

wireless world

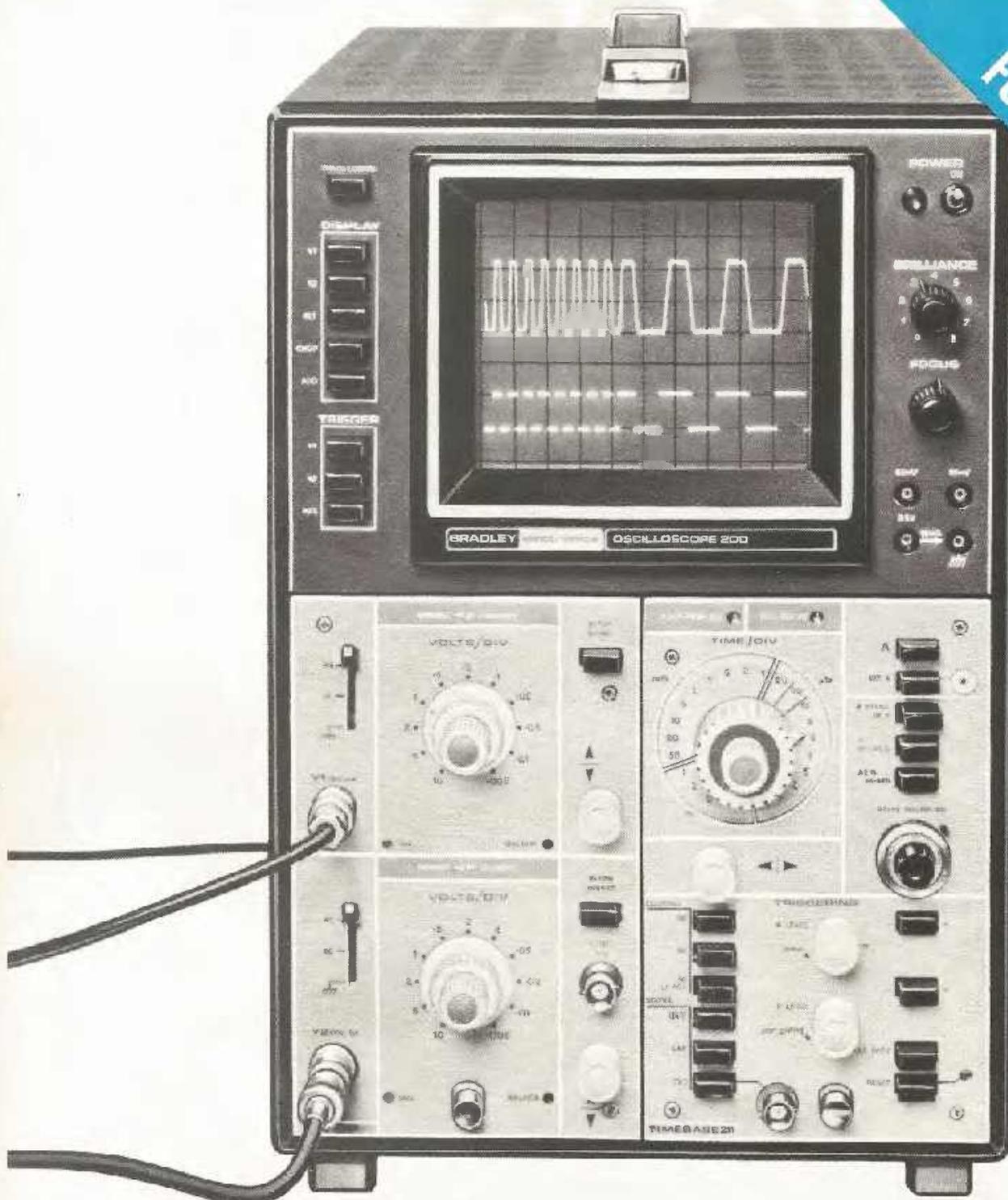
December 1973 20p

**I.C. crossover networks
Using opto-couplers**



Australia 70 cents
Belgium Fr. 41.00
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**100 MHz
OSCILLOSCOPE
FOR JUST £595***



You would have to look very hard indeed to find a double beam 100MHz scope with the price and performance of the new Bradley 200. It's a full-size, total capability instrument with the sort of accuracy, sensitivity and versatility that would cost you another £200 or £300 from most other manufacturers.

To begin with, its dual channel plug-in has a full 100MHz bandwidth on every range from 5mV/cm to 10V/cm. Vertical input modes

include Y1, Y2, Alternate, Chop and Sum. Comprehensive trigger facilities include true mixed trigger function on alternate signals.

Its dual delaying timebase plug-in provides timebase A, A intensified by B, with the latter gated or non-gated, B delayed by A, and A and B mixed. There's a comprehensive selection of trigger couplings, too – internal; external and line; AC, DC and LF reject – all of which are available in normal, single

shot or auto modes. Each timebase has a range of 50 ns/cm to 1S/cm in 24 calibrated 1, 2, 5 steps which are set by dual concentric interlocked controls.

Because Bradley engineers started from scratch when they designed the 200, all the latest design techniques and advanced circuitry could be incorporated for the surprisingly low price of £595*.

To find out more about the new-generation, value-for-money Bradley 200, just telephone Ashley Stokes on

01-450 7811, extension 113. Or write to him at this address:

G. & E. Bradley Limited,
Electral House,
Neasden Lane,
London NW10 1RR
Telex: 25583
A Lucas Company

**UK Price quoted does not include VAT*

BRADLEY
electronics

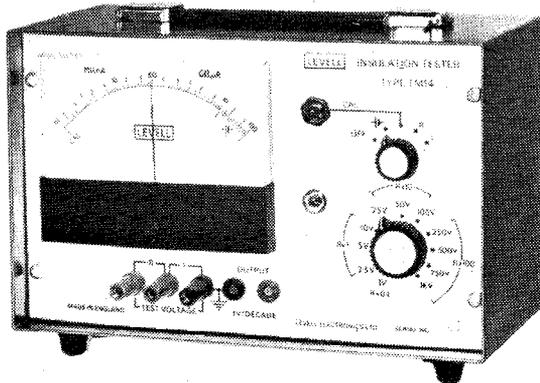
LOW COST TESTERS



LEVELL

PORTABLE INSTRUMENTS

INSULATION TESTER



A logarithmic scale covering 6 decades is used to display either insulation resistance or leakage current at a fixed stabilised test voltage. The current available is limited to a maximum value of 3mA for safety and capacitors are automatically discharged when the instrument is switched off or to the CAL condition. The instrument operates from a 9V internal battery.

RESISTANCE RANGES

10M Ω to 10T Ω (10^{13} Ω) at 250V, 500V, 750V and 1kV.

1M Ω to 1T Ω at 25V, 50V and 100V.

100k Ω to 100G Ω at 2.5V, 5V and 10V.

10k Ω to 10G Ω at 1V.

Accuracy $\pm 15\%$ +800 Ω on 6 decade logarithmic scale.

Accuracy of test voltages $\pm 3\%$ ± 50 mV at scale centre.

Fall of test voltages $< 2\%$ at 10 μ A and $< 20\%$ at 100 μ A.

Short circuit current between 500 μ A and 3mA.

CURRENT RANGE

100pA to 100 μ A on 6 decade logarithmic scale.

Accuracy of current measurement $\pm 15\%$ of indicated value.

Input voltage drop is approximately 20mV at 100pA, 200mV at 100nA and 400mV at 100 μ A.

Maximum safe continuous overload is 50mA.

MEASUREMENT TIME

< 3 s for resistance on all ranges relative to CAL position.

< 10 s for resistance of 10G Ω across 1 μ F on 50V to 500V.

Discharge time to 1% is 0.1s per μ F on CAL position.

RECORDER OUTPUT

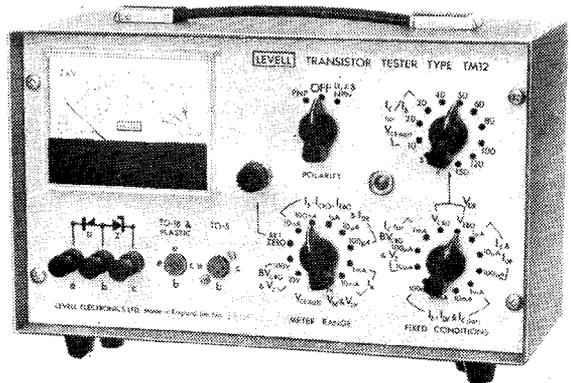
1V per decade $\pm 2\%$ with zero output at scale centre.

Maximum output ± 3 V. Output resistance 1k Ω .

type
TM14

£65

TRANSISTOR TESTER



Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1 μ A to 100mA. Breakdown voltages up to 100V are measured at 10 μ A, 100 μ A and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20, 30. The instrument is powered by a 9V battery.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO} : 10nA, 100nA, 1 μ A, 10 μ A and 100 μ A f.s.d. acc. $\pm 2\%$ f.s.d. $\pm 1\%$ at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. $\pm 3\%$ ± 100 mV up to 10 μ A with fall at 100 μ A $< 5\%$ +250mV.

BV_{CBO} : 10V or 100V f.s.d. acc. $\pm 2\%$ f.s.d. $\pm 1\%$ at currents of 10 μ A, 100 μ A and 1mA $\pm 20\%$.

I_B : 10nA, 100nA, 1 μ A ... 10mA f.s.d. acc. $\pm 2\%$ f.s.d. $\pm 1\%$ at fixed I_E of 1 μ A, 10 μ A, 100 μ A, 1mA, 10mA, 30mA, and 100mA acc. $\pm 1\%$.

h_{FE} : 3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings.

V_{BE} : 1V f.s.d. acc. ± 20 mV measured at conditions on h_{FE} test.

$V_{CE(sat)}$: 1V f.s.d. acc. ± 20 mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. $\pm 20\%$.

DIODE & ZENER DIODE RANGES

I_{DR} : As I_{EBO} transistor ranges.

V_Z : Breakdown ranges as BV_{CBO} for transistors.

V_{DF} : 1V f.s.d. acc. ± 20 mV at I_{DF} of 1 μ A, 10 μ A, 100 μ A, 1mA, 10mA, 30mA and 100mA.

type
TM12

£65

LEVELL ELECTRONICS LTD.

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

Prices are ex works less batteries, V.A.T. extra in U.K.
Optional extras are leather cases and mains power units.
Send for data covering our range of portable instruments.

Here it is!

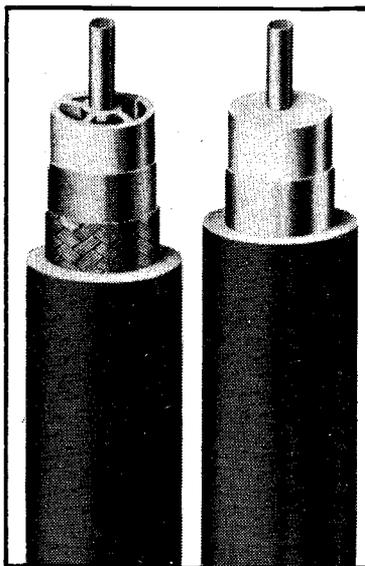
Our two new ranges of 75 ohm TV distribution cables are now made on an extrusion line unique in Western Europe.

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—005 FOR FURTHER DETAILS

Testmatic answers testing problems



Edith Parker easily handles all the Testmatic work in a sub-assembly department of 32 people. When a board leaves that department, it's faultless.

If your product uses elaborate circuitry, it takes skill to faultfind by standard test department methods. But if you put skilled staff on repetitive work, you don't deserve to keep them.

Ansafone's answer was the Testmatic TM30. Repetitive work is what it thrives on—like all machines. It frees qualified staff to do what they were trained to do. And it has other advantages that are just as important.

Mr. S. P. Robinson, a Director of Ansafone states: "An obvious benefit of the Testmatic is that it helps us educate people working on assembly. If they get faulty boards back at once, they feel that much more involved and more responsible. In fact, we don't even see the Testmatic as a tool of the Test Department but as a tool of the Production Department."

Furthermore, the Testmatic makes money by saving time. Ansafone predict that it will help them reduce routine testing time by half. This is a cool and cautious estimate. There will be people

saying "I-told-you-so" if the saving turns out to be even more dramatic than that.

Once again, that is not peculiar to Ansafone. The common experience is that from the time the TM30 is set up ("set up" rather than "programmed," because the procedure is so simple), it pays for itself in months if not weeks.

The Wayne Kerr Testmatic TM30 tests circuit boards, cableforms, and sub-assemblies. Capable of 30 separate DC measurements, which it does in seconds. For complete information, post this coupon—or call Bognor Regis (02433) 25811.

Your name _____

Company Name _____

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Wayne Kerr

Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO22 9RL.
Telex 86120 Cables: Waynkerr Bognor.

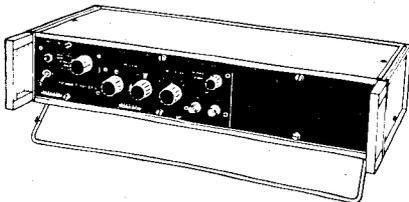
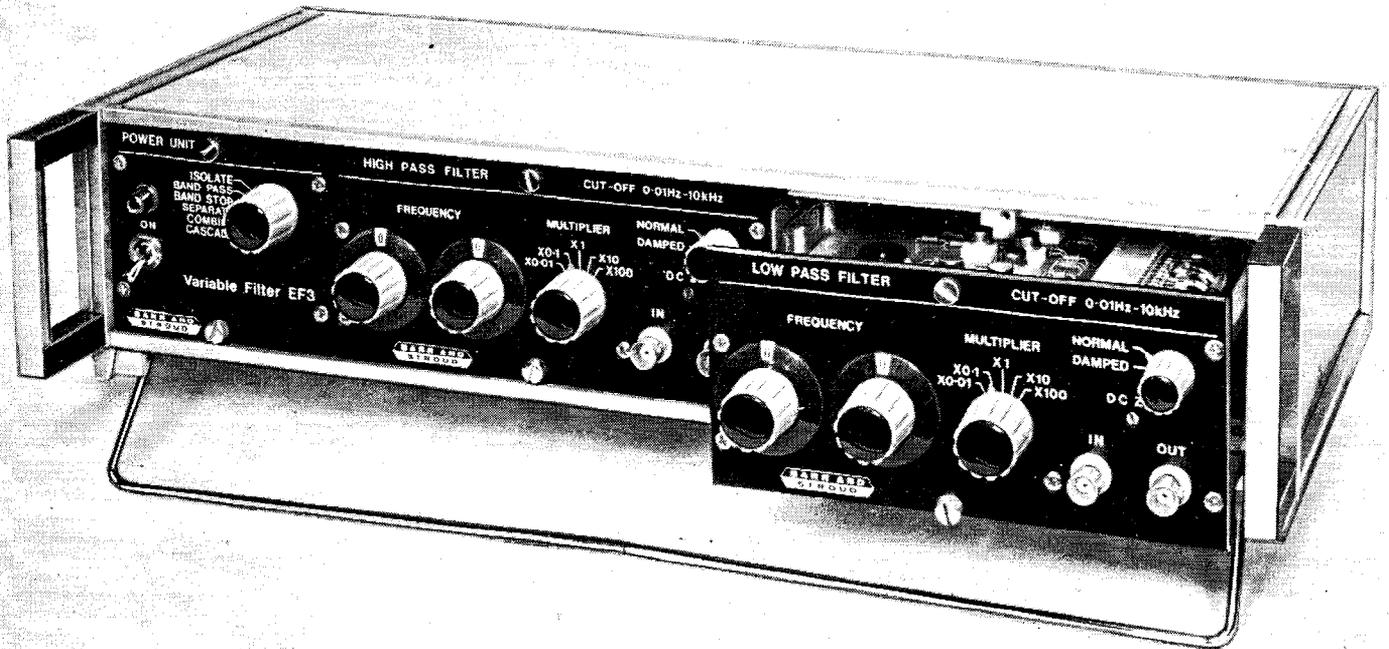
A member of the Wilmot Breejen Group.

W.W.DEC.

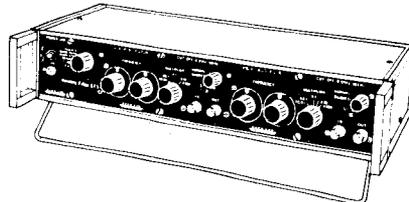
BIG NEWS FROM BARR & STROUD

Modular Filtering

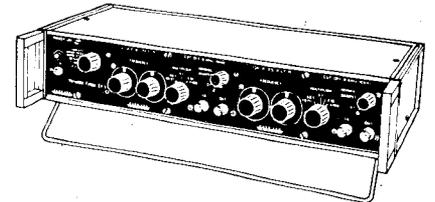
ONE MAIN FRAME—MANY OPTIONS



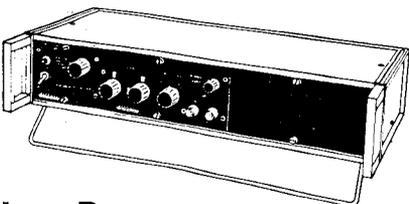
High Pass



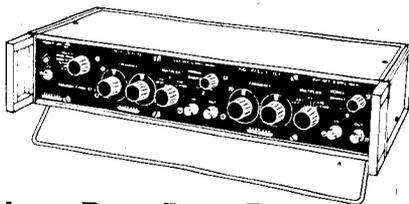
High Pass/Low Pass



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.

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 Telephone: 01-930 1541 Telex: 261877

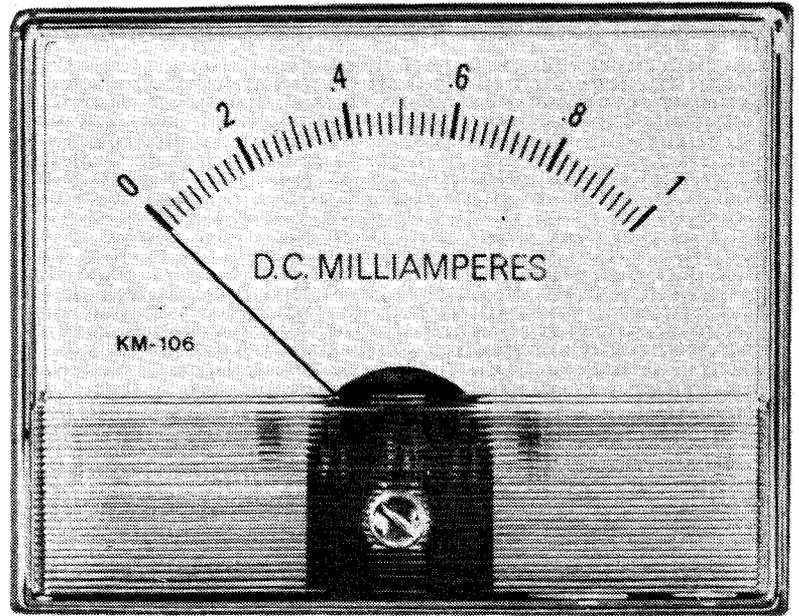
**BARR AND
STROUD**

Glasgow and London

ANDERS MEANS METERS...

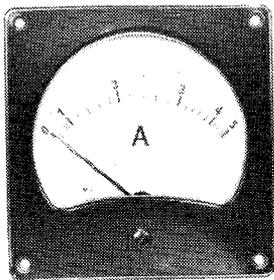
KESTREL RANGE

- Modern styling, with clearfront plastic case.
- Seven models, scale lengths from 1.3" to 5.25".
- Extensively used by many leading manufacturers of electronic and electrical equipment.
- Available in all ranges, moving coil and moving iron.
- Competitive prices.

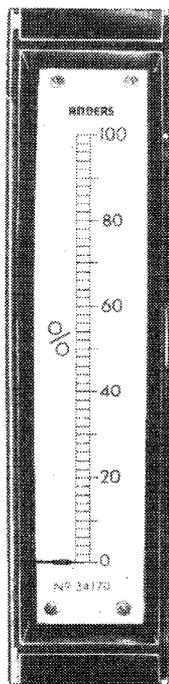


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

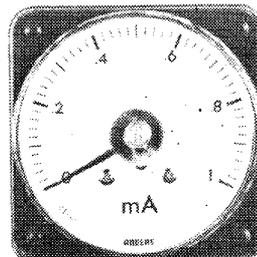
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



Vulcan Moving Iron. 4 models, 1.5", 1.8", 2.7", 3.7" scales. Voltmeters, ammeters and motor starting meters.



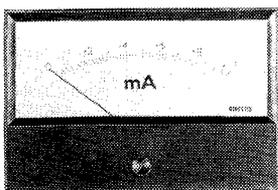
Profile 350 edgewise 4.3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.



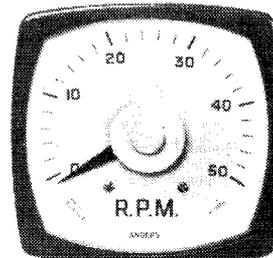
Oxford Long Scale 240°. 2 models, 5.5", 8" scales. DC moving coil and AC moving coil rectified.



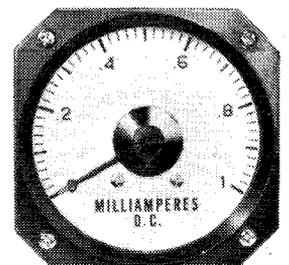
Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2" and 2". Available in sensitivities from 50 microamps Moving Coil.



Regal Range 100° flattened arc. 2 models 2.5" and 3.2" scales. Taut band. DC moving coil and AC moving coil rectified.



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.

110° Colour Television and

A number of British setmakers are now exporting slim-line colour TV receivers with 110° colour tubes, based on advanced circuitry developed in conjunction with Mullard to meet the special requirements of the European market.



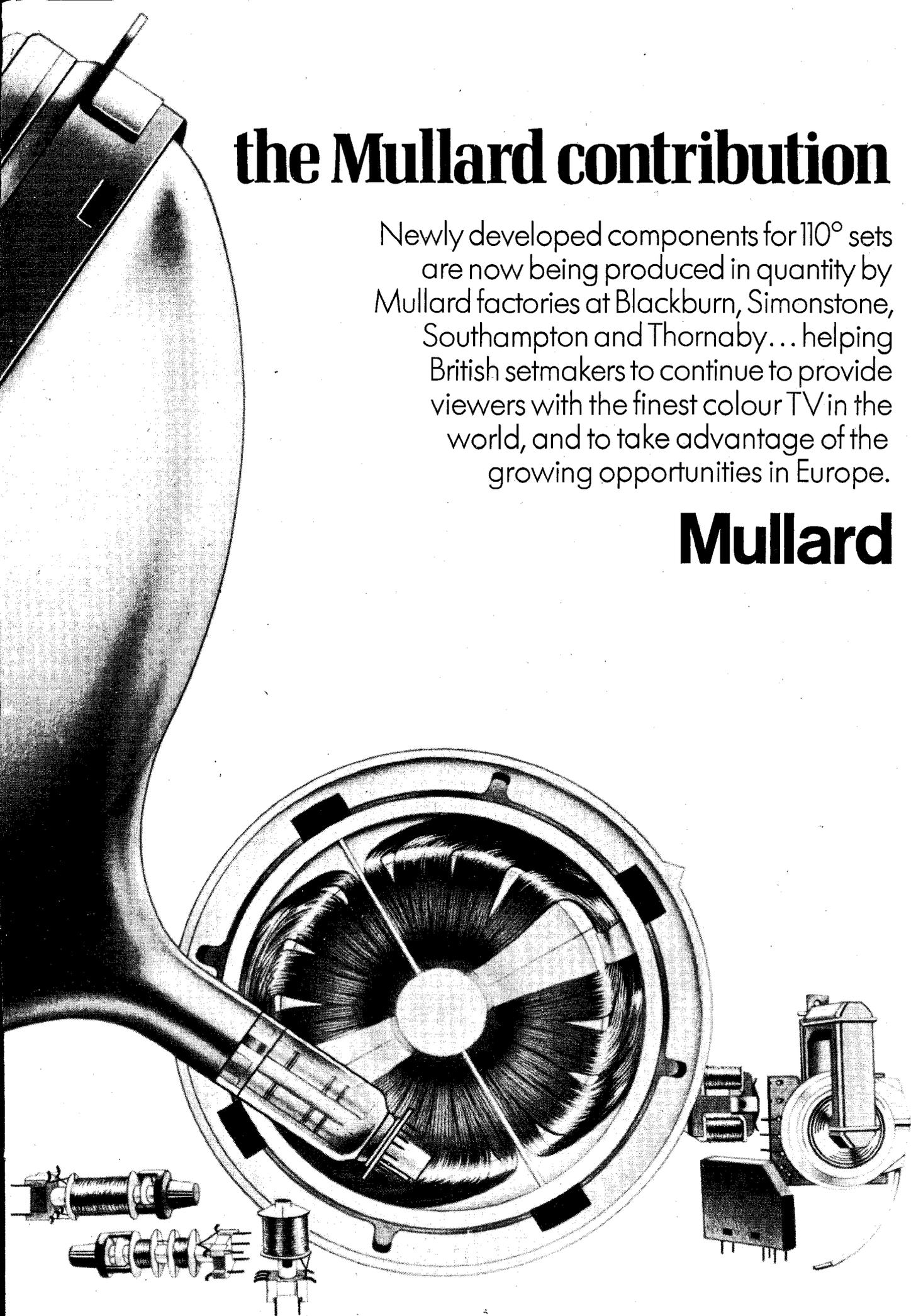
**Components for
the finest colour
tv sets in the
world.**

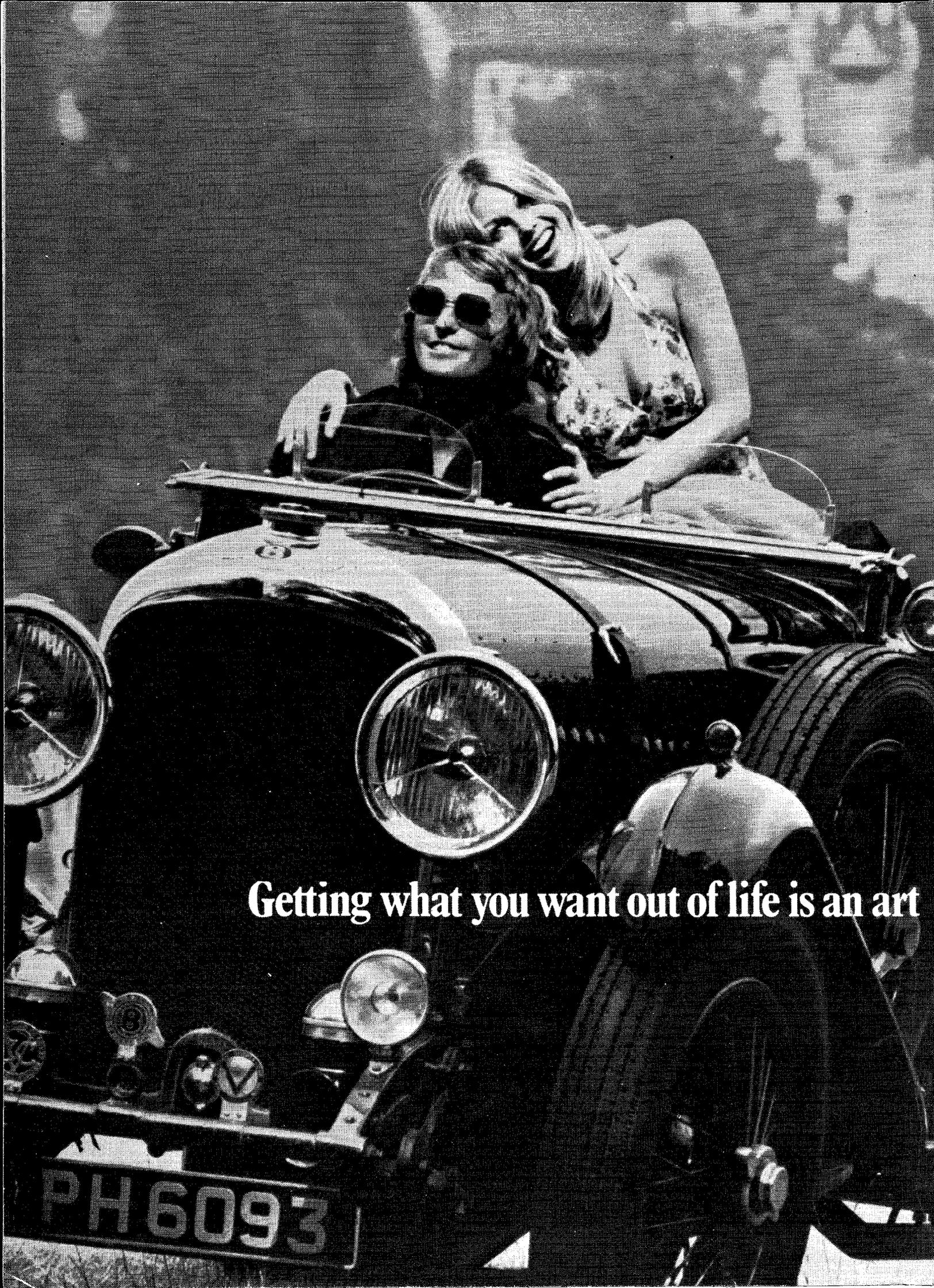


the Mullard contribution

Newly developed components for 110° sets are now being produced in quantity by Mullard factories at Blackburn, Simonstone, Southampton and Thornaby... helping British setmakers to continue to provide viewers with the finest colour TV in the world, and to take advantage of the growing opportunities in Europe.

Mullard





Getting what you want out of life is an art

PH 6093

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 transcription 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. Wow and flutter typically 0.12% peak, rumble typically -63 dB (DIN B). 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.

WW-009 FOR FURTHER DETAILS

682 PLG

Gardners line up

Line Matching Transformers from Standard to Super Fidelity

It's easy to choose the right Line Matching Transformer from the five Gardners ranges.

The Super Fidelity Series, with a frequency response of 10Hz to 80kHz - 0.5dB, gives the widest possible bandwidth for high accuracy instrumentation and recording applications.

Then there's the Wide and Extra Wide-band ranges. Outstanding performers with a frequency range 30Hz - 20kHz or more - for the 0.5dB points. Used a lot by broadcasting and recording companies throughout the world.

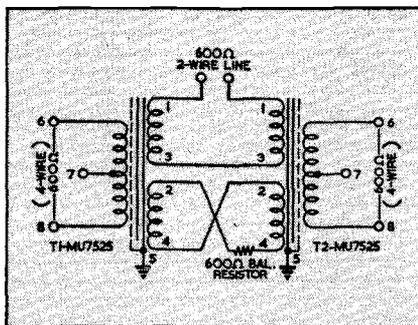


The Miniature and Standard ranges provide excellent bandwidth for most purposes, 30Hz - 22kHz for the 1.0dB points.

Except for the very smallest in the range, all Gardners Line Matching Transformers are fully magneti-

cally shielded, giving very high hum rejection ratios. Prices start from £3.19 (recommended retail price) and all types are usually available from stock.

Complete technical information is given in brochure GT.5 'Audio Frequency Transformers' which we'll be glad to send on request.



So accurate is the balancing of the windings on some of these transformers that, when used as pairs in a hybrid circuit (as illustrated) we can guarantee a rejection of better than -55dB over the frequency range 50Hz to 10kHz and normal rejection of up to -75dB may be expected.

Gardners

Specialists in Electronic Transformers and Power Supplies

GARDNERS

TRANSFORMERS LIMITED

Gardners Transformers Limited, Christchurch, Hampshire, BH23 3PN
Tel: Christchurch 2284 (STD 0201 5 2284) Telex: 41276 GARDNERS XCH.

WW-010 FOR FURTHER DETAILS



Look out for this sign

it's a good deal more meaningful than most

B & W are not playing hard to get. Far from it. We've appointed – very selectively – a national network of Authorised B & W Dealers to demonstrate, install and service our famous loudspeakers.

You can expect our dealers to have good demonstration facilities, and installation technicians who really know their stuff. Above all, B & W dealers will maintain the kind of after-sales service you've the right to expect.

Ask to hear B & W speakers where you see the sign; it could be the beginning of a totally rewarding experience.

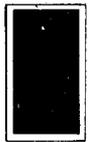


B & W loudspeakers are in great demand abroad. So much so, we have been honoured with the Queens Award to Industry for export achievement.

We would like to send you a copy of our new book of B & W loudspeakers and the address of our Authorised Dealer in your area.

B&Welectronics

Meadow Road Worthing BN11 2RX
Telephone (0903) 205611



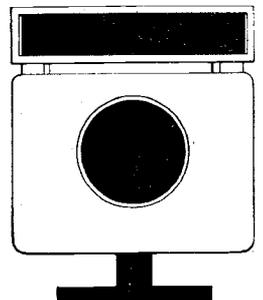
DS



DM4



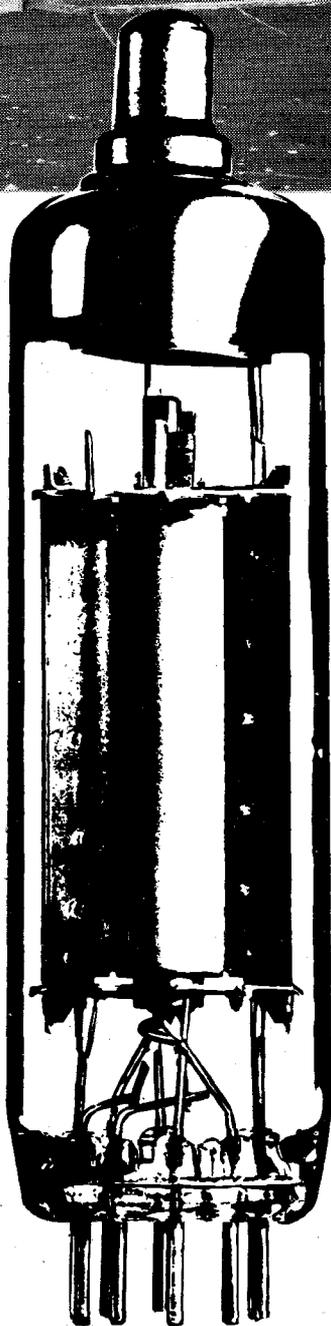
DM2



DM 70



The new home of Haltron



Haltron—International specialists supplying the widest range of electronic valves, semiconductors and integrated circuits can now give you even better service. Our modern, much larger factory provides space to expand and meet your requirements. Governments and other users worldwide specify Haltron products for their outstanding high quality and confirmed reliability. This, backed by expertise and efficient handling of export orders ensures a unique universal reputation.

Haltron

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Electron House,
Cray Avenue, St. Mary Cray,
Orpington, Kent BR5 3QJ
Telephone: Orpington 27099
Telex: 896141

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.

Photographs by kind permission of New Scotland Yard.

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

Mullard components for communications

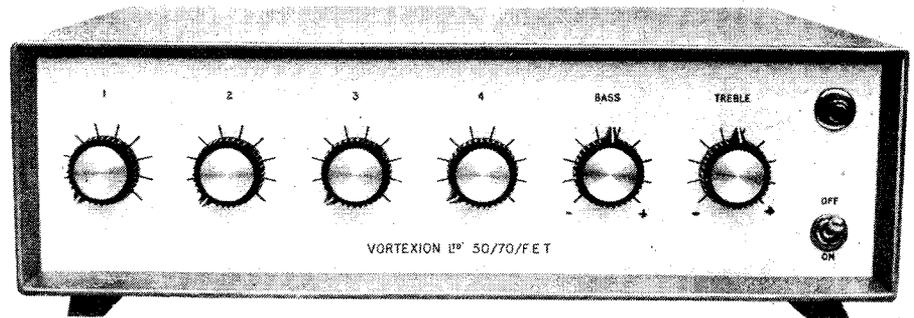


BROADCASTING · TELECOMMUNICATIONS · RADAR · NAVAIDS · MILITARY

Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.



The mixer is arranged for 2-30/60 Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt. balanced line output or 5/15 Ω and 100 volt line.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s

This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16 Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected. The Mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output .3V out on 600 ohms upwards.

100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms-15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4V on 100K ohms.

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4-channel F.E.T. mixer, 2-30/60 Ω balanced microphone inputs. 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted.

Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s-20 Kc/s \pm 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100-120V or 200-240V. Additional matching transformers for other impedances are available.

20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced and 1 auxiliary input.

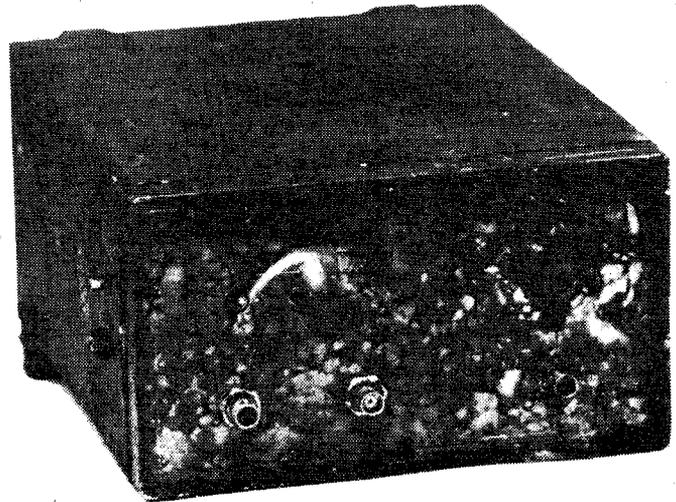
VORTEXION LIMITED,

257-263 The Broadway, Wimbledon, S.W.19 1SF

Telephone: 01-542 2814 and 01-542 6242/3/4

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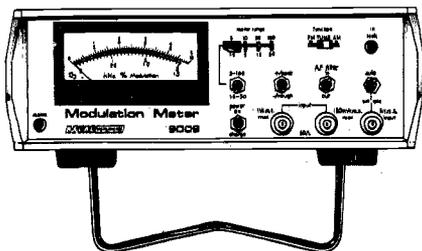
The Inside Story



Again Racal's reliable instruments make the headlines. Retrieved from the debris of a steelworks fire this frequency divider was found to be still in an operational condition. Not that Racal anticipate all its instruments will survive such treatment but it does indicate the ruggedness and reliability inherent in the design.

However the frequency divider is just one high calibre instrument among many in a new catalogue now available from Racal. Inside is all the information you need to know about the complete range.

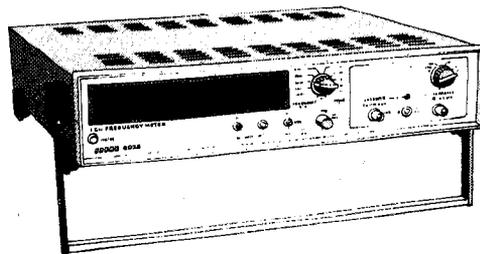
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Completely automatic—no tuning—no level setting
Carrier range extends to 1 GHz

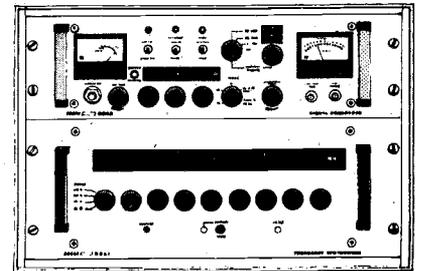
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9025 Frequency Period Meter



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Three outstanding instruments from Racal's new book - it should be on your desk now.

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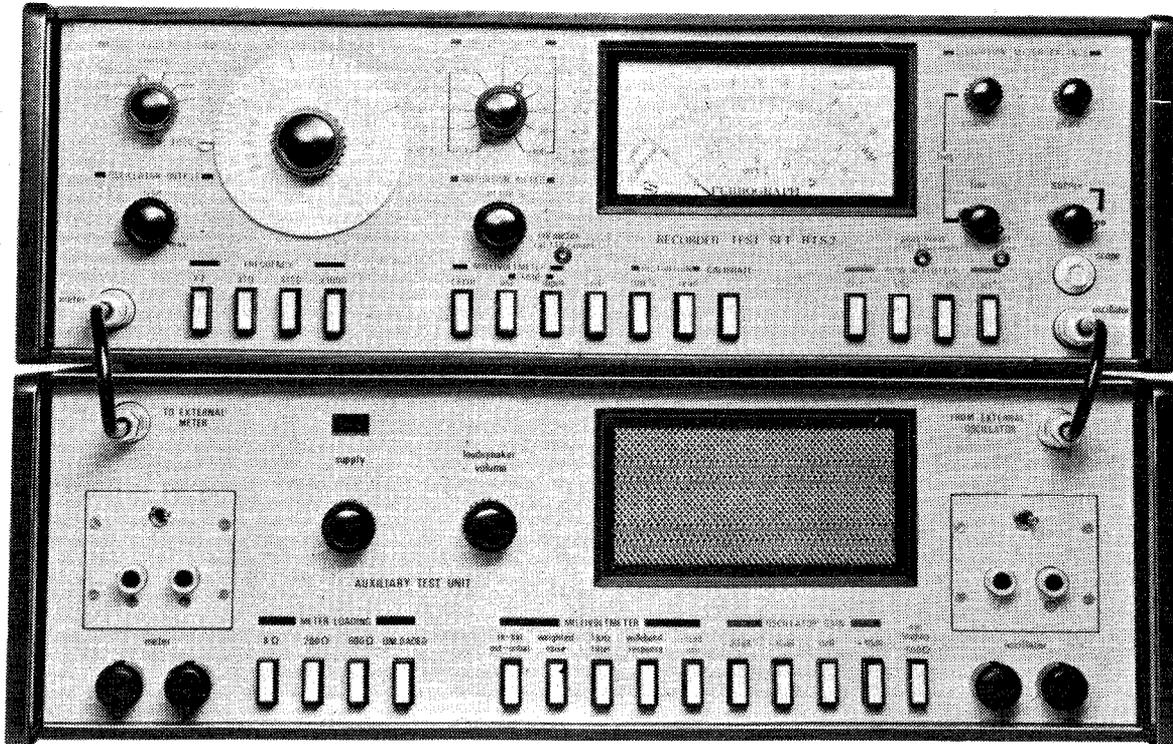
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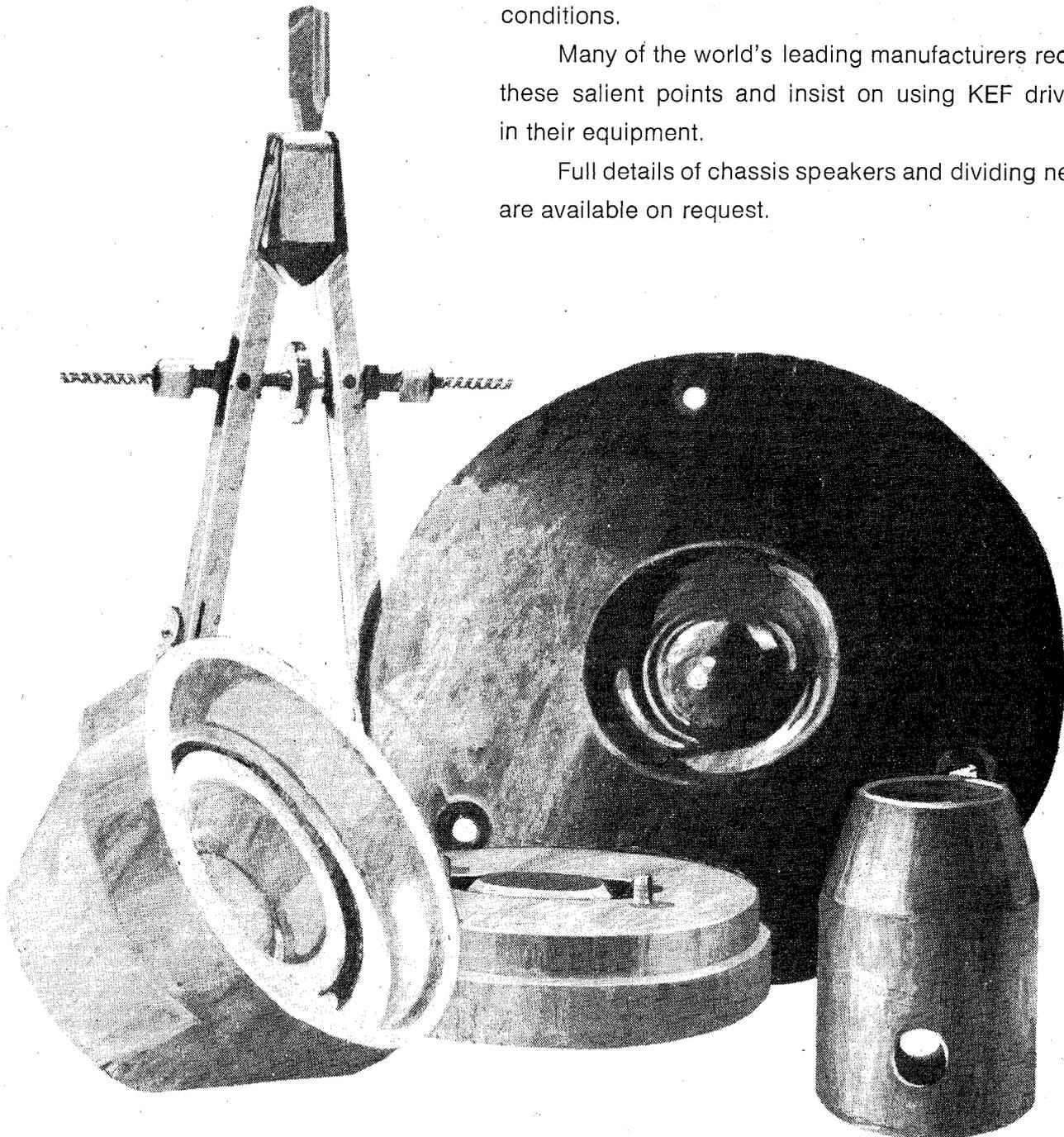

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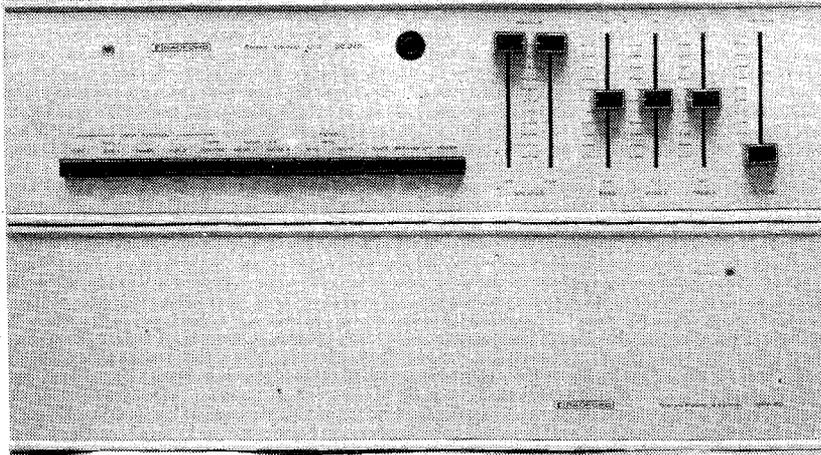
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*"Sound Investments" classification — Daily Telegraph Magazine Oct 12/73

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A power amplifier capable of supplying 60 watts per channel continuous average power into any load from 4 ohms to 8 ohms at very low distortion. Constant maximum voltage output down to 5 ohms representing approx. 90 watts continuous average power per channel. True complementary symmetry design. Pre-set adjustable for virtual elimination of crossover distortion, and harmonic distortion to less than 0.006% at half power. Mains input 100v-250v. 40-60Hz.

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EPPIFY
Essex

10. 6. 1973

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Yours faithfully

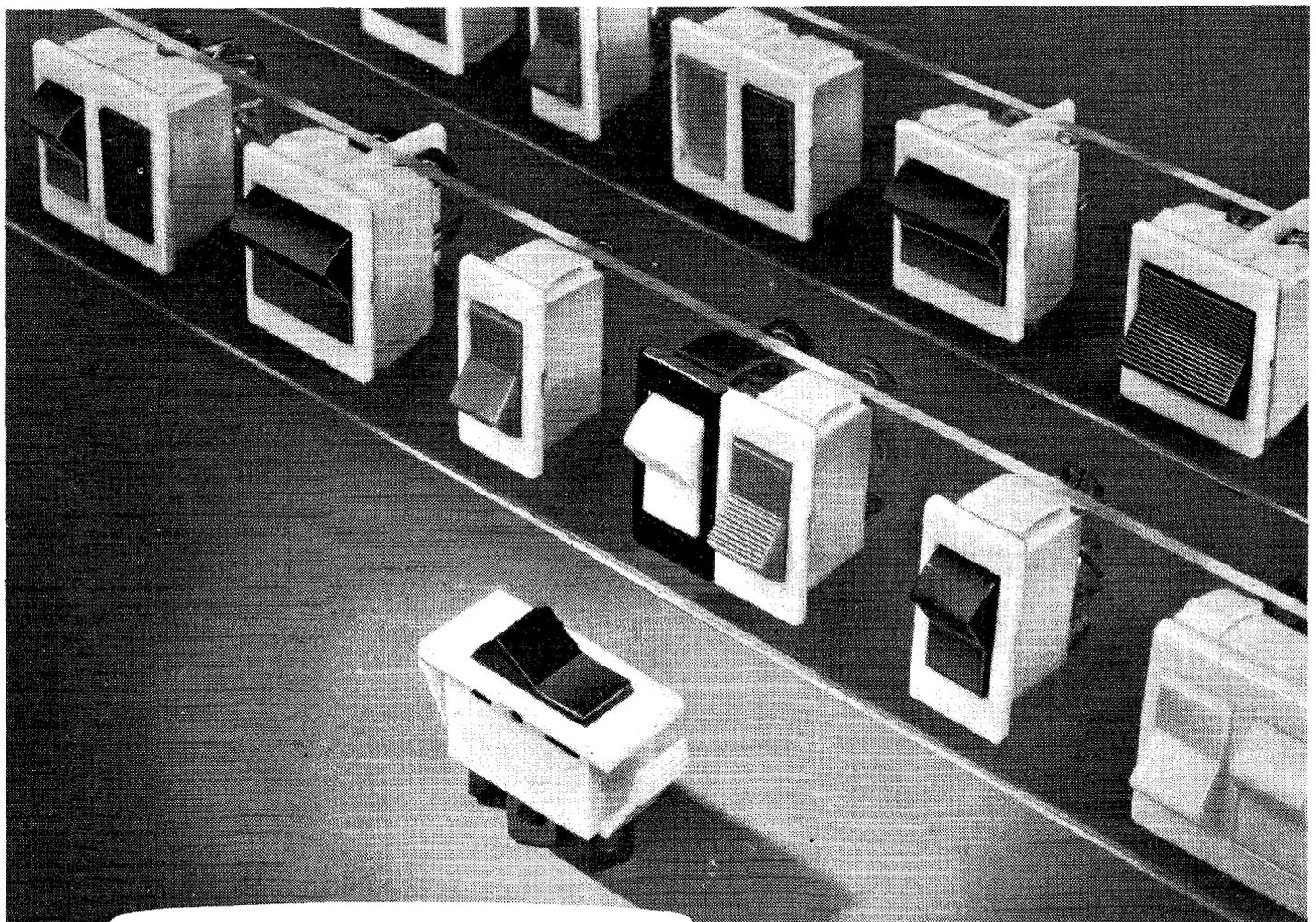
Emdoy

One of our customers puts the achievement of the G800 on record!

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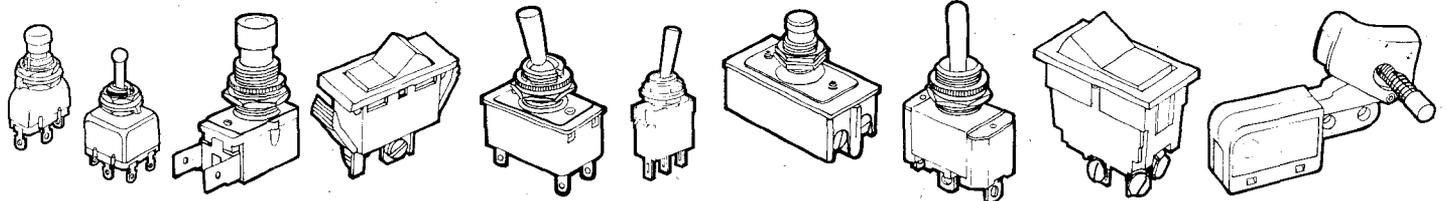


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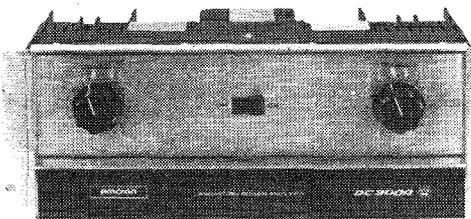
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Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, -15° DC to 20kHz, 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9 3/4" Deep
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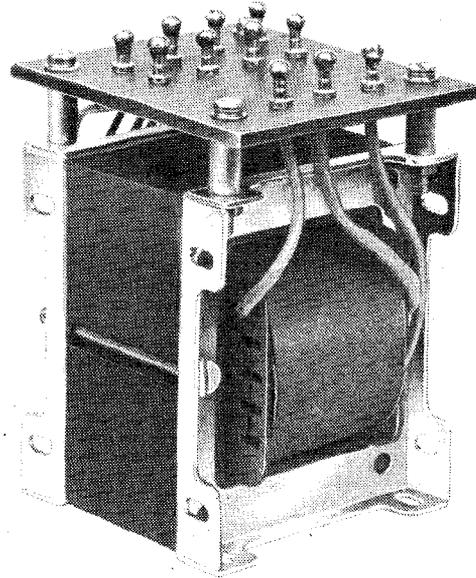
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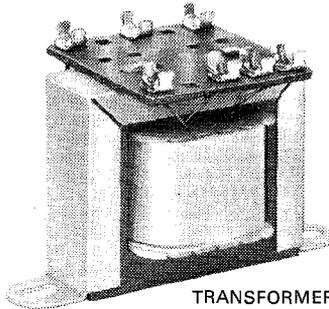
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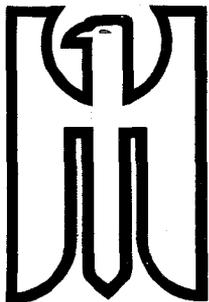
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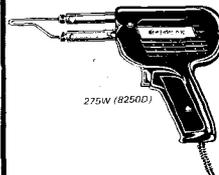
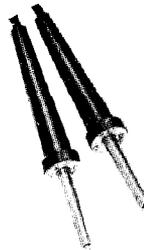
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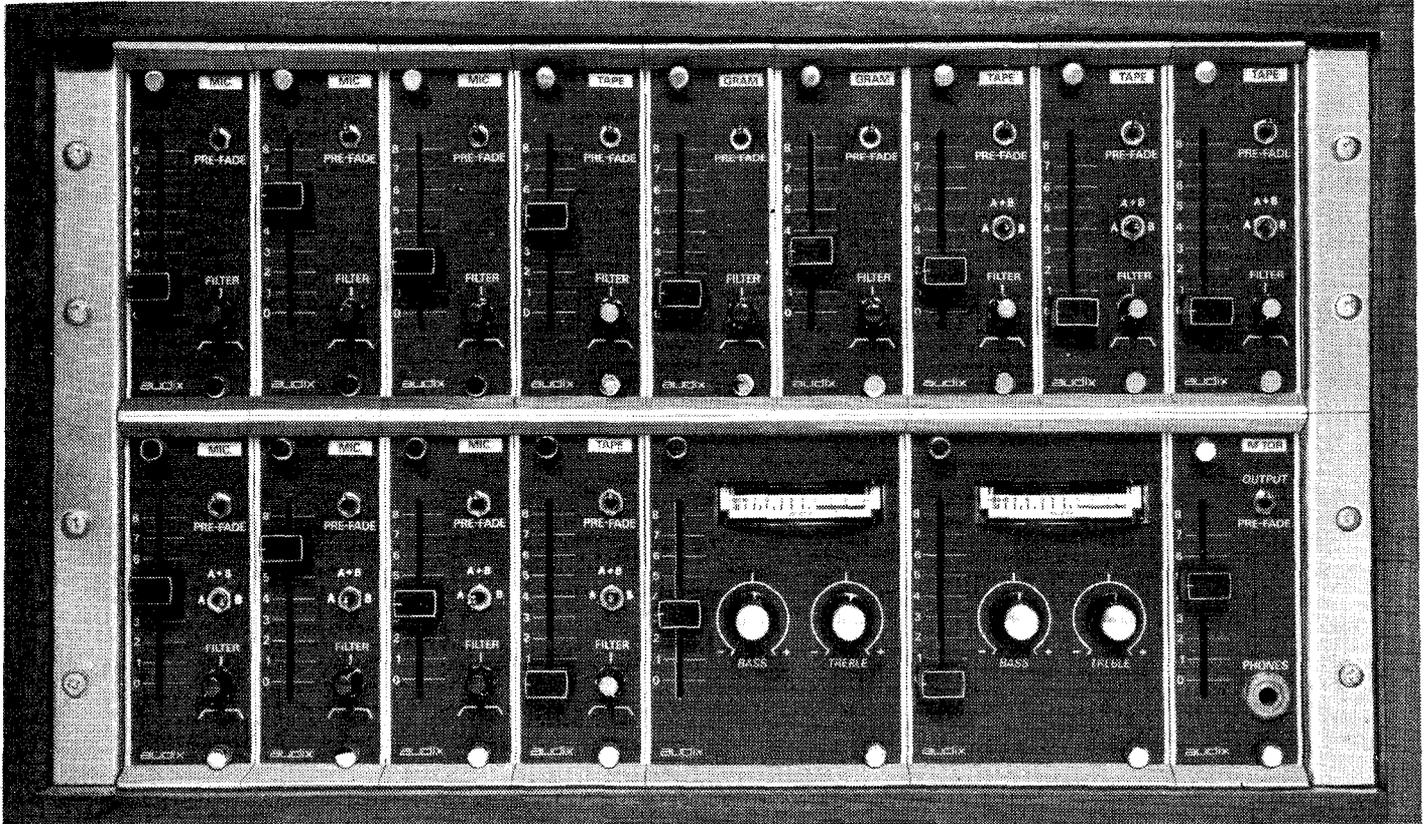
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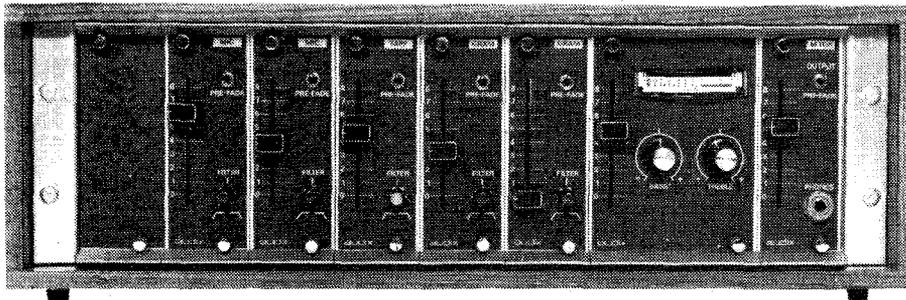
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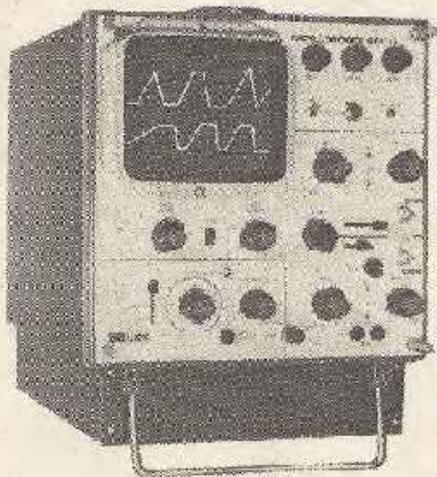
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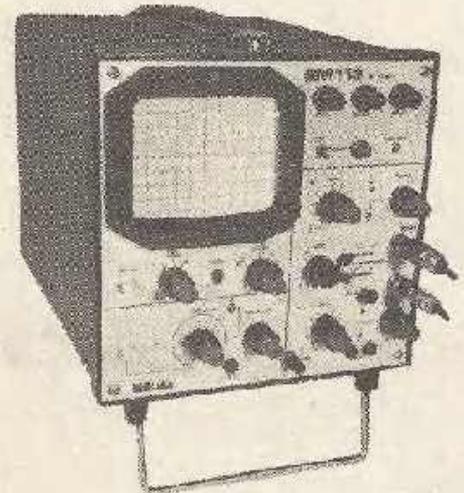
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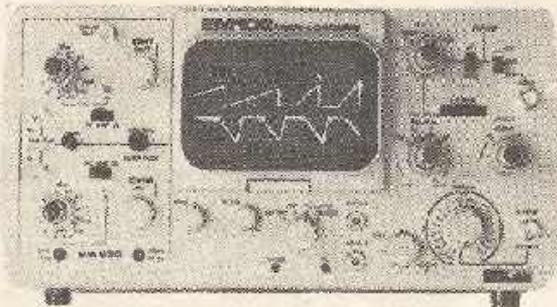
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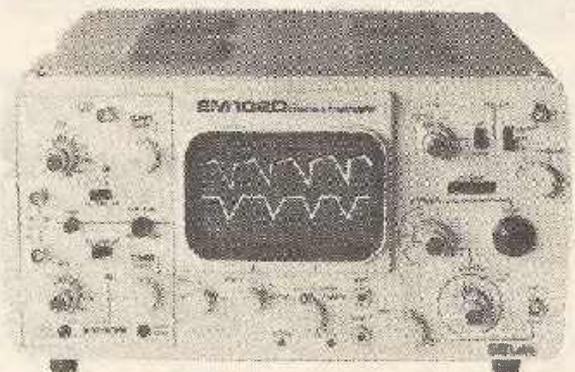
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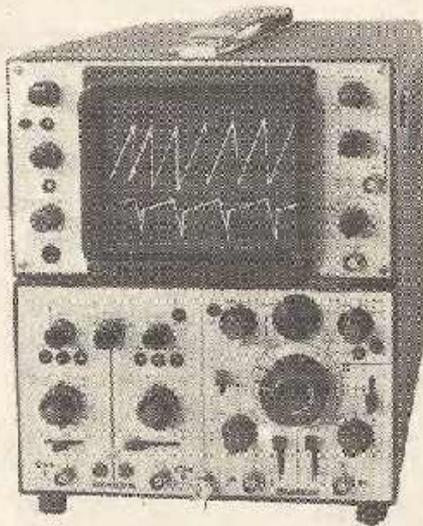


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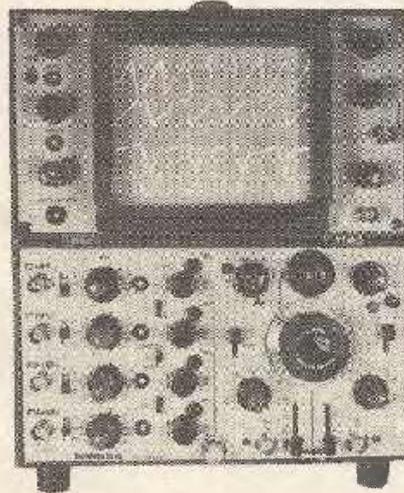


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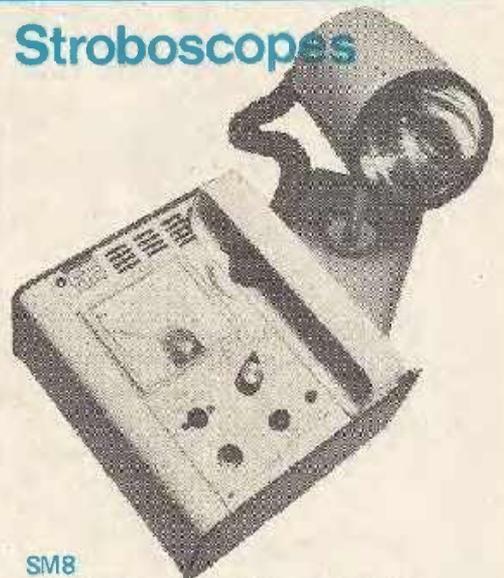
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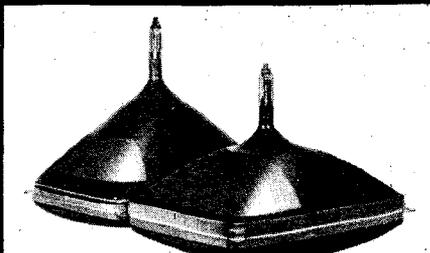
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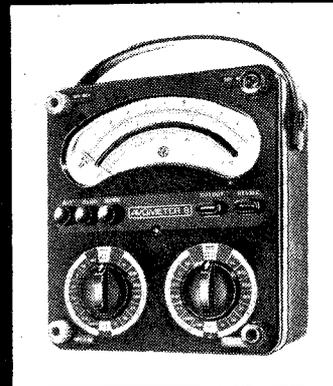
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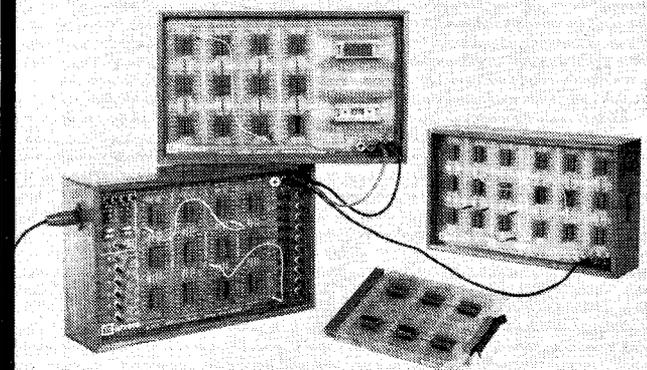
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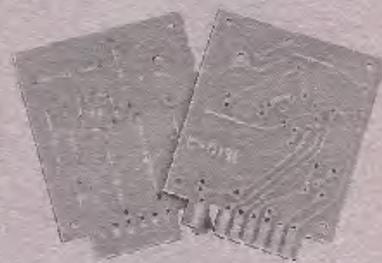
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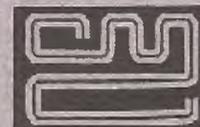
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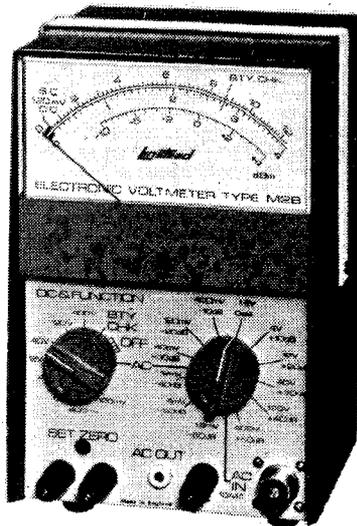
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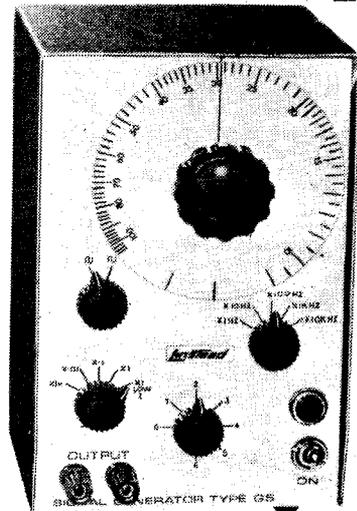
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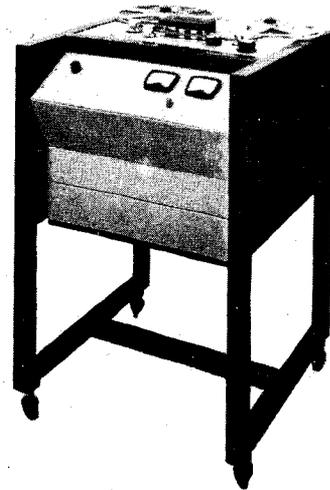
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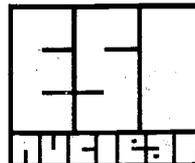
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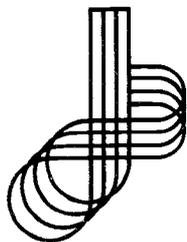
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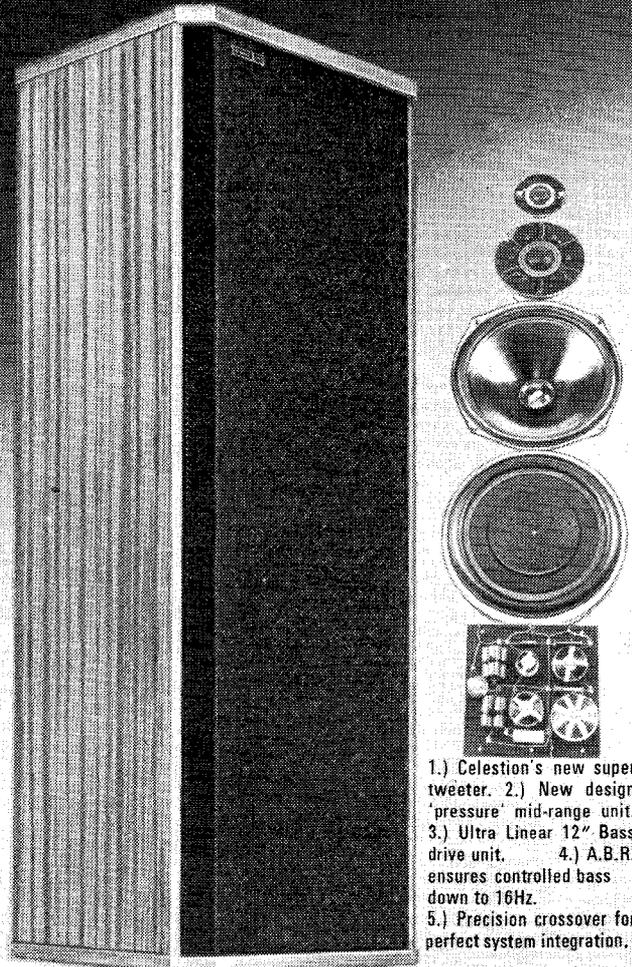
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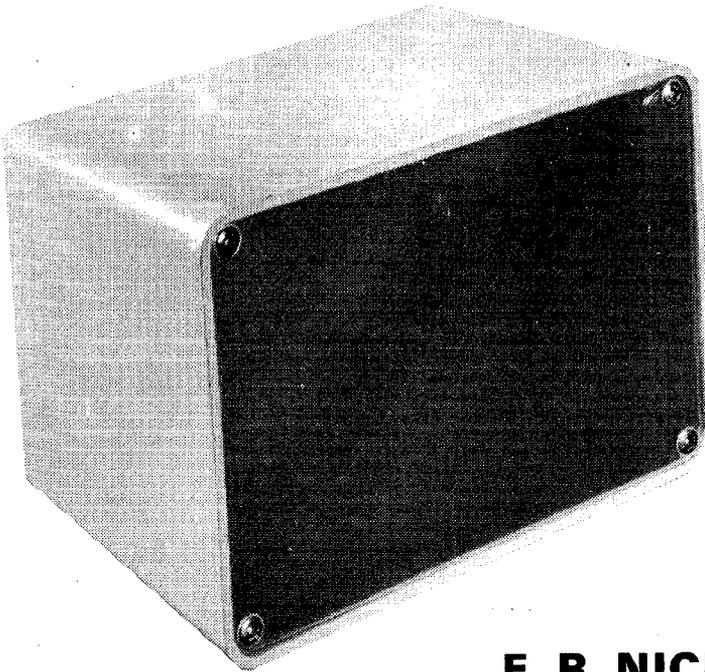
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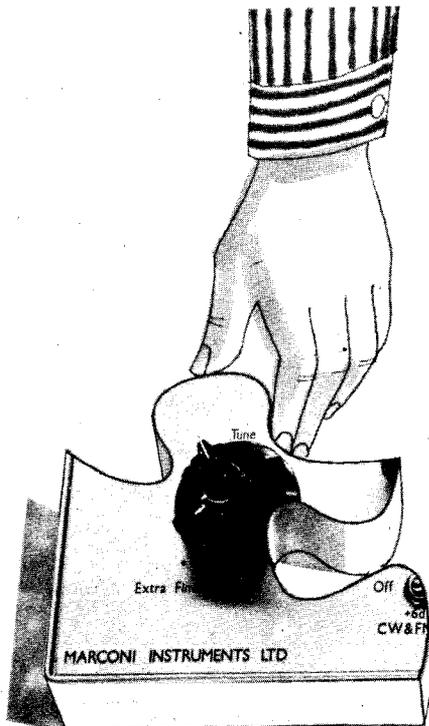
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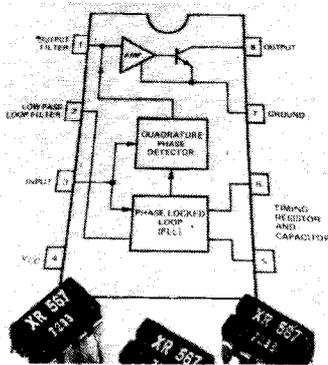
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XR-567



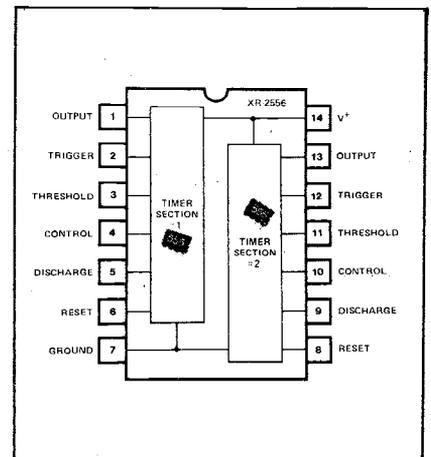
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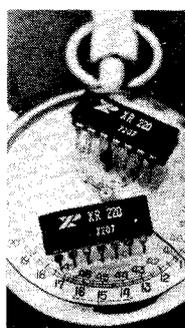
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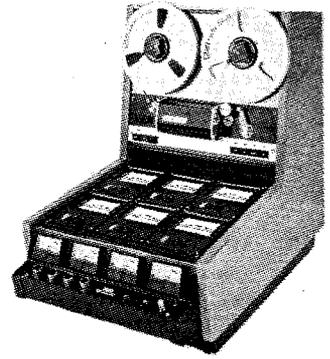


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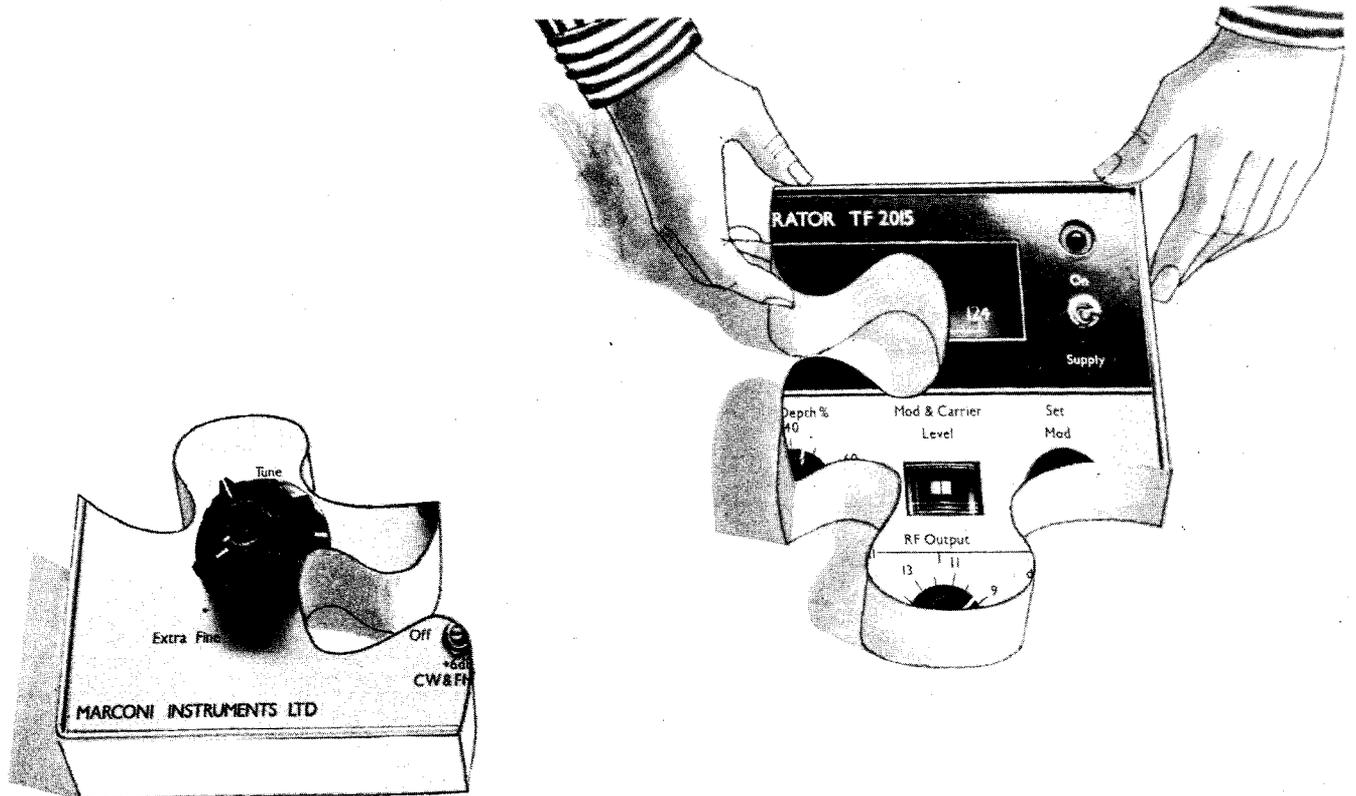
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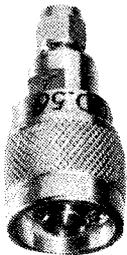
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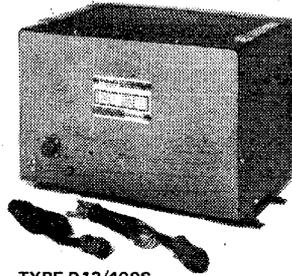
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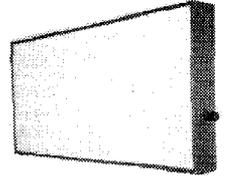
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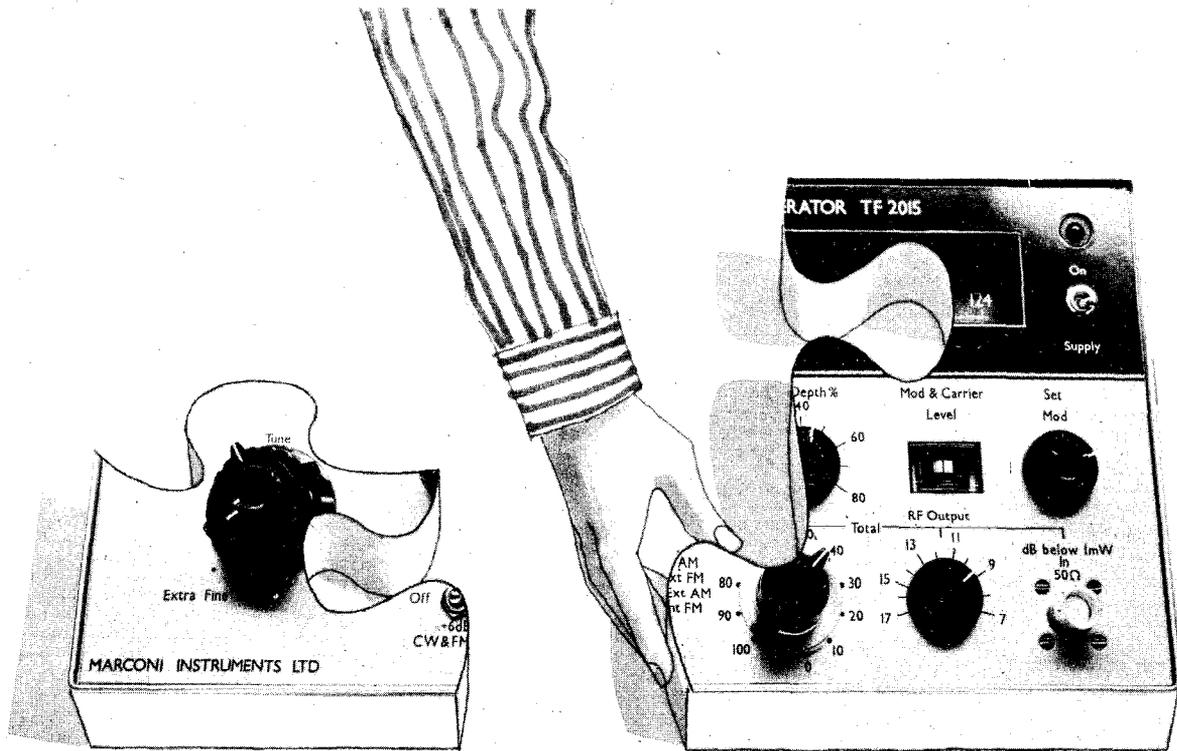
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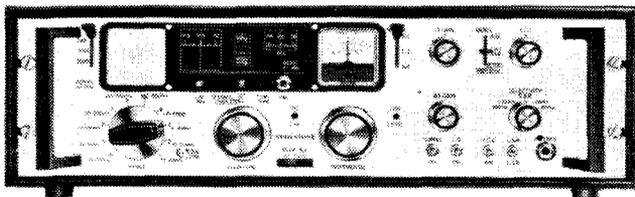
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Soft magnetic alloys

Mumetal alloys

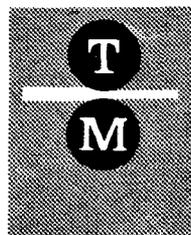
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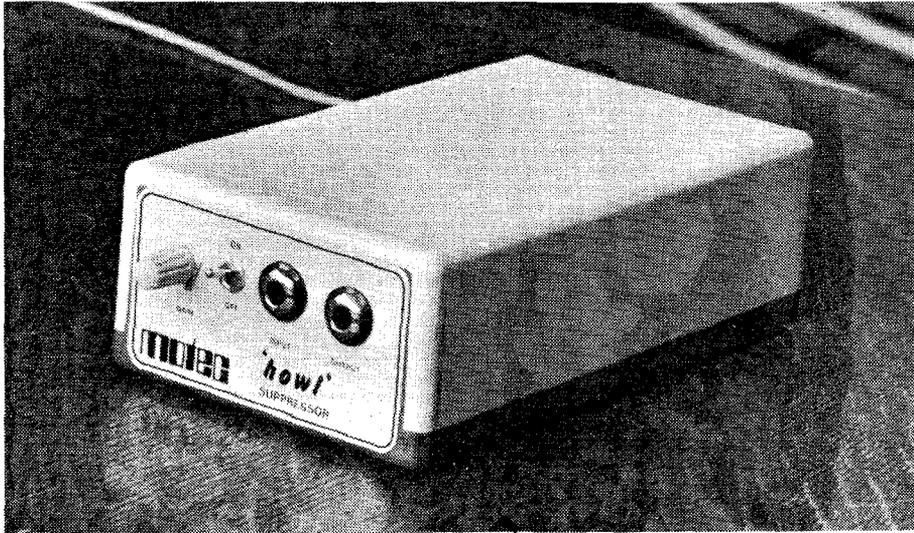


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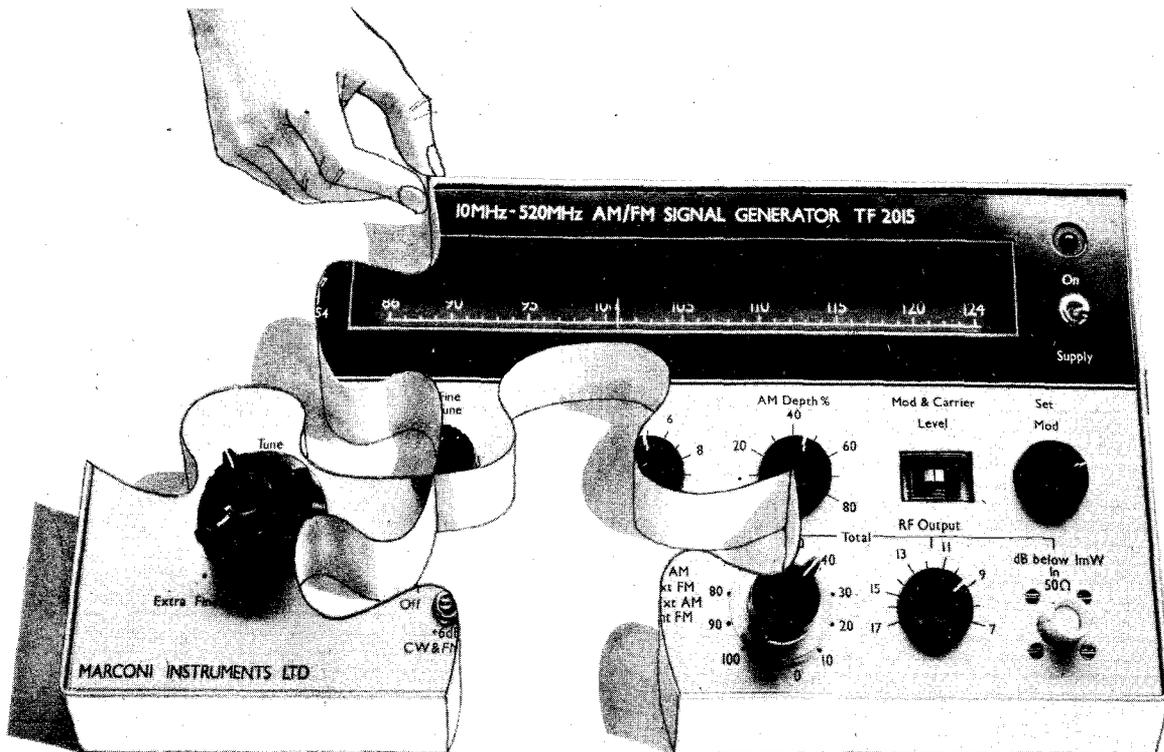


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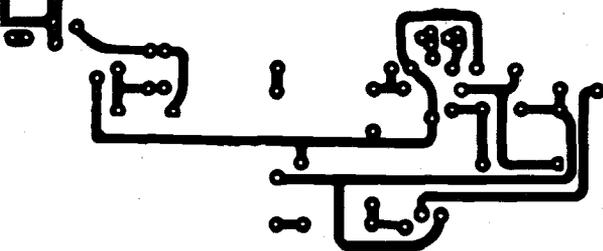
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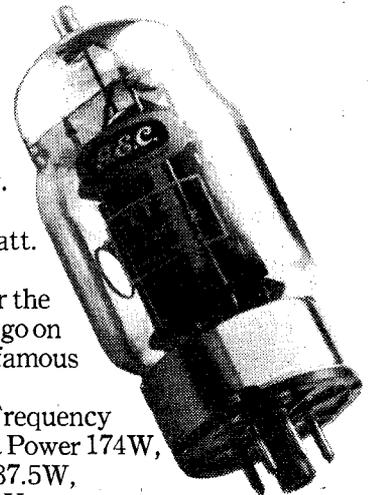
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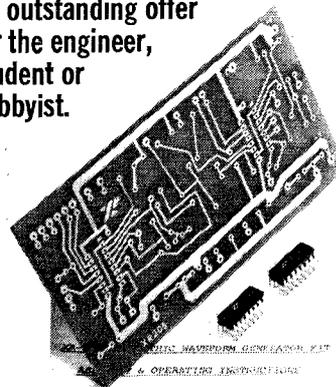
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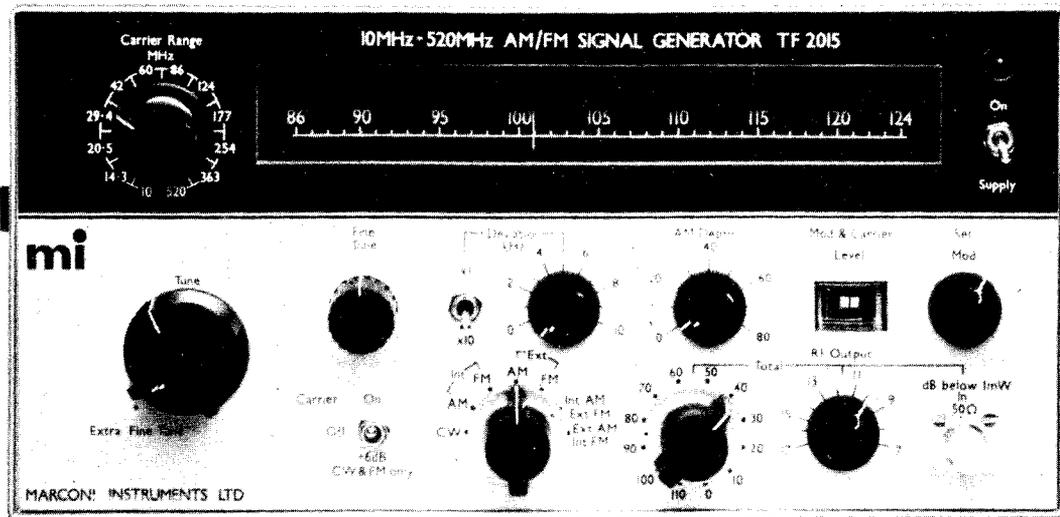
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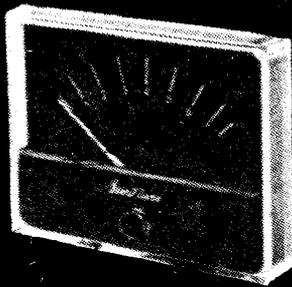
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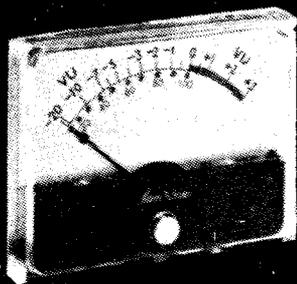
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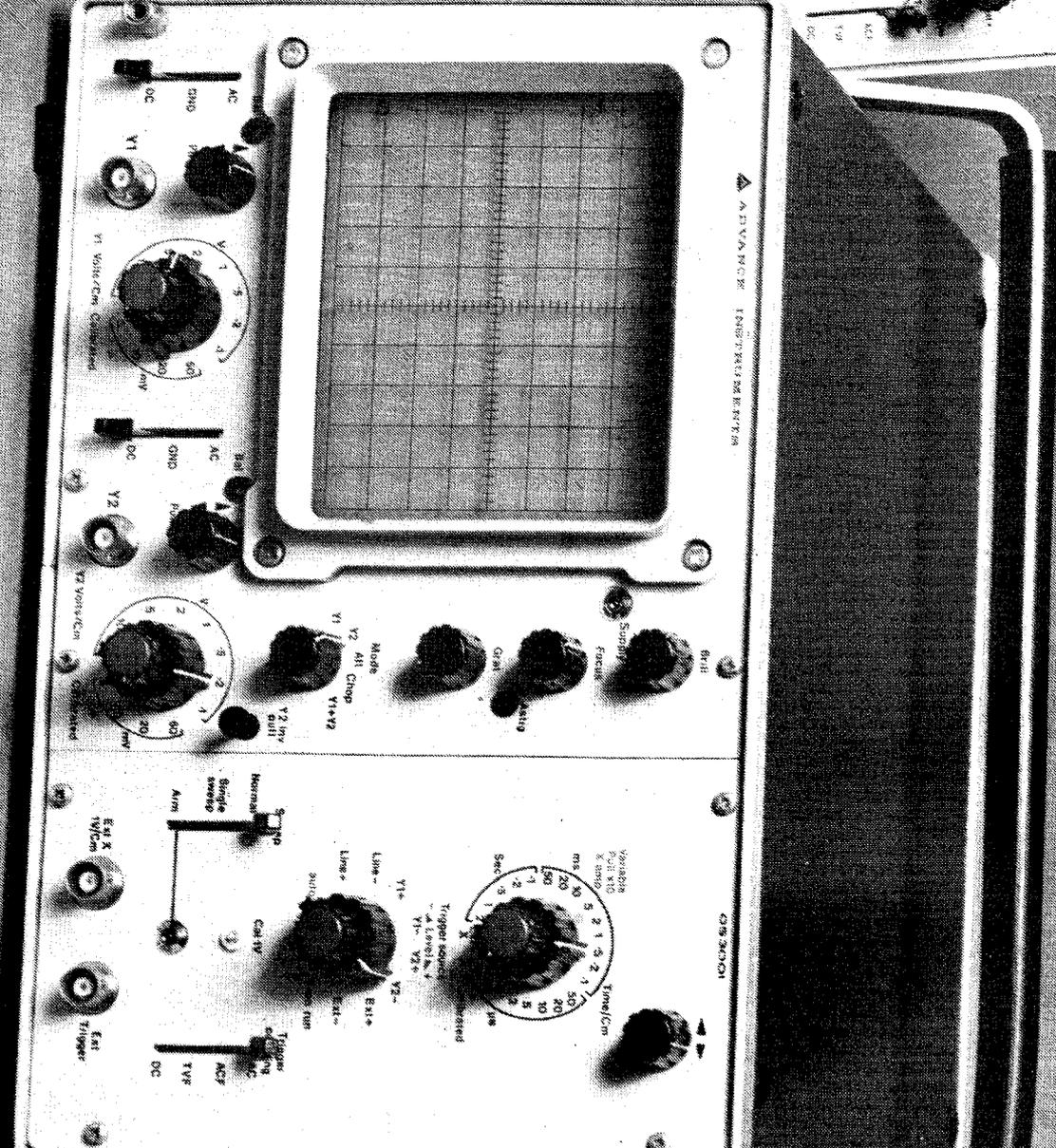
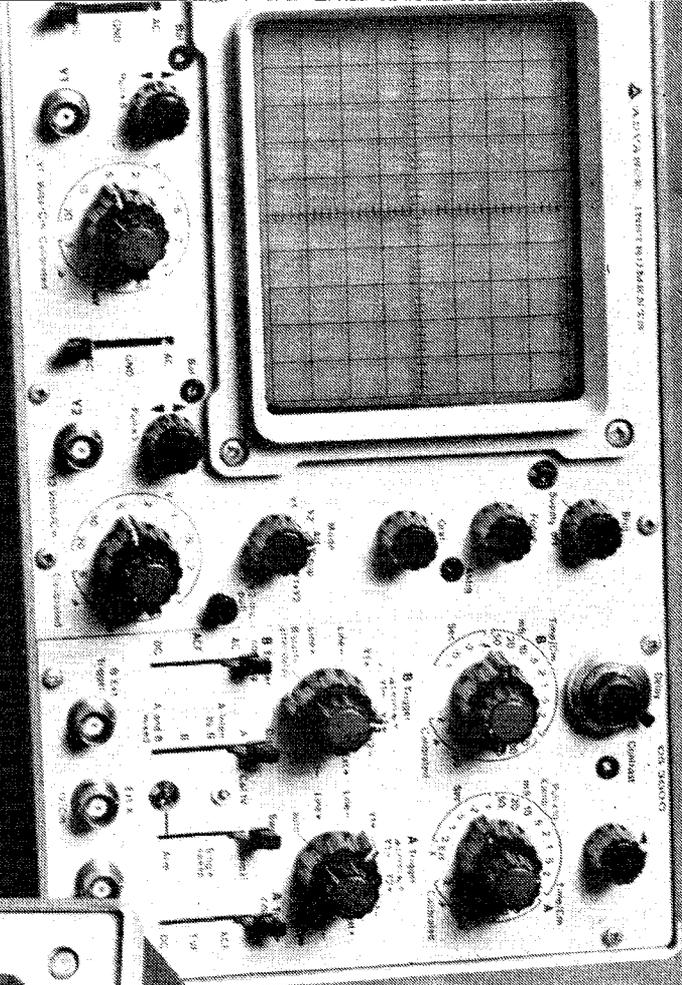
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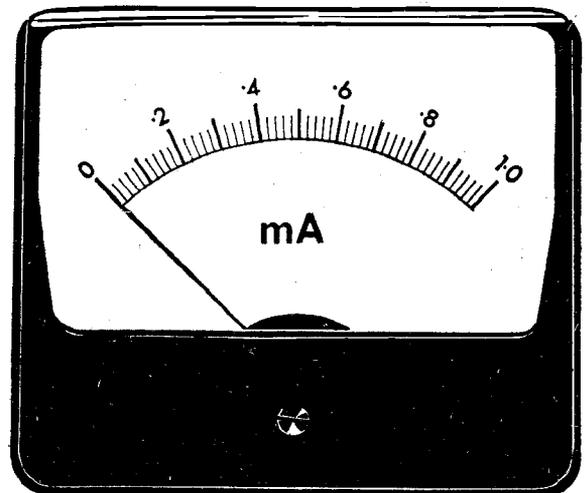
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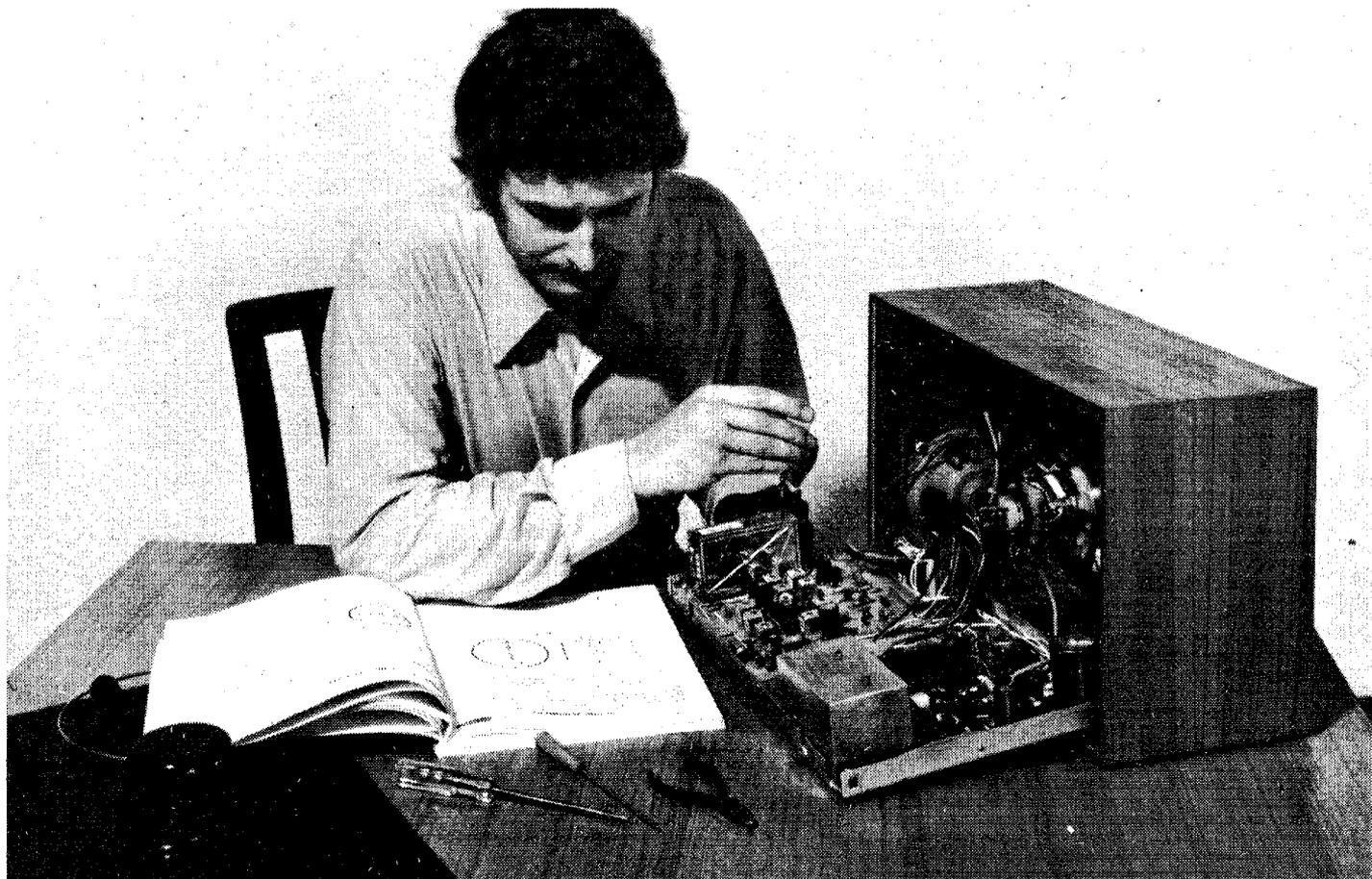
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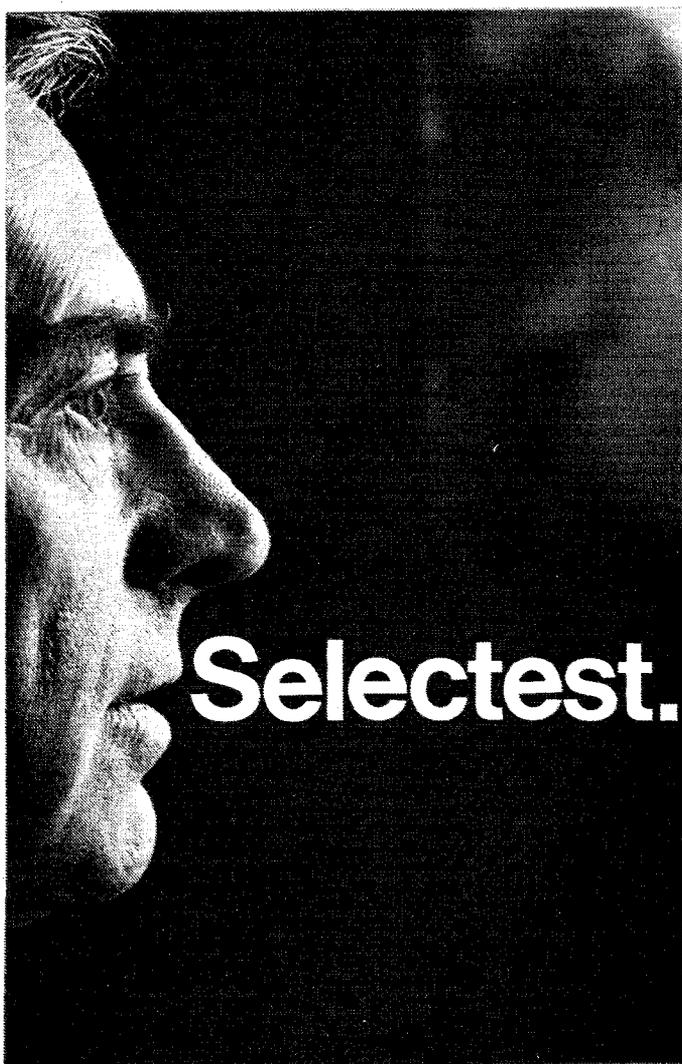
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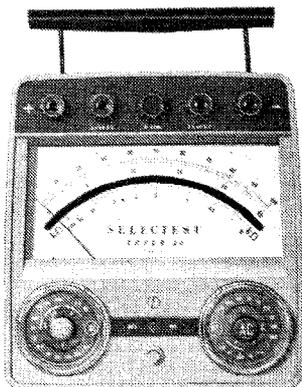


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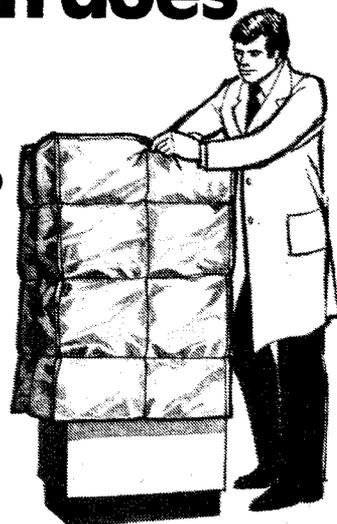
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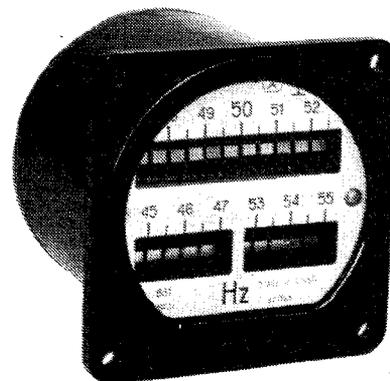
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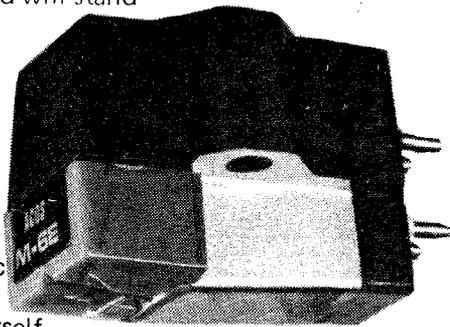
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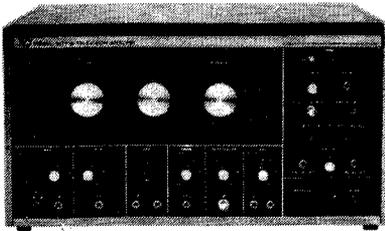
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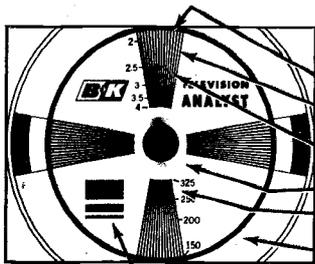


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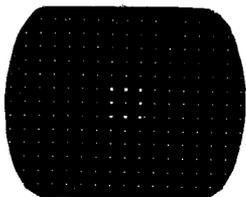


This Standard Test Pattern or other signal of your choosing may be injected at the indicated test points.

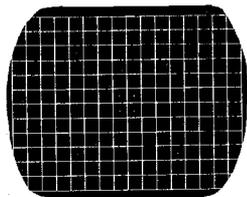
Typical problems that can be repaired using the 1077B:

- To set proper size, set top and bottom of circle to top and bottom edges of receiver screen.
- Determine frequency response at point where lines of wedge merge. Bandwidth shown in megahertz.
- Ringing or overshoot is indicated by white trailing edges.
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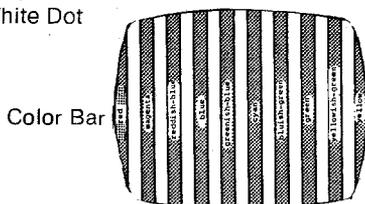
Scope Diagram



White Dot



Crosshatch



Color Bar

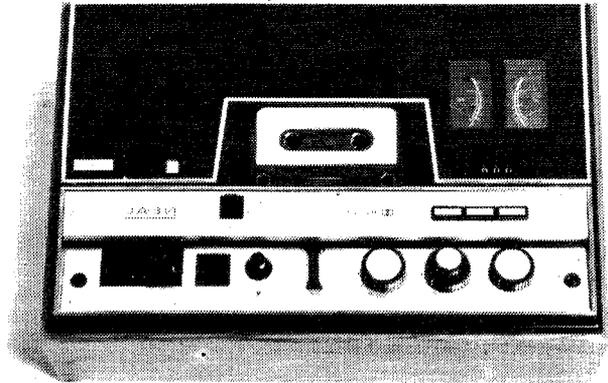
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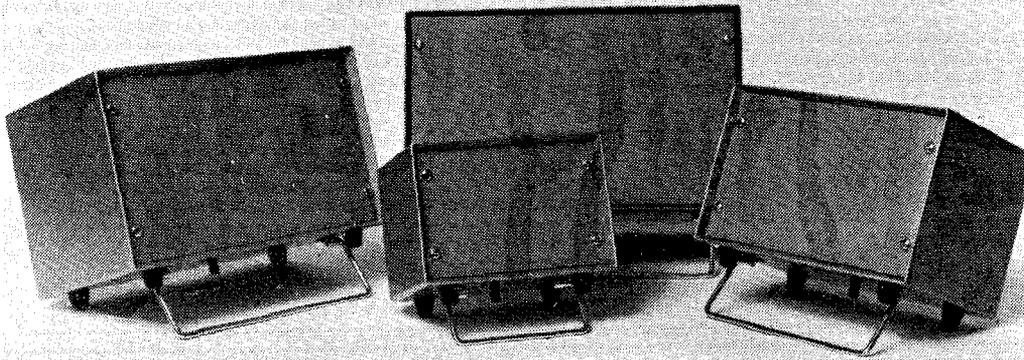
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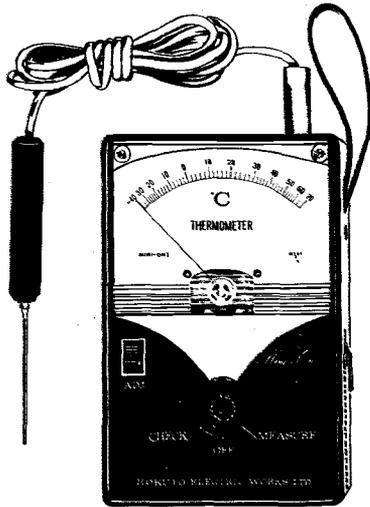
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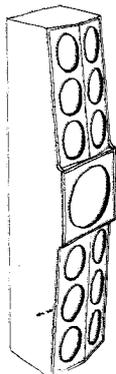
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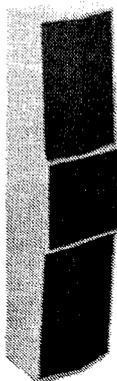


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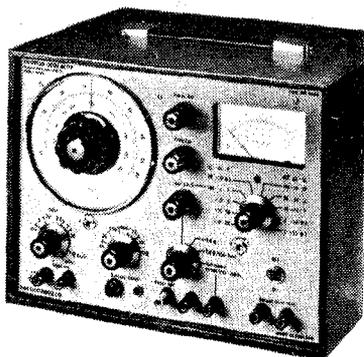
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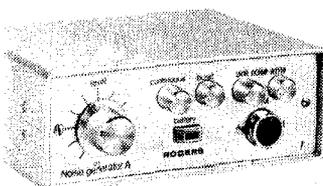
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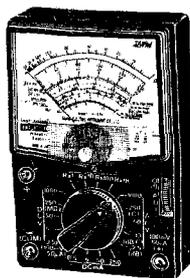
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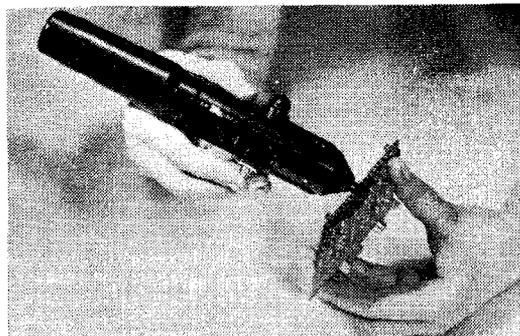
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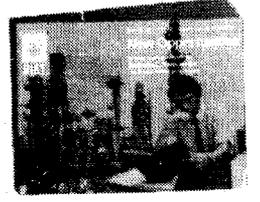
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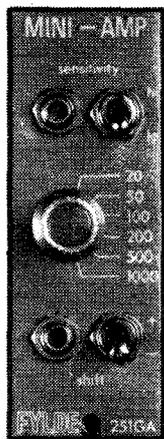
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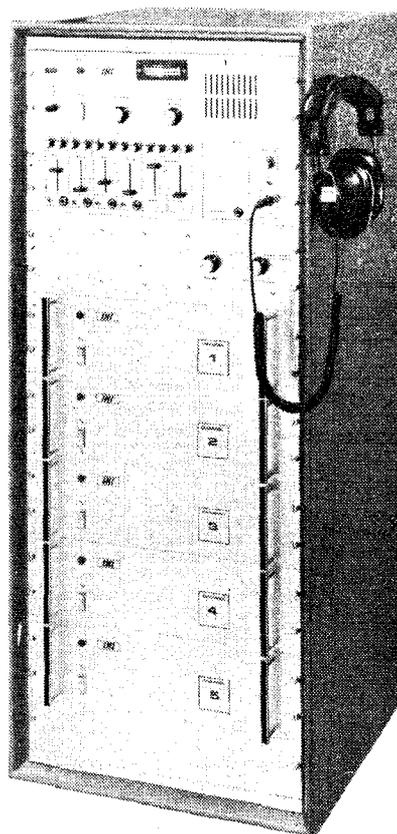
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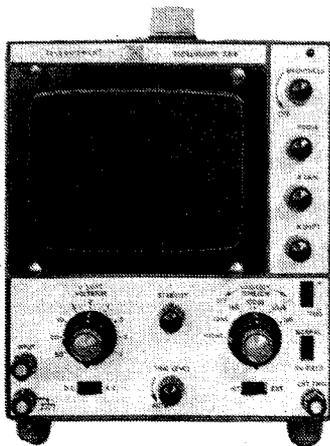
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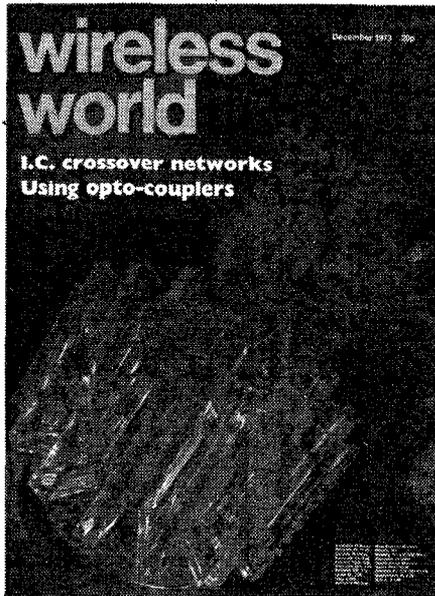
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wireless world

Electronics, Television, Radio, Audio

DECEMBER 1973 Vol 79 No 1458

SIXTY-THIRD YEAR OF PUBLICATION



This month's cover picture shows part of a demonstration of holography by Cambridge Consultants Ltd using a helium-neon laser. The acrylic injection moulding in the foreground is the object being holographically reconstructed. (Photographer Paul Brierley)

In our next issue

Horn loudspeaker design. First part of an article covering the development and appraisal of design techniques. The series will conclude with comprehensive tabulated design data and two constructional designs, for a "mini" and a "no-compromise" horn.

Electronic piano. A constructional design for an instrument which simulates the keying action of a conventional stringed piano and costs about £70.

Publication date. We apologize to readers for the lateness in publication of this issue, resulting from production difficulties at our printers.

ibpa

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Brief extracts or comments are allowed provided acknowledgement to the journal is given.

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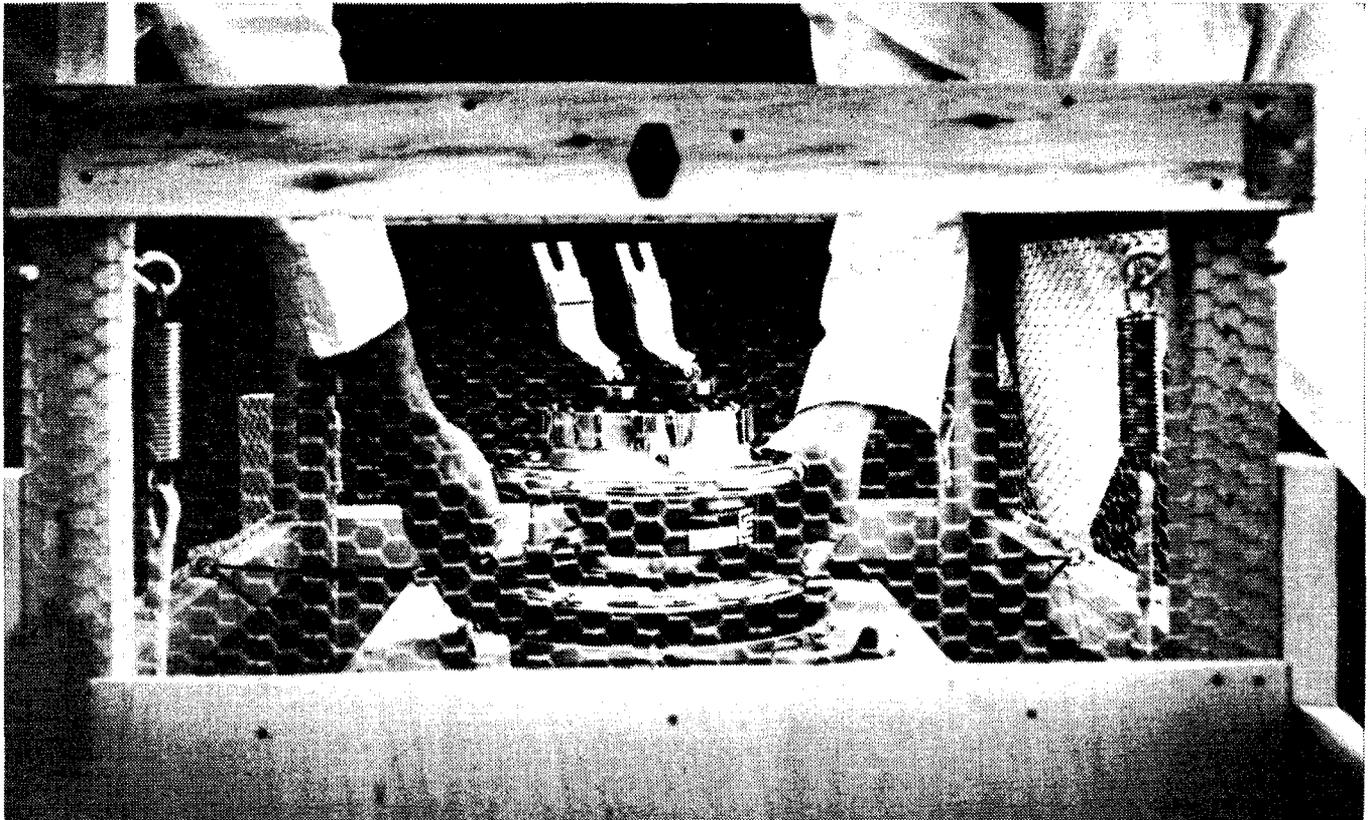
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LAP 63

wireless world

The Costs of Engineering

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In his presidential address to the I.E.R.E. Dr Ieuan Maddock criticized engineers for their apparent lack of awareness of the commercial realities of their work. "Probably the most persistent defect has been the engineer's reluctance to take cost into consideration. . . . In nearly every project I have had contact with . . . I have seen this unwillingness to face the full significance of costs and a realistic appraisal of what they may be. . . . A very few engineering projects stay within the cost forecasts, all too many greatly exceed them. . . . All too often the engineer underestimates the difficulties which will arise as the scale of the project is expanded out of the laboratory or conceptual phase."

Statements of this kind are not exactly revelations: in fact they have become part of the conventional wisdom on engineering. For this very reason they deserve to be taken out and examined from time to time. For example, when someone speaks of engineering costs rising excessively or not staying "within the cost forecasts" this must mean in relation to some pre-determined figure. It is purely relative matter. The questions then arise: who sets this figure; by what criteria is it determined, and by virtue of what superior knowledge? If, in this relative situation, we are going to question the ability of the engineer to keep his costs within a forecast we are also entitled to question the competence of those who make the forecast.

In some cases the cost limit will be set by the customer; in other cases by a group of senior men in a manufacturing company with a mixture of engineering, accounting and management skills. Where the engineering task does not require great originality the cost forecast can be made with some certainty, from experience of earlier projects of a similar kind. But where the engineering has to break new ground technologically there can be no such certainty. The costs are determined by the difficulties which the engineer does not initially know he is going to encounter. The costs are discovered by the engineer as he goes along. This is in the nature of technological progress. People are horrified at the escalating costs of designing the Concorde and the Rolls-Royce RB211 aero engine: they should really be horrified at the temerity of those who made the original forecasts.

In some projects the cost estimators are making what is not, in fact, a rational or an empirical judgement but, far more difficult, a value judgement, in which they could well make a mistake: what is the value of this engineering task to those who are going to benefit by it? In some terms the Apollo space programme could be considered a colossal waste of money; in other terms the cost of putting American men on the moon was socially justifiable because it repaired the morale of the American people after the Sputnik shock.

Of course, there is good engineering and bad engineering. But basically the task of the engineer, as he sees it, is to find the most economical, and elegant, solutions to problems set him by society. If the most economical solution to a problem turns out to cost more than some initial estimate we should look again at the problem and how it has been financially assessed before we blame the engineer.

Active filter crossover networks

Using i.cs in a flexible design to improve performance of a three-unit loudspeaker system

by D. C. Read, B.Sc

A complete loudspeaker system should have a uniform response, at least when measured in non-reverberant conditions. This implies that a degree of equalization is necessary between the multiple drive units of a system which have different efficiencies at different frequencies. The result is wasted energy and low efficiency when a passive crossover is used as an equalizer in addition to band-splitting. Also, a passive crossover network with the additional frequency dependent impedances between the amplifier and the individual loudspeaker units, required to shape the signal voltages, means that the advantage of a high amplifier damping factor (typically between 20 and 60) is lost. Because of the reduction in damping, the moving coil speaker is prone to overshoots, resonances and transference of internally reflected sounds which re-excite the cone. A solution to these problems inherent in multiple drive unit systems using passive crossover circuitry is the use of active filters with separate drive for each unit; the full transient component of the voltage waveform then has the best chance of being faithfully converted into sound.

In addition to overcoming the damping problem, active filters and separate drive will allow any part of the characteristic to be adjusted to any level, and give a choice of slopes in any part of the frequency band.

On analysis of well established passive crossovers for speakers with enclosure volumes of less than 3 cu. ft, the voltage across units in the range 1kHz to 5kHz may be between 8 and 10dB down on those at the extreme ends (i.e. below 300Hz and above 10kHz). If the bass were equalized with the mid-band level, 4dB reduction of pressure response from 200Hz to 20kHz would be necessary. The 3-4dB bass level change may well be appropriate for speakers on the floor, but the bass performance can be also affected by a corner position, a wall, or a free standing shelf. There is, therefore, a need for bass drive voltage adjustment to allow for these room effects. Resonances that occur between the passive crossover network and the speaker units make it difficult to design and make adjustments. A factor of two change in crossover component value may be necessary because of the changing impedance of the voice coil over the frequency bands. Also, during a frequency response test the resonances can produce a near zero load impedance which

can be unfortunate for the amplifier if it is not protected. If it is protected distortion will occur at these resonant points.

The design to be described was built as a result of the article describing the construction of a transmission line loudspeaker¹ so that a comparison could be made between the recommended Radford FN10 crossover unit and the active filter. From the voltage/frequency curves for the passive crossover network active filters were designed for a close voltage match. Summarizing the advantages of active filters, we have independently adjustable crossover frequencies and voltage levels, the power amplifier drives the speakers directly and maintains a high damping factor, and intermodulation distortion in the amplifier is reduced as the frequency bands are split before the signal is fed to the amplifier.

Of the circuit configurations available, the active element with a relatively low

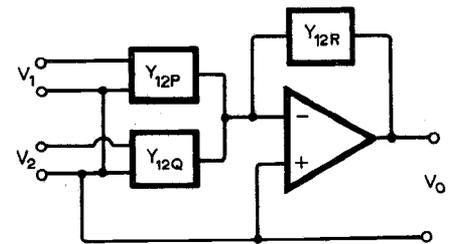
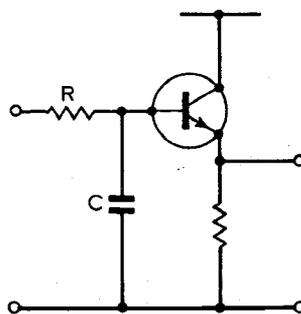
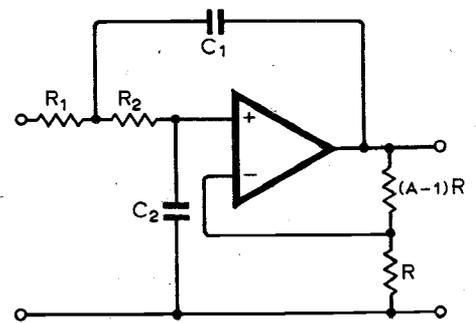


Fig. 1. Op-amp used in a dual summing single feedback configuration. See text for the input/output relationship.

Fig. 2. Circuit sections for (a) low pass, 6dB/octave (b) low pass 12dB/octave (c) high pass 6dB/octave and (d) high pass 12dB/octave active filters.

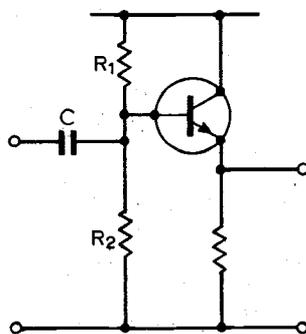


(a)

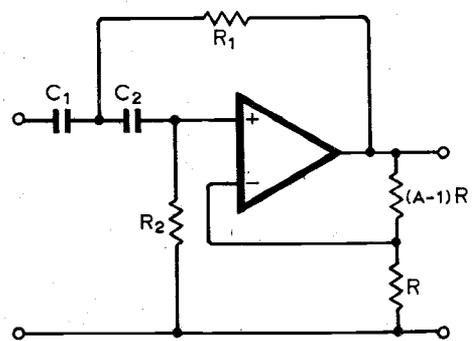


$$f_o = \frac{1}{2\pi} \sqrt{R_1 R_2 C_1 C_2}$$

(b)



(c)



$$f_o = \frac{1}{2\pi} \sqrt{C_1 C_2 R_1 R_2}$$

(d)

gain was chosen—the so-called “controlled source”—for the following reasons: a minimum number of network elements is required; output impedance is low and characteristic adjustment is simple.

Active filter network

From the general circuit in Fig. 1, and making the usual assumptions for op-amps, the dual summing single feedback configuration is defined as

$$V_o = - \left[\frac{Y_{12P}}{Y_{12R}} V_1 + \frac{Y_{12Q}}{Y_{12R}} V_2 \right]$$

The frequency pass-band function for low pass is

$$\frac{V_o}{V_i} = \frac{-A}{s^2 + \alpha s + 1}$$

and high pass is

$$\frac{V_o}{V_i} = \frac{-As^2}{s^2 + \alpha s + 1}$$

where *A* is a positive real constant specifying the gain in the pass-band and $\alpha = \sqrt{2}$ for a maximally flat response.

The band-pass expression has not been included as the active filter circuit gives a performance similar to an *LC* circuit at resonance. For the band-pass section feeding a mid-range unit, a flat pass band is required with independent control of the upper and lower roll-off characteristics and this can be obtained by putting l.p. and h.p. sections in tandem.

Fig. 2 shows the complete circuit sections for active filters with cut-off slopes of 6 or 12dB/octave. A relatively low-gain configuration ensures minimum number of network elements, low output impedance and ease of characteristic adjustment.

Practical circuit

Fig. 3 shows the three-way active filter circuit with each channel fed to a separate 30W (peak) power amplifier. Fig. 4 shows an

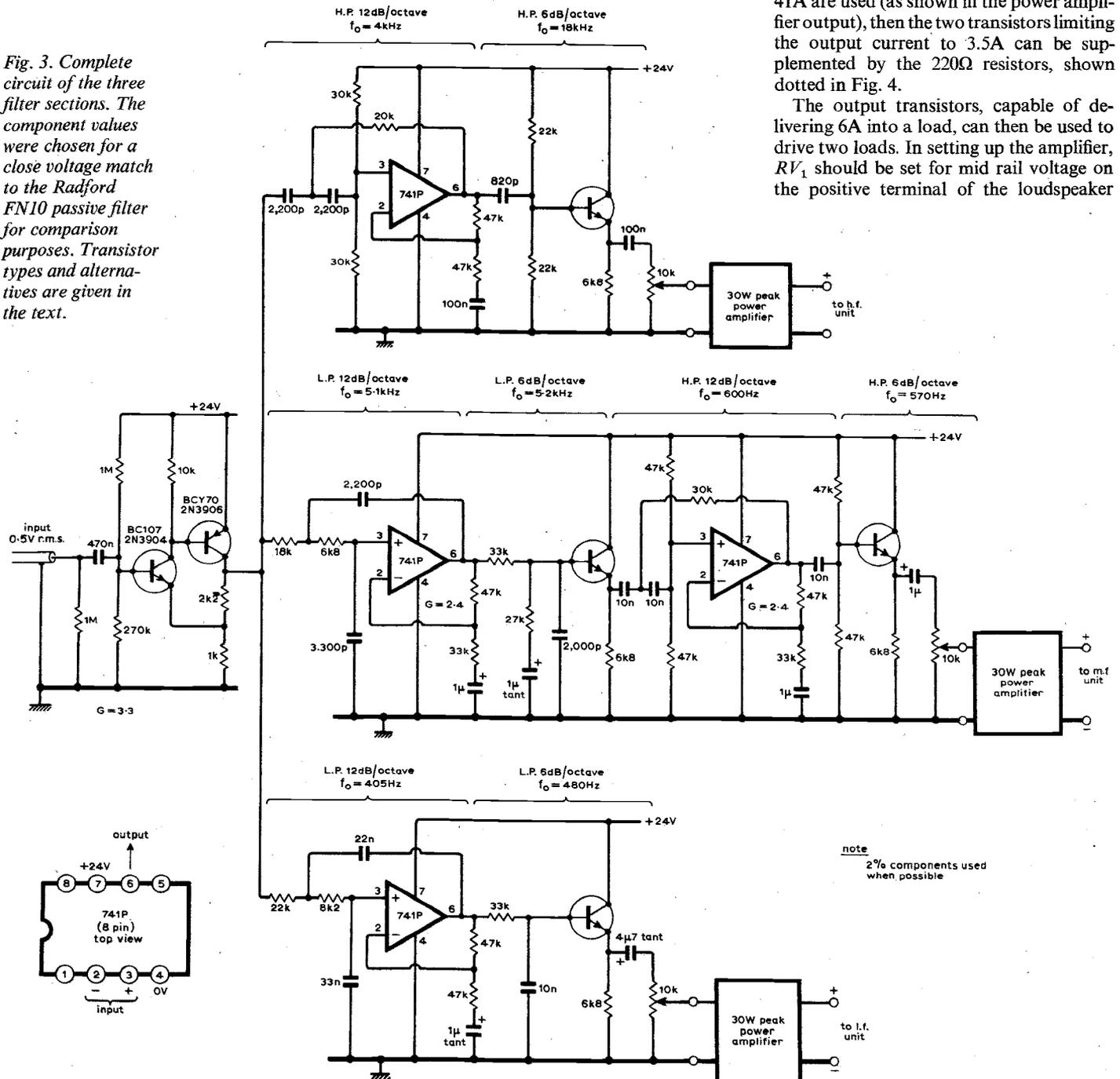
example of a suitable power amplifier—a modified version of a Texas design². The modifications are: larger amount of feedback to reduce gain; the active filter sections are operated at a relatively high level to reduce their cross-over distortion and noise contributions; 100Ω resistors are added in the emitters of the input long-tailed pair to improve stability with the increased feedback; two transistors are added (150Ω in their bases) to limit the output current to 3–3.5A maximum; for the m.f. and h.f. amplifier cards, smaller “*C*” values can be used as the lower frequencies are not present. An improvement in the quiescent current stability with temperature variations in the output stage is obtained by using a plastic transistor *Tr*₄ in a clip attached to an output transistor heat sink.

The loudspeaker coupling capacitor should have the following values: l.f. amplifier 2,200μF; m.f. amplifier 470μF; h.f. amplifier 100μF.

Note that if the transistors TIP42A and 41A are used (as shown in the power amplifier output), then the two transistors limiting the output current to 3.5A can be supplemented by the 220Ω resistors, shown dotted in Fig. 4.

The output transistors, capable of delivering 6A into a load, can then be used to drive two loads. In setting up the amplifier, *RV*₁ should be set for mid rail voltage on the positive terminal of the loudspeaker

Fig. 3. Complete circuit of the three filter sections. The component values were chosen for a close voltage match to the Radford FN10 passive filter for comparison purposes. Transistor types and alternatives are given in the text.



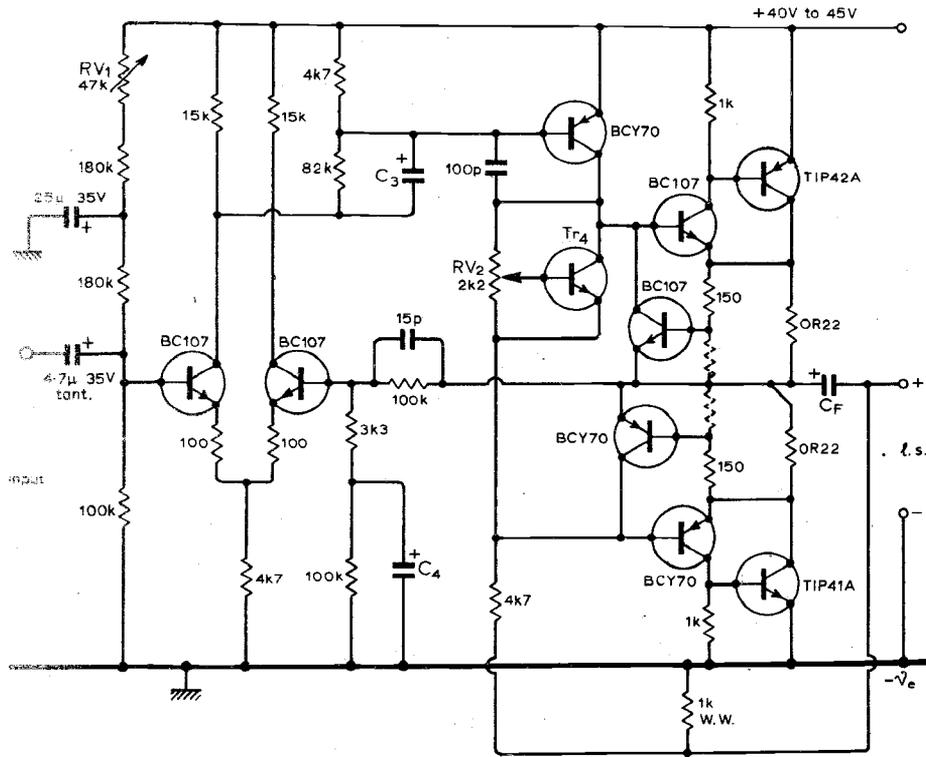
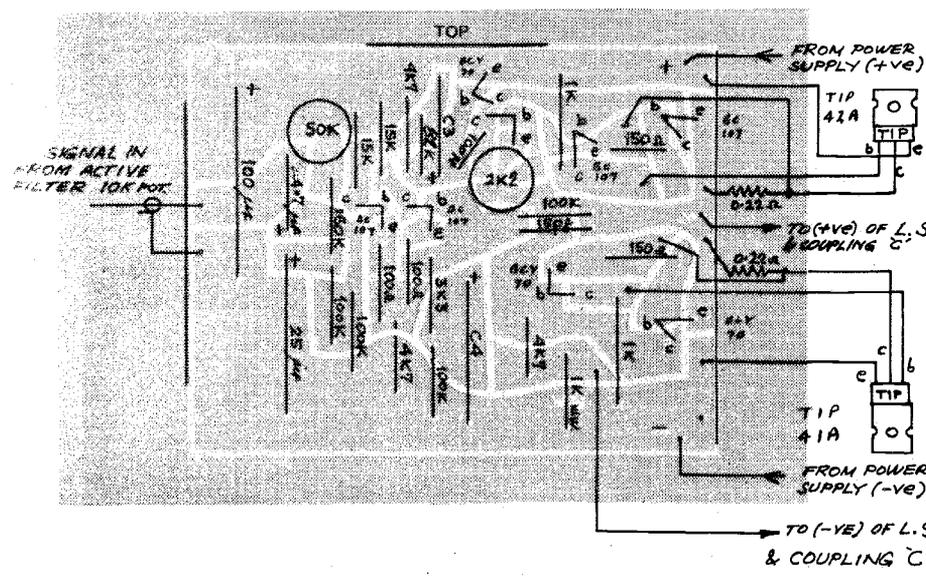
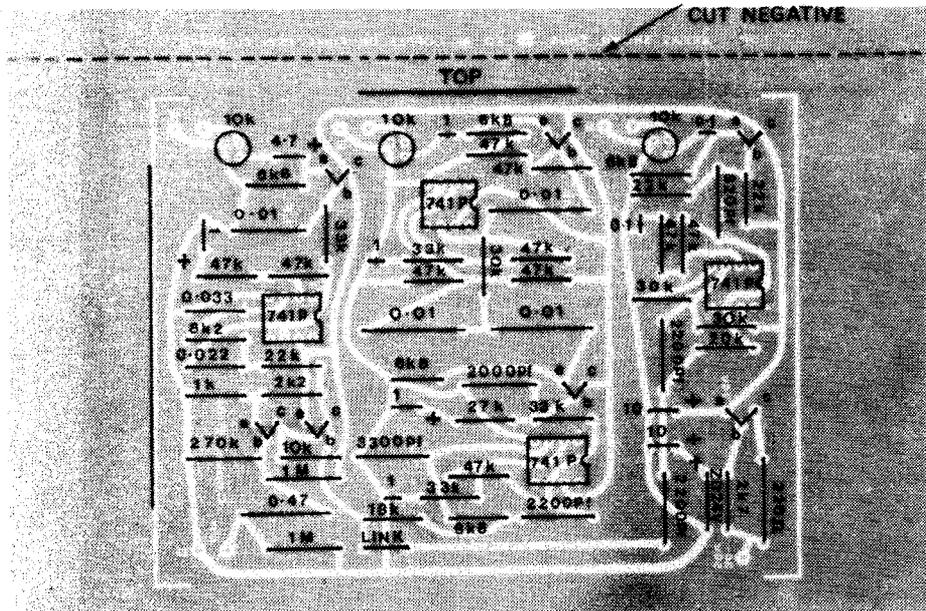


Fig. 4. Suitable 30W amplifier for use with the active filter sections.

Fig. 5. Board layout for the active filters.

Fig. 6. Component layout of the power amplifier.



coupling capacitor and RV_2 should be set for 50mA with the amplifier at room temperature (approximately 24°C).

From the voltage response for the passive crossover network, the active filter sections are designed for a close voltage match. The slopes required at crossover were met by using 6dB/octave and 12dB/octave sections in tandem. By using different "break" frequencies, f_0 , in the 6 and 12dB/octave sections, sharp changes in the response curve were softened, to simulate the passive crossover curves (not necessarily providing optimum performance, but providing a direct comparison of the two types for this particular example, in fact lowering the upper crossover frequency by approximately 2kHz gave an improvement of the performance to my ears). Adjustment of the passband gain in the 12dB/octave sections will also change the response curve shape.

To set up the filters when no comparison is to be done, the output from bass/midrange and midrange/tweeter should be equal at the crossover frequencies. This can be achieved simply by the use of a microphone, a signal level meter (VU) and an audio oscillator. Set the input from the oscillator at each crossover frequency in turn and adjust the signal level from each unit to be equal with each unit connected individually.

A second method, for matching with the FN10 passive crossover, also requires an a.f. voltmeter or c.r.o. It is worth first connecting the a.f. voltmeter direct to the audio oscillator to check that the voltage output is constant from 100Hz to 12kHz and/or the voltmeter reading is independent of frequency.

Set the b.p. active filter 10kΩ pot to $\frac{1}{3}$ clockwise and the frequency to 2kHz, connect the oscillator to the active filter input and adjust the output for, say, 1V across the midrange unit. Reset the frequency to 100Hz and transfer the voltmeter to the bass unit. Set the l.f. 10kΩ pot for 1V. For the h.f. unit, set the frequency for 11.5kHz, reconnect the voltmeter to the tweeter and adjust the h.f. 10kΩ pot for 1V.

Note that for stereo reproduction, six 30W amplifiers are required for a three unit speaker system. Peak powers of 20W occurred in all the three bands, and so a low power amplifier for the tweeter is not possible, but only a small heat sink is required.

Transistor alternatives

The transistors used in the active filter circuit can be BC107 or 2N3904 (n.p.n.) but the p.n.p. is BCY70, 71, 72 or 2N3906. Several other equivalents exist which would be suitable.

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2. Texas B68 application report.

Realm of Microwaves

7. Microwave antennae — phased arrays

by M. W. Hosking, M.Sc.
British Aircraft Corporation

The previous article concentrated on types of microwave antenna formed by a radiating aperture, either radiating directly or by reflection. Such an aperture can be considered as formed by a very large number of individual radiators and the radiated pattern as being the product of the individual patterns, i.e. a two-dimensional array. In many cases, it is just not sensible to try and replace say, a dish reflector, with a multi-element array when size becomes too great for a single reflector unit. This usually occurs at low operating frequencies and below the microwave band arrays have been well-established as the only practical method of obtaining a reasonable directivity. However, due particularly to improvements in solid-state control devices, arrays are steadily increasing their application in the microwave band.

By controlling the frequency, power and phase from each element of the array, shaped beams can be formed which can be steered without physically moving the antenna. Another important feature is that higher power densities can be produced from an array than from a continuous aperture, as each element can have its own source of power. The overall result is an antenna system capable of radiating single or multiple beams at high power levels which can be electronically scanned over wide angles at rates many times faster than mechanical systems. Microwave arrays, however, do have the disadvantages of cost and complexity and also of weight in airborne applications.

Before indicating some methods of beam steering and beam shaping, it will be useful to outline the basic relationships which affect the array pattern. Using the nomenclature of Fig. 1, we can take the simplest case and ignore all the elements except for any two adjacent ones and also assume that the electric field amplitudes are equal. The electric field of each element can be represented by an amplitude vector having a phase referenced to some convenient point and the total array field will be the sum of those individual vectors. So, taking elements 1 and 2, with 1 as reference, we wish to find the resultant field in the direction θ .

The relative phase of 2 is influenced first by the physical spacing, S , which produces the path difference $S \cos \theta$ and also by an arbitrary phase, ϕ , which can be selected

by the array operator. Thus, if the electric field amplitude of each element is E the total field of the two-element array can vary between $2E$ when the vectors are in phase, to zero when they are in phase opposition. In general, the sum is

$$E(\theta) = E \left[1 + \exp j \left(\phi + \frac{2\pi}{\lambda} \cdot S \cos \theta \right) \right]$$

By giving ϕ various values and taking the modulus of $E(\theta)$, the field patterns of a two-element array can be plotted and these can be repeated for various values of S .

Fig. 2 shows some of the patterns which can be produced from two elements as a function of spacing and phase difference; these particular combinations having been chosen because they form the basis of various other types of antenna. Note, for instance, the difference in pattern between

the $S = \lambda/4, \phi = \pi/2$ doublet and the $S = \lambda/2, \phi = 0$ doublet. In the former, the main beam lies in the direction of the axis and is termed an end-fire array. The right-hand element behaves as if it were a reflector, in this case it is leading the other element by $\pi/2$, and it is not necessary to current-feed this element to produce the end-fire pattern, as it will re-radiate the field induced by its partner.

This arrangement forms the basis of the Yagi array which at the lower frequencies is most commonly used as a domestic v.h.f. antenna. The case when $S = \lambda/2, \phi = 0$ is termed a broadside array, as the pattern is now normal to the array axis and is the most usual case. In practice, something must obviously be done about the twin radiation patterns and a reflecting screen can either be placed behind the array to reflect half the

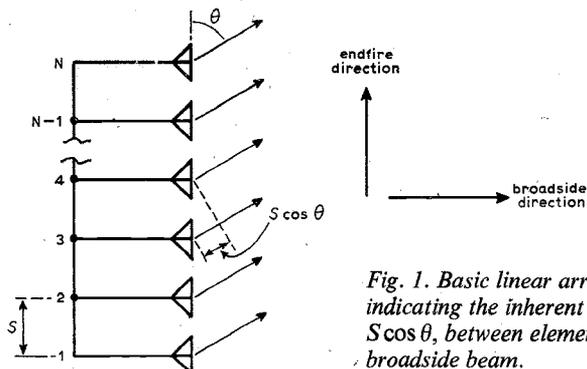


Fig. 1. Basic linear array geometry indicating the inherent path difference, $S \cos \theta$, between elements for a non-broadside beam.

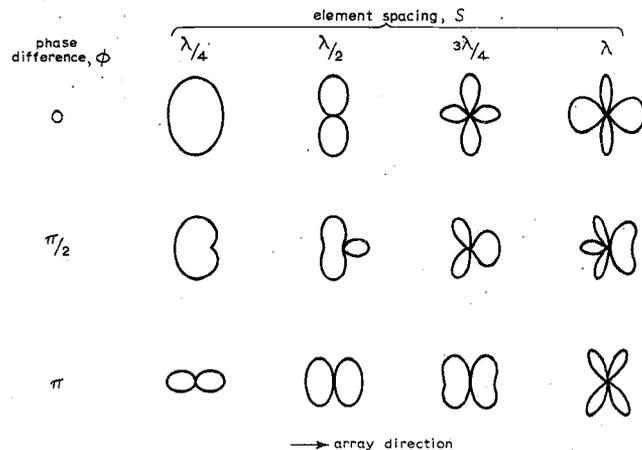


Fig. 2. Radiation pattern from a simple two-element array can assume many shapes, depending on the spacing and the phase difference between the feeds. For spacings greater than $\lambda/2$, the pattern starts to break up into an increasing number of lobes.

radiation back again; or alternatively it can be absorbed.

With a larger number of array elements, N , all being fed with or receiving equal-amplitude fields the overall radiation pattern is still found by summing that of each separate element. In this case, the above equation becomes a geometric series whose sum is

$$E(\theta) = \frac{E \sin(N\psi/2)}{\sin \psi/2}$$

where
$$\psi = \phi + \frac{2\pi}{\lambda} S \cdot \cos \theta$$

It is usual to work with the radiation power pattern, $P(\theta)$, which is the square of the field amplitude pattern and also to normalize the amplitude to the peak value of the electric field. This peak value is simply $N \cdot E$ so that theoretically the radiation pattern of a uniform (equal amplitude) array is

$$P(\theta) = \frac{\sin^2 N/2(\phi + (2\pi/\lambda)S \cdot \cos \theta)}{N^2 \sin^2 \frac{1}{2}(\phi + 2\pi S \cdot \cos \theta)}$$

So far, nothing has been said of the radiation properties of the individual elements themselves; they could be dipoles, waveguide horns or any form of directive radiator. The second equation applies to an array of isotropic sources and is sometimes called the array factor. When applied to any array of directive elements, the radiation pattern is obtained by multiplying the radiation pattern of an individual element by the array factor. In practice, however, things are not quite that simple as the radiating properties of each array element are modified by the presence of its neighbours in the array. Thus, accurately predicting side-lobe patterns and wide-angle beam distortion in a large array becomes quite a task and usually involves much empirical information. The array factor contains all of the parameters which can be varied to alter the array pattern and because of this, is worthy of further study, even if in practice an ideal spacing or phase difference has to be modified to counteract mutual coupling.

A special case of the uniform array considered so far, is the uniformly illuminated array wherein there is no phase difference given to the element feeds. Taking the broadside case, the doublet patterns of Fig. 2 show that a half-wavelength element spacing is needed and we can substitute into the last equation for $\phi = 0$ and $S = \lambda/2$. The denominator has a sine function which can be replaced by its argument, so that the equation becomes

$$P(\theta) = \left[\frac{\sin \frac{1}{2}(N\pi \cos \theta)}{\frac{1}{2}N\pi \cos \theta} \right]^2$$

which is of the form $[(\sin x)/x]^2$ and is the same type of pattern as that produced by the uniformly illuminated rectangular aperture, covered in the last article. The 3-dB beamwidth occurs when $P(\theta) = 0.5$, which is when $x = 1.39$. For arrays in which N is greater than about 5, the 3-dB beamwidth can be simplified to $102/N$ degrees. The directivity of this array can also be simply expressed as being equal to the number of elements, N .

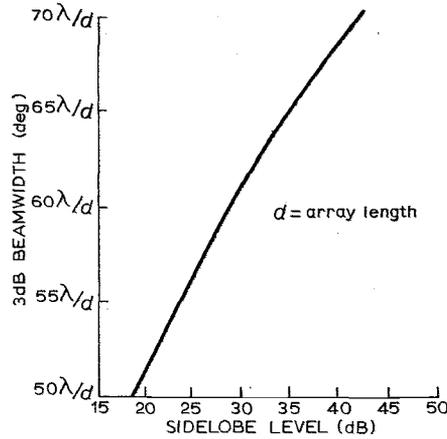


Fig. 3. When designing arrays having a Tchebyscheff amplitude distribution, a direct trade-off can be made between the half-power beamwidth and the sidelobe level. In this case, all sidelobes have equal amplitude.

A factor to be borne in mind when choosing the element spacing for an array is the appearance of what are termed grating lobes, analogous to the interference fringes of optics. These occur whenever the path difference between elements in a particular direction is a multiple of 2π radians and they take the form of a radiation lobe equal in amplitude to that of the main one. For an array which covers all angles from broadside to end-fire, then the element spacing must be $\lambda/2$ or less to prevent grating lobes, but they can also be suppressed for larger spacings by using directive elements at the expense of the full coverage.

The aperture antenna, a dish reflector for example, has been compared to a two-dimensional array in which the number of

elements is very large and the preceding article showed how the radiated pattern, particularly the side-lobe level, could be varied by the type of amplitude distribution across the aperture. In that case, the amplitude taper could only be produced by the feed antenna and reflector geometry, thereby restricting the taper to a few fairly simple distribution laws such as uniformly illuminated and cosine. These restrictions do not apply to the array where one has control of the feed to each individual element and can therefore produce any type of amplitude distribution.

In practice, there are a number of standard distributions on which most array beam-shaping is based and, while it is not necessary to get involved with the mathematics, the main functions are interesting. It has already been shown that the uniformly illuminated aperture—one across which the electric field amplitude and phase is constant—is the most efficient distribution and gives the highest directivity. However, the first sidelobe level is only 13.2dB below the main beam and many microwave systems require a much lower rejection. With the loss of about 2dB in directivity, a cosine distribution gives a sidelobe level of about -23dB.

Another important and widely-used distribution is based on a mathematical function called a Tchebyscheff (also spelt Chebyshev) polynomial. Defined as $T_n(x) = \cos(n \cos^{-1} x)$, this can be expanded as a series, for instance $T_6(x) = 32x^6 - 48x^4 + 18x^2 - 1$ and by putting $x = \cos \psi/2$, the coefficients of this series can be equated with those of the complete form of the first equation. If the field amplitude at each element across the array is then varied in accordance with this polynomial, the radiated pattern will follow a Tcheby-

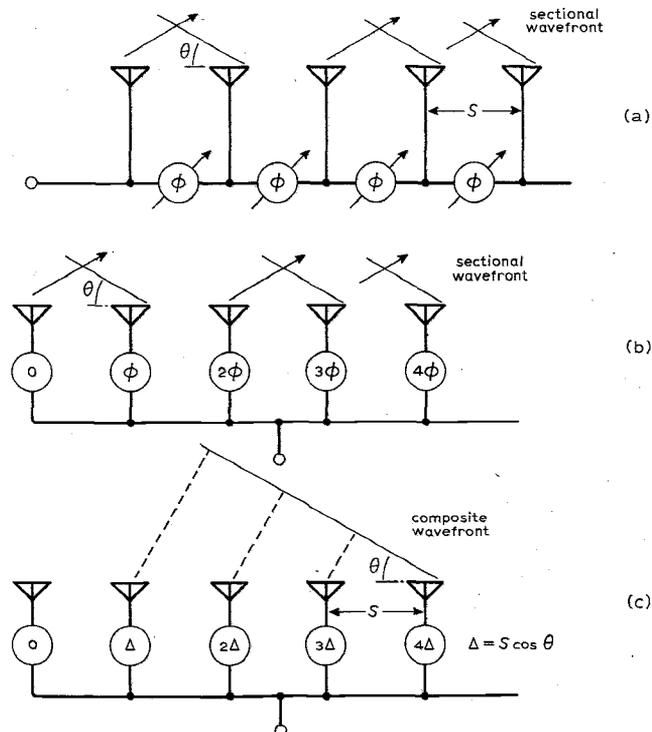


Fig. 4. Series-fed array (a) introduces more phase-shifter loss than the parallel arrangement (b), but requires more duplication of control circuitry. In each case, the phase-shift is given by $\phi = (2\pi S/\lambda) \cos \theta$ radians. For very short pulses, the transit time across the array produces distortion and a compensating delay of $S \cos \theta$ must be introduced (c).

scheff law. The result will be a pattern consisting of a single main lobe and sidelobes, but all of the sidelobes will be of equal amplitude and the beamwidth of the main lobe will be a minimum.

Aperture efficiency is quite high and sidelobe levels more than 35dB below the main lobe can be obtained for a loss in gain of about 1dB below that of the uniformly illuminated aperture. Fig. 3 shows the dependence of beamwidth on sidelobe level. This Tchebyscheff polynomial is a very useful one and is also used extensively in microwave filter design where by specifying a tolerable band-pass ripple the rate of cut-off is maximized. In this case the resonator coupling impedances are made to follow the coefficients of the series.

A special case of the Tchebyscheff polynomial is when the sidelobes are zero and the function then becomes a binomial series. Allowing the feeds to the elements to follow the binomial coefficients, the sixth-order series for instance being 1 6 15 20 15 6 1, results in a relatively wide beamwidth and for larger numbers of elements a wide variation in amplitude. Consequently, the Tchebyscheff amplitude taper is more popular. There are many other variations of beam shaping by amplitude taper, depending on application; when a Tchebyscheff distribution is applied to directive elements, the sidelobe level decreases instead of remaining constant due to the multiplication of the patterns. Thus, a small reduction in beamwidth is possible by making the array factor have increasing sidelobes which become uniform when multiplied by the element pattern. Another version is to use a modified form of $(\sin x)/x$ distribution which produces sidelobes that decay very rapidly in amplitude away from the main beam. This is useful in low-angle tracking radar, both in reducing the antenna noise figure and in keeping out spurious signals from the ground.

Electronic steering

Enough then of beam shaping by amplitude tapering and on to the major feature of the array: that of electronically varying the direction of the main beam. Within the angular coverage restricted by the appearance of grating lobes and pattern distortion, the array beam may be pointed in any direction by varying the phase shift between elements. Further, the beam can be switched from one position to another at rates which are orders of magnitude faster than those obtainable by mechanically moving the antenna.

Fig. 2 and the first equation showed that for half-wavelength spaced elements the main beam is broadside ($\theta = 0$) when there is no incremental phase shift between elements ($\phi = 0$). The beam may be repositioned at some other angle, θ , by making $\phi = (2\pi/\lambda)S\cos\theta$. For example, an inter-element phase shift of 45° would incline the main beam at about 75.5° to the horizontal. The array elements may be either series-fed or parallel-fed as shown in Fig. 4 and the phase shifters themselves could take on a variety of circuit forms. This is an application for which the p-i-n diode (described in part 5) finds much

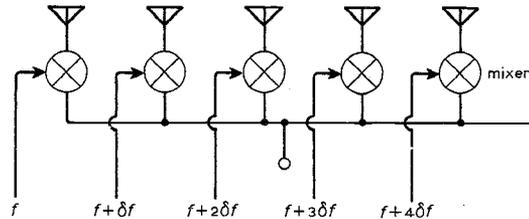


Fig. 5. Offset frequency method of scanning produces an inter-element phase shift by mixing the received signal at each element with a harmonically related frequency increment.

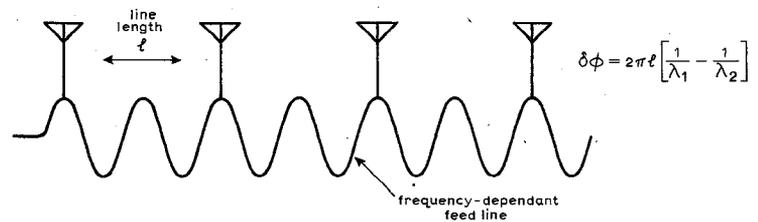


Fig. 7. Swept-frequency scanning varies the phase because of the frequency-dependant length of line between each element. A fairly wide sweep is necessary and scanning is limited to only one plane, but this method does eliminate the complex phase-shift circuitry of other types of array.

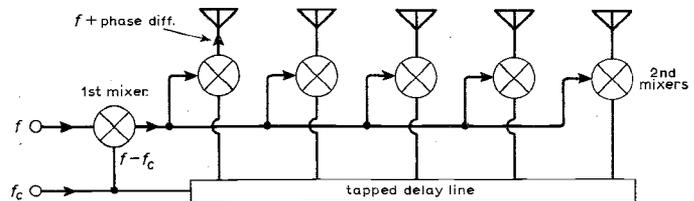


Fig. 6. In this method due to Prof. Huggins, the phase difference is produced in a tapped delay line and preserved in the mixing process at each element.

application and for medium power arrays a circuit such as that of Fig. 8 of that article might be used.

It can be envisaged from Fig. 4 that quite large quantities of microwave components are used in an array. Besides the passive feed circuitry which must be duplicated for each element even a simple phase shifter like the one referred to uses eight diodes to produce 22.5° increments of phase shift; so a square array of say 100×100 elements would have of the order of 10,000 feed branches, matching circuits and phase shifters and 80,000 diodes. Each of the diodes must be connected to the logic control circuitry—invariably a computer—and it is apparent that the series-fed array can operate with the same signal applied to each phase shifter as the phase states are all the same.

With the parallel-fed array, each phase shifter contributes a different amount of phase, although this is periodic with 2π radians, so that the control circuitry is more complex. To offset this, the series-fed array is more lossy as most of the signals have to suffer the insertion loss of several phase-shifters whereas they are only affected by one phase shifter in the parallel-fed case.

A problem which arises in phased arrays of this type is due to the path length from one end of the array to the other. Taking the series-fed case, if the array is long and the signal pulse width is short, then it is

possible for the first element in the line to have largely finished radiating the pulse before the last one has started. The result on a radar system is to have a badly distorted input signal and loss in detection efficiency.

The total path length difference across the array is made up from the inter-element differences, $S\cos\theta$. If the signal in the feed to each element is delayed by successive increments of $S\cos\theta$, the result will be a smooth wavefront with no signal distortion as depicted in Fig. 4(c). The delay elements themselves might be similar in form to the phase shifters, but would use the p-i-n diodes to switch additional lengths of transmission line in and out of circuit.

This, then, is the basis of scanning an array beam by varying the phase shift between each element. Invariably this is done digitally, either by switching a ferrite phase shifter between states or by switching p-i-n diodes on and off. The main beam of the array therefore jumps from one position to the next with the smallest jump corresponding to the smallest available phase increment. Analogue, or continuously-variable phase shifters, such as might be obtained by using varactor diodes instead of p-i-n diodes, are not yet practical due to the difficulties in manufacturing diodes with identical tuning curves and the more complex control circuitry required. Nor is there any great advantage in analogue operation

as the digital array beam can be steered in increments of about a beamwidth and can scan its allotted sector in space in a time close to a pulse width.

Typically, the array might consist of a group of half-wave dipoles or open-ended waveguides spaced a half-wavelength apart and arranged in the form of a square. A 2.5° beamwidth, X-band (8,200 to 12,400MHz) array might contain 2,500 elements in a 50×50 square. Each element can then be given a row and column identity in the matrix and allotted its appropriate phase by the control circuit. The control circuit itself can be as complicated as required, ranging from a couple of 360/651 computers with vast memories for automatic radar systems to a continuous-loop tape recording for continuous scanning, with the operator making all the decisions.

Although common, particularly for light-weight airborne application, beam steering by digital phase shifters is not the only way of doing the job. A technique particularly useful in a receiving array is the offset frequency method depicted in Fig. 5. Each array element has its own mixer, to which the received signal is directed, but the local oscillator frequency to each mixer varies by a fixed increment, Δf , along the array. The local oscillator frequency is itself derived from another mixing process in which the filtered harmonics, Δf , from a pulsed oscillator are added to a stable frequency, f . The scanning rate of the beam is given by $d\theta/dt = (\lambda/S)\Delta f/\sec \theta$ and is thus proportional to the rate at which the basic oscillator can be pulsed. Popular at the lower end of the microwave spectrum, this method has been used in r.f. propagation studies.

Another way of steering the beam using frequency control is called the Huggins method and is shown in Fig. 6. The transmitter frequency f_0 is mixed with another control frequency, f_c and the i.f. $f_0 - f_c$ is extracted and fed to an array of second mixers, one to each element. At the same time, a sample of the control frequency is fed through a delay line from which regular taps pass to the second mixers. The portion of f_c which travels the delayed route still preserves its frequency identity, but is out of phase with the portion at the first mixer by an amount $\phi = 2\pi f_c \tau$; τ being the time delay at each element. At the second mixers, the sum frequency is taken at the output which is the original frequency retarded in phase by the amount ϕ . Thus, changing the control frequency changes the element phase proportionally and thereby the angle of the radiated beam.

If certain limitations in performance can be tolerated, then all of the complex phase-shift circuitry associated with the previous arrays can be eliminated and use can be made of the frequency-dependent properties of the element feed structure. The method is known as frequency scanning, a simple arrangement being shown in Fig. 7 which consists of a long length of transmission line with periodic tapping-off points to the array elements. Waveguide is commonly used as the transmission line, folded into a serpentine-like shape to increase its length. The electrical length of the section of line between elements is $2\pi L/\lambda$ radians and is

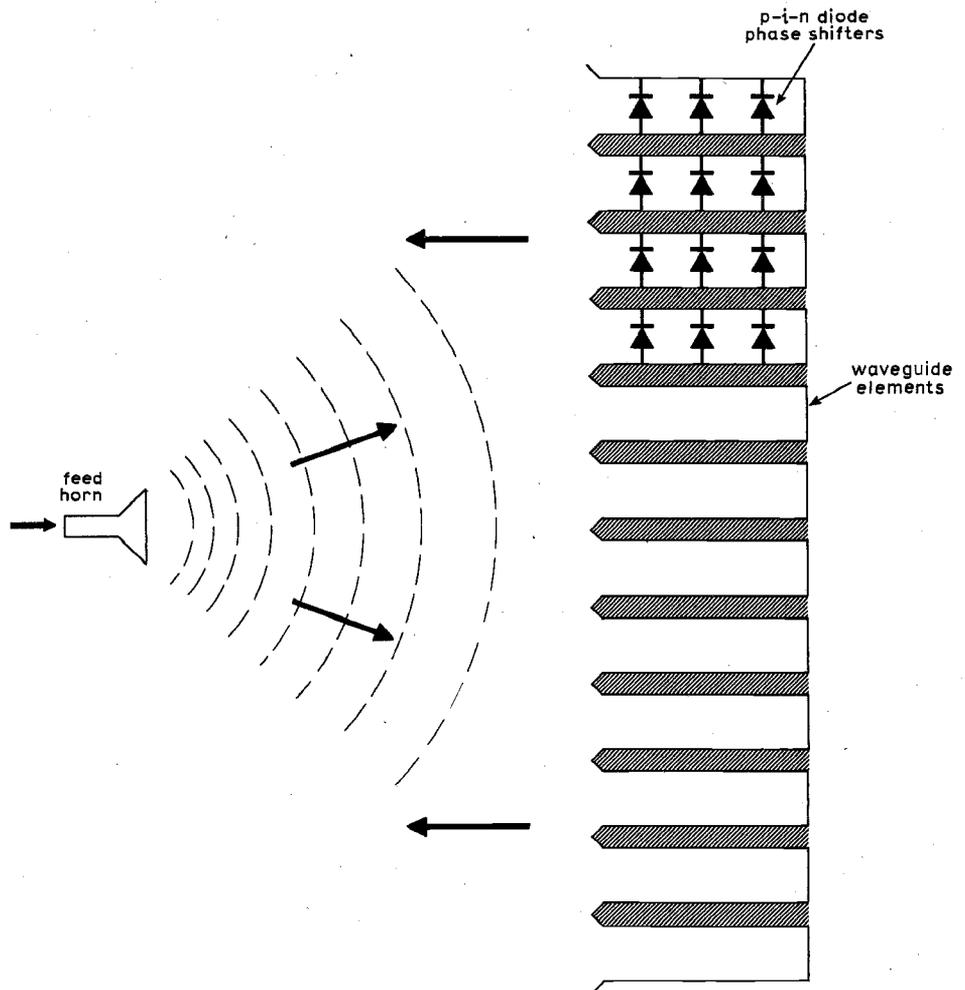


Fig. 8. Reflectarray combines the principles of the dish reflector and the phased array and cuts out most of the feed distribution circuitry. Phase of each element can be adjusted to compensate for feed errors and for sidelobe level and scanning symmetry.

thus a function of frequency and is chosen so that at a particular frequency, the beam points in a given direction, usually broadside.

As the frequency is increased, the inter-element phase increases and the array beam will scan on one direction along the line of the array. Conversely, a decrease in frequency will scan the beam in the opposite direction. Speed of scan depends on the rate at which the frequency can be changed and can thus be fast, but large frequency excursions are required for wide-angle scanning. A frequency-scanned linear array such as this radiates a fan-shaped beam and only scans in one plane, coverage in the orthogonal plane requires the complete antenna to be moved.

Alternatively, a two-dimensional planar array can be made from rows of frequency-scanned linear arrays. Instead of moving the complete structure, coverage in the non-scanning plane can be provided by one of the phase-shift methods previously described. This type of system is known as a phase/frequency array and has found considerable application in mobile search radar on land and in ship-borne acquisition radar.

Finally, we can come full circle in comparing the two-dimensional array of elements with the solid dish antenna and mention the "reflectarray"; a hybrid version of those two and one which is now receiving design attention. As shown in Fig. 8, the

solid dish of a conventional reflector is replaced by an array of elements, typically open-ended waveguides, but the feed horn design and the aperture illumination requirements remain similar to those described in the previous article. By using this type of feed, the complicated power-routing network to each element can be eliminated and a single transmitter can be used as the source. The reflection and phase shift properties are produced by loading each waveguide element with shunt-mounted p-i-n diodes as shown.

Their impedance changes between a short and open-circuit depending on the bias control current. A signal entering the waveguide travels a certain distance down the guide and then is reflected out again by one of the diodes, or by the short-circuit at the end of the guide. By varying the position of the diodes in the guide from element to element and by switching the appropriate ones to short or open-circuit, the relative phase between elements can be controlled. Besides steering the beam, this individual control can also be applied to the sidelobe level and to aperture phase errors from the feed.

The degree of individual control available within the array also enables many radiated beams to be generated simultaneously so that the antenna system can look in several directions at once.

Research Notes

Detecting sparks in tankers

Electrostatic sparks are believed to be a cause of explosions in oil tankers. For diagnosing risks of "static" it is useful to have a sensitive spark detector. Dr J. N. Chubb and his associates at U.K.A.E.A. Research Group's Culham Laboratory have obtained promising results with a simple radio receiver, shock excited by the energy from an electrostatic discharge.

The receiver consists of a resonant loop aerial, broadly tuned to 38MHz (bandwidth 2MHz), followed by a Plessey SL 611 wideband integrated amplifier.

Tests made with an artificial spark generator showed that weak static discharges are easily detected. A 19-mm sphere charged to 1kV, discharging to a plane surface, with a charge of 3 nano-coulombs and an energy of 2 micro-joules was detectable at 10 metres. (This compares with the energy of 1mJ required to produce sensation on the human skin and 0.2mJ for ignition of a petrol vapour-air mixture.) A useful feature of the detection system is that it is not sensitive to corona discharges.

For diagnosing tanker problems, it is suggested that receivers inside dark, empty tanks be used to trigger cameras for flash photography of the splashes and falling drops of water etc. which may be responsible for triggering an explosion. To prevent false operation from atmospherics it will be necessary to use two spaced receivers inside the tank and two outside. Coincidence circuits can then be used to distinguish between genuine in-tank "static" and atmospherics.

Is ball lightning a trapped radio wave?

Ball lightning is a rare natural phenomenon which takes the appearance of luminous spheres, about 20cm in diameter, which float some 50cm above the surface of the ground. Ball lightning can also occur in and around flying aircraft. Dr R. C. Jennison of the University of Kent has described how he saw such a ball emerge from the pilot's compartment of a passenger aircraft and float down the aisle to the rear. Other observers have seen balls above the trailing edge of an air-

craft's wing in flight. This seems incompatible with the notion that the balls are made of hot plasma, since they should then be carried off in the slipstream.

Dr Jennison's own explanation is that the balls are the optical manifestation of what he calls a "phase-locked loop" of r.f. energy, meaning a standing wave which is somehow constrained to oscillate in a confined volume of space. The glow could then be explained in terms of a gas discharge energized by the radio wave. Such a packet of radio energy could exist in empty space and does not require the presence of a gas. Being merely a radio wave it could, if electrically bound to a moving conducting surface such as an aircraft wing move freely through the air with the plane. The optical radiation must eventually drain the energy of the wave, causing its disappearance. The size of the ball should depend mainly on the radio wavelength, which fits in with the observation that balls do not shrink in size during their lifetime (of about a minute).

The origins of the balls is not known, but presumably they are products of the thunderstorms with which they are associated.

Do whales hear with their lungs?

Whales emit sounds over a huge range of frequency, from around 20Hz to well into the ultrasonic region. The lowest frequencies are likely to be of use for communication over long ranges, and it would be of interest to know how they are transmitted and received.

A physicist at the U.S. Undersea Centre, San Diego, California, suggests that whales' lungs may act as Helmholtz resonators. The lung volume of a fin-back whale is about 2,000 litres, and should give a resonance at 20Hz. This could perhaps be used as a filter to sort out faint incoming sounds from background noise. (Whales are believed to be able to detect sounds from other whales over a much longer distance than is possible with human technology.) The whale might adjust the tuning of its lungs by swimming at different depths. In this way differences in the sizes of the animals could be catered for.

Nuclear forces linked with electromagnetism

Physicists at the European Nuclear Research Organization (CERN) at Geneva have made an important observation which may help to forge a theoretical link between radioactivity and electricity and magnetism.

The discovery was made when high-energy neutrinos from CERN's 28GeV accelerator were shot through a bubble chamber. The neutrino is a particle with no charge and no mass. Not surprisingly, it seldom interacts with other particles: most of the neutrinos which arrive in vast numbers from the sun pass right

through the earth without hitting anything. Occasionally, however, a neutrino does interact with another particle. Until the CERN experiment the observed result had always been destructive: the neutrino was transformed into an electron or a mu-meson, a change characteristic of the mysterious nuclear "weak force" which is responsible for radioactivity.

A few years ago two theoretical physicists (Steven Weinberg and Abdus Salam) suggested that the nuclear interactions caused by the "weak force" could be considered as electromagnetic interactions. For this to be true, however, it must be possible for neutrinos to hit other particles without being transformed into something else, but merely deflected. This is what has now been observed. Neutrinos have been detected which have collided with neutrons without changing into electrons or mesons. Mathematicians are hard at work defining the links between the weak force and electromagnetism, which are now seen as different aspects of the same thing.

New frequency for interstellar communicators?

When the idea of communications with extra-terrestrial civilizations was first seriously discussed, the most likely frequency was thought to be 1,420MHz. This is the frequency emitted by neutral hydrogen in space, and as such would naturally capture the attention of astronomers, who are greatly interested in the distribution of hydrogen in the universe.

This choice of frequency has now been challenged by two American astronomers, F. D. Drake and Carl Sagan of Cornell University. They point out that for transmissions in the plane of our own galaxy the "hydrogen line" frequency is noisy, simply because of all the hydrogen in the galaxy. Why not use a "clear channel"?

Choice of a "clear channel" resolves itself into avoiding known noise. Noise from the sky has several known causes, all of which correspond to particular noise spectra. These are the universal black-body radiation at 2.7K; quantum noise of the radiation itself, which occurs because r.f. energy comes in "packets"; noise from the atmosphere; and the hydrogen line. When all these are taken into account the least noisy part of the r.f. spectrum is at frequencies of a few gigahertz.

Molecular resonances of hydrogen and the hydroxyl group OH occur in this region, at 1420 and 1667MHz. This leaves a "water hole" in between, possibly of interest to alien life forms if they are also associated with water. Drake and Sagan point out that, within the "water hole", there is another natural frequency, 1652MHz, connected with the centre of mass of the water molecule. This is not a noisy frequency, and would perhaps be a likely choice for our water-involved cousins in another world.

Experiments with operational amplifiers

16. Voltage to frequency conversion

by G. B. Clayton*, B.Sc., F.Inst.P.

A voltage-frequency converter is used to generate a sequence of pulses with repetition frequency proportional to the magnitude of a d.c. voltage. A simple circuit which employs operational amplifiers to perform this function is illustrated in Fig. 16.1.

Amplifier A_1 acts as an integrator and amplifier A_2 acts as a regenerative comparator with hysteresis. Assuming the output of amplifier A_2 is at its positive saturation limit, $V_{o\text{sat}}^+$, diode D is reverse biased and the output of the integrator falls linearly at a rate determined by the magnitude of a positive d.c. input voltage. When the integrator output reaches a voltage level $-V_{o\text{sat}}^+$ (R_1/R_2) the output voltage of A_2 switches to its negative saturation limit, diode D becomes forward biased and the integrator output runs up rapidly. Amplifier A_2 switches back to positive saturation when the integrator output reaches a positive voltage level of magnitude $V_{o\text{sat}}^-$ (R_1/R_2). The integrator output then falls linearly again.

Assuming the time taken for the integrator output to run up is much less than the run down time and since the run down time is inversely proportional to the d.c. input voltage, the frequency of oscillations is directly proportional to the d.c. input voltage. If the switching time of the comparator is negligibly small the frequency of oscillations is given by the relationship

$$f \cong \frac{e_i}{CR} \cdot \frac{R_2}{R_1(V_{o\text{sat}}^+ - V_{o\text{sat}}^-)} \quad (16.1)$$

In the circuit of Fig. 16.1 the finite switching time of amplifier A_2 allows an integrator output swing somewhat larger than $(R_1/R_2)(V_{o\text{sat}}^+ - V_{o\text{sat}}^-)$ and the frequency of oscillations is thus less than that predicted by eq. 16.1.

Typical waveforms appearing at the output of each amplifier are shown in Fig. 16.2. The traces were obtained with an applied input voltage larger than that for which the circuit converts linearly in order to show the effect of the finite switching time of the comparator. The graticule line cutting across the middle of each trace represents the d.c. zero level of the trace. A close inspection of the waveforms reveals the d.c. levels at which switching occurs. In the case of the traces shown integrator run up time

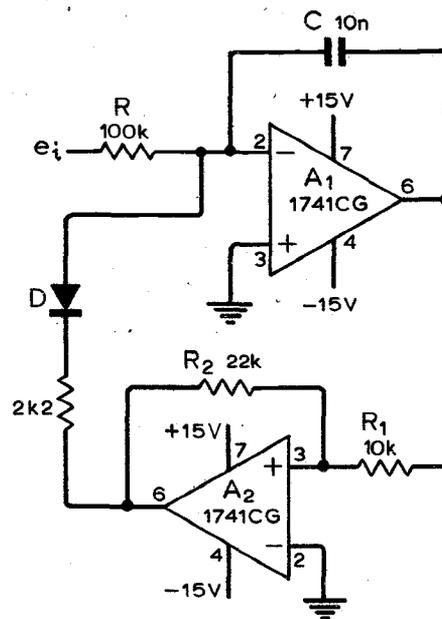


Fig. 16.1. Voltage to frequency conversion using one op-amp as an integrator and the other as a regenerative comparator with hysteresis.

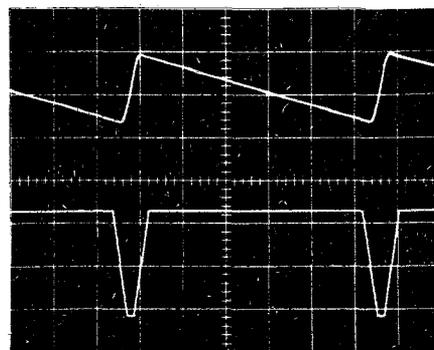


Fig. 16.2. Waveforms at the outputs of the op-amps in Fig. 16.1. Top: integrator output; bottom: comparator output. Vertical scale, 10V/div.; horizontal scale, 0.1ms/div.

is not negligible compared with the run down time, so that linearity of voltage to frequency conversion may be expected to have deteriorated at these frequencies. Deterioration in linearity is also to be expected at the lower frequencies because of inte-

grator drift. An offset balance potentiometer adjusted to cancel out integrator drift extends the lower frequency limit for linearity of voltage to frequency conversion.

The range of linear operation for the converter may be examined by applying various input voltages and measuring the frequency of oscillation for each value of input voltage. Input voltages in the range, say, 10mV to 20V are suggested. Results are conveniently plotted on logarithmic scales because of the wide range. The effect of adding an offset balance potentiometer to cancel integrator drift should be examined. It is also instructive to change component and power supply values. By examining the effect of such changes on the circuit waveforms the function of each component in relationship to the action of the complete circuit may be better understood.

*Department of Physics, Liverpool Polytechnic.

News of the Month

U.K. electronics prospect bleaker

The conclusion reached by a National Economic Development Office (NEDO) report on the U.K. electronic industry's prospects up to 1977 is that "Although home market growth prospects are on balance slightly better than during 1968-71, trade prospects are worse, and this adds up to a slowing down of the industry's growth overall". Although the prospects for home market growth look favourable when compared with the growth seen between 1968 and 1971, a comparison with available data for the major European countries shows that growth in the U.K market during 1968-71 was "markedly lower than in West Germany, France and Italy, and that prospects for future growth are no better than in these countries (and in telecommunications, distinctly worse)". The report points out the value of the computer market as one of the worst in comparison with European countries — £183M in 1971 compared with West Germany's £310M and France's £250M. No improvement on this situation is seen for the future.

The report states, "The size of the industry, as measured by its gross production, is projected approximately to double by 1977 The fast growing sectors are those on the professional and industrial side which depend on the strength of investment, mainly in the private sector. These are computers, instrument and control engineering, and control and automation systems Projections of components production are, not surprisingly, very similar to those for the industry as a whole."

The seventh edition of the "Annual statistical survey of the electronics industry" has also been published recently by the Electronics Economic Development Committee. The survey shows that, in 1972, total sales of electronics products increased considerably after the 1971 recession — by 17% over 1971 at current prices. The consumer goods sector was the main growth area. The colour television market strengthened further in 1972 and contributed to a record demand for components. Sales of colour TV sets nearly doubled the 1971 figure to reach over £200M in 1972. Total turnover for the industry for 1972 was £1,500M.

Satellite navigator for world shipping

Redifon Telecommunications have recently demonstrated their new satellite navigational equipment for marine navigation and exploration. The new equipment, known as the Redifon Satellite Navigator, is housed in a single desk-top cabinet which contains the satellite receiver, a computer and an electronic display. It receives its navigational information from five Transit satellites which continuously orbit the earth and signals are processed by the computer to give the ship's position by a direct read-out of latitude and longitude.

The new equipment achieves the incredible accuracy of better than 500 feet or about half the length of a modern tanker. The service is available over the entire earth's surface regardless of weather conditions and the equipment can be set up in less than three minutes at the commencement of the ship's voyage. No further adjustments are needed during the course of the voyage.

Redifon Telecommunications foresee the main application for the new equipment on long distance ocean carriers. Its accuracy is sufficiently high to make it a suitable aid for naval vessels, for survey ships and for cable laying.

Electronic safety helmet

An accident prevention product to help give greater safety in industry maintenance has recently been launched by the Chaloner Electronics Company of Northwood, Middlesex. It is their safety helmet for technicians, which incorporates a "personal warning" device for high voltage detection.

This helmet has been specifically designed to present an audible warning of the presence of an overhead live conductor to a technician who, in the course of working on nearby industrial equipment, might in error (and particularly at night) approach a live conductor, thus placing himself in danger of electrocution. An electronic warning device is sealed into the helmet and, as the technician approaches the high voltage conductor, the detector triggers a high-frequency tone generator causing a pulsed signal to be fed into two transducers mounted into that part of the safety helmet directly above the ears — the volume of the signal changing in relation to its distance from the high voltage conductor.

The system is powered by two zinc-silver batteries sealed into the helmet and connected for use by an external plug, which fits into a charging connector at the rear of the helmet; it is then fully operational throughout the time between recharging cycles (up to a maximum of fifteen hours). The batteries have up to three years' life.

Recording by ear

A technique for making clear speech recordings in a noisy environment by plugging a mini-microphone into the ear has

been established by scientists at the Battelle Institute, Frankfurt, West Germany. The problem of external noise is usually overcome by using a microphone which records speech signals at the larynx of the speaker. In principle it is possible to record speech at any part of the skull, since the vibrations produced by the vocal tract are transferred to the cranial bones. These in turn excite the air column of the ear.

Using a condenser microphone with a probe tube worn comfortably in the ear, Battelle scientists have succeeded in producing voice recordings of better quality than those made with a throat microphone. The speech recordings were "easier to understand", scientists report.

Records made with an ear microphone were analysed to reveal the frequency pattern, and compared with those recorded by a microphone near the mouth. Fifteen people took part in the experiments, to give a wide variety of different voices and sounds. Loss in volume took place at the higher frequencies. Transmission loss via the auditory route increases with rising frequency, and is dependent on the pitch of the sound. A loss of 10dB per octave for the spoken vowel "a" is reported and a loss of 5dB to 7dB per octave for "i".

Good quality reproduction was achieved by electronically compensating for the volume loss at the higher frequencies with an active network amplifying the speech signal by 6dB per octave rise.

Multi-colour 3D video

The Central Research Laboratory of Hitachi has developed a method for storing and reproducing multi-colour three-dimensional images in high storage density holograms. The holographic memory consists of memory elements that are used to record information in a storage medium as interference fringe patterns. The system is made up of a laser beam, memory elements, hologram illuminator and screen. High density storage of the images is made on 35mm film.

Images can be moved or switched simply by manipulation of the film. This method can be used for three-dimensional colour display of advertisements and educational, medical, recreational and other matters. In the future, as the components for this method are made more compact, three-dimensional moving pictures and three-dimensional television programmes will become possible.

High density data packing for tape

Bell & Howell has made a breakaway from the traditional analogue method of instrumentation tape recording with the introduction of a digital electronic system which provides 33,000 bits of data per inch on each track of the tape with an accuracy equal to one error in 10^7 bits.

Designed to be used with Bell & Howell's type VR-3700B instrumentation magnetic tape recorders, this high density p.c.m. technique — known as "enhanced non-return to zero" — allows more data

to be packed on to tape than has been possible before. The density of 33k bits/in., applicable at any recorder speed, means that one 15in reel of tape recorded at the highest density on 28 tracks can replace 289 10in reels of compatible tape operating at the standard density of 800 bits/in.

This high density recording facility is particularly useful in applications such as geophysical exploration where the remote nature of the sites and the vast quantities of data required to be recorded presents major problems in the storage and delivery of tapes.

In such applications, p.c.m. has the advantage of being able to provide the high frequency response of direct recording (to 4M bits/in., or 2MHz) with the wide dynamic range of f.m. (50-60dB). In contrast, direct recording provides only 20-30dB. In fact, the dynamic range of the system is only limited by the number of bits generated by the analogue-to-digital converter for each data sample.

Mullard policy on valve guarantees

Mullard have issued the following statement concerning their future policy on valve guarantees: "For many years there has been a strong feeling in the radio and TV trade about the amount of time and effort involved in obtaining replacements

for valves failing under guarantee. With the coming into force of the Supply of Goods (Implied Terms) Act, many of the major setmakers have introduced, or will introduce, comprehensive guarantees of their products. Traditionally Mullard have guaranteed their valves fitted in such equipments against failure for a period of 90 days. Moreover, they have covered the trade for a similar period against failure of valves purchased for maintenance purposes.

"With effect from November 1st 1973 Mullard will buy out their guarantee with the trade. Since there will be valves in wholesalers' and dealers' stocks and in first equipments in the pipeline (all of which will carry a 90-day guarantee) there will be a special discount of 10 per cent off the recommended trade price, in lieu of guarantee, on valve purchases made between November 1st 1973 and February 28th 1974. On March 1st 1974 — by which time the guarantees on valves in pipeline sets will have expired — the discount will be eight per cent for a further six months. This will ensure that all stocks held by wholesalers or in dealers' maintenance stocks will have been used and the 90-day guarantee satisfied. After September 1st 1974 a discount of six per cent, in lieu of guarantee, will come into force. The company considers that this is a generous allowance in view of the known low failure rate of its valves."

Surround-sound circuits

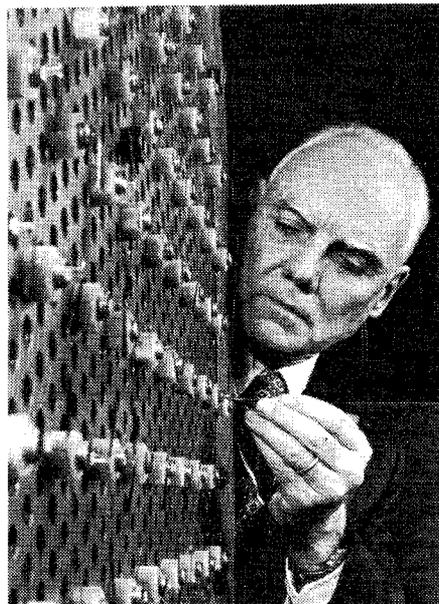
The Motorola SQ surround-sound chip, type MC1312P, mentioned in our article "Surround-sound circuits" in the March issue, is now readily available from Jermyn Industries. The one-off price of £2.24 includes a royalty payment to CBS. A printed circuit board for the March issue single-chip circuit will be available shortly, as will the chips MC1314 and MC1315P.

Briefly

Muck '74 — a national two day farm waste event, comprising field demonstrations, commercial exhibits, conference sessions, case studies and educational displays, will be held at the National Agricultural Centre, Stoneleigh, on March 27 and 28, 1974. Perhaps the electronics industry should do something about this.

Hi-Fi Factory. Demand for audio products in the hi-fi range is now so strong in home and overseas markets that Thorn Consumer Electronics have opened a special factory, at Harold Hill in Essex, solely to produce hi-fi equipment. The factory is expected to have a production rate of 5,000 units per week by the end of this year.

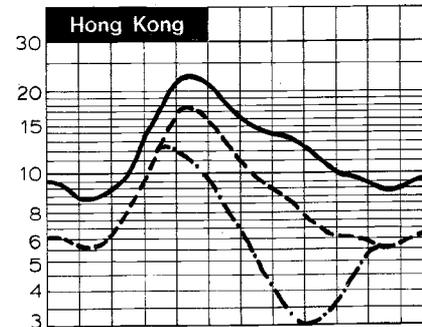
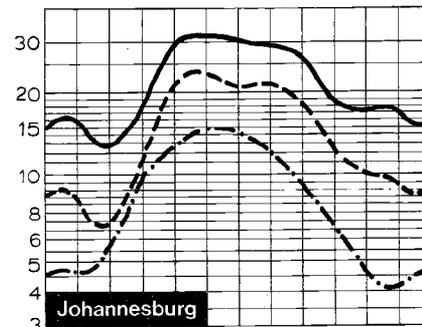
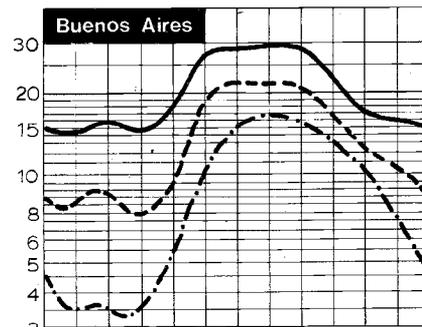
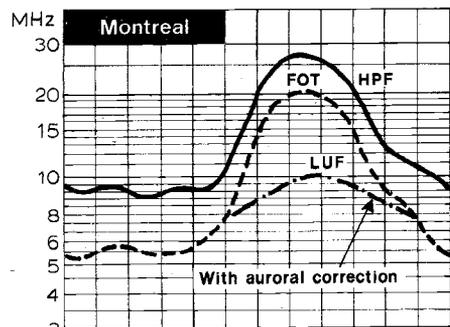
Raytheon Company scientist plugs a diode into a model of the aerial array developed in a NASA-sponsored programme for receiving microwave energy beamed to earth from an orbiting satellite. Solar cells on board a satellite fixed in position relative to the earth, and such as to be in continuous sunlight, would change the sun's energy to direct current electricity. This would be converted into microwave energy and beamed to earth where giant arrays, like this model, could receive and reconvert it into usable electrical power.



H. F. Predictions for December

The winter anomaly of increased absorption at middle latitudes can be offset by the availability of higher daytime frequencies. Day-to-day variations in circuit performance will be greater however — up to three times that experienced during summer months. Paths in mid-to-high latitudes are subject to periods of very poor working lasting several days; low latitude paths have much smaller seasonal variations.

Although the charts are calculated for specific paths between the UK and destinations as marked they give a general picture of frequency availability for North America, South America, South Africa and the Far East.



G.M.T.

Predicting amplitude response

Graphical method for op-amp circuits

by A. J. Key, B.Sc., M.I.E.R.E.

Operational amplifiers allow easy modification of the gain-frequency response of an amplifier, but prediction of the response can be tedious. This article describes a simple graphical method of assessing response of any op-amp correction circuit to within 1dB.

For sinusoidal voltages the voltage gain of the simple op-amp circuit of Fig. 1 is $V_i/V_o = -Z_2/Z_1$ within certain limitations. If Z_1 and Z_2 are resistors, say $10k\Omega$ and $100k\Omega$, then the magnitude of the gain is 10, or 20dB and is independent of frequency. If Z_1 or Z_2 or both consist of combinations of resistors and capacitors then the impedances, and hence gain, vary with frequency. This is the situation considered in this article. The boxed text on the next page illustrates the problem.

We need to consider two basic circuits only, Figs. 2 & 3. Fig. 2 circuit has a constant gain, in this case 20dB, and therefore the response is flat.

The circuit of Fig. 3 has gain, the modulus

Fig. 1

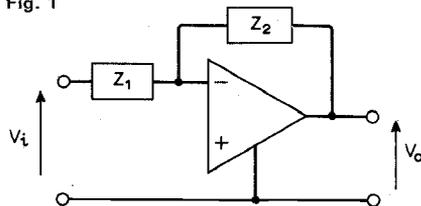


Fig. 2

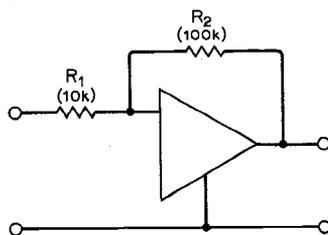
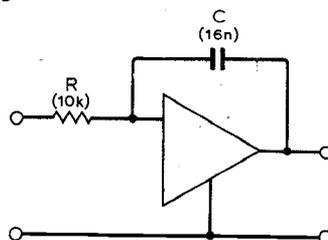


Fig. 3



of which is $1/\omega CR_1$. Clearly, with fixed values of C and R , the gain will be inversely proportional to frequency. Plotted in decibels on log-linear graph paper, it will be a straight line (Fig. 4).

Fig. 4

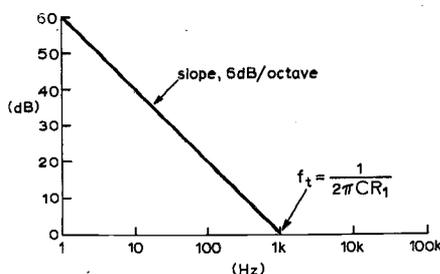
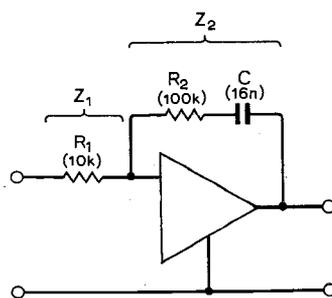


Fig. 5



Two properties of the graph are apparent. The intersection of the curve with the 0-dB axis occurs at $1/\omega CR_1 = 1$ i.e. when $f_t = 1/2\pi CR_1$. Using the values of C and R_1 in the circuit gives $f_t = 1kHz$. The slope of the curve is 6dB per octave. When using logarithmic graph paper it is easier to obtain this slope by using the ratio 20dB per decade.

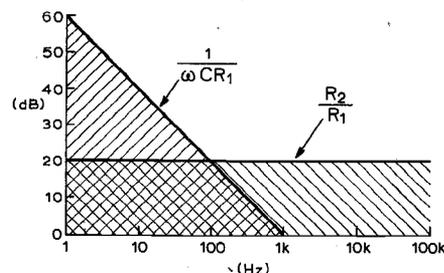
From Fig. 4 and the response of Fig. 2, we can obtain the response of any correction circuit.

As a starter, look at the system of Fig. 5. The gain is Z_2/Z_1 , and as Z_2 consists of a series combination, we know that its value can never fall below either the resistance of R_2 or the reactance of C . So we can predict that the overall response can never be below that for the resistor or the capacitor. Superposing the flat response of Fig. 2 with the

response (Fig. 4) of Fig. 3 and shading the areas below each curve as impossible zones, we get Fig. 6.

Remember that we are really trying to obtain the resultant of a real, or resistive, component, and an imaginary, or reactive, component, the magnitude of the real term being given by the R_2/R_1 curve, the magnitude of the imaginary term being $1/\omega CR_1$ curve. The resultant can of course be obtained by taking the square root of the sum of the squares in the normal way, but this is only significant when the two terms are of the same numerical order of magnitude. When either term dominates numerically at high or at low frequencies, the resultant approximates to the greater of the two terms. If the curves are greater than 6dB apart, the error involved in approximating the resultant to the upper of the two curves is less than 1dB. At 6dB apart, the correction required is 1dB; at the intersection when the two terms are equal, the correction required is 3dB.

Fig. 6



So the overall response follows the boundary of the shaded area of Fig. 6, except near the intersection when they are less than 6dB apart. Corrections of 3dB at the intersection, and 1dB at the 6dB divergence points can be applied to give the result (Fig. 7).

Parallel circuits

What about parallel circuits? Solutions of these may be undertaken with the modification that for impedances in parallel we know that the impedance of the combination can never be greater than the impedance of either.

Fig. 7

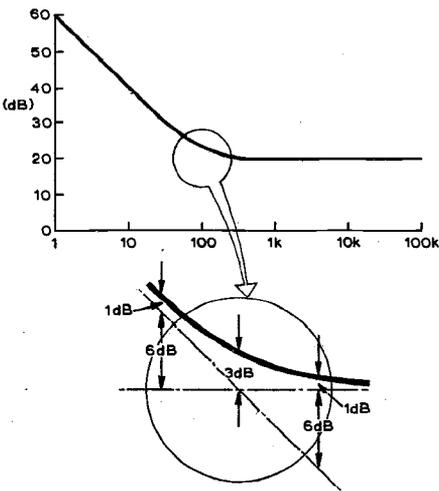


Fig. 8

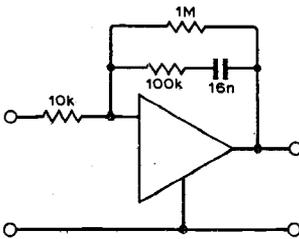


Fig. 9

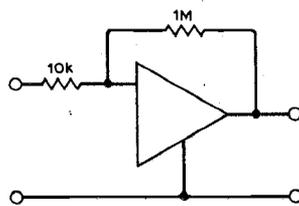


Fig. 10

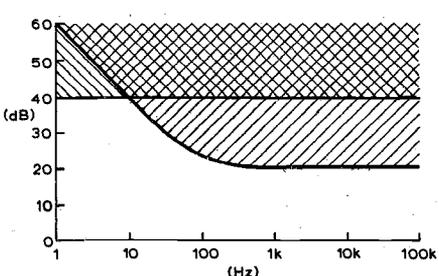


Fig. 11

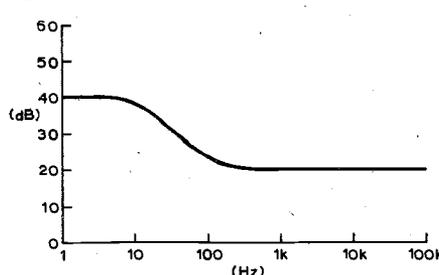
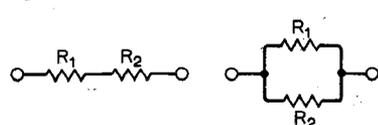


Fig. 12



Consider, for example, an extension of our previous circuit; an extension which may well be required in practice for stabilization. A 1-MΩ resistor is added in parallel with the feedback arm, as shown in Fig. 8.

Firstly, the response of our original circuit can be obtained giving the result of Fig. 7.

The response of Fig. 9 is flat, so we can shade in impossible zones above the two curves and get Fig. 10, and at the intersection, the boundary can be modified to give the final response of Fig. 11.

Corrections for parallel curves

So far we have only used the system for combining curves whose slope relative to each other is 6dB per octave. What about curves which are parallel to each other?

It is obvious that horizontal responses imply resistive components and zero phase shift, while lines at 6dB/octave imply reactive components and 90° phase shift. We know it is only when these two curves approach to within 6dB of each other that the resultant is significantly different from one or other of the curves. But how about parallel curves implying in-phase rather than quadrature addition? As might be imagined, the limits are now wider and if the curves approach within 18dB of each other, 1dB or more differences will occur between the resultant and one or other of the curves.

We are saying that in two circuits such as Fig. 12 if $R_2/R_1 > 18\text{dB}$, then the total resistance is within 1dB of either R_1 or R_2 . So in Fig. 10 we were justified in neglecting the interaction of one curve on the other over the band where they are parallel, as the curves are here more than 18dB apart. A quick calculation on Fig. 8 can be made to estimate the error involved. At low frequencies the capacitor is effectively an open circuit and the circuit becomes Fig. 9 with a gain of 40dB. But at high frequencies, the capacitor is effectively a short circuit and the circuit becomes Fig. 13, with a gain of 19.2dB. Compare this to the value of 20dB taken from Fig. 11 and you can see that this curve is correct to within 1dB.

So if curves are parallel and within 18dB of each other we must apply a correction to obtain the resultant, and this correction depends on the closeness of the curves. This correction is given in Table 1.

Table 1. Correction for parallel curves

Difference apart dB	Correction ± dB
0	6
6	3.5
10	2.5
18	1

Summary of method

The basic method is summarized by the following set of rules.

For the operational amplifier system represented by Fig. 1:

- Impedances Z_1 and Z_2 should first be written as combinations of series and parallel elements in terms of a single,

Algebraic method

Most simple impedance combinations can be written in terms of functions of the type $j\omega T$ and $1+j\omega T$. Gain of the op-amp system can usually therefore be expressed in terms of products of such functions, and as the response of each function can be drawn, the total response of the products can be obtained by summing the individual graphs when plotted logarithmically.

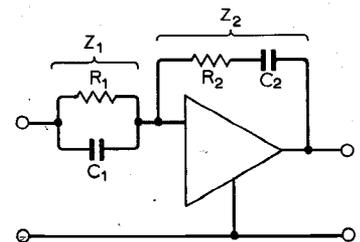
For example, supposing we have the system of Fig. A, the gain can be shown to be

$$\frac{R_2}{R_1} \cdot \left(\frac{1+j\omega C_2 R_2}{j\omega C_2 R_2} \right) \cdot (1+j\omega C_1 R_1)$$

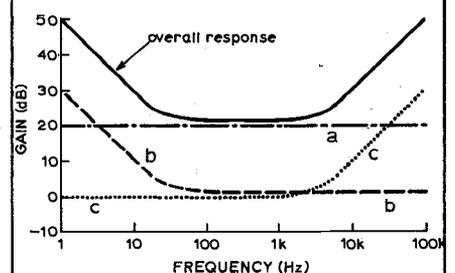
so by plotting the individual responses for these three terms and then adding them, the overall response can be obtained. The stages are shown in Fig. B. So if the overall gain can be written in terms of products, then the response can be fairly easily obtained.

The big word of course, is "if". A considerable amount of algebraic manipulation is involved even in simple circuits to write the gain in terms of products of the right form. For instance, if we required the response of the circuit shown in Fig. C, then as the gain could only easily be expressed in terms of the *sum* of these functions, the above method of adding the individual responses would not be valid.

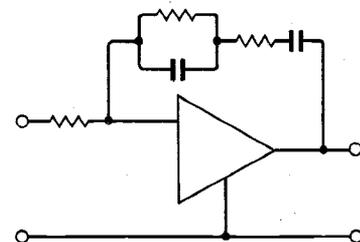
A



B



C



convenient, multiplying ohmic factor. If Z_1 is a simple resistor, then this resistor would be the most convenient factor.

- The impedance-frequency characteristic for each impedance should be obtained from that for each component, as dB above or below this factor.

1. For elements in series, the resultant is never less than that of any one of the elements.
2. For elements in parallel, the resultant is never greater than that of any one of the elements.
3. For curves intersecting with relative slopes of 6dB/Octave, the resultant follows either of the individual curves, except where the curves approach to within 6dB of each other, when a correction is required according to Table 2

Table 2. Correction for relative slopes of 6dB/octave

Difference apart d B	Correction \pm dB
6dB	1dB
0dB	3dB

4. For parallel curves, the resultant follows either of the individual curves unless they are less than 18dB apart, when a correction is required according to Table 1.

- The impedance-frequency characteristic of Z_1 is then subtracted from that of Z_2 to obtain the overall voltage gain of the system.

Example

As an example I have plotted the response for the circuit of Fig. 14.

Fig. 13

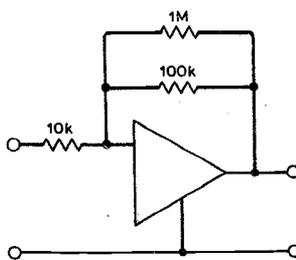
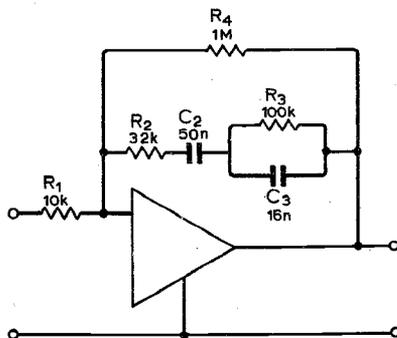


Fig. 14



Applying the first rule, the obvious ohmic factor will be the 10-k Ω input resistor R_1 . This is taken as unity or 0dB.

So we get,

- R_2 (32k Ω) written as 3.2 or +10dB,
- R_3 (100k Ω) written as 10 or +20dB,
- R_4 (1M Ω) written as 100 or +40dB.

Also, $1/\omega C_2 R_1 = 1$ at $f_1 = 320$ Hz

and $1/\omega C_3 R_1 = 1$ at $f_2 = 10$ kHz.

The responses for the individual components are shown at Fig. 15(a).

Series combination of R_2 and C_2 applying the second rules (1 & 3) gives (b).

Parallel combination of R_3 and C_3 applying the second rules (2 & 3) gives (c).

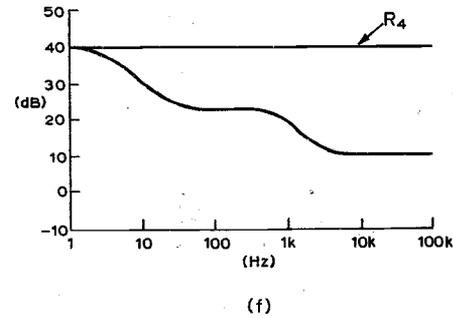
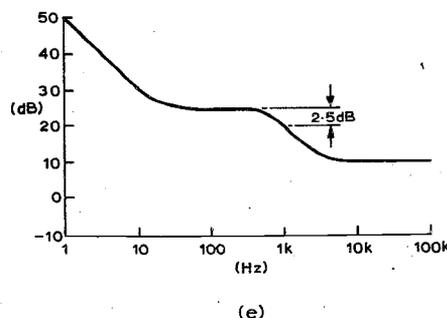
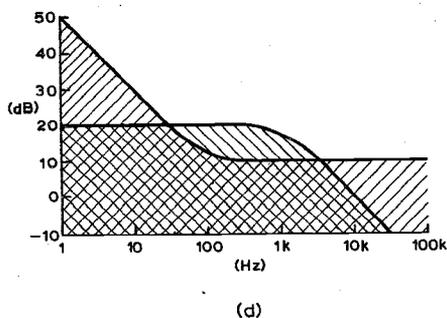
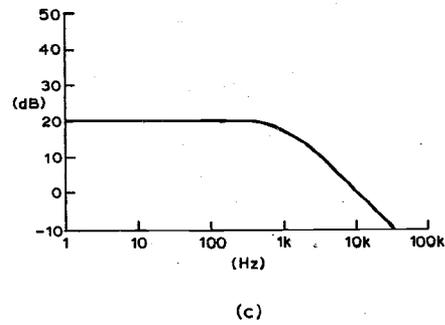
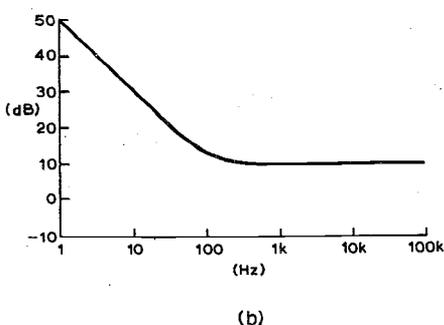
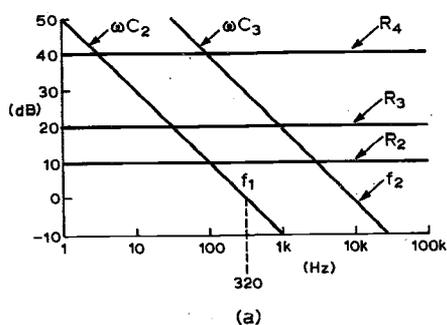
Superposition of these two, (b) and (c), with shadings to indicate impossible zones for series combinations gives (d).

Applying the second rule (4) to correct for the parallel portion of the curves gives a required correction of 2.5dB, (e).

Finally, combination of (e) with R_4 applying the second rules (2 & 3) gives (f).

As R_1 is taken as 0dB, its subtraction in applying the third rule has no effect, and the overall gain response is as Fig. 15(f).

Fig. 15



Letters to the Editor

Sale of "walkie-talkies"

Mr Harris's letter (November issue) is kindly meant, but it is dangerous to invite Authority to further interferences.

Transmitting without a licence is properly illegal, and the Ministry of Posts and Telecommunications could be encouraged to make it even riskier by increasing their detection effort. However, owning a transmitter, without a licence, I believe to be not illegal; certainly it should not be, and controls on who owns them are not needed. It is use that must be controlled, and unlicensed use curtailed. This may be splitting hairs, but laws must sometimes be like this in order to be fair.

One service that H.M. Customs and Excise could perform is to ensure that each imported unit has a large notice warning that it must not be used by unlicensed people.

D. Ferguson,
Basingstoke,
Hants.

Fast printed circuit etching

Inspired by Mr Ferguson's letter in the July issue, I would like to tell the readers about a simple method for fast p.c.b. etching which I have been using successfully for several years.

Instead of the classical ferric chloride solution, I use a mixture of one part hydrochloric acid to three parts 40% hydrogen peroxide. This solution strips the board clean of unprotected copper in less than 30 seconds.

Both chemicals are nasty and should be treated with due respect. Skin contact must be avoided, and the etching should be carried out with all windows open and within close reach of a running tap. The reaction releases a fair amount of heat, which again speeds up the process. A splash of water, though, is all that is needed if the fizzing gets too drastic.

The etching may be carried out in any shallow plastic or glass container. As no sediment is formed, the only agitation required is a gentle rocking of the tray in order to disperse the heat.

The solution should be mixed immediately before use, as the peroxide decays fairly quickly once mixed with the acid. The ratio of the ingredients

is fairly critical, although too much peroxide works better than too little. It is advisable to test the solution with a bit of scrap board before plunging in one's newly finished masterpiece.

J. Langvad,
Radford Electronics Ltd,
Bristol.

Television information systems

The recent description of television information systems (e.g. "Oracle," *W.W.* July) leads me to suggest a possible development. If each programme carried an identification code a receiver could be preselected to switch from the stand-by state automatically when the desired programme commenced. This would eliminate the irritating need to watch unwanted programmes in order to catch the start of a wanted one.

J. Keith Carter,
Maidstone,
Kent.

TV picture interference

I was interested to read the articles on Ceefax and Oracle, the proposed B.B.C. and I.B.A. information services (*WW* May and July issues).

Since the commencement of the tests for these systems my television receiver (Bush colour model CV 2211S) has displayed three lines of moving coloured dots approximately one inch from the top of the picture on all three u.h.f. channels. When inspected more closely these dots can be seen to flash on and off in a periodic manner as one would expect from a data pattern, although the data pulses for both systems should occur in the field blanking period.

At first I thought that this interference was peculiar to my receiver, but I have more recently found that other colour receivers (all of different manufacture) in the Guildford area suffer from this complaint, although monochrome receivers seem to be immune.

I am writing to ask if other readers, especially those in the Guildford area, can confirm or provide an explanation of my observations, in the hope that it can be proved whether or not the moving dots are related to the Ceefax or Oracle transmissions.

D. C. Cooper,
Guildford,
Surrey.

Comment from the B.B.C.:

I think we must disclaim responsibility for the three lines of moving coloured dots which your correspondent Mr D. C. Cooper sees approximately one inch from the top of his television picture on all three u.h.f. channels.

The experimental transmission of Ceefax takes place only on the BBC-2 network and the fact that Mr. Cooper sees it on

all three channels is, I think, conclusive evidence that it is not due to these tests. The Ceefax pulses are, as Mr. Cooper correctly states, located in the field blanking period but of course some strange happening in the flyback of a receiver could make signals in the vertical interval visible within the picture area. I cannot think of any mechanism which would make the Ceefax pulses give coloured dots and I am sorry that I cannot offer an explanation, unless it should be found that all the receivers suffering from this effect are being fed from a cable distribution system which is slightly faulty.

C. B. B. Wood,
Head of Engineering Information
Department,
Broadcasting House,
London, W1.

V.H.F. receiver performance

I feel the need to reply to Mr R. G. Young who, in your July issue, was searching for an all-consuming "figure of goodness" for stereo receivers. As you can tell from my address, I am at a disadvantage as far as the British receiver specifications are concerned, having seen just a few. Here in America, a receiver is a combination tuner and amplifier, but Mr Young refers only to tuner circuitry so I'll confine my reply to that section.

Sensitivity is a most important specification in tuners but one that should be weighed along with others and not be made to stand alone. The signal-to-noise ratio should definitely not be overlooked as it is involved in a tradeoff with sensitivity. The tradeoff provides an explanation to the situation Mr Young mentioned in his letter. To complicate matters, this tradeoff is itself involved in a tradeoff with harmonic distortion. Add frequency response to the other three factors and you arrive at a fairly reasonable "figure of goodness". These specifications are present in most British spec. sheets I've seen.

To give you an idea of American tuner spec. sheets, we grapple with the aforementioned measurements plus: station selectivity, stereo separation, image rejection, i.f. rejection, a.m. suppression, intermodulation distortion and, unfortunately, just as many that are as useful as counting the knobs on the front panel. Even with all these specifications, the approved "figure of goodness" over here is still derived from just plain listening.

Joseph Zakar,
Brooklyn, N.Y.,
U.S.A.

Current flow controversy

I was very surprised to find (Nov.'73 issue) the big guns of "Cathode Ray" ranged at the electron flow rebels. I assumed that Mr Roddam's sarcastic broadside was the

end of the battle and the whole problem was to be quietly shelved — the usual reaction of the “establishment” to a problem is to pretend it does not exist.

Also, I am saddened, not by Mr Scroggie's lack of support (his current has gone the conventional way ever since I've read him and that is more years than we both like to think of), but by the hoary old excuses and red herrings he trots out as opposition. Let us take them one by one.

“Use of electron flow would cause a great upset as all device arrows would need to be reversed” Why? Do Mr Scroggie and Mr Roddam imagine we teach our trainees using reversed device symbols? Of course not; the electrons flow against the arrows (the conventional school has to consider this so in the zener diode). If the conventional mob need arrows on devices to remind them which way their current flows then I'm sorry for their mental processes. We managed with valves to know which way current went, though it always struck me as ludicrous that the conventional supporter had to say that electrons left the cathode and went to the anode and so current went from anode to cathode — what a fairy story!

Next upset — “a great many carriers are holes. . . .” Aren't holes just a convenient way of explaining what happens when valence electrons move, albeit reluctantly, in the opposite direction? And as for positive ions — well, well, Mr Scroggie, please; are there no such things as negative ions? So all square here I think.

“Reversing nearly all the text books”. I would estimate 40 to 50% of American text (including its Armed Services) and 20% of British text is in terms of electron flow. In any case I see no reasons for the drastic step of reprinting all literature, and I really believe Mr Scroggie is deliberately creating problems here. Our advocacy is merely to use electron flow as the accepted convention so that from “R” day all current arrows would point the same way on circuit diagrams and, as Cathode Ray himself points out, V and I arrows would conveniently coincide.

Under the “Too much, too late” heading the text leaves me frankly amazed at the red herrings and the (forgive me or “Cathode Ray”) seemingly deliberate false notions introduced.

I've already stated I see no reason for reversing diode etc. symbols — we rebels manage very well as they are.

“The electric fields would have to be changed round” and + and — reversed!! For heaven's sake why? Electrons move from neg to pos; reversing these merely introduces worse confusion, for the electron would now go the wrong way and our batteries etc. would be backside first. If Mr Scroggie really believes what he has written here he is geriatric; but I suspect he's at his old game of “getting us going”.

As for left- and right-hand rules; if the current finger points to the current *source* no change is necessary (again, though, L and R are conventions and the rules only aids to memory, so I think far too much is being made out of these objections).

Mr Scroggie also mentions flow from surplus to deficit. Just what electron flow is, in fact, and so the water analogy is not upset.

Finally consider Mr Scroggie's *nom de plume* — “Cathode Ray.” What is a cathode ray? If it is pos particles he is faced with the phenomenon that they must have negative energy since by *leaving* the phosphor in a c.r.t. they are causing the emission of light energy. No such freak idea is involved with the electron, since it is the energy imported by its *arrival* which causes the phosphor to glow. I know of no member of the conventional school that teaches the c.r.t. in terms of conventional current, and who can blame them for about facing at this point?

In case Mr Scroggie gets the impression that I'm anti-“Cathode Ray” I may say I've spent an hour or two arguing with colleagues and, what will please him more, minutes in practical demonstration, to convince them of his correctness in the great “transformer controversy”. So although a great admirer of this great man (I mean this very sincerely) I must remain in this case a rebel.

D. V. Ellis,
Waterhouses,
Co. Durham.

The impression I get from the correspondence on this subject is that those who want electrons to be made positive rather than negative imagine that electronics is the only field of work which has to be consulted on the matter. Surely this is taking a rather parochial view?

Chemistry and physics today abound in electrons, and those who suggest that it would be simple to alter polarities to suit the New View of electronics must be ill-acquainted with chemists and physicists. Moreover, on a point of logic, it could easily be argued that the present atomic nuclei are rightly made “positive”, since they all differ in some point other than polarity and can be readily recognized both physically and chemically. The electron, on the other hand, is reasonably termed negative as the word suggests an absence of any but the minimum number of qualities.

From another point of view, electronics people are principally (though less so daily) concerned with metallic conductivity, and it is to be expected that they will regard this as normal, and anything else as abnormal. People beyond electronics are usually inclined to regard metallic conductivity as a special and unusual case.

The difficulties experienced in teaching students appear to spring from trying to teach one special subject in a vacuum. If a historical approach were used, or if the student were also familiar with some theoretical chemistry, the negativeness of the electron would not seem particularly strange.

P. C. Smethurst,
Bolton,
Lancs.

I would like to take up a little more space in your correspondence columns and comment on the various letters published about current flow symbols¹ and thank the writers for their remarks, significantly the kindest being from those involved in teaching.

In my original letter² I asked why agreement could not be achieved on the direction of current flow arrows on circuit diagrams and agreement by writers on what they meant by “current”. I did not, as stated by Thomas Roddam in his funny letter, “call for lots of lovely arrows, depending on whether electrons or holes are the current carriers”. I did ask that current arrows on circuit diagrams should have the same meaning.

Current flow arrows on circuit diagrams are of very considerable help in the understanding of circuits and virtually essential where current flow is switched to several different paths and where the current in parts of the circuit changes direction. Such circuits are not by any means of interest to device makers alone. Those associated with the training of television servicemen, for instance, know how helpful are current arrows and it is at this level of training where so much must be done.

“Cathode Ray”³ also seems to have missed my main point. He mentions hole and positive ion carriers. I asked if there was any serious objection to dealing with electron flow and calling it electron current or current. Arrows indicating the direction of *electrons* or electron current were the matter of agreement, not the direction of carriers, majority or otherwise.

“Cathode Ray's” rather gloomy discussion of the problems arising when explaining to students about the “positive direction of current. . . .” does not have to cause too much despondency. Just don't talk about the “positive direction of current. . . .” (whatever that may mean) but keep to the direction of electrons, which is understood.

Happily I am not in a geriatric ward and the electron direction convention does not lead to assumptions which make my “imagination boggle”, as it apparently does to “Cathode Ray”. Nor to Mr R. C. Whitehead or his students and readers apparently.

In passing may I take this opportunity of thanking “Cathode Ray” for the valuable lessons he has given me during many years. Knotty (to me) odd problems like the 90° phase shift in double tuned transformers, Miller feedback and the oscillator depending upon it and many other things have been made clear and thus easily passed on to others. “The thoughts of Cathode Ray” have been most welcome. May there be many more.

C. H. Banthorpe,
Northwood,
Middlesex.

1. Letters August 1973.

2. Letters June 1973.

3. Which Way Does Current Flow? by “Cathode Ray”. Nov. 1973.

VAT and prices

Further to the correspondence on VAT, it is interesting to note that Messrs G. W. Smith, while stating "All prices are subject to 10% VAT" in a *Wireless World* ad., do go to the trouble of adding in the VAT in their display in the *Daily Telegraph Magazine* [enclosed]. This latter approach is surely more realistic?

What would those advertisers, who do not include VAT in their prices, do if offered whisky at 60p a bottle — when asked to add £2 or so duty at the time of purchase?

I feel strongly that since VAT and other taxes must be paid, they should be included, as seems to be done at all our local shops, petrol pumps, wine merchants and so on. When dealing with those who do not include VAT in their quoted prices, I feel like asking whether they have left out anything else. For example, is their profit to be added separately? Overheads — have I to pay something on top for those? Surely a price is a price is a price!

J. Tyler,
Camberley,
Surrey.

Editor's note: The Minister for Consumer Affairs, Sir Geoffrey Howe, has stated in the House of Commons that anyone who quotes a price for goods which excludes VAT and does not make it clear that VAT is to be added when the goods are sold is at risk of prosecution under Section 11(2) of the Trade Descriptions Act.

Using c.m.o.s. devices

Your correspondent in the October issue, Mr Peter Seddon, has asked a question regarding c.m.o.s. devices, as to the necessity of the handling precautions recommended by the manufacturers. He points out, quite rightly, that there are protection diodes built into all commercially available c.m.o.s. devices, so are all the precautions needed?

Briefly, the answer is yes.

It is well known that anyone moving in a normal environment will become electrostatically charged. Normally, though, the charge disappears rapidly owing to frequent contacts with many objects leaking the charge to ground. However, it is not unusual for the charge to reach several tens of kilovolts if materials such as nylon and other plastics (clothing, carpets, etc.) are involved. No semiconductor device yet built will be capable of withstanding such a discharge across it.

Normal handling of semiconductors with low impedance does not usually present a problem, provided these extreme conditions are avoided.

In c.m.o.s., the problem is more alike since, owing to the high input impedances, the static charge may be continually building up during handling. The gate oxide insulation in a c.m.o.s. device is about 1000 angstroms thick, and will rupture with voltages over 100V applied, a voltage

which can easily be built up on an input-pin of a d.i.p. when handling the package.

To protect the c.m.o.s. elements, diodes are included on all inputs of a chip. However, as always, Murphy's law has its say, and the protection is gained at the expense of input impedance and speed.

Manufacturers therefore choose to provide what they consider will be "adequate" protection, to fit the circuit performance demanded of the c.m.o.s. In practice, provided that the manufacturer's recommendations are followed, no problems should be encountered.

So I would advise Mr Seddon to banish all nylon fabrics from his work area, ground all his test equipment and only remove the c.m.o.s. d.i.p. from its conductive plastic or from the alu-rail with a d.i.p. inserting tool (shorting the legs together) as he inserts it into his circuit board. If he wishes to disregard this advice, he may perhaps not have any difficulties, depending on his particular working conditions. However, since m.s.i. and l.s.i. c.m.o.s. circuits may constitute a considerable financial outlay, I would suggest it is better to be safe than sorry! Falk Uebe,
Motorola Semiconductor Products Inc.,
Geneva,
Switzerland.

Radiating coaxial cables

In his reply to Mr Goddard (November letters) Mr J. R. Avery states that loose-braided coaxial cables are susceptible to the contaminating effects of dirt and moisture, and goes on to imply that the cable attenuation is thereby increased. In the National Coal Board we have probably wider experience than anyone in the field of radiating cables, and conditions in our mines can be as dirty and wet as one would expect to find anywhere. In seven years' research into the subject, I have not been able to detect any increase in attenuation of loose-braided cables attributable to surface contamination or to their positioning, with braid covers as low as 67% and frequencies up to 170 MHz, even in the very wet Longannet mine (on Mr Avery's own doorstep) where the very first v.h.f. mine radio system is still operational. Other workers I know would agree with me and extend the frequency range well into the u.h.f. band. I have, on the other hand, seen evidence that some cables having longitudinal slots or larger discrete holes in the outer conductor are so affected in the u.h.f. region.

It is possible that Mr Avery is confusing loose-braided coaxial cables with unscreened twin or "ribbon" types of feeder; these certainly are susceptible to surface contamination and careless positioning, a price one pays for their cheapness. Perhaps, also, it is the coupling loss rather than the cable attenuation that Mr Avery has in mind; here, some effects of the environment may be expected, but these apply equally to the various cable constructions.

We prefer to use loose-braided coaxial cables for these purposes, for their flexibility, cheapness, and an all-round performance at least as good as that of any "better" construction. Incidentally, we also prefer to call them "leaky feeders" and so keep an open mind about the precise nature of the fields.

D. J. R. Martin,
National Coal Board,
Mining Research and Development
Establishment,
Burton-upon-Trent,
Staffs.

A. D. Blumlein

I am grateful to you for publishing the last paragraph in Mr R. N. Baldock's letter on page 451 of your September issue. As a direct result, I received a letter from the brother of one of the airmen killed in the Halifax bomber crash at Welsh Bicknor on 7 June 1942, which was the disaster when Alan Dower Blumlein also perished.

May I appeal through your columns to the next-of-kin or former friends of others who were killed on that historically important flight-testing of the H2S equipment — the equipment which later came to be called "the bomber's eye", and which altered the entire course of the war within 12 months? I am extremely anxious to include in the biography of A. D. Blumlein a brief biography of all who died with him, and still need particulars of: 33372 Sqn Ldr R. J. Sanson; 115095 Plt Off D. J. D. Berrington; 751019 Flt Sgt G. Millar; 571852 LAC B. D. G. Dear; and 1271272 AC2 B. C. F. Bicknell. All of these gentlemen were based at Defford R.A.F. Station. G. S. Hensby was a civilian attached to T.R.E., Malvern, who, before the war, had been engaged in cosmic-ray research at Birkbeck College, London.

F. P. Thomson,
39 Church Road,
Watford WD1 3PY,
Herts.

Power amplifiers

In the June issue of *WW* (p. 291) the description of the seventh Circard series gives various class A circuits with their attendant efficiencies. I believe that in circuit 3(b), the efficiency is not 12½%, but actually only 6¼%, if the bias across the transistor is equal to half the supply voltage V_s . This is so because the maximum positive output swing is only $V_s/4$, as can be seen by considering the transistor to be momentarily cut off. This feature was pointed out in a much earlier letter of mine (*WW* August 1969, p. 381) regarding a class A amplifier design of Mr Abelson. The efficiency of such an arrangement can be improved for equal load and collector resistance if the bias voltage across the active device is $V_s/3$. This allows a maximum efficiency of 8.33%. It was also

mentioned in that letter that optimum efficiency occurs if the collector resistance is $\sqrt{2}$ times the load resistance, for a bias voltage across the active device of $0.29 V_s$. Although these may seem to be small points in the present Circard context, they are important to assure symmetrical limiting in $R-C$ coupled amplifiers.

John Vanderkooy,
University of Waterloo,
Ontario,
Canada.

Microphone measurements

With reference to Mr R. V. Hartopp's letter (August issue) in which he suggests sensitivity to be equivalent to "effective area", the trouble with his idea is that ordinary microphones do not measure acoustic intensity. They commonly measure sound pressure (omnidirectional) or particle velocity (figure-of-eight pattern) or a combination of the two (cardioid).

Surely the different types of microphone should have their sensitivities expressed in terms of the ratio of the two quantities most relevant. A Bruel & Kjaer capacitor microphone has its sensitivity expressed in terms of sound pressure and voltage input to a specified impedance. A pre-amplifier for a capacitor microphone is totally unsuited to accept the output from a ribbon microphone, for instance. There is really no relevance of a universal parameter for microphone sensitivity measurement.

In order to aid comparison between microphones with an electrical output of the same form (low Z line for instance), but which are sensitive to different parameters of the sound field, surely they should all be tested in a plane-wave free field.

In that case it is the sound pressure (level) rather than the intensity (level) which is almost universally used in acoustics as an amplitude parameter. After all a microphone is usually used as a replacement for the human ear, and the ear is sensitive to sound pressure.

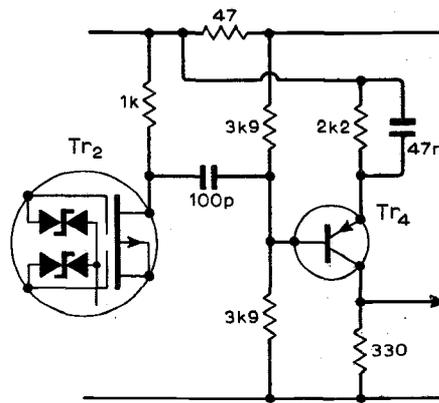
Care must be taken when reading early works on acoustics as the word "intensity" was used loosely to include sound pressure. An example is the work of Fletcher and Munson where they established the equi-loudness contours. They called the amplitude axis "intensity level" whereas it would appear that sound pressure level would be the relevant parameter.

Richard Schürmann,
Hawthorn East,
Vic.,
Australia.

Modified Nelson-Jones f.m. tuner

I was interested in the latest modifications to the Nelson-Jones f.m. tuner (June issue), particularly the lower gain version.

Surprisingly the author does not mention a further advantage of this modifi-



cation, namely the elimination of the coil L_4 and its alignment needs. L_4 can be eliminated without a gain reduction by converting Tr_4 to a common-emitter stage and RC coupling this to the mixer, as shown in the diagram. This can be readily done on the original p.c. board and makes no difference, so far as I can tell, to the results.

While testing the original version of the tuner I noticed that when receiving a weak station the background noise was high with the tuning meter at the correct central position, but less noise was obtained, at the expense of distortion, by off-tuning slightly to one side or the other. This strongly suggested a dip in the centre of the i.f. filter response.

The circuit was tested on a wobulator, feeding in the i.f. signal at the input to the Tr_4 stage and monitoring the amplitude of the signal at the input to the TAA661B. There was indeed a large dip in the centre of the response. After some time I found that this effect disappeared with the p.c. board removed from the metal box, so the trouble was due to earth loops caused by earthing the board to the box at all four metal pillars.

Removing the track from around three of the pillars, leaving only one connection to the box near the aerial input, removed the "dip" and gave a significantly better performance on weak signals.

D. J. Robinson,
Carlton,
Nottingham.

The author replies:

I have read Mr Robinson's letter with some interest and have done a few calculations. I feel that, although Mr Robinson states that the circuit works well, it is a little troubled by the high value of the base-collector capacitance (around 2-3 pF for the BC213L) for fully satisfactory operation at 10.7MHz, and the gain will therefore be somewhat lower than possible. Due then to "Miller" effect the gain will not be very high, although I grant it will be higher than in my "lower gain version".

Apart from the above, the reason why I did not suggest the use of the transistor Tr_4 without L_4 , as suggested by Mr Robinson, is that I wanted to dispense with the gain of this stage since it appeared only to be contributing a high level

of interstation noise without giving any improvement in signal-to-noise level on usable signals.

On Mr Robinson's other point regarding apparent i.f. feedback causing a dip in the i.f. response, I certainly have not had experience of this effect so far as I can remember, but equally I accept that such a fault is possible, especially in a receiver where all devices are above average gain and the overall gain is thus very high. His cure seems a reasonable one in the circumstances though it might be easier to clear the copper round the three holes by countersinking slightly on the copper side with a large drill, and then using small insulating washers under these screws on the circuit side, with a compensating thickness of metal washer on the one remaining connection.

L. Nelson-Jones.

Magnetic units

I think that the discussion on magnetic units (June issue p.299, July p.332) should not be closed without mention of the International Standard ISO 1000 which has been published this year (1973-02-01). The title is "SI units and recommendations for the use of their multiples and of certain other units".

In the foreword of this standard on SI units you will find a list of the member bodies which approved it in June 1972. The United Kingdom is, of course, included. SI units have been legal units in the Federal Republic of Germany since 1969. So the basic units of T (tesla) and A/m for the induction and field strength are compulsory in work on magnetism.

We agree with "Cathode-Ray" and with ISO 1000 that people engaged in work on magnetism will have to change to SI units whether they are forced to do so by law or not.

There is still the problem of the best multiples for day-to-day use. For small inductions the mT (millitesla) should be used but for field strength you will already find here the old A/cm and the "new" unit kA/m (factor of 10). The question of whether the A/cm or the kA/m is the better multiple of the basic unit A/m is still open here. There is also the problem of the best multiple for the energy product of permanent magnets.

Karl Reichel,
Essen 1,
Germany.

"Third method" for s.s.b.

I read Mr Turner's article in the September *W.W.* with interest, having worked on similar lines. However, I cannot agree with all the comments on the "third method". Essentially the third method is a phasing system in which the quadrature audio signals are produced by modulating the quadrature audio sub-carriers. In both degradation of audio quadrature will result in an unwanted sideband in accordance with the relationship

sideband suppression = $20 \log \cot \delta / 2$ where δ is the total phase error at the second pair of balanced modulators. This gives a maximum error of $\pm 3\frac{1}{2}^\circ$ for 30dB suppression.

The low pass filters in the audio channels will be perhaps 5-pole devices, producing a phase shift of the order of 200° at the ends of the audio band. Matching these phase shifts to say 2° (allowing $1\frac{1}{2}^\circ$ for r.f. phase error) seems to me to be comparable with maintaining a 90° difference to the same accuracy.

Turning now to the r.f. phasing, $1\frac{1}{2}^\circ$ at 25MHz is a time interval of 166ps. I doubt if such accuracy can be maintained by a logic system in the face of time and temperature even if the initial error is trimmed out, but would be interested to hear what Mr Turner does achieve.

B. Priestley,
Slough,
Bucks.

Making printed circuits

P. C. Smethurst's clever suggestion that electrolytic etching of printed circuits might be of use to the amateur may fall down on the probability, indeed certainty, that hair-line separations will result between conductors of different potential. And that will be a never ending source of trouble.

His idea for increasing the high conductivity of 10% sodium chloride (a completely dissociated salt) by adding vinegar (a dilute solution of a weak acid) would also appear to require reservations. A similar amount of water would be cheaper and almost as ineffective.

Roy Markham,
John Innes Institute,
Norwich.

Magnetic pickup loading

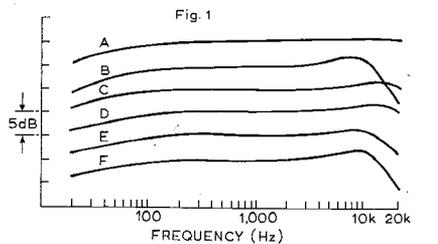
I was extremely interested in Reg Williamson's observations in the June issue on magnetic pickup loading since I have been aware of the effects noted for some time, particularly with regard to magnetic pickup response testing via an R.I.A.A. frequency test record and R.I.A.A.-equalised preamplifier. I was triggered into looking more deeply into the subject on receipt of a note from Reg requesting details of the loading I adopt when evaluating the R.I.A.A. equalisation of hi-fi amplifiers, and also during the investigation of an incompatible response readout from a top-flight cartridge. In the latter respect I now employ constant-velocity test discs and take the signal from across the recommended load via about 100pF of screened cable.

From the equalised preamplifier's point of view the presence of cartridge impedance appearing in the negative feedback path can be quite dramatic, as Reg has intimated. To secure the intrinsic equalisation response I commonly employ a signal e.m.f. via a source of about 700-ohm fed from a filter providing the reciprocal of the R.I.A.A.-equalisation

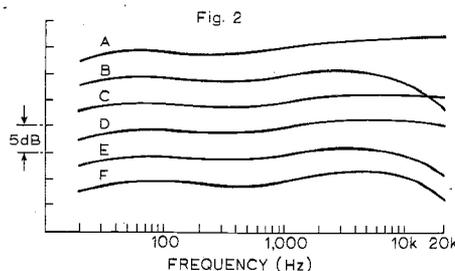
response. This is the same sort of response provided by a magnetic pickup playing an R.I.A.A. frequency test record (but without the effects of mechanical resonances), which means that if the amplifier's equalisation is accurately engineered the output will be essentially "flat" over the spectrum.

Curve A in Fig. 1 shows such a response taken from the Dual CV120 amplifier. The remaining curves were taken from the same amplifier when magnetic cartridges of the types indicated were connected through about 150pF of screened lead to the amplifier in series with the R.I.A.A.-filtered signal source, modified to look like 48 ohms. The setup thus performing as though the signal e.m.f. was derived from the cartridge. These curves clearly reveal how the treble response is affected by the loading and the impedance of the cartridge appearing in the n.f.b. path. The turnover frequency, of course, is a function of the L, C and R components involved. The input load of the Dual is 47k Ω . in common with most other amplifiers.

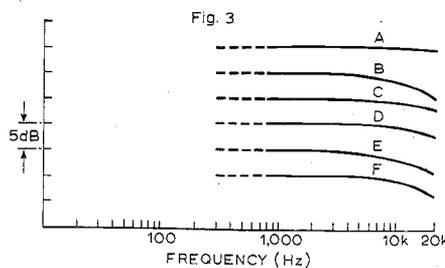
The family of curves in Fig. 2 was derived in the same manner, but with



A source = 700 Ω R
 B " = 47 Ω in series with Ortoton M15 super
 C " = " " " " " Goldring G800 super E
 D " = " " " " " ADC 220XE
 E " = " " " " " Empire 999 VE/E'
 F " = " " " " " Shure V15/III
 amplifier Dual CV120



sources as fig. 1
 amplifier Keletron KSA 1500 Mk II



sources as fig. 1
 amplifier Cambridge P50

the Keletron KSA 1500 Mk II amplifier. This also has a 47k Ω pickup load and, as with the Dual, features the common series feedback loop containing reactance to provide the R.I.A.A. equalisation.

The curves show, of course, that it is the high-frequency part of the response which is affected, but it is difficult from these to determine how much of the deviation from "flat" is contributed by the loading and how much by the pickup impedance effect on the feedback.

The curves in Fig. 3 were also derived in the same manner as those in Fig. 1, but this time the amplifier is the Cambridge P50, where the first stage is not associated with the R.I.A.A. equalisation, the first stages in this model operating aperiodically. The input impedance is resistive over the complete spectrum, a scheme which, in fact, was deliberately employed partly to eliminate unwanted modifications to the pickup cartridge response. The high-frequency roll-off on these curves, therefore, would appear to be a direct function of the loading, as highlighted by Reg Williamson.

From the amplifier testing aspect, I feel it would be unfair to plot the R.I.A.A. response with cartridge simulation since there can be no "standard" in this respect. It would be impossible for a manufacturer to arrange his R.I.A.A. equalisation to yield a "flat" output on all cartridges, and corrective switching would be out of the question. At least the test from a signal of lowish resistive source reveals how well the designer has engineered the intrinsic equalisation, while the curves in Fig. 3 give some impression of the "sensitivity" of the resistive load and shunt capacitance on a cartridge's treble response!

The reactive n.f.b. path effects are eliminated by a preamplifier "buffer", assuming series feedback, between the cartridge and the equalised stage, but there are few amplifiers using this approach to date, Cambridge being one exception. The curves indicate that the value of the inductive component of the cartridge can have a significant effect on the actual equalisation at the treble end (compare curves B, for example, in Figs. 1 and 2 with curve B in Fig. 3), but in some cases a drooping treble due to loading effects tends towards correction by the n.f.b. path effect.

This neatly brings up the question as to whether s/n tests should be performed with the input being connected to a simulated source impedance, such as a pickup cartridge to the pickup input, bearing in mind the nature of the power in the noise over the spectrum when the source is primarily inductive. Many manufacturers give the s/n referred to a short across the selected input, which of course reveals any noise sources present in series with the input circuit.

Gordon J. King,
Brixham,
Devon.

Radio control tone decoder

Logic circuitry replaces resonant reeds

by C. Attenborough

The unit to be described is a tone decoder suitable for use in multi-channel radio-controlled models. It performs the function of the resonant reeds commonly used to detect which modulation frequency is being transmitted, but has the advantage that the range of audio input frequencies can exceed an octave. This cannot be done with reeds because the reed, resonant at f , will also be activated by the second harmonic of $f/2$, giving ambiguous outputs. The decoder is also unusual in possessing an ideal band-pass-filter characteristic (steep sides, flat top), an improvement on resonant reeds, which have the characteristic of a high- Q tuned circuit. The new decoder, therefore, does not demand such great accuracy of the transmitter modulation frequency.

The basic element of the decoder has the characteristic shown in Fig.1, which will be referred to as a digital high-pass characteristic. Such a characteristic, when passed through an inverter, gives a digital low-pass characteristic. It will be shown later how several basic elements with different critical frequencies, plus some

simple gating circuitry, can give digital band-pass characteristics.

Fig.2 shows the circuit of the basic element. R_x and C_x determine the critical frequency ($150k\Omega$ and $0.015\mu F$ give a critical frequency of 900Hz). If, during one cycle of the input, C_x charges enough for the output voltage of the buffer emitter follower to exceed the upper trigger voltage of the Schmitt, S , then the output of the Schmitt goes to logic "0". If one input period is not long enough for this to occur, then the Schmitt output remains at logic "1". At the output of the Schmitt, therefore, there is a pulse waveform when the input frequency is below the critical value, and a logic "1" when it is above the critical value as shown in Fig.3. To give a continuous logic "0" below the critical frequency and logic "1" above it, the D-type edge-triggered flip-flop B_2 is used, its D input being connected to the output of S . The flip-flop is clocked by a positive-going edge which occurs at the end of the time during which C_x is charging. The Q output assumes the state

the D input was in before the clocking edge. It is this property of the flip-flop which enables it to deliver a static output even when the D input is a pulse train.

The signals to discharge C_x and to clock B_2 are provided by B_1 which divides the

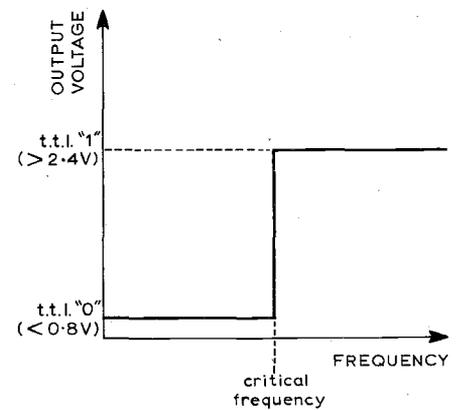


Fig.1. Frequency characteristic of basic element.

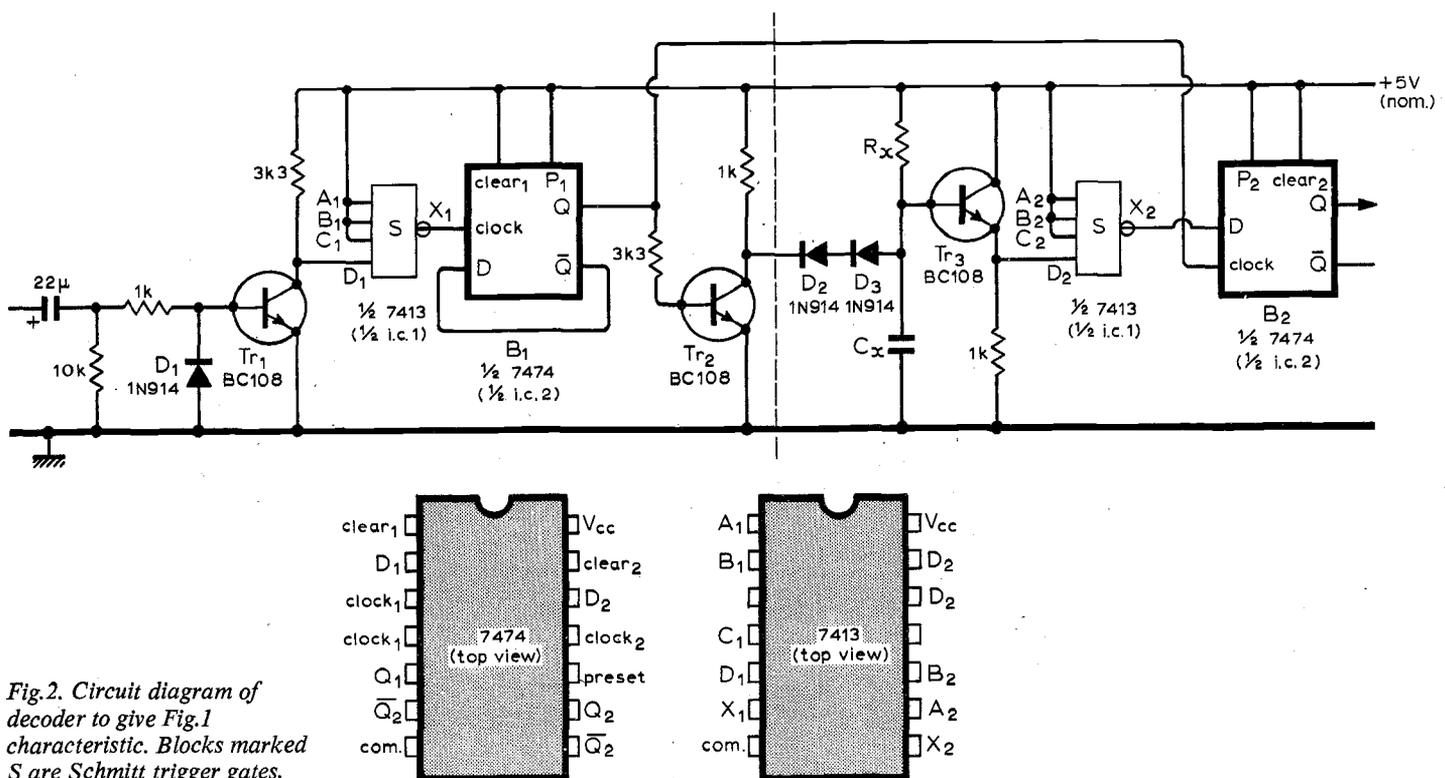


Fig.2. Circuit diagram of decoder to give Fig.1 characteristic. Blocks marked S are Schmitt trigger gates.

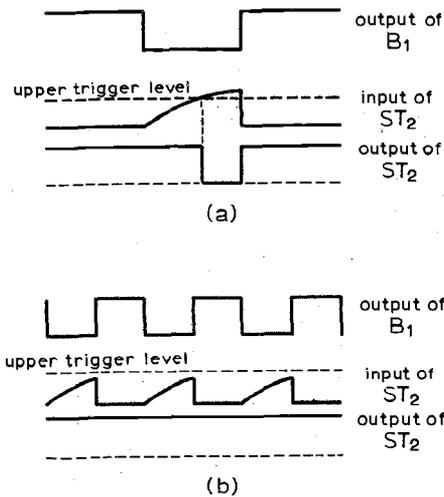


Fig. 3. Waveforms produced at output of Fig. 3 when input frequency is less than (a) and greater than (b) the critical frequency. The output of ST_2 is marked X_2 in Fig. 2.

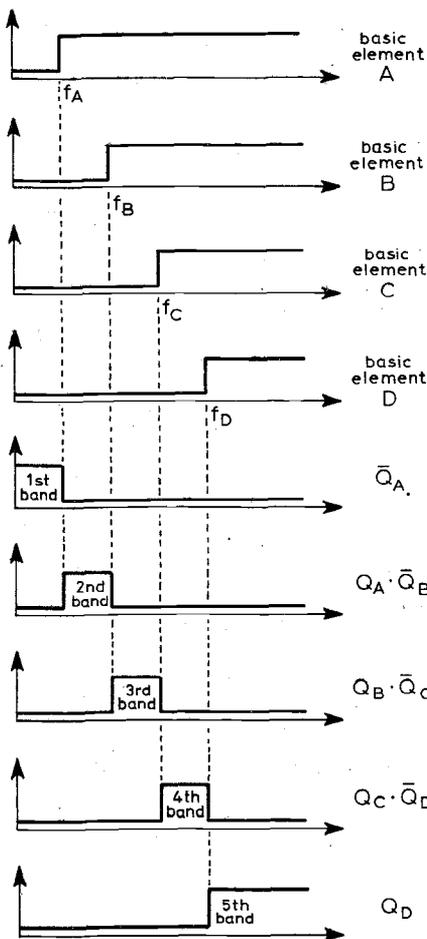


Fig. 4. The derivation of four pass-bands from four basic elements.

Fig. 6. Circuit to constrain all flip-flop Q outputs to "0" in the absence of an input signal.

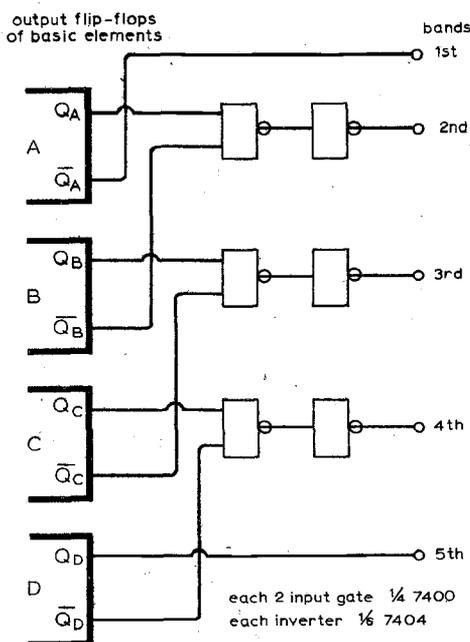
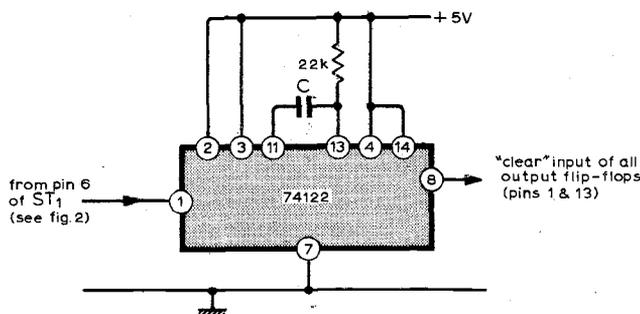


Fig. 5. Logic to perform the function of Fig. 4.

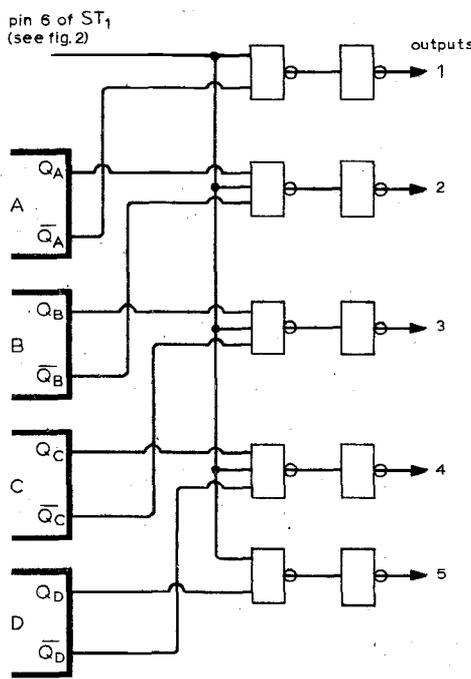


Fig. 7. Time-division multiplexing.

input frequency by two and thus removes mark/space ratio variations. If this were not done, the C_x charging time would be affected, not only by the frequency of the input, but by mark/space ratio variations. Tr_2 discharges C_x via D_2 and D_3 when the $B_1 Q$ output is at logic "1". D_1 and D_2 reduce the dependence of the critical frequency on the supply voltage to about 1% for a change from 4 to 5 volts. Tr_1 and S generate fast rise-time t.t.l. level pulses from the input signal to trigger B_1 .

To obtain n non-overlapping band-pass characteristics, we need $n-1$ basic elements with different critical frequencies. (The components to the left of the broken line in Fig. 2 may be common to all the basic elements.) Fig. 4 shows the characteristics of four basic elements with different critical frequencies, the five distinct bands with these critical frequencies as their edges, and the logic equations for these bands. Fig. 5 shows these expressions implemented with NAND logic.

Transmitter battery power may be conserved by not transmitting when all controls are in a neutral position. This means that the lowest frequency band (the first band in Fig. 4) cannot be used. Because we cannot know which state B_1 will settle in when the input signal is removed, some way of defining the state of the output bistables is necessary. Fig. 6 shows a circuit which will ensure that all the output bistables' Q outputs go to a logic "0" when the input signal is removed. The period of the retriggerable 74122 monostable must be greater than the period of the lowest input frequency; if this condition applies, then because it is retriggerable, the monostable's output will be at logic "1" while an input is present. When the input signal to the decoder is removed, the monostable's output will assume the logic "0" state; because it is connected to the CLEAR inputs of all the output bistables, all the output Q terminals will be forced to logic "0".

It has already been stated that B_1 makes the decoder independent of mark/space ratio variations of the input signal. It follows that mark/space modulation of the transmitter modulating signal may be used to provide proportional control channels in addition to multiple on/off channels provided by the tone decoder itself. It has been suggested that time-division multiplexing of the modulating signal is feasible with the new decoder. If signals in bands 1, 2, 3, 4 and 5 are applied to the transmitter modulator in sequence, then (see Fig. 4) at the decoder outputs, 1, 2, 3, 4 and 5 will go to logic "1" and return to logic "0" in succession. A modified form of output gating, shown in Fig. 7, routes a decoder input signal in band 1 out of output 1, a signal in band 2 out of output 2, and so on. Since the inputs may be modulated in mark/space ratio or (within any one band) in frequency, it seems that multiple channel proportional control should be possible with a time division multiplexed modulating signal: this presumes, however, some method of holding analogue data in each channel, while other channels are being addressed.

Using opto-couplers

An investigation of the noise characteristics of opto-couplers used with bipolar drivers

by K. F. Knott, B.Eng., Ph.D., M.I.E.E., University of Salford

One of the newer devices at present becoming available in i.c. form is the optically-coupled isolator, sometimes referred to as the solid-state relay. In this device a gallium arsenide light-emitting diode (l.e.d.) and a silicon photo-transistor are adjacent on the same chip. The light from the forward-biased l.e.d. is detected by the collector-base diode of the photo-transistor and causes current flow between the collector and emitter. By modulating the l.e.d. current it is possible to transfer a signal from the l.e.d. circuit to the photo-transistor circuit. Basically the device is a unilateral current amplifier, with incremental current gain typically in the range 0.1 to 1.5 for commercially available devices. Since the coupling between input and output is optical there is very good electrical isolation between them. Isolation to d.c. may be of the order of 1 to 5kV, and the stray capacitance between input and output may be 1pF or less.

In some applications the inherent noise of the device is unimportant; however there are some applications where one requires to know the noise behaviour so that an optimum performance can be obtained. Examples of such applications are: the elimination of ground loop signals from sensitive measuring systems, where the connection of more than one mains operated instrument completes a ground loop in which interference signals can be induced; the protection of patients from the danger of electric shock due to faulty grounding of patient monitoring systems; the extraction of small signals from circuits at a high d.c. potential (for example, one may be interested in the fluctuations of current flow to an electrode which requires a large accelerating voltage). The ultimate sensitivity in such applications is set by the inherent noise of the opto-coupler. This article describes the results of an investigation of the noise behaviour of 15 samples of opto-couplers obtained from three different manufacturers (type numbers CNY43, TIS111, MCT2).

Equivalent noise circuit

Preliminary measurements showed that the output noise current of the device was independent of the input termination. Therefore, the simplest equivalent circuit for the noise has one noise current source located at the output terminals as shown in Fig. 1. The symbols in Fig 1 are:

- I_D = l.e.d. bias current
- r_d = l.e.d. dynamic resistance
- i = small signal input current
- A_i = small signal current gain
- I_{CEO} = photo-transistor direct collector current
- i_n = short circuit output noise current
- i_o = short circuit output current

The noise factor of the circuit is found as follows:

$$F = \frac{\text{total mean square output noise current}}{\text{mean square output noise current due to } R_s}$$

The narrowband value of F is found if the spectral density of i_n is used in the equation rather than the mean square value. The spectral density of i_o due to R_s is:

$$\left. \frac{i_o^2}{\Delta f} \right|_{R_s} = \frac{4kTR_s}{(R_s + r_d)^2} A_i^2$$

$$\therefore F = 1 + \frac{(i_n^2/\Delta f)(R_s + r_d)^2}{4kTR_s A_i^2}$$

where $i_n^2/\Delta f$ = spectral density of i_n at frequency f . By differentiating this equation with respect to R_s one finds that F is minimum when

$$R_{s(opt)} = r_d$$

which gives,

$$F_{opt} = 1 + \left(\frac{i_n}{A_i} \right)^2 \frac{r_d}{kT}$$

where i_n = noise current in A/ $\sqrt{\text{Hz}}$. If it is assumed that the diode obeys the exponential law one may write,

$$r_d = \frac{kT}{q} \frac{1}{I_D}$$

$$\therefore F_{opt} = 1 + \left(\frac{i_n}{A_i} \right)^2 \frac{1}{qI_D} \quad (1)$$

(q = electronic charge = 1.6×10^{-19} C).

It is seen from equation (1) that the noise performance of the device will depend on how $\left(\frac{i_n}{A_i} \right)^2$ varies with I_D .

Experimental results—opto-coupler

Values of i_n , A_i and also cut-off frequency, f_B , were measured for 15 samples of devices obtained from three manufacturers. Complete noise spectra were taken for each sample over the range 10Hz–100kHz. In order to minimize the effects of collector-base feedback capacitance the cascode test

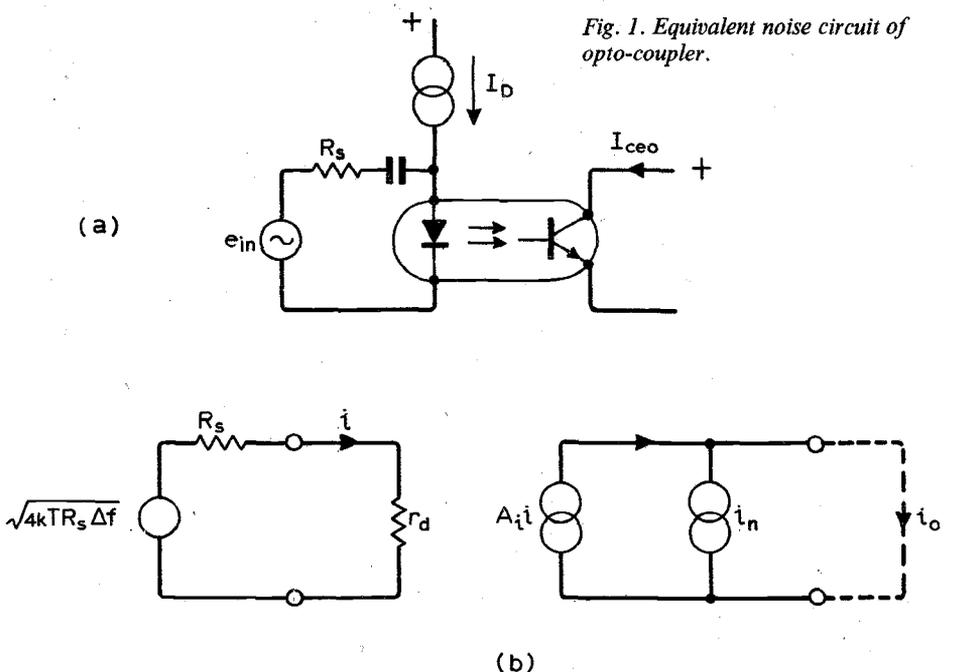


Fig. 1. Equivalent noise circuit of opto-coupler.

circuit of Fig. 2 was used. This test circuit is also useful as a post-amplifier.

In general there were no great differences between the three types of device tested so for clarity's sake the results are presented for one low-noise and one high-noise sample irrespective of type number.

The spectra of these two samples are shown in Figs. 3 and 4, with I_D as a parameter. Fig. 5 gives the variation of A_i and f_B with current for the two samples, and Figs. 6 and 7 show $\left(\frac{i_n}{A_i}\right)^2 \frac{1}{I_D}$ as a function of I_D at spot frequencies of 100Hz and 1kHz respectively. If the minimum value of F_{opt} at 1kHz is calculated for the lower noise device according to equation (1) a value of 38dB is obtained corresponding to $I_D = 500\mu A$, $R_{S(opt)} = 50\Omega$ and $f_B = 40kHz$. This device on its own therefore has a very high noise factor and also has the disadvantage of a low value of optimum source resistance. Obviously power gain is required preceding an opto-coupler if a reasonable noise performance is to be obtained.

Transistor—opto-coupler

Theory. The simplest circuit one can devise is that shown in Fig. 8(a) where the i.e.d. of the coupler is inserted directly in the collector of a common-emitter stage so that the transistor collector current is equal to the diode current I_D . In Fig. 8(b) the noise generators of the bipolar transistor and the opto-coupler have been included. By considering the various contributions to the output noise current one arrives at the expression for overall noise factor given below,

$$F = F_{bip} + \left(\frac{i_n}{A_i}\right)^2 \frac{r_e^2}{4kT\lambda R_S}$$

where r_e = incremental emitter resistance of bipolar transistor,

$$\lambda = \left(\frac{\beta r_e}{\beta r_e + R_S}\right)^2$$

(β = common-emitter current gain of bipolar transistor, F_{bip} = spot noise factor of bipolar transistor stage.)

Now, since the diode and bipolar transistor currents are equal,

$$r_e = r_d = \frac{kT}{q I_D}$$

$$\therefore F = F_{bip} + \left(\frac{i_n}{A_i}\right)^2 \frac{1}{q I_D} \frac{r_e}{4\lambda R_S} \quad (2)$$

If a low-noise transistor is used one can make an initial simplifying assumption that the transistor is noise-free compared with the coupler even when the power gain is taken into account. In this instance R_S coincides with the value for maximum power transfer i.e. $R_S = \beta r_e$ and $\lambda = \frac{1}{4}$. The second term on the right hand side of equation (2) then is equal to

$$\left(\frac{i_n}{A_i}\right)^2 \frac{1}{\beta q I_D}$$

The optimum noise factor then occurs at the same value of I_D as in the previous case.

To test the validity of the assumption that the transistor is virtually noise free, suppose

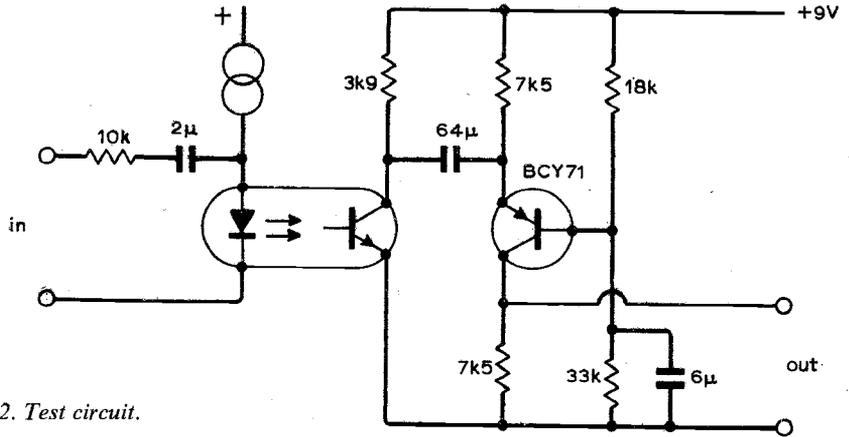


Fig. 2. Test circuit.

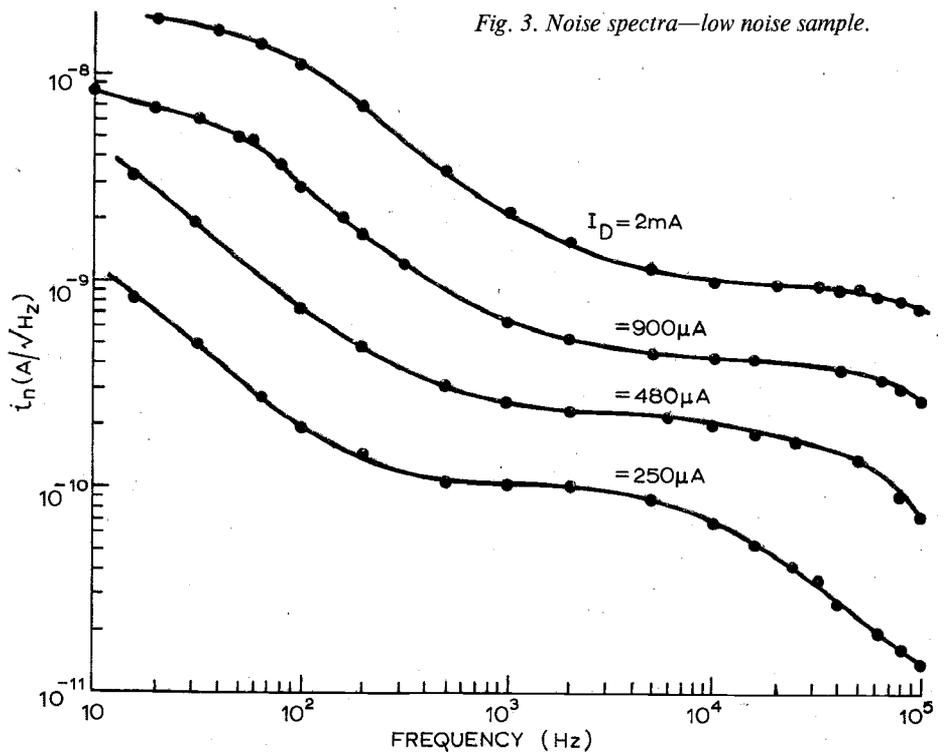


Fig. 3. Noise spectra—low noise sample.

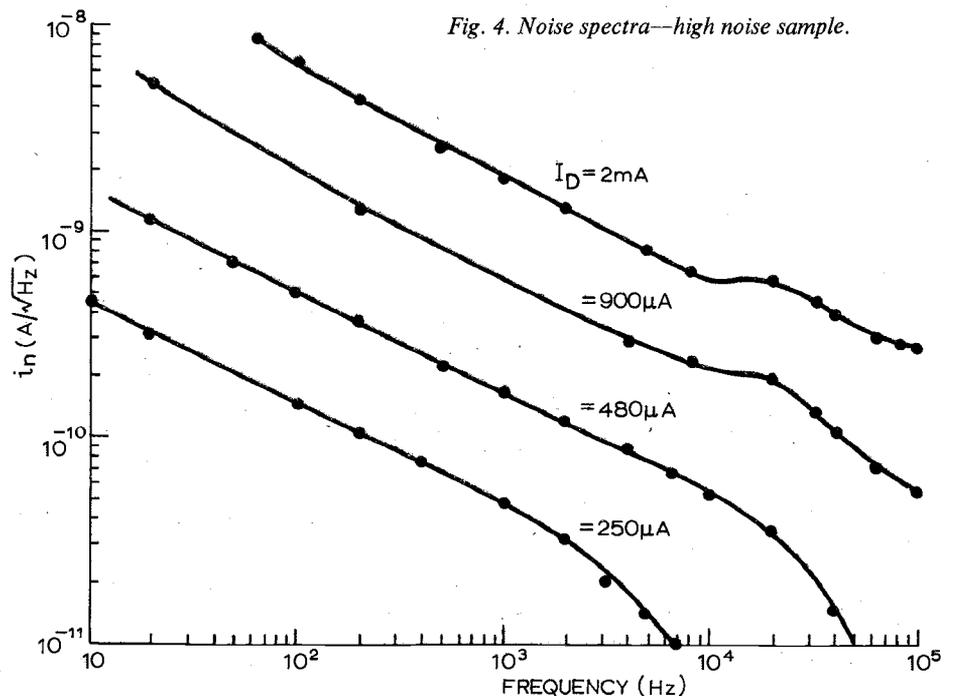


Fig. 4. Noise spectra—high noise sample.

a sample calculation is carried out at 1kHz for the lower-noise sample of opto-coupler using the following values,

$$\beta = 500$$

$$I_D = 500\mu A$$

$$\left(\frac{i_n}{A_i}\right)^2 \frac{1}{qI_D} = 6.25 \times 10^3$$

If it is assumed that the bipolar transistor is free of 1/f noise at 1kHz,

$$F_{bip} = 1 + \frac{(r_e/2) + r_{bb'}}{R_S} + \frac{R_S}{2\beta r_e}$$

where $r_{bb'}$ is the base spreading resistance. Since R_S has been chosen equal to βr_e ,

$$F_{bip} = 1 + \frac{1}{2} + \frac{1}{2\beta} + \frac{r_{bb'}}{\beta r_e}$$

The last two terms in this equation will usually be much less than one,

$$\therefore F_{bip} \approx 1.5$$

The overall value of F will therefore be,

$$F = 1.5 + \frac{6.25 \times 10^3}{500} = 14 \text{ or } 11.5\text{dB}$$

The overall value of F , excluding transistor noise, will be:

$$F = 1.0 + \frac{6.25 \times 10^3}{500} = 13.5 \text{ or } 11.3\text{dB}$$

Optimum noise factor calculations. The optimum noise factor is given by

$$F_{opt} = 1 + \frac{1}{\beta} \left(\frac{i_n}{A_i}\right)^2 \frac{1}{qI_D} \quad (3)$$

Use of Figs. 6 and 7 and equation (3) allows F_{opt} to be calculated as a function of I_D for various values of β at spot frequencies of 100Hz and 1kHz. Figure 9 shows sample results for $\beta = 500$.

Results—opto-coupler plus bipolar

The circuit of Fig. 8(a) was constructed using an unselected BC169 bipolar transistor in the common-emitter stage. The overall noise factor at $f = 1\text{kHz}$ and $I_D = 480\mu A$ was measured as a function of R_S using the lower noise sample of opto-coupler. The results are shown in Fig. 10. It is seen that the optimum source resistance is equal to βr_e but a 4:1 range of R_S could be tolerated for only a 1dB change in F . Alternatively, a 4:1 range in β could be tolerated.

The value of F_{opt} corresponding to $R_S = \beta r_e$ was then measured as a function of I_D . The results are shown in Fig. 11. Also shown on Fig. 11 is the curve calculated using equation (3) and the measured values of β . There is good agreement between the measured and calculated values of F_{opt} .

The good agreement between experimental and theoretical results justifies the simplifying assumptions made in the theory. The noise performance of both the high noise and low noise samples will be nearly optimum at a diode current of $500\mu A$, but one must bear in mind the reduced bandwidth and current transfer ratio at this current when designing any particular system. The combination of a bipolar stage and a low-raise opto-coupler has a noise

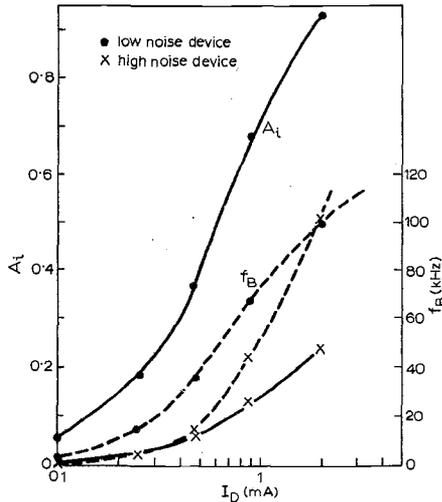


Fig. 5. Current gain and bandwidth as a function of I_D .

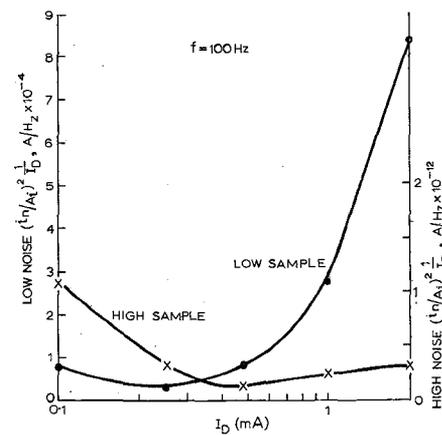


Fig. 6. $\left(\frac{i_n}{A_i}\right)^2 \frac{1}{I_D}$ as a function of I_D , $f = 100\text{Hz}$.

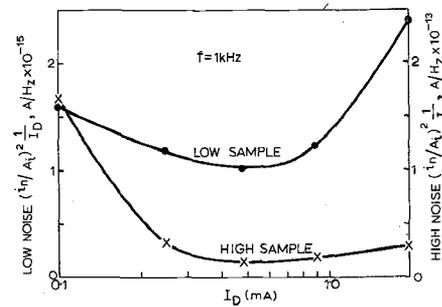


Fig. 7. $\left(\frac{i_n}{A_i}\right)^2 \frac{1}{I_D}$ as a function of I_D , $f = 1\text{kHz}$.

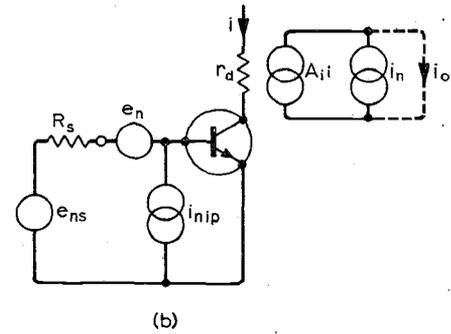
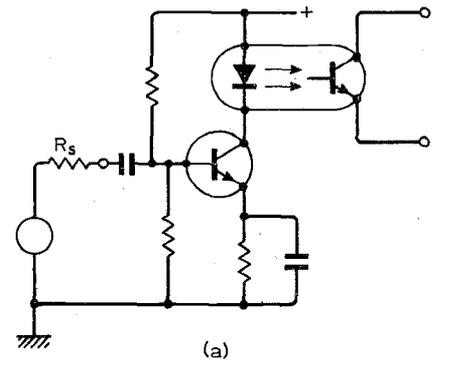


Fig. 8. Transistor-opto-coupler combination.

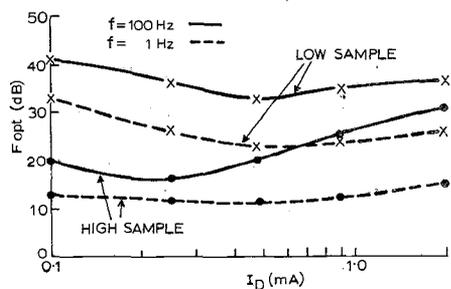


Fig. 9. Calculated F_{opt} assuming noise free bipolar stage.

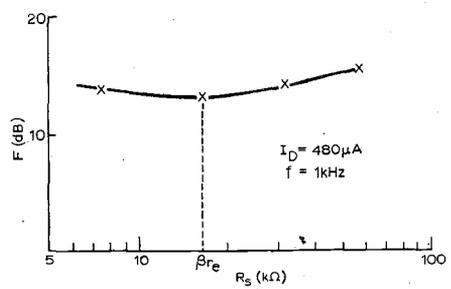


Fig. 10. F as a function of R_S for an actual circuit.

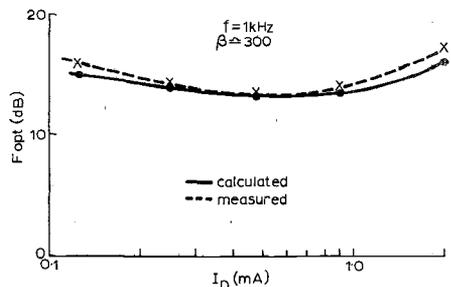


Fig. 11. Measured and calculated F_{opt} as a function of I_D for an actual circuit.

factor low enough to use as a second stage and perhaps even low enough to use as a first stage. However, the combination of a bipolar stage and the high noise sample of opto-coupler would have to be preceded by a stage of power gain in order to obtain a low overall noise factor.

A conservative worst case design using the high noise sample with a bipolar having a range in β of 150–600 would be:

$$\text{Set } R_S = 16\text{k}\Omega$$

$$I_D = 500\mu A$$

Precede this combination with a further low-noise bipolar stage having an available power gain of 30dB.

Some thoughts on transformers

What sets the limits in design

by Thomas Roddam

If you want a transformer you may set about getting it in any one of a variety of ways. At first sight the easiest is to work for a large organization which has its own group of transformer designers. You simply say what you want, wait, and up comes something which is too big for the job. That group was not hired to make your life easy, but to keep the number of sizes of lamination and bobbin held in the stores to a minimum. The experts are not usually too good if you want something really subtle, either. The extreme in elaboration that I can think of was the designer who had to design a new grinding machine to get the close tolerance he needed for the bobbin of a really closely defined transformer. Other ways are to use the nearest item you can find in someone's stock list, wind it yourself on the kitchen table, or find one of the smaller manufacturers who will make a single transformer, either because one is all you want, or as a prototype.

This last solution splits, in theory, into two possibilities. Either you go cap in hand, and say what you want the transformer to do, leaving it to the manufacturer to design it when he has time, or you design it yourself. If you leave it to the manufacturer he may have to fit it in with the main task of keeping the business running, or he may have a mysterious "designer", who is never seen and who, I suspect, either does this in spare time from his proper job, or is the lab boy at the local tech. There is a third possibility, the one which set me thinking about this article when I first heard about it: you bodge up a design. You take an existing design and ask for something the same, but different. The specific example which first introduced me to this method was the man who had been buying transformers for a 10 watt amplifier system. He changed nothing but the number of turns and then complained that he could not get 20 watts out with a higher supply voltage.

It appears to me that even if what you require is extraordinarily simple, for example a unity ratio isolating transformer, you should do some of the design work yourself. That simple isolating transformer may land you in trouble. I have met off-the-shelf units which, in the interests of economy, were designed to work at rather high flux densities. In consequence there was a sharp current peak which led to a good deal of confusion. The whole situation has become more complicated with the need to build power transformers to work at higher frequencies. If you want to handle 100 watts at 1kHz, or 20kHz, you will not get much help from your little man round

the corner. You will not get much help from most of the textbooks, either.

What makes the variety of transformers interesting is the fact that the rules seem to change. Of course the essential theory is the same, but the limiting factor for one set of conditions turns out to be unimportant for another set, because a factor which looked after itself has become predominant. It is this question of what sets the limits which I propose to examine.

The simplest transformer we use is the ordinary 50Hz mains transformer. The two limits in normal design are the flux density in the core, and the current density in the wire. Magnetizing current, as such, is not often a problem; nor, to my mind, is core loss. It is wrapped up by the matter of flux density, which always needs to include an idiot factor. If you provide taps, will someone set to 220V and connect to a nominal 240V which is actually 250V? Will the transformer be used in one of those places where they would rather have some power at 45Hz than a black-out at 50Hz? Current density is quite simply a matter of the transformer getting hot. We should consider the regulation, or so the books say, but we are more and more passing the job of controlling the final level to some clever circuits, and in many applications we find that we should like even more transformer resistance than we dare include.

A very simple guide to mains transformer design which I found somewhere or another, and which seems to give a good place to start, is that the core cross-sectional area should be

$$W^{1/2}/5\text{in}^2$$

where W is the power to be handled. I know we should not use inches, but the cores people's stock is all described in inches. A 25W transformer should, on this basis, fit nicely on a square stock with a one inch centre limb. I shall have a go at deriving this expression in an appendix, but I have a nasty feeling that with my choice of parameters I shall get a different numerical factor. The object of all these guide equations is really nothing more than offering a good starting point for the first rough design. A better method is to look back at earlier designs, if you have any, or to try to work out from the catalogue what the other chap did, at least as far as core size is concerned.

The ordinary, everyday, aspects of the design you must look up in the book. Now we are all using silicon rectifiers straight into capacitance smoothing the addition of a screen is even more important. You may

want to know the magnetizing current, for calculating the protection circuit, but it really is safer and easier to measure it.

When we leave the simple world of the 50Hz power transformer it seems natural to move to the 400Hz power transformer. If we were to do nothing special, but just design as before for a reasonable flux density just below saturation, and take no further thought, we should be in trouble. The laminations which were gently warm would now be very hot indeed. Each lamination is, of course, of finite thickness, which for the bread and butter world is 0.015in. The thickness is a small short-circuited turn, and there are rather a lot of them. Each of these turns is rather loosely coupled to the primary, and the effect of the short-circuited turns depends on both the coupling and the resistance of the turn. A detailed analysis was done by Caver, but it is pretty obvious that if we use thinner laminations the coupling to each one will be weaker, and its resistance higher. The iron-masters have decided for us that 0.004in is the right thickness to use for a 400Hz: there is no point in doing a lot of calculation and finding that it should be 0.003 or 0.005. The chaps who make the stuff think that Milton was writing about them.

A difficulty with thin laminations is that they are so thin. Fortunately we can get C-cores, which are easy to put together, have rather better magnetic properties and, because so many users prefer them, have made it almost impossible to find a source for small quantities of the 0.004in laminations. You do not need a guidance equation for C-cores: the maker tells you the power he, or his predecessor, would expect each size to handle.

Apart from this matter of using the thinner material, the key criteria are the same at 400Hz as they were at 50Hz: flux density safely below saturation, current density below overheating.

It is interesting to notice that we could have made our 400Hz transformer with the 0.015in laminations if we had kept the flux density very low. Of course this would have meant using a much bigger transformer. But this is exactly what we do when we construct an audio output transformer. At the largest signal level at the lowest working frequency we allow the flux density to be moderately high. Suppose we choose $B = 10000\text{G}$ at 40Hz. For the same signal level at 400Hz the flux density will be only 1000G. Observations on real transformers show that the eddy current loss effect is not significant. If we use 0.004in laminations to make transformers to operate from about

1kHz upwards we can see the effect of the eddy current loss. Instead of the frequency response being that of an *LR* circuit it becomes deformed. Not much, it is true, but the effect is observable.

Power applications of higher frequencies have been with us for much longer than most people think but with the development of the transistor and the thyristor it became so much easier to get powers in the range from tens of watts to tens of kilowatts that the attitude of the power user became completely transformed. One range of frequencies in common use is roughly 1kHz to 1.5kHz. I do not wish to go into matters of circuit design, but there are often good reasons when the older practice of using a tuned transformer is not practicable. The transformer designer is required to produce, let us say, a transformer to handle 200VA at 1kHz, with the primary and secondary volts specified.

In one sense there is no special problem. A probable core is selected, and the number of turns needed to give the right flux density is examined to see if they can be wound with wire which will carry the current. Then, just as we used thinner core material when we changed from 50Hz to 400Hz, so we must seek out the appropriate thickness for 1kHz. Unfortunately this drives us into the country of "specials", the things you can't get, and couldn't afford if you could get them. If you just use 0.004in material at its full flux density the core will get very hot, which is particularly undesirable when all the power being wasted has been produced rather expensively with semiconductor devices.

It is at this point that we fix a new design criterion, or perhaps more correctly a new starting point. We choose our core loss. The procedure is one of ruthless guesswork. Guess the size of core which will be needed: this gives us the weight. Guess a reasonable core loss, perhaps 3% of the total power. From these two figures we can find the core loss per unit weight and then turn to the manufacturer's data sheets to find the approximate flux density. From now on the design is straightforward but, at first, tedious. If your guess is wrong, and the transformer is obviously too big or too small, you must guess again. If the first shot was not too far out, the second design will be satisfactory. The beginner may need to have a third shot, and the more advanced designer, once the size is about right, may want to vary it to trade iron losses against copper losses. A point worth noticing in this kind of transformer is that iron losses are always with us, even if we are not using any output. This can be significant in battery operated systems which are only lightly loaded for most of the time.

For operation at high audio frequencies, that is above the classic 400Hz, it is tempting to consider the use of nickel-iron alloys. These are available as thin laminations, in a range of sizes, and in materials of high permeability and high resistivity. In an ideal world they would be perfectly suited for many applications. For some reason which I cannot understand, obtaining any of these laminations is an extremely frustrating operation.

The really fashionable power trans-

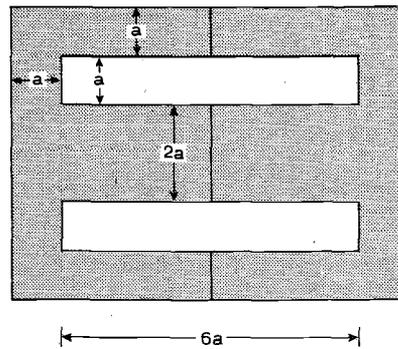


Fig. 1. Genesis of the no-waste lamination.

formers nowadays are those used in transformerless power supply units. It will not surprise the older readers who remember the domestic comments about wireless to learn that one design, at least, of these transformerless supply units has three transformers inside it, instead of the usual single transformer. As every schoolboy knows, the only phrase written by the great Macaulay which remains in my memory, these power supplies simply rectify the mains, to give some 300 odd volts, and then use an inverter running at some 20-50kHz to get some transformable a.c. The part of the system where you have to be clever, or extra clever, is passing the message back from the output to the inverter side, where all the control takes place and which is quite firmly connected to the mains. When you recall that you can get these units which provide 100A at 5V you will see that the control must be on the primary side, where if the efficiency were ideal the current would be less than 2A.

In fact these are only the latest in a long line of d.c. to d.c. converters, and are related to other power converters. It is a new high-speed, high-current rectifier which has brought the possibility of this particular system into being. The lower power systems, and the 10-20W level has had a good many applications, have been very tempting subjects for operation in the 20-50kHz range, but there are some rather interesting problems in the design of the transformer. At first sight it is attractive to use a toroidal core of the very thin nickel iron material which is, in theory, available. The thinness is essential to avoid eddy-current losses. Toroids are, however, a nuisance for winding unless you have a suitable winding machine, and even then there are some problems. Another serious difficulty for most of us is the problem which you meet when you learn to ride a bicycle: it is the problem of getting started. To get one core is much more difficult than getting 100.

The answer, if you have a need for only one unit, or as happens if you are selling to the impoverished Third World, perhaps fifty units, is to use ferrite cores. These are cheap and are easily available. The choice is then between the pot cores and the double E's or E and I forms. Pot cores have the great advantage that they are self-shielding. The external field is very small, and this can be important. However, these cores are basically designed for producing inductors. The important thing, when you are making an inductor, is that you should be able to

bang on a fixed number of turns, and come hell or high water you should get a defined inductance. I know that there have been changes since the days when iron filings were stuck to sheets of paper (ferrocast) or little spheres of carbonyl iron were all glued together with something or another but in spite of the wonders of progress the permeability of ferrites is not strictly defined. Inductor cores are therefore made to have fixed permeability by the simple process of introducing an air gap. The apparent permeability is therefore very low.

If we were to construct a high frequency transformer ignoring this factor we should carry out our design calculations in terms of the flux density, and the important detail of getting enough copper. We should take account of the rather tedious detail that ferrites do not get the heat away as well as laminations, and cannot stand a high internal temperature gradient. But after all this, we might still be in trouble. The devices must carry the useful current and the magnetizing current. It is the same problem as the elliptical load line we met so long ago in audio amplifier design.

I am well aware that ferrites do not come in the no-waste proportions, least of all the pot cores. In practice, in order to get low leakage inductance, a ferrite-cored transformer will be under-filled, and anyway, we are after guide-lines. The ratio of magnetizing current to useful current is derived in the appendix, and is

$$\frac{I_m}{I} = \frac{B}{500\mu a}$$

If we take $B = 2000$

$$\mu = 100$$

we get $\frac{I_m}{I} = \frac{1}{25a}$

Remembering that a is half the centre limb width of an E, and is thus, on a typical core, about $\frac{1}{5}$ in, we get

$$\frac{I_m}{I} = \frac{1}{5}$$

Things are really worse than this. We are thinking about d.c. converters, which operate with square waves. This value of I_m is the sine-wave r.m.s. current, but the actual current is a linear run up, and the unhappy devices concern themselves with the current peak. The devices must be bigger, or driven harder, and as this current is handled by the devices the losses will be higher. We must, therefore, use a material and core style which gives us the highest possible permeability. The alternative is to increase the size, both to increase a and also to allow us to reduce B .

I am not concerned here with the right answers: the important thing in beginning a design is to ask the right questions. The magnetizing current question is one which we need to ask in any low permeability situation, right back to the old-fashioned output transformer in the anode of a single pentode. The general question of the rough size is worth asking yourself even if the actual work of designing the transformer is to be passed on to someone else.

All this discussion has been in terms of a square stack of no-waste shape. It is fairly clear, I think, that if we vary the thickness of the stack we shall vary the voltage which can be applied to the winding for the chosen flux density. This assumes that we keep the same number of turns of the same wire gauge. The transformer wattage is thus directly proportional to the stack width. If we go into more detail we shall find a limiting process produced by the increasing turn length, but the mechanical difficulties are usually the dominating ones. When we turn away from the no-waste lamination we can reason roughly like this: keeping the turns the same for a given centre limb area, the current will be proportional to the window area. Thus the wattage is proportional to the window area.

Some of the results do not agree with the results of a perfectly general analysis. It is unfortunate that most analytical solutions to problems explain why such and such does so and so. We do not want to know why this transformer gets hot at a loading of 150 watts: we want, with less scientific precision, a transformer that stays cool, and is manufactured from standard parts. General solutions are always attractive when you are doing the theory, because you wrap up the whole problem in one bumper bundle: the bundle is an end in itself.

I had intended to conclude with the corresponding expression for inductors carrying direct current: indeed, I have done so in the appendix. The result is to give a core area of

$$A = (VI_2)^{2/3}/25\text{in}^2$$

At first I was rather unhappy about the result which showed up, which did not take account of the range of working currents. This result looks quite sensible, and a quick check on a 100-watt unit, say 100V, 1A, shows the transformer to have a core area of 1.5in^2 and the inductor to be 0.85, or just over half the size. Notice that, like the statisticians who draw little men, or little ingots of gold, to compare different systems, I have not been too clear about what size means.

Any design is a compromise: if you can save energy in getting your rough solution you can use the time to get the best compromise.

Appendix

Core properties based on one no-waste lamination

The no-waste condition ties all the lamination dimensions together, so that a standard shape can be used to establish guide formulae. The figure shows how a pair of Is is stamped out of each pair of Es. The window must have dimensions a by $3a$ for this simple picture to be true. A further simplification for the analysis is to assume that we make the core thickness $2a$, giving a square stack. The coil winders find this very attractive.

The core area is then $4a^2$.

The window area is $3a^2$.

The mean magnetic path is $12a$, if we consider what happens if we slit the E down its centre line.

The volume is $48a^3$.

In spite of the fact that all the bright young men will complain, the basic dimension a is expressed in inches, because that is how the cores are specified.

The volts/turn for this core is given by

$$\begin{aligned} \frac{V}{N} &= \frac{4.4BA_f}{10^8} = 4.4B \cdot 4a^2 \cdot 6.45f \cdot 10^{-8} \\ &= 113.5a^2Bf \cdot 10^{-8} \end{aligned}$$

The window area is not full of copper. The assumption is that one half is primary and one half secondary, that copper occupies $\pi/4$ of the available space and that only a fraction p is left after we have provided a bobbin and all the other wastage. The primary copper thus occupies an area of

$$\frac{\pi}{4} \cdot \frac{1}{2} \cdot p \cdot 3a^2 = \frac{3\pi}{8} p \cdot a^2$$

If we make

$$p = 0.85 \text{ and operate at } 1000\text{A/in}^2$$

$$\text{or } p = 0.565 \quad 1500\text{A/in}^2$$

we get the very agreeable result that

$$NI = 1000a^2$$

Multiplying this by the expression for V/N :

$$VI = 113.5Bfa^4 \cdot 10^{-5}$$

If now $B = 12.35 \times 10^3$

$$VI = 14fa^4$$

And at 50Hz

$$VI = 700a^4$$

The core area was, as we saw

$$A = 4a^2$$

$$\text{so that } VI = \frac{700}{16} \cdot A^2 = 43.8A^2$$

Now VI is the power which the transformer will handle, and to find the size of transformer for a given power, $W = VI$, we simply take a core area of

$$A = (W)^{1/2}/6.6$$

The difference between this and the form $(W)^{1/5}$ which I have been using on unknown authority, can be attributed to a number of factors. The unknown x may not have used no-waste laminations and he certainly used different values for the flux and current densities. If we allow for the frequency to be 20% low, we should get a figure of 6, but that seems to be over cautious.

Of course it does not matter. It is extremely rare to know the exact power which a transformer will need to handle. This is an expression for guidance, and should not be regarded as anything more.

At 400Hz the situation is, as I have pointed out, rather different. We are given the ratings for C-cores, which are not the no-waste shape anyway. What is also significant is that the flux density can be higher. Forgetting all this, and just putting in 400 for f .

$$VI = \frac{5600}{16} A^2 = 350A^2$$

$$A = (W)^{1/2}/18.7$$

The weight of the core will be about $12a^3\text{lb}$, and if we take what I think is a rather low core loss figure of 1W/lb at 50Hz the core loss will also be $12a^3$. The area of core surface which is not shielded by the bobbin is $72a^2$, so the dissipation of heat must be

$$12a^3(W)/72a^2(\text{in}^2) = \frac{a}{6}W/\text{in}^2$$

For values of a less than about 2in , which is the size we are always considering, this implies quite a moderate temperature rise.

Let us now turn our minds to the magnetizing current. The inductance of the primary is given by

$$\begin{aligned} L &= \frac{1.259N^2 4a^2 \cdot 6.45\mu 10^{-7}}{12a \cdot 2.54} \\ &\approx N^2 a \mu 10^{-6} \end{aligned}$$

The magnetizing current is

$$I_m = V/2\pi fL$$

$$\text{and } V = (4.4BN \cdot 4a^2 \cdot 6.45f)/10^8$$

$$\text{giving } I_m = \frac{113.5BNa^2f}{2\pi N^2 a \mu f \cdot 10^8 \cdot 10^{-6}}$$

$$= \frac{18Ba}{N\mu 100} = \frac{0.18Ba}{N\mu}$$

The useful current, the one we use for working out the power, is

$$I = 1000a^2/N$$

so that

$$\frac{I_m}{I} = \frac{0.18B}{1000\mu \cdot a}$$

or, to make it a bit simpler, we can approximate to

$$I_m/I = B/5000\mu a$$

For the input inductor of a 50Hz full-wave rectifier system we already have one simple rule:

$$\text{Inductance } L = (V/I_1) \times 10^{-3}$$

to maintain continuous current flow. Here V is the output voltage and I_1 the minimum working current. A designer will be lucky if he can get an energy storage density given by

$$\frac{LI_2^2}{\text{Vol}} = 0.1$$

where I_2 is the maximum current, or

$$LI_2^2 \approx 50a^3 \times 0.1 = 5a^3$$

This is, of course, only one point on the Hanna curve. In accordance with the rule that numbers are chosen to give simple answers, let us take

$$I_2 = 5I_1$$

$$\text{Then } LI_2 = 5V \cdot 10^{-3}$$

$$LI_2^2 = 5a^3 = 5VI_2 \cdot 10^{-3}$$

$$a^3 = (VI_2) \cdot 10^{-3}$$

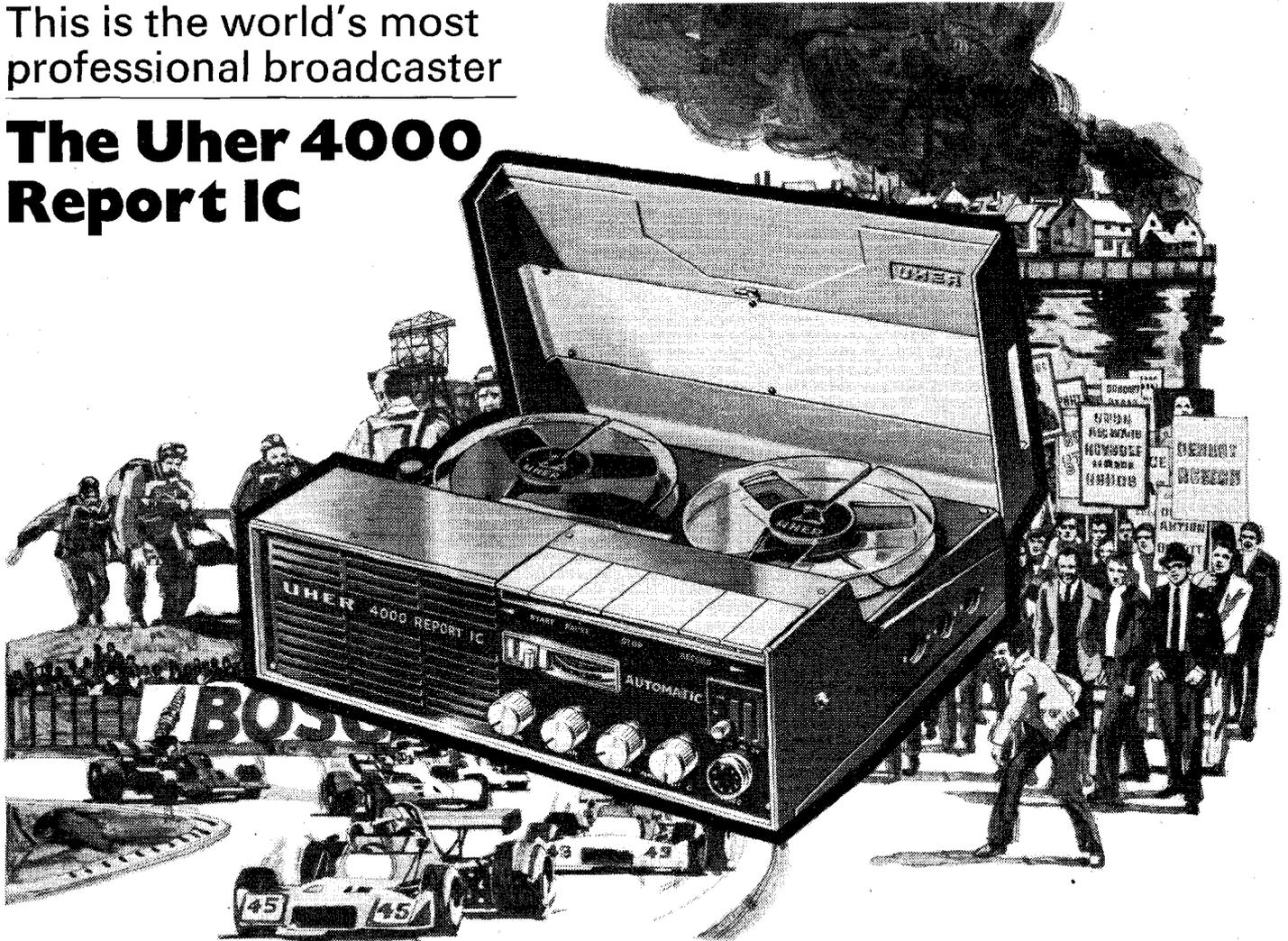
$$a = (VI_2)^{1/3}/10$$

so that the area of the centre limb is

$$A = 4a^2 = (VI_2)^{2/3}/25$$

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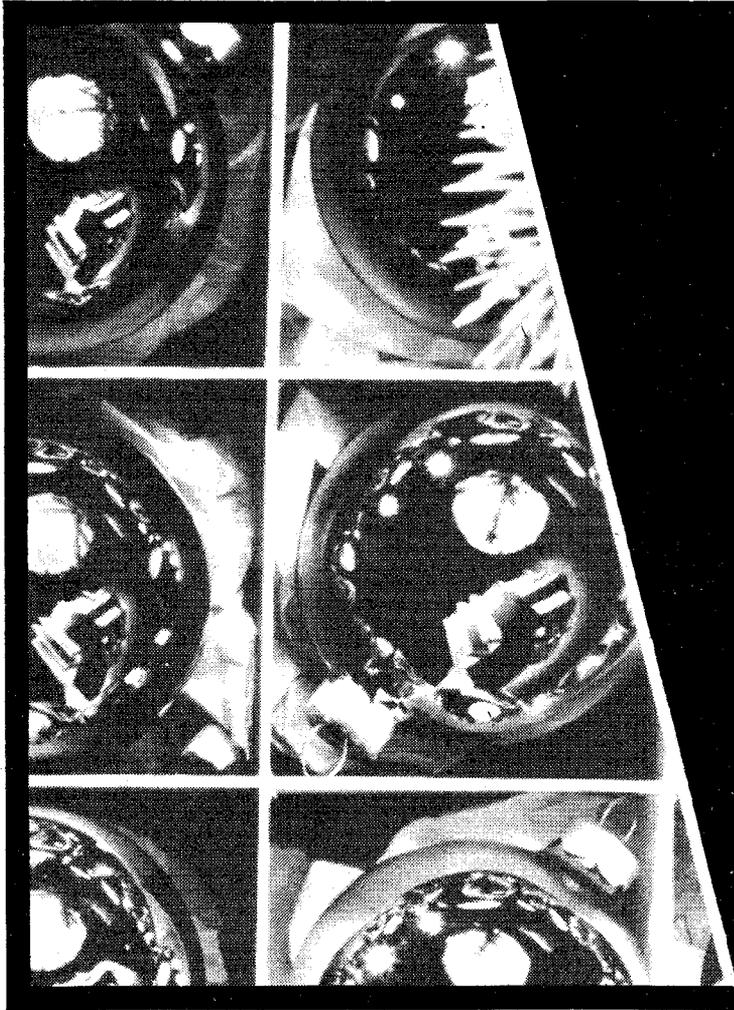
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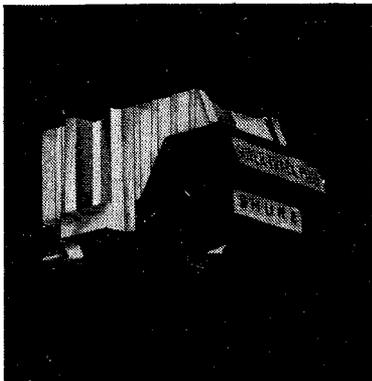
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Industrial security

A survey of the necessity, techniques and equipment available and the effectiveness of such equipment in combating industrial espionage

by W. E. Anderton, B.Sc.

Assistant Editor, Wireless World

Espionage used to be the subversive operation of "secret services" but with the encouragement of competitive free enterprise, and the massive sums of money involved in the development and operation of large industrial companies, espionage has spread. The value of "classified" information has led to the growth of a commercial industry manufacturing devices for the illegal acquisition of information and also for protection against this occurring. The commercialism of this development has become apparent by the discovery that companies selling "bugging" (eavesdropping) devices to one "side" are selling anti-bugging devices to the very people who are being bugged! — a distasteful situation to which few of the technical or commercial people involved have given sufficient political consideration. However, there is more to information security than bugging and the intent of this article is to describe the electronic equipment now deemed necessary for the full security of an establishment which contains information worth stealing.

Two levels of security are necessary. The first is the physical protection of property, from the perimeter fence which can be fitted with seismic or laser detectors (the modern equivalent of the moat), through the grounds and entrances covered by low-light television equipment to the last-ditch alarm system, the most sophisticated of which can detect movement in a room by means of ultrasonic devices. The second level of security is the protection of information itself — guarding against bugging by detection of alien devices or by transmitted message scrambling, a process which has now reached a high degree of sophistication.

The term "industrial espionage" is apparently disliked by its practitioners, who prefer the euphemism "aggressive market research", which they define as the practice of securing knowledge about competitors by any and every possible means.

"Bugs"

The manufacture of electronic bugging equipment has become big business for over 50 large companies mainly, but not exclusively, in America.

The most commonly used telephone bug is a small transistor oscillator,

operating at around 90MHz, mounted on the back of a standard telephone microphone insert or actually built into a standard insert. Either way, the bug is a direct plug-in replacement for the standard microphone insert and can be fitted in a second or two. The bug is powered by the telephone line current and, if undetected, can operate almost indefinitely. The telephone line itself acts as an aerial.

In most countries, government security organizations use direct wire tapping, or re-arrange the 'phone wiring using an elementary "third wire" technique so that the microphone becomes active even though the handset is on its rest. Industrial espionage agents generally use more elaborate methods, because the direct wire tapping techniques draw current from the telephone lines and are readily detected by conventional telephone line monitoring equipment.

Yet another telephone bug utilizes the magnetic field that exists around the hybrid transformer in the base of the telephone handset. The bug, often disguised as a telephone diary or ashtray, is placed close to the telephone so that an inbuilt coil can detect the handset's local magnetic field.

Perhaps the most ominous of all telephone tapping devices is one known as the "infinity transmitter" — a device which can be used over telephone lines thousands of miles long.

Other types of detectors are used to receive sounds through concrete and brick walls. These consist of a small radio transmitter (usually f.m.), a hearing aid microphone and batteries and have a range of about 400 yards. Sound can usually be picked up within 20 to 30ft of the microphone, depending on any obstacles between the receiver and the sound source.

The transmitters used in these devices are very simple but obviously it has not been the means of transmission which has had to be developed but miniaturization and economical battery operation. Some units switch on their transmitter only when there is a sound signal to transmit or, more ingeniously, may be provided with a power source consisting of a simple tuned circuit, diode, and large storage capacitor (imposing a size

disadvantage). The source is connected to a short aerial and, when tuned to a local broadcasting station, receives and stores sufficient power to operate a low-powered bug almost indefinitely.

Many large organizations, rather than attempting to solve their possible bugging problems, merely trample them to death by installing r.f. white noise generators. These then flood the surrounding area with r.f. noise and effectively jam any radio transmitter within several hundred feet. These r.f. generators are an anti-social means of defeating bugging intrusion for they jam all radio signals within their area of operation — legitimate or otherwise.

A more subtle means of protection is to detect devices by means of simple field strength measuring meters. This is not completely effective for, as mentioned before, some devices only transmit when there is information to be transmitted, or are remotely switched on after it is known that the room which has been bugged has been officially cleared.

A typical field strength measuring meter would probably include the following features (taken from the catalogue of a model in present use): an output meter scaled to read microvolts or dB relative to $1\mu\text{V}$, the dynamic range being from 10-100 μV and 0-40dB relative to $1\mu\text{V}$; attenuators which may be switched into the i.f. amplifier permitting voltages up to 90dB above $1\mu\text{V}$ to be measured; a sensitivity and measure switch to allow the operator to increase the sensitivity when monitoring low level signals; frequency range switch and tuning controls (v.h.f. from 34 to 225MHz and u.h.f. from 225MHz to 850MHz). The application of such a meter would be much wider than bug detection, but it is typical of the type of instrument which can be used.

While it is not possible to code direct communication by speech between individuals, it is possible to code or scramble transmitted messages and thus almost eliminate the possibility of divulging information en route.

Cryptography

The art of enciphering written messages is centuries old and has reached a high degree of sophistication with the develop-

ment of digital processing equipment. Only recently, however, has voice enciphering become possible through the speed of electronic devices necessary to code the complex sound variations of the voice which occur at high speed. The earliest units used during the second world war mixed up different frequency bands within the voice spectrum — hence the term scrambling.

A modern data enciphering system is shown in Fig. 1. Most data enciphering devices simply combine the binary representation of a message character with a pseudo-randomly generated binary key character to yield the cipher character to be transmitted. A method of coding and decoding (illustrated in the table)

Table

Bit stream encryption using an exclusive OR function

Data	1	0	0	1	1	0	0	0	1	0	1	0
Key	1	1	1	0	1	1	0	1	0	0	1	0
Cipher	0	1	1	1	0	1	0	1	1	0	0	0

Cipher	0	1	1	0	1	0	1	1	0	0	0	
Key	1	1	1	0	1	1	0	1	0	0	1	0
Data	1	0	0	1	1	0	0	0	1	0	1	0

called bit stream encryption uses an exclusive OR function both in the encoding and decoding process. If the key character changes unpredictably from character to character as in the case of a true random number series, then the result is unbreakable. To be completely safe, a cryptographic system needs a large number of codes available, an extremely long, random-like, non-linear key system, an automatic random starting point and a sophisticated interconnection between various registers and logic within the code generator.

Now to the more demanding and complicated procedure of voice encoding. Why place such a high premium on transmission by voice where written data would appear to suffice? Voice is fast and convenient, it provides immediate conversation, it allows more freedom of expression and aids positive recognition of the other party.

Fig. 2 shows the basics of a voice enciphering system analogous to the data enciphering system already described. The voice signal enters the device in analogue form and is digitized (for example in the same way that sound signals are digitized for p.c.m. transmission). The digital key characters control whatever the enciphering process involves and are prompted by a sync signal from a crystal controlled generator. This sync signal is also combined and transmitted along with the enciphered signal in order to permit synchronization of the key generator in the deciphering device at the receiver.

The latest and best proven solution for commercial/industrial purposes appears to be the rolling code band scrambler. This utilizes the principle that the shorter the message segment between code changes, the more difficult it is to defeat the code. These scramblers follow the principles shown in Fig. 2

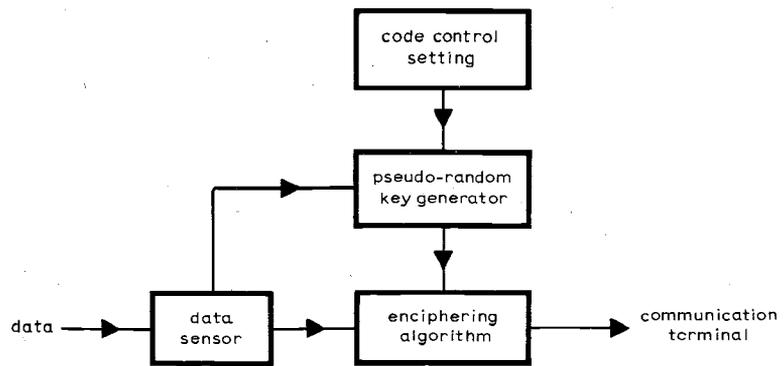


Fig. 1. Block diagram of a data enciphering system. Data enters in binary form. As soon as the sensor determines that an acceptable character is present, it requests the key generator to provide a key character. The cipher character is obtained by combining data and key characters.

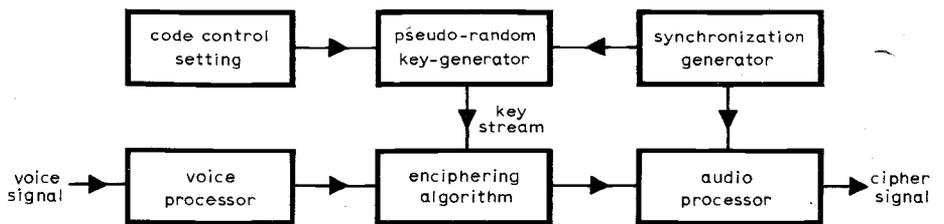


Fig. 2. Schematic voice enciphering device. Voice signals enter in analogue form and are digitally processed for enciphering. Digital key characters control the enciphering process — either digital or analogue.

and, by rapidly and automatically changing the permutation/inversion combination in an otherwise fixed band scrambler, the time needed to break the system is greatly extended.

As an estimate of the problem facing the interceptor of a coded message, the following describes part of the operation of a commercially available unit: "The clear voice input is split into five frequency bands from 377Hz to 2,477Hz, then rearranged (or scrambled) into five output bands, also from 377Hz to 2477Hz. The rearrangement is accomplished by a heterodyne process which shifts and may or may not invert the frequency bands. Theoretically there are 3,840 possible combinations. Most combinations offer little loss in intelligence (Example: inversion of the upper band only). . . . Each 0.25 second, a new combination is selected automatically, by the output of the random code generator. The code generator has over 2,000,000 possible user codes selected by thumbwheel switches behind a locked front panel. In addition, the customer selects one of 16,000,000 code families by simple internal connections, thus customizing his units".

Potential aggressive market researchers should by now be starting to go green. There's more to come, but first, to shed a ray of hope, the most accessible information for interception, tampering or pure destruction is that which is stored and processed by computer, and this affects all of us.

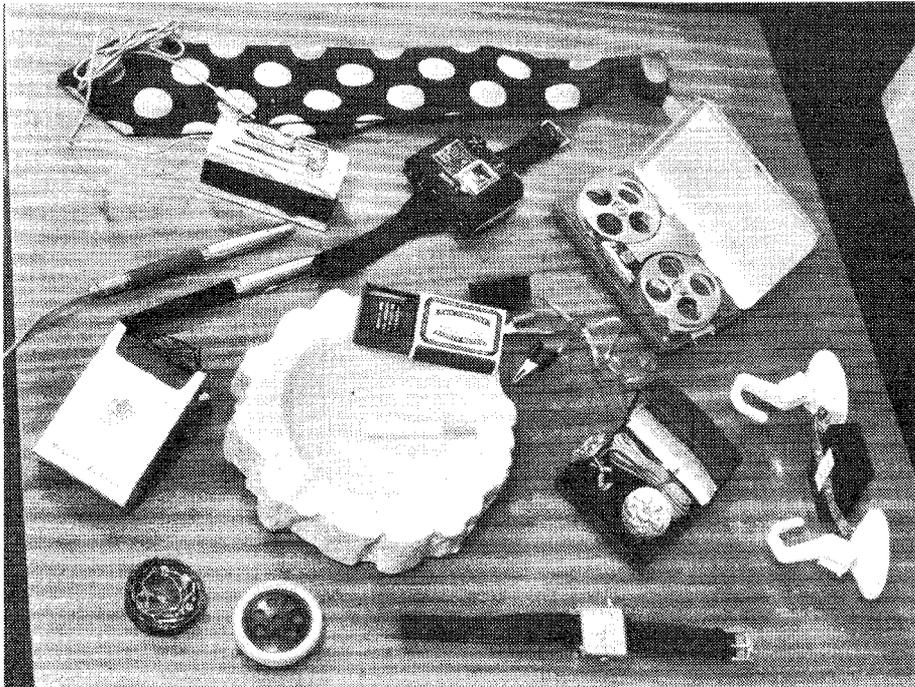
Computer security

If there were no computers, the information explosion of the last 20 years or so would have bogged us down in a mass

of uncollated, unused, unstored facts — only one sign of our rapidly growing dependence on computer facilities for dealing with vast quantities of classifiable information. But despite the apparent complexity and high speed operation of computer circuitry, its contents are as insecure as a telephone call.

High levels of security are important, not only from intentional damage or pilfering but from accidental damage to software by fire or high temperatures and humidity. Damage to hardware (core stores, processing circuitry etc.) can be caused by the proximity of high intensity magnets, but even fixed or mobile radio transmitters within a mile or two of a computer installation can slow down or prevent information transfer to and from tapes and discs. It is possible to use radio or radar transmitters to interrupt data flow for fairly long periods of time but damage to information on file would be impossible so this hazard occurs only in real time operation.

Information carried by external circuits or picked up on supply leads can be extracted easily either by direct cable tap or by current transformer probes which do not need the line to be actually broken into. Interpretation of intercepted data is no problem if it is in one of the few computer languages, but it can be ciphered in exactly the same way as the encryption techniques described. Radiation from switching circuitry, which acts as a low power transmitter, can be detected at quite long ranges. This type of interception is considered a risk only for highly classifiable information as the process of translating the switched signals is vastly complicated.



Array of "aggressive market research equipment" kept in the museum of an electronics company.

Experimental results show that oxy-acetylene cutting caused two signals, a signal at 4.2kHz due to the flame and at 1.4kHz due to equalization of stresses as the rods in a pre-stressed construction snapped.

The sensor often used in previous systems is known as the "geophone" and consists of a spring suspended metal mass within a magnetic "cage", relying on the effect of induced voltage in a coil as the inner moves with respect to the outer due to vibration. The geophone has a useful operating range from 0 to 400Hz and hence, being at its most sensitive in the false alarm region, would not provide a signal processing unit with sufficient information to enable accurate discrimination between real and false alarms. As a comparison, a piezo-electric sensor has a substantially flat frequency response from 10Hz to 5kHz.

Assuming that the most appropriate sensor is being used, the problem of signal identification becomes one of monitoring specific aspects of frequency, amplitude and duration characteristics. "Prints" of the characteristics of each type of foreseeable intrusion can be stored for comparison with alarm signals and the basic signal conditioning solutions are summarized in the accompanying table.

Despite this high degree of development necessary in a fail-safe perimeter protection system, the degree of safety can be greatly enhanced during night conditions by linking with closed circuit TV surveillance.

Once an alarm has been sounded, there still remains the problem of monitoring the area from where the alarm has sounded. A closed circuit TV system, requiring no licence to operate, can provide this facility and, as no radio broadcast transmission is involved, the system is relatively safe from eavesdroppers. In high security areas, it is desirable for the cameras and the perimeter fence system to operate from a 12V d.c. supply installation which will run off trickle charging batteries to prevent blackout in the event of mains failure. The distance between cameras and monitor screens is not subject to any limitations and may be anything from a few hundred feet to several miles with picture information carried by a coaxial line similar to a normal TV aerial feeder.

For viewing in poor light, image intensifiers can be used in conjunction with a camera tube and, typically, can be used in illumination conditions down to 10⁻⁴ lux (equivalent to a moonless cloudy night). A three-stage cascade image intensifier may amplify light by a factor of 50 to 80 thousand. An even more advanced degree of security can be obtained by a c.c.t.v. system developed by Film and Television Production Services, which will detect a change of the video waveform caused by a movement or change in the external monitored environment. When a picture disturbance takes place on a single channel, several events take place. Whichever picture is on the monitor is cancelled and the

Cause	Identification	
	min.freq. (Hz)	min.ampl. (dB)
Cutting and burning	550	10
Climbing	350	35
Tunnelling	600	25
Rain, hail, thunder, aircraft, ground movement etc.	Reject by comparison of several adjacent fence sections and rejection of signals which are similar.	
Magnetic fields	Identify frequencies and filter out.	
Stone throwing, lightning, animals and birds	Accept only frequencies above 500Hz and couple to a "one shot" excluding circuit.	
Wind	Accept only frequencies above 500Hz and apply comparison of fence sections check.	

Electromagnetic shields around an installation can protect it from disturbance by local transmitting stations, and notable installations using shields are the LACES Cargo Computer and the B.O.A.C. Boadicea computer both at London airport. High performance shields can also protect from external detection. These are used on a large number of worldwide Government security installations, where illegal computer interrogation is regarded as a serious problem.

So, in many cases before information can be obtained from a computer, or damage done to it, access must be obtained to the installation itself, and, in this context and many others where physical protection of property is necessary, intruder warning systems play a large part in information security.

Perimeter protection — low light TV

Perimeter or fence protection can provide an initial degree of high security, but

only recently have several inherent problems neared solution. Such a system needs to be able to discriminate between false alarms, either natural (hail, rain etc.) or man made (aircraft noise, articles thrown at the fence etc.), needs high reliability, the ability to couple with a wide range of alarm systems and the capability of expansion from small to large perimeters.

Signals due to deliberate intrusions can be caused by cutting, burning, climbing, tunnelling, dismantling, sabotage of sensors, scaling or acid attacks.

Experiments conducted by EMI in the development of an ideal perimeter protection system have shown significant differences in the frequency spectra of mechanical shock waves between deliberate intrusions and other disturbances. All simulated attacks have appreciable energy above 1kHz whereas incidental disturbances occupy a lower frequency band, this suggesting the use of tuned filters for the elimination of false alarms.

"disturbed" channel is selected and automatically switched to the monitor. A warning light and numerical indicator displays the selected channel number and an internal audible alarm sounds.

A plethora of well-known devices are available to detect and warn of intruders to a building, infra red and ultrasonic detectors being among the most advanced used in this aspect of security.

Security systems based on conventional sonar devices have suffered in the past from the problem of false alarms, but now equipment can discriminate between different types of motion within its range. The AFA-Minerva Fidela 3 ultrasonic detector is capable of distinguishing between intermittent movements such as flapping curtains, and the consistent movement of an intruder.

Magnetics for security

A system of great potential for security is the use of magnetic materials as a storage medium of information for recognizing the validity of identity, whether it be for obtaining access to a building or drawing money, goods or services by use of a credit card. Different levels of security can be obtained by the storage capability of the medium, the type of material used (special materials, i.e. with different properties to those of recording tape cannot be "read" with standard replay heads) and a combination of these two factors.

The U.K. is five to ten years behind the U.S.A. in the establishment and usage of this form of security, but technology in the U.K. is well advanced and EMI is already involved in applications such as cash dispenser cards, where credit cards are coated with a magnetic material, checked and authenticated (or not) by a dispenser to provide the card holder with a sum of money. Shops too are using magnetics in security with magnetic stock control tags to set off an alarm if goods are taken unpaid for through the exit with the tag still attached.

The applications here seem limitless — material handling, data handling, credit cards and so on. In the future, pre-paid cards for use in automatic vending machines or slot meters for heating, car parking etc., would need protection from fraud by a high level of security, which conventional and special magnetics can provide.

State of the art

First. A laser beam directed at the window of a room in which a conversation is being held can detect vibrations caused by speech waves. A glass movement of a few microns at a few kilohertz will necessitate a receiver bandwidth in the receiver of nearly 1GHz with a laser operating at 1000mm (300 terahertz). Readily achievable with modern technology. Conventional laser inter-

ferometers can detect movements of 1A and a detection of 0.01A has been claimed.

Secondly. The American taxpayer annually provides \$1,000M for the American National Security Agency set up by the Pentagon in 1952. This amount is about the same that Britain spends on her entire education bill. The N.S.A. is the world's largest agency dealing with codes, ciphers and electronic communication devices, but it is, above all, responsible for designing and operating the many spy satellites in space, rapidly becoming the longest arm of espionage.

Thirdly. Quote from the technical director of a company supplying spy and anti-spy equipment, "I've never given the political implications much thought."

December meetings

LONDON

3rd. IEETE — "Sounds interesting" by J. D. MacEwan at 18.00 at the I.E.E., Savoy Pl., WC2.

4th. IEE/E.Mech.E — Discussions on "Problems in applying control theory" at 17.30 at Savoy Pl., WC2.

4th. IEE — "Ferro-non-linear oscillators in electrical power networks" by G. H. Cherkez at 18.30 at Savoy Pl., WC2.

5th. IERE — "Use of split PPI techniques in clutter and other investigations" by P. D. L. Williams at 18.00 at 9 Bedford Sq., WC1.

6th. IERE — "TEC, ERB and the Technician engineer" by A. J. Kenward at 18.00 at 9 Bedford Sq., WC1.

7th. IEE/I Prod.E. — "The production of micro-electronic components" at 17.30 at Savoy Pl., WC2.

10th. I.Mech.E. — "Computer developments within British Rail Engineering Ltd" by C. J. Hudson at 17.30 at 1 Birdcage Walk, SW1.

10th. IEETE — "New mathematics: is it relevant to modern science and engineering?" by N. Gowar at 18.30 at the Faraday Room, the I.E.E., Savoy Pl., WC2.

12th. IERE — Colloquium on "Impact of micro-electronics on instrument design" at 14.30 at 9 Bedford Sq., WC1.

12th. IEE — "Electronics in urban transport" by H. H. W. Losty at 17.30 at Savoy Pl., WC2.

12th. BKSTS — "Film operations in a regional television station" by J. Cooper and D. Dickinson at 19.30 at Thames Television Theatre, 308-316 Euston Rd., NW1.

17th. IEE — "The development of an integrated digital network" by W. T. Duerdoth at 17.30 at Savoy Pl., WC2.

19th. IEE — Colloquium on "High resolution masking for electronic devices" at 14.30 at Savoy Pl., WC2.

19th. R. I. Navigation — "The pay off from improved marine navigational aids" by R. Maybourn and W. Mater at 17.00 at the Royal Institution of Naval Architects, 10 Upper Belgrave St., SW1.

20th. IEE — "A high speed intercomputer link" by Ian Dewis at 18.30 at Savoy Pl., WC2.

BRIGHTON

4th. IERE — "Future telecommunications projects in space" by W. M. Lovell at 18.30 at Brighton Technical College.

BRISTOL

5th. IERE — "Liquid crystals" at 19.00 at No. 4 Lecture Theatre, School of Chemistry, University of Bristol.

CARDIFF

12th. IERE/IEE — "Developments in data communications" by M. B. Williams at 18.30 at the Department of Applied Physics, UWIST.

CHATHAM

5th. IERE — "Electronics systems for the space environment" by A. J. Price at 19.00 at the Medway & Maidstone College of Technology.

EXETER

6th. IEETE — "Decca navigator system" at 19.30 at the Imperial Hotel.

FAREHAM

5th. IERE — "Inertia navigation" by G. U. Rands at 18.30 at H.M.S. Daedalus.

GUILDFORD

5th. IEE — "Developing countries and the engineer" by Prof. P. D. Dunn at 19.30 at the University of Surrey, Stag Hill.

LEEDS

13th. IEETE — "Fibre optics" at 19.00 at Kitson College, Cookridge Street.

LIVERPOOL

12th. IERE — "R.f. sputtering of thin films" by E. F. Lever at 19.00 at the Department of Electrical Engineering and Electronics, University of Liverpool.

LOUGHBOROUGH

4th. IERE — "The impact of advances in electronics in electrical heating processes" by J. E. Harry at 19.00 at Edward Herbert Building, Loughborough University of Technology.

MANCHESTER

13th. IERE — "The application of electronics in telephone exchange switching" by F. W. Croft at 18.15 at Renold Building, UMIST.

NEWCASTLE UPON TYNE

12th. IERE — "Computer controlled telephone exchanges" by Dr. M. T. Hills at 18.00 at Main Lecture Theatre, Ellison Building, Newcastle upon Tyne Polytechnic.

19th. IEE/IERE — Colloquium on "Computers in marine automation" at 10.00 at Henderson Hall, University of Newcastle upon Tyne.

SOUTHAMPTON

12th. IERE — "Stored program control of telephone exchanges" by B. L. Nuttal at 18.30 at the Lanchester Theatre, University of Southampton.

SWINDON

4th. IERE — "Space technology and the future" by G. K. C. Pardoe at 18.15 at The College.

PLYMOUTH

5th. RTS — "CEEFAFX" by S. M. Edwardson at 19.30 at Westward Television Ltd.

Circards

The next article in the Circards series, No. 12, "wideband amplifiers", will be published in the January issue.

Tuners and Tuner-amplifiers

The concluding part of "Tuners and Tuner Amplifiers", due to be published in this issue, has been unavoidably postponed.

Circuit Ideas

Teleprinter terminal unit uses phase-locked loop

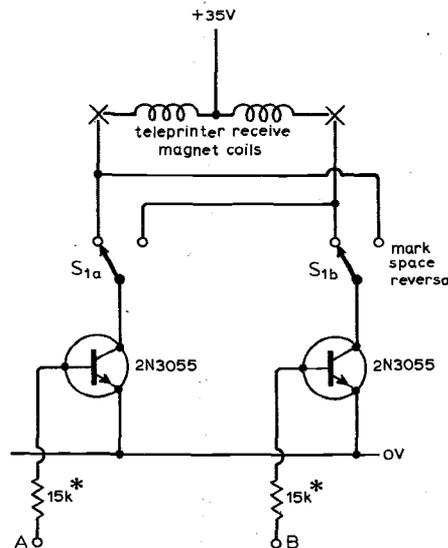
This unit uses the MC1310P integrated circuit intended for stereo multiplex decoders. The device contains a phase-locked loop which I have found suitable for demodulating teleprinter f.s.k. signals because it requires only a small input signal for phase lock, gives a visual indication when phase lock has occurred, and is relatively cheap and readily available. Fig. 1 shows the main circuit which consists of the phase-locked loop, a d.c. amplifier, and a Schmitt trigger. Fig. 2 shows the driving circuit.

Audio f.s.k. signals are applied to the input of the phase-locked loop via an input attenuator and a d.c. blocking capacitor. When the loop locks, the lamp lights, the free-running frequency being set by R_1 . A shift in audio frequency causes the loop to lock on to the new frequency, resulting in a change in the d.c. level at the output of the loop. This change is amplified by Tr_1 and Tr_2 after first filtering out any a.f. component which also appears at the output of the loop. The operating point of the amplifier is set by R_2 so that the change in voltage at a collector swings either side of the zener diode's breakdown voltage. This voltage is applied to the input of the Schmitt trigger. The result of the voltage causes Tr_3 to

switch on and Tr_4 to switch off, and vice versa. Thus the f.s.k. signal is converted into a square wave switching signal suitable to feed a teleprinter.

The magnet driving circuit consists of two 2N3055 transistors driven from the Schmitt trigger. These drive the teleprinter receive magnet via a reversal switch to allow reception of reversed r.t.t.y. signals. No surge protection was needed. My version drives a Creed 7B teleprinter and works well on all frequency shifts from 100 to 1000Hz. It also appears to work well under conditions of random noise.

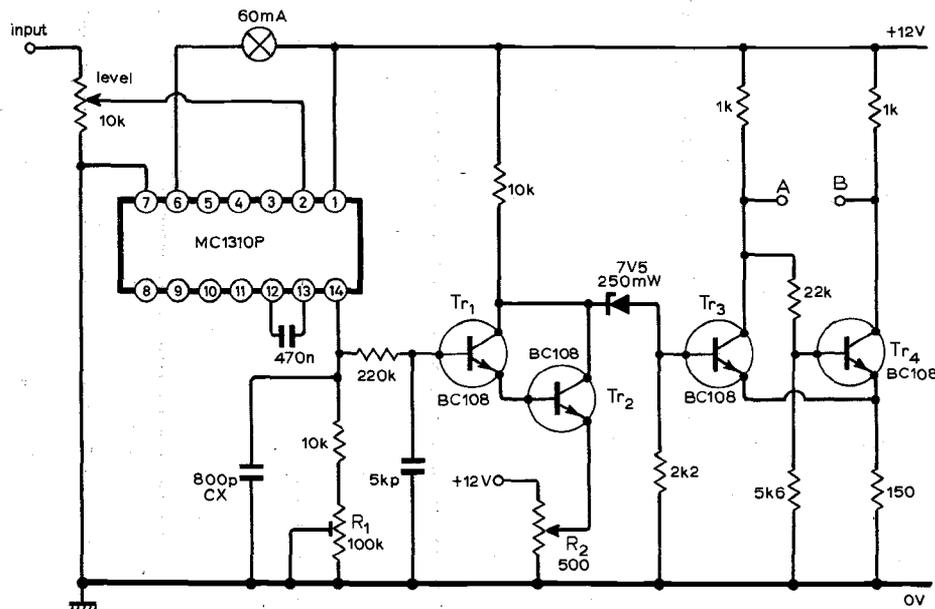
To set up, tune in r.t.t.y. signal and adjust level control so that about 300mV of signal is fed into the input of the p.l.l. Adjust R_1 until lamp lights and remains alight on both mark and space tones (no flicker). Adjust R_2 until printer operates. K. S. Beddoe, G3YOM, Titchfield, Hants.



*Adjust to give 60mA through teleprinter receive coil

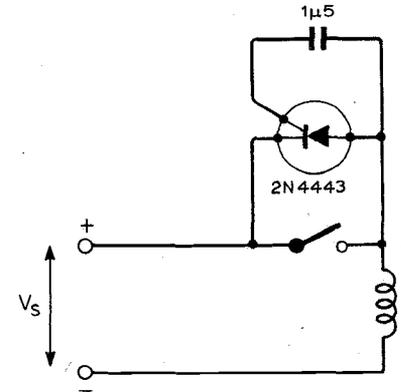
▲ Fig. 2. Teleprinter drive fed from Fig. 1 circuit.

▼ Fig. 1. Demodulator for f.s.k. uses phase-locked loop.



Switch spark quench for inductive loads

The circuit may be used to suppress arcing of switch contacts, an especially troublesome problem when switching large inductive loads. The chosen controlled rectifier must pass the full circuit current during the switch-off period and must be capable of operating at voltages in excess of twice the supply voltage. The 2N4443 quoted in the example will work up to 500V and will



switch short pulses of current of up to 80A although for this rating the current pulses must not be longer than 8ms; for longer pulse times suitable de-rating must be applied. The capacitor provides the gate drive to turn the s.c.r. on, $\approx 0.7V$, and uses the initial part of the circuit switch-off transient as the thyristor turn-on pulse. It is essential that the thyristor is fully turned on.

E. Potter
Sheffield University

Simple pulse shaper or relay driver

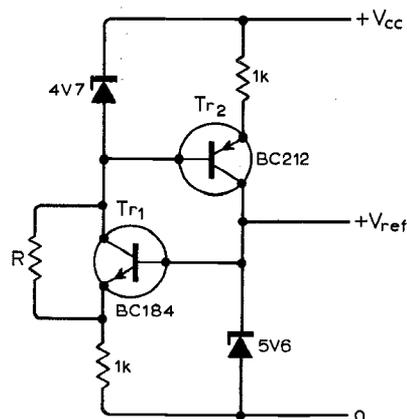
To obtain pulses of a required duration and constant amplitude, one would normally use a monostable circuit. In most cases a simpler circuit can be made using the economical Signetics 555 integrated circuit. This device can provide output pulse currents of up to 200mA and can drive a relay directly from input pulses which may have a duration of less than a microsecond.

The circuit shown uses the 8-pin dual-in-line NE555V or the equivalent TO-99 type NE555T. It provides output pulses of a duration equal to $1.1R_3C_2$; this can range from microseconds to many minutes, but R_3 should not exceed $20M\Omega$. Output pulse amplitude is a little less than V_{CC} , the exact value depending on output current. Rise and fall times are about $0.1\mu s$.

In the circuit, the input pulse amplitude must cause the voltage at pin 2 to fall to $V_{CC}/3$ or less. Inclusion of R_2 reduces the required amplitude of the pulse considerably. The value of C_1 should be chosen so that the input time constant is appreciably greater than the fall time of the leading edge of the input pulses to minimize pulse attenuation. The 555 can be triggered by a current of $0.5\mu A$ from pin 2 for $0.1\mu s$.

Self-start for ring of two

A common method of providing self-starting for the ring-of-two circuit is to connect a resistor between the bases of the two transistors. This has the disadvantage that it reduces the stabilization ratio. The circuit shown here also has a single resistor for self-starting but there is no degradation of the performance. Any change in the current through the starting resistor R is cancelled out by a change in the current through Tr_1 and so there is no net effect on the normal operation of the circuit, provided of course that there is still a reasonable current through Tr_1 . Even a value as low as $39k\Omega$ produced no noticeable alteration of the performance of the circuit shown in the diagram, while a $1M\Omega$ resistor between the bases reduced the stabilization from 5×10^4 to 2×10^4 .
Colin R. Masson,
Edinburgh.



Square-law potentiometer

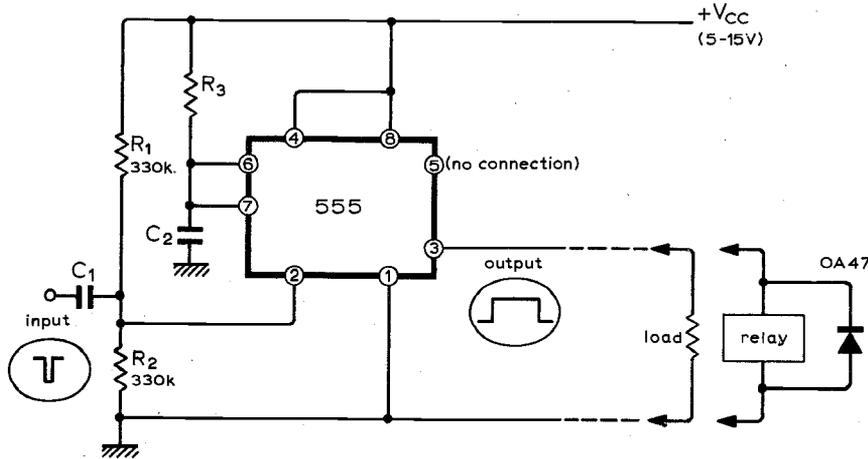
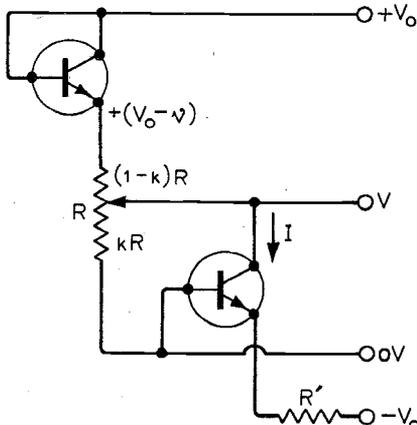
The circuit shown was developed to give a bias for a varicap diode, varying as the square of the angle of rotation of a potentiometer control. If this angle is θ and $k = \theta/\theta_0$, where θ_0 is the full angle of rotation, we have, letting v be the offset voltage for the second transistor,

$$V_o - v = (1 - k)R(I + V/kR) + V$$

$$V = k(V_o - v - IR) + k^2IR$$

Thus if $R' = R$ so that $I = (V_o - v)/R$ we obtain $V = k^2(V_o - v)$. An experimental test using transistors of type 2N5172, a $10k\Omega$ helipot and $V_o = 9$ volts yields a square-law response to better than $\pm 1\%$ over the range $0.1 < V < 8.5$ volts.

F. N. H. Robinson,
Clarendon Laboratory, Oxford.



The 555 operates with negative-going trigger pulses. If positive-going pulses with a steep trailing edge are available, the 555 can be triggered on the negative-going trailing edge. However, the use of positive-going pulses results in the output being delayed until the trailing edge of the input pulse occurs; with wide input pulses this may be unacceptable.

To operate a relay directly, the relay coil may be connected in place of the load, in which case an input pulse causes the relay to close for a time $1.1R_3C_2$. A diode must be connected across the relay coil to suppress transient voltages developed across the inductive load when the current in the coil is switched off. Such transients may damage the 555 and they have been found to cause automatic re-triggering of

the circuit as a result of pick-up. If re-triggering occurs, the relay fails to open. Not all types of diode give adequate suppression to prevent re-triggering; I found the gold-bonded types (such as the OA47) suitable.

If the relay and diode are connected between pin 3 and $+V_{cc}$, the coil will normally be energized, but the relay will open for the pre-determined time when the input pulse triggers the circuit.

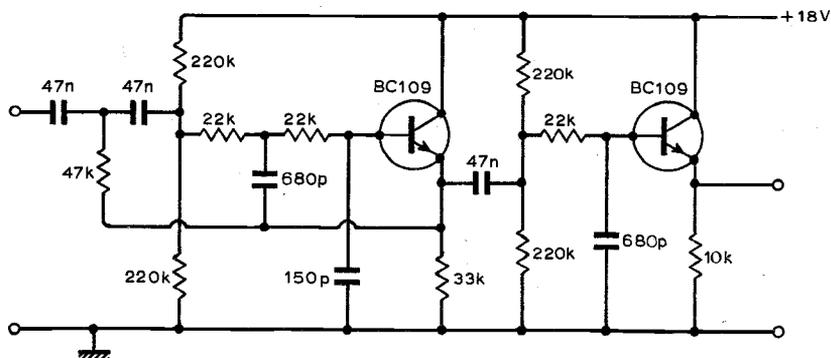
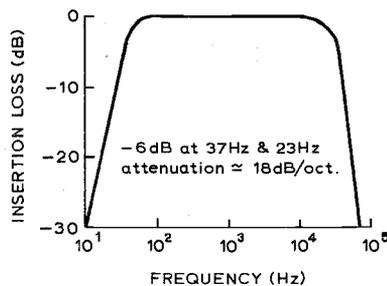
The relay should be rated to operate from a potential approximately equal to that used for V_{cc} at a current not more than 200mA. A small electromagnetic counter could be used instead of a relay.
J. B. Dance,
Alcester,
Warwickshire.

Combined rumble and scratch filter

It is widely accepted that a respectable audio amplifier should have both high-pass and low-pass filters, the normal approach being to design them as two separate stages. The widely differing turnover frequencies suggest that the two filters could be simply combined into a composite filter performing both functions with little interaction between the sections. The circuit given is an amalgam of the filters proposed by H. Walker (May & June 1971 *W.W.*) with slight modifications to certain component values due to component availability. Typical procedure would be to calculate the components required for the isolated filters and then to combine the stages in series at the input to each transistor, the first giving 12dB/octave and the second a further

6dB/octave at the turnover frequencies. Comparison of the circuit with the originals makes the design obvious. Components may be switched to provide different turnover frequencies as required, but switching to completely remove a filter is more complicated.

P. I. Day,
Jesus College,
Cambridge.



Television broadcasting from satellites

First of a two-part series describing the scope and limitations of v.h.f., u.h.f. and s.h.f. transmission by satellite

by D. B. Spencer, Ph.D and K. G. Freeman, B.Sc., A.Inst.P., M.I.E.R.E.

Mullard Research Laboratories

Since the world's first high definition television service was started in London in 1936 there has been a phenomenal growth in television broadcasting throughout the world. Now many countries have at least one national programme—often in colour. Regular exchanges of programmes take place between countries within a continent by means of terrestrial links, and between different continents by means of telecommunication satellites. Many European countries have to share the existing v.h.f. and u.h.f. television bands with their immediate neighbours and the consequent limitation of bandspace available to each country severely limits the number of programme channels which they can provide. The reception of television programmes in the home direct from an orbiting satellite may prove to be one means of providing additional channel capacity.

In the U.K. there is sufficient u.h.f. band-space available for four national television channels, and when all the 405-line transmissions are phased out (which is not likely before 1985) one or possibly two further 625-line channels could be provided at v.h.f. At the present time therefore, limitation of bandspace available for television transmissions is not a problem in this country. However, it is still desirable to consider the needs of the future and possible developments. Recent Government White Papers^{1,6} discuss the possible future U.K. trends in broadcasting in some detail.

In the developing nations, there is often a problem of rapidly building up even one national television service. This may also be accomplished by means of a satellite broadcasting system.

Methods of TV service extension

Apart from conventional v.h.f. and u.h.f. terrestrial television broadcasting it is now becoming feasible to broadcast television signals from an orbiting satellite direct to the home. In 1971 the World Administrative Radio Conference of the ITU authorized the use of further bandspace for various forms of broadcasting including satellite broadcasting². For Region I (Europe, Africa and the USSR) it authorized use of the band 620–780MHz for satellite broadcasting of frequency modulated television signals subject to these signals not causing interference with existing terrestrial systems. The band from 2.5–2.69GHz was allocated

to satellite broadcasting on a shared basis with fixed and mobile services. Use of this band is restricted to national and regional programme broadcasts to community receivers. Allocation of a band from 11.7–12.5GHz (s.h.f.) was on a shared basis between satellite and terrestrial broadcasting and the fixed and mobile services. Two other bands, namely 41–43GHz and 84–86GHz, were also allocated to the satellite broadcasting service but no consideration has yet been given to their use.

It is also possible to distribute additional television signals not by over-air broadcasts but by means of a cable distribution network which can also be used for the distribution of existing television signals. On a small scale, perhaps for the transmission of locally generated signals to a compact urban area, this is feasible and experimental services of this latter type do exist. However, national distribution of television signals using cables would probably prove to be prohibitively expensive. It has been estimated¹ that a national system to provide 96% of the U.K. population with six additional channels would cost £500M and take 20 years to complete.

The way in which television services will be extended depends to a large extent upon the country involved. A broad dividing line may be drawn between the developed countries and those which are still developing.

Developing countries are interested in rapidly building up a television service in the hope that it will aid national development by improving educational standards and agricultural practices. When the complex network of transmitters and ancillary equipment needed to cover a country the size of Britain is considered then the problem of setting up a television broadcasting system in, for example, India or Brazil using terrestrial transmitters and links, is seen to be immense. Some form of satellite broadcasting system, which could give almost instantaneous national coverage seems to offer an attractive solution to this problem.

In general the developing countries are large and have no existing u.h.f. television service; satellite broadcasting, therefore, is possible in the 620–780MHz allocation. Transmission in this band means that fairly conventional receiver techniques may be used. Large receiving aerials are also pos-

sible without their being too critical to set up. In tropical and sub-tropical countries use of the u.h.f. or 2.5–2.69GHz band is preferable because of high propagation attenuation in the higher frequency bands due to heavy rainfall. India proposes to start experiments with satellite broadcasting at u.h.f. in 1975.

Many developed countries already have extensive terrestrial u.h.f. television services and the introduction of u.h.f. transmissions from a satellite would cause intolerable interference. For this reason the 800MHz frequency allocation from 11.7–12.5GHz would almost certainly be chosen for Europe.

It is possible, of course, to transmit television programmes at s.h.f. using ground stations. West Germany has started a series of experiments in Berlin to look at the feasibility of such a system³ but transmitters will probably be required every five or ten miles as propagation loss again due to rain is fairly high. Moreover, a direct line of sight between the receiver and transmitter is essential and this may be difficult to achieve in urban areas. If this system came into being it would need a vast network of transmitters and links to serve a whole country. It is probably only feasible for urban areas which have a high population density where, because of the difficulty on many buildings of obtaining line of sight to the transmitter, it may be incorporated with a "wired-TV" system.

Compared to the vast network of transmitters and ancillary equipment needed to set up a 12GHz terrestrial broadcasting network it should be possible to provide national coverage using a single orbiting satellite. The use of satellite broadcasting to provide additional programmes to the developed countries will now be discussed together with its possible use in the provision of a primary television service to the developing nations. In both cases if receiver complexity, satellite transmitter power, co-channel interference and bandspace requirements are considered it is probable that wide-band frequency modulation will be chosen.

Satellite broadcasting

The reception of television pictures relayed by a satellite has involved expensive ground stations with large aerials. If every home or small community is to be able to pick up

signals from a satellite then the receiver and aerial must be cheap, easy to set up and require little maintenance. To be able to use such a simple receiver the broadcasting satellite of the future would need a more powerful transmitter than those used in present day communications satellites. A highly directional transmitter aerial would beam the signal down to one country. As a steerable aerial on every home to keep track of satellite movements would be uneconomic the satellite must appear stationary in the sky. This means that it would have to be stabilised in a synchronous orbit approximately 36,000km above the equator.

Consider, for example, the system which would be necessary to provide a television service to the United Kingdom. The transmitter beamwidth would be of the order of 1° (see Fig. 1) and the satellite would have to be stabilised in both position and orientation to approximately one-tenth of this. Stabilization is necessary as otherwise variation of the gravitational forces due to the Sun and Moon would cause the satellite to drift. With existing geostationary satellites, stabilization is achieved by small gas propulsion jets on the satellite which correct for the changes in these forces. The propellents for these propulsion units are stored on board and at the present time, assuming a life expectancy of 5-7 years, they account for some 20-25% of the rocket payload. It is hoped in time to be able to reduce this to some 10%.

Either direct reception of the satellite signals in the home, or community reception can be considered. In the case of community reception the signals would be picked up by a central receiver, processed and then passed on to individual TV receivers. As a community receiver could have a larger aerial and better performance than a domestic receiver a lower satellite power would be required. It is likely that community receivers will be used before domestic receivers as the cost per viewer will be lower but ultimately there will probably be a need for individual reception and the choice of system parameters must bear this in mind.

The satellite transmissions could use either conventional amplitude or frequency modulation or even some form of digital modulation. If a.m. were to be used then tens of kilowatts of transmitter power would be required for a 12GHz system. If f.m. were chosen then the transmitter power could be reduced to several hundred watts for the same picture quality. As all the power used by the satellite has to be generated "on board", probably by means of large arrays of solar cells, this is an important consideration. As it is envisaged that a series of satellites would broadcast different programmes to adjacent countries, frequency re-use is essential in order to provide adequate programme coverage. The distance between areas which can be served by the same frequency (co-channel) is governed by the tolerance to interference of the system used, as well as the directivity of the transmitter and receiver aerials, and the relative positions of the co-channel satellites. Because of the greater immunity

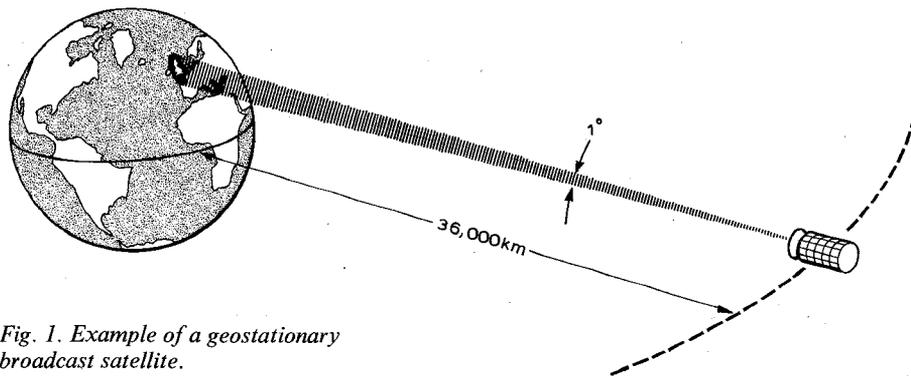


Fig. 1. Example of a geostationary broadcast satellite.

of a frequency modulated signal to co-channel interference it is found that, for a given programme coverage of a number of adjacent countries, an f.m. system requires less bandspace than an a.m. system.

Some form of digital modulation could be used for satellite broadcasting if it offered a significant advantage over other modulation techniques. (In the case of a digital system the television (video) signal is sampled at a rate of at least twice that of the highest frequency component. The resultant samples are then quantized by comparing their amplitudes with a range of discrete values and representing the sample by the discrete amplitude to which it most nearly corresponds. The quantized amplitude is then represented by a sequence of binary pulses and these pulses are used to modulate the amplitude, frequency or phase of an r.f. carrier.) From a study by one of the authors⁴ it appears that digital systems offer only a marginal improvement in performance over a wideband f.m. system. As they need more complicated and therefore more expensive receivers it is probable that frequency modulation will be chosen for satellite broadcasting both at u.h.f. and s.h.f.

The bandwidth occupied by a frequency modulated signal is given, by Carson's rule, as twice the sum of the peak to peak deviation plus the highest modulating frequency.

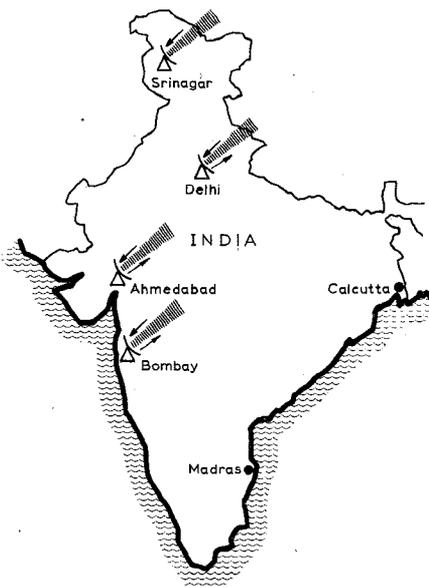


Fig. 2. Map showing the proposed Indian Earth stations.

As the peak to peak deviation is increased the transmitter power needed for the same picture quality may be reduced, and the co-channel performance improves, but of course the bandwidth per channel increases. A compromise has to be reached and work done by various international committees indicates that a total peak to peak deviation (peak to peak luminance + chroma + sound) of 14-16MHz is likely to be adopted for satellite television broadcasting. Assuming a PAL system I video signal with 6MHz sound subcarrier the occupied bandwidth would be some 26-28MHz. A guard band would in practice be necessary and the total channel width would probably be of the order of 30MHz.

To provide coverage to a large number of countries many satellites would be required. In the absence of any other constraints each satellite would ideally be placed in orbit as near as possible to the same longitude as the country which it was to serve. However, this may not be practicable. One problem is that within the periods of approximately 1st March to 11th April and 1st September to 11th October a geostationary satellite experiences one eclipse each day by the Earth. Near the centre of these periods the eclipse lasts for 70 minutes about midnight at the satellite longitude, less at the beginning and end of such periods. Although the satellite could be powered by a small nuclear generator it is more likely that an array of solar panels will be used. In this case, unless the satellite carried substantial batteries, transmissions would cease during the eclipse periods. After the longer eclipse periods time must also be allowed for warm up of the transmitter before transmissions could resume. The satellite could in practice be moved to the West of its service area so that the break in transmission would occur in the early hours of the morning when it may not be important. This complicates the planning of the broadcasting satellite system, but it is probably preferable to providing the satellite with batteries capable of providing the full transmitter power. As well as increasing significantly the satellite weight, and hence the launch cost, such batteries would probably be a limiting factor in the satellite life expectancy.

Another problem which prevents all satellites being in the same longitude as the area which they serve is that of co-channel interference. This is discussed later.

The above remarks apply to satellite broadcasting systems in general and are independent of the transmission frequency.

We will now go on to discuss u.h.f. and s.h.f. systems in more detail with particular reference to the system likely to be adopted by India and the probable parameters of a system suitable for European countries.

U.H.F. satellite broadcasting

For countries which have no terrestrial broadcasting network satellite broadcasting at u.h.f. may well prove to be feasible. In order to investigate the possibility of setting up a national u.h.f. broadcasting service, India proposes to start a series of experiments in 1975 using the American ATS-F communications satellite. The American space organisation, NASA, is to lend the satellite to India for one year and the Indian Department of Atomic Energy is to be responsible for the ground segment. All the programme material which is to be transmitted during the experiment will be produced in India. Fig. 2 shows the positions of the four proposed earth stations. Of these Ahmedabad, Delhi and Bombay will be capable of transmitting, receiving and re-broadcasting, whereas Srinagar will only be able to receive and rebroadcast the signals⁵.

The satellite is to transmit 80W of power at 850MHz into a 10 metre dish (2.6° beamwidth) using frequency modulation with a bandwidth of 30MHz. (This is not within the WARC u.h.f. allocation; a permanent service at a later date would have to lie between 620-780MHz.) Two thousand television receivers are to be used in clusters of villages in different rural areas for direct reception of the signals. These receivers will consist either of a complete f.m. TV receiver or, perhaps more likely, an f.m. front end which demodulates the incoming signal and remodulates it in a suitable form for a conventional v.h.f. a.m. receiver (see Fig. 3). With a 2-3 metre "chicken wire" dish aerial (10° acceptance angle) the receivers will have an input signal of approximately 27µV and they will require a noise figure of approximately 6dB in order to provide an acceptable picture signal to noise ratio. Signals from the satellite will also be received by the four ground stations and rebroadcast in urban areas using amplitude modulation at v.h.f. for reception by 3,000 standard v.h.f. a.m. television receivers. It is proposed to broadcast programmes for four to six hours every day.

If the initial experiments are successful the Indian government hopes to start a full scale satellite broadcasting service which would be implemented sometime within the next decade. At least one community receiver would then be needed in each of 560,000 Indian villages. In order to obtain optimum coverage of India the satellite transmitting aerial would probably be reduced to 7 metres (3.5° beamwidth). Because of this and also in order to allow more simple aerials to be used (approximately 1 metre diameter) the transmitter power may be increased considerably.

The primary aims of the Indian scheme⁵ would be to contribute to family planning objectives, improve agricultural practices and help towards national integration. Secondary objectives would be to contribute towards general education and teacher training, and also to improve health

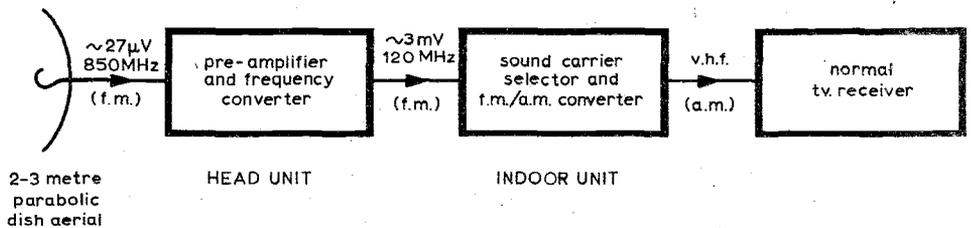


Fig. 3. Block diagram of an experimental receiver of the type which may be used in India.

and hygiene. In a technical respect the project would be useful in national development particularly in building up the nation's electronics industry, as the major portion of the required equipment would be produced in India.

When fully operational the Indian project would transmit between two and four video channels, and each channel would have associated with it up to 14 sound channels to cater for the nation's 14 major languages.

The choice of the u.h.f. band for the Indian experiments is ideal as the wide beam necessary to cover the whole country is easily obtained and the receiving aerials can be large without being critical in their alignment. A further advantage comes from the fact that conventional technology can be used for the receivers as no frequency higher than u.h.f. is involved. Although we have confined the discussion of u.h.f. satellite broadcasting to the proposed Indian project the problems and advantages associated with such a system can be applied to other developing countries. Many countries will be looking at the outcome of the Indian experiments with great interest.

S.H.F. satellite broadcasting

In the case of developed countries, which generally have an existing network of terrestrial u.h.f. transmitters, the s.h.f. band around 12GHz will probably be used for satellite broadcasting. Europe would be served with a series of geostationary satellites each with aerial beamwidths of the order of 1° to restrict coverage to the nation for which the service is intended (see Fig. 4). This perhaps highlights a common misconception about satellite broadcasting in that it is often thought to be a means of picking up television transmissions from many countries.

The political implications of beaming signals to other countries are obvious and the control of such a system would be fraught with difficulties. Furthermore, a major technical objection is that many different television standards exist throughout the world and multi-standard receivers would be expensive. (This assumes that existing receivers would be employed in conjunction with suitable converters.) Apart from this, as all satellites would not be in the same position a steerable receiver aerial

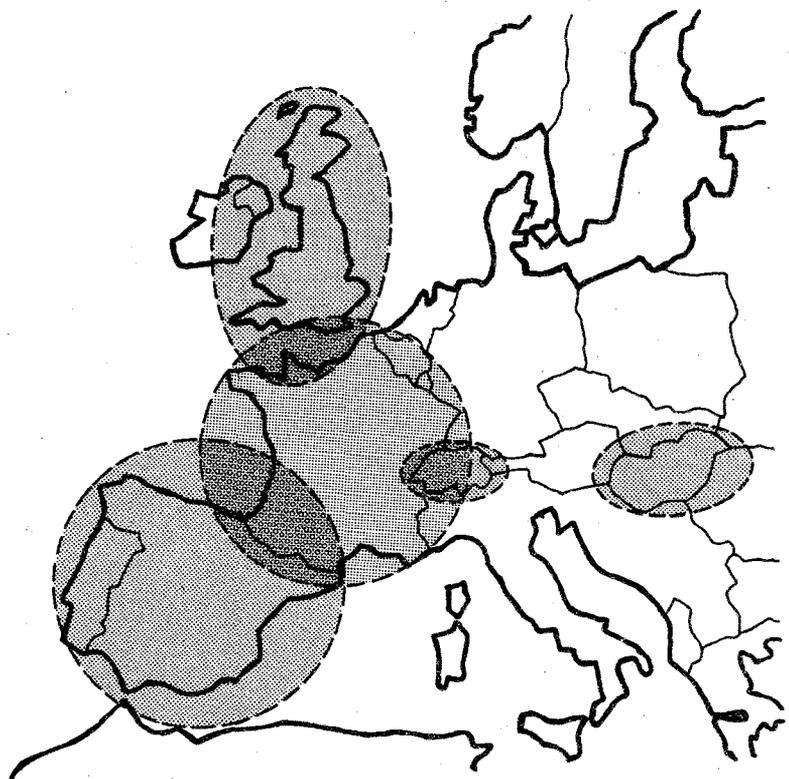


Fig. 4. Map showing the type of service areas which are envisaged for Europe.

would be needed. The limitation of satellite transmissions to individual nations means that narrow beam, high gain aerials may be used on the satellite thus allowing acceptable levels of transmitter power.

With a large number of adjacent areas to be served using a limited bandwidth (800MHz) frequency re-use is essential and co-channel protection becomes important. This protection is obtained by a combination of the transmitter and receiver aerial directivities, the separation of the co-channel satellite in orbit, and also by the separation of areas covered by the same frequency.

Studies undertaken by the CCIR show that, if 30MHz f.m. signals are assumed, some 200MHz of bandspace would be needed to provide each European country with a single channel. This indicates that with the authorized allocation it should be possible to provide each country with four.

If simple, individual receivers were used which had a receiving aerial of the order of 75cm diameter and a front end noise figure of 9dB then a satellite power of 500W would be adequate to receive a good picture. In the case of a community receiver a somewhat larger aerial, say 1.5 metre diameter, together with a front end noise figure of 6dB would be possible resulting in a satellite power requirement of 63W. Table 1 indicates how these figures were derived (because of the discrepancies between various published figures, particularly of the acceptable carrier to noise level and the expected losses due to rainfall and aerial misalignment, these figures are given as an illustration only).

Although in the long term special television receivers can be envisaged, in the early stages a typical domestic system would consist of down conversion of the 12GHz signal to a convenient i.f. After amplification and limiting this signal would be demodulated to a video plus sound sub-carrier signal. Remodulation of this signal onto a u.h.f. carrier would then be necessary using amplitude modulation to provide a suitable input for a standard television receiver. Fig. 5 shows the outline of a possible s.h.f. receiver. With the increasing use of video tape and cassette recorders in the home, future receivers may well have a video input socket making remodulation of the signal unnecessary. Looking even further to the future, receivers may incorporate a dual i.f. f.m./a.m. detection system in which case the satellite signals would enter the receiver as a u.h.f. i.f.

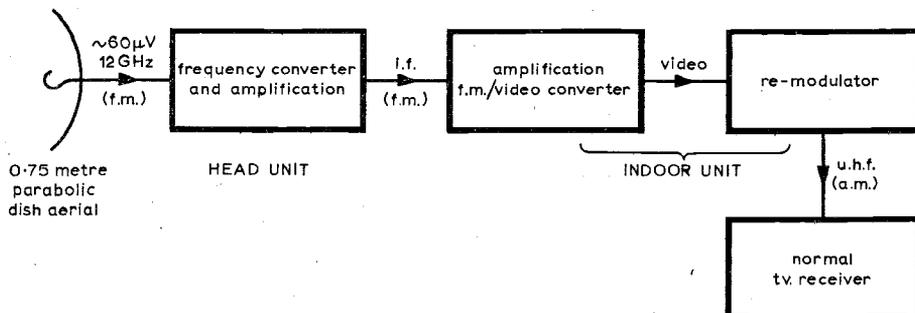


Fig. 5. Block diagram of an experimental receiver of the type which may be used for the reception of s.h.f. broadcasts.

TABLE 1
Estimated transmitter power requirement for an s.h.f. f.m. system

	individual	community
a) Receiver bandwidth (B)	28MHz	28MHz
b) Noise power at the receiver input (P) [1]	-129dBW [2]	-129dBW
c) Noise factor of receiver	9dB	6dB
d) Available receiver noise power (b+c)	-120dBW	-123dBW
e) Required carrier signal/noise (estimated)	18dB	18dB
f) Required carrier power (d+e)	-102dBW	-105dBW
g) Aerial gain referred to 1m ² effective [3]	-5dB	1dB
	(0.75m diameter)	(1.5m diameter)
h) Required flux	-97dBW/m ²	-106dBW/m ²
i) Free space attenuation [4]	162dB	162dB
j) Allowance for atmospheric attenuation (due to rainfall, snow etc.)	1dB	1dB
k) Allowance for pointing errors	2dB	2dB
l) Total propagation attenuation (i+j+k)	165dB	165dB
m) Required transmitter e.i.r.p. (h+l) [5]	68dBW	59dBW
n) Satellite aerial gain at beam edge [6]	42dB	42dB
o) Loss in transmitter feeders, filters etc.	1dB	1dB
p) Satellite transmitter power (m-n+o)	27dBW (500W)	18dBW (63W)

Notes

- [1] This is calculated from $P = K.T.B$. where K is Boltzmann's constant, T is the receiver input temperature in degrees absolute and B is the equivalent noise bandwidth.
- [2] dBW = dB relative to 1W.
- [3] This assumes an efficiency of 66%.
- [4] This is defined here as the ratio of the power radiated from an isotropic source 36,000km above the earth's surface to the power flux (power/m²) at the receiving aerial.
- [5] The e.i.r.p. is the effective isotropic radiated power.
- [6] This is calculated for the beam edge (3dB down point) of a 1° beamwidth aerial.

Up to the present time use of the microwave region of the electromagnetic spectrum for communications has been limited to military and professional applications. In order to realize microwave consumer products such as 12GHz satellite broadcast receivers, microwave components must be produced in a technology which is cheap and capable of providing reliable, mass-producible devices. In fact the whole future viability of satellite broadcasting at s.h.f. hinges upon the availability of such components.

Conclusion

The broadcasting of television programmes from a satellite should be feasible in the near future both at u.h.f. and s.h.f. frequencies. It will probably come first of all to the developing countries for whom it is an attractive solution to the problem of rapid implementation of a broadcasting service to help to improve general educational and social conditions. In this case u.h.f. f.m. transmission is the most suitable system. The technology capable of providing suitable low cost receivers and the power requirements of the satellite transmitters are already available.

In the case of developed countries s.h.f.

f.m. satellite broadcasting is one way of providing additional programme capacity. Apart from the political and national investment considerations, and assuming that further channels are desirable, the success of such a system depends upon the availability of cheap 12GHz receiver components. In the second part of this article we will examine various possible 12GHz receiver designs and discuss practical microwave technologies. Intermediate frequency processing circuits which could be applicable to either u.h.f. or s.h.f. receiver designs will also be discussed.

(To be continued)

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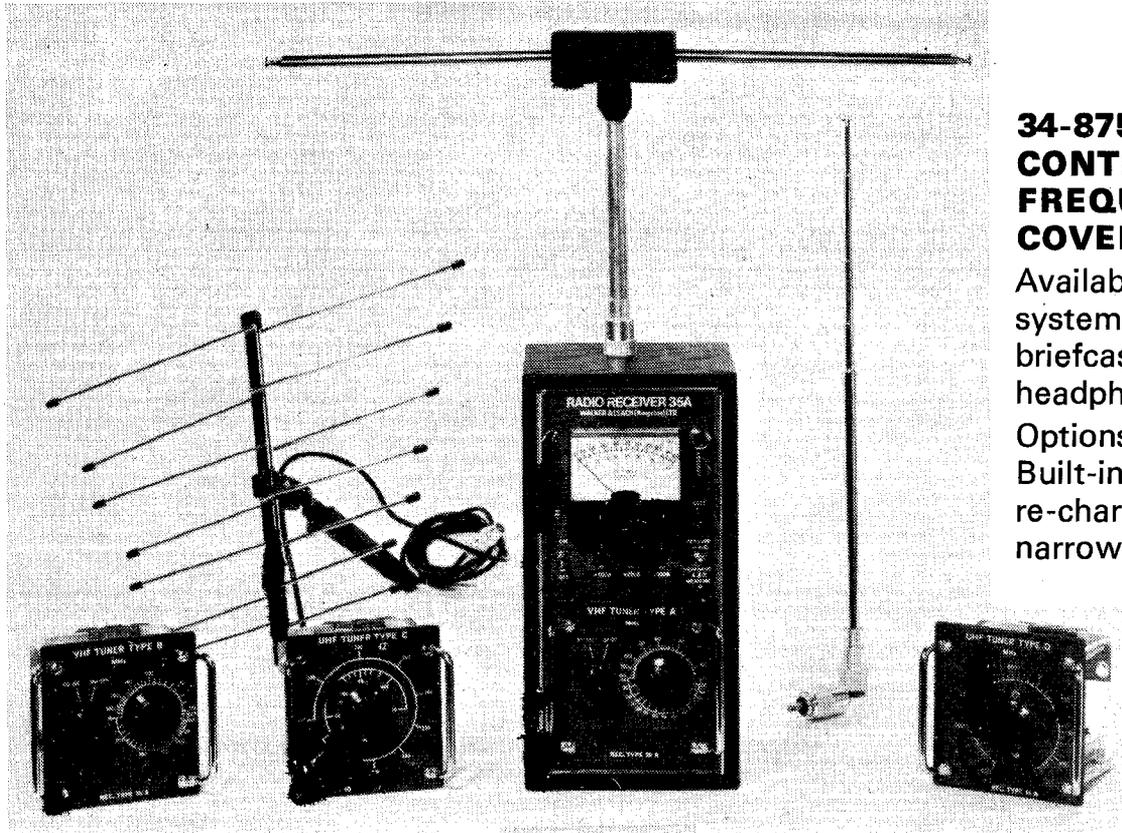
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Contrast expansion processor

A practical circuit for improving the contrast of meteorological satellite scanning radiometer pictures

by R. J. H. Brush B.Sc., C.Eng., M.I.E.E. and P. E. Baylis, B.Sc.

The latest American meteorological satellite in the Improved Tiros Operational Satellite (ITOS) series was launched successfully on November 7th. Named ITOS-F on the ground, the spacecraft now in orbit is renamed NOAA 3 (National Oceanic and Atmospheric Administration). NOAA 3 is flying in a circular sun synchronous polar orbit at an altitude of 1505 km. The orbit period is 116.19 minutes and the satellite always crosses the equator at 0830 local solar time on the north to south part of the orbit. The primary sensors in the modified ITOS series consist of scanning radiometers with spectral sensitivities of 0.5 to 0.7 μ m, visible channel and 10.5 to 12.5 μ m, infra-red channel. The two channels are time multiplexed and relayed to ground in real time, with a signal format which is compatible with existing a.p.t. (automatic picture transmission) ground receiving stations. See Fig.1. The chief advantages of the i.r. channel are sensitivity to radiated infra-red, which gives coverage of the day and night sides of the earth and accurate equivalent black-body radiation temperature calibration. The analogue video signal from the radiometer amplitude modulates a 2400 Hz sub carrier which in turn frequency modulates the transmitted v.h.f. carrier. The ITOS carrier frequency is either 137.5 MHz or 137.62 MHz and the peak deviation is ± 9 to 10 kHz.

A disadvantage of the i.r. channel is that the difference between hot and cold scenes is rather small especially at high latitudes. This leads to poor contrast when pictures are reproduced on equipment primarily designed for use with the TV

vidicons. Typically, the modulation of the subcarrier may not fall below about 30% for scenes in the vicinity of the Mediterranean and North Africa. In the polar regions, 55-70% is likely to be the lower limit. The maximum is around 90% for cold high altitude cloud tops. Cold is transmitted as high percentage modulation and reproduced as white. The greyness of the reproduced clouds clearly indicates their relative heights.

The contrast may be enhanced by passing the subcarrier from the receiver f.m. demodulator through a processor with a characteristic as indicated in Fig.2. The straight line, characteristic no.1, indicates a linear input/output characteristic, i.e. no expansion. No.2 has the effect of ignoring all values of modulation below 20% and expanding the range 20-100% to fill the complete dynamic range between black and white level. Similarly for the other characteristics. The required one is selected by a multiway switch.

Biased silicon diodes are used to fix the turn-on percentage and the appropriate line slope is selected by means of an operational amplifier with proper choice of feedback resistor. The complete circuit is in Fig.3. The diodes D_1 and D_2 have their bias fixed by resistor networks. The percentage modulation at which the diodes turn on is set by adjustment of the peak 100% value of the subcarrier presented to them. The higher the peak value, the lower the percentage turn on. The peak value is set by the feedback resistor in the input operational amplifier. The contrast expander is designed to receive a 2V peak to peak (at 100% modulation) input

at that level if the correct calibration is to be maintained.

The effect of the expander on the subcarrier waveform is shown in Fig.4 (a). If the input subcarrier is at 100% amplitude the conduction angle θ reduces for increased percentage setting of the expander, i.e. increased diode turn-on level. Since the peak/average ratio of such a waveform increases with reduced conduction angle, the peak to peak voltage at the output is made to increase with increased percentage setting, in order to maintain the average output voltage constant. Some trimming of the feedback resistors at the output operational amplifier may be found necessary. The actual values will depend on the properties of the a.m. demodulator and picture printer used. The values shown were selected for use with a full-wave demodulator followed by a low-pass filter,

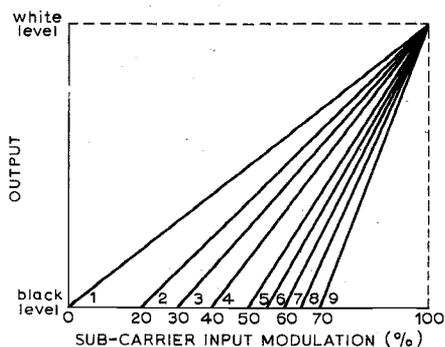


Fig.2. The required transfer characteristics for a contrast expander.

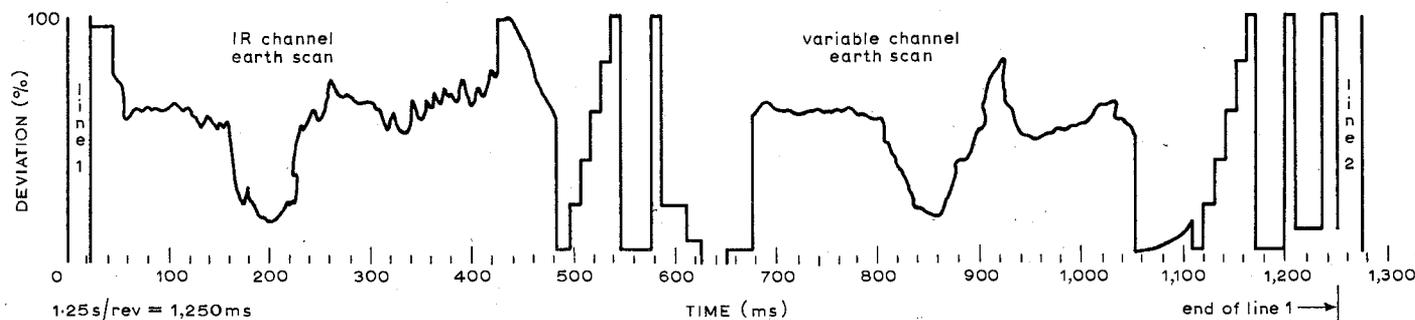
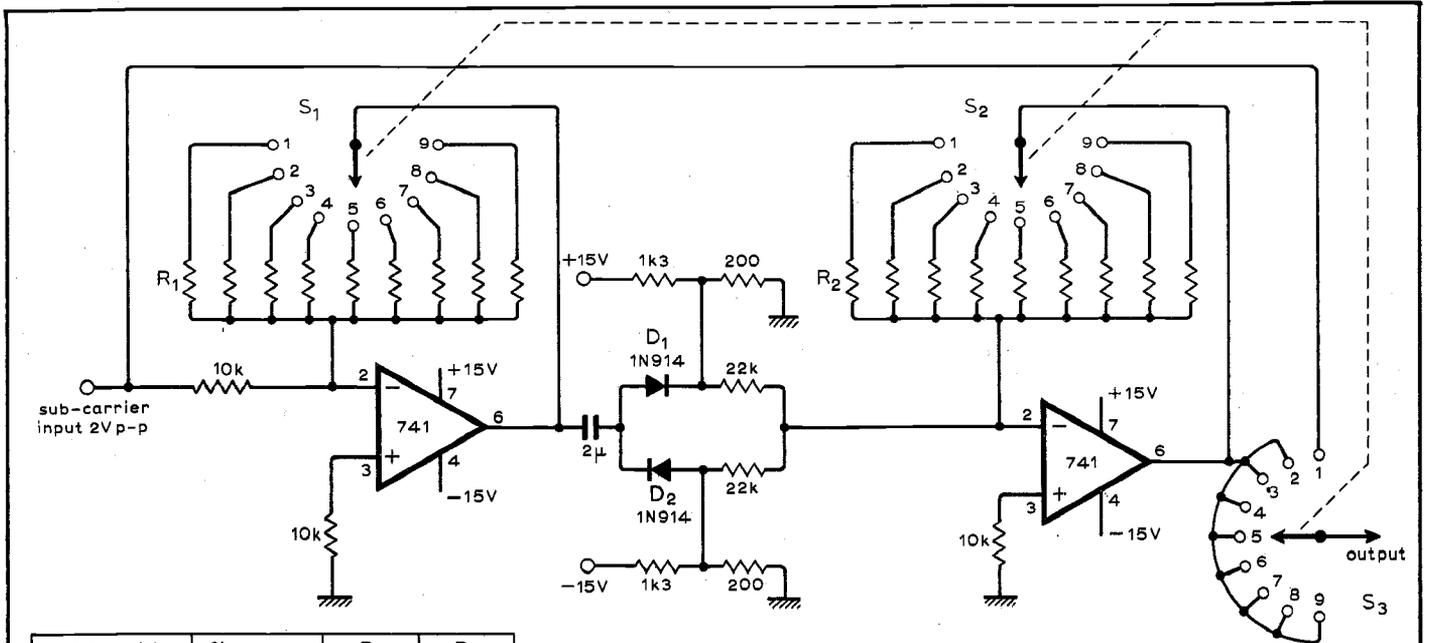


Fig.1. A typical time multiplexed i.r. and visible channel waveform; parts of the scan period are used for calibration and telemetry. (Ref. 1.)



switch position	% process	R ₁	R ₂
1	0	87k9	2k9
2	20	87k9	2k9
3	30	61k4	5k0
4	40	45k3	8k8
5	50	35k4	15k7
6	55	31k4	22k2
7	60	28k5	30k1
8	65	26k8	38k6
9	70	24k2	60k0

Fig.3. Circuit diagram of contrast expansion processor.

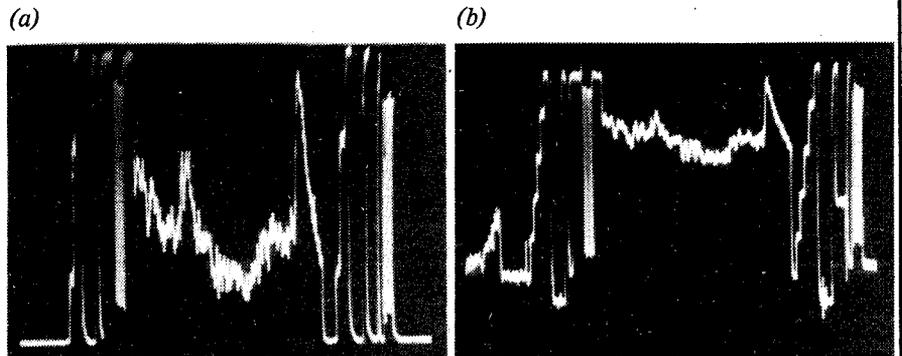


Fig.5. (a) The NOAA 2 i.r. scan line video waveform after expansion. (b) The NOAA 2 i.r. scan line video waveform before expansion.

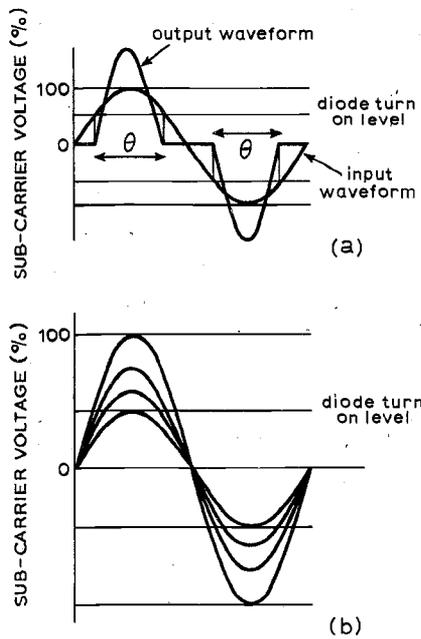
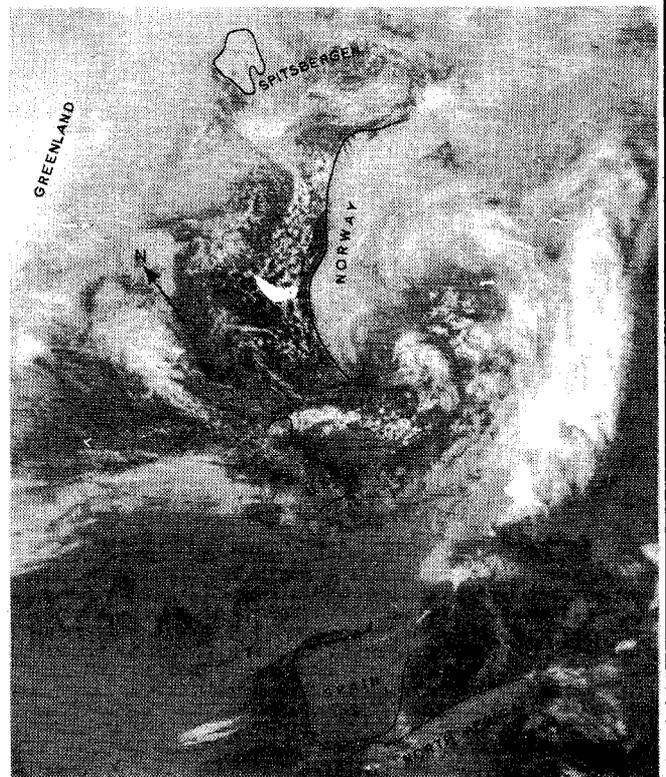


Fig.4. (a) With a fixed 100% input voltage, the conduction angle varies with diode turn on level. (b) With a fixed diode turn on level the conduction angle varies with sub-carrier peak voltage.

Fig.6. An infra-red print-out from NOAA 3 received in Dundee on 13th November. The spacecraft sensor responds to radiated i.r. and the picture format is such that white is cold and black is warm. In this way a certain amount of three-dimensional information is contained in the picture as the high altitude clouds are the colder and therefore whiter. The i.r. channel resolution is 4 nautical miles at the point on earth immediately below the satellite.



video amplifier and photofacsimile picture printer of the mirror galvanometer type.

Correct adjustment may be achieved as follows: Set the selector switch to 0% and connect the input to a 2V pk-pk 2400Hz tone source. Adjust the sensitivity of the picture printer until peak white level is reached. Set the selector switch to 20% and adjust the appropriate feedback resistor at the output operational amplifier until peak white level is again reached in the picture printer. Repeat for the remaining selector switch positions.

Not only does θ change for fixed 100% signal input with variation of diode turn-on level, as set by the selector switch, but also with a fixed diode turn-on level and variable peak input voltage. This may be seen from Fig.4(b). The effect is to cause a low level curvature of the transfer characteristics shown in Fig.2. One possible cure for this problem would be to use a square wave subcarrier input. However, a sampling circuit would be required to convert the sine wave subcarrier to square wave. Since the degree of low-level curvature is not

troublesome in practice, such a modification of the subcarrier is not necessary. An alternative method would be to re-design the circuit to act on the video waveform at the output of the subcarrier a.m. demodulator. The disadvantage would be that the circuit could not be added simply to existing a.p.t. equipment without modifying the video circuitry. The arrangement in Fig.3 can be inserted between any a.p.t. receiver subcarrier output (output of the f.m. discriminator) and the input to the subcarrier a.m. demodulator, provided the signal level is adjusted to 2V, pk-pk.

Fig.5 shows a typical i.r. scan line waveform with and without expansion. One disadvantage of the expander is its effect on noisy signals. Whenever the subcarrier voltage falls below the diode turn-on voltage, the picture printer will reproduce black. Bursts of noise such as those caused by interference or signal fades are thus exaggerated.

The processor described has given satisfactory results at the Dundee University a.p.t. station for a number of

years and has been used to reproduce i.r. pictures from NIMBUS 3 & 4, TIROS M, NOAA 1 & 2 and METEOR 10 & 12.

References

1. Modified version of the improved TIROS operational satellite (ITOS D, G) by A. Schwab, NOAA technical Memorandum NESS 35, US Department of Commerce.

Further reading

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Portune, J. E. and Owen, C. M., "A Satellite Station for Everyone", *Weather*, Vol. 25, No. 3, March 1970.

Sollom, P. W., "Just Look at the Weather". *Radio Communication*, R.S.G.B., November and December 1971.

Osborne, J. M., "Receiving Weather Pictures From Satellites", *Wireless World*, October and November 1971.

A.P.T. User's Guide. U.S. Department of Commerce.

Books Received

The Sinclair Book of Management Calculations by Christian de Lisle is a pocket book which shows how an electronic calculator can best be applied in the areas of finance and accounts, purchasing, stock control, production, marketing and sales. Easy to follow examples are given throughout the book. Price 50p. Pp.96. Woodhead-Faulkner Ltd, 7 Rose Crescent, Cambridge, CB2 3LL.

Rapid Servicing of Transistor Equipment, Second Edition, by Gordon J. King is a systematic guide to the servicing of transistor radio, television tape and hi-fi equipment. Early chapters describe semiconductor principles, characteristics and circuitry, and how transistors are set up, biased and tested and a complete chapter is devoted to signal conditions and tests. Subsequent chapters concentrate on fault diagnosis in the various fundamental types of circuit, each section concluding with a fault diagnosis summary chart. A separate chapter is devoted to the ordinary transistor portable receiver, with stage-by-stage description and complete alignment and fault-finding details. The final chapter gives practical advice on making repairs to transistor equipment and deals also with printed circuit boards. This second edition has been expanded and updated to take account of capacitor diodes, f.e.t.s and integrated circuits. Price £1.90. Pp.171. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Intermediate Network Theory Book One by R. J. Maddock introduces the reader to the essentials of network theory as a subject in its own right and presents the basic techniques of network analysis in a form that is understandable to technical college students. The opening chapter is concerned with the chosen notation for measurement of electrical variables, revision of fundamental relationships and the application of these

relationships to transient solutions for simple circuit arrangements. This is followed by a chapter on a.c. theory which includes the phasor approach and the use of j notation. The next two chapters deal with series and parallel arrangements of impedances and admittances, mesh and nodal analysis and the use and limitations of network theorems. In the remaining chapters, resonant networks, three-phase circuits and two-port networks are described in detail. Techniques and principles are illustrated throughout by worked examples. Exercises with answers are provided at the end of each chapter. Price £3.95. Pp.184. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

A Handbook of Conical Antennas and Scatterers by R. M. Bevensee presents computed theoretical characteristics of various conical aeriels as well as measured data for various conical scatterers at frequencies in the resonance region. Curves of gain, far-field and input admittance are presented for various solid and hollow conical monopoles and coaxial horns above a perfectly conducting plane and for a cone protruding from a sphere. Graphical data on measured backscatter cross-section is presented for flat-base cones and cone-spheres. This information will aid in the understanding of radar characteristics in conical missiles and space vehicles. The reciprocity theorem for transmitting and receiving aeriels is treated and formulae are presented for computation of the temporal response of an aerial or scatterer to pulse excitation, given the frequency response data. Price £10.20. Pp.173. Gordon and Breach Science Publishers Ltd, 41/42 William IV Street, London WC2.

Electrical Engineer's Reference Book 13th edition edited by M. G. Say contains 24 sections covering all aspects of electrical engineering from basic theory and standards

to environmental control and the application of electrical principles to medical science. SI units have been used throughout with some reference as necessary to the equivalent Imperial and non-SI metric units. In this edition, all sections have been extensively revised and information presented in a more compact form. Price £12.00. Pp. approx. 1600. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Dictionary of Electrical Engineering by K. G. Jackson is for electrical engineers and covers terms associated with this branch of engineering and its theory plus an extension into the related areas of electronics, lighting, constructional materials etc. Price £2.25. Pp.375. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

The Pye Book of Audio contains a series of articles on all aspects of hi-fi from 13 experts in the field of audio. The book is intended to be informative from a technical and also from the practical point of view of purchasing, installation and operation of equipment. Articles also cover the subject of manufacture of audio products. Price 95p. Pp.125. Daily Mirror Books, IPC Newspapers Ltd, 79 Camden Road, Camden, London, NW1 9NT.

Recording with Compact Cassettes is an Agfa-Gevaert production covering the subjects of choosing the right recorder, electrics and mechanics, the compact cassette, microphones, hi-fi and stereophony, Dolby noise reduction, hints on compact cassette recordings, advice on collecting cassettes, service and maintenance, translations and explanations of the technical terms used in connection with cassettes. Price 65p + 6p post and packing. Pp.98. Agfa-Gevaert, Unity House, Great West Road, Brentford, Middlesex.

Letter from America

Well, the Great Quadraphonic War is still on, with CBS still winning in terms of discs with nearly 300 on the market. It is true that the RCA-JVC group have signed up more record companies and manufacturers recently, but only 30 Quadradiscs have been issued to date. One of the reasons for the lack of acceptance of so-called discrete systems are the difficulties involved in broadcasting — a serious disadvantage for an industry that lives on the "Top Twenty".

Some time ago, the Electronic Industries Association formed the National Quadraphonic Radio Committee to study the problems, The N.Q.R.C. is working closely with the F.C.C. and they are evaluating at least ten systems for quadraphonic broadcasting. CBS claim that the SQ system, with a "logic" decoder, can give as good a separation in practice as any discrete system, but they *did* have a proposal for the committee. Several hundred f.m. stations are broadcasting SQ records but listeners do not always know which records are SQ and which are not. So, the CBS idea is to amplitude modulate the 19kHz pilot tone by 40 to 50% to activate an indicator light. The frequency suggested is 593.75Hz — the 32nd sub-harmonic.

The majority of the other systems are variations of the Quadracast system developed by L. Dorren. The main channel extends up to 15kHz and it contains the sum of all the audio signals — left and right front, plus left and right rear. A suppressed 38kHz carrier is used (just as in f.m. stereo transmissions) but the sidebands are in quadrature relationship. In other words, one set of sidebands is in the same phase as the main channel but the other leads by 90 degrees. The 38kHz carrier is supplied by the receiver and it is locked in phase to each of the pairs of sidebands. The first contains the modulation equal to the difference between the left and right information pairs $(L_f + L_r) - (R_f - R_r)$ and the second quadrature-related sidebands are modulated with $(L_f - L_r) + (R_f - R_r)$. Another sub-carrier is located at 76kHz (four times the 19kHz pilot signal) and it is also suppressed, so only the sidebands are transmitted. They carry

the diagonal difference signals $(L_f + R_r) - (L_r + R_f)$ and thus a correctly designed receiver can reconstitute the original four channels. At 95kHz there is provision for a sub-carrier used by many f.m. stations to transmit Muzak or other services to subscribers (SCA). At present the SCA band is centred on 67kHz and the F.C.C. have stipulated that any scheme for quadraphonic transmissions must include provision for SCA.

The Quadracast system has been criticized on the grounds that it contravenes F.C.C. regulations by exceeding the allocation but this is based on a misunderstanding. In fact, the regulations merely require that sidebands in the range of 120kHz to 240kHz from centre frequency be attenuated at least 25dB. The Quadracast system has been used on an experimental basis by a San Francisco station, KIOI for some time and the engineers are satisfied that there is no infringement of the regulations.

Now for a look at some of the other systems. First, Zenith: their proposal leaves the SCA band at 67kHz, but has a quadrature-related 38kHz sub-carrier like the Quadracast. A 76kHz sub-carrier is also used but it is limited to the upper sideband and it employs a small 76kHz pilot signal. Another Zenith proposal is to move the 76kHz carrier to 90.25kHz using vestigial sideband modulation, again leaving the SCA band at 67kHz. A GE proposal uses the same 38kHz quadrature sub-carrier but the 76kHz carrier has only a vestigial upper sideband so the SCA band can be transferred to 95kHz which can be phase-locked to the 19kHz signal. RCA have two systems, one almost identical to the Quadracast minus SCA (for use by stations not using that service) and a system using the quadrature method, but without a 76kHz carrier.

Some months ago the prestigious Consumers Union published a report on loudspeakers which is still being discussed by audio engineers. Briefly, what CU did was to use a computer for evaluation: first, power responses were made, using a pink noise signal and taking measurements at 10-degree intervals in two perpendicular planes. At each angle 30 readings were taken automatically and all these were fed to a computer which was also programmed to make readings of sound power each speaker radiated forward in a 60-degree cone, as well as total power radiated 360 degrees around the speaker. The computer was used to convert these figures into sones which were then converted into an accuracy percentage. A low-frequency limit of 110Hz was used because of room variations below that point.

I must admit that when I read thus far, I was appalled because this meant that a speaker with a 15dB peak at say 7kHz would get the same accuracy rating as one with several small irregularities. Moreover, the tests did not take into account other factors like transient response, colouration and distortions of various kinds. The speakers tested were small bookshelf types and top scores came out

at 89% accuracy. Interestingly enough, a listening panel agreed with the computer verdict but I am wondering whether a speaker rated at 100% accuracy would really be perfect? I am only asking!

Pay-TV never really got off the ground here but there is a revival of interest in the idea by cable TV companies. Among those involved are Time magazine subsidiaries, the Magnavox corporation, Warner Brothers and other Hollywood concerns. Special programmes such as new films and sporting events will be sent to subscribers who will pay extra for the privilege. How to collect the money? One company will operate on a monthly flat rate basis but others will use more complicated methods such as data cards to disable a set-top scrambling device or having the eager subscriber phone in to an office where his order is booked and a signal is sent back down the line to unscramble the black box. A more expensive arrangement is a two-way system that enables subscribers to send coded information back to the operator over the programme lines. Meanwhile a new society has been formed — the CPPPWINGF which translated reads: Committee to Protect the Public from Paying for What It Now Gets Free. It is sponsored by the National Association of Broadcasters — who else?

G. W. TILLET

Corrections

Model Railway Control System

We have been informed by Mr. Cowan, the author of this article, that it may be possible to order the Milliperm Special Super motor through Röwa model railway dealers in the U.K. The Danavox earpiece can be ordered by its type number 4501/01 and has an impedance of 120Ω. One or two small errors occurred in the article: diodes D_{10} and D_{12} should be reversed (Fig. 5), a 0.1μF capacitor should be connected between Tr_{18} base and emitter and a 0.047μF capacitor across R_{73} (Fig. 6). In the list of ZTX 501 used, Tr_{14} should be included, and Tr_{16} , not Tr_{14} , is TIP 31 or TIP 29. In the last paragraph, the reference to Tr_4 should be Tr_{16} .

In Linear Voltage Controlled Oscillator in the November issue there are two errors in the connection diagram Fig.8 (p.568). Pin 14 should be connected to pin 10 (not to pin 11 as shown); and pin 6 should be connected to pin 3. The circuit in Fig.7 is correct.

World of Amateur Radio

New British microwave record

An hour-long 10GHz contact between portable stations in Scotland and Wales operated by groups of amateurs from Surrey and Middlesex has established what is thought to be a new British distance record for this band. This 212.5-km link was established on September 13 when all-solid state equipment was carried to the summits of Snowdon (3560ft) and the Cairnmore of Fleet (2300ft) under far from ideal weather conditions with gale force winds, limited visibility and the stations well above cloud base. The wind made it impossible to use the planned dish aerial at the Snowdon station (GW8CKT/P) and a small horn aerial was used. An 81-cm diameter dish antenna was used in Scotland (GM8AZU/P) with its beam heading set using only a simple low-cost plastics compass. Both transmitters were based on Mullard CXY19 Gunn diodes with outputs of about 100 and 120 milliwatts. The receivers used CS10B and balanced BAW95 mixers with CL8370 local osc. and 70MHz i.f.

As part of this carefully planned expedition a 3.7MHz link was used between the two base camps and a 145MHz link from summit to summit. Contact was maintained at R5 S6/7 for over an hour. The previous British 10GHz record was 98 miles across the Bristol Channel. The amateur "world record" for the band has for many years stood at 265 miles by American amateurs.

During the period July 28 to August 3 a rare "duct" existed between Hawaii and California and this allowed a number of amateurs to make contacts of over 2500 miles on the 144MHz band. The frequency cut-off of the duct varied between about 148 to 220MHz, occasionally dropping to about 50MHz, and even longer distances would have been possible if there had been 144 MHz activity in the Pacific area beyond Hawaii.

VHF Pioneer 1933 — President 1974

The news that George Jessop, G6JP will be the R.S.G.B. president for 1974 (he will be officially installed at a gathering at the Bonnington Hotel, London WC1

on January 4) recalls some notable experiments in aircraft radio communications in which he played an important role in May and June 1933. The publicity that surrounded these experiments — believed to have been the first time that v.h.f. was successfully used in the U.K. for radio contacts between two aircraft in flight and between aircraft and the ground — may well have been one of the prime reasons that the RAF entered World War II with v.h.f. radio in its fighter aircraft.

The leading roles in these experiments, in which a number of amateurs participated, were played by the late Douglas Walters, G5CV, then radio correspondent of *The Daily Herald* and George Jessop, G6JP in two specially chartered Dragon Moth aircraft. This followed an earlier flight by Douglas Walters in May when he made radio contact with G6JP at Hammersmith and several other stations using the old 56MHz amateur band. For these flights the transmitter power was between 4 and 7 watts using batteries; reception was by means of three-valve super-regenerative receivers but because of the high level of ignition interference the aerials were disconnected from the receivers!

George Jessop was initially licensed as 2AYP in 1929, and then obtained the radiating permit G6JP in 1930. Until his retirement in 1971 he spent his working career in the valve industry, with the M-O Valve Company. His lifelong interest in v.h.f. is reflected in his book VHF/UHF Manual, one of several publications he has written and compiled on amateur radio subjects.

Another notable first is recalled, less happily, in the recent death of Don Mix, WITS who in 1923-24 was operator of WNP ("Wireless North Pole") on board the schooner Bowdoin with the MacMillan Arctic Expedition — the first of the major expeditions for which amateurs supplied radio communications. So successful was WNP that on his return Captain MacMillan predicted that "no polar expedition will attempt to go North again without radio equipment".

Box 88 Moscow

One of the most famous addresses in amateur operating is Box 88 Moscow, the headquarters of the Russian QSL Bureau and of the Radio Sports Federation — the national society for amateurs in the U.S.S.R. Following a recent visit to Moscow, J. L. Carrell, ZL1HL has described in *Break-in* his impressions of the club headquarters about 9 miles from Red Square and where there is a full-time staff of eight. The club occupies nearly 1800 sq.m. of floor space on two or three levels and includes a library of 48,000 reference books plus 12,000 technical articles, a reading room, a lecture theatre, a small lecture room, a laboratory and a workshop. The QSL bureau handles some 2.5 million cards annually and is manned by four of the staff. A headquarters station (about 35 km away) has 1kW transmitters on each of the

five h.f. bands and a 144.5MHz beacon transmitter. The U.S.S.R. has about 46,000 licensed operators and some 4500 local radio clubs. Mr Carrell received the impression that the club, like sports groups in the U.S.S.R. and other East European countries, receives substantial financial support from the government.

In the air

The A.R.R.L. has asked the F.C.C. to extend until February the time for submitting comments on the proposed use of 224 to 225MHz for a new Class E Citizens Radio Service, pointing out that the League is unalterably opposed to this proposal and that it is concerned with the ever-increasing invasion of the 28MHz amateur band by unlawful operation in and adjacent to the 27 MHz Class D citizens band.

Amateurs wishing to set up temporary stations on any of the islands within the Bailiwick of Guernsey must now give at least 48 hours notice to: The Development Controller, Development Division, States Telecommunication Board, PO Box 3, St Peter Port, Guernsey, telephone Guernsey (0481) 24211.

The R.S.G.B. education committee has offered to assist instructors providing courses for the Radio Amateurs Examination on an individual basis. Instructors having queries or requiring advice or assistance should write to the chairman: D. M. Pratt, G3KEP, 30 Lyndale Road, Bingley, Yorkshire BD16 3HE.

An Australian "intruder watch" has revealed over 100 non-amateur stations in the 7, 14, 21 and 28MHz bands. As in Europe, the most serious problem appears to be the broadcast stations and their associated jammers operating in the amateur section of the 7MHz band.

In brief

The R.S.G.B. has awarded the 1973 Calcutta Cup for the encouragement of international friendship to F. W. Fletcher, G2FUX of Ringwood, Hampshire. The Rotab Cup goes to E. A. Trowell, G2HKU — this cup, presented originally by Gerald Marcuse, G2NM, is for the encouragement of long-distance operation and recalls the one-time Royal Order of Transatlantic Brasspounders . . . At least two American amateurs have now succeeded in working all American states (including Hawaii and Alaska) through the Oscar 6 satellite . . . East Germany and West Germany now count as separate countries for the DXCC award . . . In connection with the recent item on early communications receivers, C. B. Raithby, G8GI mentions that he still has a pre-war Hammarlund HQ120X in regular use. It has only ever had two faults and outperforms many modern receivers! . . . The 1974 mobile rally of the Amateur Radio Mobile Society at RAF Cosford in Shropshire will be held on Sunday, May 19 and those wishing to take part in the trade show should get in touch with W. S. Barwick, 34 Malvern Road, London N8 0LA.

PAT HAWKER, G3VA

New Audio Products

Equipment seen at the 1973 Audio Festival and Fair

Sansui demonstrate i.c. decoder

The Sansui Variomatrix decoder is now available in integrated-circuit form. The decoder chips are available on an o.e.m. basis and makers have the option of using either three or four chips on the basis of Variomatrix adjacent-speaker separation of 12 or 20dB. The technique relies on a psychoacoustic phenomenon of directional masking. Crosstalk is decreased (to 12 or 20dB from 3dB) for prominent signals at the expense of crosstalk for the less prominent signals, it being claimed that directionality of the weaker sounds is masked by the presence of stronger sounds. The technique can also be applied to conventional stereo sources and to SQ records, as exemplified by the QRX series of receivers. The effect certainly seems to give better results than the basic 3dB matrix used in earlier Sansui equipment.

Sansui disclose that three U.K. makers have so far taken out licences for the technique — Armstrong, Quadrasonics and Millbank. Two further record companies are using Sansui coding — Vox (USA) and ERato (France).

As well as the QRX line of Variomatrix receivers Sansui have a new Variomatrix amplifier QA-7000 intended both for converting a two-channel system into a four-channel one, or for starting from scratch.

Sansui, 39, Maple St., London W.1.

WW 361 for further details

New British integrated amplifier

Since its introduction in August, the Harrison S200 integrated amplifier has created much interest on the Continent and was given its first press demonstration in London during, though not at, the Audio Fair. Designer Mike Harrison has provided 200 watts total output (into four ohms) to cater for foreseeable loud-speaker requirements from an attractive free-standing unit measuring only about 430 × 270 × 85mm. In addition to bass, treble and low-pass filter slope controls, a middle-range control is included, claimed to be preferable to the adoption of graphic equalizer systems.

Other features include i.c. pre-amplifier stages, illuminated signal-source selection with touch switches and l.e.d. VU output meters. Full electronic protection of the output stages is included. Power bandwidth is 10Hz to 40kHz at less than 0.1% harmonic distortion continuously rated. Construction includes a toroidal mains transformer and most of the circuitry is on plug-in boards. Manufactured by Harrison-Chapman Ltd, the amplifier retails at £169 plus v.a.t. Next product will be a tuner of similar high-quality construction and specification.

Available only from selected dealers, the S200 is distributed in the U.K. by Gimar Ltd and exported by Expotus Ltd, both of 10 Museum St, London WC1.

WW 362 for further details

Trio CD-4 demodulator uses p.l.l.

Model KCD-2 demodulator for the CD-4 system is a plug-in module for the latest "two-four" Trio receivers, KR-6340, 7340, 8340 and 9340. Unlike earlier CD-4 demodulators, this unit uses phase-locked loop i.c.s for increased sensitivity to carrier level. It requires external equalization.

The i.c.s are followed by a muting circuit, operated by a separate carrier detector, that automatically switches the two-/four-channel function, previously manual. Remainder of the circuit is mainly to compensate for the noise reduction technique applied during recording. UK distributors — B. H. Morris & Co. Ltd, Trio House, The Hyde, London NW9 6JP.

WW 363 for further details.

Stylus Timer

Distributed through Highgate Acoustics, the Pickering stylus timer represents a fascinating spin-off from space technology. The device consists of a small mercury coulometer which is activated every time the tone arm is removed from the arm rest. An indicator dot, easily read, travels along a mercury filled, hermetically sealed capillary tube at a rate proportional to the flow of electric current through the instrument. The power source is a small mercury battery.

The scale, divided into 100 hour increments will read up to 1000 hours and is easily re-zeroed at any time within the 1000 hour period. At the end of the full scale movement of the dot, movement can be reversed and the scale switched around for the second period and so on. The makers claim an indefinite life for the timer which is priced at £6.75 plus v.a.t. Highgate Acoustics, 38 Jamestown Rd., London NW1.

WW 354 for further details

Rotel RA-611 amplifier

Successor to the RA-610, this new model provides tape dubbing, tuner, two disc and two auxiliary inputs. Control layout is well engineered with a rotary control for selection of speakers (output for two sets), monitor, input selection and volume, slide control for left and right bass, left and right treble and balance. Pushbuttons provide power, low filter, high filter, tone defeat, mode, loudness and muting.

Brief specifications:

Power rating	30W r.m.s. into 8 Ω with 0.5% t.h.d. at 1kHz
Power bandwidth	5 to 55,000Hz, IHF at 8 Ω
Frequency response	5 to 100,000Hz, -3dB at 8 Ω
Signal to noise ratio	phono 65dB aux 70dB tuner, tape in 70dB
Damping factor	35 at 8 Ω
High filter	-10dB at 10kHz
Low filter	-10dB at 50Hz
Input sensitivity	phono 2.5mV/47k Ω tuner 150mV/40k Ω aux 150mV/40k Ω tape monitor in 230mV/47k Ω main amp in 800mV/33k Ω
Phono overload	over 100mV
Price	£92.90

Rank Audio Visual, P.O. Box 70, Great West Road, Brentford, Middlesex.

WW 352 for further details.

Sinclair Project 80 modules

Project 80 is a replacement for the Project 60 series of modules and comprises a pre-amplifier and control unit, and active filter unit, two power amplifiers, three power supply units and the Project 80 f.m. tuner and stereo decoder. Details of each unit are as follows:

Pre-amplifier and control unit include separate tone and volume slide controls for each channel, radio and tape inputs and provision for magnetic and ceramic pick-ups. Price is £11.95 + v.a.t. The active filter unit provides an h.f. cut-off of 12dB/oct at 22kHz to 5.5kHz, and l.f. cut-off of 22dB at 20Hz. Price is £6.95 + v.a.t. The Z40 and Z60 power amplifiers retail at £5.45 and £6.95 inclusive of v.a.t. Unit Z40 provides an output of 15W r.m.s. into 8 Ω while the Z60 will deliver 25W.

A choice of three power supply units is available. Priced at £4.98 + v.a.t., the PZ.5 provides 30V unstabilized, PZ.6 35V stabilized and PZ.8 45V stabilized without mains transformer. Both the PZ.6 and PZ.8 retail at £7.98 + v.a.t. The Project 80 f.m. tuner (£11.95 + v.a.t.) and the stereo decoder (£7.45 + v.a.t.) modules are separate items. The tuner provides a tuning range of 87-108MHz and distortion is claimed at 0.3% at 1kHz for 75kHz deviation. Channel separation of 40dB and an output of 150mV are provided by the stereo decoder. Sinclair Radionics Ltd., London Road, St. Ives, Huntingdonshire PE17 4HJ.

WW 356 for further details



WW 352

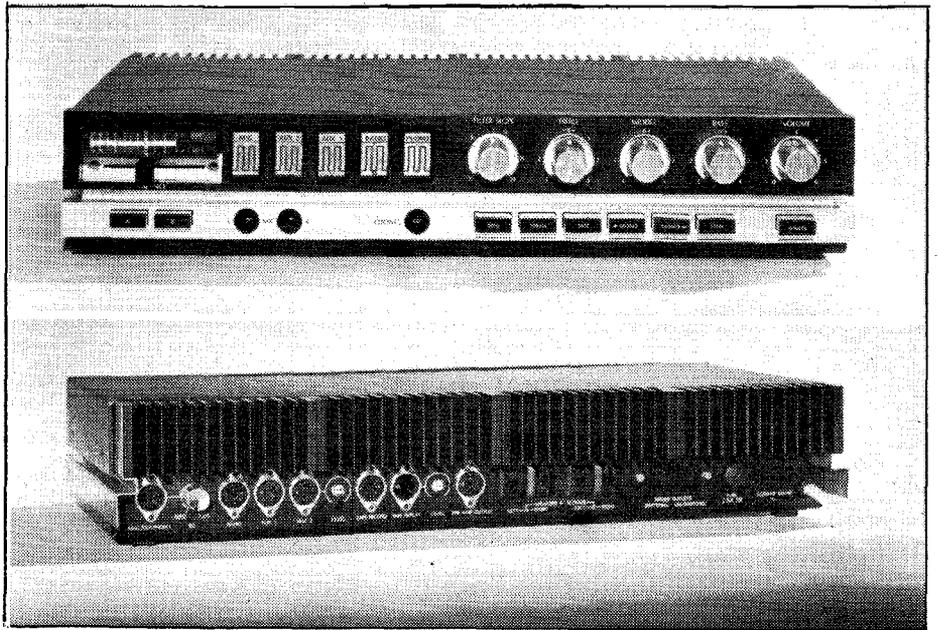
N.E.A.L. cassette recorder

A new British cassette recorder, by North East Audio was shown at Olympia for the first time this year. Called the Model 102 and illustrated in cut-away form, in the photograph, this machine uses the well known 3M Wollensak heavy duty mechanism and all-British electronics.

Capable of recording on both CrO₂ and the normal ferric oxide cassettes, a frequency response of 35Hz to 15kHz, +1dB-3dB is claimed, using the former cassette. Distortion is said to be less than 0.1% from any input to the head for an input of 80mV on the high level line input.

Signal metering is achieved with twin programme meters reading both positive and negative peaks. They indicate the true pre-emphasized recording signal and the equalized playback signal and have a circuit rise time of 2ms and a fall time of 200ms. North East Audio Ltd., 5 Charlotte Square, Newcastle upon Tyne NE1 4XF.

WW 359 for further details



WW 362

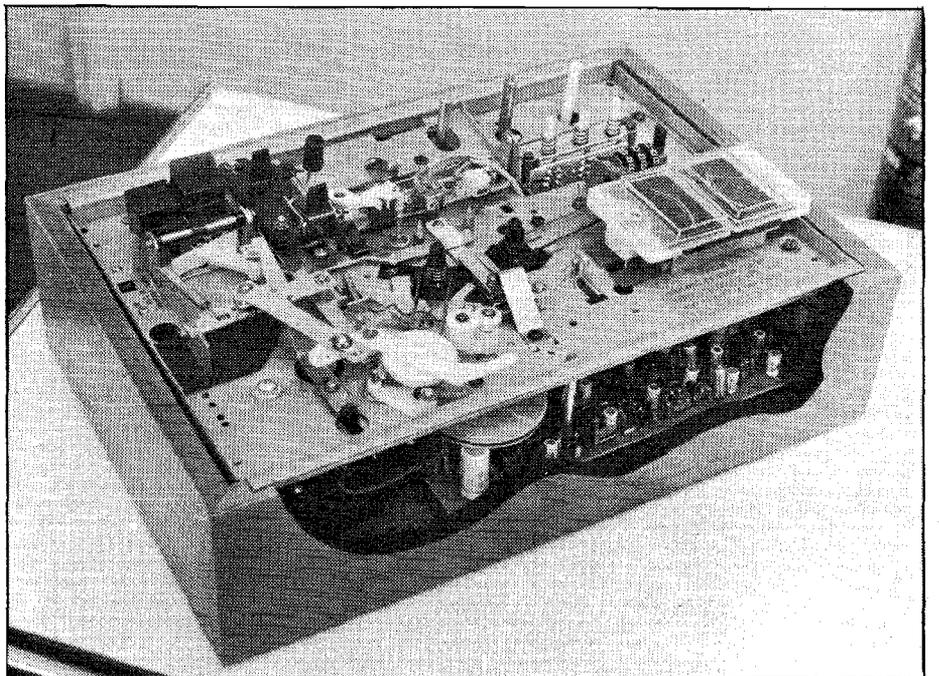
Cassette deck

Uher have developed a new mains powered cassette deck which uses the mechanism of the now well established CR124 portable machine. Providing record and playback facilities which meet the high fidelity standard DIN 45500, it will accept either CrO₂ or ferric oxide tapes.

Dolby "B" noise reduction is a feature which brings a claimed signal-to-noise ratio (DIN weighted) of 56dB with the noise reduction circuit switched in and using CrO₂ tape.

An integral power amplifier will give 10W per channel, continuous sine wave and when the mechanical system is switched off, the unit will function as a conventional hi-fi amplifier.

Three motors are fitted, two for winding and a Pabst synchronous hysteresis type for the capstan. Since the unit is solenoid controlled, a remote control facility is also offered which gives all the normal controls plus function indicator lights, headphone socket and a volume control. Price will be about £384 plus v.a.t. and the first



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production should reach the U.K. by Easter 1974. Bosch Ltd, P.O. Box 166, Rhodes Way, Watford WD2 4LB, Herts.
WW 355 for further details

Tripletone Hi-Fi 1818 Mk II

The new 1818 from Tripletone represents one of the best performance stereo amplifiers at the lower end of the price range. Dual concentric tone controls, bass mid and treble, now operate active circuits and additional circuitry includes output protection. Price is £48.50 + v.a.t. and brief specifications are:

Rated power 20W r.m.s. at 1kHz into 8Ω both channels driven
T.h.d. < 0.08% at rated power

Signal to noise better than 70dB all inputs
Tone controls bass $40\text{Hz} \pm 17\text{dB}$
mid $1\text{kHz} \pm 8\text{dB}$
treble $14\text{kHz} \pm 13\text{dB}$

Input sensitivity magnetic $47\text{k}\Omega / 2.5\text{mV}$
ceramic $47\text{k}\Omega / 30\text{mV}$
tuner, tape $47\text{k}\Omega / 100\text{mV}$

Input overload 26dB all inputs.

K. & K. Electronics Ltd., 60 St. Mark's Rise, London E8 2NR.

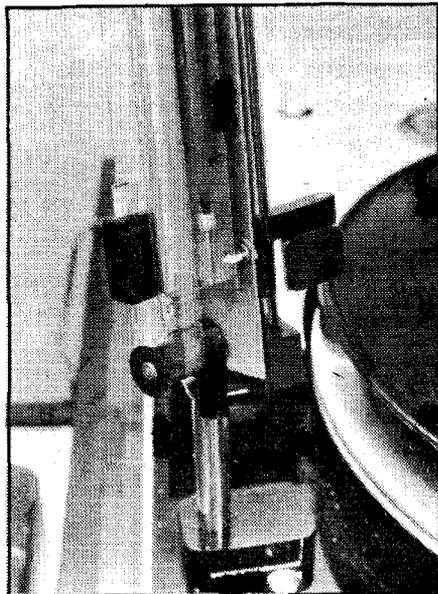
WW 357 for further details

Record Cleaner

The prototype of a fascinating record cleaner to be marketed under the brand name of Colton, was shown on the Musonic stand. Detailed photographs of the fairly complex device are below. A small rubber rimmed wheel bears on the record label and transmits drive from the disc to a plastic belt which travels across the record surface. Being electrostatically charged, dust is attracted to the belt which is then wiped clean by a felt pad held in a clip on the upper section of the belt.

Dust embedded in the record grooves is loosened by a velvet pad which tracks across the disc, from edge to centre. This, in turn, is finally picked up by the electrostatic belt. Musonic Ltd, 34-38 Verulam Rd., St. Albans, Herts AL3 4DF.

WW 360 for further details



Record brush

Decca Special Products have designed a record brush of rather novel appearance which is claimed to be an alternative solution to using nylon fibre pads. The record cleaner consists of an electrically conducting arm wired to earth carrying a brush made from a new, electrically conductive fibrous material.

It has a self adhesive pad which readily adheres to most surfaces or can be screwed onto the motor board. Adjustable for height it can be used with turntables which are flush or a little below the motor board and up to a height of 1 in. No arm rest is required since a magnet holds it in the parked position. Price £4.50 plus v.a.t. Decca Special Products, Ingate Place, Queenstown Rd., London SW8.

WW 353 for further details

Receivers with built-in CD-4 demodulators

Latest Pioneer four-channel line of receivers feature built-in CD-4 p.l.l. demodulators as well as SQ and QS/RM decoders. The QX-4000, however, omits the CD-4 demodulator and provides 10 watts per channel, all driven. The QX-646 is similar, but includes the demodulator. The QX-747 and QX-949 are more powerful and elaborate receivers. Both claim an i.f. rejection of 100dB, an image rejection of 85dB and a 38kHz rejection of 65dB. The 747 has a power output of 20 watts per channel, all four driven, and the 949 40 watts (into eight ohms). Both claim an harmonic distortion of 0.05% at the one watt level. Other notable features include an output socket for connection of a decoder for three- or four-channel broadcasts, and a display for showing levels of the four amplifiers. In this, lengths of illuminated lines indicate power,



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governed by a moving-coil shutter fed with d.c. obtained by rectifying power amplifier output. U.K. distributors — Shriro (UK) Ltd, 42 Russell Square, London WC1B 5DF.

WW 364 for further details

Latest Trio "two-four" receivers feature decoders for both SQ and QS/RM. Provision is made for adding an external CD-4 demodulator to the KR-5340, but for the KR-6340, 7340, 8340 and 9340 a new demodulator using phase-locked loop detectors can be plugged into the sets. All sets can be used in the two-channel mode with a little more than double power output per channel. Nominal output powers per channel for the series into an eight-ohm load and with all channel driven is 10, 15, 20, 25 and 40 watts respectively. Trio couldn't resist the temptation of quoting IHF dynamic output power in their spec. sheets e.g. 340 watts for the KR-9340 into four ohms! In stereo the power per channel is roughly double plus 25%. A feature claimed to be exclusive is a "double switching" stereo decoder, in which the 38kHz transformer appears to have two secondaries, feeding two diode bridges. All the tuners claim an IHF sensitivity of about $2\mu\text{V}$. UK distributors — B. H. Morris & Co. Ltd., Trio House, The Hyde, London NW9 6JP.

WW 365 for further details

Two Sanyo receivers include decoders for RM and SQ. The DCX3000 provides 10 watts per channel (at the 10% distortion level) and the DCX3300 provides 20 watts per channel. Neither incorporate the "2-4" synthesizer function of the earlier DCA1700. It is not possible to say whether the RM decoder uses phase-shift circuitry as the matrix circuits are omitted from the service manual, but we expect it does. Sanyo Marubeni (UK) Ltd, Sanyo House, Bushey Mill Lane, Watford WD2 4UQ.

WW 366 for further details

New Products

Screwholding screwdrivers

Thunder Screw Anchors Ltd announce an addition to their range of screwdrivers by the introduction of four screwholding screwdrivers. Two are suitable for slotted head screws and two for recessed head screws, their dimensions being $8\frac{1}{2}$ in and $9\frac{1}{2}$ in overall length, $\frac{3}{16}$ in and $\frac{1}{4}$ in blade diameter respectively. The screw is firmly held at the tip of the screwdriver by sliding the spring loaded shank over the head of the screw, leaving one hand free to hold the article to be fixed. It is claimed that it is possible to fix screws in the most difficult of places, where to hold a screw in the hand might normally be impossible. Thunder Screw Anchors Ltd, Victoria Way, Burgess Hill, Sussex RH15 9NF.

WW 311 for further details

An 18mm vidicon

The Electron Tube Division of EMI Electronics Ltd, has introduced an 18mm vidicon, type 9831. It is designed to operate in standard 18mm scan and focus coil assemblies and is primarily intended as a direct replacement in existing compact television cameras.

The vidicon features a low wattage heater and separate mesh construction.

This offers better shading characteristics and improved sensitivity over previous models. Specialized formats will include non-browning faceplate versions for use in fields of nuclear radiation. A version with a fibre optic faceplate for direct coupling to an intensifier, eliminates the need for an intermediary coupling lens, providing a much higher light transmission. An ultra-violet sensitive target layer will be available for use in microscopy and for inspection of items which are surrounded by intense red heat. Because this has negligible dark current, it permits the signal current to be integrated over a period of time and enables the tube to be used for low light scientific purposes. Electron Tube Division, EMI Electronics Ltd, 243 Blyth Road, Hayes, Middlesex.

WW 309 for further details

Automotive pressure module

A self-contained solid state pressure module, developed for the automotive industry, is now available in engineering quantities from Fairchild Camera and Instrument Corporation.

When connected with a pressure source, such as the engine's intake manifold, the module provides an analogue voltage that is linearly proportional to the absolute pressure at the source. This voltage can serve as a control signal for electronic fuel injection, ignition control or other systems, or it may play a part in reducing exhaust pollution. The module is among the first of a series of self-contained sub-systems being developed for automotive use by Fairchild.

The module contains a single crystal diffused silicon strain gauge with a self-contained zero-pressure reference chamber. There are two linear operational amplifiers for temperature compensation, offset adjustment and scale factor control, and a single-chip voltage regulator. The assembly uses thick-film techniques. It is packaged in a moulded unit with built-in mounting flanges and the only connections needed are for power, ground and output.

In addition, of course, a tube connection must be made to the pressure source. The finished unit measures approximately $2\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{4}$ in and operates from power supplies ranging from 8 to 32V over a temperature range of zero to 200°F.

Although the transducer was developed primarily for monitoring manifold pressure of internal combustion engines it has a variety of other applications: altitude or fluid level sensing, environmental control, monitoring of air conditions, coolants or bottled gas reservoirs and pressure-sensing in aircraft instrumentation or process control systems. Fairchild Camera and Instrument Corporation.

WW 310 for further details

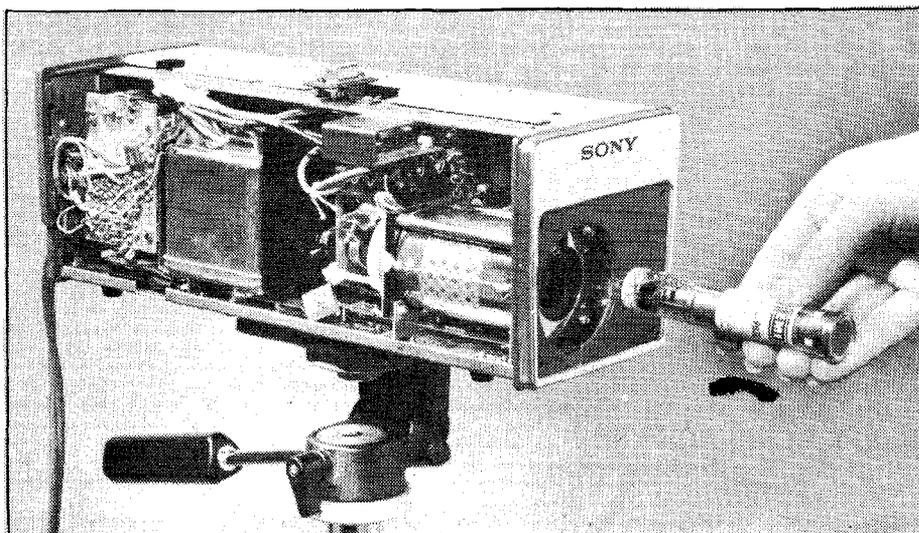
Miniature drill

The "Mini-Drill" type D-1 now available from Guest Distribution Division has been designed for drilling prototype p.c. boards and could be handy for use in laboratory, home, or in the field by service personnel. Each D-1 Mini-Drill is supplied complete with battery pack accepting four HP7 type batteries, a combined chuck key/centre punch and a 1.0mm diam. drill. Size of D-1 drill is 41×181 mm, weight is 264g (inc. batteries), and the chuck accepts drills from 0.8 to 1.4mm diam. For constant use, an adaptor type AD660 (available as an extra) can be supplied giving 6V at up to 600mA output for 240V, 50Hz input. Additional applications for the drill include clearing of soldered-through holes in p.c. boards, model making, plate making and correcting. Guest International Ltd, Redlands, Coulsdon, Surrey CR3 2HT.

WW315 for further details

Radio Microphone

The "Olympian" hand held, wide-band radio microphone from SNS Communications Group has been developed to meet the G.P.O. specification No.W6490. The hand held combined microphone and transmitter unit weighs $7\frac{1}{2}$ ozs, and needs



WW 309



WW 315

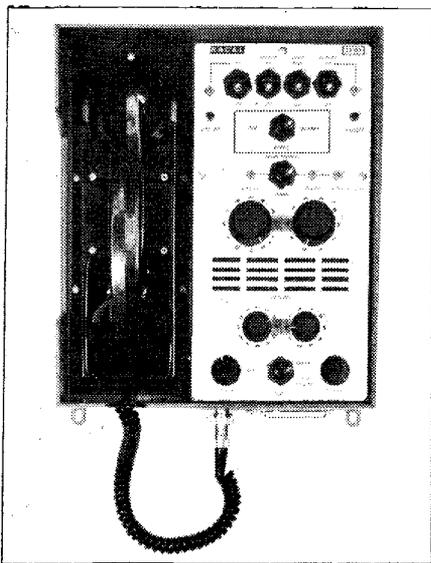
no leads or connections whatsoever. The modular design incorporates a new AKG electret microphone head type CE5 with adjustable sensitivity, and has a rechargeable battery and a recessed on/off switch with miniature indicator lamp to eliminate inadvertent switching whilst in use. Complete wide-band operation is achieved with a deviation of ± 75 kHz and frequency stability of 0.005%. The unit is readily converted, if required, to a pocket transmitter for use with a lavalier microphone.

The four-channel receiver is fully crystal controlled for precise drift free operation and absolute reliability. A transmitted carrier indicator is incorporated to confirm that the transmitter is operational. A choice of mains or battery operation is available and an integral charger has been incorporated for recharging the transmitter battery. Any one of four output impedances are selectable and both audio output level and battery level are indicated by a multi purpose meter. Output volume levels are controlled by a single rotary switch enabling levels from zero to maximum to be obtained, a jack socket is provided to enable audio monitoring facilities to be used. A shoulder slung carrying case is available for fully portable operation. SNS Communications Ltd, 851 Ringwood Road, Bournemouth, BH11 8LN.

WW 305 for further details

25W marine radiotelephone

A marine radiotelephone specially designed to cater for the requirements of operation on board warships as well as for merchant marine installations is announced by Racal Communications Ltd. To be known as the TRA.961, it is a fully synthesized



WW 316

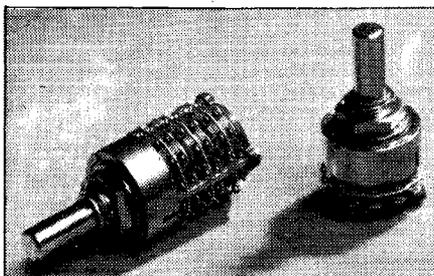
25W equipment covering all international and private channels with facilities for limiting the number of private channels, if required. Capable of operating in simplex, duplex or two-frequency simplex modes, as automatically determined in the channel selection, the TRA.961 provides operator selection on the private channels. Channel spacing is 25kHz with transmitter and receiver both covering 156.00 to 158.825MHz and the receiver also having a 160.625 to 163.425MHz capability. A "dual watch" facility monitors any two selected channels and is automatically initiated when the handset is returned to its rest position. The basic installation consists of the transceiver unit, control unit-bulkhead or bench mounted — and two dipole antennas. Up to 5 control units can be used, giving full operational facilities at each position, with one position as "Master" taking priority over the others. Racal Communications Ltd, Western Road, Bracknell, Berks RG12 1RG.

WW316 for further details

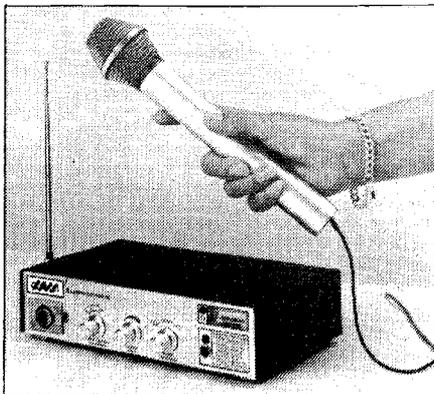
TV aerial level meter

With the recent rapid increase in the development and sales of colour television sets it has become necessary to measure aerial parameters to a much higher specification than was previously required.

Siemens have developed the SAM 3901 series of level meters as a valuable aid to all concerned with installation, testing and development of televisions and allied equipment. These all solid state testers provide a complete analysis of the television picture signal, assisting the installation engineer in the measurement of r.f. levels, noise and distortion, gain attenuation, echoes and reflections.



WW 314



WW 305

Using a selective detection system, the SAM 3901 allows for on-line measurement of amplifiers, split pads, filters etc, to determine the source of noise overloading or to perform general fault finding tasks. Working in the frequency bands 40-100MHz, 40-270MHz and 470-890MHz, these Siemens level meters provide for the measurement of all TV systems as per C.C.I.R. Rep 308-1. The power supply can be either from mains, dry cell or rechargeable nickel-cadmium batteries.

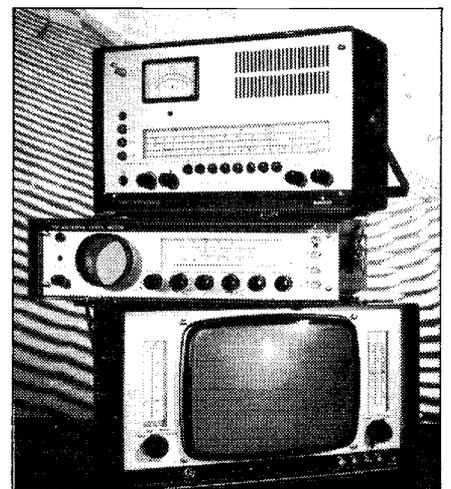
The instrument has been designed for portable use, enabling measurements to be taken in situations where a mains supply is inconvenient or impractical, such as at rooftop level. The carrying case is light but robust, specifically designed to provide ease of handling as well as adequate protection. Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex.

WW307 for further details

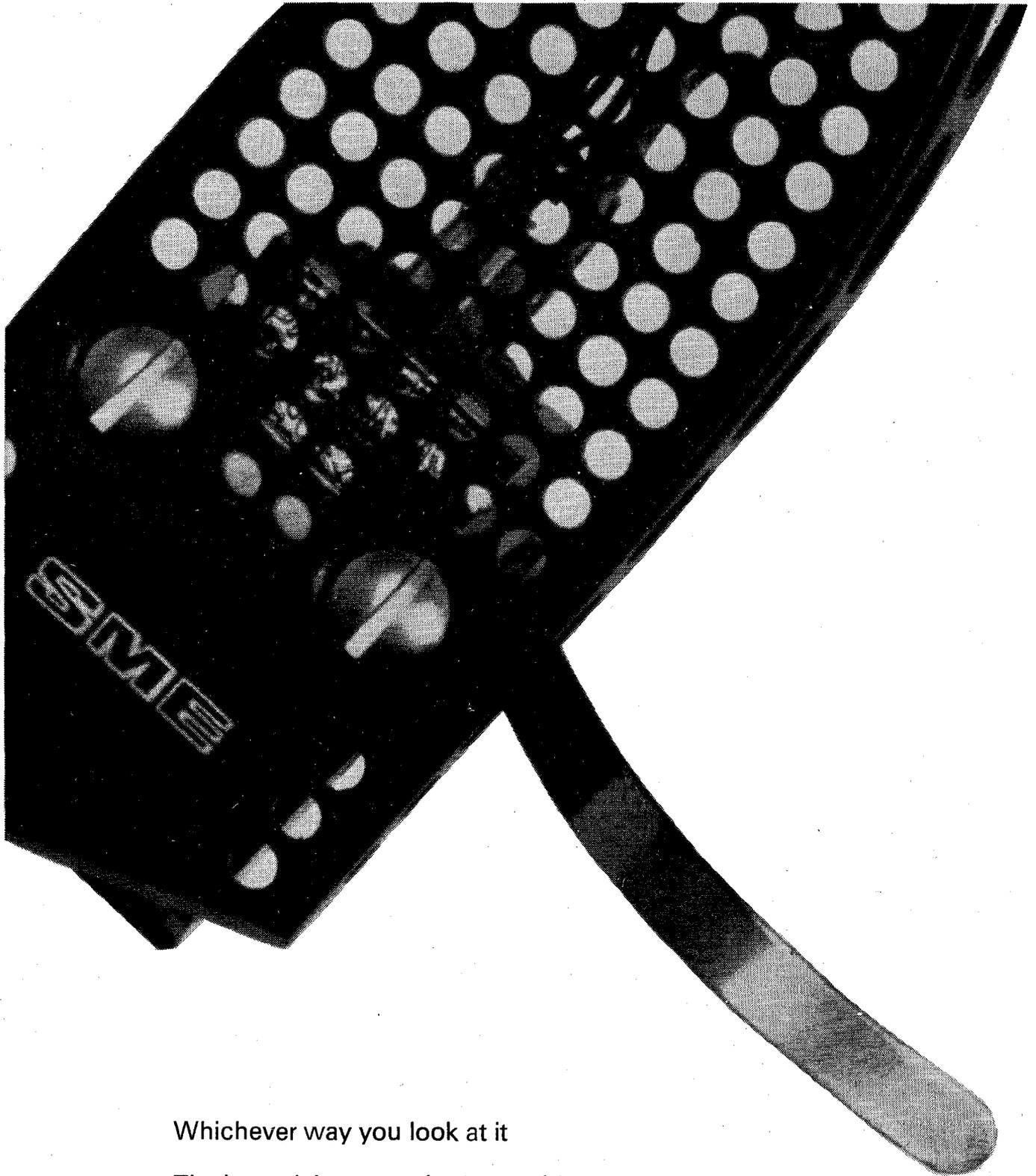
Rotary switch

The Feme series 5922, miniature panel-mounted rotary switch is available in versions giving up to 6-pole, 12-way operation. The switch is made with gold contacts in the professional version, either hermetically sealed or with adjustable stop, and as an economic version with silver contacts, not sealed, with or without adjustable stop. The units are moulded in diallyl phthylate, rated at 0.3A at 220V a.c. or 1A at 30V d.c. Units are 19mm diameter and maximum length for a 6 section unit is 46mm behind the panel. FR Electronics Ltd., Switching Components Group, Wimborne, Dorset.

WW314 for further details



WW 307



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The background music machine.

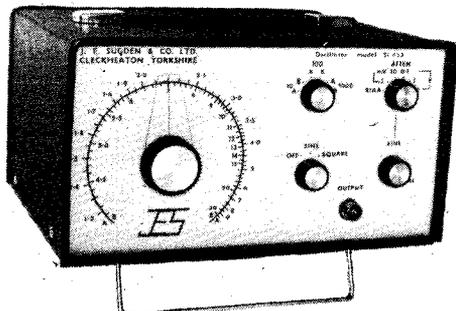
For people who want the right kind of music behind them, one name comes immediately to the fore. It is TOA – with their versatile PA-100 background music machine. This compact and easy-to-install machine plays standard 8 track cartridges, gives a programme lasting from 60-80 minutes, and can be played continuously if required. It also incorporates a solid state 15W P.A. Amplifier with 100V line output and provision for microphone and record player. It's ideal for use in hotels, bars, amusement and bingo halls and shops where it can also be used to sell as well as entertain. Get in touch with us. And we'll play over all the benefits to you.



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WW—094 FOR FURTHER DETAILS

Real and Imaginary

by "Vector"

Of Mice and Men

Apropos the Odd Ode in the October issue, my One Regular Reader has written a reproachful letter. Nobody, he says, would be so daft as to design an electronic mousetrap. Well, I'm sorry O.R.R. but I have news for you. I once did.

At that time I was on the payroll of a huge international corporation, herein-after abbreviated to HIC. Now, one of the joys of working for HIC was that if you were stupid enough to get at cross-purposes with the hierarchy, they didn't sack you; instead they posted you to one of the farthest-flung outposts of their empire — and, believe me, HIC have a choice selection of ropey far-flung outposts.

The one I collected for my sins was a sort of special offer in postings. Having no wish to go to the Tower and be shot, I won't tell you where it is, so let's just say it was in Fridgeland. Here, in due course, a helicopter set me down on a plateau in the mountains in a temperature that was giving the aurora borealis chilblains.

For all that, I wouldn't have you think that I was condemned to the life of Nanook of the North. Not at all. Although woefully short on dancing girls, the station otherwise provided most of the creature comforts. The Fridgeland engineers who staffed it were a good bunch, with hospitality their guiding star; in short, my three-months' stint didn't seem too bad to contemplate.

Then I met Enoch. It was in the small hours of the night; I was alone in the office they'd given me, trying to unravel some HIC blueprints which, as always, bore little resemblance to the transmitters I was modifying, when Enoch materialized from nowhere in particular. He was about the same size as a British house-mouse but instead of being brown all over, some Mendelian misadventure in his ancestral past had given him a white head and chest.

I took to Enoch at once. I opened up a cheese sandwich and laid a meal for him in a far corner, apologizing for the Fridgeland cheese, which is pretty awful stuff. Enoch didn't mind; before I'd got back to my chair he was chomping away heartily. Before a fortnight had passed he was taking his elevenses on the top of the desk and we were having long discussions on

the iniquities of blueprint draughtsmen.

Sad, indeed, that idylls don't last. Enoch, I discovered, had a fault. He was a blabber-mouth who must needs go and spread the word around in the stark world outside of the Hilton paradise he had found within. What pained me most was the nature of his mouse associates. Delinquents is the word that springs to mind. Common brown yobbos, uncouth and of insanitary habits. There were so many of them that frequently Enoch had to muscle his way through the rabble to get to the desk.

Enough was enough; there was, I knew, no station cat so I went to the stores and demanded mousetraps. The Fridgeland storeman's face registered stony non-comprehension. I consulted my dictionary but its compiler, foolish fellow, had evidently harboured the delusion that the country was mouseless. In despair I drew a sketch of a spring-back trap. Success! The storeman's honest face glowed with total awareness as he ferreted under the counter and triumphantly produced an ancient brass double-pole, double-throw, breaker switch. I never was any good at drawing.

I tried again, this time in pantomime. The storeman watched, fascinated, as, with the counter for a stage, my right-hand fingers became the spring of a trap and the left ones gave a virtuoso performance as a mouse. Intoxicated with the wine of Thespis I gave an encore, while the storeman continued to stare hypnotized at my dancing fingers. Then reluctantly his glazed eyes met mine.

"Not bloody doings!" he said crisply, and slammed the hatch shut.

Back in the office the hoodlums were holding a rave-up. I sat down there and then and designed a trap. In concept it was a simple device; just a hollow wooden cube with 9in. sides, with a hinged lid. A mousehole was cut in one of the sides, near the box floor; on the floor itself were two flat watch-spring spirals of bare wire, one inside the other and separated by about $\frac{3}{8}$ in. These spirals ended 1in. from the middle of the box floor.

The theory was simple, too. The idea was that you put a lump of cheese in the open space in the middle and then connected one spiral to one side of the mains supply and the other to the other side. A mouse comes jiving past the hole, smells cheese, applies anchors and enters. Feet complete circuit — pfft! — exit mouse to them thar great cheese-pastures in the sky. As a design proposal it looked good; cost: negligible; cheese consumption: nil; power consumption: nil, except when in action.

Besotted with the killer instinct, I knocked up six Mk I traps, and not until then did I realize that I might well be victim number one unless I fitted a safety cutout switch to each lid. At the same time it occurred to me that the aroma of six frying mice might be a shade overpowering, so I added a 20-second delay trip to the mains input. The modifications bumped up the price of the Mk II but, after all, that's a design norm.

At this point my exultation vanished as I saw myself for the Judas I was. For, not only was I going to annihilate the riff-raff but I was assuredly going to send my chum Enoch to the hot seat as well. So — back to the drawing board.

Clearly, an Enoch-discriminating circuit had to be introduced, otherwise it was no way, man. In the event, it wasn't difficult; Enoch had a white front and the *hoi polloi* didn't, so all I had to do was to equip each box with a light-beam, a photocell, a small amplifier, a relay and a shutter. A brown mouse wouldn't reflect enough light to affect the photocell, but Enoch would, and this would operate the shutter to seal off the entrance. (I figured that he'd have enough gumption not to back into the hole.) The idea was simple, but expensive. Just normal R and D procedure, I told myself, and anyway it wasn't as bad as Concorde.

So I indented upon the station stores for photocells and — yes, you've guessed it — it was "not bloody doings". Not one in the place. I should have called off the Mk III there and then, but having gone so far it seemed a pity to stop. Anyway, I cabled the firm asking for nine photocells (three spares), adding VERY URGENT. Then I sat back and waited. And waited. And waited, whiling away the time by sending further impassioned cables at intervals. Somewhere, far away in England, the mighty HIC stores machine was at work. I could imagine my requisition curling up to sleep for a fortnight in Bloggs's In-tray because Bloggs had got the 'flu. I could see it going into self-oscillation between the desks of Figgs, Twiggs and Jiggs because of minor irregularities in the ordering procedure and then coming to an untimely grave in the entrails of a computer.

The weeks dragged by and soon I had to sidle into my office armed with a whip and a chair. Then, unaccountably, Enoch disappeared; perhaps he departed this life from an overdose of cheese; perhaps he got mugged by the skinhead element among his low associates. I was never to know, for the very next morning I got a cable from the firm saying, in effect, come home, my son, all is forgiven. (Later, I found that they'd dreamed up an even scaler posting for me on a snake-and-mosquito-infested island in the tropics.) However, I shook the snow of Fridgeland off my boots; when last seen, the mouse hoodlums had converted the office filing cabinets into high-rise flats and were constructing love-nests from chewed-up blueprints.

I never cancelled the photocell order — have you ever tried to get the stores machinery into reverse? This all happened a few years ago, so they've probably arrived by now. Anyway, if you ever have the misfortune to go to that station and happen to have need of a photocell, you can approach the storeman with every confidence. He'll have nine that he doesn't know what to do with.

A Happy Christmas to you when it comes!

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- Digital multimeter, D. E. O'N. Waddington, 108 Mar., 177 Apr., 226 May.
- panel meter, P. Bartlam, 163 Apr.
- Dual-polarity digital voltmeter, A. J. Ewins, 470 Oct., 535 Nov.
- High-standard low-frequency source, J. M. Osborne, 20 Jan., *Correction*, 57 Feb.
- L.F. source, applications of the high-standard, J. M. Osborne, 316 July
- Logic power supplies, design criteria for, R. B. D. Knight, 41 Jan.
- Meter, digital panel, P. Bartlam, 163 Apr.
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- Meterless transistor tester, J. Lewis, 231 May
- Multimeter, digital, D.E. O'N. Waddington, 108 Mar., 177 Apr., 226 May
- simple transistor d.c., J. D. Pahomoff, 39 Jan.
- Oscilloscopes, portable, 95 Feb., 157 Mar.
- Panel meter, digital, P. Bartlam, 163 Apr.
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- Simple transistor d.c. multimeter, J.D. Pahomoff, 39 Jan.
- Source, applications of the high-standard I.F., J. M. Osborne, 316 July
- Transistor tester, meterless, J. Lewis, 231 May
- 200MHz counter prescaler, D. J. Taylor, 27 Jan.
- Versatile triangle wave generator, D. T. Smith, 87 Feb., *Correction*, 230 May
- Voltmeter, dual-polarity digital, A. J. Ewins, 470 Oct., 535 Nov.

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- A.P.A.E. annual exhibition, 8 Jan.
- Aid in spinal therapy, 224 May
- Aircraft tactical simulator, 224 May
- Alphanumerics on a TV picture, 477 Oct.
- Anti-collision braking system, 58 Feb.
- skid control by micro-circuits, 427 Sept.
- Arabian telecommunications, 113 Mar.
- Award for TV standards converter, 324 July
- B.B.C. exhibition, 8 Jan.
- local radio transmitting stations, 8 Jan.
- BSI asks for industry's view, 266 June
- Background music experiments, 392 Aug.
- Berlin highlights, 477 Oct.
- Bipolar i.c. "Process III" in production, 112 Mar.
- Brain drain, 60 Feb.
- Cable highway into the home, 174 Apr.
- Ceefax tests, 393 Aug.
- Ceramics for control and switching, 393 Aug.
- Collision prevention for cars, 266 June
- Component service from U.S.A., 324 July
- tester for relay systems, 528 Nov.
- Components Board reorganized, 6 Jan.
- Computers for fire fighting, 59 Feb.
- Conference of the Electronics Industry 1973, 59 Feb.
- Congress on Acoustics — 1974, 477 Oct.
- Defect inspection device, 223 May
- Distance measuring equipment errors, 113 Mar.
- "Donald Duck" eliminators for U.S. Navy, 528 Nov.
- Drawing by computer, 225 May
- Electronic telephone exchanges for U.K., 112 Mar.
- safety helmet, 583 Dec.
- traffic control, 175 Apr.
- warship, 60 Feb.
- Etching solution controls i.c. windows, 6 Jan.
- European weather forecast centre, 225 May
- Europe's first geostationary satellite, 8 Jan.
- Fast data link, 266 June
- Fifth Intelsat IV satellite, 477 Oct.
- First quarter TV and radio deliveries, 324 July.
- Future of TV, 393 Aug.
- Giant mobile transmitting and receiving mast, 8 Jan.
- Gramophone golden jubilee, 225 May
- High power Gunn diodes, 225 May
- density data packing for tape, 583 Dec.
- speed mobile message-switching, 175 Apr.
- Holographic computer memory, 174 Apr.

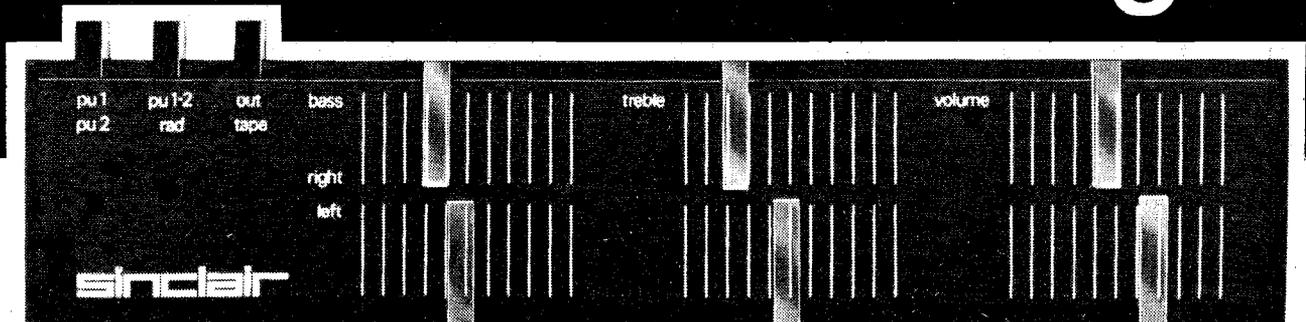
- IBC '74, 267 June
- IEA Exhibition 1974, 225 May
- Industrial security, 176 Apr.
- Inspecting aerial systems, 176 Apr.
- Intelsat V satellite, 394 Aug.
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- Largest solid-state image sensor, 528 Nov.
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- Microcircuit telephone coin mechanism, 112 Mar.
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- Police computer aid, 224 May
- Prospect for electronics industry bleaker, 583 Dec.
- Pure metal audio tapes, 394 Aug.
- Queen's Award to Industry, 267 June
- Radar plus laser for landing system, 394 Aug.
- Radio 4 in the South-west, 428 Sept.
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- Recording by ear, 583 Dec.
- Satellite navigator for world shipping, 583 Dec.
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- Stereophony pilot tone, 224 May
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- Toshiba subsidiary in U.K., 478 Oct.
- Touch terminal communication, 323 July
- Transmitters for independent radio stations, 8 Jan.
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- "Cathode Ray", 23 Jan., 71 Feb., 570 Nov., *Letters*, 332 July
- Clayton, G. B., 31 Jan., 91 Feb., 141 Mar., 241 May, 275 June, 355 July, 372 Aug., 447 Sept., 582 Dec.
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- Smith, K. L., 160 Apr.
- Spencer, D. B. & Freeman, K. G., 607 Dec.
- Stuart, J. R., 387 Aug., 439 Sept., 491 Oct., *Letters*, 330 July, 384 Aug.
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- White, G. & Dean, K. J., 2 Jan., 65 Feb., 137 Mar., 169 Apr.
- Williams, P., Carruthers, J., Evans, J. H. & Kinsler, J., 18 Jan., 85 Feb., 234 May, 291 June, 345 July, 435 Sept., 495 Oct., 557 Nov.

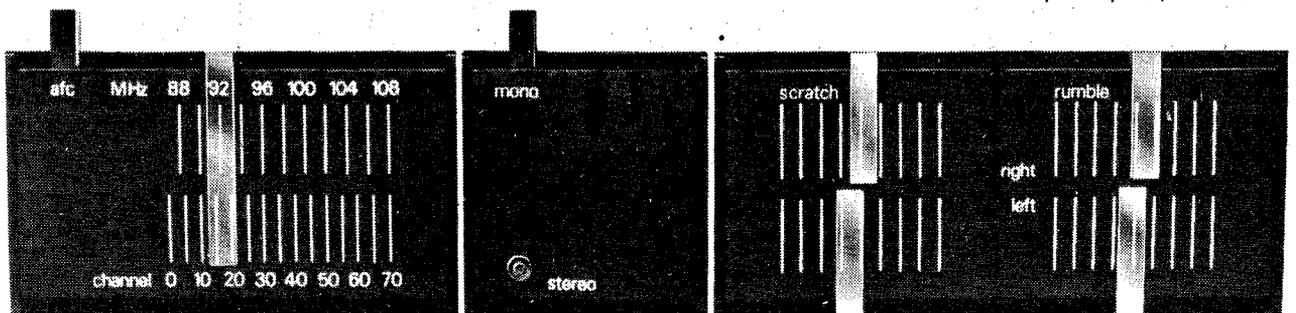
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Project 80

... exciting new thinking
in modular hi-fi design



Stereo 80 pre-amplifier/control unit

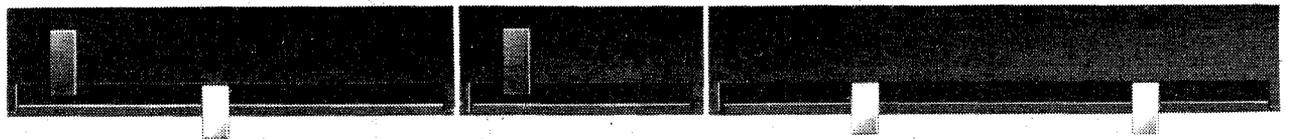


Project 80 tuner

Stereo decoder

Project 80 Active Filter Unit (AFU)

the slimmest, most elegant hi-fi modules ever made



Living with hi-fi takes on new meaning now that Project 80 is here. These amazing new modules mark a brilliant technical advance all round; their size and presentation bring exciting new opportunities to install systems in ways hitherto only dreamed about but never before made practical. You can build a Project 80 system virtually anywhere and it is unbelievably simple to install and connect up. Everything that could possibly be wanted in a top quality do-it-yourself domestic hi-fi system will be found in Project 80 — compactness, elegantly ultra-modern styling, ease of fixing and operation, new control methods, and above all superb performance. New as well as popular established ideas on installation are featured on page four of this announcement to provide just a few examples of the system's fantastic versatility..

sinclear

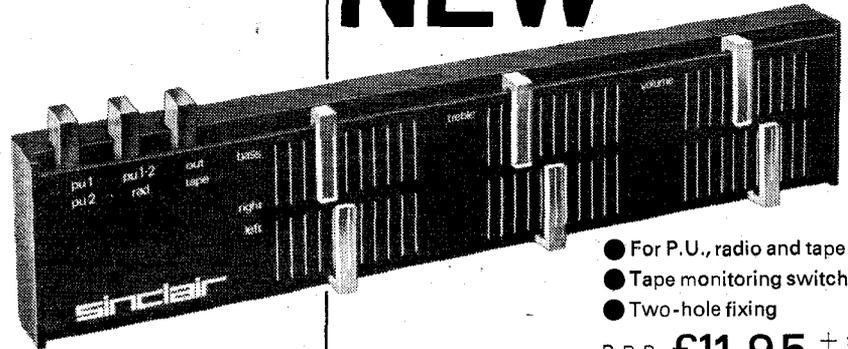
Project 80 new modules

Stereo 80 pre-amplifier and control unit

As with other Project 80 units, the Stereo 80 is mounted by means of two bolts fixed at the rear which pass through holes drilled in the wood or plastic on which modules are to be mounted. *All the electronics are contained within the $\frac{3}{4}$ " deep front panel!* Connecting leads are taken away similarly out of sight. Each channel in the Stereo 80 has its own independent tone and volume controls operated by sliders. This enables exceptionally good environmental matching to be obtained. Provision is made for magnetic and ceramic pick-ups, radio and tape in and out. A virtual earth input stage forms part of the up-dated circuitry of the Stereo 80 to ensure the finest possible quality from all signal sources. Generous overload margins are allowed on all inputs. Clear instructions with template are supplied.

TECHNICAL SPECIFICATIONS

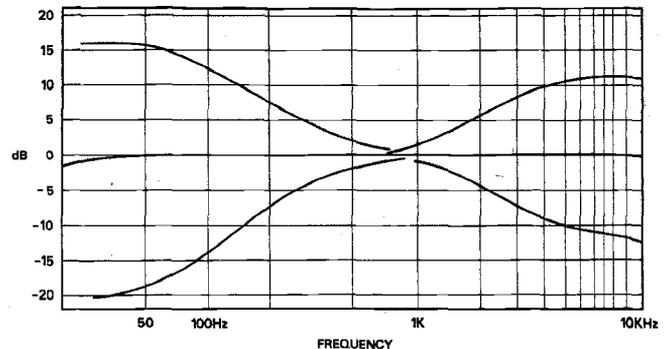
Size – 260 × 50 × 20mm ($10\frac{1}{2}$ × 2 × $\frac{3}{4}$ ins)
 Finish – Black, with white markings
 Inputs – Mag. P.U. 3mV RIAA corrected; Ceramic P.U. 300mV
 Radio 300mV; Tape 30mV
 S/N ratio – 60db
 Frequency range – 20Hz to 15KHz ± 1dB; 10Hz to 25KHz ± 3dB
 Power requirements – 20 to 35 volts
 Outputs – 100mV + AB monitoring for tape
 Controls – Press button for tape, radio and P.U. selection Volume, Bass + 12dB to – 14dB at 100Hz; Treble + 11dB to – 12dB at 10KHz



NEW

- For P.U., radio and tape
- Tape monitoring switch
- Two-hole fixing

R.R.P. £11.95 + £1.19 V.A.T.

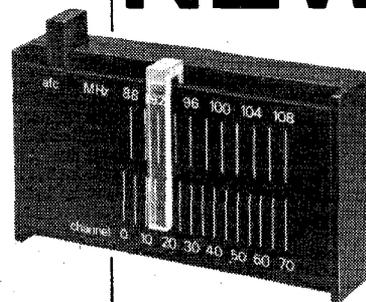


Project 80 FM tuner smaller, more efficient

A truly remarkable tuner in every way – its unbelievably compact size – its original circuitry – its dependable performance – all this in a boldly designed modern case measuring 85 × 50 × 20mm ($3\frac{1}{2}$ × 2 × $\frac{3}{4}$ ins). Greater adaptability (and possibly financial convenience) results from the tuner and stereo decoder section being made available separately.

TECHNICAL SPECIFICATIONS

Size – 85 × 50 × 20mm (approx. $3\frac{1}{2}$ × 2 × $\frac{3}{4}$ ins)
 Tuning range – 87 to 108 MHz
 Detector – I.C. balanced coincidence, for good A.M. rejection
 AFC – Switchable, with thermistor control to prevent from drift
 One 26 transistor I.C.
 Twin dual varicap tuning
 Distortion – 0.3% at 1KHz for 75KHz deviation
 Ceramic filter in I.F. section
 Aerial impedance – 75 Ω or 240-300 Ω
 Sensitivity – 4 microvolts for 30dB quieting
 Power requirements – 12 to 45 volts



NEW

- AFC switch
- Twin dual varicap tuning
- 4-hole ceramic filter
- Slider tuning

R.R.P. £11.95 + £1.19 V.A.T.

Project 80 stereo decoder

Making the Project 80 decoder separate from the F.M. tuner gives the constructor a wider choice of systems as well as saving money in cases where stereo reception may not be required. This unit gives a 40dB channel separation with an output of 150mV per channel. The gallium arsenide light emitting beacon automatically lights up to show when a stereo transmission is tuned in. Designed essentially as an integral part of Project 80 systems, this multiplex stereo demodulator may be used in many cases with existing single channel frequency modulated tuners to provide stereo reception.

Size – 47 × 50 × 20mm ($1\frac{7}{8}$ × 2 × $\frac{3}{4}$ ins)
 One 19 transistor I.C.



NEW

- Solid-state stereo indicating beacon
- Readily adaptable for use with other tuners

R.R.P. £7.45 + 0.74p V.A.T.

new constructional techniques

...and again Sinclair leads the world

- 1962 Micro-miniature power amp small enough to stand on a 10p. piece. Slimline pocket receiver smaller than a 20 cigarette pack
- 1963 Micro-6 receiver, smaller than a matchbox
- 1964 Pocket F.M. receiver; PWM amp.
- 1965 Z.12 power amplifier module; PZ.3 power supply
- 1966 Stereo 25 pre-amp/control unit
- 1967 Micromatic: Q.14 loudspeaker; the first Neoteric
- 1968 IC.10, the first ever integrated circuit for constructors' use

- 1969 Q.16 - improved version of Q.14: Systems 2000 and 3000: Project 60 launched
- 1970 IC.12: Project 60S
- 1971 Project 60 stereo FM tuner: Z.50: PZ.8
- 1972 Improvements to Project 60 with Z.50 MK.2 and PZ.8 Mk.3 The Executive Calculator: Digital multi-meter: Q.30 speaker:
- 1973 Cambridge Calculator:
PROJECT 80 LAUNCHED

... and next ?

Project 80 active filter unit

This efficiently designed unit makes a highly desirable part of any worthwhile system where inputs may be from record, radio or tape. As with Stereo 80, separate controls are applied to each channel thereby making it easier to obtain ideal stereo balance in any kind of indoor environment.

TECHNICAL SPECIFICATIONS

Size - 108 x 50 x 20mm (4 1/4 x 2 x 3/8 ins)
Voltage gain - minus 0.2dB
Frequency response - 36Hz to 22KHz, controls minimum
Distortion - at 1KHz - 0.03% using 30V supply
HF cut off (scratch) - 22KHz to 5.5KHz, 12dB/oct. slope
L.F. cut off (rumble) - 28dB at 20Hz, 9dB/oct. slope

Z.40 & Z.60 power amplifiers totally short-circuit proof

Either of these entirely new power amplifiers is intended for use in Project 80 installations although, of course, they are readily adaptable to an even wider range of applications. Both Z.40 and Z.60 incorporate built-in protection against shortcircuiting and risk of damage arising from mis-use is greatly reduced. Comprehensive instructions are supplied with each of the modules.

Z.40 Technical Specifications

Size - 55 x 80 x 20mm (2 1/8 x 3 1/8 x 3/8 ins) 9 transistors
Input sensitivity - 100mV
Output - 15 watts RMS continuous into 8 Ω (35V). 30 watts music power into 4 Ω (30V)
Frequency response - 10Hz - 100KHz ± 1dB
Signal to noise ratio - 64dB
Distortion - at 10 watts into 8 Ω less than 0.1%
Power requirements - 12-35 volts

Z.60 Technical Specifications

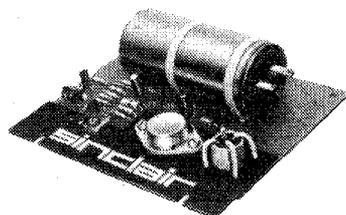
Size - 55 x 98 x 20mm (2 1/8 x 3 7/8 x 3/8 ins) 12 transistors
Input sensitivity - 100-250mV
Output - 25 watts RMS into 8 Ω (45V). 50 watts music power into 4 Ω (50V)
Distortion - typically 0.03%
Frequency response - 10Hz to more than 200KHz ± 1dB
Signal to noise ratio - better than 70dB
Built-in protection against transient overload and short circuit
Load impedance - 4Ω min; max. safe on open circuit

Sinclair power supply units PZ.8

the worlds most advanced unit in its class

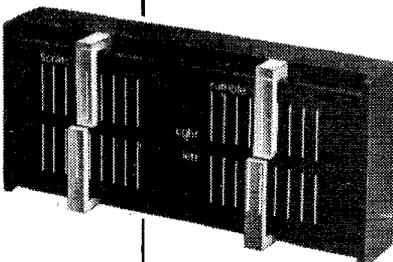
Stabilised power supply unit. Re-entrant current limiting makes damage from overload or even direct shorting impossible, a principle never before incorporated in a commercially available constructor module. Normal working voltage (adjustable) 45V.

R.R.P. £7.98 + 0.79p V.A.T.
 Without mains transformer
 PZ.5 30V un stabilised
 R.R.P. £4.98 + 0.49p V.A.T.
 PZ.6 35V. stabilised
 R.R.P. £7.98 + 0.79p V.A.T.



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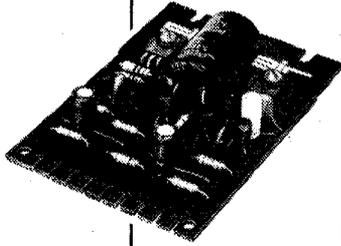
LONDON RD., ST. IVES, HUNTINGDONSHIRE PE17 4HJ
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NEW

- For scratch and rumble control
- Transistorised active circuitry

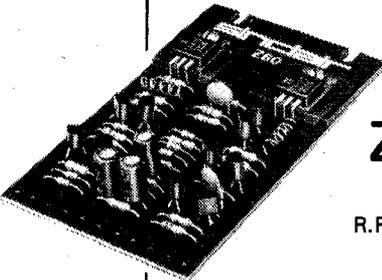
R.R.P. **£6.95** + 0.69p V.A.T.



NEW

Z.40

R.R.P. **£5.45** + 0.54p V.A.T.



Z.60

R.R.P. **£6.95** + 0.69p V.A.T.

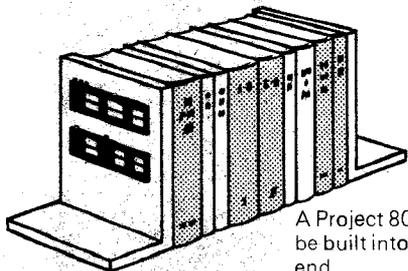
Recommended Project 80 applications

System	The Units to use	Units cost
Simple battery record player	Z.40	£5.45 +54p V.A.T.
Mains powered record player	Z.40, PZ.5	£10.43 +£1.04 V.A.T.
30W. RMS continuous sine wave stereo amp.	2 x Z.40s, Stereo 80; PZ.6	£30.83 +£3.08 V.A.T.
50W (8 Ω) RMS continuous sine wave de luxe stereo amp.	2 x Z.60s, Stereo 80; PZ.8	£33.83 +£3.38 V.A.T.
Indoor P.A.	Z.60, PZ.8	£14.93 +£1.49 V.A.T.
Car Radio	F.M. tuner, Z.40	£16.40 +£1.64 V.A.T.

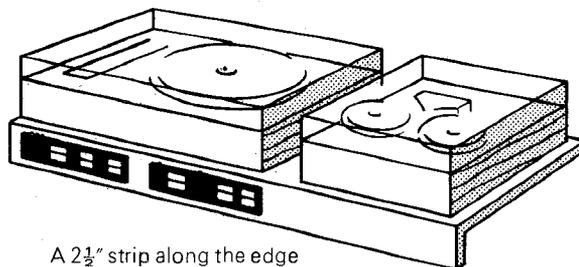
F.M. Tuner, Decoder and A.F.U. may be added as required.

From Sinclair the worlds most advanced hi-fi modules

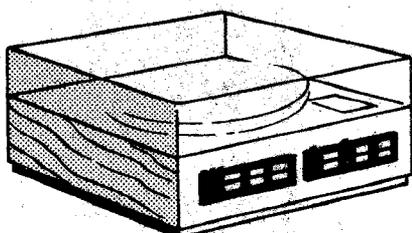
Sinclair Project 80 the ultra-modern non-obtrusive hi-fi



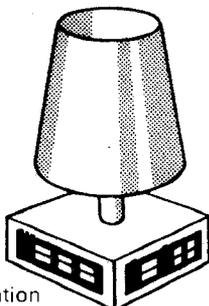
A Project 80 system could be built into a book-shelf end



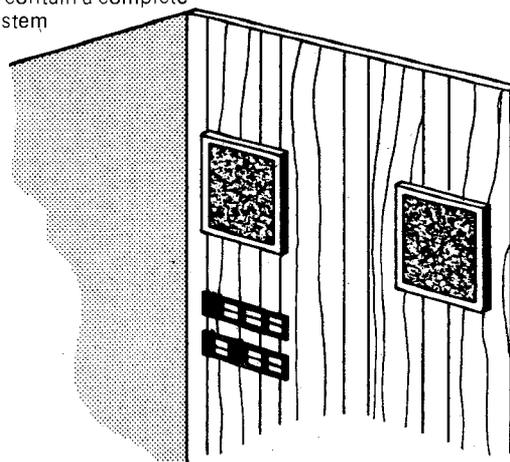
A 2½" strip along the edge of a shelf could be sufficient to contain a complete system



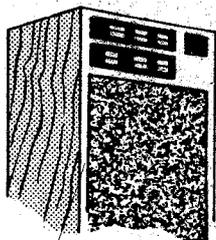
The modules mount very easily onto a playing plinth



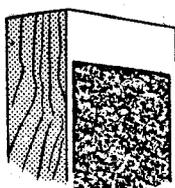
A novel application would be to build around the base of a lampshade



Two Sinclair Q.16 loudspeakers suitably positioned together with Project 80 could be mounted on to a false wall.



Project 80 could be easily mounted onto a loudspeaker cabinet



When you have seen for yourself how fantastically slim and cleverly designed these modules are, further ways will suggest themselves in which they can become a pleasing part of your particular domestic environment.

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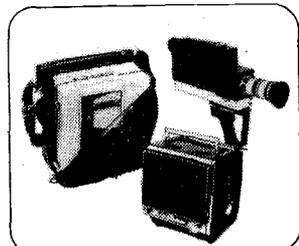
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EMI Electronics Ltd., Feltham Laboratories, Victoria Road, Feltham, Middx.
Telephone: 01-890 3600 Ext. 307

WW—100 FOR FURTHER DETAILS

Recording Heads at Half Price

Rapid expansion and a continuous development programme in the field of recording techniques have made a small selection of our good stock redundant.

We are now offering these recording heads at half the normal price.

- 1/2 track mono R.P.
- 8 track stereo R.P.
- single track cine heads R.P. and erase
- 1/2 track mono cassette erase heads
- 8 track 2 channel stereo heads
- 1/2 track mono erase
- twin stereo erase

MARRIOTT MAGNETICS LTD

TO: MARRIOTT MAGNETICS LTD
PENRYN, CORNWALL TELEPHONE 032-67 2267

Please send me a price list for the special offer of recording heads.

Name _____

Company _____

Address _____

WW—101 FOR FURTHER DETAILS

Test Case



The Sullivan Capacitance Bridge C3071 is just that – a direct reading instrument with a wide span of measurement covered by 4 ranges – making it ideal for component checking by manufacturers, electronic service engineers, development laboratories etc. Even universities and colleges have found the C3071 invaluable.

It's really quick to balance, too. Just select a range (between the 0.5pF and 50pF) and turn one dial from end to end. If no balance is achieved, merely select another range and repeat the process. For full details of the C3071, please contact the address below. We've got a convincing case to make.

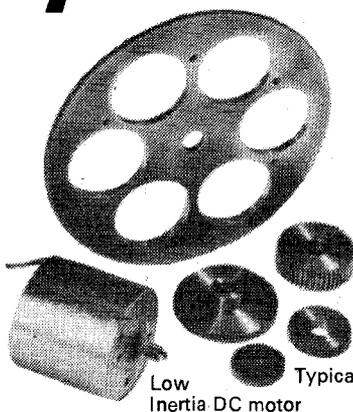
Sullivan

H. W. Sullivan Limited, Dover, Kent.
Tel: Dover (STD 0304) 202620
Telex: 96283

Thorn Measurement Control
and Automation Division.

WW—102 FOR FURTHER DETAILS

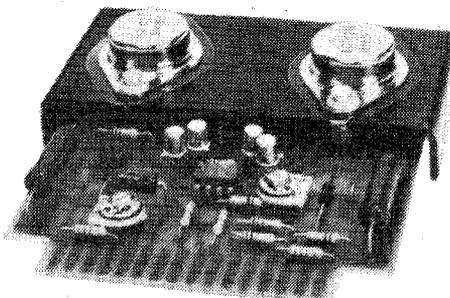
Purpose-built servo and actuator systems using standard components



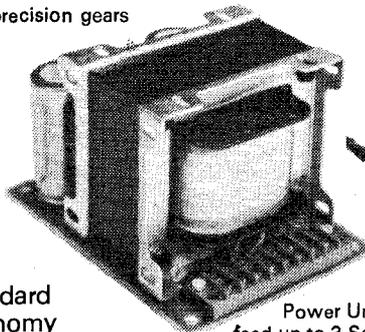
Low Inertia DC motor

Typical precision gears

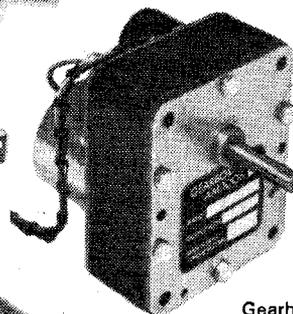
McLennan have considerable experience in the solution of actuator and servo problems using synchronous, stepping and D.C. motor techniques as well as solenoid-powered types. An important facet of our skill lies in purpose-designing around standard components for speed and economy of building.



Control Amplifier



Power Unit to feed up to 3 Servos



Gearhead with integral feed-back Potentiometer

The illustration shows a selection of modules from the McLennan standard range which are available as individual items or can be supplied engineered to custom-built systems.

Such a system could be complete in itself or form part of your own design.

Typical examples include:

Camera positioning; Plotting Devices; Self-steering Systems; Signal-seeking Aerial Drives; Professional Tape Drives; Automated Production Lines.

Stimulation of output position or velocity may be by optical, radio, electrical, mechanical, pneumatic or hydraulic signals.

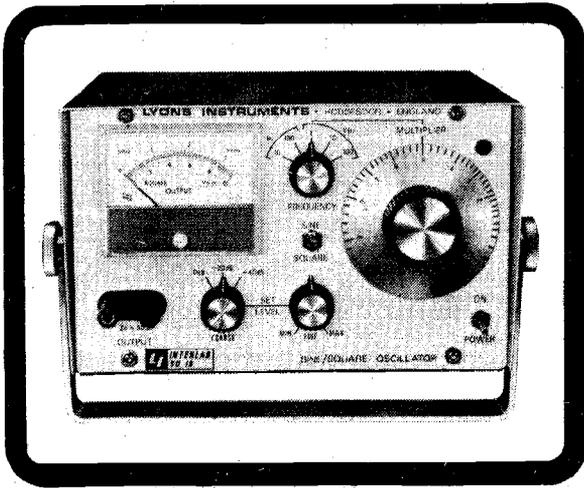


McLennan Engineering Ltd

Control Systems and Components

Kings Road, Crowthorne, Berkshire. Tel: Crowthorne 5757/8.

WW—103 FOR FURTHER DETAILS



INTERLAB® Type SQ10 Sine/Square Oscillator **£62** (UK excl. VAT)

A versatile signal source providing either a low distortion sinusoidal output or a square wave with a fast rise time. Frequency range 10Hz to 100kHz. Output 10V p-p into 250Ω, 2.5V p-p into 50Ω. Distortion better than 0.1%. Rise time less than 100ns. Also available ex-stock from Authorised Distributors: Electroplan Ltd., Royston; I.T.T. Electronic Services, Harlow. INTERLAB range includes also Pulse Generator, Distortion and Frequency Meters.



INTERLAB is a registered trade mark of
LYONS INSTRUMENTS
 Lyons Instruments Limited
 Hoddeston, Herts. EN11 9DX Tel: 67161
 A Claude Lyons Company

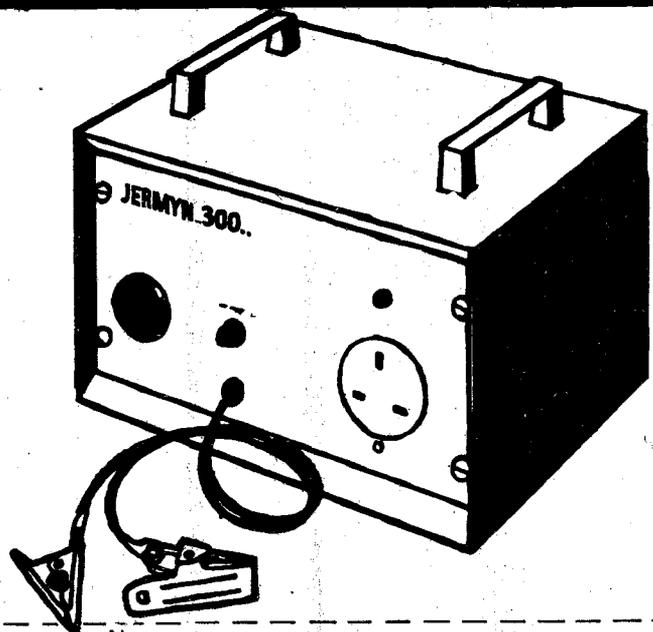
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Candles are for Eskimos.

The 1973 answer to power cuts.
 The Jermyn inverter.

When plugged into any 13 amp socket these units charge 12/24v car batteries (up to 10 amps). In the event of a power failure they automatically start inverting, providing a 240v 50Hz emergency supply at 150/300 watts. Enough for a couple of standard lamps and the TV or the central heating pump and the hi-fi. All this and full protection against overload and wrong battery lead connection.

A complete kit of parts costs £29 for the 150 watt unit or £39 for the 300 watt version (made up and tested) £39 and £49 respectively. All prices + 10% VAT



MII
 new improved circuitry

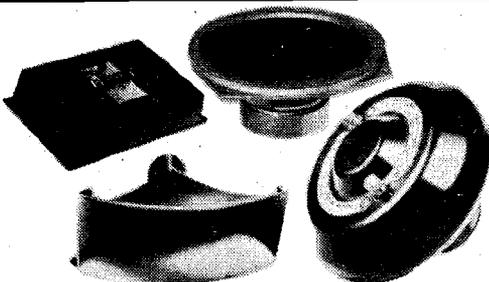
To Jermyn Industries
 119 Vestry Estate
 Sevenoaks
 Kent

Please rush me Kit(s),
 made up invertors.
 I enclose cheque/postal order for £

Name
 Address

Block Capitals Please

WW-105 FOR FURTHER DETAILS



The New Loudspeaker Range...

The sound of music, from the lowest frequency to the highest is now brought to the connoisseur of quality in sound reproduction with the new, Vitavox Power Loudspeaker Range.

The Range blends four superb units into one matchless composite, or each element as a separate unit available for use with other systems. The range gives exceptional quality of sound reproduction and handles up to 100 watts of musical power. The four units are: a High Power, High Frequency Pressure Unit and a High Power Bass Loudspeaker, each designed to give increased power handling capacity without sacrificing either efficiency or frequency response; a High Frequency Dispersive Horn, designed for use with the Pressure Unit - matching accurately the Unit's output characteristics and giving superb sound dispersion; a High Power Dividing Network for use in both high and low power systems and which ensures correct allocation of the frequency spectrum between high and low frequency units.

Carrying the Vitavox stamp of quality, this is the Range which brings you...

Please send me further information on
 your product range

V3

Name _____
 Company _____
 Address _____

The Great Sound of Vitavox



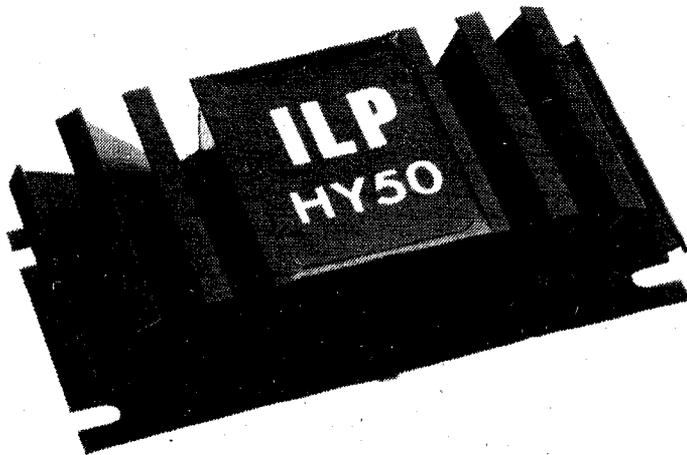
Westmoreland Road, London NW9 9RJ Telephone: 01-204 4234

WW-106 FOR FURTHER DETAILS



I.L.P. (Electronics) Ltd

SECOND GENERATION 25 WATT HYBRID



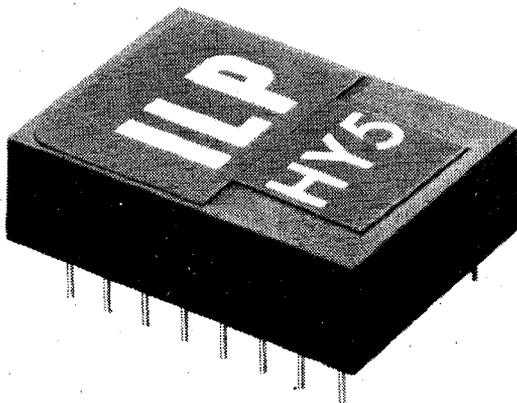
A brand new hybrid fabrication technique, recently perfected in our laboratories, has enabled us to achieve our latest range of completely integrated devices. We have now finally reduced the modular amplifier to a simple input/output device requiring only the addition of a basic unstabilized (split line) 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:	4-16 Ω into 8 Ω .
INPUT SENSITIVITY:	0db (0.775volts RMS).
INPUT IMPEDANCE:	47K Ω .
TOTAL HARMONIC DISTORTION:	Less than 0.1% at 25watts typically 0.05
SIGNAL/NOISE RATIO:	better than 75db.
FREQUENCY RESPONSE:	10Hz-50 KHz \pm 1db
SUPPLY VOLTAGE:	\pm 2.5volts.
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 (0db), 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.

INPUTS

Magnetic Pick-up 3mV (within 1db RIAA curve)
Ceramic Pick-up up to 3mV,
Microphone 10mV.
Tuner 250mV.
Auxiliary 3-100mV.
Input impedance 47k Ω 1kHz

SPEC.

OUTPUTS

Tape 100mV.
Main output. 0db (0.775volts).

ACTIVE TONE CONTROLS

Treble \pm 12db at 10kHz
Bass \pm 12db at 100Hz

OVERLOAD CAPABILITY (equalization stage) 40db on most sensitive input.

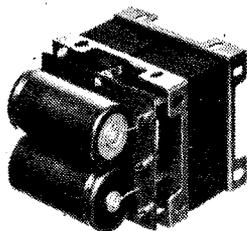
OUTPUT NOISE LEVEL (below 10mV magnetic input) 68db.

DISTORTION 0.05% at 1kHz.

SUPPLY VOLTAGE \pm 1.6-2.5volts.

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 2 $\frac{1}{4}$ inches high and can be used for either mono or stereo systems.

SPEC.

OUTPUT VOLTAGE \pm 2.5volts.

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

SOMMERKAMP

Our products are:

11m AM Walkie-Talkies, 0-2-1-2 and 5 Watt, up to 24 channels, 11m AM Cartransceivers, 6 and 24 channels, 2-5 and 10 Watt, 2m FM 10 Watt, 12-22 channels Amateur, Industrial and Marine Transceivers, 11m SSB 24ch, 300W, 220V/12V-Transceivers, 8-track Stereo-Recorder with built-in AM and FM Stereo-Radio.

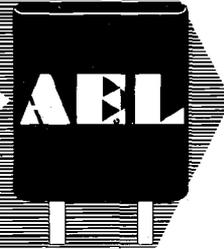
Wanted:

Qualified dealers and wholesalers of the technical line for the sale of the above highly sought-after products. Delivery is effected immediately from stock in Switzerland or ex factory Japan.

SOKA SRL,
CH 6903 Lugano, Box 176
Tel: 0041 91 688543, Telex: 79314

WW-108 FOR FURTHER DETAILS

**QUARTZ
 CRYSTALS
 -FAST!**

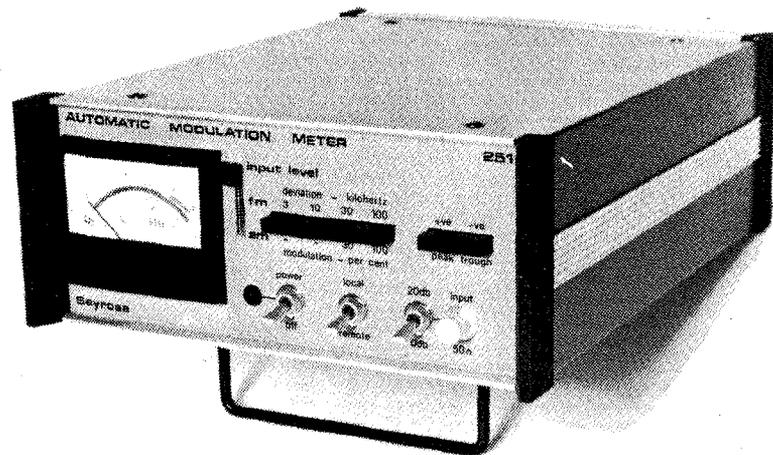


AEL GATWICK HOUSE, HORLEY, SURREY, ENGLAND
 Tel: Horley (02934) 5353
 Telex: 87116 (Aerocon Horley) · Cables: Aerocon Telex Horley

WW-109 FOR FURTHER DETAILS

MODULATION MEASUREMENT BROUGHT UP TO DATE!

The Sayrosa 251 Automatic Modulation Meter dispenses with all those tuning dials and level sets found on conventional modulation meters. To make a measurement of amplitude or frequency modulation all you need do is connect your signal, select mode and range, and you have an instant reading. The 251 does all the tuning and level setting for you in around 100 milliseconds. Designed and manufactured in U.K. the 251 is available now so call us and arrange a demonstration in your own laboratory.



- * Automatic tuning and level setting
- * AM measurement to 95% in two ranges
- * Mode and range selection programmable
- * 20MHz to 1000MHz continuous coverage
- * FM measurement to 100KHz in four ranges
- * Small size, low weight

£295*

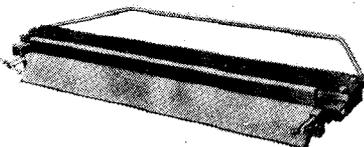
U.K. price exclusive of VAT

Sayrosa Engineers Ltd.
 Wey River House, High Street, Alton, Hants.

Telephone: Alton 84500

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PARKER SHEET METAL FOLDING MACHINES



Forms channels and angles down to 45 degrees which can be flattened to give safe edge. Depth of fold according to height of bench.

One year's guarantee. Money back if not satisfied.

Send for details:

A. B. PARKER

FOLDING MACHINE WORKS,
 UPPER GEORGE STREET,
 HECKMONDWIKE, YORKS.

Telephone 40 3997

BENCH MODEL

36" x 18 gauge capacity £35.00 carr. 75p
 24" x 16 gauge capacity £32.00 carr. 75p

Also the well-known vice model of

36" x 18 gauge capacity £17.00 carr. 50p
 24" x 18 gauge capacity £12.00 carr. 38p
 18" x 16 gauge capacity £12.00 carr. 38p

Add 10% VAT to total price of machine and carriage

WW-111 FOR FURTHER DETAILS

Thermistors

F. J. Hyde, DSc., Msc, BSc.

"Provides a very comprehensive account of the properties and applications of both negative and positive temperature coefficient types of thermistors. An extremely useful reference work on this essential circuit component — thoroughly recommended as essential reading for all control engineers."

Instrument and Control Engineering.

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 88 Kingsway London WC2B 6AB
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BG

EDUCATIONAL KITS
—all with pictorial instructions



THIS BALANCE KIT
FREE. Educational kits. Japanese made these are excellent value for money. We do not expect to be able to repeat this offer once stocks are sold. Brief description of each kit is given below and with 3 kits or more we give FREE an accurate 11 piece balance kit. Price of kits 44p each post paid. Special price for all 7 kits £23.00 with free balance kit.
KA2 Lens Kit. Eleven parts, including candle one concave lens, one convex lens, stage and slit frame, etc. Watch light rays bend as they pass through different lenses.
KA3 Water Pump Kit. The pump parts. 3 of pump is transparent so that operating parts may be observed. Small parts are brightly coloured to be seen easily while working. Three types of pump may be made: Lift pump Force Pump and Forze Pump with reservoir and nozzle.
KA4 Buzzer Kit. Eleven parts. Transparent covers allow the operation of buzzer to be seen. Instructions and leaflets show electromagnetism with an automatic switch results in an operating buzzer.
KA7 Electro-Magnet Kit. Fifteen parts, includes compass. Makes two electro-magnets, one with one layer of wire and one with several layers of wire. Picks up tacks, nails and any small parts showing how magnetism works.
KA8 Current and Resistance Kit. Twenty-nine parts, including bench and light bulb. Conduct interesting and educational projects to learn the application of "OHMS LAW" and see the difference in current and resistance with different types and lengths of wire.
KA9 Bell Kit. Eight parts, including bell and push button switch. Build a complete electric bell and see how the hammer is triggered to make the bell ring.
KA10 Morse Key buzzer and bell kit. 25 part kit, easy to construct, simple to operate.

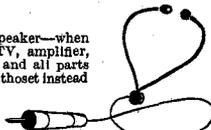
FREEZE educational kits. Japanese made these are excellent value for money. We do not expect to be able to repeat this offer once stocks are sold. Brief description of each kit is given below and with 3 kits or more we give FREE an accurate 11 piece balance kit. Price of kits 44p each post paid. Special price for all 7 kits £23.00 with free balance kit.
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KA9 Bell Kit. Eight parts, including bell and push button switch. Build a complete electric bell and see how the hammer is triggered to make the bell ring.
KA10 Morse Key buzzer and bell kit. 25 part kit, easy to construct, simple to operate.

GAS DETECTOR AND ALARM

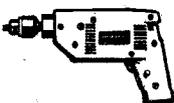
Fire, Gas and Smoke are all killers. Home Office figures recently published show that on average every 12 mins. a fire occurs in somebody's home and these fires often break out at night when the family is asleep. Don't live in a fool's paradise IT COULD HAPPEN TO YOU. Have the latest electronic protection. Install SAGA (our smoke and gas alarm). This uses the fantastic electronic sensor G.D.1 which "smells" smoke and gas and sounds the alarm immediately. In a neat case measuring approx. 5" x 3 1/2" x 2 1/2" SAGA has its own internal alarm, also a supply to external bells. You just plug it in to the mains. Special introductory price—complete Kit of parts including the case £5.99 or made up tested and working £6.99 plus 30p post and packing.

RADIO STETHOSCOPE

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. £2.20—twin stethoscopy instead of earpiece 83p extra—post and ins. 20p.



PORTABLE ELECTRIC DRILL



Very superior quality made by a famous Dutch toolmaker. Model No. ASM 890 300W—2 speed 2200/3000. With 1/2" chuck and chuck key, also separate side handle and hammer facility for dealing with concrete, etc. An equivalent British made drill would cost £15.00. £10.00—similar model but without the hammer attachment £7.95. Have either model on approval for 7 days.

BATTERY CONDITION TESTER

Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nickel—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace", "weak" or "good". The tester is complete in its case, size 3 1/2" x 6 1/2" x 2" with leads and prods. Price £2.50 plus 20p postage.



INTEGRATED CIRCUIT BARGAIN

A parcel of integrated circuits made by the famous Plessey Company. A once-in-a-lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first-grade device, definitely not sub standard of seconds. 4 of the ICs are single silicon chip GP amplifiers. The 5th is a monolithic NPN matched pair. Regular price of parcel well over £5. Full circuit details of the ICs are included and in addition you will receive a list of many different ICs available at bargain prices 25p upwards with circuits and technical data of each. Complete parcel only £1 post paid. **DON'T MISS THIS TERRIFIC BARGAIN!**

HEATERS AND ELEMENTS

Tangential Heater Unit, 2KW	Price £2.75 plus 40p post, etc.
Tangential Heater Unit, 3KW	Price £3.88 plus 40p post, etc.
Control Switch for above 44p each.	
300 watt Heat and Light Lamp.	Price 99p plus 25p post.
3KW Blower Heater	Price £19.19.
1000 watt Heat and Light Tube (Mullard) with special holder	Price £2.90 plus 30p post.
and Terry clips.	Price £2.90 plus 30p post.
2000 watt Mouldable Metal Clad Element.	8 ft. long—£1.10.
Radiant Cooker Rings.	2000 watt, 83p each. 1000 watt Fire Spirals. 22p each.
750 watt Flat Elements.	33p each. Black Heat Element Metal Clad 900 watt 14" x 1 1/2"—83p each.
Oven Element Metal Clad.	2000 watt. "W" shaped. 14 1/2" long x 3" wide. 83p each

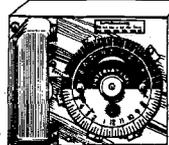
CENTRIFUGAL BLOWER

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. 4 1/2" x 4 1/2" x 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 electronic 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.



THYRISTOR LIGHT DIMMER



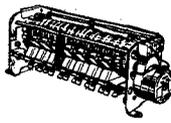
For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £2.95. Industrial model 5A (not on switchplate) £3.30.

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 3 1/2in. and depth 1 1/2in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price £2.25.

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, 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.



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 1 1/2in. 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 x 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. £2.43 plus 25p P. & P.



MULLARD AUDIO AMPLIFIERS

All in module form, ready built kits and connection tags, data supplied. Uniltex stereo 4w per channel £11.30. Model 1183 500mW power output 72p. Model 1172 750mW power output 94p. Model 2P9000 4 watt power output £1.60.



GOOD COMPANION I.C. VERSION



We can now offer these again in I.C. version using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide x 6in. high x 3 1/2in. deep. Complete assembly instructions, £5.95 plus 25p post and ins. Excellent tone wood cabinet.

MIGHTY MIDGET

Probably the finest smallest radio, as described in Practical Wireless, January 73. All electronic parts £2.20 post paid.



12 VOLT 1 AMP POWER PACK

This comprises double-wound 230/240v. mains transformer with full wave rectifier and 2000 m/Ω smoothing. Price £2.20, plus 20p post & packing.

Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 8,000mF. Price £6.33 plus 65p post.

SWITCH TRIGGER MATS



So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24" x 15" £1.60
19" x 10" £1.21

TRANSFORMER FOR GAS DETECTOR

The electronic sensor G.D.1 used in our SAGA is available separately at £2. This needs a special transformer and we can supply this also. Specification: normal mains voltage primary with thermal overload trip to cut supply. Secondary 20v. 1 amp tapped at 1v. 1 1/2 amp. Price £1.50.

UNISELECTORS

All used in automatic switch boards, etc. 24v. operated. New—all 23 way full wiper type. We have the following in stock:

3 Bank	£4.40	5 Bank	£6.90
3 Bank + C	£4.40	8 Bank	£8.90
3 Bank + Split C	£4.40	10 Bank	£9.90
4 Bank	£5.50	12 Bank	£12.00

QUICK CUPPA

Mini Immersion Heater. 350W. 200/240V. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. No post and insurance. 20p. 12V car model also available. Same price. Jug model also available £1.50 plus P. & P. 20p.



MULTI-SPEED MOTOR

Six speeds are available 600, 850 and 1,100 r.p.m. and 8,000, 12,000 and 15,000 r.p.m. Shaft is 1/4in. diameter and approximately 1 in. long. 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2 in. dia. x 5 in. long. Price 97p plus 25p postage and insurance.



EXTRACTOR FAN

Cleans the air at the rate of 10,000 cubic ft. per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact 6 1/2" casing with 5 1/2" fan blades. Kit comprises motor, fan blades, sheet steel casing, pul, switch, mains connector, and fixing brackets. £2.75 plus 30p P. & P.

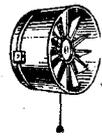


PHOTO ELECTRIC KIT

Contains photo cell, relay, transistor and all parts to make light operated switch. £1.75 plus 20p post and ins.

PC BOARD MARKER

Value action fibre tipped marking pen filled with black etch resist—It's easy with this to make a perfect PC board. Draw straight on to the copper—allow 15 mins. to dry, then immerse in ferric chloride or other etchant, on removal the circuit stands in high relief, 99p.

PHOTO TRANSISTOR BARGAIN

First class maker but slightly reject, covered, however, by our normal six month guarantee, these respond to light or infra red. Will work a burglar alarm system, make detector counter, etc. Price 22p complete with three circuits.

20 WATT CAMPING LIGHT

Also makes good car emergency light. This uses a standard 2 foot 20 watt tube and operates from a 12v. car battery drawing approx. 1A. This gives illumination per amp/hour of battery life far in excess to filament lamps and in fact to the miniature 6-3 watt camping lights often offered. Complete unit ready to operate in strong white enamelled metal frame. These would normally sell at £8, are unused but slightly soiled and we offer these at £4.50 plus 40p post and packing.

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.



REMPLOY IMMERSION HEATERS

We have the following types in stock:
Length 10" 3 KW Price £11.40 Length 11" 2 KW Price £11.65 Length 11" 3 KW Price £9.85 Length 21" 3 KW Price £2.20 Length 23" 3 KW Price £2.20 Length 27" 4 KW Price £2.70 Length 30" 3 KW Price £3.80 Length 36" 3 KW Price £3.80 Note: All these immersion heaters are the standard domestic type which screw into the flange now fitted to all standard hot water cylinders and tanks.

E.H.T. TRANSFORMER

Normal mains input primary tapped at 10v. intervals. 2 secondaries, 1 5000v. at 50 mA and the other 9v. at 1A. This is a big transformer and weighs approx. 50 lbs. Price £49.50.



SOLDER GUN

A must for every busy man, gives almost instant heat also illuminates job. 100 watt £2.47 plus post & ins. 20p.

SLIDE SWITCHES



Slide Switch. 2 pole change over panel mounting by two 6 BA screws. Size approx. 1" x 1/2" 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 (1" approx.) between fixing centres. 14p each, 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

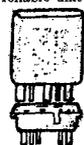
TELEPHONES



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. American only 1/2" wide x 1/2" thick and 1 1/2" 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 12-18 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price 25p including base.

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

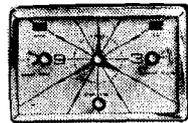
New 1kW model. Electronically changes speed from approximately 10 revs. to max. Full power at 41 speeds by finger-tip control. Kit includes all parts, case, everything and full instructions £1.95, plus 13p post and insurance. Made up model also available £2.95 plus 13p p. & p

BAKELITE INSTRUMENT CASE

Size approx. 6 1/2" x 3 1/2" x 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. Paxidils 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.

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.



Where postage is not stated then orders over £5 are post free. Below £5 add 30p. S.A.E. with enquiries please.

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(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD
Callers to 102/3, Tamworth Road, Croydon

VALVES

B12H	1-75	ECL82	0-81
CY31	0-40	ECL83	0-63
DAF96	0-40	ECL86	0-88
DF96	0-40	EF86	0-80
DK96	0-40	EF87A	0-85
DL92	0-32	EF80	0-80
DL94	0-45	EF41	0-65
DL96	0-40	EF80	0-25
DM70	0-40	EF83	0-60
DY86	0-28	EF85	0-81
DY87	0-28	EF86	0-27
DY902	0-30	EF89	0-25
E885C/01	1-08	EF91	0-27
E180CC	0-37	EF92	0-31
E180CC	0-90	EF95	0-31
E182CC	1-08	EF183	0-26
EA60	0-18	EF184	0-81
EA83C80	0-27	EF1200	0-81
EA842	0-46	EL34	0-46
EB91	0-20	EL41	0-55
EB93	0-45	EL84	0-21
EC041	0-60	EL85	0-44
EC081	0-27	EL86	0-86
EBF80	0-36	EL90	0-31
EBF83	0-40	EL95	0-86
EBF89	0-27	EL500	0-76
EC081	0-27	EL504	0-76
EC082	0-25	EM31	0-22
EC083	0-25	EM80	0-36
EC084	0-27	EM84	0-21
EC085	0-34	EM87	0-63
EC086	0-80	EY51	0-36
EC088	0-39	EY86	0-40
EC089	0-48	EY81	0-40
EC090	0-31	EZ41	0-45
EC092	0-31	EZ90	0-22
EC093	0-47	EZ81	0-24
EC091	0-58	GZ24	0-82
EC091	0-25	GZ37	0-63
EC093	0-40	KT86	2-30
EC094	0-40	KT88	2-25
EC095	0-40	QA2	3-10

OB2	0-35	R17	0-45
PBC80	0-85	R19	0-35
PC97	0-41	STV	
PC900	0-42	280/40	3-20
PC984	0-36	280/80	8-20
PC989	0-45	STV	
PC989	0-49	280/80	8-20
PC989	0-75	280/80	8-20
PC989	0-25	U25	0-70
PC989	0-27	U26	0-70
PC989	0-54	U27	0-45
PC989	0-60	U191	0-68
PC989	0-60	U90	0-70
PC989	0-45	UAF42	0-50
PC989	0-85	UBC41	0-48

UBF80	0-35	VR150/30	0-35
UBF89	0-84	2800U	1-40
UCC85	0-85	2801U	1-40
UCF60	0-60	2803U	1-10
UCH42	0-60	2800T	0-80
UCH81	0-35	1L4	0-13
UCL82	0-35	1R5	0-35
UCL83	0-55	1S4	0-30
UF80	0-30	1T5	0-30
UF89	0-35	1X2A	0-36
UL41	0-60	1X2B	0-50
UL84	0-35	3A4	0-40
UUS	0-65	3D6	0-15
UACB80	0-30	3Q4	0-55
UY85	0-35	3B4	0-65
VR105/30	0-35	3V4	0-48

5B254M	2-75	6A05	0-36
5B255M	3-10	6AQ5W	0-45
5R4GY	0-65	6A8E	0-55
5U4G	0-20	6AT6	0-30
5V4G	0-45	6AU6	0-20
5Y4G	0-25	6AX4GT	0-50
5Y3GT	0-35	6AX5GT	0-80
5Z3	0-70	6B7	0-35
5Z4	0-75	6BK7	0-80
5Z4GT	0-82	6B6A	0-25
6AB7	0-25	6BE6	0-25
6AC7	0-25	6BG6G	0-45
6A8E	0-50	6BJ6	0-45
6AK5	0-35	6B7A	0-42
6AL5	0-18	6BR7	1-09
6AL5W	0-35	6BW6	0-80
6AM6	0-35	6B9W7	0-80
6AN6	0-60	6B7G	0-30
6B7G	0-30	6C4	0-25
6C6	0-20	6CH6	0-55
6CL6	0-50	6CL6	0-50
6D6	0-15	6E6	0-15
6E6A	0-20	6EP3	0-80
6EP3	0-80	6F33	1-35
6G7	0-40	6H6M	0-25
6H6M	0-25	6I4WA	0-65
6J4WA	0-65	6K7G	0-17
6K7G	0-17	6K8GT	0-40
6L6M	1-35	6L6M	1-35
6M6	0-40	6M6	0-40
6N6	0-40	6N6	0-40
6P6	0-40	6P6	0-40
6Q6	0-40	6Q6	0-40
6R6	0-40	6R6	0-40
6S6	0-40	6S6	0-40
6T6	0-40	6T6	0-40
6U6	0-40	6U6	0-40
6V6	0-40	6V6	0-40
6W6	0-40	6W6	0-40
6X6	0-40	6X6	0-40
6Y6	0-40	6Y6	0-40
6Z6	0-40	6Z6	0-40



THE VALVE WITH A GUARANTEE

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09J TUBE	£2.50										
p & p 50p											
0A5	0-20	OC71	0-12	IN702-725	0-38	3N139	1-75	ASY67	0-48	CRS3/40	0-50
0A10	0-25	OC72	0-20	IN823A	1-30	3N140	0-97	BAW19	0-28	CS2A	0-65
0A70	0-10	OC73	0-30	IN4785	0-90	3N164	0-95	BC107	0-25	CV102	0-25
0A71	0-10	OC75	0-25	12M75	0-25	3N159	1-45	BC108	0-10	GET103	0-25
0A73	0-07	OC76	0-25	12MT10	0-63	3F85	0-45	BC113	0-10	GET115	0-45
0A74	0-07	OC81	0-20	12Z15	0-37	12FR60	0-75	BC118	0-10	GET116	0-50
0A79	0-07	OC81D	0-20	12Z10	0-63	4095A	1-25	BCY12	0-15	GEX66	1-50
(6D15)	0-10	OC81DM	0-20	2G385	0-51	4095B	1-25	BF175	0-25	NKT222	0-20
0A81	0-08	OC82	0-25	2G403	0-51	4096B	1-25	BF173	0-30	NKT304	0-50
0A81	0-07	OC82DM	0-20	2N918	0-37	4098B	1-25	BFY61	0-20	RAS10AF	
0A800	0-07	OC82E	0-25	2N1304	0-22	40660	1-40	BFY52	0-20	SD19S	0-20
0A202	0-10	OC83B	0-15	2N1306	0-25	AC126	0-25	B5	0-45	SD92S	0-20
0A200	0-55	OC84	0-25	2N1307	0-25	AC127	0-25	B52	0-47	SD92S	0-20
0A201	0-50	OC122	0-50	2N1247	0-64	AC128	0-20	BSY29	0-25	SD93S	0-20
0A202	0-50	OC139	0-25	2N2411	1-50	AC176	0-20	BV100	1-80	SD84	0-21
0A203	0-50	OC140	0-40	2N2004A	0-25	AC177	0-25	SD96S	0-40	Y405A	0-40
0A204	0-50	OC170	0-25	2N2899	4-00	AC178	0-17	BZ116	0-63	Z8A51CF	0-78
0A205	0-40	OC171	0-30	2N3053	2-20	AD149	0-50	CRS1/10	0-25	Z8A51CF	0-78
0A206	0-40	OC172	0-37	2N3054	2-20	AD161	0-35	CRS1/20	0-38	ZR11	0-38
0A207	0-40	OC200	0-40	2N3055	0-64	AD162	0-35	CRS1/30	0-40	ZR21	0-46
0A208	0-40	OC201	0-75	2N3730	0-60	AD118	0-60	CRS1/35	0-43	ZR22	0-42
0A209	0-40	OC206	0-95	2N3731	2-75	AD127	0-20	CRS1/40	0-46		
0A210	0-40	OC207	0-90	2N4172	0-50	AD159	0-30	CRS9/50	0-30		
0A211	0-40	OC208	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A212	0-40	OC209	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A213	0-40	OC210	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A214	0-40	OC211	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A215	0-40	OC212	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A216	0-40	OC213	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A217	0-40	OC214	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A218	0-40	OC215	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A219	0-40	OC216	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A220	0-40	OC217	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A221	0-40	OC218	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A222	0-40	OC219	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A223	0-40	OC220	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A224	0-40	OC221	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A225	0-40	OC222	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A226	0-40	OC223	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A227	0-40	OC224	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A228	0-40	OC225	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A229	0-40	OC226	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A230	0-40	OC227	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A231	0-40	OC228	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A232	0-40	OC229	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A233	0-40	OC230	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A234	0-40	OC231	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A235	0-40	OC232	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A236	0-40	OC233	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A237	0-40	OC234	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A238	0-40	OC235	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A239	0-40	OC236	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A240	0-40	OC237	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A241	0-40	OC238	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A242	0-40	OC239	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A243	0-40	OC240	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A244	0-40	OC241	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A245	0-40	OC242	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A246	0-40	OC243	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A247	0-40	OC244	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A248	0-40	OC245	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A249	0-40	OC246	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A250	0-40	OC247	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A251	0-40	OC248	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A252	0-40	OC249	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A253	0-40	OC250	0-90	2N4172	0-50	AD178	0-48	CRS9/20	0-38		
0A254	0-40										

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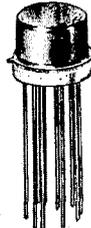
74 Series TTL (National Semiconductors and I.T.T.) LOW PRICES, HIGH QUALITY



1+		25+		100+		1+		25+		100+	
7400	18p	16p	16p	7450	18p	15p	14p	74145	£1.05	£1.35	£1.30
7401	18p	16p	13p	7451	19p	17p	16p	74150	£3.00	£2.50	£2.20
7402	18p	16p	14p	7453	19p	17p	16p	74151	£1.10	£1.05	98p
7403	18p	16p	14p	7454	18p	16p	15p	74153	£1.20	£1.05	98p
7404	19p	17p	15p	7480	18p	16p	15p	74154	£2.00	£1.70	£1.66
7405	19p	17p	15p	7470	30p	25p	24p	74155	£1.50	£1.10	98p
7406	49p	45p	40p	7472	30p	27p	24p	74156	£1.50	£1.10	98p
7407	48p	44p	39p	7473	42p	38p	24p	74157	£1.40	£1.30	£1.24
7408	26p	22p	18p	7474	40p	36p	31p	74160	£1.98	£1.87	£1.76
7409	26p	22p	18p	7475	57p	52p	49p	74161	£1.98	£1.87	£1.76
7410	18p	16p	13p	7476	50p	46p	42p	74162	£4.40	£4.13	£3.85
7411	21p	19p	17p	7480	£1.00	90p	85p	74163	£4.40	£4.13	£3.85
7412	36p	30p	23p	7481	£1.25	£1.15	£1.06	74164	£2.48	£2.39	£2.35
7413	29p	26p	21p	7482	£1.00	90p	85p	74165	£2.48	£2.39	£2.35
7416	45p	43p	34p	7483	£1.21	£1.17	£1.07	74166	£3.89	£3.58	£3.35
7417	52p	48p	46p	7484	£1.20	£1.10	£1.07	74174	£2.53	£2.42	£2.31
7420	17p	16p	13p	7485	£2.50	£2.40	£2.30	74175	£1.76	£1.65	£1.54
7422	55p	53p	50p	7486	45p	37p	33p	74176	£1.80	£1.70	£1.59
7423	55p	53p	50p	7489	£4.50	£3.90	£3.70	74177	£2.50	£2.40	£2.32
7425	55p	53p	50p	7490	75p	65p	56p	74180	£2.50	£2.40	£2.32
7426	32p	29p	23p	7492	76p	68p	62p	74181	£5.90	£5.50	£5.30
7427	50p	46p	44p	7493	75p	60p	58p	74182	£1.96	£1.84	£1.72
7428	77p	72p	66p	7494	95p	85p	80p	74184	£2.45	£2.20	£2.08
7430	18p	16p	14p	7495	£1.04	94p	89p	74190	£2.80	£2.45	£2.20
7432	38p	30p	26p	7496	£1.14	£1.05	97p	74191	£2.09	£2.04	£1.98
7433	83p	77p	71p	74100	£2.50	£2.35	£2.30	74192	£2.30	£2.09	£2.05
7437	70p	67p	65p	74104	£1.07	£1.04	97p	74193	£2.30	£2.10	£1.98
7438	70p	67p	65p	74105	£1.07	£1.04	97p	74194	£2.97	£2.86	£2.75
7440	18p	16p	14p	74107	44p	42p	40p	74195	£2.20	£2.09	£1.98
7441	74p	71p	64p	74110	61p	59p	55p	74196	£1.98	£1.87	£1.76
7442	74p	71p	64p	74111	£1.38	£1.27	£1.21	74197	£1.98	£1.87	£1.76
7443	£1.28	£1.20	£1.18	74118	£1.00	73p	64p	74198	£5.95	£5.50	£4.95
7444	£1.43	£1.38	£1.32	74119	£1.49	£1.40	£1.24	74199	£6.95	£6.50	£4.95
7445	£2.10	£1.98	£1.92	74121	43p	38p	36p	74200	£24.00	£19.20	£15.36
7446	£2.10	£1.98	£1.92	74122	£1.55	£1.45	£1.25				
7447	£1.35	£1.25	£1.05	74123	£3.05	£2.98	£2.87				
7448	£1.80	£1.65	£1.59	74141	£1.00	90p	85p				

Linear Integrated Circuits

709c DIL	1-49	50 plus	741c 14 Pin DIL	38p	31p
709c TO99	34p	29p	741c TO99	38p	31p
723c DIL	70p	55p	747c DIL	80p	68p
723c TO99	76p	58p	748c DIL	36p	31p
741c 8 Pin DIL	36p	34p	748c TO99	38p	32p



Many other types available.

General Purpose Miniature Electrolytic Capacitors (MULLARD & ERIE)

VOLT	µf	6p	10 VOLT	µf	36p	40 VOLT	µf	6p
4 VOLT	47	6p	4700	10,000	60p	6-8	15	6p
	100	6p				15	33	6p
	220	6p				33	68	6p
	330	6p				68	100	6p
	1000	12p				100	150	6p
	4700	27p				150	220	6p
6.3 VOLT	33	6p	150	7p	10p	220	470	18p
	68	6p	220	8p	16p	680	1000	24p
	150	6p	680	16p	17p	1000	2200	40p
	470	10p	1000	17p	20p	2200	3300	58p
	680	12p	2200	33p	25p	3300	6800	57p
	1000	16p	3300	34p				
	1500	18p	6800	57p				
	2200	20p						
	3300	25p						
	6800	36p						
10 VOLT	22	6p	10 VOLT	10	6p	63 VOLT	1	6p
	47	6p		22	6p		2.2	6p
	100	6p		47	6p		4.7	6p
	220	7p		100	7p		10	6p
	470	10p		150	7p		15	6p
	680	12p		220	8p		22	6p
	1000	16p		470	12p		47	6p
	1500	18p		680	16p		68	6p
	2200	20p		1000	17p		100	6p
	3300	25p		1500	20p		150	6p
	6800	36p		2200	25p		220	6p
				3300	33p		330	6p
				6800	57p		680	6p
							1000	6p
							1500	6p
							2200	6p
							3300	6p
							4700	6p
							6800	6p

(Quantity discount 15%—25 plus. 20%—100 plus. 25%—250 plus.)

MULLARD POLYESTER CAPACITORS C280 SERIES

250v. p.c. mounting 0.01µf, 0.015, 0.022, 3p; 0.033, 0.047, 0.068, 3½p; 0.1, 4p; 0.15, 0.22, 5p; 0.33, 8½p; 0.47, 8½p; 0.68, 11p; 1.0, 13p; 1.5, 20p; 2.2µf, 24p.



MULLARD POLYESTER CAPACITORS C296 SERIES

400v.: 0.01, 0.0015, 0.0022, 0.0033, 0.0047, 2½p; 0.0068, 0.01, 0.015, 0.022, 3p; 0.033, 3p; 0.047, 0.068, 0.1, 4p; 0.15, 6p; 0.22, 7½p; 0.33, 11p; 0.47, 13p.
160v.: 0.01, 0.015, 0.022, 0.033, 0.047, 0.068, 3p; 0.1, 3½p; 0.15, 4½p; 0.22, 5p; 0.33, 8p; 0.47, 7½p; 0.68, 11p; 1.0, 13p.

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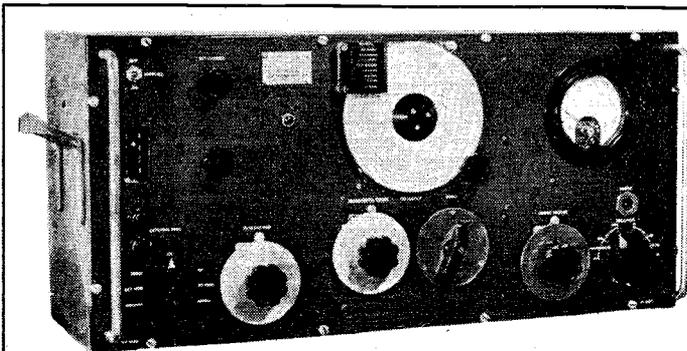
AC126	14p	BC147	13p	OC36	65p
AC127	14p	BC148	13p	OC44	10p
AC128	11p	BC149	13p	OC45	10p
AC176	12p	BC154	17p	OC70	12p
AC187	14p	BC157	17p	OC71	12p
AC188	14p	BC188	14p	OC72	14p
AD140	60p	BC159	14p	2N706	16p
AD149	60p	BC169	14p	2N2926	16p
AD161	32p	BC182	12p	2N3055	49p
AD162	32p	BC183	12p	2N3702	13p
AF114	14p	BC184	12p	2N3704	13p
AF115	14p	BC212	12p	2N3819	30p
AF116	14p	BC213	12p	40861	3p
AF117	14p	BC214	14p	40862	3p
AF139	32p	BD131	69p	40836	76p
AF239	40p	BD132	69p	OA90	5p
BC107	11p	OC25	40p	OA91	5p
BC108	11p	OC28	52p	OA202	7p
BC109	11p	OC35	52p	IN4148	5p

(Many other types stocked)

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£1 BARGAIN PACKS

- £1 10 High Power Silicon transistors, like 2N3055, Metal T03 Case tested/unmarked.
- £1 30 Plastic 2N3055 unmarked/untested TO220 case. (sample test showed good yield)
- £1



MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: $\pm 1\%$ at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400 c/s sine wave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 x 12 1/2 x 10 in. Secondhand condition. £27.50 each, Carr. £1.50.

T.1509 TRANSMITTERS (FOR EXPORT ONLY): General-purpose HF communications transmitter for use in fixed or mobile ground stations. Hand or high-speed keying. Crystal or MO control, with temperature compensated MO circuit. CW, MCW and R/T. Frequency: 1.5 to 20 Mc/s. Modulation: 100% O/put impedance: 50 ohms. Audio input: 600 ohms. Valves: Power Amplifier 2 x 813 and Modulator 2 x 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. x 2ft. D. x 5ft. H. Weight: 800 lbs. Excellent condition, price £225.00 each.

AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY): Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24v d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price £250.00 each secondhand, excellent condition.

POWER SUPPLY suitable for AN/ARC-27: 100 volts to 250 volts a.c. input. 24v d.c. output @ 41 amps fully smoothed. £45.00 each.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order. £18.50 + £1.00 carr. BC-221 Unused as new condition complete with headset, spare valves, charts. £35.00 + £2.00 carr.

CT.52 MINIATURE OSCILLOSCOPE: Portable. Operates from 115V or 250V 50-60c/s; or 180V 500c/s. A small compact tropicalised instrument designed to meet requirements of radar and communication engineers and general electronic service. Measures 9 in. x 8 in. x 6 in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2Jin. Frequency compensated amplifier up to 38dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Complete with test leads, metal transit case. As new £27.50 each. Carr. £1.

TUNING UNIT: 24V geared motor driving double 25pf double spaced variable capacitor. One m/c relay and 2 other relays. £2.50 each 30p post, good condition.

UHF ASSEMBLY: (suitable for 1,000MHz conversion) including UHF valves: 2C42, 2C46, 1B40 (complete with associated capacitors and screening), 3 manual counters 0-999. Valves 6AL5 and 8 x 6AK5. £10.00 plus 60p post, good condition.

MODULATOR UNIT: complete with transformer and 2 x 807 valves mounted in 19 in. chassis x 8 in. high x 8 in. deep. £4.50 secondhand cond., or £6.50 new cond. Carriage £1.

RF UNIT: suitable for use with the above unit. Complete with 2 x 3E29 valves. Ideal for conversion to 4 metres. £5 secondhand cond., or £7.50 new cond. Carriage £1.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 x 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition £6.50 each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5" x 6 1/2" x 7". Bitumen impregnated. £7 each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7" x 5" x 5". Mounted in steel ventilated case. £4.00 each, Carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 x 811 valves, microphone and modulator transformers etc. £7.50 each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, £3.50 each, post 50p.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. £1.25, post 30p.

AIRCRAFT SOLENOID UNIT S.P.S.T.: 24V, 200 Amps, £2 each, 30p post.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each, 0.9 ohms. Tolerance $\pm 1\%$ £3 each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance $\pm 1\%$ £3.50 each, post 30p.

TF-1041B VALVE VOLTMETER: Measures 25mV to 300V, 20 c/s to 1500 Mc/s a.c. Also 10mV to 1000V d.c. Resistance 0.02 ohms to 500 Meg, ohms. Power requirements 200-250 volts a.c. Secondhand, excellent con. £35.00. Carr. £1.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. £3 each 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high x 21 in. wide x 16 in. deep, with rear door, £12 each, £2.50 Carr. OR 4 ft. high x 23 in. wide x 19 in. deep, with rear door, £8.50, each, £2 Carr.

INSTRUMENT CABINETS: 19"W. x 16"H. x 16"D. £5.00 + £1.25 carr. 19"W. x 10"D. x 5"H. £2.50 + £1.00 carr.

TS-418/URM49 SIGNAL GENERATOR: Covers 400-1000MHz range. CW Pulse or AM emission. Power Range 0-120 dbm. £125 each. Carr. £1.50.

TN/130/APR.9 UHF TUNING UNIT: Freq. 4300-7350MHz. IF Output 160MHz with bandwidth of 20MHz and is electrically tuned by a d.c. reversible motor. £27.50 each. Carr. £1.

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SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 8 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-50 for sine wave. Am or Pulse Carrier. O/put Voltage 0.1-100,000 microvolts cont. variable. Impedance 50Ω. Price: £85 each + £1.50 carr.

CLASS "D" WAVEMETER NO. 1 MK. II: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. £7.50 each. Post 60p.

RCA TE-149 HETERODYNE WAVEMETER: V-cut, 1MHz crystal (0.005%). Accuracy better than 0.02%. Dial directly calibrated every 1KHz from 2.5-5MHz. Useful harmonics up to 20MHz. Provision for fitting internal dry batteries. "As new" complete with Manual and Spares. £14 each. Carr. 75p.

POWER UNIT TYPE 24: (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" £10 each. Carr. 75p.

ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. £17.50 each. Carr. £1.50.

ACTUATOR UNIT: With 115V d.c. geared motor; o/put 12.5 rpm; torque 16 in. oz; reversible; microswitches and potentiometer. £3.50 ea. + 40p post.

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MOTOR: 240V single phase, 2,400 rpm. 1/40 H.P. approx. Price £1.75 each, 30p post.

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CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, £2.50 each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5A amps; or 40 ohms at 2.6 amps; 500 ohms, 0.55 amps. Price (either type) £2 each, 30p post each.

AR88 RECEIVER: List of spares, 5p.

REDIFON TELEPRINTER RELAY NO. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. x 8in. x 8in. New condition £7.50. Carr. 75p.

WESTON INDUSTRIAL THERMOMETER MODEL 221: 0-100°C. 3in. dia. scale. Accuracy 1%. Precision made coil within-coil structure. Changes in temperature cause a rotary action of the Helix turning the shaft to which the pointer is mounted. £2.80 each 30p post. Unused condition.

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SYNCHROS: and other special purpose motors available. Send for list. S.A.E.

PANORAMIC ADAPTOR TYPE ALA2: Suitable for use with APR-1, APR-4, and other Receivers having an I.F. frequency of 30 MHz. Will display signals up to 5 MHz either side of the received frequency. Power Supply 115V a.c. 400 c/s. Tube 3PB1 with nu-metal screen. £8.50 each. £1 carr. S/hand cond.

TELEPRINTER EQUIPMENT: MURHEAD D-514-A TRANSMISSION-MEASURING SET: Consists of an oscillator covering audio and carrier frequencies, with suitable transmission measuring equipment. Power pack is contained in a separate case and operates from A.C. mains at various voltages, or from an accumulator. Power Supply 12V d.c. or 100/250V a.c. Freq. Range continuous 100-40,000Hz. Direct reading from decade dials. Accuracy $\pm 0.4\%$ ± 3 Hz over whole range. Oscillator o/put 5mW (+7db) or more into 600Ω at any freq. Measurement up to 50db and down to at least 45db. Price £10 each Carr. £1.

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The GNT Range of Automatic Morse Equipment is now manufactured in the U.K. and comprises complete equipment for Morse Training Schools and for Automatic Morse Transmission. Models available include:

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LAMPS, etc.

WW-117 FOR FURTHER DETAILS

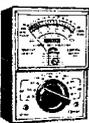
77 AKEMAN STREET, TRING, HERTS., U.K.

Telephone: Tring 3476/8, STD: 0442-82 Telex 82362, Answerback: Batelcom Tring

GUS G.W. SMITH & CO (RADIO) LTD

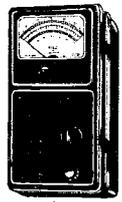
AUDIOTRONIC MODEL ATM.1

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 x 60 x 28mm. Complete with test leads.
£2.95. 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: 2/5/10/15/25/50/100/1000 V D.C. 2/5/10/50/250/500/1000V A.C. D.C. Current 100 uA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300k/3M Ohm. Complete with battery, test leads, instructions and sturdy steel carrying case.
 Our Price **£4.95. Post 20p.**



MODEL 500

30,000 O.P.V. with overload protection, mirror scale, 0/5/10/20/100/250/500/1,000 V. D.C. 0/2.5/10/25/100/250/500/1,000 V. A.C. 0/50uA/5/50/500mA. 12 amp. D.C. 0/60/1k/6 meg/50 meg. D.C. 0/£10.50. Post paid. Leather case **£1.75.**



U4312 MULTIMETER

Extremely sturdy instrument for general electrical use. 60V o.p.v. 0/31/5/17/5/30/60/150/300/600/900 VDC and 75mV. 0/31/5/17/5/30/60/150/300/600/900 VAC. 0/300uA/1/5/15/15/60/150/600mA/1/5/6 AMP. D.C. 0/1/5/15/60/150/600mA/1/5/6 AMP. A.C. 0/200/1/3k/30k Ohm. Accuracy DC 1%, AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. **£9.75. Post 25p.**



H10K1 MODEL 700X

100,000 O.P.V. Overload protection. Mirror scale. 3/6/12/1/2/1/5/3/6/12/30/60/120/300/600/1200 VDC. 1/5/15/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2k/200 k/2 Meg/20 megohms. **£14.95. Post 20p.**



MODEL C-7080 EN

Giant 6in. mirror scale. 20,000 o.p.v. 0/25/12/5/10/50/250/1000/5000V. D.C. 0/2.5/10/50/250/1000/5000V. A.C. 0/50uA/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. Range: 0/0.05/3/13/120/600/1200 V. D.C. 0/3/12/60/300/1120. A.C. 0/5uA/1/2mA/120mA/600mA 12A. D.C. 0/12A. A.C. -20 to +63dB. 0/2k/200k/20 meg. ohms. **£16.95. Post 30p.**



TMK 100K LAB TESTER

100,000 O.P.V. 6 1/2 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, 100uA, 10, 100, 500mA. 2.5 amp. Resistance: 1k, 10k, 100k, 10MEG, 100MEG. Decibels: -10 to +49 db. Plastic Case with carrying handle. Size 7 1/2 x 6 1/2 x 3 1/2. **£19.95. P. & P. 20p.**



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 mtd.



Transistor tester measures Alpha, beta and I co. Complete with batteries, instructions and leads. **£14.95. Post 20p.**

ALL PRICES ARE SUBJECT TO 10% V.A.T.

370 WTR MULTIMETER

Features A.C. current ranges, 20,000 o.p.v.
 Ranges: 0/2.5/10/50/250/500/1000 V DC. 0/2.5/10/50/250/500/1000 V AC. 0/20uA/1/10/100MA/1/10 Amp DC. 0/100MA/1/10 Amp AC. 0/5K/50K/500K/5MEG/50MEG. -20 + 62 db.
£17.50. Post 25p.



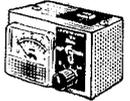
LB4 TRANSISTOR TESTER

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.**



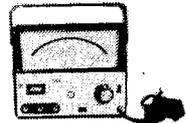
KAMODEN HM.350 TRANSISTOR TESTER

High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4in. x 4 1/2in. clear scale meter. Operates from internal batteries. Complete with instructions leads and carrying handle. **£12.50 Post 30p.**



MODEL 49A IN CIRCUIT TRANSISTOR TESTER

Checks true A.C. beta in/out. Checks Ico. Checks diodes in/out. Checks SCR etc. Beta HI 10-500. L/OE-50. Ico 0-5000uA. 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. 0/25uA/2/5/25/250 MA D.C. -20 to +63dB. 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: 0/1/0.1/1/3/10/30/100/300 v. R.M.S. 4 cps. 1.2 Mc/s. Decibels -40 to +60 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 26 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.P. **£2.12 H.V. £2.50.**



MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy -50%, D.C. 1% A.C. Scale length 165mm. 0/300/750uA/1/5/3/7/5/15/30/75/150/300/750mA. 1/5/3/7/5/15/30/75/150/300/750mA/1/3/7/5 Amp. A.C. 0/75/150/300/750mV/1/5/3/7/5/15/30/75/150/300/750V D.C. 0/750mV/1/5/3/7/5/15/30/75/150/300/750V. A.C. Automatic cut out. Supplied complete with test leads, manual and test certificates. **£49. Post 50p.**



TMK MODEL I17 ELECTRONIC VOLTMETER

Battery operated, 11 meg input, 26 ranges. Large 4 1/2in. mirror scale. Size 5 1/2 x 4 1/2 x 2 1/2in. 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.**



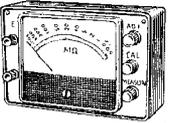
HT100134 MULTIMETER

Features A.C. current ranges, 100,000 o.p.v. Mirror Scale. Overload protection. 0/2.5/10/50/250/500/1000 v DC. 0/2.5/10/50/250/500/1000 V AC. 1/10/250MA/2/5/25/250 MA/10 Amp DC. 10 Amp AC. 0/20K/200K/2MEG/20MEG, -20 + 62 db.
£15.00. Post 25p.



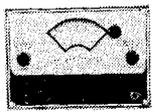
KAMODEN HMG-500 INSULATION RESISTANCE TESTER

Range 0-1000 Meg. ohms, 500 Volt. Battery operated. Wide range clear meter 4 1/2in. x 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 15-50,000 Hz Output max. +10 dB (10 K ohms), operation internal batteries. Attractive 2-tone case 7 1/2in. x 6in. x 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 600KHz. Sensitivity at 100KHz, V RMS/mm. 3-25; Preset triggered 1-3,000usec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220 x 360 x 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 Ohm. 25 PF. X amp sensitivity. -9v p-p/CM. Bandwidth 1.5 cps -300 MHz. Input Imp. 2 meg Ohm. 20 PF. Time base. 5 ranges 10 cps -300 KHz. Synchronization. Internal/external. Illuminated scale. 140 x 215 x 330 mm. Weight 15lbs. 220/240 V. A.C. Supplied brand new with handbook **£52.50. Carr. 50p.**



RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5 m/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. x 4in. C.R.T. Calibrated triggered sweep from -2 usec. to 100 mill-sec. per cm. Free running time base 50 cps-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. **£87 Carr. paid.**



ARF-300 AF/RF SIGNAL GENERATOR

All transistorised, compact, fully portable. AF sine wave 15Hz. 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.**



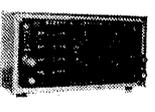
TE22 SINE SQUARE WAVE AUDIO GENERATORS

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.**



MODEL AT201 DECADE ATTENUATOR

Frequency range: 0-500KHz. Attenuator: 0-111db., 0-1db. step. Impedance 600 ohms. Max. input power 300dbm. Size 180 x 90 x 55mm. **£12.50. Post 37p.**



MODEL TE-200

20,000 O.P.V. Mirror scale, overload protection. 0/6/25/125/1000V. D.C. 0/10/50/250/1,000V. A.C. 0/50uA/250 mA. 0/60K/6 meg. -20 to + 62 db. **£4.95. Post 15p.**



MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection

0/6/3/15/60/300/1200 V. D.C. 0/6/30/120/600/1200 V. A.C. 0/30uA/6mA/60mA/300 mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db. **£7.50. Post 15p.**



TE-16A Transistorised Signal Generator, 5 ranges

400KHz-30MHz. An inexpensive instrument for the hobbyist. Operates on 9v. battery. Wide easy to read scale. 800KHz modulation. 5 1/2 x 5 1/2 x 3 1/2in. Complete with instructions and leads. **£3.95. Post 25p.**



THE MODEL TW-50K

46 ranges mirror scale. 50K/Vol. D.C. 5K/Volt A.C. D.C. Volts 125, 25, 1-25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50uA, 2.5, 5, 25, 50, 250, 500mA. 5, 10 amp. Resistance: 10K, 100K, 1 MEG, 10 MEG Ohm. Decibels: -20 to +81.5 dB. **£3.50. Post 17p.**



230 VOLT A.C. 50 c/s RELAYS

3 sets of changeover contacts at 5amp 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 40Kc/s-280Mc/s in 6 coils. 500uA Meter. 9V. battery operation. Size 180 x 80 x 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

1A. £8.75 P&P 30p
 2.5A. £10.00 P&P 35p
 5A. £14.70 P&P 37p
 8A. £19.85 P&P 50p
 10A. £28.10 P&P 75p
 12A. £29.50 P&P 100p
 15A. £31.25 P&P 125p
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MODEL S-260B Panel Mounting

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 2.5A. £10.00 P&P 35p
 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 176-260VAC. Output 120VAC or 240VAC. 200VA rating. **£11.97. Carr. 50p.**



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 x 8 1/2 x 6 1/2. **£11.97. Post 25p.**



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 7 1/2 x 5 1/2 x 3 1/2. **£19.95. Post 25p.**



240° WIDE ANGLE 1mA METERS

MW1-6 60mm. square **£3.97**
 MW1-8 80mm. square **£4.87**
 P. & P. 15p.





HIGH QUALITY CONSTRUCTION KITS
Appointed stockists at all branches. Complete with comprehensive, easy to follow instructions, and covered by full guarantee.

AF20 Mono transistor amplifier	£4.80
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HF75 FM transistor receiver	£2.88
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'AMATEUR ELECTRONICS'—The professional book for the amateur—covers the subject from basic principles to advanced electronic techniques. Our price **£3.30** complete with circuit board for making the kits listed below.

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AE6 Monostable Multivibrator	£1.02
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POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range of wattages available. Single hole fixing, in. dia. shafts. Bulk quantities available.

25 WATT 10/25/50/100/250/500/1000 ohms	£1.15
P. & P. 10p	
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P. & P. 10p	
100 WATT 15/10/25/50/100/250/500/1000 or 2500 ohms	£2.34
P. & P. 15p	



TRIO TS515/PS515 TRANSCEIVER



High quality TS515 SSB/CW amateur band receiver covering 80, 40, 20, 15 and 10 metre. Transmit/receive frequency 3.5-29.7MHz. Output 1.5 watts. Power requirements 110-120/220-240V. A.C. Sizes: TS515 330 x 185 x 84mm. PS515 200 x 168 x 84mm.

OUR PRICE £210.00 Carr. Paid

TRIO JR599 RECEIVER



9 wavebands covering 1.6-29.7 MHz, 144-146MHz and 10-60 MHz. VVVV, SSB, CW, AM and FM. AF output more than 1 watt. S Meter, Squelch control. BFO. Variable RF and AF controls. 4-16 ohm output. Accuracy. Power requirements 100/240V. A.C. 12-14V. D.C.

OUR PRICE £155.00 Carr. Paid

TRIO TR2000 TRANSCEIVER



Fully transistorised portable VHF P Transceiver. Will transmit and receive on 6 channels between 144-146 MHz. 1 watt transmitter. 12V D.C. internal or external supply. Built in charger for ni-cad cells. Power/volume switch, squelch control, channel selector, mike socket, earphone/external speaker socket. Complete with microphone, 144-48, 144-72 and 145-92 crystals.

OUR PRICE £79.50 Carr. Paid

TRIO JR310 SSB RECEIVER



Covers 3-5, 7, 14, 21, 28, 28.5 and 29-MHz bands and VVVV 15MHz SSB, AM and CW. AF output more than 1 watt. S meter, controlled BFO for SSB, S meter, ANL etc. A.C. 110/120-220/240V.

OUR PRICE £75.00 Carr. Paid

SWR METER MODEL SWR-3



Handy SWR Meter for transmitter antenna alignment, with built in field strength meter. Accuracy: 5%. Impedance: 50. Indicator: 100µA DC full scale 6 section collapsible antenna. Size: 145 x 50 x 60mm.

OUR PRICE £4.25 P. & P. 25p

SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, etc. Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100 x 80mm



100µA	£3.95
100-0-100µA	£3.90
500µA	£3.70
1mA	£3.60
20V. D.C.	£3.60
50V. D.C.	£3.60
300V. D.C.	£3.60
1 amp. D.C.	£3.60
5 amp. D.C.	£3.60
300V. A.C.	£3.70
VU Meter	£4.30

TYPE SD.830 82.5mm x 110mm Fronts



50µA	£3.40
50-0-50µA	£3.40
100µA	£3.35
100-0-100µA	£3.30
200µA	£3.30
500µA	£3.15
1mA	£3.10
5mA	£3.10
10mA	£3.10
5V. D.C.	£3.10
10V. D.C.	£3.10
20V. D.C.	£3.10
50V. D.C.	£3.10
300V. D.C.	£3.10
15V. A.C.	£3.30
300V. A.C.	£3.30
VU Meter	£3.50

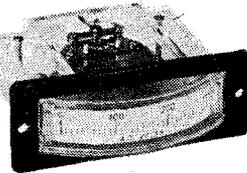
TYPE SD.640 63.5mm x 85mm Fronts

50µA	£3.05
50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£3.00
200µA	£3.00
500µA	£2.95
1mA	£2.90
5mA	£2.90
10mA	£2.90
50mA	£2.90
100mA	£2.90
500mA	£2.90
1 amp.	£2.90
5 amp.	£2.90
10 amp.	£2.90
5V. D.C.	£2.90
20V. D.C.	£2.90
50V. D.C.	£2.90
300V. D.C.	£2.90
15V. A.C.	£3.00
300V. A.C.	£3.00
VU Meter	£3.15

TYPE SD.460 46mm x 59.5mm Fronts

50µA	£2.80
50-0-50µA	£2.80
100µA	£2.75
100-0-100µA	£2.75
200µA	£2.70
500µA	£2.55
1mA	£2.60
5mA	£2.60
10mA	£2.60
50mA	£2.60
100mA	£2.60
500mA	£2.60
1 amp.	£2.60
5 amp.	£2.60
10 amp.	£2.60
5V. D.C.	£2.60
20V. D.C.	£2.60
50V. D.C.	£2.60
300V. D.C.	£2.60
15V. A.C.	£2.70
300V. A.C.	£2.70
VU Meter	£2.90

'SEW' EDGWISE METERS TYPE P.E.70



8 17/32in. x 115/32in. x 2 1/2 in. deep.

50µA	£3.75
50-0-50µA	£3.60
100µA	£3.60
100-0-100µA	£3.50
200µA	£3.40
500µA	£3.20
1mA	£3.20
5mA	£3.25
10mA	£3.25
50mA	£3.25
100mA	£3.25
500mA	£3.20
1 amp.	£3.20
5 amp.	£3.25
10 amp.	£3.25
5V. D.C.	£3.25
20V. D.C.	£3.25
50V. D.C.	£3.25
300V. D.C.	£3.25
15V. A.C.	£3.25
300V. A.C.	£3.25
VU Meter	£3.85

*** MOVING IRON— ALL OTHERS MOVING COIL**

Please add postage

TYPE MR.85P 4 1/2in. x 4 1/2in. fronts.



50µA	£4.40
50-0-50µA	£4.25
100µA	£4.25
100-0-100µA	£4.05
200µA	£4.05
500µA	£3.90
500-0-500µA	£3.90
1mA	£3.90
1-0-1mA	£3.90
5-0-5mA	£3.90
10mA	£3.90
50mA	£3.90
100mA	£3.90
500mA	£3.90
1 amp.	£3.90
5 amp.	£3.90
10 amp.	£3.90
5V. D.C.	£3.90
10V. D.C.	£3.90
20V. D.C.	£3.90
50V. D.C.	£3.90
150V. D.C.	£3.90
300V. D.C.	£3.90
15V. A.C.	£3.90
300V. A.C.	£3.95
S Meter 1mA	£3.90
VU Meter	£4.55
1 amp. A.C.*	£3.90
5 amp. A.C.*	£3.90
10 amp. A.C.*	£3.90
20 amp. A.C.*	£3.90
30 amp. A.C.*	£3.90

TYPE MR.52P 2 1/2in. square fronts.

50µA	£3.50
50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£2.95
200µA	£2.65
500µA	£2.50
1mA	£2.50
5mA	£2.50
10mA	£2.50
50mA	£2.50
100mA	£2.50
500µA	£2.50
1 amp. A.C.*	£2.50
5 amp. A.C.*	£2.50
10 amp. A.C.*	£2.50
20 amp. A.C.*	£2.50
30 amp. A.C.*	£2.50
10V. D.C.	£2.50
20V. D.C.	£2.50
50V. D.C.	£2.50
300V. D.C.	£2.50
15V. A.C.	£2.60
300V. A.C.	£2.60
S Meter 1mA	£2.60
VU Meter	£3.60
1 amp. A.C.*	£2.50
5 amp. A.C.*	£2.50
10 amp. A.C.*	£2.50
20 amp. A.C.*	£2.50
30 amp. A.C.*	£2.50

TYPE MR.65P 3 1/2in. x 3 1/2in. fronts

50µA	£3.70
50-0-50µA	£3.15
100µA	£3.15
100-0-100µA	£3.10
200µA	£3.05
500µA	£2.75
500-0-500µA	£2.60
1mA	£2.60
5mA	£2.60
10mA	£2.60
50mA	£2.60
100mA	£2.60
500µA	£2.60
1 amp.	£2.60
5 amp.	£2.60
10 amp.	£2.60
15 amp.	£2.60
20 amp.	£2.60
30 amp.	£2.60
5V. D.C.	£2.60
10V. D.C.	£2.60
20V. D.C.	£2.60
50V. D.C.	£2.60
150V. D.C.	£2.60
300V. D.C.	£2.60
15V. A.C.	£2.80
50V. A.C.	£2.80
150V. A.C.	£2.80
300V. A.C.	£2.80
500V. A.C.	£2.80
S Meter 1mA	£2.85
VU Meter	£3.70
50mA A.C.*	£2.60
100mA A.C.*	£2.60
200mA A.C.*	£2.60
500mA A.C.*	£2.60
1 amp. A.C.*	£2.60
5 amp. A.C.*	£2.60
10 amp. A.C.*	£2.60
20 amp. A.C.*	£2.60
30 amp. A.C.*	£2.60

'SEW' EDUCATIONAL METERS TYPE ED.107

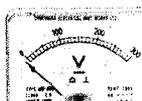


Size overall 100mm x 90mm x 108mm.

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:—

50µA	£6.90
100µA	£6.40
50-0-50µA	£6.40
1mA	£5.95
1-0-1mA	£5.95
1A D.C.	£5.95
5A D.C.	£5.95
5V D.C.	£5.95
10V D.C.	£5.95
15V D.C.	£5.95
20V D.C.	£5.95
50V D.C.	£5.95
300V D.C.	£5.95
Dual range	
500mA/5A D.C.	£7.00
1/15A D.C.	£7.00
5V/50V. D.C.	£7.00
5/15V D.C.	£7.00

TYPE MR.38P 1 21/32in. square fronts.



50µA	£2.55
50-0-50µA	£2.50
100µA	£2.45
100-0-100µA	£2.40
200µA	£2.25
500µA	£2.25
500-0-500µA	£2.25
1mA	£2.25
1-0-1mA	£2.25
5mA	£2.25
10mA	£2.25
20mA	£2.25
50mA	£2.25
100mA	£2.25
500µA	£2.25
1 amp.	£2.25
5 amp.	£2.25
10 amp.	£2.25
5V. D.C.	£2.25
10V. D.C.	£2.25
20V. D.C.	£2.25
50V. D.C.	£2.25
100V. D.C.	£2.25
150V. D.C.	£2.25
300V. D.C.	£2.25
500V. D.C.	£2.25
15V. A.C.	£2.25
50V. A.C.	£2.25
150V. A.C.	£2.25
300V. A.C.	£2.25
S Meter 1mA	£2.25
VU Meter	£2.65

TYPE MR.45P 2in. square fronts.

50µA	£2.70
50-0-50µA	£2.65
100µA	£2.60
100-0-100µA	£2.50
200µA	£2.50
500µA	£2.45
500-0-500µA	£2.40
1mA	£2.40
5mA	£2.40
10mA	£2.40
50mA	£2.40
100mA	£2.40
500µA	£2.40
1 amp.	£2.40
5 amp.	£2.40
10 amp.	£2.40
20 amp.	£2.40
30 amp.	£2.40
5V. D.C.	£2.40
10V. D.C.	£2.40
20V. D.C.	£2.40
50V. D.C.	£2.40
100V. D.C.	£2.40
150V. D.C.	£2.40
300V. D.C.	£2.40
500V. D.C.	£2.40
15V. A.C.	£2.40
50V. A.C.	£2.40
150V. A.C.	£2.40
300V. A.C.	£2.40
S Meter 1mA	£2.50
VU Meter	£2.70
1 amp. A.C.*	£2.40
5 amp. A.C.*	£2.40
10 amp. A.C.*	£2.40
20 amp. A.C.*	£2.40
30 amp. A.C.*	£2.40

'SEW' BAKELITE PANEL METERS TYPE MR.65 3 1/2in. square fronts.



25µA	
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G.W.S. G.W.S. 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 4 1/2". Dial size 5" x 3". Overall size 7 1/2" x 4 1/2" x 1 1/2" deep including knob and coupling. 1" dia. shaft.

OUR PRICE **£1-62** P. & P. 15p

RUH.6 REFLEX HORN SPEAKER

Built in driver unit. Impedance 16 ohm. Power rating 10 watt. Response 350-7000 Hz. Approx. size 6" x 6". Weatherproof and shock proof.

OUR PRICE **£4-97** P. & P. 30p

EMI LOUDSPEAKERS

Model 350. 1 1/2in. x 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. 1 1/2in. x 8in. with twin tweeters/crossover. 55-15,000 Hz. 8 watt RMS. Available 8 or 15 ohms. £3-82 each. P. & P. 25p.

HAND HELD 2 WAY WALKIE TALKIES

Battery operation. Volume and Squelch controls. Call Button and Press to Talk Button. Telescopic Aerial. Complete with carrying cases.

SKYFON 100mW. Pair **£24-95** Post 50p
P302 2 Channel 300MW. Pair **£52-50** Post 50p
P1003 3 Channel 1 Watt. Pair **£71-25** Post 50p
Licence required for operation in U.K.

MP7 MIXER PREAMPLIFIER

5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9 1/2" x 6" x 3". Inputs: Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono mag. 4mV 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. x 4in. x 2 1/2in.

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. 7 1/2" x 3" x 4 1/2in.

OUR PRICE **£7-50** P. & P. 15p

ALL PRICES ARE SUBJECT TO 10% V.A.T.



ALSO SEE PREVIOUS PAGES

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohm. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£1-87** P. & P. 30p

LIGER LH025 STEREO HEADPHONES

Lightweight headphones with padded earpieces. 4-16 ohms. 20-20,000 Hz. Complete with 6ft cord and plug.

OUR PRICE **£1-97** P. & P. 30p

TE1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive magnetic headset with soft earpads. Impedance 2,600 ohms (d.c. 800 ohms). Frequency response 200-4000 Hz.

OUR PRICE **£2-25** P. & P. 30p

SDH8V MDNO/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 ohm. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE **£7-97** P. & P. 30p

DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20-20,000 cps. Complete with lead and stereo jack plug. ONLY **£2-25**. Post 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

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

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!

SPORTSMAN AM/FM PORTABLE RADIO MODEL AR.1000

5 wavebands covering AM: 535-1065KHz. FM: 88-107MHz. AIR: 105-135MHz. PB: 147-174MHz. WB: 162.5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls and 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 x 79 x 219mm. Battery/main 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: 8.0-1.6 MHz, SW3: 1.6-24 MHz, PSB1: 30-50 MHz, PSB2: 148-174 MHz, FM: 88-108 MHz, AIR: 105-136 MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built-in aerial. AFC on FM. 6in. x 4in. speaker and personal earpiece. Battery/main operation. Size: 345 x 133 x 306mm.

OUR PRICE **£36-00** P. & P. 50p

AM/FM PORTABLE RADIO AR3000

4 wavebands covering FM: 87-108MHz, MW: 510-1605KHz, LW: 145-285 KHz, SW: 5.8-12.5 MHz. Push button wave change plus AFC and on/off. Thumb-wheel tuning. Slider volume and tone controls. Earphone socket. Built-in and telescopic aerials. Car aerial socket. Battery/Main operation.

OUR PRICE **£14-95** 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

LSH.20 Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000 Hz. £3-50. P & P 30p.

LSH.40 Two way speaker system. Individual volume controls. 8 ohms. 20-20,000 Hz. £8-95. P & P 30p.

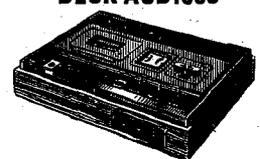
LSH.50 Professional Quality Electrostatic. Complete with self powered energiser and control unit with headphone/speaker selector. 4-32 ohms. 20-24,000 Hz. £15.95. P & P 30p.

LSH.30 Open back type. Individual tone and volume controls. 8 ohms. 30-20,000 Hz. £5-50. P. & P. 30p.

LSH.60 5in speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. £8-50. P & P 30p.

LQH.400 4-channel dynamic head-phones. 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.

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 -25dB. Noise limiter -6dB at 10KHz. Complete with phono connecting leads.

OUR PRICE **£39-50** P. & P. 50p

AHP-8D 8-TRACK STEREO TAPE DECK



Can be used with most hi-fi amplifiers. Push button track selector and illuminated track indicators. Attractive cabinet with black and silver trim. Output level 70mV. AC 220/240v.

OUR PRICE **£11-95** P. & P. 50p

AHP-8A 8-TRACK STEREO TAPE PLAYER



Incorporates built-in amplifiers giving 2 1/2-2 1/2 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

TAPE CASSETTE

Top Hi-Fi quality in library cases

Type	LOW NOISE		
	5	10	25
C60	£1-29	£2-58	£2-99
C90	£1-85	£2-62	£2-59
C120	£2-29	£4-48	£10-63
CR60	£3-41	£6-72	£12-63
CR90	£4-68	£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	90p	£4-70	£8-90

P. & P. 5p; 5 and over post free.



DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16 1/2" x 8" x 3 1/2". AC 200/250v.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz-20KHz ± 2dB. S/N better than 70dB. Full source 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

AUDIOTRONIC AHA101 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. Input: 5mV/100mV. Output: 50mW per channel.

OUR PRICE **£7-50** P. & P. 20p

DIGITAL CLOCK RADIO ADCI



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, and operating instructions.

OUR PRICE **£12-50** P. & P. 50p

STEREO HEADPHONES

LSH.20 Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000 Hz. £3-50. P & P 30p.

LSH.40 Two way speaker system. Individual volume controls. 8 ohms. 20-20,000 Hz. £8-95. 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.

LSH.30 Open back type. Individual tone and volume controls. 8 ohms. 30-20,000 Hz. £5-50. P. & P. 30p.

LSH.60 5in speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. £8-50. P & P 30p.

LQH.400 4-channel dynamic head-phones. 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 33 1/3% OR MORE! GWS

RECORD DECKS



Carriage & Packing 50p
B.S.R. McDONALD

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510/TPD1	£10.55
610	£10.55
610/TPD1	£15.45
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810	£26.30
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MP60	£39.25
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MP60/TPD2	£11.25
HT70	£11.60
HT70/G800	£14.25
HT70/TPD1	£10.55
CONNOSSEUR	
BD1 Kit	£9.10
BD1 Chassis	£11.35
BD2/SAU2/Chassis	£22.70
BD2/SAU2/Plinth/Cover	£26.20
GARRARD	
1025T Stereo	£4.95
2025	£6.35
2025 TC/KS40A	£6.95
SP25 III	£9.25
SP25 III/G800	£10.95
SP25/M44E	£13.90
AP76	£18.00
865B	£19.50
SL65B	£11.15
SL72B	£17.75
S195B	£31.15
401	£24.35
ZERO 100	£34.10
ZERO 100S	£31.40
ZERO 100SB	£27.00
GOLDRING	
G99	£22.50
G101F/C	£22.50
GL69/2	£15.75
GL72	£25.45
GL72/P	£33.75
GL75	£32.20
GL75P	£41.65
GL78	£34.00
GL78P/C	£58.25
GL85P/C	£72.00
THORENS	
TD125/II	£50.40
TD125A/B/II	£92.05
TD160C	£53.50
TD165	£43.80

RECORD DECK PACKAGES



Carriage and Packing 75p
Complete units with Stereo cartridge ready wired in plinth and cover.

GARRARD

2025 TC/9TAHCD	£11.35
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SP25 III/M55E	£18.50
SP25 III Module/M75-6	£19.45
AP76/G800	£26.45
AP76/G800E	£28.65
AP76/M44E	£27.70
AP76/M44-7	£27.30
AP76/M55E	£28.30
AP76/M75EJ	£34.90
AP76/M75EJ	£30.90
AP76 Module M75-6	£29.10
865B Module/M75-6M	£32.50
AP96 Module M75-6	£28.90
ZERO 100S Module/M93E	£44.15
ZERO 100SB Module/M75-6SM	£44.20
B.S.R. McDONALD	
210/SC7M	£7.40
MP60/ADC KS	£16.50
MP60/TPD1/ADC KS	£15.80
MP60/M44-7	£17.50
HT70/TPD1/G800	£19.20
GOLDRING	
GL72/G800	£34.20
GL75/G800	£39.10
GL75/G800E	£41.55
GOODMANS	
TD100/G800E Teak	£50.50
TD100/G800E White	£52.30
LEAK	
Delta/M75-6	£47.20
Transpac	£35.95
PHILIPS	
GA105/GP200	£13.80
GA160/GP200 Teak	£19.50
GA212/GP400	£48.05
PIONEER	
PL12D (Less cartridge)	£33.95
PL15C (Less cartridge)	£47.20
PL14D (Less cartridge)	£104.75
PL150 (Less cartridge)	£98.90
PL161 (Less cartridge)	£119.60
PLA35 (Less cartridge)	£61.55
THORENS	
TD160C/Ortofon M15E Super	£70.35
TD125 AB/II M15E Super	£112.05
TD125C	£6.15
TD165/Ortofon M15E Super	£62.55
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Linton/M44-7 Teak	£23.55
Linton/M44-7 White	£24.70

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Stereo 80 pre-Amp	£9.50
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ALL OTHER SINCLAIR PRODUCTS IN STOCK INCLUDING

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4000 FM Tuner	£31.25
Q16 Speaker	£6.10
Q30 Speaker	£16.95

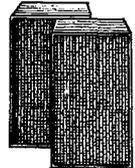
PHILIPS IC361 AM/FM MAINS/PORTABLE RADIO WITH AFC



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 14 1/2" x 9 1/2" x 9 1/2", approx. With mains lead and instructions. Rec. List Price £69.18.

OUR PRICE £39.95 P. & P. 50p.

SPECIAL OFFER!



STEREOSOUND SPEAKERS

Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14 1/2" x 9 1/2" x 7 1/2". 8 ohms, 8 watts RMS, 16 watts peak. Complete with DIN lead.

OUR PRICE £12.95 Carr. 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 autotuning will switch on again when required. AC 240v. operation. Switch rating 250v. 3A.

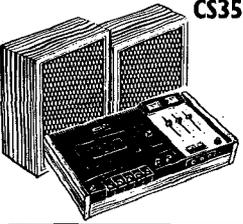
OUR PRICE £5.95 P. & P. 30p

BINATONE OS100 DIGITAL CLOCK

240v mains operation. Ivory case with large clear numbers for hours, minutes and seconds. Approx. size 6 1/2" x 3" x 3 1/2".

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.

ADM MICROPHONES

Normally £11.80 pair.

OUR PRICE £7.50

Pair. P. & P. 25p

CS30D STEREO DECK

4 track deck with piano key controls. Two VV meters. Chrome/low noise tape selector. Mic. and line inputs. Headphone socket. Index counter. 40-15,000Hz (CrO2) Automatic stop.

OUR PRICE £50.65 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.

OUR PRICE £24.95 P. & P. 50p

Also available ready built (Rec. Price £29.95)

OUR PRICE £27.20 P. & P. 25p

FM TUNER CHASSIS

6 TRANSISTOR HIGH QUALITY TUNER, SIZE ONLY 6 1/2" x 4 1/2" x 2 1/2". 3 IF 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.

MINUTEMAN MM3 POCKET CALCULATOR

Size only 4 1/4" x 3" x 1 1/4". 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 £23.95 P. & P. 25p

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 £28.50 P. & P. 25p

SPECIAL BARGAIN! PHONIC 10 2-WAY SPEAKER SYSTEM

Matched pair of compact bookshelf speakers of unique design incorporating 2in. high frequency tweeter and 6in. woofer. 8 ohms impedance. 10 watts power handling. Size 3 1/2" x 2 1/2" x 1 1/2". G.W.S. SPECIAL PRICE £9.85 per pair. P. & P. 50p plus V.A.T.

A1018 FM TUNER

Specification as above chassis but complete in a neat metal cabinet with on/off switch. Size 7 1/2" x 3 1/2" 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 esutcheon ready to fit into cabinet. Output 120mV. AC 240v. Overall size approx. 185 x 215 x 80mm.

OUR PRICE £8.95 P. & P. 50p

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

SPECIAL OFFER! FRUSTRATED EXPORT ORDER



2 track BSR deck with push button controls for easy operation. Tape counter and volume control. Complete with hand microphones, direct recording lead, 1200ft. reel of tape and spare spool. 200/250v. A.C. operation. Fully guaranteed.

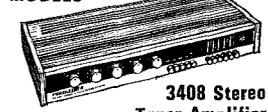
OUR PRICE £17.50 Carr. 75p



4 track, 2 speeds (3 1/2 and 1 1/2 i.p.s.). Piano key type controls, tape counter, recording level meter, volume and tone controls etc. Complete with hand microphone, direct recording lead, 1800ft. of tape with spare spool. 200/250v. A.C. operation. Fully guaranteed.

OUR PRICE £27.50 Carr. 75p

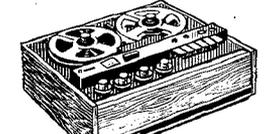
FERGUSON EXPORT MODELS



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, 7 1/2, 3 1/2, 1 1/2 i.p.s. Stereo/mono record/play. 7 reels. Inputs for dynamic mikes, radio, g. rm. Complete with cover.

OUR PRICE £41.95 Carr. 75p

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KEMPSTON HARDWICK
BEDFORD

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PLEASE ADD 10p TO ORDERS UNDER £2.

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MON.-SAT. 9 a.m.-5 p.m.
PLEASE ADD 10% V.A.T.

RESISTORS

1/4W Iskra high stability carbon film—very low noise—capless construction. 1/4W Mullard CR25 carbon film—very small body size 7.5 x 2.5 mm. 1/4W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price
1	5%	4.7Ω-2.2MΩ	E24	1-99
1	10%	3.3MΩ-10MΩ	E12	1p
1	2%	10Ω-1MΩ	E24	1p
1	5%	1Ω-3.9Ω	E12	3-5p
1	10%	4.7Ω-1MΩ	E12	1p
1	5%	1Ω-10Ω	E12	1p
1	10%	1Ω-10Ω	E12	6p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0.5 watt 5% Iskra resistors 5 off each value 4.7Ω to 1MΩ.
E12 pack 325 resistors £2.40. E24 pack 650 resistors £4.70.

POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log 1/2W, lin 1/4W).
Single, 12p. Dual gang (stereo), 40p. Single D.P. switch, 24p.

SKELTON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0-1 matrix).
Sub-miniature 0.1W, 5p each. Miniature 0.25W, 7p each.

TRANSISTORS

AC107	15p	AF126	20p	BF115	25p	OC42	12p	2N3707	12p
AC126	12p	AF139	32p	BF173	20p	OC44	12p	2N3708	10p
AC127	15p	AF178	32p	BF177	28p	OC45	12p	2N3709	11p
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
AF118	38p	BD133	75p	OC35	50p	2N3706	11p	ZTX503	20p

ZENER DIODES

400mW 5% 3.3V to 30V, 12p.

WIRE WOUND POTS

3W, 10, 25, 50Ω and decades to 100kΩ, 35p.

DIODES

RECTIFIER

BY127	1250V	1A	12p
IN4001	50V	1A	7p
IN4002	100V	1A	8p
IN4004	400V	1A	8p
IN4006	800V	1A	10p
IN4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
IN4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS

12in x 6in, 25p; 12in x 2 1/2in, 10p; 9in x 2in, 7p

THERMISTORS

VA10555	15p
VA10665	15p
VA1077	15p
R53	£1.35

SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K log. or lin. 40p.
DUAL GANG, 10K + 10K etc. log. or lin. 60p.
KNOB FOR ABOVE, 12p.
FRONT PANEL, 65p.
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THYRISTORS

2N5060 50V 0-8A	30p
2N5064 200V 0-8A	47p
106F 50V 4A	40p
106D 400V 4A	65p

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0.001μF, 0.0015μF, 0.0022μF, 0.0033μF, 0.0047μF, 2 1/2p. 0.0068μF, 0.01μF, 0.015μF, 0.022μF, 0.033μF, 3p. 0.047μF, 0.068μF, 0.1μF, 4p. 0.15μF, 6p. 0.22μF, 7 1/2p. 0.33μF, 11p. 0.47μF, 13p.
160V: 0.01μF, 0.015μF, 0.022μF, 0.033μF, 0.047μF, 0.068μF, 3p. 0.1μF, 3 1/2p. 0.15μF, 4 1/2p. 0.22μF, 5p. 0.33μF, 6p. 0.47μF, 7 1/2p. 0.68μF, 11p. 1.0μF, 13p.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0.01μF, 0.015μF, 0.022μF, 3p. 0.033μF, 0.047μF, 0.068μF, 3 1/2p. 0.1μF, 4p. 0.15μF, 0.22μF, 5p. 0.33μF, 6 1/2p. 0.47μF, 8 1/2p. 0.68μF, 11p. 1.0μF, 13p. 1.5μF, 20p. 2.2μF, 24p.

MYLAR FILM CAPACITORS 100V

0.001μF, 0.002μF, 0.005μF, 0.01μF, 0.02μF, 2 1/2p. 0.04μF, 0.05μF, 0.068μF, 0.1μF, 3 1/2p.

CERAMIC DISC CAPACITORS

100pF to 10,000pF, 2p each.

ELECTROLYTIC CAPACITORS—MULLARD O15/6/7

(μF/V) 1/63, 1.5/63, 2.2/63, 3.3/63, 4.7/63, 6.8/40, 6.8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6.3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6.3, 68/16, 100/4, 100/10, 100/25, 150/6.3, 150/16, 220/4, 220/6.3, 220/16, 330/4, 6p. 47/63, 100/40, 150/25, 220/25, 330/10, 470/6.3, 7p. 68/63, 150/40, 220/40, 330/16, 1000/4, 10p. 470/10, 680/6.3, 11p. 100/63, 150/63, 220/63, 1000/10, 12p. 470/25, 680/16, 1500/6.3, 13p. 470/40, 680/25, 1000/16, 1500/10, 2200/6.3, 18p. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6.3, 4700/4, 21p.

SOLID TANTALUM BEAD CAPACITORS

0.1μF 35V	2.2μF 35V	22μF 16V
0.22μF 35V	4.7μF 35V	33μF 10V
0.47μF 35V	6.8μF 25V	47μF 6.3V
1.0μF 35V	10μF 25V	100μF 3V

VEROBOARD

0.1	0.15
2 1/2 x 3 1/2	22p 16p
2 1/2 x 5	24p 24p
3 1/2 x 3 1/2	24p 24p
3 1/2 x 5	27p 27p
17 x 2 1/2	75p 57 1/2p
17 x 3 1/2	100p 78p
17 x 5 (plain)	82p
17 x 3 1/2 (plain)	60p
17 x 2 1/2 (plain)	42p
2 1/2 x 5 (plain)	12p
2 1/2 x 3 1/2 (plain)	11p
Pin insertion tool	52p 52p
Spot face cutter	42p 42p
Pkt. 50 pins	20p 20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2.5mm insulated	8p
Standard insulated	12p	3.5mm insulated	8p
Stereo screened	35p	3.5mm screened	13p
Standard socket	15p	2.5mm socket	8p
Stereo socket	18p	3.5mm socket	8p

D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, 15p/metre.
6 way screened cable, 22p/metre.

BATTERY ELIMINATOR £1.50

9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600μF 64V 74p	2500μF 64V 80p	4500μF 16V 50p
2500μF 40V 74p	2800μF 100V £2.60	4500μF 25V £1.68
2500μF 50V 58p	3200μF 16V 50p	5000μF 50V £1.10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0.01μF 10p	0.047μF 13p	0.22μF 20p
0.022μF 12p	0.1μF 13p	0.47μF 22p

POLYSTYRENE CAPACITORS 160V 2 1/2%

10pF to 1,000pF E12 Series Values, 4p each.

SMOKE AND COMBUSTIBLE GAS DETECTOR—GDI

The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs oxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, £2. Kit of parts for detectors including GDI and P.C. board but excluding case. Mains operated detector £5.20. 12 or 24V battery operated audible alarm £7.30. As above for PP9 battery, £6.40.

PRINTED BOARD MARKER

97p
Draw the planned circuit on to a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

LARGE RANGE ITT/TEXAS IC's NOW IN STOCK

PRICES ARE CALCULATED ON TOTAL NUMBER ORDERED REGARDLESS OF MIX

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7400	18	16	14	13	7450	16	14	13	74121	43	40	38	36
7401	18	16	14	13	7451	16	14	13	74141	100	95	90	85
7402	18	16	14	13	7453	16	14	13	74145	150	140	135	130
7403	18	16	14	13	7454	16	14	13	74150	330	280	250	220
7404	20	18	16	14	7460	16	14	13	74151	110	100	95	89
7405	20	18	16	14	7470	28	25	24	74153	120	110	105	95
7406	50	45	40	35	7472	28	27	23	74154	200	180	170	160
7407	56	50	44	38	7473	36	36	30	74155	150	120	100	86
7408	36	30	27	23	7474	36	32	28	74156	130	120	100	96
7409	36	30	27	23	7475	52	52	49	74180	155	136	112	105
7410	18	16	14	13	7476	36	32	30	74190	195	190	185	180
7411	23	21	20	18	7477	95	90	85	74191	195	190	185	180
7412	36	30	27	23	7480	115	110	105	74192	200	190	180	164
7413	34	28	26	22	7481	96	90	85	74193	200	180	170	150
7416	45	43	39	34	7482	96	95	92	74196	200	190	180	170
7420	18	16	14	13	7483	115	110	105	74197	200	195	180	170
7421	36	30	27	23	7484	245	240	230					
7426	32	29	23	20	7485	42	37	33					
7430	20	18	16	14	7486	60	52	47					
7432	40	36	32	28	7487	60	52	47					
7440	20	18	16	14	7488	92	85	79	709	14 pin DIL		40p	
7441	80	75	70	65	7489	70	65	60	741	8 pin DIL		40p	
7442	80	75	70	65	7490	68	60	52	741	14 pin DIL		38p	
7443	125	120	115	115	7494	95	85	80	723	8 pin DIL		95p	
7447	175	165	150	120	7495	100	95	90	747	14 pin DIL		85p	
					7496	95	90	85	748	8 pin DIL		45p	
					74100	250	240	235		DIL sockets	14 pin and 16 pin	16p	

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- BB1 **10** Reed Switches 1" long 3/8" dia. High speed P.O. type **55p**
- B99 **200** Mixed Capacitors. Approx. quantity, counted by weight. P & P 15p. **55p**
- H4 **250** Mixed Resistors. Approx. quantity, counted by weight. P & P 15p. **55p**
- H7 **40** Wirewound Resistors. Mixed types and values **55p**
- H9 **2** OCP71 Light Sensitive Photo Transistor **55p**
- H28 **20** OC200/1/2/3 PNP Silicon uncodded TO 5 can **55p**
- H30 **20** 1 Watt Zener Diodes. Mixed Voltages 6.8-43V. **55p**
- H35 **100** Mixed Diodes, Germ. Gold bonded etc. Marked and Unmarked. **55p**
- H38 **30** Short lead Transistors, NPN Silicon Planar types **55p**
- H39 **6** Integrated circuits, 4 Gates BMC 962, 2 Flip Flops BMC 945 **55p**
- H40 **20** BFY50/2, 2N696, 2N1613 NPN Silicon uncodded TO-5 **55p**
- H41 **2** Power Transistors Comp. Pair BD 131/132 **55p**

UNMARKED UNTESTED PAKS

- B1 **50** Germanium Transistors PNP, AF and RF. **55p**
- B66 **150** Germanium Diodes Min. glass type **55p**
- B83 **200** Trans. manufacturers' rejects all types NPN, PNP, Sil. and Germ. **55p**
- B84 **100** Silicon Diodes DO-7 glass equiv. to OA200, OA202 **55p**
- B86 **100** Sil. Diodes sub. min. IN914 and IN916 types **55p**
- H6 **40** 250mW Zener Diodes DO-7 Min. Glass Type **55p**
- H15 **30** Top Hat Silicon Rectifiers, 750mA Mixed volts **55p**
- H16 **15** Experimenters Pak of Integrated Circuits, Data supplied **55p**
- H17 **20** 3 Amp. Silicon Stud Rectifiers. Mixed volts **55p**
- H26 **40** NPN Silicon Trans. 2N3707-11 range, low noise amp. **55p**
- H34 **15** Power Transistors, PNP, Germ. NPN Silicon TO-3 Can. P & P 5p extra. **55p**

MAKE A REV COUNTER FOR YOUR CAR

The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with normal coil ignition system.

£1.10 each



OVER 1,000,000 TRANSISTORS IN STOCK

We hold a very large range of fully marked, tested and guaranteed Transistors, Power Transistors, Diodes and Rectifiers at very competitive prices. Please send for Free Catalogue.

Silicon Planar Plastic Transistors.

Unmarked, untested — factory clearance Audio PNP, similar to ZTX500, 2N3702/3, BCY70 etc. Audio NPN, similar to ZTX300, 2N3708/9, BC107/8/9, BC168/9 etc. R.F. NPN and Switching NPN. Please state type of transistor required when ordering.

ALL AT 500 for £3.30, 1,000 for £5.50, 10,000 for £44.00.

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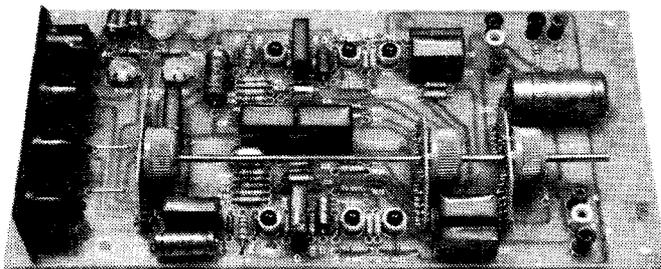
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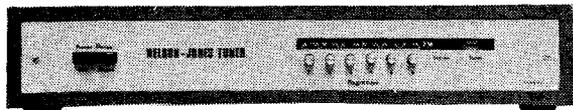
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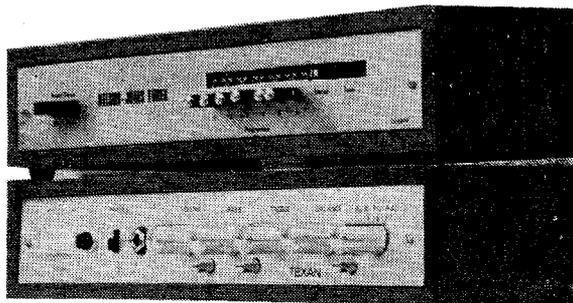
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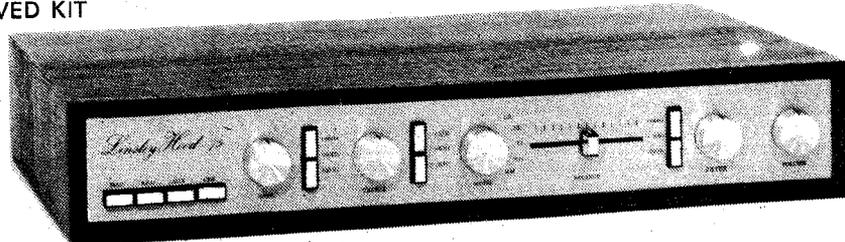
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Hi Fi News Linsley-Hood 75W Amplifier

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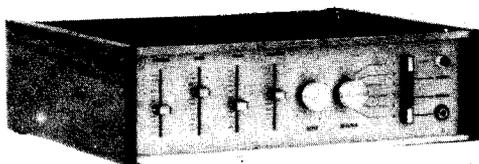
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SN7403N	0.20	0.18	0.16	SN7454N	0.20	0.18	0.16	SN74148N	2.01	2.01	1.63
SN7403AN	0.38	0.38	0.33	SN7456N	0.20	0.18	0.16	SN74150N	2.30	2.30	2.01
SN7404AN	0.24	0.21	0.18	SN7457N	0.33	0.30	0.27	SN74151N	1.15	1.15	1.00
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SN7405AN	0.44	0.44	0.38	SN7459N	0.44	0.41	0.37	SN74154N	2.30	2.30	2.01
SN7406N	0.40	0.38	0.35	SN7460N	0.48	0.48	0.42	SN74155N	1.15	1.15	1.00
SN7407N	0.40	0.38	0.35	SN7461N	0.59	0.55	0.51	SN74156N	1.09	1.09	1.00
SN7408N	0.25	0.22	0.19	SN7462N	0.45	0.36	0.32	SN74157N	1.09	1.09	0.95
SN7409N	0.33	0.33	0.28	SN7463N	0.80	0.70	0.50	SN74159N	2.44	2.44	2.14
SN7409AN	0.44	0.44	0.38	SN7464N	1.25	1.10	0.95	SN74160N	1.58	1.58	1.38
SN7410N	0.30	0.27	0.25	SN7465N	1.10	1.00	0.90	SN74161N	1.58	1.58	1.38
SN7411N	0.25	0.23	0.21	SN7466N	1.20	1.10	1.00	SN74162N	1.58	1.58	1.38
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SN7417N	0.20	0.18	0.16	SN7473N	0.75	0.70	0.63	SN74172N	5.76	5.76	5.04
SN7422N	0.28	0.28	0.25	SN7474N	0.85	0.80	0.75	SN74173N	1.66	1.66	1.45
SN7422AN	0.38	0.38	0.33	SN7475N	0.85	0.80	0.75	SN74174N	1.80	1.80	1.57
SN7423N	0.37	0.34	0.32	SN7476N	1.00	0.90	0.83	SN74175N	1.29	1.29	1.13
SN7425N	0.37	0.37	0.32	SN74100N	2.16	2.16	1.89	SN74176N	1.44	1.44	1.26
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SN7446N	2.16	2.16	1.89	SN74116N	0.72	0.72	0.63	SN74198N	3.16	3.16	2.77
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SC35B	200v	85p	
SC35D	400v	90p	
SC35E	500v	£1.29	
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SC40B	200v	95p	
SC40D	400v	£1.20	
SC40E	500v	£1.50	
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3 Amp T043	15 Amp T048		

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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	75p	
CRS 7/600	600v	95p	
SIXTEEN AMP (T043)			
CRS 16/100	100v	70p	
CRS 16/200	200v	75p	
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120 12 watt amplifier	4.70
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130 Mono control unit	3.60
605 Power supply for 115	4.55
610 Power supply for 120	4.55
615 Power supply for 2 x 120	5.73
230 AM/FM aerial amplifier	2.93
240 Auto packing light	5.30
275 Mic. preamplifier	6.68
570 LF generator 10Hz-1mHz	15.80
575 Sq. wave generator 20Hz-20KHz	14.60
590 SWR meter	12.85
620 Ni-CAD Charger 1-2-12v	8.00
630 STAB Power supply 6-12v 0.25-0.1A	8.15
690 DC motor speed Gov.	2.87
700 Electronic Chaffinch	7.00
705 Windscreen wiper timer	6.80
760 Acoustic switch	10.75
780 Metal Detector (electronics only)	9.65
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835 Delay car alarm	4.25
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875 CAP. Discharge ignition for car engine (-Ve Earth)	13.15
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255 Level indicator	6.15
525 120-160mHz VHF timer	11.30
715 Photo cell switch	7.70
795 Electronic continuity tester	4.30
860 Photo timer	13.25
371	

Henry's

U.K.'s LARGEST RANGE OF ELECTRONIC COMPONENTS AND EQUIPMENT AT BARGAIN PRICES

Latest Catalogue price 55p post paid. Complete with Discount Vouchers



Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15" x 23" x 6 1/2" 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 DOMINANT FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES:**

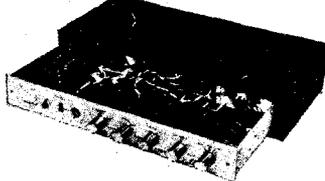
On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U. Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 30p. Distributed by Henry's throughout UK.

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20 + 20 WATT IC STEREO AMPLIFIER
As featured by *Practical Wireless* 1972



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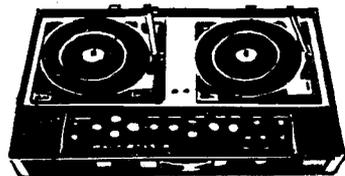
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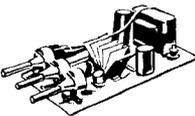
System 25 (list approx. £109) £79.50

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(plus 10% VAT and plus £1.45 carr/packing)

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FOR EVERY PURPOSE

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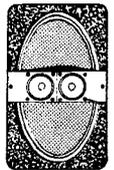
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- RP164** 6 7/8/12 volt 1 amp (Stab.) **£9.95** post 30p



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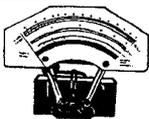
- EMI 13" x 8" full range speakers (post 20p each or 30p pair)
- *150TC—8 ohms Twin Cone 10 watt **£2.20** each or **£4.00** pair.
- *450 10 watt C/o Twin Tweeters 3, 3 or 15 ohms **£3.50** each or **£6.90** pair.
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GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Eraser heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. **£9.50** carr. 30p.



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Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg, 45p each.

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- AF105 50K/Volt with Leather case **£9.50**
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The complete testing system
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Amp AC—10 ranges from 200uA to 5A
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Resistance—1 range from 0 to 10MΩ
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Frequency—2 ranges from 0 to 500Hz and from 0 to 5000Hz
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ACCESSORIES

- Transistor tester **11.00**
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 Overload protection
 250 uA movement, clear scale
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 DC Current 0-50uA, 250 mA
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 Decibels -20 to +22 db.
 Carrying Case, Test Prods and Batteries included.
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Supplying 6 or 9 Volt DC at 200 mA
 In moulded case forming a 2 pin 5 A mains plug.
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Output switched 3, 4.5, 6, 7.5, 9 and 12 Volts at 500 mA D.C.
 Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players etc.
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 Price £3.95. Post 25p



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50 Volts 25p	50 Volts 35p	
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100 Volts 55p	50 Volts 70p	
200 Volts 59p	100 Volts 80p	
400 Volts 65p	200 Volts 90p	
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800 Volts £1.00	600 Volts £1.00	

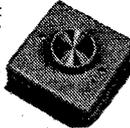
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A reliable unit ideal for timing Bathroom / Toilet Ventilators, Stairway / Cloakroom Lighting etc
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 Delay: 1-30 mins. adjustable.
 Max Load: 400 VA or 1000 Watts resistive.
 Ivory Case: 3 1/2 in. x 3 1/2 in. x 2 in.
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 Trade Price: £5.80. Post 20p.



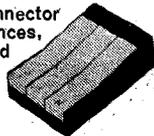
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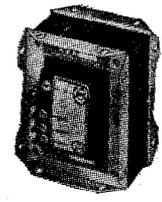
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Interwinding Screen
 Primary 120/240 Volts
 Secondary 120/240 Volts. Centre tapped

VA (WATTS)	TYPE	PRICE	POST
60	149	2.86	38
100	150	3.15	52
200	151	5.30	52
350	152	7.95	65
500	153	9.40	65
1000	154	13.55	£1.00
2000	156	22.99	£1.20
3000	158	41.25	*
5000	159	64.54	*
8000	160	105.90	*

The above are also available cased with lead and socket. *On application.



MINIATURE & EQUIPMENT

Pri. 240 Volts with Interwinding Screen.

VOLTS	mA	TYPE	PRICE	POST
3-0-3	200	No. 239	£ 1.12	D 10
0-6, 0-6	500, 500	234	1.18	10
0-6, 0-6	1000, 1000	212	1.28	22
9-0-9	100	13	.95	10
0-9, 0-9	330, 330	235	1.28	10
0-8-9, 0-8-9	500, 500	207	1.70	22
0-8-9, 0-8-9	1000, 1000	208	2.30	30
15-0-15	40	240	1.28	10
0-15, 0-15	200, 200	236	1.28	10
20-0-20	30	241	1.09	10
0-20, 0-20	150, 150	237	1.28	10
0-15-20, 0-15-20	500, 500	205	2.16	38
0-20, 0-20	300, 300	214	1.38	22
20-12-0-12-20	700 (DC)	221	1.21	30
0-15-20, 0-15-20	1000, 1000	206	3.10	38
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0-15-27, 0-15-27	1000, 1000	204	2.40	38

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AMPS	TYPE	PRICE	POST	
12V	No. 111	1.00	22	
0-5	0-5	213	1.23	22
2	1	71	1.60	22
4	2	18	2.25	38
6	3	70	2.70	42
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20	10	115	6.95	67
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30 VOLT

PRIMARY 200/240
 SECONDARY 12, 15, 20, 24, 30 AMPS

AMPS	TYPE	PRICE	POST
1/2	No. 112	1.20	22
1	79	1.64	38
2	3	2.45	38
3	20	3.00	40
4	21	3.55	52
5	51	4.40	52
6	117	5.28	52
8	88	6.80	67
10	89	8.36	67

50 VOLT

PRIMARY 200/240
 SECONDARY 19, 25, 33, 40, 50 AMPS

AMPS	TYPE	PRICE	POST
1/2	No. 102	1.60	30
1	103	2.35	38
2	104	3.25	42
3	105	4.40	52
4	106	5.48	52
6	107	8.85	67
8	118	11.27	97
10	119	14.15	97

60 VOLT

PRIMARY 200/240
 SECONDARY 24, 30, 40, 48, 60 AMPS

AMPS	TYPE	PRICE	POST
1/2	No. 124	1.60	38
1	125	2.25	38
2	127	3.55	42
3	125	5.40	52
4	123	6.98	67
5	40	8.46	67
6	120	9.20	82
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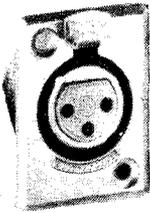
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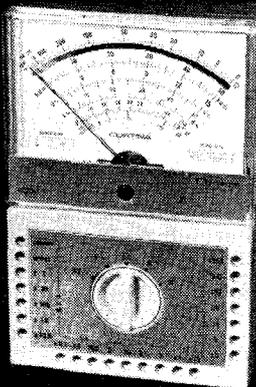
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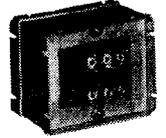
19 MULBERRY WALK, LONDON, S.W.3. TEL: 01-352 1897

WW-123 FOR FURTHER DETAILS

TRANSFORMERS

SAFETY MAINS ISOLATING TRANSFORMERS Pri 120/240V Sec 120/240V Centre Tapped & Screened P & P

Ref. No.	VA (Watts)	Weight lb oz	Size cm.	£	P & P
07	20	1 8	7-0x 7-0x 6-0	1.94	30
149	60	3 12	9-9x 7-7x 8-6	2.88	36
150	100	5 8	9-9x 8-9x 8-6	3.16	52
151	200	8 0	12-1x 9-3x 10-2	5.31	52
152	250	13 12	12-1x 11-8x 10-2	7.01	67
153	350	15 0	14-0x 10-8x 11-8	9.40	82
154	500	19 8	14-0x 13-4x 11-8	13.55	*
155	750	29 0	17-2x 14-0x 14-0	19.26	*
156	1000	38 0	17-2x 16-6x 14-0	24.97	*
158	2000	60 0	21-6x 15-3x 18-1	41.25	*
159	3000	85 0	25-5x 17-3x 17-7	64.53	*
160	6000	78 0	35-0x 20-4x 29-3	105.89	*



AUTO TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb oz	Size cm.	Auto Taps	£	P & P
113	20	1 0	5-8x 5-1x 4-5	0-115-210-240	1.02	22
64	75	2 4	7-0x 6-7x 6-1	0-115-210-240	2.00	36
4	150	3 4	8-9x 7-7x 7-7	0-115-200-220-240	2.42	36
66	300	6 4	9-9x 9-6x 8-6	" "	4.00	52
67	500	12 8	12-1x 11-2x 10-2	" "	6.98	67
84	1000	19 8	14-0x 13-4x 14-3	" "	12.69	82
93	1500	30 4	14-0x 15-9x 14-3	" "	18.39	*
95	2000	32 0	17-2x 16-6x 14-0	" "	24.00	*
73	3000	40 0	21-6x 13-4x 18-1	" "	32.67	*

CASED AUTO TRANSFORMERS

115V 500VA cased transformer, with mains lead and two 115V outlet sockets, £9.49. P & P 6p. A 20 Watt version. £2.02. P & P 22p.

LOW VOLTAGE TRANSFORMERS

Ref. No.	Amps.	12V 24V (Watts)	Weight lb oz	Size cm.	Secondary Windings		£	P & P
					Primary 200-250 Volts 12 AND/OR 24 VOLT RANGE	Secondary Windings		
111	0.5	0.25	8	4.8x 2.9x 3.5	0-12V at 0.25A x 2	1.02	22	
213	1.0	0.5	1 4	6.1x 5.8x 4.3	0-12V at 0.5A x 2	1.22	22	
71	2	1	1 12	7-0x 6.4x 6.1	0-12V at 1A x 2	1.60	22	
18	4	2	2 12	8.3x 7.7x 7.0	0-12V at 2A x 2	2.24	36	
70	6	3	3 8	8.9x 8.0x 7.7	0-12V at 3A x 2	2.70	42	
108	8	4	5 8	9-9x 8.9x 8.6	0-12V at 4A x 2	3.00	52	
72	10	5	6 4	9-9x 9.6x 8.6	0-12V at 5A x 2	3.55	52	
116	12	6	6 12	9-9x 10.2x 8.6	0-12V at 5A x 2	4.00	52	
117	16	8	8 12	12-1x 9.9x 10.2	0-12V at 8A x 2	5.48	52	
115	20	10	10 8	14-0x 9.6x 11.8	0-12V at 10A x 2	6.99	67	
187	30	15	15 8	14-0x 12.1x 11.8	0-12V at 15A x 2	12.90	82	
226	60	30	32 0	17-2x 15.3x 14.0	0-12V at 30A x 2	23.72	*	

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps		£	P & P
				Primary 200-250 Volts 12 AND/OR 24 VOLT RANGE	Secondary Taps		
112	0.5	1 4	6.1x 5.8x 4.8	0-12-15-20-24-30V	1.22	22	
79	1.0	2 4	7-0x 6.7x 6.1	" "	1.62	36	
3	2.0	3 4	8-9x 7.7x 7.7	" "	2.43	36	
20	3.0	4 8	9-9x 8.3x 8.6	" "	2.90	42	
21	4.0	6 4	9-9x 9.6x 8.6	" "	3.55	52	
51	6.0	6 12	12-1x 11.8x 10.2	" "	4.42	52	
117	8.0	8 0	12-1x 9.3x 10.2	" "	5.28	52	
88	8.0	12 0	12-1x 11.8x 10.2	" "	6.82	67	
89	10.0	13 12	14-0x 10.2x 11.8	" "	8.36	67	

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps		£	P & P
				Primary 200-250 Volts 12 AND/OR 24 VOLT RANGE	Secondary Taps		
102	0.5	1 12	7-0x 6.4x 6.1	0-19-25-33-40-50V	1.60	30	
103	1.0	2 12	8.3x 7.4x 7.0	" "	2.34	36	
104	2.0	5 8	9-9x 8.9x 8.6	" "	3.25	42	
105	3.0	6 12	9-9x 10.2x 8.6	" "	4.41	52	
106	4.0	10 0	12-1x 10.5x 10.2	" "	5.84	52	
107	6.0	12 0	14-0x 10.2x 11.8	" "	8.63	67	
118	8.0	18 0	14-0x 12.7x 11.8	" "	11.27	97	
119	10.0	25 0	17-2x 12.7x 14.0	" "	14.13	*	

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps		£	P & P
				Primary 200-250 Volts 12 AND/OR 24 VOLT RANGE	Secondary Taps		
124	0.5	2 4	7-0x 6.7x 6.1	0-24-30-40-48-60V	1.62	36	
126	1.0	3 4	8-9x 7.7x 7.7	" "	2.26	36	
127	2.0	6 4	9-9x 9.6x 8.6	" "	3.55	42	
125	3.0	8 12	12-1x 9.9x 10.2	" "	5.41	52	
123	4.0	13 12	12-1x 11.8x 10.2	" "	6.98	67	
40	5.0	12 00	14-0x 10.2x 11.8	" "	8.22	67	
120	6.0	15 8	14-0x 12.1x 11.8	" "	10.12	82	
121	8.0	25 00	14-0x 14.7x 11.8	" "	11.40	*	
122	10.0	25 0	17-2x 12.7x 14.0	" "	16.75	*	
189	12.0	29 00	17-2x 14.0x 14.0	" "	18.75	*	

Ref. No.	MA	Weight lb oz	Size cm.	Secondary Taps		£	P & P
				Primary 200-250 Volts 12 AND/OR 24 VOLT RANGE	Secondary Taps		
238	200	2	2.8x 2.6x 2.0	3-0-3	1.10	10	
212	1A 1A	1 4	6.1x 5.8x 4.8	0-6-0-6	1.27	22	
13	100	4	3.9x 2.6x 2.9	0-0-0	0.64	10	
235	330, 330	4	4.8x 2.9x 3.5	0-9-0-9	1.27	10	
207	500, 500	1 00	6.1x 5.4x 4.8	0-9-0, 0-9-0	1.70	22	
208	1A, 1A	1 12	7-0x 6.4x 6.1	0-8-9, 0-8-9	2.28	30	
236	200, 200	4	4.8x 2.9x 3.5	0-15, 0-15	1.27	10	
214	300, 300	1 4	6.1x 5.8x 4.8	0-20, 0-20	1.34	22	
221	700 (D.C.)	1 8	7-0x 6.1x 6.1	20-12-0-12-20	1.20	30	
206	1A, 1A	2 12	8.3x 7.7x 7.0	0-15-20, 0-15-20	3.08	38	
203	500, 500	2 4	8.3x 7.0x 7.0	0-15-27, 0-15-27	2.36	38	
204	1A, 1A	3 4	8.9x 7.7x 7.7	0-15-27, 0-15-27	2.38	38	

BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT (Secondary 2V, 6V, 12V)
Ref. No. Amps. Weight lb oz Size cm. £ P & P

45	1.5	1 8	7-0x 6.1x 6.1	1.81	30
5	4.0	3 4	8-9x 7.7x 7.7	2.45	42
86	6.0	6 4	9-9x 9.6x 8.6	3.70	52
146	8.0	6 12	9-9x 10.2x 8.6	4.22	52
50	12.5	12 0	14-0x 10.2x 11.8	6.29	67

*Carriage via B.R.S.
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WW-124 FOR FURTHER DETAILS

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AC107	0-20	AD161 & AD162 (MP)
AC113	0-20	AD162 (MP)
AC118	0-20	AD162 (MP)
AC117K	0-20	ADT140 0.51
AC122	0-13	AF114 0.27
AC125	0-19	AF115 0.27
AC126	0-19	AF116 0.27
AC127	0-20	AF117 0.27
AC128	0-20	AF118 0.39
AC132	0-18	AF124 0.38
AC134	0-16	AF125 0.38
AC137	0-16	AF126 0.31
AC141	0-20	AF127 0.81
AC141K	0-20	AF139 0.38
AC142	0-20	AF179 0.55
AC142K	0-22	AF180 0.55
AC151	0-17	AF181 0.55
AC154	0-22	AF186 0.56
AC155	0-22	AF239 0.41
AC156	0-22	AL102 0.72
AC157	0-27	AL103 0.72
AC165	0-22	ASV26 0.28
AC166	0-22	ASV27 0.28
AC168	0-27	ASV28 0.28
AC169	0-27	ASV29 0.28
AC176	0-16	ASV30 0.28
AC176	0-16	ASV31 0.28
AC177	0-27	ASV32 0.28
AC178	0-31	ASV34 0.28
AC179	0-31	ASV35 0.28
AC180	0-22	ASV36 0.28
AC180K	0-22	ASV37 0.28
AC181	0-22	ASV38 0.28
AC181K	0-22	ASV38 0.28
AC187	0-24	ASZ21 0.44
AC187K	0-24	BC107 0.10
AC188	0-24	BC108 0.10
AC188K	0-24	BC109 0.11
AC191	0-22	BC113 0.11
AC195	0-22	BC114 0.17
AC199	0-22	BC115 0.17
AC200	0-22	BC116 0.17
AC21	0-22	BC117 0.20
AC22	0-18	BC118 0.11
AC27	0-20	BC119 0.32
AC28	0-21	BC120 0.88
AC29	0-20	BC125 0.18
AC30	0-21	BC126 0.20
AC31	0-21	BC132 0.13
AC34	0-22	BC134 0.24
AC35	0-22	BC135 0.28
AC36	0-21	BC136 0.17
AC40	0-19	BC137 0.17
AC41	0-20	BC139 0.44
AD100	0-22	BC140 0.38
AD140	0-22	BC142 0.38
AD142	0-22	BC143 0.38
AD143	0-22	BC145 0.50
AD149	0-22	BC147 0.11
AD181	0-27	BC148 0.11
AD192	0-27	BC149 0.13

BC150	0-20	BD131 0.55
BC151	0-22	BD132 0.66
BC152	0-19	BD133 0.72
BC153	0-44	BD135 0.44
BC154	0-33	BD136 0.44
BC157	0-20	BD137 0.50
BC158	0-13	BD138 0.51
BC159	0-18	BD139 0.51
BC160	0-50	BD140 0.66
BC161	0-55	BD155 0.88
BC167	0-13	BD175 0.66
BC168	0-13	BD176 0.66
BC169	0-13	BD177 0.72
BC170	0-13	BD178 0.72
BC171	0-16	BD179 0.77
BC172	0-18	BD180 0.77
BC173	0-16	BD185 0.72
BC174	0-16	BD186 0.72
BC175	0-24	BD187 0.77
BC177	0-21	BD188 0.77
BC178	0-21	BD189 0.77
BC179	0-21	BD190 0.83
BC180	0-27	BD195 0.94
BC181	0-27	BD196 0.94
BC182	0-11	BD197 0.99
BC182L	0-11	BD198 0.99
BC183	0-11	BD199 1.05
BC183L	0-11	BD200 1.05
BC184	0-13	BD205 0.88
BC184L	0-13	BD206 0.88
BC186	0-31	BD207 1.05
BC187	0-31	BD208 1.05
BC188	0-12	BDY20 1.10
BC189	0-12	BDY21 1.10
BC189L	0-12	BDY22 1.10
BC190	0-13	BF115 0.27
BC191	0-13	BF116 0.27
BC191L	0-12	BF117 0.27
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BF397	0-33	OC195 0-22
BF398	0-33	OC196 0-22
BF399	0-33	OC197 0-22
BF400	0-33	OC198 0-22

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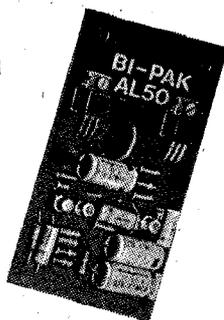
SN7400	1	25	100+	SN7451	1	25	100+	SN74145	1	25	100+
SN7401	0-18	0-17	0-18	SN7453	0-18	0-17	0-18	SN74150	22-90	22-80	22-70
SN7402	0-18	0-17	0-18	SN7454	0-18	0-17	0-18	SN74151	21-10	21-05	21-00
SN7403	0-18	0-17	0-18	SN7460	0-18	0-17	0-18	SN74152	21-30	21-20	21-10
SN7404	0-18	0-17	0-18	SN7470	0-32	0-29	0-27	SN74153	21-58	21-50	21-45
SN7405	0-18	0-17	0-18	SN7472	0-32	0-29	0-27	SN74154	21-58	21-50	21-45
SN7406	0-38	0-34	0-31	SN7473	0-41	0-39	0-35	SN74155	21-50	21-45	21-35
SN7407	0-38	0-34	0-31	SN7474	0-41	0-39	0-35	SN74156	21-50	21-45	21-35
SN7408	0-20	0-19	0-18	SN7475	0-50	0-48	0-44	SN74157	22-10	22-00	21-90
SN7409	0-20	0-19	0-18	SN7476	0-44	0-43	0-42	SN74158	22-10	22-00	21-90
SN7410	0-18	0-17	0-18	SN7480	0-74	0-71	0-64	SN74159	22-40	22-15	22-05
SN7411	0-28	0-27	0-28	SN7481	21-30	21-25	21-20	SN74160	22-40	22-15	22-05
SN7412	0-38	0-34	0-31	SN7482	0-98	0-95	0-94	SN74161	22-20	22-10	22-00
SN7413	0-38	0-31	0-30	SN7483	21-20	21-15	21-05	SN74162	22-20	22-10	22-00
SN7416	0-48	0-44	0-42	SN7487	21-10	21-05	21-00	SN74163	22-20	22-10	22-00
SN7417	0-48	0-44	0-42	SN7488	23-50	23-40	23-30	SN74164	22-20	22-10	22-00
SN7420	0-18	0-17	0-18	SN7486	0-35	0-34	0-33	SN74165	21-75	21-65	21-55
SN7422	0-55	0-53	0-50	SN7489	24-00	23-75	23-50	SN74166	21-85	21-75	21-65
SN7423	0-55	0-53	0-50	SN7490	0-74	0-71	0-64	SN74167	21-85	21-75	21-65
SN7425	0-55	0-53	0-50	SN7491	21-10	21-05	21-00	SN74168	21-50	21-40	21-30
SN7426	0-50	0-48	0-44	SN7492	0-74	0-71	0-64	SN74169	22-10	22-00	21-90
SN7427	0-50	0-48	0-44	SN7493	0-74	0-71	0-64	SN74170	22-10	22-00	21-90
SN7428	0-55	0-53	0-50	SN7494	0-85	0-82	0-75	SN74171	22-10	22-00	21-90
SN7430	0-18	0-17	0-18	SN7495	0-85	0-82	0-75	SN74172	22-10	22-00	21-90
SN7432	0-50	0-46	0-44	SN7496	0-98	0-93	0-86	SN74173	22-10	22-00	21-90
SN7433	0-75	0-73	0-70	SN74100	21-50	21-45	21-40	SN74174	22-10	22-00	21-90
SN7437	0-70	0-68	0-65	SN74104	21-07	21-04	21-00	SN74175	22-10	22-00	21-90
SN7438	0-70	0-68	0-65	SN74105	21-07	21-04	21-00	SN74176	22-10	22-00	21-90
SN7440	0-18	0-17	0-18	SN74107	0-44	0-42	0-40	SN74177	22-10	22-00	21-90
SN7441	0-74	0-71	0-64	SN74107	0-44	0-42	0-40	SN74178	22-10	22-00	21-90
SN7442	0-64	0-61	0-54	SN74110	0-60	0-55	0-50	SN74179	22-10	22-00	21-90
SN7443	21-20	21-15	21-10	SN74111	21-38	21-27	21-21	SN74180	22-10	22-00	21-90
SN7444	21-20	21-15	21-10	SN74118	21-10	21-05	21-00	SN74181	22-10	22-00	21-90
SN7445	21-20	21-15	21-10	SN74119	21-10	21-05	21-00	SN74182	22-10	22-00	21-90
SN7446	21-20	21-15	21-10	SN74121	0-50	0-48	0-45	SN74183	22-10	22-00	21-90
SN7447	21-10	21-07	21-05	SN74122	21-50	21-45	21-40	SN74184	22-10	22-00	21-90
SN7448	21-10	21-07	21-05	SN74123	21-50	21-45	21-40	SN74185	22-10	22-00	21-90
SN7450	0-18	0-17	0-18	SN74141	0-85	0-82	0-79	SN74186	22-10	22-00	21-90

The AL50 HI-FI AUDIO AMPL 50W pk 25w (RMS)

0.1% DISTORTION! HI-FI AUDIO AMPLIFIER

- Frequency Response 15Hz to 100,000—1dB.
 - Load—3, 4, 8 or 16 ohms. • Supply voltage 10-35 Volts.
 - Distortion—better than 0.1% at 1kHz.
 - Signal to noise ratio 80dB.
 - Overall size 63 mm x 105 mm x 13 mm.
- Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplifier needs.

BRITISH MADE. only £3.58 each



STABILISED POWER MODULE SPM80

£3.25



AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63 mm x 105 mm x 30 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disc Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2.15 p. & p. 25p

INTEGRATED CIRCUIT PAKS

Manufacturers "Full Outlets" which include Functional and Part-Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	= 12 x 7400	0-55	UIC46	= 5 x 7446	0-55	UIC90	= 5 x 7490	0-55
UIC01	= 12 x 7401	0-55	UIC48	= 5 x 7448	0-55	UIC91	= 5 x 7491	0-55
UIC02	= 12 x 7402	0-55	UIC50	= 12 x 7450	0-55	UIC92	= 5 x 7492	0-55
UIC03	= 12 x 7403	0-55	UIC51	= 12 x 7451	0-55	UIC93	= 5 x 7493	0-55
UIC04	= 12 x 7404	0-55	UIC53	= 12 x 7453	0-55	UIC94	= 5 x 7494	0-55
UIC05	= 12 x 7405	0-55	UIC54	= 12 x 7454	0-55	UIC95	= 5 x 7495	0-55
UIC06	= 8 x 7406	0-55	UIC60	= 12 x 7460	0-55	UIC96	= 5 x 7496	0-55
UIC07	= 8 x 7407	0-55	UIC70	= 8 x 7470	0-55	UIC100	= 5 x 74100	0-55
UIC10	= 12 x 7410	0-55	UIC72	= 8 x 7472	0-55	UIC121	= 5 x 74121	0-55
UIC20	= 12 x 7420	0-55	UIC73	= 8 x 7473	0-55	UIC141	= 5 x 74141	0-55
UIC30	= 12 x 7430	0-55	UIC74	= 8 x 7474	0-55	UIC151	= 5 x 74151	0-55
UIC40	= 12 x 7440	0-55	UIC76	= 8 x 7476	0-55	UIC154	= 5 x 74154	0-55
UIC41	= 8 x 7441	0-55	UIC80	= 5 x 7480	0-55	UIC193	= 5 x 74193	0-55
UIC42	= 8 x 7442	0-55	UIC81	= 5 x 7481	0-55	UIC195	= 5 x 74195	0-55
UIC43	= 8 x 7443	0-55	UIC82	= 5 x 7482	0-55	UIC198	= 5 x 74198	0-55
UIC44	= 8 x 7444	0-55	UIC83	= 5 x 7483	0-55			
UIC45	= 8 x 7445	0-55	UIC86	= 5 x 7486	0-55			

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC XL.

LINEAR I.C.'S—FULL SPEC.

Type No.	Case	1	25	100+
72702	DIL	14	0-50	0-45
72709	DIL	14	0-35	0-30
72710	DIL	14	0-45	0-40
72741	DIL	14	0-40	0-38
72741C	TO-5	8	0-45	0-43
72741P	DIL	8	0-38	0-36
72748P	DIL	8	0-38	0-36
SL701C	TO-5	8	0-50	0-45
SL701C	TO-5	8	0-50	0-45
SL702C	TO-5	8	0-50	0-45
TAA263	TO-72	4	0-80	0-70
TAA293	TO-74	10	21-00	21-00
TAA350A	TO-5	10	21-95	21-80
HA703C	TO-5	6	0-28	0-24
HA709C	TO-5	8	0-35	0-30
HA711	TO-5	10	0-45	0-43
EA1000	—	—	22-00	—
ZN414	TO-18	4	21-20	—

DTL 930 SERIES

Type	1	25	100+
BP900	0-15	0-14	0-13
BP932	0-16	0-15	0-14
BP933	0-16	0-15	0-14
BP935	0-16	0-15	0-14
BP936	0-16	0-15	0-14
BP944	0-16	0-15	0-14
BP945	0-30	0-28	0-25
BP946	0-15	0-14	0-13
BP948	0-30	0-28	0-25
BP951	0-70	0-65	0-60
BP962	0-15	0-14	0-13
BP903	0-48	0-43	0-40
BP904	0-45	0-40	0-38
BP907	0-45	0-43	0-40
BP909	0-45	0-43	0-40

DUAL-IN-LINE SOCKETS

Type	Description	16p	14p	12p
MAN 3M	L.E.D. 7 Segment Indicator	—	—	—
CD 66	Side Viewing 'Nixie Type' Tube 16 mm.	—	—	—
GR 116	Side Viewing 'Nixie Type' Tube 19 mm.	—	—	—

3 TERMINAL POSITIVE VOLTAGE REGULATORS

To3 Plastic Encapsulation O/P 1.5 Amps.	
HA7805 5V (Equiv. to MVR5V)	£1.78
HA7812 12V (Equiv. to MVR12V)	£1.78

BI-PAK CATALOGUE & LISTS

Send S.A.E. and 10p

TEAK VENEERED CABINETS for:

STEREO 20

TC 20. £3.95 p&p 30p

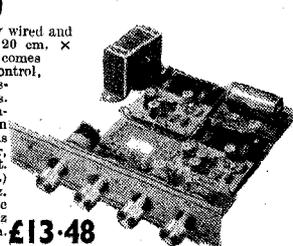
MK 50 KIT

TC 100. £6.50 p&p 30p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pair. OUR SPECIAL PRICE £35.50 per pair. £1 ONLY WHILE STOCKS LAST!

The STEREO 20

The Stereo 20 amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. x 14 cm. x 5.5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion: Bass control ± 1.2 dB at 60Hz typically 0.25% at 1 watt. Treble con. ± 1.4 dB at 14kHz.



£13.48

FRONT PANEL, 4 knobs, Headphone Socket, on/off switch and neon for PA100/MK50. PPK100 £2.95.

TRANSFORMERS

T461 (Use with AL10)	£1.88 P. & P. 15p.
T538 (Use with AL20)	£1.93 P. & P. 15p.
BMT80 (Use with AL30 & AL50)	£2.15 P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10 & AL20)	85p
SPM 80. (Use with also AL30 & AL50)	£3.25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with ceramic cartridge while the auxiliary input will suit most magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 162mm x 84mm x 35mm. PRICE £4.35.

FRONT PANELS FP12 with knobs £1.20

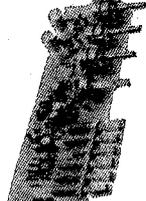
STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:
Frequency response 20Hz-20kHz ± 1 dB
Harmonic distortion better than 0.1%
Input: 1. Tape head 1.25mV into 50K Ω
2. Radio, Tuner 35mV into 50K Ω
3. Magnetic P.L. 1.5mV into 50K Ω
All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ± 1 dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p.&p.



only £13.15

BENTLEY ACOUSTIC CORPORATION LTD.

7A GLOUCESTER ROAD, LITTLEHAMPTON, SUSSEX. Tel. 6743
ALL PRICES SHOWN INCLUDE V.A.T.

0A2	0.33	6BCS	0.60	6L7M	0.50	12AU6	0.38	30P16	0.81	AZ1	0.40	0C88	0.59
0B2	0.33	6B5E	0.23	6L12	0.34	12AU7	0.25	30P19	0.34	AZ31	0.46	0C92	0.34
0Z4	0.44	6B6G	1.05	6L18	0.49	12AV6	0.28	30P4	0.75	AZ41	0.53	0C93	1.50
1A3	0.49	6B1H	0.70	6L21	0.20	12AX7	0.25	30P11	0.57	B319	0.29	0C83	1.50
1A5GT	0.49	6B1K	0.60	6L22	0.30	12AX7	0.30	30P12	0.32	BL63	0.30	0C84	0.95
1A7GT	0.49	6B1K	0.60	6L20	0.55	12BA6	0.30	30P13	0.30	CL33	0.90	0C40	0.75
1B3GT	0.49	6BQ3	0.23	6N7GT	0.60	12B7E	0.27	30P14	0.75	CV6	0.53	0C84	0.75
1C2	0.50	6BQ7A	0.60	6P15	0.23	12B7E	0.30	30P15	0.75	CV68	0.53	0C82	0.25
1G6	0.75	6BR7	0.90	6P28	0.70	12J5GT	0.35	35A3	0.48	CV888	0.10	0C83	0.25
1B5GT	0.55	6BR8	0.75	6P12	0.28	12J5GT	0.35	35A5	0.75	CV1C	0.55	0C84	0.30
1L4	0.14	6B57	1.40	6Q7G	0.50	12K5	0.55	35D5	0.70	CV31	0.46	0C85	0.34
1L5	0.68	6B1W	0.72	6Q7H	0.50	12K7GT	0.38	35L6T	0.70	D63	0.25	0C86	0.85
1L6	0.68	6B1W	0.72	6Q7M	0.55	12K7GT	0.38	35V4	0.30	DAC92	0.55	0C88	0.44
1N5GT	0.60	6B1X	0.23	6R7G	0.60	12S4GT	0.55	35Z3	0.50	DAF96	0.36	0C8189	0.53
1R5	0.28	6B1V	0.28	6R7M	0.75	12S7C	0.50	35Z4GT	0.40	DC90	0.60	0C804	0.55
1R4	0.33	6B26	0.48	6SA7M	0.44	12S7C	0.38	35Z5GT	1.00	DD4	1.00	0C807	1.00
1R5	0.25	6C4	0.28	6S7GT	0.33	12S7C	0.38	35Z6	0.35	DF91	0.30	0C8F20	0.27
1U4	0.44	6C4	0.28	6S7M	0.44	12S7H	0.35	35Z8	0.35	DF96	0.38	0C8F22	0.34
1U5	0.60	6C9	1.00	6SH7	0.44	12S7H	0.44	35Z9	0.35	DH63	0.44	0C8F86	0.64
2D21	0.44	6C86A	0.40	6S7GT	0.35	12S7GT	0.35	35Z10	0.35	DH76	0.45	0C8F84	0.64
2D24	0.55	6C12	0.28	6S7GT	0.35	14H7	0.55	35Z11	0.35	DH77	0.30	2.10	
3A4	0.36	6C17	1.00	6S7GT	0.38	14H7	0.55	35Z12	0.35	DH81	0.75	0C8H21	1.50
3B7	1.00	6C06G	0.60	6U4GT	0.70	18	1.00	35Z13	0.35	DK92	0.33	0C8H35	0.50
3D6	0.18	6C84A	0.75	6U7G	0.75	19A05	0.42	35Z14	0.35	DK49	0.55	0C8H42	0.85
3Q4	0.49	6C1H	0.55	6V7G	1.00	19B6G	0.40	35Z15	0.35	DK92	0.50	0C8H81	0.28
3Q5GT	0.55	6C1H	0.55	6V6G	0.17	19B6G	0.40	35Z16	0.35	DK96	0.45	0C8H83	0.44
3S4	0.26	6C18A	0.80	6V6GT	0.27	19H1	2.00	35Z17	0.35	DL92	0.28	0C8H84	0.44
4C6	0.55	6C1M	0.75	6X4	0.30	20D1	0.55	35Z18	0.35	DL96	0.38	0C8L80	0.40
5C8	0.55	6C1U5	0.75	6X5GT	0.28	20D4	2.00	35Z19	0.35	DM70	0.30	0C8L82	0.28
5E4GY	0.70	6C1V4	0.70	6Y7G	0.65	20P2	0.67	35Z20	0.35	DM71	0.50	0C8L83	0.52
5T4	0.30	6D3	0.60	6Y7G	1.00	20P2	0.67	35Z21	0.35	OC1	0.59	0C8L84	0.54
5U4G	0.80	6DE7	0.75	7A4	1.00	20P1	0.58	35Z22	0.35	OC19	0.59	0C8L85	0.54
5V4G	0.35	6DT6	0.75	7B6	0.75	20P1	0.58	35Z23	0.35	OC19	0.59	0C8L86	0.54
5Y3GT	0.30	6E6W	0.75	7B7	0.50	20P3	0.75	35Z24	0.35	OC19	0.59	0C8L87	0.54
5Z3	0.55	6E5	0.75	7H7	1.00	20P5	0.95	35Z25	0.35	OC19	0.59	0C8L88	0.54
5Z4GT	0.35	6E6G	0.60	7R7	1.50	25A6G	0.38	35Z26	0.35	OC19	0.59	0C8L89	0.54
6A0L2	0.55	6F12	0.17	7V7	1.00	25L6G	0.30	35Z27	0.35	OC19	0.59	0C8L90	0.54
6A8G	0.44	6F13	0.45	7Y4	0.65	25Y5	0.38	35Z28	0.35	OC19	0.59	0C8L91	0.54
6AC7	0.15	6F14	0.40	7Z4	0.60	25Y6	0.38	35Z29	0.35	OC19	0.59	0C8L92	0.54
6AG5	0.27	6F15	0.65	9RW6	0.65	25Z4G	0.35	35Z30	0.35	OC19	0.59	0C8L93	0.54
6AH9	0.50	6F18	0.50	9D7	0.40	25Z5	0.60	35Z31	0.35	OC19	0.59	0C8L94	0.54
6AJ5	0.75	6F23	0.65	10C2	0.55	25Z6G	0.70	35Z32	0.35	OC19	0.59	0C8L95	0.54
6AJ8	0.28	6F24	0.60	10C14	0.29	28D7	1.00	35Z33	0.35	OC19	0.59	0C8L96	0.54
6AJ9	0.28	6F25	0.51	10D1	0.70	30A5	0.65	35Z34	0.35	OC19	0.59	0C8L97	0.54
6AK6	0.60	6F26	0.28	10D27	0.55	30C1	0.28	35Z35	0.35	OC19	0.59	0C8L98	0.54
6AK8	0.30	6F28	0.60	10F1	0.50	30C15	0.58	35Z36	0.35	OC19	0.59	0C8L99	0.54
6AL5	0.12	6F32	0.30	10F9	0.60	30C17	0.76	35Z37	0.35	OC19	0.59	0C8L100	0.54
6AM8A	0.55	6G6G	0.38	10T18	0.55	30C18	0.70	35Z38	0.35	OC19	0.59	0C8L101	0.54
6AN8	0.49	6GH8A	0.75	10L14	0.33	30C18	0.70	35Z39	0.35	OC19	0.59	0C8L102	0.54
6AQ5	0.35	6GK5	0.65	10L11	0.70	30C18	0.70	35Z40	0.35	OC19	0.59	0C8L103	0.54
6AQ8	0.34	6G7U	0.75	10L12	0.30	30C18	0.70	35Z41	0.35	OC19	0.59	0C8L104	0.54
6AR5	0.55	6H6GT	0.18	10P12	0.30	30C18	0.70	35Z42	0.35	OC19	0.59	0C8L105	0.54
6AR6	1.00	6J5GT	0.29	10P13	0.54	30C18	0.70	35Z43	0.35	OC19	0.59	0C8L106	0.54
6AS7	0.30	6J7C	0.20	10P14	0.30	30C18	0.70	35Z44	0.35	OC19	0.59	0C8L107	0.54
6A16	0.28	6J7G	0.24	10P18	0.35	30C18	0.70	35Z45	0.35	OC19	0.59	0C8L108	0.54
6AV6	0.33	6J7UA	0.75	12A6C	0.55	30C18	0.70	35Z46	0.35	OC19	0.59	0C8L109	0.54
6AW8A	0.65	6K7G	0.19	12AD6	0.60	30C18	0.70	35Z47	0.35	OC19	0.59	0C8L110	0.54
6AX4	0.55	6K8G	0.33	12A6C	0.60	30C18	0.70	35Z48	0.35	OC19	0.59	0C8L111	0.54
6B8X	0.28	6L1	2.00	12A7G	0.30	30C18	0.70	35Z49	0.35	OC19	0.59	0C8L112	0.54
6BA6	0.25	6L9GT	0.55	12AT2	0.20	30C18	0.70	35Z50	0.35	OC19	0.59	0C8L113	0.54

EL84	0.28	P61	0.40	PY80	0.33	UY85	0.23	2N966	0.58	AF178	0.75	PSY41A	0.25	OC29	0.48
EL85	0.40	PABCO80	0.32	PY81	0.31	U0	0.45	2N1756	0.55	AF180	0.53	GD4	0.36	OC24	0.42
EL86	0.38	P82	0.32	PY82	0.25	U12/14	0.38	2N2147	0.94	AF186	0.61	GD5	0.81	OC25	0.42
EL91	0.38	PC86	0.60	PY83	0.33	U16	0.75	2N2997	0.25	AF239	0.42	GD6	0.81	OC28	0.66
EL95	0.39	PC88	0.60	PY88	0.33	U17	0.35	2N3694	0.24	ASV27	0.47	GD8	0.22	OC29	0.68
EL96	0.39	PC89	0.60	PY89	0.33	U19	0.75	2N2518	0.43	ASV28	0.30	GD9	0.22	OC35	0.35
EL97	0.39	PC90	0.60	PY90	0.33	U20	1.73	2N3053	0.36	ASV29	0.55	GD11	0.22	OC36	0.47
EL98	0.39	PC90	0.28	PY90A	0.30	U22	0.39	2N3121	2.75	BA102	0.50	GD12	0.22	OC38	0.47
EM81	0.37	PC84	0.29	PY80	0.31	U25	0.65	2N3703	0.21	BA115	0.15	GD14	0.55	OC41	0.55
EM83	0.75	PC85	0.24	PY81	0.31	U26	0.60	2N3709	0.22	BA116	0.28	GD15	0.44	OC42	0.68
EM84	0.31	PC85	0.39	PZ30	0.48	U31	0.33	2N3866	1.10	BA129	0.14	GD16	0.22	OC43	1.30
EM85	1.00	PC89	0.42	Q21	0.50	U32	1.50	2N3985	0.55	BA130	0.11	GD17	0.22	OC44	0.11
EM87	0.49	PC189	0.48	QVQ03/10	0.30	U33	0.65	2S323	0.55	BA135	0.17	GD18	0.44	OC45	0.12
EM88	0.33	PC80	0.28	Q875/10	1.20	U37	1.75	AA119	0.17	BCY10	0.50	GD19	0.22	OC46	0.12
EM89	2.00	PC82	0.33	Q875/10	1.20	U45	0.78	AA120	0.17	BCY12	0.55	GD20	0.22	OC65	1.24
EY51	0.35	PCF84	0.40	Q875/10	1.20	U47	0.65	AA129	0.17	BCY33	0.22	GD21	0.42	OC70	0.14
EY81	0.35	PCF86	0.48	Q895/10	0.49	U49	0.60	AAZ13	0.20	BCY34	0.25	GD22	0.47	OC71	0.12
EY83	0.50	PCF87	0.76	Q895/10	0.49	U50	0.30	AC107	0.17	BCY38	0.25	GD23	0.47	OC72	0.12
EY84	0.50	PCF200	0.67	Q895/10	0.49	U51	0.31	AC113	0.17	BCY39	0.28	GD24	0.47	OC73	0.12
EY85	0.50	PCF200	0.67	Q895/10	0.49	U52	0.30	AC114	0.17	BCY40	0.28	GD25	0.47	OC74	0.12
EY86	0.50	PCF200	0.67	Q895/10	0.49	U53	0.31	AC126	0.14	BC108	0.14	GD26	0.28	OC75	0.17
EY87	0.50	PCF200	0.67	Q895/10	0.49	U54	0.31	AC127	0.17	BC113	0.18	GD27	0.28	OC76	0.17
EY88	0.40	PCF801	0.48	R11	0.98	U55	0.19	AC128	0.22	BC115	0.17	GD28	0.28	OC77	0.17
EY89	0.58	PCF802	0.37	R16	1.75	U59	0.65	AC129	0.22	BC116	0.28	GD29	0.28	OC78	0.17
EZ25	0.28	PCF805	0.70	R17	0.88	U92	0.25	AC132	0.22	BC118	0.25	GD30	0.28	OC79	0.44
EZ40	0.40	PCF806	0.55	R18	0.50	U93	0.31	AC134	0.22	BC119	0.25	GD31	0.28	OC81	0.12
EZ41	0.42	PCF808	0.68	R19	0.28	U95	0.65	AC136	0.22	BC121	0.42	GD32	0.28	OC82	0.12
EZ80	0.19	PCF200	0.62	R20	0.40	U98	0.21	AC165	0.28	BF158	0.32	GD33	0.28	OC82	0.12
EZ81	0.25	PCF82	0.32	R22	0.33	U99	0.40	AC166	0.28	BF159					

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TELEVISION SWEEP GENERATOR

by Sweep systems type 505. Frequency coverage 450-940MHz. (Channels 15-80). Markers at 465/565/660/750/830 and 900MHz. Attenuated output in eight, five db steps and fine 0-10 db. Sweep width adjustable from 1-15MHz. The instrument is completely solid-state using varactor diodes and transistors throughout. Dims: 19 x 12 x 5ins. Wt.: 20lbs. Supplied in good working order, price **£59.50** + 50p carriage.



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. x 1/2 in. Offered brand new, boxed. Price **£1.50**, inc. P.&P.

'ALCAD' Sealed rechargeable Nickel-cadmium batteries. Type W3.5, 1.2V at 3.5 Ah. Size as 'U2'. Offered new in packs supplying 12V, £15. Or separately at **£1.25**.

Automatic Constant current electronic battery chargers specially designed for nickel cadmium cells. Metered and fused. Up to twelve cells can be charged up to 750mA, variable 0-750mA. Size 7x6x5ins. Brand new units. Price each **£17**.

Smiths Ltd Weight indicators, self powered, measures 0 to 20 cwts in 1 cwt divisions on a 4" circscale meter indicator, 30 feet of cable and heavy duty load cell use with bell crank or actual reading is 5 cwt for F.S.D. brand new units special price **£7.50** post 50p.

Cosor Electronic Invertors type CRA 200. A high quality device for producing a 115v 400Hz single phase output. Incorporating the following features: Input 23-28V D.C.
* Full overload protection.
* Sine wave output.
* 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 x 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-199V. 199 Measuring points. Input impedance 100Mohm. Automatic zeroing. Measurements: 155mm x 72mm x 72mm. List price was **£52.00**. OUR PRICE **£24.50**.

DIGITAL MEASUREMENT Type 2003 Digital Voltmeter. 3 1/2 Digit display. Measuring up to 1000 Volts. AS NEW **£65**.

SHNEIDER ELECTRONICS CF350 Frequency counter. Measures frequency, periods, ratios. ABC chrono inputs. Memorised display. High sensitivity and impedance. Crystal timebase. BCD outputs. Frequency range DC-12MHz. Rise time better than 50ms. Small compact unit. Completely solid-state. Send for further technical specification. Offered brand new. Price **£250**.

500 MHz FREQUENCY DIVIDER TCD 500. Sensitivity 10mV (1-300MHz), 50mV (300-500MHz). The TCD500 is designed to extend the range of existing frequency counter by 10 or 100 times to a maximum of 500MHz. Completely self-contained, no external standards required. The TCD500 is suitable for any type frequency counter over 1MHz. Solid-state, small size. Brand new. Price only **£100**.

High torque geared motors. 20RPM. 6-9V. operation. Built-in gearbox. Overall size 2ins. long by 1in. diameter. Current drain at 6V only 8mA. These are precision, Swiss made geared motors. Original price was over **£6** each. Our price each is only **£1.50** (plus 10p each post and packing).

DIGITAL FREQUENCY METER type 'FT300'—reads as frequency meter up to 99.99KHz in three ranges or as tachometer, 99,990 RPM. Solid-state instrument. Clear read-out. Size only 8in. by 5in. by 2 1/2in. Weight 4 1/2 lbs. BCD outputs. Operating voltage 110/240 V. AC. Made by famous manufacturer. These units are brand new in original makers cartons. Our price: **£55**.

Rohde & Schwarz Electronic multi-meter type URI. AC Voltage 100mV to 3kV (to 200MHz). Current 100uA to 1A. DC Voltage 20mV—30kV. Current 2nA-1A. Resistance 5 ohms to 1000M ohms. Supplied as new with all leads etc. for just **£65**.

Rohde & Schwarz HUZ. Field strength measuring receiver. Range 47 to 225 MHz. AM and FM. Sensitivity 5uV—100mV. Built-in dipole. A portable instrument. Battery or mains powered. **£105**.

RF WATTMETER. Airmec type 319A. Frequency 1-1400MHz. Measures side-bands, CW, Mod. depth. Meter range 0-100mW and 0-300mW. Input impedance—50ohms. Supplied in first-class operating condition. **£45**.

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 $\pm 0.1\%$. BRAND NEW. **£75**.

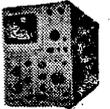
TINSLEY type 4363D Vernier potentiometer. Good condition. Price **£75**.

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.

TEKTRONIX type 545A OSCILLOSCOPE. Complete with 'CA' plug-in unit. As new. Perfect condition, calibrated to manufacturers standards. Bandwidth to 30MHz. This offer is too good to miss. Price only **£295** (plus V.A.T.)

Solartron digital voltmeter CT469 with AC plug-in. DC, 1000V. AC, 500V. Many facilities are incorporated in this instrument, c/w handbook. Sold as new condition. Price **£275**.

Rohde & Schwarz URV. 1KHz—1600MHz. UHF milli-voltmeter. Range 1mV-20V with probe insertion unit. **£75**.

SIGNAL GENERATORS

Marconi type TF801D. 10-485MHz. Excellent. **P.U.R.**

Marconi type TF867. 15KHz-30MHz. **£150**.

Rohde & Schwarz UHF Signal Generator. 1000MHz—1900MHz. In four ranges. Output 0.7—7V into 52 ohms. Piston type attenuator. Price **£125**.

Rohde & Schwarz SMCK SHF Signal Generator. 1.7-5GHz. Price **£75**.

Hewlett-Packard 202A LF Function Generator. Range .008Hz to 1.2KHz. Sine, square and triangular O.P. waveforms. As new condition. Price **£45**.



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 **£30**.

MARCONI TF340 AF power meters. As above but limited to 6 Watts. **£25** each.

MARCONI Sensitive Voltmeter type TF2600. As new. 1mV—300 Volt. Full-scale deflection. 12 ranges, with dbm markings. A modern instrument. Only **£50**.

TF2162 MF attenuator. DC-1MHz. 0-111db 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/I A.M. Signal Generator up to 470MHz.

TF1041B Voltmeter. 300mV-300V. 20Hz-1500MHz. **£45**.

MARCONI DOUBLE PULSE GENERATOR TF1400/S. With secondary P.G. Type 6600/I. As new condition. **£105**.

OA1094AHF Spectrum Analyser 100KHz-30MHz. As new.

TF1417 Counter, Frequency Meter 7 digits. Plus range extension unit TF1434/2 to 220MHz. As new.

Latest Advance DMV4 Digital readout multi-meter. AD/DC Volts, resistance, etc. Brand new. **£65**.

PO type, 316, Jack Plugs. Complete with leads. Good condition. Price **£2** for ten.

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ADVANCE type TCIA Timer-counter. Solid-state. 6 digit readout. Manual or auto. (electronic) stop/start. As frequency meter —1Hz—1MHz, or timer with all facilities. Brand new with handbook, leads, etc. **£125**.

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.

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VALVES

AZ31 0-60	DY802 0-37	ECF82 0-40	EF98 0-75	EZ50 0-28	OA2 0-40	PD500 1-30	FY82 0-35	UCH42 0-70	8S4 0-40	6BW7 0-90	6V6GT 0-45	30C15 1-05	807 0-50
AZ41 0-60	RABC80	ECH35 1-25	EF183 0-30	EZ61 0-29	OB2 0-40	PEM45DD	FY83 0-35	UCH81 0-40	3V4 0-48	6C4 0-35	6X4 0-40	30C17 1-10	6080 1-75
CB131 1-00		ECH42 1-00	EF184 0-35	EZ90 0-40	OZ4 0-45		FY800 1-00	UCL82 0-30	3R4GY 0-75	6CD6G 1-00	6X5GT 0-45	30C18 0-80	6146 1-60
CL83 1-60	BAF42 0-38	ECH81 0-30	EF190 0-50	PE86 0-60	PC86 0-60	PFL2000 0-75	FY801 1-00	UCL83 0-75	3V4G 0-75	6CH6 0-80	7B6 0-75	30F5 1-10	TUBES
CV31 0-50	BAF8010-60	ECH83 0-45	EL32 0-75	GZ30 0-45	PC88 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DAF91 0-80	EBC81 1-00	ECH84 0-45	EL34 0-80	GZ32 0-50	PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DAF95 0-80	EBC41 0-75	ECL82 0-35	EL41 0-90	GZ34 0-50	PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DC090 1-35	EBC81 0-33	ECL86 0-40	EL42 0-90	H3 0-60	PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DF91 0-80	EBF80 0-40	ECL800	EL84 0-25	HL41DD	PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DF96 0-60	EBF81 2-25		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DX21 0-45	EBF82 1-30		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DK92 0-70	EBF81 0-32		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DK96 0-60	EBF82 1-25		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DL92 0-40	EBF80 0-25		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DL94 0-48	EBF83 0-35		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DL96 0-55	EBF84 0-35		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DM70 0-60	EBF85 0-40		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00
DY86/7 0-37	ECF80 0-35		EL81 0-40		PC89 0-60	PL38 0-35	SP1 0-75	UF1 0-75	3V4G 0-60	6E1 0-70	7B7 0-70	30FL1 0-75	2AT1 4-00

TRANSISTORS

IN21 0-17	2N708 0-15	2N3709 0-10	AP116 0-25	BF195 0-15	CR83-40	GJ7M 0-37	NKT128	OA95 0-07	OC26 0-25	OC71 0-15	OC84 0-25	ORP60 0-40
IN23 0-20	2N1302 0-18	2N3710 0-10	AP117 0-25	BF196 0-15	CS10 0-45	KS100A 20	NKT211	OA200 0-07	OC28 0-25	OC72 0-25	OC123 0-65	ORP61 0-42
IN4001 0-06	2N1303 0-16	2N3711 0-10	AP139 0-80	BF197 0-15	CS102 0-13	MAT101	NKT212	OA202 0-10	OC29 0-80	OC73 0-80	OC129 0-25	SK640 0-50
IN4002 0-07	2N1304 0-16	2N3712 0-10	AP139 0-80	BF198 0-15	CS102 0-13	MAT121	NKT213	OA210 0-25	OC30 0-80	OC74 0-80	OC140 0-55	SK640 0-50
IN4003 0-08	2N1305 0-16	2N3713 0-10	AP139 0-80	BF199 0-15	CS102 0-13	MAT121	NKT214	OA210 0-25	OC31 0-80	OC75 0-80	OC141 0-80	SK640 0-50
IN4004 0-08	2N1306 0-16	2N3714 0-10	AP139 0-80	BF200 0-15	CS102 0-13	MAT121	NKT215	OA210 0-25	OC32 0-80	OC76 0-80	OC142 0-80	SK640 0-50
IN4005 0-08	2N1307 0-16	2N3715 0-10	AP139 0-80	BF201 0-15	CS102 0-13	MAT121	NKT216	OA210 0-25	OC33 0-80	OC77 0-80	OC143 0-80	SK640 0-50
IN4006 0-12	2N1307 0-16	2N3716 0-10	AP139 0-80	BF202 0-15	CS102 0-13	MAT121	NKT217	OA210 0-25	OC34 0-80	OC78 0-80	OC144 0-80	SK640 0-50
18111 0-13	2N2147 0-20	2N3717 0-10	AP139 0-80	BF203 0-15	CS102 0-13	MAT121	NKT218	OA210 0-25	OC35 0-80	OC79 0-80	OC145 0-80	SK640 0-50
18131 0-13	2N2218 0-20	2N3718 0-10	AP139 0-80	BF204 0-15	CS102 0-13	MAT121	NKT219	OA210 0-25	OC36 0-80	OC80 0-80	OC146 0-80	SK640 0-50
18132 0-13	2N2444 1-91	2N3719 0-10	AP139 0-80	BF205 0-15	CS102 0-13	MAT121	NKT220	OA210 0-25	OC37 0-80	OC81 0-80	OC147 0-80	SK640 0-50
20220 0-68	2N2926 0-10	2N3720 0-10	AP139 0-80	BF206 0-15	CS102 0-13	MAT121	NKT221	OA210 0-25	OC38 0-80	OC82 0-80	OC148 0-80	SK640 0-50
20301 0-20	2N2926 0-10	2N3721 0-10	AP139 0-80	BF207 0-15	CS102 0-13	MAT121	NKT222	OA210 0-25	OC39 0-80	OC83 0-80	OC149 0-80	SK640 0-50
20302 0-22	2N3702 0-10	2N3722 0-10	AP139 0-80	BF208 0-15	CS102 0-13	MAT121	NKT223	OA210 0-25	OC40 0-80	OC84 0-80	OC150 0-80	SK640 0-50
2N696 0-15	2N3703 0-10	2N3723 0-10	AP139 0-80	BF209 0-15	CS102 0-13	MAT121	NKT224	OA210 0-25	OC41 0-80	OC85 0-80	OC151 0-80	SK640 0-50
2N697 0-15	2N3704 0-10	2N3724 0-10	AP139 0-80	BF210 0-15	CS102 0-13	MAT121	NKT225	OA210 0-25	OC42 0-80	OC86 0-80	OC152 0-80	SK640 0-50
2N706 0-10	2N3705 0-10	2N3725 0-10	AP139 0-80	BF211 0-15	CS102 0-13	MAT121	NKT226	OA210 0-25	OC43 0-80	OC87 0-80	OC153 0-80	SK640 0-50
2N706A 0-12	2N3707 0-10	2N3726 0-10	AP139 0-80	BF212 0-15	CS102 0-13	MAT121	NKT227	OA210 0-25	OC44 0-80	OC88 0-80	OC154 0-80	SK640 0-50

Industrial Valves

1B9GT	3B98	5Z3	12B1	815	5726/	6923	CV28	CV404	CV2325	CV4043	E180F	GXU2	ME1403	Q8108/45
1B9T	3B29	5Z4G	12B14	828	6AL5W	6939	CV21	CV415	CV2361	CV4044	E180G	GXU3	ME1404	Q8109/15
1B9SA	3C22	6AF4A	13E1	830B	6D21W	7193	CV25	CV416	CV2516	CV4045	E180H	GXU4	ME1501	Q8110/30
1B9SA	3C23	6AK5	2E27	860	5749	7203	CV27	CV417	CV2519	CV4046	E180C	KT66	OA2	Q8150/40
1N21	3C24/24G	6AM5	29C1	866	5750	7308	CV28	CV418	CV2520	CV4047	E180D	KT67	OA3	Q8150/80
1N21B	3C46	6AM6	58K4	866A	5751	7586	CV29	CV419	CV2522	CV4048	E180E	KT68	OA3	Q8150/80
1N25B	3C46	6AN5	78B1	866E	5902		CV30	CV420	CV2523	CV4049	E180F	KT68	OA3	Q8150/80
1N25C	3C46	6AN5	78B1	866E	5902		CV31	CV421	CV2524	CV4050	E180G	KT68	OA3	Q8150/80
1N25D	3C46	6AN5	78B1	866E	5902		CV32	CV422	CV2525	CV4051	E180H	KT68	OA3	Q8150/80
1N25E	3C46	6AN5	78B1	866E	5902		CV33	CV423	CV2526	CV4052	E180I	KT68	OA3	Q8150/80
1N25F	3C46	6AN5	78B1	866E	5902		CV34	CV424	CV2527	CV4053	E180J	KT68	OA3	Q8150/80
1N25G	3C46	6AN5	78B1	866E	5902		CV35	CV425	CV2528	CV4054	E180K	KT68	OA3	Q8150/80
1N25H	3C46	6AN5	78B1	866E	5902		CV36	CV426	CV2529	CV4055	E180L	KT68	OA3	Q8150/80
1N25I	3C46	6AN5	78B1	866E	5902		CV37	CV427	CV2530	CV4056	E180M	KT68	OA3	Q8150/80
1N25J	3C46	6AN5	78B1	866E	5902		CV38	CV428	CV2531	CV4057	E180N	KT68	OA3	Q8150/80
1N25K	3C46	6AN5	78B1	866E	5902		CV39	CV429	CV2532	CV4058	E180O	KT68	OA3	Q8150/80
1N25L	3C46	6AN5	78B1	866E	5902		CV40	CV430	CV2533	CV4059	E180P	KT68	OA3	Q8150/80
1N25M	3C46	6AN5	78B1	866E	5902		CV41	CV431	CV2534	CV4060	E180Q	KT68	OA3	Q8150/80
1N25N	3C46	6AN5	78B1	866E	5902		CV42	CV432	CV2535	CV4061	E180R	KT68	OA3	Q8150/80
1N25O	3C46	6AN5	78B1	866E	5902		CV43	CV433	CV2536	CV4062	E180S	KT68	OA3	Q8150/80
1N25P	3C46	6AN5	78B1	866E	5902		CV44	CV434	CV2537	CV4063	E180T	KT68	OA3	Q8150/80
1N25Q	3C46	6AN5	78B1	866E	5902		CV45	CV435	CV2538	CV4064	E180U	KT68	OA3	Q8150/80
1N25R	3C46	6AN5	78B1	866E	5902		CV46	CV436	CV2539	CV4065	E180V	KT68	OA3	Q8150/80
1N25S	3C46	6AN5	78B1	866E	5902		CV47	CV437	CV2540	CV4066	E180W	KT68	OA3	Q8150/80
1N25T	3C46	6AN5	78B1	866E	5902		CV48	CV438	CV2541	CV4067	E180X	KT68	OA3	Q8150/80
1N25U	3C46	6AN5	78B1	866E	5902		CV49	CV439	CV2542	CV4068	E180Y	KT68	OA3	Q8150/80
1N25V	3C46	6AN5	78B1	866E	5902		CV50	CV440	CV2543	CV4069	E180Z	KT68	OA3	Q8150/80
1N25W	3C46	6AN5	78B1	866E	5902		CV51	CV441	CV2544	CV4070	E180A	KT68	OA3	Q8150/80
1N25X	3C46	6AN5	78B1	866E	5902		CV52	CV442	CV2545	CV4071	E180B	KT68	OA3	Q8150/80
1N25Y	3C46	6AN5	78B1	866E	5902		CV53	CV443	CV2546	CV4072	E180C	KT68	OA3	Q8150/80
1N25Z	3C46	6AN5	78B1	866E	5902		CV54	CV444	CV2547	CV4073	E180D	KT68	OA3	Q8150/80
1N26A	3C46	6AN5	78B1	866E	5902		CV55	CV44						

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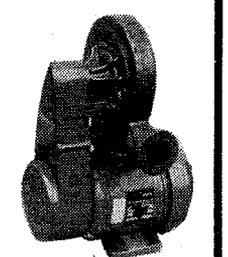
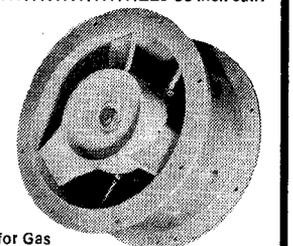
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ACY18	25p	BD122	75p	MJE3055	85p	OC76	25p	ZTX531	27p	2N3055	48p
ACY19	25p	BD123	75p	MM1813	43p	OC77	40p	1N659	7p	2N3232	64p
ACY20	25p	BD124	60p	MM1712	60p	OC81	23p	1N914	8p	2N3702	10p
ACY39	50p	BD131	75p	MPF102	45p	OC82	25p	1N916	8p	2N3703	10p
ACY21	25p	BD153	75p	MPF103		OC83	22p	1N4001	8p	2N3704	10p
AD140	55p	BD156	75p	MPF104		OC84	25p	1N4002	9p	2N3705	10p
AD149	85p	BDY11	£1.40			OC139	30p	1N4003	9p	2N3706	10p
AD161	37p	BDY17	£1.50 (2N5458)			OC140	30p	1N4004	10p	2N3707	10p
AD162	37p	BDY19	£1.95 (MPF105)			OC170	25p	1N4005	12p	2N3708	10p
ADZ11	£1.50	BF152	20p	(2N5459)	40p	OC171	30p	1N4006	15p	2N3709	10p
AF114	25p	BF194	14p	MPSA06	35p	OC200	50p	1N4007	18p	2N3771	£2.70
AF115	25p	BF195	15p	MPSA16	30p	OC201	60p	1N4148	7p	2N3772	£2.75
AF116	25p	BFX29	30p	MPSA36	35p	OC202	65p	2N692	25p	2N3773	£2.90
AF117	25p	BFX84	25p	MPSU06	75p	TIP29A	49p	2N697	20p	2N3819	55p
AF118	50p	BFX85	30p	MPSU56	70p	TIP30A	59p	2N698	25p	2N3820	55p
AF172	25p	BFX86	25p	NKT135	35p	TIP31A	62p	2N706	12p	2N3866	85p
ASY28	30p	BFX88	25p	NKT222	25p	TIP32A	74p	2N706A	15p	2N3904	22p
ASZ21	35p	BFY10	35p	NKT401	85p	TIP33A	£1.05	2N708	15p	2N3905	25p
BA102	30p	BFY44	50p	NKT404	80p	TIP34A	£1.55	2N690	20p	2N4058	12p
BA112	60p	BFY50	25p	NKT773	25p	TIP35A	£2.65	2N1132	25p	2N4059	12p
BA114	16p	BFY51	20p	NKT774	25p	TIP36A	£3.35	2N1302	16p	2N4060	12p
BA156	15p	BFY5	22p	OA5	20p	TIP41A	75p	2N1303	16p	2N4061	12p
BC107	10p	BFY5	19p	OA10	20p	TIP42A	90p	2N1304	20p	2N4062	12p
BC108	10p	BFY9	60p	OA47	10p	TIP29B	59p	2N1305	20p	2N4126	17p
BC109	10p	BLY1C	£3.00	OA70	12p	TIP30B	65p	2N1306	25p	2N4068	15p
BC147	12p	BSW6	60p	OA79	15p	TIP31B	70p	2N1307	25p	2N4087	15p
BC148	12p	BSW6	75p	OA81	10p	TIP32B	82p	2N1308	25p	2N4288	15p
BC149	12p	BSY95 A	12p	OA90	10p	TIP33B	£1.12	2N1309	25p	2N4289	15p
BC157	13p	C111	40p	OA91	10p	TIP34B	£1.68	2N1613	20p	2N4290	15p
BC158	13p	C426	30p	OA200	10p	TIP35B	£2.81	2N1711	25p	2N4444	£1.90
BC159	13p	BY100	15p	OA202	10p	TIP36B	£3.64	2N1447	70p	2N4871	35p
BC169C	13p	BY122	65p	OA210	35p	TIP41B	83p	2N1610	55p	2N4920	60p
BC182	10p	BY126	20p	OA211	35p	TIP42B	98p	2N2217	18p	2N5191	96p
BC183	10p	BY127	20p	OC19	85p	TIP29C	71p	2N2218	18p	2N5194	£1.10
BC184	10p	BY164	65p	OC22	50p	TIP30C	78p	2N2219	25p	2N5457	35p
BC212	14p	IS100	15p	OC25	50p	TIP31C	85p	2N2222	20p	2N5458	33p
BC213	14p	IS100	15p	OC28	65p	TIP32C	£1.05	2N2224	34p	2N5459	40p
BC214	14p	MJ340	50p	OC28	50p	TIP33C	£1.30	2N2398	34p	40361	50p
BC238	12p	MJ481	95p	OC35	50p	TIP34C	£1.90	2N2646	50p	40362	55p
BC239	12p	MJ2801	£1/20	OC36	60p	TIP35C	£3.20	2N2846	£1.50	40250	70p

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17 TURNHAM GREEN TERRACE,
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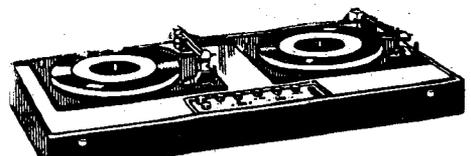
VALVE AMPLIFIERS

5 Watt	£12.50	50 Watt	£36.25
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★ SPECIAL OFFER PRICE ★

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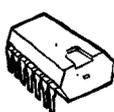
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Suitable for any 12 in. speaker, covered in Rixne and Vynair. Size: 18 in. X 18 in. X 8 in. approx. £9.90

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SN7403	20p	SN7417	30p	SN7440	20p	SN7484	90p	SN74107	50p	SN74170	£4.10
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SN7405	20p	SN7422	48p	SN7442	75p	SN7491AN	£1.00	SN74118	£1.00	SN74175	£1.35
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								SN74155	£1.55	SN74193	£2.00
								SN74156	£1.55	SN74194	£2.50
								SN74157	£1.80	SN74195	£1.85
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Cossor	Solartron
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	WM3B.
	WM7.
	WM8.
	WM16.
	WM18.
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TIL 209 H.P. 5082..... 25p

Solartron

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	WM3B.
	WM7.
	WM8.
	WM16.
	WM18.
	WM26.

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CRS 1/05.....	25p
CRS 1/10.....	30p
CRS 1/20.....	30p
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CRS 3/10.....	30p
CRS 3/40.....	30p
CRS 3/60.....	60p
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CRS 16/600.....	£1.05
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16RC/20.....	70p
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L.D.R.



ORP 12..... 50p

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Electronic Component Specialists

RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	1/20W	5%	82Ω-220KΩ	E12	9	8	7-5
1/8W	5%	4.7Ω-470KΩ	E24	1	0.9	0.75 nett	
1/4W	5%	4.7Ω-10MΩ	E24	1	0.9	0.75 nett	
1/2W	5%	4.7Ω-10MΩ	E24	1.2	1	0.81 nett	
1W	5%	4.7Ω-10MΩ	E12	2.5	2	1.6 nett	
MO	12W	2%	10Ω-1MΩ	E24	4	3	7.5 nett
WW	1W	10% ± 1/20Ω	0.22Ω-3.95Ω	E12	9	8	7.5 nett
WW	3W	5%	1Ω-10KΩ	E12	7	7	6
WW	7W	5%	1Ω-10KΩ	E12	8	8	7.5 nett

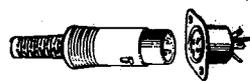
Codes: C = carbon film, high stability, low noise.
MO = metal oxide, ElectroSil TR5, ultra low noise.
WW = wire wound, Plessey.
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series, as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

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2N3055 npn silicon power	60p	BD135 npn medium power	37p	
AC153K npn germanium low power	32p	BD136 npn medium power	38p	
AC176K npn germanium low power	32p	DIODES		
AD161 npn germanium medium power	42p	OA90, OA91, OA95 each	6p	
AD162 npn germanium medium power	40p	OA200-9p; OA202-10p		
AF139 npn germanium UHF	49p	Other semi-conductors		
BC107-13p; BC108-12p; BC109-15p	} npn	AC128-17p	AF117-32p	
BC167-11p; BC168-10p; BC169-11p		} pnp	BFY51-19p	
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Lockable types, phono connectors, etc.

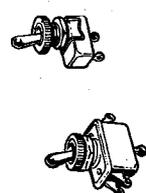
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HEATSINK
Type 6W!
Extruded aluminium
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7201 Sub-miniature DFDT 250V a.c./2A 48p



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7440	25p
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7453	25p
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7470	45p
7472	37p
7473	56p
7474	56p
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7476 (16)	59p
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7482	£1.10
7483 (16)	£1.22
7485	£1.85
7486	49p
7490	61p
7491	£1.40
7492	74p
7493	65p
7495	80p
7496 (16)	£1.40
74100 (24)	£2.10
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74107	51p
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long spindles. Double wipers for low noise.

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µF	3V	6.3V	10V	16V	25V	40V	63V	100V
0.47							11	8
1.0						11		8
2.2							8	9
4.7						8	9	8
10						8	9	8
22			8		9	8	8	10
47	8		9	8	8	8	10	13
100	9	8	8	8	8	10	12	19
220	8	8	9	10	10	11	17	28
470	9	10	10	11	13	17	24	45
1000	11	13	13	19	20	25	41	
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4700	26	30	39	44	58			
10,000	42	46						

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For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. £3-30. (Carriers supplied separately.)

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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

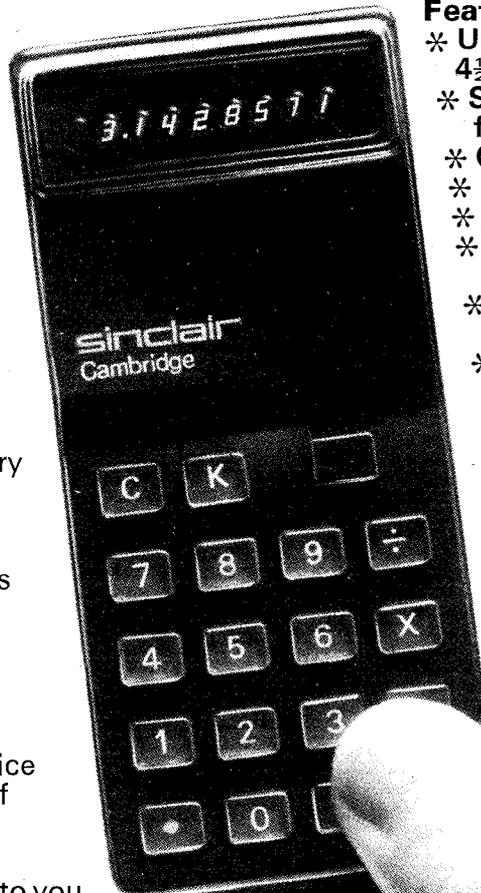
With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}'' \times 2'' \times \frac{11}{16}''$. That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on U16-type batteries which gives weeks of life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

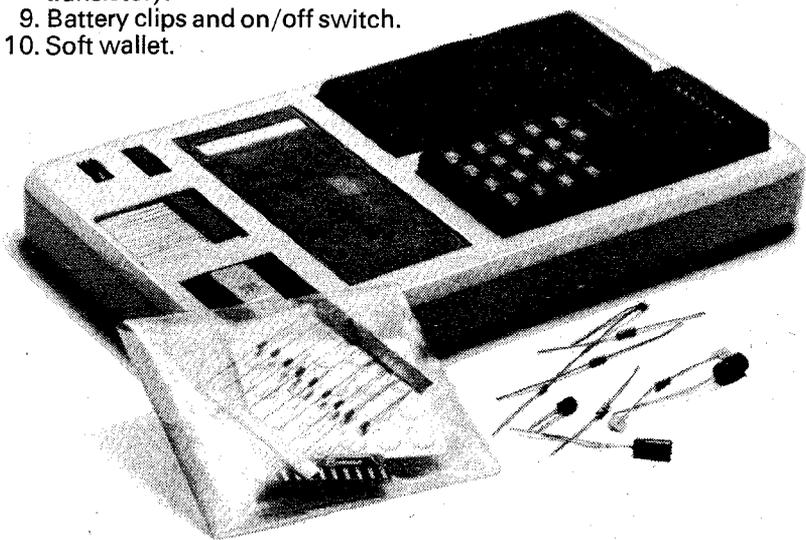
- * Uniquely handy package. $4\frac{1}{2}'' \times 2'' \times \frac{11}{16}''$, weight $3\frac{1}{2}$ oz.
- * Standard keyboard. All you need for complex calculations.
- * Clear-last-entry feature.
- * Fully-floating decimal point.
- * Algebraic logic.
- * Four operators (+, -, x, ÷), with constant on 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.



Actual size!



4 1/2 in long x 2 in wide x 1 1/16 in deep

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
- Cosines nth roots and many others...

sinclair

Sinclair Radionics Ltd, London Road, St Ives, Hunts.
Reg.no: 699483 England VAT Reg.no: 213 8170 88

Why only Sinclair can make you this offer

The reason's simple: only Sinclair – Europe's largest electronic calculator manufacturer – have the necessary combination of skills and scale.

Sinclair Radionics are the makers of the Executive – the smallest electronic calculator in the world. In spite of being one of the more expensive of the small calculators, it was a runaway best-seller. The experience gained on the Executive has enabled us to design and produce the Cambridge at this remarkably low price.

But that in itself wouldn't be enough. Sinclair also have a very long experience of producing and marketing electronic kits. You may have used one, and you've almost certainly heard of them – the Sinclair Project 60 stereo modules.

It seemed only logical to combine the knowledge of do-it-yourself kits with the knowledge of small calculator technology.

And you benefit!

Take advantage of this money-back, no-risks offer today

The Sinclair Cambridge is fully guaranteed. Return your kit within 10 days, and we'll refund your money without question. All parts are tested and checked before despatch – and we guarantee a correctly-assembled calculator for one year.

Simply fill in the preferential order form below and slip it in the post today.

Price in kit form: £24.95 + £2.50 VAT. (Total: £27.45)
Price fully built: £29.95 + £3.00 VAT. (Total: £32.95)

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WW 12/73

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071 14682	10	6800	4 amps	1oz	17p
071 15332	16	3300	2.4 amps	1oz	19p
071 15472	16	4700	3.9 amps	1oz	17p
071 15682	16	6800	5.8 amps	1½oz	22p
071 14113	10	11000 + 11000	10.6 amps	3oz	37p
072 14172	10	16500 + 16500	13.4 amps	4oz	49p
072 15782	16	7500 + 7500	10.5 amps	3oz	37p
072 15113	16	11000 + 11000	13.8 amps	4½oz	49p
072 16502	25	5000 + 5000	9.6 amps	3½oz	37p
072 16752	25	7500 + 7500	12.6 amps	4½oz	49p
072 17502	40	5000 + 5000	12.0 amps	4½oz	49p
071 18681	63	680	2.1 amps	1oz	15p

106 and 107 Series

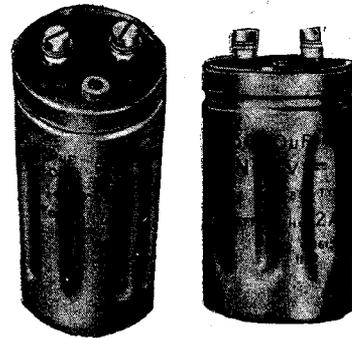
106 14153	10	15000	7 amps	4oz	57p
106 17103	40	10000	12 amps	7½oz	94p
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
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101b	42p
141b	52p
181b	62p
221b	72p



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Ref. No.	Capacity	Voltage	Price	Ref. No.	Capacity	Voltage	Price
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H8/2A	3.3 μ F	25v	4p	H7/4	64 μ F	15v	4p
H8/3	3 μ F	50v	4p	H7/4A	64 μ F	35v	5p
H8/3A	4 μ F	50v	4p	H7/5	80 μ F	16v	4p
H8/4	4.7 μ F	25v	4p	H7/7	100 μ F	25v	4p
H8/4A	5 μ F	64v	4p	H7/8	125 μ F	16v	5p
H8/5	5 μ F	10v	4p	H7/8A	100 μ F	35v	6p
H8/5A	5 μ F	150v	4p	H7/9	100 μ F	63v	6p
H8/6A	10 μ F	10v	4p	H7/9A	125 μ F	4v	4p
H8/7	10 μ F	70v	4p	H7/10	125 μ F	25v	6p
H8/8	16 μ F	35v	4p	H7/10A	180 μ F	2.5v	3p
H8/8A	16 μ F	18v	4p	H7/11	160 μ F	25v	6p
H8/9	20 μ F	6v	2p	H7/11A	150 μ F	16v	5p
H8/9A	20 μ F	70v	4p	H7/13A	200 μ F	25v	8p
H8/10	22 μ F	50v	4p	H7/14	220 μ F	50v	10p
H8/10A	22 μ F	100v	4p	H7/15	220 μ F	25v	5p
H8/11	25 μ F	12v	4p	H7/15A	220 μ F	35v	10p
H8/12	32 μ F	15v	4p	H8/1A	250 μ F	4v	3p
H8/12A	30 μ F	10v	4p	H8/2A	320 μ F	2.5v	3p
H8/13A	32 μ F	50v	4p	H6/4	320 μ F	10v	4p
H8/14	40 μ F	25v	5p	H6/4A	330 μ F	16v	5p
H8/14A	40 μ F	16v	4p	H6/5	330 μ F	25v	10p
H8/15	47 μ F	50v	4p	H6/5A	330 μ F	35v	15p
H8/15A	40 μ F	35v	4p	H6/6	470 μ F	25v	10p
H7/1	50 μ F	6v	3p	H6/6A	470 μ F	35v	20p
H7/1A	50 μ F	10v	4p	H6/9A	400 μ F	40v	20p
H7/2A	64 μ F	2.5v	2p	H6/10	750 μ F	12v	5p
				H6/13A	1000 μ F	25v	16p
				H5/2A	2200 μ F	18v	15p

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25p!
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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 50p postage. Developer and Etchant 10p. Copper-clad Fibre-glass Board—50p sq. ft. (max. 3' x 4')

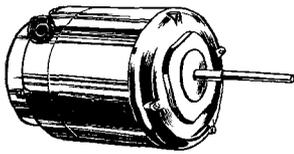
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Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes. 75mm x 100mm .. 33p. 150mm x 100mm .. 66p. 150mm x 200mm .. £1.32. 250mm x 200mm .. £2.20

SILICON N.P.N.				SILICON N.P.N.				
Type	Voltage	Frequency	Price	Type	Voltage	Frequency	Price	
BCY 71	45	200 MHz	12p	2N 3053	60	100 MHz	17p	
BFS 92	100	70 MHz	20p	2N 3707	30	900 MHz	12p	
BFS 95	40	70 MHz	17p	2N 5179	20	900 MHz	40p	
BFX 12	25	210 MHz	10p	GERMANIUM P.N.P.				
2N 2906	60	200 MHz	15p	ACY 44	50	1 MHz	10p	
2N 3702	40	100 MHz	11p	ADY 26	80	75 watts	£1	
2N 3703	50	100 MHz	12p	AF 124	20	75 MHz	20p	
SILICON N.P.N.				AFY 19	32	350 MHz	10p	
BC 108	30	150 MHz	10p	ASZ 32	25	5 MHz	20p	
BC 109	30	150 MHz	10p	ASZ 21	15	450 MHz	20p	
BF 179	225	125 MHz	40p	GET 113	32	2 watts	10p	
BF 180	30	625 MHz	25p	GET 120	32	2 watts	10p	
BFW 58	80	80 MHz	15p	OC 123	50	1 MHz	10p	
BFX 43	30	500 MHz	20p	OCP 70	Light-sensitive	20p		
BFX 86	40	50 MHz	17p	2N 1307	30	10 MHz	15p	
BFY 53	30	50 MHz	10p	2N 1309	30	75 MHz	15p	
2N 697	60	40 MHz	12p	2N 443	60	150 watts	£1	
2N 709	15	900 MHz	30p	HIGH FREQUENCY, POWER				
2N 718	60	60 MHz	12p	BFR 64	40	1,200 MHz	£5	
2N 753	25	250 MHz	12p	BLY 89A	35	650 MHz	£1	
2N 744	20	300 MHz	12p	BLY 93A	60	500 MHz	£5	
2N 1613	75	60 MHz	17p	BLY 218	36	1,200 MHz	£2	
2N 2220	60	250 MHz	15p	2N 709	15	800 MHz	15p	
MICROWAVE DEVICES				2N 3926	36	250 MHz	£1	
CL 8300	Gunn effect oscillator			9-4 GHz				£40
CL 8370	ditto			9-5 GHz				£10
CL 8380	ditto			10-5 GHz				£10
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CL 8470	ditto			9-35 GHz				£40
BXY 27	Varactor Diode. "S" Band. Cut-off			70 GHz				£1
BXY 28	Varactor Diode. Cut-off			100 GHz				£1
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BXY 35A/C	ditto			25 GHz				£1
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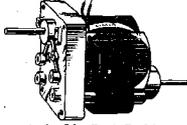
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Type SS15. These fine motors are easily reversed, starting and stopping in less than 5° without electrical or mechanical braking. Simple relay circuit can be applied to give DC, or winding for a maximum holding torque of 300oz/in with 35v at 0.35amps through winding. For AC (synchronous) operation at 120v, 50Hz. Speed 60 rpm at 60Hz, 72 rpm. STEPPING. Holding torque at 80 steps per second—100 oz/in. Can be wired to give 100 or 200 steps per revolution with accuracy of 0.1° per step non-cumulative. Torque characteristics can be modified by simple R.C. circuits. Dimensions: dia. 4", body length 4 1/2", spindle length 2 1/2" x 1/8" dia. Weight 6 1/2 lbs. BRAND NEW in maker's packing. Offered at less than 1/2 maker's price.

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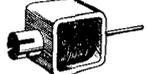
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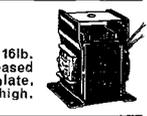


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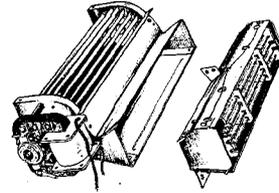
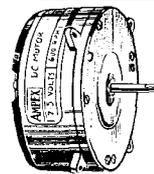
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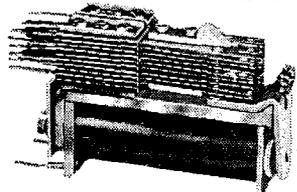
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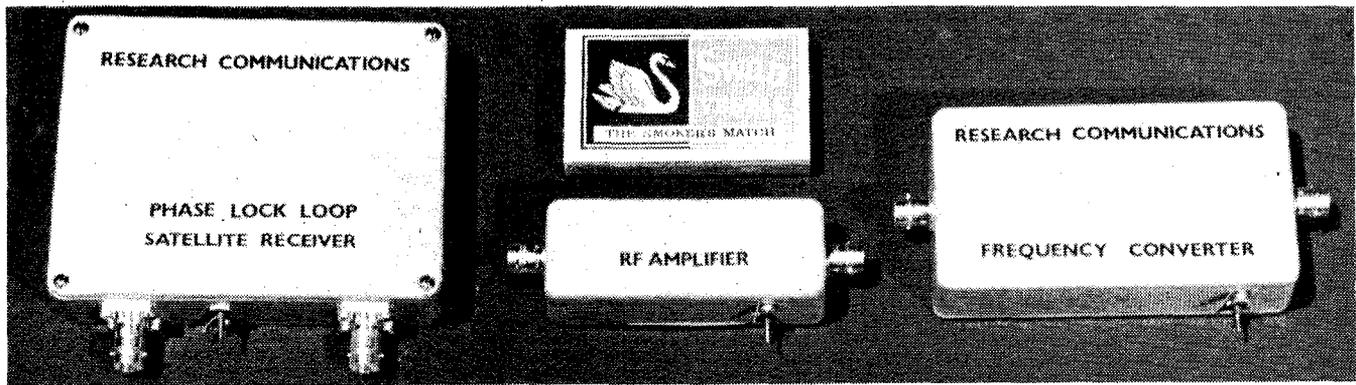
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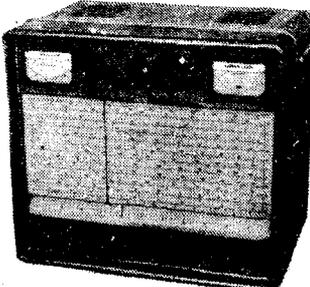
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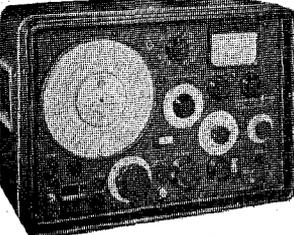
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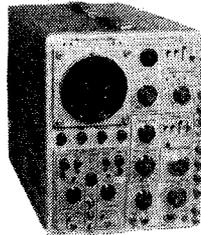
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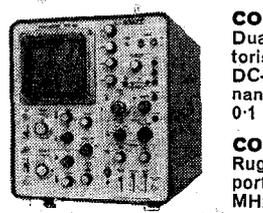
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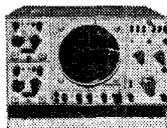
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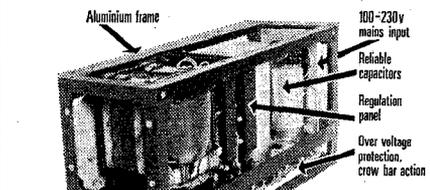
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O/P Voltage 7.5-9V. Max. load current 10 Amps. Max. ripple on full load approx. 60mV. p.p. Threshold current 10 mA. Overvolt protection. **OUR PRICE £12-50**

EX-COMPUTER HIGH GRADE FULLY STABILISED POWER SUPPLIES

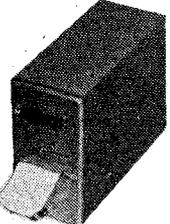
- Input 200/250V.
- ADVANCE TYPE DC 207** 20 Volts 9 Amps. 10 Volts 5 Amps. 10 Volts 3 Amps. 20 Volts 2 Amps.
 - ADVANCE TYPE DC 200** 20 Volts 13 Amps. 10 Volts 5 Amps. 20 Volts 2.5 Amps.
 - ADVANCE TYPE DC 202** 35 Volts 9 Amps. 24 Volts 4 Amps. 10 Volts 8 Amps.
 - ADVANCE TYPE DC 197** 6 Volts 7.5 Amps. 6 Volts 11 Amps. 28 Volts 9 Amps.

£18 EACH. P. & P. £3-50

LAMBDA REGULATED POWER SUPPLIES
New Range just arrived! Phone for details.

EVERSHED SAFETY OHMMETER
for testing the continuity and resistance of circuits, consists of a hand-driven generator and a direct reading ohmmeter. Range in ohms 0-4, 0-5, 0-10, 0-100, 0-300. £10

SODECO IMPULSE PRINTING COUNTER
4 Digit Decimal Counter
10c/second Electrical
Reset & Print-out 24 Volts
Type PN117.
Brand New.
PRICE £42



PHILIPS VALVE VOLTMETER MODEL GM6014 Max. 300mV, 1000Hz-30MHz. £30-00

to purchase some of the World's finest calibration instruments at savings of

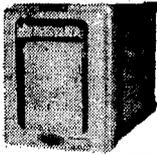
33 1/3% AND MORE!

PEN RECORDERS

THIS MONTH'S SPECIAL OFFER BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK



of America. This Recorder indicates the magnitude of current 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 £25.00



SINGLE PEN RECORDER

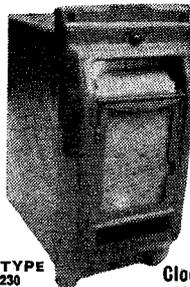
by Record Electrical. 3" chart, sensitivity 1" milliamp, chart speed 1" and 6" per hour. Size 8" x 11" x 6". Offered complete with pen assembly and spare chart. Listed at over £100—this month's special price due to bulk purchase... £39.50 plus £5.00 packing and carriage. 500uA AVAILABLE £45

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: Pt. Pt. 10% 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 12 1/2". Weight 51 lbs. PRICE £80.00

ELLIOTT SINGLE PEN RECORDER

A most versatile pen recorder producing a trace on a curvi-linear 3 in. strip chart. Two synchronous speeds: 1 in. and 6 in. per hour.



Fitted with high and low alarm contacts operated by the moving coil. Basic movement 0-1mA DC coil resistance 400 ohms. Fitted with rectifier to allow operation on AC effective coil impedance at 50Hz 1800 ohms.

Power supply required: 230V 50Hz.

Applications: Ideal for recording relatively slow changing phenomena such as:
Temperature: Gas or liquid Flow Rates, Sound Levels, Speed variations, Power Demand, Rainfall, humidity, etc. PRICE £25.00

TYPE 230

Clockwork version also available £29.50

POTENTIOMETERS

TEN TURN 3600° ROTATION

Res Ohms	Linearity	Manufacturers	Model	Price
100	0-5	Beckman	A.S.	£2.00
200	0-5	Beckman	A.	£2.00
500	0-1	Beckman	S.	£2.50
500	1-10	Relcon	HEL107-10.	£2.25
1K	0-5	Beckman	SA1101	£2.25
2K	0-25	Beckman	7216	£3.00
2K	0-25	Reliance	GPM15	£2.00
2K	0-1	General Controls	GA151/4	£2.00
5K	0-1	Relcon	07-10	£2.50
5K	0-1	Colvern	CLR2503	£3.00
10K	0-1	Beckman X	A.	£3.50
15K	0-1	Colvern	CLR2402	£3.00
25K	0-5	Helipot	SAJ337	£3.00
29K	0-05	Beckman	SA1244	£4.50
30K	0-1	Beckman	A.88	£3.50
30K	0-5	Beckman	SA1692	£3.00
50K	0-1	Reliance	07-10	£2.25
50K	0-5	Beckman	A.	£3.00
100K	0-1	Beckman	A.	£3.50
100K	0-1	Colvern	2501	£2.25
250K	0-1	Beckman	8A3902	£3.50
300K	0-1	Beckman	A.	£3.50

THREE TURN 780° ROTATION

25Q	Beckman	Type C	£2.25
100/100	Beckman	Type C	£3.00
300	Beckman	9303	£2.25
1K	Fox	PX2/H3	£2.25
10K	Beckman	C.S.	£2.25
20K/20K	Beckman	C.S.	£3.00
10K/10K	Beckman	C.S.	£3.00
50K	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

SINE COSINE POTENTIOMETER 47K

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 cosine 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: 31 oz./in. Dimensions: 4 1/2" H, 5 in. D, 7 1/2 in. W. Ex equipment. Good condition. Price £5. Carriage extra.



COMPUTER ACCESSORIES

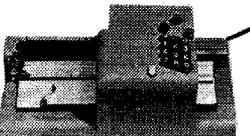
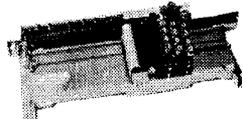
80 COLUMN HAND PUNCHES



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.

THIS MONTH'S SPECIAL MINI COMPUTER OFFER SAVE 75% OF LIST PRICE ON THIS DEC PDP SYSTEM

DEC PDP8 4K 1.5 microsecond £1250.
ASR33 Printer available £200.
PDP-12C 4K CPU and Console.
DF32 32K Disk and Control.
DW08A 1/0 Bus Level Converter.
PC12 & PC05 High Speed Reader/Punch. BA12 Peripheral Expander.
AS333 Teletype. PT08C Dual Channel Interface. KP12 Power Fail/Restart.
AFOA 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 £4150



ATTENTION: PDP 11 USERS. MEMORY UPGRADES 4K, 8K, 12K, 16K SAVE MONEY NOW. WIDE RANGE OF SPARES FOR THE FOLLOWING COMPUTERS ICL 1500, ICL 1900, SYSTEM 4, 4100, 803, AMPEX, etc.
GOSBOR VISUAL DISPLAY DID400. Consisting of Keyboard & Display 402 stand alone capability for alphanumeric data entry. Available from £500. Please phone for details.

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 1/4", 3/8" 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 £15.00

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 alphanumeric keypunch..... £340.00
025 Automatic alphanumeric printing keypunch..... £820.00
026 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 Movers: Electric Motor Input: 220/380V 50Hz 3ph Output: 220V 60Hz 3ph at 50 KVA with PF of 0.8. PRICE £450.00

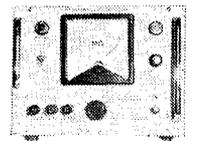
HEWLETT PACKARD DIGITAL RECORDER MODEL 565A

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

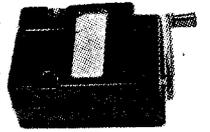
Range from 0.3-20,000 Megohms in 4 ranges at 500V. Used for the measurement of components or circuits having high parallel capacitance. PRICE £20.00



MULLARD VALVE VOLTMETER MODEL E7555/2 PRICE £20.00

WEE MEGGERS BY EVERSHED & VIGNOLE

100 volt 0-025Ω—20MΩ Series 3 Mk III £25
250 volt 0-01Ω—20MΩ Series 3 only £18
250 volt 0-01Ω—20MΩ Series 3 Mk III £22
500 volt 0-05Ω—50MΩ Series 3 Mk III £23



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 amplification. 3 size mag slip, 250 divisions, max. torque for reflected binary code 4.3 oz. ins. PRICE £10.00

WIDE RANGE OSCILLATOR TYPE 400C by DAWE 1 c/s-1,000 c/s. PRICE £35.00

FANS BY PLAINAIR

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

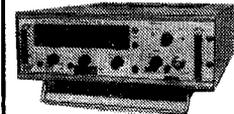
Digital Frequency Meter 0-1MHz £45.00.



VENNER 3336

Digital Counter Six Digit 0-1MHz £55.00. With 15 Meg Counter extension for above £85.00.

AMF VENNER 7737 DIGITAL COUNTER 1000 MEG £150.
POWER OSCILLATOR by WANDEL & GOLTERMAN 4-41MHz 40-108 MHz 170-333 MHz 610-950 MHz £175.
HEWLETT PACKARD PRINTER MECHANISM ONLY TYPE 130 £35.
ADVANCE BATCH COUNTER TYPE 4B41 or Predetermining Counter 4 Decades Counts up from zero with Digital Readout £49.50



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
£225.00

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

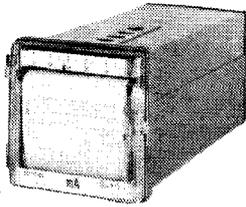
49/53 PANCRAS ROAD : LONDON NW1 2QB. Tel: 01-837 7781

ADD 10% VAT TO ALL PRICES

ELECTRONIC BROKERS RANGE

PEN RECORDERS

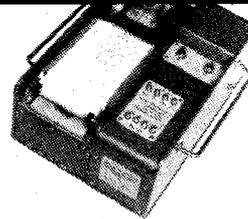
JUST OUT - NEW CATALOGUE ON FULL RANGE OF PEN RECORDERS. SEND READER'S CARD FOR FREE COPY. (WW 130)



MINIATURE PEN RECORDER

Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

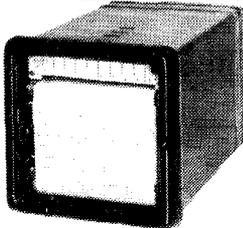
£39.00



SINGLE CHANNEL HIGH SPEED RECORDER

Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000 mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 320x340x175mm. Weight 35 lbs. Price complete with accessories

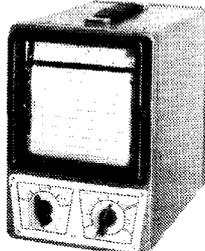
£55.00



10 CHANNEL EVENT RECORDER

Designed for recording sequences of up to ten different operations, e.g. sequence of machine tool operation, switching sequences, etc. Record is presented in the form of square "pulses". When energised, pen moves by approximately 4mm, to the right of zero line. Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160x180x255mm. Weight 9 lbs. Price complete with accessories

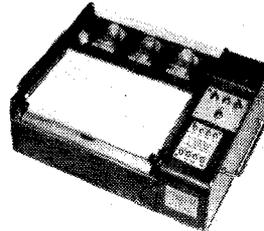
£52.00



PORTABLE AC/DC RECORDING VOLTAMMETER

Fitted with separate zero-marking pen. Accuracy 1.5% DC, 2.5% AC. Measurements ranges — AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Weight 22 lbs. Price complete with accessories

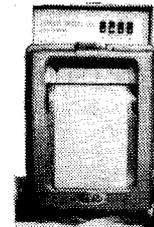
£78.00



THREE CHANNEL HIGH SPEED RECORDER

Strip Chart Recorder. Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by pushbuttons) 1.2-12-30-60-120-300-600-3000 mm. per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 510x345x175 mm. Weight 44 lbs. Price complete with accessories

£90.00



4-RANGE GENERAL PURPOSE TEMPERATURE RECORDER Type 01

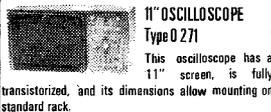
Specially designed compact self-contained instrument for recording temperatures up to 500°C. The main design objectives were for an easy-to-use, robust instrument suitable for use in the laboratory and in the field. The four ranges are 10°C, 50°C, 100°C and 500°C. These are selected by push buttons allowing full use of the 3" wide chart. Two chart speeds 1" and 6" per hour are provided by the 240V 50Hz synchronous chart drive.

£95.00

Fabulous TES Equipment

Send reader's card for free catalogue of test equipment. (WW 131)

obtainable only from Electronic Brokers Ltd.



11" OSCILLOSCOPE Type D 271

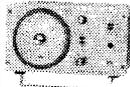
This oscilloscope has a 11" screen, is fully transistorized, and its dimensions allow mounting on standard rack.

It can be equipped with a series of plug-in units which make it highly versatile at a very convenient cost. Dual-trace, time axis logarithmic and differential amplifiers, plug-in units are provided, as well as other plug-in units for interesting and special applications. Since it incorporates the Z-axis modulator, it can be used for display of sweep curves, in conjunction with any type of sweep-marker generator, ensuring high stability and deflection linearity.

Vertical amplifier (with plug-in type CV 271-A) Bandwidth: DC to 10kHz within 3 dB DC to 10kHz within 3 dB. Sensitivity: 1mVpp to 10Vpp in 5 ranges. Input Impedance: 0.5 Mohm, with approx. 30 pF.
Horizontal amplifier. Bandwidth: 10Hz to 1kHz Sensitivity: 50 mVpp max. adjustable. Mains frequency scanning: phase-adjustable, approx. 180°. Z axis: suppression by 25Vp negative.

£120.00

Plug-in Type A, B, C, D, E, F, P.O.A.



OSCILLATOR FM Mod OF 272

Built with modern concepts, this oscillator has been developed to meet all the requirements for the calibration of any FM receiver. It can be used in conjunction with an AM oscillator, for testing on production lines, or for teaching purposes.

It is provided with good frequency resolution and stability, an efficient output attenuator and has particular built-in features which keep the irradiation field at a practically negligible level. Simplicity of construction and stability of the characteristics are combined in the circuits used. Thus an instrument has been developed which, whilst priced as a normal service oscillator, has many of the characteristics of a signal generator. Solid state.

RF frequency range: from 85 to 110 MHz. **IF frequency range:** from 9.5 to 12 MHz. **Frequency accuracy:** within ± 1%. **Max output signal:** 0.1V ± 3dB (open circuit). **Attenuator:** continuous, 0 to 100 dB approx. indication. **Output impedances:** 75 Ohm constant. **FM modulation:** frequency 400Hz ± 5% ± F adjustable until ± 100kHz, about. **Sweep frequency:** 50Hz (Meius) ± F adjustable until about ± 500kHz.

£139.50

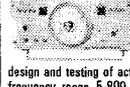


LARGE WAVEBAND OSCILLOSCOPE Mod O 373

A very reliable oscilloscope, with a flat screen tube, developed for all applications where the specific function of the trigger is not of primary importance. Completely solid state (40 semiconductors) except for the input and Y terminal for reasons of security and economy. All power supplies are stabilised, including the voltage to the tube. It has a Mumetal screen. Recommended mainly for teaching purposes and for servicing or production lines of televisions.

Vertical Amplifier Bandwidth: DC to 10MHz within 3 dB. **Deflection Sensitivity:** 20 mVpp/cm for all the range. **Input Attenuator:** from 20 mVpp/cm to 10 Vpp/cm in 9 ranges. **Risetime:** about 35 ns. **Input Impedance:** 1 Mohm with about 30 pF. **Internal Calibration:** for sensitivity control. **Horizontal Amplifier Bandwidth:** from DC to 0.5MHz. **Deflection Sensitivity:** 100 mVpp/cm — adjustable. **X-Deflection Line Voltage:** phase adjust, within 180° approx. **Time Base (uncalibrated):** from 1/2Scm to 10mScm. **Synchronization:** automatic internal and mains external, min. 100 mVpp. **Z Axis:** 20 v negative blank the intensity. **Synchronization:** automatic ± internal and mains external, min. 100 mVpp. **Z Axis:** 20v negative blank the intensity.

£169.50



SWEEP MARKER GENERATOR Mod SM 972

This generator has been specially developed for the design and testing of active and passive networks within the frequency range 5-800 MHz; by excluding the sweep, it can be used as a normal non-modulated-generator. It has a good output stability and linearity of amplitude and is particularly suitable for the observation of the curve of passing wavebands from some tenths of KHz up to hundreds of MHz.

Quartz signal markers placed at intervals of 1.5, 10 and 50 MHz (which can be included singly up to their total number) make it possible to locate frequencies with accuracy and ease. It is recommended that the 11" Oscilloscope 271 be coupled with this generator for a better performance. **Appropriate outputs** allow remote control and programming of the instrument through a keyboard so as to facilitate its use on production lines. **Solid state.** **Sweep range:** 5 to 400MHz and 400 to 800MHz ΔF variable from few KHz until all the range. **Sweep frequency:** 50 Hz (meius). **Output signal:** 1 Vpp-75 Ohm. **External attenuator:** adjustable continuously 0 to + 80 dB. **Ampl/freq linearity:** within ± 1 dB for A total ΔF. **Markers:** quartz, adjustable in amplitude. **Markers presentation:** Birdy type. **Markers interval:** 1.5-10-50 MHz as like it.

£525.00

- RCL BRIDGE Type P 986 **£245**
- AM-FM GENERATOR Type AF 1065 **£259.50**
- OUTPUT POWER METER Type MU 964 **£129**
- TV SWEEP MARKER GENERATOR Type VU 167 **£259.50**
- WOW AND FLUTTER METER Type WF 971 **£295**
- DISTORTION METER Type D566 B **£319**
- LF SIGNAL GENERATOR Type G 1165 B **£229**
- DUAL TRACE OSCILLOSCOPE Type O 371 **£369**

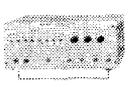


MODULATED OSCILLATOR Type OM 866

Up-to-date radio receivers possess such a high degree of sensitivity that, even in radio-service shops, a fairly high-performance oscillator is required, so as to permit the output signal to be attenuated also at high frequencies, which is the condition for avoiding saturation of the input stage in transistorized radio receivers.

This oscillator is provided with a buffer-modulator stage to prevent possible spurious modulations. An accurate shielding of the oscillator stage, and an enlarged frequency range for calibration of intermediate-frequency stages, are further features which complete the rational design of this instrument. **Frequency range:** from 150KHz to 45MHz in 6 ranges. **FM expanded range:** 430-530 KHz. **Frequency accuracy:** better than 1%; **IF range:** 0.1%. **Internal modulation:** 400 Hz; **fixed:** 30%. **External modulation:** from 20 Hz to 15 KHz. **Max RF output:** 0.2V ± 3 dB. **Attenuator:** continuous, linear and in steps. **Output impedance:** 75 Ohm constant. **VF output voltage:** 2 V approx.

£85.00

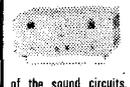


SWEEP MARKER GENERATOR Mod IF 1271

Developed exclusively for production use, this instrument allows a rapid and accurate calibration of intermediate TV frequency stages with the possibility of inserting, singly or simultaneously, a total of 8 quartz markers either of standard frequency or frequencies chosen according to the different production systems, including the colour under-carrier.

Its solid state construction makes it extremely reliable, a fundamental requirement of an instrument used on production lines. **Frequency control range:** 36.15 MHz (or 43 MHz). **Width of the sweep:** about 12 MHz. **Sweep linearity:** within 1 dB. **Sweep frequency:** 50 Hz (meius). **Output signal:** 0.4 Vp 75 Ohm. **Attenuator:** adjustable continuously from 0 to + 80 dB. **Regulation sweep phase:** max. 180°. **about.** **Quartz marker:** max. no. 8, to be precised. **Markers inclusion:** single switch. **Marker type:** best over Y axis oscilloscope. **Marker amplitude:** adjustable.

£585.00



SOUND GENERATOR Mod GS 1171B

This instrument is of great help in the production of televisions for a rapid and definitive calibration rendering superfluous the use of the emitter for a final test. It is a frequency modulated generator with a 1:10,000 stability, more than sufficient for its purpose, with the possibility of frequency tests which bring the short term stability within 50 Hz on 5.5 MHz. It can be supplied, on request, for any other frequency in the 4-12 MHz range. It is completely solid state and offers high reliability.

Central range frequency: 5.5 MHz (other frequencies on request). **Frequency deviation:** ± 25 KHz. **Frequency stability:** within ± 250 Hz (with possibility of control). **Linearity:** with 1 dB. **Modulation frequency:** 400 Hz. **Output signal:** 1 Vp, about on 75 Ohm. **Attenuator:** Continuously adjustable from 0 to + 80 dB.

£549.00

OF SELECTED TEST EQUIPMENT

All items are brand new and guaranteed for 12 months

Selected by Electronic Brokers as the finest value for money obtainable today



Sole agents for **I.C.E.**

FREE! NEW CATALOGUE NOW AVAILABLE send reader's card (WW 132)

THE REVOLUTIONARY SUPERTESTER 680R

FOUR INTERNATIONAL PATENTS — SENSITIVITY 20,000 Ohms per Volt
 10 FIELDS OF MEASUREMENT AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.
OUTSTANDING FEATURES:
 20,000 Ohm per Volt sensitivity • Fully screened against external magnetic fields • Scale width and small case dimensions (128 x 95 x 32mm) • Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading • Simplicity and ease of use and readability • Full ranges of accessories • 1000 times overload • Printed circuit board is removable without de-soldering • More ranges than any other meter. VOLTS A.C. = 11 ranges: 2-10-50-250-1000-2500. Volts and 4-20-100-500 and 2000 Volts. VOLTS D.C. = 13 ranges: 100mV-2V-10-50-200-500-1000 Volts 200 mV-4V-20-100-400 and 2000 Volts AMP D.C. = 12 ranges: 50A-500A-5 mA-50 mA-500 mA-50 Amp and 100A-1 mA-10 mA-100 mA-1 Amp and 10 Amp. AMP. A.C. = 10 ranges: 250A-2.5 mA-25 mA-250 mA-2.5 Amp and 500A-5 mA-50 mA-500 mA-5 Amp. OHMS REACTANCE = 6 ranges: x1-x10-x100-x1000-x0.000 and Low Ohms. DETECTOR = 1 range: from 0 to 10 Megaohms. FREQUENCY = 2 ranges: from 0 to 500 and from 0 to 5000 Hz. V. OUTPUT VOLTAGE = 9 ranges: 10-50-250-1000-2500 V and 20-100-500-2000 Volts. DECIBELS = 10 ranges: from -24 to +70 db. CAPACITY = 6 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains and from 0 to 20, from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3Volts battery. Bold figures indicate depress button.



£18.50
with shockproof case

ALL I.C.E. EQUIPMENT POST FREE

ACCESSORIES TO CONVERT THE SUPERTESTER 680R TO THE FOLLOWING:

Amperclamp

For measuring a.c. currents from 250mA to 500 amps. **£11.95**



Signal Injector

Producing 1 KHz and 500 KHz signals for circuit testing. **£5.95**



Transistor Tester

For transistors and diodes. **£11.00.**



Gauss Meter

For measuring magnetic field strengths. **£11.95**

Phase Sequence Indicator

To indicate the phase sequence of a 3 phase supply. **£5.95.**



Temperature Probe

Covering the range -50 to +200°C **£11.95**



Electronic Voltmeter

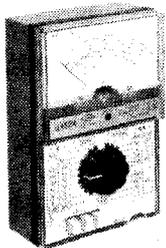


Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£18.00**

OTHER ACCESSORIES AVAILABLE

SHUNTS D.C. 25, 50 and 100 amps. **£4.50** each.
 CURRENT TRANSFORMERS A.C. 25 and 100 amps. **£7.00** each.
 E.H.T. PROBE Extends D.C. voltage to 25,000v. **£5.95.**

METERS, PROBES, ETC.



AC/DC MULTIMETER

With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
 Technical Data:
 0.06-0.6-6-60-600mA-3 Amps DC.
 0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts.
 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
 500Ω. 5-50-500kΩ resistance. Decibel range -10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements +2.5. Price with test leads, and storage case **£8.00 POST FREE**



AMPERTEST 690 NEW CLAMP TYPE AMMETER

With unique self-locking meter system retains reading until released, enabling engineer to obtain accurate results after testing inaccessible places etc.

Designed for use in one hand, the Ampertest 690 ammeter makes use of the familiar clamp or 'pincer' system to measure without breaking the circuit the current flowing in a conductor. It has six current ranges from 3 A to 600A f.s.d., with the first division at 100 mA. The ranges can be extended by means of a 10-to-1 current transformer that is supplied with the instrument, providing ranges from 300 mA to 60A f.s.d. with the first division at 10 mA. Two a.c. voltage ranges of 250 V and 600 V f.s.d. are provided. The connections for voltage measurements are made by means of two leads and probes that plug into the base of the instrument.

£39.50 POST FREE inc. leather case

AC CLAMP VOLTMMETER

Clamp-on Voltmmeter is used for measurements of AC voltages and currents without breaking circuits.

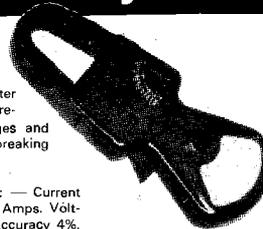
Specification
 Measurement ranges: — Current 10-25-100-250-500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283 x 94 x 36mm. Weight 1.5 lbs.

£10.50 POST FREE

MULTIMETER

0.1-1-10-100-1000mA. 2.5-10-20-250-500-1000V AC/DC. Sensitivity AC and DC all ranges except 10V-10,000 Ohm/V. Dimensions 212 x 118 x 75mm. Weight 2.9 lbs. Price complete with steel carrying case and test leads..

£4.95 POST FREE

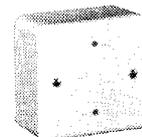


MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit actuates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.

plus 75p. packing and carriage.

£5.50 POST FREE



ELECTRONIC TIME DELAY SWITCH

Delay period 1-25 minutes adjustable. load 1000 watts maximum. Operating Voltage 180-250V a.c. 50Hz. Size 3 3/8 x 3 3/8 x 1 1/2 Standard Ivory Surface mounting Box. Trade Price **£5.80 POST FREE**



ADD 10% VAT TO ALL PRICES • PROMPT DISPATCH MAIL ORDER. CALLERS WELCOME MON-FRI 9 A.M. to 5.30 P.M.

Add £2 towards the cost of packing and carriage on all items for U.K. delivery (except where packing and carriage are already indicated).

ELECTRONIC BROKERS LTD. 49-53 PANCRAS ROAD, LONDON NW1 20B.

TEL.: 01-837 7781

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, December 7th for the January issue subject to space being available.

Electronic Engineers & Scientists

Electronic Devices

The English Electric Valve Co. Ltd., Chelmsford, and its associate, the M.O. Valve Co. of Hammersmith, London, are leading organisations engaged in the design and manufacture of a wide range of vacuum and gas filled electronic devices primarily for broadcasting, telecommunications and industrial uses. These include high power transmitter valves, travelling wave tubes, magnetrons, high power microwave tubes and a range of light conversion devices, which include C.R.T.s and storage tubes, image intensifiers, and advanced T.V. camera tubes.

Expansion of the development and production programmes has created openings for electronic engineers and applied physicists at all levels. Ideally, we seek those who have had experience in the field of vacuum tube technology but we are equally interested in hearing from others who have familiarity with the design

or production of equipment utilising vacuum electronic devices, for we are prepared to give suitable training where necessary.

Salaries and prospects for advancement are good. Employee benefits include early membership of a modern pension and life assurance scheme and assistance with relocation expenses where appropriate. All approaches will be treated in confidence and should be made by writing or telephoning (reverse charge):

J. L. Scott,
English Electric Valve Co. Ltd.,
Waterhouse Lane,
Chelmsford, Essex.
Tel: Chelmsford (0245) 61777.

[3246

DISC-CUTTING ENGINEER

CBS Records is looking for an experienced disc-cutting engineer to work at our new Studios in Central London.

Starting salary is negotiable, but will attract those already earning a basic salary of £2000-£2500. In addition to a competitive salary, the company pays an annual bonus and provides excellent terms and conditions of service.

Please write to, or ring (01-636 3434), the Studio Manager, CBS Recording Studios, 31-37 Whitfield Street, London, W.1.

CBS RECORDS

3282

Electronics Engineers

up to £5,000

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: Stuart Tait, 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 19/11

Lansdowne Appointments Register

3283

There is scope, variety and responsibility as a

Radio Technician

Join the National Air Traffic Services of the Civil Aviation Authority as a Radio Technician and you have the prospect of a steadily developing career in a demanding and ever expanding field.

ENTRANCE QUALIFICATIONS

You should be 19 or over, with at least one year's practical experience in telecommunications. Preference will be given to those having ONC or qualifications in Telecommunications.

Once appointed and trained, you will be doing varied and vital work on some of the world's most advanced equipment including computers, radar and data extraction, automatic landing systems, communications and closed circuit television.

Vacancies exist at locations near London (Heathrow), London (Gatwick) and Stansted Airports and for suitably qualified people at the Signals Training Establishment, Milton Keynes, Bucks.

Salary: £1383 (at 19) to £1836 (at 25 or over); scale maximum £2158 (higher rates at Heathrow). Some posts attract shift-duty payments. Promotion prospects are excellent and ample opportunity and assistance is given to study for higher qualifications.

Mr R F Simons,
National Air Traffic Services,
STE (Recruitment), Bletchley Park,
Bletchley, Milton Keynes, Bucks.

Please send me application form for entry as Radio Technician.

Name _____

Address _____



National Air Traffic Services

Electronics Technician

A dynamic young company in the Medical Electronics field requires a technician to assist a qualified engineer.

The person we are looking for should have a good knowledge of electronics — able to help with the construction, testing and drawing of small prototype units.

Medical Electronics is an interesting and expanding field. If you are keen to get in on the ground floor, please write to us giving full details of your present responsibilities and experience.

3242

Digitimer

Research Instrumentation

37 HYDEWAY
WELWYN GARDEN CITY
HERTFORDSHIRE
ENGLAND
telephone WELWYN GARDEN 28347

SPANISH FIRM NEAR MADRID

is looking for design and development engineers with a minimum of three years of experience in the field of P.C.M. equipment to be used by the telephone industry.

Areas of interest are encoders and decoders, P.C.M. multiplexers and R.F. equipment to transmit P.C.M. data.

Salary open.

Send resumé to:

NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

2584

Advanced Communications...

Radio Equipment Design and Development



PLESSEY HAVANT
(S. Coast/Hants/Sussex Borders)

Experienced Radio Engineers

Continued expansion of radio communications business in Plessey Avionics & Communications calls for engineers with some experience in the design of equipment for mobile and static applications to lead small and large teams at Plessey, Havant.

The laboratories are situated in the grounds of a country house, three miles from Chichester Harbour and close to the South Downs and several seaside resorts. The area is well placed for housing, shopping, schools, sailing, golf, flying and other recreational and cultural facilities.

A policy of controlled expansion ensures real opportunities for individual career promotion and high levels of job satisfaction.

We offer excellent salaries, conditions of employment, fringe benefits, generous relocation expenses and a stimulating environment.

If you have two or more years' experience in any of the following techniques:-

- HF, VHF or UHF Medium Power Transmitter Design**
- HF, VHF or UHF Receiver Design**
- MODEMS Design - Digital and Analogue**
- Digital Synthesisers**
- RF Signal Switching Techniques**
- Mobile Environment Equipment Design**
- Radio Communications System Design**

—and if you have academic qualifications equivalent to a university degree or membership of a professional institution,

Fill in the coupon or ring Havant (0701 2) 6391 Extension 200, and we will be happy to consider you for a range of appointments carrying salaries of up to £4,000 p.a. There are also opportunities for engineers with lesser experience or qualifications to take up other appointments.

3252

To: *L. Wise, Manpower Manager, The Plessey Company Limited, Martin Road, West Leigh, Havant, Hants.*

Please send me, in confidence, an application form and details of Radio Opportunities.

Name..... Age.....

Address.....

Home telephone no.....

Qualifications.....

Areas of interest.....

PLESSEY  

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. L 54.

Post Office
Telecommunications

91

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

sinclair

RADIONICS LTD

ELECTRONIC TECHNICIAN/ENGINEER

To assist on production faultfinding and analysis of various calculator models. The work involves liaison with subcontractors and troubleshooting at the beginning of production runs. Applicants should have at least O.N.C. but preferably H.N.C. in electronic Engineering or a similar equivalent qualification. Previous experience in the electronic calculator field is not essential. Salary for this position is negotiable.

JUNIOR ELECTRONIC TECHNICIANS

For training on production faultfinding and servicing of electronic calculators. An opportunity has also arisen for a Junior Technician to be employed in our Jig-making Department. The work involves building and wiring of one-off test jigs which are to be used to test electronic components or calculator and Hi-Fi P.C.B. Assemblies. A basic knowledge of electronics is required but previous experience in the Electronic Calculator Field is not essential. Salary for this position is negotiable.

Write or telephone for an application form to Mrs. L. Evans, Sinclair Radionics Ltd, The Mill, London Road, St. Ives, Huntingdonshire PE17 4HJ. Tel: St. Ives 0480 64311.

3281

Test and Calibration Engineers take it from here

When it comes to flight simulation, Link-Miles are leaders in the field. So, when it comes to Test and Calibration Engineers, we're looking for leaders in their field.

You'll be involved in testing and calibrating analogue and digital systems on simulator hardware and software. A minimum of two years' experience of debugging complex systems, backed by an education standard of HNC, will have provided the ideal groundwork for this demanding position that will utilise your engineering ability to the full. You'll

need a flexible attitude to hours of work and to readily adapt to a variety of tasks.

Link-Miles offer good salaries in line with qualifications and previous experience, supported by generous holiday and good pension, sickness and other company benefits.

Take it from Link-Miles - Engineers can go a long way. Contact: Brian Townson, Personnel Manager, The Singer Company (U.K.) Limited, Link-Miles Division, Churchill Industrial Estate, Lancing, Sussex BN15 8UE. Tel: Lancing 5881.

Link-Miles

A DIVISION OF SINGER

Electronics Appointments Register

We can get you a better job than you can get yourself.

The best jobs don't necessarily appear in the sits. vac. columns.

They are often to be found in the Electronics Appointments Register.

Our individual approach gives you a wider choice—we have lots of jobs on our specialised registers and we may well have one tailor-made for you.

The service is absolutely free to you and completely confidential.

In effect we offer you the chance to find your ideal job, all for the cost of a phone-call.

So capitalise now on your specialised knowledge. Call 01-734 6536, or fill in the coupon and we will send you an enrolment form by return of post.

G A R

Graduate Appointments Register

Please send me details of how to enrol on one of your Appointment Registers:

Name _____

Address _____

Please Indicate Salary Range £ _____

Post to G.A.R. 76 Dean Street London W.1. 01-734 6536

WW3

Slough College of Technology

Department of Engineering

Applications are invited for the post of

Lecturer I in Radio and T.V. Servicing (E/1/11)

Required to teach radio, television and electronic servicing in Radio, T.V. and Electronics Mechanics and Technician Courses.

Applicants should hold CGLI Radio & T.V. Servicing Certificate and have had good industrial experience. Teaching experience desirable but not essential.

Salary on Burnham Technical Scale, viz. £1,660-£2,685 plus additions for qualifications and training. Removal expenses up to £115 may be paid in approved cases.

Further particulars and application forms obtainable from the Vice Principal, Slough College of Technology, Wellington Street, Slough SL1 1YG, Bucks. to whom they should be returned within two weeks of the date of this advertisement.

3219

SCT

APPOINTMENTS

Radio Technician Ground Equipment

A Radio Technician is required at Heathrow Airport for the installation and maintenance of VHF and UHF equipment used for ground installation and vehicles, and the maintenance of personal calling systems.

Applicants must have a sound knowledge of VHF/UHF communication equipment. Experience of Pye and Storno equipment would be an advantage.

A current driving licence is essential.

The salary starts at £36.74 per week plus £4.50 per week shift allowance.

Additional benefits include a contributory pension scheme, sports and social facilities and concessional holiday travel worldwide.

Applications, quoting reference 107/VW/BW should be addressed to:

Manager Selection Services
BOAC
PO BOX 10
Heathrow Airport (London)
Hounslow
TW6 2JA

3217

British airways



NEWCASTLE UNIVERSITY HOSPITALS

REGIONAL MEDICAL PHYSICS DEPARTMENT
NEWCASTLE GENERAL HOSPITAL

ULTRASONIC IMAGING OF THE HEART

Applications invited from electronic engineers and physicists with practical experience in electronics for the position of Research Assistant in the Department of Medical Physics. The successful candidate will work within the Ultrasonics Section, developing new ultrasonic methods for visualising the heart.

The appointment will be for two years in the first instance with possibility of extension by a further year. Initial salary £1,566 to £2,079 according to age, experience and qualifications.

Whitley Council conditions.

Further particulars may be obtained from Professor F. T. Farmer, Newcastle General Hospital, Newcastle upon Tyne, NE4 6BE. Applications giving names and addresses of two professional referees to Secretary, Western Sub-Group, Newcastle General Hospital, Newcastle upon Tyne, NE4 6BE.

[3216]

Devices

ELECTRONIC PROJECT TECHNICIAN

An exceptional opportunity for a talented technician who has sound experience in electronic design and sufficient mechanical aptitude to ensure his effective participation in practical development work. The vacancy calls for a keen and active person who will enjoy working as a member of a small team of specialists engaged in the design and manufacture of photo-electric sorting machinery. The Company has a first class record in this field and qualified scientific advice is available within the organisation in support.

Write or telephone the following:—

**Personnel Manager,
Devices Instruments Limited,
Hyde Way,
Welwyn Garden City, Herts.
Tel: 28511 Ext. 18**

[3259]

ELECTRONICS TECHNICIAN/ENGINEER

in an Advanced Electronics Development Group. Experience in the design, development, construction and maintenance of digital and analogue instrumentation and control systems is required. A high standard of practical ability is essential. Minimum qualification is an H.N.C. or equivalent, and the salary range £2,182 to £2,557. Apply to: Professor A. R. Ubbelohde, C.B.E., F.R.S., The Department of Chemical Engineering and Chemical Technology, Imperial College, London SW7 2AZ.

[3280]

Motoring Which? ELECTRONICS ENGINEER

This post at our Car Test Unit in North Essex will involve the design, production and maintenance of varying types of electronic apparatus and instrumentation concerned with the testing of vehicles. The successful applicant will have had wide experience in both the electronic and mechanical aspects of engineering, with education to O.N.C. (and preferably to H.N.C. standard).

Salary not less than £1950 a year; lunch allowance; five weeks' annual holiday and Pension and Life Assurance Schemes. Please obtain an application form from the Personnel Officer, Consumers' Association, 14, Buckingham Street, London, WC2N 6DS. Tel: 01-839 1222.

[3267]

SENIOR TEST ENGINEER

An experienced test engineer with potential leadership ability is required for electronic testing of data preparation equipment. Considerable experience of digital logic is important. Starting salary in the region of £2,000 p.a.

Phone or write for application form to:

**MR. PIYASENA,
DATEK SYSTEMS LTD.
849 HARROW ROAD,
WEMBLEY, MIDDLESEX.
Tel: 01-904 0061.**

[3243]

The University of Leeds

DEPARTMENT OF
PHYSIOLOGY

CARDIOVASCULAR UNIT

Applications are invited for the post of EXPERIMENTAL OFFICER in Electronics. A degree or HNC is required. Responsibilities include PDP12 and PDP8 computers, electronic equipment in three physiological laboratories and three hospital catheter laboratories, and the supervision of four electronics technicians. Salary scale £1869-£2187. Preliminary enquiries may be made to the Director of the Cardiovascular Unit, Department of Physiology, The University, Leeds, LS2 9JT.

Forms of application and further particulars from the Registrar, The University, Leeds LS2 9JT (please quote 43/12/C). Closing date 10 December 1973.

[3274]

AGRICULTURAL
RESEARCH COUNCIL

Food Research Institute
Electronics Division

AN

ELECTRONICS ENGINEER

is required to assist in the design, development and maintenance of a wide range of electronic equipment associated with the Institute research programme. The successful candidate will be expected to exercise initiative whilst working as a member of a team.

Applicants should have a minimum qualification of HNC or equivalent, and a sound basic knowledge of analogue and digital techniques. Experience of data acquisition systems and general electronic instrumentation would be relevant.

The appointment will be in the Scientific Officer (£1,318-£2,177 p.a.) or Higher Scientific Officer (£2,076-£2,667 p.a.) grade, depending upon qualifications and experience; a minimum of five years' post qualifying experience is required for appointment to the higher grade.

Optional superannuation scheme, membership of which carries a salary supplement of 5% to offset contributions.

Application form and further particulars from the Secretary, Food Research Institute, Colney Lane, Norwich, NOR 70F, quoting reference 73/22.

[3258]

SYSTEMS COMMISSIONING ENGINEERS

Redifon Electronic Systems Ltd. is a leading manufacturer of computer based and digital systems. Due to our expanding order book we require more Systems Commissioning Engineers who are anxious to extend their capabilities in this fast moving field. They will be required to test and commission units and systems comprising or containing:

**-Telemetry Systems
Data Acquisition and Control Systems
Computer Controlled Systems
Marine Radar Simulation Systems
Air Traffic Control Simulation Systems
Simulated Communication Systems
Display and Control Consoles
Computer Interfaces
Video Processing Systems including CCTV and VTR**

Suitable candidates are likely to be under 26, with C & G; or ONC (Electrical). Alternatively they may have received Services training in a related field.

If you feel you measure up to the above requirements or have direct working experience in these fields we should like to hear from you.

We offer above average salaries, scope for overseas travel if desired, and the benefits and security that come from working with a member of a large International Group of Companies. Prospects for rapid promotion are enormous for those able to demonstrate their ability to carry individual responsibility. Write with brief career details to:

A. D. Cox, Personnel Manager,
Redifon Electronic Systems Ltd.,
P.O. Box 2, Manor Royal, Crawley, Sussex.

REDIFON 

A Member Company of the Rediffusion Organisation



1970

PORTSMOUTH

Highbury Technical College
Educational Television Unit

Senior CCTV Technician

Technician required for maintenance, operation and development of CCTV complex. Applicants should be qualified in electronics or telecommunications and have relevant practical experience. Knowledge of video tape recorders would be an advantage.

Salary on Grade T3/T4—£1416 to £1926 p.a.
Allowance payable for appropriate qualifications.

Forms and details from:
College Secretary, Cosham, Portsmouth, PO6 2SA. (Cosham 83131, Extn. 247)

[3260]

Storno

RADIO COMMUNICATION SYSTEMS

We have vacancies for:

SERVICE TECHNICIANS

for our Service Department based in Camberley. Applicants should be familiar with transmitter/receiver practice or have practical knowledge of television or domestic radio.

SALARIES UP TO £2000 per annum plus overtime.

ELECTRONIC TEST TECHNICIANS

based in Camberley to work in preparation, development, test and fault finding of special FM/VHF/UHF communications and control systems, preferably with previous experience in radio communications technology and control systems.

SALARIES UP TO £2000 per annum plus overtime.

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.

Telephone: 0276 29131

ELECTRONIC TECHNICIANS

The Marine division of Staveley Electrotechnic Services Ltd. is expanding its servicing facilities, with particular reference to Radar, Communications, Electronic Navigational Aids, Automation Control Systems, Data extraction, etc.

Vacancies exist at depots throughout Great Britain and Ireland for versatile Electronic Technicians, to be engaged on trouble shooting, maintenance, installation and commissioning work involving occasional travel within the U.K. and overseas.

Suitable applicants, probably over 25, will have practical experience in two or more of the above subjects, possibly gained in the Royal Navy, Merchant Navy or similar environment. A technical qualification, whilst useful, is not necessary as practical experience and ability will be deciding factors.

A good basic salary, plus overtime, brings the expected earnings to between £2250 and £2500. Expenses are additionally allowed and a 37½-hour working week is in operation. A Company vehicle is provided, three weeks annual holidays, a contributory pension scheme and free life insurance.

Applications giving full particulars of experience to date to:

**The Marine Divisional Manager,
Staveley Electrotechnic Services Ltd.,
68 Grosvenor Street,
Manchester, M1 7EW,
England.**

[3218

Installation Field Staff Telecommunications Equipment

STC require Fitters, Testers and Technicians

The company have vacancies on installation projects in London and throughout the UK. Applicants should, preferably, have had experience of telecommunications or electronics. Testing staff should hold a current driving licence.

The successful candidates will work on Multiplex, Co-axial and Submerged Repeater Systems and a working background of these systems would be a distinct advantage.

Attractive starting salaries are offered and benefits include living allowances when working away from home, and good sickness and pension schemes.

Write or telephone D. Hotchkiss
Basildon 3040 Ext. 670.

Personnel Department, STC, Chester Hall Lane, Basildon, Essex.

STC Standard Telephones and Cables Ltd
BASILDON **ITT** A British Company
of ITT

RANK VIDEO LABORATORIES

require

TECHNICAL PERSONNEL

to operate and maintain a wide range of sophisticated electronic broadcast equipment, including AVR-1 machines, flying spot telecine, HS100 Computer Controlled Editing equipment and Cassette Duplicating machinery. A broadcast background is desirable.

A SUPERVISORY MAINTENANCE ENGINEER

to take charge of a small specialist staff maintaining a wide range of sophisticated electronic broadcast equipment, including AVR-1 machines, flying spot telecine, HS100 Computer Controlled Editing equipment and Cassette Duplicating machinery. A broadcast background is desirable.

Applications should be made, in writing, giving brief details of experience to:—

**The Manager,
Rank Video Laboratory,
142 Wardour Street,
London, W1V 4BU**

or telephone 01-734 2511 for application form

[3286

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Applications are invited from qualified design engineers specialized on:

- Ground/Air Communications
- TV Colour Transmitters
- Side Band Transmitters

At least 5 years experience desirable. Company located in Madrid. Salary open.

Send resumé to:

NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2539

OPPORTUNITIES IN VIDEO

The Distributive Industry Training Board, which is charged with encouraging training in Britain's second largest industry, is establishing a Video Unit within its Information Division to produce training and information programmes on tape and cassette. The Unit, though small, will be expected to produce programmes of high quality and has vacancies for the following staff:

PRODUCER/SCRIPTWRITER (£3,330—£4,530)

who will have responsibility for researching, writing and directing programmes, giving assistance and advice on video development to organisations within the distributive trades and marketing the Unit's products. The successful candidate will almost certainly have a background in journalism, radio, television or educational video. The basic requirements are proven writing talent, a flair for visual presentation and organising ability.

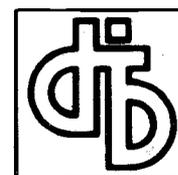
SENIOR TECHNICIAN (£2,031—£2,847)

to assist Technical Manager in maintenance and day-to-day operation of colour cameras, monitors and associated equipment. The successful applicant will have had several years' experience in television servicing, and, desirably a knowledge of studio equipment.

TECHNICAL ASSISTANT (£1,539—£2,307)

This is a post which would appeal to a young person with a lively interest in, and some knowledge of, basic electronics and the desire to expand his experience in the field of television. A technical qualification in physics or electronics would be desirable but not essential.

Please write for application form, quoting reference VU/63 to the
**Controller, Personnel & Services,
The Distributive Industry Training Board,
MacLaren House, Talbot Road, Stretford,
Manchester M32 0FP**
within the next seven days.



[3293

HF/VHF Radio Manager Sales and Service Nigeria

ITT Nigeria Limited requires an able HF/VHF professional to manage its Radio Division, based in Lagos. He will be responsible to the Managing Director for the sale, installation, commissioning and subsequent maintenance of a range of sophisticated radio communications equipment and systems. Apart from equipment and systems design expertise, the job requires the ability to adopt a marketing strategy appropriate to the technical character of the products concerned, as well as skilful management of both the sales and technical teams.

Candidates should be qualified in electronics or a similar subject to degree or equivalent level, in their mid-30's, with at least 5 years' radio

engineering experience. They should have a record of achievement in radio sales and a proven talent for penetrating technical analysis of customer requirements and accurate specification of systems to meet them. The sales and technical functions will be accorded equal importance.

An attractive salary and allowances will be paid as well as free housing and other benefits. There are good prospects of further career progression within ITT.

Please write, in confidence, with brief details of experience, qualifications, age and present salary, to the Personnel Manager, ITT Africa and the Middle East, 190 Strand, London WC2R 1DU.



3253

Peterborough and Stamford Hospital Management Committee

Appointment of

X-RAY ENGINEER

to be based at Peterborough District Hospital, and become a member of a small team engaged upon the commissioning, maintenance and repair of a wide range of diagnostic X-ray apparatus.

Candidates should possess H.N.C. (Electronics) or equivalent, but consideration will be given to suitable candidates with O.N.C. who are proceeding to a higher qualification.

Salary scale offered is £1,911 to £2,508.

Possession of a car is essential, travelling expenses being payable in accordance with agreed scales for Health Services staffs.

Application forms and job description obtainable from the Group Engineer, Peterborough District Hospital, Thorpe Road, Peterborough, to be returned completed within 14 days of the appearance of this advertisement.

[3295



City of Glasgow Police

WIRELESS TECHNICIANS

SALARY £1,809-£2,040

The City of Glasgow Police, Wireless Branch, require experienced Wireless Technicians to install and maintain a wide range of interesting equipment.

A City and Guilds Certificate in telecommunications would be an advantage, but emphasis will be on applicants' ability and experience.

These are secure, superannuated positions and successful applicants are offered scope, variety and responsibility with the prospect of a steadily developing career in a demanding and ever expanding field.

Applicants must be in possession of a current driving licence.

Conditions of service include a 37 hour week, 18 days annual holiday, plus 8 public holidays and sickness scheme.

Written applications should be submitted to
the Chief Constable, City of Glasgow Police,
21 St. Andrews Street,
Glasgow G1 5PA.

3240

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

ilea INNER LONDON
EDUCATION AUTHORITY

EDUCATION TELEVISION SERVICE
Tennyson Street, London, S.W.8.

Mobile Section Engineer

£2,907-£3,138

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.

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 EO/Estab 2A/2), The County Hall, London, S.E.1. Tel: 01-633 7456 or 01-633 7546. Closing date for completed application forms — 10th December 1973.

3275

**ONE EXPERIENCED ELECTRONIC ORGAN
SERVICE ENGINEER**

and
**ONE EXPERIENCED TELEVISION AND
HI-FI SERVICE ENGINEER**
required for expanding Organ Business
in Sussex.

Good Salary and Prospects.
Apply in writing to S. W. J. Miller, Honeywood
House, Rowhook, Horsham, Sussex.

[3231]

Central School of
Art and Design

Southampton Row, London WC1B 4AP
Department of Graphic Design

Cine-Animation Technician

To control the operating of a small but productive cine-animation section, with some lively and interesting films to its credit; the unit is largely concerned with post-graduate level work. Ability to handle sound production, recording and dubbing is essential, together with experience of 16 mm rostrum camera operation.

Grade: 5

Salary: £1,881 - £2,241 (plus £174
London allowance)

Further particulars and application form available from the Senior Administrative Officer at this School, returnable within two weeks of this advertisement appearing.

[3262]

Technical Writer

The Company

Granada TV Rental, a member of the Granada group of companies, are looking for a technical writer to join their training team at Bedford.

The Post

Involves the writing and preparation of technical information on a wide range of domestic television receivers and associated equipment for publication in the company's technical magazine and in the form of short monographs.

The person appointed will be responsible to the Technical Training Manager and work in close liaison with the technical training team occasionally assisting with the technical training courses.

The Man

we are looking for will probably already be working in the technical publications department of a manufacturer in an associated industry but looking for a more challenging post in the technical writing field.

Salary

The post carries a salary of £2200 per annum with generous group benefits.

The successful applicant will be expected to move to the Bedford area on appointment — the company will assist with re-location expenses.

Applications in the first instance to:

John Wales, Personnel Manager, Granada TV Rental, P.O. Box 31, Amptill Road, Bedford.

GRANADA



ELECTRONIC SYSTEMS

We have two vacancies in our Mechanical Equipment and Systems Division.

1. Experienced Electronics Engineer, currently active in both system and circuit design, and skilled in both analogue and digital techniques.
2. Senior Electronics Engineer, not necessarily, though desirably, with system design experience.

The Division is active in the following fields:

- aircraft equipment, including air conditioning and electro hydraulics
- aircraft and hovercraft propulsion systems
- marine automation (buoys, lightships, etc.)
- bio-medical engineering.

Please apply in writing, giving details of achievements and qualifications to:-

**The Personnel Manager,
Hawker Siddeley Dynamics Limited
Hatfield, Herts.**



Careers in Colour TV

For anyone with an electronics background, colour TV is where to be these days. Because colour TV is an industry that's growing and changing at a breathtaking pace.

And ITT is the colour TV company to be with. Sales of our wide range of sets are growing here and throughout Europe. So we need more good electronics people for important jobs in our fault diagnosis and test departments at our main factory in Hastings and at our assembly plant at St. Albans, Herts.

You'll gain valuable practical experience in the latest developments in colour TV technology. You'll develop skills and be making a start in a career that could well take you into key areas such as research and development.

Fault Diagnosis

Within our production activity we need experienced technicians to trace and diagnose faults on colour units. It's highly responsible work, so we're looking for sound colour TV experience and, ideally, an HNC or equivalent in appropriate subjects.

TV Test

Here's the perfect opportunity for home electronics enthusiasts to put their practical knowledge to work. With training, you'll soon get to grips with all the complexities of colour TV equipment, and learn the important principles of test engineering.

If you're an experienced TV service engineer, or have a good electronics training, you could take your place right away in our team of experienced test technicians.

If you want to give yourself a head start in the growing field of consumer electronics, write to Mr. P. R. M. Bebb, ITT Consumer Products (UK) Ltd., Theaklen Drive, Hastings, Sussex, giving sufficient information about yourself and whether you prefer to work in Hastings or St. Albans. 3254

Television, radio and stereo



Electro-Medical Service
Department requires

ENGINEERS

for testing and servicing electronic apparatus. Applicants should be aged 20-30, and should be of O.N.C. standard.

Apply in first instance in writing to:

SIEREX LIMITED
Electro-Medical Department,
Heron House, Wembley Hill Road,
Wembley, Middlesex, HA9 8BZ

[3244]

SERVICE ENGINEER

Due to continued expansion of domestic and overseas markets, we require an additional Service Engineer. Duties will include servicing and maintenance of all types of Audio Visual equipment. Write giving details of experience and qualifications to Works Director, British Films Limited, 260 Balham High Road, London SW17 7AN.

[3247]

Department of Atmospheric Physics
University of Oxford

Applications are invited for a

TECHNICIAN (PROTOTYPE WIREMAN)

to work on electronic equipment for a satellite project. Experience in wiring solid state circuits would be an advantage. University salary scale rising to £1794 p.a. according to age and experience. Apply in writing, giving full details of education, training, qualifications and experience to Dr. C. D. Walshaw, Clarendon Laboratory, Oxford OX1 3PU.

[3226]

CHELSEA COLLEGE UNIVERSITY OF LONDON ELECTRONICS TECHNICIAN GRADE 5

required in Applied Acoustics Laboratories for the design, development and maintenance of electronic systems for postgraduate teaching and research.

Salary scale £2182-£2557 per annum (including London Allowance).

Alternatively, a lower grade post in this field with revised duties and less responsibility would be available for a less experienced candidate. Further details and application forms from the Departmental Superintendent (5AA), (WW) Chelsea College, Pulton Place, London, SW6 5PR.

[3221]

Digital Processing Equipment

International leaders in Electronics, Records and Entertainments.

A number of advanced electronic products currently under development in Systems & Weapons Division laboratories at Feltham require an engineer to contribute to the design, construction and testing of digital processing equipment using state of the art techniques.

If you are a qualified engineer with some digital circuit experience and an interest in digital engineering then telephone or write:

Personnel Officer, EMI Electronics Limited, Victoria Road, Feltham, Middlesex TW13 7DZ phone 01 890 3600 ext 44 or outside normal working hours 01-890 3921.

EXPERIENCED AGENTS

required to service Radio, Intercom, Fire Alarm and electro-mechanical equipment.

Applicants should have own transport and telephone. Part-timers will be considered.

Rates of Pay—£2.00 per hour and 5p per mile travelling.

Please submit full details of experience and availability to

Box No. WW 3251

PRESTON COUNTY BOROUGH
PRESTON POLYTECHNIC

Senior Laboratory Technician (Computer Technician)

DEPARTMENT OF ELECTRICAL AND
ELECTRONIC ENGINEERING

Duties will be mainly concerned with assisting academic staff in operation of a PDP8/E computer installation. A good basic knowledge of electronics is required with experience in logic and/or analogue circuitry.

Salary scale Technician 4 (£1,644 to £1,926 per annum) plus £42 or £72 per annum for O.N.C. or H.N.C. or acceptable equivalent qualification. 37-hour week. Post superannuable.

Details and application forms from the Registrar, Preston Polytechnic, Corporation Street, Preston. Closing date for applications: 30th November, 1973.

In view of Local Government Reorganisation, preference will be given to applications received from Local Authority employees within the new Lancashire Area 10.

[3296

Electronic Component Sales in Eastern Europe

Empexon Limited are expanding their activities in Eastern Europe, and are looking for additional personnel:

- (1) In their overseas sales team. Applicants should have a serious interest in electronics, and a knowledge of German or other useful languages. Full training will be given both in office and field.
- (2) A buyer to assist the Sales Office Manager. Applicants should have a good knowledge of the UK electronics industry.

For both positions apply in writing to:

Mr. B. Abbott,
EMPEXON LIMITED,
233/243 Wimbledon Park Road,
S.W.18
01-874 4362.

[3261

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 WW 183 for application form to:



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

Member of GEC-Marconi Electronics



95

Southall College of Technology

Beaconsfield Road, Southall, Middlesex

Senior Laboratory Technician

required in the Department of Electrical and Electronic Engineering to oversee and co-ordinate the day-to-day work of technicians in the Electronics, Television, Electrical Power and Installations laboratories in the department and, from time to time, be responsible for general college liaison duties associated with equipment and facilities used in the tuition of students.

Qualifications at Part II City and Guilds of London Institute certificate or HNC standard in electrical engineering an advantage; relevant industrial and/or laboratory technician experience is essential.

Salary on scale £2031 to £2340 p.a. inclusive of London Weighting. Additional allowance payable for suitable qualification.

Application forms obtainable from the Registrar, Southall College of Technology, Beaconsfield Road, Southall, Middlesex (01-574 3448) to be returned within 14 days of appearance of the advertisement.

Ealing

Education Service

3239

BOTSWANA ASSISTANT ENGINEER GRADE I

Required by the Posts Telecommunications Dept to be responsible for an area including rural automatic exchanges, open wire carrier systems, VF telegraphs, some plant and 2 GHz microwave equipment.

Candidates, preferably 30-45 years, must hold the City and Guilds Final Certificate in Telecommunications or an equivalent qualification and have a minimum of five years' experience, excluding training, in the transmission/radio field. Candidates with some knowledge of automatic exchanges and subscriber apparatus will be preferred.

Commencing salary including Supplement will be in the range of £2300 to £3280. A substantial gratuity is also payable.

Because of lower rates of Income Tax in Botswana, the gross emoluments are roughly equivalent to UK salaries of

£3450 to £4550 for a single man
£4250 to £4900 for a married man
with two children.

Ref. M2K/730428/WF.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to:

crow agents

M Division, 4 Millbank, London SW1P 3JD, quoting appropriate reference number

[3271]

EAST AFRICAN POSTS AND TELECOMMUNICATIONS ASSISTANT ENGINEERS

Required to undertake appropriate duties in the following fields, based in Kenya or Tanzania:—

- (1) Radio Construction and Surveys
- (2) Radio Maintenance UHF/VHF Systems
- (3) Radio Construction Microwave Systems (Clerk of Works)

Candidates, over 25 years, must possess the City and Guilds Intermediate Certificate in Telecommunications and have at least 7 years' relevant experience.

Salary will be in the range of £2350 to £3170. A generous gratuity is also payable.

Because of lower rates of Income Tax in Kenya, for example, the gross emoluments are roughly equivalent to a UK salary of £3500 to £4350 for a single man and £3700 to £4750 for a married man with 2 children.

Ref. M2K/730669/WF.

Other benefits for both these posts include:—Subsidised Accommodation; Holiday Visit Passages; Education Allowances; Free Family Passages; Appointment Grant £100/£200 Normally Payable; 24-36 Month Tour.

CHIEF RADIO ENGINEER (Aviation)

A leading Light Aviation Company in the South of England carries out full aircraft radio equipment overhauls and repairs; the layout design for, and installation of, radio equipment and systems; radio maintenance and fault rectification.

The company is now looking for a fully Licensed (or otherwise qualified) Aircraft Radio Engineer of sound technical ability backed by 10 years practical experience including several years in a supervisory capacity for appointment as Chief Engineer (Radio).

In addition to sound technical ability the applicant chosen will be a capable administrator and have the commercial and business knowledge necessary. He will be required to control workshop through-put, to design radio installation lay-outs, to estimate costs and check costings.

As he will often be in close contact with customers a good approach and appearance is necessary.

Salary offered is in the region of £3,250 p.a. Write, in strict confidence, giving brief details of career and qualifications to:

**Mr. J. Anderson,
c/o Travers, Smith,
Braithwaite & Co.,
3 Throgmorton Avenue,
London, EC2N 2DA**

[3309]

Electronics Materials Scientists

Our substantial expansion programme in the precious metal refining industry at our Royston, Nth. Herts. Works has created the need for a man or woman with a degree in chemistry or materials physics, preferably with some research experience, to lead development and production in the preparation of materials for the electronics industry.

A good knowledge of preparative inorganic chemistry is required together with some experience in one of the above topics.

Applications should be made in writing, giving a brief description of age, qualifications and experience together with an indication of current salary to:—

**The Company Secretary (Quoting Ref. MC),
Johnson, Matthey Chemicals Limited,
Stockingswater Lane, Brimsdown, Enfield,
MIDDLESEX, EN3 7PW**

3265

Leading Munich Multitrack Pop Studio

requires

DYNAMIC SENIOR RECORDING ENGINEER

to creatively lead a team
of British recording engineers

Write to:

**UNION STUDIOS
ALLESCHER STR. 16
MUENCHEN-SOLLN
WEST GERMANY**

[3297]

£1,980 to £2,200 + RF/MICROWAVE ENGINEERS

with experience in the repair and calibration of RF and Microwave Test Equipment should come and talk to us about their prospects in our expanding company. Contact:

**Technical Manager
CALIBRATION SYSTEMS LTD.
"BLACKWATER STATION ESTATE"
CAMBERLEY, SURREY
Tel. CAMBERLEY 28121**

[3307]

ELECTRONIC VACANCIES

Engineers

Draughtsmen • Designers

Service and Test Engineers

Technicians • Technical Authors

Sales Engineers

£1,600-£5,000 pa

Permanent or Contract



Phone **MICHAEL NORTH**
01-388 0918

MALLA TECHNICAL STAFF LIMITED

334 Euston Rd., London NW1 3BG

LONDON BOROUGH OF BRENT

Willesden College of Technology

Denzil Road, London NW10 2XD

Department of Electrical Engineering

Require LECTURER 1 to teach City and Guilds Radio and Electronics Technician and Mechanics students commencing 1st January, 1974. Applicants should be well qualified with appropriate industrial experience.

Salary: £1,660-£2,847 + London Allowance £118. Starting salary will be above the minimum according to qualifications and experience.

Applications to be returned to the Registrar within 10 days.

[3316

REPAIR/CALIBRATION ENGINEER

£1,980 to £2,200 +

If you are an enthusiastic Electronics Test or Service Engineer in a rut, come and talk to us about the wide range of Test Equipment you could help us repair and calibrate. Contact:

**Technical Manager
CALIBRATION SYSTEMS LTD.
"BLACKWATER STATION ESTATE"
CAMBERLEY, SURREY
Tel. CAMBERLEY 28121**

[3306

MAJOR RECORD COMPANY
require imaginative

AUDIO ELECTRONIC ENGINEER

to develop and maintain professional recording equipment

**POLYDOR RECORDS STUDIO
LONDON
Tel. 499 8686, Ext. 51**

[3298

Electronics testing: & now for something completely different at Cambridge and Haverhill!

Completely different, because promotion potential at Pye Telecom is a firm possibility - and for very good reasons.

On the one hand, demand for radio communication products is increasing by leaps and bounds around the world. On the other, the international esteem of Pye Telecom products has resulted in an ever growing need for them at a rate greater than the general increase in demand. All that adds up to a situation where everyone with potential at Pye Telecom is enjoying the opportunity to demonstrate that potential to its full extent.

Practical experience of electronics fault-finding is the main requirement, but formal qualifications will be an added bonus. Relocation, possible assistance with local authority housing, out-of-the-rat-race locations and, of course, very tempting salaries will be further reasons for you to consider these opportunities very seriously. Get hold of further information right away from:

Mrs. A. Darkin, Cambridge Works, Elizabeth Way, Cambridge CB4 1DW. Tel: Cambridge 58985

or
Mrs. C. Dawe, Colne Valley Road, Haverhill, Suffolk. Tel: Haverhill 4422.



Pye Telecommunications Ltd

A member of the Pye of Cambridge Group

INTERNAL SALES ENGINEER

GEC Semiconductors is a leading manufacturer of specialised integrated circuits in the U.K.

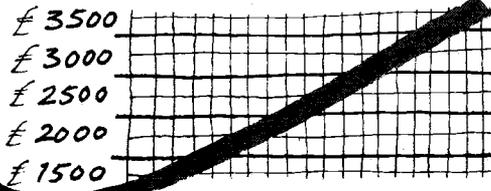
We are seeking an experienced Internal Sales Engineer to provide an office-based technical and commercial link with our customers. He should be familiar with sales office procedures, have an ability to communicate effectively both verbally and in writing, and preferably have some experience in the electronics industry.

A salary of up to £2,500 p.a. will be paid to the right applicant.

Written application should be made to: The Personnel Manager (Ref. L/557/WW), GEC Semiconductors Ltd., East Lane, Wembley, Middx. HA9 7PP.

GEC SEMICONDUCTORS

COMPUTER ENGINEERS



your line to success as a computer service engineer

Vacancies exist in the London, Manchester and Liverpool areas for engineers with computer or electronic or electro-mechanical experience. In addition a number of senior vacancies exist for engineers (particularly with teleprocessing experience) who wish to develop their existing management skills. The Company pays attractive salaries together with generous fringe benefits including bonus, car allowance and non-contributory Pension Scheme.

For further details write or telephone.



COMPUTER FIELD MAINTENANCE LTD. *a member of the Computer World Trade Group of Companies.*

99 Bancroft, Hitchin, Hertfordshire Telephone: Hitchin (0462) 51511

3196

COMPUTER ENGINEERING

We require additional Electronic and Electro-Mechanical Engineers, to be involved in the maintenance of medium to large scale digital computing systems.

Training programmes will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City & Guilds or Radio/Radar experience in the Forces.

After training, and in appropriate circumstances, shift allowances will enhance the competitive basic salary, as will our twice yearly bonus. A contributory pension plan includes generous life insurance.

Opportunities also exist for more junior trainees, aged 18 and over, who should have a good standard of education, an aptitude for, and an interest in, mechanics, electronics and computers.

Please write for an application form, Quoting Ref. WW to:— E. J. Young, NCR 1000 North Circular Road, London NW2 7TL.

Plan your future with



3255

Senior Laboratory Technicians

The BBC requires Senior Laboratory Technicians in the Service Planning Section of its Research Department at Kingswood Warren, Surrey.

Candidates should have a good knowledge of propagation theory and be familiar with basic electronic circuitry.

Education to O.N.C. or equivalent level would be an advantage. They will be expected to show initiative and, following a brief period of training, they will be expected to work with the minimum of supervision. Although based at Research Department, they must be prepared to travel and work for periods anywhere in the United Kingdom; this will include working some weekends. The normal arrangements for such duty ensure regular visits to base.

The starting salary will normally be £2040 p.a. and will rise to £2565 p.a. by annual increments of £105. Inexperienced candidates may initially be appointed at a lower grade and salary. Requests for application forms to

The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA. quoting reference no. 73E2267 and enclosing an addressed foolscap envelope. Closing date for completed application forms 14 days after publication.



ELECTRONIC SERVICE ENGINEER

Required to assist in the Servicing, Maintenance and Development of electronic and electro-magnetic equipment in a progressive printing company.

Formal technical qualifications are not essential, but applicants should have wide experience of press register and drive controls, complex relay logic, computer peripheral equipment etc. A certain amount of light mechanical work is involved.

The engineer will be engaged on shift working, and enjoy 4 weeks annual holiday, Company pension and sickness scheme.

An attractive salary will be paid commensurate with experience.

Apply to:

**Personnel Officer,
Hazells Offset Limited,
Leigh Road, Slough, Bucks.
Tel. Slough 31431.**

A member of the
British Printing Corporation Limited

[3276

Devices**ELECTRONICS
TECHNICIAN
ENGINEER**

To assist with a rapidly expanding development programme, a vacancy exists in our laboratory involving the building of photo-type assemblies, making detailed measurements and a wide variety of other interesting undertakings. This position may well suit a younger engineer keen to get ahead in his career, although older applicants are also invited to apply.

The Company is conveniently situated in a modern factory in Welwyn Garden City.

Write or telephone the following:—

**Personnel Manager,
Devices Instruments Ltd.,
Hyde Way, Welwyn Garden
City, Herts. Tel: 28511 Ext. 18**

3234

**EXPERIENCED
AUDIO TESTER**

REQUIRED BY

LEADING MUSICAL COMPANY

FOR TRANSISTOR AND VALVE
MIXERS, AMPLIFIERS AND
ECHO UNITS.

66 OFFLEY ROAD

S.W.9

01-735 6568

3270

wem**CABLE TV****Skilled Relay Cable
Television Engineer**

required to take charge of the labour force engaged on installing co-axial relay systems in South East area. He must be fully experienced in this type of work and be able to motivate the staff and develop production and control techniques.

High rates of pay, car allowance, assistance with housing and secure and progressive position with a long established public company.

Write with full details of career to date.

**Planning Engineers
or Trainees**

with electrical background to prepare specifications, drawings and layouts of co-axial relay television systems also required.

Apply

BOX No. WW3290**We require
TWO TV BROADCASTING ENGINEERS****(a) One for our Studio Centre in Birmingham.**

The successful applicant will be part of a small engineering team responsible for the installation, commissioning and maintenance of a wide range of technical equipment used in television broadcasting. A knowledge of transistor theory and applications is required.

Applicants must have had several years experience in television broadcasting or of similar work in a technical laboratory. HNC or equivalent standard is essential.

Salary within the range £2,055-£3,007 according to ability and experience, plus fringe benefits.

Application forms may be obtained by **writing to:—**

**Head of Staff Relations,
ATV Network Limited,
ATV Centre,
Birmingham B1 2JP**

Please quote vacancy number 76 (WW).

(b) One for our Elstree (London) Studio Centre.

Duties will involve installing, commissioning, and maintaining audio equipment; a broad general knowledge of electronics is required, to HNC standard.

Experience of audio design or maintenance in TV or Sound radio would be an asset.

Salary in the range £2,055-£3,007 according to experience and ability, plus £120 London Allowance.

Applications to:

**Recruitment Officer,
ATV Network Limited,
Eldon Avenue,
Boreham Wood,
Herts, WD6 1JF.**

Please quote vacancy number 81 (WW).

3241

Service Engineer**To Control the North of England**

Nuclear Chicago, a Company in the fast expanding Searle Group, require a service engineer to take responsibility for the North of England, preferably residing in the Leeds/Manchester area. He will commission new systems, maintain customer liaison and be responsible for after sales service.

A working knowledge of Digital and Analogue circuitry is essential; formal qualifications,

while desirable, are not as important as practical proficiency, and system training will be given at the Company headquarters in High Wycombe. The post carries a good starting salary with regular reviews, three weeks holiday, a company car and excellent conditions of service.

Please apply to: Mrs E M Parr, Personnel Manager, G D Searle & Co. Ltd., Lane End Road, High Wycombe, Bucks.

SEARLE

3248

Radio and Electronic Interference



Internationally recognised for its work on electromagnetic interference problems, the **ERA Industrial Applications Department** undertakes an extensive programme of **contract research**, providing clients with, among other services, a wide variety of interference research and measurement facilities.

The current research programme covers investigations on a wide range of electromagnetic interference topics, but is primarily concerned with the interference characteristics of electrical and electronic equipment and systems from avionics to computers, and techniques of measurement.

We are now seeking to strengthen the existing team by the appointment of at least two additional engineers or physicists.

The successful applicants will most likely possess an H.N.C. with emphasis on Electrical Engineering or Telecommunications. However, as the range of responsibilities is unusually wide, we are willing to consider applications from graduates and indeed from people with no particular qualification, but who have the necessary relevant experience.

All candidates must have a practical approach to problems and have an interest in, and preferably experience of, r.f. techniques. However those recently qualified with an interest in radio, electronics or communication will be considered. We will be looking for evidence of ability to write clear, concise technical reports.

Commencing salary will be assessed primarily on experience. All salaries are reviewed annually to match performance and ERA offers full scope for career development in a rapidly expanding field.

Company benefits include a contributory pension scheme, and re-location assistance where applicable. Please write to, or telephone for application form:

Personnel Manager, Electrical Research Association, Cleeve Road, Leatherhead, Surrey.

Tel: Leatherhead 74151

3315

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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**

92

**Rank Radio
International**

GRADUATE ENGINEERS

We are manufacturers of the specialist range of Leak and Wharfedale hi-fi products, and the demand for these quality products, which are designed, developed and manufactured to precise published specifications, is continually increasing.

The Company's policies therefore include controlled expansion, continuous improvement to current products and the extension of our product range.

Opportunities are available for graduates in electronic engineering or physics to join the acoustic engineering development section which is responsible for the design and development of Wharfedale loudspeakers and liaison with the production engineering function. These vacancies are suitable for graduates with not more than one year's work experience.

This is an expanding company and ample opportunities exist for future career development in this specialised field.

Please write for an application form to:

Mr. J. R. Murgatroyd
Personnel Officer
Rank Radio International
Bradford Road, Idle
BRADFORD, BD10 8SF
TEL. NO. BRADFORD 812552



RANK RADIO INTERNATIONAL

3314

THE UNITED LIVERPOOL HOSPITALS

MEDICAL

ELECTRONICS TECHNICIAN

A technician is required by the Electronics Department to assist with repair, maintenance and calibration work on medical electronic equipment, particularly laboratory equipment.

Candidates should be at least 23 years of age, and have preliminary qualifications and experience in electronics or medical laboratory work.

Salary to be on the Medical Physics Technical Grade III scale—£1,602 rising by annual increments to £2,076 per annum.

Application form obtainable from the Secretary, The United Liverpool Hospitals, 80 Rodney Street, Liverpool L1 9AP, to be returned by 14th December, 1973.

[3317]

HERIOT-WATT UNIVERSITY

Department of Civil Engineering

Applications are invited for the post of

TECHNICIAN

in the Department of Civil Engineering. This post is Grade V for a well qualified Electronics Technician.

Salary scale £2,007 x £75—£2,382.

Further particulars and application forms can be obtained from The Secretary, Heriot-Watt University, Chambers Street, Edinburgh.

[3308]

APPOINTMENTS CONT. ON P.137

SITUATIONS VACANT

ELECTRONICS TECHNICIAN Grade 3 required by Imperial College for the servicing of digital machines on-line to computers, and the construction of prototype equipment. ONC/C and G Cert. an advantage. 5-day week, 9 to 5.30, four weeks holiday plus generous leave at Easter and Christmas. Starting salary on scale £1539 to £1794 (scale under revision) plus £175 London Weighting according to experience and suitability. This is a contract appointment subject to annual renewal. Please apply to Mr. T. W. Dickson, Physics Department, Imperial College, London, SW7. [3215]

HIFI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19]

JAPANESE radio importers require engineers for servicing transistor radios, etc., part or full time to work in our London office near Moorgate underground station. Tel.: 01-628 6157. [3303]

TECHNICIAN required for electronics section concerned with Medical educational television and audio tape Recorder—Starting salary up to £1,300 depending on qualification and experience. Day release towards O.N.C. can be arranged. Duties include operation and maintenance of equipment and tape duplicating. Further details from J. Cooper, Dept. of Audio Visual Communication, British Medical Association, Tavistock Square, London WC1 H9JP. Tel: 01-387 4499. [3291]

VHT CABLE television engineer required, or television engineer, as Assistant Engineer in Private Company. For general inquiries in business hours ring Barnstaple 4283; but written applications preferred to—Barnstaple Relay Service Ltd. Church Lane, Barnstaple, North Devon. [3257]

YOUNG man required for small Coil Winding Company to work on own initiative and after training to supervise operators. Apply Airtronics Ltd., 3a, Walerand Road, London, S.E.13. Tel: 01-852 1706. [3238]

ARTICLES FOR SALE

ARVAK ELECTRONICS. 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23]

Articles for Sale—Cont. on p. 132

Test Equipment Development Engineer

Multitone — world leaders in the electronics communications industry are looking for a Test Equipment Development Engineer.

Duties involve designing and building test equipment for our Production and Test Departments. The activities range from simple jigs for testing small components to complex automatic fault diagnosis equipment.

Applicants should have thorough knowledge of solid state circuitry and integrated circuits and be familiar with radio receivers and transmitters. They must be able to follow a project through from inception to installation, designing printed circuits etc. ensuring constant product reliability.

The salary is negotiable, but will reflect the responsibilities of the job, and promotion prospects and fringe benefits are in line with the policy of a rapidly expanding international company.

Please write giving full details or, if you prefer, telephone for an application form to:



The Personnel Manager,

Multitone Electric Co. Ltd.10-28, Underwood Street
London, N.1. Tel. 01-253 8022

A FUTURE WITH MULTITONE MAKES SOUND SENSE

Research and Development Manager

A manager is required who is technically competent in audio, radio frequency and general communication systems and techniques. He should have been responsible for senior grades of engineers in his past experience and have an awareness of accounting systems and a degree of numeracy.

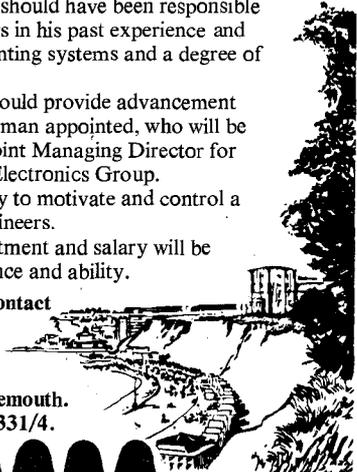
This is a key position and should provide advancement and personal growth for the man appointed, who will be directly responsible to the Joint Managing Director for all technical matters of the Electronics Group.

He must also have the ability to motivate and control a team of existing Design Engineers.

This is a high calibre appointment and salary will be commensurate with experience and ability.

For further details, please contact

Mr. R. C. Jones,
Joint Managing Director,
SNS Electronics Group,
851 Ringwood Road, Bournemouth.
Tel. Northbourne (02016) 5331/4.
Telex. 3232



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Electronics is truly the industry of the future. Many are attracted by its exciting potential but fearful of its complexity. This ICS Career Programme overcomes this and provides comprehensive training covering electro technology, electronic theory, electronic engineering and applied electronics. It will open (for you) a vast and rewarding range of career opportunities.

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Numbers of television sets in this country run into millions, presenting boundless opportunities to you as an expert technician. This ICS Career Programme can make you a trainee professional capable of servicing both colour and monochrome sets. Based on the comprehensive and thorough training you can look towards setting up your own servicing business in this fast growing industry.

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Name (PLEASE PRINT)

Address

Tel. Age

Occupation

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Bristol Polytechnic

The Admissions Office (WW), Bristol Polytechnic, Ashley Down Road, Bristol BS7 9BU.

3285

Articles for Sale—Cont. from p. 131

ANTENNA (AERIAL) BOOSTERS can produce a remarkable improvement in fringe or difficult areas. B11—for the VHF F.M. stereo radio band, B12—for the VHF Band 1 and Band 3 television, B45—for the UHF television band. Price (trade) £2.50, plus V.A.T. S.A.E. for leaflets. Electronic Mailorder Ltd., Ramsbottom, Bury, Lancs. [3227]

BARGAIN TRANSFORMERS .250 v mains in. 55-0-55(110) out. 5amps approx. weight 12lbs. (ex-equip.) £2.45 post paid. Similar 55-0-032-55 volt £2.65 pp. D. G. SMITH 12, Channel Heights, Bleadon, Weston-super-Mare. [3263]

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2 1/2 in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now! [76]

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COUNTER, Electro-mechanical, 6 Digit, & Manual Reset, 24 volts 40 Impulses/Sec. £2.70 + V.A.T. each. Ring M.I.M.C.O. Ltd., 01-969 9388. [3289]

LADDERS 8ft. 10in. closed—22ft. 6in. extended £15.64, delivered. Home Sales Ladder Centre, Haldane (North), Halesfield (1), Telford, Shropshire, Tel. 0952 586644. [22]

OSCILLOSCOPE, Solartron CD711S, Trolley, Handbook. £40 o.n.o. 10 Ivy Close, St. Leonards, Nr. Ringwood, Hants. [3237]

RADIO TELEPHONE EQUIPMENT. Expand your radio telephone system. 12 1/2 kc. G.P.O. approved units. PYE, COSSOR, G.E.C., ULTRA-BURNDEPT. etc., High Band, Marine, Lowband AM and FM. Exports to Africa and Middle East. Spa-Radio, 335/337, High Road, Cheltenham, Glos. [3229]

SONY CVR5600P Colour VTR. Mint condition. Little use from new. £575. Tel: York 27407. [3279]

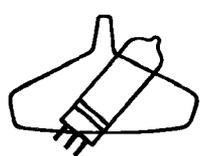
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Articles for Sale—Cont. on p. 134

★ ★ ARTICLES FOR SALE ★ ★

For ££'s more profit just look at these prices!

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Type	Goods Price									
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PCC 89	34p		BC 109	11p	BD 131	45p	EHT RECTIFIER TRAY ASSEMBLIES			
PCC 189	35.5p		BC 113	22p	BD 132	45p	Type	Goods Price		
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PCF 86	35.5p		BC 117	20p	BF 160	20p	ITN GEC/Sobell	£4.25		
PCF 801	39p		BC 125B	18p	BF 167	19p	2TG 1400 + 950 Mk II	£1.75		
PCF 802	35p		BC 132	25p	BF 173	20p	2TAK 1500 5 Stick	£1.90		
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PL 36	49p		BC 147A	8p	BF 185	21p	COLOUR TUBES			
PL 84	22p		BC 147B	8p	BF 194	8p	Type	Goods Price		
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7404 05	18	7442	75 7476 46
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[3301]

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100	£1.75	(.0175 each)
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1.5 Watt 8.2v Zener Diode
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1-24	...	0-180	each
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(150 PIV IOMA)
SILICON DIODE

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100	...	0-045	"
500	...	0-040	"
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2N4290	
2N4292	

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[3304]

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Offers must reach the above named not later than 12 noon on Tuesday, 11th December, 1973.

[3313]

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Red 3mm dia. 25p each; Red 4.45mm dia. 35p each; Green 3mm dia. 68p each; Green 4.45mm dia. 68p each.

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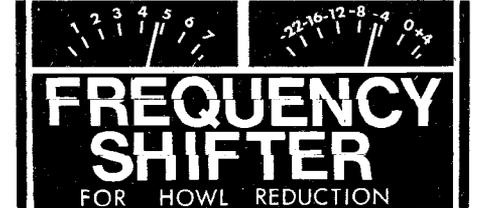
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also 200KHz version for high speed copying.

Drive circuit, 35 x 80mm, for 1mA L.H. zero meters to ED1477.
Gold 8-way Edge con supplied.

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Built and aligned	£12.00	£11.40	£10.80	£10.20

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Type 642, 71 x 56mm **£9.90**; 643, 102 x 79mm **£11.77**
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Articles for Sale—Cont. from p. 132

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Articles Wanted—Cont. on p. 135

Articles Wanted—Cont. from p. 134

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Classified—Cont. on p. 137

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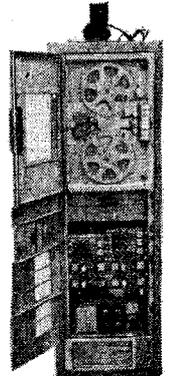
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30 volts. All tapped at 0-12-15-20-30V.					
Output Amps.	Ref. No.	Price	Output Amps.	Ref. No.	Price
500 mA	MT 112 CT	£1.43†	4A	MT 21 AT	£4.51
1A	MT 79 CT	£2.22†	5A	MT 51 AT	£5.21
2A	MT 3 AT	£3.22	8A	MT 88 AT	£8.33
3A	MT 20 AT	£3.65	10A	MT 89 AT	£9.66

50 volts. All tapped at 0-19-23-33-40-50V.					
500 mA	MT 102 AT	£2.07†	3A	MT 105 AT	£5.40
1A	MT 103 AT	£3.00†	4A	MT 106 AT	£6.67
2A	MT 104 AT	£4.20	5A	MT 107 AT	£8.07

60 volts. All tapped at 0-24-30-40-48-60V.					
500 mA	MT 124 AT	£2.33	2A	MT 127 AT	£4.10
1A	MT 126 AT	£3.28	3A	MT 125 AT	£5.96

AUTO-WOUND RANGE					
Power output	Winding tapped at	Ref. No.	Price		
20 VA	0-115-210-240	XMT 113 CT	£1.41		
75 VA	"	XMT 64 AT	£2.64		
150 VA	0-115-200-220-240	XMT 4 AT	£3.21		
200 VA	"	XMT 65 AT	£3.77		
300 VA	"	XMT 66 AT	£4.43		

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100	MT 150 AT*	£4.14	350	MT 153 AT*	£10.97
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9-0-9	50 mA	MT 13 CS**†	£1.36		
12-0-12	30 mA	MT 239 CS**†	£1.41		
20-0-20	30 mA	MT 241 CS**†	£1.41		
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0-8-9 x 2	500 mA x 2	MT 207 CT**†	£2.22		
0-15-20 x 2	500 mA x 2	MT 205 AT**†	£2.95		
0-15-27 x 2	500 mA x 2	MT 203 AT**†	£3.38		
0-15-27 x 2	1A x 2	MT 204 AT**†	£3.38		
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AT indicates open universal fixing with tags; CT is open U-clamp fixing with tags; CS is open U-clamp fixing with P.C. spalls; * with interwinding screen; † untapped 240V Primary; ‡ tapped at 210-240V; other Primaries tapped at 200-220-240V.

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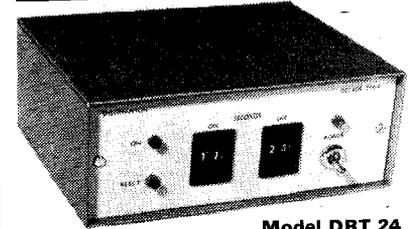
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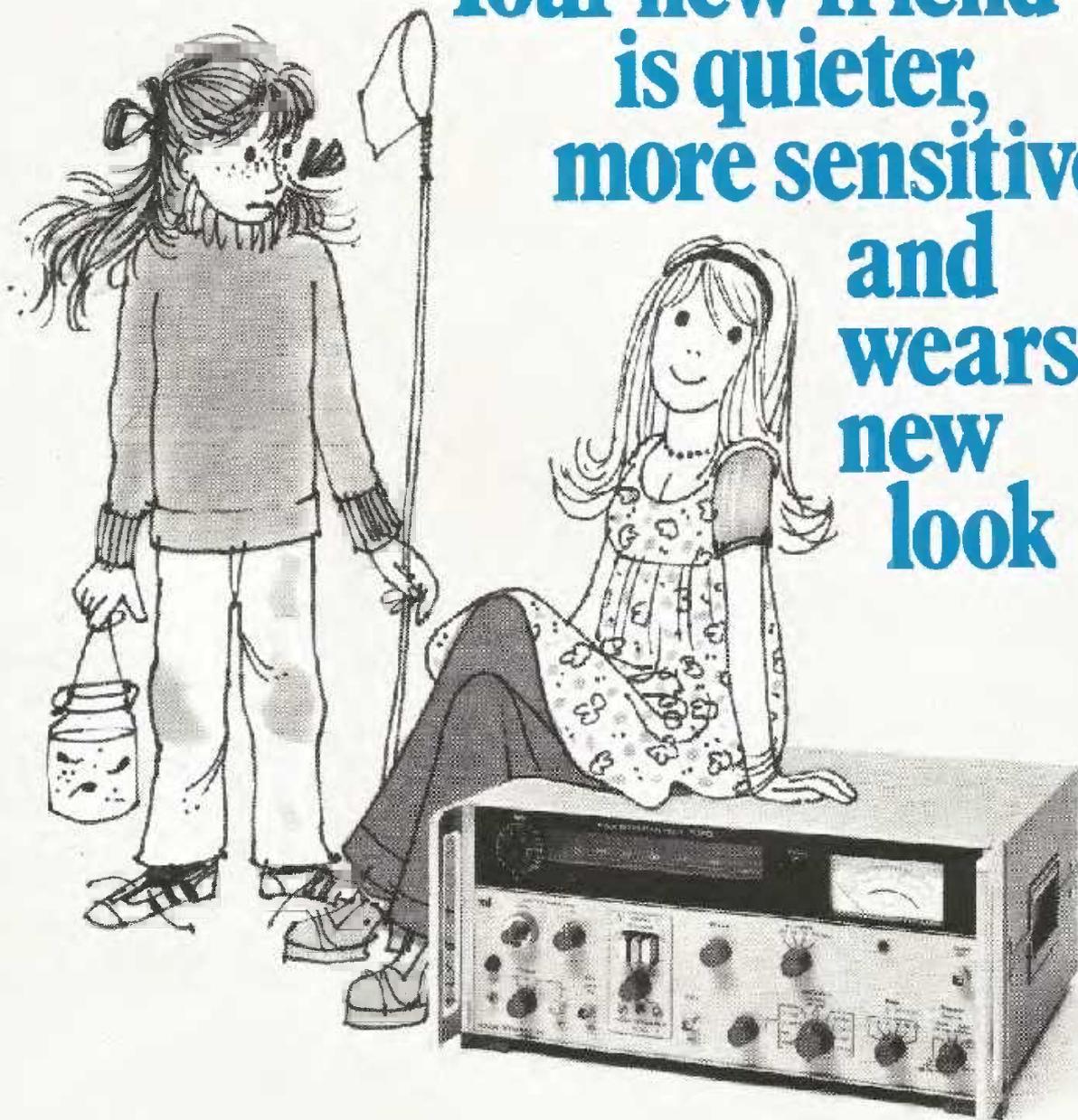
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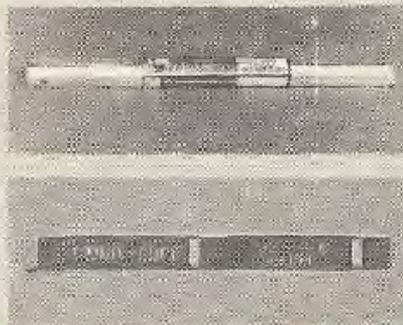
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