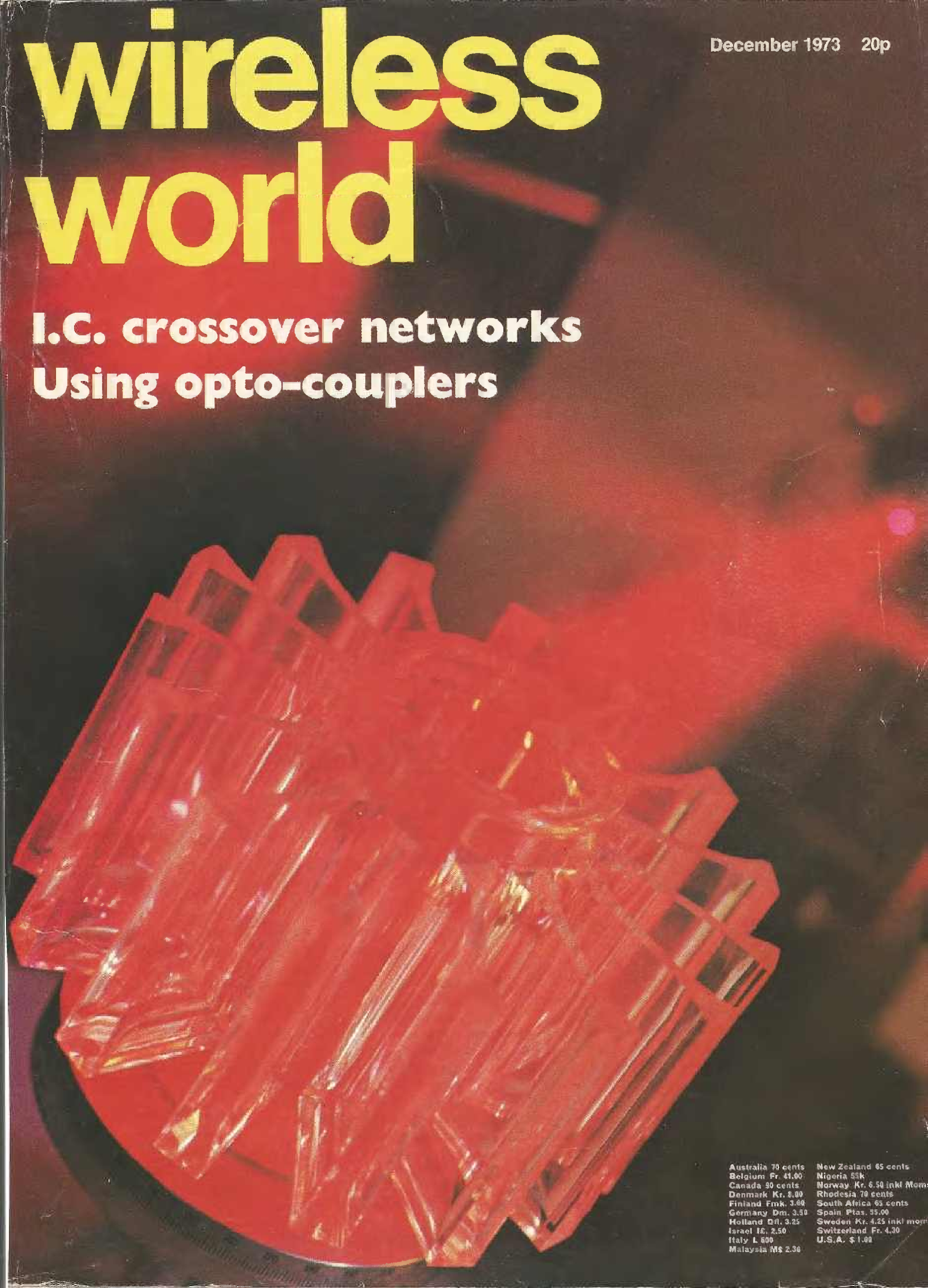
wireless world

December 1973 20p

I.C. crossover networks
Using opto-couplers



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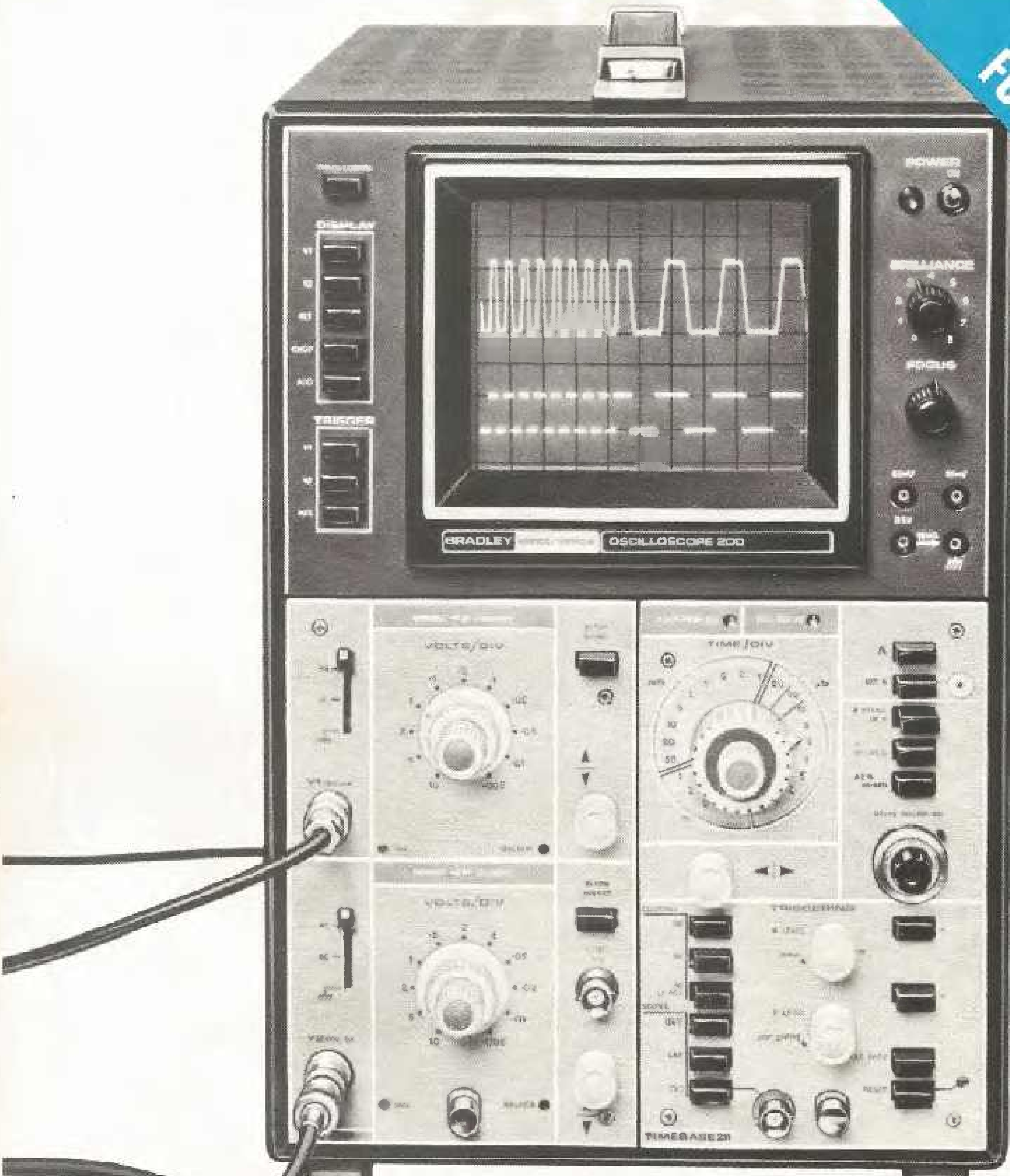
100 MHz OSCILLOSCOPE FOR JUST £595*



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*

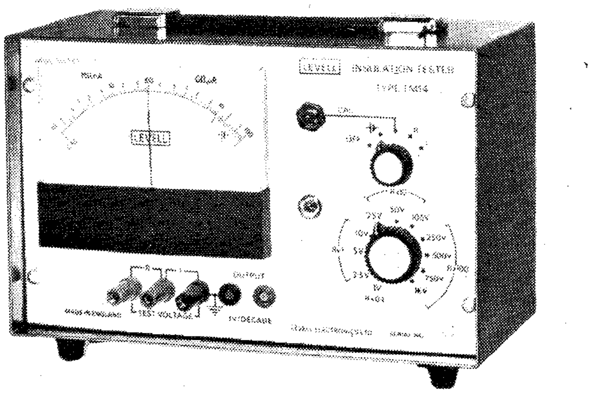
BRADLEY electronics

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 ±15% +800 Ω on 6 decade logarithmic scale.
Accuracy of test voltages ±3% ±50mV at scale centre.
Fall of test voltages < 2% at 10μA and < 20% at 100μA.
Short circuit current between 500μA and 3mA.

CURRENT RANGE

100pA to 100μA on 6 decade logarithmic scale.
Accuracy of current measurement ±15% of indicated value.
Input voltage drop is approximately 20mV at 100pA, 200mV at 100nA and 400mV at 100μA.
Maximum safe continuous overload is 50mA.

MEASUREMENT TIME

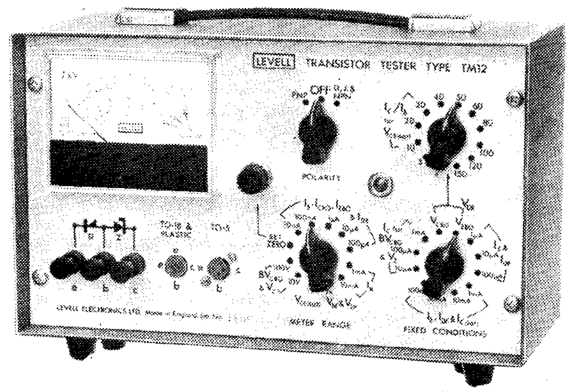
< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10G Ω across 1 μF on 50V to 500V.
Discharge time to 1% is 0.1 s per μF on CAL position.

RECORDER OUTPUT

1V per decade ±2% with zero output at scale centre.
Maximum output ±3V. 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 1μA to 100mA. Breakdown voltages up to 100V are measured at 10μA, 100μA 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, 1μA, 10μA and 100μA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10μA with fall at 100μA < 5%+250mV.

BV_{CBO}: 10V or 100V f.s.d. acc ±2% f.s.d. ±1% at currents of 10μA, 100μA and 1mA ±20%.

I_B: 10nA, 100nA, 1μA ... 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA, and 100mA acc. ±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. ±20mV measured at conditions on h_{FE} test.

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

type TM12 **£65**

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
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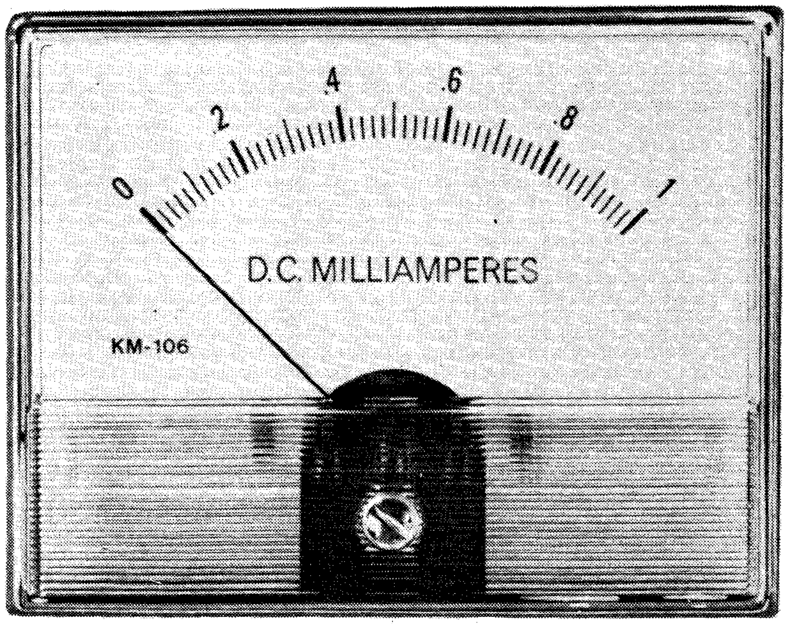
Prices are ex works less batteries, V.A.T. extra in U.K. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

ANDERS MEANS METERS...

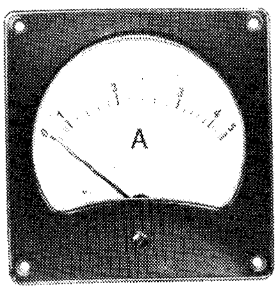
KESTREL RANGE

- 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.

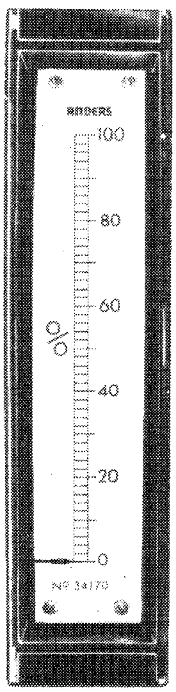


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

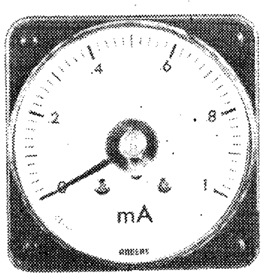
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



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

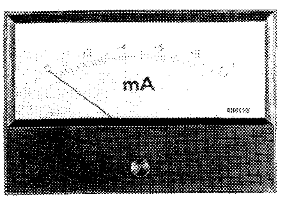


Profile 350 edgewise 4·3″ scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.

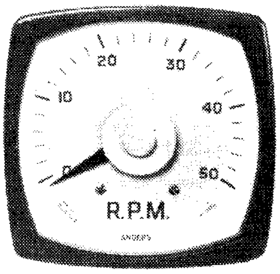


Oxford Long Scale 240°. 2 models, 5·5″, 8″ scales. DC moving coil and AC moving coil rectified.

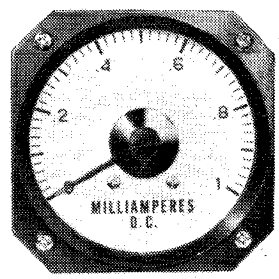
Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2″ and 2″. Available in sensitivities from 50 microamps Moving Coil.



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.

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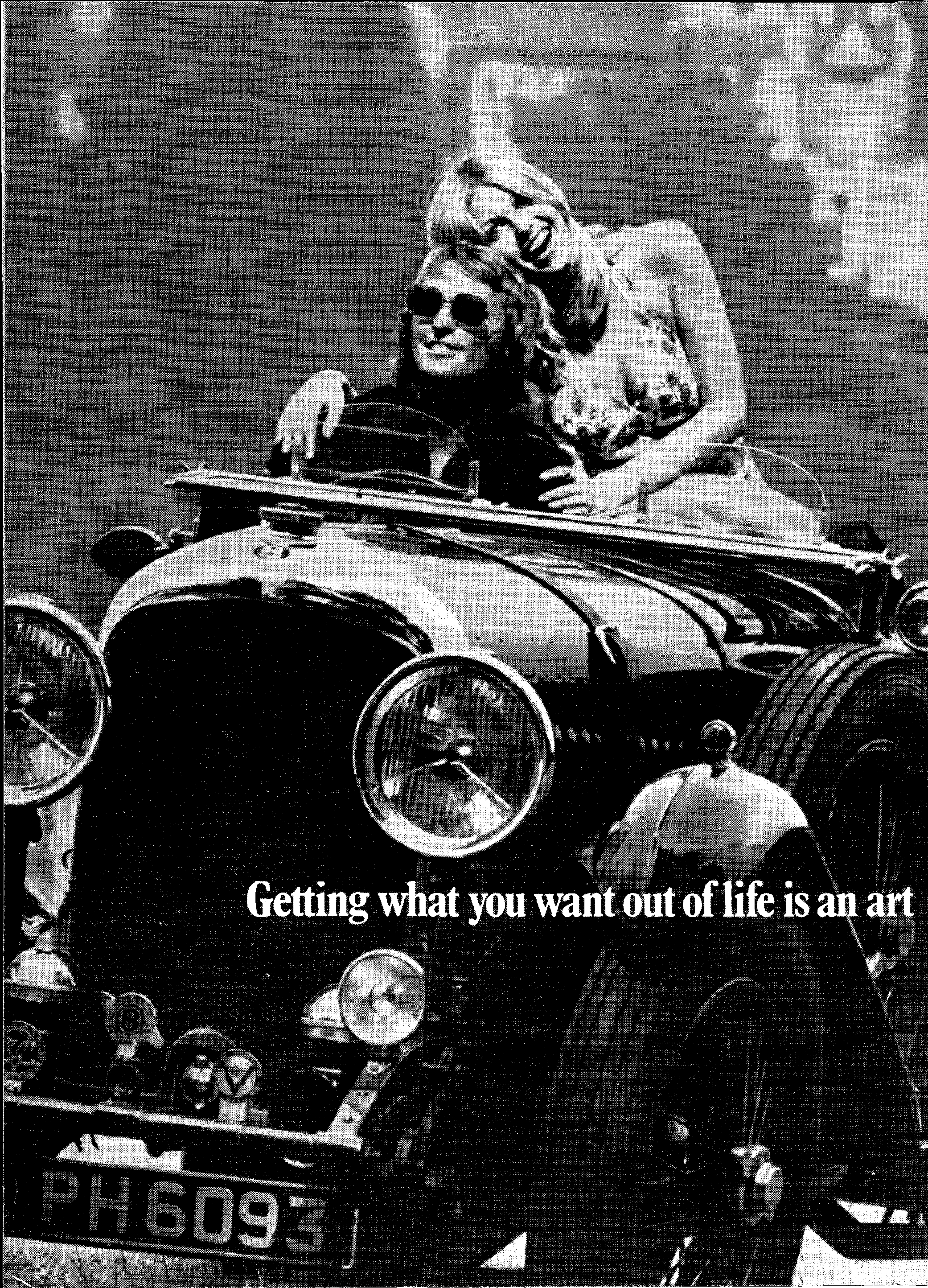

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PH 6093

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

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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.

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

and Garrard know a great deal about it.

AP 86 SB Module
Automatic single player. Performance sets a new standard in medium-priced hi-fi, a heavy, machined diecast platter, screened 4-pole synchronous motor, and new belt drive, together give highest standards. 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.

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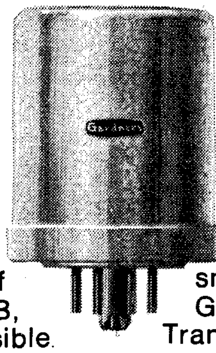
682 PLG

Gardners line up

Line Matching Transformers from Standard to Super Fidelity



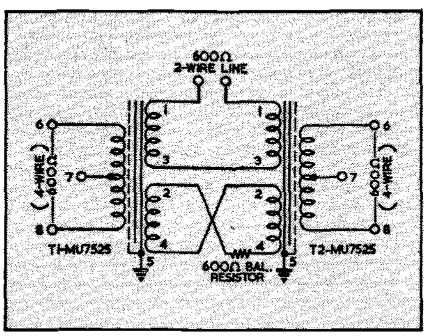
It's easy to choose the right Line Matching Transformer from the five Gardners ranges.

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 magnetically 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

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Loudspeakers
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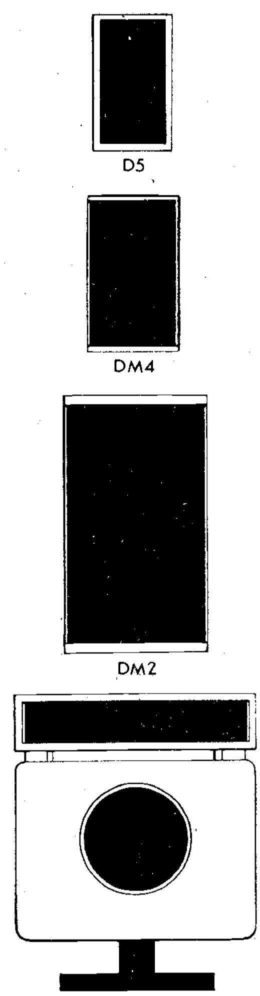
it's a good deal more meaningful than most



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.

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

1973

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&W electronics

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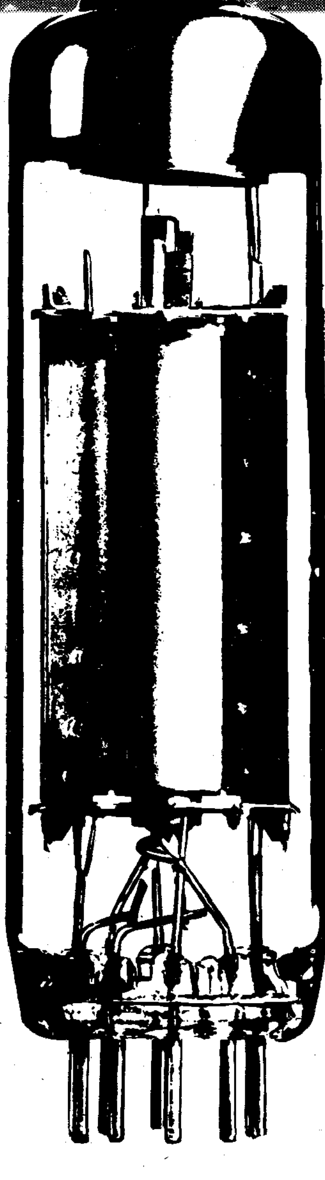
The new home of Haltron



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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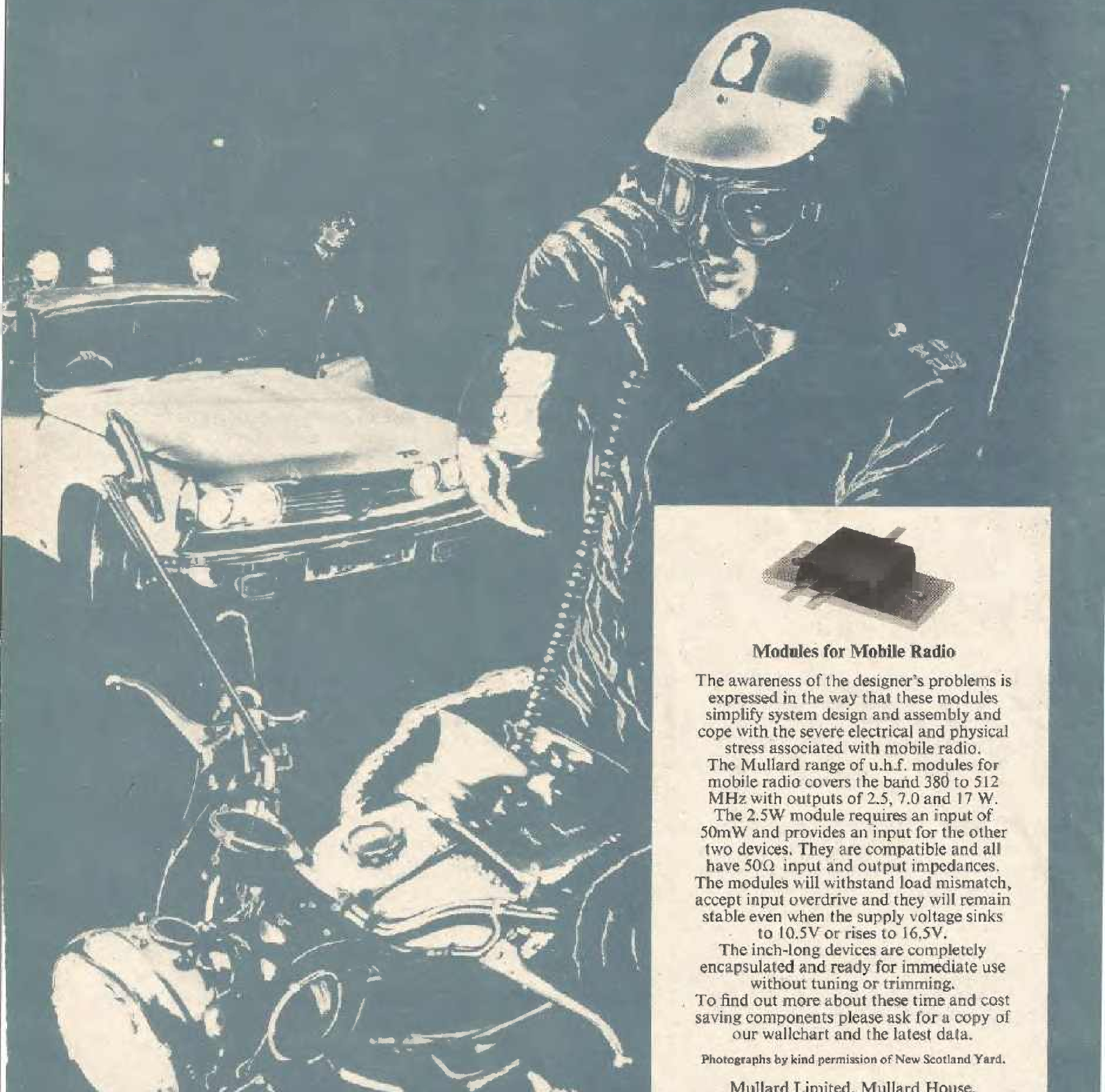
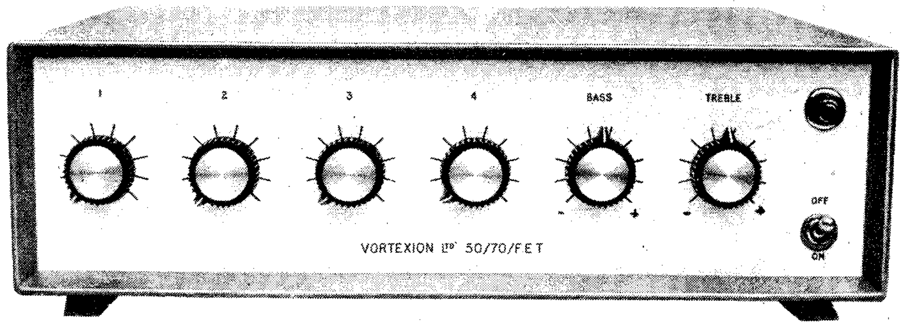


Vortexion

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 ± 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 Telegrams: "Vortexion, London S.W.19"

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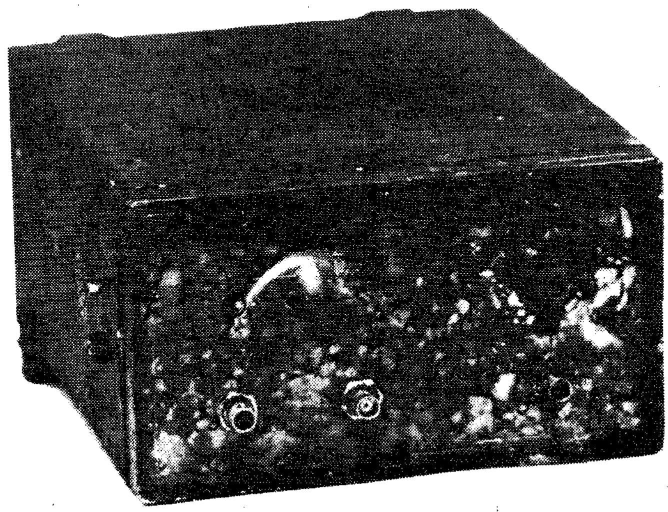
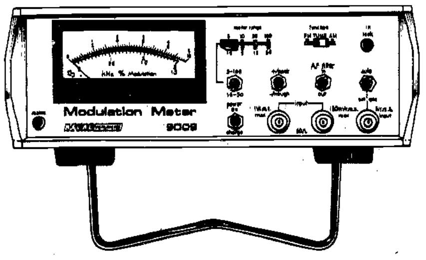
The Inside Story



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.

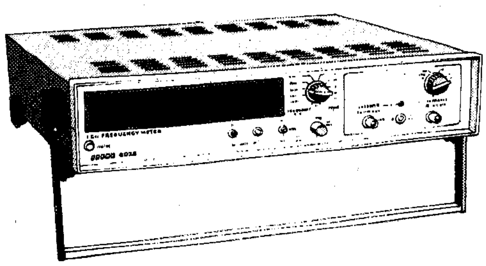
However the frequency divider is just one high calibre instrument among many in a new catalogue now available from Racal. Inside is all the information you need to know about the complete range.

9009 Modulation Meter



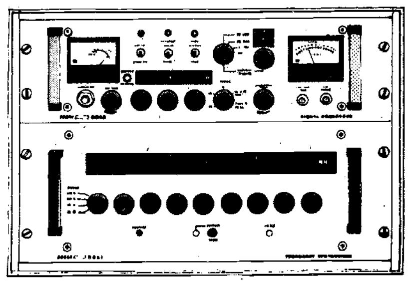
Completely automatic—no tuning—no level setting
Carrier range extends to 1 GHz
A.M. 0 to 100% in 6 ranges
F.M. 0 to 100 kHz in 8 ranges
Fully portable—mains or battery operation

9025 Frequency Period Meter



Direct reading up to at least 1 GHz
Maximum discrimination against unwanted signals and noise
Fully programmable
Sensitivity better than 50 mV

9061/2 Precision Signal Generator



10 Hz to 160 MHz in 1 or 10 Hz steps
Signal to Noise ratio 145 dB/Hz
−100 dB Spurious Levels
Full AM/FM Capability
Completely TTL programmable

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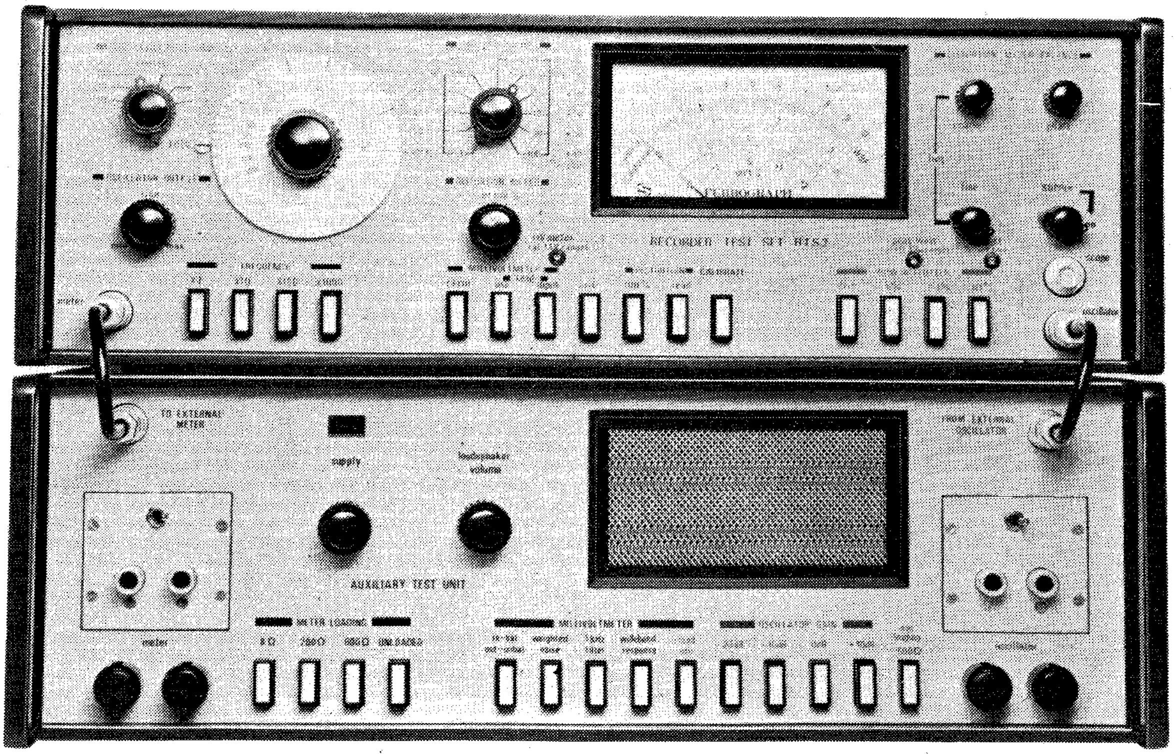
RACAL
The Electronics Group

Audio Test Set RTS 2



and Auxiliary Test Unit ATU1 for professional users

RTS2 Checks Amplifiers, mixers, tape-recorders

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

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

Send for leaflets RTS2 & ATU1

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WW—015 FOR FURTHER DETAILS

Superstars

HIGH-PERFORMANCE MF-HF RECEIVERS for
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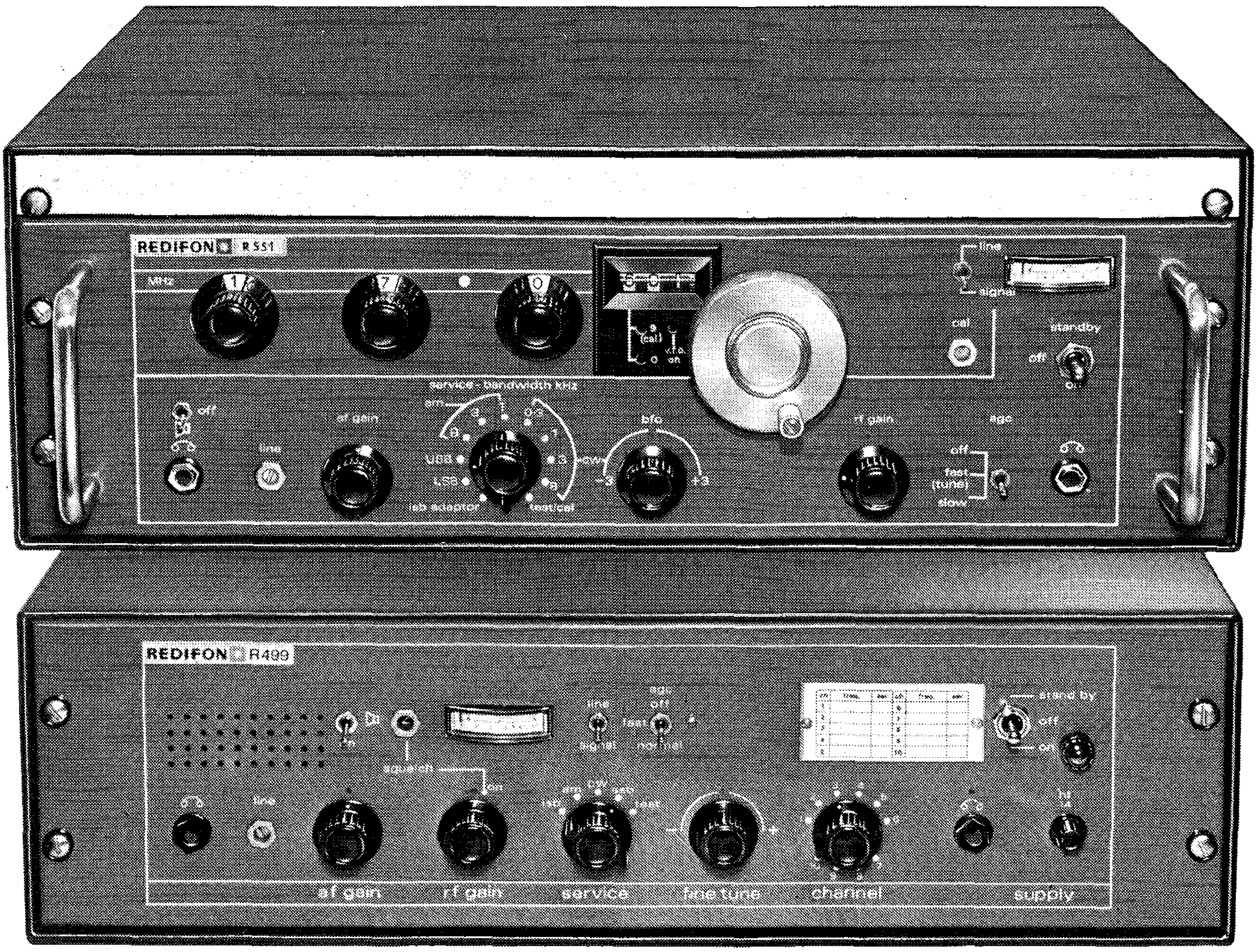

High-grade receiver designs with a choice of tuning wide enough to span the whole world of MF-HF communications.

Here is simply unbeatable performance. Outstanding frequency stability. Unyielding front-end protection. Unrivalled AGC. Plus exceptional dynamic range and blocking characteristics. From this great twosome:

R551 Selection of continuously variable or full frequency synthesis tuning 15kHz – 30MHz. Supplied to leading P. & T authorities. Type approved by British Ministry of P & T and overseas administrations as a ship's main receiver and in use by major shipping companies.

R499 10 switched channels, 255–525kHz, 1.5–30MHz. Optional filters, BFO and carrier reinsertion to provide any or all of CW, MCW, USB, LSB, ISB and DSB modes with choice of bandwidths and remote control over more than 25km. In service with P & T organisations, in civil aviation networks and in coast stations throughout the world.

Redifon Telecommunications Limited
Radio Communications Division
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Tel: 01-874 7281 Telex: 264029

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1973 THE QUEEN'S AWARD TO INDUSTRY

KEF UNITS

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TOVIL MAIDSTONE ME15 6QP
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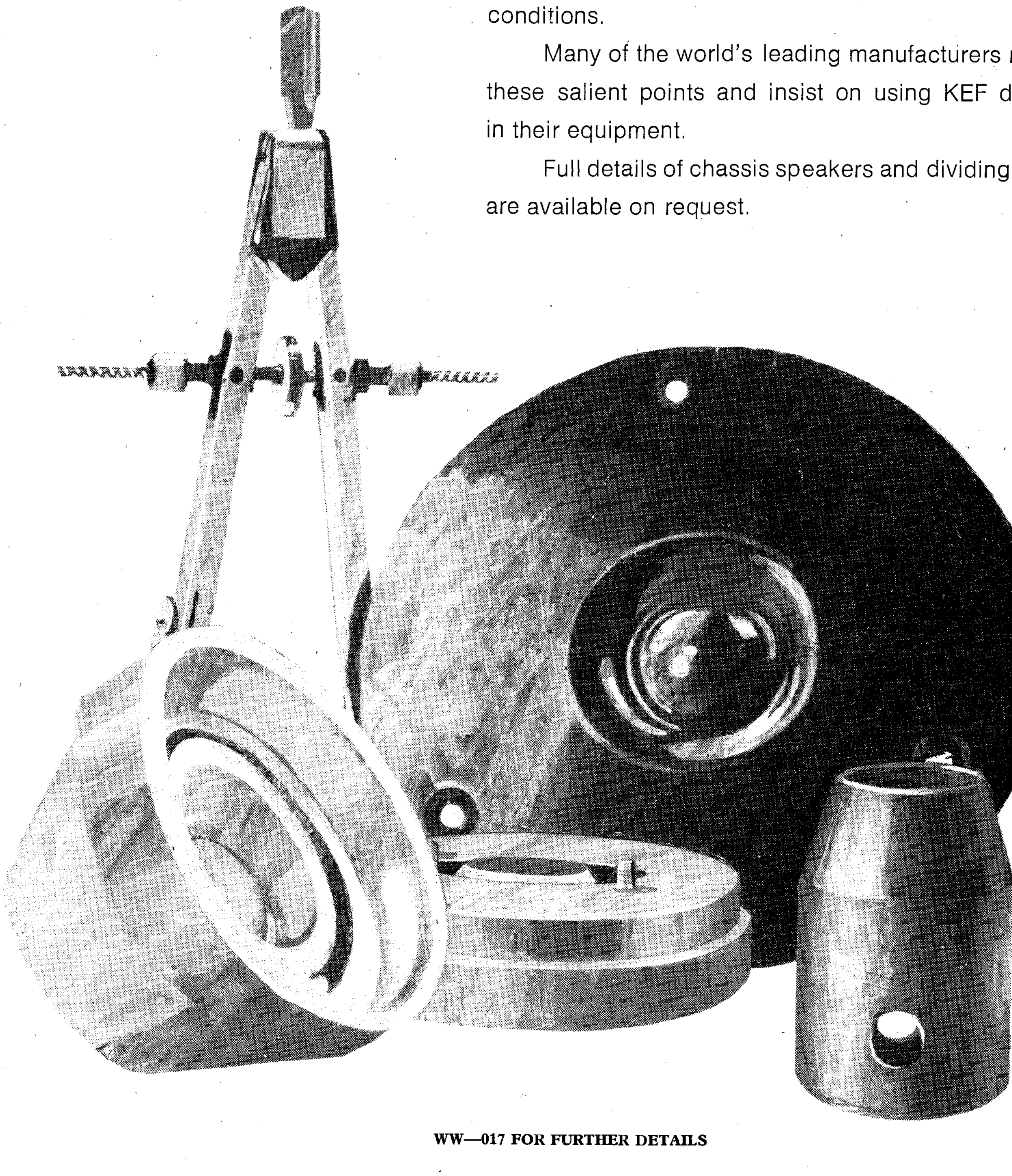
Research based on the premise that loudspeakers could be made to reproduce sound more accurately by the efficient utilisation of plastics and metal alloys has enabled KEF engineers to evolve the current range of chassis speakers.

Results of research on these materials plus spin-off from other technologies has enabled KEF to achieve precise quality control in production, reliability and accurate sound reproduction under wide extremes of operating conditions.

Many of the world's leading manufacturers recognise these salient points and insist on using KEF drive units in their equipment.

Full details of chassis speakers and dividing networks are available on request.



WW—017 FOR FURTHER DETAILS

If you're stuck for original Christmas presents ideas

AMTRON offer you a choice of 200

AMTRON produce a range of 200 electronic kits which provide something of interest for both dabbler and expert. A few examples are: Power Supplies; Pre-amplifiers; Amplifiers; Instruments; Amateur & Radio Control Transmitters and Receivers; Measuring Instruments; I.C. Digital Equipment etc. Complete Blister Packs contain full instructions plus solder.

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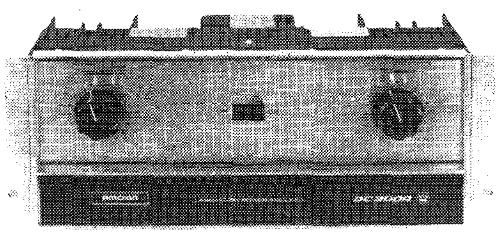
HIGH POWER DC-COUPLED AMPLIFIER



- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
- ★ DC-COUPLED THROUGHOUT
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- ★ 3 YEAR WARRANTY ON PARTS AND LABOUR

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz. The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts +1db, −0db.	Slewing Rate	8 volts per microsecond
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, 9¾" Deep

Other models in the range: D60— 60 watts per channel D150— 150 watts per channel

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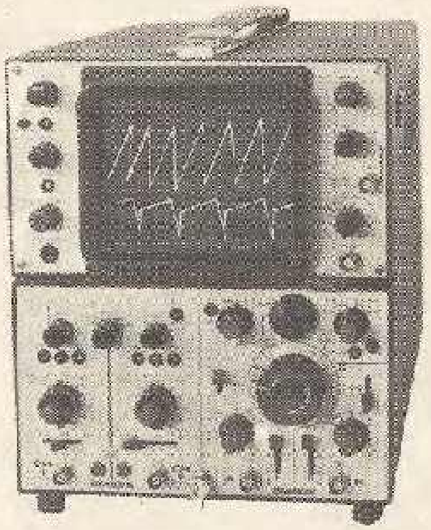
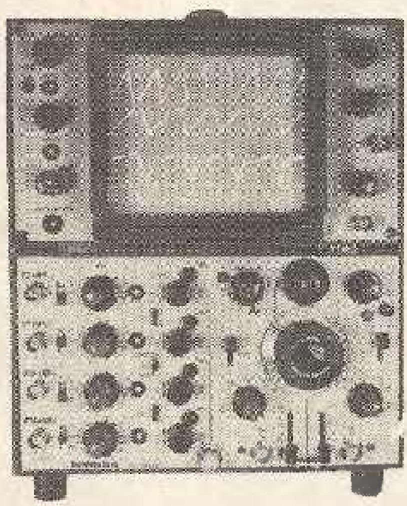
Oscilloscopes

Stroboscopes





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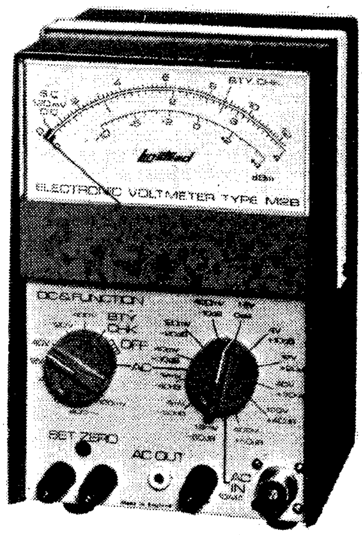

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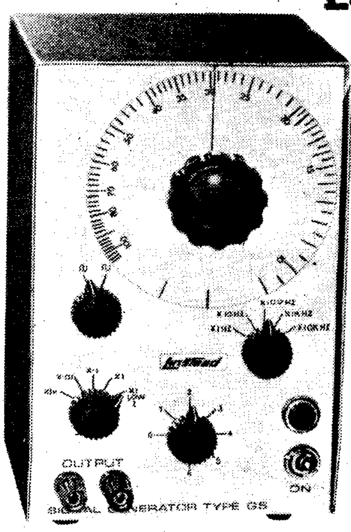

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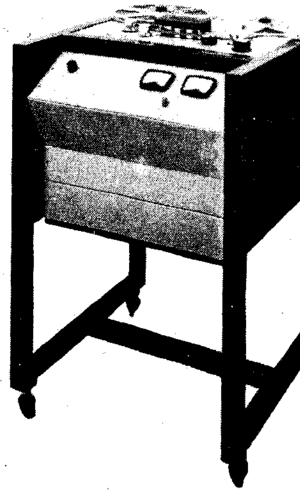

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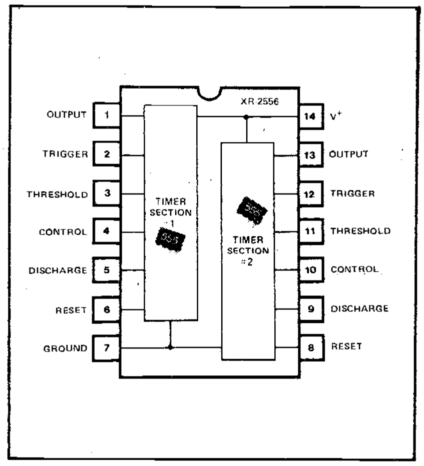
The XR-2556 does this and more! It contains two independent 555-type timers on one monolithic chip. As a result, the matching and tracking characteristics of these two sections is far superior to two separate timer packages. Each section is a stable controller capable of producing highly accurate time delays or oscillations — from microseconds to hours. Each section has independent output and control terminals and each output can source or sink 200 mA and drive TTL. Astable and monostable modes of operation are possible.



PRICE (£)	1-24	25 up	100 up	
XR2556CN	1.70	1.55	1.35	(Commercial, Ceramic)
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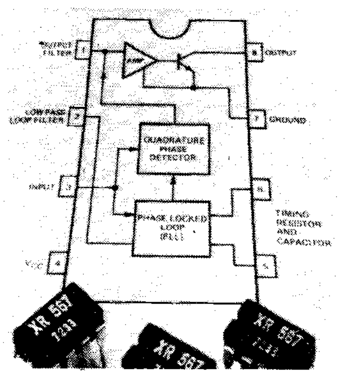
XR-567



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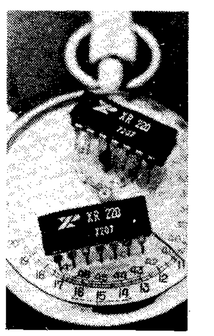

XR-320
When One Timer is Enough

Now is the time to try the low cost XR-320, a single timer similar to the 555. Timing range is 1 μsec to 1 hour • Accuracy is 1% (typical) • Temperature stability is 150 ppm/°C • Hermetic dual-in line package.

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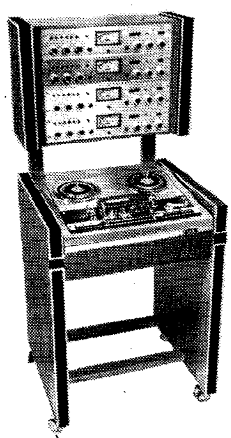

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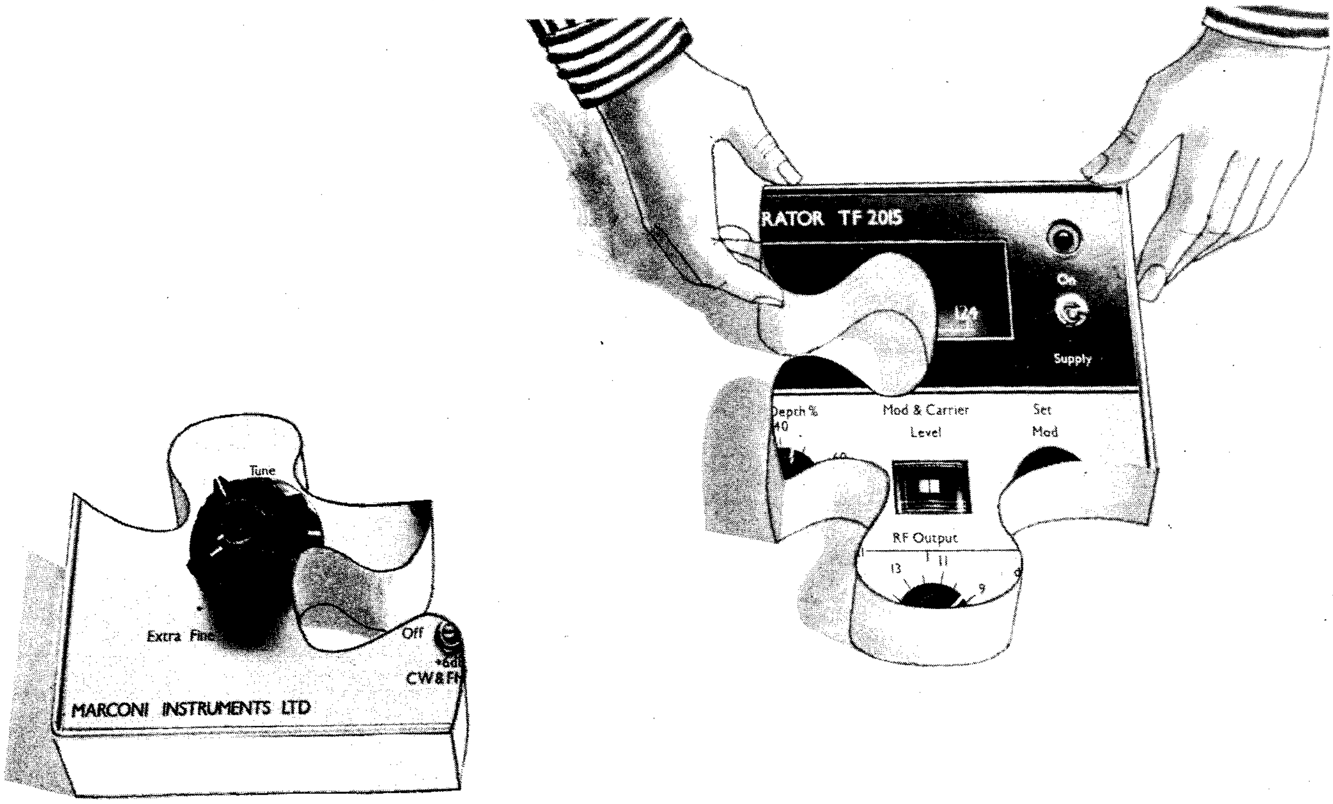

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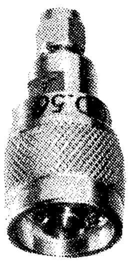

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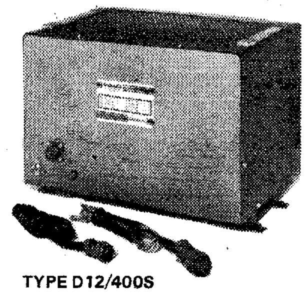
(transistorised Invertors/Convertors)



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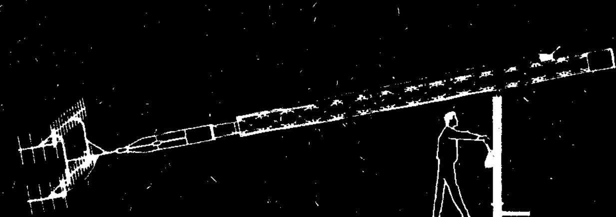

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COSMIC electronics

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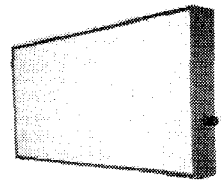

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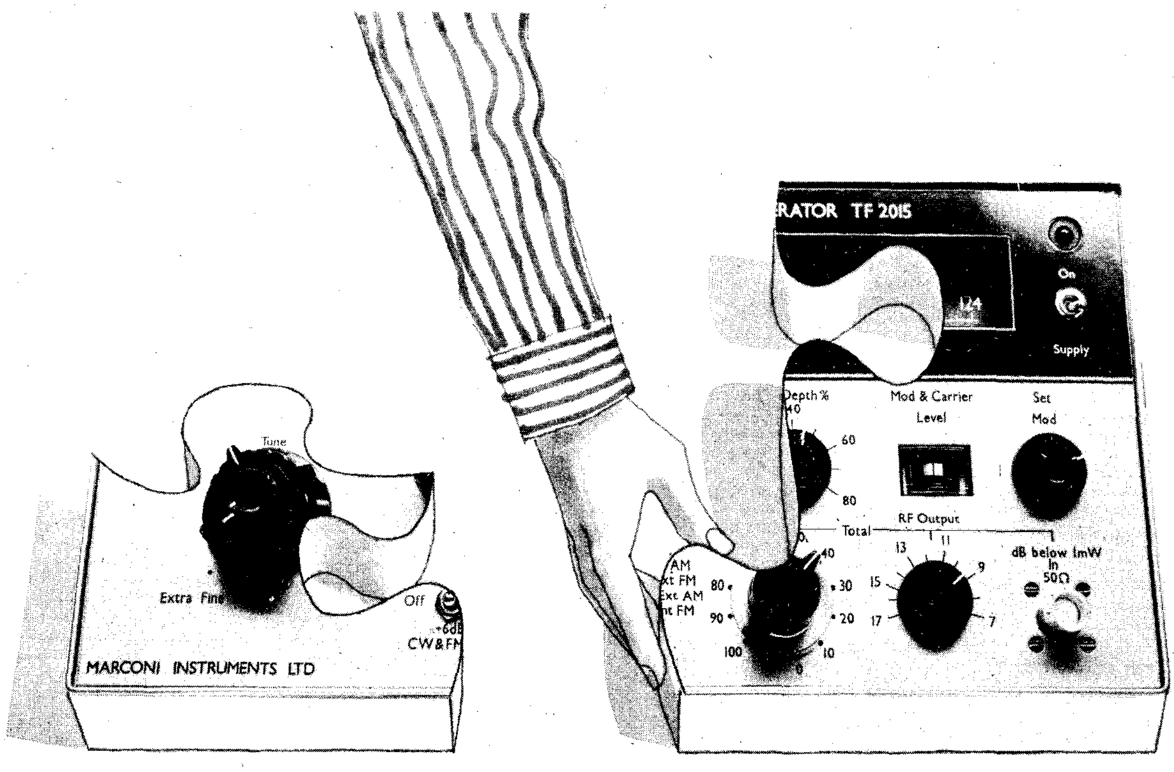

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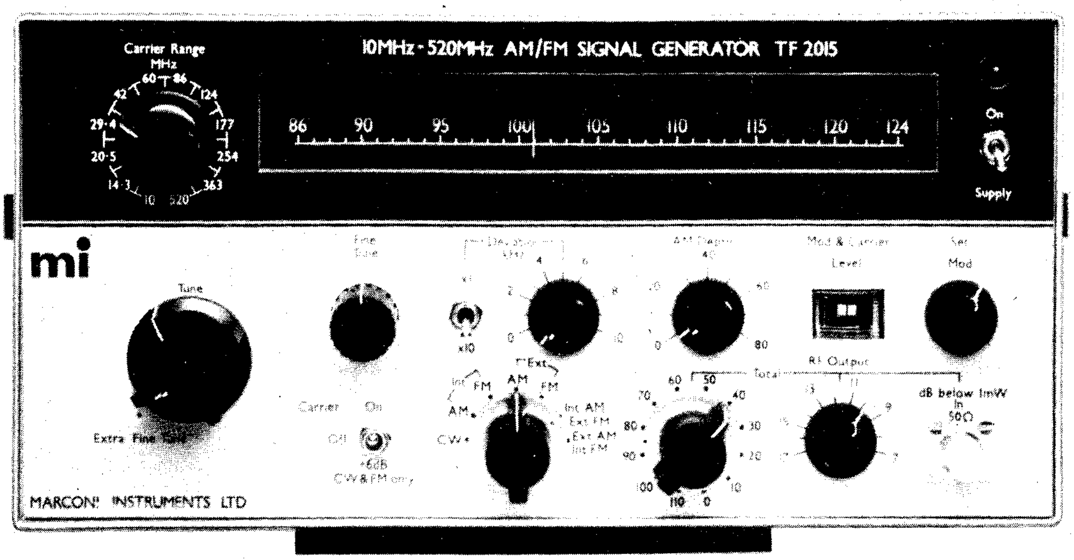

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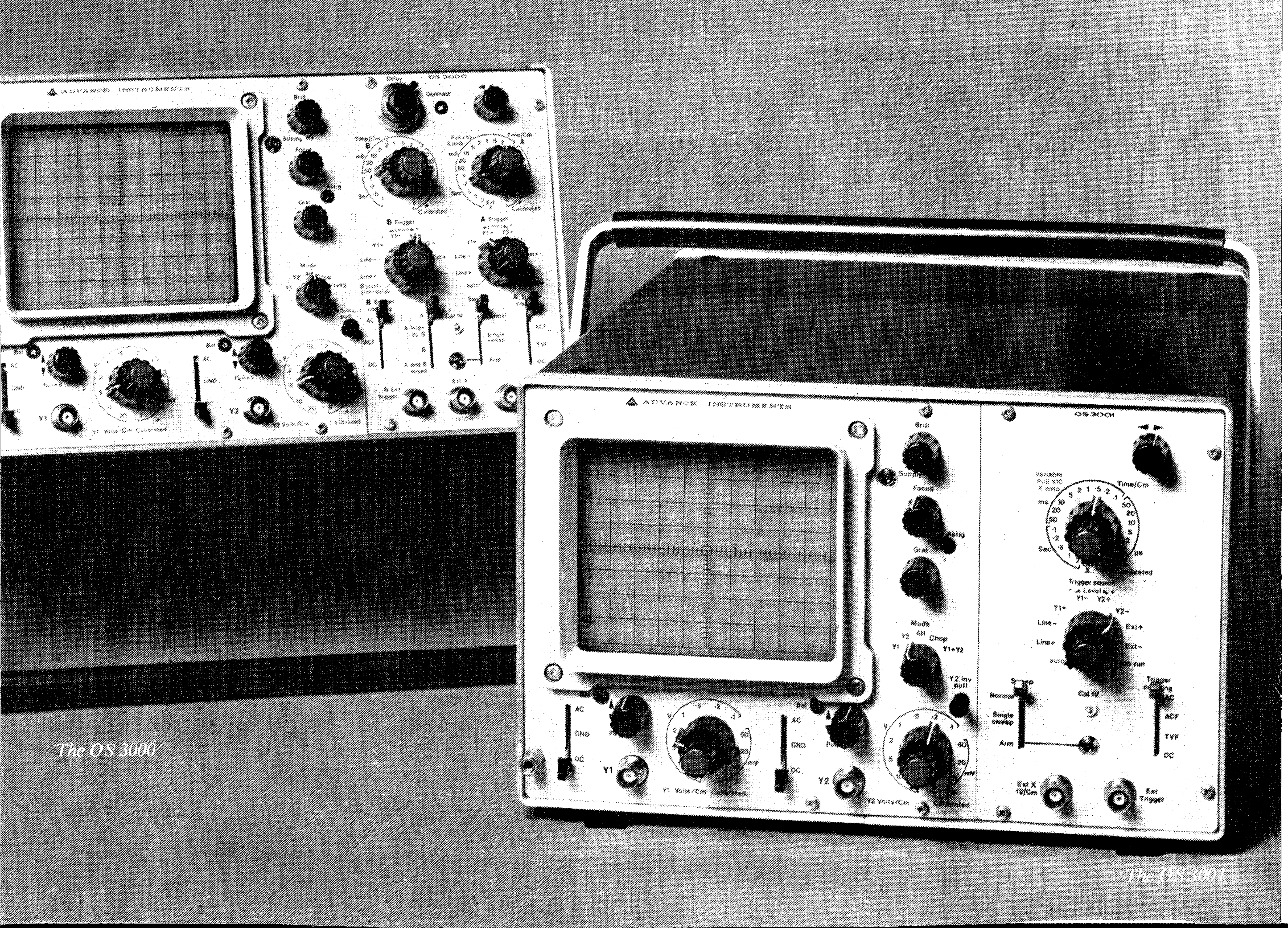
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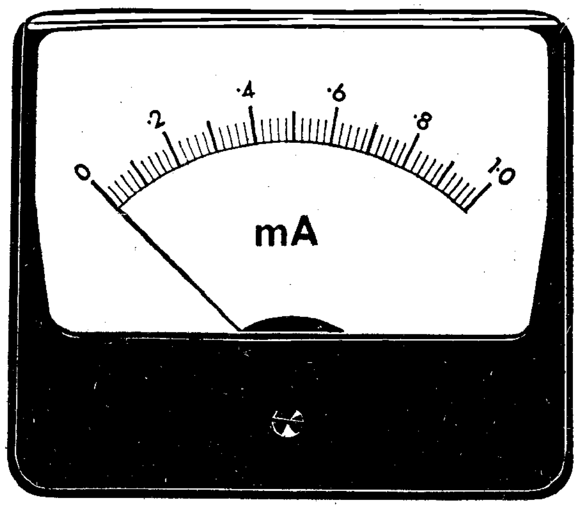

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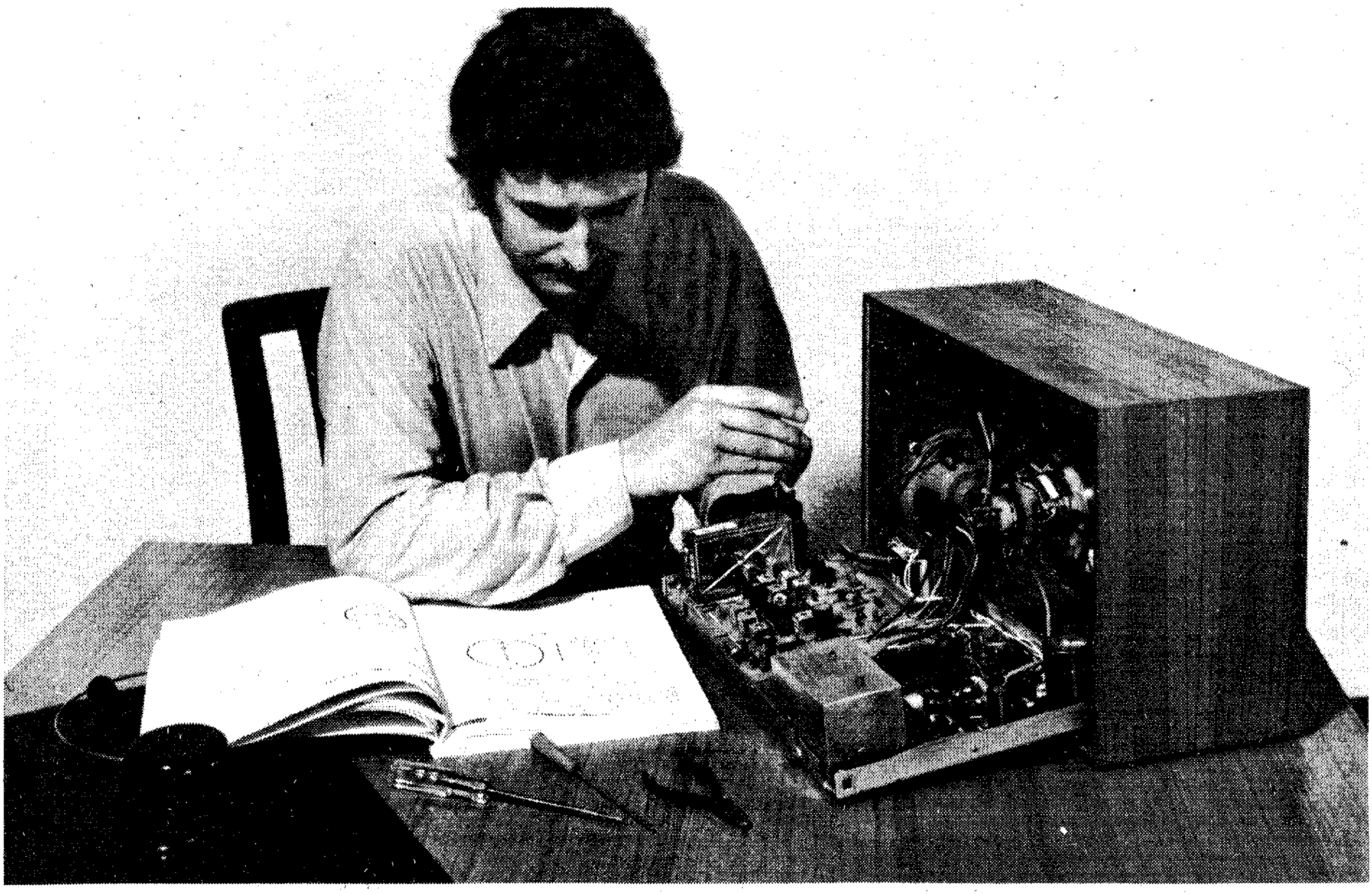

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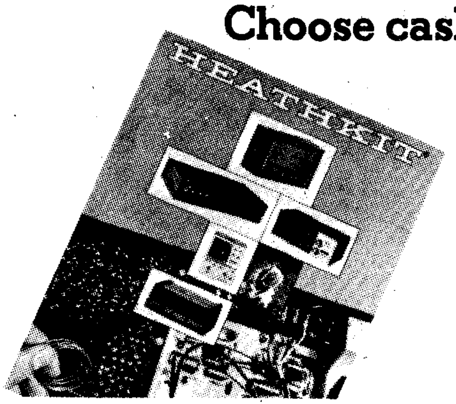

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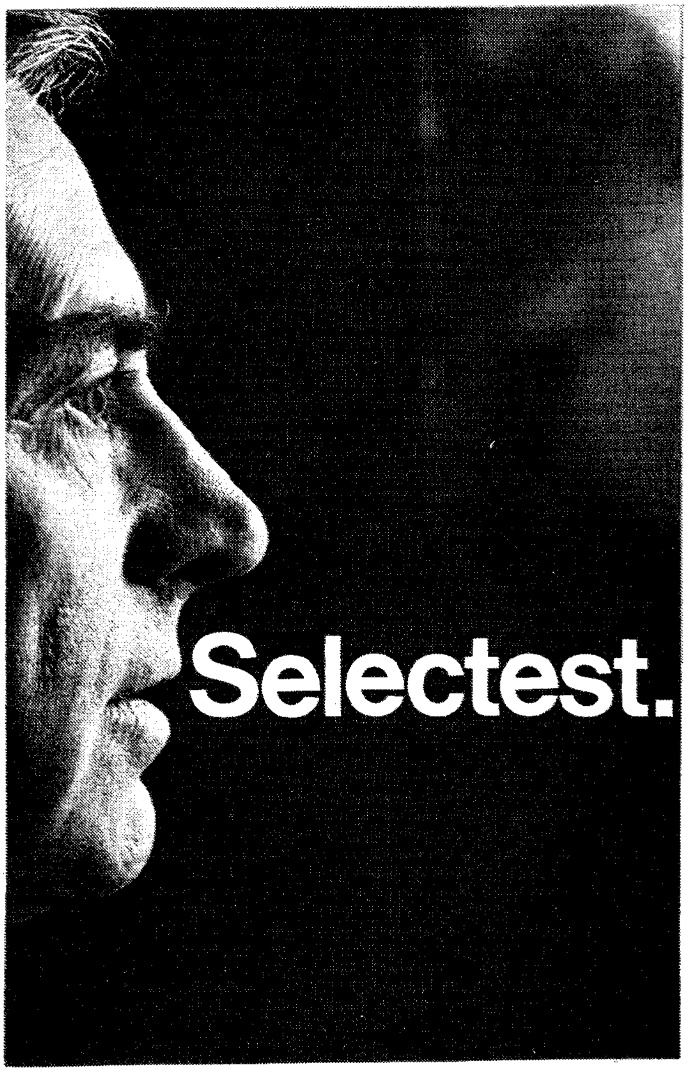

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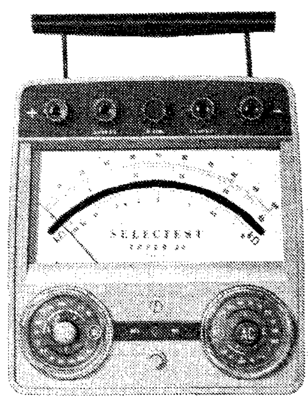

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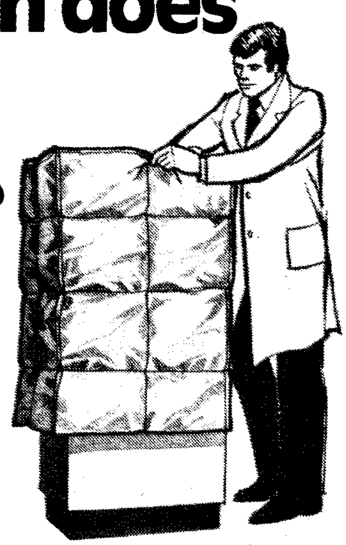

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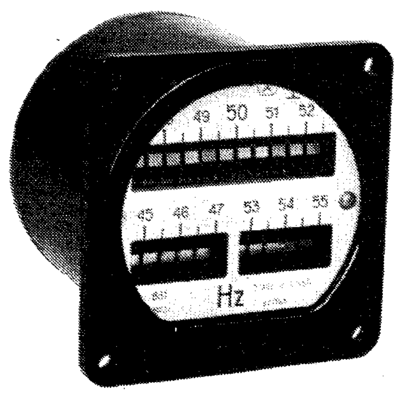

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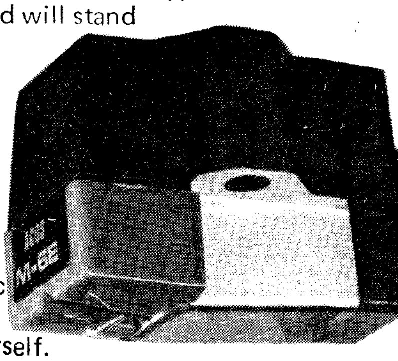

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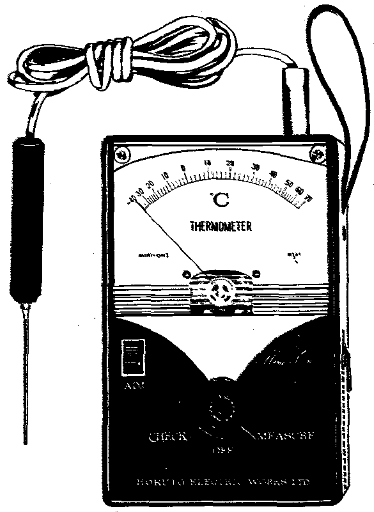

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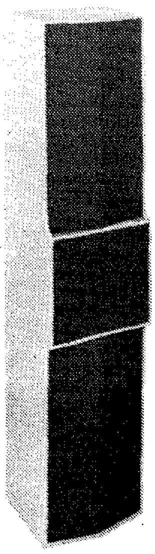

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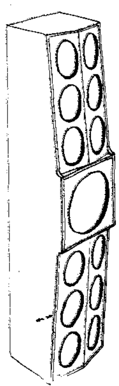

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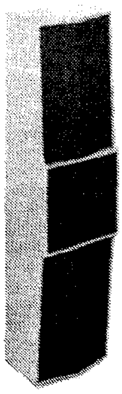

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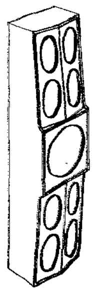

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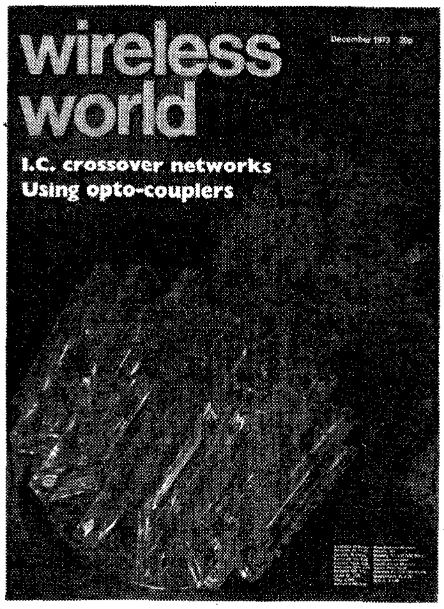
DECEMBER 1973 Vol 79 No 1458

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.

Contents

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wireless world

The Costs of Engineering

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 loudspeaker[1] 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

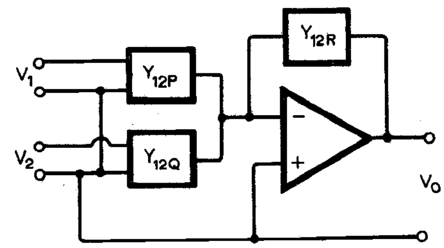
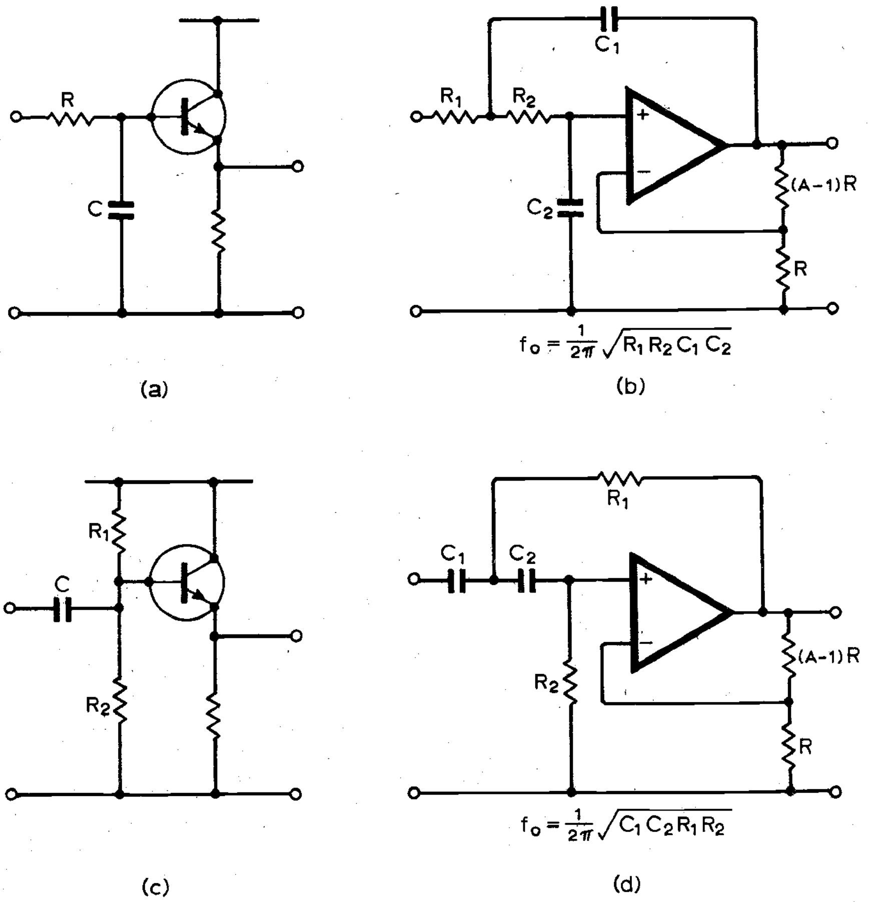


Fig. 1. Op-amp used in a dual summing single feedback configuration. See text for the input/output relationship.

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.



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 design[2]. 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

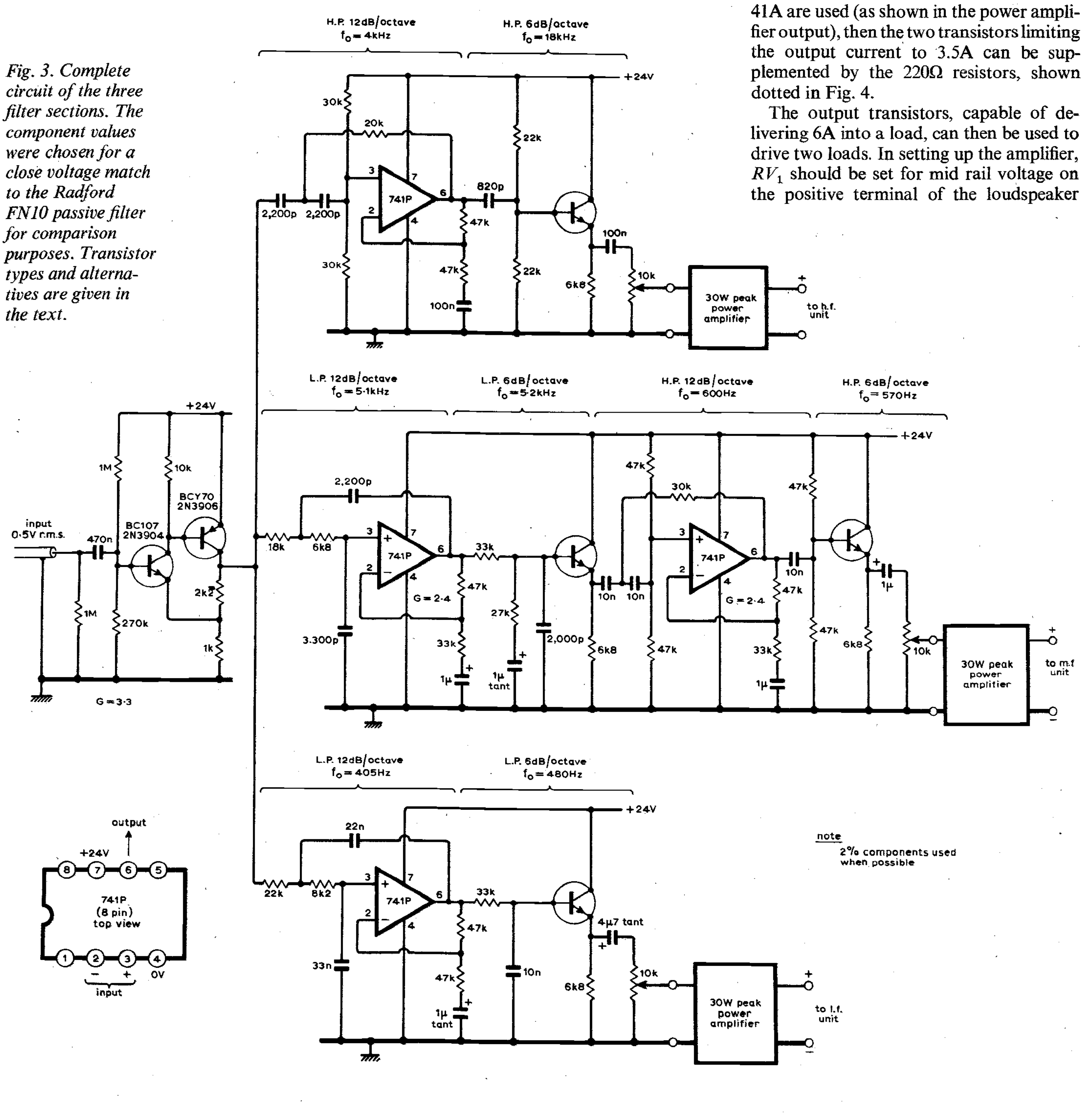
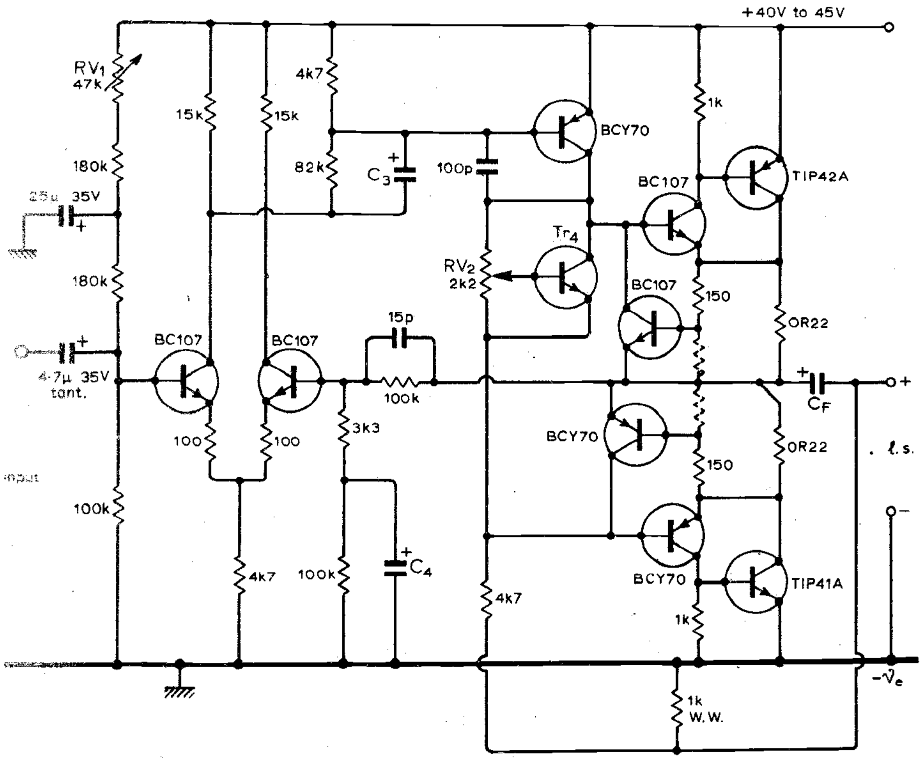
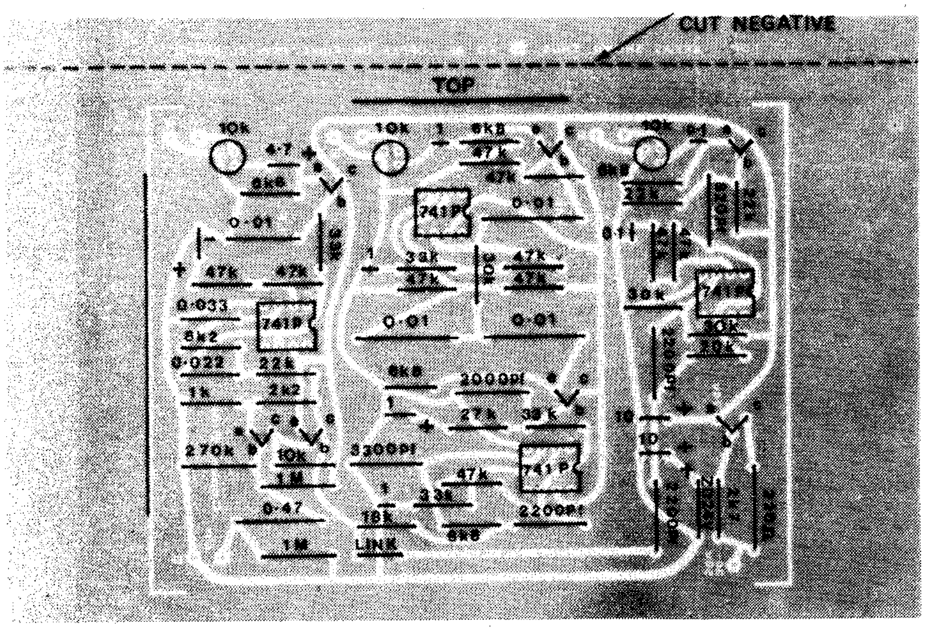


Fig. 3. Complete circuit of the three filter sections. The component values were chosen for a close voltage match to the Radford FN10 passive filter for comparison purposes. Transistor types and alternatives are given in the text.





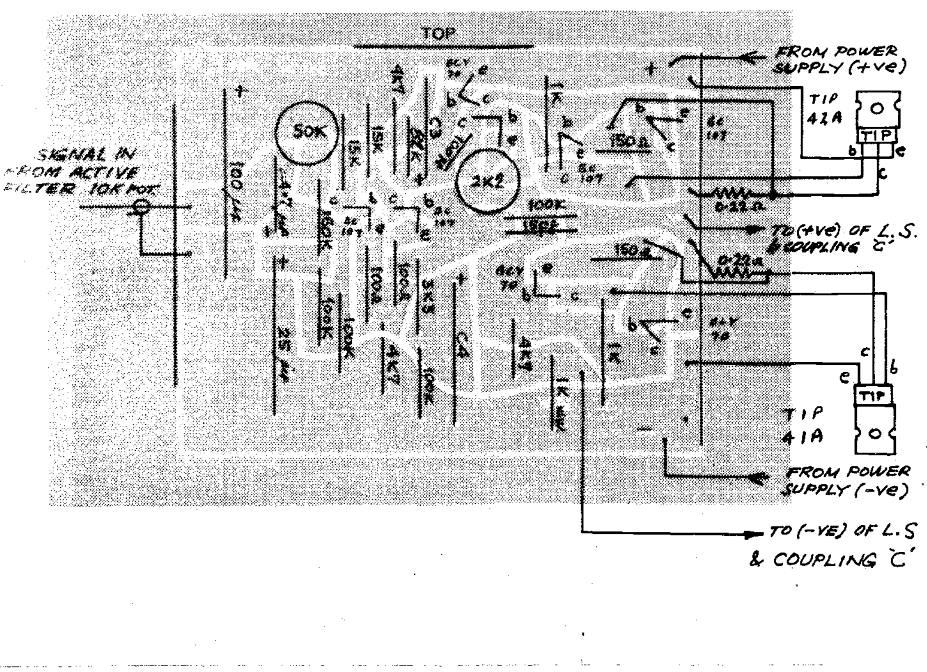


Fig. 4. Suitable 30W amplifier for use with the active filter sections.

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.

References

1. Bailey, A. R. "The Transmission-line Loudspeaker Enclosure", *Wireless World*, May 1972, pp. 215–217.
2. Texas B68 application report.

Realm of Microwaves

7. Microwave antennae — phased arrays

by M. W. Hosking, M.Sc.
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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

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

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

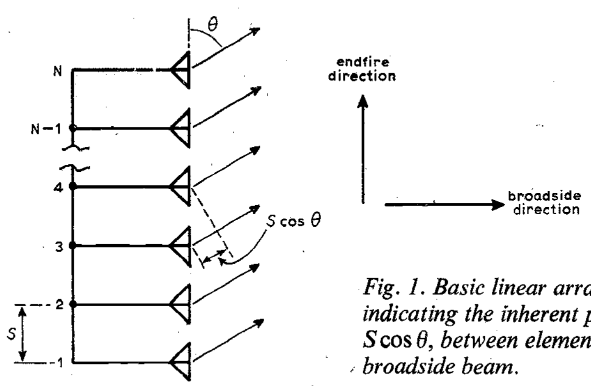


Fig. 1. Basic linear array geometry indicating the inherent path difference, $S\cos\theta$, between elements for a non-broadside beam.

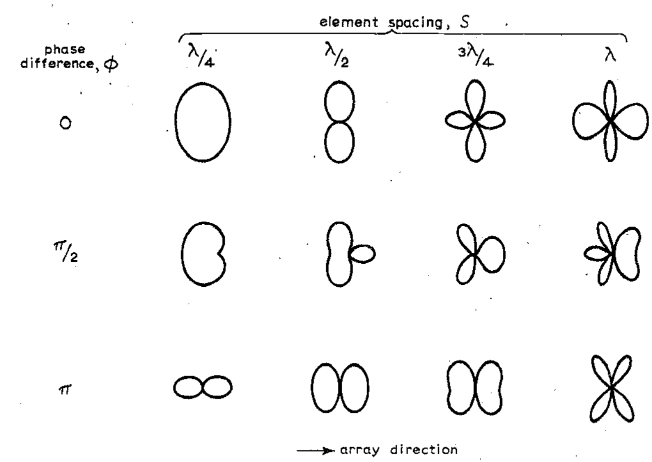


Fig. 2. Radiation pattern from a simple two-element array can assume many shapes, depending on the spacing and the phase difference between the feeds. For spacings greater than $\lambda/2$, the pattern starts to break up into an increasing number of lobes.

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

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 $N.E$ so that theoretically the radiation pattern of a uniform (equal amplitude) array is

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

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.

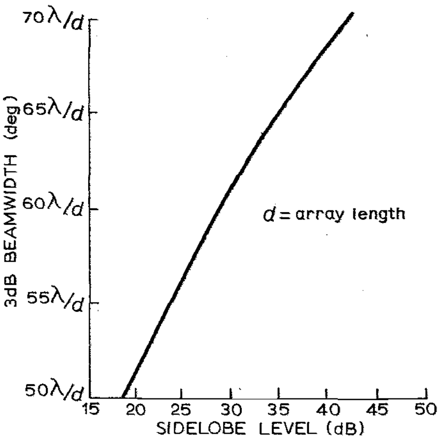


Fig. 3. When designing arrays having a Tchebyscheff amplitude distribution, a direct trade-off can be made between the half-power beamwidth and the sidelobe level. In this case, all sidelobes have equal amplitude.

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-

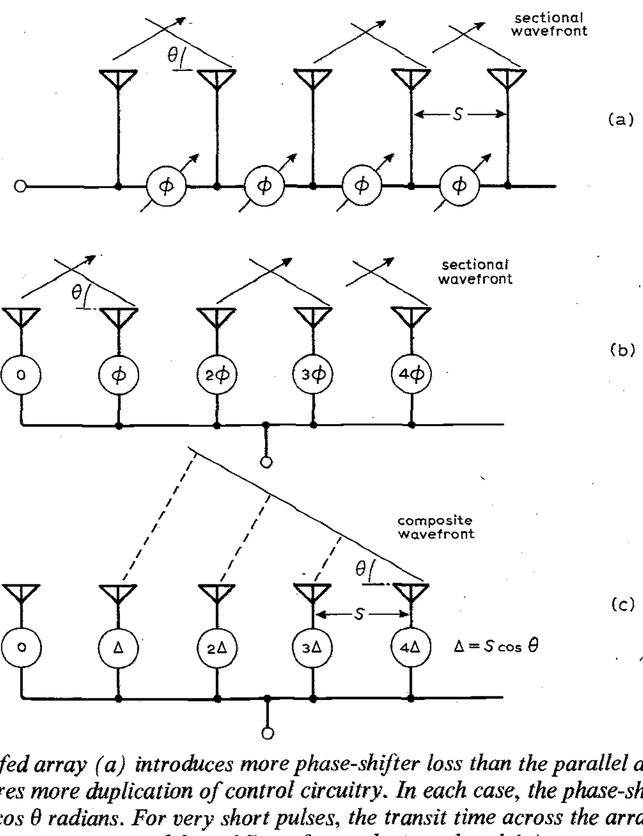


Fig. 4. Series-fed array (a) introduces more phase-shifter loss than the parallel arrangement (b), but requires more duplication of control circuitry. In each case, the phase-shift is given by $\phi = (2\pi S/\lambda)\cos\theta$ radians. For very short pulses, the transit time across the array produces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

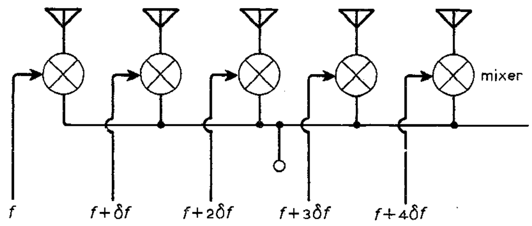


Fig. 5. Offset frequency method of scanning produces an inter-element phase shift by mixing the received signal at each element with a harmonically related frequency increment.

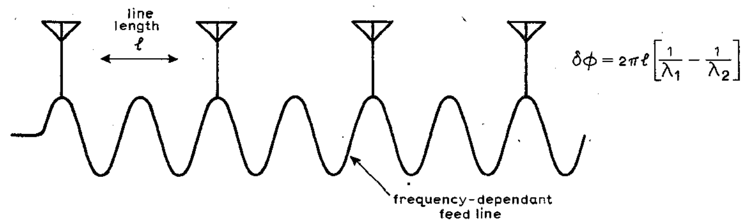


Fig. 7. Swept-frequency scanning varies the phase because of the frequency-dependant length of line between each element. A fairly wide sweep is necessary and scanning is limited to only one plane, but this method does eliminate the complex phase-shift circuitry of other types of array.

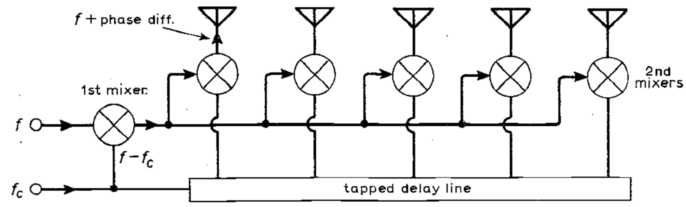


Fig. 6. In this method due to Prof. Huggins, the phase difference is produced in a tapped delay line and preserved in the mixing process at each element.

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_o is mixed with another control frequency, f_c and the i.f. $f_o - f_c$ 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 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.

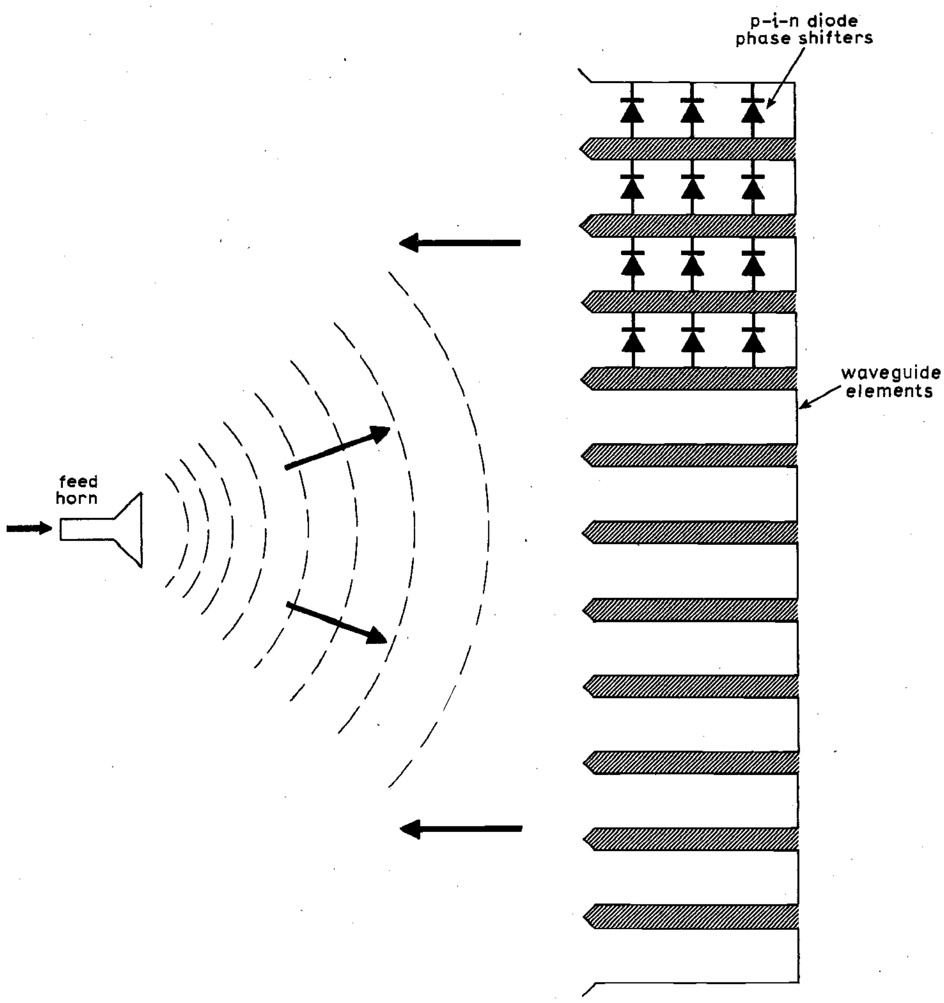


Fig. 8. Reflectarray combines the principles of the dish reflector and the phased array and cuts out most of the feed distribution circuitry. Phase of each element can be adjusted to compensate for feed errors and for sidelobe level and scanning symmetry.

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 aircraft'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, $V^+_{o\,sat}$, 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 $-V^+_{o\,sat}$ (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 integer output reaches a positive voltage level of magnitude $V^-_{o\,sat}$ (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

$$f \triangleq \frac{e_i}{CR} \cdot \frac{R_2}{R_1(V^+_{o\,sat} - V^-_{o\,sat})} \qquad (16.1)$$

In the circuit of Fig. 16.1 the finite switching time of amplifier A_2 allows an integrator output swing somewhat larger than $(R_1/R_2)(V^+_{o\,sat} - V^-_{o\,sat})$ 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 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 integrator 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.

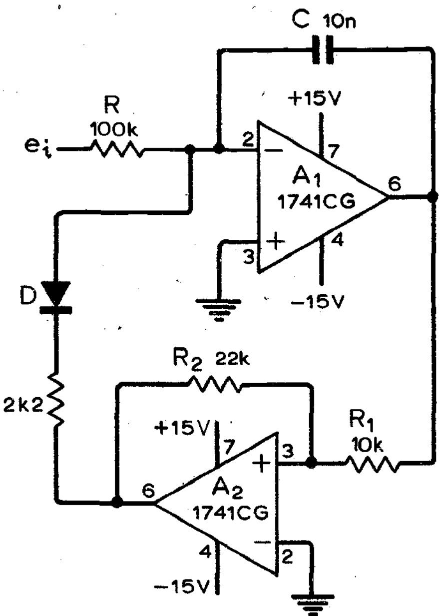


Fig. 16.1. Voltage to frequency conversion using one op-amp as an integrator and the other as a regenerative comparator with hysteresis.

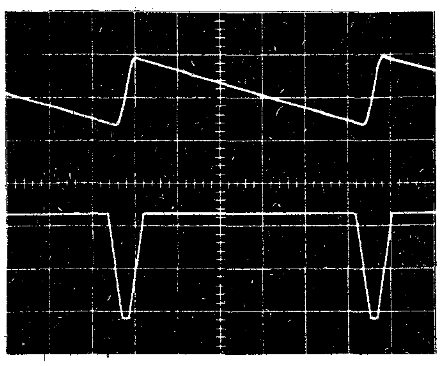


Fig. 16.2. Waveforms at the outputs of the op-amps in Fig. 16.1. Top: integrator output; bottom: comparator output. Vertical scale, 10V/div.; horizontal scale, 0.1ms/div.

*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.

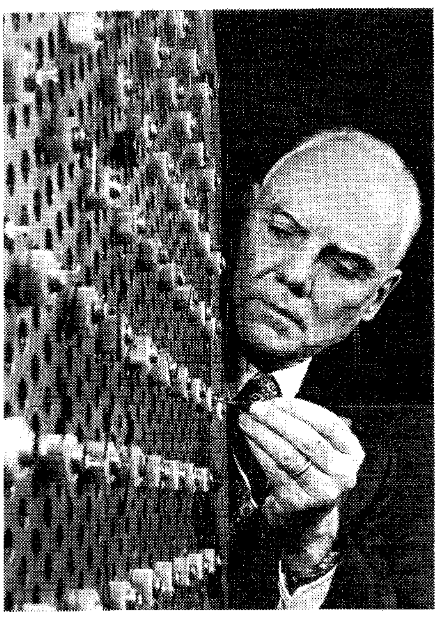
In such applications, p.c.m. has the advantage of being able to provide the high frequency response of direct recording (to 4M bits/in., or 2MHz) with the wide dynamic range of f.m. (50-60dB). In contrast, direct recording provides only 20-30dB. In fact, the dynamic range of the system is only limited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

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.



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

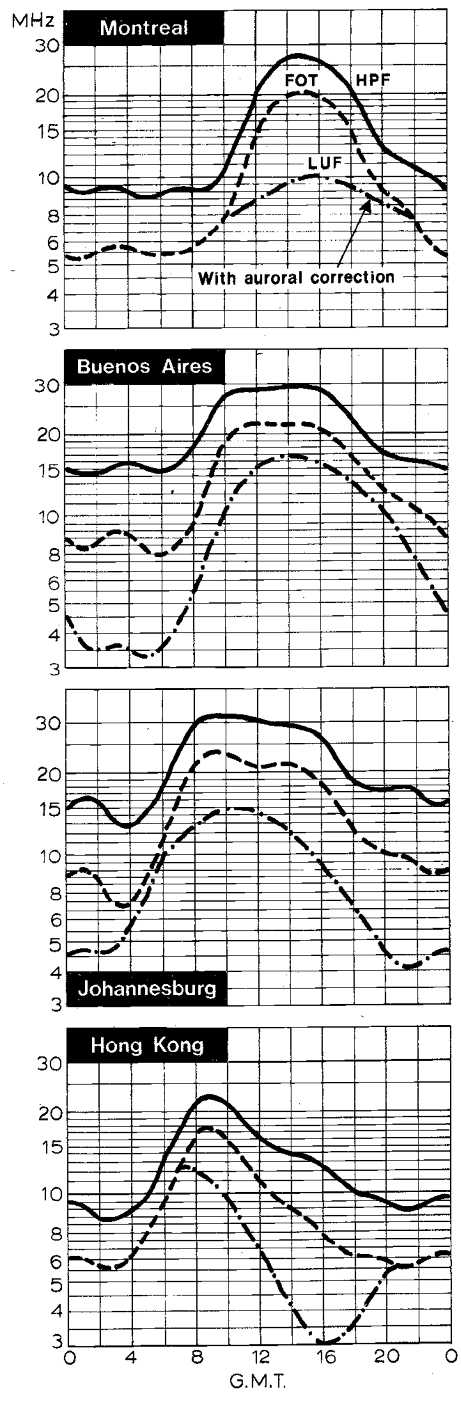
Muck '74 — a national two day farm waste event, comprising field demonstrations, commercial exhibits, conference sessions, case studies and educational displays, will be held at the National Agricultural Centre, Stoneleigh, on March 27 and 28, 1974. Perhaps the electronics industry should do something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

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.



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 10kΩ and 100kΩ, 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 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. 1

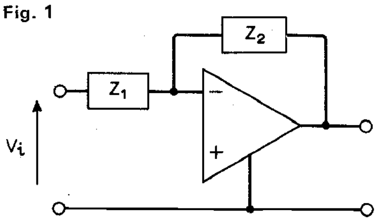


Fig. 2

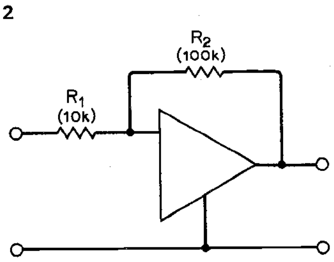


Fig. 3

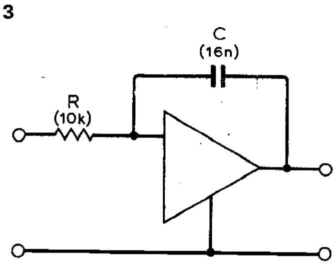


Fig. 4

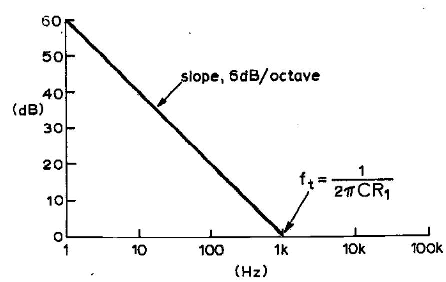
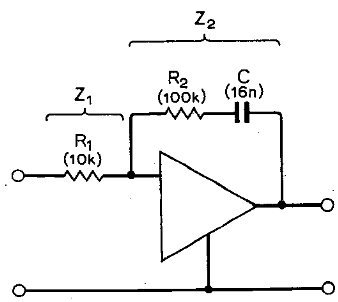


Fig. 5



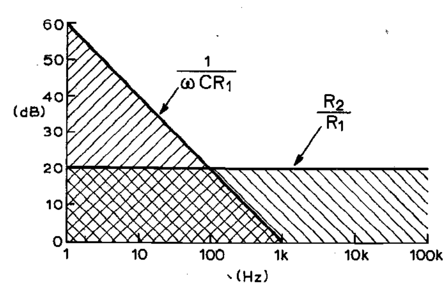
Two properties of the graph are apparent. The intersection of the curve with the 0-dB axis occurs at $1/\omega CR_1 = 1$ i.e. when $f_t = 1/2\pi CR_1$. Using the values of C and R_1 in the circuit gives f_t = 1kHz. The slope of the curve is 6dB per octave. When using logarithmic graph paper it is easier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

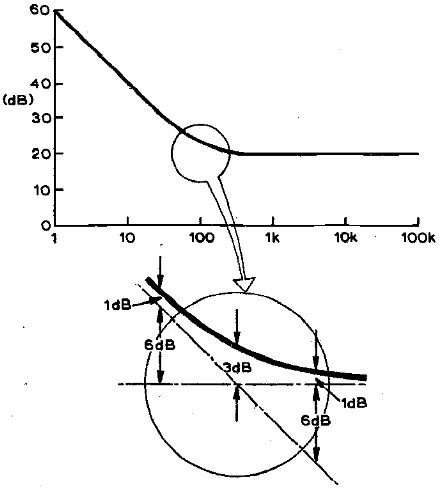


Fig. 8

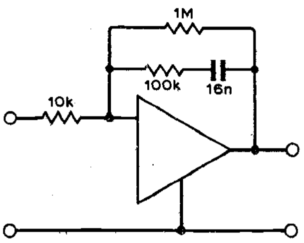


Fig. 9

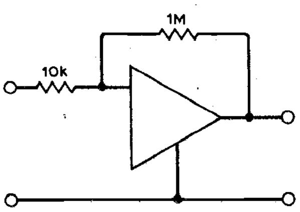


Fig. 10

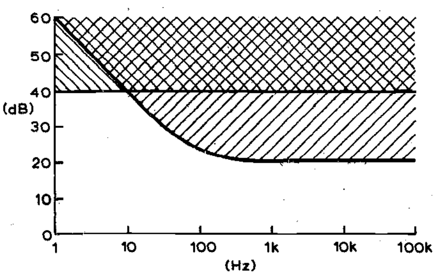


Fig. 11

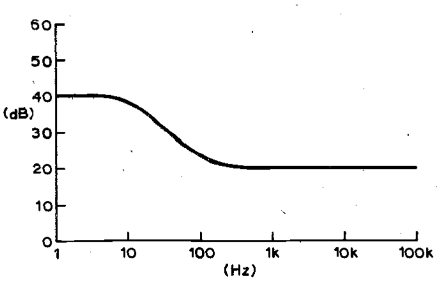
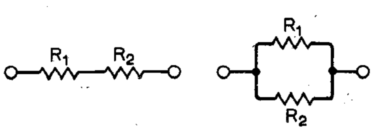


Fig. 12



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 $R_2/R_1 > 18$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.

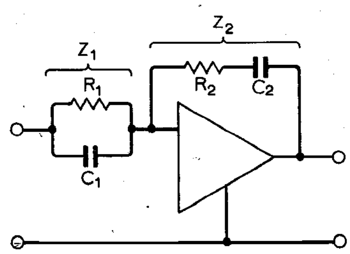
For example, supposing we have the system of Fig. A, the gain can be shown to be

$$\frac{R_2}{R_1}\cdot\left(\frac{1+j\omega C_2R_2}{j\omega C_2R_2}\right)\cdot(1+j\omega C_1R_1)$$

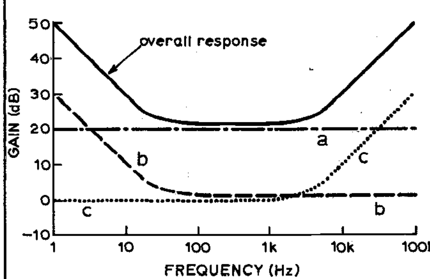
so by plotting the individual responses for these three terms and then adding them, the overall response can be obtained. The stages are shown in Fig. B. So if the overall gain can be written in terms of products, then the response can be fairly easily obtained.

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.

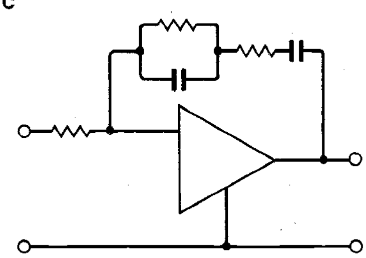
A



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 dB	Correction ±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

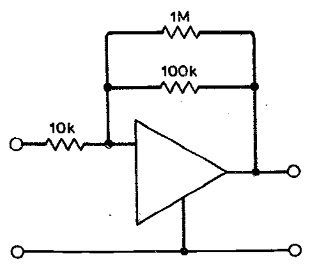
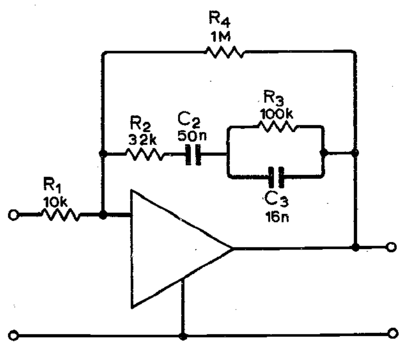


Fig. 14



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

So we get,

R_2 (32kΩ) written as 3.2 or +10dB,
R_3 (100kΩ) written as 10 or +20dB,
R_4 (1MΩ) 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).

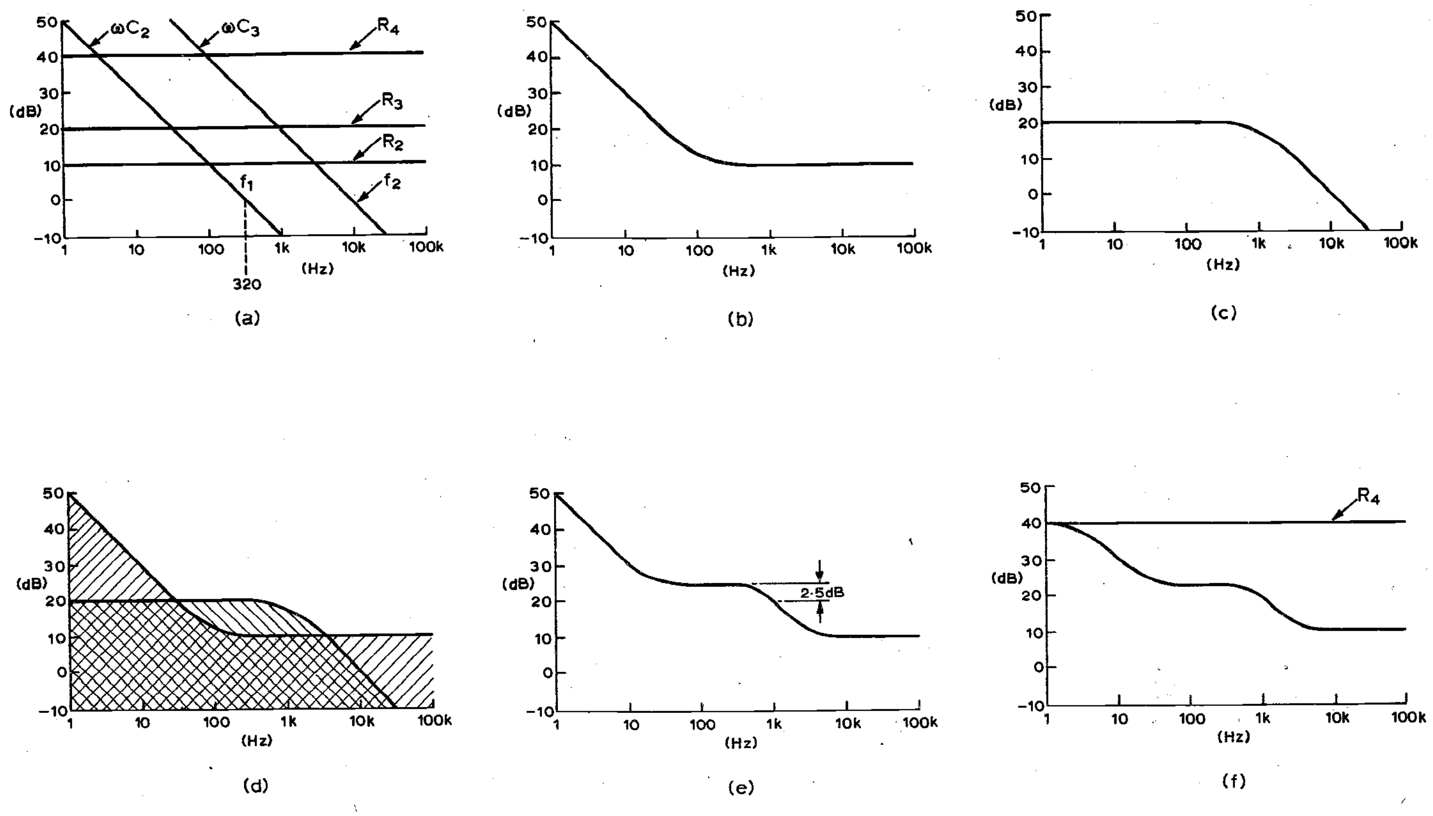
Superposition of these two, (b) and (c), with shadings to indicate impossible zones for series combinations gives (d).

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 symbols[1] and thank the writers for their remarks, significantly the kindest being from those involved in teaching.

In my original letter[2] 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 $12\frac{1}{2}$%, but actually only $6\frac{1}{4}$%, 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.

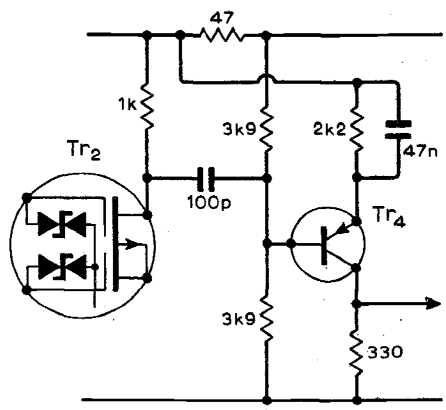
In that case it is the sound pressure (level) rather than the intensity (level) which is almost universally used in acoustics as an amplitude parameter. After all a microphone is usually used as a replacement for the human ear, and the ear is sensitive to sound pressure.

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 wobbulator, 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 $\pm\ 3\frac{1}{2}°$ for 30dB suppresion.

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 $1\frac{1}{2}°$ for r.f. phase error) seems to me to be comparable with maintaining a 90° difference to the same accurancy.

Turning now to the r.f. phasing, $1\frac{1}{2}°$ 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 betwen 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.

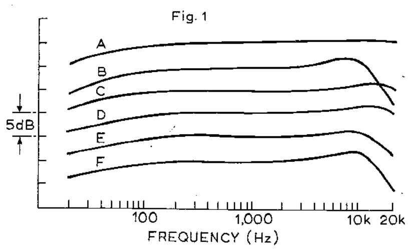
Magnetic pickup loading

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.

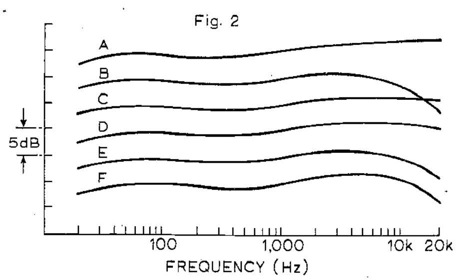
From the equalised preamplifier's point of view the presence of cartridge impedance appearing in the negative feedback path can be quite dramatic, as Reg has intimated. To secure the intrinsic equalisation response I commonly employ a signal e.m.f. via a source of about 700-ohm fed from a filter providing 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 47kΩ. in common with most other amplifiers.

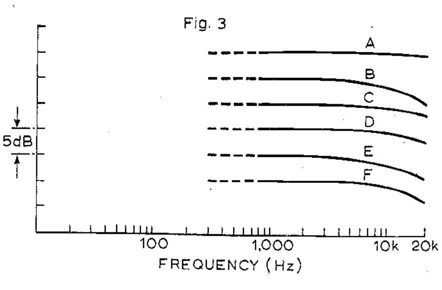
The family of curves in Fig. 2 was derived in the same manner, but with the Keletron KSA 1500 Mk II amplifier. This also has a 47kΩ pickup load and, as with the Dual, features the common series feedback loop containing reactance to provide the R.I.A.A. equalisation.



A source = 700Ω R
B " = 47Ω in series with Ortofon 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 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 (150kΩ and 0.015μF 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

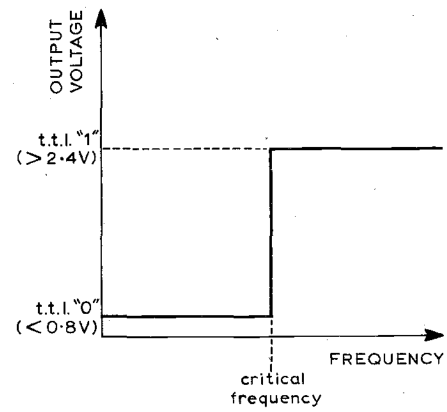
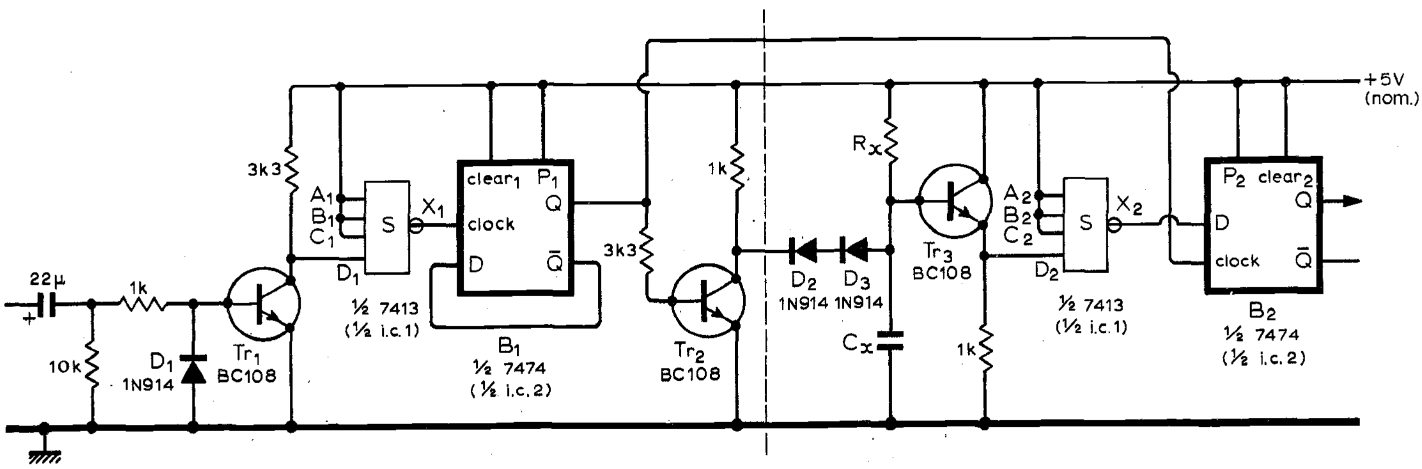


Fig.1. Frequency characteristic of basic element.



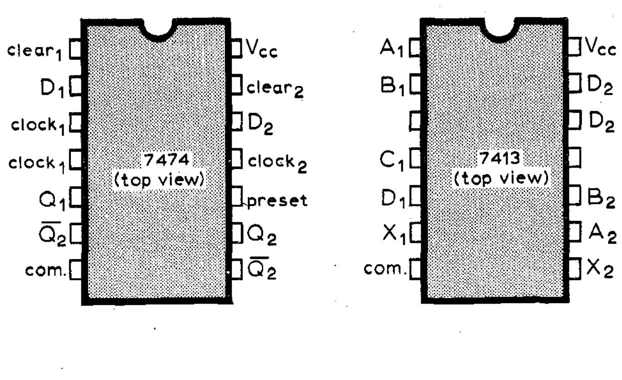


Fig.2. Circuit diagram of decoder to give Fig.1 characteristic. Blocks marked S are Schmitt trigger gates.

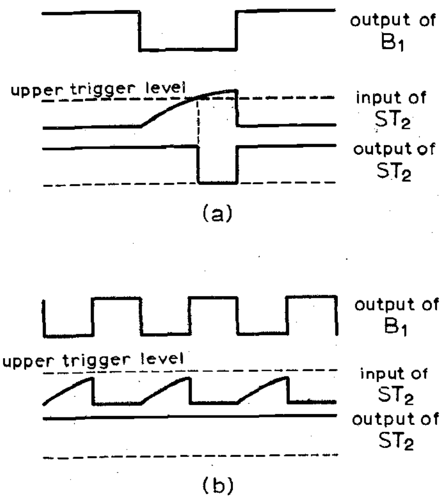


Fig.3. Waveforms produced at output of Fig.3 when input frequency is less than (a) and greater than (b) the critical frequency. The output of ST_2 is marked X_2 in Fig.2.

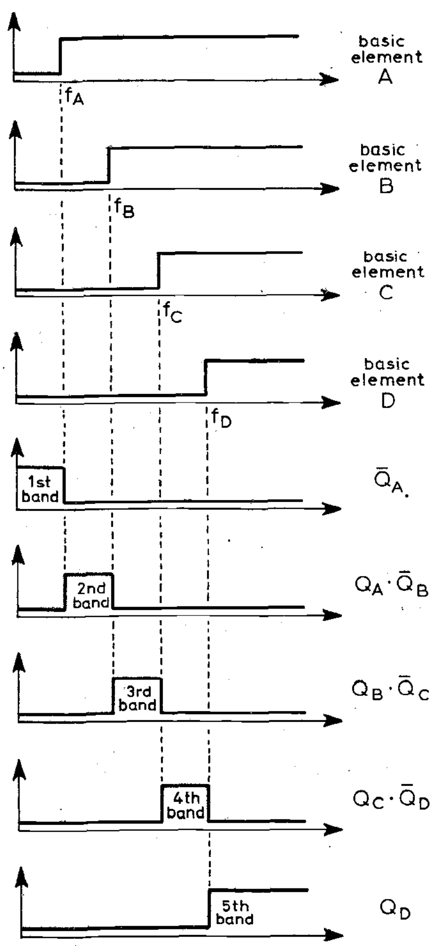


Fig.4. The derivation of four pass-bands from four basic elements.

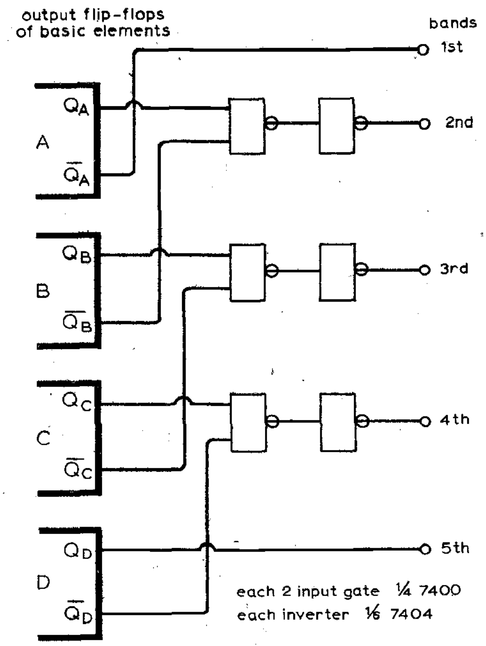


Fig.5. Logic to perform the function of Fig.4.

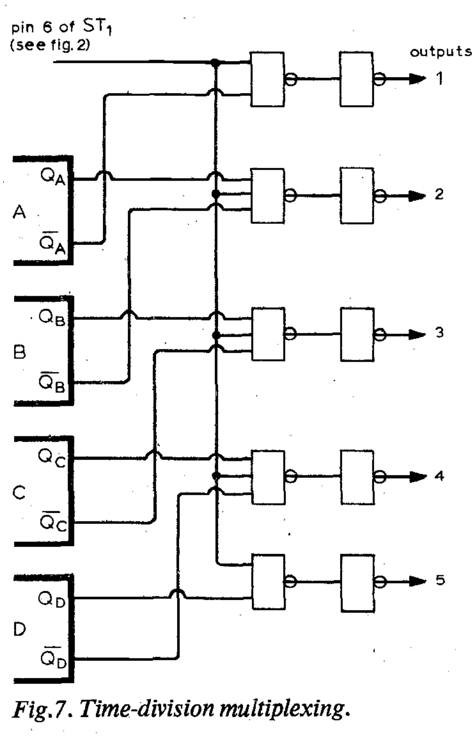


Fig.7. Time-division multiplexing.

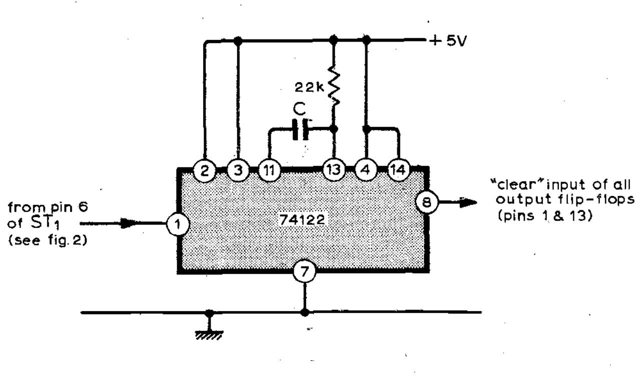


Fig.6. Circuit to constrain all flip-flop Q outputs to "0" in the absence of an input signal.

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_1 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_0 = 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_0 due to R_S is:

$$\left.\frac{\overline{i_0^2}}{\Delta f}\right]_{R_S} = \frac{4kTR_S}{(R_S+r_d)^2}A_i^2$$

$$\therefore F = 1+\frac{(\overline{i_n^2}/\Delta f)(R_S+r_d)^2}{4kTR_SA_i^2},$$

where $\overline{i_n^2}/\Delta f$ = 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

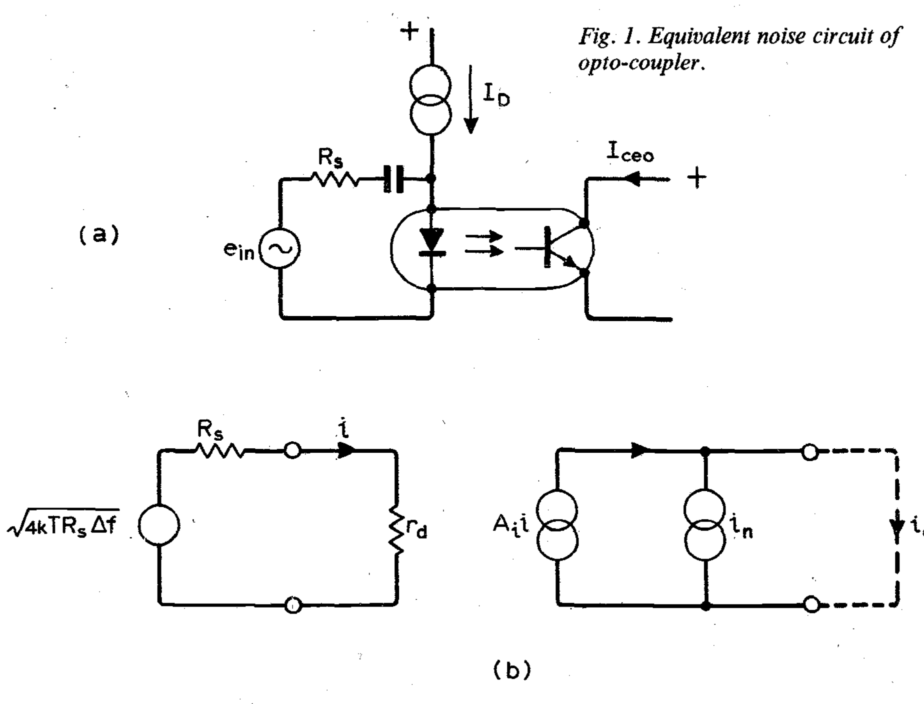


Fig. 1. Equivalent noise circuit of opto-coupler.

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.

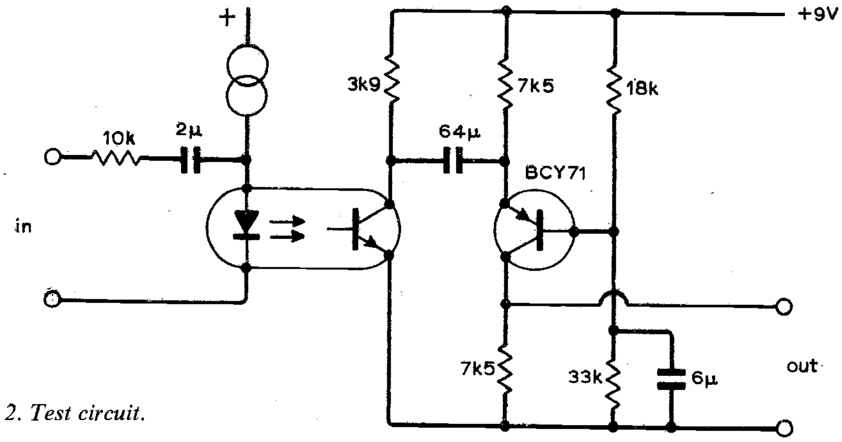


Fig. 2. Test circuit.

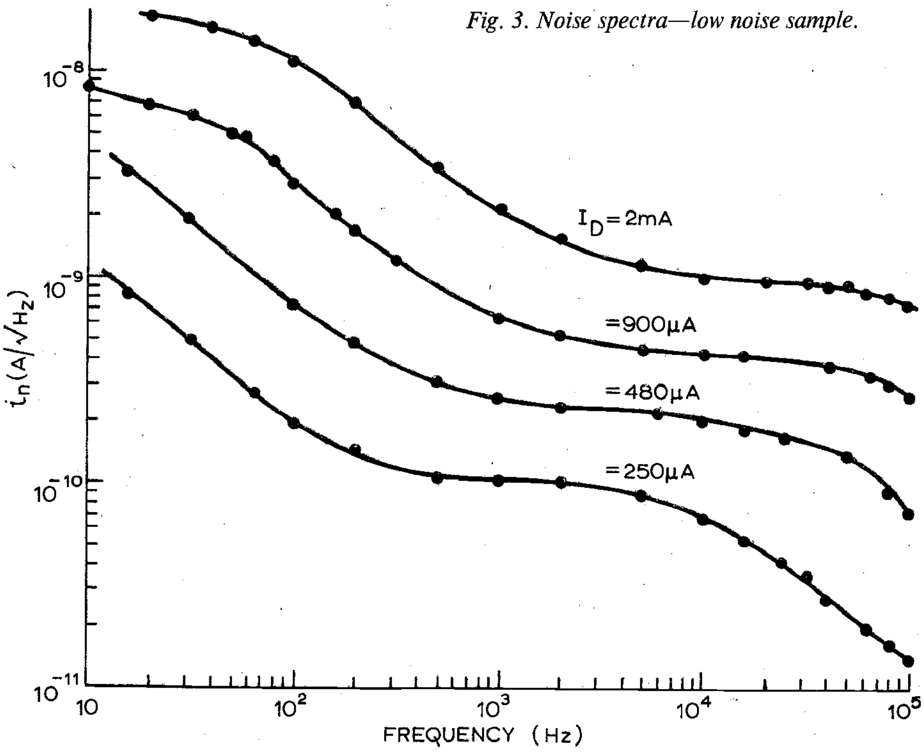


Fig. 3. Noise spectra—low noise sample.

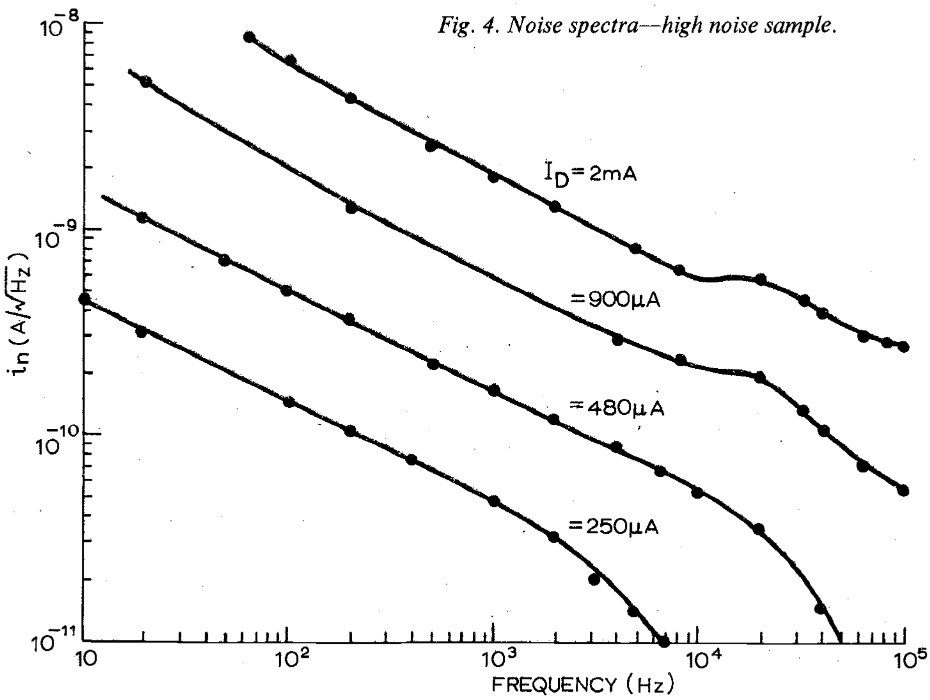


Fig. 4. Noise spectra—high noise sample.

Transistor—opto-coupler

Theory. The simplest circuit one can devise is that shown in Fig. 8(a) where the l.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,

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

$$\therefore\ F = F_{bip} + \left(\frac{i_n}{A_i}\right)^2 \cdot \frac{1}{qI_D} \cdot \frac{r_e}{4\lambda R_S}. \qquad (2)$$

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

$$\beta = 500$$
$$I_D = 500\mu A$$
$$\left(\frac{i_n}{A_i}\right)^2 \frac{1}{qI_D} = 6.25\times10^3.$$

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,

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

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,

$$F = 1.5+\frac{6{\cdot}25\times10^3}{500} = 14 \text{ or } 11.5\text{dB}.$$

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

$$F = 1.0+\frac{6.25\times10^3}{500} = 13.5 \text{ or } 11.3\text{dB}.$$

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

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

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 $f = 1$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 500μA, 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 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.

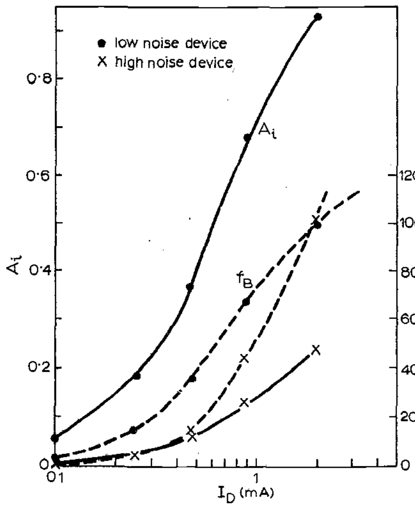


Fig. 5. Current gain and bandwidth as a function of I_D.

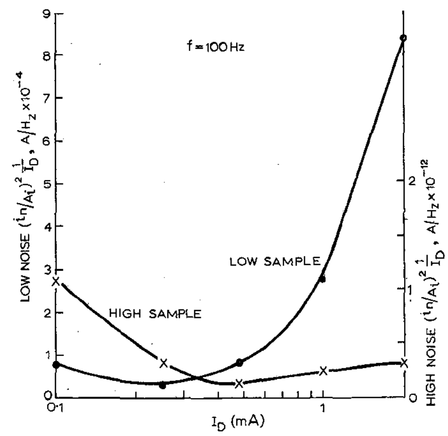


Fig. 6. $\left(\frac{i_n}{A_i}\right)^2\frac{1}{I_D}$ *as a function of I_D, $f = 100$Hz.*

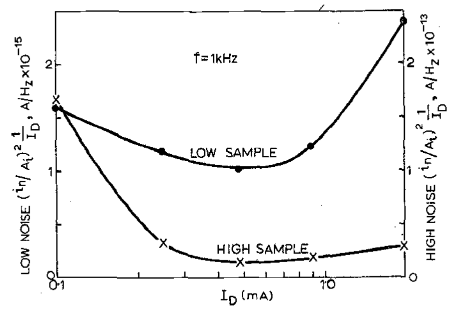


Fig. 7. $\left(\frac{i_n}{A_i}\right)^2\frac{1}{I_D}$ *as a function of I_D, $f = 1$kHz.*

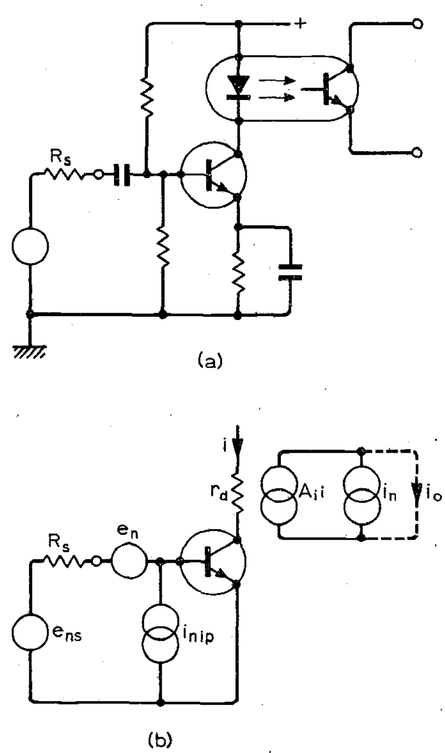


Fig. 8. Transistor-opto-coupler combination.

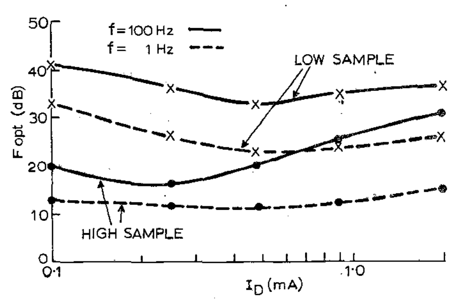


Fig. 9. Calculated F_{opt} assuming noise free bipolar stage.

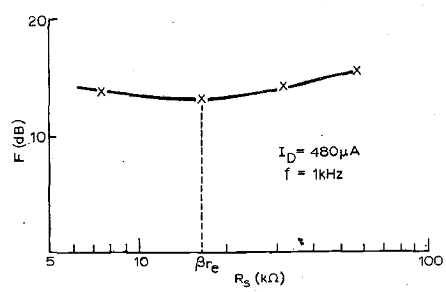


Fig. 10. F as a function of R_S for an actual circuit.

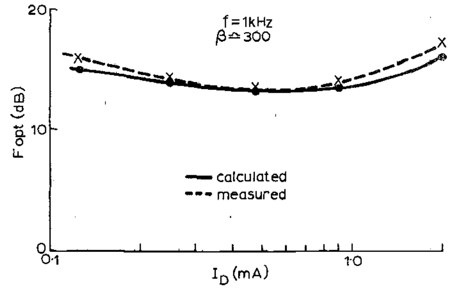


Fig. 11. Measured and calculated F_{opt} as a function of I_D for an actual circuit.

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

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

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-

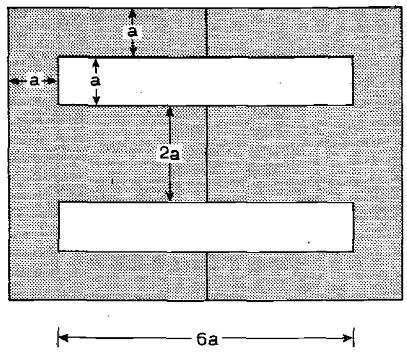


Fig. 1. Genesis of the no-waste lamination.

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 $\dfrac{I_m}{I} = \dfrac{1}{25a}$

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

$$\frac{V}{N} = \frac{4.4BA_f}{10^8} = 4.4B.4a^2.6.45f.10^{-8}$$

$$= 113.5a^2Bf.10^{-8}$$

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

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

If we make

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

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:

$$VI = 113.5Bfa^4.10^{-5}$$

If now $B = 12.35\times10^3$

$$VI = 14fa^4$$

And at 50Hz

$$VI = 700a^4$$

The core area was, as we saw

$$A = 4a^2$$

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

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 $(W)^{1/2}/5$ 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 $12a^3$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

$$L = \frac{1.259N^2 4a^2.6.45\mu10^{-7}}{12a.2.54}$$

$$\simeq N^2a\mu10^{-6}$$

The magnetizing current is

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

and $V = (4.4BN.4a^2.6.45f)/10^8$

giving $I_m = \dfrac{113.5BNa^2f}{2\pi N^2a\mu f.10^8.10^{-6}}$

$$= \frac{18Ba}{N\mu100} = \frac{0.18Ba}{N\mu}$$

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

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

so that

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

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:

$$\text{Inductance } L = (V/I_1)\times10^{-3}$$

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

$$LI_2{}^2 \simeq 50a^3\times0.1 = 5a^3$$

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

$$I_2 = 5I_1$$

Then $LI_2 = 5V.10^{-3}$

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

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

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

so that the area of the centre limb is

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

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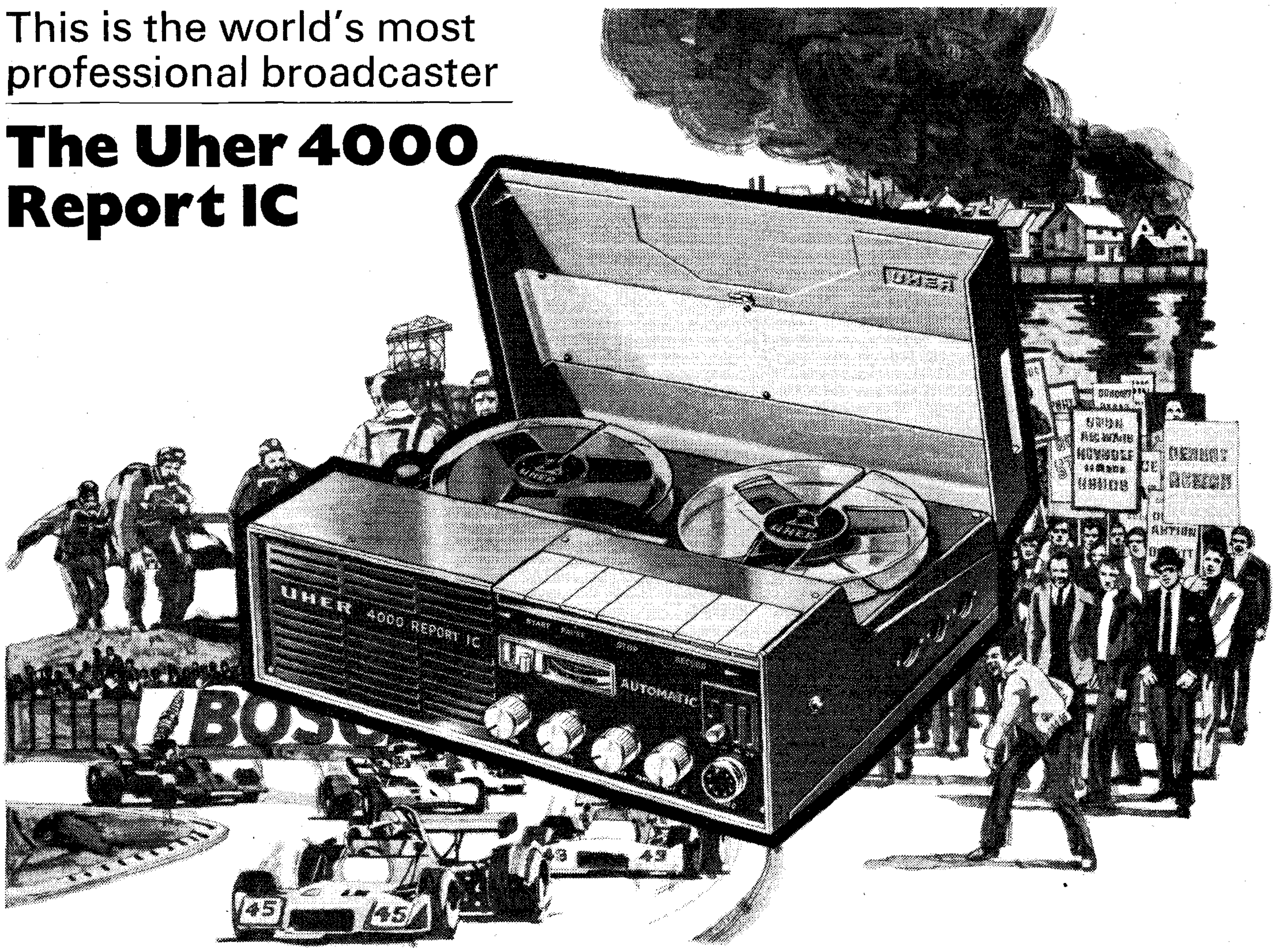

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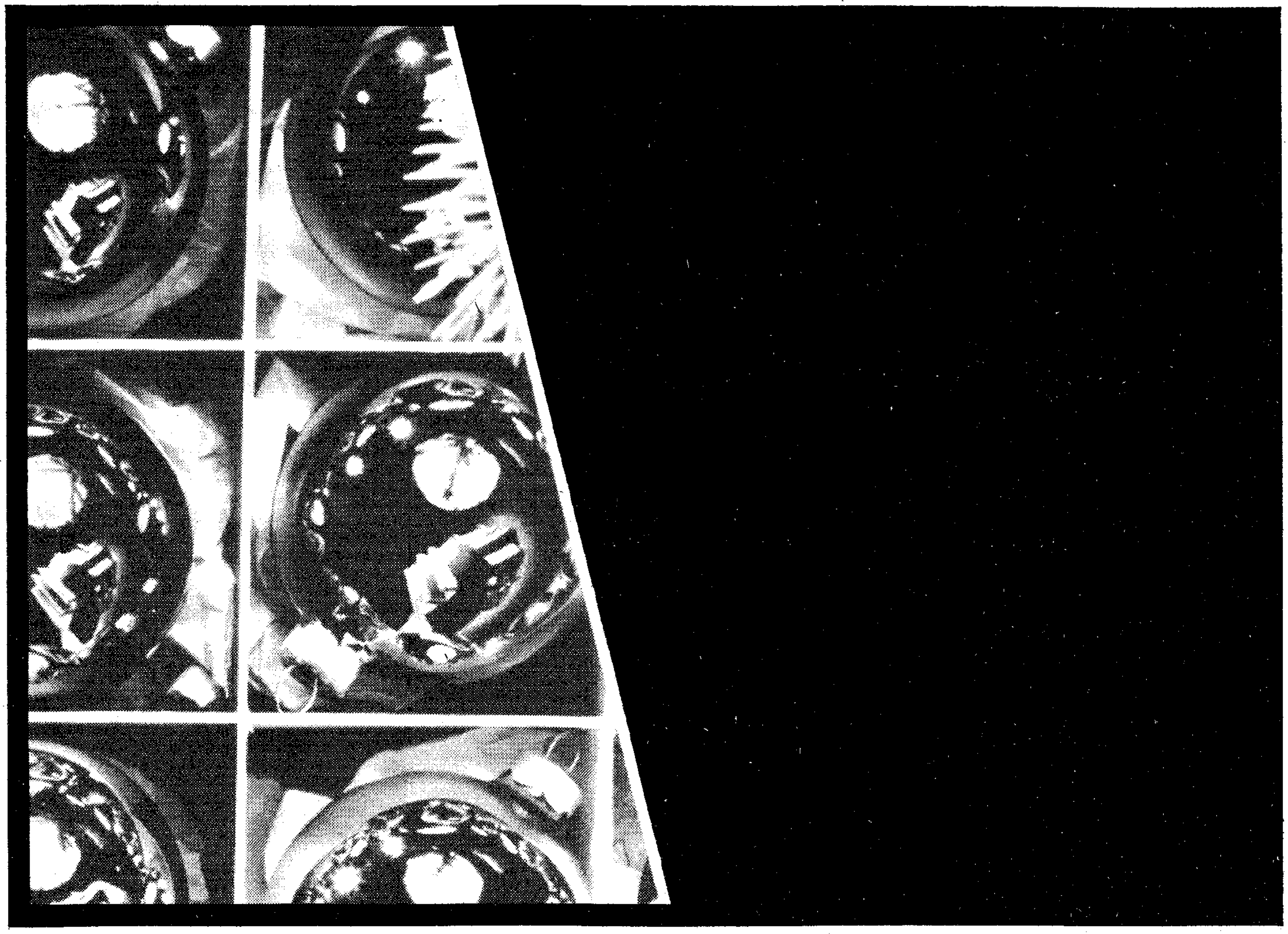

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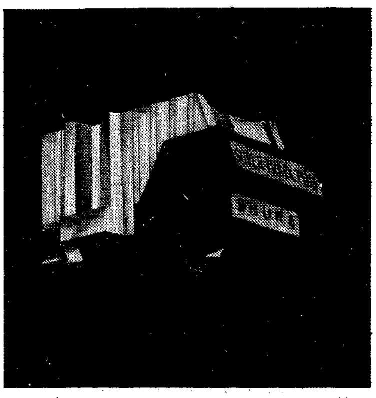

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by W. E. Anderton, B.Sc.

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 $1\mu V$, the dynamic range being from $10\text{-}100\mu V$ and 0-40dB relative to $1\mu V$; attenuators which may be switched into the i.f. amplifier permitting voltages up to 90dB above $1\mu V$ 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 development 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) called bit stream encryption uses an exclusive OR function both in the encoding and decoding process. If the key character changes upredictably 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.

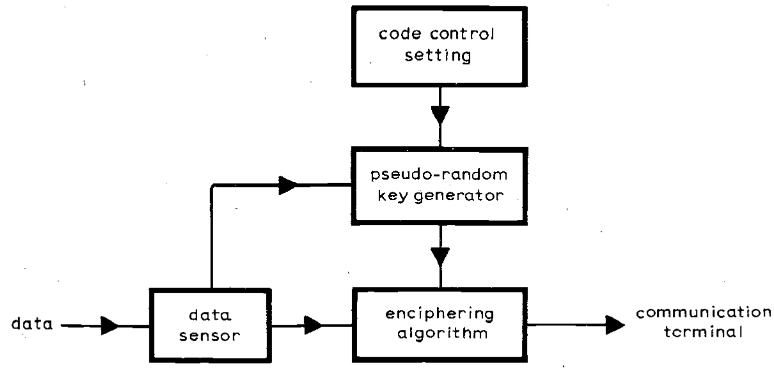


Fig. 1. Block diagram of a data enciphering system. Data enters in binary form. As soon as the sensor determines that an acceptable character is present, it requests the key generator to provide a key character. The cipher character is obtained by combining data and key characters.

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 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 .....

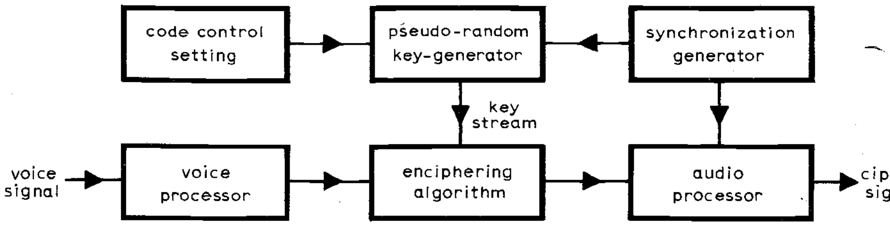


Fig. 2. Schematic voice enciphering device. Voice signals enter in analogue form and are digitally processed for enciphering. Digital key characters control the enciphering process — either digital or analogue.

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 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.

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. 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 "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. Coventional laser interferometers 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 microelectronic 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 microelectronics 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. Mateer 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 — "CEEFAX" 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

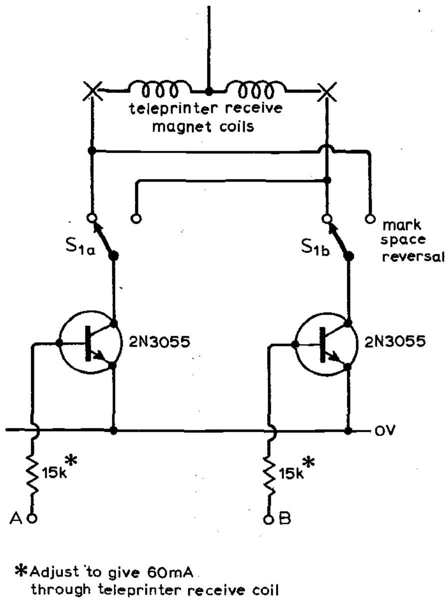
This unit uses the MC1310P integrated circuit intended for stereo multiplex decoders. The device contains a phase-locked loop which I have found suitable for demodulating teleprinter f.s.k. signals because it requires only a small input signal for phase lock, gives a visual indication when phase lock 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.

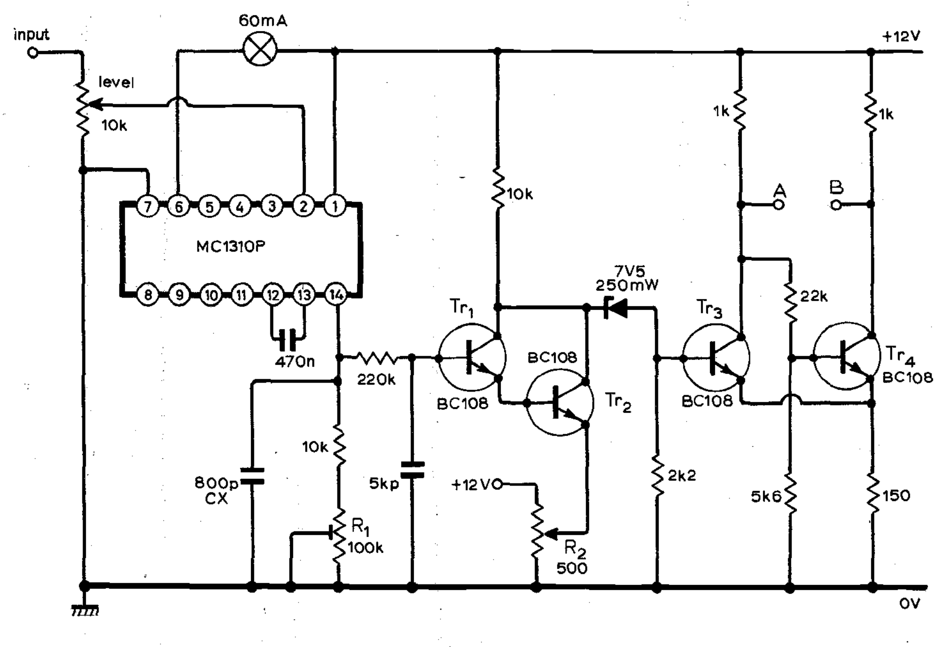
To set up, tune in r.t.t.y. signal and adjust level control so that about 300mV of signal is fed into the input of the p.l.l. Adjust R_1 until lamp lights and remains alight on both mark and space tones (no flicker). Adjust R_2 until printer operates.

K. S. Beddoe, G3YOM,
Titchfield,
Hants.



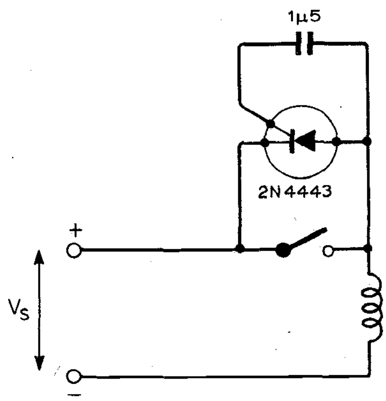
▲ *Fig. 2. Teleprinter drive fed from Fig. 1 circuit.*

▼ *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, ≈ 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.

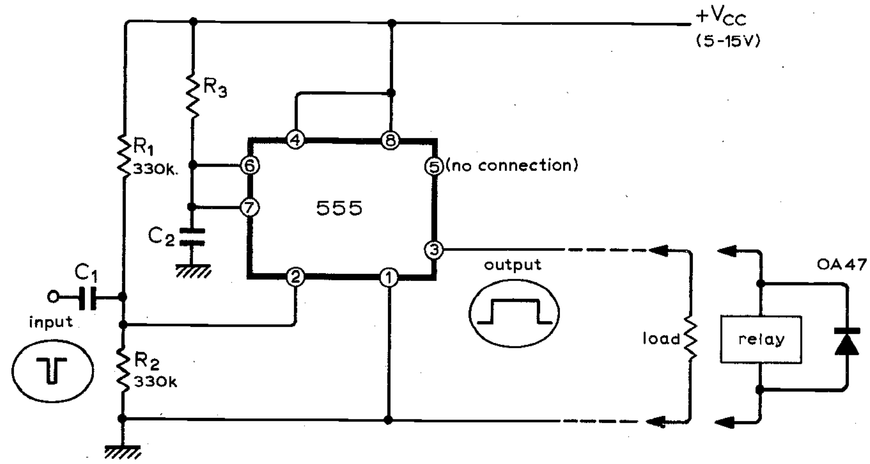
E. Potter
Sheffield University

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 20MΩ. Output pulse amplitude is a little less than V_{cc}, the exact value depending on output current. Rise and fall times are about 0.1µs.

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 0.5µA from pin 2 for 0.1µs.



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.

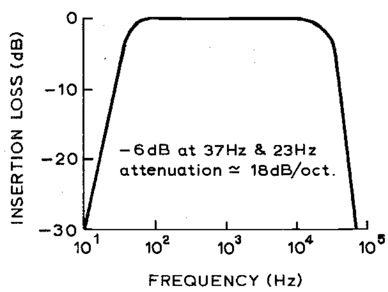
The relay should be rated to operate from a potential approximately equal to that used for V_{CC} at a current of not more than 200mA. A small electromagnetic counter could be used instead of a relay.

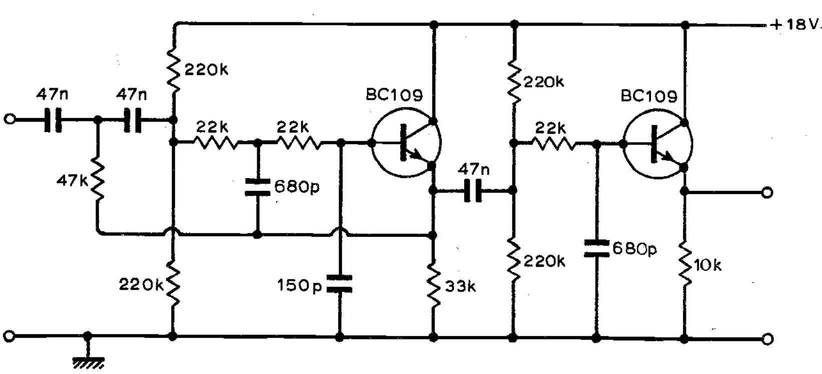
J. B. Dance,
Alcester,
Warwickshire.

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.

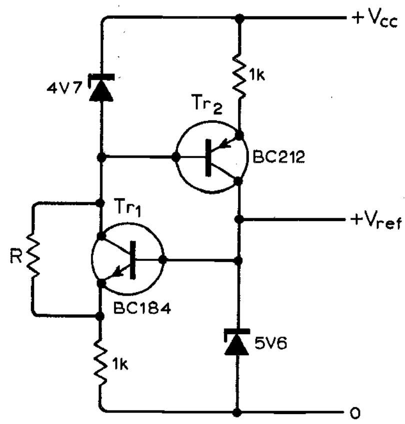




Self-start for ring of two

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 39kΩ produced no noticeable alteration of the performance of the circuit shown in the diagram, while a 1MΩ resistor between the bases reduced the stabilization from 5×10^4 to 2×10^4.

Colin R. Masson,
Edinburgh.



Square-law potentiometer

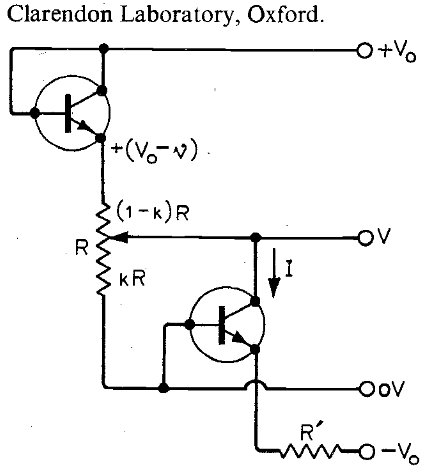
The circuit shown was developed to give a bias for a varicap diode, varying as the square of the angle of rotation of a potentiometer control. If this angle is θ and $k = \theta/\theta_o$ where θ_o is the full angle of rotation, we have, letting v be the offset voltage for the second transistor,

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

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

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 10-kΩ helipot and $V_o = 9$ volts yields a square-law response to better than ±1% over the range $0.1 < V < 8.5$ volts.

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



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. bandspace 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 broadcasting[2]. 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 estimated[1] 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 possible 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 system[3] 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.

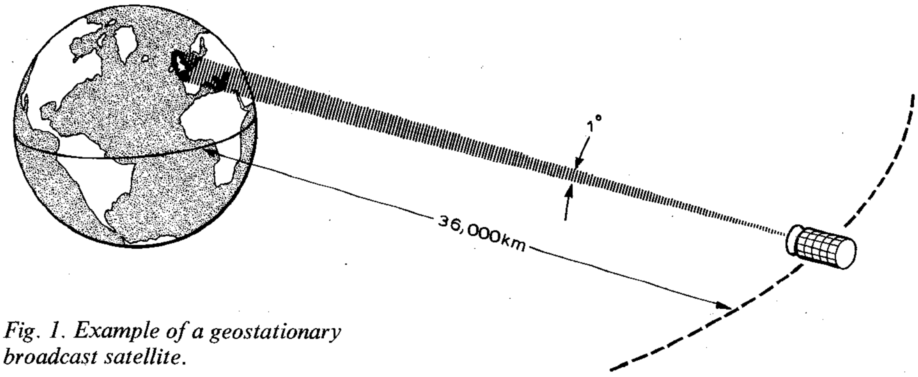


Fig. 1. Example of a geostationary broadcast satellite.

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 stabilized 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 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 authors[4] 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.

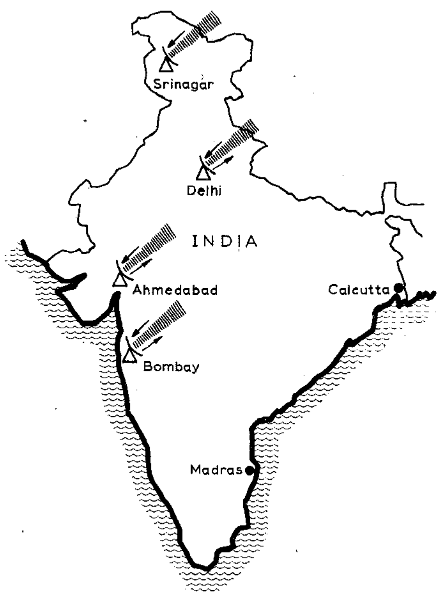


Fig. 2. Map showing the proposed Indian Earth stations.

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 rebroadcasting, whereas Srinagar will only be able to receive and rebroadcast the signals[5].

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 scheme[5] 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 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.

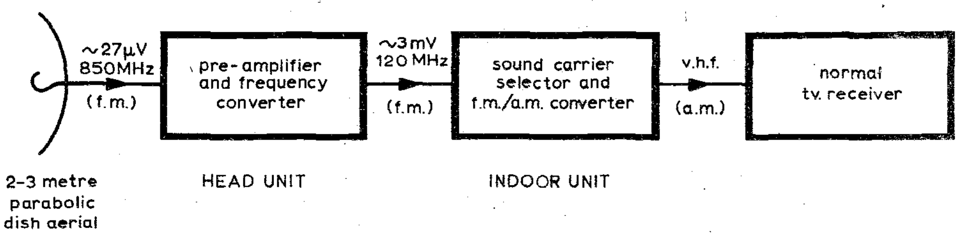


Fig. 3. Block diagram of an experimental receiver of the type which may be used in India.

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

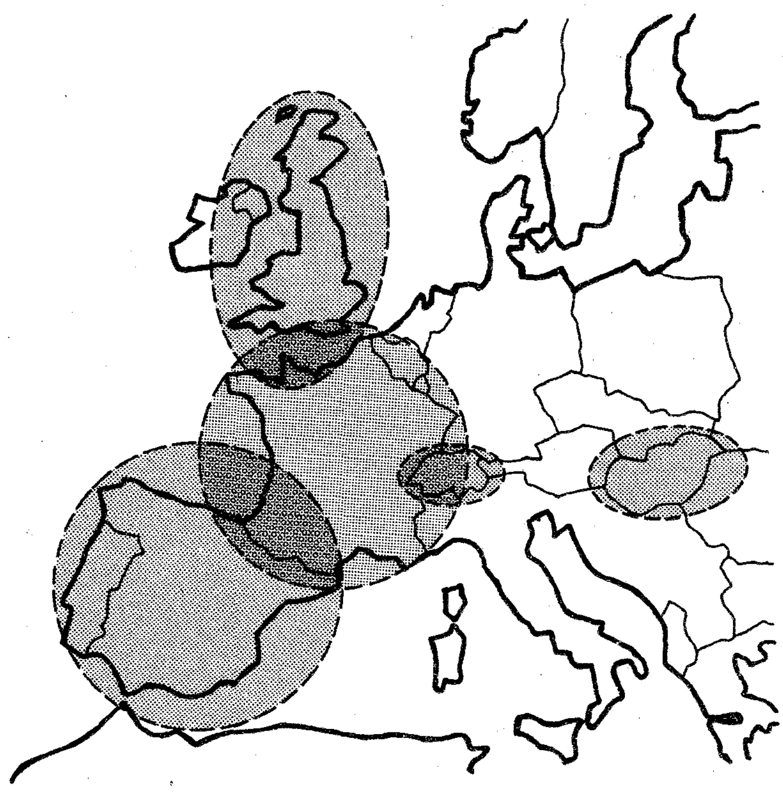


Fig. 4. Map showing the type of service areas which are envisaged for Europe.

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.

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 1m² effective [3]	−5dB (0.75m diameter)	1dB (1.5m diameter)
h)	Required flux	−97dBW/m²	−106dBW/m²
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)

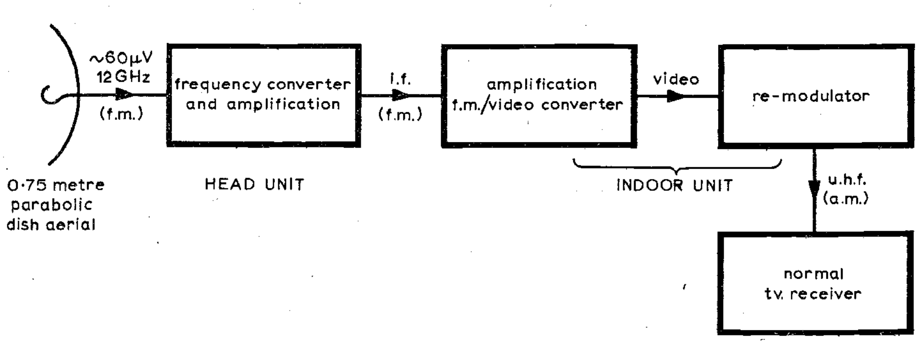


Fig. 5. Block diagram of an experimental receiver of the type which may be used for the reception of s.h.f. broadcasts.

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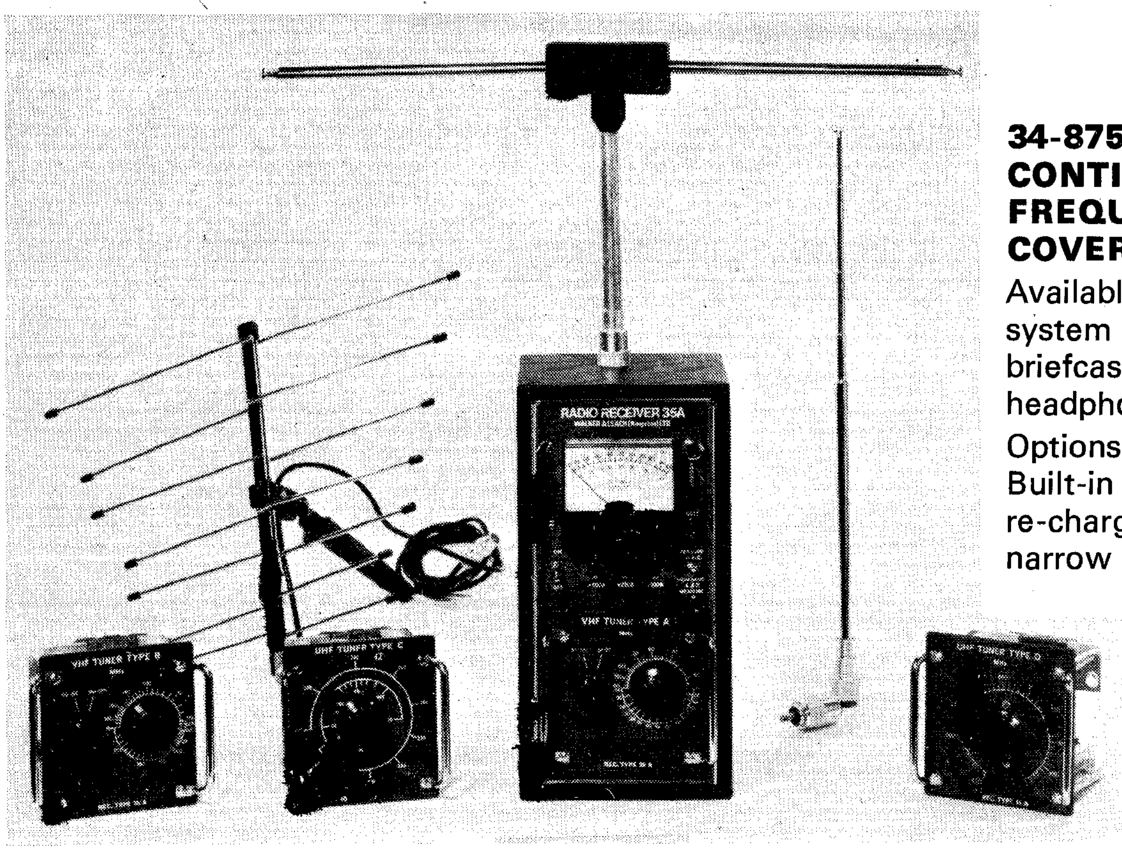

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Contrast expansion processor

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 0.7μ m, visible channel and 10.5 to 12.5μ 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 $\pm$ 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. Similiarly 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,

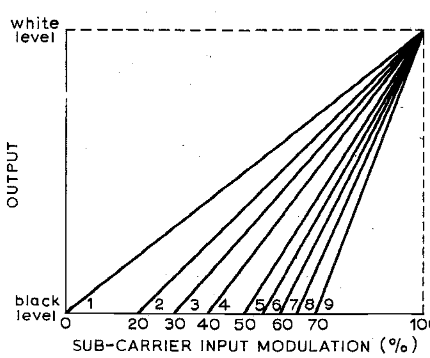


Fig.2. The required transfer characteristics for a contrast expander.

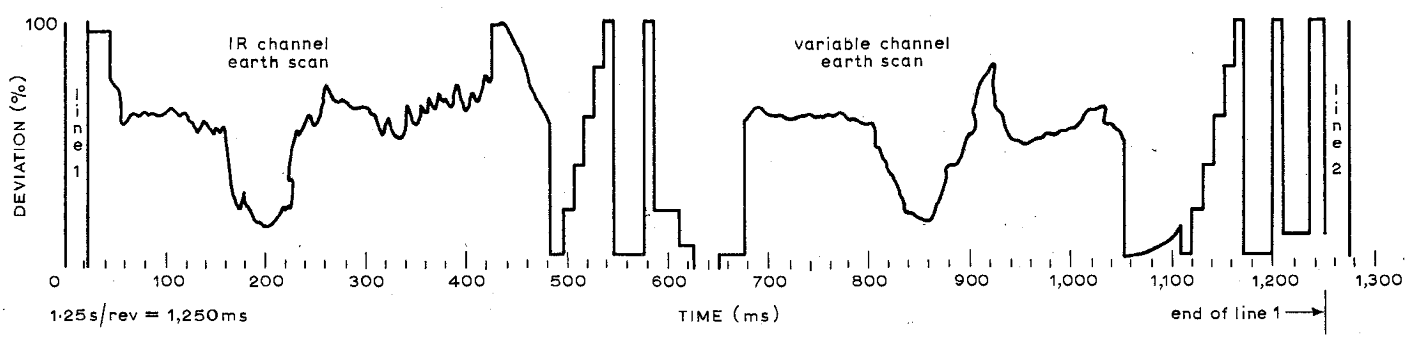
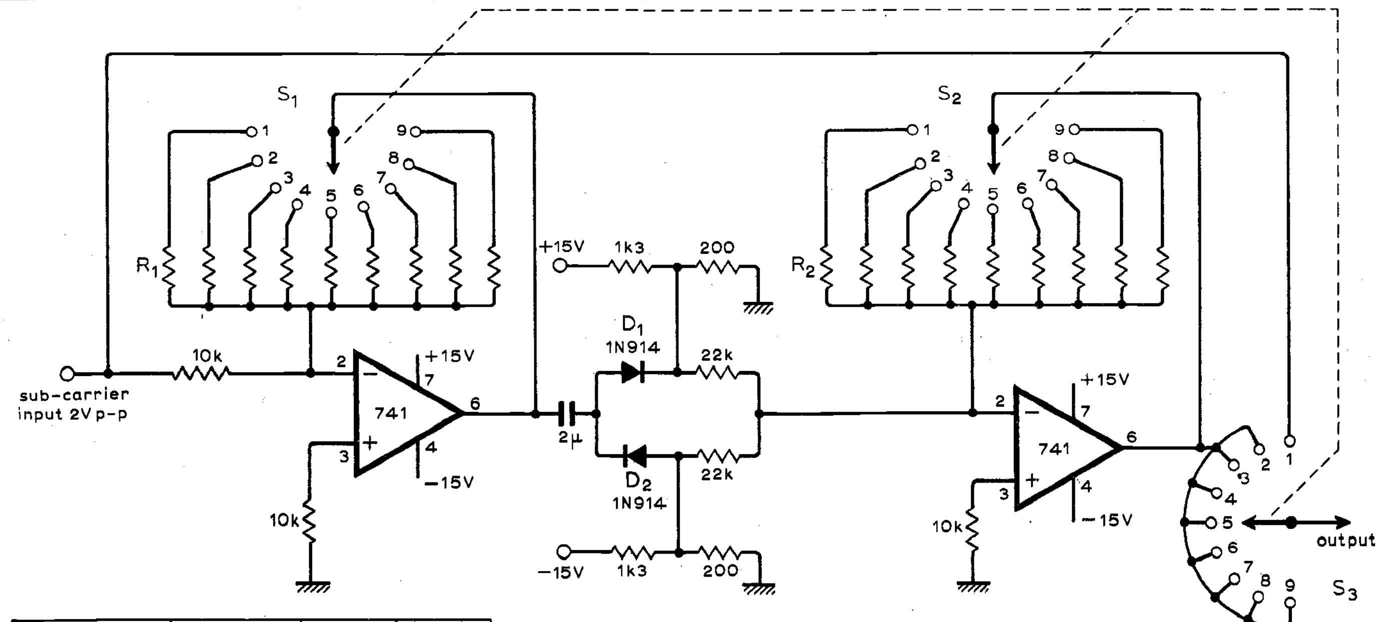


Fig.1. A typical time multiplexed i.r. and visible channel waveform; parts of the scan period are used for calibration and telemetry. (Ref. 1.)



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.

(a) (b)

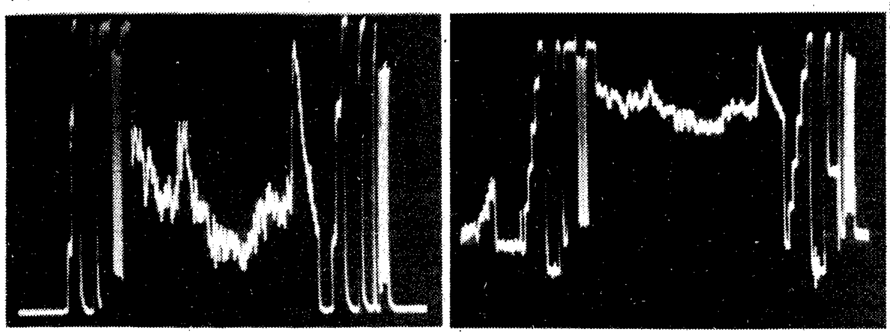


Fig.5. (a) The NOAA 2 i.r. scan line video waveform after expansion. (b) The NOAA 2 i.r. scan line video waveform before expansion.

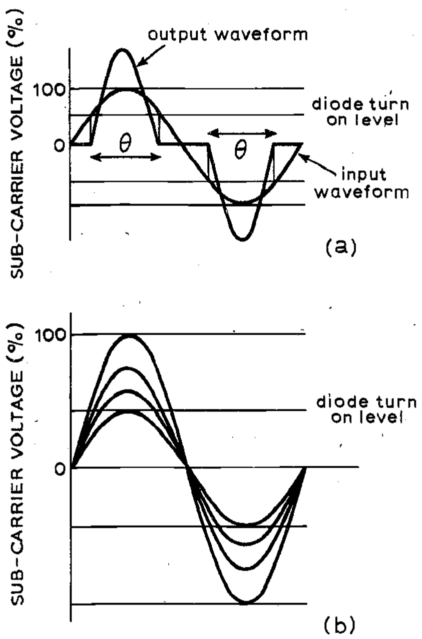
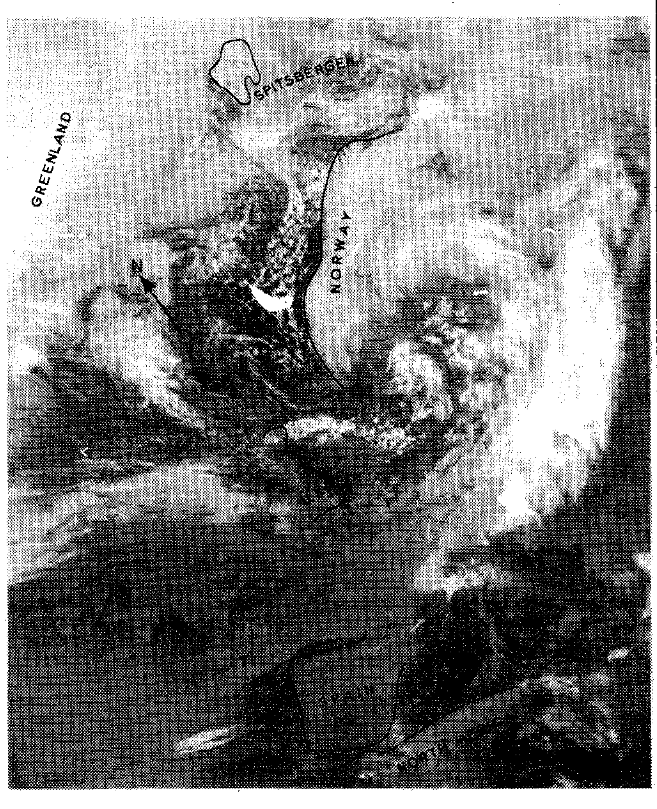


Fig.4. (a) With a fixed 100% input voltage, the conduction angle varies with diode turn on level. (b) With a fixed diode turn on level the conduction angle varies with sub-carrier peak voltage.

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. Schwalb, NOAA technical Memorandum NESS 35, US Department of Commerce.

Further reading

Kennedy, W. K. and Bargh, J. K., "An Automatic Picture Transmission Cloud Cover Receiving Station", *The Radio and Electronic Engineer,* Vol. 38, No. 3, September 1969.
Vermillion, C. H., "Weather Satellite Picture Receiving Stations". NASA Report No. SP 5080.
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.ts 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 aerials 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 aerials 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 critized 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. TILLETT

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 Cairnsmore 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, W1TS 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 loudspeaker 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.cs for increased sensitivity to carrier level. It requires external equalization.

The i.cs 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 8Ω
Frequency response	5 to 100,000Hz, −3dB at 8Ω
Signal to noise ratio	phono 65dB aux 70dB tuner, tape in 70dB
Damping factor	35 at 8Ω
High filter	−10dB at 10kHz
Low filter	−10dB at 50Hz
Input sensitivity	phono 2.5mV/47kΩ tuner 150mV/40kΩ aux 150mV/40kΩ tape monitor in 230mV/47kΩ main amp in 800mV/33kΩ
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 8Ω 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

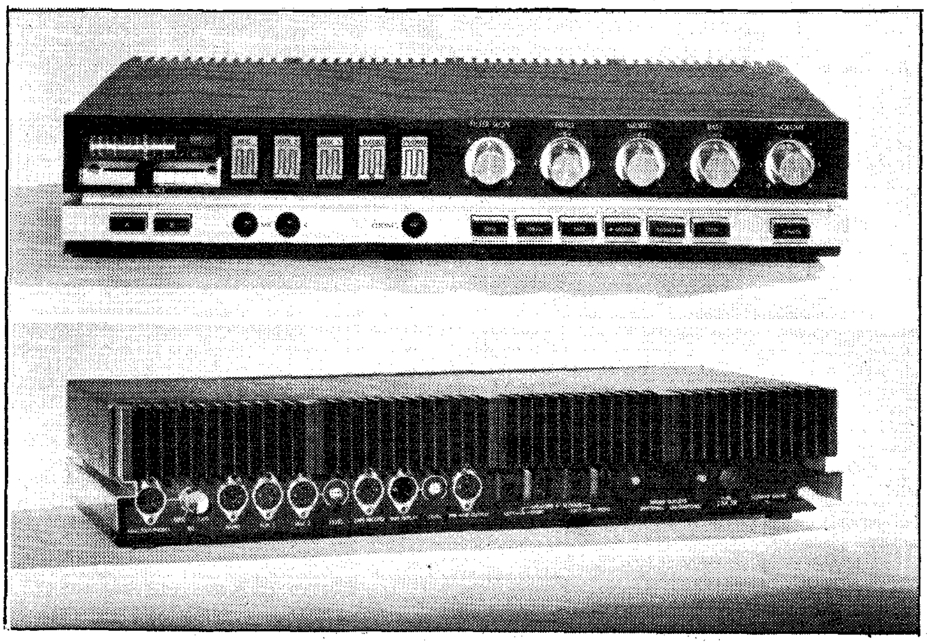
WW 352

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 CrO_2 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

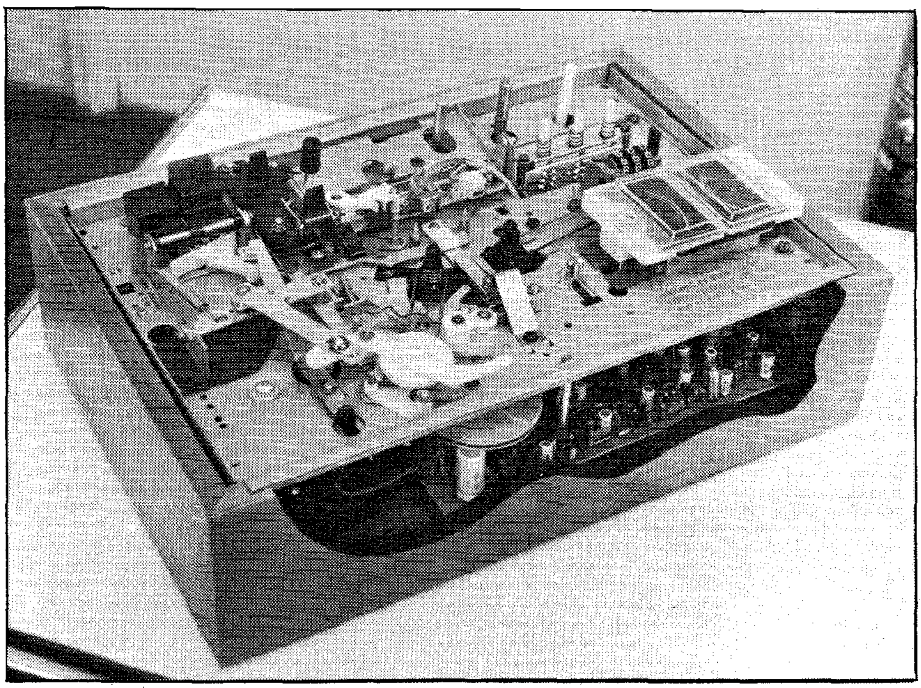
Cassette deck

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 CrO_2 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 CrO_2 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



WW 359

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 40Hz ± 17dB
	mid 1kHz ± 8dB
	treble 14kHz ± 13dB
Input sensitivity	magnetic 47kΩ/2.5mV
	ceramic 47kΩ/30mV
	tuner, tape 47kΩ/100mV
Input overlead	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.

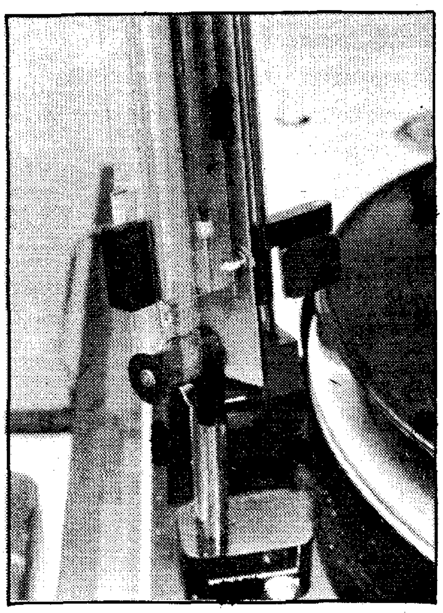
It has a self adhesive pad which readily adheres to most surfaces or can be screwed onto the motor board. Adjustable for height it can be used with turntables which are flush or a little below the motor board and up to a height of 1 in. No arm rest is required since a magnet holds it in the parked position. 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, 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 μV. 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



WW 360

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 8½in and 9¼in overall length, 3/16in and ¼in 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 2½ × 1½ × ¾in and operates from power supplies ranging from 8 to 32V over a temperature range of zero to 200°F.

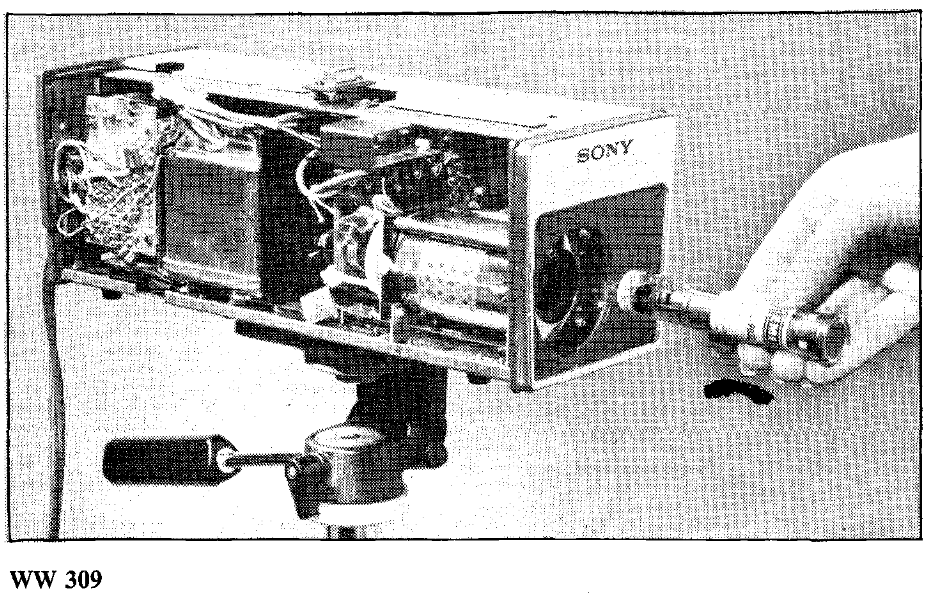
Although the transducer was developed primarily for monitoring manifold pressure of internal combustion engines it has a variety of other applications: altitude or fluid level sensing, environmental control, monitoring of air conditions, coolants or bottled gas reservoirs and pressure-sensing in aircraft 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 × 181mm, 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 7½ 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 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.

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.

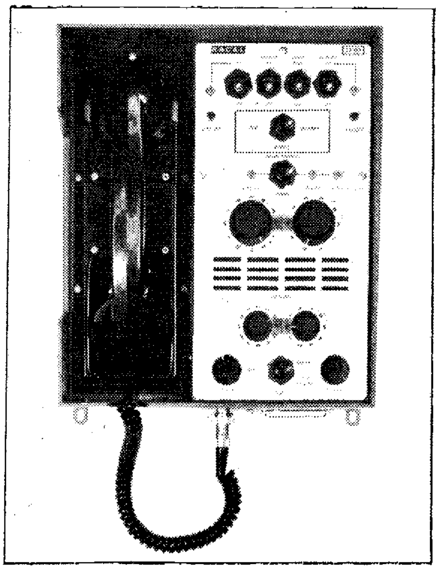
The instrument has been designed for portable use, enabling measurements to be taken in situations where a mains supply is inconvenient or impractical, such as at rooftop level. The carrying case is light but robust, specifically designed to provide ease of handling as well as adequate protection. Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex.

WW307 for further details

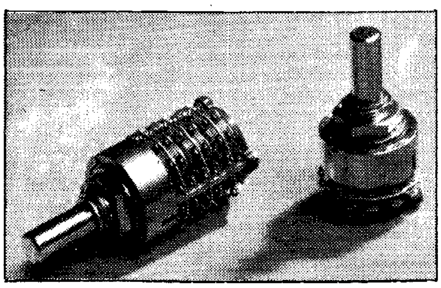
Rotary switch

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.

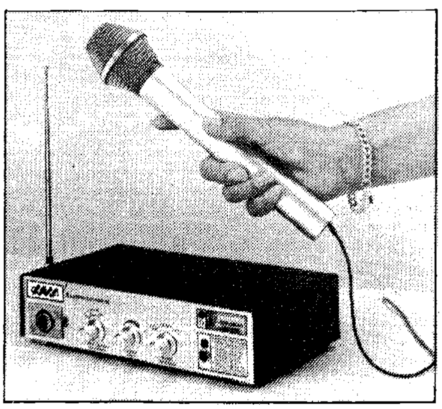
WW314 for further details



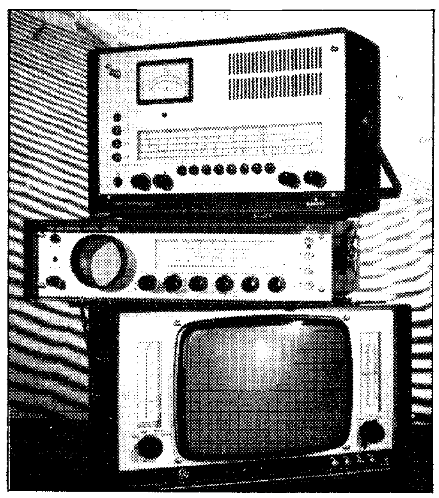
WW 316



WW 314



WW 305



WW 307

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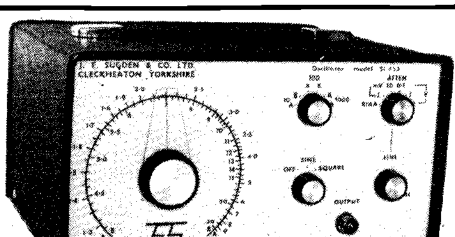

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WW—094 FOR FURTHER DETAILS

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, hereinafter 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 Fridgelander 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 Fridgelander 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 blabbermouth 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 Fridgelander 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 ⅜in. 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 — pffft! — 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 scalier 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!

General index

Volume 79, January—December 1973

General index is followed by classified and authors sections. The classified index is divided into the following sections: audio and acoustics; circuit ideas; circuitry and circuit design; communications; constructional designs; domestic equipment; editorials; education and instructional; exhibitions and conferences; letters to the editor; measurement and test; news of the month.

CLASSIFIED INDEX

COMMUNICATIONS

CONSTRUCTIONAL DESIGNS

DOMESTIC EQUIPMENT

EDITORIALS

EDUCATION AND INSTRUCTIONAL

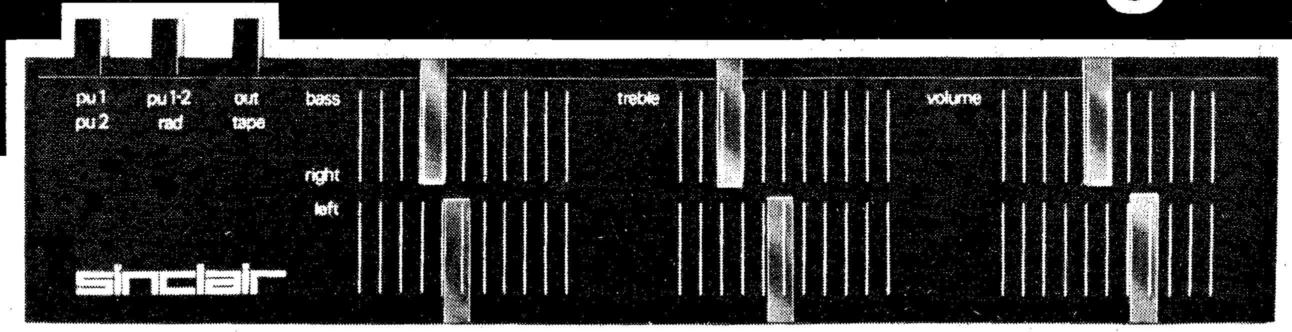
EXHIBITIONS AND CONFERENCES

LETTERS TO THE EDITOR

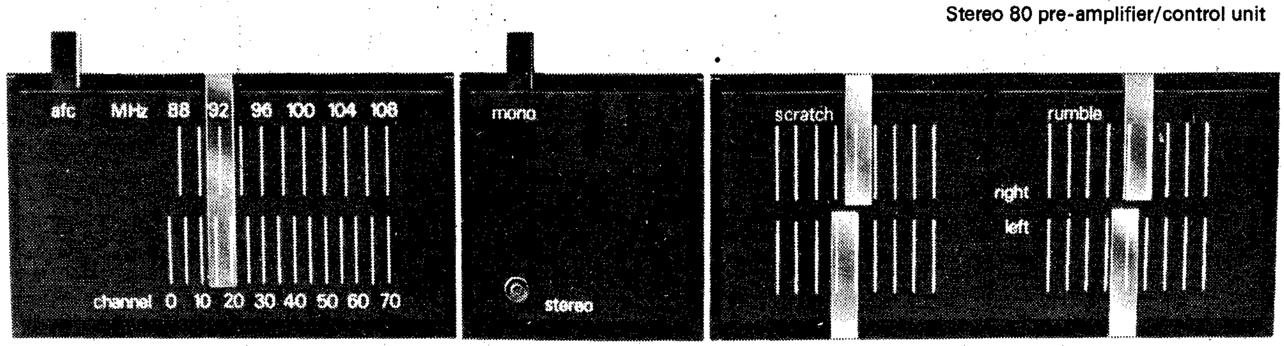
now...

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)

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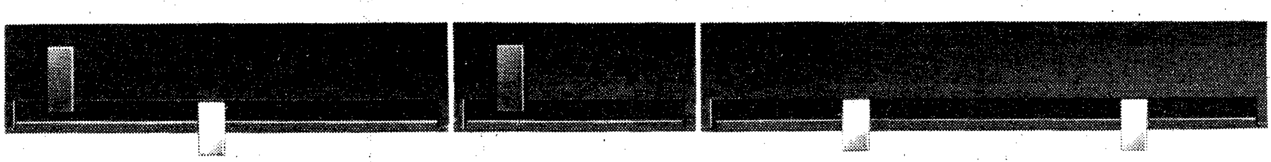


Living with hi-fi takes on new meaning now that Project 80 is here. These amazing new modules mark a brilliant technical advance all round; their size and presentation bring exciting new opportunities to install systems in ways hitherto only dreamed about but never before made practical. You can build 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.

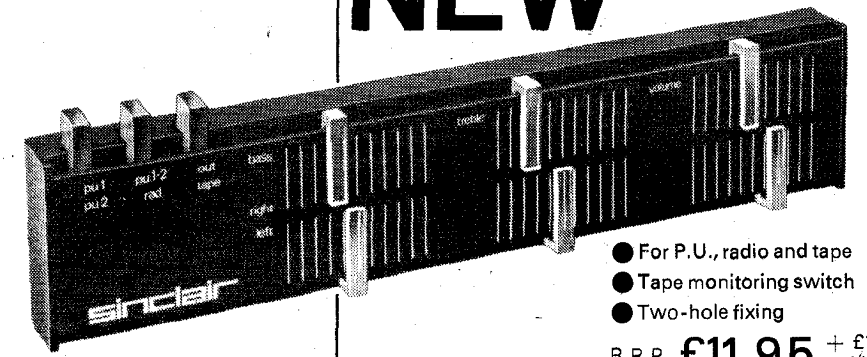
sinclair

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 ¾" 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.

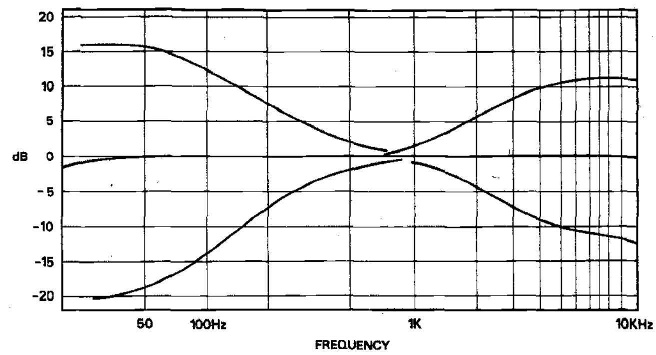
NEW



- For P.U., radio and tape
- Tape monitoring switch
- Two-hole fixing

R.R.P. **£11.95** + £1·19 V.A.T.

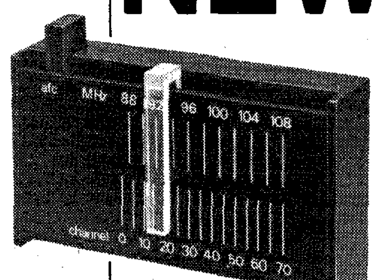
TECHNICAL SPECIFICATIONS
Size – 260 × 50 × 20mm (10¼ × 2 × ¾ins)
Finish – Black, with white markings
Inputs – Mag. P.U. 3mV RIAA corrected; Ceramic P.U. 300 mV
Radio 300 mV; Tape 30 mV
S/N ratio – 60db
Frequency range – 20Hz to 15KHz ± 1dB: 10Hz to 25KHz ± 3dB
Power requirements – 20 to 35 volts
Outputs – 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



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 (3½ × 2 × ¾ins). Greater adaptability (and possibly financial convenience) results from the tuner and stereo decoder section being made available separately.

NEW



- AFC switch
- Twin dual varicap tuning
- 4-hole ceramic filter
- Slider tuning

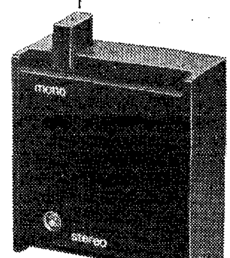
R.R.P. **£11.95** + £1·19 V.A.T.

TECHNICAL SPECIFICATIONS
Size – 85 × 50 × 20mm (approx. 3½ × 2 × ¾ins)
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 1 KHz 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

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 (1⅞ × 2 × ¾ins)
One 19 transistor I.C.



- Solid-state stereo indicating beacon
- Readily adaptable for use with other tuners

R.R.P. **£7.45** + 0·74p V.A.T.

a64

new constructional techniques

. . .and again Sinclair leads the world

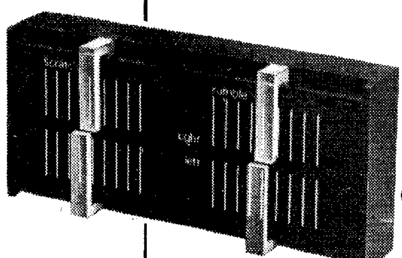
1962 Micro-miniature power amp small enough to stand on a 10p. piece. Slimline pocket receiver smaller than a 20 cigarette pack
1963 Micro-6 receiver, smaller than a matchbox
1964 Pocket F.M. receiver; PWM amp.
1965 Z.12 power amplifier module; PZ.3 power supply
1966 Stereo 25 pre-amp/control unit
1967 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 605
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 × 50 × 20mm ($4\frac{1}{4} \times 2 \times \frac{3}{4}$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



NEW

- For scratch and rumble control
- Transistorised active circuitry

R.R.P. **£6.95** + 0.69p V.A.T.

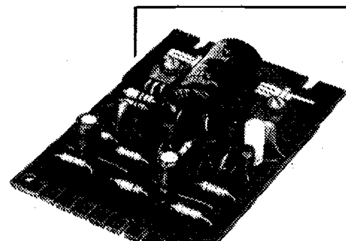
Z.40 & Z.60 power amplifiers
totally short-circuit proof

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 × 80 × 20mm
($2\frac{1}{8} \times 3\frac{1}{8} \times \frac{3}{4}$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

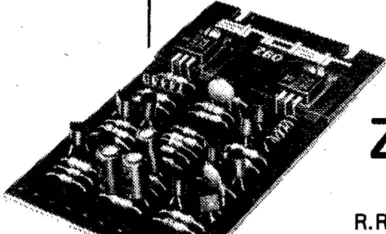
Z 60 Technical Specifications
Size – 55 × 98 × 20mm
($2\frac{1}{8} \times 3\frac{7}{8} \times \frac{3}{4}$ins) 12 transistors
Input sensitivity – 100-250mV
Output – 25 watts RMS into 8 Ω (45V). 50 watts music power into 4 Ω (50V)
Distortion – typically 0·03%
Frequency response – 10Hz to more than 200KHz ± 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

NEW



Z.40

R.R.P. **£5.45** + 0.54p V.A.T.



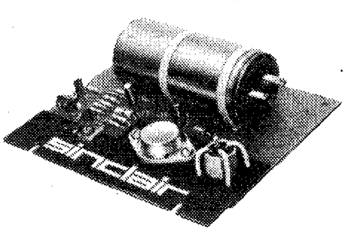
Z.60

R.R.P. **£6.95** + 0.69p V.A.T.

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 inorporated 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 unstabilised
R.R.P. **£4.98** + 0.49p V.A.T.
PZ.6 35V. stabilised
R.R.P. **£7.98** + 0.79p 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 × 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 × 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.

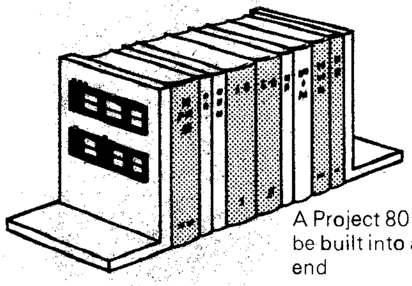
sinclair

LONDON RD., ST. IVES, HUNTINGDONSHIRE PE17 4HJ
Reg. No. 699483 England

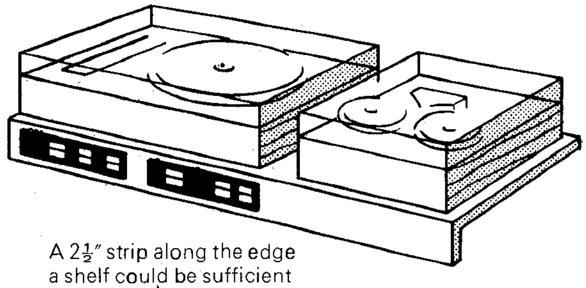
a65

From Sinclair the worlds most advanced hi-fi modules

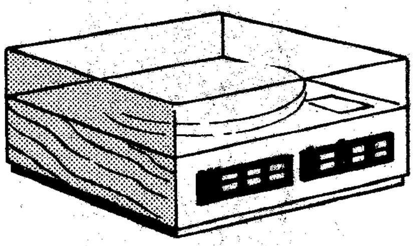
Sinclair Project 80 the ultra-modern non-obtrusive hi-fi



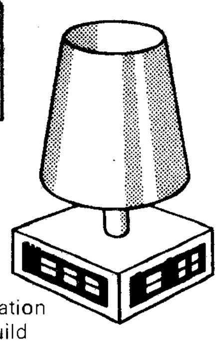
A Project 80 system could be built into a book-shelf end



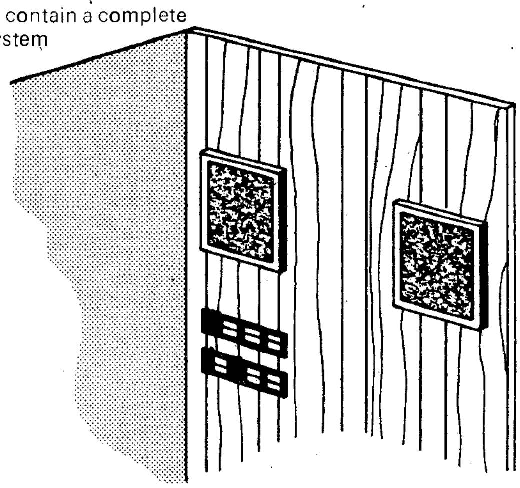
A 2½″ strip along the edge a shelf could be sufficient to contain a complete system



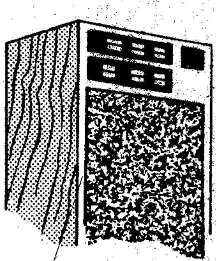
The modules mount very easily onto a playing plinth



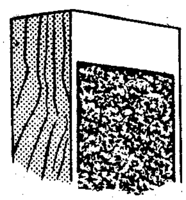
A novel application would be to build around the base of a lampshade



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.

To SINCLAIR RADIONICS LTD. ST. IVES, HUNTINGDON PE17 4HJ

Please send post paid ______________________

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for which I enclose Cash/Cheque for £________including V.A.T.

Name ______________________

Address ______________________

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Guarantee

If, within 3 months of purchasing any product direct from us, you are dissatisfied with it, your money will be refunded on production of receipt of payment. Many Sinclair appointed Stockists also offer this guarantee.

Should any defect arise in normal use, we will service it without charge. For damage arising from mis-use a small charge (typically £1.00) will be made.

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Sinclair Radionics Ltd.
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Huntingdon PE17 4HJ
Telephone St. Ives (0480) 64311

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 50μF) 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
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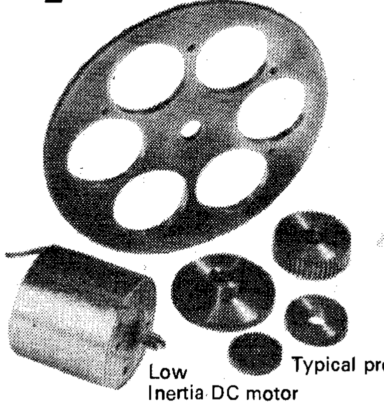
THORN Thorn Measurement Control and Automation Division.

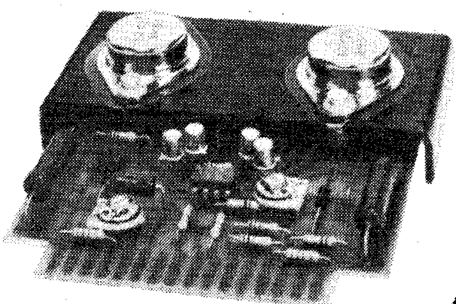
WW—102 FOR FURTHER DETAILS

Purpose-built servo and actuator systems using standard components



Low Inertia DC motor

Typical precision gears



Control Amplifier

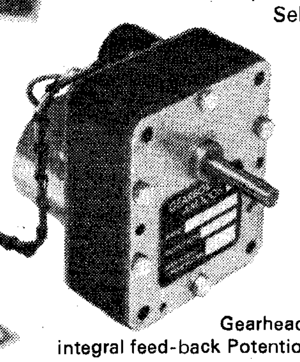
The illustration shows a selection of modules from the McLennan standard range which are available as individual items or can be supplied engineered to custom-built systems.

Such a system could be complete in itself or form part of your own design.

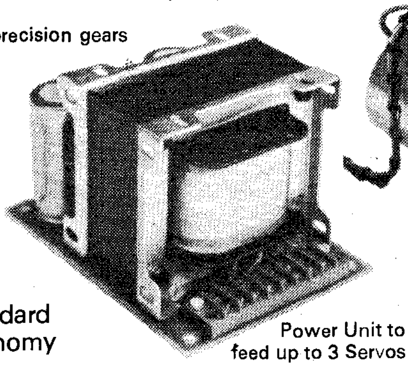
Typical examples include:

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.



Gearhead with integral feed-back Potentiometer



Power Unit to feed up to 3 Servos

McLennan have considerable experience in the solution of actuator and servo problems using synchronous, stepping and D.C. motor techniques as well as solonoid -powered types. An important facet of our skill lies in purpose-designing around standard components for speed and economy of building.

McLennan Engineering Ltd

Control Systems and Components

Kings Road, Crowthorne, Berkshire. Tel: Crowthorne 5757/8.

WW—103 FOR FURTHER DETAILS

VALVES

	£		£		£		£		£		£
B12H	1·75	ECL82	0·31	OB2	0·35	R17	0·45	UBF80	0·35	VR150/30	0·35
CY31	0·40	ECL83	0·63	PABC80	0·35	R19	0·35	UBF89	0·34	2800U	1·40
DAF96	0·40	ECL86	0·36	PC97	0·41	STV 280/40	3·20	UCC85	0·35	Z801U	1·40
DF96	0·40	EF36	0·50	PC900	0·42	STV 280/80	8·20	UCF80	0·60	Z803U	1·10
DK96	0·40	EF37A	0·85	PCC84	0·36	TT21	3·80	UCH42	0·60	Z900T	0·90
DL92	0·32	EF40	0·62	PCC89	0·45	U25	0·70	UCH81	0·35	1L4	0·13
DL94	0·45	EF41	0·65	PCC189	0·49	U26	0·70	UCL82	0·35	1R5	0·35
DL96	0·40	EF80	0·25	PCE800	0·75	U27	0·45	UCL83	0·55	1S4	0·30
DM70	0·40	EF83	0·60	PCF80	0·25	U191	0·68	UF80	0·30	1S5	0·30
DY86	0·29	EF85	0·31	PCF82	0·27	U801	0·70	UF89	0·35	1T4	0·30
DY87	0·28	EF86	0·27	PCF84	0·54	UABC80	0·30	UL41	0·60	1X2A	0·36
DY802	0·30	EF89	0·25	PCF86	0·50	UAF42	0·50	UL84	0·35	1X2B	0·50
E88CC/01	1·08	EF91	0·27	PCF200	0·60	UBC41	0·48	UU5	0·65	2K25	7·50
E180CC	0·37	EF92	0·31	PCF201	0·60			UY41	0·45	3A4	0·40
E180CC	0·90	EF95	0·31	PCF801	0·44			UY85	0·35	3D6	0·15
E182CC	1·08	EF183	0·26	PCF802	0·45			VR105/30	0·35	3Q4	0·55
EA50	0·18	EF184	0·31	PCF805	0·80					3S4	0·33
EABC80	0·27	EFL200	0·67	PCF806	0·65					3V4	0·48
EAF42	0·46	EL34	0·59	PCF808	0·85						
EB91	0·20	EL41	0·55	PCH200	0·65						
EBC33	0·45	EL84	0·21	PCL81	0·50						
EBC41	0·50	EL85	0·44	PCL82	0·30						
ECC81	0·27	EL86	0·36	PCL83	0·60						
EBF80	0·36	EL90	0·31	PCL84	0·35						
EBF83	0·40	EL95	0·36	PCL85	0·40						
EBF89	0·27	EL500	0·76	PCL86	0·43						
ECC81	0·27	EL504	0·76	PFL200	0·60						
ECC82	0·25	EM31	0·22	PL36	0·50						
ECC83	0·25	EM80	0·36	PL81	0·40						
ECC84	0·27	EM84	0·31	PL82	0·30						
ECC85	0·36	EM87	0·63	PL83	0·36						
ECC86	0·80	EY51	0·36	PL84	0·30						
ECC88	0·39	EY86	0·40	PL500	0·62						
ECC189	0·48	EY81	0·40	PL504	0·62						
ECF80	0·31	EY88	0·45	PL508	0·70						
ECF82	0·31	EZ41	0·45	PL509	1·05						
ECF83	0·67	EZ80	0·22	PL802	0·88						
ECF801	0·56	EZ81	0·24	PX4	2·50						
ECH81	0·25	GZ34	0·52	PY33	0·55						
ECH83	0·40	GZ37	0·63	PY80	0·35						
ECH84	0·40	KT66	2·30	PY81	0·30						
ECL80	0·40	KT88	2·25	PY82	0·30						
		N78	1·60	PY83	0·35						
		OA2	0·38	PY88	0·32						
				PY800	0·35						
				PY801	0·45						
				QQVO 3-10	1·10						

	£		£		£
5B254M	2·75	6AQ5	0·36	6C4	0·25
5B/255M	3·10	6AQ5W	0·45	6C6	0·20
5R4GY	0·65	6AS6	0·30	6CH6	0·55
5U4G	0·30	6AT6	0·30	6CL6	0·50
5V4G	0·45	6AU6	0·20	6D6	0·15
5Y4G	0·35	6AX4GT	0·50	6EA8	0·60
5Y3GT	0·35	6AX5GT	0·60	6F23	0·80
5Z3	0·70	6B7	0·35	6F33	1·35
5Z4	0·75	6BK7	0·60	6H6M	0·25
5Z4GT	0·32	6BA6	0·25	6J4WA	0·65
6AB7	0·25	6BE6	0·25	6J5	0·35
6AC7	0·45	6BG6G	0·47	6J5GT	0·30
6AH6	0·50	6BJ6	0·45	6J6	0·25
6AK5	0·35	6BQ7A	0·43	6J7G	0·30
6AK8	0·30	6BR7	1·09	6J7M	0·35
6AL5	0·18	6BW6	0·80	6K6GT	0·55
6AL5W	0·35	9BW7	0·80	6K7	0·40
6AM6	0·35				
6AN8	0·60				

	£		£		£
6K7G	0·17	30C15	0·70	6057	0·55
6K8GT	0·40	30C17	0·85	6060	0·50
6K25	0·70	30C18	0·75	6064	0·45
6L6M	1·35	30F5	0·80	6065	0·65
6SA7	0·40	30FL1	0·70	6080	1·55
6SA7GT	0·25	30FL12	0·95	6146	1·75
6SC7GT	0·20	30FL14	0·80	8020	3·75
6SG7	0·40	30L15	0·80	9001	0·15
6SJ7	0·40	30L17	0·80	9002	0·40
6SJ7GT	0·28	30P12	0·75	9003	0·45
6SK7	0·45	30P19	0·70	9004	0·12
6SL7GT	0·35	30PL1	0·70	9006	0·12
6SN7GT	0·35	30PL13	0·90		
6SQ7	0·45	30PL14	0·85	**C.R. Tubes**	
6SQ7GT	0·30	35L6GT	0·50	VCR97	4·00
6V6G	0·15	35W4	0·30	VCR517R	5·00
6V6GT	0·35	36Z4GT	0·55	VCR517C	7·00
6X4	0·33	50C5	0·45	88D	8·10
6X5G	0·25	50CD6G	1·10	88J	8·10
6X5GT	0·35	50EH5	0·55	88L	8·10
6Y6G	0·75	75	0·50		
6-30L2	0·85	76	0·55	**Photo Tubes**	
6Z4	0·40	78	0·50	CMG25	2·50
7B7	0·50	80	0·55	931A	4·75
7Y4	0·60	723A/B	7·00	6097C	16·00
9D6	0·30	803	5·50		
11E2	3·70	805	12·00	**Special Valves**	
12AT6	0·35	807	0·50	CV2339	18·00
12AT7	0·35	813	4·00	JP9/7D	35·00
12AU7	0·24	832A	2·70	K301	4·50
12AV6	0·40	866A	1·25	K305	11·00
12AX7	0·25	931A	4·75	K308	14·50
12BA6	0·25	954	0·35	K337	14·50
12BE6	0·35	955	0·35	KRN2A	3·15
12BH7	0·23	956	0·30	WL417A	1·35
12C8	0·30	957	0·35	3J/92/E	35·00
12E1	2·85	991	0·40	5C22	22·00
12K5	0·95	2051	0·70	714AY	3·60
12K7GT	0·45	5933	1·00	725A	22·50
12K8GT	0·40				
12Q7GT	0·40				
12SG7	0·40				
14S7	0·70				
19AQ5	0·40				
19G3	5·75				
19G6	5·75				
19H4	5·25				
20P4	1·00				
25L6GT	0·50				

COLOMOR

THE VALVE WITH A GUARANTEE

SPECIAL OFFER 09J TUBE £2·50 p & p 50p

TRANSISTORS, ZENER DIODES

	£		£		£		£		£		£
OA5	0·20	OC71	0·12	1N702-725	0·36	3N139	1·75	ASY67	0·48	CRS3/40	0·50
OA10	0·25	OC72	0·20	1N823A	1·30	3N140	0·97	BAW19	0·28	CS2A	0·65
OA70	0·10	OC73	0·30	1N4785	0·50	3N154	0·95	BC107	0·10	CV102	0·25
OA71	0·10	OC75	0·25	1ZMT5	0·35	3N159	1·45	BC108	0·10	GET103	0·23
OA73	0·07	OC76	0·25	1ZMT10	0·33	6FR5	0·45	BC113	0·10	GET115	0·45
OA74	0·07	OC81	0·20	1ZT5	0·67	12FR60	0·73	BC118	0·20	GET116	0·50
OA79 (6D15)	0·10	OC81D	0·20	1ZT10	0·63	40954	1·25	BCY72	0·15	GEX66	1·50
OA81	0·08	OC81DM	0·20	2G385	0·51	40595	1·25	BF115	0·25	NKT222	0·20
OA91	0·07	OC82	0·25	2G403	0·51	40636	1·25	BF173	0·20	NKT304	0·50
OA200	0·07	OC82DM	0·30	2N918	0·37	40668	1·25	BFY51	0·20	RAS310AF	0·33
OA202	0·10	OC83	0·25	2N1304	0·22	40669	1·40	BFY52	0·20	SD91S	0·26
OAZ200	0·55	OC83B	0·15	2N1306	0·25	AC126	0·25	BS	0·45	SD92S	0·31
OAZ201	0·50	OC84	0·25	2N1307	0·25	AC127	0·25	BS2	0·47	SD93S	0·32
OC22	0·50	OC122	0·50	2N2147	0·64	AC128	0·20	BSY29	0·25	SD94	0·21
OC25	0·40	OC139	0·25	2N2411	1·50	AC176	0·20	BU100	1·80	SD98S	0·46
OC26	0·25	OC140	0·40	2N2904A	0·25	ACY17	0·25	BYZ13	0·25	V405A	0·40
OC28	0·60	OC170	0·25	2N2989	4·00	ACY28	0·17	BYZ16	0·63	Z2A51CF	0·78
OC29	0·60	OC171	0·30	2N3053	0·20	AD149	0·50	CRS1/10	0·25	ZR11	0·33
OC35	0·50	OC172	0·37	2N3054	0·50	AD161	0·35	CRS1/20	0·38	ZR21	0·46
OC36	0·56	OC200	0·40	2N3055	0·64	AD162	0·35	CRS1/30	0·40	ZR22	0·42
OC38	0·42	OC201	0·75	2N3730	0·50	AF118	0·50	CRS1/35	0·43		
OC44	0·17	OC206	0·95	2N3731	2·75	AF127	0·20	CRS1/40	0·48		
OC45	0·12	1N21B	0·30	2N4172	0·50	AF139	0·30	CRS3/05	0·30		
OC70	0·12	1N25	0·60	S2303	0·50	AF178	0·48	CRS3/20	0·38		
		1N43	0·10	3F100	0·62	AF186	0·40	CRS3/30	0·43		
		1N70	0·07	3FR5	0·32	ASY26	0·25	CRS25/025	0·55		
		1N677	0·12	3N128	0·87	ASY28	0·25				

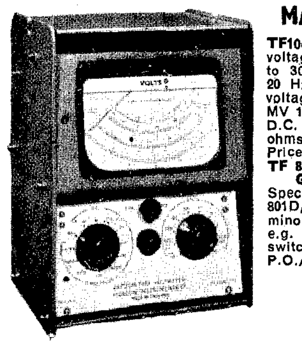
ZENER DIODES

All preferred voltage

	£
¼W	0·17
1W	0·37
1·5W	0·25
7W	0·40

MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 5p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.

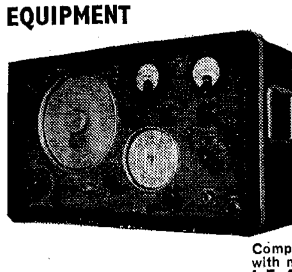
VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.



MARCONI TEST EQUIPMENT

TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges, 20 Hz-1500 MHz. D.C. voltage ranges 300 MV 1000V in 8 ranges. D.C. resistance 50 ohms to 500 ohms. Price £62·50.

TF 801B/3/S SIGNAL GENERATOR Spec, as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.



TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 µV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

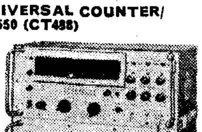
TF 562B/3 Oscillator and Detector Unit.

TF 1226B
TF 1225A } White Noise Test Set.
TM 577A

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (*a*) 85-175 µSec, (*b*) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2µV to 20mV with ×10 multiplier. **£200.**

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100µ sec., delay —1·5 to +3000µ sec., rise time < 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25µ sec, delay 0 to + 300µ sec, **£230.**

RACAL UNIVERSAL COUNTER/ TIMER SA550 (CT488)
8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Three independent inputs, self-check etc. Full spec. and price on request.



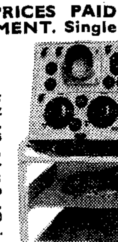
SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs **of CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0,1uV to 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0,75 kHzdev., S.F.M. —x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30µsec. width int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

HEWLETT—PACKARD
185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.
5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MH₂. Accuracy ½ 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.
540B TRANSFER OSCILLATOR. Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.
430C MICROWAVE POWER METER. Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£95.**
205AG AUDIO OSCILLATOR. Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£125.**
616B SHF SIGNAL GENERATOR. Freq. range 1,75GHz-4,2GHz, Mod.: F.M., C.W. Pulse and Ext. A.M., output. 0,1uV-200mVV. Price on application.

TF 894 AUDIO TESTER. Combined A.F. Generator (0-25kHz), Output meter (up to 2W. at 600, 15 and 3Ω,) and valve voltmeter (0-800V.), with stepped and variable attenuators. **£60.**

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

SPECTRUM ANALYSER TYPEOA1094
Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs.
Complete as illustrated, with manuals, etc. **and L.F. Adaptor.**
Price upon application.



SOLARTRON DO 905 STABILISED AMPLITUDE SIGNAL GENERATOR. Freq range 350kHz-50MHz **£70.**

TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: —50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.

PLEASE ADD 10% VAT TO ALL ORDERS

TEKTRONIX OSCILLOSCOPES.
571A—60MHz, separate P.S.U. **£150** complete.
561A—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10mV-cm.
R Transistor measurement.
P type callibration.
3A1—Dual trace 10mV-10V.
3B3—Delayed sweep time base.
EQUIPMENT
162 wave form generator.
163 Pulse generator.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) £8·50. P. & P. £1·50.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

3 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport.

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£180** plus carriage.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

OUR SALE FINISHES ON THE 27th OCT. The following items are still available, **FOR PERSONAL CALLERS ONLY** to our storage depot at Unigate Dairy Depot, entrance off Cromwell Rd, Ext. (Cedars Rd.) towards London, first left (Sutton Lane North, W.4) 1st entrance on left.

TF 885A and 885A/1 Video Oscillators **£15** and **£12** resp. **TF 936** LCR Bridges **£45. Avo CT38** Electronic Multimeters **£25, CT82** Noise generators **£2, B46** receiver **£20, Advance DVM1** AC/DC DVM **£40, TR1143** TX/RX **£8,** also some of the items previously listed.

R.F. METER 0-8 amp. 2¼" (U.S.A.) **£1·80** P. & P. 15p.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections, 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. **£7·50** new or **£4·50** slightly used. Carriage 50p.

METERS Full List of our very large stock of meters on request.

TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**

50 line AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD

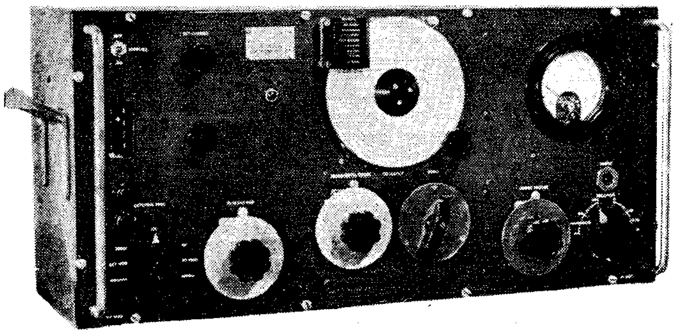
Price of each of the above on application.

RADAR SCANNER ASSEMBLY TYPE C368 Parabolic assembly 17". Complete with motor for 26V 600W, etc. **£22·50.** Carriage £2·50.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23. To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899



MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±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 sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 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 × 813 and Modulator 2 × 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. × 2ft. D. × 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. × 8 in. × 6½in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. 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 × 6AK5. **£10·00** plus 60p post, good condition.

MODULATOR UNIT: complete with transformer and 2 × 807 valves mounted in 19 in. chassis × 8 in. high × 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 × 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 × 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″ × 6½″ × 7″. Bitumen impregnated. **£7** each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7″ × 5″ × 5″. Mounted in steel ventilated case. **£4·00** each, Carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 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 ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 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 × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. **£8·50**, each, £2 Carr.

INSTRUMENT CABINETS: 19″W. × 16″H. × 16″D. **£5·00** + £1·25 carr. 19″W. × 10″D. × 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.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 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 ins. oz; reversible; microswitches and potentiometer. **£3·50** ea. + 40p post.
DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 60p post.
MOTOR: 240V single phase, 2,400 rpm. 1/40 H.P. approx. Price **£1·75** each, 30p post.
LIST OF MOTORS AVAILABLE FOR 6p.

CONDENSERS: 30 mfd 600V wkg. d.c., **£3·50** each, post 50p. 10 mfd 1000v wkg. **80p**, post 30p. 8 mfd 2500v **£5**, carr. 80p. 8 mfd 600v **45p**, post 15p. 8 mfd 1% 300v d.c., **£1·25**, post 25p. 4 mfd 3000v wkg. **£3**, post 50p. 4 mfd 2000v **£2**, post 40p. 4 mfd 600v, 2 for **£1·00**, post 30p. Capacitor 0·125 mfd 27,000v wkg. **£3·75**, post 50p. 2 25 mfd 25Kv wkg. **£20**, carr. £3. 2 mfd 12·5Kv wkg. TCC RL 7002-97, **£8·50**, carr. £1. 10 mfd 3Kv wkg, 55°C. TCC oil filled, **£7·50**, carr. £1. 5 x 1 mfd 3Kv wkg. 55°**C. £6·50**, carr. £1. 12 mfd 1500v d.c. wkg. **£3·50**, post 50p.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ 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 UNIT 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. × 8in. × 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.

TRANSMITTER UNITS: Complete with 12V vibrator unit QQVO3-20A and 5 other valves with modulation transformer, etc. Two crystal controlled channels. Suitable for conversion to 2 metres. **£5** + £1 carr.

TS 15C/AP FLUXMETER: Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gausses. ±2%. S/hand good cond. **£25** + 60p post.

SYNCHRO DISTORTION AND MARGIN TEST SET: (Onwood Type 4A2) S/hand excellent cond. **£85** each. Carr. £2.

MASTER SYNCHRO TEST SET T.101031 (U.S.A.): 115 volts 400 c/s. S/hand cond. **£15** each + £1 carr.

MAGSLIP TESTER NO. 2 MK. I: S/hand cond. **£25** each + £1 carr.

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: MUIRHEAD 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 ±0·4% ±3Hz over whole range. Oscillator o/put 5mW (+7db) or more inot 600Ω at any freq. Measurement up to 50db and down to at least 45db. Price £10 each **Carr. £1.**

TELEPRINTER TYPE 7B; Pageprinter 24V d.c. power supply, speed 50 bauds per min. 'as new' cond. in original packing case, **£25** each; or second hand cond. (excellent order) no parts broken, **£15** each. Carriage either type £2.
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INSULATION TEST SETS: A.C. or D.C. 0-5 kV. **£22·50.** S/hand cond. AND 0-3 kV. Positive and negative outputs, fine and course control. **£17·50.** S/hand cond. Carr. both types £2.

INSULATION TEST SET: 0-10 kV negative, earth with amplifier provision for checking ionisation. 110/230V a.c. input. S/hand good cond. **£30** + £1 carr.

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R.F. POWER METER: 0-30 watts s/hand good cond. **£27·50** + £1 carr.

AVO VALVE TESTER AND CHARACTERISTIC METER: S/hand good condition. **£35** each + £2 carr.

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ANTENNA MAST 30 ft. consisting of 10 × 3 ft. tubular screw sections (⅞ in. dia.), with base, guy ropes and stays, etc. **£5** each + £1·25 carr.

ANTENNA MAST 12 ft. 3 sections with suitable base to mount on the above Mast, to extend to 42 ft. **£1·50** each + 50p carr.

APN-1 ALTIMETER TX/RX: Freq. approx. 410MHz. Complete with 28V dynamotor, 3 relays, precision resistors, 11 valves. Useful breakdown for parts. **£4** each + 75p carr.

DUMMY LOAD: approx. 100 watts. Wavemeter tunable from 60-215MHz in 3 bands. Output indicated on 50 microamp meter. **£8·50** + £1 carr.

Miscellaneous Vacuum and Pressure Gauges available. Please send for list 6p.

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AT55	1,300W Triac light dimmer/speed control	£5.70
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HF395	Aerial amplifier for AM/FM bands I, II, III	£1.77
GP310	Stereo pre-amp for use with 2x AF310	£21.27
GU330	Tremolo unit for guitars etc.	£7.50
NT10	Power supply 100 m/a 9V stab. 12V unstab	£6.15
NT300	Professional stabilized power supply 2x 30 Volt, 2.2 Amp	£12.51
NT305	Transistor converter 12/15V AC/DC to 6V, 7.5V or 9V DC	£4.50
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AE8	Bass Filter	99p
AE9	Treble Filter	99p
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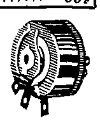
POWER RHEOSTATS



High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ⅜in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000 ohms. **£1·15** P. & P. 10p.

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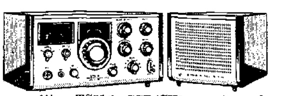
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. **£2·34.** P. & P. 15p.

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 340mm. PS515 200 x 168 x 349mm.

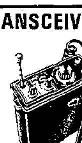
OUR PRICE £210·00 Carr. Paid

TRIO JR599 RECEIVER

9 wavebands covering 1·8-29·7 MHz, 144-146MHz and 10·00 MHz WWV, 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 and phone jack. Power requirements 100/240v. A.C. 12-14v. D.C.

OUR PRICE £155·00 Carr. Paid

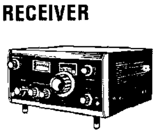
TRIO TR2000 TRANSCEIVER



Fully transistorised portable VHF 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 145·32 crystals.

OUR PRICE £79·50 Carr. Paid

TRIO JR310 SSB RECEIVER



Covers 3·5, 7, 14 21, 28, 28·5 and 29·1MHz bands and WWV 15MHz SSB, AM and CW. AF output more than 1 watt. Crystal 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: 52. Indicator: 100uA DC, full scale 5 section collapsible antenna Size: 145 x 50 x 60mm.

OUR PRICE £4·25 P. & P. 25p

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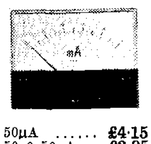
USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, etc.

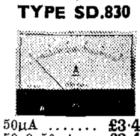
Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100 × 80mm



50µA	£4·15	100µA	£3·95
50–0–50µA	£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 × 110mm Fronts



50µA	£3·40	10mA	£3·10
50–0–50µA	£3·40	50mA	£3·10
100µA	£3·35	100mA	£3·10
100–0–100µA	£3·35	500mA	£3·10
200µA	£3·30	1 amp.	£3·10
500µA	£3·15	5 amp.	£3·10
1mA	£3·10	10 amp.	£3·10
5mA	£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

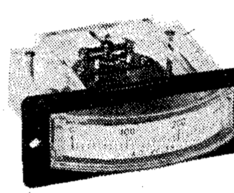
TYPE SD.640 63·5mm × 85mm Fronts

50µA	£3·05	500mA	£2·90
50–0–50µA	£3·05	1 amp.	£2·90
100µA	£3·00	5 amp.	£2·90
100–0–100µA	£3·00	10 amp.	£2·90
200µA	£3·00	5V. D.C.	£2·90
500µA	£2·95	20V. D.C.	£2·90
1mA	£2·90	50V. D.C.	£2·90
5mA	£2·90	300V. D.C.	£2·90
10mA	£2·90	15V. A.C.	£3·00
50mA	£2·90	300V. A.C.	£3·00
100mA	£2·90	VU Meter	£3·15

TYPE SD.460 46mm × 59.5mm Fronts

50µA	£2·80	500mA	£2·60
50–0–50µA	£2·80	1 amp.	£2·60
100µA	£2·75	5 amp.	£2·60
100–0–100µA	£2·75	10 amp.	£2·60
200µA	£2·70	5V. D.C.	£2·60
500µA	£2·55	10V. D.C.	£2·60
1mA	£2·60	20V. D.C.	£2·60
5mA	£2·60	50V. D.C.	£2·60
10mA	£2·60	300V. D.C.	£2·60
50mA	£2·60	15V. A.C.	£2·70
100mA	£2·60	300V. A.C.	£2·70
		VU Meter	£2·90

"SEW" EDGWISE METERS TYPE P.E.70



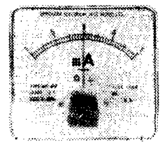
3 17/32in. × 1 15/32in. × 2¼ in. deep.

50µA	£3·75	500µA	£3·20
50–0–50µA	£3·60	1mA	£3·20
100µA	£3·60	300V. A.C.	£3·25
100–0–100µA	£3·50	VU Meter	£3·85
200µA	£3·40		

✻ MOVING IRON— ALL OTHERS MOVING COIL

Please add postage

TYPE MR.85P 4¼in. × 4¼in. fronts.



50µA	£4·40	10mA	£3·90
50–0–50µA	£4·25	50mA	£3·90
100µA	£4·25	100mA	£3·90
100–0–100µA	£4·05	500mA	£3·90
200µA	£4·05	1 amp.	£3·90
500µA	£3·90	5 amp.	£3·90
500-0-500µA	£3·90	15 amp.	£3·90
1mA	£3·90	30 amp.	£3·95
1–0–1mA	£3·90	10V. D.C.	£3·90
5mA	£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.	£3·95
		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

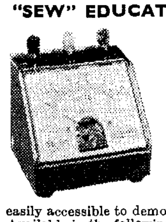
TYPE MR.52P 2½in. square fronts.

50µA	£3·50	10V. D.C.	£2·50
50–0–50µA	£3·05	20V. D.C.	£2·50
100µA	£3·00	50V. D.C.	£2·50
100–0–100µA	£2·95	300V. D.C.	£2·50
500µA	£2·65	15V. A.C.	£2·60
1mA	£2·50	300V. A.C.	£2·60
5mA	£2·50	S Meter 1mA	£2·60
10mA	£2·50	VU Meter	£3·60
50mA	£2·50	1 amp. A.C.*	£2·50
100mA	£2·50	5 amp. A.C.*	£2·50
500mA	£2·50	10 amp. A.C.*	£2·50
1 amp.	£2·50	20 amp. A.C.*	£2·50
5 amp.	£2·50	30 amp. A.C.*	£2·50

TYPE MR.65P 3½in. × 3¼in. fronts

50µA	£3·70	10V. D.C.	£2·60
50–0–50µA	£3·15	20V. D.C.	£2·60
100µA	£3·15	50V. D.C.	£2·60
100–0–100µA	£3·10	150V. D.C.	£2·60
200µA	£3·05	300V. D.C.	£2·60
500µA	£2·75	15V. A.C.	£2·80
500–0–500µA	£2·60	50V. A.C.	£2·80
1mA	£2·60	150V. A.C.	£2·80
5mA	£2·60	300V. A.C.	£2·80
10mA	£2·60	500V. A.C.	£2·80
50mA	£2·60	S Meter 1mA	£2·85
100mA	£2·60	VU Meter	£3·70
500mA	£2·60	50mA A.C.*	£2·60
1 amp.	£2·60	100mA A.C.*	£2·60
5 amp.	£2·60	200mA A.C.*	£2·60
10 amp.	£2·60	500mA A.C.*	£2·60
15 amp.	£2·60	1 amp. A.C.*	£2·60
20 amp.	£2·60	5 amp. A.C.*	£2·60
30 amp.	£2·80	10 amp. A.C.*	£2·60
50 amp.	£2·90	20 amp. A.C.*	£2·60
5V. D.C.	£2·60	30 amp. A.C.*	£2·60

"SEW" EDUCATIONAL METERS TYPE ED.107

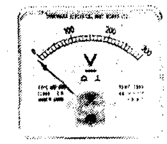


Size overall 100mm × 90mm × 108mm.

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:—

50µA	£6·90	15V D.C.	£5·95
100µA	£6·40	20V D.C.	£5·95
50–0–50µA	£6·40	50V D.C.	£5·95
1mA	£5·95	300V D.C.	£5·95
1–0–1mA	£5·95	Dual range	
1A D.C.	£5·95	500mA/5AD.C.	£7·00
5A D.C.	£5·95	1/15A D.C.	£7·00
5V D.C.	£5·95	5V/50V. D.C.	£7·00
10V D.C.	£5·95	5/15V D.C.	£7·00

TYPE MR. 38P 1 21/32in. square fronts.

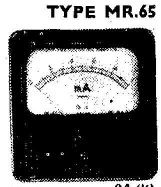


50µA	£2·55	150mA	£2·25
50–0–50µA	£2·50	200mA	£2·25
100µA	£2·45	300mA	£2·25
100–0–100µA	£2·40	500mA	£2·25
200µA	£2·25	750mA	£2·25
500µA	£2·25	1 amp.	£2·25
500–0–500µA	£2·25	2 amp.	£2·25
1mA	£2·25	5 amp.	£2·25
1–0–1mA	£2·25	10 amp.	£2·25
mA	£2·25	3V. D.C.	£2·25
5mA	£2·25	10V. D.C.	£2·25
10mA	£2·25	15V. D.C.	£2·25
20mA	£2·25	20V. D.C.	£2·25
50mA	£2·25	50V. D.C.	£2·25
100mA	£2·25	100V. D.C.	£2·25
		150V. D.C.	£2·25
		300V. D.C.	£2·25
		500V. D.C.	£2·25
		750V. D.C.	£2·25
		15V. A.C.	£2·30
		50V. D.C.	£2·30
		150V. A.C.	£2·30
		300V. A.C.	£2·30
		500V. A.C.	£2·30
		S Meter 1mA	£2·30
		VU Meter	£2·65

TYPE MR.45P 2in. square fronts.

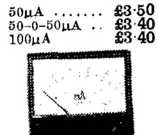
50µA	£2·70	5 amp.	£2·40
50–0–50µA	£2·65	10V. D.C.	£2·40
100µA	£2·60	20V. D.C.	£2·40
100–0–100µA	£2·50	50V. D.C.	£2·40
200µA	£2·50	300V. D.C.	£2·40
500µA	£2·45	15V. D.C.	£2·40
500–0–500µA	£2·40	300V. D.C.	£2·40
1mA	£2·40	S Meter 1mA	£2·50
5mA	£2·40	VU Meter	£2·70
10mA	£2·40	1 amp. A.C.*	£2·40
50mA	£2·40	5 amp. A.C.*	£2·40
100mA	£2·40	10 amp. A.C.*	£2·40
500mA	£2·40	20 amp. A.C.*	£2·40
1 amp.	£2·40	30 amp. A.C.*	£2·40

"SEW" BAKELITE PANEL METERS TYPE MR.65 3½in. square fronts.



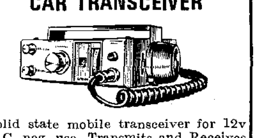
25µA	£4·60	2 amp.	£2·60
50µA	£3·55	5 amp.	£2·60
50–0–50µA	£3·05	15 amp.	£2·60
100µA	£3·00	30 amp.	£2·60
100–0–100µA	£3·00	50 amp.	£2·60
500µA	£2·70	5V. D.C.	£2·60
500–0–500µA	£2·60	10V. D.C.	£2·60
1mA	£2·60	20V. D.C.	£2·60
1–0–1m A	£2·60	50V. D.C.	£2·60
5mA	£2·60	150V. D.C.	£2·60
10mA	£2·60	300V. D.C.	£2·60
50mA	£2·60	30V. A.C.*	£2·65
100mA	£2·60	50V. A.C.*	£2·65
500mA	£2·60	150V. A.C.*	£2·65
1 amp.	£2·60	300V. A.C.*	£2·65
		500V A.C.	£2·65
		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
		50 amp. A.C.*	£2·60
		VU Meter	£3·65
		50 mV D.C.	£2·90
		100mV D.C.	£2·90

TYPE S.80 80mm Square Fronts



50µA	£3·50	100–0–100µA	£3·30
50–0–50µA	£3·40	500µA	£3·05
100µA	£3·40	1mA	£3·00
		20V. D.C.	£3·00
		50V. D.C.	£3·00
		300V. D.C.	£3·00
		1 amp. D.C.	£3·00
		5 amp. D.C.	£3·00
		300V. A.C.	£3·00
		VU Meter	£3·70

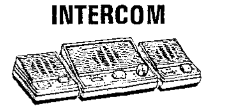
BELTEK W5400 CAR TRANSCEIVER



Solid state mobile transceiver for 12v D.C. neg. use. Transmits and Receives on any 12 of 28 channels between 144 and 146MHz. Power output 10w and 1w switchable. Controls: Volume/on/off, squelch channel selector. Internal 3" speaker. Complete with dynamic mike. PTT switch, three sets of crystals for 144·48MHz, 144·60MHz, 145·00MHz, mounting bracket and instructions.

OUR PRICE £75·00 P. & P. 50p

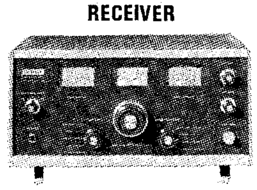
KE630 3 STATION INTERCOM



Master and two sub stations. Can be used on desk or wall mounted. Complete with cable and batteries.

OUR PRICE £5·25 P. & P. 50p

TRIO 9R59DS RECEIVER



4 bands covering 550 kc/s to 30 mc/s continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW. ANL. Variable BFO. S meter. Sep. bandspread dial. IF frequency 445 kc/s. audio output 1.5w. Variable RF and AF gain controls 115/250 v. A.C. Size: 7in. x 13in. x 10in. with instruction manual.

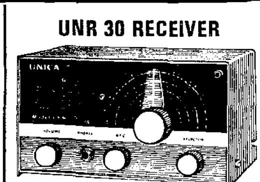
OUR PRICE £49·50 Carr. Paid.

FULL TRIO RANGE STOCKED.

ALL PRICES ARE SUBJECT TO 10% VAT

Send SAE for new 8 page list of Semi Conductors and Valves

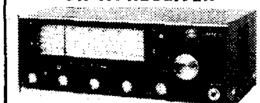
UNR 30 RECEIVER



4 Bands covering 550 kc/s-30 mc/s. B.F.O. Built-in Speaker 220/240 v. A.C. Brand new with instructions.

OUR PRICE £15·75 Carr. 37p

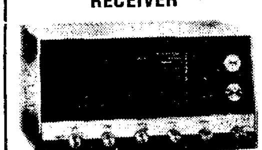
UR-1A RECEIVER



4 Bands covering 550 kc/s-30 mc/s. FET, S Meter. Variable BFO for SSB. Built-in Speaker, Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12⅛in. × 4⅝in. × 7in. Brand new with instructions.

OUR PRICE £25·00 Carr. 37p

LAFAYETTE HA-600 RECEIVER



General coverage 150-400 kc/s. 550 kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15in. × 9¼in. × 8½in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

OUR PRICE £50·00 Carr. 50p

GWS

ALSO SEE FOLLOWING PAGES

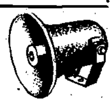
G.W.SMITH & CO (RADIO) LTD

BVD.5 VERNIER TUNING DIAL

Approx. 7-1 ratio planetary drive vernier dials. Log scale 0-180 degrees. Blank scales 1 to 5. Scale width 4½". Dial size 5" x 3". Overall size 7½" x 4⅜" x 1⅛" deep including knob and coupling. ¼" dia. shaft.

OUR PRICE £1·62 P. & P. 15p

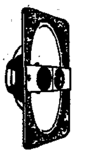
RUH.6 REFLEX HORN SPEAKER



Built in driver unit. Impedance 16 ohm. Powerrating 10 watt. Response 380-7000 Hz. Approx. size 6" x 6". Weatherproof and shock proof.

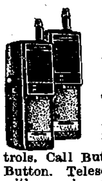
OUR PRICE £4·97 P. & P. 30p

EMI LOUDSPEAKERS



Model 350. 13in. × 8in. with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p. Model 450. 13in. × 8in. with twin tweeters/crossover. 55-13,000 Hz. 8 watts RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

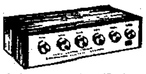
HAND HELD 2 WAY WALKIE TALKIES



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. 9½" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono mag. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE £8·97 P. & P. 20p

1021 STEREO LISTENING STATION

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6in. × 4in. × 2½in.

OUR PRICE £2·25 P. & P. 20p

EA41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet. 7¼ x 3 x 4½in.

OUR PRICE £7·50 P. & P. 15p

ALL PRICES ARE SUBJECT TO 10% V.A.T.

GWS
ALSO SEE PREVIOUS PAGES

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE £1·87 P. & P. 30p

LIGER LH02S 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 2,000 ohms (d.c. 600 ohms). Frequency response 200-4000 Hz.

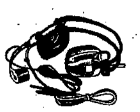
OUR PRICE £2·25 P. & P. 30p

SDH8V MONO/STEREO HEADPHONES

Two way stereo/mono with volume controls. Padded headband. 4-16 ohms. 20-18,000 Hz. Complete with lead and stereo plug.

OUR PRICE £4·97 P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE



Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.

OUR PRICE £4·95 P. & P. 30p

DH.08S Stereo Headphones

De luxe model with unique 2 way mechanical units and volume controls. 8 ohms. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE £7·97 P. & P. 30p

DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable head band. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY £2·25. Post 30p.

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

AUDIOTRONIC

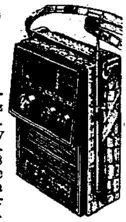
Audiotronic Products are manufactured exclusively for the Audiotronic Group of Companies and as a member of the group we are pleased to offer you this fabulous range of high quality equipment. Made to our own specifications each item provides outstanding performance and reliability at a value for money price!

SPORTSMAN AM/FM PORTABLE RADIO MODEL AR.1000

5 wavebands covering AM 535-1065KHz. FM 88-107MHz. AIR 108-135MHz. PB 147-174MHz. WB 162.5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for FM and built-in ferrite bar for AM. AFC. 3in. speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 × 79 × 219mm. Battery/mains operation.

OUR PRICE £11·50 P. & P. 35p

MULTIBAND RADIO AMB 500



5 wavebands covering MW 535-1605KHz and FM 88-175MHz. All transistor. Battery or mains operation. Built in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

OUR PRICE £6·95 P & P 35p

PORTABLE RADIO AMR-9000 GLOBAL AM/FM

10 wavebands covering: AM: 535-1605 kHz, LW: 150-380 kHz, MB 1.6-4 MHz, SW1: 4.0-8 MHz, SW2: 8.0-1.6 MHz, SW3: 16-24 MHz, PSB1: 30-50 MHz, PSB2: 148-174 MHz, FM 88-108 MHz, AIR: 108-136 MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built in aerial. AFC on FM. 6in. x 4in. speaker and personal earpiece. Battery/mains operation. Size: 345 × 133 × 305mm.

OUR PRICE £36·00 P. & P. 50p

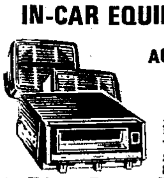
AM/FM PORTABLE RADIO AR3000

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. Thumbwheel tuning. Slider volume and tone controls. Earphone socket. Built in and telescopic aerials. Car aerial socket. Battery/Mains 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

ACR 3500 CAR RADIO

Manual tuning of Medium and Long waves. 12v. pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE £6·50 P. & P. 50p

DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16½" x 8" x 3¼". AC 200/250v.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz—20KHz±2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

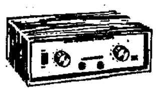
OUR PRICE £34·50 P. & P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz—20KHz± 2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

OUR PRICE £50·00 P. & P. 50p

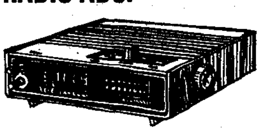
AUDIOTRONIC AHA101 STEREO HEADPHONE AMPLIFIER



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. Inputs: 5mV/100mV. Output: 50mW per channel.

OUR PRICE £7·50 P. & P. 20p

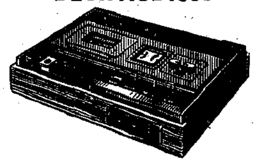
DIGITAL CLOCK RADIO ADCI



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

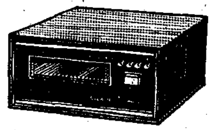
STEREO CASSETTE DECK ACD.660



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 Cr02) S/N —45dB. Crosstalk —45dB. Separation —35dB. Noise limiter —6dB at 10KHz. Complete with phono connecting leads.

OUR PRICE £39·50 P. & P. 50p

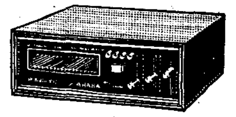
AHP-8D 8-TRACK STEREO TAPE DECK



Can be used with most hi-fi amplifiers. Push button track selector and illustrated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. AC 220/240v.

OUR PRICE £11·95 P. & P. 50p

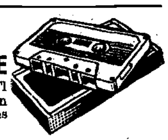
AHP-8A 8-TRACK STEREO TAPE PLAYER



Incorporates built-in amplifiers giving 2½+2½ watts rms output. Push button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. AC 220/240v.

OUR PRICE £17·25 P. & P. 50p

TAPE CASSETTE



Top Hi-Fi quality in library cases

Type	5	10	25
LOW NOISE			
C60	£1·29	£2·53	£5·99
C90	£1·85	£3·62	£8·59
C120	£2·29	£4·48	£10·63
CHROME DIOXIDE			
CR60	£3·41	£6·72	£16·63
CR90	£4·63	£9·10	£22·80

TAPE HEAD CLEANER 30p each

P. & P. 15p for 5; 10 and over post free.

8-TRACK BLANK TAPES

Type	1	5	10
40M	75p	£3·50	£6·50
80M	99p	£4·70	£8·90

P. & P. 5p.; 5 and over post free.

STEREO HEADPHONES

LSH.20 Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000 Hz. £3·50. P & P 30p.

LSH.30 Open back type. Individual tone and volume controls. 8 ohms. 30-20,000 Hz. £5·50. P. & P. 30p.

LSH.40 Two way speaker system. Individual volume controls. 8 ohms. 20-20,000 Hz. £6·95. P & P 30p.

LSH.60 3in speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. £8·50. P & P 30p.

LSH.50 Professional Quality Electrostatic. Complete with self powered energiser and control unit with headphone/speaker selector. 4-32 ohms. 20-24,000 Hz. £15.95. P&P 30p.

LQH.400 4-channel dynamic headphones. Each earpiece has 4 drive units. Two stereo jack plugs fitted to leads. 4-32 ohms. 20-20,000 Hz. £9.95. P & P 30p.

SAVE UP TO 33⅓% OR MORE! GWS

RECORD DECKS

Carriage & Packing 50p

B.S.R. McDONALD	
C114 Mini	£3·95
C129 Mono	£5·50
C137	£7·00
510/TPD1	£13·95
610	£10·55
610/TPD1	£15·45
710	£21·15
810	£26·30
710/810 Plinth and Cover	£9·15
MP60	£8·25
MP60/G800	£10·90
MP60/TPD1	£13·20
MP60/TPD2	£11·25
HT70	£11·60
HT70/G800	£14·25
HT70/TPD1	£16·55
CONNOISSEUR	
BD1 Kit	£9·10
BD1 Chassis	£11·35
BD2/SAU2/Chassis	£22·70
BD2/SAU2/Plinth/Cover	£28·20
GARRARD	
1025T Stereo	£4·95
2025	£6·35
2025 TC/KS40A	£6·95
SP25 III	£9·25
SP25 III/G800	£10·95
SP25/M75-6	£13·90
AP76	£18·00
865B	£18·50
SL65B	£11·15
SL72B	£17·75
SL95B	£31·15
401	£24·35
ZERO 100	£34·10
ZERO 100S	£31·40
ZERO 100SB	£27·00
GOLDRING	
G99	£22·50
G101P/C	£22·50
GL69/2	£15·75
GL72	£25·45
GL72/P	£33·75
GL75	£32·20
GL75P	£41·65
GL78	£34·60
GL78P/C	£56·25
GL85P/C	£72·00
THORENS	
TD125/II	£59·40
TD125AB/II	£92·05
TD160C	£50·80
TD165	£43·80

SPECIAL OFFER!
FRUSTRATED EXPORT ORDER

PHILCO FORD MODEL 5245 MAINS TAPE RECORDER

2 track BSR deck with push button controls for easy operation. Tape counter and volume control. Complete with hand microphone, direct recording lead, 1200ft. reel of tape and spare spool. 200/250v. A.C. operation. Fully guaranteed.

OUR PRICE £17·50 Carr 75p

PHILCO FORD MODEL 5248 MAINS TAPE RECORDER

4 track, 2 speeds (3¾ and 1⅞ 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

RECORD DECK PACKAGES

Carriage and Packing 75p

Complete units with Stereo cartridge ready wired in plinth and cover.

GARRARD	
2025 TC/9TAHCD	£11·35
SP25 III/G800	£16·50
SP25 III/M44E	£17·95
SP25 III/M44-7	£17·50
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	£27·20
AP76/M55E	£28·30
AP76/M75ED	£34·90
AP76/M75EJ	£30·90
AP76 Module M75-6	£29·10
865B Module/M75-6M	£32·50
AP96 Module M75-6	£33·20
ZERO 100S Module/M93E	£44·15
ZERO 100SB Module/M75-6SM	£44·20
B.S.R. McDONALD	
210/SC7M	£7·40
MP60/ADC K8	£16·50
MP60/TPD1/ADC K8	£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
Truspeed	£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
PL41D (Less cartridge)	£104·75
PL50 (Less cartridge)	£98·90
PL61 (Less cartridge)	£119·60
PLA35 (Less cartridge)	£61·55
THORENS	
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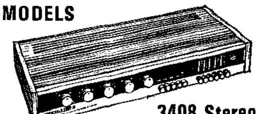
TD125 AB/11 M15E Super	£112·05
TX25 Cover	£6·15
T165/Ortofon M15E Super	£62·55
WHARFEDALE	
Linton/M44-7 Teak	£23·55
Linton/M44-7 White	£24·70

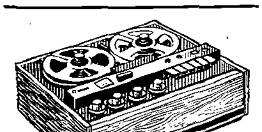
FERGUSON EXPORT MODELS



3408 Stereo Tuner Amplifier

Covers FM 88-108 MHz. Five push button tuning scales. 8+8 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

OUR PRICE £31·50 Carr. 50p



3416 Stereo Tape Deck

4 track. 7½, 3¾, 1⅞ i.p.s. Stereo/mono record/play. 7" reels. Inputs for dynamic mikes, radio, g rm. Complete with cover.

OUR PRICE £41·95 Carr. 75p

NEW FROM SINCLAIR!

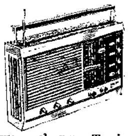
PROJECT 80 HI FI MODULES

Stereo 80 pre-Amp	£9·50
Z40 Power Amplifier	£4·30
Z60 Power Amplifier	£5·50
Active Filter Unit	£5·50
FM Tuner	£9·50
Stereo Decoder	£5·90
PZ5	£3·95
PZ6	£6·30
PZ8	£6·30
PZ8 Mains Transformer	£4·05

ALL OTHER SINCLAIR PRODUCTS IN STOCK INCLUDING

2000 Amplifier (improved)	£31·25
3000 Amplifier	£39·00
2000 FM Tuner (improved)	£31·25
4000 FM Tuner	£31·25
Q16 Speaker	£6·10
Q30 Speaker	£16·95

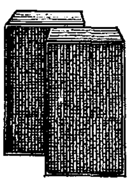
PHILIPS IC361 AM/FM MAINS/PORTABLE RADIO WITH AFC



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 × 1.5v. batteries. Size 14¼in. × 9in. × 3¾in. approx. With mains lead and istructions. Rec. List Price £69·18.

OUR PRICE £39·95 P. & P. 50p.

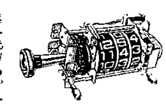
SPECIAL OFFER!
STEREOSOUND SPEAKERS



Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14½in. × 9in. × 7½in. 8 ohms. 8 watts RMS. 16 watts peak. Complete with DIN lead.

OUR PRICE £12·95 Carr. 50p

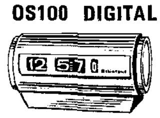
DIGITAL CLOCK MECHANISM DT.55B



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 autosetting will switch on again when required. AC 240v. operation. Switch rating 250v. 3A.

OUR PRICE £5·95 P. & P. 30p

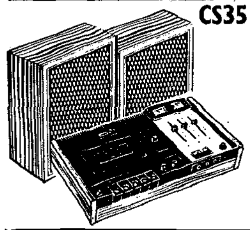
BINATONE OS100 DIGITAL CLOCK



240v mains operation. Ivory case with large clear numbers for hours, minutes and seconds Approx. size 6¼" x 3" x 3½".

OUR PRICE £4·50 P. & P. 30p

SUPER AKAI CASSETTE BARGAINS!
CS35 STEREO CASSETTE RECORDER



High quality cassette recorder with hysteresis synchronous outer-rotor motor. Has pause control with lock and selector for conventional or Chromium Dioxide tape. 4 track record/playback. Volume and tone controls. Frequency response 40-16kHz (using CrO2 tape), distortion better than 2%, wow and flutter better than 0·2% RMS. Complete with pair of matching Akai CS88 speakers. Rec. Price £96·10.

OUR PRICE £56·50 P. & P. 50p

ADM MICROPHONES

Normally £11·80 pair.

OUR PRICE £7·50 Pair. P. & P. 25p

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 (CR02) 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

MINUTEMAN MM3 POCKET CALCULATOR

Size only 4"$\frac{1}{16}$ x 3" x 1". 8 digit display with overflow and error indicators. Floating decimal. Adds, subtracts, multiplies and divides. Chain and mixed calculations. Constant factor for series multiplication or division. Complete with batteries, instructions and case.

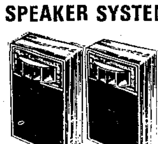
OUR PRICE £23·95 P. & P. 25p

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.

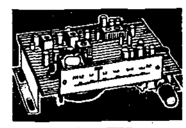
OUR PRICE £28·50 P. &P. 25p

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 348 x 228 x 110mm. G.W.S. SPECIAL PRICE £9·85 per pair. P. & P. 50p plus V.A.T.

FM TUNER CHASSIS

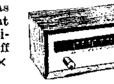


6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money.

OUR PRICE £5·95 P. & P. 20p

Stereo Multiplex Adaptor £4·97.

A1018 FM TUNER

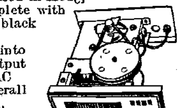


Specification as above chassis but complete in cabinet with on/off switch. Size 7½" × 3¾" × 5".

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 TD8S complete with silver and black escutcheon ready to fit into cabinet. Output 125mV. 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

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CREDIT TERMS FOR PERSONAL CALLERS (on sales of £50 and over).

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(FLITWICK) LTD.
DEPT. WW ELSTOW STORAGE DEPOT
KEMPSTON HARDWICK
BEDFORD

C.W.O PLEASE. POST AND PACKING PLEASE ADD 10p TO ORDERS UNDER £2.

Catalogue which contains data sheets for most of the components listed will be sent free on request. 10p stamp appreciated.

CALLERS WELCOME
MON.-SAT. 9 a.m.-5 p.m.

PLEASE ADD 10% V.A.T.

RESISTORS
½W Iskra high stability carbon film—very low noise—capless construction. ½W Mullard CR25 carbon film—very small body size 7·5 x 2·5 mm. ½W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
½	5%	4·7Ω–2·2MΩ	E24	1p	0·8p
½	10%	3·3MΩ–10MΩ	E12	1p	0·8p
½	2%	10Ω–1MΩ	E24	3·5p	3p
⅛	10%	1Ω–3·9Ω	E12	1p	0·8p
⅛	5%	4·7Ω–1MΩ	E12	1p	0·8p
4	10%	1Ω–10Ω	E12	6p	5·5p

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 ¼W, lin ½W).
Single, **12p.** Dual gang (stereo), **40p.** Single D.P. switch, **24p.**

SKELETON 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
1N4001	50V	1A	7p
1N4002	100V	1A	8p
1N4004	400V	1A	8p
1N4006	800V	1A	10p
1N4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
1N4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS
12in x 6in, **25p;** 12in x 2½in, **10p;** 9in x 2in, **7p**

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.

THERMISTORS

VA1055S	15p
VA1066S	15p
VA1077	15p
R53	£1·35

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, **2½p.** 0·0068μF, 0·01μF, 0·015μF, 0·022μF, 0·033μF, **3p.** 0·047μF, 0·068μF, 0·1μF, **4p.** 0·15μF, **6p.** 0·22μF, **7½p.** 0·33μF, **11p.** 0·47μF, **13p.**
160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **3p.** 0·1μF, **3½p.** 0·15μF, **4½p.** 0·22μF, **5p.** 0·33μF, **6p.** 0·47μF, **7½p.** 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, **3½p.** 0·1μF, **4p.** 0·15μF, 0·22μF, **5p.** 0·33μF, **6½p.** 0·47μF, **8½p.** 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, **2½p.** 0·04μF, 0·05μF, 0·068μF, 0·1μF, **3½p.**

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 12p

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
2½ x 3¾	22p	16p
2½ x 5	24p	24p
3¾ x 3¾	24p	24p
3¾ x 5	27p	27p
17 x 2½	75p	57½p
17 x 3¾	100p	78p
17 x 5 (plain)	—	82p
17 x 3¾ (plain)	—	60p
17 x 2½ (plain)	—	42p
2½ x 5 (plain)	—	12p
2½ x 3¾ (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 2½%
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 deoxidizing 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

	1–11 p	12–24 p	25–99 p	100+ p
7400	18	16	14	13
7401	18	16	14	13
7402	18	16	14	13
7403	18	16	14	13
7404	20	18	16	14
7405	20	18	16	14
7406	50	45	40	35
7407	56	50	44	38
7408	36	30	27	23
7409	36	30	27	33
7410	18	16	14	13
7411	23	21	20	18
7412	36	30	27	23
7413	34	28	26	22
7416	45	43	39	34
7420	18	16	14	13
7421	36	30	27	23
7426	32	29	23	20
7430	20	18	16	14
7432	40	36	32	28
7440	20	18	16	14
7441	80	75	70	65
7442	80	75	70	65
7443	125	120	115	115
7447	175	165	150	120
7448	185	175	170	165
7450	18	16	14	13
7451	18	16	14	13
7453	18	16	14	13
7454	18	16	14	13
7460	18	16	14	13
7470	30	28	25	24
7472	30	28	27	23
7473	40	38	36	30
7474	40	36	32	28
7475	55	52	50	49
7476	40	36	32	30
7480	100	95	90	85
7481	125	115	110	105
7482	100	96	90	85
7483	100	97	95	92
7484	120	115	110	105
7485	250	245	240	230
7486	45	42	37	33
7490	75	67	60	52
7491A	100	92	85	79
7492	75	70	65	60
7493	75	68	60	52
7494	95	90	85	80
7495	105	100	95	90
7496	100	95	90	85
74100	250	240	235	230
74118	100	82	73	64
74121	43	40	38	36
74141	100	95	90	85
74145	150	140	135	130
74150	330	280	250	220
74151	110	100	95	89
74153	120	110	105	95
74154	200	180	170	160
74155	150	120	100	86
74156	130	120	100	96
74180	155	136	112	105
74190	195	190	185	180
74191	195	190	185	180
74192	200	190	180	164
74193	200	180	170	150
74196	200	190	180	170
74197	200	195	180	170

LINEAR IC's

709	14 pin DIL	40p
741	8 pin DIL	40p
741	14 pin DIL	38p
723	14 pin DIL	95p
747	14 pin DIL	85p
748	8 pin DIL	45p
DIL sockets	14 pin and 16 pin	16p

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SUPPLIERS OF SEMICONDUCTORS TO THE WORLD

COMPLETE TELEPHONES

NORMAL HOUSEHOLD TYPE
AS SUPPLIED TO THE POST OFFICE
EX. G.P.O.

ONLY £1.05p
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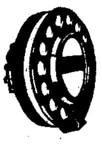

TELEPHONE DIALS

Standard Post Office type Guaranteed in working order

ONLY 27½p
P & P 16½p EACH

TESTED AND GUARANTEED PAKS

B79	4	IN4007 Sil. Rec. diodes, 1,000 PIV lamp plastic	55p
B81	10	Reed Switches 1" long ⅛" 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 uncoded 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 uncoded 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
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	1-12	13-25	26.50
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40 Watt	22p	20p	18p
90 Watt	26½p	24½p	22p
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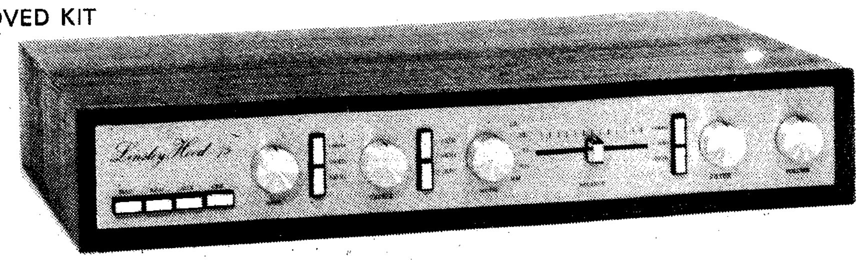

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	2 each of packs 1-7 inclusive are required for complete stereo system.	
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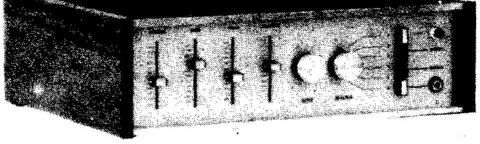

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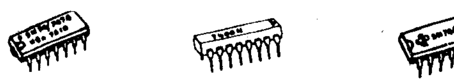

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SN7401N	0·20	0·18	0·16
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SN7403N	0·20	0·18	0·16
SN7403AN	0·38	0·38	0·33
SN7404N	0·24	0·21	0·18
SN7405N	0·20	0·18	0·16
SN7405AN	0·44	0·44	0·38
SN7406N	0·40	0·38	0·35
SN7407N	0·40	0·38	0·35
SN7408N	0·25	0·22	0·19
SN7409N	0·33	0·33	0·28
SN7409AN	0·44	0·44	0·38
SN7410N	0·20	0·18	0·16
SN7411N	0·25	0·23	0·21
SN7412N	0·28	0·28	0·25
SN7412AN	0·38	0·38	0·33
SN7413N	0·30	0·27	0·25
SN7414N	0·72	0·72	0·63
SN7416N	0·30	0·27	0·25
SN7417N	0·30	0·27	0·25
SN7420N	0·20	0·18	0·16
SN7422N	0·28	0·28	0·25
SN7422AN	0·38	0·38	0·33
SN7423N	0·37	0·34	0·32
SN7425N	0·37	0·37	0·32
SN7427N	0·37	0·37	0·32
SN7428N	0·43	0·43	0·37
SN7430N	0·20	0·18	0·16
SN7432N	0·37	0·37	0·32
SN7433N	0·43	0·43	0·38
SN7433AN	0·57	0·57	0·50
SN7437N	0·43	0·43	0·37
SN7438N	0·43	0·43	0·37
SN7438AN	0·57	0·57	0·50
SN7440N	0·20	0·18	0·16
SN7441AN	0·85	0·79	0·73
SN7442N	0·85	0·79	0·73
SN7443N	1·50	1·27	1·13
SN7444N	1·50	1·27	1·13
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SN7448N	1·50	1·27	1·13
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SN7451N	0·20	0·18	0·16
SN7453N	0·20	0·18	0·16
SN7454N	0·20	0·18	0·16
SN7460N	0·20	0·18	0·16
SN7470N	0·33	0·30	0·27
SN7472N	0·38	0·38	0·34
SN7473N	0·44	0·41	0·37
SN7474N	0·48	0·48	0·42
SN7475N	0·59	0·55	0·51
SN7476N	0·45	0·36	0·32
SN7480N	0·80	0·70	0·50
SN7481N	1·25	1·10	0·95
SN7482N	0·87	0·80	0·72
SN7483N	1·20	1·10	1·00
SN7485N	1·87	1·87	1·63
SN7486N	0·50	0·50	0·44
SN7489N	4·32	4·32	3·78
SN7490N	0·75	0·70	0·63
SN7491AN	1·10	1·00	0·90
SN7492N	0·75	0·70	0·63
SN7493N	0·75	0·70	0·63
SN7494N	0·85	0·80	0·75
SN7495N	0·85	0·80	0·75
SN7496N	1·00	0·90	0·83
SN74100N	2·16	1·89	1·89
SN74104N	0·60	0·53	0·45
SN74105N	0·60	0·53	0·45
SN74107N	0·51	0·51	0·45
SN74110N	0·57	0·57	0·50
SN74111N	0·86	0·86	0·75
SN74116N	2·16	2·16	1·89
SN74118N	1·00	0·90	0·83
SN74119N	1·92	1·92	1·68
SN74120N	1·05	1·05	0·92
SN74121N	0·57	0·57	0·50
SN74122N	0·80	0·80	0·70
SN74123N	1·44	1·44	1·26
SN74125N	0·69	0·69	0·60
SN74126N	0·69	0·69	0·60
SN74132N	0·72	0·72	0·63
SN74136N	0·63	0·63	0·55
SN74141N	1·00	0·90	0·80
SN74142N	2·88	2·88	2·52
SN74145N	1·44	1·44	1·26
SN74147N	2·30	2·30	1·83
SN74148N	2·01	2·01	1·63
SN74150N	2·30	2·30	2·01
SN74151N	1·15	1·15	1·00
SN74153N	1·09	1·09	0·95
SN74154N	2·30	2·30	2·01
SN74155N	1·15	1·15	1·00
SN74156N	1·09	1·09	1·00
SN74157N	1·09	1·09	0·95
SN74159N	2·44	2·44	2·14
SN74160N	1·58	1·58	1·38
SN74161N	1·58	1·58	1·38
SN74162N	1·58	1·58	1·38
SN74163N	1·58	1·58	1·38
SN74164N	2·01	2·01	1·76
SN74165N	2·01	2·01	1·76
SN74166N	2·16	2·16	1·89
SN74167N	4·10	4·10	3·59
SN74170N	2·88	2·88	2·52
SN74172N	5·76	5·76	5·04
SN74173N	1·66	1·66	1·45
SN74174N	1·80	1·80	1·57
SN74175N	1·29	1·29	1·13
SN74176N	1·44	1·44	1·26
SN74177N	1·44	1·44	1·26
SN74180N	1·44	1·44	1·26
SN74181N	5·18	5·18	4·53
SN74182N	1·44	1·44	1·26
SN74184N	2·16	2·16	1·89
SN74185AN	2·16	2·16	1·89
SN74188N	6·48	6·48	5·67
SN74190N	2·30	2·30	2·01
SN74191N	2·30	2·30	2·01
SN74192N	2·30	2·30	2·01
SN74193N	2·30	2·30	2·01
SN74194N	1·72	1·72	1·51
SN74195N	1·44	1·44	1·26
SN74196N	1·58	1·58	1·38
SN74197N	1·58	1·58	1·38
SN74198N	3·16	3·16	2·77
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AAZ13	10p	BC182	12p	BYZ13	35p	OC36	65p	ZTX108	10p	2N3714	1·60
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AC128	20p	BCY39	1·00	GET111	55p	OC45	18p	ZTX302	18p	2N3773	2·25
AC187	20p	BCY55	2·50	GET115	75p	OC71	15p	ZTX500	15p	2N3790	2·25
ACY17	35p	BCY70	15p	GET880	55p	OC72	25p	2G301	40p	2N3819	35p
ACY39	65p	BCY71	20p	LM309K	1·87	OC77	55p	2N697	15p	2N3866	75p
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AD161	39p	BD124	80p	MJE340	50p	OC83	25p	2N930	20p	2N4002	14p
AD162	39p	BD131	45p	MJE520	65p	OC140	65p	2N987	45p	2N4126	15p
AF117	20p	BF115	22p	MJE3055	75p	OC170	25p	2N1132	25p	2N4871	35p
AF118	50p	BF180	33p	MPF105	46p	OC200	55p	2N1304	22p	2N5457	36p
AF139	33p	BF194	13p	NKT217	45p	OC202	90p	2N1613	20p	2S001	3·00
AF186	40p	BFX13	25p	NKT404	60p	OCP71	1·00	2N1671	1·00	2S026	8·90
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ASY27	30p	BFX88	22p	OA81	10p	ORP60	45p	2N2160	69p	40250	45p
BA115	10p	BFY50	20p	OA200	8p	P346A	20p	2N2926	10p	40361	45p
BAX13	5p	BFY51	20p	OA202	10p	TIL209	25p	2N3053	20p	40362	40p
BC107	12p	BFY64	45p	OC16	85p	TIP29A	49p	2N3054	45p	40408	50p
BC108	12p	BFY90	75p	OC20	1·25	TIP30A	58p	2N3055	45p	40486	75p
BC109	12p	BLY36	6·25	OC28	65p	TIP31A	61p	2N3440	50p	40636	1·00
BC109C	14p	BSX20	15p	OC35	55p	TIP41A	74p	2N3442	1·10	40430	85p
BC113	16p	BU105	2·20			TIP42A	90p	2N3525	80p		
BC147	12p	BY100	15p			TIS43	26p	2N3614	59p		
BC169C	14p	BY127	15p			V405A	25p	2N3702	11p		

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3 AMP RANGE

Type	P.I.V.	1-11 Price Each
SC35A	100v	80p
SC35B	200v	85p
SC35D	400v	90p
SC35E	500v	£1·20

6 AMP RANGE

SC40A	100v	90p
SC40B	200v	95p
SC40D	400v	£1·20
SC40E	500v	£1·50

10 AMP RANGE

SC45A	100v	£1·05
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85

15 AMP RANGE

SC50A	100v	£1·45
SC50B	200v	£1·65
SC50D	400v	£1·95
SC50E	500v	£2·25

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Additional Types

40430	TRIAC (T066)	85p
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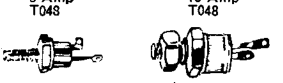

3 Amp T048 15 Amp T048

SILICON CONTROLLED RECTIFIERS

Type		1-11
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CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p
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CRS 16/100	100v	70p
CRS 16/200	200v	75p
CRS 16/400	400v	85p
CRS 16/600	600v	£1·10

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120	12 watt amplifier	4·70
125	Stereo control unit	5·70
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	5·90
275	Mic. preamplifier	6·08
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
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235	Acoustic Alarm for driver	7·60
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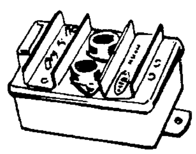

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BRIDGE RECTIFIERS

FEATURES SMALL SIZE AND LOW COST. Sizes are approximate.

250M/A QUARTER AMP

B025/05	50 PIV	16p
B025/10	100 PIV	18p

$\frac{1}{4}$ x $\frac{1}{4}$ x $\frac{1}{8}$" dia.

$\frac{1}{2}$ AMP 1-11 Pricing

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

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

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

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{16}$" dia.

1 AMP P.I.V.

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

$\frac{3}{8}$ x $\frac{3}{8}$" Tubular

2 AMPS P.I.V.

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

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{16}$" dia.

4 AMPS P.I.V.

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

$\frac{1}{2}$H x $\frac{1}{2}$L x $\frac{3}{16}$" dia.

6 AMPS P.I.V.

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

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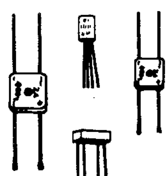

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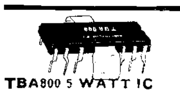
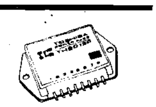


TBA800 5 WATT IC
Suitable alternative to SL403D 5/30 volt operated. 8/16 OHM 5 watt output. With circuits and data **£1·50.**



Toshiba Power and Pre-amplifier modules
TH9013P 20 watt Power amplifier 22-0-22 or single 45 volts operated. **£4·57.**
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Sinclair IC12
with circuits and data. 6 watt IC with printed circuit board. 28 volt. operated. **£1·80.**

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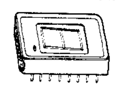
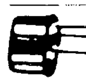


ZN414 IC
Integrated circuit radio as featured by many magazines (PW Jan. 73 Reprint Ref. No. 19 for **10p**). **£1·20.**



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

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—that's the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size $4\frac{1}{2}$" long x 2" wide x $\frac{11}{16}$" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines etc.

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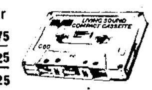
C 90	£1·33	£2·57	£4·20	£10·25
C 120	£1·62	£3·15	£5·00	£12·25



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1·5 amp PL4001 to PL4007 from **8p** ea
3 amp PL7001/IN5400 From **14p** ea
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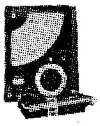
C1001 MULTIMETER



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250 ua movement, clear scale
Ranges—AC Volts 0-10, 50 250, 1000V
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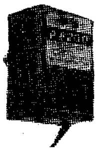
Carrying Case. Test Prods and Batteries included.
Size: 11·5×8·3×2·7 cm.
Price **£7·50.** Post 20p.

POWER UNIT Type P6200



Supplying 6 or 9 Volt DC at 200 mA
In moulded case forming a 2 pin 5 A mains plug.
2 metre output lead with 4-way multiplug giving 2·1 and 2·5 mm sockets and 3·5 mm plugs.
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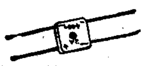
POWER UNIT Type P1076

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.
Size 7·5×5·0×14·0 cm
Price **£3·95.** Post 25p

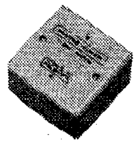
BRIDGE RECTIFIERS



ONE AMP		TWO AMP	
50 Volts	25p	50 Volts	35p
100 Volts	25p	100 Volts	40p
200 Volts	28p	200 Volts	45p
600 Volts	30p	600 Volts	50p
		1000 Volts	55p

FOUR AMP		SIX AMP	
100 Volts	55p	50 Volts	65p
200 Volts	59p	100 Volts	70p
400 Volts	65p	200 Volts	80p
600 Volts	75p	400 Volts	90p
800 Volts	£1·00	600 Volts	£1·00

ELECTRONIC MAINS TIMER

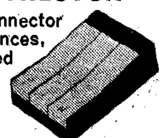


A reliable unit ideal for timing Bathroom / Toilet Ventilators, Stairway / Cloakroom Lighting etc
Gives up to 30 mins. delay before switching off.
Delay: 1-30 mins. adjustable.
Max Load: 400 VA or 1000 Watts resistive.
Ivory Case: 3⅜in.×3⅜in.×2in.
Fittings Instructions included.
Trade Price: **£5·80.** Post 20p.

DIMMER SWITCH

Type C1. 300 Watt Light Dimmer for 200/250 Volt AC operation.
Ivory Case 3⅜ in.×3⅜ in.× 1⅜ in.
Fitting Instructions included.
Price **£2·80.** Post 20p.

MAINS KEYNECTOR



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Interwinding Screen
Primary 120/240 Volts
Secondary 120/240 Volts. Centre tapped

VA (WATTS)	TYPE No.	PRICE £	POST p
60	149	2·86	38
100	150	3·15	52
200	151	5·30	52
250	152	7·05	65
350	153	9·40	80
500	154	13·55	£1·00
1000	156	22·99	£1·20
2000	158	41·25	*
3000	159	64·54	*
6000	160	105·90	*

The above are also available cased with lead and socket. *On application.

MINIATURE & EQUIPMENT

Pri. 240 Volts with Interwinding Screen.

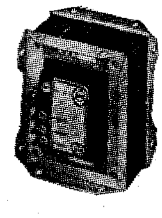
VOLTS	mA	TYPE No.	PRICE £	POST p
3-0-3	200	238	1·12	10
0-6, 0-6	500, 500	234	1·18	10
0-6, 0-6	1000, 1000	212	1·28	22
9-0-9	100	13	·95	10
0-9, 0-9	330, 330	235	1·28	10
0-8-9, 0-8-9	500, 500	207	1·70	22
0-8-9, 0-8-9	1000, 1000	208	2·30	30
15-0-15	40	240	1·28	10
0-15, 0-15	200, 200	236	1·28	10
20-0-20	30	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
0-15-27, 0-15-27	500, 500	203	2·38	38
0-15-27, 0-15-27	1000, 1000	204	2·40	38

LOW VOLTAGE

PRIMARY 200/250/Volts
SECONDARY 12 and 24 Volts.

AMPS 12V	AMPS 24V	TYPE No.	PRICE £	POST p
0·5	0·25	111	1·00	22
1	0·5	213	1·23	22
2	1	71	1·60	22
4	2	18	2·25	38
6	3	70	2·70	42
8	4	108	3·00	52
10	5	72	3·55	52
12	6	116	4·50	52
16	8	17	5·50	52
20	10	115	6·95	67
30	15	187	12·90	97
40	20	232	18·30	£1·00
60	30	226	23·70	£1·10

PLEASE ADD 10% FOR V.A.T.



30 VOLT

PRIMARY 200/240
SECONDARY 12, 15, 20, 24, 30

AMPS	TYPE No.	PRICE	POST
½	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	TYPE No.	PRICE £	POST p
½	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	8·65	67
8	118	11·27	97
10	119	14·15	97

60 VOLT

PRIMARY 200/240
SECONDARY 24, 30, 40, 48, 60

AMPS	TYPE No.	PRICE £	POST p
½	124	1·60	38
1	126	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
8	121	11·60	£1·00
10	122	15·25	£1·00
12	189	16·43	£1·10

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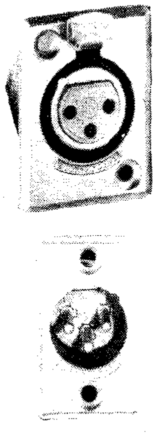

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(as in 'W.W.' July '72)

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION

Separation: 40dB 50Hz-15kHz. Distortion: 0·3%
I/P level: 560mV rms O/P level: 485mV rms per channel.
Input impedance: 50kΩ. Power requirements: 8-16V at 16mA
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB (Roller tinned), Resistors, I.C., Capacitors, Preset Potm. & Comprehensive Instructions — ONLY **£3·98** — WHY PAY MORE? post free.

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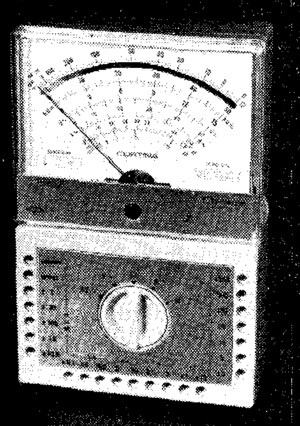

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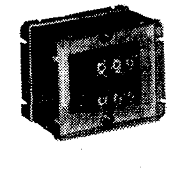
SAFETY MAINS ISOLATING TRANSFORMERS

Pri 120/240V Sec 120/240V Centre Tapped & Screened



Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P p
07	20	1	8	7·0× 7·0× 6·0	1·94	30
149	60	3	12	9·9× 7·7× 8·6	2·88	36
150	100	5	8	9·9× 8·9× 8·6	3·16	52
151	200	8	0	12·1× 9·3×10·2	5·31	52
152	250	13	12	12·1×11·8×10·2	7·01	67
153	350	15	0	14·0×10·8×11·8	9·40	82
154	500	19	8	14·0×13·4×11·8	13·55	*
155	750	29	0	17·2×14·0×14·0	19·26	*
156	1000	38	0	17·2×16·6×14·0	24·97	*
158	2000	60	0	21·6×15·3×18·1	41·25	*
159	3000	85	0	23·5×17·8×19·7	64·53	*
160	6000	78	0	35·0×20·4×29·3	105·89	*

AUTO TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P p
113	20	1	0	5·8× 5·1× 4·5	0-115-210-240	1·02	22
64	75	2	4	7·0× 6·7 ×6·1	0-115-210-240	2·00	36
4	150	3	4	8·9× 7·7× 7·7	0-115-200-220-240	2·42	36
66	300	6	4	9·9× 9·6× 8·6	,, ,,	4·70	52
67	500	12	8	12·1×11·2×10·2	,, ,,	6·98	67
84	1000	19	8	14·0×13·4×14·3	,, ,,	12·69	82
93	1500	30	4	14·0×15·9×14·3	,, ,,	18·39	*
95	2000	32	0	17·2×16·6×14·0	,, ,,	24·00	*
73	3000	40	0	21·6×13·4×18·1	,, ,,	32·67	*

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115V 500VA cased transformer, with mains lead and two 115V outlet sockets, **£9·49.** P & P 67p. A 20 Watt version. **£2·02.** P & P 22p.

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PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		8	4·8× 2·9× 3·5	0-12V at 0·25A×2	1·02	22
213	1·0	0·5	1	4	6·1× 5·8× 4·8	0-12V at 0·5A×2	1·22	22
71	2	1	1	12	7·0× 6·4× 6·1	0-12V at 1A×2	1·60	22
18	4	2	2	12	8·3× 7·7× 7·0	0·12V at 2A×2	2·24	36
70	6	3	3	8	8·9× 8·0× 7·7	0-12V at 3A×2	2·70	42
108	8	4	5	8	9·9× 8·9× 8·6	0-12V at 4A×2	3·00	52
72	10	5	6	4	9·9× 9·6× 8·6	0-12V at 5A×2	3·55	52
116	12	6	6	12	9·9×10·2×8·6	0-12V at 5A×2	4·30	52
17	16	8	8	12	12·1× 9·9×10·2	0-12V at 8A×2	5·48	52
115	20	10	18	8	14·0× 9·6×11·8	0-12V at 10A×2	6·89	67
187	30	15	15	8	14·0×12·1×11·8	0-12V at 15A×2	12·90	82
226	60	30	32	0	17·2×15·3×14·0	0-12V at 30A×2	23·72	*

30 VOLT RANGE

Ref No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	6·1× 5·8× 4·8	0-12-15-20-24-30V	1·22	22
79	1·0	2	4	7·0× 6·7× 6·1	,, ,,	1·62	36
3	2·0	3	4	8·9× 7·7× 7·7	,, ,,	2·43	36
20	3·0	4	8	9·9× 8·3× 8·6	,, ,,	2·99	42
21	4·0	6	4	9·9× 9·6× 8·6	,, ,,	3·55	52
51	5·0	6	12	12·1× 8·6×10·2	,, ,,	4·42	52
117	6·0	8	0	12·1× 9·3×10·2	,, ,,	5·28	52
88	8·0	12	0	12·1×11·8×10·2	,, ,,	6·82	67
89	10·0	13	12	14·0×10·2×11·8	,, ,,	8·36	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	12	7·0× 6·4× 6·1	0-19-25-33-40-50V	1·60	30
103	1·0	2	12	8·3× 7·4× 7·0	,, ,,	2·34	36
104	2·0	5	8	9·9× 8·9× 8·6	,, ,,	3·25	42
105	3·0	6	12	9·9×10·2× 8·6	,, ,,	4·41	52
106	4·0	10	0	12·1×10·5×10·2	,, ,,	5·84	52
107	6·0	12	0	14·0×10·2×11·8	,, ,,	8·63	67
118	8·0	18	0	14·0×12·7×11·8	,, ,,	11·27	97
119	10·0	25	0	17·2×12·7×14·0	,, ,,	14·13	*

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
124	0·5	2	4	7·0× 6·7× 6·1	0-24-30-40-48-60V	1·62	36
126	1·0	3	4	8·9× 7·7× 7·7	,, ,,	2·26	36
127	2·0	6	4	9·9× 9·6× 8·6	,, ,,	3·55	42
125	3·0	8	12	12·1× 9·9×10·2	,, ,,	5·41	52
123	4·0	13	12	12·1×11·8×10·2	,, ,,	6·98	67
40	5·0	12	00	14·0×10·2×11·8	,, ,,	8·22	67
120	6·0	15	8	14·0×12·1×11·8	,, ,,	10·12	82
121	8·0	25	00	14·0×14·7×11·8	,, ,,	11·40	*
122	10·0	25	0	17·2×12·7×14·0	,, ,,	16·75	*
189	12·0	29	00	17·2×14·0×14·0	,, ,,	18·75	*

MINIATURE TRANSFORMERS WITH SCREENS

Ref. No.	MA	Weight lb	oz	Size cm.	VOLTS	£	P & P p
238	200		2	2·8×2·6×2·0	3-0-3	1·10	10
212	1A 1A	1	4	6·1×5·8×4·8	0-6 0-6	1·27	22
13	100		4	3·9×2·6×2·9	9-0-9	64	10
235	330, 330		4	4·8×2·9×3·5	0-9, 0-9	1·27	10
207	500, 500	1	00	6·1×5·4×4·8	0-8-9, 0-8-9	1·70	22
208	1A, 1A	1	12	7·0×6·4×6·1	0-8-9, 0-8-9	2·28	30
236	200, 200		4	4·8×2·9×3·5	0-15, 0-15	1·27	10
214	300, 300	1	4	6·1×5·8×4·8	0-20, 0-20	1·34	22
221	700 (D.C.)	1	8	7·0×6·1×6·1	20-12-0-12-20	1·20	30
206	1A, 1A	2	12	8·3×7·7×7·0	0-15-20, 0-15-20	3·08	38
203	500, 500	2	4	8·3×7·0×7·0	0-15-27, 0-15-27	2·36	38
204	1A, 1A	3	4	8·9×7·7×7·7	0-15-27, 0-15-27	2·39	38

BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT (Secondary 2V, 6V, 12V)

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P p
45	1·5	1	8	7·0× 6·1× 6·1	Please note, these units do not include rectifiers	1·61	30
5	4·0	3	4	8·9× 7·7× 7·7		2·45	42
86	6·0	6	4	9·9× 9·6× 8·6		3·70	52
146	8·0	6	12	9·9×10·2× 8·6		4·22	52
50	12·5	12	0	14·0×10·2×11·8		6·29	67

***Carriage via B.R.S.**

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Type	Price
AC107	0·22
AC113	0·20
AC115	0·22
AC117K	0·32
AC122	0·13
AC125	0·19
AC126	0·19
AC127	0·20
AC128	0·20
AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·20
AC141K	0·32
AC142	0·20
AC142K	0·28
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·22
AC180K	0·32
AC181	0·22
AC181K	0·32
AC187	0·24
AC187K	0·25
AC188	0·24
AC188K	0·25
ACY17	0·28
ACY18	0·22
ACY19	0·22
ACY20	0·22
ACY21	0·22
ACY22	0·18
ACY27	0·20
ACY28	0·21
ACY29	0·39
ACY30	0·31
ACY31	0·31
ACY34	0·28
ACY35	0·23
ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·53
AD142	0·53
AD143	0·42
AD149	0·55
AD161	0·37
AD162	0·37

Type	Price
AD161 & AD162 (MP)	0·61
ADT140	0·55
AF114	0·27
AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·33
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·55
AF179	0·55
AF180	0·55
AF181	0·55
AF186	0·55
AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
ASY27	0·33
ASY28	0·28
ASY29	0·28
ASY50	0·28
ASY51	0·28
ASY52	0·28
ASY54	0·28
ASY55	0·28
ASY56	0·28
ASY57	0·28
ASY58	0·28
ASY73	0·28
ASZ21	0·44
BC107	0·10
BC108	0·10
BC109	0·11
BC113	0·11
BC114	0·17
BC115	0·17
BC116	0·17
BC117	0·20
BC118	0·11
BC119	0·33
BC120	0·88
BC125	0·13
BC126	0·20
BC132	0·13
BC134	0·20
BC135	0·13
BC136	0·17
BC137	0·17
BC139	0·44
BC140	0·33
BC141	0·33
BC142	0·33
BC143	0·33
BC145	0·50
BC147	0·11
BC148	0·11
BC149	0·13

Type	Price
BC150	0·20
BC151	0·22
BC152	0·19
BC153	0·31
BC154	0·33
BC157	0·20
BC158	0·13
BC159	0·13
BC160	0·50
BC161	0·55
BC167	0·13
BC168	0·13
BC169	0·13
BC170	0·13
BC171	0·16
BC172	0·16
BC173	0·16
BC174	0·16
BC175	0·24
BC177	0·21
BC178	0·21
BC179	0·21
BC180	0·27
BC181	0·27
BC182	0·11
BC182L	0·11
BC183	0·11
BC183L	0·11
BC184	0·13
BC184L	0·13
BC186	0·31
BC187	0·31
BC207	0·12
BC208	0·12
BC209	0·13
BC212L	0·12
BC213L	0·12
BC214L	0·16
BC225	0·28
BC226	0·39
BC301	0·30
BC302	0·27
BC303	0·35
BC304	0·40
BC440	0·34
BC460	0·40
BCY30	0·27
BCY30	0·27
BCY31	0·29
BCY32	0·33
BCY33	0·24
BCY34	0·28
BCY70	0·16
BCY71	0·20
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCZ12	0·28
BD115	0·68
BD116	0·88
BD121	0·66
BD123	0·72
BD124	0·76

Type	Price
BD131	0·55
BD132	0·66
BD133	0·72
BD135	0·44
BD136	0·44
BD137	0·50
BD138	0·55
BD139	0·61
BD140	0·66
BD155	0·88
BD175	0·66
BD176	0·66
BD177	0·72
BD178	0·72
BD179	0·77
BD180	0·77
BD185	0·72
BD186	0·72
BD187	0·77
BD188	0·77
BD189	0·83
BD190	0·83
BD195	0·94
BD196	0·94
BD197	0·99
BD198	0·99
BD199	1·05
BD200	1·05
BD205	0·88
BD206	0·88
BD207	1·05
BD208	1·05
BDY20	1·10
BF115	0·27
BF117	0·50
BF118	0·77
BF119	0·77
BF121	0·50
BF123	0·55
BF125	0·50
BF127	0·55
BF152	0·61
BF153	0·50
BF154	0·50
BF155	0·77
BF156	0·53
BF157	0·61
BF158	0·61
BF159	0·66
BF160	0·44
BF162	0·44
BF163	0·44
BF164	0·44
BF165	0·44
BF167	0·24
BF173	0·24
BF176	0·34
BF177	0·39
BF178	0·33
BF179	0·33
BF180	0·33
BF181	0·33
BF182	0·44

Type	Price
BF183	0·44
BF184	0·28
BF185	0·33
BF187	0·30
BF188	0·44
BF194	0·13
BF195	0·13
BF196	0·16
BF197	0·16
BF200	0·50
BF222	1·05
BF257	0·50
BF258	0·66
BF259	0·94
BF262	0·61
BF263	0·61
BF270	0·39
BF271	0·33
BF272	0·88
BF273	0·39
BF274	0·39
BFW10	0·66
BFX29	0·30
BFX84	0·24
BFX85	0·33
BFX86	0·24
BFX87	0·27
BFX88	0·24
BFY50	0·22
BFY51	0·22
BFY52	0·22
BFY53	0·19
BPX25	0·94
BSX19	0·17
BSX20	0·17
BSY25	0·17
BSY26	0·17
BSY27	0·17
BSY28	0·17
BSY29	0·17
BSY38	0·20
BSY39	0·20
BSY40	0·31
BSY41	0·31
BSY95	0·14
BSY95A	0·14
Bu105	2·20
C111E	0·55
C400	0·33
C407	0·28
C424	0·28
C425	0·55
C426	0·39
C428	0·22
C441	0·33
C442	0·33
C444	0·39
C450	0·24
MAT100	0·21
MAT101	0·22
MAT120	0·21
MAT121	0·22
MJE2955	0·95

Type	Price
MJE3055	0·62
MJE3440	0·55
MPF102	0·46
MPF104	0·41
MPF105	0·41
OC19	0·39
OC20	0·70
OC22	0·52
OC23	0·54
OC24	0·62
OC25	0·42
OC26	0·32
OC28	0·55
OC29	0·55
OC35	0·46
OC36	0·55
OC41	0·22
OC42	0·27
OC44	0·17
OC45	0·14
OC70	0·11
OC71	0·11
OC72	0·16
OC74	0·16
OC75	0·17
OC76	0·17
OC77	0·28
OC81	0·17
OC81D	0·17
OC82	0·17
OC82D	0·17
OC83	0·22
OC139	0·22
OC140	0·22
OC169	0·28
OC170	0·28
OC171	0·28
OC200	0·28
OC201	0·31
OC202	0·31
OC203	0·28
OC204	0·28
OC205	0·39
OC309	0·44
OCP71	0·48
ORP12	0·48
ORP60	0·44
ORP61	0·44
P20	0·55
P21	0·50
P346A	0·22
P397	0·46
ST140	0·14
ST141	0·19
TIS43	0·33
UT46	0·30
ZN414	£1·20
2G301	0·21
2G302	0·21
2G303	0·21
2G304	0·27
2G306	0·44
2G308	0·39

Type	Price
2G309	0·39
2G339	0·22
2G339A	0·18
2G344	0·20
2G345	0·18
2G371	0·18
2G371B	0·13
2G373	0·19
2G374	0·19
2G377	0·33
2G378	0·18
2G381	0·18
2G382	0·18
2G401	0·33
2G414	0·33
2G417	0·28
2N388	0·39
2N388A	0·61
2N404	0·22
2N404A	0·31
2N524	0·46
2N527	0·54
2N598	0·46
2N599	0·50
2N696	0·14
2N697	0·15
2N698	0·27
2N699	0·39
2N706	0·09
2N706A	0·10
2N708	0·13
2N711	0·33
2N717	0·39
2N718	0·27
2N718A	0·55
2N726	0·31
2N727	0·31
2N743	0·22
2N744	0·22
2N914	0·16
2N918	0·33
2N929	0·23
2N930	0·23
2N1131	0·22
2N1132	0·24
2N1302	0·16
2N1303	0·16
2N1304	0·19
2N1305	0·19
2N1306	0·23
2N1307	0·23
2N1308	0·26
2N1309	0·26
2N1613	0·22
2N1711	0·22
2N1889	0·35
2N1890	0·50
2N1893	0·41
2N2147	0·79
2N2148	0·63
2N2160	0·66
2N2192	0·39
2N2193	0·39

Type	Price
2N2194	0·39
2N2217	0·24
2N2218	0·22
2N2219	0·22
2N2220	0·24
2N2221	0·22
2N2222	0·22
2N2368	0·19
2N2369	0·16
2N2369A	0·16
2N2411	0·27
2N2412	0·27
2N2646	0·52
2N2711	0·23
2N2712	0·23
2N2714	0·23
2N2904	0·19
2N2904A	0·23
2N2905	0·23
2N2905A	0·23
2N2906	0·17
2N2906A	0·20
2N2907	0·22
2N2907A	0·24
2N2923	0·16
2N2924	0·16
2N2925	0·16
2N2926(G)	0·14
2N2926(Y)	0·12
2N2926(O)	0·11
2N2926(R)	0·11
2N2926(B)	0·11
2N3010	0·77
2N3011	0·16

Type	Price
2N3053	0·19
2N3054	0·51
2N3055	0·55
2N3391	0·16
2N3391A	0·18
2N3392	0·16
2N3393	0·16
2N3394	0·16
2N3395	0·19
2N3402	0·23
2N3403	0·23
2N3404	0·31
2N3405	0·46
2N3414	0·17
2N3415	0·17
2N3416	0·31
2N3417	0·31
2N3525	0·83
2N3614	0·74
2N3615	0·82
2N3616	0·82
2N3646	0·10
2N3702	0·13
2N3703	0·13
2N3704	0·14
2N3705	0·13
2N3706	0·13
2N3707	0·14
2N3708	0·09
2N3709	0·10
2N3710	0·10
2N3711	0·10
2N3819	0·31
2N3820	0·55
2N3821	0·39
2N3823	0·31
2N3903	0·31
2N3904	0·33
2N3905	0·31
2N3906	0·30

Type	Price
2N4058	0·13
2N4059	0·11
2N4060	0·13
2N4061	0·13
2N4062	0·13
2N4284	0·19
2N4285	0·19
2N4286	0·19
2N4287	0·19
2N4288	0·19
2N4289	0·19
2N4290	0·19
2N4291	0·19
2N4292	0·19
2N4293	0·19
2N5172	0·13
2N5294	0·60
2N5457	0·35
2N5458	0·35
2N5459	0·44
2N6121	0·75
2S301	0·55
2S302A	0·46
2S302	0·46
2S303	0·61
2S304	0·77
2S305	0·86
2S306	0·86
2S307	0·86
2S321	0·62
2S322	0·46
2S322A	0·46
2S323	0·62
2S324	0·77
2S325	0·77
2S326	0·77
2S327	0·77
2S701	0·46
40361	0·44
40362	0·50

DIODES

Type	Price	Type	Price	Type	Price
AA119	0·09	BY130	0·18	OA10	0·15
AA120	0·09	BY133	0·23	OA47	0·08
AA129	0·09	BY164	0·55	OA70	0·08
AAY30	0·10	BYX38/30	0·46	OA79	0·08
AAZ13	0·11	BYZ10	0·39	OA81	0·08
BA100	0·11	BYZ11	0·33	OA85	0·10
BA116	0·23	BYZ12	0·33	OA90	0·07
BA126	0·24	BYZ13	0·28	OA91	0·07
BA148	0·16	BYZ16	0·44	OA95	0·08
BA154	0·13	BYZ17	0·39	OA200	0·07
BA155	0·16	BYZ18	0·39	OA202	0·08
BA156	0·15	BYZ19	0·31	SD10	0·06
BA173	0·16	CG62 (OA91 Eq.)	0·06	SD19	0·06
BY100	0·17	CG651 (OA70-OA79)	0·07	1N34	0·8
BY101	0·13	OA5	0·39	1N34A	0·08
BY105	0·19	OA58L	0·23	1N914	0·06
BY114	0·13			1N916	0·06
BY124	0·13			1N4148	0·06
BY126	0·16			1S021	0·11
BY127	0·17			1S951	0·07
BY128	0·17				

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mV (DO-7 Case) **12p** ea. 1½W (Top-Hat) **18p** ea. 10W (SO-10 Stud) **32p** ea. All fully tested 5% tol. and marked. State voltage required.

10 amp POTTED BRIDGE RECTIFIER on heat sink. 100PIV. 99p each

NEW LINE
Plastic Encapsulated 2 Amp. BRIDGE RECTS.

50v RMS	35p	each
100v RMS	40p	,,
200v RMS	45p	,,
400v RMS	50p	,,

Size 15 mm × 6 mm.

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UT46. Eqvt. 2N2646. Eqvt. TIS43. BEN3000 **30p** each, 25-99 **28p** 100 UP 22p.

CADMIUM CELLS
ORP12 **48p**
ORP60, ORP61 **44p** each

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY-27/28/95A. A.I.I usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

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50	For	1·10
100	For	1·92
500	For	8·25
1000	For	14·30

SIL. G.P. DIODES £p
300mW 30..0·55
40PIV(Min.) 100..1·65
Sub-Min. 500..5·50
Full Tested 1,000..9·90
Ideal for Organ Builders.

KING OF THE PAKS Unequalled Value and Quality

SUPER PAKS NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		Description	Price
U 1	120	Glass Sub-Min. General Purpose Germanium Diodes	0·55
U 2	60	Mixed Germanium Transistors AF/RF	0·55
U 3	75	Germanium Gold Bonded Sub-Min. like OA5, OA47	0·55
U 4	40	Germanium Transistors like OC81, AC128	0·55
U 5	60	200mA Sub-Min. Silicon Diodes	0·55
U 6	30	Sil. Planar Trans. NPN like BSY95A. 2N706	0·55
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·55
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·55
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·55
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·55
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·55
U13	30	PNP-NPN Sil. Transistors OC200 & 2S 104	0·55
U14	150	Mixed Silicon and Germanium Diodes	0·55
U15	25	NPN Sil. Planar Trans. TO-5 like BFY51, 2N697	0·55
U16	10	3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·55
U17	30	Germanium PNP AF Transistors TO-5 like ACY 17-22	0·55
U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·55
U19	25	Silicon NPN Transistors like BC108	0·55
U20	12	1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV	0·55
U21	30	AF. Germanium Alloy Transistors 2G300 Series & OC71.	0·55
U23	30	MADT's like MHz Series PNP Transistors	0·55
U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·55
U25	25	300 MHz NPN Silicon Transistors 2N708, BSY27	0·55
U26	30	Fast Switching Silicon Diodes like 1N914 Micro-Min.	0·55
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·55
U29	10	1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600	1.10
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·55
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·55
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·55
U33	15	Plastic Case 1 Amp Silicon Rectifiers IN4000 Series	0·55
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	0·55
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·55
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·55
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 2S322	0·55
U38	20	Fast Switching Silicon Trans. NPN MHz 2N3011	0·55
U39	30	RF. Germ. PNP Transistors 2N1303/5 TO-5	0·55
U40	10	Dual Transistors 6 lead TO-5 2N2060	0·55
U41	25	RF Germanium Transistors TO-5, OC45, NKT72	0·55
U42	10	VHF Germanium PNP Transistor TO-1 NKT667, AF117	0·55
U43	25	Sil. Trans. Plastic TO-18 A.F. BC113/114	0·55
U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·55
U45	7	3A SCR. TO66 up to 600PIV	1·10

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

QUALITY TESTED SEMICONDUCTORS

Pak No.			Price £p
Q1	20	Red spot transistors PNP	0·55
Q2	16	White spot R.F. transistors PNP	0·55
Q3	4	OC 77 type transistors	0·55
Q4	6	Matched transistors OC44/45/81/81D	0·55
Q5	4	OC 75 transistors	0·55
Q6	5	OC 72 transistors	0·55
Q7	4	AC 128 transistors PNP high gain	0·55
Q8	4	AC 126 transistors PNP	0·55
Q9	7	OC 81 type transistors	0·55
Q10	7	OC 71 type transistors	0·55
Q11	2	AC 127/128 Complementary pairs PNP/NPN	0·55
Q12	3	AF 116 type transistors	0·55
Q13	3	AF 117 type transistors	0·55
Q14	3	OC 171 H.F. type transistors	0·55
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·55
Q16	2	GET880 low noise Germanium transistors	0·55
Q17	5	NPN 2 × ST.141 & 3 × ST.140	0·55
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·55
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·55
Q20	4	OC 44 Germanium transistors A.F.	0·55
Q21	4	AC 127 NPN Germanium transistors	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
Q23	10	OA 202 Silicon diodes sub-min.	0·55
Q24	8	OA 81 diodes	0·55
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·55
Q26	8	OA95 Germanium diodes sub-min. IN69	0·55
Q27	2	10A 600 PIV Silicon rectifiers IS425R	0·55
Q28	2	Silicon power rectifiers BYZ 13	0·55
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·55
Q30	7	Silicon switch transistors 2N706 NPN	0·55
Q31	6	Silicon switch transistors 2N708 NPN	0·55
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·55
Q33	3	Silicon NPN transistors 2N1711	0·55
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·55
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·55
Q37	3	2N3053 NPN Silicon transistors	0·55
Q38	7	PNP transistors 4 × 2N3703, 3 × 2N3702	0·55
Q39	7	NPN transistors 4 × 2N3704, 3 × 2N3705	0·55
Q40	7	NPN transistors 4 × 2N3707, 3 × 2N3708	0·55
Q41	3	Plastic NPN TO-18 2N3904	0·55
Q42	6	NPN transistors 2N5172	0·55
Q43	7	BC 107 NPN transistors	0·55
Q44	7	NPN transistors 4 × BC 108, 3 × BC 109	0·55
Q45	3	BC 113 NPN TO-18 transistors	0·55
Q46	3	BC 115 NPN TO-5 transistors	0·55
Q47	6	NPN high gain transistors 3 × BC167, 3 × BC168	0·55
Q48	4	BCY 70 PNP transistors TO-18	0·55
Q49	4	NPN transistors 2 × BFY51, 2 × BFY52	0·55
Q50	7	BSY 28 NPN switch transistors TO-18	0·55
Q51	7	BSY 95A NPN transistors 300MHz	0·55
Q52	8	BY100 type silicon rectifiers	1·10
Q53	25	Sil. & Germ. trans. mixed all marked new	1·65

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50	0·22	0·27	0·39	0·39	0·52	0·55	0·58	1·27
100	0·27	0·27	0·52	0·52	0·55	0·63	0·62	1·54
200	0·27	0·32	0·54	0·54	0·62	0·67	0·67	1·76
400	0·32	0·42	0·59	0·62	0·67	0·83	0·77	1·93
600	0·42	0·52	0·75	0·75	0·84	1·07	0·97	—
800	0·63	0·70	0·88	0·88	0·99	1·32	1·50	4·40

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PIV	300mA (DO 7)	750mA (SO 16)	1 Amp Plastic		1·5 Amp (SO 16)	3 Amp (SO 1;)	10 Amp (SO 10)	30 Apr.: (TO 48)
50	0·05	0·06	1N4001	0·05	0·08	0·15	0·21	0·60
100	0·05	0·07	1N4002	0·06	0·10	0·17	0·23	0·75
200	0·06	0·10	1N4003	0·07	0·12	0·22	0·25	£1·00
400	0·08	0·15	1N4004	0·08	0·15	0·30	0·38	£1·35
600	0·09	0·17	1N4005	0·10	0·18	0·36	0·45	£1·90
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T5	8	2G382T	OC82
T6	8	2G344B	OC44
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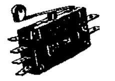

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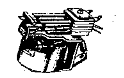

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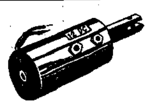

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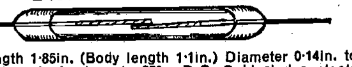

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2N456A	0·75
2N457A	0·80
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2N696	0.15
2N697	0·15
2N698	0·25
2N699	0·29
2N706	0·10
2N706A	0·12
2N708	0·13
2N709	0·40
2N711	0·30
2N718	0·21
2N718A	0·30
2N720	0·50
2N721	0·55
2N914	0·15
2N916	0·17
2N918	0·30
2N929	0·14
2N930	0·14
2N1090	0·23
2N1091	0·24
2N1131	0·20
2N1132	0·20
2N1302	0·16
2N1303	0·16
2N1304	0·20
2N1305	0·20
2N1306	0·22
2N1307	0·22
2N1308	0·25
2N1309	0·37
2N1483	0·90
2N1507	0·24
2N1613	0·20
2N1631	0·35
2N1637	0·36
2N1638	0·32
2N1701	1·10
2N1702	2·15
2N1711	0·22
2N1893	0·34
2N2102	0·30
2N2147	0·70
2N2148	0·94
2N2192	0·40
2N2192A	0·40
2N2193	0·40
2N2193A	0·61
2N2194	0·27
2N2194A	0·30
2N2195	0·13
2N2195A	0·18
2N2218A	0·30
2N2219	0·37
2N2219A	0·51
2N2220	0·20
2N2221	0·20
2N2221A	0·33
2N2222	0·31
2N2222A	0·41
2N2368	0·11
2N2369	0·15
2N2369A	0·17
2N2646	0·70
2N2647	1·20
2N2711	0·12
2N2712	0·12
2N2713	0·17
2N2714	0·17
2N2904	0·28
2N2904A	0·25
2N2905	0·71
2N2905A	0·88
2N2906	0·24
2N2906A	0·30
2N2907	0·32
2N2907A	0·33
2N2923	0·12
2N2924	0·12
2N2925	0·15
2N2926	
Green	0·12
Yellow	0·10
Orange	0·10
2N3053	0·31
2N3054	0·60
2N3055	0·75
2N3390	0·20
2N3391	0·20
2N3391A	0·22
2N3392	0·13
2N3393	0·12
2N3394	0·17
2N3402	0·12
2N3403	0·19
2N3404	0·24
2N3405	0·27
2N3414	0·10
2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3570	1·25
2N3571	1·12
2N3572	0·97
2N3702	0·11
2N3703	0·10
2N3704	0·14
2N3705	0·10
2N3706	0·09
2N3707	0·10
2N3708	0·70

2N3709	0·09
2N3710	0·12
2N3711	0·09
2N3712	0·05
2N3713	1·95
2N3714	2·29
2N3715	2·16
2N3716	3·00
2N3773	3·96
2N3779	3·15
2N3790	4·21
2N3791	4·20
2N3792	5·04
2N3794	0·10
2N3819	0·32
2N3820	0·47
2N3823	1·42
2N3824	1·33
2N3826	0·23
2N3854	0·16
2N3854A	0·16
2N3855	0·16
2N3855A	0·16
2N3856	0·16
2N3856A	0·16
2N3858	0·16
2N3858A	0·16
2N3859	0·16
2N3859A	0·16
2N3860	0·16
2N3866	1·69
2N3877	0·25
2N3877A	0·26
2N3900	0·20
2N3900A	0·21
2N3901	0·32
2N3903	0·24
2N3904	0·27
2N3905	0·24
2N3906	0·27
2N4036	0·46
2N4037	0·40
2N4058	0·16
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2N4060	0·11
2N4061	0·11
2N4062	0·11
2N4302	0·25
2N4303	0·47
2N4916	0·20
2N4917	0·17
2N4918	0·50
2N4919	0·63
2N4920	0·71
2N4921	0·50
2N4922	0·55
2N4923	0·60
2N5172	0·12
2N5174	0·22
2N5175	0·26
2N5176	0·32
2N5190	0·92
2N5191	0·96
2N5192	1·24
2N5193	1·01
2N5194	1·10
2N5195	1·46
2N5245	0·35
2N5457	0·35
2N5458	0·35
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3N128	0·73
3N138	1·65
3N139	1·42
3N140	0·92
3N141	0·81
3N142	0·58
3N143	0·75
3N152	0·92
3N153	0·81
3N154	0·84
3N159	1·17
3N187	1·55
3N200	2·49
3N201	1·05
40050	0·78
40251	0·81
40309	0·30
40310	0·50
40313	0·92
40316	0·50
40318	0·92
40360	0·46
40361	0·43
40362	0·45
40363	0·88
40389	0·46
40394	0·56
40395	0·65
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·53
40411	2·00
40414	3·55
40467	0·69
40468A	0·44
40600	0·69
40601	0·67
40602	0·46
40603	0·58
40604	0·56
40636	1·10
40673	0·70
AC107	0·35
AC113	0·16
AC115	0·16
AC117	0·20
AC121	0·13
AC126	0·25
AC127	0·20
AC128	0·20
AC141K	0·30

AC142K	0·25
AC151V	0·14
AC152V	0·17
AC153	0·22
AC153K	0·25
AC154	0·20
AC176	0·18
AC176K	0·20
AC187K	0·20
AC188K	0·26
ACY17	0·35
ACY18	0·24
ACY19	0·27
ACY20	0·22
ACY21	0·26
ACY22	0·16
ACY28	0·20
ACY30	0·42
ACY39	0·65
ACY40	0·17
ACY41	0·17
ACY44	0·31
AD136V	0·96
AD142	0·54
AD143	0·45
AD149V	0·66
AD150	0·63
AD161	0·45
AD162	0·45
AD161 }	Pr.
AD162 }	1·05
AF109R	0·40
AF114	0·25
AF115	0·24
AF116	0·25
AF117	0·20
AF118	0·50
AF121	0·22
AF124	0·24
AF125	0·20
AF126	0·19
AF127	0·20
AF139	0·38
AF170	0·25
AF172	0·25
AF178	0·55
AF179	0·65
AF180	0·50
AF186	0·40
AF200	0·35
AF211	0·55
AF239	0·41
AF240	0·72
AF279	0·54
AF280	0·54
AFY42	0·74
AL102	0·75
AL103	0·70
ASY26	0·30
ASY27	0·36
ASY28	0·28
ASY29	0·36
ASY50	0·20
ASY55	0·35
BC107	0·15
BC108	0·15
BC109	0·19
BC113	0·13
BC114	0·12
BC115	0·15
BC116	0·15
BC116A	0·18
BC117	0·21
BC118	0·11
BC119	0·27
BC121	0·23
BC125	0·15
BC126	0·20
BC132	0·50
BC134	0·11
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BC142	0·24
BC143	0·21
BC144	0·24
BC145	0·21
BC147	0·12
BC148	0·12
BC149	0·12
BC153	0·18
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BC157	0·14
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BC159	0·14
BC160	0·37
BC167B	0·11
BC168B	0·13
BC168C	0·13
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BC183L	0·09
BC184	0·11
BC184L	0·11
BC186	0·25
BC187	0·25
BC207	0·12
BC208	0·11
BC212K	0·10
BC212L	0·18
BC214L	0·21
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC252	0·18
BC253	0·23
BC257	0·09
BC258	0·09

BC259	0·13
BC261	0·20
BC262	0·18
BC263	0·23
BC300	0·42
BC301	0·34
BC302	0·27
BC303	0·54
BC307	0·10
BC307A	0·10
BC308	0·09
BC308A	0·09
BC308B	0·09
BC309	0·10
BC309A	0·10
BC309B	0·10
BC327	0·24
BC328	0·22
BC337	0·19
BC338	0·19
BCY30	0·43
BCY31	0·40
BCY32	1·15
BCY33	0·34
BCY34	0·35
BCY38	0·53
BCY39	1·05
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY58	0·21
BCY59	0·22
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·47
BCY88	2·40
BCY89	0·97
BCZ10	0·35
BCZ11	0·50
BD115	0·75
BD116	0·50
BD121	0·75
BD123	0·82
BD124	0·67
BD130	0·57
BD131	0·40
BD132	0·50
BD135	0·43
BD136	0·49
BD137	0·55
BD138	0·63
BD139	0·71
BD140	0·83
BDY10	1·25
BDY11	1·50
BDY17	1·50
BDY18	1·75
BDY19	1·97
BDY20	0·05
BDY38	1·65
BDY60	0·90
BDY61	1·25
BDY62	1·60
BF115	0·23
BF115	0·23
BF117	0·43
BF119	0·58
BF121	0·25
BF123	0·27
BF125	0·25
BF152	0·20
BF153	0·29
BF154	0·16
BF158	0·23
BF159	0·27
BF160	0·23
BF161	0·42
BF163	0·20
BF166	0·35
BF167	0·21
BF173	0·24
BF177	0·29
BF178	0·35
BF179	0·43
BF180	0·35
BF181	0·32
BF182	0·40
BF183	0·40
BF184	0·17
BR185	0·17
BF194	0·14
BF195	0·17
BF196	0·15
BF197	0·15
BF198	0·18
BF199	0·18
BF200	0·40
BF224J	0·14
BF225J	0·19
BF237	0·22
BF238	0·22
BF244	0·16
BF245	0·33
BF246	0·43
BF247	0·49
BF254	0·16
BF255	0·17
BF257	0·41
BF258	0·46
BF259	0·45
BF270	0·25
BF272	0·53
BF273	0·25
BF274	0·28
BF457	0·53
BF458	0·65
BFS21A	2·30
BFS28	0·92
BFS61	0·27
BFS98	0·28
BFW11	0·61
BFW15	0·35
BFX13	0·23
BFX29	0·30
BFX30	0·25
BFX37	0·30
BFX44	0·33

BFX63	2·48
BFX68	0·68
BFX84	0·24
BFX85	0·29
BFX86	0·24
BFX87	0·28
BFX88	0·25
BFX89	0·45
BFY10	0·35
BFY11	0·45
BFY17	0·90
BFY18	0·35
BFY19	0·35
BFY20	0·50
BFY29	0·40
BFY37	0·20
BFY41	0·43
BFY43	0·65
BFY50	0·22
BFY51	0·15
BFY52	0·20
BFY53	0·15
BFY56	0·34
BFY64	0·41
BFY75	0·40
BFY76	0·22
BFY77	0·24
BFY78	0·36
BFY90	0·60
BRY39	0·30
BSX19	0·13
BSX20	0·14
BSX21	0·20
BSX26	0·49
BSX27	0·34
BSX28	0·25
BSX29	0·47
BSX30	0·68
BSX59	0·78
BSX60	0·54
BSX61	0·42
BSX76	0·15
BSX77	0·20
BSX78	0·25
BSW70	0·28
BSY24	0·20
BSY25	0·15
BSY26	0·20
BSY27	0·15
BSY28	0·15
BSY38	0·20
BSY39	0·20
BSY51	0·25
BSY52	0·25
BSY53	0·25
BSY54	0·30
BSY56	0·79
BSY65	0·15
BSY78	0·40
BSY79	0·40
BSY790	0·45
BSY95A	0·09
BU104	1·42
BU105	2·25
C111	0·53
D40N3	0·55
GET111	0·45
GET113	0·20
GET114	0·20
GET115	0·50
GET119	0·35
GET120	0·25
GET535	0·20
GET536	0·20
GET538	0·20
GET873	0·12
GET873	0·12
GET880	0·30
GET883	0·20
GET887	0·20
GET890	0·22
GET895	0·25
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP42A	0·90
TIP2955	0·98
TIP3055	0·60
ME0401	0·18
ME0402	0·20
ME0404	0·13
ME0411	0·17
ME0412	0·18
ME0413	0·14
ME1120	0·25
ME4001	0·09
ME4002	0·11
ME4003	0·14
ME4101	0·10
ME4102	0·11
ME4103	0·10
ME4104	0·11
ME6101	0·14
ME6102	0·16
ME8002	0·17
ME8003	0·16
MJ400	0·78
MJ420	0·86
MJ421	0·88
MJ430	0·75
MJ440	0·71
MJ480	0·75
MJ481	0·85
MJ490	0·94
MJ491	1·10
MJ802	14·2
MJ901	2·65
MJ1001	2·34
MJ1800	1·88
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a-103

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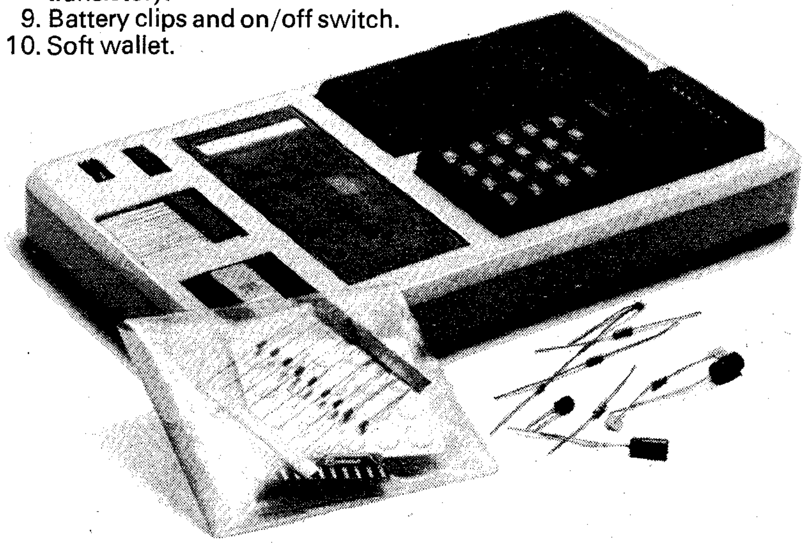


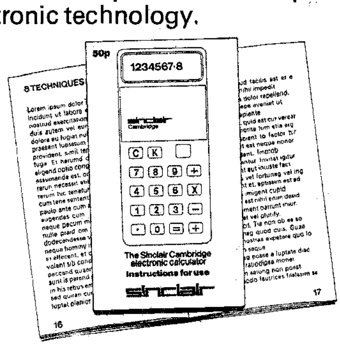
Actual size!

4½in long x 2in wide x 11/16in 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.



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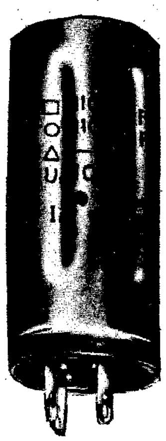

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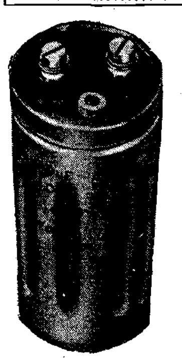

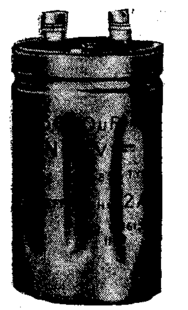

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H8/4A	5µf	64v	4p
H8/5	5µf	10v	4p
H8/5A	5µf	150v	4p
H8/6A	10µf	10v	4p
H8/7	10µf	70v	4p
H8/8	16µf	35v	4p
H8/8A	16µf	16v	4p
H8/9	20µf	6v	2p
H8/9A	20µf	70v	4p
H8/10	22µf	50v	4p
H8/10A	22µf	100v	4p
H8/11	25µf	12v	4p
H8/12	32µf	15v	4p
H8/12A	30µf	10v	4p
H8/13A	32µf	50v	4p
H8/14	40µf	25v	5p
H8/14A	40µf	16v	4p
H8/15	47µf	50v	4p
H8/15A	40µf	35v	4p
H7/1	50µf	6v	3p
H7/1A	50µf	10v	4p
H7/2A	64µf	2·5v	2p

Ref. No.	Capacity	Voltage	Price
H7/3A	64µf	25v	4p
H7/4	64µf	15v	4p
H7/4A	64µf	35v	5p
H7/5	80µf	16v	4p
H7/7	100µf	25v	4p
H7/8	125µf	16v	5p
H7/8A	100µf	35v	6p
H7/9	100µf	63v	6p
H7/9A	125µf	4v	4p
H7/10	125µf	25v	6p
H7/10A	160µf	2·5v	3p
H7/11	160µf	25v	6p
H7/11A	150µf	16v	5p
H7/13A	200µf	25v	8p
H7/14	220µf	50v	10p
H7/15	220µf	25v	5p
H7/15A	220µf	35v	10p
H6/1A	250µf	4v	3p
H6/3A	320µf	2·5v	3p
H6/4	320µf	10v	4p
H6/4A	330µf	16v	5p
H6/5	330µf	25v	10p
H6/5A	330µf	35v	15p
H6/8	470µf	25v	10p
H6/8A	470µf	35v	20p
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BFX 12	25	210 MHz	10p
2N 2906	60	200 MHz	15p
2N 3702	40	100 MHz	11p
2N 3703	50	100 MHz	12p

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BC 108	30	150 MHz	10p
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BF 179	225	125 MHz	40p
BF 180	30	625 MHz	25p
BFW 58	80	80 MHz	15p
BFX 43	30	500 MHz	20p
BFX 86	40	50 MHz	17p
BFY 53	30	50 MHz	10p
2N 697	60	40 MHz	12p
2N 709	15	900 MHz	30p
2N 718	60	60 MHz	12p
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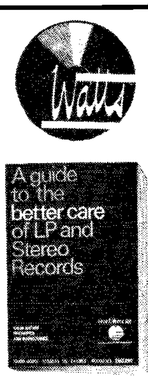

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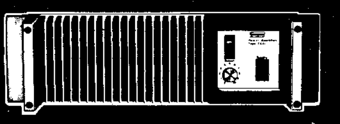

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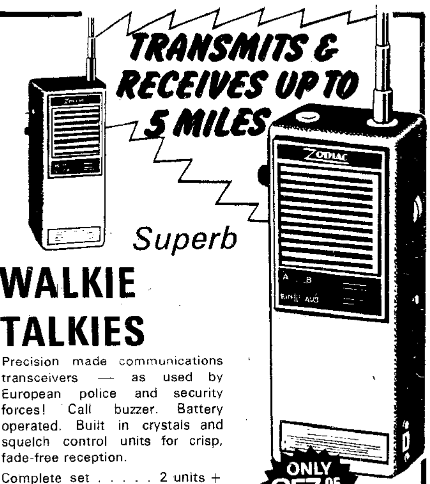

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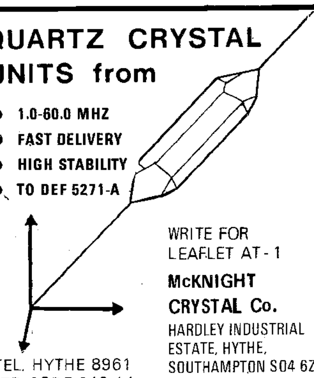

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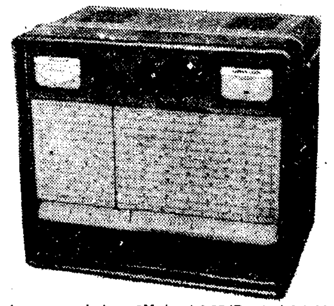

Carrier Frequency. Range: 15Kc/s-30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Stability: After warm up the drift in a 10-minute period is, typically, less than 0·005% for carrier frequencies up to 3·2Mc/s and less than 0·01% from 3·2-30Mc/s. Output Voltage: 0·4μV-4V. Impedance: 75 ohms nominal for outputs from 2-4 v. 75 ohms for outputs from 4μV-2V. 13 ohms for outputs from 0·4μV-0·4V. Accuracy: below 3Mc/s ±0·25dB ot ±0·1μV. 3-10Mc/s ±0·5dB or 00·2μV. 10-30Mc/s ±1·0dB or ±0·5μV. Power Supply: 100-125V, 200-250V 40-100c/s. Dimensions: 18 in. high × 21 in. wide × 14½ in. deep. **Price £165·00**

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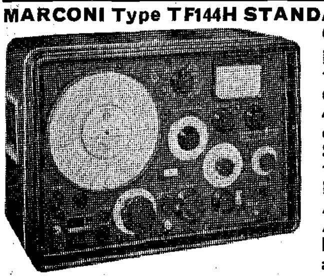

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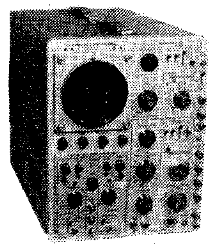

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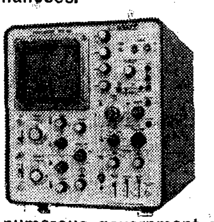

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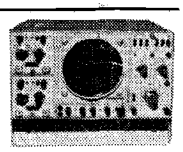

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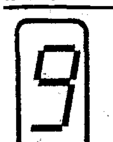

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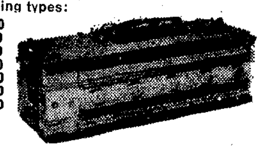

6 Volt	8 Amp	£21·00
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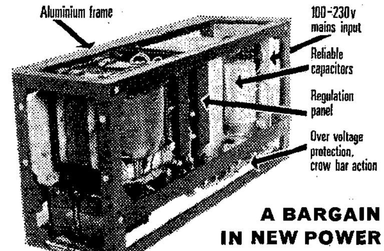

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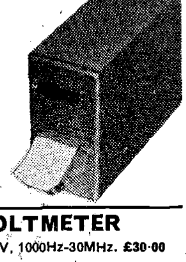

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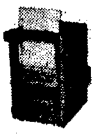
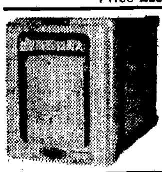


of America. This Recorder indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0-1 milliamp d.c. internal resistance 100 ohms. Chart drive motor 240 V 50Hz. Chart speed 1" per hour. Complete with handbook. Price **£25·00**



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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.
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LEEDS & NORTHRUP STRIP CHART RECORDER

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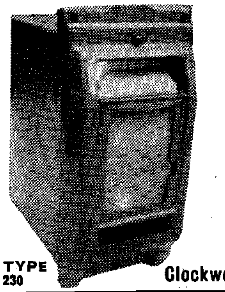

TYPE 230

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.

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TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	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	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·1	Beckman X	A.	£3·50
15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SA J337	£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		Reliance	07·10	£2·25
50K			07·5	£2·25
50K	0·5	Beckman	A.	£3·00
100K	0·1	Beckman	A.	£3·50
100K		Colvern	2501	£2·25
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A.	£3·50

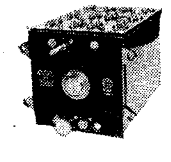
THREE TURN 780° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
25Ω		Beckman	Type C	£2·25
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.ss	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C.	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
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 coside potentiometer sections, the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max. torque: 3½ oz./in. Dimensions: W. 6½ in. H. 5 in. D. 7½ in. Wt. 7½ lbs. Ex equipment. Good condition. Price £5. Carriage extra.

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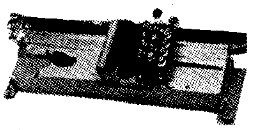

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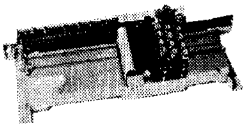
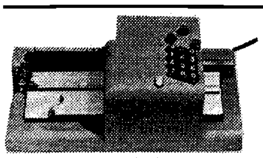


incorporating tabulating mechanism. **£79·50** plus carriage.



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£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.

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SAVE 75% OF LIST PRICE ON THIS DEC PDP SYSTEM

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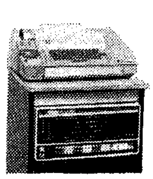

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Models S110 and R82C, 17 char. per sec. Rebuilt, available from stock. **£45.**

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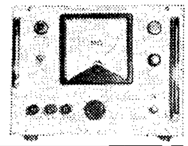

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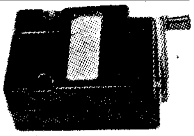

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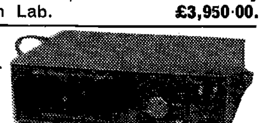

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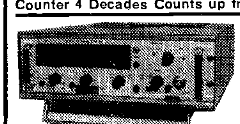

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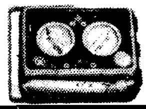

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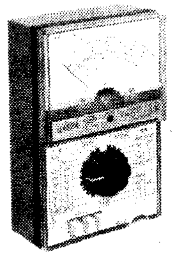

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With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
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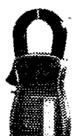

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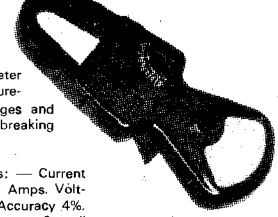

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.
Specification
Measurement ranges: — Current 10-25-100-250-500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283 x 94 x 36mm. Weight 1.5 lbs.

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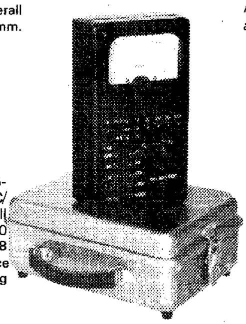

0.1-1-10-100-1000mA. 2.5-10-20-250-500-1000V AC/DC. Sensitivity AC and DC all ranges except 10V-10,000 Ohm/V. Dimensions 212 x 118 x 75mm. Weight 2.9 lbs. Price complete with steel carrying case and test leads..

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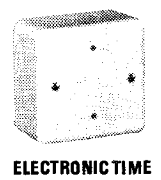

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The University of Leeds

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Forms of application and further particulars from the Registrar, The University, Leeds LS2 9JT (please quote 43/12/Cl). Closing date 10 December 1973.

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AGRICULTURAL RESEARCH COUNCIL

Food Research Institute
Electronics Division

AN

ELECTRONICS ENGINEER

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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

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 equiment, 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:

a) Ground/Air Communications
b) TV Colour Transmitters
c) 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 OFP
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.

ITT

3253

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

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

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 ilea
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, Ampthill 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:

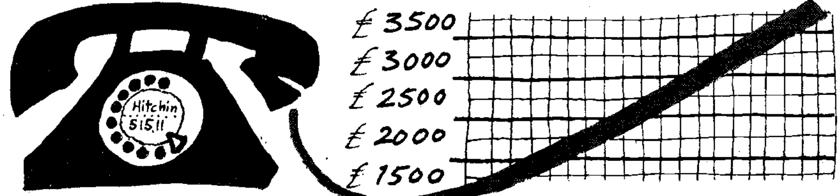
- aircraft equipment, including air conditioning and electro hydraulics
- aircraft and hovercraft propulsion systems
- marine automation (buoys, lightships, etc.)
- bio-medical engineering.

Please apply in writing, giving details of achievements and qualifications to:-

The Personnel Manager,
Hawker Siddeley Dynamics Limited
Hatfield, Herts.

HAWKER SIDDELEY dynamics

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 NCR

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. 73E 2267** and enclosing an addressed foolscap envelope. Closing date for completed application forms 14 days after publication.

BBC

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

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

RADIO OFFICERS

DO YOU HAVE PMG I PMG II MPT 2 YEARS OPERATING EXPERIENCE

POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH COMPOSITE SIGNALS ORGANISATION.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £2,527 pa; commencing salary according to age — 25 years and over £1,807 pa. During training salary also by age, 25 and over £1,350 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from
Recruitment Officer, Government Communications Headquarters, Room A/1105 Priors Road, Oakley, Cheltenham, Glos GL52 5AJ, Telephone: Cheltenham 21491 Ext 2270

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 612552 3314

RANK RADIO INTERNATIONAL

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 yeasr 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

HI-FI 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

AARVAK 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 reliabiity.

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

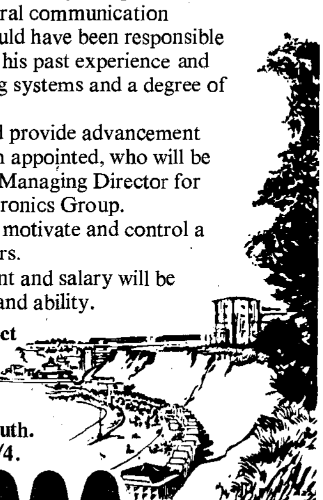
Research and Development Manager

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.

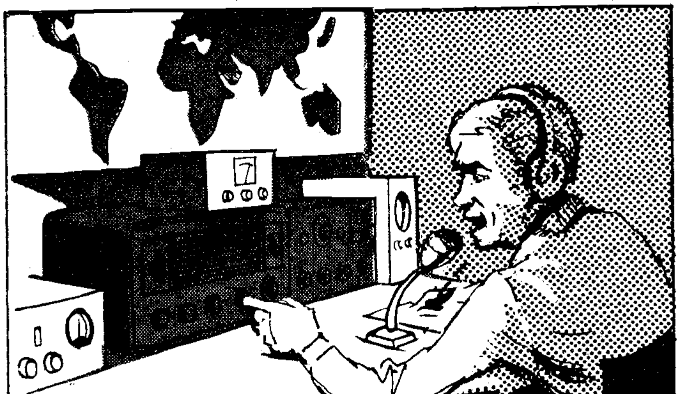
He must also have the ability to motivate and control a team of existing Design Engineers.

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

★ ★ COURSES ★ ★



become a RADIO-AMATEUR!

learn how to become a radio-amateur in contact with the whole world. We give skilled preparation for the G.P.O. licence

free! Brochure, without obligation to:

BRITISH NATIONAL RADIO & ELECTRONICS SCHOOL P.O.BOX 156, JERSEY, CHANNEL ISLANDS

NAME :

ADDRESS : WWB24

BLOCK CAPS please

NEW FROM ICS

BREAKTHROUGH CAREER PROGRAMMES

IN ELECTRONIC ENGINEERING/ TELEVISION SERVICING

Now ICS can help you break into a new better-paid field, get job security, go to the top, be your own boss.

Now the future holds far more for you than it did before . . . a new future — in either of these exciting careers. They're well-paid, secure and need ambitious people.

ICS have made a breakthrough in the home-study field — by designing home study courses that will not only coach you for your initial qualification into one of these careers . . . and go much further and give you the practical grounding on how to get ahead in that job.

Your first move: Select your future career below. Complete the coupon and post it today for full information. It will probably be the best investment you'll ever make.

ELECTRONIC ENGINEERING

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.

TELEVISION SERVICING

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.

Please complete coupon and send to ICS Dept. CP8, Intertext House, Stewarts Road, London SW8 4UJ.

Name . . . . (PLEASE PRINT)

Address . . . .

Tel. . . . . Age . . . .

Occupation . . . .

ICS CAREER PROGRAMMES 3277

Commencing January 1974

HIGHER NATIONAL DIPLOMA COURSES

in

1. **Electrical and Electronic Engineering**
2. **Mechanical Engineering** (aeronautical and production options)

Assistance can be given with industrial placement. Further information about the courses and placement may be obtained from the Polytechnic's Admissions Office.

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 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-equipt.) £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 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28

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. 12½ 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

TELEVISION VALVES. Any 10 valves 85p, 50/£3. ECC82, EY86/7, DY86/7, EF80/85/183/184, PCC84/89/189, PC97, PC86/88, PCF80/86/801/805, PCL82/84/85, PL36/504, PY81/82/800/801. Electronic Mailorder, Ramsbottom, Bury, Lancs. [3228

Articles for Sale—Cont. on p. 134

★ ★ ARTICLES FOR SALE ★ ★

Articles for Sale—Cont. from p. 132

COLOUR, UHF and TV SPARES. Colour and UHF lists available on request. New Philips G6 single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads, etc. and circuit data £3.75, or with yoke £5.00, P/P 30p. New Colour Scan Coils, Mullard or Plessey plus convergence yoke and blue lateral, £10.00, P/P 40. Mullard AT1025/05 Convergence Yoke, £2.50, P/P 25p. Mullard or Plessey Blue Laterals, £1.25, P/P 10p. BRC 3000 type Scan Coils, £4.00, P/P 40p. Delay Lines DL20, £3.50, DL1E, DL1, £1.50, P/P 25p. Lum. Delay Lines, 50p, P/P 15p. EHT Colour Quadrupler for Bush Murphy CTV 25 111/174 series, £8.25, P/P 25p. EHT Colour Tripler ITT TH25/1TH suitable most sets, £2.00, P/P 25p. KB CVC1 Dual Stand. convergence panels complete incl. 22 controls, £3.75, P/P 35p. CR1 Base Panel, £1.75, P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete: Decoder incl. I/C, £2.50, IF incl. 5 modules, £2.50, T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50, T. Base, £1.00, RGB and Sound, £1.00, P/P 25p. Pye CT70 Colour LOPT assembly incl. EHT output and Focus Control, £3.50, P/P 35p. B9D valve bases 10p, P/P 6p. VARICAP TUNERS. UHF ELC 1043 NEW, £4.50, Philips VHF for Band 1 and 3, £2.85 incl. data. Salvaged VHF and UHF Varicap tuners, £1.50, P/P 25p. UHF TUNERS NEW, Transistorised, £2.85 or incl. slow motion drive, £3.85. 4 position and 6 pos. push-button transistd., £4.95. UHF/VHF basic integrated tuners, £3.25, Cyldon UHF valve tuners, £1.50. All tuners P/P 30p. Transistd. UHF/VHF IF panels salvaged, £2.50 P/P 25p. MURPHY 600/700 series complete UHF Conversion Kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly, £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct., £1.50 P/P 35p. THORN 850 Dual standard time base panel, £1.00 P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., £1.00 P/P 30p. VHF turret tuners AT7650 incl. valves for K.B. Featherlight, Philips 19TG170, GEC 2010, etc., £2.50. PYE miniature incremental for 110 to 830, Pam and Invicta, £1.95. A.B miniature with UHF injection suitable K.B, Baird, Ferguson, 75p. New fireball tuners Ferguson, HMV, Marconi, £1.90 P/P all tuners 30p. Large selection LOPTs, Scan Coils, FOPTs available for most popular makes. PYE/LABGEAR transistd. Masthead UHF Booster, £5.75, Power Unit, £4.65 P/P 30p or Setback battery operated UHF Booster, £4.65 P/P 30p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit. Rail). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751.

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Articles Wanted—Cont. on p. 135

Articles Wanted—Cont. from p. 134

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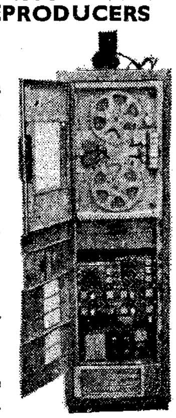

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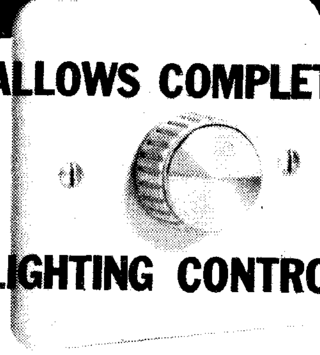

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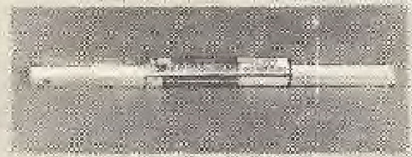

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304D / 304W	mildly activated Halide Free	10% / 25%	DIN 8527 Type F-SW 32 DTD 599A
PC.21A	activated	38%	DTD 599A; DIN 8527, F-SW 26
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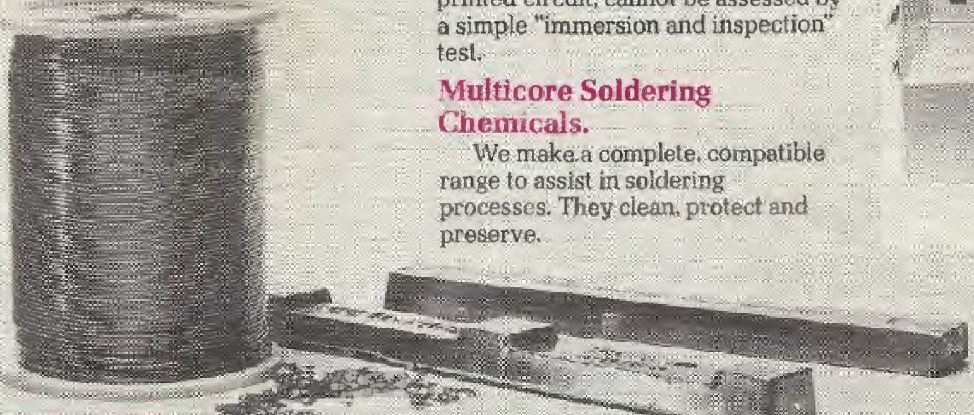

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