

SEPTEMBER 1969 2s 6d

tape recorder

RECORDING POP MUSIC

AN AUTOMATIC
TAPE TRANSPORT CONTROL

LOCAL RADIO

TRUVOX 54 AND DUBREQ
STYLOPHONE REVIEWS

SONY TC200 SERVICING

A SIMPLE TRANSISTOR
TESTER

VTR CIRCUITRY



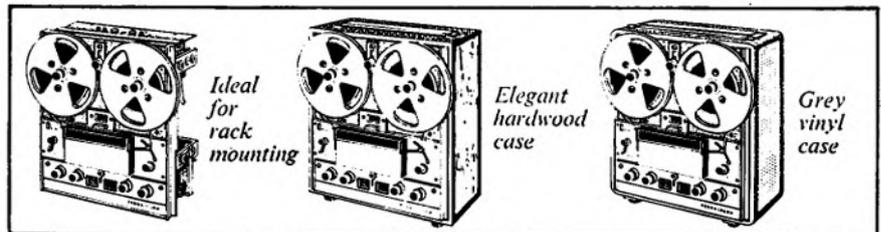
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1200' on 5" reel Double Play (Polyester) ...	43/1	27/9	81/-	157/6
1800' on 5 1/2" reel Double Play (Polyester) ...	56/1	36/-	105/-	204/-
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COVER PICTURE

Gerald Chevin, author of 'Recording Pop Music', is seen here at the Advision 24-channel mixing console. Designed by Dag Fellner, it is used mainly with an 8-track Scully. Features include pre and post fade foldback, Baxandall equalisers, echo and (EMT plate) reverberation.

SUBSCRIPTION RATES

Annual home and overseas subscription rates to *Tape Recorder* and its associated journal *Hi-Fi News* are 30s. and 47s. respectively. U.S.A. \$4.80 & \$5.60. Six-month subscriptions are 15s. (*Tape Recorder*) and 24s. (*Hi-Fi News*), from Link House Publications Ltd., Dingwall Avenue, Croydon, CR9 2TA.

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ONE OF THE MAIN reasons put forward over the years for the public's apparent apathy toward commercial tape records has been the inconvenience of fast-winding from one band or passage to another. Few domestic tape transports are capable of a satisfactory spooling speed, their sole drive power coming in most cases from a single relatively weak induction motor. Few have any form of search facility, perhaps fortunate since none have ferrite playback heads.

If this really is the main disadvantage of tape records, then the problem can now be considered at least half solved. On page 352, R. L. White of British Telecommunications Research Ltd. details an experimental device which makes searching a simple matter of button pressing. This development has come at an appropriate time, when the staple supply of domestic decks to British manufacturers is about to dry up. Alba, Baird, CWS, Dansette, Elizabethan, Fidelity, Portadyne and Wyndson, manufacturers who for years have added their own simple electronics to other people's decks, are now faced with designing and tooling for a deck of their own, or importing one from Japan. Several have already gone one stage further and are selling complete imported recorders under their own name.

At least one company with audio interests is considering producing a domestic deck to fill the impending vacuum. We may reasonably hope that they will study the automatic tape transport control system, balancing its merits and cost in relation to the domestic and studio markets.

The supposed problem of fast-winding is really only one of several factors acting against tape as a commercial playback medium. Equally important are the capital cost of copying equipment, time, labour, and the cost of raw materials. With present techniques, all these factors swing in favour of the disc medium. But new techniques are evolving. The Philips Compact Cassette is promising in terms of handling convenience and lends itself, as well as reel-to-reel, to the system described by Mr White. The cassette does not solve the problem of hardware costs, however. These have recently been reduced by riveting the plastic components rather than using nuts and bolts, though the unit price is still higher than that of an LP disc.

In January 1968 we described a new form of tape transport designed by Newell Associates Inc. of Sunnydale, California. By squeezing the supply and take-up reels hard against a central capstan drum, the tape can safely be wound so tightly that protective spools become entirely superfluous. Newell claim such great improvements in performance that one tends to overlook their system's mundane solution to the tape record cost problem. It has been confidently predicted that, using the Newell

system in conjunction with a simplified Dolby noise reduction circuit, the qualities of an LP disc can be equalled or bettered on 9.5 cm/s tape. The absence of a spool lowers the tape record raw material cost (and 'raw material' to the record manufacturer means tape, not simply oxide and plastic) below that of an equivalent disc.

Mechanically, the Newell tape transport is simpler than any conventional design. No independent reel drive is needed, no tension servo, no scrape filters, no pinch-wheel: everything from head contact to tape length counting is achieved via the capstan drum. The Newell is capable of acceleration figures beyond reach of any modern studio recorder (+304 to -304 cm/s in 100 ms) and consequently could take full advantage of an automatic tape control system. Marry the two devices and the LP gramophone record could go the way of the seventy-eight.

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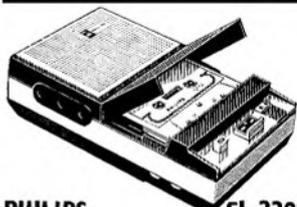
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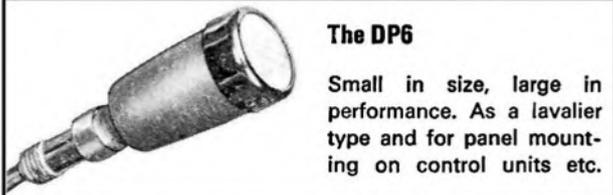
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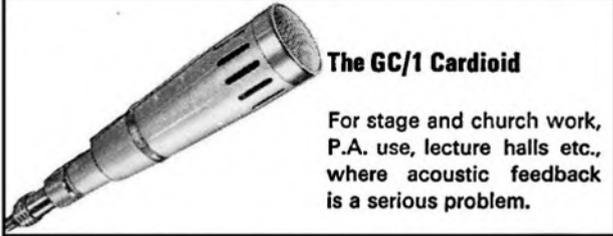
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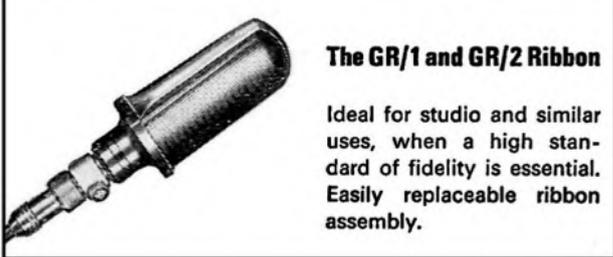
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DOLBY REACH HALF-THOUSAND

FOURTEEN NOISE REDUCTION units ordered on June 18 by Trident Studios brought the total number of *A301* orders to 500. The Trident models will be included in a 16-track and 8-track pop recording chain. Along with recent orders from Olympic (10 units for a 16-track installation) and Marquee (four units), the order marks a significant inroad into the UK studio market. Until the Elektra Corporation adopted *A301* equipment to overcome noise problems inherent in multi-track pop recording, the Dolby system was used primarily for major classical and operatic productions. The *A301* was recently employed for the first time in the production of a radio programme, a concert series featuring the Fine Arts Quartet, recorded by WFMT, Chicago.

6.5 mm VTR DEMONSTRATED IN JOHANNESBURG

AN AKAI *X-500* 6.5 mm 28.5 cm/s helical scan video tape recorder, the first model to leave Japan, was exhibited in Johannesburg at the Rand Easter Show. The demonstration was arranged by Akai's South African distributor, Glens (Pty) Ltd. Quarter-track audio heads are also fitted, allowing normal domestic audio operation at 19 and 9.5 cm/s. Spool capacity is 18 cm.



ALBRECHT FILM TRANSPORT

THE ABOVE PHOTOGRAPH of an Albrecht *MB41* sprocketed film transport was incorrectly captioned last month as a 'Sandor' (printer's version of 'Sondor'). Our apologies to F. W. O. Bauch Ltd. for a rather tactless error. The *MB41* uses a Syntronic electronic drive control system providing synchronous operation of up to 50 transports at between 0 and 100 f/s in either direction. Two versions are available, the *MB41-16* taking 16 mm magnetic film and the *MB41-35* taking 17.5 and 35 mm.

CASSETTE DATA RECORDER

A LOW-PRICED MINIATURE digital recorder using a newly patented optical synchronisation system has been developed in the USA. A recording

capacity of 140,000 characters (equal to a short novel) is achieved on a Philips Compact Cassette at rates of 0 to 120 characters per second. Maximum playback rate is 300 characters per second. The recorder will accept random data from teletypewriters, analogue to digital converters, and similar sources. The tape is driven in 1.105 mm steps by a dual capstan mechanism, each step providing space for one 9-bit character. Each character is assembled in an electronic store and recorded at the command of a pulse generated by a



photocell beneath a slotted disc fixed to the capstan shaft. Two centre tracks (see photo) carry the input data while the outer tracks contain synchronising information. Manufacturer is *Mobark Instruments Corporation, 1273 Terra Bella Avenue, Mountain View, California 94040, USA.*

ELSTONE RESHUFFLE

A CHANGE OF name for Elstone Electronics Ltd. has been announced by John Farnell. The company is now Farnell-Tandberg Ltd., reflecting the growth of Tandberg business in recent years. Another company has been formed to handle the activities of the A. C. Farnell Ltd. Industrial Division, to be known as Farnell Electronic Components Ltd.

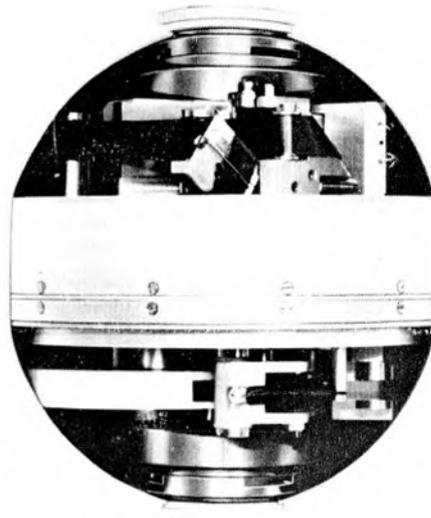
CASSETTE COPYING SYSTEM

A TRANSPORTABLE CASSETTE copying system was recently placed on the US market, manufactured by *Computerized Electronic Education Inc., 214 Long Lane, Upper Darby, Pennsylvania 19082.* The current model, *DC1542*, dubs a 9.5 cm/s master at 38 cm/s on to 4.75 cm/s Philips Compact Cassettes moving at 19 cm/s. Two $\frac{1}{2}$ -track mono channels may be copied simultaneously on to four cassettes. Where the demand for copies is great, additional 8-cassette recording units may be connected to the master player to dub up to 20 cassettes per run. The equipment can be further extended to accommodate a cassette master.



WORLD OF TAPE

An endless loop of 12.5 mm Scotch 8998 instrumentation tape is incorporated in the *Fell Avionics CO.1000-1* accident data recorder. The lower section contains a 6.25 mm voice loop. A titanium shell and (not shown in photo) 25 mm heat insulation layer protect the tapes.



SHIBADEN DISTRIBUTION

SHIBADEN TELEVISION EQUIPMENT, until recently imported from Japan by Thermionic Products, is now being handled by *General Video Systems Ltd., 61/63 Watford Way, Hendon, London N.W.4* (Tel. 01-202 8056). Among the units available to the scientific/industrial markets is the *SV-707E*, a 625-line helical-scan battery portable VTR taking 12.5 mm tape. Price is £590 including camera, zoom lens, batteries and charger. The compatible *SV-800 EC* mains recorder features a 230 mm monitor, UHF tuner and video distribution amplifier.

NEXT MONTH

'THE SYNTHESIS of Musical Instrument Tone' is the title of a series commencing in the October issue. Contributed by R. M. Youngson, it details the construction of a versatile electronic synthesizer with the unique feature of independent vibrato on each key. Terence Long reviews the *Uher 1000 Pilot* professional battery portable while Stanley Kelly covers the *Fi-Cord 800* and *850* capacitor microphones.

AN AUTOMATIC TAPE TRANSPORT CONTROL SYSTEM

the first
of a two-part
constructional
feature
by R.L.White*

IN recent years the price of domestic tape recorders has dropped considerably and therefore they have become very widely used. However the disc player still remains popular, even though the prices of both instruments are comparable for a given reproduction quality. It would appear that the tape recorder, although a more versatile piece of equipment, has certain disadvantages compared with a disc player. One of these is that it is difficult to select a particular passage of music from a long reel of tape.

This article describes the construction of the control equipment for a tape deck which allows any number of chosen passages to be selected from a suitably marked tape.

Description of Operation

After the instrument is switched on, the re-set button is pressed to ensure that the internal counter is set to zero. The tape reel is then loaded in the usual way and the required passages are selected by means of latching push button switches. The tape deck will then fast wind until the first selected passage is reached and will proceed to play this. When this piece of music has been played, it will fast wind on to the next selected passage and play that. When all the selected passages have been played the tape is rewound to the starting point and a new choice may be made.

Tape Deck

It is essential to have a tape deck which can be controlled electrically rather than mechani-

cally. Ideally the deck should have three motors and solenoid operated pinch wheel and brakes. Some tape decks do have these facilities but it should be possible to convert most three-motor decks by the addition of suitable solenoids; it may even be possible in some cases to convert a single motor deck if the drive clutches can also be operated by magnets. The motors and solenoids will be connected to relays which can be operated from the electronic circuits. Because the signals needed to control the tape deck will depend on the particular deck used, this article will describe only the means of generating the basic WIND, REWIND, PLAY and STOP signals for operating the relays. Some delay will almost certainly have to be provided between the various functions to ensure that the tape does not break or spill and this may be either allowed for in the electronic circuits or in the relays. Some of the logic may also be performed by the relays if these have sufficient contacts. A general description of these circuits will be given but the actual arrangement will have to be left to the constructor.

Tape Marking

To determine the position of the various sections of tape it is necessary to put some form of marker at the beginning and end of each section. The markers should, if possible, fulfil the following criteria:

- (a) Easily recognisable by the circuit
- (b) Give only one output pulse per marker
- (c) Be visible
- (d) Easy and cheap to put on the tape
- (e) Identifiable at any tape speed

The type of marker which seems to be most suitable is one which can be recognised by a photo-transistor. Short transparent sections in the tape were used in the prototype and these

can be provided by either removing the oxide from the tape or by inserting small pieces of transparent jointing tape. These sections need only be about 7 mm long.

Circuit Operation

The block diagram for the control circuit is shown in **fig. 1**. The photo-transistor is on one side of the tape and a small lamp is on the other side so that the photo-transistor will conduct when a transparent section of tape passes it. The output from the photo-transistor is fed into a 'Schmitt Trigger' circuit to give the pulse fast rise and fall times. This circuit drives a binary counter which, in conjunction with the counter direction control, can count either up or down depending on the direction in which the tape is moving.

When a selector key is pressed it is electrically latched by means of a small electromagnet, the 'Key Pressed Detector' senses a 'key pressed' condition and signals the tape deck to fast wind. At the same time an output is given on the appropriate wire to the coincidence detector. As the tape winds through, the binary counter counts the number of markers which pass the photo-transistor. The output from the counter is fed into a binary to 1 of 16 converter whose outputs go to the coincidence detector. When the counter reaches the same number as the key which has been pressed, an output appears on the coincidence detector which causes the tape deck control to set the tape deck to the play position. The required section of tape will then be played until the next marker appears and the counter is stepped on 1, the output from the coincidence detector will then disappear and the key will be released.

If no more keys are pressed, the output from the Key Pressed Detector will also cease, which will cause the tape deck control to set the tape

*British Telecommunications Research Ltd.

FIG. 1

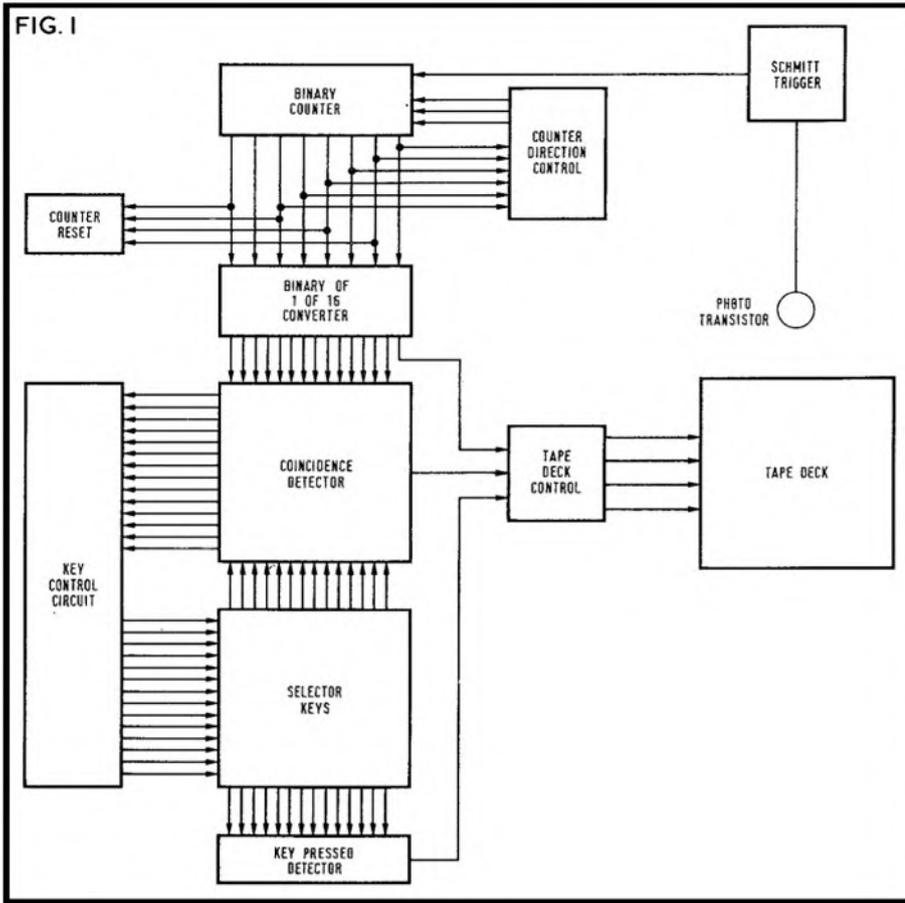
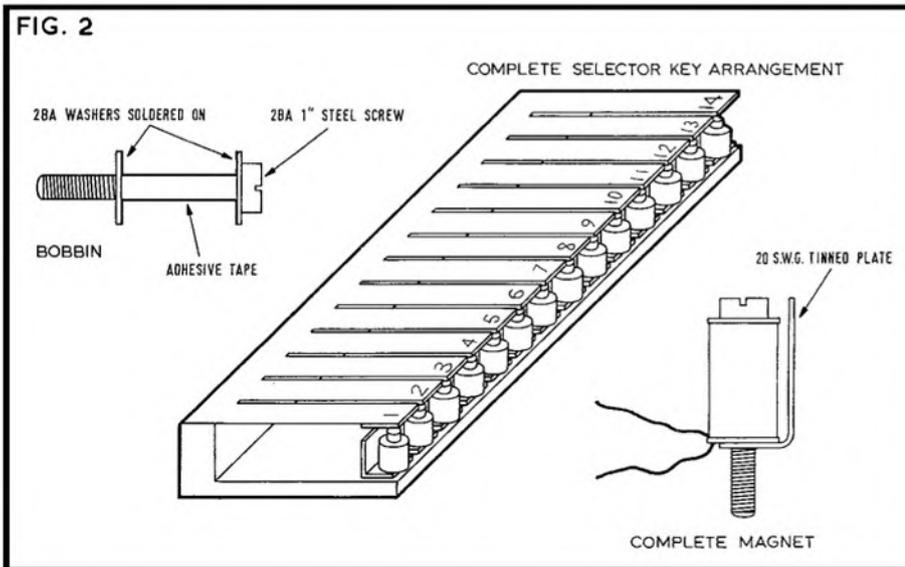


FIG. 2



deck to rewind. At the same time the counting direction of the counter is also changed so that it counts down as each marker appears. When the counter reaches zero, a signal appears on the '0' output from the binary to 1 of 16 converter which causes the tape deck control to stop the tape deck.

If several keys are pressed then the lowest numbered selection will be played first and that key released, but, since another key will still be latched, there will be an output from the Key Pressed Detector which will cause the tape deck to fast wind until the next selected piece of tape is reached. Thus the selected sections of tape will be played in numerical order and then the tape will be rewound to the beginning.

A counter re-set button is provided to set the counter to zero after switching the machine on, or in the event of the counter getting out of step with the tape for any reason.

Key Construction

The key construction is shown in fig. 2. The coil is wound on a 1 inch 2BA steel screw with washers soldered on to act as cheeks. Adhesive tape is then put round the screw and on the cheeks to ensure that the wire does not make contact with the metal. This bobbin should then be wound full of 40 SWG enamelled wire and adhesive tape applied to keep the whole in place. One end of the coil is connected to the screw and the other is soldered to a piece of flexible PVC-covered wire and brought out. The resistance of the completed coil should be about 150 ohms and if it is very different from this an alternative gauge of wire should be used.

The rest of the yoke for the magnet is made from 20 SWG tinned plate about 10 mm wide. This should either be tapped and screwed on or else soldered on (in which case it should be fixed before the coil is wound). In either case it is probably easier to attach the tinned plate flat and then bend it up and cut off the end on a level with the top of the screw head. The protruding end of the screw is pushed into a hole drilled in the base plate so that the magnets are spaced at 12 mm intervals.

The key itself is made from a 51 mm length of 26 SWG brass with a 12 x 10 mm piece of tinned plate soldered to the end. It is important to avoid getting too much solder on the underside of the tinned plate and the easiest way to do this is to tin the top of the tinned plate and the underside of the brass and then press the two together with a soldering iron on top of the brass. The brass strip is fixed to the higher piece of wood as shown and, if necessary, the brass should be bent to ensure that the tinned plate makes contact evenly with both parts of the magnet. A plastic or wood numbered button may be glued to the top of the brass.

The prototype has 14 selector keys, which is the maximum number which can be provided with the circuit to be described, but this can be extended reasonably easily by adding more stages to the counter.

Circuit Design

Although a basic knowledge of Boolean Algebra would be an advantage, it should be possible for the constructor to make this equipment without such knowledge since full details are given of all the important circuits and there should be no difficulty in arranging

(continued overleaf)

TAPE TRANSPORT CONTROL CONTINUED

those which apply to the particular deck used. However, for the purpose of explanation, a few theoretical details will be given.

Throughout the circuit the following voltage levels apply:

- Logic 1 = -12 V
- Logic 0 = 0 V

Signals in the various parts of the circuit are denoted by capital letters.

If a signal is denoted by A then \bar{A} (NOT A) is the inverse of A. In other words, if A is at logic 1 then \bar{A} is at logic 0 and vice versa. The circuit used to generate \bar{A} from A is called an inverter and is shown in fig. 3.

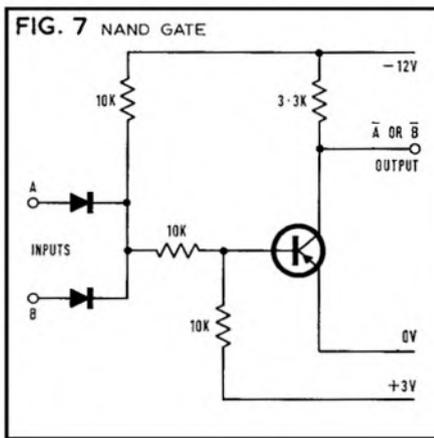
If signals A and B are fed into an OR gate then the output will be A or B. When either A or B or both are at logic 1, the output will be at logic 1. If they are both at logic 0 the output will be logic 0. The circuit of an OR gate is shown in fig. 4.

If signals A and B are fed into an AND gate then the output will be A.B (A and B). When both A and B are at logic 1 the output will also be at logic 1, but if either or both is at logic 0 the output will be logic 0. The circuit of an AND gate is shown in fig. 5.

Both these types of gate can theoretically be extended to any number of inputs with the same basic rules applying. For instance there are two 14-input OR gates in the circuit. These have a logic 1 output unless all the inputs are at logic 0.

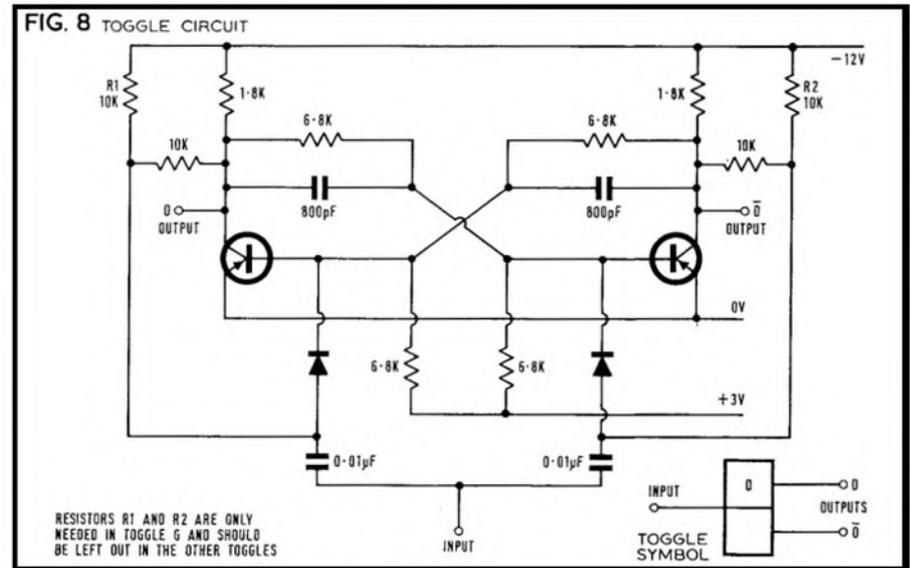
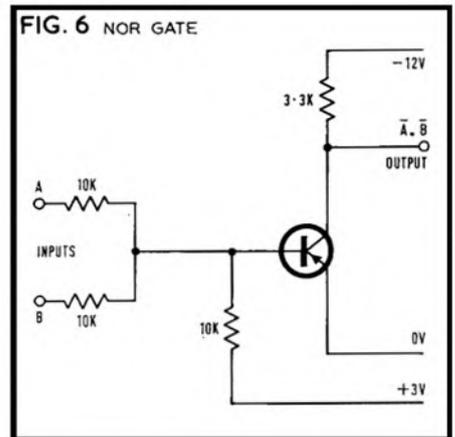
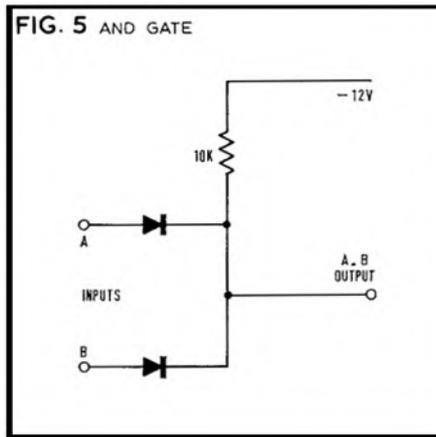
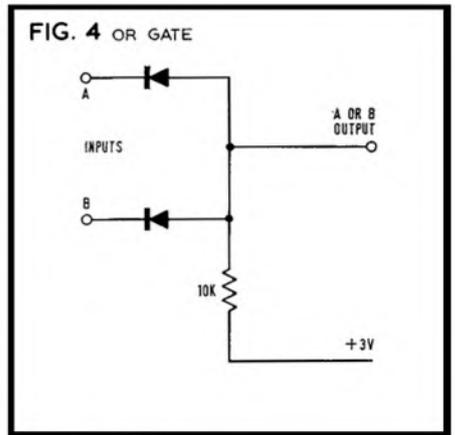
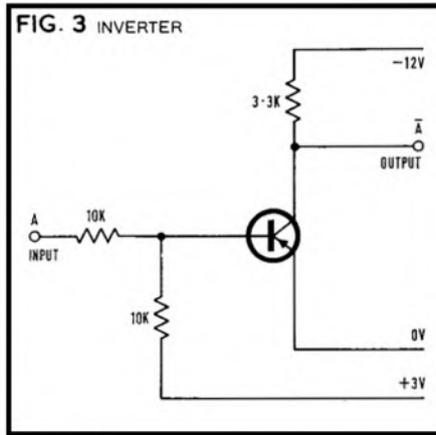
If an OR gate is followed by an inverter then the combination is called a NOR gate. It is not necessary to use diodes in a NOR gate if there are only a few inputs and the circuit of a NOR gate using resistors instead is shown in fig. 6. The output of a NOR gate is $\bar{A \text{ OR } B}$ which is equivalent to $\bar{A} \cdot \bar{B}$.

If an AND gate is followed by an inverter



then the combination is called a NAND gate. The circuit of a NAND gate is shown in fig. 7. The output of a NAND gate is $\bar{A} \cdot \bar{B}$ which is equivalent to $\bar{A \text{ OR } B}$.

The only other circuit element used is the 'bistable' or 'toggle'. This is a circuit with two



stable states which can be switched from one state to the other by an input pulse. The toggles used in this equipment have only one input and they change state whenever the signal on the input changes from logic 1 to logic 0. There are two outputs from each toggle which

are denoted by D and \bar{D} for instance. In one state D will be logic 1 and \bar{D} will be logic 0, while in the other state D will be logic 0 and \bar{D} will be logic 1. The circuit of a toggle is shown in fig. 8. Also shown is the symbol used to denote a toggle.

THE SOUND STUDIO

PART SIX

MISCELLANEOUS STUDIO FACILITIES

BY K. R. WICKS

IN this series, as far as studio circuitry is concerned, only the fundamentals have been discussed, although in fact such basic arrangements are rarely used as the inclusion of additional circuits can greatly increase the versatility of the studio.

The frequency response of the programme chains described so far has been assumed to be flat over the audio range, but it is often desirable to modify the response in order to improve quality, or to obtain a particular effect. For example, when using a ribbon microphone close to a talking subject, it is often necessary to reduce the bass response, otherwise the quality will be 'boomy'. A simple passive network

may be used to give the required bass cut, and a switch incorporated between microphone and preamp so that either the normal or the modified response may be obtained. Sometimes the degree of bass cut may be varied, but this arrangement is more common on equipment designed for use with moving-coil microphones out of doors, and is employed to reduce extraneous LF noise such as traffic rumble.

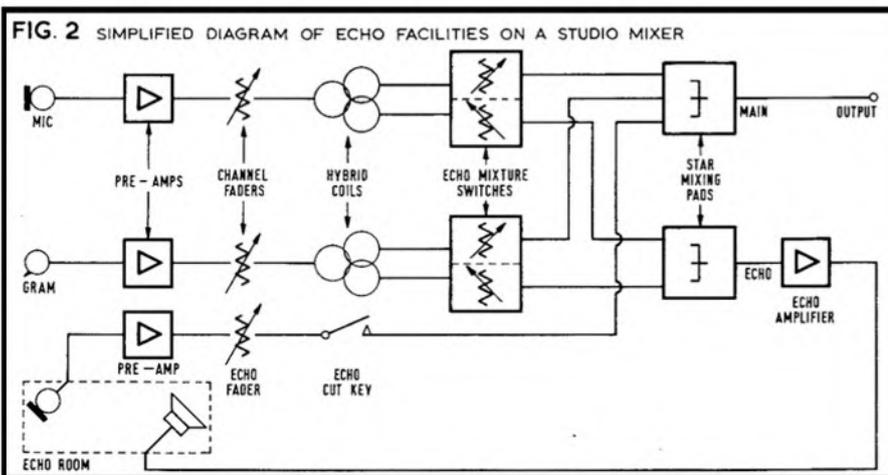
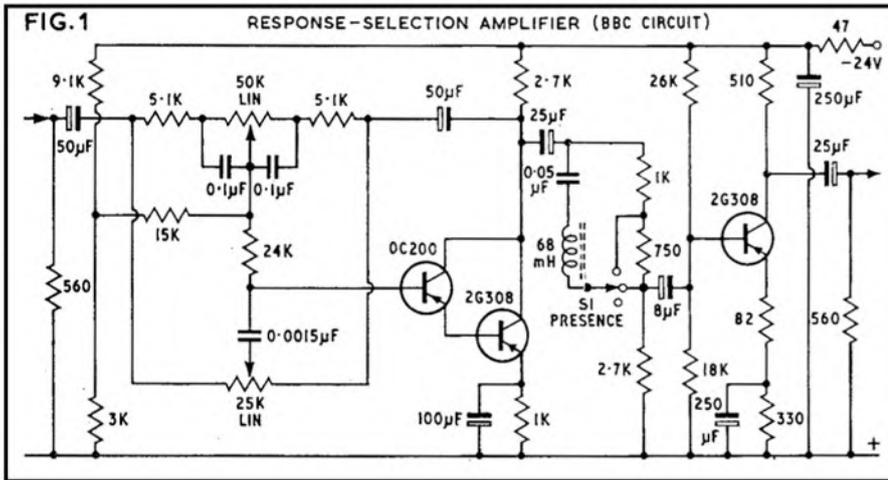
In some BBC studios, separate microphone sockets with built-in bass cut networks are provided as alternatives to the normal sockets, whilst in other studios, portable bass cut units are connected into microphone leads as required.

The 'close' microphone technique which gives rise to the need for bass correction may be used for a number of reasons. In a large hall, the reverberation time may be sufficiently long to render speech almost unintelligible unless the subject is positioned close to the microphone so that the ratio of direct to indirect sound is increased. The technique is also used by vocalists in order to provide a satisfactory balance between the voice and the backing. Another use is in studios where there is an audience, the reduced gain required in the microphone circuit minimising the chances of acoustic howls caused by feedback from the loudspeakers in the auditorium. In small studios too, it is often advantageous to place the microphone very near to the subject. The coloration associated with small studios will be reduced, firstly by the fact that the direct to indirect sound ratio is increased, and secondly, since the coloration occurs at LF, by the bass cut filter, introduced primarily to correct the direct speech quality. It can be seen, therefore, that such a filter can be used to extend the scope of most studios.

More complicated devices used to alter the frequency response of a channel are variously described as curve benders, effects units, correction units, or (better) response selection amplifiers. The circuit of one such unit used by the BBC is shown in **fig. 1**. Continuous control of bass and treble are provided by the 50 K and 25 K potentiometers respectively, and the 'presence' control S1 permits a peak of 3 dB or 6 dB to be introduced at a frequency of 2.8 kHz. Commercial sound studios tend to employ a large number of units similar to this in order to control the response of each mixer channel, this being particularly useful for 'pop' music recording.

Only a few years ago it was quite unusual for any form of tone control to be provided in BBC studios except for a Variable Correction Unit (VCU) in a few recording channels, and a modified *Quad* control unit in one or two studios. The VCU enabled a poor quality or non-standard tape or disc to be copied with bass and treble corrections as necessary in order to obtain a tape which would be acceptable when reproduced on a standard machine. The *Quad* unit was used mainly to reduce excessive surface noise on discs when it could not be successfully dealt with by the top cut filter normally provided in studio record reproducers. Nowadays, response selection amplifiers are more common than they used

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to be in broadcast studios, and are sometimes used to obtain, for example, 'telephone quality'.

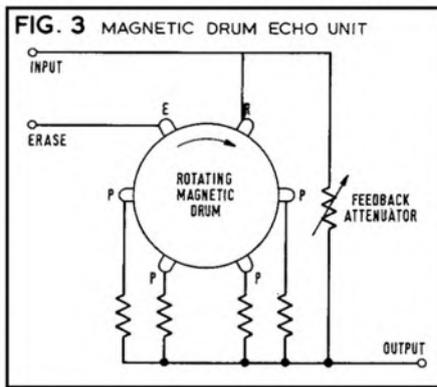
Reverberation is the effect caused by a closely following series of sound reflections, whilst the term *echo* refers (or rather should refer) to a distinctly separate reflection. In studios, however, reverberation is often called echo and it is convenient to conform to this practice. For instance you will find that 'echo mixture switches' are used to obtain the desired amount of artificial reverberation.

There are numerous ways in which artificial reverberation can be obtained. A simple method is to feed the signal to a loudspeaker in an echo room (reverberation chamber), which is an acoustically insulated room with highly reflective interior walls, the reverberative sound being picked up by a microphone placed well away from the loudspeaker in order to reduce the direct sound content. The provision of artificial reverberation means that additional circuitry has to be introduced into the studio mixer in order to be able to control the effect and apply it when necessary. Fig. 2 is a simplified diagram of a typical arrangement used in broadcast studios. The signals from the microphone and gram are first amplified and then controlled by the channel faders in the usual manner. The hybrid transformers provide two completely independent outputs per channel, one for the main chain and one for the echo chain. Each pair of outlets is fed to an 'echo mixture switch' which consists of two ganged attenuators connected in opposite sense, so that in the extreme positions, either maximum signal is fed to the main chain and no signal to the echo chain, or vice versa. Intermediate positions of the switches allow various ratios of direct to echo signals to be obtained. A star mixing pad combines the signals for the main chain of the mixer, whilst another pad is used to mix the echo outputs, this combined signal being fed to the echo room loudspeaker unit via an amplifier. The reverberation is picked up and fed into a special channel of the mixer which has, in addition to a fader, an 'echo cut key', allowing the effect to be inserted or removed instantly if required. The echo signal joins the main chain at the star mixing pad, and it is now that the reason for using hybrid transformers in each channel becomes apparent. If ordinary transformers with two secondaries were used, then any echo mixture switch in an intermediate position would provide a link, via the transformer, between the main and echo mixing pads. Since the echo signal is eventually amplified and fed to the main chain, a 'howl-round' caused by feedback would be likely to occur if the main and echo circuits were linked in this way. The hybrid transformer is, however, designed so that the linkage between the two secondaries is very small, and the problems of feedback are thus avoided. In the circuit described, the output would be taken to the main fader, or to the group fader if provided, any independent source being mixed in just after the group fader.

Echo rooms have been used effectively for many years in drama and music for special effects and also to enhance the general quality of studios used for orchestral concerts. In some cases, the echo room output is filtered in order

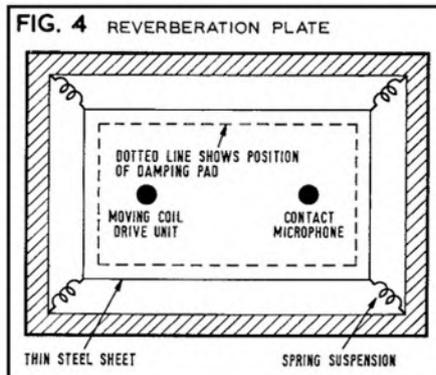
to provide additional reverberation only over the frequency range where the natural reverberation of the studio is lacking, though this practice is not so common as it was because improvements in studio design have made it possible to obtain a reasonably flat reverberation time over the audio range. Echo rooms are sometimes shared among a number of broadcast studios, the microphone and loudspeaker being plugged to the studio required, although this arrangement would not be so convenient for commercial studios producing mostly 'pop' records, as everyone would require the facility all the time.

Another way to obtain artificial echo is to use a magnetic recorder with several playback heads. The signal is recorded on a revolving oxide-coated drum, and reproduced by each replay head in turn, these outputs being combined and fed back to the record head via an attenuator, and then re-recorded. This set up is shown in fig. 3, and it is possible to obtain an approximately exponential decay curve with



this apparatus. The amount of feedback from each head, the spacing of the heads, and the speed of the drum will have a bearing on the effect obtained. With a slow speed or widely spaced heads, a long reverberation time is obtained, but individual echoes can sometimes be detected and this is usually undesirable. Feedback can be increased until oscillation occurs, the sound produced in this condition being fairly complex and related to the time taken for the signal to be transferred from the record head to the replay heads.

Several electromechanical devices have been developed to produce artificial reverberation, the best of these being the reverberation plate illustrated in fig. 4. The plate itself is a large rectangular sheet of thin steel, vertically mounted by means of springs at the corners,



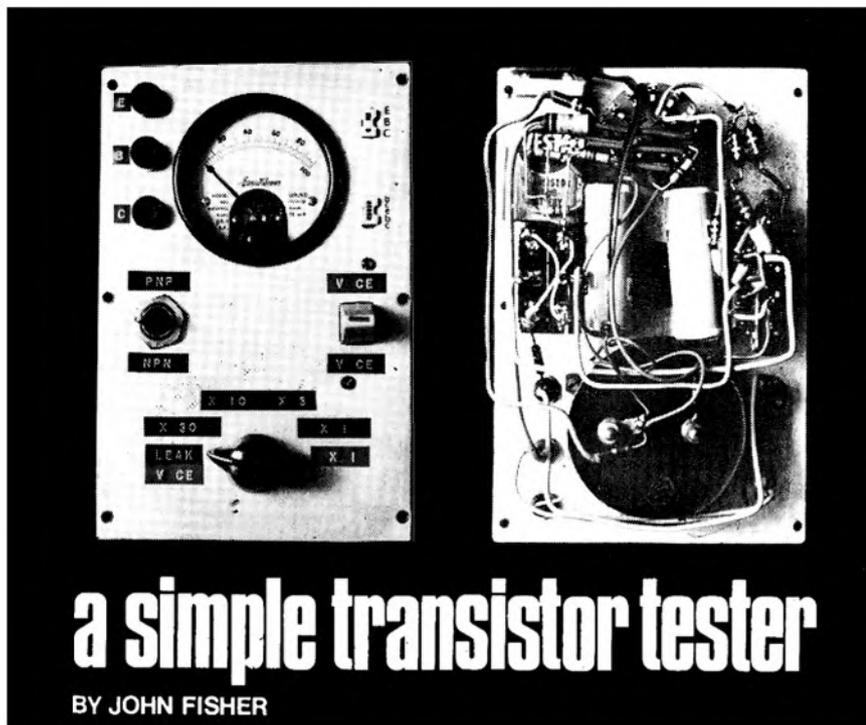
and activated by a moving-coil drive unit. The vibrations in the plate are picked up by a contact microphone, equalised to counteract the effects of plate resonance, and fed to the echo channel. The reverberation time is adjusted by varying the distance of damping pads from the plate by a motor, controlled remotely from the studio desk, an indication of the reverberation time provided at any setting of the dampers being given by a meter on the control panel.

One slight disadvantage of this system is that the reduced damping required for very long reverberation times causes the plate's natural LF resonance to become more noticeable, so that the LF response rises slightly as reverberation time is increased. A typical unit would measure 2.5 x 1.5 x 0.5 m and should be installed near the studio in a position where it is unlikely to be knocked inadvertently, as it is sensitive to mechanical disturbance although not to sounds of normal intensity. The reverberation plate is the most common device of its type now being installed in sound studios.

The requirements for tape and disc reproduction are similar: it must be possible to commence playback at any given point and at the precise moment required. Pre-fade facilities are provided on studio machines so that the required part of the recording can be found using headphones. On tape, the position can be marked with a Chinagraph pencil, and the usual procedure is to wind back about 30 cm, leaving the capstan motor running. When the material is required, the capstan is started and then the pinch wheel is engaged, causing the tape to be driven up to speed very quickly. As the mark on the tape passes the playback head, the replay fader, which is most often used as a simple in/out device, is brought up quickly, and very accurate starts can be obtained in this way. In many cases, it is convenient for a tape machine to be started remotely from the studio desk, and most recorded programmes transmitted by the BBC are started in this way, a number of start keys being provided on the continuity control panel. Fast starts are obtained on studio disc players by allowing the turntable itself to revolve continuously, the disc resting on a separate aluminium plate which can quickly be lowered on to the turntable. The position required on the record is found by playing it and listening on prefade. When the place has been located, the plate is raised to a position just above the turntable, and then, still monitoring the disc, it is carefully rotated by hand until the stylus is positioned about one-third of a revolution before this point. To play the disc, the start control is operated, and the fader opened just under a second later, by which time the disc should have attained full speed, and the desired starting point should have been reached. Only a little practice is necessary to obtain very accurate starts by this method.

On some machines, muting relays are incorporated so that no output is obtained for a short period of time after the start control has been operated. This is to prevent 'wow' starts. If a disc is set up without allowing sufficient run up, the start is 'clipped', the effect usually being less tolerable than slight 'wow'.

The most common sources of sound having now been dealt with, next month's article will cover studio tape recorders.



a simple transistor tester

BY JOHN FISHER

ALTHOUGH this article has little directly to do with tape recording, nevertheless quite a number of *Tape Recorder* readers are evidently interested in building and servicing transistor equipment, so perhaps it is not out of place to describe here a simple design for a transistor tester. It can be built for about £3, depending on where one buys the more expensive items (the meter and switches), and is therefore not too expensive an item for the home workshop. Certainly anyone venturing into the market of 'surplus' or 'unmarked' transistors should find it of some little use, as these devices vary from genuine bargains from some sources to downright junk from others.

The transistor tester to be described tests both *p-n-p* and *n-p-n* types. It will indicate a short circuit or high leakage, or similar faults, measure current gain below 1 mA for small signal transistors and gain at up to 2 mA for drivers or other higher current rating devices, and breakdown voltage in silicon transistors. It is not generally suitable for measuring the breakdown voltage of germanium transistors whose considerably higher leakage results in

meaningless indications: these are best measured by other techniques, beyond the scope of this article. The tester is *not* suitable for field effect transistors.

The unit is powered by one 9 V Ever-Ready PP3 battery and two 22.5 V batteries. It uses a 1 mA movement calibrated 0-100 which allows direct readoff of current gain or breakdown voltage in conjunction with the factors on the range scale. A centre-off biased double pole, double throw, toggle switch selects correct polarity for *p-n-p* or *n-p-n* types, and is held in the appropriate position while the test is made. The off-biased switch avoids unnecessary drain on the small battery.

In position 1, the rotary selector switch is set for the first reading which will indicate if there is an internal short in the transistor or if it is excessively leaky (the leakage should be barely readable with small-signal transistors of any type, unless faulty). This position is also used for the breakdown test. Selecting positions 2-5 covers DC current gains of 3,000 (for super high-gain specimens and compound connected pairs), 1,000, 300, 100, at collector currents of

up to 1 mA depending on the gain and range

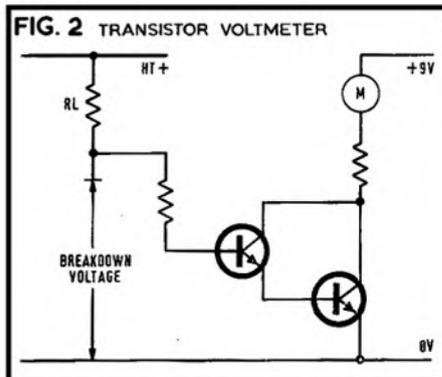
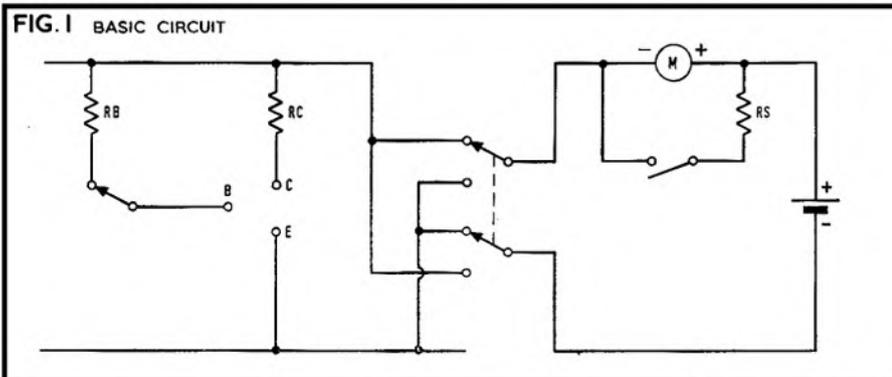
The intermediate gain ranges can give some idea of gain spread with collector current. Position 6 reads gain 0-100 at a collector current of 0-2 mA, the second wafer of the switch being used to shunt the meter appropriately. This extra position sometimes helps to indicate better the gain of medium-current driver transistors; a third wafer would have allowed the collector load resistor (which protects the meter against damage) to be reduced, allowing the check to be made at say 10 mA instead of about 2 mA. However, the prototype manages to produce useful results with the ranges as indicated.

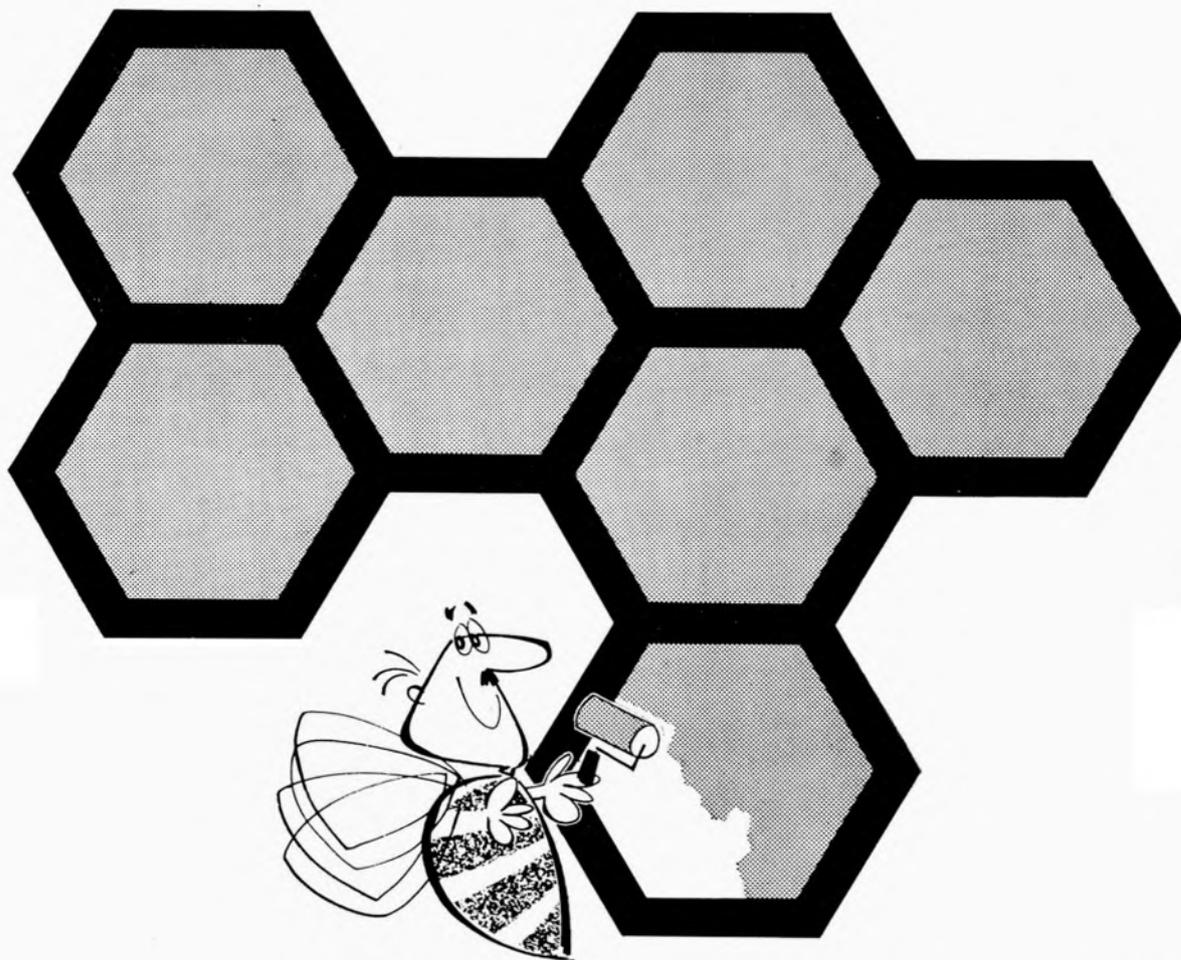
The bias resistors are 5% types, and may where necessary be made up in series. There will be a small error between germanium and silicon transistors, due to the different BE voltages causing a small change in base current. However, even allowing for this, with batteries in reasonable condition something like $\pm 10\%$ accuracy should be possible and, for matching transistors, closer tolerances should be achieved as the conditions and scale will be the same for each.

An indication of transistor breakdown voltage* is achieved by passing a small and limited current through the transistor: an HT of 45 V plus the 9 V supply is used so, provided the breakdown voltage of the transistor is below about 45 V, the voltage drop across it can be measured when the excess voltage is applied, using a high-impedance transistor-voltmeter arrangement. The instrument's meter is switched to achieve this, using a small off-biased key switch which also switches the HT supply to the transistor. As with the *p-n-p/n-p-n* switch, the off biasing helps save batteries! A second position is provided on the keyswitch to pass a higher current. In the normal position the current through the transistor is limited to about 2.5 μA , in the higher current position to 10 μA . It is not normally desirable to use the higher current source; the 2.5 μA on the other hand should not cause damage.

The transistor-voltmeter is formed by a large (88 M) series resistor plus a compound pair using 2N929 transistors which maintain their current gain to a very low current level. The meter is in the collector circuit of the transistors. Two very low gain devices were selected from a batch to give a current gain product of 1000. If the gain is slightly higher, S2b can switch a resistor across the meter to correct for this. The meter should read about 40-45 V in

(continued on page 361)





Buzz along to the Do it yourself EXHIBITION

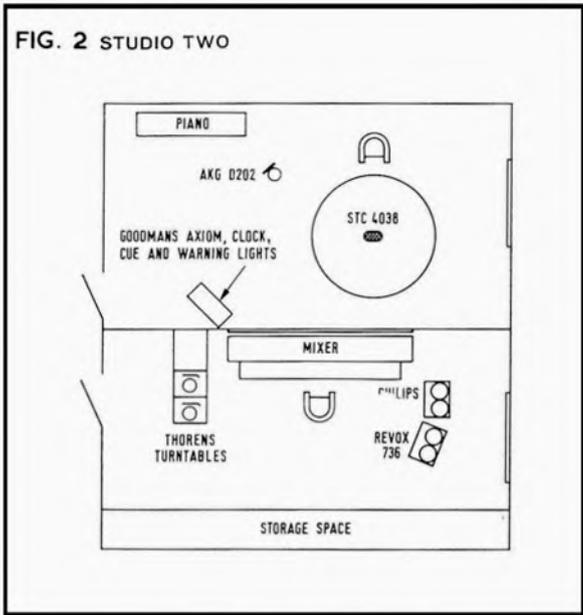
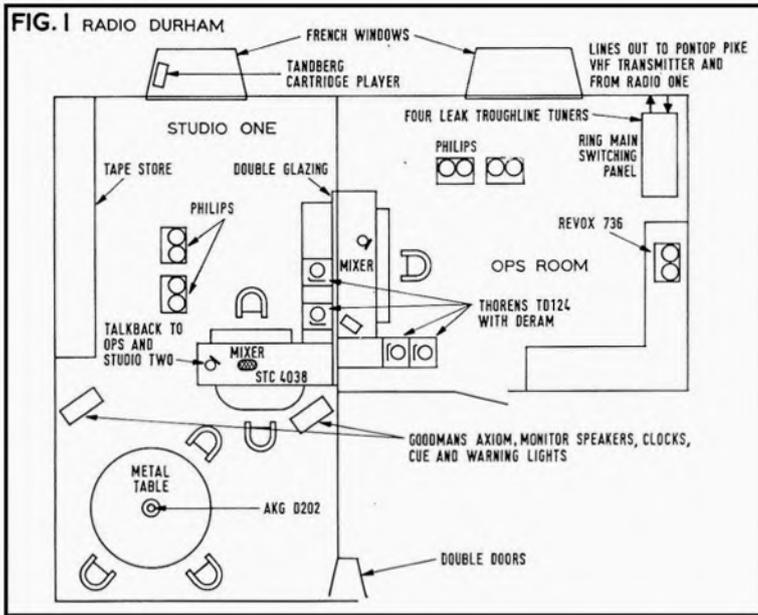
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TAPE plays a major role in the new BBC local radio experiment. By this I do not mean that there is much scope for creative or original production, but virtually all the programmes are pre-recorded, and the live programmes are generally limited to local news bulletins and record request shows. The equipment available is severely limited, as will become apparent later on, and many amateur enthusiasts can boast a higher quality than is possible in local radio. When the amateur intends to produce a tape, quality is his overriding consideration, not the laws of copyright and the requirements of needle-time.

While saying the equipment is limited, I do not mean limited in respect of cost or necessarily quality. Versatility is the limiting factor. All the equipment is based on Peto Scott mixers, and it may be helpful to refer to the diagram of Radio Durham while I describe the facilities available.

The mixers are complicated, but basically contain two microphone inputs, two gram inputs from Thorens turntables, two tape inputs, spare input, talkback to other studio and ops room, two PPM's, Ring Main and pre-fade monitoring on all inputs.

This list is in no way exhaustive but gives an idea of what is available. Ilford-Zonal tape is used, but a large proportion of what is used goes into the waste paper basket since it would be more costly to employ an engineer to splice together anything but the largest amounts than it is to buy new reels. Thus only the longest lengths of used tape ever find their way on to the *Leeraser*. The Philips *EL 3740* recorders are lent to the radio station concerned by the BBC in London. The microphones used are the well-known AKG *D202* cardioid, which is employed in Studio One for all normal applications and in Studio Two for the recording of music or discussions involving more than two persons. An *STC 4038* ribbon, which is normally set into the table, is then removed, its bi-polar diagram clearly being at a disadvantage in favour of the AKG which is omni-directional in the vertical position. The



4038 is also used in Studio One from the operating panel, if necessary by a second announcer sitting opposite, and in Studio Two for one or two persons. Beyer microphones are used with the eight Uher *4000* battery portables.

Besides the Philips recorders, which are the only machines available in the station on which editing is possible (and as there are only five, this means careful planning of editing time when a large programme is being prepared), there are three Revox *736* models. One of these is used for outside recording purposes in conjunction with a portable mixer. The Revox machines are non-standard, being converted to full or $\frac{1}{2}$ -track mono recording with full track erase and a modified input and output arrangement. The Uher machines are also modified and only operate at 19 cm/s. Various other controls have been changed to minimise the possibility of error in inexperienced hands. With modification still the byword, the Thorens *TD124* turntables are also non-

standard. These are normally equipped with a brake, which is essential for broadcasting, but the arm is not as would be supplied if the machines were purchased complete. The Decca *Deram* ceramic cartridge is used. Each station has seven of these turntables.

'Jingles' made by the Radiophonic Workshop (in the case of Radio Durham, local tunes such as Bobby Shaftoe or the Lambton Worm) are played on a Tandberg endless cartridge machine. Each station has its own Radio Car in the station's livery. This operates on the UHF waveband and is therefore extremely limited in range because the signal is lost if the car is used behind any large hill. Radio Durham may trade in the radio from the car in favour of two Spotmaster 'jingle' machines. Finally even a Robuk can be found in one of the station's offices!

I mentioned earlier the requirements of copyright and needle time. We are all too familiar with the fact that commercial discs cannot legally be copied, whether for public performance or even private use. Needle time is negotiated with the Musicians Union and Performing Rights interests, and limits the amount of commercial record material which can be played on the air every day. The Local Radio stations have only one hour of needle time per day, and the success of the experiment must be assessed in the light of this, and the fact that only 30% of the population own VHF receivers. Every record that is played is noted in a log and paid for; only if a disc is 'illustrative' is it not paid for.

Reading the long list of equipment which I have given above, the reader may doubt my earlier statement that it is limited in versatility. The reason is not to be found in the equipment itself but in the surroundings. Each studio is acoustically almost completely dead. Thus music is very difficult, and in most cases impossible to record. Piano is acceptable; voice accompanied by guitar using both microphones is reasonable; a group of singers is unmanageable. Again the fact that only two

(continued overleaf)



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Beomic 1000 Omni-directional moving coil microphone. Response 50 - 17,000 Hz \pm 2.5 dB. Sensitivity 0.1 mV/ μ bar. Hum sensitivity - 139 dB. Output: 200 ohms at 1 KHz. via 9ft lead, 5 pin DIN plug. Supplied with frequency response chart, lavalier cord, anti microphonic base, and packed in a futuristic container. Price *£9.9.0d.



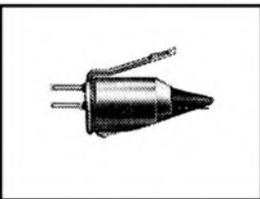
B.M.5. Studio quality Stereo ribbon microphone. Figure of 8 response: Sections may be swivelled up to 90° relative to each other for the desired stereo effect. Fitted with music/ speech switch. Response 30 - 13,000 Hz \pm 2.5 dB. Sensitivity 85 dB below 1 volt/ μ bar. Hum sensitivity - 146 dB. Output 200 ohms at 1 KHz. via 9 ft lead, 5 pin DIN plug. Supplied in rosewood presentation box with table stand. Price *£30.9.0d.

B.M.6. Mono ribbon microphone (lower half of the B.M.5). Specification as B.M.5. Supplied in presentation case with table stand, price *£21.2.0d. It may be converted to a B.M.5 by an addition of the B.M.7. (available separately price *£9.19.6d.)

Microphone Accessories Stereo/Mono extension leads: prices *15 ft £1.17.6d. 30 ft £2.9.6d. 45 ft £2.19.6d. 60 ft £3 15s. 75 ft £4 5s/Floor Stand £7.15s. Boom Arm £4.19.6d. Line matching transformer to 50 K ohm impedance; £2.9.6d.

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S.P.6. Response 20 - 20,000 Hz \pm 2.5 dB. Compliance 15 x 10⁻⁶ cm/dyne. Pressure 1.5 - 2.0 g. Stylus: 15 μ diamond. Output: 7 mV. 47K ohms. Price *£7.19.6d.
Replacement styli available: 15 μ , 75 μ , and 5 x 17 μ elliptical.

S.P.8. As S.P.6, but supplied with 5 x 17 μ elliptical stylus in Rosewood box, price *£12.19.6d.

S.P.10. Response 15 - 25,000 Hz \pm 3dB. Compliance 25 x 10⁻⁶ cm/dyne. Pressure 1.0 - 1.5g. Stylus: 15 μ naked diamond. Output: 5mV. 47K ohms. Price *£9.19.6d. Replacement styli available: 15 μ and 5 x 17 μ elliptical.

S.P.12. As S.P.10, but supplied with 5 x 17 μ elliptical stylus. Price *£14.19.6d.

* Prices indicated are recommended retail prices.
B & O quality accessories are obtainable from B & O dealers: Send for further details to the Accessory Department.
Bang & Olufsen U.K. Limited,
Eastbrook Road, Gloucester.
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AKAI M8 (S/4) ...	Our price ONLY 79 gns.
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SONY TC200 (S/4) ...	Our price ONLY 52 gns.
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FERROGRAPH 4A/N (M/2) ...	Our price ONLY 49 gns.
PHILIPS EL3536 (S/4) ...	Our price ONLY 39 gns.
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TELEFUNKEN 204E (S/4) ...	Our price ONLY 69 gns.
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PHILIPS EL3301 (BP/M/2) ...	Our price ONLY 16 gns.
SANYO 151 (BP/S/4) ...	Our price ONLY 45 gns.

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VORTEXION WVB/4 (M/2) ...	Our price ONLY 52 gns.
TANDBERG 1241 (S/4) ...	Our price ONLY 69 gns.
REVOX 736 (S/4) ...	Our price ONLY 95 gns.
FERROGRAPH 5A/N (M/2) ...	Our price ONLY 55 gns.
PHILIPS EL3534 (S/4) ...	Our price ONLY 59 gns.
BRENELL MK5M Series III (M/2) ...	Our price ONLY 69 gns.
TELEFUNKEN 85KL (M/2) ...	Our price ONLY 39 gns.
SONY TC260 (S/4) ...	Our price ONLY 72 gns.
AKAI 1710 (S/4) ...	Our price ONLY 65 gns.
SONY TC250A (S/4) ...	Our price ONLY 48 gns.
VORTEXION CBL/5 (S/2) ...	Our price ONLY 85 gns.
FERROGRAPH 422 (2/S) ...	Our price ONLY 59 gns.
PHILIPS EL3549 (M/2) ...	Our price ONLY 29 gns.
FERROGRAPH 631 (M/2) ...	Our price ONLY 72 gns.

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(HALF DAY THURSDAY)

microphones are generally in use is limiting. As an experiment, we have tried to record a jazz group consisting of saxophone, bass guitar, piano, singer, and drums. Bearing in mind the small size of the studio, and its acoustics, we taped two players, giving the others headphones for a second take to mix the first take on to a second recorder, but failed to achieve any margin of success. The studios are designed for speech only, and it is wise not to try anything too ambitious in the musical field. But the point I am trying to make is that the amateur is not at such a disadvantage with respect to the equipment he can use. The AKG D202, the Revox 736, and the Uher 4000 are found in a large number of amateur recordists' homes. With a good mixer and a room converted with cushions and blankets into a studio, plus a nearby operations room for the equipment, he can produce recordings superior to those possible in the local radio station. But most of all, the amateur has the ideas and the time to experiment. Local radios sometimes have ideas but rarely have time to exploit them.

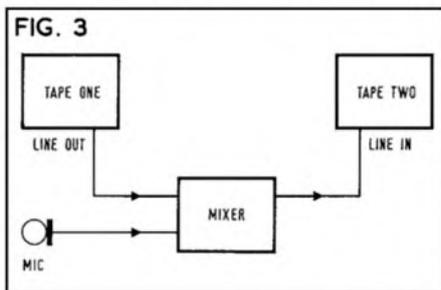
If you have a BBC local radio station in your area, I would strongly advise contacting the manager to ask what scope there is for amateur work on his station. Very often, professionals resent amateur intrusion, but not so in this case, since these stations depend to a great extent on unpaid help. Radio Leeds claims to make use of the services of 100 people for each day's broadcasting. If you have, as yet, no such station, then the making of a programme is an easy and interesting experiment. Assuming that you have two tape recorders at your disposal (failing this, the generosity of a friend

must be sought), set your equipment up as in the diagram. This diagram, of course, represents the simplest and indeed the classic method of programme compilation. Examples include all news programmes, and particularly such magazine programmes as the early morning 'Today' with Jack de Manio. The presenter sits in the studio and links together taped interviews. Suppose you intend to make a programme about the changes that have taken place in your area over 50 years. First take a recorder and visit as many of the old people in the area as you can find. When you have enough material, pick the pieces you want by listening to the material over and over again. Then edit together your choice, and separate each item with coloured leader—yellow for the leader and red for the trailer. Work out ways in which the subject matter of each interview is connected and then write your linking script. Set Tape One in the playback mode with your interviews, and Tape Two in the record mode with blank tape. Then use the pause control on Tape One to link the material into one programme.

Many amateurs like to make money out of their hobby, and there is no reason why a programme such as this should not interest

someone: a local station will almost certainly play a good quality tape over the air, but will not pay for it. But a BBC regional service is more likely to pay for material. An example will serve to illustrate the point. In the programme we make for Radio Durham, we cover University affairs, and this entails sending a reporter to all the meetings of any importance in the University. Thus one of our number covered a talk the Chief Constable gave to the Liberal Society. In this talk he made some comments on the British Penal System and, in answering a question, gave it as his opinion that the Train Robbers in Durham Jail should be quietly shot rather than kept in prison for so long. Not unnaturally, this was front page news in the following day's papers. But our reporter, by inadvertence, forgot to ask the Chief Constable about this remark in the interview arranged after the meeting; had he done so, the interview could have been played on one of the BBC's late night shows, which would have been a scoop, and the interviewer would be better off now to the tune of up to £50.

The future looks rosy for local radio. It seems to be one of the few Government experiments the Opposition supports, albeit from the commercial standpoint. The Conservative Party supports commercial radio by saying that pirate radio stations proved that the public want it. Surely the public liked the non-stop pop provided by the pirates, unhampered by the dictates of needle time, not the fact that they were commercial. But any legal commercial station will still have to abide by needle time, which will probably allow only one hour's records per day, and therefore not provide non-stop pop. What any local station will provide is an opportunity for the work of the amateur recordist to be heard in public. They deserve our support.



SIMPLE TRANSISTOR TESTER CONTINUED

the low current position and just over 50 V in the high current position.

The test voltage is fed via the p-n-p/n-p-n switch to provide the correct polarity to the transistor on test. The normal sequence after checking the other characteristics of the transistor would be, with the selector in position 1, to depress the breakdown voltage key, and note what the reading drops to when the p-n-p/n-p-n switch is operated. The breakdown voltage tester can also be used to check diodes. A word of warning—although the

transistors in the transistor-voltmeter are silicon, there is no stabilisation against temperature changes, and small fluctuations in reading over the extremes of domestic temperatures encountered are likely: with a pair of surplus general-purpose silicon transistors substituted for the 2N929s, a maximum drift over about 5 V was noted.

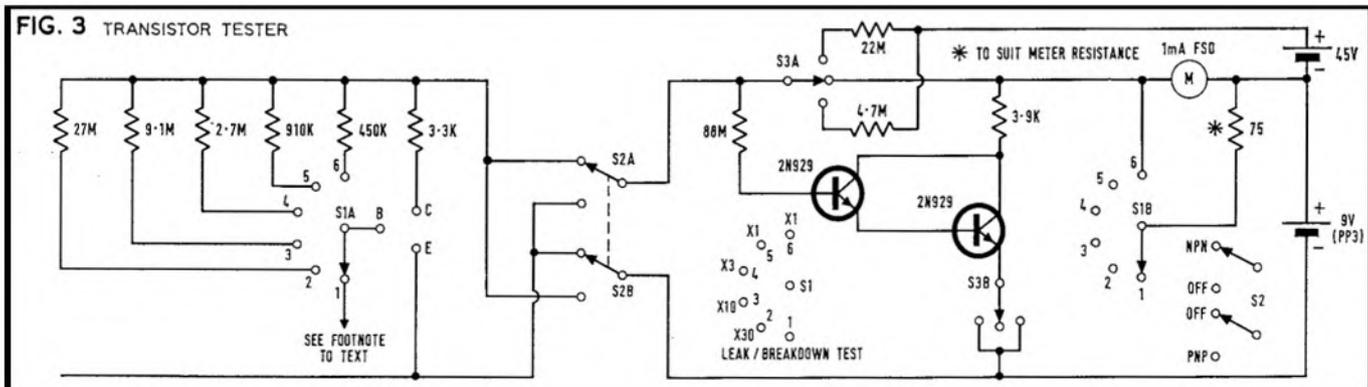
The prototype was made up on an aluminium front panel, etched matt finish. Transistor holders and wander sockets were wired in parallel to cater for most transistor types. An aluminium case was also used, padded with thick plastic foam to prevent the batteries shaking about and to avoid possible shorts.

Labelling was carried out using Dymo tape and Letraset.

Components

- Suitable 1 mA meters: Ernest Turner Instruments Ltd. Model 909 or similar
- Biased d.p.d.t. toggle switch: Halfords (car accessories) headlamp flasher
- Key switch: two-way, 2 c.o., 2 c.o., TMC Series 1000
- Transistors: Texas Instruments 2N929

*Quoted breakdown figures in fig. 3 may refer to conditions of base open circuit, base shorted to emitter or reverse-biased. Circuit drawn reads values for base o/c. Read values for base and emitter shorted by using temporary link between base and emitter wander sockets.





**M.G. Skeet describes the conversion of a Fi-Cord 1A
PART 2**

THE conversion carried out has the dubious feature that the prototype is also the finished product. Meaning that it is usual to make production models which take into account experience of the prototype/s. Having no intention of going into production, all I can do is explain what was done and suggest what might be done the second time.

First, to relate an interim phase while the machine was still mono. Adding 20 mm to its height, separate secondary-type motor batteries were provided. These were given their own micro-switch. The motor lamp was also shifted to this plinth; the whole object being to remove interference from the motor and its circuit. The switch was fitted near the motor end and was operated by a long locking push button. The lamp was similarly fitted deep down and a Perspex rod was used to allow its glow to be seen at the top end.

This has a bearing on the design of the box to house the conversion. The photographs show two 'panniers' on either side of the existing Fi-Cord with the plinth under the deck section. The outside dimensions of the finished case are 295 x 230 x 80 mm. Rather than 'panniers', perhaps a better approach would be to construct a new three-compartment box. From left to right, looking at the control end, for the electronics (except oscillator), the deck plus oscillator, and the batteries.

A strongly recommended construction method is to use pinned butt-joined plywood and a 'filler' glue such as *Cascomite*. This glue soaks into the wood, hardening the surface at corners. The usual pins used are veneer pins, or, alternately, cut down paper pins. As can be seen, the original plastic strap is still in use but something stronger is necessary due to the increase in weight. The electronics compartment is lined with tin plate obtained from large empty marmalade tins from a local works canteen. Plastic faced cloth from the local market was used to cover the outside of the box and the two-toned grey scheme was

continued. The lids and part of the underside have foam under the covering. The side compartment lids are single screw fixing by using a metal hook, bolted to the lid which fits into a slot at the bottom of the compartment. An impact adhesive is best for the tin plate and covering cloth.

Perhaps mention ought to be made briefly of other changes not directly related to the stereo conversion. These can probably be seen in some of the illustrations.

The 4.75 cm/s speed belt nearest the motor was removed by cutting. As a consequence the speed change knob was locked in the 19 cm/s position by a piece of bent metal stuck to the underside of the deck. This reduces the load on the motor. The governor requires resetting; more on this later. The existing non-revolving tape guide is no longer used. Instead, another is fitted near the revolving guide. The tape back tension lever on the feed spool is covered in a piece of PVC sleeving. The theory is that the tape back tension at the original non-revolving guide was suspect and now more control is possible by varying the tension on the feed spool lever spring. The tape deck is hinged at the control end and of course this was most useful during development. To avoid long wiring to the motor, a plug and socket connect the motor circuitry when the deck is in its down position.

The layout of the printed circuit panels and disposition of the controls can be seen in **figs 10 and 11**. The idea was to keep the record amplifiers as far as possible from the motor in case of interference pick-up. The record gain control knobs need to be within easy reach of the user's fingers. The oscillator was kept in its original position so as to minimise stray bias problems. This original printed circuit board could be cut down further than shown but an early thought was that maybe two oscillators would be needed. To allow access during development the existing cut down printed circuit board was made 'plug in' by bolting to it the plug end from a Radiospares printed circuit panel.

Fig. 12 shows the general positions of the circuits on the printed circuit panels and the positions of the tin plate screens. The wiring of the panels makes use of an unpatentable 'birds nest' technique. Some connections are soldered mid-air joints! In many cases extra insulated wires are used to make use of the many three-hole side connections. Reliability is ensured as long as a connection which should be made does not become unmade or two points that should be insulated do not become connected. It is remarkable how much can be packed on to one of these panels. The surface of the tin plate lining in the amplifier compartment is covered in white *Fablon*. All panels are screened from each other by the detachable pieces of similarly covered tin plate. Plastic foam blocks stop the panels and screens moving once the compartment lid is on.

When it came to thinking about the head changing, I considered it important to bear in mind that the head gaps should take up exactly the same positions that the existing head gaps do. Think hard before starting and measure from fixed points on the deck to each head gap. A good idea is to use bits of stiff copper wire which can be readily offered up to the new heads to check their positions.

The *LF4V* full-track erase head has the same

fixing method as the original $\frac{1}{2}$ -track head. All that was required were longer screws. The *LF4VS* differs in fixing arrangements but, as the writer has not seen one, no details can be given. The next problem was to fit the *SKN4* record head. Not wishing to disturb the pinch-wheel operating system, which is fitted to the existing head bracket, meant the rear of the head fixing screws could not be used. They were cut off. **Figs 8 and 9** show the cutting required of the head bracket, the hole in the deck and the additional support bracket behind the erase head. This latter is needed because one of the existing bracket fixing screws had to be removed to make way for the greater height of the record/playback head. In all there are now three screws holding the head assembly to the deck.

Fig. 7 shows the record head strap made of tin plate with small BA threads soldered to it. These pass through a top plate which overhangs the erase head. Two small BA screws hold this plate to the existing bracket.

FIG. 1 Arrangement of controls.

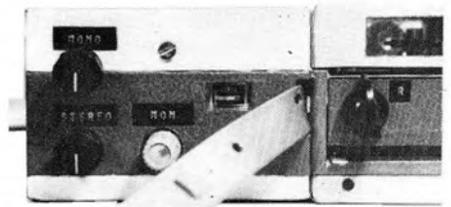


FIG. 2 Repositioned lid hinges and circuit panels.

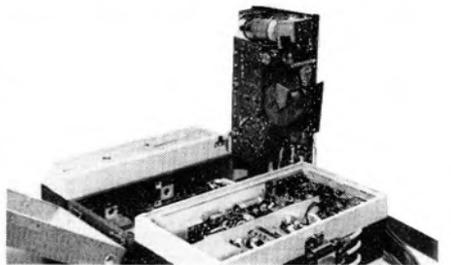


FIG. 3 Plug-in points for circuit panels.

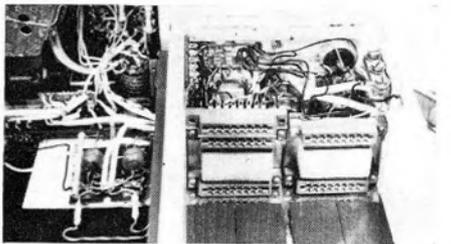
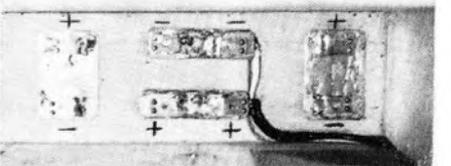


FIG. 4 Relay spring ends soldered to tin plate.



Azimuth adjustment is by the same method as Fi-Cord originally provided—albeit with nuts instead of screws. The original piece of wire can be stuck on top of the new head.

Although finished black, the deck plate is an alloy and is easily cut. Many small holes were drilled around the outline of the cutaway required. The piece to be removed was then punched out. Filing cleans up the edges. To avoid filings getting into the motor and pulleys, make use of gravity by fixing the deck in a vice, so that particles are kept away from these and other vulnerable parts. The flywheel is held to the deck by its bearing and the three screws around the capstan hold the bearing to the deck.

Setting-up tests have been carried out with the following test equipment: Tutchings Test Tape No. 3, used for azimuth adjustment. Sine-wave oscillator: 0 to 8 mV output at 22 K. Heathkit OS2 oscilloscope. Heathkit AV3 valve millivolt meter. Multimeter: 20 K/V on DC ranges.

The head azimuth was set using the test tape. Then, with the oscillator connected to the centre channel input at 0.5 mV, the level meter halfway between zero and the start of the red area, recordings were made at intervals over a wide frequency range. When played back on a Revox 736 the minus 3 dB points were 50 Hz and 15 Hz with respect to 1 kHz. The Revox has a 70 μS playback characteristic. The tape used was Philips DP (not the low noise variety). Bias was at maximum due to fresh batteries. The level on the tape was equivalent to that with the Revox at -7 dB on its VU meter.

To assess the signal-to-noise ratio, a ten second recording of a 1 kHz sine-wave was

made on the left-hand channel at full gain and at a level equivalent to 0 dB on the Revox. The ten-second recording was followed by one of half that duration with the gain control at zero. Again playing back on the Revox, the noise was 45 dB below the recorded signal.

Whilst the recording above was being made, the right-hand and centre channel inputs were short circuited and, for the first five seconds, the centre channel gain control was at zero. For the second five seconds of recording, the centre channel gain control was fully advanced. Using the Revox, the crosstalk measured -43 dB and -40 dB respectively.

As to be expected with primary cells of the type used, the voltage output varies with the load and the service life to be expected depends on the discharge rate and the length of 'recovery time'. The motor makes use of a pair of Ever Ready 1289 batteries which have already been used for the electronics down to an end point voltage of 3.8 V each, while still on load. They are then used until the lamp ceases to illuminate. The governor needs adjustment to get speed correct if nominal 9 V batteries are used.

The determining factor as far as the electronics batteries are concerned is the effect that the falling voltage has on the erase and bias voltages (see below). The first sign of low erase volts is incomplete erasure and low bias will produce more distortion and more trouble with dropout.

Subjected to the record load of around 88 mA the voltage falls quickly to 8 V and use is made of the batteries until the on-load voltage falls to 7.6 V.

Indication of expected life can be gleaned from the data kindly supplied by Ever Ready

for one No. 1289 battery (Table 1).

- The demands made by the electronics totals 88 mA at 8 V and is made up as follows:—
- Pc1 and Pc2 Two mic preamps and record amps: 13 mA each
 - Pc3 Centre channel preamp and monitor: 8 mA total
 - Pc4 Two playback amps: 2 mA each
 - Pc5 Oscillator: 50 mA total

The motor draws 130 mA from its batteries.

The data for the heads used suggest that erase and bias voltages should be 35 V and 23 V respectively at 55 kHz. The oscillator frequency was found to be 60 kHz and the voltages decided as being suitable are 37 V erase and 27 V bias for 7.6 V DC supply or 40 V erase and 30 V bias for 8 V DC supply.

Should motor speed require attention for any of the reasons mentioned, the following quote from the Fi-Cord 1A service manual should put matters right:

'Adjust speed as necessary on the small
(continued on page 381)

FIG. 5 Required battery connection bending.



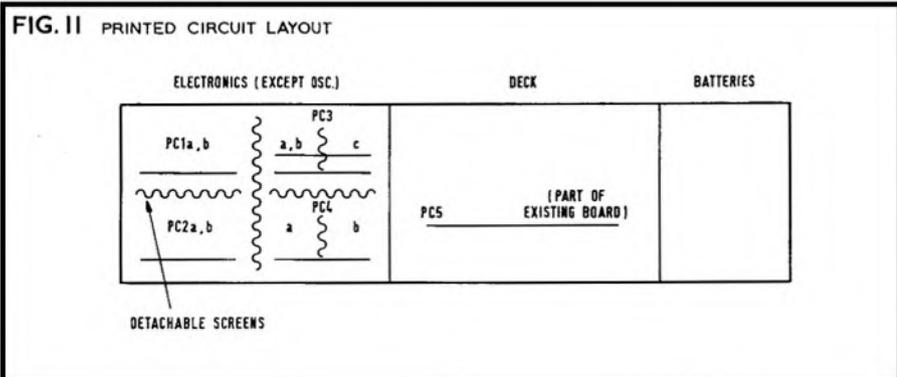
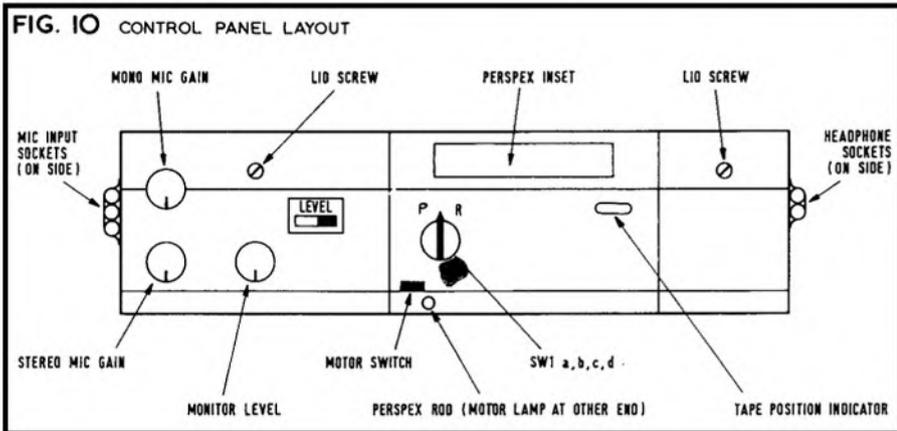
FIG. 6 Full-track erase and 1/2-track record heads.



FIG. 7 Tin plate strap soldered to threaded brass.



FIG. 8 Cut-away head bracket.



RECORDING POP MUSIC

A RECORDING engineer's activities may range from re-editing the latest cat's-food commercial to recording this week's No. 1 'pop-group'; the procedure of the latter is the subject of this article.

Before any recording session is due to start, the producer, artist and engineer (that's me!) discuss the various types of sounds and ideas the particular piece of music requires.

When the components of the *line up* are known (normally two guitars, bass, lead, drums and piano), separation screens are positioned in the studio. Their function is to restrict sounds of, say, the piano entering the microphones around the other instruments. This is known as *separation* and, in conjunction with studio acoustics, is an essential factor in modern recording techniques.

It must be stressed that the type and number of methods used by each engineer vary between studios and engineers.

Taking the drums first, I normally employ three mikes: an overall to cover the general sound, a close mike for special effects (wood blocks, etc.), and a bass drum mike for the extra thudding sound.

The bass and lead guitars may be directly injected, a split lead feeding an electric guitar amplifier on one output and through a transformer directly into the mixing console on the other. This allows a microphone to be used on the amplifier which, mixed with the direct signal, becomes quite interesting.

The piano is part of studio furniture and the engineer knows the best place for the mike.

When the microphone situation is resolved,

they are connected (through power supplies if they are the capacitor type) to mike amps. The passage of signal to the tape machine is depicted in fig. 1.

The microphone amplifier has a stepped gain which is produced by introducing maximum negative feedback at its lowest gain, and vice versa. The output is then fed into a fader which attenuates the signal like a potentiometer but retains a constant impedance for any value of resistance, which simply means that the frequency response is constant at any position of the fader; also the distortion is minimal.

The network in fig. 1 works as follows. R1, R2 and R3 are so arranged that whatever the attenuation they introduce, the impedance seen at the input and output terminals remains constant at 600 ohms. R2 and R3 form a potential divider, but whatever their resistance

ratio the effective impedance at the output is 600 ohms. Also, R1 is varied in value according to the changes of R2 and R3, so that the microphone amplifier always feeds the same load. This is achieved by mechanical linking of the resistor slides.

Choosing a specific instrument, for example the bass guitar, we can completely alter the sound by inserting an equaliser.

An equaliser alters the frequency response of the incoming signal at predetermined points in the audio spectrum. In other words, it is a glorified tone-control.

If we try a 10 dB boost at 100 Hz, the bass will become fuller and rounder whilst attenuating it at 10 kHz to suppress unwanted (hiss).

Different instruments produce sounds containing differing harmonics. Middle C on a piano will sound entirely different to the same

FIG. 1

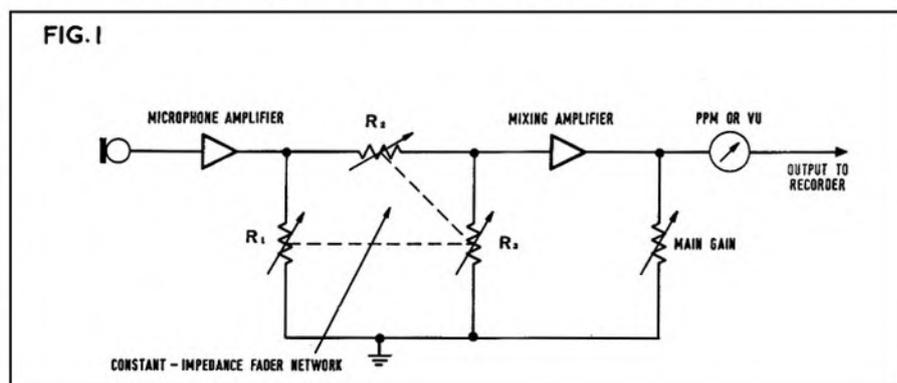
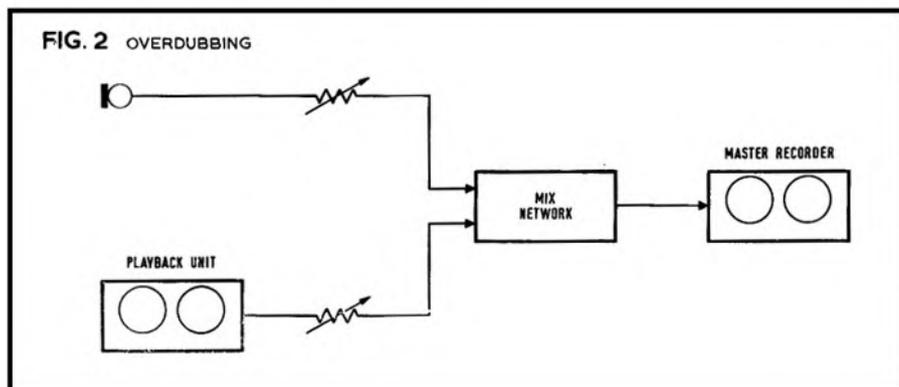


FIG. 2 OVERDUBBING



pitch on a guitar. Middle C has a fundamental frequency of 261.63 Hz, its second harmonic being equal to twice this, the third harmonic three times, and so on. So it follows that different harmonic relationships, with regard to levels (i.e., the fifth harmonic may be much louder than the fundamental), are key factors in determining why a piano sounds different to a guitar.

The equaliser can 'pick-out' quite sharply any number of harmonics contained within the fundamental and boost or attenuate them to such an extent as to create a 'new sound'. It might also be necessary to limit or compress the bass guitar by switching a limiter/compressor into the chain.

A limiter/compressor is primarily intended to stop excursions of sounds above predetermined levels.

The difference between a limiter and compressor, as well as their functions, often seems to create confusion.

A compressor is normally regarded as any device with a ratio of 2:1 to approximately 30:1. If it were 10:1, then any 10 dB increase of input signal will only increase the output by

* Senior Sound Engineer, Advision Studios.

RECORDING POP MUSIC

By Gerald Chevin *

1 dB. It is normally signified as a limiter when its ratio becomes as high as 30:1, so it can be seen that limiting is much more severe than compression but in studios the terms are normally synonymous.

If a bass guitar is compressed (sorry, limited heavily) it will produce a thud or clicking sound which may sometimes be mixed intentionally in with the overall sound.

There are several methods of recording: basically mono, stereo, 4-track and 8-track. Each has its own advantages and disadvantages which are discussed below.

A professional mono tape machine uses standard play 6.25mm tape, usually on 26.5cm spools. This type of recording entails 'mixing' all the sounds simultaneously, which means that the balance between the various instruments cannot be altered at a later date.

When recording pop music with the mono or stereo systems, the rhythm track is normally 'cut' first, then voices can be added afterwards on what is termed an *overdub* (fig. 2).

The main advantages are that one hears the final sound from the word go, and it stands to reason that the session time is reduced; or conversely more tracks may be recorded in a given time.

With four tracks, each instrument may be recorded on a separate track as follows:

- Track 1. Bass guitar
- Track 2. Lead guitar
- Track 3. Piano
- Track 4. Drums

This is advantageous because the relative balance of each instrument may be altered after recording as well as re-equalising and adding echo and/or reverberation.

There are two basic sources of reverberation; the chamber and the plate. Reverberation and echo are not synonymous; echo is a repetitive sound, whilst reverberation increases the duration of the signals, so as to create the impression that the performers are in a large auditorium.

Studio mixing consoles have controls for reverberation and/or echo, called *echo-send* and *echo-return*. Each fader has its own echo-send control either before or after the fader, and a group of faders, an overall echo-return. The arrangement is shown in fig. 3 (echo-send before fader).

A reverb chamber functions in this way; a sample of the main sound (controlled by the echo-send potentiometer) is fed to a monitor in the reverb chamber, which is an irregularly-shaped room with very smooth walls and is very 'live'. The sound is reflected from the walls and is delayed before it reaches the omnidirectional microphone at the other end.

The output from this is fed into the main signal source via the echo-return potentiometer and so adds reverberation to the original sound.

A simple reverb plate operates as follows: a sample of the main sound is fed into the drive unit of a loudspeaker, mechanically linked to a large thin metal sheet. This in turn vibrates in sympathy with the sound, and these vibrations are detected by a sensitive pickup, the output from this being connected into the main sound source. The vibrations are controlled by variable damping, remotely activated by servomotors which control the echo delay time, usually between a quarter and five seconds.

Once the appropriate amount of reverberation and the correct recording level for each track has been found, the rhythm track is recorded. This is usually done in three or four takes and, after play-back, the master take is chosen. It may be necessary to edit between different takes, to obtain a 'perfect' master rhythm track.

It can be seen that to add voices or extra instruments, mixing the four tracks down to one track of another machine is necessary, so part of this freedom to control individual instrument levels on a 'final mix' is lost. This is where extra tracks on the same piece of tape would be an asset—so they invented the 8-track machine. This system is exactly the same as 4-track, but uses 25 mm tape.

By utilizing an 8-track there are four spare tracks to add voices and things—but this is not quite as easy as it seems.

The pre-recorded tracks are re-played through head-phones to the singers. When the

vocals are added, the following procedure takes place: The pre-recorded tracks are switched to *sel-sync*; this means that they are then re-played from the record head. This eliminates the delay (between the vocal and rhythm tracks) that would occur if playback were from the normal play head during the recording process.

In addition to 8-track machines, a 24-track model is now available—the Ampex *MM1000*.

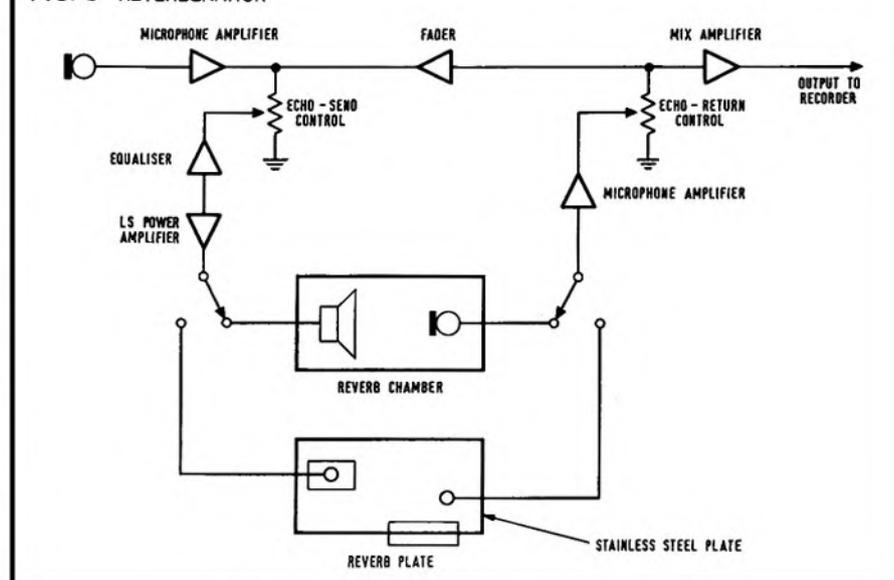
After completing all the tracks, the next stage consists of a hamburger break, then final mixing down to mono and/or stereo where all the final stages, re-equalising, compressing/limiting, reverberation/echo and reduction take place.

The 38 cm/s master tape is then re-played through the studio monitor loudspeakers and on a domestic set-up to ensure that the mix is suitable for any audio system, i.e., that the vocal is audible and the backing has sufficient bass and treble.

The recording, which probably commenced about 8 p.m. (a better atmosphere is created at night), is almost over. Copies are made on acetate discs and given to the producer and group, so they may listen at leisure to the final product of their efforts. After a week or so, when everyone is satisfied, a master disc is cut and sent to the processing plant, where pressings are made for distribution to the record shops.

Within a few weeks the record may, or may not, have soared to the top of the charts and the artists may have found fame and fortune, or may not. But the recording engineer? He's recording another pop group.

FIG. 3 REVERBERATION





SONY TC200

BY H. W. HELLYER

IT seems amazing that I should have neglected Sony in these servicing articles. To be charitable, I could say that Sony seldom need servicing. It would make a good advertising slogan, except for one consideration: manufacturers always underplay service. In their biased opinion, nothing can ever go wrong. We who know different would be glad to confirm that Sony products, in the domestic sphere, are among the best. For the past two years, I have worked extensively with Sony tape recorders, radios and video tape recorders and can claim a reasonable experience. Two points arise: their construction is good, and does not give a lot of after-sales bother. Secondly, their spares and service information facility is superb. I



will not embarrass them further but get on with the job in hand.

From the servicing aspect the *TC200* is not too difficult to get at. The chassis, complete, comes out of the wooden cabinet with the minimum of fuss, by removing screws at base and rear. There is no need to take off all the knobs and top plate unless deck adjustments have to be carried out.

The main printed circuit board runs across the front of the machine, and circumspect probing will soon prove electrical faults.

One great advantage of a fully stereo machine, which I make no apology for stressing, is the ability to 'swop' connections at any stage of the circuit for comparative tests. Thus, one need not wonder vainly whether a playback head is a little under par on one track when all one has to do is change the connections so that the suspected winding feeds the alternative channel, when any discrepancy soon shows up.

Having mentioned heads, and the worry of output and response, I must be fair and discuss the one aspect where Sony, in my humble opinion, have not done their bit. The record/play heads of this, and later machines, tend to wear rather more rapidly than is desirable for equipment of this quality. Admittedly, much of the acceleration of wear is due to abrasion and, ultimately, to a neglect of the basic professional practice of cleaning heads before each session, and never, repeat never, using inferior tape. While Bogen heads, for example, take ill-treatment in their stride for many useful hours, Sony heads will suddenly show signs of impaired high frequency response, or lower output on one track, and a visual inspection reveals that a 'pit' has worn in the head. The facing collapses inwards. I have had battles with Sony over this, even when guarantees have been involved. Their argument is that their heads are inexpensive, and, with correct usage, have long life.

Unfortunately, the ordinary chap will always neglect the niggling regimen of head and tape cleaning until it is too late. Then it becomes necessary to change the head. This is initially an easy job. The record/play heads of the *TC200*, and later models up to the *TC530*, are mounted within the shield and the whole supported in place by the adjustment screws. Four wires from the windings emerge from a hole at the back of the mounting and are soldered to pins in an insulated block beside the mounting.

So far, so easy—the dismantling problem comes when one has to remove the head from its snug mounting. It is secured by two screws through the base, passing through a height-correcting spacer block. The screws, in every case I have had to handle, seem to have been fitted by a maniacal exponent of the medieval thumbscrew. It may sound blasphemous, but the only method I have found of removing these screws without scarring the cross-cut which both Philips and *Posidriv* screwdrivers fail to engage, is to start with a hard tap from a small hammer, using a screwdriver whose end has been ground exactly to shape. The head is held firmly while doing this, the top of the mounting resting on a wood block. After this initial tap, one can unscrew gently and release the head.

When replacing, the problem is to align the holes in head, block and mounting. Beware of omitting the block by mistake. If you do so,

and then fit the screws, they will go too far up through the head mounting and damage the winding. I did so—once.

It is always wise to remove the pressure pad flap before working around the head channel. Pressure pads are sprung into engagement in the Sony style, held off by a claw bracket in the neutral position. Two small screws secure each pad flap.

We shall be taking a closer look at deck features in the next couple of articles, splitting the treatment to leave room for a few notes on circuitry. But the two prime points that need mentioning here are the rising clutch drive wheel and the selector cam. Once or twice we have had bother with clutch action, and the fault has lain with these two items. The symptoms are either jerky take-up or spillage at the right.

Way back in 1964, when I dealt with the predecessors to the current range (Sony *101*, *111*, *262*, *464* and *362*. July to October 1964), I jibed about the 'idler versus belt' controversy then being waged and cited Sony as a prime example of the efficiency of idler drive. I see no reason to go back on that statement, after several more years' experience of them.

Inspection of the take-up arrangement reveals that the clutch drive idler is mounted on a sliding arm, sprung toward engagement, and with a step at its selector end. The set of this step is very important, as is the secure mounting of the selector cam, whose ramp engages this lever. If either of these things is wrong, the lower edge of the idler can rub on the larger flange of the motor pulley, and jerky take-up will be noted, especially with lightly loaded spools.

The opposite condition (with the idler not correctly lowered to engage the larger flange of the motor pulley, as it should for fast forward winding) causes a pronounced shudder at the right-hand spool carrier. The trouble is almost always due to the riser portion of the shaped disc which lifts the set end of the idler lever.

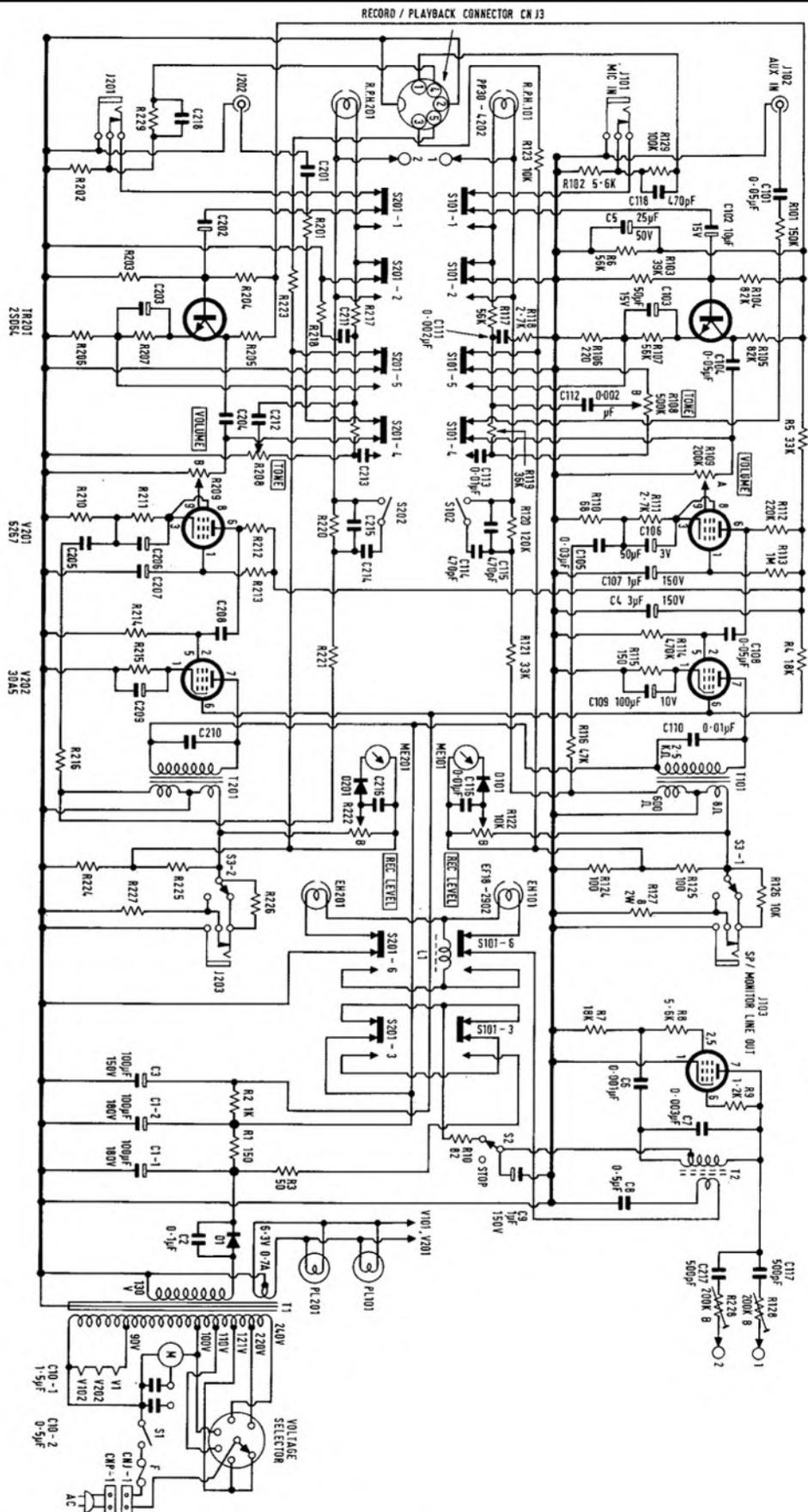
Clutches, in this and other models, are weight-dependent, and the usual requirements for clean felts and spindle bushes must be observed. On the left-hand side there is not only the felt to contend with but also the flat disc beneath it and the pulley which drives one of the tape position indicator belts. (A pair of belts is used to obtain the right position of belt entry relative to the three-digit counter.)

Brakes very seldom give trouble on these models, despite their unconventional design. At the feed side, a sprung sub lever on the rewind idler bracket halts the idler which jams solid against the wheel—the pressure depending on the torque. The spring blade at the outer part of the bracket is the only weak part. At the right, a pivoted arm with a simple brake block (on the U-piece by the outer periphery of the spool carrier rubber tyre) has a straight-forward action imparted by the central cam.

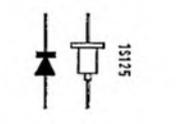
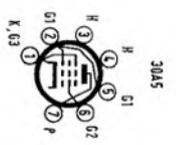
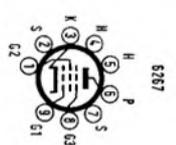
In all, the key to the whole mechanism is this cam around the selector switch, with its shaping, and the secret is to keep it well greased. One small point to watch is the fitting of the spring for the fast winding section of the knob. It can very easily slip out of place if carelessly assembled; and this knob has to come off for any deck dismantling.

Capstan and pressure roller assemblies on the Sony machines are one of the talking points
(continued on page 380)

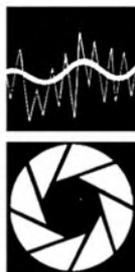
FIG. 1 SONY TC200 CIRCUIT DIAGRAM



S101-1-6, S201-1-6.....RECORD / PLAYBACK SWITCH (ON AT RECORD POSITION)
 S102, S202.....EQUALIZER SWITCH (ON AT 19CM/S POSITION)
 S1.....POWER ON/OFF SWITCH
 S2.....FORWARD / STOP SWITCH (ON AT FORWARD POSITION)
 S3-1-2.....LINE / SPEAKER SWITCH (ON AT SPEAKER POSITION)



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7"	1200'	...	36/7	25/6	5"	1200'	...
				5 1/2" 1800' ... 56/5 39/6			
				7" 2400' ... 79/7 55/6			
Long Play				Triple Play			
3"	210'	...	9/6	6/9	3"	450'	...
4"	450'	...	15/7	10/9	4"	900'	...
5"	900'	...	29/3	20/6	5"	1800'	...
5 1/2"	1200'	...	36/5	25/6	5 1/2"	2400'	...
7"	1800'	...	51/7	36/-	7"	3600'	...
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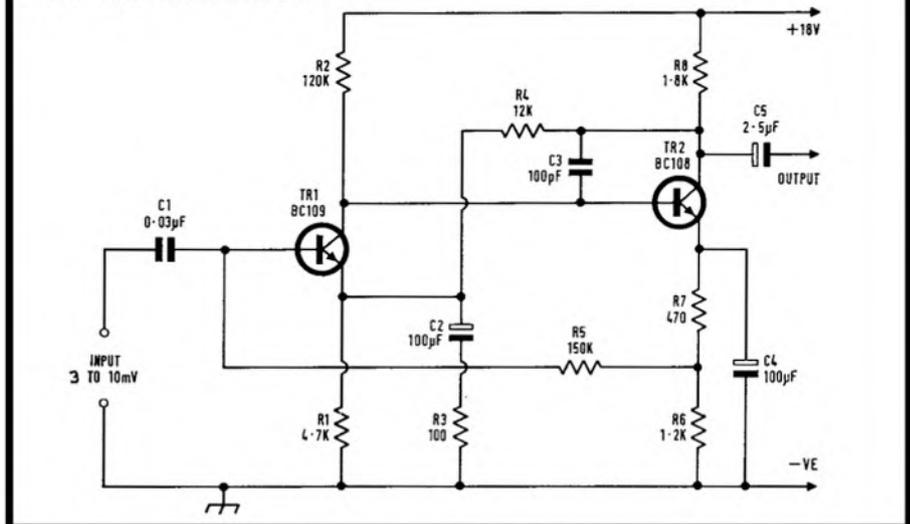
SOUND WORKSHOP

PREAMPLIFICATION
AND MIXING
BY F. C. JUDD

FIRST of all apologies to those readers who were expecting something in July about the techniques of electronic music. I had hoped to do some further research on this subject in order to present more up to date information but unfortunately time has not been on my side. However, electronic music enthusiasts may find good use for some, if not all, of the audio circuits given in this article, many of which are very recent designs, or slight variations, by Mullard Applications Laboratory employing Mullard low noise *n-p-n* BC108 and BC109 silicon transistors. I have built and used all the circuits reproduced here but it is possible that slight changes in component values may be necessary for optimum performance. It is recommended that only the transistors specified are used.

The first circuit (fig. 1) is for a very low noise, high gain microphone preamplifier. It has an input impedance of approximately 100 K with a sensitivity of 3 to 10 mV and an average output signal level of 300 to 500 mV. The input is suitable for the connection of microphone transformers with a high secondary impedance but not suitable for the direct connection of crystal microphones or microphones with an impedance of less than 200 ohms. It will operate with a 200-ohm microphone but at reduced sensitivity. Two feedback paths are provided between Tr2 and Tr1 and these ensure both a wide frequency response and stable DC operation. The frequency response is approximately 20 Hz-20 kHz ± 2 dB and noise level is around -60 dB. For optimum gain and performance, the HT should be 18 V. The current consumption is around 2 mA which means economical operation from a battery supply.

FIG. 1 MICROPHONE PREAMPLIFIER



Two or more of these amplifiers can be combined to form a very efficient microphone and high level signal mixer. This, however, requires a passive mixing network like that shown in fig. 2 and an additional amplifier to recover the 12 dB or so loss introduced by the network. The circuit of fig. 3 can be employed for this and the points X—X from the passive network connected as shown. This circuit is a modified version of fig. 1 and its gain can be controlled by varying the feedback via R4 (12 K) from the collector of Tr2 to the emitter of Tr1. The feedback is controlled by Vr1 (4.7 K) which allows an overall gain of between about 12 and 40 dB. With most of Vr1 in circuit, the gain will be around 12 dB and the input sensitivity up to 500 mV or so. This is sufficient to recover the loss of the passive mixing network. By itself, the circuit shown in fig. 3 is useful because of its variable gain and input sensitivity. For instance, with Vr1 at minimum resistance the gain rises to about 40 dB and the input sensitivity to 10 mV or less.

(continued overleaf)

FIG. 2 PASSIVE MIXING NETWORK

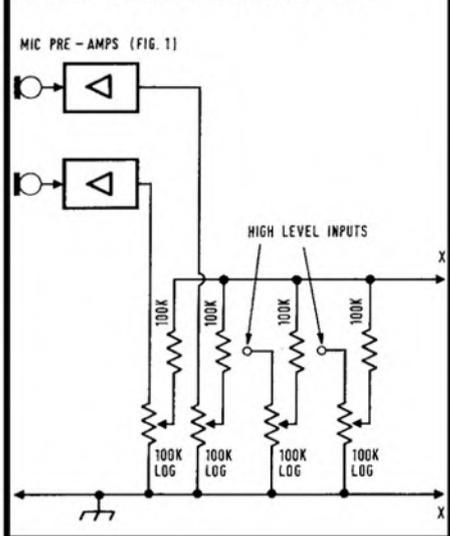
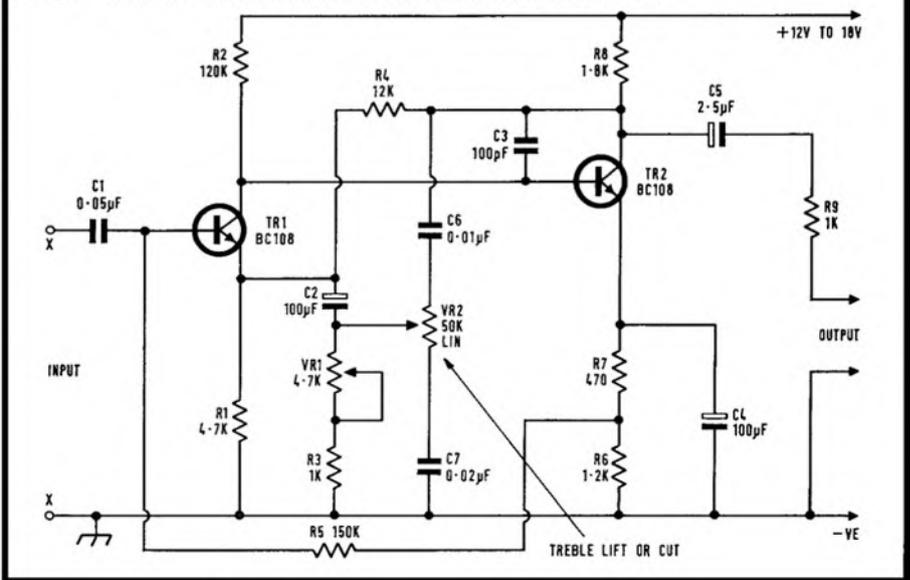


FIG. 3 VARIABLE GAIN PREAMPLIFIER WITH TREBLE LIFT AND CUT



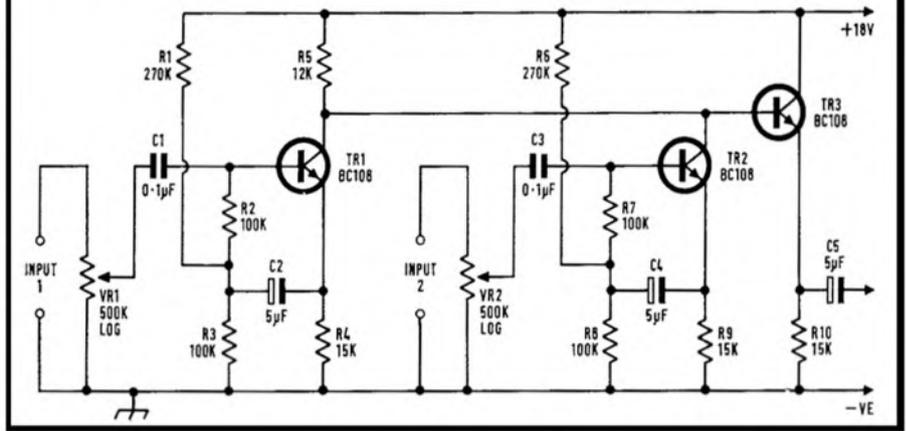
It has a fairly low output impedance and a large useful signal output.

This was produced originally as a pre-amplifier for an electric guitar magnetic pick-up but which required a large degree of treble lift or cut for a wide variation in tonal quality. The variable gain provided by Vr1 allows for an input sensitivity of between about 50 and 200 mV at an input impedance of approximately 100 K. The treble control Vr2 provides about 14 dB lift and 10 dB cut at 10 kHz.

The two-way signal level mixer in fig. 4 employs three BC108 transistors and, without the gain controls which I have added, has an input impedance of 2.5 M. The gain controls reduce this for practical purposes to about 500 K. The input signals can be taken up to 1 V for a distortion factor of not greater than 0.5%. The voltage gain through the amplifier is unity. Output impedance from the emitter follower Tr3 is approximately 70 ohms. This amplifier could be used in conjunction with the microphone preamplifier in fig. 1 and is an alternative to using a passive mixing network and amplifier as outlined earlier.

Electronic music enthusiasts may find a use for the circuit given in fig. 5, which provides a sustained decay of variable duration to any signal fed into the input. It can be used in conjunction with a tone source such as an audio

FIG. 4 TWO-CHANNEL HIGH INPUT LEVEL MIXER



generator for producing 'bell' effects. Signals of up to 1 V or so can be taken to the input, though the level should be set by VR1 to prevent overloading. With a signal at the input and the 'key' open, the 50 K control VR2 should be adjusted until the transistor is just cut off (i.e., no signal at the output). The key must be one which returns to the open condition immediately after depressing it, like an electronic organ key. The moment the key contact makes, the transistor conducts and will then slowly return

to cut off as CX charges up. The value of CX, therefore, determines the duration of the decay time and, for a very long decay, may need to be around 50 µF or more. If the control VR2 is set so that the transistor is well beyond cut-off, a very short decay can be obtained almost irrespective of the value of CX. The circuit can be run from a 9 V battery.

The white noise generator in fig. 6 has various applications in the sound workshop and is a useful signal source for electronic music and sound effects. The output is around 50 to 100 mV of noise covering the audio frequency range but which can be filtered as desired for other uses. To obtain a very high pitched noise (noise without much LF content), C4 (1 k pF) can be reduced considerably to say 100 pF or less. The crystal diode may be any ordinary radio diode GEX34, OA81, etc., but it may be necessary to adjust R1 (100 K) to obtain maximum noise signal. The current consumption is very low and an Ever Ready PP9 battery is quite adequate for the HT supply.

FIG. 5 ARTIFICIAL DELAY CIRCUIT

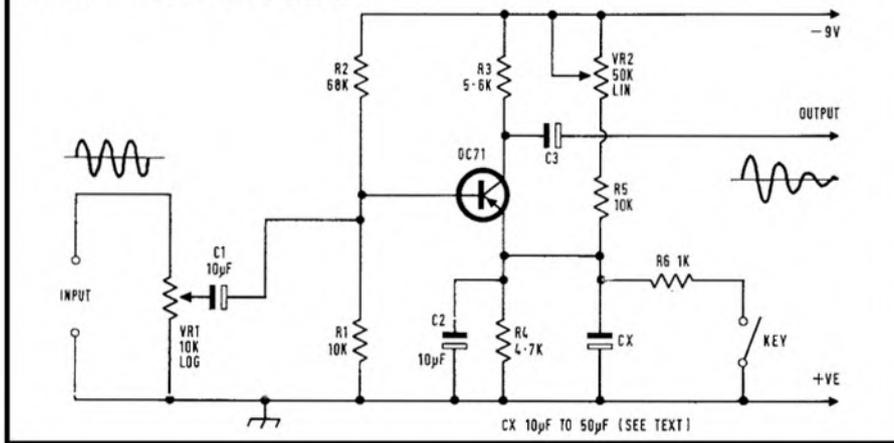
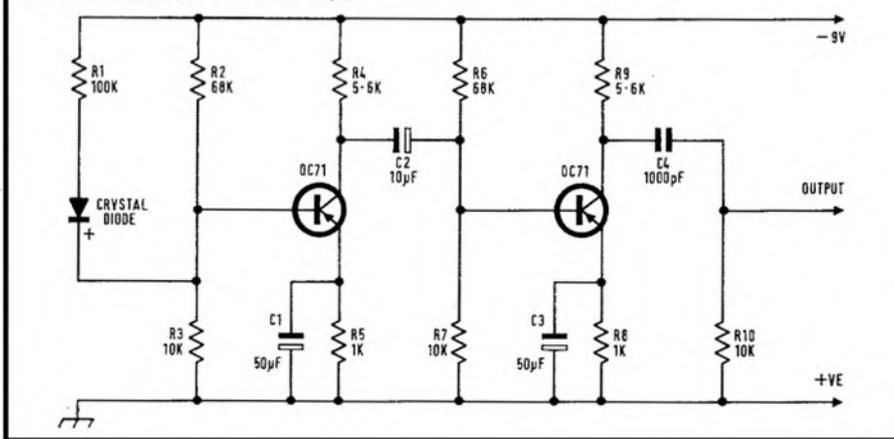


FIG. 6 WHITE NOISE GENERATOR



new releases on cassette

- PHILIPS**
Dusty in Memphis Dusty Springfield CPP1080
- FONTANA**
Colosseum CFP4041
- MERCURY**
From St. Louis to Frisco Chuck Berry CMP7029
- CBS**
The Songs of Leonard Cohen 40-63241
A Happening in Central Park Barbra Streisand 40-63432
- PYE**
Donovan in Concert CYF251
- REPRISE**
Greatest Hits Frank Sinatra CRP368
Gentle on my Mind Dean Martin CRP369
- ISLAND**
Traffic CIR15000
This Was Jethro Tull CIR15001

VTR

CIRCUITRY

PART 2

BY HENRY MAXWELL

HAVING taken at a gulp the complete video tape recording system, and looked at the sections in block form, we should now be ready to examine the detail of individual circuits. Some of these will bear a remarkable resemblance to the audio amplifier circuits we have seen in these pages many times, but others will be strange and not always obvious in their function.

One outstanding fact we may note when studying the Sony VTR circuits, is the general use of *n-p-n* transistors. Indeed, a quick glance at the blueprint of the *CV-2000B* shows that of the full complement of 55 transistors, only three are *p-n-p* types. Most of the others are silicon planar *n-p-n* types, high-performance, low-noise in their characteristics and very stable in their performance.

This is not the place for fundamental theory, but I feel a few notes on the building blocks of the circuitry, starting with the transistors themselves, may not come amiss.

As with many other innovations, the planar technique evolved from efforts to improve production methods, enabling manufacturers to make greater numbers of consistently similar semi-conductors, each physically smaller than had been possible before. They also brought the bonus of cheaper devices with an improved HF performance. The planar technique cannot be used with germanium, so we get an increased use of silicon transistors, which themselves offer more stable operation and a much better thermal tolerance than the earlier types based on the diffused junction process.

To begin with, a crystal of pure silicon is grown and then doped with an *n*-type impurity under very closely controlled conditions. This doped crystal is then sliced into thin plates about 25 mm in diameter and chemically cleaned. (Thin, in this context, is even thinner than landlady's ham—about 1 μm .) After the cleaning operation, the slices are heated to about 1200°C in pure oxygen, which covers them completely in a layer of silicon oxide. The oxidised slice is placed on a spinner and a drop of resist is placed upon it. Resist is a material which reacts to ultra-violet light by becoming very hard. This operation has to be done not only in the rigorously monitored dust-free conditions but also with the light carefully controlled.

The next step, after the photo-resist is applied (in thickness determined by the type of transis-

tor to be made and obtained simply by the speed of spinning), is to mask the disc with a photographic negative, so that the required hard portion receives a bath of ultra-violet light and the base 'window' is left in the original form and can be washed away. The slice is then baked, hardening the photo-resist still more, and the exposed oxidized areas treated with a hydrofluoric acid solution to remove the oxide and reveal the basic silicon.

After more cleaning and baking, the slice is treated with a doping impurity (usually boron) which evaporates and settles in the window area. In another hot oven, with oxygen flowing, the boron is diffused into the silicon to a controlled depth of 3 to 5 μm (in the types of transistor we are considering). This forms the base.

Another oxide layer is produced, and another pattern exposed by the photo-resist method, so that windows for the emitters are formed (the slices being treated in great numbers, not singly). The exposing and doping process is repeated, using phosphorus in place of boron, and the emitter is diffused, becoming an *n*-type material.

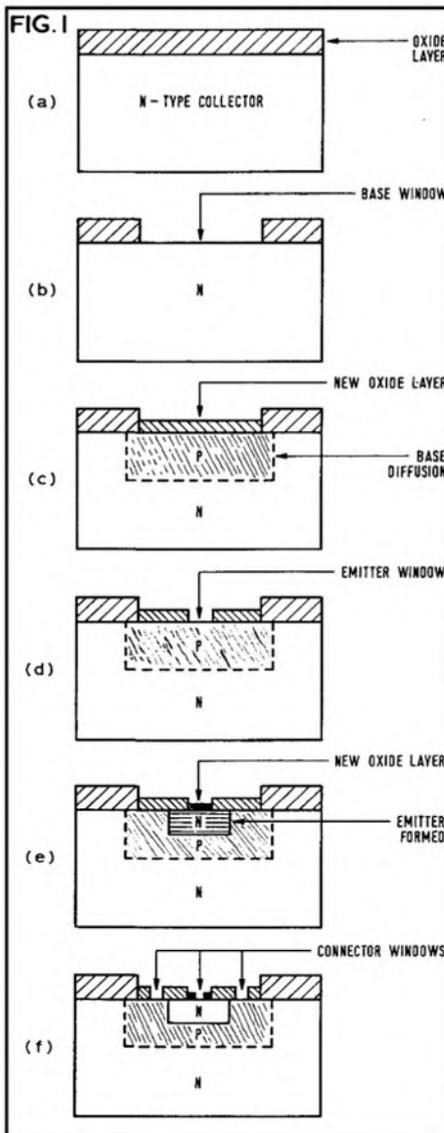
Once again, the photo-resist method is employed to produce windows over the base and emitter areas, the slice is placed in a vacuum and a fine layer of aluminium deposited. A further etching process removes unwanted aluminium except where it is needed to provide an anchor point for the contacts, which will be gold or aluminium wires.

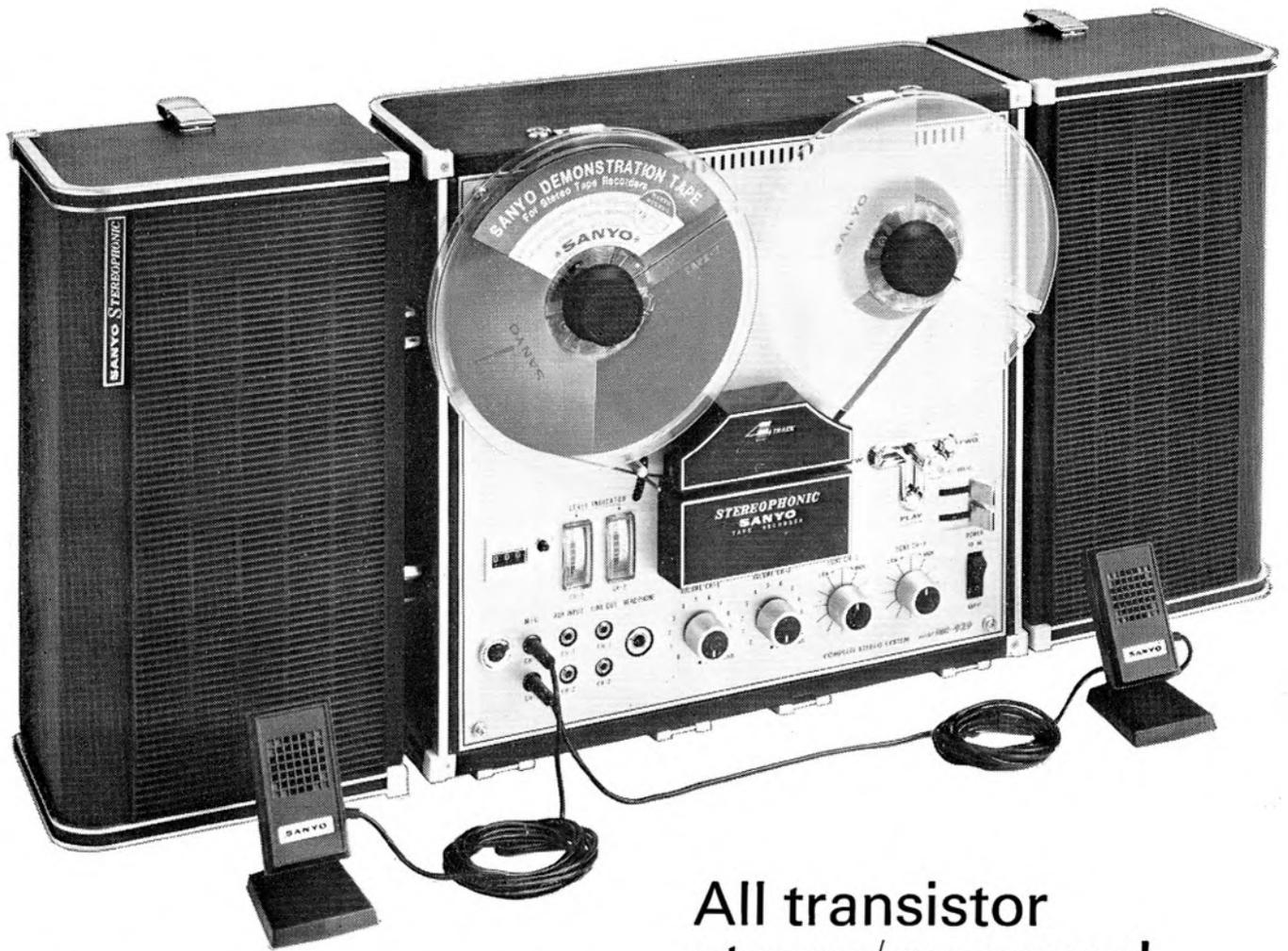
The oxide layer is removed from the collector side of the slice and the complete disc, which contains between 200 and 6000 'basic' transistors, according to type, is tested for breakdown voltage and current gain before being scribed into small squares each containing a single transistor.

There are several more stages of cleaning, attaching lead-out wires and encapsulation before the small blob we treat so casually is ready for insertion in a circuit. There are special processes for the epitaxial types, involving heavier doping. Before the first coat of resist is applied, the slice is covered by a thin layer (5 to 20 μm) of lightly-doped silicon with the same crystal orientation as the original slice.

Final testing involves measurement of 21 static and dynamic characteristics which include

(continued on page 373)





Model MR-929

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SPECIFICATIONS

Recording System: AC bias
Erasing System: AC erase
Reel Size: 7" dia.
Speeds:
 $7\frac{1}{2}$ in/sec (19 cm/sec),
 $3\frac{3}{4}$ in/sec (9.5 cm/sec)
Playing Time:
 stereo
 30 min. x 2 at $7\frac{1}{2}$ in/sec
 with 7" (18 cm),
 1,200 ft. (360m) tape

1 hour x 2 at $3\frac{3}{4}$ in/sec
 with 7" (18 cm),
 1,200 ft. (360 m) tape
 monaural
 30 min. x 4 at $7\frac{1}{2}$ in/sec
 with 7" (18 cm),
 1,200 ft. (360 m) tape
 1 hour x 4 at $3\frac{3}{4}$ in/sec
 with 7" (18 cm),
 1,200 ft. (360 m) tape
Rewind Time: 3 min. with 7" (18 cm)
Frequency Response:
 20-19,000 c/s at $7\frac{1}{2}$ in/sec
 (19 cm/sec)
 (30-15,000 c/s \pm 3db)
 30-12,000 c/s at $3\frac{3}{4}$ in/sec
 (9.5 cm/sec.)
Recording Level Indicator:
 VU meter
Power Output:
 Maximum 4W (each channel)
 Music 6.5 W (each channel)
Speakers:
 Two 4" free-edge permanent
 speaker boxes.

All transistor stereo/monaural tape recorder.

Voice coil impedance 10K ohms.

Line Outputs:

1K ohms

Power Source:

AC 100V, 117V, 125V, 220V, 240V

Dimensions:

$14\frac{1}{2}$ " wide x $12\frac{3}{4}$ " deep x 11" high
 (350mm x 330mm x 280mm)

Weight:

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reverse leakage current, reverse breakdown voltage, knee and saturation voltages and DC and AC gain. The batches are then boxed, stored and given a passing-out test before delivery. If any box fails, the whole batch goes through the complete tests again, and cannot be passed out until the specifications are met. Contrary to popular belief, the rejects are *not* sold to unscrupulous dealers in the surplus market—at least, not by Mullard, who were good enough to show me the complete manufacturing process, from which the foregoing perfunctory notes were derived. Fig. 1 condenses the processing sequence even further, for those who prefer graphics to woggles of print.

Silicon transistors are not direct substitutes for their germanium predecessors. Several queries have been received in the *Tape Recorder* office with regard to uplifting playback amplifier performance by substituting silicon devices. This is quite in order, so long as we remember that the characteristics are quite different, and biasing arrangements will have to be altered. The 'normal' bias configuration for germanium and similar devices is shown in fig. 2a, where the current is only slightly influenced by spreads in h_{FE} , but if current variations resulting from supply variations are to be kept low, a value of emitter voltage much more than V_{BE} is needed. An alternative biasing method, fig. 2b, uses just the single base resistor and gives lower changes of current with V_{BE} variations, but is very sensitive to spreads in h_{FE} . (h_{FE} , the h parameter in the common emitter arrangement for forward current gain.)

Principal differences between germanium and silicon devices are in the base-emitter voltage V_{BE} and the collector leakage current I_{CBO} . Whereas the V_{BE} of germanium transistors may be limited to 0.1 or 0.2 V, silicon devices operate at 0.6 to 0.7 V, although the actual rate of change of current with changing V_{BE} for each type is virtually the same. Hence the first difference: a larger voltage drop is needed across the emitter resistor of a circuit such as fig. 2a.

The second point, collector leakage current, is a great advance when we consider silicon devices, where it is practically negligible up to quite high temperatures. This makes biasing

circuits much more flexible, although the choice of method will still depend on the supply voltage.

A third method which will be met in the circuits to follow is current biasing with feedback from the collector to the base, such as in fig. 2c. This type of configuration will be found where there is plenty of supply available, as R_1 must necessarily be large to diminish spread in emitter current with spreads in forward current gain. So there will be appreciable collector voltage swings—indeed, there are times when the greater part of the supply voltage is developed across R_1 and the spread in V_C is directly proportional to the spread in h_{FE} .

Thus we see that, with silicon devices, the operating voltages will be different, emitter voltage proportionately higher than with germanium transistors using a similar supply, and the biasing components may appear to have unusual values. A good deal depends on what proportion of the supply can be dropped across the feedback resistor.

Fig. 3 shows the video amplifier circuits that handle the incoming video signal and process it to drive the modulator. The incoming video signal is from 0 to 3 MHz, negative-going synchronisation and 0.7 V peak-to-peak, and this is amplified in the three-transistor block to approximately 3 V for application to the FM modulator. Input impedance is 75 ohms and this is matched into the base of T1 by the shunting effect of the fixed 100 ohm resistor and the manual video level control, 500 ohms in value.

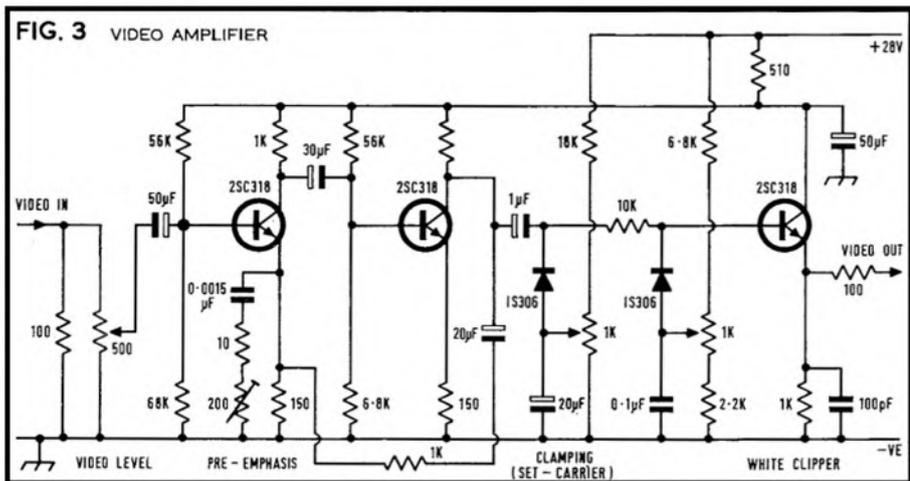
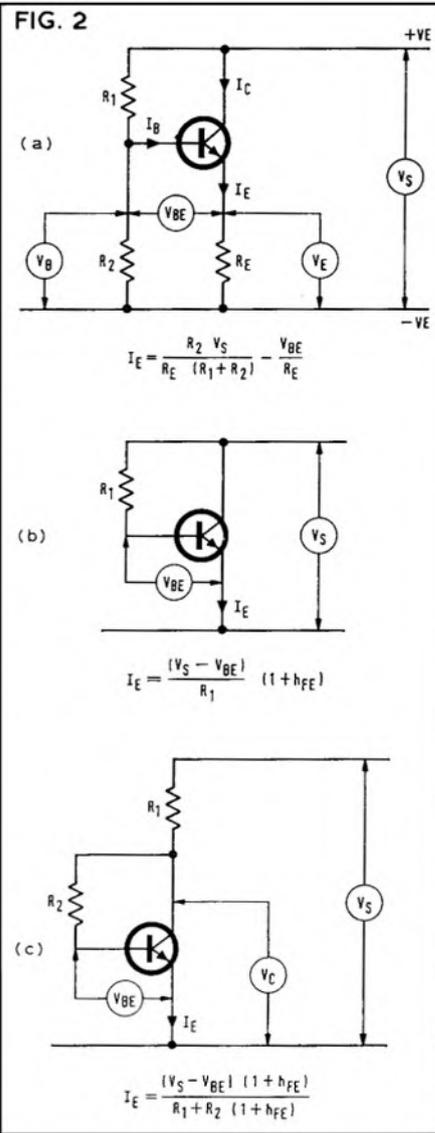
Pre-emphasis is necessary to obtain the best signal-to-noise ratio, and to obtain this and the wideband characteristic of the amplifier, a negative feedback loop from the collector of T2 to the emitter of T1 will be seen, with the emitter load of T1 shunted by another variable network. This network is best adjusted (after the clamping and carrier controls have been set) by observation of a test card and gradual increase in the resistive element until overshoot or ringing are observed. With a little practise, the backing-off point is easily determined.

Between T2 and T3 we find another peculiar circuit, with two more preset controls and series diodes to their sliders. It is necessary to obtain a DC reference level before applying the modulating signal to the FM generator and the best way is to clamp the tip of the sync

pulses. This is done by the first network, with the preset providing the bias level of the clamping circuit, being the adjustable lower leg of a potentiometer across the 28 V line.

The second network works in a similar way, except that reversal of the polarity of the diode now means that the positive tips of the modulating signal will be bypassed if they exceed a level determined by the potentiometer setting. So this control is a peak-white clipper, and can be used to prevent overmodulation—which shows itself on the video recording much as it does on your television receiver when you advance the contrast control too much; soot and whitewash picture, with greys conspicuous by their absence.

To couple the signal from the video amplifier T1 and T2 to the 1.7 MHz frequency-modulated generator, it is necessary to insert T3, an emitter follower, which provides the correct impedance match. The low output impedance of the $n-p-n$ emitter follower gives maximum transference of energy for application to the two bases of an astable multivibrator, which will begin our look at the recording circuits next month.



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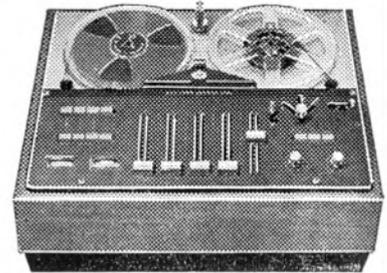
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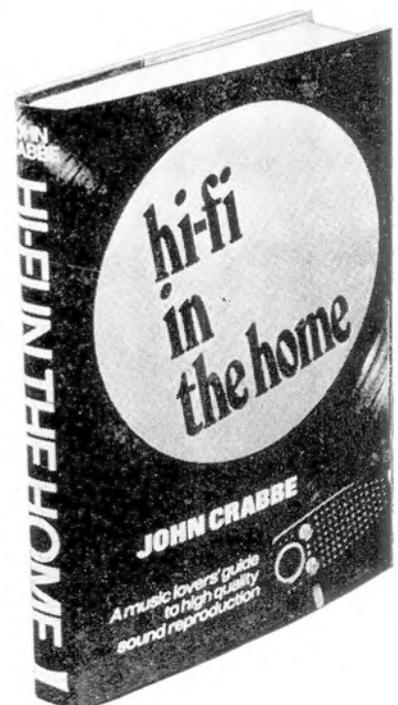
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equipment reviews

FIG. 1 TRUVOX R54 RECORD/PLAY WOW AND FLUTTER

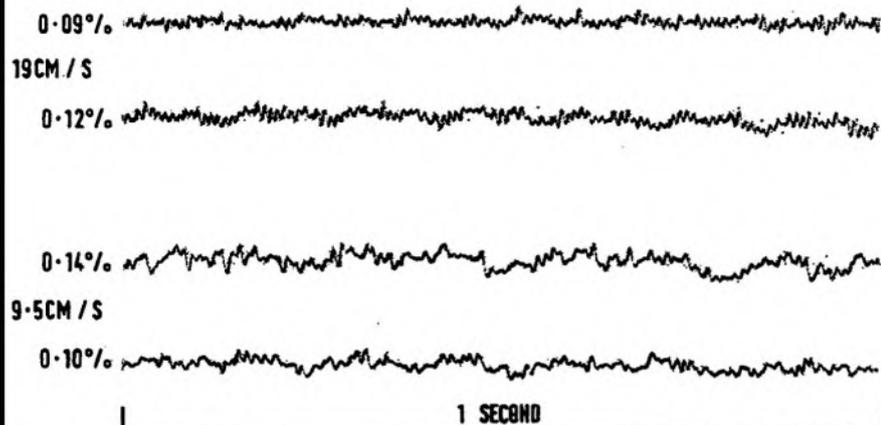


FIG. 2 TRUVOX R54 PLAY-ONLY RESPONSE (LINE OUTPUT)

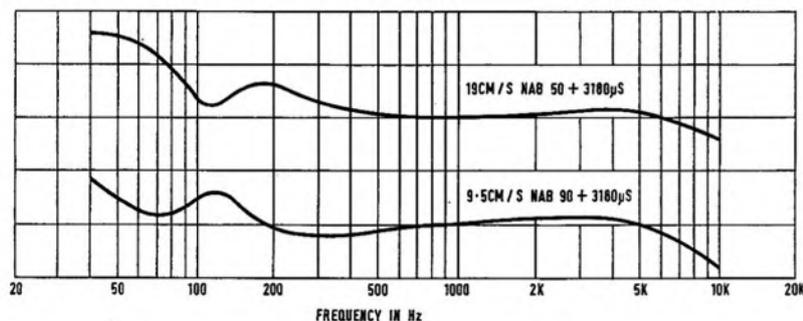


FIG. 3 TRUVOX R54 RECORD-PLAY RESPONSE (LINE IN TO LINE OUT)

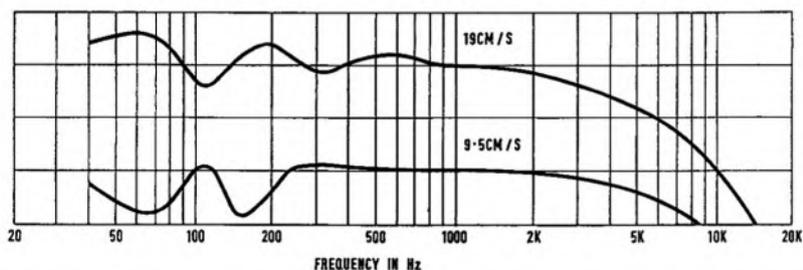
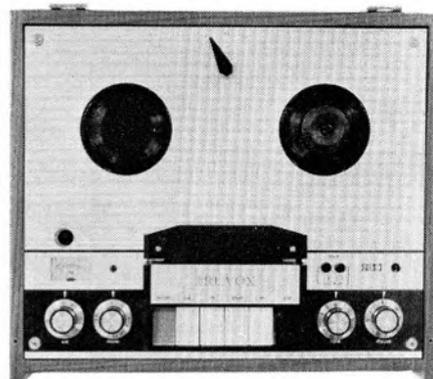
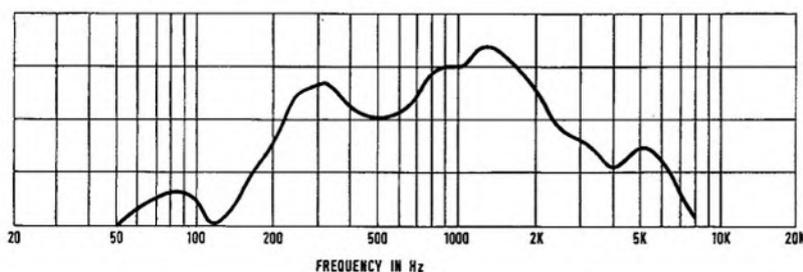


FIG. 4 TRUVOX R54 ACOUSTIC RESPONSE (WHITE NOISE TEST TAPE)



TRUVOX 54

MANUFACTURER'S SPECIFICATION (19 cm/s). Quarter-track transistor recorder with two 178 x 102 mm 15 ohm speakers wired in parallel. **Wow and flutter:** 0.14%. **Frequency response:** 30 Hz-17 kHz \pm 3 dB. **Signal-to-noise ratio:** 46 dB. **Bias frequency:** 91 kHz. **Spool capacity:** 18 cm. **Modulation indicator:** Meter, dB scaled. **Microphone input:** 150 μ V at 25 K. **Auxiliary input:** 50 mV at 200 K. **Output:** 0.5 V at unspecified impedance. **Power output:** 5 W RMS continuous at 8 ohms. **Sockets:** DIN. **Dimensions:** 340 x 380 x 180 mm. **Weight:** 11.5 kg. **Price:** £77 5s 1d.

Manufacturer: Truvox Ltd., Hythe, Southampton.

THE circuit diagram and many more details of the Truvox 50 appeared in H. W. Hellyer's 'Tape Recorder Service' article in June 1969. The controls are laid out in a logical fashion with microphone input (DIN socket) and microphone/gram mixer controls to the left of the main control keyboard, and with replay tone and loudness controls to the right. A three-digit instant reset tape position counter is mounted just above the volume control, and a pair of track selectors above the tone control connect top or bottom track for record and play with duoplay (parallel tracks) on play only. The power amplifier and speakers are in action during recording, providing simple monitoring facilities. It should also be noted that the recording pre-emphasis top rise is fed to the power amplifier and speakers, and a touch of the top cut tone control may be needed when recording from radio to restore the balance during monitoring.

The single motor drive is fairly powerful and a full 18 cm reel of LP tape (360 m) is wound or rewound in just over three minutes.

The tape counter is driven from the RH take up reel and clocks up 7 digits for 10 reel revolutions.

The three tape speeds, selected by a control at the rear of the deck, were within 2% of the nominal speeds of 19, 9.5 and 4.75 cm/s.

Short term speed fluctuations are shown in the pen recordings of fig. 1. It will be seen that a very slight trace of 14 Hz capstan

(continued on page 377)

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Double Play		Empty Spools	
3" 350'	4/-	3" ...	8d
4" 600'	6/-	4" ...	1/8
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wobble is evident at the highest speed of 19 cm/s, with 7 Hz wow at 9.5 cm/s. Nevertheless the mean wow and flutter readings of 0.1% and 0.12% RMS are about average for a good quality domestic recorder.

Fig. 2 shows the play-only responses to line output from NAB 50 and 90 μ S test tapes. Playback equalisation is close to the required time constants with a slight fall above 5 kHz and a bass rise below 200 Hz combined with 'wavelength wobbles' due to the short pole-face length of the heads.

The record-play responses of fig. 3 show the same head contour effect at low frequencies, but with a quite remarkable top droop in recording at 19 cm/s. The recording pre-emphasis was better at 9.5 cm/s with only a 5 dB fall at 10 kHz.

Peak recording level of 32 mV/mm was recorded at a VU meter reading of +3 dB. 3rd harmonic distortion at this level at 1 kHz, 19 cm/s, was 3.9%. Unweighted system noise, with no tape passing the heads, was 51 dB below peak recording level. Weighting the measurement to the IEC 'A' curve gave the remarkably low hiss level of -69 dB. Bulk-erased tape noise under these test con-



ditions was -53 dB, and tape erased on the machine was -48 dB on the top track and -53 dB on the bottom track. The difference in hiss level on machine erased tape was quite evident at all tape speeds and was not altered by degaussing the heads. It was also proved that it was not caused by difference in recording or replay responses, as the frequency responses were within 1 dB on top and bottom tracks under all conditions.

I can only assume that there is some second harmonic distortion in the bias and erase waveform which adds on one track and cancels on the other due to head phasing.

The acoustic response of fig. 4 was obtained by playing a 19 cm/s one-third octave white

noise test tape and measuring the sound output at a point midway between the front facing speakers at a distance of 30 cm with the tone control set to the maximum top position. The sound quality is rather better than might be expected from the response curve. There is some real bass response below 100 Hz, which is more than can be said for many domestic recorders, and the response is reasonably balanced about a mid-frequency of 800 Hz, but the sharp fall above 5 kHz makes one try to turn the tone control beyond its stop in an effort to add a bit of brightness to the rather dull response, particularly when recording at 19 cm/s, where the 'wetness' heard during recording just is not there on playback.

COMMENT

This is a nicely styled, easy to use domestic recorder which gives pleasant 'AM quality' sound and could be vastly improved by a little more attention to recording pre-emphasis and choice of speakers.

The slight change in noise level on top and bottom tracks also needs looking into as the system noise itself is remarkably low.

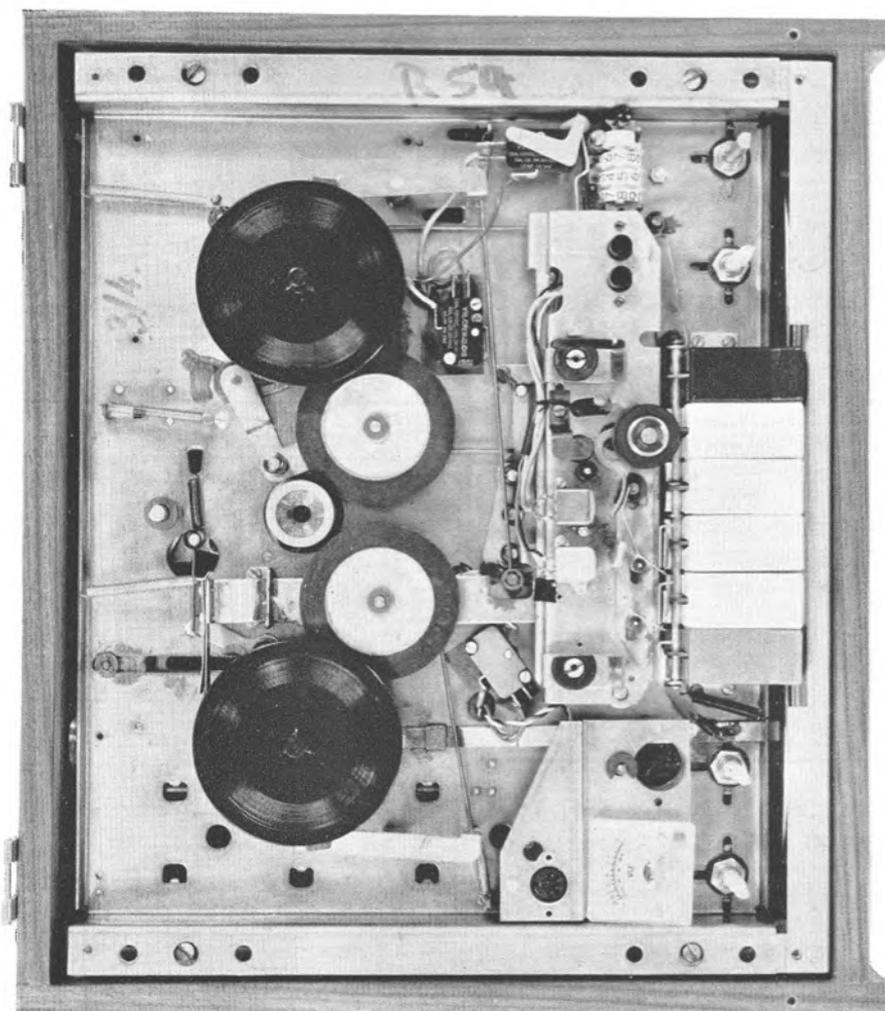
Once again I would put in a plea for tone controls to move clockwise for more bass or treble as the case may be. In this machine the tone control has to be turned fully *anti-clockwise* for maximum treble. A. Tutchings.

DUBREQ STYLOPHONE

MANUFACTURER'S SPECIFICATION. Miniature transistor electronic organ incorporating twin-T feedback oscillator, single notes obtained by resistive network in one limb of the twin-T. **Vibrato:** Switchable 6 Hz phase-shift oscillator. **Keyboard:** 20 note, A above middle C up to E. **Tuning:** Concert pitch, variable by ± 1 semitone. **Output:** 500 mV at medium impedance. Output to internal speaker: 200 mV. **Battery:** Ever Ready PP9 or equivalent. **Price:** £8 18s. 6d. **Manufacturer:** Dubreq Studios Ltd., 15 Cricklewood Broadway, London N.W.2.

ABOUT two years ago, with the help of a friend who knew all about electronic fizzes and so on, I built what I described as the smallest electronic organ in the world. It measured about 300 x 200 x 50 mm in its mahogany case and operated from a 9 V battery. All was well until Rolf Harris appeared on television with an electronic organ that made mine look like a pantechicon.

It took me very many months of searching the Saturday papers and asking in shops between London and Liverpool before I
(continued on page 379)



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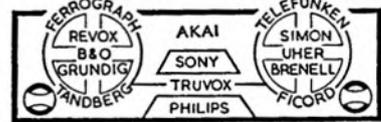
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discovered who made this 154 x 115 x 39 mm electronic marvel. Dubreq Studios derive their name from their previous profession, recording engineers. Thus 'dub' and 'recording'.

The *Stylophone* is a self-contained miniature electronic organ, working on a multivibrator principle. It has switchable vibrato and can be fed directly into an amplifier or tape-recorder. The case is black plastic with a silvered grille and a white base. The electronic components are on a printed circuit board and the whole caboodle weighs practically nothing at all—which may be a mistake, for it can be very easily knocked off a table. The keyboard consists of a separated metal surface arranged like a piano keyboard and is played by bringing a stylus (which looks like a ball-point pen) in contact with it. The technique can be staccato or glissando, according to whim. What, in fact, happens is that the contact between stylus and keyboard completes the circuit. Switching out the vibrato circuit produces a straight tone, reminiscent of a boozed-up church organ. The vibrato itself is beautiful, operating at about 6 Hz. To hear it at its best, the lowest note should be brought into circuit, resulting in a rich, pulsating sound. The keyboard is 20-note, ranging from A to E, 1.6 octaves above middle C. The organ is tuned to Concert pitch but can be 'lifted' by means of a master control set in the back of the case. This control varied the pitch four semitones. The organ is powered by a small 9 V dry battery which is easily replaced by removing the back of the case.

There are two controls on the *Stylophone*—an on/off switch and an on/off vibrato switch. There is one output socket for miniature jack plug which allows the instrument to be channel-

led direct into amplifying equipment. The internal speaker remains on and there is a whale of an output from the organ. There is no volume control on the organ, so all level-balancing has to be done on the amplifying rig. If played unamplified, the speaker can be muted by placing the hand over the grille; tonal changes can be effected in the same way (Dubreq can supply a battery-powered amplifier if necessary). The *Stylophone* does not play chords. Let me stress that straight away. Any organ which plays chords requires three or more oscillators which could certainly not be obtained for the very modest sum of £8 18s. 6d.

The tone and power through the 50 mm speaker is quite extraordinary, but use of an amplifier is desirable for recording as this can help to produce slightly different voicing by cutting bass or treble. I have tried the organ through amplifiers, reverberation units, fuzz boxes, wah-pedals and microphones, and all sorts of interesting effects can be obtained. If the *Stylophone* is fed directly into a reverberation unit, then into the recorder, a rich, round effect can be obtained, but it is necessary to have some form of control over volume. Otherwise, the organ tends to sound monotonous if played at the same audio level and in the same voice.



I have used the *Stylophone* in combination with other instruments and the results have been extremely gratifying. As yet, however, I have not produced a symphony, although this is by no means impossible! The 1.6 octave range is rather restricting but can be increased by doubling or halving tape speed. Without doubt, the best results are achieved by using a glissando technique, sliding easily from one note to the next. Big jumps of, say, an octave, are a little more difficult. I suggested to Mr Bert Coleman of Dubreq that the lead from the innards to the stylus could be split into two, providing two styli. The instrument could then be played rather like a xylophone. In fact, I experimented with this and it works well. (If both styluses are brought into contact with the keyboard simultaneously, the higher of the two notes results. The effect is that the lower frequency note is cancelled out.)

This is an extremely well-made and workable little instrument, producing results far more professional in sound than one would think from its modest appearance. A well-thought-out leaflet is included with a year's guarantee and the instrument is British made. My model came with a battery included—something that, nowadays, one expects only from Hong Kong or Japan. There are very few criticisms, the chief one being that I feel that the instrument is too light in weight. The light, shiny case has a habit of slithering about and I overcame the difficulty by sticking 6.25 mm plastic foam on the underside. The lack of a volume control and internal speaker cut-out could easily be remedied but are not, by any means, serious omissions. After all, one should remember that this little instrument costs less than £9.

I should very much like to see Dubreq make a more elaborate version, incorporating selective voicings, speaker controls, a larger keyboard and dual styli. **Peter Bastin**

FI-CORD 600 AND 650 CAPACITOR MICROPHONES (POSTSCRIPT)

AT the end of my March review of the Fi-Cord *FC650* and *FC600* microphones, I expressed a wish to test another pair of these units, as it was suspected that the measured noise levels might not be representative of production samples. Fi-Cord's immediate reaction was to send along further microphones, together with the designer armed with a pocketful of bits to satisfy my curiosity as to the circuit of the preamplifier and the capsule construction.

The *FC650* capsule is of the single diaphragm resistance controlled type with the rear of the diaphragm open to the sound through a network of damping holes in the back plate. This combines the functions of pressure element and velocity element in just the right proportions to give optimum front-to-back ratio, with the usual cardioid polar response. The field effect transistor offers a very high input impedance, even when compared with the 100 M polarising and biasing resistors, and the output of the FET is fed directly to an emitter-follower transistor to provide the specified 200 ohms source impedance. All moisture-sensitive circuit elements are potted in epoxy resin.

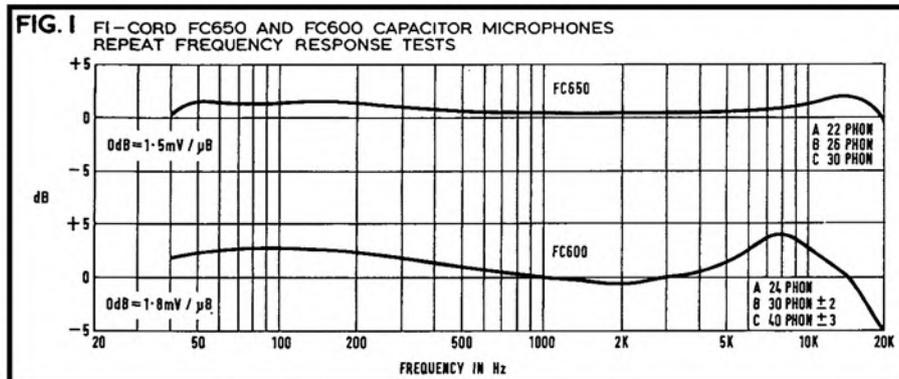
The frequency response of the second sample is almost identical to that of the first review, but the internally generated noise level is more

than 20 dB better at 22 phons when weighted to the ear's response for very low sound levels (IEC 'A' curve). The noise levels for 'B' and 'C' weightings are given for good measure. Sensitivity was exactly 1.5 mV/μB.

The *FC600* stiffness-controlled pressure microphone shows slightly more bass rise and less 8 kHz peak, combined with a higher sensitivity of 1.8 mV/μB, all of which points to a very slight reduction in the spacing of the diaphragm and back plate. The 'A' curve weighting gives an internal noise level of 24

phons; the 'B' and 'C' readings are suspect as it is difficult to find a quiet enough environment for a non-directional microphone. Very low frequency sounds, which are completely inaudible to the human ear, kick the meter and tend to obscure the true internal noise of the microphone.

Thus the specification figures, of 40 Hz to 16 kHz ±3 dB frequency response, approximately 1.5 mV/μB sensitivity and approximately 25 phon internal noise level, are completely met in these recent samples. **A. Tutchings**



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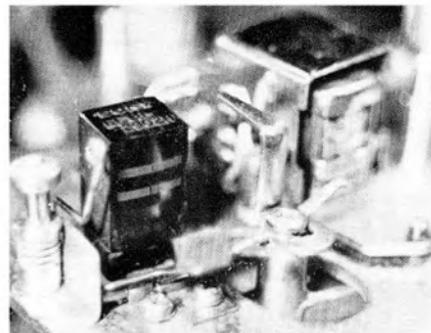
in these pages, where the sleeved capstan is widely condemned as a wow-maker. The sleeves are not as those commonly used in Japanese equipment for speed changing. They are a snug fit, held by the milled retaining screw. The only time they need removing is for frequency changing from 50 to 60 Hz mains. And then it needs a strong prising action at the bottom with a broad-bladed screwdriver to get the sleeve off.

Mains supply change, apart from the obvious voltage selector alteration, requires replacement of this sleeve and the pressure roller, then reconnection of the start capacitor adjacent to the motor, to put 1.5 μ F across the phase winding for 60 Hz, 2 μ F for 50 Hz operation. The sleeve and pinch roller are marked with a red line for 50 Hz, a white line for 60 Hz.

Circuitry of the TC200 is fairly plain with two completely separate amplifier channels and a shared oscillator. The oscillator coil gave some trouble on earlier production runs but I have not had to change one for well over a year and presume this bogey has been beaten. If trouble is experienced, look for impaired erasure as the first signs, followed by what seems to be a roughness of recording (pre-recorded tapes replaying happily). This last is caused by incorrect biasing.

Preamplifier circuits are transistorised, with 2SD64 transistors (replaced by the AC127 if in difficulty) helping keep noise levels down. Bitter experience has taught us that hiss levels are entirely dependent on the choice of transistor, and if I owned a TC200 I would be tempted to redesign the preamplifier, using a BC108/BC109 pair. But that's another story.

The valve numbers may look a bit frightening but, in fact, there are UK equivalents, or near-equivalents, available. The 6267 pentodes of the amplifier can be directly replaced by EF86 and the 30MP23 output valves are replaced by 30-A5. This last replacement is a good idea, as it happens, because one of the troubles with the 30MP23 was a grid charge build-up which

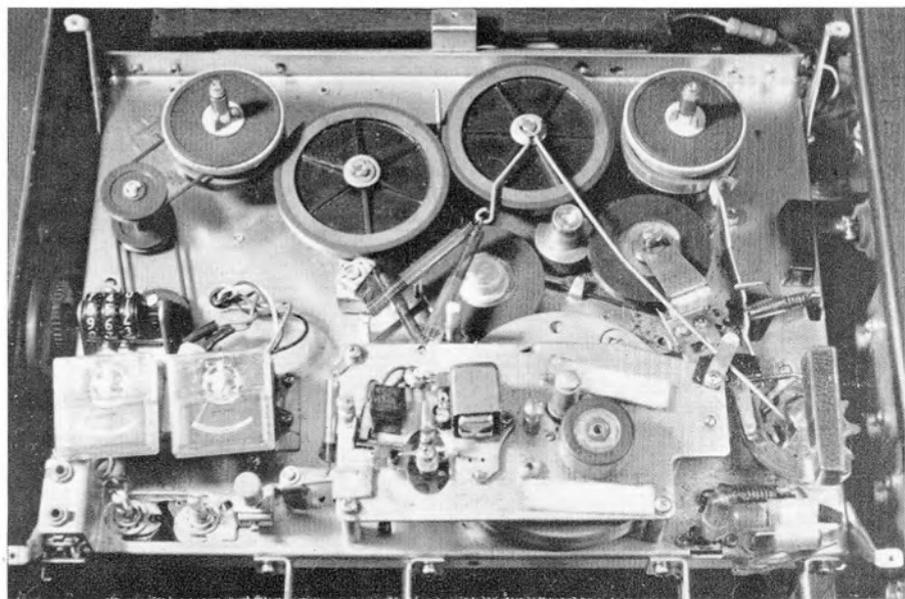


produced a positive voltage at the control grid and resulted in noise and distortion.

One final point that may help settle a few arguments: the DIN connector for record/play is not simply a paralleled duplication of the phono sockets. It permits an added facility. The DIN connector inputs are more sensitive than the auxiliary phono sockets, which have a compensating network bypassing the first stages, whereas the DIN inputs go to the microphone input point via an attenuator of approximately 18:1 at mid-frequency but with a bit of treble lift. This makes it possible to match most pickups into the machine, with perhaps a little external added matching for ceramics demanding a higher impedance load, and a shunt for some types of magnetic cartridge.

It sometimes needs a little experimentation to get the best results from various cartridges. But the -60 dB input at the microphone socket gives full modulation from a 1 mV input, and all that remains is for the impedances to be matched.

Outputs from the DIN socket are the same as from the line out socket, regrettably, which means that the signal is taken from a splitter across the secondary of the output transformer, via a simple 10 K series attenuator. This is not, in my language, a true 'Line Out', but perhaps we may postpone that argument.



14 BA screw. This is critical. Screw out anti-clockwise to increase speed. If the 14 BA screw is screwed out until its end is clear of the spring, maximum speed has been obtained. If this is not high enough, screw in the contact screw and lock it with the lock nut. This will increase the speed. Reset the speed on the small (14 BA) screw.'

It is likely that channel unbalances will trouble constructors as much as any other aspect. If compatibility with mains equipment is required, then 'all' (a small word with hidden meaning) that has to be done is to get the Fi-Cord record channels balanced. This means that the microphones should have identical outputs and that the head should put identical signals on to each track of the tape.

A suggested procedure is as follows: If two-channel mono is provided, use this to supply a signal—voice from mono microphone to both record amplifiers. If not provided, use stereo channels and short together the wipers of the ganged gain control. Listen on playback through mains equipment for a centre image. The channel putting more on tape needs attenuating. This is best done by series resistance (22 to 220 ohms) between the record amplifier emitter-follower and the following feedback pair. If greater unbalances are evident than can be corrected by the above, then transistor substitution should be tried.

Then all that remains is to get the left and right microphones and their preamps to do the same. Arrange the microphones to be used in the appropriate stereo pick-up manner. In mind here is the need for spaced use of omnidirectional types and (preferred) crossed coincident use of directional types. Speak central to the microphones, avoiding asymmetrical acoustics, and make a recording. On playback a central image should be discerned as before. The higher level channel needs attenuating and is best done by inserting a feedback resistor (22-220 ohms) between the emitter of the first transistor and the 2.2 K bypassed resistor normally connected. Again, if greater unbalances are evident than can be cured by this method, then transistor substitution should be tried.

Incidentally a quick check on the microphone

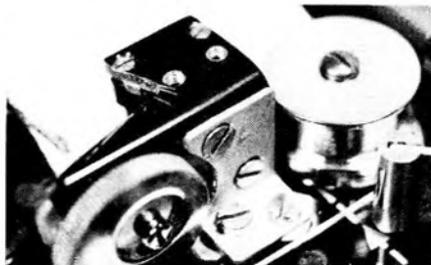


FIG. 9 Head bracket support and new guide.

output balance can be made by short-circuiting the two inputs together while speaking. The central voice will not move but of course the stereo acoustic will collapse.

Headphone monitoring central image production should be checked and adjusted by resistances in series with the monitor level control. Playback to headphones of a correctly balanced tape on the Fi-Cord should produce a central image. Probably best to put small resistances in series with the head in the channel with highest level. The above assumes that the headphones (or the listener's hearing?) are not unbalanced.

In this conversion the major difficulty has been in getting this stereo balance to be compatible among the various playback systems being employed. All the foregoing can do is to indicate some of the problems.

Although no longer servicing the IA, Fi-Cord have been most helpful in supplying information on particular aspects. It must also be recorded that Erskine Laboratories of Scarborough, the manufacturers, have been similarly helpful.

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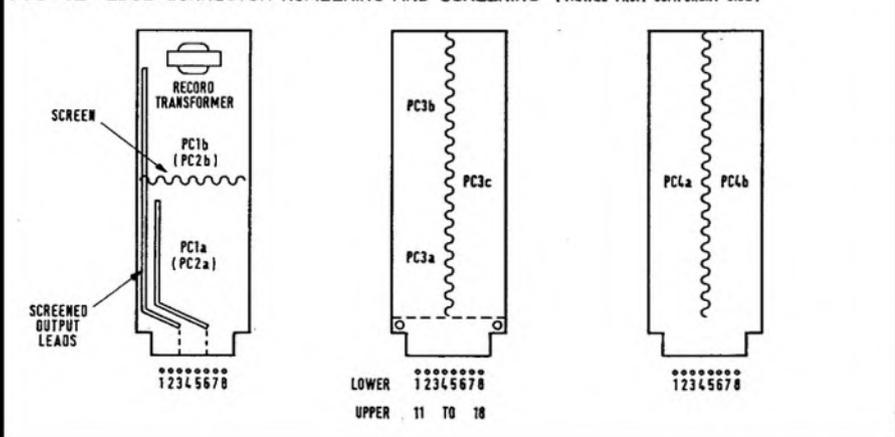
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FIG. 12 EDGE CONNECTOR NUMBERING AND SCREENING (VIEWED FROM COMPONENT SIDE)



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MISCELLANEOUS

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WANTED

Lee Electronics. The Tape Recorder and Hi-Fi Specialists wish to purchase good quality Tape and Hi-Fi Equipment for cash. 400 Edgware Road, W.2. Phone PAD 5521.

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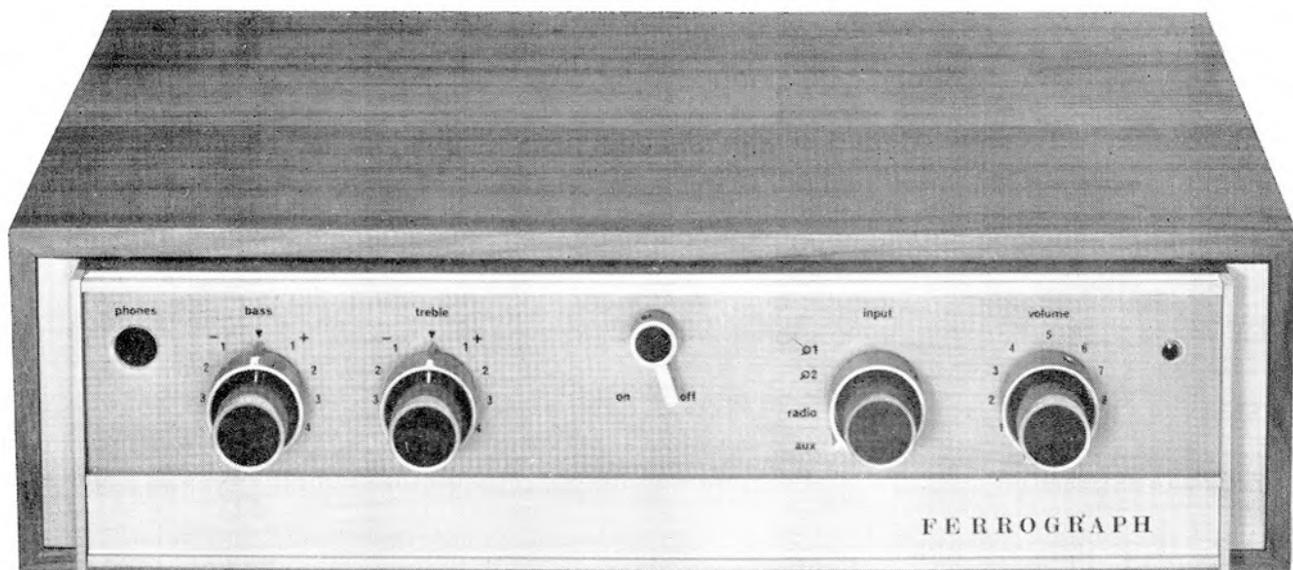
STC 4038 ribbon microphones wanted urgently. Box No. 552 (London).

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