5	290	290	2·7	4
V6	85	100	—	1·1
V7	245	245	11	11
V8	100	85	1·1	—

AC Voltages

245V or 110V applied at relevent frequency. Measured on the appropriate AC range of an Avometer model "8" 1000 ohms /volt.

PLAYBACK OR RECORD	632U 634U 245V 50c /s.	632A 634A 117V 60c /s.	632E 634E 110V 50c /s.
Voltage across capstan motor capacitor ..	520V	300V	220V
Voltage across capstan motor input socket ..	245V	117V	110V
Voltage across take up motor input socket ..	150V	80V	80V
Voltage across rewind motor input socket ..	100V	47V	47V

Measured with a valve voltmeter

68 kc/s bias volts, measured at pins of record head X5 .. 14 - 20V RMS

NOTE : Rear Two Pins for Upper Track (UT)
Front Two Pins for Lower Track (LT)

The correct values for the head will be found on a small label on the underside of the deck, generally at the centre left edge.

68 kc/s erase volts, on each erase head section (pin connections the same as the record head) .. 27 - 30V RMS.

12.2. Gain and amplifier equalisation

As the gain of the playback pre-amplifiers varies considerably with frequency (due to equalisation) and only 1 volt is available at the output jacks, it is recommended that simple resistive attenuators of 100:1 and 1000:1 be used for the various inputs and at different frequencies. The first could consist of 100 K ohms and 1 K ohms and the second of 1 M ohms and 1 K ohms resistors.

With these attenuators, 1·0 volts can be applied across them from the audio oscillator and provided the correct attenuator is used, the output will be of the same order, this can be seen more clearly in the following table.

The tests should be done with all gain controls on the front panel fully clockwise, and to carry out the first it will be necessary to prop open the deck and to lift up the amplifier to expose the underside (see Section 12).

This is necessary since the input impedances of TR1 and TR2 are extremely low and it is more convenient to measure the gain of the playback amplifier from the secondary windings of these transformers instead of the more accessible head sockets.

Pre-Amp	Attenuator	Input Point	Frequency	Gain	Position of Switch 4 (Fig. 3)
Playback	1000 : 1	Grid of V6a or V8a	40 c/s	1000	Tape
Playback	100 : 1	Grid of V6a or V8a	1000 c/s	100	Tape
Playback	100 : 1	Grid of V6a or V8a	15 kc/s	40	Tape
Record	1000 : 1	Input 1 Jack	1000 c/s	440	Original
Record	100 : 1	Input 2 Jack	1000 c/s	22	Original

The above will check the recording amplifier up to the last stage, if this is suspect, the output voltage can be measured at the head sockets SK4 or SK5 with the head leads unplugged. To do this, inject a 1000 c/s signal into input 2 and advance the gain control to register "8" on the peak level meter. 6 volts should then be present at the head socket. At 15 kc/s, with switch 3 (Fig. 2) on 7·5, this voltage will rise to roughly 20, whilst on 3·75 at 10 Kc/s it should be 25.

When the head is plugged in, the voltage developed at the head socket will drop to 60mV, although then the oscillator valve will have to be removed to prevent bias volts masking the reading.

All the above figures, including those in the table, are average values and the readings obtained on individual instruments may vary somewhat from them, this applies in particular to the playback amplifier where the gain is dependent upon the setting of the equalisation controls.

The following tests apply to both the 632 and 634 models, but in the latter case the playback head should be in the "up" position for all of them.

12.3. Head alignment

Before leaving the factory the gaps of both the record and playback stereo heads are set exactly at right angles to the tape. This alignment is done by means of a master tape and, as explained in the technical description, is vital both for the high frequency performance of the instrument itself, and to ensure that its recordings will be fully interchangeable with those made on other instruments.

For these reasons, the azimuth settings of the record and playback heads should not be interfered with under normal circumstances, but in cases where some derangement has occurred, the re-alignment will require a test tape carrying a constant level recording of a high audio frequency *e.g.*, 10 kc/s at 7·5 in/sec.

This should be played back using the upper track amplifier and the playback head azimuth screw (Fig. 2) adjusted to give a maximum output, which can conveniently be indicated on an AC voltmeter across the output jack. To adjust the record head azimuth, remove the test tape and substitute a reel of standard recording tape. Inject a 10 kc/s signal into input 1 or 2 and turn to RECORD. Set the recording level to HALF THE FIRST DIVISION on the meter and run the tape at 7·5 in/sec. Now adjust the record head azimuth by means of the front right hand screw in the head base plate until a maximum output is obtained from the playback head.

12.4. Recording level

The peak recording level corresponds to the maximum signal which can be applied to the recording head network for a given amount of distortion on playback. On these models this level will be set so as to produce not more than 3% total distortion on peaks. The process is as follows :—

Turn to RECORD, then with all record gain controls fully anticlockwise, adjust the recording level meter accurately to zero and inject a source of 1000 c/s into input 2 upper track at a level of approximately 50 mV. Connect a wave analyser or distortion meter to the upper track output jack and advance the upper track input 2 record gain control until the recording level meter reads 8. Run the tape at 7·5 in/sec., adjust the playback gain control and measure the total distortion ; it should be between 2·5 and 3%. If it is not, vary the recording level to obtain the correct figure, this will then give a reading other than 8 on the meter, and it will be necessary to re-adjust the latter to 8. This may be done by changing the value of the resistor R26 (circuit diagram, Fig. 17).

The same check may be applied to the lower track channel in a similar way but of course the meter cannot be altered again if there is any discrepancy in the record level/distortion relationship, however this is extremely unlikely.

Where a distortion meter is not available, some idea of the total distortion can be obtained by applying the output to the Y plates of an oscilloscope, at the same time connecting the X plates direct to the output of the audio oscillator.

Because of phase differences, an ellipse can be obtained on the screen of the cathode ray tube and the regularity of this ellipse used to give an indication of the distortion present. Some experience is normally necessary to relate 3% distortion to the modified shape of the ellipse, so that it is not possible to give definite guidance beyond stating that the ellipse should only be slightly distorted on the "major axis" parts of the curve.

12.5. Bias checking

If the record head has been replaced or, if after very long use it is suspected that the head requires a different value of bias, a test for optimum bias may be instituted as follows:

Unscrew the tape deck holding down screws, hinge it back so that the two bias potentiometers on the power and oscillator unit are readily accessible and prop it up in this position. Dealing first with the upper track, connect a valve voltmeter across the two rear pins of the stereo record head and an AC voltmeter to the playback output jack or the output of an amplifier connected to the same.

Turn to RECORD and, with the record gain controls fully anticlockwise, align the meter needle accurately on zero by means of the zero set control. Inject a constant 200 c/s tone at a level of roughly half a volt into input 2 and advance the corresponding gain control to give a level of 6 on the meter. Run the tape at 7·5 in/sec. and adjust the playback gain to give a convenient reading on the AC voltmeter. Now vary R80 to obtain a maximum output, all other parameters remaining fixed. The value of bias read on the valve voltmeter at this setting of R80 may be taken as the optimum for the upper track channel and the particular tape in use.

The procedure may be repeated for the lower track, plugging into the corresponding inputs and outputs and connecting the valve voltmeter to the two front pins of the stereo record head. Adjust R87 (Figs. 9 and 10) for the lower track bias.

Having fixed the bias voltages, the oscillator load equalising resistor R86 should now be set. This is done by varying R86 to keep the bias voltage constant when SW9 (knob 7 in Fig. 3) is moved from "stereo" to "upper" in the case of the upper track or "stereo" to "lower" in the lower track bias case (see important note, Page 15).

Note :—In cases where the bias is changed appreciably from the original settings, it will be necessary to re-check the frequency response curve obtained with the instrument's own recording. Due to the small variation in bias requirements on the majority of tapes available, it should not in general be necessary to re-adjust the bias when different makes are used.

12.6. Frequency Response

An A.C. voltmeter with a level response between 30 and 20,000 c/s e.g. valve-voltmeter, should be connected across the appropriate output jack. If an instrument sufficiently sensitive to read the small voltages involved (¼ Volt) is not available, an external amplifier with a linear frequency response can also be used. The following description applies to the upper track, the references in brackets being for the lower track. Switch 4 should be at TAPE throughout.

At 7·5 in/sec, playback a CCIR, 70μ sec test tape (FER 100) and advance knob 9 (10) to give a convenient reading on the meter at 1000 c/s as a reference level. Adjust R54 (R66) so that the same reading is obtained at 10 Kc/s, when all frequencies on the test tape should be within ± 3 dB of the 1000 c/s reference level.

To check the overall record/playback frequency response at 7·5 in/sec, feed an audio signal generator with a constant level output into input 2 and turn to record. Adjust knob 1 (2) to give a recording level on a 1000 c/s note at HALF THE FIRST DIVISION on the meter scale *i.e.* very low level. Start the tape running and adjust the output to give a convenient reading on the output meter. Now record a series of tones at different frequencies between 30 and 15,000 c/s and note the corresponding output meter readings. These should all be within ± 3 dB of the reference level. If necessary some adjustment may be made to the high frequency response by varying the pre-emphasis, which is effected by changing the value of C16 (C28) over a small range.

At 3·75 in/sec, the overall frequency response can be checked in the same way as for 7·5 in/sec above except that the middle frequencies are adjusted by R52 (R64) and the high frequency pre-emphasis by altering the value of C15 (C27) slightly. The response should be 40-10,000 c/s ± 3 dB.

At 1·875 in/sec, adjustment to the middle frequencies is not generally needed, but if necessary the value of R92 (R93) could be altered slightly. A small adjustment to the high frequency pre-amphasis can be effected by varying C57 (C58). The response should be 50-5,000 c/s within 8 dB.

12.7. Crosstalk

This term relates to the amount of the signal on one track which is picked up by stray coupling, etc., on the other. It varies, dependent upon whether both channels are recorded together or one at a time, being greater in the former instance. Because the order of the crosstalk is between 1/100 and 1/1000 of the signal recorded on the other track and in the latter (monophonic) instance can be comparable in level with background noise, some ancillary equipment is necessary for its measurement.

In addition to the usual external amplifier, a calibrated attenuator up to 80 db and a bandpass filter to eliminate hum and h.f. hiss are recommended and they should be connected between the playback output and a suitable AC meter.

To measure the crosstalk with SW9 (7 in Fig. 3) in the stereo position, record a 400 c/s. tone at peak level on the upper track at 7·5 in/sec. With the attenuator set to give 60 dB loss, adjust the gain control to give a convenient reading on the meter, and leave it set in that position.

Now invert and transpose the tape reels to bring the signal on to the lower track. Turn the main function switch to PLAYBACK and run the tape. Switch the attenuator to obtain the same meter readings as before, when the difference in the attenuator readings should be approximately 40 dB.

For crosstalk in the single track application, turn SW9 to "upper" and proceed exactly as before except that the initial setting of the attenuator should be 80 dB. The end result should be a figure of > 65 dB.

If the crosstalk is worse than the stated figure, the setting of R74 should be checked by playing back with the deck propped up and adjusting for minimum breakthrough from the lower track to the upper.

Also, if either of the heads has to be changed, or the original assembly altered in any way, the height setting of the heads should be checked to ensure that they are accurately aligned. With the model 632 approximately 0·010" of the upper and lower track laminations should be visible above and below the top and bottom edges of the tape respectively *i.e.*, the tape should be centrally disposed on both heads. This is most easily checked by pulling back the relevant pressure arm with the fingers whilst the tape is running. With the Model 634, the playback head should be raised to the "up" position by moving the lever backwards, when the top edges of the laminations on the record and playback heads should be level with the top edge of the tape.

To adjust the record head height, slacken the locknuts holding the 6 BA grub screws at the rear and front centre of the head, and adjust the height using a 6 BA Allen key. Now tighten the nuts to clamp the grub-screws.

To adjust the playback head on the Model 634, slacken the nut locking the 2 BA grub screw at the front left corner of the diecast mounting underneath the deck. At its other end this screw has an eccentrically mounted pin which locates in a slot in the brass sleeve to which the head is fixed. Rotate this screw (usually about ¼ turn is sufficient) till the head is at its maximum height, when the top edge of the laminations should be at least 0·010" above the top edge of the tape. Turn the grub screw until the pin contacts the bottom of its slot and continue to turn until the top of the laminations is level with the top edge of the tape. Tighten the locknut to fix the screw in this position.

On the Model 632, the screw fixing the clamp behind the head height lever should be slackened and the head moved to the correct height using this lever. Now fix the clamp so that it is resting against the lever. Unlock the 2 BA grub screw under the deck and rotate it until the pin is contacting the edge of its slot and is preventing the head height lever from moving. Tighten the 2 BA grub screw in position so that the lever is held firmly.

After any adjustment to the record and playback heads, it is necessary to check the gap alignment as described in Section 12.3., and also to check that the pressure pad is contacting the working face of the head so as to ensure intimate contact with the tape.

12.8. Signal to noise ratio

The unweighted signal to noise ratio quoted in the specification is the ratio of the RMS noise from the erased tape plus the hum content, compared with the RMS signal output from a fully recorded tape playing back at 3% distortion.

To measure it, the same ancillary equipment used in the crosstalk test can be employed except for the filter, which is omitted. Record a 1000 c/s. tone at peak level on the upper track at 7·5 in/sec. With the gain control fully clockwise and 60 dB of attenuation, adjust the gain of the external amplifier to obtain a convenient meter reading. Reduce the record gain to zero and adjust the attenuator for the same meter reading as before, the difference should be 52 dB or greater.

The principal factors affecting the signal/noise ratio are hum and high frequency noise. If the latter appears excessive, de-polarising the record and playback heads with a suitable head demagnetiser should be tried first. Valves and anode and cathode resistors in the low level stages which have deteriorated are other possible causes.

The position of the mumetal "wing" on the end of the playback head pressure arm is of vital importance to a low hum level and normally it should not be disturbed. If occasion demands however, the 8BA clamping screw can be loosened slightly and the angle of the "wing" adjusted for minimum hum with the motors running. The only precaution necessary in adjusting this is to ensure that the pressure pad contact area is not adversely affected.

Another source of hum may arise in connecting up, if two mains "earths" are used (see Para. 1) and care should also be taken to maintain a respectable distance between the instrument, especially the left hand side where the playback pre-amplifiers are located, and any large power transformers or chokes which may be associated with external amplifiers, test equipment, etc.

When switching on the motors there should not be too great a difference between the hum reading then obtained and that with the motors stopped as this would indicate that hum bucking is taking place *i.e.*, that some hum was being injected in anti-phase to that arising from some other part of the equipment. The object should be to align everything for minimum pick-up and in cases where a motor has been changed, reversing the mains input sockets on individual motors can be tried.

12.9. Wow and flutter

The only reliable method of checking "wow" and "flutter" is by instruments specially designed for the purpose. These fall broadly into two categories, one where the "wow" and "flutter" components are read together or separately on meters as an RMS "wow"

and "flutter" factor, and the other whereby the frequency modulation component on the recorded carrier is fed after discrimination to a high speed pen recorder which indicates both the peak "wow" and "flutter" factor and its nature and frequency. In the absence of a suitable measuring instrument, a rough guide can be obtained by using an oscilloscope connected to the output as described in Section 12.4 RECORDING LEVEL.

If a 1000 c/s. note is recorded and monitored, the rate and degree to which the axis of the ellipse changes should be observed, thereby indicating the instantaneous phase differences between the stable signal from the audio oscillator and the fluctuating signal from the tape. Some "wow" and "flutter" is of course inevitable ; it is, as with distortion, once again a matter of estimating the degree, and here it should be emphasized that even the extremely low figure of 0·1% can be clearly distinguished on a 1000 c/s. constant tone, whereas it would be virtually impossible to detect in music reproduction.

The causes of "wow" and "flutter" are many and various and any of the components in the tape transport mechanism can contribute to it. Beyond keeping the capstan and pinch roller driving surfaces clean, or changing a worn pinch roller or neoprene idler wheel in the field, its proper rectification is a task for the manufacturer, or an officially appointed agent with full servicing facilities.

FERROGRAPH MODELS 632H AND 634H

These are the same as the models 632 and 634 respectively except that they operate at tape speeds of 15, 7½ and 3¾ in/sec and are equalised to the CCIR characteristic (35 μ sec at 15 ; 100 μ sec at 7·5). In general the manual for the model 632 will apply except as outlined below. However, when starting the tape running at 15 in/sec it is necessary to hold the start knob on manually until the auto stop arm has ceased to oscillate. This also applies when releasing the pause control at this speed.

11.1 The Mechanical Unit

While the description still applies, the capstan motor has a special pulley and is fitted on a modified assembly. The idler wheel carriers are MP/4180B (15 in/sec, 50 c/s) or MP/4180D (15 in/sec, 60 c/s), MP/4180A (7½ in/sec) and MP/4180C (3¾ in/sec). The flywheel is MC/4178.

12.6. Frequency Response

At 15 in/sec, playback a CCIR, 35 μ sec test tape and advance knob 9 (10) to give a convenient reading on the meter at 1,000 c/s as a reference level. Adjust R54 (R66) so that the same reading is obtained at 15 Kc/s, when all frequencies on the test tape should be within ± 3 db of the 1,000 c/s reference level.

To check the overall record/playback frequency response at 15 in/sec, feed an audio signal generator with a constant level output into input 2 and turn to record. Adjust knob 1 (2) to give a recording level on a 1,000 c/s note at HALF THE FIRST DIVISION on the meter scale *i.e.* very low level. Start the tape running and adjust the output to give a convenient reading on the output meter. Now record a series of tones at different frequencies between 30 and 18,000 c/s and note the corresponding output meter readings. These should all be within ± 3 dB of the reference level. If necessary some adjustment may be made to the high frequency response by varying the pre-emphasis, which is effected by changing the value of C16 (C28) over a small range.

At 7·5 in/sec, playback a CCIR, 100 μ sec test tape and adjust R52 (R64) to give the same reading at 10 Kc/s as at 1,000 c/s. The overall response should be checked as for 15 in/sec above and if necessary the high frequency pre-emphasis varied by altering the value of C15 (C27). The response should be 30-15,000 c/s ± 3 dB.

At 3·75 in/sec, adjustment to the middle frequencies is not generally needed, but if necessary the value of R92 (R93) could be altered slightly. A small adjustment to the high frequency pre-emphasis can be effected by varying C57 (C58). The response should be 40-10,000 c/s ± 3 dB.

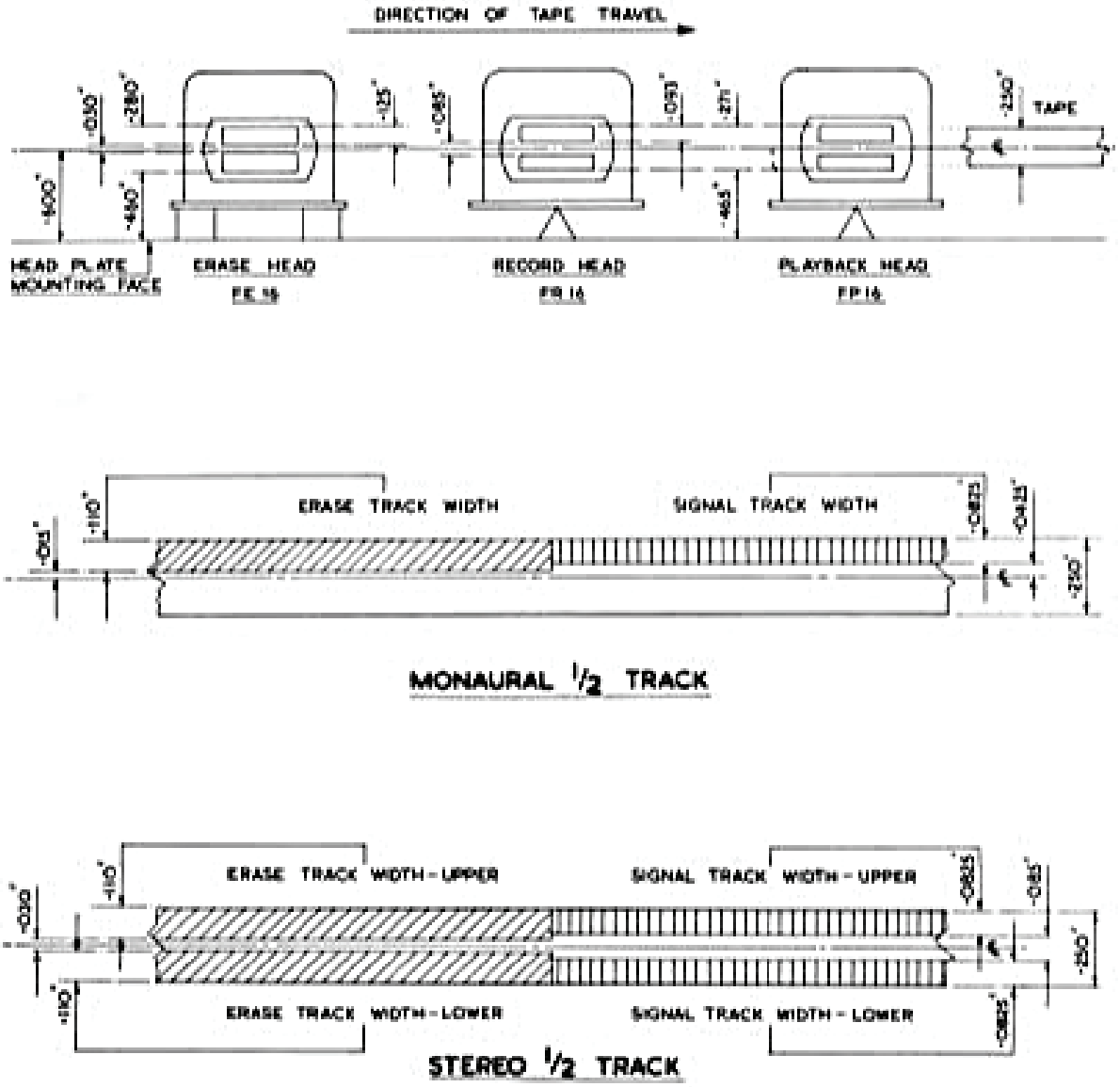
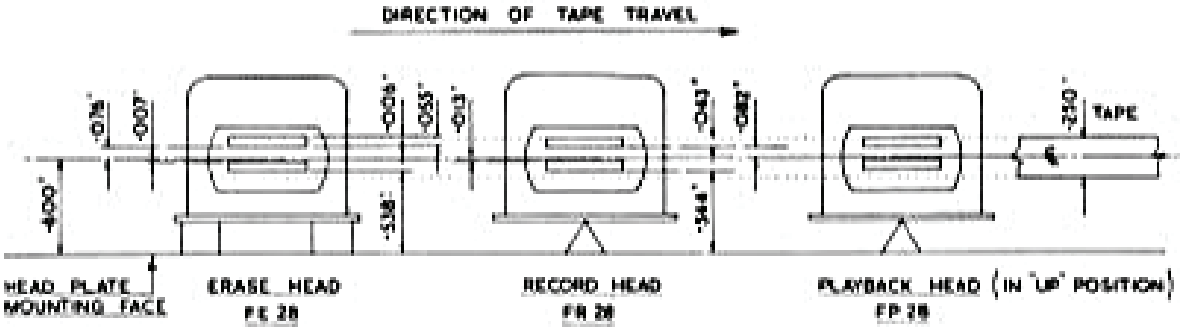
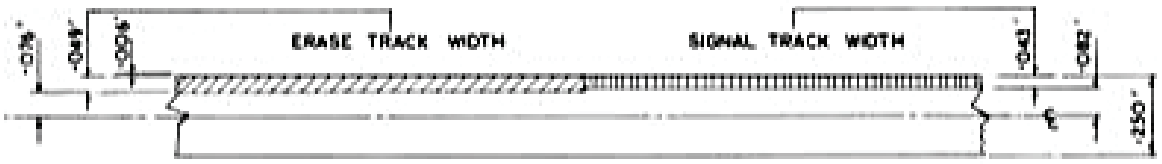
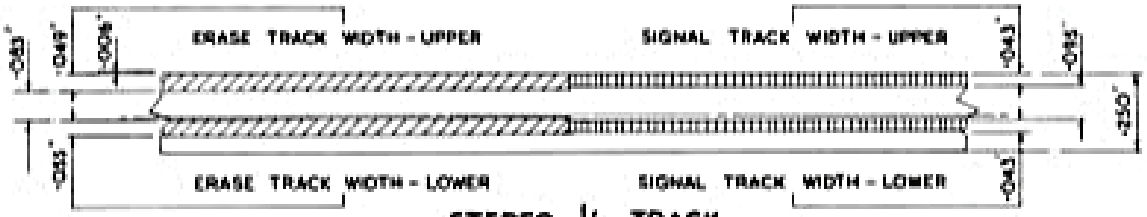


FIG. 13. HEAD AND TRACK ARRANGEMENT, MODEL 612

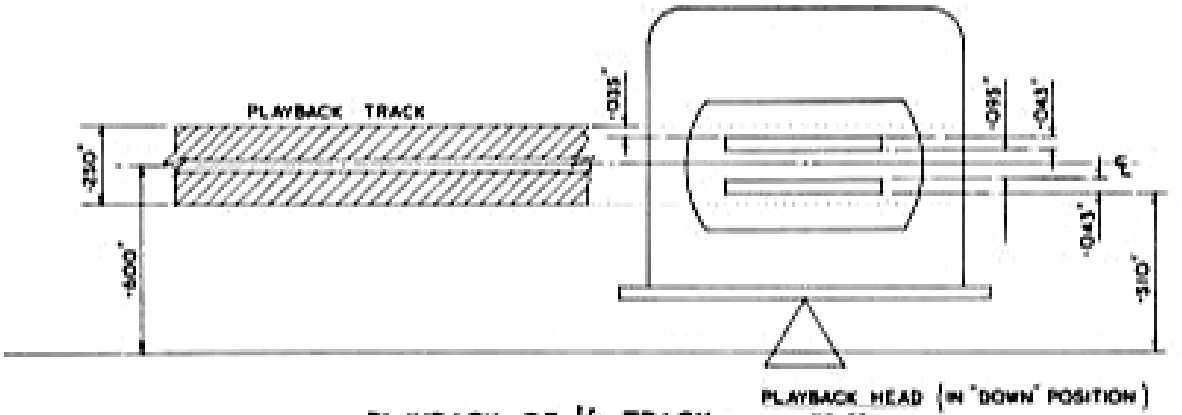




MONAURAL 1/4 TRACK



STEREO 1/4 TRACK



PLAYBACK OF 1/2 TRACK PRERECORDED TAPES

FIG. 14. HEAD AND TRACK ARRANGEMENT, MODEL 634

APPENDIX A

OPERATIONAL FAULT ANALYSIS

FAULT	POSSIBLE OPERATIONAL CAUSE
1. Instrument will not start No meter illumination.	Fuse blown (see Fig. 1). Mains lead or plug faulty. Mains Selector knob loose or missing.
2. Motors start but starting switch will not lock in.	Tape not supporting auto stop arm; check loading (Fig. 2). Setting of amplifier equalisation switch different to that of deck speed selector knob.
3. Tape slips or "wows".	Dirty capstan or accumulation of tape deposit on pinch roller. Pinch roller spindle dirty. Bad splice in tape sticking in guides or heads. Tape catching on reel cheeks due to incorrect adjustment of bobbin guides. Oil or grease on idler rim.
4. Known, well recorded tape will not play back but tape drives.	Panel switch on "original". Tape incorrectly positioned in head section Piece of splicing tape detached and left over playback head face. Correct gain control not advanced. Output jack in other track socket.
5. Tape plays back with poor frequency response.	Accumulation of foreign matter or tape coating over playback head gap. Playback and record head gaps not in line. (Check record head before adjusting).
6. Pre-recorded quarter track tape appears to play backwards.	Playback head in "down" position. (Head height lever forward). Applies to model 634 only.
7. Pre-recorded half track stereo tape plays with reduced output on the lower track.	Playback head in "up" position. Applies to model 634 only.

Appendix A—*continued*

FAULT	POSSIBLE OPERATIONAL CAUSE
8. In recording position tape erases but will not record.	Input plug not properly inserted or in wrong socket. Appropriate gain control not advanced. Microphone cable faulty.
9. Will not record or erase.	Track selector switch (7 in Fig. 3) incorrectly set for track in use.
10. Records, but incompletely erases previous recording.	Adhesions of coating, etc., over erase head gap or pieces of splicing material stuck to working face.
11. Records weakly.	Tape coating outside instead of inside.
12. Hum recorded on tape. (Check by changing playback speed, if hum is recorded, its frequency will be changed).	Microphone in hum field (also matching unit). Microphone transformers or leads insufficiently screened or too long if a crystal microphone is being used. Microphone leads or stand not properly earthed to microphone or in contact with mains leakage paths.
13. A short whistle is recorded at the end of the passage.	Winding back is commenced too quickly after recording *i.e.* pause momentarily (1 sec.) after turning to wind back before running the tape.
14. Tape runs at one speed but not at the other.	Idler carrier spring broken. Idler wheel circlip missing and wheel has "run off".
15. Tape slows up or stops on Wind back or Wind on.	Reel motor bearing out of alignment making spindle tight. Push reel carriers sideways from various directions until they can be spun freely by hand with the brakes off.

Appendix A—*continued*

FAULT	POSSIBLE OPERATIONAL CAUSE
16. Take-up reel carrier appears to run hot, especially compared to wind-back motor.	It is normal for the take-up reel carrier to feel hot to the touch. Because the wind-back motor runs at a lower voltage, the effect is less with it.
17. Tape winds unevenly especially on wind on or wind back.	"Bobbin" guides incorrectly set for height. Tape in use has stretched non-uniformly and is concave or wavy, leading to odd layers piling on at different height.

APPENDIX B

COMPONENTS LIST FOR MODELS 632U AND 634U (240V, 50 c/s)

CIRCUIT REF.	VALUE	RATING	TOL.	DISCRIPTION	PART NOS.
R1	220K Ω	½w	5%	Carbon	BP/2919/R
R2	1·2K Ω	27w		Vitreous Enamel	BP/2819/R
R3	1M Ω	½w	20%	Carbon	BP/2863/R
R4	1·5K Ω	½w	5%	High Stability	BP/2823/R
R5	100K Ω	½w	5%	High Stability	BP/2850/R
R6	1M Ω	½w	20%	Carbon	BP/2863/R
R7	1K Ω	½w	5%	Carbon	BP/2908/R
R8	270K Ω	½w	5%	Carbon	BP/2855/R
R9	220K Ω	½w	5%	Carbon	BP/2919/R
R10	250K Ω			Dual Carbon Pot. (with R37)	BP/2436/P
R11	150K Ω	½w	5%	Carbon	BP/2853/R
R12	8·2K Ω	½w	5%	Carbon	BP/2838/R
R13	500K Ω			Dual Carbon Pot. (with R39)	BP/2438/P
R14	150K Ω	½w	5%	Carbon	BP/2853/R
R15	100K Ω	½w	20%	Carbon	BP/2852/R
R16	47K Ω	½w	20%	Carbon	BP/2849/R
R18	1·8K Ω	½w	5%	Carbon	BP/2937/R
R19	1M Ω	½w	20%	Carbon	BP/2863/R
R20	8·2K Ω	½w	5%	Carbon	BP/2838/R
R21	1K Ω	½w	5%	Carbon	BP/2908/R
R22	22K Ω	1w	10%	Carbon	BP/2918/R
R23	4·7K Ω	½w	10%	Carbon	BP/2831/R
R24	100K Ω	1w	20%	Carbon	BP/2886/R
R25	1M Ω	½w	20%	Carbon	BP/2863/R
R26	*1M Ω			Selected at Works	
R27	47K Ω	½w	20%	Carbon	BP/2849/R
R28	10M Ω	½w	20%	Carbon	BP/2866/R
R29	1K Ω			Carbon Pot.	BP/2439/P
R30	1M Ω	½w	20%	Carbon	BP/2863/R
R31	1·5K Ω	½w	5%	High Stability	BP/2823/R
R32	100K Ω	½w	5%	High Stability	BP/2850/R
R33	1M Ω	½w	20%	Carbon	BP/2863/R
R34	1K Ω	½w	5%	Carbon	BP/2908/R
R35	270K Ω	½w	5%	Carbon	BP/2855/R
R36	220K Ω	½w	5%	Carbon	BP/2919/R

Appendix B—*continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NOS.
R37	250K Ω			Dual Carbon Pot. (with R10)	BP/2436/P
R38	150K Ω	½w	5%	Carbon	BP/2853/R
R39	500K Ω			Dual Carbon Pot. (with R13)	BP/2438/P
R40	150K Ω	½w	5%	Carbon	BP/2853/R
R41	100K Ω	½w	20%	Carbon	BP/2852/R
R42	47K Ω	½w	20%	Carbon	BP/2849/R
R44	1·8K Ω	½w	5%	Carbon	BP/2937/R
R45	1M Ω	½w	20%	Carbon	BP/2863/R
R46	8·2K Ω	½w	5%	Carbon	BP/2838/R
R47	1K Ω	½w	5%	Carbon	BP/2908/R
R48	22K Ω	1w	10%	Carbon	BP/2918/R
R49	1K Ω	½w	5%	High Stability	BP/2964/R
R50	330K Ω	½w	5%	High Stability	BP/2963/R
R51	220K Ω	½w	5%	High Stability	BP/2903/R
R52	250K Ω			Pre-Set Carbon Pot.	BP/2435/P
R53	10M Ω	½w	20%	Carbon	BP/2866/R
R54	250K Ω			Pre-Set Carbon Pot.	BP/2435/P
R55	220K Ω	½w	5%	Carbon	BP/2919/R
R56	500K Ω			Dual Carbon Pot. (with R68)	BP/2438/P
R57	250K Ω			Pre-Set Carbon Pot.	BP/2435/P
R58	33K Ω	½w	20%	Carbon	BP/2845/R
R59	2·2K Ω	½w	20%	Carbon	BP/2883/R
R60	47K Ω	½w	20%	Carbon	BP/2849/R
R61	1K Ω	½w	5%	High Stability	BP/2964/R
R62	330K Ω	½w	5%	High Stability	BP/2963/R
R63	220K Ω	½w	5%	High Stability	BP/2903/R
R64	250K Ω			Pre-Set Carbon Pot. Lin.	BP/2435/P
R65	10M Ω	½w	20%	Carbon	BP/2866/R
R66	250K Ω			Pre-Set Carbon Pot. Lin.	BP/2435/P
R67	220K Ω	½w	5%	Carbon	BP/2919/R
R68	500K Ω			Dual Carbon Pot. (with R56)	BP/2438/P
R69	250K Ω			Pre-Set Carbon Pot. Lin.	BP/2435/P
R70	33K Ω	½w	20%	Carbon	BP/2845/R

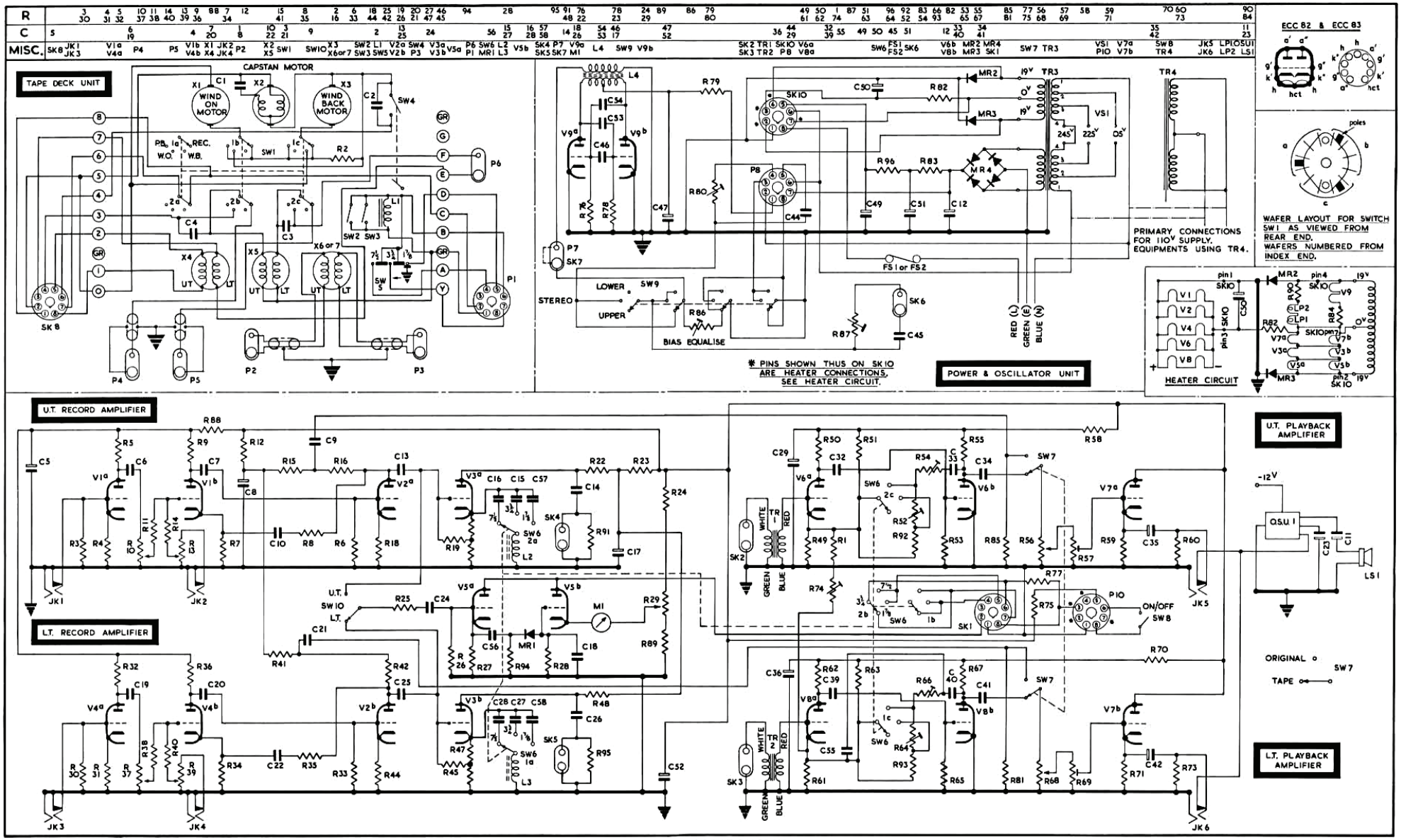


FIG. 17. COMPLETE CIRCUIT DIAGRAM

Appendix B—*continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NOS.
R71	2·2K Ω	½w	20%	Carbon	BP/2883/R
R73	47K Ω	½w	20%	Carbon	BP/2849/R
R74	500K Ω			Pre-Set Carbon Pot. Lin.	BP/2443/P
R75	620 Ω	½w	5%	Carbon	BP/2881/R
R76	10K Ω	½w	5%	Carbon	BP/2926/R
R77	100 Ω	1w	5%	Carbon	BP/2968/R
R78	10K Ω	½w	5%	Carbon	BP/2926/R
R79	5·6K Ω	1w	5%	Carbon	BP/2947/R
R80	25K Ω			Pre-Set Carbon Pot.	BP/2402/P
R81	10M Ω	½w	20%	Carbon	BP/2866/R
R82	5 Ω	6w		Vitreous Enamel	BP/2799/R
R83	620 Ω	½w	5%	Carbon	BP/2881/R
R84	47 Ω	1w	5%	Carbon	BP/2969/R
R85	10M Ω	½w	20%	Carbon	BP/2866/R
R86	5K Ω			Pre-Set Pot.	BP/2428/P
R87	25K Ω			Pre-Set Carbon Pot.	BP/2402/P
R88	15K Ω	½w	20%	Carbon	BP/2842/R
R89	220 Ω	½w	5%	Carbon	BP/2805/R
R90	56 Ω	2w		Vitreous Enamel	BP/2797/R
R91	100K Ω	½w	20%	Carbon	BP/2852/R
R92	*100K Ω			Selected at Works	
R93	*100K Ω			Selected at Works	
R94	100K Ω	½w	20%	Carbon	BP/2852/R
R95	100K Ω	½w	20%	Carbon	BP/2852/R
R96	620 Ω	½w	5%	Carbon	BP/2881/R
C1	·75μF	450v		Paper	BP/715/C
C2	·1μF	300v AC		Paper	BP/707/C
C3	2200pf	500v	20%	Ceramic	BP/527/C
C4	2200pf	500v	20%	Ceramic	BP/527/C
C5	16μF	350v		Electrolytic (with C8 and C36)	BP/773/C
C6	·1μF	400v	10%	Polyester	BP/708/C
C7	·022μF	400v	10%	Polyester	BP/704/C
C8	8μF	350v		Electrolytic (with C5 and C36)	BP/773/C
C9	·01μF	400v	10%	Polyester	BP/703/C
C10	·01μF	400v	10%	Polyester	BP/703/C
C11	1000μF	25v		Electrolytic	BP/783/C

Appendix B—*continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NOS.
C12	16μF	500v		Electrolytic (with C47)	BP/789/C
C13	·047μF	400v	10%	Polyester	BP/706/C
C14	·5μF	500v	10%	Paper	BP/780/C
C15	*5700pf			Selected at Works	
C16	*2700pf			Selected at Works	
C17	8μF	350v		Electrolytic (with C29 and C52)	BP/773/C
C18	·22μF	125v	10%	Polyester	BP/710/C
C19	·1μF	400v	10%	Polyester	BP/708/C
C20	·022μF	400v	10%	Polyester	BP/704/C
C21	·01μF	400v	10%	Polyester	BP/703/C
C22	·01μF	400v	10%	Polyester	BP/703/C
C23	350μF	12v		Electrolytic	BP/744/C
C24	4700pf	500v	+100-0%	Ceramic	BP/530/C
C25	·047μF	400v	10%	Polyester	BP/706/C
C26	·5μF	500v	10%	Paper	BP/780/C
C27	*5700pf			Selected at Works	
C28	*2700pf			Selected at Works	
C29	16μF	350v		Electrolytic (with C17 and C52)	BP/773/C
C32	4700pf	500v	+100-0%	Ceramic	BP/530/C
C33	*1000pf			Selected at Works	
C34	·02μF	400v	10%	Polyester	BP/704/C
C35	100μF	25v		Electrolytic	BP/781/C
C36	16μF	350v		Electrolytic (with C5 and C8)	BP/773/C
C39	4700pf	500v	+100-0%	Ceramic	BP/530/C
C40	*1000pf			Selected at Works	
C41	·02μF	400v	10%	Polyester	BP/704/C
C42	100μF	25v		Electrolytic	BP/781/C
C44	·047μF	400v	10%	Polyester	BP/706/C
C45	·047μF	400v	10%	Polyester	BP/706/C
C46	5700pf	350v	10%	Polystyrene	BP/521/C
C47	16μF	500v		Electrolytic (with C12)	BP/789/C
C49	50μF	500v		Electrolytic (with C51)	BP/772/C
C50	5000μF	18v		Electrolytic	BP/788/C

Appendix B—*continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NOS.
C51	50μF	500v		Electrolytic (with C49)	BP/772/C
C52	16μF	350v		Electrolytic (with C17 and C29)	BP/773/C
C53	2000pf	350v	2%	Polystyrene	BP/517/C
C54	2000pf	350v	2%	Polystyrene	BP/517/C
C55	25pf	350v	5%	Polystyrene	BP/539/C
C56	·047μF	400v	10%	Polyester	BP/706/C
C57	*12,000 pf			Selected at Works	
C58	*12,000 pf			Selected at Works	

CIRCUIT REF.	DESCRIPTION	PART NOS.
V1	Valve Type ECC83	BP/7130/V
V2	Valve Type ECC83	BP/7130/V
V3	Valve Type ECC82	BP/7118/V
V4	Valve Type ECC83	BP/7130/V
V5	Valve Type ECC83	BP/7130/V
V6	Valve Type ECC83	BP/7130/V
V7	Valve Type ECC82	BP/7118/V
V8	Valve Type ECC83	BP/7130/V
V9	Valve Type ECC82	BP/7118/V
SW1	Selector Switch	MC/3723
SW2	Auto Stop Switch	MC/4067
SW3	Manual Stop Switch	MC/1216C
SW4	Manual Start Switch	MC/1216B
SW5	Speed Change Switch	MC/3820
SW6	Equaliser Switch	BP/4080/S
SW7	Slide Switch	BP/4071/S
SW8	Toggle Switch	BP/4074/S
SW9	Mono-Stereo Switch	BP/4078/S
SW10	Slide Switch	BP/4071/S

Appendix B—*continued*

CIRCUIT REF.	DESCRIPTION	PART NOS.
JK1	Jack Socket	BP/1508/J
JK2	Jack Socket	BP/1508/J
JK3	Jack Socket	BP/1508/J
JK4	Jack Socket	BP/1508/J
JK5	Jack Socket	BP/1508/J
JK6	Jack Socket	BP/1508/J
X1	Wind on Motor } 200-250v	MC/5230/150
X2	Capstan Motor } Mains	MC/5954/240
X3	Wind Back Motor } Models	MC/5229/150
X4	Erase Head, ¼ track stereo FE16 } Model 632	MC/5537
X5	Record Head, ¼ track stereo FR16 } Model 632	MC/5529
X6	Playback Head, ¼ track stereo FP16 } Model 632	MC/5604
X4	Erase Head, ¼ track stereo FE28 } Model 634	MC/5900
X5	Record Head, ¼ track stereo FR28 } Model 634	MC/5498A
X6	Playback Head, ¼ track stereo FP28 } Model 634	MC/5498B
P1	Plug Octal	BP/2311/P
P2	Plug 2 Way	BP/2301/P
P3	Plug 2 Way	BP/2301/P
P4	Plug 2 Way	BP/2301/P
P5	Plug 2 Way	BP/2301/P
P6	Plug 2 Way	BP/2301/P
P7	Plug 2 Way	BP/2301/P
P8	Plug Octal	BP/2310/P
P10	Plug Octal	BP/2311/P
SK1	Socket Octal	BP/7050/V
SK2	Socket 2 Way	BP/3904/S
SK3	Socket 2 Way	BP/3904/S
SK4	Socket 2 Way	BP/3904/S
SK5	Socket 2 Way	BP/3904/S
SK6	Socket 2 Way	BP/3904/S
SK7	Socket 2 Way	BP/3904/S
SK8	Socket Octal	BP/3906/S
SK10	Socket Octal	BP/7050/V
TR1	Input Transformer	MC/973A
TR2	Input Transformer	MC/973A
TR3	200-250v Mains Transformer	MC/T1670

Appendix B—*continued*

CIRCUIT REF.	DESCRIPTION	PART NOS.
L1	Solenoid	MC/T1672
L2	Treble Boost Inductor	MC/781
L3	Treble Boost Inductor	MC/781
L4	Oscillator Coil Type 787	MC/5586
FS1	Fuse 1A	BP/1271/F
VS1	Voltage Selector	MC/4446C
M1	Meter Reverse Reading	BP/1933/M
MR1	Rectifier	BP/2608/R
MR2	Rectifier	BP/2605/R
MR3	Rectifier	BP/2605/R
MR4	Rectifier (Bridge)	BP/2612/R
LS1	Speaker, 5 in. dia.	BP/4159/S
OSU1	Output Stage Unit	BP/6010/T
LP1	Lamp L.E.S. 6·5V 150mA	BP/1813/L
LP2	Lamp L.E.S. 6·5V 150mA	BP/1813/L

COMPONENTS LIST FOR MODELS 632A AND 634A (117V, 60 c/s)

The Component Values for these Models are exactly as for Models 632U & 634U with the exceptions listed below :—

CIRCUIT REF.	VALUE	RATING	DESCRIPTION	PART NOS.
R2	250 Ω	27W	Vitreous Enamel	BP/2808/R
C1	2·5μF	300V	Paper A.C. Working	BP/717/3
TR4			Mains Transformer	MC/T1673
X1			Wind On Motor	MC/5230/75
X2			Capstan Motor	MC/5954/110
X3			Wind Back Motor	MC/5229/75
FS2			Fuse 2·5A	BP/1272/F

COMPONENTS LIST FOR MODELS 632E AND 634E (110V, 50 c/s)

The component values for these models are as detailed for Models 632U and 634U above, with the following exceptions.

CIRCUIT REF.	VALUE	RATING	DESCRIPTION	PART NOS.
R2	250 Ω	27W	Vitreous Enamel	BP/2808/R
C1	3μF	300V	Paper A.C. Working	BP/718/C
TR4			Mains Transformer	MC/R1673
X1			Wind On Motor	MC/5230/75
X2			Capstan Motor	MC/5954/110
X3			Wind Back Motor	MC/5229/75
FS2			Fuse 2·5A	BP/1272/F

COMPONENTS LIST FOR MODELS 632H AND 634H (U, E OR A)

The component values for these models are as detailed above for Models 632 and 634 (U, E or A respectively), with the following exceptions.

CIRCUIT REF.	VALUE	RATING	DESCRIPTION	PART NOS.
C15	*2,000pf		Selected at Works	
C16	*1,500pf		Selected at Works	
C27	*2,000pf		Selected at Works	
C28	*1,500pf		Selected at Works	
C57	*12000pf		Selected at Works	
C58	*12000pf		Selected at Works	
L2			Treble Boost Inductor	MC/727
L3			Treble Boost Inductor	MC/727

*Values are nominal only. Actual values are selected during setting up.

APPENDIX C

The following accessories are available for use with the Ferrograph.

Carrying Case for Series 6

Best quality waterproof canvas with zip fastener. Gives full protection against rain and dust.

Defluxer

For demagnetising the record/playback heads. Prevents hiss and protects tapes from cumulative background noise.

Endless Loop Cassette

As described in the manual.

Erase Link Potentiometer

As described in Manual, Section 7. BP/2434/P.

Low Impedance Microphones

Type RBL/TM, high fidelity, low impedance (30 ohms) fitted with 3 pin plug/socket mount for attaching to a floor, table or desk stand with 18 feet screened lead and plug, and incorporating matching unit in lead.

Type RBL/T, high fidelity, low impedance (30 ohms) fitted with 3 pin plug/socket mount with 18 ft. screened lead and plug.

Microphone Matching Unit

Type TA/30GL, incorporating transformer for use with 30 ohm Microphone type RBL/T above.

Microphone Stands

Heavy bases finished grey with chromium pillars. Desk model height 8 inches. Table model, adjustable, 16/24 inches. Floor model, adjustable, 3 ft./5 ft. 9 ins.

Tape

Hublok reels (full standard tape)	200 ft. Ferrograph FT3A
	600 ft. Ferrograph FT5A
	1200 ft. Ferrograph FT7A
	1750 ft. Ferrograph FT8A

Empty Reels

Hublok reels (empty)	200 ft. Ferrograph RE3
	600 ft. Ferrograph RE5
	1200 ft. Ferrograph RE7
	1750 ft. Ferrograph RE8

Miscellaneous

The following spares can also be supplied :

Meter illuminating lamp	LES 6·5V 150mA	BP/1813/L
Fuse	1A	BP/1271/F
Fuse	2·5A	BP/1272/F
Unscreened jack plug	UP7	
Screened jack plug	SP7	
Noval plug	Type BLM/9	BP/2333/P
Plug Cover	For above	BP/2334/P

Tape deck parts which may require replacement after long use or accidental damage are indicated in the illustrations. When ordering these, please specify the part number and the serial number of the Ferrograph (rear of cabinet).

Nothing contained in this publication absolves the user from the due observance of the laws relating to copyright and transcription generally.

Many of the devices described are the subject of letters patent granted to or operated by :—
THE FERROGRAPH COMPANY LTD.
THE BRITISH FERROGRAPH RECORDER CO., LTD.
WRIGHT AND WEAIRE LTD.

Due to constant efforts to improve performance and consequent modifications, it may be found that minor differences exist between the actual instrument and that described in this manual. It is therefore essential to quote the serial number of the recorder when ordering any replacement parts.

NOTES

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IM/5/67

FERROGRAPH MODELS 632, 634 & 632H

1. BIAS SWITCH

The Bias switch on the rear panel is normally set to the "Low" position, when the bias is suitable for the standard tape, Ferrotape type A, and tapes of similar quality and characteristics. When in the "High" position the bias is suitable for the special "low noise" tapes such as Ferrotape type B, Scotch Dynarange tape, etc., and with this tape a peak recording level of "9" should be used.

2. ERASE LINK

The erase link has been split into two to enable "spot erasure" and superimposition to be used, and Section 7 in the Manual should read as follows.

7. RECORD LINKS

It must be born in mind that whenever the main selector switch is turned to Record, the oscillator supplying the erase head is energised, and under normal circumstances, if the tape is run in this position any previous signal on it will be wiped off. However, it is possible to prevent any erasure by removing the two plugs on the rear panel marked "Disconnect"—"Erase Only" and "Bias Only". If both of these are removed, no erasure can take place and it is sometimes useful to do so if the recorder is to be used by the relatively unskilled for the purpose of playback only.

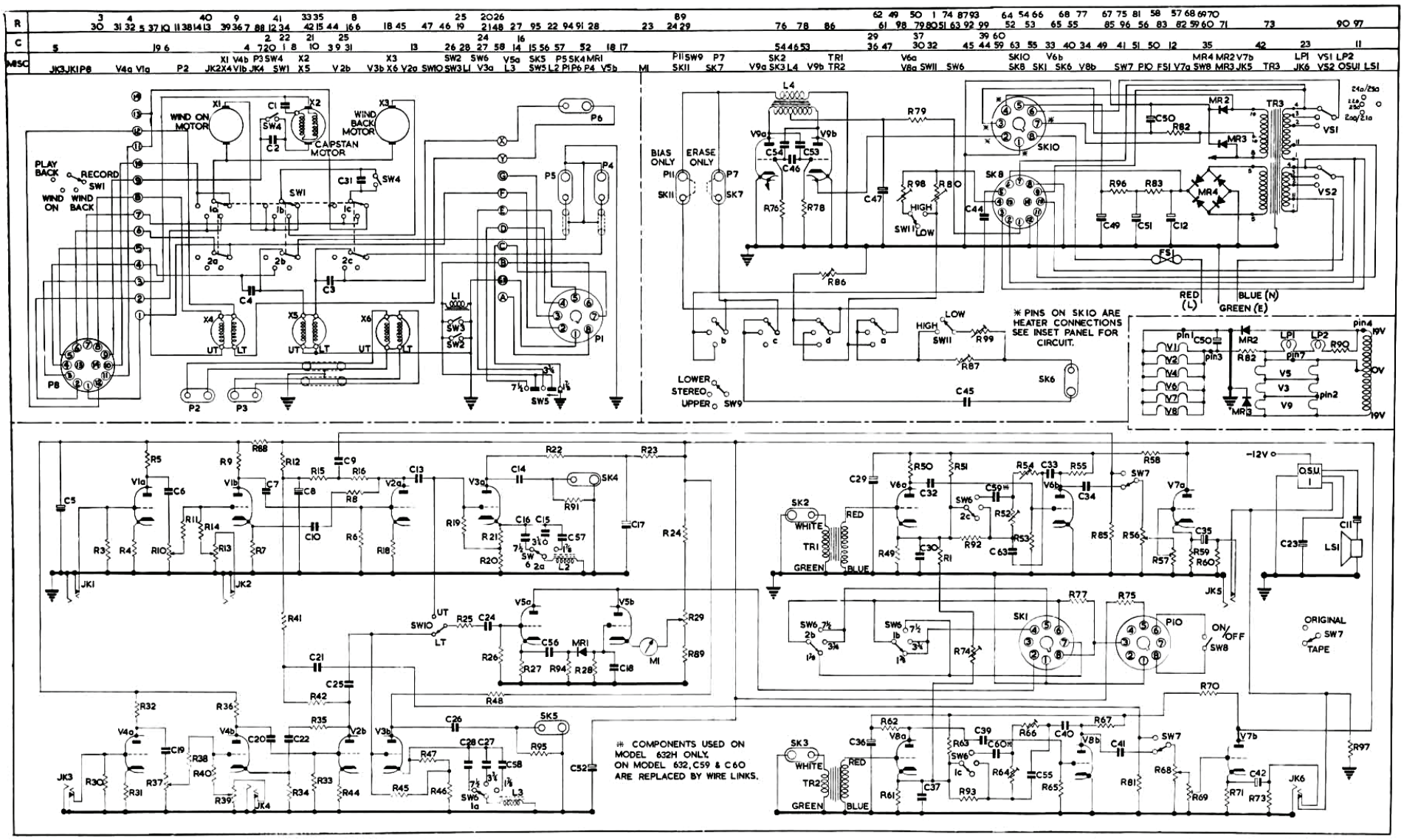
Nevertheless, as a special Record Lock device is fitted to prevent accidental turning to Record, this precaution is not normally necessary, and the main purpose of these two links is to provide the various facilities described below.

NOTE:—On no account should the "Erase Only" and "Bias Only" plugs be removed while the instrument is on Record as this may polarise the heads.

7.1. Spot Erase

By removing the plug marked "Disconnect Bias Only", the bias supply to the record head is removed and only the erase head is energised. Normally, the bias on the record head also acts as a weak erase head and erases signals on the tape prior to the erase head, so that it is impossible to erase a click, for example, without affecting other parts of the tape. However, with this link removed and only the erase head energised, it can be used to erase small sections of the tape and by utilising the monitor head this can be done very accurately. As it is possible to impose a noise on the tape (even when no bias is present on the record head) if the input signal is large and the gain is turned well up, it is essential that both record gain controls be at zero when this is being done.

The tape should be run on playback to locate the part of the tape which it is required to erase, and the start located at the face of the playback head. This precise spot is marked on the tape in some way, a "chinagraph" pencil or crayon being very useful for this. The tape is then played back to the end of the passage and this also marked on the tape. The tape is then wound back to the first mark and this is located manually against the erase head face, the "Bias Only" link removed and the deck switch turned to Record,


R
C
MISC
PLAY BACK
RECORD
SW1
WIND ON
WIND BACK
WIND ON MOTOR
WIND BACK MOTOR
CAPSTAN MOTOR
BIAS ONLY
ERASE ONLY
HIGH
LOW
SW11
LOWER
STEREO
UPPER
SW9
* PINS ON SK10 ARE HEATER CONNECTIONS SEE INSET PANEL FOR CIRCUIT.
RED (L)
BLUE (N)
GREEN (E)
-12V
ORIGINAL
TAPE
SW7
ON
OFF
SW8
* COMPONENTS USED ON MODEL 632H ONLY. ON MODEL 632, C59 & C60 ARE REPLACED BY WIRE LINKS.

simultaneously pressing the Record Lock button. For short passages the reels should be rotated manually until the second mark is against the erase head face and then the deck switch turned from record. This manual rotation avoids any possibility of a switching click due to switching on the motors, although for longer passages it is quite in order to use the motors until the second mark appears at the left hand reel. The drive should be stopped and the final part wound manually for greater accuracy and to avoid overrunning the mark.

This method is invaluable for deleting any unwanted parts of a recording or for removing any clicks which are inadvertently made on the tape.

7.2. Superimposition

Superimposition is made possible by removing the plug labelled "Disconnect Erase Only", which removes the supply to the erase head but leaves the bias on the record head. This means that by following the normal record procedure a signal can be recorded onto a previous recording *e.g.* commentary onto background music. However, as explained previously, the record head bias will also act as a weak erase head, slightly reducing the level of the original recording and also selectively erasing the higher frequencies. The result will be a reduced first recording with a diminished high frequency response and a superimposed second recording, the recording level of which will need to be judged by experience and can be checked audibly by using the monitor head. If it is required to diminish the erasing effect of the bias, a variable resistance (approximately 3,000 ohm) could be connected in place of the "Bias Only" plug and the bias reduced to obtain the required balance in quality of the two recordings.

If it is attempted to superimpose over only part of a recording by turning to record midway through the recording, a "jump" in the level of the original signal will be observed due to the change from no erasure to the slight erasure of the bias. In this case it is desirable to fade in the bias gradually to provide a smooth transition. It has been found most convenient to connect a 100 K ohm logarithmic potentiometer (carbon) in place of the "Bias Only" plug and to rotate this from maximum resistance to the zero position. Of course, recording should only take place when the bias is at its maximum value (or very nearly) otherwise distortion will occur.

It is also possible to reduce the level of the original signal by connecting a variable resistance in place of the "Erase Only" plug as explained in the next section.

The actual synchronisation of the two recordings is done using the monitor head with either headphones or loudspeaker as required. However, due to the physical spacing of the record and playback head, there will be a ½ second delay (at 7½ in/sec) between the monitor signal and the record signal and this may make very exact synchronisation a little awkward.

7.3. Interjection

This consists of fading out the original recording, interjecting the new signal and then fading back the original signal again. This is achieved by removing both the plugs and inserting two plugs wired to a wirewound, 4 watt, variable resistance of approximately 2,000 ohm maximum value. A suitable potentiometer is available in the list of

accessories, having a graded characteristic with 1,700 ohm maximum value and having an open circuit position after this. The potentiometer should be wired to one of the thick pins and to both the thin pins (linked together), when it is thus controlling both bias and erase supplies to the heads.

With the potentiometer in the open circuit position no erasure takes place and the original signal is unaffected. If the potentiometer is rotated slowly the resistance gradually falls and the erase voltage increases correspondingly. The erasure also increases and with the tape running, the original signal is gradually faded out. When the resistance is zero, the erase and bias are at their normal values and recording can commence. Afterwards the procedure can be reversed and the original signal faded back in. This method can also be used to fade in and out at the ends of a recording.

It will be found that even the above graded potentiometer does not produce the same effect as a fade made during the recording because the erase field will first selectively erase the higher frequencies (similar to the bias). This produces the phenomenon that the signal tends to grow muffled before an audible change in volume can be detected, and it is advisable to produce the fade during the recording process if this is practicable. This effect also tends to produce an apparent jump in the signal on first starting to turn from the "off" position to the maximum resistance position. The instantaneous change from infinite resistance to 1,700 ohms produces a very slight jump in the erasure of normal frequencies but a much larger one at the higher frequencies.

This can be avoided by using two potentiometers, the 1,700 ohm special potentiometer connected between the pins of the "Erase Only" plug and the 100K ohm carbon potentiometer across the "Bias Only" plug as suggested in Section 7.1. (In this case no link is required between the two plugs as the bias and erase are controlled separately). With both controls fully "off", the "Bias" potentiometer should be turned slowly till the bias is fully "on" and the high frequencies have been faded gradually out. The "Erase" potentiometer can then be turned till the desired level of erasure occurs.

This last arrangement can be very versatile and allows superimposition to occur over fully erased or partially erased signals, and as the resultant recording on the tape can be monitored almost immediately, the signal levels can be controlled to exactly the effect required.

It must again be emphasised that the "Bias only" and "Erase Only" plugs must not be removed when on "Record" and this applies equally to the potentiometers when plugged into these same sockets.

3. VOLTAGE SELECTOR (240V Models only)

The voltage selector illustrated in Fig. 1. has been superseded by twin voltage selectors, both knobs having three positions for mains supplies of 200-210, 220-230, and 240-250 volts. To select the correct setting, both knobs should be pulled outwards (they will not come entirely free), rotated till the correct range is opposite the indicator stud, then pushed firmly home.

The voltage selector knobs must always be set to the same voltage range, otherwise excessive hum will result.

4. REEL MOTORS

On playback and record, the back tension normally applied by the supply reel motor has been replaced by a special constant friction brake applied to the left hand spool carrier. The take-up reel motor is fed its usual 150V (or 75V) from the mains transformer and the deck motor switch has two poles in order to switch the reel and capstan motors separately. Resistor R2 is no longer fitted.

On fast wind, the brake is automatically removed and the appropriate reel motor is fed with 240V (or 110V) as usual. The deck switching has been modified to suit the new arrangement, three poles being used, and to accommodate the extra leads, P8 and SK8 are 14 way and use 12 core connecting cable. The two tagstrips have been replaced by a single combined tagboard mounted on the cross strap at the centre of the deck.

Parts List Changes

CIRCUIT REF.	DESCRIPTION	PART NO.
R2	No longer fitted	
R84	No longer fitted	
R97	3·3 K Ω ¼w 20% Carbon	BP/2917/R
R98	25K Ω Pre-set Carbon Pot.	BP/2402/P
R99	25K Ω Pre-set Carbon Pot.	BP/2402/P
C30	4,700pf 500V +100-0% Ceramic	BP/530/C
C31	0·1μF 300V Paper (AC Working)	BP/707/C
C37	4,700pf 500V +100-0% Ceramic	BP/530/C
C55	25pf 350V 5% Polystyrene	BP/539/C
C59	2,700pf 10% Polystyrene	BP/577/C
C60	2,700pf 10% Polystyrene	BP/577/C
C63	25pf 350V 5% Polystyrene	BP/539/C
SW4	Manual Start Switch	MC/2959
SW11	Bias Switch (Slide)	BP/4071/S
P8	Plug 14 Way	BP/2349/P
SK8	Socket 14 Way	BP/3963/C
TR1	Input Transformer	MC/973B
TR2	Input Transformer	MC/973B
L2	Treble Boost Inductor	MC/727
L3	Treble Boost Inductor	MC/727
VS1	Voltage Selector	BP/7030/V
VS2	Voltage Selector	BP/7030/V