May 1972 25p

studio sound

ELECTRONIC MUSIC

studio sound
INCORPORATING TAPE RECORDER

MAY 1972 VOLUME 14 NUMBER 5

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FEATURE ARTICLES

REGULAR COLUMNS

EQUIPMENT REVIEWS

WHATEVER HAPPENED to musique concrète? In a word, nothing. While the voltage controlled synthesiser has brought electronic music out into the market place of Pop and pseudo-Classical composition, musique concrète languishes in the rut of a tape splicing block.

Until the comparatively recent development of the synthesiser, electronic music production was virtually a matter of wrestling some kind of melody out of tone generators originally designed to assist in repairing audio equipment. This at least was the impression to be gained from the work of certain composers, where the heterodyne and the sinewave seemed a law unto themselves.

Musique concrète remains in the wrestling stage, the occupational hazard in this instance being to injure the muscles of your back through years spent bending over an editing table. The effort is nevertheless worth the musical result for the reason that musique concrète is produced from complex sounds rather than the relatively simple waveforms created in even the most elaborate modern synthesiser. The beauty of musique concrète is that the listener never knows what he will hear next. The same might be said of synthesised music, with the reservation that whatever comes next will sound distantly related to a divider organ.

Clearly the techniques of musique concrète require a degree of automation. As mentioned last month in this column, the helical scan principle employed in video recording forms an ideal basis for an audio editing machine capable of reproducing the effect of a proposed edit before any cut is made. Flatten the helix into a plain omega path, visualise one tape entering and another leaving at the peak of the Ω, rotate the head at a peripheral speed equal to the recorded speed, and there essentially you have it.

Our second suggested aid to musique concrète composition is based on the independence of time from pitch produced by devices such as the Eltro *Tempophon*. This too uses rotating heads, the exact principle being described in the late H. G. M. Spratt's *Magnetic Recording Handbook*. It allows speech to be increased in wordrate without the previously inevitable Mickey Mouseing. More usefully it permits a particular taped sound to be reproduced at any desired pitch. Combine this facility with keyboard-controlled head speed and perhaps musique concrète will come into its own.

CORRESPONDENCE AND ARTICLES

All STUDIO SOUND *correspondence should be sent to the address printed on this page. Technical queries should be concise and must include a stamped addressed envelope. Matters relating to more than one department should occupy separate sheets of paper or delay will occur in replying.*

Articles or suggestions for features on all aspects of communications engineering and music will be received sympathetically. Manuscripts should be typed or clearly handwritten and submitted with rough drawings when appropriate. We are happy to advise potential authors on matters of style. Payment is negotiated on acceptance.

SUBSCRIPTION RATES

Annual UK subscription rate for STUDIO SOUND *is £3 (overseas £3.80, $8 or equivalent).*
Our associate publication Hi-Fi News *costs £3.24 (overseas £3.66, $8.64 or equivalent). Six monthly home subscriptions are £1.50* (STUDIO SOUND) *and £1.62* (Hi-Fi News).

STUDIO SOUND *is published on the 14th of the preceding month unless that date falls on a Sunday, when it appears on the Saturday.*

PAST ISSUES

A small number of certain past issues may still be purchased from Link House, price 31p each including postage.

Photostat copies of any STUDIO SOUND article are available at 25p including postage.

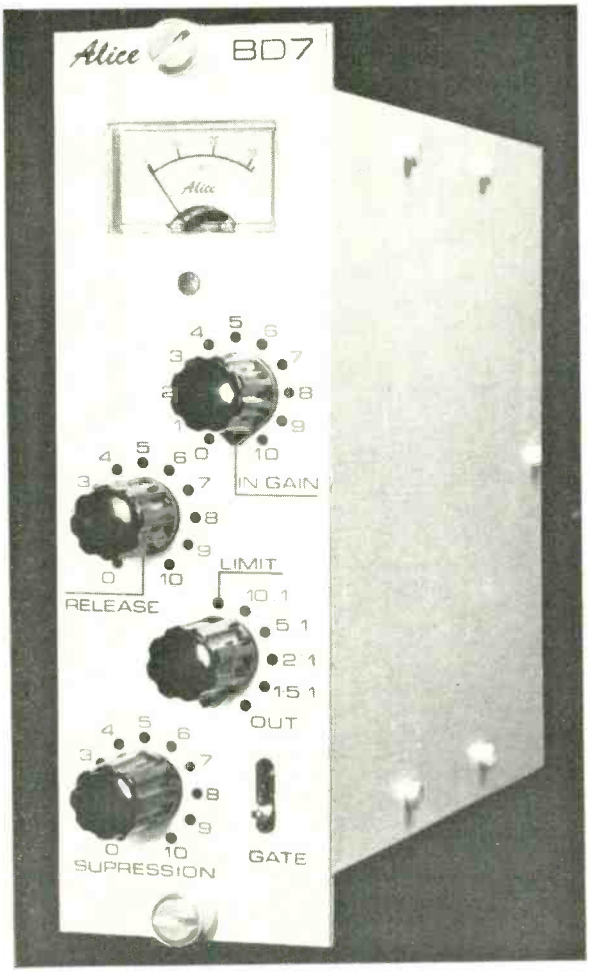
BINDERS

Loose-leaf binders for annual volumes of STUDIO SOUND *are available from Modern Bookbinders, Chadwick Street, Blackburn, Lancashire. Price is 85p. Please quote the volume number or date when ordering.*

For a long time you've been asking us for a variable ratio compressor.

Simple and quick to operate and beautiful to listen to.

Here it is—



By the way—

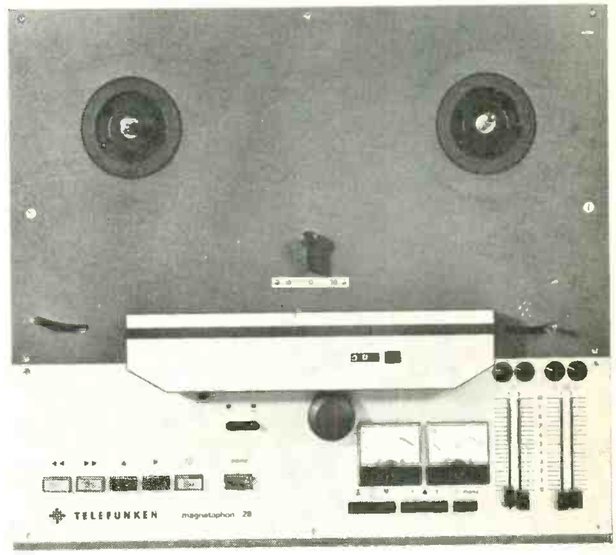
You may notice the variable suppression noise gate we have added.

You can use this compressor where before you would never have dared.

Alice (Stancoil Ltd)

15 Sheet Street, Windsor, Berks.
Tel. Windsor 61308

TELEFUNKEN M28A £633



MAGNETOPHON M28A professional tape recorder by Telefunken, the company who made the world's *first* tape recorder.

- **Three-motor tape transport** at $3\frac{3}{4}$ and $7\frac{1}{2}$ ips ensuring maximum speed constancy.

Fully comprehensive mixing facilities.

- **Solid state electronics** are used throughout. Modular construction ensures trouble-free maintenance and replacement of parts.
- **Relay operated transport control** operated by illuminated push buttons requiring only fingertip operation.
- **Two-channel monitoring and VU-meter amplifier** can be switched to two modes. In the 'before-tape' mode the amplifier is connected to the output on the mixer, while in the 'after-tape' mode it is connected to the output of the replay amplifier. Two large VU-meters calibrated to international standards are provided.
- **Interchangeable head assembly** comprising half-track, stereo, erase, record and playback heads, is mounted on a single rigid plate fixed to the main chassis. It is normally not necessary to replace or adjust heads during the normal life of the machine.

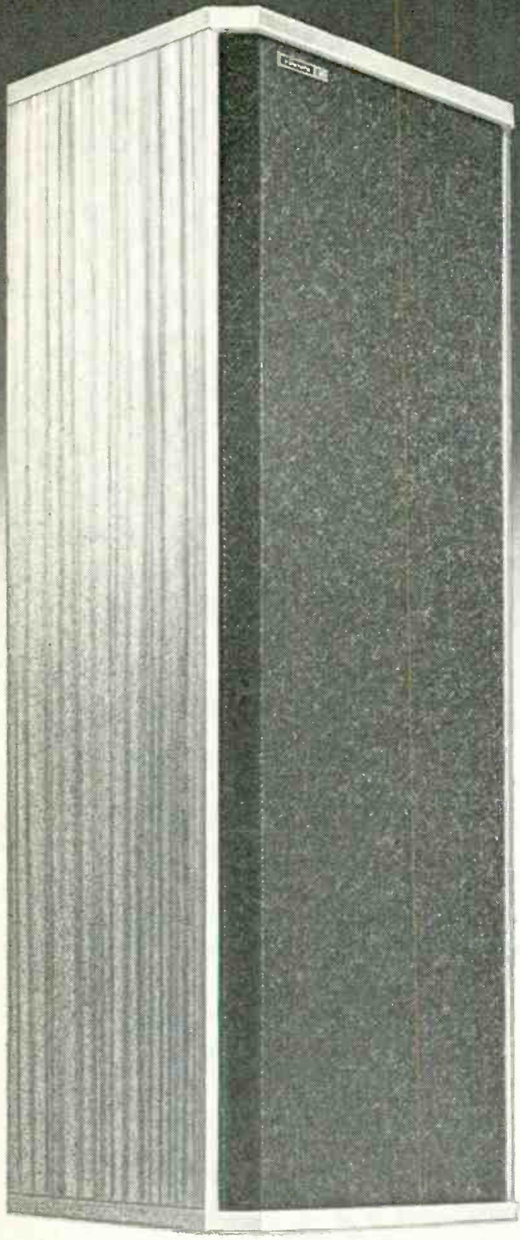
Broadcast studio versions. Models 28B and 28C are provided with tape speeds of 15 and $7\frac{1}{2}$ ips, but have no mixing or monitoring and VU-meter amplifier. Model 28B is equipped with full-track heads.

Model 28C has two-track heads and track selector switch.

A.E.G. Telefunken
A.E.G. House
Chichester Rents,
Chancery Lane,
London WC2
Tel: 01-242 9944

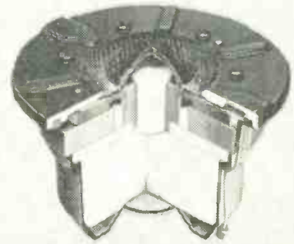
Celestion Loudspeaker Engineering advances the state of the art to a new plateau.

Ditton 66 Studio Monitor



Illustrated above is the Ditton 66 showing the beautiful appearance of the acoustic enclosure.

1.) Celestion's new super tweeter. 2.) New design 'pressure' mid-range unit. 3.) Ultra Linear 12" Bass drive unit. 4.) A.B.R. ensures controlled bass down to 16 Hz. 5.) Precision crossover for perfect system integration.



Section of the new Celestion mid-range unit giving superb power handling and detail.

Celestion Ditton Series

Loudspeakers for the Perfectionist

ROLA CELESTION LIMITED DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK

BEYER DYNAMIC

Dynamic Headphones

DT 900

Dynamic Stereo Headset

Lightweight, gaily coloured and very comfortable to wear. And—of course—high fidelity.

Specifications:
Frequency Response: 30—18000 Hz. Output Level at 400 Hz and 1 mW: 114 dB over 2·10⁻⁴µbar. Rated impedance: 600 Ω per cartridge. Required voltage: appr. 400 mV/cartridge. Maximum Load: 200 mW or 11 V/cartridge. Connection cables: 900.4 = connector LS 7, 900.7 = jack plug, 900.10 = 5 pin DIN connector.

DT 100 V

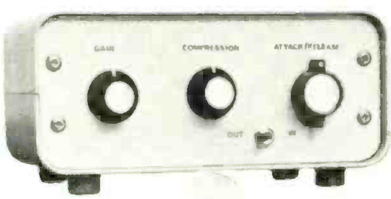
A high fidelity headset with a built-in induction receiver. No trailing cables, ideal for both home use and professional applications. Powered by 9 V battery, equipped with ON-OFF switch and volume control. Can also be used cable bound for stereo listening.

Specifications:
Frequency Response: 30—20000 Hz. Output Level at 400 Hz and 1 mW: 110 db over 2·10⁻⁴µbar. Rated Input: appr. 600 mV per cartridge. Peak Power Load: 1 W or 20 V per cartridge. Impedance: 2 x 400 Ω.

BEYER DYNAMIC (GB) LTD.

1 Clair Road, Haywards Heath, Sussex **Telephone Haywards Heath 51003**

CUT YOUR LEVEL PROBLEMS DOWN TO SIZE; WITH A CHADACRE ELECTRONICS AUDIO COMPRESSOR TYPE 9521



Almost every audio source can benefit from a degree of compression, that is to "tame" the dynamic range of the programme.

Compression will tend to increase the density of the sound, this is due to the fact that the low and medium levels are increased, relative to the maximum levels.

"The Ratio" of the compressor will determine the density, i.e., the rate at which the gain increases: e.g., a ratio of 6:1 simply means that for a 6 dB increase of input signal the resulting output will only rise 1 dB.

The speed at which the compressor reduces the level is termed attack "time", and the optimum attack time for a compressor lies between 1 and 10 Ms.

The rate at which the compressor takes to restore its gain back to normal is termed the "release time".

Both of the above time characteristics are adjustable on the 9521 compressor. They are fast attack/fast release, medium attack/medium release, special attack/slow release. Specially designed for automatic level control of a tape recorder. These "time constants" are selected via a 3-position switch. Also adjustable: input gain control, compression control, compressor in/out* for comparing the uncompressed signal and on/off control* to disconnect the supply.

The uses the 9521 compressor may be put to are very comprehensive. Below are listed just a few.

In a mixing console, where it may be inserted in individual channels between the microphone anplifier and line amplifier. Used in this sphere it will prevent overload distortion of the following stages, and may also be used to create special effects, which may suit the artistic requirements of the programme.

In conjunction with a discotheque system, to give a constant level, with the peak level; the compressor will make the R.M.S. value appear as a constant peak level, thereby packing the maximum "punch" for this type of application.

It may also be used in public address work, where it will compensate for poor microphone technique. Intelligibility may be improved and enable the amplifier to be used at a lower gain setting, with the consequential risk of acoustic feed-back howls greatly reduced.

The world of radio communication may also reap the advantages of the compressor. By applying the 9521 in this field, the "talk power" or intelligibility over a noisy channel is greatly improved, it is preferable to speech clipping, as it does not introduce harmonic distortion.

Finally, it can be effective to the hard of hearing, who may need to listen to the radio or television at an uncomfortably high volume (to others) in order to hear everything. If, however, the dynamic range of the material is compressed, the annoyance factor caused to others by the peak sound levels is reduced.

The 9521 compressor is available either as a Module mounted on a Painton 15-way plug; order 9521/M. Or built in an attractive robust case. The input and output connections are terminated on a Din socket.

The power requirements may be either satisfied from internal batteries† (ample space provided) or an external power supply may be fed into the two banana sockets provided. Order 9521/C.

** Available on cased units only.* *† Two Type PP9.*

9521—SPECIFICATION

Power requirements: 18v/4·5mA—30v/6mA.
Input impedance: 50kΩ. Output impedance: 600Ω. Ratio: continuously variable, 1:1 through 6:1. Unweighted noise level: 90dB. Fast attack/fast release: may be pre-set anywhere between 1Ms and 10Ms, normally set for 10Ms at factory. Medium attack/medium release: 0·5secs. Fast attack/slow release: attack approx. 3Ms, release approx. 7secs.*
** Longer release times available on request.*

PRICES

9521/C	1-4 £28·50	5-10 £26·50	11-25 £24.
9521/M	1-4 £19·50	5-10 £15·50	11-25 £13·50.

CHADACRE ELECTRONICS LIMITED

(AUDIO DIVISION)

43 CHADACRE AVENUE, CLAYHALL, ILFORD, ESSEX **TELEPHONE: 01-550 7119**

Precis

Metric/Imperial Equivalents

Tape speed

centimetres/second	inches/second
38	15
19	7.5
9.5	3.75
4.75	1.875

Tape length

metres	feet
270	900
360	1,200
540	1,800
720	2,400
1,080	3,600
1,440	4,800

Tape width

millimetres	inches
50	2
25	1
12.5	0.5
6.25	0.25

Distance

1 metre (m) = 39.370113 inches
1 centimetre (cm) = 0.393701 inches
1 millimetre (mm) = 0.039370 inches
1 kilometre = 0.6214 miles

Weight

1 kilogram (kg) = 2 pounds 3.37 ounces
1 gram (g) = 15.432 grains or 0.564383 drams
1 Tonne (metric ton, 1,000 kilogrammes) = 2204.6 pounds.

News

Macinnes move

THE URGENT need for extra space to handle Crown loudspeakers was the reason given by managing director, Ian Marshall, for moving Macinnes Laboratories offices and service department to Suffolk. Full address is Stonham, Stowmarket, Suffolk (Tel. Stonham 485). Macinnes have appointed Audio T, 119 Oxford Street, W1, as the London outlet for Crown International.

Electronic Music Studios Ltd

WITH REFERENCE to the editorial note on page 30 and the advertisement on page 6 (April issue), Electronic Music Studios Ltd inform us that 'Phasor Electronics' are *not* agents for EMS equipment. Our apologies to EMS for publishing the original information which was accepted in good faith.

Above: Neumann KMS *85I*.

Top right: Ortofon *GO701*.

Bottom right: King *600EC*.

Below: Sigma quadpot.

Shure literature

A TWELVE PAGE brochure detailing the Shure range of studio microphones and another dealing with signal controllers have been produced by Shure Electronics Ltd, 84 Blackfriars Road, London SE1 8HA. Copies are available on request

Stereo cutting amplifier

A HIGH PERFORMANCE stereo cutting amplifier, the *GO 701* (powered by *GE 701*) is announced by Ortofon. A sinewave output of 500W permits peak velocities of more than 30 cm/s at 20 kHz. A four pole impedance matching network between the output stage and cutting head counteracts the rising head impedance which normally prevents the transfer of high power in the treble region. Frequency response is flat well below 20 Hz (± 1 dB to 18 kHz, 3 dB down at 36 kHz), permitting half speed recording. A cutter temperature meter is incorporated, together with the usual cutter current meter. Protection from thermal overload is provided by an automatic overload control. Physical dimensions are 438 x 132.5 x 337 mm deep, 20kg. Further data is available from Ortofon, 5 Trommsalen, DK 1614 Copenhagen V, Denmark.

'Little dipper'

. . . IS WHAT Bauch choose to call the Universal Audio *565* filter set. The unit incorporates an 18 dB per octave filter operating over the 20 to 200 Hz range. Two centre frequency filters provide 50 dB lift or rejection with a notch width variable to 5 per cent. These function between 20 Hz and 20 kHz. A further 18 dB per octave filter operates between 2 and 20 kHz. Applications of the *565* include removal of mains hum, heterodynes, camera noise and lighting buzz. The unit also lends itself to producing phasing and double phasing effects. Basic price is £277. Agent: F. W. O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ.

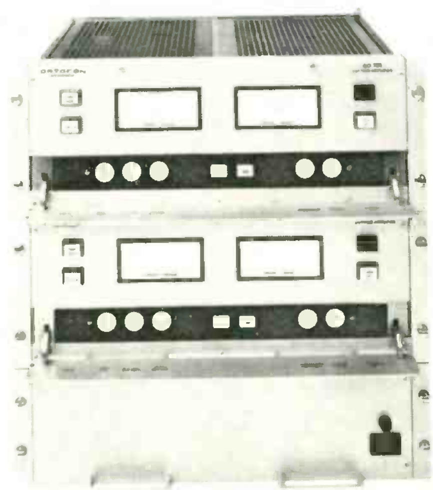
Quadpot

PROPORTIONAL CONTROL of up to four characteristics from a single joystick may be accomplished with a Sigma quadraphonic pan potentiometer. High resolution, low noise, and protection against dirt are claimed, nominal resistance value being 3.9 kΩ. Manufacturer: Sigma Products, 72 St Andrews Road, Northampton.

Cassette loader

THE ABILITY to load automatically any predetermined length of blank or prerecorded tape on to cassettes is featured in the *600EC* loader now being marketed direct to Europe by King Instrument Corporation, PO Box 496, Kane Industrial Drive, Hudson, MA 01749, USA. The complete loading sequence is automatic and proceeds as follows. The winder cuts the leader, aligns the tape, and splices, spooling starting immediately. Spooling stops exactly on the cue tone of a prerecorded programme or at a predetermined length of blank tape. The tape is cut, aligned with the leader, and the second splice completed before the loaded cassette is ejected from the winder. One operator using two *600EC* loaders can produce over 1,800 C60 cassettes per eight hour shift. The only function performed by the operator is placing the cassette on the winder. Compressed air tape handling is employed.

continued 14



the critical stage in the birth of great recordings

– the stage when highly skilled craftsmen, working under the direction of top project engineers, build sound control equipment under laboratory conditions.

Every Neve console is designed to meet the client's individual requirements and built to meet the most exacting standards.

Neve

Rupert Neve & Company Ltd.,
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Royston,
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England.
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Telex 81381

Rupert Neve of Canada Ltd.,
7528 Bath Road,
Malton,
Toronto,
Ontario,
Canada.
Tel: 416-677 6611

Rupert Neve Incorporated,
Berkshire Industrial Park,
Bethel,
Connecticut 06801
U.S.A
Tel (203) 744 6230 Telex 969638

APRS '72

ARRANGEMENTS FOR the fifth APRS Exhibition are being finalised by the Association of Professional Recording Studios. The exhibition will this year be held at the Connaught Rooms, Gt Queen Street, Kingsway, London WC2, from Friday June 23 to Saturday June 24. (not June 22 and 23 as stated by the APRS n their April advertisement). Trade tickets are available from the APRS secretary, E. L. Masek, 23 Chestnut Avenue. Chorleywood, Hertfordshire WD3 4HA.

Neumann hand microphone

A CARDIOID CAPACITOR microphone specifically for high level Pop applications has been developed by Neumann, the *KMS 85I*. Based on the *FET-80*, it incorporates a multistage mechanical filter and dual wall housing with interwall damping material. The capsule is mounted on an elastic suspension and the bass sensitivity attenuated to compensate for proximity effect. Neumann agents are F. W. O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Hertfordshire WD6 4RZ.

Mini Studio

A REMARKABLE new product from Lexor is the *Quiet Chamber* transportable sound studio. This is claimed to attenuate commonplace levels of extraneous noise (remote traffic, footsteps, conversations, office machinery, etcetera) to a degree permitting 'a professionally quiet recording'. Internal dimensions are 1.14 x 1.14 x 1.9m high, the chamber can accommodate up to two persons with or without equipment. Standard fittings include lighting, power outlets, two-speed ventilation, floor carpet, a baize covered removable desk, cable entry facilities and a lockable door. All the electrical equipment is prewired and no connections need be made when assembling or dismantling. A range of optional fittings is offered. The chamber dismantles into six separate panels, none weighing more than 46 kg. A single spanner (supplied) is the only tool required to assemble and dismantle the chamber. Basic price is £348 and delivery is in the four to six weeks region. Manufacturer: Lexor Electronics Ltd, 25/31 Allesley Old Road, Coventry.

Patents Review

MR Joseph Allen, an American, has patented a new musical instrument (BP 1258853) based on the electronic guitar. It is the same size as a guitar but the strings stop short of the fingerboard. Each string has two transducers; one to pick up transverse and the other longitudinal vibrations of the string.

The fingerboard is electronic and consists of a number of switches operated by finger capacitance. These switches control oscillators and are played as a fingerboard is normally played when strings are present. There are six rows of switches and each of the rows is tuneable.

Plucking the strings in various different positions modulates the oscillator signals according to the voltages produced by the transducers.

A scheme for frequency modulating an oscillator with a light beam is described by RCA in BP 1261265. Laser light is shone onto the bottom of a slot in the N region of a Gallium Arsenide PN junction. The light creates hole-electron pairs and the capacitance of the junction lowered. In conjunction with other reactive elements in the circuit this change in junction capacitance lowers the frequency.

For those interested in such matters Matsushita have patented a new method of analysing voices. Instead of simply filtering the voice it is compared to a standard and the difference is converted to a variable frequency signal which corrects the frequency of the original signal. After this the signal is split into a number of frequencies by a number of band pass filters. Each of the bands is then compared for maximum amplitude, and the frequency band in which the maximum values occur is stored.

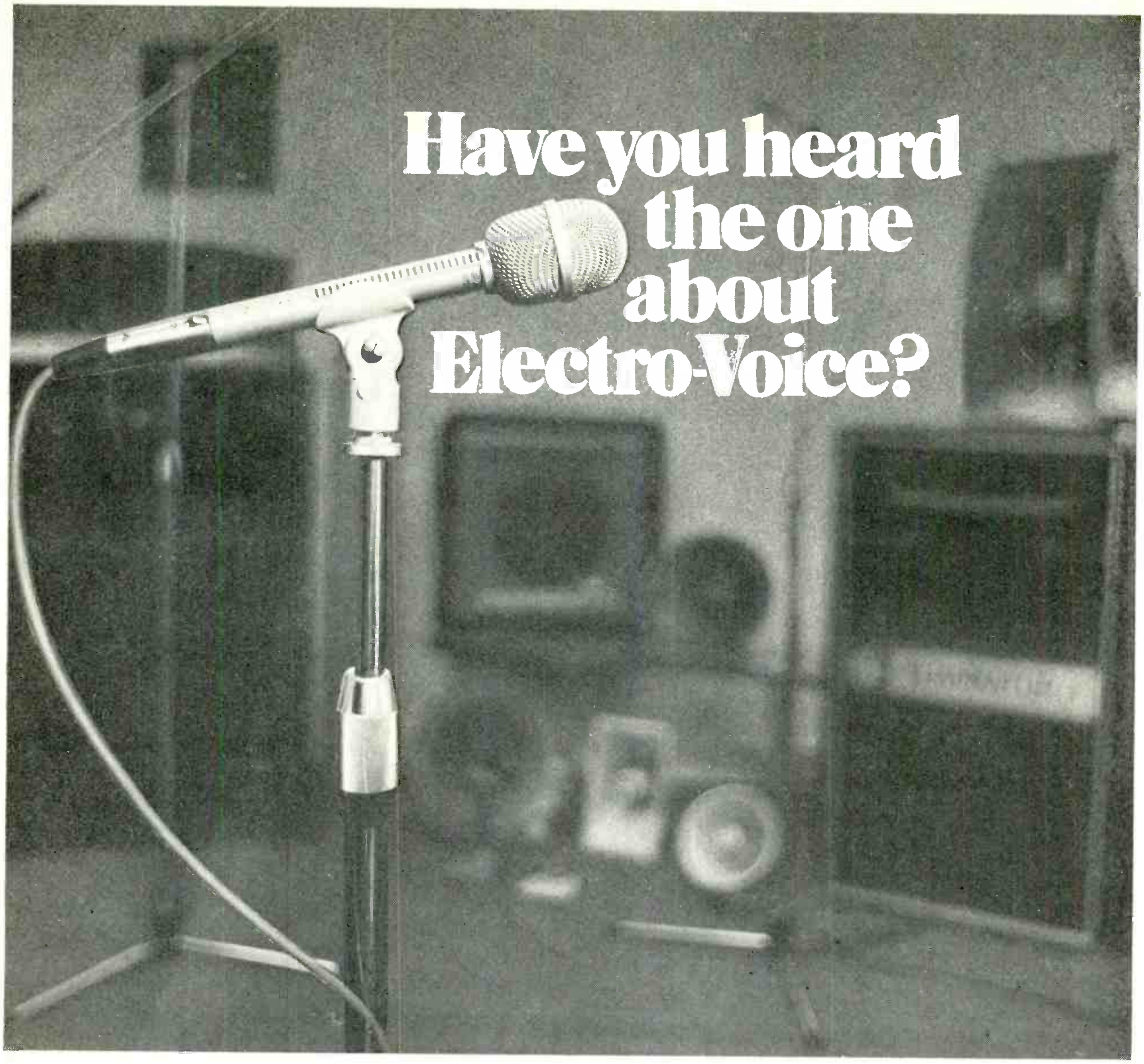
Patent 1263606 has been taken out by Eastman Kodak, who claim that their invention will enable tape to be spliced ultrasonically without making it brittle. The tape is placed between two surfaces, an upper and a lower, at an acute angle to one another—from two to five degrees—and overlapped. The two surfaces are brought together and the tape is joined by the ultrasonic vibration of the upper surface.

Should you ever want to use an acoustic lens, the Holotron Corporation has taken out a patent for some improvements to existing methods of producing them (BP 1263749). Various methods are described, and they are all variations on a theme: how best to fill a plastic bag with the 'refractive liquid'.

Hugh Ford, a contributor to this magazine, has patented a method of synchronising film and tape transports (BP 1261917). A rotary shaft is fitted to the film transport such that the shaft rotates once for a given number of frames. To this shaft is attached a transducer which will emit a given number of pulses per revolution. The pulse frequency is then compared to a reference source, such as is provided by tape transport, and a phase comparison is made between the two. Normal feedback control techniques are applied to adjust the speed of the film transport to reduce the phase lag or lead. Mr Ford states a formula relating the number of frames, the pulses per revolution, the reference frequency and the number of frames per second.

A disadvantage of the divider-organ principle is that if one of the notes should become out of tune those related to that note by octaves will also be so affected. Philips have patented an instrument which claims to overcome this disadvantage (BP 1264143). This consists of a chain of frequency dividers following a master oscillator. The principle of the invention is that if outputs are taken from selected dividers and added together they will be in a fixed relationship to others derived in a similar way arranged to form notes of the scale, no matter what the variations in the frequency of the master oscillator.

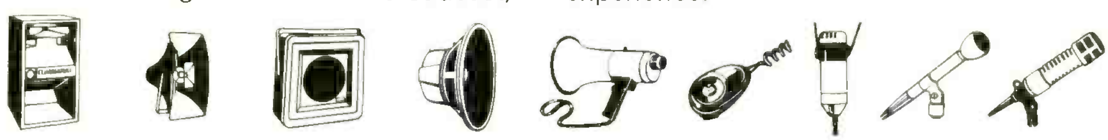
A sound effects generator which eliminates the problems of poor head contact often encountered in such devices is claimed by Sergio Montanari of Bologna (1264230). The problem is that air bubbles are formed between the magnetic material and the disc to which it adheres. The above gentleman's invention obviates this problem by putting a spiral groove on the surface of the disc.



It's more than likely that you have because most people in this business have heard of or experienced the world famous Electro-Voice range of products. So they don't need any introduction.

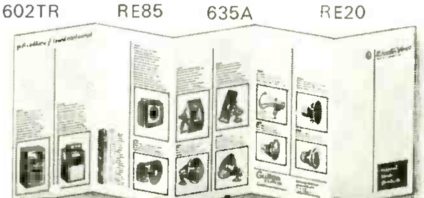
Gulton Europe are now manufacturing and marketing Electro-Voice broadcast, p.a. and recording microphones together with a range of sound reinforcement speakers.

This most important development means that Electro-Voice and their customers are already benefiting from Gulton's wide, technical and electronic experience.



ELIMINATOR 1 FC100 MUSICASTER SRO15 PM16 GAC 602TR RE85 635A RE20

As an expert you really do need a copy of our new product information brochure, so why not contact Gulton Europe for yours.
Your personal contact is Len Cole.



Gulton EUROPE

Gulton Europe Limited
ELECTRO-VOICE DIVISION
The Hyde, Brighton BN2 4JU
Telephone: 0273 66271 Telex 87172

Electro-Voice®
MICROPHONES AND PUBLIC ADDRESS EQUIPMENT

THE FOLLOWING list of Complete Specifications Accepted is quoted from the February issues of the Official Journal (Patents). Copies of specifications may be purchased at 25p each from The Patent Office, Orpington, Ken BR5 3RD.

February 2, 1972

1266555
Associated Eng Ltd
Electrical modulating arrangements
1266562
Ricoh, KK
Information processing arrangements
1266571
Bosch GmbH, Robert
System for track guidance of a movable light spot for scanning information patterns
1266579
International Computers Ltd
Digital data storage systems
1266594
Siemens AG
Cathode ray tube scanning circuit arrangements
1266598
Braun AG
Slide projector driving arrangement
1266621
General Electric Co Ltd
Homopolar dynamo-electric machines
1266627
Bell & Howell Co
Motion picture projection apparatus
1266630
Marconi Co Ltd
Amplifier arrangements
1266659
Matsushita Electronics Corporation and Matsushita Seiko Co Ltd
Drive control circuit for an induction motor
1266665
Bendix Corporation
Fluid oscillator
1266675
Motorola Inc
Miniature transmitter receiver housing
1266686
Marconi Co Ltd
Signal coding and decoding systems
1266709
Texaco Development Corporation
Amplifier system
1266732
Autocue Ltd
Prompting devices
1266741
Compagnie Francaise Thomson Houston—Hotchkiss Brandt
Optical character recognition systems
1266759
Nippon Electric Co Ltd
Synchronised carrier regeneration systems
1266804
General Electric Co
Fluidic oscillator
1266823
Sony Corporation
Cassette tape recording and reproducing apparatus
1266847
Philips Electronic and Associated Industries Ltd
Three-dimensional storage devices comprising magnetic memory elements
1266886
Micro Consultants Ltd
Constant current generators
1266908
Western Electric Co Inc
Class B transistor amplifiers
1266915
Kratomi, S.
Electrical programme control apparatus
1266916
Nippon Kogaku KK
Optical system for producing focused images of two separated objects in the same plane
1266929
Western Electric Co Inc
Speech signal transmission
1266930
Nippon Selfoc Co Ltd
Noise suppression optical filter
1266931
Kaiser Aerospace & Electronic Corporation
Visual display systems
1266933
Omron Tateisi Electronics Co
Apparatus for controlling clock pulses
1266962
Micro Consultants Ltd
Analogue to digital converter
1266999
Amp Inc
Electrical socket and an insulating carrier for an integrated circuit module
1267000
Matsushita Electronics Corporation
Method and apparatus for making colour cathode-ray tube
1267012
Bendix Corporation
Solid state ring laser
1267025
Messerschmitt-Bolkow-Blohm GmbH
Information storage means
1267085
RCA Corporation
Production of amplitude modulated light by a solid state oscillator
1267088
Dudley, L P
Stereoscopic photography
1267096
International Standard Electric Corporation
Image storage cathode ray tubes
1267101
Sony Corporation
Magnetic recording and/or reproducing apparatus
1267133
Sony Corporation
Recording and reproducing apparatus using magnetic tape cassette
1267142
Ampex Corporation
Combined demagnetiser and cleaner
1267153
International Standard Electric Corporation
Encapsulation of electrical components
1267157
Philips Electronic & Associated Industries Ltd
Tape transport device
1267211
Integrex Ltd
Stereo decoding systems
1267226
Adelmann, H
Sound proof window with natural ventilation
1267242
Dornier System GmbH
Direct current to direct current converter
1267243
Minnesota Mining and MFG Co
Transparency and sound track supporting device
1267251
Nippon Victor KK
Colour video signal correction system
1267274
Philips Electronic & Associated Industries Ltd
Recording and/or playback apparatus
1267283
Bell & Howell Co
Variable speed film movement mechanism
1267301
Reliance Electric AG
Stabilized sine wave inverter
1267319
Standard Telephones & Cables Ltd
Multitrack magnetic recording head
1267335
Borg-Warner Corporation
Inverter with prechange circuit
1267339
Leclanche SA
Method of detecting the end-of-charge condition of an electric storage battery under charge and device for the carrying out of this method
1267336
Plessey Co Ltd
Tape playback machines
1267388
Matsushita Electric Industrial Co Ltd
Semiconductor mechano-electrical transducer

February 9, 1972

1267408
RCA Corporation
Kinescope bias tracking circuits
1267410
Standard Telephones & Cables Ltd
Switched filter networks
1267414
Ricoh, KK
Electrostatic recording arrangements
1267434
International Business Machines Corporation
Apparatus and method of testing a magnetic recording medium
1267463
Westinghouse Electric Corporation
Frequency difference detector
1267487
Agfa-Gevaert AG
Film or tape spool
1267595
Dyer, NH, Perrins, M A, and Grimstone, R F
Motion picture projection apparatus
1267607
Fujitsu Ltd
Time division multiplex communication systems
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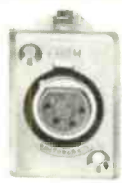

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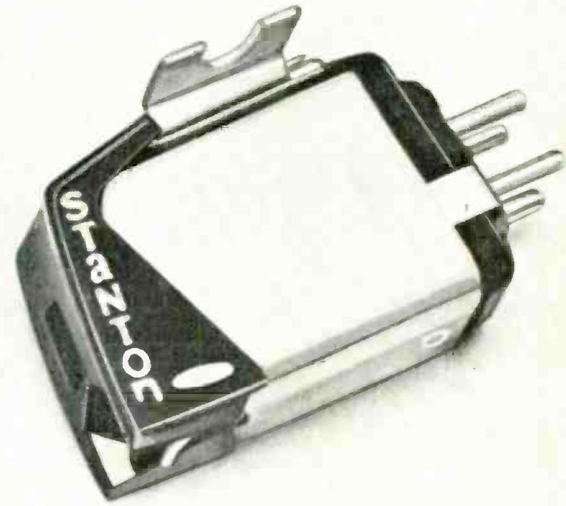

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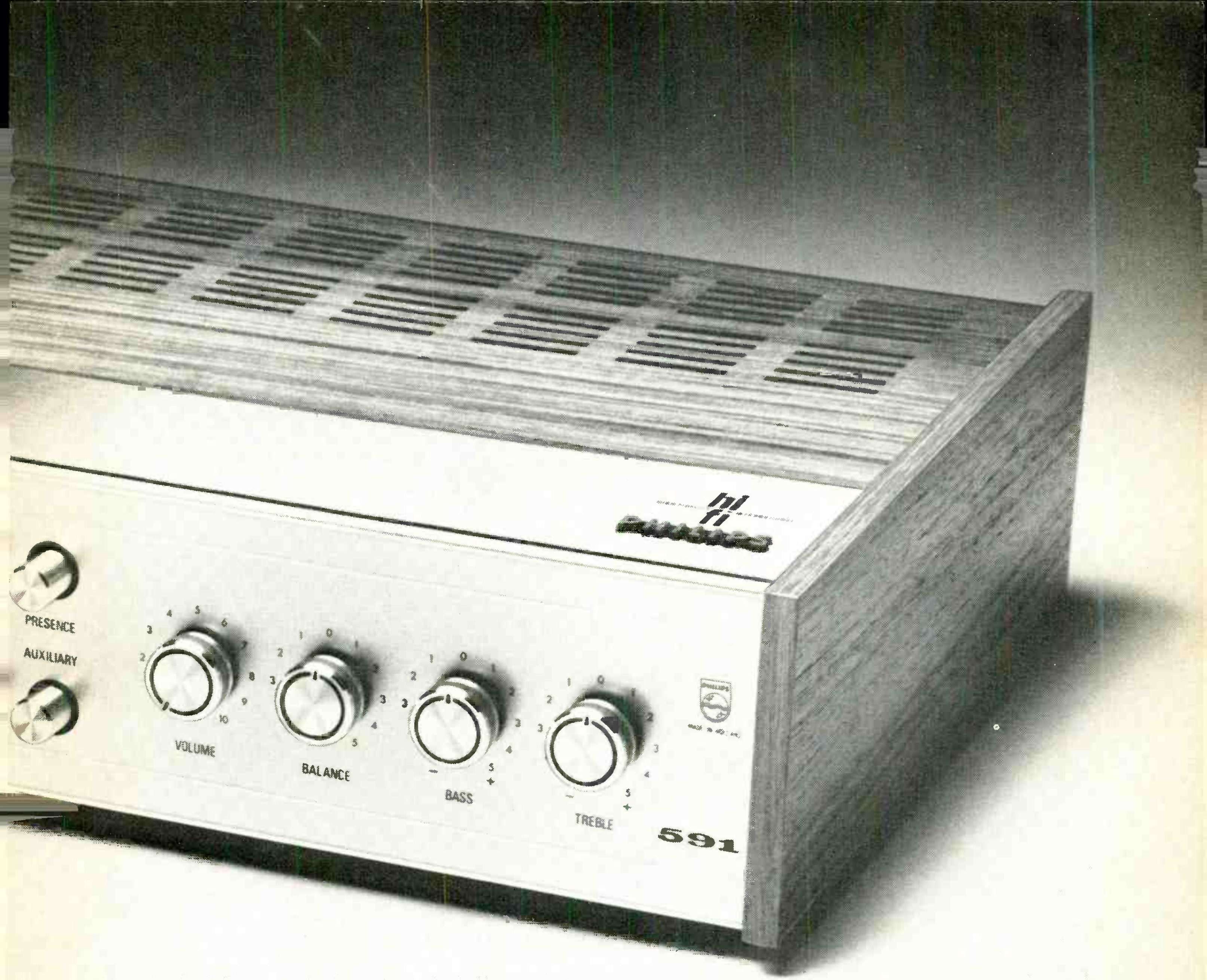

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Magnetic Storage

By Erich Sobotta (*Production Head for magnetic disc storage equipment, BASF, Willstätt*)

MAGNETIC storage of signals consists of converting alternating electric currents or trains of impulses into fluctuations in magnetisation.

The phenomenon of magnetism has been known for a very long time. It is stated that Thales of Miletus (*c* 624 to 546 BC) was already acquainted with the property exhibited by certain iron ores of attracting small particles of iron. This property was particularly pronounced in minerals obtained in the vicinity of Magnetia, a city in Thessaly, and these *lithos magnetes* are the origin of the term *magnetism*.

The property a magnet possesses of pointing to the magnetic north was discovered in ancient times in East Asia. However, it was not exploited practically for the mariner's compass in Western Europe until the Middle Ages. Quantitative investigation of the laws of magnetism began in 1785 with Coulomb, who discovered that the force of attraction or repulsion existing between two bar magnets is inversely proportional to the square of the distance between them.

The magnetic field

The sphere of influence of a magnet is referred to as its magnetic field. Any particle in this field is subjected to a force. It is well known how a compass needle aligns itself in the earth's magnetic field. The end pointing to the north is called the 'north pole' of the compass needle; and the opposite end, the 'south pole'. This directive effect is retained if the needle is broken in two; in other words, the north pole is inseparable from the south pole.

Now if the two needles thus formed are suspended so that they are free to rotate and are then brought close together, the north pole of the one will point to the south pole of the other, i.e. the unlike poles attract one another.

The field of the magnet can be easily portrayed. If iron filings are scattered over a piece of paper below which a magnet has been placed, the filings will arrange themselves along the curved lines that run continuously from the one pole to the other, as is shown in **Fig. 1 (a)**. These lines are called lines of force, because in the field in which they can be detected a force is exerted on any other bodies present in the field; for instance, a compass needle can be made to rotate out of its alignment in the earth's field if a stronger magnet is brought close to it. The number of lines of force is referred to as the total magnetic flux, Φ and this quantity divided by the area, A, yields the flux density or induction, which is denoted by B, i.e.

$$B = \Phi/A \qquad (1)$$

The unit of flux, Φ is the weber (formerly the maxwell), and the unit of flux density, B, is the tesla (formerly the gauss).

1 maxwell = 10^{-8} weber
1 gauss = 10^{-4} tesla

An important discovery was made by Oersted in 1820. He observed that a magnetic field is also formed when an electric current is passed through a conductor; the presence of this field can be verified by means of a compass needle. The direction in which the needle is deflected depends on the direction in which the current is flowing. If the conductor is perpendicular to the plane of a sheet of paper over which iron filings have been strewn, it can be seen that the lines of force form concentric circles having as centre the axis of the conductor (**fig. 1b**). Their direction can be determined with the aid of a compass needle. If the current in the conductor flows downwards through the plane of the paper, as is shown in **fig. 1b**, the lines of force run clockwise. The force exerted by the field of a permanent magnet or by the magnetic field caused by a current flowing in a conductor on an imaginary unit magnetic pole placed in the field is called the field strength, H. The unit for field strength is the amp/metre or the oersted (1 oersted is approximately 80 A/m). If the amount of current, i, flowing through the conductor is doubled the force exerted on the unit magnetic pole is also doubled, in other words, H is proportional to i, or

$$H \propto i$$

If the conductor is now bent to form a loop, as is shown in **fig. 2a**, the magnetic lines of force encircling the wire will run in the one and the same direction on the inside of the loop. The effect becomes more apparent if several of these loops are arranged in series and an electric current is passed in the same direction through each of them or, more simply, if the individual loops are connected to form a coil or solenoid (**fig. 2b**). In this case, the magnetic field established around the coil when the current flows is similar to that of the bar magnet shown in **fig. 1a**: the lines of force bundled together on the inside emerge from the coil at the one end and follow a curved path until they re-enter the coil at the other end. The larger the number of turns, n, in the conductor per unit length of coil, the greater the flux density and thus the field strength. If l is the length of the coil, the relationship is expressed mathematically by

$$H = in/l \qquad (2)$$

If the coil itself is bent to form a closed ring, as is shown in **fig. 2c**, the lines of force form a closed circle on the inside and not on the outside. An arrangement of this nature is called a toroid.

Permeability

It is thus evident that a magnetic field can be described by the flux density or magnetic

continued over

FIG. 1 LINES OF FORCE AROUND (a) A BAR MAGNET (b) A CONDUCTOR CARRYING A CURRENT

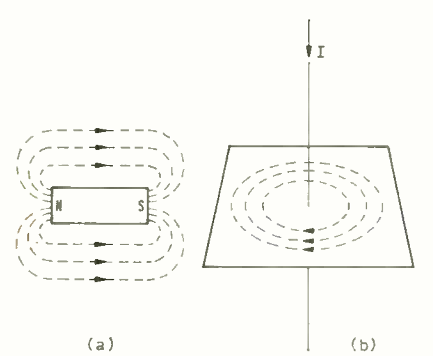
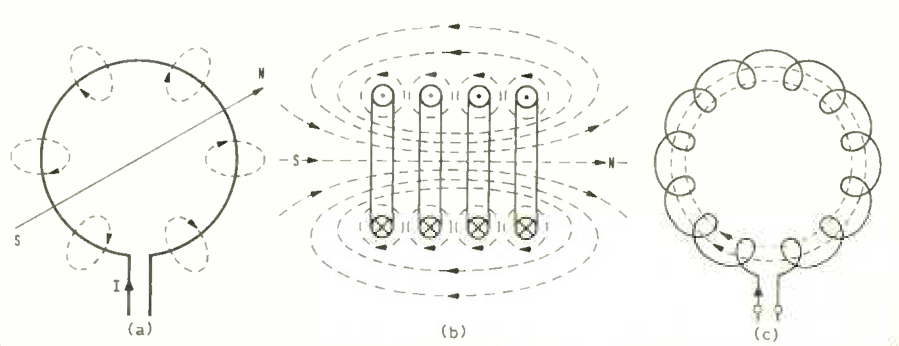


FIG. 2 LINES OF FORCE (a) AROUND A CURRENT-CARRYING CONDUCTOR BENT INTO A LOOP (b) WITHIN AND AROUND A COIL (c) WITHIN A COIL IN THE SHAPE OF A RING (TOROID)



induction, B, and the field strength, H. The ratio, B/H, of these two magnitudes is referred to as the permeability, μ. Its size depends on the nature of the material in which the field is established.

The field emerging from a solenoid carrying an electric current becomes much more effective if a length of annealed iron is inserted into the coil, i.e., the number of lines of force is much larger than that for a solenoid of the same cross-sectional area, A, but with an air core. The flux density then becomes greater than the field strength by a larger factor, i.e.,

$$B = \mu H \qquad (3)$$

where μ is greater than 1.

In the gauss system of units, the permeability of a vacuum, i.e. the absolute permeability, μ_0, is taken as unity. The ratio of the permeability of any given material to the absolute permeability is referred to as the relative permeability, μ_r. For most materials this is very close to unity, being merely slightly more or slightly less. Only the ferromagnetic materials, as they are called, e.g. iron, cobalt and nickel, and the ferromagnetic materials, e.g. Fe_3O_4, $BaFe_{12}O_{19}$, etc, possess much higher values of μ_r. In some cases, they may be as high as a few hundred thousand.

The magnetic circuit

A material with a high value of μ_r can also be formed into a toroid. As is shown by the example in **fig. 2c**, the increased number of lines of force within the toroid form a closed magnetic circuit. Thus no lines of force escape to the environment, usually air.

Now if a small gap is introduced at some point in the core material (**fig. 3**), the lines of force here must pass through air or whatever the material may be that is present in the gap, S. Since the flux, Φ and the cross-sectional area, A, are the same in the gap as in the body of the core, then according to the equation (1) the flux density, B, must also be identical. However, the permeability, μ, is not the same, with the result that the value of field strength, H, is higher in the medium with the smaller value of μ. Consequently, by introducing a material with greater permeability into the core of a solenoid, it is possible to increase the field strength, which according to equation (2) is otherwise limited by the value of the current i, flowing in the coil. An open magnetic circuit of this nature is primarily adopted for magnetic recording heads, because it permits small electric currents to yield field strengths that are large enough for magnetic recording.

Electromagnetic induction

If a coil is placed in the magnetic field produced by a larger solenoid (**fig. 4**), the magnetic lines of force obviously pass through the turns of the smaller coil as well. Then if the flux density of the field produced by the larger coil is B_1, the number of lines of force passing through the smaller solenoid is proportional to its area, A_2; according to equation (1), the magnetic flux in the smaller coil is given by

$$\Phi_2 = B_1 A_2 \qquad (4)$$

Now suppose that a galvanometer, G, is connected to the smaller solenoid. No reading will be obtained as long as the current continues to flow steadily through the larger solenoid. However, at the instant when the magnetising field collapses as a result of opening the switch, S, i.e. when the flux becomes zero, a deflection can be read off on the galvanometer during the period of time in which the change takes place. In other words, a voltage is induced in the smaller coil. A similar effect can also be observed for any alteration in the magnetising field over a finite interval of time, i.e. not only when the field is completely switched off. Conversely, a reading is also obtained on the galvanometer if the field is switched on again.

This can be expressed in a generalised form by stating that an electromotive force, E, is induced in a circuit (in the above case, the smaller coil) if the magnetic flux changes from a value of Φ_1 at a given instant of time t_1, to a value of Φ_2 at an instant t_2. Then if $\Delta\Phi = \Phi_1 - \Phi_2$ and $\Delta t = t_1 - t_2$, the statement is expressed mathematically by

$$E \propto -\Delta\Phi / \Delta t \qquad (5)$$

Another means of changing the magnetic field in the smaller coil is to pass an alternating current through the larger. In this case, the direction of the current is changed at a given frequency, in other words, the current is regularly switched off and reversed, as it were, several times in a given interval of time. The associated periodic collapse and build-up of the magnetic field induces an alternating voltage in the circuit. This is the underlying principle of a transformer. By the same means, an alternating magnetic recording can be played back in a magnetic storage system.

FIG. 3 LINES OF FORCE IN THE AIR GAP, S, OF A RING-SHAPED CORE

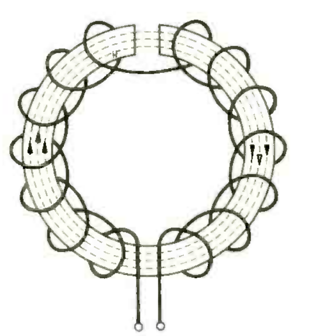
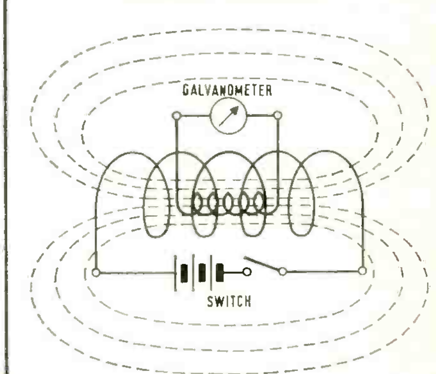


FIG. 4 APPARATUS FOR DEMONSTRATING MAGNETIC INDUCTION



The permanent magnet

The experiment used to determine electromagnetic induction can also be adopted to measure the difference in magnetic behaviour of various materials. First of all, the current is switched on in the larger coil, and the voltage thus induced in the smaller coil is read off on the galvanometer. Afterwards, a piece of copper, a strip of annealed iron, and—finally—a length of steel are inserted alternately into the smaller solenoid to act as a core, and in each case the induced voltage is measured again. The figure obtained with the copper core will be almost the same as that for the air core but much higher values will be measured for the iron and the steel cores. If the current is now switched off and a compass needle is placed in the vicinity of each of the three specimens, a surprising fact will be observed: the strip of steel itself still behaves as a magnet, i.e. it has retained its magnetism and has become a permanent magnet.

Magnetisation

As has already been demonstrated in **figs. 1a** and **2b**, the field of a permanent magnet is similar to the external field of a solenoid through which a current is flowing. If the permeability for air is taken to be unity, the flux density in the inside of the coil can be derived from equations (1) and (3). However, direct measurement must be resorted to in order to determine the flux density of a magnetic material of unknown permeability. This can be done by measuring the increase in magnetic flux caused by inserting a core of the magnetic material concerned in the coil through which the current is flowing. For this purpose, the principle of electromagnetic induction is again adopted (**fig. 4**). In this case, however, two coils, the one identical to the other except that the windings run in the opposite direction, are placed in the field of a large coil. The electromotive forces, E_1 and E_2, induced in these two coils according to equation (5) are thus equal and opposite and cancel out. The flux densities in the two empty coils, B_1 and B_2, are also equal. Now if the material with the unknown flux density, Bx, is inserted as a core into one of the two coils, the voltage induced in this coil will be increased whereas that in the other will remain unchanged. This increase in voltage can be measured and is related to the flux density within the magnetic material. The value is referred to as the intensity of magnetisation, I, of the material concerned.

Ferromagnetism and hysteresis

All chemical elements can be broken down into their smallest constituent unit, the atom, which, in turn, is also built up according to a systematic plan. The mass of the atom is largely concentrated in the nucleus, whereas the electrical, chemical, and magnetic properties are governed by the electrons and their configuration in space around the nucleus, an arrangement that follows fixed laws. It is known that the electrons have two movements: the one is rotation in a path around the atomic nucleus, and the other is rotation or spin around their own axes. Both these movements give rise to magnetic moments, which are called dimagnetism or paramagnetism depending on their direction with respect to the field and are present in all materials. One of the criteria for this is if the permeability deviates slightly above or below the value for a vacuum. Magnetic induction is only slightly strengthened or weakened by the materials, such as copper, that were mentioned in the test described above.

In solids with a crystalline structure, there is an interaction between atoms or ions. Certain arrangements of electrons in the atomic structure and certain distributions of the atoms in the crystal pattern can cause the magnetic moments of the electrons to be aligned in one direction, with a resultant spontaneous increase in the magnetic properties of the material concerned. If the magnetic moments of the electrons are aligned in the same direction as the field, the term ferromagnetism isused; if they are aligned anti-parallel thus giving zero resultant magnetism, the term antiferromagnetism applies; if complete annulment is not caused by the anti-parallel arrangement, the substance is said to be ferromagnetic. The best known ferromagnetic materials are iron, cobalt, and nickel; other representatives of this group are alloys of substances with a certain crystalline structure, such as Heusler alloys. An example of an antiferromagnetic material is cobaltous oxide. Typical ferrimagnetic materials are ferrite and, in particular, γ–Fe_2O_3, which is very important for the production of magnetic tapes.

If one considers that ferromagnetic materials can be spontaneously magnetised, it is surprising to find that, for example, the one piece of iron may deflect a compass needle, whereas another may exert no effect at all on the needle; superficially, it is completely non-magnetic.

The solution to this problem was discovered in 1907 by Pierre Weiss, who assumed that spontaneous magnetisation was restricted to certain specific blocks in the crystal. In each case, these, the elementary magnets, would be aligned owing to the interactions between atoms or ions in the crystal lattice but the resultant magnetisation of each block individually would not affect the external field. These regions are now called Weiss domains. Since adjacent domains may assume all possible directions, the possibility exists—and in the ideal case this is statistically the most feasible—that the magnetic moments cancel out externally from the macroscopic point of view. The picture we have thus formed explains why a bar of iron, considered as a macroscopic unit, becomes magnetic when it is placed in the magnetic field of a solenoid: the magnetic field of the coil aligns all the Weiss domains in the one single direction i.e. that of the applied field.

If an experiment is carried along these lines and the intensity of magnetisation of the iron bar—that is the orientation of the Weiss domains—is measured by applying the law of electromagnetic induction, it will be seen that the intensity of magnetisation is dependent on the strength of the magnetising field. Since the relationship is non-linear, it must be concluded that different amounts of magnetic force are required to align the various Weiss domains and that the number of domains that are aligned by a given field of magnetic force also differs.

In order to find out the exact relationship, the experiment just mentioned is carried out as before, but this time the magnetising field is increased in small increments. The measured results are plotted in a diagram (**fig. 5**). The strength of the magnetising field, H, is taken as the abscissa and the intensity of magnetisation, I, as the ordinate. For all external purposes, the material is completely non-magnetic when no field is applied (point O,O). If now a small magnetising field, H_1, is established, some of the easily magnetisable Weiss domains will be aligned in the direction of the field, and the magnetisation will reach the point B_1. If the field is switched off again, these domains revert to their original state (point O,O); thus the effect of the magnetising field up to this stage is reversible. If, however, the field is increased to a value above H_1, say to H_2, and then switched off again, the intensity of magnetisation, I_1, falls back not to zero but to the point I_{r1}, i.e. there is some residual flux, which is referred to as remanent magnetism. In other words, an irreversible mechanism has taken place. The explanation for it is that the magnetising force has caused certain Weiss domains that were aligned in the direction of the field to increase in volume at the expense of other domains that were not at this stage thus aligned. Since, as we stated above, magnetisation in a Weiss domain is spontaneous, a reorientation of this nature cannot occur unless the crystalline arrangement permits it. Once it has taken place, it is just as stable as before and thus remains intact even if there is no longer a magnetising field.

FIG. 5 RELATIONSHIP OF THE INTENSITY OF MAGNETISATION OF A FERROMAGNETIC MATERIAL TO THE STRENGTH OF THE MAGNETISING FIELD (HYSTERESIS CURVE)

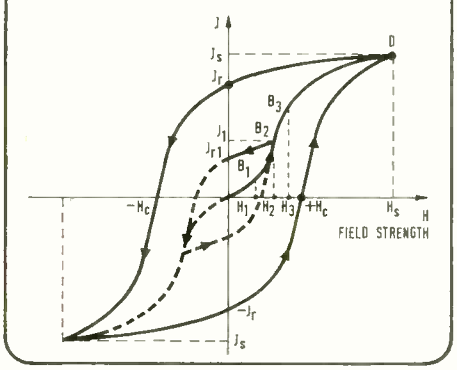
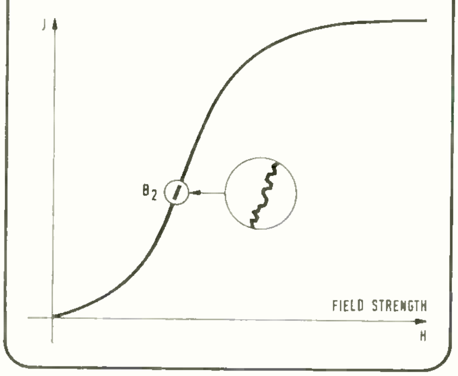


FIG. 6 MAGNIFIED SECTION OF THE STRAIGHT-LINE PORTION OF THE MAGNETISATION CURVE (BARKHAUSEN JUMPS)



This process does not proceed continuously but by leaps and bounds. These can be measured (**fig. 6**) and are referred to as Barkhausen 'jumps'. All of these processes derive the energy they require from the magnetic field of force. Once they have been completed, they cannot absorb any further energy, and this stage is represented by point B_3 on the curve. Thus any further increase in the field of force to a point above B_3 can result only in a symptotic approach of the magnetisation curve towards a maximum value, I_S.

As has already been mentioned, spontaneous magnetisation is associated with a certain crystalline arrangement and, as a consequence, all of the Weiss domains must now be aligned more or less in the direction of the field. All that can happen after this is a flexible rotation, such as elastic bending of a rod. This takes place after point D in the vicinity of B_3. Maximum orientation is attained at D; the corresponding value of magnetisation I_S, is called the intensity of magnetisation at saturation; the value of field at this point H_S, is designated the magnetising field strength at saturation. If H_S is now switched off, the value of residual magnetisation, I_r, is attained, and this is referred to as the remanence at saturation. The material is now in a state in which it displays magnetism even when the external field is zero.

In order to reduce the magnetisation to zero again, a force must be applied in the opposite direction, i.e. H must be made negative and increased in numerical value, until all the processes described above have been reversed. The value of H necessary for this, $-H_C$. is called the coercive force or coercivity. It is thus a measure of the resistance offered by the material towards its demagnetisation. Together with the remanent magnetism, it is one of the most important characteristic properties of a magnetic material. The numerical value of H can be increased in stages beyond H_C, analogous to the increase from O to D, until the negative values of magnetisation at saturation, $-I_S$, and of remanent magnetism at saturation, $-I_r$, are attained. If the magnetising field is reversed and increased in the positive direction again, a similar curve will be traced passing through $+H_C$, where the magnetisation is zero, finally attaining the value I_S at a field strength of H_S. This lag phenomenon, which incidentally is not confined to magnetism, is called hysteresis from the Greek word hysteros = coming after. In the light of the empirical results described above, it would appear that zero magnetisation could never be attained again at zero field. Nevertheless, it is possible if a number of magnetisation cycles are carried out with the value of field strength, H, being successively reduced from the initial value, H_S, in each consecutive cycle. By this means, successively smaller hysteresis loops with successively smaller amounts of

continued 25

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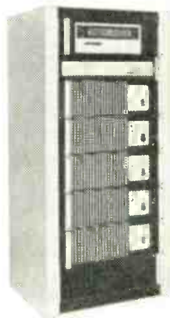

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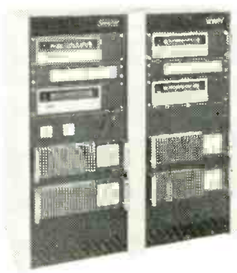

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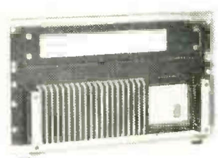

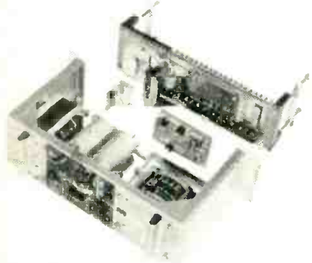

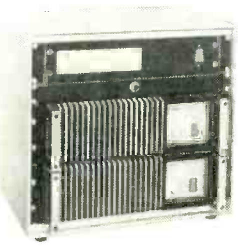

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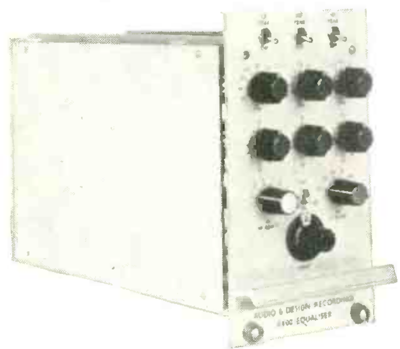

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St. Michaels, Shinfield Road, Shinfield Green, Reading, Berks. Tel: 0734 84487 remanent magnetism are obtained until the field is almost zero when the remanence is zero and thus the unmagnetised state is reached.

This procedure is called demagnetisation or, in some cases, erasure. As the field strength decreases, less and less Weiss domains are remagnetised in accordance with the continual decrease of force (**fig. 7**). The process is the converse of magnetisation as described above. Instead of forming hysteresis loops for many fields of successively decreasing field strength, alternating currents may be passed through the magnetising coil and their amperage gradually decreased to zero.

The remanence curve

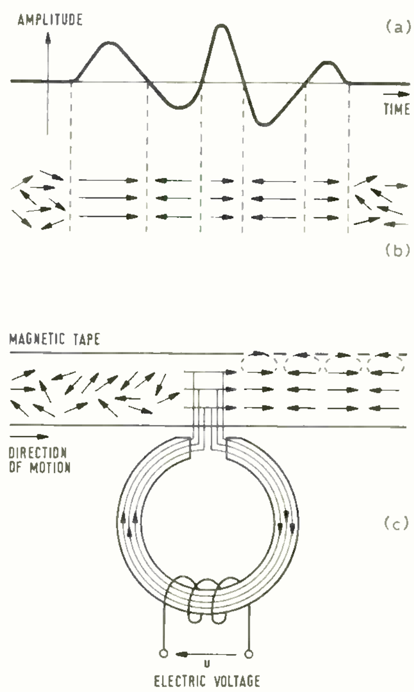
If the values of remanent magnetism associated with given values of intensity of magnetisation are read off from the curve connecting the points O, B_1, B_2, B_3 and D and plotted against field strength, the remanence curve, O–J_{rd} (**fig. 8**), will be obtained. This clearly demonstrates that the remanence or residual magnetism is not related linearly to the strength of the magnetising field.

Hysteresis curve for a single domain

Imagine a piece of ferromagnetic or ferrimagnetic material that is so small that it can accommodate only one Weiss domain. In this case, the shape of the hysteresis loop is simplified to such an extent that a rectangle is formed (**fig. 9**). The magnetisation-demagnetisation process can be conceived from the fact that only one Barkhausen jump is possible in this simple domain: either towards $+I_s$ or towards $-I_s$. It has already been stated that this Weiss domain cannot be subdivided. Hence demagnetisation for the purposes of ensuring a total non-magnetic effect externally is impossible. However, this applies only to an imaginary isolated Weiss domain. If a large number of domains are considered together, it must be remembered that they cannot be made identical. Consequently, they all yield different rectangular hysteresis loops; and if these are superimposed upon one another, a hysteresis curve with the same shape as that in **fig. 5** will again be obtained.

The size of a particle that can accommodate only the one domain lies between a few hundred and a few thousand angstroms ($1A = 1.10^{-8}$ centimetres).

FIG. 10 (a) AMPLITUDE OF THE ELECTRIC OR MAGNETIC FIELD TO BE STORED AS A FUNCTION OF TIME (b) STATE OF MAGNETISATION ON THE MAGNETIC TAPE. (c) RECORDING MAGNETIC SIGNALS



The principle of magnetic storage

The principle of magnetic storage was first developed in 1888 by Oberlin Smith, and it was put into practice by Poulsen in 1898. It is based on the fact that acoustic vibrations can be converted into electric alternating currents with the aid of a microphone. If an open magnetic circuit is now fed with these alternating electric currents, magnetic vibrations of the same frequency are obtained (see 'Electromagnetic Induction'). The open magnetic circuit in this case is called a recording head. The material used for its core must have a high permeability in order to ensure high magnetic induction; it must also have a very low coercive force in order to allow remagnetisation with the minimum magnetising current. Under these circumstances, the fluctuating magnetic field is obtained within the air gap and to some extent above it. This field is exploited to magnetise a magnetisable material in the form of, say, a wire or tape. In order to have the acoustic or electric oscillations recorded in their correct sequence, fresh magnetisable material must be fed continuously to the air gap of the recording head. That is to say the magnetic tape must move past the head (**fig. 10**). The strength of the magnetising field is proportional to the electric current flowing through the windings of the recording head. The field magnetises the magnetic carrier material and, owing to the hysteresis, some of the magnetism remains behind in the form of remanence after the magnetisable material has moved out of the field in the gap of the recording head.

By this means zones of different magnetisation are obtained on the magnetic carrier. It can be likened to an arrangement of compass needles with opposite poles. The direction of the magnetisation corresponds to the appropriate halfwave of the original sound; the longitudinal extension of a zone is directly proportional to the speed at which the magnetic carrier was moving and indirectly proportional to the frequency of the sound; the amplitude of the sound recorded is fixed by the amount of remanent magnetism, which is a function of the intensity of magnetisation causing it.

The sound thus recorded can be reproduced by passing the magnetic carrier material with the various states of remanent magnetism impressed upon it through another magnetic head. The lines of force emerging from the sequence of magnetic zones flow preferentially through the highly permeable material of the head when they arrive above the gap of the open magnetic circuit (**fig. 10c**). As the magnetic tape is led past the head, the changes in the flux density induce an alternating voltage in the coil of the open magnetic circuit. This ac voltage, in turn, can be converted back to the original sound in an acoustics process.

Since the remanent magnetism of the magnetic material is responsible for the reproduction, not the intensity of magnetisation during recording, the remanence curve shown in **fig. 8** is valid (the relationship between the strength of the magnetising field and the residual mag-

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FIG. 7 DEMAGNETISATION OF A MAGNETIC MATERIAL

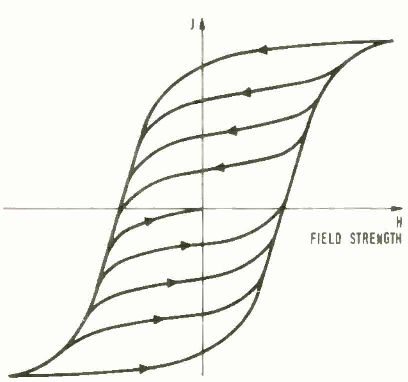


FIG. 8 REMANENCE CURVE

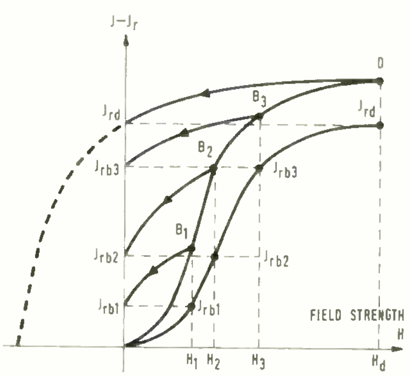
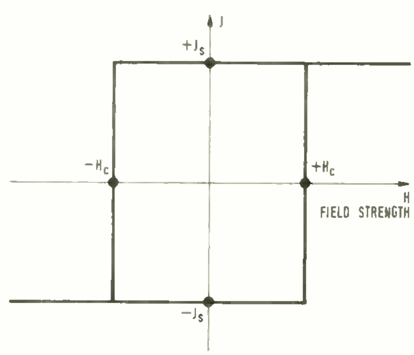
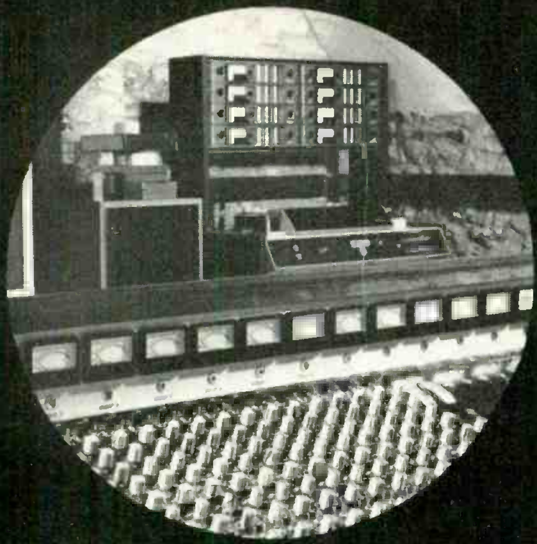
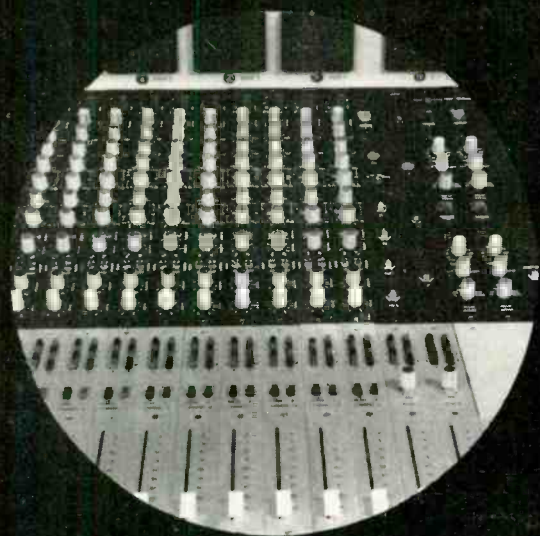


FIG. 9 HYSTERESIS CURVE FOR A SINGLE DOMAIN







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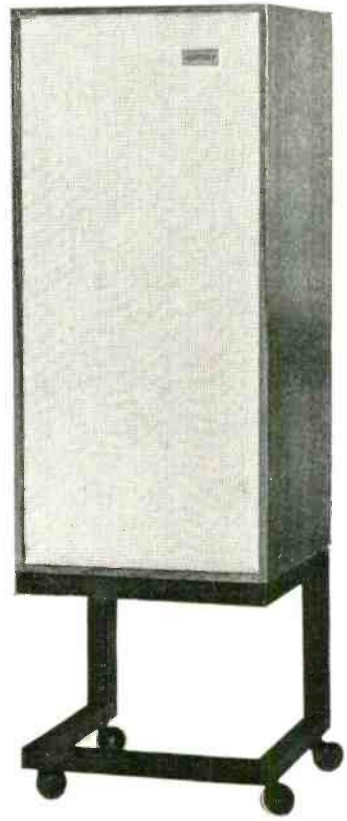

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Interview: David Stripp

John Shuttleworth talks to David Stripp (BBC Engineering Department)

J.S. *I would like to begin by asking how you would go about recording solo instruments, as distinct from spot miking in an orchestra. Solo piano, harpsichord, clavichord, solo singer, and so on.*

D.S. And you are talking about normal two channel stereo? The usual piano procedure in a large studio (and remember that different people have different techniques, even within the BBC) would be to place the microphone a little above head height. It would be directed within the bow of the piano, almost sideways on to the instrument.

The usual position is on the pianist's right, nearer if anything the tail than to the pianist's shoulder, as a rule at least 4m away. This gives the studio acoustics some say in the matter.

A piano is commonly handled on a *C24* but we often use crossed ribbon microphones, or *C12A* capacitors. If we are not familiar with a studio, we might place an additional microphone farther away to give a little extra flexibility.

If we are balancing a solo harpsichord, we treat it as a piano. We recorded many elderly keyboard instruments fairly recently at the Victoria & Albert Museum. These were in a room about 6 x 5m with a 3m ceiling height. Even there, the microphones were some 3m away diagonally across the room, possibly nearer the keyboard end than the tail. Basically sideways on.

A clavichord is a nightmare to record because there is hardly anywhere in London quiet enough to hear it. We have to employ what we would normally consider ridiculously close microphone positions in order to combat background noises. The only time I can remember recording a clavichord in stereo, we had the microphone directly above it, less than a metre away. Even so we could hear cars in the road outside.

J.S. *What characteristic and microphone angle do you use when in that close?*

D.S. We seldom change from a 90° position. We proved to our satisfaction in an early Monograph about stereo that there is nothing to be gained by using angles other than 90 between variable polar diagram microphones.

Back-to-back cardioid is worth considering; this has the advantage of producing an omnidirectional signal for the mono listener. We more normally use 90° cardioids. With clavichords, you obviously have to put a good level on the tape and then arrange to play back at a realistic reduced level. You cannot safely broadcast a clavichord 'life size' as a great many listeners simply would not hear it through the interference we know they are suffering.

J.S. *And solo singer?*

D.S. That depends on whether we want a fairly close chamber music atmosphere or the acoustics of a large hall. In Maida Vale One, we would not use a close microphone balance by any means. A solo singer can comfortably fill a very large studio. It would be quite acceptable to balance a solo singer several metres away, in mono or in stereo, bearing in mind that all BBC stereo has to be mono compatible.

In the early days of stereo, we made recordings at the Royal Albert Hall where we picked up everything including the solo singers on our only stereo microphone at least 10m away from the orchestra. When we first did Mahler's *Eighth Symphony*, the microphone was suspended 15 to 25m away and at that time we had no stereo mixing facilities. There is no doubt that a solo singer against a full orchestra, especially the way Mahler scored, is not properly balanced on a microphone at that distance in so large a building. It sounds very much better even with only a slight amount of spotting. The spot level is so very much lower than the level from the main microphone circuit that it really serves to do little more than fix the singer's position. A higher level makes the spot microphone offensive to many ears.

J.S. *One thing I have never recorded to my own satisfaction is an organ concerto.*

D.S. Not many record companies have done them to my satisfaction either. Very often, they do not sound well balanced in the hall. A composer to some extent probably writes for an organ that he knows. If you use another organ, it is difficult to know what orchestral forces you need to balance it. We have an interesting set of problems now in balancing an organ concerto at the Royal Albert Hall because of the position of the canopy over the orchestra. This makes it impossible to balance organ and orchestra on one microphone pair. We now have to use a microphone above the canopy to pick up the organ. Not all the modifications to the Albert Hall acoustics have helped the broadcaster. Mostly they have made our job more difficult. They are worthwhile for the audience, however; particularly the saucers, which reduce much of the echo.

J.S. *If you are using separate microphones for organ and orchestra, what characteristics would you use?*

D.S. That depends entirely on how close you have to get to the organ. You never should get close to an organ anyway or you hear all its breathing and mechanical noises. A cardioid is often a good pattern to use for organ balances, even if you are not balancing against an orchestra. In a lot of church and cathedral acoustics, the orchestra reverberation comes in very much from the microphone sides. If you use figure-of-eight characteristics, or halfway between this and cardioid (cottage loaf) then you pick up an enormous amount of reverberation in the out-of-phase microphone segments which gives the mono listener an unpleasantly dry balance, whereas the stereo listener will hear a perfectly acceptable reverberation balance. It is also difficult to cut a disc if you have a lot of low frequencies coming in on the difference channel. At least by using cardioids you avoid this problem. If the organ is too wide, on BBC mixing desks we can narrow the image produced by the organ mics. In doing so, we would probably find ourselves having to add yet another pair

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Rear view of David Stripp (right) in action on *It's a Stereophonic World*.

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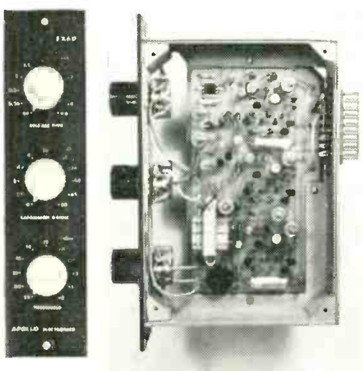

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3" 450'	0·65	—	—	0·79	—	0·85
4" 900'	1·05	—	—	1·24	—	1·33
5" 1800'	1·79	—	2·13	1·99	—	—
5¾" 2400'	2·19	—	2·62	2·39	—	—
7" 3600'	3·20	—	3·30	3·09	—	—

COMPACT CASSETTES	AGFA	PHILIPS	BASF	MAXELL	SC'CH	KJ BUDGET
	LOW NOISE				Dynarange	LINE
C.60	0·44	0·44	0·44	0·42	0·44	0·35
C.90	0·59	0·64	0·64	0·59	0·63	0·49
C.120	0·89	0·94	0·94	0·89	0·92	0·64

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INTERVIEW

continued

very much farther away in order to recover reverberation. It is a fact of broadcasting life that you must have extra microphones ready in case you need them. Balancing the Proms, we rig more microphones than we are likely to want because, until the audience is in, we are not quite sure what the direct to reverberant sound ratio is going to be. No rehearsal will tell us this and indeed many concerts don't have a full rehearsal.

We often have no chance to listen to something as inconvenient to balance as *Belshazzar's Feast* at the Proms. Only a small percentage of the chorus are present at the morning rehearsal so we have to rely on the studio manager's experience that when they all shout 'slain' the ppm exactly peaks six and the transmitters don't limit.

We generally attempt in broadcasting to fill the area between the loudspeakers with sound and not let any sound source get right into the loudspeaker cabinets. Reverberation can fill the entire sound stage, right from the centre of one speaker to the centre of the other. We tend to let the orchestra occupy the free space, which is not quite the whole of that area. The distance of the microphone from the orchestra is decided by the direct to reverberant sound ratio you want.

If you stand where you propose to put the microphone, you can easily judge the polar diagram to use. If the orchestra is going to fill more than that 90° you must not use figure-of-eight at right angles or you will send some of the instruments round in the out-of-phase areas which sounds wrong both in mono and stereo so you need to switch the polar diagram progressively towards cardioid. If you go fully to cardioid, you will only fill the loudspeaker soundstage if the orchestra occupies practically 180° round the microphone. This is a very convenient polar diagram to use for stereo drama where your actors want room to move round the studio.

We frequently use the cottage loaf compromise. We try to avoid using the word hypercardioid, let alone 'super-cardioid', to describe the intermediate characteristic as the terms are mathematically ambiguous.

The only microphone configuration which theoretically gives true mono/stereo compatibility is the back-to-back cardoid. In practice this has not turned out to be a very useful arrangement. It usually gives rather more emphasis than you want to noises coming from the audience's side.

A rather narrow sound image is produced unless you go very close to the orchestra. Also, quite a lot of practical microphones are somewhat more directional at high frequencies than at medium which means that to some extent you will lose high frequencies from the middle of the orchestra, which is right off axis of both mics. More often we use one stereo microphone reasonably close that gives all of our orchestral layout and the presence we require, plus a much more distant pair of 90° cardioids looking away from the orchestra to give us the ambience which is otherwise missing. This allows us to add more hall reverberation if the audience prove to have given a deader acoustic than we had expected. In the belt and braces world of broadcasting, if the main mic should happen to fail, you can switch the distant microphone to figure-of-eight, which then means it is looking just as much to the orchestra as away from it. This gives admittedly a slightly more distant balance but a perfectly acceptable one. With live broadcasts of public concerts, you cannot find an ideal position for a microphone before the event, nor can you be sure of consistency from one night to another.

J.S. *If you were doing a recording session, would you try and manage with a single pair?*

D.S. That depends very much on the material. Very often you get away with a single crossed pair but you have to consider deficiencies in studio acoustic or sometimes in the performance. We have found that there is no consistently perfect microphone position for a given hall.

A serious limitation of many variable polar diagram mics is that they only offer the basic characteristics of omni, cardioid and figure-of-eight. As I mentioned, we often like to use something between cardioid and figure-of-eight. Omni is a useful pattern in stereo setting up. A coincident pair of omnis should give a central mono image which immediately checks the whole of the system right through to the loudspeakers. Virtually all our variable polar diagram microphones can be remote controlled. We can't send a man along a wire 20m above the audience.

If you switch the polar diagram from figure-of-eight to cardioid, you narrow the sound image but tend to pick up more reverberation in doing so. If you leave it on figure-of-eight and reduce the width electrically by cross-connecting the two channels, then you narrow the image in the same way but reduce the reverberation. Thus you can vary the direct to reverberant sound ratio and also vary the image width without going anywhere near the microphone. Your ears use both factors to decide how close a thing is.

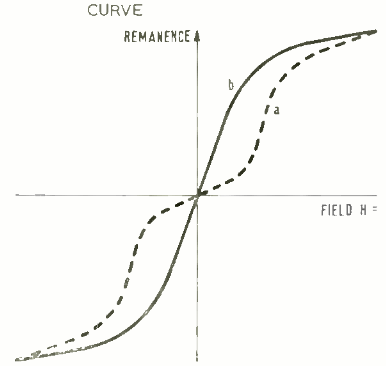
We sometimes use electrical widening, increasing the difference signal electrically, if it is inconvenient to use as close a microphone position as we would like. Some public halls understandably dislike microphones slung where the audience can see them too obviously. Listening conditions at outside broadcasts are sometimes less than ideal and you have to be very sure of your monitoring conditions before you start introducing extra difference signals.

Of course we have visual monitoring to help make up for inadequacies of listening conditions. Most of our control desks give simultaneous ppm indications of left, right, sum and difference levels. We use twin needle ppms with A and B (left and right) on one meter and A+B and A-B on another meter so that we can see any phase errors. We prefer this system to the 'goniometer' crt display. But the important thing is aural monitoring; after all, our customers listen to our programmes, they don't look at them on meters or scopes.

MAGNETIC STORAGE

continued

FIG. 11 (a) REMANENCE CURVE ACCORDING TO FIG. 8
(b) AHYSTERETIC REMANENCE CURVE



netism). This entails a non-linear relationship between recording and reproduction: distortion.

The distortion mentioned above makes faithful reproduction of sound impossible. After several unsatisfactory modifications of the recording technique, Braunmuhl and Weber succeeded in 1940 in linearising the recording characteristic by superimposing a high frequency current (50 to 100 kHz) upon the low audio frequencies. The physics of the process can be explained by the ahysteretic magnetisation effect. For this purpose, the magnetic field of the sound signal is equated with a dc field, and the magnetic field of the high frequency current with an alternating field. On applying a dc field with magnitudes of between H_1 and H_3, a series of irreversible magnetisation processes takes place during hysteresis (**fig. 5**). On removal of the field, residual magnetism with magnitudes of between zero and I_{r3} is still present. As opposed to this, if the strength of an alternating field is allowed to drop from the value H_s to zero, all these irreversible magnetisation processes would unite to give rise to a state of equilibrium, which makes the material as a whole non-magnetic in the event that the field strength becomes zero (**fig. 7**).

If these two techniques are combined, i.e. if the alternating field is superimposed on the dc field, the remagnetisation processes for a given dc field strength, H =, tend towards an equilibrium when the alternating field is decreased. The value at which equilibrium is attained depends on the value of H =. There is thus no unbalance and no hysteresis. An ahysteretic remanent magnetism curve is shown in **fig. 11b**. For comparison purposes, a normal dc field remanence curve has been included (**fig. 11a**).

The values used in plotting the ahysteretical remanent magnetism curve were measured by reducing the ac field from H_s to zero for each value of H = and then switching off H = to determine the residual magnetism. By this means, a linear relationship exists over a wide range between H =, the recording field, and the remanent magnetism on the magnetic carrier. As a result, the signal recorded and magnetically stored can be faithfully reproduced.

If you're in the audio you'll know the problems.

Scotch 206 has a much more even wind—compare it with this ordinary tape.

A new oxide coating that gives a 3 db increase in signal-to-noise ratio.

A new matt back coating which ensures better handling characteristics.

Scotch 206 professional recording tape

Scotch 206 incorporates two remarkable breakthroughs. Firstly we've developed a tough, new oxide coating which gives a 3 db increase in signal-to-noise ratio. This means you can capture extremes of frequency and volume without sacrificing any pure sound quality. And substantially reduce accumulated noise on multi-track recordings.

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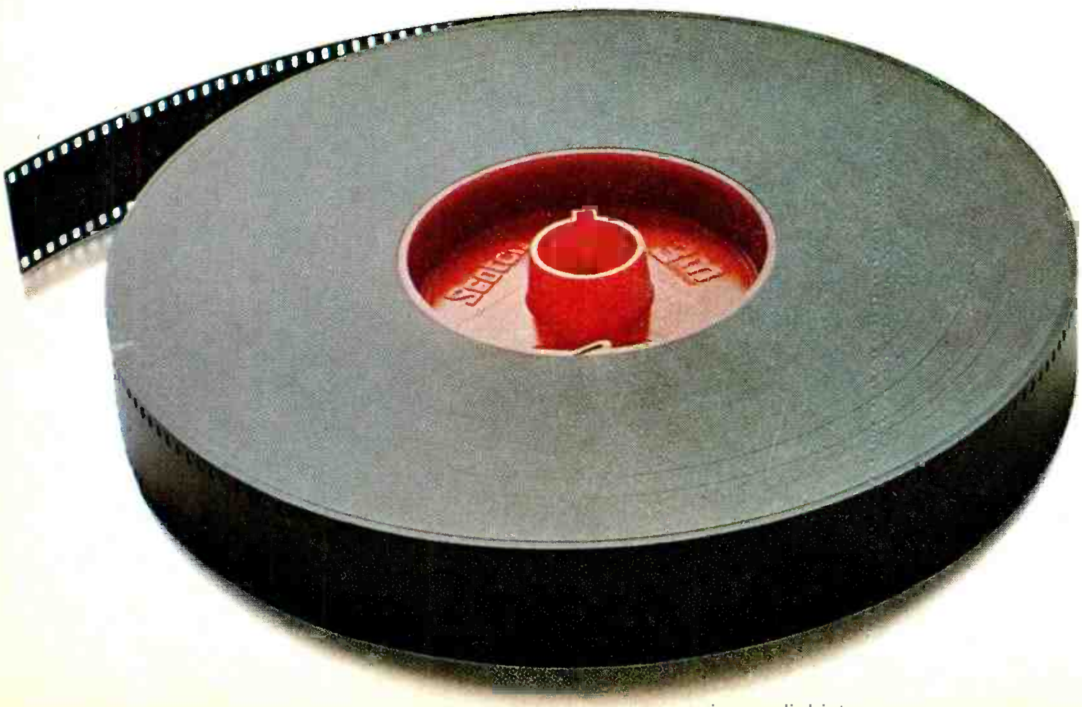
It's also electrically conductive so dirt and dust are not attracted to it, so reducing drop out caused by tape debris.



Scotch magnetic film

The wide range of Scotch magnetic films are all supplied with a low noise oxide designed to meet the exacting standards of the film, TV and professional recording industries, and are available in both 35mm and 16mm sizes.

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By using a new back coating Scotch 277 minimises physical distortion and ensures a more uniform wind. Also its new oxide formulation means an end to the problem of rub-off. We've done away with expensive returnable reels too, by using a disposable plastic hub on the longer length. Scotch 277 will give "wow" free reproduction up to three times longer than existing tapes which considering its competitive price makes it one of the best "solutions" to emerge for a very long time.

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With 3M's range of professional recording systems you have a choice of five of the most complete and advanced models made, all featuring the remarkable Isoloop tape drive. Whether you're looking for a 16 track for mastering or a full track, you can't buy better performance, convenience or higher quality than 3M.

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Scotch bulk duplicating ¼″ tape comes in two standard lengths, 1,500′ and 3,600′, and a special one, 7,200′ which is made to order. A very clean lubricant ensures minimum rub-off and longer tape life.

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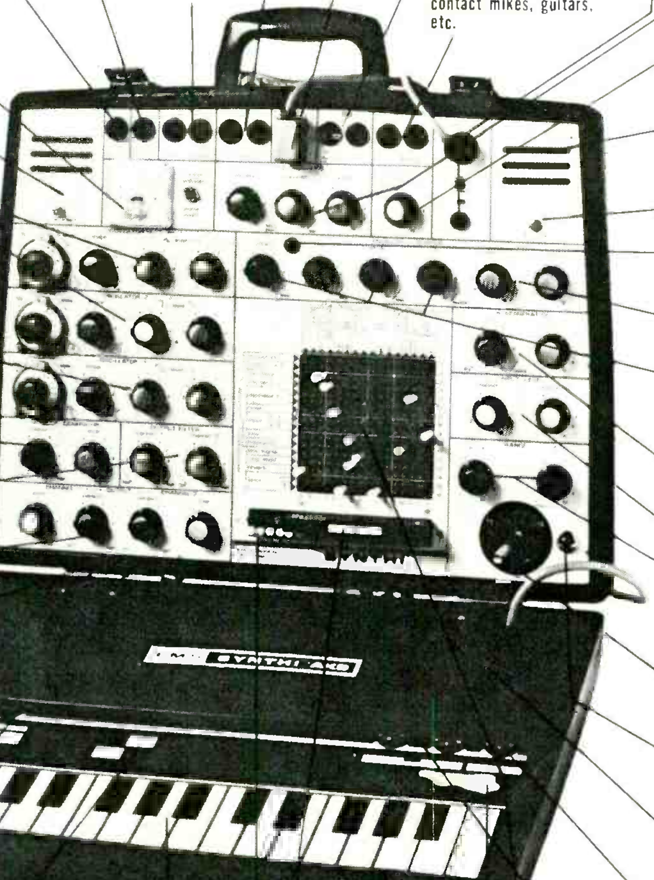
which **remembers** up to 256 notes as they are played

**Ten green apples on the tree; Good for you, good for me
Good for everybody round the tree**



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Survey: Electronic Music Synthesisers

RIGHTLY or wrongly, R. A. Moog is generally credited with the original development of the voltage controlled music synthesiser. Certainly he was the first to manufacture synthesisers on a commercial scale. His problem was to produce a link between the natural laws of electronics and the conventions of music. Voltage control was at that time, just a few years ago, one of various techniques employed by pioneer electronic music composers. Moog recognised it as a versatile means of automating an infinitely versatile yet highly labour intensive art form.

A vc synthesiser comprises, in one cabinet, many of the electronic tools formerly available (if at all) only as separate units. Moog offered more than compactness: the ergonomic convenience of an integrated synthesiser compared with a scattered array of physically and electronically ill matched components. That at least was the theory. In practice, the Moog system suffered from the same failing that beset the casually assembled equipment it was trying to replace. Routeing between modules was (and still is) by jack patch cords, raising difficulties if an operator wished to connect one output to a large number of inputs or vice versa. An additional problem with patch cords is their tendency to obscure the jack field which in Moog equipment is the control face itself. Despite this, the Moog name is as firmly established among musicians as the name Hoover among housewives. The fact that Moog is really pronounced Moge, Moag or Mogue is neither here nor there.

Another American manufacturer, Tonus Incorporated (pronounced ARP) found a tidier and more versatile alternative to patch cords, in the shape of 20 position switch rows. The ARP *2500* using this principle is field tested on page 39. Another ARP, another routeing system: the smaller *2600* combines Moog-style input/output jack sockets (miniature in this case) with internally wired module connections made by opening slide faders. The trouble with prewiring is that it can impress preconceived notions on the performer's mind, severely restricting tonal variety.

The most logical, physically convenient and versatile method of routeing synthesiser modules is the pin matrix system employed by Electronic Music Studios (London) Ltd. This company produces two basic synthesisers, the smallest being variants of the *VCS3* with a 16^2 matrix. Largest is the Synthi *100*, incorporating two 60^2 matrices. The connections of one output to 60 inputs through a 60^2 matrix would take one or two minutes; the time needed to insert 60 patch pins along one output row. The same task using patch cords could take an hour's soldering, unless you were fortunate enough to possess a one-to-60 way patch lead. The ARP 20 way switch bank comes unstuck if you wish to route more than 20 inputs independently to 20 outputs. Patching one switch bank to another in the *2500* raises this limit to 40, still less than the capacity of a pin matrix which normally equals the number of signal outputs.

As synthesisers grow more complex, these practical operational factors will acquire major importance. The pin matrix must inevitably become a standard, as will another EMS innovation: the digital sequencer. Preparing a sequence by individually tuning presets (the facility offered by Tonus and Moog) is crude and inefficient. The Synthi *100* sequencer can be programmed direct from a keyboard and stores up to 256 events in six simultaneous parameters.

Two companies, Dewtron and Chadacre, have recently started producing individual voltage control modules. Chadacre are the first mixer manufacturer to enter the synthesiser market. They will undoubtedly be followed by others, with the likely effect that voltage control techniques will start to appear in studio mixing desks.

The Chambers Dictionary definition of *synthesis* is 'building up, putting together, making a whole out of parts'; *synthetic* as 'artificially produced but of like nature with, not a mere substitute for, the natural product'; and *synthesise* as a faulty form for *synthetise*. Whichever way you read it, the synthesiser/synthesizer/synthetiser is no more artificial than a saxophone. The one produces sound from vibrating electronics, the other from a vibrating reed, the harpsichord from vibrating strings, the glass harmonica from vibrating glass and the aeolian harp from vibrating air currents.

Artificiality only arises when electronic means are employed to imitate non-electronic instruments. At the present state of the art, such exercises are neither convincing nor profitable. A £10 violin can produce vastly more complex wave structures than the largest electronic synthesiser so if you need a violin, use a violin. If you desire effects unlike anything previously heard by man or beast, then use a synthesiser. But, for the love of music, avoid the trap which faces composers of electronic Pop: using a £7,500 synthesiser to imitate unconsciously but all too successfully a cheap divider organ. It has been done and it degrades the most promising invention since the development of the chromatic keyboard.

AUDIO SYNTHESISERS

FREEMAN S.100 (Advance data only)

Polyphonic keyboard synthesiser suitable for placing above an organ or piano. May also be used freestanding. Plug-in board ic circuitry.

Keyboard Five octaves.

Controls: Legato and attack keying, sustain on/off and sustain duration. Keyboard balance, reverberation level, vibrato, light controlled expression pedal and earth disconnection switch.

Output: High impedance (jack socket) to external amplifier.

Power: 115 to 240V, 50 to 60 Hz.

Dimensions: 960 x 500 x 180 mm high.

Price: To be announced.

MANUFACTURER: Audio Synthesisers Ltd, 14a Broadwalk, Pinner Road, North Harrow, Middlesex HA2 6AD.

CHADACRE ELECTRONICS LTD

VOLTAGE CONTROLLED AUDIO MODULES

6305 white noise generator. Two noise generators, two independent variable bandpass filters and two phasing amplifiers. 45 facia, 200 x 150 x 150 mm dimensions. 20 transistor circuit with nine variable controls and two output jacks.
Price: £49.50.

6303 oscillator. Square and saw outputs. 100 kΩ input impedance permits use of a capacitor sustain memory. 200 mV per octave control sensitivity.
Price: £15.

6306 envelope shaper. Variable attack, on, decay and off times. Self-triggered.
Price (including control potentiometers): £18.

6307 white noise generator.
Price: £10.

6301 integrated circuit ring modulator.
Price: £15.50.

MANUFACTURER: Chadacre Electronics Ltd, 43 Chadacre Avenue, Clayhall, Ilford, Essex.

DEWTRON

VOLTAGE CONTROLLED AUDIO MODULES

VCA-1 amplifier. Input impedances: 50 kΩ (signal) and 100 kΩ (control). Input level: 500 mV maximum.
Price: £10.

PH-1 phasing module.
Price: £17.

SA-1 selective amplifier (vc filter).
Price: £12.

AF-1 fader.
Price: £9.

VCO-1 oscillator. Produces 500 mV saw and 700 mV square waves to feed 20 kΩ and 10 kΩ loads respectively. Oscillation commences at 1V control voltage, rising at 200 mV per octave. Square symmetry preset control facility.
Price £9.50 (£1 discount for two or more VCO-1 modules).

continued over

Joystick control: £4.50.

Patchboard sockets: £7.50 per hundred.

Patchboard plugs: 8p each (minimum of ten plugs).

MANUFACTURER: Design Engineering (Wokingham) Ltd, 254 Ringwood Road, Ferndown, Dorset.

ELECTRONIC MUSIC STUDIOS (LONDON)

SYNTHI A

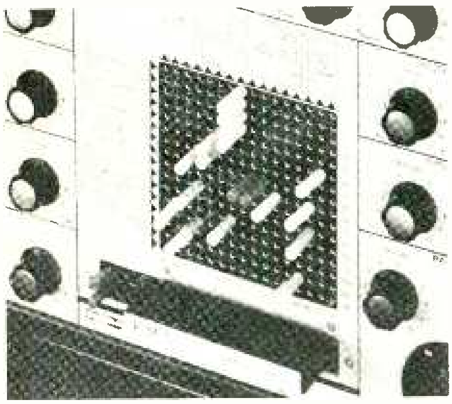
Voltage controlled electronic music/sound-effects generator.

Power requirement: 220 to 240V or 105 to 115V, 50 or 60 Hz. Battery operation possible.

Internal sources: *Oscillator 1:* 1 Hz to 10 kHz sine and ramp. *Oscillator 2:* 1 Hz to 10 kHz square and ramp. *Oscillator 3:* 0.05 Hz approx to 500 Hz square and ramp. Filter when set to self oscillate supplies variable frequency sinewave. Trapezoid signal produced by envelope generator. Noise generator with amplitude and coloration controls.

Internal treatments: Envelope (attack / decay generator), reverberation spring unit, bandpass filter and ic transformerless ring modulator.

Input sensitivities: Two 5 mV ac into 600 ohms, one $\pm 50\mu$A into 500 ohms; ± 2.5V dc or 1.8V ac into 50 kΩ.



Outputs: Two 10V into 50 ohms (headphones), two 2V into 600 ohms (line), and dc control output.

Internal monitors: Side-facing loudspeakers driven by 1W amplifiers.

Finish: Solid afrormosia cabinet. Slide-out bottom and rear panels. Plastic on heavy gauge aluminium, taking temporary wax pencil marks.

Dimensions (hwd): 438 x 444 x 419 mm.

Weight: 10.2 kg.

Price: £300 (excluding keyboard).

SYNTHI 100

Source Modules:

Three voltage controlled audio waveform generators: sine and ramp. A sine shaper is included by which variable amounts of even harmonic distortion may be added. Manual frequency range: Greater than 1 Hz to 10 kHz (extendible by voltage controls in both directions to 0.25 Hz and 20 kHz).

Three voltage controlled audio waveform generators: triangle and square. These can be varied from triangle to sawtooth ramp and from symmetrical square to short pulse, in either polarity. Manual frequency range: Greater than 1 Hz to 10 kHz. Triangle symmetry ± 5 per cent rise time to fall time equality. Other specifications as for sine/ramp oscillator.

Three voltage controlled low frequency waveform generators: Same details as before but oscillators are 20 times slower. Frequency range: Greater than 0.025 Hz (40 seconds per cycle) to 500 Hz. Voltage control: 500 mV/octave.
All nine of the above oscillators have synchronisation inputs so that they can operate at an integral multiple of another oscillator.

Three noise generators: Variable from white (central position of coloration control) to dark or light positions (low or high pass filters). Distortion: In white position, frequency content is flat ± 3 dB from 100 Hz to 10 kHz.
Dual output random control voltage source.

Treatment modules:

Three voltage controlled trapezoid generators with integral envelope shapers. A second output which lags behind the first by one quarter of a complete trapezoid cycle. The amplitude and polarity of both outputs may be adjusted independently so that, if they are summed (on the patchboard), any continuous four-line function which ends at the value at which it starts may be produced. Envelope shaper is logarithmic to within 3 dB over its 60 dB range. Voltage control function of time parameters is ideally exponential to within ten per cent (of dependent parameter) over a range of 1,000:1. This permits a single voltage applied to all inputs to compress the time scale.

Four voltage controlled filter/oscillators (low pass to resonating) may also be employed as a sine source.

Four voltage controlled filter/oscillators (high pass to resonating): Similar but complementary to low pass filters.

One octave filter bank. This consists of eight resonating filters, fixed-tune one octave apart, in the range 62.5 Hz to 8 kHz, separately controllable.

Two voltage controlled reverberation units. Each spring unit has two elements with delays of 35 and 40 ms. Maximum reverberation time: 2.4 seconds.

Three voltage controlled slew limiters. Unity gain amplifier in which the output exactly follows the input at a rate whose maximum (slew) is defined by a control voltage. Range of slew control: 1 ms to 10 s.

Three transformerless ring modulators. Can be used in series for double or triple modulation.

Sequencer: One 256 event, six simultaneous parameter, digital sequencer stores 256 'notes' and plays each at the correct time and for the correct duration. It simultaneously provides two voltages one of which might be used to define pitch and the other loudness. It is capable of controlling three voices, each with duration, pitch and loudness. The 256 note storage may be distributed to each voice in any proportion. The second and third voices need not be used as such. The information to be stored and subsequently reproduced is presented to the machine as control voltages, which are most easily supplied from the keyboards.

The machine may then be set to the edit mode. In this mode the sequence may be advanced at any speed, or step by step, so that each note may be modified or erased. A special feature allows time to be reversed.

Ten controls are provided to adjust the amplitude of the sequencer's output voltages. A further ten supervise the actual operation. Total storage capacity: 10,240 bits (of which 9,216 bits are normally used). Organisation of data: 36 bit words, each word representing one event. Start-of-event time (referred to start of sequence): ten bits. End-of-event time (referred to start of sequence): ten bits. Selection of one of three envelope shapers and one pair (out of three pairs) of digital analog converters. Also internal functions: four bits.

Data, for digital analog converters: two x six bits. Coding: The ten bit event time allows the start of each event to be defined to an accuracy of one part in two to the power ten. Thus if the clock is set to a rate of 100 pulses a second, each event may be adjusted forwards or backwards in increments of one hundredth of a second. The total sequence length would be ten seconds.

The 'end of event' time, i.e. the time at which the key is released, is similarly recorded. Thus three control signals are reproduced, each being positive during the duration of a note intended for one of the three layers of the sequence. They are available at the patchboard as switching voltages which would normally go to the supervising inputs of the envelope shapers.

Digital Analog Converters: Of the six converters, three are of accuracy appropriate to exact control of pitch on the diatonic scale. Six bits give a range of 64 notes. If greater range and/or finer resolution is required, then the output of the second converter may be added to that of the first. In this case, the player might use one keyboard to define a note on the diatonic scale, and the second to raise or lower that note by increments of one thirty-second of a tone.

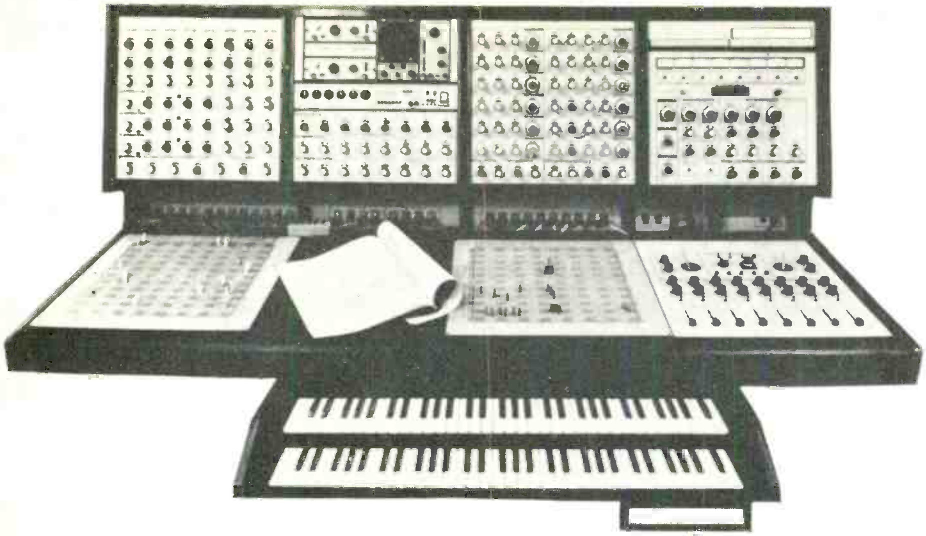
Eight Multifunction Output amplifiers: Primarily intended to be the last link in the signal chain before the tape recorder or monitor. All eight are voltage controlled.

Eight-way Fading/Panning Console

Pin Matrix Patchboards: 60 x 60 (7,200) pin locations allow any input to be connected to any output by the insertion of a single cordless pin. The pins contain resistors so that several outputs may be mixed into a single input. All device outputs are fed to the board at a low impedance, blocking any reverse signal paths. Two patchboards are provided, one intended for control signals and one for audio signals. A small number of interconnection patches between the patchboards are hard wired, as some signals can be used in both domains. It is also possible to route external signals to the patchboards by using the pins as jacks. All contacts, including the jacks, have a surface coating of silver.

Eight ac/dc input amplifiers

These convert input signals to a suitable level and impedance to feed treatment devices. Two separate microphone amplifiers are supplied which can feed any two of the above channels.



Four External Treatment Send and Returns: Provision for sending out to external echo plates and other equipment, and returning to the Studio.

One frequency to voltage converter: This device accepts inputs from a variety of sources and produces a voltage proportional to the fundamental pitch of the note played. Circuitry is incorporated to remove overtones, provided their energy constitutes no more than 90 per cent of the total signal.

Two Envelope Followers: These produce a voltage proportional to the mean level of an audio signal. The output is passed through a second order low pass filter to remove ripple while keeping a fast response. Cutoff is about 50 Hz. Output amplitude is adjustable by a centre zero knob to give positive or negative excursions of up to 1 volt per 6 dB.

Two X-Y joystick controllers: These give continuous control of two parameters together.

Two five-octave dynamically proportional keyboards: Five octave keyboards giving precise divisions of pitch or any other controllable parameter. In the case of pitch, the range would give anything between four and 40 notes per octave. By setting 12 notes per octave, the keyboard can be used as a normal melodic source. A second voltage output is proportional to touch, actually the velocity with which a key is struck. A third voltage switches positive when one or more keys are pressed. Note that the keyboard produces only one pitch voltage at any instant; when several notes are pressed, the voltage of the highest appears.

Price: £7,500.

Sequencer only: £1,500.

SYNTHI AKS

Version of *Synthi*, with following additional features: 32-note touch keyboard with no moving parts, contacts or springs. 256-event sequencer with digital memory. Independent control of speed and pitch. Additional features of the keyboard and sequencer include instant transposition, random note generation, and independent 'spread' controls. Accompaniment trigger circuit.

Instant patching facility with plug-in patches. New stabilised power supply.

More flexible, clearer to read, and easier to use patchboard.

Price: £420.

MOOG

MINI

Sound Sources: Three voltage controlled oscillators, each offering a selection of six different waveforms.
Noise Source, generating white or pink noise.
Microphone/Accessory Preamp for introducing external audio signals for processing by the Mini Moog.

Sound modifiers: Voltage-controlled lowpass filter with contour generator and emphasis controls. Voltage-controlled amplifier with contour generator controls.

Controllers: Keyboard (full-size 3½ octave) for controlling pitch and, secondarily, filter. Pitch Bender. Glide control for injecting portamento between notes. Tune control for tuning entire Mini Moog. Three external control input jacks for external control of pitch, volume and filter. Trigger input socket for external trigger. A-440 reference tone highly stable oscillator for use in tuning the Mini Moog and other instruments to Standard Pitch.

Outputs: Main signal output (phone jack) with volume control. Headphone output (phone jack) with volume control. Auxiliary power output (two dc power sockets).
Price: £660.

MODEL 10

Instrument Complement: *901* voltage-controlled oscillator. *901A* oscillator controller. Two *901B* oscillators. *902* voltage-controlled amplifier. *903A* random signal generator. *904A* voltage-controlled lowpass filter. *907* fixed filter bank. *910* power supply. Two *911* envelope generators. *951* keyboard controller. Console panel *No 11* including four input Mixer with ± and — outputs jack multiples, reversible attenuator, two control voltage and trigger outputs, two trunklines and power switch. **Patchcord Complement:** Ten 30 cm cords. Eight 60 cm cords. 30 cm switch trigger cord. 45 cm switch trigger cord. Switch trigger Y-cord.
Price: £1,668.

MODEL 1C

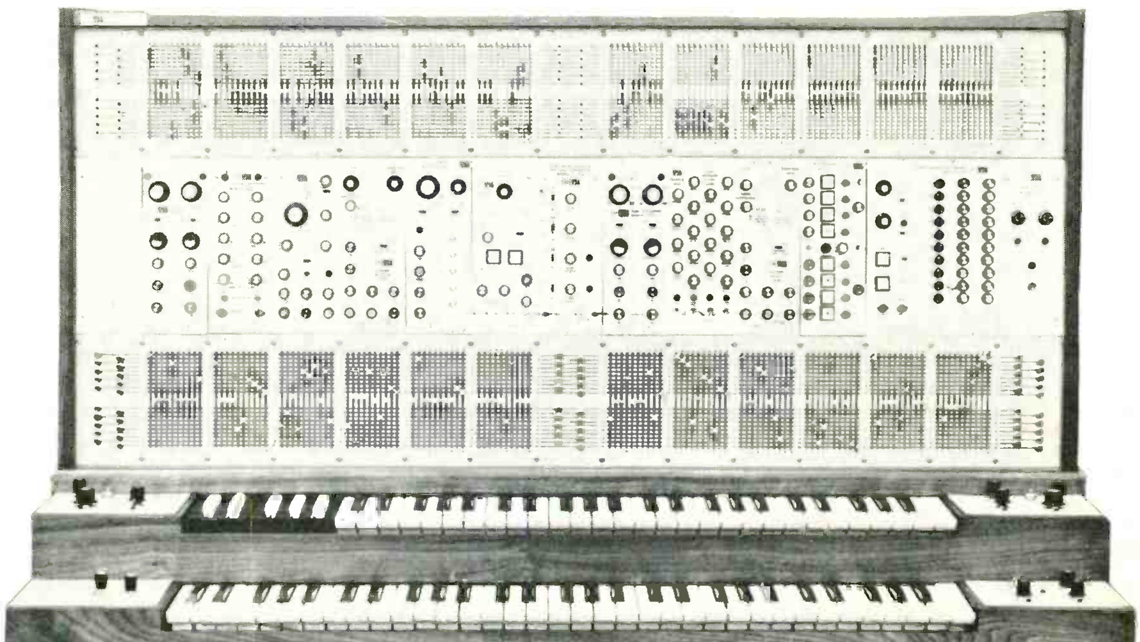
Instrument Complement: *901* voltage-controlled oscillator. *901A* oscillator controller. Two *901B* oscillators. Two *902* voltage-controlled amplifiers.

continued 37

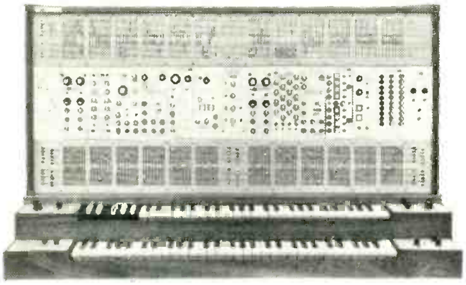
Above: Synthi *100*.

Left: Synthi *AKS* with detail of pin matrix.

Right: ARP *2500*.



Synthesize to harmonize



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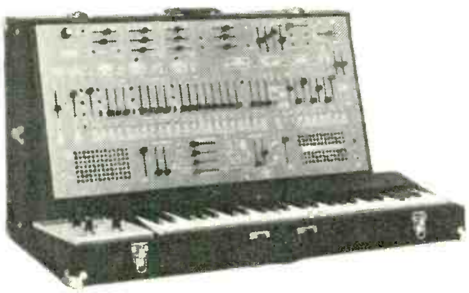

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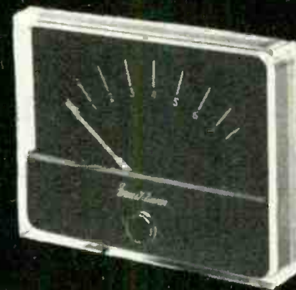

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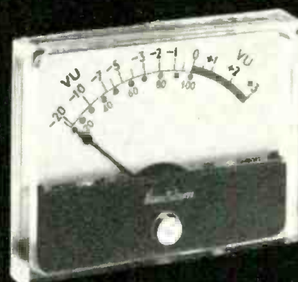

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SYNTHESISER SURVEY

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903*A* random signal generator. *904A* voltage-controlled lowpass filter. *905* reverberation unit. *907* fixed filter bank. *910* power supply. *911* envelope generators. *950* keyboard controller. *956* ribbon controller. *991* filter-attenuator panel. *994* jack multiples panel. Blank panel with power-supply wiring and space for one single-unit module. Two console panel *No 3* each including four input mixer with ± and — outputs. Two trunklines. Control voltage switches. Attenuator. Console panel *No 4* including control voltage switches. Attenuator. Trigger- and envelope-routeing switches. Three control voltage and trigger outputs. Console panel *No 8* including power switch. **Patchcord Complement:** Eight 30 cm cords. Six 60 cm cords. Four 90 cm cords. Four 1.20 m cords. Two 1.5 m cords. Two 90 cm switch trigger cords.
Price: £2,400.

MODEL 1P

Portable version of *1C*.

Price: £2,400.

MODEL 2C

Instrument Complement: *901* voltage-controlled oscillator. Two *901A* oscillator controllers. Five *901B* oscillators. Two *902* voltage-controlled amplifiers. *903A* random signal generator. *904A* voltage-controlled lowpass filter. *904B* voltage-controlled highpass filter. *904C* filter coupler. *905* reverberation unit. *907* fixed filter bank. *910* power supply. Two *911* envelope generators. *950* keyboard controller. *956* ribbon controller. *984* four channel mixer. Three console panel *No 3* each including four-input mixer with + and — outputs. Two trunklines. Control/voltage switches. Attenuator. Console panel *No 2* including lowpass and highpass filters. Jack multiples. Three control voltage and trigger outputs. One console panel *No 6* including. Control voltage switches. Attenuator. Trigger- and envelope-routeing switches. Jack multiples. Console panel *No 8* including power switch. **Patchcord Complement:** Ten 30 cm cords. Six 60 cm cords. Four 90 cm cords. Four 1.2 m cords. Two 1.5 m cords. Two 30 cm switch-trigger cords. Two 90 cm switch-trigger cords.
Price: £3,420.

MODEL 2P

Portable version of *2C*

Price: £3,225.

MODEL 3C

Instrument Complement: *901* voltage-controlled oscillator. Three *901A* oscillator controllers. Nine *901B* oscillators. Three *902* voltage-controlled amplifiers. *903A* random signal generator. *904A* voltage-controlled lowpass filter. *904B* voltage-controlled highpass filter. *904C* filter coupler. *905* reverberation unit. *910* power supply. Three *911* envelope generators. *911A* dual trigger delay. *912* envelope follower. *914* extended range fixed filter bank. *950* keyboard controller. *956* ribbon controller. *984* four channel mixer. *992* control voltages attenuator panel. *993* trigger and envelope voltages panel. Four console panel *No 3* each including four-input mixer with + and — outputs. Two trunklines. Control voltage switches. Attenuator. Console panel *No 2* Including lowpass and highpass filters. Jack multiples. Three control voltage and trigger outputs. Console panel *No 8* including power switch. **Patchcord Complement:** 14 30 cm cords. Eight 60 cm cords. Six 90 cm cords. Six 1.2 m cords. Four 1.5 m cords. Two 30 cm switch-trigger cords. Three 90 cm switch-trigger cords.

Price: £4,455.

Sequencers A and B
The *960* sequential controller, *961* interface, and *962* sequential switch are modular instruments.

Instrument Complement:

A	B	
1	2	*960* sequential controller.
1	1	*961* interface.
1	2	*962* sequential switch. Blank panels with space and power-supply wiring for conversion to Complement B.
1	1	*994* jack multiples panel (console models only).
1	1	*910* power supply (mounted inside on console models, on top of case on portable models.

Patchcord Complement:

4	8	60 cm cords.
2	4	1.2 m cords.
2	3	30 cm switch trigger cords.
2	3	30 cm switch trigger cords.
1	2	special voltage trigger to switch trigger cord.

Price: (A): £1,158.
(B): £1,980.

MODEL 3P

Portable version of *3C*.

Price: £4,455.

AGENT: Feldon Audio Ltd, 126 Great Portland Street, London W1N 5PH.

TONUS INCORPORATED

ARP 2500

Electronic music synthesiser comprising up to 15 voltage control modules between 20-way switch-banks. May be assembled from any of the following basic ARP modules: *1016* dual noise/random voltage generator. *1047* multimode filter/resonator. *1005* modamp (balanced modulator and vc amplifier). *1027* sequencer (ten step, three layer). *1050* mix-sequencer. *1036* sample and hold/random voltage unit. *1004* vc oscillator module. *1033* dual delayed exponential envelope generator. *1046* quad envelope generator. *1006* filter amplifier. *1045* voice module. Comprises oscillator, filter, amplifier and two exponential envelope generators. *1002* power supply module. *1033* dual envelope generator. *1023* dual oscillator. *1035* triple modulator. **Keyboard:** five octave model *3001*.

Price: £5,400.

AGENT: F.W.O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Hertfordshire.

ARP 2600/3604

Compact electronic music synthesiser including the following units:
Three voltage controlled oscillators covering 30 Hz to 20 kHz in two ranges. Five waveforms including variable-width pulse, triangle, sine, square and sawtooth. One voltage controlled low-pass filter. Variable resonance, dc coupled, doubling as low distortion sine oscillator. One voltage controlled amplifier with exponential and linear control response characteristics. One ac or dc coupled ring modulator. Two envelope generators. One envelope follower. One random noise generator. Output continuously variable from flat to —6 dB/octave. One bidirectional electronic switch. One sample and hold with internal clock. One microphone pre-amplifier with variable gain in 20, 40 and 60 dB ranges. One general purpose mixer with panpot. Two voltage processors with inverters. One voltage processor with variable lag. Doubles as low-pass filter. One reverberation unit. Twin uncorrelated stereo outputs. Two internal monitor amplifiers and speakers with stereo 3 Ω headphones jack. One four-octave keyboard with variable tuning, variable portamento, variable tone interval and precision memory circuit.

Price: £1,360.

AGENT: F. W. O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts.

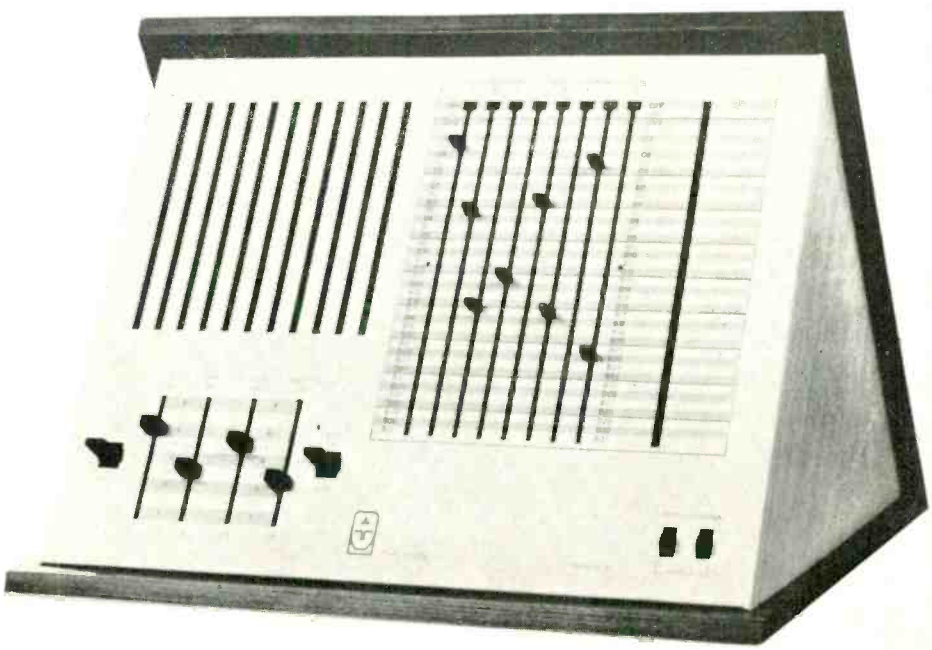
TRIADEX

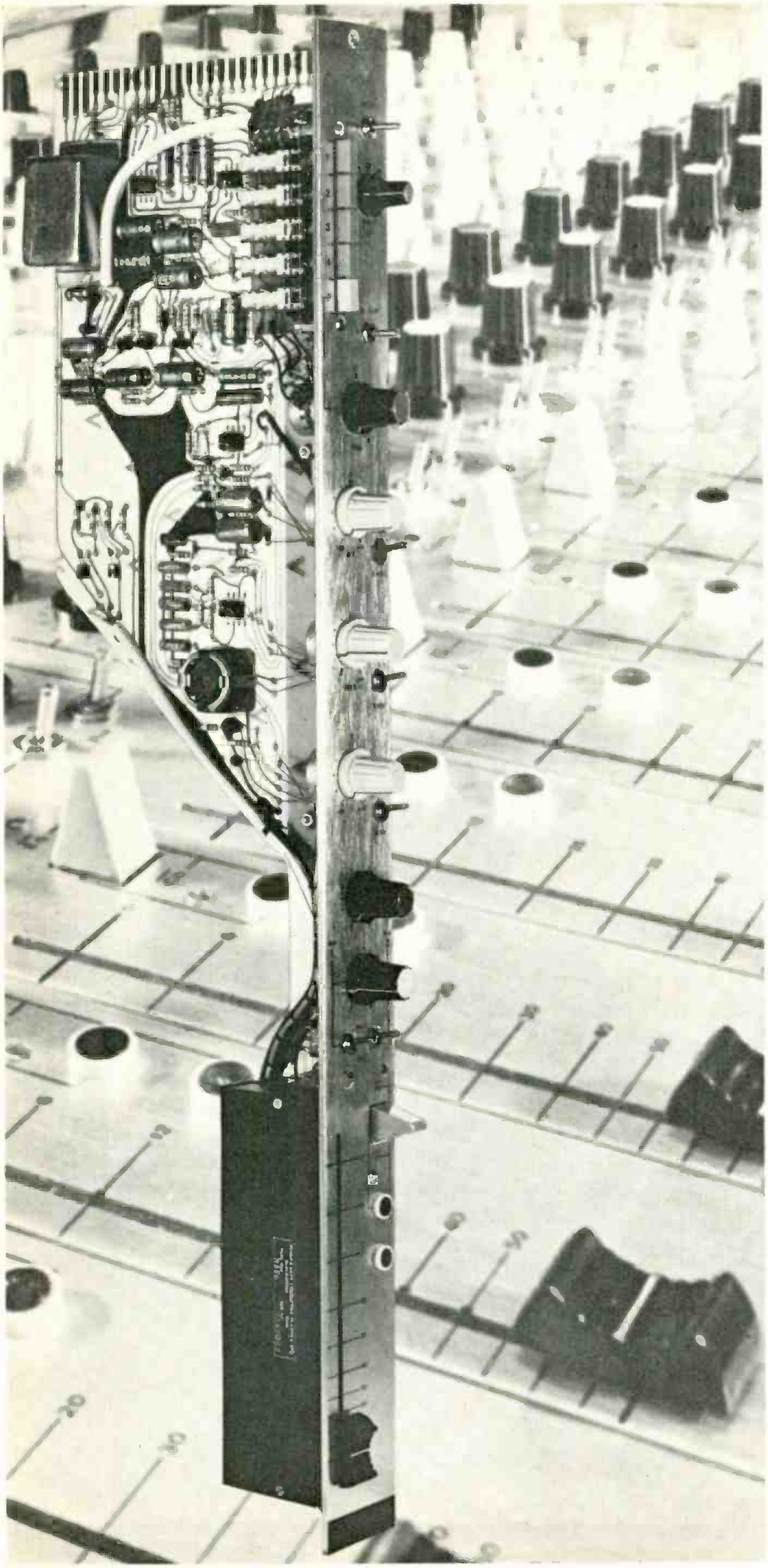
MUSE

Electronic music generator producing many permutations ('more than 14 trillion') of melody lines Fixed output waveform suitable for external treatment. Five octaves range. Internal loudspeaker Controls comprise volume, tempo, pitch, fine pitch four 'interval' and four 'theme' selectors.
Price: £250.

AGENT: Allotrope Ltd, 90 Wardour Street, London W1V 3LE.

Triadex Muse





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SYSTEM 12

Field Trials

ARP 2500 Electronic Music Synthesiser

THE ARP 2500 comes from the same stable as the smaller and cheaper *2600* examined in our January issue. There is no resemblance between the two designs, except that they both follow the now well established principle of voltage control. Readers unfamiliar with this are referred to the *2600* field trial and to 'The Fine Art of Voltage Control' (April 1971 STUDIO SOUND).

The most significant difference between one vc synthesiser and another is the means employed for routeing. In the ARP *2500*, this is achieved by switches sliding up or down through 20 discrete positions. These switches are arranged in groups of ten above and below each generating or processing module. The vertical switch positions are numbered 1 to 10 and 11 to 20. Between 10 and 11 are three non calibrated 'rest' positions where a switch would normally be placed when not in use. A bus wire connects all points in any one horizontal level together. This starts at a miniature jack socket on the extreme left and terminates at another socket on the extreme right. A similar bus connects the adjacent level contacts to each other and so on down to level 20. **Fig. 1** shows part of an ARP matrix. The arrow pointing downward indicates a signal output, a signal being routed to whichever bus on which switch 1 is set. The upfacing arrow indicates an input, taken in this case from bus 2. Why have we chosen level 2? Merely because it is unoccupied. We might equally well have used level 1, 3 or 4, provided these also were unoccupied.

Fig. 2 shows a more realistic ARP patch arrangement in which a sinewave and squarewave from oscillator A (switches 5 and 7 in the left matrix) modulate the frequency of oscillator B. A triangle wave from A simultaneously modulates the pulse width of the tone emitted from oscillator B. Two buses are used to separate the frequency and pulse control voltages. The tone produced by B is in this case switched to level 4 where it might be routed to a signal processor. Alternatively, it could be coupled through a level 4 miniature jack socket to an external amplifier.

Since a ten switch 20 position matrix is incorporated above and below each ARP module, some switches must inevitably be redundant to the system. Not every module requires ten inputs and ten outputs. The *1023* dual oscillator module, for example, has six upper-level inputs, four bottom level inputs, and two bottom level outputs. In other words, it uses 12 of the 20 switches it spans. Since the redundant switches are not even useful in connecting external equipment, one might query the sense of such a routeing system. A typical ARP *2500* might have over 60 redundant switches; 25 per cent of its total complement. Add to this the little problem of parallax confusion when looking up or down to a bank of protruding switches, plus the crosstalk between neighbouring buses, and you face the question: why don't they use pinboards? One answer is that ARP have chosen the easiest method of 'custom building' synthesisers. If so, they have reduced the flexibility of the instrument by a colossal degree, as the following crude arithmatic will attempt to show:

A typical ARP *2500* has 180 inputs or outputs which for the sake of argument we will regard as 90 inputs and 90 outputs. Each of these 180 may be switched to any one of 20 positions. The total number of theoretically possible combinations is thus 20^{180}, or 40^{90}. If the 90 outputs are arranged down a pin matrix, however, and the 90 inputs across, the number of possible combinations more than doubles to 90^{90}. This assumes that the pin matrix is restricted to one pin per row since the ARP system is inherently limited to one active point per switch.

In practice, a 90 x 90 pin matrix could accept many more than 90 pins: 8,100 to be precise. Which raises beyond comprehension even our 90^{90} combinations.

A few other basic points should be covered before we look in detail at each module.

Firstly, the photograph does the ARP much less than justice. The *2500* makes considerable use of colour symbolism. For example, a yellow switch may relate to an amber potentiometer, a green switch to a green pot, red to red and white to silver. The redundant switches are coded black.

Secondly, if you are ever called upon to move a *2500* from one room to another, resist the temptation to lift it from beneath the keyboard. The main chassis is not bolted to the keyboard module and the two short umbilicals would not prevent a mighty expensive accident if the chassis toppled.

3001 Keyboard

ARP keyboards are divided into two electrical sections; one with black naturals, white sharps, and the other following piano colours. These sections may be coupled to form a five octave unit or used entirely independently. Your left hand might control the pitch of one oscillator while the right controls another; a simple form of polyphony. More interesting applications come to mind as you grow accustomed to the possibilities of voltage control. Simple examples: the left keyboard can be patched to control loudness, notch filter fre-

continued over

Photograph and manufacturers' specification: Page 37

FIG. 1

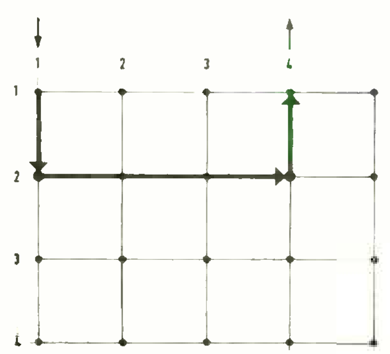
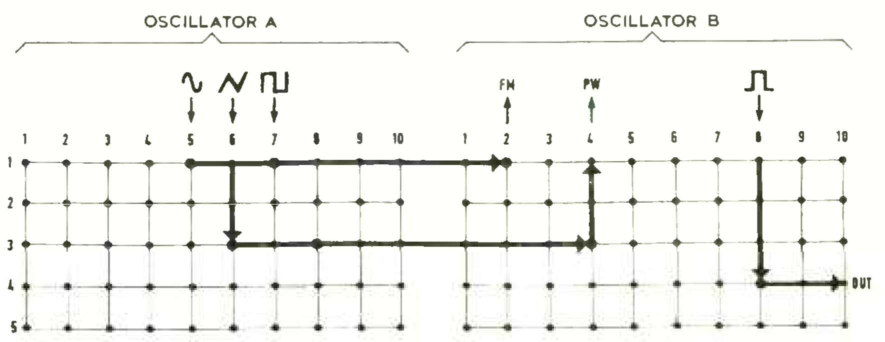


FIG. 2



quency, vibrator rate, pulse width, or all five characteristics simultaneously.

Each keyboard section supplies three items of information: ***control voltage, gate*** and ***trigger***. These are prewired to separate buses on the upper level switch groups. The *control voltage* rises by an appropriate ratio with every semitone shift up the keyboard. Twelve such intervals give a 1V rise in voltage across one octave.

The *gate* is simply a ramp voltage, a single pulse which holds for as long as a key is pressed. Not to be confused with the *trigger*, a virtually instantaneous pulse produced whenever a key is pressed but independent of note duration. Gate and trigger have obvious applications in controlling (via an envelope generator) note dynamics.

Horizontal panels left and right of the keyboard carry controls governing portamento (gliding tones), absolute tuning and tone interval. Each panel governs the adjacent keyboard section. **Fig. 3** shows these two panels. Portamento speed is variable over a fairly wide range, dependent on the rotary control setting. An adjacent switch overrides this facility. The purpose of other controls on these panels should be obvious.

FIG. 3A

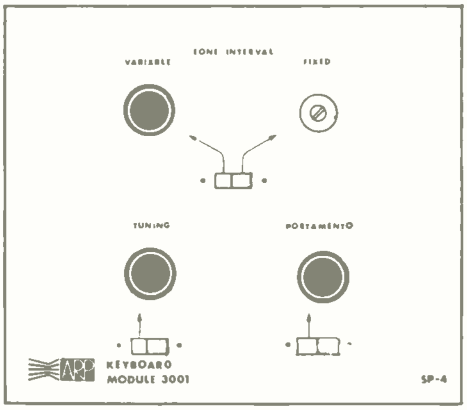
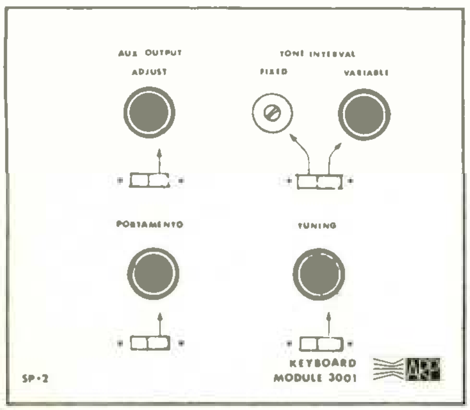


FIG. 3B



1004t oscillator

Fig. 4 shows this, one of several vc oscillators produced for *2500* synthesisers. Three ingoing arrows at the module top represent frequency control inputs with a fixed sensitivity of 1V per octave. On the bottom edge of the module, inputs 2 and 3 are also frequency controls. These may be varied in sensitivity to a maximum of 1V per octave. 'Input pwm' controls the mark / space ratio of the pulse output but has no effect on the sine, triangle, square and saw waveforms. Each waveform may be extracted independently, or switched into a single output channel (bottom right). Phase reversal switches occupy a subpanel. Two of these were incorrectly wired. Coarse and fine initial frequency controls are incorporated, plus an initial pulse width potentiometer. The 'enable' switch disconnects the module from the ARP power supply. Right of this is a low/high frequency range switch.

1023 dual oscillator

Illustrated in **fig. 5**, this module is a simplified version of the *1004t*. In the same module width it incorporates two entirely independent oscillators, each with concentric coarse and fine frequency controls. No vc pwm in these units, but pulse width presets and facilities for mixing two fm control voltages (2a, 3a and 7b, 8b).

1045 oscillator/voice

This unit (**fig. 6**) can be used as an independent oscillator (left hand subpanel) or in conjunction with the built-in envelope generator, vc amplifier and vc filter. The oscillator suffered from an intermittent fault and in the course of several days grew less inclined to oscillate.

1047 filter resonator

All ten switches beneath this module are active. One and two (bottom, **fig. 7**) are audio inputs, mixed by potentiometers bearing the same digits. Output three supplies the ingoing signal treated according to the frequency response curve immediately above switch three: maximum bass falling straight to minimum treble. Output four offers a low bass, high mid, low treble format; output seven low bass curving up to high treble; and finally the notch at output eight. Inputs five and six, via potentiometers five and six, accept frequency control voltages. A sinewave at input five, for example, would swing the peak frequency of output four up and down the audio band. A sawtooth control voltage would sweep the peak upwards, cycling instantly back to lf. Inputs 9 and 10 permit voltage control of the filter resonance. Initial filter characteristics are set by coarse and fine frequency resonance, notch and final resonance controls.

This module appeared rather too sensitive for the rest of the system and often overloaded under conditions in which other synthesisers remained stable. Slight adjustment to complex patches were often upset by the *1047* module overloading. An overload warning light is incorporated to reveal this condition.

1046 quad envelope generator

This unit (**fig. 8**) produces up to four separate envelope waveforms, plus two in antiphase, to control (through a *1006* vc amplifier/low pass filter module) audio amplitude. It might also be routed to a filter frequency control, oscillator pitch control or some less obvious control input. Attack time, initial decay time, sustain level and final decay time may be adjusted independently in each of the four sub panels. If desired, all four envelopes may be triggered from a single pulse.

1016 random generator

White noise, pink noise and random ramp voltages are produced by the *1016* (**fig. 9**). This was the middle unit of the synthesiser supplied for test and sat above and below miniature jackfields rather than switchbanks. The output labelling, conceived for switches, in this case refers to bus levels. Noise appears at levels three and five, random control voltages at seven and nine. Each of these four generators

FIG. 4

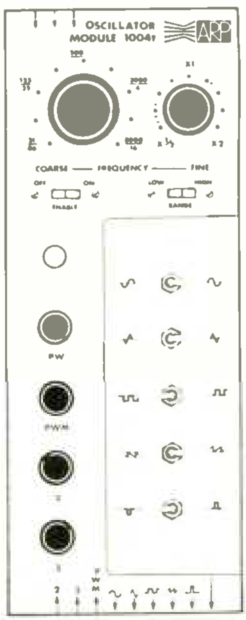


FIG. 5

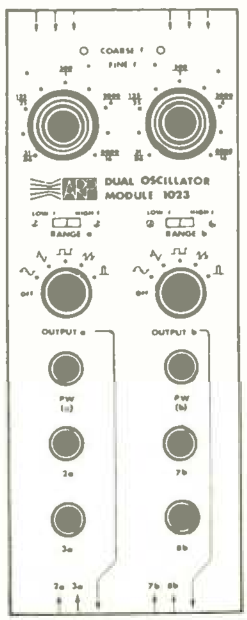
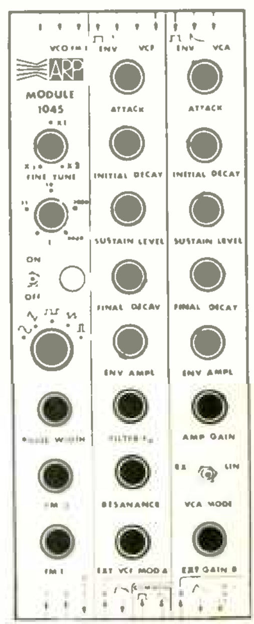


FIG. 6



may be switched off when their buses are required for other signals. The noise was clean, lacking the grittiness of the generator employed in the smaller ARP *2600*.

1027 sequencer

Fig. 10 illustrates this, a ten state three layer voltage memory. Rows A, B and C show the three layers of potentiometers used in preliminary adjustment. Suppose we wanted to programme a simple melody of ten notes duration. Control voltage output A (third from right, bottom edge) could be routed to the frequency control input of an oscillator. If the first note of our melody is the lowest in pitch, the first (topmost) sequencer control in the A layer may be set to minimum and the oscillator frequency control adjusted to the desired pitch. The sequencer at this stage is off (stationary). A green light adjacent to the top row of presets indicates the active controls. We press the 'step' button and the first state lamp extinguishes. The lamp below it comes on, and into circuit come the second set of presets. Our next note is tuned by the second from top A-layer control, step again, tune the fourth control, and so on to the end of the sequence. If you become confused in the middle of tuning a note series, the 'reset' button reverts to the beginning of the sequence.

When all ten notes are set, the square (illuminating) 'on' button sets the sequence ticking away until somebody or something triggers 'off'. The pulse width control adjusts the duration of silence between stages, from discrete notes to a series of non-zeroing ramps. Overall speed is controlled by the pulse repetition frequency knob and the adjacent coarse 'low/high' rate switch.

If we wished to vary the length of one or more notes, this could be accomplished by employing the ten B-layer presets (middle row) as a source of duration control voltages. Output B could be routed to the 'vc width' input. Thus the higher a B pot setting, the longer the related A pot note. This leaves layer C free to control an independent melody or the characteristics of another processor.

Any external pulse may be applied to the 'on' input to trigger a sequence, provided the internal trigger is over-ridden. Similarly a sequence may be halted at any time by applying a pulse to the 'off' input. Here the position gates are useful (outputs one to ten, relating to the ten groups of presets). Routeing gate ten to the off input halts the sequencer on the tenth note of each run. A slow external pulse oscillator might then be used to restart the sequence. The *1027* module occasionally became unstable at high repetition speeds, a fault usually cured by switching off for a few minutes.

1050 mix-sequencer

This unit was a delight to operate and must be one of the smallest 8/2 mixers currently available. Illuminating push-on, push-off buttons show at a glance which channels are functioning. Each input has its own level preset, feeding group faders. All 'on' channels may be cancelled at the touch of a single 'exclusive on' button. The *1050* may also be used as a sequentially controlled analogue gate, channels being activated either singly or in pairs.

1005 Amplifier

Illustrated in fig. 12, the *1005* incorporates a

continued over

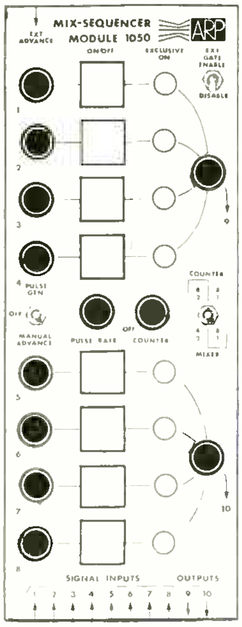


FIG. 11

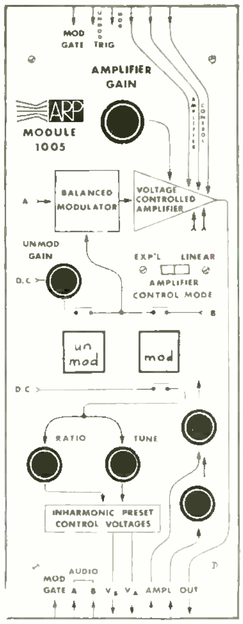


FIG. 12

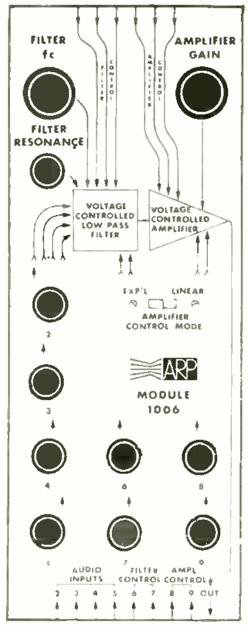


FIG. 13

FIG. 7

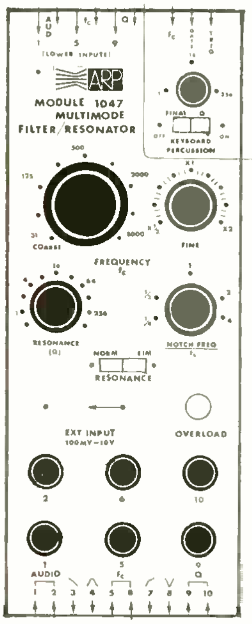


FIG. 8

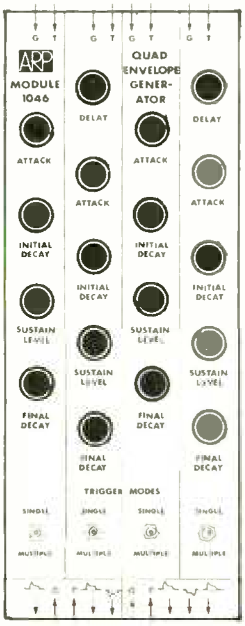


FIG. 9

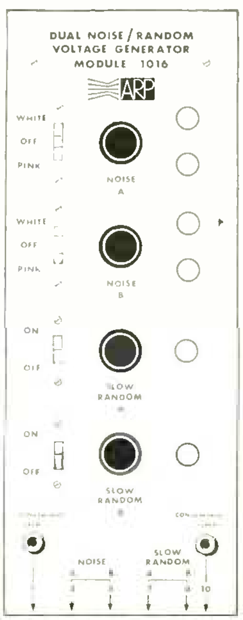
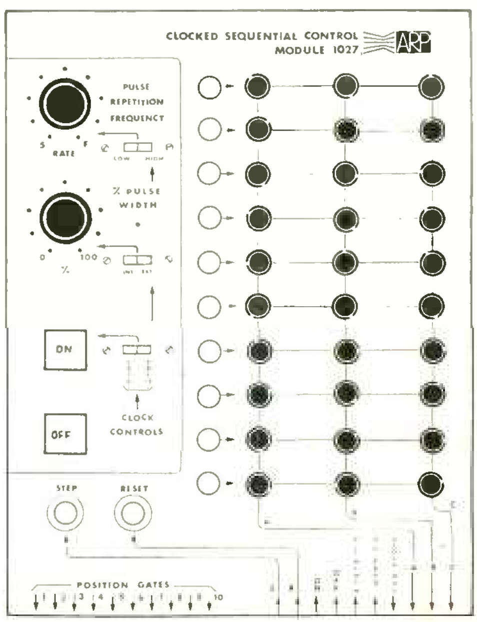


FIG. 10



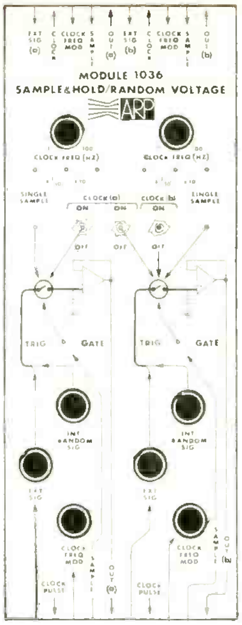


FIG. 14

balanced modulator and voltage controlled amplifier. If equal amplitude sinewaves of frequency f_a and f_b are routed to audio inputs A and B, the output will comprise the sum and difference tones $(f_a + f_b)$ $(f_a - f_b)$.

If harmonics are present in the waveform supplied to input A (f_a, $2f_a$, $3f_a$ and so on), the B input remaining a plain f_b sinewave, the resultant output signal contains the frequencies $(f_a + f_b)$, $(f_a - f_b)$, $(2f_a + f_b)$, $(2f_a - f_b)$, $(3f_a + f_b)$, $(3f_a - f_b)$, etcetera. Two internal control voltage sources may be used to modulate the oscillators feeding A and B. Ratio and initial tuning control are incorporated on the *1005* facia.

1036 sampler/random generator

Like the *1005*, this module offers facilities you are unlikely to require until completely familiar with the rest of the *2500* chain. The *1036* is a dual unit with four rotary controls per section labelled 'clock frequency', 'internal random signal level', 'external signal level', and 'clock frequency modulation'. If we apply a 1 Hz sinewave to the external signal input (bottom left, **fig. 14**) and set the clock frequency to 2 Hz, output 'a' will deliver two ramp voltages per second, briefly storing the amplitude at each moment the sine is sampled. Noise sampled in the same way produces random control voltage ramps independently of the *1016* random generator. The value of a sample and hold facility clearly exists more in sampling complex repeating waveforms than plain sinewaves. The clock frequency modulation facility makes this a particularly promising module.

There, for what they are worth, are my views of the ARP *2500*. Is the system worth £5,400? This can only be sensibly judged by comparison with other synthesisers now available. I must point out that four of the smaller ARP *2600*, for example, (totalling £5,400) would form a more flexible basis for an electronic music studio than one *2500*. You'd miss the sequencer? Then you would still do better with a chain of small synthesisers and a locally made £1,500 sequencer handling rather more than ten by three states.

David Kirk

Agents' comment*: The *2600* and *2500* are closely related in that they employ the same basic electronics for sound generation and processing, the principal difference being in the presentation of the 'package'.

Matrix switches are employed in the *2500*: (a) To provide a versatile synthesiser system capable of modification to individual requirements. (b) Each input/output may be switched to any of 40 positions, not 20 as stated. (c) To eliminate the possibility of loss or damage encountered with removable pins or patch cords.

Keyboards are available in many configurations. The keyboard reviewed did in fact have a left-hand single-voice two-octave section and a right-hand two-voice three-octave section. This right-hand section is capable of playing two different notes simultaneously.

The filter/resonator is capable of very high Q values (over 300) and may obviously become unstable if incorrectly operated. For this reason, an overload indicator is fitted. Should overloading occur, the obvious solution is to reduce the input level.

A more detailed reply is being prepared for our June issue*—Ed.**

Studio Diary

BY KEITH WICKS

THE power cuts earlier this year did not seriously affect many studios. The reason was that most studios had relatively few bookings so that it was easy to schedule sessions for periods when the risk of a power cut was known to be low. For factories, however, the cuts were more inconvenient and resulted in some studio equipment and components being delivered even later than normal.

The power was cut during a performance by Richard Harris at the Odeon, Hammersmith, for which **SARM** provided and operated the amplification system. Most of the equipment was being run from a generator but unfortunately some of the microphone power supplies were plugged to the mains. This resulted in some sections of the orchestra becoming virtually inaudible, spoiling what was otherwise an excellent show with really superb amplification. SARM were using multitrack techniques with a Neve mixer located in front of the stage. At last efforts are being made to provide studio quality sound at live performances. Anyone wanting high quality live sound can phone SARM on 346-0209.

Another specialist in live sound is **Ian Gibson**, who has provided high quality sound in the theatre for both musicals and straight plays. A few months ago, I went to see *Journey's End* and was amazed during the last act by Ian's realistic quadraphonic effects of shells whistling overhead and bursting in the back stalls. If you want a freelance designer who can also supply mixing desks and other equipment on hire, phone Ian Gibson on Heckmondwike 3948. Techniques for providing high quality live sound will be dealt with in a forthcoming series of articles in STUDIO SOUND.

Tooting Music Centre have been renamed **Viking Sound** and now offer eight track recording on a Scully for £12 per hour. Recent visitors to the studio have included the Night Riders, Arthur Brown, the Huggett Family, and Kenny Young.

The **Roger Squire Studio** for disc jockeys has been completely rebuilt and made easier to operate. The dj is provided with a panel on which there are six faders for the various record, tape, and jingle machines. Associated with each fader is an illuminated start button, enabling any source to be operated remotely by the dj.

Squire have been successful yet again in getting a dj through the BBC audition. Tony Baron has just passed the test with a demonstration programme recorded at the studio, making a total of five BBC passes in the last seven months. On Monday and Tuesday evenings Roger Squire is running dj courses in radio techniques. These courses started six months ago and, as the start of British commercial radio approaches, more and more people are becoming interested. Personally, I think that many good disc jockeys will be out of work when commercial radio comes. Although some improvement on the present needle time situation is likely, at the moment it seems that there is little chance of commercial radio stations being able to broadcast many long record programmes, so the demand for djs will not be very high. There will, however, be a demand for all round announcers, producers, and technicians. These will mostly be lured away from the BBC by the commercial radio companies, adopting the tactics used by the commercial television companies a few years ago. However, djs need not despair altogether because other countries are buying British produced record programmes. London Wavelength have recorded a number of pop programmes at the Squire Studio, mainly for sale to Australia. Also some radio stations in the USA have ordered programmes and English voice-overs from the studio and, having heard the excellent quality of the material produced at Squire, I am sure that this business will continue to increase.

Emperor Rosko will soon be in competition with Squire Sound. Chymes Audio Electronics are installing three seven channel desks with integrated circuit mixing in a new dj training studio in London which Rosko is planning to open in the summer. Remote start facilities are provided for tape and disc and the desk outputs are fed to a tutor's master control console. The setup will be operated rather like a language laboratory.

Theatre Projects Sound now have an eight track Leevers-Rich machine with electronics by Richardson. The charge for eight-track recording is £17.50 per hour. David Collison explained that they needed a good sturdy, uncluttered desk which could be bought without the electronics because they wanted to use Richardson modules. These are smaller than the Leevers-Rich modules and, I am told, cost less and provide more facilities. The studio desk has been modified for eight track working, an EMT stereo plate has been installed, and four Klein and Hummel *OY* speakers have replaced the pair of Lockwoods previously used for monitoring. As I mentioned in my report on Theatre Projects last month, the Klein and Hummel speakers measure only about 480 x 300 x 230 mm and they each contain two 30W amplifiers, one for the low and one for the mid to high frequencies. The sound produced by these speakers is very good by any standards, but considering their minute size, the sound is really incredible. I have not had the opportunity to compare them with other speakers in an A-B test and I have learnt by experience that a certain speaker can sound excellent in one room but poor in another. However I would recommend those dissatisfied with their present system to try Klein and Hummels; I feel sure that anyone with limited space in their control room would have great difficulty finding more suitable loudspeakers.

The **Orange** engineers have been continuing work on their range of recorders and, although the supply of some parts was delayed by the power strike, a machine was assembled in time for the Frankfurt International Fair held on March 5 to 9. As reported in the February issue, Orange hope to move to bigger premises in the near future. Although they have viewed many buildings, the right place has yet to be found. Studio manager Brian Hatt explained that it would be best to construct a new studio building but that would not be possible without leaving the West End. They don't want to do that so they will continue looking around for a suitable building or studio in town. If you would like to sell your studio, try ringing Brian Hatt on 01-836 7811.

At **Pan Sound Studios**, work has been started on a folk opera for the Pearl Connor Agency. The material is best described, I am told, as a 'sort of Jamaican *Jesus Christ Superstar*'. The cast of the musical *His Monkey's Wife*, recently at the Hampstead Theatre Club, recorded an album of the show. Don Crown recorded a new single, and organist David Hamilton, from the radio programme *The Organist Entertains*, recorded an album. The titles included *Tiptoe Glowworm*, *Gypsy Princess*, and *A Whiter Shade of Pale*.

Pan are still looking for musical talent, so if you think you sound like Mary Hopkin or Tom Jones phone 01-328 7222 and try to convince studio manager Vic Hawley.

Big changes are taking place at **Mayfair Sound Studios.** Their new desk is nearly finished and a new control room is being built. Dolbys are now in operation and air conditioning is to be installed. Meanwhile it's business as normal because the existing control room will remain in operation until the new one is complete.

Recent visitors to the studio have included the Casuals, Lionel Bart, and Marianne Faithful, who has now completed her album which was produced by Mike Leander.

Peter Houghton, studio manager at **Gooseberry** in Gerrard Street, tells me that a new eight track machine should arrive any time now. The slight delay in going eight track has not affected business and the studio had been very heavily booked during the last month, possibly because the charge for four track is only £5 per hour.

The Birmingham studio, **Hollick & Taylor,** have been busy with a variety of studio, mobile and dubbing work. Sound tracks have been

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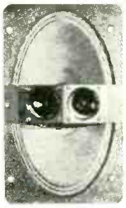

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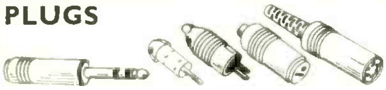

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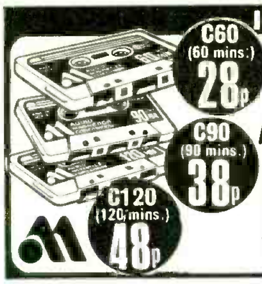

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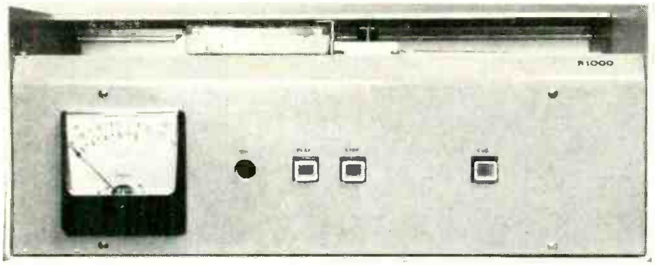

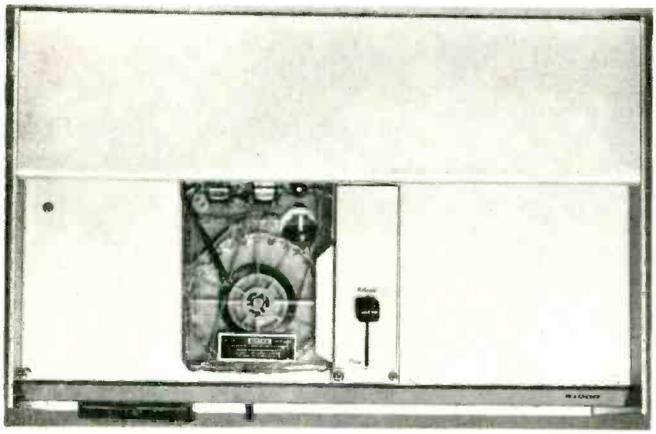

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STUDIO DIARY

continued

made for several documentary films and commercials. Raymond Froggat and the New World both recorded single material and Curtis Mayfield laid down some backing tracks. The Light Fantastic recorded two parodies of Pop songs for an advertising promotion campaign, the session being produced by Geoff Lynn of the Move for Aquarius Management. A new group called Birmingham completed a rock-jazz-blues album which has just been released on the studio's Grosvenor label. In Colchester, the Hollick & Taylor mobile unit recorded the music of the Green Jackets and Light Division who flew over from Ireland for the occasion.

Dave Stock, until recently an engineer at DeLane Lea's Dean Street studios, has sent in a report from **Eastern Sound Studios,** Toronto, where he now works. Dave has just completed engineering a blues album for the Canadian group Whisky Howl, and is now producing an album for a folk singer called Paul Ham. Tom

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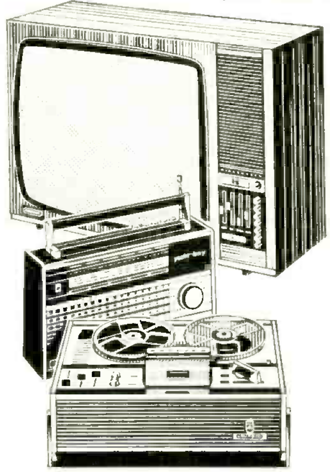

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Equipment Reviews

Allison Gain-Brain

According to the publicity material, the *Gain-Brain* is an unconventional limiter which 'knows what you want to hear'. Certainly it is an unconventional unit, but it is equipped with four knob controls and a toggle switch on the front panel, and they do not exactly twiddle themselves.

The top knob is labelled 'function' and controls the unconventional part of the unit which enables the compressor to operate on the peak incoming signal, the rms incoming signal or, when the knob is in an intermediate position, a compromise between peak and rms. The rotation of the 'function' control from the peak position to the 'rms' position also has the effect of separating the limiting thresholds by raising the peak threshold by 6 dB and lowering the rms threshold by 6 dB, thus allowing a separation of thresholds which is variable up to 12 dB.

Adjacent to the 'function' control are two indicator lights, in the form of red light emitting diodes. These are illuminated when limiting is taking place and are arranged to indicate if the peak signal, rms signal, or both, are the cause of limiting.

Underneath these indicators is the second knob which controls the release time of the limiter, calibrated in seconds from 0.05 to 5 with two intermediate calibration points. The remaining controls are an output attenuator calibrated from −35 to +15 dBm, an input attenuator calibrated from +30 to −20 dBm, and a toggle switch arranged to bypass the limiter section of the unit.

The remaining area of the front panel is occupied by the gain reduction meter which comprises a further seven red light emitting diodes which are identified by the numbers 2, 4, 6, 9, 12, 18 and 24 which represent the existing gain reduction in decibels.

The general appearance of the front panel is clean and the identification of the controls is clear; however the calibration of all the controls is very crude, there being only four calibration points associated with each knob. Furthermore only the heads of the knobs, which are colour coded for easy identification, bear any position indicator. It is therefore quite impossible to reset the knobs to any predetermined position with adequate accuracy.

All the components of the unit are mounted on a single high quality printed circuit board equipped with a standard printed plug which is intended to be inserted into the manufacturers' standard modules. All components on the circuit board are clearly identified and the board layout is very clean, all electrical connections being made by means of the printed plug.

Similarly, the manufacturers' standard module is of substantial construction, and is equipped with a clearly labelled printed circuit connector into which the 'Gain-Brain' is inserted.

Inputs and outputs

The power requirements of the unit are specified as 24 to 28V dc negative earth at 70 mA, however the specified current consumption is probably rather misleading as the sample unit only required 40 mA under no-signal conditions. When the output was terminated into 600 Ω, the unit required 75 mA when delivering +12 dBm sinewave, or 80 mA when delivering the rated output of +18 dBm. These power requirements will of course be much reduced under practical conditions where the

continued over

MANUFACTURERS' SPECIFICATION

Gain Reduction Range: 30 dB

Noise Level (20 Hz to 20 kHz): At least 83 dB below threshold of peak limiting.

Distortion: Total harmonic distortion is less than 0.3% from 40 Hz to 15 kHz.

Attack time (peak section): Less than 1.5 dB overshoot one microsecond after application of 50 kHz tone burst exceeding the threshold of limiting by 15 dB.

Attack time (rms section): 7 mS to 40 mS form 90% of ultimate gain reduction. Dependent on waveform complexity, amount of limiting and position of function control.

Release Time (peak section for transients of less than 50 µS duration): Less than 1 µS.
(for other peak signals) : Variable by release control from 50 mS to 5s.

Release time (rms section): Variable from 250 mS to 5s.

Limiting ratio (peak section): Approximately 50 to 1.

Limiting ratio (rms section): Approximately 40 to 1.

Limiting thresholds: With function control in peak position all thresholds are at —20 dBm with input level control fully clockwise.

Separation between thresholds: Rotating the function control from peak to rms raises peak thresholds by 6 dB, while lowering rms thresholds by 6 dB. This allows a separation of thresholds which is continuously variable from 0 dB (peak position) to 12 dB (rms position).

Frequency response: ±1 dB from 25 Hz to 80 kHz.

Output Level: Up to 18 dBm into 150 Ω or higher (+24 dBm may be obtained by using a 150 to 600Ω output transformer).

Multiple Limited Coupling: Connection provided for tandem limiting functions.

Front Panel Controls (Five): Input level, output level, release time, function (peak rms), in/out switch.

Power requirements: Regulated 24V dc to 28V dc negative ground at 70 mA.

Gain Reduction Meter: Seven increment sequential light emitting diode array indicates gain reduction from 2 to 24 dB.

Meter accuracy: ±1 dB (2 dB to 12 dB gain reduction); ±2 dB (18 dB to 24 dB gain reduction).

Meter speed: Virtually instantaneous. Permits accurate reading of short term fast release limiting.

Peak limiting indicator: Light emitting diode indicates when peak limiting is taking place.

Rms limiting indicator: Light emitting diode indicates when rms limiting is taking place.

Structure: Card form with high impact plastic panel, controls and metering 25.4 wide, 177.8 high, 139.7 mm deep.

Price: £153.

Manufacturers: Allison Research Inc, 7120 Sunset Boulevard, Hollywood, California 90046.

Agent: F. W. O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts.

unit is used to deliver speech or music.

Audio signal input requirements are very flexible, being specified as between –20 and +30 dBm for peak limiting. While the sample unit substantially agreed with the specification, it was found that the input impedance (which is not specified) varied from 3.41 kΩ at maximum input gain, to 4.74 kΩ at minimum input gain. Not only is this impedance variation undesirable, but even the maximum input impedance is inconveniently low for use with 600Ω lines and leads to approximately 1 dB loss when bridged across a 600Ω line.

The signal output level into 600Ω could be raised to +19 dBm before the onset of clipping and could be varied over a 50 dB range by means of the output level control which did not have any effect upon the output impedance measured as 1.9Ω at 1.59 kHz.

In addition to the audio output, a further output is provided for coupling the limiting level of two limiters for use in stereo. As only one sample unit was at hand, this facility was not tried; it is assumed that it may be extended to two or more channels.

Frequency response distortion and noise

The frequency response of the limiter was investigated at an output level of –10 dBm into 600Ω with the input level adjusted to four different degrees of limiting (0 dB, 6 dB, 12 dB and 24 dB). It is to be seen from **fig. 1** that the frequency response is within specification at the three lower input levels but, at 24 dB limiting, the bass response rises outside specification below 80 Hz. This effect was found to exist with either peak or rms limiting and to be little affected by the release time setting.

Because it was thought that sinewave testing of the frequency response might have accounted for the rise in bass at high limiting levels, the frequency response was checked by feeding the limiter with pink noise and analysing the output with a third octave filter. Very similar results were obtained, so it can only be concluded that the frequency response of the limiter goes crazy at very high limiting levels.

Investigation of the distortion introduced by the complete unit demonstrated that there was negligible variation in distortion with the output level varied up to +18 dBm, and also that loading the output had negligible effect. There is a rapid increase in distortion above +18 dBm output, but this is more than adequate for any normal use of the limiter.

Detailed investigation into the distortion at 1 kHz and its relation to limiting produced the following table.

1 kHz total harmonic distortion

Indicated limiting	Function set to rms	Function set to peak
0 dB	0.17%	0.3%
6 dB	0.16%	0.3%
12 dB	0.15%	0.3% to 0.6%
24 dB	0.12%	0.3% to 0.6%

From the above it is to be seen that distortion in the rms limiting function is satisfactorily low, as it is with the smaller degrees of limiting in the peak limiting function. However, with heavy limiting in the peak limiting function, the distortion was found to be unstable between 0.3 per cent and 0.6 per cent total harmonic content. The photograph (**fig. 2**) shows that a large part of the distortion under these conditions is in the form of pulses coinciding with the peaks of the input waveform.

Spot checks on distortion at other audio frequencies did not show any excessive distortion and low frequencies were noticeably clean, even under adverse control settings. Similarly, intermodulation distortion measured by the SMPTE method was found to be less than 0.2 per cent at all rms limiting indications.

However, a peculiar effect was observed when the input voltage was set so that the indicator was on the verge of changing from an indication of 2 dB to an indication of 4 dB. Listening to this effect with high frequency inputs produced a 'tweeting' effect. Further investigation at 10 kHz produced **fig. 3** which shows the input signal together with the total harmonic content of the output signal under the conditions mentioned above. From the photograph it is to be seen that the limiter has introduced a series of sharp spikes into the output waveform.

While this defect is dependent upon a constant input signal which is probably unusual in speech or music, it is not frequency dependent, and could lead to unpleasant distortion.

The noise output of the limiter was measured as –81 dB(A) with the output control set for 0 dBm into 600Ω or –88.5 dB(A) with the output control set to minimum, both of which indicate a satisfactory performance.

Attack and release times

The attack and release times of the various functions were investigated by applying 10 dB steps to the input signal and examining the output by means of a high speed ultra violet recorder.

Using this technique, the attack time of the rms section was found to be 50 mS for 90 per cent reduction in gain, and that of the peak section was too fast to be observed—the limit of observation being 50 mS. In neither case was there any detected overshoot in either direction.

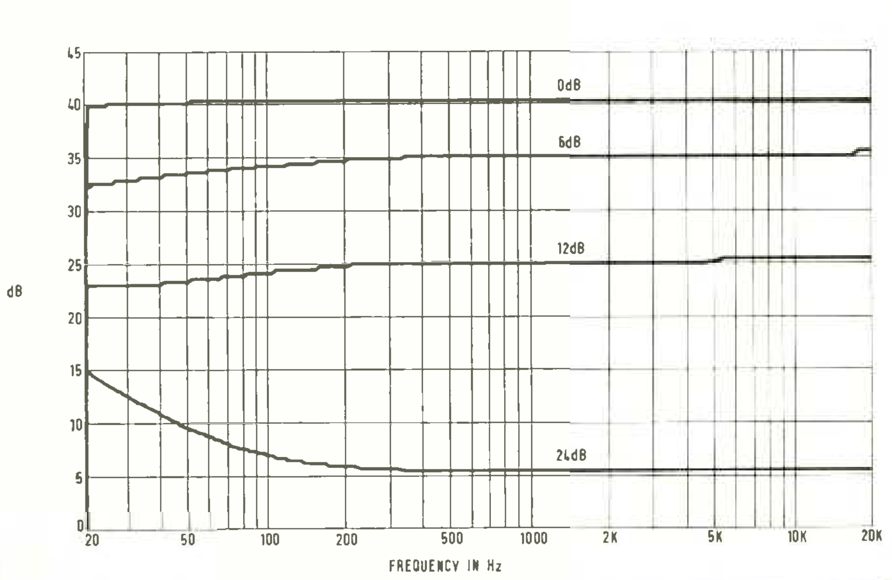
Similar investigation into the release time of both sections provided identical results which varied from 50 mS to 3.5s according to the setting of the front panel release time control. The release characteristic of the rms section, when set for the longest release time, showed a 0.5 dB overshoot which is of little practical significance.

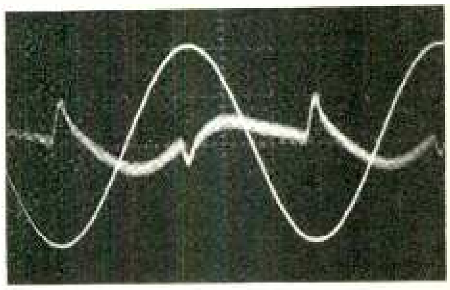
While the above figures do not exactly align with the published specification, it is likely that the difference in measurement techniques

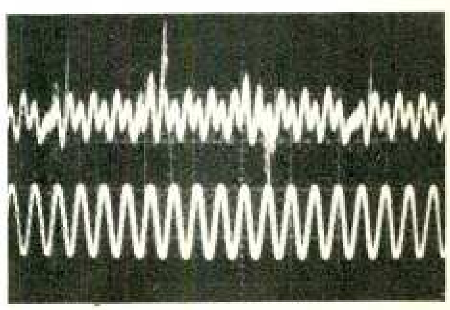
continued 55

FIG. 2 adjacent. **FIG. 3** bottom.

FIG. 1 GAIN BRAIN FREQUENCY RESPONSE (LIMITING)







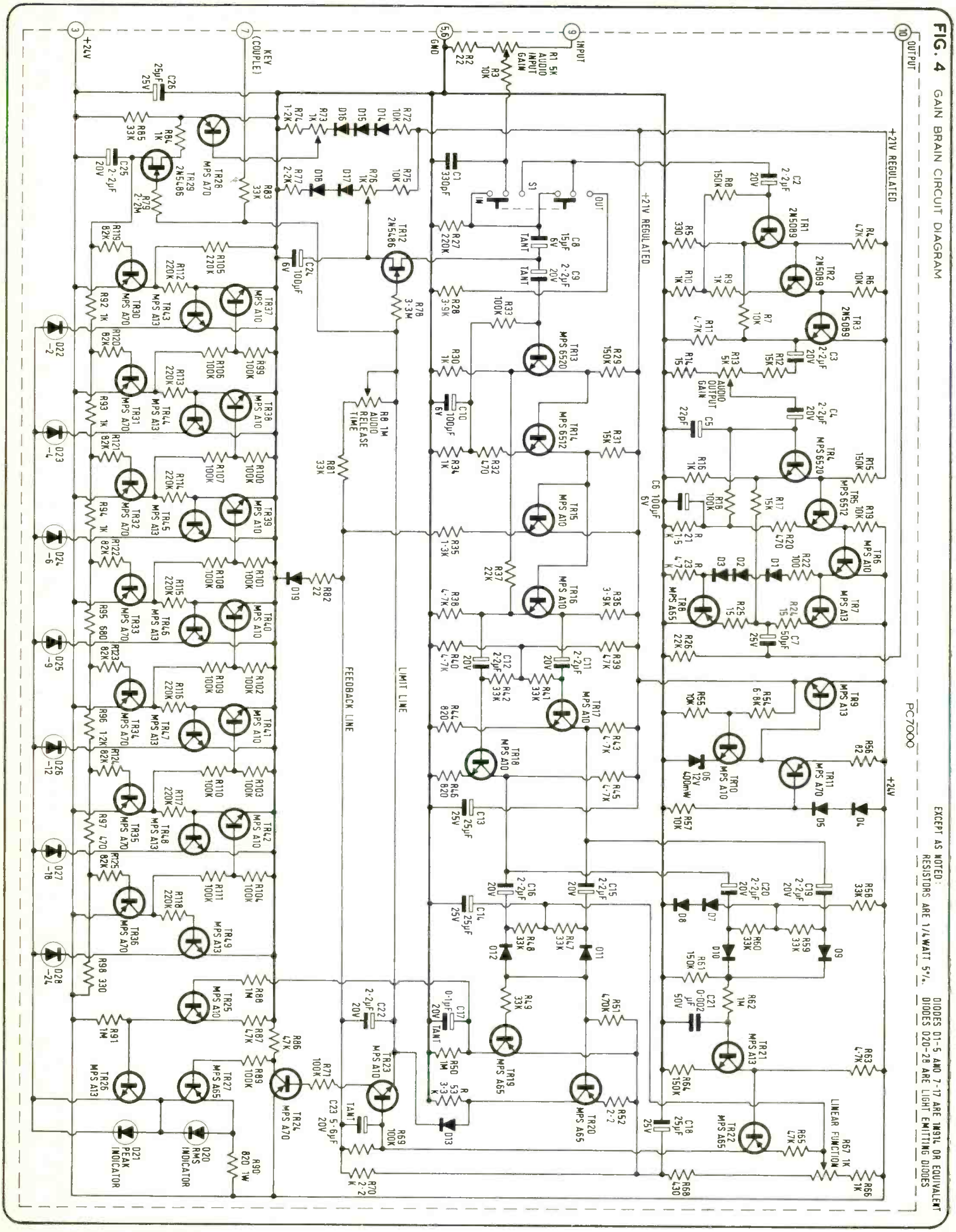


FIG. 4 GAIN BRAIN CIRCUIT DIAGRAM

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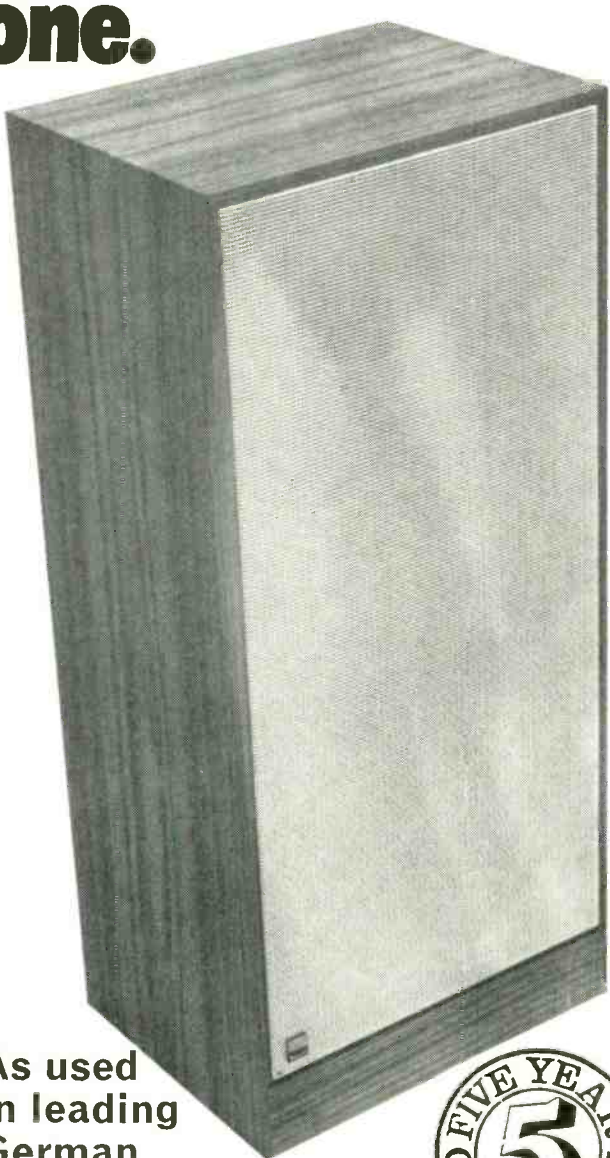

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can account for the relatively small variations.

Metering

The inbuilt display of light emitting diodes for monitoring the degree of limiting was found to be very easy to read, even in high levels of room illumination, and the inbuilt time constant of the system was sufficient to permit the reading of fast transient overloads which cause short term limiting.

The accuracy of the display was investigated by applying an overload such that the appropriate indicator was just illuminated, both with the function control in the peak position and rms position.

It will be seen from Table 1 that the indicator system is within its strict specification up to 18 dB limiting, but does under-read at an indicated 24 dB limiting.

At this juncture, a word of warning is appropriate about the method of monitoring compressor/limiter outputs when they are to be recorded on to magnetic tape. As a fundamental it is obvious that any signal that is subjected to limiting or compression will have the relation between peak and rms power disturbed. Similarly it will have the relation between mid frequency power and power at high and low frequencies disturbed such that the power at the extremes of the audible spectrum will be increased in relation to mid frequency power.

In these circumstances, monitoring the signal output with a VU meter will lead to extreme errors in recorded level because the standard VU meter was designed by means of subjective tests so that an indication of zero VU corresponded to between 8 dB and 10 db below the peak level of *normal* speech or music.

TABLE 1

INDICATED LIMITING	ACTUAL LIMITING Function Peak	ACTUAL LIMITING Function rms
2 dB	2 dB	1.5 dB
4 dB	3 dB	3 dB
6 dB	5 dB	5.5 dB
9 dB	8 dB	8.5 dB
12 dB	11 dB	11.5 dB
18 dB	18 dB	19 dB
24 dB	28 dB	30 dB

It therefore follows that the ppm is a better instrument for monitoring compressed or limited outputs, because it indicates a level that is much nearer the true peak.

However, the problem of tape equalisation characteristics will still have a very significant effect upon the distortion in the recorded signal, with the result that the only satisfactory method of monitoring greatly compressed or limited signals is *off tape*. Any attempts to monitor before tape may lead to totally deceptive results, even if a ppm is used.

Summary

The Allison Research *Gain-Brain* is a very versatile device which should find applications in both the broadcasting and recording industries in view of its very rapid attack time on peak signals and its versatility in limiting functions.

Broadly it meets its published specification but it does have a number of limitations where extreme degrees of limiting are involved. However, such degrees of limiting are only required where extreme degrees of distortion are intended, and the added distortion introduced by the *Gain-Brain* will probably pass unnoticed.

As with any form of compresssor/limiter, great caution is essential if the output is to be recorded on magnetic tape. **Hugh Ford**

Miniflux Meg 7

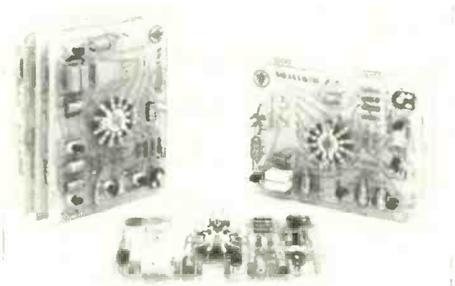
MINIFLUX Electronics Ltd have been actively interested in tape recording for many years, and their products are already well known.

The item actually submitted for review was a versatile four channel tape replay amplifier. While it is intended to work with any four channel head having about 80 mH inductance, they also submitted one of their four channel (6.25 mm) type *FCN3* heads, rightly surmising that the reviewer may not yet own such hardware.

The preamplifier was supplied in a neat diecast box 120 x 95 x 80 mm which carries a five position switch giving five different playback corrections—hence the description 'versatile' and the title 'Universal'. These cover the standard time constant requirements of 35, 50, 70, 90 and 120 μs as well as the 3180 μs bass cut and therefore covers all the tape speeds (except 76 cm/s), and most of the current standards.

The *Meg 7* is the production version of the original *Meg 3* and the complete assembly uses four identical printed circuit boards.

The first transistor pair is stabilised with dc negative feedback, while the third transistor, acting as an emitter follower, provides switched selective feedback to produce the desired equalisation characteristics. The high frequency boost, not part of any tape standard, is strictly peculiar to each head and depends on various 'losses' due to gap length, filler, head core material and even tape surface and playing tension. However, these losses are now very similar for a wide variety of heads and much less than they were a few years ago, so a second bank of each switch brings in a suitable tuning capacitor in parallel with the playback head. In the *Meg 7* the values have been chosen to suit heads with gaps between two and four microns and inductance between 80 and 150 mH. This similarity of performance is a normal phenomena. Different engineers working independently on a product to do a certain job nearly always finish up with very similar designs. They are all bounded by the same laws of nature, and it generally means they have all found the best way to do that particular job.



MANUFACTURERS' SPECIFICATION

Basic module uses five low-noise transistors in a circuit incorporating full equalisation for DIN and CCIR 38 cm/s; NAB 38 cm/s, DIN 19h and 19s, NAB 7, DIN 9 and 9 (old), all selected by a single switch.

Input: 80 to 150 mH inductance magnetic head.

Output: 1V rms from 86 pWb/mm total recorded flux (½-track on 6.25 mm tape). 2.7V rms maximum.

Supply: Normally 12 or 50V dc.

Source impedance: About 20Ω.

Price: £7.50 per channel.

Manufacturer: Miniflux Electronics Ltd, 8 Hale Lane, London NW7.

The circuit has been carefully designed to avoid sending a switching on pulse through the head winding by arranging that the base bias of the first transistor is applied via a long time constant. This avoids the possibility of magnetising the head with consequent damage to recorded tapes.

The last pair of transistors are fed from a preset gain control and form a stable, low distortion, low output impedance pair (Zo = 20Ω). The output voltage obviously depends on track width, amongst other things, but the *Meg 7* will give well over 1V rms from quarter track, fully modulated tape.

Power requirements are 12V (negative live) at about 110 mA for all four channels. Though it will work with 9V (say a *PP9* battery) and still give well over 1V output before clipping, distortion is rather higher.

Other versions using 50 volts, either polarity (48V is a continental standard) and less current, are also available. Input and output sockets are miniature coaxial type.

Workmanship and components appear to be beyond reproach, and the pc boards are the fibreglass type, noted for mechanical stability.

continued over

All resistors are five per cent tolerance for the amplifier proper and two per cent for the time constant feedback networks.

The preamplifier response was obtained by injecting a very small constant voltage into the head circuit by feeding a constant current through a non-inductive 2Ω resistor placed in the 'earthy' head lead. The curves produced show the design to be essentially correct. The five turnover frequencies 4.55, 3.18, 2.27, 1.77 and 1.33 kHz come about 1-2 dB before the lowest dip in each curve. Theoretically they should be 3 dB above the lowest part of the time constant curve. In the complete playback circuit, however, the head loss top boost starts coming in before the basic curve has levelled out. It can be seen that the 3180 µs bass attenuation is permanently in circuit. The lower bass also shows a slight falloff. This is deliberate as no one is likely to record anything as low as 20 Hz (and the *Meg 7* is only 2 dB down at 30 Hz). It is foolish to design flat too far down as unnecessary '1f' noise will get through. While infrasonic signals will not be 'heard' by decent loudspeakers, they may cause momentary amplifier overloading and will lead to a slight but audible roughening of all sounds.

After carefully demagnetising the *FCN3* head, the machine was loaded with the test tape. Azimuth is best adjusted first by reading a maximum signal (10 kHz) and then to greater accuracy by comparing the phase of different tracks on a double beam oscilloscope. This also automatically tests the test tape for freedom from stretch and warping. It is always a relief to see a nice steady pair of sinewaves on the screen, as reliable test tapes cost around £15.

This test also checks the head geometry of a multitrack head (assuming the amplifiers are identical). The azimuth, when set using any pair of tracks, should still appear correct on all other combinations of pairs of tracks. In this case no combination of tracks ever showed more than a few degrees difference, so it speaks very well for both head geometry and component tolerance in the preamplifier.

This done, the frequency response section of the tape was run and the four channels switched in turn to the level recorder for each frequency. As the test tape was to DIN 38 specification, it had no 3180 µs bass boost, so the output appears to fall below 125 Hz and the corrected values have been sketched in by hand. The slight rise at 125 Hz (and most probably the dips at 250 Hz and 40 Hz) are normal 'wavelength wobbles' common to all tape heads. These depend on the total width of the magnetic parts of the head, the head profile, the degree of wrap-round and sometimes the shape of the magnetic screen round the head as well! These wobbles are very small and no more than on any good professional head.

The similarity between the four channels is very good and, being consistent throughout the frequency range, could obviously be corrected by slight adjustment of the preset gain controls. These were not accessible without taking the preamplifier module out of its screening box. While perfectly satisfactory for high quality domestic use, the amplifier is so good as to be really in the professional class, so it would be worth while to consider a modified layout so as to make these four presets more readily accessible.

Looking again at the frequency response, the wiggles in between the blocks of tone are voice announcements, and the wiggles at the high frequency end are minor (inaudible) dropouts and only show up because a high writing speed was used.

The output from the 1 kHz reference level section of the DIN 38 test tape was 0.7V, fractionally under 0 dBm.

Noise on all channels, heads still connected of course, was –64 dB unweighted and is very good indeed, especially when one remembers that each channel is only quarter track. The noise character was 'respectable', i.e. no visible 1/f noise could be seen on the oscilloscope trace. It was more or less white noise that had been passed through an integrating filter ('brown noise'?).

Amplifier distortion was measured by feeding in a signal, as in the first set of measurements, and adjusting its level to give an output of 1.0V across a 600Ω load. Distortion measured was around 0.1 per cent at all frequencies and several determinations spread over several days gave very similar results. The measured line voltage was 12.2V.

Examination of the distortion products waveform of both system and source showed that

	Highest Measured	Lowest Measured	Source Distortion
30 Hz	0.12 per cent	0.1 per cent	0.045 per cent
100 Hz	0.1 ,,	0.07 ,,	0.045 ,,
1 kHz	0.14 ,,	0.12 ,,	0.045 ,,
10 kHz	0.07 ,,	0.05 ,,	0.05 ,,

there was no accidental cancellation of source distortion by the preamplifier distortion, so the true distortion values are if anything very slightly less than the quoted figures. With a supply of only 10.0V distortion was increased about four times for the same level of output signal.

Lastly, the whole quadraphonic system was set up and a borrowed Vanguard tape played through four identical high grade speakers. (It is a fantastic experience and I must hear more!) This is a necessary test as steady state signals do not always show up all the faults in an amplifier design. While not all of this early quadraphonic was top quality, the parts that were good showed there were no hidden faults in the design.

The *Meg 7* is thus a first class design, really in the professional class, and the only criticisms one could make are from a professional standpoint. These would be accessibility of the four channel gain presets and a means to switch the 3180 µs correction in and out.

Ralph West

FIG. 2

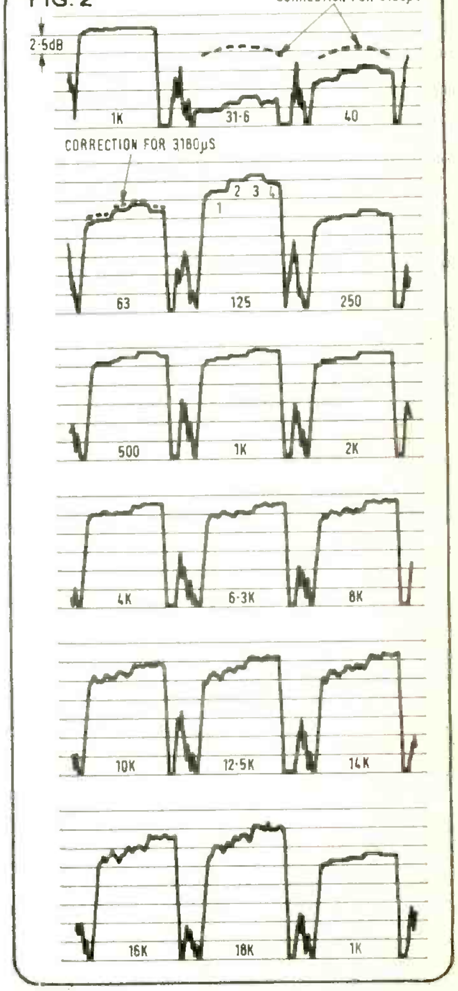
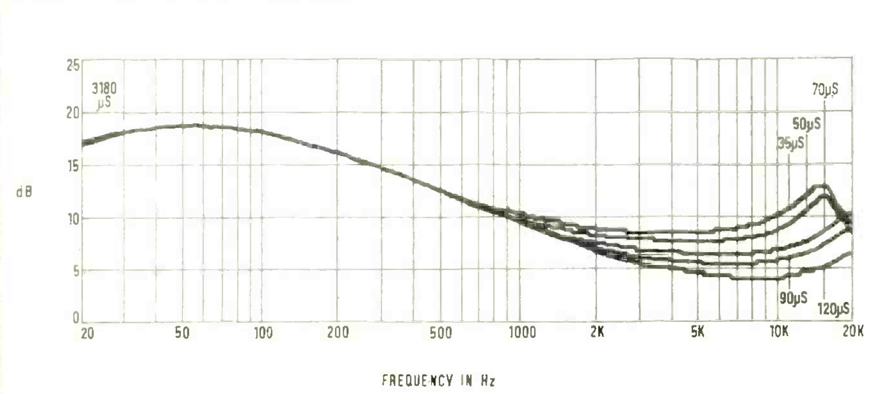


FIG. 1 MINIFLUX MEG 7 RESPONSE



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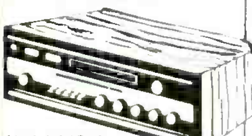

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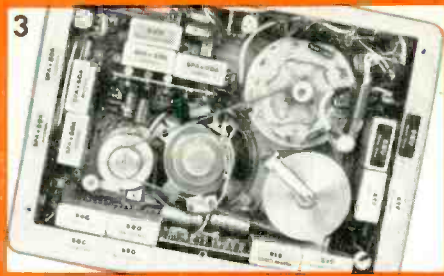

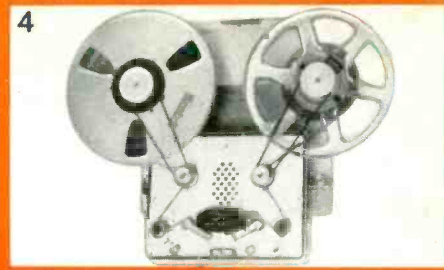

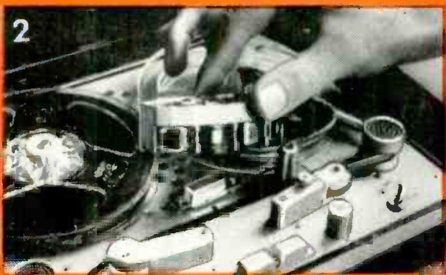

Stellavox

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1. Recorder
Weighing less than 8lb, measuring 3 x $8\frac{1}{2}$ x $10\frac{1}{2}$in, tape speeds $3\frac{3}{4}$ to 30 ips, or fully variable, 20 Hz to 20 kHz (±) 2 dB at $7\frac{1}{2}$ ips, wow and flutter (±) 0.12% DIN weighted, automatic record mode, starting time 0.1 seconds, rechargeable Ni-Cads or AA size dry cells, built-in condenser mike powering, built-in monitor speaker. Available with optional quartz crystal pilot tone generator and pilot amplifier.

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Mono—$\frac{1}{2}$ or full track. Mono—full track with neo-pilot. Stereo—$\frac{1}{2}$ or $\frac{1}{4}$ track. Stereo—$\frac{1}{2}$ track with synchrotone pilot or cue track. Stereo—0.75 mm guard band with flutter filter. Special heads to order.

3. The heart of the Stellavox SP7 is its unique and versatile servo motor, strobe lines on the motor are coupled to photo electric sensing elements which are integrated with the motor. All amplifiers are plug-in, pre-set encapsulations for easy servicing.

4. Reel Attachment
This accessory allows for the use of $10\frac{1}{2}$" NAB or 12" plastic reels; this is particularly useful for studio work at high recording speeds. The attachment can be fitted in a matter of seconds.

5. Mixer
The Stellavox AMI Mixer is the same size as the recorder and weighs 7lb. The AMI has five channels with symmetrical inputs 0.1 mV to 200 mV/200 ohms for condenser or dynamic microphones, line input up to 8V/10K ohms, bass cut, presence lift, bass and treble controls and pan pots. Stereo outputs 1.55V/200 ohms optional 4.4V/600 ohms balance.

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