Wireless World

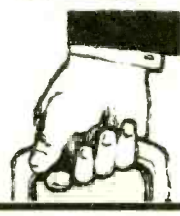
October 1973 20p

Digital voltmeter

Multi-channel remote control

Australia 70 cents
Belgium Fr. 41.00
Canada 90 cents
Denmark Kr. 8.00
Finland Fmk. 3.60
Germany Dm. 3.50
Holland Dfl. 3.25
Israel I£. 2.50
Italy L 600
Malaysia M$ 2.30
New Zealand 65 cents
Nigeria 55k
Norway Kr. 6.50 inkl Moms
Rhodesia 70 cents
South Africa 65 cents
Spain Ptas. 55.00
Sweden Kr. 4.25 inkl moms
Switzerland Fr. 4.30
U.S.A. $ 1.00

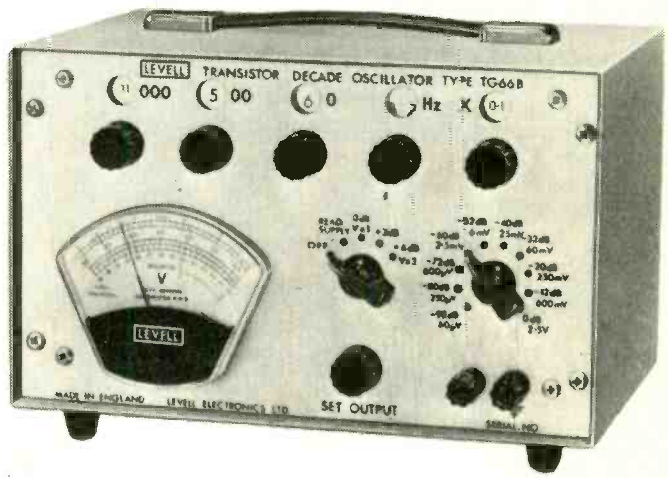
LOW COST RC OSCILLATORS 1Hz TO 1MHz



LEVELL

PORTABLE INSTRUMENTS

NOTE: All prices subject to V.A.T.



ANALOGUE

FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	7V peak down to <200μV. Rise time <150nS.
SYNC. OUTPUT	>1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s. input.
METER SCALES	0/2V, 0/7V & —14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
£42	**£45**	**£52**	**£55**
Sine O/P	Sine & Sq. O/P.	Sine O/P + meter.	Sine & Sq.O/P + meter.

DIGITAL

FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz ±0.3% from 6Hz to 100kHz ±1% from 100kHz to 300 kHz ±3% above 300kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600 Ω
DISTORTION	<0.15% from 15Hz to 15kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage & —2/+4dBm.
SIZE & WEIGHT	7″ high x 10¼″ wide x 7″ deep. 12 lbs.

TG66B	TG66A
£120	**£150**
Batteries only.	Mains unit & batteries incl.

Prices include batteries with 400 hour life.
Mains power units £10 extra. Leather cases £6 extra.

Send for literature covering our full range of portable instruments.

LEVELL ELECTRONICS LTD. Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

WW—004 FOR FURTHER DETAILS

Here it is!

Our two new ranges of 75 ohm TV distribution cables are now made on an extrusion line unique in Western Europe.

We're one of the most technologically advanced cable manufacturers, using new techniques to produce TV distribution cables at a consistently high standard to tolerances much closer than previously possible. At very competitive prices.

The two ranges:

Aeraxial Semi Air Spaced Polyethylene dielectric copper taped braided and polythene sheathed television distribution cables. Five cables in the range, with inner conductor sizes from 1.27 mm to 3.05 mm.

Solid Polyethylene dielectric copper taped and polyethylene sheathed television distribution cables. Five cables in the range, with inner conductor sizes from 0.73 mm to 3.65 mm.

Aerialite will specially manufacture TV distribution cables for any special TV application—also, you can make use of the Aerialite free technical advisory service to help you in the selection and application of distribution cables.

For further information, send for Aerialite's new publication giving full technical specifications of the latest range of TV Distribution Cables.

Aerialite

Aerialite Cables Limited,
Castle Works,
Stalybridge, Cheshire SK15 2BS.
Telephone: 061-338 2223
Cables: Aercables, Stalybridge.
Telex: 669902

To Aerialite Cables Limited:
Please send me your brochure entitled Aerialite Television Distribution Cables.

NAME ____________________

POSITION ____________________

COMPANY ____________________

ADDRESS ____________________

____

WW—006 FOR FURTHER DETAILS

Universal

Ⓐ

Ⓑ

Ⓒ

Ⓐ **SM 202** From £395.00
150 MHz Ultra High Performance Universal Counter Timer
Perhaps the most sophisticated counter timer available under £1000 - and it costs much less than half that! Full eight decade, 150 MHz, three channel spec. with almost every possible plus feature.

Ⓑ **SM 190** From £195.00
Variable Time Base (Computing) Counter Timer.
For the industrial user. Five or optionally six decade display, two channels. Total variable time base range 1 µs to 10 secs. Frequency, count (totalize) time interval & ratio modes. Stored or non-stored display. Ultra low cost.

Ⓒ **SM 200** From £175.00
25 MHz Counter Timer
Six decade, frequency, count, Period, time and ratio meter having 25 MHz bandwidth and two-line stop start at very low cost.

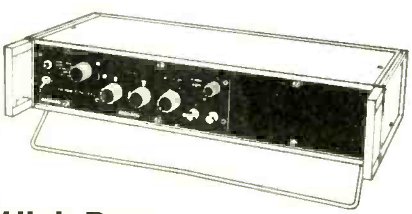
Ⓓ **SM 201** From £265.00
100 MHz Universal Counter Timer
Best value general purpose unit of 6 decade 100MHz, capability. Three channel input with seven operational modes. Standard or high stability versions.

Ⓔ **SM 209** From £495.00
500 MHz DIRECT Frequency Meter.
Nine full decade display. Input circuit giving 1 Hz resolution right up to 500 MHz. Optional I.F. subtraction circuit. Ultra fast warm up very high stability oscillator. 10mV sensitivity. All at a fraction of the price you would expect.

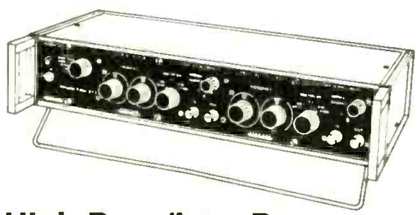
BIG NEWS FROM BARR & STROUD

Modular Filtering

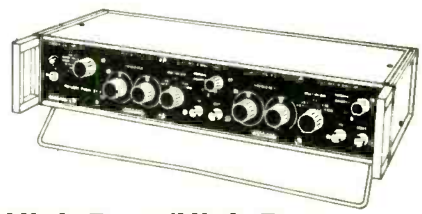
ONE MAIN FRAME—MANY OPTIONS



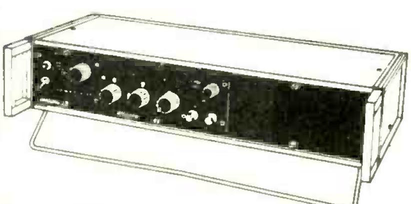
High Pass



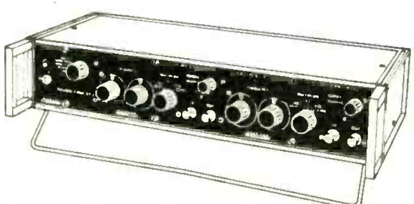
High Pass/Low Pass



High Pass/High Pass



Low Pass



Low Pass/Low Pass

and that's only the start!

Barr & Stroud's new EF3 Electronic Filter System means no more compromises when you buy variable filters. Now you can get the filter you need today, and additional plug-in units tomorrow. Today—the basic main frame and your choice of two modules to operate in low-pass, high-pass, band-pass, band-stop, band-separate, band-combine or cascade modes. Tomorrow—other interchangeable modules to meet your newest requirements. The first two modules, already available, provide filtering with variable cut-offs between 0.01Hz and 10.0kHz, stop-band attenuation of 48dB/oct. (96dB/oct. in cascade), and pass-band response from dc to 500kHz. Get full details of EF3, the big breakthrough in electronic filtering by using the reply card.

BARR & STROUD LIMITED
London Office: 1 Pall Mall East, London SW1Y 5AU
Telephone: 01-930 1541 Telex: 261877

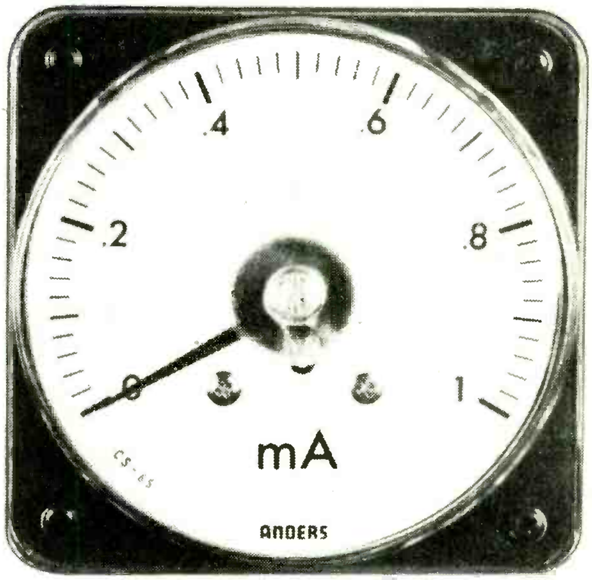
BARR AND STROUD
Glasgow and London

WW—008 FOR FURTHER DETAILS

ANDERS MEANS METERS...

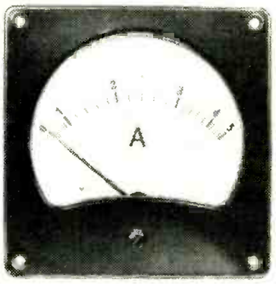
OXFORD LONG SCALE 250°

- **Now available, long scale meter to satisfy budgetary requirements for low cost equipment.**
- Models CS65 and CS85 with scale lengths of 6″ and 7·75″
- OEM quantity prices extremely competitive
- 500μA upwards, DC or AC rectified
- Shadow-free dial—easy to read scale

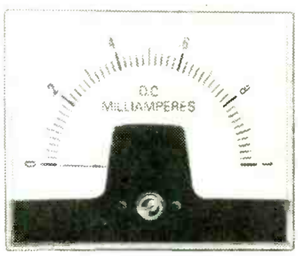


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

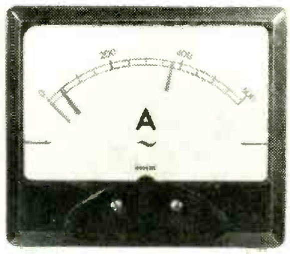
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



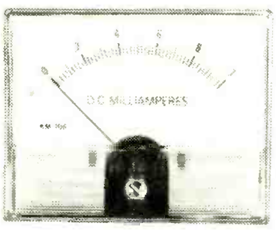
Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.



Crescent Long Scale 180°. 3 models, 4″, 5″, 6·25″ scales. DC moving coil and AC moving coil rectified. Clear plastic.

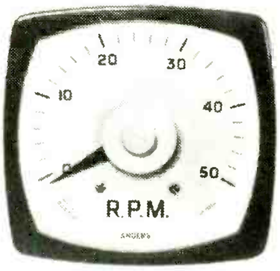


Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.



Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.

Profile 350 edgewise 4·3″ scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.



Stafford Long Scale 240 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.

Lancaster Long Scale 240°. 2 models, 4″, 5·5″ scales. DC moving coil and AC moving coil rectified.

ANDERS ELECTRONICS LIMITED 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers' requirements.

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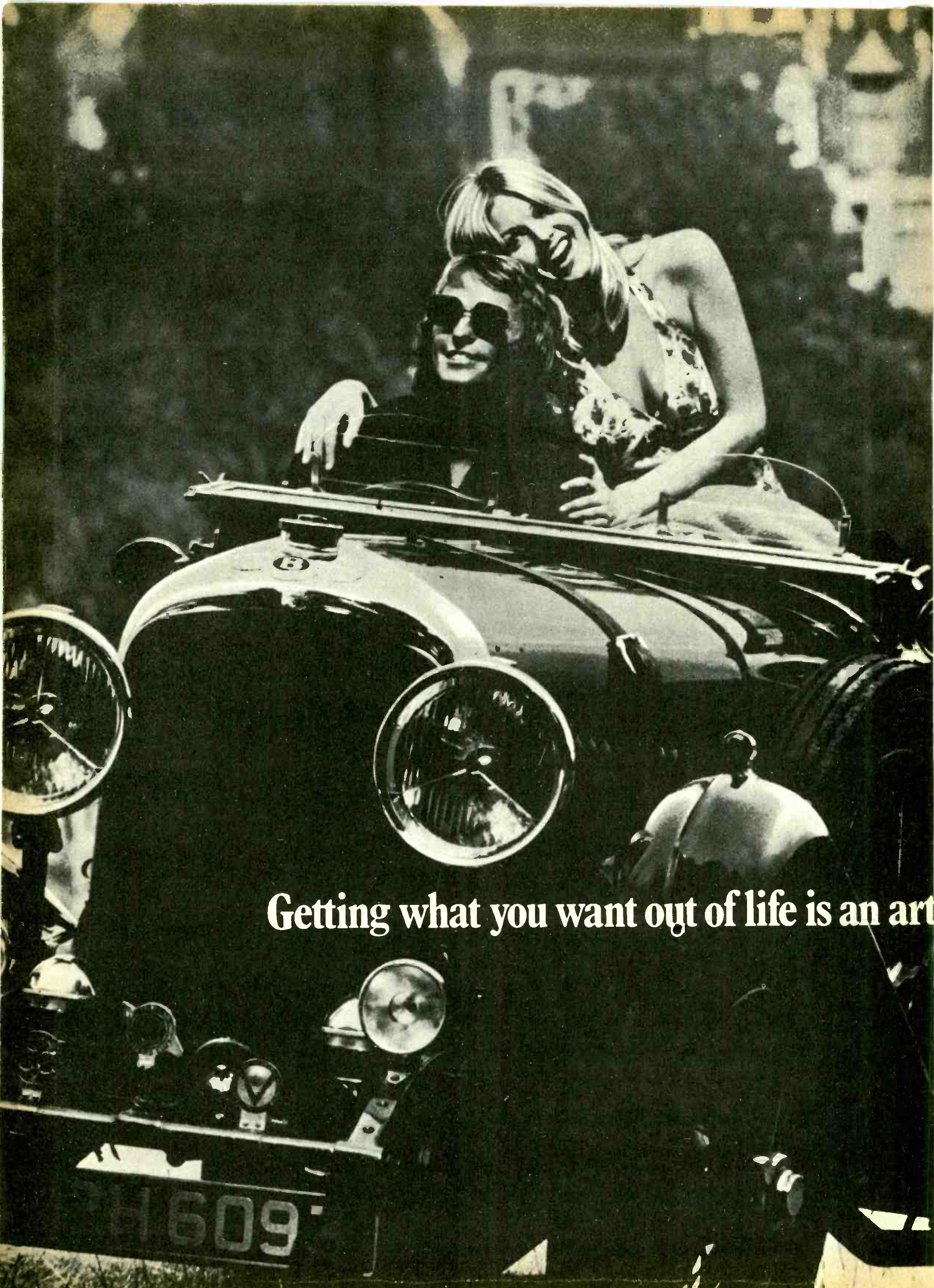
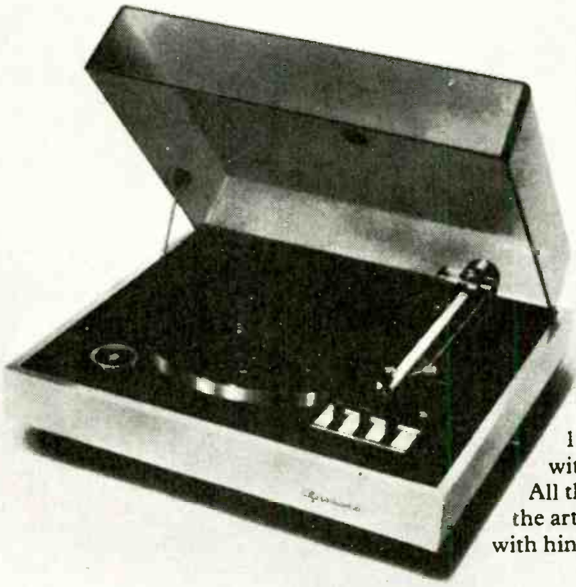

Getting what you want out of life is an art
H609

Strictly for the enthusiast.
Something to get really enthusiastic about. Garrard have some really good things to show you here.

And, as you might expect, something designed to help you get more lifelike sound reproduction – to make life richer for you.

It's time to take a fresh look at Garrard's hi-fi deck range. You'll discover these two superb units offering highly refined engineering, excellent value, plus important features including new belt drive.

Go to your hi-fi dealer and discover how you can get more out of life.



Zero 100 SB Module
Automatic single player. One of the world's most sophisticated trascription turntables, with unique tangential tracking arm; pivoting head reduces tracking error and consequent harmonic distortion. New belt drive system. Record counter monitors stylus wear. Magnetic bias compensation. Fingerlight tab controls. 12in, 10in and 7in discs can all be played with automatic set down of pick-up arm. All the best features in the present state of the art. Low resonance aluminium-clad base with hinged/lift off cover.

and Garrard know a great deal about it.

AP 86 SB Module
Automatic single player. Performance sets a new standard in medium-priced hi-fi, a heavy, machined diecast platter, screened 4-pole synchronous motor, and new belt drive, together give highest standards in maintaining constant speed. Wow and flutter typically 0.12% peak, rumble typically – 63 dB (DIN). Bias compensator adjustable to match stylus force – separate scales for elliptical and conical styli. Fingerlight tab controls. Low resonance wood grain finish base with hinged/lift off cover.

Garrard
A PLESSEY QUALITY PRODUCT
Garrard, Newcastle Street, Swindon, Wiltshire England SW1 1DA.

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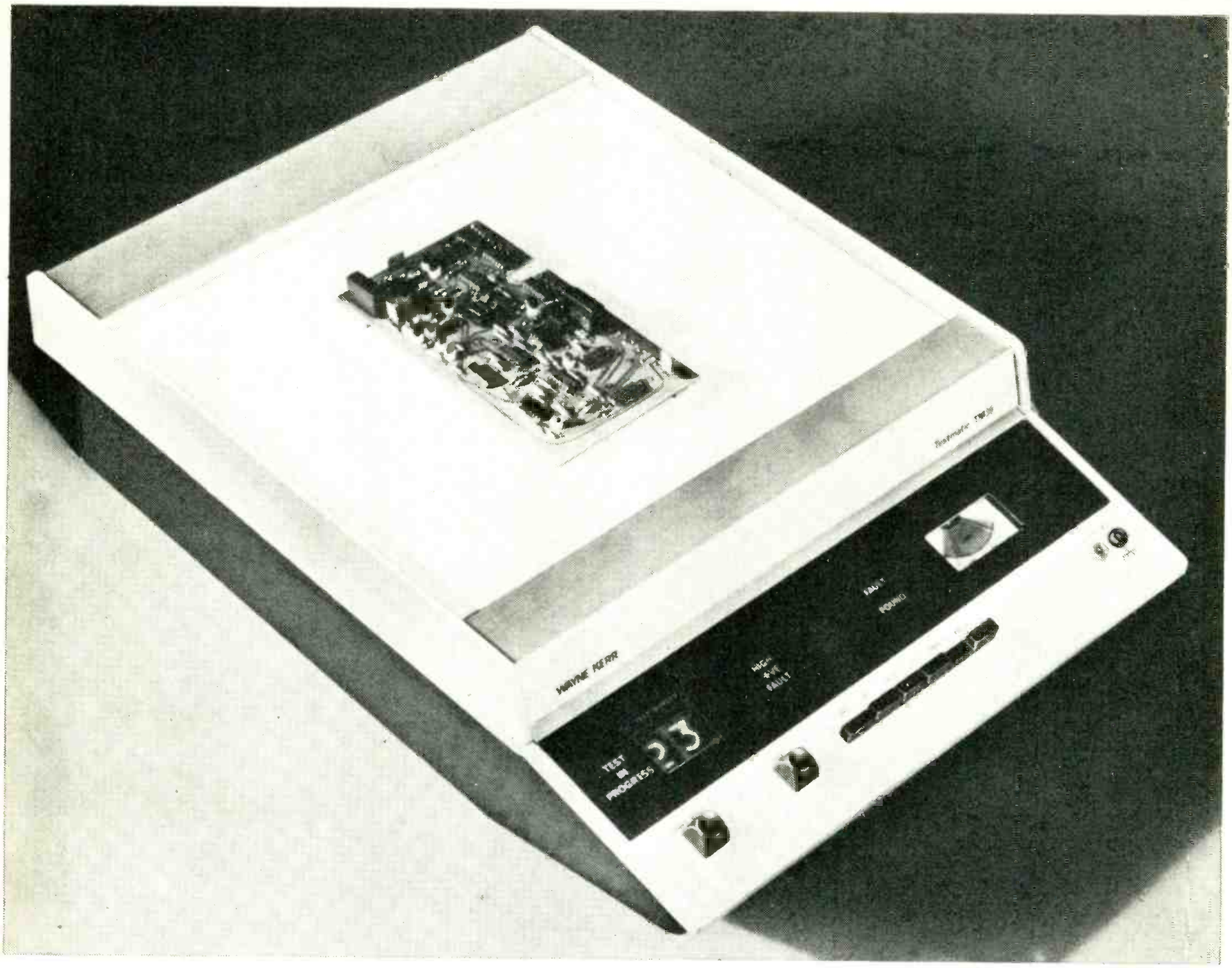

Wayne Kerr TM30:

the high-speed circuit tester that saves you high-cost time

The Testmatic TM 30 is, above all things, simple. It has been developed for efficient circuit-board testing, in the light of operational experience with the TM 60. It is designed to be worked by people who–whatever other talents they may have–need not be qualified electronics engineers. In saving time it thereby saves you money.

It will tell the operator where there is a defective circuit point, as well as indicating whether the value is high or low. And it can handle 30 tests–in seconds.

WAYNE KERR
a member of the Wilmot Breeden group

For more information phone Bognor Regis (02433) **25811**, or fill in the coupon.

Please send details of the TM 30.

For the attention of Mr____________

Company name____________

and address____________

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Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO22 9RL. WW-OCT

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The FREE Heathkit Instrumentation Catalogue describes the latest Heathkit solid-state oscilloscopes, 120 MHz frequency counter with 8 digit readout, $3\frac{1}{2}$ digit multimeter for measuring AC and DC voltage, current and resistance with automatic switching for DC polarity, Portable FET VOM with 53 ranges on 4 scales, FET/transistor tester, plus many, many more Heathkit test instruments — all designed for easy assembly and kit-form savings. Send today for your FREE Heathkit catalogue, the world's largest selection of electronic kits — test, marine, amateur radio, b/w television, stereo hi-fi, automotive, home appliances, educational and more.

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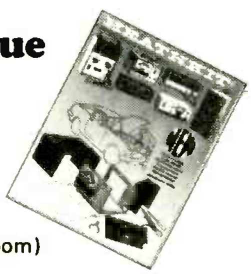

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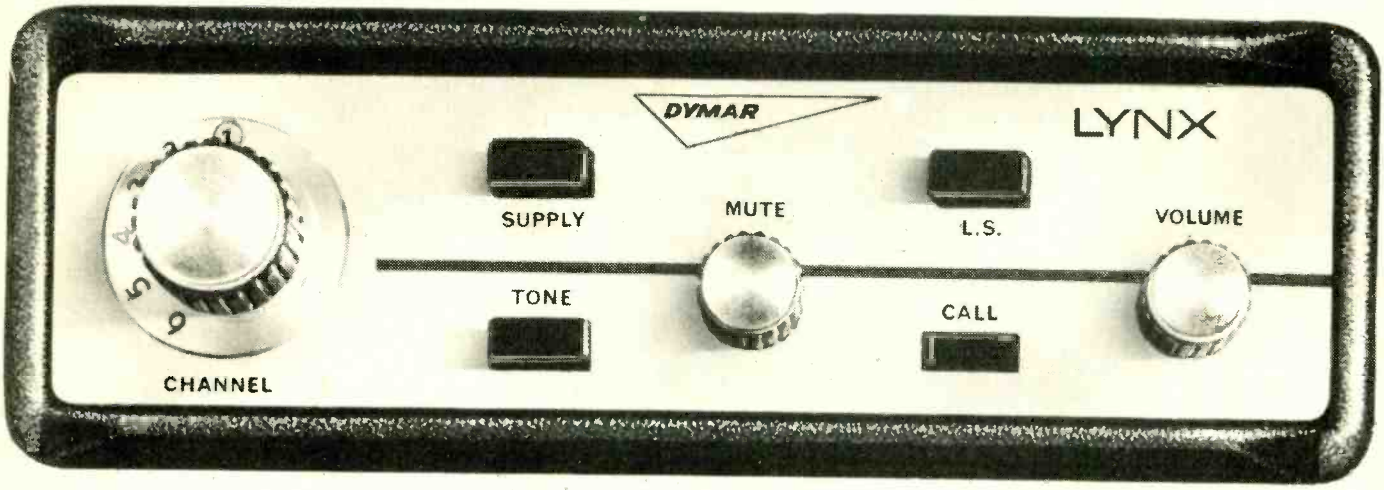

ACTUAL SIZE

The Dymar Lynx. A mobile radiotelephone system so special we put our own name on it.

This Lynx has a pedigree. Since 1964 Dymar has designed and built VHF radiotelephones which have borne some of the most famous names in the industry.

Now we have something special. A complete VHF AM and FM mobile radiotelephone system. It cost £100,000 to develop. It's different. It's our own. The name is Dymar. The brand is Lynx.

Lynx mobiles come as local control units. The entire circuitry, space for options and a 5in elliptical speaker in a single 26.4in^3 package. Or as extended control types, when the panel unit demands only 6.75 x 3.5 x 2.3in of dash space and the transmitter/receiver vanishes into the boot or under a seat.

Selective calling, if specified, is one of the options that gets built-in.

AM sets – 15/20W RF output standard– are Low, Home Office, Air, Mid or High band. FM cover Low, Home Office or High at a standard 20/25W. One, six or 10 channel versions are available, with 12.5 kHz or 25kHz channel spacing.

Before specifying a VHF mobile, check on the rest of the spec. The tough diecast aluminium construction; the clever use of ICs and FETs; the modular approach to sub-assemblies and the accessibility of components; the safety padding; the lot.

It's all in the leaflet Lynx Mobile Communication, and in a series of Data Sheets. Use the Reader Enquiry Service today, or write direct to Dymar.

DYMAR
the name in radiotelephones

DYMAR ELECTRONICS LIMITED,
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Herts. WD2 4LA. Tel: Watford 37321
Telex: 923035. Cables: Dymar Watford.

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Minimod

Made in Britain by Gardners...

First of a new range of all-British miniature encapsulated power supplies, the Minimod series is designed and manufactured by Gardners to provide reliable, regulated power supplies in a neat pack designed to plug into your P.C. board. Minimod simplifies development or production of equipment by providing power where you need it.

Minimod provides a choice of a standard 5 volt output (available up to 1 Amp) for digital circuits or 12-0-12 or 15-0-15 volts for linear circuits, using a 230 volt input. Each unit is fully stabilised with fold back current limiting, and in the case of 5 volt units, over voltage crowbar is provided . . .

Ask Gardners to tell you more about Minimod.
Standard or special models can be supplied.

Gardners

Specialists in Electronic Transformers and Power Supplies

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WW—015 FOR FURTHER DETAILS

Mullard r.f. power modules are the products of a real awareness of the designer's problems and a leading position as manufacturers of semiconductors and hybrid circuits. We have been working with the major manufacturers of mobile radio since its infancy.

Modules for Mobile Radio

The awareness of the designer's problems is expressed in the way that these modules simplify system design and assembly and cope with the severe electrical and physical stress associated with mobile radio.

The Mullard range of u.h.f. modules for mobile radio covers the band 380 to 512 MHz with outputs of 2.5, 7.0 and 17 W.

The 2.5W module requires an input of 50mW and provides an input for the other two devices. They are compatible and all have 50Ω input and output impedances.

The modules will withstand load mismatch, accept input overdrive and they will remain stable even when the supply voltage sinks to 10.5V or rises to 16.5V.

The inch-long devices are completely encapsulated and ready for immediate use without tuning or trimming.

To find out more about these time and cost saving components please ask for a copy of our wallchart and the latest data.

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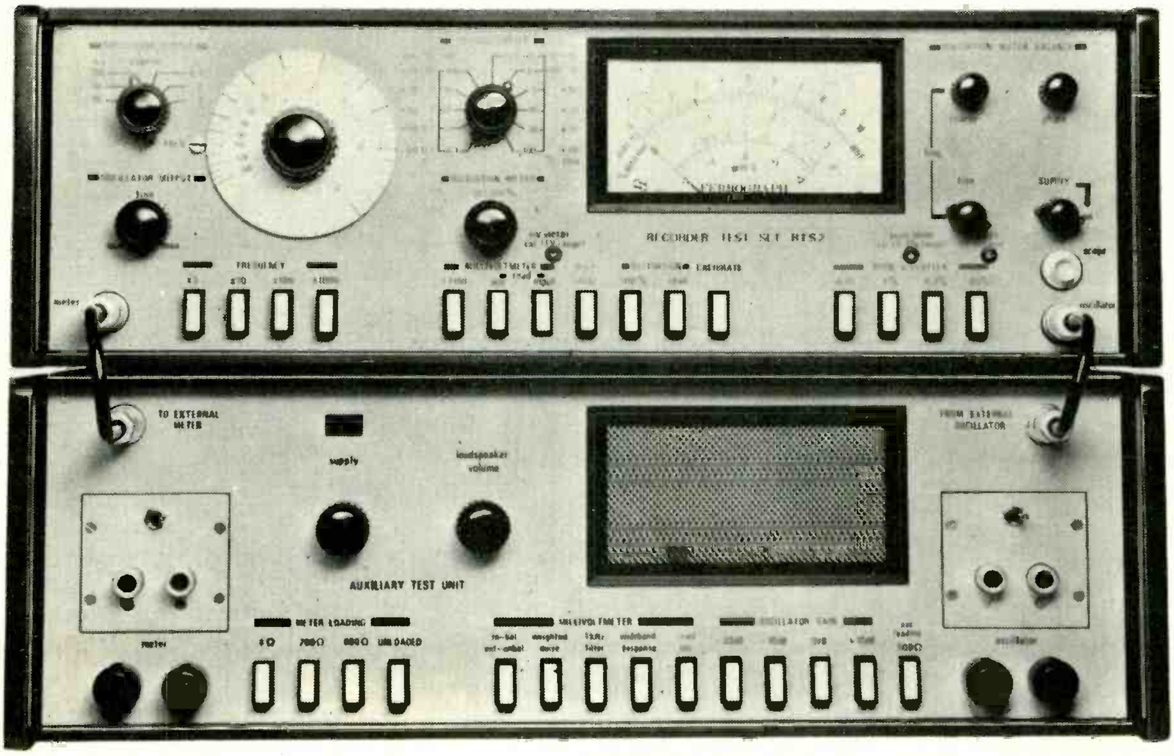
Mullard Limited, Mullard House, Torrington Place, London WC1E 7HD

Mullard components for communications

BROADCASTING · TELECOMMUNICATIONS · RADAR · NAVAIDS · MILITARY

M68

Audio Test Set RTS 2



and Auxiliary Test Unit ATU1 for professional users

RTS2 Checks Amplifiers, mixers, tape-recorders

For Frequency Response · Signal/noise ratio · Distortion · Cross-talk · Wow & flutter · Drift · Erasure · Sensitivity · Output power · Gain

ATU1 Extends output level and measurement sensitivity. Provides balanced input/output facilities. Incorporates weighting filters, loading circuits. Has built-in speaker for monitoring purposes.

Send for leaflets RTS2 & ATU1

FERROGRAPH

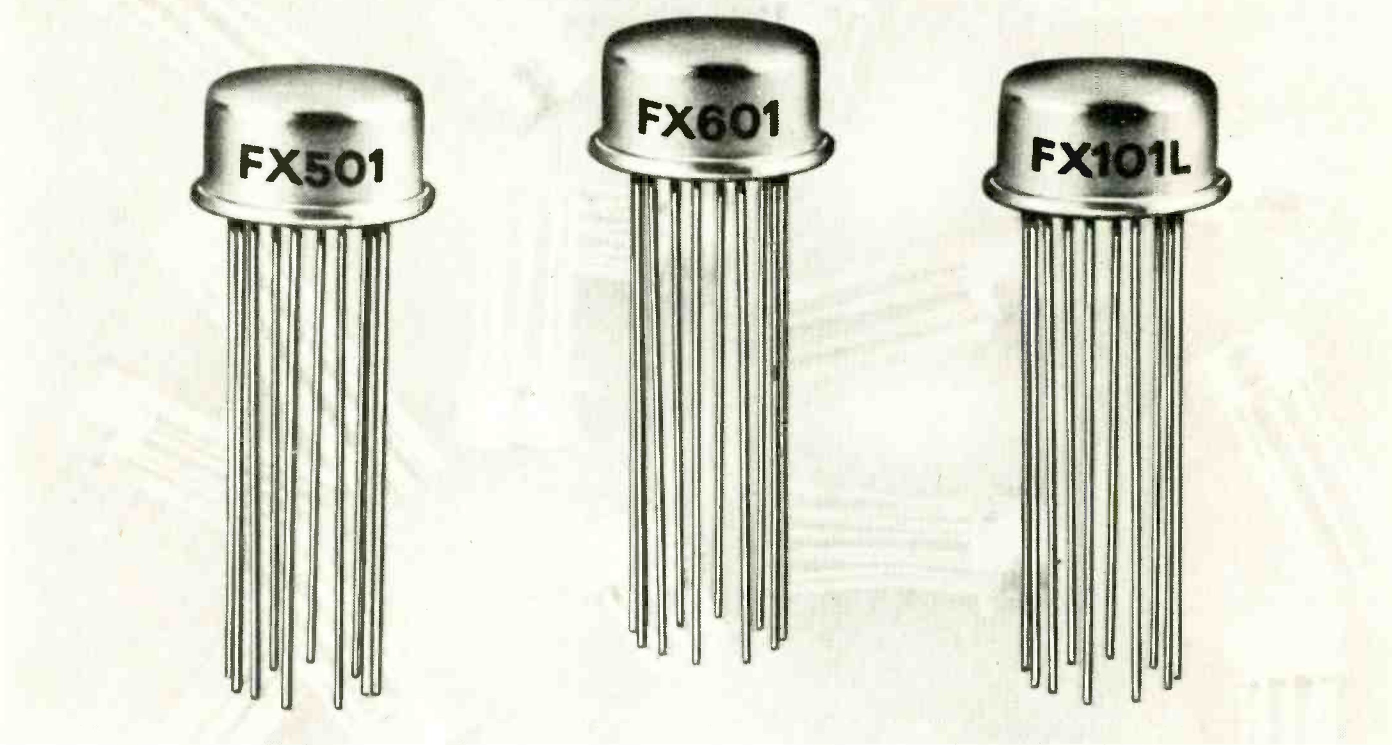
A member of the Wilmot Breeden group

Ferrograph Company Limited Auriema House 442 Bath Road Cippenham Slough Buckinghamshire SL1 6BB Tel: Burnham (062 86) 62511 Telex: 847297

WW—017 FOR FURTHER DETAILS

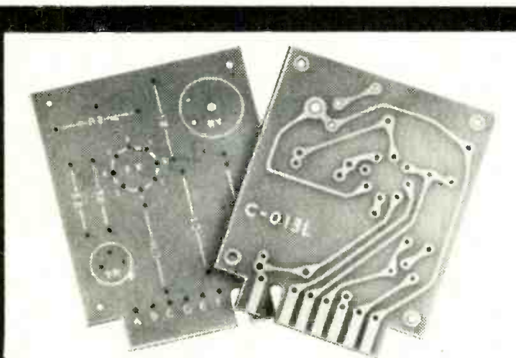
TONE Operated SWITCHING

in Monolithic Form

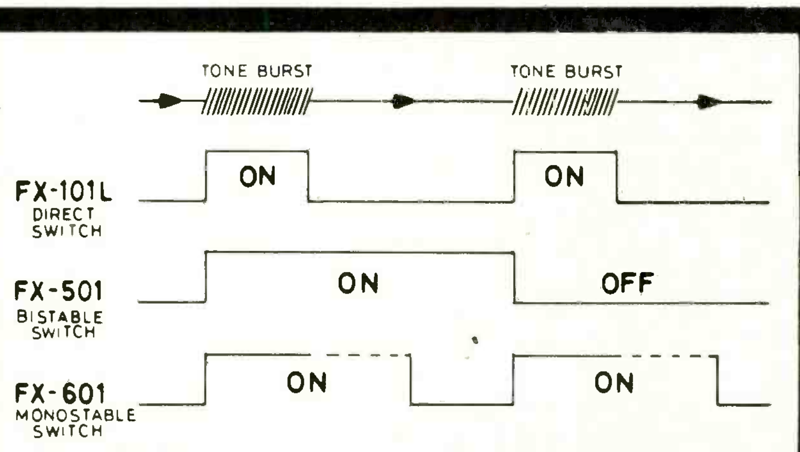


The FX-101L, FX-501 and FX-601 series of tone operated switches are designed for use as tone receivers in Remote Control, Alarm, Automation, Communications and Telemetry systems. Each device incorporates a semiconductor switch which operates when a specific input tone frequency is received. A choice of Direct Acting, Bistable or Monostable switching functions are available according to the device type. All frequency discrimination and timing circuits are included on-chip and require only the addition of simple external RC networks. Tone operating frequencies are adjustable between 10Hz and 20kHz and the devices incorporate input signal amplifiers for operation with low-level sine/square wave input signals. Rated for operation over the temperature range −30°C to +85°C, the devices require only a single low current 8V/15V d.c. supply.

All three devices available from stock.



To make your experimental breadboarding easy, two P.C.B's. are available – C-013L (for FX-101L) and C-015 (for FX-501 and FX-601). They are supplied ready drilled and with the positions of all external components screen printed. Components not included.



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CONSUMER MICROCIRCUITS LTD.

Rickstones Road, Witham, Essex
Telephone Witham 3833 Telex 99382 (Reaction)

Send for fully detailed Data Sheets and information by circling the reader reply card number.

WW—018 FOR FURTHER DETAILS

Westinghouse TV colour tubes guarantee purity in both colour and black & white

Today's Westinghouse Electric colour tubes, in addition to offering recognised excellence of colour definition, have white field purity...vitally important to reception of black and white transmission.

Two 67 cm diagonal versions
These improved Westinghouse tubes are made available in two configurations – the standard 90° and the 10 cm shorter profile wide-neck 110° version... permitting their compatibility to the needs of the larger portion of European TV set manufacturers.

Expanded European facilities
Pacing the growing demand in Europe for Westinghouse tubes, we have made a permanent commitment to fully support our customer. ■ With trained technical sales personnel in major European cities. ■ With warehousing and testing facilities in Kassel, W. Germany and Le Mans, France. ■ With a sustaining European oriented R&D programme.

Customer oriented
In these ways–compatible product availability–outstanding development facilities–local technical assistance...Westinghouse Electric respond to dynamic customer requirements – here in Europe and throughout the world.

The 110° Ⓦ A67-140X TV colour tube is 10 cm shorter in profile than the 90° Ⓦ A67-120X . . .both offer superb colour definition as well as white field purity for black & white.

Westinghouse Electric S.A.
1 Curfew Yard, Thames Street
Windsor Berks. Phone Windsor 63392. Telex 847069.

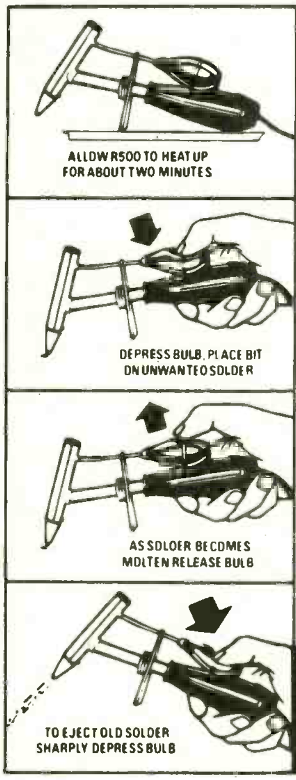
GENEVA FRANKFURT LONDON
MILAN PARIS STOCKHOLM

Westinghouse Electric

WW—020 FOR FURTHER DETAILS

new! ADCOLA R500

ELECTRIC DE-SOLDERING INSTRUMENT



Removes unwanted solder!

R500 is

- PURPOSE DESIGNED NOT AN ADAPTION TO A SOLDERING IRON
- NO AIR OR VACUUM LINES
- ONE HAND OPERATION
- ROBUST CONSTRUCTION
- EASY TO USE
- OVERALL DESIGN GIVES CLEAR VISION OF WORK PIECE
- WELL BALANCED
- TROUBLE FREE
- ALL VOLTAGES AVAILABLE

ADCOLA PRODUCTS LTD, ADCOLA HOUSE, DEPT. WW7, GAUDEN RD, CLAPHAM SW4 6LH.
REG. No. 442762 V.A.T. No. 235-6153-72

☐ Please send immediately an R500 De Soldering Instrument cheque enclosed for £7.35 plus 10% V.A.T. (postage paid U.K. only)

☐ Please send further details
(Tick appropriate box)

Post now to ADCOLA

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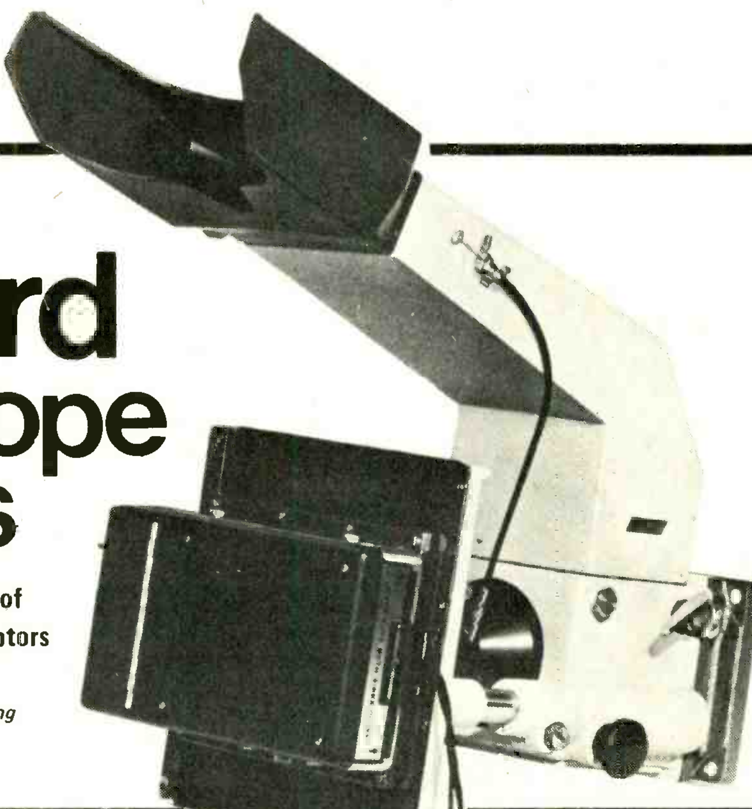
WW—022 FOR FURTHER DETAILS

Telford Oscilloscope cameras



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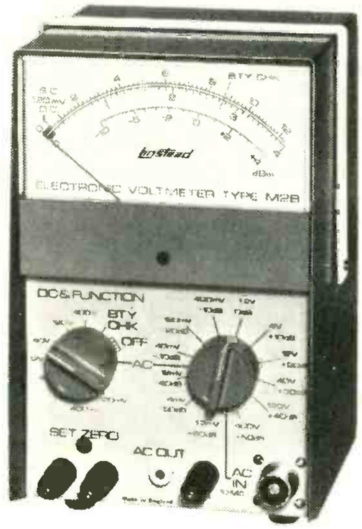

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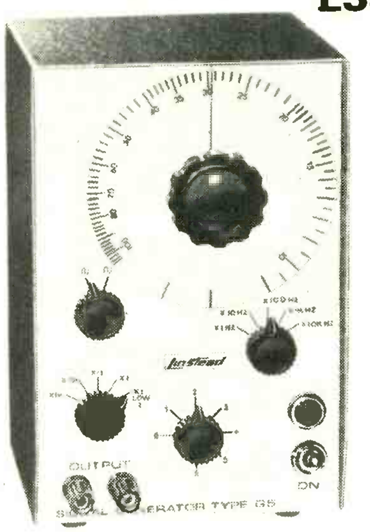

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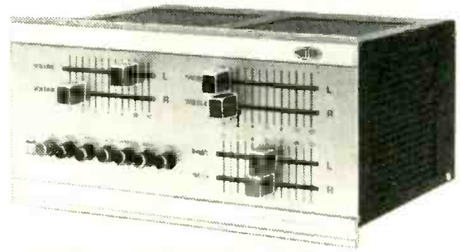

UK175 STEREO PREAMPLIFIER WITH TONE CONTROLS
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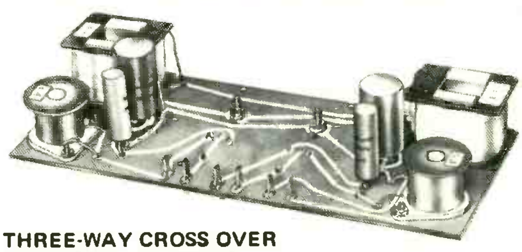

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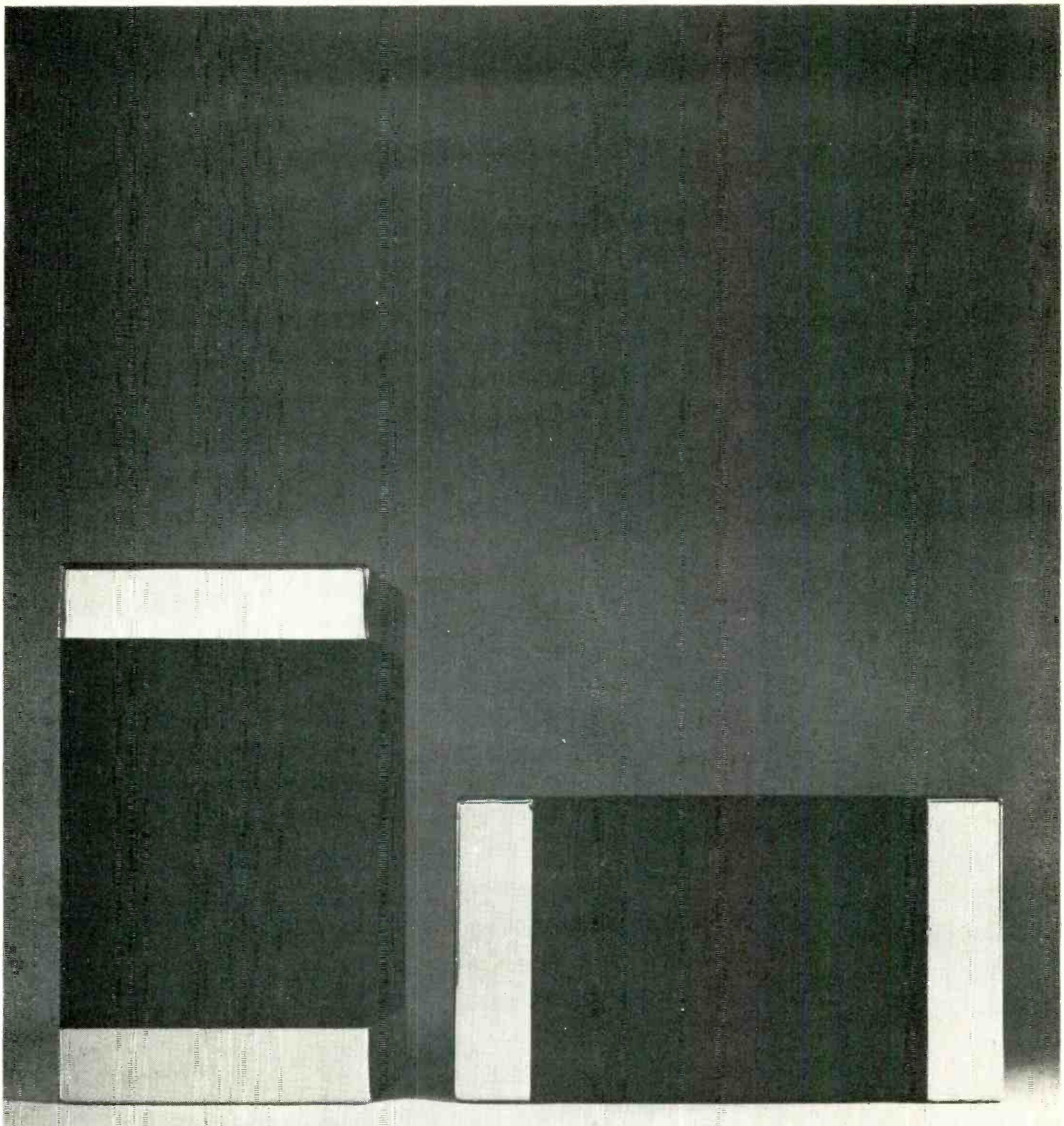

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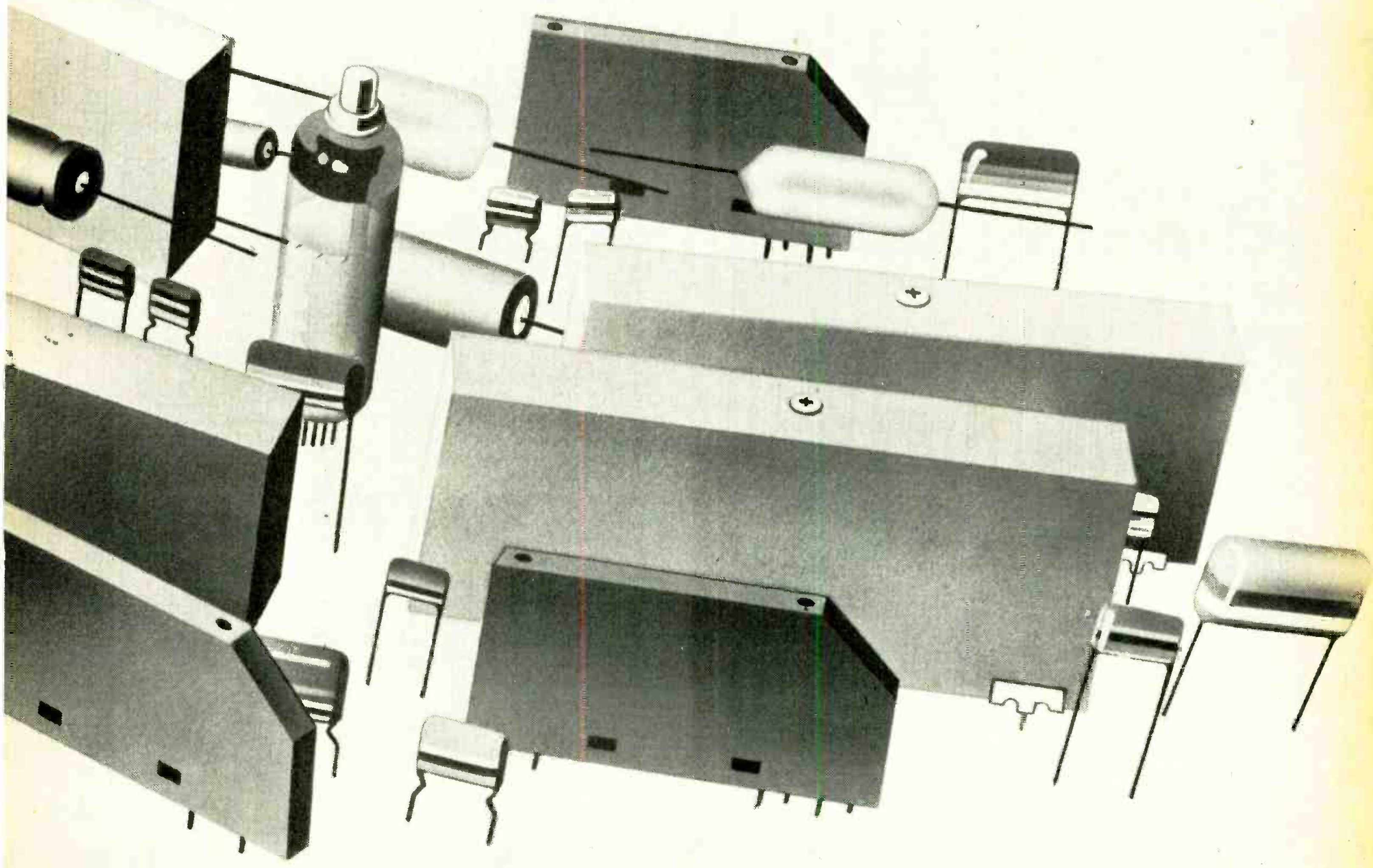

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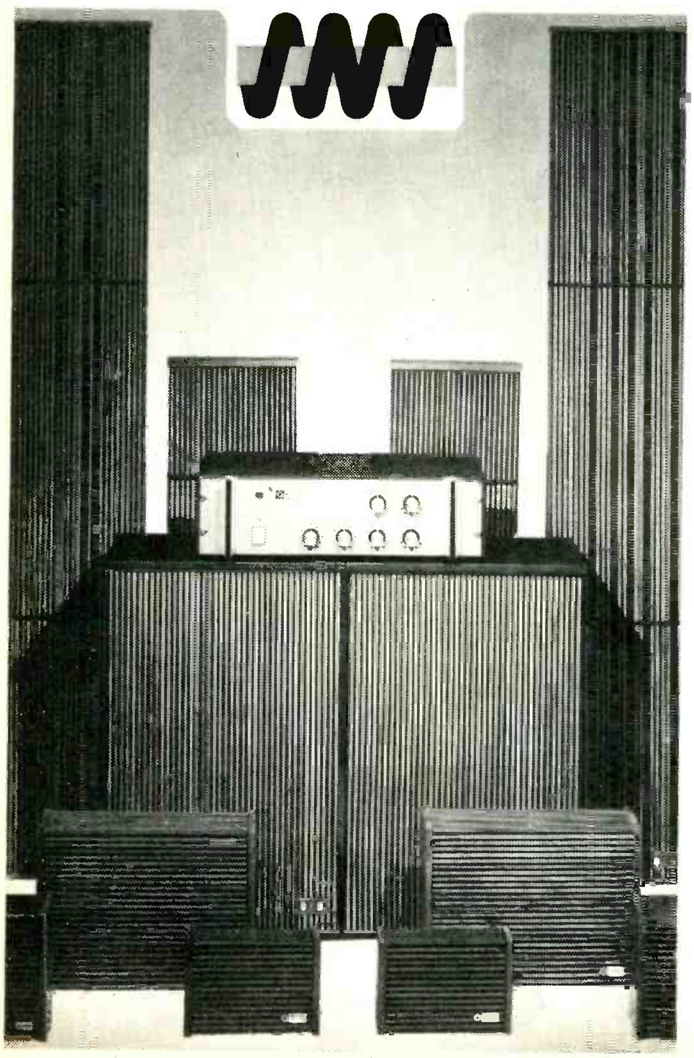

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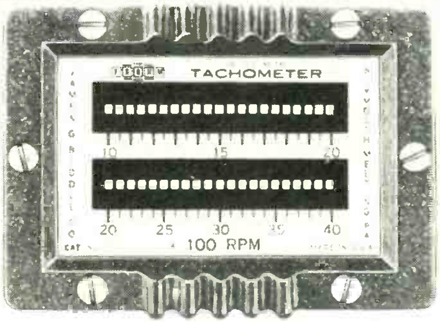

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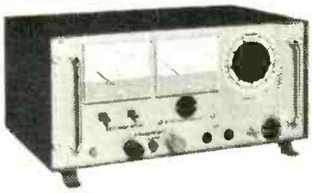

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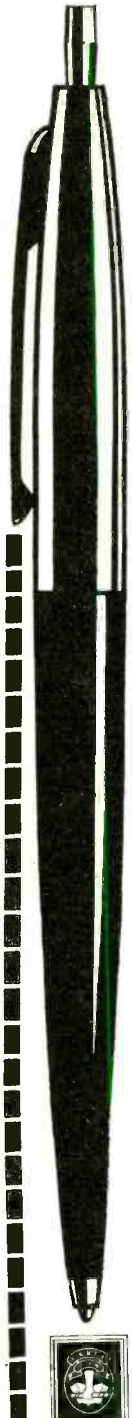

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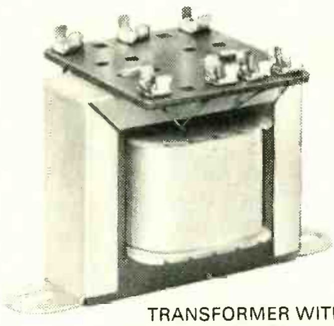

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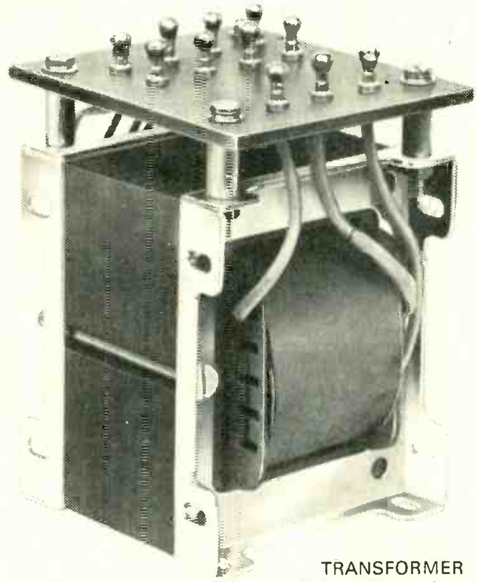

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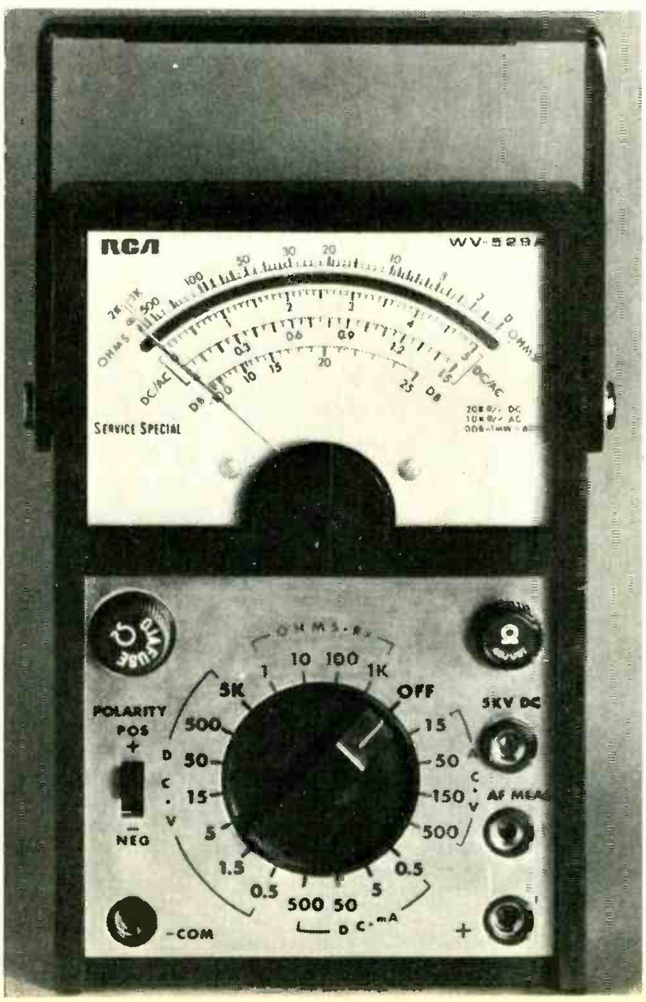

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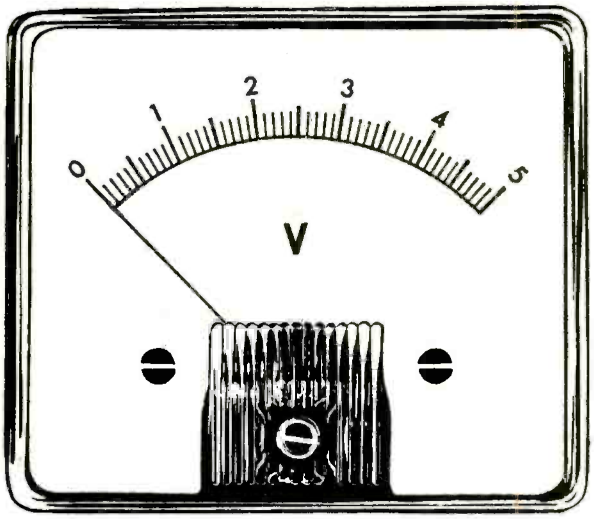

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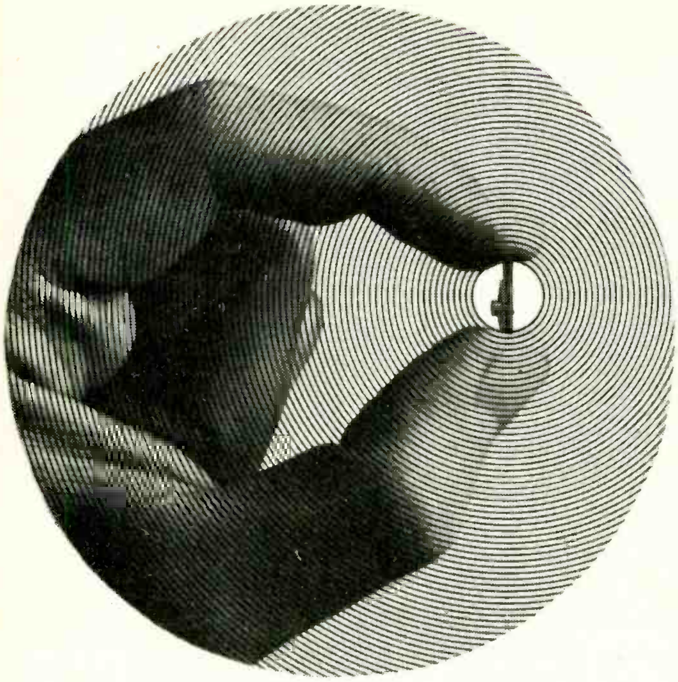

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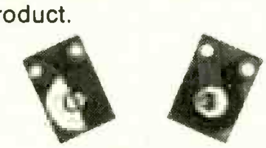

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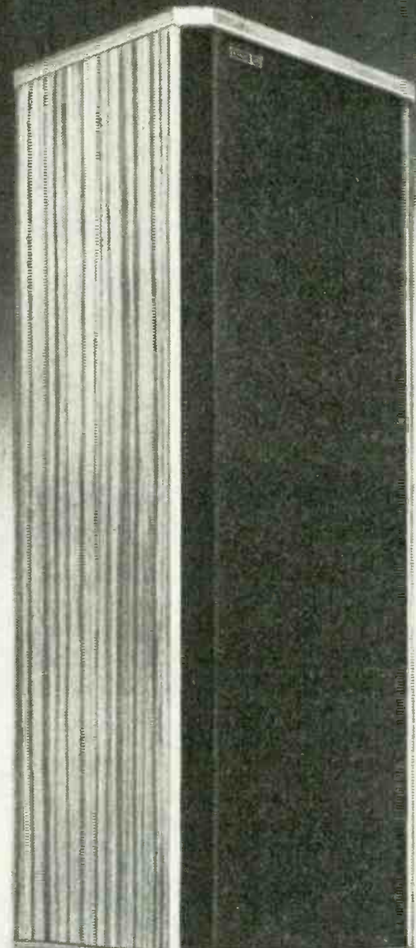

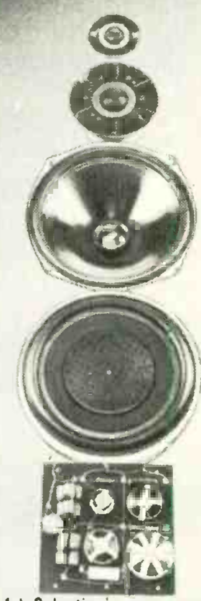

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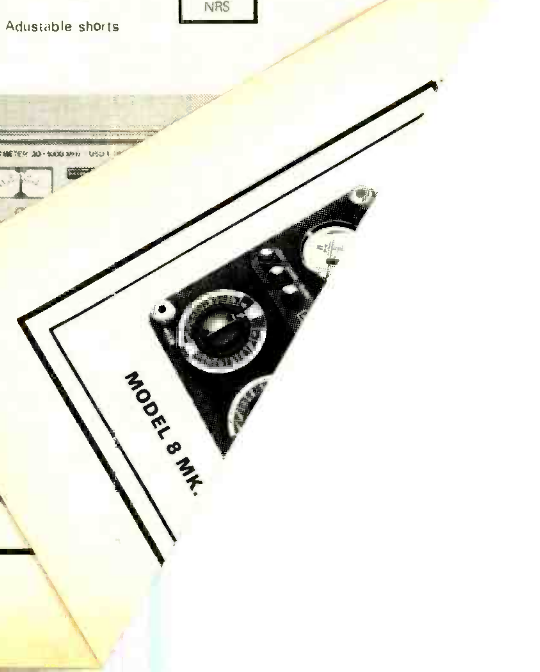

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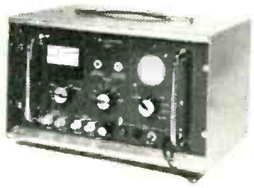

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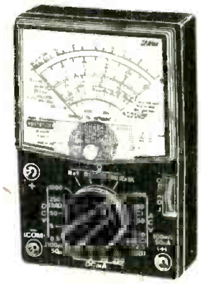

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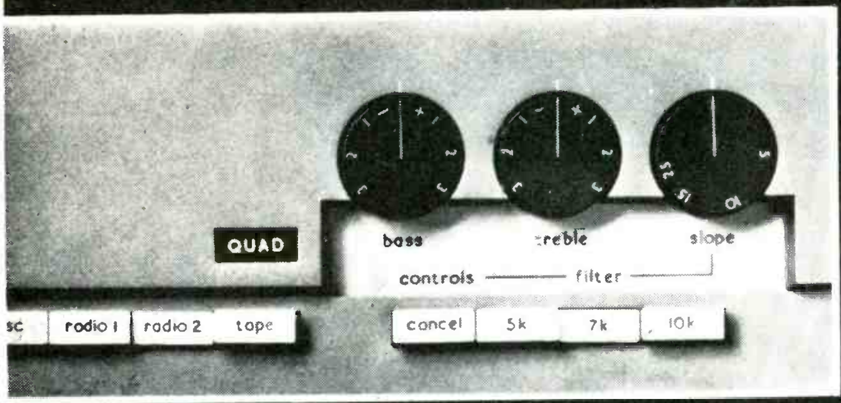

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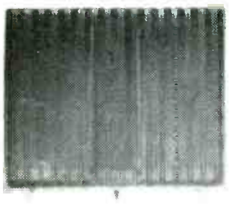

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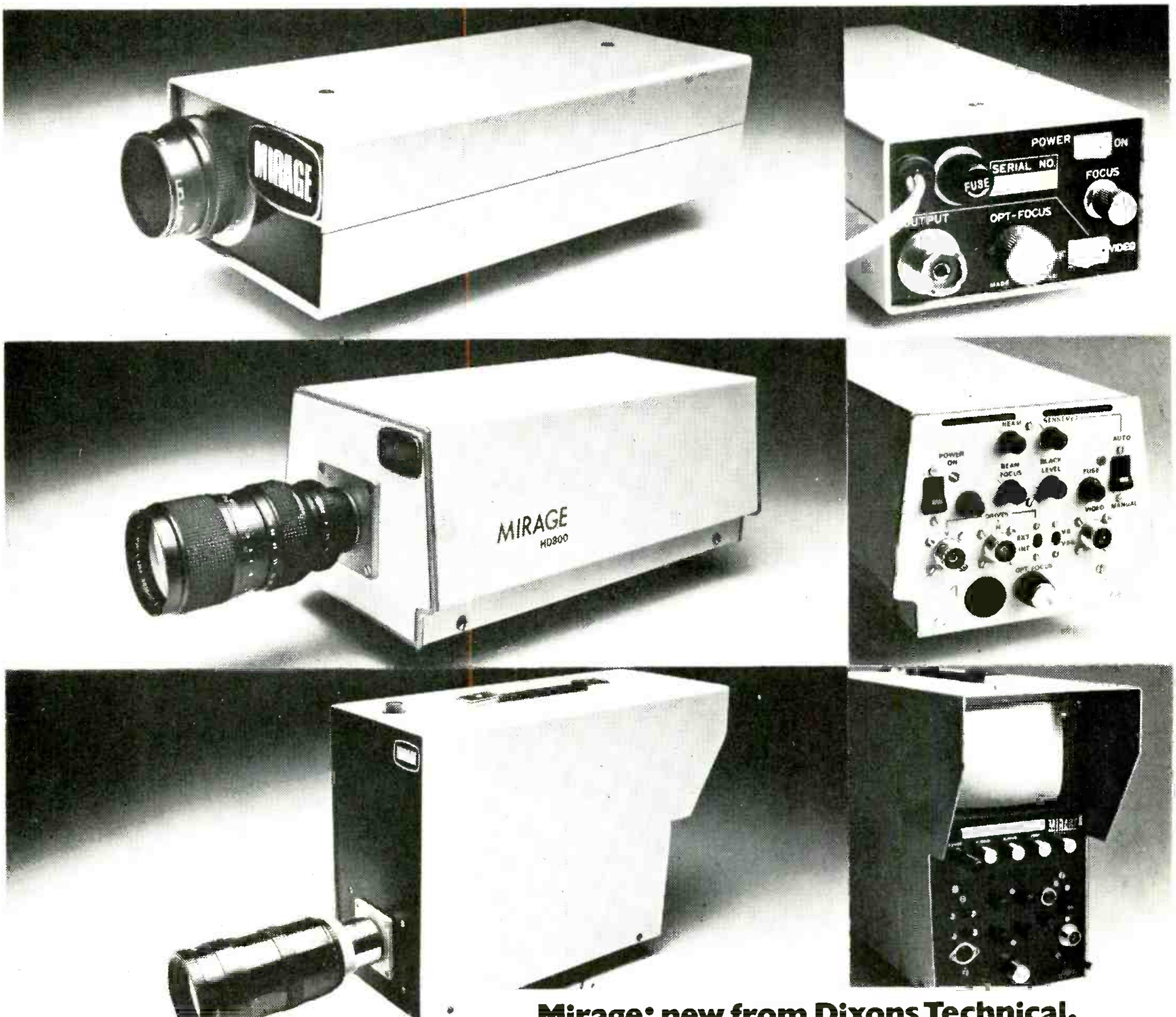

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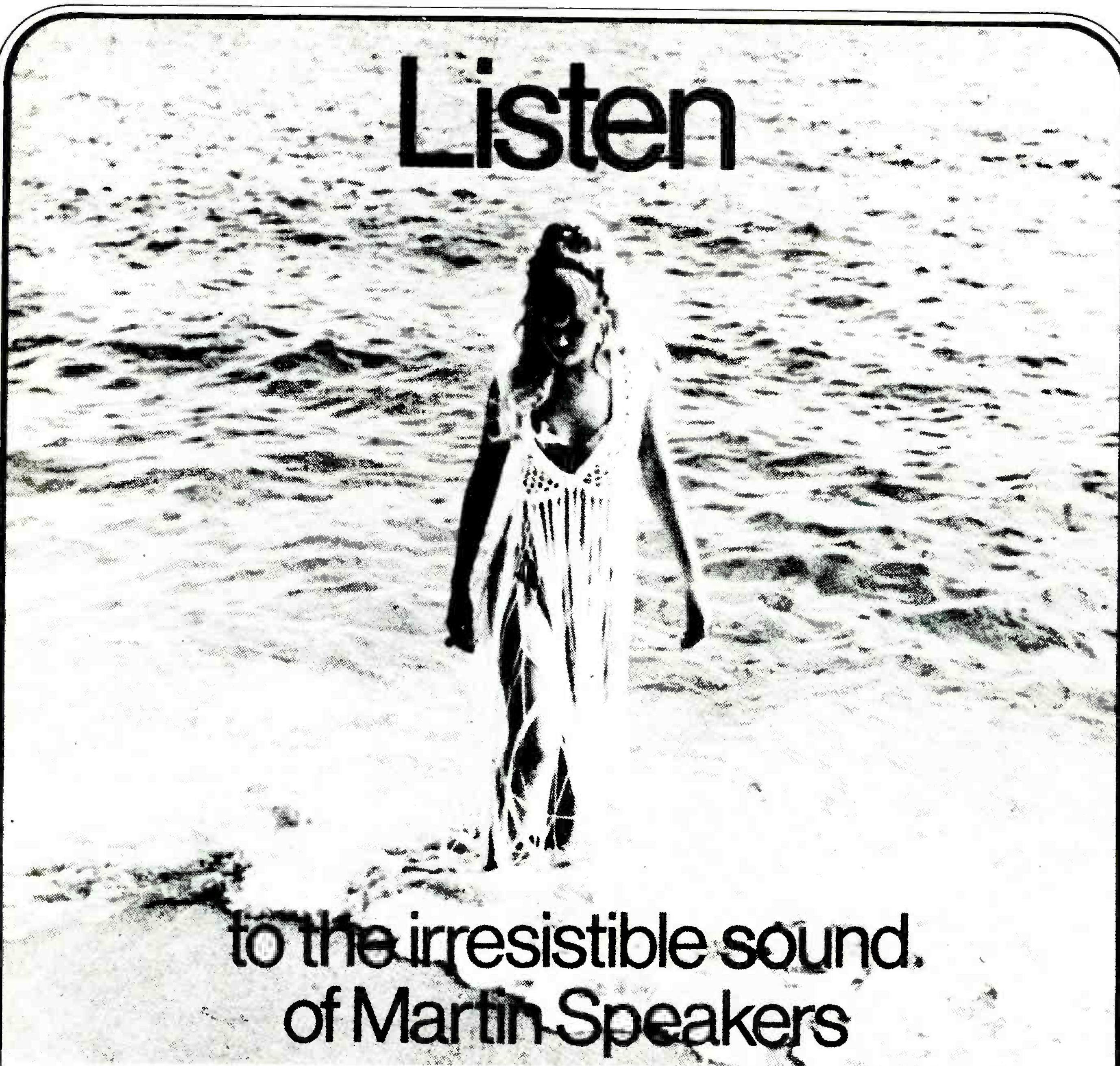

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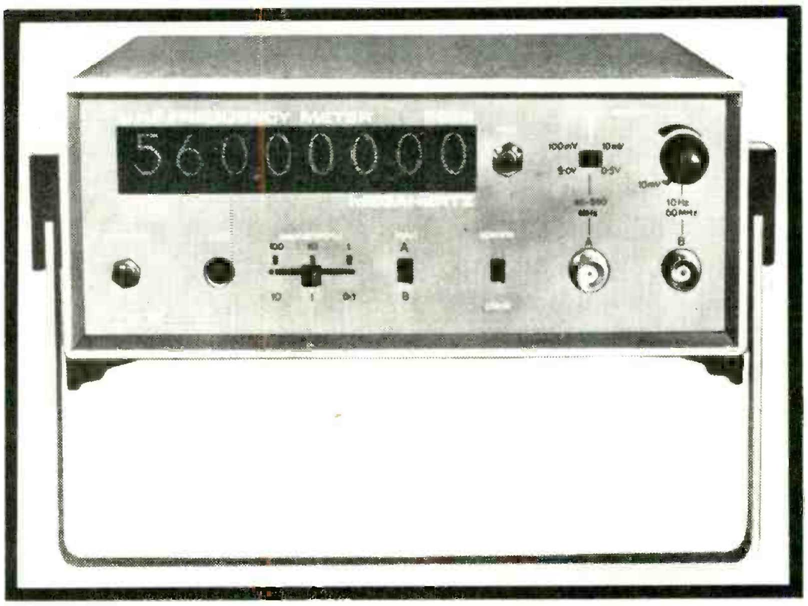

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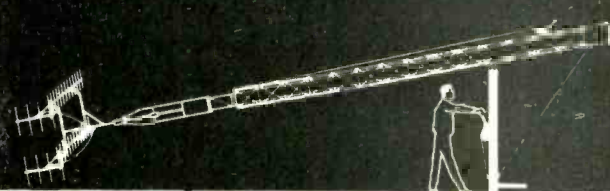

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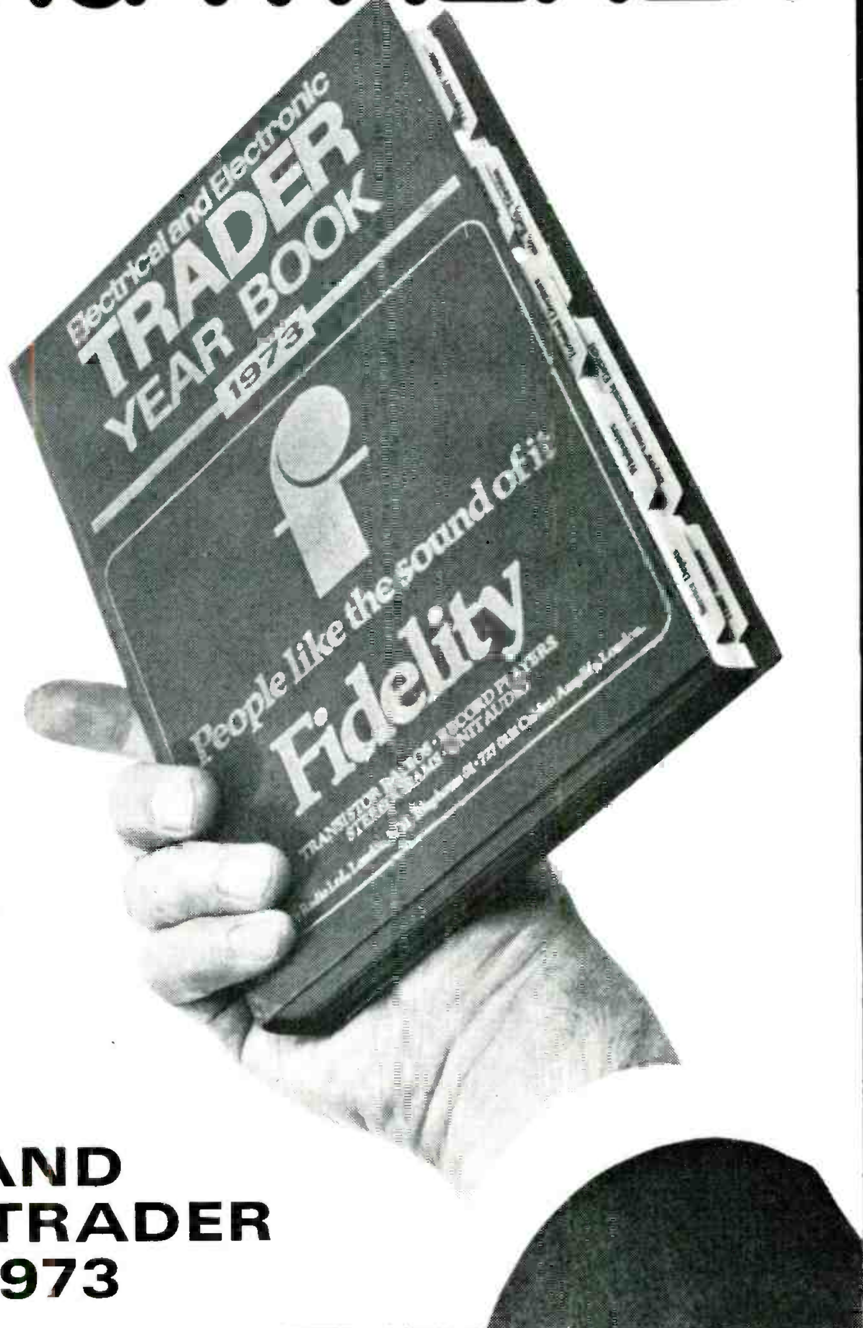

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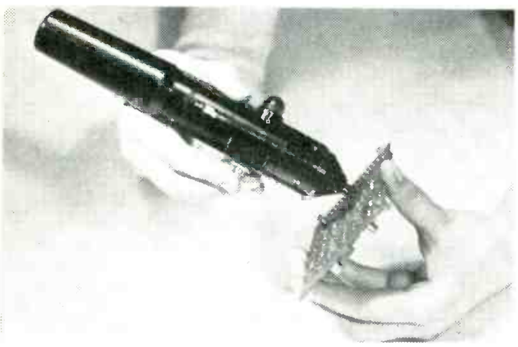

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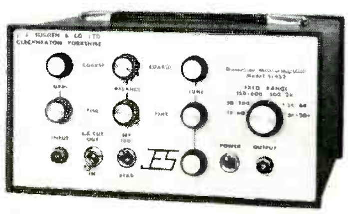

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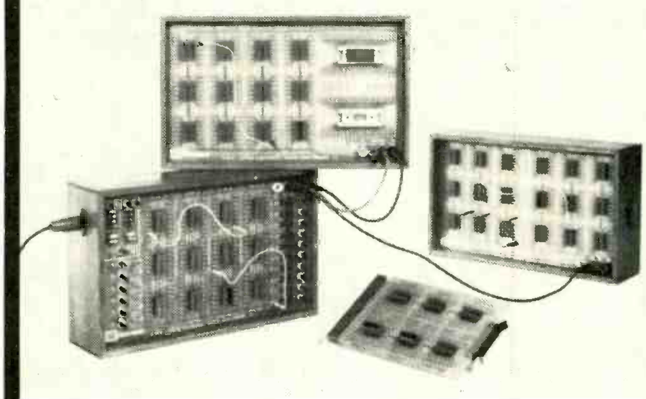

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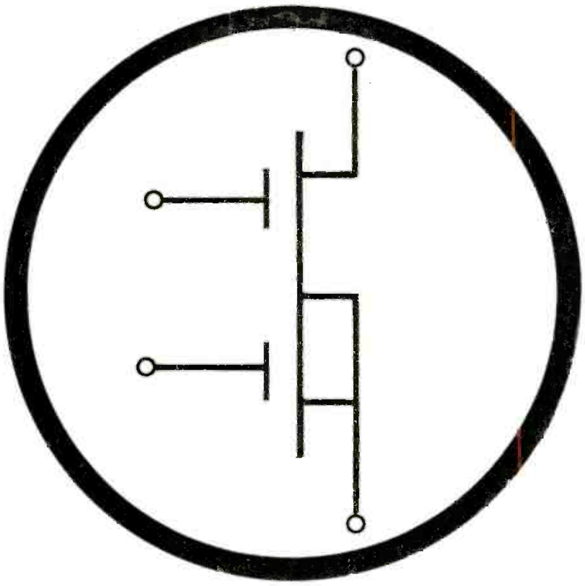

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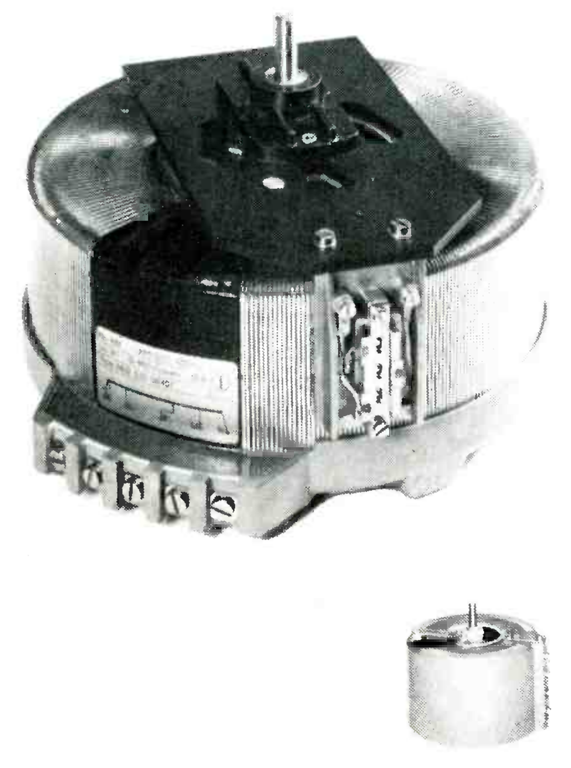

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Now Goldring bring the ideal closer with the new 820 series.

A brand new family of cartridges that builds on the advances already achieved by the Goldring 800 series. Providing cartridges that are not only capable of making the most of all that good recording can offer now, but have the capacity to keep pace with new developments in the art of quality recordings.

The 820 series retains the true transparency of sound and the true transduction techniques of earlier designs.

It brings advances in every aspect of design.

The small low-mass diamond point which is mounted on a new type of specially polished lightweight aluminium tube, combined with the new visco-elastic material used for the pivot pad, makes for greater tracking ability.

A special 'tie wire' minimises fore and aft stylus movement, reducing non-linear distortion to a minimum.

The total effect is a cartridge that, other equipment being equal, can narrow almost to vanishing point the difference between the original recording and the sound that comes out of your speakers.

There are three models in the range. The 820 with spherical stylus. The 820E and 820 Super E, both with bi-radial styli. Write for details and full specifications.

And satisfy yourself that 'what goes in comes out'.

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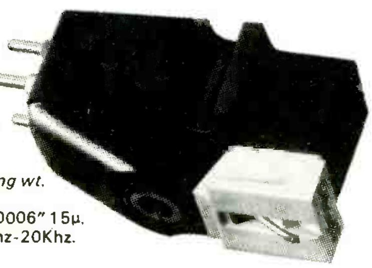

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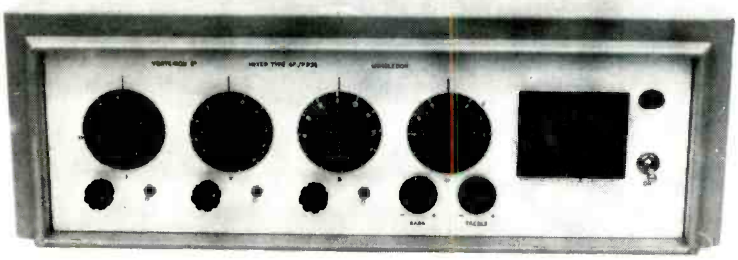

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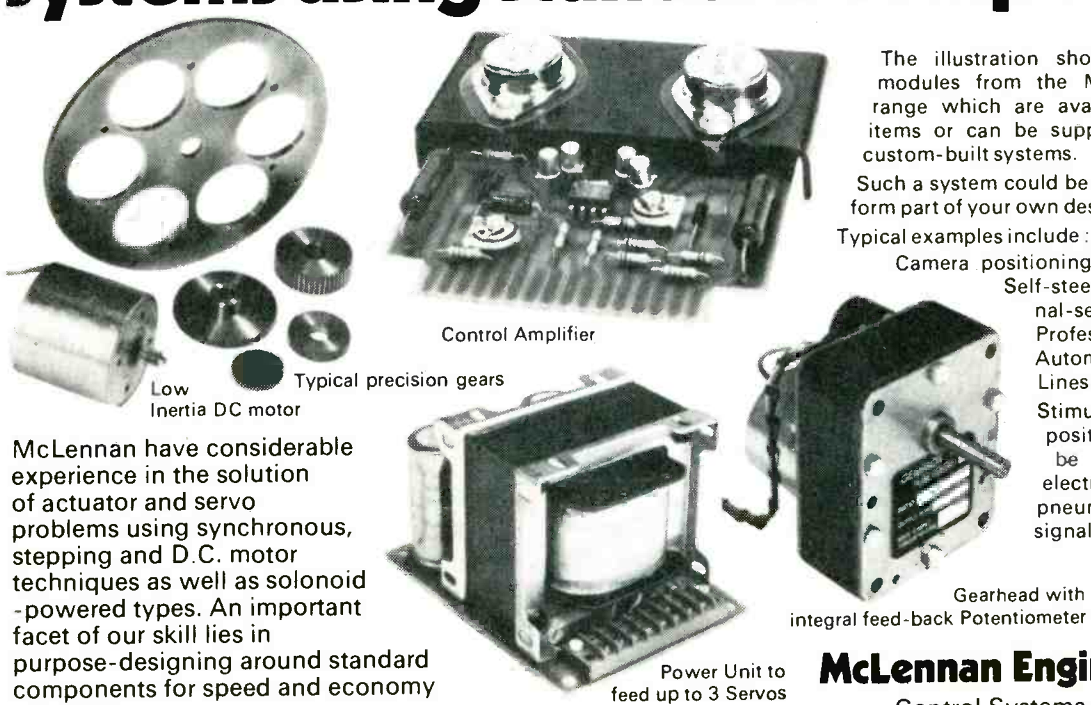

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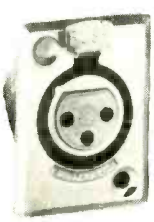

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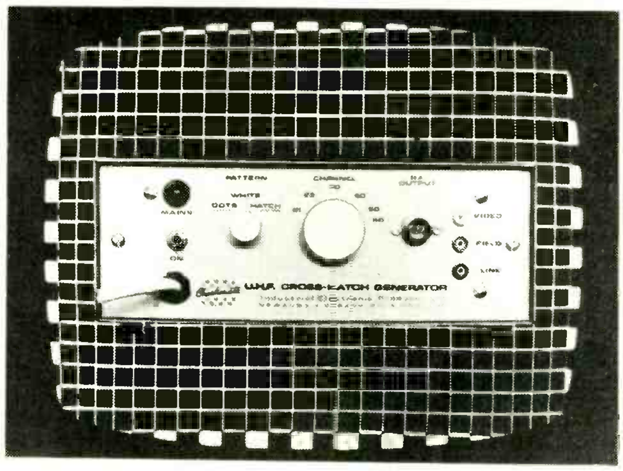

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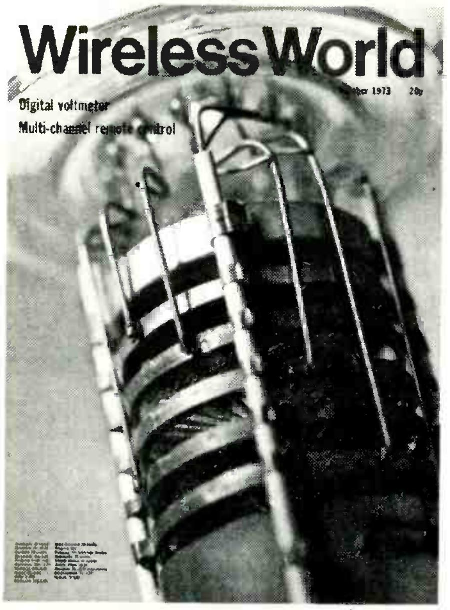
Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **October 1973** **Volume 79 Number 1456**



This month's cover picture shows part of the internal structure of an image intensifier made by Cathodeon. *(Photographer Paul Brierley)*

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Wireless World

The Educated Ear

In our July issue we published a letter bewailing the lack of a "figure of goodness" for f.m. tuners. In the August issue J. R. Stuart's article on amplifier design told of the attempt to find a co-relation between objection measurements and subjective tests of harmonic distortion. These passages, and no doubt the unexpressed thoughts of many audiophiles, indicate a yearning for that mysterious formula, an objective standard of quality in reproduced sound. In its absence we must make do with subjective assessments. Fortunately, for those in mental distress, there are plenty of people around who will give you a subjective assessment at the drop of a hat. There are those who can tell the difference between "transistor sound" and "valve sound", those who can distinguish between a high quality Class B amplifier and a high quality Class A one, and above all there are the reviewers of equipment in the audio magazines.

One presumes that these people (especially the reviewers, who publish their conclusions) have a highly discriminating sense of hearing. Perhaps they were born with it, but at any rate we are told that whatever the initial state of the faculty it can be developed by training — the ear can be educated. But what exactly is the nature of the training, what are the criteria for an educated ear, what levels of aural education are attainable, how do we know what level a particular assessor has reached, and to what extent can we rely on the judgments resulting from the training? In fact we know very little about these qualifications. It appears that the training is self-administered and consists largely of constant listening, straining to distinguish minute differences of sound quality, development of a good aural memory, and familiarization with the aural correlates of engineering measurements such as distortion. From advertisements in which items of audio equipment are endorsed by famous musicians we are led to believe that these powers of assessment are normal attributes of musically trained people — and, perhaps conversely, that equipment reviewers and other assessors have musical ability of the kind possessed by professional musicians. But this is dangerous territory — a quagmire of subjectivism.

For those who feel lost in such considerations it is comforting to know that there is, at least, an objective standard of audio equipment performance. This is the group of specifications, DIN 45 500, issued by the German standards institution Deutscher (Industrie) Normenausschuss, which lays down in quantitative engineering terms the minimum performance requirements for domestic equipment that will permit it to be described as "high fidelity". Regrettably the British Standards Institution does nothing equivalent (only recommended methods of measurement), so those British audio manufacturers that are interested are making use of DIN 45 500. For the customer who does not have an educated ear but does have a highly developed sense of value for money it must be some satisfaction to know that what he has bought is, in a sense, sound of guaranteed minimum quality. The conformity to DIN 45 500 and the figures contained in the specifications do not tell him the *nature* of this sound quality he has bought but, whatever it is, he does know that he has got it.

Dual-polarity Digital Voltmeter

1 — Circuit operation

a $3\frac{1}{2}$-digit instrument for alternating and direct voltages

by A. J. Ewins

This article describes the design and construction of the electronics of a $3\frac{1}{2}$-digit, dual-polarity digital voltmeter for measuring alternating and direct voltages in the range 200mV to 400V full-scale. It is capable of an accuracy of ±0.05% of full-scale which in practice is limited by the precision of the input attenuator resistors and the accuracy of the a.c. rectifier circuit. A relatively inexpensive attenuator system is described which is capable of being adjusted to an accuracy of ±0.1% giving an overall accuracy to the d.c. ranges of ±0.1% of reading, ±0.05% of full-scale. For the a.c. ranges the accuracy is further limited by the rectifying circuit but nevertheless an accuracy of ±0.5% of reading, ±0.05% of full-scale is achieved over a frequency range of 30Hz to 100kHz. The full-scale reading of the d.v.m. is 1999 (with suitable positioning of the decimal point) and an overload indication is given for readings in excess of this value. In spite of the overload indication it is possible to interpret readings up to an indication equivalent to 2500.

An additional feature of the d.v.m. is its ability to operate in either an automatic or a manual mode. In the auto. mode the d.v.m. continually samples the input voltage but can be made to "hold" and display the latest reading by depressing a sample/hold switch. In the manual mode the d.v.m. holds and displays the latest reading of the input voltage but can be made to further sample it by depressing the sample/hold switch, after which it again holds.

Details of the construction of the electronics on suitable circuit boards only is given, it being left to the reader to devise a suitable cabinet construction.

Design principles

The d.v.m. operates on the by now well-known dual-slope integration method. Two previous designs presented in this journal[1,2] operate on this principle and a detailed account of the theory was given in Waddington's article, "Digital Multimeter"[1]. However, for those readers who missed both previous articles and are unfamiliar with the technique a brief description of the principle will be given.

Single polarity. With reference to the block circuit diagram of Fig. 1, a capacitor C, is charged (negatively) by connecting the positive input voltage, V_{in}, (*via* the electronic switch) to the resistor R for a known time. The resistor R, capacitor C and the high-gain operational amplifier form an integrating circuit with highly linear characteristics. At the end of this time the voltage on the capacitor will be V_c, given by the expression:

$$V_c = (1/RC)\int_0^{t_1} V_{in}.\mathrm{d}t = V_{in}.t_1/RC.$$

The electronic switch now connects the resistor R to the accurately known negative reference voltage and the capacitor is discharged (positively) until V_c reaches the value it was before it was charged (usually zero volts). Thus,

$$0 = V_c-(1/RC)\int_0^{t_2} V_{ref}.\mathrm{d}t = V_c - V_{ref}.t_2/RC.$$

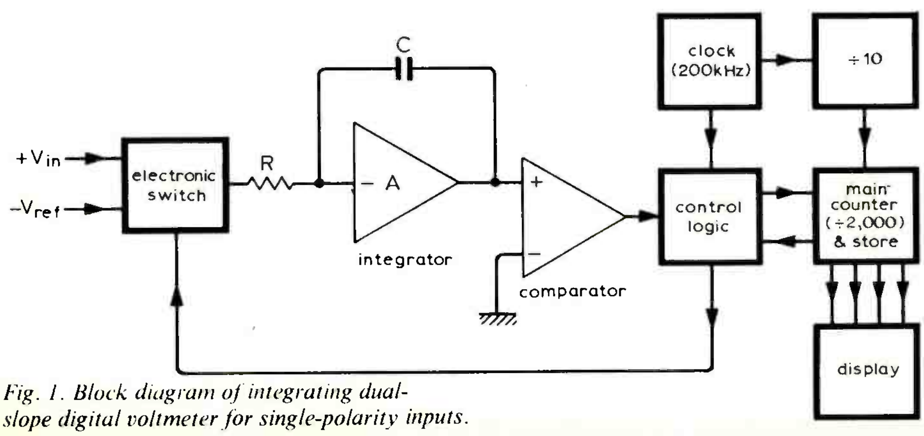


Fig. 1. Block diagram of integrating dual-slope digital voltmeter for single-polarity inputs.

Hence, $V_{in}.t_1/RC = V_{ref}.t_2/RC$ and $V_{in} = V_{ref}.t_2/t_1$.

The value of t_1 is determined by the frequency of the clock oscillator and the divide-by-10 and 2000 counters. (The divide-by-ten counter has been introduced to ensure that the control logic operates at a speed at least ten times faster than the time represented by the least significant digit of the main, divide-by-2000 counter.) At the beginning of the charging process these two counters are set to zero. The logic is so arranged that when the divide-by-2000 counter reaches a total count of 2000 (after 20,000 clock pulses, and hence after a time $2\times10^{-5}\times10^4$ = 100ms) the charging process is stopped and the discharging process begun (by disconnecting R from V_{in} and connecting it to $-V_{ref}$). The divide-by-2000 counter now counts the number of clock pulses (divided by ten) received in the time it takes to discharge the capacitor to zero volts. The comparator, of Fig. 1, detects the zero voltage level and transmits a pulse to the control logic, commanding the transfer of the time indicated by the main counter to the display. Immediately after the transfer, the divide-by-10 and 2000 counters are reset to zero and the resistor R reconnected to $+V_{in}$. A new measurement cycle then begins. (N.b., there is no need to reset the divide-by-10 and 2000 counters to zero at the end of the charging process because they automatically recycle at the end of this period.) Because the full-scale of the main counter is effectively a display of 2000, the value of V_{in} may be read directly in terms of t_2 if $-V_{ref}$ is given a value of −2 volts, i.e. $V_{in} = t_2.2\mathrm{V}/2000$. This is the case of the d.v.m. described in this article and the basic range is thus 2 volts.

The beauty of the dual-slope integration method lies in the fact that the long-term stability of the clock oscillator and the precise values of R and C are unimportant. Providing they are stable over the short-term (not more than 200ms for a full-scale reading) which may more than reasonably be expected, the accuracy of the system is theoretically only dependant upon the accuracy of the reference voltage.

As has already been mentioned, the divide-by-10 and 2000 counters are reset to zero immediately after the time t_2 has been transferred to the display. This is unlike the previous designs described in this magazine, which had a "dead period" at the end of the discharging process, whilst the main counter continued towards a total count of 2000, before reconnecting the input to the integrator to V_{in}. The modification to this design allows readings in excess of full-scale (up to a limiting value discussed later) to be accurately interpreted and is one of the reasons why existing large-scale integrated circuits were not considered for the control and display logic. The main reason, at the time of construction, was one of cost and availability. The article, "Digital Panel Meter"[2], published in this journal, amply illustrates the advantages to be obtained from using l.s.i.cs. However, while the use of individual logic circuits may be cheaper than the large-scale ones (if considerably more bulky) the author has taken advantage of the opportunity to "stamp" his own originality upon the design of d.v.m. circuits. Eventually, when the cost of l.s.i.cs become really low, the designer will no longer be free to indulge his own whims and fancies upon the basic designs, but will have to be content to accept the designs of others.

The lack of a "dead period" in the operation of the d.v.m. measurement cycle does have one other advantage in the simplification of the switching circuitry when only one resistor is used in the integrator. If more than one resistor is used, say, one for $+V_{in}$ and one for $-V_{ref}$, a possible source of error is introduced due to the differing ageing characteristics between resistors.

Dual polarity. The principle of operation of a dual-slope integrating digital voltmeter so far described has only been for a single polarity type. For a dual-polarity type, some modification to the basic block diagram of Fig. 1 is necessary. Fig. 2 is a block diagram of the dual-polarity principle adopted by the author. The method of conversion of voltage into time is exactly as described before. However, the capacitor C will be charged negatively or positively as determined by the polarity of the input voltage. Thus two reference voltages, of equal magnitude but opposite sign, are needed to discharge the capacitor, positively or negatively as appropriate. Two comparators are also required to detect the direction of the charge on the capacitor and hence select the appropriate reference voltage for discharging. Except for the addition of polarity detecting logic, the operation of the control and display logic remains unaltered.

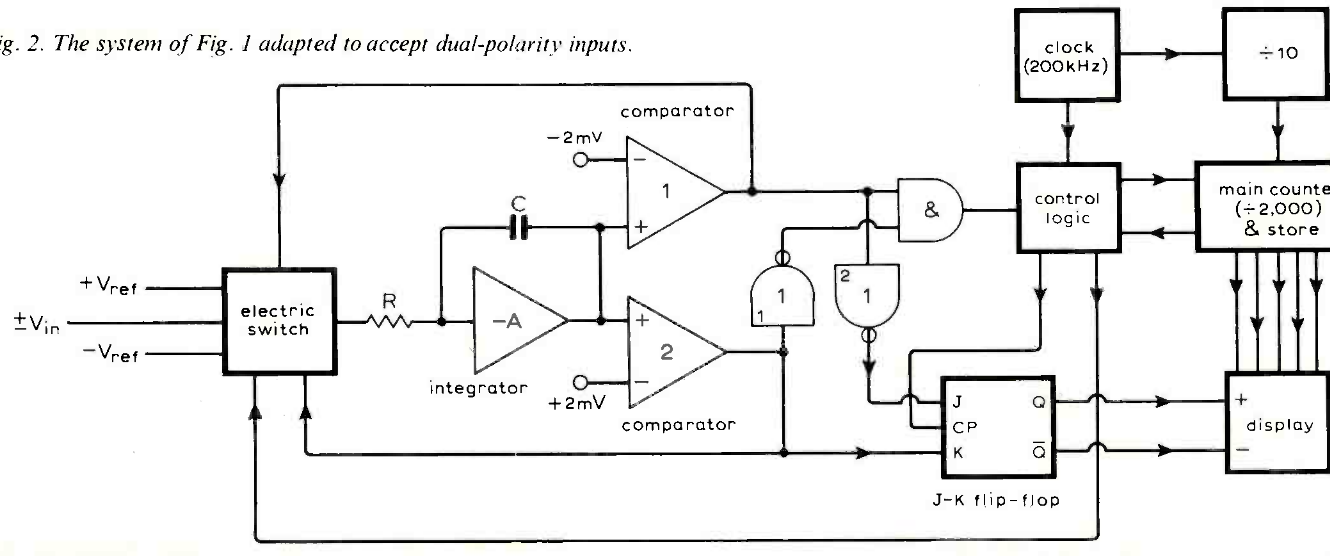
Initially the capacitor C is discharged and the output from the integrator, V_c, will satisfy the following condition; $-2\text{mV} < V_c < +2\text{mV}$. The output from comparator 1 will therefore be logical "1" and that of comparator 2, logical zero. Due to the inversion of the logical level at the output of comparator 2 by inverter 1, the input to the control logic and from the AND gate will be logical "1", which is the same as for the single-polarity d.v.m. of Fig. 1. This is thus the beginning of the measurement cycle and the control logic connects the resistor, R, via the electronic switch, to V_{in}. Providing that the magnitude of V_{in} is greater than zero, the capacitor C will be charged. If V_{in} is positive, C will be charged negatively and the output of comparator 1 will become logical zero. Comparator 2 remains unaltered at the logical zero level.

The output from the AND gate thus changes to logical zero. Similarly, if V_{in} is negative, C will be charged positively and the output of comparator 2 will become logical "1", comparator 1 remaining at the logical "1" level. Once again, the output from the AND gate becomes logical zero. At the end of the timing period, the control logic commands the connection of one of the reference voltages to the input of the integrator. The reference voltage selected is dependant upon the logical states of the two comparators fed-back to the electronic switch. If the output from both comparators is logical zero, $-V_{ref}$ will be selected and if they are both logical "1", $+V_{ref}$ will be selected. The logic of the electronic switching circuit is so arranged that a logical zero at the output of either comparator inhibits the selection of $+V_{ref}$ and a logical "1" at the output of either comparator inhibits the selection of $-V_{ref}$. Because of this it is impossible for both reference voltages to be selected simultaneously. Having connected the appropriate reference voltage to the integrator the capacitor is discharged until the voltage across it again satisfies the condition, $-2\text{mV} < V_c < +2\text{mV}$. When this occurs, the output from the AND gate again becomes logical "1", commanding the control logic to transfer the time t_2 from the main counter to the display, reset the divide-by-10 and main counters to zero and reconnect the input of the integrator to V_{in}.

Polarity indication is achieved by detecting the logical states of the two comparators at the end of the initial timing period. If at the end of this time the outputs of both comparators are logical zeros (when V_{in} is positive) the J input to the J-K flip flop will be logical "1" (due to the inverting action of inverter 2) and the K input will be logical zero. A pulse from the control logic, transmitted at the end of the timing period, transfers the logical "1" at the J input to the Q output, which in turn operates drivers in the display unit to indicate the positive sign. Similarly, if at the end of the timing period the outputs of both comparators are logical "1", then the J and K inputs will be logical zero and "1", respectively, and a logical "1" will be transferred to the $\bar{Q}$ output. Thus the negative sign will be displayed. When the input voltage is zero, the outputs of both comparators remain unaltered, from their original conditions, at the end of the initial timing period. Both J and K inputs are thus logical zeros and the polarity sign indicated is that of the last input voltage greater than zero. In this manner, the sign indicated by the display remains illuminated until an input voltage of opposite polarity is applied. By shorting the V_{in} input to earth, the polarity indication may be used to accurately set the zero reading of the d.v.m.

The -2mV and $+2$mV reference voltages applied to the negative inputs of comparators 1 and 2, respectively, are necessary in order to define clearly the discharged state of the integrating capacitor. It would not be possible to do this if both reference inputs were connected to earth. In practice it is sufficient to separate the reference levels of the comparators by such an amount as to guarantee the discharged state to be clearly defined, allowing for temperature drift of the differential offset voltages of the comparators. The fact that the two comparator reference levels are at different voltages in no way impairs the accuracy of the system. However, the closer the two reference levels, the easier it is to assess a true zero condition in the absence

Fig. 2. The system of Fig. 1 adapted to accept dual-polarity inputs.



of an input voltage, and 2mV represents a resolution of less than the least significant digit displayed.

Basic d.v.m. circuit

For convenience the basic circuitry of the d.v.m. has been split up into two. Fig. 3 is a detailed circuit diagram of all the analogue circuitry of the d.v.m. plus the electronic switching circuitry and the polarity logic. Fig. 4 is a detailed block circuit diagram of the control and display logic. It will be seen that the total circuitry uses only well known and easily obtainable, inexpensive, operational amplifiers, transistors and t.t.l. digital circuits.

Analogue circuit. Examining first of all the circuit of Fig. 3 it will be seen that Z_2, which is fed with a constant current of about 5mA by Tr_5 and its associated circuitry, provides a reference voltage of +5.6 volts. This large positive reference voltage is converted into a smaller positive one of 2 volts, with low output impedance, by IC_1 and its associated circuitry. It is similarly converted into a −2 volt reference level, with low output impedance, by the inverting action of IC_5 and its circuit. Variable resistors, R_1 and R_2, allow for a precise setting of these two reference levels. IC_3 provides a buffer input for V_{in}, has unity gain and a low output impedance. The output from IC_3 is voltage limited by zener diodes Z_3 and Z_4 for the protection of the transistors used in the electronic switch. R_3 allows the output from IC_3 to be adjusted precisely to zero when the input voltage is zero. IC_6 is the integrating operational amplifier and IC_8 and IC_9 are the comparators, 1 and 2, respectively. Tr_1 is the transistor switch for $+V_{ref}$, Tr_4 the switch for $-V_{ref}$ and transistors Tr_2 and Tr_3, in parallel, the switch for V_{in}. The operation of these transistor switches is controlled by IC_2 and IC_4 and the outputs from the two comparators via the diodes D_1 to D_8. The operation of these transistors as switches may be unfamiliar to some readers and will therefore be explained. Figs. 5(a) and 5(b) illustrate, respectively, the conventional use of a transistor as a switch and the more unconventional mode as used in this d.v.m. In Fig. 5(a), when a sufficiently large current is applied to the base of the transistor, it saturates with a collector-emitter voltage of typically 200mV, which varies little with varying supply volts, V_s, providing the collector resistor is of a reasonably high value. This offset voltage is very high when compared with a resolution for the d.v.m. of 1mV and makes the use of a transistor as a switch, in this mode, quite unsuitable. It is a curious fact, however, that when the same transistor is turned upside down, see Fig. 5(b), (V_s must not now exceed the V_{be} breakdown voltage of the transistor) and a sufficiently large current is applied to the base of the transistor, it saturates, this time with an emitter-collector voltage of only a few millivolts. Experiments with n-p-n and p-n-p transistors, types BC182 and BC212 respectively, in the test circuits of Figs. 5(c) and 5(d) (which are effectively rearrangements of the circuit of Fig. 5(b), allowing for transistor types), yielded the results in Table 1.

Table 1

V_{in} (volts)	V_{ce} (mV)	
	BC182	BC212
+2	+3.3	+2.1
+1	+1.5	+1.3
0	−0.3	+0.3
−1	−1.7	−1.0
−2	−2.8	−2.5

The above two transistors were selected randomly and others of the same two types produced only slightly different results. From the above results it was thought quite satisfactory to use a BC182, in this switching mode, for switching $+V_{ref}$ and a BC212 for switching $-V_{ref}$. The very small voltages dropped across the collector and emitter of the transistors are easily allowed for in the adjustment of the two reference levels.

Neither of the two transistors was thought ideal for switching the input voltage because, although the small voltages dropped across the transistors at V_{in} equals zero could be allowed for in the zero adjustment

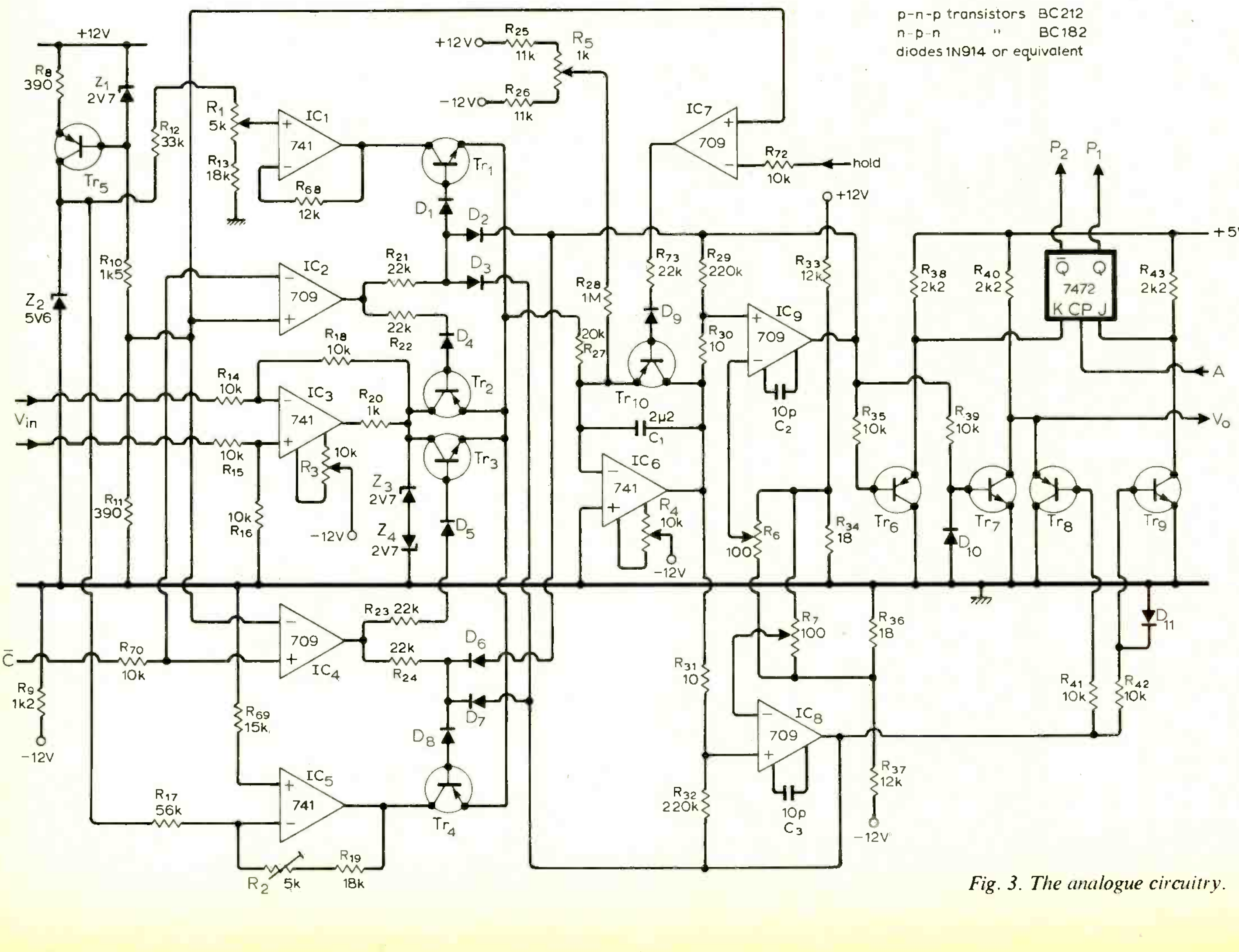


Fig. 3. The analogue circuitry.

of the input op-amp, the relationship between V_{ce} and V_{in} were not exactly linear. However, the author discovered that if both types of transistor were used (by connecting them back-to-back as in Fig. 5(e)) and were switched on simultaneously, a nearly ideal switch was produced. Using the same two transistors, as tested above, in the experimental circuit of Fig. 5(e) produced the results in Table 2.

Table 2

V_{in} (volts)	V_{ce} (mV)
+2	+2.7
+1	+1.4
0	~0
−1	−1.3
−2	−2.7

The two transistors were thus acting together to produce a switch with very nearly zero offset voltage and an effective "on" resistance of (2.7mV × 20kΩ)/2V = 27Ω. A parallel combination of a BC182 and a BC212 is thus used as the switch for V_{in}. The above table of results is interesting in view of the fact that the two transistors used were not precisely matched, except for their values of V_{ce} at zero input voltage. The author, therefore, feels fairly confident that any pair of transistors, types BC182 and BC212, should function satisfactorily in this manner without the need for special matching.

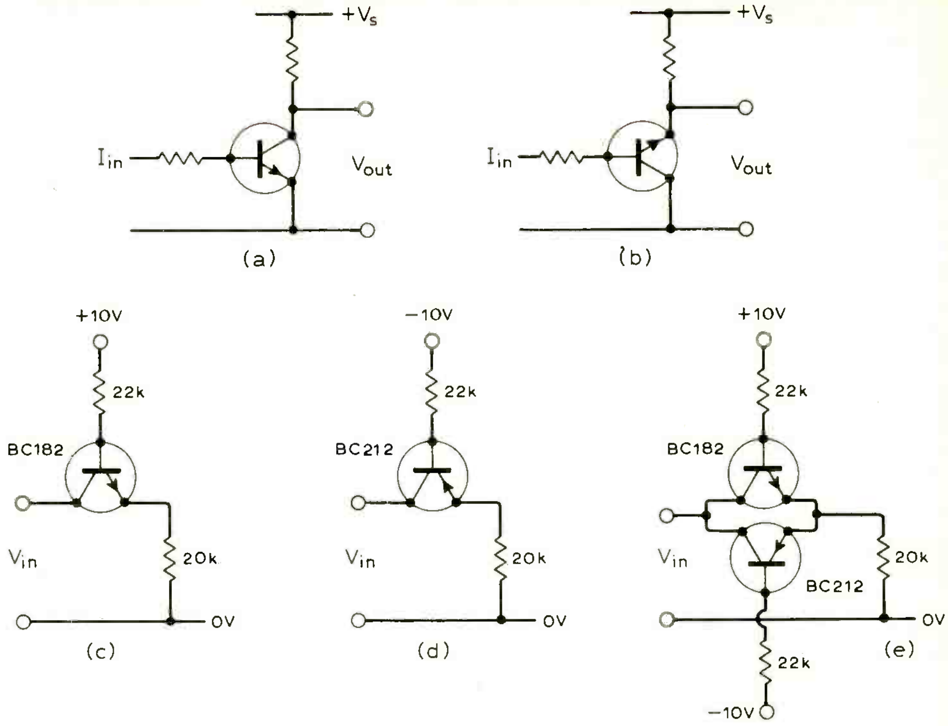


Fig. 5. (a) Conventional and (b) inverted transistor switches. Test circuits, using n-p-n and p-n-p devices are shown in (c) and (d) and (e) in the final form using both types.

Fig. 4. Control and logic circuitry.

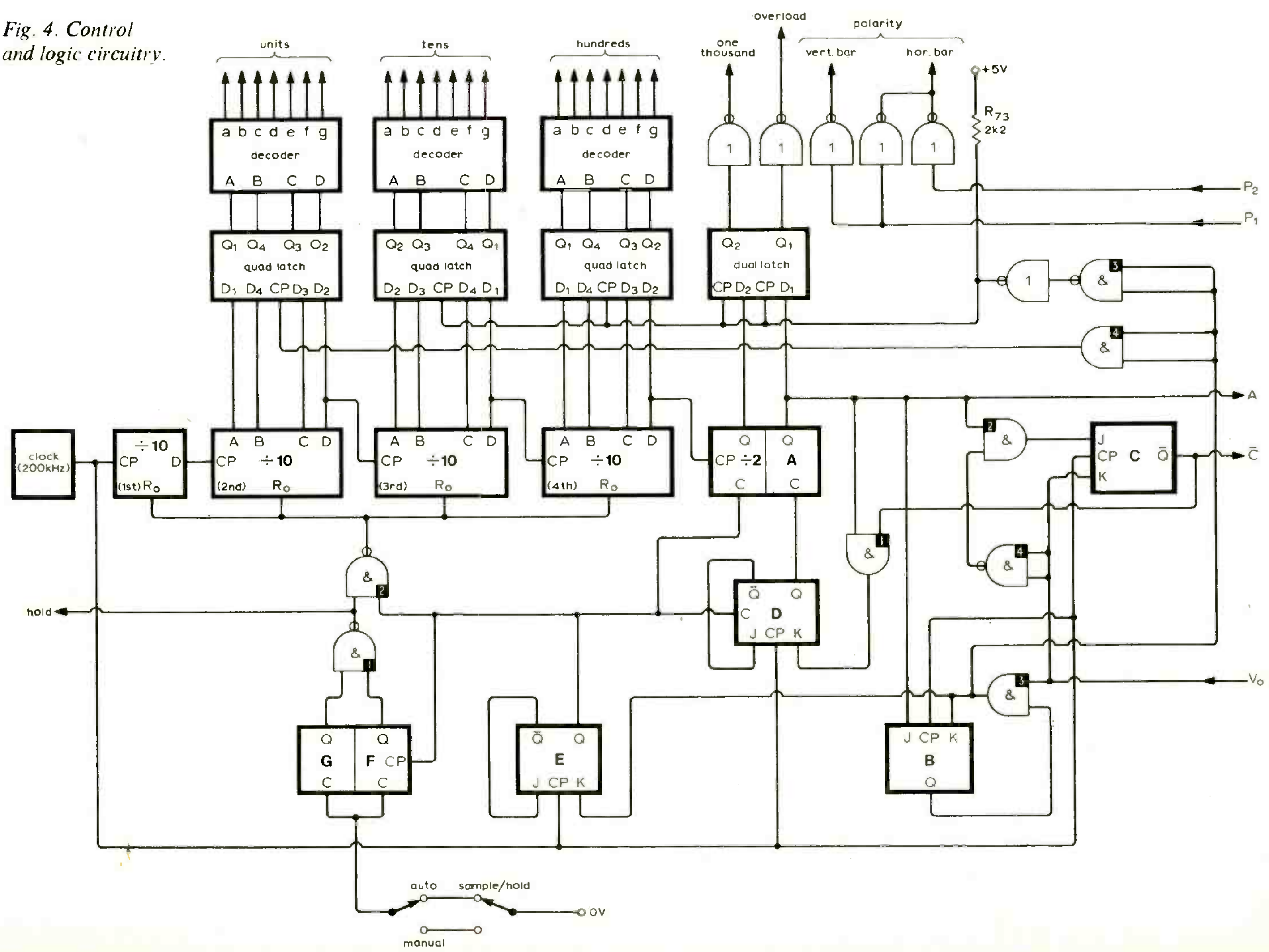


Fig. 6 illustrates the complete switching circuitry of the d.v.m. and, remembering that the outputs from the two comparators (IC_8 and IC_9) and IC_2 and IC_4 are either + or − 10 volts (approx.), operates as follows: At the onset of the measurement cycle (i.e. V_{in} connected to the input of the integrator) the voltage at the output of IC_8 is +10V; that of IC_9, −10V; that of IC_2, −10V and IC_4, +10V. The voltage at the junction of the diodes, D_1, D_2 and D_3, is thus approx. −10V and Tr_1 is OFF, the voltage at the junction of the diodes, D_6, D_7 and D_8, is approx. +10V and Tr_4 is OFF; the voltage at the base of Tr_2 is negative of its collector and therefore it is ON, and the voltage at the base of Tr_3 is positive of its collector and therefore it is also ON. At the end of the timing period the voltages at the outputs of IC_2 and IC_4 reverse, to become +10V and −10V respectively, turning transistors Tr_2 and Tr_3 OFF. In the absence of any feedback from the outputs of the two comparators, transistors Tr_1 and Tr_4 would simultaneously be turned ON, shorting $+V_{ref}$ and $-V_{ref}$ together. However, with the connections as shown and assuming a positive input voltage, the output of comparator one (IC_8) will have become −10V by the end of the timing period, the output of comparator two remaining −10V. The junction of diodes D_6, D_7 and D_8 is thus free to swing in a negative direction at the command of IC_4 and Tr_4 is turned ON connecting $-V_{ref}$ to the input of the integrator. −10V at the outputs of both comparators prevent Tr_1 from being turned ON. If the input voltage had been negative, the output of comparator two (IC_9) would have become +10V by the end of the timing period, the output of comparator one remaining +10V; the junction of diodes D_1, D_2 and D_3 would then have been free to swing in a positive direction at the command of IC_2 and Tr_1 would have been turned ON, connecting $+V_{ref}$ to the input of the integrator. +10V at the output of both comparators prevent Tr_4 from being turned ON. The diodes D_1, D_4, D_5 and D_8 prevent breakdown of the emitter-base junctions of the transistors Tr_1 to Tr_4, respectively, when they are held in their OFF states.

The switching currents feeding into the bases of the transistors Tr_1 to Tr_4 to turn them ON are of the order of 300µA to 500µA, and it is because of this relatively heavy current that the output impedances of the sources of $+V_{ref}$, $-V_{ref}$ and V_{in} must be low. A higher output impedance would result in these voltage levels being altered in the presence of the switching currents, impairing the accuracy of the d.v.m.

Returning now to Fig. 3, it will be appreciated that the outputs from the two comparators (either + or −10 volts) are not compatible with t.t.l. digital circuit logic levels. (For the t.t.l. circuits, logical $0 \equiv 0.2$V and logical $1 \equiv 2.5$ to 5.0V.)

Transistors Tr_6 to Tr_9 are included to achieve this conversion in voltage levels and to provide the inversion function of the inverters 1 and 2 of Fig. 2 and also to provide the function of the AND gate. Thus, when the output from IC_8 is +10 volts, the collector of Tr_9 is about 0.2 volts and hence the

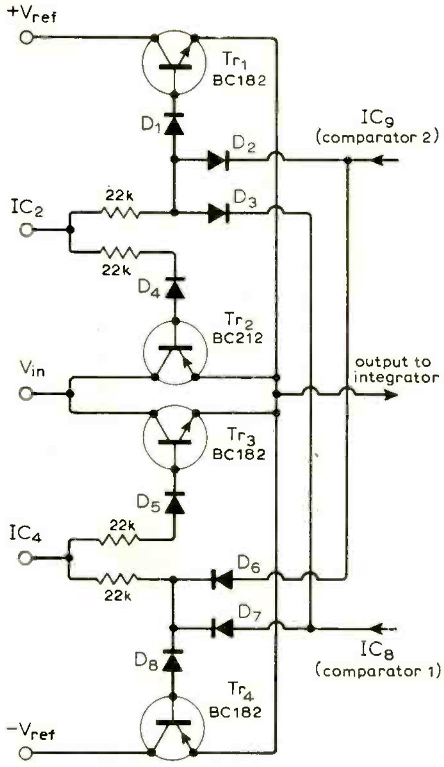


Fig. 6. The complete analogue switching circuit.

J input of the J-K flip-flop is logical "0"; when it is −10 volts, the collector of Tr_9 and the J input are at about 5 volts, i.e. logical "1". Similarly, when the output from IC_9 is −10 volts, the collector of Tr_6 is about zero volts and hence the K input to the J-K flip-flop is logical "0"; when it is +10 volts, the collector of Tr_6 and the K input are at the logical "1" level. When the outputs from IC_8 and IC_9 are +10 volts and −10 volts respectively, the output to the control logic, V_o (the junction of the collector of Tr_7 and the emitter of Tr_8), is at the logical "1" level. If either IC_8 is −10 volts or IC_9 is +10 volts, the output, V_o, becomes logical zero.

IC_2 and IC_4 are included for similar reasons to the transistors Tr_6 to Tr_9; they convert the t.t.l. logic level from $\bar{C}$ to the necessary plus and minus 10 volt levels for the operation of the electronic switch circuitry. The positive input of IC_2 and the negative input of IC_4 are held at a voltage level of about +2 volts. A logical "0" at the $\bar{C}$ output from the control logic thus produces voltage levels at the outputs of IC_2 and IC_4 of +10V and −10V, respectively. Logical "1" at the $\bar{C}$ output produces voltage levels of −10V and +10V at the outputs of IC_2 and IC_4, respectively.

It has already been stated that the inclusion of zener diodes Z_3 and Z_4 is to limit the output from IC_3 for the protection of the switching transistors. The necessity for this protection can best be understood by assuming that a voltage much greater in magnitude than 2V, say +4V, were applied to the input of IC_3. Since it has unity gain, the voltage on the collectors of Tr_2 and Tr_3 would also be +4V. Now, if the input of the integrator were connected to $-V_{ref}$ then the voltage on the emitters of Tr_2 and Tr_3 would be −2V and the emitter-base junction of Tr_2 would be in danger of breaking down, since V_{be} for all four transistors is only rated at 5 volts. (N.b., a transistor with a reverse voltage connected across its emitter and collector can only withstand a voltage equivalent to its V_{be} breakdown voltage plus the voltage across the forward biased collector-base diode.) Similar danger would be experienced if V_{in} were −4V and the input to the integrator connected to $+V_{ref}$ (+2V); the emitter-collector junction of Tr_3 would then be threatened. The emitter-collector junctions of Tr_1 and Tr_4 could also be threatened if the input to the integrator were connected to V_{in} when it was at a level of +4V or −4V, respectively. Z_3 and Z_4 limit the voltage on the collectors of Tr_2 and Tr_3 to approx. ±3.3 volts so that the magnitude of the maximum possible voltage across the collector-emitter junctions of all four switching transistors is 5.3 volts.

The variable resistors R_4 and R_5, of Fig. 3, allow the short circuit and open circuit input offsets of the integrating op-amp IC_6, to be set to zero.

The action of IC_7, together with Tr_{10} and its associated circuitry, allows the output of the integrator to be held at the zero volt level by shorting the integrating capacitor. This circuitry is used in conjunction with the auto/manual facility of the d.v.m.

Control logic. The inter-connections between the various t.t.l. digital circuits of the control and display logic are shown in the block diagram of Fig. 4. The second, third and fourth decade counters and the divide-by-two flip-flop form the basic divide-by-2000 counter. A, B, C, D, E, F and G are all J-K flip-flops and are contained in four t.t.l. circuits, type SN7473. Not shown are the connections between the outputs of the divide-by-two flip-flop and the clock pulse, C_p, input of flip-flop A, and the output of the F flip-flop and the C_p input of flip-flop G. The six inverters, which are buffer/drivers with open collector outputs capable of sinking 40mA, are all contained in the t.t.l. circuit, type SN7416. The four dual-input NAND gates are all contained in the t.t.l. circuit, type SN7400, and the four dual-input AND gates in the t.t.l. circuit, type SN7408. The clock circuit is made from a t.t.l. dual-Schmitt trigger circuit, type SN7413, together with a resistor and a capacitor. The circuit is shown in Fig. 7.

The binary outputs from the three decade counters of the main counter are transferred to suitable decoders via three quadruple latches, t.t.l. circuits type SN7475. In a similar manner, the outputs from the divide-by-two flip-flop and the A flip-flop are transferred to the inputs of two inverter buffer/drivers via a dual-latch, t.t.l. circuit type SN7474. Three other inverter buffer/drivers accept the outputs of the polarity flip-flop (see Fig. 3) and drive the horizontal and vertical bars of the polarity display. The sixth inverter buffer/driver is used to provide increased power for driving some of the C_p inputs of the latches.

In order to understand the operation of the control logic, and hence the operation of the d.v.m., Table 3 has been drawn up. It shows the logical states of the outputs of the relevant elements of the control logic for various steps in the operation of the d.v.m. For the moment the functions of flip-flops F and G have been ignored and the logical state of the output of NAND 1 is assumed to be a permanent logical "1". For the initial conditions it will be assumed that all the logical elements are in such states as at the beginning of a measurement cycle. This is as in step 0 of the above table. No clock pulses have as yet been generated, the first decade counter and the main counter are all set to zero and the output $\bar{C}$ is a logical "1". The output V_o is also a logical one. The input of the integrator is thus connected to V_{in}, which is assumed to have a magnitude greater than zero but less than 2 volts. The clock is running and the first decade counter and the main counter start to count up to a total of 20,000 clock pulses (a period of 100ms). At some time during this period the output V_o will become logical "0" and the outputs of the various logic elements become as in step 1 of Table 3.

At the end of this period the state of the main counter is again 0000 (2000 ≡ 0000) but the output of A will be logical "1", see step 2. On receipt of another clock pulse, step 3, several things happen. Output B changes from "0" to "1"; D from "1" to "0", resetting output A to "0"; and $\bar{C}$ becomes 0 connecting the input of the integrator to the appropriate reference voltage. The resetting of A to "0" transmits a pulse to the polarity flip-flop of Fig. 3, transferring appropriate logic levels to the outputs P_1 and P_2. A further clock pulse, step 4, resets D to logical "1". The main counter now continues counting and nothing further happens to the logic until V_o again becomes logical "1", indicating the end of the measurement cycle and the fact that the integrating capacitor has been discharged, see step 5. Immediately V_o becomes logical "1", the k input to flip-flop B becomes logical "1". B_k is the latch pulse and a logical "1" is immediately transmitted to the latches *via* AND gate 4, NAND gate 3 and inverter 3. The logical states of the outputs of the main counter and flip-flop A are thus transferred to the three decoders and inverter buffer/drivers 1 and 2, indicating the count reached by the main counter and whether there is an overload or not. Since the magnitude of V_{in} was assumed to be less than 2 volts the counter will not have reached 2000 and the output of A will be logical "0", indicating no overload. On receipt of the first clock pulse after V_o has become logical 1, step 6, again a number of things happen. Output B, and thus its input B_k (the latch pulse), changes from logical "1" to "0"; output E changes from "1" to "0", setting output D and the output from the divide-by-two flip-flop to "0" and also, *via* NAND gate 2, resetting all four decade counters to zero; and output $\bar{C}$ changes from logical "0" to "1", reconnecting the input of the integrator to V_{in}. Since output D has become "0" output A will also be set to "0" if it were a logical "1" before. A second clock pulse, step 7, resets E from "0" to "1", releasing the first decade counter and the main counter (allowing it to begin counting again) and flip-flop D. A third clock pulse, step 8, resets D from "0" to "1", leaving the outputs of the various logical elements exactly as at the beginning of the measurement cycle. A new measurement cycle was, in fact, begun at step 7, the moment the main counter was released after being reset.

Table 3. Sequence of logical states of control logic elements

Step	CP	Count.	A	V_o	B_j	B_k	B	C_j	C_k	$\bar{C}$	D_j	D_k	D	E_j	E_k	E
0	0	0000	0	1	0	0	0	0	1	1	0	0	1	0	0	1
1	?	??	0	0	0	0	0	0	0	1	0	0	1	0	0	1
2	0	2000	1	0	1	0	0	1	0	1	0	1	1	0	0	1
3	1	0000	0	0	0	0	1	0	0	0	1	0	0	0	0	1
4	2	0000	0	0	0	0	1	0	0	0	0	0	1	0	0	1
5	0	??	0	1	0	1	1	0	1	0	0	0	1	0	1	1
6	1	0000	0	1	0	0	0	0	1	1	1	0	0	1	0	0
7	2	0000	0	1	0	0	0	0	1	1	1	0	0	0	0	1
8	3	0000	0	1	0	0	0	0	1	1	0	0	1	0	0	1
9	0	2000	1	1	1	0	0	0	1	1	0	1	1	0	0	1
10	1	0000	0	1	0	1	1	0	1	1	1	0	0	0	1	1
11	2	0000	0	1	0	0	0	0	1	1	1	0	0	1	0	0
12	3	0000	0	1	0	0	0	0	1	1	1	0	0	0	0	1
13	4	0000	0	1	0	0	0	0	1	1	0	0	1	0	0	1
14	0	2000	1	0	1	0	1	1	0	0	0	0	1	0	0	1
15	0	2000+	1	1	1	1	1	1	1	0	0	0	1	0	1	1
16	1	0000	0	1	0	0	0	0	1	1	1	0	0	1	0	0
17	2	0000	0	1	0	0	0	0	1	1	1	0	0	0	0	1
18	3	0000	0	1	0	0	0	0	1	1	0	0	1	0	0	1

In terms of logical levels: $B_j = A$; $B_k = B.V_o$; $C_j = A.\bar{V}_o$; $C_k = V_o$; $\bar{D}_j = D$; $D_k = A.\bar{C}$; $E_j = E$; $E_k = B.V_o$

When the input voltage is zero or its magnitude is greater than 2 volts, the operation of the control logic is slightly modified. When V_{in} is zero volts, V_o does not become logical "0" so that when the main counter reaches 2000 the conditions of the various logic elements become as in step 9. After a further clock pulse the output of B becomes logical "1", so that B_k also immediately becomes logical "1" and a zero count is transferred (remembering, 2000 ≡ 0000) to the decoders. Simultaneously, the output of D becomes "0" and A is reset to zero, preventing an overload indication being given. At the end of three more clock pulses, steps 11, 12 and 13, the initial conditions, at the beginning of a measurement cycle, are arrived at once more.

When the magnitude of V_{in} is greater than 2 volts, the counter will become 2000 for a second time before V_o has become logical "1". The conditions of the outputs of the logic elements when this state is reached are as shown in step 14. Having passed 2000 the counter effectively starts counting again from 0000. Nothing further happens to the logic until eventually V_o does become logical 1, step 15. Immediately, B_k becomes logical "1" and the state of the main counter is transferred to the decoders, etc., together with the overload information on flip-flop A. Three more clock pulses, steps 16, 17 and 18, reset all the logic elements to their initial conditions. Since the overload indication represents a count of 2000, it may be added to that shown by the display to indicate a reading in excess of 2000.

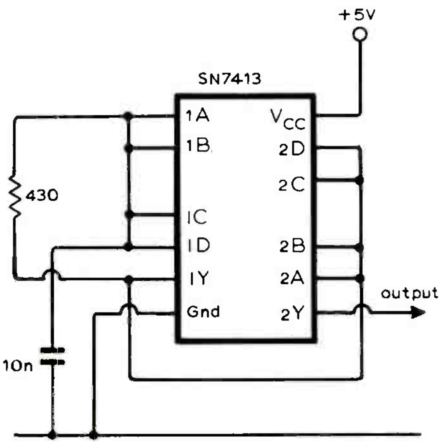


Fig. 7. Clock pulse generator, using a dual 4-input Schmitt NAND.

The upper limits for reliable readings in excess of 2000 are determined by the precise breakdown voltages of zener diodes Z_3 and Z_4, and the reverse breakdown voltage of the holding transistor Tr_{10} across the integrating capacitor. When V_{in} is negative, the integrating capacitor charges positively so that Tr_{10} will breakdown if the voltage across the capacitor exceeds about 5.7 volts (V_{be} = 5V). The integrating capacitor charges up to a voltage level, V_c, equivalent to

$$(1/RC)\int_0^{100\text{ms}} V_{in}.\,dt.$$

i.e. $V_c = V_{in}.100\text{ms}/RC$, and since $RC = 20\text{k}\Omega \times 2.2\mu\text{F} = 44\text{ms}$, $V_c = 2.27V_{in}$. Theoretically then, the upper limit for reliable readings in excess of 2000, when V_{in} is negative, is, 5.7V/2.27 = 2.500. When V_{in} is positive, the upper limit for a reliable reading in excess of 2000 is the breakdown voltage of Z_3 plus the forward diode voltage drop across Z_4 which in total, is about 3.300.

Having discussed the operation of the control logic of the d.v.m. in its Auto mode (by neglecting the operation of flip-flops F and G) it is now time to consider the function of the Auto/Manual and Sample/Hold switches and flip-flops F and G in conjunction with the hold circuitry, IC_7 and etc., of Fig. 3. As shown in Fig. 4, with the Auto/Manual switch in the Auto position and the Sample/Hold switch as indicated, the output of flip-flops F and G are held at logical zero and hence the output of NAND gate 1 is a logical "1". The operation of the control logic and the d.v.m. is therefore as described above, providing a continuous sampling of the input voltage. If now the Auto/Manual switch is switched to the Manual position, flip-flops *F* and *G* begin to count the main counter's resetting pulses transmitted by flip-flop *E*. After three such pulses the outputs of both *F* and *G* become logical "1" and hence the output of NAND gate 1 becomes logical "0" and that of NAND gate 2, logical "1". The main counter is thus held permanently reset and no further pulses are transmitted by flip-flop *E*. Simultaneously, the logical "0" level at the output of NAND gate 1 switches the output of IC_7 to -10V, switching Tr_{10} ON and holding the voltage across the integrating capacitor to zero volts. The d.v.m. remains in this state, holding the last reading of V_{in} on the display, until either the Auto/Manual switch is switched back to Auto, or the Sample/Hold switch (which is a simple, returning, push-button changeover switch) is depressed. If the Sample/Hold switch is depressed and released, the outputs of *F* and *G* are cleared to zero and the d.v.m. operates for a further three cycles until *F* and *G* are once more logical ones, when it again holds, displaying the latest reading of V_{in}. If, when the Auto/Manual switch is in the Auto position, the Sample/Hold switch is depressed and held down, the d.v.m. will hold its reading, after three further cycles, until the Sample/Hold switch is released. In this manner the d.v.m. can be made to continuously sample V_{in} and hold the information for as long as is desired by depressing the Sample/Hold switch, or sample V_{in} only on demand when the Sample/Hold switch is momentarily depressed.

Having described the operation of the d.v.m., there are now but a few points to clear up concerning the analogue circuit of Fig. 3. As mentioned earlier, the two comparators, 1 and 2, are IC_8 and IC_9 respectively. The two reference voltages, -2mV and $+2$mV, applied to the two comparators are provided by the two 100-ohm preset potentiometers and their associated circuitry. Each 100-ohm pot. provides an output voltage in the range of $+12$mV to -12mV, approximately. This allows for the offset tolerance of the 709 op-amps, used for the two comparators, of about ± 8mV. The output of the integrating op-amp connects to the non-inverting (positive) input of each comparator *via* a 10-ohm resistor. A very small amount of positive feedback is applied to each comparator by feeding their outputs back to their respective positive inputs *via* a 220kΩ resistor. In practice this results in about 2mV of hysteresis in the switching action of the two comparators. The output of comparator 2 changes from $+10$V to -10V when the output from the integrator exceeds about $+3$mV, and changes back again to $+10$V when the integrator output falls to about $+1$mV. Comparator 1 (IC_9) operates in a similar manner about levels of -1mV and -3mV. This small amount of positive feedback results in a more positive switching action of the comparators without impairing their resolution. The output from the integrator is about $2.27V_{in}$, thus 2mV hysteresis represents a resolution of about 0.88mV, which is less than the resolution of the display (1mV).

This concludes the description of the circuitry and operation of the basic d.v.m. The rest of the article deals with the description of the a.c. rectifier circuit, a suitable input attenuator and buffer stage, power supplies and, finally, circuit board layouts and a discussion on some of the components.

References

1. Digital Multimeter, by D. E. O'N. Waddington. *Wireless World*, March 1973.

2. Digital Panel Meter, by P. Bartlam. *Wireless World*, April 1973.

Correction

In the article **"Frequency Shifter for 'Howl' Suppression"** by M. Hartley Jones (July issue, pp. 317–322) the following corrections should be made.

Appendix (p. 321)

In Fig. 8, the point where the ϕ_1 curve crosses the frequency axis should be labelled f_{01} instead of f_{02}.

The line immediately after equation (2), should read

$$\left|\frac{v_o}{v_i}\right| = \sqrt{\frac{\alpha^2+\beta^2}{\alpha^2+\beta^2}}$$

Components list (p. 322)

Unfortunately there was a duplication of resistor numbers in Fig. 4 and Fig. 6. The values given in the list refer only to Fig. 4. The following additions are necessary:

Components in Fig. 4

R_{45}	6.8kΩ
IC_5, IC_6	Motorola MC1495L or Silicon General SG1495D.

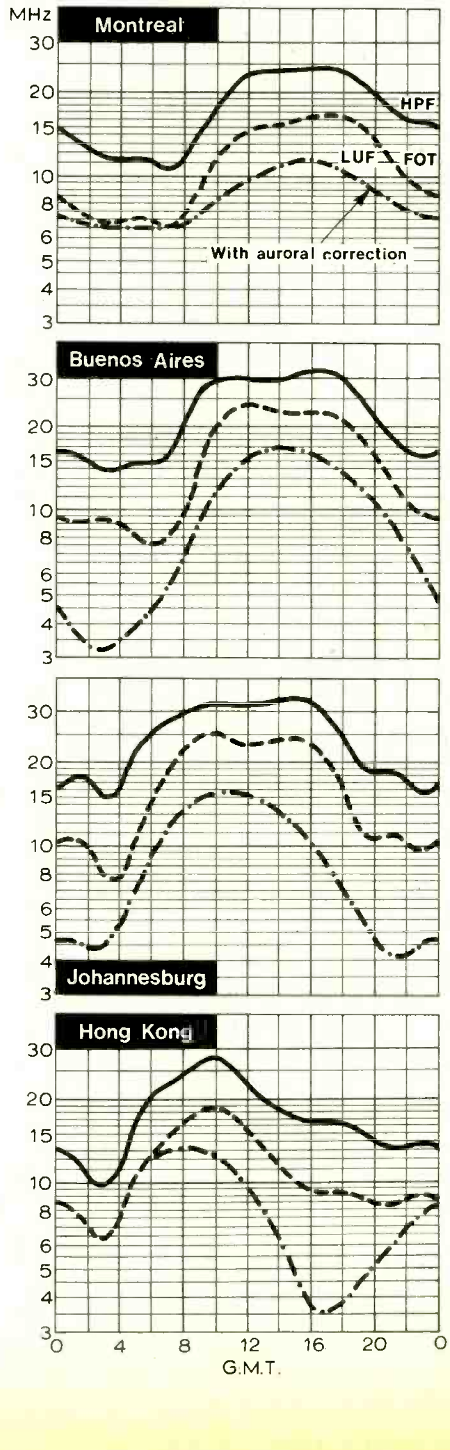
Components in Fig. 6

R_{44}, R_{45}	12kΩ
R_{46}	560Ω
C_{22}	470nF

In the article **"F.M. Tuner Design—Two Years Later"** by L. Nelson-Jones (June issue, pp. 271–275), the 68pF capacitor shown connected to the tap of L_3 in Fig. 2 should be connected to the emitter of Tr_3—as in the original article.

H. F. Predictions for October

Magnetic disturbances at 27-day intervals (one solar rotation) have been clearly evident since January of this year. Comparison with the previous sunspot cycle minimum period (as was done for the solar index in last month's notes) shows that the current disturbances are several days longer lasting than in the corresponding year of 1962. The intensity of current disturbances has dropped over the past two months, a feature also found in 1962 when, after two or three quiet rotations, the disturbances appeared consistently with each rotation for the following two years. The next most likely period of magnetic disturbance is September 23rd to October 7th.



News of the Month

Fifth Intelsat IV satellite

The latest Intelsat IV communications satellite to be launched has undergone two weeks of testing before being placed in commercial service. The fifth to be put in orbit, it is positioned over the Atlantic Ocean and has a capacity to provide an average of 5,000 two-way telephone calls or 12 simultaneous colour television programmes. By the end of this year 91 aerials at 73 earth stations in 55 countries are expected to be operating with the five Intelsats.

The first two Intelsat IVs were launched in January and December 1971 over the Atlantic to provide commercial services between the U.S.A. and Europe. The third was launched over the Pacific in January 1972. The fourth was launched last June over the Indian Ocean. Each satellite is designed to have a life of seven years.

New laser-induced electrical effect discovered

An unusual and totally unexpected electrical effect has been discovered by Robert J. von Gutfeld and Eugene E. Tynan at I.B.M's Thomas J. Watson Research Centre at Yorktown, New York.

Von Gutfeld and Tynan have found that when the surface of a thin film of a metal such as molybdenum or tungsten is irradiated with brief pulses of laser light, voltage pulses of up to 50mV are generated in the plane of the film, for 1kW of incident power. Such pulses can readily be detected without special amplification, and the planar direction of the voltage makes for simple attachment of electrical connections on the film surface.

Exploitation of the new effect could result in inexpensive arrays of fast photodetectors responsive over a broad optical spectrum and operable over a wide temperature range. Moreover, detectors based on the new effect would be resistant to the heat-degradation characteristic of such now-common photodetectors as silicon-based devices. Some experimental detectors based on the effect in fact show an actual increase in sensitivity with rise in temperature.

The new phenomenon was discovered during studies of heat conductivity in which a pulsed laser was used to "inject" bursts of thermal energy into small samples of various materials under controlled and monitored conditions. A temperature gradient through the depth of the irradiated films does appear to play a central role in giving rise to the voltage, at right angles to the gradient.

At least as surprising as the voltage direction is the fact that the voltage polarity remains the same, for fixed contacts, no matter how one rotates the film in its own plane around the axis of the laser beam. The only way to reverse polarity for a sample to which measurement contacts are fixed is to shine the laser beam on the other side of the film.

In a paper in the August 15 issue of *Applied Physics Letters,* Dr. von Gutfeld suggests that underlying the newly found effect is an asymmetry within the films themselves — microscopic distortion caused by such factors as stress arising while the film is being deposited and/or misplacement of atoms as they stack up while the film is being formed. This type of asymmetry would be independent of rotations around the laser-beam axis and could result in the "crosswise" voltage observed, as von Gutfeld shows by an analysis of the so-called Boltzmann transport equations, which relate symmetry structure to electrical and thermal parameters. The voltage would, in fact, be a photo-induced transient thermoelectric effect.

Alphanumerics on a TV picture

A new modular Series 204 "Display controller" from Ann Arbor Terminals, Inc., Ann Arbor, Michigan has been developed specifically for superimposing alphanumeric data on an ordinary TV picture in cable TV, closed-circuit TV, video tape recording, and annunciator applications.

The 204 has an alphanumeric display repertoire of 64 alphanumeric characters. Up to 16 lines with 32 characters per line may be displayed, and all 512 characters are stored in an internal m.o.s. dynamic shift register memory. Character size is proportional to screen size, and is typically 0.22in on an 11in screen. The controller accepts either picture video or composite sync from the video source. A choice of three output signals is provided: alphanumerics added to the picture; alphanumerics added to the composite sync; or synchronized non-composite alphanumerics that can be mixed externally with other video signals.

A switch is provided which allows the full screen of alphanumeric data to be added to the video for data display and annunciator applications, or 1, 2, or 3 lines near the bottom of the picture for titling applications.

Congress on Acoustics — 1974

Environmental acoustics will be the theme of the Eighth International Congress on Acoustics, to be held at Imperial College, London, on 23-31 July 1974. The main address at the opening plenary session, to be held in the Royal Albert Hall, will be given by R. H. Bolt (U.S.A.). This address will be on the general subject of acoustics and the environment. Other invited speakers will be continuing this theme in a series of lectures designed to review particular aspects of the subject. Offers of papers for the sessions of contributed papers are now invited, and full details on the submission of these are contained in the Second Circular, which is available from The Administrative Secretary, 8 ICA 1974, 47 Belgrave Square, London SW1X 8QX.

Spacelab — new agreement

Six member states of the European Space Research Organization (ESRO) have recently signed the "Arrangement between certain member states of ESRO and ESRO" for the development of the Spacelab that forms the European contribution to the American space shuttle programme. The financial contributions of the six member states concerned represent 76% of the overall sum that Europe will devote to the Spacelab programme.

Berlin highlights

The Berlin radio and television exhibition is without doubt the largest and most influential entertainment electronics show in Europe. Its strength lies not only in its size — 600,000 visitors, 88,000 sq.m area and 253 exhibitors — but also in its multi-level scope. It attracts top management, marketing executives, broadcasters, designers, dealers, enthusiasts and the public from all over Europe; indeed many came from Japan and the U.S.A. But despite its huge size it is relatively easy to find ones way about because of the superb organisation; moreover most of the 1973 exhibitors occupied the same places as they did in 1971.

There was much talk about a new magnetic video disc. Thought up by a private inventor earlier this year, it is presently being developed by Bogen in Berlin. Basic idea is to produce a disc that will record and playback pictures on a conventional turntable. In this idea, scanning is achieved by a record/playback head attached to an arm that is guided by the conventional stylus-in-groove technique. Roughly half the disc has a spiral groove to guide the arm, the remaining area being treated with chromium dioxide and scanned with 0.1μ m-gap head attached to the arm.

So far, with a rotational speed of 156 rev/min (chosen so that 78 rev/min stroboscopic markings could be used) a playing time of 5 min and a bandwidth of about 2.5MHz has been achieved (this is about four months) and work is now directed at achieving a 12-min playing time with a speed of 78 rev/min and a bandwidth of 3MHz.

Not a challenge to the Teldec video disc yet because the TED system, as it is now called, is well advanced and will be sold in Germany this coming January, the greater challenge coming from the Philips long-playing disc (see page 474, 1972), about which more next issue.

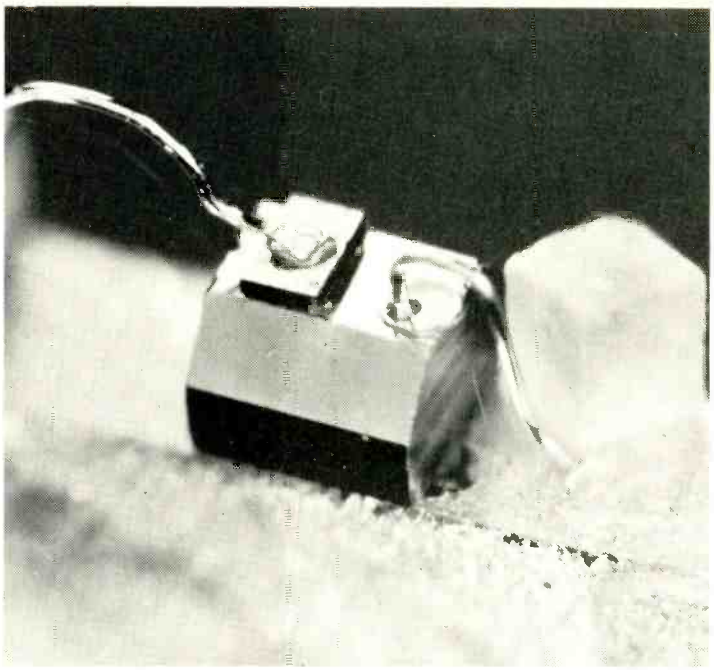
RCA's SelectaVision MagTape system was given its European première. In this ¾-in system, tape is retained in the cassette (called a cartridge by RCA) which means that the elaborate and no doubt expensive tape extraction mechanism of other systems is avoided.

In surround-sound systems it seems any question of standardization is being left to the market place to decide; but unfortunately not all systems are built into the hardware available. One system is not yet launched, though it was given its first public demonstration in Berlin. This is the "New Discrete" or QMX system, devised by Duane Cooper and developed by Nippon Columbia. It has the feature that software for it can be played in two quadraphonic modes, one using an inexpensive decoder and relying on the two audio channels on discs to give a very satisfactory performance. For better image definition a demodulator for two carrier channels can be added, the two additional audio channels having the feature that they are narrow bandwidth and as a consequence the highest frequency on this disc is around 36kHz rather than the 45kHz of the CD-4 system. Both mono and stereo compatibility sound excellent.

Meanwhile, more makers on the Continent are fitting the Motorola i.c. SQ decoder in their equipment.

Further details of these developments together with a brief look at some other areas of activity will be published in the next issue.

Much smaller than the grain of salt to its right, this solid-state laser (small rectangle on top of block) may hasten the day when the laser proves to be sufficiently reliable, efficient and economical for a future optical communications system. Bell Laboratories' scientists have developed a system which has operated a battery-powered semiconductor laser continuously for over three months.



Toshiba subsidiary in U.K.

It's not well known that Toshiba first produced surround-sound equipment in 1964 — called "dynamic stereo". Lack of public interest meant shelving the development, but Toshiba haven't been slow in introducing other innovations, like a photoelectric cartridge, an i.c. cartridge and an electret capacitor cartridge. When the Japan market was ready for surround sound, Toshiba introduced their own matrix known as QM and, more recently, they have developed a new stylus shape that gives similar advantages to the JVC Shibata stylus.

Now, of course, QM has given way to RM and the current Toshiba equipment is fitted with RM and SQ decoding functions.

The range of equipment now available through 600 U.K. dealers (50 being "hi-fi" specialists) comprises 34 products. It includes two and four-channel amplifiers and tuner-amplifiers, a matrix decoder with rear amplifiers, a stereo tuner, two open-reel tape decks (one four-channel), four cassette decks (one with Philips and two with Dolby noise limiters), headphones (one with a crosstalk switch), loudspeakers and "unit audio" systems. As well, there is an 18-in solid-state colour television receiver (Toshiba have a PAL licence) at £295, three u.h.f. black and white receivers — one 14-in model using a 110-degree tube — in-car equipment, and a few other items. An unusual feature on the amplifiers is a choice of turnover frequencies for bass and treble controls of 400Hz and 1kHz.

There is only one sad point about Toshiba's entry to the U.K. market. Data sheets we have that were printed in Japan show performance curves of equipment, but the U.K. printed ones don't.

Toshiba (UK) Ltd are at Toshiba House, Great South West Road, Feltham, Middx, telephone 01-751 1281.

Miniature Solid-state TV Camera

An all solid-state television camera using an array of 10,000 photosensors with charge coupling, assembled on a 24-pin dual-in-line package, has been demonstrated in the United States. Developed by the Fairchild Camera and Instrument Corporation, it measures 3½in × 1½in × 2¼in, weighs six ounces and has a power consumption of about one watt. The camera will work in conditions ranging from bright sunshine to subdued room lighting. Accessories include an optical viewfinder, tripod, monitor, pistol grip, a range of lenses and a separate unit providing battery power and radio transmission up to 100 feet. The camera is a commercial product and Fairchild say the price and availability will be announced later this year.

Solid-state miniature television camera made by Fairchild.

Briefly

Enter the consumer. "Consumerism is not a fad," says Nathan W. Aram, a Zenith Radio Corporation vice president. "Ignoring it will not make it go away. In fact we shouldn't want it to go away, rather let's accept consumerism. Serving today's consumer is an opportunity for all of us."

Multi-channel Proportional Remote Control

Use of t.t.l. in low cost system giving nine channels

*by M. F. Bessant**

The introduction of inexpensive servo torque units and integrated-circuit pulse-width servo amplifiers has opened up new possibilities in the field of low-cost proportional remote control for general laboratory or industrial use. Unfortunately the associated drive circuitry available commercially is intended for model radio control, and is often built on the same printed-circuit cards as a 27MHz transmitter and receiver. The cost-effective application of torque units and amplifiers to a system not requiring a radio link therefore depends upon the user's ability to construct suitable drive circuitry. This article outlines a remote control system offering a maximum of nine fully proportional channels, using medium scale integration t.t.l. to obtain a low component count and level of wiring complexity, at a lower cost than currently available construction kits.

Coder

The purpose of the coder is to scan sequentially nine parallel input commands (from potentiometers for fully proportional information and switched resistors for "go/no-go" or multi-step information) and present them to the single-line data link as a series of nine varying width pulses followed by a fixed width synchronisation pulse.

To understand the operation of the coder shown in Fig. 1, it is advisable to start on familiar ground with the collector-coupled astable multivibrator formed by transistors Tr_1, Tr_2, and Tr_3, then assume that on the initial application of power the decode counter holds a number between 0000 and 1001 (i.e. a b.c.d. number), say 0001. This will result in charging current being "pulled down" through channel 1 command resistor R_3 *via* pin 2 of the open-collector b.c.d.-to-decimal converter, thereby allowing astable action to commence. The coder's first output pulse (taken from the collector of Tr_3) will be in the 1–2ms range with an exact duration determined by the setting of R_3. The positive transition produced at the collectors of Tr_1 and Tr_2 by the termination of this pulse clocks the counter into the next state (0010) and after a 0.25ms delay fixed by the *CR* time constant at the base of Tr_3, the second coder output pulse is generated (the duration of which will this time depend upon the setting of R_4). All the command resistors will be sampled sequentially in this manner until a count of 0000 is reached, when a 0.5ms sync pulse is generated, thus "labelling" the next output pulse as a command function corresponding to channel 1 (or 0001 again).

When displayed on an oscilloscope the repeating train of nine 1–2ms varying-width pulses, with equal 0.25ms spacing, has a distinctive "concertina" appearance (see Fig. 2(a)), with each command function being sampled approximately every 20ms. (This coding is compatible with commercial radio-control equipment should interfacing become necessary.) In the event of a non-b.c.d. number being held in the counter at "switch on", resistor R_1 will enable the astable to free run at a low clock rate until one of the b.c.d.-to-decimal converter outputs goes low, preventing the system from locking up.

Fig. 1 shows channels 1–6 as fully proportional and channels 7–9 as "go/no-go" functions. This is only to illustrate the idea; in practice any mix of commands can be used, depending on the application.

Decoder

The decoder accepts the serial information from the coder (*via* some form of data link) and by detecting the sync. pulse, passes the

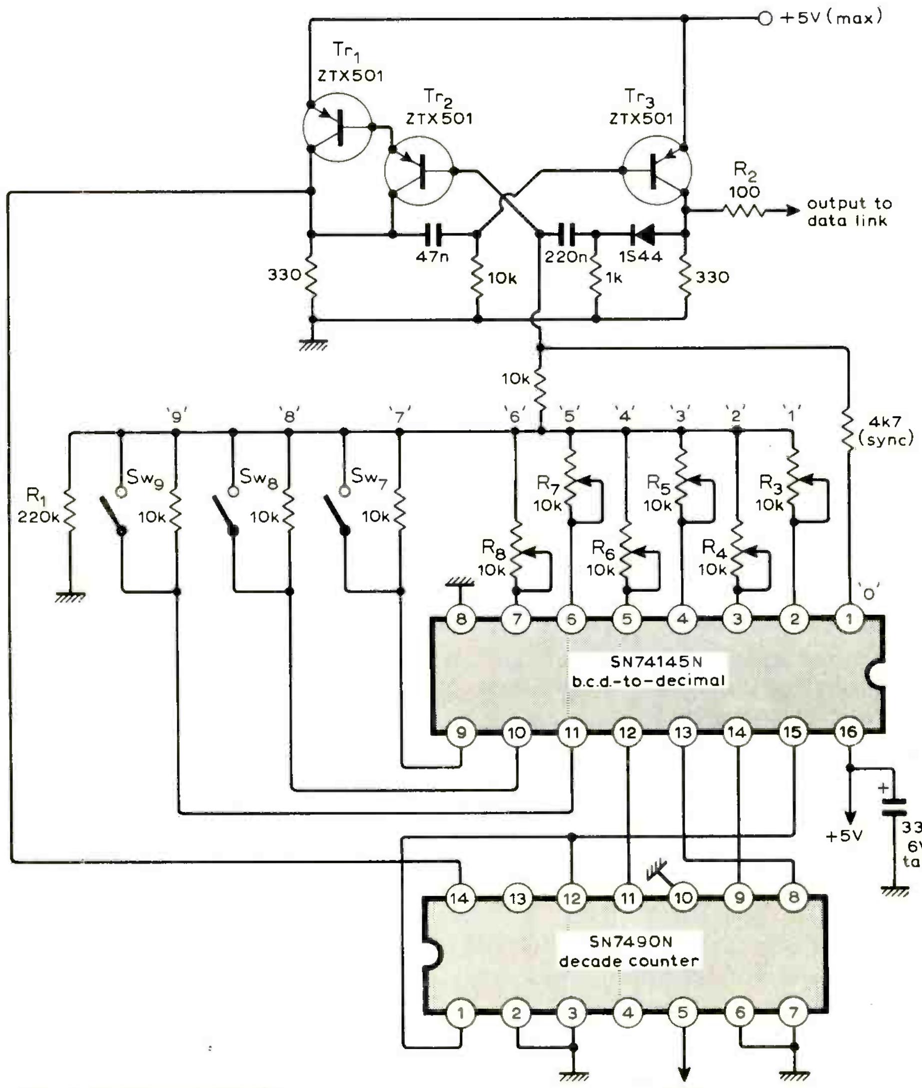


Fig. 1. Nine-channel coder.

*University of Bristol.

nine individual commands to their respective servo amplifiers. It can be seen from Figs. 2(b) and 3 that the operation of the coder and decoder is in many ways similar due to their both being effectively clocked by opposite collectors of the same astable. Both b.c.d.-to-decimal converter outputs will therefore be almost identical (the decoder output has a 0.25ms "offset") providing the counters are locked in step by the sync. detector clearing them both simultaneously. A change in the value of VR_3 for example will result in a corresponding change in the duration of the negative going pulse fed to channel 3 servo amplifier *via* pin 4 of the decoder's b.c.d.-to-decimal converter.

Detection of the synchronization pulse is achieved by comparing the length of inverted input pulses with the output of a 0.6ms monostable reference. Fig. 4 shows that as the minimum length of all command pulses exceeds 0.6ms only the 0.5ms sync. pulse presents the counter's internal "clear" NAND gate with two high inputs simultaneously, thus clearing the counter to 0000 before the arrival of the next channel 1 command pulse. A similar combination of reference monostable and gating could be used after the decoder to detect the "go/no-go" information pulses.

Data Link

If the data link between the output short-circuit protection resistor R_2 (Fig. 1) and the decoder's input consists of more than a simple cable link (optical coupling etc.) then care must be taken not to subject the decoder t.t.l. inputs to voltages outside the decoder's supply rail limits. Transistor Tr_4 (Fig. 3) has therefore to serve the dual purpose of logical inverter and voltage clamp.

Data link bandwidth limitations present no critical problems to decoder operation for the following reasons:

(a) command pulse width information is carried on positive transitions only;

(b) these transitions are reshaped before clocking the counter by the sync. detector's Schmitt/monostable. Deterioration of the incoming pulses will not, therefore, result in reduced counter noise immunity, although excessive "pulse rounding" will eventually lead to reduced servo resolution.

Compared with the widely used technique of cascading discrete-component monostables to produce "concertina" pulse trains which are then decoded by some form of shift register (s.c.r. etc.), the approach described in this article offers many advantages. One advantage not already stated is the ability to reduce the size or power consumption of the decoder simply by substituting the standard t.t.l. shown in Fig. 3 with low power or flat pack versions where appropriate.

Servo amplifier in t.t.l.

The system for driving six servo torque units from the m.s.i. decoder is based on torque units originally designed to provide radio control models with a reliable method of converting electrical commands into proportional mechanical movement.

A typical unit costing five pounds would

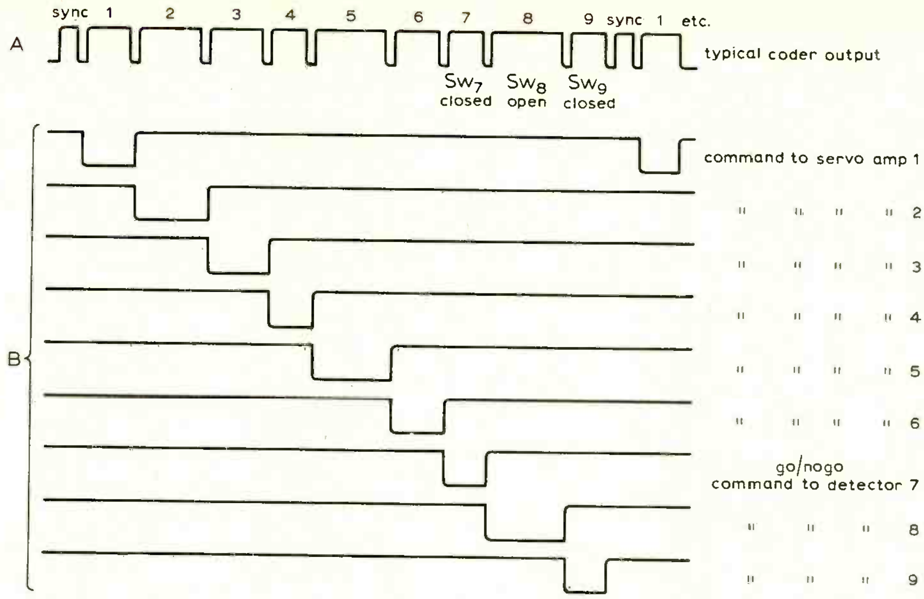


Fig. 2. Timing diagrams for (a) coder output, top, and (b) decoder output, bottom.

Fig. 3. Nine-channel decoder.

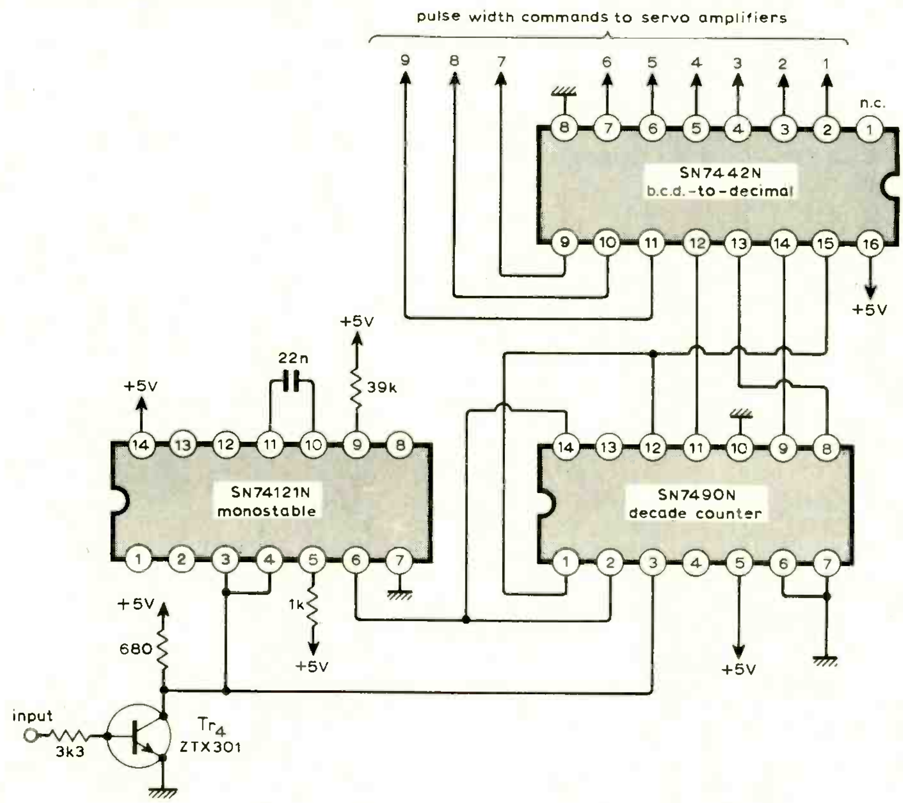
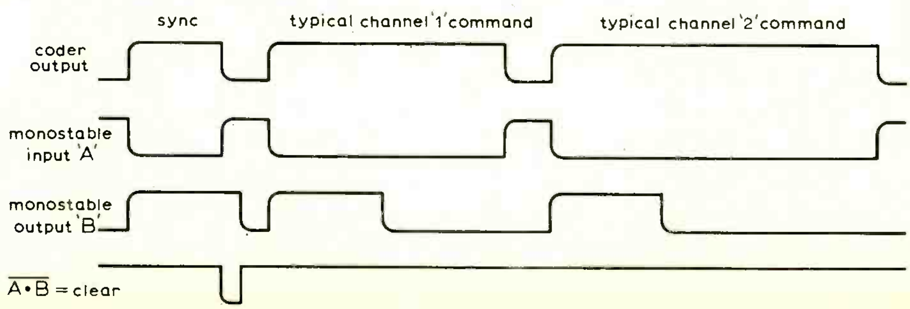


Fig. 4. Sync detector operation.



contain within its matchbox-size case a low voltage d.c. motor driving a reduction gear train, the final shaft of which connects at one end to a positional feedback potentiometer and at the other to mechanical output coupling. Backlash on this shaft would be less than 1° and stall torque approximately 15oz/in. Unloaded full drive transit time for 300° travel would be in the order of a second. These basic characteristics are compatible with low-cost, light laboratory/industrial servo applications.

The principle of pulse proportional servo control is now well established, with the most popular types of commercially available "amplifier" (for driving the motor in the required direction to cancel errors between command and feedback pulse length) falling into the following two categories:

(a) Discrete amplifiers using push-pull motor drive that require a centre-tapped supply. Apart from the high component count (typically ten semiconductor devices plus associated passive components) these amplifiers can, in the event of power supply voltage differences, have the added disadvantage of lopsided response.

(b) Integrated circuits, custom built for radio control servo manufacturers (i.e. not available directly from semiconductor manufacturers) have the obvious size and reliability advantage over discrete counterparts, plus in some cases a bridge motor drive. They are, however, rather specialized and not easily adapted to different motor voltage, gear ratio and potentiometer resistance combinations. Both fully assembled amplifiers cost between five and six pounds.

The amplifier shown in Fig. 5 is based on a t.t.l. pulse width comparator feeding a discrete bridge motor drive circuit. This combination offers a reduced component count compared with totally discrete amplifiers and improved flexibility (with comparable complexity) compared with custom i.c. amplifiers. A considerable cost saving can also be achieved if the components for all six channels are mounted on the same card (see Fig. 6). Under these conditions each t.t.l. servo amplifier will cost approximately £1.

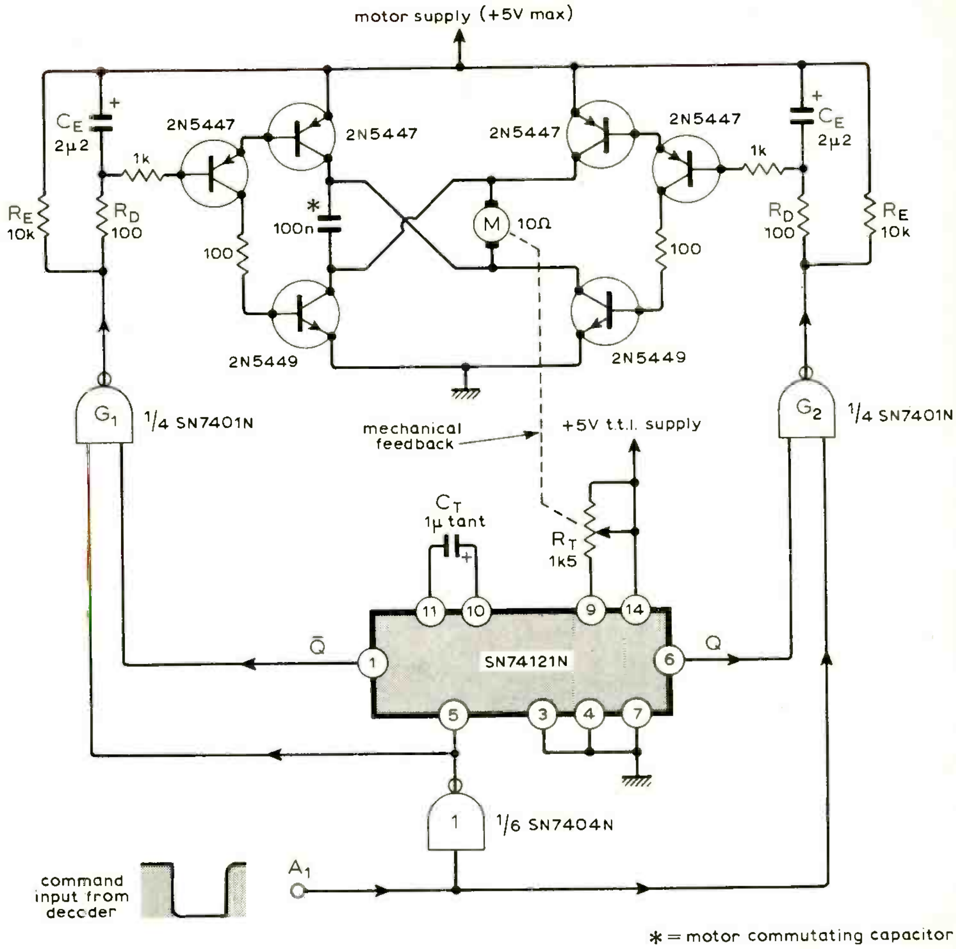


Fig. 5. Servo amplifier using t.t.l.

Circuit operation

The position of the torque units output shaft determines the value of R_T which together with C_T and a 2kΩ resistor, form the feedback monostable's timing elements. Decoded command pulses trigger the monostable *via* an inverter and are compared with the resultant Q and $\bar{Q}$ outputs. If the position requested by the command pulse differs from the output shaft's present position an error signal proportional to the difference in pulse lengths will appear at the output of either G_1 or G_2 open collector NAND gate depending on whether the feedback is longer or shorter in duration than the command (see Fig. 7). Provided that this error exceeds the drive amplifier's "turn-on pedestal", one side of the bridge will be turned on and the motor driven in the required direction (assuming the "sense" of the feedback is correct) to reduce the error below the turn-on level. When this is accomplished neither side of the bridge conducts and negligible current is drawn from the motor supply.

Expansion and deadband considerations

After being time-division multiplexed by the coder and decoder, an individual 1.25ms–2.25ms command will only appear at the input of its allotted servo amplifier approximately once every 20ms. In order to sustain motor current between commands it is therefore necessary to expand the pulse length of any error produced by the comparator. As the value of the expansion components R_E, C_D and R_D must be equal for symmetrical servo operation only one side of the bridge will be referred to below.

The pulse expansion ratio N depends on the charge and discharge time of C_E, together with the turn-on pedestal and is

$$N \approx \frac{R_E Z_{in}}{Z_{in}+R_E} \cdot \frac{1}{R_D}$$

where Z_{in} is the drive amplifier input impedance above the pedestal. In practice N must be a compromise between servo response time and "pile up" at the higher command repetition rates (i.e. all commands set to minimum width).

Resistor R_D defines the minimum error pulse capable of charging C_E to the drive amplifier's turn on pedestal and thus cause motor current to flow. An error below this level is usually referred to as being within the "deadband". In the circuit of Fig. 5 the width of the deadband t_d is

$$t_d \approx \frac{C_E R_D}{4}.$$

The minimum usable deadband width is limited by the motor and gear box inertia, which may be sufficient to cause "hunting" (oscillation about the requested position). The deadband is often expressed as a percentage of command pulse modulation. For the values given we have t_d approximately equal to 50μs with 1ms modulation; the servo is therefore said to have a 5% deadband.

Although the expansion and deadband component values shown are not critical and can be used with most commercial units in a multi-channel system, some trade off between response time and deadband may be necessary to optimize the servo for a particular application.

Complementary bridge

By using the complementary bridge configuration shown in Fig. 5 a wide range of motors can be driven (in either direction) from a single supply, and as any variation in this supply can only result in symmetrical changes in servo response time, the two main disadvantages associated with push-pull centre-tapped amplifiers has been eliminated. With the values shown the bridge is capable of saturation with motor stall current of up to 300mA (typical "motor run" current is approximately

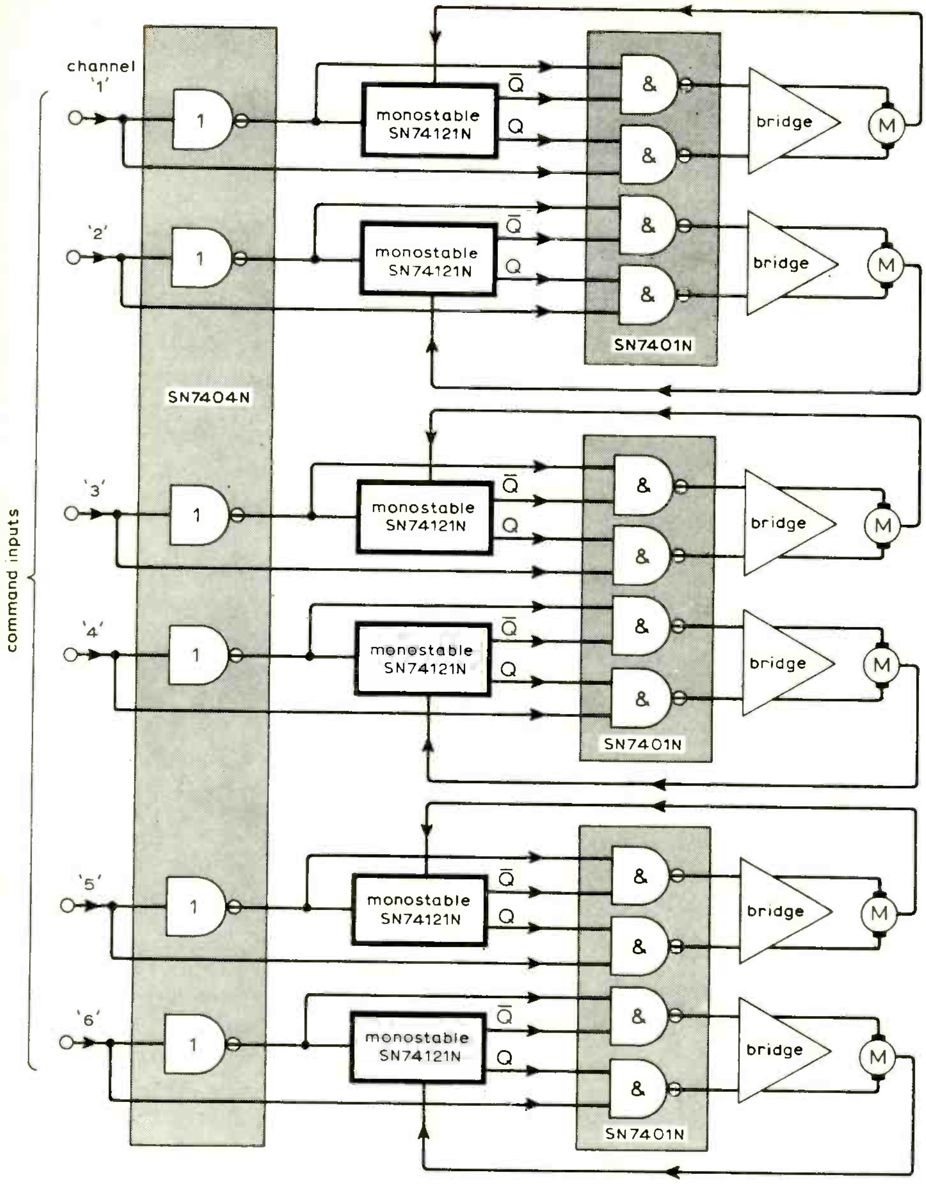


Fig. 6. Layout of components for least cost.

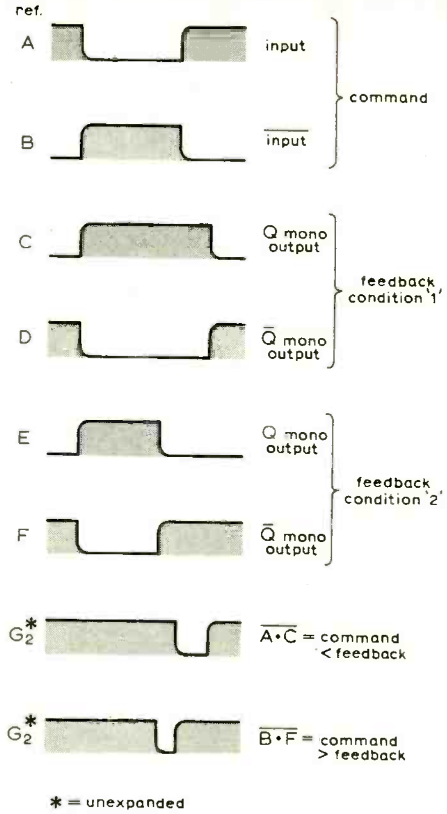


Fig. 7. Pulse-width comparator logic.

15mA). Small plastic-cased transistors are quite adequate even at higher stall currents due to the very efficient saturating nature of the bridge. In order to accommodate motor voltages in excess of the SN7410N 5-volt limit, as SN7401AN must be used, which has an open-collector rating of 15 volts. If the torque unit is capable of operating from the t.t.l. supply, decoupling between the motor and logic must be included to avoid instability.

Books Received

Transistor — TV Servicing Guide by Robert G. Middleton. The first chapter covers the overall subject of transistor servicing, test procedures, test equipment and basic circuit functions. Succeeding chapters describe the various picture and/or sound symptoms that may be encountered. A list of various circuit defects that could produce a particular symptom is presented, with procedures for analysing and isolating each effect. Price £2.25. Pp.128. W. Foulsham & Co. Ltd, Yeovil Road, Slough, SL1 4JH.

Understanding Electronic Circuits by Ian R. Sinclair explains amplifying, oscillating, switching and logic circuits, and deals extensively with the subject of integrated circuits, their merits and limitations in different applications. The level has been set for those who have some circuit wiring experience but may be uncertain of how the circuits function. Although this book is designed as a self contained work on modern circuitry, it has been written partly as a companion volume to "Understanding Electronic Components" by the same author. The two books between them offer a compact treatment covering the field of electronic components and the circuits built around them, from a practical and a theoretical point of view. Price £3.50. Pp.205. Fountain Press, Model & Allied Publications Ltd, Book Division, Station Road, Kings Langley, Hertfordshire.

Electrical Engineering Principles and testing methods by Rhys Lewis covers fundamentals of a.c. and d.c. circuits, including network theorems, three-phase a.c. systems, transformers, d.c. machines, amplifiers, instruments and principles of testing and testing methods, the latter including the basic essentials of quality control techniques. The book is for people undertaking courses leading to technician and technologist status in electrical and electronic engineering. The latter part of the book covers the common testing methods syllabus of the City and Guilds of London Institute. Much thought has also been given to the presentation of transformer theory. Price £4.00. Pp.289. Applied Science Publishers Ltd, Ripple Road, Barking, Essex.

Lightning Protection by J. L. Marshall is an examination of the phenomenon which maintains a balance in the global electrical system. It is a collation and consolidation of available information on the nature, effects and principles of protection against lightning. Its nine chapters discuss: losses resulting from lightning; the nature of lightning; magnitude of the lightning discharge; the earth as a discharge terminal for the dissipation of energy; types of protective grounding systems and methods for measuring their effectiveness; specific measures for the protection of human life; grounding communication towers and systems; protection systems for buildings and finally protection of power-transmission systems. Bibliographies are provided at the end of each chapter. Price £7.50. Pp. 190. John Wiley & Sons Ltd, Baffins Lane, Chichester, Sussex.

Independent Local Radio

Preparations for sound broadcasting service opening in October

Commercial "Independent Local Radio" services will open in London in October with a general programme provided by Capital Radio and a special news service by the London Broadcasting Company. These will be the first two of what may eventually be as many as 60 different I.L.R. programmes in the U.K., each transmitted on both v.h.f. (Band II) and m.f. By about next spring, the London services will be joined by those for Birmingham, Manchester and Glasgow, with two more — one for Swansea, the other for Tyneside and Wearside — opening in the summer of next year. Then over the next two years stations are likely to be opened in Bradford, Edinburgh, Ipswich, Liverpool, Nottingham, Plymouth, Portsmouth, Reading, Sheffield, Teesside and Wolverhampton, though not in that order. Stations are also being planned for Belfast, Blackburn, Bournemouth, Brighton, Bristol, Cardiff, Coventry, Huddersfield and Leeds. These 27 stations should provide services for just over half of the population of the U.K.

For all these services the controlling body is the I.B.A., which will build and operate all the transmitters and, in conjunction with the Post Office, provide the distribution links. The studios and studio equipment will be the concern of the programme companies, although these are required to operate within the technical characteristics set out in a detailed I.B.A. code of practice.

The planning and engineering of an entirely new series of broadcasting services is not something that happens every day — and sound radio has a life style very different from television. The problems include:

1. The search for suitable frequency allocations with the need to achieve close co-operation with the existing users of the crowded frequency spectrum.

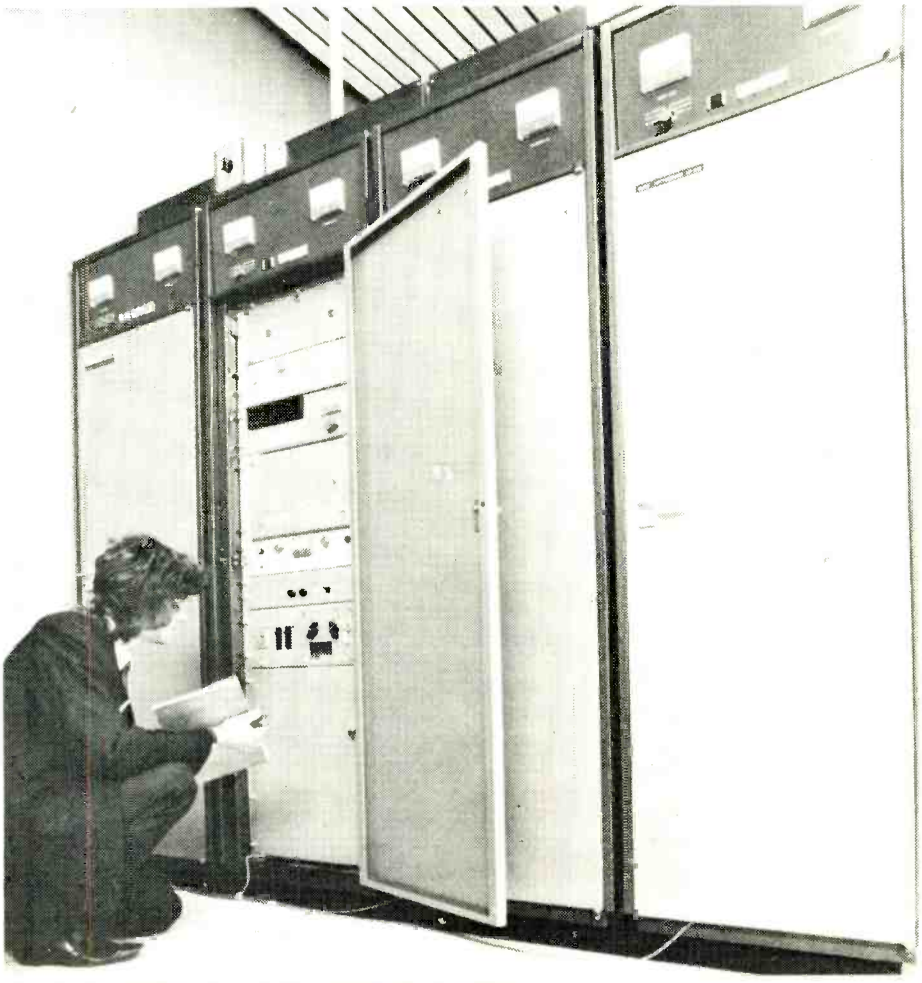
2. The search for suitable transmitter sites (with relatively large areas needed for m.f. aerial systems) close to major cities.

3. The provision of balanced coverage on both m.f./a.m. and v.h.f./f.m.

All these problems need to be solved without making the whole operation so costly that it would be no longer viable.

Before the Sound Broadcasting Act 1972 (now consolidated into the Independent Broadcasting Act 1973) reached the statute book in July 1972, preliminary planning was undertaken by the Ministry of Posts and Telecommunications, and two I.B.A. engineers — J. B. Sewter and F. Wise — were temporarily seconded to M.P.T. to help in this work.

The problems of planning frequencies and coverage areas were formidable. For many years the medium-wave band in Europe has appeared to be grossly overcrowded — and this is certainly the case after dark. Yet in daytime listeners have not been well served in programme choice compared with what is theoretically feasible. So what chance was there of setting up a whole new network — each carrying a different programme — without finally breaking the camel's back? Then again many of the views on what constitutes an adequate m.f. signal in urban centres dates back to the days before the widespread use of steel-framed buildings and car radios. And although superficially Band II might appear less crowded large sections were then occupied by police, ambulance and similar two-way mobile communications services. Further, there were some anomalies in the B.B.C. network — for example the use of Wenvoe to carry both Welsh and West regional programmes — that proved to have serious repercussions on the planning of I.L.R. stations. Again, the widening use of stereo, with its added susceptibility to adjacent channel interference, tends to emphasize the complexity of the problem. Yet another restriction arises



I.B.A. transmitter for v.h.f. coverage in London.

from the need to avoid harmonics of the 10.7MHz i.f. channel used in v.h.f. broadcast receivers.

For m.f. only one main "U.K.-assigned" channel (261m, 1151kHz) is being made available exclusively for I.L.R. stations; 1546kHz (194m) will be shared with B.B.C. stations; other frequencies will be those internationally agreed under Article 8 of the 1948 Copenhagen Convention and Article 9 of the Radio Regulations.

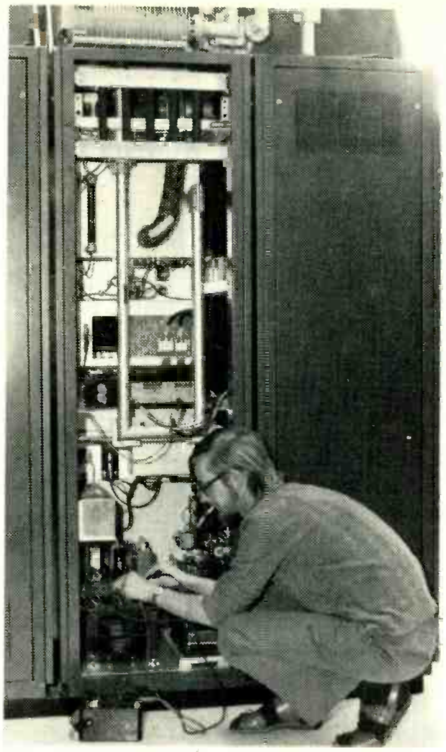
Despite these various limitations, the I.B.A. engineers felt that the setting up of a new system provided an unusual opportunity to look afresh at the technical side of sound broadcasting. Much of the standard work in this field dates back to the 'thirties before the "distraction" of television.

A small team from what was then still the I.T.A. visited North America to investigate recent experience in designing and operating local radio stations in the United States and Canada. What they found made a profound impression. For example advantage was being taken by many v.h.f. stations of mixed polarization — circular or slant polarized signals — to provide a better and more homogeneous coverage for car radios and portables using telescopic v.h.f. whip aerials; again, on m.f., there was growing use of complex directional transmitting aerials using quite large numbers of mast radiators and capable of producing deep nulls in the radiation pattern to limit interference with co-channel stations. It was also noted that American practice aimed at providing relatively strong signals in the centres of towns to overcome local screening. It is not unusual to find American planning based on providing m.f. field strengths of 50 or even 100 mV/m in city centres. One result has been that after many discussions, the contour of 3 mV/m has now been adopted for the planning of m.f. stations for the I.L.R. system: it is no secret that higher figures were proposed.

The combination of strong signals and multiple use of the same channel may seem mutually contradictory — and this would certainly be the case were the network to depend on omni-directional transmitting aerials. By opting for three- and four-mast radiators, the I.B.A. are planning to use 1151kHz in London, Birmingham, Manchester and Glasgow.

This again imposes important restrictions on the choice of m.f. sites. In the London area no less than 200 different sites were investigated. The need to reduce radiation towards Birmingham points to a site to the north-west of London from which signals can be directed over the main London area while minimized in the Birmingham direction.

Such sites are difficult to find — an even greater difficulty is that of obtaining planning permission for their use. Local authorities and local opinion are acutely conscious of questions of "environment" and they approach any suggestion of a site requiring the erection of a number of moderately high aerials with more than a little misgiving. It soon became clear to the I.B.A. that permission to use any of the possible sites in north-west London would take time, and might delay the start of the service. For that reason the decision was taken to find a temporary site where an omni-directional aerial would prove reasonably effective. This has resulted in the m.f. station at the London Transport Executive's power station at Lots Road, Chelsea, where the tall chimneys provide supports for a simple wire T aerial. The aerial has a 212ft twin-wire top loading section with a 275ft vertical radiating section in conjunction with a very effective earthing system which benefits from the presence of the Thames. The same aerial is used simultaneously for transmissions on 557kHz and 719kHz to be used by Capital Radio and London Broadcasting Company respectively. Despite the low power — less than 500 watts e.r.p. — the coverage achieved by this station is extremely good.



Working on the London v.h.f. transmitter.

Clearance for the use of 557kHz was sought in the summer of 1972 when the interference levels in the London area were shown to be low; subsequently the unauthorized ship station "Radio Veronica" off the Dutch coast moved on to this channel. Veronica causes some interference in the eastern part of the London area and more especially in areas beyond the intended coverage. I.B.A. hope to transfer these services to the permanent site at Saffron Green, near Barnet, towards the end of 1974.

For v.h.f. coverage in London a suitable site exists at the I.B.A. 405-line television station at Croydon. This introduces to the London area the problem of v.h.f. broadcasting from different sites (the B.B.C. station is at Wrotham, Kent) but it was felt that the more central site offered significant advantages. To overcome the problem of "swamping" local listeners a special transmitting aerial with a narrow beam in the vertical plane has been adopted (see April 1973 issue, p.175). The aerial — the first broadcast aerial in the U.K. designed for circular polarization — is of six tiers, with the result that all homes less than about a mile away "see" less than 100 watts e.r.p. compared with the 2kW in the main lobe.

Surveys made since the start of some preliminary tests in July-August 1973 suggest that generally there is less than 6dB difference between horizontal and vertical components of the signal, with a tendency for the vertical component to be slightly stronger towards the north. American experience suggests that although polarization is relatively unimportant in cluttered surroundings, the use of circular polarization can in clear sites give an advantage of between 6 and 12dB where reception is on portable or car receivers. The I.B.A. intend to use circular or slant polarization at all stations where new v.h.f. aerials are installed; generally circular polarization will be used.

The v.h.f. stations are designed for pilot-tone stereo and a stereo link is being provided between the local studios and the v.h.f. transmitters — because of the local nature of this operation the problems associated with nation-wide stereo distribution do not arise. It is expected that the programme companies (other than the special news station) will make considerable use of locally originated stereo. In addition, the studios will be linked by a monophonic "music" line to the local m.f. station. There will also be a monophonic distribution link between the London news station and all stations requiring a news feed.

The engineering of I.L.R. has meant the setting up of a new local radio planning group within the I.B.A. Engineering Division and a local radio section within the existing station design and construction department; most of the other work has been achieved within the structure established for television.

What is regarded as a most important engineering pre-requisite has been the drawing up and issue of a detailed Code of Practice for the technical performance of studios and the specification of audio distortion measurements. This has provided the various programme companies with a clear idea of the technical standards expected from them. It includes, for example, sections on studio acoustics, in terms of reverberation time and ambient noise levels. It is part of the determination that I.L.R. broadcasting will be based on up-to-date engineering techniques and equipment.

Clearly companies will need some time to gain experience of their facilities — time scales are such that some equipment for the London operations is likely to arrive only hours away from the start of service. But once the settling down period is over it will be fascinating to see what new head of steam is given to sound broadcasting in the United Kingdom.

Electronic Sound Synthesizer: Part 3

Final circuit details, interconnection of functions by patch-panel, keyboard and joystick control

by T. Orr† *B.Sc. *and D. W. Thomas*† Ph.D., M.I.E.R.E.

The final part of this series describing the construction and operation of a sound synthesizer completes the circuit functions provided with sample and hold, noise sources and the waveform generator circuitry.

Sample and hold

It is very useful to have an analogue memory function, for use in such cases as a long fadeout where a constant control signal may be required throughout. One method of implementing this requirement is to use a sample and hold device with the following characteristics. The output should have a very small offset voltage coupled with a low output impedance; also a long storage time, so that the output voltage will only drift by a few per cent per minute; and a high accuracy over the specified input range. The sampling period is relatively short, being initiated by a positive-going pulse. Also, there is no input buffer because the output impedance of all the units of the synthesizer is low. The input voltage range is approximately −0.5V to +6.5V, being deliberately limited by D_1 (Fig. 28).

The signal is stored on C_3, a low leakage capacitor, which is connected to the input voltage by an f.e.t. (Tr_1). This transistor is used as an analogue gate and is controlled by a monostable ($Tr_{5,6,7}$). During the monostable period, the gate is opened and the signal is sampled. The voltage stored on C_3 is monitored by Tr_3, a current-driven source follower which can be preset to give a zero input/output offset voltage. Using a 500Ω source resistor, the spread in V_{GS} may range from about −0.5V to −5.0V, for drain current drives from about 0.5mA to 10mA, respectively. The constant current source may be pre-set to lie anywhere in this range. Thus by keeping Tr_3 operating in its saturation region, and maintaining I_D virtually constant, variations in V_{GS} can be kept very low for considerable changes in V_{DS}.

Setting up procedure: set R_4 to about 500Ω (this is the "fine adjust" and it is preferable that R_4 is a trimmer) and, with the input short-circuited, initiate the sampling with a positive pulse (this clears any charge on C_3). Adjust R_8 until the output voltage is as near to zero as possible and then use R_4 to finely "zero" the output.

Storage time with input short-circuited is 30 minutes for 5% droop and sampling time 14ms.

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*Now with Electronic Music Studios Ltd

Noise sources

The noise sources fill two functions, firstly, a source of noise that can be filtered and modulated, and secondly, a low frequency source that can be used as a randomly fluctuating control voltage. This was achieved by constructing a white noise source and injecting the output into a spectrum shaping network and a low pass filter.

White noise source

The major difficulty in producing a simple, reliable white noise source is the very nature of noise itself; it is non-deterministic. Several methods were available, but the simplest and cheapest seemed to be the use of the leakage current I_{CBO} of a faulty (high leakage) germanium transistor. However, this approach requires that the leaky transistor is specially selected, or even manufactured by gentle frying! A suitable device (Tr_1) Fig. 29, should produce an average noise level of approximately 40mV pk-pk, when used in the configuration shown. The white noise generator consists of three parts; the noise source Tr_1, an equalized high gain amplifier, and an output buffer. A high gain amplifier is used because the signal level from Tr_1 is relatively low, thus particular care must be taken to isolate Tr_1 and the input of the amplifier from any power supply fluctuations. Preset R_3 is adjusted to give a suitable output level of between 2 to 3V pk-pk average.

Coloured noise source

Coloured noise is produced by driving a spectrum shaping network with white noise, this network being a Baxandall tone control. Preset R_{17} is adjusted so that with both tone control pots at maximum the output shows no signs of clipping.

V.L.F. noise

Very low frequency noise is extracted from the white noise source by two low pass filters, only one of which is available at one time, the selection being made by operating switch S_1, Fig. 29. One of the drawbacks of this method of producing v.l.f. noise, is that very little signal remains after filtering, the amplitude rapidly diminishing with decreasing cut-off frequency.

Preset R_{42} is adjusted so that the two v.l.f. outputs have the same amplitude, of approximately 3V pk-pk average.

Waveform generator

The waveform generator produces a control voltage that may be used to either frequency or amplitude modulate other units. The

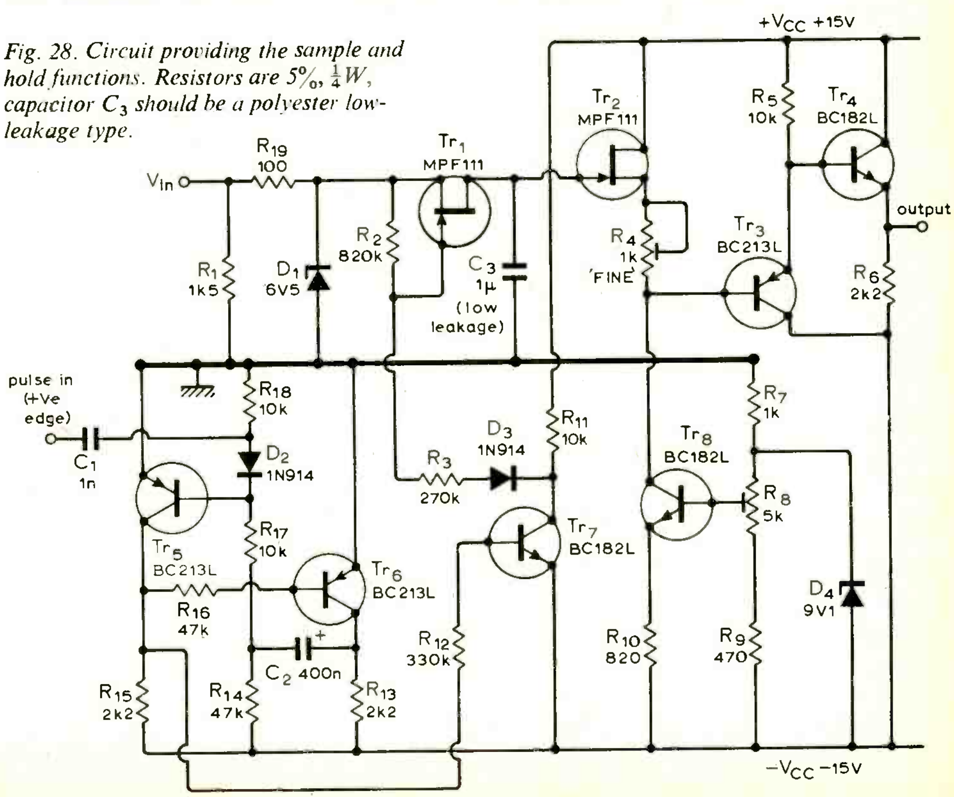


Fig. 28. Circuit providing the sample and hold functions. Resistors are 5%, ¼W, capacitor C_3 should be a polyester low-leakage type.

start of the waveform is initiated by a pulse input, the output rises "exponentially" and, after a predetermined period, falls "exponentially" (Fig. 30). Three controls are provided, attack, duration and decay and the pulse may be introduced electronically or from a manual pulse source.

The circuit operation is as follows (see Fig. 31). The first section is a current driven monostable, the monostable period or duration being controlled by the current drive which is proportional to the wiper setting of R_6. The monostable is triggered by either a positive going input pulse or from a manual pulse upon release. The square wave produced is then fed into the attack/decay section where a capacitor is charged *via* the attack control R_{14} and diode D_3. When the monostable period is over, the capacitor discharges *via* R_{12}, the decay control, and D_2. The potential across the capacitor is monitored, and an attenuated and buffered output signal is produced. A choice of duration times is available (C_3 or C_3+C_4 with S_1 closed) and also a choice of time constants (C_6 or C_6+C_7 with S_2 closed).

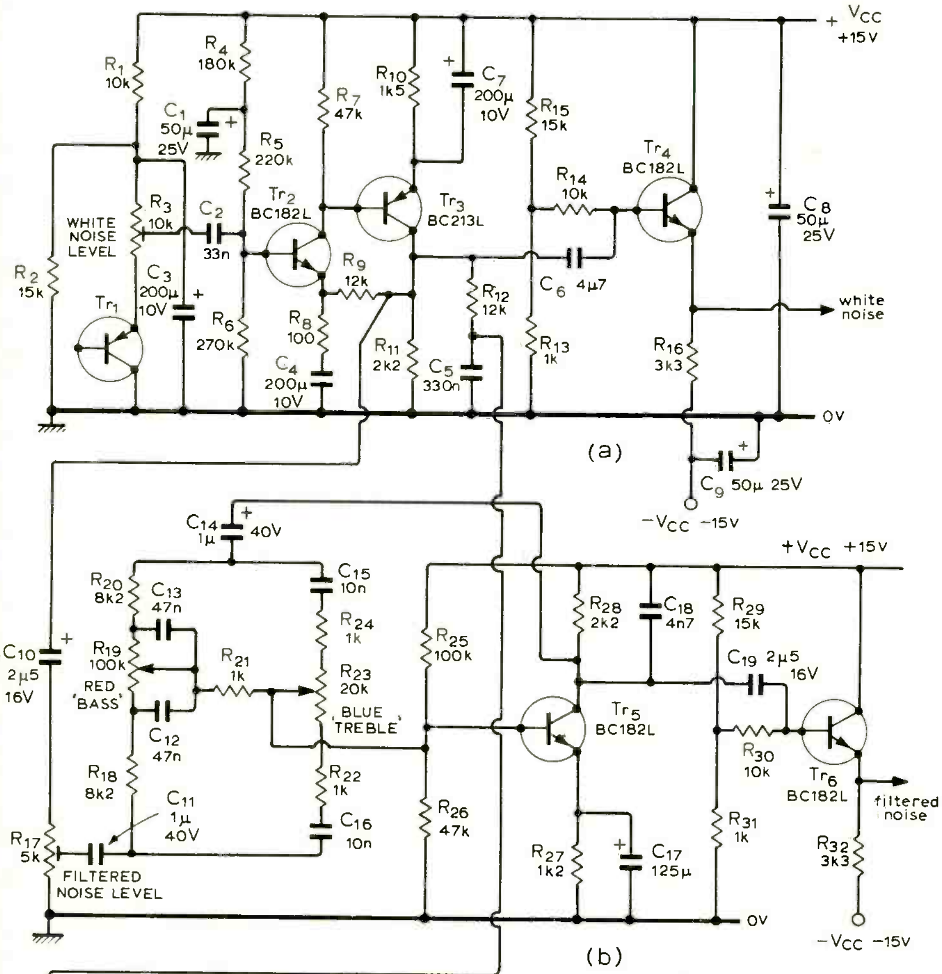
Joystick control

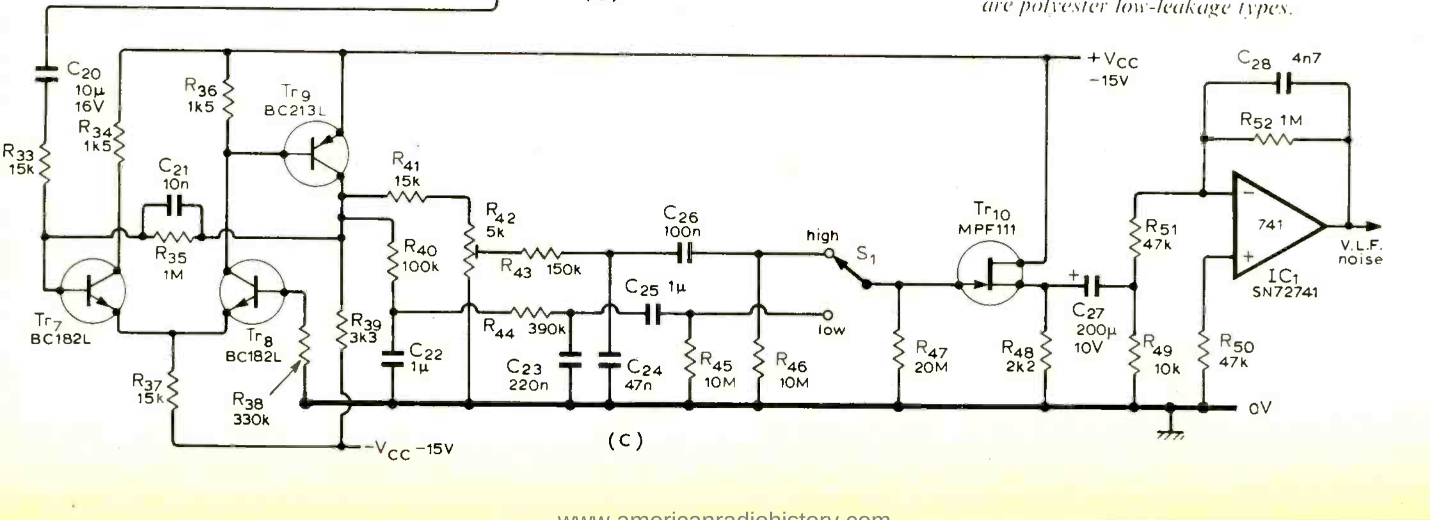
The joystick is a mechanically controlled voltage source having two degrees of freedom, and thus generating two independent control voltages, which are proportional to the stick's position. The device is essentially a position transducer (Fig. 32) with two sense pots (R_4 and R_8, Fig. 33) mounted orthogonally. The range of the joystick is limited by the rectangular opening in the front panel giving approximately 90° of freedom in both the x and y directions. An extra pot can also be seen (Fig. 32) but this is used only as a spindle. The connecting cable should be thin and flexible so as to present as little restriction as possible to the stick's movement. Also, this cable should be firmly held by two 'P' clips, one on the joystick assembly and one on the front panel so as to stop continual wear on the soldered connections.

The circuit function is illustrated in Fig. 34. A constant potential is maintained across the control pots $R_{4,8}$, in Fig. 33 and by the zener diodes $D_{2,3}$. Also, the potential of these pots relative to 0V may be shifted by presets $R_{2,6}$. Wiper crackle is attenuated by capacitors $C_{3,5}$ and the wiper is buffered to the output by $Tr_{2,3}$ and $Tr_{5,6}$. With the joystick in the bottom left hand corner of its range, the two outputs x and y are zeroed by adjusting $R_{2,6}$; movement of the joystick in the x and y directions will then produce corresponding positive increases in the potential of the respective outputs.

Keyboard

The keyboard generates a control voltage that is linearly proportional to the status of the key that is pressed. This voltage is produced for the duration of the key's depression, returning to 0V when the key is released. If two or more keys are pressed, the highest frequency key is selected automatically. Also, when a key is pressed, a pulse is generated, this being intended to trigger the waveform generator or the sample and hold unit. However, if the





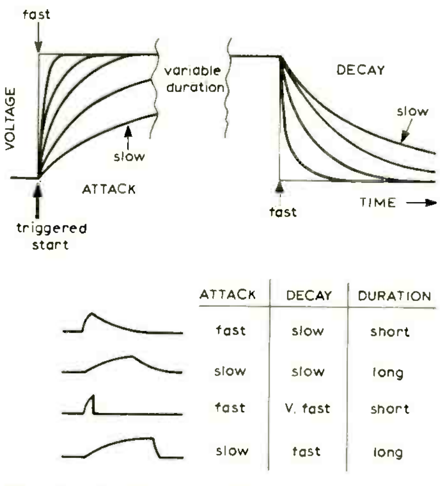


Fig. 30. Outputs available from the waveform generator.

Fig. 29. Noise source circuitry which provides white, filtered or v.l.f. noise. Resistors are 5%, ¼W, capacitors C_{22}–C_{26} are polyester low-leakage types.

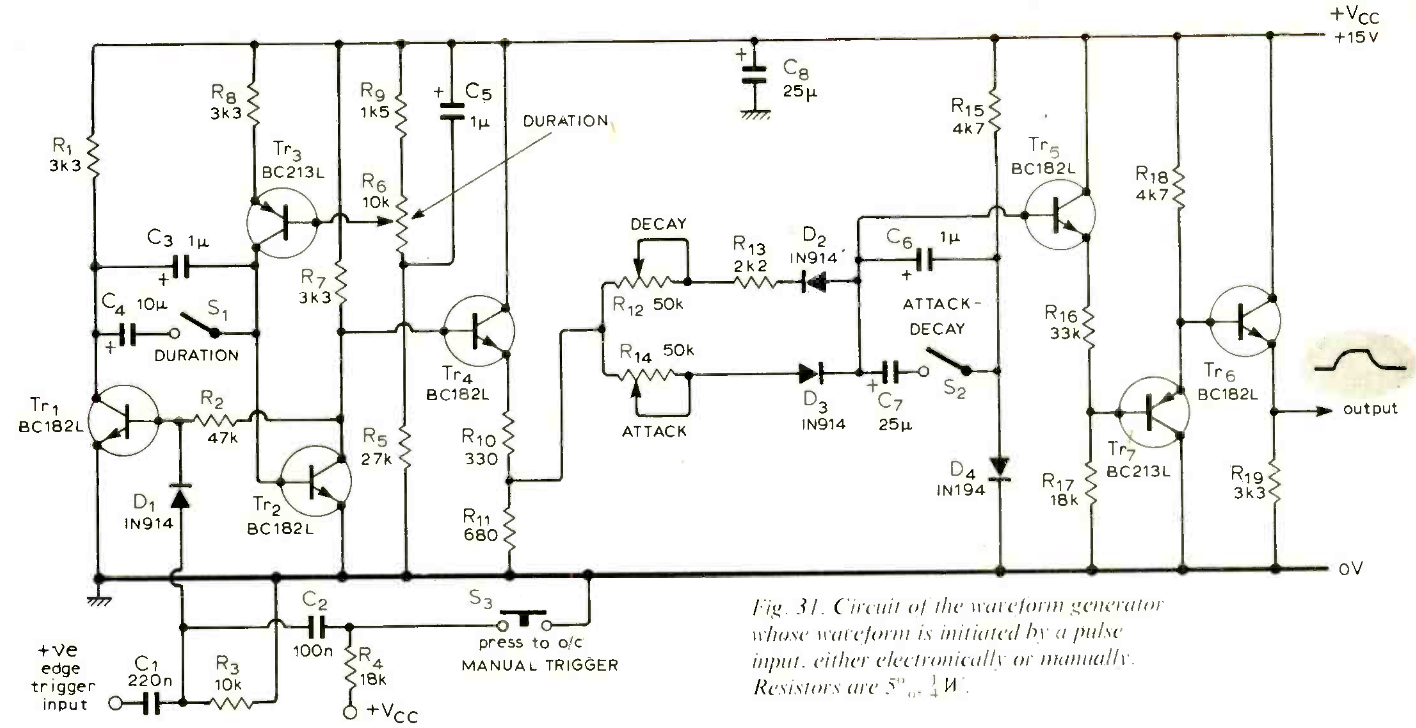


Fig. 31. Circuit of the waveform generator whose waveform is initiated by a pulse input, either electronically or manually. Resistors are 5%, ¼W.

production of this trigger pulse is required, then care must be taken when playing the keyboard to ensure that each key is released before the next key is pressed. If this procedure is not observed, then, even though the control voltage does change correctly, no pulse will be generated. The result is the production of a signal somewhat different to that intended.

The keyboard control circuit is shown in Fig. 35. A constant potential is maintained across resistors R_1 to R_{48}, and as all these resistors are the same, they form a potential divider composed of equally spaced steps. The switches S_1 to S_{49} are operated by the keyboard and form, with diodes D_1 to D_{49} and resistor R_{51}, a "Minof" analogue gate. Thus, whatever combination of switches are pressed, the most negative voltage is selected, this voltage appearing at the emitter of Tr_3. Note that when no switches are pressed, the emitter of Tr_3 rises to nearly $+V_{cc}$. This voltage must be modified so that it is in a suitable form to act as a control

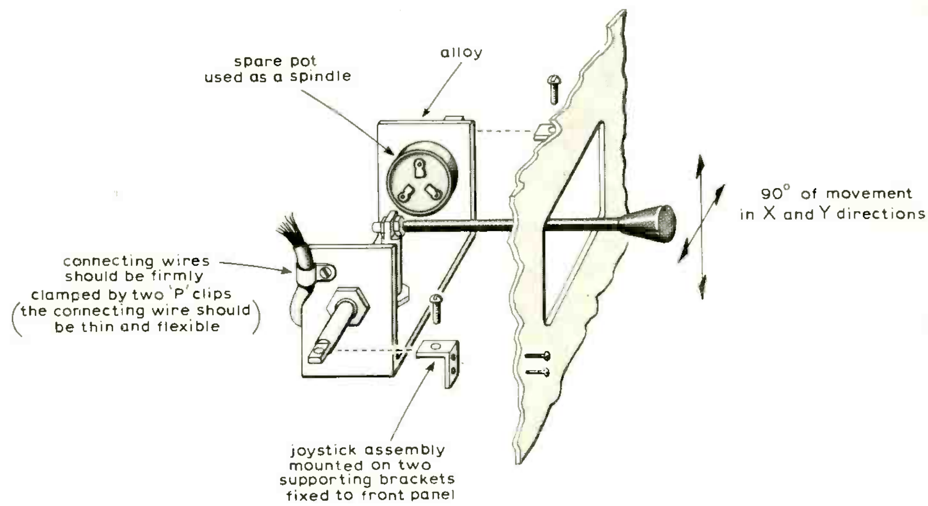


Fig. 32. Mechanical assembly of the joystick control.

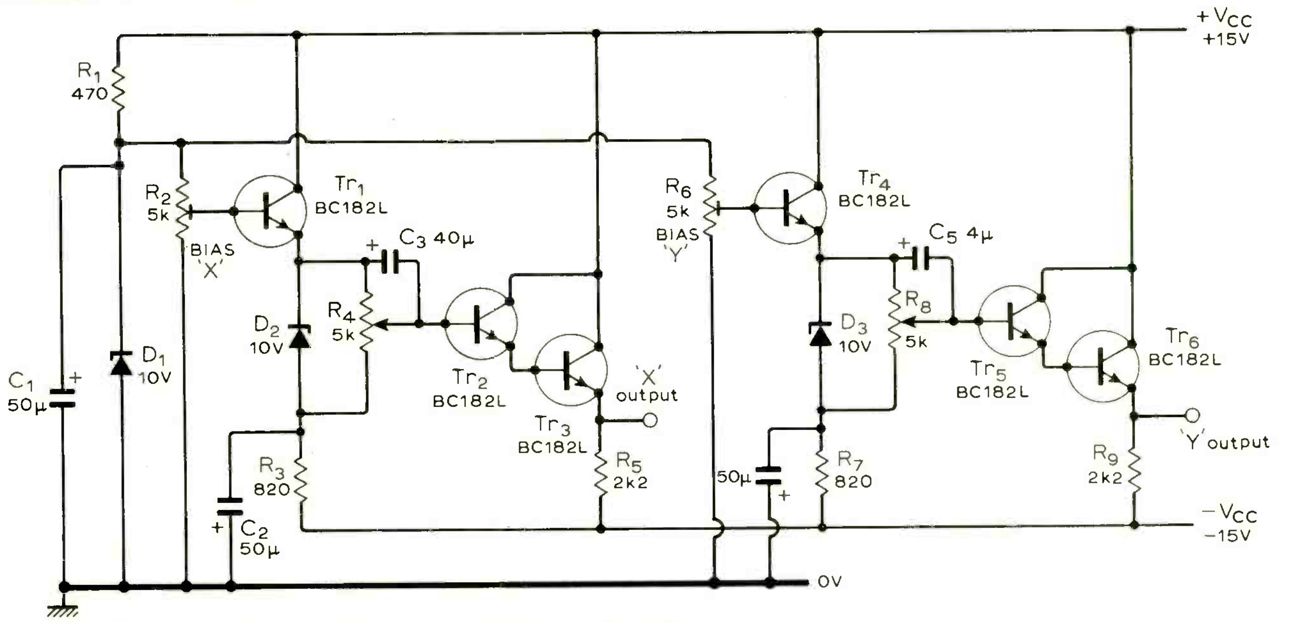


Fig. 33. Circuitry associated with the joystick control. Resistors are 5%, ¼W.

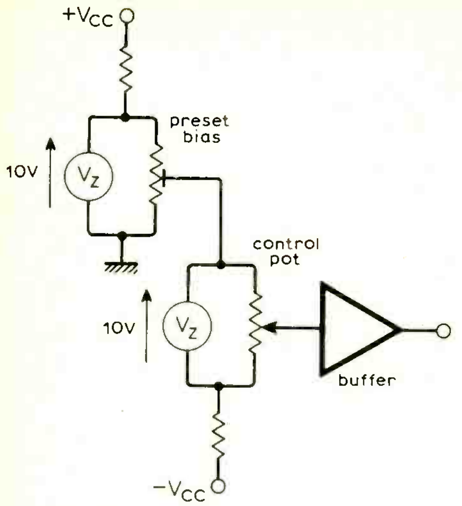


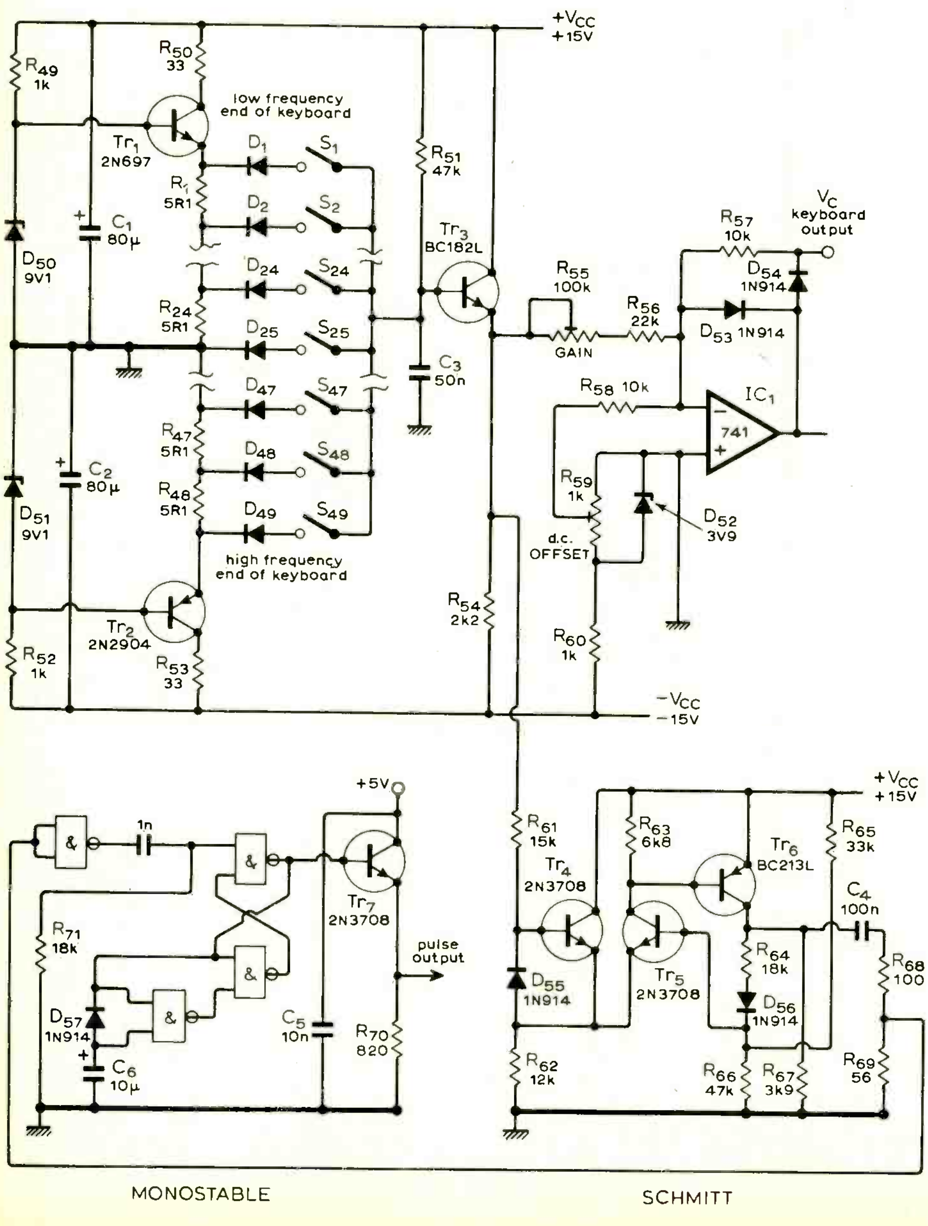
Fig. 34. Illustration of the joystick control circuit function.

Fig. 35. Keyboard control circuit. Switches S_1 to S_{49} are operated by the keyboard and form with diodes D_1 to D_{49} and resistor R_{51}, a "Minof" analogue gate. Resistors are 5%, $\frac{1}{4}$W.

signal. It is attenuated (R_{55}), inverted and its d.c. level is shifted (R_{59}) so that the range of outputs is from 0V to +3V. Also, the feedback around IC_1 is such that when no keys are pressed, and the emitter of Tr_3 rises to nearly $+V_{cc}$, the output (V_c) is prevented from going negative, and stays at 0V.

It is required that a pulse is generated at the moment when a key is pressed, but not when it is released. This would be a simple response to achieve (by detecting the transition direction of the "Minof" voltage) if it were not for the phenomenon of contact bounce. The spikes produced by the bounce can be largely suppressed (C_3) but there is still a possibility of generating a pulse by mistake. One method of overcoming this dilemma is to use a Schmitt trigger with a sizeable hysteresis loop, so that, as the "Minof" signal plus spikes rises or falls, it causes the Schmitt to change state only once. The direction of this change is determined by whether the input is rising or falling (i.e. whether the key is being released or pressed) and can thus be made to produce a pulse only on the falling transient.

Some applications of the keyboard are given in Fig. 36. Fig. 36(a) shows a patch diagram of simulated piano sound. A sinusoidal signal is given a fast attack and a slow decay. Note that the control output (V_c) from the keyboard is modified by the exponential converter, so that an equally tempered scale is produced. However, if the key is prematurely released, the output promptly changes frequency. Fig. 36(b) overcomes this difficulty, by using the sample and hold circuit to store the control signal. Also, reverberation with a slow sinusoidal modulation has been added producing a pleasant effect similar to a xylophone. Fig. 36(c) shows a network for producing bell-like "clanging" noises.



Patch panel

To provide a flexible means of programming the synthesizer, a patch panel similar to the type used in analogue computers has been included. As the input and output impedance of all the units is low, it was possible to use an unscreened system. In fact, ordinary 4mm banana plugs and sockets were eventually chosen, this decision being greatly influenced by cost factors. This choice, however, presents a danger of damage due to misuse. If two outputs are connected together, then it is possible that some damage will eventually occur, although how long it takes is difficult to predict. Certainly, from previous experience of a similar synthesizer, no lasting damage was seen to occur when an error of this sort was made. To minimize this danger the sockets are coloured, all the inputs being yellow, the outputs being any other colour.

The synthesizers on the market appear to have overcome this difficulty, but at some cost. One method is to employ a series of horizontal and parallel conductors, one set being the inputs, the other set the outputs. Pins are then plugged in to make a connection between an input and an output, thus the danger of an "output to output" never arises. Other methods are to use switches or jack plugs instead of pins. These systems are all pre-wired and so another problem, that of the "birds' nest" of patch cords (an all too familiar sight to those who have ever used an analogue computer) has also been eliminated. However, this advantage has been gained at some expense.

The layout of the patch panel was determined on a logical basis; that is, all the oscillators on one section, the v.c.as and v.c.f. in another, the noise sources in one block etc. Also, to make connections with an external amplifier, a coax. socket was included as well as two sockets which were connected to "ground" potential, these being used as a 0V reference point for external equipment such as voltmeters or oscilloscopes.

Power supply

Many units of the synthesizer are sensitive to power supply fluctuations and so a stabilized supply is desirable. The circuit diagram of the supply used is given in Fig. 37. Without this suppression it is possible to trigger a response by switching on and off unconnected (except *via* the mains) equipment. Care should be taken in constructing the power supply to avoid introducing any high current paths that might adversely affect the circuit operation.

Appendix
Voltage controlled filter

Consider a bandpass filter consisting of a series *LCR* network. The behaviour of this system is characterized by a linear second order differential equation with constant coefficients. Using analogue techniques, it is possible to model this system, but more important it is possible to make the coefficients variable, in fact, voltage controlled.

The general equation of a linear second order system is

$$F(t) = \ddot{x} + 2k\omega_n\dot{x} + \omega_n^2 x$$

Where ω_n is the undamped natural frequency, k is the damping factor (note, the quality factor $Q = 1/2k$), and $F(t)$ is a generalized forcing function. The solution of this equation consists of two parts; the particular integral that depends on $F(t)$, and the complementary function that depends on the solution of the right hand side only. Using the network shown in Fig. 38(a) it is possible to implement the complete solution. Different forms of $F(t)$ can be inserted, and by varying pots 4 and 5, the values of ω_n^2 and $2k\omega_n$ can be modified. By monitoring the voltage at the output of integrator $1(-\dot{x})$, the response of a bandpass filter, with the same coefficients, under the influence of the same forcing function $F(t)$, is observed. (The coefficients for a series *LCR* circuit would be $\omega_n = 1/LC$ and $k = R/2\ C/L$). By monitoring x, a low pass response would be seen, and $\ddot{x}$ a high pass response. If pot 4 were an electronic

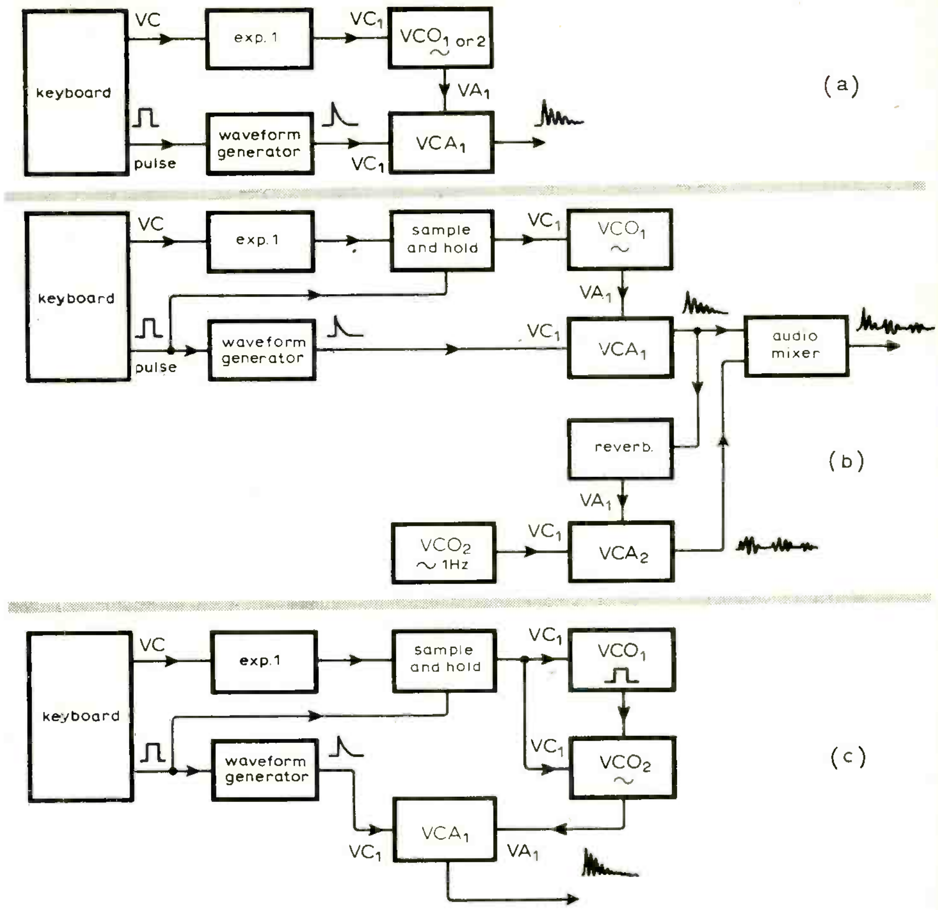


Fig. 36. Three examples of how the patch-board can be programmed for a particular sound synthesis. See text for explanation.

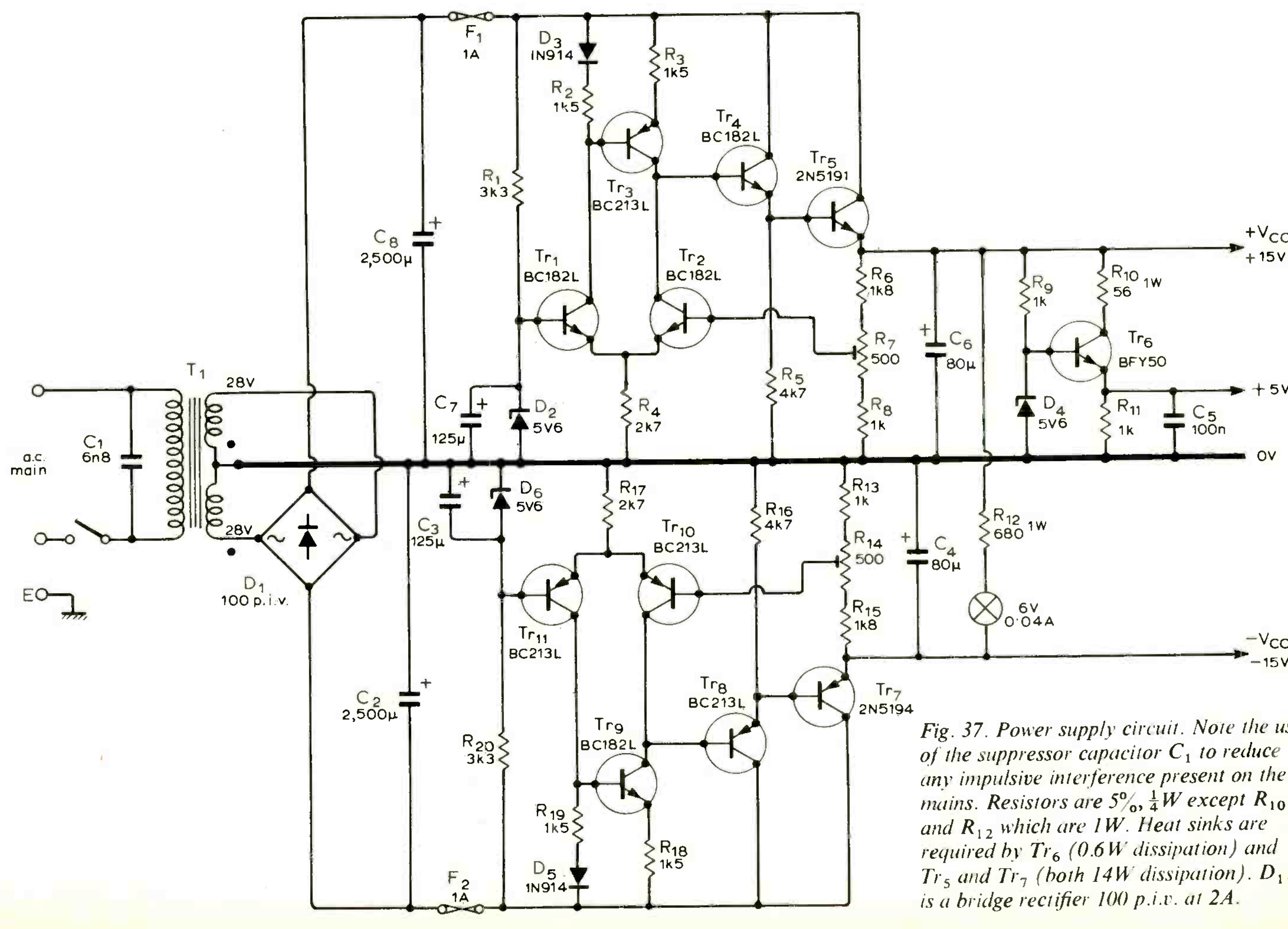
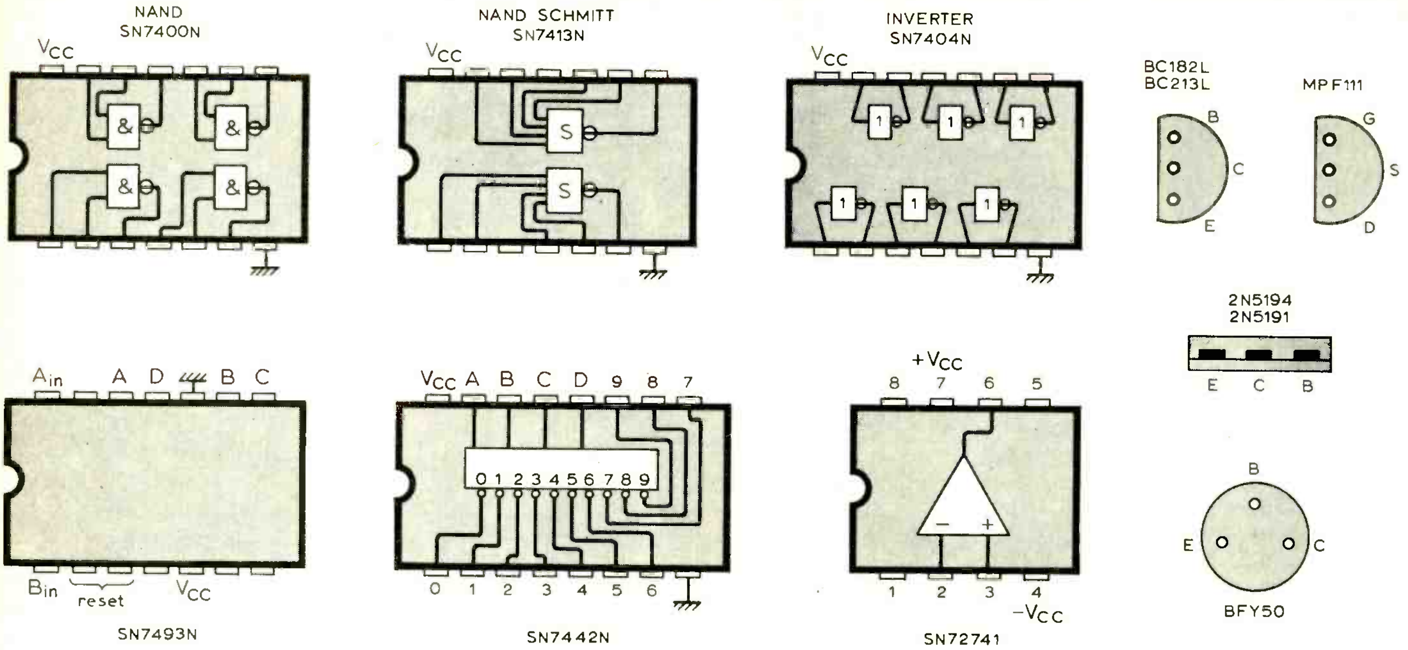


Fig. 37. Power supply circuit. Note the use of the suppressor capacitor C_1 to reduce any impulsive interference present on the mains. Resistors are 5%, ¼W except R_{10} and R_{12} which are 1W. Heat sinks are required by Tr_6 (0.6W dissipation) and Tr_5 and Tr_7 (both 14W dissipation). D_{1-4} is a bridge rectifier 100 p.i.v. at 2A.



Pin connections for the transistors and integrated circuits used in the synthesizer's circuitry.

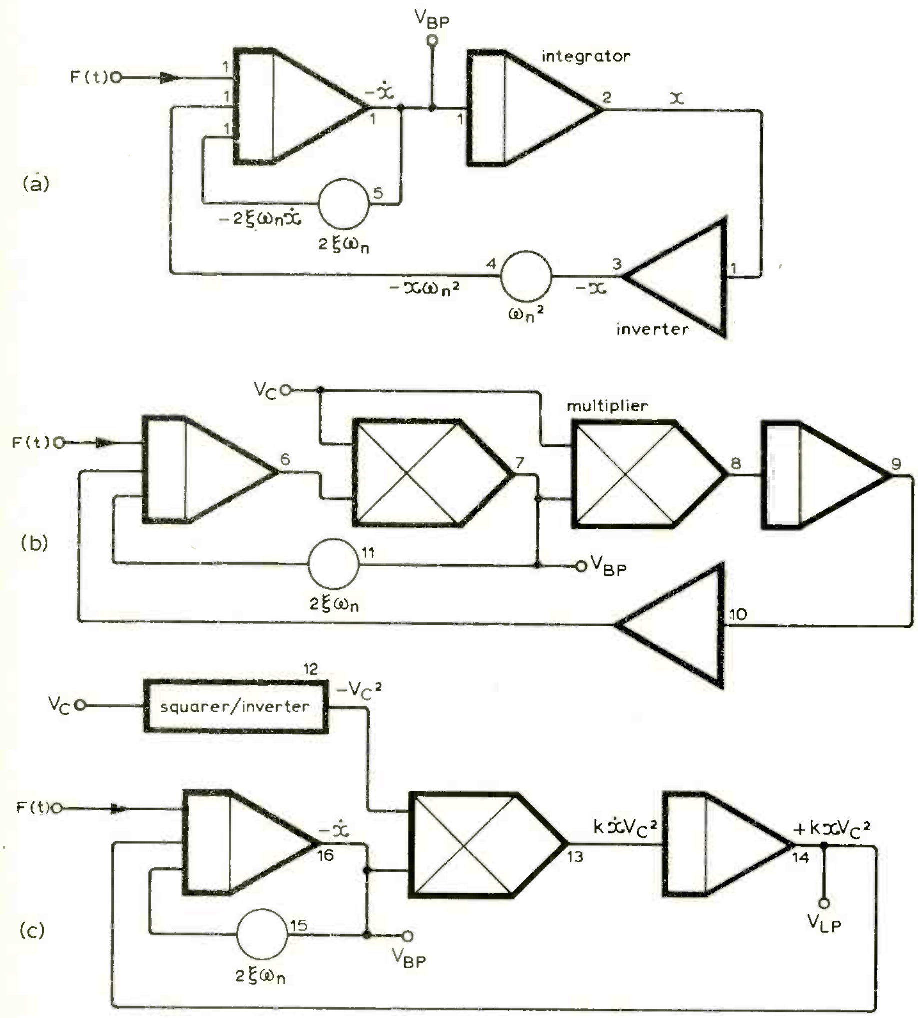


Fig. 38. Programmes for solving the second order differential equations of the form $F(t) = \ddot{x}+2\varsigma\omega_n\dot{x}+\omega_n^2x$ where $Q = 1/2\varsigma$ (see appendix).

multiplier, then ω_n (and hence k) could be voltage controlled. Now $1/2k = Q$, so it is thus possible to control both the resonant frequency and thus the quality factor. Two points are immediately noticeable; one, the Q factor increases with frequency. This is because if pot 5 remains constant, we have

$$2k\omega_n = \text{constant}$$

but $$k = \frac{1}{2Q}, \therefore \frac{\omega_n}{Q} = \text{constant}.$$

Fractional changes in pot 4 i.e. ω_n^2, result in the square root of that change in ω_n.

One method of curing both of these effects is to use two multipliers Fig. 38(b). It is easily shown that there is a linear relationship between the control voltage V_c and ω_n. Also the Q factor is invariant with resonant frequency changes (assuming multipliers 7 and 8 are matched), and the dynamic range of the filter is equal to that of one of the multipliers. It would also be possible to control the Q factor with yet another multiplier, but the use of multipliers is both expensive and introduces complications. It was for these reasons that the configuration shown in Fig. 38(c) was finally chosen. Hence, the relationship between V_c and ω_n is "linear", the dynamic range is nearly 10 to 1 and the Q factor increases with frequency. The variation of the Q factor is not as disturbing an effect as it may appear to be, especially when it is considered qualatively.

Acknowledgements

We wish to acknowledge the help received from Henry's Radio in the supply of certain parts, especially for the donation of the keyboard.

Capacitor ratings

Voltage ratings of electrolytic capacitors shown in Figs. 28–38 are as follows:

Fig. 28—C_2/35V.
Fig. 29—C_1/25V, C_3/10V, C_4/10V, C_7/10V, C_8/25V, C_9/25V, C_{10}/16V, C_{11}/40V, C_{14}/40V, C_{17}/16V, C_{19}/16V, C_{20}/16V, C_{27}/10V.
Fig. 31—C_3/40V, C_4/16V, C_5/40V, C_6/40V, C_7/25V, C_8/25V.
Fig. 33—C_1/25V, C_2/25V, C_3/10V, C_4/25V, C_5/10V.
Fig. 35—C_1/25V, C_2/25V, C_6/16V.
Fig. 37—C_2/40V, C_3/16V, C_4/25V, C_6/25V, C_7/16V, C_8/40V.

An approach to audio amplifier design

3 System design, applying the figure of merit.

by J. R. Stuart, *B.Sc. (Eng.), M.Sc., DIC, M.I.E.E.E.*

In the second part of this series, the discussion of an approach to the design of an amplifier as part of a system led to a detailed analysis of the application of negative feedback loops. Highlighted in this analysis was the way in which the open loop characteristics of an amplifier need to be related to the closed loop operating conditions in order to achieve the correct compromise of phase, transient and steady-state distortions.

Steady-state distortions

The transistor parameters which contribute to non-linearity have been listed in part 1, as follows.

- The exponential form of the relationship between i_b and V_{be} and of V_{be} with temperature.
- Variations of h_{fe} and h_{FE} with collector current i_c, with collector-emitter voltage V_{ce} (Early effect), and with temperature.

At high frequencies other effects are in variations of C_{be}, C_{cb} and C_{ce} with chip temperature, V_{ce} and i_c. Apart from controlling quiescent conditions, the major freedom available to the designer in defining the forward or open-loop characteristics of an amplifier is the choice of source and load impedance for each stage and of the amount of local feedback to be applied.

*Lecson Audio Ltd.

The two most useful techniques for reducing distortion introduced by device non-linearities are local emitter feedback (in a common emitter amplifier) and the cascode configuration. Fig. 32 shows a simple common emitter amplifier with and without local feedback supplied by R_e, and the small signal equivalent circuit for each.

We have for the case with local feedback, the trans-impedance

$$R_b = \frac{V_0}{i_S} = \frac{h_{fe} R_L R_S}{h_{11} + R_S + R_e(h_{fe}+1)}$$

Setting $R_e \to 0$ gives the case of no feedback Fig. 32(a)

$$R_a = \frac{V_0}{i_S} = \frac{h_{fe} R_L R_S}{R_S + h_{11}}$$

By partial differentiation the sensitivity of R_a and R_b to device parameters can be shown, e.g. for change of h_{fe} for whatever reasons we have:

Case (a) no feedback

$$\frac{\delta R_a}{\delta h_{fe}} = \frac{R_L R_S}{h_{11} + R_S}$$

Case (b) with feedback

$$\frac{\delta R_b}{\delta h_{fe}} = \frac{R_L R_S}{h_{11} + (h_{fe}+1)R_e + R_S}\left[1 - \frac{h_{fe} R_e}{h_{11} + (h_{fe}+1)R_e + R_S}\right]$$

This represents an improvement in gain stability of:

$$\frac{[h_{11} + (h_{fe}+1)R_e + R_S]^2}{(h_{11} + R_S)(h_{11} + R_e + R_S)}$$

Analysis will show the same improvement for many device parameters and a similar form of improvement in high frequency effects.

The cascode arrangement shown in Fig. 33 allows the common-emitter stage to be virtually freed from the Early effect and modulation of C_{ce}, as the device is allowed to operate at constant V_{ce}; this clearly also allows a higher bandwidth to be achieved by the stage for given source and load impedances as the Miller effect is considerably reduced.

Design of a system

The preceding arguments in parts 1 and 2 indicate that an amplifier designed to sound very good cannot necessarily be synthesized from the basic specification:

1. Output power in excess of 40W.
2. Power bandwidth 20Hz – 30kHz ± 1dB.
3. Very low noise and hum, say −80dB.
4. t.h.d. less than 0.1% at all frequencies and power levels in the bandwidth.
5. i.m.d., however measured, less than 0.1%.
6. Low output impedance, say 400mΩ.

However it seems reasonable in the light of the preceding discussions to propose a starting point specification for very good quality as below.

1. Output power in excess of 40W.
2. Power bandwidth 10Hz – 30kHz ± 1dB.
3. Very low noise and hum, say −80dB flat, −80dB C.C.I.R. weighted.
4. Weighted total harmonic distortion less than 0.1% at all frequencies and power levels; i.e. 10Hz – 20kHz, 0–40 watts.
5. i.m.d., however measured, less than 0.1%.
6. Low output resistance, say 400mΩ; 10Hz – 20kHz.

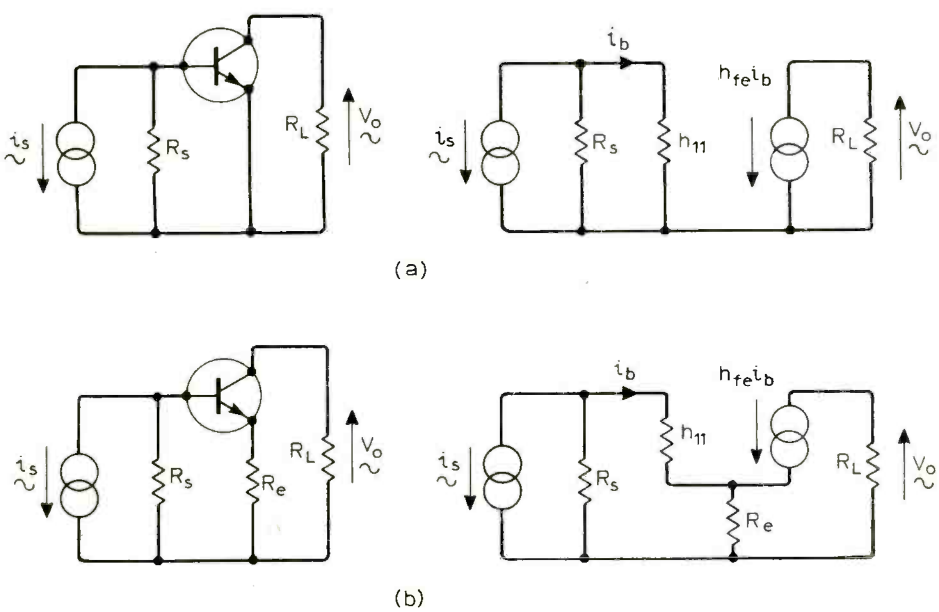


Fig. 32. Common emitter amplifier drawn (a) without feedback and (b) with feedback together with their small signal equivalents.

7. Open loop frequency response—any loop −3dB at 20kHz min.
8. Feedback factor −40dB any loop.
9. Phase accuracy ±10° 20Hz−20kHz.
10. Accurate overload characteristic inside the loops.

A typical audio amplifier system will be as shown in Fig. 34; here three major negative feedback loops are isolated. These are around the low noise input amplifier, in which equalization may be applied, the tone control stage and the power amplifier. In addition there is the volume control and a stage of filtering which need not be achieved by feedback loops.

It has been shown earlier that for any single stage to have a phase shift of 2° at 20kHz then the minimum −3dB closed loop bandwidth for that stage is 570kHz; three such stages cascaded would have a total lag of 6°. It has also been demonstrated that it is not desirable to drive any audio feedback amplifier significantly above its open-loop bandwidth; therefore if the signal can be restrained to say 45kHz in the filter stage, then the open-loop response of the two stages following the filter should be as similar as possible, thus giving a guide to the feedback factor that can be applied for a given overload margin.

The choice of 45kHz for a passive roll-off is a compromise between the phase distortion introduced by such a filter and t.i.d. in the power amplifier. It is not in any way a magic number and may be different in every design.

At this stage the designer runs seriously short of information, in particular the extent to which phase shift can be traded off for incipient t.i.d., and this is discussed later. However, it seems reasonable to me that in view of the poor phase performance of parts of the audio chain outside direct control, e.g. the recording studio, and in view of the high apparent sensitivity of the ear to t.i.d., that it would always be preferable to err on the side of a lower passive roll-off and higher phase shift—but as a compromise—not a rule.

A recent design. A commercially available amplifying system* designed by myself is shown in block diagram form in Fig. 35.

A low-noise high overload input stage is followed by an active volume contol, filters and tone control; in each case the open-loop bandwidth and feedback factor, *F*dB, is shown. Care has been taken to ensure that no transient distortion effects can arise with an audio signal, and the signal bandwidth of the system is constrained to 45kHz with a third-order Bessell roll-off which introduces a lag of 12° at 20kHz.

It is clear from the arguments presented that, for an unconditionally stable characteristic in an amplifier which exhibits no transient distortion effects in the signal bandwidth, a low feedback factor is necessary. This is because any increase of feedback factor must be accompanied (in the general and practical situation†) by a reduction of open-loop bandwidth, ω_{OL}. The consequences of this are a rise of steady-state distortion starting below ω_{OL} and an increased possibility of t.i.d. Therefore, in order that the amplifier should also have a weighted t.h.d. of less than 0.1% at any frequency or power level, it was essential to achieve a low open loop distortion figure.

The final power amplifier design, which is shown in block diagram form in Fig. 36, uses a new configuration which is the subject of a British patent application.

Use of local stage feedback combined with a complementary form and output triples operating in class AB gives an open-loop bandwidth of 17.5kHz and distortion of 0.2%. The application of 32dB of feedback reduces the weighted t.h.d. well below 0.1% and gives an unweighted t.h.d. of 0.005% between 100Hz and 3kHz.

A figure of merit

Earlier I put forward the idea of a figure of merit which describes the quality of an audio chain or a link of that chain. This is a number derived from a weighted sum of undesirable characteristics, measured in terms of the critical parameters. This figure of merit (f.o.m.) may be time variant; that is, an amplifier may have for example a rating of 0.8 (1971) and 0.7 (1973).

It was further proposed that by using collective subjective results, any parameter could be assigned a measure of significance, and further that the starting points for each parameter would be the thresholds of perception and objection—the latter Mantel[3] calls "the threshold of non-neglectability".

Successive experiments may then show improved accuracy in the choice of parameters, defining thresholds and curve fitting between the thresholds.

In this article I propose to outline a workable f.o.m. which is based on current knowledge as outlined, in the hope that its defects can be improved upon by large-scale experimental work.

The working of an f.o.m. Let us consider that the figure of merit for a chain or item in the chain be M, where M is the probability that a person will not be able to detect a shortcoming in the sound. This could be restated as M = probability of non-detection of a shortcoming by a member of the population chosen at random. Therefore an ideal audio system would have an $M = 1$ and a poor system $M = 0$.

For each stage in the chain of n elements we propose m_i ($i = 1,2 \ldots n$) such that the total figure of merit for the n cascaded stages is $M_T = \prod_{i=1}^{n} M_i \alpha_i$, where α_i is a weighting factor.

Each partial f.o.m. M_i is composed of a weighted product of factors believed to influence the quality of the sound, such that M_i shows the joint probability that any one factor may be detected as a shortcoming. Therefore in a simple example, if M_i considers only the terms

- $p(d)$ the probability of detection of d% weighted t.h.d., and
- $p(n)$ the probability of detection of ndB s/n ratio

then we may write

$$M_i = q(d) \cdot q(n)$$

where $q(d) = 1 - p(d)$

$q(n) = 1 - p(n)$

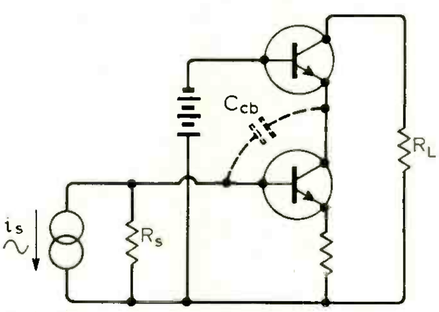


Fig. 33. The cascode circuit.

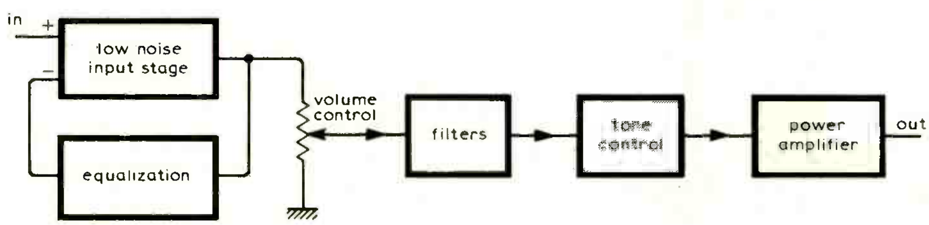


Fig. 34. Block diagram of a typical audio amplifier.

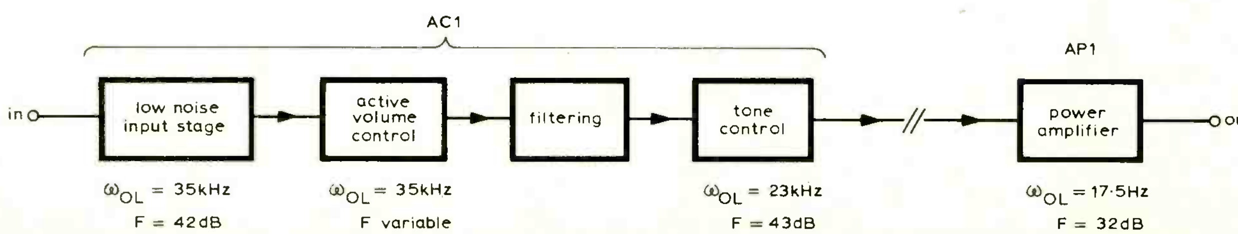


Fig. 35. Block diagram of the Lecson system showing the bandwidth and feedback factors for each section.

*The Lecson AC1 + AP1
†given output transistors e.g.

Now this is clearly a simple example and does not take account of perception thresholds or interactions of parameters and masking effects. It will not be sufficient to write, for example, $p(n)$ as the probability of detection of ndB signal to noise ratio, but possibly as a conditional probability of detection of weighted noise—say C.C.I.R. weighting—given a specific bandwidth.

So an f.o.m. which would be useful in the predictive design of audio components could be made up from tables of conditional probabilities and give a performance measure of universal use.

In this analysis I propose to use the thresholds of perception and non-neglectability ($p(x) = 0$ or 1) for all the parameters discussed so far and to discuss interpolation between these points.

In Table 1 a list is given of these parameters, and of thresholds which seem to be reasonable in the light of current knowledge.

Frequency response is treated by considering the two roll-off points—items 1 and 2—and determining a rough measure of $q(\omega_L)$ and $q(\omega_H)$ from Fig. 6 which are from results produced by Snow. Thus a response 20Hz–20kHz has a partial M of 1 while 100Hz–10kHz has a partial M of $0.9 \times 0.95 \approx 0.86$. Phase and amplitude linearity have been considered as being logarithmically interpolated in the absence of any other information—the same method has also been used by Mantel[3].

Steady state distortions are again interpolated logarithmically; this being chosen as a reasonable assumption in the absence of further knowledge. The whole basis of this experiment is to test the values and curves I have offered as a starting point.

I would suggest that at this starting point in the derivation of an f.o.m. the *a priori* measure of the likelihood of t.i.d.—the transient intermodulation index—be used, and the interpolation is as shown in the Table.

Signal to noise ratio is shown weighted according to the C.C.I.R. standard, and it is intended that this should include only hum and noise and not measures of crosstalk or other interfering signals.

Other parameters which have not been listed but are clearly essential when discussing elements of the chain other than amplifiers include a frequency modulation measurement to include wow, flutter and Doppler effects.

A review of the f.o.m. In the form proposed here it is possible to produce a single number which is intended to describe the subjective sound quality of a piece of equipment derived from objective measurements based on the following suppositions:

(i) it is possible to tabulate a conditional probability for the detection of any single shortcoming in terms of population.

(ii) that this probability will move in some way from 0 to 1 between the levels of perception and objection.

In order that a number may be derived, and that the behaviour of the f.o.m. may be investigated, I have used the thresholds discussed in this article, and tentatively proposed others with an interpolation. Clearly if such an f.o.m. is shown to give accurate results then it would be of great use to designers and users of audio equipment. However, in order that a f.o.m. of this kind can evolve, very extensive listening tests should be carried out. These are probably best controlled by and published through a respected journal such as *Wireless World*. [We are considering this.—Ed.]

The figures tabulated in Table 1 indicate that an amplifier which equals or betters the perception threshold for every parameter would have an $M_i = 1$. This rating would reduce to 0.9 with a low frequency cut off of 100Hz, or an amplitude deviation of 0.4dB or a phase deviation of 8° etc.

Table 1

Measurement	$p(x) = 0$ $q(x) = 1$	$p(x) = 1$ $q(x) = 0$	Interpolation
1. Amplitude-frequency response lower −3dB point ω_L	20Hz	1kHz	See Fig. 6 rating /10
2. Upper −3dB point ω_H	20kHz	1kHz	
3. Amplitude linearity $\pm L$dB*	0.25	30dB	$p(L) = 0.48 \log_{10}(4L)$
4. Phase linearity $\pm\theta$°	5°	100°	$p(\theta) = 0.77 \log_{10}(0.2\theta)$
5. Maximum weighted t.h.d. or i.m.d.* d%	0.1%	50%	$p(d) = 0.37 \log_{10}(10d)$
6. Transient intermodulation index (t.i.i.) ti	0.1	100	$p(d) = 0.33 \log_{10}(10ti)$
7. Rise-time $\tau\mu$s	5μs	1ms	$p(\tau) = 0.44 \log_{10}(0.2\tau)$
8. C.C.I.R. weighted s/n* n	70dB	30dB	$p(n) = (1-(n-30)/40)$
9. Cross-talk c	60dB	0dB	$p(c) = (1-n/60)$

*In the band 20Hz–20kHz or $\omega - \omega$ whichever is the smaller. Note $0 \leqslant p(x) \leqslant 1$ only.

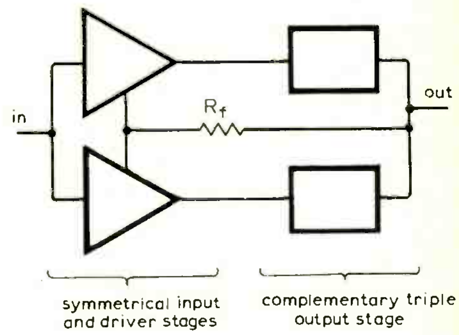


Fig. 36. Simple block diagram of the Lecson power amplifier.

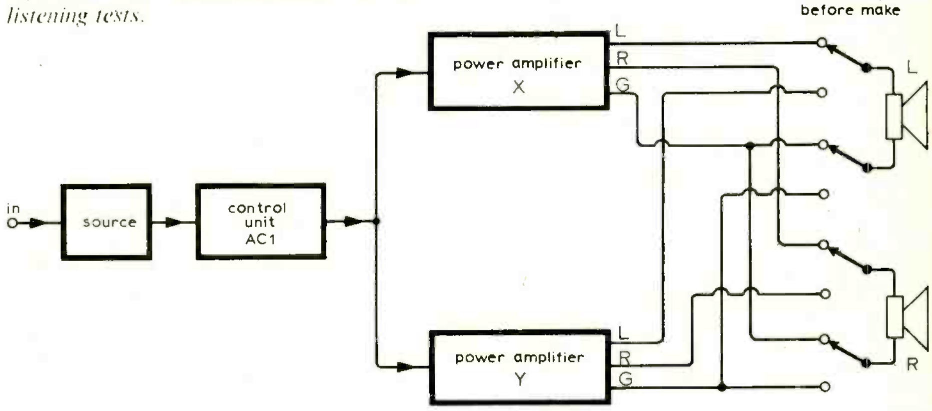


Fig. 37. Circuit switching arrangements for listening tests.

Some experiments

The author has recently carried out some listening experiments in an attempt to measure the significance of t.i.d. in high quality power amplifiers and, while the tests are not completed, some preliminary results have been obtained which are of interest.

The approach has been to use the basic Lecson AP1 power amplifier design and to vary only the open-loop bandwidth and feedback factor.

Three amplifiers were used:

1. The standard amplifier with an open loop bandwidth of 17.5kHz and feedback factor of 32dB as summarised earlier.

2. A modified version with an open-loop bandwidth of 4kHz and feedback factor of 40dB. This amplifier exhibited amplitude and phase responses identical to the first example, within the accuracy of the measurements (0.25dB, 2°), and showed t.h.d. results within 10% weighted of the first example.

3. A modified version with an open-loop bandwidth of 17.5kHz and a feedback factor of 6dB. This amplifier exhibited t.h.d. of 0.11% 50Hz–3kHz, rising to 0.18% at

Appendix

The three amplifiers used in these listening experiments were all of very high quality showing an f.o.m. based on the routine of Table 1, of 0.9, 0.82 and 0.83, for the amplifiers A, B and C respectively.

Test 1. The test routine was performed using a panel of 8 listeners. Programme was derived from a very high quality disc player and monitor-standard loudspeakers employed (Spendor BC3).

Comparison A and B. On all programme material chosen, amplifier A was preferred by 87% of the listeners. The reaction of all listeners subjectively defined a clear difference, A being preferred for greater clarity at high frequencies. On switching to B the impression was obtained of a veil being drawn over the sound, particularly with strings or percussive material.

Comparison A and C. All listeners observed audible differences; C was preferred by 62% on all programme material and by 75% on folk music or percussive music. The overall impression was that C handled transient material very well but showed slight high frequency colouration, possible due to the weighted distortion.

Comparison B and C. Of the total audience, 75% preferred C on all material. Of particular interest in this test was that the two amplifiers showed subjectively different balance, C sounding to have less high frequency content than B. Also it was noted that B showed up background noise on the disc—hiss, clicks and pops—much more than C.

Test 2. A panel of 4 listeners using a high quality disc source and monitor-standard loudspeakers (Lecson HL1).

Comparison A and B. All preferred A for reasons of high frequency clarity.

Comparison B and C. This test produced confusion, no direct results were applicable as preference depended upon the material used. The faults of amplifier B on transient sounds seemed to be contrasted with a slight lack of clarity on high notes with amplifier C.

Tests 3 and 4. Devised as a control test for the comparison B and C. Two panels took part, consisting of three and seven listeners respectively. Again a disc source was employed and small loudspeakers used (Spendor BC1). In the first test C was unanimously preferred, to the second—as before, preference depended to an extent on the source material.

A working hypothesis to explain reactions to amplifiers B and C could be, that subjectively the amount of t.i.d. produced by B was as significant as any high frequency t.h.d. or i.m.d. produced by C. However these listening tests are only the beginning of a serious programme of tests which will aim to establish significance over a much wider range, and so these results can only be considered to be provisional. For example no attempt has been made to establish an f.o.m. for the loudspeakers used in these tests or to calculate or measure any interactions in the reproducing systems.

20kHz, 35W r.m.s. The distortion was such that the second harmonic was 40dB above any other so the weighted t.h.d. was below 0.2% at all times.

In each case the output impedance at the terminals of the amplifier was less than 250mΩ 20Hz – 20kHz, so any effect that a change of feedback factor may have had on this, was swamped by the 3m long loudspeaker leads used.

Three experiments were conducted, two formal, one informal. In each case the amplifying equipment was arranged as Fig. 37; only two amplifiers are used in any one test and both are driven continually by the pre-amplifier. Instantaneous comparison on programme is made by switching the loudspeakers between the two power amplifiers.

In accordance with the testing procedures laid down by Percy Wilson the participants had no knowledge, until the end of the experiments, of the nature of the differences between the amplifiers (if any) nor of the kind of subjective difference (if any) to expect. At no time was it asked which of the amplifiers sounded most natural, but simply "which of two, X or Y, do you prefer?".

The results of the tests are summarized in the Appendix. It is clear that, between amplifiers which are otherwise extremely good, despite relatively small changes to the t.i.i. performance, differences can definitely be detected by the ear as changes in the clarity and tonal balance of sound.

In a future article the author intends to describe further listening and objective tests and procedures in an attempt to quantify t.i.d. in absolute terms within the f.o.m. and with respect to t.h.d.

Conclusions

In these articles the author has attempted to study the relationships between objective tests made on amplifiers and the subjective results. Many aspects of amplifier performance have not been covered, the discussion concentrating more on distortions.

While it has been possible to outline in detail the rigorous compromises that face the designer of negative feedback amplifiers, the way in which each of the subjective effects trade-off is still not precisely known. A figure of merit calculation is given which makes an inquiring step in this direction, but it is clearly necessary that a programmed and controlled series of tests be carried out on a large scale.

Sixty Years Ago

From time to time over the years, successive editors of *Wireless World* have taken issue with the Post Office on the subject of licensing, especially when it has been considered that the Postmaster-General has tried to overstep the bounds of reason by claiming a proprietorial interest in the forces of nature. A correspondent in 1913 obviously felt very much the same way. . . . "We have heard lately of bedsteads and gas pipes being successfully used as substitutes for receiving aerials. Suppose I go a little further and discover that I get Paris, using only domestic appliances (such as a bedstead on an upper floor as an aerial, the wires of a piano suitably connected as a tuning coil, a nest of cake tins with buttered paper between them as a condenser, a piece of washing soda and a darning needle as a detector, and my tongue in place of the 'phones), must I obtain a licence from the Postmaster-General before I dare use such apparatus to get the time from E.L.? A few more discoveries(!) in "wireless" and we shall require to get a licence from the Postmaster-General before we furnish a house, and we shall have inspectors inspecting our pots and pans to see that they conform to the wireless regulations!"

Darts Game Calculator

Apprentices at the Guided Weapons Division of the British Aircraft Corporation, Bristol, have built an experimental automatic darts game calculating system which registers and keeps scores. It comprises a special dartboard with sensing devices, and a computer-controlled display unit which acts as the scoreboard. This unit, using 120 integrated circuits, shows the running totals for the competing teams and adds up each individual score.

The dartboard is designed with each segment internally divided and connected to the display unit. Impact of a dart on each segment causes an electrical signal to be sent to the computer in the display unit. The conclusion of an individual three-dart score is signalled by the removal of the darts from the board. The system is then re-activated by the next player standing on the throwing mat, under which is concealed a proximity detector. This causes a bulb on the display unit to be lit, showing that the system is ready to accept the next score.

Any variation of the game can be fed into the display unit before the game starts, so that the starting total could be set at, say, 1001 or 301 depending on the type of game to be played. If a double is required to start the game, then a "double" light is switched on and the system ensures that electrical signals from the dartboard will not alter the setting until the first double is obtained.

The apprentices were given just 13 weeks to design, build and test the project and were allowed to spend no more than £100 on materials.

Circards — 10

Micropower circuits

*by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams**

Think small! In tune with the broadening of the frequency spectrum, so has the range of powers grown at which electronic circuits may be coerced into functioning. Within modern integrated circuits it is common to find individual transistors operating at microampere currents, with device p.ds of a volt or so. Discrete transistors can retain useful gain at currents several orders of magnitude less at room temperatures (even with silicon transistors leakage current imposes constraints on the usable current/temperature combinations). Since the leakage currents may be markedly reduced by controlling the doping levels and depth of penetration, by attention to surface impurities and by reduction of device area, it is difficult to define this lower limit. Collector currents of 1nA at 20°C and 1μA at 100°C are possible, though it would be foolhardy in the extreme to suggest that these could not be improved on — undoubtedly before publication some brilliant new process will appear capable of improving on these figures by a factor of ten or more!

The position is quite different in respect of minimum operating voltages. Fig. 1 shows the variation of I_c and I_b against V_{be} for a low-leakage planar silicon transistor operated at constant V_{ce}. No matter how low the current is reduced the fundamental relationship $I_c \propto \exp V_{be}$ ensures that the value of V_{be} changes at a much slower rate. For example, a ten-fold reduction in I_c corresponds to a reduction of approximately 60mV in V_{be} at room temperatures. Since the minimum value of I_c is likely to be fixed by load requirements etc. no amount of juggling can reduce the minimum supply voltage below that of the corresponding V_{be}, and in most circuits the supply voltage will have to be significantly higher. Excepting special cases such as certain complementary oscillators where only one of a complementary pair needs to conduct at a time, the minimum supply voltage will be greater than 1V and may have to be greater than 1.5V for op-amp type circuits.

In the above discussion no mention has been made of constraints imposed by transistor V_{ce}. At low currents the value of $V_{ce\ (sat)}$ is very much less than the V_{be} values above, though it must be observed that $V_{ce\ (sat)}$ often rises with temperature while V_{be} always falls (typically the temperature coefficient of V_{be} is -2mVK^{-1}). At high current densities the bulk resistance of the semiconductor comes to dominate the junction characteristics and the minimum p.ds may well exceed a volt for both base and collector-emitter paths. Self-heating will cause the value of V_{be} to fall somewhat but the effect should be negligible for circuits coming under the micropower heading.

The use of germanium transistors to minimize voltage requirements is well known, but the leakage currents are such that high temperatures are inconsistent with micropower operation. When using diodes, an intermediate region is provided by Schottky-barrier devices. As shown in Fig. 2, these have a p.d. appreciably less than that for a silicon diode, and can be used as bias elements as well as for rectification.

The interpretation of this term "micropower" has been made a generous one in this series because the techniques used in micropower circuits can be usefully applied in many other fields. For a given specification of load resistance and the required voltage or current swing, the minimum theoretical voltage can be determined assuming a voltage supply (if the circuit is to be supplied from a constant current then it is the minimum value of current that is defined). If this voltage is significantly greater than the minimum operating p.ds of semiconductor devices as discussed above, then standard circuit configurations may well give satisfactory results. At lower load p.ds new circuits are necessary to allow operation from correspondingly low supply voltages. As a rough guide, it is now possible to produce a.c. amplifiers, oscillators both *RC* and *LC*, voltage regulators, and astable and monostable circuits that will operate from supply voltages in the region of 1V, though with obvious limitations on output voltage swing and with reduced stability against supply/temperature variations. Other circuits such as power amplifiers and operational amplifiers may require somewhat higher voltages but nearly all functions can be provided while operating from a single dry cell. In designing these circuits a critical parameter is the minimization of wasted voltage, and this is equally applicable to conventional

*All with Paisley College of Technology.

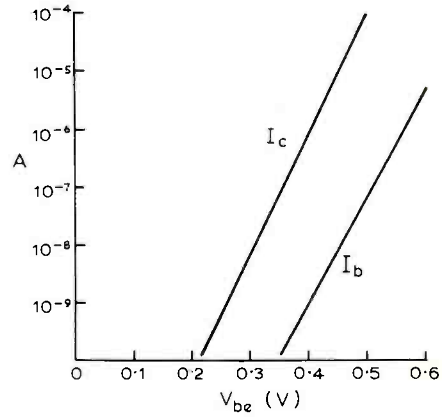


Fig. 1. Variation of I_c and I_b against V_{be} for a low leakage planar silicon transistor operated at constant V_{ce}.

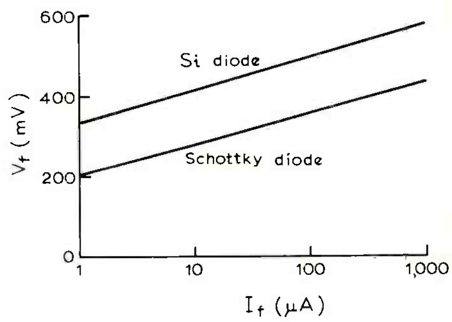


Fig. 2. The Schottky-barrier diode has a p.d. appreciably lower than that of a silicon diode.

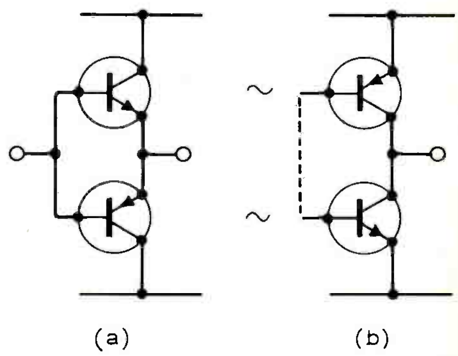


Fig. 3. Replacement of a complementary pair of emitter followers (a) by common emitter stages with emitters taken to opposite sides of the supply (b).

circuits where the load-swing is to approach the available supply voltage. A good example is the replacement of a complementary pair of emitter followers Fig. 3(a) by common emitter stages with emitters taken to opposite sides of the supply Fig. 3 (b). In the former case, since the bases can only be driven with difficulty to within hundreds of millivolts of the supply, then the output suffering an additional V_{be} loss may be up to 1V less than the supply at both extremes, i.e. the output has a peak-peak value up to 2V less than the supply voltage even at relatively low currents. In the circuit of Fig. 3 (b), though the drive conditions may be more difficult to meet, only the transistor $V_{ce\ (sat)}$ appears in series with the load, and outputs to within a couple of hundred millivolts of the supply are feasible. It is for the same reason that the series-pass transistor is in the common-emitter mode in voltage regulators where minimum input-output differential is important.

Two other related parameters that may be important in micropower circuits are maximum efficiency and the minimum quiescent power. As discussed in the article Power Amplifiers (June issue), these two conditions are often associated, as, for example, in class B power amplifiers. For minimum distortion it may be necessary to increase the quiescent power. Where the amplifier normally operates close to maximum output then this contribution to the power consumption is negligible. Conversely if the amplifier operates at full output only for short periods, then the mean power is strongly dependent on the quiescent power. In summary, for continuous operation at maximum outputs, saturation voltages will be the limiting factor, while the quiescent power needs most design ingenuity for large peak/mean ratios in output.

A different problem arises when efficiency at maximum output is really critical. Then the need to saturate the output transistor(s) to minimize lost voltage would bring the corresponding disadvantage that the base current becomes a large fraction of the load current. The combination of high current gain together with low saturation voltage is not an easy one, though at least high breakdown voltages are not required of the device. Special transistors called "super-β" devices are now used as the input stages for high input impedance operational amplifiers. These have a very thin base region, achieve gains in excess of 1,000 but have very low breakdown voltages. They are the extreme examples of another source of the trend towards low-power operation — in this case for the higher input impedance that it brings rather than for the low power itself.

The definition and control of operating current becomes difficult at low currents because of the high-value resistors needed, which are not compatible with monolithic processing in its most economic form. Circuit techniques based on the current-mirror have mitigated this problem, so that all the currents in an amplifier are controlled by a single low-current source. Recent micropower op-amps leave this to the choice of the user, with a single external resistor programming the operating currents of all the transistors in the i.c. At low supply voltages the p.d. across any such resistor, whether internal or external, becomes temperature-dependent and the design problems multiply.

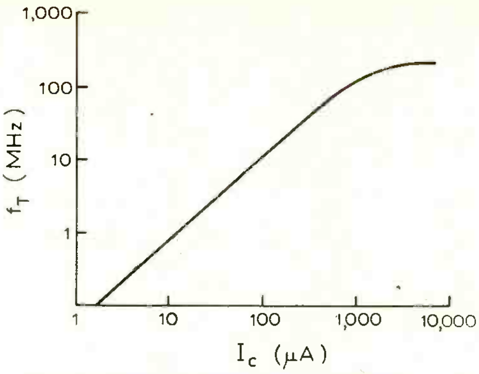


Fig. 4. At high frequencies the gain-bandwidth product of a transistor is an almost linear function of quiescent current.

Temperature problems are even more severe in low-voltage/low-current voltage regulators since conventional voltage reference elements cannot be used — the lowest zener diode has a breakdown voltage of approximately 2.7V. Combinations of dissimilar diodes (e.g. Si and Ge) can be produced that have a voltage difference which is almost temperature compensated, while i.c. designs have exploited the properties of forward-biased silicon p-n junctions to achieve the same effect.

The one area of operation where the inherent limitations of micropower operation have not been overcome is the high-frequency region. As the quiescent current in a transistor is reduced, so the rate at which it can charge its own internal and/or external stray capacitances falls. The gain-bandwidth product is an almost linear function of quiescent current (as shown in Fig. 4) with an upper limit to this parameter short of its maximum operating current for most devices. Thus a device normally thought of as a "100MHz transistor", when operated at collector currents below 1μA may have a cut-off frequency of less then 10kHz. Clearly it becomes of critical importance to minimize the stray and load capacitances in such applications. For micropower operations at high frequencies, transistors with the very highest quoted gain-bandwidth products should be selected — even 1GHz devices are not out of place provided they can sustain current gain at these low currents. Low-voltage operation brings increased problems since, for example, the collector-base diode has increasing (non-linear) capacitance as the p.d. approaches zero and eventually becomes slightly forward biased.

A major area of concern is in the digital field, where ever larger numbers of gates and other functions are being concentrated into single monolithic i.cs. These l.s.i. (large scale integration) circuits are limited in complexity by two mechanisms — the number of external connections, and the total dissipation. Complementary m.o.s. with its extremely low standby power is the ideal logic family from this latter standpoint and is likely to dominate the market. The dissipation is significant only where high-speed operation is demanded, since then the charge/discharge of internal capacitances dissipates power. Since the choice of circuits available in this family is growing so rapidly, the user is best advised to refer to the manufacturers' data sheets, while the properties of the basic gates will be discussed in the following article.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Breakdown of c.m.o.s. devices

I was very interested to read the article "Complementary m.o.s. Integrated Circuits" in the August issue. However, on page 396 there was the statement "To avoid failures due to destructive breakdown of the gate insulation, possible with such high impedances . . . etc".

Motorola in a recent leaflet entitled McMOS state that stress voltages can be caused by improper testing and even more likely causes are random electrostatic charges. They suggest that all leads are shorted together, antistatic clothing should be worn, personnel handling c.m.o.s. should be electrically grounded, equipment which comes in contact with finished pieces of equipment should be properly grounded — and yet they fit input protection diodes.

RCA claim to have fitted protection devices to the inputs of their devices which will have a controlled breakdown of something of the order of 30V-100V in the reverse direction, and have given figures for the maximum voltages which can appear between pins on the i.c.

SGS also fit input protection diodes but, so far as I can ascertain, make no claims one way or the other.

This problem of breakdown due to static build-up appears to be a serious drawback to the large-scale use of c.m.o.s., or maybe I am looking at the wrong manufacturers' data sheets!

Can any of your readers enlighten me as to whether I can safely wear my nylon coat when using c.m.o.s. or do I have to chain myself and all my test gear solidly to earth?

Peter Seddon,
Rugby,
Warwickshire.

Tuner front-end devices

I have recently read in *Wireless World* two articles which have raised some rather large doubts in my mind as to the best device available for the reduction of cross- and inter-modulation.

In June there was Mr Nelson-Jones employing dual gate m.o.s. f.e.ts in his v.h.f. tuner which, with a sensitivity of the order of 1 microvolt, one hopes will pick out a weak v.h.f. signal in the presence of strong local nearby frequencies.

In August P. Antoniazzi and A. Mauceri were saying the dual gate m.o.s. f.e.t. is not the answer and the bipolar transistor has a better performance, achieving a 40dB suppression of signals with a 4MHz separation at 500MHz. When used as the v.h.f. part of their tuner I deduce they will claim a similar performance.

I do not have available the data sheets for the BF479; however, those for the 40673 show that careful selection of bias and a.g.c. is needed to get the best out of the m.o.s. f.e.t.

The problem I wish to pose is essentially how does one receive a 1 microvolt signal, which obviously cannot produce much a.g.c., in the presence of strong nearby v.h.f. f.m. transmissions which can easily be of the order of hundreds of millivolts.

Could these respected authors clarify this point, which is becoming a real problem with the almost saturation of v.h.f. frequency spectrum? The published literature is full of wavetraps and helicoidal filters which unfortunately are to some extent attenuators for weak signals.

Even better still would be an article from some brave soul on the relative merits of bipolars and m.o.s. f.e.ts in weak signal conditions. I am sure such an article would fill a gap in a little discussed but very real problem.

F. F. Maher,
Madrid,
Spain.

Record equalization

In response to Mr Ewer's letter on record equalization (August issue) I would like to point out some factors which he has overlooked or perhaps does not know about.

First of all I must hold up the record companies' flag by saying that discs are recorded to the BS 1928 equalization standard and that there is no equipment "penny-pinching" when Neumann or Scully cutting lathes are in use.

The reason behind the apparent lack of extreme bass on some records is *not* due to the use of a modified equalization characteristic. Despite what J. L. Linsley Hood and others say, it is due to the fact that extreme bass signals, of even moderate amplitude, can (a) damage, very easily, delicate stereo cutter heads (especially if present as a difference signal) and (b) result in groove wall breakdown, i.e. "groove-jumping". To prevent cutter head damage, fast, accurate stereo limiters are employed, but to avoid the triggering of these too often a careful watch must be kept on peak levels and difference channel levels at all frequencies, with the result that occasionally a modicum of "cut" must be applied at selected places within the audio spectrum.

There are several ways to prevent (b): (i) a deeper cut — impractical because many cheaper arms and cartridges would fail to track it; (ii) wider minimum groove spacing (before use of variable groove spacing unit) — a possible solution but it conflicts heavily with the amount of time needed per disc side for a given piece of music (Varigroove is not always the answer!); and (iii) a "roll-off" of extreme bass to allow a more normal groove spacing.

So, Mr Ewer, don't blame the cutting engineers or their equipment: blame the totally conflicting elements of time and fidelity required from a poor little piece of black plastic and just turn up the bass!

Robert L. Arthurton,
London, N.16.

VAT and prices

Like your correspondent W. B. Henniker in September's letters, I have fallen foul of the "VAT addition" thing in your advertisements, in one case with further complications since by the time the VAT had been received the goods had become exhausted. At least I *think* they were, because I have heard nothing since the fourth of July.

Your advertisers in general were very slow to respond to VAT, and in some cases were showing advertisements in the May issue which were not clear about the tax addition.

If *Wireless World* depends on advertisements for a living, or if the advertisers depend on advertisements for a living, then someone will have to brighten their ideas — and their conceptions of service.

J. R. Dykes,
Winsford,
Cheshire.

Inverter for fluorescent tubes

I was very sorry to read in the September issue of the trouble that Mr Chappell has had with the heaters of his fluorescent tube in my circuit (August issue).

I can only plead that I tested the circuit with at least three different tubes and that none of them showed any sign of the discharging from which he has suffered.

This type of tube was, of course,

designed originally for operation from the a.c. mains, and the circuits in which they are normally used arrange for the feed to the heaters for starting up to be essentially the same defined current as is used in normal running. In such a circuit discharging across the heaters is no disadvantage as the power dissipated is reduced rather than increased. Furthermore there is no reason why the heater resistance, and hence its working voltage, should be tightly controlled for such service. The value may, in fact, vary appreciably from one manufacturer to another.

Mr Chappell's suggestion of the insertion of a ten ohm resistor in series with each heater looks like a very satisfactory solution to the problem.

I am sorry that I missed this point and I hope that no other readers have suffered similar trouble.

I must apologize also for the fact that Figs 3 and 4 of my article as published had the positive power supply point omitted. This should, of course, have been at the centre-tap of the transformer just as it was in Fig.1 (b).

K. C. Johnson,
Cheadle,
Cheshire.

Printed circuits the easy way

My own resists are invariably photographically produced, so I cannot speak to the drawing technique which is described by J. Ferguson on page 332 of the August issue. But it ought to go on record that the only reason commercial etching of copper is done with ferric chloride (the commercial grade of which usually contains a variable proportion of free hydrochloric acid) is that this chemical is relatively inexpensive. In amateur printed circuit work there may well be other solutions which have advantages over it.

I pass over nitric acid, since it emits brown choking fumes when attacking copper. But its action is very swift, and those whose resist can stand up to its onslaught might feel it worth trying, in 10% concentration in the open air.

My own choice would be 10% ammonium persulphate in water. This dissolves copper very well, though perhaps a little slowly, but the solution stays fairly clear and the submerged board can be seen pretty clearly. If about 5% by volume of strong ammonia solution is added to the persulphate, action is accelerated considerably, but the solution turns deep blue very quickly as copper is dissolved, and the effect on submerged pieces cannot be so easily seen.

Though I have not personally tried it, there would seem to be something in the electrolytic method of etching. Assuming that the unwanted copper areas of the board can be commoned, they can become an anode of the electrolytic cell, while any odd piece of scrap brass of roughly the same area can be used as cathode. All that is now needed is a source of 6 volts 4 amps d.c. which nearly everyone must have at hand these days.

Quite a number of possible electrolytes suggest themselves, but for first trials I would suggest 10% common salt in water. If too little current passed — a board 4 × 4 inches would probably need some 4 amps of current to dissolve the copper reasonably fast — the addition of a little vinegar (i.e. dilute acetic acid) should increase the conductivity to some extent. But it will not have anything like the effect that a few ml of a strong acid, such as hydrochloric acid, will produce.

P. C. Smethurst,
Bolton,
Lancs.

Electronic music

Having been interested in the use of electronics for musical experiments, I would like to hear from any readers who have had experience in this field. I am particularly referring to the music synthesizer using voltage controlled oscillators as well as other voltage controlled functions.

The purpose of this is to collect any ideas for the design of a small synthesizer capable of fairly advanced work while still retaining its low cost.

G. Wade,
Knowle Orchard,
Churchill,
Nr. Bristol.

Projection television

I was most interested to find reference to my old company, in conjunction with the other old stalwarts of projection television, in G. W. Tillet's Letter from America in the September issue.

It may be interesting to mention that much of the original work, culminating in the formation of White-Ibbotson Ltd, took place while I was with E.M.I. and was based on 3in. c.r.ts designed by Drs Broadway and Cairns, and using all-glass Schmidt lenses designed and made by Optical Works Ltd of Ealing. When E.M.I. decided not to proceed with the venture, I left and formed W.I. Ltd — the directors of E.M.I. giving every assistance and helpful co-operation.

Thus, we were not altogether tied to the disadvantages that Mr Tillet states applied to the Philips unit. However, I must hasten to add that *neither* system suffered from the dust occlusion problem mentioned if the systems were put together with proper precautions to exclude dust. In fact, the most serious problem with either the E.M.I. or the Philips c.r.t. was, in my experience, that of X-ray staining of the face glass. This could cause a 50% light loss in a few hundred hours running.

So far as viewing "under cinema conditions" is concerned, again I must cross swords with Mr Tillet. It is a matter of history that we had a 4ft × 3ft back projection picture running under 2.5kW of exhibition lighting at Earls Court with a very good viewability for the passing public — and this was with a standard Philips unit. Obviously we used our lenticular screen but this provided a good horizontal angle of view and, by limiting the vertical angle to about 15° (ample for normal viewing with this size of picture), we had a minimum of projection light waste and a maximum rejection of overhead lighting interference.

It may also be interesting to record that we found a French optical company who made ordinary convex lens systems for the Philips tube with similar efficiency to the Schmidt, and at very little extra cost, which clearly avoided many of the dust exclusion/cleaning problems inherent in a basic Schmidt.

At that particular time Mullard's proved a point of view that I had always held, namely that projection would come into its own with the advent of colour. They used three primary-coloured monochrome tubes and three Philips' Schmidts. Such tubes are much less expensive to produce than the traditional panchromatic black and white tubes. The results were startingly good but orientation of the Schmidts with dichroic mirrors etc. was far from practical. Had there been colour transmission at that time, we would have used the French lenses and I think a commercially viable result would have been obtained.

It's a great pity that we have had to leave it to the Japanese, yet again, to appreciate the advantages and go-ahead. However, I think that Sony have gone to a great deal of trouble in the wrong direction — if, of course, ours and Mullard's experiments meant anything.

H. Ibbotson,
Penryn,
Cornwall.

Reflex Circuits

I was delighted to read John Scott-Taggart's letter in your September issue. First, to discover that he had not departed, nor lost interest. Second, to acknowledge his very generous final paragraph. It was all the more generous in view of the fact that I have been known to indulge in a little thinly disguised leg-pulling about such things as the celebrated ST 100 (younger readers will have to ask their elders to explain). And still more generous after I had forgotten his pioneer work on the reflex circuit. For this I must plead age, not ignorance, as I will now make clear. And I hope it will also go some way towards atoning for my sins of commission and omission as I reveal for the first time that the very book from which he quoted (Thermionic Tubes in Radio Telegraphy and Telephony) provided the foundation for my knowledge of the subject, since the degree course in electrical engineering at Edinburgh in 1921 was all "heavy". During one particular course of lectures by a notoriously ineffective expositor, while most of the inflated intake of students after the War were amusing themselves at his expense I sat in the back row, where the signal/noise ratio was fractional so did not break through my concentration, and read S-T's book from cover to cover.

As it was one of the very few "historical" books that survived my drastic pruning on moving recently to smaller premises, I really have no excuse for not refreshing my memory from it.

So far as I was concerned the Scott-Taggart ubiquity to which I referred in August was mainly in print. I can recall only two sightings: one was when he came to Edinburgh about 1923 to explain and demonstrate his "Negatron"; the other was 22 years later in the Air Ministry. I am glad to acknowledge my debt to his books in the days when reliable sources of information were scarce.
M. G. Scroggie,
Bexhill,
Sussex.

"Empty" cassettes wanted

The remedial reading department at this school uses a number of devices to encourage pupils who find difficulty in learning to read.

Our most recent innovation is a tape-loop which runs for about 18 seconds and on which are recorded about half-a-dozen words containing the same sounds.

The tape-loop is housed in an ordinary cassette by fitting additional rollers. Our difficulty is obtaining cassette cases. We cannot afford to purchase cassettes at normal price and then to modify them. Would any reader having empty or broken cassettes please send them to me at the school? Postage would gladly be refunded.
C. S. Smith,
The Walmer Secondary School,
Salisbury Road,
Deal,
Kent.

New names for old devices

The headline in *Electronics Weekly* of August 8th reads, "Amorphous Devices Seeking a Role". Forgetting the updated terminology, these devices seem to be little more than the original coherer used in the early days of wireless to "detect" a signal. The r.f. signal fused iron filings in a tube, causing the passage of d.c. to indicate that a signal had been detected.

Newly fledged engineers should perhaps be reminded that we might never have developed an electronics industry but for Amorphous Devices.

Some readers may be interested to know that they can construct an amorphous memory device with a piece of wood, two pins and a blob of aluminium paint. The pins should be hammered into the wood about $\frac{1}{8}$in apart. A thin layer of paint is applied between the pins and allowed to dry. Apply about 20 volts via a few kilohms to limit the current and the aluminium particles in the paint will link together and close a "switch" capable of carrying perhaps $\frac{1}{3}$ amp. Apply about 6 volts without a current limiting resistor and the switch opens. It is rather like blowing a fuse. There is one difference — it can be mended again by applying the 30 volts activation supply for a moment.

I once caused great mystification amongst colleagues at the Emley Moor transmitting station with a little device able to switch a torch bulb on or off without using a switch or other familiar device. Readers wishing to repeat the experiment should beware of vibration; it will disturb the coherer link. In the event of failure please consult the paint manufacturer rather than myself.
P. J. Unwin,
Rochdale,
Lancs.

"Communications 74" — call for papers

An international conference, Communications 74, is being organized by *Electronics Weekly* and *Wireless World*, and will be held at the Metropole Convention Centre, Brighton, 4-7 June 1974, in conjunction with a Communications 74 exhibition. Suggestions for papers are now invited.

The conference will be divided into two parallel sessions on each of the four days, one session being on user topics and the other on technical topics. Afternoon sessions, for the presentation of short papers, and evening meetings are also being planned.

The four main subjects of the conference will be: data communications; mobile radio communications; fixed radio communications; and defence communications. Suggested topics for papers include the following:

Transmitter and receiver circuit techniques; propagation; error correction; facsimile; antennas; cables; recording systems; test equipment; components and ancillaries.

Data networks; message switching; modems; data terminals; telemetry systems.

Mobile radio equipment and systems for land, sea and air; selective calling; radio paging; frequency allocation and channel spacing; traffic control and vehicle location systems; radio navigation receivers and systems.

Radio communications equipment and systems for fixed applications; point-to-point links; remote control systems; digital encoding systems; tropospheric scatter.

Special techniques associated with military systems; electromagnetic compatibility; routing problems; equipment parameters for future requirements; underwater communications.

Microwave communication systems; microwave antennas, ground stations and receiving systems; waveguide communication systems.

Original papers are invited from industry, government departments, the armed services, universities, etc. In the first instance, authors should submit summaries of 200-300 words (in English), describing the subject and scope of the paper, to: The Editor, *Electronics Weekly*, Dorset House, Stamford Street, London SE1 9LU.

Deadline for the receipt of summaries is October 26, 1973. Speakers will be notified of acceptance by December 31, 1973. Final drafts will be due by March 11, 1974.

John Gilbert retires

After being associated with the Northern Polytechnic (now The Polytechnic of North London) for 39 years, 22 of them as head of the Department of Electronic and Communications Engineering, J. C. G. Gilbert, F.I.E.R.E., F.R.S.A. has retired. Perhaps best known to the public for his part in the television programme "Inventor's Club", his major contributions have been in the world of audio.

He was educated at Westminster City School and went on to part-time courses while, at the same time, studying music at Trinity College of Music, London, giving broadcast piano recitals between 1924 and 1928. He became interested in radio while still at school and, in 1934 joined Partridge & Mee of Leicester on the strength of two articles on disc recording published in *Wireless World*, and that summer was in control of the installation of the public address system at the Regent's Park Open Air Theatre. In September of that year, Mr. Gilbert joined the "Northern Poly" as part-time lecturer on radio servicing and in 1935 became the first full-time lecturer in radio and kindred subjects. He also took up the position of technical editor of *Music Trades Review*. During the war years he worked under Sir Robert Renwick in the Directorate of Communications Development at M.A.P. and, on return to the Polytechnic, became senior lecturer and, in 1951, head of department — a position he held until August this year. He has been chairman of several societies, among them the British section of the Audio Engineering Society, was chairman of several B.S.I. committees and is technical consultant to the journal *The Gramophone*, where he continues his work. He has written several articles for *Wireless World*. We wish him a long and happy retirement.

Synthesizer Keyboards

The following company has informed us that they can supply keyboards for the *Wireless World* sound synthesizer (see pp.485-490 this issue): Elvins Electronic Musical Instruments, 12 Brett Road, London E.8. Tel. 01-986 8455.

October Meetings

Tickets are required for some meetings: readers are advised therefore to communicate with the society concerned

LONDON

9th. AES — "The integrated circuit in audio systems" by Jonathan A. Dell at 19.15 at the IEE, Savoy Pl., WC2.

10th. IERE — Colloquium on "Electromagnetic compatibility or confusion on land, in ships and in aircraft" at 14.30 at 9 Bedford Sq., WC1.

10th. IEE — "Computers and communication — convergence or conflict?" by J. R. Pollard at 17.30 at Savoy Pl., WC2.

17th. IERE — "The feedback classroom" by K. Holling at 18.00 at 9 Bedford Sq., WC1.

18th. IEE Grads. — "The computer-oriented research laboratory by G. M. Rhodes at 18.30 at Savoy Pl., WC2.

22nd. IEE/I.Mech.E. — "Sequence control of analogue computers" by Dr. G. C. Barney and Dr. D. Miller at 17.30 at Savoy Pl., WC2.

23rd. IEE — "TV supply by a combination of omnidirectional 12GHz transmission and cable distribution networks" by Dr. J. Feldmann at 17.30 at Savoy Pl., WC2.

23rd. IEE Grads. — "Frequency synthesizers" by Dr. P. N. Nield at 18.30 at the Polytechnic of the South Bank, Borough Rd., SE1.

25th. IERE — AGM at 18.00 followed by presidential address by Dr. I. Maddock at 18.45 at London School of Hygiene and Tropical Medicine, Keppel St., WC1.

26th. IEE — Discussion on "Stripline and microstrip techniques for antennas" at 17.30 at Savoy Pl., WC2.

30th. IEE/I.Mech.E — Discussion on "Remote measurement and control using Post Office data transmission facilities" at 17.30 at Savoy Pl., WC2.

30th. IEE — Discussion on "Making the most of airborne frequency allocation" at 17.30 at the Royal Aeronautical Society, 4 Hamilton Pl., W1.

31st. IERE — Colloquium on "Remote control system organization" at 10.15 at Middlesex Hospital Medical School, Mortimer St., W1.

ABINGDON

10th. IEE — "Electricity in medicine" by Dr. D. W. Hill at 19.00 at Culham Laboratory.

AYLESBURY

16th. IEE — "Recording and reproducing quadraphonic sound" by J. C. G. Gilbert at 19.30 at Aylesbury College, Oxford Rd.

BATH

18th. IERE/IEE — "Optical fibre communications" by F. F. Roberts at 18.00 at Lecture Room 4E3, 10, the University.

BELFAST

10th. IERE — Northern Ireland section AGM followed by "T.Eng. and all that" by J. T. Attridge at 18.30 at the Board Room, Ashby Institute, Queens University.

BIRMINGHAM

3rd. IEETE — "Technician engineers and technicians — in the EEC, and elsewhere in the world" by E. A. Bromfield at 19.00 at Midlands Electricity Board, Summer Lane.

29th. IEE/I.Mech.E. —Discussion on "Applications of multivariable control theory" at 18.00 at the Midlands Electricity Board, Summer Lane.

BOURNEMOUTH

17th. IEETE — "Stereo broadcasting" by J. H. Brooks at 19.30 at The Tralee Hotel, West Hill Road, West Cliff.

BRADFORD

18th. IEETE — "The present state of colour television" by Prof. G. N. Patchett at 19.00 at the University.

20th. Sept. IERE — "Modern developments in hi-fi reproduction" by Dr. A. R. Bailey at 19.00 at the University.

CAMBRIDGE

17th. IEETE — "Technician engineers and technicians — in the EEC, and elsewhere in the world" by E. A. Bromfield at 19.00 at the University Centre, Mill Lane.

25th. IERE/IEE — "Situation display — a new and unique approach to radar presentation" by F. K. H. Birnbaum at 18.30 at the University Engineering Laboratories, Trumpington St.

CARDIFF

10th. IERE — "New integrated circuits for television receivers" by G. Baskerville at 18.30 at Dept. of Applied Physics, UWIST.

CHATHAM

3rd. IERE — "Recent advances in radio navigation" by J. E. Viles at 19.00 at Medway and Maidstone College of Technology.

CHELMSFORD

25th. Sept. IERE/IEE — "An anti-collision radar employing storage of radar pictures on tape" by J. Watt at 18.30 at the Civic Centre.

CRANWELL

24th. IERE — "Space instrumentation" by R. Young and B. R. Kendall at 19.30 at the RAF College.

DURHAM

17th IEETE — "TV and stage lighting" by E. Birch at 19.30 at the Lecture Theatre, Science Site, Durham University, South Road.

EVESHAM

20th Sept. IERE — "Colour television displays — the next stage" by W. W. Wright at 19.30 at the BBC Evesham Club.

FARNBOROUGH, Hants

24th. IERE — "Multiphonic organs" by J. H. Asbery at 19.00 at Queen's Hotel.

GLOUCESTER

18th. IERE — "Provision of communications for remote clustered visual display units" by F. B. Sanders at 19.30 at the College of Technology.

IPSWICH

17th. IERE/IEE — "Radio astronomy" by Dr. R. S. Booth at 18.30 at The Civic College.

LEICESTER

10th. IERE — "Delta modulation systems" by R. Steele at 19.30 at the Lecture Theatre 'A', Physics Block, the University.

LIVERPOOL

17th. IERE — "The semiconductor story" by Dr. K. J. Dean at 19.00 at the Dept. of Electrical Engineering and Electronics, the University.

MANCHESTER

15th. IEETE — "An engineer behind the Iron Curtain" by Prif. M. G. Say at 19.30 at Reynold Building, UMIST.

NORWICH

24th. IERE/IEE — "Sonar and underwater communications" by Dr. V. G. Welsby at 19.00 at Assembly House.

PORTSMOUTH

24th. IEETE/IEE — "The engineer in Europe" at 14.00 at the Polytechnic, Anglesea Road.

31st. IERE — "Exploring the deep oceans" by K. Haigh at 18.30 at the Polytechnic.

READING

10th. IERE — "Digital phase lock loops" by K. Thrower and P. Atkinson at 19.30 at J. J. Thomson, Physical Laboratory, University of Reading. Whiteknights Park.

REDHILL

24th. IEE — "Solid state radars by K. L. Fuller at 19.30 at the Mullard Research Laboratories, Cross Oak Lane, Salfords.

SOUTHAMPTON

17th. IERE — "Charge couple devices" by J. D. E. Benyon at 18.30 at the Lanchester Theatre, University of Southampton.

SWANSEA

24th. IERE/IEE — "Recent developments in the design of transfer function analysers" by W. A. Evans at 18.15 at University College.

WOLVERHAMPTON

16th. IERE — "The electronic control and communication network employed on the Midland links motorways by W. A. Hambrey at 19.00 at RAF Cosford, Albrighton.

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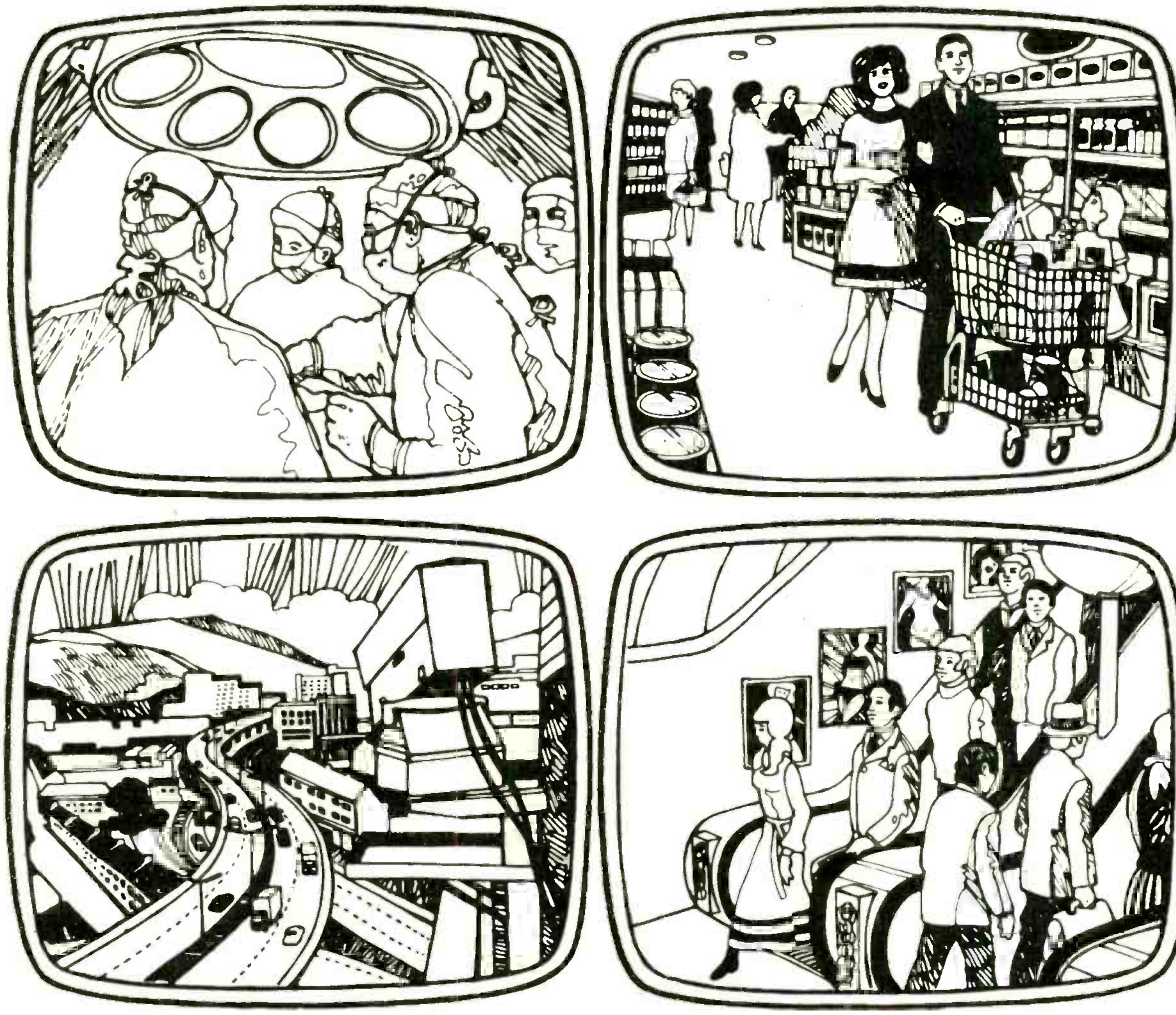

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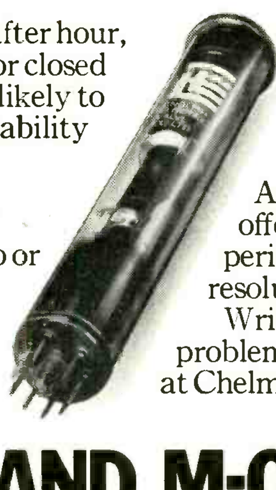

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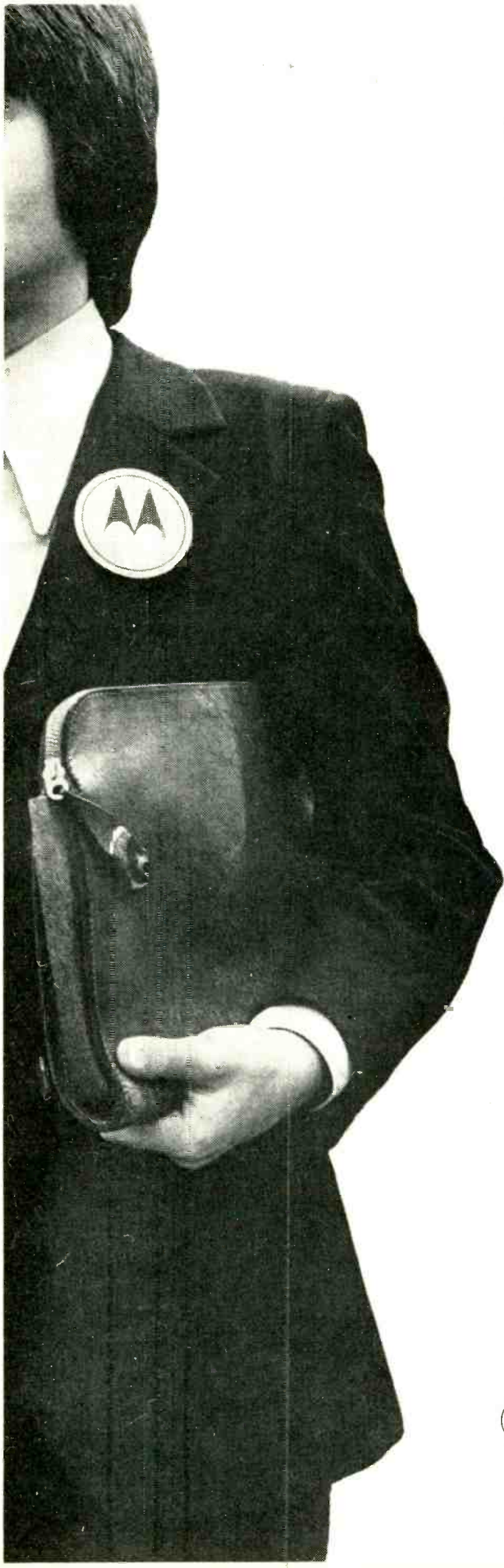

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WW—090 FOR FURTHER DETAILS

Realm of Microwaves

6. Microwave antennae

by M. W. Hosking, M.Sc.*

Microwave antennae, although no different in principle to other types, are much smaller in size for a given gain. This is because of the relatively small wavelengths involved, making it possible to use aerial dimensions tens or hundreds of times the wavelength. It thus becomes more convenient and realistic to talk about an aerial aperture for transmitting or receiving power rather than an effective height for coupling to the electric field. Before discussing individual aerials it will be as well to start off with some basic definitions.

An isotropic source is an origin of energy which radiates uniformly in all directions. Placed at the centre of a sphere, the power density anywhere on the surface of the sphere would be constant. Needless to say, such a radiator is not realisable in practice, but the concept is used as a point of reference for comparing the performance of an aerial.

Gain and directivity

There are two measures of aerial gain related by the efficiency of the aerial. The power gain G is defined by

$$G = \frac{\text{radiated power density}}{\text{power density from isotropic source}}$$

This is the figure usually quoted as it includes all the losses and imperfections associated with the antenna. Usually, gain is expressed in dB and often quoted without reference to direction, when it is then taken as applying to the peak of the main beam.

The second type of gain is the directivity D and can either be calculated or measured from the polar diagram. It is defined as

$$D = \frac{\text{maximum power density}}{\text{average power density}}$$

and as this does not take into account the effect of any losses it represents the ideal case. From the polar diagram of Fig. 1, the maximum of the pattern is readily seen and the average value is obtained by integrating the power density over the full 360° to give the directivity in that particular plane.

Further, as the directivity is a ratio, it is not necessary to know any absolute values; when working out the directivity from a polar plot, one reads off the peak value as a unit of length and divides it by the mean value obtained with the aid of a planimeter. Directivity and gain are related by $G = \eta D$, where η is the efficiency of the antenna. Depending on type and quality of manufacture, the efficiency of most microwave antennae lies between 50 and 75%.

From the definition of directivity, it is possible to obtain a "rule of thumb" estimate of the gain of an antenna from its 3-dB beamwidth. It is necessary to assume an equivalent polar diagram in which the radiated power is confined to within the solid angle formed by the product of the beamwidths in two orthogonal planes. One plane is usually taken as that parallel to the radiated electric field vector—the E-plane—and the other as parallel to the magnetic field vector—the H-plane. So if this pattern has an amplitude of unity, the maximum power density is $1/\theta_E\theta_H$, θ_E and θ_H being the half-power beamwidth in radians. The average power density is simply $1/4\pi$ and so the directivity is $4\pi/\theta_E\theta_H$, or $41{,}253/\theta_E\theta_H$ with the beamwidths in degrees. To obtain the gain an estimate must be made of the efficiency.

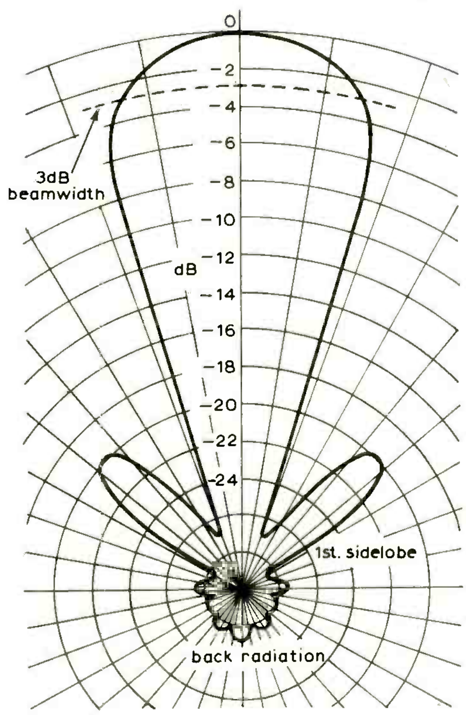


Fig. 1. General polar diagram showing the directive type of main beam that can be obtained in the microwave region. Parameters such as gain, beamwidth and side-lobe level are within the control of the designer.

Sidelobes

The great majority of polar patterns consist of a single main beam and a series of minor beams which occur at certain angular positions and the amplitudes of which decrease as the angular distance from the main beam increases. The presence of radiated power in these sidelobes is wasteful and gives a reduction in efficiency, so effort is made to reduce them. In addition, many radar systems these days have to operate in environments where they may be electrically "jammed" and the presence of high sidelobes would make them that much more susceptible. For use in low-angle tracking, high sidelobes could give rise to spurious and misleading echoes from the ground.

Antenna aperture

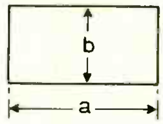
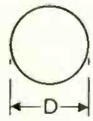
It is convenient to consider microwave antennae as having an effective area which collects the incident power. Such a concept is reasonable in the case of dish types, but not so obvious for, say, a dipole. Where there is a physical aperture to measure, the effective area is less than the geometrical one by a factor which takes into account the efficiency of the aperture as a radiator. The effective area A_e is related to antenna gain by $G = 4\pi A_e/\lambda^2$. The isotropic radiator, having a gain of unity, has an effective area of $\lambda^2/4\pi$.

Impedance is important from the point of view of maximum power transfer, either transmitting or receiving, and of therefore obtaining a good match. It happens that this parameter is exceedingly complex to determine and, apart from a few very simple antennae, it has not been possible or worthwhile to compute the impedance of all types. Instead, the quite-satisfactory process of empirical matching is carried out when needed.

Having thus established some of the main parameters used to describe the performance of an antenna, this article concentrates on a widely-used type in the microwave region which radiates from an area aperture. An interesting fact about the polar pattern produced from such a radiator is that besides the gain being governed by the

*British Aircraft Corporation

Beam dimensions from open-ended rectangular and circular waveguides

	Directivity	3-dB beamwidth E-plane	3-dB beamwidth H-plane	Width to first null E-plane	Width to first null H-plane	
Rectangular	$\frac{10.2\,ab}{\lambda^2}$	$\frac{\lambda}{b}\cdot 50^\circ$	$\frac{\lambda}{a}\cdot 65^\circ$	$2\sin^{-1}(\lambda/b)$	$2\sin^{-1}(3\lambda/2a)$	
Circular	$\frac{2.87D^{2}}{\lambda}$	$\frac{\lambda}{D}\cdot 29.4^\circ$	$\frac{\lambda}{D}\cdot 50^\circ$	$2\sin^{-1}(1.22\lambda/D)$	$2\sin^{-1}(1.7\lambda/D)$	

physical size, both the gain and the sidelobe level are functions of the electric and magnetic field amplitudes across the aperture. One can consider the whole area to be made up of a large number of small, individual radiators, each of which is supplied with its own electromagnetic fields. By varying the field strength by different amounts at different points, it is thus possible to taper the overall aperture field in any desired way. When all radiating points have the same amplitude, the aperture is called uniformly illuminated and has its maximum gain.

However, this distribution also gives the highest sidelobe level. By illuminating the aperture in various non-uniform ways and accepting a slight decrease in gain, together with widening of the main beam, the sidelobes may be reduced. A widely-used distribution, for instance, follows a cosine law, the electric field being zero at the edges of the aperture and rising to a maximum at the centre. In this case, a reduction in sidelobes of about 10dB together with a decrease in gain of 1dB would be obtained compared with a uniform illumination on a rectangular aperture.

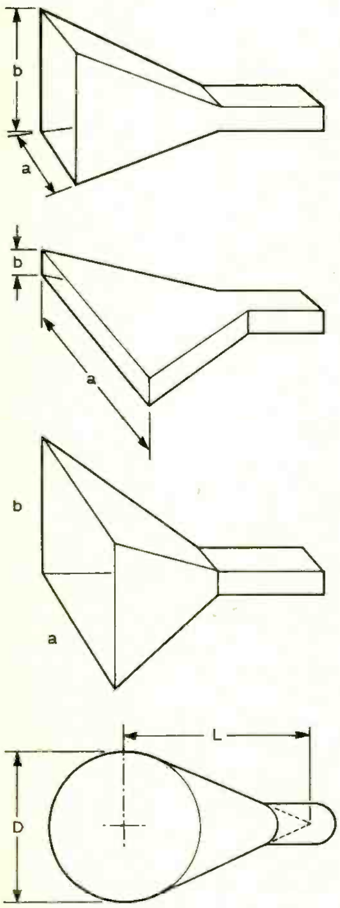


Fig. 2. Main types of waveguide horn formed by flaring the waveguide walls in a controlled fashion (a) E-plane sectoral horn, (b) H-plane sectoral horn, (c) pyramidal horn, (d) conical horn.

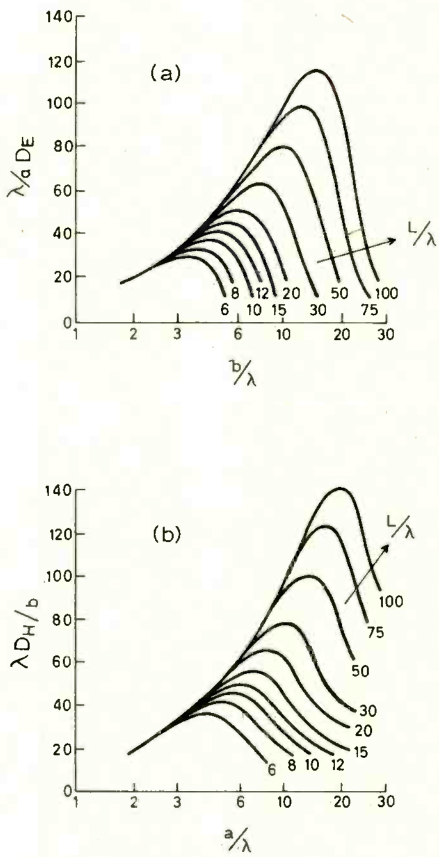


Fig. 3. For a fixed length of horn, directivity increases as the aperture widens and passes through a maximum value. Composite plots are shown here of the directivities of (a) E-plane and (b) H-plane sectoral horns having various lengths. Dimensions for an optimum horn can easily be seen.

A practical form of antenna, often used as the feed for a larger reflector-type, is simply open-ended rectangular or circular waveguide. In this case, the aperture distribution is governed by the field pattern within the waveguide, which in turn depends on the particular mode it is supporting. Usually the dominant mode is the one of interest and the Table (p. 502) lists the main beam dimensions for rectangular and circular guide when just the dominant mode is present. Both gain and beamwidth of the waveguide radiator are proportional to the area of the aperture, so that to obtain a narrow beam or high gain, a large waveguide would be needed.

As shown in part 2 of this series (March) once a certain, fairly limited, range of waveguide dimensions had been exceeded, then higher-order modes can propagate. So that using oversized waveguide to obtain a larger effective area is not recommended; any higher modes appearing would serve only to waste power and to distort the radiated pattern. Instead, the technique used is to flare out the waveguide dimensions in a controlled way to form a waveguide horn. If only two sides of a rectangular guide are flared, this is called either an E or H-plane sectoral horn as in Fig. 2; while flaring in other directions as well produces pyramidal and conical horns.

Higher-order modes can be generated at a discontinuity in a transmission line, although in the case of a guide below cut-off, they are rapidly attenuated. The horn flare angle must be chosen so that any higher-modes generated at the throat of the horn are suppressed by the time they reach horn dimensions wherein they can propagate. Within this constraint, the gain of a sectoral horn increases with increasing aperture area.

If the axial length L of the horn is kept constant, together with the height b (in the case of the E-plane horn), and the aperture then widened, the gain steadily increases, passes through a maximum and then decreases. Horns with dimensions corresponding to this maximum are called optimum horns and Fig. 3(a) shows the variation in directivity of the E-plane sectoral horn for various axial lengths. Similar results obtain for the H-plane horn with constant L and a, and are shown in Fig. 3(b).

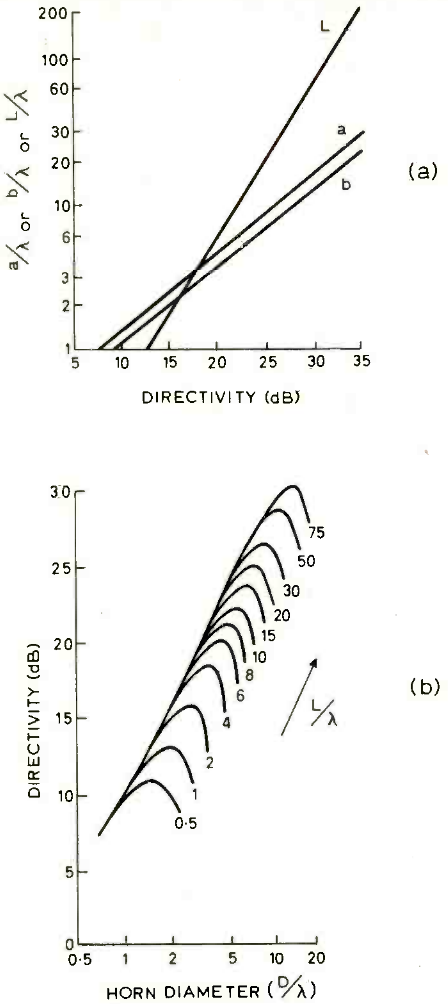


Fig. 4. In similar fashion to the sectoral horns, the pyramidal and conical versions also have optimum aperture dimensions for a fixed length. Directivities are plotted for (a) pyramidal horn and (b) conical horn.

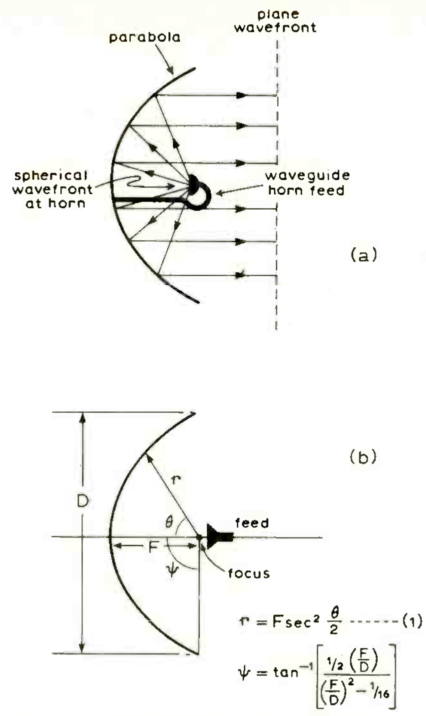


Fig. 5. Paraboloid reflector can produce high directivity and a narrow, pencil beam and allows side-lobe level control by proper design of the feed. Because all path-lengths from the feed to the far field are equal, the paraboloid converts the initially spherical wavefront into a plane-wavefront, collimated beam.

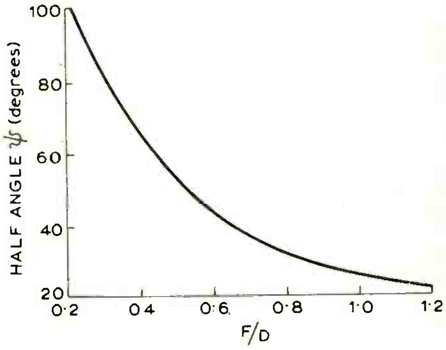


Fig. 6. For a quick estimate of feed-horn performance, this graph presents the half-angle ψ as a function of F/D ratio.

By combining the E and H-plane flares, the pyramidal horn is produced and, because the radiating mechanism is well-understood, enabling the gain to be accurately calculated, this type of horn is often used as a gain standard. Theoretically, the directivity of the pyramidal horn can be obtained from the sectoral horn directivities, D_E and D_H and is $D_E D_H \pi\lambda^2/32ab$. Optimum dimensions for this type of horn are summarized in Fig. 4(a). For example, a horn with a 25-dB directivity and of optimum proportions would have a length of 20 wavelengths and an aperture of 8.3 by 6.7 wavelengths.

Finally, circular waveguide can be used to produce the conical horn, the optimum dimensions versus directivity of which are plotted in Fig. 4(b). The dimensions of pyramidal and conical horns are very similar for a particular gain so, in that respect, there is no advantage of one over the other. The conical shape is more suited to a circularly-polarized antenna, but the useful waveguide bandwidth is lower in circular than in rectangular guide.

Reflector antenna

A widely-used class of antenna fully exploits the advantages of the small microwave wavelengths to produce a highly-directive narrow beam from a conveniently-sized aperture. This is the reflector antenna and consists of a small radiator called the primary source or feed, which is used to illuminate a large reflecting dish which reflects radiation into space in the form of a concentrated beam. The feed can be of any convenient design, but the pyramidal or conical horn is widely used. For the main dish a paraboloidal contour finds most application, the geometry of the system being shown in Fig. 5 together with some important relationships.

The parabola has two important properties which account for its wide usage. Firstly, with the feed placed at the focus of the parabola, reflected rays are concentrated within a beam parallel to the axis. Conversely, when used as a receiver, the incident radiation on the main dish will be focused to the one point on the axis. Secondly, the path lengths of rays from the focus to the reflector and out into the distance are the same. This means that, for a small feed and large dish, the feed appears as a point source with a spherical wavefront which is converted by a parabola into a plane wavefront having a uniform phase. Because the reflecting dish is usually several tens of wavelengths in diameter high gains can be achieved, 30 to 45dB being typical, resulting in beamwidths of less than 2° and making the system eminently suitable for target-tracking radar or as part of a low signal-strength receiver.

When designing a parabolic reflector, one of the first parameters to settle is the ratio of focal length to dish diameter (F/D). This is determined by both mechanical and electrical considerations, a small ratio meaning a deep dish and a large ratio meaning a very shallow one, both have their problems when it comes to mounting both dish and feed. In addition, the small diameter, large focal length dish requires a larger feed to produce the narrower illuminating beam, thereby introducing more aperture blocking, while the large dish makes feed design difficult in obtaining a uniform phase. Generally, parabolas have an F/D ratio of between 0.3 and 0.5.

Another important factor in this type of antenna and one which affects the overall efficiency is the variation in field amplitude across the aperture of the reflector. For maximum gain, a uniformly illuminated aperture is required, and to obtain that with this system, a paraboloid with large F/D ratio and a very wide-beam feed would be needed. With such a feed, a lot of the radiated power would spill over the edge of the reflector and be lost, defeating the object. On the other hand, the dish diameter could be increased, giving a small F/D ratio and intercepting more of the feed radiation. Efficiency would then fall because of the departure from a non-uniform field distribution. There would thus seem to be a compromise situation between these two effects and it is found in practice that optimum efficiency occurs for a reflector illumination such that the power level at the edge is 10 to 12 dB below that of the centre. In this case, the level of the first side-lobes below the main beam is about 23 dB.

Often, maximum gain is not all-important and a lower side-lobe level is desired, so for a sacrifice of 1 to 2 dB of gain, decreasing the edge illumination to 20 dB gives a side lobe level of about −26 dB. Clearly then, the radiation pattern of the feed is of utmost importance in controlling the efficiency of the system.

When assessing the design of a paraboloidal reflector, some useful relationships can be presented in graphical form. Equation 2 of Fig. 5, for instance, is plotted in Fig. 6 to give the subtended half-angle of the feed on the dish. Having chosen F/D, the half-angle can be used to determine the radiation pattern of the feed required to produce a particular illumination taper.

First, a correction factor must be applied. Referring to Fig. 5, the path length of a ray, r, increases as its axial angle θ increases. So as the power level of a spherical wavefront varies as the inverse square of path length, there is already some aperture taper across the paraboloid. The amount of attenuation is $20 \log_{10} (r/F)$ which from equation 1 can be written as $20 \log_{10} \sec^2 (\theta/2)$ and is plotted in Fig. 7.

Suppose we had a paraboloid with an F/D of 0.35 and we require an edge taper level of -15 dB. Fig. 6 shows that the subtended half-angle is about 71°, resulting in an inverse-square attenuation of 3.6 dB. This means that 3.6 dB of the required 15 dB is inherent in the system and, therefore, the feed has to have a radiation pattern which is only 11.4 dB down on its peak at an angle of 71°.

By taking into account the E and H-plane radiation characteristics of the feed, together with the dish illumination required, it is possible to define an overall directivity for the reflector system. The useful expression emerging is $D = D_E + D_H + 10 \log_{10} A/\lambda^2$ (dB) where A is the area of the reflector, and equals $\pi D^2/4$ for a circular parabola. Directivity factors D_E and D_H take into account the illumination taper and the type of feed. A popular feed is the pyramidal horn and for this case the directivity factors are plotted in Fig. 8. Thus, if the reflector of the previous example was required to have a directivity of 40 dB at a frequency of 20,000 MHz, $D_E = 4.8$ dB and $D_H = 4.5$ dB. So, $10 \log_{10} \pi D^2/4\lambda^2 = 30.7$ dB and the reflector diameter would need to be 58 cm. In practice, there are more losses associated with the system and typical efficiencies lie between 55 and 65%.

Finally, from the relationship given earlier between beamwidth and directivity, a rough estimate of the 3-dB beamwidth is $70\lambda/D$ degrees. In the above example, the beamwidth will be just under 2°. This serves to demonstrate the highly directive type of beam which can be produced by this type of moderately-sized antenna at microwave frequencies.

One problem that exists with this type of antenna arises from the physical presence of the feed in the aperture of the main reflector. Firstly, the feed and its support introduce aperture blocking or shadowing which has the effect of reducing the gain and degrading the sidelobe level. As the transverse feed dimensions do not change markedly with dish diameter, this effect obviously gets worse for smaller reflectors. Secondly, there is interaction between feed and dish, in that energy reflected from near the axis of the paraboloid enters the feed aperture and interacts with the primary radiation. The effect is similar to a condition of mismatch and impairs the radiation efficiency of the feed. To counteract this, various matching devices can be incorporated in the feed, or, as shown in Fig. 9(a) a plate can be placed at the apex of the paraboloid and its size and position adjusted until the reflected signal is equal in amplitude but opposite in phase to signals arriving from other parts around the apex. Under these conditions, cancellation of the mismatch occurs.

Fig. 9(b) illustrates another technique: that of offsetting the feed. The feed is still placed at the focus of the paraboloid, but is inclined to illuminate an off-centre section and the remainder of the reflector can be removed. There is no longer any aperture blocking, nor any feed/reflector mismatch effects. The main advantage of the offset feed is that it gives several dB improvement in sidelobe level. The aperture field distribution is no longer symmetrical and at offset angles greater than about 15°, transversely-polarized field components and an effective broadening of the radiation pattern start to significantly reduce the gain.

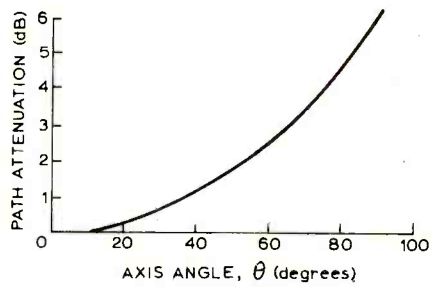


Fig. 7. Natural $1/r^2$ variation in radiated energy contributes towards the aperture taper and must be taken into account when designing the feed.

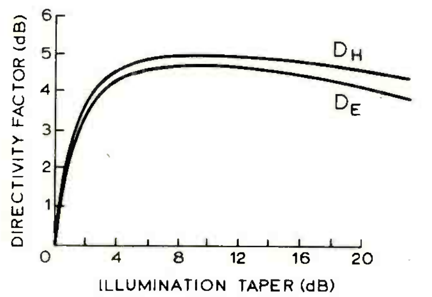


Fig. 8. Directivity of the complete parabolic aerial can be estimated with relation to the feed parameters. Plotted here are E- and H-plane directivity factors for a pyramidal horn.

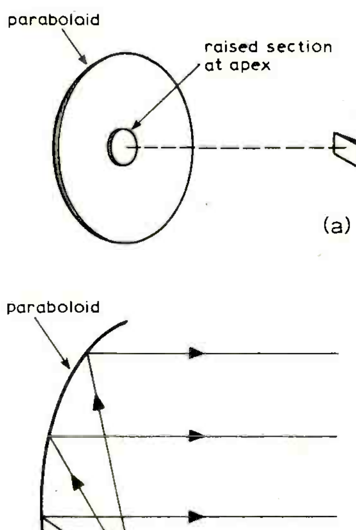


Fig. 9. Aperture blocking by the feed reduces the gain and degrades the side-lobe level of the paraboloid antenna and several methods exist for reducing the effect. Two are shown (a) raising the apex of the dish and (b) offsetting the feed.

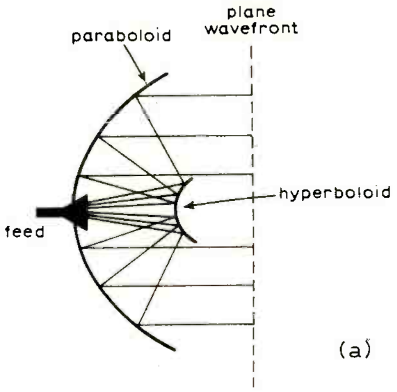
Cassegrain antenna

A widely-used variation of the simple paraboloid reflector is the Cassegrain system, which operates on the same principles as the optical versions in telescopes. Fig. 10 shows the general layout, together with some important geometrical relationships. An extra element has been added in the form of a hyperboloid sub-reflector and the position of the primary feed has been changed. The hyperboloid has two focal points, one real and one virtual, which are made to coincide with the feed position in one case and the focus of the paraboloidal main reflector in the other. The effect of this arrangement can be seen from the ray-tracing of Fig. 10(a) where an image of the real feed is produced at the virtual focus. Thus, as far as the paraboloid is concerned, it is being illuminated from this point and we have the system already described. Because of the magnifying properties of an hyperbola the image feed has a smaller effective area than the real one, but a correspondingly broader beamwidth and this can be used to advantage in cases where the feed is bulky.

One of the *raisons d'etre* of the Cassegrain system is that it has an effective focal length which is larger than the focal length of the paraboloid by a factor equal to the magnification. A paraboloid with a particular F/D ratio can be made to have the same effect as one with a larger ratio by using the Cassegrain system. As regards tapering the aperture illumination of the main dish, this is done in similar fashion to that already described. The difference in the Cassegrain system is that the focal length of the paraboloid is now the effective focal length. For simplicity, only the true Cassegrain parabola/hyperbola system has been mentioned, but to obtain various combinations of beam shape and aperture-blocking, the sub-reflector can be varied from convex to flat to concave and can also be elliptical. Similarly with the main reflector.

Aperture blocking itself is more serious with the Cassegrain type of antenna because the sub-reflector tends to be larger than a simple feed. Several methods exist for minimizing this, one of which depends on an optimum choice of dimensions for both feed and sub-reflector. Fig. 10(a) shows that the sub-reflector diameter may be reduced either by bringing it closer to the feed, or by making the feed itself more directive. After a certain point the stage is reached where the shadowing caused by the feed on the paraboloid is greater than the blocking due to the sub-reflector. There thus exists an optimum when the shadows projected by the sub-reflector and feed are equal in area.

A second technique, the principles of which will be covered in a later article, makes use of the fact that it is not necessary



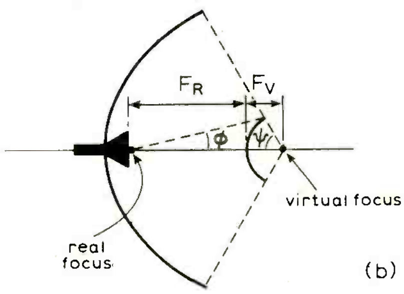


Fig. 10. Cassegrain antenna uses an additional element in the form of an hyperbolic sub-reflector and has an effective focal length which is longer than the focal length of the parabola. An image of the feed is formed at the virtual focus and illuminating radiation appears as coming from this point.

to have a solid metal dish to reflect energy. A properly designed grating of wires will do the job just as well, reflecting radiation whose electric field vector is parallel to the wires. For an E-vector perpendicular to the wires, the grating appears transparent and the radiation can pass through undisturbed. Also, by using a wire grating, it is possible to construct a reflector which will rotate the polarization of the incident radiation. So the sub-reflector could be made of a grid of horizontal wires and the main parabolic dish could incorporate a polarization-twisting arrangement. Horizontally-polarized radiation from the feed would be reflected from the sub-reflector onto the main dish and would emerge as a vertically-polarized field, to which the sub-reflector is transparent. Thus—no aperture blockage by the sub-reflector. It is evident that this system can only be used with singly-polarized antennae.

Besides the ability to tolerate a large feed, the Cassegrain antenna has several other advantages over the simple parabolic reflector. Having the feed tucked away at the rear of the dish eliminates the relatively long waveguide run and the associated losses. Although perhaps only a fraction of a dB, this is important to low-noise receivers such as might be used in radio-telescope and communication systems. Because of the positioning of the feed, there is also less noise introduced into the Cassegrain system by spill-over radiation being reflected from the ground.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

"Laser trimming techniques for thick film resistors" is a 6-page publication describing the advantages and use of laser trimming techniques. DuPont de Nemours International S.A., Post Office Box CH-1211, Geneva 24, Switzerland .... WW 401

PASSIVE DEVICES

"Precision Self-latching Electrical Connectors" is a wall chart containing details of the sizes, make-up, and electrical characteristics of standard Lemo connectors from size 00 to 06. Lemo (U.K.) Ltd, Worthing House, 6 South Street, Worthing, Sussex, BN11 3AE .... WW 402

EQUIPMENT

We have received a data sheet describing the series RO200C Parallel Display Controllers which provide alphanumeric data display from a computer data bus. Output is composite video, compatible with E.I.A. standard 525-line video monitors. Ann Arbor Terminals Inc., 6107 Jackson Road, Ann Arbor, Michigan 48103, U.S.A. .... WW 403

A leaflet describing a series of on-line and off-line electrostatic proofers designed for use with phototypesetting systems explains the "Matrix Electrostatic Writing Technique" and illustrates how Versatec Matrix Proofers fit into the proofing cycle of a phototypeset publication. Versatec Inc., 10100 Bubb Road, Cupertino, California 95014, U.S.A. .... WW 404

The HP-45 and HP-46 are pocket and desk top calculators respectively which are described in a leaflet sent to us by Hewlett-Packard Ltd. 224 Bath Road, Slough, Bucks. SL1 4DS.

Electrical and pneumatic input strip indicators are the subject of a brochure we have received. These instruments are designed in two ranges for use in control room and on-plant environments. Andrew Salanson, Penny & Giles Ltd, Mudeford, Christchurch, Hampshire BH23 4AT ..... WW 405

A six-page leaflet illustrating a comprehensive selection from their current range of electrical indicating instruments provides a selection guide for all standard ranges of Crompton instruments for applications ranging from educational and medical to industrial and military use. Crompton Parkinson Ltd, 50/52 Marefair, Northampton NN1 1NY .... WW 406

Bahco Tools Ltd, 266B St. Ann's Road, Tottenham, London N.15, has published a leaflet containing illustrations, dimensions and cutting capacities of the range of sixteen types of pliers and nippers developed by Bahco of Sweden .... WW 407

We have received four brochures on new products which B. Hepworth are to handle for the Hickok company of America. B. Hepworth & Co., P.O. Box 10, Chemical Works, Kidderminster, Worcestershire.

- Basic electronic systems technology .... WW 408
- Fluid power teaching systems .... WW 409
- Numerical control .... WW 410
- Electronics equipment for vocational/technical programs .... WW 411

GENERAL INFORMATION

The British Overseas Trade Board has published a 1973 edition of its Export Handbook for British firms trading abroad. The book is an up to date description of all the Government services available for exporters, together with mention of private agencies, addresses and a bibliography. British Overseas Trade Board, 1 Victoria Street, London S.W.1 .... WW 412

The Middlesex Polytechnic Prospectus for 1973-74 describes the available degree, postgraduate, diploma, certificate and short courses. Entry requirements are also listed. Middlesex Polytechnic, P.O. Box 40, Enfield, Middlesex EN3 4SF .... WW 413

"Training for Company Secretaryship" is one of a series of booklets published by the Department of Employment dealing with commercial and administrative occupations prepared in accordance with the procedure laid down in the Central Training Council's Memorandum No.7 for "training standards for occupations common to a number of industries". Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB .... Price 25p.

Announcements

The product range of **Integrated Photomatrix Ltd**, Dorchester, Dorset, is now handled in the United States by a subsidiary company, Integrated Photomatrix Inc. The new company is based at 1101 Bristol Road, Mountainside, New Jersey 07092.

"Stereo and Public Address Systems" and **"Video Recording"** are two courses to be presented (one lecture per week commencing in October) at Norwood Technical College, Main Building, Knight's Hill, London SE27 OTX. Applications to the Senior Administrative Officer.

Rendar Instruments Ltd have appointed Edmundson Electronic Components as their franchised distributors covering the South-East of England and the Midlands. This appointment completes a country-wide distribution network for Rendar. Customers in the South-East should place their orders for Rendar products through Edmundson Electronic Components, 30/50 Ossory Road, London SE1 5AN. Customers in the Midlands should use the Birmingham office at 40/45 Lower Tower Street, Birmingham 19. Products include control knobs, jack plugs and sockets, switches and DIN plugs.

A five day course on **"Image Processing"** will be held from 12th – 16th November at the Campus Inn, 1920 Northwestern Avenue, West Lafayette, Indiana. The course is intended to familiarize engineers and scientists with the state of the art of optical and digital image processing. For additional information contact Paul A. Wintz, Course Chairman, 605 Lingle Avenue, Lafayette, Indiana 47901, U.S.A.

Total Communications

Switching-centre applications: concluding part of an article on two-way information systems

by E. J. Gargini, * *M.I.E.E., M.I.E.R.E.*

The first part of this article (September issue) concluded with a discussion of central switching systems for use in two-way information services. In this second part I shall briefly review the progress of the Rediffusion Dial-a-Program (DAP) central switching system, using it as an indication of possible future developments.[10]

The basic DAP exchange frame comprises a 12096 cross-point system, using magnet-operated reed switches, for connecting any one of 36 input lines to any one (or more than one) of 336 output lines. After the introduction of a small-scale DAP installation at Thames Television, Teddington, a prototype exchange — capable of operating on 36 channels, but with active equipment for 12 off-air channels and a few locally originated or two-way transmissions — was installed at Dennisport in Cape Cod, U.S.A., together with a network to reach 250 dwellings in an area of about one-third

* Rediffusion Engineering Ltd.

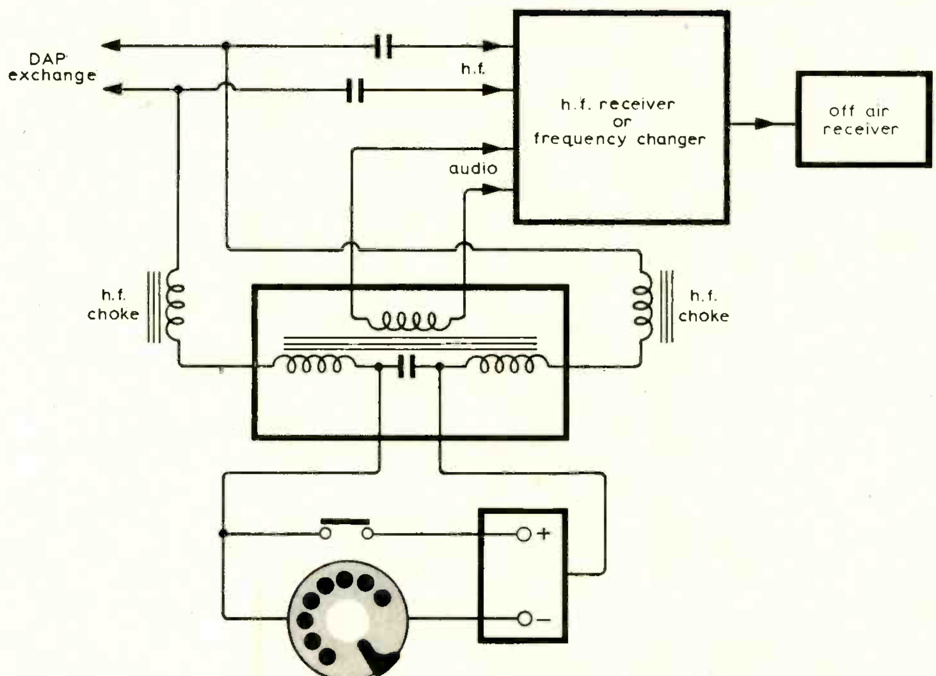


Fig.8 Subscriber's dial unit for two-wire Dial-a-Program system.

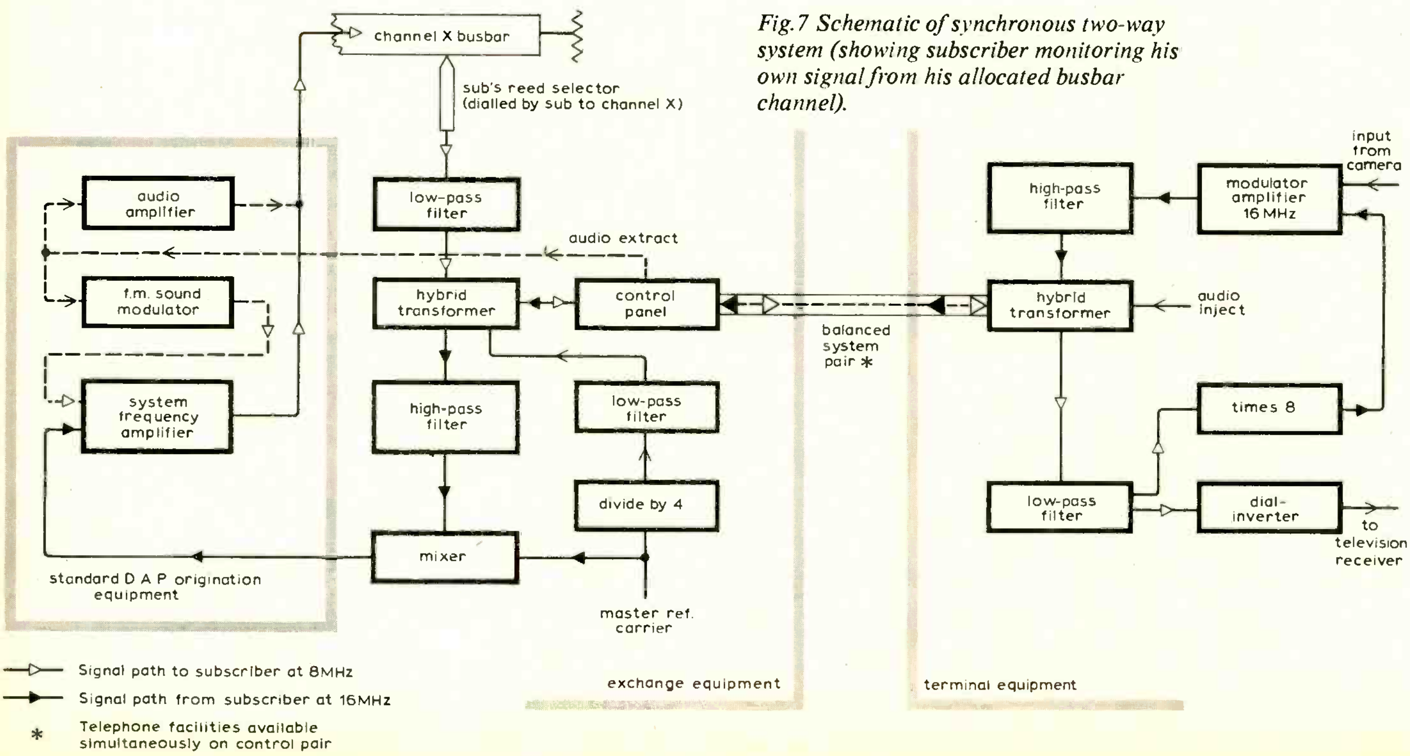


Fig.7 Schematic of synchronous two-way system (showing subscriber monitoring his own signal from his allocated busbar channel).

of a square mile. Extra lines were made available to feed extra points in half these homes. Some 160 homes are at present using this service, which became operational in August 1970. This prototype installation was undertaken as an engineering field test of the system. The results have been entirely satisfactory, both in quality of television transmission and in reliability. There has been no reported reed switch fault or failure of the distribution network, despite quite wide variation of temperature.

The Cape Cod installation includes two experimental additions which have to do with the communication concept: (1) Television cameras have been operated at two distribution points on the network, i.e. with two-way television signals passing in opposite directions on the same cable circuit; one provides local shoppers with current prices in a small supermarket, the second was used for demonstration purposes. (2) The control pair of the DAP system has been used for telephone purposes on a dedicated basis in conjunction with a two-wire version of DAP, i.e. a DAP system in which dialling and resetting signals are carried on the pair which carries the selected television signals.

Fig. 7 indicates the operation of the two-way television system in which the subscriber originated signal is sent to the exchange on a carrier frequency of twice that of output signals from the exchange. Fig. 8 shows the arrangement of the subscriber's dial unit for the two-wire DAP system.

Fig. 9 shows an application of DAP central switching now installed and working at the Case Western Reserve University at Cleveland, Ohio, U.S.A. In this system the control pair is used on a shared basis — for DAP signalling and for two-way telephonic communication between students and the video tape machine operator. The dial units can be adapted later to include a touch tone signalling system which will permit the student to control video tape machines directly.

The two-way television filtering and frequency changing equipment permits vision signal origination from a number of lecture halls which also serve as viewing centres. This equipment is of course portable and the two-way capability of the DAP system permits the use of cameras from any outlet point; thus separate feed lines for remote programme origination are not required.

Fig. 10 is an outline of a DAP installation at the Nova Park Hotel, Zurich, Switzerland, which has just become operational. This installation is a joint undertaking by Rediffusion International, Rediffusion AG, which is an independent company, and Philips. The system, when completed, will deal with a number of off-air channels and 54 locally originated channels. Eighteen of the locally originated channels and initially six channels from off-air sources will be applied to the DAP exchanges for direct selection by dialling. The remaining 36 locally originated channels will be routed to individual subscribers or groups of up to ten subscribers manually on the programme patching panel indicated. All subscribers have provision on the channel 10 position to receive a dedicated input from the patching panel, and to obtain this service the subscriber will dial a zero and use his telephone. The Nova Park Hotel is to be used as a conference centre and conference television will be available only to delegates. A "denial" panel equipped with switches for each of 560 rooms will enable hotel staff to permit conference viewing only in rooms assigned to delegates. The switches are three-position types and control the viewing of two or three classes of programme. A programme "denial" panel is provided for placing any

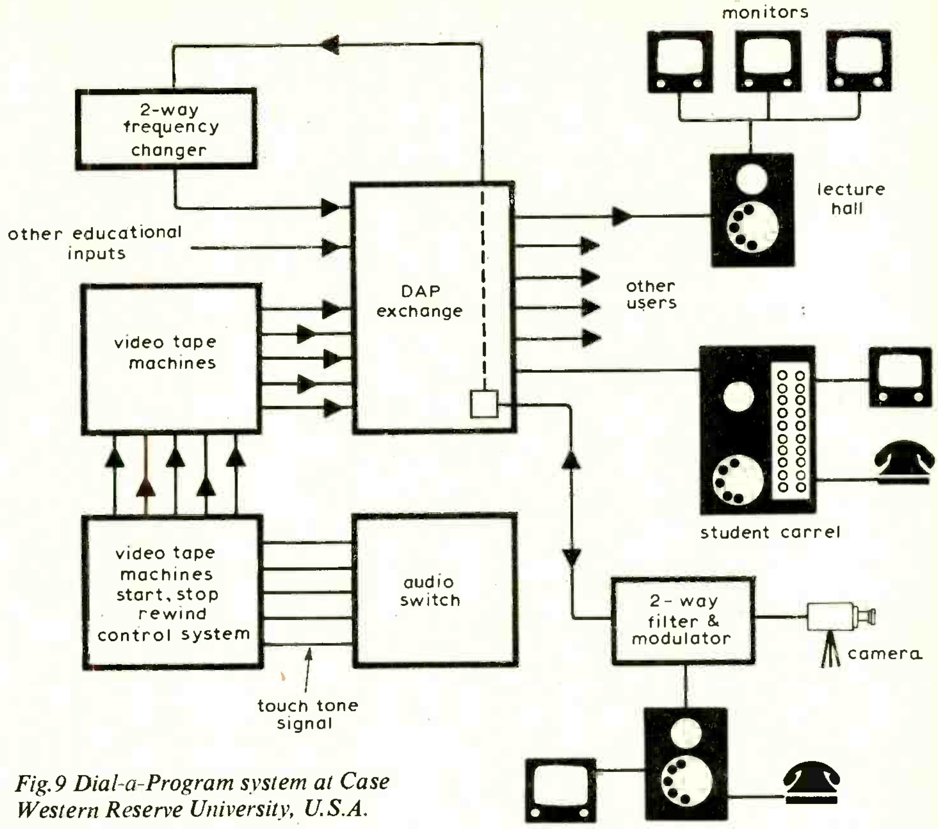


Fig. 9 Dial-a-Program system at Case Western Reserve University, U.S.A.

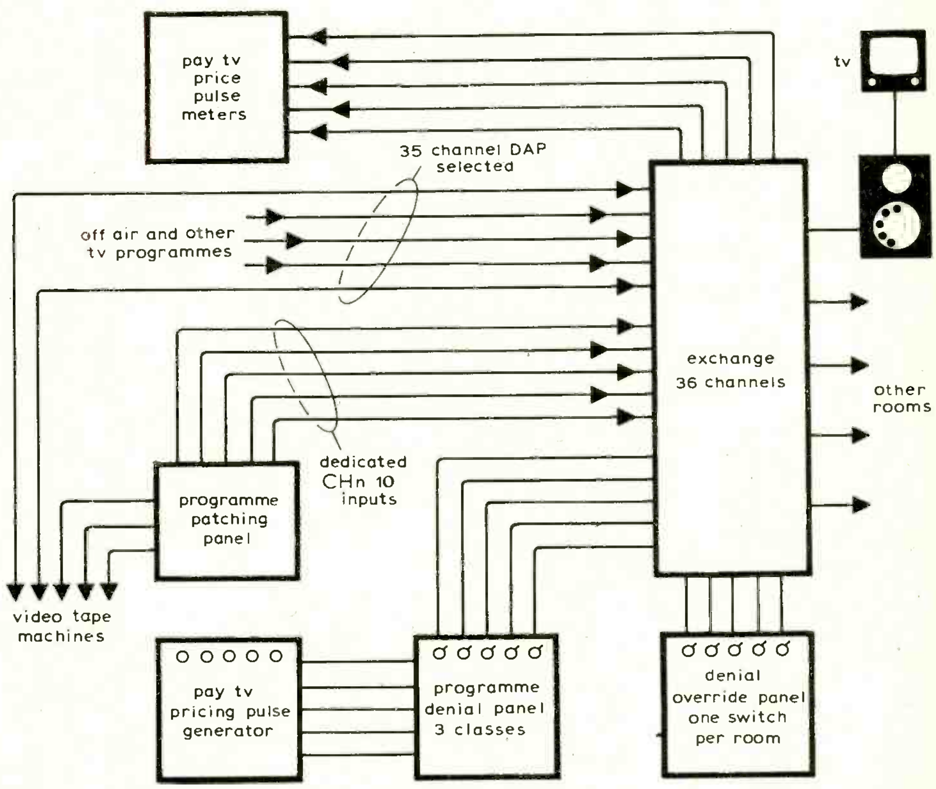


Fig. 10 Dial-a-Program conference hotel system in Zurich.

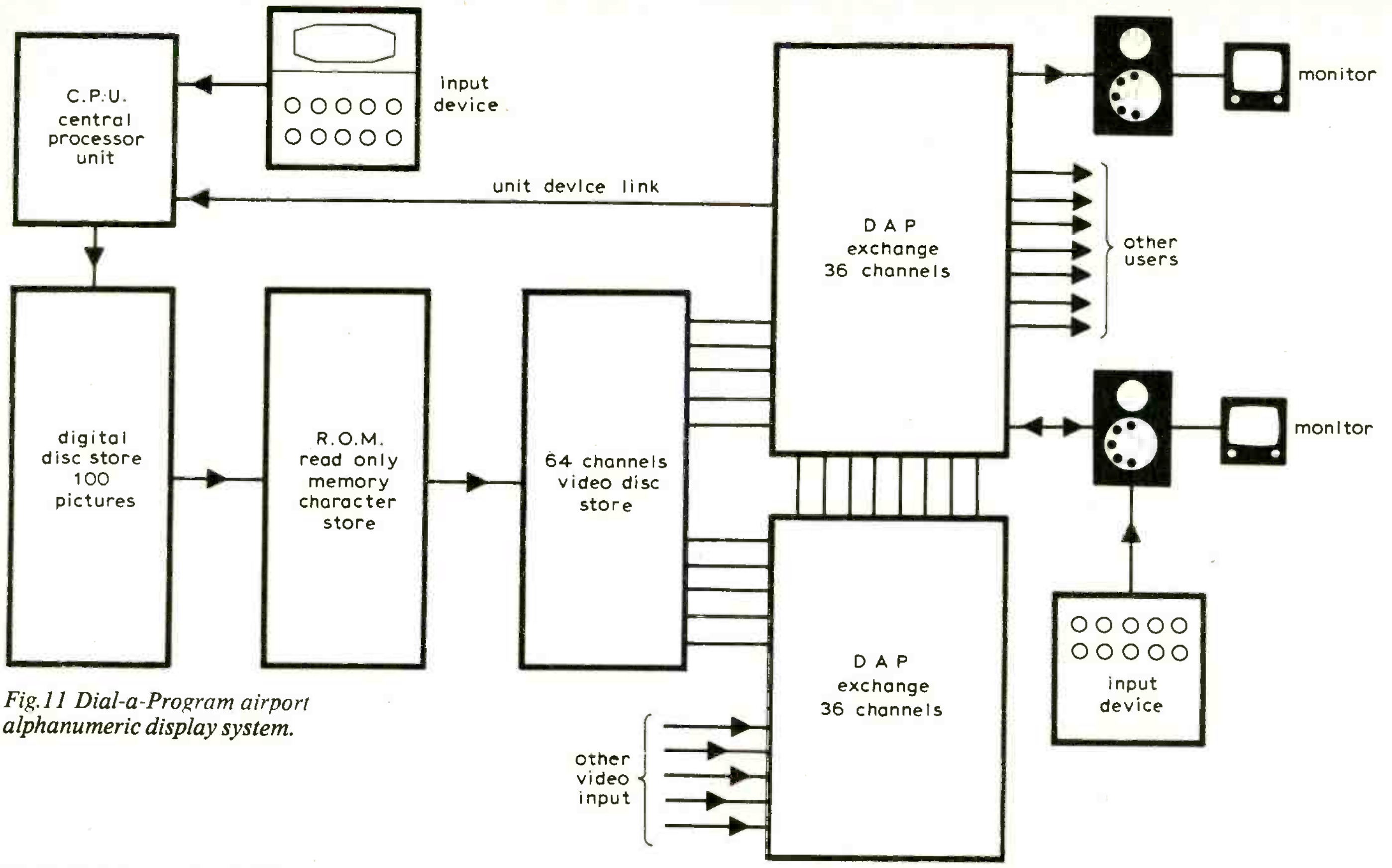
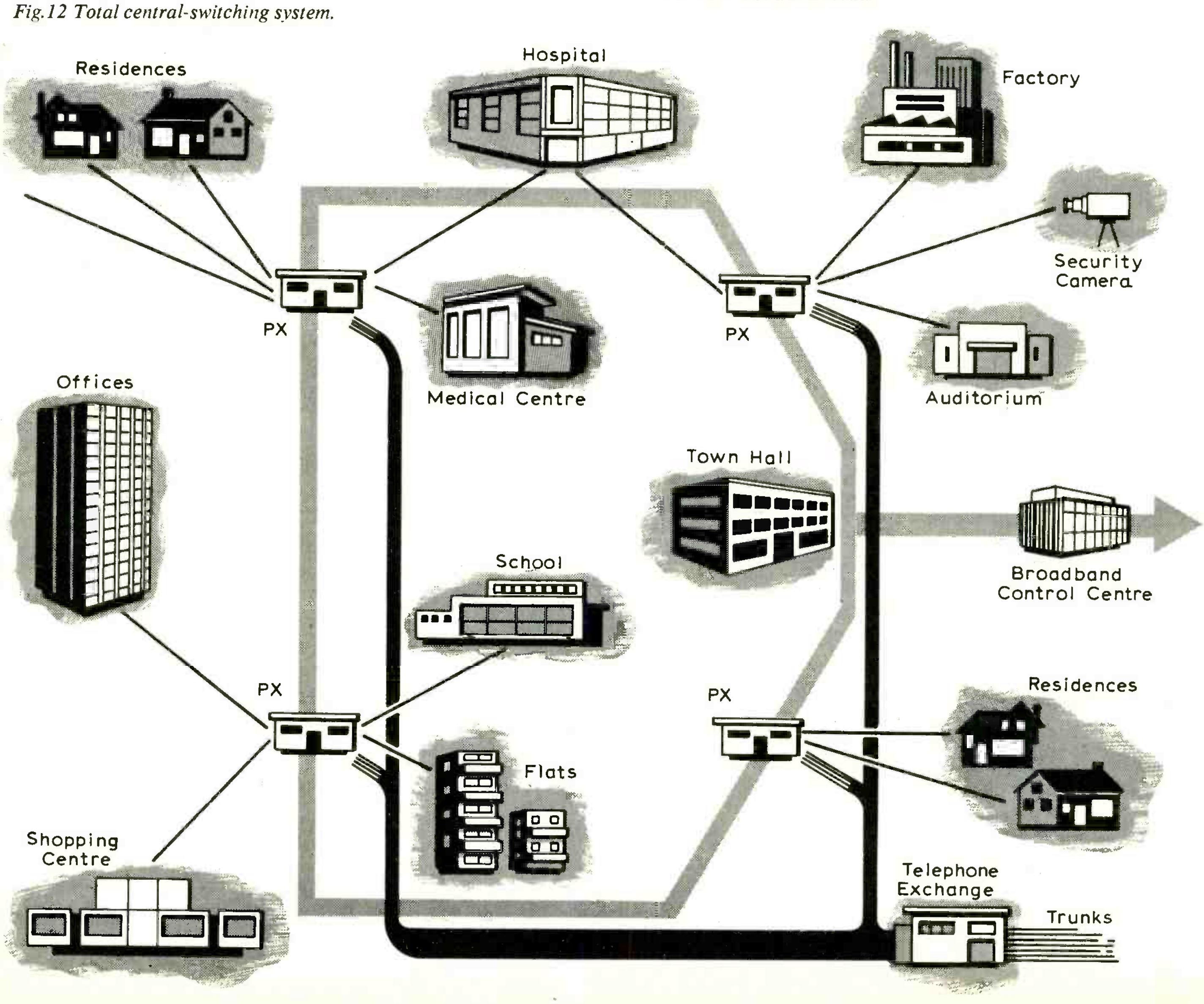


Fig.11 Dial-a-Program airport alphanumeric display system.

Fig.12 Total central-switching system.



one or more of the 36 DAP busbar channels into the three classes, i.e. two "denial" and one "non-denial".

A feature of the system is that any one or more channels can be pay-television channels, and a pricing panel is included for generating pay-TV pulses on selected channels at a rate determined by the value of the programme. Pay-TV meters, one per room, record the charge to be made to each guest.

Fig. 11 outlines a proposal for an alphanumeric system for airports and demonstrates the versatility of a central switching system. New alphanumeric information, i.e. flight arrival schedules, can be entered by keyboard into the central processor unit either directly or from any of the DAP outlet points using the two-way capability of the system to handle digital data.

Conclusions

I believe the future of telecommunication lies in a total communication system of the central switching type. Fig. 12 summarizes this concept as a marriage between the telephone system of a central exchange embracing a large area and a greater number of integrated television programme and telephone concentrators or local communication exchanges.

Some 85-90% of the wired network route in a town would be a network dedicated to individual subscribers; the remaining 10-15% would be network dedicated to bringing information into and out of communication exchanges. The subscriber network would deal with any amount of visual data and would not need replacement with development of the visual art.

Fig. 13 indicates the simplicity of equipment in the home for an integrated system which is capable of dealing with all the features discussed in this article. Fig. 14 outlines the main components of the integrated switching centre or communication exchange.

At an I. E. E. meeting early in 1972 it was suggested that telephone microprocessors could be used to organize and link up small exchanges or concentrators to large exchanges and that this possibility becomes more attractive as the cost of integrated circuits drops.

Perhaps an organization such as the Independent Communication Authority suggested by Professor H. M. Barlow[11] will be formed to consider these matters and to develop a total communication concept for the future.

Acknowledgements. I wish to acknowledge the work done by Rediffusion Engineering Ltd. and its engineers, particularly J. F. Pacey who was responsible for the installation and commissioning of the pilot Dial-a-Program projects in the U.S.A. I thank the directors of Rediffusion Engineering Ltd for permission to publish this article, although I would emphasize that the views expressed are personal and not necessarily the views of the company.

References

10. R. P. Gabriel. "Cable TV and the Wired City". Paper presented to I.E.E., 10th Nov.1971 (*Electronics & Power*, April 1972), also R. P. Gabriel. "Experience with the Dial-a-Program System". Paper presented to I.E.E.E. North East Regional Electronics Meeting (NEREM). Boston, Mass., 2nd-5th Nov.1971.

11. Prof. H. M. Barlow. "Telecommunications services in the U.K. Future development and overall policy", *National Electronics Review*, Vol.7. No.2, March/April 1971.

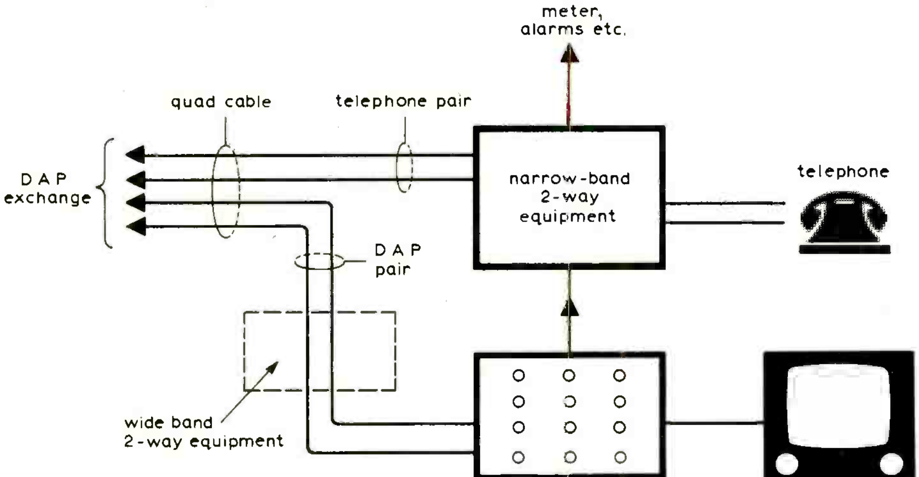


Fig.13 Home equipment for integrated Dial-a-Program/telephone system.

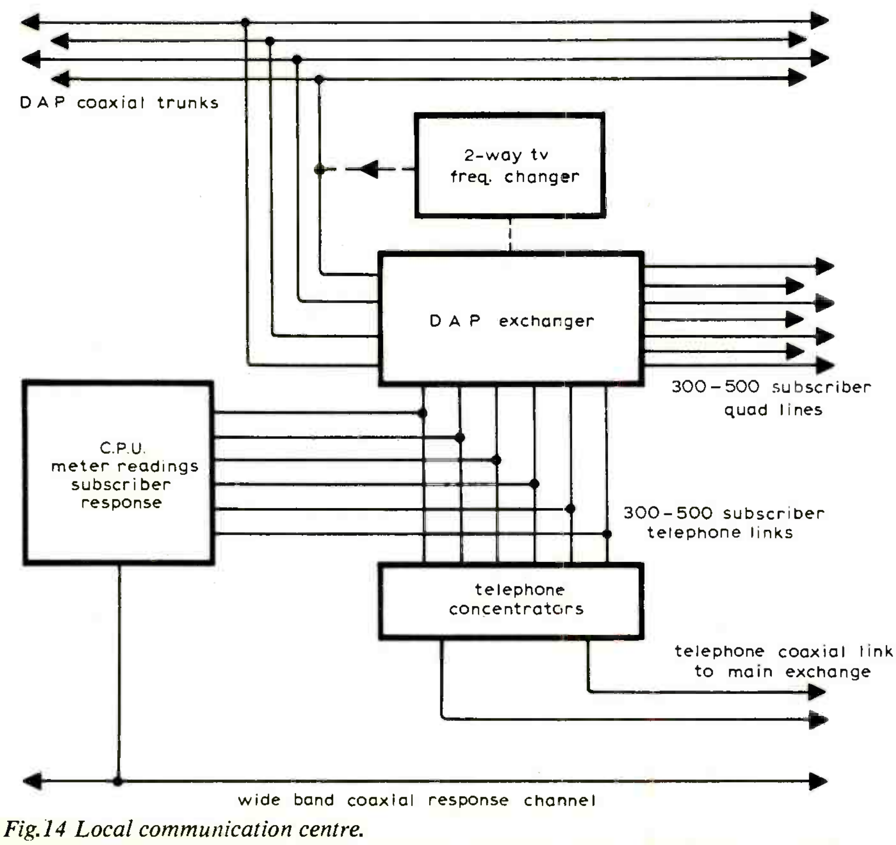


Fig.14 Local communication centre.

Presenting Maintenance Information

Techniques developed by B.B.C. use functional diagrams and minimum of text

by S.W. Amos, B.Sc., M.I.E.E.*

The introduction of the transistor and more particularly the integrated circuit have made possible the construction of extremely compact equipments. The extent of the miniaturization possible with modern solid-state devices is well illustrated by a typical integrated circuit which contains nearly one hundred transistors and as many resistors — all in a package measuring 1in by ¼in by ⅛in! An equipment with fifty such i.cs would contain nearly 5,000 transistors: to use such a wealth of active devices would have been unthinkable in the days of valves. It is practical to employ active devices in such prodigal numbers and thus to construct equipments of very great complexity because solid-state devices are inherently reliable. Nevertheless modern equipments do develop faults which must be found and corrected and this article is concerned generally with the maintenance of modern solid-state equipment and in particular with the form in which maintenance information is presented in the B.B.C.

Factors influencing the form of maintenance literature

The following three features of modern equipment have a direct influence on the form of maintenance literature:

1. The complexity of modern equipment can be such that only the designer understands it thoroughly, and he is unlikely to be enthusiastic about calls on his time to maintain one of his earlier designs. It follows that the equipment must be maintained by staff who do not understand its method of working in detail: they must, of course, understand or be capable of learning its operation in principle, otherwise they would be incapable of locating a fault.

2. Integrated circuits and other packaged components such as thick- and thin-film circuits cannot be repaired if they fail: they are replaced if faulty. Thus maintenance staff do not need a detailed knowledge of the internal circuitry of such devices. They must, however, know sufficient about the function of the device, its input and output voltage levels, terminating resistances etc., to be able to test it. Again, therefore, the maintenance man needs a general rather than a detailed knowledge of the active device.

3. Because breakdowns are rare in modern equipment, maintenance staff have little experience of tracing faults in it. When a fault does occur the maintenance man has the problem of locating the fault in an unfamiliar equipment. Thus the maintenance information must be designed to assist the rapid location of faulty areas.

Such observations prompted the B.B.C. Technical Publications Section to devote some time to experiments on the form in which maintenance information for modern equipment should be presented.

It had been known for some years that maintenance men tended to rely on circuit diagrams and did not normally read associated text unless the diagram failed to give the required information. It was decided therefore to concentrate on diagrammatic forms of presentation and to reduce text to a minimum. In early experimental forms of literature care was taken to ensure that the diagram and associated text could always be seen at the same time and the normal arrangement was for text and diagram to be on facing pages. This was an improvement on earlier layouts but still required readers to switch their attention from one page to the other in following the operation of a complex circuit. Each time the reader returned to the text or to the diagram he had to find his place and this was felt to be an undesirable interruption to the continuity of the story.

Use of functional diagrams

There is no need to give details of the circuitry of packaged components such as i.cs but the function of such components must be indicated, otherwise it is impossible to follow the diagram.

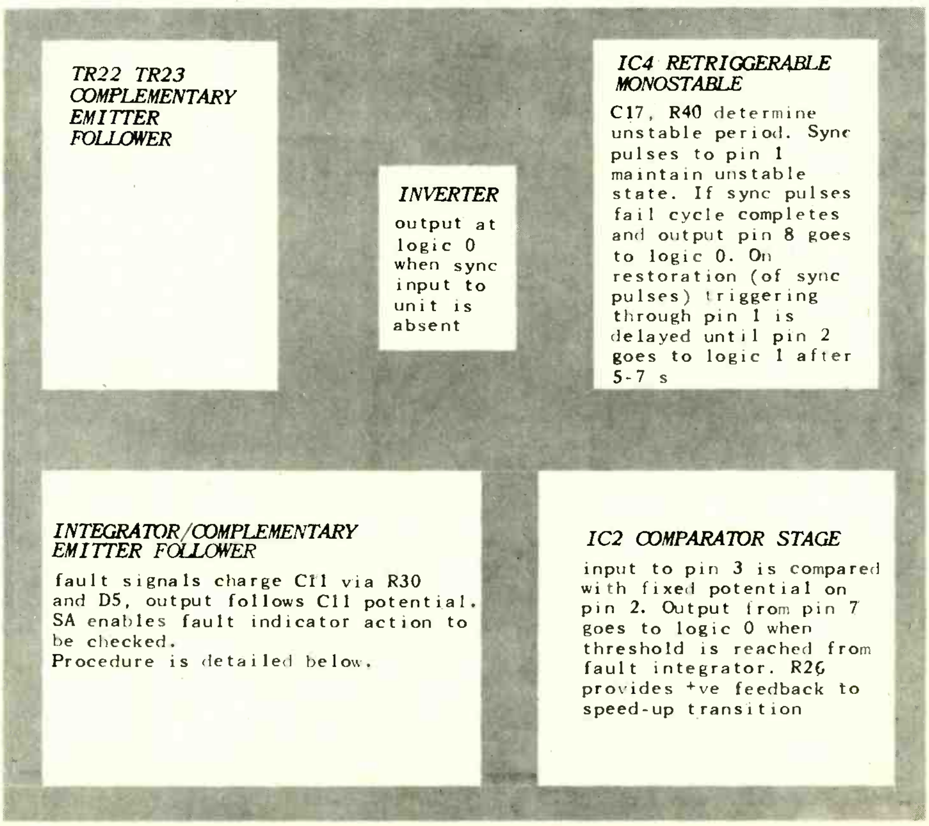


Fig. 1 Block text diagram facing circuit diagram, both divided into functional areas.

* B.B.C. Engineering Training Centre.

If the maintenance man is to be able to locate faults rapidly the diagram must show clearly the interrelationships between the stages which enable the equipment to achieve its purpose. Thus the diagram must show not only the function of i.cs but also those of other stages using for example discrete components. The functions of many basic circuits are obvious to experienced maintenance men because the circuits are (or should be) drawn with a standard layout which helps rapid recognition. Typical of such well-known circuits (which can be regarded as electronic building bricks) are common-emitter amplifiers, emitter followers, long-tailed pairs; a number of others are given in BS 3939. Although such circuits may be familiar they must be recognized before their function can be appreciated and this takes a finite time: recognition of an unfamiliar layout takes an even longer time. Thus it was decided that all stages should be labelled with their function.

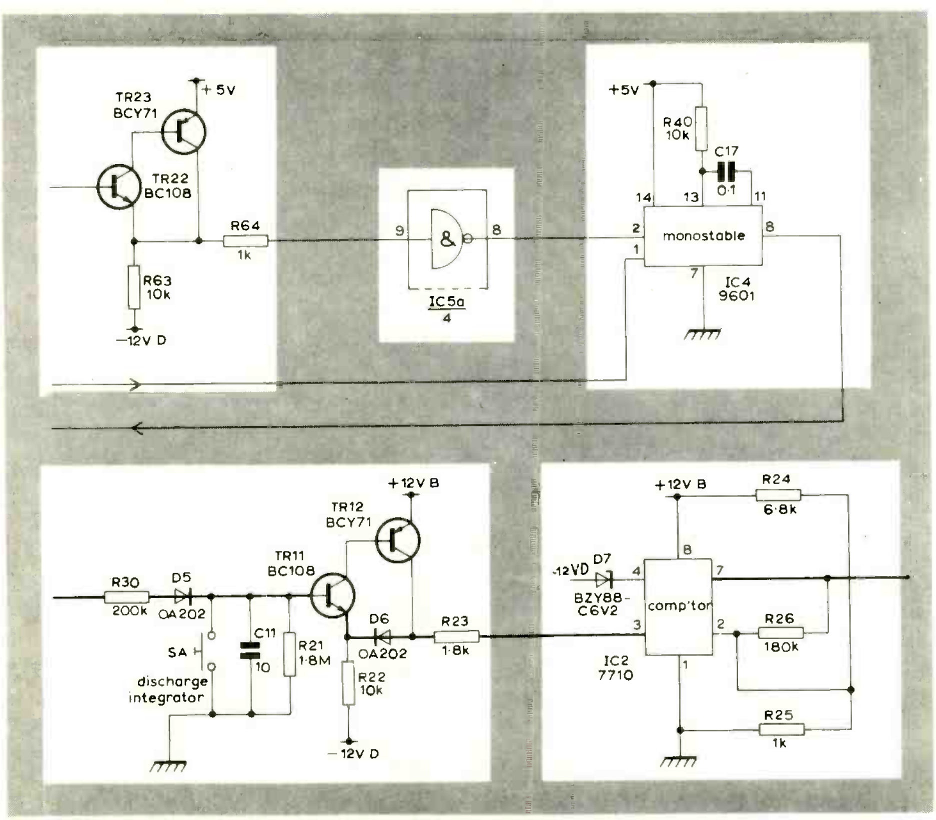
Great care is taken in arranging the functional blocks on the diagram to obtain a clear signal flow and whenever possible this is from left to right and from top to bottom of the diagram: main signal paths can be printed in heavy lines to distinguish them from subsidiary signal paths.

To define the boundaries of the functional stages these are printed on blue backgrounds (shown as white boxes in Figs. 1 and 2) so that the blue areas with the associated signal paths form a block diagram in which each block represents a mathematical or logical operation upon a signal. A light blue was chosen for the background colour

The illustrations in this article are taken from original drawings intended for reproduction on A3 size paper (approximately $16\frac{1}{2}$in by $11\frac{7}{8}$in) in BBC Technical Instructions. To obtain illustrations of a size suitable for publication in *Wireless World* only part of each diagram is reproduced — sufficient to show the type of presentation described in the article. The backgrounds of the functional areas in Figs. 1 and 2 are printed in blue in BBC Technical Instructions but are shown as white boxes in the article. The circuit diagram of Fig. 4 is intended for reproduction in black and the explanatory notes in red but in this article the circuit is shown in white and the notes in black.

because it does not impede reading of the circuit if this is printed on it in black. An important point about this kind of diagram is that each block represents a circuit function and not an item of hardware. It could happen, for a particular equipment, that functional and hardware boundaries coincide but in general they do not. Functional diagrams aid fault location because they illustrate the division of the equipment into functions and thus give directly the information required to test any individual stage: to permit this the diagram must include terminal numbers, pin and socket connections etc., so that the input and output connections of each stage can be found on the equipment itself.

It can be assumed that a number of basic circuits such as common-emitter amplifiers and emitter followers are so familiar to the maintenance staff that no text is necessary to explain their behaviour. Other circuits require text and this was located, in earlier maintenance instructions, on the page facing the functional diagram. To minimize the difficulty of locating the text for a particular functional block the text was also printed on blue backgrounds of the same size as those of the functional diagram and arranged in the same layout. An example of such a pair of facing pages is given in Fig. 1. It is certainly easy to find a wanted text of a functional circuit stage but this form of presentation is still open to the objection that the maintenance man must consult two pages and must switch his attention from one to the other in following explanations of circuit behaviour. This form of presentation can also be criticized on the grounds of duplication: the breakdown of the equipment into functional areas is shown twice, one on each page. Both difficulties can be overcome by dispensing with the block text diagram and including the text within the blue areas of each functional circuit. An example of this form of presentation is given in Fig. 2: this gives the maintenance man on one side of a piece of paper most of the information he is likely to require on the particular part of the circuit featured.



Levels of treatment

For ease in handling, diagrams are limited in size to A3 and these are folded to A4 format for inclusion in standard folders which can be accommodated in normal-sized filing cabinets. The information which can be contained on an A3 page is limited, particularly when it is combined with text, waveforms, tables and other items of information. Thus a number of diagrams, possibly as many as 20, are required to describe a complete equipment such as one capable of generating all the standard waveforms required to line up a picture monitor.

To break-down the circuitry into 20 diagrams without destroying the continuity of the treatment requires some thought, and the technique adopted is to present the information at a number of levels. The first diagram in the service manual (level 1) is a diagram of the complete equipment divided into its major functions which are limited to about 20 which is the maximum which can be accommodated on an A3 page with ancillary text while maintaining adequate clarity of presentation. To limit the number of functions may require some of the functions in the level-1 diagram to be complex, and at this stage it may be sufficient to label a function for example as a waveform processor (without indicating how many stages it contains). Clearly a diagram as general as this cannot contain details such as i.cs, transistors, resistors, etc.

In subsequent (level-2) diagrams these complex functions are split into simpler

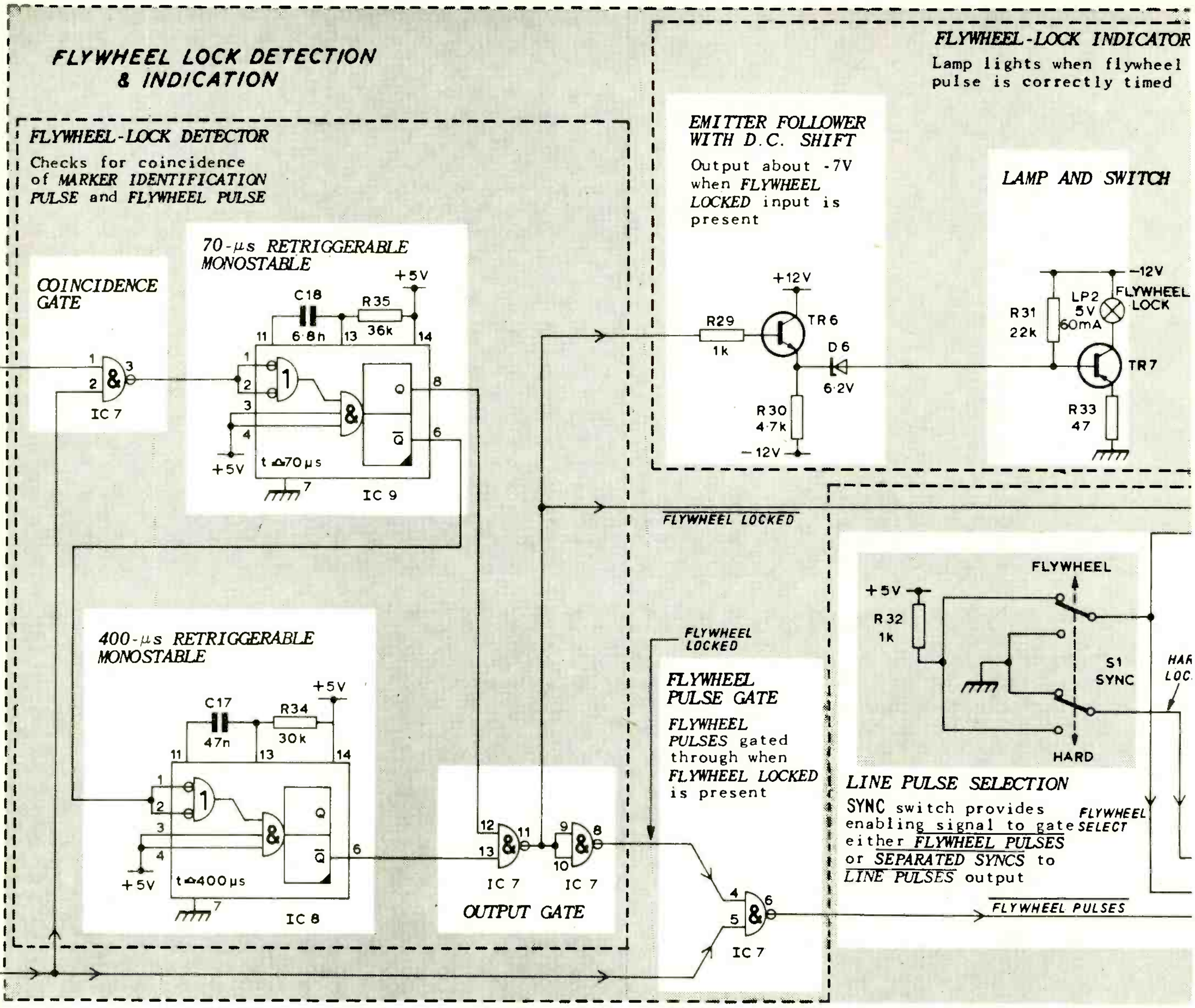
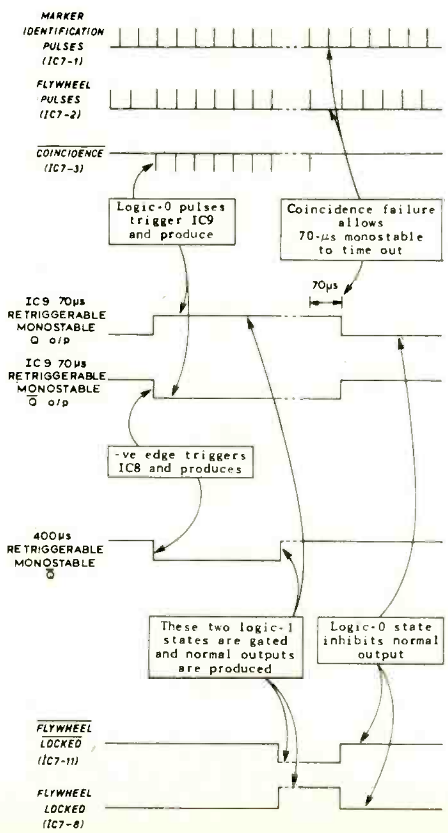


Fig. 2 Text combined with circuit diagram. Fig. 3 A waveform-text diagram.



functions, these being again chosen to keep the total number of blue blocks per page to below 20. It may be that the functions in the level-2 diagram are so simple that the circuitry can be included within the blocks without overcrowding the diagram: if not then the functions can be subdivided further to a third level at which circuit details can be included.

In all diagrams it is essential, of course, that the functional blocks should be laid out so as to emphasize the paths of signal flow.

Waveform diagrams

For certain types of equipment the circuit behaviour is best explained with the aid of waveform diagrams. If the account is given in conventional text with reference to separate waveform diagrams the explanations can become tedious. The usual method is to allocate letters to the edges and other significant features of the waveforms and to use these letters in referring to these features in the text. Such a technique has the disadvantages already mentioned that the reader has to switch his attention between text and drawing. The repeated need of the reader to find his place in text and drawing is frustrating and wastes time: it can be avoided by using the technique employed in the functional circuit diagram, i.e. by condensing the text to a minimum, breaking it into sections and by inserting these sections at appropriate points in the waveform diagram (Fig. 3). There is then no need to label the waveform features because they can be identified by arrows. To distinguish it from the waveform the text is printed in a different colour.

Relay circuits

Few examples of technical writing can be so boring and repetitious as detailed descriptions of the operation of a circuit including a large number of relays. It is better to provide the information in the form of a table designed to illustrate the sequence of operations. If it is possible perhaps the best method of explaining the operation of the circuit is on the circuit diagram itself. This might be possible, for example, by stringing the individual circuits between horizontal supply lines and arranging them in the order in which they operate. By adopting this method what little explanatory text is still needed can often be accommodated on the circuit diagram itself near the circuit in question, thus avoiding any need for separate textual description. A sample of such diagram is given in Fig. 4.

Algorithms

One way in which it is possible to help inexperienced staff to maintain equipment is by the provision of algorithms: these are charts which enable faulty areas to be found quickly. The charts state, for example, what signals should be present at certain points in the equipment and, if they are missing or distorted, indicate what the next test should be and where it should be applied to obtain further information on the location of the fault. Thus the algorithms give information on the logical steps in fault-finding which a skilled maintenance man would take instinctively. A sample of an algorithmic chart is given in Fig. 5.

Algorithms can be useful but the staff using them still need some experience in tracing faults. For example, an algorithm may suggest that if a certain waveform is missing at a particular test point then the fault lies in a specified area of the equipment. But the waveform could be absent because of a poor soldered connection at the test point itself. It is impossible to include all such possibilities in an algorithm and they are therefore of limited application.

Physical location of components

The maintenance aids described above should enable the maintenance man to locate a faulty area in an equipment. However, additional information is needed to enable him to find any particular circuit point physically in the equipment and this is necessary of course during fault location. Functional diagrams can

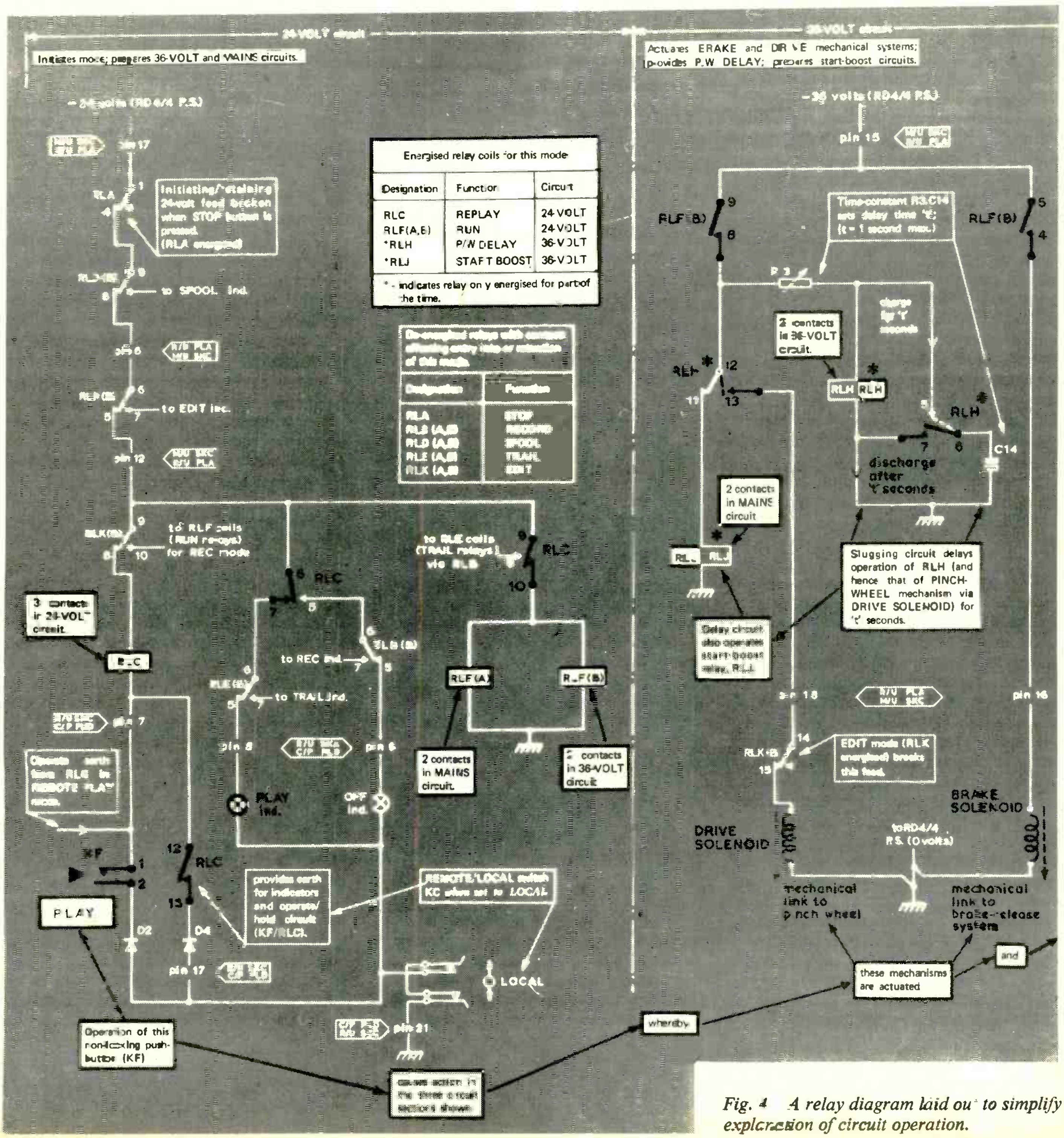


Fig. 4 A relay diagram laid out to simplify explanation of circuit operation.

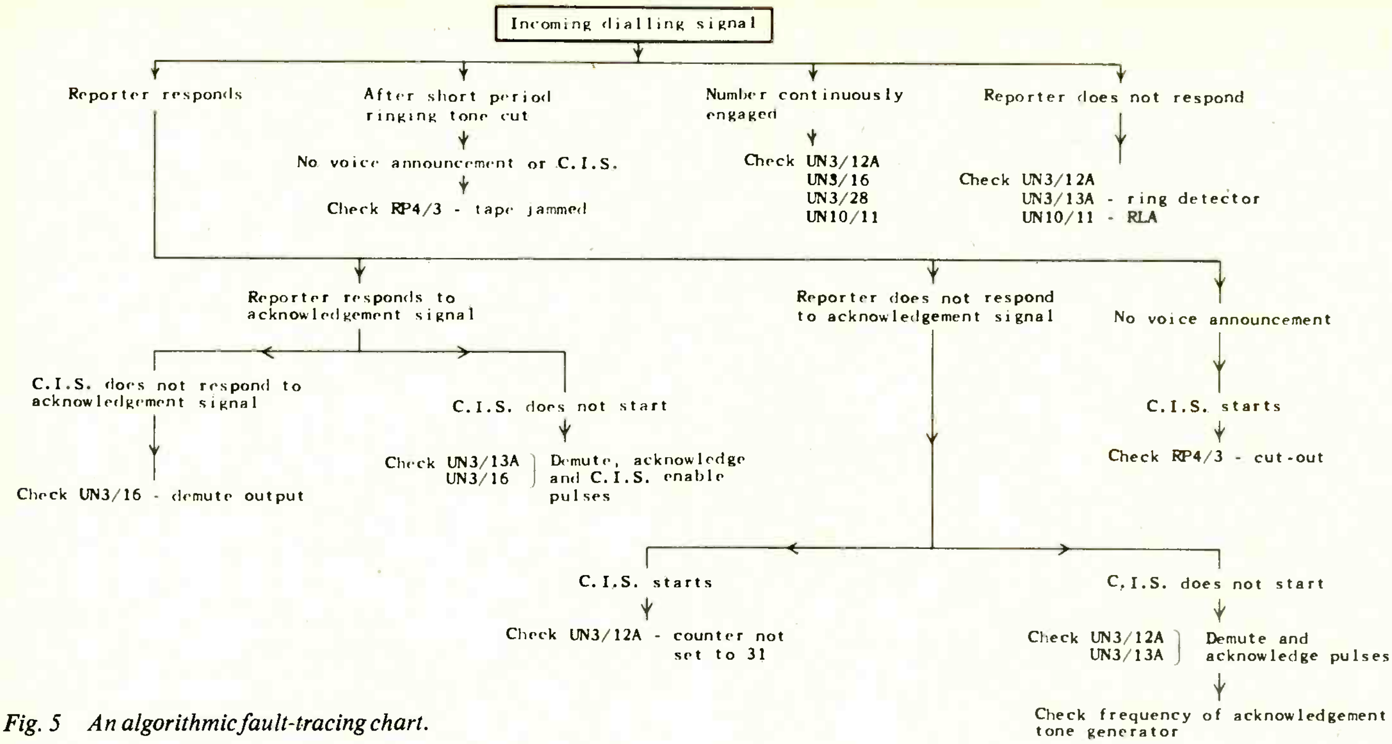


Fig. 5 An algorithmic fault-tracing chart.

provide some locational information if the terminals of transistors and the pin numbers of i.cs and of plugs and sockets are numbered. However, further information is required to enable, for example, the junction of a particular resistor and capacitor to be found physically. To this end diagrams showing the layouts of components on the printed cards are also provided and particular care is taken to identify test points on the cards.

Wiring diagrams

For equipment which consists of a number of inter-connected units it is essential, of course, to give complete information on the inter-unit wiring. This can be in the form of a diagram or a list of connections. Probably the diagram is better, particularly if it shows the units in their correct relative positions: this simplifies transfer of attention from the printed page to the equipment itself.

Parts lists

If a component is faulty it may still be recognizable and the type number may still be legible: all the information is then available to enable a replacement component to be obtained. Often, however, the faulty component has been destroyed (e.g. a resistor has burned out) or any markings on it have become illegible. The component cannot now be replaced until sufficient information on it has been obtained. The circuit diagram can supply some details, e.g. the resistance of resistors and the capacitance of capacitors, but this is often insufficient to enable a suitable replacement component to be obtained. Complete information on all components should therefore be included in the maintenance information. Equivalent components are sometimes satisfactory as replacements but there are some components for which replacements must be precisely the same type as those used originally.

Conclusion

The methods outlined in this article have been introduced into B.B.C. Technical Instructions over the last three years and are regarded by the maintenance staff as a considerable improvement over earlier methods of presenting maintenance information. In particular the reduction in the volume of conventional text and the introduction of the functional diagrams have been welcomed. Experiments in presentation will continue but it is anticipated that changes will be confined to details in the immediate future.

Books Received

Electronic Maintenance Management contains the contributions made to the 1973 Symposium of the Society of Electronic and Radio Technicians held at the University of Nottingham earlier this year. Subjects covered range through maintenance philosophies, technical documentation and design requirements to personnel organizations and careers. Speakers at the symposium represented all sectors of the industry from large to small specialized companies. Titles of the 21 papers contained in the proceedings include — Education and Training for Maintenance Management, The Economics of Servicing, Training in Fault Diagnostic Techniques, The Effect of Service on Design, The Use of Algorithmic Fault Finding Guides, The Maintenance Task on Commercial Computers — A Different Approach, and The Need for a Standard Format of Maintenance Data for Electronic Equipment. Price £5 (incl. p & p.). Pp. 189 plus unpaginated papers (3). Society of Electronic and Radio Technicians, Faraday House, 8-10 Charing Cross Road, London WC2H 0HP.

Search the Solar System by James Strong discusses the future role of unmanned interplanetary probes. Emphasis has now been placed on the continued exploration of the Solar System by probes similar to the "Mariner" reconnaissance of Mars and Venus and the "Pioneer" probe now on its way to Jupiter. Because every planet presents a fresh set of problems, various types of space probe will be necessary. Some will be purely reconnaissance orbiters while others will soft-land sophisticated capsules that will search for evidence of life on the surface by remote control. The author discusses ways of exploring hot planets, like Venus and Mercury, and how fast- or slow-moving comets can be intercepted. He also describes how to control a television-guided mobile probe, special balloon probes and radar satellites, how to explore the rings of Saturn, and describes a new way of maintaining continuous radio communication between Earth and a planetary surface anywhere in the Solar System. The book also describes the latest techniques for sending fast probes to the Outer Planets and a "kamikaze" probe to take close-up pictures of the Sun. Price £3.25. Pp. 160. David & Charles (Holdings) Ltd, South Devon House, Newton Abbot, Devon.

Included in recent additions to the list of books in the Foulsham-Tab series and published by W. Foulsham & Co. Ltd, Yeovil Road, Slough, SL1 4JH are:

Radio Control Manual — Systems Circuits and Construction by Edward L. Safford. Price £1.25. Pp.190.

Audio Systems Handbook by Norman H. Crowhurst. Price £1.25. Pp.189.

New IC FET Principles & Projects by K.W. Sessions and D. Tuite. Price £1.10. Pp.160.

Simple Transistor Projects for Hobbyists and Students by Larry Steckler. Price £1.25. Pp.192.

Video Tape Production & Communication Techniques by Joel L. Efrein. Price £1.30. Pp.252.

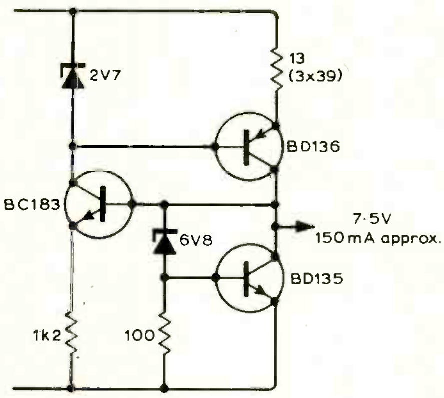
Circuit Ideas

Avoiding power supply hum

Units such as a radio tuner or tape recorder feeding into an amplifier normally require their own separate power supplies, though it is often more convenient if such feeders, with their relatively small requirements, could take their supplies from the amplifier itself. This cannot be achieved without the earth line between feeder and amplifier being shared by both the power supply and the signal. The result of this arrangement is considerable hum due to positive feedback.

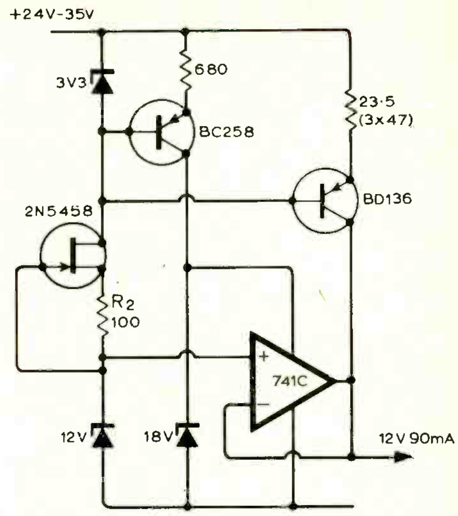
This can be relatively easily overcome. The power supply used by the amplifier will almost certainly be of higher voltage than that needed by the feeder, and thus a "potentiometer" can be used to reduce the voltage. If this consists of a constant-current source in series with a constant-voltage sink, and is close up against the feeder, then feedback is eliminated as there will be no current fluctuations in the power supply line.

The first circuit (left) provides power for a small cassette recorder. It supplies up to 150mA at 7.5 volts from supplies varying from 12 to 24 volts, and gives completely hum-free service.



In the more difficult case of a high-quality tuner (e.g. Nelson-Jones), together with stereo decoder, the second circuit has been used with similar success, even at the end of eight feet of cable.

With its exceedingly low output impedance, this circuit not only eliminates all likely sources of feedback, but also provides the high degree of smoothing required by this tuner.



With the values shown the constant-current supplied is about 100mA of which 10 to 15mA are "sunk" by the 741. The circuit requires careful setting up as the current that can be sunk is severely limited. Coarse adjustment of the current source is achieved by altering R_1, the BD136 emitter resistor, fine adjustment by R_2.

Giles Hibbert,
Blackfriars,
Oxford.

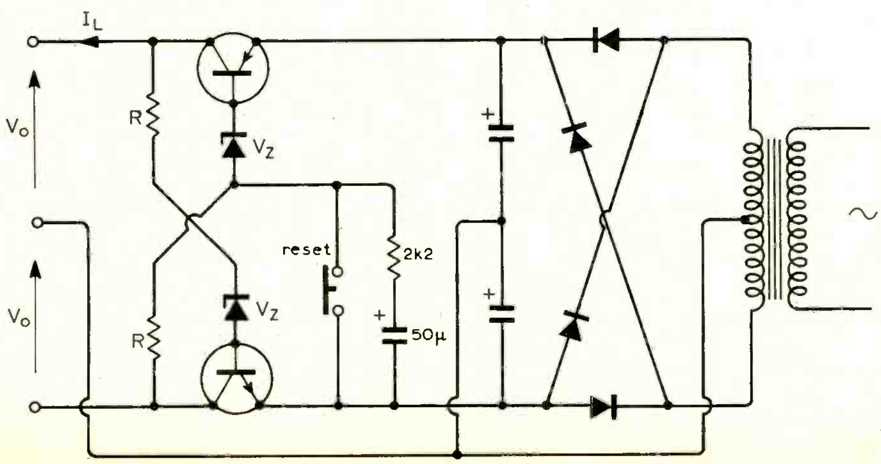
Symmetrical power supply

Shown is a simple power supply having symmetrical outputs and overload protection such that if a heavy load or short circuit is applied to either output both switch off rapidly. Each transistor derives its forward bias from the opposite supply rail and while the transistors are in saturation an increasing load will cause the output to fall under the regulation of the transformer. With a further increase in load the transistors come out of saturation and eventually remove each other's forward bias. If the trip circuit is used with an active power supply having negligible output resistance then switch off occurs solely to the transistors coming out of saturation. The zener voltage must be between V_o and $2V_o$ and the value of R

$$\leqslant \frac{h_{FE}(2V_o - V_Z - 0.7)}{I_L}$$

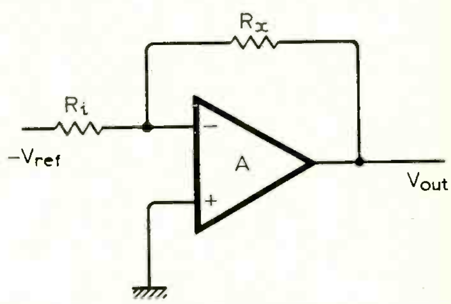
where I_L is the maximum load current required.

L. D. Thomas,
Post Office Research Department.



Resistance-to-voltage converter has low output impedance

Driving a constant current through an unknown resistance R_x yields a voltage across it proportional to the unknown's value. This commonly used method provides a linear conversion function, but the signal source has an output resistance equal to R_x. Better drive capability is available by using an operational amplifier in the inverting configuration, resulting in closed loop gains of $-R_x/R_i$ when the unknown value functions as the feedback resistor. Constant input V_{ref} then results in output voltage directly proportional to the resistance value and a power of ten scaling factor selected by proper choice of R_i and V_{ref}. Output voltage from the amplifier has a very low source resistance, which approaches zero as R_i is set at higher values and loop gain decreases.



David R. Schaller,
Milwaukee,
Wisconsin.

World of Amateur Radio

A dinner for direction-finding enthusiasts which it is hoped will be the first of an annual event is to be held at "The Chicken in the Basket", Benson, between Oxford and Wallingford on Friday, November 16.

Should there be a U.K. novice licence?

The U.K. is one of the very few countries with a large amateur population (total of Class A and B licences has just passed the 18,000 mark) that eschews "incentive licensing" and any form of novice or beginner's licence. Once anyone has qualified for a Class A or B licence no restrictions are placed on their activities or whether this includes any element of "self-training". As an individualist such freedom from official pressures seems wholly admirable — but as one concerned with the future development of the hobby this absence of incentives seems puzzling. A British "beginner's licence" was announced in March 1968 but did not appear to be part of any fully thought-out scheme and was never implemented.

One of the latest countries to introduce such a system is Norway where a new novice-type Class B licence is now being issued. This is valid for two years only and is not renewable, is for c.w. operation with a maximum input of 15 watts and has the prefix LB to distinguish these stations from the Norwegian Class A stations which use the LA prefix. Such facilities encourage newcomers to become proficient in Morse operation by learning while using. Should the U.K. look again at this now well tried system of encouraging newcomers to become experienced in h.f. Morse operation? Or is it accepted that the day of the Morse key is now almost done?

Communications receivers now 40 years old

Although it could be argued that "communications receivers" are as old as radio, the type of receiver which this term usually defines really emerged in the early thirties with the coming of low-noise single-signal-superhets. A major step forward came in 1931 when James Lamb of A.R.R.L. showed how the crystal i.f. filter — developed in the U.K. by Dr J. Robinson in 1929 for his broadcast "stenode" receiver — could be put to extremely good use for amateur operation. One of the first receivers using such a filter and intended for amateurs was the National FBXA of 1934 — and this was a later version of the FB7 receiver of 1933, regarded by some amateur historians as perhaps the first true "communications receiver". During the next five years a whole string of such receivers appeared and pushed aside the "straight" regenerative receivers: the HRO Senior in 1936; the Hammarlund Comet Pro and Super Pro; the RME69; the Tobe Deutschmann kit; the wide range of Hallicrafters from the £7 Sky Buddy to more advanced sets with crystal filters. At about the time when such receivers began appearing on the British market in 1936-37, the only home product was possibly the £20 Evrizone single-signal-superhet. A sign of the change was the use by the leading British station of the 1936 BERU contest of a Comet Pro — but the Australian winner still used a straight 0-v-2 receiver. Because of their widespread wartime use, the HRO and the slightly later RCA AR88 (first marketed in 1940-41) remain as outstanding examples of the early days of communications receivers: in how many other branches of electronics can equipment built over 30 years ago still prove capable of performing well even in comparison with modern equipment?

Coming Soon

The second Midland National Amateur Radio & Electronics Exhibition at Granby Halls, Leicester on October 25-27 will feature a fully equipped amateur station, GB3ARE, plus a reproduction of the 1913 club station of the Derby and District society. A film theatre will show films of interest to amateurs and a Tombola stand is being run on behalf of the Radio Amateur's Invalid & Bedfast Club. Trade stands look like being fully booked.

One of the very popular Racal Amateur Radio Club Junk Sales — at which an unusually wide range of ex-professional equipment usually changes hands — is being held at St Sebastian's Hall, Nine Mile Ride, Crowthorne, Berkshire on Saturday, October 27 at 2 p.m.

The South East Counties H.F. Convention on Sunday, November 18 from 11 a.m. until 7 p.m. at the Airport Hotel, Crawley, Sussex, will include trade stands, club stands, informal lectures and an operational station.

More courses for would-be amateurs

Additions to last month's list of places where evening courses are being run for would-be amateurs — based on information supplied by the R.S.G.B. — include:

London and the Home Counties: Acton, Bedford, Borehamwood, Brentwood, Chingford, Croydon, Harlow, Harrow, Highgate, Ilford, Islington, Princes Risborough.

Provinces: Aldridge, Staffs, Bangor, Co. Down, Birkenhead, Bridgend, Glam. Brighton, Bury, Chesterfield, Glasgow, Grantham, Grimsby, Loughborough, Newport, Mon., Oldham, Perth, Plymouth, Portsmouth, Stoke-on-Trent, Wolverton and Wombourne (near Wolverhampton).

In Brief

A recent BBC Radio 4 programme ("In Touch") for visually handicapped listeners included an explanation and taped demonstrations of amateur radio operation by Philip Storey, G3ZGG. He said there are now about 50 blind amateurs in the U.K. and advised those interested to gain experience by listening on a communications receiver; where necessary assistance may be obtained from the Radio Amateur Invalid & Bedfast Club (Hon. Secretary Mrs Frances Woolley, G3LWY, Woodclose, Penselwood, Wincanton, Somerset) . . . What is thought to be the longest-distance contact ever made on "Top Band" (1.8MHz) was made last July between Tokuro Matsumoto, JA7AO and VP8KF on the Falkland Islands. The Japanese amateur has also contacted Fred Laun, LU5HFI (formerly HS5ABD) in Cordoba. Argentina . . . The Harlow and District Mobile Rally is to be held at Netteswell Comprehensive School, Harlow, on Sunday, September 23 (talk-in stations on 144, 3.5 and 1.8MHz) . . . The prefix DT is being used by some DM stations until the end of the year to mark the 20th anniversary of amateur licensing in the German Democratic Republic . . . Walter Turner, GW3YPH, of Pontypridd was electrocuted while putting up an aerial in his back garden not far from an overhead electric cable . . . By the end of August, Oscar 6 has completed 4000 orbits. British and French amateurs have made contact through Oscar 6 with KL7MF at Anchorage, Alaska, at distances of over 7000 km. F9FT in Rheims has made more than 2500 contacts through the amateur satellite.

PAT HAWKER, G3VA

WW—091 FOR FURTHER DETAILS

The Sinclair Cambridge... no other calculator is so powerful and so compact.

Complete kit – £24·95!

(PLUS VAT)

The Cambridge – new from Sinclair
The Cambridge is a new electronic calculator from Sinclair, Europe's largest calculator manufacturer. It offers the power to handle the most complex calculations, in a compact, reliable package. No other calculator can approach the specification below at anything like the price – and by building it yourself you can save a further £5·50!

Truly pocket-sized
With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}$" x 2" x $\frac{11}{16}$". That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on U16-type batteries which gives weeks of life before replacement.

Easy to assemble
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

The cost? Just £27·45!
The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £32·95 – so you're saving £5·50! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.

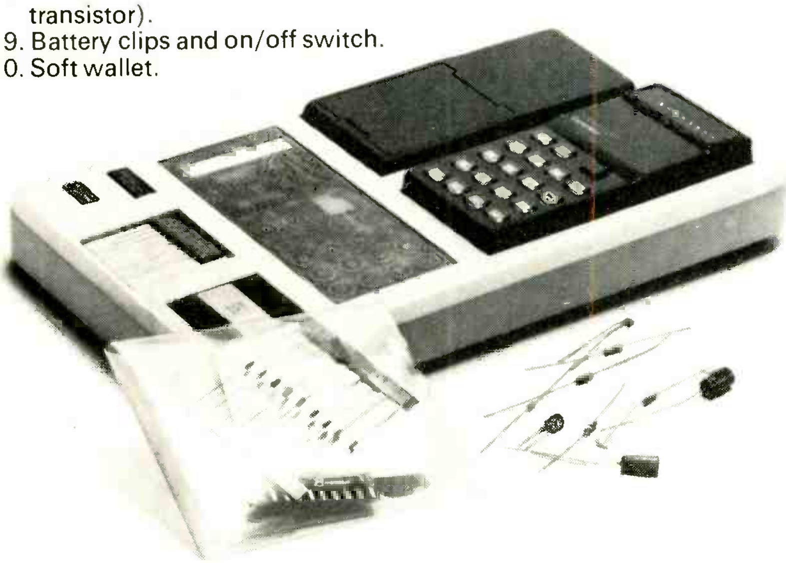
Features of the Sinclair Cambridge

* Uniquely handy package. $4\frac{1}{2}$" x 2" x $\frac{11}{16}$", weight $3\frac{1}{2}$ oz.
* Standard keyboard. All you need for complex calculations.
* Clear-last-entry feature.
* Fully-floating decimal point.
* Algebraic logic.
* Four operators (+, –, x, ÷), with constant on all four.
* Constant acts as last entry in a calculation.
* Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £30.
* Calculates to 8 significant digits, with exponent range from 10^{-20} to 10^{79}.
* Clear, bright 8-digit display.
* Operates for weeks on four U16-type batteries. (MN 2400 recommended).

A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container.
It contains all you need to assemble your Sinclair Cambridge.
Assembly time is about 3 hours.

Contents:
1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.



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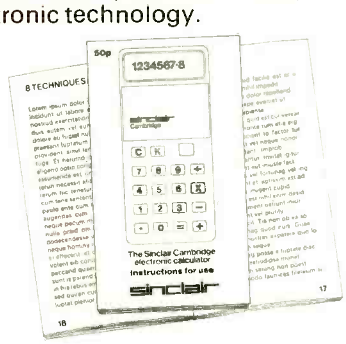
This valuable book – free!

If you just use your Sinclair Cambridge for routine arithmetic – for shopping, conversions, percentages, accounting, tallying, and so on – then you'll get more than your money's worth.

But if you want to get even more out of it, you can go one step further and learn how to unlock the full potential of this piece of electronic technology.



How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations like:

Logs	Tangents	Currency conversion
Sines	Reciprocals	Compound interest
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*I enclose cheque for £__________, made out to Sinclair Radionics Ltd, and crossed.
*Please debit my *Barclaycard/Access account. Account number __________

*Delete as required.

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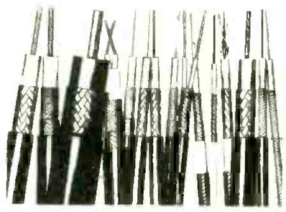
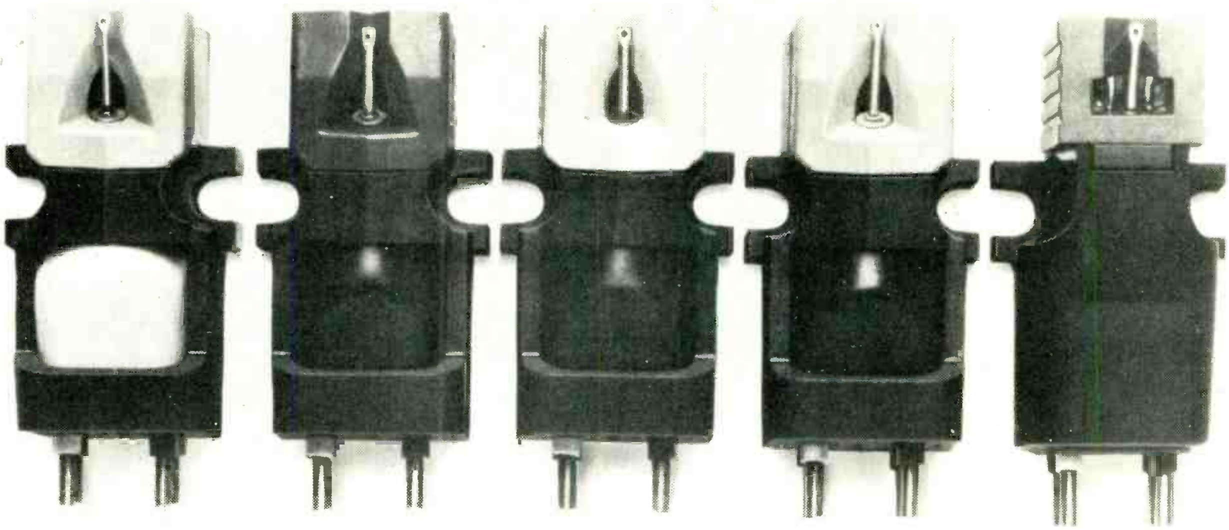
WW—092 FOR FURTHER DETAILS





New Products

Two-tone generator

Racal Instruments have introduced a two-tone generator, Model 9063, which complements the r.f. synthesized signal generator system introduced earlier this year. Designed primarily as a modulation source, the 9063 provides an aid to s.s.b. servicing and alignment.

An entirely self-contained instrument covering the 10Hz to 100kHz frequency range, the 9063 provides a stable synthesized tone referenced to an internal crystal standard and a second tone derived from a tuneable oscillator. The two tones may be used independently or combined, the intermodulation distortion being less than −70dB. Fully remotely programmable using t.t.l. logic, the instrument provides outputs from 100μV to 10V with low hum and spurious content. The 9063 is 88mm (3.5in) high, 483mm (19in) wide and 406mm (16in) deep and weighs 13.7kg (30lbs). Racal Instruments Ltd, Duke Street, Windsor, Berks SL4 1SB.

WW 316 for further details

50MHz portable oscilloscope

The dual-trace oscilloscope, model D75 from Telequipment is a light-weight portable oscilloscope with a vertical sensitivity of 5mV/div. on both channels over the full 50MHz bandwidth. The sensitivity can be increased to 1mV/div. at all frequencies up to 15MHz by the operation of the ×5 gain switch. Both vertical channels can be used independently or in alternate, chopped, added or differential modes, and the vertical signal delay which is incorporated allows the leading edges of signals to be observed.

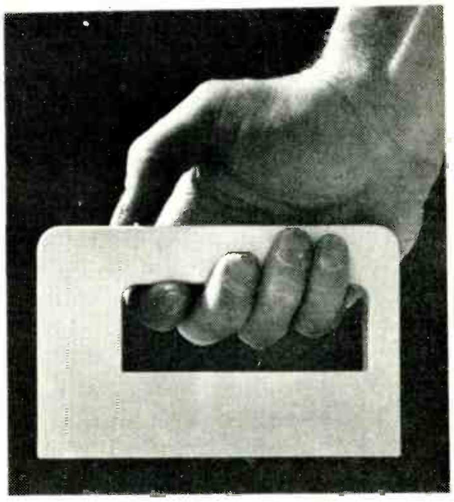
The horizontal deflection system consists of a dual timebase which provides normal sweep, mixed sweep, sweep intensifying, sweep delaying and single shot facilities. The fastest normal sweep speed of 100ns/div. can be increased to 10ns/div. by switching on the ×10 sweep magnifier. Time measuring accuracy is ±3% with the magnifier off, ±6% with the magnifier on. A useful extra feature is the "trace locate" button which reduces vertical and horizontal deflection so as to present an on-screen display and free runs the main timebase.

A built-in calibrator provides square wave test outputs on the front panel of 30mV, 300mV and 3mA peak-to-peak with an accuracy of ±1% at a nominal frequency of 1kHz. The c.r.t. is a single-gun mesh tube, operating at a potential of 15kV. The U.K. list price of the D75 is £420 excluding v.a.t. The weight is 25.5lb and the dimensions are 5$\frac{3}{8}$in high, 15in wide, and 18$\frac{3}{4}$in deep. Tektronix U.K. Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts.

WW307 for further details

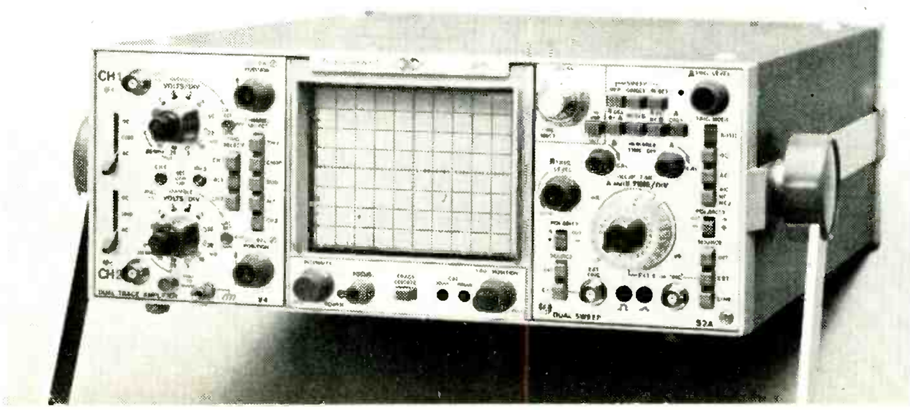
Metal detector

The Contil-Voll metal detective, marketed by West Hyde Developments, is pocket size, hand held, very light (under $\frac{1}{2}$lb) and so easy to operate that a child can use it. It is held in either hand and a small knurled knob is turned by the thumb until a red indicator light



goes out. It is then ready for use: any nearby metal turns the light on again. The Contil-Voll metal detective reacts to all metals and finds them through any other substance. To quote West Hyde, "just think of the possibilities; this means the metal clip on your pen through your jacket; the money in your pocket; a gun in your belt! It will find a paper staple at $\frac{1}{4}$in and a paper clip buried under a pile of papers 2in thick. But think of the practical possibilities in a factory or at home!" Made in tough impact-proof plastic and using a single 9V battery as the power source, it is priced at £22.85 plus v.a.t. West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Northwood, Middx HA6 1NN.

WW308 for further details



Electronic watches

Solidev Ltd announce a range of solid quartz controlled electronic watches. They have no hands and no dials. Instead, a simple black face registers time and date by l.e.d. display. Control is by push button.

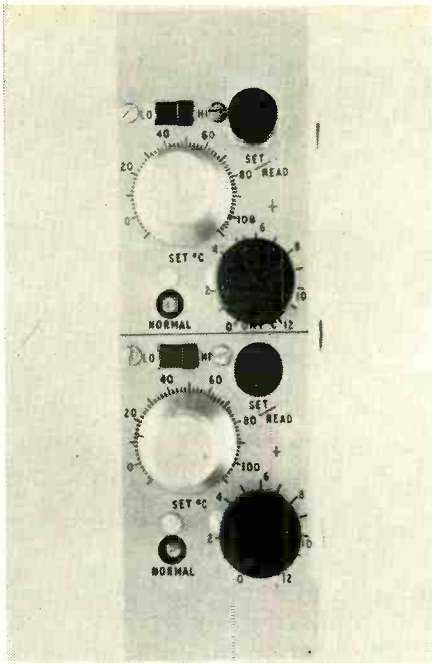
There are several models available in both men's and ladies' styles. All feature gold bracelets. All are accurate to within 1 digit over the course of a year, and cost £180 r.r.p. Solidev Ltd, Edison Road, Elms Industrial Estate, Bedford MK41 0HG.

WW 319 for further details

Trip amplifiers

Rotraco Systems Ltd have developed a range of trip amplifiers which are compatible with their Model 4 and 4R monitoring and alarm systems. The trip amplifiers are intended for operation from signal sources providing 0-2.5V, 4-20mA, or direct from thermocouples, resistance thermometers, thermistors, strain gauge pressure transducers, tachometers etc. They can be combined with alarms to provide alarm and trip systems for plant and process control applications. Facilities are also provided for an indication of temperature, pressure etc. either on a common indicator or individual indicators. The indicator unit can also be used to inject a signal to check the trip setting.

The basic trip amplifiers carry two trip channels with controls for set point and differential but other versions are available e.g. one channel with two trip settings, switch selection of trip high or low, fixed differential etc. A light emitting diode indicates whether or not a channel has tripped. The setting and differential potentiometers of temperature trip amplifiers are calibrated directly in degrees centigrade and for other parameters they



are calibrated in percentage. Rotraco Systems Ltd, Garden Street, Darlington, Co. Durham DL1 1QR.

WW 314 for further details

Liquid level control units

The ELC2 electronic level control produced by Gearing & Watson (Electronics), is used to control the level of liquids where the conductivity varies with level, such as water, milk, sewage etc. Two level probes may be used, so that the level is controlled between the two probes; for example a container may be filled to the upper level probe but the level may fall to the lower probe before the control operates to restore the level to the upper probe again. The ELC2 is designed for "fill" applications, the ELC24 is available with a reverse action.

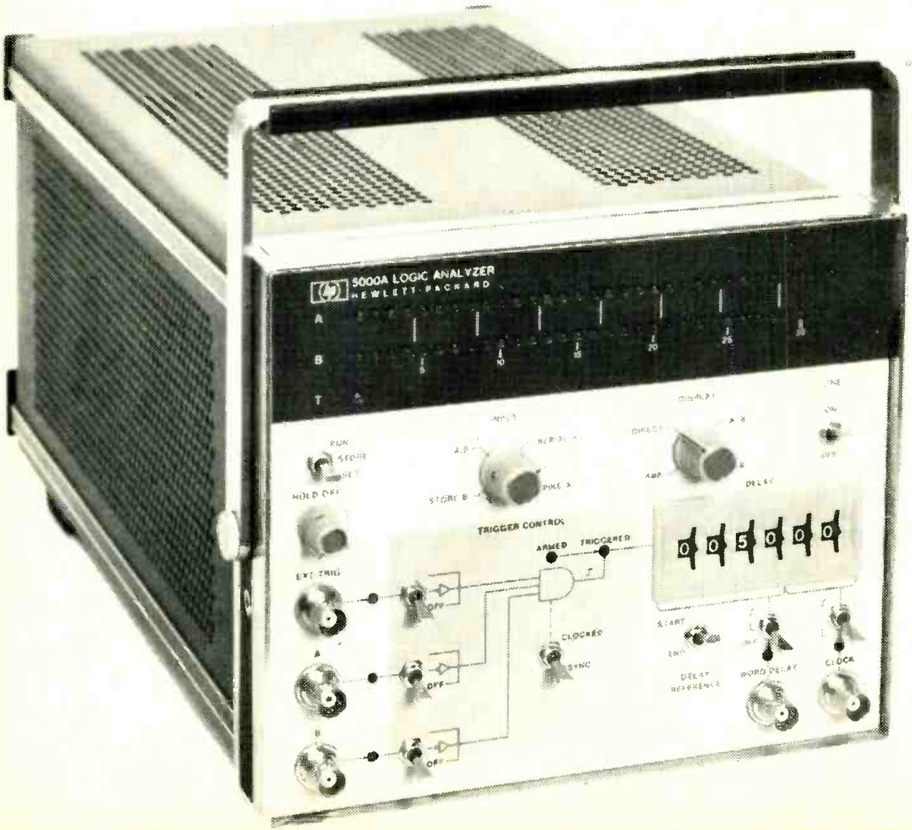
The ELC2 uses modern semiconductor technology, the level comparator being an integrated circuit, while the load switch is a triac; thus no contact maintenance is required. The probe circuit is insulated by a double wound mains transformer from the supply for complete safety. The unit is encapsulated for protection and can operate in high ambient temperatures. Electrical connections are by "Faston" connectors. Dimensions 63.5 × 51 × 108mm. Gearing & Watson (Electronics) Ltd, Birch Close, Eastbourne, Sussex BN23 6PE.

WW306 for further details

Logic analyzer

Logic circuit analysis by the "freezing" and display of the states of any 32 bits in a stream is the function of a new instrument by Hewlett-Packard, the Model 5000A. A light-emitting diode array indicates the "up" or "down" states of the 32 selected bits, which are selectable by thumbwheel switches from a stream of information in relation to a trigger signal (before it as well as after). A fault condition can be made to trigger the display. The instrument will cope with clock frequencies up to 10MHz and is compatible with all logic families. L.e.ds display the state of the input signal, and if the probe is not making contact, the fact is again indicated by l.e.d. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks SL1 4DS.

WW305 for further details



Glass miniature trimmers

Voltronics are now manufacturing a range of glass dielectric trimmers up to 40pF capacitance, but 40 per cent shorter in length than the standard MIL-C 14409C capacitor. Two mounting styles, for vertical or horizontal mounting, are available. Both are sealed, providing protection against pressures up to 40 p.s.i. to keep out dust, moisture and encapsulents. The non-rotating piston construction permits more linear tuning, no capacitance reversals, high *Q*, longer life, low constant inductance and a high self-resonant frequency. Suvicon Ltd, Hagley House, Hagley Road, Birmingham B16 8QW.

WW304 for further details

Hall effect d.c. motors

Communication Technology have announced a range of constant speed brushless d.c. motors for instrumentation and recorder applications. Incorporating Hall effect elements to control the coil current by sensing the rotor position, the PHM series can be programmed to operate at selected motor speeds or for reverse rotation. By the addition of an external switching circuit, multi-speed operation and forward or reverse rotation can be arranged without the need to use a separate gear box for this purpose.

The rotator is external to the fixed coils and as there are no brushes or a commutator, as in a conventional d.c. motor, friction is greatly reduced and

no electrical noise is generated. The use of special copper sleeve bearings is said to ensure a minimum of motor noise and long life. Communication Technology Ltd, 279 Addiscombe Road, Croydon, CRO 7HY.
WW303 for further details

Audio mixers

Neltronic (UK) Ltd is to enter the audio market with a range of audio mixers, with full mixing input channels and frequency response 20Hz to 20kHz. In size and sophistication the range covers many requirements but units can be designed specially to fulfil customers' needs. The equipment is made in the UK, to a design which employs up-to-date technology and components to bring the price of the standard unit, model 6/2, to under £900. For the standard unit, the mixer features switching for one microphone and one line input, a sensitivity −80 to ±10dBM in 10dB steps, filters covering low, mid and high frequencies and horizontal faders. Cueing to internal speaker from all channels and all outputs is available with independent reverberation, selectable mix, 2 reverberation units for stereo operation, switchable to main output, a fold-back output for mixed signals and a p.u. unit with R.I.A.A. equalization. Two v.u. meters switchable to every channel and all outputs; pan between 1 and 2 on every channel. Outputs 2 group, 2 fold-back, 2 reverberation and one monitor. Neltronic (UK) Ltd, 442 Bath Road, Slough SL1 6BB, Bucks.
WW302 for further details

Noise generator cards

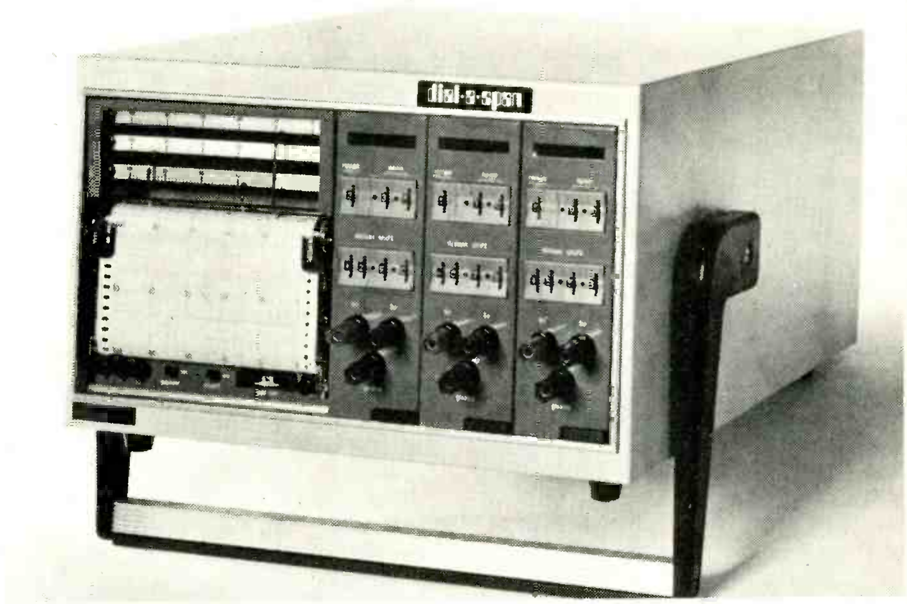
Manufactured by Elgenco, Inc., U.S.A., specialists in noise generators, the Series 3600 noise generator cards cover the range of 10Hz to 5MHz with an output level of 3V r.m.s. open circuit. A dynamic range of 3.5:1 peak to r.m.s. is provided. Output impedance is 600Ω or 200Ω depending on the upper frequency specification, with other output impedances optionally available. The amplitude probability distribution is Gaussian.

Cards are available with specified uniformities of ±0.5dB, ±1dB, ±2dB and ±3dB for many frequency ranges between lower frequencies of 10Hz, 20Hz, 50Hz, 200Hz and 5kHz and upper frequencies of 20kHz, 50kHz, 100kHz, 200kHz, 500kHz, 1MHz, 2MHz and 5MHz. Size is $4\frac{1}{2} \times 6\frac{1}{2} \times \frac{7}{8}$in and weight approximately 7oz. Single unit prices range from £87 to £285 (excluding duty and v.a.t.), lower prices in quantity. Lyons Instruments Ltd, Hoddesdon, Herts.
WW313 for further details

Three-pen recorder

The Model 303 "Dial-a-Span" three-pen recorder by Chessell Ltd is designed to provide good flexibility. The ranging facility is controlled by front panel thumbwheel selectors to give 450 spans per channel from 1mV to 99V plus 1999 datum shift settings permitting at least 10 times span suppression or elevation on all ranges, with a constant input impedance of 10MΩ.

The calibrated datum shift facility allows 1 metre chart width resolution on a 100mm chart. Other features include high speed pen servos and 10-speed electronic chart drive. The Model 303 recorder is available in two forms: a free-standing model with integral carrying handle/tilt stand and a 19in rack mounting version. Chessell Ltd, Broadwater Trading Estate, Southdownview Road, Worthing, Sussex BN14 8NL.
WW 311 for further details



Low-cost TV system

Pye Business Communications has introduced a low-cost television system — the Philips' "Mini-Studio". Designed for educational and industrial training purposes, the equipment, constituting a basic studio, costs £1,450. The system includes two cameras with various lenses (zoom, standard microscopy), tripods, camera fixings, headsets, telecine, mounting rack with three 10cm monitors and control unit, microphone and audio mixer with all necessary cables, stands and connections. The TV equipment can be used with either a video tape recorder (from £150) or video cassette recorder with professional facilities (from £750). Pye Business Communications Ltd, Cromwell Road, Cambridge.
WW 310 for further details

D.I.P. heat pipes

Small flat pipes for cooling flat packs and d.i.p. devices are the latest designs from Jermyn Manufacturing. Each pipe is 0.1in thick and 0.25in wide and will easily fit under d.i.p. packs. The flat surface of a d.i.p. heat pipe makes it easy to add or remove heat and due to the isothermal characteristics of heat pipes all devices will be maintained at the same temperature.

The d.i.p. heat pipes can be fabricated in matrix configurations with the heat pipe tails terminating in a cold wall and on a 4 × 7in matrix up to 80 d.i.p. packs can be maintained within 1°C of each other.

The normal temperature of operation is 20°C to 150°C and a 6in long d.i.p. heat pipe will handle 18 watts at 100°C and with a weight of only 10g these components are suitable for airborne applications. Jermyn Manufacturing, Sevenoaks, Kent.

WW 312 for further details

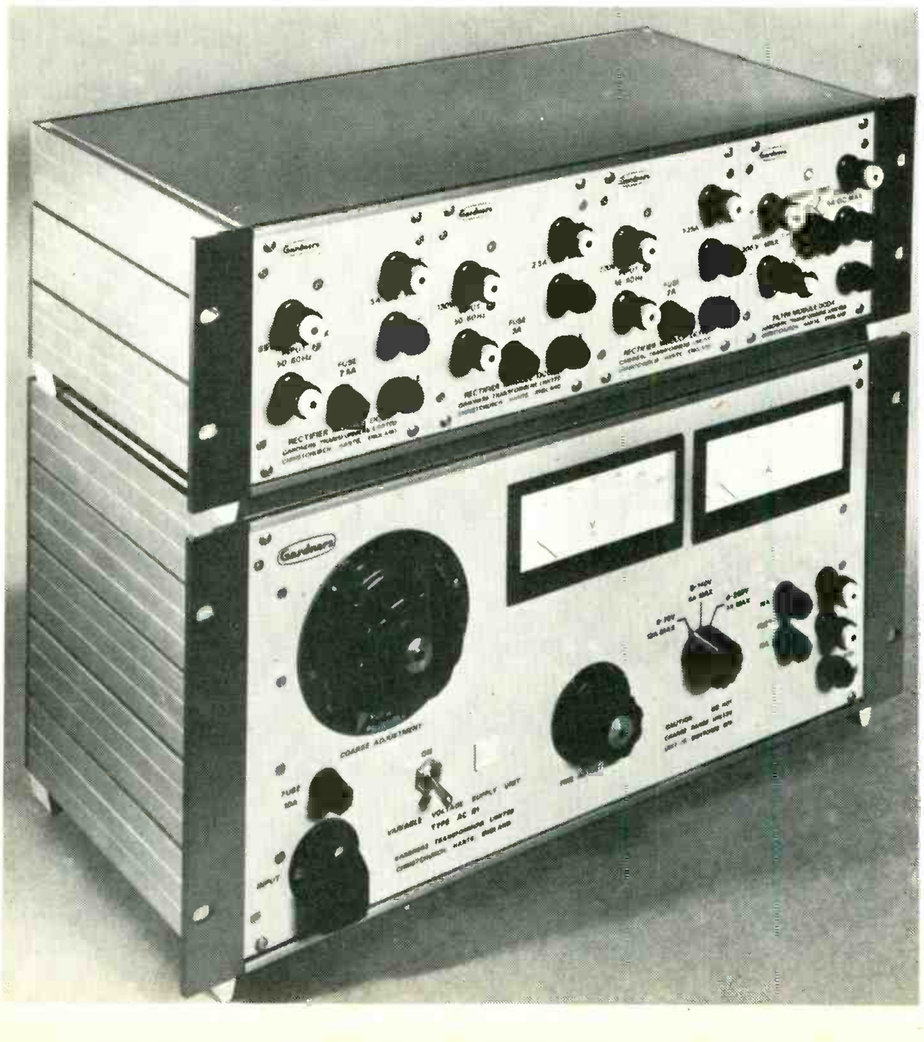
Modular bench supply

Gardners Transformers have introduced a power supply system for industrial and educational laboratory applications where either a.c. or d.c. may be required at power levels up to several hundred watts. The complete power supply system comprises a basic a.c. module, ACO1, and four d.c. modules. The a.c. modules provide a continuously variable a.c. output, fully isolated, with coarse and fine controls, together with meter monitoring. There are three output ranges: up to 70V at 12A; up to 140V at 6A; and up to 280V at 3A.

The incorporated isolation transformer ensures that the user and valuable test equipment are protected against the risks associated with testing circuits connected to mains earth. This feature, coupled with the usual flexibility of the system as a whole, should be valuable where students or inexperienced personnel are involved.

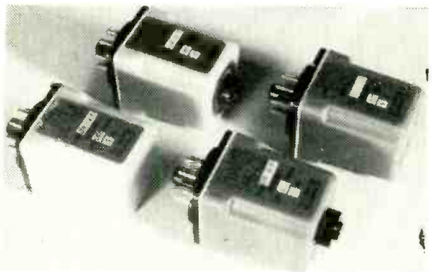
Three of the d.c. modules are rectifier-capacitor units matching the three output ranges of the a.c. module. The fourth d.c. module, which can be used in conjunction with any of the other d.c. modules, is a filter and protection unit offering very low output ripple levels in addition to full short-circuit and over-voltage protection. The complete system is housed in two instrument cases which may be used on the bench or mounted in standard 19in racks. Gardners Transformers Ltd, Christchurch, Hants.

WW309 for further details



Time delay modules

The time delay modules TM and TD by Keyswitch can be supplied for a.c. or d.c. applications where timed delay periods of 2.5 to 300s are required. The units are



"non-blip", and the delay period is set by potentiometer adjustment. This potentiometer can be included on the discrete unit, or wired from a remote situation. At the end of the set delay period (which is initiated by connection of the supply) the timer will deliver an output.

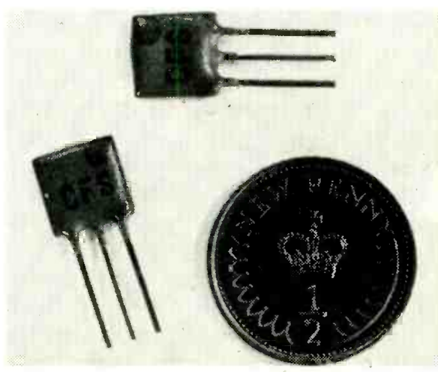
The TM timer incorporates a Keyswitch MS relay with changeover contacts rated at 2A. The TD version is designed for use with an external relay, and at the end of the timed interval the TD timer output is supplied via an integral s.c.r. circuit. The solid state switch rating is 300V, 10-800mA.

Both timers have 120ms reset time, and are supplied in polypropylene casings 1.3in (33mm) wide × 1.2in (33mm) deep, overall height above socket 2.025in (51mm). Gothic Electronic Components, Beacon House, Hampton Street, Birmingham 19.

WW 315 for further details

Ceramic filters

10.7MHz centre frequency ceramic filters, type CFS 107M, are offered by Toko (UK) Ltd. The five ranges available have centre frequencies between 10.64 and 10.76MHz, each with an accuracy of ±300kHz at 3dB and ±600kHz at 20dB. Insertion loss is not more than 6dB, and impedance 330Ω ±15%.



The performance parameters are closely specified, and include a centre frequency shift within ±150 p.p.m. per °C in the temperature range −10 to +60°C.

Delivery times are short and prices competitive for these type CFS 107M ceramic filters claim the suppliers, Toko (UK) Ltd, Shirley Lodge, 470 London Road, Slough, Bucks SL3 8QY.

WW301 for further details

Solid State Devices

Each section under the title of Solid State, is devoted to the new semiconductor products offered by one manufacturer or distributor. The type number and device title is given in bold type, followed by a brief description of features or application. The section is terminated with the address of the company together with reader reply card numbers associated with the device numbers or types.

Announced from Guest International Ltd:

SH730. Sample and hold amplifier manufactured by Hybrid Systems Corporation. This is characterized by a linearity of 0.01% and the capability of acquiring a ±10V to this accuracy in less than 1μs. The mode control is t.t.l./d.t.l. compatible and the droop rate of 5mV/ms can be improved by the addition of an external capacitor which, however, lengthens the acquisition time.

4403 and 4440 Red-Lit high brightness l.e.ds are Gallium Arsenide devices having a luminous intensity of 1.2mcd at 20mA and a power dissipation of 200mW. The 4440 is a lower cost version with a luminous intensity of 0.8mcd at 20mA. Both can be soldered directly to a p.c.b. or mounted in a panel with a snap-in mounting clip.

DAC328-4-BCD 4 decade b.c.d. current output digital-to-analogue converter, packaged in a 2 × 2 × 0.4in module. It is t.t.l./d.t.l. compatible and operates from a standard ± 15V power supply.

Industrial Electronic Components Division, Guest International Ltd, Redlands, Coulsdon, Surrey CR3 2HT.
WW350 sample/hold amplifier
WW351 high brightness l.e.ds
WW352 4 decade b.c.d.

Announced from Mullard:

TAA320A voltage level detector is an i.c. for use in flame control systems, radiation detectors, timers, thermostats and liquid level detectors. It is a development of the audio amplifier TAA320. Operating with an input current of only 1pA, it will produce an output of 60mA at 20V when a predetermined input threshold voltage is exceeded.

SAJ110 frequency divider i.c. is suitable for electronic organ applications and will produce seven different notes. Thus, twelve i.cs with oscillators to generate the fundamentals will provide all the notes required in an electronic organ. Combining outputs via resistor networks produces an increased range of harmonics and facilitates the synthesis of a wider number of tones.

TCA420 i.f. amplifier for use with f.m. receivers, contains a four-stage i.f. amplifier/limiter and a symmetrical quadrature detector providing a high degree of a.m. rejection. It will also supply an output for a tuning meter, and an automatic stereo inhibit switch when the signal drops below a predetermined value. The switch hysteresis can be adjusted to prevent its continual operation by small signal changes. Inter-station muting is provided and to assist tuning the TCA420A also has "side response" damping.

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW353 voltage level detector
WW354 frequency divider
WW355 i.f. amplifier

Announced from Burr-Brown International Ltd:

SHC23 hybrid sample/hold amplifier has a guaranteed dynamic non-linearity of less than ±0.01%. The addition of an external capacitor enables optimization of acquisition time and hold time. The device is packaged in a TO-8 can and is available with an operating temperature range of 0°C to +70°C.

3506J and 3508J high-gain wideband operational amplifiers. The model 3506J has a small signal bandwidth of 12MHz and a slew rate of 7V/μs and is internally compensated for stability at all gains, including the unity gain voltage follower configuration. Model 3508J has a gain-bandwidth product of 100MHz, a slew rate of 35V/μs and is internally compensated for all gains greater than five. Both units have an open loop gain of 103dB into 2kΩ, a common mode rejection of 100dB, bias current of 25nA and a differential input impedance of 300MΩ.

3507J high-slew operational amplifier has a slew rate of 120V/μs, a settling time to 0.1% of 200ns and a gain-bandwidth product of 20MHz. For gains greater than 3 the roll-off is 6dB/octave and by adding a single external 20pF capacitor the 3507J can be stabilized at unity gain.

3505J fast settling operational amplifier will settle to 0.1% in 300ns, gives a slew rate 30V/μs and a gain-bandwidth product of 12MHz. The amplifier is stable at all gains down to unity, without the need for external compensation.

4310 true r.m.s.-to-d.c. converter uses the thermal conversion technique. The heart of the device is a pair of monolithic chips, each containing a resistor-transistor element. The function of the converter is first input voltage to heat, followed by conversion of the heat into a current change and finally from the current change to a d.c. voltage equivalent to the true r.m.s. value of the input voltage. Two versions are available, the 4130K characterized by midrange accuracies of 0.05% and non-linearity of 0.4mV, and the 4130J providing an accuracy of 0.1% and non-linearity of 1.0mV. Minimum bandwidth of both units is 40Hz to 100kHz and a 10MHz minimum upper frequency limit for 2% accuracy. Crest factors from 5:1 up to 100:1 maximum and the ability to accept from 100mV r.m.s. to 2V r.m.s. with peaks up to ±10V are also typical. Fully protected from over-voltage, the 4130 also features an input impedance of 10kΩ, a settling time of 4s or less, external adjustments for gain, offset voltage and l.f. cut-off.

UAF11/15 series and UAF21/25 series hybrid active filters. Both of these are produced in d.i.l. packages and can be externally tuned for gain, frequency and *Q* over their specified ranges by adding four resistors. The basic filter utilizes the state variable principle in which low-pass, bandpass and high-pass responses are simultaneously available as outputs from a single 2-pole filter element. Complex responses can be realized for almost any filter function by cascading units. Full power bandwidth for the UAF11/15 series low pass output is 10kHz for ±10V signal ranges and is useable at frequencies up to 100kHz for ±1V signal ranges. The UAF21/25 series have a full power bandwidth of 100kHz at the low-pass output for ±10V signal ranges and is useable up to 1MHz for ±1V signal ranges.

Burr-Brown International Ltd, 25A King Street, Watford WD1 8BT.

WW356 hybrid sample/hold amplifier
WW357 wideband operational amplifiers
WW358 high-slew operational amplifier
WW359 fast settling operational amplifier
WW360 true r.m.s.-to-d.c. converter
WW361 hybrid active filters

Real and Imaginary

by "Vector"

Odd Ode
(with apologies to Cyril Fletcher et al)

This is the tale of Phil A Ment
Whose pa, a scientific gent,
Subjected himself religiously
To r.f. in large quantity
"For", quoth he, "This dosage will
Prove as effective as the Pill."
— Alas for Family Planning, when
His spouse conceived a sudden yen
— Quite devoid of rhyme or reason —
For strawberries right out of season
Which forced papa in chagrined terror
To admit experimental error
With his "Letter to Nature" finishing in
A convenient waste-paper bin.
But the r.f. currents by some means
Had gingered the paternal genes
For baby Phil 'twas plain to see
Was born an infant prodigy
At six months old the little tot
Instead of lying in his cot
And practising his coo and drool
Was learning Fleming's Left-hand Rule
And by the tender age of three
Had mastered trigonometry,
Sine waves and alternating forces
And eddy currents and their losses
Capping this tour de force sans fuss
With differential calculus —
By five he'd found a grievous flaw
In Einstein's monumental Law.
His school career through "prep" and "high"
And likewise university
Was lustrous with "distincts" and "hons"
(He frequently advised the dons.)
Thus at the age of twenty he
Acquired a king-sized Ph.D.
Young Phil, his banner thus unfurled
Emerged into the outside world
Turning his back on cloisters he
Elected to join our industry
And soon the rash youth deftly nabs
A job at the Gargantuan Labs.
His team-mate here was Humphrey Naild
A redbrick Bachelor of Science (failed)
Who thought that Ohm was where the 'eart is
And only shone at office parties.
Phil, being an ambitious lad
And anxious to acquire a wad
Of doubloons, burnt the midnight tapers
And churned out reams of Learned Papers
Which brought him references in flocks
But nothing else, for Learned Socs.
Adopt the parsimonious stance
That honour is adequate advance —
A commodity which honest toilers
Find incombustible in boilers
Or for settling bills or monies due
To H.M. Inland Revenue.
His colleague Humphrey, sad to say,
Did nothing to enhance his pay
Or prestige, filling in his tome
With noughts-and-crosses, ribald rhyme,
Electronic timing for his Mini
Or amplifiers for home cine,
With evenings spent in loosening hip-joints
In Soho's less salubrious clip-joints.
But Phil, who scorned such carnal larks
As making love to birds in parks,
Reorientated his intention
And sought his fortune by invention.
He patented in quick succession
Brain-children in a long procession
Including a unique device
For electronically catching mice.
His grateful Company, while pocketing
Royalties which sent the shares a-rocketing,
Displayed their human circumspection
By raising Phil to Chief of Section
And — mark the carrot, gentle reader —
Hinted a future as Group Leader;
A circumstance which came to pass
Helped by a calculating lass
Named Alpha Kerve, a lab assistant
With ash-blonde hair and aim persistent
Towards a matrimonial life
As a Lab. Manager's gracious wife —
A laudable ambition quite
For which she laboured day and night.
But colleague Humphrey stayed immune
From Cupid's dart and, like a loon,
Withdrew his hem from toil and strife
In his laboratory life —
Conduct which labelled him "also ran"
With his employers, Gargantuan,
Who showed their grievous discontent
By freezing Humph's emolument.
Thus, on the ladder's lowest rung
Humphrey precariously hung
While Phil continued still to thrive —
The busiest bee in all the hive
(not a foot wrong and ne'er a cropper
A perfect ant to Humph's grasshopper
In you'll forgive this rhymster for
The mixing of a metaphor.)
And so the youthful years flew by
With Phil advancing annually
While Humphrey, wallowing in sloth,
Sowed oats sufficient for them both —
An object-lesson and reminder
To keep our hooters to the grinder
If in life's rat-race we'd succeed
And thus aspire the field to lead.

EPILOGUE

A figure in moth-eaten rags
Squats miserably upon the flags
Outside the tube at Baron's Court
"WIFE AND TV TO SUPPORT"
Proclaims the placard on his chest
And, touched by this oblique request,
The passer-by donates his mite
Despite the cost of living's bite;
Pfennig and centimes tinkle in
The thoughtfully provided tin.
But stay! A sleek Rolls-Royce approaches
And o'er the double line encroaches
While from the car steps a retainer
Depositing tuppence in the container
And then his Christian duty done,
Lord Humphrey Naild is driven on
While Phil the coinage quickly clutches
And gratefully his forelock touches. . . .

. . . .

Patience, reader, I'll explain
'Til truth's as clear as windowpane
Our Phil's inventive wells ran dry
And brought him to redundancy,
While Humphrey, tired of bread and water
Craftily wed the Chairman's daughter
Becoming, through this master-plan,
The whizz-kid of Gargantuan.

MORAL:

There isn't one.

mavis

ELECTRONIC CROSS-OVER

The Mavis 3 way electronic cross-over is intended for use primarily with music and speech amplifying systems. It enables the bass range, mid-range and treble range to be separately controlled. The cross-over frequency for each range can be specified if required but will be, in the standard unit, as follows:
Bass roll-off 45 c.p.s.
Bass to mid-crossing point 800 c.p.s.
Mid to treble crossing point 5000 c.p.s.
The unit's output is balanced 600 ohm Line for each channel capable of driving six 600 ohm balance sources. The input to the cross-over is also 600 ohm balance.

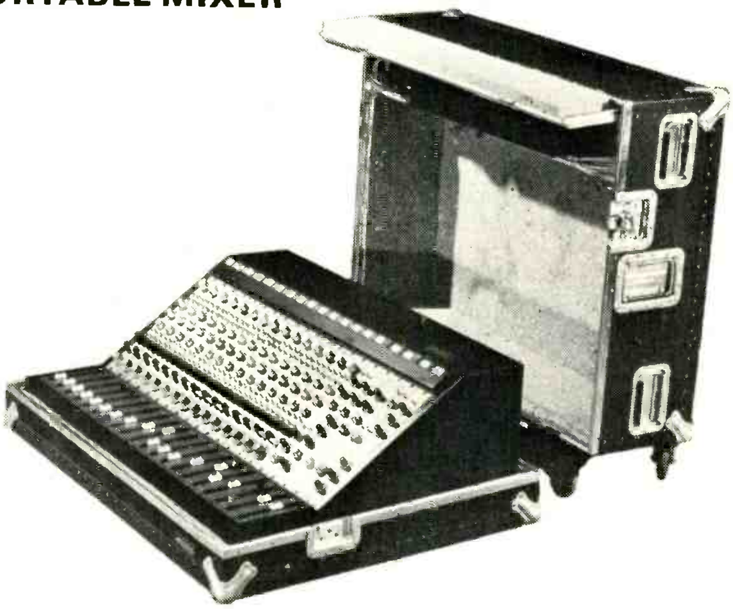
GENERAL SPECIFICATION

Size	19" x 12" deep x 7" high (standard 19" racking)
Weight	35lb.
Input	0 dbm 600 ohm balance
Output	+10 dbm 600 ohm balance
Power Requirements	110/230 volts 50/60 c.p.s. at 80 watts approx.
Optional extra	Sub plate

PRICE — £500

WW—111 FOR FURTHER DETAILS

PORTABLE MIXER



This mixer has been designed for mobile use in conjunction with high quality audio systems. It has basically 15 fully equalized input channels, plus 2 high level auxiliary input channels. The mixer can be used in two configurations, either 4 track full range output or 2 track output split into 3 channels each track, each channel controlled by an electronic cross-over. The remaining 2 tracks can be used either as full range tracks or re-mixed into tracks 1 & 2 as sub-mixers. The mixer also has 2 fully equalized independent monitor outputs and drive facilities for an external echo system. There is also an output for use with headphones to listen through for cueing each channel.

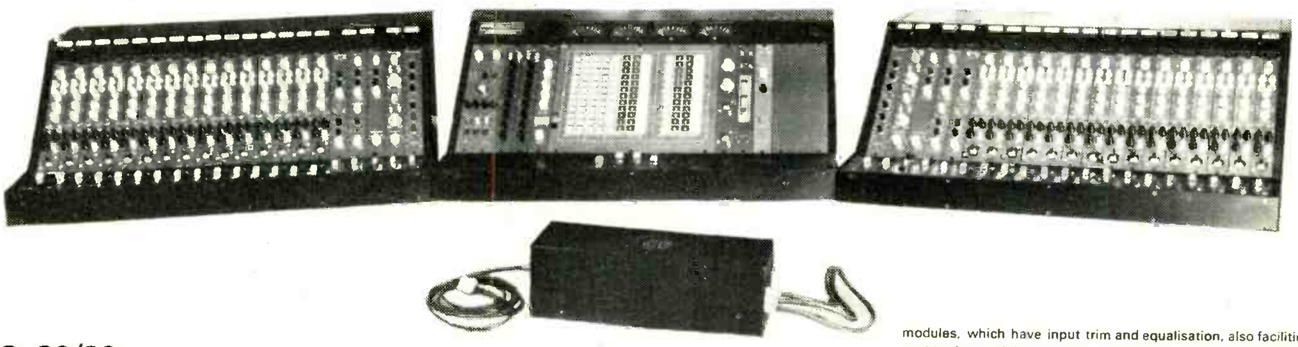
GENERAL SPECIFICATION

Size	38" x 27" x 12"
Weight	190lb approximately
Power Consumption	80 watts approximately
Input Impedance	600 ohm balanced
Output Impedance	600 ohm balanced
Input level 15 modules	—60 dbm
Input level auxiliary 2 inputs	—0 dbm
Output level	+10 dbm all channels
Cue output level	—300 milliwatts
Equalisation range	± 14 db treble
	± 20 db mid
	± 14 db bass
	± 20 db bass peak
Overall noise	better than — 60 db below full output
Channel separation	better than — 80 dbm

PRICE — £6,000 INCLUDING FREIGHT CASE

WW—112 FOR FURTHER DETAILS

INTRODUCING THE P.A.S. 30/30



P.A.S. 30/30

This 30 Channel Desk is a development of the Mavis Four Group 15 Channel Mixer to meet the growing demands of modern P.A. and Studio work. It is designed such that every channel may be operated with total flexibility in a four channel quadraphonic setup, and for purposes of live recording it is unique in the fact that a multi-track tape machine of up to 30 tracks may be directly coupled to the channels and a 4 track Tape Machine to the mains groups. The Mixer can then at a later stage be used for mixing down to a stereo or quad master using the main group outputs.
As a compromise between a P.A. Mixer and a conventional Studio Desk, it differs from the latter in the fact that apart from the usual foldback, echo send, cueing facilities etc., only eight sub-groups and four main groups are employed when the desk is used in total; the line drives for recording are derived directly from each channel, and are fully equipped for patching in auxiliary equipment, and may be switched before or after the channels' "EQ" section.
The desk is built in three sections. Two wings (which may be used independently in stereo for P.A.) are equipped with fifteen channels each and a complete output arrangement including four groups and a stereo cross-over. The third section — the routing for the two wings and all the extra equipment needed for master quad control and mix-down into four or two track. This is dealt with in Section B of the Instruction Manual.
Using an extra stereo cross-over each wing can drive a quadraphonic P.A. system.

GENERAL SPECIFICATION

The 30/30 Mixer is divided into four parts. A Centre Desk containing Routing, Foldback, Monitor, Talkback, Echo & Cueing Combiner, Oscillator and Master Quad and Pan facilities with 4 Master Faders. There also can be built-in remote control facilities for Dolby's Machine Control and Auto Tape Locators. The Centre Desk has 4 group outputs, 4 machine inputs, two foldback outputs and 4 monitor outputs also group break "in and out" facilities. There are also sockets to connect this desk to the two wings and a plug for the power supply. Two input wings which are mirror images, and contain 15 input modules, which have input trim and equalisation, also facilities which enable the module to supply a line level drive for a tape machine with or without equalisation also 4 group outputs which may be combined by switches to be used as quadraphonic output or a pan output. There are facilities for 2 monitor or effects outputs and one echo output.
The module has a switch which controls the output to group, off or cue.
There is also a switch which enables a break socket on the rear panel for effects drive and inputs to be switched in and out
The fourth unit is the power supply which powers the Centre Desk and two wings and provides a 48 volts Phantom Microphone supply to the thirty microphone inputs.

Wing and Centre Desk Size	101 x 82 x 41 cm. approx.
Weight Wing	120 Kg. approx.
Centre	100 Kg. approx.
Power Consumption	500 watts.
Input Impedance	600 or 1200 ohms. Balanced
Output Impedance	600 ohms. Balanced
Maximum Input Sensitivity	
Microphone Input	−60 dbm
Machine Input	0 dbm
Nominal Output	+10 dbm PA
Nominal Output	0 dbm Machine
Cue Output	300 milliwatts
Monitor Output	+10 dbm
Foldback Output	+10 dbm
Echo Output	+10 dbm

11a SHARPLESHALL ST., LONDON, N.W.1

Tel. 01-722 7161/2/3/4 Telex: London 27655

WW—113 FOR FURTHER DETAILS

Sinclair Project 60

New performance standards ...new safety margins

Z.50 Mk 2

Such are the results of using a PZ8 Mk.3 to drive two Z.50 Mk.2 power amplifiers. Developed from the original Z.50, the Mk.2 has improved thermal stability, better regulated D.C. limiting to ensure more symmetrical output voltage swing with still less distortion at lower outputs and automatic transient overload protection. The PZ.8 Mk.3 is the most advanced power supply unit ever to be made at a reasonable price. It cannot be damaged by direct shorting, nor will it fail through overloading, because of an ingenious re-entrant current limiting principle used usually only in expensive laboratory equipment. Because output voltage is variable, the PZ8 Mk.3 makes a worthwhile alternative where PZ.5 and PZ.6 are recommended for Project 60 applications, particularly since this most powerful of all Sinclair supply units can be operated from a smaller mains transformer. Together, the Z.50 Mk.2 and PZ8 Mk.3 provide new standards of performance and reliability and these modules are compatible with earlier types in the Project 60 range.

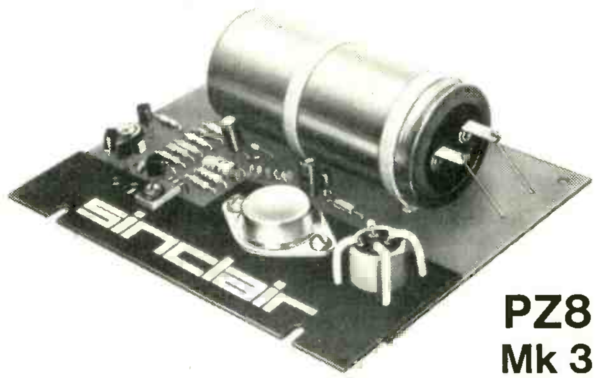
Z.50 Mk.2 SPECIFICATIONS
Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See published curve
Frequency response 10Hz to more than 200 KHz ± 1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit

£5.48 + V.A.T. 54p

PZ.8 Mk.3 SPECIFICATIONS
Nominal working output 45V.
Adjustable between 20 & 50V.

£7.98 + V.A.T. 79p

Mains Transformer £5.98 + V.A.T. 59p



PZ8 Mk 3

Other power supplies

In addition to the remarkable Sinclair PZ.8 Mk.III as described, there are two other power units available, which should be chosen according to their types in order to buy to best advantage. All are for operation from A.C. mains 240V.

PZ.5 30 volt, unstabilised **£4.98** + V.A.T. 49p

PZ.6 35 volt, stabilised (Not suitable for Super IC.12). **£7.98** + V.A.T. 79p

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you. A small charge may be made in those cases where damage arises through miss-use. No charge is made for postage by surface mail. Air Mail charged at cost.

Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	Z.50	Crystal P.U., 12V battery volume control, etc.	£5.48 + V.A.T. 54p
Mains powered record player	Z.50, PZ.5	Crystal or ceramic P.U. volume control, etc.	£10.46 + V.A.T. £1.04
12W. RMS continuous sine wave stereo amp. for average needs	2 x Z.50, Stereo 60; PZ.5	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	£25.92 + V.A.T. £2.59
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	2 x Z.50, Stereo 60; PZ.6	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	£28.92 + V.A.T. £2.89
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	2 x Z.50 Mk.2, Stereo 60; PZ.8 Mk.3 transformer	As above	£34.90 + V.A.T. £3.49
Indoor P.A.	Z.50 Mk.2, PZ.8 Mk.3 transformer	Mic., guitar, speakers, etc., controls	£19.44 + V.A.T. £1.94

A.F.U. (**£5.98** + V.A.T. 59p) may be added as required.

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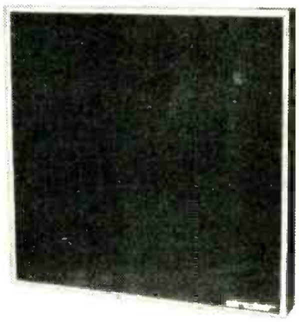
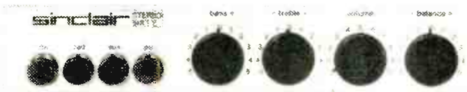
Q.16 high fidelity loudspeaker



The Q 16 employs original and by now well proven acoustic principles in which a special driver assembly is meticulously matched to a uniquely designed cabinet. In performance it comfortably stands comparison with very much more expensive loudspeakers. A solid teak surround is used with a special all-over cellular black foam front chosen both for its appearance and ability to pass all audio frequencies without masking.

Specifications
Construction: A sealed seamless sound or pressure chamber is used with internal baffle, and special high flux driver
Loading: Up to 14 watts RMS, into 8 ohms
Frequency response: From 60 to 16,000 Hz
Size and styling: 248 mm square x 120 mm deep (9¾" x 4¾") with neat pedestal base.

£7.70 +V.A.T. 77p



Stereo 60 pre-amp/control unit

Designed specifically for Project 60 systems, the Stereo 60 is equally suitable with any high quality power amplifier. Silicon epitaxial planar transistors used throughout ensure high signal-to-noise ratio and excellent tracking between channels. Input selection is by press buttons, with accurate equalisation on all input channels. The unit is easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV; correct to R.I.A.A. curve ±1dB: 20 to 25,000Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 × 40 × 207mm.

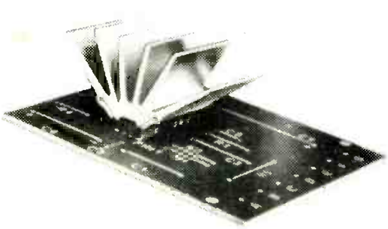
Built, tested and guaranteed. **£9.98** +V.A.T. 99p

AFU filter unit

For use between Stereo 60 and two Z 30's or Z 50's in stereo formation. Cut off frequencies are continuously variable, with 12dB/octave cut in the rejection band. Two stages of filtering – rumble (high pass) and scratch (low pass). Amplitude and phase distortion are negligible. Supply voltage needed – 15–35V. H.F. cut-off (–3dB) 28KHz to 5KHz: L.F. (–3dB) 25Hz to 100Hz. For Project 60 or any good stereo system. Built, tested and guaranteed

£5.98 +V.A.T. 59p

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, which was the first time an IC had ever been made available for such purposes, we followed it with an even more efficient version, the Super IC.12. This needs very few external resistors and capacitors to make an exceedingly efficient high fidelity amplifier for pick-up, F.M. radio or small P.A. set up etc. The free 40 page manual supplied details many other applications which this remarkable IC make possible. The Super IC.12 is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all likely requirements. The Super IC.12 is also compatible with those Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS
Output power: 6 watts RMS continuous (12 watts peak) into 6–8 Ω. **Frequency Response:** 5Hz to 100KHz ± 1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0.1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feed-back. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 × 45 × 28mm including pins and heat sink.
Manual available separately 15p post free

With FREE printed circuit board and 40 page manual.
£2.98 +V.A.T. 29p Post free

Project 605

the simple way to build a Project 60 system without soldering

For the many audio enthusiasts anxious to build to high standards without too many involvements, there could be nothing better or simpler than Project 605. It offers the advantages of Project 60 and is absolutely complete down to the last piece of wire cut to length. Whilst not as powerful as assemblies using Z.50 power amplifiers, we know from experience that there are many for whom the specifications of Project 605 are ideal, particularly in relation to the environment in which it is required to be used. In Project 605 you have everything necessary to build a versatile Project 60 thirty watt high fidelity amplifier system suitable for all domestic requirements. The convenient pack includes two Z.30 power amplifiers, a Stereo 60 pre-amp control unit and the special Masterlink unit to and from which all input and output connections are made. For power a PZ.5 is provided. Building is particularly easy since all necessary leads are supplied colour coded, cut to length and terminated by contact clips which connect firmly to the modules. There is absolutely no soldering to be done. Complete with comprehensive, easy to follow instructions manual.

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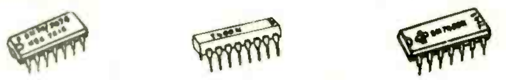

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SN7401AN	0·38	0·38	0·33	SN7451N	0·20	0·18	0·16	SN74145N	1·44	1·44	1·26
SN7402N	0·20	0·18	0·16	SN7453N	0·20	0·18	0·16	SN74147N	2·30	2·30	1·83
SN7403N	0·20	0·18	0·16	SN7454N	0·20	0·18	0·16	SN74148N	2·01	2·01	1·63
SN7403AN	0·38	0·38	0·33	SN7460N	0·20	0·18	0·16	SN74150N	2·30	2·30	2·01
SN7404N	0·24	0·21	0·18	SN7470N	0·33	0·30	0·27	SN74151N	1·15	1·15	1·00
SN7405N	0·20	0·18	0·16	SN7472N	0·38	0·38	0·34	SN74153N	1·09	1·09	0·95
SN7405AN	0·44	0·44	0·38	SN7473N	0·44	0·41	0·37	SN74154N	2·30	2·30	2·01
SN7406N	0·40	0·38	0·35	SN7474N	0·48	0·48	0·42	SN74155N	1·15	1·15	1·00
SN7407N	0·40	0·38	0·35	SN7475N	0·59	0·55	0·51	SN74156N	1·09	1·09	1·00
SN7408N	0·25	0·22	0·19	SN7476N	0·45	0·36	0·32	SN74157N	1·09	1·09	0·95
SN7409N	0·33	0·33	0·28	SN7480N	0·80	0·70	0·50	SN74159N	2·44	2·44	2·14
SN7409AN	0·44	0·44	0·38	SN7481N	1·25	1·10	0·95	SN74160N	1·58	1·58	1·38
SN7410N	0·20	0·18	0·16	SN7482N	0·87	0·80	0·72	SN74161N	1·58	1·58	1·38
SN7411N	0·25	0·23	0·21	SN7483N	1·20	1·10	1·00	SN74162N	1·58	1·58	1·38
SN7412N	0·28	0·28	0·25	SN7485N	1·87	1·87	1·63	SN74163N	1·58	1·58	1·38
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SN7413N	0·30	0·27	0·25	SN7489N	4·32	4·32	3·78	SN74165N	2·01	2·01	1·76
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SN7417N	0·30	0·27	0·25	SN7492N	0·75	0·70	0·63	SN74170N	2·88	2·88	2·52
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SN7423N	0·37	0·34	0·32	SN7496N	1·00	0·90	0·83	SN74175N	1·29	1·29	1·13
SN7425N	0·37	0·37	0·32	SN74100N	2·16	1·89	1·89	SN74176N	1·44	1·44	1·26
SN7427N	0·37	0·37	0·32	SN74104N	0·60	0·53	0·45	SN74177N	1·44	1·44	1·26
SN7428N	0·43	0·43	0·37	SN74105N	0·60	0·53	0·45	SN74180N	1·44	1·44	1·26
SN7430N	0·20	0·18	0·16	SN74107N	0·51	0·51	0·45	SN74181N	5·18	5·18	4·53
SN7432N	0·37	0·37	0·32	SN74110N	0·57	0·57	0·50	SN74182N	1·44	1·44	1·26
SN7433N	0·43	0·43	0·38	SN74111N	0·86	0·86	0·75	SN74184N	2·16	2·16	1·89
SN7433AN	0·57	0·57	0·50	SN74116N	2·16	2·16	1·89	SN74185AN	2·16	2·16	1·89
SN7437N	0·43	0·43	0·37	SN74118N	1·00	0·90	0·83	SN74188N	6·48	6·48	5·67
SN7438N	0·43	0·43	0·37	SN74119N	1·92	1·92	1·68	SN74190N	2·30	2·30	2·01
SN7438AN	0·57	0·57	0·50	SN74120N	1·05	1·05	0·92	SN74191N	2·30	2·30	2·01
SN7440N	0·20	0·18	0·16	SN74121N	0·57	0·57	0·50	SN74192N	2·30	2·30	2·01
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BAX13	5p	BFY51	20p	OA202	10p	TIL209	25p	2N3053	20p	40362	40p
BC107	12p	BFY64	45p	OC16	85p	TIP29A	49p	2N3054	45p	40408	50p
BC108	12p	BFY90	75p	OC20	1·25	TIP30A	58p	2N3055	45p	40486	75p
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SC35D	400v	90p
SC35E	500v	£1·20
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85

6 AMP RANGE

SC40A	100v	90p
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SC40D	400v	£1·20
SC40E	500v	£1·50

10 AMP RANGE

SC45A	100v	£1·05

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CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p
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230	AM/FM aerial amplifier	2·79
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275	Mic. preamplifier	5·83
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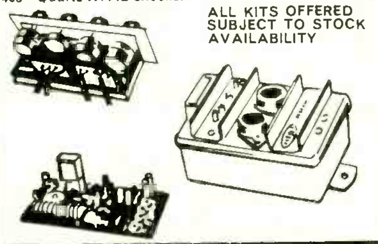

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⅛ x ⅛ x ⅛" dia.

½ AMP 1-11 Pricing

Type	P.I.V.	Price ea.
B05/05	50v	20p
B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

⅛H x ⅛L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

⅛H x ⅛L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

⅜ x ⅜" Tubular

2 AMPS P.I.V.

B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

⅛H x ⅛L x $\frac{3}{16}$" dia.

4 AMPS P.I.V.

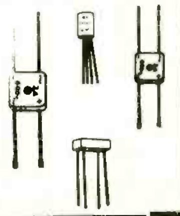
B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	65p
B4/600	600v	75p
B4/800	800v	£1·00

⅛H x ⅛L x $\frac{3}{16}$" dia.

6 AMPS P.I.V.

B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

⅛H x ⅛L x $\frac{3}{16}$" dia.



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All types of Transistors Rectifiers—Bridges SCR's—Triacs Integrated Circuits F.E.T.—Light Devices
OVER 1500 DIFFERENT DEVICES
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More Devices ★ New Prices ★ New Ranges ★

This is a must for all Semi-conductor Users. (Ask for booklet No. 36.)

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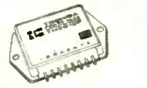
TBA800 5 WATT IC
Suitable alternative to SL403D 5/30 volt operated. 8/16 OHM 5 watt output. With circuits and data £1·50.

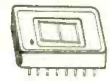


Toshiba Power and Pre-amplifier modules
TH9013P 20 watt Power amplifier 22-0-22 or single 45 volts operated. £4·57.
TG9014P Stereo on two channel preamplifier. £1·50 (circuit book No. 42 price 10p).

Sinclair IC12
with circuits and data. 6 watt IC with printed circuit board. 28 volt. operated. £1·80.

Ultrasonic Transducers
Operate at 40Khz up to 100 yds. Ideal remote switching and signalling. Complete with data transmitter and receiver new I.C circuits. Per pair £5·90.

ZN414 IC
Integrated circuit radio as featured by many magazines (PW Jan. 73 Reprint Ref. No. 19 for 10p). £1·20.



3015F 7 SEG.
I.C. size complete with data price **£2** each or 4 for **£7** (digital clock circuits ref. No. 31, 15p).

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—thats the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4⅓" long x 2" wide x $\frac{11}{16}$" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines etc.
Price £24·95 + VAT. Also available assembled ready to use £29·95 + VAT.

LIVING SOUND LOW NOISE TOP QUALITY CASSETTES MADE BY EMI TO INTERNATIONAL STANDARDS ESPECIALLY FOR HENRY'S. ALL POST PAID LESS THAN ½ REC. PRICES.

	3 for	6 for	10 for	25 for
C 60	£1·00	£1·80	£2·80	£6·75
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Quantity and trade enquiries invited.

LEARN A LANGUAGE—complete with phrase book. German—French—Spanish—Italian £1·36 per course. £5 for any 4.

A SELECTION OF INTERESTING ITEMS

C3025	Compact transistor tester	5·50 p & p 15p
E1300	Mono mag. cart. preamp.	1·95 p & p 15p
E1310	Stereo mag. cart. preamp.	4·95 p & p 25p
Easiphone	telephone amplifier	6·15 p & p 25p
D1203	Teleamp. with PU coil	3·60 p & p 20p
LL1	Door Intercomm. and chime	11·95 p & p 25p
Chattalite (lights as you talk)		13·90 p & p 20p
1 Kw Dimmer/controller		3·00 p & p 10p
9" Twin spring unit	For	2·75 p & p 15p
16" Twin spring unit	Reverbs	6·50 p & p 25p
Car Tachometer Electronic		7·50 p & p 15p
VHF 105 Aircraft band converter		3·95 p & p 15p
VHF 205 Marine band converter		3·95 p & p 15p
B2005 4 Ch. mic. mixer		2·95 p & p 15p
B2004 2 ch. Stereo mixer		4·75 p & p 15p

Henry's RADIO LIMITED
EDGWARE ROAD, W2

ELECTRONICS FOR EVERY PURPOSE
See facing page for addresses

TOP QUALITY SLIDER CONTROLS
60mm stroke high quality controls complete with knobs (post, etc., 15p any quantity).
Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg, 45p each.
Ganged Log and Lin 10K, 22K, 50K, 100K, 250K, 65p each. (Quantity discounts available.) Complete with knobs.

MARRIOT TAPE HEADS
4 TRACK MONO or 2 TRACK STEREO. '17' High Impedance **£2·00**. '18' Medium Impedance £2·00. R730/E73 2 track mono Record/Erase low Imp. 75p pair. Erase Heads for '17' and '18' 75p. '63' 2 track mono, Hi Imp. £1·75. '43' Erase Head for '63' 75p. (Post, etc., 15p any quantity.)

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U.K's LARGEST RANGE OF ELECTRONIC COMPONENTS AND EQUIPMENT AT BARGAIN PRICES

Latest Catalogue price 55p post paid. Complete with Discount Vouchers

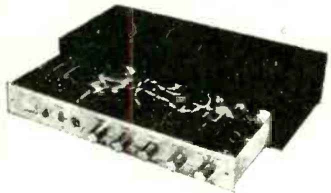
BUILD THE TEXAN

20 + 20 WATT IC STEREO AMPLIFIER

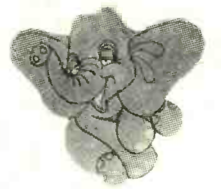
As featured by *Practical Wireless* 1972

Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15½"x2¾"x6¾" 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY AND STABILITY ARE PREDOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES. On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U. Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 **30p.** Distributed by Henry's throughout UK.

FREE—Teak cabinet with complete kit. Kit price £28·50 (+VAT+50p carr/packing) or built and tested £35·00 (+VAT+50p carr/packing) as illustrated.



BUILD THE NEW HENELEC STEREO FM TUNER



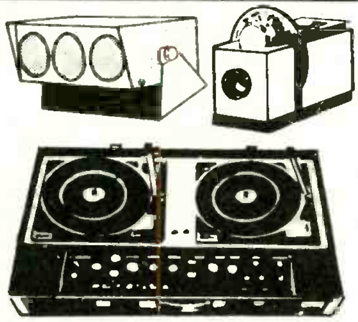
You pay less VAT with Henry's Low Prices

A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages. LED indicators, Tuning meter, AFC, easy to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet etc. Available as a kit to build or ready built. Overall size 8" x 2¼" x 6¾".

Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 **30p**). Henry's are sole distributors UK and Europe.

Kit price £21·00 (+ VAT) or built and tested £24·95 (+ VAT).

EARN YOURSELF EASY MONEY, WITH PORTABLE DISCO EQUIPMENT



DISCO MINI A complete portable disco, fitted mixer/preamp, 2 decks all facilities £98·50
100 watt amplifier for above £38·75
SL100 100 watt mixer/amplifier with slider controls £69·00
R50 50 watt mixer/amplifier £49·50
DISCO AMP 100 watt mixer/amplifier chassis unit £65·85
DISCO MIXER/PREAMPLIFIERS (OP for up to 6-100 watt amplifiers)
SDLI (rotary controls) £49·50
SDLII (slider controls) £58·50
DISCO VOX (slider controls) the complete disco unit £69·50
DJ100 100 watt power amplifier for above £38·75
DJ30L 3 channel 3kw sound to light £29·50
DJ40L as 30L plus built in microphone £38·75
DIMANATIC 1 kW adjustable speed auto dimmer £25·00
SCENE STROBE £19·00. **ROAD STROBE** £25·00
Disco anti-feedback microphone £11·95
Colt 150 watt liquid wheel projector £22·50
150 watt QI liquid wheel projector £50·00

150 watt QI cassette wheel projector £50·00
Spare Effects cassettes large range of patterns £8·00
Mini spot bank fitted 3 lamps £11·00
Auto Trilite (mini with flashers) £17·00
Mixer/Misc/Speakers/Lighting UK's largest range.
FREE stock list ref. No. 18 on request.

TEXAN STEREO SYSTEM

PLUS PRICE SAVINGS

The Texan Stereo Systems include the high quality Texan Stereo amplifier assembled and ready to use. A pair of Type 200 20 watt Speaker-Tweeter systems size 21" x 12" x 10" and a choice of Garrard players built into a plinth with cover with Goldring G800 magnetic cartridge. Systems 25 uses Garrard SP25 Mk III and system 76 the Garrard AP76 de luxe turntable. All necessary leads are supplied.

System 25 (list aoprox. £109) £79·50
System 76 (list approx. £117) £89·50
(plus 10% VAT and plus £1·45 carr/packing)

SINCLAIR AND MINIATURE AMPLIFIERS

AMPLIFIERS (carr. etc. 20p).

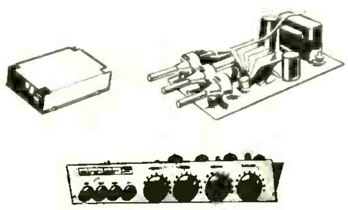
4-300, 0·3 watt 9 volt	£1·75
104, 1 watt 9 volt	£2·20
304, 3 watt 9 volt	£2·50
555, 3 watt 12 volt	£2·85
E1208, 5 watt 12 volt	£4·50
608, 10 watt 24 volt	£4·10
410, 10 watt 28 volt	£4·95
Z30, 15 watt 30 volt	£3·57
E1206, 30 watt 45 volt	£9·75
Z50, 30 watt 50 volt	£4·37
E1210, 2½ + 2½ watts 12 volt	£5·25
RE500, 5 watt IC mains operated Amplifier with controls	£6·30
SAC14, 7 + 7 watt Stereo with controls	£8·00
SAC13, 15 + 15 watt Stereo with controls	£11·00

SINCLAIR UNITS (carr. 20p)

Z30 3·57 Z50	£4·37
Stereo 60 Preamplifier	£7·97
PZ5 £3·97, PZ6 £6·37, PZ8 (for Z50) (TRANS £2·95)	£4·77
AFU	£4·45

SINCLAIR PACKAGE DEALS (Post 25p)

2 x Z30, Stereo 60, PZ5	£15·95
2 x Z30, Stereo 60, PZ6	£18·00
2 x Z50, Stereo 60, PZ8	£20·25
Transformer for PZ8	£2·95
PROJECT 605 KIT	£19·95



POWER SUPPLIES FOR EVERY PURPOSE

(All cased unless stated chassis)

470C 6/7½/9 volt 300 MA (Includes Multi-Adaptor for Tape Recorders, etc.)	£1·95 post 20p
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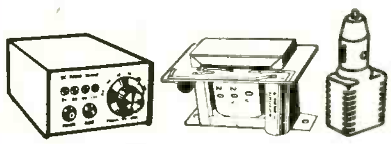
SC202 3/6/7½/9 volt 400mA	£3·25 carr. 30p
HC244R Stabilised version	£4·25 carr. 30p
P500 9 volt 500mA	£2·80 post 20p
P11 24 volt 500mA (chassis)	£2·80 post 20p
P15 26/28 volt 1 amp (chassis)	£2·70 post 20p
P1080 12v 1 amp (chassis)	£3·25 post 20p
P1081 45v 0·9 amp (chassis)	£4·40 post 20p
P12 4½-12 volt 0·4-1 amp	£6·75 post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.)	£9·15 post 25p
RP164 6/7½/9/12 1 amp (Stab.)	£9·95 post 30p



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Big Discounts—Demonstrations
Phone 01-402 5854 for quotes on stocklist.
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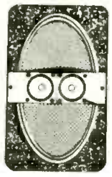
LOW COST HI-FI SPEAKERS



SPECIAL OFFER
EMI 13" x 8"—full range speakers (post 20p each or 30p pair)
*150TC—8 ohms Twin Cone 10 watt £2·20 each or £4·00 pair.
*450 10 watt C/o Twin Tweeters 3, 8 or 15 ohms £3·50 each or £6·90 pair.
EW 15 watt 8 ohms C/o Tweeter £4·30 each or £7·90 pair.
350 20 watt C/o Tweeters 8 or 15 ohms £7·50 each or £14·20 pair.
* Polished wood cabinet £4·60 post 35p.

8 ohms full range (post 20p)

FR4	4"	5 watt	£4·00
FR65	6½"	10 watt	£5·50
FR8	8"	15 watt	£7·60
FR23	9 x 6"	15 watt	£6·00

BASS & MID RANGE—8 ohms (post 20p)

AA12	5"	15 watt	£3·20
B110	5½"	15 watt	£5·60
B200	8"	15 watt	£6·45
B139/2	13" x 8"	30 watt LF	£10·25

TWEETERS AND CROSSOVERS (post 20p)

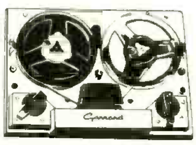
K2006	10 watt	8 or 15 ohms	£1·90
FHT6	15 watt	8 ohms	£3·20
K2011	30 watt	8 ohms	£3·75
T27	KEF		£4·25
Axcent 100	30 watt	8 ohms	£4·90
K4009	1kHz/5kHz	C/o	£2·00
SN75	3kHz var.	C/o	£1·75

SPEAKER KITS (carr. etc. 35p)

20-2	8"	30 watt	£10·00 each
20-3	8"	40 watt	£15·00 each
LINTON 2	20 watt		£15·95 pair
GLENDALE 3	30 watt		£28·95 pair
DOVEDALE 3	50 watt		£42·00 pair
KEF KK2			£20·40 each
KEF KK3			£32·00 each

GARRARD BATTERY TAPE DECK

GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits.
£9·50 carr. 30p.



TEST EQUIPMENT MULTIMETERS

(carr. etc. 30p)

200H	20K/Volt Slimline with case	£4·95
TLH33D	2K/Volt Robust with case	£4·95
U437	10K/Volt Steel case. AC up to 40KHz	£4·95
U4324	20K/Volt with AC current ranges	£8·00
AF105	50K/Volt with Leather case	£9·50
U4313	20K/Volt AC current. Steel case	£10·50
U4341	Plus Built in transistor tester	£10·50
Model 500	30K/Volt	£9·95

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Henry's RADIO LIMITED

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COMPONENTS FOR W.W. AMPLIFIER DESIGNS

100W AMPLIFIER (FEB. 1972)
Designer approved kit.

Semiconductor set	15·60
Resistors, capacitors, pots	2·50
F/Glass PCB	1·30

POWER SUPPLY (For 100W Amp.)
Designer approved kit.

Semiconductors, Resistors, capacitors, pots, transformers, F/Glass PCB	14·70

30W BLOMLEY (New approach to class B)

Semiconductor set	5·60
Resistors, capacitors, pots	1·85
F/Glass PCB	0·70

30W BAILEY (Single power rail)

Transistor set	4·60
Resistors, capacitors, pots	1·45
F/Glass PCB	0·65

LINSLEY-HOOD CLASS A (Dec., 1970, circuit)
Designer approved kit.

2N3055 pair, BC212L, 2N1711	1·20
Resistors, capacitors, pot	1·80
F/Glass PCB	0·60

LINSLEY-HOOD 20W CLASS AB
Designer approved kit.

MJ481/491, MJE521, BC182L, BC212L, zener	3·35
Resistors, capacitors, pots	2·20
F/Glass PCB	0·70

Please state 8Ω or 15Ω

REGULATED 60V POWER SUPPLY
A 5 transistor series stabiliser, suitable for a pair of Bailey or Blomley amplifiers, featuring very effective S/C protection. All Semi/C's, R's, C's, F/Glass PCB .. 4·85
Power supplies for other amplifiers also available

BAILEY/BURROWS PRE-AMP (Aug., 1971)

Component Set: Mono	2·75
Component set: Stereo	6·35

Each component set comprises of all specified resistors, capacitors, transistors pots, including special balance control for stereo sets.

Stereo F/Glass PCB	1·60

STUART TAPE RECORDER

Set of stereo f/glass PCBs	2·70

Components sets on price ist.

'TEXAN' TEXAS INSTRUMENTS DESIGNED & APPROVED FULL KIT

£28·50 INCLUDES TEAK CASE

20 Watt per channel stereo amplifier designed by Richard Mann of Texas Instruments and published in Practical Wireless May-July 1972.
This low distortion (0.09% at 20W into 8 ohm), wide bandwidth (—3dB 5Hz-35KHz) design is offered as a Texas Instruments approved full kit (including all metalwork and Teak case for a total of **£28.50** post paid. Full details in price list.

METALWORK SYSTEM

Designed to house Bailey, Blomley or Linsley Hood Class AB amplifiers with simple or regulated power supplies and Bailey Burrows pre-amp. Options of standard or hum reducing toroidal mains transformer.

TOROIDAL TRANSFORMER 60 volt 2 amp.

Max. height 2in. Suitable for our regulated power supply	£7.40
Simple clamp	£0.20
Magnetically screening clamp	£0.75

SEMICONDUCTORS

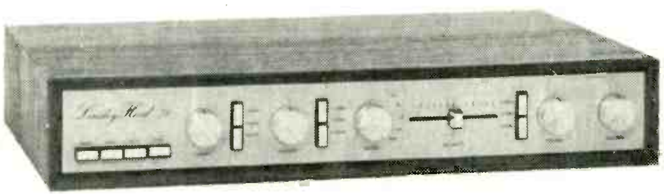
2N699	0·25	BC184L	0·11
2N1613	0·20	BC212L	0·12
2N1711	0·25	BC214L	0·14
2N2926G	0·10	BCY72	0.13
2N3053	0·15	BF257	0·40
2N3055	0·45	BF259	0·47
2N3442	1·20	BFR39	0.25
2N3702	0.11	BFR79	0.25
2N3703	0.10	BFY50	0·20
2N3704	0.10	BFY51	0.20
2N3705	0.10	BFY52	0.20
2N3706	0.09	MJ481	1·20
2N3707	0.10	MJ491	1·30
2N3708	0.07	MJE521	0·60
2N3709	0.09	MPSA05	0·30
2N3710	0.09	MPSA12	0·55
2N3711	0.09	MPSA14	0·35
2N3819	0·23	MPSA55	0·35
2N3904	0·17	MPSA65	0·35
2N3906	0·20	MPSA66	0·40
2N4058	0·12	MPSU05	0·60
2N4062	0·11	MPSU55	0·70
2N4302	0·60	SN72741P	0·58
2N5087	0.42	SN72748P	0·58
2N5210	0.54	THB11	1·10
2N5457	0·30	TIP29A	0·50
2N5830	0·30	TIP30A	0·60
40361	0·40	TIP31A	0·60
40362	0·45	TIP32A	0·70
BC107	0·08	TIP33A	1·00
BC108	0·08	TIP34A	1·50
BC109	0·08	TIP41A	0·74
BC125	0·15	TIP42A	0·90
BC126	0·15	TIP3055	0·60
BC182K	0·10	1B08T20	0·50
BC212K	0·12	1B40K20	1·40
BC182L	0·10	1N914	0·07
		1N916	0·07
		1S44	0·05
		1S920	0·10
		1S3062	0·25
		5B05	1·20

HI-FI NEWS 75 WATT AMPLIFIER

BY J. L. LINSLEY-HOOD

Published Nov. 1972 to Feb. 1973

DESIGNER APPROVED KIT



SLIMLINE STYLE CHASSIS DIMENSIONS: 17.0in. x 2.0in. x 12.0in.
This slimline unit has been made practical by the use of a specially designed TOROIDAL TRANSFORMER and highly compact printed circuit boards which have been fully tested and approved by Mr. Linsley-Hood.

★ **75 WATTS PER CHANNEL**
★ **BANDWIDTH (3dB) 3HZ-40KHZ**
★ **DISTORTION LESS THAN 0.01%**
★ **UNCONDITIONAL STABILITY**

COMPONENT PACKS

Pack		
1	Fibre glass printed circuit board for power amp.	£0.75
2	Set of resistors, capacitors, pre-sets for power amp.	£1.50
3	Set of semi-conductors for power amp. (highest voltage version)	£5.50
4	Pair of 2 drilled, finned heat sinks	£0.80
5	Fibre glass printed circuit board for pre-amp	£1.10
6	Set of low noise resistors, capacitors, pre-sets for pre-amp	£2.70
7	Set of low noise, high gain semi-conductors for pre-amp	£2.10
8	Set of potentiometers (including mains switch)	£1.55
9	Set of 4 push button switches, rotary mode switch	£3.10
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V. secondaries: 33-0-33 V. 24-0-24 V., electrostatic screen	£9.15
11	Fibre glass printed circuit board for power supply	£0.55
12	Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts., mains input skt. fuse holder, interconnecting cable, control knobs	£3.25
14	Set of metal workparts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook, based on Hi-Fi News articles	£0.30
16	Teak cabinet	£7.35

2 each of packs 1-7 inclusive are required for complete stereo system.

FREE TEAK CASE

WITH 75 WATT PER CHANNEL COMPLETE AMPLIFIER KITS

Total cost of individually purchased packs:
£63.95

Cost of complete kit:
£56.60

TRADE ENQUIRIES WELCOME

P.S. Full circuit description in handbook **30p**

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MAIL ORDER ONLY POST FREE TO U.K. OVERSEAS AT COST

U.K. Orders Subject to 10% V.A.T. Surcharge

Basic Component Set

Set of semi-conductors, resistors, capacitors, printed circuit boards for stereo power amp, pre-amp, and power supply.

£31.35

Handbook Included

New Branches **BOLTON COVENTRY SUNDERLAND STOCKPORT**
opening Sept. at **DONCASTER**

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BRADFORD 10 North Parade (Closed Wed.)
COVENTRY 17 Shelton Square (Closed Thurs.) Tel : 25983
DARLINGTON 19 Northgate (Closed Wed.)
DERBY The Spot, 26 Osmaston Rd. (Closed Wed.) Tel.: 41361
DONCASTER 3 Queensgate, Waterdale Centre.
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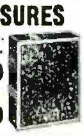

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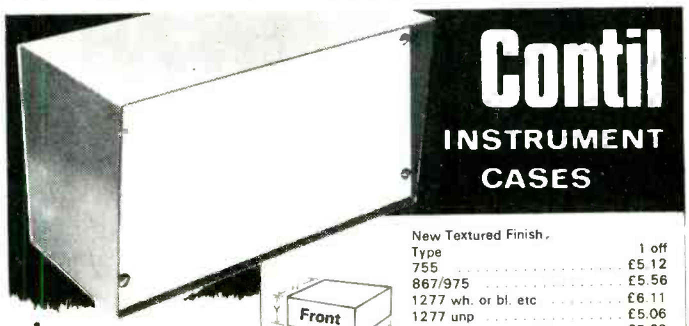

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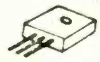

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DAWE 412B Pulse generator.
DAWE 1400B sound level meter.
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HEWLETT PACKARD 428A Clip on Ammeter.
HEWLETT PACKARD 456A Current probe.
MARCONI TF1400 Double pulse gen. with TM6600 Secondary pulse unit.

MARCONI TF1073 Attenuator.
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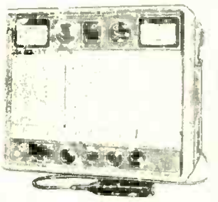

MARCONI TF 867 SIGNAL GENERATOR
Range: 15KHz to 30MHz. Output 0.4µV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. **£138** including carr.

MARCONI SIGNAL GENERATOR TF 801B/3/S. Range 12 Mc/s to 485 Mc/s. P.O.A.

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TF1345/2 COUNTER FREQUENCY METER with plug-in units up to 220 Mc/s. P.O.A.

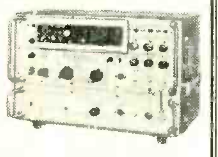
OA.1094A/3 H.F. SPECTRUM ANALYSER with trolley and L.F. extension unit type TM6448. Frequency range: 3-30 MHz in nine bands. Selectivity: 6, 30, 150 Hz at 3 dB. Spectrum width: 0-3 kHz and 0-30 kHz in two ranges. Sweep duration: 0·1, 0·3, 1, 3, 10 and 30 sec. and manual control.

TF 144H SIGNAL GENERATOR. Frequency range: 10 kHz-72 MHz. Stability: 0·002%. High discrimination, plus crystal calibrator. Good r.f. waveform at all frequencies. Protected thermocouple level monitor. Price and spec. on request.

A.P.T. CONSTANT CURRENT POWER SUPPLY MODEL 515S
D.C. voltage: 0-500v (cont. var.) in 4 ranges. D.C. current: 0-450mA adjustable 0-350mA in 7 steps, 0-90mA in 9 steps and 2-13mA var. A.C. voltage 6·3v at 10A. **£52** incl. carr.

L.F. RESOLVED COMPONENT INDICATOR TYPE VP 253·2. This instrument will indicate, by means of two centre-zero 6-in. scale meters, the resolved components of a signal voltage with respect to the applied reference energisation. Frequency range: nominal range 0·5 c/s to 1 Kc/s. Accuracy of Indication: ±3% of full scale on all ranges **£70.**

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)



8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. and price on request.

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Carrier range: 3 to 30 Mc/s. Sweep width: up to 30 Kc/s. 60 dB amplitude differences measurable. P.O.A.

THERMOCOUPLES. Mineral Insulated Metal Sheathed. Conductors: Positive Nickel—Chromium. Negative Nickel—Aluminium. Conductor Diameter: ·011 inch nominal. Tolerance: ± 3°C. up to 400°C. ± ¾% between 400°C. and 1000°C. Length 3ft. 2in. (96 cm. approx.). £2·25 post paid.

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AMPLIFIER ASSEMBLY Mk. 112AA for Monitoring Equipment Type IN.C.A.

ALPHA COUNTER Mk. INH.
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L.F. SOLATRON DECADE OSCILLATOR TYPE OS103.2. Frequency range: 0·01 c.p.s.—11·1 c.p.s. In steps of 0·01 c.p.s. with multipliers of 10, 100 and 1000 giving a maximum frequency of 11·1 Kc/s. Frequency accuracy ±1·5%. **£90.**

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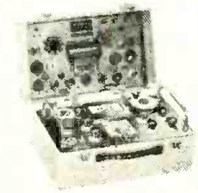
Enables comprehensive characteristics to be plotted, or measures valves on a simple good/bad basis. £55 incl. carr.



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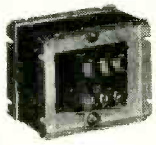
MAINS ISOLATING SERIES
Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded
ALSO AVAILABLE WITH 115/120V SECONDARY WINDING

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P p
07	20	1	11	7·0 × 6·0 × 6·5	1·94	30
100	60	3	8	8·9 × 8·0 × 7·7	2·88	36
61	100	5	12	10·2 × 8·9 × 8·3	3·16	52
30	200	9	8	12·0 × 10·3 × 10·0	5·31	52
62	250	12	4	9·5 × 12·7 × 11·4	7·61	67
55	350	15	0	14·0 × 10·8 × 12·4	9·40	82
63	500	27	0	17·1 × 11·4 × 15·9	13 55	*
92	1000	40	0	17·8 × 17·1 × 21·6	24 97	*
128	2000	63	0	24·1 × 21·6 × 15·2	41·25	*
129	3000	84	0	21·6 × 21·6 × 20 3	64·53	*
190	6000	178	0	31·1 × 35·6 × 17·1	105 89	*



440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £11·40. P & P 67p.

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P p
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	1·02	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	2 00	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·42	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	4·70	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	6 98	67
84	1000	16	0	11 4 × 14·0 × 14·0	,, ,,	12·69	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	18 39	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	24 00	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	32 67	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS
115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets. £9 49. P & P 67p
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PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	1·02	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·22	22
71	2	1	1	9	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·60	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	2·24	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·70	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	3·00	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	3·55	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	5·48	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	6·98	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	12·90	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	23·72	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	1·22	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·62	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	2·43	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·99	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	3·55	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	4·42	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	5·28	52
88	8·0	10	0	14·0 × 11·7 × 10·0	,, ,,	6·82	67
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	8·63	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·60	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	2·34	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	3·25	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	4·41	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	5·84	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	8 63	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	11·27	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	14·13	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·62	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	2·26	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	3·55	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	5·41	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	6·98	67
120	6·0	16	12	13·3 × 12 1 × 12·1	,, ,,	10 12	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	16·75	*

EQUIPMENT TRANSFORMER
REF 238 PRI 0240 SCREEN SEC 3·0 3V RMS at 200mA SIZE CM 2·8 x 2·6 x 2·0 WEIGHT 2oz £1·19 P & P 10p.

LEAD ACID BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P p
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·61	30
5	4·0	3	11	10·2 × 7·0 × 8·3		2·45	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·70	52
146	8·0	6	4	8·9 × 10 2 × 10 2		4·22	52
50	12·5	11	14	13·3 × 10 8 × 12·1		6·29	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

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25+ 7·5p
100+ 6·5p
500+ 6·0p
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2N 3055 60p each with mica and bushes
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500+ 40p

AD 161/162 60p pair with mica and bushes
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8½×5¼×1/16 in. **12½p** sheet, 5 for **50p**
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11×8×1/16 in. **20p** sheet, 3 for **50p**
16½ x 4 x 1/16 in. (Fibreglass), **30p** sheet.
Offcut pack (smallest 4×2 in.) **50p** 300 sq. in.
P&P single sheet **4p**. Bargain packs **10p**

SPEAKERS AND CABINETS
E.M.I. 13×8 in. (10 watt) with two tweeters and cross-over 3/8/15 ohm models. **£3·75.** P.P. 25p.
E.M.I. 20 watt (13×8 in.) with single tweeter and "X-over" 20 Hz to 20,000 Hz. Ceramic magnet 11,000gss. **£8.** P.P. 40p. 20 watt base unit only. **£6.** P.P. 40p.
CABINETS for 13 × 8 in. speakers manufactured in ¾ in. teak-finished blockboard. Size 14 × 10¼ × 9 in. **£5** ea. P.P. 40p.
20W. CABINET. 18 × 11 × 10 in. **£6.** P.P. 50p.

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5 digit (Reset) 12v. **£3.** P.P. 5p.

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250 WATT ISOLATION TRANSFORMER. 240v. double wound. **£3·25.** P.P. 50p.
E.H.T. TRANSFORMER. Prim. 240v. Sec. 2·5-0-2·5 kV. 12 mA.; 7.5v. 1 amp. 2.5v. 2 amp. **£2·50.** P.P. 25p.
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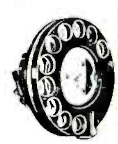

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2G374	0·15
2N174	1·40
2N404	0·43
2N456	0·75
2N456A	0·75
2N457A	0·80
2N491	3·25
2N696	0·15
2N697	0·15
2N698	0·25
2N699	0·29
2N706	0·10
2N706A	0·12
2N708	0·13
2N709	0·40
2N711	0·30
2N718	0·21
2N718A	0·30
2N720	0·50
2N721	0·55
2N914	0·15
2N916	0·17
2N918	0·30
2N929	0·14
2N930	0·14
2N1090	0·23
2N1091	0·24
2N1131	0·20
2N1132	0·20
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·37
2N1483	0·90
2N1507	0·24
2N1613	0·20
2N1631	0·35
2N1637	0·36
2N1638	0·32
2N1701	1·10
2N1702	2·15
2N1711	0·22
2N1893	0·34
2N2102	0·30
2N2147	0·70
2N2148	0·94
2N2192	0·40
2N2192A	0·40
2N2193	0·40
2N2193A	0·61
2N2194	0·27
2N2194A	0·30
2N2195	0·37
2N2195A	0·18
2N2218A	0·30
2N2219	0·37
2N2219A	0·51
2N2220	0·20
2N2221	0·20
2N2221A	0·33
2N2222	0·31
2N2222A	0·41
2N2368	0·11
2N2369	0·15
2N2369A	0·17
2N2646	0·70
2N2647	1·20
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·28
2N2904A	0·25
2N2905	0·71
2N2905A	0·88
2N2906	0·24
2N2906A	0·30
2N2907	0·32
2N2907A	0·33
2N2923	0·12
2N2924	0·12
2N2925	0·15
2N2926	
Green	0·12
Yellow	0·10
Orange	0·10
2N3053	0·31
2N3054	0·60
2N3055	0·75
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·17
2N3402	0·12

2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3571	1·12
2N3572	0·97
2N3702	0·11
2N3703	0·10
2N3704	0·14
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2N3706	0·09
2N3707	0·10
2N3708	0·70
2N3709	0·09
2N3710	0·12
2N3711	0·09
2N3712	0·95
2N3713	1·95
2N3714	2·29
2N3715	2·16
2N3716	3·00
2N3773	3·96
2N3779	3·15
2N3790	4·21
2N3791	4·20
2N3792	5·04
2N3794	0·10
2N3819	0·32
2N3820	0·47
2N3823	1·42
2N3824	1·33
2N3826	0·23
2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	1·69
2N3877	0·25
2N3877A	0·26
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·24
2N3904	0·27
2N3905	0·24
2N3906	0·27
2N4036	0·46
2N4037	0·40
2N4058	0·16
2N4059	0·09
2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4302	0·25
2N4303	0·47
2N4916	0·20
2N4917	0·17
2N4918	0·50
2N4919	0·63
2N4920	0·71
2N4921	0·50
2N4922	0·55
2N4923	0·60
2N5172	0·12
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5190	0·92
2N5191	0·96
2N5192	1·24
2N5193	1·01
2N5194	1·10
2N5195	1·46
2N5245	0·35
2N5457	0·35
2N5458	0·33
2N5459	0·33
3N128	0·73
3N138	1·65
3N139	1·42
3N140	0·92
3N141	0·81
3N142	0·58
3N143	0·75
3N152	0·92
3N153	0·81
3N154	0·84
3N159	1·17
3N187	1·55
3N200	2·49
3N201	1·05
40050	0·78
40251	0·81
40309	0·30
40310	0·50
40313	0·92

40316	0·50
40318	0·92
40360	0·46
40361	0·43
40362	0·45
40363	0·88
40389	0·46
40394	0·56
40395	0·65
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·53
40411	2·00
40414	3·55
40467	0·69
40468A	0·44
40600	0·69
40601	0·67
40602	0·46
40603	0·58
40604	0·56
40636	1·10
40673	0·70
AC107	0·35
AC113	0·16
AC115	0·16
AC117	0·20
AC121	0·13
AC126	0·25
AC127	0·20
AC128	0·20
AC141K	0·30
AC142K	0·25
AC151V	0·14
AC152V	0·17
AC153	0·22
AC153K	0·25
AC154	0·20
AC176	0·18
AC176K	0·20
AC187K	0·20
AC188K	0·26
ACY17	0·35
ACY18	0·24
ACY19	0·27
ACY20	0·22
ACY21	0·26
ACY22	0·16
ACY28	0·20
ACY30	0·42
ACY39	0·65
ACY40	0·17
ACY41	0·17
ACY44	0·31
AD136V	0·96
AD142	0·54
AD143	0·45
AD149V	0·66
AD150	0·63
AD161	0·45
AD162	0·45
AD161 }	Pr.
AD162 }	1·05
AF109R	0·40
AF114	0·25
AF115	0·24
AF116	0·25
AF117	0·20
AF118	0·50
AF121	0·24
AF124	0·24
AF125	0·20
AF126	0·19
AF127	0·20
AF139	0·38
AF170	0·25
AF172	0·25
AF178	0·55
AF179	0·65
AF180	0·50
AF186	0·40
AF200	0·35
AF211	0·55
AF239	0·41
AF240	0·72
AF279	0·54
AF280	0·54
AFY42	0·74
AL102	0·75
AL103	0·70
ASY26	0·30
ASY27	0·36
ASY28	0·28
ASY29	0·36
ASY50	0·20
ASY55	0·35
BC107	0·15
BC103	0·15
BC109	0·19
BC113	0·13
BC114	0·12
BC115	0·15
BC116	0·15
BC116A	0·18
BC117	0·21
BC118	0·11
BC119	0·27

BC121	0·23
BC125	0·15
BC126	0·20
BC132	0·50
BC134	0·11
BC135	0·11
BC136	0·15
BC137	0·15
BC138	0·24
BC140	0·34
BC141	0·39
BC142	0·24
BC143	0·21
BC144	0·24
BC145	0·21
BC147	0·12
BC148	0·12
BC149	0·12
BC153	0·18
BC154	0·18
BC157	0·14
BC158	0·13
BC159	0·14
BC160	0·37
BC167B	0·11
BC168B	0·13
BC168C	0·13
BC169B	0·13
BC169C	0·11
BC170	0·11
BC171	0·13
BC172	0·11
BC182	0·10
BC182L	0·12
BC183	0·09
BC183L	0·09
BC184	0·11
BC184L	0·11
BC186	0·25
BC187	0·25
BC207	0·12
BC208	0·11
BC212K	0·10
BC212L	0·18
BC214L	0·21
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC252	0·18
BC253	0·23
BC257	0·09
BC258	0·09
BC259	0·13
BC261	0·20
BC262	0·13
BC263	0·23
BC300	0·42
BC301	0·34
BC302	0·27
BC303	0·54
BC307	0·10
BC307A	0·10
BC308	0·09
BC308A	0·09
BC308B	0·09
BC309	0·10
BC309A	0·10
BC309B	0·10
BC327	0·24
BC328	0·22
BC337	0·19
BC338	0·19
BCY30	0·43
BCY31	0·40
BCY32	1·15
BCY33	0·34
BCY34	0·35
BCY38	0·53
BCY39	1·05
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·21
BCY59	0·22
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·47
BCY88	2·40
BCY89	0·97
BCZ10	0·35
BCZ11	0·50
BD115	0·75
BD116	0·50
BD121	0·75
BD123	0·82
BD124	0·67
BD130	0·57
BD131	0·40
BD132	0·50
BD135	0·43
BD136	0·49
BD137	0·55
BD138	0·63
BD139	0·71
BD140	0·83
BDY10	1·25
BDY11	1·50
BDY17	1·50

BDY18	1·75
BDY19	1·97
BDY20	0·05
BDY38	1·65
BDY60	0·90
BDY61	1·25
BDY62	1·00
BF115	0·23
BF117	0·43
BF119	0·58
BF121	0·25
BF123	0·27
BF125	0·25
BF152	0·20
BF153	0·29
BF154	0·16
BF158	0·23
BF159	0·27
BF160	0·23
BF161	0·42
BF163	0·20
BF166	0·35
BF167	0·21
BF173	0·24
BF177	0·29
BF178	0·35
BF179	0·43
BF180	0·35
BF181	0·32
BF182	0·40
BF183	0·40
BF184	0·17
BF185	0·17
BF194	0·14
BF195	0·17
BF196	0·15
BF197	0·15
BF198	0·15
BF199	0·18
BF200	0·40
BF224J	0·14
BF225J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BF245	0·33
BF246	0·43
BF247	0·49
BF254	0·16
BF255	0·17
BF257	0·41
BF258	0·46
BF259	0·45
BF270	0·25
BF272	0·53
BF273	0·25
BF274	0·28
BF457	0·53
BF458	0·65
BFS21A	2·30
BFS28	0·92
BFS61	0·27
BFS98	0·28
BFW11	0·61
BFW15	0·35
BFX13	0·23
BFX29	0·30
BFX30	0·25
BFX37	0·30
BFX44	0·33
BFX63	2·48
BFX68	0·68
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·28
BFX88	0·25
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·35
BFY19	0·35
BFY20	0·50
BFY29	0·40
BFY37	0·20
BFY41	0·43
BFY43	0·65
BFY50	0·22
BFY51	0·15
BFY52	0·20
BFY53	0·15
BFY56	0·34
BFY64	0·41
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY78	0·36
BFY90	0·60
BRY39	0·30
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·49
BSX27	0·34
BSX28	0·25
BSX29	0·47
BSX30	0·68
BSX59	0·78
BSX60	0·54

BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·15
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·20
BSY39	0·20
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
SY56	0·79
BSY65	0·15
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
BU104	1·42
BU105	2·25
CIII	0·53
D40N3	0·55
GET111	0·45
GET113	0·20
GET114	0·20
GET115	0·50
GET119	0·35
GET120	0·25
GET535	0·20
GET536	0·20
GET538	0·20
GET873	0·12
GET880	0·30
GET883	0·20
GET887	0·20
GET890	0·22
GET895	0·25
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP42A	0·90
TIP2955	0·98
TIP3055	0·60
ME0401	0·18
ME0402	0·20
ME0404	0·13
ME0411	0·17
ME0412	0·18
ME0413	0·14
ME1120	0·25
ME4001	0·09
ME4002	0·11
ME4003	0·14
ME4101	0·10
ME4102	0·11
ME4103	0·10
ME4104	0·11
ME6101	0·14
ME6102	0·16
ME8002	0·17
ME8003	0·16
MJ400	0·78
MJ420	0·86
MJ421	0·88
MJ430	0·75
MJ440	0·71
MJ480	0·75
MJ481	0·85
MJ490	0·94
MJ491	1·10
MJ802	14·2
MJ901	2·65
MJ1001	2·34
MJ1800	1·88
MJ2500	2·92
MJ2501	3·25
MJ2955	1·00
MJ3000	2·47
MJ3001	2·79
MJ3701	0·9
MJ4502	4·44
MJE340	0·47
MJE370	0·73
MJE371	0·80
MJE520	0·59
MJE521	0·73
MJE1092	1·93
MJE1102	1·57
MJE2801	1·19
MJE2901	1·56
MJE2955	1·65

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We stock the full range of the low number SN 7400 series—some examples:

SN7400	28p	SN7430	28p	SN7472	40p
SN7401	38p	SN7432	48p	SN7473	57p
SN7402	28p	SN7437	52p	SN7474	48p
SN7407	56p	SN7440	20p	SN7475	96p
SN7410	28p	SN7441	75p	SN7476	64p
SN7411	22p	SN7442	79p	SN7481	£1·25
SN7413	48p	SN7443	£1·04	SN7483	£1·00
SN7420	20p	SN7444	£1·04	SN7484	95p
SN7421	22p	SN7445	£1·85	SN7485	£1·90
SN7422	48p	SN7446	£2·00	SN7490	£1·00
SN7423	52p	SN7447	£1·30	SN7491	£1·60
SN7425	48p	SN7450	20p	SN7493	£1·00
SN7426	32p	SN7451	20p	SN7494	85p
SN7427	48p	SN7452	20p	SN7495	80p
SN7428	50p	SN7454	28p	SN7496	£1·00

We also stock the unusual numbers as follows—

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SN 74118	£1·00	SN 74155	£1·55	SN 74181	£7·00
SN 74119	£1·92	SN 74157	£1·80	SN 74190	£1·95
SN 74121	£0·60	SN 74160	£2·60	SN 74191	£1·95
SN 74122	£1·35	SN 74161	£2·60	SN 74192	£1·90
SN 74123	£1·35	SN 74164	£2·26	SN 74193	£1·90
SN 74141	£0·90	SN 74165	£4·00	SN 74196	£1·60
SN 74145	£1·50	SN 74167	£6·25	SN 74198	£4·60
SN 74150	£3·35	SN 74174	£2·00	SN 74199	£4·00
SN 74151	£1·10	SN 74175	£1·35		

NE555 TIMER I.C. 90p

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400MW—BZY88 and IN SERIES. 11p.
1 watt—IN, IZM and IS SERIES, 17p. 1·5 watt—ZL SERIES, 25p.
10 watt—ZS SERIES, 40p. 20 watt—BZ 93 SERIES, 52p.

BRIDGE RECTIFIERS

PIV	50	100	200	400	600
1A	24p	26p	35p	35p	40p
2A	32p	37p	41p	46p	52p
4A	60p	70p	75p	85p	95p
6A	62p	75p	80p	£1·10	£1·25

DIODES & RECTIFIERS

IN5171 (1·5 amp 50 pv)	8p
IN5172 (1·5 amp 100 pv)	9p
IN4517 (1·5 amp 200 pv)	10p
IN5173 (1·5 amp 400 pv)	11p
IN5176 (1·5 amp 600 pv)	12p
IN5177 (1·5 amp 800 pv)	15p
PL4007 (1·5 amp 1000 pv)	20p
IN5400 (3 amp 50 pv)	15p
IN5401 (3 amp 100 pv)	17p
IN5402 (3 amp 200 pv)	20p
IN5404 (3 amp 400 pv)	22p
CL7005 (3 amp 600 pv)	25p
CL7006 (3 amp 800 pv)	27p
CL7007 (3 amp 1000 pv)	30p

CL1002 (10 amp 100 pv)	35p
CL1003 (10 amp 200 pv)	40p
CL1004 (10 amp 400 pv)	47p
CL1005 (10 amp 600 pv)	56p
ANODE & CATHODE STUD	
IN1183 (35 amp 50 pv)	92p
IN1184 (35 amp 100 pv)	£1·12
IN1186 (35 amp 200 pv)	£1·57
IN1188 (35 amp 400 pv)	£2·66
IN1190 (35 amp 600 pv)	£3·15
CATHODE STUD ONLY	
IN3766 (35 amp 800 pv)	£3·65
IN3768 (35 amp 1000 pv)	£4·20

IN34A	10p	BA141	17p	BY237	12½p	OA79	7p
IN914	7p	BA142	17p	BYZ10	35p	OA81	8p
IN916	7p	BA144	12p	BYZ11	32p	OA85	10p
AA119	7p	BA145	17p	BYZ12	30p	OA90	7p
AA129	15p	BA154	12p	OA9	10p	OA91	7p
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BA102	25p	BY126	15p	OA47	7½p	OA200	7p
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MINITRON 3015F 7-SEGMENT INDICATOR (16 PIN DIL) £2
DRIVER SN 7447 £1·30
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TIL 209 LIGHT EMITTING DIODE. (Red). 35p

SCORPIO ignition kit £10 + 50p P. & P.

WIRE-WOUND RESISTORS

2·5 watt 5% (up to 270 ohms only). 7p
5 watt 5+ (up to 8·2kΩ only). 9p
10 watt 5% (up to 26kΩ only). 10p

POTENTIOMETERS

Carbon:
Log. or Lin., less switch, 16p
Log. or Lin., with switch, 27p
Wire-wound Pots (3W), 38p
Twin Ganged Stereo Pots, Log. or Lin., 47p

PRESETS (CARBON)

0·1 Watt 6p VERTICAL
0·2 Watt 6p OR
0·3 Watt 7½p HORIZONTAL

SLIDE POTENTIOMETERS

58mm. TRACK
SINGLE GANGED, LOG or LIN 1k to 1M. 30p each
TWIN GANGED, LOG or LIN 1k to 500k. 50p each

SMALL VALUE
SUB-MIN. ELECTROLYTICS
Wide range of values only 6p each

Post & Packing 13p per order. Europe 25p. Commonwealth (Air) 65p (Min.)

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OA2	0·33
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OZ4	0·44
1A3	0·49
1A5GT	0·49
1A7GT	0·33
1B3GT	0·49
1C2	0·50
1G6	0·75
1H5GT	0·55
1L4	0·14
1LD5	0·66
1LN5	0·66
1N5GT	0·60
1R5	0·28
1S4	0·33
1S5	0·22
1U4	0·44
1U5	0·80
2D21	0·44
2GK5	0·55
3A4	0·36
3B7	1·00
3D6	0·19
3Q4	0·49
3Q5GT	0·55
3S4	0·26
4CB6	0·55
5CG8	0·55
5R4GY	0·70
5T4	0·30
5U4G	0·30
5V4G	0·35
5Y3GT	0·30
5Z3	0·53
5Z4G	0·34
5Z4GT	0·38
6/30L2	0·55
6A8G	0·44
6AC7	0·15
6AG5	0·27
6AH6	0·50
6AJ5	0·75
6AJ8	0·28
6AK5	0·27
6AK6	0·60
6AK8	0·30
6AL5	0·12
6AM8A	0·55
6AN8	0·49
6AQ5	0·22
6AQ8	0·34
6AR5	0·55
6AR6	1·00
6AS7	1·00
6AT6	0·30
6AU6	0·28
6AV6	0·33
6AW8A	0·65
6AX4	0·55
6B8G	0·25
6BA6	0·19

6BC8	0·60
6BE6	0·20
6BG6G	1·35
6BH6	0·70
6BJ6	0·39
6BK7A	0·60
6BQ5	0·23
6BQ7A	0·50
6BR7	0·90
6BR8	0·75
6BS7	1·40
6BW6	0·72
6BW7	0·50
6BX6	0·23
6BY7	0·28
6BZ6	0·49
6C4	0·28
6C6	0·22
6C9	1·00
6CB6A	0·40
6C12	0·28
6C17	1·00
6CD6G	0·80
6CG8A	0·75
6CH6	0·55
6CL6	0·46
6CL8A	0·80
6CM7	0·75
6CU5	0·75
6CW4	0·70
6D3	0·60
6DE7	0·75
6DT6	0·75
6EW6	0·75
6E5	0·75
6F1	0·70
6F6G	0·35
6F12	0·17
6F13	0·45
6F14	0·40
6F15	0·65
6F18	0·55
6F23	0·65
6F24	0·60
6F25	0·51
6F26	0·28
6F28	0·60
6F32	0·30
6G6G	0·38
6GH8A	0·75
6GH5	0·65
6GU7	0·75
6H6GT	0·18
6J5GT	0·29
6J6	0·20
6J7G	0·24
6J7(M)	0·38
6JU8A	0·75
6K7G	0·12
6K8G	0·33
6L1	2·00
6L6GT	0·55

6L7(M)	0·50
6L12	0·34
6L18	0·49
6L19	2·00
6LD12	0·30
6LD20	0·55
6N7GT	0·60
6P1	1·75
6P15	0·23
6P28	0·70
6PL12	0·28
6Q7G	0·44
6Q7GT	0·47
6Q7(M)	0·55
6R7G	0·60
6R7(M)	0·75
6SA7M	0·35
6SC7GT	·33
6SG7(M)	·39
6SH7	0·44
6SJ7GT	·35
6SK7GT	·44
6SQ7GT	·38
6U4GT	0·70
6U7G	0·75
6V4	0·19
6V6G	0·17
6V6GT	0·27
6X4	0·27
6X5GT	0·28
6Y6G	0·65
6Y7G	1·00
7A7	1·00
7B6	0·75
7B7	0·50
7F8	1·00
7H7	0·55
7R7	1·50
7V7	1·00
7Y4	0·65
7Z4	0·80
9BW6	0·65
9D7	0·40
10C2	0·65
10C14	0·29
10D1	0·70
10DE7	0·55
10F1	0·50
10F9	0·65
10F18	0·55
10L14	0·33
10LD11	0·70
10LD12	·30
10PL12	0·30
10P13	0·54
10P14	2·00
10P18	0·28
12A6	1·00
12AC6	0·55
12AD6	0·60
12AE6	0·60

12AT6	0·28
12AT7	0·20
12AU6	0·38
12AU7	0·21
12AV6	0·28
12AX7	0·22
12AY7	0·80
12BA6	0·30
12BE6	0·30
12BH7	0·27
12J5GT	0·33
12J7GT	0·55
12K5	0·53
12K7GT	·38
12Q7GT	0·45
12SA7GT	·55
12SC7	0·50
12SG7	0·38
12SH7	0·35
12SJ7	0·44
12SK7	0·55
12SQ7GT	0·55
14H7	0·55
14S7	0·75
18	1·00
19AQ5	0·42
19BG6G	·80
19G6	1·40
19H1	2·00
20D1	0·55
20D4	2·00
20F2	0·67
20L1	0·80
20P1	0·55
20P3	0·75
20P4	0·80
20P5	0·95
25A6G	0·38
25L6G	0·20
25Y5	0·38
25Y5G	0·70
25Z4G	0·33
25Z5	0·60
25Z6G	0·70
28D7	1·00
30A5	0·65
30C1	0·26
30C15	0·58
30C17	0·76
30C18	0·55
30F5	0·61
30FL1	0·58
30FL2	0·60
30FL12	0·69
30FL13	0·50
30FL14	0·66
30L1	0·29
30L15	0·55
30L17	0·65

30P4MR	0·95
30P12	0·69
30P16	0·31
30P19/	
30P4	0·65
30PL1	0·57
30PL12	0·29
30PL13	0·75
30PL14	0·75
30PL15	·87
35A3	0·48
35A5	0·75
35D5	0·70
35L6GT	0·42
35W4	0·23
35Z3	0·50
35Z4GT	·24
35Z5GT	·30
50B5	0·35
50C5	0·32
50CD6G	2·17
50EH5	0·55
50L6GT	·45
72	0·33
77	0·53
85A2	0·43
85A3	0·40
90AG	3·38
90AV	3·38
90CG	1·70
90CV	1·68
90C1	0·59
150B2	0·58
150C2	0·33
215SG	0·33
301	1·00
302	0·83
303	0·75
305	0·83
807	0·59
956	0·10
1821	0·55
5702	0·80
5763	0·50
6060	0·30
7193	0·53
7475	0·70
A1834	1·00
A2134	0·98
A3042	0·75
AC2PEN	0·98
AC2PENDD	0·98
AC6/PEN	0·38
AC/PEN(7)	0·98
AC/TH1	·50
AC/TP	0·98

AL60	0·78
ARP3	0·35
ATP4	0·40
AZ1	0·40
AZ31	0·46
AZ41	0·53
B319	0·29
BL63	0·50
CL33	0·90
CV6	0·53
CV63	0·53
CV988	0·10
CY1C	0·55
CY31	0·29
D63	0·25
DAC32	0·55
DAF96	0·36
DC90	0·60
DD4	1·00
DF91	0·16
DF96	0·36
DH63	0·44
DH76	0·45
DH77	0·30
DH81	0·75
DK32	0·33
DK40	0·55
DK92	0·50
DK96	0·45
DL92	0·26
DL96	0·38
DM70	0·30
DM71	0·50
DW4/350	0·38
DY87/6	0·22
DY802	0·30
E80CC	1·65
E80F	1·20
E83F	1·20
E88CC	0·60
E92CC	0·40
E180F	0·90
E182CC	1·00
E1148	0·53
EA50	0·27
EA76	0·88
EABC80	0·30
EAC91	0·38
EAF42	0·48
EAF801	·50
EB34	0·25
EB91	0·12
EBC41	0·48
EBC81	0·29
EBC90	0·30
EBC91	0·28
EBF80	0·30
EBF83	0·38
EBF89	0·26

EBL21	0·60
EC53	0·49
EC54	0·50
EC86	0·59
EC88	0·59
EC92	0·34
ECC32	1·50
ECC33	1·50
ECC35	0·95
ECC40	0·68
ECC81	0·20
ECC82	0·21
ECC83	0·22
ECC84	0·30
ECC85	0·34
ECC86	0·40
ECC88	0·35
ECC189	·48
ECC804	0·55
ECC807	1·00
ECF80	0·27
ECF82	0·25
ECF86	0·64
ECF804	2·10
ECH21	0·63
ECH35	0·50
ECH42	0·59
ECH81	0·28
ECH83	0·38
ECH84	0·34
ECL80	0·28
ECL82	0·28
ECL83	0·52
ECL84	0·54
ECL85	0·54
ECL86	0·33
EF22	0·63
EF40	0·49
EF41	0·58
EF42	0·33
EF73	0·75
EF80	0·23
EF83	0·54
EF85	0·28
EF86	0·27
EF89	0·23
EF91	0·17
EF92	0·30
EF94	0·28
EF97	0·55
EF98	0·65
EF183	0·25
EF184	0·27
EF804	1·20
EFP60	0·50
EH90	0·34
EK90	0·20
EL32	0·18
EL34	0·48
EL35	1·00
EL41	0·53

EL81	0·50
EL83	0·38
EL84	0·23
EL85	0·40
EL86	0·38
EL91	0·38
EL95	0·32
EL360	1·20
ELL80	0·75
EM80	0·37
EM81	0·37
EM83	0·75
EM84	0·31
EM85	1·00
EM87	0·49
EY51	0·35
EY81	0·35
EY83	0·54
EY84	0·50
EY87/6	0·27
EY88	0·40
EY91	0·53
EZ35	0·28
EZ40	0·40
EZ41	0·42
EZ80	0·19
EZ81	0·20
EZ90	0·27
FW4/500	0·75
FW4/800	0·75
GY501	0·75
GZ30	0·33
GZ32	0·39
GZ33	0·70
GZ34	0·57
GZ37	0·67
HABC80	0·44
HL13C	0·20
HL23DD	0·40
HL41DD	0·98
HL42DD	0·50
HN309	1·40
HVR2	0·53
HVR2A	0·53
IW3	0·38
KT2	0·25
KT8	1·75
KT41	0·98
KT44	1·00
KT63	0·35
KT66	0·80
KT74	0·63
KT76	0·63
KT81	2·00
KTW61	·63
KTW62	·63
KTW63	·50
M8162	0·63
MHL4	0·75
MHLD6	·75
MKT4	0·98
MU12/14	0·38
N308	0·95
N339	0·44

P61	0·40
PABC80	0·32
PC86	0·44
PC88	0·44
PC95	0·53
PC97	0·36
PC900	0·29
PCC84	0·29
PCC85	0·24
PCC88	0·39
PCC89	0·42
PCC189	0·46
PCF80	0·26
PCF82	0·30
PCF84	0·40
PCF86	0·44
PCF87	0·76
PCF200	0·67
PCF800	·53
PCF801	0·28
PCF802	0·37
PCF805	·55
PCF806	0·55
PCF808	0·66
PCH200	·62
PCL82	0·29
PCL83	0·54
PCL84	0·32
PCL86	0·36
PCL88	0·75
PCL800	·75
PCL801	0·57
PCL805/	
PCL85	0·37
PD500	1·44
PEN4DD	1·38
PEN45	·80
PEN45DD	0·80
PEN46	0·20
PEN453DD	0·98
PENA4	0·98
PENDD /4020	0·88
PFL200	0·50
PL33	0·38
PL36	0·46
PL81	0·43
PL81A	0·48
PL82	0·31
PL83	0·30
PL84	0·28
PL302	0·65
PL504/	
PL500	0·60
PL508	0·90
PL509	1·00
PL801	0·69
PL802	0·85
PM84	0·31
PY33/2	·50

PY80	0·33
PY81	0·25
PY82	0·25
PY83	0·26
PY88	0·31
PY301	0·65
PY500	0·80
PY500A	0·80
PY800	0·31
PY801	0·31
PZ30	0·48
QP21	0·50
QQV03/10	1·20
QS75/20	0·63
QS95/10	·49
QS150/15	0·63
QV04/7	0·63
R11	0·98
R16	1·75
R17	0·88
R18	0·50
R19	0·28
R20	0·60
R52	0·33
RK34	0·38
SP13C	0·63
SP61	0·75
TH4B	0·50
TH233	0·98
TP2620	·98
UABC80	·30
UAF42	0·49
UBC41	0·45
UBC81	0·40
UBF80	0·33
UBF89	0·33
UBL21	0·55
UC92	0·35
UCC84	0·33
UCC85	0·33
UCF80	0·31
UCH21	0·60
UCH42	0·57
UCH81	0·29
UCL82	0·30
UCL83	0·54
UF41	0·50
UF42	0·60
UF80	0·35
UF85	0·34
UF86	0·63
UF89	0·27
UL41	0·54
UL84	0·28
UM80	0·33
UR1C	0·55
UU5	0·38
UU9	0·40
UU12	0·20
UY41	0·38

UY85	0·23
U10	0·45
U12/14	·38
U16	0·75
U17	0·35
U18/20	0·75
U19	1·73
U22	0·39
U25	0·65
U26	0·60
U31	0·31
U33	1·50
U35	0·83
U37	1·75
U45	0·78
U47	0·65
U49	0·60
U50	0·30
U76	0·24
U78	0·27
U153	0·25
U191	0·65
U192	0·25
U193	0·31
U251	0·62
U281	0·40
U282	0·40
U291	0·50
U301	0·40
U329	0·62
U381	0·23
U403	0·33
U404	0·38
U801	0·76
U4020	0·55
VP2	0·53
VP13C	0·35
VP23	0·40
VP41	0·38
VT61A	0·35
VT501	0·15
VU111	0·44
VU120	0·60
VU120A	·60
VU133	0·35
W76	0·38
W81M	0·68
W107	0·50
W729	0·60
XE3	5·00
XFY12	0·48
XH1-5	0·48
X41	0·50
X61	0·50
X65	0·50
X66	0·50
Z329	0·61
Z729	0·27
Z749	0·65
Transistors and Diodes	
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1N4952	0·55
2N404	0·20

2N966	0·58
2N1756	0·55
2N2147	0·94
2N2297	0·25
2N2369A	·24
2N2613	0·43
2N3053	0·36
2N3121	2·75
2N3703	0·21
2N3709	0·22
2N3866	1·10
2N3988	0·55
28323	0·55
AA119	0·17
AA120	0·17
AA129	0·17
AAZ13	0·20
AC107	0·17
AC113	0·28
AC114	0·44
AC126	0·14
AC127	0·19
AC128	0·22
AC132	0·22
AC154	0·28
AC156	0·22
AC157	0·28
AC165	0·28
AC166	0·28
AC167	0·66
AC168	0·42
AC169	0·36
AC176	0·61
AC177	0·31
ACY17	0·28
ACY18	0·22
ACY19	0·21
ACY20	0·20
ACY21	0·21
ACY22	0·17
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AF102	0·99
AF106	0·55
AF114	0·28
AF115	0·17
AF117	0·21
AF121	0·33
AF124	0·28
AF125	0·19
AF126	0·20
AF139	0·72

AF178	0·75
AF180	0·53
AF186	0·61
AF239	0·42
ASY27	0·47
ASY28	0·36
ASY29	0·55
BA102	0·50
BA115	0·15
BA116	0·28
BA129	0·14
BA130	0·11
BA153	0·17
BCY10	0·50
BCY12	0·55
BCY33	0·22
BCY34	0·25
BCY38	0·25
BCY39	0·28
BC107	0·14
BC108	0·14
BC113	0·28
BC115	0·17
BC116	0·28
BC118	0·25
BCZ11	0·42
BF154	0·28
BF158	0·32
BF159	0·28
BF163	0·22
BF173	0·42
BF180	0·33
BF181	0·44
BF185	0·44
BF194	0·17
BFY50	0·25
BFY51	0·21
BFY52	0·22
BTX34/400	2·20
BY100	0·20
BY101	0·17
BY105	0·20
BY114	0·20
BY126	0·17
BY127	0·20
BYY23	1·10
BYZ10	0·28
BYZ11	0·28
BYZ12	0·28
BYZ13	0·28
BYZ15	1·93
CG12E	0·22
CG64H	0·22
FSY11A	·25

FSY41A	·25
GD4	0·36
GD5	0·31
GD6	0·31
GD8	0·22
GD9	0·22
GD11	0·22
GD12	0·22
GD14	0·55
GD15	0·44
GD16	0·22
GET113	·22
GET116	·44
GET118	·22
GET119	·27
GET573	·42
GET587	·47
GET872	1·05
GET873	·17
GET882	·55
GET887	·25
GET889	·25
GET890	·25
GET896	·25
GET897	·25
GET898	·25
GEX13	0·20
GEX35	0·25
GEX36	0·55
GEX45	0·36
GEX55	0·83
GT3	0·28
M1	0·17
MAT100	·43
MAT101	·47
MAT120	·43
OA5	0·31
OA9	0·14
OA10	0·47
OA47	0·11
OA70	0·17
OA73	0·17
OA79	0·10
OA81	0·10
OA85	0·09
OA86	0·22
OA90	0·14
OA91	0·10
OA95	0·10
OA200	0·10
OA202	0·11
OA210	0·53
OA211	0·75
OC19	1·38
OC22	0·42

OC23	0·42
OC24	0·42
OC25	0·42
OC28	0·66
OC29	0·69
OC35	0·35
OC36	0·47
OC38	0·47
OC41	0·55
OC42	0·69
OC43	1·30
OC44	0·11
OC45	0·12
OC46	0·17
OC65	1·24
OC70	0·14
OC71	0·12
OC72	0·12
OC74	0·25
OC75	0·12
OC76	0·17
OC77	0·30
OC78	0·17
OC78D	0·17
OC79	0·44
OC81	0·12
OC81D	0·12
OC82	0·12
OC82D	0·12
OC83	0·22
OC84	0·26
OC123	0·25
OC139	0·25
OC140	1·05
OC169	0·25
OC172	0·39
OC200	0·24
OC201	0·42
OC202	0·47
OC203	0·33
OC204	0·33
OC205	0·47
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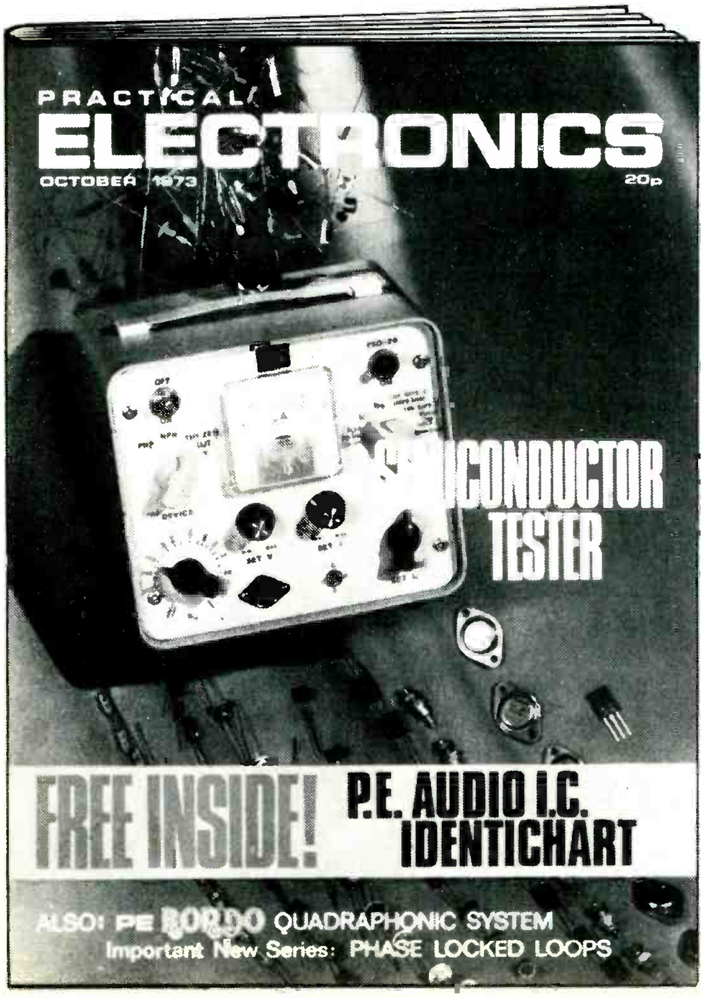

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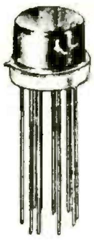

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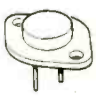

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AC187	14p	BC157	17p	OC71	12p
AC188	14p	BC158	14p	OC72	14p
AD140	60p	BC159	14p	2N706	12p
AD149	60p	BC169	14p	2N2926	10p
AD161	32p	BC182	12p	2N3055	49p
AD162	32p	BC183	12p	2N3702	13p
AF114	14p	BC184	12p	2N3704	13p
AF115	14p	BC212	12p	2N3819	30p
AF116	14p	BC213	12p	40361	31p
AF117	14p	BC214	14p	40362	36p
AF139	32p	BD131	69p	40636	76p
AF239	40p	BD132	69p	OA90	5p
BC107	10p	OC25	40p	OA91	5p
BC108	10p	OC28	52p	OA202	7p
BC109	10p	OC35	52p	IN4148	5p

(Many other types stocked)

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SIGNAL INJECTOR

The UK 220 Signal Injector is a "must" for repairmen engaged in the repair and servicing of radio receivers and AF amplifiers. It permits a thorough check of the various stages to the antenna coupling circuit due to the signal it delivers, which has a frequency spectrum extending from the lowest acoustic frequencies to the highest short wave band frequencies. The unit is designed to perform quickly and efficiently all the operations involved in fault tracing, and many cases that would normally call for the set to be taken back to the repair-shop can be successfully carried out on the spot.

Specifications

Frequency:	500 Hz
Harmonics:	up to approx. 30 MHz
Output voltage:	1 V peak-to-peak
Maximum voltage applicable to the probe:	500 V DC
Power supply:	1·4 V DC
Transistors:	(2) BC208B

£2·57

UP TO 25% DISCOUNT OFF ALL OUR SEW CLEAR PLASTIC PANEL METERS

MR38P 1 21/32" Square fronts.

	Normal Price	Our Price
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0-1mA	£2·50	£2·10
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Edgewise meters 3 17/32"×1 15/32"

500µA	£3·50	£2·95
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Resistors

		100 plus
¼ watt 5% carbon	1p	·7p
½ watt 5% carbon	1p	·7p
1 watt 10% carbon	2½p	2p
range 10 ohms to 4·7 megohms.		
½ watt m/o 2%	3p	2·4p
range 10 ohms to 1 megohms.		

Transformers

12-24 volt

Secondary Volts	Amps	Volts	Amps	Part No.	Price Inc. P/P.
12	500mA	24	250mA	MT111	£1·20
12	1	24	500mA	MT213	£1·28
12	2	24	1	MT71	£1·89

30 volt

Secondary 12, 15, 20, 24 30v.

Amps	Part No.	Price Inc. P/P.
1	MT79	£2·02
2	MT3	£2·78
5	MT51	£5·21

50 volt

Secondary 19, 25, 33, 40, 50 volts

Amps	Part No.	Price Inc. P/P.
1	MT103	£2·54
2	MT104	£3·75
4	MT106	£6·00

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259019 RCA	7 TRACK	1215872 TYPE 1301	7 TRACK
257124 RCA	8 TRACK	5007821 POTTER	7 TRACK
282812 RCA	8 TRACK	19467 EPSYLON	8 TRACK
303489 RCA	7 TRACK	76815/948 BURROUGHES	9 TRACK
73927 RCA	7 TRACK	652623DRI 12/101	12 TRACK
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2N1557 .... 50p
2N1908 .... £6·00
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2N3055 .... 45p
2N3442 .... £1·02
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2N5322 .... 50p
AC126 .... 20p
AC127 .... 25p
AC128 .... 20p
AF115 .... 25p
AF116 .... 25p
AF117 .... 25p
BC107 .... 8p
BC108 .... 8p
BC109 .... 8p
OC35 .... 40p
OC42 .... 40p
OC71 .... 12p
CV7006/OC72 .... 20p
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6 watt (peak) Amplifier 240v. AC. with inputs for Radio, Tape Recorder, freq. response 80-12,500Hz, bass and treble controls, 2 speakers. Dimensions 265 x 235 x 580 mm. Net weight 10Kg. Ideal for education seminars etc. £00·00 incl. carriage.

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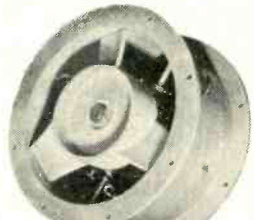

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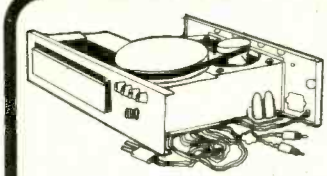

8 TRACK ONLY £11

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The latest **B.S.R. 8 Track cartridge Replay Deck. Ready to install in your Hi-Fi Stereo System.** This unit comes complete with Hi Gain Stereo Pre-Amplifier, 4-Programme Indicator Lamps, Track Selector Switch, all leads and plugs, etc. for 230 volt A.C. mains operation.

5W & 10W AMPS

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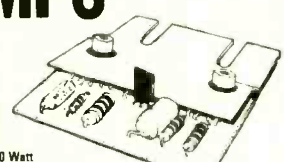

inc. P. & P. and V.A.T.

Specification:—	5 Watt	10 Watt
Nominal Volts	12-14V	25-30V
Into 3 Ohms	5W	10W
Into 8 Ohms	2W	10W
Into 15 Ohms	1W	5W
Typical Distortion	5%	5%
Freq. response at 3dB	10Hz to 30KHz	10Hz to 30KHz
Sensitivity (Typically)	20mV	20mV
Full power consumption (30 Ohms)	650mA	580mA
Size	2¼" x 1¾"	2¼" x 1¾"

The 5W matchbox sized amplifier will run satisfactorily from a 12V car battery. Can also be used for portable voice reinforcement such as public functions where mains supply is not accessible. A small mains unit kit is available.
Two amplifiers are ideal for Stereo. Complete connection details and treble, bass, volume and balance control circuit diagrams are supplied with each unit.
Discounts are available for quantity orders.

Cheapest in the U.K. Built and tested

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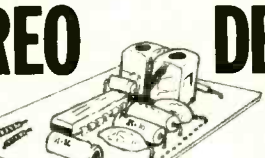

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incl. P. & P. and VAT

A ready built unit, ready for connection to the I.F. stages of your existing FM Radio or Tuner. A tell tale light can be connected to show the presence of a Stereo transmission and correct operation.
The Unit is in the form of a small printed circuit, and no further alignment is necessary, as all preset adjustments have already been carried out at the factory.
It is recommended that a L.E.D. is used as the indicating light and a suitable device is available from us at 36½p.
Supplied with all necessary instructions.

I enclose £ .... for .... 8 Tracks/ ....
5W Amps/ .... 10W Amps/ .... Decoders
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071 14682	10	6800	4 amps	1oz	17p
071 15332	16	3300	2·4 amps	1oz	15p
071 15472	16	4700	3·9 amps	1oz	17p
071 15682	16	6800	5·8 amps	1½oz	22p
071 15103	16	10000	7·9 amps	2½oz	27p
071 18222	63	2200	5·8 amps	3oz	30p
072 14113	10	11000 + 11000	10·6 amps	3oz	37p
072 14173	10	16500 + 16500	13·4 amps	4oz	49p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	4½oz	49p
071 16222	25	2200	2·2 amps	1oz	15p
072 16502	25	5000 + 5000	9·6 amps	3½oz	37p
072 16752	25	7500 + 7500	12·6 amps	4½oz	49p
072 17342	40	3400 + 3400	9·1 amps	3½oz	37p
072 17502	40	5000 + 5000	12·0 amps	4½oz	49p
071 18681	63	680	2·1 amps	1oz	15p
072 18172	63	1650 + 1650	7·8 amps	3oz	37p

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Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
106 14153	10	15000	7 amps	4oz	57p
106 15103	16	10000	7 amps	2½oz	65p
106 16223	25	22000	17 amps	10oz	£1·12
106 17103	40	10000	12 amps	7½oz	94p
106 18153	63	15000	28 amps	18oz	£1·79
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 17562	40	5600	5oz	25p
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A discount of 10% may be deducted from above prices on lots of 100 of any one type,

Please calculate the weight of your order and include appropriate postage.

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2lb	21p
4lb	25p
6lb	29p
10lb	37p
14lb	47p
18lb	57p
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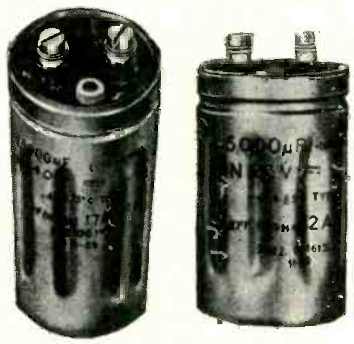

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Ref. No.	Capacity	Voltage	Price
H8/1	1µf	150v	4p
H8/2	2·2µf	25v	4p
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H8/3	3µf	50v	4p
H8/3A	4µf	50v	4p
H8/4	4·7µf	25v	4p
H8/4A	5µf	64v	4p
H8/5	5µf	10v	4p
H8/5A	5µf	150v	4p
H8/6A	10µf	10v	4p
H8/7	10µf	70v	4p
H8/8	16µf	35v	4p
H8/8A	16µf	16v	4p
H8/9	20µf	6v	2p
H8/9A	20µf	70v	4p
H8/10	22µf	50v	4p
H8/10A	22µf	100v	4p
H8/11	25µf	12v	4p
H8/11A	24µf	275v	4p
H8/12	32µf	15v	4p
H8/12A	30µf	10v	4p
H8/13A	32µf	50v	4p
H8/14	40µf	25v	5p
H8/14A	40µf	16v	4p
H8/15	47µf	50v	4p
H8/15A	40µf	35v	4p
H7/1	50µf	6v	3p
H7/1A	50µf	10v	4p
H7/2	50µf	50v	4p
H7/2A	64µf	2·5v	2p
H7/3A	64µf	25v	4p
H7/4	64µf	15v	4p
H7/4A	64µf	35v	5p
H7/5	80µf	16v	4p
H7/6	100µf	25v	5p
H7/6A	100µf	15v	4p
H7/7	100µf	25v	4p
H7/8	125µf	16v	5p
H7/8A	100µf	35v	6p
H7/9	100µf	63v	6p
H7/9A	125µf	4v	4p
H7/10	125µf	25v	6p
H7/10A	160µf	2·5v	3p
H7/11	160µf	25v	6p
H7/11A	150µf	16v	5p
H7/13A	200µf	25v	8p
H7/14	220µf	50v	10p
H7/14A	220µf	16v	6p
H7/15	220µf	25v	5p
H7/15A	220µf	35v	10p
H6/1A	250µf	4v	3p
H6/2			
H6/3A	320µf	2·5v	3p
H6/4	320µf	10v	4p
H6/4A	330µf	16v	5p
H6/5	330µf	25v	10p
H6/5A	330µf	35v	15p
H6/7	400µf	15v	5p
H6/8	470µf	25v	10p
H6/8A	470µf	35v	20p
H6/9			
H6/9A	400µf	40v	20p
H6/10	750µf	12v	5p
H6/13A	1000µf	25v	16p
H5/2A	2200µf	16v	15p

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray .. .. £1·00 plus
Developer and Etchant .. .. 50p postage
Copper-clad Fibre-glass Board—50p so. ft. (max. 3' × 4')

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Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.

75mm × 100mm	33p
150mm × 100mm	66p
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Epoxy-Resin	
75mm × 100mm	22p
100mm × 150mm	44p
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2½in × 1in × 0·15in	6p
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5in × 2½in × 0·15in	25p
5in × 3¾in × 0·15in	30p
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3¾in × 3¾in × 0·1in	25p
5in × 2½in × 0·1in	25p
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500,000 in STOCK!!!

·001µf	·0018µf	·0056µf	·015µf
·0012µf	·0022µf		·033µf
·0015µf	·0027µf	·012µf	·082µf

20p dozen; 75p-100; £5-1,000; £40-10,000

·15µf ·18µf ·22µf ·39µf ·68µf

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3p each; 24p dozen; £1·75 per 100

10pf	68pf	560pf
15pf	100pf	620pf
22pf	150pf	680pf
33pf	220pf	1,000pf
39pf	330pf	
47pf	470pf	

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BAGS CONTAINING 1,000 ASSORTED DIODES. SILICON/GERMANIUM/ZENER. UNTESTED, BUT MAINLY O.K. **£1**

MIXED COMPONENTS, ALL NEW, UNUSED. RESISTORS, CARBON/WIRE. POTS., DIODES, TRANSISTORS, CAPACITORS, ELECTROLYTIC/PAPER/CERAMIC/SILVER MICA. FANTASTIC VALUE. PRICE PER 2lb. MIXED BOX **£1**

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TO3-NPN DIFFUSED SILICON PLANAR EPITAXIAL.
VCBO COLLECTOR TO BASE—80 VOLTS.
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AERIAL CHANGE/OVER RELAYS of current manufacture designed especially for mobile equipments, coil voltage 12v., frequency up to 250 MHz at 50 watts. Small size only, 2 in. × ⅞ in. Offered brand new, boxed. Price **£1·50**, inc. P.&P.

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* Remote control facilities.
* Completely Solid State (Silicon transistors).
* Built to Aircraft specifications.
* 180VA of output continuous.

May be run in series operation for 3 phase requirements. Offered brand new boxed units. Price **£17·50** Carriage 50p.

AUDIO OSCILLATORS AMERICAN TS-382/U
Covers 20 c/s-200 Kc/s in four ranges. Output voltage 1 micro volt to 10 v. in seven ranges. Built in calibrator. Sine wave O.P. is excellent over complete range. Supplied with transmit case, adaptors and circuits and transformer for 240 A.C. **£20.**

MINIATURE AEI UNISELECTORS
12 position × 3 bank 250 ohm coils, 1 bridging and 2 non-bridging wipers available now—Type 2200A complete with bases. Price **£4.**

BRAND NEW DIGITAL PANEL VOLTMETERS
10MV-1·99VV. 199 Measuring points. Input impedance 100Mohm. Automatic zeroing. Measurements: 155mm × 72mm × 72mm. List price was £52·00. OUR PRICE £24·50.

DIGITAL MEASUREMENT Type 2003 Digital Voltmeter. 3½ Digit display. Measuring up to 1000 Volts. AS NEW £65.

Noise Generator Model CT-82
Range 15kHz to 160MHz very useful noise for factor measurements of receivers/wide band I.F. amplifiers etc., the instrument is directly calibrated in noise factor and displayed on panel meter, also output meter calibrated in dbs, for 115-250 vac operation offered in good used condition, small size low price only **£8** Carr. 50p.

H. W. SULLIVAN STANDARD AIR SPACED CONDENSERS
Capacitance range 0 to 100 pf fully screened with engraved vernier subdivided into 100 equal divisions complete with vernier index and original manufacturers seal offered brand new, at only **£25** each.

BARGAIN OFFER—LOW VOLTAGE STABILISED POWER SUPPLIES
*Voltage Range 16-24V.
*Current Range to 6 Amps.
*Full over-voltage and Current protection.
*AC Ripple content better than 5mV. These PSUs are constructed to exacting standards and incorporate the very best of components and circuit design for long life and reliability. Employs Silicon transistors, thyristors, C-Core transformer etc. Offered in perfect condition, carefully checked before despatch. List price over £125. Our price only **£26.50.** Carriage £1.

Cossor Radio Telephones Type CC303
All Solid State except for O-P Valves 25 Watt A.M. offered brand new for high bond applications boot control console. Complete manual supply. Prices **£75** each + V.A.T.

SCHOMANDL PRECISION FREQUENCY METER TYPE FDI WITH FDMI ADAPTOR
GPO approved equipment for Radio Telephone Marine servicing etc., offered in as new condition with calibration certificate.

G.E.C. Uniselectors, 8-banks, 25 position full wipe. 75 ohm coil. Not new but excellent working condition. Each **£2.**

Brand new GEC 3 banks of 25 position uniselectors with fitted suppressor. £2·50 each.

SIX Level A.E.I. Uniselectors miniature plug in type 2216A coil 125 ohms. non-bridging wipers with index. 12 position 6 bank. Absolutely brand new in makers cartons sold complete with base. **£6·50**

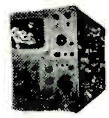
CAMBRIDGE PORTABLE POTENTIOMETER type 44228. The ideal tool for checking thermocouples and auxiliary temperature measuring equipment. Accuracy ± 0·1%. BRAND NEW. £75.

TINSLEY type 4363D Vernier pontetiometer. Good condition Price £75.

FRIGIDAIRE, AIR-CONDITIONING UNIT. Table-top model. 4 inch diameter pipe outlet. Complete and ready for use. Price £125.

WAYNE KERR type B521 Component bridge. Accurate measurement of LC & R. £55. Excellent order throughout.

TEKTRONIX OSCILLOSCOPES



Type 545A with 'CA' plug-in. (Or 'L'). DC—30MHz.
Type 561A with 3A1 and 3B3 units. DC—10MHz.
Type 535 with CA plug-in unit. DC—15MHz.
Type 551. Double-beam with L&G units. DC—27MHz.
Also available:
Dynamco D7100 with 1Y2 and 1X2 plug-ins. Portable, DC—30MHz.
Hewlett-Packard 175A. 1781 and 1755A plug-ins. DC—30MHz.
Marconi TF1300. s/b. DC-15MHz. **£75.**
Roband RO50A with 5G plug-in. DC—15MHz. Price **£125.**
Solartron CD1400. With two CX1441 and a CX1443 units.
Extremely sensitive instrument. Twin differential inputs.

SIGNAL GENERATORS

Marconi type TF801D. 10-485MHz. Excellent. **P.U.R.**
Marconi type TF867. 15KHz-30MHz. **£150.**
Hewlett-Packard 616A. 1780-4000MHz. **£75.**
Advance C2H. Spot-frequency production-line test instrument. 12 freqs. in bands 500KHz-30MHz. **£25.**
Rohde & Schwarz U.H.F. 990-1900MHz. **P.U.R.**
Rohde & Schwarz SMAF. A.M. & F.M. 4-300MHz. FM Dev. 0-100KHz in 2 ranges. Fundamental-frequency generator ideal for radio-telephone test equipment. **P.U.R.**

MARCONI TEST EQUIPMENT. All items have been calibrated, reconditioned and guaranteed.

Wave Analyser **TF455E.** Frequency range 20Hz. **£105.**

TF893 Audio Wattmeter. Range 20Hz-35KHz. Power range 20uW-10W. Impedance 2·5 Ω to 20K Ω in 48 steps. Direct calibration in Watts and dbm. Price **£45.**

TF2600 Sensitive Valve Voltmeter 1mV f.s.d. to 300V f.s.d. Accuracy ± 1%. Offered as new, price **£55.**

TF1370A Wide-range oscillator 10Hz to 10Mz. Squarewave up to 100KHz. High output—up to 1MHz 31 Volts. 75,100 or 600 Ω output. List price pre VAT—£308. Offered as new at **£125.**

TF2162 MF attenuator. DC-1MHz. O-111db attenuation in ·1db steps. Impedance 600 ohms unbalanced. Price **£50.**

TF2163 U.H.F. Attenuator. DC-1 GHz. 0-142db in 1db steps. Z, 50 ohms. Max. power input 0·5W. As new Price **£75.**

TF801D/1 A.M. Signal Generator up to 470MHz.

TF1106 Noise Generator 1-200MHz. **£75.**

TF1041B Voltmeter. 300mV-300V. 20Hz-1500MHz. **£45.**

TF1301 Noise Gen. 200-1700MHz. 50 ohms. **£55.**

TF1099 20MHz Sweep Generator as new **£75.**

OA1094AHF Spectrum Analyser 100KHz-30MHz. As new.

TF1417 Counter, Frequency Meter 7 digits. Plus range extension unit TF1434/2 to 220MHz. As new.

JERROLD 900B Sweep Generator with SD8A sweep driver unit. V.H.F. and U.H.F. 0-1200MHz. centre frequency. 1, 10 and 100MHz markers. Built-in detector, attenuators etc. This instrument is probably the most comprehensive sweeper ever made. **P.U.R.**

ADVANCE AUDIO SIGNAL GENERATOR TYPE H1. 15Hz-50KHz in three ranges. Sine/square wave output. Supplied in first-class working condition. **£15.** Carriage £1 each.

R216 V.H.F. AM/FM Communications receivers. Coverage 19-157MHz. Film scale dial 2 frequency crystal calibrator. Plus all other facilities. Complete with A.C. power supply connecting lead. Supplied in full working order in excellent secondhand condition.

PLEASE ADD 10% V.A.T. TO THE TOTAL AMOUNT WHEN ORDERING. INCORRECT AMOUNTS WILL CAUSE DELAY IN DESPATCH. THANK YOU.

VALVES

Type	£
B12H	1·75
CY31	0·40
DAF96	0·40
DF96	0·40
DK96	0·40
DL92	0·32
DL94	0·45
DL96	0·40
DM70	0·40
DY86	0·29
DY87	0·28
DY802	0·30
E88CC/01	1·08
E180CC	0·37
E180CC	0·90
E182CC	1·08
EA50	0·18
EABC80	0·27
EAF42	0·46
EB91	0·20
EBC33	0·45
EBC41	0·50
ECC81	0·27
EBF80	0·36
EBF83	0·40
EBF89	0·27
ECC81	0·27
ECC82	0·25
ECC83	0·25
ECC84	0·27
ECC85	0·36
ECC86	0·80
ECC88	0·39
ECC189	0·48
ECF80	0·31
ECF82	0·31
ECF83	0·67
ECF801	0·56
ECH81	0·25
ECH83	0·40
ECH84	0·40
ECL80	0·40

Type	£
ECL82	0·31
ECL83	0·63
ECL86	0·36
EF36	0·50
EF37A	0·85
EF40	0·62
EF41	0·65
EF80	0·25
EF83	0·60
EF85	0·31
EF86	0·27
EF89	0·25
EF91	0·27
EF92	0·31
EF95	0·31
EF183	0·26
EF184	0·31
EFL200	0·67
EL34	0·59
EL41	0·55
EL84	0·21
EL85	0·44
EL86	0·36
EL90	0·31
EL95	0·36
EL500	0·76
EL504	0·76
EM31	0·22
EM80	0·36
EM84	0·31
EM87	0·63
EY51	0·36
EY86	0·40
EY81	0·40
EY88	0·40
EZ41	0·45
EZ80	0·22
EZ81	0·24
GZ34	0·52
GZ37	0·63
KT66	2·30
KT88	2·25
N78	1·60
OA2	0·38

Type	£
OB2	0·35
PABC80	0·35
PC97	0·41
PC900	0·42
PCC84	0·36
PCC89	0·45
PCC189	0·49
PCE800	0·75
PCF80	0·25
PCF82	0·27
PCF84	0·54
PCF86	0·50
PCF200	0·60
PCF201	0·60
PCF801	0·44
PCF802	0·45
PCF805	0·80
PCF806	0·65
PCF808	0·85
PCH200	0·65
PCL81	0·50
PCL82	0·30
PCL83	0·60
PCL84	0·35
PCL85	0·40
PCL86	0·43
PFL200	0·60
PL36	0·50
PL81	0·40
PL82	0·35
PL83	0·36
PL84	0·30
PL500	0·62
PL504	0·62
PL508	0·70
PL509	1·05
PL802	0·88
PX4	2·50
PY33	0·55
PY80	0·35
PY81	0·30
PY82	0·30
PY83	0·35
PY88	0·32
PY800	0·35
PY801	0·45
QQVO 3-10	1·10

Type	£
R17	0·45
R19	0·35
STV 280/40	3·20
STV 280/80	8·20
TT21	3·80
U25	0·70
U26	0·70
U27	0·45
U191	0·68
U801	0·70
UABC80	0·30
UAF42	0·50
UBC41	0·48

Type	£
UBF80	0·35
UBF89	0·34
UCC85	0·35
UCF80	0·60
UCH42	0·60
UCH81	0·35
UCL82	0·35
UCL83	0·55
UF80	0·30
UF89	0·35
UL41	0·60
UL84	0·35
UU5	0·65
UY41	0·45
UY85	0·35
VR105/30	0·35

Type	£
VR150/30	0·35
2800U	1·40
Z801U	1·40
Z803U	1·10
Z900T	0·90
1L4	0·13
1R5	0·35
1S4	0·30
1S5	0·30
1T4	0·30
1X2A	0·36
1X2B	0·50
2K25	7·50
3A4	0·40
3D6	0·15
3Q4	0·55
3S4	0·33
3V4	0·48

Type	£
5B254M	2·75
5B/255M	3·10
5R4GY	0·65
5U4G	0·30
5V4G	0·45
5Y4G	0·35
5Y3GT	0·35
5Z3	0·70
5Z4	0·75
5Z4GT	0·32
6AB7	0·25
6AC7	0·45
6AH6	0·50
6AK5	0·35
6AK8	0·30
6AL5	0·18
6AL5W	0·35
6AM6	0·35
6AN8	0·60

Type	£
6AQ5	0·36
6AQ5W	0·45
6A86	0·30
6AT6	0·30
6AU6	0·20
6AX4GT	0·50
6AX5GT	0·60
6B7	0·35
6BK7	0·60
6BA6	0·25
6BE6	0·25
6BG6G	0·47
6BJ6	0·45
6BQ7A	0·43
6BR7	1·09
6BW6	0·80
9BW7	0·80

Type	£
6C4	0·25
6C6	0·20
6CH6	0·55
6CL6	0·50
6D6	0·15
6EA8	0·60
6F23	0·80
6F33	1·35
6H6M	0·25
6J4WA	0·65
6J5	0·35
6J5GT	0·30
6J6	0·25
6J7G	0·30
6J7M	0·35
6K6GT	0·55
6K7	0·40

Type	£
6K7G	0·17
6K8GT	0·40
6K25	0·70
6L6M	1·35
6SA7	0·40
6SA7GT	0·25
6SC7GT	0·20
6SG7	0·40
6SJ7	0·40
6SJ7GT	0·28
6SK7	0·45
6SL7GT	0·35
6SN7GT	0·35
6SQ7	0·45
6SQ7GT	0·30
6V6G	0·15
6V6GT	0·35
6X4	0·33
6X5G	0·25
6X5GT	0·35
6Y6G	0·75
6-30L2	0·85
6Z4	0·40
7B7	0·50
7Y4	0·60
9D6	0·30
11E2	3·70
12AT6	0·35
12AT7	0·35
12AU7	0·24
12AV6	0·40
12AX7	0·25
12BA6	0·25
12BE6	0·35
12BH7	0·23
12C8	0·30
12E1	2·85
12K5	0·95
12K7GT	0·45
12K8GT	0·40
12Q7GT	0·40
12SG7	0·40
14S7	0·70
19AQ5	0·40
19G3	5·75
19G6	5·75
19H4	5·25
20P4	1·00
25L6GT	0·50

COLOMOR THE VALVE WITH A GUARANTEE

Type	£
30C15	0·70
30C17	0·85
30C18	0·75
30F5	0·80
30FL1	0·70
30FL12	0·95
30FL14	0·80
30L15	0·80
30L17	0·80
30P12	0·75
30P19	0·70
30PL1	0·70
30PL13	0·90
30PL14	0·85
35L6GT	0·50
35W4	0·30
35Z4GT	0·55
50C5	0·45
50CD6G	1·10
50EH5	0·55
75	0·50
76	0·55
78	0·50
80	0·55
723A/B	7·00
803	5·50
805	12·00
807	0·50
813	4·00
832A	2·70
866A	1·25
931A	4·75
954	0·35
955	0·35
956	0·30
957	0·35
991	0·40
2051	0·70
5933	1·00

Type	£
6057	0·55
6060	0·50
6064	0·45
6065	0·65
6080	1·55
6146	1·75
8020	3·75
9001	0·15
9002	0·40
9003	0·45
9004	0·12
9006	0·12

C.R. Tubes

Type	£
VCR97	4·00
VCR517B	5·00
VCR517C	7·00
88D	8·10
88J	8·10
88L	8·10

Photo Tubes

Type	£
CMG25	2·50
931A	4·75
6097C	16·00

Special Valves

Type	£
CV2339	18·00
JP9/7D	35·00
K301	4·50
K305	11·00
K308	14·50
K337	14·50
KRN2A	3·15
WL417A	1·35
3J/92/E	35·00
5C22	22·00
714AY	3·60
725A	22·50

VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.

SPECIAL OFFER O9J TUBE £2·50 p & p 50p

TRANSISTORS, ZENER DIODES

Type	£
OA5	0·20
OA10	0·25
OA70	0·10
OA71	0·10
OA73	0·07
OA74	0·07
OA79 (6D15)	0·10
OA81	0·08
OA91	0·07
OA200	0·07
OA202	0·10
OAZ200	0·55
OAZ201	0·50
OC22	0·50
OC25	0·40
OC26	0·25
OC28	0·60
OC29	0·60
OC35	0·50
OC36	0·56
OC38	0·42
OC44	0·17
OC45	0·12
OC70	0·12

Type	£
OC71	0·12
OC72	0·20
OC73	0·30
OC75	0·25
OC76	0·25
OC81	0·20
OC81D	0·20
OC81DM	0·20
OC82	0·25
OC82DM	0·30
OC83	0·25
OC83B	0·15
OC84	0·25
OC122	0·50
OC139	0·25
OC140	0·40
OC170	0·25
OC171	0·30
OC172	0·37
OC200	0·40
OC201	0·75
OC206	0·95
1N21B	0·30
1N25	0·60
1N43	0·10
1N70	0·07
1N677	0·12

Type	£
1N702-725	0·36
1N823A	1·30
1N4785	0·50
1ZMT5	0·35
1ZMT10	0·33
1ZT5	0·67
1ZT10	0·63
2G385	0·51
2G403	0·51
2N918	0·37
2N1304	0·22
2N1306	0·25
2N1307	0·25
2N2147	0·64
2N2411	1·50
2N2904A	0·25
2N2989	4·00
2N3053	0·20
2N3054	0·50
2N3055	0·64
2N3730	0·50
2N3731	2·75
2N4172	0·50
82303	0·50
3F100	0·62
3FR5	0·32
3N128	0·87

Type	£
3N139	1·75
3N140	0·97
3N154	0·95
3N159	1·45
6FR5	0·45
12FR60	0·73
40954	1·25
40595	1·25
40636	1·25
40668	1·25
40669	1·40
AC126	0·25
AC127	0·25
AC128	0·20
AC176	0·20
ACY17	0·25
ACY28	0·17
AD149	0·50
AD161	0·35
AD162	0·35
AF118	0·50
AF127	0·20
AF139	0·30
AF178	0·48
AF186	0·40
ASY26	0·25
ASY28	0·25

Type	£
ASY67	0·48
BAW19	0·28
BC107	0·10
BC108	0·10
BC113	0·10
BC118	0·20
BCY72	0·15
BF115	0·25
BF173	0·20
BFY51	0·20
BFY52	0·20
BS	0·45
BS2	0·47
BSY29	0·25
BU100	1·80
BYZ13	0·25
BYZ16	0·63
CRS1/10	0·25
CRS1/20	0·38
CRS1/30	0·40
CRS1/35	0·43
CRS1/40	0·48
CRS3/05	0·30
CRS3/20	0·38
CRS3/30	0·43
CRS25/025	0·55

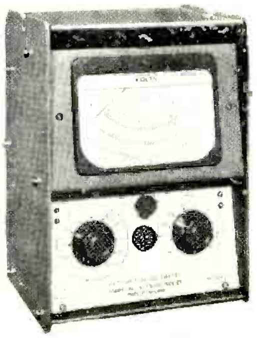
Type	£
CRS3/40	0·50
CS2A	0·65
CV102	0·25
GET103	0·23
GET115	0·45
GET116	0·50
GEX66	1·50
NKT222	0·20
NKT304	0·50
RAS310AF	0·33
SD918	0·26
SD928	0·31
SD938	0·32
SD94	0·21
SD988	0·46
V405A	0·40
Z2A51CF	0·78
ZR11	0·33
ZR21	0·46
ZR22	0·42

ZENER DIODES
All preferred voltage

Type	£
¼W	0·17
1W	0·37
1·5W	0·25
7W	0·40

MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 5p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.

MARCONI TEST EQUIPMENT



TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges, 20 Hz-1500 MHz. D.C. voltage ranges 300 MV 1000V in 8 ranges. D.C. resistance 50 ohms to 500 ohms. Price £62·50.

TF 801B/3/S SIGNAL GENERATOR
Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100μ sec., delay —1·5 to +3000μ sec., rise time < 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25μ sec, delay 0 to + 300μ sec. **£230.**

RACAL UNIVERSAL COUNTER/ TIMER SA550 (CT488)
8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Three independent inputs, self-check etc. Full spec. and price on request.

SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs **of CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0.1uV to 0.224V at 50 ohms. Modes of operation CW-HI. CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M. —x1, x10. x100, 0-75. 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30μsec. width int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 μV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.
TF 562B/3 Oscillator and Detector Unit.
TF 1226B
TF 1225A White Noise Test Set.
TM 577A
TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (a) 85-175 μSec, (b) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2μV to 20mV with ×10 multiplier. **£200.**

HEWLETT—PACKARD
185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.
5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MHz. Accuracy ± 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.
540B TRANSFER OSCILLATOR. Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.
430C MICROWAVE POWER METER. Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£95.**
205AG AUDIO OSCILLATOR. Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£125.**

616B SHF SIGNAL GENERATOR. Freq. range 1,75GHz-4,2GHz. Mod.: F.M., C.W Pulse and Ext. A.M., output: 0,1uV-200mV Price on application
TF 894 AUDIO TESTER. Combined A.F. Generator (0-25kHz), Output meter (up to 2W. at 600, 15 and 3Ω,) and valve voltmeter (0-800V., with stepped and variable attenuators. **£60.**

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

SPECTRUM ANALYSER TYPEOA1094
Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs.

Complete as illustrated, with manuals, etc. and **L.F. Adaptor.**
Price upon application.

SOLATRON DO 905 STABILISED AMPLITUDE SIGNAL GENERATOR. Freq. range 350kHz-50MHz £70.
TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: —50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.
BC 624 RECEIVER (Part of SCR 522 TX/RX) 100-156 mcs. no valves, requires separate PSU for 28V. £2.50. Carriage 50p.
TR 143 TRANSMITTER RECEIVER 100/1261mcs, requires separate PSU for 28V. Price **£12.00.** Carriage £1.50.

TEKTRONIX OSCILLOSCOPES.
541A—33MHz, plug-in Y amps.
531-57—60MHz, separate P.S.U.
561A—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10mV-cm.
R Transistor measurement.
P type calibration.
3A1—Dual trace 10mV-10V.
3B3—Delayed sweep time base.
134—P6021 probe and current probe amplifier, 1mA-15A p. & p., new and boxed, **£125.**
EQUIPMENT
162 wave form generator.
163 Pulse generator.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) £8·50. P. & P. £1·50.
AR88 SPARES. We hold the largest stock in U.K. Write for list.
3 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport.

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

SEE OUR SALE on page xx

V.A.T.
PLEASE ADD 10% TO ALL ORDERS

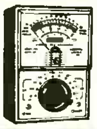
REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£180** plus carriage.
HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.
R.F. METER 0-8 amp. 2¼" (U.S.A.) **£1·80** P. & P. 15p.
29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. £7·50 new or £4·50 slightly used. Carriage 50p.
METERS Full List of our very large stock of meters on request.
TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**
50 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**
Price of each of the above on application.
RADAR SCANNER ASSEMBLY TYPE C368 Parabolic assembly 17". Complete with motor for 26V 600W, etc. **£22·50.** Carriage £2·50.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23. To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

GWS G.W.SMITH & CO (RADIO) LTD

AUDIOTRONIC MODEL ATM.1

Top value 1000 o.p.v. pocket multimeter. Ranges: 0/10/50/250/1000v. AC and DC. DC Current 0-1mA/100mA. Resistance 0/150k ohms. Decibels —10 to +22dB. Size 90 × 60 × 28mm. Complete with test leads. £2·50. Post 15p.

RUSSIAN 22 RANGE MULTIMETER

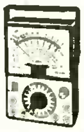
Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 μA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3M Ω. Complete with batteries, test leads, instructions and sturdy steel carrying case. Our Price £4·95. Post 25p.

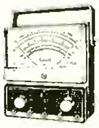
MODEL 500

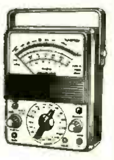
30,000 O.P.V. with overload protection, mirror scale. 0/·5/2·5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. £9·95. Post paid. Leather case £1·75.

U4312 MULTIMETER

Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150 600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C. 0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. £9·75. Post 25p.

HIOKI MODEL 700X

100,000 O.P.V. Overload protection. Mirror scale, ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30μA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. —20 to +63db. £13·50. Post 20p.

MODEL C-7080 EN

Giant 6in. mirror scale. 20,000 o.p.v. 0/·25/1/2·5/10/50/250/1000/5000V. D.C. 0/2·5/10/50/250/1000/5000V. A.C. 0/50μA/1/10/100/500mA/10 amp. D.C. 0/2K/200K/20 meg. —20 to +50 db. £13·95. Post 35p.

KAMODEN 72.200 MULTITESTER

High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0/·06/·3/3/30/120/600/1200V. D.C. 0/3/12/60/300/11,200V A.C. 0/6μA/1·2mA/120mA/600mA/12A. D.C. 0/12A. A.C. —20 to +63dB. 0/2K/200K/2 meg/200 meg ohms. £16·95. Post 30p.

TMK LAB TESTER

100,000 O.P.V. 6½ in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5K/Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: —10 to +49 db. Plastic Case with carrying handle. Size 7½ × 6⅞ × 3⅛. £18·95. P.& P. 25p.

MODEL S-100TR MULTIMETER/TRANSISTOR TESTER

100,000 o.p.v. MIRROR SCALE/OVERLOAD PROTECTION.

0/·12—·6/3/12/30/120/600 V DC.
0/6/30/120/600 V. AC.
0/12/600uA/12/300MA/12 Amp. DC.
0/10K/1 MEG/100 MEG.
—20 to + 50 db. 0·01 —·2 mfd.
Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. £13·50. Post 25p.

ALL PRICES ARE SUBJECT TO 10% V.A.T.

370 WTR MULTIMETER

Features A.C. current ranges. 20,000 o.p.v. 0/·5/2·5/10/50/250/500/1000 V DC 0/2·5/10/50/250/500/1000 V AC 0/50μA/1/10/100MA/1/10 Amp DC. 0/100MA/1/10 Amp AC. 0/5K/50K/500K/5MEG/50MEG. — 20 + 62 db. £15. Post 25p.

LB4 TRANSISTOR TESTER

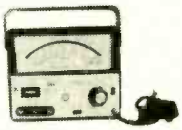
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5v batteries. Complete with all instructions etc. £4·50. Post 20p.

LB3 TRANSISTOR TESTER

Tests ICO and B. PNP/NPN. Operates from 9v. battery. Complete with all instructions etc. £3·95. Post 20p.

KAMODEN HM.350 TRANSISTOR TESTER

High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4in. × 4½in. clear scale meter. Operates from internal batteries. Complete with instructions leads and carrying handle. £12·50 Post 30p.

MODEL 449A IN CIRCUIT TRANSISTOR TESTER

Checks true A.C. beta in/out. Checks Icbo. Checks diodes in/out. Checks SCR etc. Beta HI 10–500. LO2–50. Icbo 0-5000μA. 220/240V. A.C. operation. £17·50. Post 25p.

KAMODEN HM.720B F.E.T. V.O.M.

Input impedance 10 meg. ohms. Ranges: 0/·25/1/2·5/10/50/250/1000V, D.C. 0/2·5/10/50/250/1000V. A.C. 0/25μA/2·5/25/250 MA D.C. —20 to +62dB 0/5K/50K/500K/5 meg/500 meg ohms. £14·95. Post 30p.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels —40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17·50 Carr. 25p.

TE-65 VALVE VOLTMETER

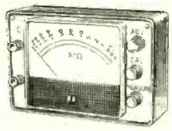
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation Complete with probe and instructions. £17·50. Post 30p. Additional Probes available: R.F. £2·12 H.V. £2·50.

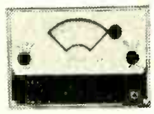
MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

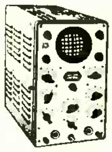
Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm. 0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. D.C. 0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. A.C. 0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300 750V. D.C. 0/750mV/1·5/3/7·5/15/30/75/150/300/650V. A.C. Automatic cut out. Supplied complete with test leads, manual and test certificates. £49. Post 50p.

TMK MODEL 117 ELECTRONIC VOLTMETER

Battery operated, 11 meg input. 26 ranges. Large 4½in. mirror scale. Size 5⅞ × 4⅛ × 2⅛in. DC Volts 0·3-1200V. AC Volts 3-300V RMS. 8·0-800V. P-P. DC Current ·12-12MA. Resistance up to 2000M ohm. Decibels —20 to +51 db. Complete with leads/instructions. £17·50. P. & P. 20p.

KAMODEN HMG-500 INSULATION RESISTANCE TESTER

Range 0-1000 Megohms, 500 Volt. Battery operated. Wide range clear meter 4½in. × 4in. Complete with de luxe carrying case, batteries, instructions. £19·95. Post 30p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in. Price £17.50 Carr. 17p.

CI-5 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. .1–25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz, V RMS/mm. .3–25; Preset triggered sweep 1–3,000μsec.; free running 20–200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. £39·00. Carr. paid.

TO-3 PORTABLE OSCILLOSCOPE 3in. TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps —1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook £47·50. Carr. 50p.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s–1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87 Carr. paid.

MODEL AT201 DECADE ATTENUATOR

Frequency range: 0–200KHz. Attenuator: 0-111db., 0·1db. step. Impedance 600 ohms. Max. input power 30dbm. Size 180 × 90 × 55mm. £12·50. Post 37p.

ARF-300 AF/RF SIGNAL GENERATOR

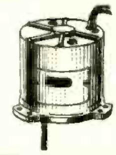
All transistorised, compact, fully portable. AF sine wave 18Hz. to 220KHz. AF square wave 18Hz. to 100KHz. Output sine/square 10v. P-P. RF 100KHz. to 200 MHz. Output 1v. maximum. Operation 220/240v. A.C. Complete with instructions and leads. £29·95. Post 50p.

TE-20 D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s-500 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. Size 140 × 215 × 170 mm. £17·50. Carr. 37p.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms, 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads, £17·50. Carr. 37p.

230v/240v SMITHS SYNCHRONOUS GEARED MOTORS

Built-in gearbox. All brand new and boxed. 30 RPH CW; 2 RPH CW; 20 RPH CW; 2 RPH ACW; 30 RRH CW. 50p each. Post 12p.

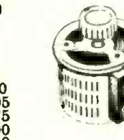
230 VOLT A.C. 50 c/s RELAYS

3 sets of changeover contacts at 5 amp rating 40p each. Post 10p (100 lots £30) Quantities available.

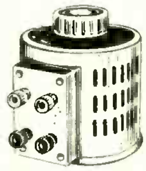
MODEL TE-15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector Frequency range 440Kc/s–280Mc/s in 6 coils. 500μA Meter. 9V. battery operation. Size 180 × 80 × 40mm. £15·00. Post 20p.

"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS
Excellent quality at low cost. All models—Input 230v. 50/60 c/s. Variable output 0-260v.

MODEL S-260 GENERAL PURPOSE BENCH MOUNTING


1 Amp ..	£7·00
2·5 Amp ..	£8·05
5 Amp ..	£11·75
8 Amp ..	£15·90
10 Amp ..	£22·50
12 Amp ..	£23·60
20 Amp ..	£49·00
25 Amp ..	£58·00
40 Amp ..	£82·50

MODEL S-260B

Panel Mounting.

1 Amp ..	£7·00
2·5 Amp ..	£8·05

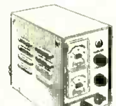
Carriage and Packing Extra

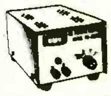
AUTO TRANSFORMERS
0/115/230V. Step up or step down. Fully shrouded.

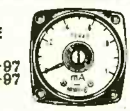
80 W	£2·35	P. & P. 18p
150 W	£3·00	P. & P. 18p
300 W	£4·00	P. & P. 23p
500 W	£5·80	P. & P. 33p
1000 W	£8·25	P. & P. 38p
1500 W	£11·25	P. & P. 43p
2250 W	£19·00	P. & P. 50p
5000 W	£40·00	P. & P. £1

MCA. 220 AUTOMATIC VOLTAGE STABILISER

Input 88-125 VAC or 176-250VAC. Output 120VAC or 240VAC. 200VA rating. £11·97. Carr. 50p.

PS.200 REGULATED P.S.U.

Solid state. Variable output 5-20 volt D.C. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240 V. A.C. Size 7½" × 5⅛" × 3⅞". £19·95. Post 25p.

PS.1000B REGULATED P.S.U.

Solid state. Output 6-9 or 12 V. D.C. up to 3 amps. Meter to monitor current. Input 220/240 V. A.C. Size 4" × 3¼" × 6¼". £11·97. Post 25p.

240° WIDE ANGLE 1mA METERS

MW1·6 60mm. square £3·97
MW1·8 80mm. square £4·97
Post extra.

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.
25 WATT. 10/25/50/100/250/500/1000 ohms. 95p. P. & P. 10p.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. £1·35. P. & P. 10p.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. £1·95. P. & P. 15p.

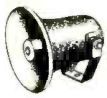
GWS G.W.SMITH & CO (RADIO) LTD

BVD.5 VERNIER TUNING DIAL

Approx. 7:1 ratio planetary drive vernier dials. Log scale 0-180 degrees. Blank scales 1 to 5. Scale width 4½". Dial size 5" x 3". Overall size 7½" x 4½" x 1⅞" deep including knob and coupling. ¼" dia. shaft.

OUR PRICE **£1·62** P. & P. 15p

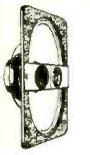
RUH.6 REFLEX HORN SPEAKER



Built in driver unit. Impedance 16 ohm. Powerrating 10watt. Response 380-7000 Hz. Approx. size 6" x 6". Weather-proof and shock proof.

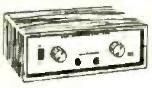
OUR PRICE **£4·97** P. & P. 30p

EMI LOUDSPEAKERS



Model 350. 13in. × 8in. with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p. Model 450. 13in. × 8in. with twin tweeters/crossover. 55-13,000 Hz. 8 watts RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

HA-10 STEREO HEADPHONE AMPLIFIER



All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9 v. battery. Inputs: 5mV/100mV. Output: 50mW per channel.

OUR PRICE **£6·97** P. & P. 20p

MP7 MIXER PREAMPLIFIER

5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9¾" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono mag. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE **£8·97** P. & P. 20p

1021 STEREO LISTENING STATION

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls. speaker on-off slide switch, stereo headphone sockets. 6in. × 4in. × 2½in.

OUR PRICE **£2·25** P. & P. 20p

EA41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet. 7½ × 3 × 4½in.

OUR PRICE **£7·50** P. & P. 15p

ALL PRICES ARE SUBJECT TO 10% V.A.T.

GWS ALSO SEE PREVIOUS PAGES

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£1·87** P. & P. 30p

LIGER LHO2S STEREO HEADPHONES

Lightweight headphones with padded earpieces. 4-16 ohms. 20-20,000 Hz. Complete with 6ft cord and plug.

OUR PRICE **£1·95** P. & P. 30p

TE1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive magnetic headset with soft earpads. Impedance 2,000 ohms (d.c. 600 ohms). Frequency response 200-4000 Hz.

OUR PRICE **£2·25** P. & P. 30p

SDH8V MONO/STEREO HEADPHONES

Two way stereo/mono with volume controls. Padded headband. 4-16 ohms. 20-18,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£4·97** P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE

Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.

OUR PRICE **£4·95** P. & P. 30p

DH.08S Stereo Headphones

De luxe model with unique 2 way mechanical units and volume controls. 8 ohms. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE **£7·97** P. & P. 30p

4-CHANNEL STEREO HEADPHONES

TTC G3600—Soft vinyl covered head cushion and earphones. Each earpiece incorporates two 2" speaker units. Fitted 2/4 channel changeover switch. Impedance 4-16 ohm. Frequency response 20-20,000 Hz. Complete with 15ft. coiled lead fitted two stereo plugs.

OUR PRICE **£9·95** P. & P. 30p

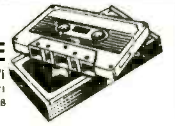
DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable head band. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY £2·25. Post 30p.

AUDIOTRONIC

Audiotronic Products are manufactured exclusively for the Audiotronic Group of Companies and as a member of the group we are pleased to offer you this fabulous range of high quality equipment. Made to our own specifications each item provides outstanding performance and reliability at a value for money price!

TAPE CASSETTE



Top Hi-Fi quality in library cases

LOW NOISE			
Type	5	10	25
C60	£1·20	£2·53	£5·99
C90	£1·65	£3·62	£8·59
C120	£2·29	£4·48	£10·63
CHROME DIOXIDE			
CR60	£3·41	£6·72	£16·63
CR90	£4·63	£9·10	£22·80
TAPE HEAD CLEANER 30p each			

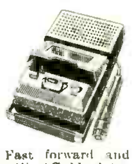
P. & P. 15p for 5; 10 and over post free.

8-TRACK BLANK TAPES

Type	1	5	10
40M	75p	£3·50	£6·50
80M	99p	£4·70	£8·90

P. & P. 5p.; 5 and over post free.

ACR.14 BATTERY/MAINS CASSETTE RECORDER



Portable twin track mono recorder with automatic recording level control. Built-in speaker. Earpiece socket. Input for radio or record player. Fast forward and rewind. Output 500mW. AC 220/240v. or 6v. DC operation. Complete with remote control microphone, mains lead, earpiece and batteries.

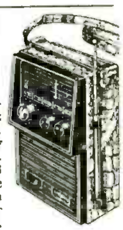
OUR PRICE **£10·50** P. & P 50p

SPORTSMAN AM/FM PORTABLE RADIO MODEL AR.1000

5 wavebands covering AM 535-1605KHz. FM 88-107MHz. AIR 108-135MHz. PB 147-174MHz. WB 162.5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for FM and built-in ferrite bar for AM. AFC. 3in. speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 × 79 × 219mm. Battery/mains operation.

OUR PRICE **£11·50** P. & P. 35p

MULTIBAND RADIO AMB 500



5 wavebands covering MW 535-1605KHz and FM 88-175MHz. All transistor. Battery or mains operation. Built in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

OUR PRICE **£6·95** P & P 35p

PORTABLE RADIO AMR-9000 GLOBAL AM/FM

10 wavebands covering: AM: 535-1605 kHz. LW: 150-380 kHz. MB 1.6-4 MHz. SW1: 4.0-8 MHz. SW2: 8.0-16 MHz, SW3: 16-24 MHz, PSB1: 30-50 MHz. PSB2: 148-174 MHz. FM 88-108 MHz. AIR: 108-136 MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built in aerial. AFC on FM. 6in. × 4in. speaker and personal earpiece. Battery/mains operation. Size: 345 × 133 × 305mm.

OUR PRICE **£36·00** P. & P. 50p

STEREO CASSETTE DECK ACD.660

A beautifully styled 4-track stereo deck with an outstanding specification offered at a remarkably low price. Incorporates a host of features including switchable noise filter, normal/chrome tape selector, twin VU meter, slider record/playback level controls, front panel headphone socket, recording indicator lamp, phono/Din line input sockets, 3.5 mm. mike input sockets etc., etc. Frequency response 100-8KHz (100-12KHz CrO2) S/N —45dB. Crosstalk —45dB. Separation —35dB. Noise limiter —6dB at 10KHz. Complete with phono connecting leads.

OUR PRICE **£39·50** P. & P. 50p

DIGITAL CLOCK RADIO ADC.1

Covers AM 540-1600KHz. FM 88-108 MHz with AFC. 24 hour leaf type digital clock with one minute division time change. Illuminated dial. 24 hour alarm setting. Wake up to the sound of music or loud buzzer. Unique sleep switch will automatically turn off radio when you have gone to sleep. Slider volume control. Internal speaker plus socket for earpiece or pillow speaker. AC 240v. Size 254 x 92 x 178mm. Complete with earpiece, FM aerial and operating instructions.

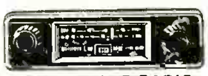
OUR PRICE **£12·50** P. & P. 50p

IN-CAR EQUIPMENT

ACP. 8 8-TRACK PLAYER

Attractive black and silver finish. 12v. neg. earth. Slider controls for Volume, Tone and Balance. Channel selector button with red pilot lamp. Complete with speakers, mounting brackets and instructions.

OUR PRICE **£12·50** P. & P. 40p



ACR 3500 CAR RADIO

Manual tuning of Medium and Long waves. 12v. pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£6·50** P. & P. 50p

DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16½" × 8" × 3¼". AC 200/250v.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz—20KHz±2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

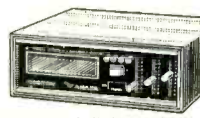
OUR PRICE **£34·50** P. & P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz—20KHz± 2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

OUR PRICE **£50·00** P. & P. 50p

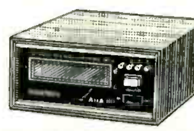
AHP-8A 8-TRACK STEREO TAPE PLAYER



Incorporates built-in amplifiers giving 2½+2½ watts rms output. Push button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. AC 220/240v.

OUR PRICE **£17·25** P. & P. 50p

AHP-8D 8-TRACK STEREO TAPE DECK



Can be used with most hi-fi amplifiers. Push button track selector and illustrated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. AC 220/240v.

OUR PRICE **£11·95** P. & P. 50p

AUDIOTRONIC LA.1700 SYSTEM

17+17 watt amplifier, Garrard AP76, plinth and cover, G800 cartridge, pair of Wharfdale Linton 2 speakers and all leads.

OUR PRICE **£92·50** Carr. & Ins. £1·50

Matching LT1700 AM/FM Stereo Tuner £37·50.

STEREO HEADPHONES

LSH.20 Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000 Hz. **£3·50.** P & P 30p.

LSH.30 Open back type. Individual tone and volume controls. 8 ohms. 30-20,000 Hz. **£5·50.** P. & P. 30p.

LSH.40 Two way speaker system. Individual volume controls. 8 ohms. 20-20,000 Hz. **£6·95.** P & P 30p.

LSH.60 3in speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. **£8·50.** P & P 30p.

LSH.50 Professional Quality Electrostatic. Complete with self powered energiser and control unit with headphone/speaker selector. 4-32 ohms. 20-24,000 Hz. **£15.95.** P&P 30p.

LQH.400 4-channel dynamic headphones. Each earpiece has 4 drive units. Two stereo jack plugs fitted to leads. 4-32 ohms. 20-20,000 Hz. **£9.95.** P & P 30p.

SAVE UP TO 33⅓% OR MORE! GWS

RECORD DECKS

Carriage & Packing 50p

B.S.R. McDONALD

C114 Mini	£3·95
C129 Mono	£5·50
C137	£7·00
510/TPD1	£13·95
610	£10·55
610/TPD1	£15·45
710	£21·15
810	£26·30
710/810 Plinth and Cover	£6·15
MP60	£8·25
MP60/G800	£10·90
MP60/TPD1	£13·20
MP60/TPD2	£11·25
HT70	£11·60
HT70/G800	£14·25
HT70/TPD1	£16·55

CONNOISSEUR

BD1 Kit	£9·10
BD1 Chassis	£11·35
BD2/SAU2/Chassis	£22·70
BD2/SAU2/Plinth/Cover	£28·20

GARRARD

1025T Stereo	£4·95
2025 T/C Stereo	£6·35
SP25 III	£9·25
SP25 III/Acos GP104 Ceramic	£8·50
SP25 III/G800	£10·95
SP25/M75-6	£13·90
AP76	£18·00
SL65B	£11·15
SL72B	£17·75
SL95B	£31·15
401	£24·35
ZERO 100	£34·10
ZERO 100S	£31·40

GOLDRING

G99	£22·50
G101P/C	£22·50
GL69/2	£15·75
GL72	£25·45
GL72/P	£33·75
GL75	£32·20
GL75P	£41·65
GL78P/C	£56·25
GL85P/C	£72·00

THORENS

TD125/II	£59·40
TD125AB/II	£92·05
TD160C	£50·80
TD165	£43·80

ALBANY HOUSE AM 108 SYSTEM

8 + 8 watt amplifier MP60, plinth and cover. G800 cartridge, pair of Medway T138 speakers.

OUR PRICE **£50·95** Carr. £1·25

TRIO KA 2000A SYSTEM

16+16 watt amplifier. SP25 or MP60 plinth and cover, G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE **£70·95** Carr. £1·25

RECORD DECK PACKAGES

Carriage and Packing 75p

Complete units with Stereo cartridge ready wired in plinth and cover.

GARRARD

2025 TC/9TAHCD	£10·65
SP25 III/G800	£15·90
SP25 III/M44E	£17·40
SP25 III/M44-7	£16·95
SP25 III/M55E	£17·85
SP25 III Module/M75-6	£19·45
AP76/G800	£25·55
AP76/G800E	£28·10
AP76/M44E	£27·05
AP76/M44-7	£26·60
AP76/M55E	£27·50
AP76/M75ED	£31·70
AP76/M75EJ	£30·30
AP76 Module M75-6	£29·10
AP96 Module M75-6	£33·20
ZERO 100S Module/M93E	£44·15

B.S.R. McDONALD

210/SC7M	£7·40
MP60/G800	£15·00
MP60/TPD1/G800	£15·80
MP60/M44-7	£16·60
HT70/TPD1/G800	£19·20

GOLDRING

GL72/G800	£31·50
GL75/G800	£36·65
GL75/G800E	£39·15

GOODMANS

TD100/G800 Teak	£46·85
TD100/G800 White	£48·60

LEAK

Delta/M75-6	£47·20
Truspeed	£35·95

PHILIPS

GA105/GP200	£13·80
GA160/GP200 Teak	£19·50
GA308/GP400	£32·75
GA308 (less cartridge)	£23·95
GA212/GP400	£48·05

PIONEER

PL12D (Less cartridge)	£31·75
PL15C (Less cartridge)	£44·25
PL41D (Less cartridge)	£104·75
PL50 (Less cartridge)	£98·90
PL61 (Less cartridge)	£110·30
PLA35 (Less cartridge)	£61·55

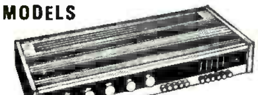
THORENS

TD160C/Ortofon M15E Super	£70·35
TD125 AB/11 M15E Super	£112·05
T165/Ortofon M15E Super	£62·55

WHARFEDALE

Linton/M44-7 Teak	£23·55
Linton/M44-7 White	£24·70

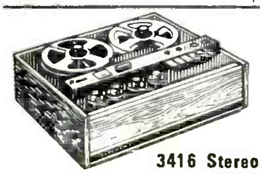
FERGUSON EXPORT MODELS



3408 Stereo Tuner Amplifier

Covers FM 88-108 MHz. Five push button tuning scales. 8+8 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

OUR PRICE **£31·50** Carr. 50p



3416 Stereo Tape Deck

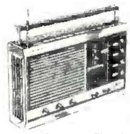
4 track. 7½, 3¾, 1⅞ i.p.s. Stereo/mono record/play. 7" reels. Inputs for dynamic mikes, radio, gram. Complete with cover.

OUR PRICE **£41·95** Carr. 75p

SINCLAIR PROJECT 60 PACKAGE DEALS

2×Z30 Stereo 60/P/Z5 £15·95. P. & P. 37p.
2×Z30/Stereo 60/PZ6 £18·00. P. & P. 37p.
2×Z50/Stereo 60/PZ8 £20·25. P. & P. 37p.
Transformer for PZ8 £3·65
Active Filter Unit £4·45
Pair of Q16 Speakers £10·70 P. & P. 50p.
Sinclair Project 605 £20·97. P. & P. 37p.
All other Sinclair Products in stock.
2000 Amplifier £22·95. P. & P. 50p.
3000 Amplifier £28·95. P. & P. 50p.
2000/3000 Tuner £26·30. P. & P. 50p.
Q830 Speaker £14·99. P. & P. 50p.

PHILIPS IC361 AM/FM MAINS/PORTABLE RADIO WITH AFC



Covers LW, MW, FM, SW1, SW2 and 49 metre band. Fine tuning of SW and Pre set tuning of three FM stations. Bass, treble and volume/on/off controls. Press button wave change. Tuning/battery indicator. Tape/Gram input. Earpiece socket. AC 110-140v. or 6 x 1.5v. batteries. Size 14¼in. × 9in. × 3½in. approx. With mains lead and istructions. Rec. List Price £69·18.

OUR PRICE **£39·95** P. & P. 50p.

HANIMEX HRC 3061 CASSETTE RADIO

Record/Playback facilities plus slide rule tuning of AM 535-1620 KHz and FM 88-108 MHz. Slider volume controls. Built in condenser microphone plus separate hand/desk microphone. Telescopic aerial. Complete with earpiece, batteries and instructions. (Tape not supplied.) (Rec. List price £55·56).

OUR PRICE **£22·75** P. & P. 50p

MINUTEMAN MM3M

as above with addition of memory key, percent key and a fixed or floating decimal. Complete with rechargeable batteries, AC adaptor, instructions and case.

OUR PRICE **£34·95** P. & P. 25p

BINATONE DS100 DIGITAL CLOCK

240v mains operation. Ivory case with large clear numbers for hours, minutes and seconds Approx. size 6¼" x 3" x 3½".

OUR PRICE **£4·50** P. & P. 30p

SUPER AKAI CASSETTE BARGAINS!

CS35 STEREO CASSETTE RECORDER

High quality cassette recorder with hysteresis synchronous outer-rotor motor. Has pause control with lock and selector for conventional or Chromium Dioxide tape. 4 track record/playback. Volume and tone controls. Frequency response 40-16kHz (using CrO2 tape), distortion better than 2%, wow and flutter better than 0·2% RMS. Complete with pair of matching Akai CS88 speakers.
Rec. Price £96·10.

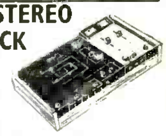
OUR PRICE **£56·50** P. & P. 50p

ADM MICROPHONES

Normally £11·80 pair.

OUR PRICE **£7·50** Pair. P. & P. 25p

AKAI CS35D STEREO CASSETTE DECK



4 track record/playback deck. Accepts chrome/regular tape cassettes.
Rec. Price £68·30

OUR PRICE **£44·45** P. & P. 50p

NEW! SINCLAIR CAMBRIDGE CALCULATOR

To build yourself. Complete kit of parts with step by step instructions to build a full specification pocket sized calculator.
(Rec. Price £27·23)

OUR PRICE **£24·95** P. & P. 50p

Also available ready built (Rec. Price £39·95)

OUR PRICE **£27·20** P. & P. 25p

MINUTEMAN MM3 POCKET CALCULATOR

Size only 4"1/16 x 3" x 1". 8 digit display with overflow and error indicators. Floating decimal. Adds, subtracts, multiplies and divides. Chain and mixed calculations. Constant factor for series multiplication or division. Complete with batteries, instructions and case.

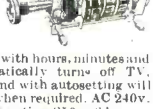
OUR PRICE **£27·50** P. & P. 25p

FANTASTIC OFFER! PORTABLE CASSETTE RECORDER CT5050

Instant recording and playing. Piano key controls. Automatic level control. Built in speaker. Complete with remote control microphone, carrying case and shoulder strap.

OUR PRICE **£8·50** P. & P. 50p

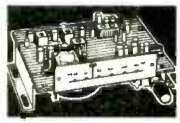
DIGITAL CLOCK MECHANISM DT.55B



Features 24 hour alarm setting with built in buzzer. On/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off TV, radio, light etc. and with autosetting will switch on again when required. AC 240v. operation. Switch rating 250v. 3A.

OUR PRICE **£5·95** P. & P. 30p

FM TUNER CHASSIS



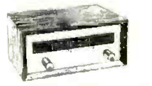
6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. × 4in. × 2¼in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money.

OUR PRICE **£5·95** P. & P. 20p

Stereo Multiplex Adaptor £4·97.

A1018 FM TUNER

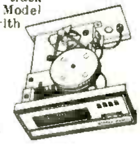
Specification as above chassis but complete in cabinet with on/off switch. Size 7¼" x 3⅜" x 5".



OUR PRICE **£9·65** P. & P. 30p

Stereo Multiplex Adaptor £4·97.

BSR8 TRACK PLAYER CHASSIS



Famous BSR 8 track chassis as used in Model TD88 complete with silver and black escutcheon ready to fit into cabinet. Output 125mV. AC 240v. Overall size approx. 185×215×80mm.

OUR PRICE **£8·95** P & P 50p

SPECIAL OFFER! STEREO SPEAKERS

Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14¼in. × 9in. × 7¼in. 8 ohms. 8 watts RMS. 16 watts peak. Complete with DIN lead.

OUR PRICE **£12·95** Carr. 50p

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27, Tottenham Court Rd, W.1	Tel: 01-636 3715	378, Harrow Road, W.9.	Tel: 01-286 9530
87, Tottenham Court Rd, W.1	Tel: 01-580 3739	**ESSEX**	
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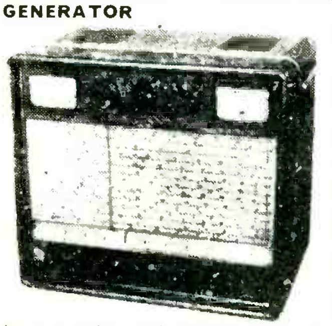
GENERATORS

MARCONI TF867 STANDARD SIGNAL GENERATOR



Carrier Frequency Range: 15Kc/s-30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Stability: After warm up the drift in a 10-minute period is, typically, less than 0·005% for carrier frequencies up to 3·2Mc/s and less than 0·01% from 3·2-30Mc/s. Output Voltage: 0·4μV-4V. Impedance: 75 ohms nominal for outputs from 2·4 v. 75 ohms for outputs from 4μV-2V. 13 ohms for outputs from 0·4μV-0·4V. Accuracy: below 3Mc/s ±0·25dB of ±0·1μV. 3-10Mc/s ±0·5dB or 00·2μV. 10-30Mc/s ±1·0dB or ±0·5μV. Power Supply: 100-125V, 200-250V 40-100c/s. Dimensions: 18 in. high × 21 in. wide × 14½ in. deep. **Price £165·00**

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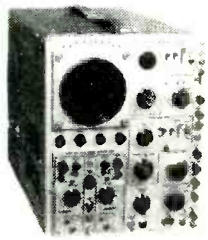

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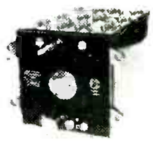

Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame. Each unit contains two sine and two coside potentiometer sections, the sliders being ganged together. Electrical connections: 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max. torque: 3½ oz./in. Dimensions: W. 6¾ in. H. 5 in. D. 7¾ in. Wt. 7¾ lbs. Ex equipment. Good condition. Price £5. Carriage extra.

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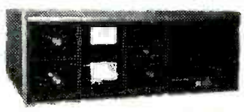

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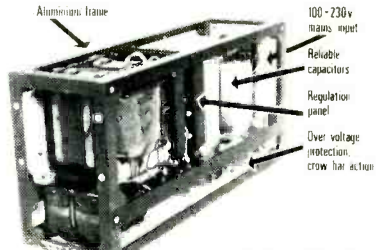

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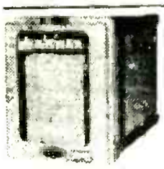
PEN RECORDERS

BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK

of America. This Recorder indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0-1 milliamp d.c. internal resistance 100 ohms. Chart drive motor 240 V 50Hz. Chart speed 1" per hour. Complete with handbook. Price **£35·00** plus **£5·00** packing and carriage.



SINGLE PEN RECORDER

by Record Electrical. 3" chart, sensitivity 1 milliamp, chart speed 1" and 6" per hour. Size 8" x 11" x 6". Offered complete with pen assembly and spare chart. Listed at over £100—this month's special price due to bulk purchase . . . **£39·50** plus **£5·00** packing and carriage.

LEEDS & NORTHRUP STRIP CHART RECORDER

This well-known Instrument is fitted with a Series 60 control unit servo amplifier 101041 BR EQ. Range: 5·571 to 18·855. Ref. junction 320F. Primary element: P1. P1. 13% RH JMC. Response time: 5 secs. for f.s.d. Chart width: 7 in. Chart speed: 1 in. per hour. Power supply: 120V 50 Hz (auto-transformer available). Dimensions: Ht. 18", width 11", depth 12½". Weight 51 lbs. **PRICE £80·00**

POTENTIOMETERS

TEN TURN 3600 ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
100/100/100		Beckman	A	£4·00
100	0·5	Beckman	A.S.	£2·00
200	0·5	Beckman	A	£2·00
500	0·1	Beckman	S	£2·50
500		Colvern	2501	£2·25
500		Foxes	PX4	£2·00
500		Colvern	2610	£2·50
500		Colvern	26/1000/11	£3·00
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·5	Beckman	A	£3·00
10K	0·1	Beckman X	A	£3·50
10K	0·1	Colvern	CLR26/1001	£3·50
15K		Colvern	CLR2402	£3·00
18K		Beckman	A	£3·00
25K	0·5	Helipot	SA.337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K		Colvern	2402	£1·50
30K		Beckman	SA95C	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
30K	0·25	Beckman	SA1679	£3·25
30K	1·0	Colvern	2402/1	£1·50
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K		Colvern	2503	£2·25
50K	X	Foxes	PX4	£2·25
50K	0·5	Beckman	A	£3·00
50K	0·1	Beckman	A	£3·50
100K/100K		Ford	A	£5·00
100K	0·1	Beckman	A	£3·50
100K	0·5	Beckman	A	£3·00
100K		Colvern	2501	£2·25
100K		Colvern	2610	£2·50
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780 ROTATION

100/100	0·5	Beckman	C	£3·00
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.ss	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400 ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

TWENTY TURN 7200 ROTATION

1 Meg.	General Controls	PXM130	£4·00
50K	Reliance		£2·00

156 TURN 56/60 ROTATION

460	Kelvin Hughes	KTP0701	£9·50

FIVE TURN 1800 ROTATION

200	Relcon	HEL07-05 F/11	£2·25
500	Colvern	CLR2505	£2·00
U1 5K	Colvern	CLR2605	£2·00

FIVE-AND-A-HALF TURN

500	Colvern	2405	£2·00

OUR STOCKS ARE CONSTANTLY CHANGING —PLEASE LET US KNOW YOUR EXACT REQUIREMENTS

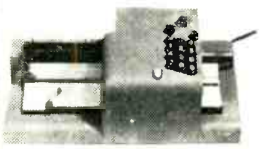
COMPUTER ACCESSORIES

80 COLUMN HAND PUNCHES

Ideal for stock control, sales analysis, back-up in existing computer installations, DP training centres, schools, etc. New low cost model £59·50 plus carriage.

DE LUXE MODEL

Incorporating tabulating mechanism. £79·50 plus carriage.



ELECTRIC HAND VERIFIER

£89·50 plus carriage.

All machines supplied with numeric keytops and dust-cover and covered by our three month guarantee. Delivery ex-stock. Optional extras alpha keytops and chip tray.

Special Computer Offer !

SAVE 75% OF LIST PRICE ON THIS DEC PDP SYSTEM

PDP-12C	4K CPU and Console
DF32	32K Disk and Control
DWO8A	1/0 Bus Level Converter
PC12 & PC05	High Speed Reader/Punch
BA12	Peripheral Expander
ASR33	Teletype
PTO8C	Dual Channel Interface
KP12	Power Fail/Restart
AFO1A	A/D Converter/Multiplexer

- Fully maintained by DEC since new
- DEC maintenance available on resale
- Available in our showroom now
- Only three years old

£5000

Also available PDP 8F with ASR 33 **£1150**

TELETYPE PUNCH

BRPE High-speed punch. Self-contained, consists of punch unit, base, motor unit. For use in many data communication systems. Operating speeds up to 100 characters per second. (1100 words per minute). Available for punching 5, 6, 7, or 8, level codes, into 11/16", 7/8" tape. Synchronous. parallel-wire input. **£145**

WELMEC 7 & 8 HOLE ELECTRO-MECHANICAL PUNCHES & READER

Models S110 and R82C. 17 char. per sec. Rebuilt, available from stock. **£45.**

ICT KEYBOARDS

In original packing—Numerical from **£4·50**

ICT KEYBOARDS

In original packing—Alpha-numeric **Prices from £12·50**

Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER, ICL Magnetic Drums. From **£75.**

IBM PUNCH CARD EQUIPMENT FULLY GUARANTEED

		Prices from
024	Automatic alphanumerical keypunch	£340·00
026	Automatic alphanumeric printing keypunch	£820·00
056	Verifier features and operation same as 024, 026	£380·00
082	Sorter 500 cards per minute are sorted	£740·00

Carriage extra.

FREQUENCY CONVERTER MODEL B.40

50 KVA to 60 Hz power frequency converter. Fully overhauled.
Specification:
Prime Mover: Electric Motor
Input: 220/380V 50Hz 3ph
Output: 220V 60Hz 3ph
at 50 KVA with PF of 0·8. **PRICE £450·00**

HEWLETT PACKARD DIGITAL RECORDER MODEL 565A

Data Entry, parallel to 11 columns. Print speed 5 lines per second. **PRICE £85·00.**

HEWLETT PACKARD 200 CD Sine wave Oscillator

5Hz-600KHz 10 Volts. **£59·00.**

PYE HIGH RESISTANCE OHMMETER MODEL 10B

Range from 0·3-20,000 Megohms in 4 ranges at 500V. Used for the measurement of components or circuits having high parallel capacitance.
PRICE £20·00

MULLARD VALVE VOLTMETER MODEL E7555/2

PRICE £20·00

COLVERN DIGITAL CODERS (Shaft Digitisers)

Digital Coders are electromechanical devices, which give a unique parallel digital code output representing the angular position of the shaft. The current handling capacity is sufficient to operate relay decodes and indicators direct without intermediate stage of amplication. 3 size magslip, 256 divisions, max. torque for reflected binary code 4·5 oz. ins. **PRICE £10·00**

WIDE RANGE OSCILLATOR TYPE 400C by DAWE

1 c/s-1,000 c/s. **PRICE £35·00**

FANS BY PLANNAIR

115V-3 Phase 400 c/s-11,000 rpm. Type 1PL41-234 **PRICE £4·00**

R.C. OSCILLATOR TYPE G432 by FURZEHILL

Square and sinewave. 250 Kc/s. **PRICE £25·00**

SPECIAL OFFER SPECTRUM ANALYSER HEWLETT PACKARD 8551B

10MHz-12GHz and 851B Extension to 40GHz. With W/G Mixers and very little used Ex Calibration Lab. **£3,950·00.**

VENNER 3334

Digital Frequency Meter 0-1MHz **£45·00.**

VENNER 3336

Digital Counter Six Digit 0-1MHz **£55·00.**
With 15 Meg Counter extension for above **£85·00.**

DYNAMCO 2001

Digital Voltmeter 50μV-2KV 0·05% **£175·00.**

DYNAMCO type 2022S

Long scale D.V.M. and Ratiometer. The 2022 is a high accuracy long scale instrument operating on the potentiometric principle. It features a very high input impedance with exceptionally low current errors, an external scaling facility, seven operating modes and digital output.

Scale		39999
Range		10μV to 2kV
Resolution		1 part in 40,000
Accuracy	Long term	0·0025% of F.S.D.
		0·01% of reading
	Optimum	0·0025% F.S.D.
		0·0025% of reading
Input Impedance		> 25,000 M ohm
C.M.R.		160 dB at DC } Typical
		120 dB at 50Hz } Typical

£275·00

MEGGER CIRCUIT TESTING OHMMETER

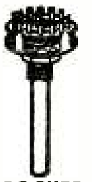
For Measuring conductor resistance. By Evershed and Vignale. **£22·50.**

BELL & HOWELL

5-12 and 18 Channel U.V. Recorder **£395.00.**
5-127 12 Channel **£350·00.**

ELECTRONIC BROKERS LIMITED
49/53 PANCRAS ROAD : LONDON NW1 2QB. Tel: 01-837 7781

ADD 10% VAT TO ALL PRICES



MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way, 1 pole, 12 way. All at **25p** each.

TOGGLE SWITCHES

Metal, all standard types with metal dolly 240v. 3 amp: SP, ST **17p** SP, DT, **22p** DP, ST **22p** DP, DT. **28p** less 10% for ten of same type.

ROCKER SWITCH

13 amp self-fixing into an oblong hole. Size approximately 1in. × ½in., **9p** each, 10 for **82p**.

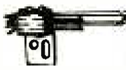
SLIDE SWITCHES

Slide Switch. 2 pole change over panel mounting by two 6 BA screws. Size approx. 1" × ½" rated 250v lamp. **8p** each, 10 for **72p**.

Ditto as above but for printed circuit **7p** each. 10 for **63p**.

Sub Miniature Slide Switch. DPDT 19mm (¾" approx.) between fixing centres. **14p** each or 10 for **£1·26**.

DOUBLE LEAF CONTACT



Very slight pressure closes both contacts. **8p** each. 10 for **72p**. Plastic push-rod suitable for operating. **6p** each, **54p** for 10

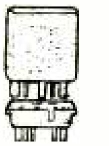
TELEPHONES

Complete as illustrated. Save your legs, time and temper, simply by putting in some telephones. Ex. G.P.O. not new—but guaranteed in good condition and serviceable. Supplied with diagram and instructions showing how to connect. 3 types available as illustrated less internal bell **£1** each. Ditto with bell but less dial **£1·25** each. As illustrated with dial and bell **£1·50** each. Post etc. 50p each.

1 REV. PER MINUTE MOTOR WITH GEAR-BOX

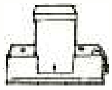
Made by the famous Chamberlain & Hookham Ltd. These could be made to drive clock or similar. Really robust reliable unit Price **99p** each.

MINIATURE SEALED RELAY



American made. Our Ref. No. REL A1. Measures only ¾" wide × ½" thick and ¾" high and it's a double change over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9-12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price **28p** including base.

METAL CHASSIS



14 gauge sheet steel—size approx. 7" × 3½" × 1¾" deep. Cadmium plated punched in the centre to take 3 P.O. 3000 type relays. There is also a removable cover over this section measuring 4½" long × 3½" × 2¼". The chassis also has a few holes and could take a small transformer and/or valve holders also some ⅜" holes for controls, pots etc. This is an ideal chassis for making up a relay unit or similar. These are ex-equipment but in excellent condition and may have a few resistors etc. still attached. Price **40p** each.

12V CAR BLOWERS

Units made by Delco. 6 bladed 5" dia. fan inside heavy duty cylinder. These have really powerful series wound motors giving a terrific air flow suitable for ventilating or heating a car, boat, caravan, etc. Price **£2·20** plus 40p post and insurance. (Note these are intended for 12V D.C. but can be run from A.C. up to 30V. The higher the voltage the more the air flow.)

DRILL CONTROLLER

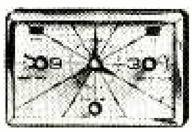
New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·65**, plus 13p post and insurance. Made up model also available **£2·48** plus 13p p. & p.

BAKELITE INSTRUMENT CASE

Size approx. 6¾"×3¾"×2" deep with brass inserts in four corners and bakelite panel. This is a very strong case suitable to house instruments and special rigs, etc. Price **50p** each. Paxlids **11p** extra.

15A ELECTRICAL PROGRAMMER

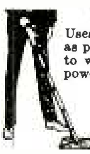


Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price **£2·15** + 20p p. & p. or with glass front chrome bezel **83p** extra.

WATERPROOF HEATING ELEMENT

13 yards length 35W. Self-regulating temperature control. **55p** post free.

HIGH ACCURACY THERMOSTAT

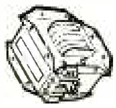


Uses differential comparator I.C. with thermistor as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack **£6·15**.

TREASURE TRACER

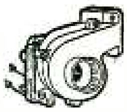
Complete Kit (except wooden battens) to make the metal detector as the circuit in Practical Wireless August issue. **£3·85** plus 20p post and insurance.

AUTO TRANSFORMER



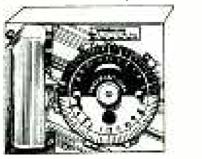
Primary 220-240v. Secondary 110-120v. Well built and varnish impregnated. 250 watt intermittant rating. Size approx. 3½ × 3 × 3in. **£1·10** plus 20p post and insurance.

CENTRIFUGAL BLOWER



Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at **£2·25**.

ELECTRIC TIME SWITCH



Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·75** post and ins., 23p. Additional time contacts **55p** pair.

MICROSWITCHES Button Operated

Ref. MS AU1. Made by Burgess, 250v. 15 amps, single pole, off/on, that is they are normally off until depressed. Price **17p** each.

Ref. MS AU2. Made by Honeywell, 250v. 10 amp, change over. Price **25p** each.

Ref. MS AU3. Ditto but 5 amp. Price **10p** each. ex-equipment.

Ref. MS S1. Made by Burgess 15 amp on/off that is they are on until button is depressed. Price **17p** each.

Sub Miniature

Ref. MS S4. Made by Burgess, their type no V4 T6. These measure only ¾" × ⅜" × ¼" thick—have change contacts and tag connection. Price **32p** each.

Ref. MS S3 two of V4 T6 mounted in light frame with roller for operating **75p** each.

Lever Operated

Ref. MS AU7. Made by Honeywell. Lever length approx. 2½". 15 amp 250v change over. Price **28p** each.

Ref. MS AU8. Made by Honeywell. This is an extra sensitive switch with a 4" lever. 10 amp 250v change over. Price **33p** each.

Ref. MS S2. Made by reputable French company. 250v 5 amp off/on. Price **12p** each.

Ref. MS S3 Made by Honeywell lever is a looped wire. 250V. 15 amp change-over. **35p** each.

Ultra Sensitive

Ref. MSD1. 5amp change over at 230v. This has a wire lever attached and is so sensitive it will trigger with its own weight. Price **44p** each.

Panel Mounted

All made by Honeywell. These are 250v 10 amp change over microswitches fitted into a bracket with spring plunger and are operated by pushing a dished black knob. Mounting is through ⅝" hole and two locking nuts.

Ref MS AU4. Single change over switch. Price **33p** each.

Ref. MS AU5. Two bank, that is 2 change over 10 amp microswitches, both operated by the single plunger. Price **44p** each.

Ref. MS AU6. Three bank, that is 3 change over microswitches all operated by one plunger. Price **55p** each.

All subject to quantity discounts:—10-49 = 10%, 50-99 = 15% 100-up = 20%.

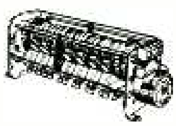
THYRISTOR LIGHT DIMMER

For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£2·95**. Industrial model 5A **£3.30**

10 AMP DIMMER CONTROL

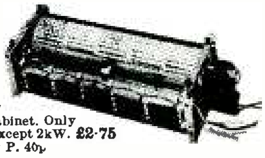
For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price **£8·25**.

HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated and signs, Signalling, etc. Price from makers probably over £10 each. Special snip price **£6·33** plus 25p post and insurance. Don't miss this terrific bargain.

TANGENTIAL HEATER UNIT



This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. **£3·85**. 2kW. Model as above except 2kW. **£2·75** Don't miss this. Control Switch **44p**. plus VAT P. & P. 40p

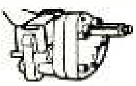
30KV EHT UNIT

This unit is self contained and on wheels. It stands approx. 6 ft high and 3 ft square. On the front panel is a Variac, Voltmeter, a 60 second Timer as well as the normal overload trip on/off switch and cut outs, etc. The transformer itself is oil filled and rated at 7 KVA 30KV. The variac is in the primary so all voltages up to 35 KV are available. We believe the normal use for such a unit would be as a break down and flash tester. 1 only—not new but in good order. Price **£99**.

HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **£1·65**. Post and ins. 23p.

SPIT MOTOR



200-250v. Induction Motor, driving a carter gear box with 1⅛in. o output drive shaft running at 5 revs. per minute. Intended for roasting chickens, also suitable for driving models, windmills, coloured disc lighting effect, etc., etc. **£2·05** plus 20p post and insurance.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work, **£2·48** plus 25p P. & P.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output **72p**.
Model 1172 750mW power output **94p**.
Model EP9000 4 watt power output **£1·60**.
EP9001 twin channel or stereo pre amp. **£1·99**.
10% discount if 10 or more ordered.

CAR PANEL SWITCH

Our Ref. No. SO1. Arco made. Has long flat ended toggle black and chrome finish. Rated 2A. at 250v. and is double pole on/off. Listed at 45p. Our price **22p** each.

CAR PANEL AUTO SWITCH

Ref. No. SO3. Again a flat ended toggle. Made by Arrow. A 3 position double pole change over switch centre off for auto aerials. reversing motors etc. **30p** each.

6V D.C. POWER MOTOR MADE BY REDMUND

For driving a bilge pump and similar applications. This motor we understand develops on ⅛ H.P. It is extremely powerful and although rated at 6v, this operates up to 12v. for short periods with very much increased power, (probably at least ¼ H.P.) We understand that from the makers they cost over £5. At **£2·20** each plus 25p post on one and then 15p each.

8 AMP VARIACS

These are variable voltage transformers. British made by the famous Zenith Co. Fully enclosed for bench use and fitted with calibrated scale and control knob. Zenith model No 100 LM. 220-240v. A.C., output 0-240v. up to 8 amps, This model is listed at over £20. We have a limited quantity only, absolutely brand new, still in maker's cartons, offered to you at **£13·75** each plus £1 carriage and insurance up to 400 miles.

MOTOR GENERATOR

Made for Admiralty. 24 volt D.C. input, 240v. 50 cps. output. Admiralty rating 80 watts but we have tested this to 50% overload voltage regulated so suitable to operate TV or instrument. In case with metal cover controls on front include voltmeter. Unused. Probably cost £200 each to make. Our price only **£25** each plus carriage £2 up to 200 miles, £4 up to 400 miles.

MULLARD THYRISTOR TRIGGER MODULE MY 5001

This produces pulses for phase control triggering, it has two isolated outputs, so one thyristor or two thyristors (in separate arms of bridge) may be controlled by one module. The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current sources. Provision is made for feedback where automatic control is required. Price **£4·95** each or for 10 **£45·00**.

9V GRAMOPHONE UNIT

Battery operated on unit plate 2 Speed auto-stop, Price **£2·50** plus 40p post and insurance.

BUY TIME SLOT METER

Made by Sangamo Weston. 3 types, one for each coin 2½p, 5p or 10p. Price **£1·75** each plus 25p post and ins.

4 STATION TRANSISTORISED INTERCOM

Solid State three transistor printed cct. mater and tree sub station push button/ press talk system. 200mW output, complete with installation accessories and 9v. Ever-ready power pack approx. 3 × 1¾ × 4in. Price **£8·50** plus 20p.

PHOTO ELECTRIC KIT

Contains photo cell, relay, transistor and all parts to make light operated switch. **£1·75** plus 20p post and ins.

AC/DC MILLIAMMETERS 3 RANGE

Moving iron mirror scale laboratory instalate. Ranges 52 and 50 and 100mA by selection switch (coil resistance marked) size 7½ × 5 × 3½in. type 35999/1. Price **£6·60**.

GALVOMETER 7—0—7 UA F.S.D.

Moving coil precision laboratory instrument of extremely high sensitivity (3 × 10·7 A per division), size approx. 6½ × 2½ × 2 in. Price **£7·50**.

ACOS. 'G' METERS

For use with transducers and accelerometers. These are precision instruments they measure "g" in three steps 0-10, 0-100 and 0-1000 directly on a large clear meter scale 0-1. Two models available:—Standard model (IDOOL price **£12** and Auto cutout model (IDOOL) which has an inbuilt circuit with relay to trip the external circuit (trip level is adjustable by a control which is virtually linear with the meter scale). The trip load may be up to 2a. Once the circuit has been tripped it can be restored by a reset button. Price of this model is **£18**

VOLTAGE CHANGING TRANSFORMERS MADE BY PARMEKO

Upright mounting, fully shrouded and with terminal blocks for input and output. For changing mains voltage, ideal for working low voltage equipment from 230/240 mains and for increasing voltage due to losses in long leads. Voltage up or down between 190-250v. 250 watts. Price **£1·65** plus 30p post etc.

DOOR OPENING OR PLATFORM ROTATING MOTORS

Very powerful motors estimated rating at ⅛ H.P. Reversible with gearbox and "V" belt drive wheel of 7" diameter. These are by a French maker using trade name LUXOR and name plated Moteur Asynchrome. Capacitor start but with 6 connections. At the time of writing this we haven't a connection diagram and if any reader has met this motor before and can tell us how to connect and anything about it we would be obliged. Price of motor which weighs approx. 15 lbs. is **£10**.

Note. These are ex-equipment but guaranteed for six months.

SPRING RETURN WAFER SWITCH

As used in intercom and other similar equipment a two wafer 6 pole 3 way switch, spring return from centre position when turned clockwise and permanent off or on when turned anti-clockwise. Price **55p** each.

A.C. BUZZERS

12v. Fix these into a box which will resonate and they will give a loud piercing note. Suitable for alarms or signal. **33p** each.

PUSH ON TAG CONNECTORS

These are being increasingly used on cars and domestic appliances. 2 sizes prevail, the most popular being for ¼" tag. We offer these at attractive prices. 10 for **10p** . . . 50 for **40p** . . . 100 for **70p** and 1,000 for **£5**.

WALL THERMOSTATS

This Month's Snip. Made by the famous Smiths Instrument Co. called Colourstat. Wall mounting and in a handsome plastic case. (Cream and beige) Adjustable by slider (lockable) and may be set to control temperatures from around freezing through to 50°C. The slide panel is engraved and indicates (frost) (warm) (very warm) etc. The thermostat. will control heaters etc. up to 15 amp at normal mains voltage and is ideal for living room, bedroom and greenhouse etc. Price **£1·65**. Don't miss this.

Where postage is not stated then orders over £5 are post free. Below £5 add 30p. S.A.E. with enquiries please.

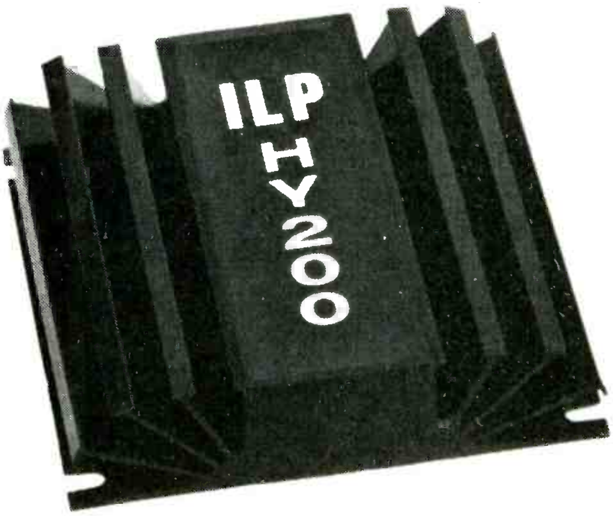
J. BULL (ELECTRICAL) LTD.

(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD

Callers to 102/3, Tamworth Road, Croydon

I.L.P. (Electronics) Ltd

100 WATTS!



★ NO EXTERNAL COMPONENTS
★ MECHANICALLY & ELECTRICALLY ROBUST
★ INTEGRAL HEATSINK
★ HERMETICALLY SEALED UNIT
★ ATTRACTIVE APPEARANCE
★ LOW COST
★ BRITISH BUILT
★ 100 x 105 x 25mm

With the development of the HY200, ILP bring you the first COMPLETE Hybrid Power Amplifier.
COMPLETE: because the HY200 uses no external components!
COMPLETE: because the HY200 is its own heatsink!

By the use of integrated circuit technique, using 27 transistors, the HY200 achieves total component integration. The use of specially developed high thermally conductive alloy and encapsulant is responsible for its compact size and robust nature.

The module is protected by the generous design of the output circuit, incorporating 25amp transistors. A fuse in the speaker line completes protection.

Only 5 connections are provided, input, output, power lines and earth.

Output Power: 100 watts RMS; 200 watts peak music power into 8Ω
Input Impedance: 10KΩ
Input Sensitivity: ODb (0.775volt RMS)
Load Impedance: 4-16Ω
Total Harmonic Distortion: less than 0.1% at 100 watts typically 0.05%
Signal: Noise: Better than 75Db relative to 100 watts
Frequency response: 10Hz-50KHz ±1Db
Supply Voltage: ±45volts
APPLICATIONS: P.A., Disco, Groups, Hi-Fi, Industrial.

PRICE: £14.90 inc. VAT & P & P
Trade applications welcomed

CROSSLAND HOUSE · NACKINGTON · CANTERBURY · KENT
CANTERBURY 63218

I.L.P. (Electronics) Ltd

SECOND GENERATION 25 WATT HYBRID

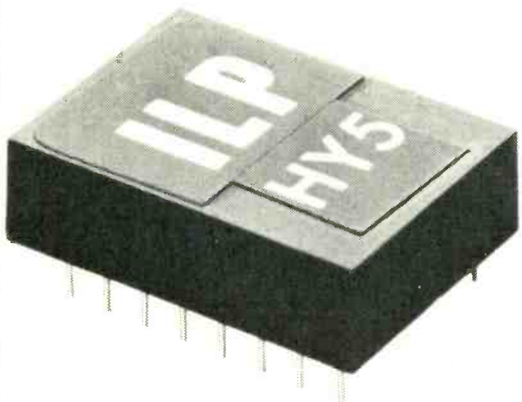
A brand new hybrid fabrication technique, recently perfected in our laboratories, has enabled us to achieve our latest range of completely integrated devices.
We have now finally reduced the modular amplifier to a simple input/output device requiring only the addition of a basic unstabilized (split line) power supply.
The HY50 takes medium power modules to their logical conclusion by incorporating with it a heatsink, which is designed in special high conductivity alloy, sufficient for normal audio use without additional chassis sinking. All this without significantly increasing the size of the module comparable in size to a packet of 'King-size' cigarettes.
Consistent with modern thinking a triple rated output circuit with a load fuse allows for peak transient response without distortion but ensures the necessary protection.

SPEC.

OUTPUT POWER:	25watts RMS, 50watts peak music power.
LOAD IMPEDANCE:	4-16Ω into 8Ω.
INPUT SENSITIVITY:	Odb (0.775volts RMS).
INPUT IMPEDANCE:	47KΩ.
TOTAL HARMONIC DISTORTION:	Less than 0.1% at 25watts typically 0.05
SIGNAL/NOISE RATIO:	better than 75db.
FREQUENCY RESPONSE:	10Hz-50 KH2 ± 1db
SUPPLY VOLTAGE:	± 25volts.
SIZE:	105x50x25mm.

Price £5.40 mono £10.80 stereo.
Price inclusive of VAT & P & P.

NEW HY5 PRE-AMPLIFIER



Unchallenged for two years, the HY5, our unique multifunction preamplifier/tone hybrid, has been brought into line with the advancements in our power hybrids.
Like the HY50, the new HY5 has no external components & has been redesigned to run off a split power line with improvements in signal/noise, overload capability & reduced distortion. The output has been increased to match the power module (Odb), and to share the same power supply.
Overall size is reduced by the use of a new thin film circuitry while the device still retains all the functions of the earlier device.
When combined with the HY50 & power supply only potentiometers are required to complete a simple mono amplifier with input & output facilities expected to be found on Hi-Fi amplifiers.
The combination of two HY5's two HY50's sharing a common power supply (PSU50) are linked by a balance control to form a complete stereo system.

SPEC.

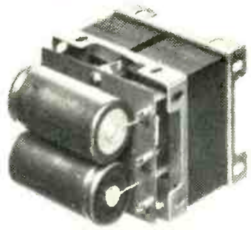
INPUTS
Magnetic Pick-up 3mV (within 1db RIAA curve)
Ceramic Pick-up up to 3mV.
Microphone 10mV.
Tuner 250mV.
Auxiliary 3-100mV.
Input impedance 47kΩ 1kHz

OUTPUTS
Tape 100mV.
Main output. Odb (0.775volts).

ACTIVE TONE CONTROLS
Treble ± 12db at 10kHz
Bass ± 12db at 100Hz
OVERLOAD CAPABILITY (equalization stage) 40db on most sensitive input.
OUTPUT NOISE LEVEL (below 10mV magnetic input) 68db.
DISTORTION 0.05% at 1kHz.
SUPPLY VOLTAGE ± 16-25volts.
SUPPLY CURRENT 15mA.

Price £4.51 mono £9.02 stereo
Price inclusive of VAT & P & P.

POWER SUPPLY PSU50



The new PSU50 has a low profile look being only 2¼ inches high and can be used for either mono or stereo systems.

SPEC.
OUTPUT VOLTAGE ± 25volts.
INPUT VOLTAGE 210-240volts.
SIZE L.70 D.90 H.60mm.
Price £5.23.
Price inclusive of VAT & P & P.

CROSSLAND HOUSE · NACKINGTON · CANTERBURY · KENT

CANTERBURY 63218

WW—111 FOR FURTHER DETAILS

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT : £9.90 per single col. inch.
LINE advertisements (run-on) : 55p per line (approx. 7 words), minimum two lines.
BOX NUMBERS : 25p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE : Allan Petters on 01-261 8508 or 01-928 4597.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisement accepted up to 12 noon Thursday, October 4th for the November issue subject to space being available.

COMMERCIAL RADIO

TECHNICAL MANAGER / CHIEF ENGINEER

SWANSEA SOUND LIMITED

If you believe you have suitable qualifications and/or the right practical experience, and you want to face the unusual challenge of heading up the engineering facility of the new commercial radio station in Swansea, we would like to hear from you.

Swansea Sound's new chief engineer will equip the station within the budgets and standards laid down, recruit and train the technical staff and bring the station to a fully operational state for an air-date in early summer 1974.

He will have full responsibility for his department.

The successful candidate could be a young man with a creative flair for audio electronics, or he could possess a broader experience of radio engineering but with a fresh and flexible approach to the job demanded by the particular workings of commercial radio.

In either case he will be expected to make his own contribution to the success of the station motivating and leading a compact team of technicians.

Salary will match the qualifications and abilities of the successful man.

Write in confidence to:

Keith Lunniss, Director
Radio Advertising Bureau Ltd.,
35 Curzon Street
London W1Y 7AE

[3068

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Has an immediate opening for

An experienced Design and Development Engineer for Audio Equipment, including Highly Professional Mixing Desks, Compressors, Limiters, Audio Monitoring Amplifiers, etc. Systems Experience is desirable.

Salary open.

Send resumé to:

NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2540

C.C.T.V. STUDIO TECHNICIAN

Hambro Life Assurance Limited are installing a high quality, three-camera colour television studio at their offices in Old Park Lane, W.1.

Facilities will include video recording, editing and telecine. Additionally, two black and white camera and U-matic recording chains have been acquired.

We now wish to add to the small, professional team working on this project an enthusiastic, hard working individual who will be responsible for the technical quality of the studio output, keeping equipment lined up and trouble shooting where necessary. Other aspects of the job are wide and varied, including establishment of studio sets, assisting during recordings (e.g. sound or vision mixing), liaison with suppliers, etc.

Enthusiasm and experience will be regarded as more important than technical qualifications for this position. We believe that a related engineering background with an inclination to turn a hand to all parts of the production of a video-recording are the most appropriate characteristics. Filming experience, either as an amateur or professional, would be an added advantage. Salary will be negotiable around £2,500. Working conditions are excellent and there are non-contributory pension, life assurance and B.U.P.A. schemes.

Telephone Harry Catton, 01-499 0031, for any further information and an appointment for interview.

[3098

RADIO OFFICERS would you come ashore for £2,300 a year?

As a Radio Operator with the Post Office Maritime Service you can continue your career ashore in an interesting and expanding service. And earn over £2,000 a year, including compulsory pension contributions, at 25 years of age working only a 41-hour week of shift duties —with overtime this could rise to £2,300 and possibly more.

Post Office Radio Operators benefit from a shorter pay scale than sea-going officers. You have good opportunities for promotion to positions earning basic salaries of up to £3,290, and prospects of further advancement into Post Office Senior Management.

To apply you need to be 21 or over and to hold a 1st class or General Certificate issued by the MPT or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

If you would like to know more, please write to the Inspector of Wireless Telegraphy, Post Office, IMTR/WTS1.1.3, Union House, St. Martin's-le-Grand, London EC1A 1AR. L52

Post Office Telecommunications

91

Foreign and Commonwealth Office

Telecommunications Technicians

. . .at Hanslope Park, Milton Keynes, for work on various receivers and associated test equipment, recorders, telephone and teleprinter equipment, electronic ancillary equipment (some using analogue and digital techniques), voice frequency telegraph and other specialised equipment.

Candidates, normally aged at least 23, must have ONC or equivalent in electrical/electronic subjects *and* have served an apprenticeship or had equivalent training.

Starting salary £1,628 (at 21) — £1,810 (at 23) — £2,210 (at 28 or over on entry); scale maximum £2,418. Prospects of promotion up to £3,515. Non-contributory pension scheme.

For full details and an application form (to be returned by 12 October 1973), write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone BASINGSTOKE 29222 ext. 500 or LONDON 01-839 1992 (24 hour answering service). Please quote T/8370

3055

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cadac

The company specialise in the design and production of sound control equipment for the recording industries.

With the continued expansion of the company, vacancies arise for the following:

SENIOR TEST ENGINEER
TEST ENGINEERS

Applicants should have a theoretical knowledge of electronics and/or experience in studio engineering techniques and practices.

It would be preferable that the Senior Test Engineer has had studio experience.

Salaries by negotiation and to be commensurate with that of the position.

Apply to:

Cadac (London) Ltd.,
Lea Industrial Estate,
Batford,
HARPENDEN
Herts.

Tel: **Harpenden (STD 05827) 64698**

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The best young Engineers have computers in mind.

Are you aged 21 to 25?

Do you want a flying start to a career in computers? Here is your chance. Train as a Field Engineer with ICL, Europe's leading computer manufacturer.

Training
You will be given thorough training on ICL electronic equipment leading to computers.

Qualifications
You should be aged between 21 and 25 and be on your final year or have attained City & Guilds electronic certificates or an HNC in electronics. You should have completed an electrical engineering apprenticeship or have at least two years' industrial experience on electronics.

Job satisfaction
As an ICL Field Engineer you have a high degree of responsibility for a customer's installation. You need technical expertise, tact and personality. So you are important as a representative of ICL.

There are opportunities of starting with us in several areas in the UK. Get the full details now by completing and returning this coupon today.

To: Mr A E Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15 2TQ.

Please send me an application form for job openings in Field Engineering.

Name ....

Address ....

International Computers ICL

(WW8)

2589

Electronics Test Engineers

Pye Telecommunications of Cambridge and Haverhill have immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery: applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable. Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs A E Darkin at
Cambridge Works, Elizabeth Way, Cambridge CB4 1DW.
Telephone: Cambridge 51351.
or Mrs C Dawe at
Colne Valley Road, Haverhill, Suffolk.
Telephone: Haverhill 4422.

Pye Telecommunications Ltd

A member of the Pye of Cambridge Group

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THE OPEN UNIVERSITY

SOUND RECORDING ENGINEER

A vacancy exists in The Open University for a sound recording engineer; five years minimum experience in the recording and editing of master tapes for radio, film, cassettes and discs. The successful candidate will be based in the sound studio (APRS member). The Open University is located in the new town of Milton Keynes and a housing scheme in conjunction with the Milton Keynes Development Corporation is operated.

Salary up to £2,241 per annum.

Applications should be made in writing stating full details of age, experience and qualifications and names and addresses of three referees to The Acting Personnel Manager, **The Open University (RE2), P.O. Box 75, Walton Hall, Milton Keynes, MK7 6AL,** as soon as possible.

[3023

BERRY'S RADIO

has vacancies for

(a) SENIOR SALESMEN
(b) SENIOR ENGINEERS

TOP RATES OF PAY
5-DAY WEEK ● PERMANENCY
Apply: Mr. K. (405-6231)
319 High Holborn, London WC1

[97

Brighton Education Committee
Brighton Technical College

Senior C.C.T.V. Technician

Technician required as soon as possible to head a team responsible for the maintenance of closed circuit television equipment and other audio visual aids.

Applicants should possess a City & Guilds finals certificate in radio and television servicing and have had relevant practical experience.

SALARY ON GRADE T4 £1,530—£1,830. (CURRENTLY UNDER REVIEW)

An additional allowance is payable for appropriate qualifications.

Application form and details available from:

Chief Administrative Officer,
Brighton Technical College,
Pelham Street,
Brighton, BN1 4FA.
Telephone: Brighton 685971.

[3057

Electronics Engineers

up to £4,000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.
Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free!

To: The Registrar, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name ....

Age (20-45 only) ....

Address ....

....

WW 17/9

lansdowne Appointments Register

3047

ENGINEER

to service ELECTRONIC ORGANS B & O AUDIO and C.T.V.

The work is interesting and varied, a Company vehicle is provided and there are vacancies in Birmingham and Manchester.

Telephone or write to:
**W. Swan, Jnr. or Mr. D. C. Kay,
SWAN'S,
84-86 Oldham Street, Manchester M4 1LF
Tel: 061-228 3821**

[2959

SERVICE ENGINEER

LKB INSTRUMENTS LTD.

requires an additional engineer to be resident in the South London, S.E. England area for field servicing of their Scientific and Technical instruments installed in Academic, Medical and Industrial Laboratories.

The successful applicant will possess a sound basic knowledge of modern electronics and will preferably have some field experience, although this is not essential.

The Company is internationally renowned for the quality of its products and offers excellent working conditions including company car, pension scheme, superannuation and profit sharing bonus scheme.

Write for application form to:
**The Service Manager,
LKB Instruments Limited,
232 Addington Road,
South Croydon, Surrey, CR2 8YD**

[3079

Telecommunications Technicians

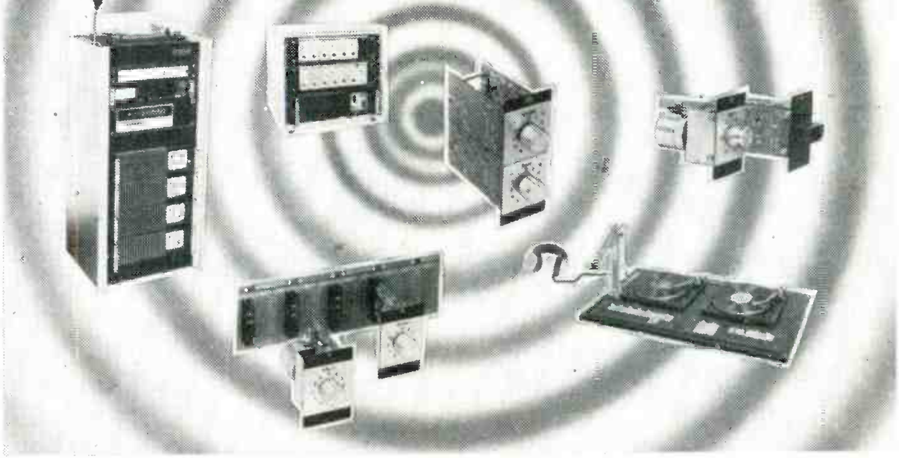
Looking for Variety?

The Ministry of Posts and Telecommunications needs skilled, suitably qualified Technicians to work in London on a broad range of projects. These posts offer challenge, involvement in advanced new development, and the opportunity to develop your experience across a whole spectrum of sophisticated technology.
The Ministry is responsible for the planning of television and sound broadcasting, space communications, maritime and land mobile services; the technical monitoring of radio transmissions and radio regulatory control, together with the design of equipment for detecting, measuring and suppressing radio interference. There are opportunities to participate in the work of national and international conferences and there are good promotion prospects.

You should be at least 23, and must hold ONC Engineering with a pass in Electrical Engineering 'A', or ONC in Applied Physics, or a recognised equivalent such as C&G Telecommunications Technicians (No. 49). In addition you should have at least 5 years' experience of skilled work on radio, radar or electronics.
Salary: Grade II £2,593 rising to £2,902; Grade III £1,985 at 23 – £2,385 at 28 or over on entry; scale maximum £2,593. Level of appointment will depend on age and experience. Non-contributory pension scheme.
For full details and an application form (to be returned by 10 October 1973), write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke 29222 ext 500 or London 01-839 1992 (24 hour answering service). Please quote T/8349.

Grampian

Series 7 Modular Sound Systems



In order to keep pace with the ever increasing demand for large audio installations we require further staff.
Specifically System planners, Supervisors, Wiremen and Test Technicians.
If you consider your ability and experience suits you for one of these positions please phone or write to us.
You will enjoy long term security and involvement in extensive contracts for the manufacture of technically advanced systems for use throughout the world.

**GRAMPIAN REPRODUCERS LIMITED
Hanworth Trading Estate, Feltham, Middlesex.
Telephone: 01–894 9141.**

HM PRISON AND BORSTAL SERVICE

TRAINING INSTRUCTOR £1,853 – £2,514

LEWES, Sussex and possibly elsewhere

Inmates of prisons and borstals are given vocational training so that they may earn their living when they leave. In addition, the training is used directly in industrial work contracted for by Prison Industries. Most of the training is to ITB specification and prepares people for City and Guilds or equivalent examinations. The service now needs the following additional instructor at HM Prison, Lewes, Sussex.

RADIO AND TELEVISION SERVICING

To train inmates in Radio and Television Servicing and to prepare them for City and Guilds examinations.

QUALIFICATIONS Applicants should have served a full apprenticeship or have had equivalent recognised training followed by at least five years industrial experience in the radio and television and/or electronic servicing industry. City and Guilds certificate (or equivalent) is desirable. Teaching or instructing experience are added advantages.

STARTING SALARY (Civilian Instructional Officer, Grade III) £1,853 at age 26; £2,082 at age 28 and above, rising to £2,514. Non-contributory pension scheme and prospects of promotion.

HOURS 40 hour week, excluding meal breaks. 4 weeks 2 days annual holidays plus 8½ days public and privilege leave.

FOR AN APPLICATION FORM Please phoneor write to The Establishment Officer, Home Office, Portland House, Room 10/10 (17A) Stag Place, London, SW1E 5BX (telephone 01-828 9848 Ext. 666). Closing date 28 September 1973.

HOME OFFICE

Senior Quality Assurance Project Engineer

This new appointment in the Feltham Laboratories of our Systems and Weapons Division requires a qualified engineer who is able to supervise a wide range of Quality Assurance activities concerned with Instrumentation and Data Systems.

The duties will consist of liaison with development engineers from the project definition stage to production on Ministry Contracts.

Experience in Data Systems together with a sound knowledge of modern test equipment for functional test purposes, is essential.

Knowledge of Defence Standard 05-21/29 would be an advantage.

Applications should be made quoting reference number QA/11 to: **Mr. J. Morrison, Personnel Officer, EMI Electronics Ltd, Victoria Road, Feltham, Middlesex Tel. No. 01-890 3600 Extension 44**

EMI International leaders in Electronics, Records and Entertainment.

Redland Tiles Development Department at Redhill

VERSATILE ELECTRONICS TECHNICIAN

Required to construct and install a wide range of electronic and electrical control equipment using both contactor and integrated circuit techniques.
A good practical man is required capable of working on his own initiative from circuits and sketches when necessary. Good mechanical aptitude would be an advantage.
The applicant should be qualified to drive and be prepared to travel occasionally at short notice.
May suit EXPERIENCED PROTOTYPE WIREMAN following course of instruction leading to technician status. Write or telephone:

D. F. Matthews
REDLAND TILES LIMITED
Philanthropic Road, Redhill, Surrey
Telephone Redhill 64671 [3046

SOUND ENGINEER SOUTH AFRICA

Major South African Record Company are expanding their studio operations. They require an experienced Sound Recording Engineer to head up a team that will operate a new multitrack complex with the latest equipment. Salary negotiable.
Write giving full details of professional background and experience to box WW 3067.

KEY SELECTION
Require for Clients
ELECTRONIC, DEV. TEST & SALES ENGS. & TECHNICIANS
(All grades—all areas of U.K.)

Why not give your career that much needed boost by contacting Maurice Wayne on 01-487 3411, Key Selection, 126, Wigmore Street, London, W.1. [3029

MARINE ELECTRONICS

Positions available for experienced, or trainee marine electronics engineers and operator technicians. Our work involves Oceanographic Surveys and will require personel to work for periods overseas. This company is based at Yarmouth and for further information please write giving details of education and experience to:

OCEANEERING INTERNATIONAL SERVICES LTD.
Riverside Road, GORLESTON Norfolk

ilea

Education Television Service

Tennyson Street, London SW8

Mobile Section Engineer

£2907 - £3138

responsible for the technical operation and maintenance of one of the mobile control rooms, working with the Education Director and a crew of two. The MCRs are equipped with 3 monochrome Plumbicon cameras, an eight-channel sound desk and 2 inch or 1 inch videotape recorders as necessary. All members of the crew share rigging duties and the driving of vehicles. A current driving licence should be held and training will be given for the taking of an HGV driving test.
Applicants should possess a thorough knowledge of broadcast television engineering practices have appropriate qualifications and experience, and sound health.
Salary according to qualifications and experience.
Hours of work will be in accordance with the requirements of the service but the basic week is 35 hours. Hours are of necessity rather irregular, often involving overtime, but time off in lieu will be granted or, where that does not prove possible, overtime payment will be made. Weekend working is very seldom necessary. The annual leave entitlement, after qualifying service, is 5 weeks and 1 day.

Application forms and details from the Education Officer (Ref EC/Estab 2A/2). The County Hall, London SE1. Tel: 01-633 7546 or 01-633 7456. Closing date for completed application forms October 1.

[3021

MARCONI INSTRUMENTS LIMITED

ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Test Technicians, Senior Test Technicians or Technician Engineers according to experience and qualifications. Our servicing and production programme, geared to our recognised export achievement, provides employment combined with prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company at Luton and St. Albans.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please write or telephone, quoting reference WW178 for application form to:

mi

Mr. M. Leavens, Works Manager
Telephone: Luton 33866, or
Mr P Elsip, Personnel Officer
Marconi Instruments Ltd
Longacres, St. Albans, Herts
Telephone: St. Albans 59292

1971 THE QUEEN'S AWARD TO INDUSTRY

Member of GEC-Marconi Electronics

95

Lancashire County Council Health Department

The Health Education Service has a vacancy for a

TECHNICIAN (TV/PHOTOGRAPHY)

Grade Tech. 4

Salary £1,530-£1,803

Television is becoming an integral part of audio visual aids in the provision of health education. T.V. studio facilities are being developed and the Health Education Service requires a technician whose duties will include the technical operation of T.V. equipment.
The person appointed will, of course, be knowledgeable in the use of normal projection equipment. It will be an advantage for applicants to have some expertise in camera work and photography.
The post is full time, permanent, superannable and subject to medical clearance.
Application forms obtainable from the County Medical Officer of Health, Serial No. 9693, East Cliff County Offices, Preston, to be returned by the 20th September, 1973.

[3097

Maintenance Engineers

Saudi Arabia £4-£6500 (tax free)

Opportunities exist in Saudi Arabia for Engineers experienced in the installation, commissioning and maintenance of complex radar systems, on-line real time computer systems and their associated peripherals, other sophisticated digital hardware, tropospheric scatter systems and telecommunication systems. These posts involve 1-2 years unaccompanied tours for which inclusive salaries between £4000-£6500 will be paid. Free air-conditioned individual accommodation, and local transportation is provided. U.K. leave entitlement is 16 days after each 24 weeks. Candidates, aged 23-50 years, should have extensive relevant practical experience (particularly experience of 3-D Radar), together with a formal qualification or services background. Excellent opportunities exist for career development and those selected will become permanent staff with all the benefits that this implies. Regional interviews will be conducted. Write or telephone for application form to:

lansdowne Recruitment Limited

Chris Jamieson, Lansdowne Recruitment Limited, Design House, The Mall, London W5 5LS. Tel 01-579 6585 (anytime – 24 hour answering service)

TECHNICAL REPRESENTATIVES
TO SELL
TELEQUIPMENT EDUCATIONAL PRODUCTS

In order to satisfy the special needs of EDUCATION, three posts have been created. Successful applicants will be required to call on EDUCATION AUTHORITIES and COLLEGES in (1) England NORTH of the Wash and North Wales
(2) EASTERN counties Wash to Thames
(3) SOUTH England and South Wales

They will need sufficient knowledge of electronics to justify the product training provided by the company. Experience with oscilloscopes or knowledge of physics would be an advantage.

Basic salary £2,000 TOTAL EARNINGS with commission and company profit share will be in the region of £2,600-£2,900. Company car — Pension Scheme.

Contact Keith Retallic — SALES MANAGER

We also need TECHNICIANS at HARPENDEN, MANCHESTER and LIVINGSTONE (SCOTLAND) service centres.
CONTACT MR. R. M. GARRATT

TEKTRONIX UK LTD.
P.O. BOX 69, HARPENDEN, HERTS.
05827 61251

TELEQUIPMENT

BURNDEPT

Customer Engineers
Junior Engineers
Testers

We require a wide range of staff for our expanding Customer Engineering Department. We design and produce Mobile Radio control equipment for a varied range of customer requirements, we need engineers to design, supervise production, test and commission a wide range of mobile radio telephone equipment.

If you are an engineer, an ambitious service engineer or tester who is looking for a career opportunity, and you have experience on one or more of the following:-

1 V.H.F. or U.H.F. radio equipment
2 Systems design
3 Circuit design of A.F., R.F., or D.C. switching circuits
4 Testing or servicing of Mobile Radio telephone equipment
5 If you can work with the minimum of supervision

Contact Mrs. L. Dyne, Personnel Dept.
ERITH 39121 Burndept Electronics (E.R.) Ltd.,
St. Fidelis Road, ERITH, Kent DA8 1AU.

SERVICE ENGINEER EXTRAORDINARY

We are seeking an unusual mixture to offer an exciting challenge, good prospects and pay. The service engineer sought should have both digital and analogue experience, mechanical aptitude and if possible knowledge of nuclear physics. He will cover the North of England, London and the South East, responsible for after-sales service of liquid scintillation equipment. Please reply in confidence to:

MANAGING DIRECTOR
INTERTECHNIQUE LIMITED
COTTRELL HOUSE
53-63 WEMBLEY HILL ROAD,
WEMBLEY HA9 8BE

[3095

WIGGINS TEAPE RESEARCH AND DEVELOPMENT LTD.
Butlers Court, Beaconsfield, Bucks.

SENIOR ELECTRONICS TECHNICIAN

Applications are invited for this post to lead a small team engaged in applying electronics to papermaking research and allied processes at the Central R. and D. Unit of an international papermaking group. Based at Beaconsfield the duties will include design, development, manufacture and maintenance of a wide variety of electronic, electro-mechanical and opto-electronic instrumentation.

Applicants should be of H.N.C. standard and have several years development experience with linear and digital circuits.

The salary is negotiable in the range £2,000 to £3,000. The unit provides excellent working conditions, a pension scheme and luncheon vouchers.

Application forms from Mr. A. W. Massey, Personnel Department. Tel: 0494 5652.

[3091

Computer Engineers

We're going to select a number of able, decisive, productive and logical minds to become expert on our very large computer systems.

We will train you for twelve to eighteen months in basic and advanced hardware and software; after this you will be responsible for ensuring that large computer systems of a particular type are kept in first-class order. This could lead to your being in charge of a team of high-calibre engineers.

Each assignment is unique and may be in Britain, Europe or elsewhere and would appeal to the young qualified engineer who wants a high degree of responsibility, has the personality, tact and resourcefulness required of a representative of ICL and who wishes to travel whilst broadening his knowledge of large computer systems.

Applications are welcomed from experienced Computer Engineers or graduates with highly logical minds and a degree in maths, physics or engineering science.

You will initially, and during training, be based in one of the following locations:

Letchworth/Stevenage
West Gorton, Manchester
Kidsgrove, Staffordshire

Write for an application form, quoting reference WW496C, to A E Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15 2TQ.

International Computers ICL
think computers – think ICL

Storno

RADIO COMMUNICATION SYSTEMS

We have vacancies for:

SERVICE TECHNICIANS

based at Camberley, to work in a specialised Department dealing with miniaturised transmitter/receivers on fault diagnosis and correction. Technical experience of communications systems is an advantage.

FIELD SERVICE ENGINEERS

in the Greater London Area. Applicants should have experience in fault finding and testing of UHF/VHF radio equipment. Current driving licence essential, company vehicle provided.

The Company has much to offer those who are interested in the sophisticated, modern world of radiotelecommunications and who can demonstrate their ability in this field.

Please contact:

The Personnel Officer,
STORNO LTD.,
Frimley Road, Camberley, Surrey.
Telephone: 0276 29131

3081

ELECTRONIC ENGINEERS

required for equipment maintenance and associated engineering projects. Knowledge of professional tape recording equipment, studio operations, or high speed tape duplicating systems is desirable. Salary will be according to age and experience. Please write giving details of age, qualifications, experience and present salary to Chief Engineer, Rediffusion Reditune Ltd., Cray Avenue, Orpington, Kent.

REDIFFUSION

SUPERVISOR
(EVENING SHIFT)

A music cassette/cartridge plant requires a man aged 28 or over to supervise their duplicating department. Applicants must have some practical experience in the audio field, and an understanding of tape recording principles is essential.
We can offer good working conditions and a salary in the region of £1750 p.a. dependant on ability and experience.

Apply to: Mr. R. A. Goodwin,
Trident Tape Services,
4/10, North Road,
Islington, N.7.
Tel: No. 609 0087.

[3058

UNIVERSITY OF KENT
AT CANTERBURY
A

TECHNICIAN (Grade 3)

is required for the Audio Visual Aids Service. He must be experienced in present-day television servicing and, desirably, should also have a keen interest in cine-projection and other visual aids to teaching. The salary scale is £1539 - £1794. Further particulars and application forms may be obtained from R. Robson, Assistant Registrar, The Registry, The University, Canterbury, Kent quoting reference T73/10. The closing date for completed applications is 29th September, 1973.

[3061

Ulster—The New University
INSTITUTE OF
CONTINUING EDUCATION
MAGEE UNIVERSITY COLLEGE
LONDONDERRY

C.C.T.V. TECHNICIAN

Applications are invited for the above post. Duties will include the operation and maintenance of CCTV services and preparation of programme material.

Qualifications: HNC, or equivalent, plus at least seven years previous experience.

Salary scale: £1,881-£2,241 per annum.

Application forms and further particulars should be obtained from The Registrar, The New University of Ulster, Coleraine, Co. Londonderry, Northern Ireland (quoting Ref. No. 73/130/149/31/98) to whom completed applications, including the names and addresses of three referees, should be returned not later than 31st October, 1973.

[3088

UNIVERSITY OF SHEFFIELD

AUDIO VISUAL TECHNICIAN

(Grade 3) responsible for maintenance and operation of audio visual equipment (film, slide and overhead projectors, tape recorders, P.A. systems, photo-copying, etc.).

Familiarity with photographic techniques an advantage. Salary scale £1,539 x £51 (5)—£1,794 p.a.

Write giving details of experience and qualifications, to the Deputy Director of Services (Ref. B.333/BW), The University, Sheffield, S10 2TN.

[3096

KING'S COLLEGE HOSPITAL MEDICAL SCHOOL (University of London) Denmark Hill, London SE5 8RK

ELECTRONICS EXPERIMENTAL OFFICER

A vacancy exists in the Department of Biomedical Engineering for an Experimental Officer to work as part of a multi-disciplinary team on the development and construction of prototype electronic instruments for use in medical research. Salary will be in the range of £1,401 — £2,154 according to age and experience and the appointment will be for two years in the first instance. Candidates should have had adequate experience either in industry or in hospital and will be expected to hold an HNC in electronics or light current electronic engineering as a minimum. Applications to the Director, Department of Biomedical Enginnering.

[3071

ELECTRONIC ENGINEER

Recording Studio of major Record Company require young Audio Electronic Engineer with a fresh approach to the problems of modern recording electronics.

POLYDOR RECORDS STUDIO LONDON 01-499 8686 ext 51

[3077

IPSWICH AND DISTRICT HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS TECHNICIAN

Applications are invited for the above post. Candidates should possess H.N.C. or equivalent qualifications, but consideration will be given to suitably qualified and experienced candidates in this field.

SALARY SCALE: £1,602 to £2,076 p.a. According to qualifications and experience.

Please note: that although the salary scale for this post rises from £1,602 to £2,076, new entrants to the Health Service are normally required to start on the lowest point of the scale. The successful candidate will be a member of a new and expanding department, servicing a wide range of electronic/bio-medical equipment.

For further details of this post, please telephone Ipswich 56481, Ext. 33 or write to:- The Group Engineer, Ipswich and District Hospital Management Committee, 26 Broughton Road, IPSWICH, IP1 3QS.

[3038

Draughtsmen!

EMI, one of the world's leading Companies in the fields of military and commercial Electronics, are forming teams to undertake several new and important projects in their divisions at Hayes, Middlesex – challenging work on the design of highly advanced electronic equipment. This opens up first class opportunities for

Senior Intermediate and Junior Draughtsmen.

with a mechanical, electrical or electronics background.

To work in the following fields:

* Radar and associated projects
* Television and Aerial Systems
* Microelectronics – thick and thin film work
* Microwaves tubes and components

Starting salaries up to £2600 p.a. If you are looking for a good career in the forefront of Electronics technology, please write giving career details, or phone for an application form: **Richard Black, Personnel Department, EMI Electronics Ltd., 135 Blyth Road, Hayes, Middlesex. Tel: 01-573 3888 Ext. 2887.**

EMI

International leaders in Electronics, Records and Entertainment.

METROPOLITAN WATER BOARD

Assistant Communications Officer

(£2,733–£3,105)

Applications are invited for the above-mentioned post which will be based at the Board's Head Offices.

Duties are to assist in project investigation, planning and development of mobile radio, telecommunications (telephone and telegraph) and data transmission networks.

The successful candidate should possess a suitable qualification, e.g. Degree, H.N.C., etc., and be experienced in Post Office procedures and have had practical experience at supervisory level in one of the following fields for at least five years.

(1) V.H.F./U.H.F. mobile radio communications.

(2) Telecommunications—privately switched networks, large P.A.B.X. installations (cross-bar type), transit switching techniques, Post Office telephone equipment, and data transmission.

An application form returnable by 5th October, 1973, may be obtained from the Establishment Officer, Metropolitan Water Board, New River Head, Rosebery Avenue, EC1R 4TP, or telephone 01-837 3300 Ext. 19.

[3090

HARTLEPOOL HOSPITAL
MANAGEMENT COMMITTEE

Electronics Technician

Applications are invited for this new post to undertake the maintenance of electronic equipment in hospitals in and around Hartlepool.

The appointment is to the Staff of the Group Engineer, to whom the successful applicant will be accountable for the repair and planned preventive maintenance of a wide range of electronic equipment, including electro-medical and laboratory apparatus, H.F. pocket-paging receivers and transmitters, engineering controls, and audio/radio frequency distribution systems.

Applicants should preferably hold H.N.C. (Electronics or light current Electrical engineering) or City and Guilds Full Telecommunications Certificate.

National Health Service Conditions.

Starting Salary within the scale of £1,602-£2,076 p.a., depending on age, experience and qualifications.

Application forms are available from:—

GROUP PERSONNEL OFFICER,
HARTLEPOOL HOSPITAL MANAGEMENT COMMITTEE,
CENTRAL ADMINISTRATION,
GENERAL HOSPITAL,
HARTLEPOOL.

[3019

AUDIO SERVICE ENGINEERS

Lindair, London's leading Hi-Fi Retailers, require 2 Audio Service Engineers for their Service Dept. in the West End.

The Service Department deals with leading top-quality brands of Hi-Fi equipment, such as Amps., Receivers, Tape-Recorders, and Loudspeakers.

Applicants must be fully competent to work under the minimum of supervision. Ideally they should have appropriate City and Guild and/or "O" levels in Maths and Physics, but qualifications are not as important as the ability to complete a job once started.

Minimum age 22.

High Salaries will be paid, other attractive conditions of service include 3 weeks' paid holidays.

To arrange an interview write or phone:—

**Mr. George Welsh, Lindair, Kirkham House, 54a Tottenham Court Road. London. W1
Telephone: 01-637 1601**

LINDAIR

THE HOSPITAL FOR SICK CHILDREN
GREAT ORMOND STREET, LONDON, WC1N 3JH

ELECTRONICS TECHNICIAN

required by the Medical Electronics Workshop to set and maintain high standards of serviceability and safety of a wide range of electronic apparatus used in the workshop and the Hospital.

Applicants must have sufficient constructional ability to enable them to assist with the modification and improvement of both existing and new apparatus. Experience of medical equipment would be an advantage but is not essential.

Salary on a fixed scale of £1,728 to £2,202.

Qualifications should be a minimum of O.N.C. or equivalent.

Day release for further study is available.

Application forms may be obtained from the Deputy Hospital Secretary.

[3031

RADIO OFFICERS

**DO YOU HAVE PMG I PMG II MPT
2 YEARS OPERATING EXPERIENCE**

POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH COMPOSITE SIGNALS ORGANISATION.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £2,527 pa; commencing salary according to age — 25 years and over £1,807 pa. During training salary also by age, 25 and over £1,350 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from
Recruitment Officer, Government Communications Headquarters, Room A/1105 Priors Road, Oakley, Cheltenham, Glos GL52 5AJ, Telephone: Cheltenham 21491 Ext 2270

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CLASSIFIEDS—Continued on p. 125

SALES MANAGER

to market commercial sound products including the newly acquired 'Altec' Agency.

Salary negotiable: £3,000 plus.

Apply in writing to:

THEATRE PROJECTS SOUND LIMITED,
10 Long Acre, London, W.C.2

[3112

Electronics Engineer

We are a London-based Studio and we are looking for a young Engineer who is capable and eager to learn. He will be working with Broadcast Colour cameras, VTR and Telecine.

Write or phone: Jon Hocking, Technical Director,

ZOOM TELEVISION LIMITED
15-19 New Fetter Lane,
London E.C.4
Tel. 01-353 3641

[3110

London Borough of Haringey
Education Service

Laboratory Technician

Salary £1,416—£1,635 per annum plus recent pay award. Commencing salary according to qualifications.
Full-time Laboratory Technician required at Stationers' Company's School, Mayfield Road, N.8, to work 36 hours per week × 52 weeks per annum.
Minimum qualifications: Ordinary National Certificate or Ordinary National Diploma; City and Guilds Laboratory Technicians Certificate; 4 G.C.E. passes with 2 at 'A' Level in appropriate subjects; Membership of Institute of Science Technology OR an equivalent suitable qualification OR 5 years suitable experience. Qualifications in Electronics would be an advantage.
Candidates will be responsible for the maintenance of the Language Laboratory and will be required to assist in the upkeep of Audio-Visual aids throughout the School and help monitor a computer link-line.
The post is ideal for a candidate who wishes to gain experience in the maintenance of a fairly wide range of equipment.
Application forms obtainable from Chief Education Officer, Somerset Road, N.17, returnable by 29 October, 1973.

[3111

CLASSIFIEDS—Continued from p. 124

SITUATIONS WANTED

MARINE RADIO OFFICER: (Aged 27), eight years sea service seeks employment ashore within the electronics field in either field service, sales engineering or communications. PMG Certificate (2), DTI Radar Certificate. Willing to learn new fields and travel either at home or abroad. Permanent position, preferably in Scotland. Box WW 3099.

SURPLUS components and computer boards purchased for cash. 01-692 2009. [3108

ARTICLES FOR SALE

AMPEX FR 1400 Instrumentation Tape Recorder/Reproducer, £375.00. EMI TR 52 two-channel audio Tape Recorder, £120.00. EMI magnetic drum Echo System (ex Abbey Road), £185.00. Hewlett Packard Series 3900 Tape Unit (new), £75.00. Kearfott Gyro T2502, £7.50. ERA solid-state 400Hz Inverter, 100VA, £15.00. Tinsley 50Hz Tuning Fork in polished wood case, £12.00. IBM Standard Electric Typewriter mounted on table, £55.00. IBM Selectric Typewriter on table, £95.00. Solartron CD 1400 d.b. Oscilloscope, £140.00. Solartron LM 903 a.c. Converter/Voltmeter, £12.00. ICT adjustable 6V Supply with twin meters, £16.00. Deltron 12V/20A Supply with twin meters, £12.00. Ekco M 5024 six-digit ttl Counter-Timer, £25.00. Advance TC 2A 1MHz Counter-Timer (Crystal Clock), £39.50. Raymond ffoulkes, Frensham Heights, Rowledge, Farnham, Surrey. Or phone Godstone 3106. [3074

CLASSIFIEDS—Continued on p. 126

Senior Wireless Engineer

(£3237-£4098)

. . . . to be responsible for the technical direction and control of staff engaged in the examination of problems associated with the planning, design, progressing installation and maintenance of a wide variety of telecommunications systems. These include mobile radio systems, message switching, networks to interface with large data processing computer systems, closed circuit television, radar and allied techniques, and control room design for fixed locations.

Candidates should have satisfied the academic and training requirements for corporate membership of an appropriate professional institution. They should have a broad knowledge of modern telecommunications, both radio and line, and have specialised in system planning and/or system research or have had experience in the control and management of a large-scale maintenance organisation.

Starting salary within the quoted scale. Promotion prospects. Non-contributory pension scheme.

For full details and an application form (to be returned by 10 October 1973) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone BASINGSTOKE 29222 ext. 500 or LONDON 01-839 1992 (24 hour answering service), quoting T/8376.

HOME OFFICE Directorate of Telecommunications

3052

Marine Radio Design

IMRC is a leading company involved in the design and supply of radio communications equipment to the merchant shipping industries of the world.

We have the following vacancies in our development team working on new transmitter and receiver design projects.

Senior Electronics Development Engineer

Experience: A minimum of three years in circuit design for radio communications equipment, ideally with some time having been spent on projects in the MF and HF bands. A sound understanding of both linear and logic techniques associated with this field would be advantageous.
Qualifications: Degree or HNC standard — but ability and experience are our major concern.

Senior Design Draughtsman

Experience: At least five years in the layout, detailing and documentation of electro-mechanical designs including the layout and preparation of artwork for printed circuit boards.

Please write or phone with brief details of your experience or qualifications to:

Miss S. J. Lemmon
International Marine Radio Co. Ltd.,
Peall Road, Croydon CR9 3AX
Tel: 01-684 9771

3049

ITT Marine

CERN

European Organization for Nuclear Research

Organisation Européenne pour la Recherche Nucléaire

CERN is a modern research laboratory, situated near Geneva, which offers first-class social and financial conditions of employment, and the opportunity to work in an international atmosphere.

A vacancy exists for a young

Electronics Technician (VHF)

to follow the progress of the construction, by external manufacturers, of the 200 MHz electronics equipment associated with beam position detectors of the 300 GeV proton synchrotron, now under construction. The successful candidate will also design and build circuits for reception tests, will perform these tests, will install the equipment and participate in its commissioning and maintenance.

Applicants should have a technical college diploma and some years of practical experience in the design and construction of HF and VHF circuits. Good knowledge of English or French desirable.

Please write for an application form to the address given below, quoting the reference: 8-051-CO-BM-361, to

Head of Personnel
CERN,
1211 Geneva 23, Switzerland.

[3027

Marine Radio Engineers

The International Marine Radio Company, a leading company in the marine electronics field, have an immediate vacancy for one additional engineer to work from their Tilbury Depot on service and installation of marine radio and associated equipment.

Candidates must be ex-Merchant Navy Radio Officers with a minimum of three years' sea-service and preferably have had previous experience of installation and maintenance of equipment.

Please write, giving sufficient details of qualifications and experience to:

Miss S. J. Lemmon
INTERNATIONAL MARINE RADIO COMPANY LIMITED,
1 Peall Road, Croydon, Surrey, CR9 3AX

[3030

ITT Marine

APPOINTMENTS—Continued on p. 131

BOOKS

ESSENTIAL BOOKS!

HANDBOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES. Includes many thousands of British, USA and Japanese transistors. 78 pages. 40p. p.p. 5 pence. **HANDBOOK** Of Radio TV and Industrial Tube & Valve Equivalents. 40p. p.p. 5p.
PRINCIPLES OF ELECTRICITY & MAGNETISM. Page & Adams. A course in Electricity & Magnetism for student, technician and Electronics Engineer. As recommended to technical colleges, universities and polytechnics. Fully illustrated. 532 pages. Published at £4.50. Special offer of £2.25 per copy. p.p. 30p.
CONSTRUCTORS MANUAL OF ELECTRONIC CIRCUITS FOR THE HOME. Just published. Contains many interesting and useful gadgets for the home. Full circuits, data and instructions. 50p. post free.
HOW TO MAKE WALKIE-TALKIES FOR LICENSED OPERATION. 40p. p.p. 10p.
ELECTRONIC NOVELTIES FOR THE MOTORIST. 50p. post free.
HANDBOOK OF PRACTICAL ELECTRONIC MUSICAL NOVELTIES. 50p. post free.
PRACTICAL TRANSISTOR NOVELTY CIRCUITS. 40p. p.p. 5p.
THE THEORY OF GUIDED ELECTROMAGNETIC WAVES. R. Waldron. The most comprehensive book ever written about Waveguides. Transmission Lines. Cavity Resonators. Micro-Waves etc. Published at £11.50. Special offer of £6.25. p.p. 35p.
THE SCATTERING & DIFFRACTION OF WAVES. A goldmine of information for the experimenter, amateur and scientist. Published by Oxford Univ. Press. £1.60. p.p. 15p.
THE GOVERNMENT SURPLUS WIRELESS EQUIPMENT HANDBOOK. Gives circuits data and illustrations, plus valuable information for British/USA receivers, transmitters, trans/receivers. With modifications to sets and test equipment. Latest impression £3.25 including postage.
DIRECTORY OF GOVERNMENT SURPLUS WIRELESS EQUIPMENT DEALERS. Gives details of surplus wireless equipment stores and dealers including addresses and equipment that they are likely to have available. A valuable book only 40p. p.p. 10p.

NEW BOOKS. Publication date for these three titles is Nov. 15th. Order now to avoid disappointment as the first impression of each is expected to be a sell-out.
MOBILE RADIOTELEPHONE EQUIPMENT HANDBOOK. Gives circuits data, and illustrations plus some valuable [illegible] commercial radio-telephone equipment including PYE and other popular makes. £4 including postage.
HOW TO MAKE 2 & 4 METRE CONVERTERS FOR AMATEUR USE. 50p. p.p. 10p. **ADVANCED BOOK OF CRYSTAL SET DESIGNS.** 35p. p.p. 5p

A COMPREHENSIVE WORKING HANDBOOK OF SATELLITES AND SPACE VEHICLES. A handbook that provides important data both tabular and graphical enabling space scientists, technicians and telecommunication space vehicle design, launching, orbiting etc. Includes a detailed coverage of Communications in Space. An imposing book of 457 pages. Published at £8.20. Available at £6.50. post free.
HI-FI, P.A., GUITAR & DISCOTHEQUE AMPLIFIER DESIGN HANDBOOK. Includes circuits up to 1100 watts output. Tremolo, Vibrato, and Fuzz-Box Etc. 75p. post free.
ANY BOOK IN PRINT OBTAINED FOR YOU. State Author, Title Publisher. SEND S.A.E. FOR FREE LISTS OF RADIO, TECHNICAL, SCIENTIFIC, ELECTRONICS, & GENERAL BOOKS. PLEASE STATE YOUR INTERESTS.

GERALD MYERS (W.W.)
18 SHAFTESBURY STREET,
LEEDS LS12 3BT.
Bookseller & Publisher
NEW SHOWROOM & TRADE COUNTER OPEN AT
8 HARTLEYS YARD,
OFF TOWN STREET,
ARMLEY, LEEDS 12. (near White Horse Inn) CALLERS WELCOME.

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CLASSIFIEDS—Continued from p. 125
ARTICLES FOR SALE—Continued

AARVAK ELECTRONICS. 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

COMPUTER CONSTRUCTORS. I.B.M. 6420 Processor complete, working when removed from site, with documentation £40 (contains 296 P.C. cards). Mullard AW3767 10K x 4 bit Core Store (modern) £40. Electric Typewriter suitable for output printer £20. Fi-Cord miniature tape recorder (Swiss) £30. S-Band amplifier and power supply (Deneo) £20. —BRIGHTON (0273) 554992 after 6 p.m. [3036

CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28

CLASSIFIEDS—Continued on p. 127

BOOKS

PRACTICAL BOOKS

World Radio and TV Handbook 1973	£3·00
Intergrated Circuit Pocketbook, 282 pp.	£2·65
Electronic Engineers Ref. Book, 1532 pp. Illus.	£7·90
Electronics Pocketbook, 314 pp. Illus.	£1·55
Foundations of Wireless and Electronics, 552 pp.	£1·98
110 Intergrated Circ. Proj. for the Home Cons.	£1·35
110 Semiconductor Proj. for the Home Cons. 134 pp.	£1·35
Intergrated Circuit Engineering, 406 pp. Illus.	£11·30
Intergrated Circuit Systems, 236 pp. Illus.	£3·65
Aerials (P3) TV and FM Receiving Aerials, 112 pp. Illus.	95p
Loudspeakers and Loudspeaker Cabinets, 120 pp.	95p
Radio Valves, 134 pp. Illus.	95p
Stereo Handbook, 150 pp. Illus.	£1·10
Transistors in Logical Circuits, 132 pp. Illus.	95p
Practical Oscilloscope Handbook, 118 pp. Illus.	£1·95
Principles of Feedback Design, 246 pp. Illus.	£1·35
Principles of Transistor Circuits, 318 pp. Illus.	£1·65
Ques. & Ans. on Electronics, 112 pp. Illus.	75p
Ques. & Ans. on Transistors, 96 pp. Illus.	75p
Radio & Electronic Laboratory Handbook, 628 pp.	£4·95
Semiconductors: Basic theory & devices, 272 pp. Illus.	£2·65
Simplified Modern Filter Design, 193 pp. Illus.	£2·95
Telecommunications Pocketbook, 152 pp. Illus.	£1·35
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CLASSIFIEDS—Continued from p. 126

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CLASSIFIEDS—Continued from p. 127
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CLASSIFIEDS—Continued on p. 131

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BC182	10	2N3055	47	EZY88C—	
BC184	10	IN914	5	3V3-15V	10

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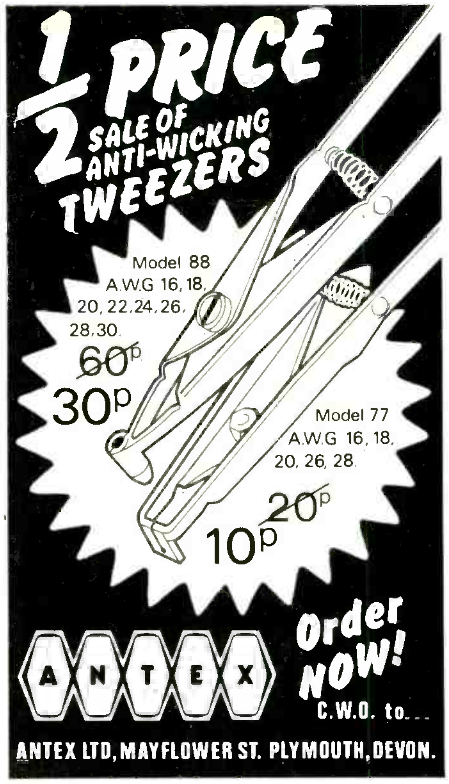

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CLASSIFIED

CLASSIFIEDS—Continued from p. 128

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[3037

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APPOINTMENTS—Continued from p. 126

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2966

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AC128	15p	AF180	40p	BF178	32p	OC70	12p	2N3710	11p
AC131	12p	AF181	40p	BF179	32p	OC71	12p	2N3711	11p
AC132	12p	BC107	12p	BF180	32p	OC72	12p	2N3819	32p
AC176	15p	BC108	12p	BF181	32p	OC81	12p	2N4062	12p
AC187	22p	BC109	12p	BF194	14p	OC82D	12p	2N4286	20p
AC188	22p	BC147	12p	BF195	14p	2N2646	60p	2N4289	20p
AD140	50p	BC148	12p	BF197	15p	2N2904	20p	40360	35p
AD149	45p	BC149	12p	BF200	32p	2N2926	10p	40361	35p
AD161	33p	BC157	14p	BF750	20p	2N3054	58p	40362	40p
AD162	36p	BC158	14p	BF751	20p	2N3055	60p	40408	40p
AF114	20p	BC159	14p	BF752	20p	2N3702	13p	ZTX108	15p
AF115	20p	BC187	22p	BU7105	225p	2N3703	12p	ZTX300	15p
AF116	20p	BD131	75p	OC26	45p	2N3704	13p	ZTX302	20p
AF117	20p	BD132	75p	OC28	50p	2N3705	12p	ZTX500	15p
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7401	18	16	14	13
7402	18	16	14	13
7403	18	16	14	13
7404	20	18	16	14
7405	20	18	16	14
7406	50	45	40	35
7407	56	50	44	38
7408	36	30	27	23
7409	36	30	27	33
7410	18	16	14	13
7411	23	21	20	18
7412	36	30	27	23
7413	34	28	26	22
7416	45	43	39	34
7420	18	16	14	13
7421	36	30	27	23
7426	32	29	23	20
7430	20	18	16	14
7432	40	36	32	28
7440	20	18	16	14
7441	80	75	70	65
7442	80	75	70	65
7443	125	120	115	115
7447	175	165	150	120

7448	185	175	170	165
7450	18	16	14	13
7451	18	16	14	13
7453	18	16	14	13
7454	18	16	14	13
7460	18	16	14	13
7470	30	28	25	24
7472	30	28	27	23
7473	40	38	36	30
7474	40	36	32	28
7475	55	52	50	49
7476	40	36	32	30
7480	100	95	90	85
7481	125	115	110	105
7482	100	96	90	85
7483	100	97	95	92
7484	120	115	110	105
7485	250	245	240	230
7486	45	42	37	33
7490	75	67	60	52
7491A	100	92	85	79
7492	75	70	65	60
7493	75	68	60	52
7494	95	90	85	80
7495	105	100	95	90
7496	100	95	90	85
74100	250	240	235	230

74118	100	82	73	64
74121	43	40	38	36
74141	100	95	90	85
74145	150	140	135	130
74150	330	280	250	220
74151	110	100	95	89
74153	120	110	105	95
74154	200	180	170	160
74155	150	120	100	86
74156	130	120	100	96
74180	155	136	112	105
74190	195	190	185	180
74191	195	190	185	180
74192	200	190	180	164
74193	200	180	170	150
74196	200	190	180	170
74197	200	195	180	170

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709	14 pin DIL	40p
741	8 pin DIL	40p
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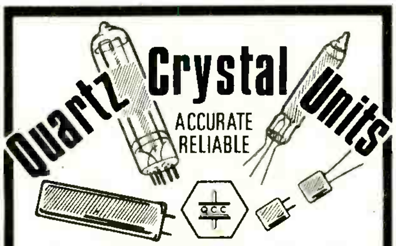

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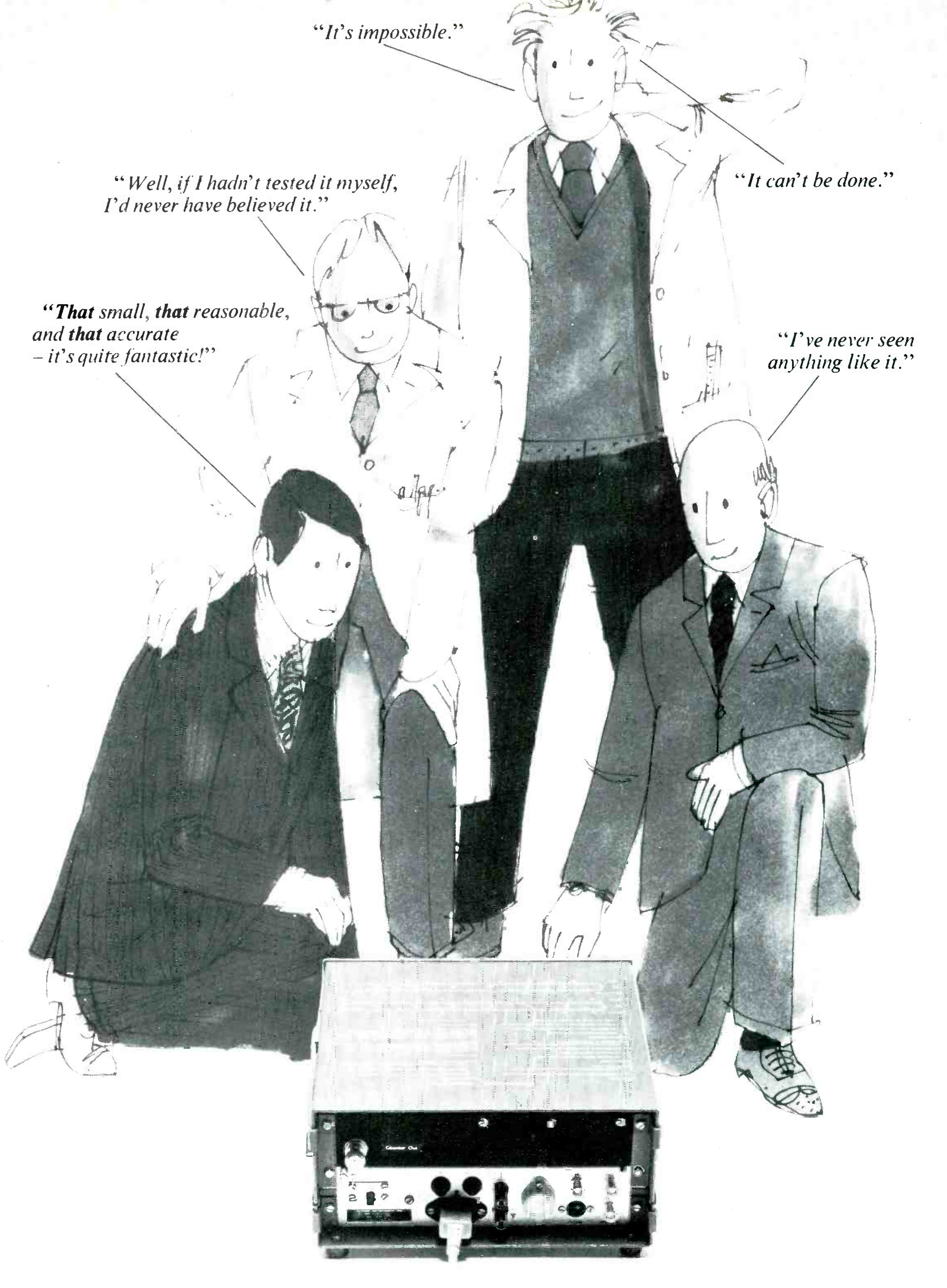
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