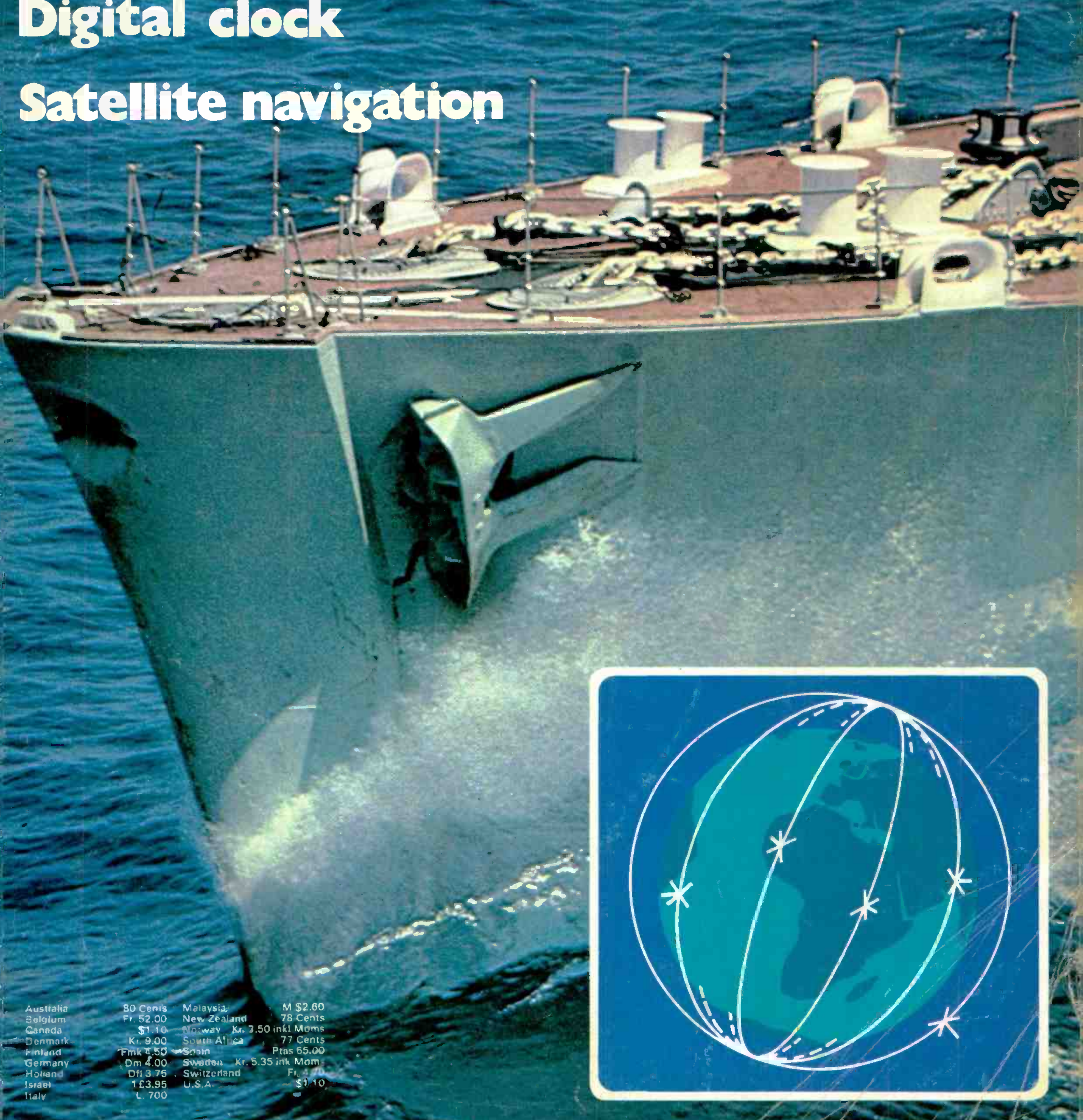
wireless world

FEBRUARY 1975 30p

Digital clock

Satellite navigation



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Vital Issues

The issues are quite regular – and they discuss issues of vital importance to everyone who uses electronic test equipment.

The periodical, *Marconi Instrumentation*, which is mailed out free to all **mi** customers three times annually, contains technical articles about our latest instruments and up-to-the-minute information on their application to the solutions of measurement problems. It is written by engineers *for* engineers in English with summaries in four other languages.

And that's not all, by any means. **mi** *Contact* is a newspaper published six times a year to keep you in touch with news and progress in the measurement business. Then there are our hardback publications, too. Already, there is a volume on TV Video Transmisson Measurement written by the Head of BBC Measurement Systems Laboratory, and another book discusses the techniques and development of 'white noise' testing. Shortly we will be publishing a book on pulse code modulation, by a senior Post Office engineer.

There are technical data sheets, applications notes, catalogues, concise catalogues and product brochures, all aimed to help you measure.

Are you reading us?

mi : THE COMMUNICATORS

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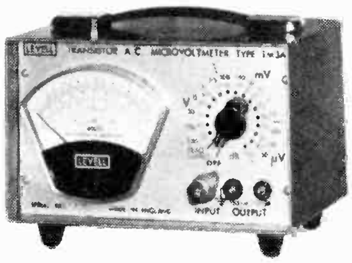
PORTABLE INSTRUMENTS

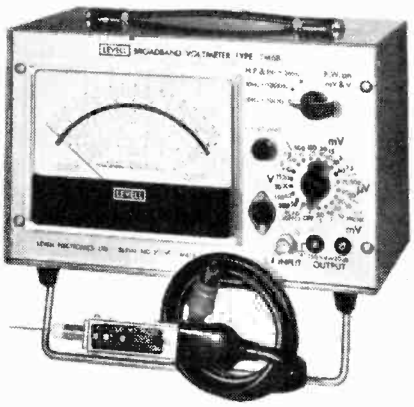
These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 3¼" scale meters, and case sizes 5" x 7" x 5". B types have 5" mirror scale meters and case sizes 7" x 10" x 6".



A.C. MICROVOLTMETERS

VOLTAGE & db RANGES: 15µV, 50µV, 150µV ... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1 µV at 1 kHz. – 100, – 90 ... + 50dB, scale – 20dB/+ 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0·3dB from 4Hz to 1 MHz above 500 µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10 kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV : > 4·3MΩ < 20pf. On 50 µV to 50mV : > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

type TM3A **£65** type TM3B **£80**



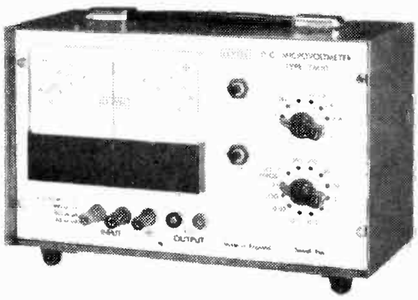
BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV ... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. – 50dB, – 40dB, – 30dB to + 20dB. Scale – 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0·7dB from 1 MHz to 50MHz. ± 3dB from 300kHz to 400MHz.

L.F. RANGES: As TM3 except for the omission of 15µV and 150µV.

AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

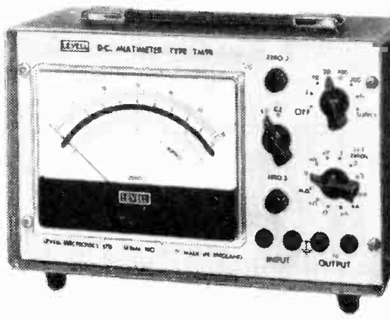
type TM6A **£110** type TM6B **£125**



D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30 µV, 100 µV, 300 µV ... 300V. Acc. ± 1%, ± 2% f.s.d., ± 1 µV. CZ scale.
CURRENT RANGES: 30 pA, 100 pA, 300 pA, 300 mA. Acc. ± 2%, ± 2% f.s.d., ± 2 pA. CZ scale.
LOGARITHMIC RANGE: ± 5µV at ± 10% f.s.d., ± 5 mV at ± 50% f.s.d., ± 500 mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into > 1kΩ

type TM10 **£67**



D.C. MULTIMETERS

VOLTAGE RANGES: 3µV, 10µV, 30µV ... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1 µV. LZ & CZ scales.

CURRENT RANGES: 3pA, 10pA, 30pA ... 1mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales.

RESISTANCE RANGES: 3 Ω, 10 Ω, 30 Ω ... 1kM Ω linear. Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.

RECORDER OUTPUT: 1V at f.s.d. into > 1k Ω on LZ ranges.

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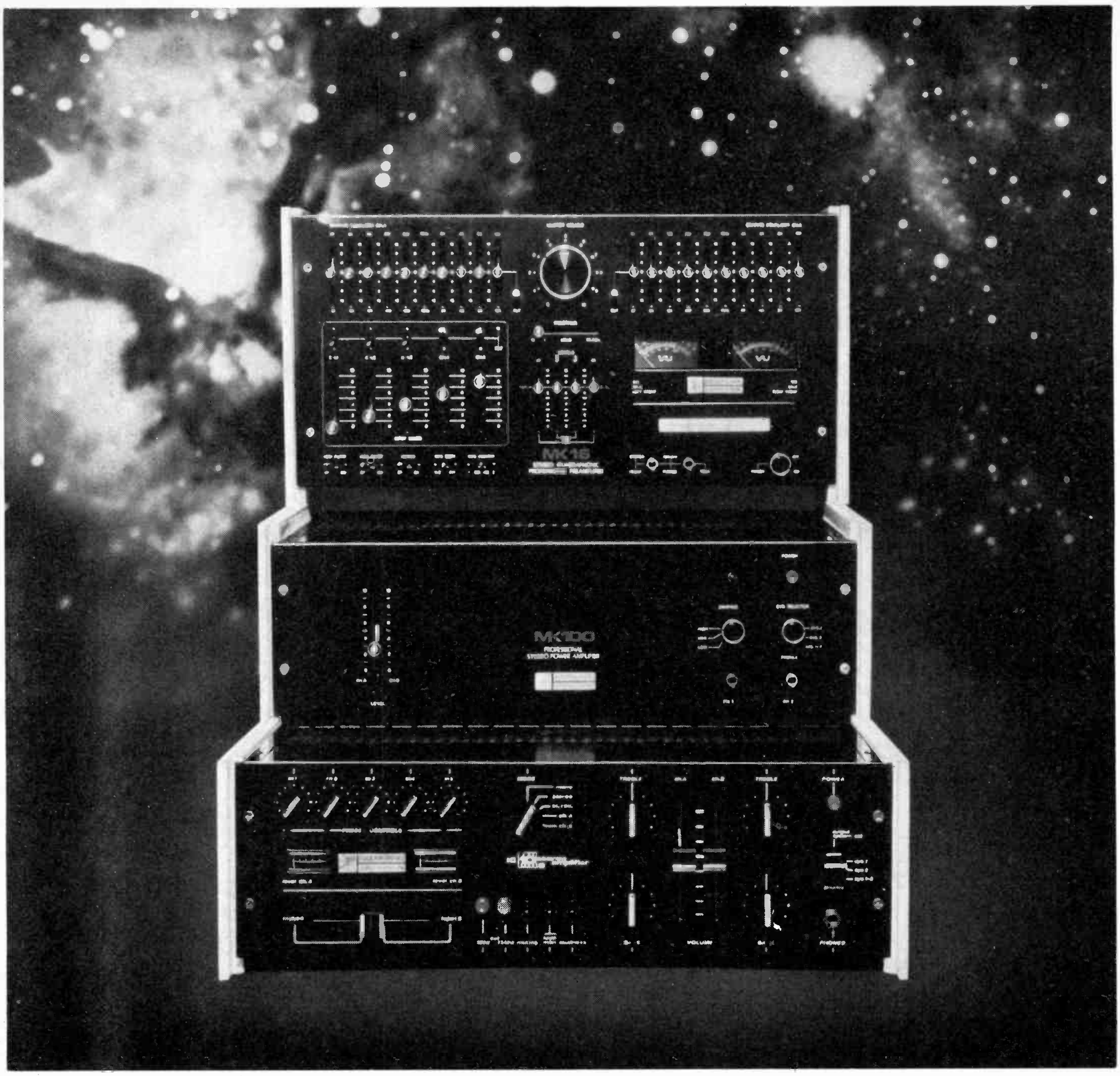
Prices include batteries and U.K. delivery. V.A.T. extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.



Who else but the Italians could have produced the most sophisticated range of mixing and fading facilities ever offered in such a beautifully designed range of equipment.

Yet still apply the most precise and exacting manufacturing standards to provide the operational stability and reliability such complex electronics demand.

This is why we are able to guarantee all Goodmans/Galactron equipment for three years.

And your guarantee will be signed personally by the quality controller who tests it before it leaves the factory in Italy.

Galactron Mk 10
Stereo Integrated Amplifier

A remarkably compact pre and power amp combination with 90 watts RMS per channel. Features 5 mixable stereo inputs, 5 plug-in-modules—two of which can be cross-faded by slide potentiometer.

Galactron Mk 16
Stereo/Quad Amplifier

No comparable equipment has all these 3 functions. 5 inputs, independently mixable and equalised by plug-in modules. Twin graphic equalisers having 10 filters each (±16dB) at octave intervals from 32Hz to 16kHz. Plug-in quadrophonic decoder panels for discrete and matrix systems allied to 4 output level controls.

Galactron Mk 100
Stereo Power Amplifier

Originally designed as a monitor amp for recording studios, the Mk 100 is designed for use with the Mk 16 preamplifier. 100 watts RMS per channel output.

Full facts and figures are available from Goodmans Loudspeakers Limited, Downley Road, Havant, Hants.

THORN
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Goodmans
GALACTRON

WW—080 FOR FURTHER DETAILS

Hi-fi starts here

The quality of the sound you hear from your hi-fi depends on the quality of transcription from the record–so you won't want to skimp on quality. When you choose your turntable deck, you'll probably choose Garrard.

Fifty-five years of Garrard experience and know-how in producing top-quality record playing equipment is concentrated in the range of record playing units now available. There are three modules complete with attractive bases and lift-off covers, ready-wired for instant installation.

The SP25 mk IV is the most popular budget unit on the market. It features the famous Garrard four-pole synchronous motor to ensure smooth, constant speeds, the finely engineered pickup arm with resiliently mounted counterbalance weight, calibrated bias compensation and damped cueing.

The 86Sb represents just about the best buy in hi-fi today. It incorporates belt drive, the famous Garrard four-pole synchronous motor, high inertia turntable, contoured mat, precision pickup arm with fine stylus force adjustment and bias compensation calibrated for elliptical and conical styli.

The Zero 100SB has every quality feature you could expect to find on a record deck. What makes it truly unique is the tangential tracking pickup arm virtually eliminating tracking error and consequent harmonic distortion. Other features include, adjustable, resiliently-mounted, counterbalance weight, fine stylus force adjustment, magnetic bias compensation calibrated for elliptical and conical styli, high inertia turntable with contoured mat, a record counter and the famous Garrard four-pole synchronous motor.

Use the coupon to obtain your free copy of the full-colour brochure on the complete range of Garrard record playing units.

Garrard
A PLESSEY QUALITY PRODUCT

Garrard, Newcastle Street, Swindon, Wiltshire.

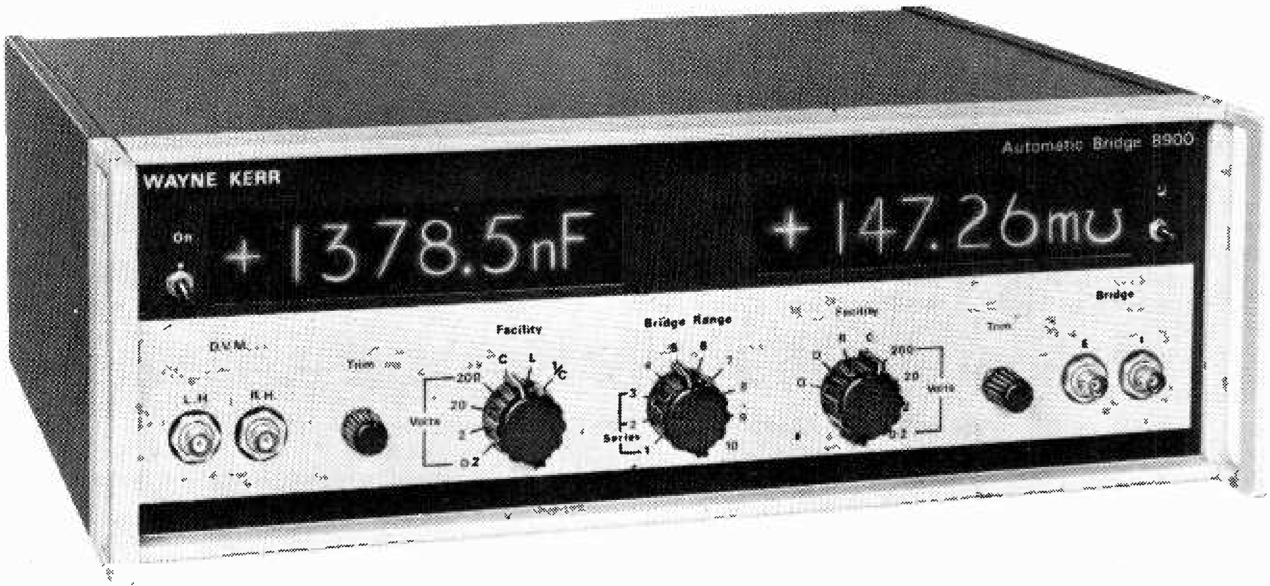
Please send me your full-colour brochure describing the famous Garrard range of top-quality hi-fi equipment.

Name

Address

623 P036

New automatic digital bridge from Wayne Kerr



Wayne Kerr's new B900 is one of the best value-for-money bridges in the world.

It is universal, has a wide range, and gives immediate digital readout of resistive and reactive terms–simultaneously.

On all ten ranges, for every type of measurement available, the displays provide a complete indication of the numerical value (up to 19999), polarity, decimal points and units–automatically and in half a second.

Direct measurements of Q, dissipation and dc volts.
2, 3, & 4–terminal. Automatic lead compensation.
4–Quadrant: +ve or −ve C, L, 1/C, G and R.
Overall coverage:

10μΩ	-	200MΩ	1nH	-	20kH
0.001pF	-	20,000μF	10p℧	-	200℧

Accuracy: 0.1% (10Ω–200MΩ), 0.3% (10mΩ–10Ω) in all quadrants. Frequency: 1kHz Outputs: Analog and TTL.

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

Please send me details of the B900.

For the attention of Mr__________________

Company name and address__________________

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WW—Feb

Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO22 9RL

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A member of the Wilmot Breeden group.

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50mHz OSCILLOSCOPE TYPE C1-64

Made in USSR

Lightweight, portable, transistorized, dual trace oscilloscope.

Display:
Rectangular CRT 6×10 div. (48×80mm) with illuminated graticule.

Vertical deflection:
Two input channels operated in alternate or chopped modes or algebraically summed.

Bandwidth:
DC to 50mHz DC coupled.
3Hz to 50mHz AC coupled.

Sensitivity:
Channel I and II: 5mV/div. to 10V/div.
Summing mode: 1mV/div. max.

Horizontal deflection:
Sweep 'A'–0.1µs/div. to 1s/div.
Sweep 'B'–0.1µs/div. to 50ms/div.

Sweep delay:
1µs to 10s.

Time Base Modes:
'A' only; 'B' only; 'A' brightens 'B'.
'B' delayed by 'A'; 'A' and 'B' chopped or alternate.

Power supplies: 115/230V±10%, 50–40 Hz.
Dimensions: 300×200×420 mm.
Weight: 19kg.
PRICE, complete with full complement of connectors, cables, adaptors and accessories **£470** exclusive of VAT.

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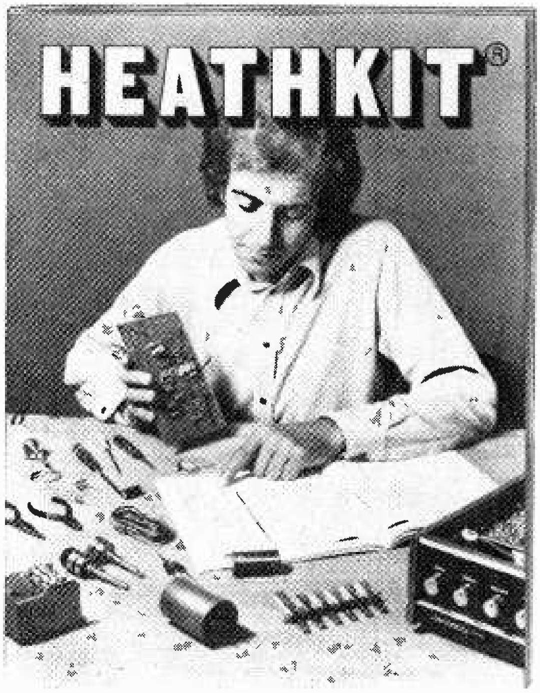


The new Heathkit catalogue is now out. Full as ever with exciting, new models. To make building a Heathkit even more interesting and satisfying.

And, naturally, being Heathkit, every kit is absolutely complete. Right down to the last nut and bolt. So you won't find yourself embarrassingly short of a vital component on a Saturday evening–when the shops are shut.

You'll also get a very easy to understand instruction manual that takes you step by step through the assembly.

Clip the coupon now and we'll send you your free copy to browse through.

With the world's largest range of electronic kits to choose from, there really is something for everyone.

Including our full range of test equipment, amateur radio gear, hi-fi equipment and many general interest kits.

So, when you receive your catalogue you should have hours of pleasant reading.

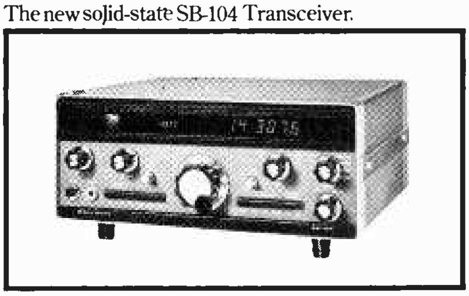
And, if you happen to be in London or Gloucester, call in and see us. The London Heathkit Centre is at 233 Tottenham Court Road. The Gloucester showroom is next to our factory in Bristol Road.

At either one you'll be able to see for yourself the one thing the catalogue can't show you.

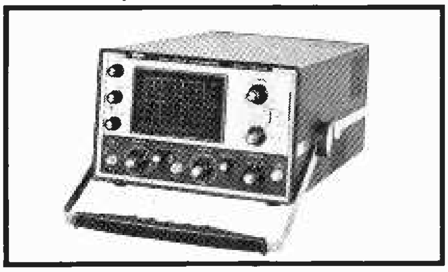
Namely, how well a completed Heathkit performs.

Heath (Gloucester) Limited, Dept.WW-25, Bristol Road, Gloucester, GL2 6EE. Tel: Gloucester (0452) 29451.

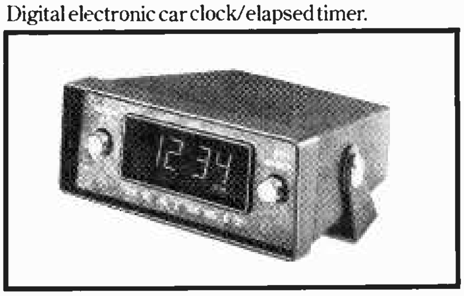
The new solid-state SB-104 Transceiver.



An oscilloscope from the Heathkit range.



Digital electronic car clock/elapsed timer.



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To: Heath (Gloucester) Limited, Dept.WW-25 Gloucester, GL2 6EE. Please send me my free Heathkit catalogue.

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Remember easy terms are available with the Heathkit Monthly Budget Plan.

HEATH Schlumberger

Three Ways To Easier Colour Servicing

1.

Colour Bar Generator

* 10 test signals
* Variable amplitude of colour burst signal
* 4 preselected channels on the RF output
* Small size, low weight

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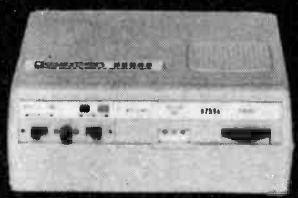

Convergator

* Battery operated
* UHF output covers 10 channels
* Video signal can be switched off for purity adjustment

3.

T.V. Visual Field Strength Meter

* Varicap tuner with four channel selectors
* High sensitivity
* 6" picture tube
* Mains or battery operation

The speed and efficiency of your colour servicing with this Decca test equipment will save you time and therefore money. Send us the coupon or give us a call and we'll send you the full details

DECCA

Decca Radio & Television Ltd.
Educational and Industrial Services Division
Ingate Place, Queenstown Road,
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Please send me further details of your colour TV test and service equipment:

Name...

Address...

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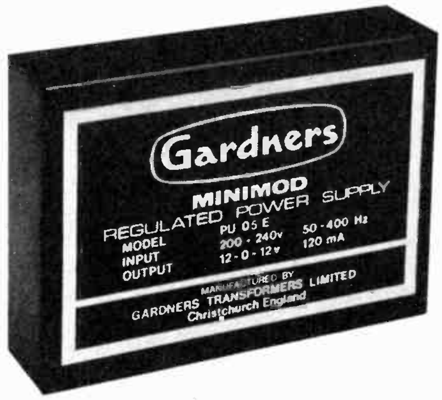
WW2



Now suitable for U.K., European and American voltages...

Minimod, the versatile British made range of encapsulated power supplies first introduced in 1973, has now been extended to cover European and North American mains voltages (and is interchangeable with most American types). Normally available ex-stock, all units are fully stabilised with fold back current limiting – the 5V models have over voltage crowbar too!

STANDARD MODELS

Type Number	Output Voltage	Output Current Amps	Short Circuit Current mA (Typical)	% Regulation Line and Load (Typical)
PU01	5 ± 0.1	0.5	370	0.3
PU02	5 ± 0.1	1.0	770	0.5
PU03	15–0–15 ± 0.2	0.10	37	0.1
PU04	15–0–15 ± 0.2	0.20	84	0.1
PU05	12–0–12 ± 0.2	0.12	45	0.1
PU06	12–0–12 ± 0.2	0.24	120	0.2

Input voltage ranges 103 - 126V, 200 - 240V. 210 - 250V. Frequency 50 - 400 Hz all types.

Comprehensive specification given in brochure GT 29b which is available on request.

★SPECIAL DESIGN SERVICE

Custom built units for applications requiring different specifications are produced as part of our standard service. Try us first.

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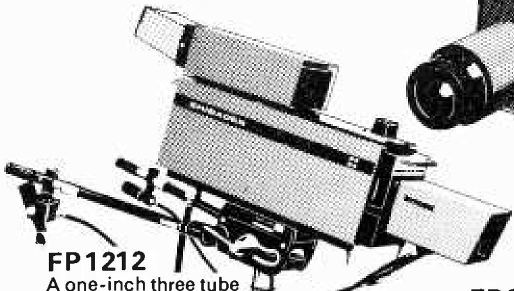
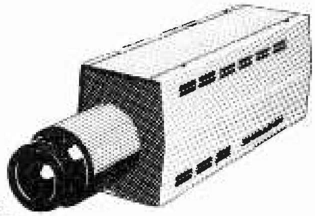
WW—056 FOR FURTHER DETAILS

5 good reasons why Shibaden colour cameras are the best!



FP 1500 As the HV 1500 but fitted with a 3" viewfinder for studio use.



HV 1100
An extremely compact, lightweight three tube colour TV camera ideal for surveillance and observation applications.

HV 1500
Compact, highly mobile unit, the only colour CCTV camera available with a single one-inch filter integrated colour vidicon tube.

FP 1212
A one-inch three tube Plumbicon® Camera with freely detachable electronic viewfinder. Ideal for outside broadcast work and studio.

FPC 1000
A vidicon/chalnicon camera designed to meet all NTSC and PAL requirements.

® Trade Mark N.V. Philips

The Shibaden range of colour cameras are compact, easy to operate and versatile in their application through educational, medical, business and broadcasting studios. Shibaden Colour Cameras are designed with the customer in mind both from an application and performance stand point. They are fully backed by Shibaden's in-depth opto-electronic technology, which has proved to be superior through many years of application in a vast range of broadcasting equipment.

When you buy Shibaden you buy the best.

For further details on the Shibaden range of Colour Cameras, contact the Technical Service Department.

Hitachi Shibaden (UK) Limited
BROADCAST & CCTV EQUIPMENT MANUFACTURERS
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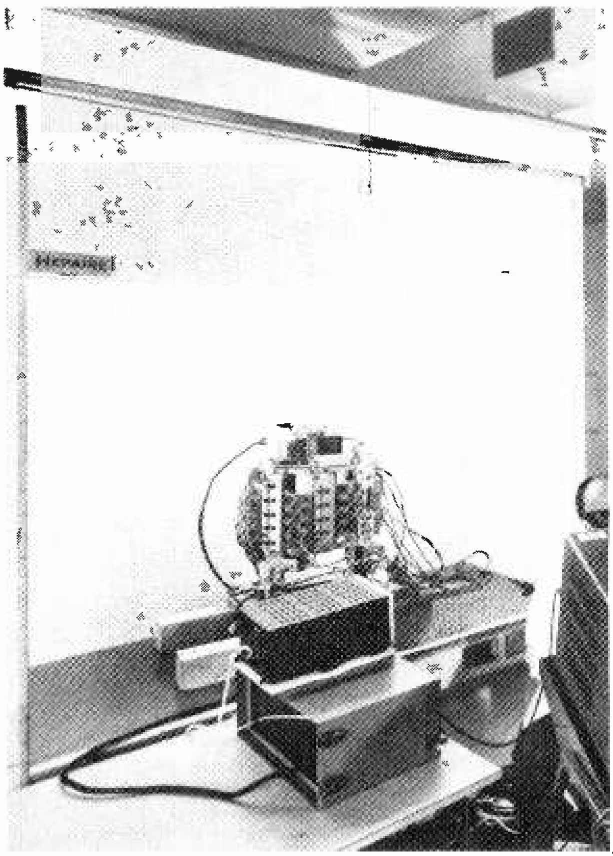
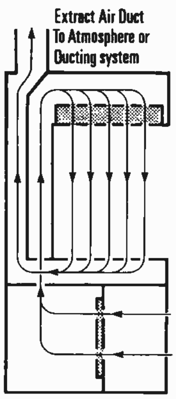
WW—122 FOR FURTHER DETAILS

Vertical Laminar Flow work stations by HEPAIRE





Provides vertical flow of filtered air. Free standing unit utilising minimum floor space. Uses standard single phase electrics. Clean design.

DESIGNED FOR SAFETY

Cabinet draws in air through pre-filter beneath work bench. Air is pressurised and passes through absolute filter vertically downwards and through perforated work surface. Dirty air is then extracted to atmosphere via extract duct mounted on top of cabinet.

Write for technical details.

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INCREASED PRODUCTION MEANS REPRESENTATION REQUIRED IN MANY U.K. AREAS

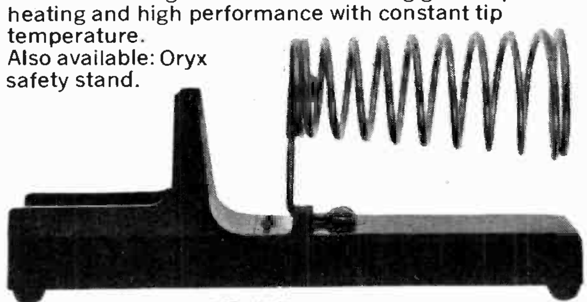
WW—051 FOR FURTHER DETAILS

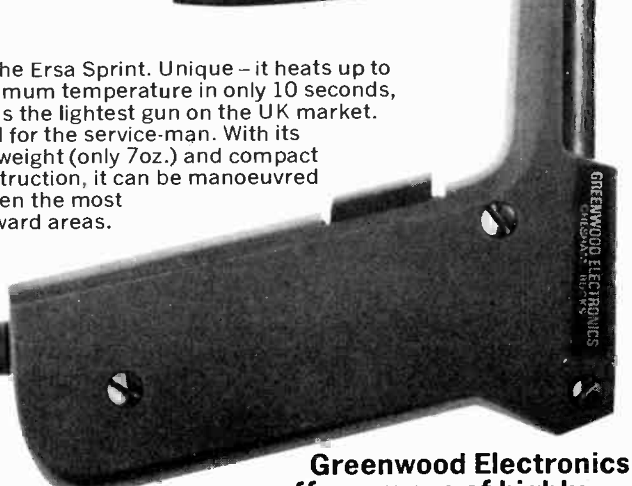
The Greenwood guide to professional soldering.

The Ersa Multitip. A top-quality iron that's ultra-light, offering reliability so necessary to achieve constant production flow. A range of different shaped tips simply push onto the stem of the iron. It has the unique advantage that you can change the element in seconds.

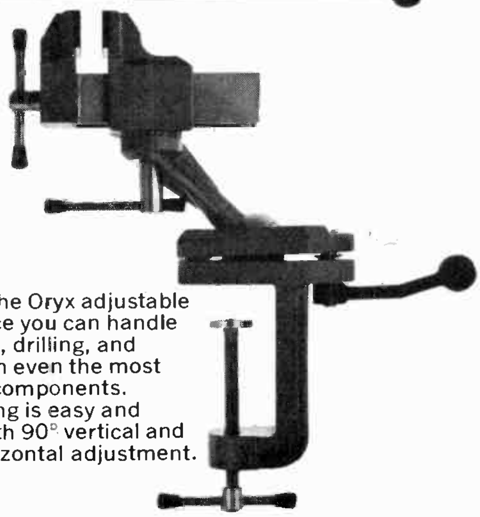
The Iso-Tip. A safe, high-powered iron which works anywhere without a mains lead. The breakthrough? Nickel Cadmium cells that are re-chargeable. (A charging stand is included for 240v or 115v A.C.) Each charge gives at least 60 soldering joints. Weight? Only 6oz.

The Oryx 50. A temperature controlled mains soldering iron. (Temperature control within ± 2%.) Adjustment (200°–400°C) can be made whilst iron is operating using the same tip. Light, compact and easy to handle. A large 50W element loading gives rapid heating and high performance with constant tip temperature.
Also available: Oryx safety stand.





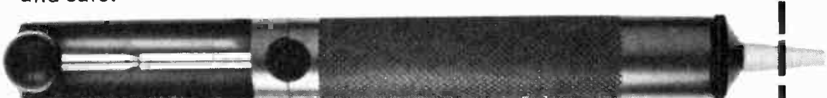
The Ersa Sprint. Unique – it heats up to maximum temperature in only 10 seconds, and is the lightest gun on the UK market. Ideal for the service-man. With its lightweight (only 7oz.) and compact construction, it can be manoeuvred in even the most awkward areas.



With the Oryx adjustable bench vice you can handle soldering, drilling, and cutting on even the most delicate components. Positioning is easy and quick, with 90° vertical and 360° horizontal adjustment.

Oryx SR3A desoldering tool. Ideal where components are tightly grouped. Instantly removes unwanted solder from printed circuits etc. Accurate, reliable, speedy, and safe.

Greenwood Electronics offer a range of highly advanced products specifically for professional soldering applications.
For more detailed information about the comprehensive Greenwood range, send us the coupon today.



Please send me more details about the Greenwood range of soldering equipment.

Name ____________________

Address ____________________

____________________ WW4

Greenwood Electronics

21 Germain Street, Chesham, Bucks, HP5 1LL
Tel: 02405 4808 Telex: 83647

WW—010 FOR FURTHER DETAILS

Eddystone Radio

Eddystone

Economy! Simplicity! Reliability!

1830 Series C.W, M.C.W, A.M, S.S.B

- Crystal controlled
- Transistorized HF/MF general purpose receiver
- 120 kHz – 30 MHz in 9 ranges
- Rack mounting as standard
- Cabinet optional extra
- AC or battery operation
- British MPT approved as ships reserve receiver
- DCA No. 10D/CA 10696

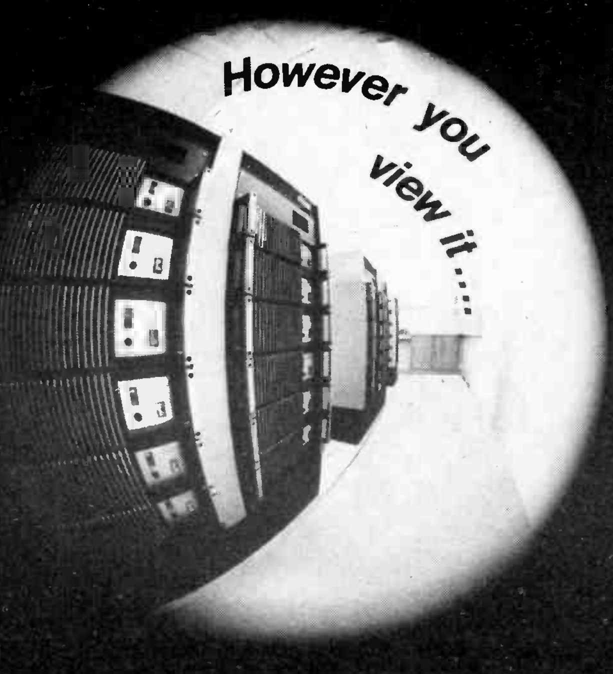
Illustrated brochure from:

Eddystone Radio Limited

Alvechurch Road, Birmingham B31 3PP. Tel: 021-475 2231. Telex 337081.

A member of Marconi Communication Systems Ltd

WW—047 FOR FURTHER DETAILS



...the choice is **Grampian**

SOUND EQUIPMENT

GRAMPIAN REPRODUCERS LIMITED
HANWORTH TRADING ESTATE, FELTHAM, MIDDLESEX.
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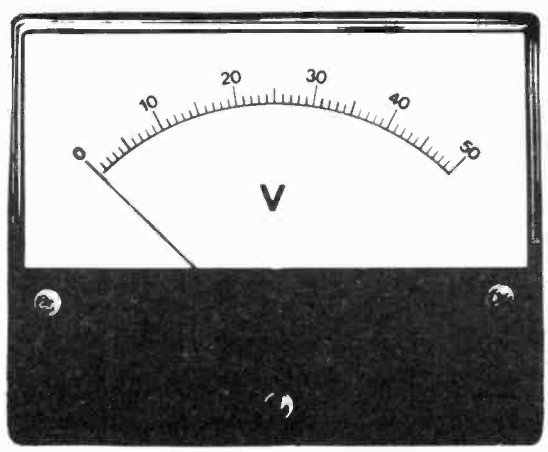
X205

METER PROBLEMS?



A very wide range of modern design instruments is available for 10/14 days' delivery.

Full Information from:

HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

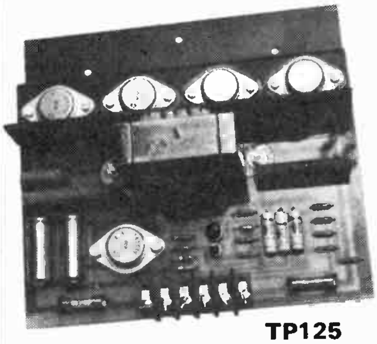
WW—016 FOR FURTHER DETAILS

TUAC

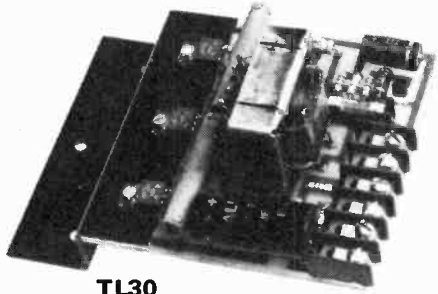
TRANSISTOR UNIVERSAL AMPLIFICATION CO.LTD.
163 MITCHAM RD·LONDON SW17 9PG 01·672 3137/9080

MANUFACTURERS OF ELECTRONIC & AMPLIFICATION EQUIPMENT, ALSO QUALITY TRANSISTOR EQUIPMENT.
OPEN MON–SAT 9.30am–6.00pm.

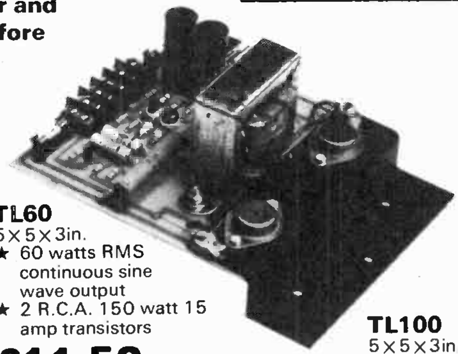
NEW TUAC POWER MODULES offering more power and quality than ever before



TP125 7×6½×3in.
★ 4 R.C.A. 150 watt 15 amp output transistors
★ 125 watts RMS continuous sine wave output
£17·00



TL30 4×5¼×2¼in. **£7·90**
★ 30 watts RMS continuous sine wave output
★ 2 R.C.A. 40 watt output transistors



TL60 5×5×3in.
★ 60 watts RMS continuous sine wave output
★ 2 R.C.A. 150 watt 15 amp transistors
£11·50

TL100 5×5×3in.
★ 100 watts R.M.S. continuous sine wave output
★ 2 R.C.A. 150 watt 15 amp transistors
£13·20

★ Rugged layer wound driver transformer
★ Short—Open—and Thermal overload protection
★ Only 6 connections

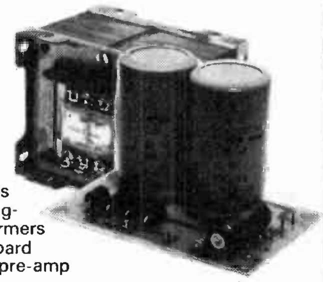
Specification on all power modules: All output power ratings ±1dB; Output impedance 8–15 ohms; THD at full power 2% typically 1%; Input sensitivity 60mV into 10kΩ; Frequency response 20Hz–20kHz ±2dB; Hum and noise better than −70dB.

TUAC DISCOTHEQUE MIXER WITH AUTO FADE £26·50

PANEL SIZE 18 × 4½ in. DEPTH 3 in.

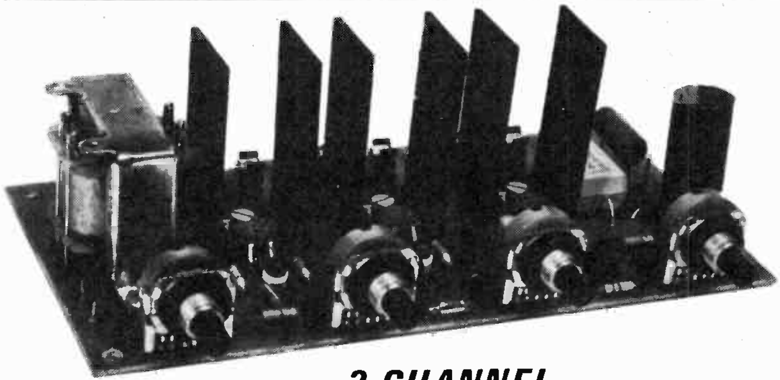
Designed for the discerning D.J. of professional standard. Offering a vast variety of functions. Controls: Mic Vol; Tone, over-ride depth; auto/Manual Sw; Tape Vol; L & R Deck Faders; Deck Volume; Treble and Bass; H. Phon Vol Selector; Master Vol On/Off Sw. Max output IV RMS.

Specification: Deck Inputs—50mV into 1mΩ; Deck Tone Controls *Treble +20 −10dB at 12kHz. Bass +22 −15dB at 40Hz; Mic input—200 ohms upwards. 2mV into 10kΩ; Mic Tone Control—Total Variation Treble 15dB. Total Variation Bass 10dB; Tape input—30mV into 47kΩ; Power Requirements—30–45 volts at 100mA.



Power supplies vacuum impregnated Transformers with supply board incorporating pre-amp supply:

PS 125	+50 volts for one TP125	**£11·50**
PS 100	+45 volts for one TL100	**£10·50**
PS 60	+40 volts for one TL60	**£9·30**
PS 30	+50 volts for one TL30	**£5·90**
PSU 2	for supplying disco mixer	**£4·65**



3 CHANNEL LIGHT MODULATOR

- R.C.A. 8 Amp Triacs ● 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 100W
- Full wave control—12 easy connections

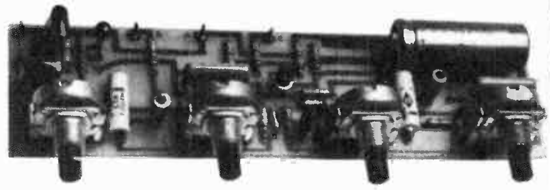
£14·90

Single Channel Version 1500 watts **£6·60**

ALL PRICES INCLUDE V.A.T. POST & PACKING FREE

HOW TO ORDER BY POST

Make cheques/P.O's payable to TUAC (WW2). OR QUOTE ACCESS/BARCLAY CARD NO. and post to TUAC LTD (WW2) 163 MITCHAM ROAD, LONDON SW17 9PG. We accept phone orders against ACCESS/Barclay Card Holders. Phone 672-3137.



PREAMPLIFIERS

All TUAC audio modules are constructed on glass fibre P.C. board, are ready assembled and fully tested. Low noise silicon and FET transistors together with H.S. carbon film resistors are used throughout. Extensive research has gone into various wide range tone control circuits producing superb sound quality from any signal.

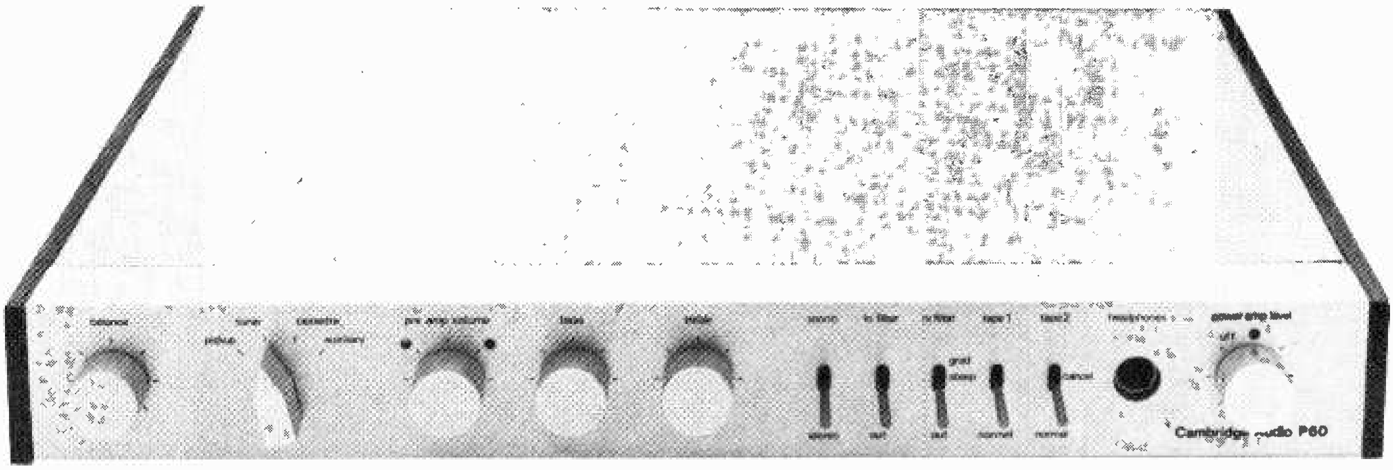
VA08 Vol. Treble, Mid and Bass controls. Hi. IMP. FET. I/P. suitable Mid. Guitar. Radio. Crystal/Ceramic P.U. Sensitivity 4mV. Treble +35dB at 16kHz. Mid +20 −15dB at 1Hz. Bass +20 −10dB at 40Hz. **£4·90**

VA06 Vol. Treble and Bass controls. Sensitivity 8mV. Treble +28 −15dB at 12kHz. Bass +18dB at 40Hz. **£4·15**

Stockists, Callers only

ARTHUR SALLIS LTD, 28 Gardner St, BRIGHTON, Sussex. Tel. 65806
BRISTOL DISCO CENTRE, 86 Stokes Croft, BRISTOL 1. Tel. 41666
SOCODI, 9 The Friars, CANTERBURY. Tel. 60948
CALBARRIE AUDIO, 88 Wellington St, LUTON. Tel. 411733
A.1 MUSIC CENTRE, 88 Oxford St, MANCHESTER. Tel. 236 0340
DAMON ELECTRONICS, 99 Carrington St, NOTTINGHAM. Tel. 53880
MITCHELL ELECTRONICS, 64 Winchester St, SALISBURY. Tel. 23689
WEC LIGHTING, 35 Northam Road, SOUTHAMPTON. Tel. 28102

A WORLD FIRST* FROM CAMBRIDGE AUDIO



THE NEW P60 INTEGRATED STEREO AMPLIFIER

Low profile design only 2″ high.
Recording with or without tone correction.
*Peak level indicator for tape recording.
Suitable for continual high power operation.
Dual independent tape operation.
*Light Emitting Diodes for level monitoring in main and pre-amplifiers.
Toroidal mains transformer.
Facilities for three tape recorders.
*Separate main and pre-amp gain controls.
Fully protected output stages.
RIAA phono correction unaffected by cartridge inductance.
Ultra low distortion circuits.
*New tape monitoring, A-B and A-B-C facilities.
International state-of-the-art circuitry from Cambridge Audio in Britain.

*To the best of our knowledge these features have never been included in a comparable amplifier hitherto.

Cambridge Audio

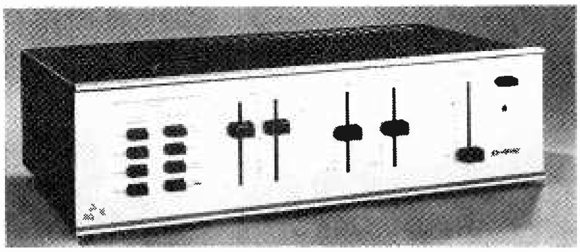
for people who listen to music

Cambridge Audio Limited
The River Mill, St. Ives, Huntingdon PE17 4EP
Telephone: St. Ives 62901

Please send me details of the revolutionary New Cambridge P60 Integrated Stereo Amplifier.
Name
Address
WW 25

A NEW STANDARD FOR SOUND REPRODUCTION

HD250 High Definition Stereo Control Amplifier



Designed for disc and tuner input and two tape machines, with complete recording and reproducing facilities.

The HD250 amplifier establishes a new standard in amplifiers for sound reproduction in the home. Improvements have been made in respect of performance, engineering design and quality of construction. We believe that no other amplifier in the world can match the overall specification of the HD250. Look at extracts from the specification below.

Power output.
Rated: 50 watts average continuous power per channel, into any impedance from 4 to 8 ohms, both channels driven.
Maximum: 90 watts average power per channel into 5 ohms load.

Distortion.
Pre-amplifier: Virtually zero. (Cannot be identified or measured as it is below inherent circuit noise.)
Power amplifier.
at rated output: Less than 0.02% (typically 0.01% at 1kHz).
at 25w output: Typically 0.006%.

Overload margin.
Disc input 40 dB min.

Hum and noise output.
Disc: —83dBV Measured flat with noise bandwidth of 23kHz (ref. 5mV.)
—88dBV Measured with 'A' weighted characteristic (ref. 5mV.)
Line: —85dBV Measured flat (ref. 100mV.)
—88dBV 'A' weighted (ref. 100mV.)
Size: 17 inches × 4¾ inches × 11 inches deep overall.
Weight: 21 lb.

Write or phone for leaflet which describes the design philosophy and conception of the HD250 together with a complete specification.

RADFORD AUDIO LIMITED, BRISTOL, BS3 2HZ Telephone: 0272 662301

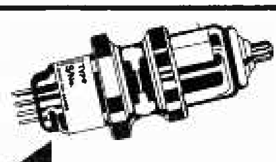
WW—060 FOR FURTHER DETAILS

DIOTESTOR IN-CIRCUIT TRANSISTOR TESTER

BRITEC LIMITED, 17 Devonshire Road, London SE23 3EN
Tel: 01-699 8844 Telex: 896161

WW—137 FOR FURTHER DETAILS

AEL



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A new service from one of the largest United Kingdom exporters of tubes and semiconductors

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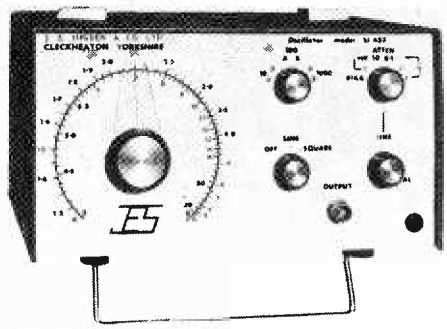
WW—107 FOR FURTHER DETAILS



JES AUDIO INSTRUMENTATION

Illustrated the Si453 Audio Oscillator

SPECIAL FEATURES:

★ very low distortion content—less than 0.03%
★ an output conforming to RIAA recording characteristic
★ battery operation for no ripple or hum loop
★ square wave output of fast rise time

£50·00

also available

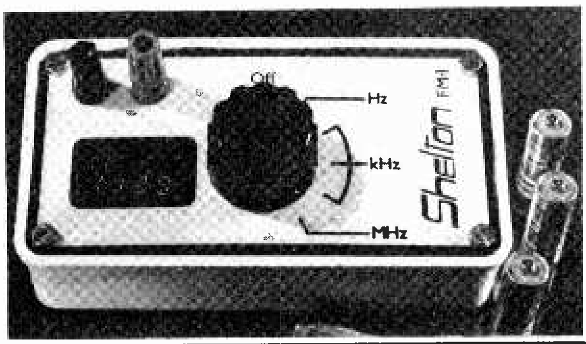
Si451 Millivoltmeter
★ 20 ranges also with variable control permitting easy reading of **relative** frequency response. **£42·50**

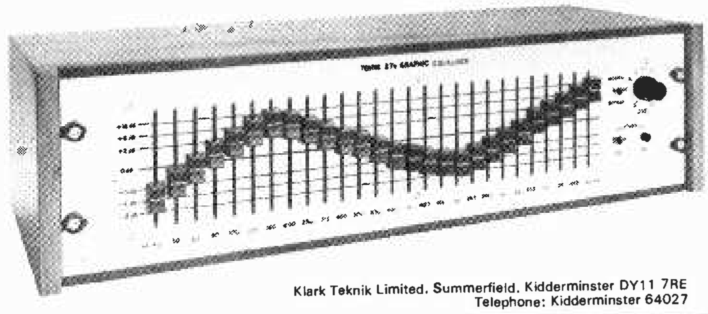
Si452 Distortion Measuring Unit
★ low cost distortion measurement down to 0·01% with comprehensive facilities including L.F. cut switch, etc. **£35·00**

ALL PRICES PLUS VAT

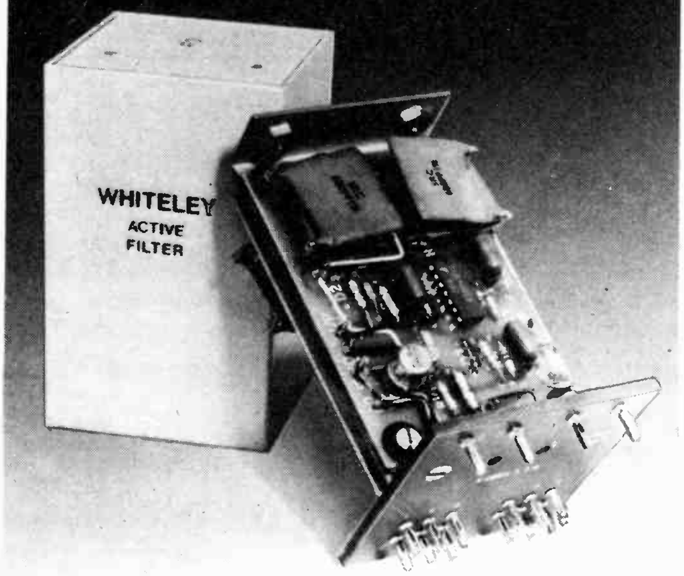
J. E. SUGDEN & CO. LTD., CARR STREET, CLECKHEATON, YORKS. BD19 5LA. **Tel: 09762-2501**

WW—031 FOR FURTHER DETAILS


Off
Hz
kHz
MHz
Shelton FM1



New active filter takes over from passive networks



These active filters are designed to take over the functions of passive filter networks in audio telecommunications systems. They offer several advantages, in space – saving, economy and reliability.

As a size comparison, one active filter will take up the same space as two Post Office Type 3000 relays. By using the same fixing and terminal holes as the relays, it offers an extra convenience when baseboards are being prepared. By replacing inductive components with solid state devices, filter characteristics have been obtained at less cost, without insertion loss, and with increased flexibility and economy. These new active filters have B.P.O. approval, and have wide applications, in the audio area and in signalling and control systems.

Whiteley

versatility...

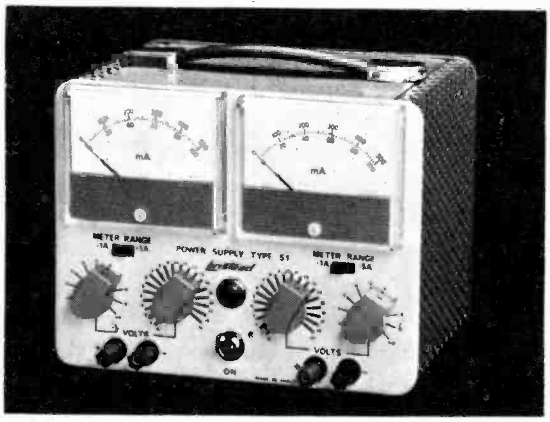
ELECTRONIC & ELECTRICAL DESIGN
PRODUCTION CAPABILITY
CABINET MAKING
SHEET METAL FORMING/FINISHING
PLASTICS MOULDING
ENCAPSULATION

WHITELEY ELECTRICAL RADIO CO. LTD.
Mansfield, Notts, England. Tel. Mansfield 24762
London Office: 109 Kingsway, W.C.2. Tel. 01-405 3074

WW—042 FOR FURTHER DETAILS

Linstead Twin Stabilised Power Supplies

Each comprising:
Two powerful bench supplies.
Continuously variable.
Independently operable, or in series, or parallel.
Fully protected against overload and short circuit.
In one compact robust case.



S1

2 x 0 to 20V 0 to 0.5A
with twenty 1 volt steps and fine control.
Voltage set by controls.
Current continuously monitoreu, 0 to 100mA, 0 to 0.5A.
Current limiting protection.

£78.80 plus VAT

S7

2 x 0 to 30V 0 to 1A.
Set by switches and fine control.
Meters switchable for volts,
0 to 100mA and 0 to 1A.
Re-entrant protection. Pilot indication of overload.

£87.70 plus VAT

Linstead
the best for less
BRITISH MADE BY LINSTEAD
Linstead Electronics, Roslyn Works, Roslyn Road London N15 5JB. Telephone 01-802 5144

Ireland, Lennox Laboratory Supplies Ltd., 3-4 South Leinster Street P.O. Box 212A, Dublin 2
Denmark, Scanfysik, 13-15 Hjorringgade, DK 2100, Copenhagen
Sweden, EMI Svenska A/B, Tritonvagen 17, Fack, 171 19 Solna 1
Norway, EMI Norsk A/S, Postboks 42 Korsvoll, Oslo 8
Malaysia, Laboratory Equipment Sdn. Bhd., P.O. Box 60, Batu Pahat
Benelux, A.S.E. Ltd., Nationalestreet 38, B-2000 Antwerp

WW—057 FOR FURTHER DETAILS

100% MODULAR

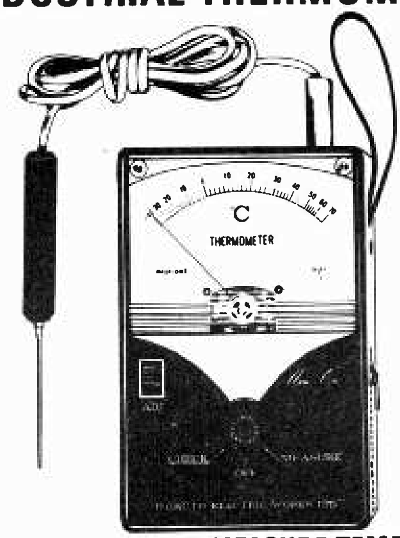
SOLID STATE TELEVISION MONITORS

MODTEC solid state Series M monitors offer the most advanced design in video monochrome monitors available to date. 800 line resolution provides crisp, detailed pictures. The 100% modular chassis consists of five individually shielded circuit modules that plug in directly from the rear of the chassis. This unique and exclusive feature simplifies and speeds necessary maintenance with minimum down time. All plug-in circuit modules are common to 9, 12, 15, 19, and 23" CRT's.

LEE ENGINEERING LIMITED
Ashley House, Ashley Road
Walton-On-Thames, Surrey KT12-1JE
Phone: Walton-On-Thames 287-83/4
Telex: 928-475

WW—135 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

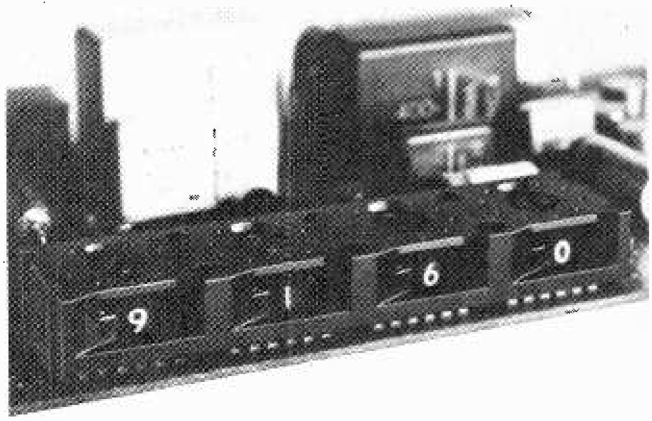
A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop, Probe, and internal 1½ volt standard size battery.

Model "Mini-On 1" measures from − 40°C to + 70°C, price £17.50
Model "Mini-On Hi" measures from + 100°C to + 500°C, price £20.00 (V.A.T. EXTRA)

Write for further details to

HARRIS ELECTRONICS (LONDON),
138 GRAY'S INN ROAD, LONDON WC1X 8AX
('Phone 01-837 7937)

WW—094 FOR FURTHER DETAILS



NOW!
a thumb switch for direct PC mounting

EECo STRIPSWITCH

The Series 21 Stripswitch which is available in units comprising up to six stations is mounted directly to the printed circuit board. The switch solder tabs are used to provide the mechanical mounting to the circuit board and also the interconnection between the switch and the printed circuit.

Series 21 switch assemblies may be mounted horizontally or vertically and on either side of a P.C. board. The bezels offer a finished appearance if the switches are exposed through the equipment panel. Toothed wheels provide for a rapid setting of the switch positions but the Series 21 may also be used as a preset screwdriver operated switch. Knurled shafts which are available on request provide an alternative means of a rapid setting.

WAYCOM LIMITED
Wokingham Road, Bracknell, Berks RG12 1ND
Tel: Bracknell 22751 Telex: 848402

WW—140 FOR FURTHER DETAILS

MAPLIN ELECTRONIC SUPPLIES

Get your 1975 CATALOGUE!

Includes dozens of useful and interesting circuits you can build; data; hundreds of pictures, transistor equivalents list and hundreds of new lines. Packed with information. Only 35p

SUPERSONIC SAME-DAY-SERVICE - MEANS QUALITY COMPONENTS - FAST!

● RESISTORS

CARBON FILM
$\frac{1}{4}$W 1Ω to 1M : 5%, IM2 to 10M : 10% E12
$\frac{1}{2}$W 1Ω to 10Ω : 5%, IM2 to 10M : 10% E12
1Ω to 910k : 5% E12 & E24 **1p** each.

METAL OXIDE
$\frac{1}{2}$W 10Ω to 1M : 2% E12 & E24 **4p** each

WIREWOUND
3W 0.22Ω, 0.27Ω, 0.33Ω, 0.47Ω : 10%
1Ω:5% **17p** each
1.2Ω to 270Ω:5% E12 **13p** each

Other ranges stocked. See our catalogue for details.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and decades.
E24: 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and decades.

● POTENTIOMETERS



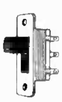
Rotary miniature carbon track $\frac{1}{4}$" spindle. Values available: 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1M, 2M.
Log. signle-gang **16p**. Lin. single-gang (+1k) **16p**
Log. or Lin. single-gang with switch **33p**
Log. or Lin. dual-gang without switch **49p**
Slider 60mm track. Metal-cased: overall length 86.15mm less knob (7p extra).
Log. or Lin. single-gang 1k, 5k, 10k, 25k, 50k, 100k, **36p** each.
Log. or Lin. dual-gang 1k, 5k, 10k, 25k, 50k, 100k, **45p** each.
Presets: 0.1W vertical or Horizontal.
100Ω, 220Ω, 470Ω, 1k, 2k2, 4k7, 10k, 22k, 47k, 100k, 220k, 470k, 1M **7p** each.

● CAPACITORS

Sub-miniature
Axial lead electrolytic

Mfd	V	Price	Mfd	V	Price	Mfd	V	Price
1	63	6p	68	6.3	6p			
1.5	63	6p	68	16	6p			
2.2	63	6p	68	63	14p			
3.3	63	6p	100	4	6p			
4.7	63	6p	100	10	6p	470	6.3	6p
6.8	40	6p	100	25	6p	470	10	14p
6.8	63	6p	100	40	6p	470	25	16p
10	25	6p	100	63	16p	470	40	25p
10	63	6p	150	6.3	6p	680	6.3	14p
15	16	6p	150	16	6p	680	16	16p
15	40	6p	150	25	6p	680	25	25p
15	63	6p	150	40	14p	680	40	28p
22	10	6p	150	63	16p	1000	4	14p
22	25	6p	220	4	6p	1000	10	16p
22	63	6p	220	10	6p	1000	16	25p
33	6.3	6p	220	16	6p	1000	25	28p
33	16	6p	220	25	14p	1500	6.3	16p
33	40	6p	220	40	16p	1500	10	25p
47	4	6p	220	63	25p	1500	16	28p
47	10	6p	330	4	6p	2200	6.3	25p
47	25	6p	330	10	6p	2200	10	28p
47	40	6p	330	16	14p	3300	6.3	28p
47	63	6p	330	63	28p	4700	4	28p

● SWITCHES



Rotary adjustable stop. 1 pole, 2 to 12 way; 2 pole, 2 to 6 way; 3 pole, 2 to 4 way; 4 pole, 2 or 3 way **36p** each.
Slide Sub-min. DPDT **9p**
Slide min. DPDT **13p**
Push to make non-locking SPST **14p**
Push-on, push-off locking DPDT 250V 4A **48p**
Rocker white DPST 250V 10A **40p**
Rotary mains DPST 250V 2A **20p**
Toggle with ON/OFF plate DPDT 250V 1.5A **25p**

BCD OUTPUT SLIDE SWITCH
Marks the end of the old-fashioned thumb-wheel switch. With 7-segment type read-out. Full details in our catalogue **£1.38**

● TRANSISTORS & DIODES

AC127	18p	BFY52	20p
AC12B	18p	BY126	13p
AC176	17p	BY127	13p
AD161/		BY164	49p
162MP	93p	BZYB8	
BA100	9p	series	13p
BA145	22p	MPF102	36p
BC107	10p	OA91	6p
BC10B	10p	OA200	7p
BC109	13p	OC71	20p
BC109C	15p	SC146D	88p
BC142	23p	T1S43	28p
BC143	26p	WO05	30p
BC147	10p	WO4	33p
BC148	10p	1N914	4p
BC149	12p	1N4001	6p
BC16BC	12p	1N4002	6½p
BC169C	12p	1N4003	7p
BC178	17p	1N4004	7½p
BC182L	10p	1N4005	8p
BC183L	12p	1N4006	8½p
BC1B4L	12p	1N4007	9p
BC212L	14p	1N414B	4p
BC213L	15p	2N1302	20p
BC214L	18p	2N1303	20p
BCY71	22p	2N1304	30p
BD131	45p	2N1711	24p
BD132	54p	2N2219	25p
BD131/		2N2646	45p
BD132MP		2N2905	33p
	£1.20	2N2926 Or.	
BD135	36p	Ye. or Gn	10p
BD139	49p	2N3053	18p
BD140	69p	2N3055	49p
BF258	35p	2N3819	22p
BF259	25p	2N5459	51p
BFX29	30p	7400	16p
BFX30	33p	7413	39p
BFX84	30p	7447	£1.10
BFX85	36p	7473	54p
BFX87	30p	7474	45p
BFX88	25p	7490	93p
BFY50	20p	7493	93p
BFY51	22p	74121	39p

L.E.D. RED.
2mcd $\frac{1}{4}$" only **15p**
Panel mtg. clip **5p**
(Other colours and 7-seg. displays in our catalogue.)

● INTEGRATED CIRCUITS

CA3046 (14-pin DIL) **69p**
LHOO42CH (TO99) **£4.25**
MC1310P (14-pin DIL) **£2.50**
MC1496 (UA796) (14-pin DIL) **95p**
MFC4000B **59p**
MFC6040 **83p**
NE555V (8-pin DIL) **65p**
SG1495 (14-pin DIL) **£2.70**
SG3402 (14-pin DIL) **£1.69**
μA741C (B-pin DIL) **36p**
(14-pin DIL) **45p**
μA747C (14-pin DIL) **£1.05**
μA748C (8-pin DIL) **39p**
ZN414 (TO18) **£1.20**

VOLTAGE REGULATORS
μA7805 5V 1.5A (TO3) **£2.30**
μA7815 15V 1.5A (TO3) **£2.30**
MVR 5V, 15V, 500mA (TO3) **£1.60**
μA78M05 5V 100mA (Plastic power) **£1.30**
μA78MO5 15V 500mA (plastic power) **£1.30**
μA78LO5 5V 100mA (TO92) **60p**
μA78L15 15V 500mA (TO92) **60p**
μA723C variable 2 to 37V (TO99) or 14-pin DIL) **75p**
Our catalogue contains application circuits and data for all the above I.Cs and many more.

● DISCOUNTS ●

Details in our catalogue. Start collecting MES Discount Vouchers NOW!

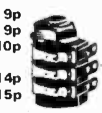
● PLUGS AND SOCKETS

DIN	PLUG	CHASSIS SOCKET
2-pin	8p	6p
3-pin	9p	7p
4-pin	10p	7p
5-pin A(180°)	10p	7p
5-pin B(240°)	10p	7p
6-pin	10p	9p

JACK PLUGS

2.5mm plastic barrel	9p
2.5mm metal barrel	15p
3.5mm plastic barrel	9p
3.5mm metal barrel	15p
$\frac{1}{4}$in. std. mono plastic barrel	13p
$\frac{1}{4}$in. std. mono metal barrel	24p
$\frac{1}{4}$in. std. stereo plastic barrel	18p
$\frac{1}{4}$in. std. stereo metal barrel	30p

JACK CHASSIS SOCKETS



2.5mm open-type metal	9p
3.5mm open-type metal	9p
$\frac{1}{4}$in. std. mono open-type metal	10p
$\frac{1}{4}$in. std. mono moulded with 2 break contacts	14p
$\frac{1}{4}$in. std. stereo open-type metal	15p
$\frac{1}{4}$in. std. stereo moulded with 3 break contacts	18p

PHONO

Plastic-topped plug	5p
Screened plug	12p
Chassis socket single	4p
Chassis socket twin	6p

● MAINS CONNECTORS

P360 3-pin 1.5A chassis plug with line socket **30p**
SA2190 3-pin 5A chassis plug **22p**
SA1862 Line socket for SA2190 **25p**
P437 3-pin 5A chassis socket with line plug **55p**

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(Size both approx. 30×27×25mm)
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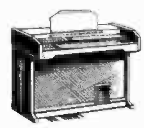
● ORGAN CONSTRUCTION

A Full-Scale Electronic Organ that you can build to your own specification.

FULL CONSTRUCTIONAL DETAILS IN OUR LEAFLETS



Leaflet MES 51: price **15p**, describes a fully polyphonic basic organ which can later be used as the basis of a large sophisticated instrument.
Leaflet MES 52: price **5p**, continues the description of the MES 50 series organs and shows you how to add a second keyboard with lots more stops.
Further leaflets to follow at approx. two-monthly intervals.

● THE AMAZING DM02

A ready-built, tested and guaranteed digital master oscillator. Accurately generates the top 13 notes for your organ system and reduces the complete tuning of your organ to ONE SIMPLE adjustment. New design gives selectable C to C output ranges of (approx.) 4k to 8k (highest) or 2k to 4k or 1k to 2k, etc., right down to 16Hz to 32Hz! And this new compatible design is even smaller: only 3.5in.×3.7in., including gold-plated edge connexion.
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Sloping-front 61-note C to C	£20.44
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*Spring line unit (short)	£3.05
*Spring line unit (long)	£7.59
*Reverberation driver module	£5.34

*S.a.e. please, for full details: leaflet MES 24.
Gold-clad phosphor-bronze wire **30p** per yd.
Palladium earth bar **15p** per octave length
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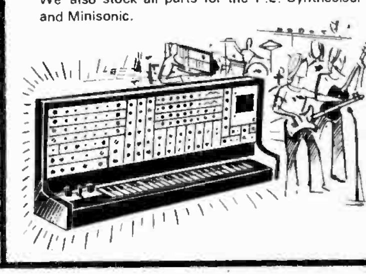

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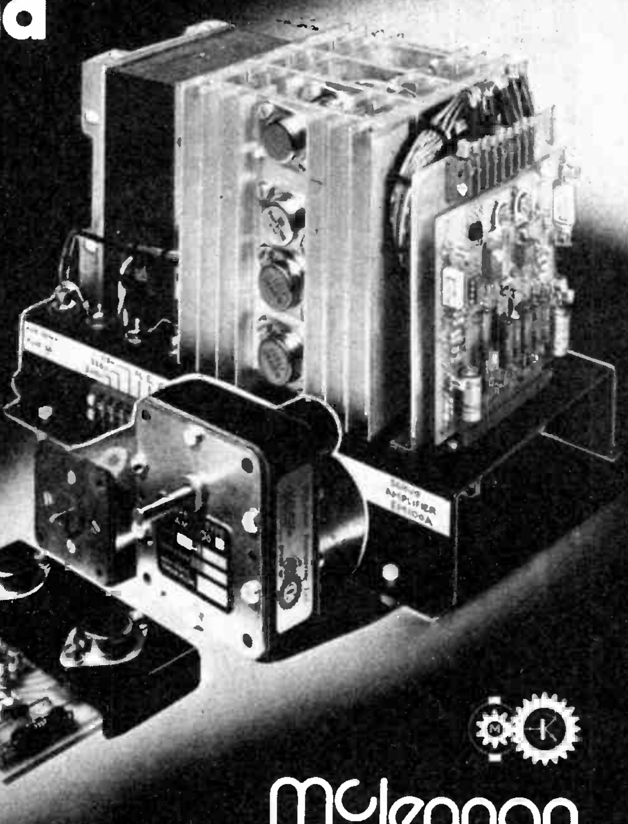

McLennan

McLennan Engineering Ltd
Kings Road, Crowthorne, Berkshire.
Tel: Crowthorne 5757/8

WW—106 FOR FURTHER DETAILS

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7402	16p	7440	20p	7490	52p
7403	22p	7441	75p	7492	68p
7404	18p	7442	70p	7493	55p
7405	25p	7445	216p	74100	200p
7406	42p	7447	95p	74107	45p
7407	42p	7448	120p	74121	34p
7408	20p	7450	20p	74122	76p
7409	28p	7451	20p	74141	85p
7410	16p	7460	20p	74142	200p
7412	30p	7470	30p	74145	150p
7413	28p	7472	30p	74160	160p
7414	90p	7473	36p	74161	160p
7416	33p	7474	34p	74184	225p
7417	38p	7475	52p	74185	225p
7420	16p	7476	37p	74190	220p
7422	25p	7480	65p	74191	220p
7425	37p	7482	87p	74192	220p
7427	37p	7483	120p	74193	220p
7430	16p	7485	187p		

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NE560	High Phase Locked Loop	290p
NE562	High Phase Locked Loop with AM Demod	290p
NE562	High Phase Locked Loop with Vco	290p
NE565	Precision Phase Locked Loop	290p
NE566	Function Generator	200p
NE567	Tone Decoder	250p
709	Op. Am. with external compensation	26p
710	Differential Voltage Comparator	47p
741	Op. Am. with internal compensation	28p
747	Dual 741	70p
748	Op. Amp. with external compensation	38p
ICL8038	Voltage-Controlled Oscillator	290p

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	50V	100V	400V	600V
250mA	16p	—	—	—
1 Amp	20p	21p	24p	25p
2 Amp	30p	35p	45p	48p
4 Amp	47p	48p	60p	70p
6 Amp	55p	60p	78p	98p

SCR—THYRISTORS

	50V	100V	400V	600V
1 Amp	42p	48p	60p	78p
3 Amp	43p	49p	78p	100p
7 Amp	—	80p	84p	115p
16 Amp	—	82p	98p	—

Other
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10 Amp	109p	154p	165p
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OA70	9p
OA79	10p
OA81	8p
OA85	10p
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OA91	7p
OA95	7p
OA200	8p
OA202	10p
1N914	4p
1N916	6p
1N4148	4p

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BY126	12p
BY127	12p
BY133	15p
BYZ10	38p
BYZ11	35p
BYZ12	33p
BYZ13	38p
1N4001	5p
1N4004	6p
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PL4004	10p
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LED
TIL209 18p

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3.3V to 33V

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10W	40p
20W	65p

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AC 127	9p	8p
AC 128	9p	8p
AC 128/AC 176 m.p.	18p	16p
AC 176	9p	8p
AC 187	10p	9p
AC 188	9p	8p
AF 114	11p	10p
AF 115	11p	10p
AF 117	11p	10p
BC 109C	9p	8½p
BC 147B	6p	5p
BC 148B	6p	5p
BC 149C	7p	6p
2N 2926 (TO-106) R B O	6p	5p
2N 2926 (TO-106) G Y	7p	6p

The above offers are for a limited period only AND subject to present stocks being available.

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OCP71	65p
2N5777	50p

Light Dependent Resistors

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ORP60	55p
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Seven Segment Displays
3015F (Filament) 120p MAN-3M (LED) 120p

TGS GAS SENSOR

Semiconductor 200p
Data Sheet 10p

Transistors

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AC126	11p	BC137	17p	BD132	45p	BFY50	14p	OC81	12p	2N1306/7	28p	2N4059	10p
AC127	11p	BC138	17p	BD153	65p	BFY51	14p	OC82	12p	2N1308/9	28p	2N4060	13p
AC128	11p	BC142	35p	BD156	60p	BFY52	14p	OC83	18p	2N1613	20p	40360	35p
AC141	18p	BC143	35p	BDY60	75p	BSX19	16p	OC84	18p	2N1711	20p	40361	36p
AC142	18p	BC147	7p	BDY61	65p	BSX20	16p	OC200	50p	2N2218	21p	40362	38p
AC176	11p	BC148	7p	BF115	22p	BSX21	22p	OC201	50p	2N2219	20p	40409	50p
AC187	12p	BC149C	8p	BF167	23p	BU105	220p	TIP41A	70p	2N2220	19p	40410	50p
AC188	11p	BC157	14p	BF170	23p	MJ490	95p	TIP42A	88p	2N2221	20p	40411	200p
AD140	46p	BC158	12p	BF173	25p	MJ491	130p	ZTX107	12p	2N2222	20p	40594	65p
AD142	55p	BC159	14p	BF177	26p	MJE340	45p	ZTX108	10p	2N2369	14p	40595	75p
AD143	50p	BC169C	12p	BF178	28p	MJE370	72p	ZTX109	13p	2N2484	30p	40600	69p
AD149	43p	BC171	12p	BF179	33p	MJE371	84p	ZTX300	14p	2N2904	20p	FETs	
AD161	36p	BC177	18p	BF180	33p	MJE520	68p	ZTX301	14p	2N2905	18p	BF244	36p
AD162	36p	BC178	17p	BF181	33p	MJE521	80p	ZTX302	18p	2N2906	20p	MPF102	31p
AF114	13p	BC179	18p	BF182	33p	MJE2955	90p	ZTX303	15p	2N2926RB	7p	MPF103	31p
AF115	13p	BC182	10p	BF184	22p	MJE3055	65p	ZTX304	24p	2N29260	8p	MPF104	31p
AF116	13p	BC183	10p	BF185	22p	MPSA12	50p	ZTX500	15p	2N2926YG	9p	MPF105	31p
AF117	13p	BC184	11p	BF194	11p	MPSA06	30p	ZTX501	15p	2N3053	18p	2N3819	20p
AF118	50p	BC212	11p	BF195	12p	MPSA56	32p	ZTX502	19p	2N3054	45p	2N3820	57p
AF121	33p	BC213	10p	BF196	14p	MPSU06	62p	ZTX503	45p	2N3055	40p	2N3823	60p
AF124	30p	BC214	14p	BF197	15p	MPSU56	78p	2N404	26p	2N3441	80p	2N5457	31p
AF125	30p	BC237	12p	BF200	32p	OC26	40p	2N696	15p	2N3442	140p	2N5458	31p
AF126	30p	BC238	11p	BF257	32p	OC28	55p	2N697	13p	2N3702/3	11p	2N5459	31p
AF127	30p	BC239	12p	BFR39	30p	OC35	48p	2N698	30p	2N3704/5	11p	MOSFETs	
AF139	33p	BC307	11p	BFR40	30p	OC36	52p	2N706	12p	2N3705/6	10p	3N140	85p
AF181	45p	BC308	11p	BFR41	30p	OC41	15p	2N708	18p	2N3707	11p	3N141	75p
AF186	48p	BC309	12p	BFR79	30p	OC42	15p	2N914	18p	2N3708/9	9p	40603	58p
AF239	38p	BCY70	18p	BFR80	30p	OC44	11p	2N918	40p	2N3771	170p	40673	80p
BC107	9p	BCY71	22p	BFR81	30p	OC45	11p	2N929	20p	2N3772	180p	UJTs	
BC108	9p	BD115	55p	BFX29	30p	OC70	11p	2N930	18p	2N3773	240p	TIS43	26p
BC109	10p	BD121	100p	BFX30	30p	OC71	11p	2N1131	18p	2N3866	70p	2N2160	80p
BC115	20p	BD123	100p	BFX84	26p	OC72	11p	2N1132	18p	2N3903/4	15p	2N2646	34p
BC135	17p	BD124	65p	BFX87	20p	OC73	50p	2N1302/3	17p	2N3905/6	15p	2N4871	31p

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MC1310	Coilless FM Multiplex Decoder	245p
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TBA800	5 Watt Audio Amplifier	100p
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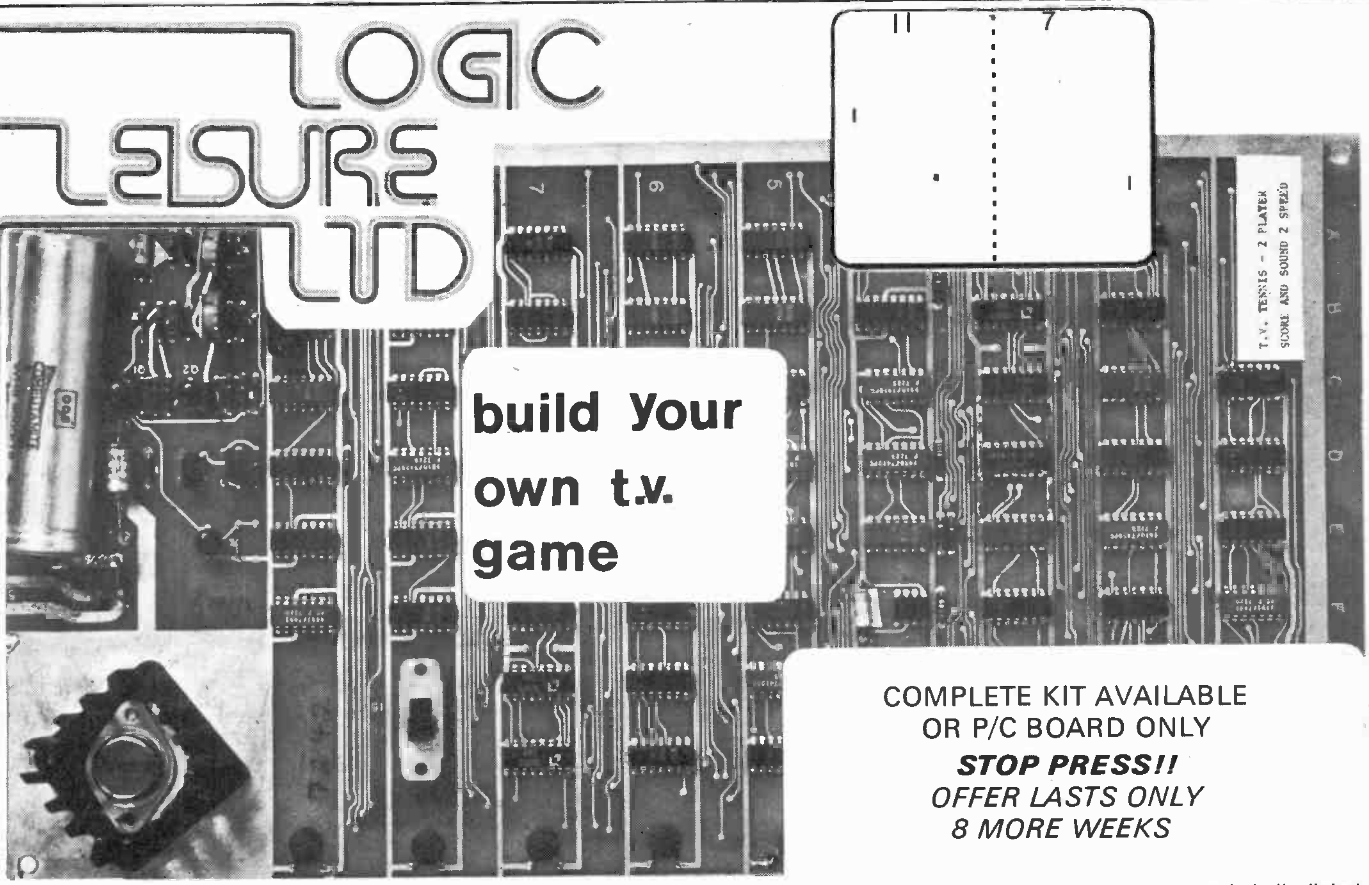

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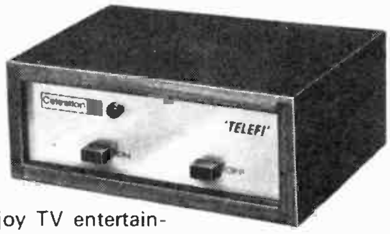
Eliminate TV receiver distortion with Celestion *TELEFI*



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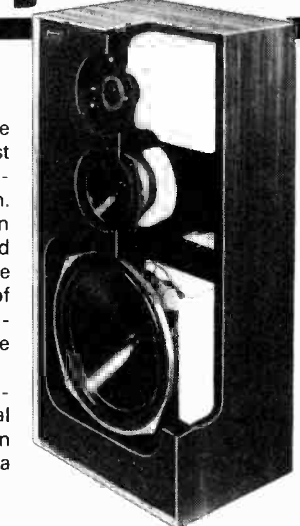
At last you can enjoy TV entertainment with the added pleasure of true Hi-Fi sound. Telefi is a unique electronic invention which picks up VHF from the TV and relays this through your own Hi-Fi equipment. Telefi ensures crisp, full-range, distortion-free reproduction of music and speech providing an improvement over ordinary TV sound which will amaze you. Telefi is safe and requires no permanent connection to the TV set. Telefi is indispensable to the TV viewer who requires Hi-Fi TV sound.

"As selected for The Design Centre, London".

LOUDSPEAKERS



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WW—059 FOR FURTHER DETAILS

RADFORD

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Specification:

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Output voltage:	10 volts r.m.s. max.
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Output attenuation:	0–100dB (eight, 10dB steps plus 0–20dB variable)
Output attenuation accuracy:	1%
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Price: 150 ohms unbalanced output: £250
150/600 unbalanced/balanced floating output: £300

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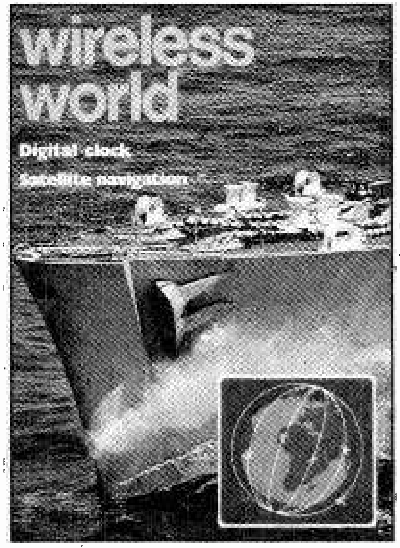

This month's front cover picture introduces the article on navigation by satellite in this issue and shows the polar orbits of the "Transit" satellites used in the system described.

IN OUR NEXT ISSUE

Simple f.m. tuner
Easy to build high quality design using commercial front end and new i.c. phase locked loop demodulator

Noise-confusion in more ways than one
Many special terms and ideas, seeming to have little in common, make it difficult to follow discussions about noise. This article looks at some of the basic ideas and prepares the ground for later articles

Using video tape recorders with domestic TV
The interface between video tape recorders and domestic receivers is examined, together with changes in receiver design to accommodate a reduced-quality video signal

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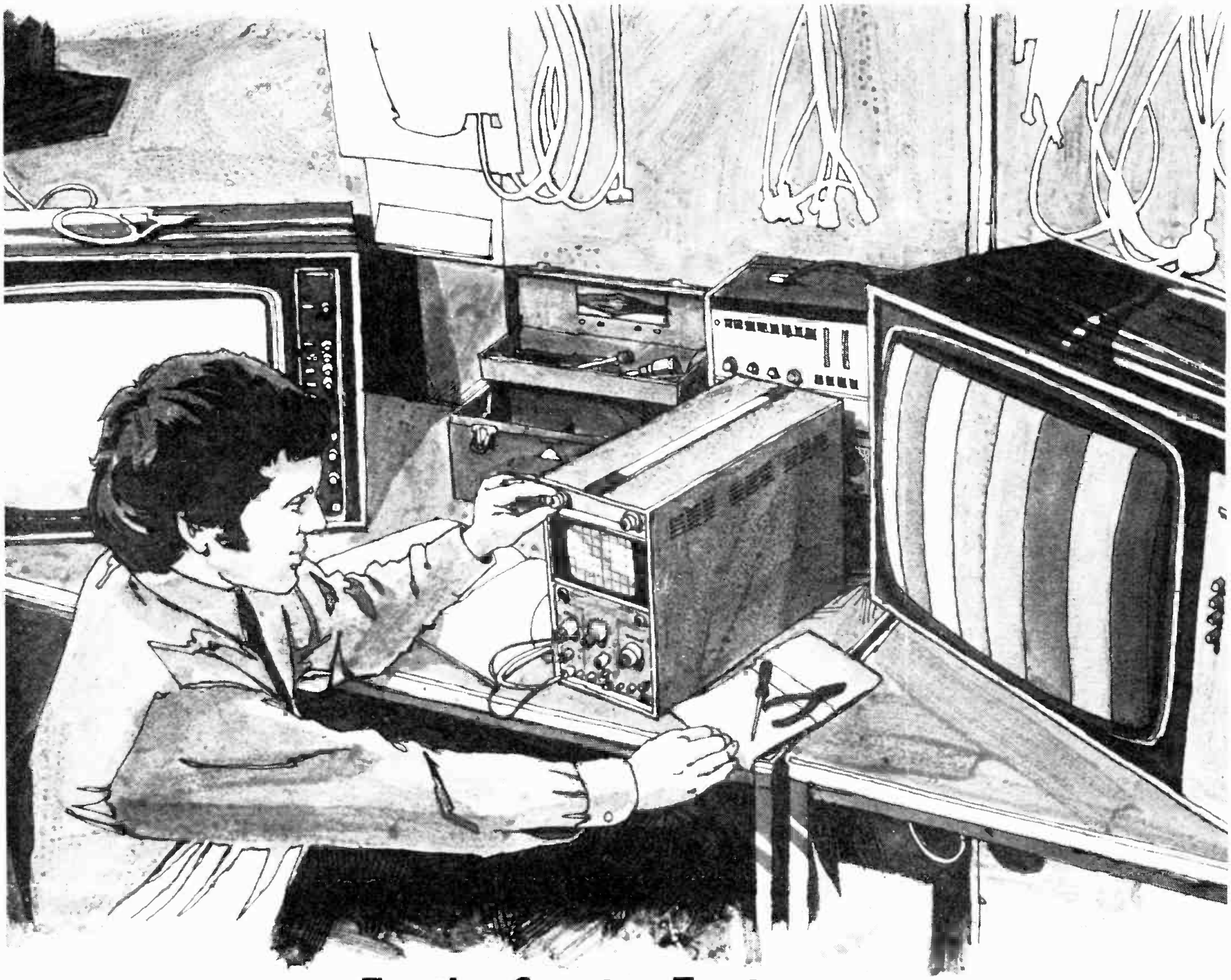

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Measuring what we perceive

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An electronic reproduction system does not end at the acoustic or visual transducer but at the human brain, passing information via the human sense organs. Considering this, it's surprising how little work has been done on the psychology of perception in relation to electronic systems. The most familiar psychometric tests are of course the subjective assessment of sound quality from loudspeakers and of picture quality from television displays. With loudspeakers the commonest method is to make comparisons between two speakers at a time and from these derive an order of rank of the speakers under test. With television systems graded scales are often used, giving either grades of picture quality from "excellent" to "bad" or grades of picture impairment from "imperceptible" to "unusable". The trouble is that there are so many methods in use—for example eight different scales for picture assessment. It's unlikely that we shall make any important progress in the psychometry of electronic systems until international standardization of techniques is achieved.

The greatest prize to be won by improved methods of subjective assessment is the correlation of the subjective evaluations with objective data obtained from measurements. The aim, of course, is to be able to measure quality—hitherto a human experience—by instruments. With television systems this is not too difficult because picture quality can be largely defined by the magnitudes of various effects (e.g. noise) seen on the screen—which acts as a kind of oscilloscope—and these effects have direct electrical counterparts. With audio systems, as everyone knows, it is much more difficult, especially as subjective judgements are complicated by aesthetic responses of liking and disliking certain characteristics of the sound. Recently, however, there has been an interesting piece of research in Denmark* which claims to have derived two "psychological dimensions" from experimental data obtained through listening tests on loudspeakers. These "dimensions" cannot be explained by the subjects but are nevertheless composed of groups of the 35 subjective qualities (e.g. "brilliant") used in the listening tests. Correlations are claimed to exist between the subjective judgements made under the two "dimensions" and the measured sound pressure, power and phase responses of the loudspeakers.

Standardization of psychometric tests is needed first of all in the test conditions (e.g. room lighting for television, room acoustics for audio). Secondly, it is needed in the method of selecting subjects (e.g. whether experts or laymen or both). Then of course there must be standardization of the qualities to be assessed and standard terms to describe them, translatable into different languages. We also need standardization of the grading of scales and of the numerical "scores" assigned to particular grades. Finally there should be standardization of the statistical methods used, for example, to determine the uncertainty of the subjective data and the dependence of this data on the subjects and on the "programme" material. Only when such stringent controls are applied will it be possible to establish relationships between the results of different workers and so achieve real progress.

*Staffeldt, Henrik, "Correlation between subjective and objective data for quality loudspeakers." *J. Audio Eng., Soc.*, vol. 22, no. 6 (1974).

Navigation by satellite

Ship position finding using hyperbolic system and Doppler shift provided by orbiting satellite u.h.f. transmitters

By W. Blanchard

Redifon Telecommunications Ltd

The US Navy's navigation satellite system, using five "Transit" satellites, has been in operation for some years. This article, after explaining the basic principles of the system, describes modern British ship-borne equipment for navigating by it and discusses accuracy and uses.

Many radio navigation systems have been proposed in the last 50 years; quite a few of them never got any further than the files of patent offices, while of those that were actually built only a small number gained recognition as useful adjuncts to the navigator's stock-in-trade. Just about all the possible combinations and permutations of land-based systems have been investigated at some time or another, or so it seems when one goes through the files, and the emergence of a radically different system is a very rare event.

Examination of systems in current use reveals that as range is extended or accuracy requirements increase the problems become severe, particularly where both these features are demanded simultaneously. Very high accuracy at very short ranges is possible; moderate accuracy at moderate ranges is relatively easy; rather poor accuracy at very long ranges is also possible; but to give very high accuracy at very long ranges is beyond the capabilities of existing land-based techniques. It is not difficult to see why this should be so. The earth is approximately spherical, and to achieve long ranges means that whatever radio frequency is used must be capable of following the curve of the earth's surface. Medium and low frequency ground-waves do this to some extent, but changes in ground conductivity have a perturbing effect that can ruin any pretentions to high accuracy, as well as making sure that the wave does not get very far anyway. Ionospherically-reflected sky-waves also can follow the curve, sometimes without any great attenuation for many thousand of miles, but now the great variation in the reflecting medium itself from hour to hour is the agency that prohibits any serious attempt at good accuracy. The highest accuracies are obtained by the use of radio frequencies sufficiently high to operate in the space-wave mode, which by definition cannot follow the earth's curvature and consequently have a very limited range. So the would-be designer of a world-wide high-accuracy system faces fundamental physical limitations that, until the advent of satellites, were insurmountable.

Satellites opened up new possibilities. Now it became possible to put u.h.f. transmitters out into space where they could "see" a large proportion of the earth's surface at one time, and the use of the virtually unperturbed space-wave from these transmitters allowed highly accurate measurements. It was not long before an experimental navigation satellite had been launched, and by 1964 the first complete system for marine navigation was in being.

Like so many other advances, the US Navy Navigation Satellite System (NNSS) did not happen as a result of an official committee being appointed to study the problem. Observation of the Doppler changes in the signals from the Russian Sputnik in 1957 ("Artificial satellites of the earth," *Wireless World*, December 1957, page 574) led to speculation that it should be possible to establish the position of the observer if the satellite orbit were already known, and preliminary experiments confirmed that this was indeed so. There were considerable practical problems in implementing the basic idea, one of them being the difficulty of designing an ultra-stable 5MHz frequency source for the satellite that would survive the launch and remain stable without human intervention for years afterwards. Naturally, if the satellite frequency was unstable, unpredictable apparent Doppler shifts would be measured by the receiver. The current satellites were designed as a result of lessons learnt in the earlier tests, and have proved to be very reliable. There are five of them, orbiting the earth at an altitude of about 600 miles. The satellites are in polar orbits, and the orbit planes are at angles of about 45° from each other.

One way of describing the principles of the NNSS system is by comparing it with the perhaps better-known hyperbolic radio systems, Loran, Omega, and Decca (see "Hyperbolic radio navigation systems" by F. S. Stringer, *Wireless World*, August 1969, page 353). In these the receiver establishes a difference of range between two transmitters by measuring the difference in time of reception of radio signals transmitted at precisely known intervals. It is usually assumed that the speed of radio wave propagation is known and therefore that time can be translated into distance (although this is not always a safe assumption in practice). The operational differences between these systems lie in the actual modes of transmission, the radiated frequencies, the format of the transmission, and the way in which the signals are detected and used in the receiver—the underlying principle always remaining the same. This fundamental principle also applies to satellite positioning systems. The earth-bound systems usually have little difficulty in locating their transmitters to a high degree of precision, but they have considerably more difficulty in translating time intervals into distances. Until comparatively recently it was impossible to know precisely, at a remote site, the exact time at which a transmitter emitted (say) a pulse, absolute time standards not being good enough. Direct range measurements could not be made, and a differential system requiring two transmitters was necessary. Because these two could only provide a single position line, the familiar triplet came into being to provide two position lines and hence a fix. Again, because difference of range was being measured the single position line was hyperbolic in form, and it was this that gave these systems their generic name. It should be noted that the familiar hyperbolae drawn on navigation charts are actually only the intersection of hyperboloids with the earth's surface, and if the receiver is not on the earth's surface the use of these hyperbolae can cause errors.

The same principles can be applied to satellite navigation by thinking of the satellite as a moving transmitter successively occupying the positions that the transmitters of a hyperbolic system might have used, as shown in Fig. 1. If the interval between the satellite's positions P_1 and P_2 is two minutes, then the "baseline" between P_1 and P_2 is about 960km, and a measurement of range difference between these points produces a hyperboloid exactly as for a ground system. The intersection of two or more hyperboloids will uniquely locate the receiver, not only on the earth's surface, but also in the vertical plane (although this last measurement is not particularly accurate). Obviously, considerably more than three satellite transmitter positions will be available and the resultant fix will be that much more accurate.

But some basic problems remain. How do we know where the satellite is every two minutes (or whatever interval we choose), and how do we measure these range changes?

Superficially, the determination of a satellite's orbit is not particularly difficult, at least to the degree of accuracy sufficient for pointing aerials, but when a fix accuracy measured in metres is required something rather better is necessary. In fact, four tracking stations in the USA are engaged solely on the job of continuously tracking all the five satellites, known as Transit satellites, in the system described here. The resultant orbital data is used to compute, for some 16 hours ahead, where each satellite will be every two minutes throughout this period—or rather to compute the orbital parameters that will enable these positions to be calculated. There would be a massive logistics problem if this data had to be distributed to all potential users world-wide and renewed every few hours —in fact it would be an impossible task. So it is arranged that the satellites themselves broadcast the data. A ground station injects into them their orbital parameters, where they are retained in a store and broadcast as phase modulation of the transmitted carriers. Because of the bumps and bulges on the earth's surface, which cause the satellites to follow a somewhat wobbly path, there are two sets of numbers: a "fixed" set, describing the basic Keplerian average orbit for the next 16-hour period, and a second "ephemeral" set which changes every two minutes and describes the variations from basic at each two-minute interval (Fig. 2).

The only other thing necessary for satellite position determination is accurate timing. With the satellite travelling at some $7\frac{1}{2}$km/s, a fraction of a second error could throw the fix out by several kilometres. It is still not possible to ensure precise absolute time world-wide to the required accuracy, so the satellite provides its own timing standard. Every two minutes it transmits a series of 23 digital ones, followed by a short burst of 400Hz audio modulation. The transition between these indicates an exact even minute of Greenwich Mean Time accurate to within 33μs, reducing the residual error from this source to the order of centimetres. This audio "beep" can be heard quite easily on the satellites' transmission and is an easy way of identifying the Transit satellites, as well as being a very accurate time check. The phase modulation is at a 50 bit/s rate, sounding rather like a subdued mains hum.

The only other measurement to be made is the difference of range. It might be possible to do this directly by using a pulsed

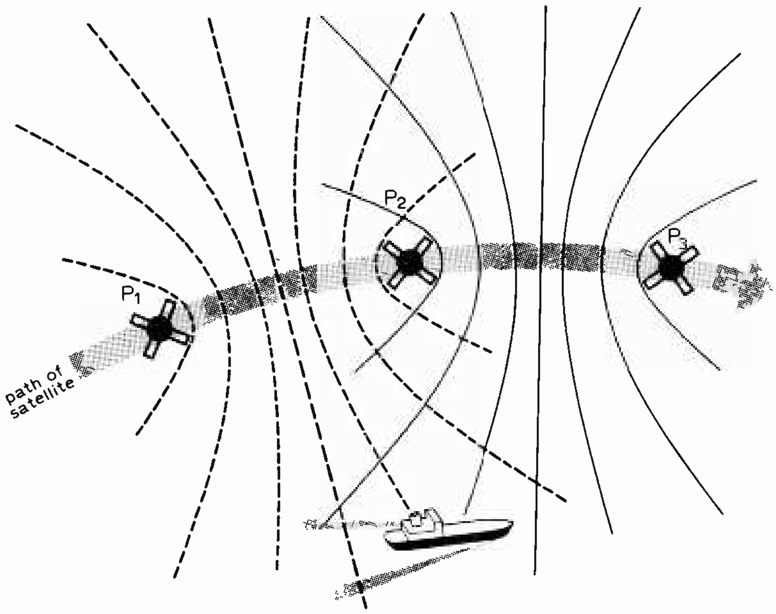


Fig. 1 Hyperbolae representing range differences measured in a ship between "transmitters" at P_1, P_2 and P_2, P_3, which are in fact successive positions of an orbiting satellite carrying a u.h.f. transmitter. Intersection of two (or more) hyperbolae locates the ship's receiver.

transmission but it would require the ground station mentioned above to transmit and would suffer the usual limitations of all such co-operative systems. If the ground station cannot transmit, the only course left open is to use the Doppler shift of the satellite's transmitted frequency. Since this is caused entirely by the motion of the satellite relative to the observer, integration over a fixed time period yields the necessary change of range measurement.

The requisites for this to work are that (a) the satellite's frequency does not drift appreciably over the measurement period, (b) the receiver's standard frequency reference does not either, and (c) the transmission path does not itself introduce any Doppler shift. Both (a) and (b) can be controlled to a sufficient degree

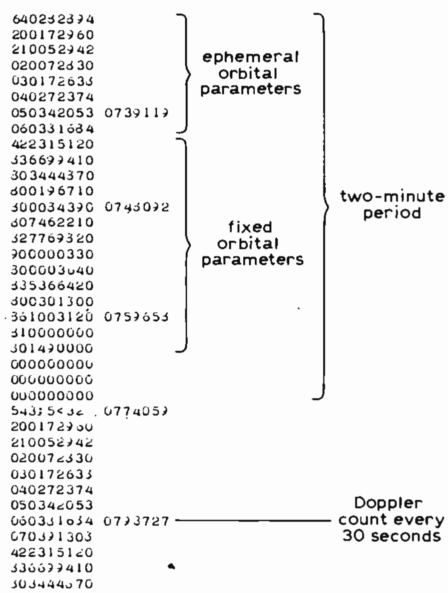


Fig. 2 Real-time printout of orbital parameters transmitted by a Transit satellite.

by careful design, but (c) cannot be controlled and is actually, for daylight satellite passes, the limiting factor on overall system accuracy. There are two causes of such unwanted shifts: an effect proportional to frequency caused by tropospheric bending, and an effect inversely proportional to frequency caused by the ionosphere. The tropospheric effect is unfortunately of the same character as the wanted Doppler shift, and cannot be separated from it, although a reasonable correction can be made by measuring local meteorological conditions and applying an empirical correction in the computing process. Fortunately, the effect is not very large and does not normally contribute more than a few tens of metres to the final fix error even without specific correction.

The ionospheric effect, which can cause much larger errors, is separable from the wanted shift provided that measurements on more than one frequency are available, and to this end the satellites transmit two frequencies. These two frequencies are controlled by the same reference oscillator and one is an exact multiple of the other (8/3). The actual frequencies transmitted are 400MHz offset by 32kHz (399.968 MHz), and 150MHz offset by 12kHz (149.988MHz). (The offsets are to prevent operation near nulls on crossovers, which would reduce the accuracy of the final Doppler count.) Under extreme conditions, a possible error of some 90 metres can be corrected in this way.

It is interesting to note that the correction falls to zero for most of the night hours, and hence the system is actually more accurate at night than by day—the reverse of most other radio navigation systems. When the system is being used only for normal marine navigation it is quite usual for only the 400MHz transmission to be utilized since, without highly accurate velocity sensors, the errors intro-

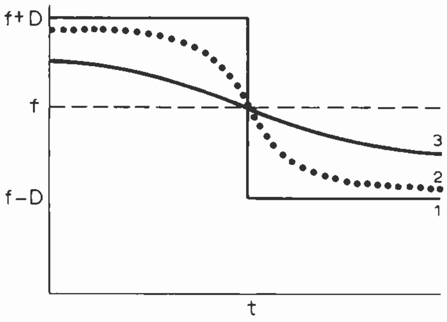


Fig. 3 Doppler shifts for observers at three different distances from the satellite's orbital path.

duced by unknown ships' motion will greatly outweigh ionospheric errors.

The actual Doppler shift to be expected on each of the two frequencies is not difficult to calculate for the extreme cases where the satellite is either directly approaching or receding from the observer. If the average orbital height is 600 miles (960km) then the orbital velocity will be about 7.37km/s, and since a frequency of 400MHz is a wavelength of 0.75 metre, the Doppler shift comes out at 9827Hz. At 150MHz it will be 3685Hz. If the observer were actually directly in the path of the satellite (equipped with a space suit, no doubt!) this shift would stay constant at all times, the only change being a sudden one from $f+D$ to $f-D$ as it passed him, as shown in graph 1 of Fig. 3. If he is a little farther away from the orbital path, the change would not be quite as sudden (graph 2) and farther away still it would start taking on the character of an S-shaped curve (graph 3), until in the limiting case where he is so far away that there is no change of range at all, the curve would be a straight line. There is obviously direct correlation between change of range and the shape of this curve.

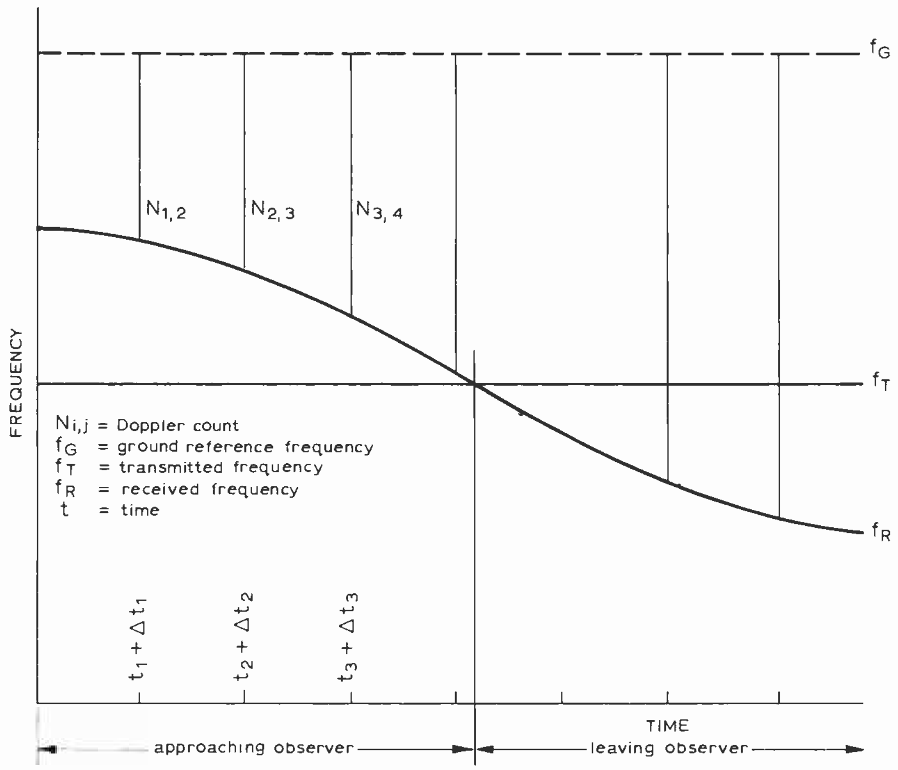


Fig. 4 Integrated Doppler count: f_T is the satellite's transmitted frequency; f_R the received frequency, f_G the ship's reference frequency; and $N_{1,2}$ etc. the Doppler count (t=time).

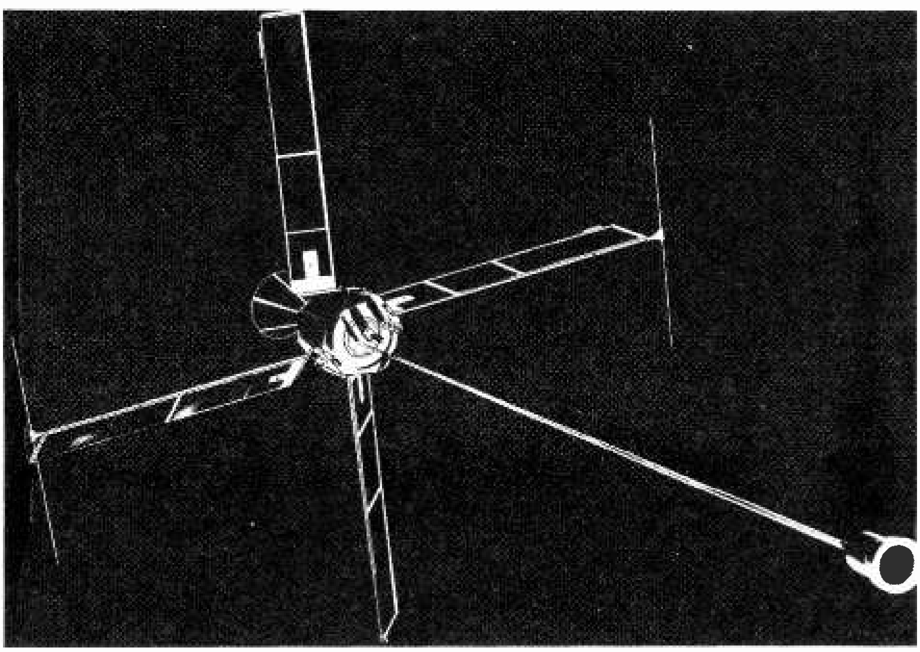


Fig. 5 Basic structure of a Transit satellite.

The transformation of these measurements into position is as follows:

The satellite transmits a stable frequency f_t which is received by the ship-borne navigator and designated f_r. This is compared to a stable local oscillator output frequency f_g to produce a frequency difference

$$\Delta f = f_g - f_r \qquad (1)$$

Fig. 4 indicates the relationship between the frequencies. Over any time interval the number of beat cycles of the frequency difference are counted and integration accomplished.

From Fig. 4, using the first two intervals:

$$N_{1,2}=\int_{t1+\Delta t1}^{t2+\Delta t2}(f_g-f_r)dt=$$

$$(f_g-f_t)(t_2-t_1)+f_g(t_2-t_1) \qquad (2)$$

On the assumption that $f_t=f_r$ then $N_{1,2}$ is the Doppler count corresponding to the first and second time marks. Further, the time difference $\Delta t_2-\Delta t_1$ is related to the slant range between satellite and receiver at P_1 and P_2:

$$t_2-t_1=\frac{1}{c}(S_2-S_1) \qquad (3)$$

where c = vacuum speed of e.m. waves
S_1 = slant range from ship to satellite at P_1
S_2 = slant range from ship to satellite at P_2

Substituting (3) into (2) and solving for the difference in distance from the user to satellite yields the effective baseline, i.e.

$$\Delta S_{1,2}=S_2-S_1=$$

$$\frac{c}{f_g}N_{1,2}-(1-\frac{f_t}{f_g})c(t_2-t_1) \qquad (4)$$

Similarly

$$\Delta S_{2,3}=S_3-S_2=$$

$$\frac{c}{f_g}N_{2,3}-(1-\frac{f_t}{f_g})c(t_3-t_2) \qquad (5)$$

Noting that $t_{i+1}-t_i$ where $i=1, 2, \ldots n$ multiplied by c is the distance travelled by light in the time interval, allows some simplifying assumptions to be made. Further, note that $f_g=f_t+\Delta f$ and Δf is very small compared with f_t; thus, to preserve computational accuracy, the above equations must be rearranged to avoid calculations of the form $\Delta f/f_g$. This is easily accomplished by using an additional point P_4. Manipulating a third equation which is similar to the two above yields

$$-S_1+2S_2-S_3=\frac{c}{f_g}(N_{1,2}-N_{2,3}) \qquad (6)$$

$$-S_2+2S_3-S_4=\frac{c}{f_g}(N_{2,3}-N_{3,4}) \qquad (7)$$

where S_i are functions of the ship and satellite positions at each point i where $i = 1, 2, \ldots\ldots 9$. Hence two equations in two unknowns allow the determination of the ship's two unknown co-ordinates, latitude and longitude.

A usable maximum of nine two-minute data points is available during optimum satellite passes. However, many factors—low elevation, interference, etc.—can cause data to be missed or be invalid in this basic two-minute Doppler, least squares formulation. The situation can be improved by dividing the two-minute period into smaller data intervals, when temporary loss of data would only involve discarding one of the smaller data intervals instead of the whole two minutes. Thereby the number of data intervals is increased, and the inherent noise rejection properties of the least squares formulation permit a more accurate position computation, provided that the interval chosen is not too small. The optimum interval appears to be about 23–30 seconds, and when such an interval is chosen, it is known as the short Doppler formulation.

The "Transit" satellites

The five satellites, launched into nearly circular polar orbits by Scout rockets, orbit the earth at heights from 450 to 700 miles. The choice of orbit is determined by the need to maintain them in almost a circular path to minimise acceleration and deceleration characteristics of non-circular paths, and to negate the precession of orbital planes towards eventual overlap which might occur with non-polar orbits.

Each satellite contains a command receiver; a data decoder; switching logic and memory banks; readout control circuits, digital data to phase modulation encoder; stable 5MHz oscillators; and $1\frac{1}{2}$-W 150 and 400MHz transmitters. They weigh about 150 pounds and measure 18in × 12in excluding solar panels and a stabilisation boom. The last-mentioned is necessary to ensure that the satellite is always oriented with its aerials pointing at the earth, eliminating unwanted modulation effects and enabling the use of simple aerials for ships' receivers. It also allows the use of a directional aerial on the satellite itself which radiates a circularly-polarised signal with some concentration of power towards the edges of cover.

Primary power is provided by a set of nickel-cadmium cells, recharged by the solar panels, providing about 30 watts of power at launch, dropping to some 25 watts after five years. Mechanical design is relatively simple, with no moving parts other than a few relays which operate only very infrequently. There are no tape recorders, television cameras, or anything like that, and reliability has been very high, as is shown by the fact that three of the five satellites now in use have been operating uninterruptedly for over six years.

Electronically, they are quite sophisticated, containing some 35,000 magnetic store cores and 6,200 other electronic components. Of the 46,000 permanent joints, 40,000 are welds, and only 6,000 are solder connections. Generally, except for certain telemetry functions that could be lost without destroying operational usefulness, redundant wiring and solder connections are used, and where plugs have to be used, complete redundancy is provided.

The injected orbital data is stored in a magnetic core memory and transmitted as phase modulation on both frequencies that are radiated, these frequencies being derived from the stable 5MHz oscillator that provides the basic timing and frequency for the satellite. This phase modulation is symmetrical so as not to introduce offset errors in the Doppler measurement, typical waveforms being shown at Fig. 6. The memory, read out every two minutes, contains 156 words of 39 bits each, plus an additional 19 bits. There are 11 semi-fixed parameters describing the satellite's orbit, and a further eight words that are used to describe the corrections that must be made to these 11 parameters, as described earlier.

Receivers. At one time receivers for the system tended to be rather large and bulky, the practice being to include the receiver, computer, power supplies and controls within a standard 6-ft 19-in rack. This approach is now obsolete, the same facilities being obtainable within a much smaller space, as demonstrated by the Redifon equipment shown in Fig. 7. This requires only a single unit 19in wide and 10in high in addition to the aerial unit. The aerial itself sometimes surprises those who imagine that all satellite operations require aerials of the Goonhilly type, being only a small quarter-wave whip and ground plane (Fig. 8). Installation is correspondingly easy.

A block diagram of the receiver is shown in Fig. 9. The antenna signal is fed to a 400MHz filter with a bandwidth of 5MHz which is used to reject spurious

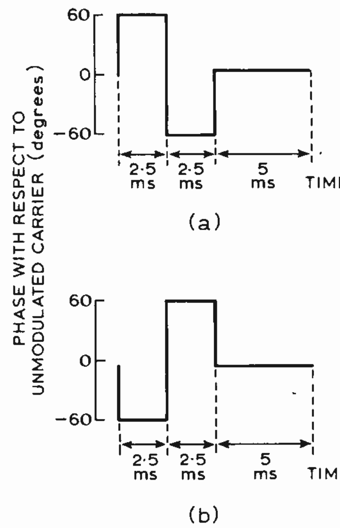


Fig. 6 Phase modulation patterns for transmitting orbital data from satellite to ship in binary digital form. Patterns representing 1 and 0 digits are: 1, the (a) pattern followed by (b) pattern; 0, the (b) pattern followed by (a) pattern. These choices, avoiding (a) (a) and (b) (b), keep sidebands at a safe separation whatever bit sequences occur.

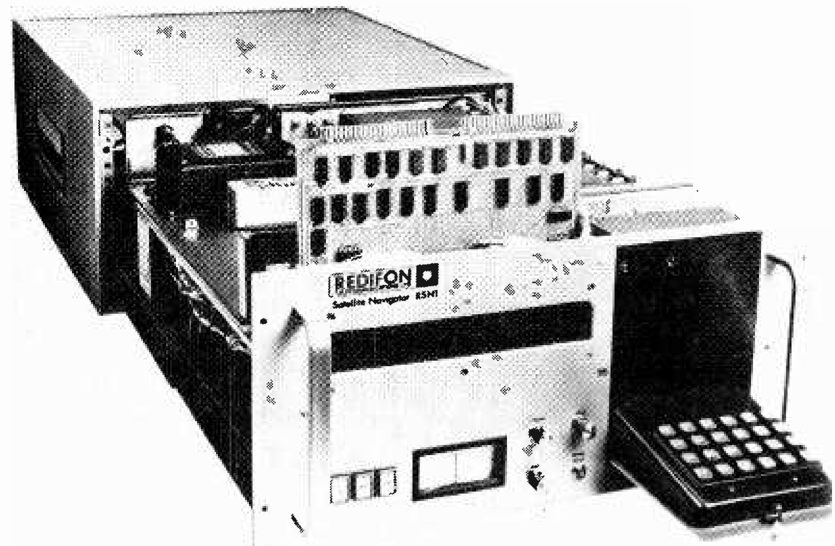


Fig. 7 Satellite navigation receiver (Redifon RSN-1) showing computer keyboard and printed circuit board.

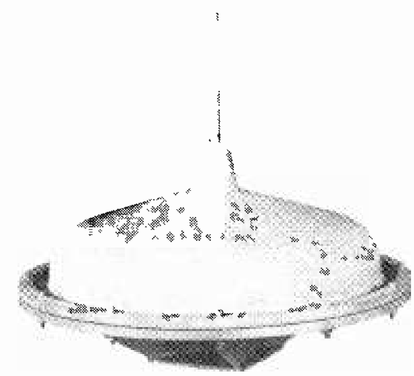


Fig. 8 Aerial used with receiver in Fig. 7.

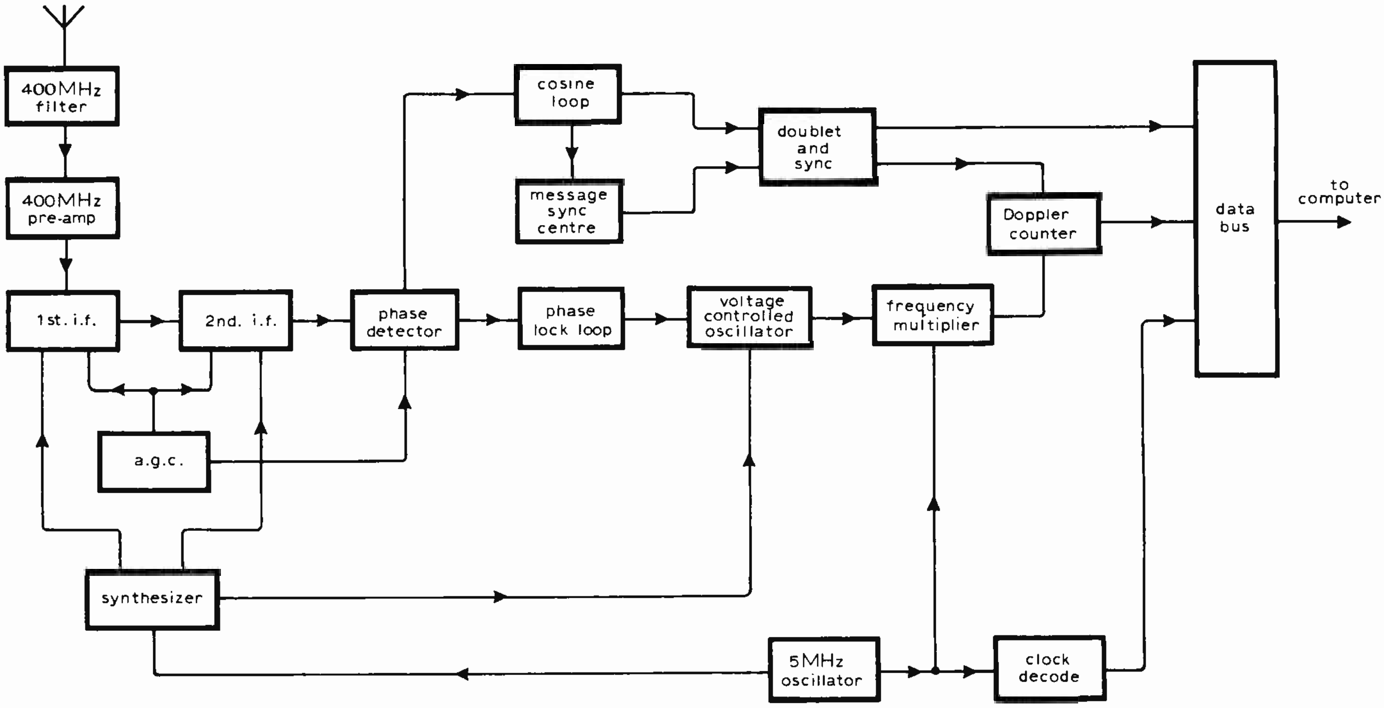


Fig. 9 Simplified receiver block diagram.

and unwanted signals. Signal output from the filter is received and amplified by a 400MHz amplifier with a gain of 30dB, a bandwidth of 15MHz, and 2.5dB noise figure. The overall sensitivity of these sub modules is −135dBm.

The i.f. section of the receiver is composed of two i.f. amplifiers. The inputs to the first, double balanced, i.f. amplifier/mixer are: (a) the received signal (400MHz —32kHz ± Doppler shift); (b) a 360MHz reference signal, and (c) an a.g.c. signal with 70dB range. The output of the module is therefore a signal of 40MHz–32kHz ± Doppler shift. The second i.f. stage has a gain of 65dB and a 65dB a.g.c. signal. The output of this stage is an i.f. signal at a frequency of 15MHz ± Doppler shift. The crystal mixer contained within this module has a 1.5kHz bandwidth. This is followed by a phase detector, the output of which is a signal representing the Doppler shift frequency, the input signal from the second i.f. stage being compared to a 15MHz–32kHz reference signal. The bandwidth of this stage is less than 3MHz but is immaterial as the overall bandwidth is controlled by the crystal mixer. The phase modulated data transmitted from the satellite is now detected and phase quadrature signals generated. The phase and correlation outputs are transmitted to the "cosine loop" and phase lock loop amplifier, respectively.

The phase lock loop amplifier inputs are the correlation and phase signal outputs of the phase detector and a d.c. to 200Hz reference signal. The primary purposes of this amplifier are to null the difference error of the phase detector input and provide the acquisition control signals.

This module is designed for either automatic or manual tuning.

The voltage controlled oscillator functions as a combination of a v.c.x.o. amplifier and an oscillator/multiplier section. The bandwidth of the v.c.x.o. and amplifier is 20Hz with a second order loop implemented.

The basic functions of the cosine loop, message sync counter, doublet and sync modules, are to take the delayed acquisition, fast acquisition and correlation output signals from the phase lock loop and phase detector and to generate the demodulated signal information as well as forming the timing (or synchronization) signal. The cosine loop contains a phase locked crystal oscillator and a digital phase detector. The basic phase output frequency is 101Hz. The output of the doublet and sync module is the basic satellite orbital data signal at a 50Hz bit rate.

The frequency standard for the satellite receiver and the external real-time clock is a 5MHz crystal oscillator, featuring good short-term stability, low phase noise and ageing as low as 1×10^{-9} per day. It employs a 5MHz, third overtone metal-enclosed crystal mounted in an oven.

The software is responsible for the formation of the satellite message word and Doppler count accumulation. Some of the salient interface features include computer control via a strobe and clear command and a "hold while data transferring" feature to eliminate the possibility of writing one bit over one being transferred.

The computing operations for the Redifon satellite navigators are provided by a Data General Nova computer, fitted with memories appropriate to the user's requirements. This is a general purpose computer with a 16-bit word length and a 1.2 microsecond memory cycle time. It is organised around four accumulators, two of which can be used as index registers, providing efficiency and ease of programming. As part of its standard configuration, it has a direct memory access data channel in which data passes to the memory without having to go through the central processing unit. With its console removed, the Nova is operated as an integral part of the satellite navigator, and is controlled by the operator via a small keyboard on the front panel of the main receiver unit (see Fig. 7). This eliminates any need for a teleprinter to be installed for the sole purpose of "talking" to the computer, and does not presuppose any expertise in computer operation on the part of the operator. The most-used functions are given separate keys—latitude, longitude, GMT, etc.—while the inclusion of numerical keys allows the use of auxiliary functions.

Operation. Due to the Doppler shift the received frequency can be anywhere within a 20kHz band centred on the actual transmitted frequency, and with only a 1.5kHz bandwidth provision has to be made for sweeping over the band of possible frequencies. This is done by applying a ramp signal to the voltage controlled oscillator, which is locked out when a transmission is detected. Lock-on is indicated both by a light and by the meter. Also incorporated in the receiver is a small loudspeaker to give aural indications. Once the signal is locked, the next step is to synchronise with the satellite message. Obviously, large errors could occur if the data stream were entered at the wrong point. This is done, as described earlier, by sensing an end-of-message signal. When this is achieved, a green lamp lights and the computer begins message acquisition. Every two minutes, the data stream is repeated, the number of repetitions actually received depending upon the length of time the satellite is above the horizon. At least three repetitions are required by the computer before it will process the message, in order to provide a measure of redundancy in the face of possible noise bursts. Therefore, if part of one message is destroyed by noise it can be filled by a subsequent repetition, and even if lock is completely lost on the satellite the computer can still derive a fix provided either that lock is regained subsequently on the same satellite, or sufficient repetitions have already been received. The period of lost lock can be as long as four minutes.

The Doppler count itself is performed by the computer in 30-second blocks (see Fig. 2). Older equipments used a full two-minute period, which meant that fewer counts were obtained in any one pass and that the final fix was more liable to degradation due to noise. This 30-second count period has enabled a much higher proportion of satellite passes to be used than formerly.

Once the satellite signal is lost the computer suspends operations while the receiver searches for the signal in case the loss of lock has only been due to noise. After four minutes, if no signal reappears, the computer declares "end-of-pass" and starts to calculate the fix, although it has first to decide whether it has sufficient Doppler and orbital information. If not, it will not proceed further.

Initially, the programme uses the dead-reckoned position already stored in the computer as a starting point to calculate a Doppler shift curve, using the orbital parameters received from the satellite. This is compared with the curve actually measured, and unless they coincide, a new curve is computed using a slightly different position. This goes on until the two curves do actually coincide within certain limits, and the last position is assumed to be the actual true position. This takes no more than a few seconds, and the final fix is displayed to an accuracy of one-thousandth of a minute of arc (about 6 feet) of both latitude and longitude, together with the time of fix to one second. The fix can thus be plotted directly on to normal marine charts, without any need for special charts or conversion tables.

The part played by the operator in all this is quite small, since the receiver itself operates without intervention and the computer needs only a few initial settings when first switched on. The most important of these are approximate latitude, longitude, and GMT. None of these need be very accurate—latitude and longitude need be only within 3° (about 120 nautical miles at 50°N)—and time within 15 minutes.

After this, there is no absolute need for operator intervention at all. The navigator equipment can be switched into the "auto" mode, wherein it will produce GMT, latitude and longitude, updated every 18 seconds. The first usable satellite pass after switch-on will produce an accurate fix which will re-set the navigator's estimate to precise position—provided the two are not widely different (Fig. 10). This feature is incorporated so that in cases where a large difference exists the navigator can make his own decision whether or not to accept the satellite fix. There are other reasons why the computer may not automatically update the dead reckoned position, since it is programmed to perform mathematical tests on its computation and, if not satisfied, it will present the calculated fix together with an indication why it was not used for updating. The reason may be excessive noisiness of the data, inability to make calculated and actual Doppler curves fit precisely, insufficient data, and so on. But the navigator can always make the final decision.

```
SS01

+051,27.3457, -000,11.9570
FREQ + 1924439
ITER 0003
RES. 0009
11E1 1111 1111 1111 1000 0000 0000 0000
DLAT + 0000034 DLON - 0000276
```

Fig. 10 Satellite fix message: top line, satellite fix; second line, offset frequency; third, number of iterations; fourth, highest residual; fifth, Doppler string; bottom line, difference between dead reckoning and satellite fixes in feet.

System accuracy. Somebody once said that accuracies are just a matter of statistics, and after all the arguments about whether error curves have a Gaussian, exponential, square-law, or what-have-you distribution, or whether r.m.s., c.e.p., mean or standard deviations should be quoted, there sometimes seems to be little point in quoting anything at all.

But, anyway, of the ultimate accuracy of satellite navigation, it can be said that when used as a survey tool, put into a fixed position, and averaged over a period of some days, the repeatability accuracy has been shown to be better than 5 metres. Naturally, a receiver on board a moving vessel is not going to get anywhere near this figure, and it is interesting to see how the error budget is built up.

One of the errors used to be a rather imperfect knowledge of the earth's gravitational field, leading to errors in prediction of satellite position, but this knowledge has now been refined a great deal—over 415 parameters are now recognised as important in this respect—and this factor alone has led to a doubling of system accuracy over the last six years. Errors due to this do not now exceed 30 metres maximum for a single pass.

Another effect is refraction in the ionosphere and atmosphere, already mentioned. Tropospheric refraction is relatively unimportant, contributing only about 30 metres to the final error under worst-case conditions, but ionospheric refraction is more important, contributing about 90 metres error if uncorrected.

The major source of error for a ship at sea is uncertainty of the ship's velocity, particularly when this is in a north-south direction, and we are talking here of velocity over the ground, not through the water. Where greater accuracy is necessary, velocity-over-ground inputs are usually obtained either from Doppler sonar, or from hyperbolic radio systems such as Loran-C.

One other correction has to be made, for aerial height. Actually, this is aerial height above the spheroid being used for calculation, and not simply height above sea-level, but the difference can be read directly off simple maps.

Usually, static accuracies of about 150 metres from a single pass for a single frequency, and about 50 metres for two-frequency equipment can be expected. Differences between individual equipments are very small—less than 15 metres.

Where a vessel is under way the additional errors due to movement are more complex to evaluate, but where sophisticated velocity-over-ground sensors are not installed, and only the standard ship's log and gyrocompass are available, a degradation of accuracy to some 500 metres may be expected. When these sensors are available, the accuracy reverts almost back to the static figures.

Uses. The strength of satellite navigation lies in its ability to provide virtually world-wide fixes to a high degree of accuracy, and its weakness in the fact that these fixes are not continuously available. The Redifon satellite navigation receivers overcome this latter problem by carrying on dead-reckoning between fixes, so that a position is always available. Provided that accurate inputs of speed and heading are available to the computer the accuracy of dead reckoning can be very high, but it is always time-dependent. Therefore satellite navigation becomes of less and less use as the vehicle velocity gets higher, and aircraft, for instance, make virtually no use of the system at all.

But slower vehicles such as ships are making excellent use of "satnav" for normal navigation as well as for the very demanding purposes of seismic and geophysical survey work. There is a growing trend for ships to carry automatic navigation systems to lessen the workload of the relatively few skilled officers they now carry, and satnav is an important ingredient of all such systems. In the field of geophysical exploration, the integration of a satellite navigator with hyperbolic systems is now common practice, the satnav providing ambiguity resolution for the hyperbolics. Satnav is even being used to provide remote location of buoys, a "bare-bones" receiver on board the buoy recording the Doppler curve as the satellite goes over, and transmitting it in digital form back to shore via another satellite link or via an h.f. link, where a central processor turns it into position.

Surveyors are using it, particularly in remote areas, for the location of control points. A portable receiver is set up at the point to be checked and records all satellite passes over perhaps two or three days. Later analysis results in a precise position that can be as good as 5 metres, referred to another known point. If a number of passes can be analysed, it is even possible to derive height above sea-level with a reasonable degree of accuracy.

Transformer phase reversal

An experimental demonstration for schools

by T. Palmer, B.A., Assoc. I.E.R.E.

Acton Technical College

After reading Cathode Ray's article*, I repeated some experiments I had performed on transformers at very low frequencies (0.1Hz) using centre-zero meters. Ordinary transformers do not have enough inductance to show the desired effects at 0.1Hz but a 45,000H coil sold by Unilab is satisfactory. It has two windings, A and B. Winding A has 20,000 turns and sits on one limb of a C-core. B has 17,000 turns and sits on the second limb. Coil A is used as the primary of a transformer.

The first step is to determine the sense of the windings. The C-core has a portion at the top, which I shall call the cap; it can be detached from the main body of the core. When this has been removed, and the transformer is placed in a horizontal position, we can use a compass needle to find that current entering the primary at *P* gives clockwise flux in the core; so does current entering the secondary at *C*. Since flux is the most important feature of a transformer, terminals *P* and *C* were regarded as analogous.

An advantage of using centre-zero meters is that we do not know how to connect them until we have thought about conventions. Here are mine: Primary voltage is positive when *P* is positive to *Q*. Secondary voltage is positive when *C* is positive to *D*.

Now we know how to connect the voltmeters in a consistent way: the positive terminal of the primary voltmeter, V_1, is connected to *P*; that of the secondary voltmeter, V_2, is connected to *C*, as shown in Fig. 2.

In later stages of the demonstration, we shall wish to connect centre-zero micro-ammeters. Secondary voltage is positive when *C* is positive to *D*. Secondary current will be regarded as positive when current is flowing from *C* through the secondary load. We connect the positive terminal of the meter which measures secondary current, A_2, to *C*.

Conditions are not the same in the primary. The reason why current flows at all in the primary is that an alternating voltage is applied to it. We regard the applied voltage as the "prime mover" and connect the positive terminal of the primary current meter to P_1 and the negative terminal to *P*.

*Cathode Ray, "Transformer phase reversal". *Wireless World*, June 1971.

Of course, no claim is made that these are the only suitable conventions; I think Cathode Ray would regret that they have been mentioned; but in demonstrations at 0.1Hz they seem unavoidable. Perhaps this is an argument for not performing experiments at low frequencies; but, by now, I am hooked.

With voltmeters V_1 and V_2 connected as shown in Fig. 2, when an alternating voltage is applied to the primary, it is easy to see that V_1 and V_2 swing in phase. On the basis of our conventions, there is no phase reversal.

Primary current shown on A_1 lags voltage by about 90°.

It is found that when the transformer is horizontal, compass needles placed at the junction of the cap and the main body of the core have sufficient leakage flux surrounding them to reverse their directions as the primary current passes through zero. It was the main purpose of the original experiments to draw attention to the alternation of the flux, which seems to me to be the most important feature of transformer action that should be understood by elementary students. After the alternation of the flux has been shown by the compass needles, the transformer should be put in a vertical position. The weight of the cap reduces the minute air-gap at the junction and reduces leakage flux. When the transformer was horizontal, the cap had to be supported by a book at the correct height.

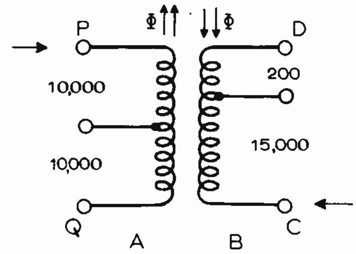


Fig. 1. Arrangement of Unilab transformer windings.

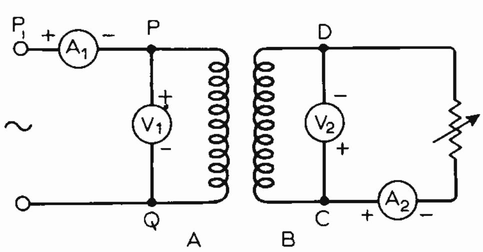


Fig. 2. Connection of meters to the transformer.

We can now go on to show that as the resistance of a secondary load is reduced, the secondary current increases, and so does the primary current. It must be admitted that the resistance of the primary and secondary windings does not allow a very large increase of primary current; but it can be seen.

Having shown the effects on centre-zero meters, with no electrical connection between primary and secondary, it seemed a pity not to show the waveforms for primary and secondary voltages on a double-beam oscilloscope. The Airmec display oscilloscope 252, with a very slow time base, is suitable. Since terminals *Q* and *D* on the transformer are analogous, they were strapped together and connected to the earth terminal of the scope. The input terminal for one trace was connected to *P*; that for a second trace, to *D*. The centre-zero meters can remain in circuit and the meters and the oscilloscope tell the same story in their own ways.

Almost the same story. The scope shows that secondary e.m.f. leads primary voltage by an angle too small to be detected on the meters. It is no doubt due to the voltage drop across the resistance of the primary winding (about 4kΩ). The small phase difference does not seem large enough to worry elementary students who, initially, are not concerned with primary resistance.

The oscilloscope shows that to avoid distortion in the transformer, the peak value of the voltage applied to the primary should not exceed 4V.

To appreciate the phase relationships on the centre-zero meters, it is convenient to have edgewise meters mounted one above another on a panel. We have a panel with four 50–0–50 μA meters. To use a meter as a voltmeter, a 220kΩ resistor was connected in series. To measure primary current, a meter was shunted by a 47Ω resistor.

News of the Month

BBC demonstrate matrix system

Research Department work at the BBC into quadraphonic (four-speaker) surround-sound systems was made public at an "exposition of quadraphony" during December. Organised by the IEE electronics division, demonstrations were given in separate rooms by the four commercial surround-sound proponents as well as by the BBC. Concentrating initially on two transmission channels, the research department have studied the commercial matrix systems (SQ, QS, BMX), finding that they suffered from poor stereo or mono compatibility or both. This led to the development of a matrix system that is similar to the Cooper/Nippon Columbia BMX matrix but modified in the light of experiments on directionality of the hearing system. The BBC say the coding gives improved stereo compatibility over other systems.

● We hear from Nippon Columbia that the BMX matrix is to be altered slightly, reducing the phase difference between channels for a centre front signal and improving stereo compatibility.

EEA promotions for 1975

The Electronic Engineering Association in the continuance of its policy to support industry operations concerned with overseas markets, will again sponsor and co-ordinate participations with the support of the British Overseas Trade Board during 1975. EEA-sponsored projects for UK based electronics companies will be on a world-wide basis. On the American continent groups will be organised to show at IEEE INTERCON in New York in April; The National Association of Broadcasters event, Las Vegas in April; SEMICON V, San Mateo in May and the WESCON Show, San Francisco in September. In late October there will be a group in Toronto attending the International Electrical-Electronic Conference and Exposition in October.

Other group participations are scheduled to be held at the Japan Electronics Show and Conference, Osaka in October; in the same month a group will show at the Australian International Radio Electrical and Electronics event being held in Sydney in August. Nearer home, EEA will sponsor groups to Moscow Communications Exhibition, the Montreux TV event; both shows being held in May. In September another UK contingent will exhibit at MICROWAVE '75 due to take place in Hamburg. Further information can be obtained from The Electronic Engineering Association, Leicester House, 8 Leicester Street, London WC2H 7BN.

Troposcatter equipment for PO

Equipment has been ordered for two new radio stations to be set up near Peterhead in Aberdeenshire and on South Shetland to provide reliable high-quality world-wide communication for oil production platforms operating out of sight of land. The stations ordered from Marconi Communication Systems by the Post Office are expected to come into operation during October. The contract covers erection of 12 large dish aerials—four of 12m and two of 18m diameter near Peterhead and two of 12m and four of 18m diameter on South Shetland as well as the transmitters and receivers, switchgear and control equipment for operating a quadruple-diversity, space polarization system (see "Electronics in Oil" published in the January issue). The Frigg, Beryl, mid-pipeline and Piper platforms will act as "master" platforms in the North Sea network, providing communication for other platforms in their areas over microwave links.

The troposcatter links will operate in 1° beams between onshore aerials with a gain of 47dB and offshore aerials with a 41dB gain. At the distances to be bridged by the troposcatter links, the common volume or that part of the troposphere "visible" to the transmitting and receiving aerials, lies about 1km above sea level. Attenuation of the signal is about 210dB. Tropospheric turbulence varies almost continuously and the level of signal received is on average 130dB below 1W.

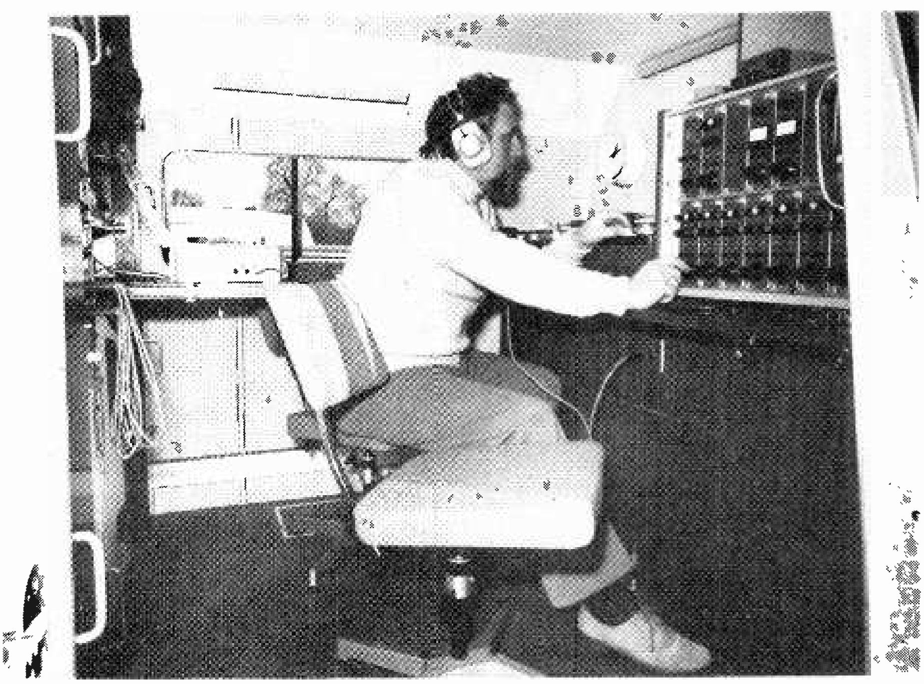
Miniature solid-state TV camera

A miniature solid-state television camera has been introduced which is the second in a planned series using charge-coupled device technology. The camera has a cylindrical body, three inches in diameter and just under two inches deep while the weight is 11 ounces. The usual, comparatively bulky Vidicon tube used in TV cameras has been replaced by a compact image-sensing device which contains 10,000 photosensors on a standard 24-pin dual-in-line integrated circuit unit.

Power consumption of the camera is 1.5 watts and it responds to illumination levels as low as two lux and is suitable for low-light applications such as night security and surveillance. Other applications include remotely piloted vehicles, space systems, periscopes and process control. Low geometrical distortion of the c.c.d. system allows its use in scientific measurement, medical instrumentation and microscopy.

The camera has a spectral response extending almost into the infrared range. It has a 100-line horizontal resolution and a bandwidth of 1MHz. Although a five-inch TV monitor adapted to the 123 frames per second c.c.d. camera sweep-rate is supplied as standard equip-

Sound outside broadcast van during its test programme before shipment by Pye TVT to Sierra Leone. The vehicle is equipped with an eight-channel mixer, two transcription units, two tape-recorders, u.h.f. outside broadcast link, radiotelephone and is fully air-conditioned.



ment, the camera may be interfaced with any conventional monitor by a simple adjustment of the sweep-rate.

Operation is up to distances of 100 feet from the monitor and an optional battery pack is available when complete portability is required. The new camera is designated type MV101 and supersedes the MV100 which was introduced about 18 months ago by the Fairchild Camera and Instrument Corporation. (The MC100 was described in News of the Month, October 1973.)

Monitoring monitors

The US Electronic Industries Association announces the availability of two new standards for television monitors. They are RS-375-A, "Electrical Performance Standards for Direct View Monochrome Closed Circuit Television Monitors 525/60 Interlaced 2:1" and RS-412-A, "Electrical Performance Standards for Direct View High Resolution Monochrome Closed Circuit Television Monitors".

These new standards replace the earlier versions, RS-375 and RS-412, which were the first developed by any standards organization relating to monochrome closed-circuit television monitors. They outline significant parameters describing the operation of closed-circuit monitors and also the minimum levels of performance desirable to develop an acceptable display. The standards will promote interchangeability of products from different manufacturers, thereby eliminating confusion on the level of performance that can be expected from an appropriately specified device. They will also assist the purchaser in selecting and obtaining the proper product for a particular need.

Electronics industry surveyed

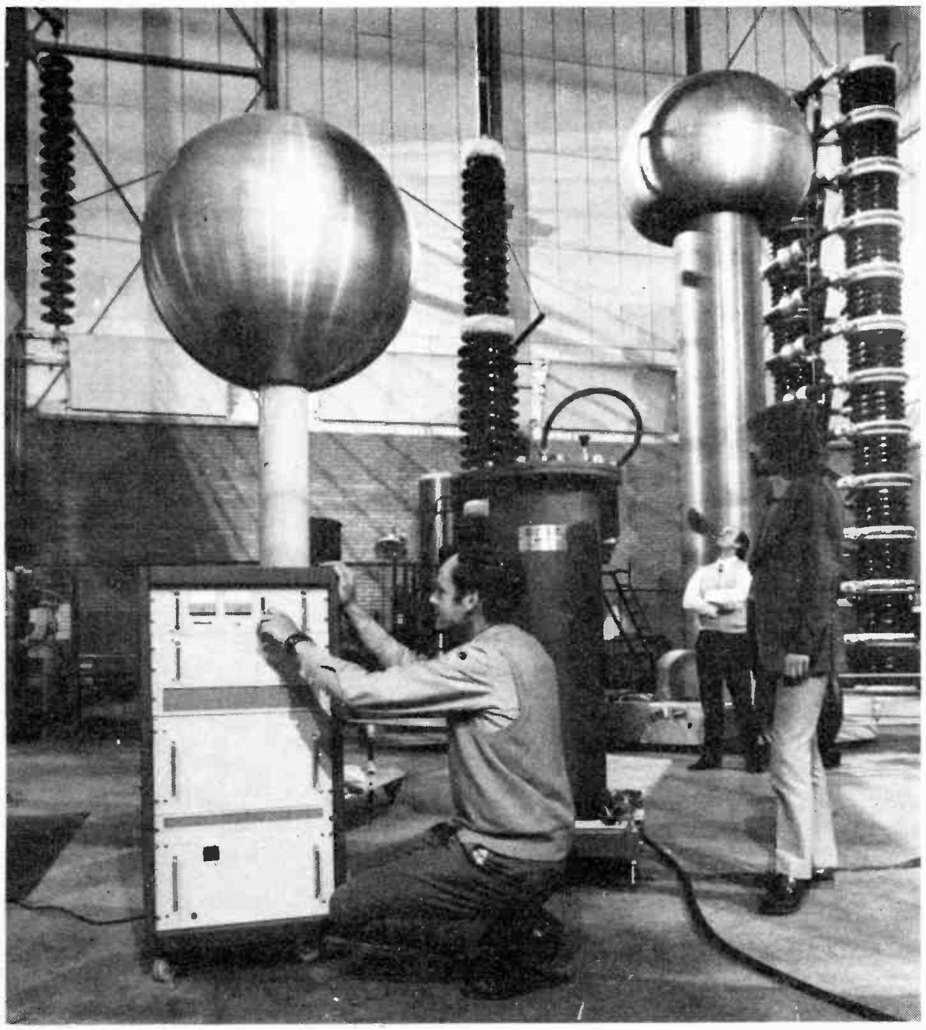
The eighth edition of the annual statistical survey of the electronics industry* has been published by the Electronics Economic Development Committee. This charts the industry's progress in 1973 revealing that total sales reached over £2,600 million, a 12 per cent increase over 1972. After a brief pause in 1971/1972 the industry's expansion resumed but at a slower rate than before. Nevertheless it is clear that the industry's output has more than doubled since 1968.

The survey shows that the electronics industry's renewed growth was led by the components sector with an 18 per cent growth rate and the consumer goods sector with a 16 per cent rate.

While the industry re-established its pattern of growth in 1973, the home market underwent enormous expansion. The resulting trade deficit was £268 million, almost a four-fold deterioration over 1972. The largest deficits were in consumer goods (£219 million), active components (£68 million), and computers (£52 million). None of the sectors with positive trade balances improved their position although the instruments sector exported a slightly higher proportion of total sales.

*Available from Neddy Books, NEDO, Millbank Tower, Millbank, London SW1P 4QX, price £1.

Operating the control panel during a run of what is believed to be the first British all-solid-state precision 300kV d.c. power supply developed by Wallis Electronics. The high voltage assembly contains the r.f. power source and, in the tank, the voltage multiplier and feedback resistor chain. The high voltage output is available via a screened polythene cable.



New trade exhibition

The Board of the Association of Manufacturers of Domestic Electrical Appliances (AMDEA) and the Executive Council of the British Radio Equipment Manufacturers' Association (BREMA) have recently decided to sponsor a trade exhibition at the new National Exhibition Centre near Birmingham. The trade exhibition will open on Sunday May 23, 1976.

It will be organized as a single event, with separate exhibits for domestic electrical and electronic goods in adjacent halls with free access between the two areas. The BREMA section of the show will also be opened to the public for four days at its conclusion.

AMDEA's and BREMA's intention is to create a national electrical and electronic consumer goods trade show, of interest to retailers throughout the United Kingdom and which will also be of international standing to provide a world showcase for British goods.

AES Convention 1975

The fiftieth convention of the Audio Engineering Society will take place at the Cunard International Hotel, Hammersmith, London W6, from Monday, March 3 to Friday, March 7, 1975. A comprehensive programme of technical papers on subjects connected with audio engineering and acoustics is being arranged. Anyone wishing to present a paper at the Convention should in the first instance submit an abstract of 200–250 words to: Dr J. M. Bowsher, Audio Engineering Society, Department of Physics, University of Surrey, Guildford, Surrey, England.

An exhibition of professional products will also be held at the Cunard International Hotel.

Charge-coupled devices

3—Signal processing

by D. J. MacLennan
University of Edinburgh

Previous articles in this series have dealt with the basic operation of the c.c.d. as an analogue shift register (Dec., 1974) and the techniques for c.c.d. fabrication (Jan., 1975). This article outlines some of the primary considerations in designing c.c.ds for signal processing, with some simple examples taken from the radar and communication fields. Comparisons with the alternatives to charge-coupled devices are made.

When charge is transferred from one capacitor or gate to the next, a small fraction of this charge is left behind under the previous gate. The result of this charge transfer inefficiency is a "smearing" or bandwidth reduction. This may be visualized by considering an impulse or a single "one" being applied to the input of the device. The output should ideally consist of one pulse. Due to the transfer not being complete, however, there will be trailing pulses which corrupt the output signal. The magnitude, and hence the degradation in the signal quality, is a function of the charge left behind at each transfer, or the transfer inefficiency. In simple mathematical terms[1,2], if we assume a fraction of charge ϵ is left behind, then the fraction of charge transferred is given by

$$\alpha = 1 - \epsilon$$

where α is known as the transfer efficiency, and ϵ the transfer inefficiency. Fig. 1, which shows the charge distribution within a single-phase, six-element c.c.d., demonstrates the time sequence of charge packets at the output as

$$\alpha^6, 6\epsilon\alpha^6, 21\epsilon^2\alpha^6, \ldots$$

As demonstrated by Vanstone[2] *et al*, this sequence is independent of the number of clock phases used, to a first approximation. The size of the trailing pulse relative to the required pulse is a function of both the inefficiency and the number of transfers.

Fig. 2 demonstrates the effect of inefficiency on both impulse and frequency response of a device. As can be seen, for $n\epsilon < 1$, the pulse immediately after the required signal is the largest residual, and its magnitude relative to the required signal is $n\epsilon$. The $n\epsilon$ product may thus be used as a criterion for device performance.

As an example, consider a device with $n\epsilon = 0.1$ used in a pulsed radar system. At the output there will be an echo of any return at a level of 20dB below the required signal, making it impossible to distinguish any target smaller than this within that range bin. For an application where pure analogue delay is required, the actual bandwidth of the device is not only limited to half the sampling frequency by the Nyquist sampling criterion, but also by a factor depending on the $n\epsilon$ product, Fig. 2(b). It is thus obvious that an appropriate $n\epsilon$ product must be specified for

Clock phase		1	1	1	1	1	1
Transfer element	1	2	3	4	5	6	Output
Discrete time	1						
	ϵ	α					
	ϵ^2	$2\epsilon\alpha$	α^2				
	ϵ^3	$3\epsilon^2\alpha$	$3\epsilon\alpha^2$	α^3			
	ϵ^4	$4\epsilon^3\alpha$	$6\epsilon^2\alpha^2$	$4\epsilon\alpha^3$	α^4		
	ϵ^5	$5\epsilon^4\alpha$	$10\epsilon^3\alpha^2$	$10\epsilon^2\alpha^3$	$5\epsilon\alpha^4$	α^5	
	ϵ^6	$6\epsilon^5\alpha$	$15\epsilon^4\alpha^2$	$20\epsilon^3\alpha^3$	$15\epsilon^2\alpha^4$	$6\epsilon\alpha^5$	α^6
	ϵ^7	$7\epsilon^6\alpha$	$21\epsilon^5\alpha^2$	$35\epsilon^4\alpha^3$	$35\epsilon^3\alpha^4$	$21\epsilon^2\alpha^5$	$6\epsilon\alpha^6$
	ϵ^8	$8\epsilon^7\alpha$	$28\epsilon^6\alpha^2$	$56\epsilon^5\alpha^3$	$70\epsilon^4\alpha^4$	$56\epsilon^3\alpha^5$	$21\epsilon^2\alpha^6$

Fig. 1. Charge distribution within a six-element, single-phase c.c.d. when a single packet of charge is clocked from input to output.

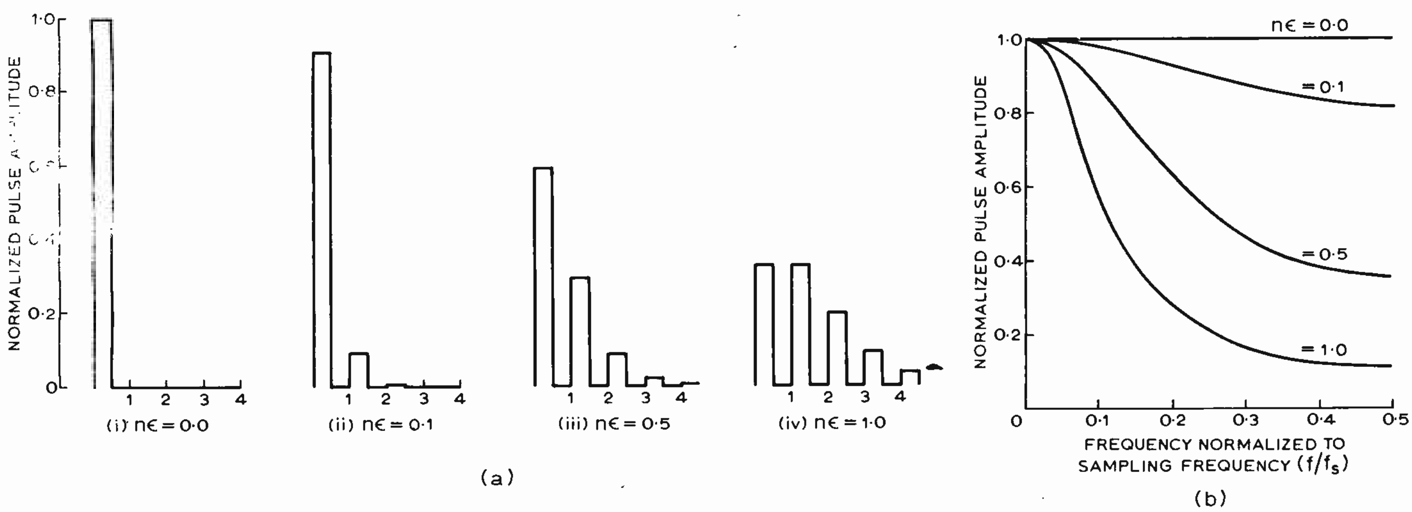


Fig. 2. Impulse response of a c.c.d. analogue delay line with varying nϵ product (a). Frequency response modification for a c.c.d. analogue delay line with varying nϵ product (b).

any given system application.

Transfer inefficiencies of the order of 10^{-5} have been obtained at frequencies of MHz and 10^{-4} at 125MHz. It should thus be possible to fabricate linear (meaning serial) devices with up to several thousand storage elements, which operate at several tens of MHz.

In addition to the incomplete transfer of charge, a small amount of charge is lost at each transfer due to recombination.

Device input

Several methods exist for putting charge into the c.c.d., each having its own advantages and disadvantages. All commonly-used techniques consist of a diode as a source of minority carriers (signal charge) and some form of gate structure, as in the m.o.s. transistor, to control the amount of charge, or the instant at which charge enters the c.c.d. register. A typical input structure for the linear injection of charge into a c.c.d. is shown in Fig. 3[3]. Operation of this input structure is as follows.

The input signal, V_{ig}, is applied to the input gate, When the first transfer electrode, ϕ_1, is pulsed on the input diode is held at a voltage, V_{id}, which saturates the potential well under the first transfer electrode. The input diode voltage is then modified to empty the well. When the surface potential under the first electrode is equal to the surface potential below the input gate, no more charge will leave the well, thus setting the surface potential (and hence signal charge) under the transfer electrode to the potential under the input gate.

Signal detection

There are many methods for converting the signal charge stored in the c.c.d. to an electrical signal. As for the input structure case, each technique has its own particular advantages and disadvantages. In this article it is intended to concentrate on three particular circuits. The first is in common use as an output circuit in the simple analogue delay type of applications. The second is for use in situations where multiple outputs with fixed weighting coefficients are required from the device, as in matched filtering applications. The third is similar to the previous method, but in this case the weighting coefficients are electrically programmable.

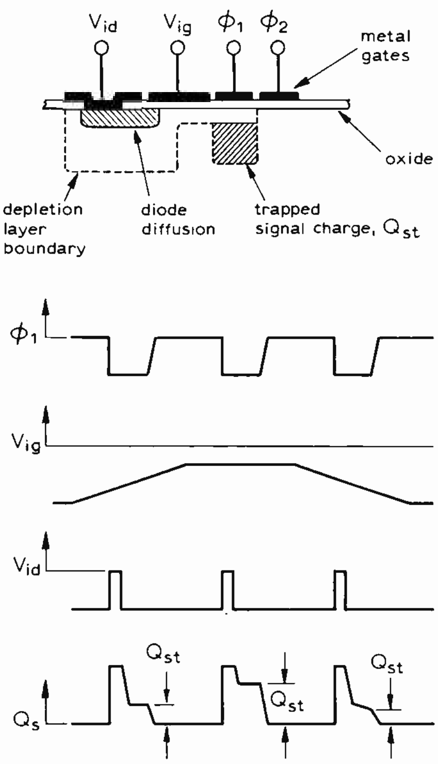


Fig. 3. Technique for the linear injection of charge into a c.c.d.

Floating diffusion reset. In this detection method[4], a diode diffusion is reverse-biased by being charged to some appropriate potential, V_{gg}, through an m.o.s. transistor, Fig. 4.

Assuming negligible leakage current, the diode will remain at this potential when the charging transistor is switched off. If a charge signal is now clocked into the diffusion, at the end of the ϕ_3 pulse, the potential on the diode and sensing transistor will change due to the new charge distribution. This change may then be amplified by the sensing transistor. A reset pulse is then applied to the charging transistor prior to the arrival of the succeeding charge packet.

Split gate tapping. This technique for sensing the signal charge being clocked along a shift register is attributable to Buss[5] *et al.* When charge is clocked under one of the split electrodes (Fig. 5), the current in each of the clock lines supplying this electrode is measured, i.e. I^+ and I^-; output is proportional to the difference between the two. The magnitudes of the currents are directly proportional to the quantity of signal charge present; the voltage on the gate is maintained constant and thus current must be supplied from the clock source to maintain charge equilibrium. The difference between the currents, for a given quantity of charge, is determined by the position of the split in the electrode. The smaller area "sees" a lesser portion of the signal than the larger area and as a result requires less current to maintain charge equilibrium.

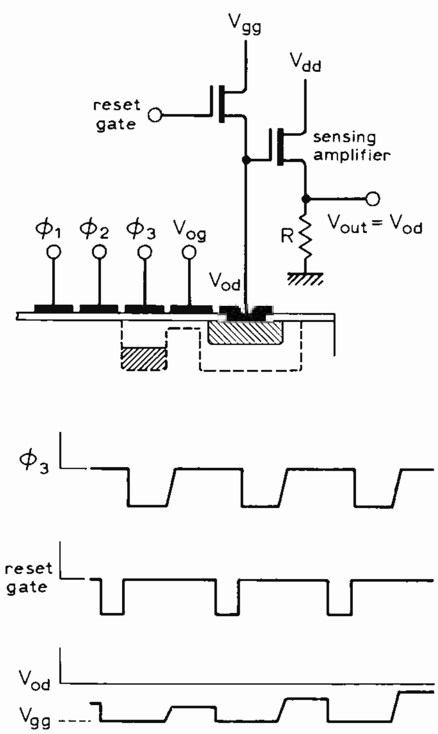


Fig. 4. Floating diffusion reset method of converting the charge present in a c.c.d. to an electrical signal.

A means has therefore been realized for not only sensing the signal charge present in the device but also for multiplying this signal by some fixed weighting coefficient. The usefulness of this technique is discussed later. One of the limitations is that the weighting coefficients cannot be modified subsequent to device fabrication. However, in situations where many identical filters are to be realized with fixed responses, this type of device is likely to be extremely useful.

Biased floating gate. This technique is basically similar in operation to the first technique, except that instead of charging a diffusion, a gate electrode is charged to an appropriate d.c. level, V_{gg} (Fig. 6).

When the preceding clock electrode, ϕ_1, switches off, signal charge is injected into the depletion; well below the charged gate. The resultant redistribution of charge in the capacitive network results in a potential variation on the charged gate which may be sensed and amplified by an m.o.s. transistor. When the next clock electrode, ϕ_3, is turned on, the gate potential reverts to its original potential. It is thus not necessary to reset the gate at every clock period. The signal charge is not destroyed or degraded, allowing other outputs to be taken at tapping points further along the register.

The moving target indicator

In many systems, it is required to monitor targets which are moving relative to the transmitter but may be surrounded by stationary objects. For this type of system it is necessary to eliminate the stationary clutter from the observer's display. To perform this a measurement of the phase changes due to Doppler shift in the frequency of the return signal in succeeding radar returns is required. It is therefore necessary to store one radar return, compare this with the succeeding return and subtract the two signals. Alternatively, in the frequency domain, it is necessary to build a notch filter which rejects frequencies of zero and multiples of the radar pulse repetition frequency. Both these methods of visualizing the problem are in fact identical and may be implemented as shown in Fig. 7[7]. Fig. 8 shows the performance of such a filter both in the time and frequency domain. The filter used was more complex than the simple schematic of Fig. 7—to obtain improved cancellation of clutter, steeper sides were required on the notch filter and this was achieved using three c.c.d. shift registers as delay elements in a three-pole Chebychev filter. The filled-in

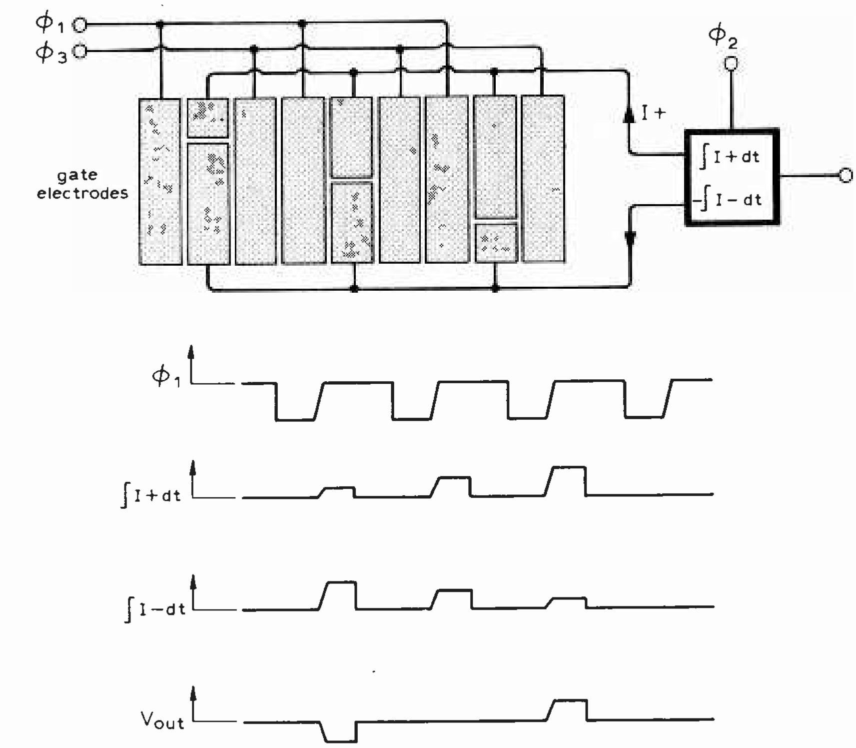


Fig. 5. Split-gate tapping technique for the fabrication of fixed weighting coefficient transversal filters.

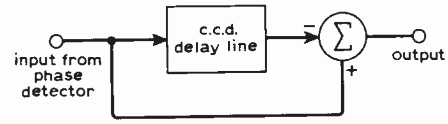


Fig. 7. Schematic diagram for the implementation of a m.t.i. filter.

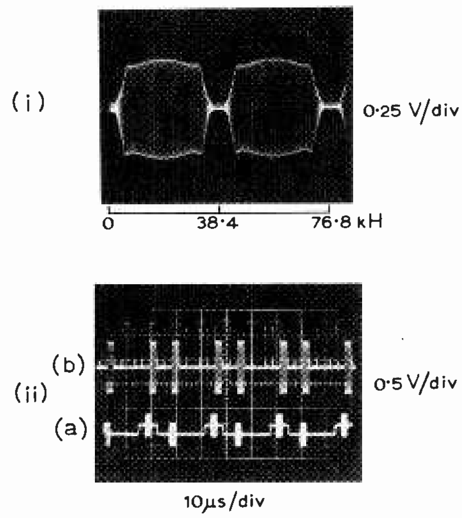
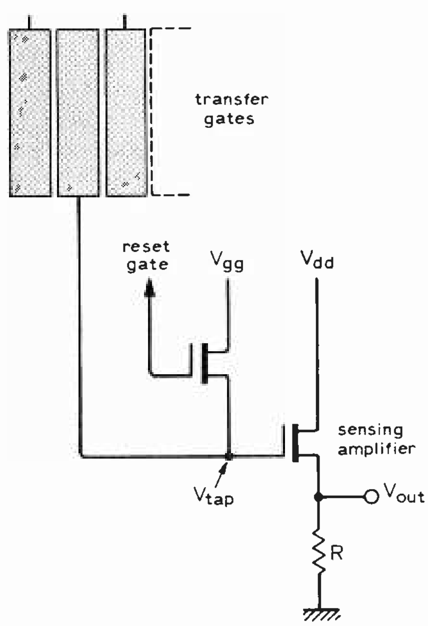


Fig. 8. Swept frequency response (i) and simulated clutter cancellation (ii) of a moving target indicator using c.c.ds. (Lower trace: filter input; upper trace: filter output.)



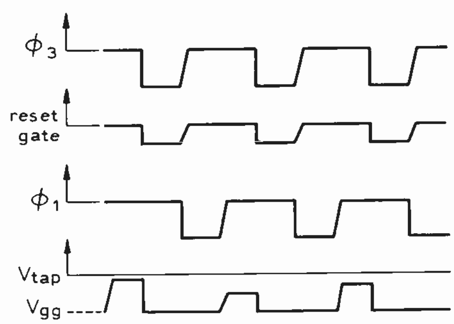


Fig. 6. Biased-gate tapping technique for the fabrication of transversal filters with electronically-variable weighting coefficients.

effect of the Doppler pulses on the simulated clutter cancellation photograph are due to many oscilloscope traces being photographed. As can be seen, the clutter has been effectively cancelled by the filter, there being >30dB of clutter rejection available.

Frequency filters

The filtering capabilities of a filter may be obtained by taking the Fourier transform of the time domain response, i.e. the response of the filter to an electrical impulse. It is thus possible, knowing the frequency response required of a filter, to define the necessary impulse response.

If we now consider a c.c.d. analogue delay line, constructed so that an output may be taken at each bit without degrading the signal being clocked along the device, and connect each of the outputs as shown in Fig. 9, the response of this device to a charge impulse, will be the sequence of pulses

$$h_1, h_2, h_3, h_4, \ldots h_n.$$

This device is more commonly known as a transversal filter and by controlling the weighting coefficients at each tapping point, it is possible to fabricate a virtually infinite number of different filters. Unfortunately, the impulse responses to many desirable filters are of infinite duration and therefore have to be truncated in such a device—only a finite number of coefficients are available—resulting in a non-ideal frequency response for the filter. In many cases, it is possible at the design stage to determine the impulse response required of any particular filter and ascertain the number of weighting coefficients necessary to specify the frequency response to any desired accuracy. Techniques are also available whereby the end weighting coefficients may be reduced to an insignificant level by speeding up the decay time of the impulse response.

This is not the only type of frequency filtering structure that may be realised using c.c.ds. The moving target indicator is an example of a recursive filter. In these types of filters the poles and zeros in the frequency domain response are determined by the weighting coefficients applied to the feedback loops used. In many situations, the loop feedback coefficients are critical to filter performance, leading to a requirement for extremely stable gain in the loop. Applications of c.c.ds in recursive filtering applications would at present appear to be limited and their use as transversal filters much more promising. The primary advantages in using a recursive filter rather than a transversal filter are that an infinite impulse response is achievable, because of the feedback, and a smaller number of delay elements is required using this technique. These advantages are at present offset by the need for highly stable on-chip amplification in a technology compatible with c.c.ds.

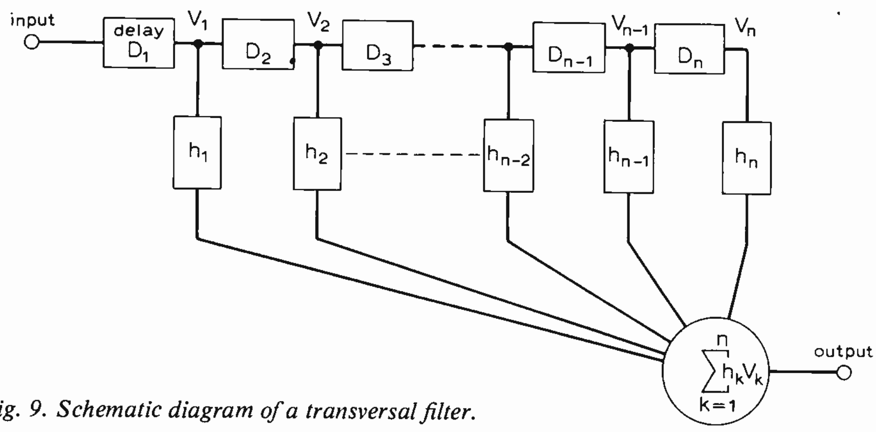


Fig. 9. Schematic diagram of a transversal filter.

Matched filtering

In matched filtering, a special case of transversal filtering, the signal is coded to increase its bandwidth by some predetermined amount prior to transmission. On reception the signal is decoded in a transversal filter which is matched to the coded waveform. As an example of matched filtering, consider the transmitted sequence as being

$$1,1,1,1,1,-1-1,1,1,-1,1,-1,1.$$

This sequence is commonly known as the 13-bit Barker code.

The impulse response of the filter which is matched to this waveform is the time reverse of the transmitted sequence, i.e. the weighting coefficients h_1 to h_{13} are given by the sequence

$$1,-1,1,-1,1,1,-1,-1,1,1,1,1,1.$$

Fig. 10 shows the effect of passing the received waveform into this filter. The output sequence is the autocorrelation function of a 13-bit Barker coded sequence

$$1,0,1,0,\ldots 0,13,0,1,\ldots 0,1.$$

One of the most important aspects of matched filtering is the improvement in signal-to-noise ratio obtained over conventional processing techniques.

Consider the filter described above with an input signal which includes white additive noise. The output noise power is the product of the number of taps (13) and the input noise power; the noise at each tap is summed. The output signal power however is proportional to output signal voltage squared. Hence the output signal to noise ratio has been improved by a factor of 13. Typical waveforms for this situation are shown in Fig. 11, where the received Barker sequence is totally immersed in noise. The output correlation peak from the c.c.d. matched filter can clearly be identified in the upper trace.

Charge-coupled or digital filters?

Some potential uses of charge-coupled devices have been discussed briefly in simplified terms. The fine detail of the design processes have been omitted in the interest of clarity and brevity.

It is essential at this stage to discuss the relevent advantages and disadvantages of the c.c.d. with respect to other techniques for performing such basic filtering functions as described in this article—the simple lumped element filter, for example, along with some more exotic devices such as acoustic surface wave and digital filters.

The simple lumped filter is not discussed further due to its limitations with respect to critical alignment and bulk. Acoustic surface-wave devices have in the past few years created a visible impact on the radar and communications field at radio and intermediate frequencies. The linear frequency-modulated matched filter has in particular been extremely successful in radar applications and a television i.f. filter has also been fabricated. However, at low frequencies and large time delays, acoustic surface-wave filters become impractical. Hence, at base-band, the c.c.d. has to compete with digital matched filters in cost, performance, power, weight, reliability and flexibility.

A comparison of the advantages relevant to the adoption of either c.c.d. or digital filters in system implementations is given in the following table:

Charge-coupled versus digital devices

CCD	Digital
Low cost	Flexible
Small size	Longer time delay possible
Low power	Proven technology
High reliability	
Standard m.o.s. production	

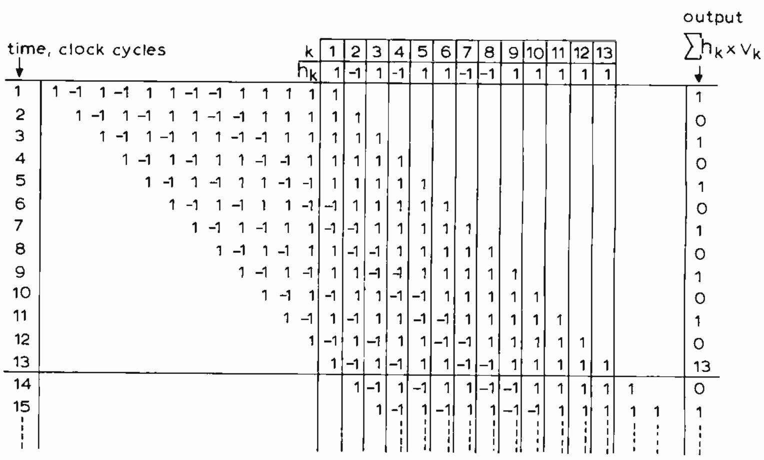


Fig. 10. Schematic of the operation of a matched filter when coded with a 13-bit Barker sequence. At clock cycle 1, the received sequence has just entered the matched filter. As the sequence progresses through the receiver filter, the auto-correlation function is output.

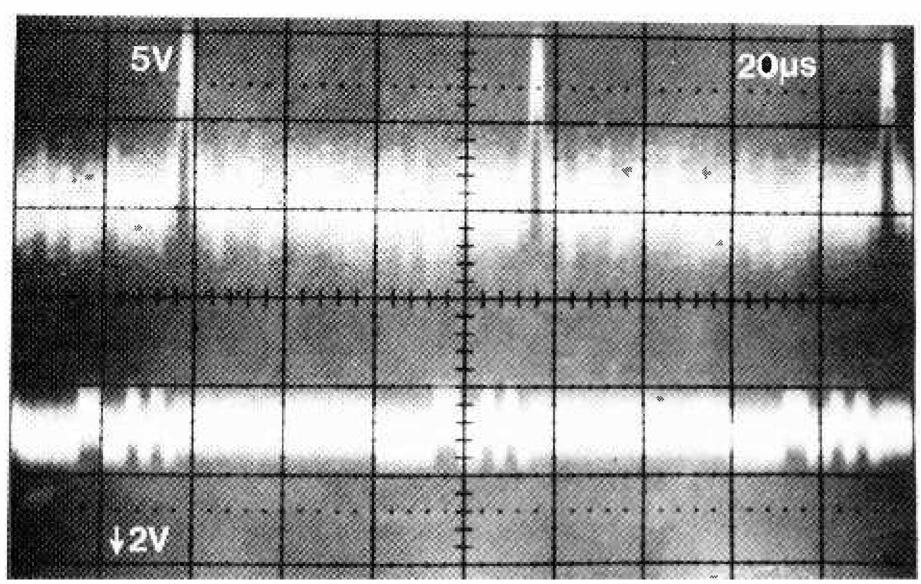


Fig. 11. Correlation of a 13-bit Barker sequence immersed in white additive noise. (Lower trace: input to c.c.d. matched filter; upper trace: filter output.)

Charge-coupled device performance

Sampling rate	≈ 10MHz
	> 100MHz with some techniques
Time delay	up to 1s
No. of storage elements	> 10^3 linear
	> 10^5 in array form
Transfer inefficiency	< 10^{-4} at 10MHz
Signal/noise ratio	> 70dB for a 256-bit linear device
Harmonic distortion	< −40dB
Time-bandwidth product	> 10^3

The potentially low cost of c.c.ds emphasized in this table is attributed to the inherently high level of integration obtainable. Elimination of analogue-to-digital and digital-to-analogue converters is one of the more obvious cost benefits along with a potential reduction in the number of packages required to implement a system.

Performance parameters for c.c.ds given above are typical of their present capabilities and the c.c.d. designer should be prepared to meet specifications within these capabilities.

The c.c.d. is an extremely high packing density, low power consumption, analogue shift register which is rapidly becoming accepted as an extremely useful device in many signal processing applications. In reasonable quantities, it is expected to be extremely cost effective. It can be considered as a means for realizing systems in other implementations. Commercial application potential in the signal processing field alone is enormous. Ability to produce lower cost, higher quality filters—both recursive and non-recursive—is of prime importance in the manufacture of modems. The c.c.d. can also potentially perform functions in the field of sonar similar to those performed by acoustic surface-wave devices in radar systems.

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Letters to the Editor

QUAD BROADCASTING—AN ALTERNATIVE VIEW

With reference to the article by Messrs Carey and Sager on quadraphonic broadcasting (Nov. 1974 issue) I would like to discuss one or two of the points that were raised.

To say that the problem of quadraphonic broadcasting is where to put the third and fourth channels is to virtually ignore the many suggestions for matrixed quadraphony systems (4-2-4) that only require two broadcast channels. In contrast broadcasters must give 4-2-4 systems very careful consideration as they might be able to provide a relatively inexpensive and more immediate answer to the problem. Not until it has been shown that all 4-2-4 systems are clearly incapable of providing both satisfactory quadraphony and compatible stereophonic and monophonic reception, can such systems be cast aside in favour of the more technically difficult and expensive 4-3-4 and 4-4-4 systems.

Why are the 4-3-4 and 4-4-4 systems more difficult and expensive? In the first instance if the transmission occupies the same r.f. channel bandwidth and uses the same transmitter power then the overall signal-to-noise ratio for the listener is likely to suffer. While in the "fringe area" there might be a relatively slight loss of signal-to-noise ratio for the monophonic listener, the loss could be significant for the stereo listener and, in many cases, quadraphonic reception might not be worthwhile. The exact figures will depend on the system being broadcast, the mode of operation of the receiver (mono, stereo or quad), and the relative depth of modulation associated with each component of the composite signal. In this matter Carey and Sager's estimates may not be too far out.

On the other hand in the present circumstances, quadraphonic listeners might also be at risk from adjacent channel interference. Messrs Carey and Sager state that 4-3-4 and 4-4-4 systems "do not inhibit the optimum use of bandwidth by other stations". I agree that the addition of the second 38kHz channel or even the 76kHz channel may not very greatly increase the maximum bandwidth occupied by the transmitted signal. However, this is not the whole story. For mono and stereo listeners with conventional receivers there would be an increase in the sensitivity to co- and adjacent-channel interference similar in magnitude to the decrease in signal-to-noise ratio, and largely for the same reason, viz. the reduction in the modulation depth of the components of the signal to which their receivers respond, and which has to be made to accommodate the additional quadraphonic information.

The corresponding increases in sensitivity to interference for the quad listener are less easy to predict but it is estimated that, relative to stereo reception of the existing pilot-tone system, quadraphonic reception of 4-3-4 would require about 6dB greater protection against co-channel and adjacent-channel interference at either 100kHz or 200kHz frequency spacing. With a 4-4-4 system, the increase in the required protection ratio against the adjacent channel could well amount to about 15dB. This particularly large penalty associated with the 4-4-4 system results not so much from the change in the transmitted signal spectrum as from the fact that the quadraphonic receiver is equipped with a 76kHz subcarrier detector. This produces an audible output from interference components in the range 61–91kHz to which a conventional stereo receiver does not respond.

The other technical difficulty which was unfortunately overlooked in the article is the problem of compatibility between the suggested new broadcast format and existing v.h.f. stereo receivers: in particular there is the problem of crosstalk between the two 38kHz subcarrier channels. In existing stereo receivers the phase accuracy of the regenerated 38kHz subcarrier determines the accuracy of eventual decoding but it is not very critical. If for example the phase error is 20°, this would introduce crosstalk between the left and right stereo channels at only −30dB, which is negligible in this context. If, however, the same receiver were used to receive stereo from a quadraphonic transmission using two quadrature 38kHz channels, the crosstalk between these for a phase error of 20° would be −9dB. The effect of this would depend on the design of the receiver. With an idealized square-wave-switching or synchronous-detector decoder the crosstalk would be substantially linear and the effect might be only a change in disposition of the audio images across the stereo sound stage; with many practical decoder circuits however the crosstalk could be appreciably distorted with rather more serious consequences.

With regard to cost, the susceptibility to noise and interference of the 4-3-4 and 4-4-4 systems implies that, with the present transmitter network, the stereo coverage of service areas could be prejudiced and, for quadraphony, may be appreciably less than that required. A substantial increase in transmitter powers could avoid the degradation caused by random noise but it would not solve the interference problem within the UK and could give rise to interference problems internationally.

These, then, are some of the reasons why a broadcasting organization may not readily share Carey and Sager's enthusiasm for the immediate adoption of a three or four channel solution to the quadraphonic broadcasting problem. If, however, further studies show that a 4-2-4 system cannot provide a sufficiently good quadraphonic service, whilst maintaining the present stereo and mono standards, then it may well be necessary to think again.

The other aspect of the article by Carey and Sager dealt with the possibility of a three-dimensional surround-sound system, i.e. quad plus height. Whilst it appears to be true that four suitable microphones arranged in a tetrahedral cluster can pick up and record the three dimensions of the original sound field, it is very doubtful whether four loudspeakers are sufficient to provide the wanted subjective result.

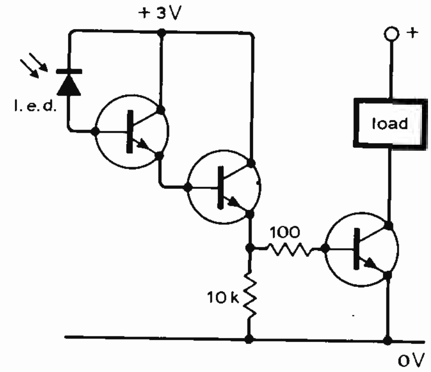
D. J. Meares,
BBC Research Department,
Tadworth,
Surrey.

USE OF LEDs AS PHOTO-CELLS

Light-emitting diodes made from gallium arsenide-phosphide or gallium phosphide have recently become available and are being made in very large numbers for sale at low prices. The question arises whether these devices can be used as photo-cells since they contain a semiconductor junction in an encapsulation designed to transmit visible light. It is not suggested that they are likely to perform better than properly designed cells; only that they may be more readily available to many readers.

Electrically the junctions have normal shaped diode characteristics but with forward conduction starting in the region of +2 volts, due to the wide energy-gap of the material, and reverse voltage limited to about −3 volts, since no special care is taken to prevent breakdown. The leakage current at this voltage, however, is extremely low provided the devices are kept dark. When light falls on them the leakage does indeed increase as expected, although the value must still be measured in nano-amps rather than milliamps.

The sensitivity varies considerably between different types of device, but every sample so far tested shows the effect to some extent. The diagram shows how two ordinary silicon transistors can be used as a simple Darlington pair to amplify the current and turn on a third transistor. Such an arrangement can be expected to switch tens of milliamps in the load with a threshold at about the normal indoor light level. The dark current of this sort of circuit is particularly low as the tran-



sistors lose gain at low currents, but the frequency response is poor as the stored charge can only be removed by internal recombination. There is no problem, though, in devising faster amplifier circuits, particularly if d.c. response is not required, and the inherent speed of the l.e.d. can be expected to be high.

The theory of energy levels tells us that the spectral response of the devices as photo-cells will be fairly broad and will lie on the high frequency (blue) side of the emission colour. If the normal emission process involves two or more quantum jumps in sequence, as I believe it does, then the absorbtion peak may be considerably more towards the blue than the emission. This leads to the idea that the major cause of the variations in the sensitivity between different types may perhaps be nothing more fundamental than the absorbtion characteristics of the dye which is put into the plastic lens to improve its appearance. There does seem to be some evidence that devices with paler plastic work better as photo-cells, and the manufacturers might perhaps consider this when selecting the mixture to be used in future designs.

K. C. Johnson,
Cheadle,
Cheshire.

KEYPAD LAYOUT: TELEPHONES AND CALCULATORS

Mr Harold Barnard (Letters, December issue) is not justified in taking the Post Office or industry to task for the keypad layout of telephones.

Confusion is not likely to result from the co-existence of two different layouts. The great majority of telephone users are not, and never likely to be, users of calculators in close proximity to a telephone. For those who are, the British Post Office foresaw a potential clash between the requirements for the two devices before either keypad layout had become standardized. In consequence, the Post Office sponsored a research project at the Medical Research Council's Applied Psychology Unit at Cambridge.

The results (available in 1966 and confirmed by a further study carried out independently by the same body in 1968) provided significant evidence in favour of the present telephone keypad layout. They showed that although there was little to choose between one arrangement and another in respect of keying speed, there was a statistically significant advantage in keying accuracy from the version in present use—even when users had already been conditioned to some other layout (such as the calculator layout standardized by ISO in 1967).

A standard layout for telephone keypads throughout the world is clearly desirable because of the growing volume of international travel. The International Telegraph and Telephone Consultative Committee recommended the current layout (which was already in use in America and due for early introduction in Japan and Latin America) and the British Post Office observes this international agreement.

R. E. Abbiss,
Director, Public Relations,
Post Office,
London, W1.

OPTICALLY COUPLED VFO

I was most interested in A. K. Langford's article in the November issue, "Optically coupled v.f.o.". What a perfect way to isolate a v.f.o., and a fairly cheap one at that! I was, however, a little unhappy about the idea of using the 5082-4350 optical isolator at 5MHz and above. There are two basic modes which the output transistor of the isolator can operate in: common collector, as used by Mr Langford, and common emitter. The former is only really suitable for low-frequency operation, and the response of the isolator in this mode effectively drops to zero by 3MHz, according to the spec. It is very likely that most devices will be comfortably within this spec., and will be usable at 5MHz, but it is not good design practice to assume this.

The common emitter mode, on the other hand, gives a usable response in excess of 10MHz with the same load resistor (470 ohms). So, I suggest the 470-ohm pot. is transferred to the collector circuit, and the emitter grounded. Assuming the gain and bandwidth of the output amplifier is sufficient, I see no reason why the circuit should not be used up to 15MHz reliably. Mr Langford does mention the common emitter mode, but in using the common collector mode, which offers no advantage in this circuit, he does not seem to have allowed for worst-case conditions.

Apart from that minor detail, I like it!

Richard Sterry, G4BLT,
Reading,
Berks.

Mr Langford replies:

I appreciate Mr Sterry's concern over the configuration of the isolator output transistor that was used in my final design. There were two reasons for choosing the common collector mode. First, the output using the "high frequency" common emitter configuration offers no advantage when working into the low impedance broadband amplifier, and at 5MHz the output is actually less than that obtained using the "phototransistor" mode, with a crossover point at about 2MHz. Secondly, the high output impedance at the collector made matching into the broadband amplifier difficult, and susceptible to stray pick-up unless the connection was very short. Using the low output impedance of the common collector configuration eliminated this problem; which is very important if good isolation is to be achieved without having to contend with a critical layout.

However, as mentioned in the article, with a tuned circuit in the collector of the optically coupled isolator the useful output can be extended well beyond 5.5MHz.

FRONT PANEL LETTERING

For "one-off" jobs, the production of a nicely-lettered front panel is a considerable problem. One solution is the use of transparencies of the kind that are used on so-called overhead projectors in classrooms.

The transparency is made from a pencil drawing of the front panel lettering by passing this drawing and transparency film through a special heater. (One example is the 3M "Thermofax" machine.) The transparency may then be sandwiched between a thin, clear Plexiglass sheet and the metal front panel of the equipment. The Plexiglass sheet is retained on the panel by the potentiometer and switch fixing nuts.

The advantages of the process, provided one has access to a suitable machine, are: the front panel layout may be done in pencil; the layout may be easily revised; and special symbols and lines may easily be incorporated.

P. Hiscocks,
Ryerson Polytechnical Institute,
Toronto,
Canada.

SUICIDE SOLDERING

Our company has been soldering m.o.s. transistors and i.cs with great success for some time now.

Mr Jack's letter in the November issue is of course rather worrying to us, as we too don't want to kill ourselves to protect our i.cs, and we would like to know more of the precise nature of the hazard.

We use the earthed terminal on our oscilloscope or power supply as a convenient point to discharge any static electricity. Is this dangerous, and is the hazard still present if the equipment is used in normal circumstances?

Also, during cold weather some of our operators seat themselves on an ordinary domestic convector heater, to centrally heat themselves while working at the bench. Apart from any medical side effects, is this practice electrically dangerous?

D. M. Parkins,
Greenbank Electronics,
Bebington,
Cheshire.

ELECTRONIC MUSIC JOURNAL

Interest in electronic music has grown and because of my wide experience in the medium—both theoretical and practical—I am starting a new journal entitled *Analog Sounds.*

Wireless World has been a great stimulus to me in the development of my own creative work with the electronic medium. To help spread the word, I intend including with each issue of *Analog Sounds* a cumulative directory of relevant articles published in electronic magazines including yours. This directory will take the form of a subject index with abstracts. *Analog Sounds* is a quarterly journal, depending solely on readers for support.

Jacob Meyerowitz,
Editor, *Analog Sounds,*
New York, U.S.A.

VARIABLE FREQUENCY DIVISION

I must congratulate Mr Winn of Racal Communications for his excellent article on the RA1772 synthesized communications receiver (October 1974).

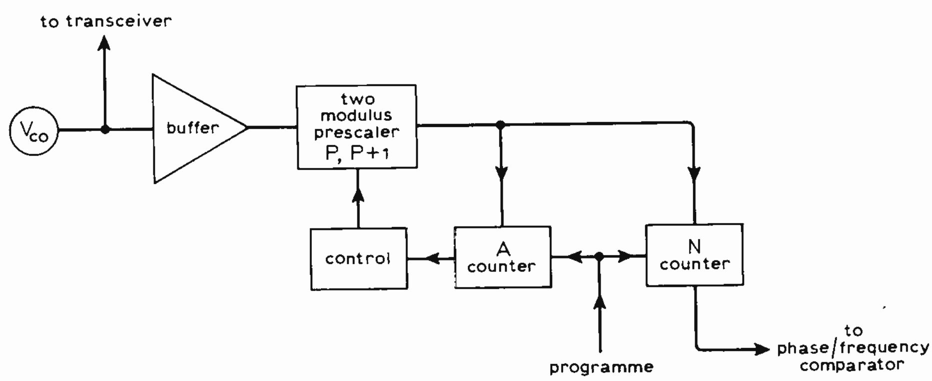
In his discussion of the limitations of synthesizers, Mr Winn says that the present "state of the art" of digital integrated circuits makes it impossible to use variable frequency division at frequencies above 50MHz.

However, by using a two-modulus e.c.l. prescaler—say, the Plessey Semiconductors SP8645—in conjunction with t.t.l. programmable dividers, it is practical to directly synthesize from frequencies up to 500MHz.

The basic two modulus prescaler ($\div$10/11), is usually combined with other e.c.l. counters to generate ratios of 20/21, 40/41 or 80/81—depending on the channel spacing required in the complete synthesizer. A typical scheme is shown below.

The total division ratio shown is:

$$N_{T.T}=P.N+A$$



The only restriction is that A is less than N. If for any reason A must be greater than N, then a three-modulus counter, i.e. $\div$40/41/42, can be used, thus halving the A count.

P. E. Battrick,
Plessey Semiconductors,
Swindon, Wilts.

Mr Winn replies:
It is agreed that recent developments have allowed an increase in the frequency at which variable division can take place, particularly by using the latest Plessey e.c.l. devices. As a small point, I did not state "impossible to use variable division above 50MHz" but that we divide directly from 50MHz and use a prescaler for higher output frequencies. It might still be preferable to do this since a hazard to be avoided in any digital-divider, phase-lock loop system is phase jitter. We find that a synchronous divider is essential to minimise the resulting noise sidebands produced by the division process as is also the need to restrict the division ratio of the final output loop as far as practicable.

ELECTRICITY AND MAGNETISM

The articles by "Cathode Ray" concerning fundamentals of electricity and magnetism (September, October) reminded me of a principle, if indeed it be a principle, that I deduced from purely practical considerations as an engineering student.

The principle is, briefly, that when one is wholly immersed together with one's instruments in a magnetic field (such as Mr O in the article) it is not possible to determine one's velocity through the magnetic field, even if its strength be known, by measuring an *e.m.f.* generated by a flux cutting conductor.

I should be most interested to know if "Cathode Ray" or your readers believe this crypto relativistic principle to be true, novel, or obvious.

C. P. J. Meade,
London, S.W.15.

"Cathode Ray" replies:
I am on record (in the September issue, p.348) as saying that observer O', moving in a magnetic field, finds also an electric field proportional to the magnetic flux density and his velocity. I discreetly refrained from explaining the means by

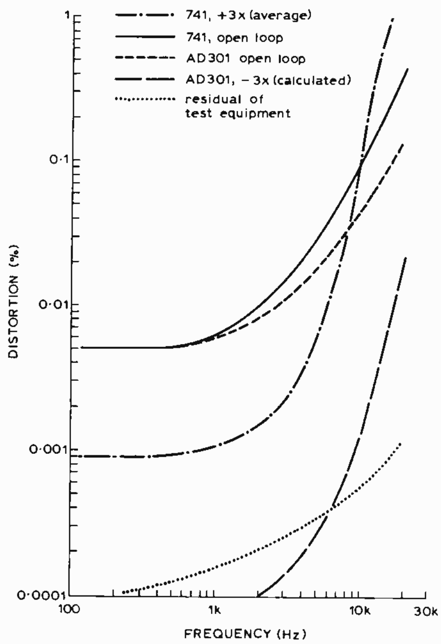
which he could find this. There is no doubt that he would be *subject to* an electric field caused by his motion through the magnetic field. Besides what the theory books say to this effect, there is a practical liquid flow meter which relies on precisely this principle. But the field is measured by a voltmeter that is *not* moving with the liquid. The observer O′, moving along with the liquid, could measure his velocity through the magnetic field by reading this meter as he went past it. Because of the relative velocity between himself and the meter there would be a relativistic correction. Our comparison of the observations of O and O′ did indeed lead to the necessity for such a factor, β.

I cannot offhand think of any instruments that O′ could take with him which would disclose his velocity through the magnetic field. Connecting a voltmeter to the ends of his conductor would form a closed loop embracing a constant magnetic flux, so there would be no reading. Whether this case could be extended to a general proof of Mr Meade's theorem I cannot say. Intuitively I feel it is true; I have no information on whether it is novel; and the last question reminds me of the story of the professor who, after saying that a certain statement was obvious, stopped abruptly, retired to his room for deep thought, and an hour later emerged to announce triumphantly to the by now empty lecture room "Yes, gentlemen, it *is* obvious".

SERIES AND PARALLEL FEEDBACK

Some time ago a debate was going on in your "Letters" columns about the virtues of parallel feedback as compared with series feedback. On that occasion Mr Linsley Hood stated that the distortion with operational amplifiers in the series-feedback mode was higher due to common-mode failure. Recently I have been able to verify his statement, although the distortion figures obtained were rather lower than those measured by Mr Linsley Hood. A Weston CD100 precision oscillator was used as a signal source. The output of this generator was filtered with a twin-T filter to suppress the last traces of the harmonic to be measured. The output of the test amplifiers was kept at 2V r.m.s. Twin-T and active notch filters were used to suppress the fundamental while harmonics were measured separately using synchronous detection methods.

With this test set-up it proved impossible to measure the distortion of the op-amps, connected as $-3\times$ amplifiers by parallel feedback, below 8kHz. Open-loop differential mode measurement yielded more useful results and from these distortion figures for the parallel-feedback connection were computed. They agreed well with the measured figures about 8kHz. The series-feedback connection, set for a gain of +3, produced harmonics that were readily measurable. Almost identical results were obtained from open-loop measurements



with common-mode signals of equal amplitude, proving Mr Linsley Hood's point about common-mode failure. It turned out that results varied widely between specimens, the best of the 20 op-amps tested producing about 0.001% at 2V output and the worst about 0.1%, when measured with series feedback at 8kHz ($A_v=3$). From this one can conclude that it is wise to avoid series feedback at gains of less than, say, $10\times$ when using these operational amplifiers in low-distortion circuits.

Unfortunately, the "error take-off" method of distortion reduction, as described by Mr Sandman in your October issue, suffers from the same drawback as the series-feedback arrangement, as can be seen in Mr Sandman's Fig. 2. Here the full input signal is present at the inputs of A_2 as a common-mode signal. Particularly when the circuit is set for a low gain, this can easily lead to an increase in distortion rather than a decrease. Incidentally, the "error take-off" method has been known for some time now as "feedforward control". It has been thoroughly investigated at Delft University of Technology, where a more elegant circuit was devised that avoids the "floating" load, while preserving the advantages of feedforward control.

T. Magchielse,
Almelo,
Netherlands.

Editor's note: Mr Linsley Hood asks us to state that his earlier figures were for a 1kΩ load, whereas those of Mr Magchielse could well be for a much higher output load (possibly the input impedance of his measurement equipment) and i.cs, like most other similar amplifiers, give a lower distortion into a higher load impedance.

Mr Sandman replies:
Unfortunately Mr Magchielse has misunderstood the functioning of both the error take-off and Delft University circuits! A_2 in my Fig. 2 handles only a small signal and distorts only the distortion which is only a small effect and the Delft circuit offends against the principle of "non/interaction" and as its A_l has no negative feedback that of "rigidity of interconnection" as well.

ACTIVE CROSSOVER NETWORKS

As a designer of p.a. systems using active crossover networks, I was very interested to read the article by D. C. Read in your November, 1974, issue. However, I feel that readers may be confused by the graphs for the B110 unit in Fig. 1, and in particular by the conclusions drawn from them.

The graphs are obviously drawn for the free field responses, and predominantly show the effect not of internal cabinet volume, but of external cabinet dimensions. In fact the sound power output response for this unit is *improved* by the smaller cabinet, the 0.33cu. ft enclosure being near the optimum for the B110, the enclosure Q being just under 1 at around 75Hz, giving a response flat down to around 80Hz and dropping at 12dB/octave below this. Response curves for small speakers such as this should always be taken under the same conditions as their normal use, in this case almost certainly up against a wall, corresponding roughly to half-space conditions. Under these conditions the B110 will show a flat response up to around 600Hz, rising after this up to about 2kHz, where it levels out again. This unit should not be used on bass signals in as large a cabinet as 1cu. ft, as there will be almost no stiffness control over the low-frequency cone excursions.

A worthwhile improvement with these small enclosures is to provide, electronically, deliberate cross-talk between stereo channels below about 150Hz, thus cutting down considerably on cone excursions with bass signals predominantly in one channel or the other, unfortunately quite common with modern recording techniques. To the best of my knowledge, the first company to do this commercially was Servo-Sound.

K. C. Gale,
Poole,
Dorset.

THE STRIP IN BANK NOTES

A year or so ago, we were warned that spurious £5 and £1 notes were in circulation. I had a chance to examine some of these and one thing they all lacked was the metal strip. Surely (I thought) one of the metal detector circuits in the cashier's desk is all that is required. Then out of curiosity I tried to measure the resistance of the metal strip. It was infinity!

Question: what is the metal strip in a note made of?

A. Sproxton,
Home Radio (Components) Ltd.,
Mitcham, Surrey.

Solid-state digital clock

1—Design

by David C. Clegg

With the increase in the number of educational programmes on both radio and television, the Open University programmes for example, many now have to be broadcast at both unsocial, and very often, inconvenient times. While there is no substitute for watching or listening to the programme live, the next best thing is to record* it. This requires some sort of time switch which must be both accurate and reliable, which implies that the time switch should be independent of the mains electricity supply. It was to solve this, and other similar problems, that the digital clock described in this article was designed.

The priorities which were considered when designing this clock are as follows:

Accuracy. Three frequency references were thought to be practical in this application; the mains 50Hz, an electronically maintained tuning fork, and a quartz crystal oscillator. The mains was rejected because it limits the uses to which the clock can be put (it is no longer portable in the true sense of the word) and the stability (short term) and reliability of the mains leaves a lot to be desired, especially at the present time. A maintained tuning fork was rejected because of its high cost compared to the quartz crystal, which was finally adopted as the frequency reference. A good compromise between stability, size and power consumption was obtained by using a frequency of about 200kHz with a c.m.o.s. maintaining amplifier and divider stages. Using an unovened crystal (frequency 204.8kHz) a stability of about one second per week was obtained.

Power consumption. The clock uses an l.e.d. display which does not result in low power consumption. Two supplies are, therefore, used: a main 12-volt supply and

*Subject to copyright regulations.

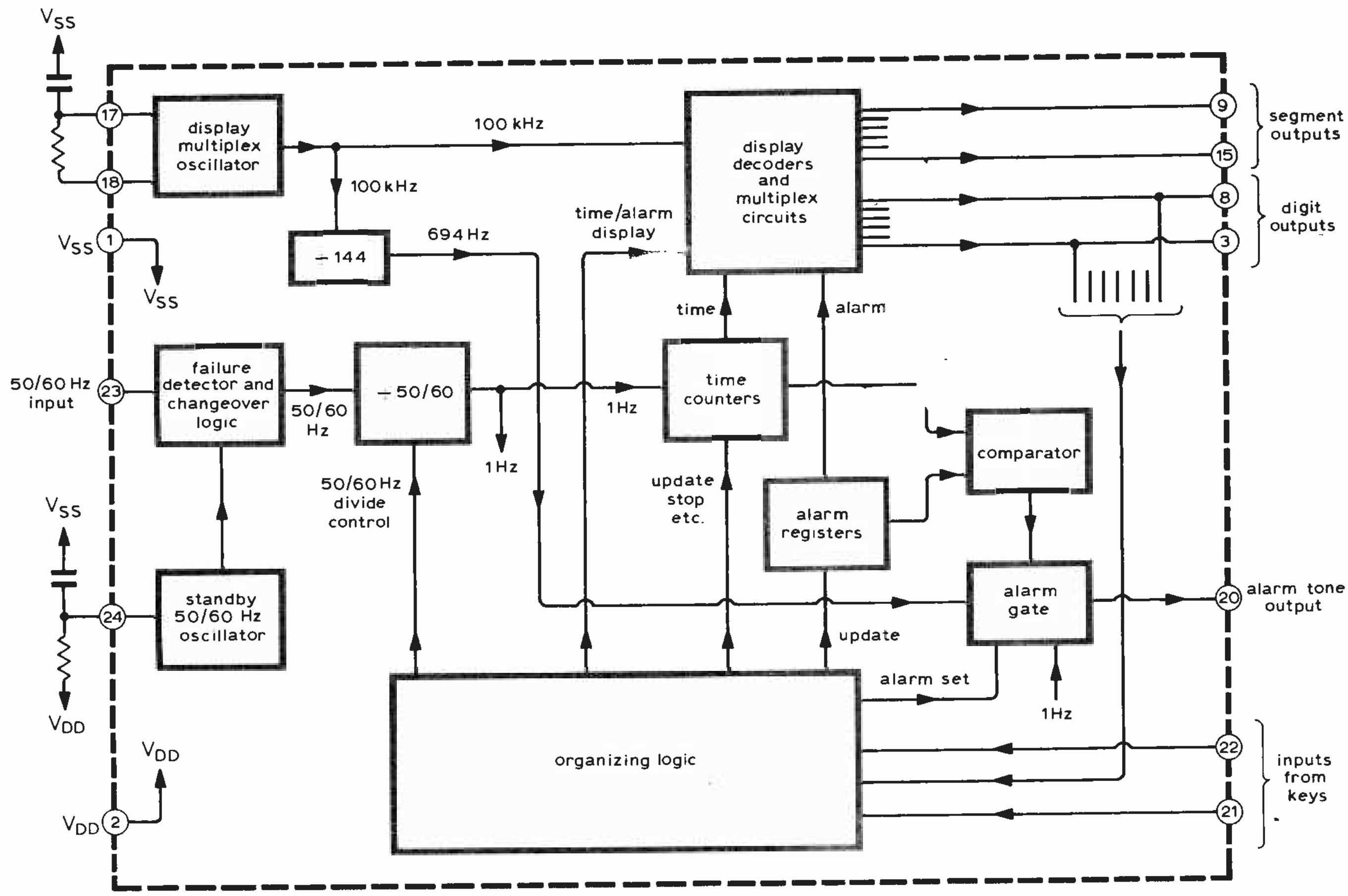


Fig. 1. Block diagram of the digital clock logic.

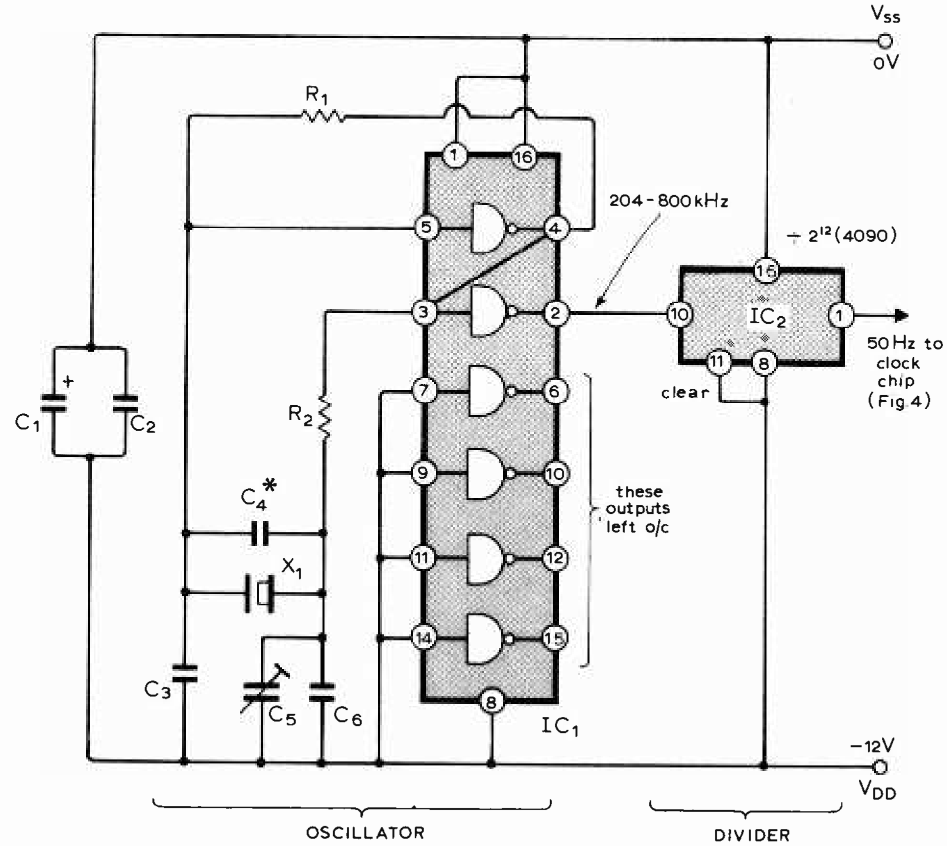


Fig. 2. Crystal oscillator and frequency divider. (For note on asterisked C_4 see next month.)

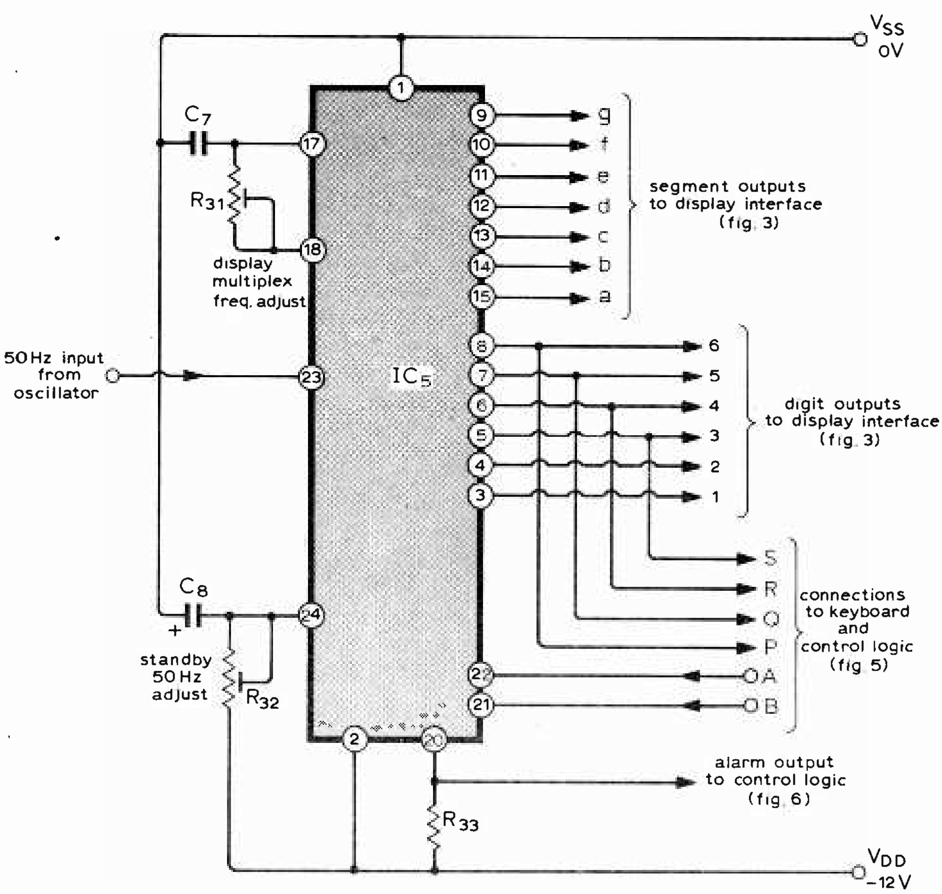


Fig. 4. The clock chip with its associated presets and outputs.

a standby 9-volt supply. The standby supply may consist of either nickel-cadmium re-chargeable cells or a dry battery. When the 12-volt supply is present, both the clock logic and the display are powered and if the standby cells are nickel-cadmium, these will be trickle charged. Under these conditions the current is a maximum of 120mA; i.e., a power consumption of 1.44W.

When the 12V supply is absent, the display is not powered and the standby supply powers the logic (and the crystal oscillator). Under these conditions the current is 8mA; i.e., a power consumption of 72mW.

A key is provided to enable the time to be read under standby conditions. Use of this key should be kept to a minimum since the current from the 9V supply rises to over 80mA.

Size. The overall dimensions of the printed circuit board are 6.75in × 4.5in × 1in. All the operator controls are push-buttons arranged as a 3 × 4 keyboard. In the author's prototype the standby power supply consisted of nickel-cadmium cells and was mounted, together with the alarm speaker, in a perspex block under the p.c. board.

Circuit design

The clock was designed around the Mostek MK-5017-AA p.m.o.s.-l.s.i. integrated circuit, which contains all the logic required for a digital alarm clock. A block diagram is shown in Fig. 1.

The input to the chip may be either 50 or 60Hz, this being selected by the organizing logic. There is also a built-in relaxation oscillator which will generate a 50/60Hz waveform to keep the clock going in the event of failure of the external 50/60Hz. The frequency determining components for this oscillator are connected to pin 24. The stability is very poor, being dependent, both on temperature, and supply voltage.

In order to minimize the number of pins required on the package, the display is multiplexed. To further reduce the pin count, there are only two control inputs, but a matrix of diodes is formed with the two control inputs and four of the digit scanning outputs, making it possible to input the nine required control signals through these inputs. The frequency determining components for the display multiplex oscillator are external to the chip and consist of a resistor and capacitor chosen to give a frequency of 100kHz. This frequency is also divided by 144 to provide the alarm tone of 694Hz.

If the alarm has been enabled, pin 20 outputs the 694Hz alarm tone, interrupted at 1Hz intervals when the time counters and the contents of the alarm register agree.

Two additional facilities, which are not used in this design, are provided by the MK-5017-AA chip. Operation in the 12-hour mode is achieved by omitting diode D_9; an a.m./p.m. indication is available at pin 16, logic 1 (V_{ss}) indicating a.m. A 1Hz output is available at pin 19.

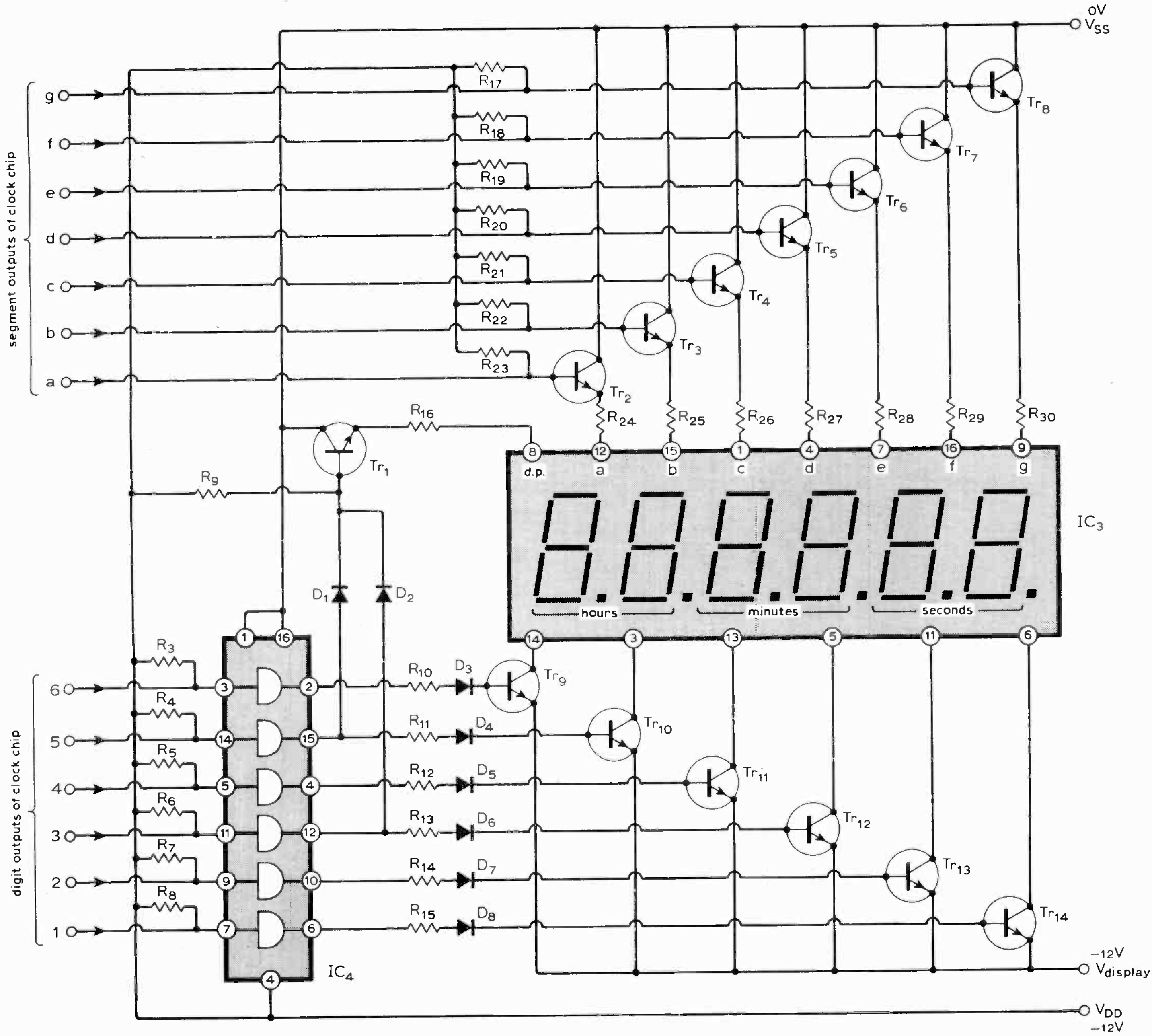


Fig. 3. Interface to enable the p.m.o.s. chip to drive the l.e.d. display.

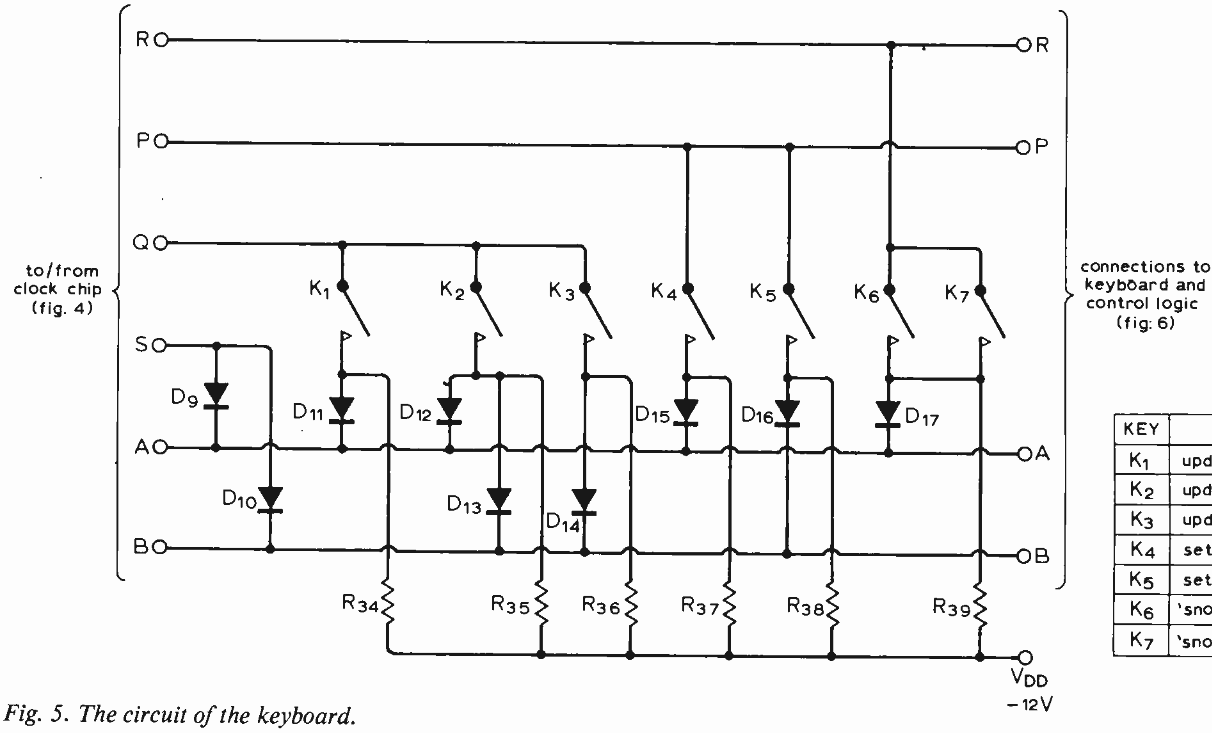
Crystal oscillator. In order to minimize power consumption of the oscillator, shown in Fig. 2, it was decided to use both c.m.o.s. maintaining amplifier and a c.m.o.s. divider to provide the 50Hz required by the MK-5017-AA. At the time of designing this clock, there were no c.m.o.s. dividers capable of dividing by an integral power of 10—the next best thing was the RCA CD4040 which contains 12 binary dividers. Whilst it would have been possible, by the addition of external gating, to make the CD4040 divide by an integral power of 10, it was decided to use this device as a divide by 4096 and to choose a suitable crystal frequency. Since the MK-5017-AA can accept either 50 or 60Hz, there are two possible crystal frequencies to choose from: 50 × 4096 = 204.800kHz, or 60 × 4096 = 245.760kHz. The only reason for choosing the former was that it is a "simpler" frequency. The cost of having a crystal manufactured to the design frequency of 204.800kHz is very little more than that of purchasing a crystal of, for example, 200kHz.

The crystal is not mounted in an oven because of the considerable power requirements. While the external supply could power a suitable oven, the drain on the standby supply would be unacceptable; not to power the oven under standby conditions would cause an unacceptable frequency shift. The crystal is cut for operation at room temperature (20°C) and provided the clock is used in an environment of reasonably constant temperature it will maintain a stability of one second per week.

The maintaining amplifier is a c.m.o.s. inverter biased into its linear mode by a 10MΩ feedback resistor. For a more complete description of the design of such an oscillator, readers are referred to RCA application note ICAN-6539.

Display interface. The MK-5017-AA chip is not capable of driving an l.e.d. display directly, so the interface shown in Fig. 3 must be provided. The segment interface circuits consist of emitter followers with current defining resistors in the emitters.

The digit outputs from the clock chip are also used to scan the control logic and to preserve the logic levels, the digit outputs being buffered by IC_4. Diodes D_3 to D_8 are to protect the base/emitter junctions of the digit drive transistors from reverse breakdown when the display supply is removed. D_1, D_2 and Tr_1 illuminate the decimal points between the hours and minutes and between the minutes and seconds.



KEY	FUNCTION
K_1	update hours
K_2	update tens minutes
K_3	update units minutes
K_4	set time
K_5	set/display alarm
K_6	'snooze'
K_7	'snooze'

Fig. 5. The circuit of the keyboard.

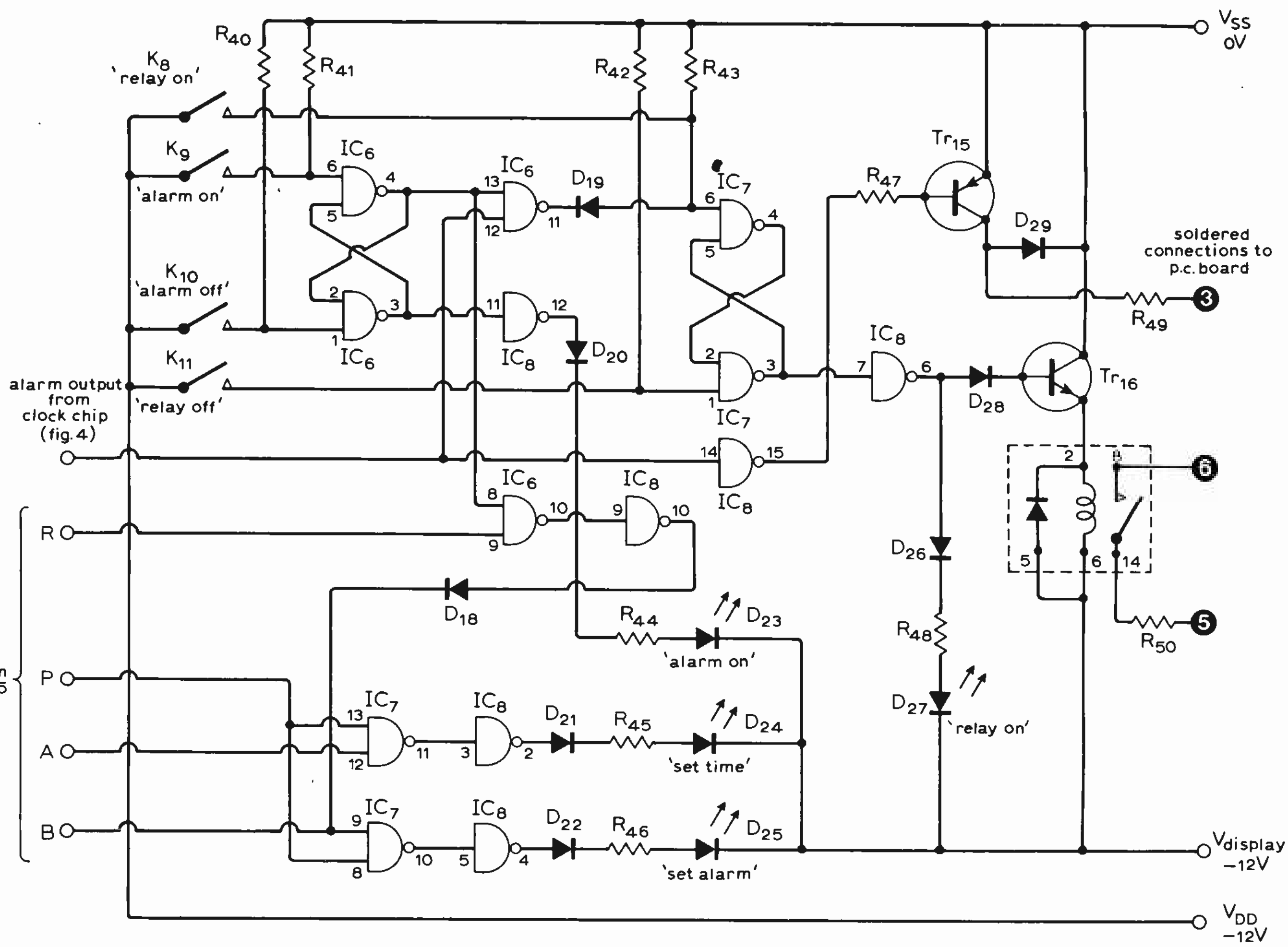


Fig. 6. Control logic circuit.

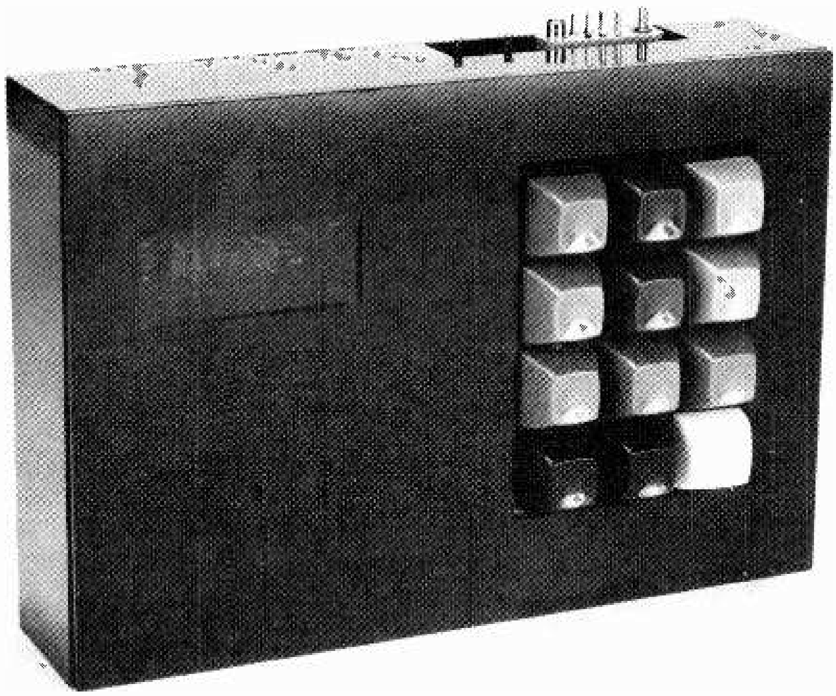


Fig. 7. The prototype clock. The unit is primarily intended as a timer, the display being of secondary importance. Connexions at top right are for an external power supply and switched output.

SPECIFICATION

Display. 6-digit 0.1 in l.e.d. display.
Displays time in the 24-hour mode with decimal point between hours and minutes and between minutes and seconds, e.g. 18.27.36
4 single l.e.ds indicate the following:
1) Alarm Set.
2) Relay On.
3) Display showing Alarm Time.
4) Count Stopped.
The display is not powered in the event of a supply failure.

Frequency
Reference. Quartz crystal, f_r 204.800kHz.
c.m.o.s. maintaining amplifier.
c.m.o.s. divider. Division ratio 2^{12} (4096).
Output of divider 50Hz.
Stability about $1\frac{1}{2}$ parts in 10^6

Power. Main supply 12V 120mA max. (1.44W)
Standby supply 9V Ni-Cd cells or dry battery, providing 8mA max. (72mW) or 80mA with display on (720mW).

Alarm. Alarm time is adjustable in one-minute intervals.
Alarm tone is a 694Hz interrupted at 1Hz intervals.
When alarm sounds it may be completely cancelled or silenced for seven minutes after which time it will sound again.

Relay. When the alarm sounds the relay contact closes and remains closed even if the alarm is cancelled.
Independent control of the relay is also possible.
Contact rating: 100V max.
80mA max.
OFF resistance ∞ Ω

ON resistance 68Ω

Dimensions
$6\frac{3}{4}$ in × $4\frac{1}{2}$ in × 1 in.

Control logic. Most of the controls provided require only momentary closure of the control keys; diodes and resistors are, therefore, all that is required to connect the appropriate digit lines to the control inputs of the clock chip. This is shown in Fig. 5.

The alarm on/off and relay on/off functions require a bistable, to store the information supplied by momentary closure of the selected key. The bistables are formed by IC_6 and IC_7 in Fig. 6 which, as before, are c.m.o.s. integrated circuits to reduce to a negligible amount the power required.

Single l.e.ds D_{25} and D_{27} indicate that the alarm has been enabled, and that the relay contact is closed, respectively.

Single l.e.d. D_{23} indicates that the display is showing the contents of the alarm register, i.e., the time for which the alarm has been set, D_{24} indicating that the count has been stopped.

A series resistor is connected in the relay contact circuit, to prevent damage to the reed relay due to large cable discharge currents. This resistor, R_{50}, may be reduced in value, or removed altogether if the length of cable from the switched appliance to the relay is short. Without the series resistor the contact is rated at a maximum current of 250mA, to switch a load of not more than 10W.

The alarm output from the clock chip is buffered by an inverter in IC_8 and amplified by Tr_{15} to drive a medium impedance speaker, the impedance of which should be in the region of 1kΩ. The author used a miniature dynamic microphone, but better results were obtained by using a 3in 70Ω moving coil speaker and a matching transformer. R_{49} is to prevent damage to Tr_{16} should the output be inadvertently shorted to V_{dd}.

(To be continued)

About People

Edward Fennessy, C.B.E., B.Sc., F.I.E.E., was made a Knight Bachelor in the New Year Honours List. Mr Fennessy is managing director of Post Office telecommunications and was formerly managing director of the electronics group at Plessey. As an RAF group captain on the staff of 60 Group he led the teams working on Gee, Oboe and other ground radar chains, becoming head of the Decca Navigator Company after the war. He later formed Decca Radar and in 1972 was awarded an honorary doctorate by the University of Surrey.

Also in the Honours List is the award of the O.B.E. to **John Scott-Taggart**, M.I.E.E. for "services to radio engineering". Mr Scott-Taggart has been a well-known innovator and writer on radio since the early years and, during the war, was Wing-Commander responsible for the majority of radar ground stations in England and Wales, including the training of their personnel. In 1963 he was made Knight Officer of the Order "Al Merito della Repubblica Italiana" by the Italian President.

Dr Per V. Bruel has received the Rayleigh Gold Medal of the Institute of Acoustics in recognition of his services to acoustics. Dr Bruel, one of the founders of Bruel and Kjaer, was presented with the Medal by the Hon. Guy Strutt, a descendant of Lord Rayleigh.

Godfrey Hounsfield, of the EMI Central Research Laboratories, has been awarded the Wilhelm Exner Medal by the Austrian Industrial Association for his work on the EMI-Scanner X-ray brain examination system. The system uses a computer to correlate a large number of readings from a narrow X-ray beam, the source rotating about the patient's head. Detailed cathode-ray tube displays can then be presented, giving about 100 times more information than a simple X-ray technique. Mr Hounsfield studied at the Faraday House College, obtaining a Diploma, and later joined EMI, working on radar and computers—in particular the EMIDEC 1100, for which he was head of the design team. He began work in the X-ray field in 1968, and in 1972 gained the McRobert Award for the work on EMI-Scanner.

Electronic engineers' slide rule

Designed for ease of calculation of commonly required parameters such as inductive and capacitive impedance and decibel ratios

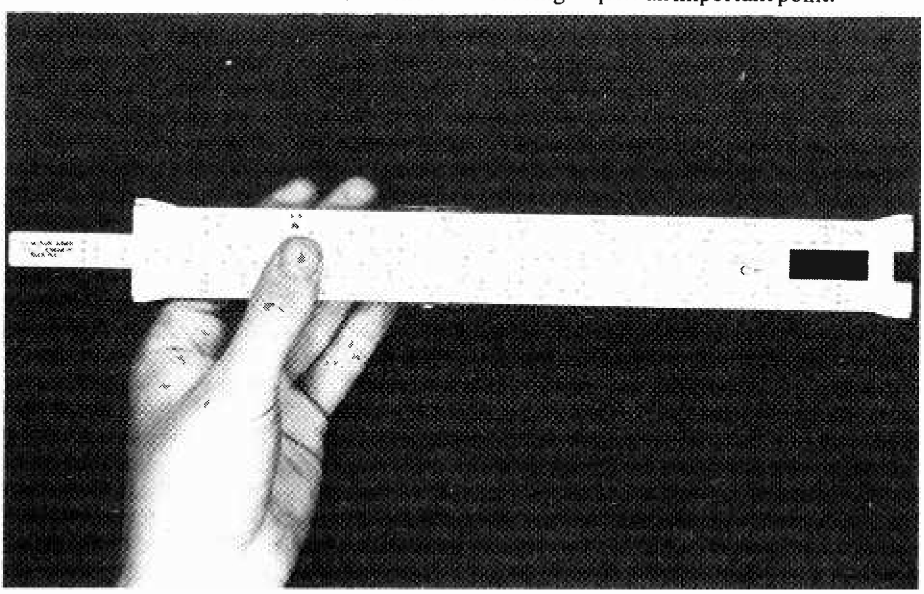
by L. Nelson-Jones, F.I.E.R.E.

I have had a special slide rule for a number of years now which has a dB scale drawn up against the A and B scales of an otherwise standard slide rule, so that relative voltage dB ratios can be quickly calculated for any particular reference level. This rule has saved me many hours' work when drawing up response curves, both in audio and radio frequency work. Converting a table of readings to decibels can be a very tedious business using tables or logarithms; whereas, using the slide rule, one has only to move the slide to set the reference voltage against the "0dB" point of the dB scale and then all the other values are read off merely by moving the cursor to the voltage of each reading whose dB value is required.

Some months ago someone unknown stole the properly engraved version of the rule that I had been using, leaving me with only the very old hand-made wooden slide rule on which I first tried out the idea of the dB scale. Realizing how useful this rule had been to me, I decided to approach a slide rule manufacturer to put my ideas into practical form so that the idea could be made more widely available. This approach was made at the IEA exhibition and was received with interest, as the firm concerned was the one that had made the Units Converter for *Wireless World* (June 1969).

At that time I also had an *L/C* "slide rule" originally distributed by the old A. H. Hunt (Capacitors) company as an advertising hand-out. This rule was made of stiff card and was very useful for quickly deriving the impedance of any *C* or *L*; however, it had very cramped scales since it tried to cover a quite unnecessarily wide range of frequency (0.000005Hz to 20GHz).

I decided therefore to aim at a double-sided rule having the dB scale added to the basic slide rule scales on one side and a simplified *L/C* calculator on the reverse. I tried many types of *L/C* scales using a large sized cardboard mock-up. With the scales chosen one first sets the slide against a triangular reference mark for the frequency of interest. The cursor is then moved to the value of the capacitor or inductor on the slide scale and the value of the impedance is read off from the appropriate scale on the body of the rule. The capacitive impedance scales have three ranges, for pF, for nF and for μF. Likewise the inductive impedance scales have three ranges, for μH, for mH, and for henrys. In this way, and by restricting the frequency range to 1Hz to 100MHz, the scales have been made relatively uncramped and will be quite accurate enough for most such calculations. I find the prototype of the new rule very easy to use for *L/C* calculations and it does not lend itself easily to misreading—quite an important point.



Reverting to the normal scales of the slide rule: The usual A,B,C, and D, scales (X^2 and X) are provided, together with the reciprocal scale C1($1/X$) used with the C and D scales, and the LL2 and LL3 ($e^{0.1x}$ and e^x). These provide all the necessary scales needed in everyday electronic circuit design work. I am sure some engineers will nevertheless find their favourite scale missing, but in the limited space available on a slide rule I had to choose those scales likely to be the greatest use to the greatest number of electronic engineers. In choosing the scales I was greatly assisted by the helpful comments and suggestions of the editorial staff of *Wireless World*.

I am sure many readers will at first wonder why I have chosen to introduce a new slide rule design at a time when calculators are getting so commonplace, and to this I would answer that, unless one has the price of a fully programmed calculator available (and few of us have), one cannot quickly do a dB calculation, or the *L/C* calculation for that matter. The slide rule on the other hand is quick and easy to use for these calculations, and its accuracy is usually more than adequate for everyday electronics. Until a simple and cheap electronic calculator capable of these calculations is available I, for one, shall be using the new slide rule.

Please do not think that I am anti-calculator, as some are. I most certainly am not. I have had a calculator of my own for some two years now, and it has proved invaluable in my work. Incidentally, on the occasions when I have been without it I find that I can add up much faster and more accurately than I used to be able to, before I had the calculator (critics of the "It gives you a lazy mind" school please note).

The new rule is available to *Wireless World* readers at a price of £2.50 + VAT and it is supplied complete with a full instruction book.

For a limited period until the end of February, 1975 the rule will be available at a special introductory price of £2.22 + VAT (equals £2.40 at the current rate of 8% VAT) to *Wireless World* readers. The above prices apply to UK and Eire only. Overseas please add appropriate carriage. Enquiries and orders (with cheque or Postal Order) should be sent to KEY Electronics, PO Box 7, Bournemouth BH7 7BS.

Low-cost emergency power generator

220V sine-wave generator using a lawn-mower engine and a scrap car dynamo

by J. M. Caunter

It has long been the dream of the author to become independent of the national grid during what seems to be the annual "silly season" of threatened disruptions in the supply of electricity. Inverters are attractive, being cheaper than petrol generating sets, but still expensive when one considers the batteries needed to run them. Most inverters have square-wave outputs, for optimum efficiency, which are not suitable for central heating pumps, 25% of the power being wasted in harmonics which could overheat the motors. Television sets should have the input taps changed because of the different peak-mean value of square waves. Sine-wave inverters are available at a price, but these are less efficient, and require even bigger batteries.

Alternative methods of generating low-cost power for the home have been investigated. The author's solution costs about £12 and makes use of a petrol mower. A 12V car dynamo rescued from a scrapyard provides an excellent skeleton for an alternator, and a transformer at about £8 saves a tedious winding process. A scrap 12V battery supplies the excitation current, and about £2.50 secures enough components to monitor the frequency of the output voltage and protect the field winding from setting fire to the garden shed when the motor stalls while you are in the bath (metaphorically speaking).

The armature of the dynamo is rewound for a slightly higher voltage which does not cause insulation problems but keeps brush currents down, since the area of contact with the slip rings is less than that with the original commutator. The design to be described is by no means an optimum one and can easily be changed to suit the reader. For example, if the armature was wound for 110V a.c., it would require about 78 conductors of 22swg per slot. However, the insulation would need more careful selection than in this proposed design.

Armature construction

Remove the armature from the dynamo yoke and dismantle from the drive-end bearing plate. Push out the paper rope filler from the outer edge of each armature slot, and after cutting the wires at the commutator remove the windings.

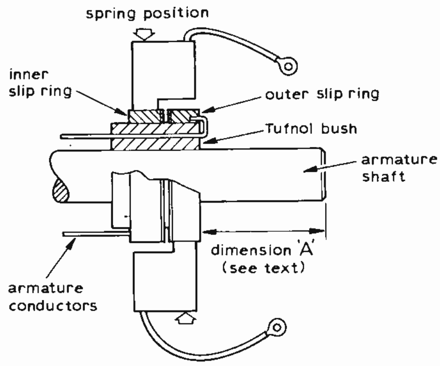


Fig. 1. Sectional view of slip-ring assembly and brushes.

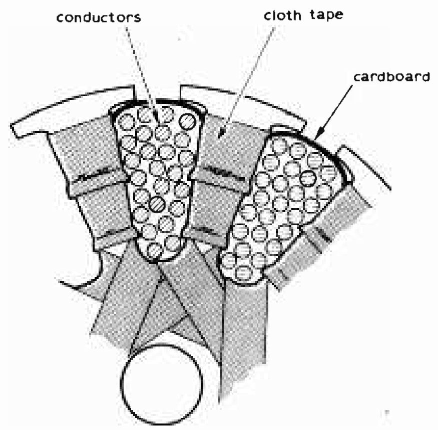


Fig. 2. Armature insulation.

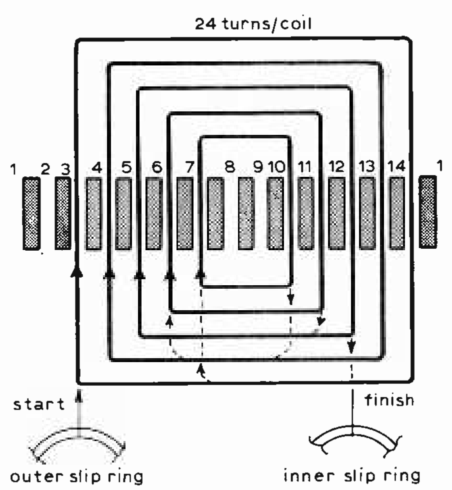


Fig. 3. Developed winding diagram.

Clean the armature core with paraffin and then dry. Before removing the commutator measure its major dimensions and its position relative to the end of the shaft which is shown as dimension A in Fig. 1. Note the width and relative position of the brush marks on its circumference. These dimensions are vital to ensure correct alignment between brushes and slip rings, especially on dynamos without brush inspection windows. With reference to Fig. 1, the author's slip-ring assembly was made to the following dimensions:

overall diameter 37.25mm;
insulating bush bore 15mm;
width of each slip ring 8.5mm;
gap between slip rings 3mm.

The remaining dimensions are less critical and can be varied to suit the reader. The commutator is now pulled off the shaft by brute force or ignorance.

Construction of the slip-ring assembly is shown sectioned in Fig. 1. The copper slip rings are retained on the Tufnol bush by Araldite or Loctite adhesive. When completed, the assembly is pressed or drifted on to the shaft to a position determined by dimension A. The old armature insulation must be removed from the slots and renewed. The most successful method was to wind single layers of black cloth insulation tape between adjacent slots and between diametrically opposite bottoms of the slots as shown in Fig. 2. This has the added advantage of building up a cone-shaped collar where the shaft enters the armature laminations and greatly aids the winding operation. One or two layers of tape are also wound tightly around the armature shaft between this collar and the slip-ring assembly.

Before commencing with the winding, Fig. 3, which shows the armature slots laid out flat for simplification, should be studied. Each pair of slots is wound with 24 turns of 18swg enamelled wire except the two outer pairs which are left empty. The slot nearest the hole through the slip-ring bush is designated slot 3; the remaining slots are numbered clockwise from this, through 14 and back to 2. When one is winding between slots 5 and 12 the coil is divided equally on each side of the armature shaft. Use thin but strong card cut into strips to insulate the open end of the armature slots as shown

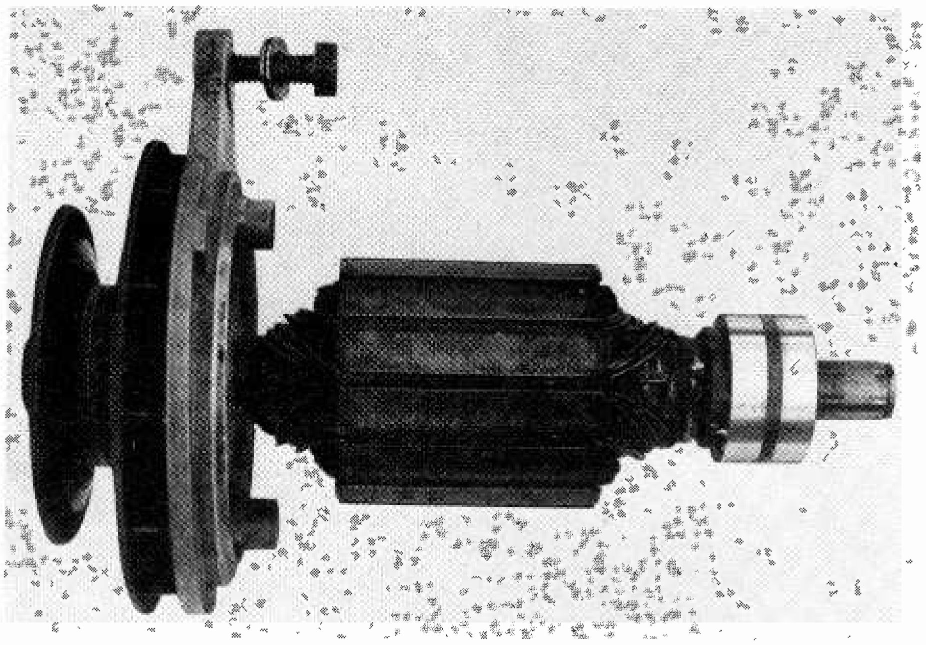


Fig. 4. Completed armature assembly.

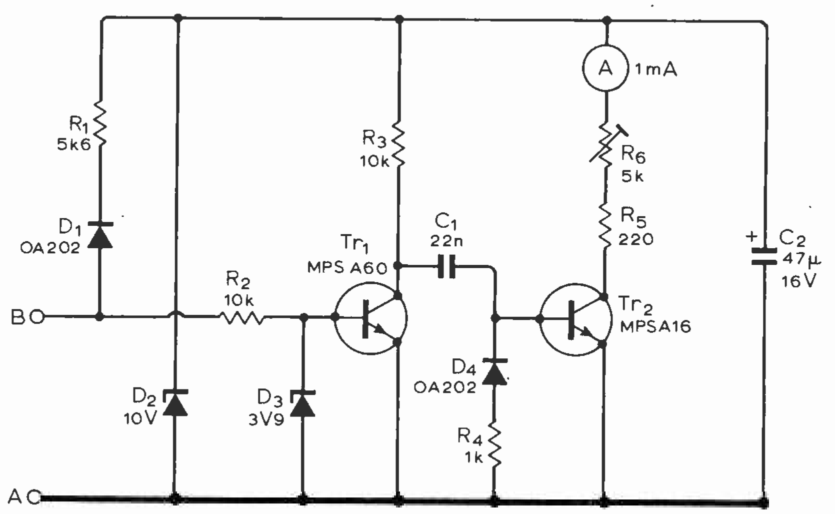


Fig. 5. Frequency-meter circuit diagram.

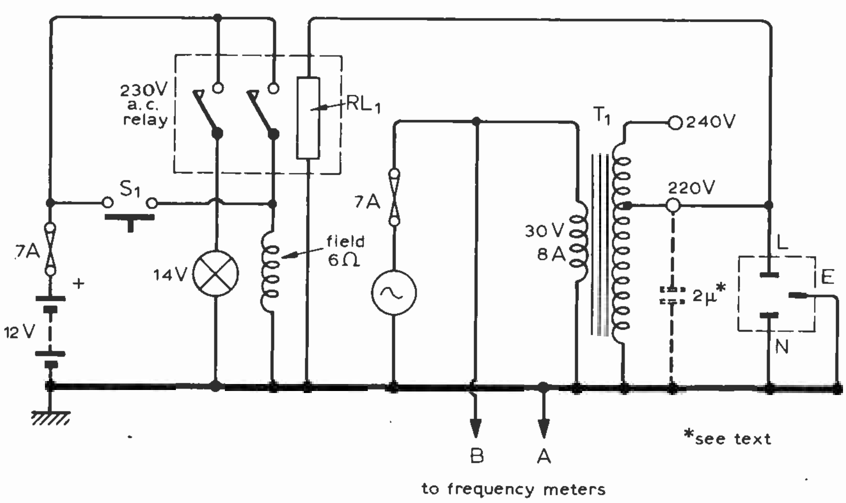


Fig. 6. Cut-out and output circuit.

in Fig. 2. By tapering one end, the cards slide into position fairly easily. Bind the armature shaft with thin string, where the conductors enter the slip-ring bush, and tie securely. Impregnate the whole winding with shellac applied by brush, ensuring that the liquid penetrates the slots. The completed armature is shown in Fig. 4.

The brush gear

The brushes are modified to contact the slip rings as shown in Fig. 1. In the author's model the brushes were filed back to a width of 6.5mm. If new brushes are used it may be necessary to bed them in with the aid of fine-grade carborundum paper wrapped around the slip rings. When finally fitting the brushes to the end plate it is important to position the pressure springs over the contact area as shown. The alternator may now be assembled.

Frequency indicator and control circuit

To ensure that the alternator is driven at the correct speed it is necessary to monitor the frequency of the output voltage. Fig. 5 shows the circuit of a suitable frequency meter. D_1, R_1, D_2 and C_2 provide a stabilized 10V d.c. supply to the circuit, derived from the input. The input voltage is squared by Tr_1 to minimize errors caused by changes in input amplitude. R_2 and D_3 protect Tr_1 from transients and reverse base-emitter potentials. A differentiating circuit—R_3, C_1 and D_4 into Tr_2 is driven by Tr_1 whose collector current is limited by R_4 when discharging C_1. The current pulses developed in the collector circuit of Tr_2 are of constant width and varying repetition rate depending on the input frequency. These pulses are integrated by the inertia of the meter movement and displayed as a steady reading, changing only with input frequency. The linearity of this circuit is dependent on the mark/space ratio of the current pulses at the maximum operating frequency. The values chosen for the differentiator in the author's circuit give a negligible error at the maximum meter reading of 100Hz. The meter scale is calibrated directly from 0 to 100Hz, and R_6 is adjusted to give a reading of 50Hz when the input is fed with 10V–60V a.c. from a mains-connected transformer. Fig. 6 shows the cut-out and output circuitry. The output from the alternator is stepped up to mains voltage by a transformer T_1 which has a rating of 250W. An auto transformer would be ideal for this function on the basis of size and cost. It is important for safety reasons to connect the N and E terminals together on the output socket and return both to the metalwork of the complete unit. The output of the transformer is used to energize a 230V a.c. relay, the contacts of which complete the field circuit with the 12V excitation voltage. A separate set of contacts is used for the indicator lamp to prevent the back e.m.f. from the field winding fusing the bulb when the relay drops out. The lamp is positioned on the control panel to illuminate the frequency meter. The relay

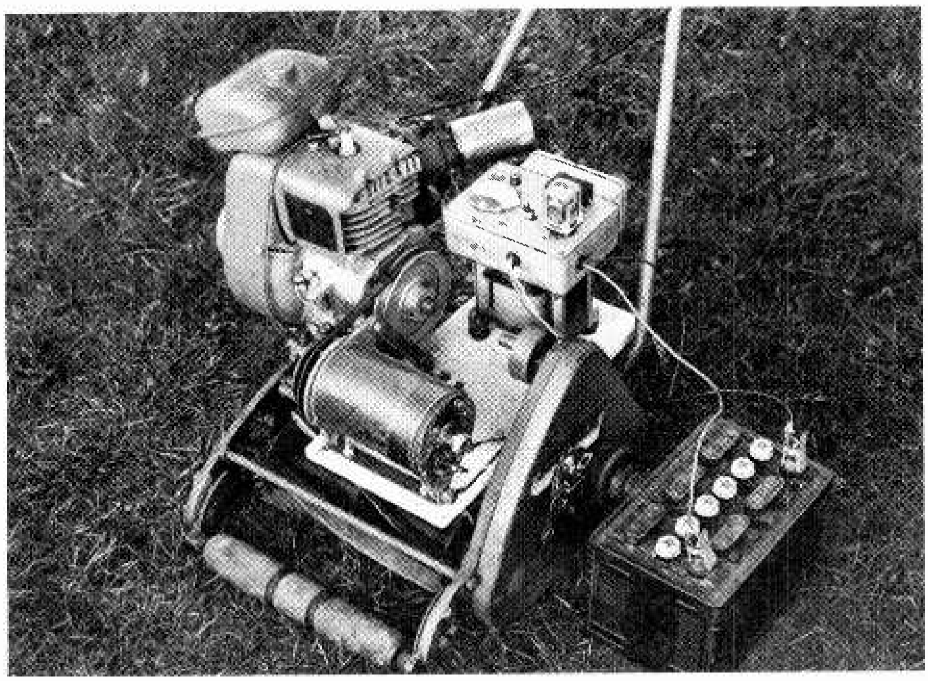


Fig. 7. Complete generator.

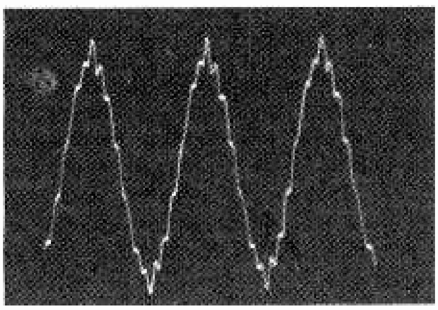


Fig. 8. Output waveform.

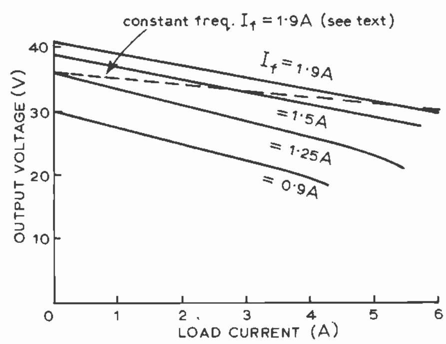


Fig. 9. Load characteristic for alternator.

drops out if, for any reason, the output falls below 150V a.c., e.g. overload or engine failure, the latter causing loss of air cooling to the field coils. To reset the output S_1 is depressed. A battery charger may be connected to the output to maintain battery charge if needed.

Driving the alternator

The unit is shown mounted on a motor mower in Fig. 7. This engine is ideal because it has a governor incorporated at the air intake of the cooling fan which maintains a fairly constant speed during changes in load. The drive pulley is five inches in diameter giving a step-up ratio of about 2:1. This ratio was chosen to give maximum economy with minimum noise. A further reduction in noise was effected by fitting a cocoa tin, suitably perforated and filled with glass wool, over the silencer and held in place by a capacitor clip. The engine, at full load, runs for one hour on one pint of petrol if the carburettor is correctly adjusted.

Performance

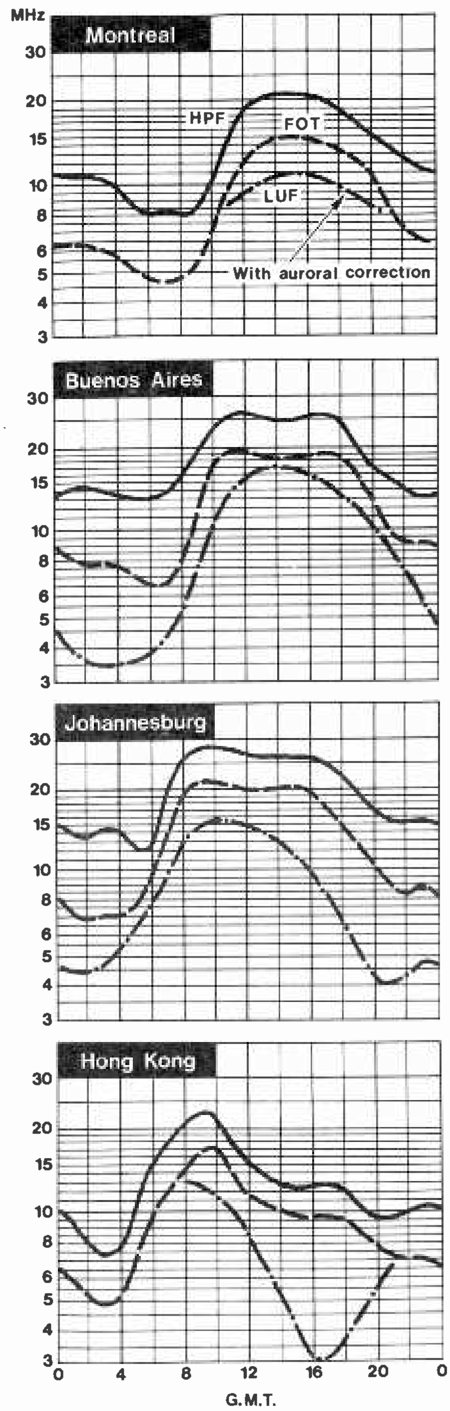
The output waveform is shown in Fig. 8. A component at 700Hz is present due to the variation in reluctance of the magnetic circuit as the armature slots rotate. This can be reduced by means of a 2μF 240V a.c. capacitor connected at the output (Fig. 6) but some distortion of the waveform will result due to armature reaction on the field flux.

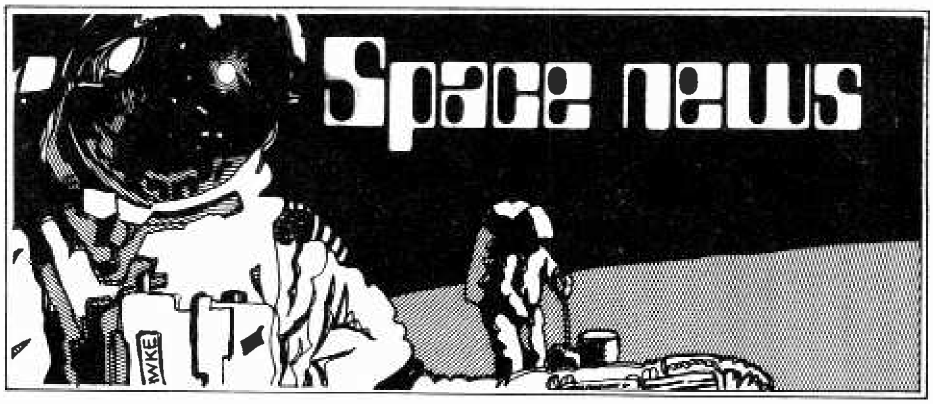
The open circuit output of the alternator at $I_f = 1.9$A is 0.72V r.m.s./Hz and the load characteristic for varying excitation is shown in Fig. 9. The speed regulation of the engine is such that a load of 180W reduces the output frequency from 56Hz to 50Hz. The load characteristic of Fig. 9 includes the drop in output caused by the change in frequency. The broken line shows the output regulation at $I_f = 1.9$A with the frequency held constant at 50Hz. For a full-load voltage of 200V at 50Hz, the no-load voltage is 265V at 56Hz.

This generating set, while crude in its concept, is quite adequate to supply the demands of a typical central-heating system and has been used to power a monochrome television set with good results. The performance tests have prompted the author to experiment with a higher-power, self-excited version incorporating electronic regulation, using the same alternator and output transformer.

HF predictions

Ionospheric attenuation and MUF are directly proportional to sunspot number so they are both low at sunspot minimum. Less attenuation gives in turn a lower LUF but the degree of MUF reduction is much greater. Normal undisturbed conditions thus give good communication but the available spectrum is small. Disturbed conditions lower MUF further but raise LUF so small disturbances have a great effect on communication at sunspot minimum.





Solid state data recorder

A solid state NASA-developed data recorder with no moving parts may replace magnetic tape recorders aboard spacecraft in the 1980s. Other possible applications include use as aircraft flight data recorders. Failure of moving mechanical parts accounts for 70 per cent of magnetic tape recorder malfunctions aboard spacecraft. The new recorders offer high reliability and experimental models of the device have been pronounced successful.

Technology for such a recorder is based on the use of very small magnetic domains or spots known as "bubbles". These magnetic bubbles exist in specially prepared garnet chips. By applying a thin film of magnetic material in appropriate patterns over the chips, these bubbles can be moved and controlled to perform logic functions. The present experimental model has a 60-thousand bit data storage capacity. The overall objective of the present research programme is to provide a solid-state data storage system with a 100-million bit capacity by 1978. If successful, flight versions of such a recorder could be ready at the end of this decade.

Magnetosphere exploration

The International Sun Earth Explorer (ISEE) programme is a joint NASA/ESRO venture involving three satellites, two of which ISEE-A and ISEE-C are being developed under NASA auspices whereas ISEE-B is the responsibility of ESRO. The satellites will explore the Earth's magnetosphere and adjacent regions of interplanetary space close to Earth. As a result of previous satellite missions the main features of the magnetosphere are already known. However, there is still much to be discovered about its dynamic behaviour and the influence of the solar wind.

Satellites ISEE-A and ISEE-B, equipped with similar experiments will travel at a carefully controlled and variable distance from 100km to 5,000km between each other. These two satellites will be launched by a single Thor Delta Rocket in Autumn 1977 and their orbit will be highly eccentric, close to the ecliptic plane. By this means, similar features will be seen by both spacecraft sequentially with a time interval between observations making it possible to distinguish between spatial and temporal variations of the physical and dynamic features recognized. A third spacecraft, ISEE-C will be launched one year later into a solar wind, undisturbed by the presence of Earth. Thus while A and B satellites are examining disturbances in the magnetosphere, the ISEE-C will provide vital information on the actual solar wind input to the magnetosphere.

New communications satellite

Contracts have been awarded for development of the communications payload of the ESRO maritime satellite MAROTS. This is to provide ship-to-shore communication vastly improved on the present, highly congested, conventional radio links. The launch of MAROTS is scheduled for the Autumn of 1977.

Marconi Space and Defence Systems, prime contractors for the communications payload, are also to study and define the basic parameters of the ship-borne and shore-based terminals. The former will be made as simple as possible and, to this end, MAROTS is to be equipped with a high-efficiency shaped-beam antenna coupled with a transistorized L-band power amplifier. Ships will use the L-band frequencies to communicate to and from the satellite. As shore terminals will be able to use more sophisticated equipment, the shore-to-satellite frequency will be in the 14GHz band while the satellite-to-shore communication will use the 11GHz band.

Radio and space research 1971–73

The triennial report of the Science Research Council's Appleton Laboratory was published during December. One section of the report is devoted to an outline of important developments in work during the period 1971–73; these include UK and co-operative satellites such as Ariel-IV, Ariel V, and UK contribution to the International Ultra-Violet Explorer satellite and the UK experiment on the American satellite Copernicus involving the use of four X-ray telescopes. A major high latitude rocket campaign late in 1973 in Andøya, Norway, involved the launching of Skylark and Petrel rockets in a co-ordinated programme which included the first trials of a new pulse code modulation telemetry system and Doppler range measurement system. The report describes the Laboratory's own research in space science and on the scientific aspects of the propagation of radio waves through the ionosphere and troposphere. Copies are available from HMSO at £1.25.

Also recently published is a comprehensive survey published by the European Space Research Organization which summarizes European activities in space research and technology and the skills and facilities developed by European industry in this field.

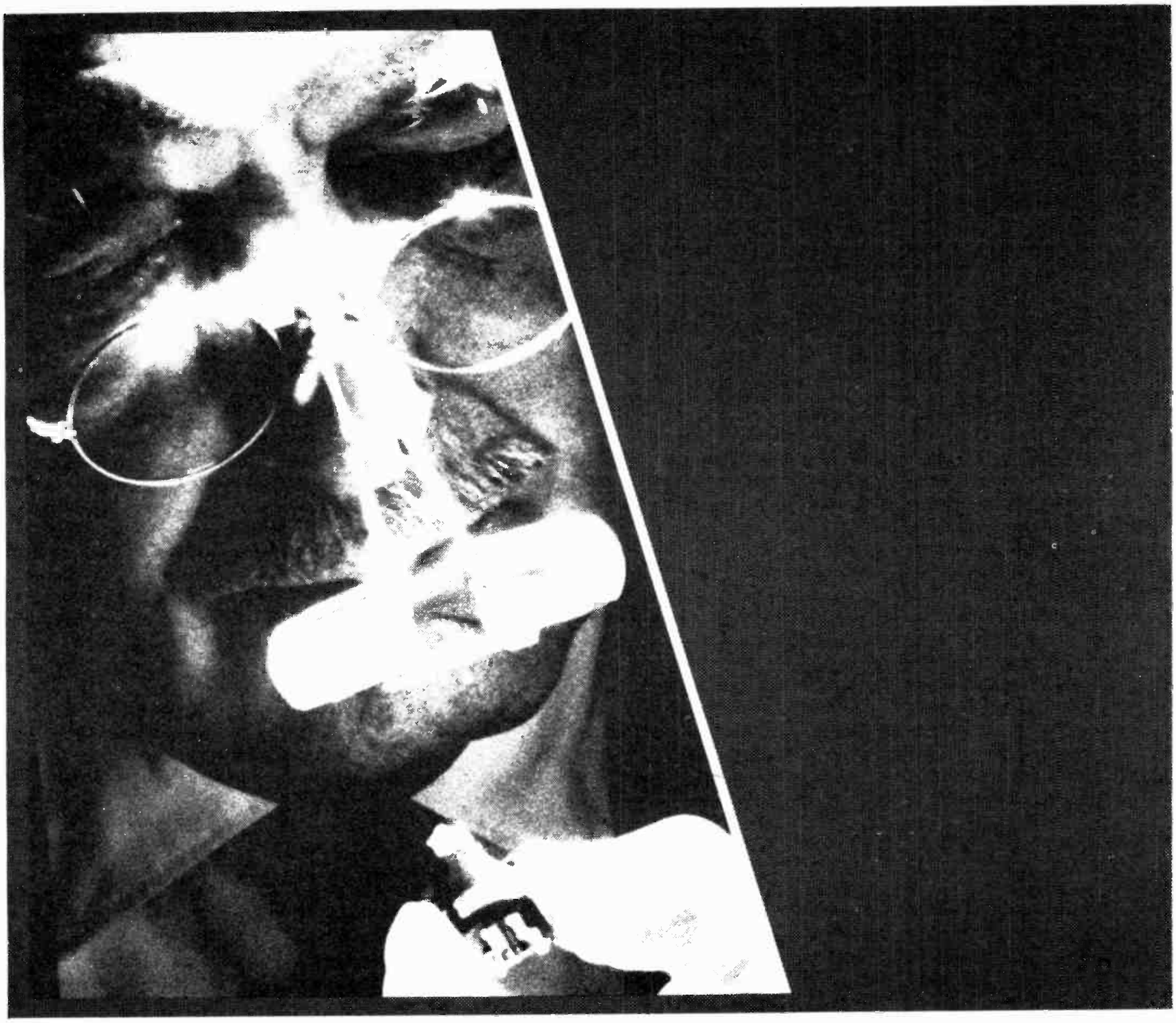
Crop inventory experiment

The launch of the second Earth Resources Technology Satellite (ERTS-B), scheduled for launch during January is to make possible the next steps of experimentation in the various earth resources disciplines.

Several experimental demonstrations designed to show the practical benefits to resource management of multispectral remote sensing from space have been selected to include water management, agriculture, land use planning, and monitoring ice conditions in navigable lakes. One of these experiments is a "Large Area Crop Inventory Experiment" to test whether the use of data gathered by spacecraft and analyzed with the aid of computers can improve the timeliness and accuracy of major crop forecasts. At the outset, LACIE will concentrate on wheat grown in the North American area. The experiment will combine crop acreage measurements obtained from ERTS-B data with meteorological information from NOAA satellites and from ground stations designed to relate weather conditions. If during the first year this activity proves useful, it will be extended in the second year to other regions and other crops.

Did you know?

Pioneer 11, latest Jupiter probe transmits an eight-watt radio signal which reaches NASA's antennas with a power of 1/100,000,000,000,000,000 watts. Collected for 19 million years, this energy would light a 7.5-watt Christmas tree bulb for one-thousandth of a second.



A.f. and r.f. clipping for speech processing

by D. A. Tong, B.Sc., Ph.D.
Datong Electronics Ltd

A comparison of audio and radio-frequency clipping for increased transmitter efficiency

If one examines the human voice using an oscilloscope, one of its most striking features is the low ratio of average amplitudes to peak amplitudes. An example is given in Fig. 1 which shows the first vowel sound in "hello". To the operators or designers of speech transmission equipment this small average-to-peak ratio can be an embarrassment because if the peak signal handling capability of the system (e.g., a radio transmitter or a public address system) is adequate to handle the peaks without distortion, it will be inefficiently utilized during the remaining sections of the speech waveform, that is, for most of the time. In a radio transmitter using any form of amplitude modulation (e.g., a.m. or s.s.b.) this means that for a given average radiated power a much higher peak power capability is required. Unfortunately the cost of a transmitter rises rapidly with its peak power capability. Additionally there is usually a statutory limit on the peak power that can be used. A radio transmitter using f.m. would similarly need a high peak deviation for a given average deviation, but here the cost is not in money but in frequency spectrum width.

For the above reasons there has long been much interest in "speech-processing" devices which raise the average-to-peak amplitude ratio of the speech waveform. In the remainder of this article we compare and contrast three speech-processing techniques which are at present quite extensively used. The techniques are audio-frequency clipping, audio-frequency compression, and radio-frequency clipping (that is, clipping of a single-sideband suppressed-carrier (s.s.b.) waveform). Reasons will be given for the marked superiority of r.f. clipping over the other methods.

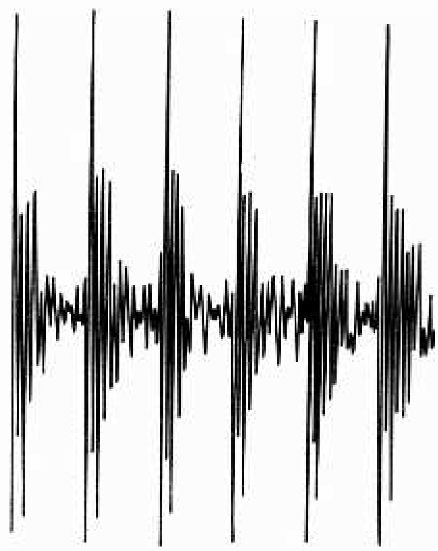


Fig. 1. A section of the first vowel sound in the word "hello" as seen on an oscilloscope

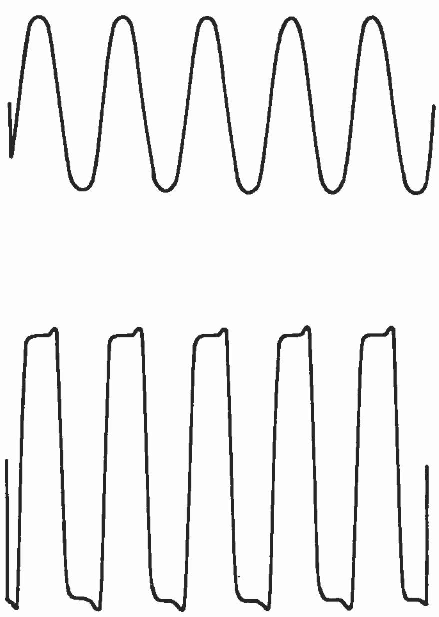


Fig. 2. Top: the output of an a.f. clipper when fed with a sine wave at a level just below the clipping threshold. Bottom: the same but with the input level increased by 20dB.

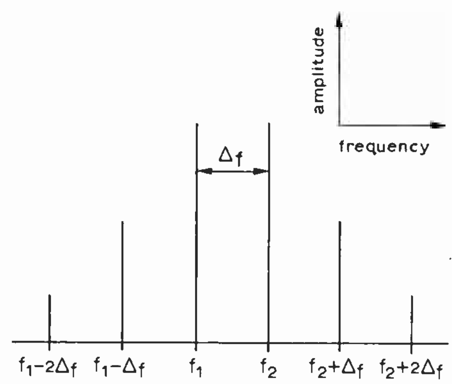


Fig. 3. Intermodulation products produced by clipping a two-equal-tone signal, omitting the products centred on harmonics of the two basic frequencies.

A.f. clipping

This is probably the most obvious treatment and is probably also the simplest. As the name implies, one "clips" off any portion of the audio-frequency waveform which exceeds a given amplitude. Fig. 2 shows a sinewave at 500Hz after passage through an a.f. clipper and 3kHz low-pass filter at levels just below the clipping threshold (top) and with 20dB of clipping (bottom). The clipping effect is clearly visible and if the input were a speech waveform its average-to-peak ratio would be greatly increased.

But there are snags. Firstly, a lot of distortion is introduced; secondly, the output signal is for a fundamental reason unsuitable for feeding into a single sideband transmitter (the most common kind in use today).

The distortion comprises both harmonic and intermodulation distortion.[1] For example, if the input signal were simply two equal-amplitude sinusoids with frequencies f_1 and f_2, the output would contain the intermodulation products

$$(f_1+f_2)/2 + n(f_1-f_2)/2$$
$$(n=1,3,5\ldots \text{etc.})$$

as shown in Fig. 3, together with other overlapping series of products centred on harmonics of f_1 and f_2, i.e.,

$$m(f_1+f_2)/2 + mn(f_1-f_2)/2$$
$$\text{where } n=1,3,5\ldots \text{etc.,}$$
$$\text{and } m=2,3,4\ldots \text{etc.}$$

Thus if the two frequencies were 1kHz and 2kHz the output of the clipper would contain components every 0.5kHz. Obviously, when more than two input signals are present the number of possible intermodulation products becomes very large indeed. As a result speech passed through an audio-frequency clipper acquires an unnatural and characteristically "clipped" sound. Despite this the intelligibility is hardly impaired. This kind of processor has been widely used in conventional a.m. or f.m. transmitters because of its simplicity: the gain in "talk-power" more than offsets the quite high distortion.

The reason that the technique is unsuitable for s.s.b. transmitters is that it generates "square" waveforms. An ideal s.s.b. modulator with a square wave input signal would produce s.s.b. with peaks of infinite amplitude. Obviously in a real situation this is impossible but the "square" waves from an a.f. clipper can result in a s.s.b. signal with no improvement in the average-to-peak ratio to offset the considerable distortion.

This effect is illustrated in Fig. 4 which contrasts the s.s.b. signal at 60kHz (a) produced from a sinewave (b) with that (c) produced from a "square" wave (d). These waveforms were obtained using a specially adapted commercial r.f. speech clipper made by Datong Electronics Ltd. Normally the s.s.b. signal shown is not accessible. Signals (d) and (b) were monitored at the output of the frequency-shaped preamplifier in the Datong r.f. clipper and this accounts for the distortion of the "square" wave. The point to note about these waveforms is that the peak amplitude ratio of the s.s.b. signals is 1.5 times that of the two input signals.

To some extent this difficulty can be partly circumvented by pre-emphasizing high frequencies in the speech bandwidth to such an extent that only speech components above 1kHz are clipped. The harmonics then fall outside the speech bandwidth and are cut out by the 3kHz low pass filter. But then, in addition to the distortion, the speech is excessively "toppy" and even more unnatural.

A.f. compression

Audio-frequency compressors use an automatic gain control system to ensure that if the input signal (the unprocessed speech waveform) exceeds a certain threshold, the gain is reduced rapidly (typically within 10ms). A second time constant, usually one second, allows the gain to recover much more slowly to its full value. Some devices of this type allow the gain to "hang" at a fixed value for a predetermined time if the input signal ceases. This avoids a distracting effect wherein the background noise rises to a high level between bursts of speech.

A.f. compressors are effective in maintaining a fairly constant peak signal level. Thus they can compensate nicely for unwitting changes in voice level or for different speakers. On the other hand they are not well suited to the task of raising the average-to-peak ratio of the speech waveform. In the limiting case of a compressor with zero "attack" and "decay" time constants there would be no difference between it and the audio clipper already discussed. But as soon as the time constants become non-zero (as they must to make the a.g.c. loop stable, and if distortion is to be less than that produced by an a.f. clipper) it is clear that, following a peak, the overall gain will be reduced for a time dependent on the decay time constant, and that this will reduce the amplitude of weaker signals following the peak. Unfortunately in speech, weak sounds which are important for intelligibility tend to closely follow strong peaks and therefore a compressor tends to affect adversely the intelligibility of the speech if its time constant is made low enough to increase the average-to-peak ratio[2].

R.f. clipping

An ideal speech-processing device would combine the instantaneous response of the a.f. clipper with the low distortion of a compressor with a long decay time constant. This ideal is closely approached by the so-called r.f. clipper. The essence of the technique is not to clip the a.f. waveform directly, but to first translate it to some much higher frequency. It is then a single sideband suppressed carrier (s.s.b.) signal. If this signal is clipped a similar range of products is generated internally as in the a.f. clipper, but with the important difference that $(f_1 + f_2)$ is now very much greater than $(f_1 - f_2)$. It is then a trivial matter to filter out all the components with $m>1$. In the example used earlier of two tones at 1kHz and 2kHz, if the r.f. clipping is carried out at say 60kHz, f_1 and f_2 will be 61 and 62kHz. Products associated with different m values will then be centred on integral multiples of 60kHz and the separate groups no longer overlap.

If the clipped s.s.b. signal is then heterodyned back to its original audio frequency range, the only frequencies left in the output will be

$$(f_1 + f_2)/2 + n(f_1 + f_2)/2.$$
$$(n = 1,3,5 \ldots \text{etc.}).$$

The harmonic frequencies which were produced by the a.f. clipper do not appear and with them disappear a large number of intermodulation products as well.

A commercial device for doing the whole operation, audio→s.s.b.→clipped s.s.b.→audio, the Datong Electronics Ltd "Universal r.f. Clipper", is shown in Fig. 5

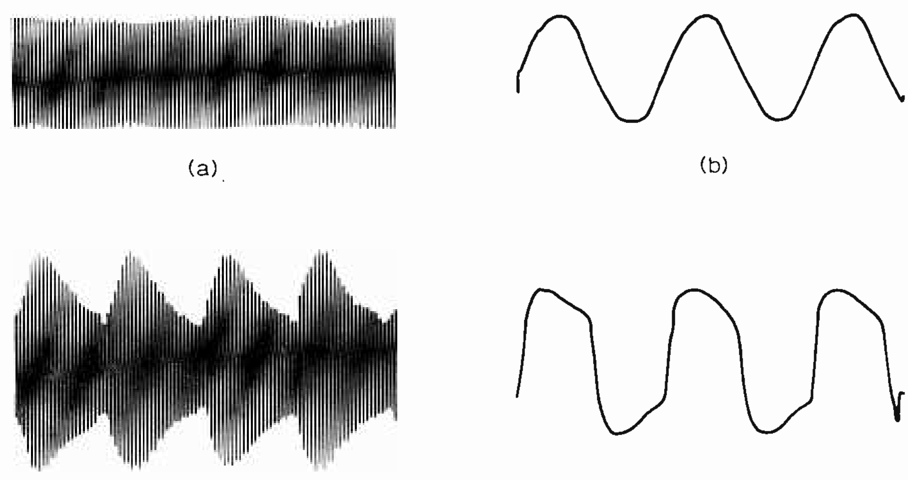


Fig. 4. S.s.b. signals produced from different input signals. A is given by B, and C by D. The peak amplitude ratio of the s.s.b. signals is greater than that of the inputs.

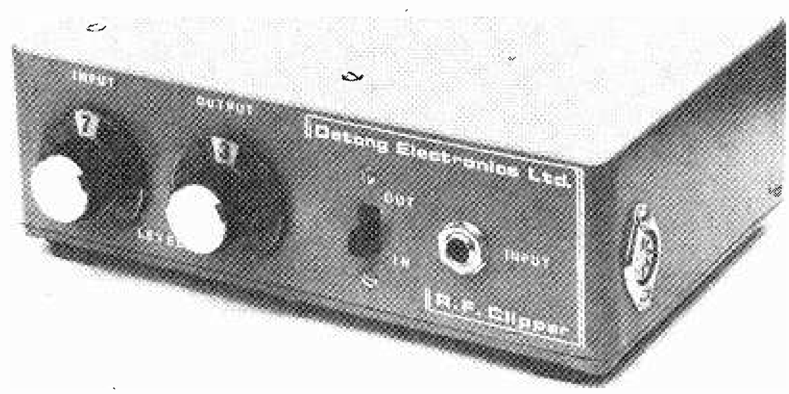


Fig. 5. Photograph of the Datong Electronics Ltd r.f. speech clipper. It is basically a closed-circuit s.s.b. transmitter, clipper, and receiver, operating at 60kHz. Thus both input and output are at audio frequencies and the device is designed simply to connect in series with the microphone lead on any transmitter.

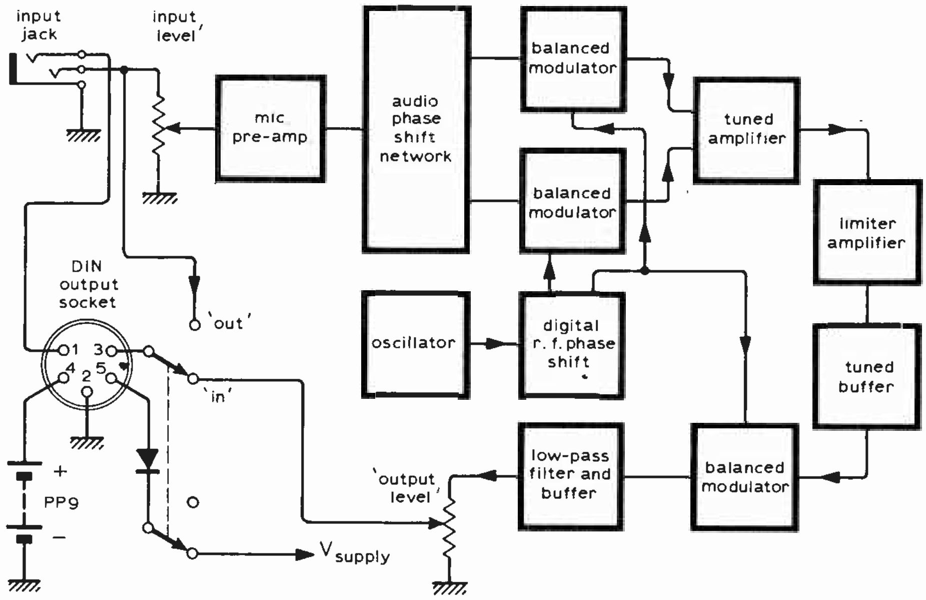


Fig. 6. Block diagram of the Datong Electronics Ltd r.f. speech clipper.

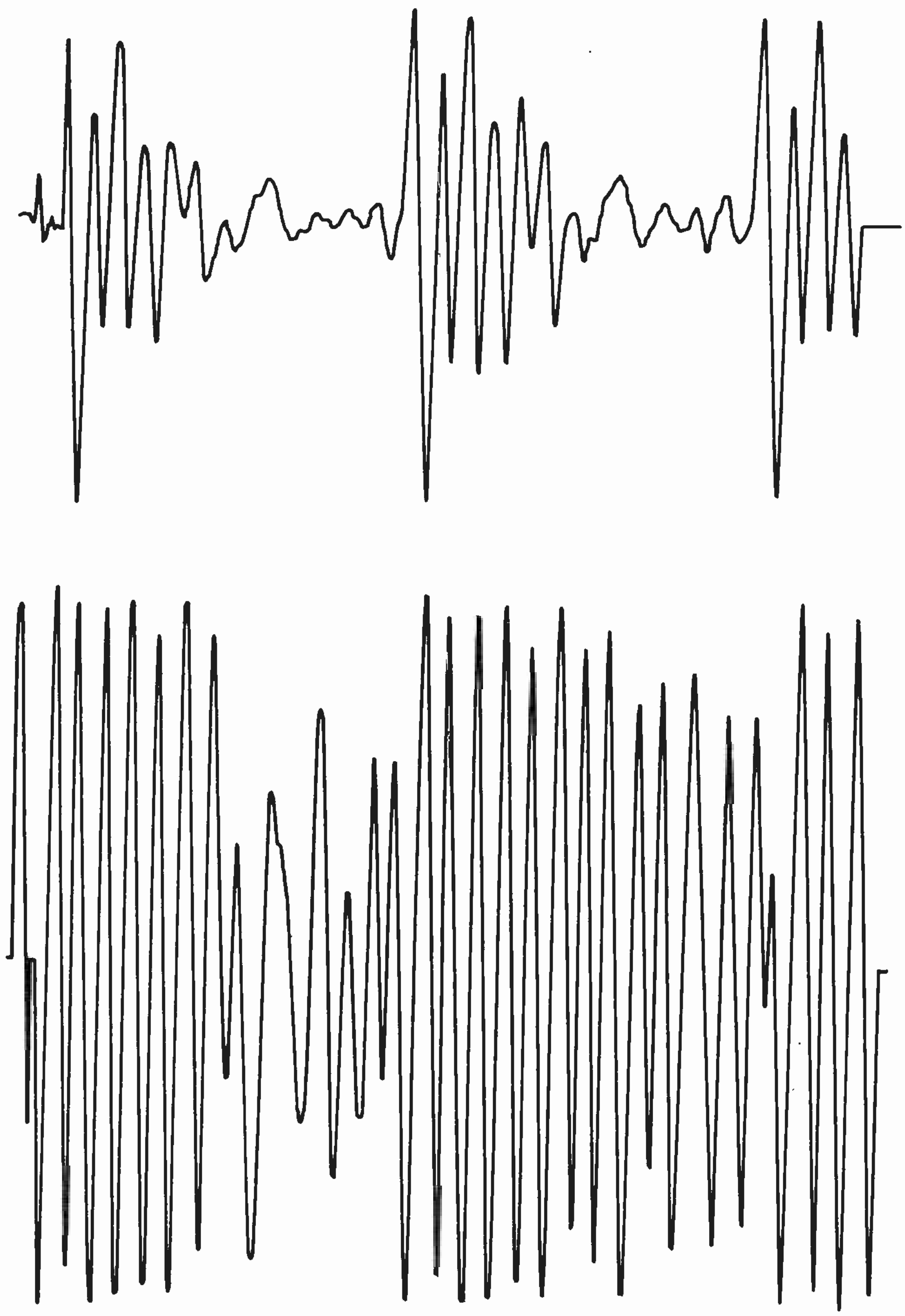


Fig. 7. Top: same speech sound as in Fig. 1 appearing at the output of the Datong r.f. clipper with peak amplitude just below the clipping threshold. Bottom: same but with 20dB of clipping, showing the absence of harmonic distortion.

and its block diagram is shown in Fig. 6. The device is intended for use as an accessory with existing communications transmitters and it is fitted simply by plugging in series with the microphone of the transmitter. The output waveform obtained using 20dB of r.f. clipping with a section of the same speech sound as in Fig. 1 is shown in Fig. 7. A comparison of the top and bottom traces shows the large gain in average-to-peak ratio which is obtained. (For the top trace the input level was reduced until the peaks were just below the threshold of clipping). The "non-clipped" appearance of the output waveform shows that the output is entirely compatible with s.s.b. transmitters. Fig. 8 shows the output of the Datong r.f. clipper when fed with a sinusoidal input at 500Hz and using 20dB of r.f. clipping. The absence of harmonic distortion is clearly shown.

Subjectively, speech sounds remarkably undistorted when processed in this way but becomes strikingly louder for the same peak amplitude. Indeed a similar kind of device to the Datong clipper has even been used for short-wave broadcasting[3]. The considerable increase in average-to-peak amplitude ratio which is possible using r.f. clipping allows the average side-band power output of an a.m. or s.s.b. transmitter (or deviation for an f.m. transmitter) to be greatly increased. It is generally agreed among the increasingly large number of radio amateurs who use r.f. clipping that it gives about the same improvement to a s.s.b. transmission as if its peak power rating were increased by a factor of ten, and at a far lower cost. Surprisingly perhaps, it also seems to be true that the intelligibility of the speech is actually increased by the r.f. clipping process so that there is a double benefit.

Obviously a s.s.b. transmitter already contains part of the circuitry shown in Fig. 6, therefore why duplicate it? In fact there are adaptors commercially available which allow the s.s.b. signal already produced inside the transmitter to be clipped, but contrary to what one might expect, there is almost invariably an extra cost penalty to add to the inconveniences of having to make connections internal to the transmitter and of the restriction to s.s.b. transmitters only. The reason is that in a device such as the one illustrated in Figs. 5 and 6, the internal s.s.b. signal is not radiated and therefore its spectral purity is irrelevant from the stand point of adjacent channel interference. Unwanted products close to the information bandwidth can be easily and cheaply re-

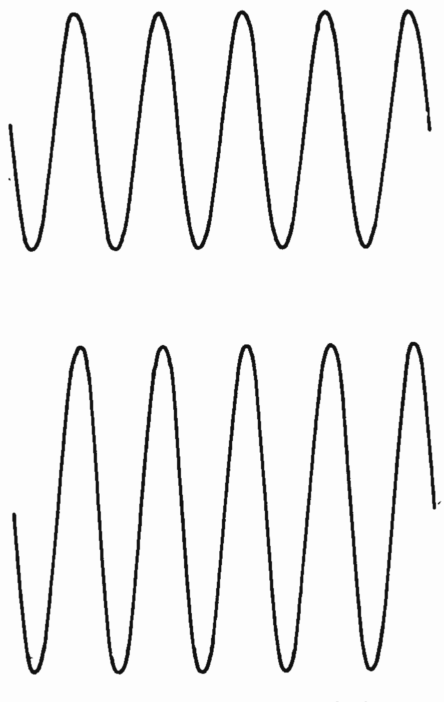


Fig. 8. Top: output of Datong r.f. clipper with input sinusoid just below clipping threshold. Bottom: same but input level 20dB above clipping threshold.

moved by an audio filter after the demodulator. In contrast, if the clipped s.s.b. signal is to be radiated directly, signals outside the information bandwidth must be reduced to a very low level to avoid radiating interference. This requires that a high-performance quartz crystal, ceramic, or mechanical filter be fitted. The high cost of such filters more than compensates for the cost of the duplicated circuitry in the "audio in/audio out" type of device.

To summarize, it can be said that a.f. clippers provide a useful improvement in average-to-peak ratios at the cost of quite severe distortion. They also have a fundamental disadvantage when used with s.s.b. transmitters.

A.f. speech compressors are good for maintaining a constant peak speech level despite different speech volume levels or different speakers, but are not very effective in raising the average-to-peak ratio.

R.f. speech clippers also compensate for different speech levels but at the same time give a big increase in average-to-peak ratio with negligible apparent distortion. Provided they are of the "a.f. in/a.f. out" type they are suitable for all modulation modes.

References

1. D. A. Tong, "Theoretical intermodulation distortion levels resulting from clipping a two-tone s.s.b. signal; with a note on the effects of crossover distortion", *Wireless World*, to be published.
2. L. R. Kahn, "The use of speech clipping in s.s.b. communications systems", (1957) *Proc. I.R.E., 45.2*, 1148–9.
3. G. O. Herrick and H. W. Fallis, "A new approach to speech clipping for international broadcasters", I.E.E. Conference Publication No 69, International Broadcasting Convention (1970) 21–23.

Literature Received

ACTIVE DEVICES

A 24-page catalogue from EMI-Varian lists over 350 microwave devices, and includes information on the company's capabilities in p.c. aerials, ceramics, power supplies and pulse modulators. EMI-Varian Ltd, 248 Blyth Road, Hayes, Middx. WW401

Intel are to publish a bi-monthly technical magazine on their range of memories, microcomputers and m.o.s. devices. The magazine, *Intel News*, is available free from Intel Corp. (UK) Ltd, Broadfield House, 4 Between Towns Road, Cowley, Oxford WW402

Three leaflets from Brimar describe oscilloscope graticules, a 14-cm data display tube and a range of c.r.t. deflection yokes. Thorn Radio Valves & Tubes Ltd, Mollison Avenue, Brimsdown, Enfield, Middx. EN3 7NS WW403

Abridged data on the AEI range of microwave semiconductors and modules is contained in the new short-form catalogue from AEI Semiconductors Ltd, Carholme Road, Lincoln, LN1 1SG .. WW404

We are informed that Semiconductor Specialists have available the new Siliconix catalogues and price lists. New products include the dual-gate f.e.ts and 3½-digit meter circuits. Semiconductor Specialists (UK) Ltd, Premier House, Fairfield Road, Yiewsley, West Drayton, Middx. WW405

A brochure from EMI describes a range of magnetically-focussed image intensifier tubes for use in spectroscopy, X-ray and electron diffraction and other low-light investigations. The publication is obtainable from EMI Electronics Ltd, Electron Tube Division, 243 Blyth Road, Hayes, Middx. .. WW406

PASSIVE DEVICES

Rastra have sent us a leaflet on the AUGAT range of individual pin sockets for i.cs and a series of feed-through terminals. Catalogue 273 is obtainable from Rastra Electronics Ltd, 275–281 King Street, Hammersmith, London W6 9NF. WW407

A range of connectors for printed-circuit use and some multi-way plugs and sockets are illustrated on a wall-chart from Varelco, which gives full specifications. Hand tools are also featured, as is a modular racking system. Varelco Ltd, Exning Road, Newmarket, Suffolk. WW408

A leaflet-cum-wallchart, in colour, which is also a short-form catalogue of knobs, dials and turns-counting mechanisms, is obtainable from Argo Electronic Components Ltd, 28(b) Hamlet Court Road, Westcliff-on-Sea, Essex. WW409

The range of OT toroidal transformers by Avel Lindberg is described in leaflet AL4.71. The transformers are rated at between 15 to 500VA and are equipped with flying leads. Dimensions of the 15VA model are 57mm outside diameter, 36mm deep, with a central fixing hole. Avel-Lindberg, South Ockendon, Essex, RM15 5TD. WW410

A new brochure on the range of aerosol chemicals and lubricants has been published by Electrolube Ltd, Oxford Avenue, Slough, Bucks SL1 4LB. .. WW411

Aluminium "foil" or strip for coil winding is described on technical data sheet No. M204 from Rolled Products Division, British Aluminium Co. Ltd, Phelps House, Heath Road, Twickenham, Middx. WW412

GENERAL CATALOGUES

The new RS Components catalogue for Dec, 1974 to March, 1975 is now with us, new products this time including new 20VA transformers, plastic cabinets, displays, a voltage regulator and several others. RS Components Ltd, PO Box 427, 13–17 Epworth Street, London EC2P 2HA (on company letter-head).

The new Heathkit catalogue is now published. The kits are produced for a wide range of equipment for the consumer and for industrial and professional use. New models include a digital clock-cum-radio, a calculator, engine tuning equipment and several others. Heath (Gloucester) Ltd, Gloucester GL2 6EE. WW413

A publication entitled "Weir—The Facts" is a 16-page brochure on the company's capabilities in proprietary and custom-built electronic equipment. Available from Weir Electronics Ltd, Durban Road, Bognor Regis, Sussex. WW414

EQUIPMENT

A brochure giving specifications and installation information on the Data Sense 300 series of load cells has been sent to us by Transducers (CEL) Ltd, Trafford Road, Reading. WW415

Analogue multiplexers in the c.m.o.s. technology are fully described in a leaflet MPC80, MPC168 from Burr-Brown Research Corp. The units feature 7.5mW standby power, break-before-make switching and a two-microsecond settling time to within 0.1%. International Airport Industrial Park, Tucson, Arizona. WW416

The new catalogue of measuring instruments made by EIP, Exact, Cushman and Dana is now available from Dana Electronics Ltd, Collingdon Street, Luton, Beds. WW417

A guide to manufacturers and service organizations working in the field of digital electronic systems—the System Product Guide 1975—has been produced by Gershire Ltd, 103 Kent Road, Dartford, Kent, and is available from the publishers at £4.50.

The complete range of Pye and Philips broadcasting equipment, including cameras, telecine, audio gear and transmitters, is covered by the new Pye TVT catalogue, which is available from John Hawes, Publicity Manager, Pye TVT Ltd, Coldhams Lane, Cambridge. WW418

Oxford Electronic Instruments have sent us a leaflet on the Fenlow 710-A digital voltmeter—a 4½-digit instrument, which tracks the mains frequency to retain an 80dB series-mode rejection ratio from 49–51Hz. The leaflet is obtainable from Oxford at Osney Mead, Oxford OX2 0DX... WW419

We have received a brochure from D. A. Pitman on their range of Gastec gas detector tubes, including a new one for use with vinyl chloride. The Gastec system uses a piston-type volumetric pump, in conjunction with a range of 72 tubes. D. A. Pitman Ltd, Mill Works, Jessamy Road, Weybridge, Surrey. WW420

Standard impulse generators for the simulation of lightning and other transients in the range 200 to 3000kV are described in a leaflet by Hipotronics, Brewster, NY, USA. WW421

Modular r.f. shielded enclosures in the L3000 series are described in a brochure from Belling and Lee Ltd, Great Cambridge Road, Enfield, Middx. WW422

A wide range of strain gauge transducers and associated instrumentation for measurements of pressure, flow and level is dealt with in a 110-page catalogue from Marketing Services Department, Siemens Ltd, Great West House, Great West Road, Brentford, Middx. WW423

Univac signal processing equipment, a transient recorder and a power line disturbance monitor are briefly described in a short catalogue from Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR. WW424

Performance characteristics and applications information on the DMC 800 series voltage-to-frequency converters (27 models) are given in an eight-page catalogue from Amplicon Electronics Ltd, Lion Mews, Hove BN3 5RA. WW425

We have received from MI two leaflets describing equipment in the Autotest range of automatic test systems, one covering r.f. testing and the other on printed-circuit boards. Marconi Instruments Ltd, St. Albans, Herts. WW426

Figure-of-merit for front-end selectivity of f.m. tuners

by Gordon J. King

Gordon J. King (Enterprises) Ltd

The documents of the British Standards Institution (BSI) and the Institute of High Fidelity (IHF, American) under BSI 4054:1966 and IHFM-T-100 respectively, along with others, describe methods for measuring and expressing the performance of a.m. and f.m. radio receivers and tuners, but in several areas these are dated with respect to state-of-art designs and the requirements for the contemporary f.m. tuner in particular.

With the advent of commercial radio broadcasting and the increasing utilisation of Band II for f.m. broadcasts, the ability of an f.m. tuner to respond, without interference, to a required signal in the presence of strong interfering signals is assuming increasing importance. A tuner hitherto operating from aerial signals of moderate level (*circa* 0.5 to 3mV p.d.) due to the three BBC transmissions and possibly the "local" f.m. station, might suddenly be subjected to an additional, more powerful signal due to the launching of a nearby commercial f.m. station, this being aggravated by lack of station co-siting.

The degree of susceptibility of a tuner in this respect is determined by both the large-signal handling performance of the r.f. stage and the selectivity and quality factors up to the mixer. A tuner with inadequate front-end selectivity, therefore, might exhibit spurious responses within the tuning range or coincident with the frequency of the wanted signal, a typical example being image response. Insufficient signal handling capability of the input devices can also encourage increasing intermodulation, due to decreasing linearity of the transfer characteristic. Cross-modulation in general is not such a big problem with f.m., of course, since this can only occur if the interfering signal has a.m. components, though this is not to imply that all interfering signals will be free from amplitude modulation. Moreover, if the i.f. selectivity is also poor, adjacent signal intermodulation products might encourage a warbling type of interference on stereo.

One solution, of course, would be to attenuate the aerial signal, but unless a frequency-selective attenuator is used, (and one writer has advocated the use of a tunable notch filter with a tuning control separate from that of the main tuning for notching out a strong, unwanted adjacent channel signal!) required signals of moderate level could be reduced sufficiently in level to impair the signal-to-noise ratio, particularly on stereo. Another solution might be an aerial of greater directivity allowing orientation for maximum discrimination against an unwanted signal, but this is not always the answer because a different orientation may be required for the least multipath distortion.

The real solution, of course, lies in the design of the receiver or tuner. The chief offender is the simple receiver whose front-end consists of a not particularly linear r.f. amplifier operating at low emitter current with an aperiodic input from the aerial and proceeded by a solitary variable tuned circuit to the mixer. Such simplicity is not found in hi-fi tuner design, however, the least in this type of design being two variable-tuned circuits up to the mixer (three in all, including the local oscillator tuning). The next step up the scale is the design with three variable-tuned circuits from aerial to mixer with possibly dual-gate m.o.s. f.e.ts for r.f. amplification and mixing. The square-law input characteristic of this type of transistor makes it particularly useful where a high degree of spurious response suppression is required and, of course, it is the ideal law for low-noise mixing. It has recently been demonstrated, however, that a bipolar transistor operating at 5mA, I_e can exhibit excellent linearity[1] and large-signal handling performance, though f.e.ts, when carefully biased, are still regarded by some workers as the ultimate in the present state of the art. A dual-gate f.e.t. as mixer gives a good isolated input for the local oscillator signal and avoids oscillator pulling problems, but again[1] it has been demonstrated that a low cost Mullard BF245 f.e.t. can also be arranged for very acceptable results in this respect (see later).

Noise performance and hence usable sensitivity are not improved much by the use of two r.f. stages, but this technique is sometimes adopted to facilitate the introduction of an additional variable-tuned circuit or bandpass pair. Expensive f.m. tuners sometimes employ four or even five variable-tuned circuits in front of the mixer and dual-gate m.o.s. f.e.ts for r.f. amplification and mixing, along with an oscillator buffer stage to minimise oscillator pulling. Maximum usable sensitivity threshold (just below 1μV p.d. 75Ω) is being achieved by some top-flight designs, and more recently, attention has been directed towards generally improving the input dynamic range.

The various tests for measuring the spurious responses of f.m. tuners are well known, as are those for measuring the IHF adjacent and alternate channel selectivity. To supplement the latter in terms of front-end selectivity performance the author, in collaboration with Ted Rule*, set out to devise a simple "figure of merit"-test based on the use of two generators with the result being referred to the IHF usable sensitivity. This test, of course, does not measure the intrinsic large-signal handling capability of the front-end (for this a more elaborate test setup with spectrum analyser is often used), but it does fairly reflect the overall goodness of the front-end selectivity and thus provide a fair impression of the spurious response interference likely from a front-end of given transistors and design. It is meant to complement rather than supersede the more conventional spurious response tests such as i.f. and image rejection ratios, half i.f. rejection, etc., and it has also been found to correlate more meaningfully with the interference obtained from a multiplicity of signals fed to tuners from a six-over-six aerial array.

The test set-up is given in Fig. 1 where two v.h.f. generators are combined in a matched T-pad to the input of the tuner under test. Tuner output is monitored on the $y1$ beam of an oscilloscope while being applied to the input of a distortion factor unit. The output of the distortion factor unit is coupled to an audio millivoltmeter through a decade attenuator, the signal at this point being monitored on the $y2$ beam of the oscilloscope.

IHF usable sensitivity

The first test is for IHF usable sensitivity, which is conducted with generator No. 1

*Armstrong Audio Ltd.

switched off. Generator No. 2 is adjusted for about 1mV, e.m.f. at f_2 which, as will become apparent later, should be around 88MHz†, and the signal is modulated 100% (i.e., ±75kHz deviation) at 400Hz or 1kHz. The distortion factor unit is switched on and set to the "set 100%" position and the decade attenuator adjusted for a convenient 0dB datum on the audio millivoltmeter, ensuring that the tuner is accurately adjusted to the generator signal. The distortion factor unit is then switched to the "read" position and its notch tuned and balanced to the frequency of the f_2 modulation, while reducing the audio millivoltmeter attenuation correspondingly.

The IHF usable sensitivity is the least p.d. at f_2 required at the tuner input for 30dB ratio (as established by the decade attenuator) between the "set 100%" and "read" positions. It is generally necessary to optimise the tuning for the least distortion factor (i.e., noise plus total harmonic distortion). The IHF usable sensitivity (in μV or dB) should be noted in terms of setting of the attenuator of generator No. 2.

Generator No. 1 is next switched on and its frequency (f_1) adjusted so that $f_1 - f_2$ equals the i.f., which is usually close to 10.7MHz, though some exploring may be necessary since tuners with ceramic i.f. filters may be slightly removed from the nominal. Attenuator No. 1 is adjusted for 50mV p.d. at the tuner input and, initially, attenuator No. 2 is adjusted likewise. If both generators are modulated and the tuner adjusted away from f_1 or f_2 the $y1$ trace will display a modulation beat when the mixer yields the i.f. from $f_1 - f_2$. The modulation of generator No. 1 is then switched off, leaving only the modulation of f_2.

The scheme is then to run through the same exercise as for IHF usable sensitivity when the tuner is adjusted to f_2+400kHz. A greater difference may be necessary where the i.f. selectivity is poor to avoid blocking. The dB ratio for the "figure of merit" can be obtained from attenuator No. 2 by subtracting the dB setting for the IHF usable sensitivity from the dB setting finally used.

The display on $y2$ trace is useful for ensuring that it is the noise-plus-distortion which is giving the readout!

A very simple tuner with aperiodic aerial coupling and single variable-tuned circuit to the mixer will exhibit little more than 20dB ratio. Two variable-tuned circuits increase the ratio to 30–35dB, while three variable-tuned circuits can take the ratio up to 60dB or more, *depending on the quality factors of the selectivity*. One tuner tested with four variable-tuned circuits (using mechanical capacitors as

†IHF standard test frequencies are 90, 98 and 106MHz

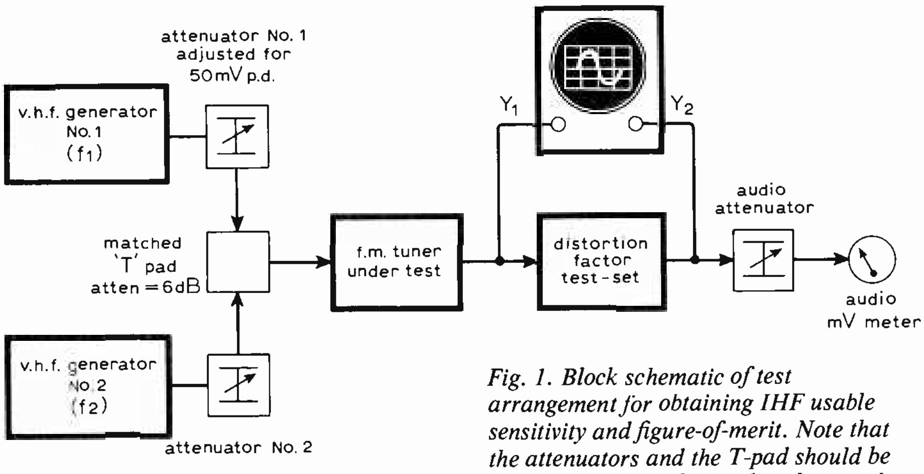


Fig. 1. Block schematic of test arrangement for obtaining IHF usable sensitivity and figure-of-merit. Note that the attenuators and the T-pad should be matched to each other and to the aerial input of the tuner.

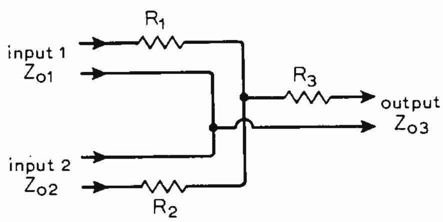
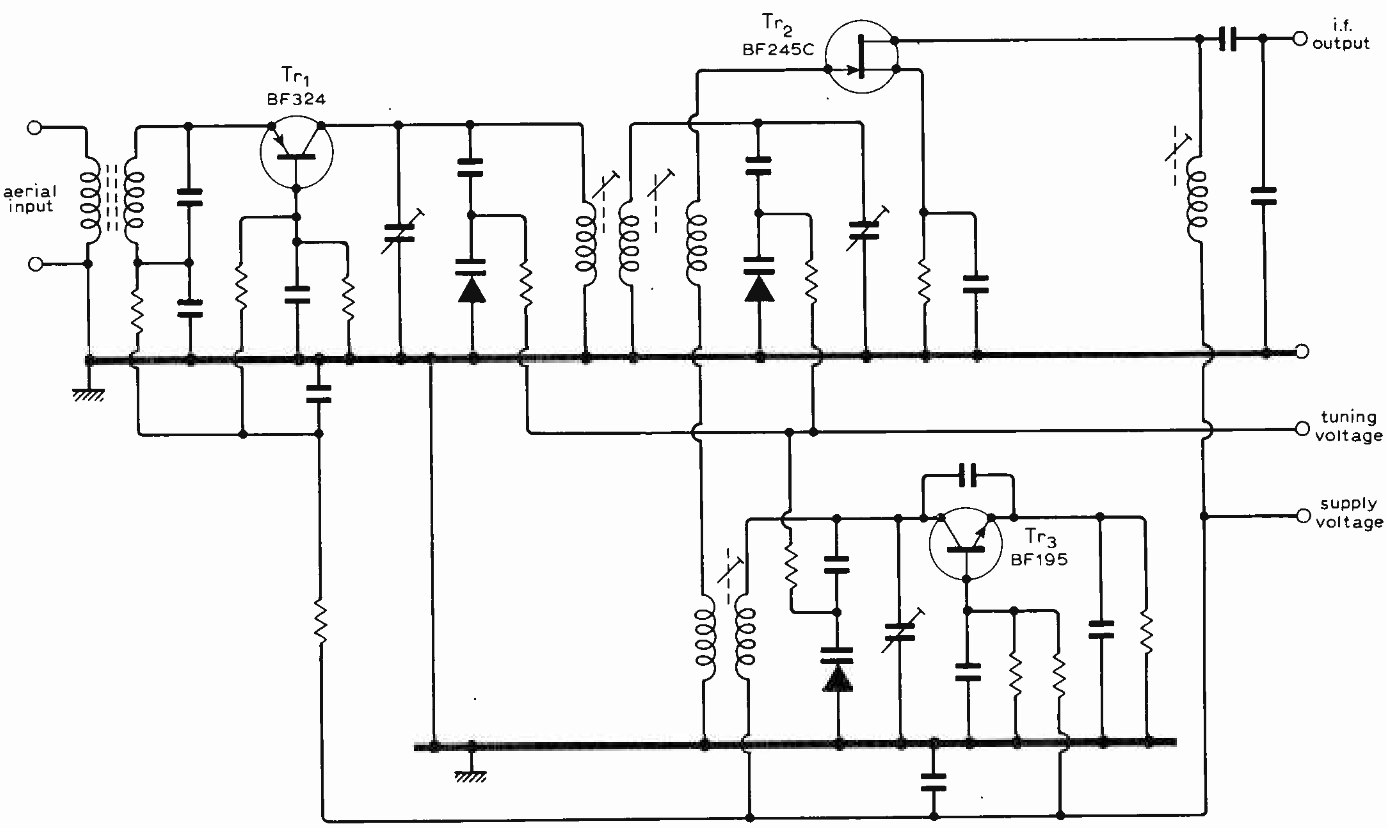


Fig. 2. Simple matched T pad for combining the outputs of two generators. When $Z_{01} = Z_{02} = Z_{03}$ $R_1 = R_2 = R_3$, such that $R_1 = Z_{01}(n-1)/n+1$, where n is the number of inputs (two in this case). Insertion loss is 6dB.

Fig. 3. Mullard f.m. front-end referred to in the text.



distinct from varicaps) up to the mixer, returned a ratio as high as 100dB.

Detailed evaluation of other second-order and higher-order intermodulation products, of course, requires different signal combination using the receiver (i.e. BS 4054:1966, 43.1) or a spectrum analyser to detect them. Reference 1 gives a set-up for measuring cross-modulation and hence intermodulation, since they are shown to be related effects, using three generators in a simulated single-sideband arrangement, in conjunction with a spectrum analyser.

One practical manifestation of third-order intermodulation arises from the three signals of Radios 2, 3 and 4 of f_2, f_3 and f_4, such that $f_2+f_4-f_3$ falls at f_3. Thus tuners prone to third-order products will tend to exhibit Radio 3 interference when operating in areas where the signal fields of Radios 2, 3 and 4 are very strong.

The almost exactly square-law of f.e.ts helps to reduce this trouble, and hi-fi tuners using correctly biased dual-gate f.e.ts with good front-end selectivity are capable of operating in most areas without interference and without the need for aerial attenuation.

Another cause of interference on stereo results from the sensitivity of some decoders to near harmonics of the 38kHz switching frequency which can be present at the output of the f.m. detector under a number of interference conditions. As the audible note so produced is perturbed by the modulation, a warbling type of interference results, which has become known as "birdies". This problem is solved, or at least significantly reduced, by the inclusion of the low-pass filter (f_0 *circa* 55kHz) between the f.m. detector and the stereo decoder, and many manufacturers are now fitting this.

As already mentioned, local oscillators and oscillator pulling are other aspects of f.m. tuner design that are receiving attention. An interesting design by Mullard[1] for improving the signal handling capability and reducing oscillator pulling at relatively low cost includes a BF254C f.e.t. for almost square-law mixing, a loosely-coupled oscillator feed to the gate, giving freedom from oscillator pulling for aerial signals as high as 250mV e.m.f., 75 ohms; and a bipolar BF324 common-base r.f. amplifier which, at 5mA I_e, has a large signal-handling capability and excellent linearity, thereby—from the input overload point of view—obviating the need for input selectivity, which helps from the noise aspect. The oscillator uses a BF195 also in common-base mode and operates at 1mA, I_c and 9V, V_{ce} for low noise and good stability. As shown in the circuit in Fig. 3, varicaps are used for bandpass tuning while the r.f. input is aperiodic.

Reference

1. Mullard Technical Communications, Vol. 12, No. 119, July 1973. Also issued as Application Note TP1395.

Meetings

LONDON

4th IEE—"Earth survey and weather applications of satellites" by R. Watson-Laing at 17.30 at Savoy Pl., WC2.

4th IEE—"Air traffic control in the vicinity of a major airport" by S. Ratcliffe at 17.30 at Savoy Pl., WC2.

5th IEE—"Technology push versus market pull —the horns of the designer's dilemma" by D. A. E. Pannenborg at 17.30 at Savoy Pl., WC2.

5th IERE—"Hybrid computers and applications" by Dr R. L. Davey at 18.00 at 9 Bedford Sq., WC1.

6th RTS—"The role of law in today's environment of international broadcasting" by H. Bloom at 19.00 at London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

11th AES—"Some acoustic thoughts on lightweight partitions" by P. Lord and "The use of acoustic scale models" by B. Day at 19.15 at the IEE, Savoy Pl., WC2.

12th IERE—"Channel approach aid for Milford Haven Conservancy Board" by A. P. Tuthill at 18.00 at 9 Bedford Sq., WC1.

18th IEE—Discussion on "Area Navigation" opened by J. Inglefield and G. Belcher at 17.30 at Savoy Pl., WC2.

19th IEE—Discussion on "Oil rig instrumentation" opened by K. Gibbs, J. Ingram, D. Lomas and G. Thurgood at 17.30 at Savoy Pl., WC2.

20th IEE—"The social computer", Faraday lecture by D. H. Pitcher at 18.00 at Central Hall, Westminster, SW1.

20th RTS—"A time multiplexed machine control system for broadcast television" by K. Allcock and J. Barrett at 19.00 at London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

21st IEE—"The social computer", Faraday lecture by D. H. Pitcher at 18.00 at Central Hall, Westminster, SW1.

26th IEE—"Fast megavolt pulse generators" by J. C. Martin at 17.30 at Savoy Pl., WC2.

26th IERE—"A novel low attenuation waveguide" by Prof. P. J. B. Clarricoats at 18.00 at 9 Bedford Sq., WC1.

BLANDFORD

11th IERE—"Autonull"—the suppression of large interfering signals in single- and multi-equipment installations" by M. M. Zepler at 18.30 at the School of Signals, Blandford Camp.

BIRMINGHAM

19th RTS—"The opening of a commercial radio station" by David Pinnell at 19.00 at the BBC Broadcasting Centre, Pebble Mill Road.

27th IEETE/IES/IHVE/ASEE—Symposium on "Integrated environmental design" at 19.00 at the Bing Kendrick Suite, University of Aston, Gosta Green.

CARDIFF

5th IERE/IEE—"Digital techniques in broadcasting" by Dr C. J. Dalton at 19.00 at the Chemistry Lecture Theatre, Room 164, U.W.I.S.T.

ENFIELD

25th IEE—"The generation of electricity from sunlight" by P. Howell at 18.30 at Middlesex Polytechnic, Queensway.

FARNBOROUGH, Hants

6th IERE—"Bubble memories" by Dr J. R. Fairholme at 19.00 at Farnborough Technical College.

GLASGOW

25th IEETE—"Emergency stand-by generators" by H. A. Smedley at 19.00 at the Royal Stuart Hotel, Jamaica Street.

GUILDFORD

12th IEE—"An Institution of Engineers?" by Dr G. F. Gainsborough at 19.30 at C.E.G.B., Burymead House, Portsmouth Road.

IPSWICH

5th IERE—"Radar approach to weather forecasting" by Prof. E. Shearman at 18.30 at Ipswich Civil College.

LEEDS

20th IERE/E & CS—"Oracle—information by domestic TV" by G. A. McKenzie and P. R. Hutt at 18.30 at Yorkshire TV Studios.

LEICESTER

6th IEE—"The social computer", Faraday lecture by D. H. Pitcher at 14.30 and 19.15 at the De Montford Hall.

LIVERPOOL

11th IEETE—"Thyristor controls for industry" by C. Smith at 19.30 at MANWEB Social Club, Thingwall Road.

12th IERE—"Solar energy" by W. R. Crooks at 19.00 at North East Liverpool Technical College.

LLANDAFF

12th SERT—"The RBM Z179 110° colour chassis" (lecturer from Rank Radio International) at 19.15 at Llandaff College of Technology.

MAIDSTONE

12th IEETE—"Protection against electrocution and electrical fires" (speaker from Allen West-EAC Ltd) at 19.30 at the Royal Star Hotel, High St.

MALVERN

5th IERE—"Active filters" by Dr D. R. Wilson at 19.30 at The Foley Arms.

PLYMOUTH

6th IERE/IEE—"Television engineering—a look into the future" by M. Cox at 19.00 at the Main Lecture Theatre, Plymouth Polytechnic.

PRESTON

17th IEETE—"The watchful eye—computer monitoring in colour" by B. Baker and D. Wood at 19.15 at Preston Polytechnic, Corporation St.

READING

12th IERE—"CAD of type 2 phase lock loops" by P. Atkinson and A. Allen at 19.30 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

SHEFFIELD

11th IEE—"The social computer", Faraday lecture by D. H. Pitcher at 10.15, 14.30 and 19.30 at the City Hall.

SOUTHALL

27th IEETE—"Understanding noise" by L. Minikin at 19.30 at Southall College of Technology, Beaconsfield Road.

SOUTHAMPTON

12th IERE—"Electronic ignition—is it worth it?" by Dr. E. M. Stafford at 19.30 at Southampton College of Technology, East Park Terrace.

19th SERT—"Aspects of electronic copying" by R. Hickman at 19.30 at Southampton College of Technology.

26th IERE—"Time series feature detection" by Dr D. W. Thomas at 18.30 at the Lanchester Theatre, Southampton University.

STONE, Staffs

20th IERE/IEE/IPOEE—"Communications—bit by bit" by H. B. Law at 19.15 at P.O. Training Centre, Duncan Hall.

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

World of Amateur Radio

All-solid-state stations

Recently in contact on 7MHz with DJ6SI in Cologne I was interested to discover that his very good signals were coming from one of the small "Atlas 180" all-transistor transceivers. This particular unit provides up to 180 watts p.e.p. on 1.8 to 14MHz with an s.s.b. filter exciter on 5520kHz. It is one of several compact units employing multiple r.f. power transistors and broadband techniques that have appeared on the amateur market in the past year or so; others include the Swan SS-200 and the new Heathkit SB104 which has just been launched in the United States. This covers all the amateur h.f. bands from 3.5 to 29.7MHz with an r.f. power output of up to 100 watts p.e.p. (also providing a low-power output of 1 watt) for upper and lower sideband or 100 watts c.w. The transmitter and receiver tuned stages are broadbanded and it is claimed that, for example, it takes less than 10 seconds to change from c.w. on 3500kHz to s.s.b. on 29MHz. Another feature is direct six-digit read-out of frequency. With some 31 integrated circuits, 75 discrete transistors and 171 diodes and with a total of some 2800 components this unit must be one of the most ambitious kits ever produced for home construction; in its basic form it operates from 12-volt car batteries and measures only 6 by 14 by 14 inches.

Artificial radio aurora

In his 1966 inaugural address as president of the IEE, J. A. Ratcliffe noted that when the long-wave broadcasting station at Droitwich is switched on the temperature of the electrons at a height of about 100km increases by about 45°C. This technique of using radio transmitters to heat up the electrons in the ionosphere is being investigated in the United States and the USSR as a means of producing artificial radio aurora to permit scatter communication on frequencies up to u.h.f. over distances of some hundreds of miles. Details of this work, on behalf of the US Department of Defence, have recently been given in two American amateur journals with a view to further participation by amateurs. Much of the basic research has been done by the Institute for Telecommunications Sciences (ITS) and the Stanford Research Institute and has already shown that this propagation mode could be of interest to amateurs. For example, on May 11, 1972 K7PXI in Phoenix was heard via ARA in Socorro, New Mexico. In these tests very high-power h.f. transmissions (typically about 5MHz) are beamed upwards with an e.r.p. of the order of 5 megawatts, raising the temperature of the electron gas, forcing it to expand along the magnetic field and so permitting scattering from the field-aligned irregularities.

The tests have shown that the effect on forward-scatter signals is almost coincident with the switching on and off of the "heater" transmitter both in the F-layer and the E-layer. High-power transmitters suitable for this work currently exist at Platteville, Colorado and at Arecibo, Puerto Rico and also in the USSR at Gorki.

Repeaters and beacons

With at least five 144MHz f.m. repeaters now operational or testing in the UK (GB3SN Four Marks, Hampshire; GB3BC Mynydd Machen, South Wales; GB3PI Barkway Ridge, Cambridge; GB3LO Crystal Palace, London; and GB3MH Malvern Hills, Gloucester) and half a dozen more proposals at various stages including a recent attempt to gain support for a repeater in the Chelmsford area of Essex, this is currently one of the fastest growing areas of amateur radio. But, for a variety of reasons, including the fear that the operation of repeaters with simple hand-held and mobile equipment may diminish interest in the more advanced equipment needed for tropospheric and other long-distance modes, a number of British amateurs appear to be firmly opposed to this development. One even hears persistent stories of deliberate interference to the operation of the repeaters. In the United States an important relaxation in the regulations now permits operation through more than one repeater simultaneously, thus opening the way to the establishment of v.h.f. trunk networks stretching across the Continent.

GB3SN, the repeater of the UK FM Group (Southern) at Four Marks, has been undergoing trials as a beacon on 145.725MHz before coming into operation as a repeater. At the time of writing this is controlled by a time-switch which switches it off for a couple of hours in the early morning and again from 1800 to 2015 GMT. Early reports indicate wide coverage and reliable operation.

Despite some lack of sensitivity the linear transposers on board Oscar 7 seem to be functioning well and one British amateur is reported to have been in contact with a station in California on the 432/145MHz unit. Frequencies for Oscar 7 are: Mode A uplink 145.85 to 145.95MHz, downlink 29.4 to 29.5MHz (beacon 29.5MHz); Mode B uplink 432.125 to 432.175MHz, downlink 145.925 to 145.975MHz (beacon 145.98MHz). Additionally there is a beacon on 435.10-MHz. Mode A and Mode B repeaters are operated on alternate days.

A 28MHz beacon station, K6HME at Oceanside, California has been operating on 29.0MHz using a Swan SS-200 solid-state transmitter. A low-power 1-watt beacon operates on 28.150MHz from Hopkinton, Mass.

Slow-scan progress

Richard Thurlow, G3WW of March, Cambridgeshire, comments on the increasing interest in slow-scan television transmission in the United Kingdom. There are now at least 125 amateurs authorized for this type of transmission. In the first ten months of 1974, C. C. Robinson, G3IAI, had two-way s.s.t.v. contacts with amateurs in more than 70 different countries; the total for G3WW is now more than 60 and several overseas stations including VU2AIK and W4MS are over the 80 mark.

Although rather over 100 amateurs in Japan are permitted to use s.s.t.v., it is believed that the number will increase considerably quite soon as a large backlog of applications developed during some reorganization of the licensing departments.

In brief

Among the recent qualifiers for the 5-band DXCC award is Arthur Milne who recently celebrated holding his callsign G2MI for 50 years. The German amateur Rudulf Bluel, DL8AL also joined those with 50 years of operating. Originally TS4SAC, his callsigns have included EZ4SAB, D4BWT, D4QBT and 9S4AL and he was also one of the German amateurs who held German wartime licences in 1942–44 under circumstances that seem to have had something in common with the special G7 permits held by some prominent British amateurs in the closing stages of the war. According to *The Chiltern Carrier* (newsletter of the Chiltern Amateur Radio Club) a firm of Southampton stamp dealers has recently been offering for sale QSL cards commemorating the first 1.8MHz contacts between Tristan da Cunha and various other countries at prices between £4.50 (Brazil) and £7.50 (England)—the first time I have ever heard of anyone attempting to sell QSL cards in this way. A new 10kHz "window" for Japanese 3.5MHz stations, between 3793 and 3803kHz, is expected to increase the number of contacts on this band with European and American s.s.b. stations (normal Japanese 3.5MHz allocations are limited to 3500 to 3525kHz c.w. and 3525 to 3575kHz phone). The Australian amateur, Bill Hall, VK2XT, is believed to be the first station outside Japan to gain a JARL award for working all 644 Japanese cities. Several American states now have laws prohibiting the use of twin earphones while driving, although these regulations are apparently aimed at those using earphones for stereo and other entertainment.

PAT HAWKER, G3VA

Pseudo-random binary sequence generators

Used to construct fast, synchronous, programmable frequency dividers and a frequency synthesizer

by F. Butler, O.B.E., B.Sc., F.I.E.E., M.I.E.R.E.

A pseudo-random binary sequence generator (p.r.b.s.) alternatively known as a linear recursive sequence generator, (l.r.s.), is an assembly of bistables and exclusive-OR gates designed to produce a pulse sequence, of any desired length, in which individual pulses and spaces are randomly distributed over the sequence length. The bistables, in a shift-register configuration, are driven by a common clock pulse and each bistable drives the next in line. Outputs from certain stages, always including the last, are applied to an exclusive-OR gate, or to an array of such gates, the final output being taken back to the input of the shift register.

Illustrated in Fig. 1(a) is a general though not necessarily a practically useful method of connecting up such a system. The symbols for exclusive-OR gates have not been rigidly defined, nor has the terminology since the gates are also known as modulo-2 adders. Commonly-used symbols are shown in Fig. 1(b). Without using jargon, the properties of such a two-input gate are that when two identical inputs; 0 or 1, are applied the output is at one particular logic level and when the inputs are different, the opposite logic output appears. In tabular form these properties can be expressed digitally as:

$1+1=0$	or,	$1+1=1$
$0+0=0$	(equally	$0+0=1$
$1+0=1$	valid)	$1+0=0$
$0+1=1$		$0+1=0$

A standardized way of writing the exclusive-OR addition or modulo-2 sum of two quantities has been agreed upon. It is expressed as $C=A\oplus B$ and is read as "C equals A circle-sum B". The above tables should be written in this way and, strictly speaking, one should differentiate between exclusive-OR and exclusive-NOR gates.

Before discussing practical circuits and applications, it will clear the ground if some of the statistical properties of linear recursive sequences are mentioned. The statements will be in the form of assertions, not backed by mathematical proofs, which would lead us into very deep water.

First, the maximum possible number of bits in the sequence generated by n bistables is $N=2^n-1$, one less than 2^n which might have been expected. The all-zero combination is inadmissible. If it occurs, the bistables latch or lock up and the sequence stops. This condition must be avoided.

With large, but still practicable, numbers of bistables, very long sequences can be generated. For example, 60 stages give a sequence length of about 1.15292×10^{18} bits. Such long sequences can be used in enciphering digital signals. In any given sequence, remembering that the total number of bits is always odd, there are, as nearly as possible, equal numbers of 0's and 1's. There are half as many runs of two bits, one quarter as many runs of three, and so on. At the end of a cycle, the sequence starts again and gives another identical train of pulses. The student of Fourier will recognize that such a sequence is not truly random but is periodic with a period equal to the cycle length. It has a line spectrum with discrete frequencies which can be filtered out by suitable equipment.

Though superficially the l.r.s. resembles random noise, more so as the cycle length increases, true random noise has a band spectrum with components at infinitesimal frequency separation. If a complete sequence is compared, term by term, with a cyclically shifted version of itself, the number of pulse polarity agreements and disagreements, every possible pattern of n bits in the total sequence length N will appear once, and only once, at the outputs.

Exclusive-OR gates

Although these are available in packaged form, one integrated-circuit block containing four 2-input gates, it is instructive to see how they can be assembled from simple AND/OR or NAND/NOR gates. Fig. 2 shows in principle what has to be done, and how in practice, the scheme is implemented. By putting various inputs to the gate, the reader can verify that the exclusive-OR logical function is actually realized. If the two inputs A and B are taken from bistables, their complements $\bar{A}$ and $\bar{B}$ are normally accessible. The modulo-2 gate can then be simplified and assembled from three NAND gates only. A spare gate is then available in a quad package and can be used as an extra output buffer amplifier or inverter.

Practical generators

Integrated-circuit packages are currently available with quite large numbers of bistables assembled in shift-register form. Circuit blocks of this type, together with multiple modulo-2 gates will be used later

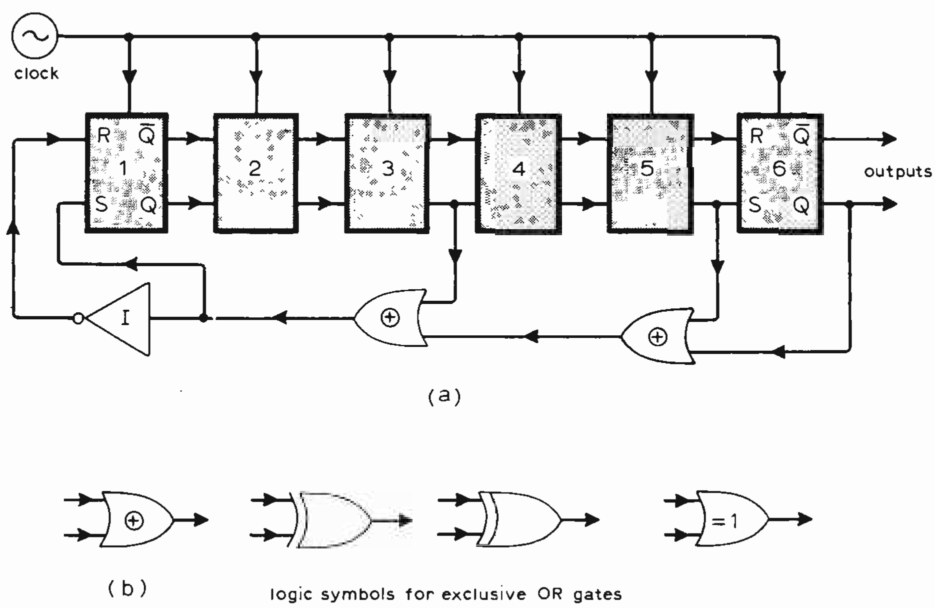
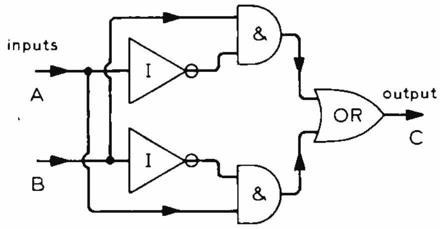


Fig. 1(a). P.r.b.s. generator using a shift register with exclusive-OR (modulo-2) feedback.

to produce long l.r.s. streams in an economical way but it is instructive to build one or two simple models with bistables and NAND-gates using d.t.l. logic. These blocks are inexpensive and readily available. Though slower than t.t.l. equivalents, they are fast enough for many purposes and are trouble-free in use. Clock frequencies up to 4MHz can be used with reasonably complex systems. A relatively simple but useful generator is shown in Fig. 3. Seven bistable stages are used to give a sequence length of 127 bits. Because both Q and $\overline{Q}$ outputs are available from the bistables, the modulo-2 gate can be assembled from three of the four gates in a quad NAND-gate package, leaving one spare two-input gate for use as an inverter amplifier.

The d.t.l. bistables, SGS types 9945/9948, or their equivalents are basically R-S flip-flops but they can be used in the J-K mode by connecting the outputs back to the inputs. Direct set and clear inputs override other inputs, allowing the unit to be presented as required. The 945 unit has a higher value load resistor than the 948 and is better able to drive capacitive loads. The 948 has a faster pulse rise time.

The experienced user can wire up the complete generator directly on printed circuit board though it would be wise to check all units before assembly. Alternatively, plug-in holders can be used, making it easier to trace faults or to replace defective units. The clock source can be any type of oscillator, square-wave or sinusoidal, crystal-controlled or not, up to a frequency around 4MHz. Sinusoidal inputs must be squared up by Schmitt trigger or clipper circuits and must be



$C = A.\overline{B} + \overline{A}.B$
$= A \oplus B$

Fig. 2. Logic function and circuit realization of exclusive-OR (modulo-2) gate.

capable of driving the load presented by the seven bistables. The random sequence can be taken from any bistable output Q or $\overline{Q}$. Outputs from consecutive bistables are identical but delayed in time by one clock period. Because of its random nature it is rather difficult to lock the trace on an oscilloscope display but with perseverance it can be done, allowing the sequence to be examined visually.

It will be noticed that feedback to the exclusive-OR gate is taken from the sixth and last bistable in the register. The adjoining Table shows the requisite feedback connexions for sequences of different lengths. It should be mentioned that any feedback connexions will produce a sequence of sorts but to get the maximum possible length of $N=2^n-1$ bits, only certain arrangements are admissible. Those given are suitable though not unique. For example, in a seven-stage register, one feedback link must always be from the last stage. The other can be from stage 3, 4 or 6. Because both Q and $\overline{Q}$ outputs are accessible it is possible to use a simplified exclusive-OR gate. It will also be noticed that the output from this gate goes directly to one data input of the shift register. It is also applied to the other input through an inverter, which is in fact one of the four two-input NAND gates in a quad package. The other three gates form the modulo-2 adder.

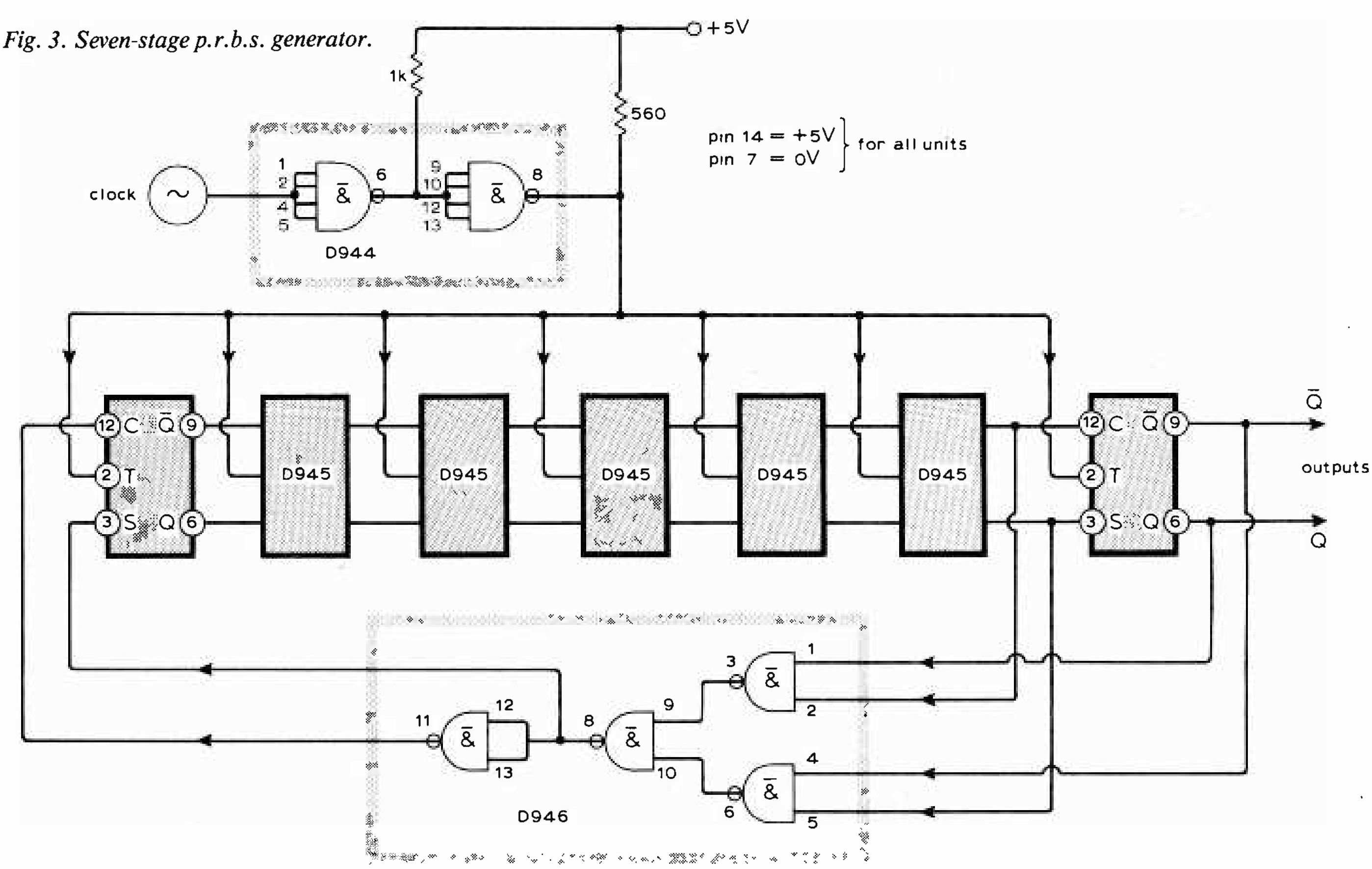
Standard frequencies from pseudo-noise sources

The generator just described produces a pulse sequence which repeats after 127 bits, although the stream is random within this period. Suppose the clock frequency is exactly 127kHz, derived from a crystal-controlled source. Clearly a run of 127 bits repeats at 1,000 times per second and it follows that the fundamental frequency of the complex waveform is 1kHz. It has harmonics at all integral

Feedback connexions for sequence length

Number of bistables n	Sequence length N	Feedback connexions
2	3	1, 2
3	7	2, 3
4	15	3, 4
5	31	3, 5
6	63	5, 6
7	127	6, 7
8	255	4, 5 and 6, 8
9	511	5, 9
10	1023	7, 10
11	2047	9, 11
12	4095	6, 8 and 11, 12
13	8191	9, 10 and 12, 13
14	16383	4, 8 and 13, 14
15	32767	14, 15

Fig. 3. Seven-stage p.r.b.s. generator.



multiples of 1kHz and these can be picked out, one by one, using a sufficiently selective tunable amplifier or filter.

Mathematical analysis shows that the amplitude of the harmonics falls off in a predictable way, roughly as indicated in Fig. 4. The first zero occurs at 127kHz. It is well known that a train of narrow pulses with a stable recurrence frequency also has a spectrum of the same general form and the reader may well ask why one should construct a complex l.r.s. generator when something so much simpler would appear to do the same job. The advantage of the pseudo-noise source is that the harmonics are very much stronger because the power density of the noise spectrum is greater than that from a train of narrow pulses. Moreover, the amplitude of the higher harmonics falls off relatively slowly. Experience shows that with a clock frequency of 127kHz, strong harmonics up to 100kHz are available. Thus at least 100 standard frequencies of high stability can be picked out. The best equipment to do this is a wave analyzer. Such instruments commonly cover the band 0–50kHz with extremely high selectivity, bandwidths of ± 10Hz to the -40dB points being typical.

If the 127kHz clock source is followed by several decade divider stages, the wave analyzer can easily pick out 100 frequencies between 0 and 1kHz in 10Hz steps, and 100 between 0 and 10kHz in 100Hz steps as well as the 1kHz series just discussed. The synthesized frequencies are extremely "clean", free from noise and undesirable modulation. A lower limit to the usable frequency separation of signals is set by the selectivity and calibration reliability of the wave analyzer. By using more decade dividers to achieve a low clock frequency, standard frequencies with periods of several minutes have been picked out by means of a gyrator, the waveform being checked with a chart recorder. The upper limit of frequency depends on the speed of the logic elements; 4MHz is easily achieved and 100MHz is not unreasonable as a clock frequency for use with the latest circuits.

Many laboratories already possess wave analyzers and the construction of a p.r.b.s. generator could hardly be simpler. The useful range of standard frequencies so derived is good enough for routine work such as checking receivers, calibrating oscillators and testing filters. The system can provide clock sources for digital work and can generate coherent signals on multiple frequencies, the freedom from spurious signals and responses being of particular value.

The wave analyzer functions basically as shown in Fig. 5, though a practical instrument incorporates many refinements. The complex signal to be filtered is fed to a mixer or balanced modulator along with a higher-frequency signal from a tunable oscillator. The difference frequency is picked out by a narrow-band crystal filter, amplified and applied to a second mixer, together with the same variable-frequency oscillator signal. The desired component of the complex signal is thereby restored

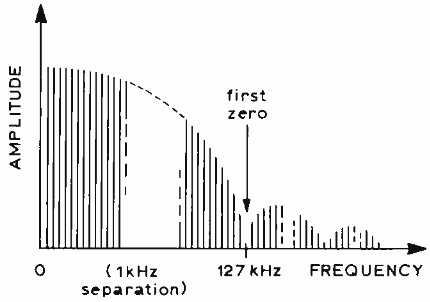


Fig. 4. Line spectrum of a 127-bit l.r.s. clocked at 127kHz.

to its original frequency but cleared of all other components. There is no degradation of signal frequency stability due to the v.f.o.. In the first mixer we derive $f_o - f_s$. In the second we recover $f_o - (f_o - f_s) = f_s$. This drift-cancelling technique is used in some communications receivers for much the same purpose.

It might be objected that the crystal-controlled clock frequencies are awkward, non-standard values but it is surprisingly easy to grind down readily-available crystals to the required size on a cast-iron lap using in turn coarse, medium and fine carborundum paste. Thus to produce 127kHz requires a stock 100kHz bar. Values such as 1023kHz are easily produced from a 1MHz standard, though of course it is impossible to modify glass-encapsulated units.

A solid state wave analyzer (illustrated), covering 0–150kHz has been built for use with l.r.s. sources as well as for the more usual applications of a tunable filter. A good deal of work is involved in the construction although, apart from the cost of the crystal filter, the instrument is not unduly expensive to build.

Programmable frequency dividers

The circuit of Fig. 3 is relatively easy to modify for use as a variable-ratio divider, programmable by a row of single-pole change-over switches, and hence adaptable for some forms of direct digital control.

In a normal shift register, initially loaded with a particular setting of bits, each clock pulse shifts the pattern along the register one bit at a time. This is also the case for a p.r.b.s. generator, except that the serial input to the register is derived by modulo-2 addition of selected outputs of the constituent bistables. An n-stage register displays in turn on its n outputs every possible combination of bits, the pattern repeating after every $2^n - 1$ clock pulses.

If we could recognize some particular pattern as it appeared during the sequence we could then use this information to reset the register and start again without going through the remainder of the sequence. This is easily done. All we need for an n-stage register is an n-input AND or NAND gate with the inputs connected via switches to the Q or $\overline{Q}$ terminals of successive stages of the register. When the selected pattern appears, the resulting gate output resets the shift register and the count starts again.

An arrangement which satisfies these requirements is shown in Fig. 6. Such a counter or frequency divider is fast, synchronous with the clock, easily set up or programmed and very reliable. It uses just about the minimum number of logic blocks and requires only simple precautions in construction. However, a race condition can come about in the following way. Suppose a particular pattern appears in the register and it satisfies the gate condition. A gate output pulse appears which attempts to reset all the bistables in the register. If one is much faster than the rest, it resets first, changes its output and destroys the gate condition before the remaining bistables are reset. To avoid this effect, the gate output can be used to trigger a pulse monostable, the output of which lasts long enough to reset all the bistables. At the same time the pulse must have disappeared before the arrival of the next clock pulse. Durations around one-tenth of a microsecond are about right for d.t.l. units at the fastest clock rates. The only other objectionable feature of the divider is that the natural output is a very narrow pulse, whereas a square wave would be preferable, particularly for synthesizer applications.

There is no obvious way of producing a square wave from a narrow pulse which is effective over a wide frequency range. A pulsed monostable can do this at a fixed frequency whereas if a bistable is used we get a true square wave but have to put up with a further division by two. We end up with a device which divides only by even numbers. This defect of course plagues other types of divider. One way out is to double the input frequency which allows us to end the chain with a bistable. Several aperiodic doublers are known but they will not work with square wave or pulse inputs.

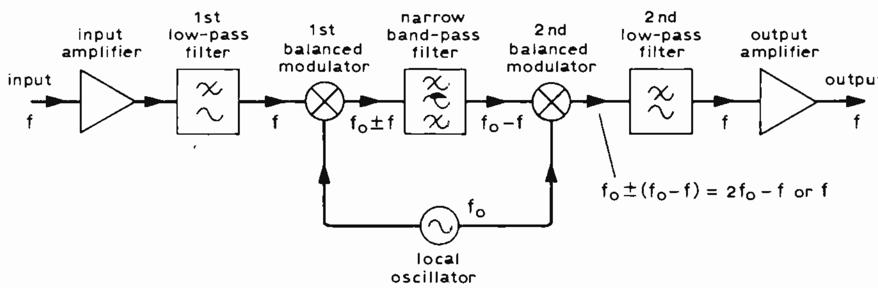


Fig. 5. Wave analyzer used in restored-frequency mode as a narrow-band tunable filter.

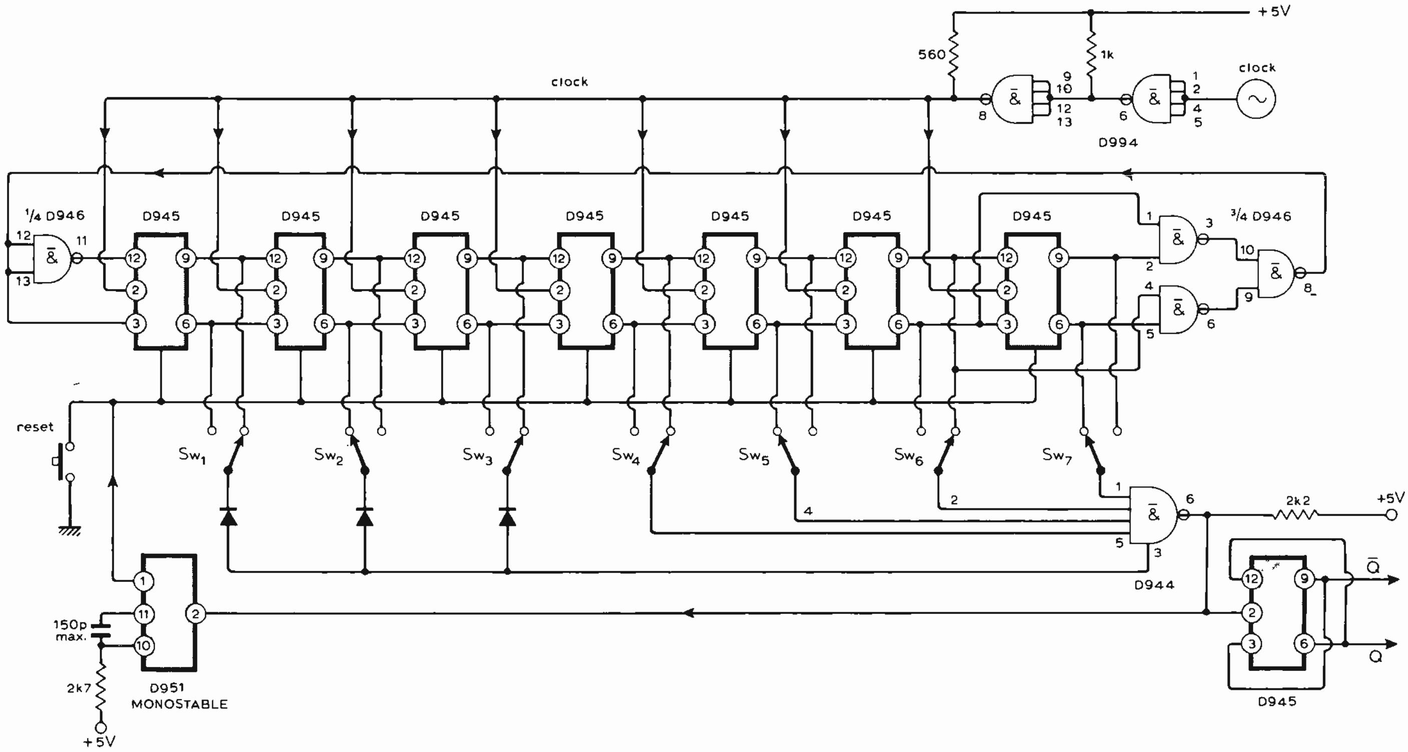


Fig. 6. Programmable frequency divider (all even divisions 2–254).

A seven-stage shift-register divider as in Fig. 6 will give a square wave output for every even divisor between 2 and 254. It will operate at clock frequencies up to 4MHz. Different divisors are selected by changing the switch settings. It is of course necessary to tabulate all these settings and this operation must be performed methodically. The equipment required is a counter and a stable oscillator. First, the switch settings must be found corresponding to division by two. Depending on the convention adopted for the switch positions, the pattern will be either 1000000 or 0111111, the switch positions along the line being counted from the input end of the register. To divide by four, the second switch along the line must be changed over, thus moving the pattern along one bit to the right. The first switch may or may not need to be altered.

The correct setting is that which gives the proper divisor as checked by the counter. Each successive change involves moving the switch pattern along, cyclically, one step at a time and, if necessary, changing the setting of the first switch to give the next even-number divisor in the sequence. The procedure sounds tedious and complicated when described in words but is quick and simple in practice. Naturally it is not so easy as setting up a row of decade switches but it is a less expensive system and it has the advantages of fast synchronous working and simple wiring. Preparing the table of switch settings does not call for particularly high accuracy of the clock source or counter. For example, a clock source of 1MHz divided by 200 gives an output of 5kHz. dividing by 202 gives a result about 1%, 50Hz, lower, a difference which is easily resolved.

Examination of the switch-setting table will bring out some interesting points. If we look down the first column we see the order of bits in a 127-pulse sequence. The second column down is a similar sequence, delayed by one clock pulse, and so on for the other columns. We notice to, that each switch setting pattern occurs once, and only once, as it should.

Referring again to Fig. 6, the seven bistable outputs eventually feed a seven-input NAND gate. This is not a standard item. Instead, we use a four-input gate which has an expander or extender node to which other inputs may be connected, (through diodes with d.t.l. units). The diodes may be discrete components or may be contained in a special extender package, (SGS type 9933 or equivalent).

Generators using i.c. shift registers

One of the first published papers[1] giving practical information on random pulse

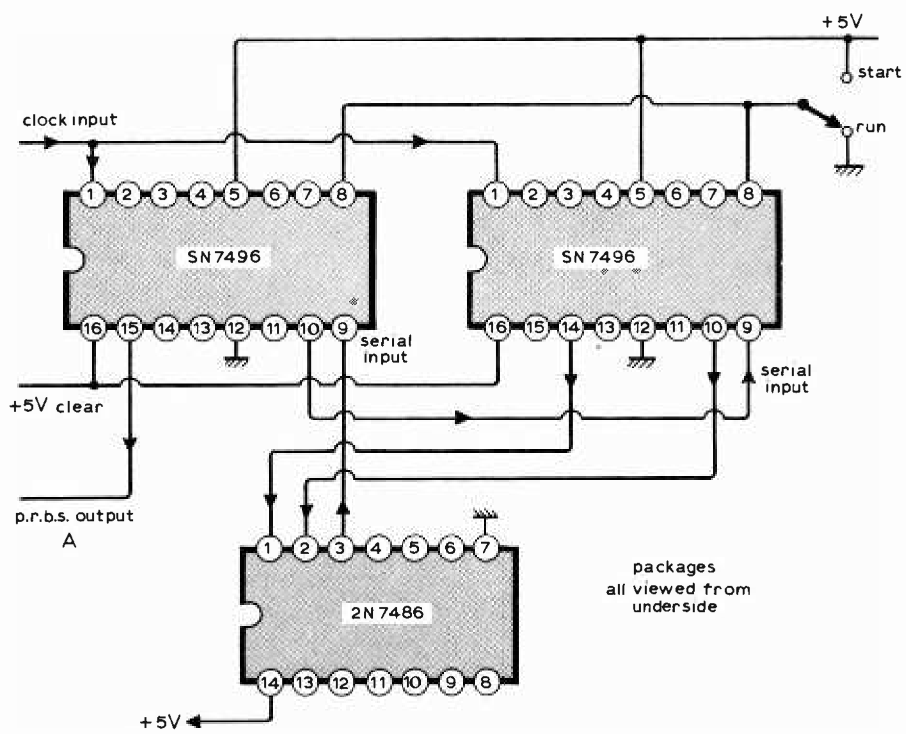


Fig. 7. 1023-bit l.r.s. generator using two five-bit t.t.l. shift registers and an exclusive-OR gate.

generators is still worth reading for the valuable background material it contains, its account of some applications, and because it shows the amount of effort required to construct such a generator from discrete components.

In contrast, an even more complex generator will now be described which can be built using only three integrated circuit packages.[2] These comprise two five-bit shift registers and one exclusive-OR gate from a quad package. Both these items are in the type 7400 t.t.l. range. The gate, SN7486, calls for no particular comment but reference must be made to the properties of the shift registers. To clear all stages, logic 0 must be applied to the clear input, pin 16. For normal use, apply logic 1. To preset the register for any particular starting sequence, the individual presets must be set to 0 or 1 as required. The sequence is read into the register by applying logic 1 to the master preset input, pin 8. During normal operation, pin 8 must be at logic 0. Shift in the register occurs when the clock input switches from 0 to 1.

The complete wiring diagram of the 1023-bit generator is shown in Fig. 7. The output may be taken from any of the Q terminals. In the diagram it is shown coming from the first. When clocked at 1023kHz, over 1,000 standard frequencies may be picked out by a suitable filter or selective amplifier.

Some extra packages are required to construct a programmable divider. Besides the multiple-input gate and bank of ten switches, we need ten inverter amplifiers to obtain the complements of the register outputs. Two standard packages provide twelve of these leaving two spares for use as buffers. Though unlikely, it may be necessary to drive a monostable from the gate output when resetting the register at the end of a count. Shorter sequences or simpler dividers can of course be built by omitting certain packages or units; in fact it is a simple matter to include switching to pick out runs of any length.

There is a growing interest in logic systems employing m.o.s. techniques. These i.c. packages are characterized by low power consumption, very high input impedance, tolerance to wide variations in supply voltage and high noise-immunity. Manufacturing processes are simpler than bipolar techniques and large-scale integration is possible. At present, speeds are rather lower than for t.t.l. but fast enough for most purposes.

Motorola has embarked on a big programme of complementary m.o.s. development and most logic requirements can be met by off-the-shelf units at moderate prices. The range includes modulo-2 gates and a variety of shift registers suitable for use in p.r.b.s. generators and frequency dividers of almost any degree of complexity.

A publication entitled "McMOS by Motorola", lists all the packages now in production and contains some useful, though brief, application notes. One of these refers to a 255-bit p.r.b.s. generator of the type under discussion.

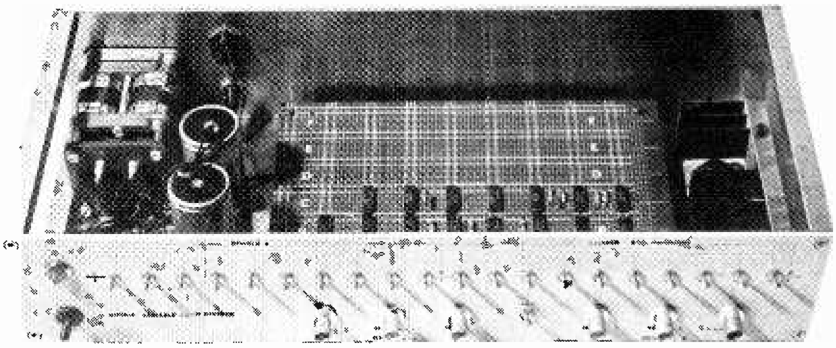


Fig. 8. Internal layout of the dual ten-stage 1023-bit p.r.b.s. generator/programmable frequency divider.

Miscellaneous uses of generators

Apart from their use as pseudo-noise sources and synchronous dividers these devices find application as test-signal sources, modulators in secure communication systems and as key generators for enciphered digital communications. A note on this last application may be of interest. Suppose that a plain text message in the form of a stream of binary digits is to be enciphered by the addition of a random bit stream, the key synchronous with the traffic. The two sequences can be added modulo-2 and securely transmitted by line or radio. At the receiving end an identical key stream is once more added (exclusive-OR), to the enciphered signal. It will be found that the original plain text is recovered. An example illustrates the principle:

Transmitting

Plain text
1011000111101100101101l

Random key
0010110001000011l011001

Enciphered text
01100010010100001111101

Receiving

Enciphered text
01100010010100001111101

Random key
00101100010000111011001

Plain text
10110001111011001011011

It will be seen that the last line is the same as the first and the plain text has been completely recovered. Security clearly depends on the random nature of the key which must have a very long sequence before repeating; indeed it should never repeat.

Referring back to the statistical properties of l.r.s. generators it is not difficult to see that if two identical sequences are produced and matched up pulse for pulse and space for space, then if they are exclusive-OR gated together the logical output will be 1 (continuous high). If a similar operation is conducted with one of the sequences displaced from the other by an amount corresponding to one clock period then the gate output will be almost zero (low), if averaged over the whole period of the sequence because, as already

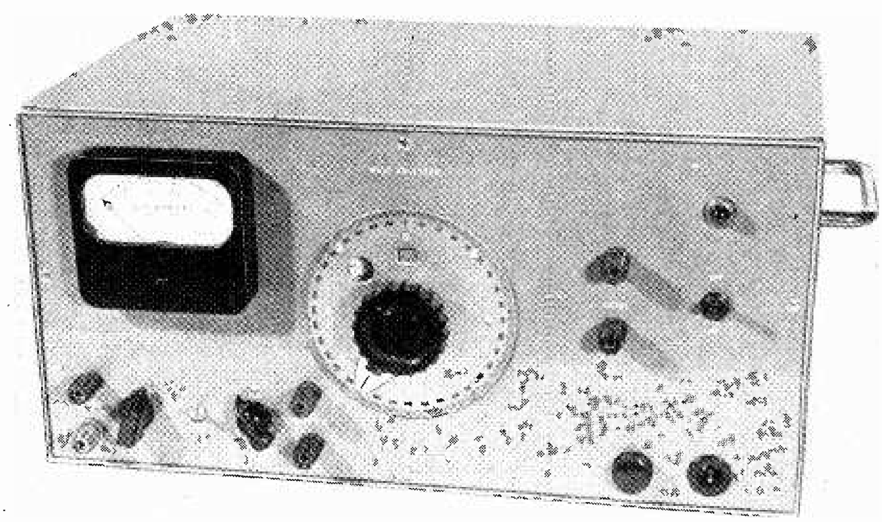


Fig. 9. Wave analyzer—used as a narrow-band tunable filter.

stated, the number of agreements and disagreements of the two patterns will, at most, differ only by unity. The same is true for any other relative shifts of the two patterns. This points to the possibility of developing a secure communications system.

If instead of transmitting a carrier, modulated or keyed in amplitude, frequency or phase, we transmit a random pulse train, this will sound like noise in the receiving telephones. If we switch from one sequence to a different one, or to a cyclically shifted version of the first, the transmission will still sound like noise, identical to the other. But if these digital streams are properly correlated with the outputs of similar generators at the receiving end, then intelligible communication becomes possible in Morse or in any normal printer code. There are obvious problems in setting up practical systems. Precise synchronization of the generators at each end of the link is required, the bandwidth of the transmission at high bit rates is very large and, in the h.f. band, multipath propagation effects cause difficulties.

An unauthorized interceptor hears nothing but noise during transmission. To read the traffic he must be in possession of l.r.s. generators exactly the same as those used on the link and even if he had such generators there is still the problem of synchronization and of finding the correct starting point in the sequence to give maximum correlation of the two bit streams. With 60-bit shift registers, the intercept task is a daunting one.

Few problems have been encountered in constructing the items so far discussed but, in the event of trouble, attention should be paid to the following points. Wiring runs should be as short as possible and a symmetrical layout of parts should be adopted. Some d.t.l. packages seem to work best with a supply voltage rather less than the nominal 5V. Capacitive decoupling at the unit power supply pins may sometimes be required. Mains transients can sometimes stop or interrupt the pulse sequence. Noise immunity of some units is not all it might be and it may occasionally be found that, after switching on, a sequence generator fails to start. This is because the shift-registers lock up in the all-zero state. Though it is possible to incorporate logic to avoid this, it is simpler to switch off and start again.

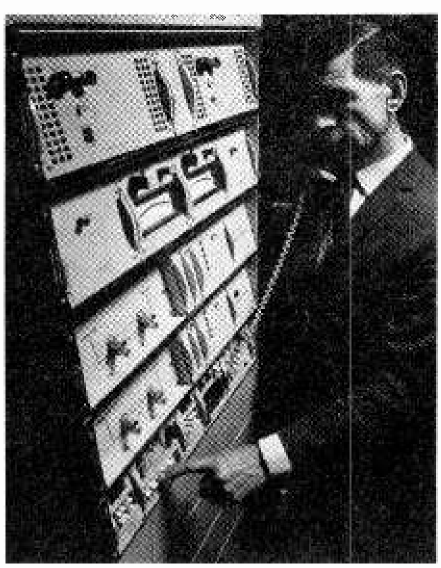
References

1. "Random Pulse Generator Tests Circuits; Encodes Messages", B. K. Ericksen, J. D. Schmidt, *Electronics*, June 23, 1961, pp.56–59.
2. "A pseudo-Random Pulse Train Generator with Controllable Rate for Modelling of Audiometric Systems", J. K. Moss, R. J. Simpson and W. Tempest, *Radio and Electronic Engineer*, Vol. 42, No. 9, September, 1972, pp.419–424.

High capacity p.c.m. system

A high bit-rate p.c.m. line transmission system, working at 120Mbit/s, has been put into field trial operation by the Post Office between Guildford and Portsmouth. Built by Standard Telephones and Cables, it is claimed to be the first of its kind in Europe and represents the Post Office's first step in developing a digital trunk network capable of carrying a variety of traffic. Of course there are p.c.m. systems already operating in the UK but these work at only 1.5Mbit/s, carrying 24 simultaneous telephone conversations over distances up to about 30km. The 120Mbit/s system is capable of accommodating 1,680 telephone channels, one colour television channel, 14 viewphone channels, 224 broadcast-quality sound channels, or a mixture of these types of traffic within its capacity.

The p.c.m. signals are transmitted along two coaxial "tubes" of an existing eight-tube cable which is already in use for 12MHz analogue carrier (f.d.m.) transmission. Repeater spacing and electrical power feeding are identical with those of the 12MHz system and in fact the 78 p.c.m. repeaters between Guildford and Portsmouth are installed in existing repeater stations—some of which are underground watertight and pressurized housings. Most of the repeaters' active functions are performed by the well proved BFY90 transistors. To allow maximum repeater spacing and remove d.c. component from the signal, the 120Mbit/s binary information is converted for transmission into a 90Mbaud ternary code consisting of the three voltage levels +6V, 0 and −6V.



A main repeater for the 120Mbit/s p.c.m. system between Guildford and Portsmouth.

At the Post Office's Portsdown repeater station near Portsmouth a demonstration was given, using a 30-channel p.c.m. terminal, of voice transmission over a distance of 130km from Portsmouth to Guildford and back. This used the system's multiplexing process for telephone channels. First, 30 channels are multiplexed to give a 2.048Mbit/s stream, then four such streams are multiplexed to give a 8.448Mbit/s stream and finally 14 of these are multiplexed to give the 120Mbit/s stream.

International discussion of the multiplexing of digital signals based on the 30-channel p.c.m. system has now resulted in the following hierarchy being adopted for use throughout Europe:

1st order	2.048Mbit/s	30 channels
2nd order	8.488Mbit/s	120 channels
3rd order	34.368Mbit/s	480 channels
4th order	139.264Mbit/s	1,920 channels

The first and second orders have already been adopted by the Post Office for the UK. Future plans for digital radio relay, and higher rate transmission on coaxial cable, will be based on the fourth order in the hierarchy, approximately 140Mbit/s, and multiples of this. The same basis will also be used for waveguide and optical fibre systems.

Sixty Years Ago

Humour was certainly an important component in the armoury of the wireless engineer of 1915. This was exemplified by a *Wireless World* reader's letter published in February of that year proposing a somewhat novel method of electric propulsion for ships, and reporting on several apocryphal experiments.

"Last week, after a short paper on 'Directional aerials', one of the members suggested that as action and re-action are equal and opposite there would certainly be in a directional aerial a force produced in the contrary direction to that in which the maximum energy was sent, therefore in his opinion if a good directional aerial were installed on a vessel, it would experience a force in the direction of the free end of the aerial, and so would be propelled. The free end, of course, would be generally over the bows of the vessel in order that she should move forward, but to move astern it could easily be arranged to shift the downleads to the other end. The speaker predicted that this would be the method of propulsion of the future—at any rate for small craft—and he became so excited, sir, over that prospect, that he wanted to communicate his idea to the Admiralty personally and without delay. He had great trouble, so we could hear at the porter's lodge, and was only persuaded to come quietly back on the promise of an extra bun for tea."

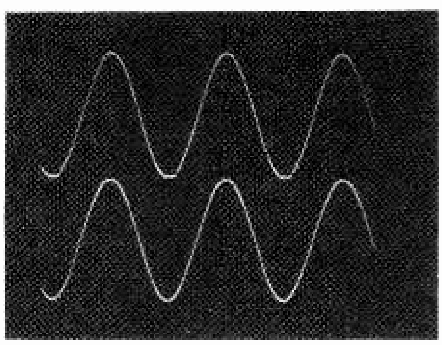
Circuit Ideas

D.C. level clamp

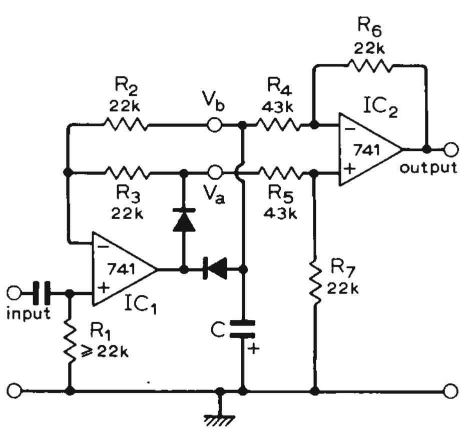
The need sometimes arises, e.g. after a stage of a.c. amplification, to clamp the minimum level of a signal voltage to a d.c. reference voltage. The circuit illustrated was developed to clamp, to the zero-volt level, signals having an amplitude of between 10mV and 10V. The familiar diode-and-capacitor clamp circuit is unsuitable here because of the diode's forward conduction characteristic.

In each cycle, the capacitor, C, charges to the peak negative value ($V_b = -V_p$) of the input voltage, V_i. The voltage V_a then follows the input voltage ($V_a = 2V_i + V_p$) while V_b remains at the level to which the capacitor was charged, decreasing only with a time constant

$$T \approx \frac{(R_4 + R_6)R_2 C}{R_4 + R_6 + 2R_2}$$



Lower trace is the input signal; upper trace is the output from the restorer. Oscillogram was obtained with the circuit operating on a 150Hz signal with an amplitude of 40mV peak-to-peak.



The required voltage waveform, with its minimum d.c. level restored to zero, appears as $V_a - V_b$. A low-impedance single-ended output is provided by IC_2 and, in this case, unity gain overall.

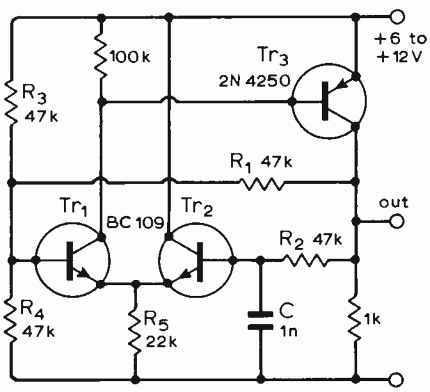
Using a 250-μF electrolytic capacitor, the circuit clamps sinusoidal waveforms between 3Hz and 10kHz with little distortion. For use at higher frequencies, IC_1 should have a faster slew rate. Lower distortion can be achieved if IC_2 has a higher input impedance—allowing larger values of R_4 and R_5 to be used.

C. B. Mussell,
United Liverpool Hospitals.

Tolerant astable circuits

Some simple one-capacitor astable circuits are described below. They have none of the usual problems experienced with Eccles-Jordan and one-capacitor circuits, since they are reliable over a wide temperature and voltage range, and are substantially independent of transistor gain spreads.

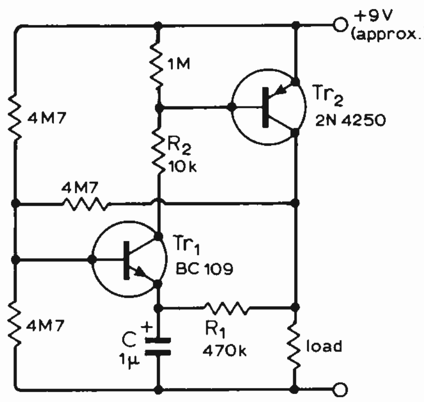
Fig. 1 shows a 20-kHz astable which can have 50 p.p.m./deg C temperature coefficient of frequency if an NP0 capacitor, and low-coefficient wire-wound resistors are used, providing the transistors Tr_1 and Tr_2 are of the same type. Frequency varies by 0.05% over 6 to 12V supply, under these conditions.



Timing may be varied with resistors R_1 and R_2, and with capacitor C. Duty cycle is determined by the ratio of resistors R_3 and R_4. The values shown give 50% duty cycle. Resistor R_5 may be decreased in value to allow higher output currents and/or high frequency operation; however, temperature stability is then slightly degraded.

Fig. 2 shows a high-performance pulser, capable of operating at from 10% to 1% duty cycle, approximately. The on current may be up to 50mA, and the off current drawn by the pulser is about 1μA. This allows effective battery-power economy when operating at very low duty cycles. Standard Eccles-Jordan circuits cannot approach this performance.

Components R_2 and C determine the on time; however, the 4.7MΩ resistors and Tr_1 gain affects this time at short duty cycles. Components R_1 and C determine the off time. As shown, the circuit pulses about twice each second. This varies by



about 10% over the −20°C to +100°C temperature range. This variation may be reduced to about 1% by the addition of an emitter follower on the base of Tr_1, of complementary polarity to Tr_1, to cancel the V_{BE} temperature drift of this transistor.

This pulser circuit has been used for animal temperature and heart-rate studies. It is possible to have implanted transmitters operating from one mercury button cell for more than one year with a suitable choice of resistor values.

C. Horwitz,
University of Sydney,
Australia.

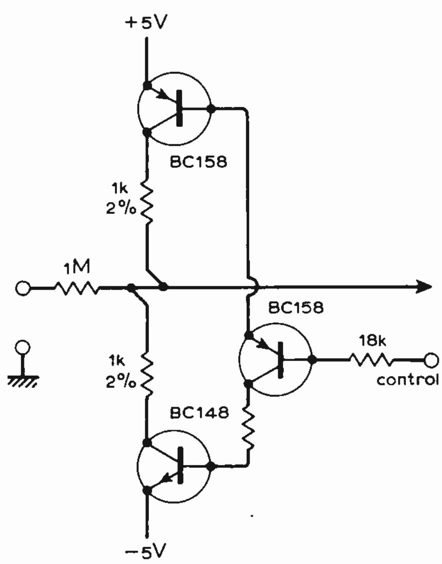
Analogue gate with no offset

An analogue gate capable of controlling audio signals by means of t.t.l. levels is shown. It is an improvement over existing gates in that when off there is negligible d.c. offset present at the output, thereby simplifying design of any subsequent stages in a large system.

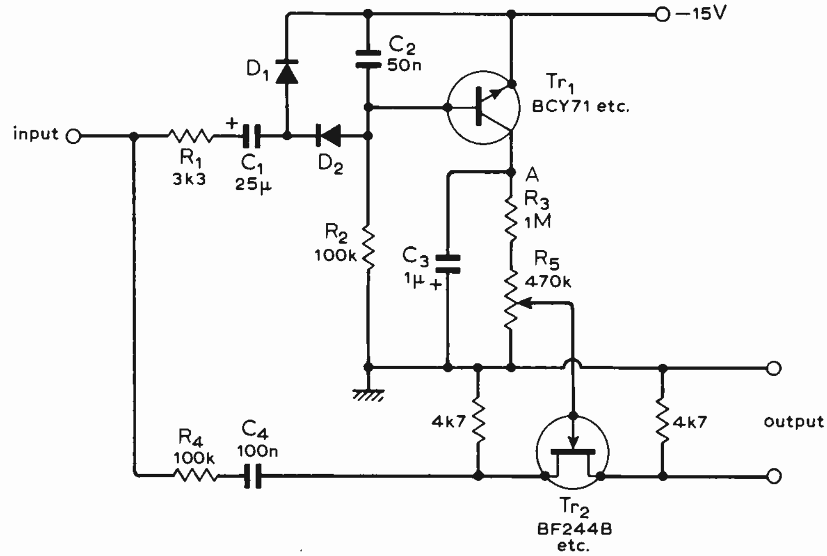
Attenuation when off is approximately 66dB and negligible when on and fed into high impedence stages. The control should be logic 1 (+5V) to open the gate, and logic 0 (0V) to close it again.

There are many possible applications for such a circuit in the design of programmed channel selectors in the field of music synthesis for instance, for which it was designed.

L. Cook,
Prescot,
Lancs.



Electronic organ to piano



A circuit was needed which would simply convert an organ to a more piano-like instrument. It exponentially attenuates the output from an oscillator to zero in a manner adequate to mimic the waveform of a piano. In addition this circuit has the advantage of being self-triggering. Thus the exponential decay starts only when the waveform from a multivibrator is applied—dispensing with the need for extra contacts on the keyboard. It has been used in conjunction with the J. H. Asbery multiphonic organ published in the June 1973 issue of *Wireless World*, although it has many other applications.

Operation of the circuit is as follows: when no signal is being applied, R_2 draws a current through Tr_1 thus biasing it on and maintaining the voltage at A at supply potential. Application of a signal results in Tr_1 turning off—due to the rectifying and smoothing action of D_1, D_2 and C_2. Capacitor C_3 then discharges through R_3 and R_5.

The f.e.t. gate is controlled by this discharging capacitor. Potentiometer R_5 ensures the f.e.t. just switches off when C_3 is fully discharged. When the signal is removed Tr_1 conducts, C_3 charges and so rapid manipulation of the keyboard is possible.

C. J. Outlaw,
Farnham,
Surrey.

Complementary ramp generator with independent amplitude/slope control

A circuit was required to generate two complementary ramps to be used to amplitude modulate auditory signals to either ear to create the impression of a left to right scan.

It is a simple matter using standard circuit techniques to either generate complementary ramps or to generate one ramp with independent control over amplitude and frequency. For this application, however, it was desirable to have control of amplitude and frequency of the two ramps at the same time, while avoiding interaction between the two controls. This is accomplished as follows: a ramp is generated between a reference voltage, V_{ref}, and earth and its complement is generated by inversion through an operational amplifier and a level shift of V_{ref}.

The time taken to discharge a capacitor from an initial voltage V_{ref} to zero volts depends on two parameters, discharge current and the initial voltage. If the discharge current is from a constant current source and if the current source is made voltage controlled, it can easily be shown that $T = CR$, which is independent of V_{ref}, the ramp amplitude. The ramp time is then independently controlled by R_s. For the circuit shown, the output ramp amplitude and time are variable from 400mV to 8V, and 50ms to 2.0s, with negligible interaction between the two controls.

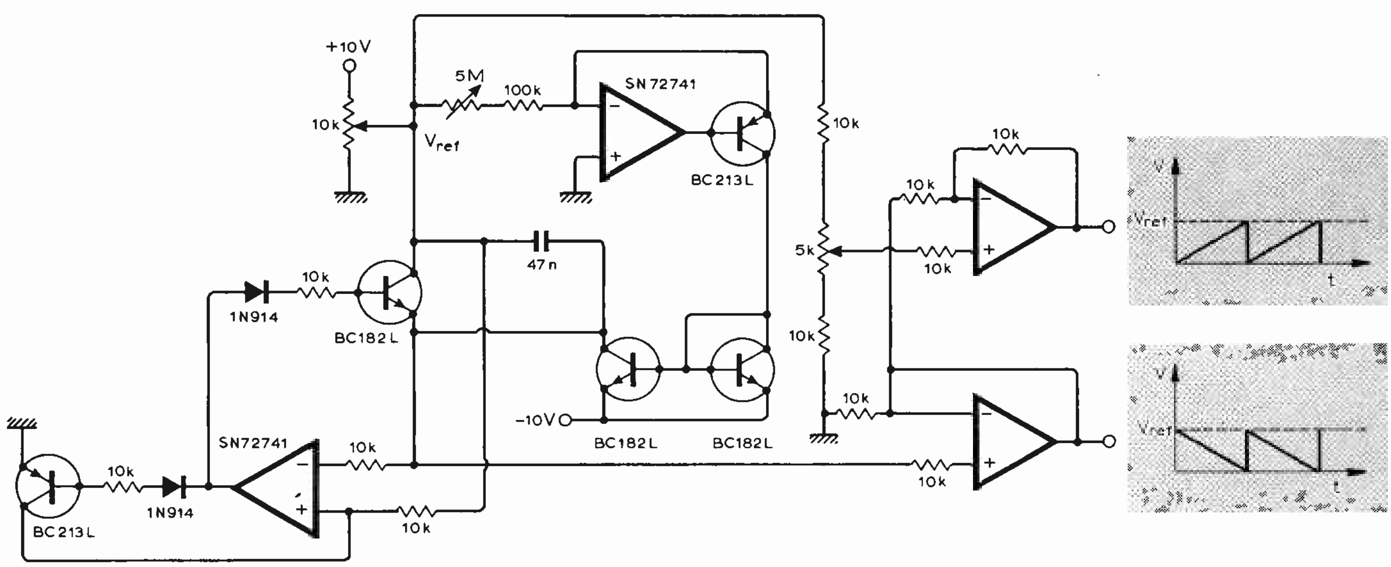
The capability of effecting this type of control described depends on a constant current source which avoids non-linearity due to V_{be} drops when V_{ref} becomes comparable to 0.7 volts. Hart* provides such a circuit which uses the high gain properties of operational amplifiers to reduce the effect of the V_{be} drop. It can be shown that this reduction is by a factor of $1/(1+A)$ where A is the open-loop forward voltage gain of the amplifier.

A conventional current mirror is then used to transfer the constant current to a useful voltage level and this current is then used to discharge the ramp capacitor. Each time the capacitor reaches approximately zero volts, it is reset to V_{ref} by a switching transistor controlled by a comparator. At the same time, a positive feedback loop is changing the comparator switching voltage to V_{ref} so that when the capacitor voltage reaches this value, the shorting transistor is switched off and the capacitor again begins discharging towards zero volts.

Due to the very high impedance at the ramp output, effectively that of the current source, a voltage follower output stage is required as an impedance transformer. Another op-amp is used for the inversion and level shifting of the complementary ramp, and so both ramps are available from very low impedance sources.

L. J. Retallack,
Southampton University.

*Hart, B. L., Current generators, *Wireless World*, vol. 27, 1970, pp. 511–4.



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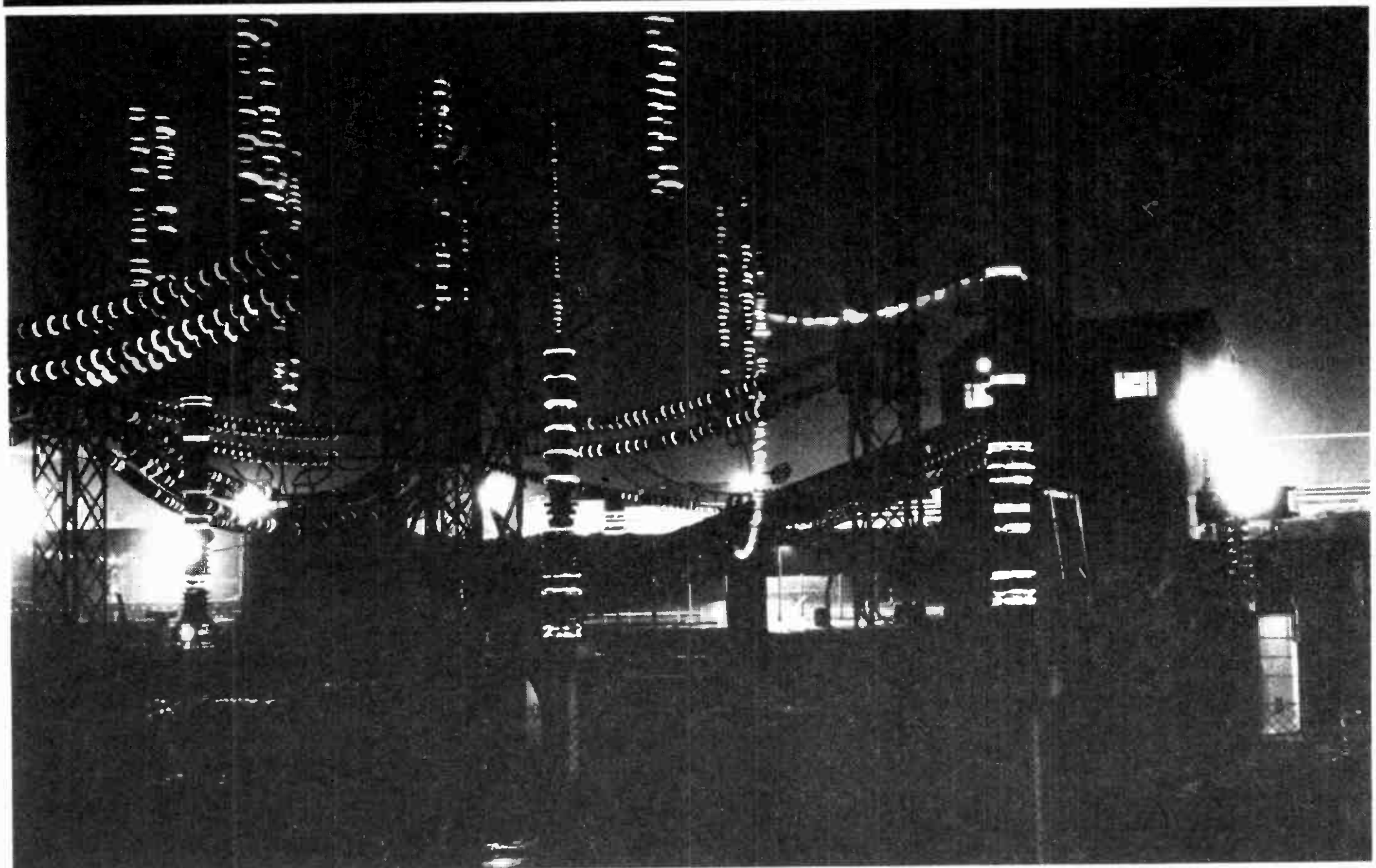

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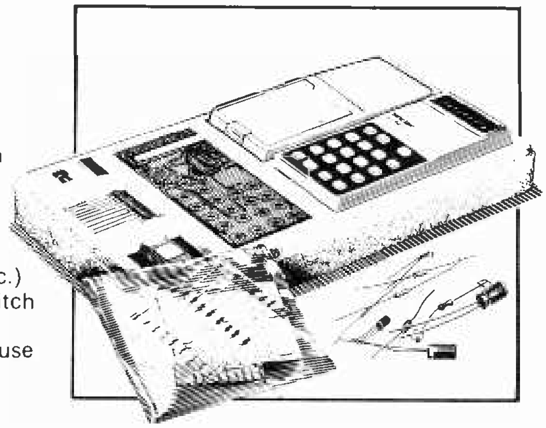

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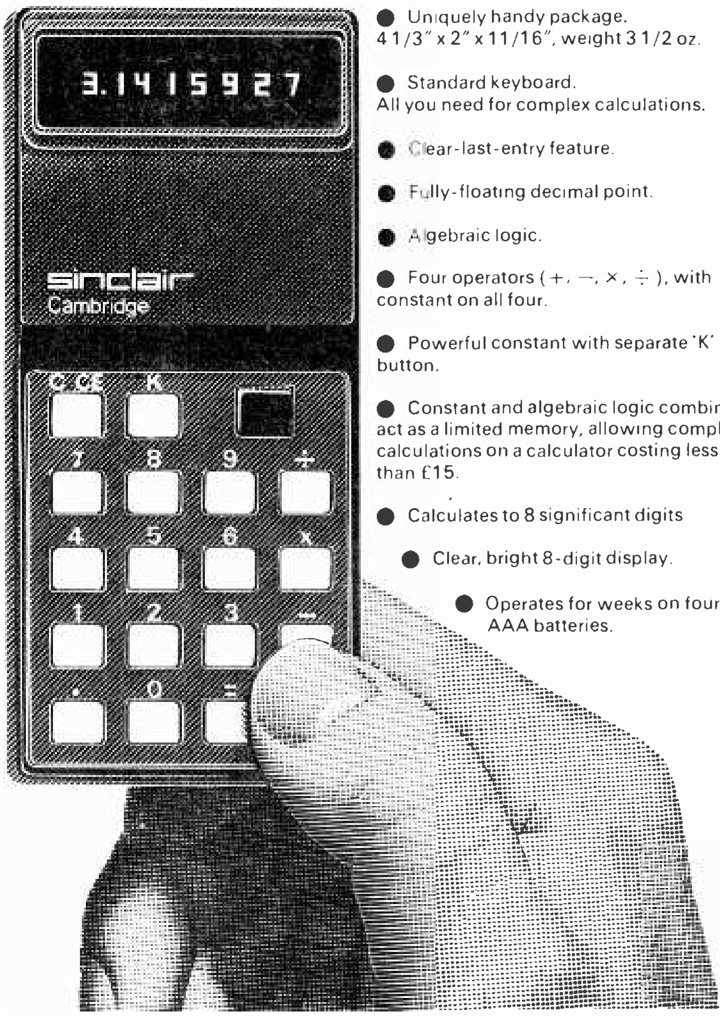

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Transistor pairs

The pros and cons of d.c.-coupled pairs, circuits for which are given in set 20 of Circards

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

Paisley College of Technology

"Supplementary or complementary, opposites or composites?" asked Tweedledum. "Contrariwise", said Tweedledee. It is not the intention to rewrite "Alice . . .", but it is not always clear what the advantages are in d.c.-coupled pair configurations—voltage gain plus impedance change, super current-gains, p-n-p simulation, thermal compensation or perhaps a current source as a stabilizing network.

The *pièce de resistance* might be the long-tailed pair or differential amplifier (where would the linear i.c. be without it?) which provides some satisfying amplifying properties—some possible variations for small-signal operation are shown in Fig. 1. For example, the connection shown in Fig. 1(a) converts a signal difference between two inputs to equal, but antiphase collector signals. Signals common to both inputs (e.g. superposed noise signals from the same source) are reduced without affecting the differential gain, which is that due to a single transistor.

The ability of this amplifier to prevent amplification of a common signal is called the common-mode rejection ratio, being the ratio of the differential voltage gain to the common mode gain, usually expressed in dB. The single-ended inputs of Fig. 1(b) and (e) produce an output at Tr_2 collector, equivalent to Tr_1 as an emitter-follower driving Tr_2 as a common-base amplifier. In addition, the output of Tr_1 is equal in magnitude but antiphase to that of Tr_2, on the assumption of constant total current (long-tail). Hence the differential output in Fig. 1(b) is twice the single-ended output. The voltage gains are approximately R/h_{ib} and $R/2h_{ib}$ for Fig. 1(b) and (e) respectively, where h_{ib} is the effective input resistance of the common base configuration. Fig. 1(c) and (f) are not used as amplifiers, but are useful as a means of determining the gain to common mode signals. This should be much less than unity to give good rejection.

The common-emitter, common-base, connection shown in Fig. 2(a) is the cascode amplifier, where the first stage transistor Tr_1 has current gain, and the second stage Tr_2 has voltage gain. The advantages are a large gain-bandwidth product and also, for high voltage outputs, the high breakdown value of the common base transistor Tr_2 is essential.

The common collector-common collector pair of Fig. 2(b) is the familiar Darlington connection, where the effective current would be approximately β^2, if the transistors were identical. This would be true for short-circuit outputs, but a practical value for the β of each transistor

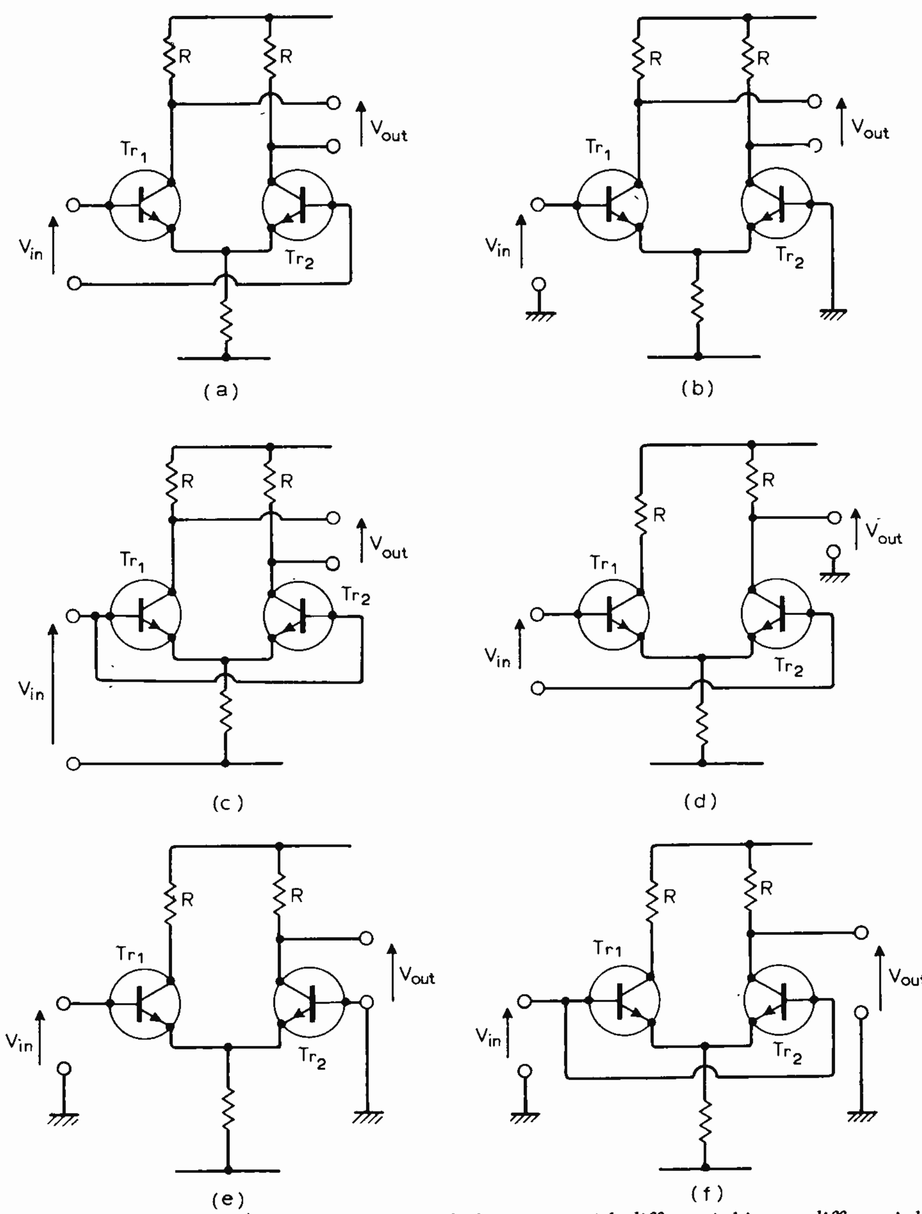


Fig. 1. Variations of the long-tailed pair include circuits with differential input, differential output (a), single-input, differential output (b) & (c), differential input, single output (d), and single input and output (e) & (f).

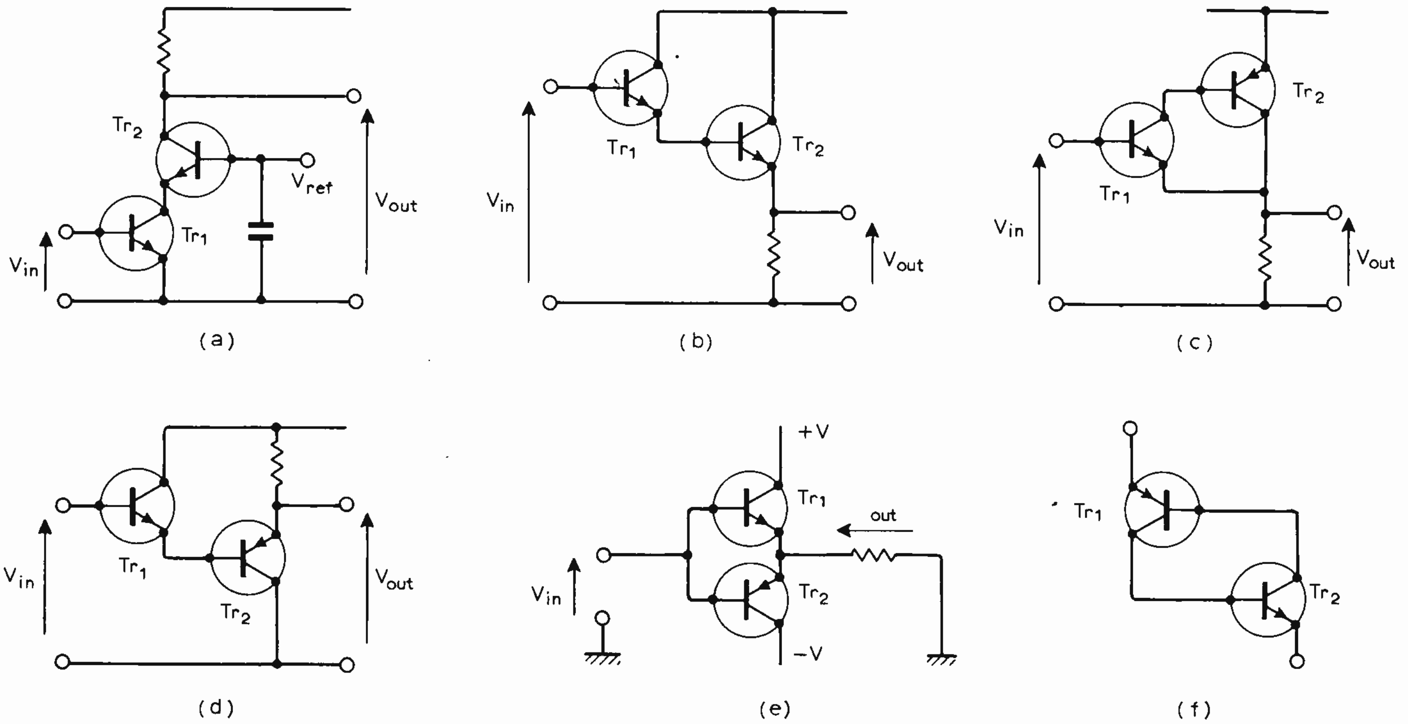


Fig. 2. Other ways of connecting two transistors are common-emitter, common-base i.e. cascode (a), common-collector pair i.e. Darlington (b), complementary pair with only one V_{be} drop (c), complementary pair with no V_{be} drop (d), symmetrical complementary pair i.e. class B amplifier (e), and the regenerative pair (f).

would be to specify the minimum value quoted by a manufacturer (assuming that discrete transistors are being discussed, because it must be remembered that super-β packages are also available with defined current gains). The complementary connection of Fig. 2(c) provides only one V_{be} drop compared with Fig. 2(b), and that of (d) cancels the V_{be} drops, but offers some second-order residual offset between input and output, and requires a separate bias path (not shown) for Tr_1 emitter current and Tr_2 base current. Complementary versions may provide an advantage, in that the transistor choice for the first stage can be that with the highest current gain at low currents.

When opposite types of transistors are connected in complementary form, such as Fig. 2(e), we have the basis of a class-B amplifier. The circuit for each half-cycle of signal is essentially identical, and the load is driven from a low-impedance source, because each transistor acts as an emitter follower. An advantage is that interstage and output transformers are not necessary when such a circuit is used at audio frequencies.

The interconnection of n-p-n and p-n-p transistors as in Fig. 2(f) provides a regenerative switching action due to the positive feedback between collectors and bases. It is similar in operation to a unijunction transistor, and there are of course similarities with the thyristor. Switching speeds can be faster than a single unijunction device because high-frequency transistors can be employed. The same arrangement is the basis for a constant-current circuit (Circards set 6, card 5), while those sources which may be classed as current controlled tend to use the current-mirror—no self-respecting operational amplifier would be without one!

The complementary-symmetry m.o.s. pair has been an excellent addition to the pair family. Besides being the basis of several logic gates, it also has application in multivibrators and as a linear amplifier.

A close study of most linear integrated-circuits will reveal the use of two or more of the pairs mentioned, to provide a composite arrangement which offers advantages that no single transistor or pair can do.

Titles of cards in set 20 of Circards (available shortly) are:

High current gain I (Darlington)
High current gain II
Cascode
Long-tailed pair
Current mirror
Complementary pair
Complementary emitter follower
CMOS pair
Mixed pairs
Triples

What are Circards?

Circards are a new method of collating and presenting data about circuits in a compact and easily retrievable way. The sets of 203 × 127mm (8 × 5 in) double-sided cards are designed for easy filing in standard boxes and for easy access at the desk or at the bench, where transparent plastic wallets keep the cards in good condition.

Each card normally describes operation of a selected circuit, gives *measured* performance data and graphs, component values and ranges, circuit limitations and modifications to alter performance. Suggestions for further reading are included together with cross references to related circuits. The Circard concept was outlined more fully in the October 1972 issue of *Wireless World*, pp.469/70.

How to get Circards

Order a subscription by sending £13.50 for a series of ten sets to:
Circards
IPC Electrical-Electronic Press Ltd
General Sales Department, Room 11
Dorset House
Stamford Street
London SE1 9LU

Specify which set your order should start with, if not the current one. One set costs £1.50, postage included (all countries). Make cheques payable to IPC Business Press Ltd.

Topics covered so far in Circards are:
1 active filters
2 switching circuits (comparator and Schmitt circuits)
3 waveform generators
4 a.c. measurement
5 audio circuits (equalizers, tone controls, filters)
6 constant-current circuits
7 power amplifiers (classes A, B, C & D)
8 astable multivibrator circuits
9 optoelectronics: devices and uses
10 micropower circuits
11 basic logic gates
12 wideband amplifiers
13 alarm circuits
14 digital counters
15 pulse modulators
16 current-differencing amplifiers—signal processing
17 c.d.as—signal generation
18 c.d.as—measurement and detection
19 monostable circuits

New Products

P.c.b. supports

Ilex pillars are designed to support and insulate p.c.bs from a chassis. The pillars are made from nylon and have a girder-shaped section with a spring-in fastening at the top and a push-in clip at the base.

The supports may be mounted horizontally or vertically and are available in sizes from $\frac{1}{4}$in to $1\frac{1}{2}$in from West Hyde Developments Ltd, Ryefield Crescent, Northwood Hills, Middx HA6 1NN.

WW300 for further details

Digital watch kit

A series of l.e.d. digital watch kits designated LWS-6120 has been announced by Litronix. The kits are all based on the LMC-6120 low-power c.m.o.s. chip which counts hours, minutes and seconds. Also included in the kits are two monolithic n-p-n bipolar arrays, the LBC-1060 digit driver and the LBC-1070 segment driver. All three circuits are supplied in chip form intended for hybrid assembly methods. Eight different display options are available which may be supplied either as monolithic l.e.d. chips or pre-packaged and aligned for flow solder mounting to the watch module. The kits are priced from £16.62 in quantities of 100. Litronix, Bevan House, Bancroft Court, Hitchin, Herts SG5 1LW.

WW301 for further details

Digital X-Y plotter

The model WX511 plotter is designed for use with mini-computers or data output terminals. The instrument is compatible with a standard t.t.l. interface as well as t.t.l.-level pulses to give $+x$, $-x$, $+y$, $-y$, pen up and down (z axis), reset and chart change or feed operations. Specifications for the plotter are: a writing speed, in the x/y axis, of 400 steps/sec with a step width of 0.1mm. A maximum z axis speed of ten times/sec, and a rise time of 1μs with a pulse width of 1μs. The machine, which is claimed to have an overall accuracy to within $\pm 0.2\%$, has a writing area of 350×250mm and overall dimensions of $400 \times 496 \times 140$mm. Environmental Equipments Ltd, Eastheath Avenue, Wokingham, Berkshire RG11 2PP.

WW302 for further details

I.c. heat sink

A heat sink suitable for use with d.i.l. i.cs is available from G.D.S. The dissipator, which is designated LIC214, has a "staggered finger" configuration with a top plate for securing the i.c. in position. The heat sink will dissipate approximately 400mW for every 10°C rise in junction temperature. Overall dimensions for the device are: width $\frac{3}{4}$in, length 1.8in, and fixing holes 1.043in between centres. GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Berks.

WW303 for further details

Colour checker

Two colour checkers for shadowmask and Trinitron tubes have been introduced by BSP Ltd. The checkers, which are similar in shape to a cheque card with a viewing window, are intended for use on static pictures such as test cards. The card is placed horizontally on the screen with the window over a selected part of the picture. The window area is a grid of lines in the Trinitron version and a matrix of black dots in the shadowmask type. This enables the colours to be analyzed separately.

Two colour checkers are supplied (mail order only) in a wallet with an instruction booklet for £2.58 including v.a.t. and postage. BSP Ltd, Sandwich, Kent CT13 9LP.

WW304 for further details

Hi-fi label kit

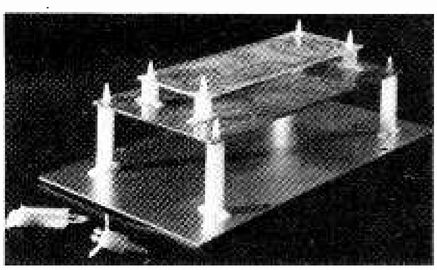
Bib Accessories are now marketing a pack of 76 printed-p.v.c. labels suitable for identifying audio leads. Each title has two labels and in the case of left and right leads the labels are printed in red and black. The kit also contains 38 blank labels enabling miscellaneous titles to be written. Bib Hi-Fi Accessories Ltd, Hemel Hempstead, Herts.

WW305 for further details

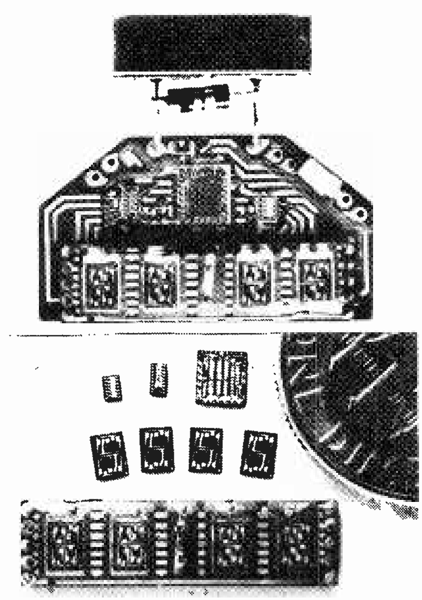
Liquid crystal display

A range of liquid crystal displays is now available from Hamlin Electronics. The range comprises $3\frac{1}{2}$ digit types and one 8 digit type all operating in the dynamic scattering mode. The devices in the 3302 series are suitable for wrist-watch applications and have a power consumption of 30μW. Series 3400 consists of digital clock type displays and incorporate am/pm indication, while the 3600 series is suitable for instrument readouts. The eight digit devices in the 3500 series have been specifically designed for use in calculators and incorporate a floating decimal point. Hamlin Electronics Ltd, 14 New Road, Southampton, Hants SO2 0AA.

WW306 for further details



WW300



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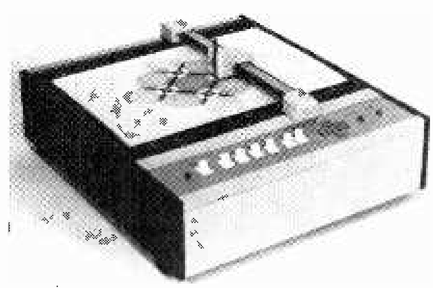

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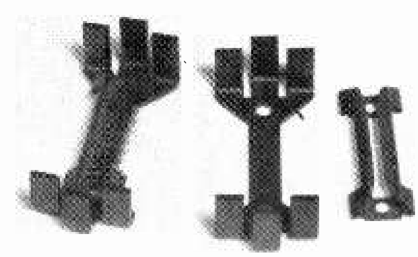


WW303

Instrument case handles

A range of 12 handles comprising heavy duty, folding, and flush types, each having variation of size and fixing, has been introduced by West Hyde Developments. All of the models have concealed spring clips which hold the hinged handles in either the open or closed position. Rubber buffers are also incorporated to ensure quiet operation. Apart from the smallest version, which is constructed from chromium plated steel, the handles are polished aluminium with metal base plates and are supplied either un-assembled and unpainted or complete and painted. West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middx HA6 1NN.
WW307 for further details

Interference filters

The JX5100 series of filters is designed to protect equipment from mains-borne noise as well as protecting the mains from equipment noise. The filters are available for operation at +125°C and 250V a.c. in a range of current ratings from 1 to 30A. The series is claimed to withstand a test voltage of 2100V d.c. to ensure protection against high-voltage transients. Sprague Electric UK Ltd, 159 High Street, Yiewsley, West Drayton, Middx.
WW308 for further details

Digital multimeter

The DM2 multimeter from Sinclair is a five-function four-range instrument with a $3\frac{1}{2}$ digit l.e.d. display. The meter uses a m.o.s. l.s.i. chip which has built-in 7-segment decoding and provides an input impedance of typically 10MΩ. A chain of metal film resistors form a voltage divider to obtain ranges up to 1000V, and to provide current shunts for ranges up to 1A. A mean averaging a.c. to d.c. converter is also incorporated, to provide alternating voltage and current ranges; overload protection is provided. The meter is battery powered, measures $9 \times 6 \times 2$in, and costs £59.00 plus v.a.t. Sinclair Radionics Ltd, London Road, St. Ives, Huntingdon, Cambs PE17 4HJ.
WW309 for further details

Resistor modules

ITT have introduced a range of single-in-line packaged resistor modules comprising nine types in four package sizes. Resistor values between 10Ω and 1MΩ ±10% are available with a power rating of 125mW per resistor in the temperature range −40 to +75°C. The networks cost between 6p and 13.5p and are available from ITT Components Group Europe, Film Circuit Operation, Brixham Road, Paignton, Devon.
WW310 for further details

Thermal wire-stripper

Litesold have introduced a pair of thermal wire-strippers suitable for removing p.v.c. and p.t.f.e. coverings up to 4mm diameter. The electrically heated V-shaped jaws melt the insulation material which is then drawn off the conductor. The model PVC is a 14W, 12 or 24V, tool for low temperature insulations while the model PTFE is a 48W 24V stripper suitable for p.t.f.e. insulations only. Light Soldering Developments Ltd, 97–99 Gloucester Road, Croydon, Surrey.
WW311 for further details

Ultrasonic transducer

The Linden Laboratories model 70100 ultrasonic transducer is available for operation at two standard frequencies. The 25kHz ±2kHz version has a bandwidth of 0.4kHz at −6dB, a receiving sensitivity of −50dB, relative to one volt per microbar, a capacitance of 1500pF and a tuning inductance of 26mH. The 40kHz ±2kHz version also has a 0.4kHz bandwidth at −6dB but the receiving sensitivity is −60dB with a capacitance of 1600pF and a tuning inductance of 10mH. Both types of transducer use a piezoelectric ceramic housed in an aluminium case measuring 20.6×26mm. Linden Laboratories Inc., PO Box 920, State college, Pa. 16801, USA.
WW312 for further details

Waveform monitor

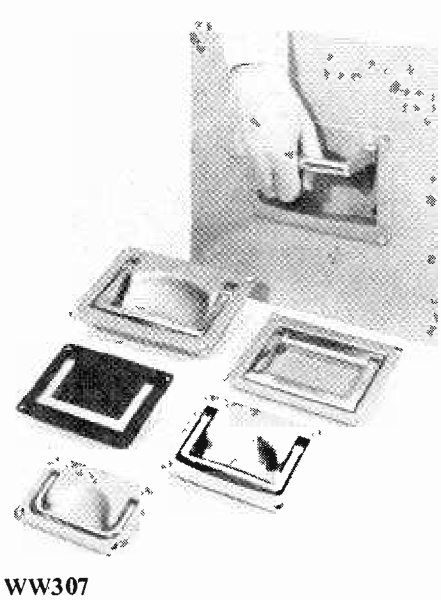
The EV4040 colour-television waveform monitor is available in PAL or NTSC versions and offers a bright display under high gain conditions. The instrument can also display remotely-commanded RGB signals, and has internal/external sync selection. A filter switch enables individual display of low frequency components, chrominance, differential gain and line time non-linearity. An active d.c. restorer may be selected to maintain the position of the back porch on the display regardless of average picture level. The illuminated graticule has ten divisions with major parameter lines emphasised. Electronic Visuals Ltd, PO Box 16, Staines, Middx.
WW313 for further details

Miniature transformer

The E75A is a recent addition to the 75 range of transformers from Belclere. This mains transformer will mount directly on to a p.c. board and occupy a volume of about 0.65 cubic in. The secondary winding, which is centre tapped, provides an output of 0.2VA and the makers claim that the temperature will not exceed 55°C when the secondary winding is shorted. Belclere Ltd, Cowley, Oxford OX4 2BU.
WW314 for further details

Digital signal generator

The DG2 is a crystal controlled signal generator providing a square wave output from 0.1Hz to 1MHz. The output can be set to three significant figures above 1Hz with an amplitude of either 5 or 2.5V. An accuracy of ±20 p.p.m. at 25°C with a stability of ±50 p.p.m. from 0 to +60°C is claimed for the instrument which can also be used to multiply an input frequency by factors from 0.001 to 1000. The generator, which has both internal battery and



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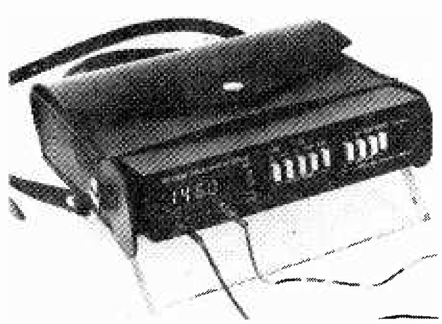

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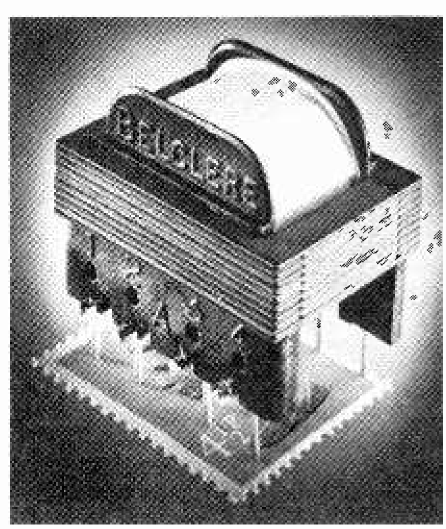


WW314

mains power supplies, measures 59 × 215 × 254mm and costs £140 from Jiskoot Autocontrol Ltd, Tunbridge Wells, Kent.
WW315 for further details

Transistor covers

A range of insulating covers for T03 and T066 packages is available from Jermyn. There is a choice of either stretch on, screw hole or flange fixing types with different heights. All the covers are moulded from nylon and will withstand a temperature of 125°C. Jermyn Manufacturing, Sevenoaks, Kent.
WW316 for further details

Audio spectrum analyzer

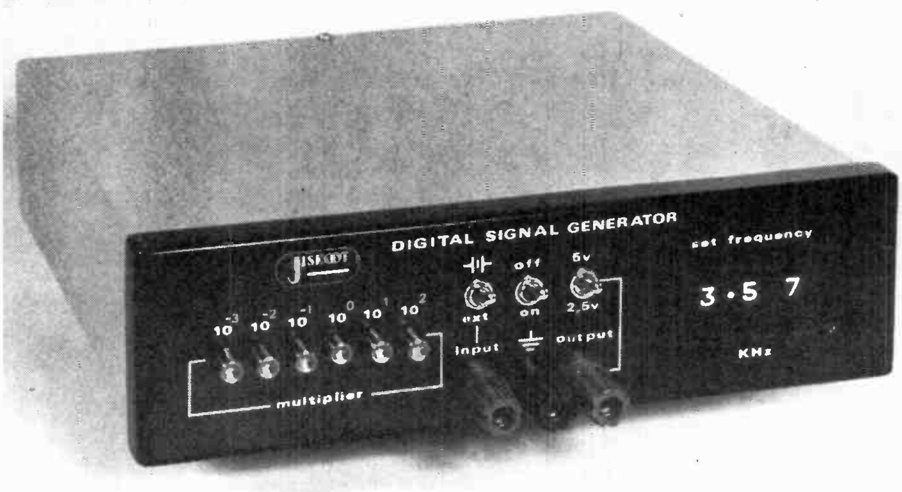
The Amber Audio model 4550 analyzer provides visual representation of the spectral energy content of an audio signal. The unit is a relatively low-cost, compact instrument (13.3 × 21 × 27.9cm) whose application is in sound recording, mixdown of multichannel recordings and broadcasting. The device may also be used for acoustic and vibration analysis. Audio input is divided into ten octave-width segments (20Hz to 20kHz), each octave being displayed on a vertical column of ten l.e.ds. The instrument includes two independent accumulating memories and four inputs can be displayed separately or in any combination by means of front panel push buttons. The display range may be set to either 10 or 20dB while a step type attenuator varies the input sensitivity in 2dB increments over a 20dB range. A sample button allows short spectra samples to be taken. Other main specifications are: centre frequencies 31.25, 62.5, 125, 250, 500Hz, 1, 2, 4, 8, 16kHz; centre frequency accuracy ±5%; filter slope 12dB/octave; accuracy of display dB steps ±0.25dB noncumulative; input impedance greater than 18kΩ. The display indicates within 1dB of actual value within 2ms above 1kHz or four cycles or less 1kHz and below (40ms at 100Hz, 80ms at 50Hz). Display decay time is 2.3 seconds for a fall of 20dB. The unit weighs 3.6kg and is priced at £815.00 net. Scenic Sounds Equipment, 27–31 Bryanston Street, London W1H 7AB.
WW317 for further details

Products seen at Electronica 74

Ion-implant r.a.m.

As well as showing single, two-chip and four-chip microprocessors, General Instrument Microelectronics announced their emphasis on static memories for use with microprocessors. The new 1024-bit random access memory for instance requires no external clock or peripheral refresh circuitry and its organization (4 × 256) means that a complete 256-word eight-bit memory can be assembled with two of the new chips (RA-3-4256) instead of eight

WW313



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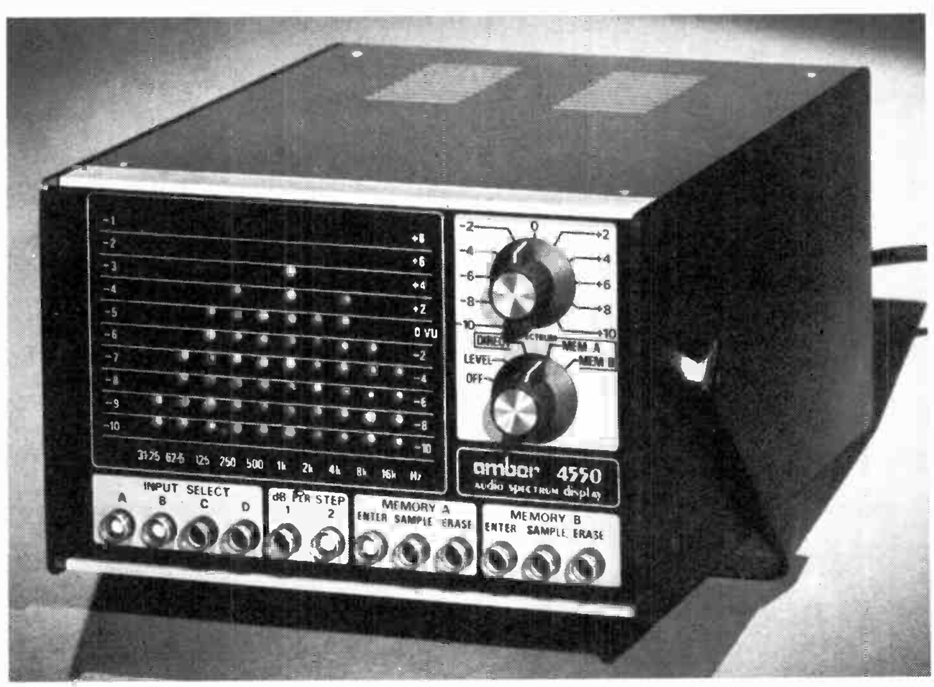

WW317

1024×1 bit r.a.ms. It has separate data input and output lines, eliminating the need for external multiplexing circuitry. Tri-state data outputs allow easy assembly of larger memories. Operated from a single +5V supply, read access and write cycle time is 1μs. The circuit is the first to use General Instruments Giant II n-channel ion-implantation facility at Glenrothes. General Instruments Microelectronics Ltd, 57 Mortimer Street, London W1N 7TD.
WW320 for further details

Dynamic r.a.m.

National Semiconductor 4096×1-bit random access read/write memory is a dynamic memory featuring a common input/output. The fully-decoded memory has an access time of 200ns and a cycle time of 400ns. The device is manufactured using the n-channel silicon gate technique with a single transistor cell providing a high memory density. It is housed in an 18-pin dual-in-line package. National Semiconductor GmbH, D808 Furstenfeldbruck, Industriestrasse 10, Germany.
WW321 for further details

Hybrid active filters

Tantalum thin-film active filters by Siemens feature a maximum temperature coefficient of 40×10^{-6} parts per Kelvin (e.g. a temperature change of 50 deg C will give a change in frequency of 0.2%). The close compensation of resistance and capacitance coefficients is achieved by using tantalum nitride resistors and beta-tantalum capacitors. Op-amp types TAA861, 761 or TBA 221 are used in these hybrid circuits. The synthesis technique used allows design of second-order filters with a Q factor of 100 from 100Hz to 1kHz and a Q of 50 up to 10kHz. Siemens Ltd, Great West House, Great West Road, Brentford, Middx.
WW322 for further details

Chalnicon TV tube

The Toshiba Chalnicon TV camera tube is claimed to have advantages over conventional vidicon and Plumbicon tubes in medicine, broadcasting, and industrial application. It has a target structure of photoconductive cadmium selenide, giving an almost-flat spectral response with a sharp cut off beyond 700nm. Toshiba say that the dark-current increase or decrease in light sensitivity that occurs in conventional vidicons, and the white spot growth that occurs in Plumbicons seldom occurs in the Chalnicon. Tubes are available with either magnetic or electrostatic focus in 18 or 25-mm sizes, having a 600mW heater. One tube, type E5095 intended for compact TV cameras, has a target to all-other-electrode capacitance of 2pF. Tube types E5001 and E5063, intended for use with image intensifiers in x-ray equipment and featuring a sensitivity of 1.5 times that of the Plumbicon and 3.5 times that of the vidicon, enables patient x-ray dose to be reduced proportionately. Toshiba (UK) Ltd, Tube & Semiconductor Dept, Toshiba House, Great South West Road, Feltham, Middx TW14 0PG.
WW323 for further details

Semiconductor memory

A new type of semiconductor memory—the factory programmable read-only memory or f.r.o.m.—announced by Motorola offers advantages of a high-speed fusible-link p.r.o.m. but at lower cost. Like the standard p.r.o.m., programming is carried out by fusing nichrome resistor links, but in this case it is factory programmed. Because programming currents are applied using probes directly on the chip, the need for fuse-current steering and addressing circuitry is eliminated. The new device is produced in emitter-coupled circuitry with an organization of 256 word ×4 bits. Enable-to-output access time is 7ns, while address-to-output access time is 20ns. This speed is achieved with a 150-mA drain from a −5.2-Volt supply. Motorola Ltd, York House, Empire Way, Wembley, Middx.
WW324 for further details

Domestic infra-red headphone links?

The new photodiode type BPW34 from Siemens is developed especially for receiving modulated infra-red radiation over a room link from either television, radio or record players to headphones. The diffuse distribution of infra-red radiation means the head is free to turn in any direction. The problem in designing the photodiode is to collect as much radiation as possible whilst keeping capacitance small to obtain a high cut-off frequency. The Siemens diode can operate with modulation of a 100-kHz and a bandwidth of 50kHz despite the relatively large area of 9mm². An infra-red filter layer prevents visible light entering. Transmitter is an array of four LD241 luminescent diodes, the peak power of 60mW being adequate for medium-sized rooms. Siemens Ltd, Great West House, Great West Road, Brentford, Middx.
WW325 for further details

Counter for electronic watches

A silicon-on-sapphire timing circuit (TA6778) is the first s.o.s. device from RCA. Use of sapphire as an insulating substrate rather than silicon for m.o.s. structures results in smaller unwanted capacitances, leading to higher speeds and lower power dissipation than with standard c.m.o.s. circuits. The timing circuit is a ripple-counter for single-battery circuits. Voltage range is 1.1 to 5V but for a watch using a 4.195-MHz AT-cut crystal, range is 1.45 to 1.6V and for a 1.048-MHz SL-cut crystal range is 1.1 to 1.6V. Circuit is capable of operating up to 80MHz for 1.6mW at 5V. Consumption at 1MHz and 1.6V is about 2μW. RCA Ltd, Sunbury-on-Thames, Middx
WW326 for further details

Solid State Devices

The names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Sample and hold

A sample and hold amplifier, model 4855, has an acquisition time of 250ns and conversion rates of over 250kHz with a claimed accuracy to within 0.01%. Bandwidth is 80kHz and aperture settling time is 0.2s.
WW350 for further details — **Teledyne Philbrick**

Switching transistors

Types BUY86 and BUY87 have a maximum current rating of 7.0A with collector-to-emitter saturation voltages of 1.0 and 1.3V respectively. Both transistors are n-p-n silicon planar, epitaxial types in TO-3 metal cases and have a V_{CEO} of 100 and 150V respectively.
WW351 for further details — **Mullard**

R.f. transistors

A range of r.f. power transistors, MRF230 to MRF234, for use in the 40–100MHz band have power outputs of 1.5, 3.5, 7.5, 15 and 25W respectively from a 12.5V supply. All devices purchased are tested at 30:1 v.s.w.r. at all phase angles.
WW352 for further details — **Motorola**

High speed p.r.o.m.

The type 3604 4k p.r.o.m. is organised as 512 words of 8 bits. The device has a typical power consumption of 0.3mW per bit, an address-to-output delay of 70ns, and a chip select-to-output delay of 30ns.
WW353 for further details — **Walmore**

High voltage op-amp

The new 3580 series of f.e.t.-input operational amplifiers provide output swings of up to 290V peak-to-peak. The devices, which are either encapsulated modules or integrated, have self-contained automatic thermal protection and will dissipate about three watts or up to 4.5W with a suitable heat sink.
WW354 for further details — **Burr Brown**

Suppliers

Teledyne Philbrick, Heathrow House, Bath Road, Cranford, Middx.
Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middx.
Walmore Electronics Ltd, 11–15 Betterton Street, Drury Lane, London WC2 9BS.
Burr Brown, 25A King Street, Watford, Herts WD1 8BT.

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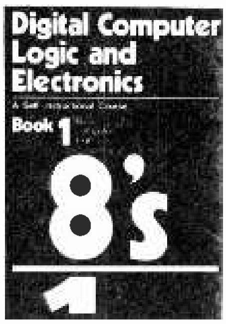

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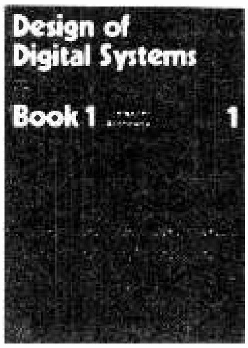

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ACY20 0·22
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ACY22 0·18
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AF178 0·55
AF179 0·55
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AF181 0·55
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AF239 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 0·09
BC108 0·09
BC109 0·09
BC113 0·11
BC114 0·17
BC115 0·17
BC116 0·17
BC117 0·20
BC118 0·11
BC119 0·33
BC120 0·88
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BC126 0·20
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BC140 0·33
BC141 0·33
BC142 0·33
BC143 0·33
BC145 0·50
BC147 0·11
BC148 0·11
BC149 0·13

BC150 0·20
BC151 0·22
BC152 0·19
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BC161 0·55
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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 0·16
BC182L 0·16
BC183 0·16
BC183L 0·16
BC184 0·22
BC184L 0·22
BC186 0·31
BC187 0·34
BC207 0·12
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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 0·22
BCY72 0·16
BCZ10 0·22
BCZ11 0·28
BCZ12 0·28
BD115 0·68
BD116 0·88
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BD123 0·72
BD124 0·76

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BD133 0·72
BD135 0·44
BD136 0·44
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BD138 0·55
BD139 0·61
BD140 0·66
BD155 0·88
BD175 0·66
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BD187 0·77
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BD189 0·83
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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 0·39
BF177 0·39
BF178 0·33
BF179 0·33
BF180 0·33
BF181 0·33
BF182 0·44

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BF184 0·28
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BF187 0·30
BF188 0·44
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BF196 0·16
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BF270 0·39
BF271 0·33
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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
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2N388A 0·61
2N404 0·22
2N404A 0·31
2N524 0·46
2N527 0·54
2N598 0·46
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2N697 0·15
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2N711 0·33
2N717 0·39
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2N727 0·31
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2N744 0·22
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2N2222 0·22
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2N2369 0·16
2N2369A 0·16
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2N2412 0·27
2N2646 0·52
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2N2712 0·23
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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

DIODES
AA119 0·09
AA120 0·09
AA129 0·09
AAY30 0·10
AAZ13 0·11
BA100 0·11
BA116 0·23
BA126 0·24
BA148 0·16
BA154 0·13
BA155 0·16
BA156 0·15
BA173 0·16
BY100 0·17
BY101 0·13
BY105 0·19
BY114 0·13
BY126 0·16
BY127 0·17
BY128 0·17

2N3053 0·19
2N3054 0·51
2N3055 0·45
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
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2N3616 0·82
2N3646 0·10
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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
BY130 0·18
BY133 0·23
BY164 0·55
BYX38/30 0·46
BYZ10 0·39
BYZ11 0·33
BYZ12 0·33
BYZ13 0·28
BYZ16 0·44
BYZ17 0·39
BYZ18 0·39
BYZ19 0·31
CG62 (OA91 Eq.) 0·06
CG651 (OA70-OA79) 0·07
OA5 0·39
OA5SL 0·23
BB104 varicap back to back 0·16

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
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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
OA10 0·15
OA47 0·08
OA70 0·08
OA79 0·08
OA81 0·08
OA85 0·10
OA90 0·07
OA91 0·07
OA95 0·08
OA200 0·07
OA202 0·08
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Q51	7 BSY 95A NPN transistors 300MHz	0·55
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PIV	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
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 Amp (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
800	0·12	0·19	1N4006	0·11	0·20	0·38	0·55	£2·10
1000	0·14	0·30	1N4007	0·12	0·25	0·48	0·65	£2·50
1200		0·35			0·30	0·58	0·75	£3·00

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	1	25	100+
SN7400	0.15	0.14	0.13
SN7401	0.15	0.14	0.13
SN7402	0.15	0.14	0.13
SN7403	0.15	0.14	0.13
SN7404	0.15	0.14	0.13
SN7405	0.15	0.14	0.13
SN7406	0.39	0.34	0.31
SN7407	0.39	0.34	0.31
SN7408	0.25	0.24	0.23
SN7409	0.25	0.24	0.23
SN7410	0.15	0.14	0.13
SN7411	0.25	0.24	0.23
SN7412	0.28	0.27	0.26
SN7413	0.32	0.31	0.30
SN7416	0.30	0.29	0.28
SN7417	0.30	0.29	0.28
SN7420	0.15	0.14	0.13
SN7422	0.30	0.29	0.28
SN7423	0.40	0.39	0.38
SN7425	0.40	0.39	0.38
SN7426	0.40	0.38	0.36
SN7427	0.40	0.38	0.36
SN7428	0.45	0.42	0.40
SN7430	0.15	0.14	0.13
SN7432	0.40	0.38	0.36
SN7433	0.42	0.40	0.38
SN7437	0.35	0.32	0.30
SN7438	0.35	0.32	0.30
SN7440	0.15	0.14	0.13
SN7441	0.74	0.71	0.64
SN7442	0.74	0.71	0.64
SN7443	£1.20	£1.15	£1.10
SN7444	£1.20	£1.15	£1.10
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SN7446	£1.20	£1.15	£1.10
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SN7450	0.15	0.14	0.13
SN7451	0.15	0.14	0.13

	1	25	100+
SN7453	0.16	0.15	0.14
SN7454	0.16	0.15	0.14
SN7460	0.16	0.15	0.14
SN7470	0.32	0.29	0.27
SN7472	0.32	0.29	0.27
SN7473	0.41	0.39	0.35
SN7474	0.41	0.39	0.35
SN7475	0.60	0.58	0.56
SN7476	0.44	0.43	0.42
SN7480	0.16	0.58	0.55
SN7481	£1.10	£1.05	£1.00
SN7482	0.90	0.85	0.80
SN7483	£1.20	£1.15	£1.05
SN7484	£1.00	0.97	0.95
SN7485	£1.60	£1.55	£1.50
SN7486	0.35	0.34	0.33
SN7489	£4.00	£3.75	£3.50
SN7490	0.65	0.63	0.60
SN7491	£1.10	£1.05	£1.00
SN7492	0.74	0.71	0.64
SN7493	0.74	0.71	0.64
SN7494	0.85	0.82	0.75
SN7495	0.85	0.82	0.75
SN7496	0.96	0.93	0.86
SN74100	£1.50	£1.45	£1.40
SN74104	0.60	0.58	0.55
SN74105	0.60	0.58	0.55
SN74107	0.44	0.42	0.40
SN74110	0.60	0.55	0.50
SN74111	0.90	0.88	0.85
SN74118	£1.00	0.95	0.90
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SN74121	0.50	0.48	0.45
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SN74123	0.75	0.73	0.70
SN74141	0.85	0.82	0.79
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SN74150	£1.50	£1.40	£1.30
SN74151	£1.10	£1.05	£1.00

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SN74155	£1.20	£1.15	£1.10
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SN74161	£1.40	£1.35	£1.30
SN74162	£1.40	£1.35	£1.30
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SN74175	£1.10	£1.05	£1.00
SN74176	£1.25	£1.20	£1.15
SN74177	£1.25	£1.20	£1.15
SN74180	£1.25	£1.20	£1.15
SN74181	£3.95	£3.85	£3.75
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SN74184	£1.80	£1.75	£1.70
SN74190	£1.95	£1.90	£1.85
SN74191	£1.95	£1.90	£1.85
SN74192	£1.95	£1.90	£1.85
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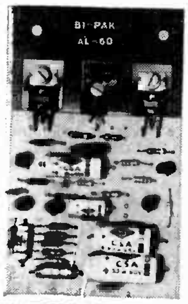
SN74194	£1.30	£1.25	£1.20
SN74195	£1.10	£1.05	£1.00
SN74196	£1.20	£1.15	£1.10
SN74197	£1.20	£1.15	£1.10
SN74198	£2.75	£2.70	£2.65
SN74199	£2.50	£2.40	£2.30

Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £4.25

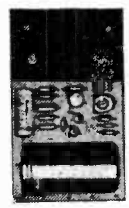
- Max Heat Sink temp. 90°C.
- Frequency Response 20Hz to 100KHz
- Distortion better than 0.1% at 1KHz
- Supply voltage 15-50 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm .. 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.



FULLY BUILT—TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25



SPm80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BmT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

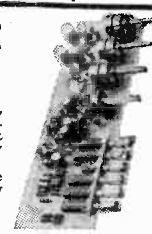
INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00=12×7400	0.54	UIC46=5×7446	0.54	UIC90=5×7490	0.54
UIC01=12×7401	0.54	UIC48=5×7448	0.54	UIC91=5×7491	0.54
UIC02=12×7402	0.54	UIC50=12×7450	0.54	UIC92=5×7492	0.54
UIC03=12×7403	0.54	UI351=12×7451	0.54	UIC93=5×7493	0.54
UIC04=12×7404	0.54	UIC53=12×7453	0.54	UIC94=5×7494	0.54
UIC05=12×7405	0.54	UIC54=12×7454	0.54	UIC95=5×7495	0.54
UIC06=8×7406	0.54	UIC60=12×7460	0.54	UIC96=5×7496	0.54
UIC07=8×7407	0.54	UIC70=8×7470	0.54	UIC100=5×74100	0.54
UIC10=12×7410	0.54	UIC72=8×7472	0.54	UIC121=5×74121	0.54
UIC20=12×7420	0.54	UIC73=8×7473	0.54	UIC141=5×74141	0.54
UIC30=12×7430	0.54	UIC74=8×7474	0.54	UIC151=5×74151	0.54
UIC40=12×7440	0.54	UIC76=8×7476	0.54	UIC154=5×74154	0.54
UIC41=5×7441	0.54	UIC80=5×7480	0.54	UIC193=5×74193	0.54
UIC42=5×7442	0.54	UIC81=5×7481	0.54	UIC199=5×74199	0.54
UIC43=5×7443	0.54	UIC82=5×7482	0.54	UICXI=25 Assorted 74's	1.65
UIC44=5×7444	0.54	UIC83=5×7483	0.54		
UIC45=5×7445	0.54	UIC86=5×7486	0.54		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

STEREO PRE-AMPLIFIER TYPE PA100



Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	3·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	75mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	3mV into 50KΩ	Signal/noise ratio	better than +65dB
All input voltages are for an output of 250mV.		Input overload	+26dB
Tape and P.U. inputs equalised to RIAA curve		Supply	+35 volts at 20mA
within ±1dB from 20Hz to 20kHz.		Dimensions	292×82×35 mm

only **£14.25**

MK 60 AUDIO KIT

Comprising: 2×AL60, 1×SPM80, 1×BTM80, 1×PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Prices: £29.75 plus 30p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16½"×11⅛"×3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9·95 plus 30p postage.

LINEAR I.C.'s—FULL SPEC.

Type No.	1	25	100+
72702	0.50	0.48	0.45
72709	0.25	0.23	0.20
72709P	0.20	0.19	0.18
72710	0.35	0.33	0.30
72741	0.30	0.29	0.28
72741C	0.28	0.27	0.26
72741P	0.30	0.29	0.28
72747	0.85	0.80	0.75
72748P	0.38	0.36	0.34
SL201C	0.59	0.45	0.40
SL701C	0.50	0.45	0.40
SL702C	0.50	0.45	0.40
TAA263	0.80	0.70	0.60
TAA293	£1.00	0.95	0.90
TAA350A	£1.85	£1.80	£1.70
μA703C	0.28	0.26	0.24
μA709C	0.20	0.19	0.18
μA711	0.35	0.33	0.30
μA712	0.35	0.33	0.30
TBA800	£1.50	£1.45	£1.40
76003	£1.50	£1.45	£1.40
76023	£1.50	£1.45	£1.40
76660	0.95	0.93	0.90
LM380	£1.00	0.97	0.95
NE555	0.65	0.63	0.60
NE556	0.95	0.93	0.90

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

1975 BI-PAK CATALOGUE & LISTS

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DUAL-IN-LINE SOCKETS

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100up
TSO 14 pin type	33p	30p	27p
TSO 16 " "	38p	35p	32p
LOW COST No.			
BPS 14 " "	16p	14p	12p
BPS 16 " "	17p	15p	13p
BPS 8 pin type	15p	13p	11p

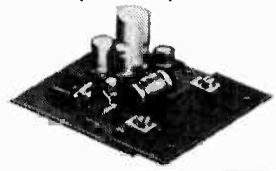
NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron	£1.50
MAN 3M	L.E.D. 7-segment 0-127"	£1.90

All indicators 0.9 + Decimal point. All side viewing. Full data for all types available on request.

SHP80 STEREO HEADPHONES, 4-16 ohms impedance. Frequency response 20 to 20,000Hz. Stereo/mono switch and volume controls. £4.95

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po=3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3"×2½"×1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	[illegible]	30	30
Power output for 2% T.H.D. (RL=8Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	[illegible]	[illegible]	£3.20

EDSR 3166 TRIPLE 66 BIT DYNAMIC SHIFT REGISTER TTL Compatible. Low Clock Capacitance, High Speed Diode Protected Inputs Wired 'OR' Capability SPECIFICATION SHEET AVAILABLE £1 each

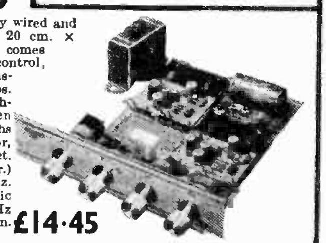
TEAK VENEERED CABINET for: STEREO 20

TC 20. £3.95 p&p 30p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £30 per pair P.& P. £1. ONLY WHILE STOCKS LAST!

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.



£14·45

3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO.3 Plastic Encapsulation

μA7805/L129 5V (Equv. to MVR5)	£1.35
μA7812/L130 12V (Equv. to MVR12V)	£1.35
μA7815/L131 15V (Equv. to MVR15V)	£1.35
μA7818 18V	£1.35

TRANSFORMERS

T461 (Use with AL10) £1·60 P. & P. 15p.
T538 (Use with AL20 & AL30) £2·30 P. & P. 15p.
BMT80 (Use with AL60) £2·75 P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30) 95p
SPM 80. (Use with AL60) £3.25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4·35

Frequency response—
20Hz–50KHz (—3dB
Bass control—
± 12dB at 60H
Treble control—
±14dB at 14KHz
*Input 1. Impedance
1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance
30 K ohms
Sensitivity 4mV

FRONT PANELS FP12 50p

All prices inclusive of V.A.T. Giro No. 388 - 7006
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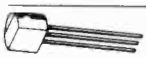
H41	2	Sil Power transistors comp pair BD131/132
H63	4	2N3055 type NPN Sil. power transistors. Below spec. devices
H64	4	3819 N Channel FETs 2N3819 in plastic case



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B86	100	Sil. Diodes sub. min. IN914 and IN916 types
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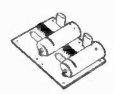
SS102 Pre-amp for low-output stereo magnetic cartridges etc. **£2.25**

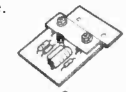
SS103 Compact I.C. amp. 3 watts R.M.S. Single channel (mono). On P.C.B. size 3" × 2" with all components. **£1.75**



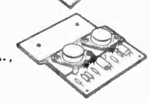
SS1033 Stereo version of above. (Two I.Cs.) **£3.25**

SS105 A compact all-purpose power amp. Can be run from 12V car battery. Size 2½" × 1¾". Useful 5w output (mono). Excellent value. **£1.95**

SS110 Similar in size to SS105 but will give 10w output (mono). Two in stereo five first class results, suitable for many domestic applications. **£2.40**

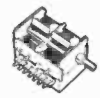


SS140 Beautifully designed. Will give up to 40w R.M.S. into 4Ω. Excellent S.N.R. and transient response. Fine for P.A., disco use etc. **£6.26**

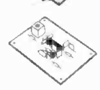


FM Tuners

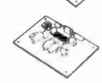
SS201 Front End Assembly. Ganged tuning condenser with well engineered slow motion geared drive in robust housing and diseminator stage. Excellent sensitivity. 88–108mHz. **£6.25**



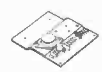
SS202 I.F. Stage (with I.C.). Designed to use with SS201 uses I.C. Carefully checked before despatch. **£5.25**



SS203 Stereo Recorder. Designed essentially for use with SS201 and SS202, this excellent decoder can also make a stereo tuner of almost any single channel FM tuner. Supplied ready aligned. A L.E.M. can easily be fitted. **£5.62**



SS300 Power Supply Stabiliser. Add this to your unstabilised supply to obtain a steady powerful working voltage for your audio system. Money saving and very reliable. **£5.62**



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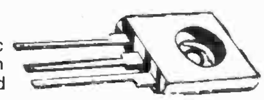

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40 Watt	20p	18p	16p
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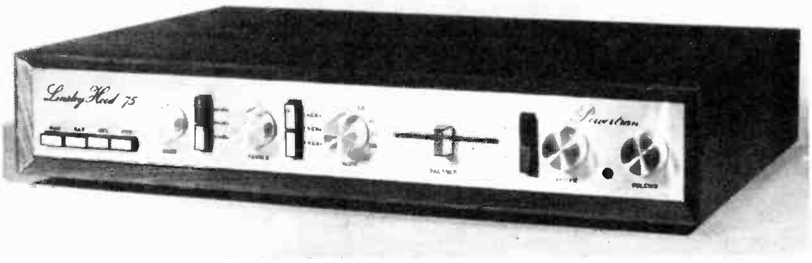
AMPLIFIER KITS OF *Distinction*

DESIGNER-APPROVED KIT

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75 W Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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2	Set of resistors, capacitors, pre-sets for power amp.	£1.70
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5	Fibreglass printed-circuit board for pre-amp.	£1.30
6	Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2.70
7	Set of low noise, high gain semiconductors for pre-amp.	£2.40
8	Set of potentiometers (including mains switch)	£2.05
9	Set of 4 push-button switches, rotary mode switch	£3.70
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V, 25-0-25 V.	£9.15
11	Fibreglass printed-circuit board for power supply	£0.65
12	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs	£4.25
14	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook	£0.30
16	Teak cabinet	£7.35
	2 each of packs 1–7 inclusive are required for complete stereo system	
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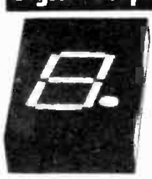

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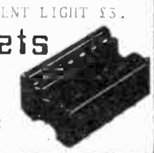

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Component packs for a choice of three outstanding amplifiers are stocked together with packs for a regulated power supply suitable for use with a pair of any of them. Also stocked are packs for a very well-established pre-amplifier—the Bailey-Burrows design which features six inputs, a scratch and rumble filter and wide range tone controls which may be either rotary or slider operating.

30W BAILEY

Pk. 1 F/Glass PCB	£0.80
Pk. 2 Resistors, capacitors, pots	£1.75
Pk. 3 Semiconductor set	£4.70

30W BLOMLEY

Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.15
Pk. 3 Semiconductor set	£5.60

20W LINSLEY-HOOD

Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.40
Pk. 3 Semiconductor set	£3.35

60V REGULATED POWER SUPPLY

Pk. 1 F/Glass PCB	£0.75
Pk. 2 Resistors, capacitors, pots	£1.40
Pk. 3 Semiconductor set	£3.10

BAILEY-BURROWS PRE-AMP

Pk. 1 F/Glass PCB	£2.05
Pk. 2 Resistors, capacitors, pre-sets, transistors	£4.95
Pk. 3R Rotary potentiometer set	£1.60
Pk. 35 Slider potentiometer set (with knobs)	£2.70

STUART TAPE RECORDER

A set of three printed-circuit boards has been prepared for the stereo integrated circuit version of this high-performance Wireless World published design.

TRRP Pk. 1	Reply amplifier F/Glass PCB	£0.90
TRRC Pk. 1	Record amp./meter drive cct. F/Glass PCB	£1.40
TROS Pk. 1	Bias/erase/stabilizer cct. F/Glass PCB	£1.00

For details of component packs for this design please write for free list.

TOROIDAL T20 + 20

Developed from the famous Practical Wireless Texan

Designed by Texas engineers and published in a series of articles in **Practical Wireless**. The TEXAN was a remarkable breakthrough in delivering true Hi-Fi performance at exceptionally low cost. Now further developed to include a true Toroidal transformer, this slimline integrated circuit design, based upon a single F/Glass PCB, features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and headphones socket.

20 WATTS/CHANNEL

FREE TEAK CASE and HANDBOOK with full kits

KIT PRICE only **£28.25** post free (U.K.)

Pack		Price
1	Set of all low noise resistors	£0.80
2	Set of all small capacitors	£1.50
3	Set of 4 power supply capacitors	£1.40
4	Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs, etc.	£1.90
5	Set of slide and push-button switches	£0.90
6	Set of potentiometers and selector switch	£1.45
7	Set of all semiconductors	£8.25
8	Special Toroidal Transformer	£4.95
9	Fibreglass PC Panel	£2.50
10	Complete chassis work, hardware and brackets	£4.20
11	Preformed cable/leads	£0.40
12	Handbook	£0.25
13	Teak Cabinet	£2.75

ACTIVE FILTER CROSSOVER

An essential and critical component in a high-quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, though introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in **Wireless World**, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20-watt amplifier, based on a proven Texas circuit, was also described by Mr Read. The printed-circuit board for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

ACTIVE FILTER

Pack		
1	Fibreglass PCB (accommodates all filters for one channel)	£1.05
2	Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors	£4.20
3	Set of semiconductors	£2.65

2 off each pack required for stereo system

SUITABLE ALSO FOR FEEDING ANY OF OUR HIGH-POWER DESIGNS

READ/TEXAS 20w amp.

Pack		
1	Fibreglass PCB	£0.70
2	Set of resistors, capacitors pre-sets (not including O/P coupling capacitors)	£1.10
3	Sets of semiconductors	£2.40

6 off each pack required for stereo system

4	Special heat sink assembly for set of 3 amplifiers	£0.85
5	Set of 3 O/P coupling capacitors	£1.00

2 off packs 4, 5 required for stereo system

POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

Pack		
1	Fibreglass PCB	£0.50
2	Set of rectifiers, zener diode, capacitors, fuses, fuse holders	£2.60
3	Toroidal transformer	£4.95

ENQUIRIES WELCOME
For quality sets of speakers

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2N3704	£0.10	40362	£0.45	BDY56	£1.60	MPSA65	£0.35	TIP42A	£0.90
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2N3711	£0.09	BC108	£0.10	BF259	£0.47	MPSU05	£0.60	IN916	£0.07
2N3819	£0.23	BC109	£0.10	BFR39	£0.25	MPSU55	£0.70	IS920	£0.10
2N3904	£0.17	BC125	£0.15	BFR79	£0.25	SN72721P	£0.58	5B05	£1.20
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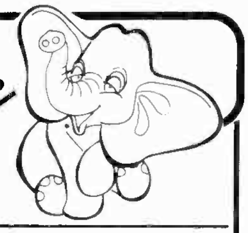

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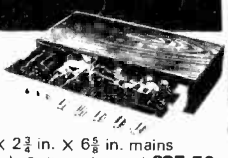

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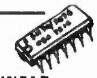

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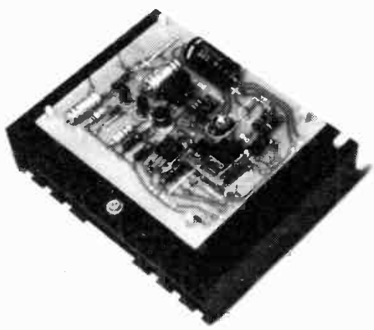

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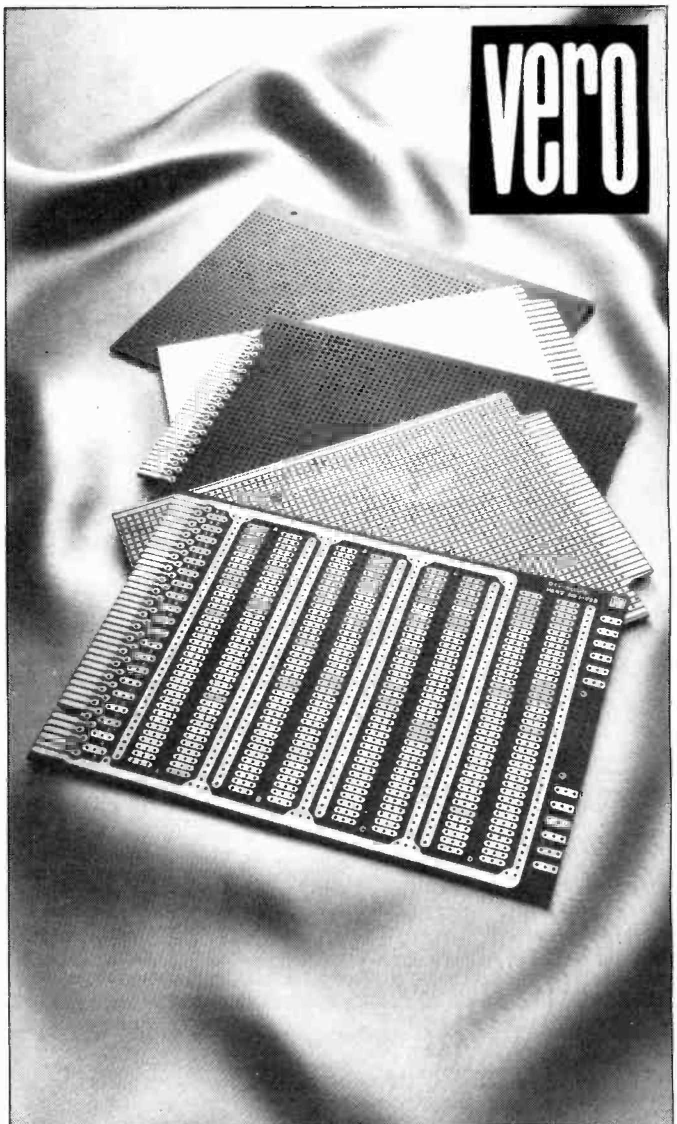

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SN7412	28p	SN7447	£1.30	SN7484	95p	SN74141	£1.00
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2N2905	24p	40406	44p	BC169C	13p	BF238	22p	OC72	25p
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2N3706	9p	AC188K	34p	BC308	12p	LM301A	46p	ZTX500	15p

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Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P p
07	20	1	8	7·0× 7·0× 6·0	2·55	38
149	60	3	12	9·9× 7·7× 8·6	3·98	45
150	100	5	8	9·9× 8·9× 8·6	4·45	45
151	200	8	0	12·1× 9·3×10·2	7·39	53
152	250	13	12	12·1×11·8×10·2	8·93	73
153	350	15	0	14·0×10·8×11·8	10·80	73
154	500	19	8	14·0×13·4×11·8	12·41	91
155	750	29	0	17·2×14·0×14·0	18·65	•
156	1000	38	0	17·2×16·6×14·0	26·50	•
157	1500	46	0	21·6×13·4×18·1	30·25	•
158	2000	60	0	21·6×15·3×18·1	33·70	•
159	3000	85	0	23·5×17·8×19·7	53·25	•

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	1·52	30
64	75	2	4	7·0× 6·7 ×6·1	0-115-210-240	2·64	38
4	150	3	4	8·9× 7·7× 7·7	0-115-200-220-240	3·75	45
66	300	6	4	9·9× 9·6× 8·6	,, ,,	5·29	53
67	500	12	8	12·1×11·2×10·2	,, ,,	8·02	67
84	1000	19	8	14·0×13·4×14·3	,, ,,	12·44	91
93	1500	30	4	14·0×15·9×14·3	,, ,,	16·65	•
95	2000	32	0	17·2×16·6×14·0	,, ,,	22·00	•
73	3000	40	0	21·6×13·4×18·1	,, ,,	31·90	•

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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	1·34	23
213	1·0	0·5	1	4	6·1× 5·8× 4·8	0-12V at 0·5A×2	1·58	30
71	2	1	1	12	7·0× 6·4× 6·1	0-12V at 1A×2	2·09	38
18	4	2	2	12	8·3× 7·7× 7·0	0-12V at 2A×2	2·60	38
70	6	3	3	8	8·9× 8·0× 7·7	0-12V at 3A×2	3·75	45
108	8	4	5	8	9·9× 8·9× 8·6	0-12V at 4A×2	4·15	45
72	10	5	6	4	9·9× 9·6× 8·6	0-12V at 5A×2	4·67	53
116	12	6	6	12	9·9×10·2×8·6	0-12V at 5A×2	5·02	53
17	16	8	8	12	12·1× 9·9×10·2	0-12V at 8A×2	6·62	60
115	20	10	18	8	14·0× 9·6×11·8	0-12V at 10A×2	9.45	73
187	30	15	15	8	14·0×12·1×11·8	0-12V at 15A×2	12·29	85
226	60	30	32	0	17·2×15·3×14·0	0-12V at 30A×2	15·30	•

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	1·65	30
79	1·0	2	4	7·0× 6·7× 6·1	,, ,,	2·18	38
3	2·0	3	4	8·9× 7·7× 7·7	,, ,,	3·18	38
20	3·0	4	8	9·9× 8·3× 8·6	,, ,,	4·12	45
21	4·0	6	4	9·9× 9·6× 8·6	,, ,,	4·67	53
51	5·0	6	12	12·1× 8·6×10·2	,, ,,	5·83	53
117	6·0	8	0	12·1× 9·3×10·2	,, ,,	6·51	60
88	8·0	12	0	12·1×11·8×10·2	,, ,,	9·00	67
89	10·0	13	12	14·0×10·2×11·8	,, ,,	8·97	73

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	2·35	30
103	1·0	2	12	8·3× 7·4× 7·0	,, ,,	3·08	38
104	2·0	5	8	9·9× 8·9× 8·6	,, ,,	4·26	45
105	3·0	6	12	9·9×10·2× 8·6	,, ,,	5·28	53
106	4·0	10	0	12·1×10·5×10·2	,, ,,	6·91	67
107	6·0	12	0	14·0×10·2×11·8	,, ,,	11·00	67
118	8·0	18	0	14·0×12·7×11·8	,, ,,	11·80	85
119	10·0	25	0	17·2×12·7×14·0	,, ,,	15·45	•

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	2·12	38
126	1·0	3	4	8·9× 7·7× 7·7	,, ,,	3·10	38
127	2·0	6	4	9·9× 9·6× 8·6	,, ,,	4·62	45
125	3·0	8	12	12·1× 9·9×10·2	,, ,,	6·84	60
123	4·0	13	12	12·1×11·8×10·2	,, ,,	7·96	67
40	5·0	12	00	14·0×10·2×11·8	,, ,,	8·87	73
120	6·0	15	8	14·0×12·1×11·8	,, ,,	10·27	85
121	8·0	25	00	14·0×14·7×11·8	,, ,,	13·64	•
122	10·0	25	0	17·2×12·7×14·0	,, ,,	15·93	•
189	12·0	29	00	17·2×14·0×14·0	,, ,,	18·16	•

MINIATURE TRANSFORMERS WITH SCREENS

Ref. No.	MA	Weight lb	oz	Size cm.	VOLTS	£	P & P p
238	200		9	2·8×2·6×2·0	3-0-3	1·40	10
212	1A 1A	1	4	6·1×5·8×4·8	0-6 0-6	1·67	30
13	100		4	3·9×2·6×2·9	9-0-9	1·28	13
235	330, 330		4	4·8×2·9×3·5	0-9, 0-9	1·42	19
207	500, 500	1	00	6·1×5·4×4·8	0-8-9, 0-8-9	1·75	30
208	1A, 1A	1	12	7·0×6·4×6·1	0-8-9, 0-8-9	3·00	38
236	200, 200		4	4·8×2·9×3·5	0-15, 0-15	1·30	19
214	300, 300	1	4	6·1×5·8×4·8	0-20, 0-20	1·76	30
221	700 (D.C.)	1	8	7·0×6·1×6·1	20-12-0-12-20	1·98	38
206	1A, 1A	2	12	8·3×7·7×7·0	0-15-20, 0-15-20	3·15	38
203	500, 500	2	4	8·3×7·0×7·0	0-15-27, 0-15-27	2·73	38
204	1A, 1A	3	4	8·9×7·7×7·7	0-15-27, 0-15-27	3·50	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	1·82	38
5	4·0	3	4	8·9× 7·7× 7·7		3·30	38
86	6·0	6	4	9·9× 9·6× 8·6		4·64	53
146	8·0	6	12	9·9×10·2× 8·6		5·52	53
50	12·5	12	0	14·0×10·2×11·8		7·85	67

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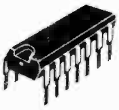

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7401	£0·15	£0·125	£0·10	7443	£1·275	£1·062	£0·85	7495	£0·63	£0·525	£0·42
7402	£0·15	£0·125	£0·10	7445	£0·855	£0·712	£0·57	7496	£0·72	£0·60	£0·48
7403	£0·15	£0·125	£0·10	7446	£1·05	£0·875	£0·70	74104	£0·315	£0·262	£0·21
7404	£0·18	£0·15	£0·12	7446A	£1·05	£0·875	£0·70	74105	£0·315	£0·262	£0·21
7405	£0·18	£0·15	£0·12	7447	£1·05	£0·875	£0·70	74107	£0·315	£0·262	£0·21
7406	£0·375	£0·312	£0·25	7447A	£1·05	£0·875	£0·70	74121	£0·315	£0·262	£0·21
7407	£0·375	£0·312	£0·25	7448	£0·855	£0·712	£0·57	74122	£0·45	£0·375	£0·30
7408	£0·15	£0·125	£0·10	7450	£0·15	£0·125	£0·10	74123	£0·63	£0·525	£0·42
7409	£0·15	£0·125	£0·10	7451	£0·15	£0·125	£0·10	74141	£0·75	£0·625	£0·50
7410	£0·15	£0·125	£0·10	7453	£0·15	£0·125	£0·10	74151	£0·69	£0·575	£0·46
7412	£0·195	£0·162	£0·13	7454	£0·15	£0·125	£0·10	74153	£0·69	£0·575	£0·46
7413	£0·345	£0·287	£0·23	7460	£0·15	£0·125	£0·10	74155	£0·69	£0·575	£0·46
7416	£0·345	£0·287	£0·23	7472	£0·255	£0·212	£0·17	74156	£0·69	£0·575	£0·46
7417	£0·345	£0·287	£0·23	7473	£0·153	£0·262	£0·21	74160	£1·005	£0·837	£0·67
7420	£0·15	£0·125	£0·10	7474	£0·315	£0·262	£0·21	74161	£1·005	£0·837	£0·67
7423	£0·27	£0·225	£0·18	7475	£0·465	£0·387	£0·31	74162	£1·005	£0·837	£0·67
7425	£0·27	£0·225	£0·18	7476	£0·315	£0·262	£0·21	74163	£1·005	£0·837	£0·67
7426	£0·27	£0·225	£0·18	7480	£0·435	£0·362	£0·29	74166	£1·425	£1·187	£0·95
7427	£0·27	£0·225	£0·18	7482	£0·75	£0·625	£0·50	74174	£1·20	£1·00	£0·80
7430	£0·15	£0·125	£0·10	7483	£0·825	£0·687	£0·55	74175	£0·975	£0·812	£0·65
7432	£0·25	£0·225	£0·18	7485	£1·275	£1·062	£0·85	74192	£1·275	£1·062	£0·85
7437	£0·27	£0·225	£0·18	7486	£0·315	£0·262	£0·21	74193	£1·275	£1·062	£0·85
7438	£0·27	£0·225	£0·18	7490	£0·465	£0·387	£0·31	74198	£2·10	£1·75	£1·40
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BXY37C/D	ditto	100GHz	£1
BXY38C/E	ditto	120GHz	£1
BXY39C/D	ditto	150GHz	£1
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Boards cut to any multiple of 6". Max. size 3' × 4'.

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We have bought a huge assortment of volume controls.

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Manufacturing quantities of some types available.

Write or phone for details.

Sample bag 100 mixed £2·50

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Several thousand of each of the following types. Silly price to clear!

ALL NEW STOCK

5µf 10V	**35p** dozen
10µf 10V	**35p** dozen
50µf 10V	**35p** dozen
100µf 10V	**35p** dozen
330µf 16V	**45p** dozen
330µf 25V	**60p** dozen
330µf 35V	**80p** dozen
2200µf 16V	**£1** dozen
15000µf 25V	**50p** each

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- ★ **Capacitors, Silver-mica, Paper, Ceramic, Polyester and Electrolytic**
- ★ **Controls, Volume, Pre-set, Carbon, Wire**
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We have made up packs of 2lb gross weight, all are different in content, and contain a mixture of components from the above list. This is a fantastic, unrepeatable offer that will enable you to get a good stock of spares at a tiny fraction of normal price!
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And the price that we are asking? Only **£1·50** including both postage and VAT!
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£1 — 100 ½ WATT RESISTORS, 100 CERAMIC CAPACITORS, 100 DIODES — POSTAGE 25p — PACK No. 1

£1 — 100 RESISTORS, 100 CERAMIC CAPACITORS, 100 POLYSTYRENE CAPACITORS — POSTAGE 25p — PACK No. 2

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VALVES

Type	£	Type	£
A1065	1.25	ECL80	0.55
AR8	0.55	ECL82	0.35
ATP4	0.50	ECL83	0.70
B12H	3.00	ECL86	0.50
CY31	0.50	EF36	0.65
DAF96	0.50	EF37A	1.20
DF96	0.55	EF40	0.75
DK96	0.55	EF41	0.65
DL92	0.40	EF80	0.30
DL96	0.60	EF83	1.25
DY86/87	0.40	EF85	0.35
DY802	0.45	EF86	0.35
E88CC/01	1.20	EF89	0.30
E180CC	0.70	EF91	0.45
E182CC	1.25	EF92	0.50
EA50	0.40	EF95	0.40
EABC80	0.40	EF183	0.35
EAF42	0.75	EF184	0.35
EB91	0.30	EFL200	0.75
EBC33	1.00	EL33	2.50
EBC41	0.75	EL34	0.70
EBF80	0.40	EL36	0.80
EBF83	0.50	EL41	0.80
EBF89	0.40	EL81	0.60
EC52	0.35	EL82	0.55
ECC81	0.40	EL84	0.30
ECC82	0.35	EL85	0.60
ECC83	0.35	EL86	0.45
ECC84	0.35	EL90	0.45
ECC85	0.40	EL504	0.80
ECC86	0.90	EM31	0.60
ECC88	0.50	EM80	0.55
ECC189	0.70	EM84	0.40
ECF80	0.40	EM87	1.00
ECF82	0.40	EY51	0.45
ECF801	0.75	EY81	0.45
ECH42	0.80	EY86	0.40
ECH81	0.35	EY88	0.50
ECH83	0.45	EZ40	0.70
ECH84	0.45	EZ41	0.75

Type	£	Type	£	Type	£
EZ80	0.30	PL509	1.35	U191	0.75
EZ81	0.30	PL802	0.95	U801	0.75
GY501	0.75	PY33	0.60	UABC80	0.40
GZ34	0.70	PY80	0.40	UAF42	0.65
GZ37	1.00	PY81	0.40	UBC41	0.60
KT66	2.50	PY82	0.40	UBF80	0.40
KT88	3.00	PY83	0.40	UBF89	0.40
MH4	0.75	PY88	0.45	UBL1	1.00
ML6	0.65	PY500	1.00	UBL21	0.70
OA2	0.45	PY800	0.45	UCC85	0.45
OB2	0.45	PY801	0.50	UCF80	0.75
PABC80	0.40	QQVO3-10	1.40	UCH42	0.75
PC97	0.50	QQVO6-40A	8.00	UCH81	0.45
PC900	0.50	QVO3-12	1.10	UCL82	0.45
PCC84	0.40	R19	0.60	UCL83	0.65
PCC85	0.40	SC1/400	3.00	UF41	0.70
PCC88	0.60	SC1/600	5.00	UF80	0.35
PCC89	0.58	SP61	0.75	UF85	0.45
PCC189	0.60	TT21	5.00	UF89	0.50
PCF80	0.48	U25	0.85	UL41	0.70
PCF82	0.40	U26	0.75	UL84	0.40
PCF84	0.60	U27	0.65	UY41	0.45
PCF86	0.60			UY85	0.40
PCF200	0.75			VR105/30	0.45
PCF201	0.75				
PCF801	0.55				
PCF802	0.50				
PCF805	0.90				
PCF806	0.75				
PCF808	0.90				
PCH200	0.80				
PCL81	0.55				
PCL82	0.40				
PCL83	0.65				
PCL84	0.45				
PCL86	0.50				
PCL805	0.60				
PFL200	0.70				
PFL200	0.70				
PL36	0.60				
PL81	0.50				
PL82	0.45				
PL83	0.45				
PL84	0.45				
PL504	0.80				
PL508	1.00				

Type	£	Type	£
VR150/30	0.45	3D6	0.40
X66	0.65	3S4	0.40
Z800U	2.78	3V4	0.85
Z801U	2.70	5B/254M	4.00
Z900T	1.20	5B255M	3.50
1A3	0.55	5R4GY	0.90
1L4	0.25	5U4G	0.50

VAT 8% EXTRA

Type	£	Type	£
3A4	0.60	5V4G	0.55
1R5	0.40	5Y3GT	0.55
1S4	0.30	5Z3	0.80
1T4	0.30	5Z4	0.80
1X2A	0.60	5Z4TG	0.55
1X2B	0.75	6AB7	0.60
2D21	0.50	6AC7	0.60
2K25	9.00	6AH6	0.70

Type	£	Type	£	Type	£
6AK5	0.40	6C6	0.50	6L6G	0.40
6AK8	0.40	6CB6	0.50	6L7G	0.40
6AL5	0.30	6CH6	1.45	6SA7	0.50
6AL5 W	0.55	6CL6	0.75	6SA7GT	0.40
6AM6	0.45	6D6	0.55	6SC7GT	0.40
6AN8	0.45	6EA8	0.85	6SG7	0.50
6AQ5	0.45	6F7	1.10	6SJ7	0.55
6AQ5W	0.70	6F8G	0.75	6SJ7GT	0.35
6AS6	0.80	6F23	0.90	6SK7	0.55
6AT6	0.45	6F32	0.75	6SL7GT	0.50
6AU6	0.40	6F33	3.50	6SN7GT	0.50
6AV6	0.45	6H6	0.35	6SQ7	0.55
6AX4GT	0.75	6J4WA	1.25	6V6G	0.15
6AX5GT	1.00	6J5	0.65	6V6GT	0.50
6B7	0.70	6J5GT	0.50	6X4	0.40
6BA6	0.35	6J6	0.30	6X5G	0.40
6BE6	0.40	6J7	0.60	6X5GT	0.50
6BG6G	0.90	6J7G	0.40	6Y6G	0.90
6BJ6	0.65	6K6GT	0.80	6Z4	0.65
6BQ7A	0.60	6K7	0.55	6-3OL2	0.90
6BR7	1.20	6K7G	0.30	7B7	0.80
6BW6	1.00	6K8GT	0.58	7Y4	0.80
6BW7	1.00	6K25	1.00	9D6	0.40
6C4	0.40	6L6	1.25	9D2	6.00
				12AG	0.55
				12AT6	0.45
				12AT7	0.40
				12AU7	0.35
				12AV6	0.50
				12AX7	0.35
				12BA6	0.45
				12BE6	0.50
				12BH7	0.50
				12C8	0.55
				12E1	3.50
				12K5	1.10
				12K7GT	0.50
				12K8GT	0.70
				12Q7GT	0.70
				12SA7GT	0.70
				12SG7	0.55
				12SJ7	0.55
				12Y4	0.40
				14S7	1.00
				19AQ5	0.65
				19G3	8.00
				19G6	6.60
				19H5	14.00
				20P3	0.60
				20P4	1.10
				25L6GT	0.70
				30C15	1.00
				30C17	1.00
				30C18	0.90

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THE VALVE WITH A GUARANTEE

Type	£	Type	£
30F5	1.00	957	0.50
30FL1	1.00	1629	0.78
30FL12	1.10	2051	1.00
30FL14	0.90	5933	3.00
30L15	0.95	6057	0.75
30L17	0.95	6060	0.78
30P12	1.00	6064	0.60
30P19	1.00	6065	1.00
30PL1	0.95	6080	2.30
30PL13	1.10	6146	2.25
		6146B	3.25
		8020	5.00
		9001	5.00
		9002	8.50
		9003	0.70
		9004	0.35
		9006	0.35

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Type	£
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35W4	0.50
35Z4GT	0.70
50C5	0.60
5DCD6G	1.10
75	1.00
75C1	0.75
76	0.75
78	0.70
80	0.75
85A2	0.75
723a/b	8.00
803	6.00
805	14.00
807	0.65
813	6.50
866A	1.20
931A	6.00
954	0.50
955	0.50
956	0.50

C.R.TUBES

Type	£
DG7-5	12.00
DG13-2	18.00
DG13-34	12.00
MW13-35	35.00
VCR139A	8.00
3BP1	4.50
88D	9.00
88J	8.00
88L	9.00

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Type	£
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M503-2J42	42.00
K301	7.00
KRN2A	6.00
725A	23.00

A lot of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable.

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Please write or phone for current price of any of the transistors, diodes shown below.

AC113	AF178	BF167	GET116	OC36	SX754	2N2062
AC126	AF186	BF185	GEX66	OC42	ZR11	2N2147
AC127	AFZ12	BFY51	NKT222	OC44	ZR21	2N2411
AC128	ASY26	BFY52	OA5	OC45	1N23A	2N2989
AC176	ASY27	BFY90	OA47	OC70	1N25	2N3053
ACY18	ASY28	BSY27	OA70	OC73	1N32A	2N3054
ACY19	BC108	BSY38	OA71	OC78	1N38A	2N3055
ACY20	BC118	BSY95A	OA73	OC78D	1N43	2N3390
ACY28	BC119	BYZ16	OA79	OC81	1N70	2N3391
ACY39	BC136	CRS1/10	OA91	OC82	1N277	2N3730
ACY40	BC137	CRS1/20	OA200	OC82D	1N415C	2N3731
AD149	BC148A	CRS1/30	OA202	OC82DM	1N4148	2N3819
AD161	BC172	CRS1/40	OAZ200	OC83	2N456A	2N4038
AD162	BC172A	CRS3/10	OC22	OC139	2N708	2N4058
ADZ11	BC212A	CRS3/20	OC22	OC140	2N918	2N4061
ADZ12	BCY31	CRS3/30	OC26	OC170	2N1304	2N4785
AF114	BCY33	CRS3/40	OC28	OC172	2N1305	2N5295
AF115	BCY72	CRS25/025	OC29	OC200	2N1307	3N128
AF116	BF115	GET115	OC39	OC206	2N1309	3N154
AF117						3N159
AF118						2S303
AF124						404
AF125						2082
AF126						40250
AF127						40251
AF139						40668

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

RACAL RECEIVERS Models RA17, RA17 Mk. II, RA 17L, RA17W, RA117E, in condition from working "as seen" to brand new in cabinets. Prices on application. **DIVERSITY SWITCH TYPE MA168B**, solid state, £45.00.

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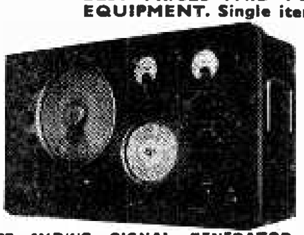
TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.

TF 1226B, TF1225A, TF 577A. WHITE NOISE TEST SET £185·00. Full spec. on request.

MARCONI TF 995A/5 FM/AM SIGNAL GENERATOR. Four additional tuning controls facilitate narrow band measurements. 3 Int. A.M. mod Freq. of 400. 1000 & 1500Hz at up to 50% F.M. deviation ± 5kHz– ± 120kHz. Output 0.1µv–200mV depending on termination. Freq. Range 1.5–220MHz. P.O.A.

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 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 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. freq. 10Hz to 100kHz, 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.

MARCONI OA 1094A/3 SPECTRUM ANALYSER with L.F. extension unit. Freq. range 100MHz. Full Spec & P.O.A.

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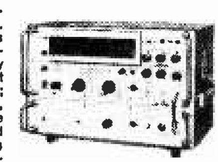
8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. £145.



PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

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

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Oscilloscopes 585 DC to 100MHz. Separate time bases with delay and 5X magnifier. Time base A: 0·05 microsecs to 2 sec/cm in 24 stages also continuously variable between steps. Time base B: 2 microsecs to 10 sec in 18 stages. Delay 1 microsec to 10 sec. Complete with type 81 adaptor enabling use of all letter series plug-ins. Type 80 plug-in (less probe) also available.

541A-33MHz. Choice of plug-ins. P.O.A.
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CA—24 MHz dual trace 50MV-20V.
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N 600MHz sampling 10MV-cm.
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BOONTON FM/AM SIGNAL GENERATOR TYPE 202E. 54–216MHz in 2 ranges, complete with separate power supply **£175.**
EHV POWER SUPPLY 115V input 100KV at 5mA output **£150.**

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AS 870.3 CURRENT LIMITING POWER SUPPLY 0–30v in steps of 10, 1. 0.1V at up to 3A **£50.**

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185A SAMPLING OSCILLOSCOPE. 800MHz. complete with 188A 1mV/CM dual trace plug-in. 1GHz probe and manual. Full spec & P.O.A.
524C ELECTRONIC COUNTER/TIMER direct reading to 10MHz. extended to 500MHz depending on converter plug-in. also period and time measurement. 8 digit in-line display on Nixie tubes. **£165** with one plug-in (as below) 524B model. spec as for 524C but display on 6 neon lamp decades and 2 meters **£115** with one of the following plug-ins: 526A Video amp. 525A: 10-100MHz. 525B: 100-220 MHz. (525C: 100–500MHz **£45** extra).
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TELEQUIPMENT 543C & D43H OSCILLOSCOPES £80.
KAHN SSB ADAPTOR MODEL RSSB=62=1B. Designed for receivers with 455–500kHz I.F. (eg Collins 51J: AR88D etc) at 100mV (max) input. Features: Electronic A.F.C.. carrier frequency diversity to combat fading: 20 sec R.C. memory to maintain tuning during severe fading: individual carrier meters: nuvistors: low distortion product demodulator. Full spec & P.O.A.

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EXCITER/TRANSMITTING MODE SELECTOR Freq. 2–32MHz. M.O. and 10 crystal positions. Vernier tuning U.S.B./L.S.B. var carrier insertion etc. **£200.**
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500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

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.

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TRANSCEIVERS
19, 19HP, 38, 62.
C-13 TRANSMITTERS
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We are able to offer a comprehensive selection from the range of this modern high class equipment including, receivers, L.F. Converters, SSB adaptors, panoramic adaptors, diversity switches, transmitter driver units, linear amplifiers can be built to customers' requirements. Please send us your enquiries.

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TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**
50 line AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD
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2C	4-16-24-32v	4	£4·95	45p
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3A	24-30-36v	10	£9·00	60p
3B	24-30-36v	5	£7·50	50p
3C	24-30-36v	2	£3·50	40p
4A	12-20-24v	20	£12·00	75p
4B	12-20-24v	10	£7·50	60p
4C	12-20-24v	5	£4·95	40p
5A	3-12-18v	20	£10·00	60p
5B	3-12-18v	10	£6·95	60p
5C	3-12-18v	5	£4·50	40p
6A	48-56-60v	2	£4·50	40p
6B	48-56-60v	1	£3·50	40p
7A	6-12v	20	£7·90	60p
7B	6-12v	10	£4·50	40p
7C	6-12v	5	£3·50	40p
8A	17-32v	8	£8·00	60p
9A	12-24v	1	£2·50	30p
10A	9-15v	2	£2·50	30p
11A	8-0-8v	2	£2·50	30p

PLEASE ADD 8% V.A.T.

HEAVY DUTY UNSHROUDED TYPES 9 INCH FLYING LEADS ALL PRIMARIES 240v.

Type No.	Sec. Volt Tap.	Amps.	Price	Carr.
1	24-30-36	20	£14·95	£1·00
2	12-20-24	30	£14·95	£1·00
3	3-12-18	30	£14·95	£1·00
4	6-12	50	£14·95	£1·00

TRANSFORMERS FOR LINSLEY HOOD AMPLIFIERS
Fully shrouded, terminal block connections. Pri. 220-240v. Screen tap. Sec. 30-25-0-25-30v., 2 amps. **£4·75**, carr. 40p. Heavy duty type 36-25-0-25-36v. 5 amps. **£9·75**, carr. 50p.

STEP DOWN 240/110v AUTO TRANSFORMERS
3000 watts. Built into steel case with two American 2 pin grounded socket outlets. Carry handle. 6 ft. mains lead. **£29·50**, carr. £2. Without case and fittings **£22·00**, carr. £1·50. **Other Types Available**. 80-1500 watts, fully shrouded, with American socket outlet and 6 ft. mains lead. Let us know your requirements. Lists available.

HOWELLS "C" CORE TRANSFORMERS
Pri. 200-220-240v. screen. Sec. 70-0-70v. 10 amp. table top connections. size 7×7×7 inches, **£15·00**, carr. £2·00. Pri. 220-240v Sec. 18-0-18v 12·5 amps conservatively rated. Table top connections **£10·00**, carr. £2·00.

PARMEKO ISOLATION STEP DOWN TRANSFORMERS
Pri. 200-220-240v Sec. 90-100-110-120v 7·5 amps conservatively rated. Size 8×8×8 inches. Enclosed type. Table top connections. **£19·50**, carr. £2·00.

PARMEKO ISOLATION 1-1 TRANSFORMERS
Pri. 190-260v in 10v steps. Sec. 240v 10 amp conservatively rated. Size 12×10×8 inches. Enclosed type. Table top connections. **£29·50**, carr. £3·00.

DRAKE ISOLATION 240/110v TRANSFORMERS
Pri. Tapped 10-0-200-220-240 Sec. 110v 400 watts. Shrouded. **£6·50** carr. 75p.
Pri. 200-220-240v Sec. 110v 50 watts unshrouded. Table top connections **£2·25** P.P. 40p.

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Pri. 380-440v. Star Sec. Tapped 6·1-6·7-7·3v, 28 amps delta. **£12·50**. Carr. £2·00. Pri. 105-110-115-120-200-220-230-240-250 Star Sec. 12v, 58 amps Delta, C core. **£25·00**. Carr. £3·00. 3 Phase Isolation Transformer Pri. 415v. Sec. 415v, 2KVA **£25·00**. Carr. £3·00. Pri. 415 ± 3% Star Sec. 13·1v 150a. Star. **£35·00**. Carr. £5·00.

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Pri. 230-240v. Sec. 10v 160 amp 50KV WKG. **£25·00**. Carr. £5·00.

ADVANCED COMPONENTS CONSTANT VOLTAGE TRANSFORMERS
Pri. 240v Sec. 28v 10 amps. **£7·50**. Carr. £2·00.

GRESHAM EHT TRANSFORMERS
Suitable for scope replacements.
Pri. 240v., Sec. 2300v 10 M/A. 300-0-300v 50 M/A. 6·3v 4A. 6·3v 1·5A. Table top connections. Size 5×3¾×3¼ ins. **£3·75**. P.P. 45p.

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Pri. 110-220-230v. Sec. 250-0-250v. 60 M/A 2·8-0-2·8v 28 amps. 24v 3 amps. 6·3v 3 amps. 5v 2 amps. **£4·75**. P.P. 65p.

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PARMEKO Admiralty Pattern. Pri. 230v. Sec. 230v. C.T. 20 amps. Very conservatively rated. Test to earth 2000 v. Size 17×14×16ins. Weight 320 lbs. £50 plus carriage.

RICH AND BUNDY. Pri. 220-230-240-250v. Sec. 265-270-275v. 1400 watts. Conservatively rated. Size 8×8×7 ins. Terminal block connections. **£15·00**, carr. £1·00.

GARDNERS C CORE L.T. TRANSFORMERS
Table top connections. Primaries 200-220-240v. No. 1 Size 2·65-0-2·65v 42 amps. **£4·50**, P.P. 70p. No. 2 2·5v 10 amps and 2·5v 5 amps twice. **£3·50**, P.P. 60p. No. 3 24v 3 amps. **£3·00**, P.P. 40p. No. 4 25-0-25v 154 M/A and 7v 1·35 amps. **£1·75**, P.P. 25p. No. 5 36v 350 M/A. **£1·00**, P.P. 25p. No. 6 73v tapped at 68v 0·6 amp and 6v 1 amp. **£3·00**, P.P. 35p. No. 7 4·2v 1 amp. **75p**, P.P. 25p.

GRESHAM MULTI TAPPED L.T. TRANSFORMERS
Pri. 110-220-240v. Sec. 21-22-23c27-28-30v 10a and 23-24-26v 2·5a. Twice and 15-16-18v 5a Twice and 25-0-25v 50 m/a three times. C. core type. Table top connections **£10·00**, carr. £1·00.

PARMEKO L.T. TRANSFORMERS
Open types. Pri. 110-220-240v. Sec. 30v 5·5 amps and 12v 2·2 amps. Table top connections. **£4·95**, P.P. 75p. Pri. 240v, Sec. 26v 10 amps and 12v 0·1 amp. Table top connections. **£5·50**, P.P. 75p. Potted types. Pri. 115-230v, Sec. 24-30-32v 2 amps. **£2·75**, P.P. 35p. Pri. 220-240v. Sec. 50v 0·4 amp. **£1·50**, P.P. 35p. Pri. 115-230v Sec. tapped 40-45 50v 5 amps. **£8·50**, Carr. 75p.

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Pri. 110-220-240v Sec. 30v 1 amp and 70v 1 amp. Enclosed type. **£4·00**, P.P. 75p. Pri. 110-220-240v Sec. 12v 6 amps and 15·6v 1·5 amps. **£3·75**, P.P. 75p. Pri. 220-240v, Sec. 63v 1·5 amps, 20-22-24v 0·8 amp and 6·3v 1 amp. **£2·50**, P.P. 75p. Pri. 220-240v, Sec. 15v 2·5 amps and 13v 6 amps. **£3·50**, P.P. 75p. All types open construction table top connections.

H.T. TRANSFORMERS BY FAMOUS MAKERS
No. 1 Pri. 110-210-230-250v Sec. 230v 200 M/A and 6·3v 7A. potted type **£3·00**, P.P. 50p.
No. 2 Pri. 110v-220-240v Sec. 250v 80 M/A. 15v 1·2A 6·3v 4·5A. Open type **£2·00**, P.P. 35p.
No. 3 Pri. 220-240v Sec. 250-0-250v 75 M/A 6·3v 3A **£1·75**, P.P. 35p.
No. 4 Pri. 200-220-240v Sec. 400-375-350-0-350-375-400v 150 M/A 6·4v 7A twice 6·4v 3A. 6·4v 2A 6·4v 1A 6·4v 0·5A potted type **£5·00**, carr. 75p.
No. 5 Pri. 110-220-240v Sec. 70v 1A and 30v 1A potted type **£3·75**, P.P. 75p.
No. 6 Pri. 220-240v Sec. 1875v 60 M/A and 500 31 M/A potted type **£4·75**, P.P. 75p.
No. 7 Pri. 220-240v Sec. 630-0-630v 105 M/A. 5v 4A 5v 2A **£4·50**, P.P. 75p.
No. 8 Pri. 220-240v Sec. 140v 195 M/A 6·3v CT 1·25A. 50v potted type 1A **£3·50**, P.P. 50p.
No. 9 Pri. 220-240v Sec. 385v 175 M/A and 218v 175 M/A potted type **£3·50**, P.P. 50p.
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H.T. SMOOTHING CHOKES
GARDNER 'C' core types. 10H 250 M/A **£2·00**, post. 40p. 20H 180 M/A **£2·00**, post. 40p. 12H 100 M/A 85p, post. 25p. 50H 25 M/A **85p**, post. 25p. **PARMEKO** Potted types, 10H 180 M/A **£2·00**, post. 40p. 5·2H 350 M/A **£2·50**, post. 50p. 10H 300 M/A **£2·50**, post 50p. 5H 100 M/A 75p, post. 25p. 15H 75 M/A 75p, post 25p. 50H 25 M/A 75p, 25p.

L.T. SMOOTHING CHOKES
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Pri. 200-220-240v SCR. Sec. 18-0-18v 12·5 amps 'C' core. Table top connections. Conservatively rated. Fraction of maker's price. **£8·50**, carr. £1·50.

SPECIAL OFFER OF RELAYS
Omron relays: MK2P plug-in type. 230v AC 2 CO contacts. **75p**. MK3P plug-in type. 12v DC 3 CO contacts. **75p**. MK2P plug-in type. 12v DC 2 CO contacts. **65p**. MK2P plug-in type. 24v DC 2 CO contacts. **65p**. MK3 12v DC 3 CO contacts. MK3 24v AC 3 CO contacts. Single hole fixing. **60p**. Postage: 1-3 relays. 20p; 4-6, 30p.
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ROBINSON 240v. AC RELAYS. Two 5 amp change over contacts, single hole fixing. Size 2½×1½×1½ ins. **60p**. p.p. 10p.

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280Ω 12-15v DC 4 CO, **60p**. 430Ω 15-24v DC 2 CO, **50p**. 1250Ω 4 CO 24-30v DC, **50p**. 2500Ω 35-45v DC, **50p**. 5000Ω 40-60v DC 2 CO, **50p**. Postage 5p each.

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Dorman Loadmaster SP circuit breakers type M3. AC 240-440v 20 amps. Overall size 3×2×1 ins. **£1·25**, P.P. 20p.

ITT LEVER SWITCHES
Type 601 AAO 72-42 4 CO contacts, overall size 1¾×2×½ Ins. White lever gold flash contacts, **60p**. Three for **£1·50**, post paid.

PLESSEY MINIATURE MICRO SWITCHES
Type LIC 7134. One CO one break. Gold flash contacts. Size ⅞×¾×½ in. Three for **50p**, post paid.

SANGAMO SYNCHRONOUS A.C. 240v MOTOR TYPE 7
4 rev. per hour. Size 1¾ plus ½ spindle. 1¾ inch dia. **£1·25**, P.P. 25p.

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6 volt DC 6 inch dia. Gong. Overall size 4½×6×6 inches. **£3·50**, P.P. 50p.

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0-8v DC. 3 in. square, 2½ in. panel hole. **£1·25**, P.P. 25p.
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BENSON SOLENOIDS
AC 240v 25% duty. Approx 2 ins. ½ in. pull. Size 2×1½ × 1ins. Res. 350Ω 75p P.P. 10p.

OIL-FILLED BLOCK CAPACITORS

MFD	DCV WKG	PRICE
8	2500	£3·00
8	800	75p
8	600	60p
8	350	40p
6	750	60p
6	600	50p
4	2000	£1·00
4	1000	60p
4	600	40p
4	350	30p
1	600	20p
1	200	10p

P.P. Add 5p each 1-4 MFD.
10p each 6-8 MFD.
25p each 8 MFD 2500v.
Plessey 2+2+2 MFD 1500v. WKG 70°C. **75p**, P.P. 10p.
TCC block electrolytic capacitors 1000 MFD 100v DC WKG **50p**, P.P. 15p.

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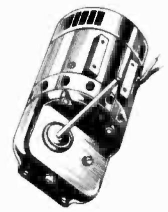
By famous makers 240v induction type, cont rating 4·2 RPM **£3·75** carr. 75p. Overall size 7 ins. Dia 3½ ins. Length of spindle 2½ ins.



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AIR BLOWERS 50-60v D.C. HP. 1/40th RPM 6000 cont rating. Size of motor 4×2¾×2¼ ins. Cowling 5 ins. dia. Outlet 1½×1¼ ins. **£2·50** carr. **45p**.

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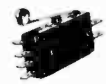
2 pole CO 15A contacts. 2nd pole actuates after 1st pole. Leaf roller action **60p**, post 5p.



REDCLIFF C CORE HEAVY DUTY L.T. TRANSFORMERS
Pri. 200-220-240v Sec. 25v 30 amps twice. **£15·00**, carr. £2·00.

HEAVY DUTY HT CHOKES
Parmeko potted type. 9 H 500 M/A 5 KV WKG. **£8·50**, carr. £2·00. Gardners enclosed type. 1 H 1 amp. **£3·50**, carr. £1·00. Gardner C core type. 10 H 350 M/A **£3·00**, carr. 75p.

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Input 240v + 20% — 10% output 240v + or — 0·5% 30 watts enclosed in metal case, 5¼×4×4 ins **£2·00**, P.P. 50p.

LEMARK L.T. TRANSFORMERS
Pri. 240v. Sec. 40v. 6a. 5-0-5v 2a. 5-0-5v. ½a. Open frame design. **£4·50**, carr. 75p. Pri. 240v. 16-0-16v. 2·5a. 24v. 630 m/a twice. 24v. 65 m/a and 115v. 2a. auto tap on primary. Open frame table top connections **£3·50**, carr. 50p. Pri. 240v. Sec. 20-0-20 ½a. 5-0-5 2a. **£1·75**, carr. 35p. All above transformers have a screen winding. Pri. 220-240v. Sec. 56v. CT. 10a. Shrouded terminal block connections. **£8·50**, carr. 75p.

PARMEKO High Voltage Transformers. Pri. 220-250v. in 10v. steps. Sec. 1320-0-1320v. 250 m/a. 1·01 kv pk wkg. Open frame type. Terminal block connections. New in maker's carton. **£12·00**, carr. £1·00.

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Pri. 200-220-240v SCR. Sec. 250-0-250v 240 M/A 6·3v 10A. **£4·50**, P.P. 75p. Pri. 115-230v SCR. Sec. 350-0-350v 200 M/A. 6·3v 5A. 5v 3A. Potted type. **£4·50**, P.P. 75p.

GRESHAM. Type 1 16·3v. 1a. twice 10v. 1a. twice. 22·5-25-28v. 5a. 26v. 2·5a. 23v. 1a.. 6·3v. 2a. 145-0-145v. 200 m/a 'C' core **£4·95**, carr 75p. Type 2 38v. 4a. 20v. 4a. 40v. 7a. 29v. 2a. 30v. 2·6a. 26v. 3·8a. 51v. 200 m/a. All separate windings, 'C' core **£8·50**, carr. £1. Type 3 25v. 2a. twice, 16v. 4a. twice, 25v. 5a. 31v. 7a., all separate windings. open frame table top connection, **£8·50**, carr. £1·00.

AMOS "C" CORE CHOKES
10 M/H 25 amps., **£8·75**, carr. £1.00.

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Partridge. Tapped 0-220-230-240-250v 500 watts unshrouded table top connections **£2·50**, carr. 40p. Lemark tapped 0-240 115v 500 watts unshrouded table top connections **£5·00**, carr. 60p. 300 watts **£3·50**, carr. 50p.

12 volt 2 amp TRANSFORMER
enclosed in metal case. Size 5×4½×3 ins. with fitted input and output fuses. On/off switch. Output sockets and 4 ft. 240v. mains lead. **£2·75** p.p. 35p.

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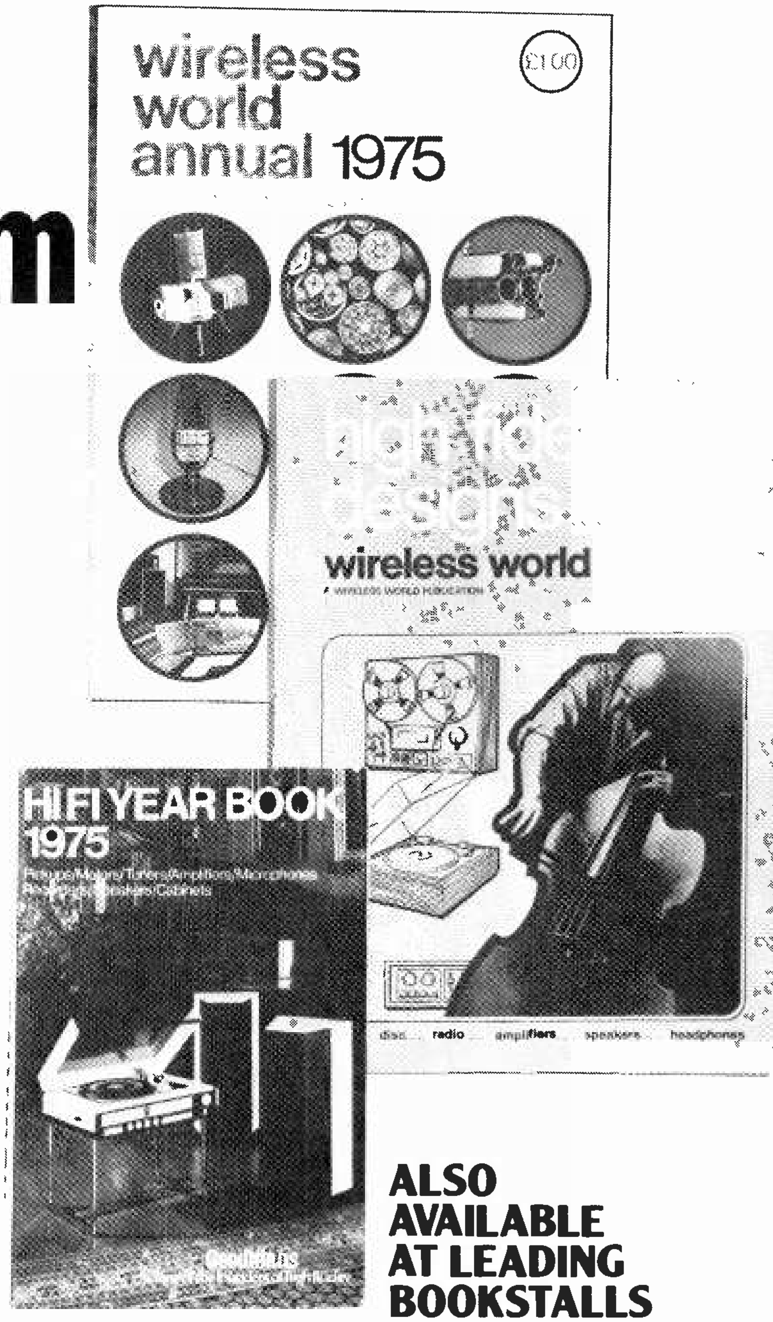
Pri. 240v. E.S. Sec. 26v. 10A and 12v. 0·1A, open frame, table top connections, **£5·50**, carr. 50p. Pri. 200-220-240v., Sec. 1, 37v. 6A, Sec. 2, 37v. 2A, 21v. 11A, open frame table pot connections, **£9·50**, carr. £1.

The big three from Wireless World



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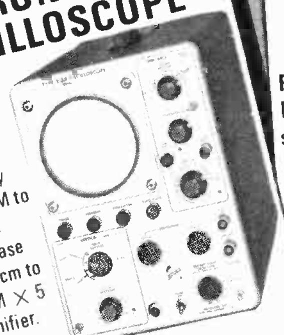

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PRICE £125

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Commercial Designation Solartron CD1014

General Purpose Dual Beam DC 6MHz flat faced double gun cathode ray tube operating at 1.6kV. The time base velocity is continuously variable between 1cm/usec. and 1cm/sec. TIME BASE Free running or triggered from positive or negative pulses. Sweep speed 1cm/usec to 1cm/sec.

Synchronisation: positive or negative going internal from either channel or external continuous waves. Internal 3mm P/P. External 100mVP/P. Sensitivity 100mV/cm: maximum on Y2 amplifier 1mV/cm. Size 9½" × 11½" × 15". Wt. 25 lb.

PRICE: **£69.50.** Solartron 1014 .2 & 3 **£85**. Tektronix Sampling Scope 661 **£295.**

ADVANCE SQUARE WAVE GENERATOR SG21

Frequency Range 9Kc/s to 100Mc/s, Rise time less than 1nS Ex-Demonstration. New condition in manufacturer's original carton.

9Kc/s to 100Mc/s continuously variable.
Accuracy ±4%. ±1% F.S.
MAIN OUTPUT 20mV–1V into 50 ohm external termination continuously variable.
Accuracy ±5%.
Maximum output on open circuit 2V.
RISE TIME less than 1nS up to 500mV.
TRIGGER OUTPUT
0.2. 0.4. 1.0. 2 0V into 50 ohm external termination maximum output on open circuit 4V.
Rise time nominally 1.5nS.
Fall time nominally 3.5nS.
Size: 11inW. 5½inH. 9inD.
Wt. 7.1 lb.
LAST LISTED PRICE £95

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Also available SG21A 100Kc/s–30Mc/s.

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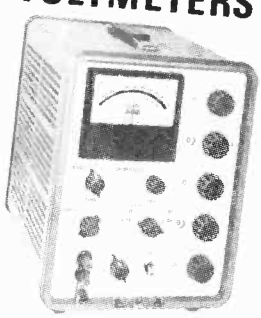

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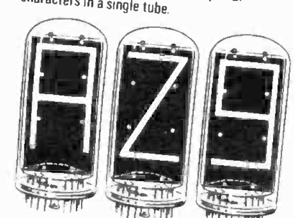
The Alphanumeric NIXIE tube has the ability to display all the letters of the alphabet, numerals 0 thru 9 and special characters in a single tube.



From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ 170V–21mA ★ All DC operation
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★ Memory with simple solid state drive circuits
★ Readability in high ambient light ... 200 footlamberts brightness ★ Long life with no loss of brightness
★ Character height 2½ ins.

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£18.50 with shockproof case

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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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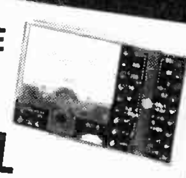

Taut suspension movement. Simple multimeter combined with audio/I.F. Test Oscillator providing AC and DC Voltage ranges. D.C. current ranges and resistance ranges, 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
Scale length: 65mm. D.C. voltage ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V. A.C. voltage ranges: 2.5, 10, 15, 250, 500, 1000V. D.C. current ranges: 0.05, 0.5, 5, 50, 500mA.
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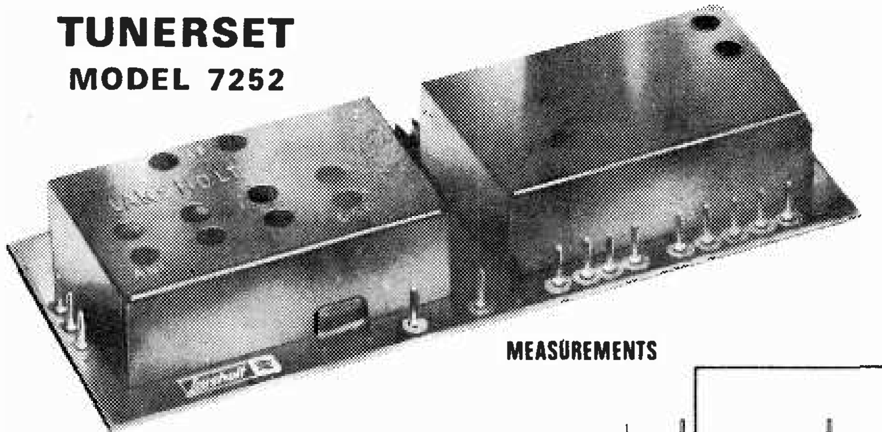

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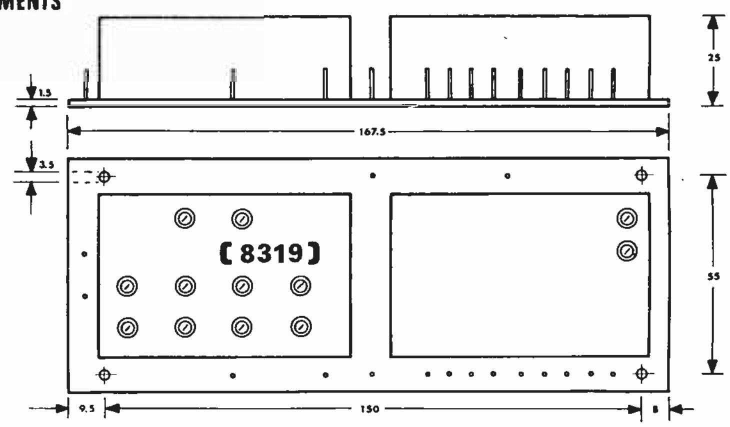

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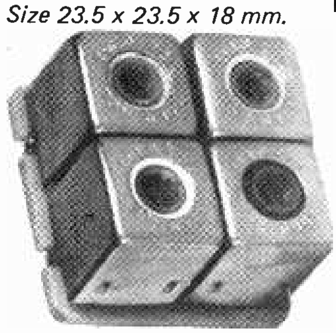

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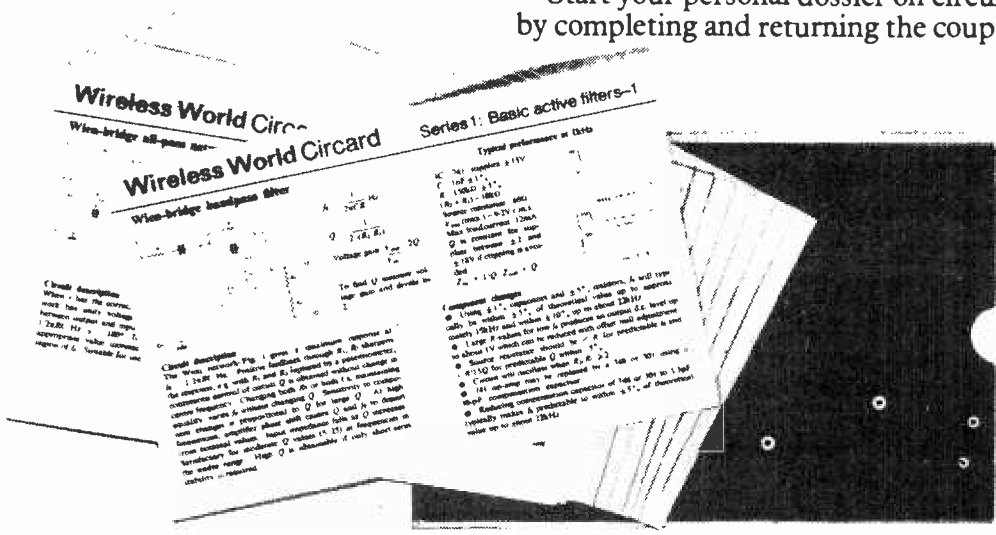

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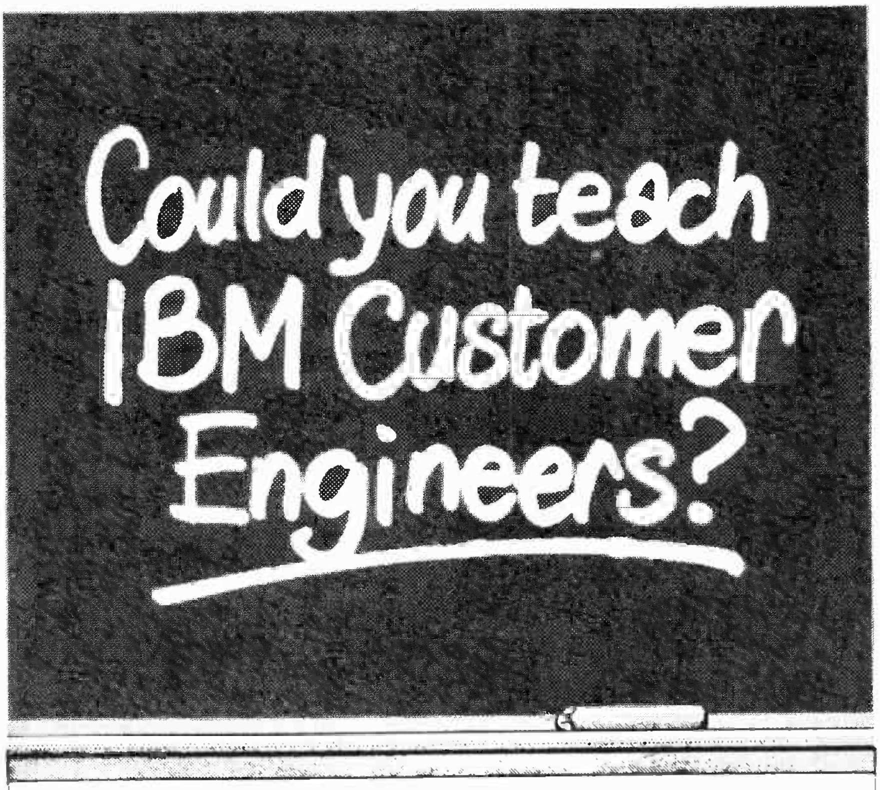

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Radio/Electronics Officers

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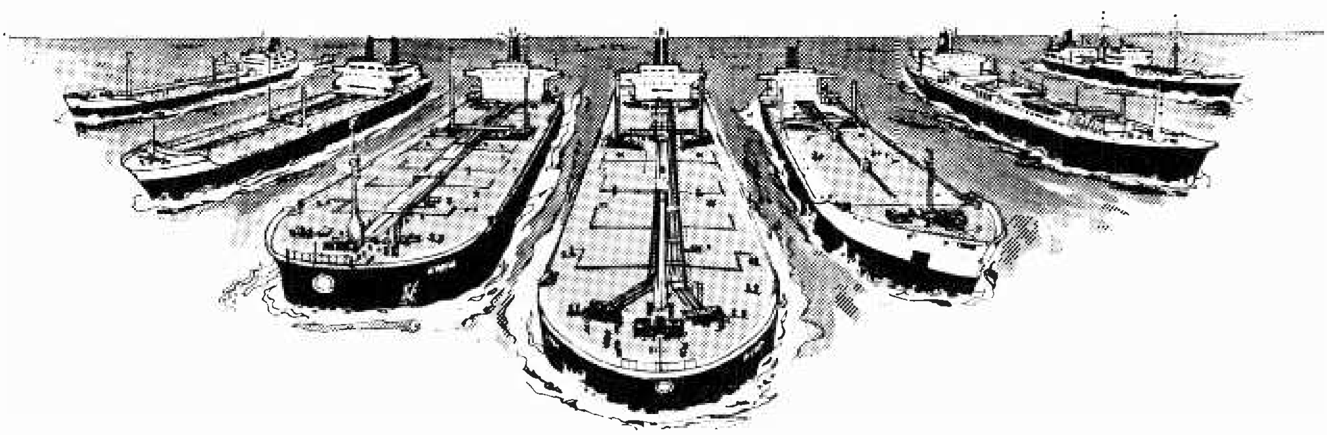

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Post Office Telecommunications

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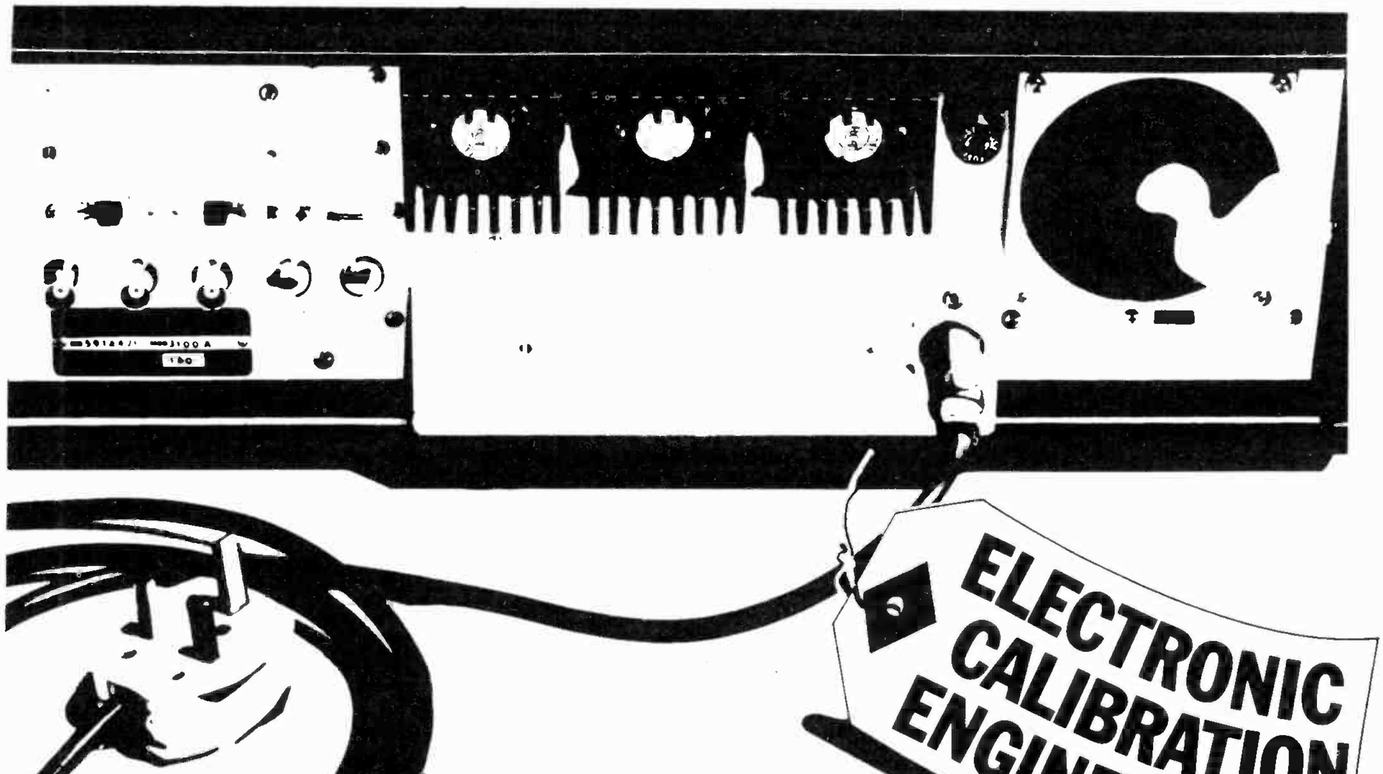

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Telephone: 01-855 1101.**

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....

.... WW/23/1

lansdowne Appointments Register

97

PHILIPS CROYDON

Electrical Design Engineer

An Engineer is required for electrical design and development of new mass production TV receivers, at Philips Croydon, an ultra modern TV manufacturing plant, within the international Philips Group of Companies.

The vacancy would suit an experienced graduate level electrical engineer, aged 23-32, wishing to broaden his career potential.

Good theoretical knowledge of circuits and experience of TV design is necessary.

Excellent conditions of employment apply, including more than 4 weeks holiday and annual bonus. Starting salary will match successful applicant's experience and qualifications. Substantial assistance will be provided towards removal costs where appropriate.

Applicants should submit brief details to:

**Mr. L. H. Lewis, Personnel Officer, Philips Croydon, Commerce Way. Purley Way, Croydon CR9 4JA,
Telephone: 01-688 7766, ext. 2286.**

[4383

PHILIPS

Merton, Sutton and Wandsworth Area Health Authority (Teaching)
Wandsworth & East Merton Teaching District
ST. GEORGE'S HOSPITAL, LONDON, SW1

OPPORTUNITY IN ELECTRONICS

A vacancy exists in the Electronics Section of the Department of Medical Physics. The work involves the design, development and manufacture of a wide variety of medical and research instruments; in particular, the solution of problems arising from the use of cardiac pacemakers. Experience with digital integrated circuits very desirable. The salary is on the M.P.T. II scale, which is £2,727-£3,516 p.a. plus Threshold. Minimum qualification H.N.C. or the M.P.T. III scale, which is £2,316-£2,943 p.a. plus Threshold. Minimum qualification O.N.C. The salary point on the above scales depends on experience and qualifications.

Further information and application forms are available from the

**Hospital Secretary's Office,
St. George's Hospital, Hyde Park Corner,
London SW1X 7EZ.**

[4395

Yorkshire
Regional Health
Authority

Regional Medical Physics Unit

MEDICAL PHYSICS TECHNICIAN (GRADE III)

A Medical Physics Department is to be set up at Grimsby, as an integral part of the new District General Hospital now under construction. In the first stage, a pilot scheme is to be operated with one Medical Physics Technician Grade III. Initially, the service, mainly relating to Radioactive Isotopes, will be provided at Grimsby General Hospital to the Consultant Staff in the District. Subsequently, the variety of work will be largely dependent upon the demands made upon the Service and the experience and initiative of the person appointed.

Applications are invited from persons qualified to H.N.C. standard in Medical Physics or Electronics, or equivalent, with three years' relevant experience, and preferably in hospital work. Persons with O.N.C. qualifications and broader experience will also be considered.

Starting salary within the range £2,190 to £2,355 rising by annual increments to £2,817 plus threshold of £13.92 per month.

The person appointed will work under the supervision of a Physicist and will receive training as necessary to provide the physics service.

Application forms to be obtained from and returned to the Regional Administrator, Yorkshire Regional Health Authority, Park Parade, Harrogate, HG1 5AH, within 14 days of the appearance of this notice.

[4378

WEST BERKSHIRE HEALTH DISTRICT

AUDIO ENGINEER

(SCIENTIFIC OFFICER)

to join busy group of surgeons, scientists and audiology technicians working with child and adult patients. Duties include running small well-equipped electro-acoustic laboratory, calibrating and maintaining audiometric instruments, assessing performance of hearing aids, with occasional CCTV, tape-recording and apparatus design jobs. Applicants should have HNC or degree (in physics, applied physics or electrical engineering) and relevant experience would be an advantage. Salary on scale £1,689–£2,994 + threshold payments (approx. £229 p.a.).
Further details from Dr. R. J. Bench, Audiology Unit, Royal Berkshire Hospital; applications to Hospital Secretary, Royal Berkshire Hospital, London Road, Reading.

[4377

Telecommunications Engineer

Commercial Cable Company have a number of vacancies for Engineers experienced in telephony and data transmission. Salary according to experience and qualifications but not less than £3,700 per annum. Please telephone Chief Engineer, Commercial Cable Company. Telephone: 01-251 1577 for appointment.

[4399

Harrow College of
Technology & Art

FILM AND TELEVISION TECHNICIAN

up to £2,677

A Technician/Engineer in Television and Sound is required for a post in the Film and Television Department of the School of Photography. Duties will include the technical operation and routine maintenance of a CC TV Studio requiring electronic and mechanical skills and knowledge in the television field.

Reasonable removal expenses reimbursed, lodging allowance of up to £6 per week and up to £500 towards legal and estate agents fees may be payable.

Good conditions of service including pension.

For more information and an application form telephone 01-864 4411 Ext. 31 or write to Harrow College of Technology & Art, Northwick Park, Watford Road, Harrow.

[4018

WEST SUSSEX COUNTY COUNCIL

INSTRUCTOR

Industrial Training Centre, College Road, Crawley

The person appointed will be required to give industrial training in electronics to First Year "Off the Job" trainees at both Craft and Technician level. Candidates for this post should possess qualifications of at least an appropriate Ordinary National Certificate level. The present salary scale is £1,900 x £54(3) x £57(9) to a maximum of £2,575 (under review) plus London Allowance. The commencing point on the scale is determined by qualifications and previous experience. Application forms and further particulars may be obtained from the Manager (Electrical) at the above Centre. Requests for application forms should be made within 14 days of this advertisement.

[4367

UWIST CARDIFF

University of Wales Institute of Science and Technology

Department of Applied Physics and Electronics

M.Sc./DIPLOMA COURSE IN ELECTRONICS

Applications are invited for places in the full-time one-year M.Sc./Diploma course in Electronics, commencing October 1, 1975.
Further details may be obtained from the Academic Registrar, UWIST, Cardiff CF1 3NU.
Application forms should be completed and returned to the College as soon as possible.

4371

THE UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF OPHTHALMIC OPTICS

ELECTRONICS TECHNICIAN (GRADE III) (REF: 0/172/AU)

Required in the electronics workshop of the visual sciences research section of the above department. The duties will be varied over a wide range including equipment repair, maintenance and prototype wiring and testing. Opportunities will exist for gaining experience in computer programming and electronic design. A sound knowledge of electronic techniques is essential and some experience in workshop practice would be an advantage. Qualifications required are O.N.C. or equivalent together with relevant experience.

Salary within the scale: £2.013-£2,343 per annum.

Write for application forms, quoting reference, to the Registrar, U.M.I.S.T., P.O. Box 88, Manchester, M60 1QD, to whom completed applications should be returned by 3rd February, 1975.

[4370

ARE YOU LONDON'S TOP VIDEO ENGINEER?

We need the very best there is to take complete charge of the Engineering Side of our busy Video Company.

We are probably the country's biggest independent systems house and already have top Grade Engineers so are looking for someone really special, capable of organisation and above all Technically Sound.

We are prepared to pay a super salary with fringe benefits, car, etc. commensurate with the responsibility of this situation. If you are capable of hard work and want to get right to the top in an Expanding Business this is the job for you. This sort of opportunity only comes once in a lifetime. Please contact:—

Ian Crammond, Managing Director,
Teletape Video,
76, Brewer Street,
London W1R 3PH.
Tel: 734/1319 434/1267.

[4394

KING'S COLLEGE LONDON
Department of Electrical and Electronic Engineering

ELECTRONICS TECHNICIAN

Interesting new position for electronics technician, Grade 5, preferably with interest and experience in digital electronics. Some circuit design ability essential. The post offers good opportunity to acquire experience in computer systems. Four weeks annual holiday. Contributory Pension scheme. Salary on scale £2,849—£2,939 rising to £3,305 p.a. including London weighting. Apply in writing giving details of age, experience and qualifications to Head Clerk, (Ref. WW 138749) King's College London, Strand WC2R 2LS.

[4398

EALING, HAMMERSMITH AND HOUNSLOW AREA HEALTH AUTHORITY (T)

CHARING CROSS HOSPITAL

DEPARTMENT OF MEDICAL PHYSICS

Electronics Technician (Grade II)

Applicants should have a wide experience of analogue equipment and preferably a good working knowledge of digital techniques. Knowledge of Medical equipment an advantage but not essential.

ALSO

Graduate Electronic Engineer

Knowledge of medical equipment an advantage but not essential. Whitley Council conditions of service apply. Salaries for both posts within the range of £1,689-£3,390 p.a. plus London Weighting at £126 p.a. (under review) and current Threshold payments. Point of entry on scale dependant upon qualifications and experience. Temporary single accommodation may be available for single men.

Application form and job description available from Mr. C. J. Hill, Personnel Department, Fulham Palace Road, Hammersmith, London W6 8RF. Te: 748 2050 Ext. 2992. Please quote ref. 106. Forms should be returned by 4th February 1975.

[4364

INSTITUTE OF GEOLOGICAL SCIENCES

Professional and Technology Officer Grade IV

Applications are invited for appointment as a Professional and Technology Officer Grade IV in the Geomagnetism Unit of the Institute.

DUTIES

The maintenance of equipment for the continuous monitoring of the Earth's Magnetic Field, to make the necessary calibrations and absolute observations and to assist in their reduction. There will be opportunities to assist in new development and proving.

Direct experience is not required as appropriate training will be given. Some electronic experience is, however, essential. The successful applicant may undergo a period of training at the Unit's geophysical observatory at Eskdalemuir, Dumfriesshire, prior to appointment to a permanent station.

QUALIFICATIONS

(a) ONC or equivalent, in electrical engineering.
(b) All candidates must have served an apprenticeship, or have had equivalent training, appropriate to the duties of the post, plus, normally, at least 3 years of suitable engineering experience (preferably assembly and testing of electronic equipment).
(c) Ability to drive would be an advantage.

SALARY

£1845 (age 21)—£2260 (age 27 or over on entry)—£2625. In addition Cost-of-Living supplement of £19.14 per month is paid. Non-contributory superannuation arrangements are available.

Application forms and further particulars, including the location in the UK of the Institute's geophysical observatories, may be obtained from Establishments, Institute of Geological Sciences, Exhibition Road, London SW7 2DE. Please quote Ref. ESK/75.

Closing date for applications: 22 January, 1975.

NATURAL ENVIRONMENT RESEARCH COUNCIL

4407

AUDIO/VISUAL TECHNICIANS

(TWO POSTS)

The Commonwealth Institute has vacancies for two Audio Visual Technicians as follows:—

(A) **A/V Officer** to head small A/V Unit under Chief Exhibitions Officer.
The successful applicant will possess extensive knowledge of A/V equipment (slide/tape, video, cine, etc.) and have practical experience in the operation and maintenance of such equipment related to exhibitions. The vacancy offers a varied and interesting position in congenial atmosphere for a person of initiative.

(B) **A/V Assistant** with good working knowledge of operation and maintenance of all A/V equipment. Practical experience essential.
Post (A) is graded Scientific Officer with salary range £2,002 by 12 increments to £3,085 inclusive of London Allowance.
Post (B) is graded Technician III with salary range £1,997 by 7 increments to £2,436 inclusive of London Allowance.
Both posts attract a cost of living supplement of £19.14 per month.
Good working conditions, 4 weeks' holiday.
Non-contributory pension scheme.
Some weekend working will be obligatory in both posts.
Application forms are obtainable from the Establishment Officer, Commonwealth Institute, Kensington High Street, London W8 6NQ. 01-602 3252.

ENGINEERING PUBLICITY WRITER

required for

BBC's ENGINEERING INFORMATION DEPARTMENT in Central London

Salary according to experience, in the range £4,329–£4,725 rising to £5,319. Pensionable post.

Duties include writing leaflets and booklets, mainly about broadcast reception and drafting reports and letters. Some exhibition work may also be included.

The job requires an ability to write clearly and attractively on technical subjects—both for Engineers and the general public.

Applicants must have experience in the design and layout of printed material, also a good basic understanding of radio theory, television technology and audio reproduction allied to a natural flair for writing and public relations.

Requests for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London, W1A 1AA, quoting reference no. 74.E.2417/WW and enclosing self-addressed envelope at least 9" × 4". Closing date for completed application forms 14 days after publication.

BBC

4013

TECHNICAL OPERATIONS MANAGER

(Television Service)

For the Educational Television Unit at Guildford County College of Technology. To be responsible for the daily operations of a team of technicans concerned with production and presentation of ETV material.

Applicants need a sound knowledge of closed-circuit television systems including colour, together with experience with helical-scan recorders and vidicon cameras. Organising ability, and an interest in the development of television and other audio-visual equipment as teaching aids, of considerable importance.

Salary (including Threshold and Surrey Allowance) £2,275–£2,947 according to age, qualifications and experience.

Application form and details from the Vice-Principal, Guildford County College of Technology, Stoke Park, Guildford.

SURREY
COUNTY COUNCIL

4024

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 £3,096 pa; commencing salary according to age—25 years and over £2,276 pa. During training salary also by age, 25 years and over £1,724 pa with free accommodation.

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

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

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

Full details from:

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

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ELECTRONIC TECHNICIAN GRADE III

An electronic technician is required for the Electronics Department dealing with the maintenance of a wide variety of electronics and electro-medical apparatus./Applicants must possess HNC, HND or ONC in electronics or equivalent City and Guilds Certificate /General diagnostic maintenance experience in the electronic field is necessary. Training in maintenance experience in the electronic field is necessary. Training in maintenance of specialised hospital equipment will be given./Salary scale from £2,190 to £2,817 p.a. plus Threshold payment. Additional payments are made if overtime is required /Applications stating age, qualifications and experience, together with two referees should be sent to the Area Works Officer, Coventry Area Health Authority, The Birches, Tamworth Road, Keresley End, Coventry CV7 8NN

COVENTRY
Area Health Authority

4020

ELECTRONIC ENGINEER

aged 25—35 years, with knowledge of Logic and Audio equipment design, required by expanding Group of Companies. Must have H.N.C. or equivalent.

Write or telephone:
Personnel Department
SONTRANIC (C.H.C. GROUP) LTD.
The Forum, High Street,
Edgware HA8 7HB
Telephone: 01-952 6666

[4022

TOP ARTISTS RECORDING STUDIO

Well established in the heart of Paris have an opening for experienced recording engineer who is also able to do some maintenance on electronic recording equipment. Excellent prospects for a bachelor age about 25. Living accommodation, bachelor flat, will be provided.

Please contact to-day
Loulou Gasté Studios
5 Rue du Bois de Bologne
Paris 16
France

[4386

Electronics Test Engineers: career openings that affect all sorts of people...

. . . you most of all, naturally. Mainly because, by joining the world's largest exporter of radio-telephone equipment you will inevitably open up for yourself career advantages that very few companies can provide. Pye Telecom is growing at an ever-increasing rate – and the potential for its products has as yet been only fractionally utilised.

But the work you do will also be vital to an incredible number of others. Very frequently, life itself depends on the efficiency of the UHF and VHF equipment you'll be working on. Police, firemen and ambulance staff are a small sample of the extensive range of users. Which explains the exacting specifications of the test procedures in operation – and why previous fault-finding and testing experience is an essential requirement. If it relates to communications equipment, so much the better, but this is not absolutely essential. More important is practical proficiency, which may well have been gained in the armed forces.

Find out more right now by phoning or writing to Mrs Audrey Darkin at:

Pye Telecommunications Ltd
Cambridge Works, Elizabeth Way,
Cambridge CB4 1DW. Tel: Cambridge 58985

A member of the Pye of Cambridge Group

4292

MARCONI INSTRUMENTS Ltd.
AT ST. ALBANS AND LUTON
ELECTRONIC TECHNICIANS

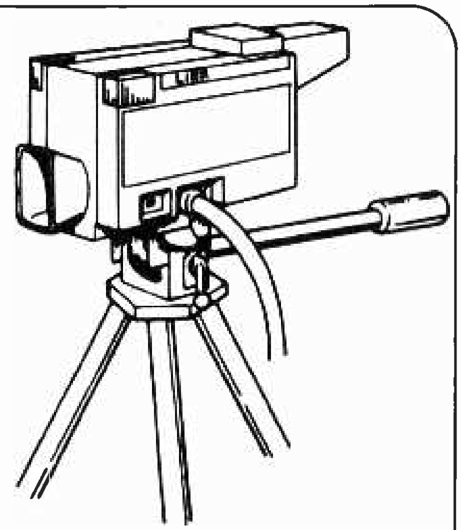
We are a company that manufactures precision electronic measuring instruments and have a range of technical career vacancies within our Production and Engineering departments at St. Albans and Service Division at Luton.
To fill these posts we are looking for people with a good electronic background, but not necessarily qualified.
Attractive salaries are offered for the right candidates along with the normal benefits of staff employment.

For further information and or application forms contact John Prodger, mi Ltd., Longacres, St. Albans, Herts. Tel:59292.

A G.E.C. Marconi Electronics Company.

4356

LINK
ELECTRONIC TEST ENGINEER
TV CAMERAS



We are looking for another engineer to join our young team testing and commissioning TV studio equipment.

Link Electronics is a successful, independent company making a complete range of units for TV broadcasting, from monochrome and colour cameras to complete studio systems and Outside Broadcast mobiles. Our modern factory, on the edge of Andover, is currently being extended to help us meet the increasing demand for our products.

For this position formal qualifications are less important than direct experience of similar equipment and this means you are unlikely to be younger than 23. A knowledge of both digital and linear techniques is essential and you should be used to fault finding down to component level.

We offer a competitive salary with above average benefits including subsidised canteen, excellent pension scheme with free life assurance, free health insurance and financial assistance with re-location where necessary.

Please write or telephone, giving brief details only at this stage, to M. D. Comber.

LINK ELECTRONICS

LINK ELECTRONICS LTD.
Walworth Industrial Estate,
Andover, Hampshire, England
Telephone: Andover (0264) 61345

4411

T.V. Engineers for New Zealand

Are you dissatisfied with your present position, feeling like a change of scene? Do something about it now! Be our guest—come down under and join the Tisco Team, N.Z.'s largest service organisation.
We are in service only and our engineers are all important people, every one of our 30 managers is an ex engineer.
We are now selecting staff to sponsor under the Immigration Scheme to arrive in N.Z. mid 1975.

If you,

- Have 5 years experience, preferably some in colour.
- Single or married with 3 children or less.

write now enclosing a photograph and details of past experience to:-
The Technical Staff Supervisor, Tisco Ltd, Private Bag, Royal Oak, AUCKLAND, NEW ZEALAND.

[4070

LEEDS CITY COUNCIL
Department of Education

Leeds Polytechnic
Educational Technology Unit

TELEVISION ENGINEER

(REF. 13/21)
T.3. £2,187—£2,538
plus Threshold payment

To work with media production team in the operation and maintenance of the colour television studio and related recorded facilities.

Application form (quoting ref. no.) together with further particulars from the Administration Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE.

[4023

Radio Technicians

A secure future with Overseas Division of one of the world's largest airlines is within easy reach if you are interested in either aircraft or ground radio and have at least 5 years' experience.

The vacancies are at Heathrow Airport —London.

Starting pay is £49.66 per 40 hour week and there are chances of rapid promotion to £56.04 per week.

Additional benefits include a contributory pension scheme, a first-class sports and social club and opportunities for concessional holiday air travel world wide.

Please write, quoting reference 430/WW/BW, to:

Manager Selection Services, British Airways Overseas Division, PO Box 10, Heathrow Airport—London, Heathrow TW6 2JA

4021

British airways

CLASSIFIED

ARTICLES FOR SALE

B. BAMBER ELECTRONICS

20 WELLINGTON STREET, LITTLEPORT, CAMBS.
TEL: ELY (0353) 860185 (TUESDAY–SATURDAY)

TERMS OF BUSINESS: CASH WITH ORDER. ALL PRICES INCLUDE POST & PACKING (UK ONLY). *EXPORT ENQUIRIES WELCOME.* **PLEASE ADD 8% VAT.**
CALLERS WELCOME BY APPOINTMENT **MINIMUM ORDER £1**
PLEASE ENCLOSE STAMPED ADDRESSED ENVELOPE WITH *ALL* ENQUIRIES 4404

PYE AC10 POWER SUPPLY

240V input, 12V (nominal) at 10amp output, stabilized, fully enclosed, fused, used by tested **£30.00**

TEST EQUIPMENT

MARCONI UHF SIGNAL GENERATOR, TF762B, 300–600MHz, **£50.00**
MARCONI STANDARD SIGNAL GENERATOR, TF867/2, 15kHz–30MHz, **£100.00**
MARCONI TV SWEEP GENERATOR, TF1104/1, **£66.00**
MARCONI VALVE VOLTMETER, TF428C, **£28.00**
MARCONI AMPLITUDE MODULATOR, TF1102, **£35.00**
MARCONI VALVE MILLIVOLTMETER, TF899A, **£30.00**
MARCONI STANDARD SIGNAL GENERATOR, TF144H, 10kHz–72MHz, **£195.00**
WAYNE KERR VHF FREQUENCY STANDARD, 12-channel, **£20.00**
AIRMEC BRIDGE HETERODYNE DETECTOR, Type 775, **£65.00**
AIRMEC SIGNAL GENERATOR, Type 201, 30kHz–30MHz, **£75.00**
AVO PORTABLE TRANSISTOR ANALYSER, Mk II, **£45.00**
HEWLETT PACKARD UHF SIGNAL GENERATOR, Type 614A, 800–2300MHz, **£175.00**
SOLARTRON DIGITAL VOLTMETER, Type LM1420/2, with "TRUE RMS AC UNIT", 10mV–1000V, 5-digit display, new condition, **£400.00**
TEKTRONIC TYPE-526 VECTORSCOPE, 240V input, complete but needs slight attention, good external appearance.
Offers please

HIGH-QUALITY SPEAKERS

8⅜in. × 6in. elliptical, 2in. deep, 4 ohms, inverse magnet, rated up to 10Watts, **£1.50** each, or 2 for **£2.75** (quantity discount available).

ELECTROLYTIC CAPACITORS

AXIAL LEAD AND SINGLE ENDED

MFD	6.3V	10V	16V	25V	35V	50V
22	30p	–	–	–	–	40p
33	–	30p	35p	40p	40p	45p
47	–	–	–	40p	45p	–
100	35p	40p	–	45p	60p	–
220	40p	40p	–	50p	75p	–
330	40p	45p	60p	75p	95p	95p
470	45p	60p	–	95p	–	–
1000	–	–	95p	95p	–	–
3300	95p	95p	–	–	–	–

PRICES PER PACK OF 5
Trade enquiries welcome for quantity

MAINS TRANSFORMERS

240V in, voltages quoted approx. RMS.
TYPE F27BS (ex Pye F27 base station TX) 500V at 350mA, 6.3V at 8A, **£6.00**.
TYPE 40/2 40V at 2A, **£1.00** each.
TYPE 18/8 18V at 8A, **£4.50** each, carriage 50p.
TYPE 16/6 16V at 6A, 45V at 100mA, **£4.00**, carriage 50p.
TYPE 28/4 28V at 4A, 125V at 500mA, **£4.00**, carriage 50p.
TYPE 63/1 6.3V at 1A, 85p each, 2 for **£1.50**.
TYPE 129 400V at 20mA, 200V at 10mA, 6.3V at 500mA, **£1.25**.
TYPE 70462 250–0–250V, 50–0–50V, 6.3V, **£1.75**.

RADIOSPARES 500-WATT AUTO TRANSFORMER, 100/110/150/200/220/240/250V tapped input and output, step up or step down facility, ex new equip. **£6.00**

MAINS ISOLATING TRANSFORMER, 375VA, tapped primary, 240V output, new, £6.00.
MAINS ISOLATING TRANSFORMER, (ex equip), in metal cases, totally enclosed, tapped mains input, 110–240V etc., output 240V at 3A + 12V at 0.5A, **£11.00**.
AS ABOVE, output 240V at 12A + 12V at 3A + 22V at 2.5A, **£27.50**, carriage £2.

PLUGS AND SOCKETS

TV PLUGS (metal type) 6 for **50p**
TV SOCKETS (metal type) **50p**
TV LINE CONNECTORS 5 for **50p**
PL259 (PTFE) PLUGS 50p each or 5 for **£2.25**
SO239 (PTFE) SOCKETS 50p each or 5 for **£2.25**
25-WAY ISEP PLUGS and SOCKETS 40p set (1 plug + 1 skt). Plugs and sockets sold separately at **25p** each
CANNON Right-angled plugs XLR LNR15 **75p**
DIN SPEAKER SKTS, 2-pin, 4 for **30p**
STANDARD JACK PLUGS, ¼in., 4 for **50p**
ANDREWS 44AN FREE SKTS (N-TYPE) for FH4/50B or FHJ4/50B cable **£1.00** each
SO239 BACK-TO-BACK SOCKETS £1.25 each
BNC INSULATED SOCKETS (single-hole type) **65p** each

VALVES

QQVO3/20A (ex equipment) **£2.10** each
QQVO3/10 (ex equipment) **75p** each
2C39A (ex equipment) **£1.00** each
QQVO2/6 (ex equipment) **£1.00** each
4CX250B (ex equipment) **£2.10** each
4X250B (ex equipment) **£1.50** each
DET-22 (ex equipment) 2 for **£1.00**
EF80 (new) **25p**, **EZ81** (new) **25p**
ECC81 (new) **30p**, **ECC83** (new) **30p**

TEST EQUIPMENT

RACAL 125MHz DIGITAL FREQUENCY METER, Type 801R/2, 0.01V to 1V sensitivity, 8-digit readout, new condition, **£275.00**
ROHDE and SCHWARZ SIGNAL GENERATOR, SMAF, 4–300MHz, AM/FM, attenuation to 0.05 microvolt, deviation and modulation metered, complete, but needs attention, **£300.00**
ROHDE AND SCHWARZ FREQUENCY DEVIATION METER, FMV, AM/FM, 20–300MHz **£300.00**

PYE RADIO-TELEPHONE EQUIPMENT

Cambridge, Westminster, Motofone, Europa series. Send s.a.e. for full details, stating requirements, frequency, channel spacing, etc.

MISCELLANEOUS

MAGNETIC DEVICES PROGRAMMERS, contain 9 microswitches with 9 adjustable drums for period switching (needs slow-motion motor to drive drum) many switching applications **£1.00** each.
ITT HIGH-GRADE ELECTROLYTICS, 6800 mfd at 25V, screw terminals, complete with capacitor clip for vertical mounting, **50p** each (quantity discount available).
MULTICORE CABLE, ½" dia. PVC covered, in 22ft. lengths with plug and socket fitted, 24 core stranded + 1 screened + 1 twin screened (ideal mobile control lead) **£2.10** each.
TWIN HEAVY DUTY CABLE, PVC-covered, 50/0.25mm, **15p** per metre, or **£10.20** per 100 metre reel.
CURLY LEADS, 4-core telephone-type 18in. closed, approx. 5ft. extended, 2 for **20p**.

TEST EQUIPMENT

ROHDE AND SCHWARZ POWER SIGNAL GENERATOR, SMLM, 30–300MHz, up to 5V output, **£300.00**
GRESHAM LION 625-LINE PULSE/BAR/STAIRCASE GENERATOR, £25.00
TEKTRONIX 524D SCOPE, DC–10MHz, **£70.00**

PYE MF TRANSMITTERS

2 × 5B254Ms in final, VFO 340 to 540kHz (can be modded upward), 2 × 5B254Ms in Modulator, cw/mcw (can be modded for AM), units complete, but no PSUs, (supplied with circuits of TX and PSU) brand new, boxed, **£20.00**.

We've got prices to put power in your profits

TOSHIBA VALVES

Type	Goods Price (p)	Type	Goods Price	Type	Goods Price	Type	Goods Price	Type	Goods Price	Type	Goods Price
DY87	30.0	PL508	67.0	AF115	23p	BC147A	08p	BF173	25p	BU108	£2.10
DY802	30.0	PY88	35.5	AF116	23p	BC148	08p	BF178	35p	BY126	11p
ECC82	28.0	PY500A	85.0	AF117	23p	BC149	12p	BF179	40p	BY127	12p
EF80	29.5	PY800	29.0	AF118	50p	BC153	20p	BF180	35p	E.1222	30p
EF183	34.5	**SEMI-CONDUCTORS**		AF139	42p	BC154	22p	BF181	35p	IN60	05p
EF184	34.5	AC127	17p	AF178	45p	BC157	12p	BF184	21p	MJE340	45p
EH90	31.5	AC128	15p	AF180	45p	BC158	10p	BF185	21p	OA202	7.5p
PC900	24.5	AC141K	30p	AF181	45p	BC159	14p	BF194	15p	OC71	15p
PCC89	40.0	AC142K	30p	AF239	45p	BC173	18p	BF195	15p	OC72	15p
PCC189	41.0	AC151	20p	BA145	14p	BC178B	20p	BF196	20p	BU105/02	£2.40
PCF80	31.5	AC154	18p	BC107	11p	BC182L	12p	BF197	17p	2SC1172B	£2.40
PCF86	39.0	AC155	18p	BC108	11p	BC183L	12p	BF198	23p	R2008B	£2.00
PCF801	42.0	AC156	20p	BC109	12p	BC187	28p	BF200	25p	R2010B	£2.00
PCF802	40.0	AC176	22p	BC113	25p	BC214L	15p	BF218	30p	**INTEGRATED**	
PCL82	39.0	AC187	19p	BC116	25p	BD124	70p	BF224	35p	**CIRCUITS**	
PCL84	34.0	AC187K	30p	BC117	20p	BD131	45p	BF258	40p	TAA550	49p
PCL85	39.5	AC188	20p	BC125	25p	BD132	45p	BF336	28p	TBA120AS	£1.00
PCL86	41.0	AC188K	30p	BC132	25p	BD235	49p	BF337	35p	TBA120SQ	£1.00
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PL84	25.0	AD161	38p	BC138	40p	BF115	20p	BFY52	20p	TBA920Q	£2.90
PL504	60.5	AD162	38p	BC142	26p	BF160	20p	BSY52	35p	TBA990Q	£2.90
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BC178	18	2N3702	12	1N4002	5
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7404	18	17	16
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7410	17	16	15
7413	36	34	32
7420	17	16	15
7442	70	66	63
7447	90	85	80
7473	38	36	34
7474	35	33	31
7476	38	36	34
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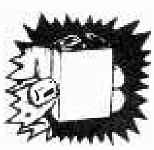

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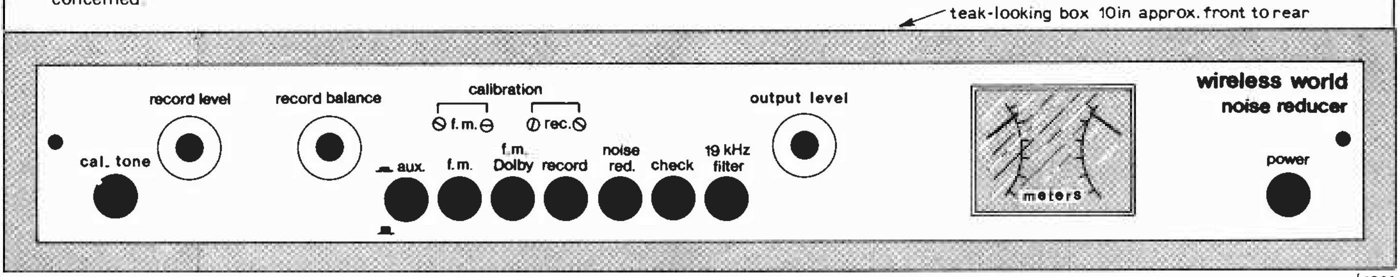

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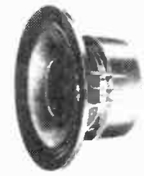

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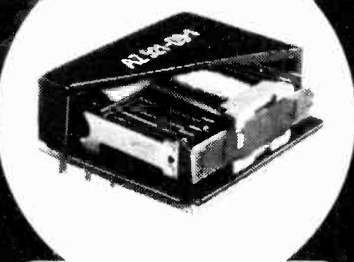

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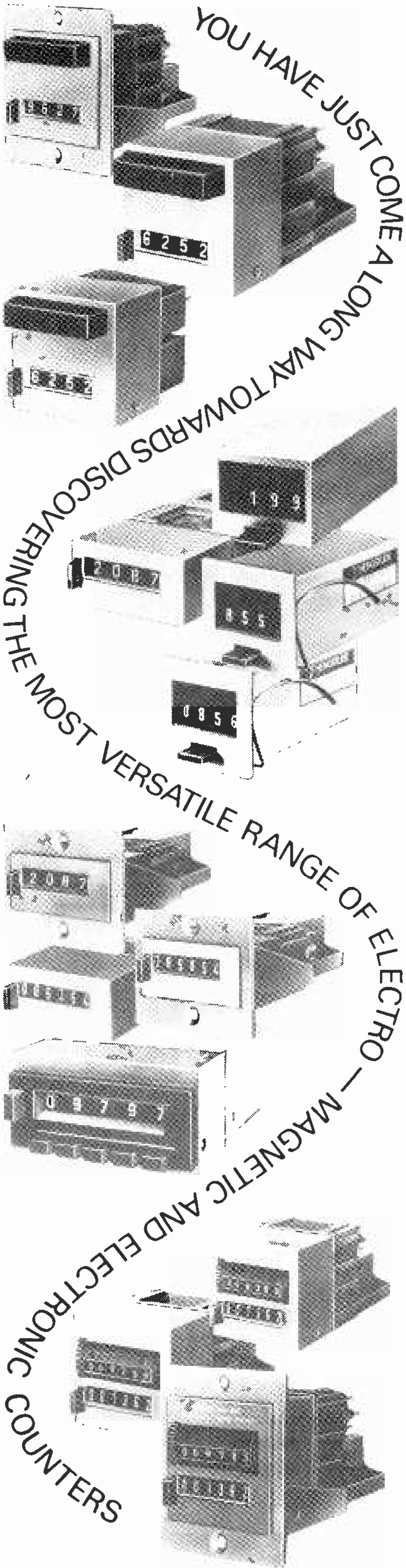

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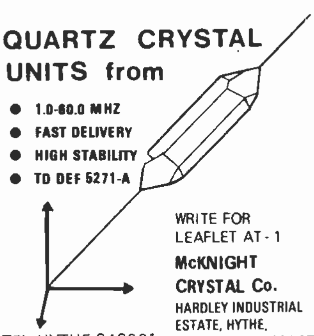

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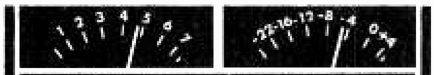

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0·68μF (2"×⅝")	**80p**	10·0μF	**£2·00**	**£1·60**	**£1·40**
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2·0μF (2"×1")	**£1·22**				

TANTALUM BEAD CAPACITORS—Values available: 0·1, 0·22, 0·47, 1·0, 2·2, 4·7, 6·8μF at 15V/25V or 35V; 10·0μF at 16V/20V or 25V; 22·0μF at 6V/10V or 16V; 33·0μF at 6V or 10V; 47·0μF at 3V or 6V; 100·0μF at 3V. ALL at **10p** each, 10 for **95p**, 50 for **£4.**

TRANSISTORS					
BC107/8/9	**9p**	BC183/183L	**11p**	BFY50	**20p**
BC114	**12p**	BC184/184L	**12p**	BFY51	**20p**
BC147/8/9	**10p**	BC212/212L	**14p**	BFY52	**20p**
BC153/7/8	**12p**	BC547/558A	**12p**	AF178	**30p**
BC182/182L	**11p**	BF194	**12p**	OC71	**12p**
		BF197	**13p**	2N3055	**50p**

POPULAR DIODES—1N914 **6p**, 8 for **45p**, 18 for **90p** 1N916 **8p**, 6 for **45p**, 14 for **90p**; 1S44 **5p**, 11 for **50p**, 24 for **£1·00**; 1N4148 **5p**, 6 for **27p**, 12 for **48p**; 1N4001 **5½p**; 002 **6p**; 003 **6½p**; 004 **7p**; 005 **7½p**; 006 **8p**; 007 **8½p**.

LOW PRICE ZENER DIODES—400mW, Tol. ±5% at 5mA. Values available: 3V, 3·3V, 3·6V, 4·7V, 5·1V, 5·6V, 6·2V, 6·8V, 7·5V, 8·2V, 9·1V, 10V, 11V, 12V, 13V, 13·5V, 15V, 16V, 18V, 20V, 22V, 24V, 27V, 30V, 33V. All at **7p** each, 6 for **39p**, 14 for **84p**. SPECIAL OFFER: 100 Zeners for **£5·50.**

RESISTORS—High stability, low noise carbon film 5%. ½W at 40°C, ¼W at 70°C. E12 series only—from 2·2Ω to 2·2MΩ. ALL at **1p** each, **8p** for 10 of any one value, **70p** for 100 of any one value. SPECIAL PACK; 10 of each value 2·2Ω to 2·2MΩ (730 resistors) **£5.**

SILICON PLASTIC RECTIFIERS—1·5 amp. brand new wire ended DO27; 100 P.I.V. **7p** (4 for **26p**) 400 P.I.V. **8p** (4 for **30p**); 800 P.I.V. **11p** (4 for **42p**).

BRIDGE RECTIFIERS—2½ amp, 200V **40p**; 350V **45p**; 600V **55p.**

SUBMINIATURE VERTICAL PRESETS—0·1W only. ALL at **3p** each; 50Ω, 100Ω, 220Ω, 470Ω, 680Ω, 1kΩ 2·2kΩ, 4·7kΩ, 6·8kΩ, 10kΩ, 15kΩ, 22kΩ, 47kΩ, 100kΩ 250kΩ, 680kΩ, 1MΩ, 2·5MΩ, 5MΩ.

PLEASE ADD 10p POST AND PACKING ON ALL ORDERS BELOW £5. ALL EXPORT ORDERS ADD COST OF SEA/AIRMAIL.

PLEASE ADD 8% V.A.T. TO ORDERS.
Send S.A.E. for lists of additional ex-stock items.
Wholesale price lists available to bona fide companies.

MARCO TRADING (Dept DII)
The Old School, Edstaston, Nr. Wem, Shropshire
Tel. Whixall (Shropshire) (STD 094872) 464/5
(Proprs.: Minicost Trading Ltd.)

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, SE1 9LU

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- **Rate: 86p PER LINE. Average seven words per line. Minimum THREE lines.**
- **Name and address to be included in charge if used in advertisement.**
- **Box No. Allow two words plus 35p.**
- **Cheques, etc., payable to "Wireless World" and crossed " & Co."**
- **Press Day February 7th, 1975 for March, 1975 issue. Subject to space being available.**

NAME..

ADDRESS ....

....

....

REMITTANCE VALUE.................................... ENCLOSED

PLEASE WRITE IN BLOCK LETTERS. CLASSIFICATION.............................. NUMBER OF INSERTIONS.................

INDEX TO ADVERTISERS

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...nted in Great Britain by Hazells Offset Ltd., Leigh Road, Slough, Bucks., and Published by the Proprietors I.P.C. ELECTRICAL-ELECTRONIC PRESS LTD., Dorset House, Stamford St., London, SE1 9LU telephone ...1 8000. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service, Ltd. ... & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd.: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distributors Inc. 155 West 15th Street, New York, N.Y. 10011. CONDITIONS ... AND SUPPLY. This periodical is sold subject to the following conditions namely that it shall not without the written consent of the publishers first given be lent re-sold, hired out or otherwise disposed of Trade at a price in excess of the recommended maximum price shown on the cover, and that it shall not be lent, re-sold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised ... of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

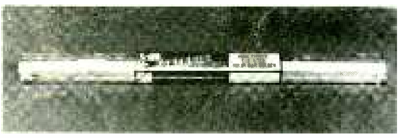
P.E. 7236 ... (24v) ± 12V with artificial earth
≥ 5,000 µF 50v

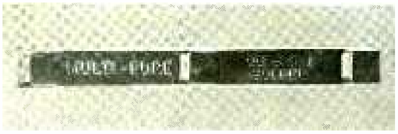
Multicore– the complete answer for printed circuit soldering.

Most printed circuit soldering problems can be avoided by using quality products and seeking quality advice. Naturally, we suggest ours. First, let's talk about quality products.

Extrusol and Multipure.

EXTRUSOL Extruded Bars and MULTI-PURE Cast Bars are made from specially processed ultra high purity solder. EXTRUSOL bars and pellets are protected by plastic film from the moment they are made to the moment they are used. And MULTI-PURE bars are probably the smoothest and brightest solder bars you will ever see.





Liquid Fluxes.

We have a whole family of them, so you're bound to find the right one for your job. One of our latest is PC 26, exceptionally fast but non-corrosive and non-conductive. Eliminates "icicles" and "bridging."

Right, those are the products. Now for the advice. And we can't really say any more than: if you've a soldering problem or question, call us. We really do have all the answers and the widest range of problem soldering test equipment.

ERSIN Flux No.	Type	Solids Content w/w	Specifications
ROSIN BASE			
0360	non-activated	38%	MIL-F-14256D Type R; DTD 599A DIN 8527 F-SW 31
5381	mildly activated Chloride and Bromide free	25%	MIL-F-14256D Type RMA; DTD 599A
304D	mildly activated	10%	DIN 8527 Type F-SW 32
304W	Halide Free	25%	DTD 599A
PC.21A	activated	38%	DTD 599A; DIN 8527.F-SW 26
PC.26	activated (extra fast)	15%	DTD 599A; DIN 8527.F-SW 26
366	activated (extra fast)	38%	Meet DIN 8511 Type F-SW 26 and
366A-25	activated (extra fast)	25%	pass DTD 599A Corrosion Test
ORGANIC ACID			
PC.101	water base	12%	Water soluble residues must
PC.112	solvent base, fast drying	9.5%	be removed after soldering.
INORGANIC ACID			
ARAX	water base extremely active	40%	Used with most "very difficult to solder" metals. Not for electronics assembly joints.

Ersin Multicore Savbit.

This cored solder has countless uses. For instance, it avoids erosion of copper plating and wires as well as prolonging the life of soldering iron bits.

Solderability Test Instrument.

Already used by major electronic companies throughout the world, this novel instrument saves production costs by controlling solderability of component leads which, unlike a printed circuit, cannot be assessed by a simple "immersion and inspection" test.

Multicore Soldering Chemicals.

We make a complete, compatible range to assist in soldering processes. They clean, protect and preserve.

For full information on these or any other Multicore products, please write on your company's letterhead direct to:
Multicore Solders Limited, Maylands Avenue, Hemel Hempstead, Hertfordshire HP2 7EP.
Tel: Hemel Hempstead 3636. Telex: 82363.