TECHNICAL INSTRUCTION
R.11

Portable Tape Recorders

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AMENDMENT RECORD

Amendment Sheet No.	*Initials*	*Date*	*Amendment Sheet No.*	*Initials*	*Date*
R.11— 1	AC	3.2.6			
R.11— 2					
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Fig. 1 Fi-Cord No. 1A: Circuit Diagram and Printed Wiring Card

PORTABLE TAPE RECORDERS

SECTION 1

FI-CORD 1A RECORDER

1.1 Introduction

The Fi-Cord 1A magnetic-tape recorder is a transistorised type, operated with an 8-volt battery and suitable for speech recording only. It originates from a foreign-made prototype (Stellovox) and is manufactured in this country.

The instrument is extremely light (4 lb) and can be used for either recording or playing while being carried by means of a detachable shoulder sling. The recorder, a microphone and a special mains-operated battery charger are marketed as a complete outfit, but for BBC purposes the complement has been altered by choice of a different microphone. This appears with the other two items in Fig. 1.1.

Features of the recorder are:

Record/play head	Upper half-width track.
Tape speeds	$7\frac{1}{2}$ in./sec and $1\frac{7}{8}$ in./sec.
Tape-spool diameter	$3\frac{1}{4}$ in.
Monitoring facilities	Headphone and external feed (both recording and replay); internal loud-speaker (play only).

Fig. 1.1 Fi-Cord 1A Recorder with Microphone and Battery Charger

Unlike most uni-directional machines the tape transfer for recording and playing is from right to left. At $7\frac{1}{2}$ in./sec the single-run duration with a spool of standard-play tape is $4\frac{1}{2}$ minutes. At the lower speed of $1\frac{7}{8}$ in./sec, the single-run duration with a spool of standard-play tape is 18

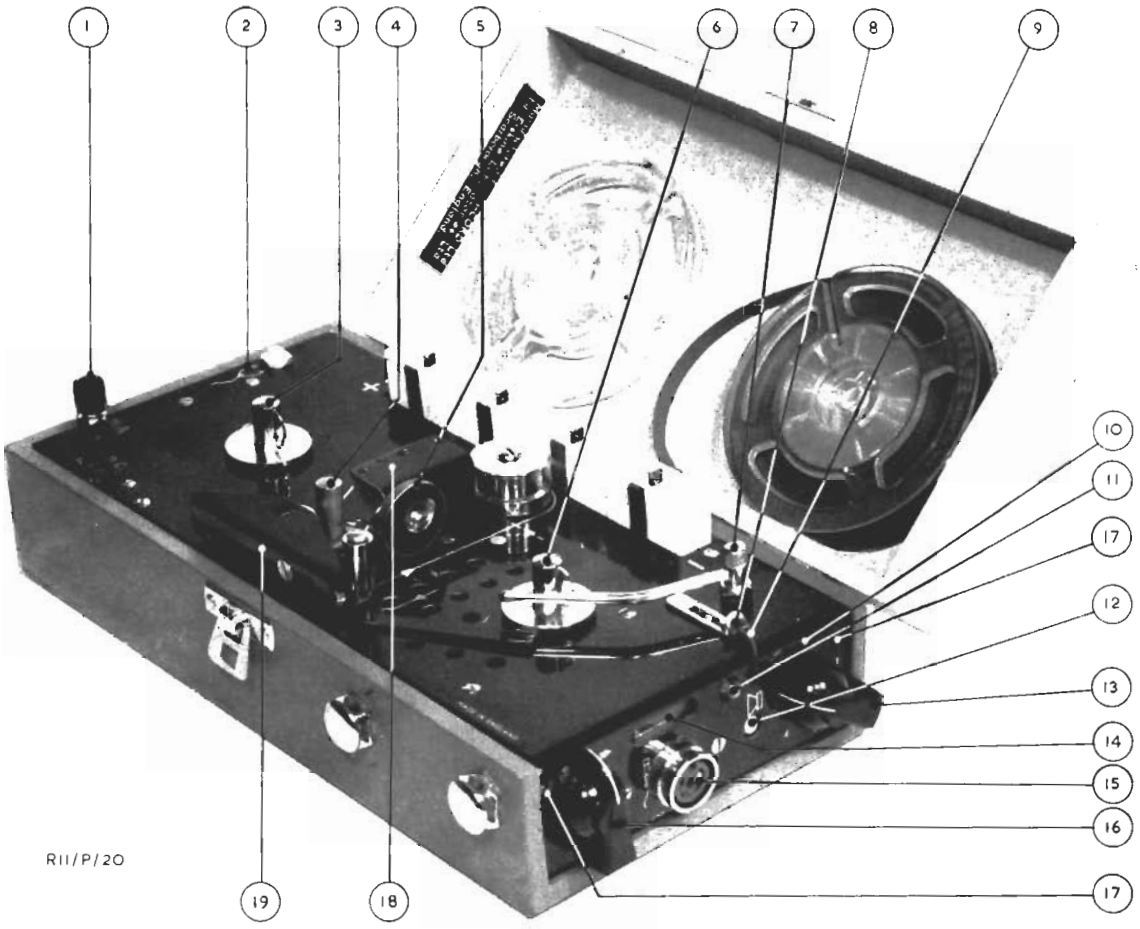


Fig. 1.2 Fi-Cord 1A Recorder

1. *Change-speed Knob*
2. *Headphone Socket*
3. *Take-up Spool Spindle*
4. *Drive Capstan*
5. *Pressure-roller Locking Disk*
6. *Feed-spool Spindle*
7. *Friction Arm*
8. *L.S. Muting-switch Lock*
9. *L.S. Muting Switch*
10. *Tape Indicator*
11. *Indicator Lamp*
12. *Output Socket (C.C.I.R.)*
13. *Volume Control*
14. *Volume Indicator*
15. *Microphone Socket*
16. *Record/Play Switch*
17. *Panel-securing Screw*
18. *Record/play and Erase Heads*
19. *Pressure Roller*

minutes, but the quality is unsuitable for broadcast transmission.

1.2 General Description of Equipment

(*a*) *Recorder*

Various parts of the recorder are identified by annotation of the photograph in Fig. 1.2, intended particularly as a guide for later description.

A plastic-coated aluminium panel carries the complete assembly, comprising the heads, tape-transport mechanism and motor, a printed wiring card, the battery and a loudspeaker. Controls are on an extension at right angles to the main panel and thus remain accessible when the lid is closed to protect the heads and spools. The case is fitted with pairs of studs for attaching the shoulder sling and their placing is such that the controls are conveniently to hand when the recorder is in the slung position.

The battery of four hermetically-sealed lead-acid cells has a capacity that should give reliable operation of the recorder for $1\frac{1}{2}$ hours at least. It is housed with terminals downward in a well on the main panel, the cells being individually retained by spring clips.

The dimensions of the case are $9\frac{5}{8}$ in. by 5 in. by $2\frac{3}{4}$ in. and the weight, inclusive of the battery, is 4 lb.

(*b*) *Microphone*

This is a moving-coil type, Grampian DP4/M, the suffix letter denoting the medium impedance (600 ohms) presented through a built-in transformer connected with a voice coil having a standard 25-ohm impedance. A separate 6-ft cable is provided, with one end terminating in a locking-ring connector suiting the fitting in the base of the microphone and the other end carrying a quick-detach connector for the recorder.

The weight of the microphone, less cable, is 8 oz.

(*c*) *Battery Charger*

The charger is designed specifically for the particular battery used with the recorder and is adjustable for use with a.c. inputs in the ranges 110-130, 160-180 and 220-240 volts. The complete assembly is mounted on the panel shown in Fig. 1.1.

Charging is possible only with all four cells in position and individual cells are automatically disconnected as each reaches the fully-charged state. The charging rate is approximately 50 mA and the full-charge period is up to 10 hours. Associated with each cell are two lamps, red and white, to indicate the charging and fully-charged states.

The charger has dimensions of $8\frac{3}{4}$ in. by $4\frac{1}{2}$ in. by $2\frac{1}{4}$ in. The total weight is made up of 2 lb for the unit and 6 oz for the battery.

1.3 Facilities

Following description quotes bracketed numbers which refer to the photograph in Fig. 1.2.

Under tone-test conditions the frequency-response characteristic at $7\frac{1}{2}$ in./sec is within ± 1 dB from 50 c/s to 10 kc/s and therefore meets the C.C.I.R. specification for that speed. These figures apply where the tape is replayed either through the recorder, with an output taken from socket (12), or on a standard tape reproducer. Individual recorders differ to some extent in their wow and flutter values, but are satisfactory for speech recording.

The above-mentioned socket (12), identified by a loudspeaker symbol, is intended primarily for feeding the recorder output to remote positions. The requisite load impedance for this outlet is at least 500 kilohms and therefore the feed to line, even one that is relatively short, must be through an amplifier meeting this condition. Other essentials are a 35-dB gain to provide signals at +4 dB from a 75-ohm output impedance, that is, the values appropriate to O.B. practice.

An output for checking by headphones is provided at socket (2), on the main panel and identified by a stethophone symbol. Monitoring by the internal loudspeaker is available only when tape is played. This facility is disconnected either automatically by closing the recorder lid, which opens muting switch (9), or manually by locking the muting switch open with sliding catch (8). The microphone is not switched out of circuit under the play condition and therefore, to avoid the deleterious effect of acoustic feedback, it should be disconnected from the recorder while the internal loudspeaker is in use.

The recorder is provided with three indicators, comprising:

(*a*) Volume Indicator (14). In this miniature-lamp device is a luminescent spiral with a green glow which becomes dimmer with increasing modulation and, with volume control (13) correctly adjusted, is extinguished as peak volume is reached.

(*b*) White Lamp (11). This miniature lamp is lit when switch (16) is set for recording (mouth symbol) or play (ear symbol) and it flickers to show operation of a governor on the motor.

(*c*) Tape Duration Marker (10). This is a simple lever arrangement operated by friction bar (7) which rides on the tape in the feed spool (6) and shows, at cursor (10), the amount of tape left in the spool.

The lower tape speed ($1\frac{7}{8}$ in./sec) gives wow and flutter too great for the recorder to be used in programme transmission, although speech is sufficiently intelligible for other purposes, such as script dictation or rehearsal recording.

1.4 Circuit Description (Fig. 1)

With the conventional circuit diagram in Fig. 1 is a reproduction of the printed wiring card to which most of the components are attached. The drawings are related by numbers to identify various parts of the circuit diagram with black areas representing metallic portions of the card; in later description the numbers are quoted with reference to working voltages.

The equipment employs pnp-type transistors generally, four in a record/play amplifier, two in a biasing-and-erasing oscillator and two in an output stage associated with the internal loudspeaker.

(*a*) *Record/play Amplifier*

This has four single-transistor stages and a gain control which is placed intermediately. Initial amplification is provided by TR1 and TR2, working with base-applied inputs and directly coupled one to the other. As a pair these transistors have overall negative feedback, with TR2 collector and TR1 emitter connected via C4 and R4, and are d.c.-stabilised by use of R6. The first stage is designed to work with signal-source impedances between 400 and 1,000 ohms; for recording the value is 600 ohms, that is the impedance presented by the secondary of the transformer inside the casing of the DP4/M microphone.

The TR2 output is applied to RV1 for adjusting the input-signal amplitude to TR3. This transistor has the common-emitter configuration of preceding stages and operates with negative feedback because only one of two resistors in the emitter circuit is decoupled by C9. It is also directly coupled to the final stage in which TR4 is used to provide and emitter-follower output. The d.c.-stabilising for these stages is effected with R14.

(*b*) *Oscillator*

The oscillator uses TR7 and TR8 in a base-coupled relaxation circuit, the values of the frequency-determining components being suited to generation at a nominal 50 kc/s; within liberal limits any departure from that figure is relatively unimportant. The output transformer T3 has a secondary tuned by C17 and from this combination the voltage obtainable is in the range 40 to 50 volts r.m.s.

(*c*) *Loudspeaker-output Stage*

TR5 and TR6 operate under the class-B condition in a single-ended push-pull circuit obviating need of an output transformer. In its play position the switch S1c connects the output of the record/play amplifier to input transformer T2 provided muting switch S2 is closed.

(*d*) *Volume Indicator*

The miniature triode assembly V1 is both a volume indicator and means of knowing that the oscillator is functioning normally. The last-mentioned is implicit in filament heating by current-sharing connection with R34 in the TR7/TR8 emitter circuit and use of the 50-kc/s output of T3 as the anode supply. V1 grid is driven negatively with d.c. from half-wave rectifier MR1, the input to which is a.f. from a voltage-divider shunting the circuit feeding the recording head. Thus the luminescence of the spirally-formed anode varies between maximum with no signal (zero grid-volts) and extinction as the signal reaches a predetermined value short of that giving overloading in the record/play amplifier.

(*e*) *Motor*

The motor has a permanent-magnet stator and is arranged for constant-speed operation by an alternation between two values of current through the armature winding.

During starting and while running below normal speed the current is determined with R33 alone. Above normal speed the current is reduced by the additional resistance of the combination of R32 in parallel with R35 and LP1; the value is about 60 ohms.

The change occurs by governor action of a centrifugally-operated switch on the shaft of the motor. The fixed switch-contact is a collar fitted directly on the shaft and the insulated moveable member is a bent flexible arm connected externally via a rubbing-contact strip. This switch operates with a fairly rapid trembler action, evident from flickering of LP1, and hunting is confined to narrow limits such that a substantially fixed speed is obtained.

Note that the motor is a separately-insulated item because the frame is connected to the armature winding via the shaft. Special separation of the

transmission system is unnecessary as drive is applied through rubber bands linking a succession of pulleys and a flywheel.

(*f*) *Selector Switch S1*

The record and play positions, marked R and P in Fig. 1, are identified pictorially with a mouth and an ear respectively.

The switch has two sections, S1a and S1b, controlling the battery supply selectively so that the oscillator and volume indicator are in operation at the record setting only.

S1c completes the primary circuit of either T1 for recording or T2 for play.

S1d connects the record/play head either to the secondary of T1 via R30 and C16 for recording or to the input of TR1 for play. C18 is shunted across the T1 secondary to provide a low-impedance path at the oscillator frequency and thereby safeguard in a shunt arm which provides low-frequency correction. The approximate level obtainable from this outlet is —30 dB; conditions under which it is used for external feeding have been specified under heading 1.3.

1.5 Battery Charger

The general appearance of this unit is to be seen in the Fig. 1.1 photograph. The charger has a conventionally-arranged circuit, as in Fig. 1.3, apart from the means of automatically halting the charging of individual cells as the fully-charged state is reached. The readily-accessible items are a mains-input fuse screwed into the front panel and transformer-tapping selector panels in a recess on the underside of the case.

The cells are fitted as on the recorder, in the inverted position with their spring-tongue terminals

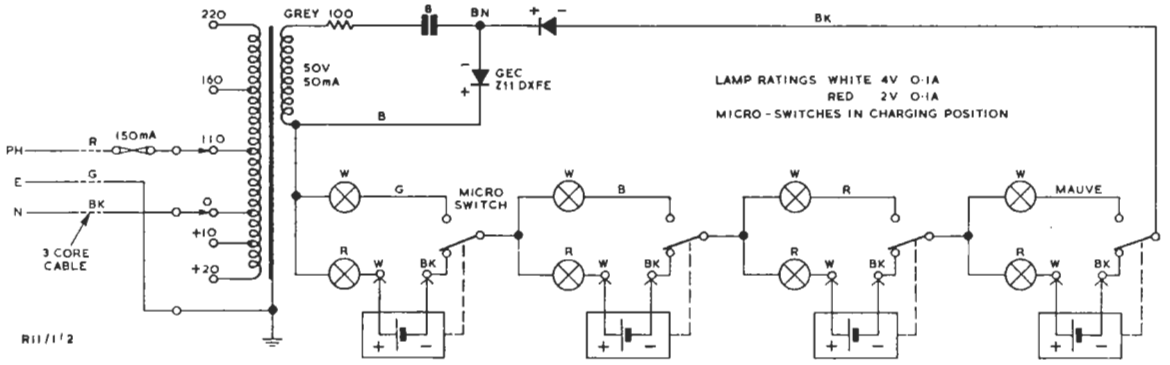


Fig. 1.3 Circuit Diagram of Battery Charger Unit

TR4 from intermodulation effects. Signal current through the recording head is determined by R30 and C16, the capacitor serving as a top-lift element (effective above 4 kc/s approximately) to compensate head losses that increase with frequency.

(*g*) *Sound Outlets*

The output of the record/play amplifier is continuously available at two jack positions, pictorially identified as indicated by abbreviated designations in Fig. 1. The stethophone position is for monitoring with high-impedance headphones at a programme volume of about —10 dB.

The loudspeaker jack is fed through an equaliser to produce an output frequency-response conforming to the C.C.I.R. standard. The equaliser comprises R17, R18 and C11 in a series arm giving high-frequency correction and R19 and C12 making connection through studs in the floor of the battery compartment and each subject to the light downward pressure of a retaining clip. The micro-switches are fixed externally to one wall of the compartment, with their operating buttons passing inwards through holes so that they rest against the sides of individual cells.

The hermetically-sealed cell has a plastic casing capable of distension by gas evolved during charging. At the fully-charged state the internal pressure builds up rapidly until the cell swells sufficiently to disconnect itself by actuating the micro-switch. This change is shown by a white-lamp indication in place of the red-lamp indication while charging is in progress.

N.B. The cells are symmetrical and care should be taken to avoid their being fitted into the

charger with polarity reversed. This is particularly important because the charger will appear to be functioning normally with the battery incorrectly connected.

1.6 Operation

In following description the various parts of the recorder are referred to by numbers with which the Fig. 1.2 photograph is annotated.

Warning. The transmission system is arranged for forward drive only and is liable to damage by even slight counter-clockwise rotation of the capstan.

The reverse movement can be caused by:

(*a*) Failure to release the pressure-roller locking disk (5), to free the capstan (4), before making use of a hand-rewind facility. Note that the disk ought to be released whenever possible to avoid flats being formed on the rubber track of the pressure roller (19).

(*b*) Insertion of the battery in the wrong sense.

(*c*) Supply from a battery correctly inserted but reverse-charged owing to insertion in the wrong sense in the charger; see note at end of 1.5.

(*d*) Direct hand manipulation of the capstan.

Loading

This sequence applies both to preparation for recording and to playing of tape which has been recorded.

Turn the friction bar (7) outwards to allow the feed spool to be placed on the feed spool spindle (6). The tape should have the magnetic coating inside and be drawn off counter-clockwise from the left-hand side of the spool.

Place the take-up spool on its spindle (3). Pull about 12 in. of tape from the feed spool and lace it along the path indicated by a white solid line inscribed on the panel. Ensure that the tape lies squarely across the two heads (18) and is central between the pressure roller (19) and capstan (4). Trap the tape in position by means of the pressure-roller locking disk (5).

Fit the free end of the tape into the slot on the take-up spool and draw in the excess tape by turning this spool counter-clockwise. Restore the friction bar (7) by clockwise movement to lie against the tape in the feed spool. Remove tape slack by momentarily closing the record/play switch.

This completes the loading operation except that, as noted previously, the pressure-roller locking disk (5) should be released if the recorder is not to be used immediately.

Rewinding

To emphasise the warning already given, the pressure-roller locking disk (5) must be released before any action by which tape is returned from the take-up spool to the feed spool.

The ancillary item for hand rewinding is a cranked handle which is used in engagement with one of the slots of the feed spool. The maker's suggested alternative is a transposition of spools followed by the use of the motor for forward drive. The method is intended as a direct spool-to-spool transfer, with the tape travelling along a path indicated by the dashed-line marking on the panel.

Microphone

The connector in the microphone base has bifurcated contacts set into orifices of cruciform cross-section, a shape which may cause uncertainty about the requisite orientation for the blades on the microphone-cable connector. Care must be taken to ensure correct alignment as otherwise the fittings are liable to damage by an attempt to force them into attachment.

The approved method of using the microphone is to speak across the grille protecting the voice coil, from a distance of between 4 and 12 inches. It is not possible to be specific about recording level but the setting of the volume control on the recorder should, at least tentatively, be one that causes momentary extinction of the volume indicator on speech peaks.

1.7 Maintenance and Test Data

Recorder Assembly: Notes on Removal and Inspection

Before taking the assembly out of its case the battery should be removed from the housing and the spools from their spindles. The assembly is freed by extracting three retaining screws, two through the control panel (see positions 17 in Fig. 1.2) and one nesting in a cupped washer on the underside of the case. Careful removal of the assembly is essential to avoid forcing an electrolytic capacitor against the governor-switch on the motor. The method is to raise the chassis with the main face slightly tilted in order that the control-panel end will emerge first; the speed-control knob is useful in lifting the chassis clear of the case.

With the chassis inverted there is immediate access to the motor and associated transmission (referred to later) as well as the printed wiring card. The exposed face of the card is that shown in Fig. 1,

making it easily possible to undertake measurements and carry out circuit tracing. The only items which can be detached from the outer face are diode MR1 and the transistors, as all other components are mounted on the inward side. The transistors occupy holes in the card and can be drawn from these either before or after their leads have been unsweated to permit removal from the printed wiring.

Note that TR5 and TR6, feeding the internal loudspeaker, are a matched pair which must be rejected in favour of another matched pair if either becomes faulty. This applies also to TR7 and TR8 in the oscillator circuit.

As an emergency measure it is possible to cure an open-circuit fault by fitting a new component, excepting the transformers and oscillator coil, on the outside face of the printed card.* Fault-clearance work that involves separating the card from the remainder of the assembly must not be attempted; this servicing is extremely difficult and is therefore undertaken only by C.M.U., London.

Motor and Drive

Unsatisfactory tape transport can occur through failure of the motor or its governor switch, faulty transmission in the pulley-and-belt train (including drive to the take-up spool) and a partial seizure of the bearing for the capstan-and-flywheel assembly.

Local maintenance of motor units is forbidden and recorders which develop motor faults must be returned complete for servicing by C.M.U. The armature-winding currents, measured in wire 44 (Fig. 1), under idling and tape-transport conditions are about 90 mA and 150 mA respectively. Note that a meter for check measurement will try to respond to governor-switch operation, but the consequent vibration of the pointer is so rapid that the fluctuations from a mean reading are negligible.

It is permissible to cure transmission slip by fitting new belts, and spares are provided to enable this to be done. The same applies to replacement of the pressure roller (19) if a flat on the rubber track is suspected.

Excessive wow and flutter can result from abnormal friction in the sintered oil-retaining bearing supporting the spindle to which the capstan and flywheel are fitted. The recommended interval for cleaning the bearing is 12 months but again, particularly because of complex dismantling to make the bearing accessible, this work must be done by C.M.U.

Frequency-response Test (Record/play Amplifier)

Fig. 1.4 is a schematic of the arrangment for this test, which can be conducted without removing the recorder from its case.

The tone source (output impedance 600 ohms) is set for zero-level output at all test frequencies and is associated with a balanced loss pad, formed of three standard-value resistors, to provide the amplifier with an input at −75 dB. Possibly the easiest way of feeding the amplifier is to utilise a microphone cable with the 150-ohm resistor connected to the blades of the fitting remote from the recorder. For test purposes the recorder should be operated with the volume control adjusted so that the volume indicator is barely extinguished, and with the loudspeaker-muting switch locked at the open position. Owing to slight imprecision of the test conditions, especially the level for extinction of the volume indicator, it is not to be expected that figures quoted later can be obtained with an accuracy better than ±2 dB. The relative values, however, should be maintained within ±0·5 dB.

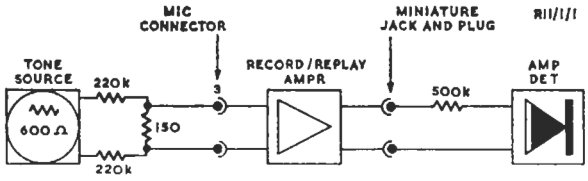


Fig. 1.4 Test Arrangement for Checking Frequency Response of Record/play Amplifier

Output levels are measured with the amplifier-detector in the high-impedance input condition and signals applied to it through a 500-kilohm resistor. To facilitate measurement at two outlet-jack positions it is desirable to make a patch-cord connector with the resistor in the lead joining the tip contacts of the miniature plug suiting the recorder and a standard P.O. type 310 plug ordinarily needed for connection with rack-mounted measuring equipment.

For completeness the specimen figures in Table 1 include a set referring to an indirect frequency-response test by use of tape, as a check on the complete recording chain. The lettered references apply to:

(*a*) Measurement at jack (12 in Fig. 1.2) providing an output corrected to C.C.I.R. requirements.

(*b*) Measurement at jack (2 in Fig. 1.2) for headphones.

**Instruction G.I deals with servicing of printed wiring cards*

(*c*) Recorded on E.M.I. 77 tape, with input as for (*a*) and (*b*). Played on Ferrograph half-track recorder and measured by standard method.

The noise figures in columns (*a*) and (*b*) are relatively inferior to that under (*c*), but these discrepancies disappear if wire 44 is disconnected to immobilise the motor. Under working conditions the input-circuit screening is such that all signal/noise ratios are better than those obtained in testing.

Overload measurement is undertaken with a standard Harmonic Routine Tester (FHP/3). For this the tone source output-level is increased by 10 dB and the total harmonic content should not exceed 5 per cent.

D.C. and A.C. Measurements

Typical direct-voltage measurements on the printed wiring card are given in Table 2. These measurements were taken with an Avometer Model 8 on the 12-volt range and in all except one instance they are positive with respect to point 17 (Fig. 1).

To insert a meter for total-current measurement is difficult. The values given below were obtained with the instrument acting as a link between two cells in the battery compartment.

Table 1

Frequency	*Condition*		
	a	*b*	*c*
50 c/s	−32	−12	−12·5
100 c/s	−32	−13	−10
1 kc/s	−32	−14	−11·5
3 kc/s	−32	−15	−11·2
5 kc/s	−32	−15	−11·2
8 kc/s	−32	−18	−10·5
10 kc/s	−32	−23	−13
12 kc/s	−32·5	—	—
Noise	−55	−35	−45

Table 2

Record/play Amplifier				*L.S. Power Stage*		*Oscillator*	
TR1 and TR2		*TR3 and TR4*		*TR5 and TR6*		*TR7 and TR8*	
Test point	*Volts*	*Test point*	*Volts*	*Test point*	*Volts*	*Test point(s)*	*Volts*
3	6·9	12	6·7	24	3·7	35	7·75
4	1·35	13	5·4	25	3·85	36	7·75
5	7·25	14	3·2	26	7·8	37	7·95
7	5·3	15	6·9	28	3·9	38	7·95
9	3·9	16	7·15			34—40	1·0
11	5·4	18	5·6				

Oscillator current	(TR7 and TR8)
Oscillatory state	45mA
Non-oscillatory state	80/90 mA

Total current	
Play condition (motor idling)	170 mA
Play condition (tape transport)	215 mA
Record condition (tape transport)	240 mA

In Table 3 are a.f. voltages at various points on the printed wiring card. They were obtained by using 1,000-c/s tone as for the frequency-response test described with reference to Fig. 1.4 and are r.m.s. values measured with a valve voltmeter. The datum for all readings is point 1 (Fig. 1), connected to chassis.

Table 3

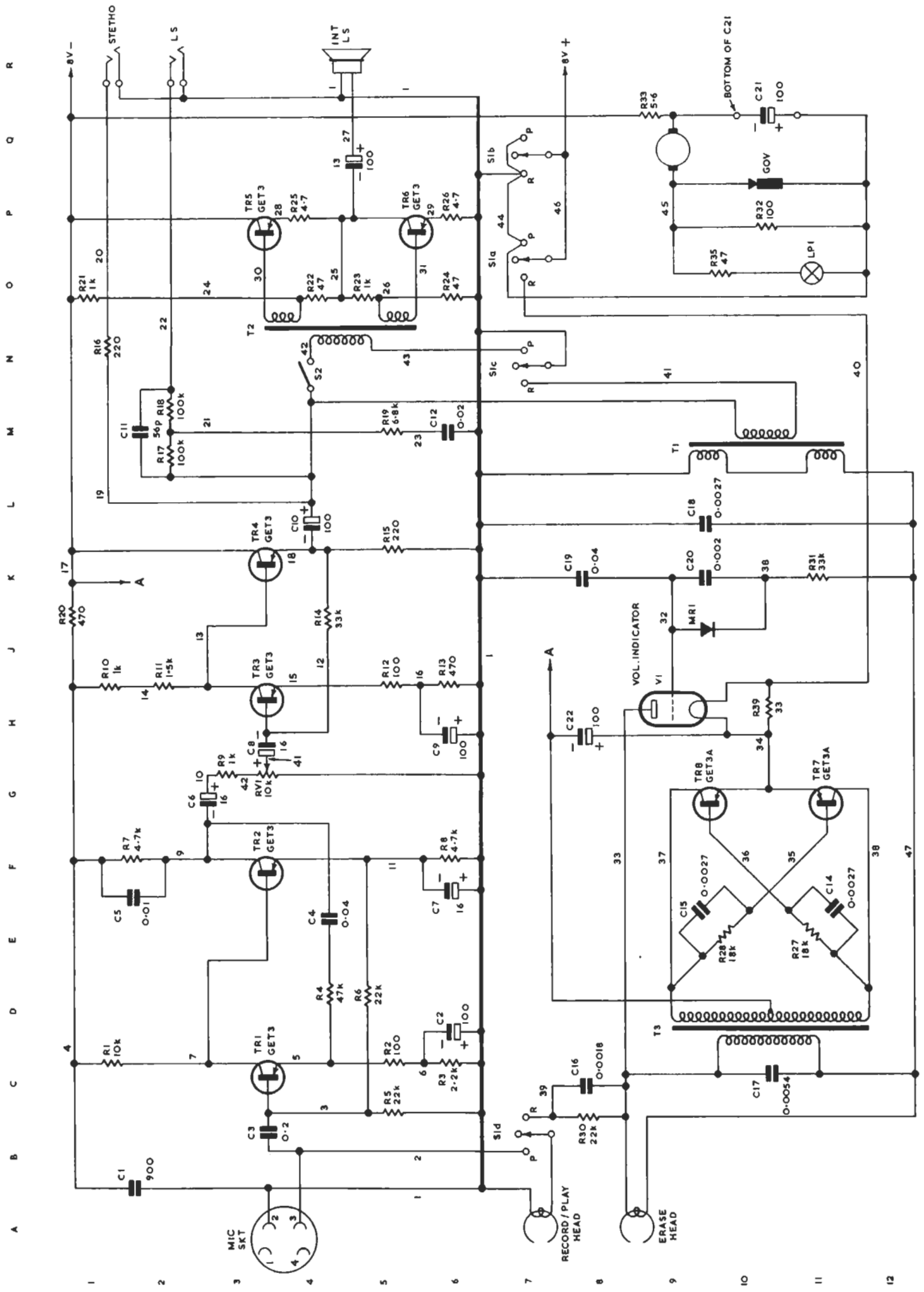
Test point	2	10	19	27	35	36	37	38
Volts	0·0002	1·1	1·45	2·1	4·0	4·0	0·4	0·4

Microphone

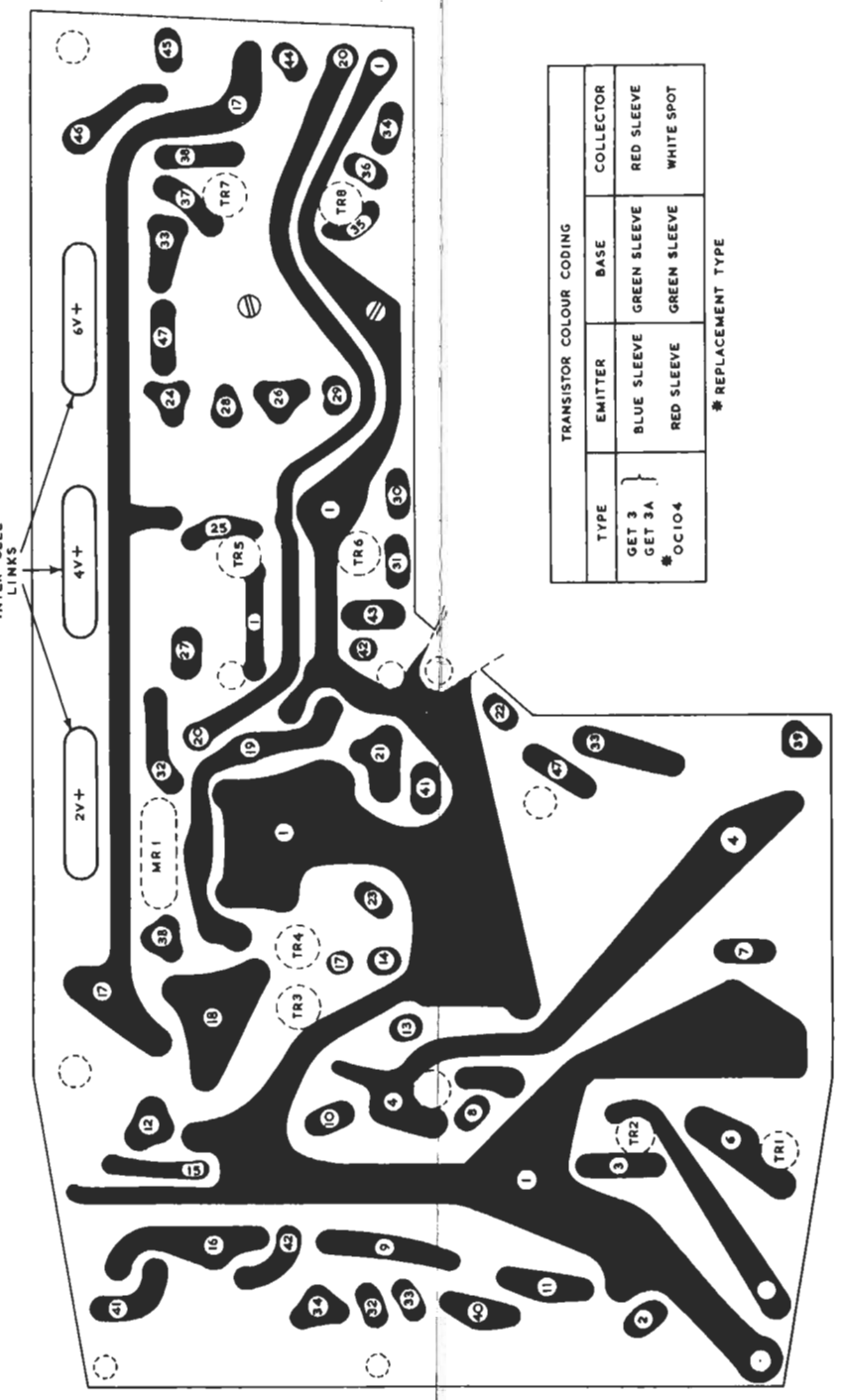
A microphone suspected of being faulty should be checked by comparison with one known to be free of defects. Faulty instruments should be returned to C.M.U., London.

EFW/0363

FIG I



CIRCUIT DIAGRAM



TRANSISTOR COLOUR CODING			
TYPE	EMITTER	BASE	COLLECTOR
GET 3 GET 3A *OC104	BLUE SLEEVE RED SLEEVE	GREEN SLEEVE GREEN SLEEVE	RED SLEEVE WHITE SPOT

* REPLACEMENT TYPE

PRINTED WIRING CARD

FICORD No I-A : CIRCUIT DIAGRAM & PRINTED WIRING CARD