

JULY 1966 TWO SHILLINGS

# tape recorder



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SIMPLE SYNC • WHAT'S IN A SPEC? • TRANSISTOR RECORDING AMPLIFIERS



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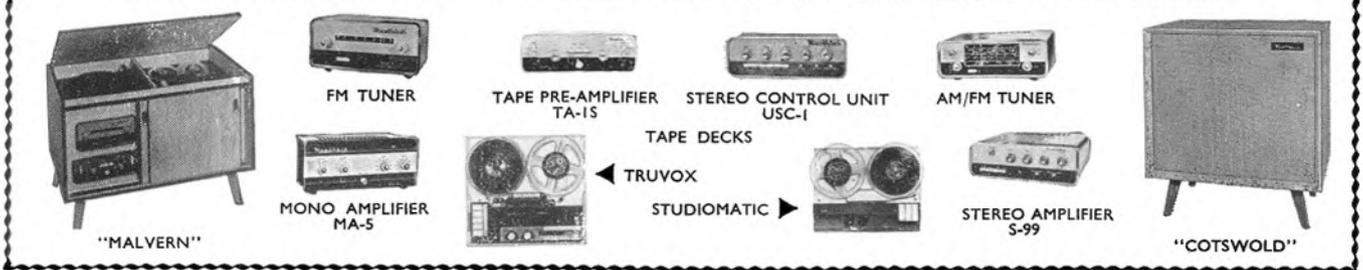
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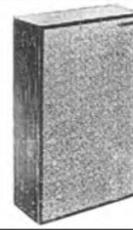
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HT-2

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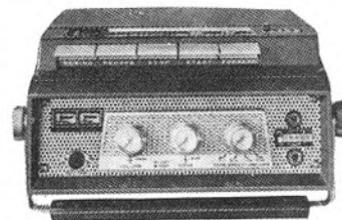


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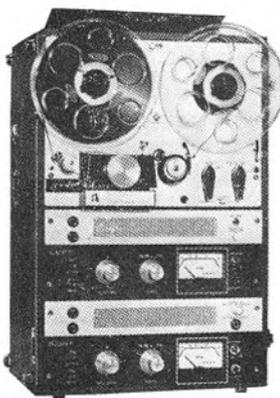
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# tape recorder

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## editorial

A RECENT ARTICLE in a national newspaper, written by a well-known novelist, brought attention to certain oddities in relation to international copyright. The author complained that, while journeying in North Africa, he had come across copies of his books being marketed cheaply by an unfamiliar publisher. Anxious to protect his own rights and those of the original publisher, he endeavoured to identify the profiteer. The latter was soon discovered to be operating from behind the iron-curtain, in an area free from the restrictions of International Copyright Conventions. No permission had been sought from the author, and no payment made, since the dissemination of literature to the world, it appeared, was not a matter for financial gain. The author was willing to concede this principle, but rightly queried why the iron-curtain publisher was selling its books at an obvious profit, rather than giving them away.

Within days of the article appearing, several readers wrote to enquire whether this situation worked both ways. One writer expressed a sincere desire to circumvent—not the *cost* of full copyright—but the time-consuming, mind-twisting *complexity*. He wished to know whether the many low-price discs currently being imported from the USSR could be copied domestically and reproduced publicly without permission of the *Mechanical Copyright Protection Society Ltd.*, of the distributor, of the musicians or the composer.

Another correspondent was worried by a rumour that record companies were planning to include a supersonic tone on their discs to prevent unauthorised tape recording (the idea being to induce audible beating between the tone and the recording bias oscillator).

Both these points seemed worthy of clarification and we therefore contacted the MCPS for the benefit of their advice. In his reply, Mr. B. W. Pratt, General Manager, states:

"As the USSR does not recognise copyright in a sound recording and is not a party to any International Convention, I suggest it would not be an infringement to reproduce by 'dubbing' recordings of Russian manufacture imported into the United Kingdom, although it is possible that the importer or concessionaire would be in a position to take action in Common Law to restrict such 'dubbing' for whatever purpose.

"I believe a similar position may obtain in respect of the use of such imported records for the purpose of providing a public performance."

Mr. Pratt goes on to point out the rights of the composer:

"The reproduction by 'dubbing' of an imported recording of Russian manufacture, of a musical work which in the United Kingdom is protected by copyright, would however constitute an illegal act in the absence of licence of the copyright owner, and this would apply equally to tape recorded copies intended for private and domestic use, as for copies made for sale."

Concerning the "supersonic tone", he continues: "I believe that certain manufacturers have incorporated some sound device into discs of a special character in order to prevent or detect infringement by illegal copying . . ."

We have made our own enquiries to determine the nature of such devices and have been informed by recording companies that a few discs may carry a signal permitting *detection* of illegal copies when

replayed in a certain manner on special equipment, but this does not prevent domestic tape copying and is not akin to the rumoured "supersonic tone". This rumour is stated to be totally unfounded. How many record-reproducers and domestic tape recorders would respond in the region of 30Kc/s anyway?

Returning to Mr. Pratt, his letter concludes: "We all know that in a considerable number of cases records are borrowed from friends, hire libraries and municipal free libraries and 'dubbed' by the owners of tape recording equipment, and it is obvious that this practice does to some extent depress the sale of records, to the detriment of manufacturers, music copyright owners and artistes. I am in fact appalled at the number of admissions we have received at this office that this practice is followed, with no intention to rectify by obtaining prior licence of any of the interested parties."

We cannot agree. If anything is "appalling" it is the failure of "the interested parties" to co-operate with each other and with the audio fraternity. Tape enthusiasts are generally prepared to pay for their pleasure, but are wholly unwilling to become endlessly involved in the procedure of obtaining permission. Feelings run high on this topic, and the reader's letter on page 239 is typical; we plan to publish an article on the ethics of copyright in the near future, including a plea for a rationalised approach.

It seems that in the field of strictly *music* copyright there has been some progress (see news item on page 149, May issue), and the MCPS point out that their efforts in this sphere—to which they are necessarily confined—may have helped to pave the way for an eventual overall system. It is apparently in the record industry where the main problems lie, due to extremely complex contractual obligations to performers. Musicians, creative artist's and composers deserve some reward for the pleasure they give, but it is up to their representatives to alter the unenforceable existing law.

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### COVER PICTURE

Apparatus constructed at the Harlow laboratories of STC is shown on this month's cover. A horizontally rotating head mechanism permits repetitive playback of short recorded passages, the reproduced signals being monitored on headphones and displayed on a slow time base oscilloscope. The equipment is employed in speech analysis.

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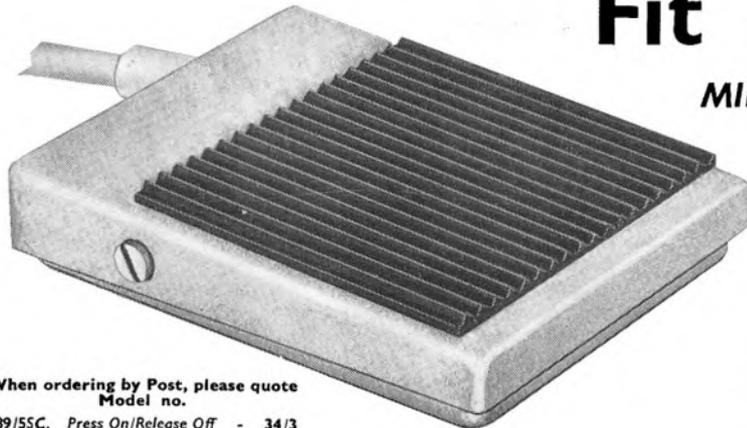
### SUBSCRIPTION RATES

Annual subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 38s. respectively. Overseas subscriptions are 32s. 6d. (U.S.A. \$4.50) for *Tape Recorder* and 38s. (USA \$5.40) for *Hi-Fi News*, from Link House Publications Ltd., Dingwall Avenue, Croydon, Surrey. *Tape Recorder* is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday

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Philips EL3534 ...	24 3 0	6 0 9	92
Tandberg 74 ...	24 8 3	6 2 1	93
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Akai M8 ...	38 6 6	9 11 8	146

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Grundig TK18L ...	10 15 3	2 13 10	41
Tandberg 823 ...	14 3 6	3 10 11	54
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Ferroglyph 631 ...	24 18 9	6 4 9	95
Ferroglyph 631H ...	26 5 0	6 12 11	100
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Ferguson 3212 ...	8 13 3	2 3 4	33
Philips EL3558 Teak ...	11 0 6	2 15 2	42
Grundig TK17L ...	11 5 9	2 16 6	43
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4-TRACK STEREO/MONO

- ★3 Speeds 7½ & 3½, 1½
- ★2 VU Meters
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- ★Auto Stop
- ★Exclusive precision micro gap head for high fidelity reproduction.

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# world of tape

## BRITISH RAIL TAPE THEIR WAGONS

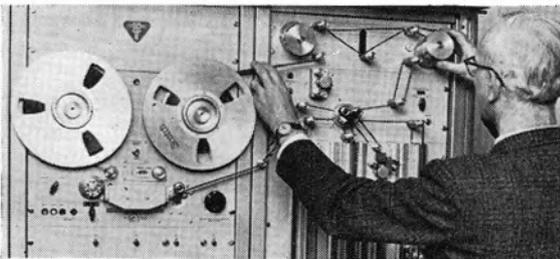
**E**ASTERN Region marshalling yards are currently experimenting with *Edison Midgetape* and *Grundig EN3* battery dictaphones as part of their system of Advance Traffic Information. Purpose of the system is to provide yard administrators with details of freight prior to its arrival, improving wagon handling efficiency and reducing delivery time. A freight train may comprise up to 70 wagons, and the labels of each wagon are noted on tape by guards. The tape is then passed to a Telex operator who transcribes the details onto punched tape, this being transmitted to divisional and headquarters offices. Other regions have shown interest in the system and it is expected to spread to other parts of the country.

## OH, TO SPEAK LIKE CHAUCER

**L**ANGUAGE laboratory equipment at Michigan State University is being used to teach Americans "how to speak like Chaucer". And while some of the University's 4,250 language students concentrate on medieval English, others practise the art of television and radio announcing. Arabic, Chinese, French, German, Italian, Russian and Spanish are among the foreign languages taught in the 122-booth laboratory, the installation being complemented by a "listening centre", where individuals or groups may hear educational tapes. Much of the work is undertaken on *Scotch* recording tape.

## LEEVERS-RICH PROBES HAAS EFFECT

**T**HE Institute of Sound and Vibration Research at Southampton University recently purchased a *Leevers-Rich* two-speed FM recorder to aid their investigation into the Haas effect. The machine can record up to four channels, with staggered heads providing variable echo delay. Three of the heads may be shifted by means of coarse and fine controls, providing up to two seconds delay. Tape speeds of 60 and 30 i/s are employed, with provision made for analysis of continuous loop recordings.



FIRE AT B & O

**S**ERIOUS damage has been caused to the newly-built *Bang and Olufsen* factory at Struer, Denmark, by a recent fire. The distributors state that supplies were affected, though production is now back to normal.



ASTRONIC  
TAPE  
PLAYER

**A** TAPE-PLAYER for use in retail and manufacturing establishments is being produced by *Associated Electronic Engineers*. The *Astronic Auto Music* was developed to play tapes supplied by an associate company—*Music for Lease*—and incorporates a version of the *Brenell* deck. Automatic track changing at each end of the tape is provided by driving the tape in two directions. Separate bass and treble controls allow adjustment to suit the user's taste, an internal 10W amplifier providing power for small installations. External amplifiers of up to 1,000W can be supplied when needed. **Manufacturer: Associated Electronic Engineers Ltd., Dalston Gardens, Stanmore, Middlesex.**

## MADE IN JAPAN

**T**HE Sony *TCV2010* domestic video tape recorder (currently being marketed in the USA and detailed on page 246) appeared in a BBC television programme *Made in Japan*, broadcast on 5th May. The film gave a fascinating insight into the workings of Japanese Industry and the apparent extreme dedication of employee towards employer, which has led to many manufacturers (notably *Hitachi*) building entire factory-towns, complete with cemetery.

In the course of touring the Sony factory, we were privileged to witness a demonstration of the video recorder and to observe the quality of the picture. Although contrast could not be assessed through the lens of a film camera, the picture was seen to be remarkably stable. The time taken to achieve an unbroken frame when the equipment was switched to play was notably less than that of considerably more expensive helical-scan recorders.

## EXPANSION AT STEREO INTERNATIONAL

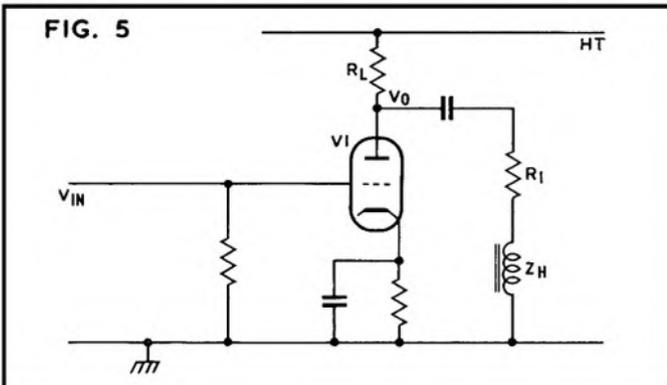
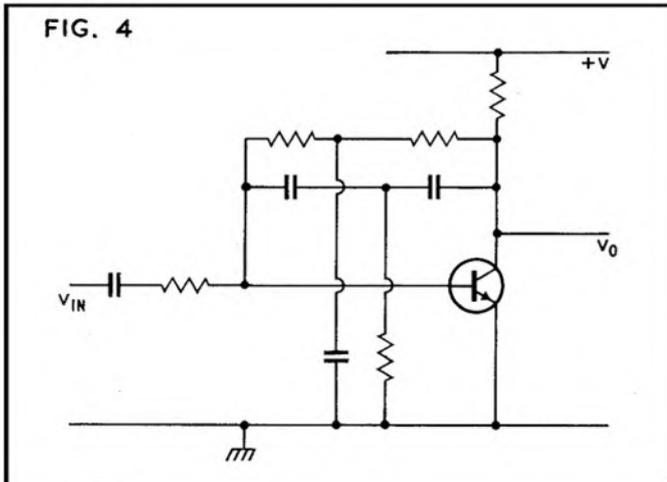
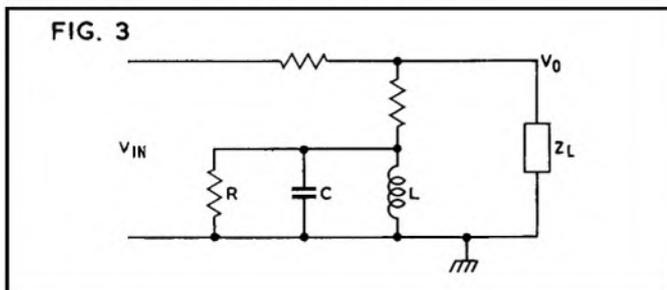
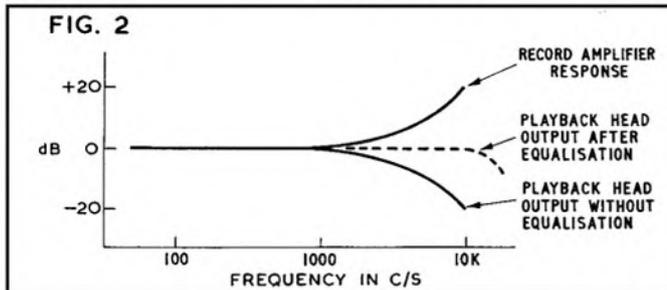
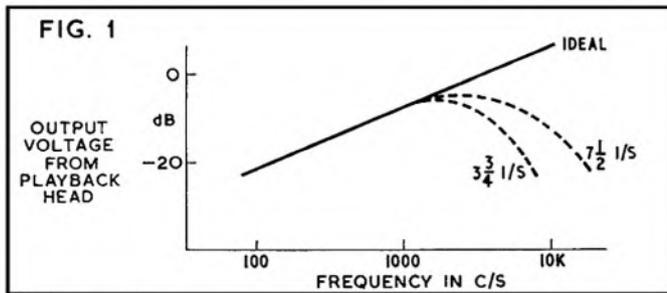
**R**E-ORGANISATION of *Stereo International* has resulted in the appointment of a new International Director, division of the club into geographical zones, and the introduction of a sound magazine. All existing members in the U.K., and all new members on receipt of their 1gn. annual subscription, are to be sent copies of a tape-recorded journal, new editions of which will be produced each year. Members' live recordings and reviews of tape equipment comprise the programme, which is supplied on a 5in. tape. The club is endeavouring to link with *Stereo Recording Enthusiasts of America* and has ambitions to become a world centre for the exchange of information and tape recordings between local societies. Details of membership may be obtained from: **L. Burchall, 36 Nevitt House, New North Road, London, N.1.**

## REVISION OF THE LAW

**A**N error appeared in the circuit on page 109 of the April issue, part of the article *Successful Home Recording* by John Law. The first stage in each section is an emitter-follower, and consequently the connection to the base of the second stage should come from the first stage emitter (top of  $R_2$ ) and not from the collector as shown. The second stage is a straight amplifier, the 0.25 $\mu$ F capacitor going to the collector (12K/2M junction) and not to the emitter. We apologise to any constructors who have been misled by these errors.

## NEXT MONTH

**A GREEN COVER** will adorn the August issue, to be published on Thursday, 14th July. Fundamentals of video recording, with a look at old and new television equipment, will be explained in the first of a short series—*Television on Tape*. Michael Woodward describes the construction of *Budget Booms*, while Alec Tutchings reviews the *Fidelity Playmaster*. Undergoing field trial will be the *Optacord 416*.



**transistor recording AMPLIFIERS**

C. W. W. READ DESCRIBES  
CONTEMPORARY CIRCUIT TECHNIQUES

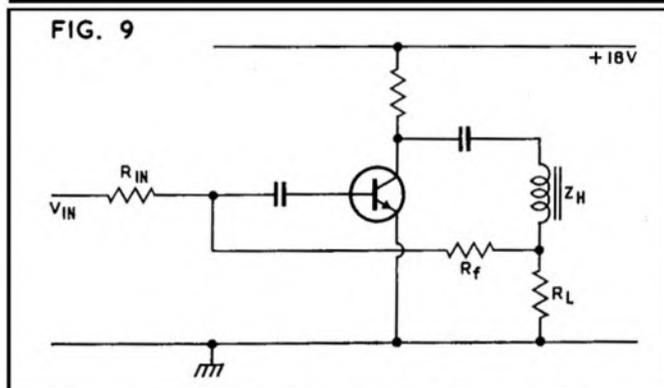
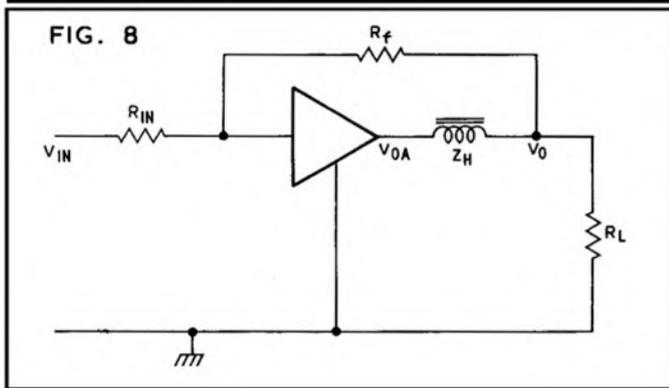
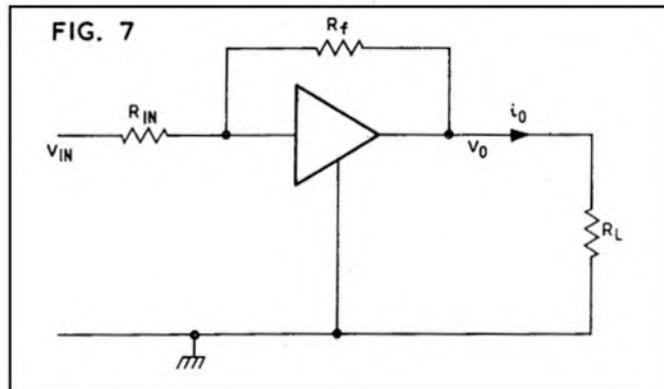
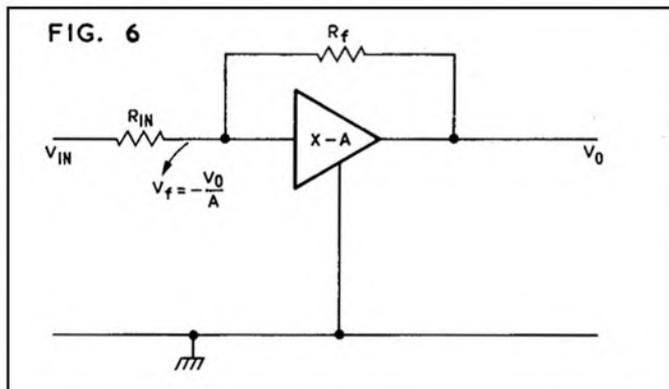
**M**AGNETIC tape recording heads are normally driven by a current which, neglecting equalisation for the moment, is constant with frequency. This results in an essentially constant flux-versus-frequency condition on the tape.

The output voltage from the playback head is then proportional to the rate-of-change of flux and so increases at 20dB per decade as the frequency increases. This is true from low frequencies up to a few Kc/s. Beyond these frequencies, playback head losses cause the output voltage to drop; this is illustrated in fig. 1.

In order to obtain a flat response from a tape recording system, CCIR has decreed that the record amplifier should compensate for the high frequency losses, and the playback amplifier for the low frequency losses. We can see from fig. 1 that the frequency characteristic of the record amplifier must have a rising response above 1 Kc/s so that the falling playback head output voltage is exactly balanced; this is shown in fig. 2.

A popular method of achieving the record amplifier response in valve amplifiers is to use a resonant L-C circuit as shown in fig. 3. Here the rate of rise of the response is controlled by the Q of the circuit, and at the lower tape speeds—when this needs to be high—the Q must be high, and the input impedance of the following stage,  $Z_L$ , must be high, typically 1M. This need not be a disadvantage with transistorised circuits, as input impedances of 1M are readily obtainable with silicon transistors, run at low currents, without resorting to bootstrapping.

Another method of obtaining the record amplifier response is by



using a parallel-T. A feedback configuration is shown in fig. 4. The circuit can be less effective at the lower tape speeds when a high Q is required, though this can be obtained when precision components are used.

**Valve amplifiers.** Let us assume our record head has an inductance of 200 mH and that the optimum recording current is 200μA RMS.

To obtain the current drive with valves, the circuit of fig. 5 was often used. Here  $R_1$  is chosen to be large compared with the impedance of the recording head,  $Z_H$ . If  $V_o$  is the signal voltage appearing at the anode of V1, then the current flowing in  $R_1$  and hence  $Z_H$ , will be  $V_o/R_1$ .

At 20 Kc/s,  $Z_H=26K$ , so if we choose  $R_1=220K$  we can work out the magnitude of  $V_o$  for 200μA driving current :

$$V_o = [200 \times 10^{-6} \text{ (amps)}] \times [220 \times 10^3 \text{ (ohms)}]$$

$$= 44V \text{ RMS or } 123V \text{ p-p}$$

This is a large voltage swing, but should be obtainable with valve amplifiers. The technique is very inefficient, as only a small fraction of  $V_o$  is dropped across  $Z_H$  and most of the power developed in V1 is dissipated in  $R_1$ .

**Transistor amplifiers.** The technique of using a large resistor in series with the head has been applied to transistor circuitry. In one case, high voltage transistors were used with a 60V rail. This is an unsatisfactory solution; firstly, because high voltage transistors are expensive, and secondly, because the only function of the 60V rail was to drive the last two transistors in the recording amplifier, unnecessarily complicating the power supply.

Another circuit used an 8:1 step-up transformer to obtain the large

voltage swing. The transformer needs to be of high quality, to maintain good low frequency response, and is therefore expensive and bulky.

Another possibility is to use a low-impedance recording head, when the series resistor can be smaller and hence the voltage swing required is less. This may be undesirable when the head is required to perform the dual function of record and playback, as the playback voltage is proportional to the inductance.

We shall now see that there are techniques available for current-driving a high impedance head from low voltage rails.

**Feedback Amplifiers.** Let us consider an inverting amplifier having zero input current and a voltage gain of A. In the circuit of fig. 6 we have now put feedback round the amplifier and can derive an expression for the gain with feedback :  $G = V_o/V_{IN}$ .

From fig. 6  $V_f = V_o/A$  and if A is very large  $V_f$  is very small. Now, the input current will be  $V_{IN} - V_f/R_{IN}$ , and if  $V_f$  is very small this becomes  $V_{IN}/R_{IN}$ . This current can either flow into  $R_f$  or into the amplifier, but as we have specified that the amplifier shall have no input current, it must all flow into  $R_f$ ; i.e. the current flowing into R is  $V_{IN}/R_{IN}$ .

In addition, the potential across  $R_f$  is  $V_f - V_o$ , and if  $V_f$  is very small this becomes  $-V_o$ . We now have another expression for the current flowing in  $R_f$  :  $-V_o/R_f$

Equating these expressions gives us :  $\frac{V_{IN}}{R_{IN}} = \frac{-V_o}{R_f}$

or  $\frac{V_o}{V_{IN}} = \frac{-R_f}{R_{IN}} = G$ , the gain with feedback.

**TRANSISTOR  
RECORDING  
AMPLIFIERS  
CONTINUED**

If we now add a load resistor,  $R_L$ , fig. 7, then the current flowing in  $R_L$  is  $\frac{V_o}{R_L} = -\frac{V_{IN} R_f}{R_{IN} R_L} = i_o$ , which is independent of frequency.

If we now include our record head as in fig. 8, then the current flowing in the head will also be that flowing in  $R_L$  (some current also flows in  $R_f$  but this will be constant) and is similarly independent of frequency.

Another way of understanding the technique is to regard  $V_o$  in fig. 8 as held constant by the feedback action, then as the frequency increases and  $Z_H$  increases, the amplifier output,  $V_{oA}$ , also increases to maintain the same current flow and thus keep  $V_o$  the same. We have therefore achieved the desired current drive, independent of frequency, through the record head.

In order to design the amplifier we must decide upon the voltage swing required,  $V_{oA}$ , and the values of  $A$  and  $G$ . If the record head current is  $200\mu A$  RMS ( $560\mu A$  p-p), and the impedance of the head at 20 Kc/s is 26K then the voltage across the head will be  $V_H = 560 \times 10^{-6} \times 24 \times 10^3 = 14.5V$  p-p. If  $R_L$  is now chosen so that the voltage dropped across it,  $V_o$ , is small compared with  $V_H$ , then  $V_{oA}$  at 20 Kc/s will be 14.5V p-p and an 18V rail will be adequate.

Let us assume  $R_L = 1K$ , which will mean  $V_o = 500$  mV p-p. If we now consider the value of  $A$  required, it can be shown that  $G = -R_f/R_{IN}$  to within 10% if  $A = 10G$ . Now, it is possible to obtain  $A = 100$  from a single transistor, in which case, if  $G = 10$  the input sensitivity will be 50mV p-p. A single transistor amplifier with feedback is shown in fig. 9; DC stabilising components are omitted for greater clarity.

The major disadvantage with this scheme is that the record head is isolated from earth, which could complicate switching when the head has to perform the dual function of record and playback.

**Complementary Drive.** Another method of obtaining current drive to the record head is by using complementary drive.

If we consider the circuit of fig. 10, the output current from the transistor will divide between  $R_L$  and  $Z_H$ , and the magnitude of the current flowing in  $Z_H$  will depend on the frequency. In order that all the output current from the transistor flows into  $Z_H$ ,  $R_L$  must be very large, i.e. about ten times the value of  $Z_H$  at 20 Kc/s. This gives  $R_L = 220K$ , and to drive  $500\mu A$  p-p recording current implies a rail voltage of 100.

This problem can be solved by replacing  $R_L$  with another transistor, of the opposite polarity to T1, operating as a constant-current source. A *p-n-p* transistor connected as a constant-current source is shown in fig. 11.  $R_1$  and  $R_2$  form a potential divider across the rails, the potential on T2 base being  $V_p$ . The emitter voltage of T2,  $V_E$ , is then equal to  $V_p + V_{be}$  where  $V_{be}$  is the base-emitter potential of T2. Thus the current flowing in T2 is  $V - V_E/R_{E2}$ .

The output impedance is the collector impedance of T2, which for silicon transistors is of the order of megohms. We can now replace  $R_L$  of fig. 10 by the circuit of fig. 11, resulting in fig. 12.

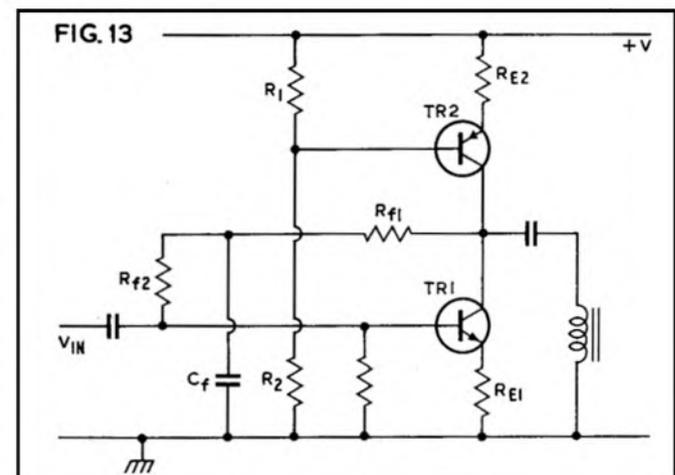
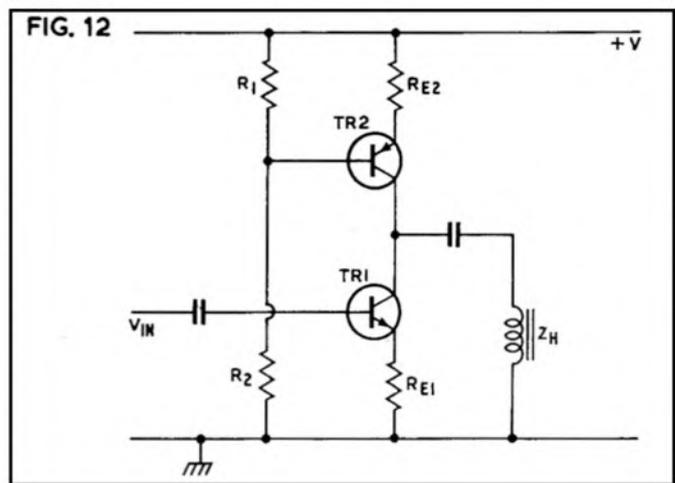
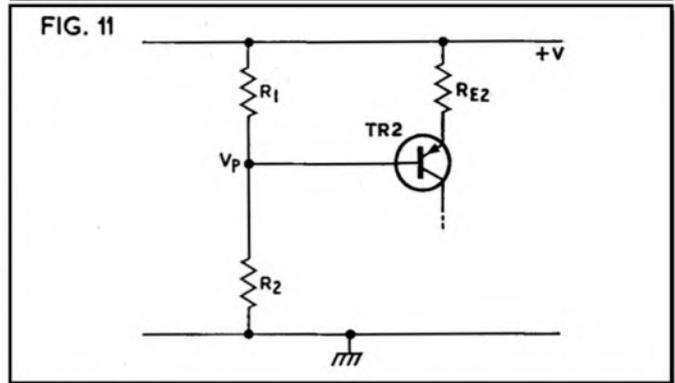
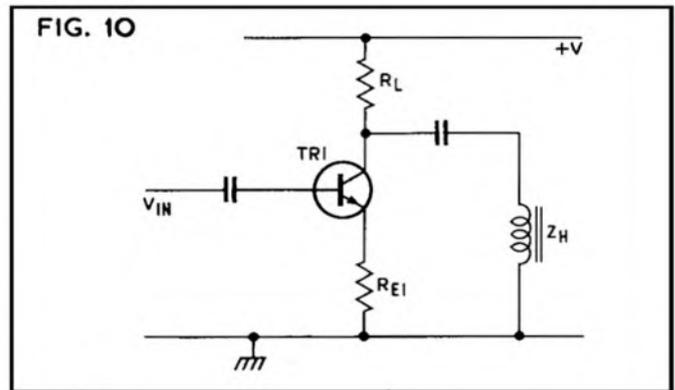
The final problem in the design is to stabilise the DC potential of T1 and T2 collectors. This can be achieved by taking feedback from the collectors to T1 base as shown in fig. 13. The feedback must be decoupled, by  $C_f$  to avoid signal feedback which would effectively reduce the output impedance of T2. Again, to ensure all the signal current flows in  $Z_H$ ,  $R_{f1}$  must be 220K or larger.

As before, an 18V rail is adequate if only a few volts are dropped across  $R_{E2}$ . T2 may be run at a current which is an order greater than the recording current, i.e. about 5mA.

The sensitivity for  $500\mu A$  p-p recording current is defined as follows. If the input voltage is  $V_{IN}$ , the signal appearing on the emitter of T1 will be very nearly  $V_{IN}$ , so the signal current flowing will be  $V_{IN}/R_{E1}$ .

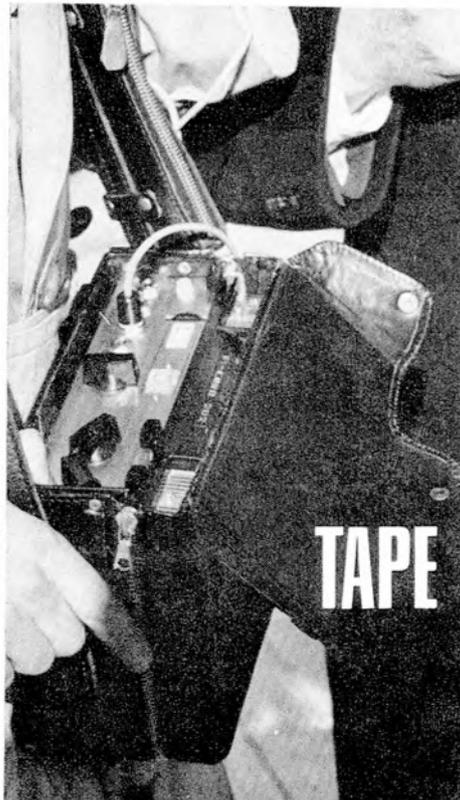
To keep the voltage gain of the stage linear,  $R_{E1}$  should not be less than 100 ohms, which will give an input sensitivity of  $500 \times 10^{-6} \times 100 = 50mV$  p-p.

The sensitivity is similar to that obtained using feedback, but an extra transistor is required. The latter method does not have the disadvantage of a floating drive and is probably the better circuit to use in a system where the head is switched from record to playback.



# BATTERY POWERED

# TAPE RECORDERS



## Number eight NEW BATTERIES FOR OLD BY MICHAEL GORDON

**I**N the main, portable and quasi-portable tape recorders are powered from internal batteries either of the *all-dry* (primary) or *nickel-cadmium* (secondary) type. The cells comprising such batteries are fully detailed in Part 1 of this series: to recapitulate, the primary cell is wholly expendable and is discarded when exhausted, while the secondary cell can be re-charged when its energy store falls below that necessary to run the machine properly.

Small, truly portable models almost all employ several medium-capacity primary cells in the form of a series-connected battery, while larger models, suitable for both field and indoor activities, usually contain a battery of secondary cells with a charger built into the recorder so that when the machine is operated near a mains power supply it can be energised from that source.

The load on the cells, of course, is reduced when the machine is running from the mains supply, but for a full and proper charge it is usually necessary to connect the machine to a mains power outlet for a number of hours while it is mechanically and electronically inactive. In that way the inbuilt charger is able to direct maximum charging current to the cells.

The small recorder designed for use with primary cells can sometimes be 'upgraded' by changing the primary cells for equivalent size secondary cells and employing an external charger. However, it is not always possible to obtain secondary cells of equivalent size to the primary cells. Moreover, secondary cells are often formed into complete batteries, making it difficult to accommodate them in the housing of a small recorder. Then, of course, there is the voltage (and capacity) aspect to consider.

On no account should a battery recorder be connected to a supply exceeding the nominal voltage of the designed-for battery by about 8-10%. A greater voltage would be likely to impair the efficiency of the transistors and cause overheating and excessive sparking in the drive motor and governors.

It is usually possible to run such a recorder, however, on a lower voltage, for the design of most recorders of this kind ensures that the machine will continue working reasonably well when the battery is getting close to the end of its working life. Thus, a supply input up to 20% below the nominal battery voltage is permissible.

If a battery composed of re-chargeable secondary cells cannot be fitted into the recorder housing proper, it may be worth considering the possibility of housing the battery in a separate container, especially if the machine is used extensively for field work where the rate of primary cell use is excessive. It may be that the recorder is carried in a leather or plastic case with sufficient extra room for the rechargeable battery.

This should be connected through wires to the terminals in the compartment normally carrying the primary cells. Care must be taken, though, to see that the battery polarity is observed—positive to positive and negative to negative. A reversed battery will almost certainly harm the transistors in the majority of small machines.

It is interesting to note, however, that some models employ a protective device in the form of a semiconductor diode between the battery and the power input of the machine, as shown in fig. 1. Here the diode is shown connected in the positive battery lead with its *anode* to the battery and *cathode* to the circuit. Connecting this way puts it into forward conduction, and as the effective resistance of a silicon device so biased is very low it affords very little resistance to the current flow and has no effect on the operation of the circuit. However, should the battery connection be inadvertently reversed, the diode is biased for reverse conduction and its effective resistance rises greatly, thereby substantially reducing the current flow through the equipment and thus protecting it from the effects of reversed battery polarity.

This artifice can be included in the battery supply circuit of any portable recorder, but the diode must have a rating at least equal to that of the full-load current demanded of the equipment. It can, if more convenient, be connected in the negative battery lead, but here it must be reversed so that the *anode* is connected to the equipment and the *cathode* to the battery.

Users of small battery-powered equipment sometimes wonder whether it is possible to extend the life of ordinary primary batteries by some process or other. This thought arises in particular when dry-cell-powered equipment is used extensively in the field and the cost of battery replacements becomes quite real!

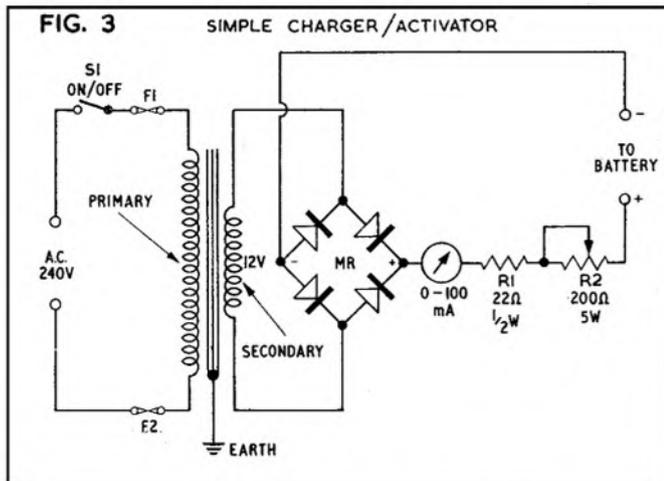
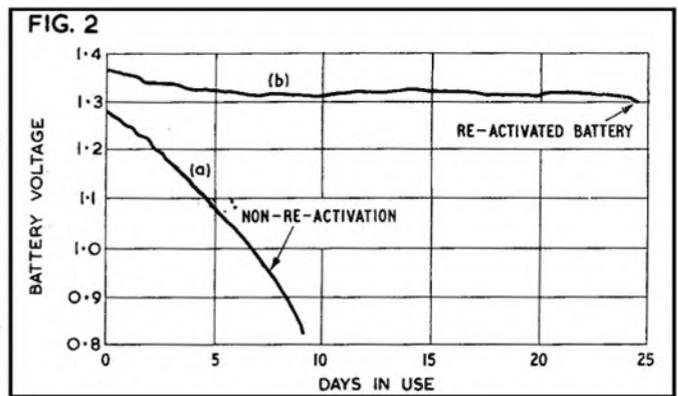
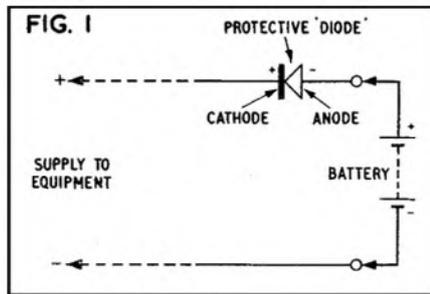
While it is possible to secure some success in terms of re-activating dry batteries, it must be thoroughly understood at the outset that such batteries are definitely not designed for re-charging and that by far the best plan is to employ nickel-cadmium batteries or proper rechargeable secondary batteries when the cost of battery replacement becomes a major item of economics.

The information which follows, therefore, is of an experimental nature only, and it should not be taken to imply that the ordinary all-dry cell can be used to replace the special re-chargeable type. Nevertheless, some degree of success has been attained in the 'charging' or 're-activation' of all-dry cells, as we shall see.

A dry battery is discarded when its internal resistance rises to the extent that the terminal voltage on load is insufficient to work the equipment properly. Usually, when such a load is connected across a

(continued overleaf)

**BATTERY  
POWERED  
TAPE RECORDERS**  
continued



battery the internal chemistry reacts so that the internal resistance rises even more, thereby seriously impairing the useful current that the battery is able to deliver to the load (i.e., tape recorder).

A major cause of increase in internal resistance is the inability of the depolariser to deplete sufficiently rapidly the accumulation of hydrogen around the carbon or positive electrode of the battery. Another cause is loss of electrolyte due to evaporation, but this happens mainly after many months of use and is only a relatively minor factor, particularly in applications where the battery is called upon to deliver fairly high currents. Here, then, depolarisation is of the greatest concern.

Of recent years the big battery manufacturers have invested in research to minimise the depolarisation problem, and they have had a deal of success as illustrated by the advent of the new, long-life, extra-high-power cells that are currently available.

Even so, it would seem that many batteries still need to be discarded long before the negative zinc electrode has deteriorated and the carbon and depolarising elements have been fully exhausted. In other words, the discarded batteries still contain all the ingredients necessary for their efficient working, yet they are inhibited by the presence of hydrogen in the region of the positive carbon electrode.

This has been the problem since the advent of the first Leclanché cell, and a number of schemes have been put forward to quell the rate of polarisation in a battery on load, leading, of course, to the efficient depolariser which is featured in today's batteries. It will be recalled from Part 1 that the function of the depolariser is to neutralise the accumulations of hydrogen in the neighbourhood of the carbon electrode.

Early experimenters discovered that a new lease of life could be given to a primary cell of the Leclanché principle by connecting across it a potential a little above its nominal terminal voltage and padding the 'charging' circuit for a small (milliamperes) current flow. To avoid short-circuiting the battery and charging circuit the polarities were matched—positive to positive and negative to negative—in the ordinary battery charging pattern.

Indeed, during the war, when dry batteries were not always readily available, the author recalls charging (*re-activating* is probably a better term) 4½V flat flashlight type batteries from an ordinary 6V accumulator charger. The charge current was fairly high in this instance, and appreciable activity was achieved after a period of about 30 minutes.

The battery voltage is recalled to have risen from the nominal 4½V to almost 6V after this period, and it was necessary to let the battery stand for a while before putting it back into service.

Further early experiments at much lower currents dictated a somewhat longer time period for the best results. Cells of the U½ size were charged best with a current of about 12mA, while the smaller size responded best with about 8mA re-activating current over periods of approximately 24 hours in both cases.

The low current technique avoids heating of the electrolyte, with consequent loss due to evaporation. Excessive re-activating current will, of course, result in internal gassing, with a strong likelihood of the cell or battery of cells exploding!

The re-activating process would appear to reverse the action of the battery and thus destroy the accumulations of hydrogen round the carbon electrode, while also to some extent transferring back to the zinc electrode any metal dissolved due to the normal discharge cycle of the battery.

During the 1950's commercial attempts were made to popularise a dry battery 're-activator'. A device called an *Activette* was put on the market by *Amplion*, and this would appear to have enjoyed a term of reasonable 'success'. That it did not catch on permanently may have been due to the fact that battery-powered equipment of over a decade back was nowhere as near in the limelight as is present-day equipment employing solid-state devices and more efficient electric motors. It is possible, therefore, that a similar piece of equipment launched today would have greater success. However, it must be borne in mind that the latest dry batteries are more efficient than their counterparts of fifteen years ago, so the degree of success of re-activation may not be so high as it was with the old-style cells (see fig. 2).

Nevertheless, some enthusiasts may wish to revive the early experiments, and with this in mind the circuit of a simple nickel-cadmium charger, which can also be used as a dry cell re-activator, is given in fig. 3.

This consists of a small isolating mains transformer with a primary winding to suit the local mains voltage (usually around 240V) and a 12V secondary winding rated at about 1A. The primary is connected to the mains supply through 2A fuses, F1 and F2, and on/off switch S1.

The transformer secondary is connected across the AC terminals of a 1A, 12V bridge, rectifier system, such as Cat. No. MR48, by *Home Radio (Mitcham) Ltd.*, while the DC output terminals of the bridge are connected negative direct to the battery and positive through a 0-100mA charging current meter, fixed resistor R1 and wire-wound variable resistor R2. The former acts as a current limiter and the latter provides adjustment of the charging or re-activating current.

A 200-ohm R2 normally gives sufficient charging current adjustment, but if extra small cells are charged separately R1 can be increased above 22 ohms. This is an inexpensive ½W resistor, though its wattage rating may have to be increased if its value is substantially increased to avoid overheating.

If the unit is built on to a small metal chassis, the chassis is best earthed to make it safe in the event of a transformer short or leakage to mains. However, if a wooden or insulated board is used, the metal core of the transformer should be earthed as shown in the circuit.

Next month we shall look at some of the very small nickel-cadmium chargers designed for building into equipment, and also consider the charging rate of nickel-cadmium cells, which tends to cause confusion. We shall then commence an investigation into the battery-powering of tape recorders designed specifically for all-mains powering.

# WHAT'S IN A SPEC



A LOOK AT  
TAPE  
RECORDER  
SPECIFICATIONS  
BY G. T. ROGERS



THE number of firms marketing mains and battery domestic tape recorders in this country is considerable, and new models are appearing every year. At the present time, however, there is a tendency for manufacturers to introduce added facilities, such as mixing, superimposition and monitoring, which were formerly only found in highly priced semi-professional and professional machines. Also, the use of four tracks and the introduction of very slow speeds have become widespread since they enable great economies in tape to be achieved.

All this has an obvious advantage where economy and versatility are the main objects, but within any given price bracket there must be a compromise between the number of facilities available and the quality of construction and performance, and thus the reliability achieved.

For those in search of good performance and reliability in a particular price range, the choice of a recorder can be a very difficult task—one has to decide how much has been spent on versatility and how much on real quality. Having decided on the essential features required, the best guide to quality is to understand and compare the technical specifications given by the makers of various recorders, and then confirm the choice by careful listening tests under good demonstration conditions. In the present article the important items of a typical specification will be considered in turn.

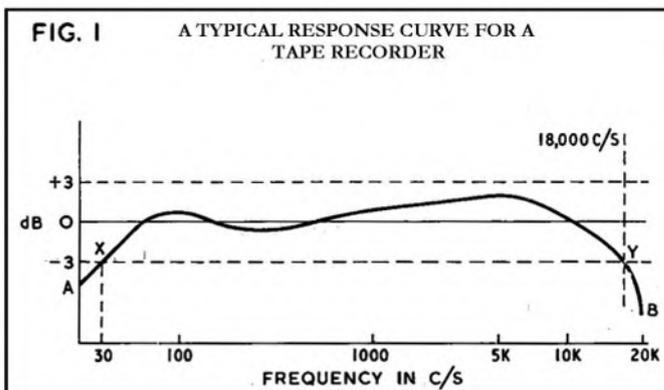
Plastic and wood are the common constructional materials for cabinets, the latter being protected by a washable plastic covering. The important requirement here is that it must be strong enough to withstand constant use over long periods. Obviously the external appearance will be a matter of personal choice, but a neat layout, with easily accessible controls and cable sockets, is a feature of good design which will pay dividends in convenience of use. Remember also that some recorders will not operate with the lid closed.

If the recorder is to form part of a permanent installation its weight is not important, but 30lb. can be taken as maximum if it is to be moved around a lot.

In domestic equipment the most common tape speeds are  $7\frac{1}{2}$  and  $3\frac{3}{4}$  inches per second, although  $1\frac{1}{8}$  and even  $\frac{1}{16}$  i/s are found in some machines, and 15 i/s is the standard speed used professionally. It may be said that, with all other conditions remaining constant, the faster the tape speed the better the quality; so in a two speed machine the higher speed would be used for serious music, with the slower speed reserved for speech and background music, where quality is not so important.

With improvements in recording and reproducing heads, and also in magnetic tape, acceptable results can now be obtained at  $3\frac{3}{4}$  i/s; but for high quality a speed of  $7\frac{1}{2}$  i/s is really necessary. In some models, however, such as the *Tandberg* series, excellent results can be obtained at  $3\frac{3}{4}$ —but these are engineered to very fine limits and are competitive only with the more expensive machines.

The main difficulty encountered in the design of the tape transport system is persuading the tape to move over the heads at constant speed, any speed fluctuations showing up as wow and flutter. When the speed variation occurs at very low frequency, in the order of ten times per second, it is known as wow, whereas flutter is applied to a speed variation of relatively high frequencies, in the order of 100 times per second. The effect of wow and flutter is particularly noticeable during the reproduction of sustained notes such as those produced by



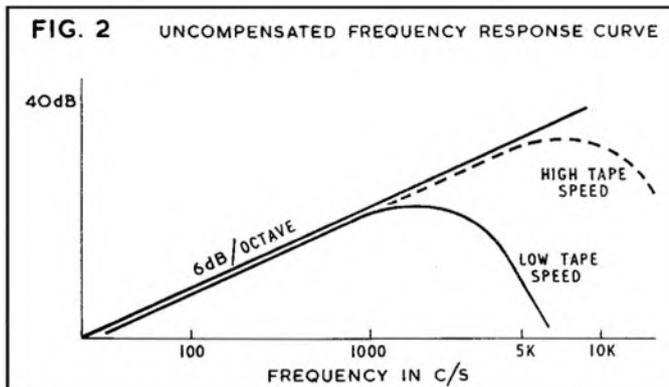
a piano, when it takes the form of fast and slow fluctuations in pitch.

Wow and flutter are generally stated as the percentage variation of the normal speed, and a figure below 0.1% is imperceptible to the human ear. In expensive professional recorders values of less than 0.15% at 15 i/s tape speed are quite common; however, in domestic equipment the figures are usually around 0.3% at  $3\frac{3}{4}$  i/s and 0.2% at  $7\frac{1}{2}$  i/s, although there are some machines which can improve on this.

A point of considerable importance when considering wow and flutter figures is whether the values given in a specification will apply in practice after the recorder has been in use for several months. Obviously the heads and capstan have to be scrupulously clean to obtain the specified wow and flutter figures in any machine, but the pointer to reliability in proper conditions of use is a high standard of mechanical construction and assembly, which is not attained cheaply. For high fidelity results, 0.2% of wow and flutter must be taken as the absolute maximum, although 0.3% is acceptable for speech and background music. To obtain a figure of 0.2% the capstan and pressure-roller must be concentric with their axes and machined to a very high degree of accuracy. Also, the bearings in which their spindles run must be of high quality, and in some of the better instruments ball-races are used which stand up to hard use for a long time. Wow and flutter originate from a number of factors, the most important of which will now be mentioned.

The feed reel can offer a varying drag on the tape, hence wow, and this is especially true if the tape rubs on the spool rim. In some machines, bobbin guides are provided which can be adjusted to check this. Friction of the erase head and recording head and pressure pads, if present, can also cause drag, although if these parts are kept clean their contribution to wow and flutter should be negligible. As mentioned earlier, eccentricity of the capstan is another cause of wow and flutter, and this depends on the accuracy with which it is made. A larger diameter capstan is fitted to some machines, such as the *Ampex 351* professional recorder: this reduces wow and flutter due to eccentricity. On the other hand, in recorders such as the *Ferrograph 422 U*, the size of the capstan is kept to a minimum (in fact it has recently been reduced within the limits required to prevent wobble) to

(continued overleaf)



improve wow and flutter. Apparently, in this latter case, use is made of the fact that when the speed of the capstan is increased the constancy of tape speed is improved.

The capstan is driven by the capstan motor, the power being transmitted in one of three main ways. In some machines the motor spindle is extended to form the capstan and its speed will depend on the diameter of the latter and on the tape speed required. Very thin spindles (around 2mm.) for the capstan are too fragile and are liable to wobble and cause wow. Conversely, a large diameter is desirable in diminishing capstan eccentricity; but a large capstan has to be driven at a low speed for any given tape speed, and slow synchronous motors, with their large number of poles, present their own problems. A further disadvantage of this system is that only one speed is usually available, although two-speed motors, which incidentally are heavy and expensive, are used in some machines. The Revox 736 is an example.

The second method of linking the capstan to its motor is to use a cord transmission so that a speed reduction can be achieved. This enables the advantages of a large diameter capstan to be coupled with a high-speed motor, and high-speed induction motors are easier to manufacture, hence cheaper, than the slower ones.

The mechanical problem of speed change is, however, still present. The most popular method, involving a rubber intermediate wheel, enables a high-speed motor to drive a stepped spindle and then a large diameter capstan, through the intermediate wheel. Any number of desired speeds can then be obtained according to the number of steps on the spindle. An added advantage of this type of drive is that the intermediate wheel acts as a mechanical filter, smoothing irregularities in the motor speed and its rotation. In all machines the heavy flywheel smooths out these fluctuations inherent in the capstan motor even further, and also suppresses irregularities in the tape feed mentioned earlier. Because of the higher speed of the capstan and any intermediate wheels in the drive mechanism, better wow and flutter figures are invariably obtained at the higher tape speeds.

Elasticity and permanent elongation of the tape itself are minor causes of wow and flutter, and improvements along these lines are being made by the leading tape manufacturers.

According to the ideas of the manufacturer, tape recorders can have one, two or three motors. In three-motor machines one drives the capstan whilst the other two are reserved for the tape reels. Such an arrangement has the advantage of simplicity in mechanical design with the possibility of added reliability. At the same time there are many well tried single-motor recorders available, of which the Grundig TK20 and Brenell Three Star are two very good examples in which a high standard of mechanical construction and assembly have been obtained. In the Grundig, a belt drive transmits power from a large flywheel to the reels through a friction clutch, whose engagement is proportional to the weight of tape on the reels. In the Brenell, the take-up reel is belt-driven from a stepped pulley which is attached directly to the capstan motor spindle.

In three-motor machines it is possible to modify the motor circuit so that the fast wind can be continuously controlled from fast forward to fast rewind. Details of this, which is extremely useful in tape editing, were described in the June 1965 issue of this magazine.

In portable machines, where weight is a prime factor, one motor is usually employed; this also applies to some high priced professional

portables such as the *EMI L4* and *Ampex 601* series. However, in general-purpose recorders a high standard of construction is the criterion of quality, and not the number of motors employed.

The term 'track' refers to that width of tape used to store a single recording. In two-track machines the signal is recorded on both the upper and lower halves of the tape and the width of each single track is about 0.09in. When four tracks are used, however, this figure will be reduced to about 0.04in.

Obviously the use of four tracks enables tape expenses to be halved and this could mean the introduction of four-track cassettes containing stereophonic music at prices competitive with stereo disc records. For high fidelity results, however, the use of four tracks is not to be recommended unless a fairly high price is to be paid for the recorder.

A four-track machine is always inferior to an equivalent two-track model, and there are two main reasons for this. One is that the audio signal has to be stored on a narrower strip of oxide at the expense of a poorer signal-to-noise ratio. The second reason is an inferior 'cross-talk' separation caused by physical overlap between tracks recorded closely together, and this shows up as a faint background signal. In the better machines this latter objection is eliminated by accurate alignment of the tape heads and the tape path. When everything is well engineered the difference between a four-track and the equivalent two-track can be very small, and this is shown by the Tandberg series 72 and 74. In the two-track model there is an improvement of 3dB in the signal-to-noise ratio and a slightly better cross-talk.

As noted by A. Tutchings, in his review in *Tape Recorder* April 1963, normal listening tests could not reveal the four-track model, although instantaneous comparison showed a marginally better high note response from the two-track model. It should be emphasised, however, that the Tandberg is a no-compromise machine of the highest standard and inevitably expensive. In the medium priced recorders very careful attention should be paid to the noise and cross-talk figures when deciding whether to buy a two-track or four-track machine.

The signal-to-noise ratio compares the signal voltage at 100% modulation to the noise voltage originating from the amplifiers and the unrecorded tape. In high quality work a signal-to-noise ratio of better than 50 decibels is essential, though that of a domestic tape recorder in the medium price range will be in the order of 40dB. This means that the noise is 40dB quieter than the recorded signal, and this is perceptible to the ear on careful listening. To obtain the specified signal-to-noise ratio it is vital that the heads are kept clean and free from permanent magnetism, and to overcome this latter difficulty use of a head defluxer is strongly recommended.

Noise from a tape recorder always shows up more when played back through really wide-range equipment, and if the recorder is likely to be used with high fidelity amplifiers and loudspeakers a noise-ratio of at least 50dB is necessary for good results. The crispness and clarity associated with high quality equipment is essential for natural reproduction, and this will be impaired by a poor signal-to-noise ratio. The dependence of signal-to-noise ratio on the effective track width has already been mentioned, better figures invariably being obtained with two-track machines than the equivalent four-track model.

When a two-track machine is used in the monophonic application, overlap from the track not in use is referred to as track rejection, and this should be better than 50dB if no background is to be heard. In stereo, however, because of the common bias signal applied to both tracks, a cross-talk in the order of 40dB is often encountered, and this is more than adequate for top quality stereo.

What is more important than the nominal cross-talk figure for stereo is the fact that the upper track should stay under the top head and the lower track under the bottom head. A careful inspection of the number of tape guides and their position relative to the heads and the tension of the tape when the machine is working, will indicate just how good the recorder is going to be in this respect.

Before dealing with the frequency response of tape recorders it will be instructive to say something on the nature of sound waves and the limitations of the human ear.

A pure tone consists of a vibration, normally in air, and its pitch varies according to the frequency of vibration, the higher the frequency the higher the tone. A musical note, on the other hand, consists of a fundamental frequency tone accompanied by a series of overtones, each of which is a multiple or near-multiple of the fundamental frequency. It is these overtones or partials which determine much of the individual character of many musical instruments.

The organ of hearing, the ear, is by far the most important and universal detector of sound waves and it has an enormous frequency

range and sensitivity. It can easily distinguish frequency differences of as little as 1% and in many cases can analyse complex sounds into their component notes. In order to satisfy this highly complex detector of sound, a smooth frequency response, that is one which does not vary very much in audible level with respect to the frequency, is essential. The audible frequency range extends from about 16 c/s to an upper limit which depends on the age of the individual and can be as high as 20 Kc/s in the younger age groups. The lowest frequency that can be heard depends to a great extent on the physical size and acoustics of the listening room.

The frequency range of a tape recorder gives the lower and upper limits between which the machine will record and playback. Clearly, a high range, up to say 18 Kc/s, is desirable, but it is by no means as important as a smooth response. This is denoted in the specification by a decibel variation figure after the actual frequency range, thus: 30 c/s—18 Kc/s±3dB. This means that the machine will record and replay between the frequencies indicated and the level of any sound in this range will not vary by more than three decibels either way. This is shown in fig. 1, which represents a typical response curve for a tape recorder, where the useful range extends from X to Y.

A change of 3dB is equivalent to a power change of two-to-one, and this doubling or halving of power results in a change of audible level which, broadly speaking, is slightly but definitely perceptible to the normal ear. The actual detectable change in audible level is, however, very dependent upon the intensity and frequency being observed, a change of 120dB being necessary at 1 Kc/s, and only 60dB at 20 c/s, to cover the span between the thresholds of hearing pain (see 1966 *Audio Diary*, page 53). A change of 3dB for a frequency range of 30 c/s—18 Kc/s is very acceptable, though some of the higher priced recorders can restrict the variation in level to ±2dB. An example of this is the Tandberg Series 6 which has a response of 30 — 16 Kc/s ±2dB at 7½ i/s. It is worth remembering that if no decibel variation is quoted in a frequency 'response' specification, the frequency span given might be the absolute range (A to B in fig. 1) and not the useful range where the response is level.

The uncompensated frequency response curve (fig. 2) is, for a given tape recorder with constant current in the recording head, similar in shape and only varies with the tape speed. The output increases with frequency to about 1 Kc/s, when it falls off due to head loss and self-demagnetisation. The dotted line shows the shape unchanged with a higher tape speed, but it is shifted parallel to the heavy line which rises at about 6dB per octave.

Without going into the theory underlying the curves, this means that when the response is equalised, the higher speed will give the more extended frequency range. A good recorder running at 7½ i/s might have a range of 30 c/s—18 Kc/s±3dB, whereas at 3¾ i/s the upper limit might drop to as low as 10 Kc/s±3dB, which is perfectly adequate for good quality music, in fact, though responses as extended as this at those speeds are sometimes achieved at the expense of distortion and noise.

As mentioned above, a smooth or flat overall frequency response is essential for a good performance, and to achieve this the response shown in fig. 2 has to be equalised at some stage in the record/replay process. Several methods of doing this are available to the engineer, though it is now common practice to apply a small part of the total correction to the record process and the bulk to the replay amplifier.

In some machines, such as the Ferrograph 422 U and most professional models, there is a choice of either NAB or CCIR playback equalisation. CCIR (*Comite Consultatif International Des Radio Communication*) is the standard in Britain and Europe, whereas NAB (*National Association of Broadcasters*) is the standard used in America, the differences being in the choice of time-constants or turnover frequencies for the equalisation in the playback amplifiers.

A choice of both standards is important when pre-recorded tapes from Europe and America are to be played to the highest possible standards on the same machine, though normally the difference can be handled by discriminating use of the tone controls. NAB recorded tapes, played back via CCIR (particularly the 'old' CCIR) generally have an extra 'brightness' which may be preferred on some recordings of classical music, but not in pop music which is recorded at a higher level.

## our readers write . . .

### . . . about that competitive design

From : Carlos P. Druillet, Calle Misiones 1371, Montevideo, Uruguay.  
DEAR SIR, I would like to discuss Mr. D. J. Bolt's letter *About Competitive Designs* which appeared in the February issue.

Mr. Bolt evidently assumes his needs to be typical of the average hi-fi enthusiast, but appears to overlook the different requirements of the hi-fi man and the tape enthusiast.

The hi-fi man is the one who looks on a tape recorder as another music reproducing instrument, with the advantage over the turntable that it can copy records from the neighbour and from FM broadcasts. Tape recording enthusiasts use their recorder as a creative instrument, ever seeking new applications, and enjoying recording just as others enjoy slide-photography or cine.

Mr. Bolt prefers shape and fancy to performance, light weight to quality. He prefers, perhaps, a well-styled body to a reliable chassis; the kind of person who would rather drive a *Cadillac* than a *Rolls-Royce* (*A questionable metaphor!*—Ed).

Answering his points numerically, as they were made:

(1) "Solid-state" is a bright advertising phrase, attracting only those who have never tried to service their equipment. Old-fashioned tubes give me very fine results and are easily checked when faulty. I should like to see Mr. Bolt trying to trouble-shoot a transistor circuit. Monitoring facilities are essential on any recorder.

(2) This is a very important point in which I agree with Mr. Bolt: three good ½-track stereo heads for good results. I strongly advocate the ½-track system, but would be happy to see an extra ¼-track replay head for those wishing to reproduce American commercial tapes.

(3) Having read *Tape Recorder* for many years, I realise that the British manufacturers were pioneers in bringing to the amateur fine and dependable three-motor decks: *Ferrograph*, *Brenell*, *Truvox* and *Collaro*. Back in 1960 I possessed a *Vortexion WVB*, with the *Wearite* deck, which gave very fine results. Now I own a *Revox G36*, made by another three-motor pioneer. I would like to see more three-motor decks on the market, not less; each motor for its own task.

(4) For my work I really need bigger reels and am pleased to see *Ferrograph* providing for 8½in. reels and a version of the *Brenell*

*Mk.V* deck having a 10½in. capacity. My recordings are priceless, at least for me, and I do not like to risk them on double and triple-play tapes—a fine source of print-through.

(5) There are many of us, perhaps the majority, who like to operate our recorder horizontally.

(6) On the matter of style, I agree that clean style is pleasant, but not at all the most important thing on a recorder. Observe that the Japanese, American and German manufacturers need continually to change the shape and style of their models to survive on the market. *Ferrograph*, *Brenell* and *Revox*, however, have acquired world-wide prestige with their designs and have restyled their products only in minor ways throughout many years. If one reads the list of winners of the 1965 IARC (CIMES) contest, one will see the kind of recorder that gave the necessary standard of quality.

Yours faithfully

### . . . about the MCPS licence

From : Charles W. Aitken, 32 Muirfield Crescent, Dundee.

DEAR SIR, In the May issue you published some facts about the licence which is being issued to amateur recorder operators by the *Mechanical Copyright Protection Society Ltd.* As I wished to make use of this licence in a national tape contest, I sent off 10s. and duly received my licence.

Apart from the legal jargon, the bare bones are that I am allowed to make recordings of musical works of the Society which have been issued on gramophone records, and use these in the home, the tape club, and in the tape contest. I am also advised to keep a note of the "make and number" of gramophone records I so use. Up to this point I was very pleased with myself!

The bitter punch line comes well down the licence form and states that this licence does not give the right to make recordings of gramophone records, as permission for this must be obtained from the manufacturers themselves! And as we all know, the various record manufacturers will not give permission. I made enquiries of just one to check.

It does seem to me that the MCPS is making a nice little cash rake-off without giving amateur recordists permission to do anything at all. The sooner we have some set-up as in Germany, with a levy placed on the retail prices of recorders, the better it will be for everyone.

Yours faithfully

WYNDSOR SABRE  
AND TRIDENT

BY H. W. HELLYER



**T**HE name of *WyndSOR* is well-known in the tape recorder world. Making no pretensions, no claims for professional quality at supermarket prices, they have turned out competitively priced 'domestic' models in moderate quantities for a number of years. The circuits are not elaborate, but they are examples of basic design principles, and the models dealt with this month have some features that enable us to discuss general principles.

It should perhaps be mentioned that the earlier models have been described fairly extensively in the latter section of *Tape Recorder Servicing Manual*, published by *George Newnes Ltd.*, and need not take up any of our space here.

The circuitry of the *Trident* and *Sabre* models is similar, and is given on the adjoining page (fig. 1). Later models, including the 707/2, 707/4 and the new and very promising *Vanguard*, have rather more elaborate circuitry and will have to be dealt with separately.

To put matters in perspective, the *Trident* was the earlier model, coming out early in 1963, using the *Collaro* (now *Magnavox*) *Studio* deck, and reviewed by Mr. Tutchings in January, 1964. The *Sabre*, which has a BSR deck and a slightly different amplifier layout, was released in late 1964.

There are quite a number of these models in use, and despite the simplicity of the circuit, the results obtained are sufficiently good for it to be recommended as a good second-hand buy. The great advantage of such bargains is that any replacement parts that may be needed are standard items. Other, more ambitious models, which may seem attractive, can be pigs in pokes when we discover that vital parts have failed and the manufacturer no longer wants to know about past history. This happens too often, even with the most popular makes, and readers would do well to take warning before wasting money on attractive-seeming bargains. It is worth nothing that practically every part, down to the knobs and cabinet trim, of the two models under discussion, is either a standard, current component or can be replaced with no trouble by a suitable substitute.

On the subject of substitutes, a digression may be in order. Many readers have had difficulty in obtaining 6BR7 valves, and have appealed

to us to find an equivalent. This valve was used in the *Regent*, *Victor*, *Viscount* and *Dauphin* models. No direct plug-in equivalent is given, but there are other ways of surmounting the problem. The 6BR7 is a Brimar valve, a low-noise, low-microphony pentode suitable for use as a preamplifier. Its special feature is the internal screening, and design of the circuitry around the base is particularly critical to make the most of its virtues. Therefore, when replacing it with another, similar valve, which has a slightly different base pin connection sequence, some care should be taken to keep input and output sections of the circuit separate. A glance at fig. 2 may make this more obvious, when we see that the Mullard EF86, which can be used in place of the 6BR7, has a different pin layout which may mean a change in component placing, or wiring, to retain the low-noise characteristic.

As a matter of interest, the 6BR7 has a Service equivalent, known as the CV2135, and another valve, the 8D8, is also fairly easily obtained, having similar characteristics, but again a different base layout, similar to the EF86. In other words, a few minutes with the soldering iron can save weeks of frustrated waiting for supplies—or being refused valves across the counters of those retailers who consider we 'owner-drivers' to be some species of blackleg!

After which digression we should get back to the main circuit of fig. 1. The first stage, V1, is the valve we have just been discussing, a low-noise EF86 pentode, directly loaded by the crystal microphone during record and by the head winding during playback, across the 1M grid load.

Note that a stage of this type has a value of anode load and a screen resistor that may seem very high to those brought up on 'conventional' Class-A amplifiers. The stage operates with quite low anode and screen voltages. Although these are not given on the drawing, measurements of between 45V and 75V at the anode and 40V to 80V on the screen are not unusual. The important point is that the current-carrying resistors shall be of good quality, and noise-free. WyndSOR use gold-band types, and a similar quality component for the cathode bias resistor. If the occasion arises for replacement, use components equally good, or better, such as the newer moulded types, or metal-oxide resistors.

The coupling capacitor C2 should also be a good quality component, and as the screened connections to switches and controls are rather longer than one would have liked, the siting of any replacement is also important. The 'chassis' in these models is a paxolin board, drilled for captive tags, to which the components are anchored. Hence, any earth returns that are made must be to the same connecting tags, linked by wiring. This may help eradicate hum loops during design, but certainly makes it imperative that service (if Mr. Callaghan will forgive the term!) is a matter of exact replacement both as regards components and siting.

This is not to say that the manufacturer always has the last word. Some slight improvement can be made by returning the earthy ends

(continued on page 242)

FIG. 1

WYNSOR TRIDENT CIRCUIT DIAGRAM

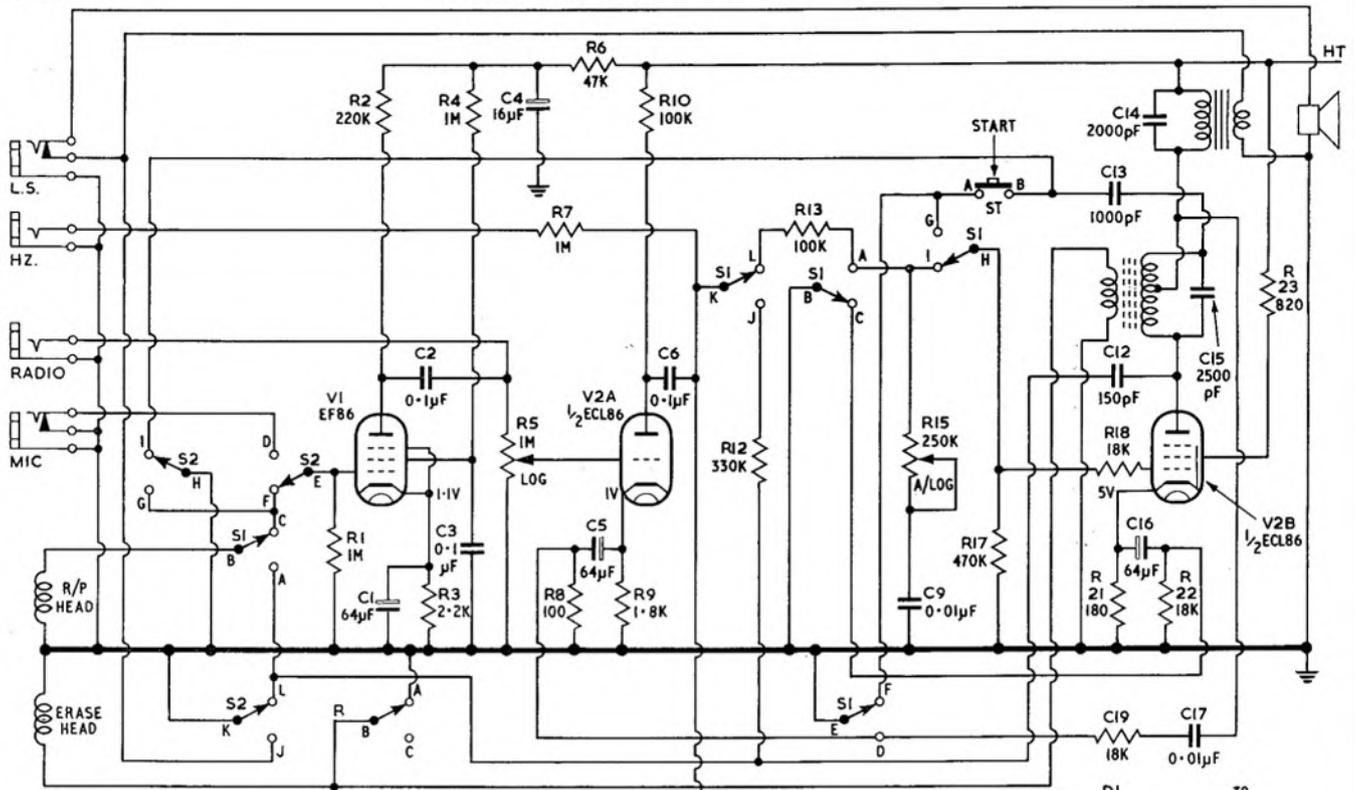
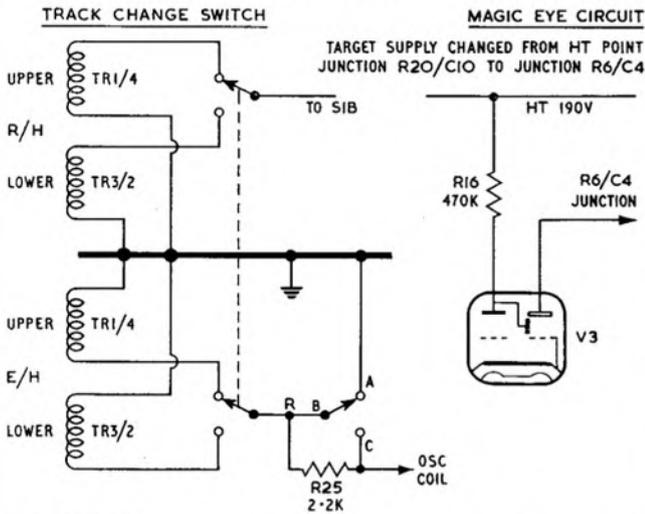


FIG. 3 QUARTER TRACK VARIATIONS

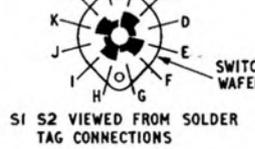
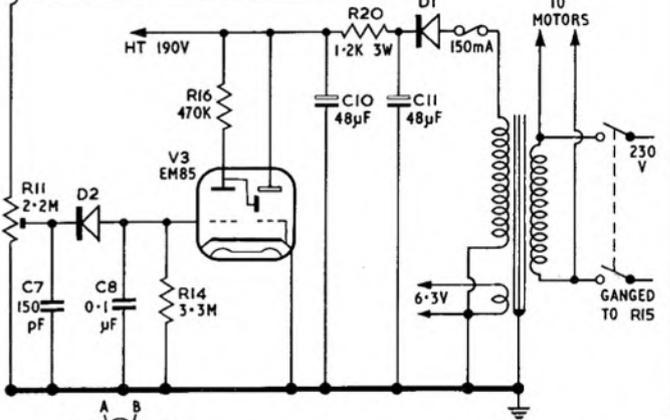
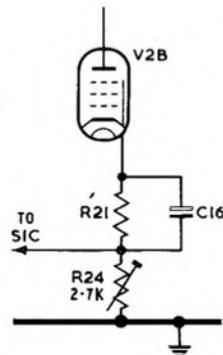


OSC CIRCUIT

CATHODE V2B, R22 (18K) DELETED, R21 + C16 PARALLELED AND TAKEN TO CHASSIS VIA R24. R24 SHORTED BY S1 BC DURING PLAYBACK, OSCILLATOR COIL SECONDARY WINDING TO ERASE HEADS VIA SWITCH CONTACT CHANGED TO RC R25 (2.2K) 1/4 W RESISTOR ADDED ACROSS CONTACTS RB-RC

PB CIRCUIT

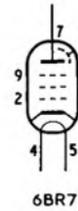
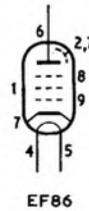
C2 CHANGED TO 0.01µF C17 CHANGED TO 0.005µF



CIRCUIT DRAWN IN PLAY-BACK, NO SIGNAL. VOLTAGE READINGS TAKEN WITH AVO 8 S1 S2 ROTARY R/P SWITCH ST A-B-START BUTTON SWITCH RA-C 'R' SWITCH ERASE VOLTAGE 20V BIAS VOLTAGE 40V

FIG. 2

BASE CONNECTIONS



of R1, R3, C1 and C3 to the same point, which is the spigot of the EF86 valve base. An attempt was made in one rather objectionable hum case to reduce unloaded input hum still further by returning C4 negative lead to this point, but although this may be good in theory, in practice it had little beneficial effect.

The output from V1 is coupled to the volume control, R5 and thence to the grid of the triode section of the ECL86, V2A. Radio input is also to this point, with a 250mV signal for fully modulated tape. The signal from most tuners is more than enough, and a modification worth carrying out here is to feed the tuner input to a more appropriate load, between 50 and 100K, with a series 680K to the junction of C2 and R5. But it should be remembered that this loading must be out of circuit during replay to avoid shunting the output of V1. The high sensitivity is also too much for some pickups and matching pads may be needed to suit special cases.

Equalisation on these models is not quite so straightforward as would at first appear. There is a comprehensive feedback loop from the anode of V2B to the cathode of V2A, with C17 providing bass compensation, and C5/R8 involved in further corrections. This can lead to a bit of bother if the output is taken from the high level (HZ) output to feed another amplifier and the tone control R15 altered on the Wyndsor: for part of its middle travel it appears to act in reverse. The correct technique, of course, is to leave it in the mid-position and tailor the response to suit on the external amplifier. As there is a 1M resistor (R7) in series with the HZ output, it is important to avoid high cable capacity when feeding signals to extend amplifiers, otherwise there will be severe HF losses.

Note that during record, this feedback loop is out of action, S1D taking the negative end of C5 to earth and shunting C17/R19 also to the return point. The start key (marked Record on the earlier decks) puts C13 in the oscillator feedback circuit during record, but uses the same sequence to shunt it to earth during play, giving a little top cut. The oscillator comes into action when the feedback is applied and also when C16 negative return is opened by S1B.

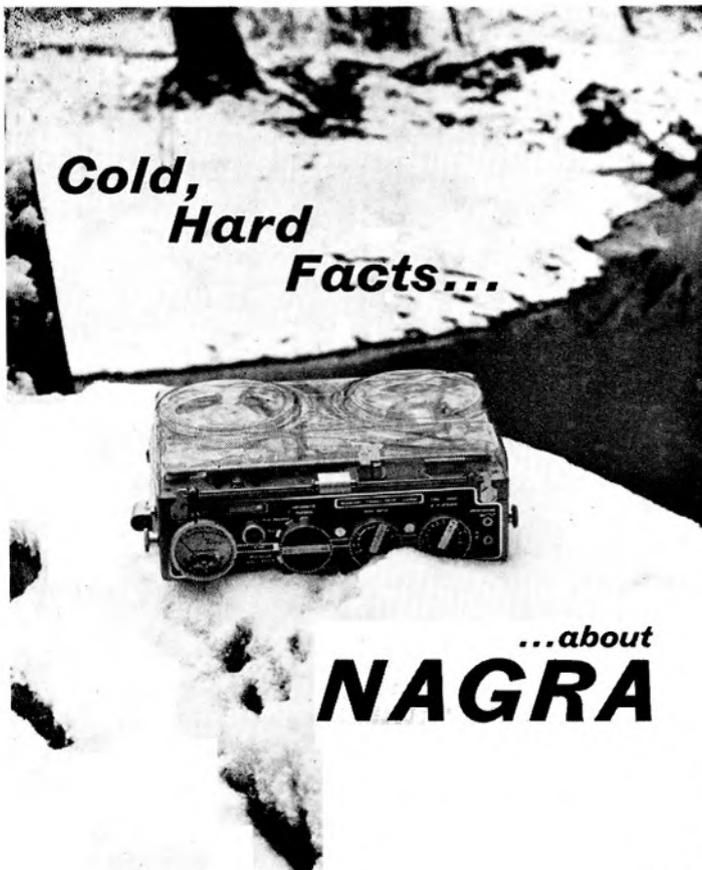
Record level indication is by magic-eye V3, with the signal tapped off from the output of V2A and rectified by D2, which is a small M3 type, for which an OA81 would be a suitable replacement. R11 adjusts the level at which the magic-eye closes, and this can be adjusted for experimental recording level before actually switching to start, simply by moving the Record button downwards. One small warning with these decks: it is occasionally possible to switch to Record accidentally by forcing the button down during Play, and care must be taken not to fall into this trap if pre-recorded tapes are to be protected.

The ¼-track models have small variations, and these are given in fig. 3. Apart from the track switching, the changes are minor ones, involving an oscillator output adjustment in the cathode return of V2B, the changing of the target voltage of the EM85 by tapping it from the lower HT point, halving the feedback capacitance on play and reducing the coupling component C2 to 0.01µF.

From the foregoing it can be seen that servicing should be straightforward. This has always proved the case in our own experience; the majority of faults have been ordinary deck troubles, such as the 'popular' dented idler on the Studio, or brake bands that have become sticky and fail to release cleanly, causing tape snatch and spillage, binding bearings on the BSR deck and overheated motors.

Note the article on lubrication that appeared in the May issue. Many troubles reduce to dirty heads, worn guides, binding brakes, hardened clutches, and what is politely termed 'foreign matter' in the bushes and bearings of rotating parts. All of which should be routine matters to the initiated.

As before, we come finally to the matter of dismantling, not to be perverse, but simply because the makers have been most generous to us, both in these and in later models, by making the job very simple. The only real trick is to make sure and remove the hinge screws of the Trident, two of which go through the cabinet to the deck supports. This model is easiest removed from its case by turning the whole contrivance upside-down and withdrawing cabinet from deck and chassis combined, after removing these and the four 2BA screws at the sides. The Sabre is even simpler, the complete deck and amplifier lifting upwards, but we should warn readers to watch the plastic decorative piece at the bottom left when refitting.



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- Wow and flutter ±0.06% RMS at 15 l.p.s.
- Battery operated, fully transistorised and completely portable. Weighs approx. 20lb. with batteries.
- Signal to noise ratio better than 70db at 15 and 7.5 l.p.s.
- Speed variation between beginning and end of 7" reel ±0.2%.
- Operates within the temperature range -20°C and +50°C.

*These typical performance figures are impressive but they are just part of the story. If you would like to know more write for literature from the sole U.K. agents for Kudelski Nagra Tape Recorders:—*



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**T**APE recording enthusiasts who also possess a 35 mm camera will no doubt have thought about, maybe even produced, a tape commentary to go with colour slide shows. When I first set out to do just this I decided that a simple non-synchronous commentary on its own was hardly better than reading the same chat off a script each time. So I went the whole hog and produced a synchronised commentary with music and sound-effects. Complete synchronisation between tape and slides is only possible between a fully automatic projector and a tape recorder which has either pulse recording facilities or, and this is the theme of this article, automatic stopping facilities.

Readers are probably familiar with the basic idea of the 'pulse' system of controlling a projector, and are similarly aware of the cost of converting a recorder—maybe to the tune of £15 if one buys a ready-built add-on unit.

The system which I use has the advantage of being just as reliable as the pulse system, while being much less expensive. Its cost is that of a 12V relay and a little time with soldering iron and wire.

The basic idea is that the tape guide which is normally used for stopping the tape at its end on the metallic stop-foil is used to provide a short-circuit, which in turn operates a relay to trigger the automatic projector. Hence, pieces of metallic foil which are attached at the appropriate points on the tape base will switch the projector at this point.

One cannot usually connect a projector remote lead directly to a

At first I used ordinary non-adhesive foil held down by pieces of editing tape such that  $\frac{1}{4}$  in. of foil was still showing. This is fine while editing the tape and experimenting with different ones, because it is easily peeled off and tried elsewhere.

However, for the finished job, I strongly recommend Scotch self-adhesive sensing tape, which does the job very well: one reel is sufficient for about 600 slide changes!

One important point to note is that the rear of the sensing guide *must* be scrupulously clean—a little metal polish will do the trick. Before each programme it is wise to check this point and to give the guide a quick polish. This is advisable because although the system uses a low voltage, some slight sparking may occur and dirty the guide over a period of time. An extra capacitor (C in fig. 1) will reduce this tendency (about .01 $\mu$ F), and normal take-up tension will provide the necessary intimacy between foil and sensing guide.

As an 'optional extra' readers might like to have a switch on a length of lead which they can plug into the recorder in parallel with the guide so that they can then have a manual control as well.

A word or two on the use of synchronisation of slides and tape: **Be ambitious.** Accurate timing is needed every time you wish slides to appear or disappear on a given word, syllable, sound-effect or note of music! A good sound track tremendously enhances a good set of slides, and can provide the professional touch to what would otherwise be 'just another slide show'.

## SIMPLE SYNC

AN INEXPENSIVE SYNCHRONISER FOR TAPE RECORDERS AND SLIDE PROJECTORS  
BY MICHAEL BAKER

split tape guide for the following reason. The actuating solenoid in the projector is, in my case, connected to the live terminal of the mains and the push-button provided connects the other side of the solenoid to neutral. It doesn't require an electronic genius to foresee that if the projector was inadvertently wrongly connected to the mains, then live mains would be present on the tape deck—a most undesirable situation!

Not only this, but the high inductive voltage concerned would cause considerable sparking as foil moved over the guide, causing rapid destruction of the foil, induced clicks in the replay circuits, pitting of the tape guide, and possibly even audible clicks induced on to the upper track.

So we use a relay and circuitry actually present in the recorder (even if it is missing, installation should present no difficulties and add only a little to the cost) to provide a power supply for the relay.

Fig. 1 is typical of an auto-stop for a recorder. When the stop-foil bridges the split pillar, a solenoid S is energised and a mechanical link stops the recorder. By connecting a suitable relay instead of the solenoid, switching is achieved with low, safe voltages on the deck, and none of the disadvantages listed earlier as applied to direct connection.

Fig. 2 shows a practical arrangement incorporating a slide-switch such that in one position the recorder functions normally with the auto-stop, while in the other, it will switch the projector when foil passes the split guide.

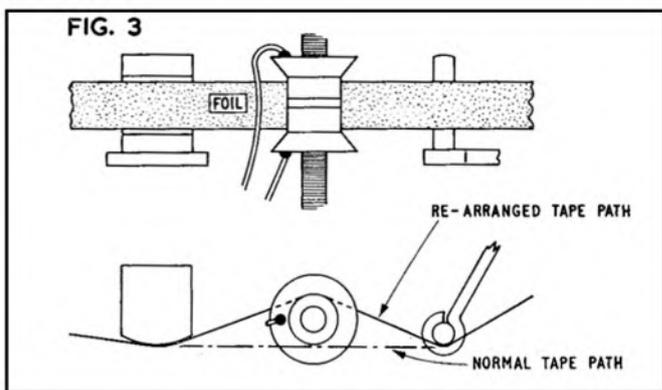
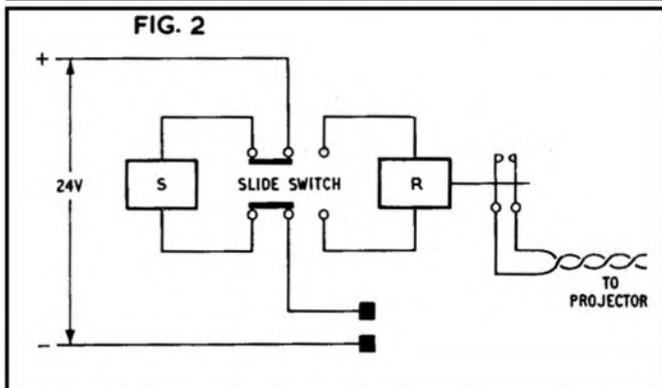
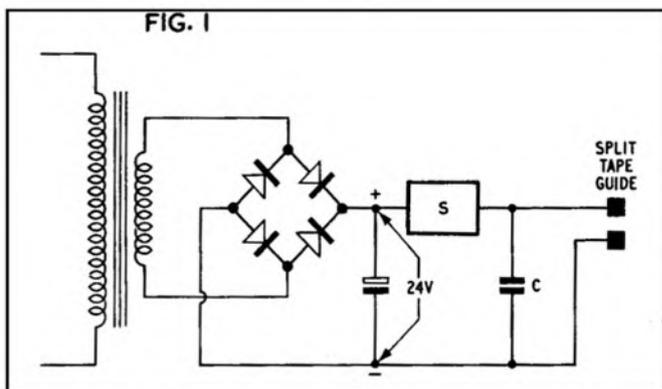
With regard to the actuating foil, I experimented using various widths and lengths of foil, but eventually determined the smallest piece of foil that could be used with reliability.

The length of the foil strip is fixed by the time taken for the projector solenoid to initiate a slide change, and also by the reaction of the relay, which must hold the 'made' position for at least as long as the projector requires it. The width of the strip is largely arbitrary, as long as the foil lies symmetrically about the gap of the split guide when it is in contact.

Obviously the piece of foil must be at a point on the tape *before* the place at which the next slide must be on the screen. The actual distance depends on the time that the projector takes to change from one slide to the next, and, of course, the tape speed!

With my equipment, a *Telefunken 85KL* recorder and *Prinzmatic S* projector, I use strips of adhesive metallic sensing foil 1 in. by about  $\frac{1}{4}$  in. laid along the base of the tape as shown in fig. 3.

As the metallic side of the foil is facing outwards from the base of the tape, some rearrangement of the tape path will be necessary so that the foil comes into contact with the rear of the guide. I illustrate my own solution but, of course, readers will have to adapt their own recorder according to its layout.





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# videotape comes home

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**Right:** Ampex HVR helical-scan recorder operates at 9.6 i/s.  
**Above:** Sony TCV-2010 incorporates a transistor monitor/receiver.



**Left:** Ampex HVR 6200 console permits recording of television broadcasts without need of an external receiver. CC-323 camera and 60-minute tape are also shown.  
**Centre-left:** Tripod-mounted Sony CVC-2000 camera.

## DOMESTIC TELEVISION RECORDING IN THE USA BY ROGER GREGORY

**H**OW'S your golf swing? Will that forthcoming speech be free from extraneous distractions? Does your wife's performance in the local repertory production contain all the drama it should? Soon, you will be able to see yourself in action on the golf course, eliminate your errors in public speaking and improve your wife's repertory performance through the use of home videotape recorders. Here in the United States the first low priced video recorders have been introduced to the general public. The price of video recording equipment previously had been so high that only the richest and most avid enthusiasts could afford it. The new recorders are all priced in the £300 region, which is a considerable decrease from the £20,000 needed for the first professional video recorders.

Videotape recording was introduced to the broadcasting industry in 1956 and won immediate acceptance from television engineers and producers as a new and flexible medium with which to work. Videotape was of particular benefit to the three big American television networks which prior to the introduction of tape, were forced to make films of programmes as they were performed in regional broadcast centres. The films were then screened to each of the remaining three time zones.

Film was not only a poor and expensive means of recording television programmes for this application, but it also proved to be highly impractical for recording colour transmissions. Colour motion picture film was used, despite its expense and the fact that it could only be exposed once. When black and white videotape was introduced in 1956, followed two years later by colour, acceptance was immediate from both the artistic and monetary standpoints.

The first video recorders were intended primarily for professional use and—as results from such applications—complexity was exceeded only by price. Up to five 19in. equipment racks were required for all the electronic equipment associated with the recorder. The introduction of professional VTR's sparked the first glimmer in the eyes of home tape enthusiasts. Many were asking: "If we can magnetically record sound with such comparative ease, why not record pictures as well?" This question undoubtedly occurred to engineers at the Ampex Corporation and resulted in the manufacture of a limited number of *Signature* consoles which contained a complete VTR, in addition to a television receiver and a component stereophonic sound system. The *Neiman-Marcus* Department Store, a noted shopping place for Texas oil millionaires, offered the console as an ideal Christmas gift priced at about £20,000. It is easy to understand why there were not many *Signature* consoles sold.

Before low-priced VTR's were to become a reality there were many obstacles to be overcome. Instead of recording frequencies up to 20 Kc/s, as in the familiar audio tape recorder, a video recorder should be able to record frequencies of more than 3 *Megacycles*. While this high frequency limit can be reduced, picture quality will also be degraded. Based on our knowledge of audio recorder circuits and head designs, an attempt to record a wide bandwidth video signal would require a tape speed approaching 90 mph and an exceptionally high bias frequency. Since this kind of tape speed and such a high bias frequency are beyond the limits of standard audio engineering, some other means of recording a video signal on tape had to be developed. Early

*(continued overleaf)*



Above: Ampex VR303 fixed-head video recorder employing  $\frac{1}{2}$  in. tape.



Left: Large and small cases containing Sony video recorder and camera kit.

## videotape comes home

experiments determined that it was not the actual linear speed of the tape that was important, but the *relative* speed created between the moving tape and the recording head. Thus, even though the tape might only be moving across the tape transport at  $7\frac{1}{2}$  or 15 i/s, the head could be rotated at a high enough speed to record frequencies of 4 or 5 Mc/s.

The first Ampex professional video recorders had four recording heads positioned on a drum which was rotated at a speed of 14,400 r.p.m. This permitted a high frequency response (at 15 i/s) up to 4 Mc/s. The tremendous speed of the rotating head assembly required the use of a vacuum shoe assembly to maintain intimate tape-to-head contact. Owing to the complex nature of the electronics needed by the early video recorders, the large 2 in. tape and the cost of replacement heads, it was to be some time before engineers could introduce a prototype machine suitable for home use. After all, who is going to tolerate having two living room walls full of VTR equipment?

By 1963 sufficient progress had been made and a new series of compact, easy-to-operate video recorders (intended primarily for closed-circuit use) were introduced. Instead of the previous system of transverse scanning, the new machines employed a helical scanning technique. In these VTR's, one or two recording heads are mounted on a moving drum and record the video signal upon the tape in a diagonal curve known as a helix. The actual tape speed used can then be lowered to 10 i/s or less. The frequency response obtained at these lower speeds, while not adequate for recording colour signals, is entirely sufficient for broadcast quality monochrome tapes. Due to further developments in the areas of head design and amplifier circuitry, it became practical for a VTR to have a frequency response up to 3.5 Mc/s with a relative tape-to-head speed of only 1,000 i/s.

Although the helical scan VTR's provide a better quality picture than any fixed-head recorders, both Ampex and Wesgrove have manufactured fixed-head units. The Ampex VR-303, introduced and withdrawn in 1965, utilised a tape speed of 100 i/s, and a video bandwidth (-3dB reference points) from 250 c/s to 1.5 Mc/s was claimed for the fixed-head recorder. The VR-303 was sold for approximately £1,100 and it was one of the few recorders to use  $\frac{1}{2}$  in. wide tape. The manufacturer emphasised that special video or high quality audio tape could be used. Primarily designed for use in closed circuit industrial applications, the Ampex VR-303 was priced very much lower than any units previously available, and this factor, coupled with simplicity of

operation and small size, made the machine ideal for use in a complete home entertainment centre. The combination of a VTR with a 23 in. Motorola colour television receiver and a component stereophonic sound system yielded the Ampex Signature Six console. A closed circuit television camera and two omni-directional microphones were provided to complement the Signature Six equipment.

The British Wesgrove VKR-500, a fixed-head machine available in both kit and factory-built versions, is the lowest priced home video recorder currently available in the United States. Supply of these machines has been something of an on-again, off-again affair, but distributors have now reportedly been established on both the East and West coasts.

Just about a year ago, in Chicago, came the news of a new series of low priced VTR's designed specifically for the home user. Rumours had been circulating in the trade for many months that such recorders were on their way, but it was not until the new Ampex HVR Series was introduced, that rumour became fact. The HVR Series is presently available in three versions: model 6100, a basic deck designed for use in custom installations with any existing television receiver; model 6200, a console with a video control centre and walnut base; and model 6300, a console with room for the mounting of virtually any television receiver. At least three or four more versions of the Ampex HVR will be announced in the very near future.

One-inch wide tape is used on the Ampex machines and it is available in 500, 1,500 and 3,000ft. lengths. The maximum reel size is  $9\frac{1}{2}$  in. which will permit one hour's continuous taping at a speed of  $9\frac{1}{2}$  i/s. Video bandwidth is from 20 c/s to 3.5 Mc/s, with a video signal-to-noise ratio of 40dB. Flutter and wow are less than 0.2% RMS. Video input and output impedances are both 75-ohms unbalanced, and the input and output voltage requirements are also the same: 1V p-p. Audio specifications are quite modest for a machine of this calibre. The frequency response, at 9.6 i/s, is 70 c/s to 12 Kc/s  $\pm$ 4dB, while a signal-to-noise ratio figure of 45dB is expressed. The weight of the Ampex HVR is 65lb., which puts it in the weight class of a semi-professional sound recorder.

While Ampex have settled on the new speed of 9.6 i/s, the Sony Corporation elected to use the more familiar  $7\frac{1}{2}$  i/s in its new low-cost VTR Series. The fully transistorised Sony VTR uses  $\frac{1}{2}$  in. wide tape and the deck will handle reels up to 7 in. diameter. So, even though the speed of the Sony recorder is less than the Ampex HVR, one hour's continuous recording is the maximum for either machine on a single reel of tape. The portable Sony TCV-2010 records programmes in black and white and is equipped (at approximately £330) with an integral 9 in. transistorised television receiver. This compact receiver can be used for recording, playback, or for separate viewing.

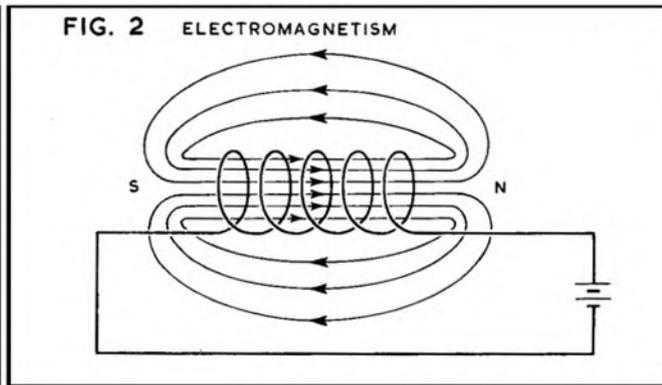
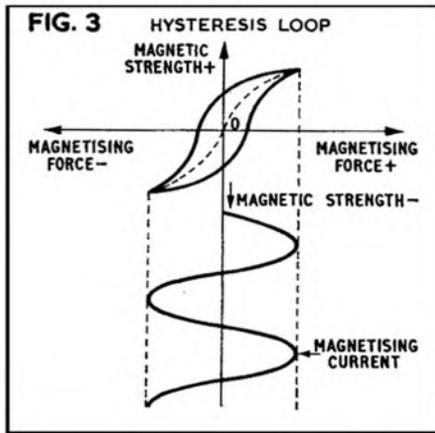
The operation of the Sony VTR is very different from the other home recorders in at least one major respect: it does not record all 525 lines that compose a U.S. television picture. Instead, it records every other scanning line and therefore requires a special TV receiver for both recording and playback. A rotary two-head drum contains the video recording heads, while a conventional fixed-head is used for the recording of audio and the control track. A total of 76 transistors, 38 diodes and 4 thermistors are used in the Sony record/playback circuits. The microphone input impedance is 600-ohms, unbalanced, while both the audio line input and output are high impedance. No provision is made for the connection of an external TV receiver.

An accessory camera kit has been developed by Sony and this includes the camera, a 25mm.  $f$ 1.9 lens, cables and carrying case. The camera is transistorised, compact and operates on standard household current. At the time of writing, Sony V-30 video recording tape is available in lengths of 1,240 and 2,370ft. which play for one-half hour and one hour, respectively. The Sony recorder is also available in a walnut cabinet complete with clock timer to permit the recording of programmes when the owner is absent.

Concord Electronics, another firm with Japanese connections, has scheduled the introduction of a home VTR by mid-summer. The recorder will be built for Concord by Matsushita Electric Industrial of Osaka, Japan. Concord are keeping the entire project under wraps until introduction time, but word has leaked out that the new recorder uses  $\frac{1}{2}$  in. tape and operates at 12 i/s. The Concord will also be equipped with its own monitor, but, unlike the Sony recorder, adapters for use with regular home receivers will be available at extra cost.

The three helical-scan recorders outlined in the preceding paragraphs are not the only units available in the United States. The Philips EL3400 VTR is also available, but on a more limited basis. Roberts

(continued on page 257)



## part three

### MAGNETIC MATERIALS AND HYSTERESIS

BY C. N. G. MATTHEWS

# magnetic sound recording

WE all know that a magnet will attract iron and steel and that if a bar magnet is suspended by its centre it will settle into a position that is approximately North and South. We call the end that points North the north pole of the magnet and the end that points South the south pole. So far, so good ; but for recording purposes we need to know rather more than this about magnetism.

A property of magnets which is obvious, but not always fully appreciated, is that since they will attract small pieces of iron and steel without actually coming into contact with them, they must have a sphere of influence which extends beyond the confines of the material from which they are made.

This influence is called the magnetic field. We can represent it graphically by what are called lines of magnetic force. And we can explain magnetic behaviour by assuming that invisible threads of force do exist and that they have the following properties:

1. Every line runs from a north pole to a south pole.
2. Like stretched rubber bands, the lines tend to contract along their own length.
3. Lines running in the same direction repel each other.
4. Adjacent lines running in opposite directions merge into each other.

In fig. 1(a) we see the field associated with a bar magnet. The lines run in closed loops from north pole to south pole. You could draw these lines for yourself by dusting iron filings on to a sheet of paper placed on top of a bar magnet. If you gently tap the paper the filings will settle into position along the lines of force.

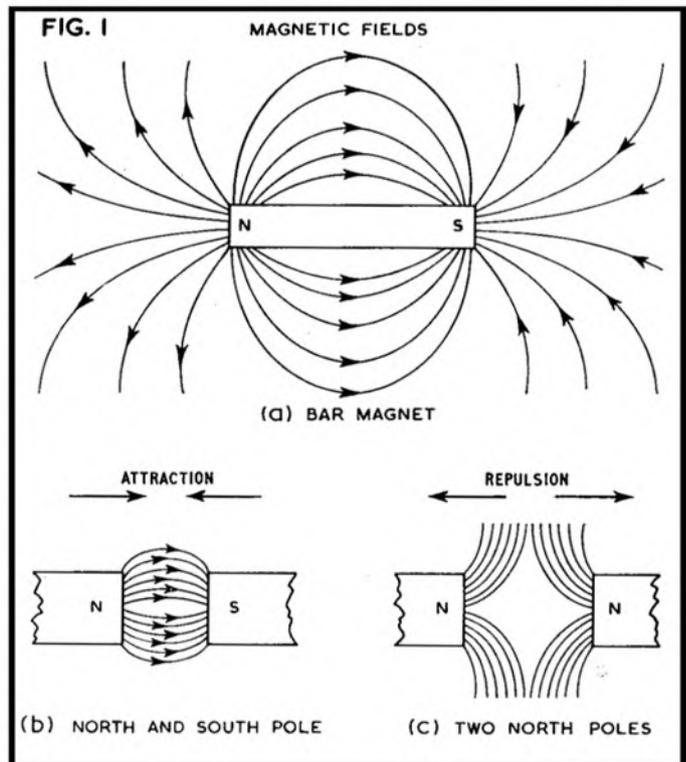
Fig. 1(b) shows the composite field produced when a north pole is brought close to a south pole. The lines run from north to south, fanning out because of their mutual repulsion. Since the lines tend to contract, a reasonable assumption is that the two poles will be attracted towards each other. If you care to try this with a pair of bar magnets you will find that the attractive force does in fact exist. At the same time, using paper and iron filings, you could confirm the nature of the magnetic field.

Finally, fig. 1(c) shows the field set up between two north poles. Now the lines cannot run from pole to pole and are compelled to spread out in search of south poles on which to end. This causes them to run parallel to each other, which in theory should produce a repulsive force between the poles. Again, using two bar magnets you will find that one pole does in fact repel the other and that the field is of the shape shown.

Now suppose we pass a current through a long coil or solenoid as shown in fig. 2. We will find that the coil behaves in exactly the same way as a weak bar magnet. It will cause iron filings to take up the bar magnet field pattern and if suspended it will point North and South. If we increase the number of turns we will increase the strength of the field, but the magnetic effect will never be really strong.

But if we wind the coil on a soft iron former the lines of force will be so concentrated that the magnetic field will be very powerful indeed. We shall in fact have made a magnet whose field can be switched on and off with the current. This is called an *electromagnet*. Commercially, electromagnets attached to cranes are used to move tons of iron at a single lift. This has the great advantage of eliminating manually attached hooks and slings.

The mere fact that increasing the number of turns in a coil increases the strength of its magnetic field indicates that each turn has a field of its own. It is their combined effect that produces the total field of the coil.



This, provided we know something of atomic structure, gives us a clue to the nature of magnetism. The atoms of which all substances are composed consist of electrons orbiting a heavy nucleus. Since what we call an electric current is a movement of electrons, we can look upon each orbit as a tiny current which must set up a magnetic field at right angles to its axis—just like the turns of the coil. But in normal materials the direction of the electron orbits is random. Thus the fields cancel each other and the net magnetic effect is nil.

In magnets a proportion of the electron orbits have been rotated into parallelism. Now their combined effect is additive and gives the material the property we call magnetism. There are only a few substances in which the electron orbits can be rotated in this way, and of these iron and steel are notable examples. Basically, the chemical composition of these two materials is the same, but between their physical natures there is a tremendous difference which is echoed in their magnetic behaviour.

Soft iron is soft because the relative positions of its electron orbits can be fairly easily changed. So if we wind the coil on a soft iron core the magnetic field set up by the current will rotate a fair proportion of the electron orbits into additive parallelism, to form a powerful combined magnetic field. As soon as the current is switched off the magnetising force is removed and, because of their end-to-end repulsion, the electron

(continued overleaf)

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### MAGNETIC SOUND RECORDING CONTINUED

orbits resume their random arrangement. Thus the iron remains magnetised only for so long as a current flows.

Steel is different. It is hard because its atoms are firmly locked into their relative positions by bonding between adjacent electron orbits. The firmer this bonding, the harder the steel. When electron orbits are interlocked in this way it is not easy to rotate their axes. Consequently, steel is far more difficult to magnetise than soft iron. On the other hand, once the electron orbits have been moved they tend to remain in their new positions after the magnetising force has been removed. Thus the steel remains permanently magnetised.

This is why the materials used for making permanent magnets—usually special steels or ceramic compounds of iron—are so hard that they tend to break if the magnet is dropped. The electron orbits are so rigidly locked into place that magnetisation is extremely difficult. But once the orbits have been moved the magnetism is equally difficult to remove.

It is from materials of this magnetic nature that the tapes used for modern magnetic recording are made. Naturally it would not be possible to form such substances into a tape by themselves, so the procedure normally adopted is to mix a powdered ceramic compound of iron with a binding medium such as nitro-cellulose and to coat this composition on to a paper or plastic tape.

Once we have made the tape, our problem is to cause the sound signal, which the electronic circuitry of the recording equipment has converted into an alternating current comprising an amalgam of frequencies and amplitudes, to make a permanent recording on it. This, as we saw last month, is achieved by drawing the tape past a gap in the recording head.

The head itself is an electromagnet whose soft iron core is bent so that the ends almost touch. Through the coil of this magnet the audio-frequency current is passed, setting up a powerful magnetic field across the narrow gap. But this is not the steady field which would be built up by a direct current. Since it is produced by an alternating current it will itself alternate, varying in frequency, direction and strength with the current.

So as the tape passes the gap it will be magnetised to a degree which, according to the quality of our equipment, more-or-less faithfully echoes the original sound. It will in fact be converted into a succession of flexible bar magnets whose strength depends upon the amplitude of the signal and whose length depends upon the frequency. Since higher frequencies mean more rapid changes of current as the tape glides past the gap, it is the highest frequencies that produce the shortest magnets.

This is a beautifully simple system in theory, but all magnetic materials have certain limitations which we should consider before proceeding further.

The first of these arises from the very nature of a permanent magnet, which of course will only retain its magnetism if the electron orbits are difficult to move. This, as shown by the graph of fig. 3, means that the recording head must supply energy. If this were not so, the curve—which is a closed loop—would take the form of the dotted line drawn inside it.

This tendency of a magnetic material to retain its original degree of magnetism is called magnetic *hysteresis* and the curve is called a *hysteresis loop*. The wider the loop, the more energy is consumed. We can do little about this, because if there were no hysteresis there would be no permanent magnets and no tape recorders.

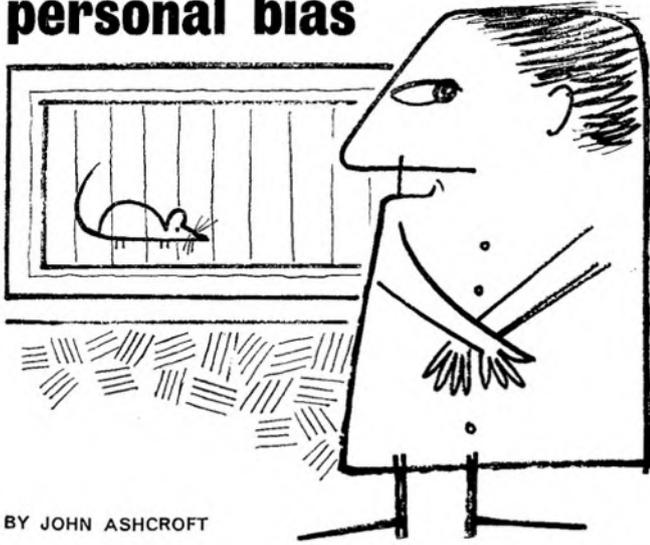
From the existence of hysteresis we can deduce that there must, for any magnetic material, be a minimum magnetising force below which no electron orbits will be moved. Consequently the amplitude of the smallest signal we wish to record must be above a specific minimum.

At the other end of the scale, there must be a limit to the number of electron orbits which can be rotated. As we approach this limit the effect of an increase in magnetising force will grow less. In other words, the recorded signal will be 'compressed'.

Thus, if we are going to achieve anything like a faithful recording, we must keep the current applied to the recording head within specific upper and lower limits. Many tape recorders have indicators such as meters or magic-eyes which enable us to keep the signal at optimum level by adjusting the gain control. And of course it is possible to buy recorders with automatic level control.

Next month we shall be considering a complete recording system in some detail. From there we can go on to examine the individual processes and the problems that arise in connection with them.

# personal bias



BY JOHN ASHCROFT

## THE CATCHERS AND THE CAUGHT

"MMMMM..." mused the doctor, glancing up from the electroencephalograph squiggles. "Harmonic distortion in the medulla oblongata, print-through in the cortical thalamus, and severe feedback from the cranial cavity to the soles of both feet, producing great fits of twitching. Any traumatic experience lately?"

The likeliest cause was a recent visit to my usual hi-fi dealer's premises, when I put three quid and some change before a new assistant and asked for two mercury battery packs for my portable. He produced them and politely said: "I'm sorry, sir, but you're two pounds short."

"Come come, laddy, don't mock the aged"

He showed me the price tag; sure enough, it said over fifty bob a pack. After a ghastly sinking feeling came glorious relief: superciliously I said, "Obviously a copying error—the five should be a three. Never mind, son, it can happen to the best of us."

"True," he replied, and showed me the official price-increases notification.

When the fog dispersed I was sitting against a demonstration Wharfedale with one assistant fanning me with an LP sleeve while the manager poured head-clearing fluid down my throat, some of which spilled over my Bib. They claimed I'd been sitting there for three minutes, eyes crossed, pawing the air and repeating: "Sixty per cent up, hic; sixty per cent up, hic; sixty per cent up, hic—" like a tape loop with a scruffy splice. Even so, I think they had a real cheek saying that *they'd* had an unnerving experience.

Cost of the recommended batteries discouraged several taping colleagues from choosing this superb portable; now, when it costs over a fiver to power it, there's a deterrent that NATO might well envy.

### WALTZING BLITHELY

Speaking of portables... I shrink from waltzing blithely out to interview random passersby. People face enough hazards without having a microphone wagged under their noses while an amateur asks questions. These thoughts were prompted by a chat with a friend—the secretary of one northern tape club—during which he described his first interview-outing. Manchester being a busy village, traffic noise made main-road interviews rather impracticable; also, it was cold, and a mid-winter evening.

You see the implications? Muffled up to the eyebrows like cartoon anarchists, members selected their victims up quiet side-streets in the dark. I don't know how many people they frightened, but apparently the first chap who had the *DP/4* brandished at him mistook it for a cosh and resolved at least to take two or three of them with him. I can't help sympathising: side-alleys in bad light are creepy places even without seeing muffled figures that survey you calculatingly and move to intercept.

In some instances the victim spoke first and groups returned to headquarters with tapes beginning as follows:—

Group A: "Go away, I'm a respectable mother of triplets..."

Group B: "I've left my spectacles at home, and anyway I don't want you revolting postcards."

Group C: "I'll vote for him if he'll improve the street lighting."

Group D: "I use any washing powder, but yours especially, whatever it is; I mean, well, it's so soft to the hands..."

Group E came back utterly shattered with: "Leave me alone, or I'll shout and I'll scream and I'll shriek, and cause agonising distortion, overmodulation, and horrific print-through on that cut-price triple play tape you're undoubtedly using."

Readers are invited to submit their own most memorable adventure in public interviewing. Entries should be sent to me, accompanied by a 7in. reel of LP tape; the winning entrant can name any professional portable described in the current *Hi-Fi Year Book*, and I'll send him a neatly typed specification from the same volume.

### DON'T BLAME ME

Another point. After taping a busker, Beefeater or bone-gatherer, it seems stingy not to let him hear any of the results. But remember the battery expense. "So what you do," explained a friend who's had ample experience, "is tell a little white lie—the portable is for recording only, and the tape must be replayed on mains equipment at home." I pass on the idea; but don't blame me if you end up with a parlour full of buskers, Beefeaters and bone-gatherers.

Moral problems worry me nowadays. I must be developing a conscience, and that's a sure sign of incipient senile decay.

At least, Ebenezer says acquiring a conscience is the first step on the road to senile decay, and I suppose he ought to know, although he must have reached the destination by an alternative route.

Or maybe I'm just a coward. Anyway, before recording someone I'd explain that no replay is possible. Granted, I might lose likely candidates; on the other hand, if I interview (and probably annoy) someone bigger than me and then airily tell him he can't hear the recording he might make sure I don't either.

By the way, my tape colleagues agreed that the BBC *Sound Hunters* broadcast was excellent, but the same bit jarred violently on all of us—the extract from *The Real Thing* wherein John Bradley interviewed the rag-and-bone man. Whatever people say about dynamic reporting and so on Mr. Bradley's aggressive approach shook me. The inane laughter and false joviality of TV comperes make pretty sick listening, admittedly; but this interview struck me and several others as being dangerously near the other extreme. Comments, anyone, please? (*Preferably not from Mr. Bradley's solicitor—we rather liked The Real Thing!*—Ed)

My first encounter with my own voice as anything but an echo from distant farm buildings came in a French Lesson longer ago than I like to recall. Apart from being stunned by the flat nasal Lancashire accent emerging from the machine's loudspeaker, I realised with horror just how consistently I slurred and shirked the letter "Rrrrr." It did explain why an otherwise friendly teacher gritted his teeth when I said: "*Notre roi y arrivera trois heures apres l'aurore...*"

Years later came the arty-crafty party when I tried to swing the conversation from satire to hi-fi by murmuring to a deb-type wench that I derived a lot of pleasure from woofers and tweeters. Her eyes lit in sheer delight. "Oh, so do I," she whispered; "just fancy that—let's talk about this somewhere quieter."

Hello-hello-hello, I thought, then she added: "But surely you mean woofers and Flook?"

I'll save millions of faithful readers the expense of sending anxious telegrams inquiring into the well-being of that optician extraordinary, tape tinkering eccentric and electronic hornswoggler *par excellence*, Ebenezer (Neb) McPhee. No, he isn't ill and his customers haven't caught him yet. Last weekend his wife announced that she'd had an inspiration for a new recipe, and he's skeddaddled up to the Pennine caravan until the debris settles. They have a kind of reciprocal arrangement.

Oh, and the tape-club secretary and company went taping in Manchester again this week; from the counter of a coffee-bar, in the time it takes to lower a cup to a saucer, one *Grampian DP/4* with wind-shield "melted into air, into thin air", as the lad from Stratford said. Memo to location recordists: chain your equipment to your wrist and hope the thieves aren't keen enough to amputate.



**N**INETEEN sixty-six has been a good year for the Audio Fair—apart from the unexpected mid-April snow, which inconvenienced queues of waiting visitors on the first day. The Hotel Russell positively bulged with new designs, original ideas and pleasing demonstrations.

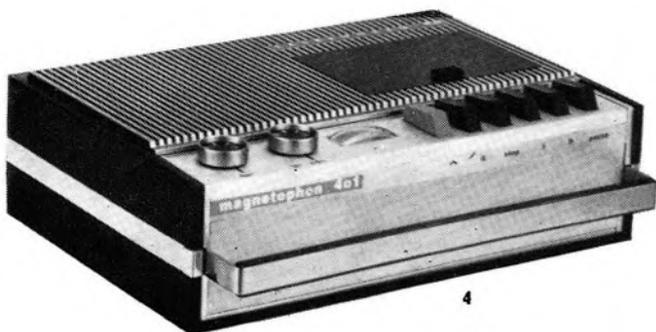
From the tape recording standpoint, reasonable sound quality had at last become an almost universal accomplishment, and manufacturers were evidently concerning themselves with increasing versatility rather than squeezing out that last elusive kilocycle. Witness the *Wyndor Vanguard*, making nice noises with a very low-price mechanism, the *Telefunken M.204*, the *Ferroglyph Connoisseur* and *Akai X-300*.

And with versatility came the accessories—a low-price *STC* ribbon microphone, three new mixers from *Grampian*, the *Philips EL7500* build-it-yourself microphone, and *Ferranti* silicon transistor tape amplifier circuits.

We shall endeavour to retain some semblance of logic in this report by tracing the alphabetical route set in our May Preview. In so doing we hope to define the scenery, and comment on the sound, for those readers unable to visit the hotel in person. For those who did see the demonstrations we offer a second opinion, for what it is worth, in praise and (constructive?) condemnation of the exhibits. Avoiding the ever-present danger of, in effect, merely rehashing the preview, we shall concentrate in the main upon tape equipment actually introduced at the 1966 Fair. Exceptions will occur when the mode of display seemed outstanding.

*Agfa-Gevaert* had this year abandoned their usual bright demonstration—of interest to hundreds—in favour of a trip to Paris for the two persons who happened to guess correctly the length of a tangled bundle of tape in a transparent box. A pity.

Ever since they 'borrowed' the styling of the *Ampex 601*, *Akai* have made a profitable living by marketing recorders of basically



# SEEN AT THE FAIR

American design. 'Resemblance to the innards of any existing machine' may have been coincidental where the *X-4* battery portable is concerned, but the trend seems a little out of hand in the case of the *PT5011*, which is extraordinarily similar to the old *Ampex 351* studio console. The resemblance applies not only to the sloping tape transport, but to the very screw locations and design of components on the control panel. Perhaps we may seek consolation in noting that the new *Akai 910* is, at £65 3s., less than one-seventh the price of the (£486) *Ampex 601*, while the *PT5011* is some £200 cheaper than the *Ampex 351*.

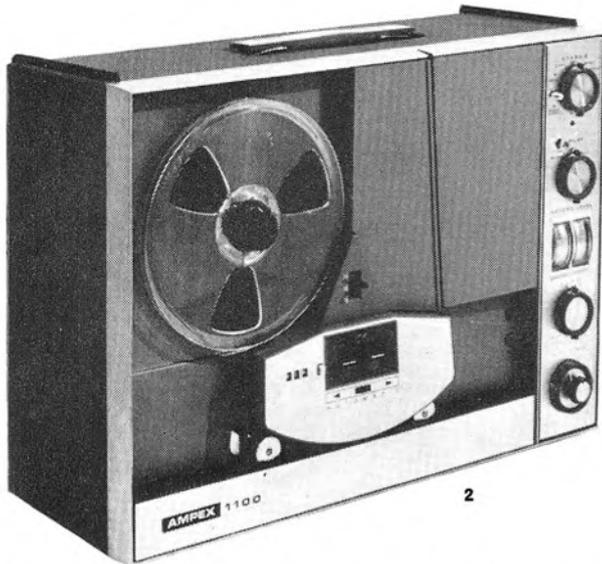
A colour slide display explained the *Akai* offerings, to which have been added an attractive non-solenoid version of the *X-355*—a stereo machine capable of taking 10½ in. spools without adapters and designated the *X-300*. Other newcomers are the *X-PK1* battery portable, operating at 1½ i/s (or 1¼ i/s with slip-on capstan sleeve) and the *1700* stereo. A version of the *M8* has also been introduced—the *X-100D* tape unit, expected to sell in the region of £95.

*AGK* once more adopted a rather static display, visitors to Room 302 experiencing the atmosphere of quiet respect common to the corridors of the British Museum. There, behind the glass cases, stood the *C51* studio capacitor and *D150* dynamic microphones. The former, convertible from non-directional to cardioid pickup response by changing the capsule, features a nuvistor preamplifier. Variable bass attenuation is built in to the power supply unit. Suitable for studio and outdoor recording, the *D150* is aimed at professionals and "the connoisseur with professional pretensions", while the *D109* has been introduced as a general-purpose stick microphone in the lower price range.

Critics of ¼-track stereo may have shared our surprise at the performance of the *Ampex 1100* tape recorder, which was demonstrated through *Ampex* accessory loudspeakers. Also shown were the

## A REPORT ON THE 1966 INTERNATIONAL AUDIO FESTIVAL AND FAIR

- 1 Akai X-PK1 battery portable
- 2 Ampex 1100 stereo
- 3 Philips EL7500 microphone kit
- 4 Telefunken M.401 cassette portable
- 5 Sony TC-260 stereo
- 6 Tandberg Series 12 stereo



2

2000 and 800 series, offering various configurations of power amplifiers, internal speakers and cabinet finish. Great play was made by Ampex of the twin-capstan transport employed in the three recorders, two 3½lb. flywheels being incorporated on either side of the head block, each with a solenoid-controlled pinch-wheel. The automatic-threading box, far from concealing a complex array of snaking arms, was seen to cover a simple split-hub single-flange spool. Take-up is achieved simply and effectively by dropping the tape across two slots in the hub, allowing the rotating spool to catch the trailing tape against the hub wall. An aluminium frame houses the mechanism, while silicon transistors and tantalum capacitors are incorporated in the recording amplifiers. Also shown was the *AG-350* professional console recorder, a transistor model introduced in the USA last summer.

Audio and Design, agents for Teac tape recorders, showed a range of professional recording machines and accessories, including their own limiter amplifier. The unit is transistorised and is designed to hold signals within a predetermined volume range. Intended for professional use, the limiter incorporates a PPM level indicator, has an overload range of more than 35dB above threshold, and a 60dB signal-to-noise ratio. The equipment was demonstrated, as their entry in the Audio Fair Catalogue stated, by "specialist engineers whose burning enthusiasm for technical perfection in their own fields is second only to making a profit!"

Centre-piece of the BASF exhibit was an illustrated talk on the preparation and synchronisation of slide displays. This was accompanied by a 'please tape one' series of pre-recorded lectures, copies of which were presented free to visitors.

One of the first non-professional recorders to feature an easily changed head assembly was shown to be the *Braun TG60*, a stereo machine now being imported by *Fi-Cord International*. Three motors,



3

solenoid controls, separate record and play heads, speeds of 7½ and 3¼ i/s, and a price tag of £308, make a machine appealing to the wealthier enthusiast. It is hoped to review this model in due course.

Brenell, who professed to us a fear that our Preview remarks may have been taken amiss, displayed the uniqueness of the deck on which their range of recorders and tape units is based. We would take this opportunity to point out that the *Wearite* and *Brenell* transports have only one thing in common—they are among the best semi-professional decks currently being made in Britain.

The *British Kinematograph, Sound and Television Society (BKSTS)* had some interesting demonstrations of various audio effects, the music tapes used being of exceptionally pure quality and emanating from a self-efficiency tape purist by the name of Terry Long, who we understand is available for recording work requiring the very highest standards.

Multi-channel mixers, peak-programme meters and a range of amplifiers and components were displayed by *Elcom*, in conjunction with an *EMI BTR4* console recorder. The company specialise in attenuators and quadrant faders, though their claim of "exceptionally low cost" is unlikely to apply to the price standards of home constructors. Professional recording and sound relay systems are the company's main interest.

*Elizabethan* have been making tape recorders for years. This was the first Audio Fair in which they participated, however, their display comprising some very moderately-priced domestic machines built around the three-speed *BSR* and *Magnavox* tape decks. Centre-piece of the display was the *LZ.711*, a ¼-track stereo recorder with detachable loudspeakers.

*EMI* flew a flag for the professionals, but the *Ferranti* circuits fell between two stools. Here, it seemed, was a silicon transistor tape

(continued overleaf)



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6



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amplifier within reach of the home constructor. But on looking closer we discovered that the £16 12s. and £15 10s. price tags on the *TR100C* and *TR100W* Tape Recorder Kits respectively, referred to the semi-conductors alone, and did not include the other components. Also on show was a capacitor microphone preamplifier based on the *ZFT12* field effect transistor, featuring an input impedance of 120M.

**Ferrograph**, having lately brought a pleasing new approach to advertising by 'displaying the works', held a fifth floor demonstration of their *Series 6* range, with emphasis placed on the new *Connoisseur 633*. Selling at £126, the 633 is based on the three-speed *Wearite* deck and includes almost every facility to be wished for on a semi-professional design—with the rather surprising exception of stereo. A three-year guarantee covers the recorder.

**Fi-Cord** had a range of established accessories, but probably the best stocked booth on the ground floor hall was displayed by **Gramplan**. To their existing range of microphones and recording accessories have been added a battery-powered mixer for the amateur and a large semi-professional mixer—available in several forms—with built-in level meter. A development of the *636 Reverberation Unit*—designated the *666*—was introduced as a means of enlivening the acoustic of 'dead' lecture halls and home music rooms.

In the world of microphones, 'capacitor' can generally be translated as 'expensive', though the *M.100* demonstrated by **Hammond** was really quite reasonably priced at £30 9s. Evolved from the *Microkit*, which first appeared in 1963, the *M.100* renders it, as the manufacturer states, "no longer necessary to regard the microphone as the 'weakest link' in the recording chain". Recordings made with the microphone were reproduced from tape and certainly fulfilled claims regarding its superiority over "the 'run-of-the-mill' dynamic microphone".

**Lustraphone** were following the path of miniaturisation predicted in our preview, while **Peto Scott** and **Philips** were doing a roaring

business on the third floor, where everything from the 7 gn. *EL7500* "build-it-yourself" microphone kit to the £800 *EL3400* helical-scan video tape recorder were to be seen. Also on show were the *P31* and *EL6033* microphones, with respective prices of 18 gn. and £24. By twisting a ring below the *EL6033* head, pick-up response can be converted from omni-directional to cardioid. The 40 gn. *NP1630* car tape installation, based on the *EL3301* cassette recorder, offered background music for the motorist while—possibly at the motorist's destination—the *SM990* offered "functional music" for suggested use by the retail and catering trades or as an alternative to *Music While You Work*. The deck features two playback heads, with a central capstan. No pressure-pads are used, the head on the supply spool side of the capstan being selected to suit the tape track. The ½-track player operates at 3½ i/s in two directions, reversing at the end of each reel, and is supplied on a rental basis.

One-by-one professional-recorder manufacturers are going over to transistors. This year was the turn of **Revox-Studer**, who displayed the new *A.62*. Removable printed-circuit boards are employed for the amplifiers and oscillator, and tape speeds are 15 and 7½ i/s. Equalisation may be set for CCIR or NAB, overall frequency response being 30 c/s—15 Kc/s ±1½dB. Full and ½-track models are being marketed at £566 and £712 respectively.

After some years of manufacturing "precision tape heads for the Government and Industry", **Scopetronics** announced a range of studio console recorders using a three-head tape transport selling for £140 10s. The range comprises various combinations of heads, electronics and deck, the *Type A* mono tape amplifier (excluding replay power amplifier) costing £179 7s. The metal console is being marketed for £70 5s. 6d. while the power-supply/twin-oscillator unit costs £47 15s.

**Sennheiser** had a range of microphones and accessories, while a



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# SEEN AT THE FAIR

- 7 Philips EL6033 microphone
- 8 Well-laden Gramplan booth
- 9 Philips SM990 tape player
- 10 Elizabethan LZ.711
- 11 Scopetronics professional tape deck
- 12 Philips EL3400 video tape recorder

useful device introduced by Shure (to join the microphones mentioned in May) was the M61 transistor stereo pre-amplifier, which incorporated equalisation and amplification to suit tape head and magnetic gramophone cartridges. Connected direct to a tape head, the unit gave sufficient power to drive the line-input of a tape recorder or feed a low-sensitivity audio amplifier.

STC took considerable trouble over their microphone demonstration, and the result was probably the most competently organised display to be found in the Hotel. The reaction of four microphones (the 11 gn. 4113 cardioid ribbon, £22 10s. 4105 dynamic, £50 4028 bi-directional ribbon and £65 4126 capacitor) to a Dvorak String Quartet was recorded and used to illustrate the variation in performance to be expected from microphones of different price and different purpose. Most marked was the superiority of the 11 gn. ribbon microphone on music over the more expensive 4105, which had been designed specifically for speech work and had a rather coarse quality. Similarly emphasised was the Law of Diminishing Returns when the more costly ribbon and capacitor microphones were compared with the 4113.

If the Tandberg Series 12 sells as well as its predecessor, the Series 7, Elstone Electronics should have no worries. Conventional Tandberg styling is adopted, the new model being very similar to the old, but having several extra facilities and, at £110 5s., a rather higher price. Currently available only in ¼-track stereo form, the recorder features two 10W amplifiers with continuously variable tone controls (replacing the bass cut and lift switch) and a multiplex pilot-tone filter to overcome bias-beating in recording future stereo radio broadcasts.

Tape Recorder had a stand and room shared with Hi-Fi News, and we had many interesting chats with enquiring readers. The new Audio Annual sold like hot cakes throughout the weekend.

The Telefunken M.401 introduced itself as being quite pretty and, considering the 2 i/s speed, quite pricey. Retailing at £48 6s., the recorder employs DC International cassettes, of which two types are available, giving playing times of 45 minutes and one hour on each of two tracks. Twin contra-rotating flywheels are incorporated to reduce tape speed instability when the recorder is used outdoors and—a useful feature—a commutator-free motor is said to give complete freedom from motor crackle.

Among other items, the Truvox 100 Series tape units were demonstrated, one of which is reviewed in this issue.

We were rather surprised by the Wyndor Vanguard. Considering the price of the Magnavox Studiomatic upon which it is based, the recorder seemed to perform very well. This machine perhaps illustrates that facilities such as off-tape monitoring, sound-on-sound, separate bass and treble controls, and echo, do not necessarily push prices to the sky. We noted also that the Vanguard Instruction Manual includes a full circuit diagram and the advice that, in event of difficulty, the owner need merely contact the manufacturer "where every effort will be made to assist you". A rare sentiment, but one that was accompanied by neither the Wyndor address nor telephone number!

Probably the most fascinating tape recorder in London during Audio Fair weekend was to be seen, not at the Hotel Russell, but at the United States Trade Centre. Here was held a display of American Audio Manufacturers' products, notably including the Crown range



of professional machines. The stereo Crown SS824 bristles with controls and is pleasantly lacking in decorative trimmings. Ten-inch spool capacity, speeds of 7½, 3½ and 1½ i/s, a solenoid mechanism, modular transistor preamplifiers, and a claimed response of 50 c/s—25 Kc/s ±2dB are featured, accompanied by a U.S. price tag of some £540. A four-channel (in effect, double stereo) version with in-line heads sells at some £800. No plans have been announced for distribution of these machines in Britain.

Still outside the Hotel Russell, the Sony TC-260 was displayed at the Welbeck Street premises of Debenhams Electrical. The recorder is transistorised, has a 7in. spool capacity and operates at 7½ and 3½ i/s. Retailing at £99 15s. it offers ¼-track stereo recording and replay, separate bass and treble controls, and a claimed frequency response of 30 c/s—18 Kc/s ±3dB. A tape speed stroboscope is incorporated on the pinch-wheel. Demonstration tape and stick microphones are among the accessories supplied with the machine.

Mastertape also opted out of the Audio Fair hubbub by taking a room at the Morton Hotel. Here they arranged an eye-catching wall display of tape and tape materials. A roll of transparent base material was displayed beneath a photograph of the company's Colbrook coating installation. This was followed, in turn, by a roll of coated tape being 'fed' into a photo of their tape slitting equipment. Streams of tape left this illustration to form an attractive pattern as they fed to spools pinned to the opposite end of the display. Also shown were rolls of coloured leader prior to slitting.

We culminated the 1965 Audio Fair Report in the following prophetic manner: "With so many low-priced video tape recorders in the wind, the 1966 Audio Fair may well herald the second phase of the tape recording hobby—but we must wait and see."

Well, there's always 1967!

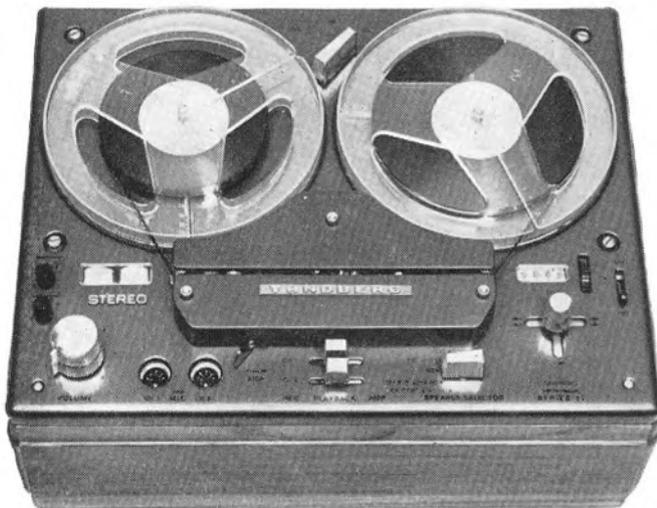
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12



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" TK.6	...	67/6
" TK.8	...	63/-
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18L	...	67/6
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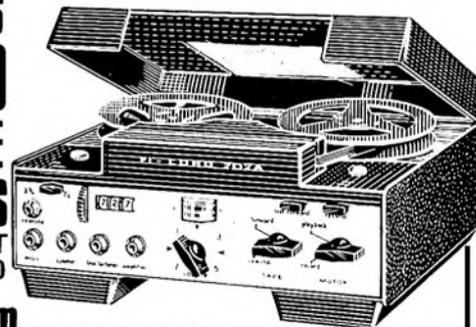
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# equipment reviews



## TRUVOX PD 104 STEREO TAPE UNIT

**MANUFACTURER'S SPECIFICATION.** Transistor 4-track stereo tape unit with separate record and play amplifiers up to 100-ohm emitter-follower outputs. **Spool Capacity:** 7in. **Tape Speeds:**  $7\frac{1}{2}$ ,  $3\frac{3}{4}$  and  $1\frac{7}{8}$  i/s. **Wow and Flutter** (respective): 0.1%, 0.15% and 0.25% RMS. **Frequency Responses** (respective): 30c/s—17 Kc/s  $\pm 2$ dB, 40 c/s—10 Kc/s  $\pm 2$ dB and 60 c/s—8Kc/s  $\pm 3$ dB. **Oscillator Frequency:** 90 Kc/s. **Price:** £93 9s. **Manufacturer:** Truvox Ltd., Neasden Lane, London, N.W.10.

**T**HE PD 104 tape unit provides 4-track stereo recording from microphone, radio and gram inputs, with playback at 1V line level for connection to external amplifiers and wide-range speakers.

Mixing facilities for microphone and line inputs are provided, and monitoring from line input or tape output is possible with A-B switching. Track-to-track transfer is also possible by operation of simple push-button panel controls. VU-meters are fitted for accurate record level indication. GPO jack sockets are fitted for right and left microphone inputs at the left-hand end of the stacked control panels, with microphone, radio/gram and playback level controls at the centre. These controls are not coaxial, but have to be set to the same scale readings for each input or output for correct stereo balance.

The twin VU-meters are illuminated and are placed side-by-side on the upper panel with the A-B switch, track-to-track transfer buttons being below them on the bottom panel.

Record buttons are provided on each panel, and these glow red when depressed for recording. The deck controls must also be set independently to record by depressing the lower finger key and at the same time setting the spring-loaded record knob to the clockwise position. When the tape is stopped, this control automatically resets itself to the play position.

A recessed panel on the right of the dark wood plinth contains four phono sockets for radio/gram inputs and line outputs. Four 3ft. leads terminated in matching phono-plugs are provided for connecting to external equipment.

Absolute tape speed was checked at the beginning and end of a 7in. reel and found to be within the specified  $\pm 1\%$ .

Short-term speed fluctuations were measured by recording a 3Kc/s test-tone at each speed and replaying through a limiter and frequency discriminator to a high-speed pen recorder to give the fluttergrams of fig. 1. The integrated RMS readings for a 300 c/s audio bandwidth were: 0.08% at  $7\frac{1}{2}$  i/s, 0.09% to 0.1% at  $3\frac{3}{4}$  i/s and 0.16% to 0.17% at  $1\frac{7}{8}$  i/s.

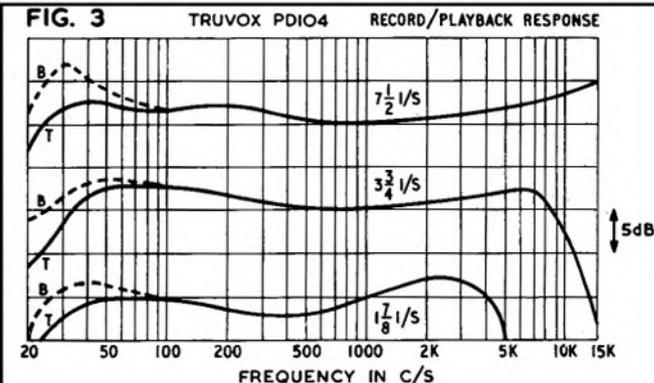
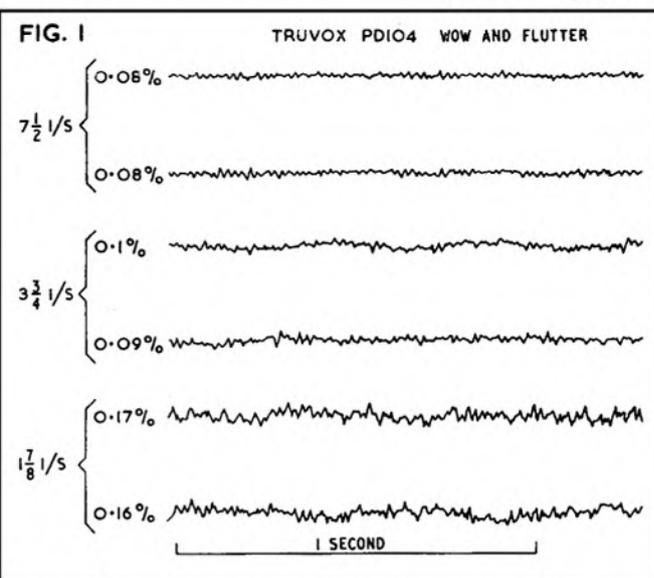
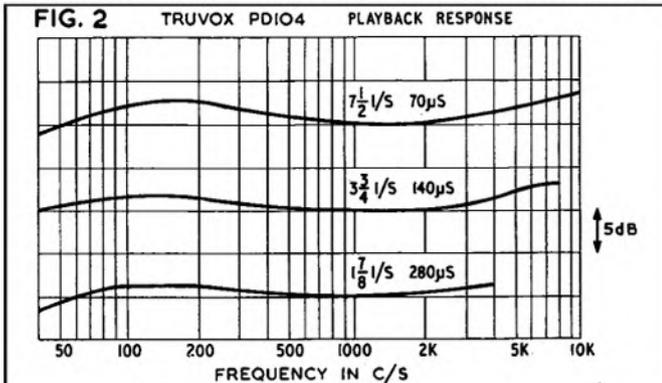
No wow was visible or audible at  $7\frac{1}{2}$  i/s. A 2 c/s wow was just audible at  $3\frac{3}{4}$  i/s on a sustained tone, but it could not be detected on any musical recording. Even at the lowest speed of  $1\frac{7}{8}$  i/s it was difficult to detect any wow or speed variation on tone or music, but the high frequency tape flutter and the slightly curtailed frequency response shown in fig. 3 gave the only audible clues to the tape speed being used. Operation of the A-B switch showed that the average casual listener could not detect with certainty which speed was in use on nearly 50% of programme material when listening at low background music level.  $3\frac{3}{4}$  i/s was perfectly satisfactory at higher listening levels with good quality tape, and the highest speed of  $7\frac{1}{2}$  i/s was only required for direct comparison with the highest quality FM radio or LP disc.

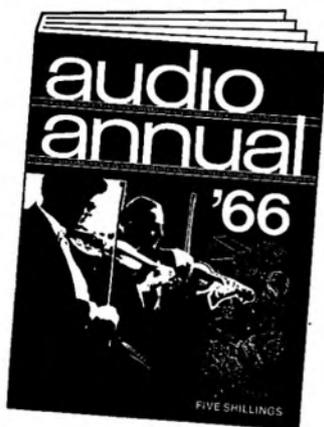
Playback equalisation was checked by playing test-tapes recorded to the standard recording characteristics of  $70\mu$ S,  $140\mu$ S and  $280\mu$ S at tape speeds of  $7\frac{1}{2}$ ,  $3\frac{3}{4}$  and  $1\frac{7}{8}$  i/s. Fig. 2 shows that the resultant responses are level within  $\pm 2$ dB limits for all frequencies on the test-tapes.

System noise, with no tape passing the heads, was 32dB below test-tape level on the top track and 30dB below test-tape level on the bottom track. CRO examination of the noise showed it to be very low frequency transistor noise which was hardly audible above the very faint transistor hiss on a 10W amplifier and *Tannoy Monitor* dual concentric speaker in a 6 cu.ft. enclosure.

The overall record/play responses of fig. 3 show that the extreme low note response below 50 c/s is up some 3-4dB on the bottom track; the similarity of the curves at the three tape speeds would indicate that this is an amplifier rather than a head effect. Responses meet the specification at  $7\frac{1}{2}$  i/s and  $3\frac{3}{4}$  i/s, but there is a sharp cut in response above 5 Kc/s at  $1\frac{7}{8}$  i/s. The response shown is that to be expected when

(continued on page 257)





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## TRUVOX PD104 REVIEW CONTINUED

the bias is set for minimum distortion and intermodulation at the higher tape speeds. It could only be improved appreciably by reducing bias or recording level for optimum results at the lower speed.

All tests were made at test-tape level 12dB below peak recording level, where tape distortion is approximately 3% 3rd harmonic. Test-tape level was recorded with the VU-Meter reading -6dB. Peak recording level as defined above was well off the meter scale, but, as is well-known, it is standard practice to set VU-meters 6dB above constant tone level to allow for the dynamics of the meter movement.

The total unweighted signal-to-noise ratio is thus 40dB on the bottom channel, and 42dB on the top or left-hand channel. Weighting the

meter response to match that of the ear at low listening levels improved the readings by 10dB to better than 50dB on either channel.

Recorded noise was low and tape erased and recorded on the machine was only just perceptibly noisier than bulk-erased tape.

### COMMENT

At last we have an all British recorder which equals the best Continental and Scandinavian product in accurate equalisation and wide frequency response, and which at the same time gives that subtle subjective satisfaction and impression of smoothness and effortless dynamic range which is so difficult to define and measure.

The well-tested Truvox deck and rugged transistor electronics should result in a product with a long and useful life which will not become out of date for some considerable time. **A. Tutchings.**



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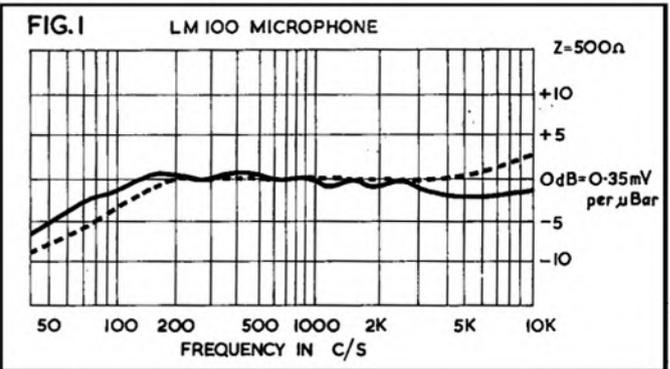
**MANUFACTURER'S SPECIFICATION.** Dynamic omni-directional microphone with balanced output. **Frequency Range:** 50 c/s—15 Kc/s. **Impedance** (review model): 500 ohms at 0.3mV  $\mu$ Bar. **Cable:** 6ft. twin screened. **Colour:** Two-tone grey. **Dimensions:** 4½ x 1½ in. **Weight:** 3½ oz. **Accessories:** Keyhole stand (1s. 6d.), table wire stand (3s. 9d.) and Lavalier attachment (7s. 6d.). **Price:** £2 19s. 6d. (Also available in 200, 50—60 ohms and high-impedance versions, with respective prices of £2 19s. 6d., £3 2s. 6d. and £3 14s. 6d.). **Manufacturer:** London Microphone Co. Ltd., Eardley House, 182/4 Camden Hill Road, Kensington, London, W.8.

**T**HIS is an excellent low-priced microphone particularly suited for use with transistor circuits. The one submitted for review was the popular 500-ohm version.

The dotted curve of fig. 1 is the mean reference curve mentioned in the specification, and all production microphones are said to be within  $\pm 4$ dB of this response.

The solid curve shows the measured response in a constant white-noise sound field, and this is certainly within the specified 4dB limits. The slight bass rise relative to the standard response is probably due to the close-up (1ft. from sound source) measurement, where the wavefront is slightly spherical and so gives rise to the well-known close talking effect due to the method of bass compensation used on this microphone, where a sound inlet is provided in the stick case at the end remote from the diaphragm.

The sound quality is smooth and sweet, and completely lacking the



sibilant emphasis so common in cheap microphones with a peak in the 3-4Kc/s region.

The sensitivity is remarkably high for a microphone with such a small diaphragm area, and the impedance of 500 ohms (in sample) is well chosen to work into a simple earthed-emitter transistor amplifier with low noise and little risk of high note loss even with quite long leads. Handling noise is low, and its size and weight makes it particularly suitable for use as a Lavalier microphone, hung around the neck.

### COMMENT

I give this microphone top marks for appearance, performance, and above all price. With transistor circuits taking over, for at least the input stages of most modern quality recorders, it meets the need for a reasonably priced unit which will do justice to the wide frequency response of modern heads and tapes. **A. Tutchings.**

## videotape comes home

(Akai) and the Scotch concerns have issued statements concerning their forthcoming home video recorders, though technical details are still lacking. Fairchild have produced a prototype high-speed, fixed-head recorder suitable for home use and they are just about ready to commence quantity production of these machines. Several other manufacturers are either actively developing a video tape recorder, or are just waiting for the market to grow a little before jumping on the bandwagon.

The Sonic-Vee Corporation of New York announced a new scanning system last summer which permits a wide bandwidth signal, such as a television picture requires, to be reduced to a spectrum encompassing some 30 Kc/s instead of 4.5 Mc/s. The most interesting aspect of this scanning system, at least as far as home video recording is concerned, is that a specially built adapter will compress the video signal into a narrow bandwidth signal which may be recorded on a high quality audio recorder operating at 15 i/s. The estimated cost of a signal processor for such applications is approximately £70. Negotiations are currently being conducted with interested manufacturers, though it will be some time before a commercial adapter, using the Sonic-Vee system, will be available.

The introduction of Polaroid cameras, with their almost instant pictures, caused quite a stir in photographic circles several years ago.

The introduction of low-priced home video tape recorders is expected to cause a similar reaction, particularly among home movie enthusiasts. Recorded tapes are immediately playable, without any delay for processing, and they can be erased and re-recorded hundreds of times. Videotape costs, at 9.6 i/s or 7½ i/s, are approximately one-half that of an equivalent amount of 8mm. colour film. As video recording becomes more popular the cost of raw tape will probably drop even further.

Within a few years time most manufacturers are planning colour video recorders for home use, especially in view of the tremendous increases in colour receiver sales in 1965 and early 1966. Only Ampex are promising that black and white tapes made on their HVR will be compatible with any future Ampex colour machine. Helical-scan recording has been selected by some manufacturers, but it is rather unfortunate that video tapes made on Machine A cannot be played on Machine B. In fact, unless the machines are specially calibrated, tapes cannot be exchanged between two machines of the same model. Added to this lack of interchangeability is the wide range of speeds being used by each manufacturer. According to industry sources, the lack of compatibility is not being considered as a major problem.

The cost of video recorders for home use is expected to remain fairly stable, and even the colour VTR's to come are expected to be in the £300 to £400 region. All the home VTR manufacturers sell television cameras as optional extras, though this adds another £100-odd to the complete system price. Accessories such as tape splicers, video signal mixers, lighting equipment and other assorted paraphernalia will add still another interesting phase to home video recording.

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# READERS' PROBLEMS

Readers encountering trouble with their tape equipment are invited to write to the editorial office for advice, marking their envelopes "Readers' Problems—Tape". Replies will be sent by post and items of general interest may also be published in this column at a later date. This service does not, however, include requests for information about manufacturers' products when this is obviously obtainable from the makers themselves. Queries must be reasonably short and to the point, limited to one subject whenever possible. In no circumstances should such letters be confused with references to matters requiring attention from other departments at this address. We cannot undertake to answer readers' queries by telephone.

### A CLANKING TRICORDER

Dear Sir, I have a *Stuzzi Tricorder* which has been giving me a great deal of trouble. There seems to be a mechanical fault, for a strange clanking sound comes and goes from within. I have checked and rechecked but cannot find the cause of the fault. The machine has had very little use and is kept scrupulously clean.

Yours faithfully, R.T.H., Ashford.

The 'strange clanking' you report from the *Stuzzi Tricorder* may be due to incorrect setting of the pulley which engages the flywheel. Its position is determined by the rod which sits in a cut-out of the crescent bracket of the control switch, and this rod may need bending slightly. Alternatively, check the motor cradle itself, especially the side spring which should aid the return motion.

### WEIGHTING AND UNWEIGHTING

Dear Sir, My problem is less a technical than a linguistic one. It refers to the word *weighted* which appeared in the December 1962 issue of your magazine. On page 505 of that issue, in the *Manufacturer's Specification* included with the *Ferrograph Series 5A* review, it was stated that the signal-to-noise ratio is 45dB, *unweighted* including hum. Later, on page 509, appears the passage "Erase and bias noise was within 1dB . . . when *weighted* to reduce hum." I would be grateful if you could explain the meaning of these two terms.

Yours faithfully, L.W., Dresden, East Germany.

An *unweighted* signal-to-noise ratio is simply a ratio as measured in terms of the voltages of wanted and unwanted signals, expressed as decibels. The *weighted* ratio takes account of the ear's declining sensitivity at low frequencies. Thus, although a 50 c/s hum signal measured at only 40dB below the wanted signal may seem bad on paper, the ear is in fact less sensitive at 50 c/s by a factor of 10-40dB, depending on the reference level adopted at mid-frequencies. Thus, in terms of listening quality, it is considered practical and realistic to give a *weighted* figure, otherwise the part played by the low frequency hum in the total noise may appear to be unduly exaggerated, thus degrading the total noise figure as quoted, even though in practice it may not be quite as serious as it looks.

### CUPPING TAPE

Dear Sir, I have between 20 and 30 reels of tape and find that about half a dozen of them have become wrinkled and will not now play or record properly on my ¼-track *Tandberg*. Could you please tell me what causes this condition and what remedy there is for it?

Yours faithfully, J.M., Nottingham.

The effect you describe is undoubtedly that known as 'cupping', whereby after a time the tape acquires a permanent set, curved more or less severely about the longitudinal axis. A tape in this condition can make good contact with the heads only at or near its edges, and then possibly intermittently, unless the tape tension is very high or the pressure pads very fierce. Neither of these conditions exist on the *Tandberg*, and neither is desirable.

The cause of cupping goes back usually to the drying conditions in the tape coating machine and possibly even further to the chemical formulation of the coating itself. If the solvents used in the paint are not completely removed at this stage, or are inherently too slow to be removed completely, they continue to evaporate afterwards and cause the coating to contract, unhindered by the setting process which is

included in the final stage of oven drying. The base does not contract, of course, and so the tape cups.

Tape manufacturers naturally do their best to prevent this kind of thing happening, but it is not always predictable and may take months or even years to appear. However, any reputable maker will gladly replace such tape provided it shows no evidence of maltreatment, and in some cases subject to the tape having been bought within a certain number of years before the complaint. Best first course is to return it to the makers, preferably, or to the dealer from whom you bought it.

You may want to keep the recordings on the tapes. In this case, your best plan is to copy them on to other tapes before you send them back. If they are replaced, you cannot expect to have the originals returned as well, although some makers will do this. And, understandably, no maker will undertake to copy recordings for you—indeed, most of them specifically exclude any consequential liabilities from their responsibilities to the customer, confining themselves to the replacement of goods suffering from faulty description, materials or workmanship.

To copy a cupped tape, you will need to borrow a machine which will play it properly, usually a matter of trial and error among your friends. Some of the continental 2-track machines have quite high tape tensions; otherwise, if the recordings you want are not made on all four tracks but only the two outers or the two inners, they can often be played on the older 2-track machines with high-pressure pads. Transferring to a new tape on your own machine is then quite simple.

If all else fails, the tape can frequently be heat-treated with success. First rewind the reels to give a reasonably tight even wind and stick or clip the end down in your usual way. Then place on a wooden tray or board in an oven set to not more than 100 degrees F. and leave for not more than a half-hour at first. Inspect for improvement, and repeat if it seems necessary, increasing the heating time if required but not the temperature. Rewind after each treatment if the tape appears to have loosened on the spool, and continue treatment until it ceases to do so. The loosening will be due to the coating contracting, of course. The aim of this treatment is eventually to stretch the tape slightly, which tends to reduce the common positive cupping (with the coating concave) by introducing some negative cupping (with the coating convex). Strange but true, and it usually works. The two snags are the risk of overdoing it and the certainty of putting up the print level vastly if there are recordings on the tape.

#### HUM ON THE TRUVOX III

Dear Sir, I wonder if you could help me with a problem I am experiencing. I have a Truvox Mark III tape deck and Truvox Type K Mark II tape amplifier. The trouble is that the power pack is mounted beneath the tape heads and the heads pick up 100 c/s mains hum. The original heads have been changed by Truvox recently and this cut down the hum to quite an extent. There is only one way you can cure the hum, and that is to make the cabinet three inches taller and to mount the power pack in the left hand front corner. When this is done there is still a slight trace of hum which I want to eliminate completely. A friend tells me that a hum-bucking coil might do the trick. Can you give me any information regarding this?

Yours faithfully, P.R., Sidcup.

The problem of hum pick-up is a very real one, especially with a heavy steel deck such as yours mounted in a cabinet with the power pack directly beneath it. Even if it means doing some rough carpentry at the rear of the cabinet, it would be advisable to move the power pack well clear, perhaps extending it to a small shelf below and behind the main assembly.

But before doing anything this drastic you had better check that hum is being picked up by direct radiation in this way. The power pack should be released from the cabinet and moved about while the equipment is working at full gain (mind your fingers!). Very often transformer lamination vibration is transmitted through the cabinet to give an acoustic pickup that can be similar, surprising as it may seem, to that experienced on gramophones. You could try buffer mounting on rubber feet if such is the case.

A hum-bucking coil could be made from a loop of one or two turns of single 26 swg copper wire, about an inch in diameter, wired in series with the return lead of the head, and positioned on a stand-off connection of an inch or two to allow movement to the best place. This method is not greatly recommended, however, as it can introduce as much hum as it is supposed to cure.

Finally, don't forget to check that the unused heads on your machine are short circuited during the appropriate direction of replay.

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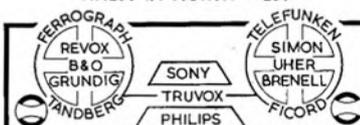
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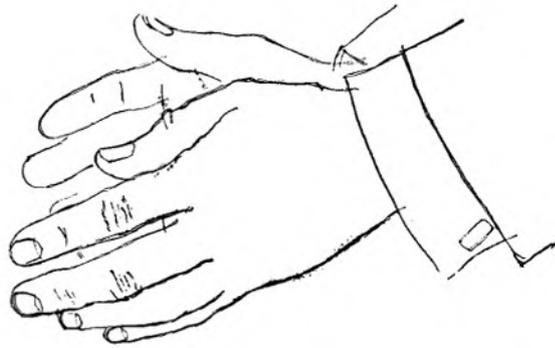
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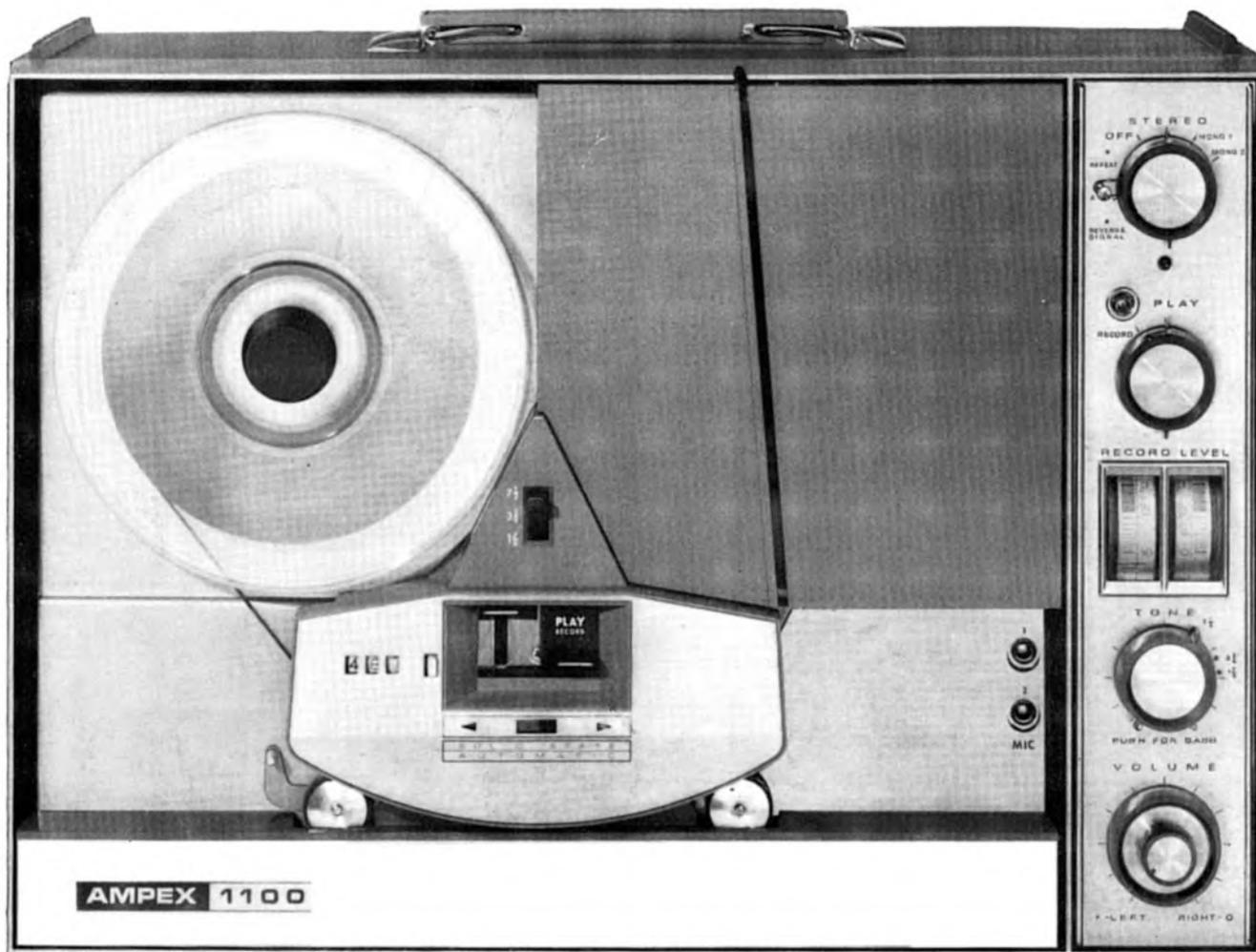
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