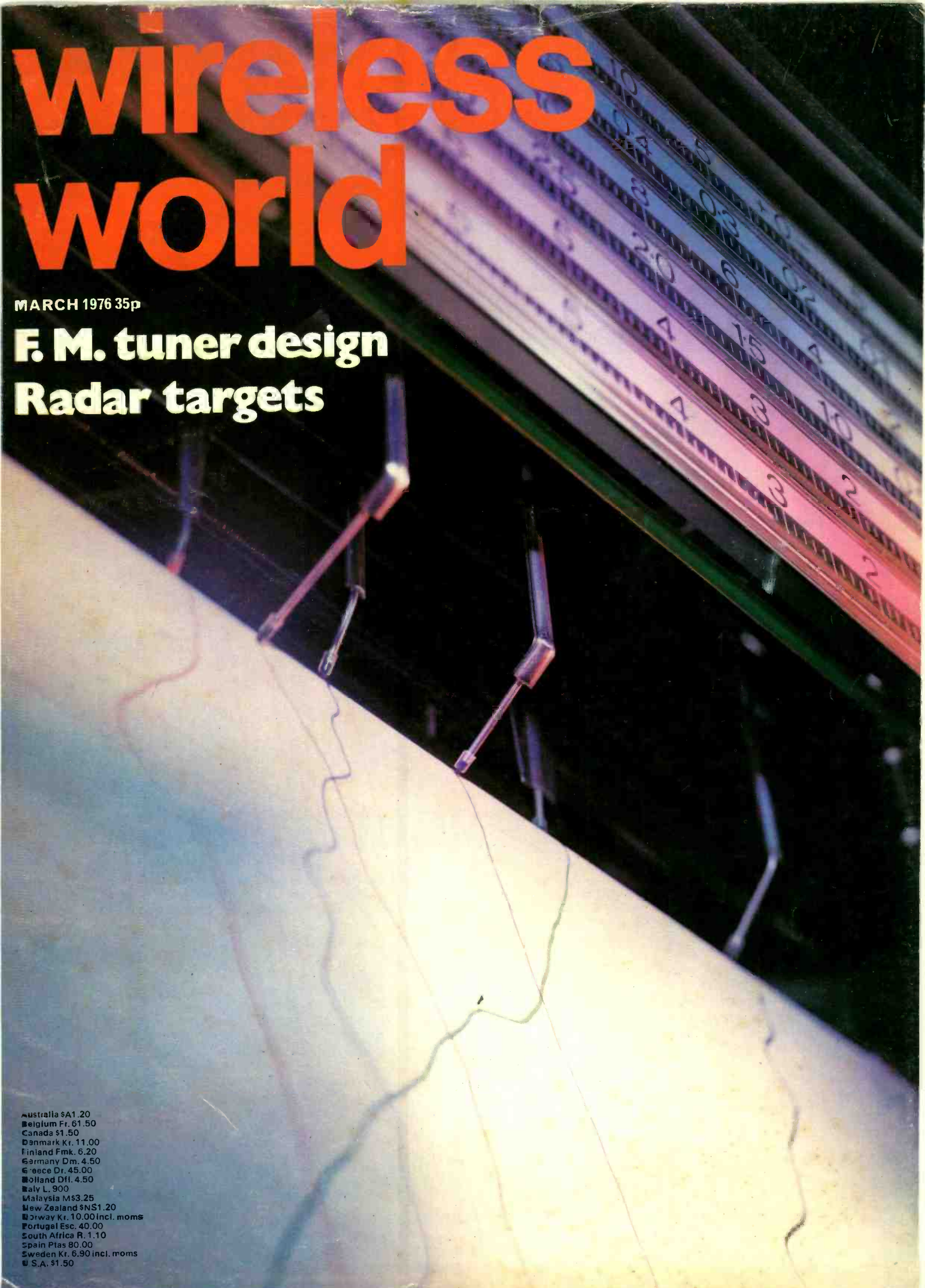
wireless world

MARCH 1976 35p

F. M. tuner design
Radar targets



Australia $A1.20
Belgium Fr. 61.50
Canada $1.50
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Finland Fmk. 6.20
Germany Dm. 4.50
Greece Dr. 45.00
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Sweden Kr. 6.90 incl. moms
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mi's TF 2015 a wider view of signal generation...

The TF 2015 is a versatile 10-520 MHz signal generator with calibrated a.m. and f.m. and an accuracy of output level setting normally found only in instruments costing three times as much. A special system gives very fast tuning across the bands yet provides smooth control within the narrowest of passbands. Leakage radiation is carefully screened out to enable accurate measurements to be made even at levels below 1μV.

Matched Synchronizer

The clip-on Synchronizer TF 2171 transforms the performance of TF 2015 into the equivalent of a synthesizer at less than half the comparable cost. The frequency is locked to crystal stability and can be dialled in 100 Hz. steps. Tuning is quick and easy – set the decade dials, switch to "lock" and tune the generator to the approximate frequency and the synchronizer will finish the job for you. Now you can change the frequency by up to 2% using the decade dials **without touching the generator** - and all to an accuracy of 2 parts in 10^7. It stays locked all day and doesn't degrade **any** aspect of the generator performance.

I.F. Probes

These are an invaluable aid to the testing of receivers with squelch or battery economiser circuits. These circuits are inactivated when the crystal-controlled signal from the probes is brought into the proximity of the receiver's i.f. strip. This makes it easy to tune the generator to a receiver when its channel frequency is unknown. The probes can also be used to check exact tuning by adjusting for zero beat.

mi: THE SIGNAL GENERATORS

MARCONI INSTRUMENTS LIMITED

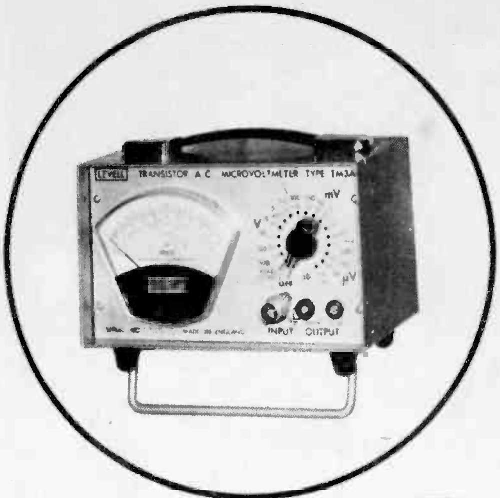
Longacres, St. Albans, Hertfordshire, England, AL4 0JN · Telephone: St. Albans 59292. Telex: 23350.

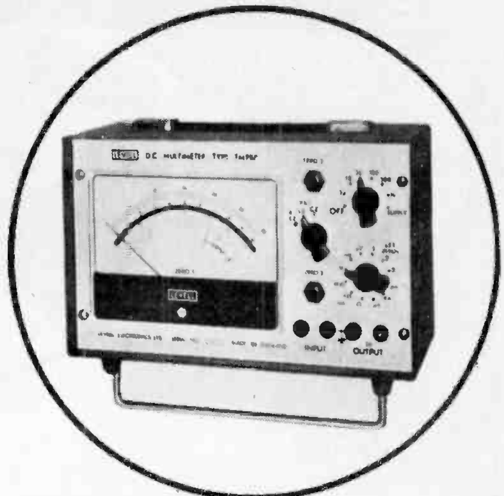
A GEC–Marconi Electronics company.

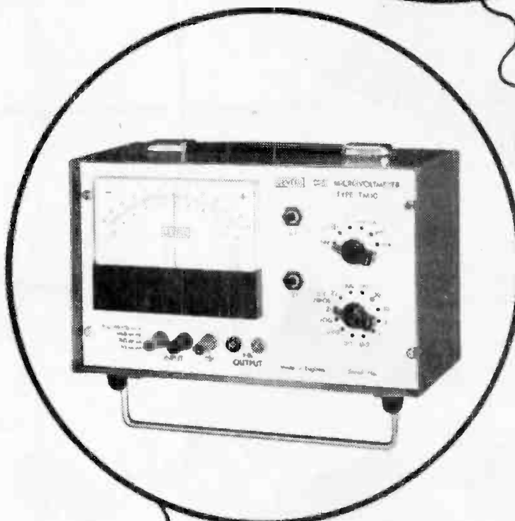
WW—001 FOR FURTHER DETAILS

LOW COST VOLTMETERS from the range of LEVELL

LEVELL PORTABLE INSTRUMENTS







A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES: 15µV, 50µV, 150µV . . . 500V. Acc. ± 1% ± 1% f.s.d. ± 1µV at 1kHz — 100, — 90 . . . +50dB.
Scale — 20dB/ + 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4Hz to 1MHz above 500µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV >4 3MΩ<20pf. On 50µV to 50mV > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

type TM3A **£77** type TM3B **£88**

D.C. MULTIMETERS

VOLTAGE RANGES: 3µV, 10µV, 30µV . . . 1kV. Acc. ± 1% ± 1% f.s.d. ± 0.1µV. 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: 3Ω, 10Ω, 30Ω . . . 1GΩ linear Acc. ± 1% ± 1% f.s.d. up to 100MΩ.
RECORDER OUTPUT: 1V at f.s.d. into > 1kΩ on LZ ranges.

type TM9A **£110** type TM9BP **£125**

BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV . . . 3V. Acc. ± 4% ± 1% f.s.d. at 30MHz. — 50dB, — 40dB, — 30dB to + 20dB. Scale — 10dB/ + 3dB rel. to 1mW/50Ω. ± 0.7dB from 1MHz 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 **£125** type TM6B **£135**

D.C. MICROVOLTMETERS

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

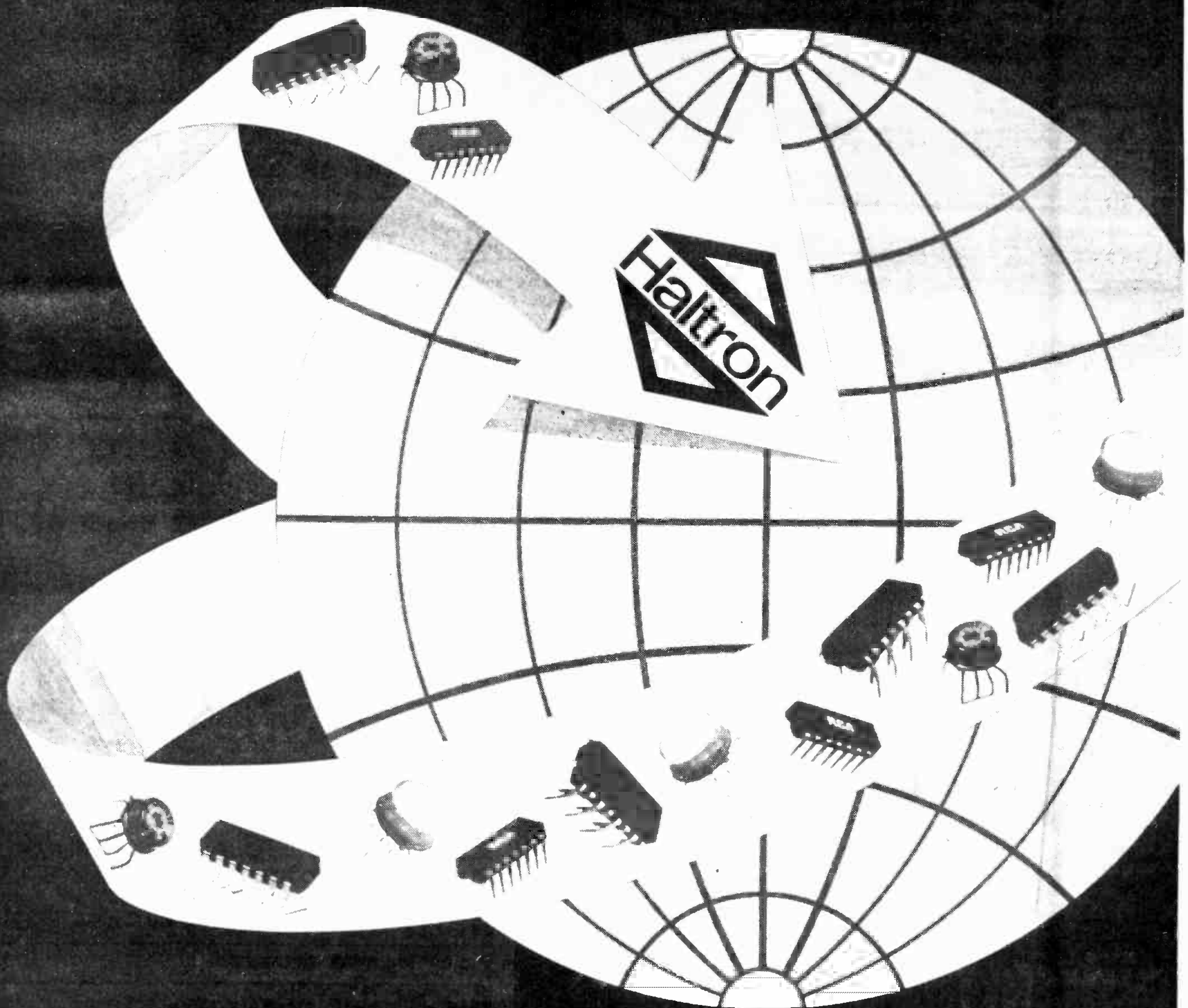
type TM10 **£73**

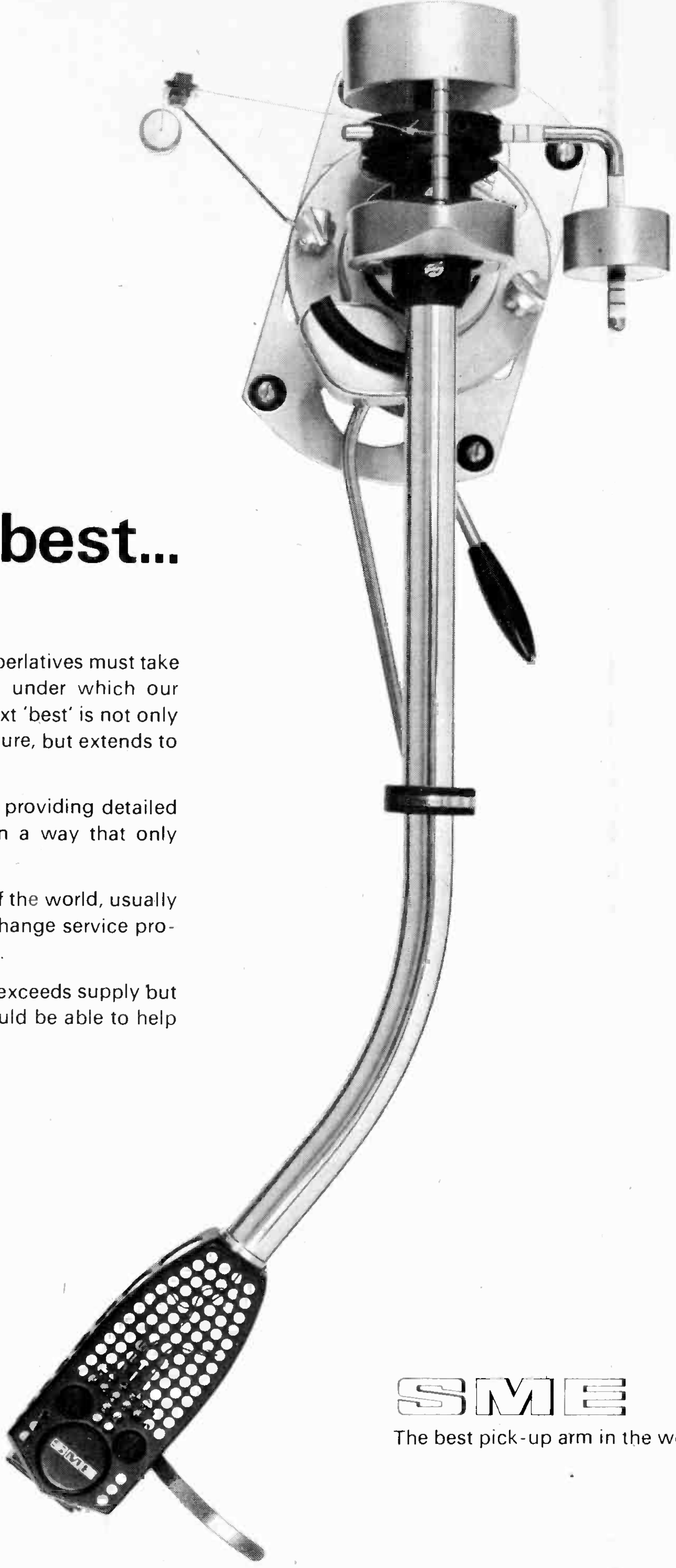
These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 83mm scale meters, and case sizes 185x110x130mm. B types have 127mm mirror scale meters and case sizes 260x125x180mm.

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

Prices include batteries and U.K. DELIVERY. VAT extra. Optional extras are leather cases and mains power units, send for data covering our range of portable instruments.

WW—010 FOR FURTHER DETAILS


Haltron



Good, better, best...

All things are a matter of compromise and superlatives must take account of it. Few will dispute the slogan under which our precision pick-up arms are sold. In this context 'best' is not only a reference to quality in design and manufacture, but extends to service which we believe is unequalled.

Every week we send out hundreds of letters providing detailed advice and answering customers' queries in a way that only specialisation permits.

Spares are despatched promptly to all parts of the world, usually the same day, and a recently introduced exchange service provides new arms for old on very attractive terms.

Because of these things demand sometimes exceeds supply but delivery is yet another matter in which we should be able to help if you write to

SME Limited · Steyning · Sussex · England

SME

The best pick-up arm in the world

LTD/S36

WW 012 FOR FURTHER DETAILS

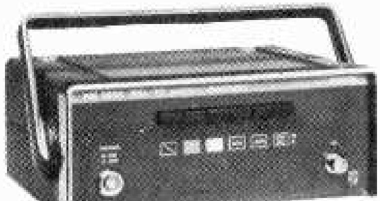
PHILIPS

Follow the 'Philips Plus' way to prosperity

Now with HP restrictions eased

Prepare for an increase in trade by making sure that your workshop is the most efficiently equipped and that your service engineers' home visits are the fastest and most effective. Get these Philips instruments now. You won't find better value for money.

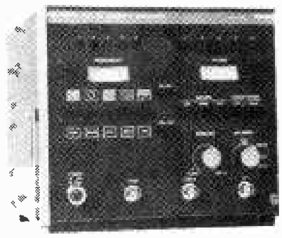
NEW



PM5501 PAL TV Pattern Generator Price £149

Extremely light, portable instrument for service in customers' home. 5 different test patterns for colour and black white installation and service. RF output signal switchable: VHF Band III and UHF Band IV. 1 kHz tone for sound performance checks.

PM5509 PAL TV Pattern Generator Price £350



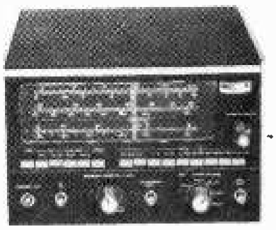
The ultimate in pattern generators. Full IF coverage; band I, III, IV and V. Electronic tuning with 5 preset channels. 10 test patterns (colour and black white). Adjustable chroma burst and HF-amplitude. Special sync, video and VCR outputs.

NEW

PM6456 FM Stereo Generator Price £192

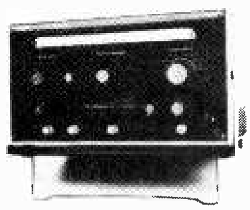
Complete stereo signal. L & R signal. Internal L.F. modulation: 1 & 5 kHz. External stereo modulation possibility. X-tal controlled pilot. Adjustable multiplex signal.

PM5324 HF Generator Price £297

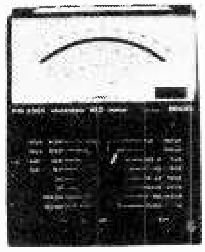


Frequency range 100 kHz – 110 MHz. X-tal calibration. Special band spread ranges. High frequency stability. Electronically stabilised output max. 50 mVrms in 75 Ω. Facilities for internal and external AM and FM modulation.

PM5334 TV Sweep Generator Price £399



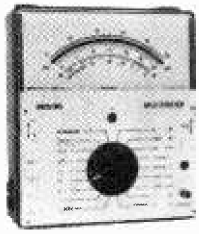
8 frequency ranges, 3 MHz – 860 MHz. Sweep width continuously adjustable over selected range. Sweep frequency adjustable, 8 – 50 Hz. One variable and 3 fixed markers. Signal frequency is accurate and thermally stable. Stabilised output into 75 Ω load.



PM2503 Electronic Multimeter Price £69

AC DC voltage ranges 100 mV–1 kV. AC DC current ranges 1 μA – 1 A. Resistance ranges 100 Ω – 10 M Ω. 2–3% accuracy on all ranges. Resistance measurements: unique linear scale. No zero adjustment necessary. Automatic polarity indicator.

PM2412 General Purpose Multimeter Price £48



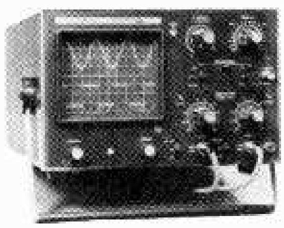
DC voltage 300 mV – 1000 V.
AC voltage 3 V – 600 V.
DC current 10 mA – 6 A.
AC current 100 mA – 6 A.
(a.c. values f.s.d.)
Resistance 1 Ω – 10 M Ω. Tautband 40,000 Ω V. suspension-type meter.

NEW

PM2513 Low Cost Digital Multimeter Price £95

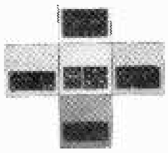
DC voltage ranges 0.2 – 1000 V. AC voltage ranges 0.2 – 600 V. AC DC current ranges 0.2 mA – 2 A. Resistance ranges 200 Ω – 2 M Ω. Full circuit protection. Provision for temperature measurements, —60 to 200 C.

PM3110 10 MHz dual-trace oscilloscope Price £243



Fully automatic triggering, including TV line and frame. Large 8 x 10 cm screen. 10 MHz 50 mV, 5 MHz 5 mV. Overload protected. Ergonomic styling and lightweight construction.

The Philips Plus is the quality of design, specification and appearance – particularly in terms of human engineering – of every instrument. A total test and measuring range capability, which includes 'scopes, meters, counters, pulse generators, power supplies, recorders and generators. The ability to supply all the user's needs from a single source.
All prices exclude VAT.
For prompt delivery of any of these instruments, send us your cheque. If you require further information, use the reader reply service or write to or telephone



Pye Unicam Ltd
Philips Electronic Instruments Dept.
York Street Cambridge England CB1 2PX
Tel: Cambridge (0223) 58866 Telex: 817331

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On balance the best

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The all in one 16mm/35mm Telecine
for 625/525 Standards.
Instant Start – Fast Shuttle – Still Frame
Automatic Facilities.

Cintel 9000

Economy with Super High Band
Broadcast Performance
the obvious choice for the
cost and quality conscious user.

RANK CINTEL

Watton Road, Ware, Hertfordshire, SG12 0AE, England. Telephone: Ware 3939, Cables: Rank Ware, Telex: 81415.
A trading unit within RPI Ltd.

WW — 080 FOR FURTHER DETAILS

In a range of multimeters with pointers whats the point of one without

The point is that for some applications, a digital indicator makes a lot of sense. That's why AVO makes the the Digital Avometer DA 114. It offers you a choice of DC, AC and resistance ranges at high accuracy. High input impedance, comprehensive built-in calibration check facilities, two versions – one for mains operation, the other with built-in rechargeable battery and mains operation.

It offers you the best of the traditional AVO features – reliability, ruggedness, range, repairability, readability and, perhaps above all, AVO accuracy. Plus the best of the new generation multimeters.

As you can imagine, our designers took a long hard look at digitals before they produced a Digital Avometer. For instance, they realized that the displays on some digital meters could be a positive nuisance in many applications. After all, you don't always need accuracy to the 'nth degree – so where you'd normally just glance at an analogue pointer you could find yourself screwing your eyes up at a diminutive and faintly glowing digital. A few hours of that and the average engineer would be begging for the return of his old analogue meter.

That's why we gave the DA 114 numerals big and bright enough to read across a room. And it's the reason that AVO, while producing one of the few 'serious' digital multimeters, still produces what is probably the widest range of analogue multimeters for the electronics engineer.

The AVO range for Electronics Engineers includes Model 8 Mk 5, Model 72, and the high impedance models EM 272 and EA 113.

AVO

For full details of the range, contact your distributor or write to:
AVO Limited, Archcliffe Road, Dover, Kent CT17 9EN. Telephone: Dover (0304) 202620. Telex: 96283

Thorn Measurement Control and Automation Division

WW — 114 FOR FURTHER DETAILS

GRAMPIAN REPRODUCERS LTD. HANWORTH TRADING ESTATE FELTHAM, MIDDLESEX TELEPHONE 01-894 9141

X209

WW—061 FOR FURTHER DETAILS

A message for dealers in exclusive high quality audio equipment – everywhere.

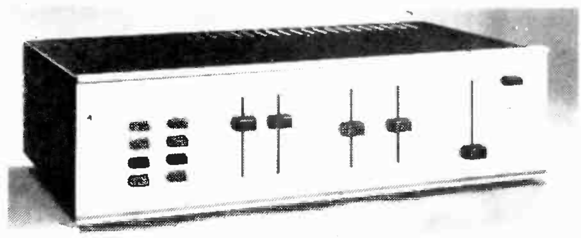
It is now proposed to expand the distribution of RADFORD products by supplying from the factory in BRISTOL direct to franchised dealers outside the United Kingdom.

If you have a discriminating clientele looking for the finest audio equipment and loudspeaker components available, you could profit from a direct RADFORD franchise.

Write today for details and leaflets.

Radford Audio Ltd
Ashton Vale Road
Bristol BS3 2HZ England

RADFORD



ZD22
Stereo Pre-amplifier Control Unit
A stereo pre-amplifier of virtually zero distortion. Inputs for disc, tuner, and two tape machines.
Size 17" x 4¾" x 10" deep. £145.00

HD250 Stereo Integrated amplifier
Incorporates ZD22 pre-amplifier with low distortion power amplifier of 50 watts per channel into 4-8 ohms load. Headphone output. Illustrated above.
Size 17" x 4¾" x 11". £195.00

ZD100 Power amplifier
Power output 120 watts in 4 ohms and 75 watts into 8 ohms. Distortion less than 0.004% up to clip level.
Size 17" x 4¾" x 13". £175.00

ZD200 Power amplifier
Power output 250 watts into 4 ohms and 150 watts into 8 ohms. Distortion less than 0.004% up to clip level.
Size 17" x 7" x 13". £295.00

WW—030 FOR FURTHER DETAILS

Bridge in a thousand

One part in one thousand is the accuracy of Universal Bridge B224 from 10 ohms to 1 gigohm, 0.1pF to 10 microfarads and 1 nanomho to 100 millimhos. Monitor its 1592Hz source frequency and also get 0.1% from 1mH to 10kH. With reducing accuracy, coverage extends above and below the ranges quoted, on R, C, G and L. Resistive and reactive terms read simultaneously. Sockets for 200Hz—50kHz operation. Internal rechargeable battery. Many other valuable features detailed in Data Sheet B224.

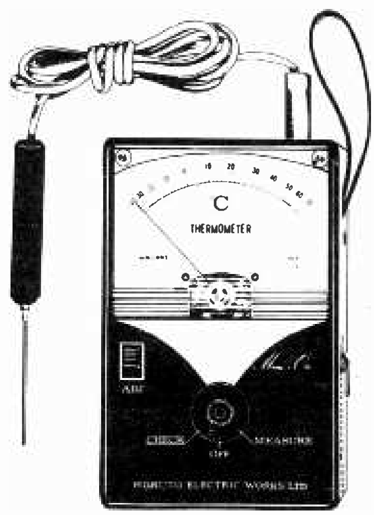
WAYNE KERR

A member of the Wilmot Breeden group

For more information phone Bognor (02433) 25811, or write to Wayne Kerr, Durban Rd., Bognor Regis, Sussex PO22 9RL

WW — 081 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 with carrying case, Probe and internal 1½ volt standard size battery.

Model "Mini-Z 1" measures from—40° C to + 70° C
Model "Mini-Z 2" measures from—5° C to + 105° C
Model "Mini-on Hi" measures from + 100° C to + 500° C
PRICE £20.00 each (VAT 8% EXTRA)

Write for further details to

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

WW—059 FOR FURTHER DETAILS

Reed Relays

1—10,000 for same day shipment

Prices from 49p 100 rate

Military grade-
ask for NATO conversion list

Custom design specials-
7—10 days for samples

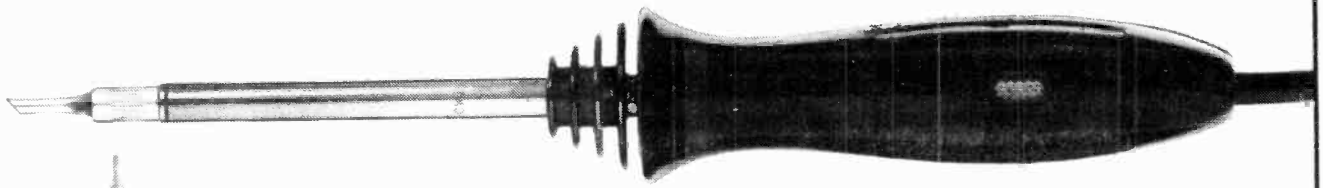
15 years experience

Equivalents to most European & U.S. type available

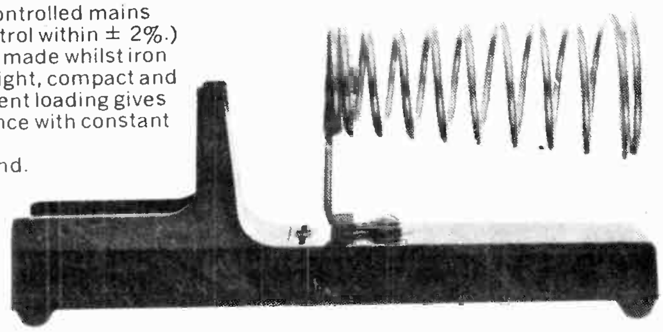
Erg Components Telephone: 0582-62241
Luton Road, Dunstable, Bedfordshire, LU5 4LJ England.

WW—108 FOR FURTHER DETAILS

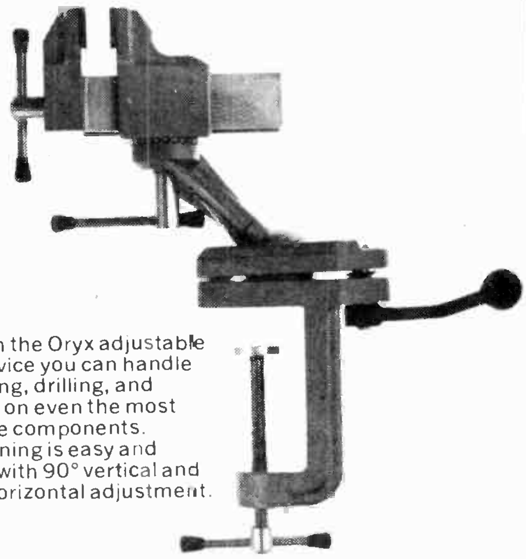
The Greenwood guide to professional soldering.



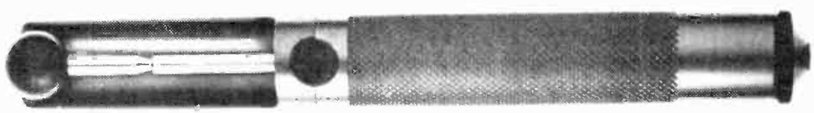
The Oryx 50. A temperature controlled mains soldering iron. (Temperature control within ± 2%.) Adjustment (200°–400°C) can be made whilst iron is operating using the same tip. Light, compact and easy to handle. A large 50W element loading gives rapid heating and high performance with constant tip temperature.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



The 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.



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, write to address below.

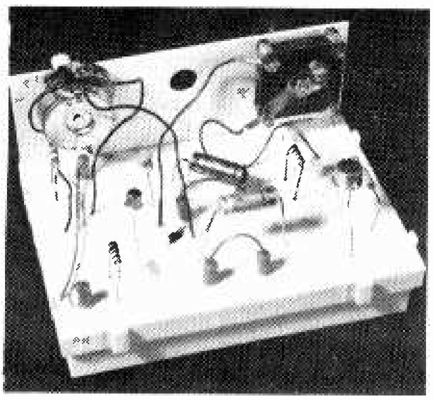
Greenwood Electronics

Portman Road, Reading RG3 1NE. Tel: Reading (0734) 595844. Telex: 848659.

Due to expansion we are seeking additional distributor/stockists.

WW—113 FOR FURTHER DETAILS

S–DEC Solderless Breadboard 50p off + free solder board.



Designing circuits? It's easy with S-DEC! NO SOLDERING – just plug your components in. So they can be re-used indefinitely. As used by the Schools Project Technology Courses.

FREE with this offer – booklet giving a range of quick-assembly circuits for the S-DEC, including radio receiver; 3-stage amplifier, and many others.
Also, FREE control panel for mounting switches, lamps etc.

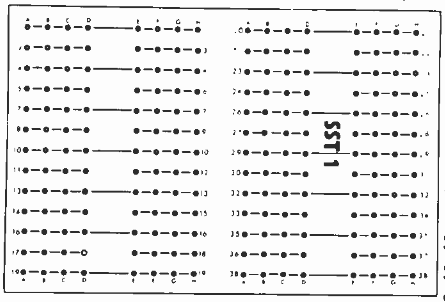
This offer also applies to the T-DEC, U-DEC, and the T- and U- super solder boards. Simply take this page to your local dealer, or send it direct to us.

S-DEC BREADBOARD + FREE SUPER SOLDER BOARD. £1.48 (send £1.80 to cover postage, packing and V.A.T.).

T-DEC + SUPER SOLDER BOARD £3.87
U-DEC A + SUPER SOLDER BOARD £4.31
U-DEC B + SUPER SOLDER BOARD £7.71
} covers postage, packing and V.A.T.

To use ICs with T and U-DEC A, 16 DIL adaptor with socket, £1.92; 10 to 5 adaptor with socket, £1.80.

NEW Low cost PB DEC Super Solder Boards.



When your circuit is proved working on your DEC, simply plug the components into a Super Solder Board – a fibre-glass, drilled, roller-tinned finished circuit board using the same layout as the DEC breadboard. Once the components are plugged in, in the same positions as on the DEC, solder! (No cutting or drilling of contact rails.) The result – a perfect, finished, printed circuit board.

Super-solder boards are available in packs of 1 or 3 off.

SUPER SOLDER BOARD SSS-1 for use with S DEC circuits, only: 1 off £0.39; 3 off £1.00.

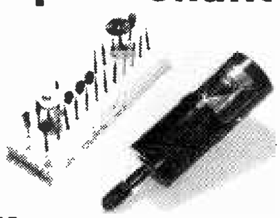
SUPER SOLDER BOARD SST-1 for discrete circuits: 1 off £0.59; 3 off £1.60.

SUPER SOLDER BOARD SSU-1 for discrete and DIL circuits: 1 off £0.59; 3 off £1.60.

SUPER SOLDER BOARD SSN-1 for discrete and DIL sockets. Up to 40-lead 0.6 in. DIL, and for the direct insertion of TO5 packages or 0.1 in. lead-out sockets: 1-off £0.69; 3-off, £2.00

When ordering, please also send £0.40 for post, packing and V.A.T.

Expo Reliant Drills and Kits.

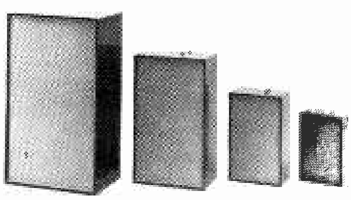


Powerful, miniature, low-voltage drills capable of sawing, grinding, burring, brushing and polishing – as well as drilling holes up to 3 mm. diameter through virtually any material.

The Expo drill operates from a power supply of 12V d.c. or, using the Titan transformer/rectifier unit (0220), from a.c. mains supplies at 200-250V a.c., 50Hz.

The Expo Reliant Mini Kit, consists of the Reliant Standard Drill (0150) and a set of 20 assorted tools (0305), providing a powerful, versatile kit for use both by the professional and the hobbyist. Prices: £9.40 including postage and packing, and V.A.T.

Zippy Cabinets. Ideal For All Assembly Cabinets.



Robust ABS plastic assembly boxes, front panel designed to be cut and drilled, slots inside for mounting circuit boards attractive colouring and styling.

TP1 80 x 50 x 30mm £0.72 1 OFF   TP3 155 x 90 x 50mm £1.62 1 OFF
TP2 115 x 65 x 40mm £1.27 1 OFF   TP4 210 x 125 x 70mm £2.27 1 OFF

Discount for quantity prices include Post & VAT

Resist Coated Circuit Board Lowest price in U.K.
12" x 12" Glass Fibre 1/16 coated with resist £1.50 each.

Circuit Board Manufacture, Fast delivery, Low Price, any circuit board made in days.

NIGHT GUARD.
Dimmer with a difference, Guards your home from theft, SET, darkness comes, lights come on, dawn, lights go off. Dims room lights up to 500 watts. £5.95 + £1.05 VAT & POST

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16 DIL ADAPTOR	£0.99
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2410

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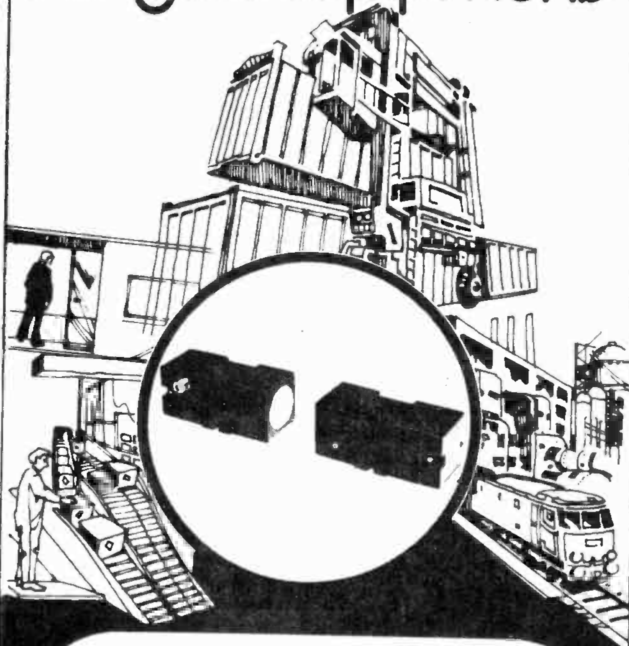

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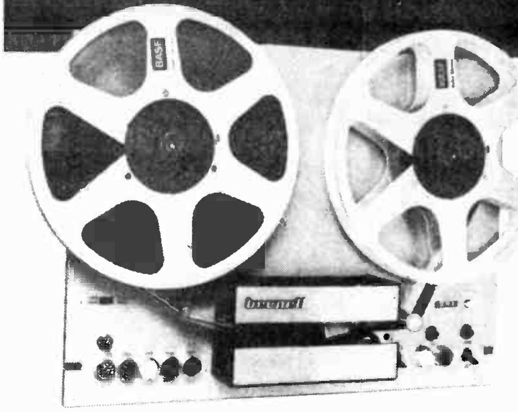

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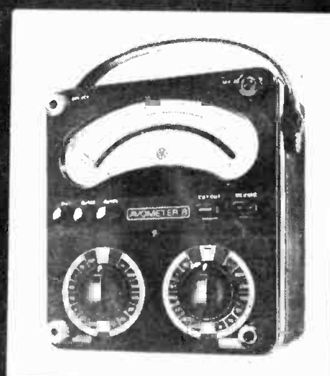

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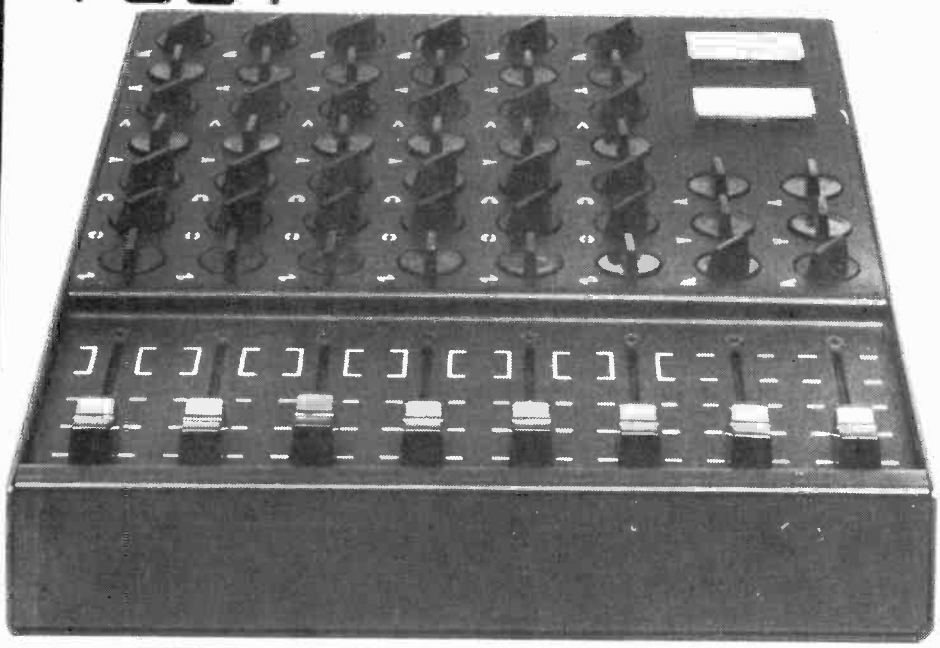

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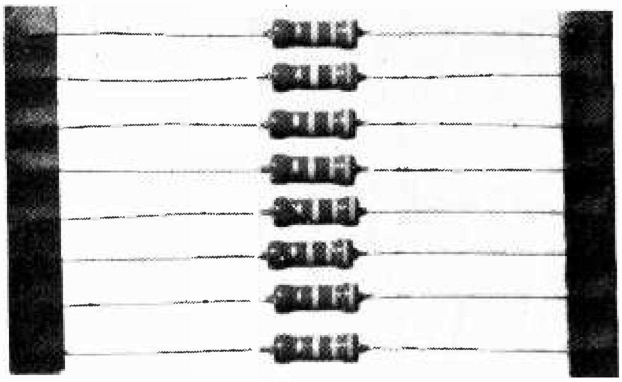

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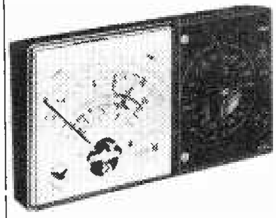

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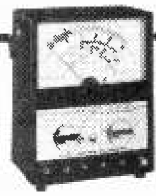

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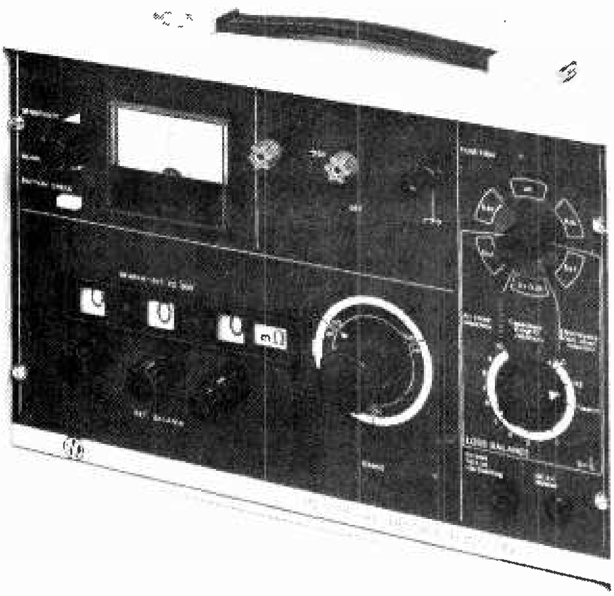

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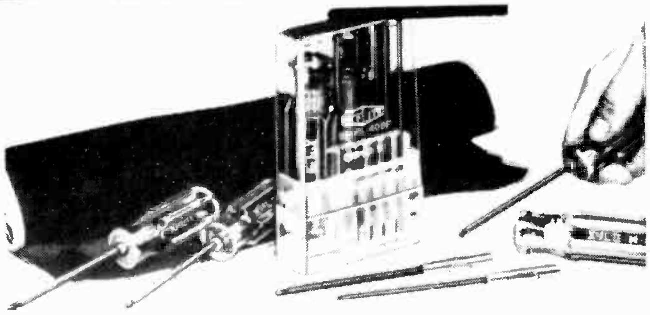

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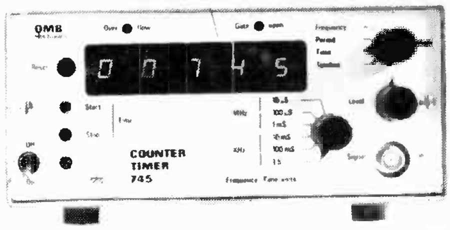

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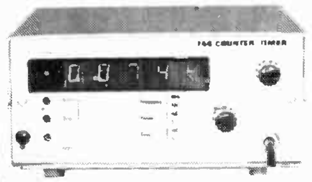

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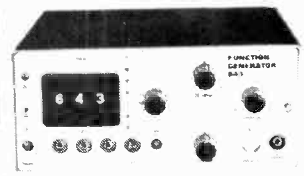

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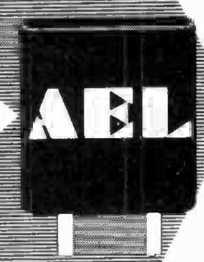

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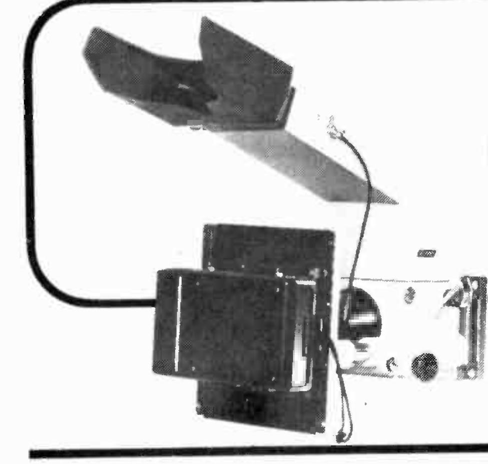

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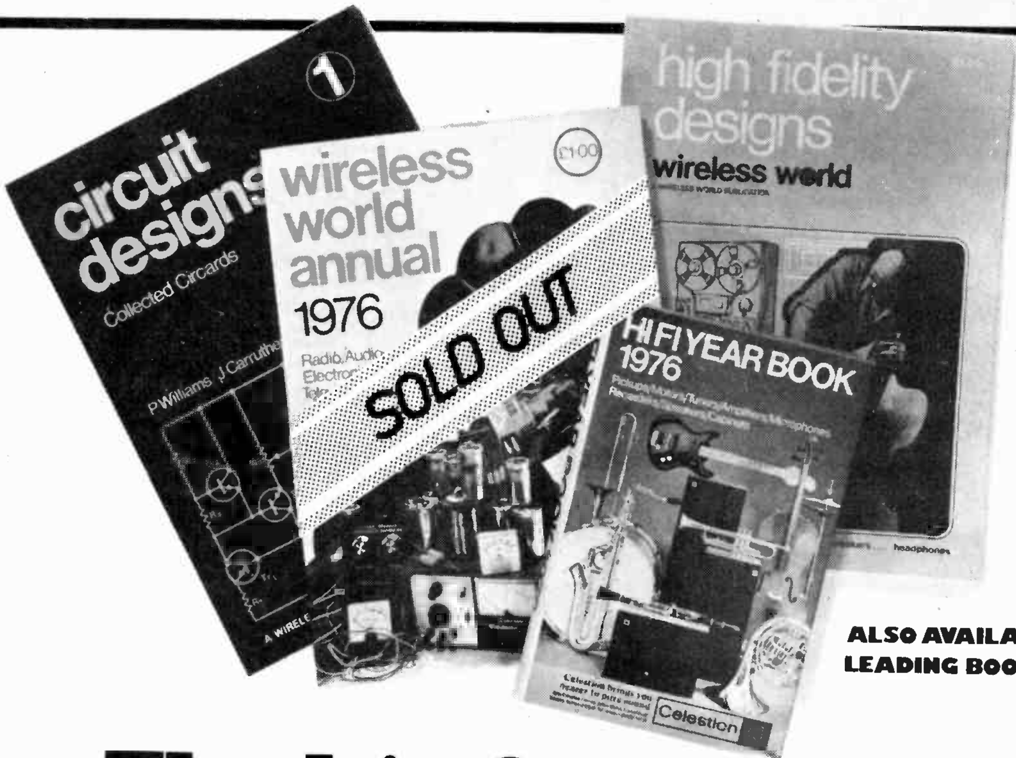

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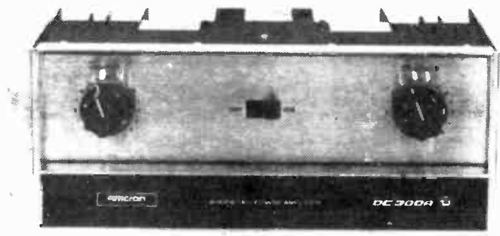

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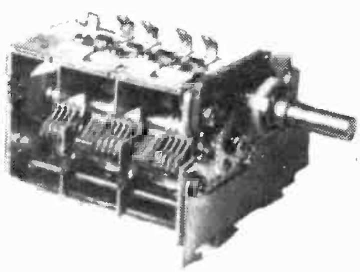
NT3302 · fet fm tunerhead +AM gang



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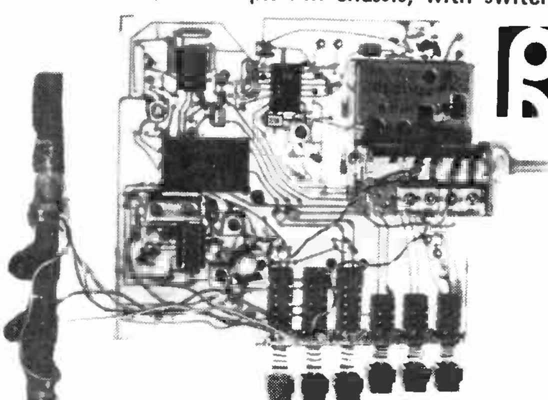

distributed by Ambit international, 37 High St Brentwood, Essex. tel:216029, tlx:848095.
ALL 9000 chassis enquiries to Ambit please.
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ERA

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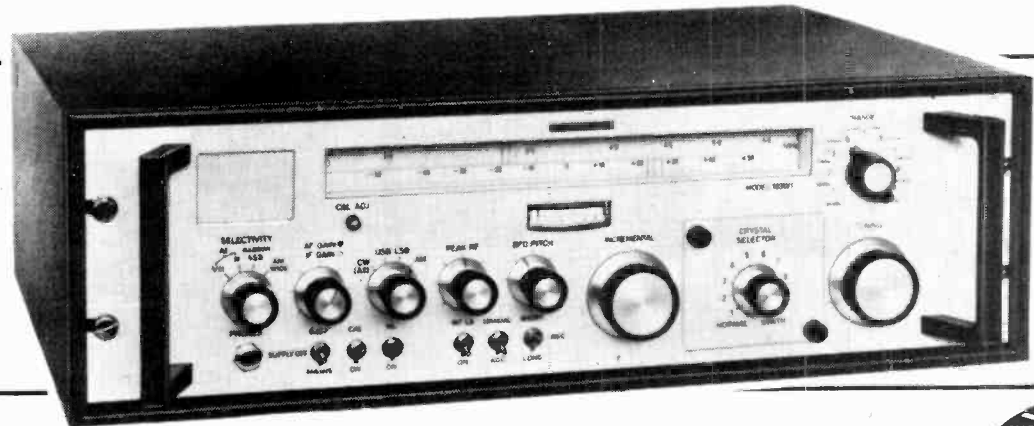

Eddystone Radio Limited
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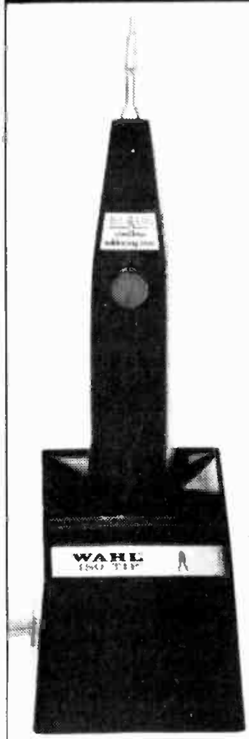

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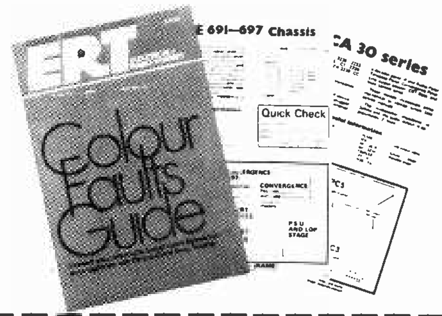

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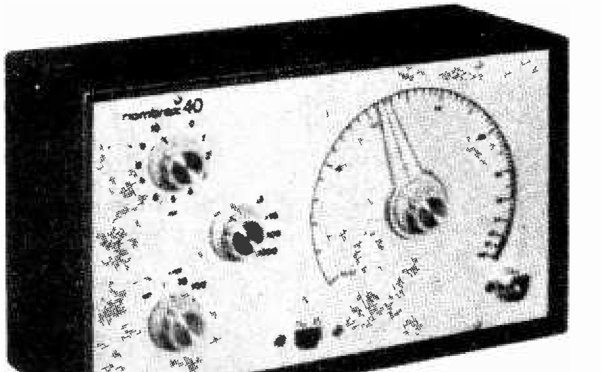

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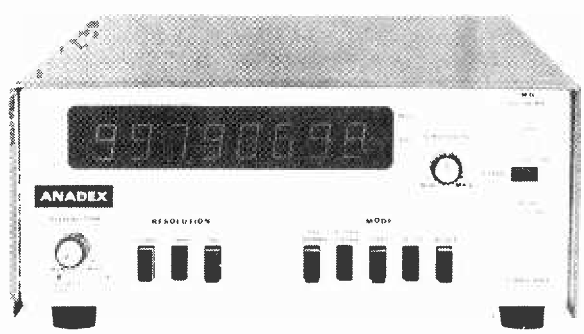

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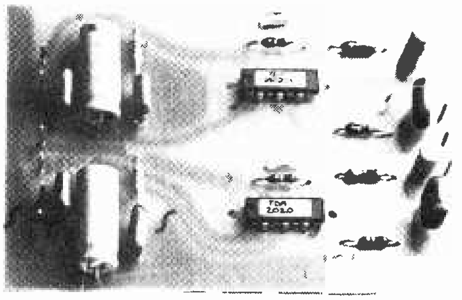
SGS Audio ICs



The much heralded TDA2020 is here. And just to make sure that you don't go wrong, so is the SGS application test circuit PCB for a stereo 15 + 15 (RMS) Hi Fi amplifier.

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BD378	pnp		32p
BD515	npn	2A/45v	27p
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BD609	npn	10A/90v	70p
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We've moved

To accomodate expanded R & D facilities, AMBIT has moved sales and administration to 25 High St. Brentwood. The existing 37 High Street premises are retained for the engineering activities.

One of the first products of this move has been the development of a TV sound tuner, from an "off air" system, using its own varicap UHF TV tuner, with ICIF amplifiers and block filters by TOKO. And then one of our best ever circuits - an electronic touch tuner, with scanning mode, and facilities for 6 preset stations. The unit is suitable for use with FM, and now AM of course, and offers a complete tuner system without any moving parts. Selection is by means of touch tuning in all cases, with manual scan and preset switching automatically interlocked.

Our R&D facilities are available for general consultancy to OEMs: further details on application. Standard project estimation fee, including project evaluation comment data is £15.00 payable in advance.

Modules & Kits

New modules:

8011	Totally touch tuned varicap controller built £14.99.
8005	Larsholt tunerset accesory unit, with pilot tone filter and audio stages, rectifier, IC stabilizer, meter driver circuits. £4.99 (kit)
8001	55kHz low pass filter (mpx birdy filter) £2.35 built £1.75 (kit)
2001	Stereo scratch and rumble filter, with continuously variable operating frequencies. £5.80 (built) £4.60 (kit)
3000	Stereo control preamp - a wide dynamic range, low distortion AF preamp, with vol, bal, bass and treble controls. kit £5.78
2020k	The TDA2020 stereo amp kit photographed on the left. £7.85
7700	TV off air UHF sound tuner - built £26.00 (4 preset stations)

9000 kit	AM/FM mpx tuner chassis, with mech. tuner	£17.50
7004 kit	MW/LW varicap tuner module, inc. ferrite rod	£9.95
7252	HiFi MOSFET FM tuner module by Larsholt	£24.00
7253	HiFi FET FM tuner module inc decoder	£24.00
5600	Hi Q MOSFET varicap tunerhead by TOKO	£11.25
EC3302	FET tunerhead from TOKO	£5.00

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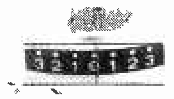

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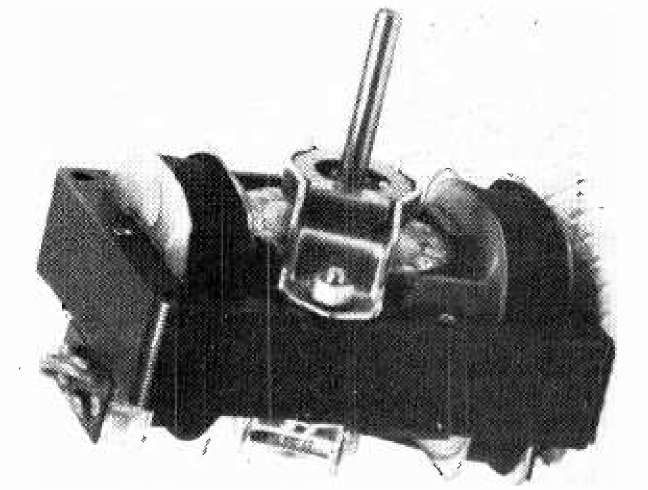

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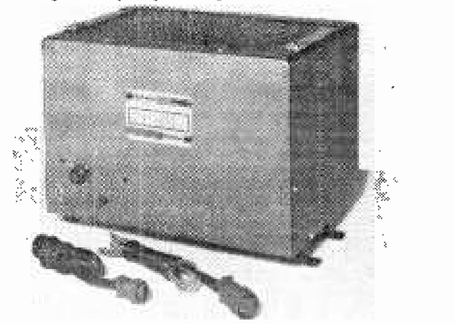

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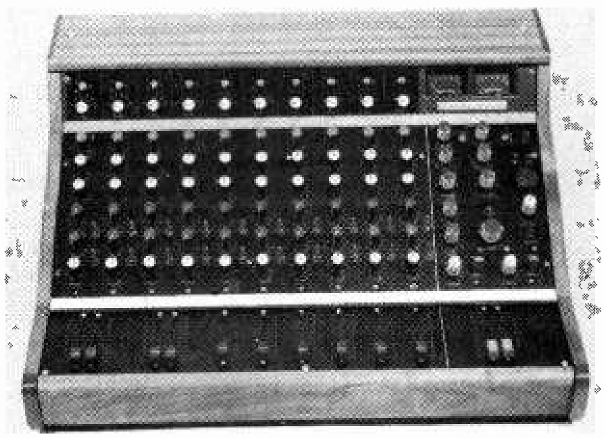

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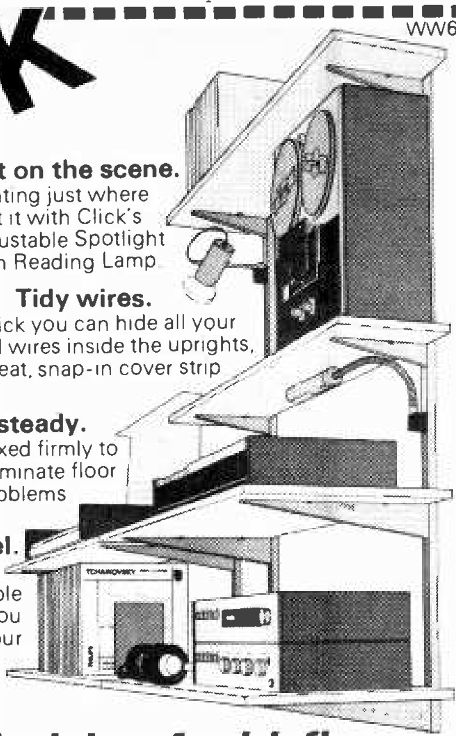

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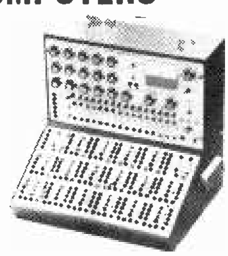

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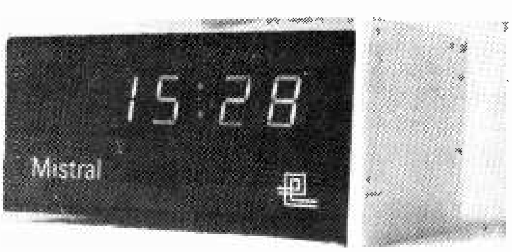

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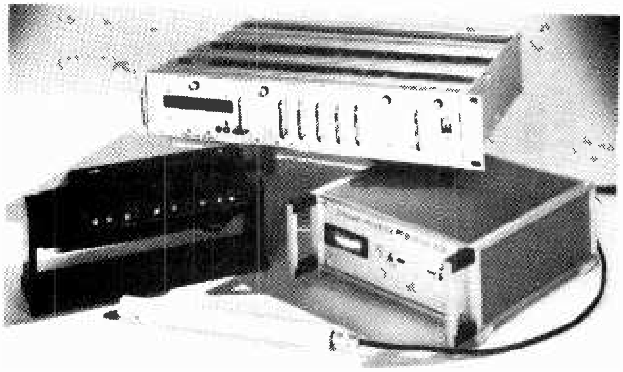

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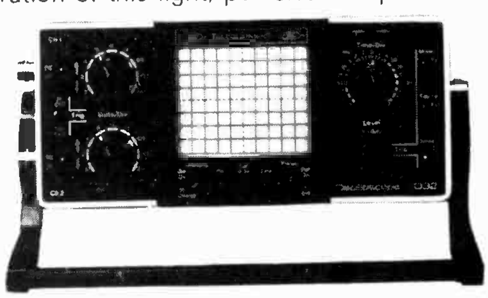
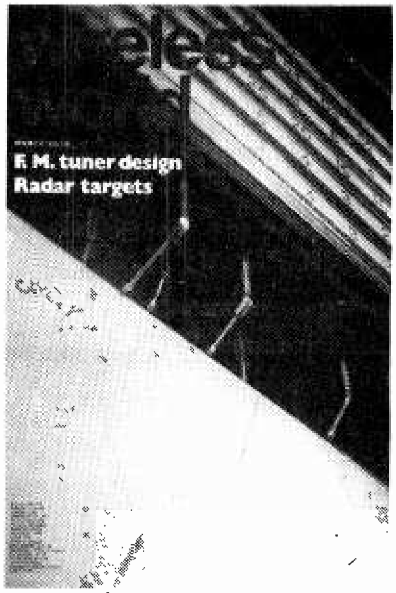


wireless world

Electronics, Television, Radio, Audio

MARCH 1976 Vol 82 No 1483

Contents



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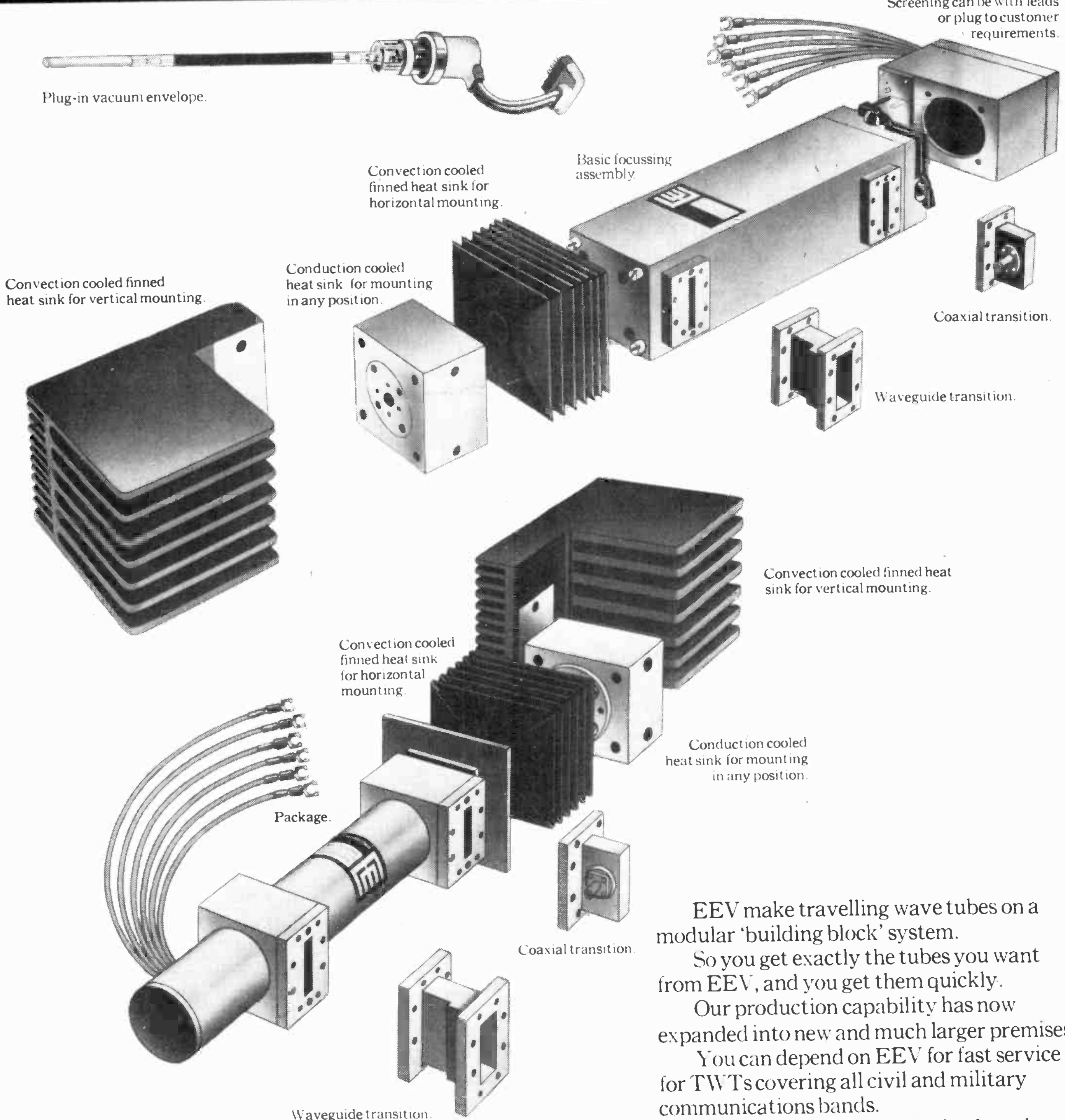

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Our daily bread

Birmingham University was recently advertising for an electronics technician, to construct and maintain electronic instruments, for a salary of £2013 rising to £2343 p.a. There are, in fact, many employers expecting to get qualified and experienced electronics people for less than £2500. These figures are pathetically low, considering the skilled nature of the work and the kind of pay now being received by unskilled and semi-skilled workers in other fields (the national average for male industrial workers is £60.80 per week). The situation for professional engineers in our field is similarly discouraging. Last year's survey of chartered engineers by the Council of Engineering Institutions showed median incomes in electronic engineering ranging from £2460 at ages below 25 to a maximum of £5500 at 60 and over. For all engineers, the CEI comment that, taking into account the retail price index, over the two years up to April 1975 "there has been a reduction in the real value of income over the whole profession". Another electronics magazine has said "in Britain today your certificate, diploma or degree in technology is a passport to poverty".

What can we do about it? Individual solutions include emigration, "moonlighting" and self-employment. For most of us, however, the best hope lies in collective action. There are about 50,000 electronics people in the UK — a small number but considerable in its influence on society. We could benefit from a trade union of our own. At present electronics engineers and technicians can belong to unions associated with the particular sectors of industry and public services in which they work. As such they are fragmented and cannot speak with one voice. But simply to press for higher pay through collective bargaining is not enough. Such action tends to be negated by counter-action from other groups of workers anyway. It must be backed up and psychologically justified, first by raising our inherent status and secondly by making ourselves more influential.

Status can and should be raised by improving the standard of our professional qualifications. Our "C. Eng", for example, doesn't cut much ice in other European countries, with their technical universities and doctor-engineers. Getting to be more influential is not quite so straightforward, but one opportunity comes to hand in the Government's recent move to establish "industrial democracy" in the UK — which means putting workers on the boards of companies. This system is already accepted and operating in several countries including West Germany and Sweden. An independent Committee of Inquiry on the proposal was set up in December and is now receiving evidence and representations from interested groups. UKAPE is sending in a paper on the professional engineer's point of view. Legislation could result from the 1976-77 session of Parliament after the committee of inquiry produces its report in the autumn.

Remember that white-collared intellectuals peering into oscilloscopes are just as much "workers" as blue-collared craftsmen tending capstan lathes.

Radar Targets

How objects look to radio-wave eyes

by M. W. Hosking, M.Sc., M.I.E.E.

British Aircraft Corporation, Filton

The purpose of the radar system is to obtain information about its target and, in many cases, to try and differentiate between, or identify, several objects which may have reflected the system's questing beam.

The types of target encountered are many and varied. There are high speed targets such as missiles, low-level strike aircraft and shells or bullets; there are slower targets such as victims of police speed traps or the ground itself as used in radar altimeters. Sometimes targets such as hills, trees, clouds or rain are unwanted clutter to be suppressed and ignored and, in other applications such as terrain mapping or meteorology, they are of prime interest. Whichever the case, the radar target is diverse in nature and can appear in many guises depending on the aspect angle, frequency, or polarization with which it is viewed.

Consequently, much work has been devoted over the years to obtaining both theoretical and practical information about the radar target and it still forms an important area of study. In addition, the subject holds much interest and also happens to be one which has occupied much of my time in the past, particularly in the tracking characteristics of guided missiles. So we shall examine just how various objects appear to eyes which respond only to electromagnetic radiation.

Radar cross section

In the first instance, it is necessary to have some sort of definition of the ability of a target to scatter the incident radiation back again along the same path to the receiver. In some cases, one also wishes to know how much is scattered in some other direction. But, as this only introduces yet another variable by having to tag any definition with a set of coordinates, we will stay with the more widely-used practical case of transmitter and receiver in close proximity.

This scattering ability of a target object, when used in this radar context, turns out to have units of area and is called the radar cross section or echo area. It forms the coupling element between the radar transmitter output and the receiver input and a knowledge of its magnitude enables a very important parameter to be determined — radar range.

The formal definition or radar cross section conjures up that theoretical convenience the isotropic scatterer, that is, one which scatters power equally in all directions. The radar cross section is then the area which would be needed in the first place to intercept sufficient power for an isotropically scattered signal at the receiver to be of the same strength as that from the target. In practice, however, things are not quite as simple as this may sound. For on thing, the radar cross section generally bears no resemblance at all to the geometrical cross section of a target and the only statement that can be made with any confidence is that an increase or decrease in physical size will produce the same trend in radar cross section.

For another thing, radar cross section is directly related to and is strongly dependant on, frequency. More specifically, it relates to the number of (wavelengths)^2 contained within the effective geometrical cross section. It also depends on the polarization of the incident field; that is, horizontal, vertical or circular and also on the angle from which it is viewed. Thus, for real life targets such as aircraft, missiles, meteorological conditions, terrain, as opposed to theoretically convenient shapes, a definition of radar cross section, to be meaningful, must be accompanied by a statement of the above parameters.

To show, mathematically, the place of the radar cross section in the scheme of things, we can derive on a straightforward basis a much simplified but basic form of the radar equation. Take the transmitter of the tracking radar as having an output of P_T watt and the target as being at a distance R metre. Then, if the antenna could radiate uniformly in all directions, this power would be spread evenly over the surface of an ever-expanding sphere. At the point when this sphere touched the target, it would have a surface area of $4\pi R^2$ and so the power density at the target is $P_T/4\pi R^2$ W/m^2. Now real antennas do not radiate omnidirectionally, but concentrate the power into a directional beam and it may be recalled from a previous article that the degree to which the antenna concentrates the power is called the gain. And so, for the practical case where the transmitter antenna has a gain G_T in the direction of the target, the actual power density at the target is $P_TG_T/4\pi R^2$ W/m^2.

A proportion of this power is then scattered back in the direction of the transmitter and, from the foregoing definition or radar cross section, this amount is $P_T/4\pi R^2\sigma G_T$ watt, where σ is the symbol adopted for radar cross section and is usually given the units of (metre)^2. From the same reasoning as before, except that this time the directive properties of the radiation are inherent in the radar cross section, the power density arriving back at the receiving antenna is $P_T G_T \sigma/(4\pi R^2)^2$. This is the basic form of the radar equation and, whilst it can be written in terms of many other system parameters, nearly all of these are within the control of the system designer and the one that is not in the radar cross section. The received power is directly proportional to the radar cross section and so directly affects the detection probability, hence maximum effective range of the radar. Due to the complex nature of practical targets wherein the returned signal is made up from many individually scattered signals from different areas, it is necessary to know not only the average or rms value of σ, but also how it fluctuates.

Target characteristics

To find out how a target behaves when tracked by a particular radar system, there are the two obvious courses open: calculate the radar cross section or measure it. For all but the simplest of shapes such as spheres, cones, rods, flat plates, the scattering calculations become extremely complex. Once the target starts to consist of sudden changes in section with surface protruberances, holes and changes in material such as are encountered in practice, then multiple reflections occur across the target. When the sources of these multiple reflections are widely spaced compared with the wavelength, as is usually the case, then a true interference situation exists with the returned signal being composed of the vectorial sum of many individual ones.

As a consequence, the amplitude of the returned signal — hence radar cross section — becomes very sensitive to aspect angle. So, whilst a mathematical formulation and method of solution of the problem do exist, the actual computation, which boils down to determining surface current distributions, is so involved that even with the large, high-speed digital computers now available, it is hardly a practicable exercise.

One method of obtaining a rough estimate of a complex target's radar cross section is to split it up into a number of more simple shapes about which more is known and then to add the separate scattering effects. Consequently, a lot of work has been done to predict the scattering from such shapes as cones, ogives, cylinders with a large degree of success. With all of these targets, their radar cross sections are a function of aspect angle and can, even for simple shapes, fluctuate quite considerably; signal fluctuations of 10 to 20dB per degree being quite common.

An important exception to this rule, though, is the sphere which has a radar cross section independent of aspect angle. Fig. 1 shows how the signal

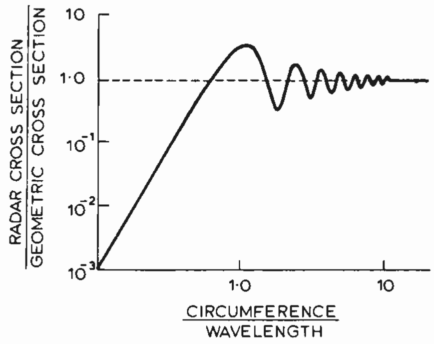


Fig. 1. Variation in radar cross section of a conducting sphere as wavelength decreases. Note approach to a limiting value equal to geometrical cross section: region in which the sphere is often used as a calibration reference.

return from a sphere varies with frequency over the transitory spectrum from when its diameter is smaller than the wavelength to when it is much larger. The region where the sphere is much smaller then a wavelength, called the Rayleigh region, is of interest when studying the behaviour of small particles such as raindrops and the radar cross section varies as D^{-4}.

When the sphere diameter increases past the point where the circumference exceeds one wavelength, the radar cross section varies as a damped oscillation which tends to a limiting value equal to the geometrically projected cross section of the sphere. The amplified oscillations are due to a surface wave which propagates around the back of the sphere and combines with the main relection in varying phase.

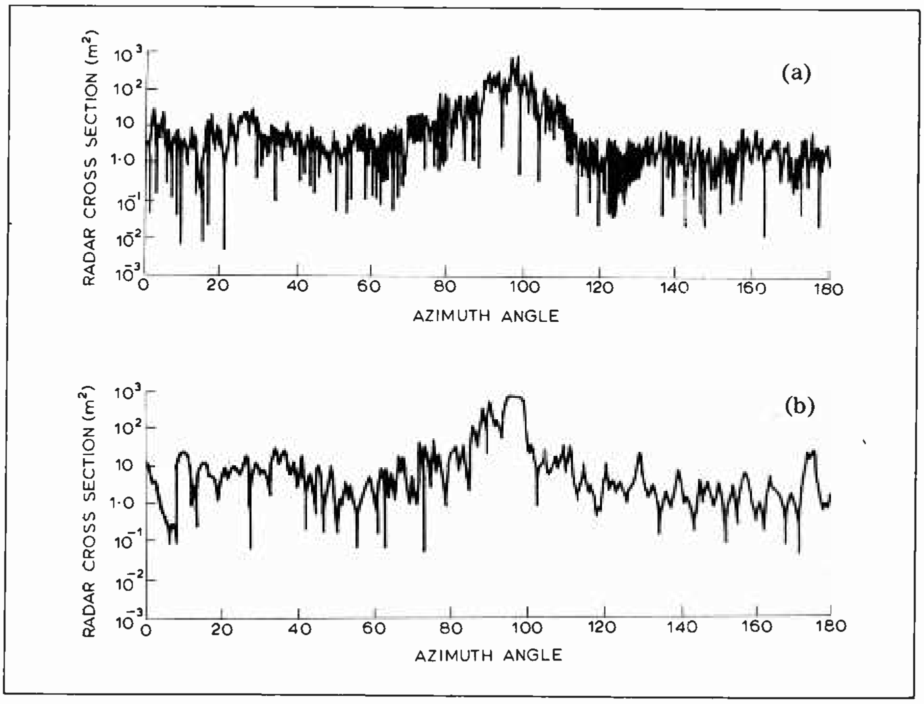
Fig. 2. Image of the HS125.600 aircraft as seen from about the same elevation angle as photo on page 44 at about 600 MHz (a) and at 3000 MHz (b) over nose-to-tail azimuth bearings.

Other types of target also have this overall tendency in behaviour but in a less well-defined manner and the sphere is generally used as a calibration reference for cross section measurements. Provided that the circumference is greater than about 10λ and that the conductivity, sphericity and surface finish are good, then its radar cross section is equal to the projected area πr^2 to a high degree of accuracy and is independent of aspect, type of linear polarization and further increase in frequency.

At the other end of the scale, in terms of complexity, lies a radar target such as an aircraft. This consists of a multitude of different reflector shapes and angles, all of various sizes and it is just not possible to arrive at an accurate radar cross section theoretically. Measurement is thus the only answer and must be carried out over all aspect angles, frequencies and polarizations of interest. This consists of positioning the target on an essentially reflection-free site, illuminating it with the radar and recording the signal strength of the reflected echo. Calibration is obtained by comparing this return with that from a known sphere.

For a large target such as an aircraft it is usual to carry out the measurements on a scale model rather than the real thing and to increase the frequency by the same scaling factor to maintain the same electrical size. The HS125 aircraft shown on page 44 was measured in this way to produce the radar cross section plot of Fig. 2 (a). This is the aircraft as seen by the radar from about the same elevation angle as in the photograph as the azimuth angle varies from nose-on through broadside to tail-on. Equivalent frequency was about 3GHz using vertical polarization.

Another plot under the same conditions except at the equivalent frequency of about 600 MHz is given in Fig. 2 (b)



wherein it can be seen that although the pattern follows the same shape, the scintillating effects of small reflectors are not so apparent at this longer wavelength, so producing a smoother return.

Besides these characteristics of inanimate targets, there is a lot of interest in determining the radar reflection properties of birds and flocks of birds. On the one hand, the echoes from such objects appear as clutter on the radar screen and in some cases can substantially mask the returns from small aircraft. It is thus desirable to know the fluctuating characteristics of flocks of birds so that the information obtained by tracking or surveillance radars can be properly interpreted.

In addition, there is the danger of bird strike itself, particularly for the case of fast, low-flying aircraft and it is thus important for air traffic control (a.t.c.) radars to be able to identify and to try and predict bird movements. Radar can be used to monitor bird migration movements and thereby plays a part in planning flight operations as well as providing information for ornithologists and for environmental studies.

Besides the usual radar cross section dependence on frequency, polarization and aspect angle, the reflections from birds can be characterized by several additional parameters; amplitude variations due to wingbeat, further characteristic amplitude variations due to movements from other parts of the body and the speed of flight itself. A practical difficulty often encountered is that different types of radar system are best suited to obtaining different bits of the total information and not all radar sites possess this full capability. For instance, surveillance radars for a.t.c. are pulsed, continuously rotating types best suited for obtaining coarse amplitude variations, possibly the relatively slow velocities and the range, whilst the characteristic spectral "signature" from general body movements is obtained using c.w. Doppler radars.

A good deal of bird target information has been accumulated over the last decade, however; much of it by this country's Royal Radar Establishment and, on many occasions it has proved possible to identify a particular bird species (and hence predict movement) entirely on the information displayed by the radar.

Individual birds to not have a very large radar cross section, but in flocks they can present quite a big reflection. There has been found to exist a fairly simple relationship between bird weight and radar cross section (ref. 1). For instance using S-band radar (2 to 4GHz), vertical polarization and side-on targets, a bird such as a starling weight 70g has an average radar cross section of $10^{-3}m^2$ and a mallard duck of 1kg appears as $10^{-2}m^2$.

Out of interest the radar cross section of a man is shown in Fig. 3 (ref. 2). It has also been found that the radar signal reflection from birds is quite distinctly amplitude modulated and that the modulation frequency is inversely related to the size of the bird. The more common species, ranging in size from swallows to herons for example have wingbeat frequencies lying between 2 and 10Hz. Flight movement with time is represented by a number of wingbeats followed by a rest period and flight speeds themselves are found to lie mainly in the 20 to 35 mile/h region. Thus, by combining the data on airspeed, wingbeat frequency and wingbeat pattern, one can start to identify birds as a particular type of radar clutter and, in many cases, can form a good estimate of the species itself.

A further source of information about this type of target can be obtained by monitoring their reflections with a coherent source such as a c.w. Doppler radar. The display thus obtained is one of the Doppler frequencies (or relative velocities) versus time caused by the relative movements of different parts of the bird's body, such as head, wings, tail. As different species tend to have different degrees of movement, this composite spectrum is analogous to a fingerprint classification, though it is difficult to resolve unambiguously.

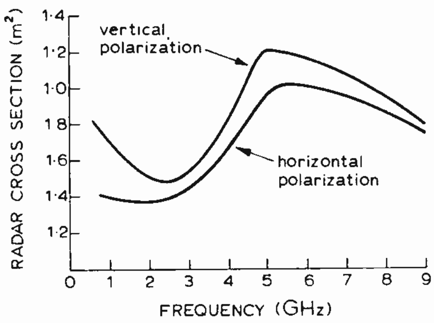
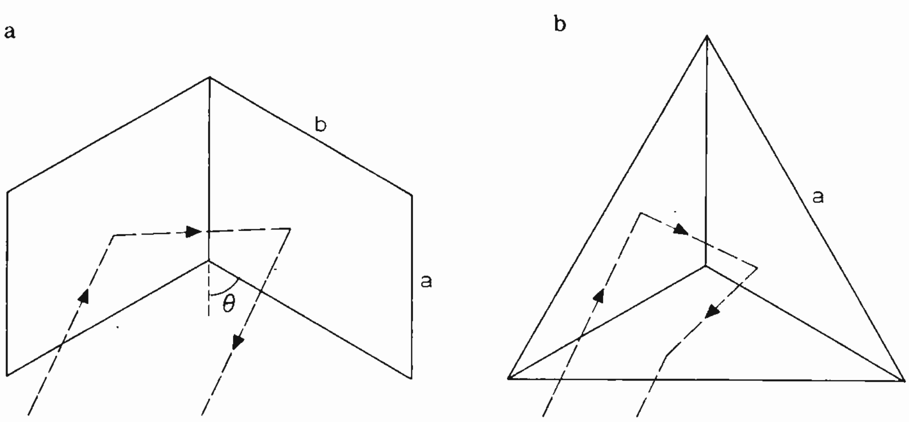


Fig. 3. Variation in radar cross section of a man as a function of frequency and polarization.

Fig. 4. These types of reflectors are used as calibration sources and as target enhancers. The dihedral (a) has a broad response in one plane and a sharp cut-off in the other whilst the trihedral (b) has a better all-round coverage.



$$\text{max. r.c.s.} = \frac{8\pi(ab)^2}{\lambda^2}$$

Several years ago, the Royal Radar Establishment used the surveillance radar on top of Gibraltar Rock to monitor bird migration movements through southern Spain, across the Straits and into north Africa. A film was made of the "speeded-up" movements taken over a long period of time from the radar display and clearly demonstrated the flight patterns and routes taken by various migrating species. This sort of information is of great interest to designers of radar systems and displays, to air traffic control and to ornithologists alike.

Echo enhancement

Sometimes, as in the case of small objects such as guided missiles and towed targets, it is necessary to find means of augmenting the radar cross section to enable them to be tracked reliably. A missile is by no means ideally suited for radar tracking, the only protruding surfaces generally being fins and wings. In addition, pitch and yaw angles greater than 50° occur very seldom during target following and the majority of aspect angles are likely to be very much less than this. The subtended angle at the missile is also decreasing with increasing range. Consequently, very little extra enhancement is provided by the wings and fins and the total return consists of a rapidly varying pattern of peaks and nulls.

With this type of pattern, it is quite possible for the missile to be positioned at a point of abnormally low return. Coupled with the possibility of also observing very rapid signal fades, this could be interpreted as loss of acquisition and result in premature self-destruction of the missile. The radar cross section of a typical missile at the highest frequencies normally used might have a mean value of $5 \times 10^{-3}m^2$ with peaks of $0.1m^2$ and nulls of $10^{-4}m^2$. The 20dB variation in returned signal strength could occur within a fraction of a degree difference in aspect angle and represents a very severe fade.

The amount of space available for

enhancement is severely limited and is further restricted by aerodynamic drag requirements. The body diameter of typical missiles ranges from 120mm to 300mm, most of which is taken up by propellant, exhaust nozzel, servo mechanisms, warhead and electronics. A reasonable requirement might be for a mean radar cross section of $0.2m^2$ maintained at all aspect angles from 0° to ±50°, with additional restrictions on the extent and duration of the nulls.

A major factor affecting the enhancer design is the presence of the motor exhaust. Some systems employ a continuously burning motor during the flight and others an energetic initial boost followed by a coasting phase. In both cases, though, the motor flame must be taken into account as having a detrimental influence on the tracking signal. The overall effect is one of attenuation resulting from reflective, diffractive and absorbtive losses. This is most severe within the region about 5° from zero aspect angle and, depending upon the frequency, can give a two-way mean return loss of up to 40 dB.

A tail-mounted enhancer system is clearly rendered useless at these aspect angles and a typical solution to the problem is to mount additional enhancers at the wing tips to provide coverage within this region. Because of aerodynamic considerations, these must be small in size, and, as such, usually have a limited angular coverage and do not contribute significantly to the enhancement at large aspect angles.

A particularly useful design on which to base wide-angle enhancers is the corner reflector. Fig. 4(a) shows a right angle dihedral form of this reflector in which the incoming signal undergoes a double reflection. When viewed as drawn from different angles of θ, the reflected signal is returned in the same direction as the one incident and so the dihedral has a relatively large radar cross section in this plane, proportional to the projected area in the direction of view. In the vertical plane, the dihedral behaves as a flat plate, with the incident energy glancing off at the incidence angle and so has a fairly sharp and limited response.

Better all-round coverage can be obtained with the trihedral corner reflector shown in Fig. 4(b). Once again, the signal is reflected back again towards the source, but with a more uniform response in the vertical as well as the horizontal plane.

An additional factor which must often be taken into account in the design of enhancer systems arises from the frequent use of circular polarization in the tracking radar. This is used to enable some discrimination to be made between the wanted target and precipitation clutter such as rain or hail. Every time a circularly-polarized wave undergoes a reflection, the electric field component is phased-reversed and the sense of polarization is also reversed. If, say right-handed polarization was transmitted, then the radar receiver would only be receptive to a right-hand polarized reflection.

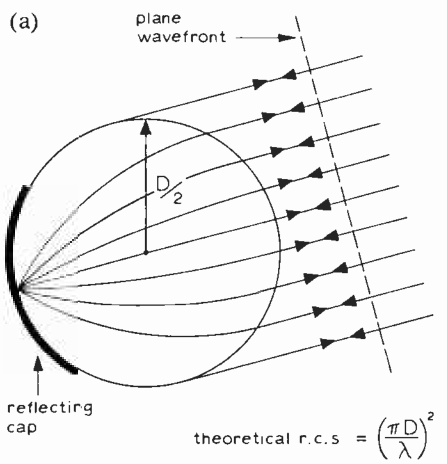
In rain, whilst multiple scattering between droplets exists, the predominant reflection appears as having undergone an odd number of bounces and so has the wrong sense of polarization to be received. The wanted return from a complex target such as a plane or a missile, however, is essentially of the original polarization and so is detected. A slight penalty of 6 to 8dB is paid on the mean level of the radar cross section by using circular instead of linear polarization. But typically this technique can provide about a 25dB target to clutter discrimination. It does mean that any enhancer designs must take this into account and provide the equivalent of an even-bounce system.

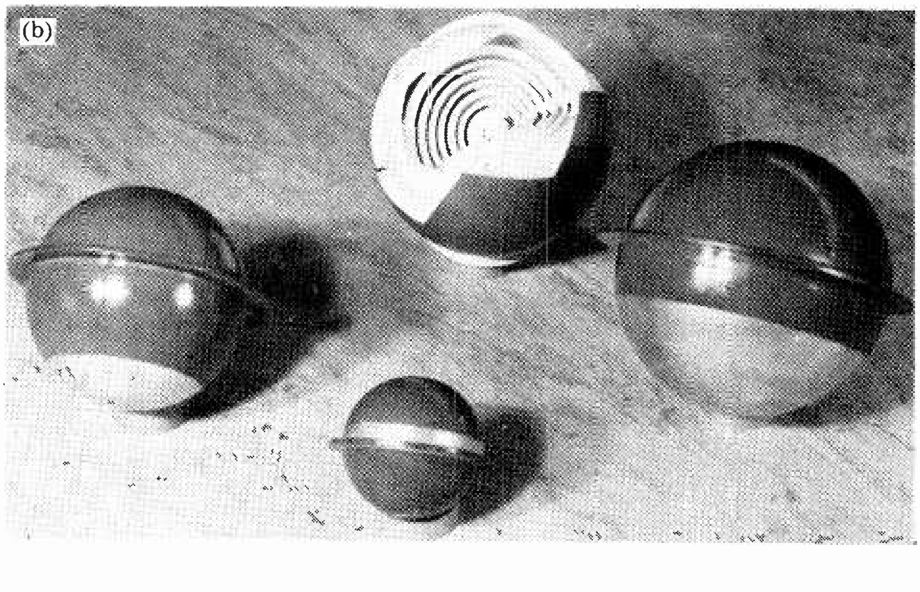
Another application for radar cross section enhancement lies in the type of towed target often used for missile firing trials. Whilst physically small in size, they might be required to appear electrically as a small aircraft. Particularly convenient is a device known as the Luneberg lens, first postulated as an optical device but only realized practically at microwave frequencies. Usually, the lenses are spherical as shown in Fig. 5 and, if the dielectric constant can be made to vary with radial distance, r, according to the law $\epsilon_r = 2-(r/R)^2$, a plane wave incident on the lens will be focused to a point on the opposite surface. By placing a reflecting cap at this point, then the energy can be returned as a plane wave to the source. The above equation requires a dielectric constant of unity at the lens surface when $r=R$, increasing uniformity to a value of 2 at the lens centre when $r=0$. Such a gradual variation is not possible to achieve in practice but, with careful design, it is possible to achieve the required result by building up the lens from concentric shells, each of a slightly different dielectric constant. This method of construction is shown in the cutaway lens of Fig. 5(b).

Theoretically, the radar cross section of the Luneberg lens is the same as that of a flat plate having the same diameter, D, namely: $4\pi A^2/\lambda^2$ where λ is the wavelength and A is the cross sectional area equal to $\pi D^2/4$.

Theoretically at, say, 10GHz the radar cross section of the lens is $8.6m^2$ compared with the geometrical cross sectional area of $0.025m^2$. In practice, the lenses do not have 100% efficiency and, as indicated by the calibration, the signal return is typically up to 1dB lower than that from the plate.

Fig. 5. The Luneberg lens focuses a plane wavefront to a point on its surface (a) from which it may be reflected back again and the theoretically required uniform variation in dielectric constant is achieved in practice by a concentric shell construction (b).





Acknowledgement

Thanks to Hawker Siddely Aviation for the HS125 photograph and to ACL Adelphi for permission to use the corresponding radar cross section data. I am also grateful to my colleagues of the Plastics department at B.A.C. Stevenage for Fig. 5(b).

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FM tuner designs

Two designs with various circuit options

by D. C. Read, B.Sc.

Among the many benefits conferred on the home constructor by the increasing sophistication of available packaged components is that these allow complex circuit ideas to be not just considered as expensive ideals but realised in practice with comparative ease and economy. This is particularly true in the field of f.m. stereo reception. L. Nelson-Jones pointed the way in his articles*. Further development of these ideas has led to a more comprehensive design, two versions of which are described below. For both, apart from the usual consideration of first-class performance and stability of operation, the main aim has been to eliminate time-consuming r.f. and i.f. alignment difficulties and the possible need for expensive test equipment. In the following description, modifications and optional extra facilities are discussed, and the necessary constructional details given (see also part 2).

The first, and simplest. version makes use of the well-proven Nelson-Jones i.f. and demodulator sections (though slightly modified) and replaces the discrete-component front end with a voltage-controlled tuner module. It also incorporates on the same board a phase-locked loop stereo decoder circuit based on the Motorola chip. Pre-selected station change is by means of push-button switching with an extra switch position giving access to a manual control for tuning over a large part of Band II. Included in the design are regulator circuits for providing both the main supply rail and the constant-voltage source for tuning control.

The more advanced development uses an RCA CA3089E package containing i.f. amplifier/limiter and demodulator circuits which are sufficiently sensitive to allow all the i.f. pass-band shaping to be performed at a lower level: limiting starts with an input of about 15μV for the RCA integrated circuit. Thus, only a small amount of gain in the preceding stages is required, to make up for ceramic filter losses and provide impedance matching, and the 20dB gain i.c. (CA3053) used in the simple version is therefore not needed.

> **Performance**
>
> **Signal-to-noise ratio.**
> Simple version 62dB at 1mV input
> 27dB at 1μV input
> f.e.t. version offers an improvement for low signal levels of 1-100μV e.g. 55dB instead of 47dB at 10μV.
>
> **Distortion.** Simple version: 0.5% at 1kHz and 75kHz deviation (1mV), see text for method of improving to 0.1% f.e.t. version gives 0.12% at 1mV, 0.08% at 10μV.
>
> **Crosstalk.** 34dB 80Hz to 5kHz with C_{28}, R_{27} optimized.
>
> **RF performance.** See part 2.

In addition to the composite signal output, the CA3089E produces:

- delayed a.g.c. voltage
- push-pull current supply for a.f.c.
- adjustable inter-station muting voltage.
- direct voltage proportional to the r.f. signal amplitude to actuate a tuning meter or show received field strength.

Of these, the first is most useful. It is used here to control the gain of an additional aerial-fed r.f. amplifier which, as well as giving the tuner increased sensitivity for reception of weak incoming signals, attenuates those of excessive strength to reduce the risk of local-oscillator pulling, an effect which can occur when the LP1186 module is over-driven. More particularly the a.g.c. circuit using this control feed can easily be tailored to suit different reception conditions according to location and requirement.

In the simple version of the tuner, an a.f.c. feed is conventionally derived from the demodulated audio and, because of other precautions taken against drift, is more than adequate for all practical purposes. The availability of a separate a.f.c. supply is not therefore particularly significant except that it does more readily offer a choice of control sensitivity. Similarly, the other two CA3089E outputs have only limited application in the present design. For general household use muting is not required with stable push-button tuning; neither is there need to inspect the incoming signal level. These optional facilities are included only to allow for band-searching by manual tuning.

The decoder, stabilizer and tuning-voltage circuits are the same in both versions of the tuner.

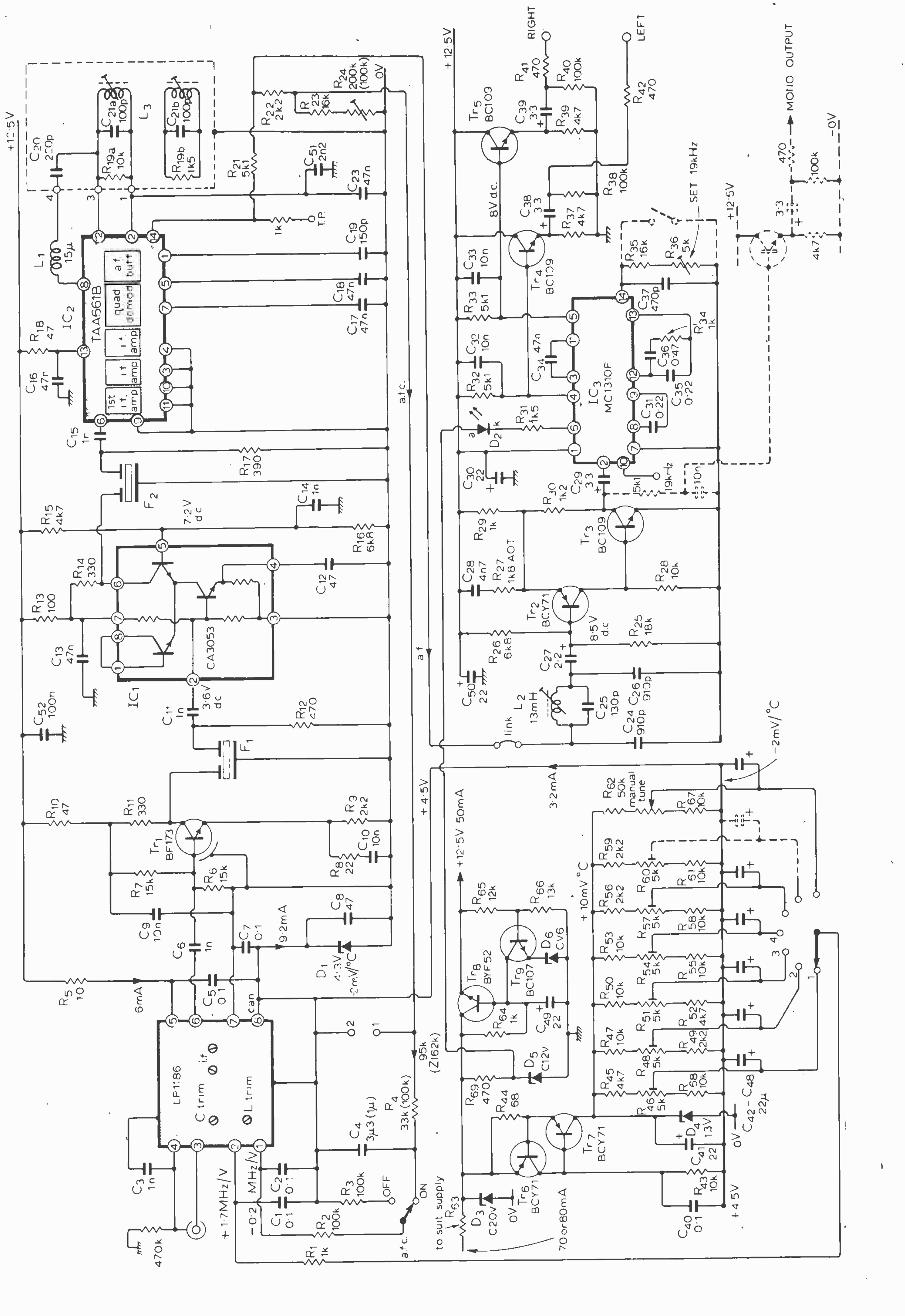
Simple version

The LP1186 module circuit is "floating", but is made unbalanced by C_3 (Fig. 1) so that it is suitable for connection to the aerial via a 75-ohm co-axial feeder. A.C. earthing is used because the module negative supply rail and the metal cover is held at about +4.5 volts with respect to the main chassis earth by zener diode D_1. There are two reasons for this, first, the LP1186 requires an 8 volt supply, instead of 12.5 volts nominal as in the remainder of the tuner circuit. And second, the local-oscillator frequency-control circuit operates about a 0-volt zero error signal at pin 1 (ref, pin 8) but the a.f.c. voltage produced by the TAA661B has an on-tune centre value of around 5.4 volts, reduced to about 4.5 volts, in the chain R_{22}, R_{23} and R_{24}.

A minimum incoming r.f. signal of about 2 μV r.m.s. for 30dB quieting is

Fig. 1. Simpler version of tuner design using LP1186 module. Stereo decoder and tuning circuits are common to the two tuner designs. See part 2 (April issue) for modification for Toko module. Station selection switch should have break-before-make contacts. Resistors can be 5% high stability or metal film types, rated at ¼ watt. Capacitors are 2% polystyrene types for signal circuits, disc ceramics for r.f. decoupling, and tantalum types for audio coupling and decoupling. Switch shown with broken lines is closed for mono reception to kill 76kHz oscillation. Values in parentheses are for lower a.f.c. sensitivity.

* F.M. Stereo Tuner. *Wireless World*, vol. 77 1971, pp.175-80, 245-9. See also p.376, vol. 78 1972, pp.179-83, pp.318/9 and vol. 79 1973 pp.271-5. p.591. All reprinted in "High Fidelity Designs", IPC Business Press Ltd, 1974.



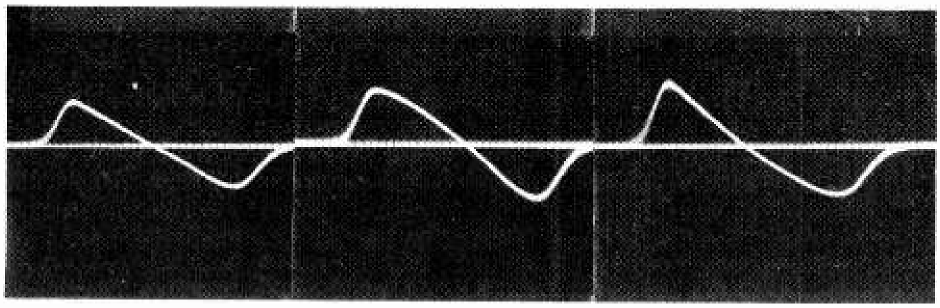


Fig. 2. Effect of changing dummy circuit resonance on transfer slope of demodulator. (a) left, optimum setting (b) middle, upper core "in" on optimum setting (c) right, upper core "out" on optimum setting. (1V/cm.)

necessary to give adequate limiting in the TAA661B amplifiers; and a maximum amplitude of between 5 and 10mV is recommended to prevent oscillator pulling.

The remaining LP1186 module at pin 2 is the tuning control voltage from the push-button selector circuit which has selected values between 4.7 volts and 6 volts; a somewhat greater range is provided in the continuously-variable manual tune position. Both this voltage feed and the a.f.c. line are decoupled (R_1/C_1, R_2/C_2) to prevent spurious modulation effects which could be caused by hum fields or other stray signals picked up on wiring to and from switches.

AFC sensitivity

Following normal practice, of course, the a.f.c. feed passes through components, C_4, R_4, which filter out the audio modulation. The input resistance at pin 1 of the LP1186 is 62kΩ, if R_4 has the value 100kΩ in Fig. 1, the useful a.f.c. voltage change is about one-third of the total available. If greater sensitivity is required, therefore, the value of R_4 must be reduced and that of C_4 raised to maintain effective audio rejection. A suggested pair of values is 33 kΩ and 3.3μF. With these in circuit a 50% increase in sensitivity is achieved but at a greater risk of locking to an adjacent station.

The problem of incorrect selection because of excessive a.f.c. is aggravated by the interleaving allotment of transmitter frequencies and therefore mis-selection is most likely to occur at points where interleaved channels are received at comparable strengths. A typical instance might be a location midway between the Oxford and Wrotham transmitters which radiate basically the same Radio 1, 2 and 3 programmes on interleaved frequencies. In such circumstances, the station chosen by the receiver might not be the wanted one; the choice will arbitrarily depend on the direction of tuning change. As the tuning shifts up or down the band from one selection to the next, the local oscillator might be captured by an in-between transmission which creates a large enough a.f.c. voltage to make it lock to this station in error. Over-sensitivity of the a.f.c. can also result in station-jumping effects where the receiver suddenly changes tuning and switches away from one transmission to some other because of a reduction in received signal strength; aircraft flutter, particularly, causes such mis-operation.

It is obviously good practice then to set the a.f.c. sensitivity so that it is no more than just sufficient. In the event that particular reception conditions are such that sensitivity is already too large, even with the circuit as given in Fig. 1, two pairs of diodes in series (types 1N914 and 1N916 are suitable) can be connected back-to-back across C_2 at the LP1186 a.f.c. input. With this modification, the frequency-control swing is limited to less than the 300kHz station spacing and thus station jumping or mis-selection will be prevented.

The 10.7 MHz output from across pins 6 and 7 is fed to Tr_1 which provides the correct source impedance for the first ceramic filter, and also gives some amplification. The amount of gain is set by the value for R_8 and should be such that, for a low r.f. input of 10μV to the tuner, a suitable signal level (say 10mV) is available to drive the first i.f. amplifier in the demodulator module; this gives 40dB quieting. A 20dB amplifier stage comprising the cascode-connected circuit in IC_1 provides the correct source impedance for F_2 which finally passes the band-shaped i.f. signal to IC_2.

Remember that the Vernitron type FM4 components used for F_1 and F_2 must have the same colour marking. The green-coded type is recommended because these have a pass band centred on 10.7MHz and therefore match the curve normally provided by the maker's preset adjustment of LP1186 modules. If ceramic filters of another colour code are used, it may be advantageous to re-tune the two output band-pass coils in the LP1186 for optimum performance. These are accessible through holes in the module cover. The best way of making the adjustments is to use a frequency-sweep input signal displayed on an oscilloscope connected across the demodulator input (pin 6 of the TAA661B). Such ideal methods are rarely available to the home constructor, however, and the practical compromise is to select a weak incoming signal and then adjust the coils for least background noise in the sound output from the tuner.

For reception of weak signals it may be worthwhile to carry optimization of the LP1186 one step further and adjust its input circuit to match the aerial. Two other holes in the LP1186 cover allow separate access to the aerial trimming coil and its associated capacitor. Because these components affect opposite ends of the tuning range, their adjustment is a relatively simple matter: using the manual tuning control, select a weak station radiating in the 87-89 MHz range and tune the coil for minimum noise; no more than a fraction of a turn is needed to show either that a reduction in noise is possible or that the optimum setting already exists. Change to a weak signal towards the other end of the band (96-97 MHz) and similarly adjust the trimmer capacitor. This is not an essential adjustment and will, at best, give only small improvement for weak stations.

Quadrature demodulator

The circuit surrounding IC_2 shows two main differences compared with that in the original Nelson-Jones tuner. First, the i.f. signal sample used to derive the quadrature-phase demodulating signal is taken through an inductor L_1 instead of a capacitor (note that C_{20} in Fig. 1 is now simply a d.c. blocking component). This is done so that the resulting demodulator transfer slope is in the correct sense for a.f.c. Second, the phase-shifted carrier itself can optionally be produced by two tuned circuits with twin coils L_3 having separate cores but mounted on the same former. As Fig. 1 shows, one of these circuits is a dummy, the tuning of which is adjusted so that the modifying component of current induced in the main tuned circuit is of suitable phase and amplitude to give a straighter transfer slope. The effect of changing the dummy circuit resonance is illustrated by the three sweep photographs which show: (a) the transfer slope for an optimum setting; (b) and (c) non-linearity resulting from two incorrect settings.

There is, unfortunately, a difficulty to be met in using this apparently simple and cheap modification: it is only effective if properly adjusted and although adjustment is relatively easy, it necessarily entails the use of extra test equipment. Further, the basic reduction in tuner output distortion is marginal (typically, 0.5% total harmonic content for the one-coil circuit; 0.1% with two coils) and would be hard to detect aurally. Even so, a low level of harmonics in the demodulated signal, helps to prevent intermodulation products in the overall stereo decoding process and, provided that suitable test equipment is available, the additional circuit and set-up procedure offers a worthwhile advantage.

There are two possible methods of adjustment. The first uses a distortion meter to measure the total harmonic content in the audio output (taken via a 15kHz low-pass filter such as that described later) for an r.f. tuner input modulated by 1kHz at ±75kHz deviation. The filter is needed here to reject the 19kHz pilot tone as well as the 23kHz transmitter switching signal remaining in the audio output. The dummy tuned circuit (upper core) is then simply adjusted to give a minimum reading on the meter. However, since the distortion figure which can be achieved is low (about 0.1%), the exact null point may be somewhat masked by noise. The alternative method overcomes this. It uses a wave analyser tuned to the 3rd harmonic of the incoming 1kHz modulation which is again at the maximum deviation of ± 75kHz; in this instance there is no requirement for a low-pass filter. The adjustment of dummy circuit tuning is made for a minimum output at 3kHz.

The demodulated multiplex signal from pin 14 of IC_2 at about 0.5 volts r.m.s. for ± 75kHz incoming f.m. deviation has a d.c. component of about + 5.4 volts for the in-tune condition. In fact, the value given here is a nominal one and varies between different examples of the TAA661B; since this varying direct voltage is used to operate the a.f.c. circuit and must be matched to the supply offset provided by D_1 (4.3 volt zener), variable resistor R_{24} is included in the a.f.c. potentiometer chain to allow fine adjustment.

The method suggested for adjustment is as follows. Switch a.f.c. off. Using the manual control, set the tuner well away from any station, i.e. completely off-tune. Measure the direct voltage at the IC_2 pin 14 test point (this connects with the demodulator output via a protecting 1kΩ stand-off resistor); normally, the value obtained will be about 5.4 volts positive.

Tune through a reasonably strong incoming signal and, by observing the voltage change from maximum positive to maximum negative (a total peak-to-peak swing of, say, between 2.5 and 3.5 volts) sample the S curve to find the on-tune point, which is at a voltage nearly equal to that already established for the off-tune condition. With the tuning set at this point, transfer the meter to the tuning-indicator connection points marked 1 and 2 in Fig.1. In the on-tune condition and with R_{24} set at a maximum, terminal 1 will be positive with respect to 2. Adjust R_{24} to bring this potential difference to zero. Switch a.f.c. on and observe the possible slight change of meter reading. Again adjust R_{24} to restore it to zero. Finally, check the voltage appearing at the test point and operate the a.f.c. switch to ensure that this voltage remains unchanged with and without a.f.c. applied.

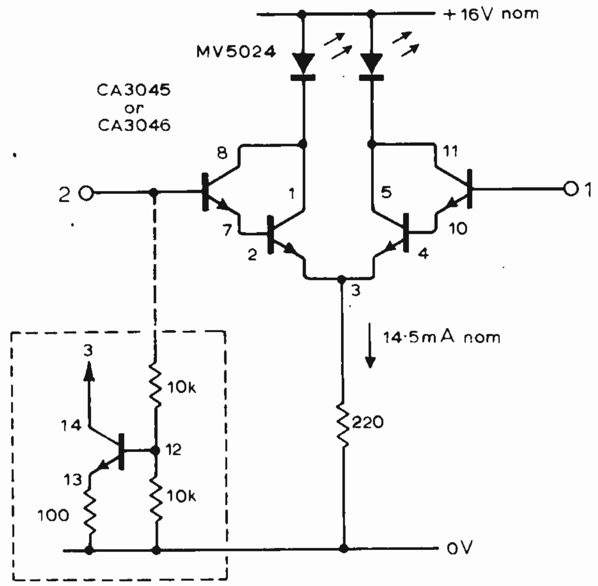
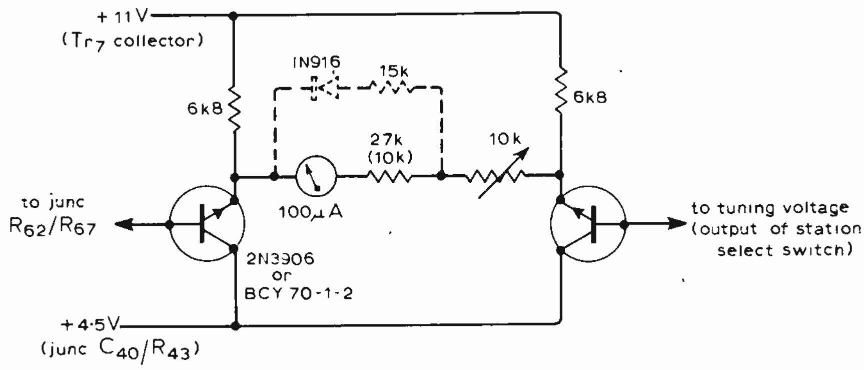


Fig. 3. In this tuning indicator option, the 220ohm resistor can be replaced with the circuit shown in broken box to ensure equal lamp brightness either side of tuning position.

Fig. 4. Optional meter circuit provides tuning scale for manual tuning. Meter is RS Component MR100.



Tuning voltage selector circuit

The circuit used to provide a selection of pre-set direct voltages for tuning purposes in the LP1186 module forms the lower left of Fig. 1; this part of the circuit also includes the main supply-voltage stabilizer.

All the tuning voltages are derived as proportions of a fixed voltage from zener diode D_4 which is supplied with a constant current by the stabilizer circuit of Tr_6 and Tr_7. D_4 is returned to 0 volts instead of the 4.5 volt rail used by the LP1186 module and the rest of the tuning voltage circuit, so of the 13-volt reference potential provided by D_3, only about 8.5 volts is used for tuning. The main reason for this arrangement is that by allowing for a greater reference voltage than necessary, the zener diode used to provide it has a positive temperature coefficient large enough to give the degree of frequency-drift correction required. The coefficient of a suitable lower-value zener, although still positive, would be too small for this purpose; the figures for comparison here are +10.5mV/°C for D_4 and —10kHz/°C for the oscillator.

Thus, with D_4 connected as shown, the variation of control voltage with temperature has an effect on the tuning frequency which both opposes and, after accounting for potentiometer action and the 4.3 volt zener offset in the selector circuit as well as the tuning-voltage/frequency relationship, is about equal to the variation caused by a similar temperature change on the local oscillator itself. Obviously, for automatic compensation to become fully effective, the relevant components in the tuner must themselves have reached their normal working temperature.

If the number of pre-selected stations required is more than, say, 12 then as each chain takes about 0.4mA the total drain on D_4 might be greater than its reserve of current and it would no longer be effective in maintaining a constant voltage. In this event, it will be neccessary to increase the current supply from Tr_7 by reducing R_{44} to the next lowest preferred value (56 Ω).

Transistor Tr_8 and Tr_9 form the main parts of a conventional series regulator acting with reference to zener diode D_6 to provide the main supply rail of 12.5 volts from the nominal 16 volt d.c. input.

An incoming feed of this value is conveniently obtained by peak rectification of the output from a mains-to-12 volt transformer. It should be capable of supplying at least 250 mA r.m.s. at 12 volts to ensure the required rail voltage.

The 12 volt zener, D_5, provides a reserve of current for supplying the stereo indicator D_2 so that the main supply rail is not affected by current changes as this l.e.d. is switched on and off.

Stereo decoder and output circuit

The right hand of Fig. 1 shows the decoder module feeding twin audio output circuits and preceded by a low-pass filter mainly comprising L_2. This filter passes the composite multiplex signal obtained from the demodulator including the upper subcarrier sideband extending to 53 kHz but rejects frequency components outside this range. Ideally, the filter should have a flat pass-band with negligible phase distortion so that the mono and stereo information channels occupying 0 to 15 kHz and 23 to 25 kHz, respectively, can be recovered with equal fidelity. It should also cut off sharply to give the maximum possible attenuation to all signals outside this band, especially in the range 99 to 129 kHz, which includes the first odd harmonic of the stereo channel subcarrier with sidebands.

To satisfy such a requirement would entail the use of a complex network; in practice, the simple, single-section filter used in the tuner is adequate, even more so if the demodulator dummy tuned circuit, discussed earlier, is used to reduce the level of interfering harmonic components. As an added refinement, the tuning of L_2 can, if desired, be adjusted to set the first rejection frequency so that optimum separation is obtained for signals in the region of 5kHz; this is the upper end of the audio range over which good stereo separation is most important.

Further overall response adjustment is given by the feedback stage of Tr_2/Tr_3. The C_{28}, R_{27} circuit causes a basic 6dB/octave rise which is modified by R_{29} so that the resulting slope counteracts a general slight fall in the preceeding circuits. As before, equality of level for both the mono and stereo information channels at the decoder input is the criterion. The low output impedance presented by Tr_2/Tr_3 is a necessary factor in the proper operation of the MC1310P circuit; separation at the lower end of the audio band suffers if this requirement is not met.

The decoder module, IC_3, is operated in a normal manner with surrounding circuit values much the same as in an article which introduced the MC1310P (*Wireless World* July 1972). The only addition is the optional 76 kHz oscillator-disabling switch shown in Fig. 1. If fitted, this is used to inhibit stereo operation for exceptionally weak incoming signals when the resulting 20dB improvement in signal to noise ratio offers a worthwhile advantage.

De-emphasis of the decoded audio signals taken from open collectors at pins 4 and 5 of the MC1310P is arranged by shunting each of the load resistors, R_{32} and R_{33} with $0.01\mu F$ capacitors. The twin output signals are then available from buffer emitter followers, Tr_4 and Tr_5. Apart from the more obvious benefits of having low-impedance outputs, these are particularly useful, with series resistors R_{41} and R_{42} suitably changed in value, for feeding the 15 kHz low-pass filters (part 2) which may be inserted between the tuner and its following amplifiers.

Extra circuits

Where stereo programmes are to be used to make mono recordings, the emitter follower circit shown dotted in the lower right hand corner of Fig. 1 would be a useful addition. This simply provides a low-impedance output of the separately de-emphasized multiplex signal.

Another possible extra facility is the tuning indicator circuit illustrated by Fig.3. This basically comprises two Darlington pairs in a single i.c. with a common-emitter load and light-emitting diodes in the collector feeds. When connected to a.f.c. circuit points 1 and 2 in Fig.1, these diodes show equal illumination for equal input voltages at pins 6 and 9 to indicate the in-tune condition whereas one or other is brighter on either side of this point. An optional refinement to the basic Fig.4 circuit (shown boxed) overcomes possible asymmetry in individual diode brightness for off-tune conditions. As the modification shows, the common-emitter resistor is replaced by a constant-current source using a spare transistor in the i.c. and two additional resistors.

As a further aid to station selection, the reader may like to include the circuit shown in Fig.4 and thus provide a tuning-scale facility. The added circuit mainly uses a readily-available and reasonably cheap edgewise meter which in my installation is mounted together with the pre-selection buttons and other controls on a remote front panel. Fig.4 shows how the meter is connected into the main tuning/selection system detailed in the Fig.1 circuit which requires only two small modifications. One is the addition of a series resistor between R_{62}, the manual tune control, and the 11-volt maintained tuning-voltage supply rail. The value of the added component (typically 18kΩ) is chosen on test so that the meter full-scale deflection (indicating 98 MHz) occurs at the fully-clockwise slider setting of R_{62}. Second, the value of R_{67} will need changing to, say, 22kΩ to make the R_{62} fully-anticlockwise setting coincide with a tuning frequency of 88 MHz. The values actually required might be different because the tuning-voltage spread for the LP1186 varies by about 1 volt at the low end of Band II and about 3 volts at the top end.

With the meter circuit as shown full line in Fig.4 the scale (constructed by experiment) will be cramped at the low-frequency end. This is an advantage if all the pre-selected station frequencies are here, because the more open upper-end markings then give better accuracy when exploring/setting in the manual tune position. However, in some other instance it may be necessary to make the scale marking more linear and this can be done by modifying the meter circuit as shown dotted in Fig.4 whereby the scale already provided with the meter can conveniently used such that 0 ≡ 88 MHz and 10 ≡ 98 MHz.

Part 2 will include details of the "advanced" version of the f.m. tuner.

Printed circuit boards

Wireless World has arranged a supply of glass fibre p.c.bs. One off price is £3 inclusive from M. R. Sagin, 11 Villiers Road, London NW2.

Announcements

Amplicon Electronics Ltd. Lion Mews, Hove. BN3 5RA, have been appointed sole UK agents for Semiconductor Circuits Inc, of Massachusetts, USA. S.C.I. is a large producer of encapsulated mains power supplies and d.c. to d.c. converters.

West Hyde Developments Ltd have been appointed agents for the American TEC Company for their **v.d.u. data terminals.**

Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL, have been appointed agents for the Monroe line of scientific and statistical **programmable calculators.**

Swisstone Electronics Ltd, 4/14 Barmeston Road, London SE6 3BN is a new company which will specialize in the **servicing of Rogers audio equipment.** Swisstone have obtained the premises, stock and plant of Rogers Developments, now in liquidation, and have also retained the services of key personnel.

Omni Components Ltd, 22 Portman Road, Reading, Berks, has been appointed a franchised distributor for semiconductor products by **Thomson-CSF United Kingdom Ltd.** Thomson-CSF, based in France, with U.K. headquarters at Basingstoke, is a major European manufacturer of electronic equipment and components.

E. I. du Pont de Nemours and Company, Post Office Box, CH-1211 Geneva 24, Switzerland, has been licensed by N. V. Philips of the Netherlands to market in Europe a VCR cassette for the half-inch Philips VCR format. The Du Pont cassette contains "Crolyn" magnetic tape, a chromium dioxide tape developed by Du Pont. The cassettes will be available with playing times of 30, 45 and 60 minutes. Du Pont has previously been licensed to market VCR cassettes in the United States for Philips Broadcast Equipment Corporation.

News of the Month

Video editing for BBC External Services

By late 1977 staff at the BBC's External Services in Bush House will be supplementing pen, paper and typewriter with a 14in video screen. The Corporation is to modernize its production and distribution of news and current affairs at Bush House by installing a £1.2M ITT computer-based news distribution system. Instead of conventionally producing the material and stencilling it for distribution to various language services for transmission, the news staff will feed news stories, talks and features into the computer through video display units, which have comprehensive editing facilities.

The BBC decided on the new system as a means of speeding up the complex machinery of its external broadcasting operation, which is in action round the clock seven days a week, uses 39 languages and has an output of almost 700 programme hours each week. Display terminals for the news distribution system are being supplied by Delta Data Systems Ltd of London. They are to supply 47 of their type 4000 v.d.us as part of an eventual total of about 240 terminals to be used for entering, displaying or printing information.

Oilmen on the 'phone

Beryl is the first North Sea oil platform to be provided with an automatic public telephone service. The service is a business link but workers on the platform will be able to ring their homes in the event of urgent personal business. The new troposcatter microwave link is the first part of a multi-million-pound network of off-shore microwave radio links being set up by the Post Office. The link from Beryl to the Shetlands has been in operation since early December but was officially opened in mid January after proving its claimed reliability of 99.98%. Sir Edward Fennessy, deputy chairman of the Post Office and managing director of telecommunications, inaugurated the service by making a three-way international 'phone call from the Post Office Tower, London. The call linked him with the Beryl platform and with Mobil's headquarters in New York.

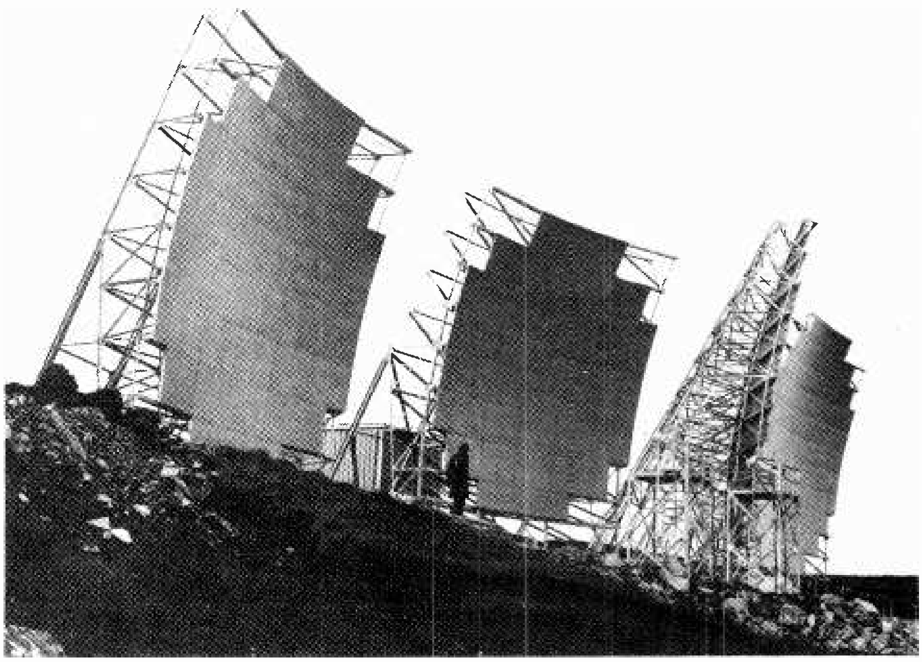
Because the oil and gas production platforms are well out of sight of land, microwaves, normally used for line-of-sight communication, are scattered by turbulence in the troposphere and as a result become "visible" to aerials beyond the horizon. Focal points of the new off-shore network are two radio stations, strategically sited to serve almost all the British sector of the northern North Sea gas and oil field areas. One station, the control centre, is sited near Fraserburgh, Aberdeenshire. The other is on South Shetland.

Oil pollution threat reduced

Electronics is helping to eliminate the risk of an oil tanker breaking from its mooring during load or discharge, thus minimizing the possibility of damage to the environment through oil pollution. An electrowriting recorder is being used to monitor the load on a single point mooring buoy about four miles off the English coast near Grimsby. The recordings are also expected to produce substantial economies in mooring line costs for terminal operators by enabling them to predict to a certain degree the safe working life of the mooring lines.

The equipment uses a load transducer attached between the buoy mooring lug and the mooring rope. The signal from the transducer is fed into a combined encoder/transmitter unit and is then received on shore and decoded to provide a voltage output proportional to the applied load. The load readout is recorded on a Servocorder, supplied to designers at the British Hovercraft Corporation by Environmental Equipments Ltd. An alarm system working off the inkless pen recorder is incorporated so that a warning tone can sound at the shore station and through the normal shore-to-ship radio speech link when the strain on the mooring buoy exceeds its safety limit.

Aerials at the new radio station on South Shetland (see news item) one of two shore stations for the new network of radio links with oil platforms over the northern sector of the North Sea.



Harmony for cables and flex

The publication of three revised British Standards dated December 1975 has marked an important step towards common specifications for wiring cables and flex in Europe. In February 1973, one month after gaining full membership of the EEC, Britain became a signatory to the Low-Voltage Directive (see "Electrical safety, standards and the law" Sept. 1975, pp.401-404). The main purpose of this Directive is to ensure the safety of the user. The Electrical Equipment (Safety) Regulations, which came into force on April 1, 1976 are among the measures being taken to implement the LV Directive.

The agreement between European countries to harmonise standards for electrical products has been an important method of ensuring compliance with the Directive. The new standards, which are being published in the UK as revisions to BS6500, 6004 and 6007, can be regarded as logical extensions in the process of metrication of cable standards which was initiated in the 1969 edition of the specifications. Members of the Electric Cable Makers Confederation will be able to provide users of cables and flex with any advice or guidance they may require on the new specifications.

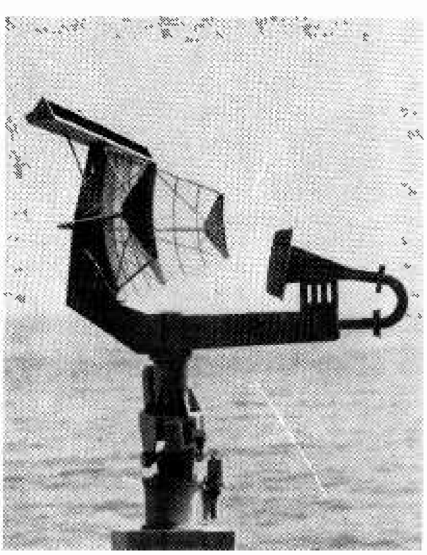
IEE's director of qualifications

A new director of qualifications has been appointed at the Institution of Electrical Engineers, London. Mr Allan Charles Sensicle, B.Sc., M.I.E.E., currently director of the Tayside Schools' Technology Centre Association, Dundee, took up this position in February. As director of qualifications, Mr Sensicle will be in charge of the department which deals with membership matters including the standards of educational qualifications and training required by the IEE. The department also gives advice and information to school leavers on careers in electrical engineering and provides a continuing education service, by correspondence course, for electrical engineers.

When asked about the role engineering institutions can play in education, Mr Sensicle said: "The low status of engineers in industry, science and technology indicates some of the attitudes to professional engineering prevalent in Britain today. This gives rise to a shortage of recruits, particularly those of high calibre, into the profession. Institutions can do a lot to show the relevance of applied science and its importance to society. In showing that engineering is human and exciting they can demonstrate that there is likely to be a great deal more that educationalists can gain from industry and can thereby provide young people with a greater understanding of the importance of engineering". (This month's leader comments on the pay of electronics engineers and technicians.

Mr Gilbert Briggs (right) early loudspeaker pioneer, discussing some of the latest products of his former employers in the new acoustic engineering block at the Wharfedale Works of Rank Audio Visual. The building, named Briggs House in his honour, was officially opened on December 15, 1975.

Lightweight stabilized antenna and a high performance transmitter-receiver which make extensive use of digital techniques are used in the new Plessey AWS-5 tactical radar system. A contract was recently awarded to Plessey by the Royal Danish Navy for the supply of the AWS-5.



Data dialled to South Africa

Computer users are now able to send data to South Africa on a directly dialled call — the first intercontinental Datel service to be put on the international subscriber-dialled network. Calls can be dialled direct to the South African towns which are available on ISD from the UK. The International Datel 600 service provides half duplex, serial transmission of digital data within the speed range of 600 to 1,200 bits/s while the Datel 200 service provides full duplex, serial transmission at speeds up to 200 bits/s. The Post Office are advising customers who have not previously used any of the international Datel services to contact their local telephone area offices to make sure they have suitable equipment.

Doubts on UK Citizens' Band

The Home Office still has reservations about the introduction of a Citizens' Band in this country (see Letters, January and March issues). They state that at a time when it is difficult to meet all the frequency requirements of public services and commercial users, and strict economy in the use of the spectrum is increasingly necessary to make existing resources last out, even a small Citizens' Band is a luxury we can ill afford. In Europe the Citizens' Band facility is of comparatively recent origin and those countries that allow it have not yet been confronted with such widespread problems as in the USA where the 27MHz Citizens' Band has been in use for many years. Nevertheless, the Home Office understands from its contacts in three European governments that they are concerned about the extent of Citizens' Band activity in urban areas, where interference to television reception seems to be the main trouble. According to a late item of news, the Citizens' Band licence has been withdrawn in Holland and will be replaced by a form of amateur licence for which an examination pass is required.

Sound '76 public address exhibition

This year's exhibition of the Association of Public Address Engineers is to be held at the Bloomsbury Centre Hotel, Coram Street, London WC1, from March 16 to 18. Admission is free and anyone with a trade or professional interest may attend during the opening hours of 10.00 to 18.00 (final day 10.00 to 17.00). The exhibition covers nearly 7,000 square feet of stand space and will show audio-visual communications and associated equipment. About 30 manufacturers will be participating. Further information can be obtained from APAE Secretariat, 47 Windsor Road, Slough, Berkshire.

Frequency modulation illustrated

Oscillograms obtained using a Fourier synthesizer illustrate the significance of sidebands in a frequency-modulated signal

by P. L. Taylor, M.A., F.I.M.A., F.I.E.E.

Department of Electrical Engineering, University of Salford

Textbooks on frequency modulation show that if a carrier oscillation of magnitude E_c and (angular) frequency ω_c is frequency-modulated by a sinusoid of frequency ω_m the result can be expressed as

$$e_c = E_c\cos(\omega_c + \beta\cos\omega_m t)t \ldots\ldots (1)$$

where β, the modulation index, is the ratio of the swing in carrier frequency ω_c to the modulating frequency ω_m. The books go on to state that (1) can alternatively by expressed as

$$\begin{aligned} e_c = E_c[&J_0(\beta)\cos\omega_c t \\ &+ J_1(\beta)\{\cos(\omega_c+\omega_m)t - \cos(\omega_c-\omega_m)t\} \\ &+ J_2(\beta)\{\cos(\omega_c+2\omega_m)t + \cos(\omega_c-2\omega_m)t\} \\ &+ J_3(\beta)\{\cos(\omega_c+3\omega_m)t - \cos(\omega_c-3\omega_m)t\} \\ &+ \ldots] \qquad \ldots\ldots\ldots (2) \end{aligned}$$

where $J_0(\beta)$, $J_1(\beta)$, etc, are Bessel functions of the carrier and sidebands for modulation index β. Values are found from tables.

It is explained that this represents a carrier-frequency oscillation together with pairs of sidebands at frequencies $\omega_c \pm \omega_m$, $\omega_c \pm 2\omega_m$, $\omega_c \pm 3\omega_m$ and so on.

Waveform synthesis

A student may perhaps be forgiven for doubting the "reality" of sidebands; after all, some of the early pioneers were equally doubtful. However, the significance of sidebands may be illustrated with the aid of a Fourier synthesizer, which consists of a number of oscillators working at successive harmonics of some lowest (fundamental) frequency. All the harmonic oscillators are phase-locked to the fundamental oscillator. There is provision for altering the amplitude and also the phase of each oscillator, so that for example the third harmonic output can be $\sin 3\omega_m t$ or $\cos 3\omega_m t$ or any phase in between. The primary purpose of a Fourier synthesizer is, of course, to show that a non-sinusoidal periodic waveform can be built up by adding together purely sinusoidal waveforms at the fundamental frequency and its harmonics, each with suitable amplitude and phase.

Such an instrument can also be used to illustrate f.m. as follows. Suppose we regard, say, the sixth harmonic oscillator as providing a "carrier" of frequency $\omega_c = 6\omega_m$, then the fifth harmonic has the frequency $\omega_c - \omega_m$ (where ω_m is the fundamental) and the seventh has the frequency $\omega_c + \omega_m$. Together these oscillators can provide the first pair of sidebands. In the same way the fourth and eighth harmonic oscillators can provide the second pair of sidebands at $\omega_c \pm 2\omega_m$; and so on for the higher-order sidebands. Thus it is possible to build up a series such as equation (2). Fig. 1 shows the result. The synthesized oscillation has a constant amplitude, but its frequency is varying. One cycle of frequency variation occurs for each cycle of the fundamental.

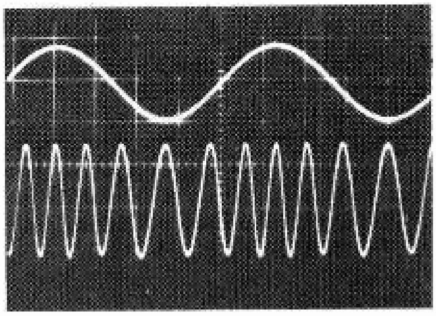


Fig. 1(a), top. Two cycles of the fundamental-frequency oscillation of a Fourier synthesizer. Below is a synthesized frequency-modulated waveform (b) based on a "carrier" of six times the fundamental frequency.

Clearly the result is indistinguishable from what would be obtained from a true frequency modulator. Equally clearly, if an f.m. receiver can handle the synthesized waveform it can handle the other. The converse is also true: if the receiver cannot handle the synthesized waveform it will distort the "true" waveform. For example, if the receiver has a restricted bandwidth it will distort the synthesized waveform because it rejects the high-order sidebands. It will equally distort the waveform from a modulator. The sidebands are real, at least in the sense that one ignores them at one's peril!

It is not just a question of adequate amplitude bandwidth; the phase response is equally important. Fig. 2(a) shows what happens if the relative phases of the sidebands are altered (as might happen in a receiver with a poor phase/frequency response), leaving their amplitudes unchanged. Considerable amplitude modulation has been introduced by the phase-shifts. The situation is not retrieved by amplitude limiting in the receiver shown in Fig 2(b). On the contrary: there is something clearly wrong with the f.m. information. The illustration is admittedly an extreme one, but the moral is clear. It is no use measuring just the amplitude-bandwidth of a receiver, and especially not after the limiter. This latter can yield an inflated figure which gives no guarantee that the phase response is satisfactory.

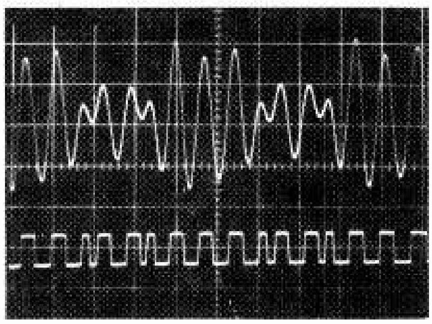


Fig. 2(a). The top waveform contains exactly the same components as the waveform (b) below, but with the components in the wrong phases. The waveform after amplitude-limitation (and amplification) is shown below (b).

Phasor diagrams

An even deeper insight into the significance of the sidebands is obtainable from a phasor diagram. The phasor which represents a frequency-modulated carrier, equation (1), has a constant length $\dot{E}_c$ and rotates with an average angular velocity ω_c. Its instantaneous velocity varies above and below ω_c because of the modulation. If in the usual way a constant angular velocity ω_c is subtracted the phasor simply oscillates backwards and forwards so that its tip traces out an arc of a circle, each oscillation occupying one cycle of modulation. The greater is β the wider the angle of swing and the larger the arc of the circle.

Let us see how the sidebands combine to give this result. Subtracting the constant value of ω_c from each of the frequency terms in equation (2) leaves

$$e_c = E_c[J_0(\beta) + J_1(\beta)\{\cos\omega_m t - \cos(-\omega_m)t\} + J_2(\beta)\{\cos 2\omega_m t + \cos(-2\omega_m)t\} + J_3(\beta)\{\cos 3\omega_m t - \cos(-3\omega_m)t\} + \ldots] \quad \ldots\ldots\ldots(3)$$

The phasors corresponding to the terms in this series are shown in Fig. 3. In this figure the scaling factor E_c has been omitted, and positive cosine quantities are reckoned upwards.

Starting from the origin O the first term, the carrier, is represented by a phasor of length $J_0(\beta)$ pointing upwards, which does not rotate. The first pair of sideband phasors each have length $J_1(\beta)$. The upper sideband phasor starts off at $t=0$ by pointing upwards (its sign is positive) and subsequently rotates anticlockwise (the sign of ω_m is positive). The lower sideband phasor starts off at $t=0$ by pointing downwards (its sign is negative) and subsequently rotates clockwise (the sign of ω_m is negative). As these phasors rotate their resultant moves from left to right along the line BAC. The total length of this line is $4J_1(\beta)$.

If β is small (narrow-band f.m.) $J_1(\beta)$ is small, and the line BAC is short. It is then by itself a good enough approximation to a small arc of a circle, and no higher-order sidebands are necessary. If β is larger then the straight line is not a good approximation to an arc; but then the second pair of sidebands becomes significant. These phasors are both of length $J_2(\beta)$; both start off at $t=0$ by pointing upwards (both their signs are positive). At $t=0$, therefore, the resultant of this pair of phasors raises the centre of the straight line, point A, up to E.

The resultant of the second pair of phasors, as they rotate clockwise and anticlockwise respectively, always lies along a *vertical* line. These phasors are rotating at twice the velocity of the first pair, with the result that, when they are added in, the outer ends of the line BC are bent downwards to the points D and F respectively. Thus the resultant of all the phasors considered so far traces out the parabola DEF. The third pair of phasors, like the first, have a resultant which always lies on a horizontal line. Adding them in tucks in the points D and F to G and H, and broadens out the arc in the region of the apex E. If, as in Fig. 3, the third pair of sidebands are the last significant ones, the arc GEH is part of a circle. (Note the general rule that the odd-order pairs of sidebands produce horizontal deflections, even-order pairs produce vertical deflections.)

Diagrams such as Fig. 3 are difficult to sketch and tedious to compute and plot; which is where the synthesizer can help. Fig. 4 shows successive stages for the case $\beta = 1$. In (a) the c.r.t. spot is moved upwards, using the y-shift control, by an amount $J_0(1)$ to represent the tip of the carrier phasor. In (b), the fundamental oscillator is applied to the x plates to produce a horizontal deflection of peak-to-peak amount $5J_1(1)$. In (c), the application of the second-harmonic oscillator to the y plates to produce a peak-to-peak vertical deflection of $4J_2(1)$ bends the straight line into an arc. Finally, in (d), addition of a small amount of third-harmonic oscillation to the x plates rounds off the arc into a

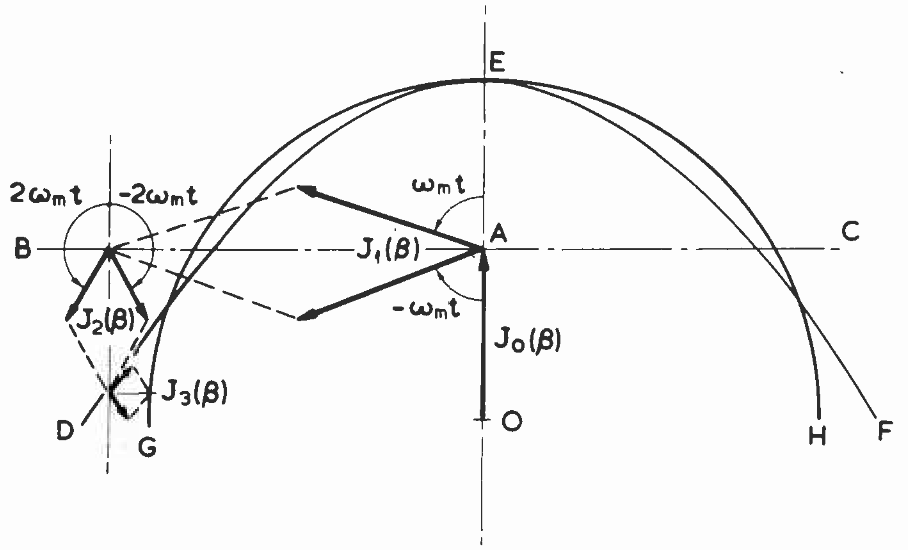
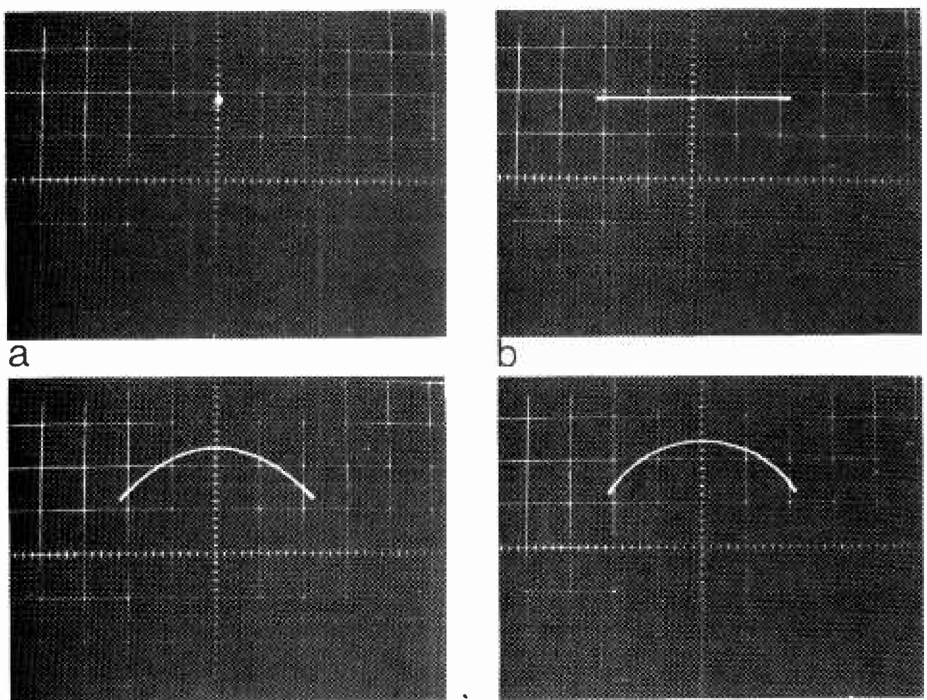


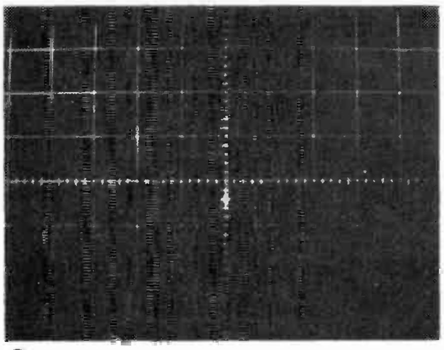
Fig. 3. The sideband phasors combine to trace out a circle.

Fig. 4 (below). Oscillograms obtained by adding successive harmonic oscillations to the x and y plates alternatively, representing (a) the carrier, (b) carrier plus first sidebands, (c) plus second sidebands, (d) plus third sidebands. Modulation index $\beta = 1$.



a b c d

Fig. 5 (right). A much larger number of sidebands is required when $\beta = 5$. Each picture is numbered according to the order of the sideband added. The appropriate values of the Bessel functions are:
$J_0(5) = -0.178$, $J_1(5) = -0.328$,
$J_2(5) = 0.047$,
$J_3(5) = 0.347$, $J_4(5) = 0.391$, $J_5(5) = 0.261$,
$J_6(5) = 0.131$, $J_7(5) = 0.053$, $J_8(5) = 0.018$,
$J_9(5) = 0.006$



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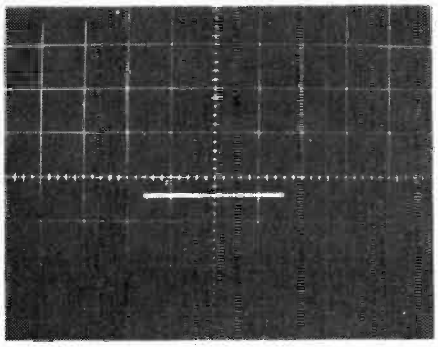

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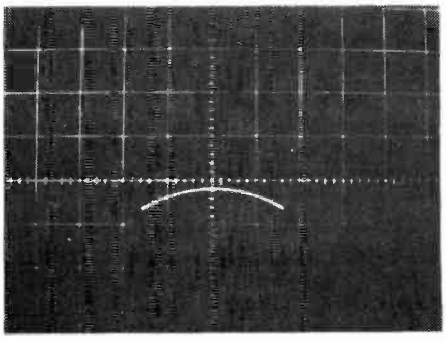

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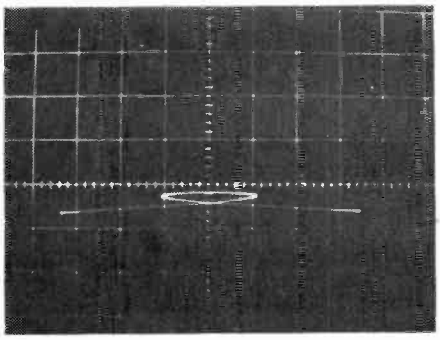

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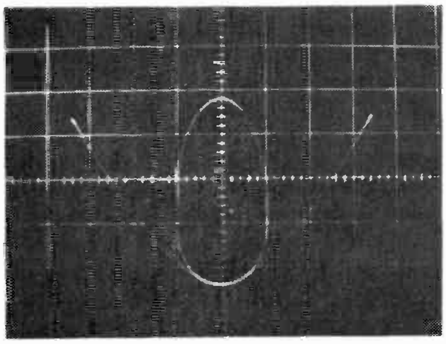

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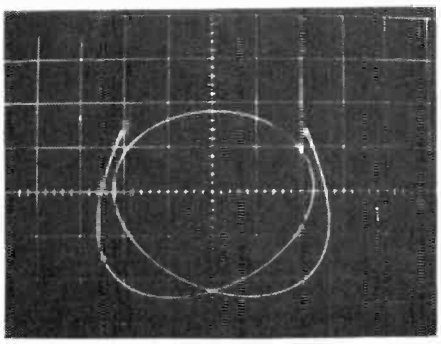

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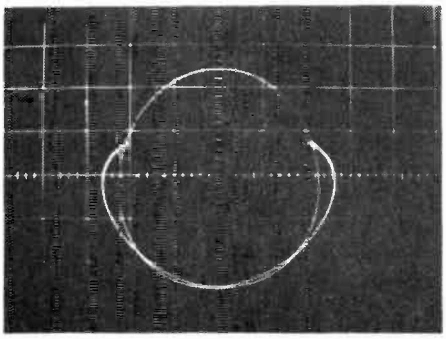

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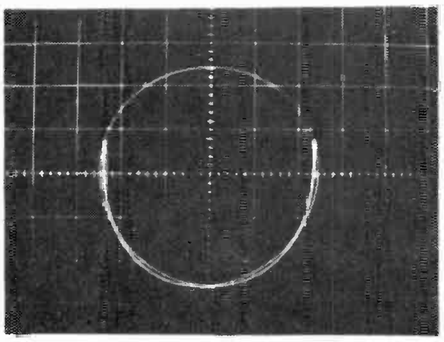

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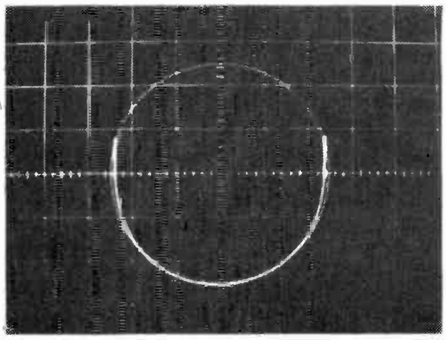

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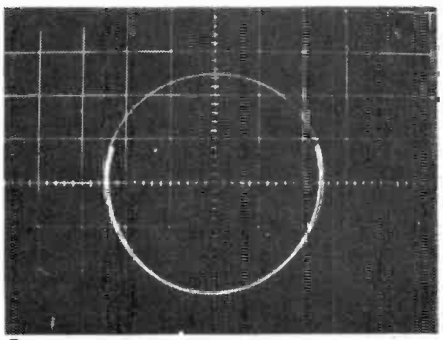

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circle. For $\beta = 1$ only sideband-pairs up to the third are important.

Fig. 5 shows the case $\beta = 5$. A much larger number of successive harmonics, applied alternatively to x and y plates, is required to produce a movement of the c.r.t. spot round a much greater arc of a circle. These pictures show quite clearly why (a) a larger number of sidebands is required if the modulation is increased; (b) the upper and lower sidebands of a pair always have the same amplitude; (c) if β is changed then the amplitudes of *all* sidebands must change– it is not just a question of adding in extra sidebands as β is increased, leaving existing ones unchanged; and (d) the amplitude of the carrier must also change.

Books Received

Transmission and Display of Pictorial Information by D. E. Pearson attempts to explain the principles of electronic systems which process, store and transmit information ultimately entering the human eye. The book starts with a mathematical analysis of images and then covers the properties of the eye affecting system design. Subsequent chapters discuss scanning, reception and display of monochrome pictures, transmission of monochrome information, displays in colour and the transmission of colour information. A concluding chapter deals with the subjective assessment of picture quality. Price £5.95. Pp. 225. Pentech Press, 8 John Street, London WC1N 2HY.

Guide to Amateur Radio by Pat Hawker G3VA (16th edition) has been published by the Radio Society of Great Britain. The publication has been enlarged and revised to incorporate the latest trends in amateur radio such as the greater use of single sideband techniques. A new chapter on amateur radio equipment includes a survey of over 160 receivers, transmitters and transceivers. Price £1.10 (post paid). Pp. 112. Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE.

Light Sense by Integrated Photomatrix is a handbook of optoelectronic devices and systems. The text starts with the facts of light and progresses through the detection process, the technology, integrating detection and the light-activated switch. Subsequent chapters cover self-scanned arrays, camera systems and special space applications. The book is well illustrated with circuit diagrams, graphs and block diagrams, and several industrial systems are described. A concluding chapter gives IPL product data. Price £2.50. Pp. 147. Integrated Photomatrix Ltd. The Grove Trading Estate, Dorchester, Dorset.

Letter from America

Last November, the first newspaper production operation in the world to be controlled through a communications satellite was officially dedicated by Dow Jones & Co., publishers of the *Wall Street Journal*. The journal is set in type in Chicopee, Massachusetts and facsimiles of full-size pages are sent via Westar I to another plant in Orlando, Florida – about 1,200 miles away. The reproduction proofs are individually wrapped around a transmitting drum and a light beam scans the page at 800 lines per inch, converting the print to electrical impulses. Transmission rate is 150,000 bits per second to Westar, 22,300 miles over the Equator, which relays the information to the earth station at Orlando. The receiving unit then converts the impulses back into light, which exposes the image on page-size (15 by 26 inches) sheets of film in an average time of three minutes. The developed film is laid over a sheet of treated aluminium to make a lithographic plate, which is then attached to the printing press. The earth stations use 10-metre diameter dish aerials and the electronics have automatic switchover based on fault monitoring of selected sections. The engineers responsible, the American Satellite Corporation, have supplied a number of similar satellite links to the US Government.

The NQRC (National Quadraphonic Radio Committee) has now presented its report to the Federal Communications Commission concerning the feasibility of quadraphonic broadcasting. A long series of tests included subjective listening to closed-circuit and over-the-air transmissions from five different proposed f.m. broadcast systems. There were seven panels, composed of nearly 100 engineers and other representatives of the industry. A considerable amount of data was collected and the report states: "The subjective tests positively demonstrate the compatibility, the feasibility and practicality of quadraphonic broadcasting. Specifically, the requirements for interconnecting facilities and broadcast transmitters were examined and it was concluded that the state-of-art equipment is sufficient to perform the quadraphonic service . . . The NQRC's results are not intended to recommend a specific system but are intended to replace a Federal Committee of Inquiry, and the FCC should now be in a position to propose rules for this new service." Elsewhere in the report it is stated: "To accommodate a quadraphonic service, modulation levels must be reduced and noise levels increased. However, the reduction in signal to noise is not large enough to significantly reduce the coverage of existing stereophonic services."

Since Tesla's day, the possibility of transmitting electrical power through the air has fascinated engineers all over the world. Much has been achieved with microwaves and waveguides but some very promising results have been obtained with electromagnetic beams and large parabolic dish aerials in experiments conducted in the Mojave desert. The engineers responsible are from the California Institute of Technology and Raytheon's Microwave and Power Tube Division, but the work is being sponsored by NASA. The object is to develop equipment capable of transmitting power from a solar energy collector in space to a receiving station on earth. According to Peter Glaser of Arthur D. Little Inc., a typical satellite using a 10cm microwave beam could provide 10,000MW and a network of such satellites could provide enough power to meet a significant portion of the foreseeable US demands. The distance covered and the power transmitted in the Mojave experiments are relatively small – 30kW of d.c. power over 1.54km – but this is only the beginning. The transmitter uses a klystron with a maximum output of 450kW at 2.388GHz, a 26 metre-diameter parabolic reflector aerial and a 100ft collimation tower. The receiving aerial consists of dipole rectifiers separated one-half wavelength from each other. Present collection efficiency is 82%, but is is stated that this will be improved to 90% as the Schottky barrier diodes used are potentially extremely efficient.

Citizens' band transceiver from Canada, the PocketCom. Uses a large-scale i.c. to provide two channels of 100mW r.f., crystal-controlled.

The year 1975 saw the sudden extraordinary rise of interest in CB (Citizens' Band) radio and old-established firms are competing with newcomers in a frantic rush to get a share of the market. A Personal Communications Show (PC-76) is to be held in Las Vegas at the end of March and plans are under way for a New York Show later. A new trade publication – Communications Retailing – was launched last October and another one is due to appear soon. There are already about six million CB radios in use, from 85 manufacturers (or importers) giving the "Cb-ers" a choice of more than 500 different models! If all the optimistic 1976 forecasts were added together, the total sales would be over $800,000,000, but a more realistic figure would be $400,000,000 – which is still a lot of money even for this affluent society! Most CB equipment is designed to fit into a car, with only about 5% hand-held models. One of the smallest is the JS & A "PocketCom" which measures only 5¼ by 1½ by ¾in. It uses a large-scale i.c. and the r.f. output is 100 milliwatts. Among the features are a beep-tone paging system, switch-selected two-channel operation (crystal controlled), a l.e.d. low-battery warning indicator, squelch control, and a 60dB a.g.c. circuit. Sensitivity is quoted as "better than 1 microvolt" but no noise figures are given.

What has caused this tremendous interest in CB? Some say the truckers (lorry drivers) were the first people to find out how useful two-way radio could be when they wanted to buy petrol during the fuel shortage, and to warn each other of police radar traps! Be that as it may, these days all kinds of people use CB – salesmen reporting to the office, security patrols in apartment complexes, workers on construction sites, housewives and students – anyone who can afford to buy one. No licence is required for outputs below 100 milliwatts. There is a recognised 10 code: for example, 10-4 means yes, 10-30 means danger and 10-33 help me quick. Truck drivers have been mainly responsible for the colourful but expressive vocabulary. For instance, "Plain Wrapper" means a police car with no markings, a "Seat Cover" is a passenger – usually female, and a "Pregnant Rollerskate" is – you've guessed it – a Volkswagen!

G. W. Tillett

Progress in Teletext

The views of broadcasters, equipment makers, device designers and the Post Office were fully aired at an IEE Colloquium on broadcast and wired teletext systems, held in January at Savoy Place.

The morning session was devoted to papers on the organization and transmission of teletext. John Chambers of the BBC Research Department described a technque for measuring the quality of the data signal by means of an "eye" display, also referred to in the summary of a paper by Bernard Rogers of Rank Radio International. The diagram in Fig. 1 shows that when the edges of the data bits have been distorted, due to amplitude/frequency response inadequency, group-delay inequalities, noise or multipath propagation, the "eye" aperture reduces in height. A pseudo-random pulse sequence is used and the eye pattern of the data from one line held on a storage display for recording or inspection. Mr Chambers described a number of variations on this theme.

Mr Chambers also pointed out that when regional transmitters carry networked programmes from London, the teletext signal is transmitted with them but that, as no special equalization equipment is used, the data is degraded, restricting the service. When teletext emerges from the experiment stage, its digital nature will enable local engineers to regenerate the data in video form prior to transmission. It has also been found that translators, which receive the broadcast signal and re-transmit it without detection and re-modulation, do not significantly degrade the teletext data waveform.

S. Fedida, of the Post Office Research Centre, read a paper on the Viewdata system, which was described in *WW*, Nov. 1975. This interactive system has an enormous potential data base which, if thoroughly catalogued and indexed, will provide extremely rapid access, very simply. A Viewdata terminal was in the exhibition and many private terminals are now in use experimentally, including one in Brussels.

BREMA have produced a market research report, in which it is pointed out that a considerable amount of publicity for teletext is absolutely essential – one exposure to the system interests people, but the impression quickly fades. However, it appears already that 12% of people who have, or will soon have, a colour receiver say they will buy teletext equipment.

Reception

Receiver and decoder design was discussed in the session under the chairmanship of Bernard Rogers, who made some general comments in his opening address. His main point was that the industry should not aim for standardization in techniques too precipitately. A number of design options are still open and the best solutions have yet to be found. For example, the question of data storage may be solved by r.a.ms., but serial storage is not completely out of court (charge-coupled devices were mentioned by R. Parsons): large-scale integration of current decoding circuitry is important, but the microprocessor may well be a good alternative. In the television receiver itself, a good group-delay performance can be obtained by the use of acoustic surface-wave filters, although conventional tuned circuits with correction might be better.

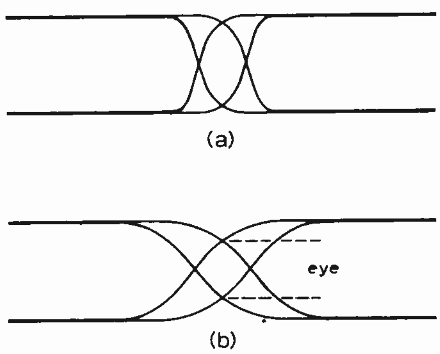


Fig. 1

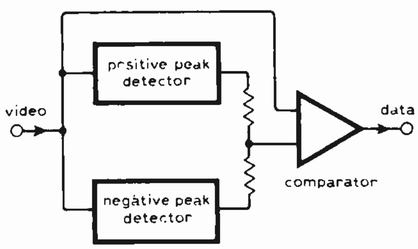


Fig. 2

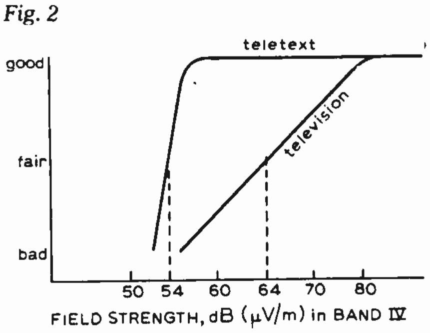


Fig. 3

J. Schaffer of Decca was of the opinion that a.s.w. filters were essential for i.f. amplifiers, saying that a group delay of less than 50ns is needed. His view was that synchronous demodulation was preferable to the envelope detector in its provision of equal positive and negative going data edges. It also reduces the effect of overmodulation, which can produce teletext vision interference on sound. Mr Schäffer also contended that a static data slicer (the circuit which extracts data from the video signal by "slicing" it at half amplitude) does not take account of varying signal levels and should be discarded in favour of the adaptive type, which is also able to reject low-frequency interference. A suggested circuit is shown in Fig. 2. Some encouraging evidence was given on the robustness of the teletext signal, the diagram in Fig. 3 showing that a good teletext display is often seen when the received signal is of too low a level for an acceptable television picture. The graph takes no account of multipath propagation, which can render a high level signal quite useless for teletext, although this would only happen rarely.

Papers from G. Crowther, J. Kinghorn and G. Summers of Mullard and R. Parsons of Texas Instruments illustrated two approaches to the integration of decoding circuitry. Mullard have three decoder i.cs, the "front end", which operates on the video input to produce clocks, syncs and data, being fabricated with linear bipolar devices, while the digital data acquisition and control sections are in LOCMOS. Texas use a variety of i.c. techniques and produce the Tifax module, which consists of 14 i.cs on a printed circuit board. TI obtain their character rounding by accessing a fast (180ns access time) character-generator r.o.m. twice.

In brief

- In reply to a French observer, it was mentioned that the CCIR and EBU are considering the implications of teletext on international standards.
- The only way to transmit teletext on 525/60 systems is to reduce the data rate and number of data lines.
- A plea of "Guilty" was entered by the assembled experts when accused of confusing us with differing keypad layouts. This will be rectified, the delegates were assured.
- Twenty-five organizations have already signalled their willingness to be information suppliers of Viewdata.
- The independent television companies are already experimenting with teletext advertisements.

PRD

Letters to the Editor

MICROPROCESSORS OVERSOLD?

Much of the published material on microprocessors can be misleading. We are told that this device has considerable computing power. It most certainly has, but only when surrounded by many more times the cost in other items. It must be made quite clear that the microprocessor chip on its own will do little or nothing; only when it is surrounded by many more chips can one start to think about the central processor unit doing something. At this stage thinking has to start in terms of what is now required to make this microcomputer (a much more correct description) work.

Now comes the shock situation, not only in engineering time, but also in many cases the cost of external devices required to make it do simple exercises. Memory has to be programmed, which means detailed software to be written and proved; some means of communicating with the microcomputer has to be devised; and input and output ports have to be interfaced to the system under control so that information can be fed in and the result of computation fed out. For more complex operations, items like teleprinters, c.r.t. terminals and magnetic stores all have to be considered as input/output ports to the microprocessor.

The microprocessor is here to stay so let's set about using it in an intelligent way and dispose of the image that as a chip it is a cure for all ills. If any of your readers are interested in forming into a society to spread the good news on microcomputers, their problems, their uses, programming them or even giving them up, then if they would care to contact me I am prepared to do some of the work in getting all of us who are learning together so that our labours may be made less difficult.

C. A. Hill,
Hepworth Electronics,
Worcester Road,
Kidderminster, DY10 1BG.

AUDIBILITY OF PHASE DISTORTION

The article by H. D. Harwood in the January issue on the non-audibility of phase distortion on programme[1] makes me feel in the position of being one-eared in the country of the deaf! As Geoffrey Horn pointed out some while ago[2], a high quality (reasonably phase linear) microphone feeding a Quad electrostatic loudspeaker produces a sound which is quite obviously different in quality when the speaker is connected in one phase than in the other. I suggest that your readers in a position to do so try this test; it convincingly demonstrates that the ears *can* hear phase on good quality musical programme.

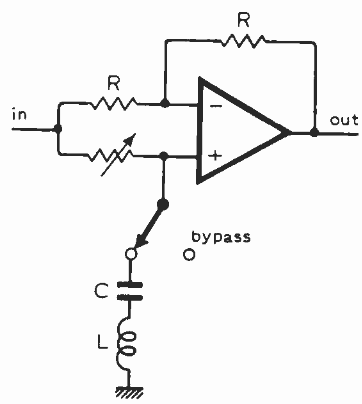
I suspect that most experimental reports purporting to prove that phase response is inaudible (provided that the rate of change of phase with log-frequency is not large)[1,3] on programme are simply demonstrating the inadequate quality of programme used. One source of poor programme is the use of microphones with a poor phase response and polar diagram at high frequencies, since phase errors are particularly noticeable on microphones with outstanding phase response in the extreme treble. Another source of degradation may be tape recording, which introduces phase degradation and also tends to "squash" high frequency information that may be important unless recording levels well below commercial practice are used. A third important source of degradation is the power amplifier. My experience shows that most commercial power amplifiers (even those that measure well in conventional tests)[4] introduce programme degradation considerably in excess of the changes produced by simple phase inversion. Without stating precautions taken to remove the effect of these variables, subjective tests on phase audibility cannot be evaluated sensibly by readers.

Readers wishing to inform themselves about conditions under which phase is known to be audible will find the two surveys in references 5 and 6 particularly informative. For example[6], it is known that the subjective audibility of second harmonic distortion on sinewaves depends on the phase relationship between the fundamental and second harmonic; this effect is *not* one involving a change in the envelope of a signal.

Phase response is particularly important in the high frequency region above 5kHz, where it is possibly used[7] to aid vertical sound localisation. A resonant all-pass network of the type shown in the figure can cause a "shrieky" quality that is difficult to tame even with a heavy treble cut. Such all-pass resonances give many pickups their distinctive sound quality despite resonably flat frequency responses.

Harwood[1] is perfectly correct in observing that straightforward phase response plots are almost meaningless, since their appearance is drastically modified simply by introducing a constant time delay. Probably a group delay plot is the most unambiguous presentation of phase response effects.

The argument is used in ref. 1 that very poor phase responses associated with room reflections or interference effects are not audible, and so phase response is unimportant – this is just wrong! I don't think that anyone claims that phase response on its own must be linear quite irrespective of whatever the frequency response is. It is quite possible that to each ragged frequency response there might be an optimum phase response, which will not generally be linear unless the frequency response is flat. For example, it has been suggested that the ears can hear the high-frequency phase response of speakers despite the effect of room reflections by looking at the signal following a transient for a period too short to include the arrival of delayed room reflections.



Resonant all-pass circuit, with variable Q control and bypass switch.

Finally, it may be[1] "very difficult to see how (phase) can be effective (on stereo image formation) above about 2kHz", but experimental studies on the effect of interspeaker phase on one-octave bandwidth signals[8] do report such effects at both 4kHz and 8kHz. Difficulties in understanding (and human hearing is full of them) should not make us ignore experimental results because they do not fit our present conceptual framework. A new conceptual framework (picturing the ear as a "bispectral" analyser as well as a spectral analyser) that *does* predict audibility of phase effects at high frequencies has been derived by the writer and submitted elsewhere for publication.

It is, of course, impossible ever to *prove* that some defect (e.g. of phase response) is inaudible, and the very greatest care is required in attempting to show that the defect is below a practical threshold of audibility. It is true that phase response defects *are* subtle compared to many other defects afflicting current programme material and hi-fi equipment, but they are audible under some high-quality programme conditions.

Michael A. Gerzon,
Mathematical Institute,
Oxford.

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2. Horn, G., "Hobby Horse", *Hi-Fi News*, Feb. 1973. pp.315
3. Bauer, B. B., "Audibility of Phase Distortion", *Wireless World*, vol. 80, Mar. 1974, pp.27–28.
4. (compiled by) Hughes, F. M., "17 Amplifiers taken to task"," *Hi-Fi for Pleasure*, vol. 3, Dec. 1975, pp.52-77.
5. Stodolsky, D. S. "The Standardization of Monaural Phase", *I.E.E.E. Transactions on Audio & Electroacoustics*, vol. AU-18, Sept, 1970, pp. 288-299.
6. Schroeder, M. R., "Models of Hearing", *Proc I.E.E.E.*, vol. 63, Sept. 1975, pp.1332-1350.
7. Gerzon, M. A. "Dummy Head Recording", *Studio Sound*, vol. 17, May 1975, pp.42-44.
8. Bower, J. S. "The subjective effects of interchannel phase-shifts on the stereophonic image localisation of narrowband audio signals", BBC Research Dept. Report BBC RD 1975/28, Sept. 1975.

Mr Harwood replies:
I note that Michael Gerzon can detect the difference in the quality of monophonic programme when the terminals of a loudspeaker are reversed. He mentions that this can be clearly demonstrated using a reasonably phase-linear microphone feeding a Quad electrostatic loudspeaker. I have carried out such tests under controlled conditions in a listening room but no one from a team of fifteen experienced listeners was able to detect any effect. This does not necessarily mean, of course, that no one else could have heard it, but it leads me to believe that those who can hear such effects must represent a very small proportion of the population.

He mentions the effect of phase relationship on the audibility of the second harmonic of a sine wave. I agree that this can occur; it is one of the sharp, relatively narrowband effects to which I referred. However, they do not appear to be audible on programme.

My view that phase information above 2kHz is relatively unimportant was based on a number of articles in the literature including some work[1] of my own. This was concerned with the permissible phase shift between the A and B channels of a stereophonic system and was used by the EBU in setting international tolerances; it showed that the permissible phase change at high frequencies was set, not by stereo effects, but by the monophonic compatibility when the two channels were added.

Michael Gerzon quotes a BBC Research Department report[2] against this view but Fig. 2 in the report shows that when octave bands of speech are applied with equal amplitudes to two loudspeakers such that one channel is 180° out of phase with respect to the other, the images extend right across the stage for frequencies up to and including 2kHz but that above this frequency the image is substantially central and relatively narrow. Hence my conclusion that phase has little apparent effect above 2kHz.

Clearly the argument concerning linear phase is unresolved.

May I take this opportunity to say in reply to Mr Bowers' letter in the February issue (p.44) that I consider the linear-phase theory to be worthy of careful consideration and certainly not a "gimmick" as in the subheading inserted by the editor. I was considering the subject from an academic standpoint snd made no reference to any manufacturer or specific loudspeaker. It is fair to add that the opinions expressed were based upon work carried out before the B & W loudspeaker was available.

References
1. Shorter, D.E.L., Harwood, H.D., Manson, W.I. "Stereophony: the effect of interchannel differences in the phase/frequency and amplitude/frequency characteristics". BBC Eng. Div. Monograph No. 56, Dec. 1964.
2. Bower J.S. "The subjective effects of interchannel phase-shifts on the stereophonic image localisation of narrowband audio signals". BBC Research Dept. Report 1975/28.

BAIRD'S RECEIVER

In their article in your January issue, "John Logie Baird and the Falkirk Transmitter," the authors seek to discover the methods used by Baird for his first public demonstration in 1926. I suggest that one conclusion from this survey must be that the receiver illustrated, now in the Science Museum, is incompatible with any of the transmission systems discussed, since this receiver is known to have a single spiral of 30 holes as opposed to the 8, 16 or perhaps 32 lines used for the picture generation. This does not bring us nearer to the truth, but even if the receiver at the Museum is not original (and indeed there are some reasons for doubting it) a receiver purporting to be such, and illustrated in *The Times* only a week after the demonstration, also appears to be quite small and compact judging from the cabinet, which is all that can be seen. It is difficult to imagine this could contain the complexity of wheels and discs shown in Fig. 4 and one is tempted to surmise the use of a simple single-spiral disc of perhaps 32 holes which would of course nearly fit the suggested 32-lens single-spiral transmitting disc illustrated in Fig. 2. However, one appreciates that so far there is little solid evidence.

One clue only touched on lightly is the statement that a model of the "original transmitter" was presented to Glasgow University as early as 1927. It is said that some parts of it are still in existence, but the implication seems to be that nothing significant (such as the scanning system) has been preserved. How does this come about? Can the University help us here?

The authors are to be complimented on their careful research including the discovery of the little-known "Falkirk Transmitter" and maybe they will have more to reveal in the future.

T. H. Bridgewater,
London, NW7.

We apologize that the photographs above the captions Fig. 6 and Fig. 7 on p.46 of the article were transposed. – Ed.

CITIZENS' BAND WANTED IN UK?

If low cost Citizens' Band radio facilities were extended to the UK I am sure they would not be unduly abused (Letters, Jan. issue). Among those benefitting would be weekend mountaineers, sailors, and others indulging in outdoor sports where accidents happen and time is lost searching for the incident. Sports and outdoor show organisers would also benefit – as is evidenced by the illegal use of small handsets at such events.

I cannot believe that the amateur radio fraternity would suffer in any way as those seriously devoted to radio communication would surely be put off by the low power and other restrictions of CB radio. So far as "Smokey Bear" messages are concerned, offenders could be charged with impeding the police in the execution of their duty, with a suitable fine as penalty.

Let us hope that the Home Office comes up with a suitable system so that the present impossibly high cost of a short range, light weight, low power radio telephone could be avoided by those who do not require the high standards of performance given by the present business radio type of equipment.

Walter Webber,
Long Ashton,
Bristol.

Editor's note: Mr J. R. Brinkley, chairman and managing director of Redifon Telecommunications Ltd and a well known pioneer in the development of mobile radio in the UK, made the following remarks when opening a recent IERE conference on civil land mobile radio. " . . . There are now about 4 million vehicles in the US equipped with Citizens' Band 27MHz mobile radio and the numbers are increasing by about 750,000 per year. So great has the recent growth been that the FCC has decided to increase the number of channels available to the service by 12. The demand for quartz crystals caused by this development is now in excess of 9 million per year and rising. Urgent consideration is therefore being given to providing l.s.i. synthesizers for the equipments to reduce this phenomenal demand for individual channel crystals . . . If a parallel Citizens' Band development had been taking place in the UK there would now be probably some 500,000 vehicles equipped with CB radio, many more than currently fitted under the present conventional licensing basis. This US development is interesting from two points of view. First, it seems to argue that there is a very large pent up demand for mobile radio. Secondly, it indicates that a tremendous utilisation can be got out of 12 channels. All this on a.m. too! Should we, I wonder, introduce Citizens' Band radio in the UK? On the face of it I cannot see why not. I feel it might well be a very healthy development."

STEREO NOISE LIMITER IMPROVEMENT

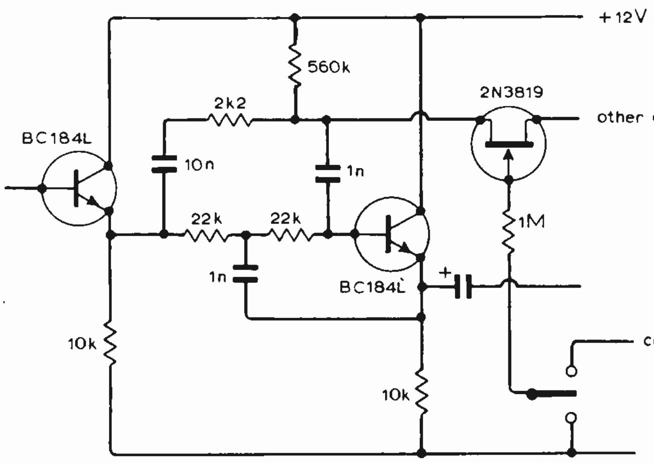
The two circuit ideas shown on p.474 of the October issue can be developed and combined in an interesting way. The dynamic noise limiter offered by Mr Richter is not really satisfactory as it stands since the switch-over from stereo to mono, even at low volume level, can be disconcerting to say the least.

However, the hiss which he is attempting to remove by this means is precisely an antiphase effect; thus a low pass filter, designed along similar lines to Mr Oldfield's stereo rumble filter, will remove it – with very little detriment to the overall signal. The f.e.t., driven by the amplifier output (or whatever – I prefer to drive it direct from the tuner), is now used to switch the filter into operation rather than to switch over to mono.

The component values shown in the circuit give very good results, and it was found that with a 2N3819 taken at random switch-over occurred abruptly at V_{gs} about −2V. Operating the f.e.t. from the positive line, as shown, facilitates switching the device in and out.

The bypass capacitor for non-filtering operation, 10nF, requires a resistor (2k2) in series with it to prevent excessive lowering of the input impedance at high frequencies. Otherwise the circuit is the low-pass corollary of Mr Oldfield's. I feel that the simple ingenuity of his circuit deserves considerable commendation.

Giles Hibbert,
Blackfriars,
Oxford.



Mr Hibbert's improved noise limiter circuit

PHASE AUDIBILITY: RATE OF CHANGE

I have in my laboratory a Fourier synthesiser, consisting of a fundamental oscillator at a frequency of 256Hz and harmonic oscillators up to the twelfth, all phase-locked to the fundamental. It is possible to alter independently the amplitude and phase (through a full 360°) of each of the harmonic oscillators. Thus it is possible to synthesise a wide variety of waveforms*, for listening tests.

The consensus of opinion among my colleagues is that the tonal quality of a sound depends solely on the amplitudes of the harmonic components and not on the phases. The phase of any harmonic may be altered individually by any amount without, apparently, altering the tonal quality. This applies when the phase-control knobs are stationary; while any one of them is being moved, i.e. while there is a rate of change of phase, the ear readily detects that "something is happening" (it is difficult to describe the effect in words). But since rate of change of phase is synonymous with frequency it is arguable that the detectability of the effect is due to the fact that a harmonic component becomes slightly inharmonic while the phase knob is being rotated.

The effect is very similar to that caused by any movement in the laboratory where the tests were carried out. This is acoustically quite lively, so that there must have been a marked standing-wave pattern, which would alter as a result of movement by anybody in the room. What seems to me surprising is (a) the sensitivity of the ear to movement, and (b) the fact that when movement ceases the sound appears to revert to its original tone quality, in spite of the fact that in this case one would expect the amplitudes as well as the phases of the harmonic components to have altered at the position of the ear.

These were all rather rough experiments, and I hope in time to do something more precise. But the fact is that we know so little about how the ear and brain perceive sounds that we do not even know what are the crucial experiments we should perform.

P. L. Taylor,
University of Salford.

* See Mr Taylor's article "Frequency modulation illustrated" in this issue. – Ed.

TV SOUND: BOOSTING WEAK SIGNALS

I have noted with interest the recent articles on television tuner design (Oct. 1975—Jan. 1976 issues), especially with reference to television sound reception. In this area of Ireland the cross-channel u.h.f. TV stations provide alternative programmes – if they can be received. U.h.f. signals in the 600MHz region from a 100kW e.r.p. transmitter 120 miles away are usually very weak and suffer from severe tropospheric fading, even at elevated sites. From experience I have found that only at 1000ft a.s.l. are signals acceptable.

Those of us at lower altitudes receiving u.h.f. signals have to cope with signals on television receivers that are loaded with noise to say the least. I have been experimenting for some time in order to get less noisy reception and offer the following comments.

At extreme distances fading occurs on signals at different rates at different frequencies and this includes u.h.f. television signals. Even when receiving steady but noisy video signals the audio signals are usually quite noisy also, not due to deficiencies in the f.m. system but to the fact that they are attenuated in the inter-carrier sound detection process. Having a few various u.h.f. tuners, I tried feeding them directly into the input of a sensitive f.m. portable (Tandberg TP41). The reception of weak signals using this method was much superior to that of the normal television receiver, especially when the outboard tuner was re-aligned to the v.h.f.-f.m. band frequencies acting as i.f. and detection stages. Mechanical and varicap tuners gave similar results. In fact when tested on a signal generator, signals of 3 to 5 microvolts of sound carrier in Band 4 gave good acceptable signals, and I am sure these figures could be bettered.

Desmond J. Walsh,
Carrick-on-Suir,
Co. Tipperary, Republic of Ireland.

Time-code receiver clock — 2

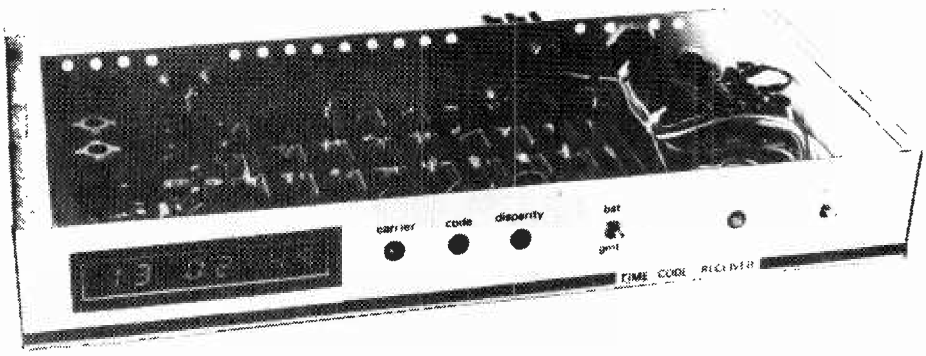
Control logic and display

by A. F. Cross, B.Sc.

Thames Television Ltd

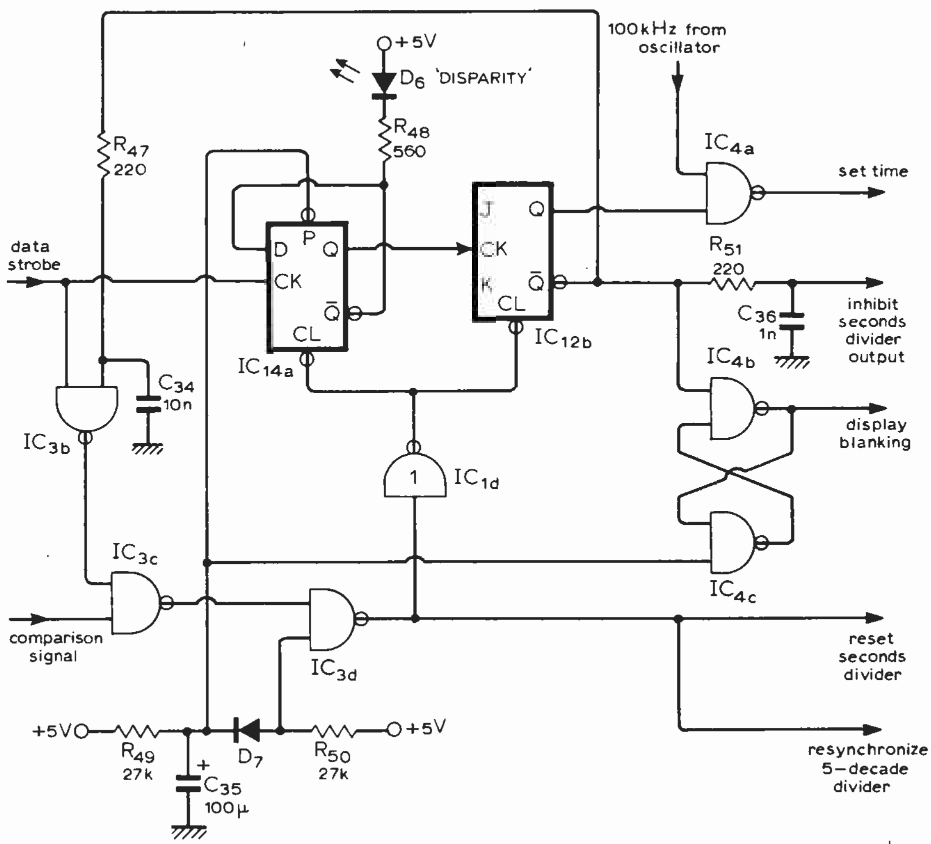
The control logic is shown in Fig. 10. A negative data-strobe pulse from the time-code register is applied to the clock input of the D-type flip-flop IC_{14a}. This operates as a divide-by-2, and is clocked by the data-strobe pulse. If, at the time of the data-strobe pulse, the comparator logic indicates no disparity between the incoming data and the display-dividers, a simultaneous reset pulse is applied to the clear input of the D-type via gates $IC_{3b,c,d}$ and inverter IC_{1d}. Thus the clock pulse will have no effect. If, however, the comparator is indicating disparity, the reset will not be applied, and the data strobe will clock the D-type into the 1 state. This is remembering that a disparity has arisen, but no action is taken apart from lighting the disparity indicator (the benefit of the doubt is given to the display-dividers). One of two things can happen on the next code one minute later; if no disparity is signalled by the comparator the D-type will be reset, and the previous disparity ignored. If a second disparity is indicated the reset pulse will not appear, and the clock pulse will now cause the D-type to revert to the 0 state, clocking the JK flip-flop IC_{12b} to a 1 as it does so. With the JK flip-flop's Q output at 1, gate IC_{4a} is enabled and passes 100kHz pulses into the minutes and hours-dividers, thus advancing the indicated time. When the time in the hours and minutes-dividers becomes equal to the received code, the comparator produces an equal signal which resets the JK and D-type flip-flops, thus disabling the 100kHz clock pulses. The inhibit-seconds-output signal from the Q output of the JK flip-flop ensures that gate IC_{4d} in Fig. 3. does not inhibit the 100kHz pulse train. The data-strobe signal also resets the seconds dividers and resynchronizes the 5-decade divider, so long as there is no comparator error signal.

The initial conditions upon switching on the clock are provided by C_{35}, D_7 and the cross-coupled NAND-gate ($IC_{4b,c}$) bistable. Capacitor C_{35} is initially discharged and presents a 0 to the input of IC_{3d} via diode D_7. Thus a low reset is provided on the clear inputs to bistables a and b via inverter IC_{1d}. However, the



Complete clock showing one matrix board containing all the circuitry except for the power supply.

Fig. 10. Control logic.



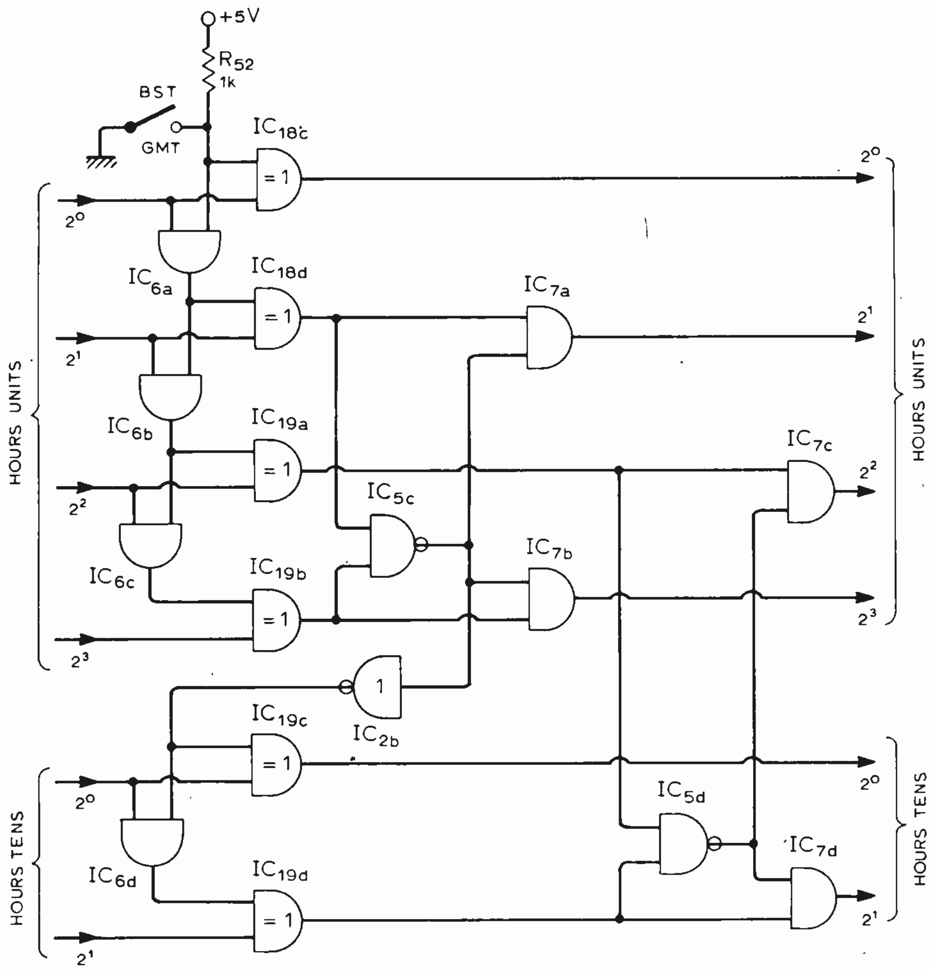


Fig. 11. GMT/BST converter. This section adds one to the hours code presented to its input, and is essentially a simplified binary adder.

preset condition is also applied to bistable a. As C_{35} charges its potential rises and diode D_7 ensures that the logic 0 disappears from the input of IC_{3d} (and therefore from the clear inputs of the bistables) before the preset is removed from bistable a. This bistable is left in the set state, and bistable b in the reset state. The disparity lamp will light, and on the first received time code the display dividers will be set to match it, rather than the normal running procedure of waiting for the second received code before setting the display dividers. The cross-coupled NAND-gate bistable is also reset by capacitor C_{35}, and set when the $\bar{Q}$ output of bistable b goes low, which occurs when the control logic is setting the time in the display-dividers. The output of IC_{4b} controls the blanking input to the b.c.d.-to-7segment decoder-driver. Thus, on switching on, the display will be blanked until the first time code is received.

The GMT/BST Converter, when enabled, adds one to the hours code presented to its input as shown in Fig.

Component list

Resistors (all ⅓W, 5% unless stated)

R1, 2, 3	220k	31	220
4	10k	32	56k
5, 6	220k	33	4k7
7	10k	34	10k
8	33k	35	4k7
9	18k	36-39	220
10	3k9	40	560
11	2k2	41	470k
12	1k5	42	2k2
13	4k7	43	470k
14	1M	44	10k
15	82k	45	4k7
16	4k7	46	330
17	470k	47	220
18	100k	48	560
19	27k	49, 50	27k
20	3M3	51	220
21	270	52	1k
22	330	53-58	4k7
23	10k	59-64	820
24	1k	65-71	270
25	4k7	72	180, ½W
26	15k	73	20k skelton preset
27	10k	74, 75	10k skeleton preset
28	15k		
29	2k2		
30	4k7		

Capacitors (± 10% unless stated)

C1	1n polystyrene
2	500p Trimmer (RS Components)
3, 4, 5	100n
6, 7	5n polystyrene (4n7 + 270p) see text
8-14	100n
15	2μ2 10V electrolytic
16	47μ 10V electrolytic
17	33n
18	1n
19, 20	4μ7 35V tantalum bead (± 20%)
21	470n
22	100n
23	1n
24, 25	10n
26	1n
27	10n
28	4-20p trimmer
29	39p silvered mica (RS Components)
30	500p silvered mica (RS Components)
31	1n5 silvered mica (RS Components)
32	33p
33	2μ2 10V electrolytic
34	10n
35	100μ 10V electrolytic
36	1n
37	4,700μ 16V electrolytic
38	10μ 10V tantalum bead

Additionally a 10n ceramic disc across the 5V supply at each i.c. is recommended.

Integrated circuits

IC	Function	Type No
1	Inverter	SN7404N
2, 3, 4, 5	2-I/P NAND	SN7400N
6, 7	2-I/P AND	SN7408N
8	3-I/P NAND	SN7410N
9, 10	4-I/P NOR	SN7425N
11	B.c.d./7 segment decoder	SN7447AN
12, 13	J-K flip flop	SN7473N
14	D-type flip flop	SN7474N
15, 16, 17, 18, 19 20, 21, 22, 23, 24	Exclusive -OR	SN7486N
25, 26, 27, 28	Decade counter	SN7490N
29, 30, 31	Divide-by-12	SN7492N
32	Monostable	SN74123N
33	One-of-ten decoder	SN74145N
34, 35, 36, 37	8-I/P Multiplexer	SN74151N
38, 39	8-bit shift register	SN74164N
40	5-volt regulator	LM309K

Transistors

Tr 1-8	BC 108
9-12	2N4123
13, 14	BC 108
15	2N4123
16-21	MPS6534 (Motorola)

Diodes

D1, 3, 4	IN 914
2	Light emitting diode: yellow (RS Components)
5, 6	Light emitting diode: red (RS Components)
7	OA47
8	Full wave bridge, type REC 76 (RS Components)
9	Light emitting diode: green (RS Components)

Display
Seven segment l.e.d. type, Litronix DL 707 (Forward drop 1.7V at 20mA): 6 required

Crystal
100kHz type MG5X (Quartz Crystal Co. Ltd)

Transformers

T1, 2	Wound on Mullard Cores type LA 1416 (adjuster LA 1503): Primary: 100 turns 36 s.w.g. (1.42mH) Secondary: 10 turns 36 s.w.g.
3	Mains transformer 20VA. 9V r.m.s. (RS Components, type 207-122)

Aerial
Ferrite rod 8in × 5/16in diameter. Denco.

Miscellaneous
Heatsink for regulator 8°c/W or better. Mains fuse 300mA slow.

11. It is essentially a simplified binary adder, with modifications to cater for the decimal count and twenty-four hour reset. The BST enable signal is effectively a one-bit number which is added to the six-bit hours code. With the BST enable line at logic 1 (switch open), a 1 is added to the GMT code to produce a BST output; with the BST enable line at logic 0, nothing is added to the incoming hours code and it passes unaltered through the converter. Gates IC_{6a} to IC_{6d}, $IC_{18d, d}$ and $IC_{19a, b, c, d}$ perform the add function. The operation on each bit is identical. The first addition is performed by exclusive —OR gate IC_{18c} and the AND gate IC_{6a}. With the switch closed, a 0 is presented to one input of each gate; thus the AND gate is inhibited, and the output of the exclusive —OR gate follows the hours code input. With the switch open, a 1 is applied to one input of both gates. When the hours code 2^0 input is a 0 the BST bit will convert the output of the exclusive —OR gate to a 1, but, because the code input is low, it inhibits the AND gate; no carry is therefore passed to the next stage. With the hours code 2^0 input at logic 1, the gates provide the required 0 output on the 2^0 line and a carry bit to the next significant level where the process is repeated on the 2 input. Because speed is unimportant, this ripple-through technique is quite suitable.

Truth table for multiplex clock

Output code of ÷ 12

D	C	B	A	Digit enabled
X	0	0	0	Tens of hours
X	0	0	1	Units of hours
X	0	1	0	Tens of minutes
X	0	1	1	Units of minutes
X	1	0	0	Tens of seconds
X	1	0	1	Units of seconds
X	0	0	0	Tens of hours
X	0	0	1	Units of hours
	etc			etc

(X = irrelevant)

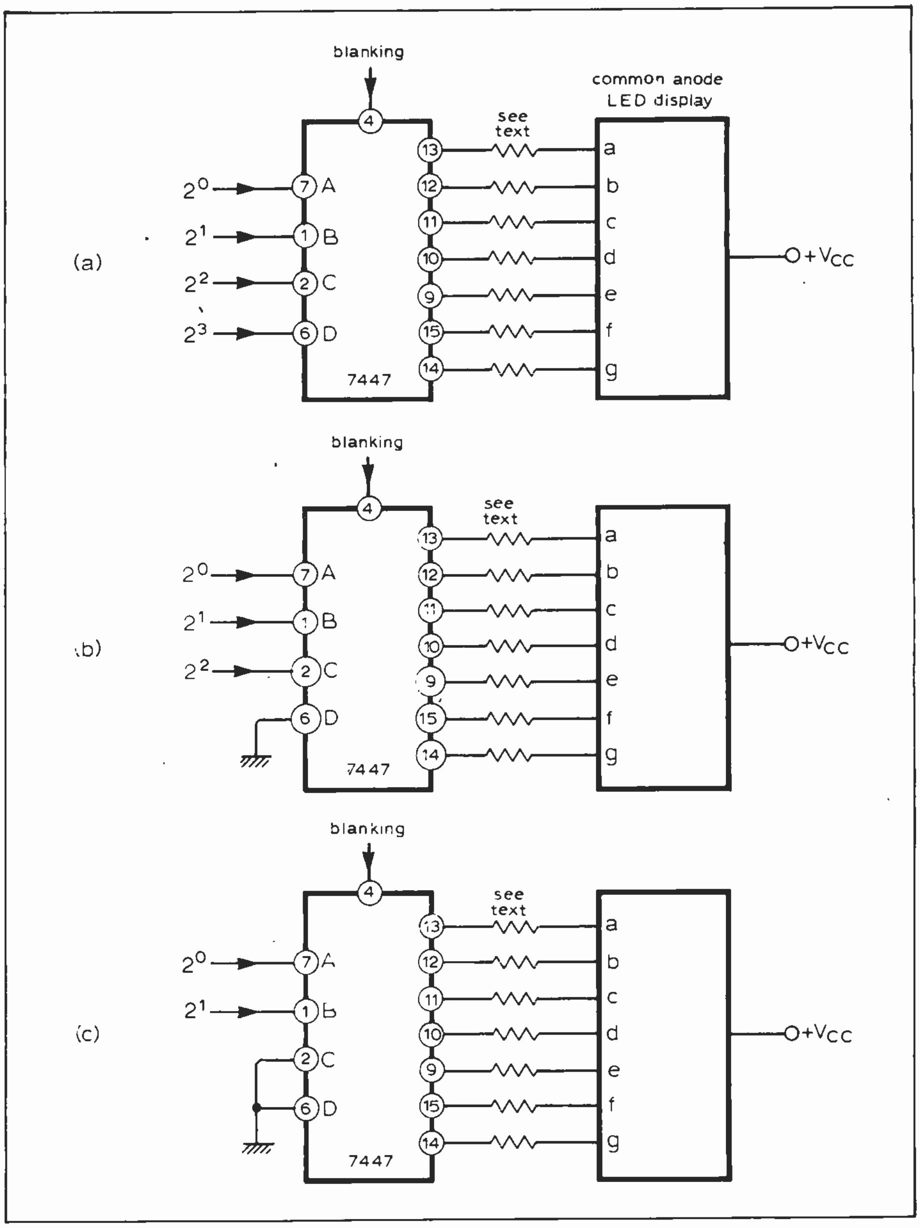
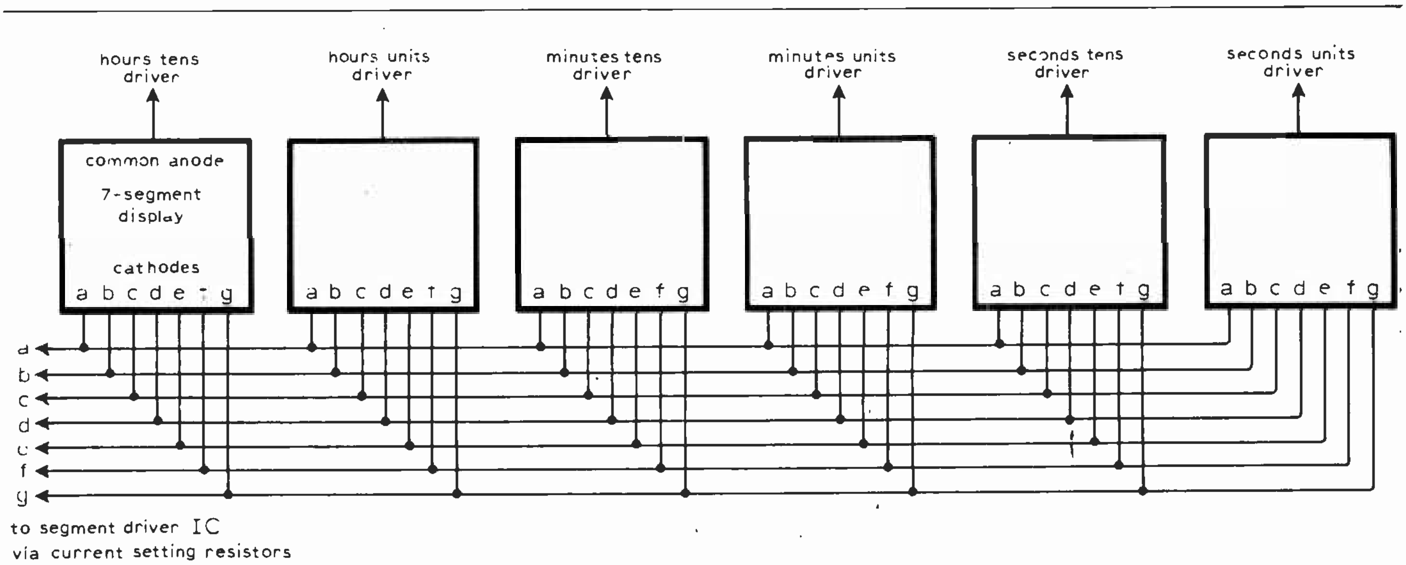


Fig. 12. (a) Drive for units of hours, minutes and seconds (3 required), (b) drive for tens of minutes and seconds (2 required), and (c) drive for tens of hours.

Fig. 13. Multiplex connection details for display which uses a total of six anode and seven cathode connections.



Gate IC_{5c} detects the condition 1010 (decimal value 10) on the hours-units output, produced by a decimal value 9 input. When this happens the hours units must have an output 0000 and a carry must be passed to the tens-of-hours. A low output from IC_{5c} inhibits the outputs of gates IC_{7a} and IC_{7b}, which produces the carry 1 from inverter IC_{2b} for the tens-of-hours adder. Gate IC_{5d} detects the decimal value 24 (10 0100) on the output of the adder and inhibits the gates IC_{7c} and IC_{7d} to produce the required all-zeros output.

Display

The display can take several forms, using either numerical indicator tubes or seven-segment displays. The author's clock uses seven-segment l.e.d. displays. Two modes of display operation have been used by the author and both are described.

The simplest method uses a SN 7447 AN b.c.d.-to-seven-segment decoder-driver for each digit, as shown in Fig. 12. Any unused data inputs to the decoder must be grounded. The resistors between the decoder outputs and the segment cathodes set the currents to about 10mA. Supply potentials other than 5V may be used for the display, provided that the resistor value is adjusted and the voltage rating of the decoder output is not exceeded. It may be convenient, for example, to run the display from the d.c. supply feeding the 5V regulator, rather than from its output, to reduce the current demand on the regulator. This parallel method of driving the displays, while simple in principle, does involve 42 current-setting resistors, and 43 connections to the display board. For about the same component cost, but with only seven current-setting resistors and thirteen display board connections, the multiplex mode of operation may be used. This has been adopted for the prototype clock and is shown in Fig. 14.

With this method the digits are not driven simultaneously, but in sequence, and at a rate which appears as a continuous drive of all digits. Only one b.c.d.-to-seven-segment decoder-driver is used, which receives in turn the input code for each digit. In this case each digit code is applied for 1mS, and is repeated every 6mS. Synchronously, with each digit code being applied to the decoder-driver input, the appropriate common anode connection is switched to the supply rail by the associated driver transistor. The multiplexing of the six-digit codes into the decoder-driver is performed by four 8-input multiplexers, type SN 74151N. The digit code is selected by the three-bit code applied to the selector inputs of the multiplexers, and derived from the A, B and C outputs of the divide-by-12, IC_{31}. The counting sequence, and the digit-code enabled for each state are shown in the table. The count outputs are also applied to the inputs of the 1-of-10 decoder, IC_{33}. Each input state produces one low output only, and this is used to switch on the anode driving transistor for the display digit whose code is currently controlling the display cathodes. Because only one digit common-anode is driven at any time, the equivalent cathodes in all displays may be connected together as shown in Fig. 13. This results in a total of six anode and seven cathode connections.

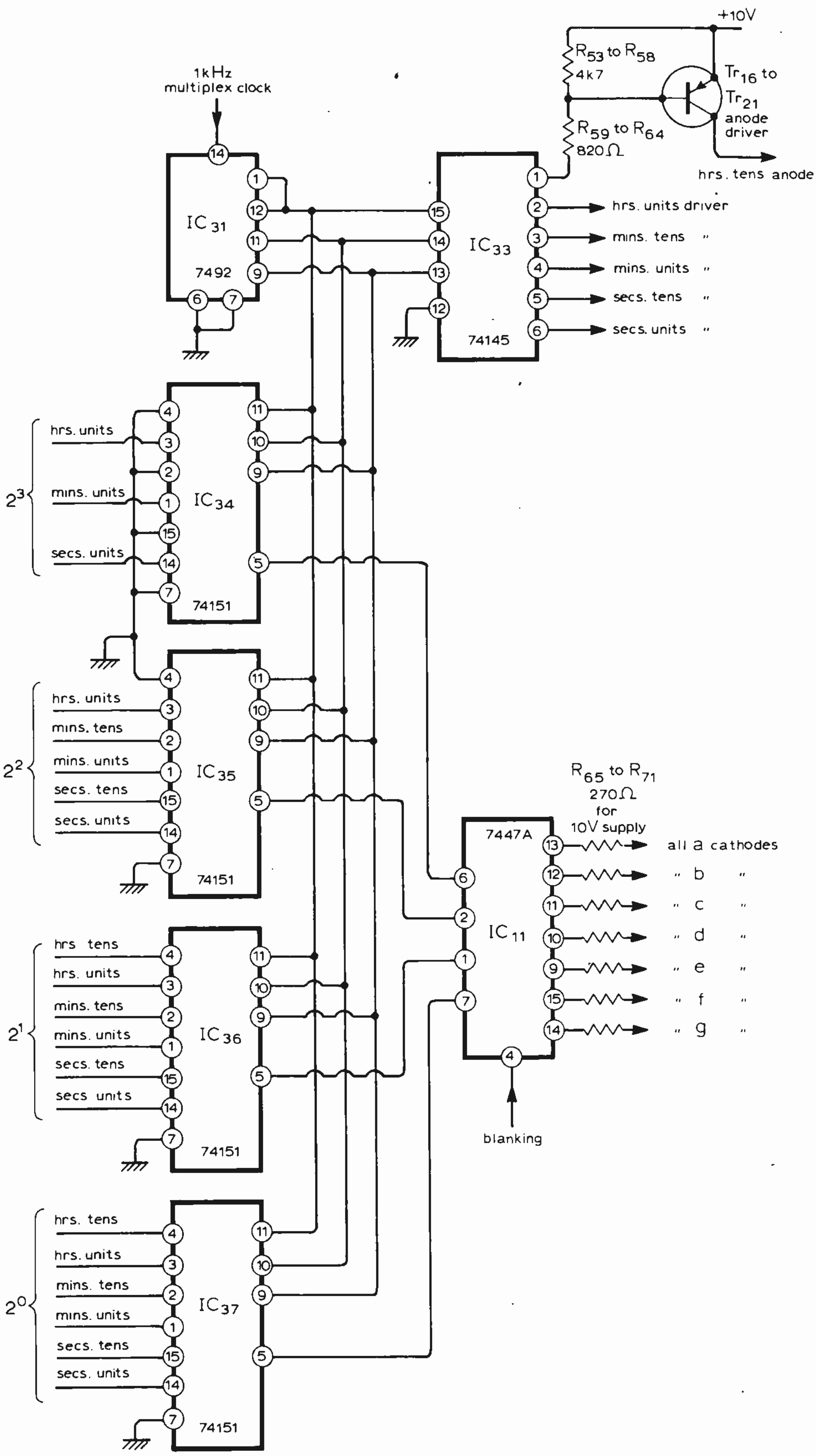


Fig. 14 Multiplex display logic drivers. This method of driving the displays only requires seven current-setting resistors and thirteen display board connections.

Conferences & Exhibitions

Supplementing list in January issue

LONDON
Mar. 16-18 Bloomsbury Centre Hotel
Sound '76 — Public address exhibition
(APAE Secretariat, 47 Windsor Road, Slough, Berkshire)

Mar. 22-26 Imperial College
Seminex '76 (seminar of semiconductor technology and applications)
(Seminex Ltd., 2 Old Stone Link, Ship Street, East Grinstead, WestSussex RH19 4EF)

Mar. 23-25 New Horticultural Hall
Computermarket '76 exhibition

Mar. 30-Apr. 1 West Centre Hotel
Tempcon (Temperature Measurements and Control exhibition and conference)

Apr. 27-May 2 Heathrow Hotel
Hi-Fidelity '76 exhibition
(Emberworth Ltd, 8 Furlong Road, Bourne End, Bucks.)

June 8-12 Olympia
Internavex — International Audio Visual Aids Exhibition
(Brintex Exhibitions Ltd., 178/202 Great Portland Street, London W1N 6NH)

June 8-12 Olympia
Infofair — information retrieval exhibition
Brintex Exhibitions Ltd., 178/202 Great Portland Street, London W1N 6NH)

Aug. 24-26 Holland Park School
Education and Communication Technology exhibition

Sept. 13-19 Olympia
International Audio Festival and Fair
(Iliffe Promotions Ltd.. Dorset House, Stamford Street, London SE1 9LU)

Sept. 14-16 Heathrow Hotel
Eurocomp — European Computing Congress

Nov. 16-18 West Centre Hotel
International Minicomputer Conference and Exhibition

BIRMINGHAM
Nov. 15-19 National Exhibition Centre
National Design Show
(Fairs and Exhibitions Ltd., 21 Park Square East, Regent's Park, London NW1 4LH)

BRIGHTON
Mar. 9-11 Metropole Convention Centre
Electro-Optics/Laser International Conference and Exhibition

Oct. 19-21 Metropole Convention Centre
Internepcon/UK Electronic Production conference and exhibition

BRISTOL
Mar. 2-4 Esso Motor Hotel
Computermarket '76 exhibition

CAMBRIDGE
June 21-24
Training and Career Development for Engineers
(I.Mech.E., 1 Birdcage Walk, London, SW1)

EDINBURGH
Mar. 9-11 Assembly Rooms
Computermarket '76 exhibition

Sept. 2-3 Heriot-Watt University
Institute of Acoustics Autumn Conference
(Institute of Acoustics, 47 Belgrave Sq., London, SW1X 8QX.)

FARNBOROUGH
Sept. 5-12 Royal Aircraft Establishment
International Air Show

HULL
Apr. 7-9 University of Hull
Electronics Teaching Conference
(Department of Electronic Engineering, The University, Hull HU6 7RX)

LEEDS
June 29-July 1 University of Leeds
Leeds Electronics Exhibition

LIVERPOOL
Apr. 12-14 Liverpool Polytechnic
Institute of Acoustics Spring Conference
(Institute of Acoustics, 47 Belgrave Square, London SW1X 8QX)

MANCHESTER
Mar. 16-18 Wythenshawe Forum
Computermarket '76

NOTTINGHAM
Mar. 24-26 Nottingham University
Industrial Robot Technology conference and international symposium on industrial robots

SOUTHAMPTON
Apr. 7-9 Southampton University
Interaction of electrons with solids
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

July 5-8 Southampton University
Marine Electronics Symposium
(Society of Electronic and Radio Technicians, 8-10 Charing Cross Road, London WC2H 0HP)

WEMBLEY
Sept. 13-17 Conference Centre
Micro 76 — International symposium and exhibition of microscopes and ancillary equipment

Oct. 11-14 Conference Centre
Coil Winding International 76 exhibition and conference

Oct. 26-29 Conference Centre
Microforum International exhibition

Nov. 23-25 Conference Centre
Compec — computer peripheral and small computer systems exhibition and conference

OVERSEAS
Mar. 14-21 Leipzig
International Spring Fair

Mar. 18-28 Rome
International Exhibition of Electronics Nuclear Energy and Aerospace Technology

Mar. 21-24 Chicago
30th Broadcast Engineering conference

Mar. 22-24 Rome
International Scientific Congress on Electronics

Mar. 23-26 Hamburg
Automatic Testing '76 exhibition and conference
(Network, 84 High Street, Newport Pagnell, Bucks, MK16 8EG)

Mar. 23-27 Basle
Didacta — European Educational Materials Fair

Apr. 7-8 Paris
International Symposium on Deposition and Packaging of Hybrid Circuits

Literature Received

An application note from RCA (AN-6330) describes a safe-area rating system for transistors used in power invertors. Circuits employing self-excited single transformers, s-e double transformers and driven types working into R, C or L. loads are covered by the system. RCA Ltd, Solid State-Europe, Sunbury-on-Thames, Middx. WW416

A chart from Lambda illustrates and tabulates a full range of power supplies and over voltage protectors. Single, twin and triple supply units are described. Lambda Electronics Ltd, Abbey Barn Road, High Wycombe, Bucks WW417

A descriptive leaflet and Technical Bulletin from Multicore contain a full description and application information on 96S Arax silver solder wire, designed for the jointing of stainless steels, particularly in food handling equipment, where lead-free materials are a requirement. Multicore Solders Ltd, Hemel Hempstead, Herts. . . . WW418

Switches, keyboards and displays for digital applications are fully described in a cataloque from Cherry. Characteristics. drawings and data are included. Cherry Electrical Products (UK) Ltd, Lattimore Road, St. Albans, Herts. WW419

An application note entitled "Low-csot, high-speed a-to-d conversion with the DAC-08" is available from Precision Monolithic. Three designs are described, of 4, 2 and 1μsec conversion times, and a printed-board layout is provided for the 1μsec design. Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx. WW420

Scientific instruments, mainly in the nucleonic field, are briefly described in a short-form catalogue from ESI Nuclear. Many of them are said to be designed for low cost, although no prices are given in the catalogue. ESI Nuclear, 6A Holmesdale Road, Reigate, Surrey RH2 0BQ. WW421

The new Heathkit catalogue will be available in February. New kits this time include a stop watch, ignition analyser, s.s.b. transceiver, 2-metre hand-held transceiver and a 30MHz counter. Heath (Gloucester) Ltd, Bristol Road, Gloucester GL2 6EE. WW422

The new Brimar Design Data Handbook on industrial cathode-ray tubes is now available, covering tubes for oscilloscopes, radar, television, data display and monitor equipment and special types such as flying-spot scanners and monoscope character generators. The charge for the Handbook and a newsheet service is £2,00 in the first year and then £1 per year. Thorn Radio Valves & Tubes Ltd, Mollison Avenue, Brimsdown, Enfield, Middx.

Electrovalue have sent us their catalogue No. 8, which is rather bigger than previous issues. All varieties of component are listed — semiconductors, hardware, materials and kits. The Catalogue costs 40p by post, but this will be refunded if goods costing £5 or more are ordered. Electrovalue Ltd, 8 St. Jude's Road, Englefield Green, Egham, Surrey.

A leaflet by Varelco describes a range of accessories for mounting dual-in-line integrated circuits — sockets and d.i.p. plugs and covers. Varelco Ltd, Exning Road, Newmarket, Suffolk. WW423

Ferranti have produced a new product guide to their range of t.t.l. i.cs — standard and low-power series. BS9000 approval is under way for many of the types listed. Ferranti Ltd. Gem Mill, Chadderton, Oldham. WW424

Synchronous motor-driven timers made by the Italian company, cdc, are characterized in a leaflet available from Tempatron Ltd, 5 Loverock Road, Reading. WW425

Television from India

Experimental stations in Dublin and Sheffield have been receiving All India Radio television programmes via the ATS-6 direct broadcasting satellite

The ATS-6 satellite, at present in geostationary orbit at longitude 35°E over Lake Victoria in Africa, is being used to re-broadcast domestic television to rural parts of India. The transmissions are of an experimental nature and are scheduled to last only until August 1976. They are on a frequency of 860MHz with f.m. vision on 625 lines, 50 fields/s. Sound is also f.m., with two channels, one at 5.5MHz and the other at 6.0MHz above baseband. Although the 30ft parabolic antenna on the satellite is pointing at India and giving a 2.8° beam, Europe is at worst about 12° degrees off the beam axis so that signals of approximately 30dB down or less on the on-axis signal can be expected, corresponding to an expected field strength of 3.3μV/m. The following reports are from two experimental stations, one in Eire and the other in England, where the Indian television pictures have been successfully received (see also News, February, and leader, December).

Report from G. Baird, T. McKenna, E. O.'Mongain and John White.
University College, Dublin.

The system used at University College, Dublin, shown in Fig. 1, consists of a 20ft diameter parabolic dish with a helical antenna wound for 860MHz and terminated in a manner similar to that described by E. H. Davis, in *Wireless World*, November 1968 (pp. 386-387). This is followed by a coaxial switch, making it possible to check at any time the frequency alignment of the electronics or the signal level compared with a 50Ω load. A high-pass filter is necessary in order to minimise local interference from harmonics of local television transmitters. A local oscillator at 790MHz is used to produce an i.f. at 70MHz. This frequency was chosen simply because of the availability of 70MHz equipment. The remainder of the laboratory equipment is more or less standard and the only problem arises from local sources of interference,

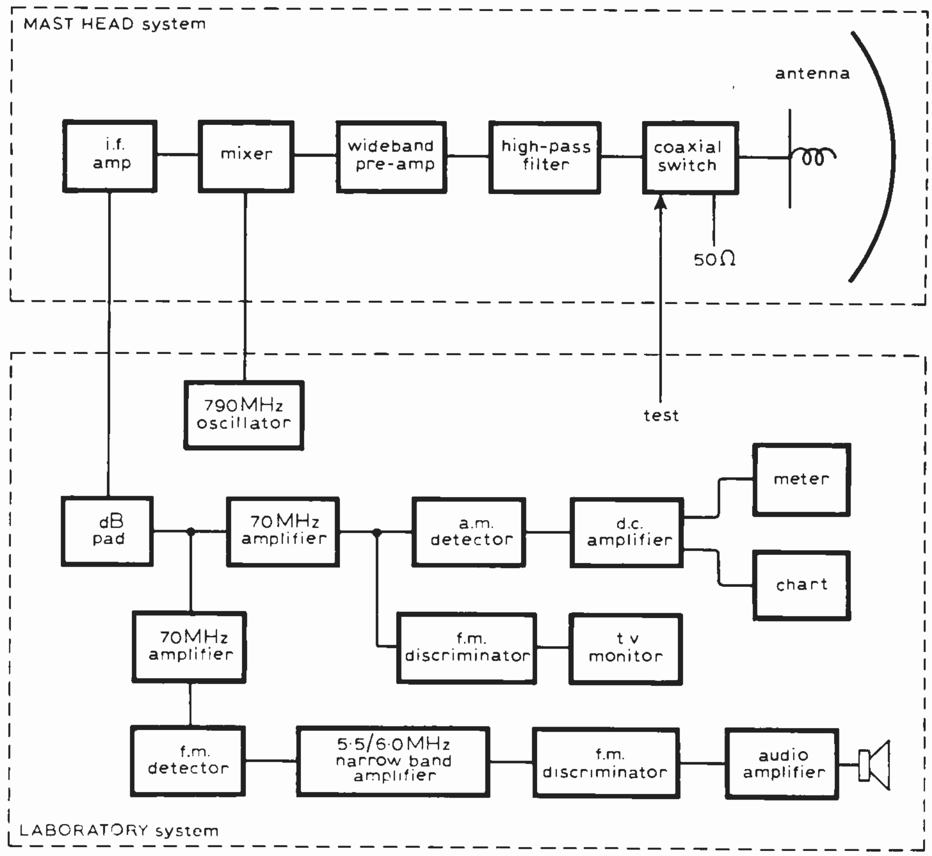
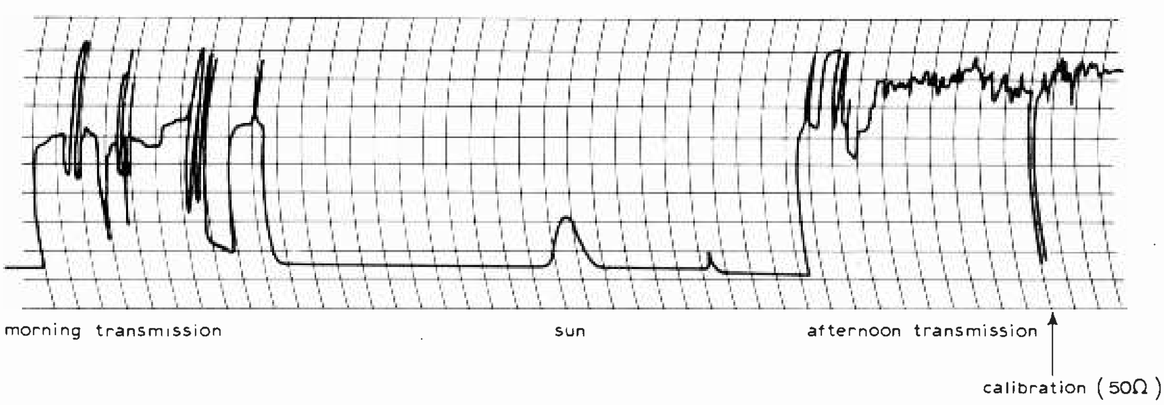


Fig. 1 (above). Receiving system used at University College Dublin.

Fig. 2 (below). Recording of satellite signal strength at Dublin.



which make it necessary to set the bandwidths of the various amplifiers very carefully in order to maximise the signal to noise ratio.

Fig. 2 shows a typical recording of the signal strength from both the morning (0330 to 0600 hr) and afternoon (1200 to 1500 hr) transmissions with a typical signal strength of approximately 8dB above 50Ω. The signal marked "sun" is caused by the sun traversing the field of view during the early part of October. This sun signal was also used to calibrate the system.

The photographs from the television screen (see also News, Feb. issue) are typical of the picture quality, recorded under good conditions. Local weather conditions do affect the signal strength somewhat, causing 1.5dB decrease in signal under heavy cloud, but the transmitted power also appears to vary suddenly, often by as much as 5 or 6dB (see morning transmission section of Fig. 2). Sound on both programmes has also been detected but is of very poor quality due to local sources of interference. In general, the total detected signal strength is approximately 1.6μV/m.

The 20ft paraboloid with helical antenna used at the University College Dublin station.

Two pictures photographed at the Dublin station. (See also the example in News last month.)

Report from S. J. Birkill, *Sheffield*.

First, an estimate was made of the field strength expected if a 5ft dish, already to hand, were used. A beam-centre e.i.r.p. of around 51dBW (125kW) is radiated by the satellite (i.e. 80W to the 30ft parabolic reflector), centred on Nagpur. This puts the receiving location at Sheffield approximately 12° off beam, at which angle in the absence of published data we might guess the radiated power to fall about 30dB below that of the main lobe. If we assume a probable minimum figure of 30dB, the down-path power budget is as shown in Table 1.

It was clear that results if any would be marginal. Nevertheless a receiver was constructed around the Signetics NE561B integrated phase-lock loop as f.m. demodulator, preceded by a standard u.h.f. television tuner and a wide-band limiting amplifier at the 35MHz intermediate frequency. The 5ft mesh paraboloid, shown overleaf, was fitted with interchangeable helical feeds for both senses of circular polarisation (at the time I had been unable to ascertain the polarisation used) and a transistor head amplifier was mounted on the feed support structure. The receiver fed a standard 625-line television monitor. No signals were received, and thus it remained until early December 1975, when the project was reviewed and a further attempt decided upon.

The head amplifier was rebuilt using a lower-noise transistor (a 2GHz stripline device similar to BFR91) in a cascode configuration with a BF180 as the common-base element. The limiting i.f. amplifier was replaced by a linear stage of 26dB gain, to improve demodulation at carrier/noise values below threshold, and a variable attenuator allowed adjustment of phase-lock loop drive level, effectively to control the demodulation bandwidth. A bandpass filter tuned to 860MHz with a bandwidth of 5MHz was inserted between the head amplifier and the converter, to define the frequency when tuning and to set the maximum noise bandwidth. This is just sufficient to pass the deviation limits of the carrier. (The transmitted f.m. channel is some 30MHz wide.) Finally, a dipole feed was constructed in case polarisation should be linear.

With this arrangement, overleaf, Fig. 2, the first pictures were received on December 13, 1975. Though transmitted polarisation on axis is right-hand circular, the received signal at the Sheffield location is predominantly plane polarised, 5° from vertical (clockwise as seen from satellite) and shows no detectable variation of signal strength or polarisation with time. Carrier/noise ratio of 10dB is reached in a bandwidth of between 100 and 500kHz (suggesting pessimistic estimates in our down-link calculation). This has the unusual effect, on tuning through the signal, of making the various levels of the grey scale emerge from and in turn subside into the noise. The transmission frequency does not appear to be clamped to black level or sync tip, so without receiver a.f.c. changes in picture content necessitate frequent

Table 1

(a)	Satellite transmitter power (80 W)	19dBW
(b)	Transmitting aerial gain over isotropic (30ft diam.)	32dB
(c)	Satellite e.i.r.p. to India (a + b)	51dBW
(d)	Off-beam loss (assumed minimum)	30dB
(e)	Satellite e.i.r.p. to UK (c−d)	21dBW
(f)	Free-space attenuation at 860MHz $(4\pi d/\lambda)^2$	183dB
(g)	Receiving aerial gain (5ft diam.)	19dB
(h)	Receiver input power (e−f+g)	−143dBW
(i)	Required carrier/noise for threshold (say)	+10dB
(j)	Permissible receiver noise power (h−i)	−153dBW
(k)	Receiver overall noise factor (estimated)	3dB
(l)	Noise power at receiver input (j−k)	−156dBW
(m)	Boltzmann's constant	−228.6dB/°K−Hz
(n)	Receiver input temperature (290°K)	24.6dB°K
(o)	Bandwidth in which threshold is attained (l−m−n)	48dBHz (i.e. 63kHz)

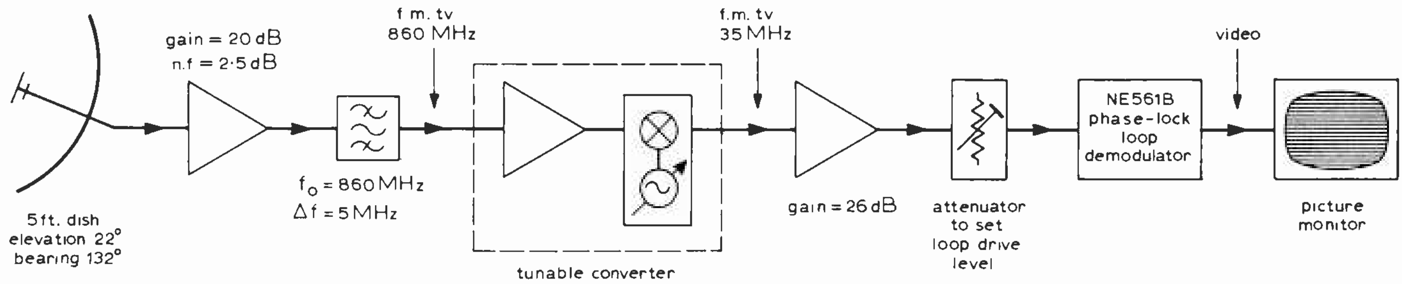


Fig. 2. Receiving system used at Sheffield in December 1975 to obtain first pictures.

Later this year we hope to publish a report on television reception of the ATS-6 broadcasts in India itself. This will be written by a British engineer who has been to India to study the Satellite Instructional Television Experiment.

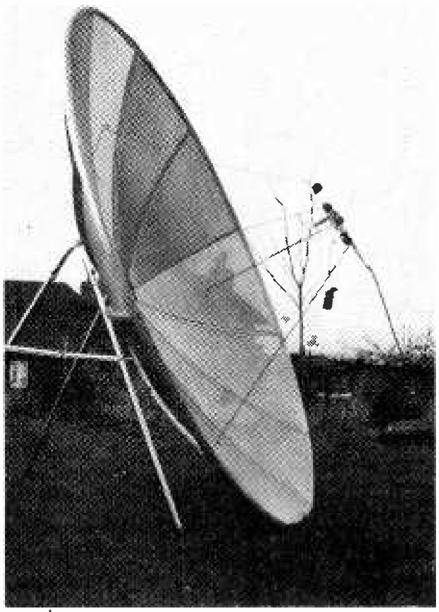
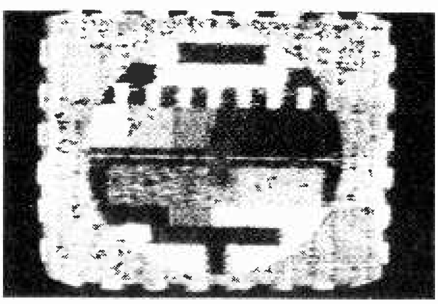


Fig. 1. The 5ft paraboloid antenna used at Sheffield.



Philips test card photographed at Sheffield.

Screen picture of a presentation announcer photographed at the Sheffield station.

re-tuning for optimum results. These effects are eliminated if loop bandwidth is increased to 2MHz, but carrier/noise then drops to 4dB and pictures are very noisy.

No 860MHz carrier is radiated outside programme, pre-programme line-up and test transmission times. The "evening" broadcast begins at about 1150 GMT each day with test waveforms, including at 1215 (for a few seconds) a slide showing the transmitting Earth station. A test-card (the Philips PM5544) follows at 1220 until 1229, when identification captions are shown, leading to presentation and start of programmes at 1230. Programme source switching occurs regularly, and is accompanied by views of the originating Earth stations. Close-down is at 1500. The "morning" transmission the writer must admit to only having seen once, for the perhaps understandable reason that it ran from 0350 to 0600 GMT. On that occasion (a Sunday morning) it consisted largely of captions on vision to identify test tones carried on the sound channels (which at present are outside the receiver bandwidth).

For others who may be interested in receiving these transmissions, unless a dish of realistic dimensions is available, capable of being efficiently illuminated at this frequency (the 20ft one at Dublin is superb) a preferable system might be an array of stacked long-yagis, with which 26dB gain would seem an attainable figure. At this gain, an elevation of 22°, bearing 132° should bring ATS-6 within the beam for most of the UK and enable the signal to be found. The u.h.f. bandpass filter could be dispensed with, a better solution perhaps being an i.f. filter of lesser bandwidth (dependent on signal strength) with the u.h.f. converter swept by the demodulated video, keeping the instantaneous carrier frequency within that bandwidth and so forming an elementary threshold-extension demodulator. A varicap television tuner seems the obvious choice for this application. Anticipated improvements to the writer's receiving system are in these directions and a parametric amplifier is also under construction.

Television Society honours Baird

On January 26 the Royal Television Society celebrated the 50th anniversary of J. L. Baird's demonstration of television to members of the Royal Institution by holding a supper party and unveiling a plaque in 22 Frith Street, in London's Soho district, where the demonstration took place. (See January issue, pp. 43-46). Several people who knew or worked with Baird were present, including T. H. Bridgewater who contributes a letter to this issue on the question of the apparatus used for the 1926 demonstration. Eight of the guests had received the Baird system 30-line television transmissions when they were subsequently broadcast by the BBC from the London Regional medium-wave station.

The plaque was unveiled by William C. Fox, aged 86, a retired journalist who had been a friend of Baird's. He had helped Baird in getting publicity for his television experiments, and at the Frith Street demonstration his job had been to take the names of the Royal Institution visitors as they arrived. After the demonstration, Mr Fox recalled, he eavesdropped on the learned gentlemen's conversation. He heard ". . . a mountebank" and ". . . this young man doesn't know what he's doing" and several other derogatory remarks, but one visitor who himself had been experimenting with telegraphic transmission of pictures had exclaimed enthusiastically "He's got it!"

An article describing Baird's early work, "Television fifty years ago" by George Shiers, is published in the January-February issue of *Television*, the journal of the Royal Television Society.

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State-of-the-art circuit design, incorporating high-quality components, has resulted in a professional, 3½ digit instrument of outstanding performance and reliability at a realistic price.

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The instrument reads to ± 1999 and has a basic accuracy on the 1 V DC range of 0·3% ± 1 digit. Four 8 mm LED displays provide excellent legibility and angle of view. Battery operation allows complete independence of mains supply.

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Wireless World Teletext decoder

5—Selection, control logic, control codes decoding and display

by J. F. Daniels

Last month's article concluded the description of the circuitry on digital board 1. This month we continue the description by looking at board 2, which contains the page and time selection circuits, read/write control logic, control codes decoding, graphic and alphanumeric display circuits.

Page and time detection

This part of the circuit indicates when the selected page is reached in the transmission sequence, and it does this by looking at the Hamming-coded information contained in the page header (row address zero) of every page. When a page header is found which contains the same page number as that selected on the thumbwheel switches, an output pulse is obtained which lasts for the length of the data line. If the time-coded mode of operation is selected, a comparison is also made between the transmitted time and the setting of the time-selection thumbwheel switches. The pulse is fed to the read/write control logic which initiates the sequence of writing data into the memories. Before we look at the writing operation in more detail we will consider how this pulse is obtained.

The method of achieving the detection of page number and time coding information is by means of a chain of D-type flip-flops, IC numbers 55, 79, 80, 72 and 64. It should be remembered from an earlier article describing the clock-divider circuits, that IC_{47} produces clock pulses timed to occur during each of the Hamming-coded groups in the page header. (IC_{47}, pin 2 is a strobe pulse during the magazine number group – IC_{47}, pin 10 a strobe pulse occurring during the hours tens group.)

The first of the flip-flops (IC_{55}) is used to define which of the rows are page headers. The first half detects the least significant bit, and the second half the other four, by being fed with output zero of the b.c.d.-to-decimal decoder, IC_{48}. This i.c. is employed very usefully to provide decimal outputs of all the b.c.d.-coded addresses, and these outputs may be fed to all the decimal thumbwheel switch inputs in parallel. It will be noticed that the inputs to this i.c. are not fed directly by the Hamming corrector output, the D input being fed via gates (71, 8) and (63, 8). This is necessary because of the Clear Page bit which may occur during the minutes tens group. If the extra gating was not employed then correct time detection of pages which included a clear bit would not be obtained. The hours tens group does, of course, also contain extra bits to indicate newsflash and subtitle pages, but it is unlikely that either of these types of page will ever need to be time selected, and so no precautions have been taken in this respect.

The action of the chain of flip-flops is initiated by the preset input of IC_{55} which is fed by the Data Allow waveform. By doing this, only valid data rows are interrogated. IC_{55}, pin 8 goes to 1 only during page headers and this waveform is gated with the output of the magazine number flip-flop, to allow operation of the fourth flip-flop, the page units detector.

The wiring of the thumbwheel switch for magazine number detection is slightly different to the rest of the thumbwheel switches. This is because maagazine number eight is coded 000 – or 0 in decimal terms, and there is no magazine number 0 or 9. This switch is wired normally from inputs 1-7, but input 8 must be fed from IC_{48}, pin 1, not pin 10, and inputs 0 and 9 should be left unconnected, as these are unused positions on the switch. From the page units detection flip-flop through to the hours tens flip-flop the i.c.s. form a simple repetitive chain and the output pulse is obtained either from IC_{80}, pin 8 in the normal mode, or IC_{64}, pin 8 in the time-selection, mode of operation.

Read/write logic

This part of the circuit performs a large number of different functions, and before attempting to describe the circuit operation, these will be summarised as follows.

- The basic function is to provide write pulses to the random-access memory store during transmissions of the selected page, in order that the page may be written into the store. As explained in an earlier article, the page is written into the store every time it is received, and not just the first time, in order that any errors may be corrected, and also so that self-changing, and updated pages will be automatically written into the store.
- It must provide a constantly changing time indication in the top right hand corner of the display, and also a continuously changing page header during the time between the "clear" button being pushed and the receipt of the selected page.
- It should detect the clear-page bit, if it is present in the page header of the selected page, and then erase the stored information before writing the new page into the store.
- Finally, in the "auto newsflash" mode of operation, newsflashes selected on the thumbwheel switches must not be written into the store until one is detected that contains a clear-page bit, indicating an updated newsflash.

The circuitry to achieve the above functions is shown in Fig. 1, together with the page and time-selection circuits.

Page selection. The pulse from the page detection circuitry (which goes to 1 during the page header of the correct page) is used to preset the D-type flip-flop IC_{79} after being gated in (71, 6) with the output of inverter (63, 4). This waveform is an inversion of that appearing at gate (12, 12) and was shown in the clock-divider waveform diagrams in Part 2 of the series. It only goes to 1 after the Hamming bits of the page header row address have finished, and it is gated here with the page detection pulse in order to prevent the Hamming bits from being written into the store.

The action of presetting IC_{79} sets the Q output to 1, and this is then gated in (45, 8) with the output of the parity checker, the Data -Allow waveform and the line-blanking waveform. The output of the parity checker is normally at 1 for valid bytes of data, but if a parity error is detected it goes to 1, inhibiting the write pulses. The Data-Allow waveform is gated in at this point to ensure that only valid data lines are written into the store, and the line blanking waveform further restricts the writing action by inhibiting writing during the framing code and control and row address group bytes. Gate (45, 8) will therefore go to 0 when we require to write information into the store. This, in turn, sets (62, 6) to 1, which allows the write pulses (from 66, 2) through gate (70, 8) and into the read/write input of the store.

This process initiates the writing of information into the store, but it must also be stopped at the end of the page, an operation which is not quite as straightforward as it might appear. The difficulty arises because there is nothing to indicate that the page transmission has finished. Detection of row number 23 to stop the writing action is not feasible because this may be a blank row, in which case it may not be transmitted. The same reason rules out a "stop" signal after a count up to 24 rows. It is possible that more than 24 rows may be transmitted in any given page, as there may be more than one page header containing the correct page number transmitted at any time during the transmission of the page. This may be done to update the time information in the top right hand corner of the display at regular seconds intervals. This last piece of information also precludes another possible way of ending the writing sequence, that of using the detection of the next page header after the correctly detected one. (At the present time the BBC quite often transmit two page headers consecutively, and the reason for this will be dealt with later in the article.)

The only way to end the writing sequence is to detect a "wrong" page header, meaning a header of any page other than the one selected on the thumbwheel switches, and this is done by clocking IC_{79} with page header detections, while the D input is held at 0. This returns the Q output to 0 and stops the writing sequence. It may not seem obvious why this does not still stop the writing action even if a second 'correct' page header is transmitted. The reason is that the preset input will always overide the action of the clock input (which only operates on positive-going edges), and the preset input will always be present during the correct page header detections.

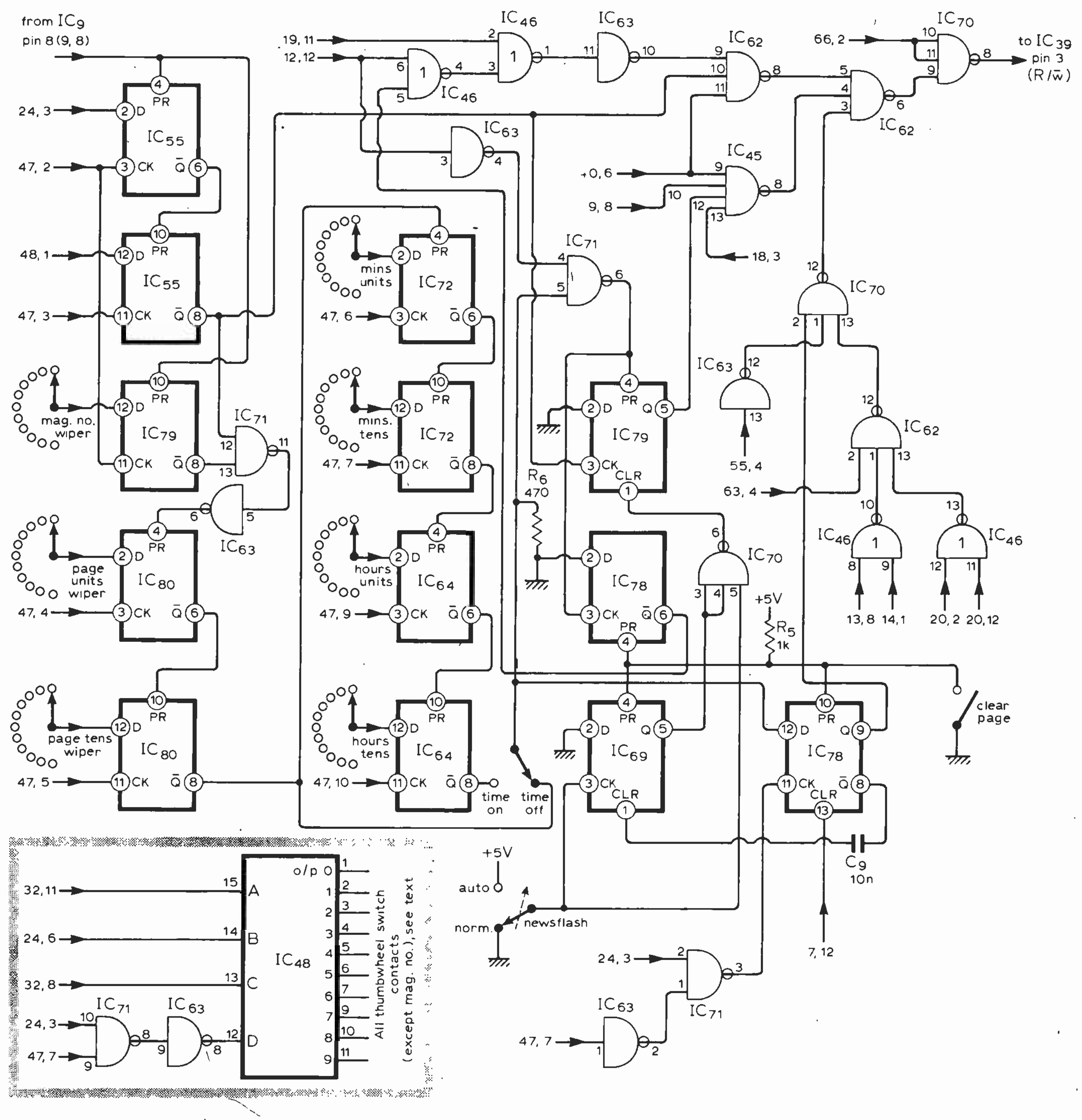


Fig. 1. Page and time detection circuits and read/write control logic.

It will be noticed from the circuit diagram that the clear input of IC_{79} is fed from the output of (70, 6). However, this only has any effect in the auto-newsflash mode of operation which will be dealt with later. During normal operation the clear input is held at 1 because one input of (70, 6) is held at 0 by the auto/normal switch.

Time display. Having looked at the operation of writing normal pages into the store let us now look at how the continuously changing time information is obtained in the top right hand corner of the screen, and also how the page header is made to "rotate" when the Clear button is pushed. The QD output of counter 19 is very useful in this respect because it goes to 1 only during the last eight bytes of data on each line, which happen to coincide with the point at which the time display information is transmitted on the page header.

This waveform is fed through gates (46, 1) and (63, 10) into gate (62, 6) where it causes the output to go to 1 (so enabling the write pulses) only during parity-correct information. The action of pushing the clear button presets IC_{78}, which is a D-type flip-flop. This sets the $\overline{Q}$ output to 0 which is fed to one input of the two-input NOR gate (46, 4). Here it is gated with the waveform which inhibits writing during the Hamming-coded bytes and is then fed into (46, 1) where it causes the whole of the page header information to be written, instead of just the time information as before.

Page clearing. Another function performed by this part of the circuit is the action of clearing the page when a clear bit is detected in the Hamming bytes at the start of the page header. The clear bit is transmitted during the header of any page which contains new information, i.e. during automatically-changing page, every time it cycles on to the next one of the group, or whenever a single page is transmitted for the first time with updated information.

In order to effect the operation of clearing the page, the store must be filled with 'space' characters, by writing them into the store at all the positions used for display purposes. Now the most convenient way to do this is to use the display period to write in these space characters as the store automatically cycles through all its positions during this time. In fact the system specification allows us to do this as it states that:– "A clear page command for a particular page, and new information for that page will not be transmitted in the same field blanking interval to allow time for the receiver store to be cleared" (hence the need to transmit two page headers in succession occasionally).

Detection of the clear page bit is achieved in gate (71, 3), where bit 8 from

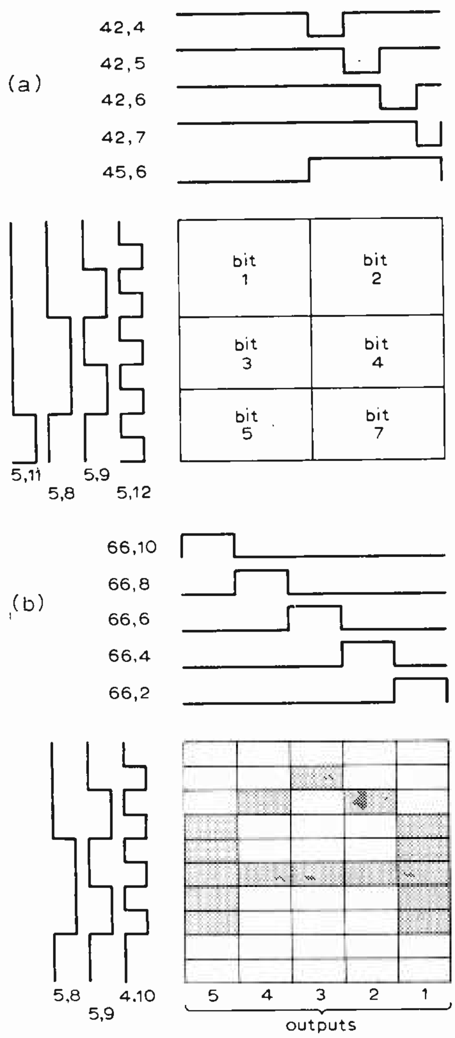


Fig. 2 (a) Graphic character segments are of unequal sizes to avoid gaps between characters. Alphanumeric generation is shown at (b), which does not include the three vertical columns for gaps between characters.

the Hamming corrector is strobed by a pulse from IC_{47}, pin 7. The resulting, short, negative-going pulse is used to clock IC_{78}, pin 11, and if the D input is at 1, which it will be during correct header detections, the Q output will also go to 1.

Now there is one slight problem which prevents us using this output directly to initiate the writing action during the display period. This problem is that the header which contained the Clear Page bit will be erased from the store by the action of writing during the display period and the page will then be displayed with no header, except for the time information which will, of course, reappear almost instantly. In this design that is prevented from happening by inhibiting the Clear Page action during the part of the display normally occupied by the header, that is, all the displayed header row except the part occupied by the Hamming coded bytes, which are still erased.

This is achieved with gates (46, 10), (46, 13) and (62, 12) which gate out a waveform corresponding to the display header position on the screen. This waveform is gated with (78, 9) and also the inverse of the Data Allow waveform in (70, 12) to provide the Clear Page action. The inverse of the Data-Allow waveform is gated in at this point to prevent the Clear Page action taking place on valid data rows. The Clear Page action can also be initiated by operation of the Clear Page button which presets IC_{78}, which again sets the Q output to 1. IC_{78} is cleared by negative-going frame sync pulses obtained from (7, 12) which stops the clearing action at the end of the display period.

The operation of deriving the space character codes to be written into the store is achieved in the serial-to-parallel convertor, IC_{21} (74164). In fact, a space character code is not used in this design, merely a set of eight zeroes, obtained by clearing the shift register outputs during the display period. It will be seen from the code table that this is in fact a NUL control character, which is not designated to any particular function, and is in fact inhibited from doing anything in the control codes decoder. (To be described later in this article.) It will of course be displayed as a space character, as are all control characters.

Newsflash. The only other function of this part of the circuit is to provide the Auto Newsflash facility, which is merely a method of preventing any newsflash (or any other pages) being written into the store, until one is found which contains a Clear Page bit.

When one of these "new newsflashes" is detected, the decoder reverts to normal operation, i.e., it writes all the succeeding newsflash pages into the store as well as the one containing the clear bit. In this way errors can still be corrected as described last month.

Normally the auto mode is inhibited by means of gate (70,6), the output of which is held at 1 by virtue of the auto/normal switch. When the auto mode is first selected the positive transition at the clock input of IC_{69} sets the Q output to 0 and this still allows the first newsflash received to be read into the store, regardless of whether it contains a clear bit. However, if the Clear Page button is pushed, this presets IC_{69} Q output to 1 and the output of gate (70,6) goes to 0. This clears IC_{79} and thus prevents any further pages from being written into the store. The Clear Page bit detection circuitry, however, still works as usual and if a newsflash is detected which contains a clear bit, IC_{69} is cleared by a pulse from C_9. This sets the circuit back to normal operation, and all the succeeding newsflash pages are read into the store until such time as the Clear Page button is pushed again.

Graphics generation

Figure 2(a) shows the way in which graphics characters are formed. Bits 1, 2, 3, 4, 5 and 7 each represent one sixth of the graphic shape, and it is intended that when a bit is 1 its corresponding section of the graphics rectangle should be 'illuminated'. The decision as to how much area shall be occupied by each of the bits is left to the circuit designer, and a number of possibilities will be considered here. If rectangles of equal size were chosen for each of the six bits of information, then the best arrangement would be for the bits each to occupy three lines on each TV field and three out of the four available vertical columns. (The actual size of the complete character box available is ten lines per field and eight clock pulses wide in the horizontal direction.)

This arrangement would, however, give gaps between each of the graphics characters in the vertical direction, as only nine out of the ten available lines would be used, and in the horizontal direction, as only six out of the eight available clock pulses would be used. Now, although this method would give characters with equal size components, the effect of having gaps between each of them would be most undesirable for displays where large areas of colour were intended to be shown.

In fact the effect of having unequal size rectangles forming the graphics characters is far less disturbing than the effects caused by having gaps between them, and this design uses the format shown in Fig. 2(a) which uses four TV lines per field for bits 1 and 2 and three lines for each pair of the other four bits. In the horizontal direction the bits are equal in width, each one being formed from four out of the eight clock pulses. The reason for making bits 1 and 2 larger than the other pairs of bits, was purely one of simplicity, requiring fewer gates than any other arrangement.

The circuit for generating the graphics characters is shown in Fig (3a). Six, three-input open collector NAND gates are used, one for each bit of the displayed character. One input of each of these gates is fed with the bit information from the output of the r.a.m. store, and the other inputs are fed, one with the horizontal gating waveform, and the other with the vertical gating waveform. The six outputs are added together by the open-collector connexion of the gates and the output at this point is negative-going graphics information. The horizontal gating waveform for the right hand half of the graphics character is obtained at the output of gate (45,6) and the waveform for forming the left-hand half of the characters is simply the inverse of this waveform.

The vertical gating waveform for bits 1 and 2 is obtained by gating two of the line divider waveforms, (5,11) and (5,8) together in NOR gate (43,10). Bits 3 and 4 require the slightly more complicated gating arrangement, achieved with gates (44,8), (50,3) and (59,6), and finally the waveform for bits 5 and 7 is obtained from gate (50,6).

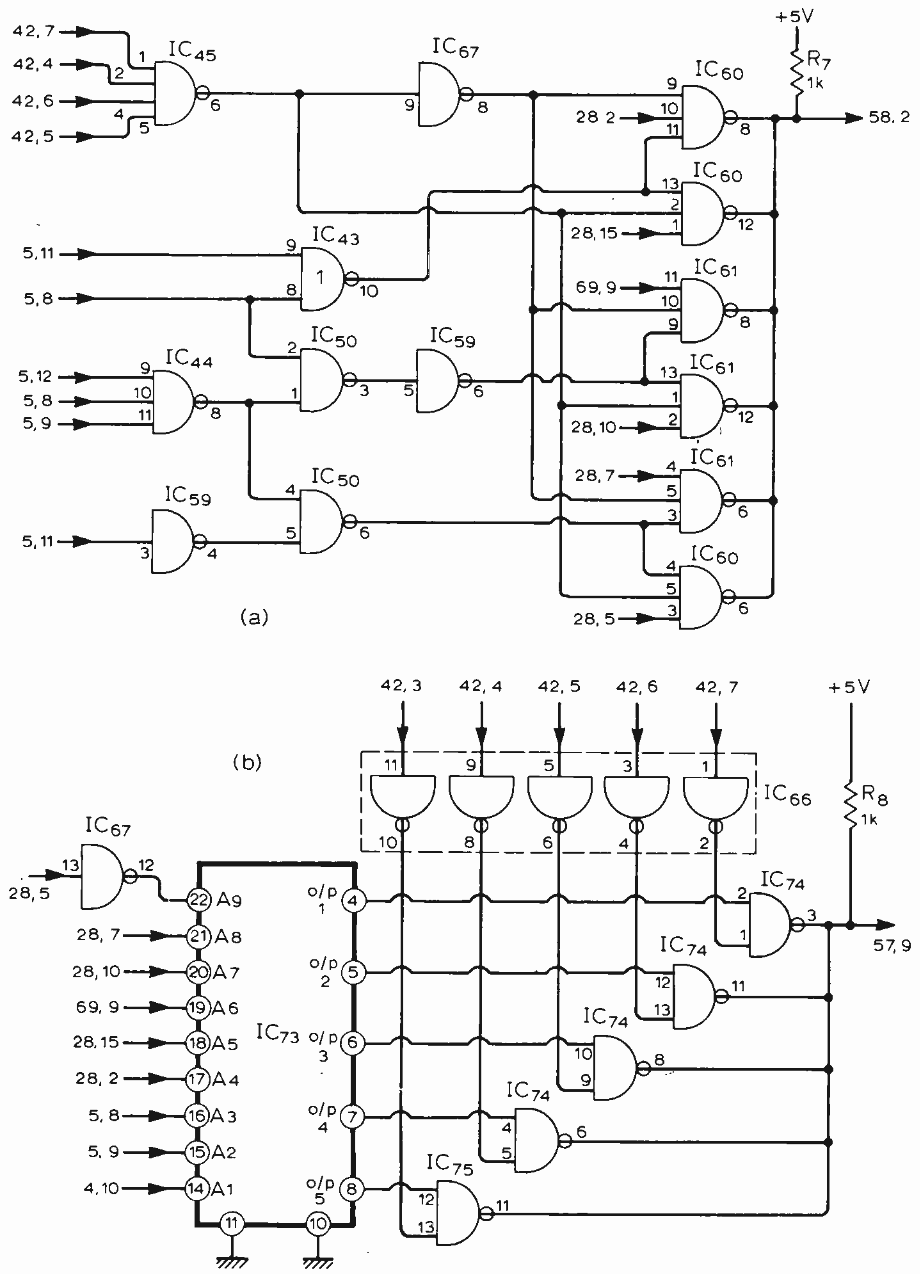


Fig. 3(a) Circuit of the graphics generator. The r.o.m. character generator is at (b).

Alphanumeric characters

The generation of alphanumeric characters is similar in many respects to the graphics characters, the main difference being that each of the alphanumeric characters is formed from thirty-five small squares situated in the character cell. In fact, the character cell is divided into a total of fifty squares, as shown in Fig. 2(b). (This does not include the gaps between characters in the horizontal direction, which take up three extra columns).

The top row of five squares is normally left blank to give a space between rows of characters, and the two lines of five empty squares at the bottom of the character cell are used when lower case characters, which normally descend below the line (g, j, p, q, and y), are generated.

Figure 3(b) shows the circuit diagram of the alphanumeric character generator. It is not practical to use the same approach as in graphics generation using discrete i.cs to form the characters, because this would result in an extremely large number of components. Special i.cs are in fact manufactured to perform the function of character generation, and these are called read-only memories or r.o.m.s. The one shown in the circuit diagram is manufactured by Signetics and contains information for sixty-four different characters, including all the upper-case alphabet and various other characters such as brackets, numerals etc.

There are five outputs from the i.c., one for each column of the character, as indicated in Fig. 2(b), and nine address inputs. Three of the address inputs (called row addresses) are used to define which of the horizontal rows of the character is to be displayed, and the other six inputs are used to decide which of the sixty-four characters will be displayed. The row address inputs are fed from the line divider outputs (5,9) and (5,8), also (4,10) which has been gated to inhibit the output during the last two lines of the character cell. It does this by making the row address "000" during the last two rows, and in this particular r.o.m. the output is always '0' when this row address is present.

The other six address inputs are fed directly from the r.a.m. store outputs. A quick look at the code table might indicate that bit numbers 1-6 should be used here, but as this i.c. is capable of producing upper-case only characters, this would result in lower-case alphabet letters appearing as numerals and various other odd symbols. If, however, bit 6 is replaced with bit 7 inverted, the desired effect of lower-case letters appearing as capitals is achieved.

The outputs of the i.c. are gated with their respective vertical column information in five 2-input open-collector NAND gates, where they are added together to form negative-going alphanumeric characters.

Control-codes decoding and output

This part of the circuit, shown in Fig. 4, performs several functions.

- To detect all the various control codes that are transmitted, for colour, graphics, flashing and boxing information and to switch the output gates to the correct state.
- To provide switching between the graphic and alphanumeric information in the "alphanumeric blast through" mode.
- To add line and field blanking information to the output waveform, and also to blank out the control characters, which of course are not intended for display.

There is also a problem caused by the fact that the standards of transmission have been changed recently, in terms of the position in the code table of some of the control characters. (On February 2, 1976, BBC1 began to transmit the new standard, BBC2 reverting to the old standard.) This problem is overcome by providing three links on the printed board which can be changed according to which type of transmission is being received.

(To be continued)

Corrections

In the list of i.cs, published last month, IC_2, was incorrectly given. It should be 74164.

On page 48, Fig. 3, the connexion to IC_{40}, pin 8 should come from IC_{30}, pin 9, not pin 19.

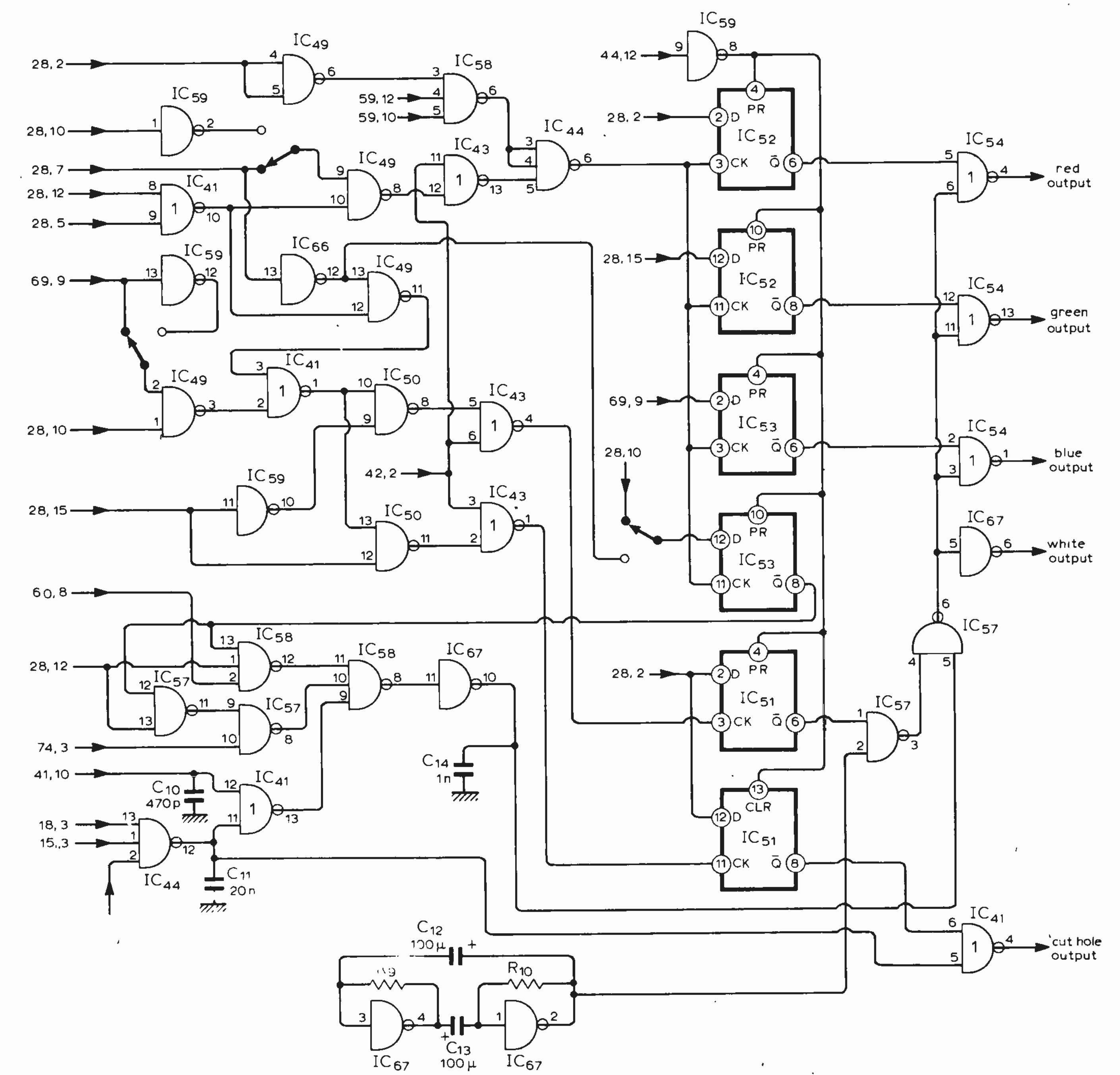


Fig. 4. The control codes decoder and output circuit.

Phase and sound quality

". . . there is almost overwhelming evidence that the preservation of waveshape is of no significance and that in consequence phase shift in a monaural channel is of little importance . . ."

by James Moir, F.I.E.E.

James Moir & Associates

As the distortions that have the major effect on the quality of reproduced sound become more clearly understood it is natural that the remaining minor distortions should be subject to critical examination. Claims about the advantages of minimizing phase shift have appeared in advertisements for amplifiers and loudspeakers. In the light of the current interest in the problem and its controversial nature this article reviews the arguments both for and against the importance of phase in affecting the quality of reproduced sound.

The ensuing discussion is about the phase differences between the frequency components that can appear in a *single* channel. The effect of the phase differences that may exist between signals in *different* channels is not considered in the present contribution; for example there is no discussion of the effects of the phase differences that may appear between the signals in the two channels of a stereo system, though they are of vital importance in achieving a good stereo image. It is probably advantageous to start by explaining what is meant by "phase shift."

Phase shift indication

When power supply engineers required a technique for indicating that the current maxima and the voltage maxima in their circuits did not always occur at the same instant in time, they invented the concept of phase. The time of a cycle of the supply frequency (20 milliseconds for our supply frequency of 50Hz) was divided into 360 degrees and where the maxima of voltage across a load and the maxima of the current in the load did not occur simultaneously, they indicated the difference in fractions (degrees) of the time of one cycle. At a later date when they discovered that their supply voltage waveforms included harmonics of the supply frequency they were able to specify the "phase" of the harmonic voltage with respect to the maxima in the waveform of the 50Hz voltage by quoting the "phase difference" in degrees. Basically it is a time difference that is being indicated, but the use of degree units is a satisfactory alternative when single frequency working is being considered because the time duration of one cycle of the supply voltage waveform is (very) constant and a phase shift of one degree always represents the same time interval (0.056ms).

The technique of specifying a time difference in degree units has been carried over to the communications field, but it is not so useful to the communication engineer because his circuits rarely work at a single frequency and in consequence a fixed difference between the time of two events is not a fixed phase shift expressed in degrees. A constant time difference of say 10 milliseconds between the current and voltage maxima is a phase shift of 180 degrees if the operating frequency is 50Hz., 1800 degrees at a frequency of 500Hz, and 18,000 degrees if the frequency is 5,000 Hz. If a circuit produces a fixed time delay measured in milliseconds it has a phase/frequency response that is linearly proportional to frequency as indicated in Fig. 1.

The complications are minimized in the following discussion by referring to a time difference wherever this is applicable, but including comment about the equivalent phase difference where this clarifies the situation. It seems reasonable to suggest that the phase shift concept should really be confined to those situations where the phase shift is less than one cycle of the fundamental frequency. This infers that it be used when dealing with power supply and similar circuits where any high frequency components occur only at harmonics of the basic frequency. Indeed, it is often troublesome to apply to communication circuits where the phase shift between two unsynchronized frequency components is continuously changing.

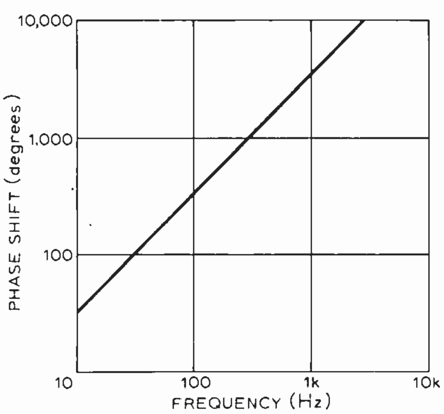


Fig. 1. Phase shift versus frequency for a constant time delay of 10ms.

Cause of phase shift

It is worth while looking at the simplest mechanism that results in these phase shifts. A typical audio amplifier includes a series of amplifying stages coupled together by combinations of resistance and capacitance to allow the appropriate d.c. potentials to be maintained in each stage. Each series combination of *C* and *R* shifts the phase of the output voltage with respect to the input voltage, the output voltage across the resistor leading the input voltage to the combination by an angle that is:

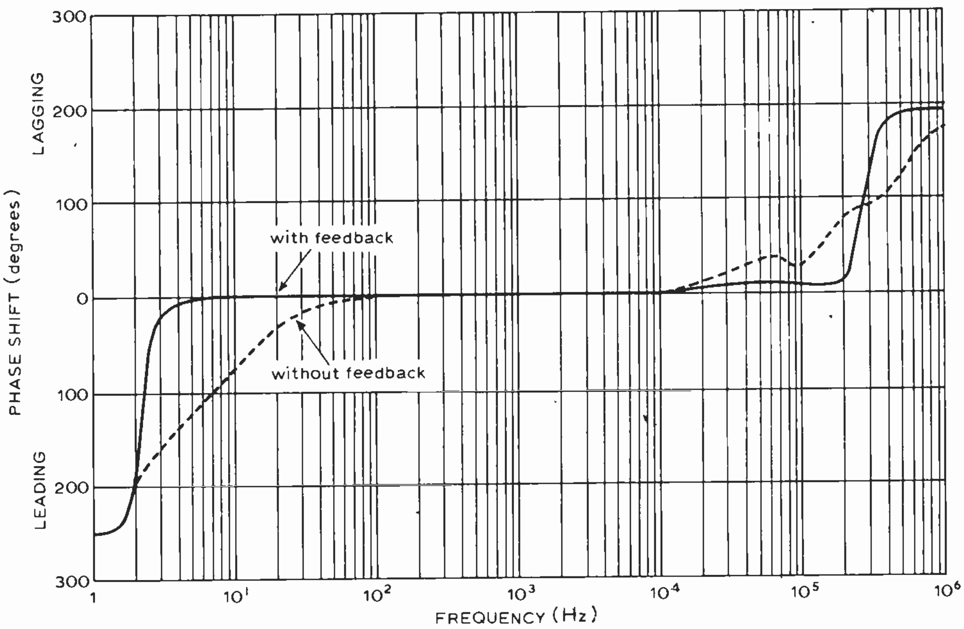
$$\theta = \tan^{-1} X_c / R$$

In addition to the discrete components in the coupling network there is always stray capacitance in parallel with the input and output resistance of each stage. This parallel combination of resistance and reactance results in a phase shift in the opposite direction, the output voltage across the capacitor lagging the input voltage by an angle

$$\theta = \tan^{-1} R / X_c$$

A typical amplifier of many stages

Fig. 2. Typical phase shift characteristic of a high quality domestic amplifier.



will generally have a more complex phase shift/frequency response, similar to that shown in Fig. 2 as the overall phase shift between the input and output circuits of the amplifier is the sum of many phase shifts both leading and lagging. It should be noted, however, that the phase shift between the limit frequencies of 10Hz and 10^5 Hz is only a few degrees. In this particular amplifier it will be seen that the output voltage leads the input voltage at low frequencies, and lags at high frequencies. In consequence the low frequency signal components arrive first, followed by the mid-frequency components and finally the high frequency signal appears.

The series and parallel combinations of *R* and *C* are probably the simplest network that introduce phase shift, practically any combination of inductive or capacitive reactance and resistance producing a phase shift in one direction or the other. Amplifier input and output transformers produce phase shifts at both high and low frequencies as do gramophone pickups, loudspeakers, tone control networks and almost every other component in an audio system.

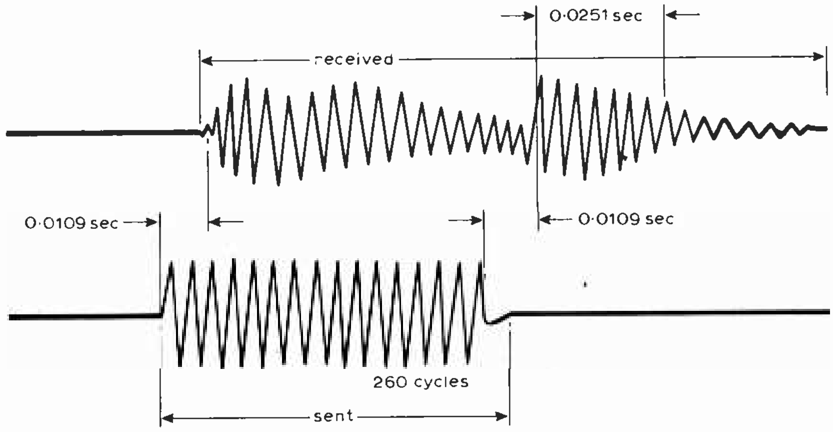
To produce phase shifts of more than 180 degrees, combinations of several reactive elements must be employed and if a time delay of more than a few milliseconds is to be produced, electronic, acoustical or mechanical delay mechanisms must be used. Time delays in the millisecond range also result from transmission over long telephone lines which may include hundreds of amplifier stages.

Fig. 3 illustrates the effect of time delay on the waveform of a transmitted pulse, the lower curve being the transmitted pulse and the top curve the received pulse. In this instance the time delay is 10 milliseconds and it will be seen that the consequent waveform distortion is enormous.

Now common sense suggests that accurate reproduction of the signal waveform is an essential aspect of the performance of a good amplifier, but anticipating the outcome of the discussion that follows it will be shown that an accurate reproduction of the signal waveform may be of little consequence in determining the quality of the reproduced music.

At this point it is important to recognise that manipulating either the amplitudes, or the relative phases of the components of a complex tone can produce changes in waveform. However, it is easy to demonstrate that even small changes in waveshape, hardly discernible on an oscilloscope, but produced by changes in the *amplitude* of the harmonic components can produce devastating changes in sound quality, while the very similar but much greater changes in waveshape produced by changes in the relative *phase* of the harmonics have no apparent effect on the quality of the sound. Amplitude clipping and cross-over distortion are typical examples of waveform distortion produced by changes in the harmonic amplitudes that produce very audible changes in sound quality when present in such small amounts that they are detectable as a waveform change only to an experienced observer. All the changes of waveform produced by changes in the amplitude of the various components of a complex wave are excluded from the discussion that follows.

Fig. 3. Effect of time delay on the waveform of a transmitted pulse.



Effect of phase shift on test tones

The significance of the phase differences that may appear in a single channel on the sound quality of a complex note have been investigated by many workers beginning with Ohm and it is fair to say that their overwhelming conclusion has been that the phase difference between the components of a single complex tone has no significant effect on the quality of the resultant sound. In other words the accurate reproduction of waveform is of no great importance. But beginning with an investigation by Mathes & Miller (see Bibliography), there has been a steady flow of research workers claiming to have found that the waveform changes produced by changing the phase of the components of some complex waves may be audible.

Mathes & Miller's circuitry, essentially a balanced a.m./f.m. modulator, generated three tones, a carrier and two side bands (the modulating signal) and allowed them to vary the phase of the carrier with respect to the two side bands. At low values of the modulation index a frequency modulated carrier has the same side band structure as an amplitude modulated wave, but the side bands are shifted in phase by 90 degrees. By shifting the phase of the carrier, Mathes & Miller could change the relative phase of the sidebands without changing the side band or carrier amplitudes.

The paper quotes a considerable number of findings but typically a wave consisting of a carrier at a frequency of 1kHz with two side frequencies is said to sound "raucous and rough" when the modulated envelope is that of an a.m.

wave, but to what sounds like a "combination of pure tones accompanied by an apparent pitch sensation of twice the signal (modulating) frequency," when the carrier phase is shifted through 90 degrees. They note that the tonal quality difference resulting from shifting the phase of the side band frequency disappeared when the signal (side band) frequencies exceeded about 40% of the carrier frequency but that this effect was a function of the listening level.

The waveforms of the test signal were those characteristic of a modulated carrier similar to those shown in Fig. 4 (a) and (b). Mathes notes that the effects were only audible over a limited range of modulation depths in the region where the modulation depth exceeded about 85%. This may be of significance for the appearance of audible effects seems to depend on the envelope of the combined signal approaching zero at some points in the cycle. Mathes and Miller also note that direct transmission to the ear was most important, as attempts to observe these effects with a loudspeaker were defeated by the complex phase and amplitude effects characteristic of the standing wave patterns in a room.

There are a lot more results of a similar type quoted in the Mathes paper that do not justify present repetition in-so-far as the results already mentioned confirm that they had discovered conditions in which shifting the phase of the components of a complex tone could produce audible changes in the sound quality.

In a generally similar investigation two later workers, Craig and Jeffries, produced some results that are unusual in several ways. As the test signal they used a tone of 250Hz and its octave, and they found that over a restricted range of sound levels the test subject could detect a change in quality of the combination of notes when the phase of the 500Hz component was changed. Other investigators have consistently failed to find this effect. Surprisingly, the changes in quality with change of phase were in opposite directions for the two subjects involved in the experiment, one observer describing the phase reversal as producing a note that sounded 'higher pitched, louder and purer' whereas the second subject described it as 'lower pitched, softer or less pure.' This contradictory result has apparently been observed by other investigators using similar combinations of tones.

A more recent investigation is described in a paper by Hanson and Madsen. They described results that are claimed to show that changing the phase of the components of a square wave produce audible changes in sound quality, a repetition of our experiment described later (see Fig. 7). They reject the use of simple passive phase shifting networks to distort the square wave, on the quite unjustifiable ground that they introduce amplitude changes in addition to the wanted phase shifts. In one of their experiments Hanson and Madsen employ a phase shifting technique that requires four recordings and replays of a square wave test signal, including in the chain a loudspeaker, microphone and an anechoic chamber.

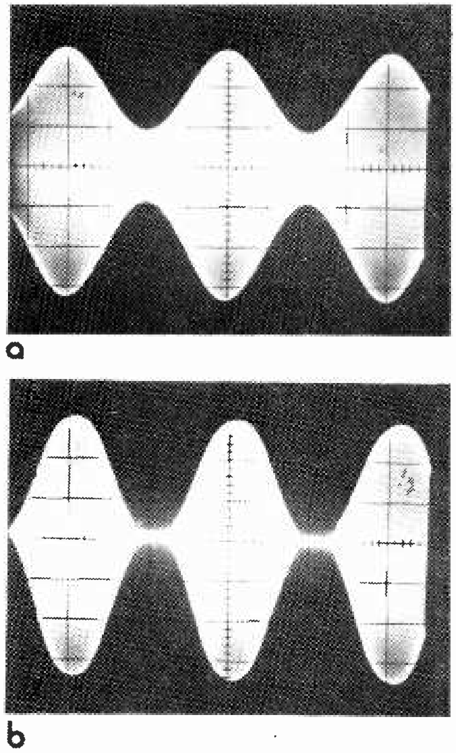
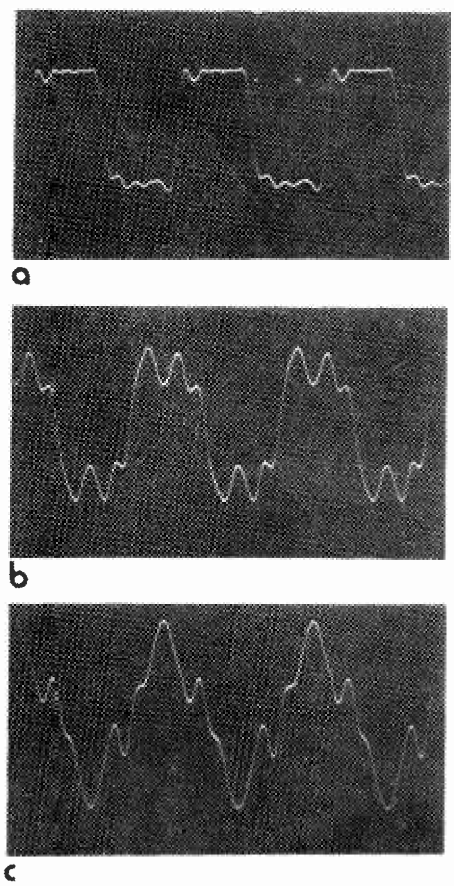


Fig. 4. Modulated carrier test signals in (a) and (b) used to examine the effects of phase shifts on test tones.

Fig 5. Effect on the waveform of a square wave shown in (a) of changing the phase of the (b) 5th harmonic shifted by 100° and (c) 3rd harmonic shifted by 100°.



Now even the supporters of the claim that "phase shifts affect sound quality" would agree that any effects are indeed very subtle. The distortions introduced by the multiple recording and replaying of a taped square wave and the introduction of a loudspeaker, microphone and anechoic chamber into the reproducer system, are certain to be far more obvious than the effects of any phase shifts. The paper makes the valuable point that polarity is important but the validity of many of the other conclusions are suspect for several reasons, not least the remark that "improving the performance of the loudspeaker used to reproduce the test signals resulted in the phase shifts becoming less audible."

Nevertheless taken together the three papers and those listed in the bibliography in the Craig and Jeffries paper can be accepted as confirming that there is some combination of tones for which change in the relative phase of the various components produces some change in the acoustic quality of the resultant sound. The hearing system is not completely insensitive to the effect of phase shift but it seems obvious that the phase sensitivity is very low. However none of the authors have directly suggested that the effects are significant when reproducing programmes, nor have they attempted to confirm that there are phase effects that are audible in music.

Phase sensitivity

Having confirmed that there are conditions under which phase shift may produce audible effects, it is worth attempting to decide on how sensitive the hearing system is to phase change effects and how significant they are in determining the quality of the reproduced sound.

Relatively simple apparatus enables complex waveforms such as that shown in Fig. 5 to be produced by adding harmonics to the basic sinusoidal waveform. The same equipment allows the phase of the added harmonics to be varied with respect to the fundamental sinusoidal signals. There are an infinite number of possible combinations but Fig. 5 illustrates the effect on the waveform of changing the phase of the 3rd and 5th harmonics with respect to the fundamental frequency. We have never been able to detect any audible change in the quality of the resulting waveform as the waveshape is changed from (a) to (c), even when the listener is making the change and the waveforms are simultaneously visible on an oscilloscope.

An experiment that only requires simple equipment will go far towards convincing any listeners that if there are any phase effects, they are rather subtle. Two audio oscillators having their outputs coupled together through separate resistors are coupled into an amplifier driving a good loudspeaker and the frequencies set a few hertz apart. This ensures that there is a continuous variation in the relative phases of the two signals. If the resultant signal is reproduced at a level not greater than about 50dB (conversational speech at about 10ft) it will be found that though the waveform varies continuously through extremes similar to those shown in Fig. 5 the sound quality changes are those due to the amplitude changes only.

Following the discussion of the causes of phase shift earlier in this contribution, it will be fairly evident that tone controls are likely to introduce considerable phase shifts for they are almost invariably combinations of RC networks. Fig. 6 illustrates a typical result, curve A being the measured phase shift through an amplifier and control unit of high repute with the tone controls set to "flat" while the dotted curves result when the bass and top controls are set at min and max. Perhaps this is another reason for the purists' objection to tone controls.

Reproduction of transients

The experiments just described demonstrate that gross changes in phase may produce no significant effect on the sound quality of a continuous note but while agreeing with this, the supporters of the "phase changes effect sound quality" point of view suggest that any phase changes that reduce the steepness of the wavefront of a transient sound must affect the quality of these transients. Again, this statement is incapable of either rigid proof or positive contradiction, but it is easily possible to demonstrate that gross changes in the phase of the component harmonics in a square wave may not produce any significant changes in the quality, although the wavefronts of a square wave are presumably typical transients.

The second waveform shown in Fig. 7 is merely the first waveform with the phase of all the higher frequency harmonics shifted by 180 degrees by inserting a simple passive lattice network. It always appears incredible that such gross changes in waveform should be inaudible, but it is true to say that no member of the development team, or any other hi-fi enthusiast who has heard this demonstration has been able to detect any audible difference between the two waveforms, even when the waveform changes were being made by the observer and were simultaneously visible on an oscilloscope. This was an experiment first made around 1945 when the writer was investigating the effect of phase in an attempt to decide whether the phase changes inherent in any normal sound reproducer amplifier were of any significance, but it has been used as a demonstration during many lectures on sound reproduction given since then.

This is a particularly interesting finding, for if it is confirmed, it indicates that it is not necessary to reproduce the steep wavefronts that are assumed to characterize a transient in music. If this conclusion is right, it raises the question as to what reviewers mean when they claim that some amplifier or loudspeaker has a particularly good transient response. It has a second interesting aspect, for when listening to the phase distortions of a square wave (Fig. 7) the writer found that the effects were no more obvious on headphones than when listening in a typically furnished lounge. This was surprising, in that it was initially considered that the acoustic phase shifts produced by an enclosure were masking the electrical phase shifts produced by the lattice network phase shifter. The masking effects of the phase changes introduced by the room are now thought to be only a small part of the explanation for any failure to observe audible effects due to shifting the phase of the components in music.

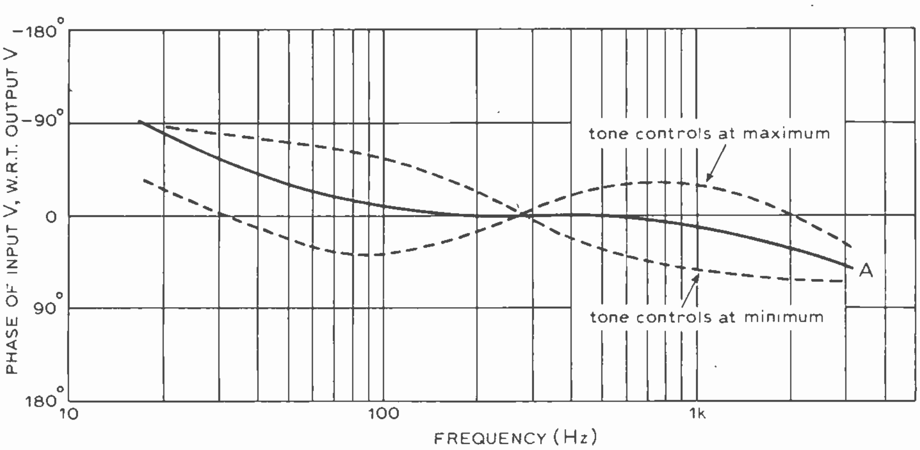
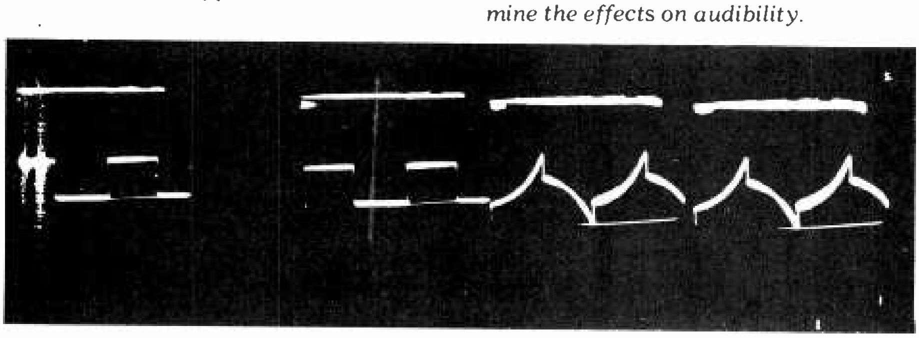


Fig 6 (above). Phase shift effected by tone controls in a typical amplifier.

Fig. 7 (below). Changing the phase components of a square wave to determine the effects on audibility.



Reproduction in an enclosure

An alternative approach is to consider what happens if an attempt is made to reproduce a square waveform in a room or hall. At any point in a room the instantaneous waveform of the complex note emitted by an orchestra, or a loudspeaker, is the vector sum of all the component harmonics arriving at that point. Sounds arrive at every point in an auditorium by direct transmission following a straight path from source to listener, but also by a multitude of indirect paths that include multiple reflection from the room boundaries. The reflected components having travelled by longer paths than the direct components, arrive delayed in time, and in consequence, with their phases radically changed. Because the reflective properties of a boundary surface are almost invariably a function of frequency, the time of arrival at any listener's ear receiving the reflected components changes rapidly with frequency and with the position of the listener in the room. As a result there is no single acoustic waveform that characterizes the sound of the orchestra at any particular instant. There is a different waveform for almost every position in which the measuring microphone is placed, yet there is no significant difference in the sound quality in adjacent seats.

It is easy to confirm that the acoustic waveform varies widely with position, by using a loudspeaker fed with a square wave electrical signal and using a precision capacitor microphone to pick up the waveform at points in the auditorium. Fig 8 shows typical waveforms measured at two points only four inches apart in a normal domestic lounge, when a high quality speaker system was driven by a square wave voltage signal. Experiment confirms that it is usually difficult to find two points in an enclosure where the waveforms are similar. A square wave electrical signal applied to a loudspeaker produces as many different acoustic waveforms in space as there are positions for the measuring microphone.

Exactly the same conditions apply to the reproduction of the waveform of the music of a real orchestra. Not only does the orchestra produce a different waveform at every seating position in the auditorium, but wide changes in the waveform appear if any of the instrumental groups or individual instrumentalists are moved with respect to the rest of the orchestra. Thus if the quality of the sound depended on the accuracy of the reproduction of waveforms, each instrument in the orchestra would have to be precisely located in a carefully pre-determined position in space. As the optimum location for every instrument would depend on the position of every other instrument, the determination of the "correct" location for the 100 odd instruments in a symphony orchestra would require many months of investigation. The final position would be so critical that the instrument would have to be permanently fixed in position and the player would have to adjust his position to suit. When this had been done, there would only be one seat in the auditorium in which the sound would be acceptable.

Phase shifts in programme material

The aspect that is of real interest to the hi-fi enthusiast is not the audibility of phase changes on special test signals, but the effect of phase shifts on the quality of music and speech. My own interest in the effects of phase on the quality of sound arose in 1945 after having worked for a time on the design of wide band amplifiers for radar where it is essential to preserve the waveform of the radio signal. On returning to the problem of designing sound reproducer amplifiers it was thought that the preservation of waveshape might improve the sound quality obtained in cinemas. Our investigations showed that nothing was to be gained, amplifiers having substantially zero phase shifts having no obvious advantage over conventional amplifiers in which no special attempts have been made to minimize the phase shifts that result from standard design procedures.

At a recent *Wireless World* seminar on linear phase loudspeakers, H. D. Harwood of the BBC Research Department indicated that they had been quite unable to detect any "distortions"due to the effect of phase shifts in sound reproducer amplifiers. A recently published paper reaching the same conclusions is that by Ashley in the *Journal of the Audio Engineering Society* for April 1971.

Acceptable time delays

It will be obvious that absolute time delays are not of any consequence. Signals may be stored on tape for years

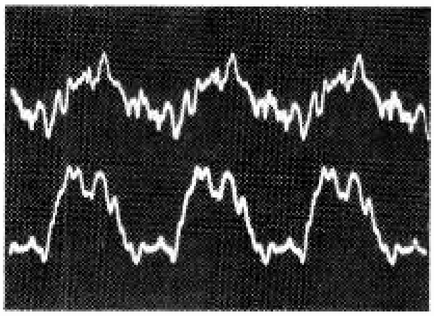


Fig. 8. Waveforms from the same signal source measured at points four inches apart.

without the storage time affecting the sound quality. It is the differential time delay, or group time delay that is of significance. This is the difference between the time delay occurring towards the extremes of the audio frequency band and the delay that occurs at some suitable reference frequency in the middle of the band. Clearly there must come a point where the delaying of one section of the frequency spectrum with respect to other parts of the spectrum must result in some changes in the quality of the reproduced sound. If the low frequency components in a musical passage arrive to-day, the high frequency components cannot be allowed to arrive tomorrow. Establishment of the "just detectable" differential delay time would be a significant point in any discussion about the effect of phase shifts or time delays.

Because of its importance to telephone administrations, the time delay that is "just detectable" when producing speech has been the subject of many investigations. It is worth mentioning that effects of these differential time delays are much more obvious on speech than on music. The differential time delays result in a kind of metallic echo following each syllable or word. Much greater time delays are permissible before the distortion becomes obvious on music. The experimental procedure was substantially the same in all the investigations. A high quality reproducer system was used with arrangements to allow the introduction of time delays either by the use of all-pass networks or long telephone lines. The listener was allowed to increase the time delay until the effects were detectable on an immediate comparison with the un-delayed condition. This is a highly critical test, for under normal listening conditions the listener does not have any opportunity of making an instantaneous comparison, and as it will appear, the effects of phase shifts are rather subtle even when present in large amounts. Thus the opportunity of detecting a particular distortion is immensely improved if an immediate comparison of the "distorted" and "undistorted" condition is possible.

It is not proposed to go through all the experiments in detail, but merely to quote the authority and the order of the time delay they found to be "just detectable." Bell Telephone Laboratories inserted a series of delay networks into a high quality reproducer system and directly compared the output signal with the input signal, using reproducer equipment of the highest quality. Distortion on speech was just audible when the 5-8 kHz band was delayed by 5-8 milliseconds behind the 1-3kHz band. At the low frequency end they found that delays of 70-90 milliseconds were innocuous.

Similar tests were made at a later date by Belger, Pavel & Rindfleisch of the German Post Office and the German Broadcasting Organisation using long telephone lines to produce time delays. Their findings were in good agreement with those of Bell Telephone Laboratories. They concluded that permissible delay was 70 millisecond at 50 Hz and 8 millisecond at 8 kHz.

After reviewing all the information available, C.C.I.F., the authority that fixes the performance standards for international telephone lines, specified substantially similar limits for lines intended for the transmission of speech and musical programmes. They consider that signals may be delayed with respect to the mid-band (1kHz) signal by the times given:— in the 50Hz band they may be delayed by up to 80 ms, in the 100Hz band they may be delayed by up to 20 ms; in the 8kHz band they may be delayed by up to 8 ms.

Though there is almost overwhelming evidence that the preservation of waveshape is of no significance and that in consequence phase shift in a monaural channel is of little importance, there can be no doubt that the relative phase of the signals in a two channel stereo system is of considerable importance. Unless the corresponding instantaneous signals are emitted by the two loudspeakers at the same instant in time, the stereo image will be deflected towards the loudspeaker emitting the leading wavefront. If the time delay (phase shift) between the two speakers is a function of frequency the stereo image will be unstable.

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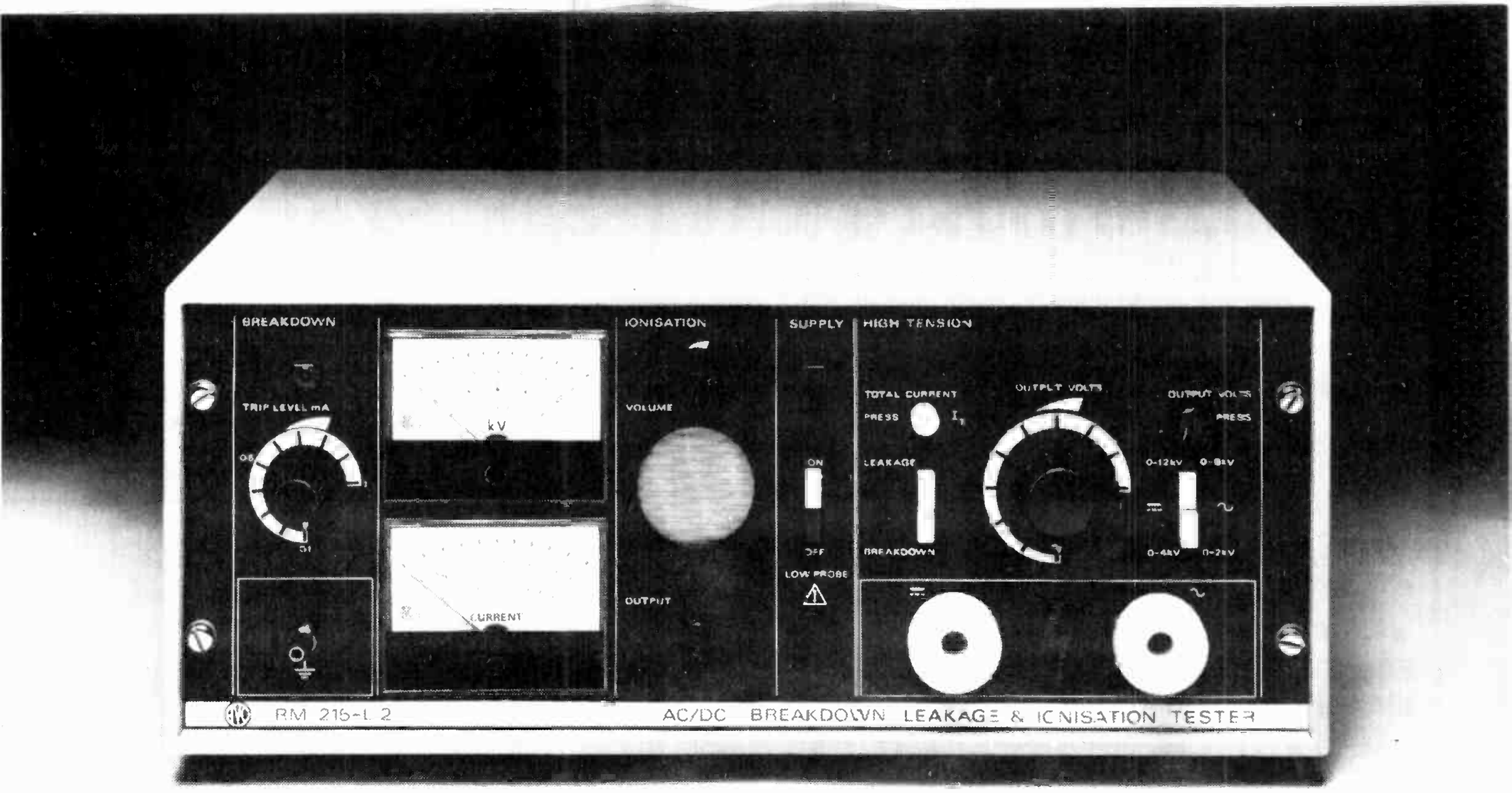

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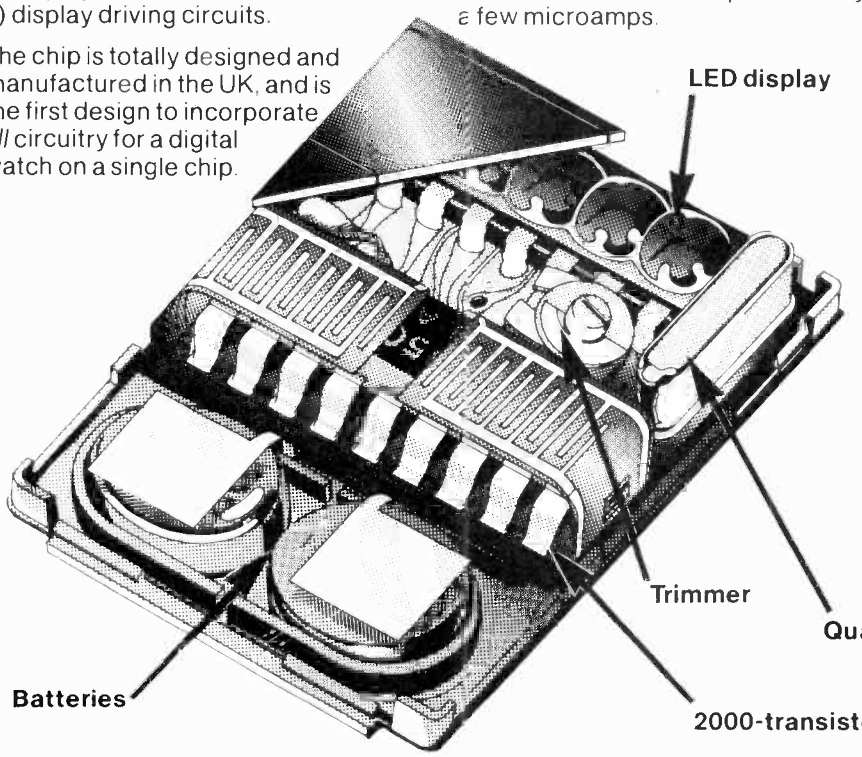

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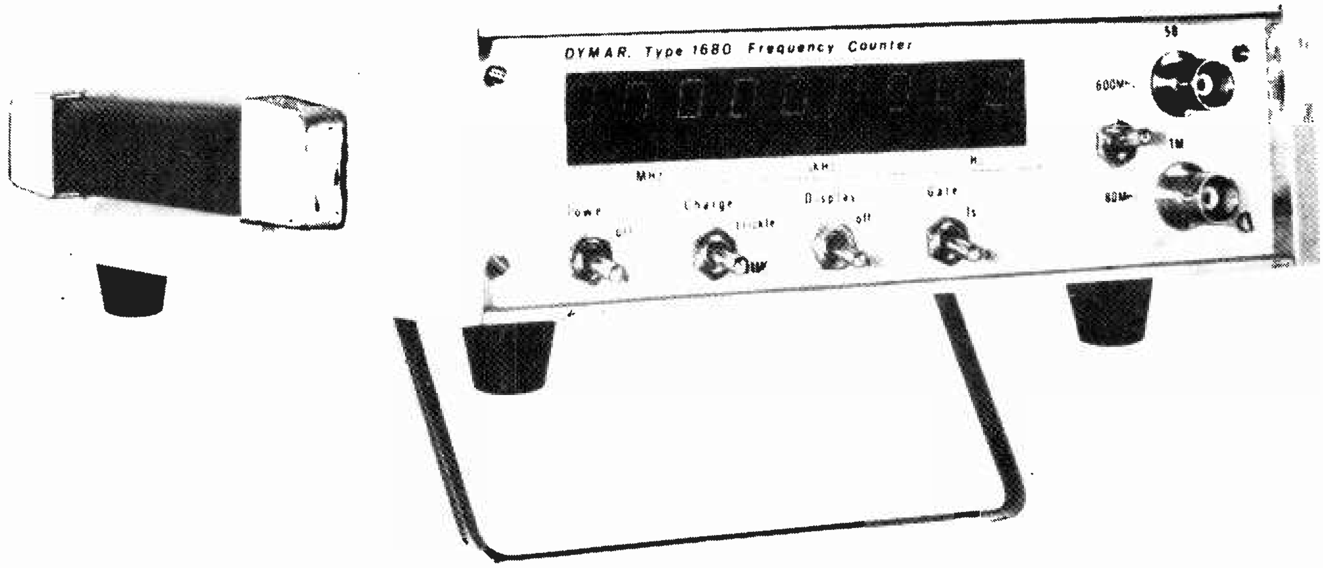

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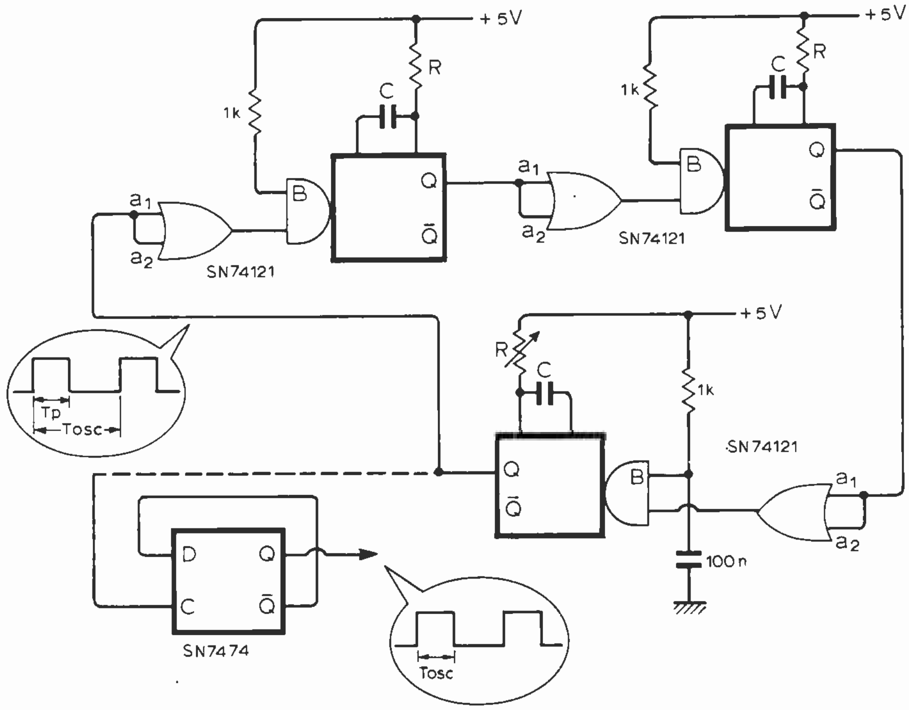
Circuit Ideas



Monostable ring oscillator

The circuit shown generates square waves which are suitable as clock signals in sequential digital circuits. The monostable multivibrator SN74121 requires an external timing resistance – $2k\Omega < R \leqslant 40k\Omega$ and an external timing capacitance – $10pF < C \leqslant 10\mu F$ to generate a pulse of duration $T_p = CR\log_e 2$ seconds. Each monostable is set for a similar pulse duration giving a 33% duty-cycle and a complete ringing cycle with a period of $T_{osc} = 3 \times T_p$ seconds. When the CR-pairs are selected within the above ranges, the nominal period T_{osc} may be varied between 150ns and 120s giving frequencies from 7MHz to one cycle in two minutes. By realizing one timing resistance as a 2kμ fixed resistor in series with the next highest preferred value multi-turn potentiometer, adjustments of approximately ±20% about the nominal frequency are possible. The inhibit inputs (B) are returned to the +5V supply with 1kΩ resistors whilst one is decoupled with a capacitance of at least 0.1μF to ensure oscillation when power is first applied. The stability of oscillation-frequency is dependent upon the tolerances of the external timing components. For an even mark/space clock, T_{osc} is set to half the required period and a divide by 2 bistable SN7474 is used from any Q or $\bar{Q}$ output. With a further chain of bistables, this ring-of-three circuit has been used to generate clock signals for asynchronous data transmission applications.

A ring-of-four circuit requires a fourth monostable in the ring with each T_p being set to $\frac{1}{4} \times T_{osc}$. When the external resistances of any two non-adjacent monostables are realised as variable components, the oscillator generates a selection of multiphase pulses which may be derived from any Q or $\bar{Q}$ output as required. This latter configuration has been used in conjunction with certain microprocessor devices.

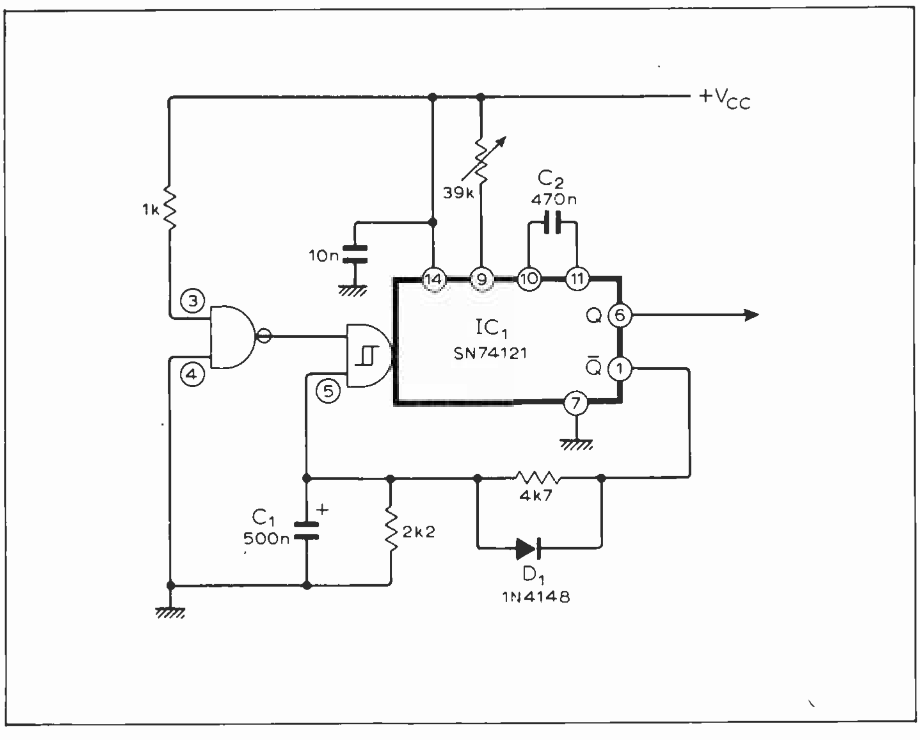
P. J. Best,
Dept of Electrical Engineering & Electronics,
Manchester University.

P.w.m. oscillator to vary display-intensity

Intensity control of solid-state displays by pulse width modulation is now a standard technique. Conventional systems employ a separate oscillator and modulator. The circuit suggested here combines the two functions using a common t.t.l. device. With $\bar{Q}$ high, C_1 will charge toward the switching potential of the B input Schmitt trigger, firing the monostable. $\bar{Q}$ will go low, discharging C_1 via D_1. At the end of the triggered period, which is set by the potentiometer with C_2, $\bar{Q}$ will go high, repeating the cycle.

A fan out of 10 is available from the Q output. This follows a high-off convention and is suitable for displays such as the Hewlett-Packard 7300 series. Should the complement be required a smaller fan-out is available from $\bar{Q}$.

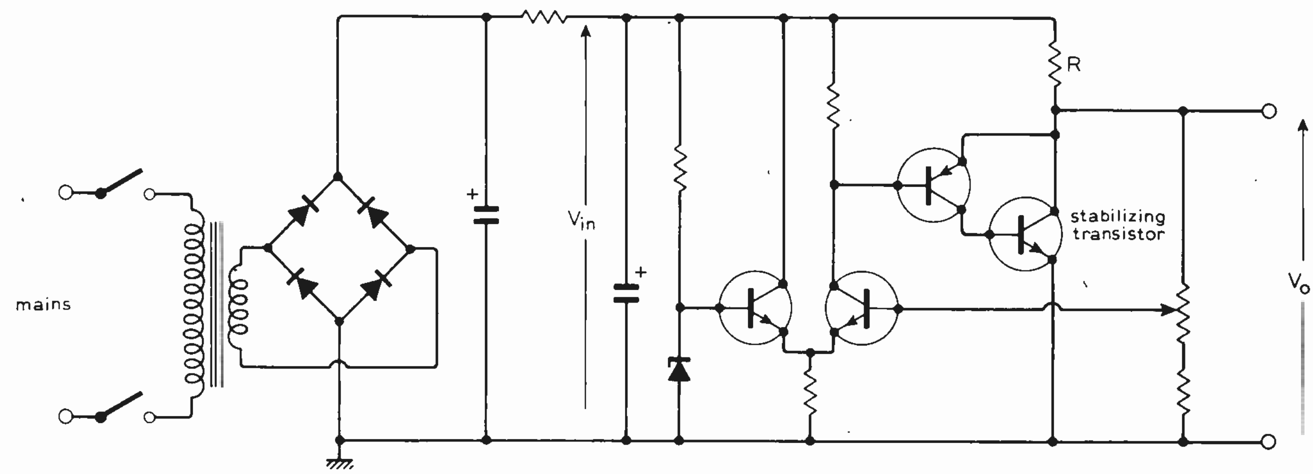
C. Bartram.
Department of Metallurgy & Science of Materials,
Oxford.



Shunt stabilized power supply

This circuit offers an improved power handling capacity over a simple zener stabilized circuit. It is short-circuit proof and less likely to damage delicate loads in the event of a fault in the supply. In many cases less power will be dissipated, by the regulating transistor, than in conventional series stabilizers. In the circuit shown, a feedback amplifier has been added to compare the output and zener voltages. The regulating transistor carries current equal to the difference between maximum and instantaneous currents. Therefore, if the load normally takes close to maximum current, the power dissipation will be low and a cheaper transistor may be used, particularly if the unregulated input voltage is very much larger than the required output voltage.

J. Suter,
Wallasey,
Cheshire.



Simple window discriminator

The voltages at the input terminals of the comparator are as shown. V_A is an attenuated form of the input V_i, but V_B is offset by an amount $-bV_S$ (V_S = supply voltage), and rises linearly with V_i until D_1 becomes reverse biased, when it is clamped to V_{ref}. Thus the V_A and v_B curves cross twice, giving rise to the two switching points. V_B, below the knee, is given by $V_B = V_{in}(1-b) - bV_S$, and above by $V_B = V_{ref}$. Because $V_A = aV_{in}$, the lower switching point occurs at;

$$aV_{in} = (1-b)\,V_{in} - bV_S$$

i.e. $$V_{in} = -bV_S/(a+b-1),$$

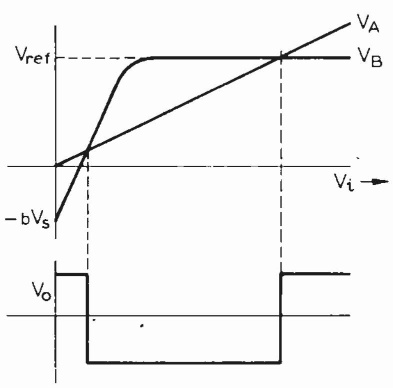
and the upper switching point at;

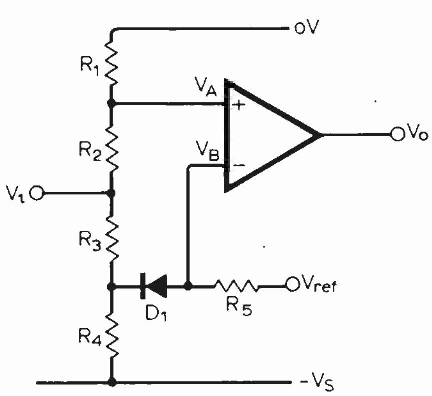
$$aV_{in} = V_{ref}$$

i.e. $$V_{in} = V_{ref}/a.$$

By fixing the ratio, the two switching points may be varied independently by adjusting b and V_{ref} for the lower and upper points respectively. As shown, the circuit will work only with positive going input voltages, but by reversing the polarity of D_1, V_{ref} and $-V_S$, may be made to work with negative going inputs.

M. J. Newman,
Stockton,
Teesside.





$$\frac{R_1}{R_1+R_2} = a;\quad \frac{R_3}{R_3+R_4} = b;\quad R_5 \gg R_3 \| R_4$$

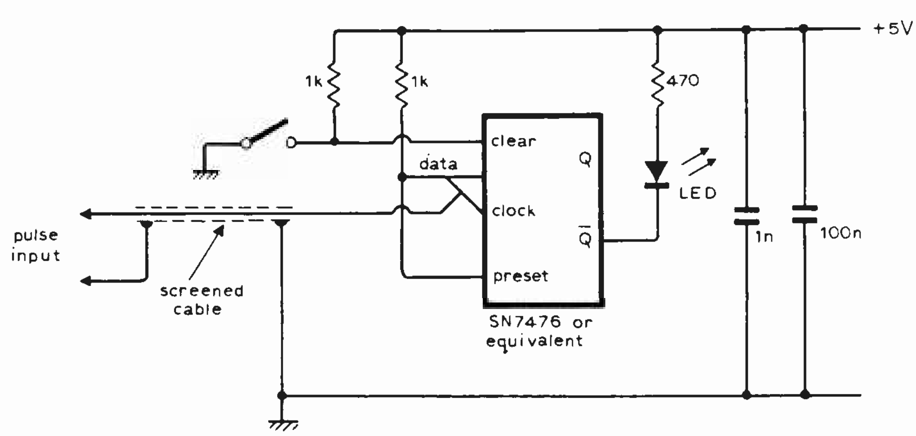
Digital pulse detector

The display of digital pulses, on an oscilloscope, becomes difficult if they are not repetitive. Pulses of a fairly long duration (milliseconds) may be displayed on a storage oscilloscope but the display of microsecond and nanosecond pulse widths becomes particularly difficult, if not impossible.

This circuit provides a simple method for detecting such pulses. Because the D type bistable transfers the information from its data input to the Q output on the positive going edge of the clock pulse, both positive and negative pulses with widths down to approximately 10ns may be detected.

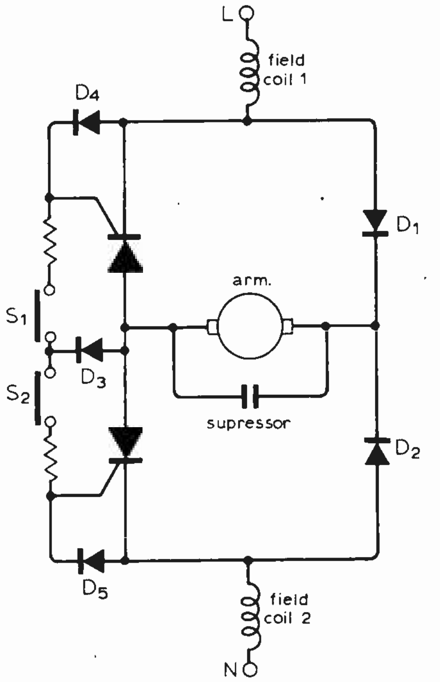
Any positive-edge triggered bistable may be used provided the correct conditions are wired to the J and K or data inputs.

P. V. Prior,
Ipswich,
Suffolk.



Universal-motor reverser

Universal motors are basically series types and, if the direction of rotation is to be reversed, the field connection must be reversed relative to the armature. The field winding usually consists of two coils, one at either end of the armature. These connections are made internally and must be cut, the ends being brought out separately. The field coils are connected to line and neutral with the armature in a full-controlled bridge rectifier circuit. Switches S_1 and S_2 allow either of the thyristors to conduct when forward biased. With S_1 closed, the current in the field coils is from neutral to line, i.e. the motor only uses half the a.c. cycle. With S_2 closed the current in the field coils is from line to neutral. Because the current in the armature is always from right to left, the effective direction between field and armature is changed. The starting current, on a full half wave, is five times larger than the rated load current. Unless frequent stop-starts or reversals are contemplated, only modest rectifiers and thyristors are needed and large heatsinks are not required.



Diodes D_4 and D_5 need only be low voltage types but D_3 must have a 400V rating for use on 240V a.c. supplies.

A. Refsum,
Queen's University,
Belfast.

Contributors to Circuit Ideas are urged to say what is new or improved about their circuit early in the item, preferably in the first sentence.

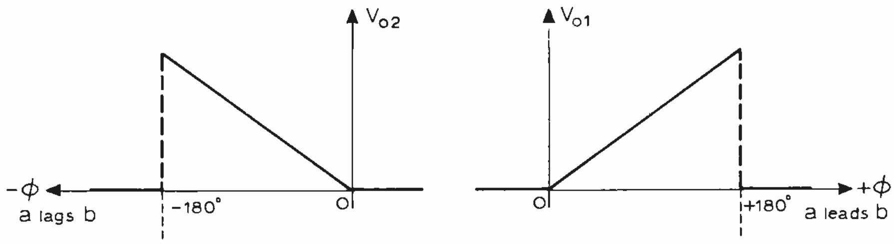
Non-symmetrical phase-sensitive detector

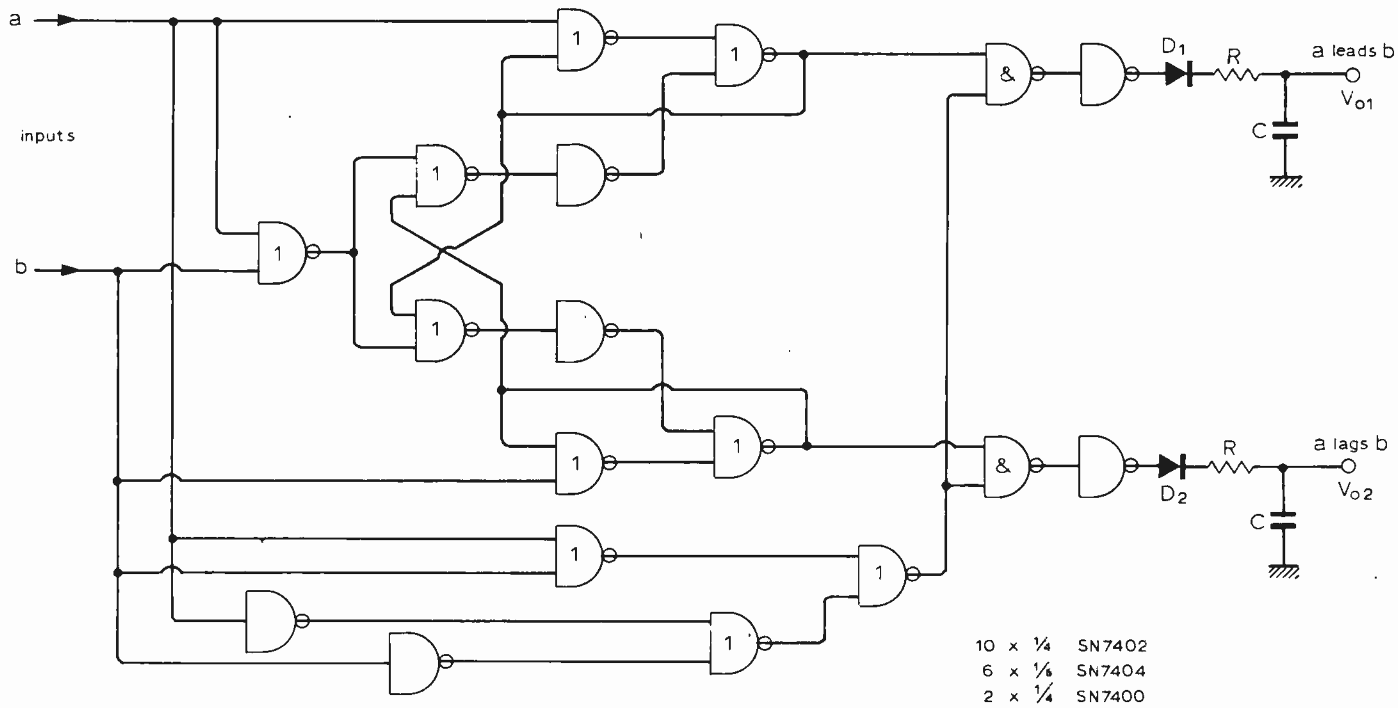
This circuit gives an output voltage proportional to the phase angle between signal and reference waveforms, at one of two outputs dependent on whether the signal leads or lags the reference.

An exclusive-OR gate is used as a p.s.d. and the output of this is switched between the two outputs by a sequence detector consisting of two RS flip-flops interconnected in a lock-out system, the flip-flops being reset during the period when both signal and reference are at zero. The values of R and C must be calculated from the frequency of the signal and the input resistance of the following stage. R should not be lower than 4k7 to avoid overloading the final inverter gate.

There is a discontinuity at ±180° and hence the circuit is unreliable at this point. The maximum output swing is approximately 2.5V.

G. C. Plain,
Barnby,
Suffolk.

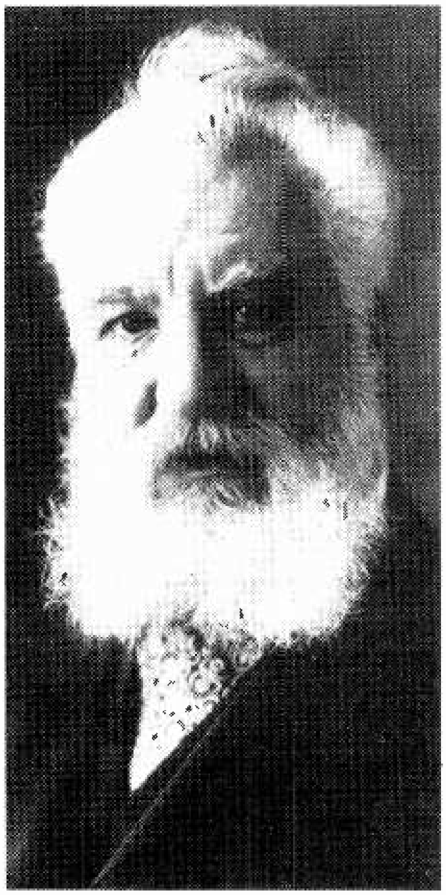




10 x ¼ SN7402
6 x ⅙ SN7404
2 x ¼ SN7400

Centenary of the telephone

A hundred years on and electronics is taking over



Alexander Graham Bell, 1847-1922, inventor of the telephone.

Alexander Graham Bell, the Scotsman who invented the telephone and first demonstrated it in Philadelphia in 1876, would not have been particularly surprised at the idea of sending telephone conversations over optical fibres, for he did something similar himself. He also invented the "photophone", an apparatus which transmitted voice waveforms along a beam of light and picked them up at the receiving end with a photoelectric cell. But he certainly would be surprised at the many other developments in telephone technology which have resulted from the application of electronics to his invention: communication satellites, undersea repeaters, viewphones, computer controlled electronic exchanges, waveguides, digital transmission, adaptive line equalizers – the whole host of devices which are now becoming familiar ideas to the telecommunication engineers of 1976.

Leaving aside radio telephony and such marvels as conversations between the moon and earth, Bell would have been astonished at the multitude of other devices that have now been put on to the lines and cables originally set up for telephony. Facsimile, data transmission, telemetry, sound and television broadcasting distribution are just a few. The "wired city" with its interactive information systems is not all that far off in 1976. Actually this year is a notable one for communication anniversaries in the UK: it is also the quincentenary of the introduction of printing to England by Caxton and the quinquagenary of Baird's demonstration of television to members of the Royal Institution (see January issue). The symbols and pictures disseminated by these techniques are now in fact being transmitted on the switched telephone network along with the phonemes of speech, and increasingly this is being done with the help of electronics. The diagram opposite (taken from "Telecommunication developments in the United Kingdom and their social implications" by W. J. Bray and A. A. L. Reid, *IEEE Trans. Commun.* Com-23 No. 10 Oct. 1975) shows the development of such information services from the year 1870 up to a projected situation in 2000 AD.

Just in time for 1976 the Post Office decided to open its new research centre at Martlesham Heath, near Ipswich in Suffolk. Claimed to be the most advanced centre for telecommunications research in Europe, it cost nearly £11 million to build and will employ 1,800 people. Here the visitor is very much aware of the dominance of electronics, and the following notes outline some of the main areas of work.

Optical fibres

Transmitting digital signals over optical fibres may eventually be more economic than using coaxial cables for most inter-city trunk routes. Optical fibres would avoid the need for buried repeaters on routes between urban-area telephone exchanges, would get rid of intermediate repeaters in most c.a.t.v. connections and would reduce the number of repeaters required in c.c.t.v. connections. Further simplification would follow from the use of space division multiplexing. Fibres can be assembled into cables, which can be drawn into ducts like those now used for conventional telephone cables. Fibre cables would be smaller, lighter and more flexible than metal cables of similar information carrying capacity.

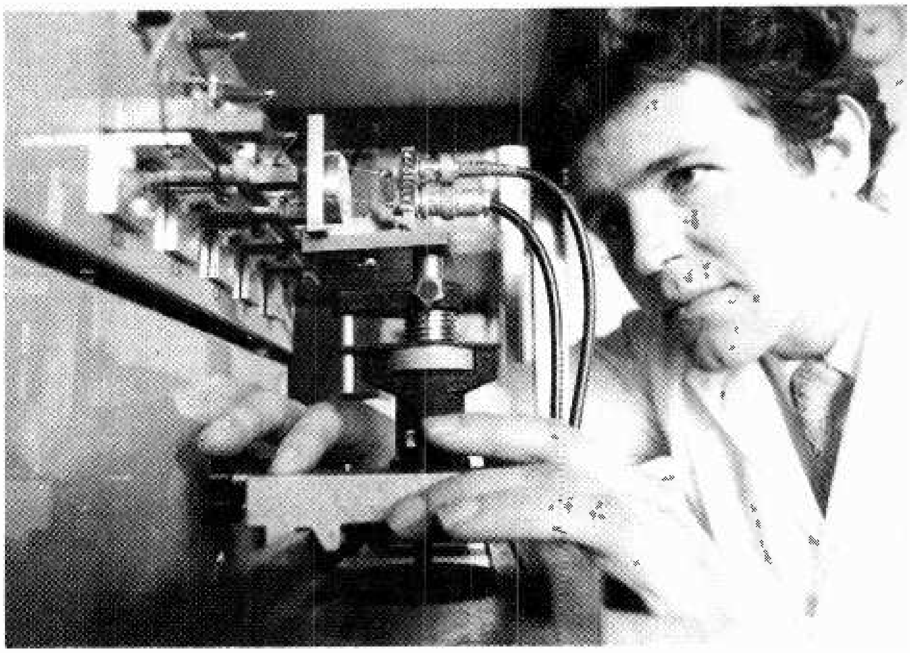
In a p.c.m. transmission system an infra-red light source, e.g. a light emitting diode or solid-state laser (see photo), is coupled to the fibre and switched on and off in accordance with the digital pulses. At the receiving end of the fibre the light signals are coupled to a photo-diode and converted back into electrical signals, which can then be processed in the same way as digital signals in other systems. Analogue transmission – of, say, television signals — is also possible over optical fibre lengths of several kilometres. Digital transmission is preferred for all kinds of signals over long (e.g. inter-city) distances.

A great deal of work has been put into developing fibres with low attenuation, to reduce the number of repeaters needed for a given distance. A few years ago we were hearing of attenuations of 20dB/km but now they are generally below 10dB/km and even approaching 1dB/km in some cases. At Martlesham an 8 Mb/s optical fibre transmission system is being developed which will be capable of handling 120 telephony channels over a 4km to 5km length of each fibre. This system uses a gallium arsenide light-emitting diode operating at the infra-red wavelength of about 900nm, together with a large-core multi-mode fibre with an attenuation of about 7dB/km. For the detector at the receiving end a silicon avalanche photodiode detector is used, and the resulting electrical signal is regenerated by conventional solid-state electronic circuits.

Electronic exchanges

Britain's first commercially produced electronic telephone exchange, the TXE4, is about to go into service at the Rectory Exchange at Sutton Coldfield near Birmingham. (Experimental electronic exchanges have been on public trial for short periods over the past decade or so.) Meanwhile more TXE4s are being manufactured for public service in exchanges handling 3,000 to 40,000 lines, and these, gradually replacing the existing Strowger and crossbar electromechanical exchanges, are expected to remain in service for about 25 years.

The TXE4, however, is not fully electronic, because the final connections between the speech wire pairs of subscribers are made by reed relays arranged in a matrix switching system. The operation of these relays is automatically controlled by electronic, solid-state, computer-like equipment working under programme control. Consider the analogy of a human switchboard operator using eyes, brain and hands in a manual exchange. The hands making connections are equivalent to the reed relay switching apparatus; the eyes looking at indicators are equivalent to electronic scanning and storage equipment examining the state of the incoming lines to see whether calls are being made on them; while the operator's brain is equivalent to electronic "control units" which identify calling subscribers, determine the connections required, select suitable routes through the network and finally operate the reed relays.



Bell used a reflecting diaphragm to modulate the light beam in his "photophone": nowadays, with optical fibres, the transducer is a laser. Here a Post Office scientist is checking the performance of solid-state lasers for optical fibre transmission as part of a device reliability study.

Programme control for the "brain" part — an ordered sequence of instructions which must be followed to set up each connection — is provided physically by a permanent wired programme. This consists of energizing wires running in various paths through an array of small ferrite cores carrying sensing windings. Each wire is energized in turn by having a current pulse passed through it, and this causes a particular combination of the cores to be magnetized — forming an instruction. Whichever pattern of cores is magnetized (the instruction) is read out by the sensing windings.

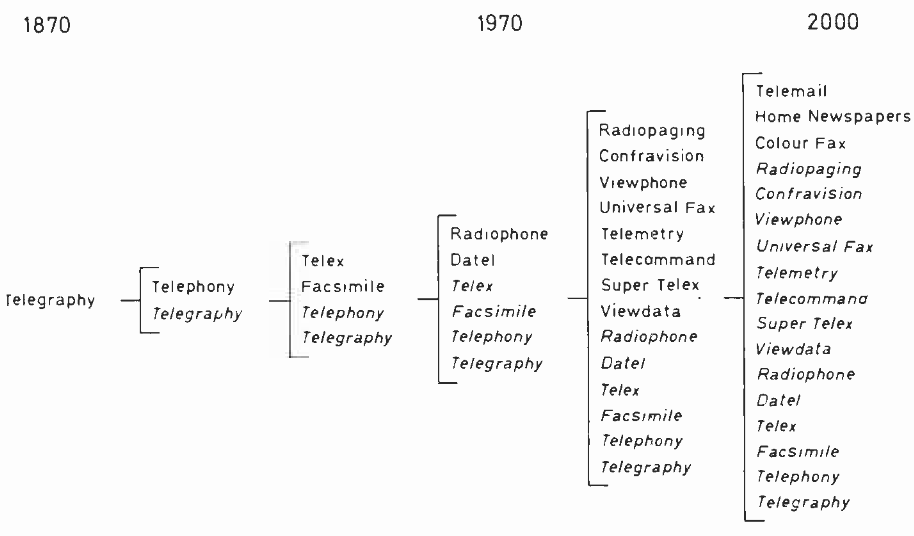
In later electronic exchanges the wired programme will be replaced by an alterable stored programme as used in digital computers. The stored programme control exchange on which the Post Office is working at Martlesham is called System X — presumably because its final form is not yet known. The essential thing about it, however, is that the actual connections between lines will be made by solid-state switches. Whether these will be diodes, or f.e.ts or something else is not yet decided, but they will almost certainly be integrated in m.s.i. or l.s.i. form. Already the i.c. manufacturers are putting small cross-point switching devices on the market.

The advantages offered by System X will be greater versatility and the ability to both cope with changing requirements from customers and take in future advances in electronics technology. Reductions in cost, weight and size are also likely, and, of course, there will be no electro-mechanical components producing noise and requiring regular maintenance. The system will use a range of control processors compatible with the GEC Mark IIBL computer which has been chosen as the main processor for System X. The first parts of System X to be introduced will provide digital switching for trunk routes.

Meanwhile at Martlesham a small local telephone exchange has been designed as part of the switching research programme for System X. It makes extensive use of digital processor control, and the processors are arranged in a three-level hierarchy. At the highest level is a highly reliable digital processor at a remote site. This enables the cost of tasks which require large electronic stores, or which are not used very frequently such as fault diagnosis or control of special facilities, to be shared between many exchanges. A smaller, local processor is responsible for the control of the basic telephone service. At the lowest level in the hierarchy a number of single-chip microprocessors perform simple tasks, and these are replicated over several units so that the failure of any one degrades, but does not interrupt, the service. Speech paths are switched by reed relays as the constraints imposed by the standard telephone make this necessary.

The register which receives the dialled or keyed information from the customer is an example of microprocessor control. The programme in the microprocessor discriminates between different types of signalling by examining the signal characteristics and then uses an analysis programme to interpret the information. Thus a mixture of telephones, with conventional dials or keypads, can be connected to the exchange. Whatever the type of sig-

The development of British Post Office telecommunications services. (Telex = teleprinter; Datel = data communication; Confravision = conference television; Fax = facsimile; Viewphone = video telephone; Viewdata = textual information displayed on television set; Telemail = overnight letter facsimile service.)



nalling, one digit at a time is passed up to the local processor which controls the call connection.

Call processing is normally performed by the main machine unless a failure is detected. This detection is achieved by simple checking circuits and simple software routines which monitor the accuracy and duration of each stage in the setting up of each call.

Sooner or later research and development contracts for System X will be placed with the telephone equipment manufacturers.

Communications satellites

The latest communications satellite to come into service is the first of the Intelsat IV-A series, which began operating in January (see Space News, February). Carrying 20 transponders, it will handle 6,000 telephone circuits or 20 television channels or various combinations of other services. The next series of comsats will be the Intelsat Vs, due to come into operation in 1979. These will use not only the present 4 and 6GHz frequency bands but also the higher satellite bands at 11 and 14GHz. These higher frequency systems can only be economically and efficiently designed if there is sufficient long-term statistical data on the propagation characteristics of the satellite-earth paths. Such data can be obtained from measurements on signals radiated from geostationary satellites, and at Martlesham a 6m diameter steerable aerial has been built for this work. Path attenuation and depolarisation measurements at frequencies from 11 to 30GHz will be made possible by the availability in the next three years of two experimental satellites. These are the ATS-6, now stationed at 35°E over East Africa (see p.68), and the OTS (European Space Agency) satellite which will become available in late 1977. Martlesham started working with ATS-6 in July 1975, and data at 20 and 30GHz will be collected until mid-1976, when the satellite will be returned to its original position at 95°W after the Indian television broadcasting experiment. The OTS satellite will provide data at 11 and 14GHz.

In the absence of experimental satellites, sky noise temperature measurements can be used to determine slant-path attenuation over a range of about 10dB. Radiometers working at 20 and 30GHz have been built and their use is being validated by the ATS-6 measurements.

Digital transmission

Pulse code modulation is being widely adopted for signal transmission because it gives large improvements in economy and performance. Already over 3,000 p.c.m. systems are operating in the UK. Latest work is concentrated on a high-capacity 120 Mb/s system (February 1975 issue, p.92). In February 1976 we reported on experiments by the Post Office, BBC and IBA in digitizing colour television signals and sending them over the Guildford-Portsmouth 120 Mb/s system. At Martlesham the Post Office is studying methods of coding television signals to reduce the required transmission capacity to a practical minimum. This involves making use of the statistical redundancy of television pictures and also the psychological and physiological limitations of the human visual system. So far these studies have been concerned with coding the composite PAL colour signal to allow this signal format to be preserved throughout a mixture of analogue and digital links. When there are enough digital transmission systems in use to provide a completely digital television network, it may be a good idea to distribute colour signals by multiplexing separately encoded colour components.

Future research will aim at reducing the redundancies of the digitised colour signal components by using coding techniques that have been developed for monochrome pictures. These include differential coding using predictions based upon samples in the same line, the previous line and the previous frame of each signal or in the associated colour components. First parameters to be established — subjectively — are the minimum necessary sampling rates (and bandwidths) and numbers of bits per sample for each colour component.

As for digitisation of speech, it's possible that in addition to the p.c.m. being used between exchanges, in the future digitized signals could come right into the home, to and from the telephone handset. The idea is to use time division multiplexing to get more telephone conversations on to the existing local telephone lines, in order to utilize them more economically. Methods being tried at Martlesham include delta-sigma modulation, which is fairly simple to implement and is economical in bandwidth compared with straight p.c.m. Measurements are being made to find out whether existing local lines and cables will be able to handle the higher frequencies present in digital signals.

Waveguide for the trunk network

As an alternative to coaxial cable, microwave relays and optical fibres, long distance waveguides carrying millimetre waves could be an economic possibility for the trunk routes of the future. Now being tested is a 14km length of circular waveguide running between Martlesham and Wickham Market in Suffolk. It consists of a 50mm diameter helix of fine copper wire set within a lossy resin-impregnated, glass-fibre tube. Typical attenuation is less than 3dB/km from 32 to 110GHz, falling to less than 2dB/km between about 40 and 80GHz. For the trial the frequency range has been split into five bands, 32-40, 41-49, 52-68, 72-88 and 90-110 GHz. The first two bands are each subdivided into 16 channels, the next two into eight channels, and frequencies above 90GHz are used for monitoring purposes. Using relatively simple filters and four-phase modulation, each of the 16 go plus 16 return channels can provide an information capacity of about 500Mbit/s, while each of the eight go plus eight return channels has a capacity of about 2Gbit/s. This means that when exploited up to about 90GHz the system could handle 24Gbit/s each way — the equivalent of more than 300,000 two-way telephone circuits, with further capacity available above 90 GHz.

Digital repeaters using solid state devices and microwave i.cs are installed at each end of the waveguide run so that a digital signal, comprising colour television and simulated multi-channel telephony, can be transmitted from Martlesham and looped back at Wickham Market up to four times in each direction — a total transmission distance of about 112km with repeaters at 14km intervals.

The wired city

Viewdata, the Post Office's new television screen information service now on pilot trial (November issue, p.532), is just one of the many communication services which could be provided in addition to the telephone by the "domestic terminal" of the future. Facsimile, data, viewphone, television and others shown in the diagram are also possible. Although existing local cables are designed only for the telephone, higher frequency signals can often be transmitted over the relatively short distances of the local network. The existing network is already being used for services such as data and subscriber-carrier telephony, and a viewphone service with a bandwidth up to 1MHz might also be possible.

In the future signals of much greater bandwidth than can be handled at present will need to be transmitted if all the new services shown in the diagram are to be offered. A new network for wideband transmission—about 500MHz – being studied at Martlesham makes use of coaxial cable laid in closed loops around the service area. Customers would have access to this wideband "highway" through nearby electronic "accessors". Signals would circulate in one direction, out from the exchange and back again. The upper part of the spectrum could transmit broadband video signals in analogue form for educational TV, surveillance and traffic control, and for broadcast entertainment TV. The lower part of the spectrum, below about 100MHz, could be allocated to two-way switched services, such as speech, data, facsimile, viewphone, operating in the digital mode. The advantages of digital techniques here would be negligible transmission impairment, cheaper switching and compatibility with the new p.c.m. trunk network.

World of Amateur Radio

Not appliance operators!

The ARRL has strongly rebutted the frequent charge that radio amateurs have degenerated to the status of mere appliance operators who simply purchase all equipment and no longer care or know about the technical aspects of electronics. In a guest editorial in *QST*, Vic Clark, W4KFC, dismisses this as "nonsense". He agrees that in the early days amateurs were required by circumstances to construct most of their equipment "although many wound coils and wired circuits simply by dutiful adherence to designs developed by the more knowledgeable". Today, he claims, few are content merely to use purchased equipment but continually seek new horizons of technical and operational effectiveness in the best amateur tradition: "we devise, construct, modify, reconfigure, test, diversify, substitute and repair as necessary . . . in the process we learn and make contributions to society and to the state of the art."

Indeed, Vic Clark suggests that today there is vastly more technical interest and experimentation than at any time and that this is carried out "within the framework of an orderly, progressive and self-disciplined radio service which places a minimum burden on the public coffers . . . amateur radio has more to be proud of today than ever."

Technical innovations

One outcome of the supposed "black box" concept of amateur radio is the belief that the equipment and techniques of radio communication are now so developed that there is little scope for experimentation. In practice, fortunately, this is far from true: a surprisingly large number of new ideas in systems, circuits and aerials continue to emerge from the hobby, with British amateurs playing their full part. Although any selection must be invidious, the following could be among those of the last few years that clearly have applications beyond the hobby itself.

The rapidly increasing use of s.s.b. up to and including 1.3GHz (currently in the UK, v.h.f. amplitude modulation seems to be disappearing as rapidly as a decade ago it did on h.f.); renewed interest in low-cost phasing methods of generating s.s.b. (including digital r.f. phase-shifting, third-method and the more recent polyphase approach which, although developed initially at STL for professional use, has been taken up and developed for h.f. and v.h.f. by amateurs) and combinations of filter with phasing methods to allow relatively low-cost filters to be used primarily for cleaning up the output; pseudo-stereo methods of enhancing the reception of weak c.w. signals as developed by F. Charman, G6CJ, and R. Harris, G3OTK; the simple use of PAL television delay lines to stabilise variable frequency oscillators as proposed by Brian Rose, G3ULR; a new general theory on dual-frequency resonance of aerial elements discovered by Leslie Moxon, G6XN.

If one adds the large number of new techniques for the display of slow-scan television images; conversion units for transcoding between c.w. teleprinters and visual displays; the increasing interest in circular and dual polarization for fixed and mobile communications; the OSCAR space techniques, earth-moon-earth and similarly exotic systems, it can still be fairly claimed that amateur radio continues to contribute to the art and practice of radio communication and is not content to ride on other people's development work.

On the ultra highs

Since November 1975, American amateurs have been permitted to use "all frequencies above 300GHz" a ruling that recalls the famous "200 metres and down" edict of 1912. In addition they have been allotted: 48 to 50GHz; 71 to 76GHz; 165 to 170GHz; and 240 to 250GHz.

Considerable progress was made during 1975 in moonbounce work, partly due to the use for tests of the 150-ft dish aerial of the Stanford Research Institute, (WA6LET) and many stations in the USA are now interested in 144MHz e-m-e operation; 432MHz is used world-wide (Peter Blair, G3LTF and S. J. W. Freeman, G3LQR helping to put the UK on the e-m-e map); and some activity on 50MHz in those countries where this band is available.

Three times as much use in being made of the 432 to 144MHz OSCAR transposer in Europe as in North America, with more West German than American users.

1975 saw the first use of the 24GHz band in the UK by L. W. G. Sharrock, G3BNL, and A. Wakeman, G3EEZ, who are believed to have established a world record by making contact over distances up to 154km. A new RSGB microwave award is available to amateurs making contact over distances exceeding 600km on the 1.3GHz band.

Japanese "explosion"

The "incredible explosion" of amateur radio in Japan during the past decade – today more than a half-million Japanese hold operator licences, more than double the number of Americans – may have provided the home market on which the country's commercial prowess in this field is based, but it has clearly resulted in many local problems. Hal Offutt, K8HVT/JA1ZXX, says that many, finding the bands swamped, soon lose interest; only about half of the total hold station licences and less than 30,000 the first and second class licences; there are about 30,000 with "novice-type" licences but the overwhelming majority never progress beyond the 10-watt radiotelephone-only licences. Unlike Europe or America, these phone-only licences cover h.f. as well as v.h.f., skating around international regulations on the grounds that they do not cause "harmful interference" to other services. Although (as many of us would confirm) Japanese amateurs heard in Europe are among the most courteous and competent of operators, there is much flaunting of the power and frequency restrictions. Many give up after about six months and regard amateur radio almost entirely as a hobby with little or no interest in the public service or educational aspects. The national society, JARL, has 70,000 members.

In brief

An industrial dispute has delayed the holding of amateur radio examinations, including those for the new novice category, in Australia. . . . The French national society, REF, has increased membership from about 6,200 in 1968 to over 12,000. . . . ARRL membership has increased to over 120,000. . . . The FCC has lifted restrictions on crossband operation of repeaters permitting the output to be on a different band from its input. . . . Roger Taupiac, F8KT, who died recently, acted as a resistance radio operator of the Brutus network during the period November 1, 1942 to September 30, 1944 and used much of his pre-war equipment in repairing many clandestine transmitters. . . . The first of the "six-band" worked all continents awards has gone to Tokuro Matsumoto, JA7AO. . . . Good quality, high-voltage variable capacitors for home constructors are described as "a species near extinction" in the USA and some amateurs are now making their own using the slide trombone technique of moving cylindrical plates one inside the other. . . John Johnston, K3BNS, has become chief of the Amateur and Citizens Division of FCC. . . . The 1975 Sarnoff Award of the Radio Club of America went to Edgar F. Johnson, a pioneer amateur who in 1923 began a mail-order business selling components to radio amateurs.

PAT HAWKER, G3VA

Meetings

MARCH

LONDON

1st. IEE/IERE — Colloquium on "The influence of high level languages on computer system design" at 10.30 at Savoy Pl., WC2.

1st. BKSTS — Symposium on "Sound from microphone to ear" at 19.00 at Thames Television, Studio 7, Euston Road, London NW1.

2nd. AES — "Acoustic loading of loudspeakers" by John D. Collinson at 19.15 at the IEE, Savoy Pl., WC2.

3rd. IEE — Colloquium on "Low cost microwave components and subsystems" at 10.30 at Savoy Pl., WC2.

3rd. IERE — Colloquium on "Tropospheric scatter communications" at 14.00 at 9 Bedford Sq., WC1.

4th. IEE — 67th Kelvin lecture on "The pulsar dynamo" by Prof. A. Hewish at 17.30 at Savoy Pl., WC2.

10th. IEE/IERE — Colloquium on "Centenary of the telephone" at 10.00 at Savoy Pl., WC2.

10th. BKSTS — "CCTV applications" by Peter Thompson at 19.30 at Thames Television Theatre, 308-316 Euston Road, London NW1.

11th. R.Soc. — Discussion on "New particles and new quantum numbers" at 10.15 at 6 Carlton House Terrace, London SW1.

11th. IEE — "Commercial electric vehicles" by Dr. M. A. Hind at 18.00 at Thames Polytechnic, Wellington St., SE18.

15th. IEE — Colloquium on "Dynamics and control theory for biological applications" at 14.30 at Savoy Pl., WC2.

16th. IEE/R.Ae.S. — Symposium on "Equipment and system design for minimum cost of ownership" at Royal Aeronautical Society, 4 Hamilton Pl., W1.

16th. IEE — "The application of radar to meteorology" by Dr. B. C. Taylor at 17.30 at Savoy Pl., WC2,

17th. IEE/Operational Research Soc. — Colloquium on "Everyday use of business models" at 10.30 at Savoy Pl., WC2.

17th. IEE — "From d.c. to light: pulses and plasmas" by Dr. J. E. Carroll at 17.30 at Savoy Pl., WC2.

18th. IEE — Colloquium on "Physiological aspects of biological control systems" at 10.30 at St. Thomas' Hospital, Lambeth Palace Rd., SE1.

18th. IEETE — "Terotechnology" by Dennis Parkes at 18.00 at the IEE Lecture Theatre, Savoy Pl., WC2.

18th. IERE — "Global communications" by D. Weedon at 18.00 at 9 Bedford Sq., WC1.

22nd. IEE — Discussion on "Remote audio conferencing" at 17.30 at Savoy Pl., WC2.

22nd. IEE — "Planning of the u.h.f. television transmitter network" by W. F. Williams and G. H. Taylor at 18.30 at Savoy Pl., WC2.

23rd. IEE — Colloquium on "Programmable controllers" at 10.30 at Savoy Pl., WC2.

24th. IEE — Colloquium on "Logic design using microprocessors" at Savoy Pl., WC2.

25th. IEE — "Measurement of earth resources by optical means" at 17.30 at Savoy Pl., WC2.

25th. IEE — "New talks for science and technology" by Sir Alan Cottrell at 17.30 at Savoy Pl., WC2.

29th. IEE — Colloquium on "CCTV in difficult environments" at 14.30 at Savoy Pl., WC2.

ABINGDON

10th. IEE — "Sonar and underwater acoustic communications" by V. G. Welsby at 19.00 at Culham Laboratory, Nr Abingdon.

BATH

17th. SERT — "Recent developments in land mobile radio" by Prof. W. Gosling at 19.15 at the University of Bath

BIRMINGHAM

17th. RTS — "Charge coupled television cameras" by Harold Brown at 19.00 at A.T.V. Centre, Broad Street.

BOURNEMOUTH

11th. IEETE — "Advanced passenger train" by P. Cautley at 19.30 at Cotford Hall Hotel, Knyveton Road.

BRISTOL

10th. BKSTS — "Let's talk sound" (discussion on sound-recording techniques) at 19.30 at BBC, Whiteladies Road.

CHATHAM

17th. IERE — Discussion on "Education and training for the electronic engineer" at 19.00 at Medway and Maidstone College of Technology.

GRIMSBY

10th. SERT — "The Trinitron tube" by a speaker from Sony (UK) Ltd. at 19.30 at Grimsby College of Technology.

HATFIELD

18th. IERE — "The technology of scientific satellites" by G. G. Lewis at 19.45 at Hatfield Polytechnic.

IPSWICH

24th. IEETE — "Radio Orwell" by R. G. Allison at 19.30 at Room 2, Ipswich Town Hall.

11th. SERT — "Engineering aspects of sound reproduction" by Mr Watling at 19.30 at the Civic College.

LIVERPOOL

19th. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele in the afternoon and evening at the Philharmonic Hall.

MAIDSTONE

1st. IEE/Maidstone District — "Stereophonic and ambisonic reproduction" by Prof. P. B. Fellgett at 19.00 at S.E.E.B., Maidstone District Offices, Parkwood, Sutton Road.

MIDDLESBROUGH

30th. SERT — "Latest developments in measuring instruments" at 19.45 at the Cleveland Scientific Institute.

PRESTON

2nd. SERT — "Current trends in television power supplies" by a speaker from Granada TV at 19.30 at Room G7, Preston Polytechnic.

SHEFFIELD

24th. IEETE — "Electrical and electronics engineering in the hospital services" by K. H. Dale at 19.30 at Granville College of Further Education, Granville Road.

SLOUGH

16th. IEETE. — "CEEFAX: a new form of broadcasting" by J. P. Chambers at 19.30 at Slough College of Technology, Wellington Street.

SWANSEA

10th. IEETE — "Hi-fi, a technical appreciation" by J. Ham at 19.30 at University College, Singleton Park.

WORCESTER

30th. IEETE — "The history and development of radio astronomy" by D. M. A. Wilson at 19.00 at the MEB Training Centre, Whittington, Nr Worcester.

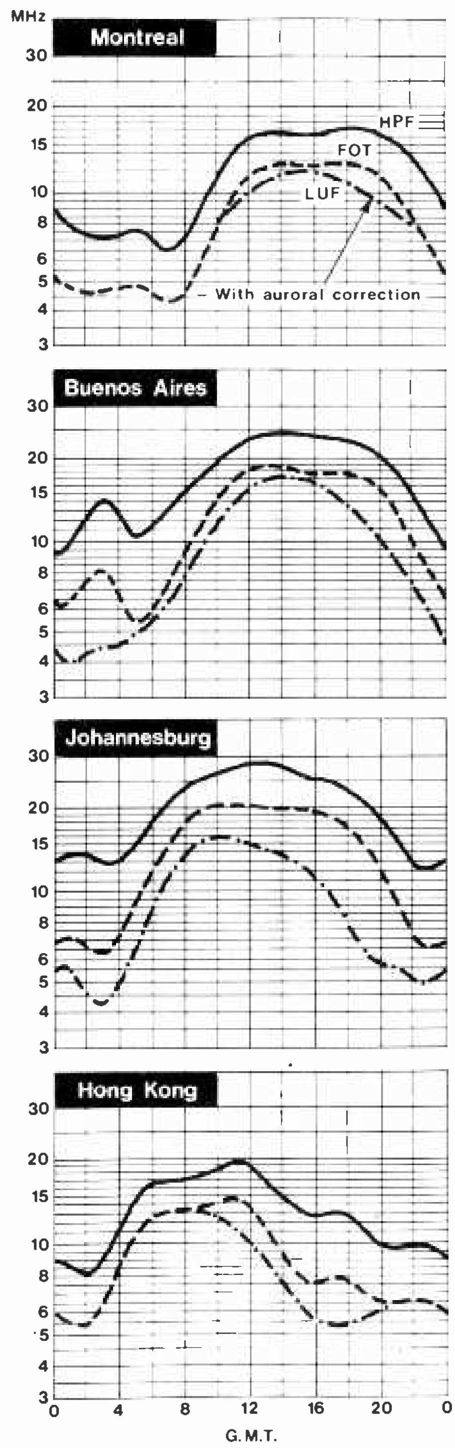
Tickets are required for some meetings: readers are advised therefore to contact the society concerned.

HF predictions

Solar activity summary for 1975 from data supplied by the Royal Greenwich Observatory:

	A	B	C	D	E	F	G	H
Jan				0	22	11		14
Feb			1	0	27	10		20
Mar				0	27	9		16
Apr				0	22	5		19
May				0	32	8		21
Jun				0	39	10		25
Jul	1			12	45	28		22
Aug	2	6	5	9	66	35	2	24
Sep				0	39	16		26
Oct				0	20	9	1	22
Nov	1			0	44	18		19
Dec				0	22	12		12

A, sunspots greater than 500 millionths of the sun's visible hemisphere; B, sudden enhancement of atmospherics at 28.5kHz; C, solar flares; D, lowest of daily sunspot numbers; E, highest of daily sunspot numbers; T, mean of daily sunspot numbers; G, new cycle spots; H, number of days on which sunspot counts were made.



Every day, our customers establish new reliability records in data collection and display....

...in-air, offshore, even underground, SE provides effective economical solutions to instrumentation recording problems....

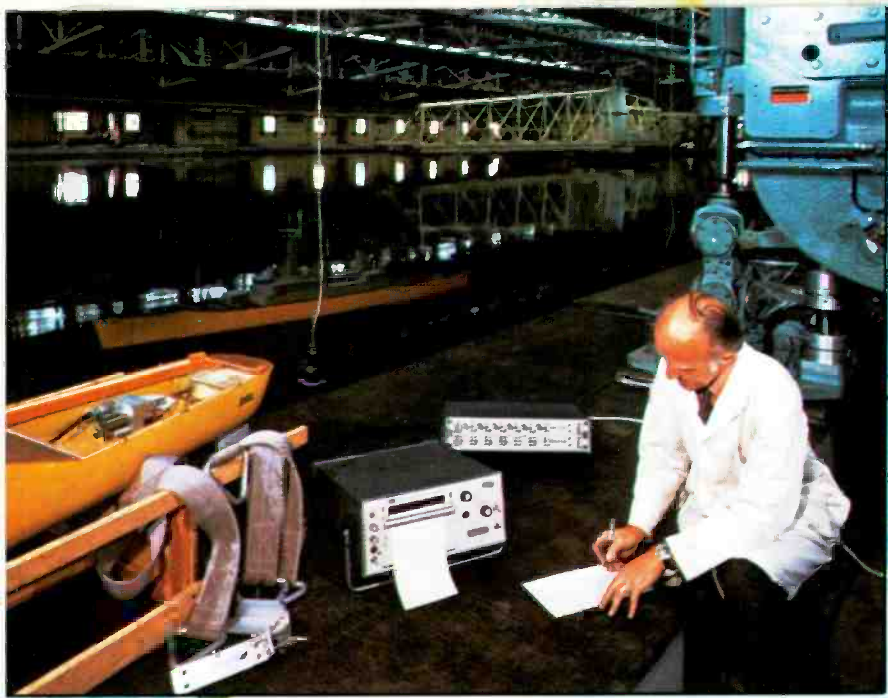
No-one covers a more diverse range of data recording and display requirements than SE. There are sophisticated SE pressure transducers monitoring the engines of in-flight Tri-stars, ultra-violet recorders and signal conditioning equipment measuring vibration levels of construction machinery in the new Dartford Tunnel, high performance analogue tape recorders checking vital parameters in the design of offshore platforms and ships.

And whether your application is in aerospace, industry or research, you can pinpoint your precise needs from our range of transducers, signal conditioning equipment, oscillographs and analogue tape recorders.
And all SE equipment offers the high reliability — and above all *Guaranteed Value* — needed today.
For further information on the most effective instrumentation recording system to match your needs, contact SE.

A JCB excavator loader undergoes intensive strain and hydraulic pressure tests at the company's Rocester research area. Measurements are recorded on an SE 7000 portable instrumentation recorder for subsequent laboratory analysis.

Analogue Magnetic Tape Recorders.

There are four instruments in the SE range from four channel portable equipment weighing only 11.5 kg to the SE 5000 high performance mid-band recorder, established leader in multi-format analogue magnetic tape recording, offering 14, 28 or 42-track operation with direct recording to 600 kHz, FM to 80 kHz and PCM to 2Mbps.
Another outstanding instrument is the SE 7000A, fully portable but with all the facilities you normally associate with a fixed installation. It offers single switch selection of recording speeds and a built-in calibration system allowing all parameters to be checked, set-up and monitored instantly. All this in a true portable mains or battery operated 14-channel device weighing only 43 kg. Another key feature of the SE 7000A is the ability to record and reproduce at all speeds in the range 60 to 15/16 ips without the need to change plug-in filters/equalisers or to adjust zero and gain settings.
If you want the best — and value for money, contact SE.

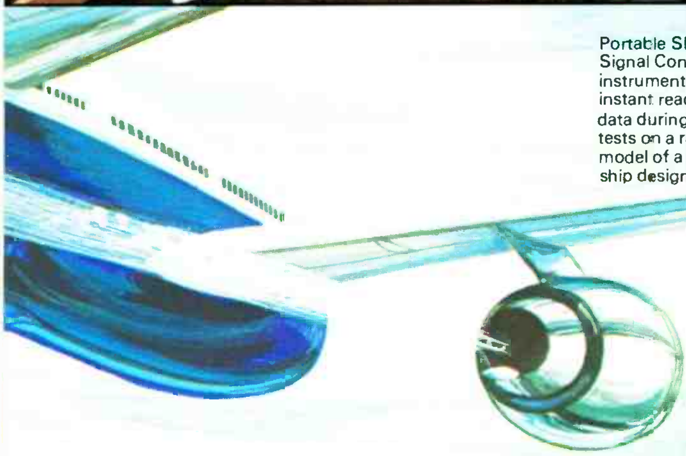


Oscillographs and Conditioning Equipment.

Seven well-proven light-beam recorders each one offering an outstanding price/performance package. Extending from a 6-channel portable unit weighing only 7.6kg to the state-of-the-art 50-channel SE 6012 capable of chart speeds of 5mm/sec to 5000mm/sec with a chart width of 12in.

Recorders in the range use SE galvanometers which have measurement sensitivities of 0.8μA/cm to 36mA/cm and high fidelity recording from dc to 8 kHz.
A general purpose X-Y pen recorder complements the range with a choice of sensitivity configurations giving a maximum 0.05V/cm on an A4 chart.
SE also offer a wide range of compatible signal conditioning equipment.

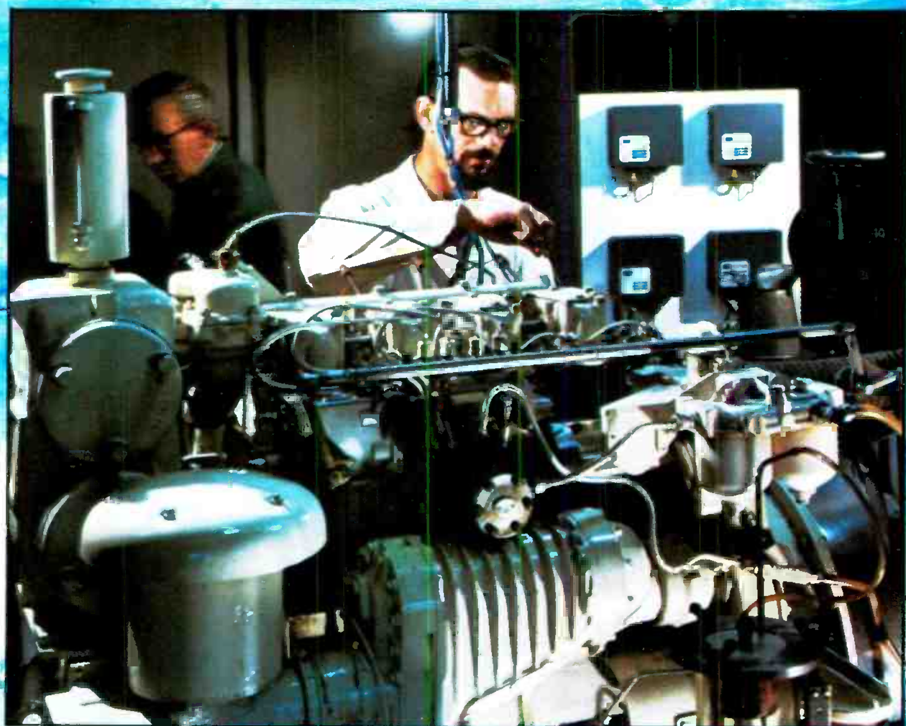
Portable SE Oscillograph and Signal Conditioning instrumentation providing instant readout of seakeeping data during hydrodynamic tests on a radio-controlled model of a proposed ship design.



Pressure and Displacement Transducers.

SE provide one of the most comprehensive ranges of high reliability instrument transducers for aerospace and industrial applications.
These include variable reluctance "wet-wet" pressure devices for use with the vast majority of corrosive media. Latest addition to this range is the new SE21 Series of low cost industrial units. Designed specifically for data logging and process control applications, they incorporate the technology — high reliability pressure capsule and sophisticated built-in electronics — that has been proven in the demanding aerospace environment.
Semi-conductor pressure and miniature piezoresistive strain gauge dc devices are also available, in a variety of configurations. Completing the range are the SE dc/dc miniature and long stroke displacement transducers, ideal for measuring small displacements with high accuracy and infinite resolution. External signal conditioning equipment can be provided to meet all requirements.

Ruggedised SE 21 variable-reluctance pressure transmitters monitoring the oil pressures and flow rates of a diesel engine used in oil performance tests.



Compare the value of SE reliability, SE systems capability, SE service with any other in the instrumentation recording field.

In addition to providing standard off-the-shelf instruments suitable for displaying, recording and monitoring data for a wide range of applications, SE will provide a tailor-made system package to match specific requirements — from displaying pressure diecasting and plastic extrusion phenomena to hydraulic and strain test monitoring etc. We can provide the entire system, hardware to software, and guarantee its system function. And SE provides the quick-reacting service back-up to ensure you get the best out of your equ pment. In the UK there are full calibration/ service centres at Feltham, Manchester, Nottingham, Wells and Glasgow, and facilities for swift, emergency on-site service. Overseas SE companies and service agents offer a similar capability.

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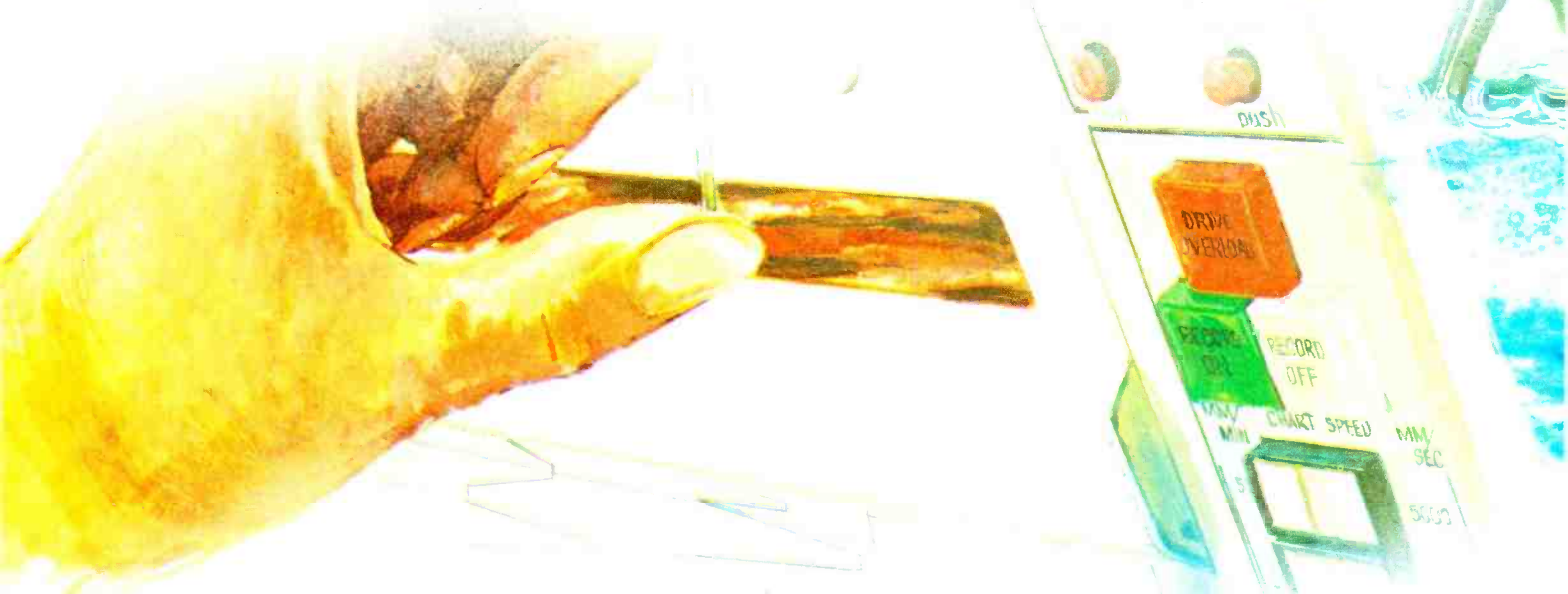

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Germany: Kontron Elektronik GMBH, D8051 Eching, Postfach 105. Phone: (08165) 77-1 Telex: 05 26 719

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Sweden: EMI (Sweden) Ltd., Svenska AB., Tritonvägen 17, Fack S-171, 19 Solna 1. Phone: 08-730-0060 Telex: 10046

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New Products

Modular power units

Coutant Electronics have introduced a range of switched-mode power supply units called the SAC series. The circuits employ a conventional mains transformer as the first stage followed by a h.f. inverter switching stage incorporating optical isolation to produce the required regulated d.c. output via a rectifier. This method is claimed to result in lower voltage stress in the switching circuits, low ripple and noise, suitability for multiple output applications and the possibility of operating from all conventional a.c. inputs (i.e. 102-256V, 45-65Hz) and 40-56V d.c. inputs. There are nine units available in the series ranging from the 60/5 (a 5V, 60A unit measuring 125 × 190 × 285mm and weighing 10kg) to the 4/24 (24V, 4A output in a 4kg module). The units' r.f.i. performance will be of interest to designers who have previously avoided switching-mode supplies due to their higher levels of radiated and conducted interference. Coutant Electronics Ltd, 3 Trafford Road, Reading, Berks RG1 8JR.

WW 301 for further details

Meter for temperature and humidity

A portable instrument for measuring both temperature and humidity uses a thin-film capacitor for humidity sensing and a silicon semiconductor to measure temperature. The display is a l.e.d. type and the instrument uses rechargeable batteries. Lee-Dickens, the makers, say that the response time on the 0-100 relative humidity range is one second to achieve 90% of the final reading at room temperature. Calibration is within 0.5% and hysteresis (20-80-20% reading excursion) is less than 1%. The 0-100°C temperature range is within 0.5°C in both calibration and linearity. The instrument is designed as a pistol-grip device, with a probe for use in free air or for the testing of conditions in loose materials or ducts. Lee-Dickens Ltd, Desborough, Kettering, Northants.

WW 302 for further details

Printer

Known as the series 100 printer, a unit which accepts parallel b.c.d. logic from a variety of digital sources, such as digital clocks, digital voltmeters, electronic counters and computers, has been introduced by Pye TMC Components Ltd. The b.c.d. logic is decoded and printed with the print-out legibility of an electric typewriter. Two basic types are available giving the choice of a maximum capacity of either 8 or 16 columns. Where special print formats are required, these can be designed to customers' specifications. All inputs and outputs are t.t.l. compatible. Character control is by means of up to 16 columns of parallel, four-line, b.c.d. Print rate is two lines per second when a logic 0 is applied to the print command input. The print drum has 13, 2.2mm high by 1.5mm wide characters in each column and incorporates a replaceable type ink roller which has a life of more than 100,000 lines. Paper width is 58mm. Pye TMC Components Ltd, Controls Division, Roper Road, Canterbury, Kent CT2 7ER.

WW 303 for further details

Sensitive reed relay

High coil resistance of 500 ohms is the main feature of the dual-in-line reed relay 97-1-C-5/7 introduced by Pickering Electronics. It requires 10mA, from a 5V supply. Consequently the relay can be driven directly from low level t.t.l. Hitherto, many 5V changeover d.i.l. reed relays have needed a 40mA driver, and had a coil resistance of about 140 ohms or even less. The new relay can switch 3W, with a maximum voltage of 28V and a maximum current of 0.25mA. Pickering Electronics Ltd, Brunel Road, Clacton-on-Sea, CO15 4NL.

WW 304 for further details

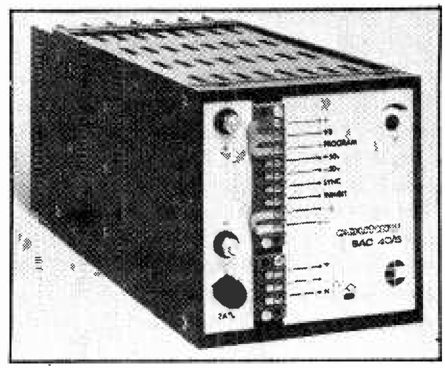
Heat sinks

Two extruded aluminium heatsinks for use with d.i.l. integrated circuits have been developed by Wakefield Engineering Inc. and are available from Dage Eurosem Ltd. The models 650 and 651 have transverse and longitudinal fins respectively for natural or forced air cooling. The heatsinks are mounted to the i.c. using thermally conductive and electrically isolating epoxy adhesive. Both types are supplied in ¾in lengths, with longer units available to order. Dage Eurosem Ltd, Haywood House, Pinner, Middlesex.

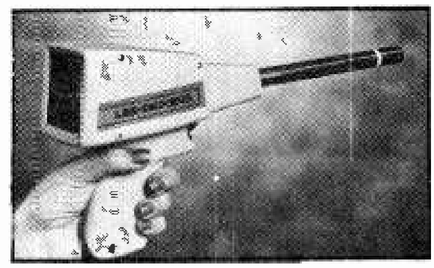
WW 305 for further details

Automatic device-tester

The Datest 1 automatically tests and identifies transistors, including all classes of f.e.ts, both in and out of



WW 301 for further details



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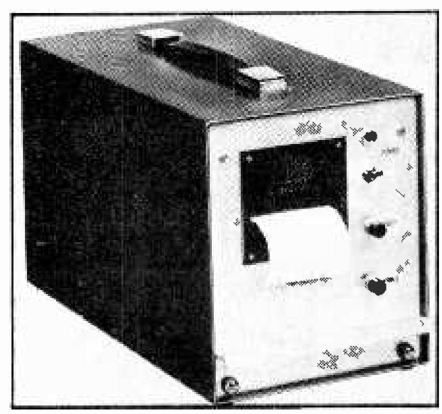

WW 303 for further details

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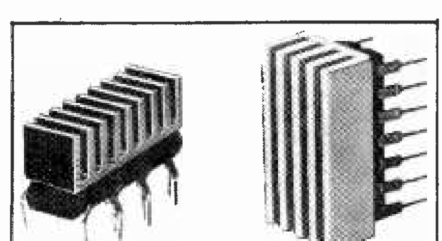


WW 305 for further details

circuit, and op-amps out of circuit. No prior knowledge of device polarity is required. The instrument displays the polarity together with parameter information on a six l.e.d. display which also indicates when the battery voltage is low. Six different test sockets are incorporated and the unit is supplied with special probes for in-circuit testing. Datong Electronics Ltd, 11 Moor Park Avenue, Leeds LS6 4BT.

WW 306 for further details

Sound level meters

Bach-Simpson have announced two new portable sound level meters which comply fully with BS3489-1962 and IEC723-1961. A calibrator, precision band filter and carrying case are also available. The model 884 gives coverage from 50 to 130dB in seven ranges with A weighting, and fast or slow response. An output jack socket is also provided for interfacing with other instrumentation. The model 886 gives coverage from 40 to 140dB in 9 ranges, with A B and C weighting and fast or slow response. This meter has a detachable microphone for remote measurements, and two external filter jack sockets for use with an octave band filter. Bach-Simpson Ltd, Trenant Industrial Estate, Wadebridge, Cornwall, PL27 6HD.

WW 307 for further details

Mains filter and inlet socket

A combined filter for protecting equipment against mains-borne transients and standard mains inlet socket, conforming to CEE 22, is introduced by Belling-Lee. Available in 2A and 6A ratings, it is suitable for standard mains supplies at 250V a.c. or at frequencies up to 400Hz. The mating face is in accordance with publications CEE 22 and IEC 320 and accepts standard free connectors, which can also be supplied. Side or end terminations are designed for use with either push-on or soldered connections. Overall length is 52mm. Belling-Lee Ltd., Great Cambridge Road, Enfield, Middlesex.

WW 308 for further details

Cutters that clinch

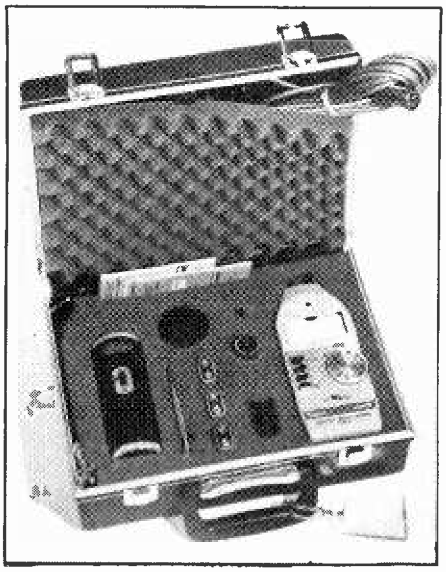
A cutter which severs and clinches a lead in one action has been developed by Light Soldering Developments Ltd, for cutting component leads after they have been located in a p.c.b. The action prevents components from being dislodged during handling and soldering even if the board is inverted. The Litesold Cut/Clinch pliers are equally suitable for use with hand or wave soldering techniques and eliminate the need for special assembly frames to hold the components in place. The pliers cost £4.82 plus v.a.t. Light Soldering Developments Ltd, 97-99 Gloucester Road, Croydon, Surrey.

WW 309 for further details

Pulse and function generator

In addition to sine,. square and ramp waveforms the Interstate Electronics F72 pulse and function generator produces positive, negative or bipolar pulses with variable rise and fall times at repetition frequencies from 20μHz to 20MHz and with pulse widths from 15ns to 1s. Output frequency can be controlled by an external voltage, while input signals can be converted to digital levels and be shaped, offset and amplified, using the rise/fall and output amplifier controls. High and low outputs with 30dB difference are provided and both may be used simultaneously. Maximum output of bipolar waveforms is 30V peak-to-peak into open circuit and 15V peak-to-peak into 50 ohms. The generator may be connected directly to logic circuits such as m.o.s. and the sync output provides a t.t.l. compatible squarewave which may be used as an auxiliary digital circuit drive. Euro Electronic Instruments Ltd., Shirley House, 27 Camden Road, London NW1 1YE.

WW 310 for further details



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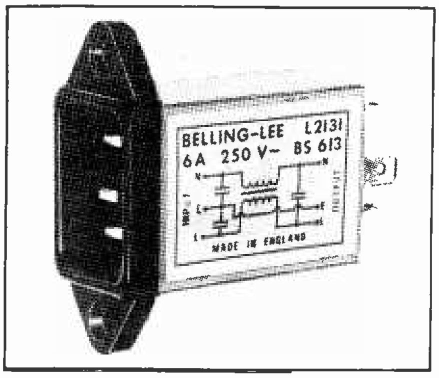

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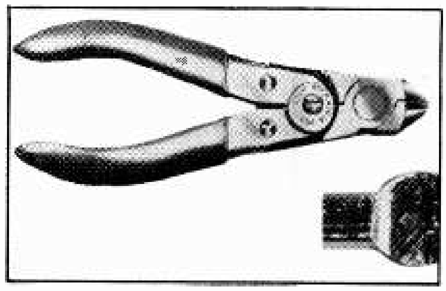

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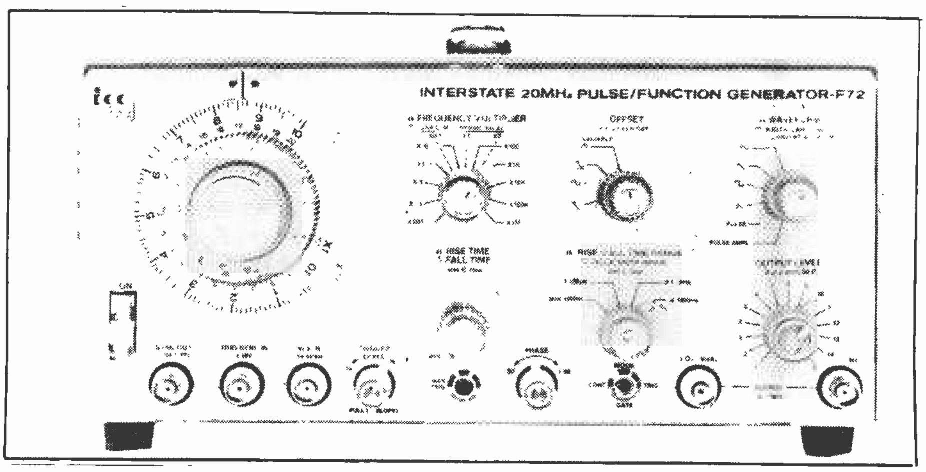


WW 310 for further details

Edge connector

The Series 6072 printed-board edge connector is new to the Varelco range. It is made in glass/phenolic plastic and uses bifurcated spring nickel gold-plated contacts on a 0.1in pitch. The connector is provided with up to 178 contacts, in two rows, with wire-wrap or solder terminations. Mounting brackets are of metal or plastic, and board guides can be used on any length of connector. Varelco Ltd, Exning Road, Newmarket, Suffolk CB8 OBB.

WW 311 for further details

Selective level meter

The selective level meter CE-24A made by Cushman Electronics has a frequency range of 200Hz, and is portable, weighing 9.1kg (20 pounds). It can operate from a.c. mains and also has built-in rechargeable cells for field use. A plug-in option, type 241, is available for noise measurement in N and ON carrier systems. Level range is −110 to +12 dBm. An l.e.d. frequency read-out gives 10Hz resolution. Frequency accuracy is 1×10^{-5}. Automatic frequency control reduces errors due to drift, and the time-consuming signal peaking, and the instrument has phase-lock stability. A residual phase jitter of 1° peak-to-peak permits phase jitter measurements at carrier frequencies. Alternative bandwidths of 1.74kHz or 3.1kHz are provided for channel noise measurement, and there is also a 45Hz narrow bandwidth for single-tone measurement. Five switched impedances are available. Price is £1,615. Dana Electronics Ltd., Collingdon Street, Luton, Beds.

WW 312 for further details

Miniature circuit breakers

Available in thermal, thermal magnetic or magnetic configurations, Stopcircuit miniature circuit breakers are available from Rilton Electronics Ltd. Current ranges are from 40mA to 25A and up to four poles operated by a single pair of buttons. Fixing can be by a single nut, two screws, plug-in or DIN rail. Rilton Electronics Ltd, Crowborough, Sussex, TN6 1JS.

WW 313 for further details

Etch-resistant transfers

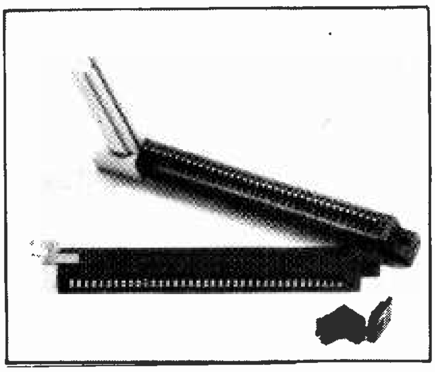
Electro Circuit symbols are a range of etch-resistant transfers for direct use on copper clad printed circuit boards. The shapes are deposited on to the copper by rubbing a backing sheet (similar to Letraset) to produce a complete layout. The final board is then etched and the transfers subsequently removed. The symbols are supplied in wallets of five 10cm × 10cm sheets at around £0.90 per pack. An evaluation kit is also available which comprises 10 sheets of assorted symbols, three pieces of copper clad laminate, a jar of etching solution, and a plastic dish for etching.

This kit is priced at £6.70 inclusive and is available from Theta, P.O. Box 10, Martock, Somerset TA12 6LT.

WW 314 for further details

A-d converter

The low power analogue/digital converter ADC585-12 performs 12-bit conversion with a power consumption of 20 to 30mW from a single + 12V to + 15V d.c. source. Conversion time is 100ms. Suitable for battery powered applications, it measures 2 in × 2in × 0.4in. The device can be arranged to convert either a 0 to +10V unipolar or a −10 to +10V bipolar input signal range by the external connection of two module pins. Corresponding digital outputs are c.m.o.s. level binary (unipolar) and offset binary (bipolar) codes that are simultaneously available at the module pins in both a 12-line parallel format and a single line serial format. Input impe-



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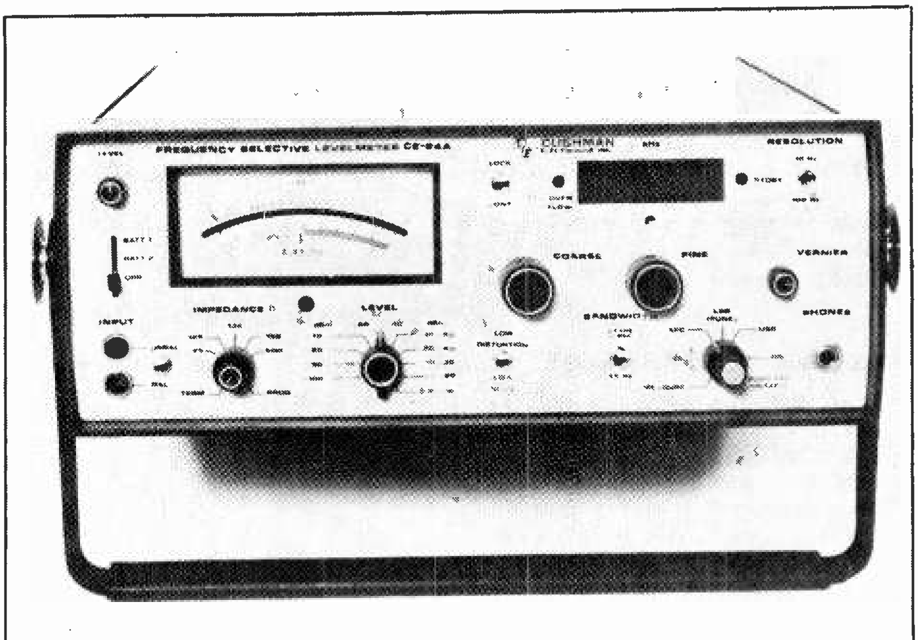

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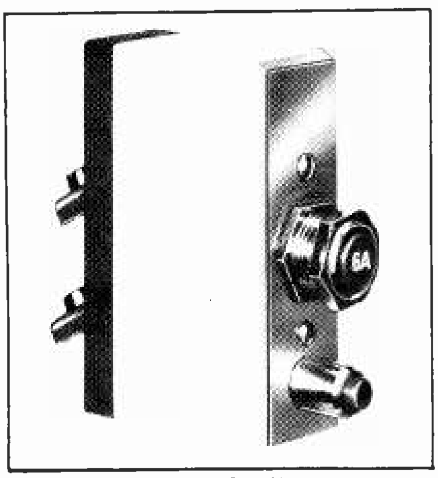


WW 313 for further details

dance is 400kΩ bipolar and 1MΩ unipolar. Maximum linearity error is 0.02% and temperature coefficient accuracy is 35 p.p.m./°C over the operating temperature range of 0°C to +70°C. Hybrid (Component) Systems U.K. Ltd, 12a Park Street, Camberley, Surrey.

WW 315 for further details

Capacitor range

Plessey Capacitors has announced an extension to the 1.60 series Minibox capacitor range with the introduction of a new range of low cost miniature metallized-polyester capacitors with radial leads of 5mm spacing. Intended as a direct replacement for monolithic ceramics, the range is designed for such applications as decoupling up to 1MHz, timing and general use at a.f. Capacitance values offered are 1000pF to 0.15μF for 63V and 100V d.c. Tolerances are 20% and 10%; at 4700pF and above, 5% tolerance is also available. These capacitors have better electrical properties than high K ceramics because the capacitance is not voltage dependent and their dissipation factor and insulation resistance are usually better. Plessey Capacitors, Bathgate, West Lothian, Scotland EH48 2RL.

WW 316 for further details

R.f. chokes

Moulded chokes to the MIL-C-15305 specification are available from Aladdin. Inductance values are between 0.1μH and 10mH, the four body sizes lying between 2.4 × 6.4mm and 6.1 × 18.8mm. The cases, which are in a plastic which does not support combustion, are colour-coded and the units are intended for military and industrial use. Aladdin Components, Aladdin Building, Western Avenue, Greenford, Middlesex.

WW 317 for further details

Microwave attenuator

An 11-bit digital-to-analogue converter is used to control a p-i-n diode in the 61060 precision digital attenuator made by Anaren Microwave Inc. The converter is compatible with t.t.l. outputs and its analogue output is linearized and corrected for temperature variations before being applied to the diode attenuator. Insertion loss is, at most, 5dB and the range of controlled attenuation is 0 to 64dB at a maximum non-linearity of 0.5dB. Attenuation errors do not exceed 0.3dB from 8.5 to 9.6GHz, at all settings, and phase shift is less than 10°. The unit will accept 100mW at the input, with permissible overload to 1W, at a characteristic impedance of 50 ohms. Walmore Electronics Ltd, 11-15 Betterton Street, London WC2H 9BS.

WW 318 for further details

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Miniature 1A rectifier bridges

The Varo range of miniature 1A rectifier bridges comprises seven devices with peak repetitive reverse voltage ratings from 50 to 1000V d.c. Peak surge current for all types is 25A, and the operating temperature range is −50 to +150°C. The devices are housed in 4-pin d.i.l. packages which measure approximately 8 x 9½ x 3½mm. Prices vary from 28 to 40p in one-off quantities. **Marshall**

Optically coupled isolators

A series including types 4N22, 4N23 and 4N24 designed to meet optical coupling requirements in high reliability applications is available from Norbain Electronics Ltd. They are similar to Optron's OPI 102 and OPI 103 standard isolators, available in a hermetically sealed TO-5 package, and are suitable as solutions to such problems as common mode noise rejection, ground loops and voltage level translation. Guaranteed minimum current transfer ratios are 25% for the 4N22, 60% for the 4N23 and 100% for the 4N24. All devices in the new isolator series are rated at 1kV isolation. **Norbain**

High voltage rectifiers

Semtech have released versions of their FF series of fast recovery silicon rectifiers available at 300V, 400V and 500V. The 3FF30, 40 and 50 series have a 30ns reverse recovery time from 0.5A forward current to 1.0A reverse current. The devices are suitable for high frequency applications. **Bourns**

Voltage regulators

Lambda Electronics have introduced 22 new d.c. voltage regulators for positive and negative applications. The fixed-voltages range from +5 to +28V in the LAS1500 range and −2 to −28V in the LAS1800 range. All of the devices are housed in TO-3 packages and are rated at 1.5A. Current limiting protection is provided in the regulators which are designed for operation in a temperature range from −55 to +150°C. Typical characteristics for these devices are; line regulation 0.4%, load regulation 0.3%, and temperature coefficient 0.015%/°C. **Lambda**

S.c.r. module

A recent addition to the Pace Pak series of encapsulated thyristor elements is the PR102W. This module contains two thyristors and three flywheel diodes arranged as a single phase half-controlled bridge for use on 240V a.c. supplies. The device is suitable for applications such as motor speed control or variable power-supplies and can deliver a direct current up to 24A. Compared with conventional discrete components, the Pace Pak offers a cheaper and quicker solution to many power-control problems. Connection to the module is by six screw-terminals. **I.R.**

Presettable counters

Two new presettable up/down counters have been added to the comprehensive CD4000 series of c.m.o.s. digital integrated circuits produced by RCA Solid State-Europe. The CD4510BE is a presettable b.c.d. up/down counter and the CD4516BE is a presettable binary up/down counter; each device consists of four synchronously clocked gated D-type flip-flops connected as counters. Applications include up/down difference counting, multistage synchronous counting, multistage ripple counting and synchronous frequency division. The devices are designed for medium speed operation (typically 7MHz) and incorporate facilities for resetting and presetting. The counters can be cascaded in ripple mode by connecting the carry-out to the clock of the next stage and both devices are supplied in 16-lead d.i.l. plastic packages. **RCA**

Suppliers

Norbain Electronics Ltd, Norbain House, 44 London Street, Reading RG1 4SQ.

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx. TW3 1TE.

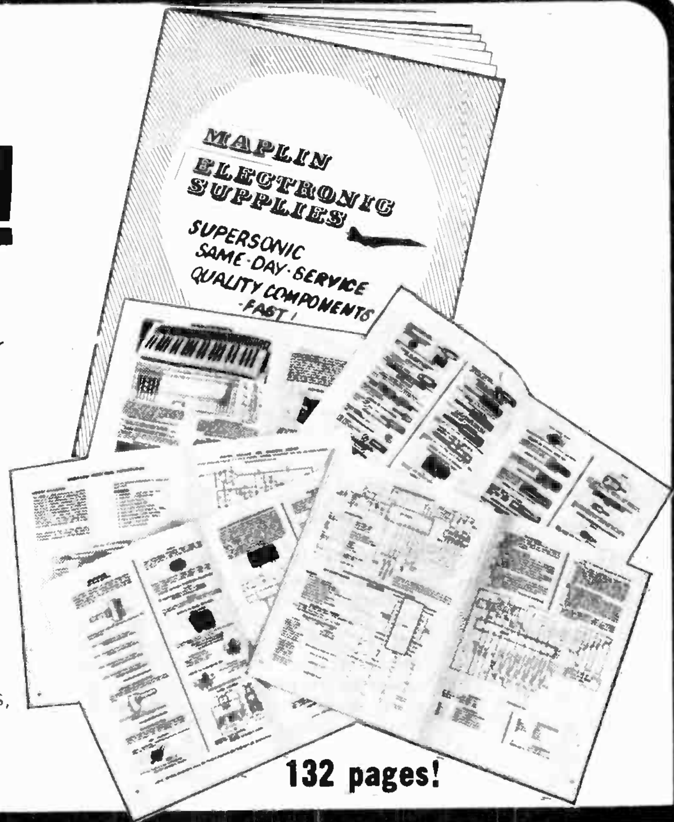
RCA Solid State-Europe, Sunbury-on-Thames, Middx.

A. Marshall (London) Ltd, 42 Cricklewood Broadway, London NW2 3ET.

International Rectifier Ltd, Hurst Green, Oxted, Surrey.

Lambda Electronics, Abbey Barn Road, High Wycombe, Bucks, HP11 1RW.

More than just a catalogue!



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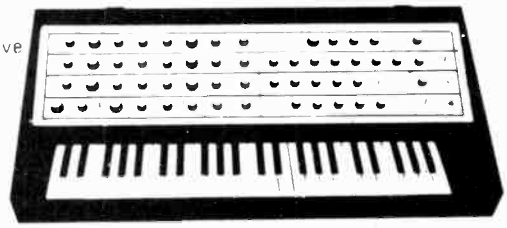
The 3600 SYNTHESISER

The 3600 synthesiser includes the most popular features of the 4600 model, but is simpler. Faster to operate, it has a switch patching system rather than the matrix patchboard of the larger unit and is particularly suitable for live performance and portable use.



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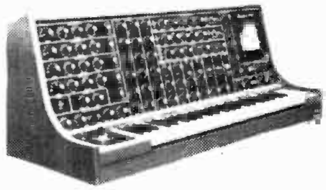
The 4600 SYNTHESISER



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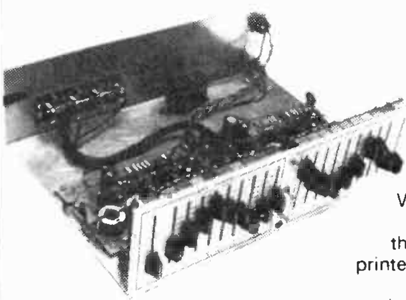

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Solid-state switching and new footages along with a pedal board and a further extension of the organ's range are shown in leaflet MES53, price 35p. (Pre-publication price 15p).

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Now our prices are GUARANTEED (changes in VAT excluded) for two month periods. We'll tell you about price changes in advance for just 30p a year (refunded on purchases). If you already have our catalogue send us an s.a.e. and we'll send you our latest list of GUARANTEED prices. Send us 30p and we'll put you on our mailing list — you'll receive immediately our latest price list then every two months from the starting date shown on that list you'll receive details of our prices for the next GUARANTEED period **before** the prices are implemented! — plus details of any new lines, special offers, interesting projects — and coupons to spend on components to repay your 30p.

NOTE: The price list is based on the Order Codes shown in our catalogue so an investment in our super catalogue is an essential first step.

Call in at our shop, 284 London Road, Westcliff on Sea, Essex.
Please address all mail to

MAPLIN ELECTRONIC SUPPLIES
P.O. Box 3 Rayleigh Essex SS6 8LR

WW

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For ____ copy/copies of your Catalogue
Name ____________
Address ____________
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MAPLIN ELECTRONIC SUPPLIES P.O. Box 3 Rayleigh Essex SS6 8LR

SERVICE TRADING CO

RELAYS

SIEMENS PLESSEY, etc.
MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4-8	2c/o	75p*	700	16-24	4 M2B	65p*
58	5-9	6 c/o	85p	700	16-24	4 c/o	85p*
185	8-12	6 M	65p*	1250	18-36	2 c/o	65p*
230	9-18	2 c/oHD	75p*	2500	36-45	6 M	65p*
430	15-24	4 c/o	85p*	2500	31-43	2 c/oHD	65p*
600	10-20	6M	85p	15k	85-110	6 M	65p
700	12-24	2 c/o	65*				

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

OPEN TYPE RELAYS

6 VOLT D.C. 1 make con **45p**. Post 15p

9 VOLT D.C. RELAY
3 c/o 5 amp contacts 70 ohm coil **85p**. Post 15p

12 VOLT D.C. RELAY
3 c/o 5 amp contacts 120 ohm coil **85p**. Post 15p

24 VOLT D.C.
2 HD c/o 700 ohm coil **85p**. Post 15p
4 c/o 300 ohm coil **95p**. Post 15p
100 VOLT a.c. 2 c/o **75p**. 3 c/o **85p**. Post 15p

ENCLOSED TYPE RELAYS

6 VOLT DC 3 c/o **85p**. Post 15p

24V DC 3 c/o **85p**. Post 20p Base 15p

24 VOLT A.C. M.f.g. ITT 3 h.d. c/o contacts **65p**.
Post 20p Base 15p extra

55 VOLT A.C.
3 heavy duty c/o contacts Price **65p**. Post 20p Base 15p

230 VOLT A.C. RELAY
240V A.C. heavy duty 3 c/o contacts.
Price **85p**. Post 20p Octal base 15p extra

220/240 VOLT AC RELAY
3 c/o 5 amp cont Sealed M.f.g. ISKRA **£1.35**. Post 20p
Base 15p extra

ARROW 230/240V AC 2 c/o 15 amp contacts
Amp connectors **£1.10**. Post 20p

110 VOLT A.C. 2 c/o 20 amp **£1.35**. Post 15p

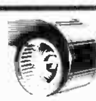
CLARE-ELLIOT Type RP 7641 G8
Miniature relay 675 ohm coil 24 volt D.C. 2 c/o **80p** P.P.

MANY OTHERS FROM STOCK, PHONE FOR DETAILS

LATCHING RELAY

Twin latching relay 'flip-flop' 2c/o each relay. Mains contacts 115 volts A.C. or 50 volt D.C. operation or 240 volts A.C. with 2.5K resistor **85p**. Post 20p

PRECISION CENTRIGUGAL BLOWERS



Mfg. by Smiths Industries Miniature model Series SF/200 Size 95mm x 82mm x 82mm Aperture 38mm x 31mm. 12 c.f.m. **£2.75**. Post 50p

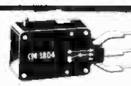
Mfg. by Airflow Developments Ltd.
Precision made, continuously rated, smooth running 230/240v A.C. motor 80c.f.m. As illustrated but with round aperture. **£6.50**. Post 75p

Mfg. by Woods
Extremely powerful 220/250v A.C. 0.3 amp 2,700 r.p.m. continuously rated Capacitor start Cast construction Aperture 66mm x 50mm. O/A 200mm **£12.00**. Post £1.00

230 VOLT FAN ASSEMBLY

Continuously rated, removable aluminium blades. Price **£1.25**. Post 50p
VAT 25%

C/O MICRO SWITCH



VERY SPECIAL OFFER Mfg. by C.E.M. 3 amp 250 volt 10 amp 125 volt 50 for **£3**. Post 36. 100 for **£5**. Post 50p 1,000 for **£45**. Post paid
DOUBLE POLE C/O or 2 make/2 break micro switch 10 amp 250 v.A.C. With detachable roller assembly 10 for **£2.50**. Post 50p (Min. order 10)

COIN MECHANISM (Ex-London Transport)

Unit containing selector mechanism for 1p, 2p & 5p coins. Micro switches relays solenoid-operated hopper 24 volt D.C. Precision built to high standard Incredible VALUE at only **£2.50**. Post £1 **VAT 25%** (Total price inc VAT & Post **£4.21**)

230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½ lb pull. Size of feet 1⅜" x 1 3/16" Price **£1.00**. Post 25p

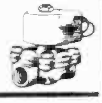
SOLENOID HEAVY DUTY MODEL

230/250v A.C. Apprx. 10lb. pull, 4" long x 2⅜" wide x 3" high. **£2.50**. Post 50p

24 VOLT DC SOLENOIDS

UNIT containing 1 heavy duty solenoid approx 25 lb pull at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ⅛ in. travel. 6 solenoids of approx. 4 oz. pull at ⅛ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay Price **£2.50**. Post £1.00
ABSOLUTE BARGAIN.

240 V.A.C. SOLENOID OPERATED FLUID VALVE



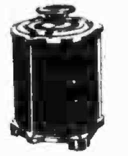
Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body stainless steel core and spring ⅛ in. b.s.p. inlet/outlet Precison made British mfg. PRICE **£2.25**. Post 50p NEW original packing

600 WATT DIMMER SWITCH

Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lighting except fluorescent at mains voltage. Complete with simple instructions **£2.75**. Post 25p

1000 watt model	£4.00. Post 25p
2000 watt model	£8.00. Post 40p

VARIABLE VOLTAGE TRANSFORMERS



Carriage extra
INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260v. A.C.
BRAND NEW. All types.

200W (1 Amp)	£10.00
0.5 KVA (Max. 2½ Amp)	£11.50
1 KVA (Max. 5 Amp)	£16.50
2 KVA (Max. 10 Amp)	£30.00
3 KVA (Max. 15 Amp)	£33.00
4 KVA (Max. 20 Amp)	£60.00
(max. 37.5 Amp)	£102.50

LT TRANSFORMERS

0, 6, 12 volt @ 10 amp	£5.60 Post 70p
0, 10, 17, 18 volt @ 10 amp	£7.90 Post £1.00
0, 6, 12 volt @ 20 amp	£9.00 Post £1.00
0, 12, 24 volt @ 10 amp	£9.20 Post £1.00
0, 4, 6, 24, 32 volt @ 12 amp	£9.90 Post £1.00
0, 6, 12, 17, 18, 20 volt @ 20 amp	£10.40 Post £1.00

Other types to order at short notice. Phone your enquiries.

AUTO TRANSFORMERS

Step up step down 0, 115, 200, 220, 240 volts
At 75 watt **£3.00** Post 40p. 150 watt **£4.30** Post 50p. 300 watt **£6.20**. Post 60p. 500 watt **£9.20** Post 75p. 1000 watt **£13.50** Post 90p.

RING TRANSFORMERS

Functional Versatile Educational

These multi-purpose Auto Transformers, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT 100 V.A. Model the output could be wound to give 8V @ 12½ Amp., 4V @ 25 Amp. or 2V @ 50 Amp., etc. Price

RT 100VA 3.18 turns per volt **£5.00**. Post 75p
RT 2KVA 1.5 turns per volt **£21.00**. Post £1.50
RT 3KVA 1.5 turns per volt **£28.00**. Post £1.50

STROBE! STROBE! STROBE!

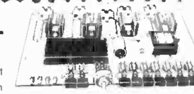
★ **HY-LIGHT STROBE Mk. IV**
Latest type Xenon white light tube. Solid state timing and triggering circuit 230/240 volt A.C. operation. Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc. Light output greater than many (so called 4 Joule) strobes. Price **£15.40**. Post 75p

★ **XENON FLASH GUN TUBES**
Range of Xenon tubes available from stock. S.A.E. for full details.

★ **ULTRA VIOLET BIG BLACK LIGHT**
400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£21.00**. Post £1.50 Spare bulb **£8.00**. Post 65p

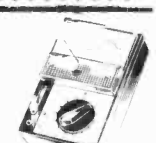
★ **ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES**
4ft. 40 watt £5.50 (callers only) **2ft. 20 watt £4.25**. Post 60p. (For use in stan bi-pin fittings) MINI **12in. 8 watt £1.60**. Post 25p **9in. 6 watt £1.30**. Post 25p Complete ballast unit and holders for either 9" or 12" tube **£1.70**. Post 30p (9" x 12" measures approx.)

SQUAD LIGHT



A new conception in light control. Four channels each capable of handling 750 watts of spotlights, floodlights or dozens of small mains lamps. Seven programs all speed controlled plus flash modulation, effectively giving 14 different displays. Makes sound-to-light obsolete. Completely electrically and mechanically noise free. Price only **£58.00**
Post 75p S.A.E. (Foolscap) for further details

WHY PAY MORE?!



MULTI RANGE METER A.C. volts 2.5-500. D.C. volts 2.5-500 (Sensitivity 2000Ω/V OC & AC) DC current 0/1/10/100 mA. Ohms range Sturdy compact moving coil instrument with 21 ranges, dimensions 120x 80x 44mm Weight 0.32 kg SERVICE TRADING CO Price **£5.00**. Incl. leads and battery Post 50p. (Total price inc VAT & Post **£5.94**)

METERS NEW

90mm Diameter.
Type 65C5 2A D.C. M/C. 5A D.C. M/C. 10A D.C. M/C. 20A D.C. M/C.
Type 62T2 1A A.C. M/I. 20A A.C. M/I. 300V A.C. M/I. ALL ABOVE **£2.50**. Post 30p
Type 65L5 300V A.C. R/M/C. **£2.75**. Post 30p

VAT
VAT AT 8% MUST BE ADDED TO ALL ORDERS
FOR THE TOTAL VALUE OF GOODS INCLUDING POSTAGE UNLESS OTHERWISE STATED

GEARED MOTORS

36 R.P.M. REVERSIBLE

230/240 volts AC 60 lb. ins. Torque Continuously rated. Size Length 235mm Width 120mm Height 125mm Spindle Dia. 13mm. Length 60mm. Fitted mounting feet M.f.g. CROYDON Brand New **£15.00**. Post £1.00

100 R.P.M.

115 lb. ins. 110 volt. 50Hz. 2.8 amp., single phase, split capacitor motor. Emense power. Continuously rated. Totally enclosed. Fan cooled. In-line gear box. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm. **£14.00**. Post £1.50. Suitable transformer 230/240 volt operation ex-equipment tested **£8.00**. Post 75p

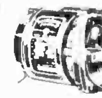
15 R.P.M.

Type SD48 15 r.p.m. 80 lb. ins. Input 100/120 volt A.C. Length incl. gearbox 270mm. Height 135mm. Width 150mm. Shaft drive 16mm. Weight 8.5 Kilos. BRAND NEW Price **£10.00**. carr. £1.00
Suitable transformer for use on 220/240 volt A.C. **£3.85**. Post 50p

60 R.P.M. REVERSIBLE

220/240 volt A.C. Small, powerful, continuously rated motor. Mfg. BERGER (Germany) Size 80mm x 65mm x 65mm. Spindle dia. 6mm. Length 5mm. Weight 725 grams **£6.50**. Post 50p

BODINE TYPE N.C.I. GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle .38 amp
(Type 2) 28 r.p.m. torque 20 lb. in. **Reversible** 1/80th h.p. 50 cycle .28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v **A.C.** Supplied complete with transformer for **230/240v A.C. input**.
Price, either type **£6.25**. Post 75p or less transformer **£3.75**. Post 65p.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc. etc.

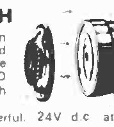
20 r.p.m. GEARED MOTOR

230/240 volt 20 r.p.m. motor **£1.00**. Post 20p

REVERSIBLE MOTOR 230V A.C.

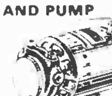
General Electric 230v A.C. 1,600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested **£3.00**. Post 50p.

BENDIX MAGNETIC CLUTCH



A superb example of Electro-mechanics! The main body is in two sections. The coil section is fixed and has a ⅜in. sleeve. The drive section rotating on the outer perimeters. The uniting plate has ⅜in. ID bearing concentric with main section and 18-tooth cog wheel.
When energized transmission is extremely powerful. 24V d.c. at 240MA. OUR PRICE JUST **£3.50**. Post 45p

ROTARY VACUUM AIR COMPRESSOR AND PUMP



Carbon vane, oil-less 100/115v A.C. 1/12 h.p. motor. 50/60 cycle 2875/3450 r.p.m. 20" vacuum 1.25 c.f.m. 10 p.s.i. (approx. figures) New unused surplus stock, with elect. connection data. Fraction of maker's price. **£12.00**. Post £1.00. Suitable transformer **£3.50**. Post 50p

TIME SWITCH

'Horstmann' Type V Mk II Time Switch. 200/250 volt A.C. Two on/two off every 24 hours, at any manually pre-set time. 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case, with glass observation window. Built to highest Electricity Board spec. individually tested. Price **£7.75**. Post 50p (Total inc. VAT £8.91.)

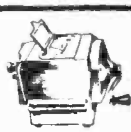
A.C. MAINS TIMER UNIT

Based on an electric clock with 25 amp single-pole switch, which can be preset for any period up to 12 hrs ahead to switch on for any length of time from 10 mins to 6 hrs, then switch off. An additional 60 min audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm x 130 mm x 60 mm. Price **£2.25**. Post 40p (Total inc VAT & Post **£2.87**.)

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10, 25, 100, 150, 250, 500, 1k, 1.5k ohm **£1.70**. Post 20p **50 WATT** 1, 5, 10, 25, 50, 100, 500, 1k ohm **£2.10**. Post 25p **100 WATT** 1/10/25/50/100/250/500/1k/1.5k/2.5k/5k ohm. **£3.30**. Post 35p
Black Silver Skirted knob calibrated in Nos. 1-9, 1½ in. dia brass bush. Ideal for above Rheostats, 22p ea.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., Ht. 6 in., weight 6 lb.
500 VOLTS 500 megohms **£30.00**. Post 80p.
1000 VOLTS 1000 megohms **£36.00**. Post 80p.

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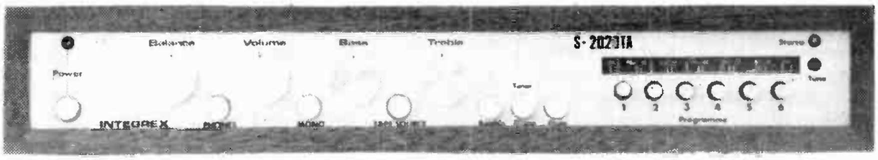
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



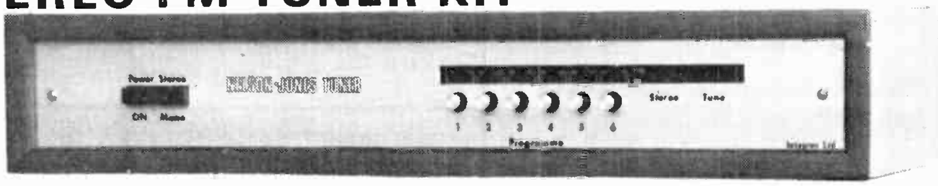
A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc), THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.8μV THD typ. 0.4%

PRICE: £48.95+VAT

NELSON-JONES STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection—85dB. THD typically 0.4%
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price

Mono £26.31+VAT
With ICPL Decoder £30.58+VAT
With Portus-Haywood Decoder £32.81+VAT

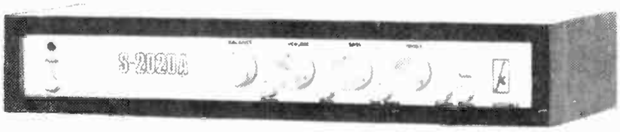
STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC

Sens. 30dB S/N mono @ 1.8μV
THD typically 0.4%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Mono £25.55+VAT
Stereo £28.65+VAT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Typ. Spec. 20+20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £30.94+VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT . **£13.13**+VAT
BASIC MODULE TUNER KIT (Mono) . **£13.25**+VAT
BASIC MODULE TUNER KIT (stereo) . **£15.25**+VAT
PHASE-LOCKED IC DECODER KIT . . . **£4.47**+VAT
PUSH-BUTTON UNIT . . . . **£3.50**+VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT . . . . **£7.93**+VAT

WW — 079 FOR FURTHER DETAILS

KINNIE COMPONENTS

10, NELMES WAY, HORNCHURCH
ESSEX RM11 2QZ
HORNCHURCH 45167

CIRCUIT BOARD
P.C.B. 1/16. 1 oz. COPPER

FORMICA
Dim. 8.4 x 7.7 in 3 pcs., **75p**
Dim. 9.4 x 8.1 in 3 pcs., **90p**
Dim. 10.1 x 7.9 in 3 pcs., **£1.00**
Dim. 13.1 x 9.4 in 3 pcs., **£1.20**
Dim. 17.0 x 9.0 in 2 pcs., **£1.20**
Post & Packing 30p each pack.

BARGAIN PACK
10 pcs. 10.1 x 7.9 in. Plus free ½lb etching Xtals **£3.00** P.P. 55p.

FIBRE GLASS P.C.B.
Dim. 6 x 6 in. **35p** each
Dim. 12 x 6 in. **60p** each
Dim. 12 x 12 in. **£1.00** each
Equals less than **1p** sq. in.
Post & Packing 10p per sheet.

RESIST COATED P.C.B. FORMICA
10.1 x 7.9 in. **55p** ea.
13.1 x 9.4 in **70p** ea.

RESIST COATED P.C.B. FIBRE GLASS
6 x 6 in. **50p** ea.
12 x 6 in. **90p** ea.
12 x 12 in. **£1.50** ea.
Post & Packing 10p per sheet.

BLUE P.C.B. INK
Etch resist use with any pen. Much cheaper than ready loaded pens.
50c.c. **55p.** P.P. 10p.

FERRIC CHLORIDE ETCHING XTALS
1 lb - 1 litre pack, **60p** P.P. 25p.
5 lb - 5 litre pack, **£1.95** P.P. 55p.

QUADROPHONIC DECODER MODULE
C.B.S./S.Q. Type using I.C. MC 1312P. With slight modification direct substitute for P.E. "RONDO" Board. Complete with Data. **£4.60** each. P.P. 25p.

PRINTED CIRCUIT KIT
The no frills all value kit. Containing 4 pcs 8 x 7 Formica laminate. 1 pce 6 x 6 Fibre glass laminate. 1 lb Etching Crystals. 50 c.c. Resist ink, with instructions.
£2.30 P.P. 50p.

TELEPHONE DIALS
(New) **£1** P.P. 25p.

EXTENSION TELEPHONES
(Type 706). Various colours. **£3.95** P.P. 75p.

12V MINIATURE UNISELECTOR
11 ways. 4 bank (3 non bridging, 1 homing). **£2.50** P.P. 35p.

UNISELECTORS
(New) 25 way. 12 Bank (Non bridging). 68 ohms. **£6.50** P.P. 50p.

MINIATURE UNISELECTOR
(Ex. Equip.) 6 Bank (5 non bridging. 1 bridging) 100 ohms 24-30 V.D.C. **£1.50** P.P. 50p.

1,000 TYPE KEY SWITCHES
Single 2 x 2 c/o Locking. **50p.** P.P. 10p
Bank of 4-2 x 4 c/o each switch (one biased), **£1.20** P.P. 25p.

MULTICORE CABLE
6-core (6 colours) 14/0076 Screened P.V.C. **30p** per yard; 100 yards at **£16.50** P.P. 2p a yard, 7-core (7 colours) 7/22 mm. Screened P.V.C. **30p** per yard; 100 yards **£16.50** P.P. 2p per yard.

RIBBON CABLE
(8 colours); 10m. **£1.65.** P.P. 20p. 100m. 8-core x 14/0.19mm. Bonded side by side **£11.50** P.P. £1.

P.T.F.E. CONNECTING WIRE
1/20 Black or White 100 m. Drum **£2.50** P.P. 30p.

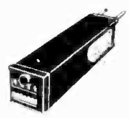
H.D. ALARM BELLS
6in. Dome. 6/8v, d.c. Heavy cast housing for exterior/interior use. **£3.75** P.P. £1.
Connecting wire (twin/twisted) 220yd. reel **£3** P.P. 75p.

HIGH CAPACITY ELECTROLYTICS
250mfd/63 volt, **20p** P.P. 8p.
1,000mfd/100 volt, **70p** P.P. 25p.
2,200mfd/100 volt, **90p.** P.P. 25p.
4,700mfd/25 volt, **65p.** P.P. 20p.
6,800mfd/16 volt, **50p.** P.P. 15p.
10,000mfd/25 volt, **75p.** P.P. 25p.
25,000mfd/40 volt, **£1.25.** P.P. 30p.
47,000mfd/40 volt, **£2.00.** P.P. 50p.
100,000mfd/10 volt, **£1.50.** P.P. 50p.
160,000mfd/10 volt, **£2.00.** P.P. 50p.

OVERLOAD CUT-OUTS
Panel mounting 800 M/A. 1.8 amp. 10 amp. **55p** ea.

SMITHS GEARED MOTORS
250V A/C 4 rpm, **£1.50** P.P. 25p.

HIGH-SPEED MAGNETIC COUNTERS

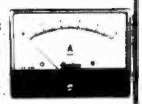


4 digit (non reset) 24v or 48v (state which)
4 x 1 x 1 in. **£1.** P.P. 20p.
5 digit (non reset) 24v **1.50.** P.P. 20p.
3 digit 12v (Rotary Reset) 2¼ x 1¾ x 1¼ **£1.40.** P.P. 15p.
6 digit (Reset) 220v. a.c. **£3.50.** P.P. 25p.

S-DECS AND T-DECS
S-DEC **£1.90** T-DEC **£3.60**
U-DEC A **£4.20** U-DEC B **£6.90**
Post & Packing 25p.

MINIATURE METERS
500 micro-amp (level stereo beacon, etc) scaled half back/half red. Size 1 x 1 in. **65p.** P.P. 15p.

PANEL METERS
2⅜ in. x 1⅞



T1	50µA	T8	500mA
T2	100µA	T9	1Amp
T3	500µA	T10	50v.a.c.
T4	1mA	T11	300v.a.c.
T5	10mA	T12	50/0/50µA
T6	50mA	T13	100/0/100µA
T7	100mA	T14	500/0/500µA

All at **£3.75.** P.P. 15p.

PANEL METERS
4½ ins. x 3¼

D1	50µA	D3	200µA
D2	100µA	D4	500µA

All at **£4.60.** P.P. 15p.

S.T.C. CRYSTAL FILTERS
(10.7Mhz) 445-LQU-901A (50 Khz spacing), **£3.** P.P. 20p.
445-LQU-901B (25Khz spacing). **£4.** P.P. 20p. 10.7Mhz Canned I.Fs. Size 1 x ½ x ½ in. (with data) **65p.** P.P. 10p.

3 GANG TUNING CAPACITOR
8.5 PF, to 320 P.F. **80p.** P.P. 20p.

V.H.F./U.H.F. POWER TRANSISTORS
(type BLY 38). 3 watt output at 100-500 Mhz. **£2.25.** P.P. 10p.

SIEMENS MINIATURE RELAYS
6v.4 c/o **65p.** 24v.2 c/o **50p.**

MINIATURE RELAYS
(1⅜ x 1¼ x ½) 24 v.4 c/o **35p.** P.P. 5p.

MAINS RELAY 240v.a.c.
3 c/o 10 amp. contacts **80p.** with base P.P. 20p

24v a.c. RELAY (PLUG IN)
3 pole c/o **75p.** P.P. 15p.
2-pole c/o **55p.** P.P. 15p.

S.C.R.
5 amp. 400 P.I.V. (T.I.C.106c) **30p.** P.P. 8p.

MINIATURE "ELAPSED TIME" INDICATORS
(0.5000 hours) 45 x 8mm **75p.** P.P. 15p.

BULK COMPONENTS OFFER
Resistors/capacitors 600 new components **£2.75.** P.P. 36p.
Trial order 100 pcs **75p.** P.P. 20p.

D.C. SUPPLY
Input 240v. a.c. giving 17½v d.c. at 1½ amp (unsmoothed) 2¾ x 2½ x 2¼ in. **£2.25.** P.P. 45p.

ADVANCE TRANSFORMERS "VOLSTAT"
Input 240v. a.c. C.V.50. 38v. at 1 amp; 25v. at 100/m/a; 75v. at 200 m/a **£3.** P.P. 65p.
C.V. 75.25v. at 2½ amp. **£3.25.** P.P. 75p.
C.V. 100.50v. at 2 amp; 50v. at 100 m/a **£4.** P.P. 75p.
C.V. 250.25v. at 8 amp; 75v. at ½ amp **£6.50.** P.P. £1.50.
C.V. 500.45v. at 3 amp; 35v at 2 amp **£12.** P.P. £1.75.

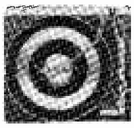
TRANSFORMERS

H.T. TRANSFORMERS. Prim. 110/240v. Sec. 400v. 100 m/a **£3.** P.P. 65p.
L.T. TRANSFORMER. Prim. 240v. Sec. 27-0-27 at 800 m/a 7.5 amp. **£2.25.** P.P. 50p.
L.T. TRANSFORMER. Prim. 110/240v. Sec. 50v. at 10 amp. **£10.** P.P. £1.50.
L.T. TRANSFORMER. Prim. 240v. Sec. 18v at 1.5 amp. & 12v. at 1 amp. **£2.25.** P.P. 50p.
L.T. TRANSFORMER. Prim. 240v. Sec. 18v. 1 amp. **£1.** P.P. 30p.
L.T. TRANSFORMER. Prim. 240v. Sec. 12v at 1 amp. **80p.** P.P. 25p.
L.T. TRANSFORMER. Prim. 110/240v. Sec. 23/24/25v. at 10 amps **£7.** P.P. £1.
L.T. TRANSFORMER. Prim. 110/240v. Sec. 20/21/22v. at 8 amp. **£6.** P.P. £1.
L.T. TRANSFORMER. Prim. 110/240v. Sec. 0/24/40v. at 1½. amp. (Shrouded). **£1.95.** P.P. 50p.
L.T. TRANSFORMER. Prim. 200/250v. Sec. 20/40/60v. at 2 amp. (Shrouded). **£3.** P.P. 70p.
L.T. TRANSFORMER. (H.D.) Prim. 200/250v. Sec. 18v. at 27 amp; 40v at 9.8 amp; 40v. at 3.6 amp; 52v. at 1 amp; 25v. at 3.7 amp. **£17.50.** P.P. £2.50.
L.T. TRANSFORMER. Prim. 240v. Sec. 20v. at 2.5 amp. **£2.** P.P. 50p.
L.T. TRANSFORMER ("C" CORE) 200/240v. Secs. 1-3-8-9c. All at 1.5 amp. 50v. at 1 amp. **£2.50.** P.P. 50p.
L.T. TRANSFORMER ("C" CORE) 200/240v. Secs. 1-3-9-27v. All at 4 amp. **£4.** P.P. 50p.
L.T. TRANSFORMER ("C" CORE) 200/240v. Secs. 1-3-9-27v. All at 10 amp. **£7.50.** P.P. £1.50.
L.T. TRANSFORMER ("C" CORE) 200/240v. Secs. 1-3-9-20v. All at 4 amp. **£5.50.** P.P. 75p.
L.T. TRANSFORMER ("C" CORE) 120/120v. Secs. 1-3-9-9v. All at 10 amp. **£6.50.** P.P. £1.50.
L.T. TRANSFORMERS ("C" CORE) 110/240v. Secs. 1-3-9v. 10 amp. 35v. 1 amp; 50v. 750 M/A. **£6.50.** P.P. £1.50.

MAIL ORDER ONLY. PERSONAL CALLERS BY APPOINTMENT

RETURN OF POST MAIL ORDER SERVICE

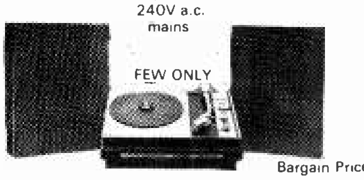
BSR HI-FI AUTOCHANGER
STEREO AND MONO



Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C. 200/250V. Size 13½-11¼in., 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE **£10.95** Post 75p

PORTABLE PLAYER CABINET
Modern design. Rexine covered. Vynair front grille. Chrome fittings. Size 17 x 15 x 8in. approx. **£5.25** Post 75p
Motor board cut for BSR or Garrard deck

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in., 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls 240V a.c. mains



Attractive Teak finish
Bargain Price **£25** £1 carriage

SPECIAL OFFER!
SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0—60 MINUTES £2.50 Post 35p
Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 18¼ x 10½in—**75p.** 10½ x 7⅞in—**45p.**

WEYRAD P50 — TRANSISTOR COILS

RA2W Ferrite Aerial	**85p**	Driver Trans LFDT4	**65p**
I F P50/2CC 470 kc/s	**40p**	Printed Circuit, PCA1	**65p**
3rd I F. P50/3CC	**40p**	J.B Tuning Gang	**£1.20**
Spares Cores	**3p**	OPT1	**65p**
P50/1AC	**60p**		

Ferrite Rod 8 x ⅜in., **20p.** 6 x 5/16in., **20p.** 3 x ⅜in **10p**

VOLUME CONTROLS
5kΩ to 2MΩ. LOG or LIN. L/S **25p.** D.P. **40p.** STEREO L/S **55p.** D P **75p.** Edge 5K. S P. Transistor **30p.**

80 Ohm Coax 8p yd.
BRITISH AERIALITE AERAXIAL-AIR SPACED 40 yd **£3;** 60 yd. **£4.50** FRINGE LOW LOSS Ideal 625 and colour **15p yd.**

ELAC HI-FI SPEAKER 8in. or 10 x 6in.

Dual cone plasticised roll surround. Large ceramic magnet 50-16,000 c/s. Bass resonance 55 c/s. 8 ohm impedance. 10 watts music power **£4.35** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!
With tweeter and crossover 10 watt. State 3 or 8 ohm. As illustrated **£5.25** Post 35p
Bass Woofer, 20 watts, 8 or 15 ohm. **£6.60** Post 45p

With flared tweeter cone and ceramic magnet 10 watt. Bass res 45-60 c/s. Flux 10 000 gauss. 8 ohm 40 to 11,000 c/s **£3.45** Post 35p

Bookshelf Cabinet Teak finish 16 x 10 x 9in. For EMI 13 x 8 speakers. **£6.95** Post 75p

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A C mains 200/250V. Leaflet S A E. Will also demagnetise small tools **£4.35** Post 30p

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16x6—**£1.45;** 16 x 10—**£1.70.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM
This famous unit now available, 10 watts, 8 ohm. **£3.45** Post 35p

RCS LOW VOLTAGE STABILISED POWER PACK KITS
All parts and instructions with Zener diode, printed circuit, rectifiers and double wound mains transformer. Input 200/240V a c. Output voltages available, 6 or 7.5 or 9 or 12V d c at 100mA or less. Size 3 x 2½ x 1½ in. Please state voltage required **£2.95** Post 45p

RCS POWER PACK KIT
12 VOLT 750mA. Complete with printed circuit board and assembly instructions. **£3.35** Post 30p
12 VOLT 300mA KIT, **£3.15.** 9 VOLT 1 AMP KIT, **£3.35.**

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with Battery 9-12V or H T line 200-300V d.c. operation. Size: 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in approx. S.A.E. details. Full instructions supplied.

MAINS TRANSFORMERS
ALL POST 50p

250-0-250V 70mA, 6 5V, 2A	**£2.90**
250-0-250 80mA, 6 3V 3.5A, 6 3V 1A or 5V 2A	**£4.60**
350-0-350 80mA, 6 3V 3 5A, 6.3V 1A or 5V 2A	**£5.80**
300-0-300V 120mA, 6.3V 4A C.T, 6 3V 2A	**£7.00**
MIDGET 220V 45mA, 6 3V 2A	**£1.25**
HEATED TRANS 6 3V ½ amp **£1;** 3 amp	**£1.40**

GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.00.** 3 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6 06V 500mA **£1,** 9V 1 amp **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA **£1,** 10V, 30V, 40V, 2 amp, **£2.75,** 20V, 3 amp, **£2.45,** 40V, 2 amp, **£2.95,** 22-0-22V, 4 amp d c, **£3.45,** 16V, ½ amp, **£1,** 16V, 2 amp, **£2.20,** 0, 5, 8, 10, 16V, ½ amp, **£1.95,** 20V ½ amp, **£1.75,** 20V, 1 amp **£2.20.**
AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**
FULL WAVE BRIDGE CHARGER RECTIFIERS
6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**
CHARGER TRANSFORMERS 1½ amp **£2.75;** 4 amp **£4.60.**

GOODMANS 6½in. HI-FI LOUDSPEAKERS

4 ohm or 8 ohm. 10W. Large ceramic magnet. Special Cambric cone surround. Twin cone. Frequency response, 30-15,000 c/s. HI-FI Enclosure Systems, etc **£4.60**

NEW ELECTROLYTIC CONDENSERS

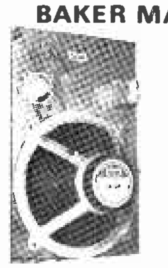
2/350V	20p	250/25V	20p	50+50/300V	50p
4/350V	20p	500/25V	25p	900/350V	95p
8/350V	28p	100+100/275V	65p	32+32/250V	20p
16/350V	35p	150+200/275V	70p	32+32/450V	80p
32/500V	60p	8+8/350V	50p	350+50/325V	85p
25/25V	15p	8+16/350V	50p	100+50+50/350V	85p
50/50V	15p	16+16/350V	60p	32+32+32/350V	65p
100/25V	15p	32+32/350V	60p	4700/63V	95p

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p;** 50V **95p.**

TRIMMERS 10pF 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF **5p.** Silver Mica 2 to 5000pF **5p.**
PAPER 350V-0 1 **7p;** 0 5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0.001 to 0 05 **5p;** 0 1 **10p;** 0 25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, "0-0" 208pF + 176pF **£1.20;** 500pF standard **75p;** 365 + 365 + 25 + 25pF. Slow motion drive **50p.** 120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V AC/DC. Amber or red. **30p.**
RESISTORS. ¼W, ½W, 1W 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt, 10 ohms to 100K **12p** each
TAPE OSCILLATOR COIL Valve type, **35p.**

NEW MODEL **BAKER LOUDSPEAKER,** 12IN. 60 WATT. GROUP 50/12, 8 OR 15 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY. 30-16,000 CPS MASSIVE CERAMIC MAGNET. ALUMINIUM DOME CENTRE **£14.50** Post 80p

BAKER MAJOR 12" £11.50



30-14,500 c/s, 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE. 3 or 8 or 15 ohms must be stated.
Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions **£14.50** Post 60p each
Please state 3 or 8 or 15 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post 50p each

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£8.95** 3 or 8 or 15 ohm	12in 40W **£10.50** 3 or 8 or 15 ohm	15in 75W **£19.50** 8 or 15 ohm

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in **£12.50** Post 95p
For 13x8in or 8in speaker 16x10x7in **£6.95** Post 75p
For 8x5in speaker 16x8x6in **£5.80** Post 50p
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

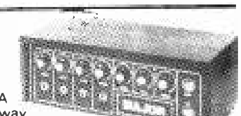
R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco P A, where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output. Produced by demand for a quality **valve** amplifier. Send for leaflet Price **£85** carr £2 50

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
Horn Tweeters 2-16kc/s, 10W 8 ohm or 15 ohm **£3.60**
De Luxe Horn Tweeters 2-18kc/s, 15W, 15 ohm, **£4.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHMS. 7x4in **£1.50;** 6½in., **£1.80;** 8x5in., **£1.90;** 8in **£2.20.**
SPECIAL OFFER: 80 ohm 2¼in 2¾in 35 ohm 2in, 3in, 25 ohm, 2½in dia 3in dia 5in dia 8 ohm 2½in 3in, 3½in, 15 ohm, 3¼in dia, 6x4in, 7x4in, 8x5in, 3 ohm, 2½in, 2⅝in, 3½in., 5in dia **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, ceramic magnet **£1.75.**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;** 12in diameter 6W **£3.50.** 3/8/15 ohms, please state
VALVE OUTPUT TRANS. 40p; MIKE TRANS. 50:1 **40p.**
Mike trans mu metal 100:1 **£1.25.**

Loudspeaker Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting ¼in. spindle **65p**

BAKER 100 WATT ALL PURPOSE AMPLIFIER



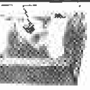
All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 8/15 ohm. a c Mains. Separate treble and bass controls. Guaranteed. Details S A E. **£59** Carr £1 00 each
NEW MODEL MAJOR—50 watt, 4 input, 2 vol. Treble and bass. Ideal disco amplifier **£49.95**
100 WATT DISCO AMPLIFIER Chassis volume, treble, bass controls 500 M V input. Four loudspeaker outputs 4 to 16 ohm **£55**

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output 9V **£5.20**
TWO STEREO CHANNEL VERSION £6.85
BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready Built, with volume, Treble and bass controls 18 volt d c Mains Power Pack **£3.45** **£4.50**

COAXIAL PLUG 10p. PANEL SOCKETS 10p. LINE 18p. OUTLET BOXES, SURFACE 40p. FLUSH 60p. TWIN 85p. BALANCED TWIN RIBBON FEEDER 300 ohms. 7p yd. JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead-Socket 45p. Phono Plugs 8p. Phono Socket 8p. JACK PLUGS Std. Chrome 30p; 3.5mm Chrome 15p. DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p. DIN SOCKETS lead 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CERAMICS 10p; CANS 10p.

R.C.S. SOUND TO LIGHT KIT
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel **£12.50.** Post 35p. Easy to build. Full instructions supplied, cabinet **£3.** As featured in December Practical Wireless

E.M.I. TAPE MOTOR £2



E.M.I. TAPE MOTORS. 240V a c 1 200 r p m 4 pole 185mA Spindle 0 187x0 75in Size 3¼ x 2½ x 2¼in **£2.** Post 40p
120V Model, £1

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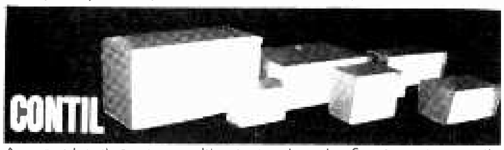
WH WEST HYDE **Instrument cases** WEST HYDE WH

Offer instrument manufacturers low-cost cases ex stock. Blue PVC coated steel strength and rigidity. PVC aluminium grey front and rear panels are removable. PCB and PSU mounting system available. Also available in black, 301 price of 302 Bk 302 303, Bk 304 305



A range of eyebrow cases in blue textured acrylic. Front panels normally white zintec or PVC aluminium also available unpainted up to 1277 size. Aluminium panels 20p extra up to 16127 only

All dimensions are Width x Height x Depth

PRICES 1 off inc P & P but not VAT

MOD 3 (including chassis)		
301	7x3 x5¼	4.75
302	7x4½x5¼	5.10
303	7x6 x5¼	6.50
304	11x3 x5¼	5.85
305	11x4½x5¼	6.90
306	11x6 x5¼	8.25

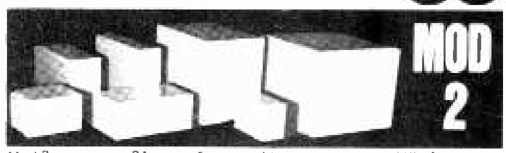
CONTIL TEXTURED		
755	7x5x5"	6.95
867	8x7x6"	8.25
975	9x5x7	8.25
1277	12x7x7"	9.50
1277	unpainted	7.05
16127	16x7x12"	13.10
191010	19x10x10	17.95

ELF CASES Grey (inc chassis)		
Elf	6x4x4"	2.40
Bare Elf	(less lt, ch pnl)	1.95
Giant Elf	8x5½x5"	3.60
Long Elf	9x4x3"	2.90
Jumbo Elf	10½x5¼x5⅛	4.80

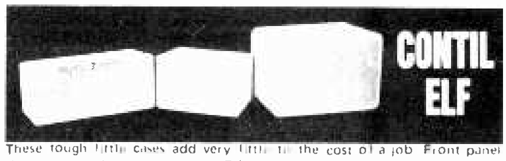
MOD 2 CASES (including chassis)		
A	4.5x 3x 6.5"	5.00
B	4.5x 7x 6.5	5.80
C	4.5x10x 6.5	7.10
D	9 x 3x 6.5	7.10
E	9 x 7x 6.5"	7.85
F	9 x10x 6.5	9.25
G	13 x 3x 6.5	7.85
H	13 x 7x 6.5	9.25
I	13 x10x 6.5	10.45
J	18 x 3x 6.5	9.25
K	18 x 7x 6.5"	12.75
L	18 x10x 6.5"	15.75
M	4.5x 3x13	5.80
N	4.5x 7x13	7.85
O	4.5x10x13	10.45
P	9 x 3x13	7.85
Q	9 x 7x13"	10.45
R	9 x10x13"	12.75
S	13 x 3x13"	10.45
T	13 x 7x13	12.75
U	13 x10x13"	15.75
V	18 x 3x13"	12.75
W	18 x 7x13"	15.75
X	18 x10x13"	18.50

Mod 2 in Woodgrain or Black finish in sizes A L & N

Prices as for one price up on Mod 2, e.g. Mod 2A Woodgrain or Black is £5.80 as Mod 2B



Mod 2 cases over 24 sizes. Front and back panels grey PVC. Aluminium chassis included. Packed flat. Outer casing blue PVC steel or up to size L also available in wood grain and black. (Price as for next price higher ie A Black is B price)



These tough little cases add very little to the cost of a job. Front panel aluminium with protective coat. Elf cases are available in 4 sizes, all dough moulded in grey glass polyester, all panels, feet and chassis included.

All West Hyde cases are available with substantial discounts for quantities. Most cases have discounts at 5 off and 25 off with discounts up to 25% at 100 off. Prices include P & P and are less 10% if collected on first three price breaks on cases only

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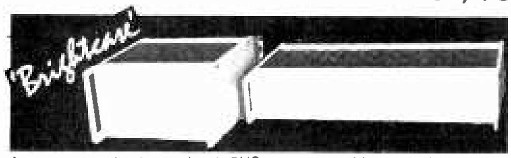
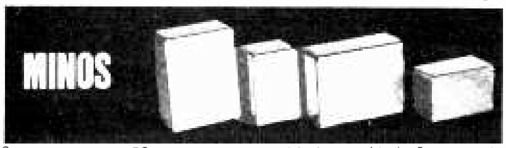


A prestige anodised case, black PVC steel top and bottom which can be supplied louvred at no extra cost. Free standing or rack mounting, available in rack or half width assembled in special polystyrene pack for safe postage



Smart miniature ABS cases in tough rigid high gloss black. Front panels either al or PVC steel. Built-in slots for PC cards, dividers etc. Chassis or PC boards can be supported on 'P' clips from internal pillars

Instrument cases

BRIGHTCASE MARK II	
BC212 (3½" Full Rack)	15.25
BC222 (3½" Half Rack)	14.00
BC312 (5¼" Full Rack)	16.50
BC322 (5¼" Half Rack)	15.25

Rack Brackets available

No extra for Louvres add L

MINOS		
M2	65x100x50mm	0.55
M3	100x130x50mm	0.70
M2	Bare	0.36
M3	Bare	0.41

SAMOS		
S1	100x 50x50mm	1.03
S2	100x100x50mm	1.17
S3	100x150x50mm	1.31
S4	125x 50x75mm	1.47
S5	125x100x75mm	1.68
S6	125x150x75mm	1.97
S7	125x200x75mm	2.19

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12x10x7"	15.00

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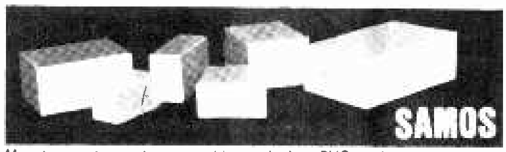
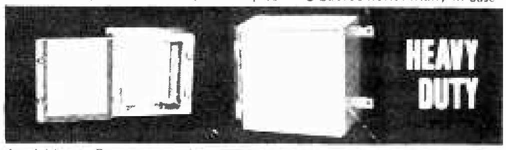


Miniature instrument cases in blue and white PVC steel. Assemble in the lower half, clip in feet, 2 screws allow the cover to hinge off cases. 2 more to fix. PC feet are available to hold up to 4 PC boards horizontally in case



Available in 3 sizes. Heavily constructed in zintec steel, welded corners with heavy hinges, 2 screw fixings and foam around the door. In the base is a gland plate with gasket and a chassis with screws provided

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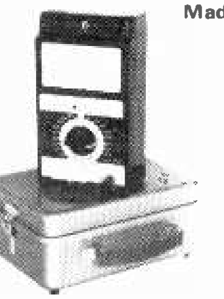

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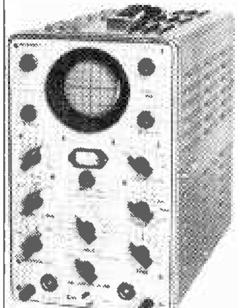

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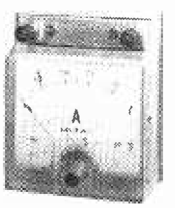

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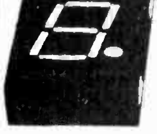

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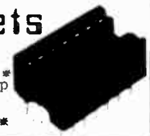

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TELEPRINTER TYPE 7B: Pageprinter 24V d.c. power supply, speed 50 bauds per min. second hand cond. (excellent order) no parts broken. **£20** each. Carriage £3.

AUTO TRANSFORMER: 230V 50c/s, 1000 watts. Mounted in strong steel case 5" x 6½" x 7". Bitumen impregnated. **£12.00.** Carr. £1.50.

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BRIDGE MEGGER: 2,500V., series 1. **£30** each. Carr. £1.

CRYSTAL TEST SET TYPE 193: used for checking crystals in freq. range 3000-10,000KHz. Mains 230V 50Hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction witn a freq. meter. **£25.** Carr. £1.50.

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MUIRHEAD PHASEMETER D-729: A.M. **£85.** Carr. £3.

RACAL RA17 Front Panels: £5. £1 post.

CT.343 VALVE VOLTMETER: in ruggerised steel case. Range 1.2mV to 400V. 6 ranges indicated on 3" meter. 230v a.c. input. **£25.** Carr. £2.

UHF MICROWAVE MILLIWATTMETER TYPE 14: Direct reading, can be used to measure power from 100MHz upwards. F.S.D. on 4in. scale meter 2.5mW. **£40** each. Carr. £1.

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TF-1278/1 TRAVELLING TUBE WAVE AMPLIFIER: £125. Carr. £2.

BPL A.C. MILLIVOLTMETER TYPE VM.348-D Mk. 3: 2 millivolts-2 volts, 6 ranges. **£30.** Carr. £1.

CAWKELL REMSCOPE TYPE 741 : Memory scope, 'as new' cond. **£150.00.**

MANSON SYNTHESISER Q115-URC: 2-30 mc/s. **£175.00.**

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X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. **£125** each. Carr. £1.

BACKWARD WAVE OSCILLATOR TYPE SE-125: 6.3 heater, 105V Anode 7.9mA. Mnfr. Watkins & Johnson. **£85** each. Carr. £1.

TEKTRONIX TIME MARK GENERATOR TYPE 180-SI: 5, 10, 50 MHz. **£65.** Carr. £2.

ROTARY INVERTERS: TYPE PE.218E — input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1Ph. P.F.9. **£20.00** each. Carr. £2.50.

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DF96	0.60	EF85	0.40	OB2	0.45
DK96	0.75	EF86	0.45	PABC80	0.40
DL92	0.50	EF89	0.35	PC86	0.65
DL96	0.70	EF91	0.60	PC88	0.65
DY86/87	0.45	EF92	0.50	PC97	0.55
DY802	0.45	EF95	0.45	PC900	0.55
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EABC80	0.40	EL35	0.70	PCF82	0.40
EAF42	0.70	EL37	2.20	PCF84	0.65
EB91	0.30	EL41	0.80	PCF86	0.65
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EBC41	0.75	EL84	0.35	PCF201	0.90
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EBF83	0.45	EL86	0.50	PCF802	0.55
EBF89	0.40	EL90	0.50	PCF805	1.10
EC52	0.40	EL91	1.00	PCF806	0.90
ECC81	0.45	EL95	0.70	PCF808	1.10
ECC82	0.35	EL504	0.80	PCH200	0.80
ECC83	0.35	EL821	1.80	PCL81	0.60
ECC84	0.35	EM31	0.70	PCL82	0.40
ECC85	0.45	EM80	0.55	PCL83	0.70
ECC86	1.25	EM84	0.40	PCL84	0.50
ECC88	0.55	EM87	1.00	PCL86	0.55
ECC189	0.80	EY51	0.45	PCL805/85	0.60
ECF80	0.45	EY81	0.45		
ECF82	0.45	EY86/87	0.45	PFL200	0.70
ECF801	0.75	EY88	0.50	PL36	0.60
ECF804	2.50	EZ40	0.70	PL81	0.55
ECH42	0.85	EZ41	0.75	PL82	0.50
ECH81	0.40	EZ80	0.30	PL83	0.50
ECH84	0.60	EZ81	0.35	PL84	0.50
ECL80	0.60	GT1C	5.00	PL504	0.85
ECL82	0.40	GY501	0.80	PL508	0.95
ECL83	0.75	GZ32	0.65	PL509	1.35
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PY80	0.60	U26	0.80	UF41	0.70	1A3	0.55	5U4G	0.55	6AQ5W	0.70
PY/81/800	0.50	U27	1.00	UF80	0.40	1L4	0.30	5V4G	0.65	6AS6	0.80
		U191	0.75	UF85	0.50	1R5	0.50	5Y3GT	0.60	6AS7G	1.00
PY82	0.45	U801	0.80	UF89	0.50	1R4	0.35	5Z3	1.20	6AT6	0.60
PY83	0.50	UABC80	0.45	UL41	0.70	1S5	0.35	5Z4G	0.60	6AU6	0.40
PY88	0.50	UAF42	0.70	UL84	0.50	1T4	0.35	524GT	0.65	6AV6	0.50
PY500	1.10	UBC41	0.60	UY41	0.50	1X2B	0.75	6AB7	0.60	6AX4GT	0.75
PY801	0.50	UBF80	0.50	UY85	0.50	2D21	0.50	6AC7	0.60	6AX5GT	1.00
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QQV06-40A	8.00	UBL1	1.00			3A4	0.60	6AK5	0.45	6BA6	0.40
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QV03-12	1.60	UCC85	0.50			3S4	0.50	6AL5	0.30	6BG6G	1.00
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SP61	0.80	UCH81	0.50	Z800U	3.00	58/255M	5.00	6AM6	0.60	6BR7	1.30
TT21	6.00	UCL82	0.45	Z801U	3.00	58/258M	5.50	6AN8	0.70	6BW6	1.10

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AF186, AF239, AF212, ASY26, ASY27, ASY28, BC107, BC108, BC109, BC113, BC116, BC118, BC136, BC137, BC148A, BC172, BC172A, BC212A, BCY31

BCY33, BCY72, BF115, BF167, BF173, BF185, BFY51, BFY52, BSY27, BSY38, BSY95A, BY100, BYZ16, CRS1/20, CRS1/30, CRS3/10, CRS3/20, CRS3/30, CRS3/40

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OC26, OC28, OC29, OC35, OC36, OC42, OC44, OC45, OC70, OC73, OC75, OC78, OC78D, OC81, OC82, OC82DM, OC83, OC83B, OC139, OC140

OC170, OC172, OC200, OC204, OC206, ZR11, ZR21, ZR22, 2N456A, 2N525, 2N696, 2N708, 2N918, 2N1305, 2N1307, 2N1309, 2N2062, 2N2411, 2N2989, 2N3053

2N3054, 2N3055, 2N3391, 2N3730, 2N3819, 2N4038, 2N4058, 2N4061, 2N4172, 2N5295, 3N126, 3N128, 3N154, 3N159, SX754, 2S303, T12082, 40235, 40250, 40251, IN23A, IN25, IN38A, IN43, IN70, IN677, IN4148, IN4785

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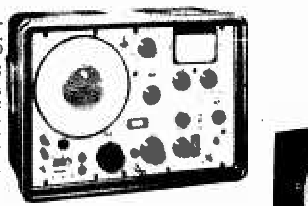
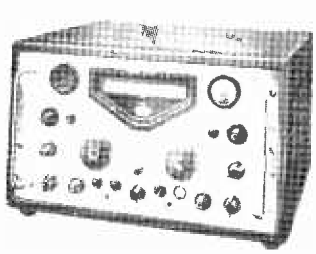


TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.



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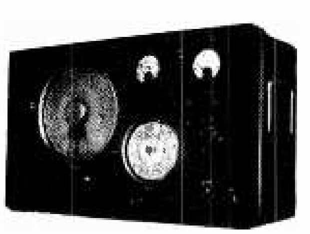

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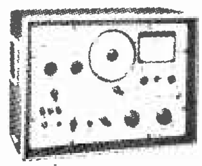

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CD4049AE	69p *	58p *	46p *
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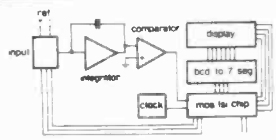

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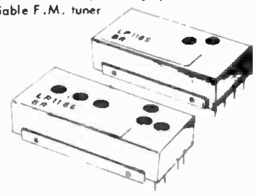

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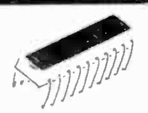

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7409	16p*	13p*	11p *
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7413	29p*	24p*	20p *
7417	27p*	22½p*	20p *
7420	16p*	13p*	11p *
7427	27p*	22½p*	18p *
7430	16p*	13p *	11p *
7432	27p*	22½p*	18p *
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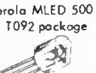

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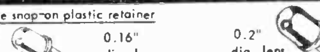

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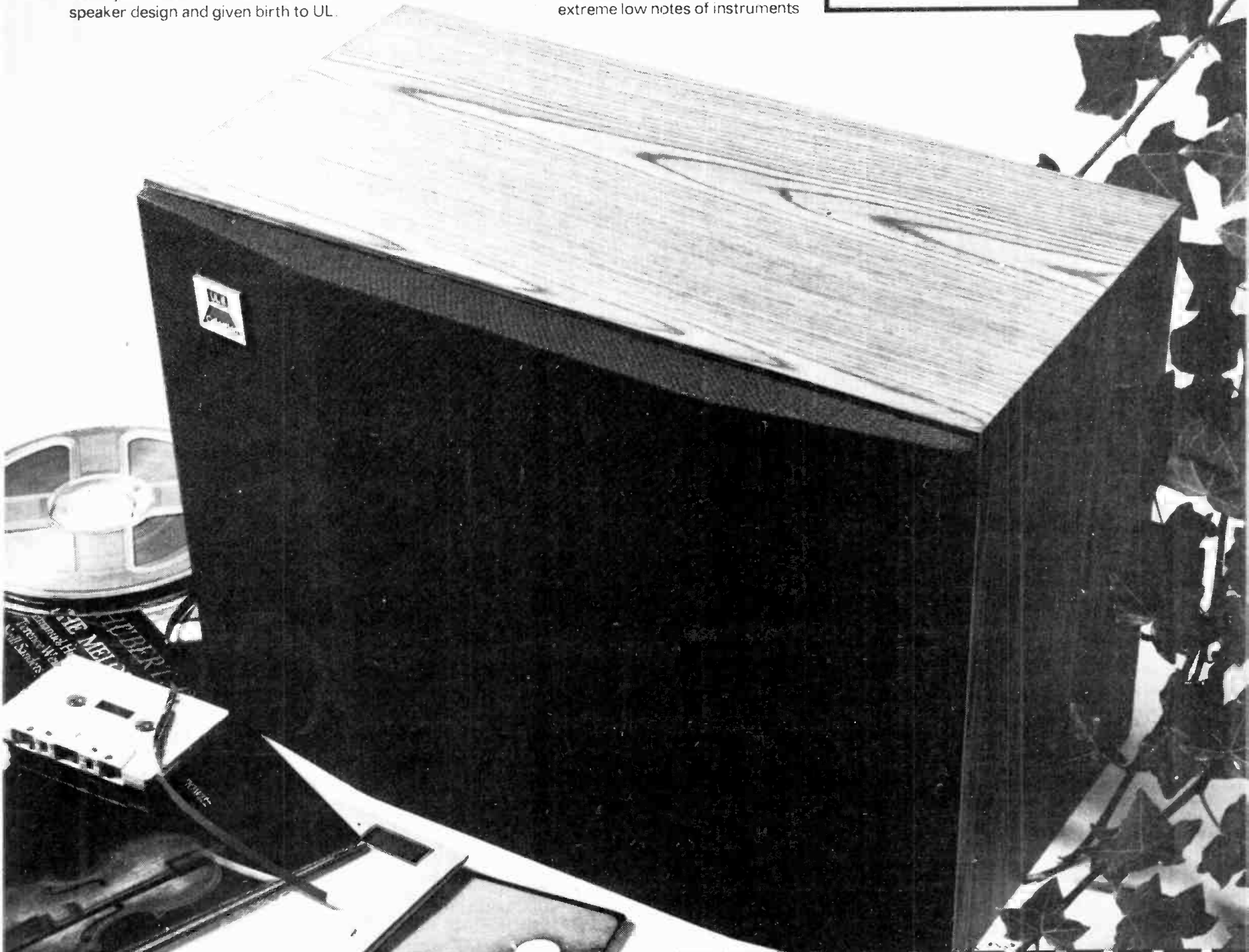
The UL6 speaker has precise and beautiful balance both aurally and visually.

Celestion



Hear the full range speak for itself: W9

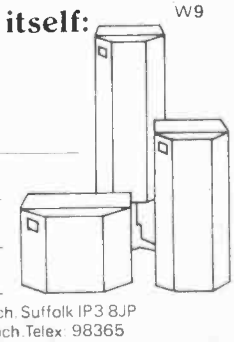
Please send me full details of
UL6 ☐ UL8 ☐ UL10 ☐ and inform me of my nearest franchised demonstration centre.

Name ____________________

Address ____________________

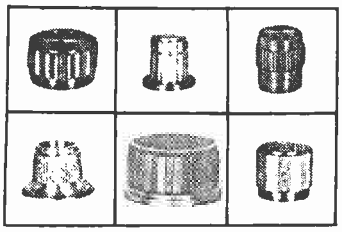
____

____



Rola Celestion Limited, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP
Telephone Ipswich (C473) 73131 Cables: Voicecoil Ipswich Telex: 98365

TOYA



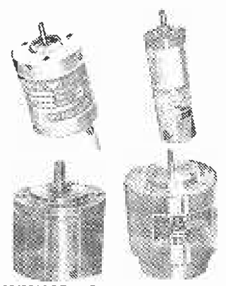
High quality competitively priced Knobs in production quantities only. Min. order 1000 Pcs of any one of 266 types!

KNOB CAT.: WW124 FOR FURTHER DETAILS

We can now offer a range of Mini and Micro Motors with or without gear heads for AC and DC option

MOTORISED ZOOM LENSES FOR TV & CCTV USE

DC pulse driven Turntable Units of especially high performance.



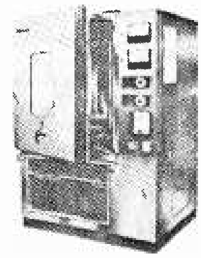
NDK CAT.: WW125 FOR FURTHER DETAILS

TABAI

ENVIRONMENTAL TEST EQUIPMENT

A Standard Range offering the following facilities:

High temperatures to 500° C
Low temperatures to −75° C
Humidity Cycling
Thermal Shock
Vibration
Pressure Cycling
Sand and Dust exp.
Corrosive Gas exp.
Explosion Test



Also embraced in the range of manufacture are:

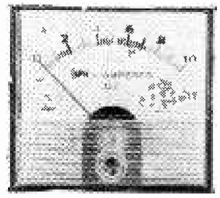
VACUUM DRYING EQUIPMENT

HYPERBARIC OXYGEN SURGERY CHAMBERS

TABAI INFO.: WW126 FOR FURTHER DETAILS

ALPS

LABORATORY TYPE SE65E



TYPE TAD

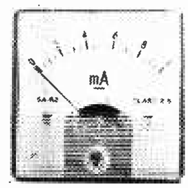
Dims in x mm	48 x 42	66 x 50	85 x 70	118 x 106	150 x 110
50 μA	£3.73	£3.91	£4.10	£5.00	£5.55
500 μA	£3.44	£3.61	£3.82	£4.72	£5.42
1mA	£3.37	£3.54	£3.74	£4.63	£5.33
15vDC	£3.40	£3.59	£3.77	£4.67	£5.36
300vAC	£3.57	£3.76	£3.94	£4.83	£5.40

VU METERS AVAIL.

TYPE SA

Dims in x mm	43 x 43	51 x 51	61 x 61	82 x 78
50 μA	£3.62	£3.69	£3.97	£4.22
500 μA	£3.31	£3.38	£3.63	£3.86
1mA	£3.21	£3.28	£3.53	£3.82
15vDC	£3.25	£3.32	£3.60	£3.86
300vAC	£3.49	£3.56	£3.77	£4.02

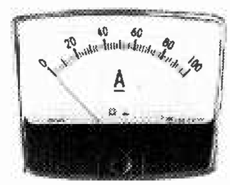
VU METERS AVAIL.



FOR YOUR PRODUCTION REQUIREMENTS USE

ALPS PANEL METERS

Substantial quantity discounts to manufacturers
Remember! We are the sole importers!



TYPE SR

Dims in x mm	73 x 56	78 x 63	92 x 72
50 μA	£4.03	£4.28	£4.52
500 μA	£3.68	£3.93	£4.18
1mA	£3.58	£3.83	£4.08
15vDC	£3.70	£3.94	£4.19
300vAC	£3.83	£3.97	£4.32

SPECIALIST STOCKISTS OF SERVOMOTORS, SYNCHROS, TEST EQUIPMENT, METERS AND CONNECTORS

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LEMANIA AIRCREW CHRONOGRAPHS

Stainless steel case with screw back, luminous hands and markings. One-fifth sec sweep hand controlled and independently of main movement by press to start stop and return to zero button. 15-jewel movement. Many of these watches are as new but all have been completely overhauled and checked for accuracy. Fitted strap. White face **£18.80.** Black face **£19.75** inc P &P

GS WATCHES

All with brushed stainless steel case with screw back and black faces. Manufactured by TIMOR, ETERNA LEMANIA, VERTEX RECORD, CYMA, etc., to a standard specification. Completely overhauled. Fitted strap **£9.05** (inc P &P) We also have limited quantities of these watches by BUREN, HAMILTON and IWC at **£15.30** inc P &P. SMITHS GS watch with sweep second hand **£9.25** inc P.&P & VAT. **All watches: Inspection against remittance.**

LEMANIA STOPWATCHES fitted with one red and one black sweep hands independently controlled enabling elapsed periods forming part of the main period to be measured separately without stopping the measurement of the main time period. Absolutely mint condition but cleaned and checked. **£15** inc P.&P. & VAT.

1/10 SEC. STOPWATCHES, overhauled, **£6.50** (inc. P.&P. & VAT).
1/100 SEC. STOPWATCHES, 0-6 sec., **£8.50** (inc P.&P & VAT).
CAMBRIDGE INST. MIRROR GALVOS, 4.50 ohm, **£10** (inc. P.&P & VAT).
500-WATT CW TRANSMITTERS, 1.5 to 26MHz, P.O A
HEAVY DUTY FLEXIBLE POWER CABLES, Type A 2 core each 750A 440 VAC Type B 4 core each 200A 440 VAC 100 ft lengths

REED SWITCH INSERTS

Overall length 1 85in (Body length 1 1in) Diameter 0 14in to switch up to 500mA or 250vDC Gold clad contacts **74p** per doz **£4.15** per 100 **£29.65** per 1,000 All carriage paid U.K
Operating Coils for 12v supply to accept up to four standard reeds **£2.50** per doz **£12.60** per 100 All carriage paid U.K
Heavy duty type. (Body length 2in) Diameter 0 22in to switch up to 1A at up to 250vAC Gold clad contacts **£1.45** per doz **£6.95** per 100, **£52.00** per 1,000 **Changeover Heavy Duty type £2.80** per doz All carriage paid U K
Magnets for HD reeds **£1.50** per doz A few coils available for HD reeds

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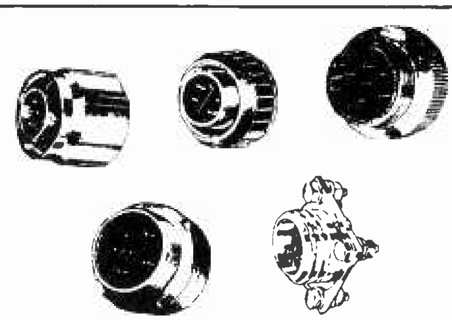
MIL SYNCHROS AND SERVOMOTORS

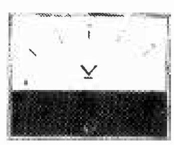
EX STOCK

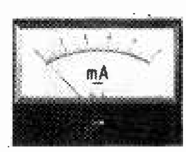


OVER 300,000 RF AND MULTIWAY CONNECTORS IN STOCK. TELEX YOUR REQUIREMENTS NOW!

NEW ADDITIONS to our range of PANEL METERS available at present only in MANUFACTURING QUANTITIES

SE45 64 × 52 mm
SE52 80 × 60 mm
SE65 100 × 80 mm
SE85 120 × 100 mm





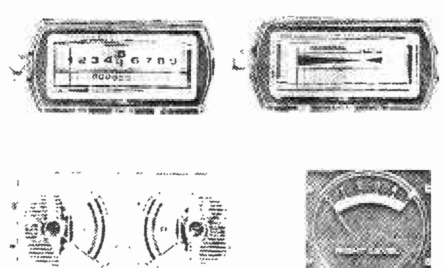
SU45 69 × 53 mm
SU55 87 × 63 mm
SU65 105 × 77 mm

Above meter forms are for moving coil movements only and may house S-meter and VU-meter instruments.

ENGINE TEST EQUIPMENT

SERVO AUTOTESTER No. 1. 0-3 2 & 0 16v, 0-80 A-DC & 0 20K Ohms, dwell angle and speed for 4, 6 & 8 cyc engines and E H T SEC VOLTS A substitute capacitor is incorporated Size 26 5 × 14 × 16 5cm wt 3.25Kg. With handbook **£30.37** inc P &P & VAT
SERVO AUTOTESTER No. 2. 0-16v, 0 80A dwell angle and speed for 4, 6 & 8 cyc engines Size 16 × 9 5 × 6 5 cm Wt. 0.45Kg With instns. **£11.15** inc P &P & VAT
SERVO AUTOTESTER No. 3. Simultaneously on separate meters 0-16v & 0 80A Size 17 × 10 × 7 cm Wt 0 45Kg Price **£9.78** inc P &P. & VAT
SERVO AUTOTESTER No. 4. Dwell angle and engine speed Hand held instt Size 14 × 8 × 5 cm Wt 0 26Kg Price **£6.35** inc P & P & VAT

MULTIRANGE TEST METERS & LOW-PRICE INDICATORS AND PANEL METERS AVAILABLE WITH PERSONALISED SCALES



METERS CAT.: WW127 FOR FURTHER DETAILS

FORTHCOMING EXHIBITIONS

Institution of Electronics, University of Edinburgh, 16-18 March 1976
IEA-Electrex 1976 National Exhibition Centre, Birmingham, 3-7 May 1976
Leetronex 1976, Leeds University, 29-30 June, 1 July, 1976
Tickets free on receipt of SAE (1 for each Exhibition please)

WW—092 FOR FURTHER DETAILS

TRANSFORMERS

CASED TRANSFORMERS

Housed in smart resin coated steel cases with 3 core power cable and outlet socket, fused primary winding. Isolation types are fitted with 3-pin outlet sockets and are available with 110 volt or 240 volt output (Please state). Auto types are fitted with 2-pin flat style sockets up to 500 VA. 3-pin sockets from 750 to 3000 VA. See Auto and Isolation sections for prices. Plugs extra.

SAFETY ISOLATING

Prim. 120/240V. Sec. 120/240V. Centre Tap with screen

VA (WATTS)	REF No.	PRICE Cased £	PRICE Plugs 2 Pin + 1 Earth £	PRICE Open £	Post £
20	148	5.25	0.98	3.75	0.72
60	149	9.03	0.98	4.70	0.72
100	150	9.87	0.98	5.35	0.85
200	151	12.29	0.98	8.61	0.97
250	152	13.81	0.98	10.31	1.18
350	153	16.54	0.98	12.50	1.28
500	154	18.38	0.98	14.31	1.44
750	155	28.72	1.25	22.12	0.A.
1000	156	37.44	1.25	30.57	0.A.
1500	157	44.37	1.25	34.98	0.A.
2000	158	52.45	2.95	38.91	0.A.
3000	159	77.18	2.95	61.51	0.A.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	REF No.	PRICE £	Post £
3-0-3	—	200	—	238	1.56	0.34
0-6	0-6	500	500	234	1.56	0.34
0-6	0-6	1000	1000	212	2.12	0.46
9-0-9	—	100	—	13	1.60	0.34
0-9	0-9	330	330	235	1.62	0.34
0-8-9	0-8-9	500	500	207	1.69	0.46
0-8-9	0-8-9	1000	1000	208	2.79	0.46
15-0-15	—	40	—	240	1.55	0.34
0-15	0-15	200	200	236	1.56	0.34
20-0-20	—	30	—	241	1.55	0.34
0-20	0-20	150	150	237	1.56	0.34
0-15-20	0-15-20	500	500	205	2.88	0.58
0-20	0-20	300	300	214	2.03	0.61
0-20	—	3500	No Screen	1116	3.45	0.97
20-12-0	—	700	—	221	2.50	0.61
12-20	—	(D.C.)	—	—	—	—
0-15-20	0-15-20	1000	1000	206	2.85	0.72
0-15-27	0-15-27	500	500	203	3.16	0.58
0-15-27	0-15-27	1000	1000	204	4.55	0.72

12 and 24 VOLTS PRIMARY 200-240 Volts

AMPS 12V	AMPS 24V	REF No.	PRICE £	Post £
0.3	0.15	242	1.66	0.34
0.5	0.25	111	1.60	0.46
1	0.5	213	1.90	0.61
2	1	71	2.47	0.61
4	2	18	3.07	0.62
6	3	70	4.50	0.72
8	4	108	5.11	0.85
10	5	72	5.63	0.85
12	6	116	5.80	0.85
16	8	17	7.26	0.97
20	10	115	10.96	1.18
30	15	187	14.06	1.36
40	20	232	15.63	0.A.
60	30	226	17.70	0.A.

30 VOLTS

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

AMPS	Ref. No.	Price £	Post £
0.5	112	2.04	0.61
1	79	2.57	0.66
2	3	3.91	0.72
3	20	4.80	0.85
4	21	5.58	0.85
5	51	6.75	0.95
6	117	7.52	0.97
8	88	9.93	1.18
10	89	10.27	1.18

50 VOLTS

PRIMARY 200/240V
SECONDARY 19, 25, 33, 40, 50V

AMPS	Ref. No.	Price	Post £
0.5	102	2.71	0.61
1	103	3.58	0.76
2	104	5.30	0.85
3	105	6.10	0.85
4	106	7.97	1.08
6	107	12.93	1.18
8	118	13.75	1.44
10	119	17.79	1.86

AMPS	Ref. No.	Price £	Post £
0.5	124	2.51	0.72
1	126	3.75	0.72
2	127	5.36	0.85
3	125	7.91	0.97
4	123	9.20	1.18
5	40	10.22	1.18
6	120	12.10	1.36
8	121	15.74	0.A.
10	122	20.10	0.A.
12	189	18.87	0.A.

BRIDGE RECTIFIERS

ONE AMP	Price	FOUR AMP	Price
50 P.I.V.	0.25	100 P.I.V.	0.55
100 P.I.V.	0.26	200 P.I.V.	0.59
200 P.I.V.	0.28	400 P.I.V.	0.65
800 P.I.V.	0.30	600 P.I.V.	0.75

SPECIAL OFFER!

2 KVA ISOLATORS

Fully impregnated & screened

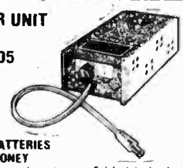
2 primary windings 110V each
2 secondary windings 115V each
(2 matching transformers)
£29.50 plus carr. & VAT.

TWO AMP	Price	SIX AMP	Price
50 P.I.V.	0.35	50 P.I.V.	0.65
100 P.I.V.	0.40	100 P.I.V.	0.70
200 P.I.V.	0.46	200 P.I.V.	0.80
400 P.I.V.	0.50	400 P.I.V.	0.90

Add 25% VAT on all prices

POWER UNIT TYPE CC12-05

British Made



SAVES BATTERIES
SAVES MONEY

Housed in smart steel case, finished in hard epoxy coating. Screened for safety.

Output switched 3, 4.5, 6, 7.5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players, etc. Size 7.5 × 5.0 × 14.0 cm. Price £4.15. Post 35p. Plus 8% VAT.

AUTO TRANSFORMERS

VA (Watts)	Ref. No.	PRICE Cased	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	4.31	0.25	1.88	0.61
Tapped at 115, 200, 220, 240 Volts					
150	4	6.99	0.25	4.28	0.72
200	65	7.67	0.25	5.21	0.78
300	66	8.67	0.25	6.11	0.85
500	67	11.82	0.25	9.48	1.18
750	83	14.81	0.95	11.30	1.28
1000	84	18.38	0.95	14.35	1.44
1500	93	23.26	0.95	19.22	O.A.
2000	95	35.07	1.80	25.49	O.A.
3000	73	50.61	2.35	34.87	O.A.

NEW! 2" AND 4" PANEL METERS

2"

SIZE: 60mm Wide × 45mm High × 40mm Deep.

Movement	I.R. Ohms
0-50 micro A.	1250
0-100 micro A.	580
0-500 Micro A.	170
0-1 mA	170
0-5 mA	170
0-10mA	6
0-590 mA	0.5
0-100 mA	0.5
0-500 mA	0.5
0-1 AMP	0.5
0-2 AMP	0.5
0-25 Volt	15K
0-50 Volt	50K
0-300 Volt	300K
"g" Meter	170
VU Meter	9250

4"

SIZE: 110mm Wide × 82mm High × 43mm Deep.

Movement	I.R. Ohms
0-50 micro A	1400
0-100 micro A	730
0-500 micro A	200
0-1 mA	200
0-5mA	200
0-10 mA	6
0-50 mA	0.5
0-100 mA	0.5
0-500 mA	0.5
0-1 AMP	0.5
0-2 AMP	0.5
0-25 Volt	15K
0-50 Volt	50K
0-300 Volt	300K
"g" Meter	200
VU Meter	5250

VU Meters are complete with detectors. Modern wide view. Price 2" £3.20 Post 10p. Price 4" £4.00 Post 10. Lamps 60p per set. Plus 8% VAT

C1000 MULTI-METER

Compact General Purpose Mini Multimeter
Input Resistance 1000 ohms per volt
Ranges AC Volts 0-15 50 250 1000 Volts
DC Volts 0-10 50 250 1000 Volts
DC Current 0-1 mA 0-100 mA
Resistance 0-150K ohms
Size 60 × 24 × 90 mm
Complete with Batteries, Test Prods, Instructions

Special price **£3.35** Post 30p Plus 8% VAT.

¼-WATT CARBON FILM RESISTORS

also available ¼ watt at 70°C E 12 range 10Ω—1MΩ 5% tol above 470KΩ 10% tol. at **95p** per 100. Plus 25% VAT.

MINIATURE NEONS

6mm dia., 12mm length leads length approx. 20mm. Recommended ballast resistor 150K ohms for 240 Volt operation. Price: Packet of 10 for **60p**. Postage 15p. Plus 8% VAT.

PLEASE ADD 8% VAT ON ALL TRANSFORMERS

Send 25p for Catalogue

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WW—043 FOR FURTHER DETAILS

Hanover makes Markets

afresh every year

28 April - 6 May 1976

Hanover Fair

● Day visit by jet flight from Luton Airport Thursday, 29th April for £49 per person;
● Day visit by jet flight from Gatwick Airport Tuesday, 4th May for £49 per person;
● Day visit by jet flight from Gatwick Airport for the Aerospace Show Tuesday, 4th May for £44 per person;
● Package tours inclusive of scheduled flights
First and tourist class accommodation in *central* Hanover from £68 for two days (one night), Price includes entrance ticket;
● Good clean private accommodation in *central* Hanover for two days by scheduled flight from £67. Also sleeping car berths available at the fairground itself for two days by air from £89.

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(ask for Ian Stewart for immediate confirmation)

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33 Maddox Street,
London W1R 9LD.

KUONI TRAVEL LTD

WW — 067 FOR FURTHER DETAILS

ADVANCED CLOCK KIT

Complete kit including attractive slim case for 6 digit alarm clock with bleep alarm, snooze and automatic intensity control, high brightness display driving with optional touch switch controls and crystal control/battery-back-up (both extra) using MK50253 and LED displays. Kit also includes PCBs, active and passive components, IC socket, miniature cool transformer, switches, flat cable, loudspeaker, mains plug and lead, perspex panel, and full instructions. With 0.5" JUMBO FND500 Displays £27.31

SEND LARGE S.A.E. FOR DETAILS AND PRICES OF THIS MONTH'S P.E. CAR/BOAT CLOCK/JOURNEY TIMER OR PHONE FOR IMMEDIATE DESPATCH.
SEND LARGE S.A.E. FOR DETAILS OF OUR MODULAR STOPWATCH SYSTEM USING CMOS.
SEND LARGE S.A.E. FOR DETAILS OF ATTRACTIVE SIMPLE 4 DIGIT GREEN CLOCK 50Hz CRYSTAL TIMEBASE KIT FOR CLOCKS INCL. ADVANCED KIT ABOVE £6.28

CMOS ICS		CD4031	1.82	CD4062	7.33	CD4518	1.03	**DISPLAY INT.**	
RCA MOT. ONLY		CD4032	0.88	CD4063	0.90	CD4520	1.03	SN75491	0.81
CD4000	0.17	CD4033	1.14	CD4066	0.58	CD4527	1.30	SN75492	1.02
CD4001	0.17	CD4034	1.56	CD4067	2.95	CD4532	1.16	7447	1.05
CD4002	0.17	CD4035	0.97	CD4068	0.18	CD4555	0.74	7448	0.85
CD4006	0.97	CD4036	1.82	CD4069	0.18	CD4556	0.74		
CD4007	0.17	CD4037	0.78	CD4070	0.18	MC14508	2.37	**FLAT CABLE**	
CD4008	0.79	CD4038	0.88	CD4071	0.18	MC14528	0.86	20WAY1M	1.00
CD4009	0.46	CD4039	2.86	CD4072	0.18	MC14534	6.04	10M for	8.50
CD4010	0.46	CD4040	0.88	CD4073	0.18	MC14553	4.07	10WAY1M	0.60
CD4011	0.17	CD4041	0.69	CD4075	0.18	MC14566	1.21	10M FOR	4.80
CD4012	0.17	CD4042	0.69	CD4076	1.27	MCM14552	8.05		
CD4013	0.46	CD4043	0.83	CD4077	0.18			**IC SOCKET PINS**	
CD4014	0.83	CD4044	0.77	CD4078	0.18			100	0.50
CD4015	0.83	CD4045	1.15	CD4081	0.18	**CLOCK CHIPS**		1000	4.00
CD4016	0.46	CD4046	1.10	CD4082	0.18	MK50253	5.60	3000	10.60
CD4017	0.83	CD4047	0.74	CD4085	0.59	MM5314	4.44		
CD4018	0.83	CD4048	0.46	CD4086	0.59	AY51224	3.66	**LSI SOCKETS**	
CD4019	0.46	CD4049	0.48	CD4089	1.27	AY51202	4.76	**PINS + SUP-PORTS**	
CD4020	0.92	CD4050	0.46	CD4093	0.66				
CD4021	0.83	CD4051	0.77	CD4094	1.63	**CMOS BOOKS**		24 PIN	0.30
CD4022	0.79	CD4052	0.77	CD4095	0.86	No VAT or P&P		28 PIN	0.30
CD4023	0.17	CD4053	0.77	CD4096	0.86	RCA1975	2.67	40 PIN	0.30
CD4024	0.64	CD4054	0.95	CD4099	1.50	MCMOS	2.77		
CD4025	0.17	CD4055	1.08	CD4502	0.98			**VERDCASES**	
CD4026	1.42	CD4056	1.08	CD4510	1.12			751410J	2.64
CD4027	0.46	CD4057	20.35	CD4511	1.28	**DISPLAYS**		751411D	3.04
CD4028	0.74	CD4059	10.64	CD4514	2.56	5LT-01	5.80	751412K	4.00
CD4029	0.94	CD4060	0.92	CD4515	2.56	DL704E	0.85		
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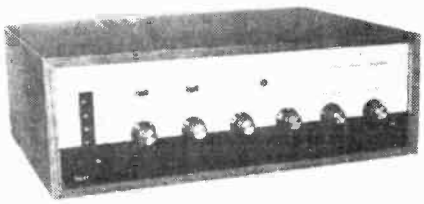

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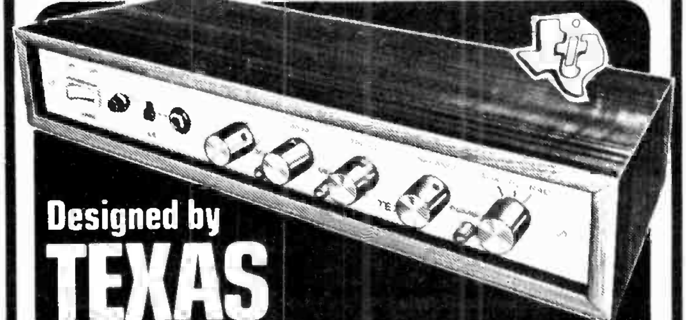

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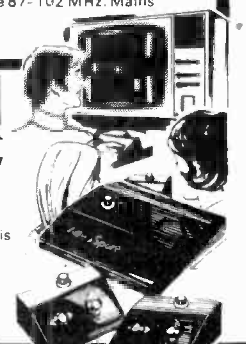

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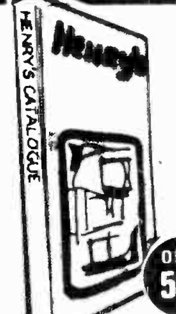

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AC115	*0.20	BC172	0.10	BFY51	*0.20	2N727	*0.29
AC117K	*0.30	BC173	0.15	BFY52	*0.20	2N743	*0.20
AC122	*0.12	BC174	0.15	BFY53	*0.18	2N744	*0.20
AC125	*0.18	BC175	*0.35	BSX19	*0.16	2N914	*0.15
AC126	*0.18	BC177	*0.19	BSX20	*0.16	2N918	*0.31
AC127	*0.19	BC178	*0.19	BSY25	*0.16	2N929	*0.21
AC128	*0.19	BC179	*0.19	BSY26	*0.16	2N930	*0.31
AC132	*0.15	BC180	*0.25	BSY27	*0.16	2N1131	*0.20
AC134	*0.15	BC181	0.25	BSY28	*0.16	2N1132	*0.22
AC137	*0.15	BC182	0.15	BSY29	*0.16	2N1302	*0.15
AC141	*0.19	BC182L	0.15	BSY38	*0.19	2N1303	*0.15
AC141K	*0.30	BC183	0.15	BSY39	*0.19	2N1304	*0.18
AC142	*0.19	BC183L	0.15	BSY40	*0.29	2N1305	*0.18
AC142K	*0.26	BC184	0.20	BSY41	*0.29	2N1306	*0.21
AC151	*0.16	BC184L	0.20	BSY95	*0.13	2N1307	*0.21
AC154	*0.20	BC186	*0.29	BSY95A	*0.13	2N1308	*0.24
AC155	*0.20	BC187	*0.29	BU105	*2.04	2N1309	*0.24
AC156	*0.20	BC207	0.11	C111E	*0.51	2N1613	*0.20
AC157	*0.25	BC208	0.11	C400	*0.31	2N1711	*0.20
AC165	*0.20	BC209	0.12	C407	*0.26	2N1889	*0.32
AC166	*0.20	BC212L	0.13	C424	*0.26	2N1890	*0.46
AC167	*0.20	BC213L	0.13	C425	*0.51	2N1893	*0.38
AC168	*0.25	BC214L	0.17	C426	*0.36	2N2147	*0.73
AC169	*0.15	BC225	0.26	C428	*0.20	2N2148	*0.58
AC176	*0.20	BC226	0.36	C441	*0.31	2N2160	*0.61
AC177	*0.25	BC301	*0.28	C442	*0.31	2N2192	*0.36
AC178	*0.29	BC302	*0.25	C444	*0.36	2N2193	*0.36
AC179	*0.29	BC303	*0.31	C450	*0.22	2N2194	*0.36
AC180	*0.20	BC304	*0.37	MAT100	*0.19	2N2217	*0.22
AC180K	*0.30	BC440	*0.31	MAT101	*0.20	2N2218	*0.20
AC181	*0.20	BC460	*0.37	MAT120	*0.19	2N2219	*0.20
AC181K	*0.30	BCY30	*0.65	MAT121	*0.20	2N2220	*0.22
AC187	*0.22	BCY31	*0.65	MJE521	*0.56	2N2221	*0.20
AC187K	*0.23	BCY32	*0.70	MJE2955	*0.88	2N2222	*0.20
AC188	*0.22	BCY33	*0.60	MJE3055	*0.57	2N2368	*0.18
AC188K	*0.23	BCY34	*0.65	MJE3440	0.51	2N2369	*0.15
ACY17	*0.26	BCY70	*0.15	MPF102	*0.43	2N2369A	*0.15
ACY18	*0.24	BCY71	*0.20	MPF104	*0.38	2N2411	*0.25
ACY19	*0.24	BCY72	*0.15	MPF105	*0.38	2N2412	*0.25
ACY20	*0.24	BCZ10	*0.50	OC19	*0.36	2N2646	*0.48
ACY21	*0.24	BCZ11	*0.50	OC20	*0.65	2N2711	0.21
ACY22	*0.24	BCZ12	*0.50	OC22	*0.47	2N2712	0.21
ACY27	*0.19	BD115	*0.63	OC23	*0.49	2N2714	0.21
ACY28	*0.19	BD116	*0.81	OC24	*0.57	2N2904	*0.18
ACY29	*0.36	BD121	*0.61	OC25	*0.39	2N2904A	*0.21
ACY30	*0.29	BD123	*0.67	OC26	*0.30	2N2905	*0.21
ACY31	*0.29	BD124	*0.70	OC28	*0.51	2N2905A	*0.21
ACY34	*0.21	BD131	*0.51	OC29	*0.51	2N2906	*0.16
ACY35	*0.21	BD132	*0.61	OC35	*0.43	2N2906A	*0.19
ACY36	*0.29	BD133	*0.67	OC36	*0.51	2N2907	*0.20
ACY40	*0.18	BD136	0.41	OC41	*0.20	2N2907A	*0.22
ACY41	*0.19	BD137	0.46	OC42	*0.25	2N2923	0.15
ACY44	*0.36	BD138	0.51	OC44	*0.16	2N2924	0.15
AD130	*0.39	BD139	0.56	OC45	*0.13	2N2925	0.15
AD140	*0.49	BD140	0.61	OC70	*0.15	2N2926G	0.13
AD142	*0.49	BD155	*0.81	OC71	*0.15	2N2926Y	0.11
AD143	*0.30	BD175	*0.61	OC72	*0.15	2N29260	0.10
AD149	*0.51	BD176	*0.61	OC74	*0.15	2N2926R	0.10
AD161	*0.36	BD177	*0.67	OC75	*0.16	2N2926B	0.10
AD162	*0.36	BD178	*0.67	OC76	*0.16	2N3010	*0.71
AD161 &		BD179	*0.71	OC77	*0.26	2N3011	*0.15
AD162(MP)		BD180	*0.71	OC81	*0.16	2N3053	*0.18
		BD185	*0.67	OC81D	*0.16	2N3054	*0.47
	*0.69	BD186	*0.67	OC82	*0.16	2N3055	*0.42
ADT140	*051	BD187	*0.71	OC82D	*0.16	2N3319	0.15
AF114	*0.25	BD188	*0.71	OC83	*0.20	2N3391A	0.17
AF115	*0.25	BD189	*0.77	OC139	*0.20	2N3392	0.15
AF116	*0.25	BD190	*0.77	OC140	*0.20	2N3393	0.15
AF117	*0.25	BD195	*0.87	OC169	*0.26	2N3394	0.15
AF118	*0.36	BD196	*0.87	OC170	*0.26	2N2295	0.18
AF124	*0.31	BD197	*0.92	OC171	*0.26	2N3402	*0.29
AF125	*0.31	BD198	*0.92	OC200	*0.26	2N3403	*0.29
AF126	*0.29	BD199	*0.98	OC201	*0.29	2N3404	*0.29
AF127	*0.29	BD200	*0.98	OC202	*0.29	2N3405	*0.34
AF139	*0.31	BD205	*0.81	OC203	*0.26	2N3414	0.16
AF178	*0.51	BD206	*0.81	OC204	*0.26	2N3415	0.16
AF179	*0.51	BD207	*0.98	OC205	*0.36	2N3416	0.29
AF180	*0.51	BD208	*0.98	OC309	*0.41	2N3417	0.29
AF181	*0.51	BDY20	*1.02	OCP71	*0.44	2N3525	*0.77
AF186	*0.51	BF115	*0.25	ORP12	*0.60	2N3614	*0.69
AF239	*0.38	BF117	*0.46	ORP60	*0.60	2N3615	*0.76
AL102	*0.68	BF118	*0.71	ORP61	*0.60	2N3616	*0.76
AL103	*0.68	BF119	*0.71	P20	*0.51	2N3646	0.09
ASY26	*0.26	BF121	0.46	P346A	*0.20	2N3702	0.12
ASY27	*0.31	BF123	0.51	P397	*0.43	2N3703	0.12
ASY28	*0.26	BF125	0.46	ST140	*0.13	2N3704	0.13
ASY29	*0.26	BF127	0.51	ST141	*0.18	2N3705	0.12
ASY50	*0.26	BF152	0.56	TIP29	0.44	2N3706	0.12
ASY51	*0.26	BF153	0.46	TIP30	0.52	2N3707	0.13
ASY52	*0.26	BF154	0.46	TIP31A	*0.56	2N3708	0.08
ASY54	*0.26	BF155	*0.71	TIP32A	*0.68	2N3709	0.09
ASY55	*0.26	BF156	*0.49	TIP41A	*0.68	2N3710	0.09
ASY56	*0.26	BF157	*0.56	TIP42A	*0.81	2N3711	0.09
ASY57	*0.26	BF158	0.56	TIS43	*0.31	2N3819	*0.29
ASY58	*0.26	BF159	0.61	UT46	*0.28	2N3820	*0.51
ASY73	*0.26	BF160	0.41	ZN414	*1.11	2N3821	*0.60
ASZ21	*0.41	BF162	0.41	2G301	*0.19	2N3823	*0.29
BC107	*0.08	BF163	0.41	2G302	*0.19	2N3903	0.29
BC108	*0.08	BF164	0.41	2G303	*0.19	2N3904	0.31
BC109	*0.08	BF165	0.41	2G304	*0.25	2N3905	0.29
BC113	0.10	BF167	*0.22	2G306	0.41	2N3906	0.28
BC114	0.16	BF173	*0.22	2G308	0.36	2N4058	0.12
BC115	0.16	BF176	0.36	2G309	0.37	2N4059	0.10
BC116	0.16	BF177	*0.36	2G339	0.20	2N4060	0.12
BC117	0.19	BF178	*0.31	2G339A	0.17	2N4061	0.12
BC118	0.10	BF179	*0.31	2G344	0.19	2N4062	0.12
BC119	*0.31	BF180	*0.31	2G345	0.17	2N4284	0.18
BC120	*0.81	BF181	*0.31	2G371	0.17	2N4285	0.18
BC125	0.12	BF182	*0.41	2G371B	0.12	2N4268	0.18
BC126	0.25	BF183	*0.41	2G373	0.18	2N4287	0.18
BC132	0.12	BF184	*0.26	2G374	0.18	2N4288	0.18
BC134	0.19	BF185	*0.31	2G377	0.31	2N4289	0.18
BC135	0.12	BF187	*0.28	2G378	0.17	2N4290	0.18
BC136	0.16	BF188	0.41	2G381	0.17	2N4291	0.18
BC137	0.16	BF194	0.12	2G382	0.17	2N4292	0.18
BC139	*0.41	BF195	0.12	2G401	0.31	2N4293	0.18
BC140	*0.31	BF196	0.15	2G414	0.31	2N5172	0.12
BC141	*0.31	BF197	0.15	2G417	0.26	2N5194	0.56
BC143	*0.31	BF200	*0.46	2N388	0.36	2N5294	*0.56
BC145	0.46	BF222	*0.98	2N388A	0.56	2N5296	*0.56
BC147	0.10	BF257	*0.46	2N404	0.20	2N5457	*0.32
BC148	0.10	BF258	*0.61	2N404A	0.29	2N5458	*0.32
BC149	0.12	BF259	*0.87	2N524	0.43	2N5459	*0.41
BC150	0.19	BF262	0.56	2N527	0.50	2S102	*0.69
BC151	0.20	BF263	0.56	2N598	0.43	2S301	*0.51
BC152	0.18	BF270	*0.36	2N599	0.46	2S302A	*0.43
BC153	0.29	BF271	*0.31	2N696	0.13	2S302	*0.43
BC154	0.21	BF272	*0.81	2N697	0.14	2S303	*0.56
BC157	0.19	BF273	0.36	2N698	0.25	2S304	*0.71
BC158	0.12	BF274	0.36	2N699	0.36	2S305	*0.80
BC159	0.12	BFW10	*0.61	2N706	0.11	2S306	*0.80
BC160	*0.46	BFX29	*0.28	2N706A	0.12	2S307	*0.80
BC161	*0.51	BFX84	*0.22	2N708	0.14	2S321	*0.75
BC167	0.12	BFX85	*0.31	2N711	0.31	2S322	*0.43
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7401	0.14	0.13	0.12	7489	3.70	3.47	3.24
7402	0.14	0.13	0.12	7490	0.60	0.58	0.56
7403	0.14	0.13	0.12	7491	1.02	0.97	0.93
7404	0.14	0.13	0.12	7492	0.69	0.66	0.59
7405	0.14	0.13	0.12	7493	0.69	0.66	0.59
7406	0.36	0.31	0.29	7494	0.79	0.76	0.69
7407	0.36	0.31	0.29	7495	0.79	0.76	0.69
7408	0.23	0.22	0.21	7596	0.89	0.86	0.80
7409	0.23	0.22	0.21	74100	1.39	1.34	1.30
7410	0.14	0.13	0.12	74104	0.56	0.54	0.51
7411	0.23	0.22	0.21	74105	0.56	0.54	0.51
7412	0.26	0.25	0.24	74107	0.41	0.39	0.37
7413	0.30	0.29	0.28	74110	0.56	0.51	0.46
7416	0.28	0.27	0.26	74111	0.83	0.81	0.78
7417	0.28	0.27	0.26	74118	0.93	0.88	0.83
7420	0.14	0.13	0.12	74119	1.39	1.30	1.20
7422	0.28	0.27	0.26	74121	0.46	0.44	0.41
7423	0.37	0.36	0.35	74122	0.65	0.63	0.60
7425	0.37	0.36	0.35	74123	0.69	0.68	0.65
7426	0.37	0.35	0.33	74141	0.79	0.76	0.73
7427	0.37	0.35	0.33	74145	1.20	1.16	1.11
7428	0.42	0.39	0.37	74150	1.39	1.30	1.20
7430	0.14	0.13	0.12	74151	1.02	0.97	0.93
7432	0.37	0.35	0.33	74153	0.93	0.88	0.83
7433	0.39	0.37	0.35	74154	1.57	1.43	1.48
7437	0.32	0.30	0.28	74155	1.11	1.06	1.02
7438	0.32	0.30	0.28	74156	1.11	1.06	1.02
7440	0.14	0.13	0.12	74157	0.93	0.88	0.83
7441	0.69	0.66	0.59	74160	1.30	1.25	1.20
7442	0.69	0.66	0.59	74161	1.30	1.25	1.20
7443	1.11	1.06	1.02	74162	1.30	1.25	1.20
7444	1.11	1.06	1.02	74163	1.30	1.25	1.20
7445	1.48	1.44	1.39	74164	1.67	1.62	1.55
7446	1.11	1.06	1.02	74165	1.67	1.62	1.55
7447	1.02	0.99	0.97	74166	1.48	1.44	1.39
7448	1.02	0.99	0.97	74174	1.48	1.44	1.39
7450	0.14	0.13	0.12	74175	1.02	0.97	0.93
7451	0.14	0.13	0.12	74176	1.16	1.11	1.06
7453	0.14	0.13	0.12	74177	1.16	1.11	1.06
7454	0.14	0.13	0.12	74180	1.16	1.11	1.06
7460	0.14	0.13	0.12	74181	3.66	3.56	3.47
7470	0.30	0.27	0.25	74182	1.16	1.11	1.06
7472	0.30	0.27	0.25	74184	1.67	1.62	1.55
7473	0.38	0.36	0.32	74190	1.81	1.76	1.71
7474	0.38	0.36	0.32	74191	1.81	1.76	1.71
7475	0.56	0.54	0.52	74192	1.81	1.76	1.71
7476	0.41	0.40	0.39	74193	1.81	1.76	1.71
7480	0.56	0.54	0.51	74194	1.20	1.16	1.11
7481	1.02	0.97	0.93	74195	1.02	0.97	0.93
7482	0.83	0.79	0.74	74196	1.11	1.06	1.02
74197	1.11	1.06	1.02	7483	1.11	1.06	0.97
74198	2.55	2.50	2.45	7484	0.93	0.90	0.88
74199	2.31	2.21	2.11	7485	1.48	1.44	1.39

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.

*D.T.L. 930 SERIES

Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
BP930	0.14	0.13	0.12	BP948	0.28	0.26	0.23
BP932	0.15	0.14	0.13	BP951	0.65	0.60	0.56
BP933	0.15	0.14	0.13	BP962	0.14	0.13	0.12
BP935	0.15	0.14	0.13	BP9093	0.12	0.40	0.38
BP936	0.15	0.14	0.13	BP9094	0.42	0.40	0.38
BP944	0.15	0.14	0.13	BP9097	0.42	0.40	0.38
BP945	0.28	0.26	0.23	BP9099	0.21	0.40	0.38
BP946	0.14	0.13	0.12				

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

*THYRISTORS

PIV	0.6A TO18	0.8A TO92	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
10	0.13	0.15	—	—	—	—	—	—	—	—
20	0.15	0.18	—	—	—	—	—	—	—	—
30	0.19	0.22	—	—	—	—	—	—	—	—
50	0.22	0.28	0.20	0.25	0.36	0.36	0.48	0.51	0.54	1.18
100	0.25	0.30	0.25	0.25	0.48	0.48	0.51	0.57	0.58	1.43
150	0.31	0.38	—	—	—	—	—	—	—	—
200	0.38	0.44	0.25	0.30	0.50	0.50	0.57	0.62	0.62	1.63
400	—	—	0.30	0.39	0.55	0.57	0.62	0.71	0.77	1.79
600	—	—	0.39	0.48	0.69	0.69	0.78	0.99	0.90	—
800	—	—	0.58	0.65	0.81	0.81	0.92	1.22	1.39	4.07

LINEAR I.C.s

Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
72702	0.46	0.44	0.42	TAA350A	1.71	1.67	1.57
72709	0.23	0.21	0.19	uA703C	0.26	0.24	0.22
72709P	0.19	0.18	0.17	uA709C	0.19	0.18	0.17
72710	0.32	0.31	0.28	uA711C	0.32	0.31	0.28
72741	0.28	0.27	0.26	uA712C	0.32	0.31	0.28
72741C	0.26	0.25	0.24	uA723C	0.45	0.43	0.40
72741P	0.28	0.27	0.26	76003	1.39	1.34	1.30
72747	0.79	0.74	0.61	76023	1.39	1.34	1.30
72748P	0.35	0.33	0.31	76660	0.88	0.86	0.83
SL201C	0.46	0.42	0.37	LM380	0.93	0.90	0.88
SL701C	0.46	0.42	0.37	*NE555	0.45	0.43	0.40
SL702C	0.46	0.42	0.37	*NE556	0.88	0.86	0.83
TAA263	0.74	0.65	0.56	TBA800	1.39	1.34	1.30
TAA293	0.93	0.88	0.83	ZN414	1.11	—	—

SILICON RECTIFIERS

PIV	300mA (DO7)	750mA	Plastic	1A (SO16)	1.5A (SO16)	3A (SO10)	10A (SO10)	30A (TO48)
50	0.05	0.06	IN4001	0.05	0.07	0.14	*0.19	*0.56
100	0.05	0.07	IN4002	0.06	0.09	0.16	*0.21	*0.69
200	0.06	0.09	IN4003	0.07	0.12	0.20	*0.23	*0.93
400	0.07	0.14	IN4004	0.08	0.14	0.28	*0.35	*0.25
600	0.08	0.16	IN4005	0.09	0.16	0.33	*0.42	*1.76
800	0.11	0.18	IN4006	0.10	0.18	0.35	*0.51	*1.94
1000	0.13	0.28	IN4007	0.11	0.23	0.44	*0.60	*2.31
1200	—	0.32	IN4007		0.28	0.54	*0.69	*2.88

*TRIACS

Case	100V	200V		400V
2 Amp	TO5	0.31	0.51	0.71
6 Amp	TO66	0.51	0.61	0.77
10 Amp	TO48	0.77	0.92	1.12

DIACS

BR100 *0.23
D32 *0.23
(These two diacs are recommended for use with triacs.)

SUPER UNTESTED PAKS

Pak No.		Description	Price
U1	120	Glass Sub-min G.P. Germ. diodes	0.60
U2	50	Mixed Germanium transistors AF/RF	*0.60
U3	75	Germ. gold bonded sub-min like OA47	0.60
U4	30	Germ. transistors like OC81, AC128	*0.60
U5	60	200mA sub-min silicon diodes	0.60
U6	30	Sil. trans. NPN like BSY95A, 2N706	*0.60
U7	16	Sil. rect. 750mA up to 1000	0.60
U8	50	Sil. diodes DO-7 250mA like OA200/202	0.60
U9	20	Mixed voltages, 1 Watt Zener Diodes	*0.60
U10	20	BAY50 charge storage diodes DO-7	0.60
U11	20	PNP Sil. trans. TO-5 like 2N1132, 2N2904	*0.60
U13	30	PNP-NPN Sil. trans OC200 & 2S104	*0.60
U14	150	Mixed silicon and Germ. diodes	0.60
U15	20	NPN Sil. trans TO-5 like 2N696	*0.60
U16	10	3Amp Sil. rect. stud up to 1000 PIV	*0.60
U17	30	Germ. PNP AF trans. TO-5 like ACY17-22	*0.60
U18	8	6Amp sil. rect. BYZ13 up to 600 PIV	*0.60
U19	20	Silicon NPN trans. like BC108	*0.60
U20	12	1.5 Amp sil. rect. top hat up to 1000 PIV	0.60
U21	30	AF Germ. trans. 2G300 series & OC71	*0.60
U23	25	MADT's like MHz series PNP series	*0.60
U24	20	Germ. 1 Amp rect. GJM up to 300 PIV	0.60
U25	25	300MHZ NPN sil. trans. 2N708, BSY27	*0.60
U26	30	Fast switching sil. diodes like IN914	0.60
U29	10	1 Amp SCRs TO-5 up to 600 PIV	*1.20
U32	25	Zener diodes 400mW DO-7 3-33 volts mixed	0.60
U33	15	Plastic 1 Amp sil. rect. IN4000 series	0.60
U34	30	Sil. PNP trans. TO-5 BCY26, 2S302/4	*0.60
U35	25	Sil trans. PNP TO-18 2N2906	*0.60
U36	20	Sil. NPN trans. TO-5 BFY50/51/52	*0.60
U37	30	Sil. trans. SO-2 PNP OC200, WS322	*0.60
U38	30	Fast switch sil. trans. NPN 400MHz	*0.60
U39	30	RF. Germ. PNP trans. 2N1301/5 TO-5	*0.60
U40	10	Dual trans, 6 lead TO-5 2N2060	*0.60
U43	25	Sil. trans. plastic TO-18 BC113/114	0.60
U44	20	Sil. trans. plastic TO-5 BC115	0.60
U45	7	3A SCR TO66 up to 600 PIV	*1.20
U46	20	Unijunction trans. similar to TIS43	*0.60
U47	10	TO220AB plastic triacs 50V 6A	*1.20
U48	9	NPN sil. power trans. like 2N3055	*1.20
U49	12	NPN sil. plastic power 60W like 2N5294	*1.20

Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

UNTESTED TTL PAKS*

Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	= 12x7400	0.60	UIC70	= 8x7470	0.60
UIC01	= 12x7401	0.60	UIC72	= 8x7472	0.60
UIC02	= 12x7402	0.60	UIC73	= 8x7473	0.60
UIC03	= 12x7403	0.60	UIC74	= 8x7474	0.60
UIC04	= 12x7404	0.60	UIC75	= 8x7475	0.60
UIC05	= 12x7405	0.60	UIC76	= 8x7476	0.60
UIC06	= 8x7406	0.60	UIC80	= 5x7480	0.60
UIC07	= 8x7407	0.60	UIC81	= 5x7481	0.60
UIC10	= 12x7410	0.60	UIC82	= 5x7482	0.60
UIC13	= 8x7413	0.60	UIC83	= 5x7483	0.60
UIC20	= 12x7420	0.60	UIC86	= 5x7486	0.60
UIC30	= 12x7430	0.60	UIC90	= 5x7490	0.60
UIC40	= 12x7440	0.60	UIC91	= 5x7491	0.60
UIC41	= 5x7441	0.60	UIC92	= 5x7492	0.60
UIC42	= 5x7442	0.60	UIC93	= 5x7493	0.60
UIC43	= 5x7743	0.60	UIC94	= 5x7494	0.60
UIC44	= 5x7744	0.60	UIC95	= 5x7495	0.60
UIC45	= 5x7745	0.60	UIC96	= 5x7496	0.60
UIC46	= 5x7746	0.60	UIC100	= 5x74100	0.60
UIC47	= 5x7747	0.60	UIC121	= 5x74121	0.60
UIC48	= 5x7748	0.60	UIC141	= 5x74141	0.60
UIC50	= 12x7450	0.60	UIC151	= 5x74151	0.60
UIC51	= 12x7451	0.60	UIC154	= 5x74154	0.60
UIC53	= 12x7453	0.60	UIC193	= 5x74193	0.60
UIC54	= 12x7454	0.60	UIC199	= 5x74199	0.60
UIC60	= 12x7460	0.60	UIC XI	= 25 assorted 74s	1.50

V.A.T.

All prices EXCLUDE V.A.T.

Please add 8% to all prices marked *

Remainder add 25%

AVDEL BOND

SOLVE THOSE STICKY PROBLEMS!

with

CYANOACRYLATE C2 ADHESIVE

The wonder bond which works in seconds — bonds plastic, rubber, transistors, components permanently, immediately!

OUR PRICE ONLY 70p

for 2gm phial

VOLTAGE REGULATORS

TO.3 Plastic Encapsulation

uA.7805/L129 5V (equiv. to MVR5V)	1.25
uA.7812/L130 12V (Equiv. to MVR12V)	1.25
uA.7815/L131 15V (Equiv. to MVR15V)	1.25
uA.7818 18V (Equiv. to MVR18V)	1.25

D.I.L. SOCKETS

	1	25	100+
TS?24 24 pin type	0.69	0.64	0.62
BPS8 8 pin type (low cost)	0.14	0.12	0.10
BPS14 14 pin type (low cost)	0.15	0.13	0.11
BPS16 16 pin type (low cost)	0.16	0.14	0.12

DIODES

AA119	0.08	BYZ16	0.41
AA120	0.08	BTZ17	0.36
AA129	0.08	BYZ18	0.36
AAY30	0.09	BYZ19	0.28
AAZ13	0.10	CG62	
BA100	0.10	(OA91 Eq)	0.06
BA116	0.21	CG651	
BA126	0.22	(OA70-OA79)	0.07
BA148	0.15	OA5 Short	
BA154	0.12	Leads	0.21
BA155	0.15	OA10	0.14
BA165	0.14	OA47	0.07
BA173	0.15	OA70	0.07
BB104	0.15	OA79	0.07
BY100	0.16	OA81	0.07
BY101	0.12	OA85	0.09
BY105	0.18	OA90	0.07
BY114	0.12	OA91	0.07
BY124	0.12	OA95	0.07
BY126	0.15	OA200	0.07
BY127	0.16	OA202	0.07
BY128	0.16	SD10	0.06
BY130	0.17	SD19	0.06
BY133	0.21	IN34	0.07
BY164	0.51	IN34A	0.07
BYX38/30	0.43	IN914	0.06
BYZ10	0.36	IN916	0.06
BYZ11	0.31	IN4148	0.06
BYZ12	0.31	ISO21	0.10
BYZ13	0.26	IS951	0.07

SIL G.P. DIODES

300 mW 40 PIV (min) SUB-MIN
FULLY TESTED
Ideal for Organ builders
30 for 50p, 100 for £1.50, 500 for 5 1,000 for £9

G.P. SWITCHING TRANS*

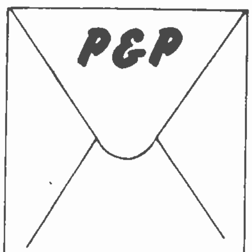
TO18 SIM. TO 2N706/8 BSY27/28/95A. All usable devices. No open and shorts. ALSO AVAILABLE IN PNP similar to 2N2906, BCY70.
20 for 50p, 50 for £1, 100 for £1.80, 500 for £8, £1,000 for £14.
When ordering please state NPN or PNP

GP 300

115 WATT SILICON TO3 METAL CASE

Vcbo 100V, Vceo 60V, IC 15A, Hfe 20-100 suitable replacement for 2N3055, BDY11 or BDY20.

1-24	25-99	100+
50p	**48p**	**46p**



Postage and packing add 25p. Overseas add extra for airmail. Minimum order £1

BI-PAK

PO BOX 6, WARE, HERTS

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON

STEREO FM TUNER

OUR PRICE ONLY

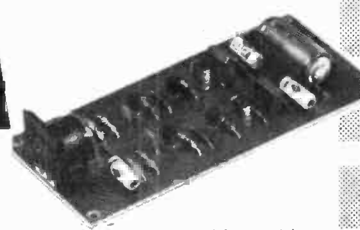
£19.95 Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T461.**
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

★ FET Input Stage
★ VARI-CAP diode tuning
★ Switched AFC
★ Multi turn pre-sets
★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

£2.65

VAT ADD 25%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER

PA100

OUR PRICE **£13.50**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

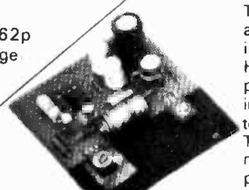
Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to RIAA curve with 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.
Dimensions 299mm x 89mm x 35mm

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £27.55.** plus 62p postage

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £9.20** plus 62p postage.

AL10-20-30 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 devices 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 home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV. RMS**

AL10 3w R.M.S. £2.30 **AL20 5w R.M.S. £2.65** **AL30 10w R.M.S. £2.95**

STEREO 30

COMPLETE AUDIO CHASSIS
7+7 WATTS R.M.S.

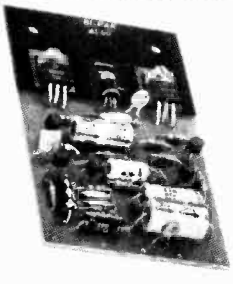
P & P 45p

£15.75

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £3.65 plus 62p p & p.

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,5, 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.

£3.95

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.50

PS12

Power supply for **AL10/20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.20

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.00

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ELECTRONIC COMPONENTS DISTRIBUTOR FOR INDUSTRY AND HOBBYIST

MONTHLY SPECIALS

— Close out Sale Special Purchase While They Last —

CT 5001	12 Digit 4 Funct.	.59	CT 5006	12 Digit 4 Funct. w/Mem	.79
CT 5002	Batt Oper 5001	.69	CT 7001	4 or 6 Digit Alarm	3.50

— Memories Are Made of These Specials —

1101	256 - Bit Ram Mos.	.99	5262	2048 - Bit Ram	3.95
1103	1024 - Bit Ram Mos.	1.45	1702A	2048 - Bit Prom.	9.95
5260	1024 - Bit Ram	1.45	5203	2048 - Bit u/Violet Proms	8.95
5261	1024 - Bit Ram L/power	1.45	2102	1024 - Bit Status Ram	2.75

TTL

7447	.59	74123	.39
7475	.29	74145	.49
7490	.35		

ICL 8038 Funct. Gen Volt Contr Oscillator Sine Sq. 1.95

9-Digit LED display Comm. Cathodes Comp w/8-digit Clk Chips 12" Char 1.95

TTL 7400 SERIES

7400	£ 0.11	7440	£ 0.11	7485	£ 0.85	74155	£ 0.69
7401	0.11	7441	0.60	7486	0.24	74156	0.69
7402	0.11	7442	0.55	7488	2.50	74157	0.69
7403	0.11	7443	0.55	7489	1.50	74158	0.69
7404	0.13	7444	0.60	7490	0.40	74160	0.89
7405	0.13	7445	0.75	7491	0.55	74162	0.89
7406	0.22	7446	0.85	7492	0.43	74163	0.89
7407	0.22	7447	0.75	7493	0.43	74164	1.05
7408	0.14	7448	0.65	7494	0.49	74165	1.05
7409	0.14	7450	0.12	7495	0.49	74166	1.05
7410	0.11	7451	0.13	7496	0.55	74170	1.65
7411	0.16	7453	0.13	74100	0.89	74175	0.90
7413	0.26	7454	0.14	74107	0.27	74180	0.80
7416	0.22	7460	0.11	74121	0.27	74181	2.50
7417	0.22	7470	0.24	74122	0.37	74182	0.80
7420	0.11	7472	0.21	74123	0.49	74192	0.90
7426	0.23	7473	0.25	74145	0.57	74193	0.85
7430	0.12	7474	0.25	74150	0.59	74194	0.85
7432	0.22	7475	0.37	74151	0.59	74195	0.80
7437	0.25	7476	0.26	74153	0.69	74198	1.70
7438	0.25	7483	0.69	74154	1.05	74199	1.70

HIGH SPEED 74H00

74H00	£ 0.16	74H20	£ 0.16	74H52	£ 0.16	74H71	£ 0.21
74H01	0.16	74H21	0.16	74H53	0.16	74H72	0.26
74H04	0.16	74H22	0.16	74H54	0.21	74H74	0.28
74H05	0.21	74H30	0.16	74H55	0.16	74H76	0.28
74H08	0.16	74H40	0.16	74H60	0.16		
74H10	0.16	74H50	0.16	74H61	0.16		
74H11	0.16	74H51	0.21	74H62	0.16		

CMOS 4000 SERIES

4000A	£ 0.19	4014	£ 1.10	4028	£ 0.95	4071	£ 0.23
4001	0.19	4015	1.10	4030	0.50	4072	0.25
4002	0.19	4016	0.55	4042	0.95	4073	0.25
4006	0.90	4019	0.67	4043	1.20	4075	0.25
4007	0.19	4020	1.15	4044	1.20	4078	0.25
4008	1.30	4021	1.10	4049	0.48	4081	0.25
4009	0.49	4023	0.19	4050	0.48	4082	0.29
4010	0.49	4024	0.85	4066	0.75	4528	0.85
4011	0.19	4025	0.19	4068	0.23	4585	1.25
4013	0.39	4027	0.75	4069	0.23		

DTL

930	£ 0.10	936	£ 0.10	944	£ 0.10	962	£ 0.10
932	0.10	937	0.10	946	0.10	963	0.10

LINEARS

LM300	TO99	£ 0.45	340U	TO92	£ 1.25	739	A DIP	£ 0.65
301	V DIP	0.29	380	A DIP	.80	741	V DIP	0.22
302	TO99	0.45	381	A DIP	1.05	747	A DIP	0.44
304	TO100	0.50	546	V DIP	0.51	748	V DIP	0.27
305	TO99	0.60	550	A DIP	0.55	5556 (1456)	V DIP	0.65
307	V DIP	0.38	555	V DIP	0.45	5558 (1458)	V DIP	0.65
	TO99	0.45	556	B DIP	0.75	ULN 2111	A DIP	0.95
308	A DIP	0.59	560	B DIP	2.55	LM3900	A DIP	0.35
	TO99	0.79	561	B DIP	2.55	75450	V DIP	0.45
309K	TO3	1.45	562	B DIP	2.55	75451	V DIP	0.45
310	T pkg	0.65	565	A DIP	1.25	75452	V DIP	0.45
311	V DIP	0.90	566	V DIP	1.20	75453	V DIP	0.45
320K	TO 3-NEG		567	V DIP	1.25	75454	V DIP	0.45
	5.2, 12, 15	1.25	709	A DIP	0.22	75491	A pkg	0.65
324	A DIP	1.07	710	A DIP	0.25	75492	A pkg	0.75
339	A DIP	1.49	711	A DIP	0.30	ICL8038 Funct Gen Volt Contr Oscillator, Sine, Sq		1.95
340K	TO3 12V 1 AMP	2.10	723	A DIP	0.38			

V = Mini Dip A = 14L Dip B = 16L DIP TO99 8-Pin Header TO100 10-Pin Header
Data sheets supplied on request. Add .20 ea. excepted as noted.

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1101	256 Bit Ram Mos	£ 1.79
1103	1024 Bit Ram Mos	2.25
7489	(8225) 64 Bit Ram TTL	1.50
8223	Programmable ROM	2.50
5260	1024 Bit Ram Low Power	1.95

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5002	Cal Chip	1.19
5005	Cal Chip	1.49
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5312	Clock Chip	2.95
5313	Clock Chip	2.95
5314	Clock Chip	3.45
5316	Clock Chip	3.95
Data only for any of above Refundable Against Purchase		0.50

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MAN I Red 7 Seg .270"	1.30
MAN 3A Red Seg. .127	.35
MAN 5 Green 7 Seg. .270	1.75
MAN 6 .6 Solid Seg.	2.50
9 Digit Array Fairchild 37 with clear magnifying lens	2.95

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2N 2219A	TO5	£ 0.37	2N 4124	TO92	0.10
2N 2222	TO18	0.15	2N 4126	TO92	0.10
2N 2369	TO18	0.10	2N 4401	TO92	0.10
2N 2905A	TO5	0.38	2N 5225	TO92	0.10
2N 3227	TO18	0.32	2N 5226	TO92	0.10

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SPIT MOTOR WITH CARTER GEAR BOX, probably one of the best spit motors made Originally intended to be used in very high priced cookers, however, this can be put to plenty of other uses for instance your garden barbecue or to drive a colour disc for a dance or display or to drive a tumbler for stone polishing in fact, there is no end to its uses Normal mains operation Special price during January and February £2 50 + 20p. post 30p + 2p

MULTIPLE CONTACT PANEL, size approx 4½" x 2¼", this has 200 contacts each cross referenced above and below alphabetically and numerically so each can be easily identified Contacts are capable of making positive connection with a strip or wire as each contact is spring loaded and has a gold "pip" Ideal if you want to make yourself a computer or for circuit bread-boarding (resistors etc plug straight in) or for working out printed circuits, even for teaching electronics and novelties such as puzzles combination locks, etc Taken from unused computer panels price only £2 + 16p each which works out to only 1p per contact, probably less than the value of the gold pip Post 15p + 1p

REMEMBER 7.029? Electricians of the old school most certainly will, and most will agree how much better this is than its modern replacement 1 5 mm It has greater current carrying capacity (20 amps against 13 amps) and being stranded it will not break so easily and being larger it is easier to use A fortunate buy enables us to offer 3 core 7 029 cheaper than we could offer 3 core 1 5 mm, namely £8 against £11 If you are contemplating installing a ring main, an immersion heater storage heaters or fires then you should definitely buy some of this cable It is p v c covered correctly colour coded and up to all British standards, in fact, was made by one of our most famous cable companies Price £8 + 64p per 100 metre coil Carriage £2 50 + 20p

REED RELAY IN SOLENOID, Resistance 1 5K, this will operate from voltages of 10v upwards or a current of 1.2mA upwards The flow of the control current closes the reed switch but if you bias this with a small magnet or an opposing current then the flow of the control current could be made to open the reed switch Price 75p + 6p

MULTI-TURN POTS, American made ' rlL 2K-20K These are an expensive control but perform a most useful function Limited stocks £1 00 + 8p each

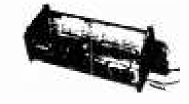
19-PIECE SOCKET SET. These were a very popular line when we last had them, we have just secured a further delivery Covering sizes from ¼" to 15/16" with ratchet handle and two 'L' shaped handles altogether in a wall mounting holder A must for every man s bench, also useful for carrying in your car Price £1.40 + 11p, post 50p + 4p

CAR ELECTRIC PLUG, another item which we have been out of stock for some time but which has just come in again Fits in place of a cigarette lighter so is a useful method of making a quick connection into the car electric system for a mini immersion heater, razor cassette player, etc Price 58p + 5p each

NYLON DRIVE CORD. We are always getting asked for this in the shop so we expect quite a lot of our post customers are needing it too Standard 6 ft lengths suitable for most receivers Price 20p + 5p per length

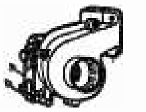
LUBRICANT AEROSOL. You have probably often found the need to lubricate inaccessible places the aerosol we have is just right for this, you can direct it in a fine spray The lubricant forms a dry film, it is in fact ICI Fluon L169 Price 45p + 4p per can or 12 cans £4 + 32p

TANGENTIAL HEATER UNIT



This heater unit is most efficient and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller, 2kW element, and 1kW element allowing switching 1, 2 and 3 kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet Only needs control switch. **£5.82** plus post & VAT £1 2kW Model as above except 2kW **£4.25** plus VAT & post 75p. Don't miss this Control Switch **44p**. P.&P. 40p.

CENTRIFUGAL BLOWER



Miniature mains driven blower centrifugal type blower unit by Woods. Powerful but specially built for quick running—driven by cushioned induction motor with specially built low noise bearings. Overall size 4½" x 4½" x 4". When mounted by flange, air is blown into the equipment but to suck air out, mount from centre using clamp Ideal for cooling electrical equipment or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering, etc, etc. A real bargain at **£3.30** + 60p post & VAT

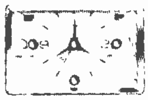
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of flex cable Wired up ready to work. **£2.75**, VAT & postage 65p

AUDIO AMPLIFIER

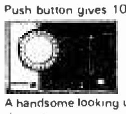
Part of the famous Reditune background music system secondhand but believed in good order However no guarantee, we are selling for spares value only These are 6 valve amplifiers the output valves are 2 x EL 84 in push/pull complete with mains transformer, rectifier and ample smoothing equipment The mains transformer alone, today would cost at least £4 Size is 9½" x 5½" x 4½" Price only **£2.00** + postage & VAT £1 50

15A ELECTRICAL PROGRAMMER



Learn in your sleep Have radio playing and kettle boiling as you awake — switch on lights to ward off intruders — have a warm house to come home to All these and many other things you can do if you invest in an electrical programmer Clock by famous maker with 15 amp on/off switch Switch on time can be set anywhere to stay on up to 6 hours Independent 60 minute memory jogger A beautiful unit Price **£2.95**. VAT & Postage 60p or with glass front chrome bezel **£1.50** extra

SMITHS CENTRAL HEATING CONTROLLER



Push button gives 10 variations as follows (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only — then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating Supplied complete with wiring diagram Originally sold we believe at over **£15** — we offer these while stocks last at **£6.95** each VAT & Postage 85p each

TERMS: Where order is under £5 please add 30p surcharge to offset packing expenses

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12V MINIATURE RELAY with plastic dust cover This has 4 sets of gold plated change-over contacts, the offical rating of which we are not sure, but they look plenty big enough for 5 amps Size of the relay 1⅛" high x ¾" wide x 1⅛" thick Price £1 + 8p

110V OPERATED CONTACTOR. This has 4 sets of 10 amp contacts. This is really a relay but much more robust than the normal type and with bakelite separators between the contacts to prevent flashovers If it is not convenient to work two of these in series 230/240 volts, then use a condenser in series to cut down the voltage A real bargain at £1 50 + 12p which is less than half manufacturer s price.

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PULSE TRANSFORMER with circuit for sound to light unit It is a very simple circuit and all parts are readily obtainable from us or you may already have them in your junk box Price of the transformer with circuit 75p Post and V A T paid

ORP 12 LIGHT CELL. This device has been going for some years now but it has not been bettered and new applications keep being found for it We have good stocks, price 65p + 5p

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PAPST MOTOR. These are German made but a very special feature about them which has made them popular for use in tape recorders and other applications requiring a very constant speed is that instead of the centre rotating it is in fact the outer which rotates and this being a fairly heavy casting acts as a flywheel or capstan These motors are also capacitor start so easy to reverse We have just received delivery of a 200-240v AC papst motor, maker's ref KLZ 32-50-4-3500 which we estimate to be 1/40th HP, size is 3" diameter 3" high Price £6 + 48p, post 40p + 3p We also have a **similar, but slightly larger motor** (estimated 1/20th HP), 115v working, price £2 50 + 20p, post 30p + 3p

110 R.P.M. MOTOR. We have good stocks of very well made (American) induction motor coupled to gear box reducing speed to 100 r.p m

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MLM 304 G 20 mA 0 1 40 0 V Negative	£1.25
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1 Amp	Positive Voltage—£1.20	Negative Voltage—£1.60
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12 Volt	MC 7812 CP	MC 7912 CP
15 volt	MC 7815 CP	MC 7915 CP
18 volt	MC 7818 CP	MC 7918 CP
24 volt	MC 7824 CP	MC 7924 CP
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All from Monsanto MAN Series

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Please specify colour height and type number reqd

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CMOS common cathode MC 14511 CP	£1.23
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Motorola

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Signetics	
Data/Applications book over 1600 pgs	£4.00
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No V A T this section

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W23 and W24 are available up to 27 kΩ all other standard values available

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1N 4004	400 V	£0.08
1N 4005	600 V	£0.09
1N 4006	800 V	£0.10
1N 4007	1000 V	£0.13
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MR 501	100 V	£0.17
MR 502	200 V	£0.18
MR 504	400 V	£0.20
MR 506	600 V	£0.25
MR 508	800 V	£0.29
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MR 750	50 V	£0.27
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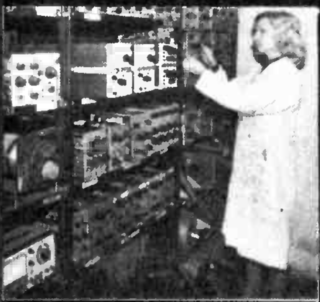

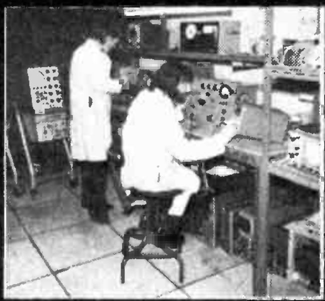

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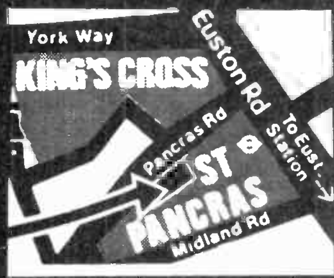

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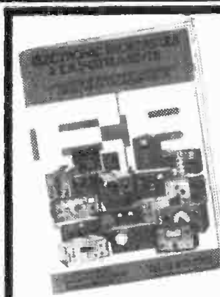

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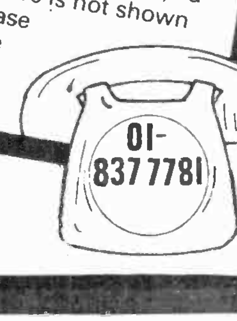

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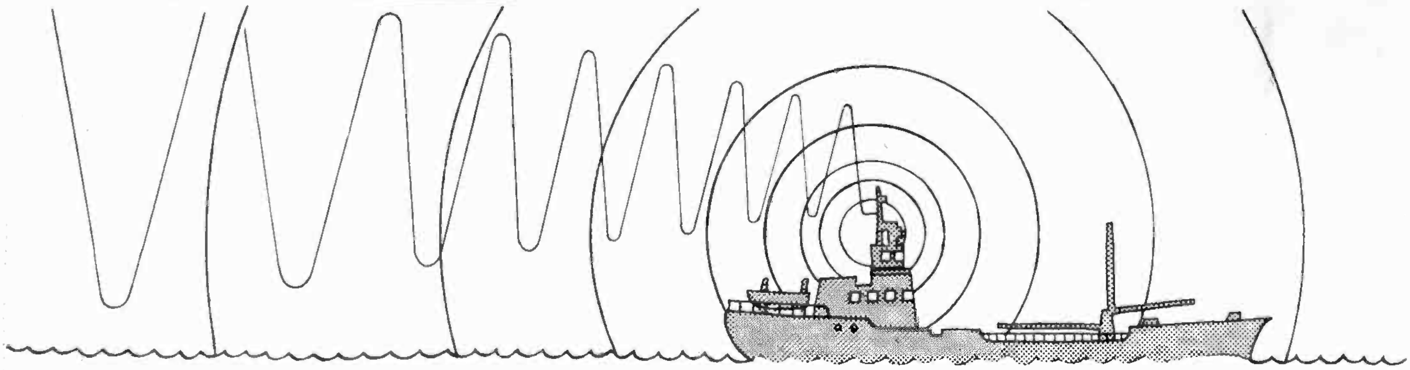

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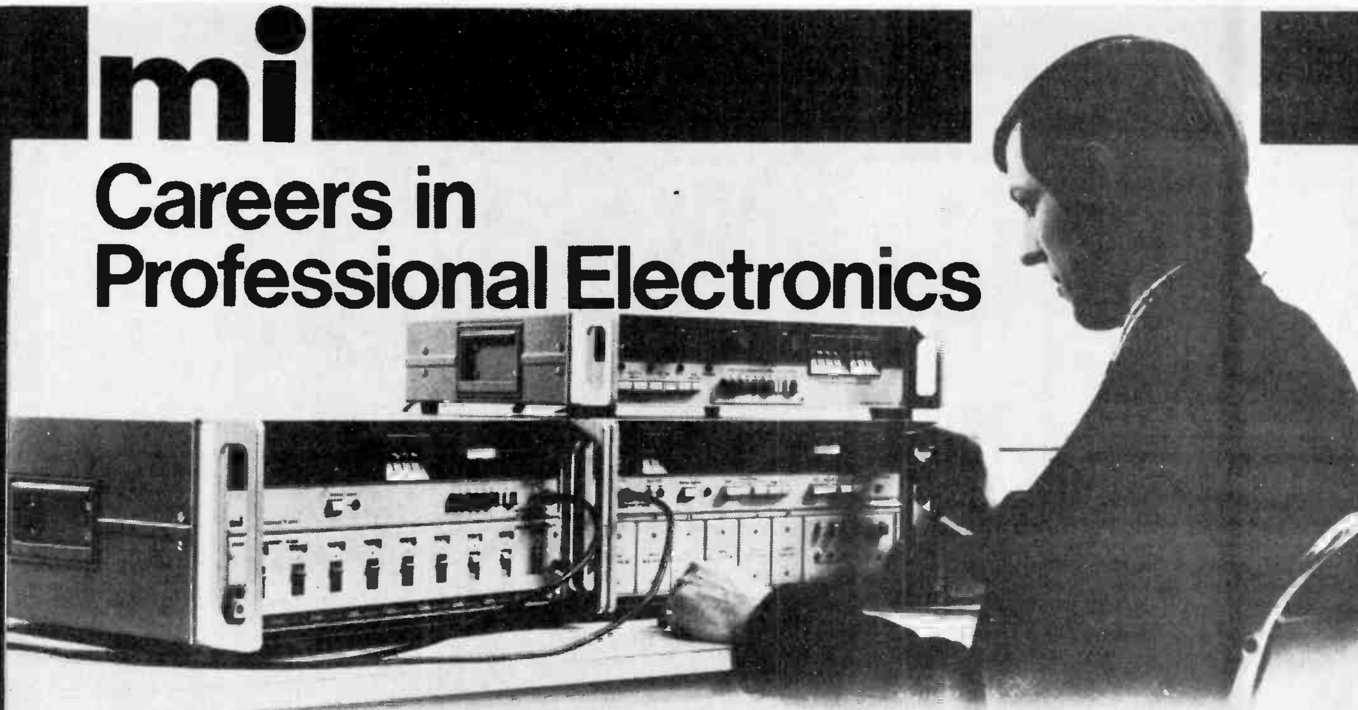

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Dolby Laboratories Inc.
346 Clapham Road
London, S.W.9
Tel. 01-720 1111

ELECTROSONIC
S E LONDON

INSTALLATION ENGINEERS

The hire department requires an engineer to set up equipment in the factory and install and operate on site. The equipment is principally for exhibition and audio presentation and includes lighting and audio systems.

Essential requirements are attention to detail with a mature and a presentable manner. The job will appeal to young engineers with an interest in electronics and travel. A clean driving licence is desirable. Salary according to age and previous experience in the range £2000-£2600 + overtime and allowances.

Applications should be made by telephone or in writing to: Mr. R. D. Naisbitt, Personnel Director, Electrosonic Ltd., 815 Woolwich Road, London, SE7. Tel: 01-855 1101.

(5177)

DOLBY SYSTEM®

APPLICATIONS ENGINEER

Dolby Laboratories manufacture and market professional noise reduction equipment which is widely used by major recording companies, recording studios and broadcasting authorities throughout the world. The Company has enjoyed successful growth from incorporation in 1968, and recent promotion leads to the present vacancy.

Reporting to and working closely with the International Sales Manager the person appointed will be involved in all technical aspects of sales, e.g. field servicing, providing technical information to overseas distributors and directly to customers, giving demonstrations and training courses, and visiting recording studios and broadcasting organisations, both in the UK and abroad.

The successful applicant will be an electronics engineer who enjoys dealing with people and problems. Aged between 25 and 35 he or she will probably have a degree and may well have experience of recording studio or broadcasting practice. European languages would be useful but are not essential.

Salary is expected to be around £4,000 but the right person may justify more.

Write with brief details, or telephone:

ELMAR STETTER, International Sales Manager
Dolby Laboratories Inc., 346 Clapham Road, London SW9 9AP
Tel: 01-720 1111

(5180)

Looking for a new job?

Perhaps we can help!

We have regular contact with hundreds of electronics and electrical companies needing qualified electronics engineers and technicians and TV service engineers.
We can, therefore, help you to find an interesting and well paid job. All you need to do is to return the coupon below or give us a ring. Our service is confidential and costs you nothing.

TJB Technical Services Bureau,
3A South Bar,
Banbury, Oxfordshire.
Banbury (0295) 53529

TJB

Technical Services Bureau is a division of Technical & Executive Personnel Ltd and is solely concerned with job placement in the Electronics and Electrical Industries

Please note that this service is available only for engineers who are (or will be) available in the U.K. for interview.

Please send me an "Application for Registration" form
NAME ....
ADDRESS ....
....
.... (90)

TEST GEAR ENGINEERS

Rediffusion, a major British company in television manufacture, is developing a new, state of the art receiver at its Chessington laboratories. To support this project we require additional Test Equipment Design and Development Engineers at senior and intermediate levels to help produce our sophisticated production test equipment. Rediffusion test equipment leads the industry and uses both analogue and digital techniques along with an up-to-date approach to jigging.

Applications are invited from well qualified and experienced test equipment engineers, who will be offered the opportunity to join a young and energetic team. Our work is usually demanding, often under pressure but always stimulating, using new ideas to speed production testing whilst reducing the demands on our test operators.

Salaries, which will depend on experience, are excellent and assistance with relocation will be given where appropriate. Some travelling to our production factories in Co. Durham will be necessary from time to time to assist in the installation and commissioning of new equipment since our design engineers are expected to be responsible for all aspects of their project.

If you are a high calibre engineer and wish to have your ability recognised and rewarded, come and join us.

Write or 'phone to:

A. J. Litteck,
Test Equipment Group Leader,
Rediffusion Consumer Electronics Ltd.,
Fullers Way South,
Chessington, Surrey.
Phone 01-397-5411

REDIFFUSION

(5164)

Systems Engineers

Complex Systems North London

The company is Crosfield Electronics, a leader in the field of sophisticated electronics equipment for the printing industry. They need engineers to work on final testing of systems involving analogue, digital electronics and a degree of optical and photographic functions.

The right people will be aged 20 to 32 and either up to HNC standard with three to five years' relevant experience or with a suitable service background. Knowledge and experience of computer software and hardware would obviously be an important advantage.

A starting salary depending on age and experience will be attractive and benefits are all those expected of a company that is a member of the De La Rue Group.

Please write with brief career details to: Miss L. Geers, Crosfield Electronics Limited, 766 Holloway Road, London, N19.

(5139)

CROSFIELD
ELECTRONICS

UNIVERSITY OF EDINBURGH

SENIOR TECHNICIAN

required by

AUDIO-VISUAL SERVICES

Duties include the operation and maintenance of a C.C.T.V. studio including telecine and helical scan video tape recording and editing facilities, provision of video and audio recording/replay facilities outwith studio and maintenance of university departments' video and audio equipment.

Applicants must be qualified and have worked for a minimum of 5 years in a C.C.T.V. or broadcast studio complex and have a sound knowledge of electronics with diagnosing and repairing experience. The post is one of responsibility and requires drive, initiative and tact in dealing with technicians in the unit and academics using the facilities.

Salary on scale £3666-£4122 p.a. Annual holidays 4 working weeks and 4 days, plus public holidays. The names and addresses of two referees will be required.

Applications, quoting post reference No. A161, should be addressed to the Personnel Officer, University of Edinburgh, 63 South Bridge, Edinburgh EH1 1LS. Telephone: 031-667 1011, ext. 4446.

(5172)

CHELSEA COLLEGE
University of London

ELECTRONICS TECHNICIAN

GRADE 5

required for a new SRC research contract to work on a wide band tuning range microwave solid state oscillator. A high level of skill in electronic design and construction and experience in microwave techniques is essential. The appointment is for two years. Salary in the range £3161-£3617 inclusive. Application forms and further information from Mr. M. E. Cane (5ER), Department of Electronics, Chelsea College, Pulton Place, London SW6 5PR.

(5173)

UNIVERSITY OF ABERDEEN

ELECTRONICS TECHNICIAN

required for the Department of Medical Physics for work in developing and servicing electronic instruments used in Aberdeen Hospitals. The successful candidate will work as a member of a team of graduates and technicians in a hospital environment and will have an opportunity of experience in the application of electronics to medicine. Applicants should hold an ONC (or equivalent qualification) and have about 4-5 years' experience. Salary on scale £2325-£2655 with appropriate placing.

Applications giving details of age, qualifications and experience should reach the **Secretary, University Office, Regent Walk, Aberdeen, AB9 1FX,** by 1st March and quote Ref. No. 12/76.

(5125)

The Polytechnic of North London

Department of Chemistry

Applications are invited for the following appointment:

Laboratory Technician (Grade 4)

Required immediately in the spectroscopy laboratories of the Department. The main duties will involve the maintenance and development of electronic instrumentation.

Applicants should have practical experience in electronics but specific knowledge of spectroscopic instruments is not essential.

Normally candidates should hold C & G/IST Ordinary Certificate, ONC or C & G Part 2 (or equivalent) in Electronics subjects, and have seven years' experience.

Salary scale: £2559-£2940 plus £411 London Allowance.

Apply for further details and application form to the Head of the Department of Chemistry, The Polytechnic of North London, Holloway Road, London N7 8DB.

(5132)

Opportunities in the

ELECTRONICS FIELD

People with analogue or digital qualifications / experience seeking higher paid posts in: TEST - SERVICE - DESIGN SALES.

Phone: Mike Gernat, Ref. W.W.

NEWMAN APPOINTMENTS
360 Oxford Street, W.1,
01-629 0501 (94)

UNIVERSITY OF LIVERPOOL
DEPARTMENT OF INORGANIC, PHYSICAL AND INDUSTRIAL CHEMISTRY

ELECTRONICS TECHNICIAN

Required to assist with construction development and maintenance of electronic equipment for teaching and research purposes. Candidates must possess ONC, HNC or an appropriate equivalent qualification and have several years' experience. Salary within a range up to £3,207 per annum. Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool, L69 3BX. Quote ref. RV/679/WW.

(5199)

RCS ELECTRONICS have the following vacancies: Electronic Engineer with general electronic experience for work on 74 Series Logic R.F. and Digital Circuits. Design & Development Engineer with wide experience in R.F. and Digital Equipment. Apply: R.C.S. Electronics, National Works, Bath Road, Hounslow, Middx. Phone: 01-572 0933. (5140)

COMPUTER SERVICE ENGINEERS

Sintrom Electronics, leading suppliers of minicomputer systems and peripherals, are continuing to expand and require several engineers to service their high technology products.

The work is varied and will provide adequate opportunities for promotion and career development within the company.

Field Service Engineers

To install, commission, and provide after sales service on a broad range of products. The job involves travel around Southern England with occasional visits to Europe to assist our local Agents. The work is both interesting and challenging and will provide an excellent foundation for progress into Sales or Design.

The rewards are substantial and include a company car and other fringe benefits.

Junior Engineer

We have a vacancy for a young engineer to perform in-house repairs on equipment. This is an ideal opportunity to learn about computer equipment and electronics in general and will provide for progression into Field Service with its additional benefits. Some knowledge of fundamental electronics is required but training will be given in all relevant fields. This is a vacancy which could provide a solid career for the right applicant.

For further details of these vacancies write or telephone:

SINTROM ELECTRONICS LIMITED

Colin Richards — Service Manager
2 Arkwright Road
Reading, Berks.
RG2 0LS

Tel. Reading (0734) 85464

(5175)

DISTRICT WORKS DEPARTMENT
Electronic and Bio-Medical Engineering Section

TECHNICIAN

A Technician is required for the above Department, to be responsible for the maintenance of medical, mechanical and electronic apparatus used by the Hospital. The technician will carry out a continuous servicing and overhauling programme to ensure that the equipment in their charge will run at the peak of its available efficiency at all times.

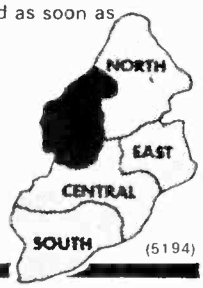
Salary: Dependent on qualifications and experience.

Application Form and Job Description to be obtained from District Works Officer, Dudley Road Hospital, Dudley Road, Birmingham B18 7QH.

Complete Application Forms to be returned as soon as possible.

Please quote Ref. 12511/WW.

West Birmingham Health District



(5194)

BIRMINGHAM AREA HEALTH AUTHORITY (TEACHING)

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Siemens is one of the world's biggest international electrical and electronics organisations.

Behind us, 10 years of consistent growth in Britain.

Ahead of us, a vigorous programme for continued expansion.

That's why we now require an.....

Electronics Service Engineer

This work involves the servicing of Siemens closed circuit TV– used in hospital installations for X-ray examination.

Despite the medical application of the equipment, someone with around 3 years experience of basic TV maintenance (and preferably a C&G or R.T.E.B. Final) would have sufficient qualifications–as full training will be given in specialist areas of the job.

Offering a competitive salary, this position is based at our West-End headquarters.

A company car will be provided for travel around London and the Home Counties.

Add four weeks holiday, a generous benefits package (including non-contributory retirement, widow's and children's pension schemes), and it's easy to see why Siemens' growth in quality staff is keeping pace with its expansion in commercial success.

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Write to: Miss C. M. Lewis, Siemens Limited, Medical Group, 15-18 Clipstone St., London W1P 8AE. Tel: 01-580 2464

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Crown Agents

CROWN AGENTS

TELECOMS PROJECT STAFF

As consulting engineers we are compiling a register of former members of the BPO or overseas telecommunication administrations with suitable qualifications who would be willing to undertake assignments either in the UK or overseas on contract terms for short periods of from 3 to 24 months in connection with telecommunication projects; including traffic studies and forecasts, development planning feasibility studies, external line plant planning, radio route surveys, exchange engineering, project management, installation and commissioning.

Interested applicants should write to Crown Agents, Appointments Division, 4 Millbank, London SW1P quoting reference M5/510/12/WF, and giving brief details of qualifications and experience.

Natural Environment Research Council
BRITISH ANTARCTIC SURVEY
WIRELESS OPERATOR MECHANICS

required for expedition to spend approximately 30 months in Antarctica.

Applicants must be single and aged 22-30. They should have experience of maintaining and operating SSB transmitters and receivers, Teleprinter experience desirable.

Salary from £2,060 per annum depending on qualifications and experience. Low income tax, polar clothing and messing free.

For further details and an application form, please write stating full qualifications and experience to:

Establishment Officer, British Antarctic Survey, 2 All Saints Passage, CAMBRIDGE CB2 3LS. Tel: Cambridge (0223) 61188. Please quote ref. BAS 12.

(5192)

UNIVERSITY OF ST. ANDREWS
Department of Psychology
Technician Grade 5 (Electronics)

Applications are invited for the above post in the Electronics Workshop of the Psychology Department. Applicants should have a good electronics background together with practical experience in the development and construction of digital equipment and the design of computer interfaces.

The person appointed will work together with other members of the technical staff on the development of on-line experimental facilities using the Department's Data General computers. Experience with small general purpose digital computers and a knowledge of programming languages is desirable. The duties will also involve the use and maintenance of other electronic equipment in the Department.

Salary scale £2751-£3207. Applications, with full details of career to date, and the names of two referees, should be sent to the Establishments Officer of the University, College Gate, St. Andrews, Fife, by 22nd March, 1976.

(5191)

PROGRESSIVE COMPANY
seeks services of
YOUNG ENGINEER

with experience of VHF Marine and land mobile equipment. Suit keen amateur ham. Driving experience an advantage, good salary and expenses by negotiation.

Frank Cody Electronics Ltd., 40 Sunbury Cross Centre, Sunbury-on-Thames, Middx. Tel. Sunbury-on-Thames 88705. (5158)

KELLY COLLEGE, TAVISTOCK, DEVON. (HMC. 275 boys 13-18, 28 VIth Form girls, country town 15 miles from Plymouth). Graduate required September, 1976, to teach Physics to A Level. Wireless station, electronics club. Rugger/hockey player especially welcome. Own sailing, canoeing, fishing. Bachelor accommodation. Apply to the Headmaster with curriculum vitae, naming two referees. (5179)

RADIO-TELEPHONE Service Engineer Wanted for workshops in S. London, must be reilable and experienced. Salary neg. 680 1010. (5141)

SITUATIONS WANTED

EX SENIOR DIRECTOR for Electronics Components Distributor in late fifties seeks management position in London or South East after premature retirement. If you are interested in vigorous healthy man with 10 years' experience in running a company with significant success, please contact BBox No. 5185.

SWEDISH ELECTRICAL ENGINEER, 33, spec. Mobile Radio VHF UHF, English, Swedish, German seeks inter. empl., pref. Canada. Please reply Box No. (5121)

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Prototype or long run — we will supply your printed circuit requirements
Also facilities for Design, Assembly and Test
Prompt and efficient service assured

contact David Webster
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Appointments

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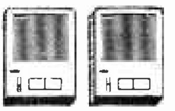
WIRELESS INTERCOM

All prices incl. VAT



Each unit plugs into the mains & transmits down the mains cable (up to ¼-mile of wiring is possible) **£12 below the recommended price at ONLY**

£19.20 + 75p P&P

ULTRASONIC REMOTE CONTROL SWITCH

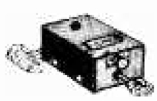
£14 below recommended price

By pointing the transmitter at the receiver, mains appliances (TV's, radios, lights, etc.) can be switched on/off. 600 watt max Range up to 40ft.

ONLY £14.95 + 65p P&P

240V MAINS AC/DC CONVERTOR

SIX VOLTAGE model



Switchable 3, 4½, 6, 7½, 9 & 12 volts DC at 500 mA Metal case, pilot light and on/off switch Output to std battery cut-out plug. **Unique 4-way multiplug** to suit almost all radios/cassettes/calculators. **50p extra.**

ONLY £4.95 + 45p P&P

CAR SOLDERING IRON

12 volt, 30 watt, complete with lead and lighter plug.

Spares available. **ONLY £1.25** + 30p P&P

240v mains 40 watt iron **£1.95** + 30p P&P

C.3025 TRANSISTOR CHECKER

—miniature, neat, compact checker for germanium and silicon transistors — PNP/NPN flick switch selection rotary settings for B & Iceo factors. Panel meter. 9v internal battery Quick check socket. Metal case List price £9.55 — our price **£3.95** plus 35p P&P

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Fast delivery of prototype and production quantities to your specification. EG

100 KHz	0.005%	HC13/U	£2.50 each: £1.900 per 1,000
1 MHz	0.005%	HC6/U	£2.50 each: £1.600 per 1,000
2.097152 MHz	0.0025%	HC6/U	£3.05 each: £1.550 per 1,000
3.2768 MHz	0.0025%	HC6/U	£2.70 each: £1.500 per 1,000
10 MHz	0.002%	HC18/U	£2.00 each: £1.100 per 1,000

Also, Statek L.F. crystals in TO-5 package, many stock frequencies in the range 10-240 KHz, e.g., 10, 12.8, 16.384, 32.768 & 100 KHz, prices from £2.55 each: £1.400 per 1,000.

Please send for further details.

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VACUUM is our speciality, new and second-hand rotary pumps, diffusion outfits, accessories,, coaters, etc. Silicone rubber or varnish outgassing equipment from £40. V. N. Barrett (Sales) Ltd., 1 Mayo Road, Croydon. 01-684 9917. (24

60 KHz MSF RUGBY RECEIVERS. BCD TIME-OF-DAY OUTPUT. High performance, phase locked loop radio receiver. 5V operation with LED indication. Kit complete £9.50; assembled and tested unit £11.12 (prices include postage and V.A.T.) Also available low power receiver with signal and audio outputs. Send for details Toolex, Sherborne (4359) Dorset. (21

TIDY PACK with 6 different sizes of heat shrink sleeving each 1M in length 100 self-locking cable ties and a roll of black PVC tape. All for only £2 inc. VAT & PP. B.D.O. Products Ltd. Retail Division, 13A Heath Road, St Albans, Herts. (5090

WE INVITE ENQUIRIES from anywhere in the World. We have in stock several million carbon resistors ⅛th, ¼, ½, and 1 watt. ½ million wire wound resistors 5 and 10 watt — 1 million capacitors — 1 million electrolytic condsensers — ½ million transistors and diodes, thousands of potentiometers, and hosts of other components. Write, phone or call at our warehouse — Broadfields & Mayco Disposals Ltd., 21 Lodge Lane, N. Finchley, London, N.12. 01-445 0749, 445 2713. (5097)

Demonstration/ Service Engineer

T.V. Broadcast Equipment

This is an interesting opportunity within the Planning and Installation Department of Pye TVT in Cambridge. As a major manufacturer of TV broadcast equipment, we can provide excellent scope to a capable engineer with an outgoing personality who can combine technical expertise with organising ability.

Main duties will include maintaining and controlling TV broadcasting studio equipment; demonstrating it to customers either in our own demonstration studio or elsewhere and assisting in after sales follow-up activities both in the UK and overseas.

A good standard of general education is required together with technical qualifications appropriate to TV broadcasting, e.g. HNC or City & Guilds. Previous experience of colour TV studio systems, preferably with a broadcasting organisation, is essential and applicants must be capable of carrying out and demonstrating performance tests.

Write with details of experience and qualifications to Mrs. J. A. Macnab, Personnel Manager, Pye TVT Limited, Coldhams Lane, Cambridge CB1 3JU.

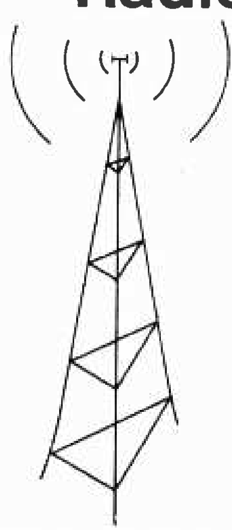
(5126)

Pye TVT Limited
PO Box 41 Coldhams Lane
Cambridge England CB1 3JU
Tel: Cambridge (0223) 45115
Telex: 81103

A member of the Pye of Cambridge Group

Are You Interested In

Radio or Television



and do you have some knowledge or practical experience in these fields

then the Metropolitan Police may have a job for you as a Radio Technician

we offer

Good pay
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Phone our Engineer Mr. H. G. Fielding on 01-653 0881, during office hours, to arrange an informal interview, or write to Metropolitan Police, Telecommunications Dept., Room 1627, New Scotland Yard, Victoria Street, London SW1H 0BG.

THE BRITISH COUNCIL

KING FAISAL UNIVERSITY, DAMMAM, SAUDI ARABIA

ENGINEER

For TV Studios and Equipment

An Assistant Project Engineer is required for August 1976, possibly earlier, for the maintenance of TV Studios, Video and Language Laboratory equipment, for a Language Service Centre.

Applicants, men only, with suitable qualifications and/or experience.

Salary: £4969-£5524 p.a.

Benefits: Allowances of £750-£1500 according to marital status. Free furnished accommodation; travel costs; outfit and baggage allowances; passage-paid annual home leave.

One-year contract, probably renewable.

Further particulars and forms of application obtainable from Overseas Educational Appointments Department, The British Council, 65 Davies Street, London W1Y 2AA. Please quote reference 75 AU 107-116.

(5157)

TRANSFORMER DEVELOPMENT ENGINEER

REQUIRED:

Must have a sound knowledge of wound component design and associated circuitry. Experience in TV wound components preferred. This person must be able to work with a minimum of supervision.

Position entails direct liaison with customers.

Attractive salary will be offered to the successful applicant.

Please write giving details of experience and qualifications to:

Managing Director
ST. IVES WINDINGS LIMITED
4 Edison Road, Industrial Estate, St. Ives
Huntingdon, Cambs. PE17 4LT

(5155)

product engineer

Grampian, a member of the Telephone Rentals group, manufacture a wide range of audio and telephone equipment. We have a vacancy for a Product Engineer to work in conjunction with Development and Production Departments to ensure the satisfactory introduction into production of new items of equipment, and to provide technical support for equipment already in production. We are seeking somebody with previous Product Engineering experience within the Electronics Industry, having suitable technical knowledge and qualifications to enable them to appreciate the production implications of circuit design and equipment practice. In return we offer a competitive salary and generous Pension and Life Assurance schemes.

For application form or further details please contact Mr. G. N. Turner

Grampian

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(5195)

ARTICLES FOR SALE

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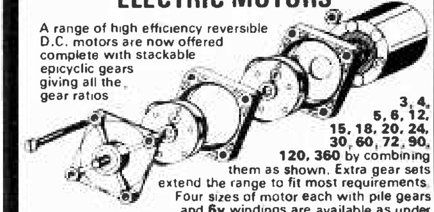

A range of high efficiency reversible D.C. motors are now offered complete with stackable epicyclic gears giving all the gear ratios 3, 4, 5, 6, 12, 15, 18, 20, 24, 30, 60, 72, 90, 120, 360 by combining them as shown. Extra gear sets extend the range to fit most requirements. Four sizes of motor each with pile gears and **6v** windings are available as under

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EM136P 1½ watts, 5000rpm size 24 × 24 × 74mm Max. gearbox torque **2kg.cm**	6.55
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EM141P 8 watts, 5000rpm size 35 × 35 × 109mm Max. gearbox torque **5kg.cm**	7.40
EM141P/1 Spare gear set with 3.4 5.6 ratios	2.10
EM145P 20 watts 7000rpm size 52 × 52 × 180mm Max. gearbox torque **10kg.cm**	9.55
EM146P 30 watts 4000rpm. size 52 × 52 × 200mm Max. gearbox torque **10kg.cm**	11.80
SPECIAL OFFER 'Gearbox pack'. All items above	34.00
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EM131. 0 8 watts, 20g cm 8000rpm, ϕ17mm	4.65
EM136. 1 2 watts, 40g cm 5000rpm, ϕ21mm	4.35
EM139 4 2 watts, 160g cm 5000rpm, ϕ30mm	4.15
EM141 8 watts, 320g cm, 4500rpm, ϕ30mm	4.85
SPECIAL OFFER "Motorpack". All motors above	16.00

Suggested applications. Laboratory equipment, stirrers pump drives, servo systems, positioning of aerials, dampers doors, power for models trains, boats, drills, cutting wheels etc **SAE for DATA SHEETS. All prices are inclusive in U.K**

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TDA1415 15V 450mA		75	72	70
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BC182. 184		12	11.5	11
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H-P 0.2" LED red + clip		19	18	17
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7400	13	12
7402	13	12
7403	13	12
7404	15	13
7405	15	13
7410	13	12
7413	28	24
7420	13	12
7430	13	12
7442	60	54
7447	85	80
7473	28	24
7474	30	26
7476	30	26
7486	28	24
7490	45	38
7492	55	50
7493	45	38
74121	33	28

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4001	16	15
4002	16	15
4006	104	95
4007	17	16
4008	95	88
4009	50	46
4010	50	46
4011	16	15
4012	16	15
4013	45	40
4014	90	82
4015	85	80
4016	48	44
4017	85	80
4020	99	93
4023	16	15
4024	68	62
4025	16	15
4027	48	44
4028	78	71
4030	48	44
4040	93	85
4046	117	107
4049	48	44
4050	48	44
4068	17	16
4071	16	15
4078	17	16
4081	16	15
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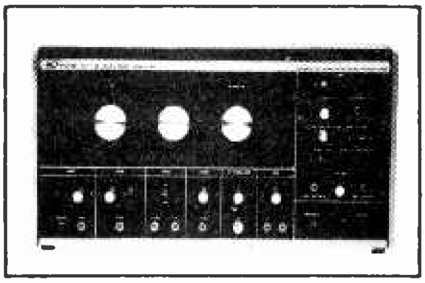

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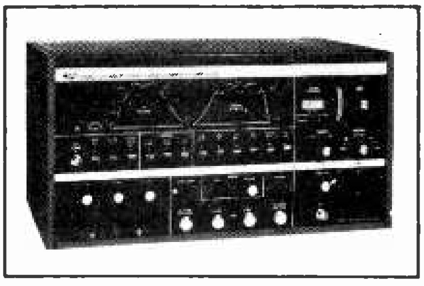

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- ★ Addo 5/8 track Tape punches £48.00

We have a varied assortment of industrial and professional Cathode Ray Tubes available. List on request.

INSTRUMENTATION-TAPE RECORDER-REPRODUCERS

- ★ Ampex TM2 4 speeds, 7 tracks ½"
- ★ Ampex FR-1100, 6 speeds, 2 tracks ¼"
- ★ Ampex FR600, 4 speeds, 7 tracks ½"
- ★ Ampex FR600, 4 speeds, 14 tracks 1"
- ★ D.R.I. RM1 4 speeds, 4 tracks ¼"
- ★ EMI BTR1, 1 speed, 1 track ¼"
- ★ EMI R301G, 2 speeds, 2 tracks ¼"
- ★ Mincom CMP-100, 6 speeds, 7 tracks ¼, ½, 1"
- ★ Racal T.5000, 2 speed, 7 tracks ½"
- ★ Leevers Rich DA-2P, 2 speeds, 2 tracks ½"

Prices of above £70 to £400

Also Transport Decks only available

COMPUTER HARDWARE

- ★ PRINTER, High speed 1000 lines p.m.
- ★ TAPE READER, High speed 5/8 track 800 c.p.m.
- ★ CARD READER 80 col. 600 c.p.m.

Prices on Application

PLEASE ADD CARRIAGE AND V.A.T. AT APPROPRIATE RATE TO ABOVE

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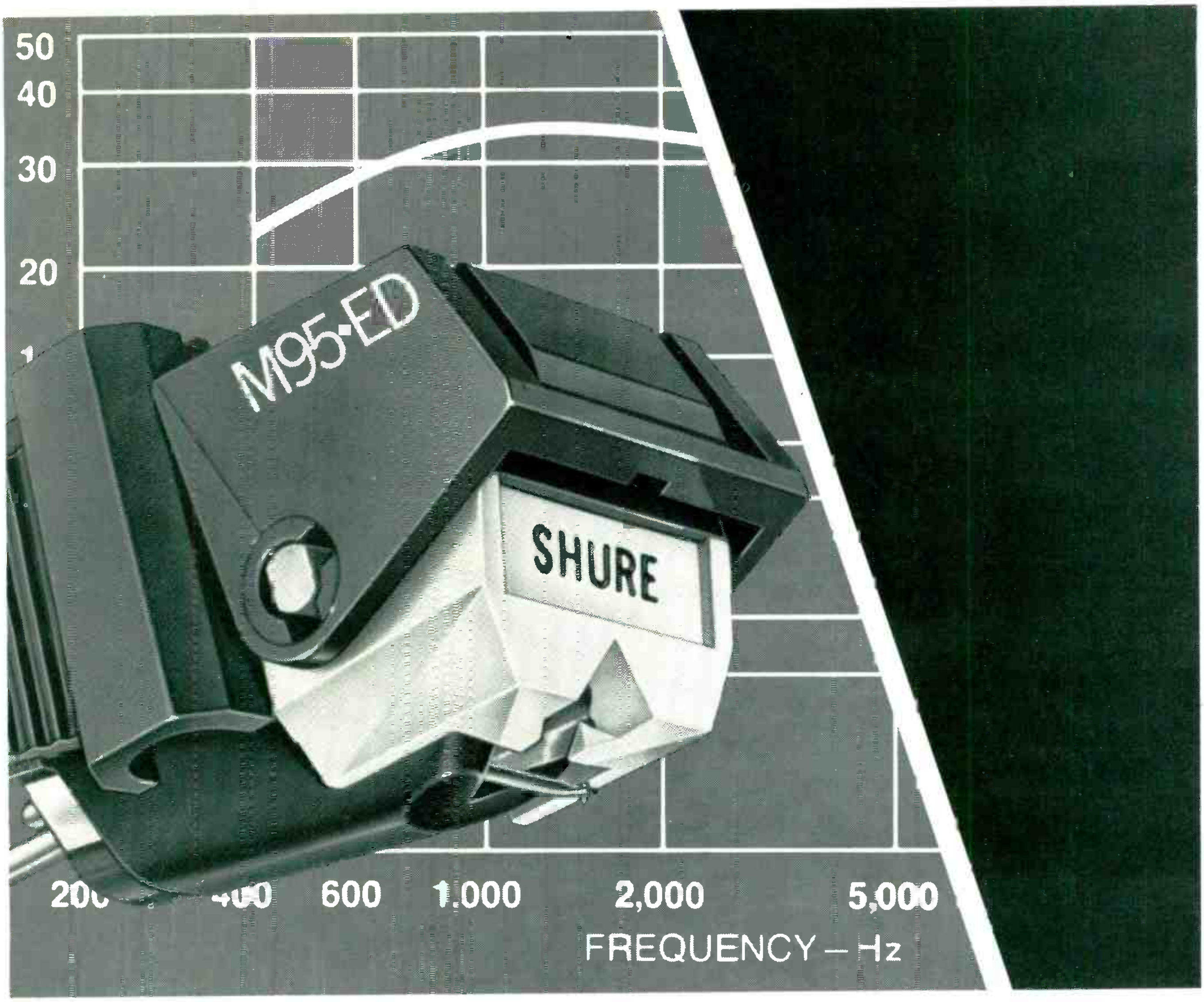
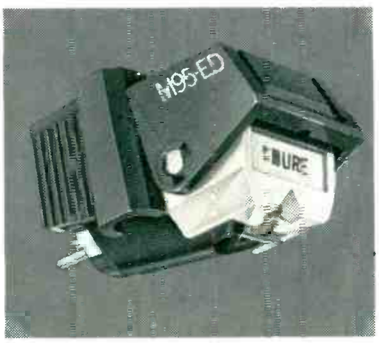


M95ED: A Significant Technological Innovation



Shure now introduces a superb, moderately priced pick-up cartridge with a performance second only to the renowned V-15 Type III. The technologically advanced electromagnetic structure with a newly designed pole-piece virtually eliminates hysteresis loss. The frequency response from 20 to 20,000 Hz remains essentially flat. Operating at extremely light tracking forces of between ¾ and 1½ grams, the exceptional trackability of the M95ED enables it to trace the very high recorded velocities encountered on many modern recordings with the result that in addition to providing faithful reproduction of the recorded sound, stylus and record wear are reduced to minimum proportions. The M95ED: A notable addition to the Shure range with a performance never before available at such a competitive price.

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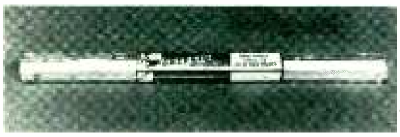
WW—002 FOR FURTHER DETAILS

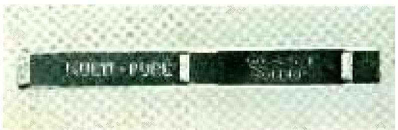
Multicore– the complete answer for printed circuit soldering.

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.





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.

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 solving 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.

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:
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Tel: Hemel Hempstead 3636. Telex: 82363.