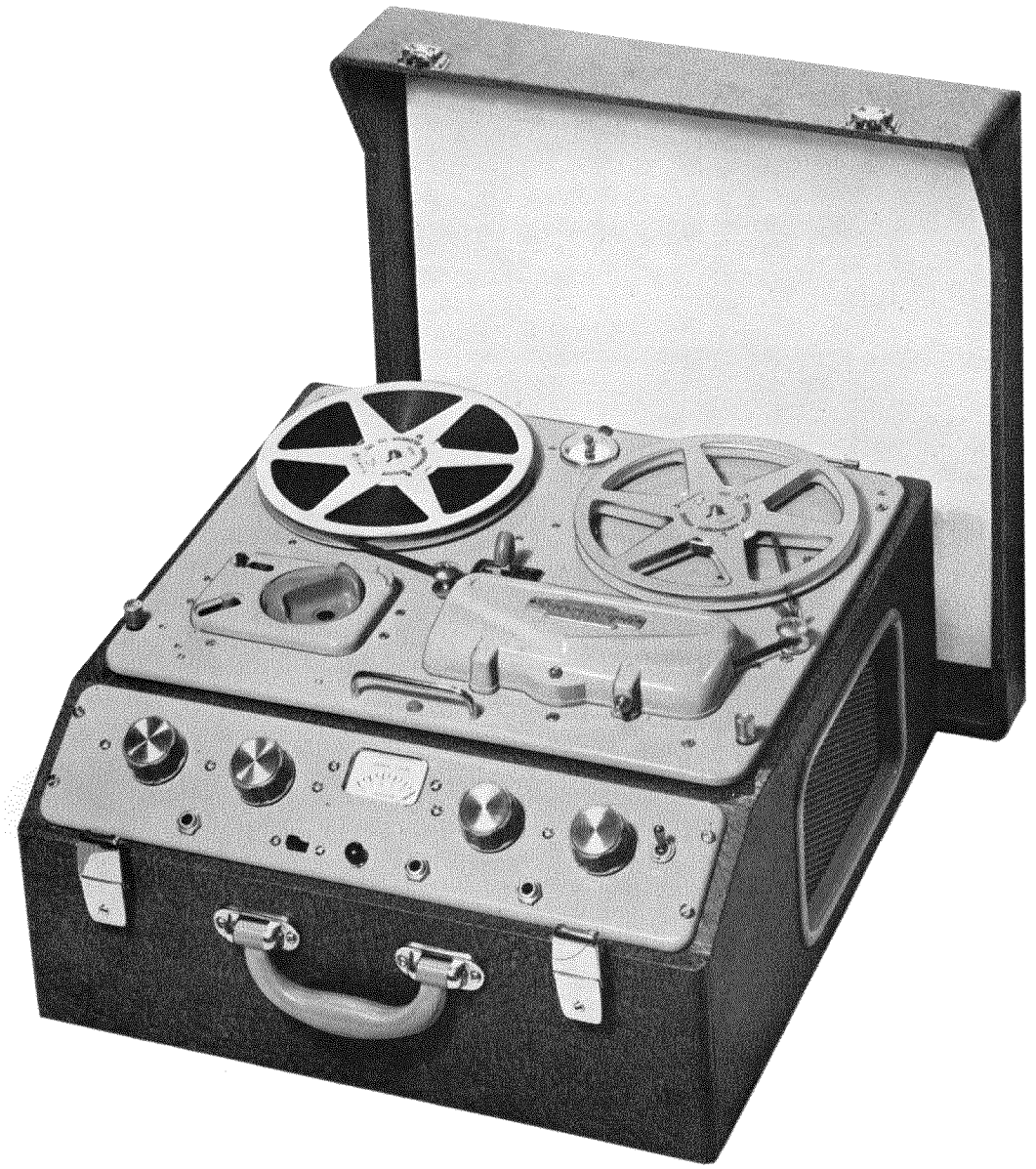
THE MANUAL
OF THE
"FERROGRAPH"
SERIES 5

Ferrograph



SERIES 5 FERROGRAPH

THE MANUAL
OF THE
"FERROGRAPH"

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

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, the recorder should never be switched to or from the "record" position unless there is a properly connected plug in one of the input sockets or the gain control is at its zero setting.

This 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.

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LIST OF DIAGRAMS AND PLATES

"FERROGRAPH"
MAGNETIC TAPE RECORDERS
SERIES 5

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.
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"FERROGRAPH" MODEL 5A

GENERAL SPECIFICATION

RECORDING MEDIUM	Standard or "Extra Play" $\frac{1}{4}$" plastic coated tape. On reels up to a maximum of $8\frac{1}{4}$" dia. coating inside.
TRACK WIDTH	0.1"—displaced to one edge.
NUMBER OF TRACKS	2
OPERATING TAPE SPEEDS ..	$7\frac{1}{2}$ and $3\frac{3}{4}$ ins./sec. $\pm$ 2%
PLAYING TIME PER TRACK ..	Large Reel 45 mins at $7\frac{1}{2}$ ins/sec. 1,750 ft. Std. Tape 90 mins at $3\frac{3}{4}$ ins/sec.
PLAYING TIME PER REEL ..	$1\frac{1}{2}$ hours and 3 hours respectively. NOTE :—The above playing times will be increased when "extra play" tape is used.
REWIND TIME (AND WIND ON) ..	Less than one minute for 1,750 ft. reel standard tape.
FREQUENCY RESPONSE .. .. (Tape to Spec.WW372/49 with amendments)	$3\frac{3}{4}$ ins./sec. 40—10,000 c.p.s. $\pm$ 3dB $7\frac{1}{2}$ ins./sec. 40—15,000 c.p.s. $\pm$ 3dB
"WOW & "FLUTTER" .. .. (As a change in tape velocity)	Less than 0.16% at $7\frac{1}{2}$ ins./sec.
LONG TERM SPEED STABILITY .. (For constant Mains Input Frequency)	Better than 0.5%
ERASE AND BIAS FREQUENCY ..	68 kc/s. approximately.
INPUT LEVELS, (For full Depth Recording)	Input 1, minm. signal 0.003V RMS. Input 2, minm. signal 0.15V RMS. Impedances, 1 Megohm and 80Kohms respectively.
OUTPUT ARRANGEMENTS ..	15 ohms 10" x 6" internal elliptical speaker. Socket on front panel for external speakers.
OUTPUT POWER	$2\frac{1}{2}$ watts into 15 ohms.
SIGNAL TO NOISE RATIO .. (Tape to Spec. WW372/49)	In the range 200 c.p.s. to 15 Kc/s., better than 50dB. Unweighted, including hum, 45dB.
WORKING VOLTAGE	200—250V. AC.
POWER CONSUMPTION	110 watts.
OVERALL DIMENSIONS	$18\frac{1}{2}$" x $17\frac{1}{2}$" x $9\frac{3}{4}$" high, with lid.
WEIGHT	$49\frac{3}{4}$ lbs.

THE "FERROGRAPH" MODEL 5A

GENERAL INFORMATION

The "Ferrograph" stores its sound images in the form of magnetic patterns in the oxide coating of a thin plastic tape. The tape itself is $\frac{1}{4}$" wide and only two thousandths of an inch in thickness. 1,250 ft. are accommodated on a reel 7 ins. in diameter.

Because it is a magnetic phenomenon only which is involved and not a physical change in the medium, tape recording has the great advantage over other forms that the medium is not irrevocably consumed each time a recording is made. If a recording is not required for future reference, the tape can be replaced on the "Ferrograph" and used over and over again, the old recording automatically being erased as a new one is made.

Tape is also capable of great fidelity if properly handled, and if the approach to recorder design has been along strict engineering lines. With the "Ferrograph", the aim has been to make it a strictly linear device, *i.e.*, one which over the recording/reproducing process changes the character of the original signal in no way except in intensity.

While this cannot be achieved completely, as far as normally available signals are concerned it is possible to approach it very closely. However, its pursuit has necessitated special treatment in the design of many sections, notably in the recording heads, record level monitoring and hum suppression.

Briefly the "Ferrograph" consists of the following main components :—

1. An amplifier for magnifying the relatively weak signals from a microphone or the stronger signals from radio apparatus to a predetermined level.
2. A recording head for the conversion of this amplified electrical energy into magnetic energy for impression on to the tape medium.
3. A supersonic oscillator for supplying power to the recording head during the recording operation to assist in the retention of a faithful replica of the original signal and also for feeding an erasing head which obliterates previous recordings.
4. A mechanical drive system for transporting the tape past the heads at given speeds, and for rewinding the tape after recording.
5. A playback or reproducing head for subsequently picking up the magnetic impressions stored on the tape and converting them back into electrical form.
6. An amplifier for amplifying these weak signals, correcting them, and feeding them to the loudspeaker for re-conversion into sound energy.

Economy has suggested, however, and practice has proved, the great advantage of using common circuits and equipment for those operations which are not really required simultaneously, and applying the economic potential thus set free to a general improvement in basic design and facilities. Thus in the "Ferrograph" it has been found expedient to have one amplifier suitably switched, performing the functions of both 1 and 6, and to have a single combined record/reproduce head playing the part of both 2 and 5. Practically speaking, therefore, the instrument resolves itself into three main units :—

A. The mechanical deck carrying the motors, heads, reels, etc.
B. The power unit and oscillator.
C. The amplifier chassis containing the amplifier, monitor meter, etc.

The Mechanical Unit is the Wearite "Tape-Deck". It is connected to the amplifier unit by detachable plugs and sockets. Many noteworthy features are incorporated in it, and simplicity of operation is one of its chief characteristics. Among the facilities it provides are :—

1. A double track provision which allows double the amount of recorded material to be stored on one reel without any cross talk or sacrifice in performance. This is possible as it operates on only half the tape width at any one time.
2. Two running speeds—allowing yet a further doubling of playing time where the frequency range permits.
3. Rapid wind-back *and wind-on* of tape.
4. An automatic stop switch cutting off the unattended instrument (during record or playback) at the end of a reel, in the event of tape breakage or on the stopping of the take-up reel.
5. An instantaneous stop and start of tape transit, preventing slurring.
6. A cueing indicator giving an index of tape consumed.
7. The ability to accept a continuous loop cassette in place of the standard reels.
8. A third head *position.* This is located after the combined record/reproduce head. Standard or stereo heads may be plugged in, and there is an adjusting screw for gap alignment.

The Power Unit and Oscillator employing two valves is mounted on the floor of the cabinet with its control panel accessible at the rear of the instrument.

Further to extend the scope of the instrument, a socket outlet is provided at the rear panel to which H.T., L.T., and certain other internal connections of the Ferrograph are brought.

The Amplifier, which employs five valves, is mounted together with its operating panel along the front of the instrument.

In the amplifier are several points also worthy of mention at this stage, so that a rapid appreciation of the scope of the instrument will be possible :—

1. Two input sockets for accepting the signal to be recorded are provided, each a stage apart in the amplifier, and for low and high level signals respectively.
2. Measurement of recording level before application to the tape is carried out by a special peak reading valve-voltmeter which gives sudden transients their true reading, and which allows the maximum possible signal to be impressed upon the tape without fear of overloading or distortion.
3. While recording, the quality of the signal cannot be modified by the operator. Providing therefore that the signal itself is good, a full frequency range recording will always be made.
4. On playing back however, tone control of both the bass and treble ends of the response is possible, and the frequency spectrum may be varied to suit individual tastes. The level response position is easily set if this facility is not required.

5. The general performance of the instrument is such as to warrant playing back over loudspeaker systems capable of rather better acoustical treatment than is possible in the instrument's own case. To this end a 15 ohm outlet has been provided for this and other purposes.
6. Arrangements have been made to break the supersonic and erase feed circuits at will, so that interjection, by gradual fading in and out, and superimposition are possible.

Having thus set out very briefly—with the General Specification on Page 2—the broad scope of the instrument, consideration may now be given to the operation proper.

OPERATING INSTRUCTIONS

1. BEFORE PUTTING INTO OPERATION

Make sure that the mains input voltage selector knob at the rear of the instrument is in the hole appropriate to the mains voltage on which the recorder is to be used. (See Fig. 1). As delivered it will always be in the highest voltage position.

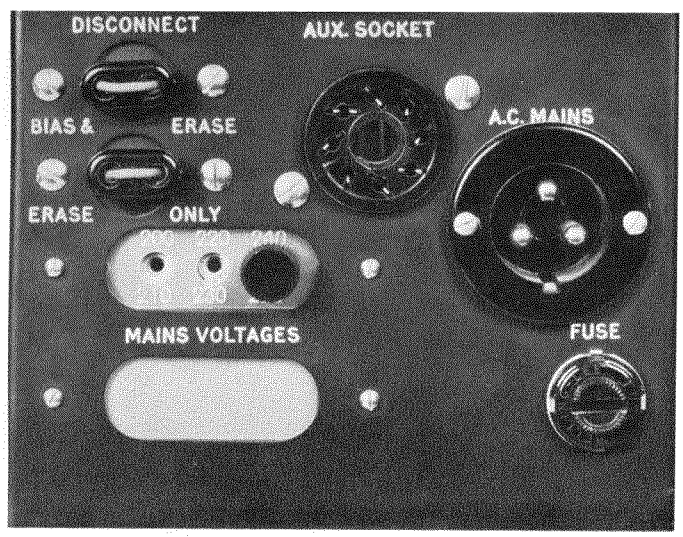

FIG. 1. SUPPLY PANEL

Three tappings are provided to cover the range of 200 to 250 volts, marked as follows :—200 and 210v. 220 and 230v, 240 and 250v.

Having correctly adjusted the mains input and affixed the right type of plug to the end of the lead, the instrument may be switched on by the toggle switch at the extreme right of the panel. (See Fig. 4). The two bulbs illuminating the meter will light up immediately, although the starter button will not hold in until after approximately 20 seconds.

THE RECORDER IS SUITABLE FOR AC MAINS ONLY. DO NOT ATTEMPT TO USE ON DC MAINS.

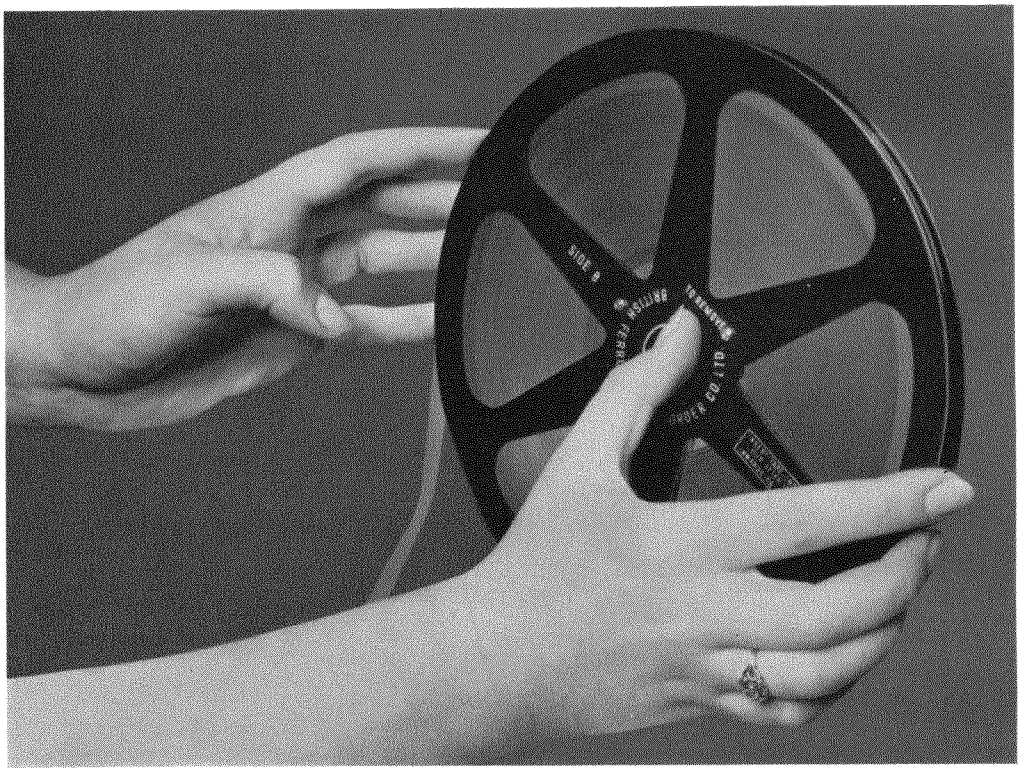

FIG. 2. LOADING THE INSTRUMENT

2. TO LOAD THE INSTRUMENT

First turn the main function switch on the deck to either fast wind position, indicated by the word 'FAST' over an arrow in the knob aperture. This automatically opens the tape gates under the head cover. Load the full reel of tape on the left hand drum adaptor, with the free end at the front and pointing to the right. The coating should then be on the inside.

If "Hublok" reels are being used, observe carefully the method of attaching and detaching them. The small projection should be deflected in the direction of the arrow with the thumb while the reel is being gripped at its rim by the fingers. Do not force the reel on or off without first deflecting this release knob.

Open the head cover, and thread the tape past the heads and over the guides as shown in Fig. 3. The free end should be secured to the empty hub by the built in clip. The red portion is pushed inwards and the tape nipped between the green and cream sections. A few turns of tape can then be wound around the hub by rotating the reels manually in a counter clockwise direction.

The main function switch should now be turned to either record or playback as desired, these operations being indicated by the words 'REC' or 'PLAY' in the knob aperture. Then, after checking that the tape is in its correct position and held against the heads by the pressure pads, the head cover can be closed.

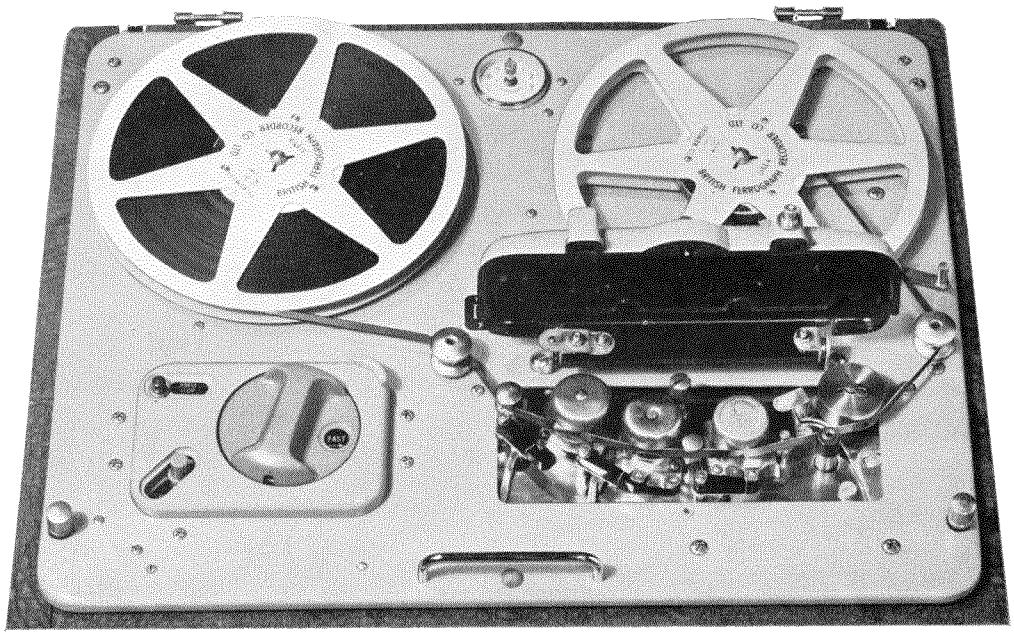

FIG. 3. TAPE LOADING

The motors may be started, once the machine has been switched on at the panel, by pulling the start button down towards the left hand corner. If the machine is properly warmed up (this usually takes about 20 seconds after switching on) the start button will automatically lock in the "on" position. If it does not lock in and the machine has had ample time to warm up, it is an indication that the tape is not properly positioned in the guides and is allowing the automatic stop switch to operate, or that the speed selector and equaliser switch are incorrectly set (see below).

With the tape running, the adjustment of the "bobbin" guides should be checked, if there is any tendency for the tape to catch on the reel cheeks, the guide may be adjusted for height by first twisting the top and bottom in opposite directions on the support screw to unlock it. The two parts can then be screwed up or down, and locked together finger tight at the required height.

To stop the motors, depress the stop button, keeping the hand clear of the starting knob which will then automatically return.

WHILST THE MAIN FUNCTION SWITCH CAN BE TURNED BETWEEN THE FAST WIND POSITIONS WITHOUT STOPPING THE TAPE, THE STOP BUTTON MUST BE PRESSED AND THE START BUTTON RELEASED BEFORE SWITCHING TO OR FROM RECORD OR PLAYBACK. An automatic locking device has been incorporated to prevent this being done, and any attempt to do so will only impose undue strain on this mechanism.

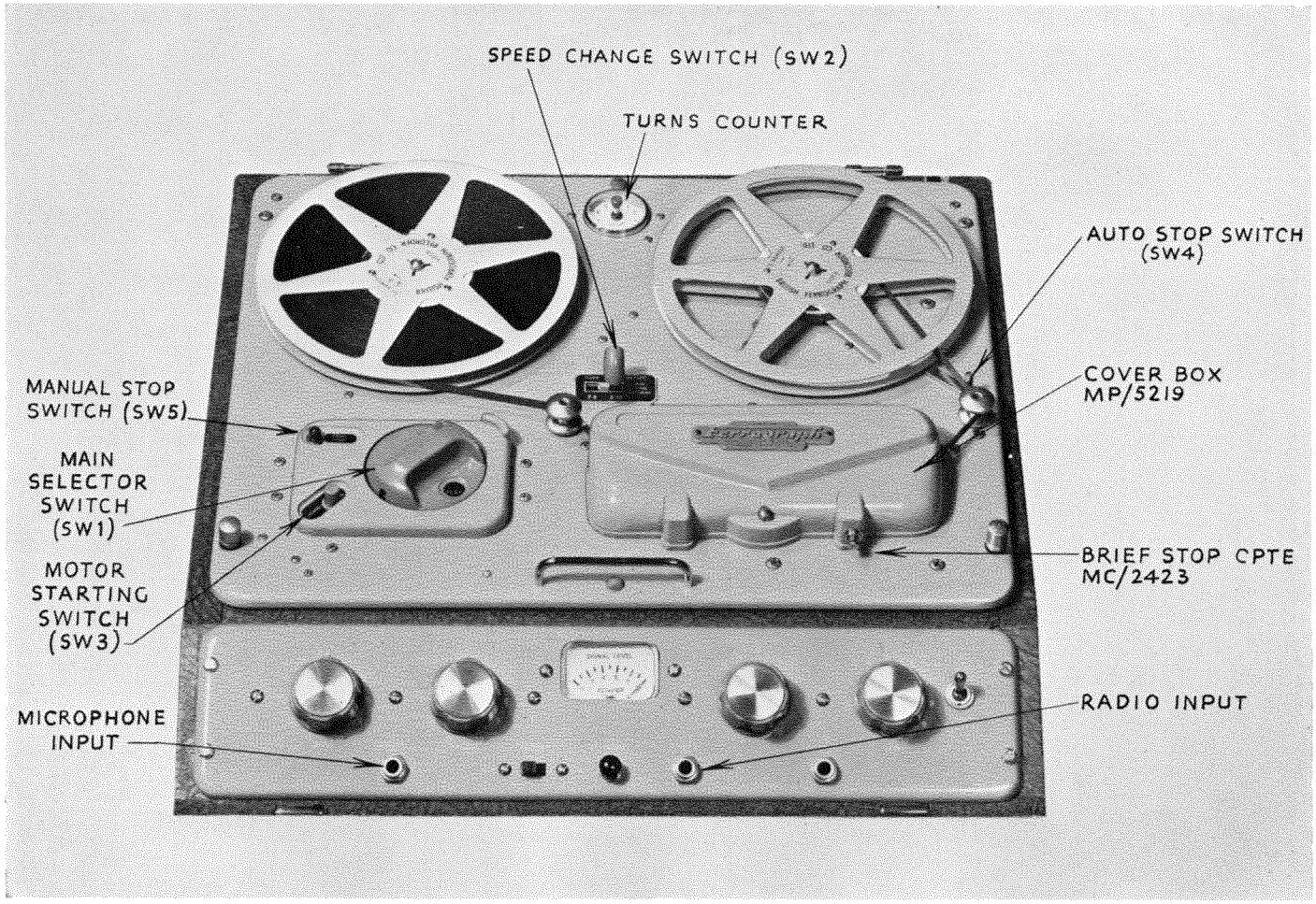

FIG. 4. CONTROLS

3. TO SELECT SPEED FOR RECORD OR PLAYBACK

On the Model 5A the correct tape speed may be obtained by pulling forward the lever at the centre of the "Tape-Deck" and moving it sideways to the required position, when it will spring backwards into the slot. To select the equalisation the knob on the amplifier panel should be turned to the same speed position as the speed selector on the deck, and an interlock arrangement is incorporated so that the starting knob will not lock on unless these two are both set to the same speed. Also, as it is not advisable to change speed with the tape running, this interlock is arranged to stop the tape on moving the speed change lever forward.

4. TO PLAY BACK

The instrument should be loaded with a tape known to be recorded with a good quality signal, preferably orchestral music at $7\frac{1}{2}$ i.p.s., the correct tape speed and equalisation selected, the main function switch turned to the 'PLAY' position and the starting knob pulled on. If the gain control is rotated clockwise the recording should be heard playing back on the internal speaker.

At this stage the operation of the tone controls may be briefly investigated. Counter clockwise rotation of the left hand knob will gradually remove the bass from the reproduction, whilst the next knob controls the upper (treble) register and counter clockwise rotation removes the high frequencies. Both these controls are dealt with in greater detail in Section 8.1.

5. WINDING BACK AND WINDING ON

To wind back rapidly for playing over again, or to return to the start of a recording, it is merely necessary to turn the main function switch to the position where 'FAST' and an arrow pointing to the left appear in the knob aperture, then pull the 'RUN' knob. The amount of tape to wind back is indicated on the dial at the rear centre of the deck. This turns counter is driven from the take-up motor via a worm gear and flexible cable and has a scale calibrated from 0 to 10 with 10 sub divisions per unit giving 100 small divisions covered by one revolution of the large pointer. At the same time the small pointer moves 10 small divisions to the figure 1 on the scale. The gear ratio is such that one revolution of the take up reel corresponds to a movement of one small division by the large pointer, so that the full scale is equivalent to 1,000 turns, and these and any intermediate number can be read to one turn giving a good cueing indication. A 1,200 feet reel of standard tape will give a total reading of approx. 1,030 on the dial and with "extra play" tape this might further overrun to around 1,500.

A zero setting device is provided, operated by the small external knob projecting from the centre of the dial.

The wind-on facility operates in a similar manner and provides a means of rapidly reaching any particular part of a recording in the middle of a reel. It is possible to turn the selector switch from one fast wind position to the other without stopping the tape, thus enabling the user to "shuttle" to the correct position.

During both the wind-on and wind-back operations the internal speaker will automatically be silenced, unless the speaker switch is in the 'ON' position.

Note. The auto stop switch does not operate during these fast winding operations. It is unnecessary, as the instrument should be under supervision throughout the short time involved.

6. TO RECORD

Generally speaking, in the average application one or two sources will provide the material to be recorded :—a radio receiver or a microphone. In the latter case the recording is usually spoken of as "live".

Two input sockets are available on the "Ferrograph" each providing the best arrangement to deal with the particular source involved.

A characteristic common to all recording is that the erasing head on the machine will be operating throughout this particular process. It is not necessary to load the machine 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. Recording from Radio Receivers

There are several methods which can be employed to inject the radio signal into the recorder. The most popular, since it can be done without modification to the receiver, is by the use of the extension speaker sockets. This, with some other systems, is dealt with in detail below.

6.1.1. Extension Speaker Socket System

Most modern radio sets have extension speaker sockets brought out at the rear and 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 similar to that supplied with the intrument. The appropriate socket on the recorder in which to insert this plug is that marked Input 2 (see Fig. 4).

Extension speaker sockets are themselves of several types. Some are merely placed in parallel with the set's internal speaker and are alive under all conditions.

Others come into operation only by means of a switch which may or may not disconnect the internal speaker. In those cases where the internal speaker of the set is left connected, nothing further need be done except to ensure that if one of the connections is earthed at the receiver, the same lead is connected to the earthy side of the input plug at the recorder. (This is the longer connection blade under the jack plug cover).

Where insertion of the extension speaker plugs requires that the internal speaker shall be disconnected, it will be necessary to connect across the extension leads at some point, near either the set or the "Ferrograph", a resistance equal to the loud-speaker impedance (normally about 3 ohms) so as to maintain the load on the output valve of the receiver.

This done, the desired station should then be tuned in and brought up to a good listening level on the set's own speaker. Any tone controls should be rotated to the normal or highest fidelity positions. With the "Ferrograph's" main selector switch in the 'Play Back' position, the extension connection may then be made when, subject

to rotation of the instrument's gain control, the programme matter should be audible on the "Ferrograph's" own speaker. A fairly strong signal is desirable from the set so as to be appreciably greater than any hum produced in the receiver's output stage.

If the main selector switch is now turned to the "Record" position, two things will happen. The internal speaker will be silenced and the recording Signal Level Meter in the lower panel will commence to read. Taking these in order, the fact that the recorder's speaker is silenced will be no inconvenience if the receiver's own loudspeaker is working. If it is necessary that the receiver's speaker should also be silent when the extension facility is being used, the speaker switch on the front panel may be set to "ON", when the internal speaker will operate and can be used for monitoring purposes. However, the normal position for this switch will be "OFF". (The reason for this silencing of the speaker is discussed in Section 6.3.).

The Signal Level Meter fitted to the Model "5A" "Ferrograph" is of a special pattern. It will have been observed that when not switched on, its pointer occupies the extreme right hand scale position, although the scale at that point reads 10 and not zero. This is intentional, and has been done for a special purpose.

When the main selector switch is turned to 'Record' the meter circuit will be energized, and in the absence of a signal the pointer will automatically move to the normal zero position. At this point its zero should be set. To do this the gain control of the recorder should be turned fully counter-clockwise so that no signal is presented to the recording network. The knob marked 'Set Zero' should then be rotated slightly in order to make the pointer of the meter coincide approximately with the zero scale mark. If the gain control of the recorder is now turned up the meter will commence to indicate the relative readings of the material to be recorded. It will be found to climb very rapidly at the commencement of loud passages or short loud signals, but to fall comparatively slowly as softer passages follow. Its object is to provide a means of ensuring that all signals, even those of short duration, do not exceed a certain maximum value indicated by a red graduation at '8' on the meter scale. This is the value which should not be exceeded if a recording of low inherent distortion is to be made.

For many applications, *e.g.* speech, it is not quite as critical, as the ear is tolerant of a certain amount of distortion in certain cases, but with high quality programme material, careful attention is worth while.

Only the loudest signals should drive the meter up to the specified maximum reading, and the gain control should be so adjusted on typically loud passages before actual recording commences. Once set, it should not be necessary to readjust the gain control during recording, as the station or studio engineer will be monitoring the programme in a similar manner to prevent overloading the transmitter.

On soft passages the meter may scarcely rise at all, but providing that with the same gain control setting it has previously risen to the stated maximum mark, there need be no cause for concern. There is always a tendency at the beginning to turn up the gain control when the meter appears to read very low in a mistaken idea that the

programme will not be recorded sufficiently loudly. This must be resisted, as it will be found that subsequently, when a loud passage comes along, overloading will result. Once the recording is overloaded, turning down the gain control during playback will not remove any distortion which has been introduced.

Having thus ascertained that the receiver is properly tuned in and that the signal level is correct, the tape may be started and the recording proper commenced. The turns counter reading should be noted at its commencement, so that it may be wound back to without difficulty for playback.

6.1.2. Direct from Detector System

The method described above is perfectly satisfactory from well designed receivers. Cases may arise however where poorly filtered H.T. supply systems may cause hum to be generated in the receiver's ouput stage, and although this may not be unduly noticeable on the set's own speaker, the superior low frequency response of the "Ferrograph" may make it a source of annoyance.

A better method exists for those who are able to employ it, which involves taking the output from 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 normally associated with such stages. Here the signal will normally be of a lower level, and may be taken into Input 1 of the recorder if adequate gain is not provided at Input 2. If the latter socket is used, and the lead from the detector stage is coming off at high impedance, it will be necessary to insert a shorting plug in the left hand socket (see technical notes on circuitry, Section 18.3.).

In the same category of radio recording may be included the use of specially designed high quality tuner units, which can be powered from the octal socket at the rear of the instrument provided that their supply requirements do not exceed the figures given in Para. 11 (Auxiliary Socket). In general, this will apply to most "AM" tuner units, but not to the "FM" variety (these usually have their own power supply).

A popular tuner unit uses a straight aerial and H.F. section followed by an infinite impedance detector. As it has no output stage, monitoring during recording is usually carried out either through the 15 ohm extension speaker socket or through the internal speaker, when the speaker switch should be set to "ON".

6.1.3. Microphone Method

Although hardly worthy of mention as a serious means of recording, this is included for the sake of completeness. It is a method which should be used only in the last resort when the others are completely out of the question, or when special effects are required. It involves the use of a microphone placed near the loudspeaker of the receiver while it is operating normally. This brings it almost into the category of a live recording and substantially the same remarks apply. It is therefore largely dealt with under this heading.

6.2. Gramophone Record Transcriptions

Where a record player or radiogram is involved, the technique of transcribing gramophone records will be exactly similar to that described above for radio recording insofar as the connections to the recorder and the adjustment of recording level are concerned. It is also possible to take the connections from the pick-up directly into the "Ferrograph", providing that the appropriate low frequency tone correction network recommended by the makers of the pick-up is included in the lead between it and the instrument.

6.3. Live Recording

Live recording involves the use of a microphone and a somewhat different technique, greater attention to detail being required for optimum results. The quality of the final recording will depend amongst other things upon the type of microphone used, the acoustics of the room involved, and its placing therein. A certain amount of experiment may be necessary with the last of these factors before the very best arrangement is found, but this is no great hardship with magnetic recording as during the initial tests none of the medium is permanently consumed.

There are several types of microphone which may be used with the "Ferrograph", ranging from the cheap diaphragm crystal types, through the medium priced dynamics and multi-crystals, to the very expensive moving coil or ribbon dynamics. There is little point in purchasing microphones having a frequency response greatly in excess of the instrument itself and costing almost as much. At the same time it is pointless to restrict the overall fidelity by using the very cheapest. Generally speaking, having regard to all the factors involved, the most suitable for general purposes is undoubtedly the medium priced low impedance moving coil or ribbon microphone. A type of the latter exceptionally well suited to the "Ferrograph" is included in its list of accessories. The necessary matching transformer is also listed.

The great advantage of the low impedance version is that long leads (up to 40 ft.) may be used without picking up unwanted hum, providing the matching transformer is used close to the recorder. High impedance moving coil and crystal microphones may be used, but some care will be necessary with the screening of the cable and connections and it is not normally practicable to operate these with very long leads because of hum troubles. Because of the relatively low output voltage delivered by microphones they will always require to be plugged into the left hand socket (see Fig. 4).

It is during live recording that the necessity arises for silencing the internal speaker to prevent acoustic feedback, particularly where the recorder and microphone are in the same room. This takes the form of a howl as the noise from the speaker feeds back into the microphone, is itself amplified and transmitted again through the speaker in a vicious circle, gradually building up in volume. It is for this reason that the speaker switch should be set to "OFF" when recording with the microphone, and for the same reason the 15 ohm external speaker (if in use) should be unplugged if any sound from it is likely to reach the microphone. It is always desirable during recording to keep the instrument as far

away from the microphone as possible as a certain amount of mechanical noise or vibration from the recorder is inevitable, and where the highest quality recordings are sought it is undesirable that even the faintest unnecessary noise should be present.

The chief point of difference between live recording and recording from a radio signal, is that the studio control of dynamic range usual in the latter is not present. This means that more attention will need to be paid to the signal level meter and the gain control. Because the dynamic range of certain programme material may exceed that of the tape, a certain amount of volume compression may be necessary. This means reducing the level of the loudest passages and increasing that of the weakest so that the former shall not overload the tape nor the latter be lost in the background noise.

With regard to the detailed use of microphones, individual manufacturers will issue appropriate instructions depending upon the types and whether or not they are directional. Here, detailed consideration will be given only to the model listed among the accessories.

This is a ribbon microphone carrying within its case a transformer matching the ribbon to a 30 ohm line, and it is available with a floor, table or desk stand. Its frequency response is entirely suitable for all forms of speech and musical recording. To connect to the "Ferrograph", a matching unit (30 ohm to 1 Megohm) is necessary and this can be supplied either built into the lead or as a separate unit, the latter being advantageous if extension cables are to be used. The microphone head is tablet shaped and may be inclined backward on its mounting. Although it is largely modified by wall and ceiling reflections in normal rooms, under free field conditions the microphone has very little pick-up of sounds originating at the sides, consequently it can be of great value in suppressing unwanted noise.

When it is being used for speech it should be addressed frontally but very close talking should be avoided as this causes bass accentuation with ribbon types. The optimum distance is about 12″. Should closer usage be necessary because of high local noise, speaking should take place across the front at a minimum of 3″. When recording speech with any microphone, an apparent lack of sensitivity might be noted, in that a high setting of the gain control for peak level, compared to that required for singing or music, is necessary. This is mainly due to the peak level meter not following the short duration 'spiky' speech waveform. Accordingly, concern need not arise if the meter fails to reach 8, as much lower average readings will be found to give a good recorded level.

Generally speaking, it is undesirable to use any microphone very closely, particularly if it has been kept in a cold room, for condensation may temporarily affect the performance and if continued may cause corrosion.

Finally, the microphone should be treated with the care it deserves ; never leave it where it may come into contact with steel dust as it incorporates powerful magnets.

6.4. Recording from 600 ohm lines

Input 2 of the instrument will handle adequately the .77V. of 1 milliwatt in 600 ohm lines, and in these circumstances the input plug may be terminated accordingly. The input circuit thus provided will not be balanced to ground, but a 1-1 balanced to unbalanced transformer unit embodying the appropriate jack is available. If the input plug is terminated with 600 ohms it will not be necessary to insert the shorting plug in the left hand socket. (See notes on circuit design, Section 18.3.).

6.5. Simultaneous Live and Relayed Recording

It is sometimes useful to be able to record from two sources at the same time without going to the lengths of a separate mixer unit. For example, a spoken commentary may be required during the transcription of a radio programme or gramophone record. This may be done using the left hand socket for the microphone and the right hand for the relayed material, providing that the input to the latter is arranged to come from a high impedance source, and its level controlled independently of the "Ferrograph". In the case of extension speaker socket systems, the first requirement can be met by connecting a resistance of approximately 200,000 ohms in series with the ungrounded lead to the jack plug and as close to it as possible. This should of course be *after* any low resistance necessary to replace the receiver's speaker load.

7. BRIEF STOP

When making a series of short recordings it may be noticed that a slight click is put on the tape at the start and finish of each recording. Normally this is of little consequence and can be ignored. It can be eliminated however, by the use of the 'brief' stop, the operating button of which is shown in Fig. 4. The action of depressing this pushes the pinch roller off the capstan and holds the tape against the right hand guide peg, stopping the movement of the tape immediately. The housing of the button has a standard Leica camera thread, so that a shutter release cable can be screwed on for remote operation if desired.

8. TO PLAY BACK AFTER RECORDING

As the same amplifier, suitably switched, is used both for recording and playing back, it is necessary to remove all the input plugs from the front of the unit before this latter operation is possible. It is as well to withdraw them while winding back is taking place. Having wound back to the commencement of the recording, the switch can be turned to the "Play Back" position and reproduction commenced. The speaker switch is inoperative on playback.

A 10″ x 6″ elliptical speaker is built into the "Ferrograph" to deliver the sound output and it is capable of very good reproduction. However, certain limitations are inherent in built-in speakers as the small size of the cabinet does not allow special acoustic treatment at the lower frequencies and, where a better acoustic standard is sought, larger speakers in special cabinets should be used. The general performance of the instrument certainly warrants their use and a 15 ohm extension speaker jack socket has been provided for this. It is to this socket, suitably terminated, that all measurements and specifications of frequency response, distortion and output power relate. Insertion of the extension speaker plug will automatically disconnect the internal speaker.

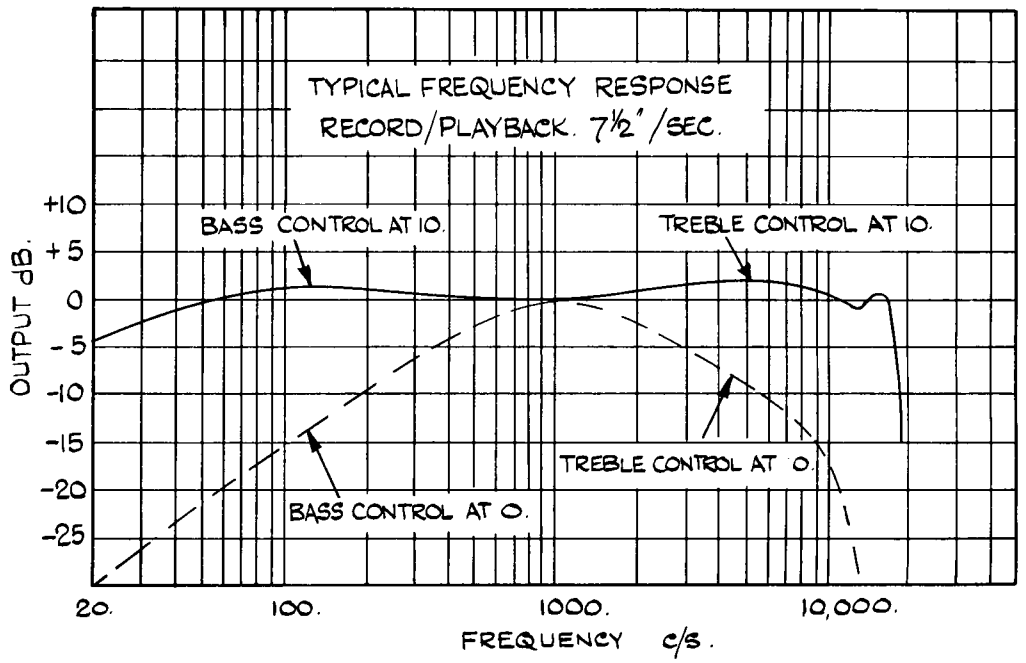

FIG. 5. FREQUENCY RESPONSE CURVE 7½ i.p.s.

8.1. The Use of the Tone Controls

While for many engineering applications the recorder is required to operate as a strictly linear device, reproducing electrically the original signal as closely as possible, in the important general case where the output is listened to directly from a loudspeaker, some ability to modify the frequency spectrum (or tone) is desirable. Here the loudspeaker and the human ear cannot be ignored but must be considered as part of the reproducing chain, the ear being known to have some peculiar characteristics. If, for example, a complex sound is replayed at different levels of loudness, the individual frequency components making up the tone will not always be heard in the same volume ratio. As the sound intensity is increased, the low notes will seem to gradually become more prominent.

The effect of this phenomenon in recording is that, under linear conditions, unless the reproduction is played back at the same sound level as the original, it will not sound *exactly* the same. Speech is usually played back much more loudly than the original and in consequence it often sounds somewhat boomy. It is here that the bass control is properly brought into play to remove this undue emphasis.

Again, to preserve naturalness, an extended bass reponse is out of place unless balanced by a corresponding extension of the higher frequencies from a certain mid-value. Thus if for any reason the high frequency response has to be restricted *e.g.* to eliminate hiss from disc or radio, a proportionate cut in bass can be made to restore the naturalness of the reproduction. The treble tone control operates from about 2,000 c.p.s. upwards and the bass control from 500 c.p.s. downwards, as shown in Figs. 5 and 6.

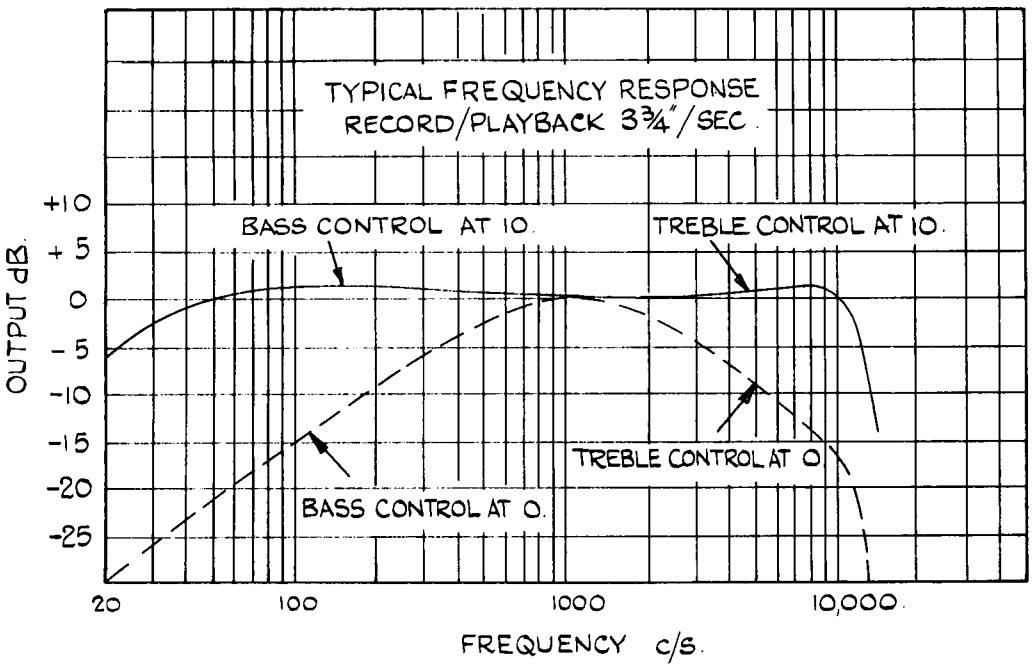

FIG. 6. FREQUENCY RESPONSE CURVE 3¾ i.p.s.

The pre-set controls inside the recorder are adjusted at the factory so that a level frequency response is obtained when the two controls are set to the fully clockwise position (scale reading 10), which is their normal setting.

8.2. To play back over other Amplifiers, Disc Recorders, etc.

Occasions often arise where it is desirable to playback recordings over existing sound distribution networks, P.A. systems, etc. Alternatively it may be necessary to feed the ouput into a disc recorder for dubbing purposes. In both cases adequate provision has been made in the 15 ohm outlet socket. No fear need be entertained here that the remarks concerning receiver output apply. The output stage necessarily has had to receive special attention as it is part of the recording amplifier. The only precaution to be observed is that the plug employed to take off the output shall be shunted with a 15 ohm resistor to provide the load on the output valve, as the internal speaker will be disconnected by its insertion. Comfortable peak output levels of 3 Volts or so are obtainable in this way. Should this be greatly in excess of the requirements, it is better to attenuate it by tapping off the 15 ohm resistor than by too drastic use of the instrument's gain control.

In cases where the use of this low impedance output is undesirable—and indeed they are very few—it is possible to extract a signal at high impedance before the output stage of the amplifier. It is obtainable at Input 2 (acting as an output) and provides approximately .75V. peak across an effective impedance of approximately 100,000 ohms. It is

not subject to the instrument's gain control, and since it is merely in parallel with V.3 grid (see circuit), the load into which it feeds should not be less than .2 Megohms. In this application, of course, a shorting plug must not be inserted in the left hand socket.

NOTE.—Such equipment will invariably be earthed at some point or other, which means that by its connection the "Ferrograph" will also be earthed indirectly. As it incorporates a very high gain audio amplifier, it may be found that on certain mains supplies at certain times, a slight high pitched hum will be audible. Reversing the mains input connections to the "Ferrograph" will almost always effect a cure. In the same way under other conditions and mains supplies, it may be found that a common earth connection will reduce any slight residual electrostatic hum pick-up. In any case it is always worth while reversing the mains leads and noting the effect on residual hum level.

9. TO ERASE UNWANTED RECORDINGS

It must be borne in mind that when the main selector switch is in the 'Record' position the oscillator supplying the erasing head is energised and that if the tape is run in this position, any previous signal on it will be erased. Accordingly, the switch should only be turned to this position when it is desired to make a new recording or when the erasing facility is purposely required. To erase unwanted material without impressing a new signal, the tape should be run in the 'Record' position over the desired length with the gain control at zero. Failure to turn the gain control to zero may result in a whistle being put on the tape in place of the original signal, due to amplifier instability in the absence of an input plug. Erasing by this means deals with only one track of the tape, the other track is completely unaffected.

There is another method of erasing small excerpts—not to be highly recommended—which involves passing the particular piece of tape concerned over a small permanent magnet. This naturally affects both tracks since its field cannot be confined. It also leaves the particular piece of tape with a relatively high background noise. Recordings may also be erased from tape in bulk, while on the reels, by a special bulk eraser.

10. RECORD LINKS

On the rear panel of the recorder will be found two small shorting plugs marked 'Disconnect' —'Bias & Erase' and 'Erase Only', respectively. The former, known as the Erase Link, is in the lead from the supersonic oscillator output and its removal literally disconnects the erase and bias supplies to the deck. Similarly the latter, known as the Superimposition Link, disconnects the supply to the erase head when removed. The application of these features is given below.

10.1. Erase Link

The Erase Link plug is labelled 'Disconnect Bias & Erase' and has a two-fold purpose. Firstly by removal of the plug, it ensures that recordings cannot be accidently erased, and this 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 signals (*e.g.* spoken comments) 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 this arrangement is to provide a gradual but complete fade out of the previous recorded material, a smooth insertion of the new material followed by a gradual restoration of the original.

This is achieved by plugging into the 'Bias & Erase' socket a new plug which is connected by a foot or so of twin lead to a 1,000 ohm wirewound rheostat of 4 Watts dissipation and with a logarithmic characteristic. Having carefully noted, by time interval or turns counter reading, the positions at which the interjection is required, the instrument is turned to "Record" but with the variable resistor set to the maximum resistance position, the new recording level set and the tape started. However, running in this way no erasure (or recording) takes place.

As soon as the appropriate point is reached the variable resistor is rotated slowly to its zero resistance position. At this point both the erase and bias will be fully operative, the old material will have been faded out and the new can be inserted. When this is finished the resistor should be rotated slowly back to its maximum position, when the original signal is no longer erased.

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.

10.2. Superimposition Link

The Superimposition Link is labelled 'Disconnect Erase Only', and its removal disconnects the erase head supply 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, the record head bias will 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 volume of which will need to be judged by experience. If it is required to diminish this erasure, a variable resistance (3,000 ohm, logarithmic) could be connected in place of the 'Bias & Erase' plug and the bias reduced to obtain the required balance in quality of the two recordings. The actual synchronisation of the two recordings will have to be attempted using accurately noted time intervals or with the counter readings as above, when quite reasonable results can be obtained with practice. For more accurate synchronisation a monitor head and amplifier are required, although the $\frac{1}{4}$ second delay between monitor signal and record signal at $7\frac{1}{2}$ i.p.s. may prove awkward at first.

By suitable use of the Erase Link and Superimposition Link facilities, a variety of recording effects can be obtained. The 1,000 ohm potentiometer is now included in the list of accessories available for use with the "Ferrograph".

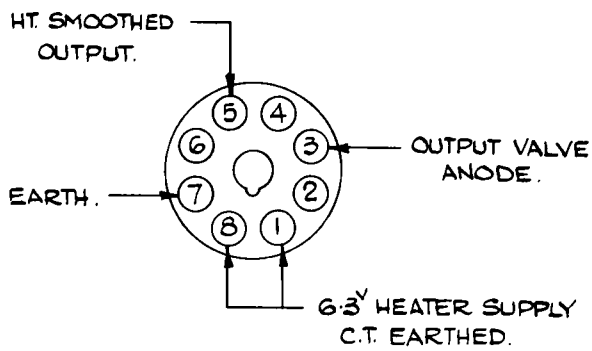

FIG. 7. AUXILIARY SOCKET WIRING

11. AUXILIARY SOCKET

To increase its scope, the "Ferrograph" is provided with an international octal (valve base) auxiliary socket which is located on the rear panel. From it may be taken both H.T. and L.T. supplies for powering ancillary equipment such as tuner units, mixers, etc. The appropriate connections are shown in Fig. 7., and it should be noted that the L.T. winding has its centre tap connected to chassis.

During recording, 1 Amp of L.T. (6.3 V., A.C.) and 15mA of H.T. (+250 V., D.C.) may be taken from this socket, with an increase of 40mA H.T. current on playback only. Also on this socket is a connection from the anode of the output valve.

A suitable octal plug to fit the socket is given in the list of accessories in Appendix C.

12. TO CHANGE TRACKS

The manner in which the tracks are disposed upon the tape is shown in Fig. 8. The advantage of this system is that two tracks can be accommodated side by side, thereby doubling the length of playing time per reel. In practice the system is operated in this way. After a full half hour's recording has been made upon the top track in the normal way, the magazine reel will be empty and all the tape will be on the take-up reel. The reels are then removed and the

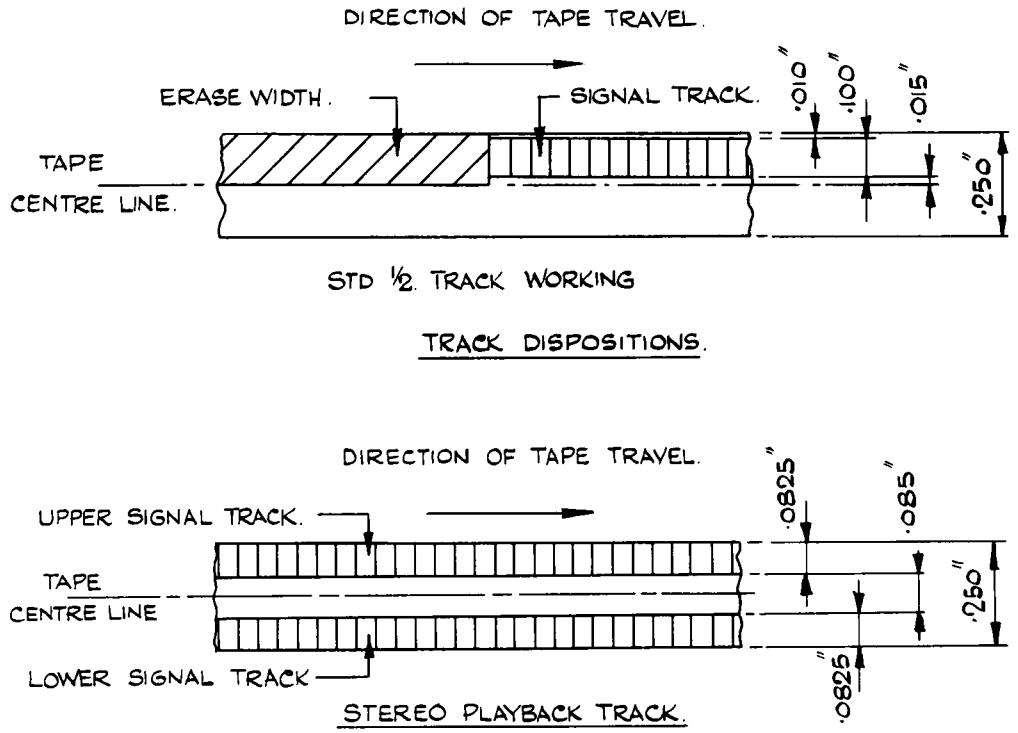

FIG. 8. TRACK DISPOSITIONS

full reel is inverted on to the magazine spindle. The empty reel taken from this position is moved to the take-up spindle. The full magazine is henceforth treated in the same manner as a straightforward unrecorded reel. After the second track has been fully recorded the tape will, of course, be found to be wound back on to the take-up spool in such a way that if the reels are again transposed, immediate playback at the start of the first track is possible. One hour's recording or playback is therefore available at $7\frac{1}{2}$ i.p.s. with a break of only a few seconds half way, for the reel transposing operation.

If necessary, the tracks can be reversed in the middle of a reel by turning the main selector switch to fast wind and raising the head cover box. Both reels are then removed and inverted in the same direction, the tape being repositioned as for loading, with no twists. The reels are then refitted.

13. EDITING AND SPLICING TAPE

One of the great advantages of tape recording is that is is easily edited. Unwanted passages

may be cut out and the ends rejoined. Composite programmes of selected material may be built up in this way. It is of course only possible to edit one track, though cutting out pieces of the tape obviously affects both tracks. However, once the editing has been done for the single track, the composite tape may be put back on the recorder and the other track recorded in the normal way with material which does not require editing.

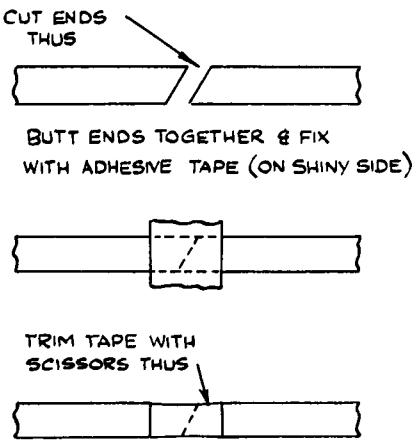

FIG 8 TAPE SPLICING.

FIG. 9. TAPE SPLICING

Splicing and joining of the ends of cut or broken tape is normally carried out by means of suitable adhesive tape applied to the back *i.e.* the shiny side of the tape. Fig. 9 makes clear the method of doing this.

14. SPOOLS

Several sizes of spool are available as follows :—

200 ft.	giving	5	mins	per	track	at $7\frac{1}{2}$	i.p.s.
600 ft.	„	15	„	„	„	„	„
1200 ft.	„	30	„	„	„	„	„
1750 ft.	„	45	„	„	„	„	„

The ability to take the last mentioned large reel, which is a feature of the Series 5 "Ferrograph", will be found of the greatest use, particularly to music-lovers where it will enable many more whole works to be recorded on one track without a break.

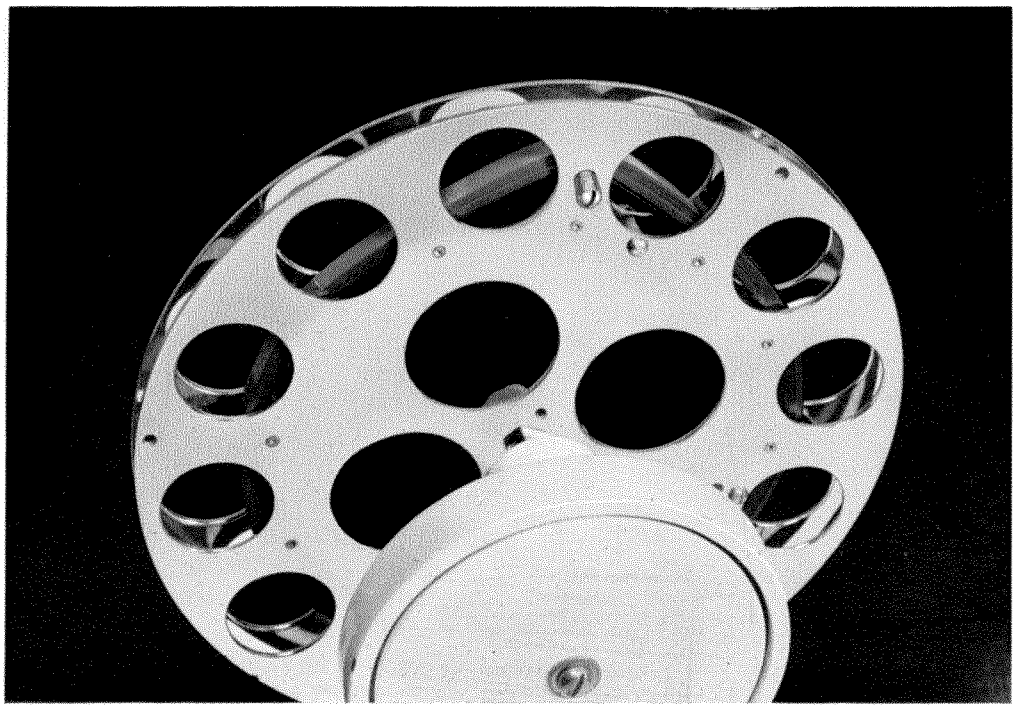

FIG. 10. LOADING OF LOOP CASSETTE

It should be noted however that the large reels slightly overhang the deck and it is not possible to replace the lid of the instrument with these reels in position. For the same reason no attempt should be made to hinge back the deck when these reels are fitted.

15. 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 mins. at $7\frac{1}{2}$ i.p.s. or 8 mins at $3\frac{3}{4}$ i.p.s. 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 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 automatically or manually the deck is shut down so that afterwards, on playback, the conditions leading up to the establishment of the fault can readily be traced.

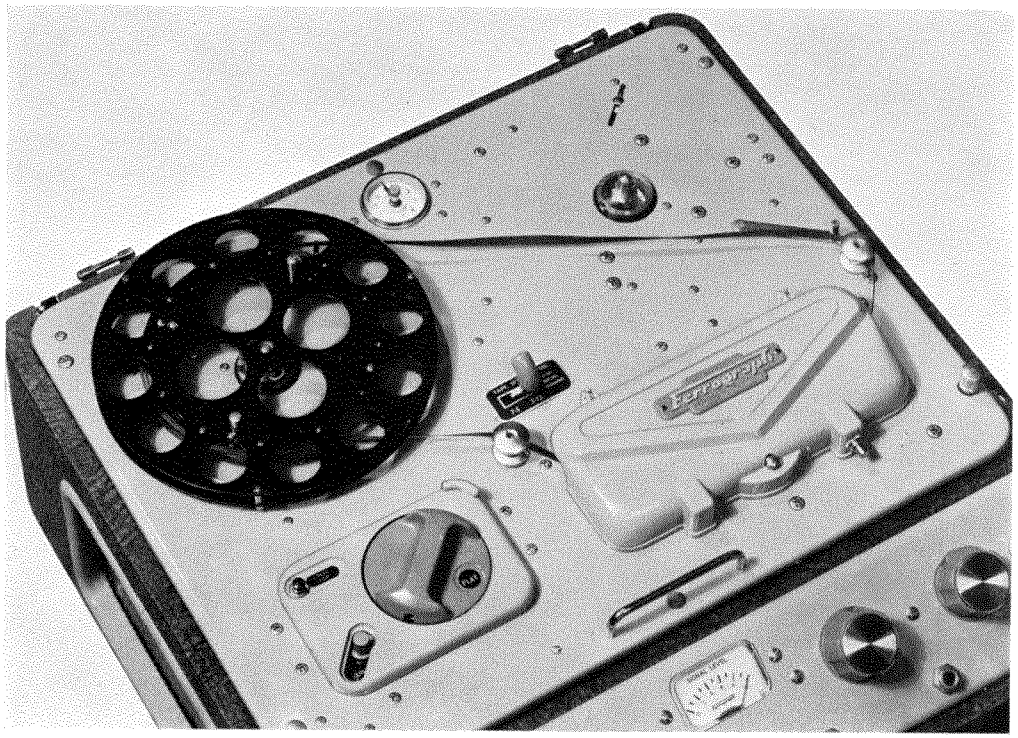

FIG. 11. LOOP CASSETTE IN OPERATION

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 O and 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 $7\frac{1}{2}$ i.p.s. the tape velocity is $37\frac{1}{2}$ ft./min., and at $3\frac{3}{4}$ i.p.s. it is $18\frac{3}{4}$ 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 layers of tape 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. 10. 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

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. 11 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 ($\frac{1}{2}$ 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 auto stop arm.

When first run after loading on to the machine, 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 loop has been running for some few minutes the tape can then be re-spliced at the original joint 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. 11 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.

16. STORAGE OF RECORDINGS

Where a library is being compiled, or where individual recordings have to be stored for indefinite periods, care should be taken to see that the tape is wound evenly and fairly tightly on the reels before storage. Do not keep them where they are likely to be subjected to heat, mechanical vibration or magnetic fields. Above all, protect the reels from damage—buckled reels can cause "wow" if they scrape on the deck, or an unpleasant mechanical noise as the tape rubs past their bent edges.

17. 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 surfaces 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 used gently. 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 /playback head is a vital part and its working face should be treated with great care. After a time it will have acquired a very high polish, and this is a very desirable condition to be maintained. Never allow any abrasives to come into contact with it, and never approach it with steel tools which may have become magnetised. Furthermore, never attempt to remove the cylindrical head cans, as the gap setting or the alignment of the head faces may be upset with serious results.

The capstan and pinch roller also require great care to see that their surfaces remain undamaged. Here too, tape coating material and dirt may accumulate causing "wow". New tape quickly leaves a fine deposit, so periodically, or whenever they are suspected of causing poor tape transport, these surfaces 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 Aeroshell fluid number 3 should be introduced into the top and bottom bearings of each 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.

If desirable, due to 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.

Apart from such tasks as replacing fuses if necessary, this is about as far as the unskilled should go in the matter of adjustment. Anything further, for example adjustments under the deck, should be left to the approved service engineers who have the necessary specialized instruments for the correct setting.

The manufacturers can accept no responsibility for faulty performance caused by tampering with the setting of any internal components or controls.

18. TECHNICAL DESCRIPTION—DESIGN DETAILS

A full theoretical circuit is given in Fig. 20, but the circuitry notes are appended by way of amplification of some of the less obvious points which may have a bearing on certain engineering applications.

18.1. The Mechanical Unit

The mechanical unit is situated entirely on the hinged deck of the instrument. Three motors are employed; one, running counter-clockwise when energised, takes up the tape after it has passed through the capstan assembly ; the second, running clockwise when energised, rewinds the tape after recording. During the record and playback functions this motor is partially energised to maintain a small back-tension on the tape. The sole function of the third motor is to drive the capstan/flywheel assembly. It is a split phase capacity type induction motor with sufficient reserve of power to make it relatively insensitive to small changes of applied voltage or load, and therefore its speed, 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 brass pulley against each step of which is a neoprene rimmed idler wheel driving a heavy flywheel. Rigidly coupled to this flywheel is the capstan proper, having a brass bush to which is bonded the loaded neoprene traction surface. This assembly is mounted on greased angular contact ball races, rendering any regular lubrication unnecessary.

The head assembly consists of the dual purpose record/playback head X5, preceded by the erase head X4. The erase head is mounted rigidly on the base plate but small shims are usually fitted underneath for exact adjustment of its height. The record/playback head is screwed to a small metal plate which pivots on two cone pointed screws on its centre line, one at the front and the other at the rear. These screws, turned by a 6 BA Allen key, fit into tapped holes in the plate and are locked by 6 BA locknuts. They are used to set the head height correctly. The plate and head may be rocked over a small angle by a screw at the right hand front corner. This is to enable the gap of the head to be aligned against a standard recorded tape so that all instruments will have a gap precisely at right angles to the tape travel and so ensure that a recording made on one can be played back on another without the loss of high frequencies which would occur if the recorded track and gap were at different angles.

On the immediate right of the head X5, *i.e.* following it, is head position 3. This consists of a small cast body, pivoted to permit gap alignment and containing a valve holder into which any Ferrograph record/playback head may be plugged and screwed down firmly. For height adjustment between head and tape, shims may be inserted between head and body. To the rear and left of head position 3 will be found the adjusting screw for its gap alignment.

Model 5A is issued with a "dummy" head in the third position, but this can be replaced at any time with either a stereo head type FP16 to convert to model 5S or a standard head type FR7A for monitor purposes. In the latter case the monitor amplifier should be connected to the 'UT' socket on the rear panel and if a head matching transformer is required it should be type 977.

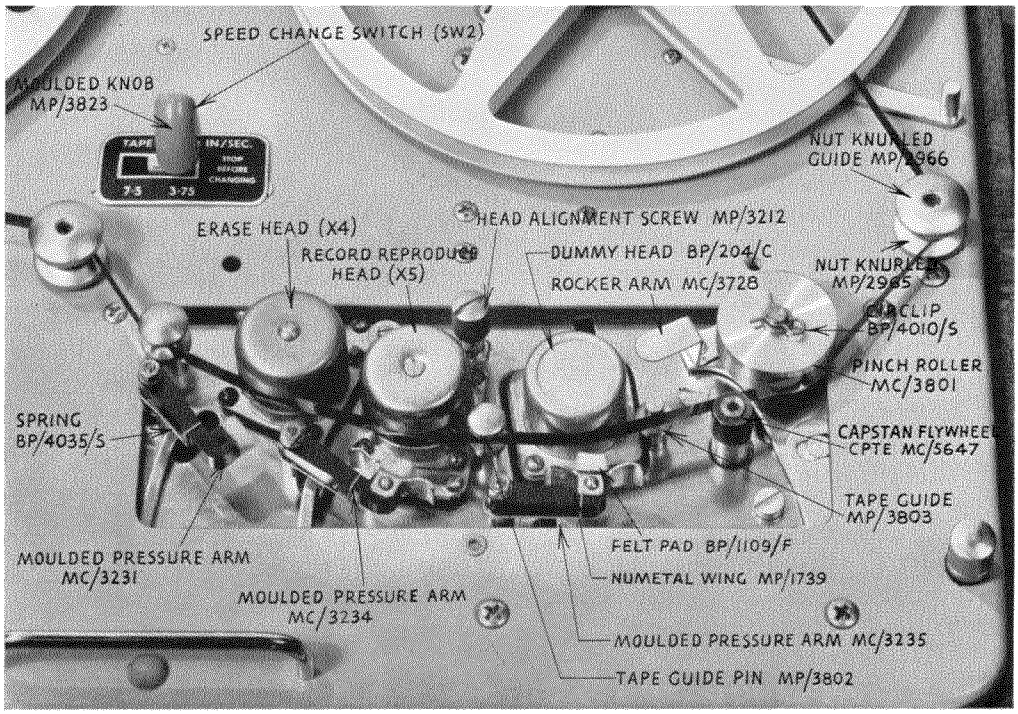

FIG. 12. HEAD AND CAPSTAN ASSEMBLY

The manner in which the tracks are disposed on the tape is shown in Fig. 8. It will be observed that the erasing track is ·025″ wider than the signal track to ensure complete erasure, and the heads are aligned on the plate so that the spreading is substantially equal on either side of the signal track.

Behind and to the right of the head assembly is situated the Automatic Stop Switch SW4, consisting of a swinging arm above the deck coupled to a moving contact underneath the deck, and at the end of this arm is a short vertical rod resting lightly across the tape between the right hand bobbin guide and the take-up reel. In normal operation, on record or playback the light spring tension on this arm is offset by the tape tension and the switch is held off. Should the tape run out or break, or the take-up reel stop, the arm will be pulled inwards, the moving contact will connect with a fixed contact and will short out the solenoid, thus releasing the starter bar.

The Automatic Stop does not function during the fast winding operations, when the arm is held clear of the tape mechanically, but as winding on or back is 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, the knob of which protrudes through the small panel at the front left of the deck. Pulling this arm diagonally towards the front of the equipment operates the main motor

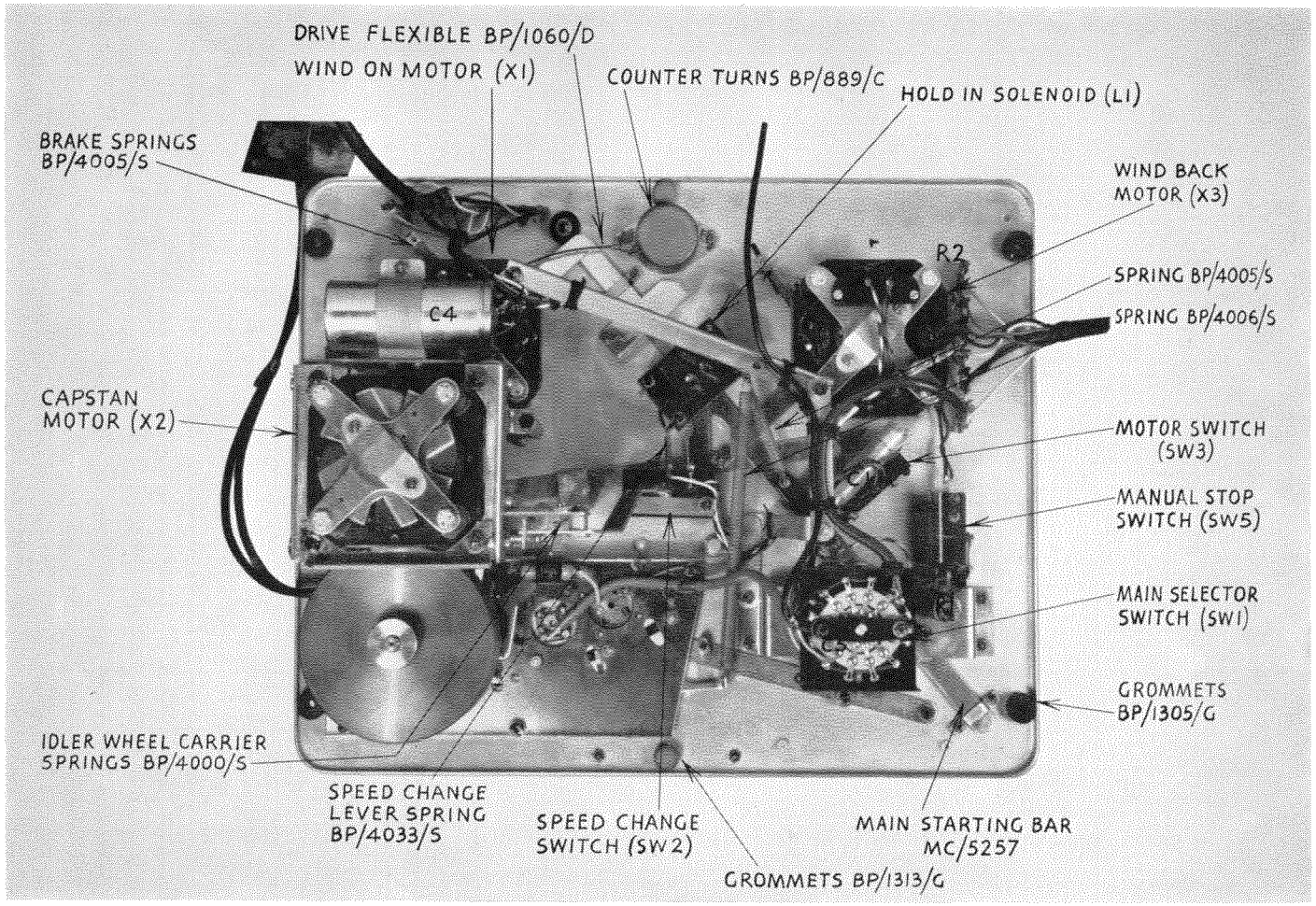

FIG. 13. TAPE DECK, UNDERSIDE VIEW

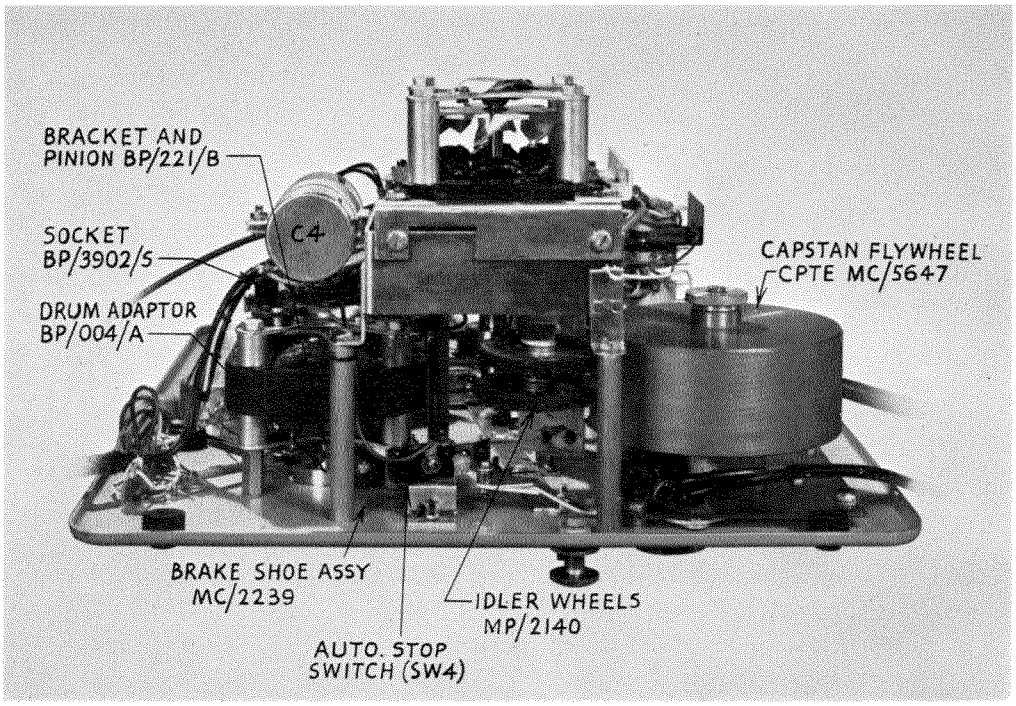

FIG. 14. TAPE DECK, SIDE VIEW

switch (SW3), across which is capacitor (C1) 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 energised from the negative side of the H.T. feed to the amplifier. To stop the instrument this solenoid is shorted by the push switch (SW5) or by the contacts of the auto stop switch previously referred to, when the arm is allowed to return under its spring tension. This switches off the motors and applies the brakes to the reel drums. These brakes are so arranged as to have self-wrapping properties, that is to say 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 tension 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 pressure roller and the neoprene rimmed idler wheel of the motor 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 rubber parts, which may be caused if they are left in engagement under spring tension for prolonged periods. On switching off, these members are knocked out of engagement.

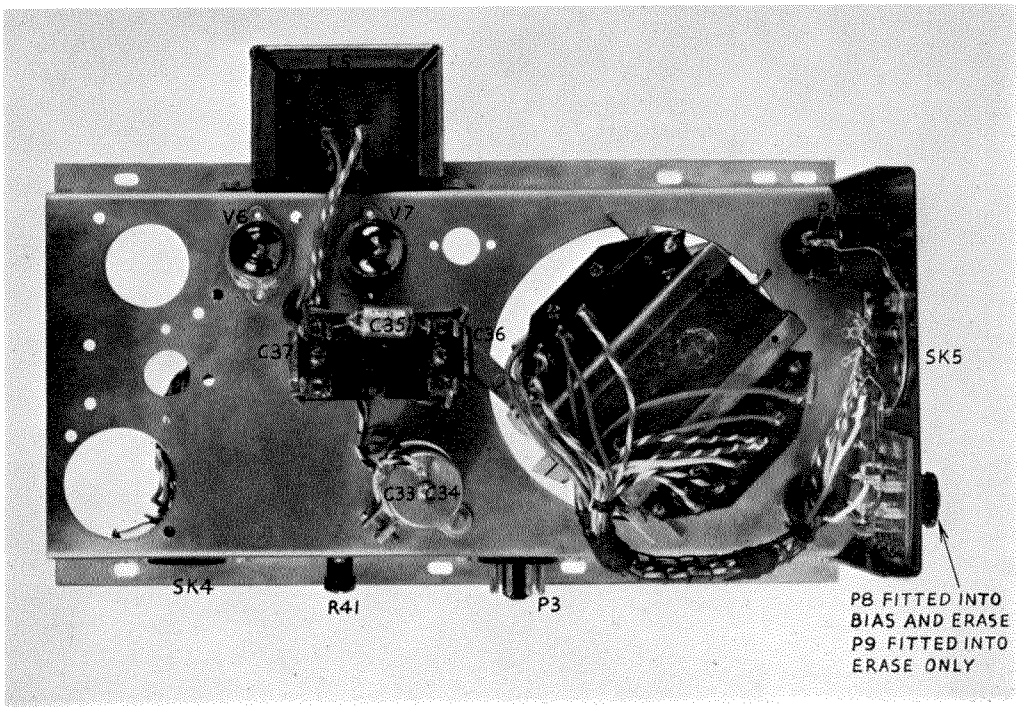

FIG. 15. POWER UNIT, TOP VIEW

The appropriate connections to the heads and motors for the various operations are selected by the ceramic wafer switch (SW1). One wafer of this looks after the motor feeds and H.T. supply to the oscillator, while the lower controls the switching of the head from the record to the playback function. This switch is linked by a cam arrangement to the lever which deflects the pressure pads from the heads, and the capstan pressure roller even further from the capstan during fast rewind or wind on. When these members are so deflected, easy tape loading is possible.

All the connections from the deck other than the head playback lead are taken down through a pair of cables ending in octal plugs and sockets to engage with similar plugs and sockets on the amplifier.

18.2. The Oscillator

Because of the relatively high frequency response of the "Ferrograph" for a $7\frac{1}{2}$ i.p.s. instrument, the oscillator frequency must itself be fairly high and it is set at approximately 68 Kc/s. The oscillator is located on the power unit chassis and consists of a double triode, V6, used in a conventional push-pull circuit with the primary of the oscillator coil L4 tuned by the capacitors C35, C36 and C37.

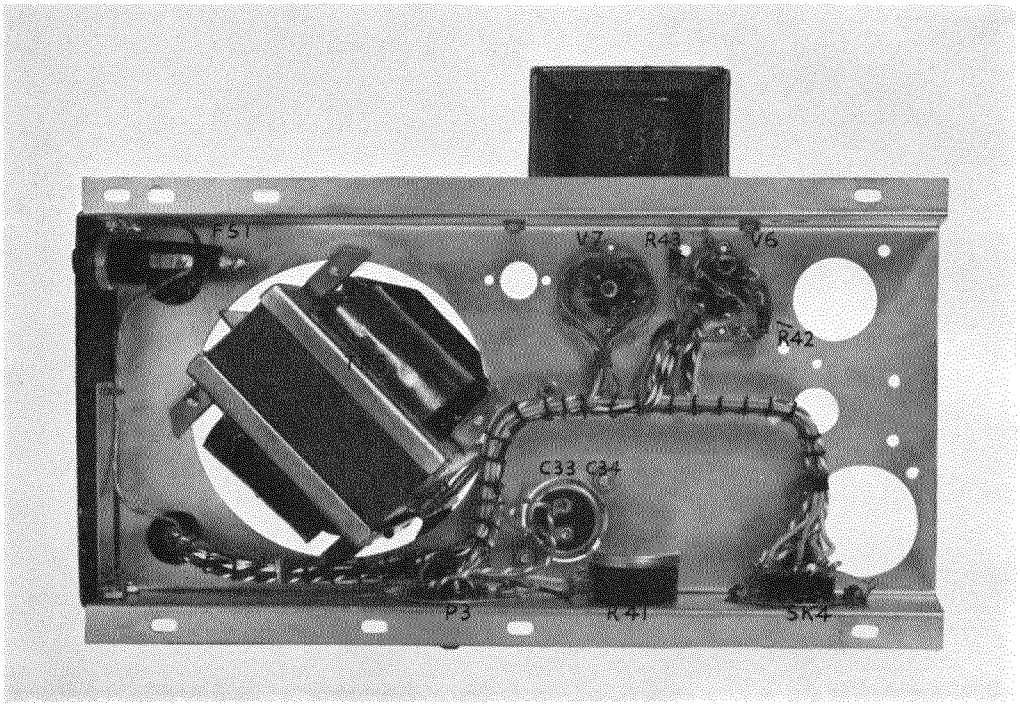

FIG. 16. POWER UNIT, UNDERSIDE VIEW

While this is designed to give as pure a waveform as possible, under certain circumstances individual components of the residual distortion may occasionally beat with the local oscillators of radio sets during recording if adequate spacing and screening precautions are not taken. The remedy is of course to ensure that the aerial and other leads to the receiver are not taken close to the recorder itself.

The output of the oscillator is taken to the heads on the deck via the Erase and Superimposition Links on the rear panel, for the purposes previously mentioned in Section 10.

18.3. Recording Amplifier

During recording, the first valve V.1 is not used. Insertion of the plug into the Input 1 jack disconnects the feed from it and its associated frequency correction network. This is done so that any hum or noise generated in the first stage shall not be passed on to the succeeding stages.

Input 2 is between V.2 and V.3 but is not switched as it is required for extracting signals from previous stages in addition to providing the higher level input feed. This socket is principally intended to work from low impedance sources, *e.g.* 600 ohm lines

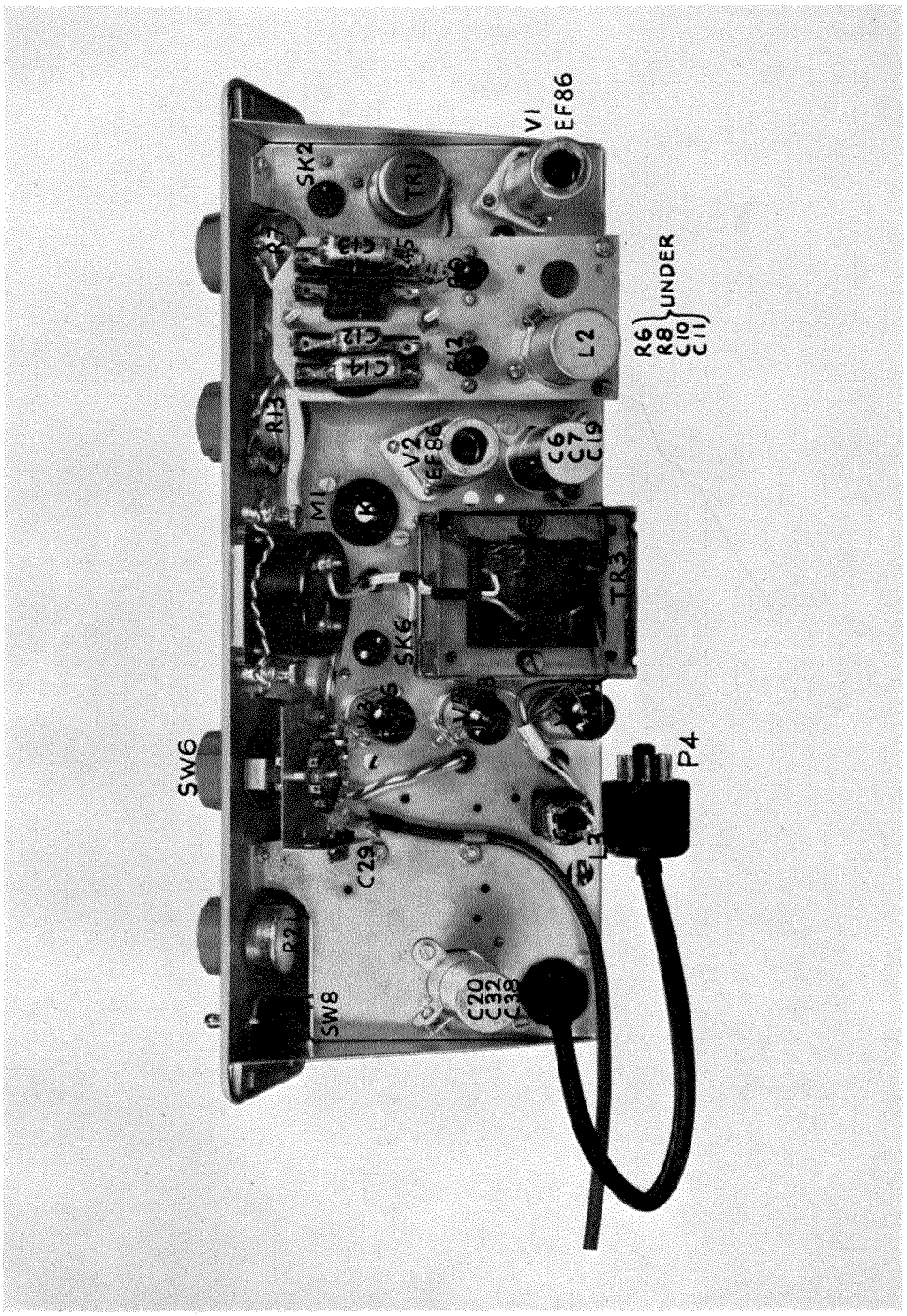

FIG. 17. AMPLIFIER, TOP VIEW

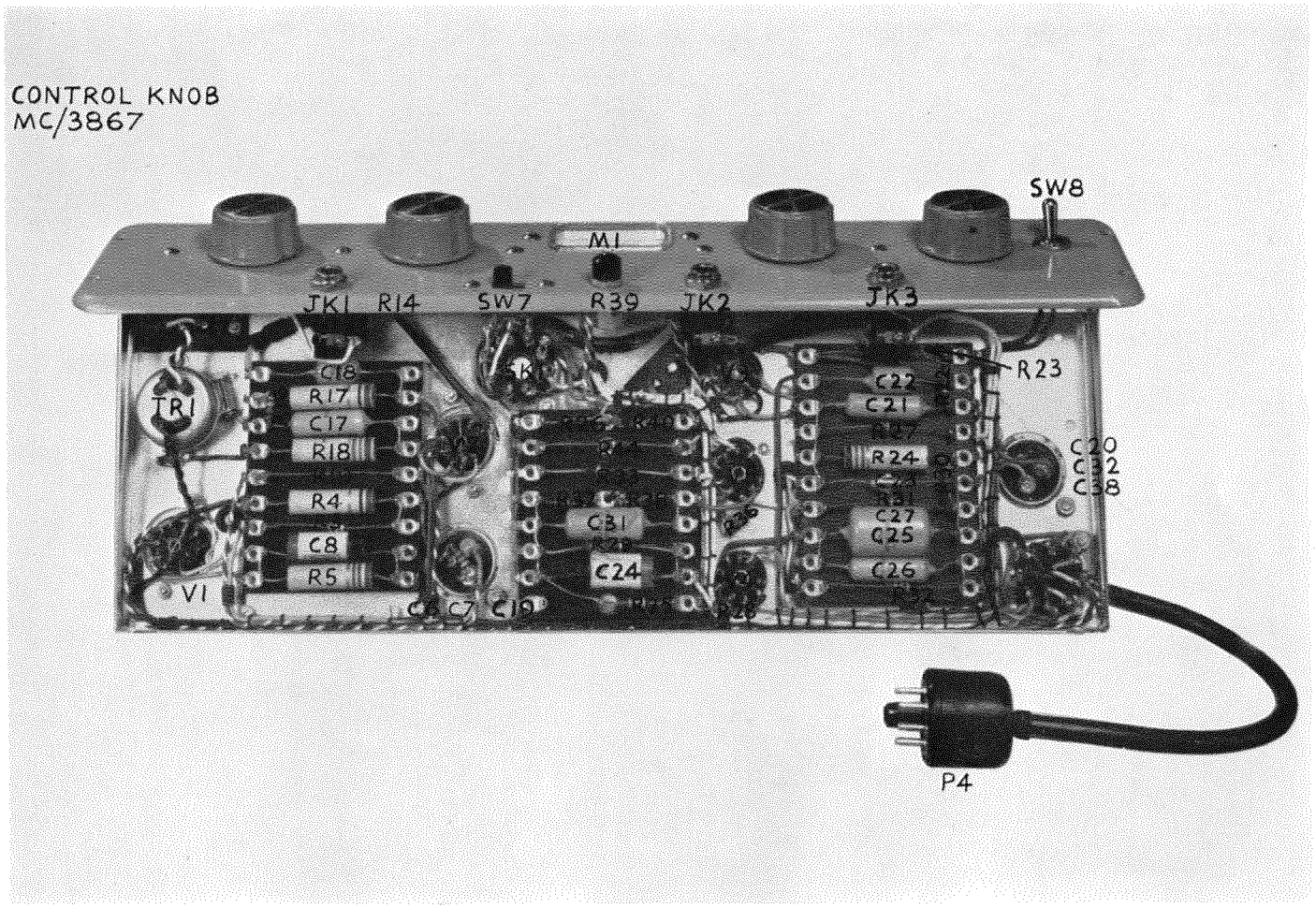

FIG. 18. AMPLIFIER, UNDERSIDE VIEW

and extension speaker connections, where during recording the previous stages will be effectively shorted down and their local noise thereby nullified. Where Input 2 is fed from high impedance sources it is necessary to insert a shorted plug in Input 1 to short the grid of V.2 to ground.

V.3 and V.4 together may be said to constitute the output stage, as the main feedback loop encompasses both, and for recording from Input 2 will provide a maximum voltage gain of approximately 200. Adding V.2, a gain of 7,000 is available from Input 1. The load on the output valve during recording is provided through the output transformer by a 15 ohm resistor or the internal speaker depending upon the position of SW7, or, when the extension speaker plug is in, by whatever load is connected. The feedback makes this reasonably noncritical; thus a 15 ohm speaker, or headphones shunted with a 15 ohm resistor, may be used at this point for monitoring during recording.

The recording amplifier, as far as the 15 ohm output socket is concerned, has an essentially flat frequency characteristic from 50 to 15,000 c.p.s. The recording head is fed from the anode of the output valve through an isolating capacitor and a filter network to provide substantially constant current conditions. A small amount of high frequency pre-emphasis is introduced into this network mainly to compensate for variation of head inductance and consequently flux, with frequency, slightly more being applied at $3\frac{3}{4}$ i.p.s. than at $7\frac{1}{2}$ i.p.s., switched by SW6.

Approximately 25 volts are required for peak modulation at the anode of V.4. The actual value is made to correspond to a reading of '8' on the level meter. The meter is a diode-triode, sustained peak reading valve-voltmeter with a rapid rise-characteristic on transients and a slow die-away. It has been found to be the only truly satisfactory way of ensuring that the greatest signal-to-noise ratio is maintained, consistent with a given maximum value of distortion on peaks, and although costly, is well worthwhile.

To improve the meter characteristics, a reversed zero instrument has been used. When in operation, the meter is backed off to a steady state current of 1mA. by the adjustable "Set Zero" control, in which condition the pointer indicates zero on the scale. The anode of V.4, at which monitoring takes place, is brought out to one pin of the Auxiliary Socket to facilitate measurements.

18.4. The Playback Amplifier

Essentially the same amplifier is used for playing-back as for recording, except that V.1 is brought into circuit. The grid of this valve is coupled to the head by a special 1-5 matching transformer. Between V.1 and V.2 is the frequency correcting network. Because the recording characteristic is on a constant current basis the induced voltage on the head during playback rises at the rate of 6 db per octave up to the point at which self-demagnetization of the tape sets in. The rate at which it falls away thereafter is determined by the tape coating itself. Obviously, a reverse characteristic has to be included in the playback circuit to produce a flat overall response. This is the function of

the network between V.1 and V.2. The unequalised response falls with frequency at the rate of 6 db per octave from the mid-frequency position, and this causes hum to limit the low frequency response possible for a given value of signal to total unweighted noise ratio. The reason for the extensive hum reducing precautions in the deck and amplifier will therefore be appreciated. As has already been described in the text, variable elements have been introduced into the correcting network to provide a certain amount of tone control. Attenuation of both bass and treble is provided, a level response being secured with full clockwise rotation of both controls.

During playback the full negative feedback is maintained on the output valve, consequently distortion is low up to about $2\frac{1}{2}$ watts across the 15 ohm supply and good output regulation and speaker damping are secured. Over $2\frac{1}{2}$ watts, distortion naturally increases very rapidly.

19. TESTING AND ALIGNMENT

Where a major component has been replaced it may be necessary to carry out certain re-alignment of the amplifier network. This section is included for the benefit of the Service Engineer, and details the whole testing and setting-up procedure. It cannot be too strongly emphasised that indiscriminate re-adjustments 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 specialized 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.

19.1. Voltages

Measured with a Model 8 Avometer (20,000 ohms per volt) the following readings should be obtained :—

	On 'Playback'	*On 'Record'*
Voltage between chassis and input to smoothing choke L5 .. .. .. =	285	275
Voltage between chassis and output from smoothing choke L5 .. .. =	275	265
Voltage between chassis and input to deck solenoid L1 .. .. =	—16	—19
Voltage between chassis and junction of R19/R26..	215	200
Voltage between chassis and junction of R15/R19..	157	150
Voltage between chassis and junction of R3/R15 ..	110	105

AC Voltages (245V or 110V, 50 c.p.s. applied)

Valve heater voltage (incl. rectifier heater) = 6.3 $\pm$ 0.2V

Measured on the relevant AC range of an Avometer model "8" (1,000 ohms per volt)

Playback or Record	245V Model	110V Model
Voltage across capstan motor capacitor ..	500V	220V
Voltage across capstan motor input socket ..	225V	117V
Voltage across take up motor input socket ..	150V	80V
Voltage across rewind motor input socket ..	100V	47V

VOLTAGES ASSOCIATED WITH VALVES

On Playback

Valve No.	*Anode Voltage*	*Screen Grid Voltage*	*Cathode Voltage*
V1	37	65	1.3
V2	48	92	1.9
V3	72	120	2.3
V4	254	275	8.5
	On Record		
V5	a′ — 265	—	—
V6	a′ — 265 a′ — 265	—	—

Measured with a valve voltmeter

The 68 Kc/s. bias voltage across the bias winding of the record head (two front pins) should be variable from 7V—22V R.M.S. The correct value for the actual head is indicated on a label on the underside of the deck.

The erase voltage between tags 2 and GR should be 35V—45V R.M.S.

Note. Voltage values are approximate only, especially those connected with V1, V2 and V3 where the tolerances on large value resistors and valves themselves may lead to certain variations.

19.2. Gain

The gain should be checked at 400 c.p.s. for the overall measurement including the head lift transformer. Some form of attenuator with a low output impedance will be necessary, *i.e.* less than 10 ohms.

The test should be made with the bass, treble and volume controls fully clockwise and the output voltage should in all cases be measured across Pins 3 and 7 of the auxiliary socket, *i.e.* at the anode to the output valve.

The following figures should be obtained :—

A. *Overall Gain*
Injecting ·5 m.V. across primary of TR1—a voltage gain of 230,000-300,000

B. *Input* 1 *Stage Gain*
Injecting 10 m.V. into JK1—a voltage amplification of 7,500-8,500.

C. *Input* 2 *Stage Gain*
Injecting 400 m.V. into JK2—a voltage amplification of 175-225.

When testing the stage gains of Input 1 and Input 2 it is convenient to check the frequency responses of these stages. They should be linear from 40 c.p.s. to 15 Kc/s. within ± 1 d.B.

19.3. Equalisation

If a fault is suspected in the equalisation network it may be statically checked according to the table below to ensure that each element is functioning properly over the frequency band it controls. No attempt should be made to carry out this check unless all the equipment necessary for the re-setting of the instrument in accordance with 19.6.4. is at hand. The circuits will have been carefully adjusted at the factory having regard to the fact that different heads will require slightly different treatment in order to obtain a linear response, but in the test it will be necessary to destroy this adjustment.

Using the audio generator with the low impedance attenuator, inject ·5 m.V. at 400 c.p.s. across the primary of TR1. Adjust the volume control (leaving the bass and treble controls fully clockwise) until a reading of 25V is obtained across Pins 3 and 7 of the auxiliary socket on an A.C. meter with a linear frequency response. With the deck and amplifier speed controls set to $7\frac{1}{2}$ i.p.s., voltages as shown in the table should be obtained at other frequencies.

FREQUENCY	OUTPUT METER READING VOLTS	REMARKS (See Figs. 17 and 20)
60 cycles/second	Not less than 125	
400 cycles/second	25	Set by volume control.
2000 cycles/second	8	Set by R9
6000 cycles/second	4·0—8·0	Will depend on value of C12
9000 cycles/second	Not less than 3	Ensure that R12 is fully in.
12,000 cycles/sec.	Not less than 2	
17 Kc/s ± 1 Kc/s.	Not less than 5	This reading to be taken at the frequency where the output "peaks".

The frequency response of the amplifier as set for $3\frac{3}{4}$ i.p.s., may vary more from instrument to instrument, but if the 400 c.p.s. level is set at 25V, the 60 c.p.s. level should be approximately the same for the $7\frac{1}{2}$ i.p.s. equalisation. The 2000 c.p.s. output will depend largely upon the value of R10 and C13 (Figs. 17 and 20), and the resonant peak should lie between 10 and 11 Kc/s and give an output greater than 20V.

19.4. Bias Trap

The purpose of Coil L3 is to form (with C28) a parallel resonant filter at the bias frequency. This is inserted in the feed to the head during recording and by its high impedance prevents the appearance of bias volts, in a reverse direction through the head, at the anode of the signal output valve. Conversly, it prevents the anode circuit of this valve loading the oscillator bias circuit through the transformer action of the head.

The proper adjustment of the inductance of L3 by its iron core is a compromise between adequate bias voltage at the head winding and a low 68 Kc/s voltage at the anode of V4. Complete cancellation of the H.F. appearing at this anode point is not necessarily the condition for proper performance. In general, there should be less than 0·5V of H.F. at this point and it should be possible to adjust the bias volts at the bias winding of the head by the appropriate resistor (R41) up to 22V.

19.5. Head Alignment

As the recorder leaves the factory its recording head will have been aligned so that its gap is accurately perpendicular to the plane of tape travel. This is carried out against a master tape kept for the purpose. It is important insofar as it controls the degree to which interchangeability of recordings between different machines is possible without loss of high frequency response. For this reason the recording head should not be interfered with. In practice it is the component least likely to give trouble.

In cases where derangement of the head setting has been unavoidable, re-alignment will require a test tape carrying a standard signal of high frequency. This is played back and the head is adjusted on the plate on which it sits by the head azimuth screw until a maximum output position is obtained. As the head gap is rocked from one side of the perpendicular to the other, the high frequency output may pass through successive maxima but it is, of course, the greatest of these which represents the position to be finally adopted.

19.6. Checking the Entire Instrument

The complete alignment of the recorder and the measurement of its performance requires a great deal of test equipment. Much of this will not be in the hands of the normal Service Engineeer. In the following description, alternative methods of measuring the various factors involved are given, but it must be pointed out that in some cases these will be little more than estimates, particularly in respect of distortion and "wow".

19.6.1. Recording Level

It is assumed that the tests of gain, etc., previously detailed have been carried out. The next step is the checking of the peak recording level *i.e.* the maximum signal which can be applied to the head network for a given amount of distortion on playback. As the instruments leave the works this level will be set so as to produce not more than 3% total distortion on peaks. The process is as follows :—

With the main selector switch turned to "record" and the gain control at zero check that the bias voltage agrees with the stated value, which is to be found on the small label on the underside of each deck. The bias can be measured with a valve-voltmeter across the two front pins of the record head.

Adjust the recording level meter accurately to zero and inject a source of 400 c.p.s. into Input 1 at a level of approximately 10 m.V. Connect an A.C. voltmeter and a wave analyser or distortion meter between Pins 3 and 7 on the auxiliary socket. Then adjust the gain control until the recording level meter reads 8. Check that the reading on the A.C. voltmeter is between approximately 20 and 28V.

Re-adjust the gain control until the level meter reads 6 and then record a short length of tape at this level at $7\frac{1}{2}$ i.p.s. Stop the tape, making a suitable reference signal or mark and then proceed to record another passage with the signal level meter reading 7. Repeat the procedure at readings of 8 and 9.

Rewind to the start of the test signals and then playback into the wave analyser or distortion meter. Measure the distortion obtained for each signal input level and note that which produces the 3% referred to. This reading is then the proper peak signal level.

This particular test signal may be replayed with the gain control turned fully clockwise so as to check that the playback level off the tape is sufficient to load the amplifier fully. This will be shown by a reading on the A.C. meter of at least 135V above which serious distortion should ensue.

Where a distortion meter is not available, some idea of the total distortion can be obtained by applying the output from Pins 3 and 7 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 can be 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 difficult to give definite guidance.

Should it be found that a meter reading greater than 8 is necessary before the 3% distortion point appears, the values of R38 and R37 may be adjusted so as to produce a lower meter reading for a given applied voltage.

19.6.2. Bias Checking

If a recording 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:—

Record a 200 c.p.s. note at a level of approximately 3 on the meter with values of bias voltage (as measured across the two front pins of the record head with a valve-voltmeter and obtained by adjusting R41) of 6, 8, 10, 12 and 14V. Play back these test recordings with all controls at their clockwise maximum and note the output voltage across Pins 3 and 7 on the auxiliary socket corresponding to each different bias setting.

It will be found that the output voltage will rise with increasing bias to a given point and will then slowly fall off. The correct bias setting to use is a voltage slightly in excess of that which gives the maximum signal output.

19.6.3. "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 R.M.S. "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 19.6.1., Recording Level.

If a 1,000 c.p.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 emphasised that even the extremely low figure of 0·1% can be clearly distinguished on a 1,000 c.p.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.

19.6.4. Frequency Response

Due to the slight variations in the response from individual heads, certain components have been made variable and are located on the equaliser panel as shown in Fig. 17 and in the circuit diagram Fig. 20. R10, C12, C14 and C15 may be changed by unplugging from their sockets, and R9 and R12 are continuously variable. In addition, C13 and R45 are fitted across R10 and C15 respectively, although either may occasionally be omitted.

In the description of the equalisation procedure for $7\frac{1}{2}$ i.p.s. given below, the figures in brackets apply correspondingly to $3\frac{3}{4}$ i.p.s. Each of the variable components is most effective in a specific part of the audio frequency band as follows :—

R9 (R10) has most effect in the range around 2,000 c.p.s.

C12 (C13) controls the part of the spectrum approximately 5—10 Kc/s. (4—9 Kc/s.).

C14 (C15) is used to resonate L2, taps 1—2 (taps 1—3), and has a vital effect on the higher frequencies above 12 Kc/s. (7 Kc/s.).

R12 (R45) is connected in parallel with C14 (C15) and controls the amount of this high frequency lift.

To adjust or check the frequency response at $7\frac{1}{2}$ i.p.s. ($3\frac{3}{4}$ i.p.s.), a frequency sweep from a constant voltage output, audio signal generator over the frequency range 30—16,000 c.p.s. (30—12,000 c.p.s.) should be recorded at a reading of approximately $\frac{1}{2}$ on the signal level meter scale, the low level being necessary to avoid overloading the tape at the higher frequencies due to the pre-emphasis. In the absence of a synchronous continuous sweep it is advisable to record in short, independent steps, carefully noting the frequency at each step.

An A.C. meter or valve-voltmeter having a level response over the frequencies in question should be connected across a 15 ohm resistor plugged into the 15 ohm output socket, the frequency sweep or steps played back, and the various output levels noted. R9 (R10) should be adjusted so that the output meter shows the same reading at 2,000 c.p.s. as at 400, then R12 (R45) should be adjusted so that the response is level at the higher frequencies. If this proves difficult, some alteration in the value of C14 (C15) may be required, the normal resonating frequency being 16—17 Kc/s. (11—12 Kc/s.). If there is a peak or a dip in the curve around 6—9 Kc/s. (5—8 Kc/s.), this may be taken out by making C12 (C13) larger or smaller respectively. The final response should be 40—15,000 c.p.s. $\pm$ 3 dB. (40—10,000 c.p.s. $\pm$ 3 dB.).

19.6.5. Hum Level

If any major work has been carried out upon the amplifier or deck, the hum level may be affected. The main factors controlling this are :—

A. The first valve of the replay chain.

B. The position of TR3.

C. The adjustment of the Mumetal wing on the playback head pressure arm.

Secondary factors affecting the hum may be :—

D. The second valve (this is the first valve of the recording chain and may cause hum to be recorded).

E. The position of L2.

F. The position of the microphone matching transformer (if one is used).

G. The polarity of the mains input.

The presence of hum is most easily detected by a sensitive meter, or a cathode ray tube with an amplifier, connected across Pins 3 and 7 of the auxiliary socket. It can be controlled in some measure by the position of the mains transformer TR3 which is arranged so that it can be rotated for minimum hum pick-up on the sensitive components. Any adjustment to it should be made while the motors on the deck are running as this of course is the proper condition of playback.

Care should be taken to see that there is not too great a difference between the readings with the motors running and with the motors stopped, as this will indicate that hum bucking is taking place, *i.e.* that some hum is 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. With full amplifier gain the hum voltage should not exceed ·75V R.M.S. with motors both running and stopped.

A useful method of obtaining a final minimum figure is by varying the angle the mumetal wing on the playback head pressure pad arm makes with the tape. The only precaution necessary in adjusting this is to ensure that the pressure pad contact area is not adversely affected.

The position of L2 can be altered by loosening its clip and rotating, although this should not be done too drastically or the leads to it may break. Although only a secondary factor, it will have a slightly bigger effect at $3\frac{3}{4}$ i.p.s.

The polarity of the mains connection can also be checked as this sometimes effects a desirable reduction.

19.6.6. Signal to Noise Ratio

The unweighted signal to noise ratio quoted in the specification is the ratio of the R.M.S. noise from the erased tape plus the hum content compared with the R.M.S. signal output from a fully recorded tape playing back at 3% distortion. This means that the gain control must not be turned fully clockwise as this will obviously overload the amplifier.

20. USE AS AN AMPLIFIER

While intended primarily for tape reproduction, the "Ferrograph" can be used as a "straight" amplifier for a tuner unit or pick-up by turning the main function switch to playback. If the signal is now fed into Input 1 or 2 as on record and the gain control advanced, it will be heard on the internal speaker, or external speaker if connected. As the tone controls are only effective on tape playback, the amplification will be linear.

21. CONVERSION OF 5A TO 5S

All that is necessary to convert a model 5A to a 5S is to unscrew the "dummy" in head position 3 and replace it by a stereo head type F.P.16. This is supplied with shims which must be inserted between the head and the holder to align the head correctly with the tape.

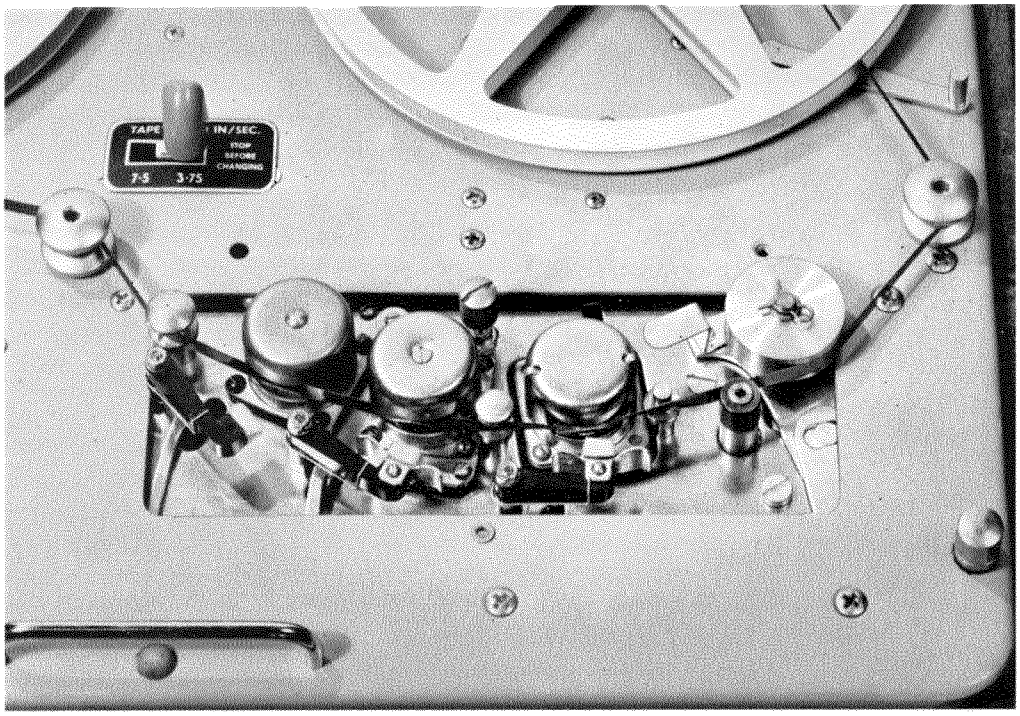

FIG. 19. MODEL 5 S. SHOWING STEREO HEAD IN POSITION

After fitting, the head height should be checked to ensure that the laminations (visible as a bright silver colour against the brass spacing pieces) overlap equally the top and bottom edges of a tape running through on playback. If not, the shims should be adjusted accordingly.

The stereo head will then require its gap aligning at right angles to the tape by adjustment of the rear screw as outlined in the 5S instructions "PLAYING BACK PRE-RECORDED TAPES".

"FERROGRAPH"
MODEL 5 S

FERROGRAPH MODEL 5 S

GENERAL DESCRIPTION

This model is very similar to the model 5A, the only difference being that a stereo playback head type F.P.16 is fitted in "head position 3" instead of the dummy head. The connections from this are taken directly to two sockets marked 'STEREO OUTPUT UT and LT' (upper and lower tracks respectively) on a small panel at the rear of the cabinet.

By connecting suitable external amplifiers to these sockets, stereo pre-recorded tapes can be played back. These amplifiers should include pre-amplifiers having inputs for a tape head and incorporating some form of equalisation, as described below.

CONNECTION OF EXTERNAL AMPLIFIERS TO STEREO OUTPUT SOCKETS

1. Output Available

As the connections to the UT and LT stereo sockets are straight from the stereo head windings, the output signal is unequalised and at low impedance, and thus the external amplifers must include the appropriate playback compensation to give a level response. Most tape head inputs are intended for high or medium impedance heads and it is recommended that head matching transformers (one per track) be used between them and the stereo head windings, which are approximately 150 ohms at 1,000 c.p.s.

These small transformers are astatically wound for minimum hum pick-up and are completely screened in a mumetal can. For high impedance inputs of the order of 1 Megohm the transformer to use is the type 973, which has an effective step up ratio of about 22 : 1 and which gives an available peak voltage (from a full depth recording) of 11 mV. at the secondary. For medium impedance inputs of less than 500 K ohm, the transformer recommended is the type 969, having an effective step up ratio of approximately 8 : 1 and giving 4 mV. output at the secondary. It is recommended that screened lead *e.g.* co-axial cable, be used for these leads and that the transformers be mounted as near to the amplifier inputs as possible.

Without a matching transformer the peak voltage available is 0·5 mV.

2. Equalisation

Due to manufacturing tolerances it is difficult to specify a fixed equalisation circuit. It is recommended that if an absolutely flat frequency response is required, a test tape is used and the equalisation set up with the aid of a suitable output meter. On a pre-recorded tape to the C.C.I.R. characteristic it should be easily possible to obtain a response of $\pm$ 3 dB between 60 and 10,000 c.p.s. at $7\frac{1}{2}$ i.p.s.

CONNECTIONS

The following is intended as a general guide.

The plug for the "stereo" sockets on the rear panel is PAINTON and Co's type P2/CT 313260 or Ferrograph type BP/2330/P.

The Ferrograph and the external amplifiers should have a common mains "earth" connection to avoid the possibility of hum due to "earth loops", and also when positioning the various units the power supply section on the external amplifier should be kept away from the immediate vicinity of the Ferrograph, especially from the bottom left hand corner. In addition, some adjustment of the stereo output sockets on the rear panel may be necessary to obtain the lowest possible hum from the combination. This procedure may be carried out as follows :—

First slacken off the four screws spaced round the sockets, then with everything set up in an operating condition, slowly rotate each socket and plug for a minimum hum position on each track. Care should be taken not to rotate the sockets more than the full circle to avoid damage to the leads connected at the back. A further method of hum reduction which might usefully be employed at the same time is to slightly loosen the screw in the stereo head pressure arm securing the mumetal "wing", so that the latter can be inclined (in a horizontal plane) over a small arc relative to the head. This operation will be found to have some effect on the residual hum, and combined with the socket rotation, will enable the lowest possible hum level to be obtained. Before tightening the mumetal wing in its final position, check that the pressure pad is still acting over the full width of the tape and ensuring intimate contact of the latter against the head, also that the 'wing' has not been inclined so much that it contacts the head can.

PLAYING BACK PRE-RECORDED STEREO TAPES

It is recommended that, before commencing to play pre-recorded stereo tapes, the "Bias & Erase" plug be removed from the rear panel socket. This will completely disconnect the oscillator supply from the tape deck and so prevent any possibility of erasure or recording of "clicks", due to accidentally turning to the "record" position. If no specific instructions are given with the pre-recorded tape, the usual convention is to have the two loudspeakers spaced 7—10 feet apart with the upper track speaker on the left.

The gain control of the Ferrograph should be turned to zero to prevent an additional upper track playback through the standard head and internal speaker.

As the model 5S leaves the factory, the stereo head gap will be aligned exactly at right angles to the tape, but if for any reason there is a deficiency in the upper register, the adjusting screw (see section 18.1) can be turned for maximum treble response. It is sometimes easier to align on background hiss with the ear close to the loudspeaker.

The external amplifiers will presumably have either separate gain controls or some form of balance control to adjust each track for the same output level.

'MONITOR' APPLICATION

During monaural recording, the upper track of the stereo head can also be used for monitoring the signal off the tape provided it is recognised that the "cross talk" between tracks in the stereo head is of the order of 40dB, so that a faint signal from the lower track (if this is recorded) might be heard when monitoring.

APPENDIX A

OPERATIONAL FAULT ANALYSIS

FAULT	POSSIBLE OPERATIONAL CAUSE
1. Recorder will not start; meter lamps do not light up.	Fuse blown (see Fig. 1). Mains lead or plug faulty. Mains selector knob loose or missing.
2. Motor starts, but starting switch will not lock in, amplifier having had time to warm up.	Equalisation Switch and Speed Change Switch set at different speeds. Tape not set correctly on Auto Stop Arm.
3. Start switch only just holds in, or releases during playing.	Low mains voltage. Check position of selector knob and actual mains voltage.
4. Tape slips in drive or "wows"	Dirty capstan or accumulation of tape deposit on pinch roller. Bad splice in tape, sticking in guides or heads. Buckled reels scraping on deck. Dirt in gate mechanism preventing proper closure Oversize tape. Oil or Grease on idler wheel rim.
5. Known, well recorded tape will not play back but tape drives.	Input plug left in. Unconnected output speaker plug left in. Tape incorrectly positioned in head box. Piece of splicing tape sticking over head working face. Gain control at zero.
6. Tape plays back with poor frequency response.	Accumulation of foreign matter or tape coating over head gap.
7. In recording position tape erases but will not record.	Microphone or input plug not properly inserted, or in wrong socket. Microphone cable faulty. No input signal.

Appendix A : *continued*

FAULT	POSSIBLE OPERATIONAL CAUSE
8. Records, but incompletely erases previous recording.	Heads incorrectly aligned with tape, *i.e.*, lower track is heard. Dirt over erase head gap or splicing material stuck to working face. "Erase Only" Link removed.
9. Records weakly and with very poor frequency response.	Tape coating outside instead of inside. No bias voltage at record head.
10. Low pitched hum during playback (tape stationary).	Instrument being operated over power cables or near equipment with high external fields, *i.e.*, saturable reactors.
11. Hum recorded on tape. (Check by changing speed. If hum is recorded, its frequency will be halved).	Microphone in hum field. Microphone transformers or leads insufficiently screened. Microphone leads or stand indifferently earthed, or in contact with mains leakage paths.
12. Tape runs at one speed but not at the other.	Idler carrier spring (Fig. 13) broken. Idler wheel circlip missing and wheel has "run off".
13. Tape slows up or stops on Wind Back or Wind On.	Reel motor bearings out of alignment making spindle tight—Push drum adaptor sideways from various directions until motor can be spun freely.
14. Tape winds unevenly, especially on Wind Back or Wind On.	"Bobbin" guides incorrectly set for height. Tape in use has stretched non-uniformly and is concave or wavy, leading to odd layers spooling at different heights.
15. Take-up drum adaptor appears to run hot especially compared to wind back motor	It is normal for the take-up drum adaptor to feel hot to the touch; because the wind back motor runs at a lower voltage, the effect is less with it.
16. Hands on counter dial remain stationary.	Drive cable broken. Fit new cable. When fitting do not push ends too far down spindles so that cable assumes a 'flattened' curve.

APPENDIX B

LIST OF COMPONENTS MODEL 5A. 240V. 50 c.p.s.

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NO.
R1	1·2K Ω	27w	5%	Wire Wound	BP/2819/R
R2	100 Ω	½w	20%	Carbon	BP/2802/R
R3	270K Ω	½w	5%	Carbon	BP/2855/R
R4	100K Ω	1w	5%	High Stability	BP/2850/R
R5	1·5K Ω	1w	5%	High Stability	BP/2823/R
R6	100K Ω	½w	5%	Carbon	BP/2851/R
R7	500K Ω			Carbon Pot. Logarithmic (Bass Control)	BP/2411/P
R8	4·7K Ω	½w	10%	Carbon	BP/2831/R
R9	5K Ω			Wire Wound Pot. (Preset) Linear.	BP/2428/P
R10	*3·9K Ω	½w		Carbon	
R11	†				
R12	25K Ω			Carbon Pot. (Preset) Lin.	BP/2402/P
R13	500K Ω			Carbon Pot. Logarithmic (Treble Control)	BP/2411/P
R14	1M Ω	½w	20%	Carbon	BP/2863/R
R15	47K Ω	½w	20%	Carbon	BP/2849/R
R16	270K Ω	½w	5%	Carbon	BP/2855/R
R17	100K Ω	1w	5%	High Stability	BP/2850/R
R18	1·5K Ω	1w	5%	High Stability	BP/2823/R
R19	22K Ω	½w	20%	Carbon	BP/2843/R
R20	†				
R21	500K Ω			Carbon Pot. Logarithmic (Gain Control)	BP/2411/P
R22	270K Ω	½w	5%	Carbon	BP/2855/R
R23	100K Ω	½w	5%	Carbon	BP/2851/R
R24	1·5K Ω	1w	5%	High Stability	BP/2823/R
R25	470K Ω	½w	20%	Carbon	BP/2861/R
R26	15K Ω	½w	20%	Carbon	BP/2842/R
R27	*13K Ω	½w	5%	Carbon	BP/2841/R
R28	22K Ω	½w	20%	Carbon	BP/2843/R
R29	220 Ω	1w	10%	Carbon	BP/2807/R
R30	47K Ω	½w	20%	Carbon	BP/2849/R
R31	150K Ω	½w	5%	Carbon	BP/2853/R
R32	33K Ω	½w	20%	Carbon	BP/2845/R
R33	15 Ω	1w	20%	Carbon	BP/2801/R

Appendix B : *continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NO.
R34	†				
R35	†				
R36	100K Ω	½w	20%	Carbon	BP/2852/R
R37	*200K Ω	½w		Carbon	
R38	2·2M Ω	½w	5%	Carbon	BP/2864/R
R39	2·2K Ω			Carbon Pot. (Set Zero)	BP/2441/P
R40	470K Ω	½w	20%	Carbon	BP/2861/R
R41	5K Ω			Wire Wound Pot. (Preset) Linear.	BP/2428/P
R42	10K Ω	½w	5%	Carbon	BP/2926/R
R43	10K Ω	½w	5%	Carbon	BP/2926/R
R44	4·7 Ω	½w	10%	Carbon	BP/2795/R
R45	*22K Ω	½w		Carbon	
R46	†				
C1	0·1 μF	350v		Paper	BP/707/C
C2	†				
C3	0·22 μF	125v	10%	Polyester	BP/710/C
C4	0·75 μF	450v		Paper (A.C. Working).	BP/715/C
C5	4700 pf		+100–0%	Ceramic	BP/530/C
C6	8 μF	350v		Electrolytic (with C7, C19)	BP/773/C
C7	16 μF	350v		Electrolytic (with C6, & C19)	BP/773/C
C8	50 μF	12v		Electrolytic	BP/763/C
C9	2000 pf	350v	2%	Polystyrene	BP/517/C
C10	0·1 μF	400v	10%	Polyester	BP/708/C
C11	0·039 μF	400v	10%	Polyester	BP/705/C
C12	*4000 pf	350v		Polystyrene	
C13	*4000 pf	350v		Polystyrene	
C14	*11,400 pf	350v		Polystyrene	
C15	*3,100 pf	350v		Polystyrene	
C16	†				
C17	0·1 μF	400v	10%	Polyester	BP/708/C
C18	0·047 μF	400v	10%	Polyester	BP/706/C
C19	16 μF	350v		Electrolytic (with C6, & C7).	BP/773/C
C20	16 μF	350v		Electrolytic (with C32, C38)	BP/773/C
C21	0·1 μF	400v	10%	Polyester	BP/708/C

Appendix B : *continued*

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NO.
C22	0·047 μF	400v	10%	Polyester	BP/706/C
C23	25 pf	350v	5%	Polystyrene	BP/539/C
C24	100 μF	25v		Electrolytic	BP/781/C
C25	0·47 μF	400v	10%	Polyester	BP/739/C
C26	0·1 μF	400v	10%	Polyester	BP/708/C
C27	250 pf	350v	2%	Polystyrene	BP/541/C
C28	300 pf	350v	2%	Polystyrene	BP/542/C
C29	250 pf	350v	2%	Polystyrene	BP/541/C
C30	†				
C31	0·47 μF	125v	10%	Polyester	BP/712/C
C32	8 μF	350v		Electrolytic (with C20 & C38)	BP/773/C
C33	16 μF	350v		Electrolytic (with C34)	BP/782/C
C34	8 μF	350v		Electrolytic (with C33)	BP/782/C
C35	5700 pf	350v	2%	Polystyrene	BP/521/C
C36	2000 pf	350v	2%	Polystyrene	BP/517/C
C37	2000 pf	350v	2%	Polystyrene	BP/517/C
C38	16 μF	350v		Electrolytic (with C20 & C32)	BP/773/C

CIRCUIT REF.	DESCRIPTION	PART NO.
V1	Valve Type EF86	BP/7106/V
V2	Valve Type EF86	BP/7106/V
V3	Valve Type EF86	BP/7106/V
V4	Valve Type EL84	BP/7108/V
V5	Valve Type ECC83	BP/7130/V
V6	Valve Type ECC82	BP/7118/V
V7	Valve Type EZ80	BP/7109/V
SW1	Selector Switch (Rotary Ceramic)	MC/1755
SW2	Speed Change Switch	MC/3820
SW3	Motor Switch	MC/1216B
SW4	Auto Stop Switch	MC/4067
SW5	Manual Stop Switch	MC/1216C
SW6	Equaliser Switch (Rotary)	BP/4073/S
SW7	Speaker Switch (Slide)	BP/4071/S
SW8	On/Off Switch (Toggle)	BP/4074/S

Appendix B : *continued*

CIRCUIT REF.	DESCRIPTION	PART NO.
JK1	2 Way Jack Socket	BP/1500/J
JK2	2 Way Jack Socket	BP/1500/J
JK3	2 Way Jack Socket	BP/1500/J
X1	Wind On Motor	MC/5230/150
X2	Capstan Motor	MC/5516/240
X3	Wind Back Motor	MC/5229/150
X4	Erase Head Type FE7	MC/5075
X5	Record/Playback Head Type FR7A	MC/1217
P1	Octal Plug	BP/2311/P
P2	2 Way Plug	BP/2301/P
P3	Octal Plug	BP/2310/P
P4	Octal Plug	BP/2311/P
P5	†	
P6	2 Way Plug	BP/2301/P
P7	†	
P8	2 Way Plug	BP/2301/P
P9	2 Way Plug	BP/2301/P
P10	Mains Plug (On Panel)	BP/2307/P
SK1	Octal Socket	BP/7050/V
SK2	2 Way Socket	BP/3904/S
SK3	Octal Socket	BP/3906/S
SK4	Octal Socket	BP/7050/V
SK5	Octal Socket	BP/7050/V
SK6	2 Way Socket	BP/3904/S
SK7	†	
SK8	2 Way Socket	BP/3904/S
SK9	2 Way Socket	BP/3904/S
SK10	Mains Socket (On Cable)	BP/3957/S
SK11	2 Way Socket	BP/3933/S
SK12	2 Way Socket	BP/3933/S
TR1	Head Input Transformer	MC/977
TR2	†	
TR3	Output Transformer	MC/T1663
TR4	†	
TR5	Mains Transformer	MC/T1677B

Appendix B: *continued*

CIRCUIT REF.	DESCRIPTION	PART NO.
L1	Hold In Solenoid	MC/T1404
L2	Treble Boost Inductor	MC/762
L3	Filter Coil (20mH.)	MC/666
L4	Oscillator Coil	MC/5586
L5	Smoothing Choke (12 H)	MC/T1551
M1	Meter, 1mA. D.C. F.S.D., Reverse Reading	BP/1933/M
FS1	Fuse 1A	BP/1252/F
LS1	Speaker Elliptical 10″ x 6″	BP/4157/S
LP1	Lamp L.E.S. 6.5V .15A	BP/1813/L
LP2	Lamp L.E.S. 6.5V .15A	BP/1813/L

LIST OF COMPONENTS FOR MODEL 5A, 110V, 50 c.p.s.

The component values for this model are as detailed for Model 5A, 240V, 50 c.p.s., above, with the following exceptions.

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NO.
R1	250 Ω	27w	5%	Wire Wound	BP/2808/R
C4	3 μF	300v		Paper AC. Working	BP/718/C
TR5				Mains Transformer	MC/T1677A
X1				Wind On Motor	MC/5230/75
X2				Capstan Motor	MC/5599/110
X3				Wind Back Motor	MC/5229/75
FS1				Fuse 2A	BP/1253/F

LIST OF COMPONENTS FOR MODEL 5A, 110V, 60 c.p.s.

The component values for this model are as detailed for Model, 5A, 110V, 50 c.p.s. above, with two exceptions.

CIRCUIT REF.	VALUE	RATING	TOL.	DESCRIPTION	PART NO.
X2				Capstan Motor	MC/5683/110
C2	2·5 μF	300v		Paper AC. Working	BP/717/C

*Note :— Throughout all lists * values are nominal only. Actual values are selected during setting up. † These components not fitted.*

APPENDIX C

The following accessories are available for use with the Ferrograph.

Erase Link Potentiometer

As described in Section 10.1 of Manual. BP/2434/P

Carrying Case for Series 5 Ferrograph

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

Defluxer

For demagnetising the record/playback head. Prevents hiss and protects tapes from cumulative background noise. See note at front of Manual.

Endless Loop Cassette

As described in the Manual.

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) microphone with 3 pin plug/socket mount and fitted with 18 ft. screened lead and plug.

Microphone Matching Unit

Type TA./30/GL, 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./5ft. 9 ins.

Tape

Hublok Reels (full standard tape) .. 200 ft. Ferrograph F.T.3A
600 ft. Ferrograph F.T.5A
1,200 ft. Ferrograph F.T.7A
1,750 ft. Ferrograph F.T.8A

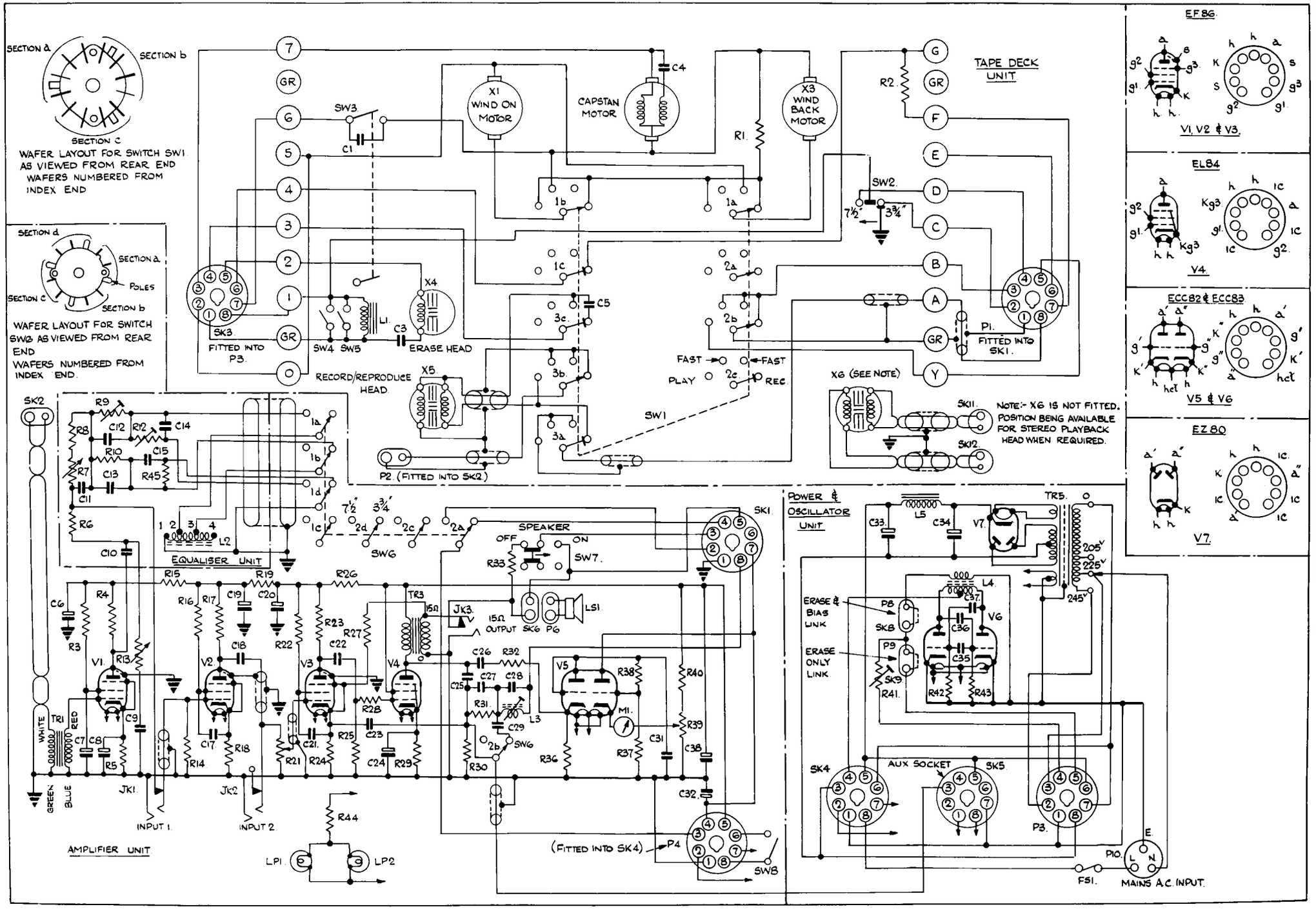

FIG. 20. CIRCUIT DIAGRAM MODELS 5 A & 5 S

Empty Reels

Hublok Reels (empty)	200 ft. Ferrograph R.E.3.
	600 ft. Ferrograph R.E.5.
	1,200 ft. Ferrograph R.E.7.
	1,750 ft. Ferrograph R.E.8.

Miscellaneous

The following spares can also be supplied

Meter Illuminating Lamp	LES 6·5V 150mA BP/1813/L
Fuse	1A BP/1252/F
	2A BP/1253/F
Unscreened jack plug	UP7
Screened jack plug	SP7
Octal plug	Bulgin Q575 BP/2303/P

NOTE :—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 quote the Serial Number of the recorder, as given on the rear of the cabinet.

WEARITE DE-FLUXER

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.