wireless world

JANUARY 1982 70p

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Clandestine radio

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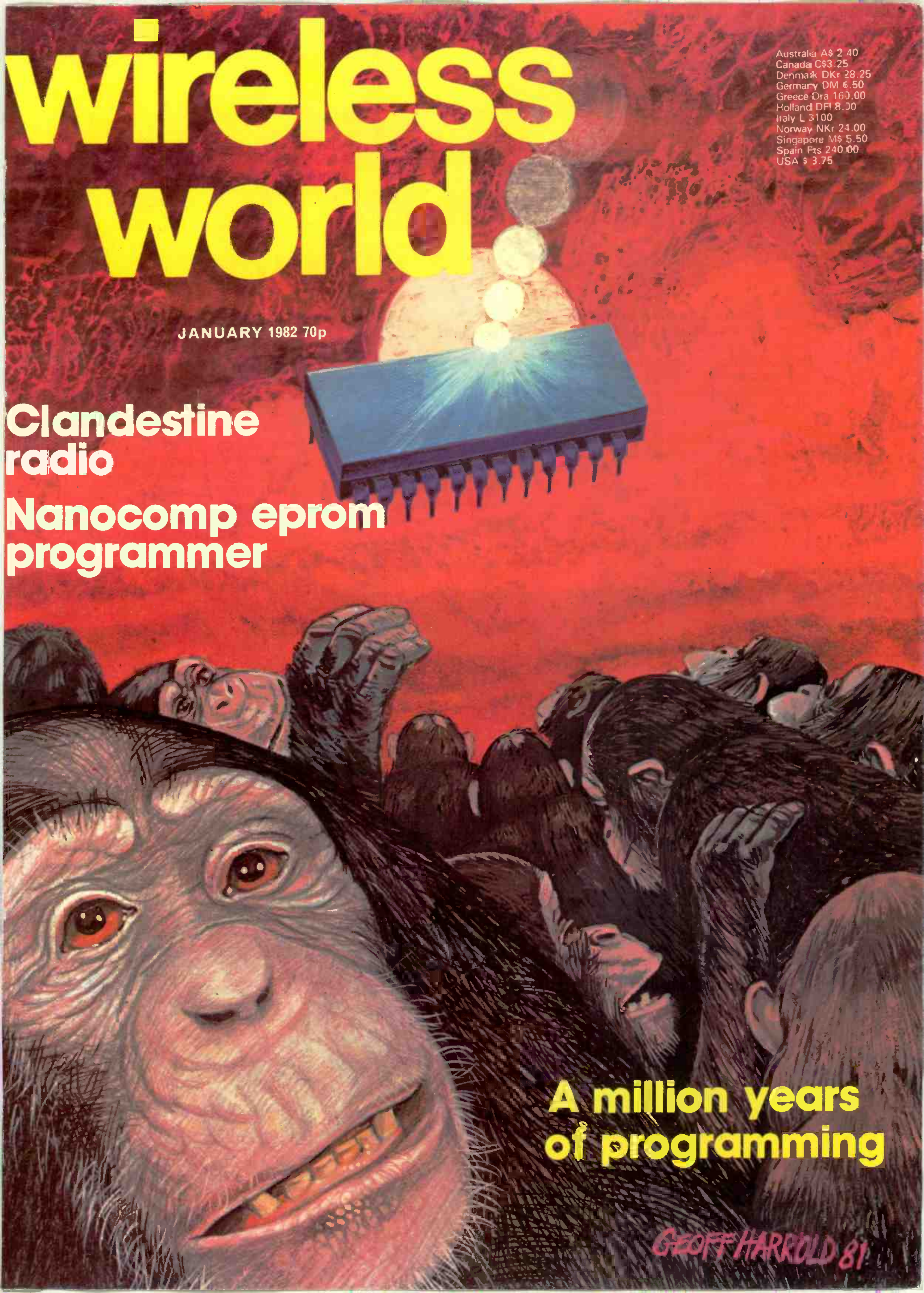
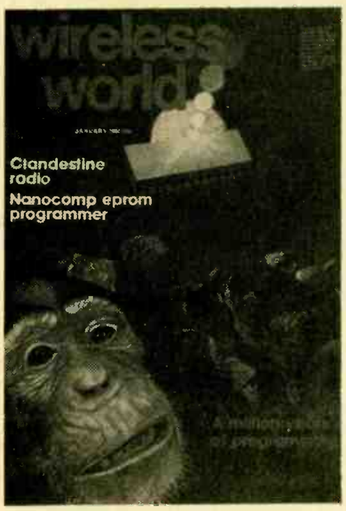


A million years of programming

wireless world

ELECTRONICS
TELEVISION
RADIO
AUDIO

JANUARY 1982 Vol 88 No 1552



Front cover picture, painted by Geoff Harrold, is discussed in this month's editorial "A million years of programming".

IN OUR NEXT ISSUE

Video camera interface allows a microcomputer to accept, store and display a picture generated by a television camera.

Cassette data recording at high speed on a low-cost audio recorder is obtained by circuit used for Open University's Radiotext project.

Active-deflector television improves reception of u.h.f. transmissions in remote areas of poor signal strength.

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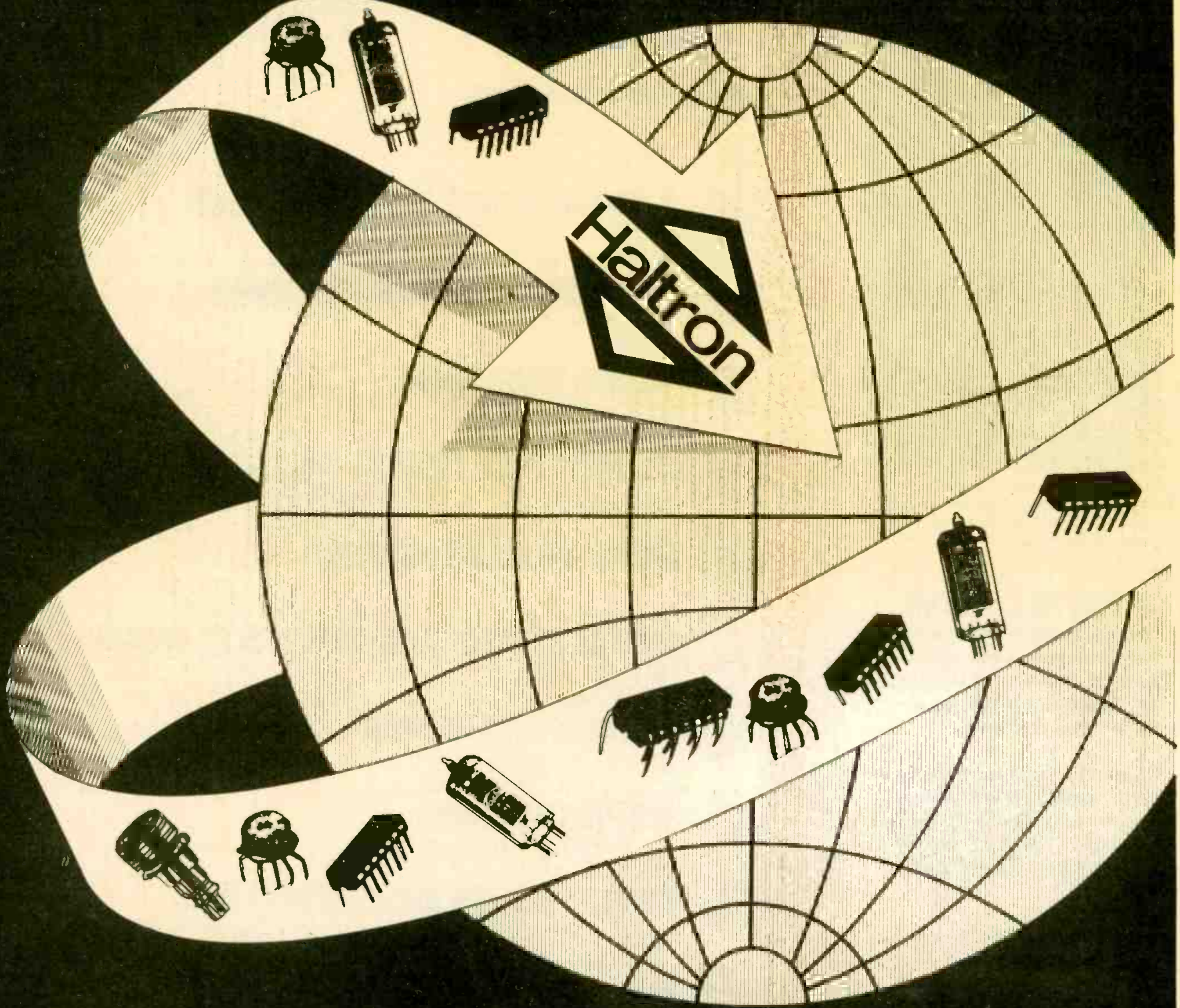
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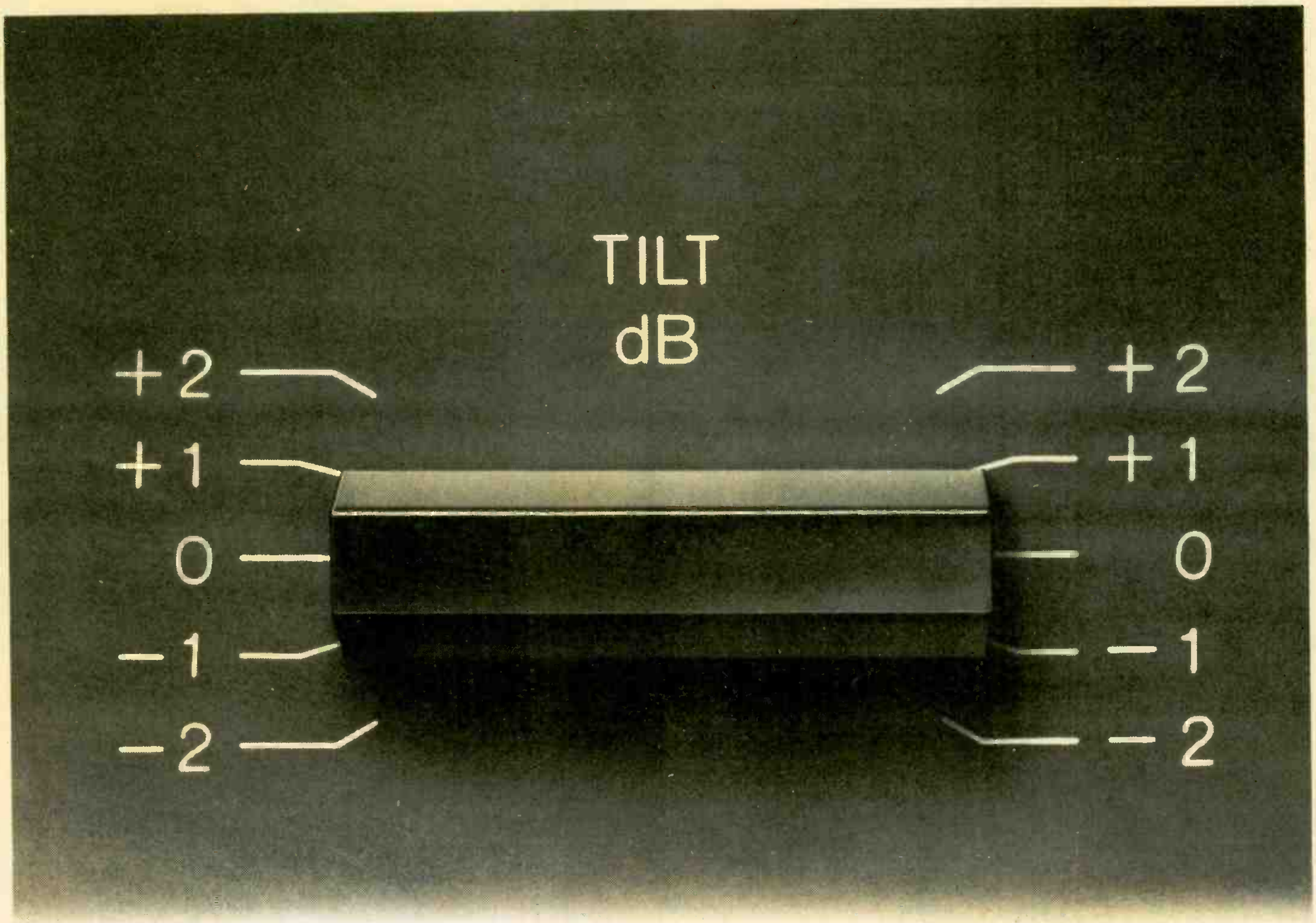

Tilt.

Nothing to do with pinball wizardry, has a great deal to do with programme balance.

The recording or broadcast engineer attempts to capture the ambience of the studio or concert hall but what the listener perceives is the aggregate of this and the reverberation characteristics of his listening room.

If all listening rooms were equal the engineer could make due allowance, but since some listening rooms are more equal than others, the engineer has to assume some arbitrary norm, and the chances are that further correction and compensation will give improved results. Thus a reverberant recording reproduced in a 'live' listening room will sound overbright and a dry recording reproduced in an overdamped or 'dead' room will sound dull and bass heavy.

The tilt control on the Quad 44 cannot alter the reverberation characteristics of your room but by gently sloping the frequency response of your system about a centre point, chosen to maintain a constant overall subjective level, it can produce a more natural programme balance, without introducing unwanted colouration.

If you are in any doubt that the listening room characteristics have a fundamental effect upon the final results try listening to the same record played on the same equipment in two different rooms.

To learn all about the Quad 44 write or telephone for a leaflet.

The Acoustical Manufacturing Co. Ltd., Huntingdon PE18 7DB.
Telephone: (0480) 52561.

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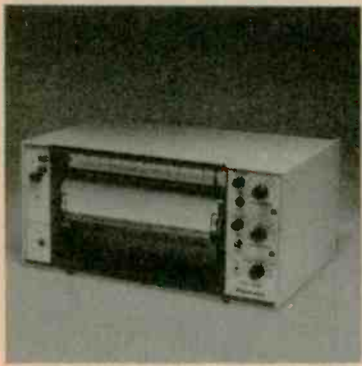
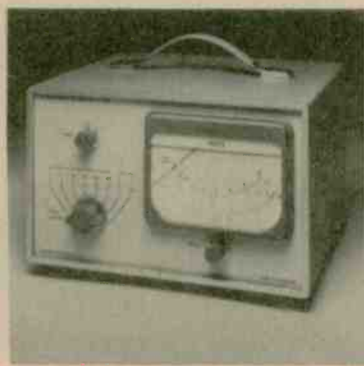
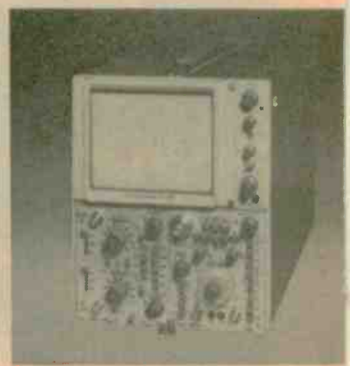


Yokagawa
3047 2 Channel Chart Recorder. 0.5mV-100V: 2cm/hr-60cm/min. **£435.00**

Marconi
TF995B/2 unused condition. AM/FM Signal Generator 200KHz-220MHz. 1µV-200mV. 75KHz deviation on FM ... **£750.00**



Marconi
TF2603 R.F. Electronic Millivoltmeter 1mV—3V r.m.s. in 8 ranges 50KHz-1500MHz Supplied with accessories in case ... **£525.00**



Telequipment
D83 Oscilloscope with S2A—V4 plug ins DC—50MHz 5mV—20V/div full delayed sweep ... **£725.0**

ANALOGUE VOLTMETERS AND MULTIMETERS

AVO
EA113 Electronic Multimeter ... **£115.00**

Marconi.
TF2600 AC Millivoltmeter. 10Hz-5MHz. 1mV-300V ... **£175.00**
TF2603 RF Millivoltmeter 300µV Sensitivity 50KHz-1.5GHz ... **£525.00**
TF2604 Electronic Voltmeter. AC 20Hz-1.5GHz. 300mV-1KV. DC 10mV-1KV. 0.2Ω-500MΩ ... **£350.00**

ANALYSERS

Dymar
1771 Wave Analyser 20Hz-50KHz ... **£275.00**

General Radio.
1911A Sound and Vibration Analyser. C/W Graphic level recorder. 4.5Hz-25KHz. 1/3 or 1/10 octave ... **£950.00**

Hewlett Packard
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332A Distortion Meter 5Hz-600KHz ... **£495.00**
333A Distortion Meter with Auto null **£675.00**
8407A/8412A Network Analyser ... **£1950.00**

Marconi
TF2370 Spectrum Analyser. 30Hz-110MHz. 0.1dB and 5Hz resolution ... **£6500.00**

Tektronix
R491 Spectrum Analyser 10MHz-40GHz ... **£3500.00**

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Marconi
TF1313 Univ Bridge 0.25% ... **£395.00**
TF1245A + TF1246 'Q' meter ... **£1100.00**
TM4520 Set of Inductors ... **£350.00**

Rohde & Schwarz.
LRT (BN6100) Inductance Meter 1pH-100µH. 2.2-285KHz ... **£395.00**

Wayne Kerr
B221 + Q221 Bridge ... **£250.00**
B601 R.F. Bridge ... **£395.00**
B801 VHF Admittance Bridge ... **£450.00**
B901 VHF Admittance Bridge ... **£350.00**
SR268 Source and Detector ... **£875.00**
B801B S161. R161 Admittance Bridge. Source and Detector LCR 1MHz — 100MHz 2% ... **P.O.A.**

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184 Time-mark Generator with markers from 100nS to 5S Sinewave 10, 20 and 50nS 1 volt into 50Ω ... **P.O.A.**
191 Constant Amplitude Generator. 350KHz-100MHz ... **£350.00**

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TF2430 unused condition. 7 digit 10Hz-80MHz 25MV Sensitivity ... **£175.00**
TF2431 Frequency Calibrator ... **£250.00**

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A243 5½ Digit DMM. AC/DC volts. resistance. 1µV resolution. 30 day warranty ... **£375.00**
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7065 plus processor control and RS232 interface ... **£995.00**

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AVO 8 20KΩ/volt ... **£70.00**
Full lead kit ... **£6.25**

S.E.I.
Super 50 Selectest. 20KΩ/volt ... **£77.00**

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182C + 1805A + 1825A 100MHz Dual Trace ... **£1250.00**
140B—C52 + 1415A TDR Set-up in mint cond ... **£750.00**

Marconi.
TF2213/1 + TK2214 X-Y Display and memory ... **£550.00**

SE Labs
SM121 6 Ch. nnel Monitor. 12" crt. internal sweep ... **£395.00**

Tektronix.
465 Dual Trace Portable Oscilloscope. DC — 100MHz 5mV-5V/div. Full delayed sweep ... **£1350.00**
465B Dual Trace Portable DC-100MHz 5mV-5 volts/DIV. Full Delay Sweep ... **£1650.00**
466 Dual Trace Portable Storage Oscilloscope. Spec as per 464 but max writing speed 3000div/µS ... **£2875.00**
475 200 MHz portable Scope ... **£2000.00**
5403 with 5A18N 2MHz Dual Trace plug-in. 5A21N 1MHz differential plug-in. 5B42 Delay Sweep plug-in ... **P.O.A.**
7603 mainframe complete with 7A18N 5mV Sensitivity 75MHz bandwidth. 7B53N Delay Sweep T'base ... **£3000.00**

Telequipment.
D75 Dual Trace Portable Oscilloscope. NEW TUBE 5mV Sensitivity. DC — 50MHz delay sweep ... **£750.00**

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EB90 X1 Probe. 1.2 mtr length DC — 20MHz ... **£7.00**
EB91 X10 Probe 1-2 mtr length DC — 100MHz ... **£8.50**
EB95 X1. X10 Probe. 1.2 mtr length DC — 10MHz or DC — 100MHz ... **£11.50**

Tektronix
P6013 12KV 1000 x Probe ... **£175.00**
P6019 Current Probe with 134 amplifier. 1mA to 1A/DIV 12Hz — 40MHz ... **£175.00**

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Advance.
MG5-60 5V @ 60A switching ... **£160.00**
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Racal.

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TEST EQUIPMENT

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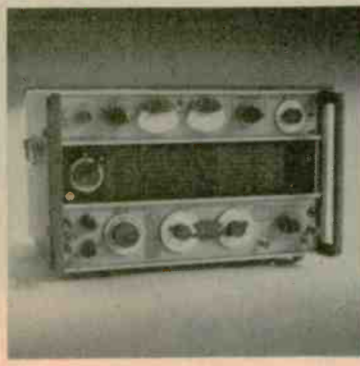

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G1C Stereo Generator. Internal or ernal modulator. 100MHz carrier at mV-100mV £375.00

Philips
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Marconi
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F VHF Signal Generator 455MHz £600.00
B UHF Signal Generator 1 8 to 4 2GHz Int e Mod £1000.00
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1 60/2 UHF Signal Generator - 200MHz £495.00

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TF2002B AM/FM Signal Generator. 10KHz-88MHz. 0.1μV-1V. 20Hz-20KHz Mod frequency £1200.00
TF2005R 2 Tone Signal Source. 20Hz-20KHz 0-111dB in 0.1dB steps £295.00
TF2015 AM/FM Signal Generator 10-520MHz 0.2μV to 200mV £995.00
TF2361 Sweep Generator with TM9693 Plug in to give 1-300MHz with internal or external markers. TM9695 attenuator 0.5-500m Volts in 1dB steps. TM9701 UHF detector. TM9558 RHO-Bridge to measure V.S.W.R. £1500.00

Philips.
PM6456 Stereo Generator Separate L and R Signals. Carrier frequency 100MHz ± 1%. RF O/P 3mV pk-pk £250.00

Radiometer
SMG1 Stereo Generator L or R Channel internal or external modulation. 100MHz carrier at 10MV to 100MV £375.00

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1983 Sound Level Meter. 70-120dB. A weighting £195.00

T.V. TEST EQUIP

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TF2343 Quantization Distortion Tester checks A.F. to A.F. distortion of P.C.M. Systems £600.00

Siemens.
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W2007 + D2007 Carrier Level Test Set. 6KHz-18.6MHz. —120 to +20dB £1800.00

Wandel and Golterman.
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8745A S Parameter Test Set. Fitted with 11604A Universal Arms 0.1-2GHz £2750.00

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TK2214 X-Y Memory £250.00
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TF2500 AF Power Meter. 7 ranges 100μ watts to 25 watts. Impedance 2.5Ω to 20KΩ in 40 steps £275.00
TF2950/5 mobile Radio Test Set AM/FM Sig Generator, modulation meter, in line power meter to 25 watts AF Oscillator and AF Voltmeter to cover mobile bands 65-470 MHz £1550.00
TM8339 AC/DC mixer for TF2702 .... £295.00

Miles Hivolt
IT30 Insulation Tester ministry version CT587/3 (mint) £850.00

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PM9380 Camera and Accessories (as new) £200.00

Rohde and Schwarz.
MSC Stereo Coder. 30Hz-15KHz £500.00

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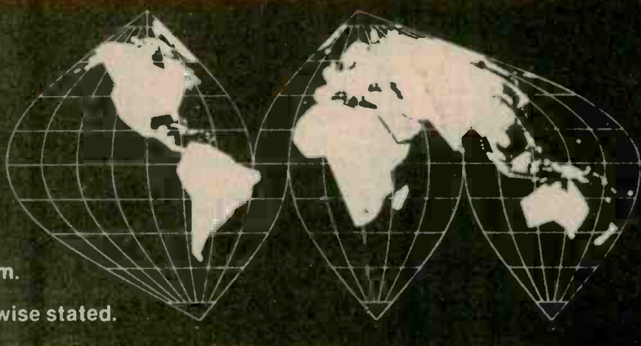

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RL211 10 meg and ctl	£3200.00
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RJM02 RM02 and ctl	£11,500.00
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RJP04 RP04 and ctl	£7950.00
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VT52 DECScope, 20mA or RS232	£525.00
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PDP8E 8KW Core	£1350.00
PDP8E 16KW Core	£2145.00
MM8AA 8KW Core	£500.00
MM8AB 16KW Core	£995.00
MM8E 4KW Core	£175.00
MM8EJ 8KW Core	£795.00
MS8-CB 32KW MOS	£750.00
AD8E Analogue/Digital	£695.00
BE8A Omnibus Expander	£395.00
DK8EA Real Time Clock	£150.00
DP8EB Communications Adaptor	£395.00
DR8EA Parallel I/O	£175.00
G111 Memory Sense/Inhibit module	£150.00
G227 Memory XY Driver module	£40.00
H220 Memory Core module	£125.00
H724A Power Supply	£275.00
KA8E Positive I/O Bus	£95.00
KC8EA Front Panel module only	£125.00
KC8M Operators panel	£150.00
KC8ML Programmers Panel module	£125.00
KD8E Databreak	£145.00

KE8E Extended Arithmetic	£695.00
KG8EA Redundancy Check	£75.00
KL8E Asynchronous Interface	£175.00
KL8JA Asynchronous Interface	£275.00
KL8M Modem Control	£175.00
KM8E Memory extension	£195.00
KP8E Power Fail	£95.00

CABINETS

DEC
A Selection of 6ft, 4ft and low-boy cabinets usually available — please ring for latest stocks

PAPER TAPE PUNCHES

Digitronics P135/20 paper tape punch. Solenoid-actuated unit capable of punching 5 to 8 channel tapes at speeds up to 35 cps. Pulse amplitude 27 VDC compact table-top unit
SPECIAL CLEARANCE OFFER—ONLY **£45.00**
Facit 4070 top quality paper tape punch that has become an industry standard. Asynchronous 75 cps operation. Adjustable for punching 5, 6, 7 or 8 level tape. Self-contained desk-top unit incorporating supply and take-up spools, chad box, and TTL-compatible control logic .... from **£650.00**

KEYBOARDS

KB756MF 56-station keyboard with full upper/lower case ASCII, parallel input, mounting frame for extra rigidity, power requirements +5V, −12V (NEW) **£39.00**
KB771MF as per 756MF but with 71 keystations incorporating numeric pad and cursor control keys (NEW) **£55.00**
KB771MF installed in metal enclosure (NEW) **£70.00**

PRINTERS

Anderson-Jacobson AJ832 Daisy Wheel printer, keyboard model with integral stand and RS232 interface **£995.00**
Centronics 101A Heavy Duty Matrix printer with 64 ASCII upper case character set, 165 cps operation, 132 print positions with adjustable tractor feed. Parallel input.
SPECIAL OFFER A FEW ONLY REMAINING **£295.00**
Data Products 2470 1250 Lpm Drum Printer 132 col **£5500.00**
Diablo Hyterm 1620 Daisy Wheel KSR (keyboard-send-receive) model with standard RS232 interface, 45 cps print speed, 110/150/300 baud, switch-selectable parity, top-of-form selector, graphics capability under software control **£1275.00**
Diablo 1355 Receive-only Daisy Wheel printer with parallel interface **£895.00**
Digital LA35 DECwriter 30 cps 132 col .... from **£250.00**
Digital LA36 DECwriter 10, 15, 30 cps 132 col .... from **£450.00**
Digital LA180 DECprinter 180 cps 132 col .... from **£495.00**
Seikosha GP80 (NEW) 80 col 30 cps RO matrix printer. Full upper/lower case ASCII and graphics mode, parallel (Centronics-type) interface **£199.00**

Tally 1602 160 cps matrix printer with full 96 upper/lower case ASCII character set 7 x 7 dot matrix, 132 col with adjustable tractor feed, bidirectional printing, double-width character feature, self test facility, Centronics-type parallel interface **£875.00**
Teletype low cost printer offer. Teletype 33 printer mechanism including case but no keyboard or electronics, 64 upper case ASCII, 10 cps, pinfeed platen, ideal for the electronic hobbyists .... only **£85.00**

LOW COST VDUs

H2000 Superb spec including full XY cursor addressing and edit facility, 27 x 74 display, upper case ASCII, RS232 interface, switch-selectable baud rates
H2000C NOW ALSO AVAILABLE with 25 x 80 line format and C-MOS logic **£375.00**

SPECIAL QUANTITY DISCOUNT OFFER

1—2	£299.00
3—4	£275.00
5—9	£255.00
10+	£250.00

Hazeltine H1000, 12 x 80, upper case ASCII, 110/300 or 300/1200 baud, RS232 (other baud rates combinations up to 9600 — £25.00 surcharge) **£199.00**
Also available from time to time
Hazeltine 1500 from **£575.00**
Hazeltine 1510 from **£650.00**

GRAPHICS EQUIPMENT

Calcomp Drum plotter model 565 .... **£850.00**
Houston Instruments flat bed plotter type DP3-1/5 .... **P.O.A.**
Tektronix 4010-1 Graphics Terminal with high-resolution graphics mode, standard alphanumeric mode, printer port, integral stand **£1750.00**
Tektronix 4014-1 Graphics terminal with enhanced graphics **£6950.00**
Tektronix 611 XY Storage display graphics monitor .... from **£1150.00** to **£1500.00**
In addition some with slight burns from £750

MISCELLANEOUS

Data General Nova 1210 CPU type 8133-2 with 4KW "AS IS" **£395.00**
Hewlett Packard desk top computer type 9830A with 8K memory extended I/O ROM, string variables ROM, 1 serial and 3 parallel interfaces **£1150.00**
Racal Modem type LS126, 1200/2400 baud 2/4 wire .... **P.O.A.**

WW 201 for further details

Electronic Brokers
NEW PRODUCTS

Hameg

HM412-5 OSCILLOSCOPE (illustrated)

Bandwidth DC-20 MHz
Triggering to 40MHz
Overscan Indication
Delayed Sweep

The model HM412 demonstrates the exceptionally high standard of quality and operating comfort achieved by HAMEG. The rectangular flat-faced CRT with quick heating cathode has a 8 × 10cm internal graticule to eliminate parallax errors. Regulated power supplies ensure that line fluctuations do not adversely affect the display and specified measuring accuracy. The multitude of operating modes is very impressive. The vertical sensitivity of both channels can be increased to 2mV/cm. Fully matched X-Y operation is available, also the channels can be added or subtracted. Special features of the HM412 are the vertical overscanning facility, automatic peak value triggering to 40MHz, and sweep delay for the expansion of relatively small signal portions across the full screen area. The alternate trigging of two asynchronous signals, variable holdoff time, TV and line triggering, single sweep, raster illumination, trace rotation, Z-modulation, ramp output, built-in calibrator, and a burn-in resistant CRT phosphor make the HM412 a most versatile oscilloscope at a competitive price. **£350**

Also available
HM307 Single Trace DC-10MHz **£138.00**
HM512 Dual Trace DC-50MHz + delay **£580.00**

HM 203 PORTABLE OSCILLOSCOPE

Dual Trace, DC to 20MHz. 8 × 10cm display. Risetime 17.5nS. Sensitivity 5mV/cm-20V/cm. Timebase 0.5μs-0.2s. X5 magnifier. X-Y operation. Auto or variable trigger. Channel 1. Channel 2, line and external. Coupling AC. or TV low pass filter. Weighs only 6Kg. Size (m.m.) H. 145. W. 285. D. 380.

Europe's standard service scope Unbeatable value at **£220.00**

All the above scopes are available with P7 long persistence C.R.T's (except HM 307) prices on application

The above prices do not include carriage or VAT (15%). Please send for Technical Literature.

WW 202 for further details

Fluke

FROM LONDON'S LARGEST DISTRIBUTOR
* NOW WITH A 2 YEAR WARRANTY

* Fluke 8022B (Illustrated)

3½ Digit hand held LCD. DMM. AC/DC volts, DC/AC current, resistance, diode test. 0.25% basic DC accuracy. Overload protection. Vinyl carrying case C90 £8.00 .... **£75.00**

* Fluke 8021B.

Same spec as 8022B with additional audio tone for continuity. Vinyl case C90 £8.00 .... **£85.00**

*Fluke 8020B

3½ digit 0.1% basic DC accuracy. DC/AC volts, DC/AC current, resistance, diode test and conductance. Continuity beeper. Vinyl case C90 £8.00 .... **£117.00**

*Fluke 8024B

3½ digit. 0.1% basic DC accuracy. DC/AC volts, DC/AC current, resistance. Diode test, conductance, logic + continuity detect + temperature. Peak hold on voltage and current functions, continuity beeper. Vinyl case C90 £8.00 .... **£155.00**

FLUKE 8050A

4½ Digit LCD DMM with true RMS on AC volts and current DC volts 200mV-1KV, 10μV resolution AC volts. 200mV-750V, 10μV resolution. DC/AC current 200μA-2A, 0.01μA resolution resistance 200Ω-20MΩ, 0.01Ω resolution. Also reads dB direct referenced to 16 stored impedances. Conductance ranges 2mS and 200nS. **£245** mains model **£285** mains battery.

FLUKE 8012A

3½ Digit LCD DMM with true RMS on AC volts and current. DC volts 200mV-1KV, 100μV resolution. AC volts 200mV-750V, 100μV resolution. DC/AC current 200μA-2A, 0.1μA resolution. Resistance 200Ω-20MΩ, 0.1Ω resolution Low resistance 2Ω and 20Ω, 1mΩ resolution Conductance ranges 2mS-20μS-200nS **£218.00** mains model **£244.00** mains battery.

FLUKE 8010A

3½ Digit LCD DMM Same spec as 8012A plus a 10Amp AC/DC current range, but not low resistance range. **£167.00** mains model **£193.00** mains battery.

Also available a range of accessories including current shunts, EHT probe, rf probe, Temperature probe and touch and hold probe. Full details on request.

The above prices do not include carriage or VAT (15%). Please send for Technical Literature.

WW 203 for further details

I.C.E.

680G MULTIMETER (ILLUSTRATED) 48 RANGES

DC volts: 100mV-2-10-50-200-500-1000V AC volts: 2-10-50-250-1000-2500V DC current: 50-500μA-5-50-500mA-5A AC current: 250μA-2.5-25-250mA-2.5A Resistance Ω × 1-Ω × 10-Ω × 100-Ω × 1000 and LowΩ, full range 1Ω-10MΩ Up to 100MΩ can be measured using ext. AC supply. dB scale-10 to +22dB. OdB = 1mW into 600Ω Sensitivity DC 20KΩ/V, AC 4 KΩ/V. Accuracy 2.0% AC and DC. Battery Eveready No. 8 Overload capability 1000:1 on resistance ranges. Protected by internal 3ΩFuse. Size with case 10.8 × 11 × 3.7cm. Meter size 10cm. Supplied with leads and carrying case.

£24.50

680R HIGH ACCURACY MULTIMETER 80 RANGES

DC volts: 100mV-2-10-50-200-500-1000V AC volts: 2-10-50-250-1000-2500V DC current: 50-500μA-5-50-500mA-5A AC current: 250μA-2.5-25-250mA-2.5A X2 switch on all voltage and current ranges except 2500V AC setting. Resistance: Ω × 1-Ω × 10-Ω × 100-Ω × 1000 and LowΩ, full range 1Ω-10MΩ, up to 100MΩ can be measured using ext. AC supply. dB scale—10 to + 22dB. OdB = 1mW into 600Ω Sensitivity DC 20KΩ/V. AC 4KΩ/V. Accuracy DC 1%, AC 2%. Battery Eveready No. 3. Overload capability 1000:1 on resistance ranges. Protected by internal 3Ω fuse. Size with case 13.7 × 10.4 × 5.4cm. Meter size 12cm. Supplied with leads and carrying case.

£32.00

MICROTEST 80 POCKET SIZED MULTIMETER 40 RANGES

DC volts. 100mV-2-10-50-200-1000V AC volts: 1.5-10-50-250-1000V DC current: 50-500μA-5-50-500mA-5A AC current: 250μA-2.5-25-250mA-2.5A Resistance: Ω × 1-Ω × 10-Ω × 100 and Low Ω, full range 1Ω-5MΩ dB scale —10 to +22dB, odB = 1mW into 600Ω Sensitivity: DC 20KΩ/V, AC 4KΩ/V Accuracy 2% AC and DC. Battery Mallory RM 625N. Overload capability 1000:1 on resistance ranges. Protected by internal 3Ω fuse. Size with case 9.3 × 9.6 × 2.3cm. Meter size 8.5cm. Supplied with leads and carrying case.

£16.60

Please add £1.50 carriage per meter plus 15% VAT on total meter and carriage price. Send for Literature.

WW 204 for further details

Electronic Brokers Limited
61/65 Kings Cross Road
London WC1X 9LN England
Telephone: 01-278 3461
Telex: 298694 Elebro G

Hours of Business: 9a.m. - 5p.m. Mon-Fri. Closed lunch 1-2p.m.
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Electronic Brokers

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(Regd Trade Mark)

SOLDERING TOOL

TYPE 444

with

Electronic Temperature Control Circuit

contained within the handle

DESIGN FEATURES

- NO MOVING PARTS
- NO MAGNETIC EFFECT
- NO MAINS SPIKING
- MINIMAL MAINTENANCE
- FULL RANGE OF PUSH IN SOLDERING TIPS
- FAIL SAFE CIRCUITRY

The Adcola 444 operates from 24VAC. 50 VA. 50/60Hz. supply. Temperature range normally factory set at 360°C is fully variable between 220°C -420°C. The control circuit is based on a specially designed integrated circuit and uses a thermocouple temperature sensor.

Full specifications and prices from

ADCOLA

(Regd Trade Mark)

ADCOLA PRODUCTS LIMITED

ADCOLA HOUSE, GAUDEN ROAD, LONDON SW4 6LH.
Telephone: 01-622 0291/4 Telex 21851 ADCOLA G

WW – 034 FOR FURTHER DETAILS

MICROCOMPUTER COMPONENTS

LOWEST PRICES – FASTEST DELIVERY

Device	Price
MEMORIES	
2114L-200ns	1+1.28
	25+1.19
2114L-300ns	1+1.28
	25+1.19
2708 450ns	1.99
2716 450ns	1+2.49
	25+2.37
2716 350ns	6.95
2532 450ns	1+5.50
	25+5.31
2732 450ns	1+4.80
	25+4.08
4116 150ns	1+1.15
	25+1.06
4116 200ns	1+0.80
	25+0.72
6116 200ns	10.95
4118 200ns	3.90
8264 200ns	12.00
5516 200ns	22.86
CRT CONTROLLERS AND GRAPHIC DISPLAY PROCESSORS	
EF9364	5.94
EF9365	62.90
EF9366	62.90
BUFFERS	
81LS95	0.90
81LS96	0.90
81LS97	0.90
81LS98	0.90
8T26A	1.50
8T28A	1.50
8T95	1.50
8T97A	1.50
8T98	1.50
DATA CONVERTERS	
ZN425E-8	3.50
ZN426E-8	3.00
ZN427E-8	6.28
ZN428E-8	4.78
ZN429E-8	2.10
ZN432CJ-10	28.09
ZN433CJ-10	22.59
ZN440	56.63
MISCELLANEOUS	
AY-3-1015	3.90
AY-5-1013	3.45
AY-5-2376	6.95
MC1488	0.64
MC1489	0.64
MC14411	6.94
MC14412	7.99
RO-3-2513L	7.70
RO-3-2513U	7.70
ZN450E	7.61
7805	0.50
7812	0.50
7905	0.55
7912	0.55
ZILOG Z80 FAMILY	
Z80 CPU	4.00
Z80A CPU	4.82
Z80 CTC	4.00
Z80A CTC	4.00
Z80 DART	7.18
Z80A DART	7.18
Z80 DMA	11.52
Z80A DMA	9.99
Z80 PIO	3.78
Z80A PIO	3.78
Z80 SIO-0	13.95
Z80A SIO-0	13.95
Z80 SIO-1	13.95
Z80A SIO-1	13.95
Z80 SIO-2	13.95
Z80A SIO-2	13.95
EFCIS 6800 FAMILY	
EF6800	3.70
EF6802	5.11
EF6803	11.80
EF6809	11.95
EF6810	1.35
EF6821	1.74
EF6840	4.20
EF6845	9.50
EF6850	1.70

Device	Price
EF6862	6.91
EF6871-A1T	18.70
EF6880	1.07
EF6887	0.80
EF68488	9.11
EF6875	4.18
6502 FAMILY	
SYP6502	4.95
SYP6520	3.15
SYP6522	4.95
SYP6532	7.95
8080 FAMILY	
8085A	5.50
8212	1.70
8216	1.70
8224	2.45
8228	3.95
8251	3.95
8253	7.95
8255	3.95
CMOS 4000 'B' SERIES	
4000	0.12
4001	0.13
4002	0.13
4006	0.60
4007	0.17
4008	0.55
4009	0.28
4010	0.28
4011	0.14
4012	0.17
4013	0.33
4014	0.58
4015	0.58
4016	0.28
4017	0.45
4018	0.58
4019	0.29
4020	0.58
4021	0.60
4022	0.62
4023	0.17
4024	0.38
4025	0.16
4026	0.99
4027	0.30
4028	0.55
4031	1.65
4033	1.60
4034	1.55
4035	0.72
4040	0.57
4041	0.69
4042	0.54
4043	0.59
4044	0.64
4045	1.65
4046	0.68
4047	0.68
4048	0.54
4049	0.30
4050	0.30
4051	0.59
4052	0.68
4053	0.59
4054	1.20
4055	1.20
4060	0.89
4063	0.95
4066	0.34
4068	0.17
4069	0.17
4070	0.19
4071	0.19
4072	0.19
4073	0.19
4075	0.17

Device	Price
4076	0.60
4077	0.22
4078	0.24
4081	0.14
4082	0.19
4085	0.63
4086	0.69
4093	0.39
4502	0.69
4507	0.39
4508	1.90
4510	0.60
4511	0.49
4512	0.60
4514	1.49
4515	1.49
4516	0.75
4518	0.40
4519	0.28
4520	0.69
4521	1.49
4522	1.20
4526	0.70
4527	0.89
4528	0.70
4532	0.89
4541	1.39
4543	0.99
4553	2.90
4555	0.49
4556	0.54
4585	0.98
LOW POWER SCHOTTKY TTL ICs – 74LS SERIES	
74LS00	0.11
74LS01	0.11
74LS02	0.12
74LS03	0.12
74LS04	0.13
74LS05	0.13
74LS08	0.13
74LS09	0.13
74LS10	0.13
74LS11	0.14
74LS12	0.15
74LS13	0.22
74LS14	0.44
74LS15	0.13
74LS20	0.12
74LS21	0.14
74LS22	0.14
74LS26	0.18
74LS27	0.14
74LS28	0.19
74LS30	0.12
74LS32	0.14
74LS33	0.16
74LS37	0.16
74LS38	0.16
74LS40	0.13
74LS42	0.34
74LS47	0.39
74LS48	0.60
74LS49	0.59
74LS51	0.14
74LS54	0.15
74LS55	0.15
74LS73	0.20
74LS74	0.17
74LS75	0.28
74LS76	0.20
74LS78	0.24
74LS83	0.50
74LS85	0.70
74LS86	0.17
74LS90	0.30
74LS91	0.80
74LS92	0.35
74LS93	0.34

Device	Price
74LS95	0.44
74LS109	0.25
74LS112	0.25
74LS113	0.25
74LS114	0.25
74LS122	0.39
74LS123	0.55
74LS124	1.00
74LS125	0.28
74LS126	0.28
74LS132	0.45
74LS136	0.28
74LS138	0.34
74LS139	0.37
74LS145	0.75
74LS148	0.90
74LS151	0.34
74LS153	0.35
74LS155	0.39
74LS156	0.38
74LS157	0.34
74LS158	0.36
74LS160	0.39
74LS161	0.39
74LS162	0.39
74LS163	0.39
74LS164	0.47
74LS165	0.99
74LS166	0.84
74LS173	0.70
74LS174	0.54
74LS175	0.54
74LS181	1.30
74LS190	0.55
74LS191	0.55
74LS192	0.69
74LS193	0.59
74LS194	0.39
74LS195	0.39
74LS196	0.58
74LS197	0.65
74LS221	0.60
74LS240	0.89
74LS241	0.89
74LS242	0.79
74LS243	0.79
74LS244	0.79
74LS245	0.89
74LS247	1.34
74LS248	1.00
74LS249	0.68
74LS251	0.39
74LS253	0.39
74LS257	0.44
74LS258	0.38
74LS259	0.38
74LS261	1.90
74LS266	0.23
74LS273	0.90
74LS279	0.34
74LS283	0.44
74LS290	0.56
74LS293	0.45
74LS365	0.34
74LS366	0.34
74LS367	0.34
74LS368	0.34
74LS373	0.74
74LS374	0.74
74LS375	0.47
74LS377	0.89
74LS378	0.69
74LS379	0.84
74LS386	0.28
74LS390	0.59
74LS393	0.59
LOW PROFILE DIL SOCKETS	
Number of Pins:	
8	0.07
14	0.09
16	0.09
18	0.15
20	0.17
22	0.21
24	0.23
28	0.25
40	0.29
CRYSTALS	
1 Mhz	3.00
1.8432 Mhz	2.50
4 Mhz	1.65

SPECIAL OFFERS MEMORIES

2114L 200 ns	0.99	4116 150 ns	0.75
2708 450 ns	1.48	4116 200 ns	0.67
2716 450 ns	2.10	6116 200 ns	6.50
2532 450 ns	3.99	5516 200 ns	11.95
2732 450 ns	3.20	4118 200 ns	3.85

* OFFER VALID FROM DEC 1st–JAN 1st SUBJECT TO AVAILABILITY

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2113 Audio Frequency Spectrometer	1400
2203 Sound Level Meter	450
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4230 Sound Level Calibrator	95
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BRIDGES & V and I STANDARDS

GENERAL RESISTANCE

DAS56 DC V and I Calib 1µV-10V 30mA	600

HEWLETT PACKARD

4261A Digital Automatic LCR Bridge	975
4342 QLC Meter 22 KHz-70 MHz	1400

MARCONI

TF868A Universal LCR Bridge	250

WAYNE KERR

B521 LCR Bridge	115

COMMS & CABLE TEST EQUIPMENT

CHASE

35A Field Strength Meter 20-850 MHz	600

HEWLETT PACKARD

3556A psophometer 20 Hz-20 KHz	250

TEKTRONIX

1502 TDR Cable Tester CRT + Recorder	2950

COMPUTER EQUIPMENT

CENTRONICS

702 matrix printer	500

TEKTRONIX

4610-1 Hard copy printer for 4010 series computer display terminals	1800

COUNTERS & TIMERS

FLUKE

1910A-1 125 MHz 7 digit Cntr. AC/Batt	300
1912 520 MHz 7 Digit Counter	375
1912A01 As 1912A but inc. re-charging batteries	430
1920A 520 MHz 9 Digit Counter inc. Brst. mode	575
1920A14 1250 MHz otherwise as 1920A	750

HEWLETT PACKARD

5300A 6 Digit Display Unit — P/in reqd.	160
5305B 1300 MHz Counter for 5300	325

RACAL

9024 600 MHz 7½ digit Counter	220
9025 1 GHz 8 digit Counter	450
9905 200 MHz 8 digit Counter Timer	360

SYSTRON DONNER

6053 3 GHz 9 digit Counter BCD O/P	790
5103B Strip Printer for 6053/6054	375

DIGITAL TESTING EQUIPMENT

HEWLETT PACKARD

5011T Logic troubleshooting kit	125
1600S Logic Analyser 32ch 20 MHz	2750

TEKTRONIX

7D01F Logic Analyser 16ch 50 MHz P/in	2650
832 Datacomm Test V24/RS232/I loop	1150

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Digital and analogue true RMS AC voltmeter and power meter. Frequency range 10 Hz-20 MHz.
Readout – 3½ digit LED display and analogue meter for peak and null adjustments.
Ranges – 2mV FSD to 700V FSD plus dBm ranges reading power delivered to 12 standard input impedances from 50Ω to 1200Ω. Also relative dB mode for flatness/difference measurements.
Will measure AC power/volts in presence of DC offset — Automatic or manual ranging.
£825

M.L. ENGINEERING — NANO AMMETER/MICRO VOLTMETER

DC Analogue Meter with centre zero scale.
12 Current Ranges from 100nA to 30mA FSD.
12 Voltage Ranges from 100µV to 30V FSD.
Can be used in conventional mode or as a sensitive null meter.
These instruments are new.
£45

ONE YEAR GUARANTEE

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MAINS TEST EQUIPMENT
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T1007 Volt/Freq/Spike Monitor Rec O/P	110

DATALAB

DL019 Mains Interface for DL905	300

DRANETZ

606 3ch Volts Av/Spike/Time/Printer	2950

GAY

LDM AC/DC/Spike/Time inc Printer	1250

MISCELLANEOUS

AVO

RM215 AC/DC Breakdown/Leakage Tester	475

COMARK

1601BLS Thermom 10ch 87 + 1000°C type K *N.B. Thermocouples not included*	50

DATALAB

DL901 Digital Transient Recorder	500

HEWLETT PACKARD

X382A Rotary Vane Attenuator WG16	175

MULTIMETRICS

AF120 Dual H/Pass L/Pass active filter 20 Hz – 2 MHz	600

RESEARCH INSTRUMENTS

Micro manipulator — 4 Probes moveable in all planes. Adjustable test table — Watson Burnet optics. Complete system mounted in perspex enclosure	475

TEKTRONIX

521PAL Vectorscope	2200
528 TV Waveform Monitor	750
575 Semiconductor Curve Tracer	425
1485C TV Waveform Monitor PAL/NTSC	2300

NETWORK ANALYSERS/ PHASEMETERS

DRANETZ

305B/3001 Phasemeter 2Hz-700KHz	990

HEWLETT PACKARD

8405A Vector Voltmeter 1–1000 MHz	2350
8414A Polar Display for 8410 N.W.A.	750

OSCILLOSCOPES & ACCESSORIES

GOULD ADVANCE

OS3300B 50 MHz 1mV 2 Trace 2T base	675

HEWLETT PACKARD

1804A 50 MHz 20mV 4 Trace Plug-in	625
1825A Dual Timebase Plug-in	500
1805A 100 MHz 5mV 2 Trace Plug-in	625

PHILIPS

PM3211 15 MHz 2mV 2 Trace TV trig	390
PM3212 25 MHz 2mV 2 Trace TV trig	550
PM3244 50 MHz 5mV 4 Trace 2T base	1450
PM3260 120 MHz 5mV 2 Trace 2T base	1475
PM3262 100 MHz 5mV 2 Trace 2T base Tr View	1150

TEKTRONIX

465 100 MHz 5mV 2 Trace 2T base	1250
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485 350 MHz 5mV 2 Trace 2T base	2300
661/4S3/5T1A 1 GHz Sampling scope	775
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7A18 75 MHz 5mV 2 Trace Plug-in	420
7A19 500 MHz 10mV 1 Trace Plug-in	990
7A22 1 MHz 10µV Differential Plug-In	595
7A24 350 MHz 5mV 2 Trace Plug-in	990
7A26 200 MHz 5mV 2 Trace Plug-in	655
7B53A 2 Timebase Plug-in 100 MHz Trig	530
7B80 Single Timebase 400 MHz Trig	575
7B85 Timebase with delay 400 MHz Trig	670
7603 100 MHz CRT r/out 3 slot M/Frame	1350
7704A 200 MHz CRT r/out 4 slot M/Frame	1450
P6013A X1000 12KV Probe	95

TELEQUIPMENT

D63/V1/V1 15 MHz 2 Trace 1mV	499
D83/V4/S2A 50 MHz 1mV 2 Trace 2T Big CRT	750
D1015 15 MHz 5mV 2 Trace TV trig	295

VUDATA

PS935/975 35 MHz 5mV 2 Trace – unit has built-in 3½ digit DMM + 3½ dig. cnter	675
Note: we hold a range of cameras	P.O.A.

OSCILLOSCOPES (STORAGE)

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1703A 35 MHz 10mV 2 Tr 2TB 1000 Div/ms	1400

TEKTRONIX

466 100 MHz 5mV 2 Tr 2TB 1350cm/µs	2950

Prices from £

603 Bistable Storage Monitor XYZ amps	750
T912 10 MHz 2mV 2 Tr 1TB 250cm/ms	850
7834 400 MHz 4 Slot M/Frame 2500cm/µs	4990

POWER MEASUREMENT

HEWLETT PACKARD

8481A Type N Coax sensor for 435A	200

MARCONI

TF2512 DC-500 MHz Powermeter	189
TF893A 10 Hz-20 KHz Powermeter	135

POWER SUPPLIES etc

ADVANCE

1V5S Inverter 24V DC to 240V AC 500W	300

FARNELL

FFSL 5 V – 20 A PSU module	100
L30B 0-30V variable 1A Metered	60

FLUKE

415B 0-3.1 KV variable 30mA Metered	550

HEWLETT PACKARD

6966A 0-36 V variable 10 A metered	450

PHILIPS

PE1646 0-75V variable 6A Metered V + I	495

PULSE GENERATORS

ADVANCE

PG57 10 Hz-50 MHz 10V 50Ω Vari RT 6ns	190

EH RESEARCH

132 10 Hz-3.5 MHz 50V 50Ω RT 10ns 2 pulse	120

MARCONI

TF2025 0.2 Hz-25 MHz 10V 50Ω RT 7ns 2 pulse	350

RECORDERS & ACCESSORIES

BRUNO WOELKE

ME102B Wow and Flutter meter	75

BRYANS SOUTHERN

BS316 Chart 10" 6 Pen 16 speed	2500

HEWLETT PACKARD

7015A XY 1 pen A4 size	700
7046A XY 2 pen A3 size	995

PHILIPS

PM8041 XY 1 pen A4 size	750
PM8251 Chart 10" 1 pen 12 speed	375

SE LABS

994 6 ch galvo preamp + DC bridge supply	450
6008 UV chart 8" 25 ch 16 speed	950
6150/51 UV recorder 12 ch-inc 6 ch amps	1000

SMITHS

RE541 Chart 8" 1 pen 8 speed	250
RE501/4701 Cht 4" + XY 1ch 10 spd AC Batt	200

SOLARTRON

3240 Modular Data Logger system	P.O.A.

Note: UV recorders are priced less galvos

SIGNAL ANALYSIS EQUIPMENT

MARCONI

TF2300A Mod Meter 1 MHz-1 GHz AM/FM	450
TF2330 Wave Analyser 20 Hz-50 KHz	900

Note: see also "Spectrum Analysers"

SIGNAL/FUNCTION/ + SWEEP GENERATORS

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GENERAL RADIO

1362 Generator 220-920 MHz	375

HEWLETT PACKARD

8640B Generator 500 KHz-512 MHz AM/FM Phase Lock	3800
618B Generator 3.8-7.5 GHz	975
612 Generator 450-1230 MHz	750
614 Generator 0.8-2.1 GHz	825

MARCONI

TF144H/4S Generator 10 KHz-72 MHz AM	550
TF801D Generator 10 MHz-470 MHz AM	180
TF955/2 Generator 0.2-220 MHz AM/FM	670
TF1066B/1 Generator 10-470 MHz AM/FM	690
TF2012 Generator 400-520 MHz FM	560
TF2015 Generator 10-520 MHz AM/FM	1150

PHILIPS

PM5127 Function 0.1 Hz-1 MHz Sin Sq Tri Rmp	450
PM5129 Function 1 mHz-1 MHz Sin/Sq/Tri/Ramp/Pulse + Sweep + Burst	645

TEXSCAN

9900 Sweeper 10-300 MHz 6/in CRT disp	525
VS60 Sweeper 5-1000 MHz	890

SPECTRUM ANALYSERS
Prices from £

HEWLETT PACKARD

141T/8552B/8555A Complete .01-18 GHz	8500
3580A 5 Hz-50 KHz with digi store disp	2450
8445A Pre-selector 0.01-18 GHz	2000
8558B 0.1-1500 MHz Plug-in for 180 series	3750

MARCONI

TF2370 30 Hz-110 MHz Digi-store display built-in counter and tracking gen	7700

VOLT/MULTI-METER (ANALOGUE)

AVO

8 Mk4 AC/DC/—VI + Ω	70

BOONTON

92C AC/RF 10 KHz-1.2 GHZ ½ mV-3V	350

HEWLETT PACKARD

400E 10 Hz-10 MHz 1mV-300V DC O/P	285
400H 10 Hz-4 MHz 1mV-300V	75
411A 0.5-500 MHz 10mV-10V DC O/P	175
427 AC/DC/V/Ω	195
3400 TRMS 10 Hz-10 MHz 1mV-300V DC-O/P	390

MARCONI

TF2603 50 KHz-1.5 GHz 300µV-3V	300
TF2604 20 Hz-1.5 GHz 300mV-300V	425

PHILIPS

PM2454B 10 Hz-12 MHz 1mV-300V DC O/P	250

RACAL

9301 RMS 10 KHz-1.5 GHz 100µV-300V	550

VIBRON/E.I.L.

33B-2 1mV-1V Electrometer	200

VOLT/MULTI-METER (DIGITAL)

BOONTON

92AD 1999FSD 10 KHz-1.2 GHz 10µV res	525

FLUKE

8010A 2000 FSD TRMS AC/DC/VIΩ	140
8010A01 As 8010A + re-charging batteries	159
8020A 2000 FSD Handheld AC/DC/VIΩ + cond.	99
8022A 2000 FSD Handheld AC/DC/VIΩ	75
8030A-1 2000 FSD AC/DC/VIΩ Batt + AC	165
8050A 20000 FSD AC/DC/VIΩ dB TRMS	215
8800A 200000 FSD AC/DC/VΩ	550

GOULD

DMM7 1999 FSD AC/DC/V/I/Ω	100

HEWLETT PACKARD

3490A 100000FSD AC/DC/V/Ω	625

SOLARTRON

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A203 19999FSD AC/DC/V/Ω	175
A205 19999FSD TRMS AC/DC/V/Ω	195

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EXAMPLES:

Model 3030	Single trace 15 MHz 5mV sensitivity with built-in component tester	£145
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Full details and specification of equipment listed, available. Because of long copy dates this list is not comprehensive – ring for inventory update or tell us your SPECIFIC NEEDS. Hours Monday to Friday 9.00 am-5.30 pm (4.30 pm Fridays). **Prices exclude delivery and VAT.** We take Access or Barclaycard.

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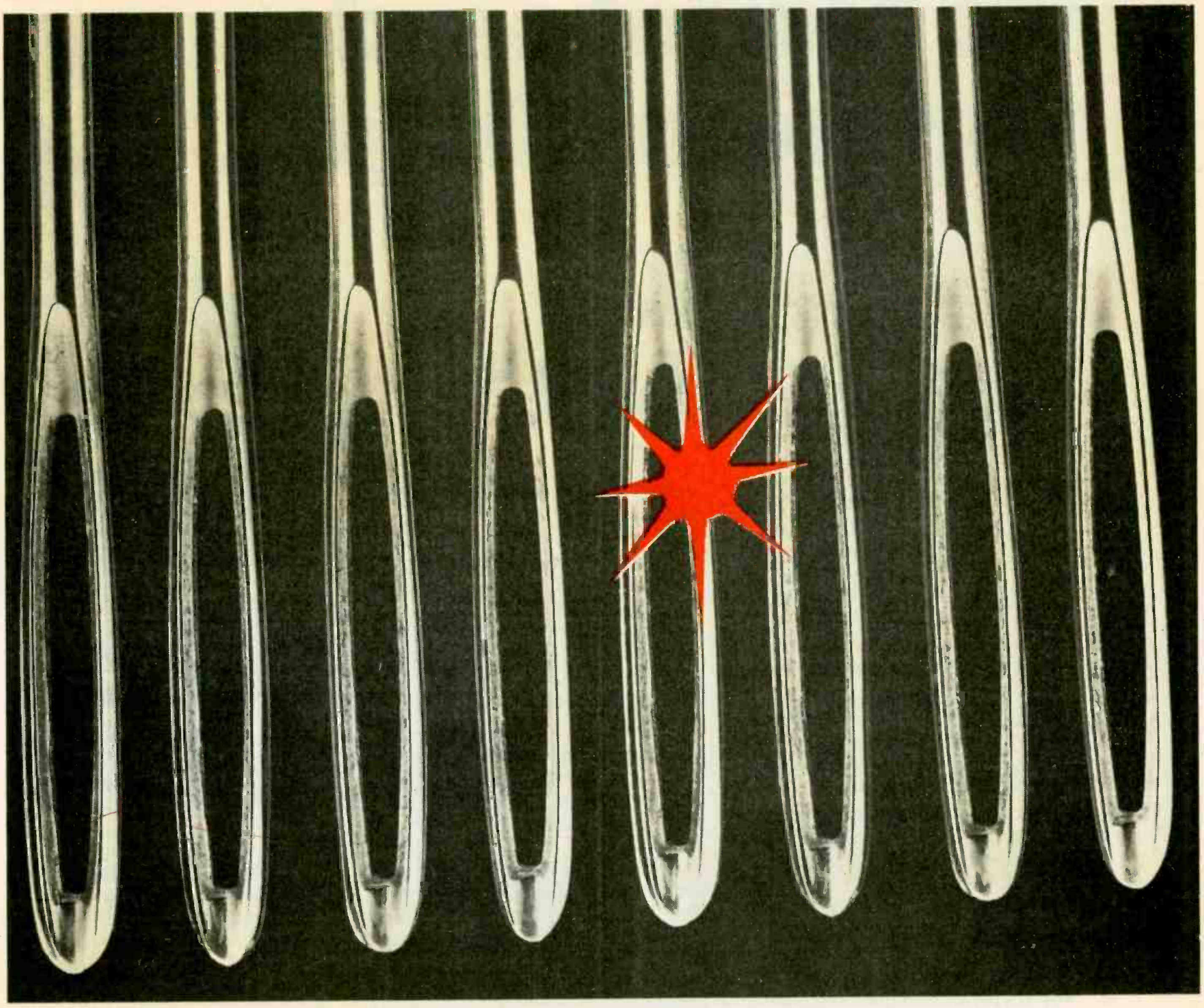

IMO Precision Controls Ltd.,
1000 North Circular Road, Staples Corner, London NW2 7JP.
Telephone: 01-452 6444. Telex: 28514.

ter-

Available now-the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

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How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. Order

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

☐ Please tick if you require a VAT receipt TOTAL £

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RELIABLE WITH 18 months GUARANTEE

DT-410, 10 MHz	DT-415 15MHz	DT-420 20MHz

- ★ CH1, CH2 5mv/div – 20v/div.
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- ★ Trigger: Level control, ± Slope selection.
- ★ Auto, Normal, TV Triggering.
- ★ External Trigger
- ★ Z-Modulation
- ★ CAL output 1v 1kHz.
- ★ Graticule blue ruled 8x10 div. (4in. CRT).
- ★ Size: H215mm, W165mm, D280mm.
- ★ Weight: 4kg.

PROBE (XI-REF-X10) £10.50

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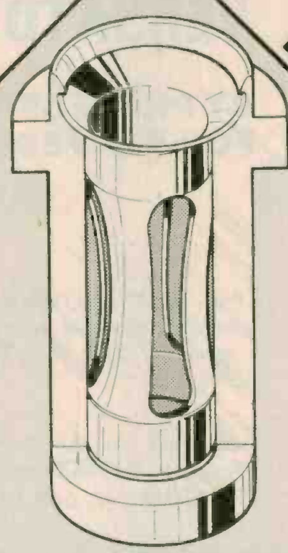

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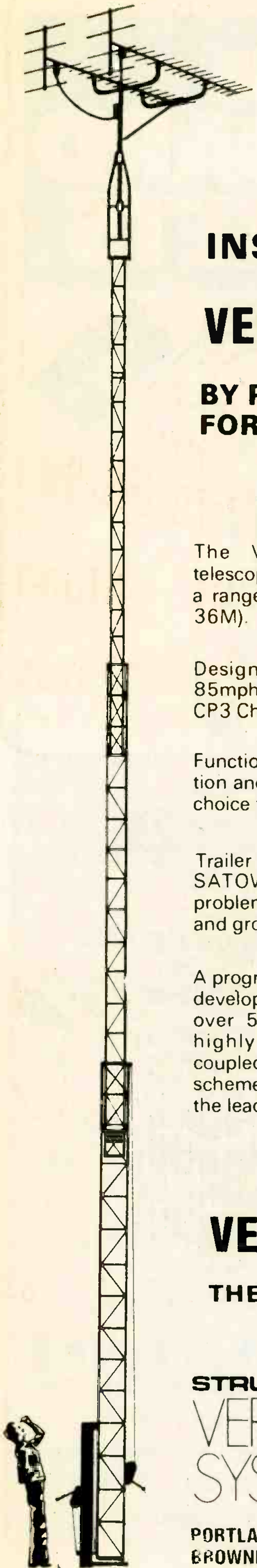

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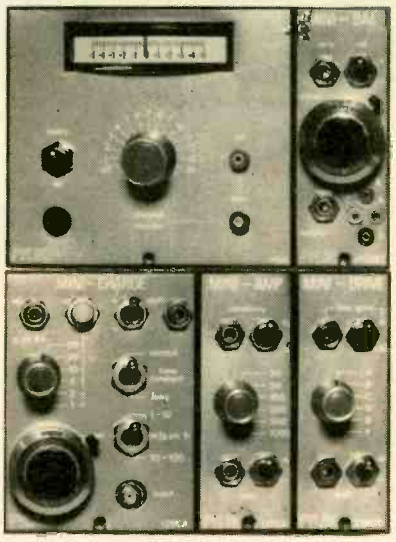

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*2035A	3½-Digit L.C.D. Hand DMM	8700	10MHz Universal Frequency Counter/Timer
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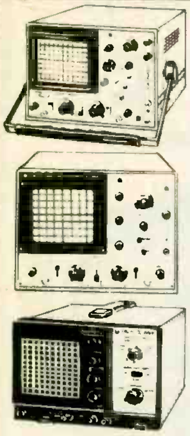
TRIO OSCILLOSCOPES



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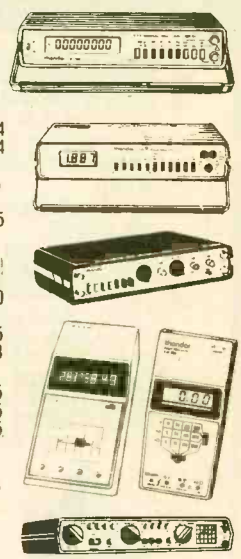

Reliable low cost portable instruments, bench models all 25.5 x 15 x 5cm. Generators mains operated rest battery (supplied). UK c/p Hand models 65p, bench £1.15)

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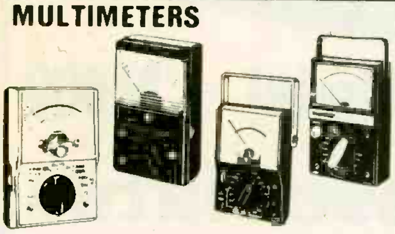
OPTIONAL ITEMS
Carry case (bench only) £6.84 AC Adaptors (state model) £5.69

MULTIMETERS



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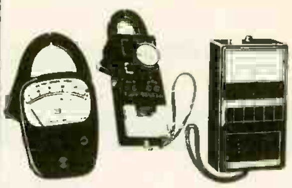
CLAMP-ON-METERS INSULATION TESTERS



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*K2606 300A, 600V, AC 8 ranges £44.00
K2803 300A, 600V, AC 9 ranges £53.95
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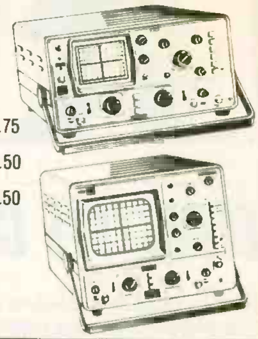

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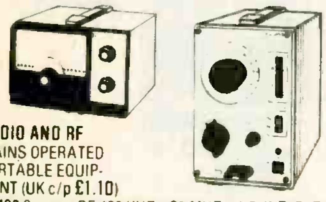

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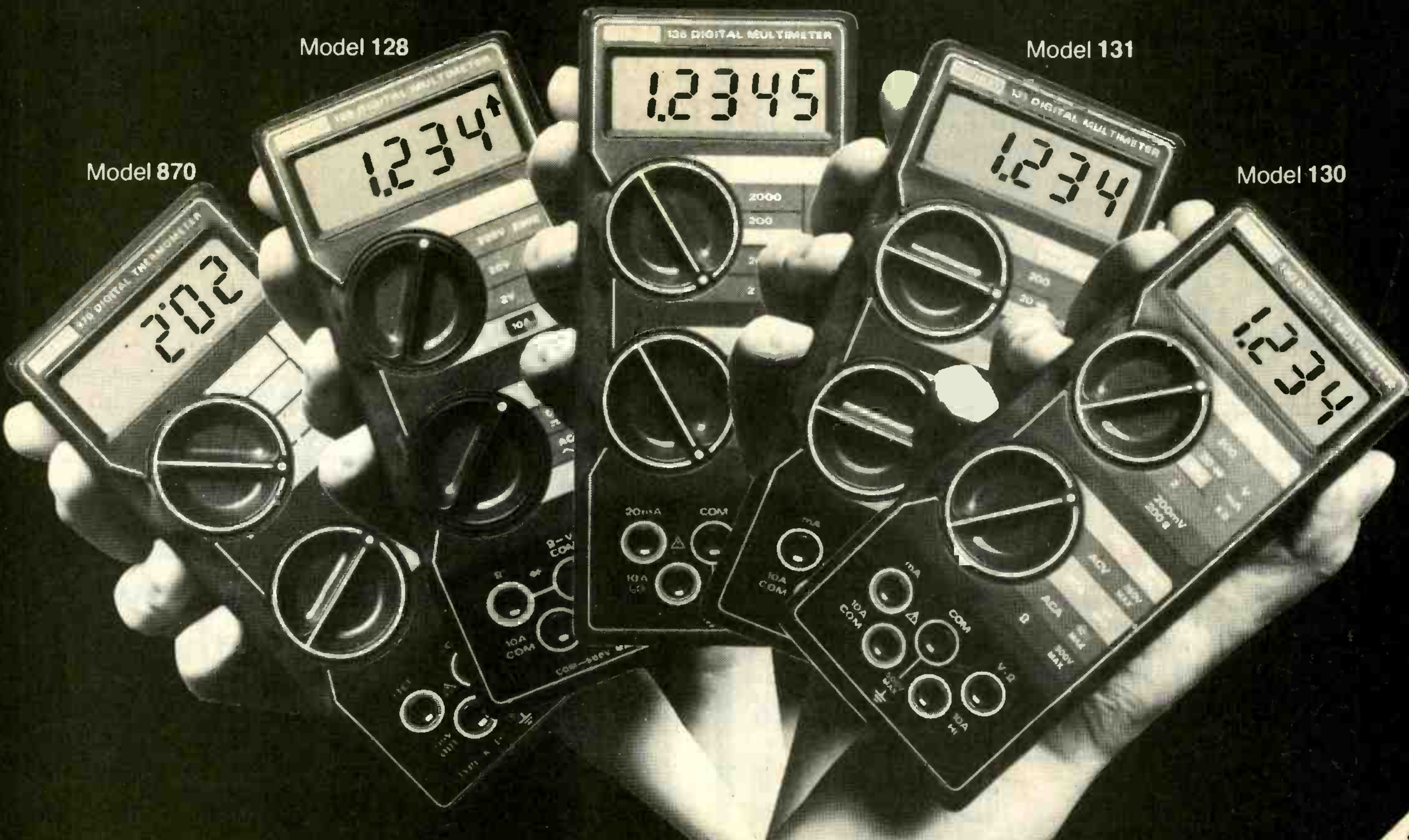

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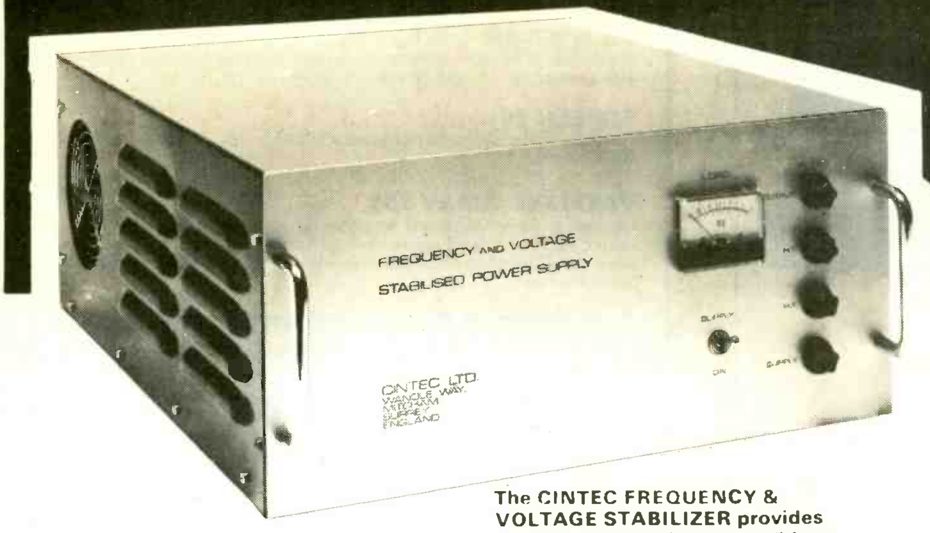

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OUTPUT	115 volts at 230 volts
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Frequency	± 0.01% No load to full load
FREQUENCY	50Hz or 60Hz. Single or dual versions
WAVEFORM	SINUSOIDAL
DISTORTION	Less than 2%
AMB TEMP	−20°C to +40°C
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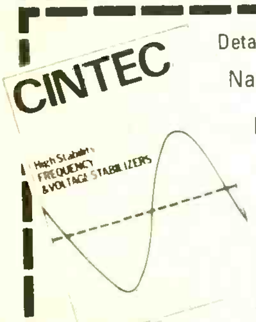

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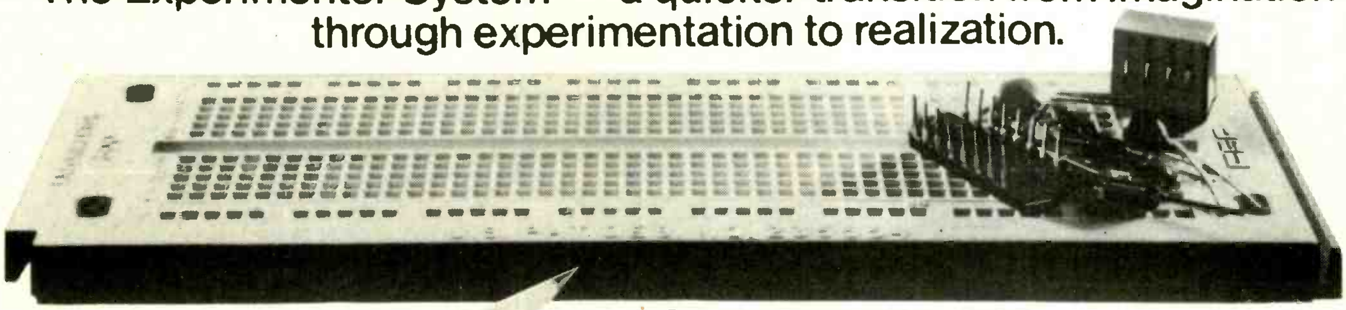

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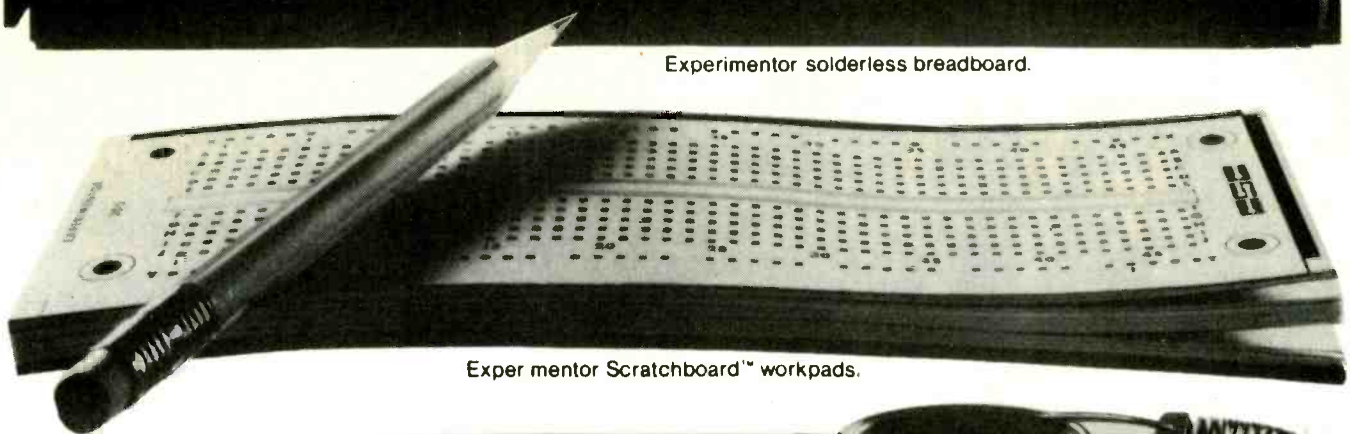

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A million years of programming

This month's front cover is our contribution to the UK's Information Technology Year, just starting. A somewhat bizarre one, you may think. It is, in fact, an idea borrowed by artist Geoff Harrold from the imaginative film *2001: A Space Odyssey* (for which, incidentally, the screenplay was written by our one-time contributor Arthur C. Clarke). The mysterious crystalline monolith seems to be the instrument by which the man-apes at the beginning of the film are touched by conscious thought, rationality and an awareness of history and their own mortality – by which they became *Homo sapiens*. In our picture the monolith becomes that public symbol of modern technology "the microchip", better known to electronics engineers as the microprocessor.

If "information technology" is anything more than a convenient phrase to describe a range of already existing techniques (computers, telecommunications and microelectronics, according to the DOI) it certainly owes its existence to, more than anything, the availability of the microprocessor as an off-the-shelf electronic component. We have had the ability to measure and transmit information in binary digital form for a good many decades, but we were only able to process it conveniently, in the huge variety of ways we do, when programming became generally available in the last decade, using the principles of the stored-program digital computer. This mechanization of certain logical mental processes, in cheap and flexible electronic equipment, is the real innovation at the heart of what we are now calling information technology.

The mechanization of logic is the product of a living organ, the human brain, which itself was already capable of logical thinking and thus had generated the conceptual models for the hardware and its functioning. With this as a parallel, it is tempting to speculate on how much the invention of programming – first seen in early clocks and barrel organs – owes to the biological programming given by the genetic code in living creatures. Although in machines the instructions may be carried out in a time sequence, the program as an entity usually exists as a spatial pattern, first on paper then in the Memory of a computer or microsystem. There seems to be some justification for an analogy between the pattern of binary digits in, say, an e.p.r.o.m. and the pattern of nucleotides in the DNA molecule of the living cell.

Beyond this point, however, the analogy breaks down. Whereas the program in the computer memory can be readily changed, the genetic code in DNA is highly conservative. We are almost always born with the same number of limbs and other organs, although mutations such as a hand with six fingers can sometimes occur.

Nevertheless in *Homo sapiens* the genetic code preserves an organism which is capable of extraordinary flexibility in its behaviour. Its power to communicate and act socially, passing on knowledge from person to person and from generation to generation, has resulted in, among other things, the technology of electronics and devices such as the microprocessor. The significant programming now is the way our behaviour is ordered by social activity, and this has been going on for perhaps only a million years. For example, some anthropologists maintain that we are neither inherently aggressive nor inherently peaceful but so flexible that we can be socially programmed to *become* aggressive or peaceful. The outcome for *Homo sapiens* is a world in which his now highly complex technology is a major factor in his own environment. It interacts with his material life and hence with his social being and indirectly with his personal awareness of himself as a social creature. By modifying his environment in this way he is therefore moulding his own psychology, yet most of the members of the species probably do not realize this is happening.

The situation is both exciting and dangerous. What is encouraging is that this process really can be under our own control. For example, we have realized that we no longer have to propitiate the gods to save us from natural disasters. But much of the programming is being done by powerful individuals who are both heedless of the process and strongly influenced, intellectually and emotionally, by historical events which are no longer relevant to present problems. Somehow we must learn to understand what we are actually doing and get control of it.

Nanocomp e.p.r.o.m. programmer

Low cost programming of 2516 and 2532 type memories

by R. Coates

Nanocomp was originally designed as a microprocessor trainer using the 6802 device (January 1981) and was later uprated (July 1981) to provide an evaluation system for the 6809. This e.p.r.o.m. programmer will operate with either unit and uses software to do much of the work, which reduces the hardware cost. The programmer software can be loaded into the Nanocomp r.a.m. or permanently stored in the e.p.r.o.m. if a 2 or 4K device is used.

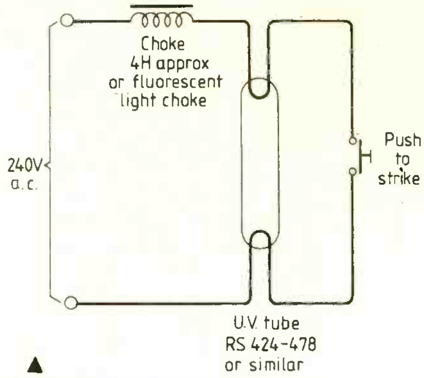
To enable the Nanocomp to be used as a dedicated controller or as the basis of a development system, spare e.p.r.o.m. space can be made available if a 2K or 4K memory is used. This allows user software to be placed in the e.p.r.o.m. and obviates the need to constantly reload a program. Also, the space allows larger programs to be stored in the 1K r.a.m. The only problem with e.p.r.o.ms is their programming, but this is not as difficult as the price of commercial programmers may suggest, particularly if the types of memory is restricted to two, i.e. the single rail 2516 and 2532.

Erasing and programming

Before an e.p.r.o.m. can be programmed, the previous data must be erased by exposure to u.v. light. Commercially available erasure units are the best solution, but prices start at around £40. Sunlight is not very practical as it would take around four weeks for erasure in Britain. However, an erasure unit can be constructed for about £15 using a commercial tube. Fig. 1 shows a simple circuit which can erase up to four e.p.r.o.ms simultaneously in about 20 minutes.

The i.cs should be placed about 2-3 cm from the tube, which is started by pressing the switch for a couple of seconds, repeating if the tube does not strike. It should be noted that u.v. light emitted from the tube will damage the eyes so the unit must be constructed in a light-tight case and switched off before inserting or removing the devices. Erasure can be impeded if there is dirt or grease on the e.p.r.o.m. window so ensure that the glass surface is clean. When an e.p.r.o.m. is erased, all the data bits are set to 1. Bits which must be set to 0 are programmed electrically by 25V applied to the V_{pp} pin of the device. This sets the e.p.r.o.m. to the programming mode and converts the data output pins to high impedance data inputs.

The address of the byte to be programmed is set on the address pins, and



▲ ***Fig. 1.*** *Wiring diagram for an e.p.r.o.m. eraser.*

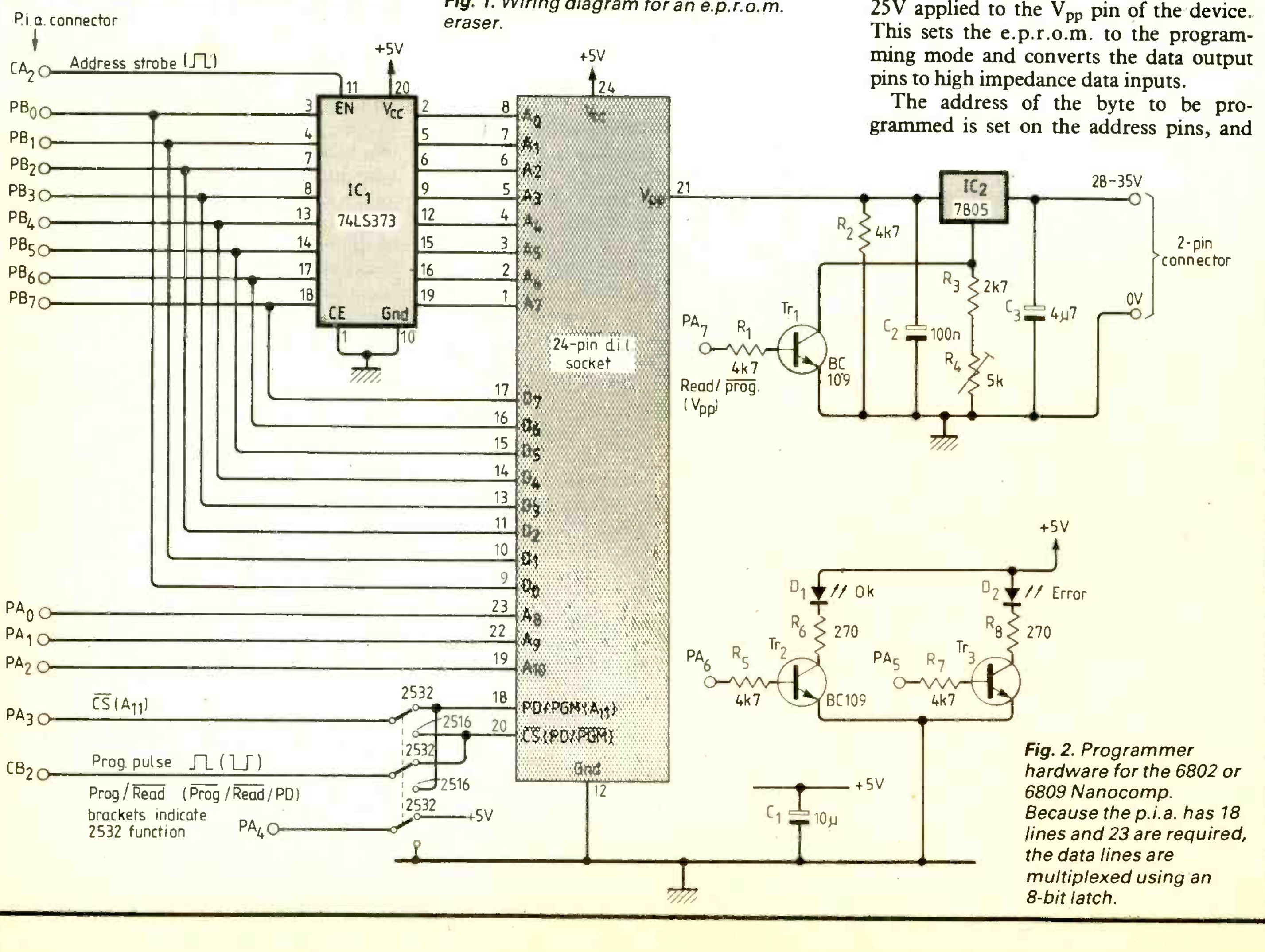


Fig. 2. *Programmer hardware for the 6802 or 6809 Nanocomp. Because the p.i.a. has 18 lines and 23 are required, the data lines are multiplexed using an 8-bit latch.*

the data byte to be programmed is presented to the data input pins.

A 50ms pulse is then applied to program the byte, and this procedure is repeated at each address of the e.p.r.o.m. Both types of device are programmed in this way, but there are small differences which will be described later. To avoid confusion, note that the two types of e.p.r.o.m. which can be used with the Nanocomp and programmer are the Texas TMS 2516 and TMS 2532 or their equivalents. For the 2516, most other manufacturers use 2716, but this is not equivalent to the Texas TMS 2716 which is a three supply-rail device. For the 4K device there are now two types. Intel continue to use two pins for device enable whereas Texas have reduced this to one, which means that the two types are not compatible. If purchasing from another manufacturer, check carefully that their device is TMS 2532 compatible.

Hardware

The complete circuit shown in Fig. 2 has been kept simple by using software to do most of the work. The basic programming operations can be performed using a peripheral interface adaptor (p.i.a.) with the microprocessor. The 6802/9 then writes the address and data information to the p.i.a. which in turn drives the e.p.r.o.m. Unfortunately, this requires 23 p.i.a. output lines, and only 18 are available. Two devices could be used, but the Nanocomp only has one available. This problem can be overcome by multiplexing the data lines and the eight least-significant address lines

Fig. 3. Software flowchart.

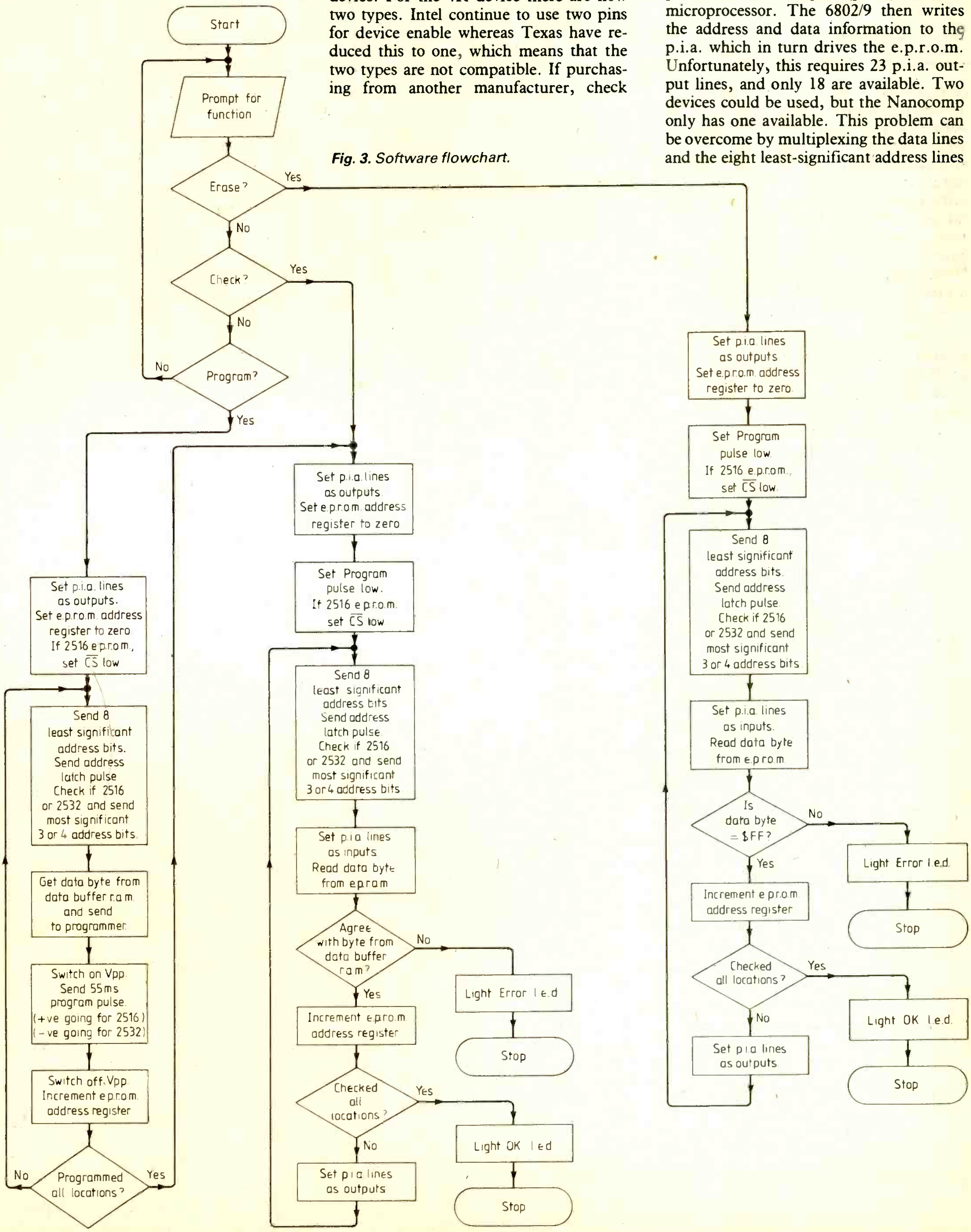


Table 1. E.p.r.o.m. sectors.

Sector no.		e.p.r.o.m. address		
1		0000	–	01FF
2		0200	–	03FF
3		0400	–	05FF
4		0600	–	07FF
5		0800	–	09FF
6	2532	0A00	–	0BFF
7	only	0C00	–	0DFF
8		0E00	–	0FFF

Table 2. Programmer operating instructions.

Erasure check

Press E
Connect programmer
Switch on Vpp supply
Press AB
Wait for ok or error l.e.d.
Switch off Vpp supply
Unplug programmer
Press RST

Programming and program check

Press P to program or C to check
Enter start address (SA) of data
Enter sector number (SEC=) of e.p.r.o.m. (1-4 or 1-8)
Connect programmer
Switch on Vpp supply
Press AB
Wait for ok or error l.e.d.
Switch off Vpp supply
Unplug programmer
Press RST

to the outputs of the p.i.a. Therefore, the data and addresses appear on the same lines at different times. Software first sends the address information via the p.i.a. B lines while deselecting the e.p.r.o.m. using its chip select input. This ensures that the e.p.r.o.m. data pins, which are connected to these p.i.a. pins, are in the high impedance state and have no effect. The p.i.a. B pins are also connected to the inputs of a 74LS373 8-bit latch which can store the data and present it at its output pins after a positive pulse is received by the latch enable input, even if the input data has been removed. Therefore, when CA2 sends a positive pulse, after the address has been set by the p.i.a., the address is latched at the outputs of IC1, which are connected to the address pins of the e.p.r.o.m. The p.i.a. outputs then change to the data which is held while the programming operation takes place. The three other address lines required by both types of e.p.r.o.m. (A8, 9, 10) are driven from p.i.a. lines PA0, 1 and 2.

Pins 18 and 20 of the two e.p.r.o.m. types differ in the following ways. For the 2516, pin 18 is the power-down pin in the Read mode which deselects the device and reduces the power consumed if set to 1. When programming, pin 18 is normally 0 and set to 1 for 50ms to produce the program pulse. Pin 20 is the chip select input. For the 2532, pin 18 is the extra address line required (A11) and 20 is the power down/program pulse pin. A separate chip-select pin is not provided, and the program pulse is negative going. Switching is provided to facilitate these differences by using three poles of a four-pole two-way d.i.l. switch. PA3 drives chip select/A11 and CB2 provides the program pulse. The third pole of the switch connects an input, PA4, to 1 for the 2532 and 0 for the 2516. This is used to inform the software which type is being programmed.

Table 3. Hex listing for the (a) 6809 and (b) 6802 Nanocomp.

(a) 1200 - 13A6 RELOCATABLE

```
P 1200 - 13A6
1200 10 CE 13 D0 86 40 1F 8B 8E 69 11 BF 13 FA 8E 00
1210 00 BF 13 FC BF 13 FE BD 7C 20 81 15 10 27 01 35
1220 81 23 10 27 01 08 81 21 26 ED 8D 7F 8E FF FF BF
1230 13 E0 BE 13 E0 30 01 BF 13 E0 B6 13 E1 97 01 86
1240 3C 97 02 86 34 97 02 B6 13 E0 8A 80 6D 58 26 02
1250 8A 08 97 00 8D 1B 81 FF 26 0D 8D 4A 26 0E 8C 07
1260 FF 26 CF 86 C0 20 02 86 A0 97 00 13 8C 0F FF 20
1270 F0 34 04 86 38 97 03 4F 97 01 86 34 97 03 6D 26
1280 26 06 96 00 84 F7 97 00 17 00 94 96 01 6D 17 26
1290 06 D6 00 CA 08 D7 00 C6 38 D7 03 C6 FF D7 01 C6
12A0 3C D7 03 35 04 39 D6 00 C5 10 39 8E 00 00 9F 02
12B0 30 1F 9F 00 8E 34 3C 9F 02 8E 88 00 9F 00 8E 7D
12C0 DB BF 13 F2 13 39 8E 3D 6F BF 13 FE BD 7C B5 BF
12D0 13 DE BF 13 E2 8E 3D 79 BF 13 FA 8E 7B 11 BF 13
12E0 FC 8E 00 00 BF 13 FE BD 7C E4 4D 27 E8 81 08 22
12F0 E4 4A 48 8D B6 8D AF 26 02 8A 08 8A 80 97 00 39
1300 BE 13 E0 30 01 BF 13 E0 B6 13 E1 97 01 96 3C 97
1310 02 86 34 97 02 96 00 84 FE BA 13 E0 97 00 39 4F
1320 4A 26 FD 39 4F C6 20 4A 26 FD 5A 26 FA 39 8D 96
1330 8E FF FF BF 13 E0 BE 13 E2 E6 84 30 01 BF 13 E2
1340 8D BE 17 FF 2C 34 04 A1 E0 10 26 FF 1A 8C 01 FF
1350 26 E4 16 FF 0E 17 FF 6E 17 FF 4B 26 04 86 34 97
1360 03 8E FF FF BF 13 E0 BE 13 DE E6 84 30 01 BF 13
1370 DE 8D 8D C1 FF 27 29 D7 01 8D A4 96 00 84 7F 97
1380 00 17 FF 22 26 0A 86 3C 97 03 8D 98 86 34 20 08
1390 86 34 97 03 8D 8E 86 3C 97 03 96 00 8A 80 97 00
13A0 8C 01 FF 26 C2 20 89
+
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(b) 1200 -13B8 RELOCATABLE

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P 1200 - 13B8
1200 8E 00 40 CE 69 11 DF 7A CE 00 00 DF 7C DF 7E BD
1210 7C 20 81 15 27 4E 81 23 27 4C 81 21 26 F1 8D 48
1220 CE FF FF DF 52 DE 52 08 DF 52 96 53 B7 40 01 86
1230 3C B7 40 02 86 34 B7 40 02 96 52 8A 80 8D 68 26
1240 02 8A 08 B7 40 00 8D 22 81 FF 26 0D 8D 59 26 0F
1250 8C 07 FF 26 D0 86 C0 20 02 86 A0 B7 40 00 3E 8C
1260 0F FF 20 EF 20 68 20 9A 20 43 37 86 38 B7 40 03
1270 4F B7 40 01 86 34 B7 40 03 8D 2C 26 08 B6 40 00
1280 84 F7 B7 40 00 8D 49 B6 40 01 8D 1B 26 08 F6 40
1290 00 CA 08 F7 40 00 C6 38 F7 40 03 C6 FF F7 40 01
12A0 C6 3C F7 40 03 33 39 F6 40 00 C5 10 39 CE 00 00
12B0 FF 40 02 09 FF 40 00 CE 34 3C FF 40 02 CE 88 00
12C0 FF 40 00 CE 7D E2 DF 72 3E 39 20 89 20 8B 20 3B
12D0 20 64 20 71 20 94 CE 3D 6F DF 7E BD 7C B5 DF 50
12E0 DF 54 CE 3D 79 DF 7A CE 78 11 DF 7C CE 00 00 DF
12F0 7E BD 7C E4 4D 27 EB 81 08 22 E7 4A 48 8D AE 8D
1300 A6 26 02 8A 08 8A 80 B7 40 00 39 20 58 20 98 20
1310 B9 20 B9 20 C1 20 BD DE 52 08 DF 52 96 53 B7 40
1320 01 86 3C B7 40 02 86 34 B7 40 02 B6 40 00 84 FE
1330 9A 52 B7 40 00 39 4F 4A 26 FD 39 4F C6 1A 4A 26
1340 FD 5A 26 FA 39 8D 8F CE FF FF DF 52 DE 54 E6 00
1350 08 DF 54 8D C2 8D BE 11 26 B7 8C 01 FF 26 ED 20
1360 AE 20 AA 20 E2 8D AC 8D A4 26 05 86 34 B7 40 03
1370 CE FF FF DF 52 DE 50 E6 00 08 DF 50 8D 99 C1 FF
1380 27 30 F7 40 01 8D AF 96 40 00 84 7F B7 40 00 8D
1390 D0 26 0B 86 3C B7 40 03 8D A1 86 34 20 09 86 34
13A0 B7 40 03 8D 96 86 3C B7 40 03 B6 40 00 8A 80 B7
13B0 40 00 8C 01 FF 26 BE 20 8E
+
```

Pin 21 of the e.p.r.o.m., V_{pp}, is the input or programming-enable voltage and is at +25V to program or +5V to read. This input must be switchable because, as well as programming, it is necessary to read the data in the e.p.r.o.m. before programming to check that it is fully erased, and after to check that it has been programmed correctly. These voltages are provided by an external 28-35V supply rated at 30mA. When the p.i.a. PA7 output is at 1, Tr_1 is turned on which connects IC_2 to 0V and supplies +5V to pin 21 of the i.c. socket. If PA7 is at 0, Tr_1 is turned off and IC_2 is connected to 0V through resistors R_3 and R_4 which develop 20V at the common terminal, and provide a 25V regulated output. Therefore, the software switches two voltage levels to V_{pp}.

Outputs PA5 and PA6 drive two l.e.ds via Tr_2 and Tr_3 to indicate that an operation has been completed without error or that an error has occurred. Although the obvious way of indicating an error is by the Nanocomp display, while the p.i.a. is driving the programmer, the display will not function normally.

The e.p.r.o.m. programmer can be used with any microcomputer system which has a peripheral port, and all that is required is a change of software to follow the flow chart in Fig. 3.

Software

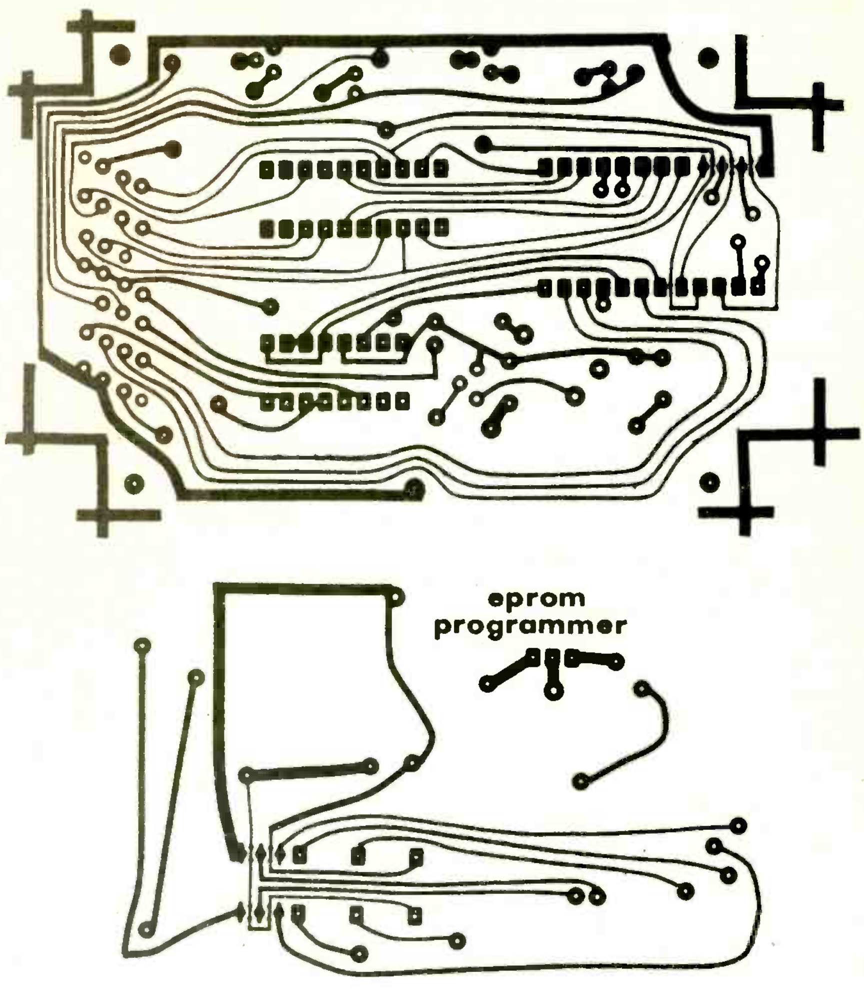
When programming a 2K or 4K e.p.r.o.m. with a microcomputer containing only 1K of r.a.m., the normal method of placing data into r.a.m. and then copying it into the e.p.r.o.m. cannot be used. Instead, the e.p.r.o.m. must be programmed in several smaller sections. With 1K of r.a.m. the e.p.r.o.m. memory map can be divided into 512-byte sections, which enables 512 bytes to be loaded and 512 bytes of the r.a.m. to be used for the operating software. The 512-byte sector to be programmed is specified, and the process is repeated four times (8 for a 2532) to completely program a 2K device, see Table 1.

If the e.p.r.o.m. is to be used in the Nanocomp, it is probable that the monitor will also need to be copied in. To facilitate this the address of the data to be programmed is also specified, which allows the operating e.p.r.o.m. to be directly copied in 512-byte blocks. The operating software has been designed to run at address 1200 inwards in r.a.m. and occupies about 450 bytes which are relocatable and can be placed in e.p.r.o.m. if desired. Three commands are available (1) to check for erasure of the entire e.p.r.o.m. (essential before programming) which switches on an ok or error l.e.d. when completed; (2) to program an e.p.r.o.m. sector, read it and check that it has been programmed correctly, which also provides an ok or error indication when complete; finally, a command to perform the read and check function.

Although the 25V is only required when programming, the external supply must be connected when using the other two commands because 5V is required to read the e.p.r.o.m.

Construction and operation

A double-sided printed circuit board is used as shown in Fig. 4. The 24-pin d.i.l. socket should be a low insertion-force type, and if only one type of e.p.r.o.m. is to be programmed, the 4-pole 2-way switch can be replaced by wire links. To simplify assembly, a p.c.b. transition connector is used for the ribbon cable, but the conductors can be soldered directly to the board. When construction is complete, apply the programming voltage and adjust R_4 until 25V appears at pin 21 of the e.p.r.o.m. socket. Note that the 7805 regulator is mounted on the underside of the p.c.b. so that the unit can be mounted close to the lid of a box, with cut-outs for the slide switch and e.p.r.o.m. socket.



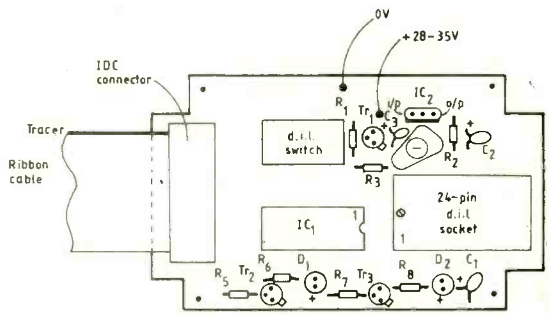


Fig. 4. Printed circuit layout and component location diagram. A double-sided p.c.b. will be available for £4.50 inclusive of v.a.t. and postage from M. R. Sagin, 23 Keyes Road, London N.W.2.

To run the programmer, load the software into r.a.m. from address 1200 unless it is in the Nanocomp e.p.r.o.m. Next, load the 512-byte block of data to be programmed at 1000-11FF unless a section of the monitor e.p.r.o.m. is to be copied. Ensure that the e.p.r.o.m.-select switch is correctly set, then, with the monitor prompt indicating, enter "G 1200" or the appropriate start address. The software then replies with "F", requesting a function (erase check, program or check) to be entered. Table 2 lists the procedures for each of the functions. The end of an operation is indicated by one of the programmer l.e.ds.

If an erasure check has been performed and the error l.e.d. switches on, one or more bits are not at 1 so further erasing is required. The program-check operation reads each location in a block of the e.p.r.o.m. and compares it with the data block. If a location does not agree, an error is indicated. Unfortunately the whole e.p.r.o.m. must then be erased and programmed again. However, with full-spec. devices this problem is very rarely encountered.

The program-check operation is performed automatically after a programming operation. The ok l.e.d. indicates that programming of the last block was performed correctly and the next block can be programmed after entering new data into r.a.m. Note that during the operation of all functions, random illumination of the display will occur because it is being driven in parallel with the programmer.

Table 3 gives an e.p.r.o.m. programmer hex listing for the 6802 and 6809 Nanocomp.

Clandestine radio – the early years

The beginnings of portable, low-power h.f. communications equipment

by Pat Hawker, G3VA

German Agentenfunk (Afu) transmitter in two cases, one for the batteries.

High-risk covert radio links during 1935-45 played an important, yet seldom recognized, part in the development of fully portable, low-power, h.f. communications equipment. Pat Hawker describes the equipment, the organizations involved, and some of the people.

Late in 1980, a farmer found unexpected buried treasure in a field near Wrexham, North Wales – a compact h.f. transmitter, later officially identified as of "East European" manufacture. It served as a reminder that clandestine or covert radio communication still has a role (if only that of a "set in place") in the tangled web of international espionage.

Such finds are rare: for a previously disclosed find in the UK one has to go back 20 years to the "Gordon Lonsdale" Naval secrets case. Then a basically similar transmitter, wrapped in plastics, was uncovered beneath the kitchen floor of the Ruislip home of "Peter Kroger" (Morris Cohen) and his wife. The crystal-controlled transmitter could provide 150W output and (like the Wrexham unit) had an automatic keying device that enabled previously-prepared Morse tapes to be sent for up to ten minutes at an average speed of some 240 words per minute. A transmitter of this type, attached to perhaps 50 feet of aerial wire and under the control of an experienced operator, would have little difficulty in passing traffic to East Europe.

No evidence was given at the Old Bailey trial in March 1961 that the Krogers had *used* the transmitter; though it was disclosed that they regularly received "broadcast" instructions from a high-power transmitter located near Moscow. For this they used a conventional h.f. broadcast receiver, recording messages on magnetic tape which could be transcribed by replaying at lower speed or by dusting the tape with iron-oxide powder and so rendering visible the Morse symbols. Outgoing messages, it would seem, were normally sent in the form of microdot photographs through the post, the h.f. transmitter being reserved for emergencies.

These disclosures showed, at least to some of us, that the basic principles and practices of clandestine radio, as developed in World War II, were universally understood and still practised by the major powers. But, though much has been written of the personal exploits of radio spies and resistance workers during the war years, little attempt has been made to assess the contribution they made – all too often at the cost of their lives – to the development of low-power, portable radio-communication equipment, or to understand the human and technical problems that had to be overcome. Kipling's "Great Game" was played with high stakes by the several hundreds of radio operators who went from Allied bases into European and Far Eastern occupied territory, some more than once, and many never returned.

Paradoxically, many of those working on behalf of the Allies were drawing on the work of the German Abwehr and RSHA* (which included the SD and Gestapo) intelligence services which pioneered many ideas in covert radio that were subsequently successfully employed against them. Russian military intelligence was also an early user of secret radio, for example by the Sorge ring in Japan (where Max Klausen proved an experienced and effective radioman); indeed their agent/operators were sometimes expected to build their own transmitting equipment, or have it built locally, in order to avoid the problem of smuggling the bulky radio transmitters across peacetime frontiers, a practice subsequently used also by the Germans in North and South America.

Components were then large and heavy, and transmitting valves bulky and fragile. But by the mid-1930s it became possible to think in terms of "portable" stations. For example, a former British amateur, Ted Cook (then ZT6AQ, now ZS6BT), travelled (legally!) around South Africa with a 30-watt transmitter (double-triode 6A6 driving an 812 power amplifier) built into a Burndept portable-radio case about 18 by 18 by 8 inches; an 0-V-2 receiver in a second similar case. He contacted fellow amateurs over long distances from locations that included a seventh-floor flat in the centre of Johannesberg. One of his most difficult problems was to avoid causing "key-clicks" on an estimated 400 broadcast receivers within a radius of 1000ft of his makeshift aerial.

In the early days (ignoring the efforts to use spy radios in World War I that proved less effective than homing pigeons) clandestine operation must have seemed equally easy: no monitoring/intercept organizations of the 1930s could contemplate watching continuously all the newly-important h.f. band, with the added problem of skip zones and the considerable limitations of h.f. direction-finding in the days before "huff-duff" (h.f. d/f) c.r.t. displays and the German wide-aperture Wullenweber ring aerials.

F. R. Hornby of Military Intelligence built a small transmitter in his garage and concealed it in a standard car radio; then he visited a number of sensitive defence establishments, including the Royal Aircraft Establishment at Farnborough and Boscombe Down, and naval establishments in the Portsmouth area. He would copy out an innocuous document and radio the contents from the establishment's car park to his father's house in

*Reichssicherheitshauptampt, into which the Military Intelligence organization or Abwehr was later incorporated. The RSHA was directly linked with the Nazi party and came under the control of Himmler.

Bournemouth. The official Y intercept services, operated by the Navy, Army, Air Force and civilian agencies, were warned in advance of his intentions and given an idea of the frequencies he would use. Yet very few indeed of his transmissions were reported by Y, underlining the urgent need for a special intercept organization devoted to seeking out clandestine traffic – and possibly accounting for the official ban on all car radios in the UK from 1940 to 1944.

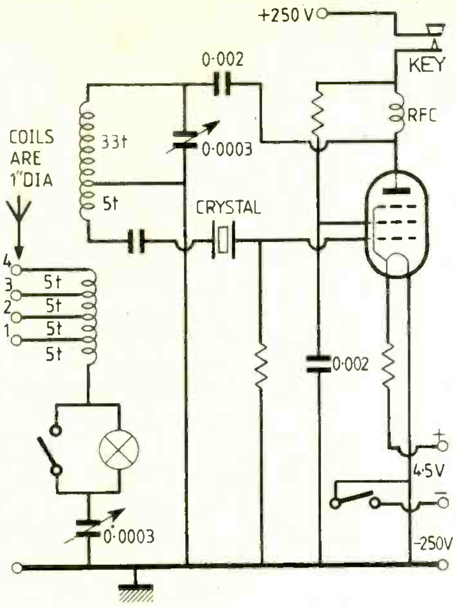
There already existed within MI5 the Radio Security Service but this was little more than a nucleus, staffed largely by Post Office interference-investigation teams and having as a prime objective the tracing of any medium-wave navigational beams that German agents might try in wartime to establish in the UK (they never tried!). Soon after the outbreak of war in 1939, RSS was greatly expanded, including the secret recruitment by Lord Sandhurst of more than 1000 former radio amateurs (who had been officially closed down on September 1, 1939) as voluntary interceptors (VIs) aided by a number of full-time police and Post Office radio operators. The VIs listened enthusiastically but located very few enemy radio spies; for the very good reason that from September 1939 until May 1945 virtually all enemy agent radio activities in the UK were conducted by 'turned' agents with the assistance of RSS and the Doublecross (XX) Committee.

This web of deception followed on from the arrival in the summer of 1939 of an Abwehr Afu (Agentenfunk) radio at Victoria Station, intended for use by a Welsh engineer, Johnny Owens. But Owens was already a double agent and ensured that the Afu (with cipher and signal plan) was promptly turned over to the British. A later arrival, Hans Hansen (Tate) sent over 1000 messages to the Germans, via Hamburg or Abwehr stations in the Iberian peninsular. There were a couple of dozen others at various times.

But the VIs search of the h.f. bands soon brought to light something that was to prove even more rewarding: by mid-1940 they had teased out an elaborate complex of German Intelligence radio-communications networks. These were not only for working to agents (mainly from the Hamburg and Wiesbaden control stations) but also for handling the very busy communications links between intelligence offices (KOs in neutral countries, Asts in occupied countries) and the main intelligence centres in Berlin, Vienna etc, using hand ciphers and the Enigma machine. Later Abwehr Enigma keys were cracked; though a Gestapo Enigma remained unbroken.

Ewen Montagu ("Beyond Top Secret U") has written: "A number of Abwehr and other stations in the Aegean and Greek Islands were sending out informative reports . . . for a very long time they constituted virtually our only information from these areas".

The effectiveness of German special communications (Signal Regiment 506) and agent-radio equipment was demons-



German battery-powered Afu transmitter, designed to be carried in a leather case slung over the shoulder, with the batteries in another. Aerial coupling coil taps allowed for different aerial lengths, the indicator lamp showing tune. Frequency range was 4 to 8.5 MHz.

trated during the German invasion of Norway in April 1940 – an operation which simultaneously made clear to the British the *ineffectiveness* of their own Service radio communications from unprepared sites over distances of some hundreds of miles; later this was rubbed in by the unreliability of hastily built British military radios in hostile environments (I am told that less than 30 per cent of the British WS No 19 sets worked without failure in North Africa!).

After Dunkirk in May 1940, the need for a British equivalent to the Abwehr/RSHA networks became urgent, although the UK was by no means "cut off from the Continent" as is often supposed. In the 'phoney war' period from September 1939 to May 1940, there had seemed little requirement for truly portable 'agent' radios. But there were Intelligence out-stations, mostly under diplomatic cover, in neutral countries, and radio links were established from about 1936 onwards.

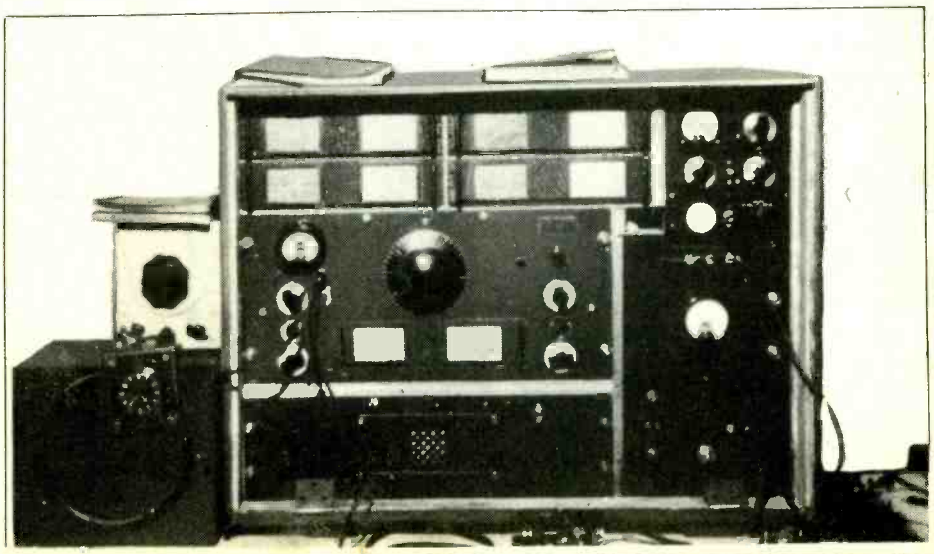
The successful breaking of the German Air Force Enigma machine cipher early in 1940 created an entirely new requirement; it led directly to the creation of what was to become a reliable semi-covert (or "low profile"), secure communications network dedicated to the distribution of this vital intelligence material (ULTRA). The Army and the RAF agreed to the setting up of an MI6 system under F. Winterbotham (the Navy insisted on its own system) whereby ULTRA information was passed through Special Communications Unit operators to Special Liaison Units attached to Overseas Commands from a multi-operator station at Windy Ridge, Whaddon, near Bletchley.

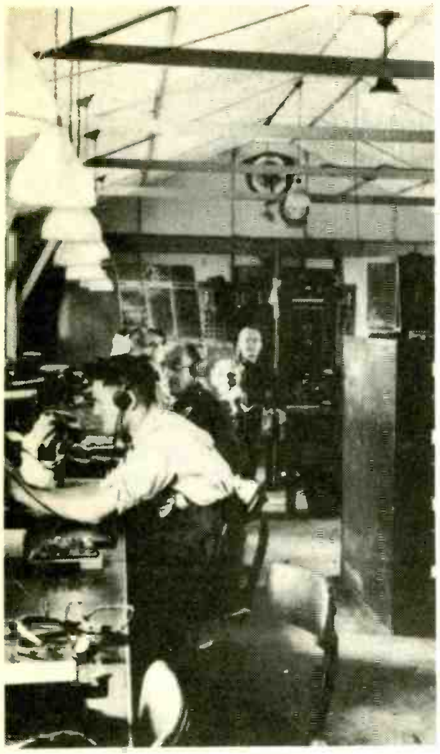
For this network the outstations comprised HRO or AR88 receivers and Special Communications Mark III transmitters. By 1944 there were almost 40 SLU/SCU outstations.

The Mark III, of which many hundreds were built at the Special Communications factory near Whaddon, was a simple, straightforward, but effective two-stage transmitter (6V6 crystal oscillator, 807 power amplifier) with plug-in coils. Most were in small wooden cabinets with the power supply unit accounting for much of the weight. Later, a "coffin" assembly was devised in which a Mark III or XV transmitter, HR0 receiver and its set of plug-in coil assemblies, together with power supplies, formed a large and awkward but reliable station which could be powered from a 350-watt Onan petrol-electric generator or local supply mains. Perhaps the worst fault of the Mark III was the ease with which it could be tuned to a harmonic frequency without this being obvious to an unwary operator. The Mark V had a t.r.f. (l-V-l) receiver in a separate wooden box.

During 1940 to 1945, the MI6 radio section, based at Whaddon, gradually expanded into a series of about a dozen Special Communications Units under Brigadier (later Sir) Richard Gambier-

Mk III/HRO transmitter/receiver assembly in its 'coffin', with coil assemblies and power supplies in one unit





One of Special Communications control stations for links with Western Europe.

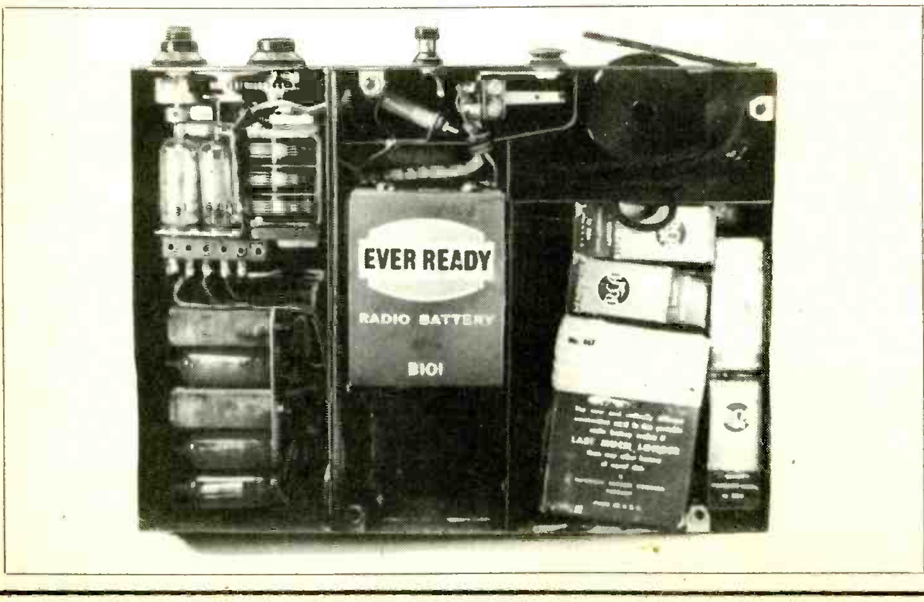
Parry, with Colonel E. Maltby as his deputy.

"G-P", a World War I officer who had been thrice wounded, was a former radio amateur (G2DV), and an ex-Information Executive (1926-31) at the BBC where he had battled with the Baird Company over the BBC's reluctance to use the 30-line mechanical television system and dealt with technical correspondence; he was, as they say, "attached to the Foreign Office" in 1938. Colonel Maltby had come from the management side of the highly-competitive radio receiver industry. When, after some intense skirmishing and the personal intervention of Sir Winston Churchill, MI6 won control of RSS operators from MI5, he was given responsibility for building the Special Intelligence intercept station at Hanslope Park. One suspects he was a little nonplussed when he discovered that the RSS operators were mostly a bunch of independently-minded radio amateurs, happiest when searching for weak and fading signals but with no wish "to play soldiers". From January 1942, Lord Sandhurst was responsible for the links with agents (Plans section).

G-P also gathered around him people, with considerable professional or amateur-radio experience of h.f. communications, but who were not unwilling to pick up tips from their Abwehr counterparts or to lift ideas from the Radio Amateur's Handbook. G-P could also draw on the mathematical genius Alan Turing, who, after expounding in the 1930s the principles on which all modern computers are based, joined GCCS/MI6 at Broadway Buildings and Bletchley, where with T. Flowers of Post Office Research he was to develop Colossus, the first cryptographic electronic computer. There were also specialists seconded on occasions from industry, including the aerial engineer F. J. Charman, G6CJ, of EMI.

And if the more senior MI6 officers had an eye for good-looking horses and good-looking women, they also showed good judgement in buying from the United States high-performance equipment that had been developed in the late 1930s for the American amateur radio market. Throughout the war, Special Communications largely depended on the National HRO and (later) the RCA AR88 receivers, two of the finest general-purpose receivers ever manufactured in large numbers, backed up by simple regenerative 0-V-1 and I-V-I agent receivers. They were also much taken with the 6.3V metal-octal valves, the reliable 807 beam-tetrode and later the new miniature 1.5V-filament battery valves and layer batteries. Their most expensive (and longest-lasting) purchase was the 600kW "Aspidistra" m.f. broadcasting transmitter, which was bought in 1941 for £111,801 4s 10d and installed at Crowborough, Sussex. Since the war, it has carried the BBC external services programmes, though due to go into honourable retirement shortly. Special Communications, almost by accident, was the transmission agency for Rex Leeper's "black" outfit at Woburn Abbey, whose secret existence was instrumental in enabling the BBC to concentrate on the more "truthful" propaganda.

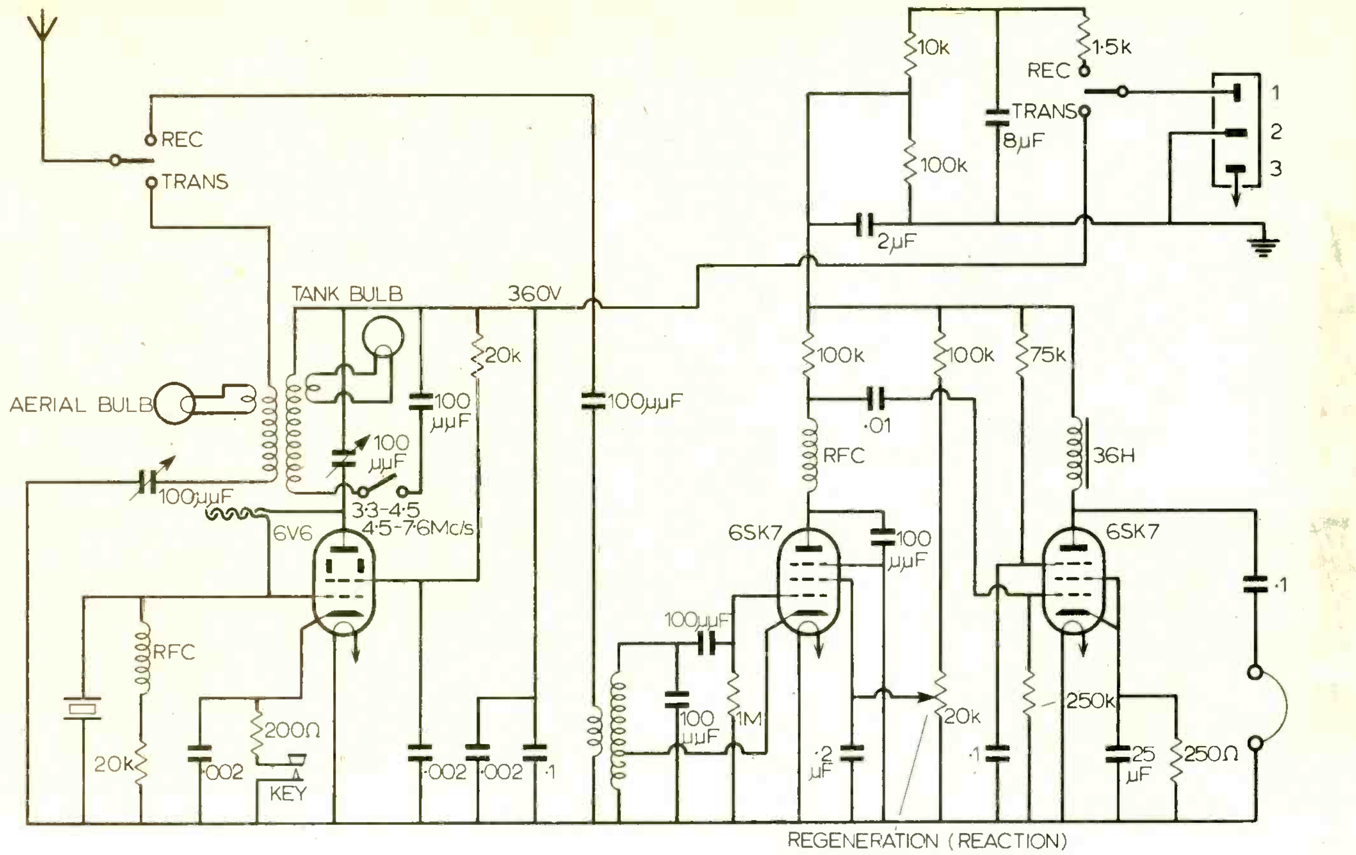
Special Communications briefcase receiver, using 1.5V valves and layer batteries, about 1943-4.



The fall of France and the potential requirement for "stay behind" agents within the UK had changed the situation profoundly. A new sabotage and operations organization (Special Operations Executive or SOE) was established in the UK in July 1940. Intelligence and secret operations groups began to assemble around the governments-in-exile and the Free French who set up in London the Bureau Centrale de Renseignements et Action (BCRA) under "Colonel Passy" (Andre Dewarin). Military intelligence department MI9 was charged with recovering shot-down Allied aircrew and other evaders from the occupied territories. MI6, recovering from the blows inflicted on its intelligence networks early in the war, began rebuilding its links with the occupied countries, seeking co-operation with all who might be induced to oppose the Germans, even among the Vichy security organizations.

In the absence of anything more suitable, the wooden-boxed Mark III (and later Mark XV) equipments were pressed into service in "unoccupied" France and elsewhere. Considerable success was achieved with these early clandestine links but, in September 1942, German intelligence negotiated a deal with the Vichy-controlled Deuxième Bureau that enabled them to put some 300 Abwehr, Gestapo (RSHA) and ORPO (Ordnung Polizei) men and women, furnished with false French identity papers, into the unoccupied zone to stamp out the growing amount of undercover radio activity. (ORPO was the branch of the regular German police force responsible for the mobile direction-finding units in occupied countries. Based on Lyons, Marseilles and Montpellier, these pseudo-French teams soon located and closed most of the early clandestine transmitters.)

But by that time, new compact transmitter-receivers which could be carried in small attache cases were becoming available, including the Special Communications Mark VII that was to prove one of the most effective of all sets for medium distance working. The Mark VII had an 0-V-1 receiver, using two 6SK7 valves, and a 6V6 crystal oscillator, with miniature Morse key, in a compact metal-box container. There were no meters, but two pilot lamps gave assurance to the user that the oscillator was working and feeding a few watts of r.f. to a long-wire aerial. Separate power units were provided for mains and 6V battery (vibrator-type unit). The entire equipment, with aerial wire, earphone, mains adaptors, etc., fitted into a small attache case. When not in use, the valves were removed from their sockets and clipped into the lid, reducing overall size when the box was shut. Most of the

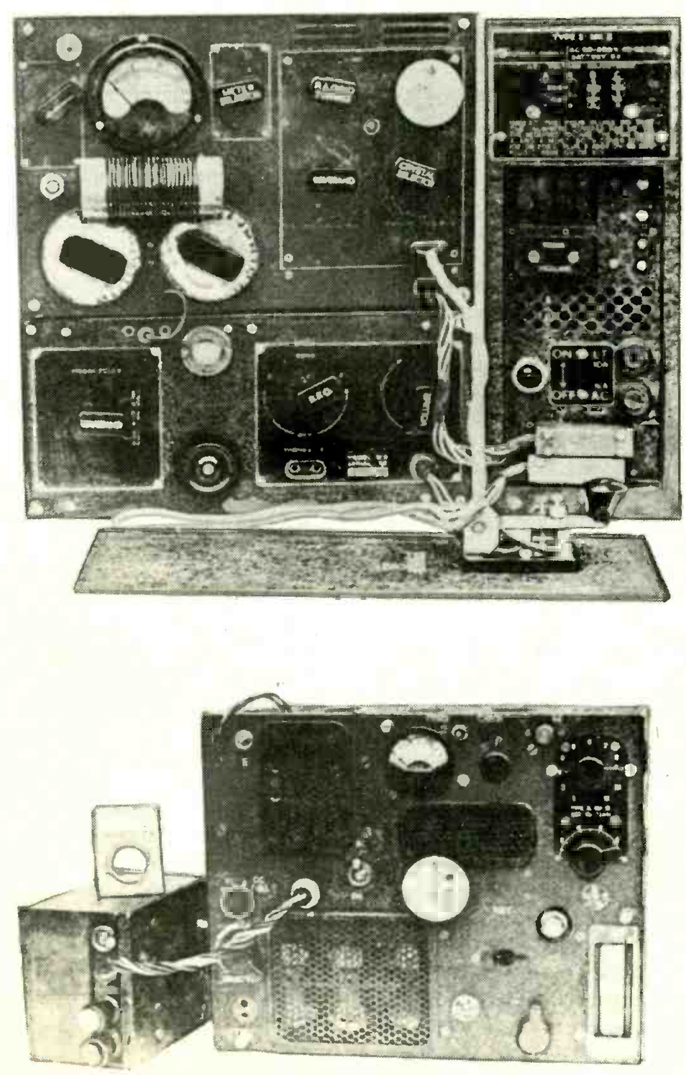


Special Communications MK VII transmitter/receiver

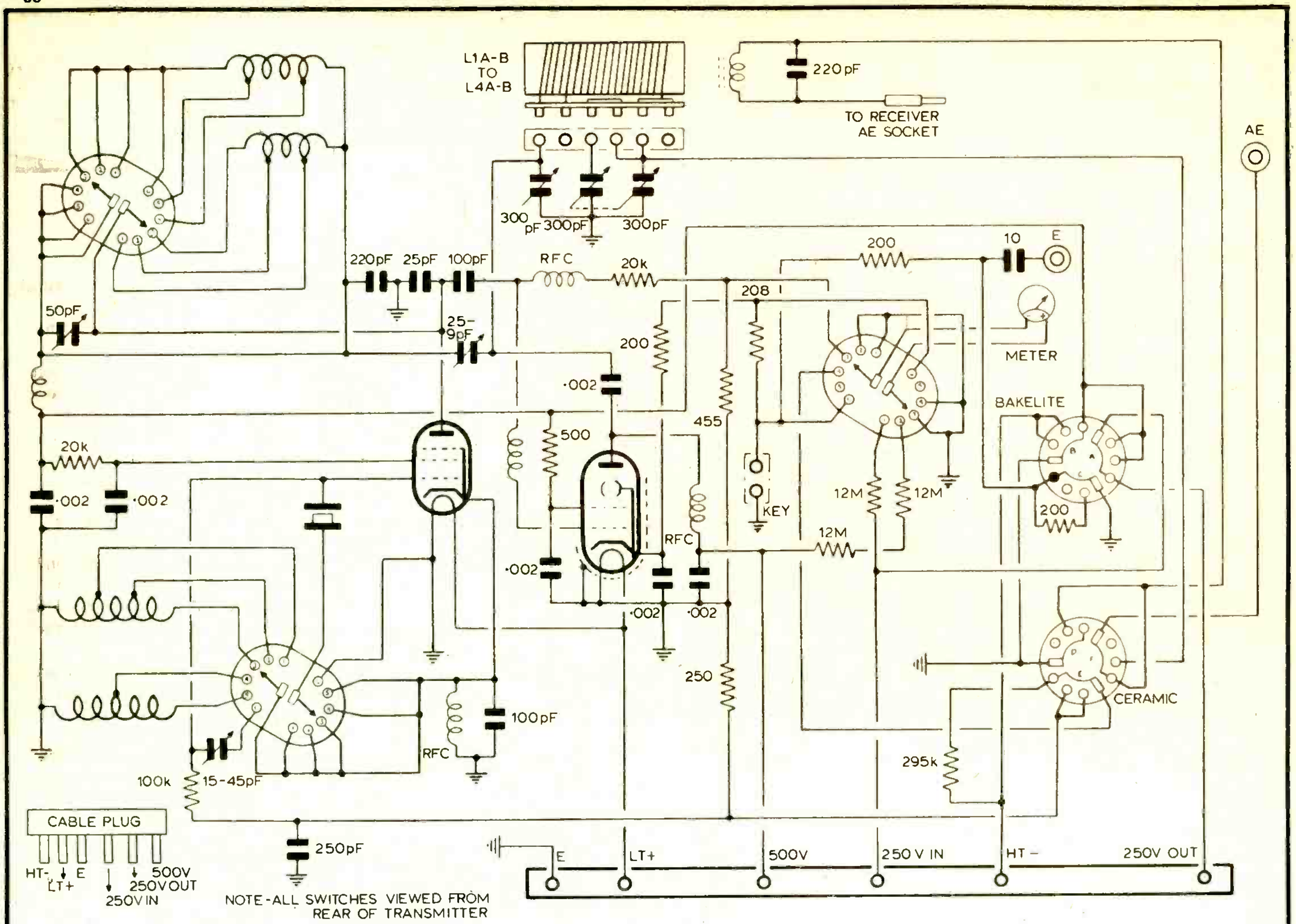
early Special Communications equipments used "straight" receivers, whereas virtually all other Allied clandestine radios used superhet circuitry, though often these receivers had such excessive "image" response that they became virtually unusable after dark.

Later the Whaddon factory produced a number of battery-operated equipments, such as the Mark XXI, using miniature valves and powered by layer batteries. With r.f. output in milliwatts, however, these equipments, when used with poor aerials and by inexperienced operators, tended to be far less effective than transmitters having rather greater output. There were also many "specials", including disguised sets and very simple transmitters that required no tuning.

Until mid-1942, SOE depended upon Whaddon for its secret radio links but, following considerable friction, was authorized to set up its own Signals Directorate for 'F' Section only. It should be appreciated that Special Operations and Special Intelligence can never make good bed-fellows. Intelligence and escape organizations have no wish to have people blowing up bridges, factories or railways or attempting assassinations exept when these are in direct support of imminent military operations. For them, an apparently dormant population is more to be desired than an atmosphere of police raids, hostage taking and road and rail



B2 (Type 3 MkII) at top and B2 Minor (Type A Mk III) SOE equipment, by Marconi and John Brown.



B2 transmitter, developed for the Special Operations Executive by the Inter-Services Research Bureau at St Albans. It covered 3 to 15.5 MHz.

searches. Relations between SIS and SOE/BCRA etc were at times extremely strained: later, SOE combined with the covert operations element in the American OSS to form "Special Forces". The Secret Service endeavoured to retain control over as much of SOE's communications as possible, as well as the links with its own agents and those of the Governments-in-Exile. Only the Poles and Czechs achieved a real degree of independence to handle their own traffic at the UK end, though the Danes and the Dutch designed and built in occupied territory a considerable amount of their own equipment.

The SOE Signals Directorate established an equipment design team at St Albans (Inter-Services Research Bureau) and developed the much more widely known B2 and B2 Minor sets, the MCR1 miniature communications receiver, the 450MHz "S-phone" for example though manufacture of these sets was in the hands of industry (Marconi, Philco (GB), etc.). The Poles were responsible for a series of compact "Polonaise" transmitter-receivers. Towards the end of the war, a number of American suitcase sets designed for the OSS (Office of Strategic Services, the forerunners to the post-war CIA) were also used in Europe, though many were intended for the longer distances of the Pacific and were rather too bulky for convenient use in the extremely dangerous urban conditions in occupied Western Europe (as indeed was the all-too-conspicuous B2 equipment).

The SOE equipments were probably the most technically advanced of any. The transmitter section of the B2 series (eg Type 3 Mark 11) was an effective design with a crystal oscillator that could work on fundamental or harmonic (tritet) frequencies with a neutralized 6L6 power amplifier (with plug-in coils) and a pi-network impedance-matching network to feed the random-length aerial. It covered 3 to 15.5MHz. The four-valve superhet receiver (two 7Q7, two 7R7 valve) had a 470kHz i.f. With no r.f. stage the receiver suffered badly from "image" response. It all fitted into a large (and distinctive) suitcase and at about 15kg was not something to be carried for long. A more valid criticism, however, is that the design was better suited to a fully trained or experienced radio operator than to many of the hastily-trained SOE F-section agents.

SOE also produced the more compact B2 Minor (for example, the Type A, Mark 111) that in size was roughly comparable to the Special Communications Mark VII. It similarly used a single-valve keyed crystal oscillator. The receiver was a superhet with regenerative i.f. at 1215kHz. The complete transmitter/receiver, with mains/battery power unit, box of spare valves, aerial, headphone, neon tube for testing, fitted in a 13 × 4 × 8 inch fibre attache case and weighed about 8kg. Both were significantly more rugged and operationally reliable than much of the standard wartime military communications equipment. Of the A Mk III, Sir Robert Telford, managing director of GEC-Marconi Electronics Ltd, has recently written: "It was used by SOE, SAS and others and was a miracle of miniaturization in relation to the component technology of the day. Furthermore, it was produced in no time at all!" It remains a moot point, however, whether it was operationally superior to either the simple Special Communications Mk VII or the Polish sets with miniature superhet and keyed 6L6 crystal oscillator as a "spy set" in Western Europe.

Over 25,000 MCR "miniature communications receivers" were manufactured for SOE/Special Forces by Philco (GB), many being dropped "blind" into Europe. Apart from Special Communications equipment such as the battery-operated Mark XXI transmitter-receiver, the MCR was among the first British equipment to use miniature 1.4V battery valves and layer-type h.t. batteries developed in the USA. Although a communications-type receiver, the MCR was intended primarily for listening to broadcast transmissions, including the so-called personal messages. In many areas large numbers of domestic receivers were removed by the occupation forces.

To be concluded.

Letters to the Editor

Leap seconds

Dr Essen's article "Leap seconds" in your July 1981 issue left unanswered what has been puzzling me ever since I built my "Rugby controlled" clock a few years ago. From my observations it appears the "atomic time" has to be corrected by adding the leap second at fairly regular intervals of just over a year. Fixed intervals mean a calibration error, i.e. the definition of the "atomic time" could be improved upon. At a rough estimate 9,192,632,000 cycles, instead of 9,192,631,770, would result in a better agreement, i.e. the leap second would have to be added less frequently.

If the sidereal clock deviated randomly from an imaginary "ideal clock" the best definition of the "atomic time" would be such that would result in the leap second having to be added with random sign at random intervals. I realize the sidereal clock, apart from random variations, also slows down as the Earth's rotation slows down. But this makes things worse: the atomic clock is already too fast.

Why has the apparently not-quite-correct definition been adopted? Perhaps sufficiently accurate data were not available at the time. But Dr Essen quotes an uncertainty of ±20 cycles, while one second in a year corresponds to approximately 290 cycles in $9.192 \ldots \times 10^9$.

Andrew Romer
Bognor Regis
Sussex

The author replies:

Mr Romer's comments on my article indicate that several points were not fully appreciated and deserve to be emphasised. The first is that leap seconds are not corrections to atomic time. The atomic second is the legal unit of time and is therefore constant by definition, as are the other fundamental units of measurement. Before it was adopted it was made equal to the existing astronomical unit in order to preserve the continuity of measurement, but is now used with its full accuracy and without any further reference to, or dependence on, astronomical measurements.

A scale of time could most logically be constructed by counting the number of seconds on a decade scale, a time interval being the number of seconds between two events; but it is a great convenience to use the atomic time scale, which is continuously transmitted, to give the time of day as well. The seconds are therefore counted using the traditional scales of 60 × 60 × 24 giving units of minutes, hours and days and designating these intervals by distinguishing marks. The scale was set so that it gave correct astronomical time on January 1, 1958. The time of day, determined of course from astronomical measurements, gradually diverges from atomic time as the rate of rotation of the Earth varies. When the divergence exceeds 0.5s the marker is moved along by 1s so that the signals give the time of day directly with an error not exceeding about 0.7s. These leap seconds must be removed for the measurement of true time interval.

Mr Romer also notes that leap seconds have, so far, all been in one direction. The explanation of this is that the atomic second was made as nearly as possible equal to the second of ephemeris time which was believed to represent the average value of the sidereal second over more than 200 years. If the rate of rotation of the Earth varies in the future as it has done in the past, then, in the long run, leap seconds should be required equally in the two directions although they would be expected to be in the same direction for a number of years.

In retrospect it might have been more convenient if a different value had been chosen for the unit; but some leap seconds would have been required in any case. The value chosen is not of much importance. The important thing is that we now have an extremely convenient, precise and constant unit in which to measure frequencies and intervals of time including the periodicities of the bodies of the solar system.

L. Essen

Radio Amateurs' Examination

Criticisms of the Radio Amateurs Examination which have appeared in recent issues of your journal may have caused concern to the many thousands of individuals who annually seek this qualification, and I shall be grateful if I might be allowed space to answer, in some detail, the points which your correspondents have raised.

The examination, according to Mr Pat Hawker in your May 1981 issue (page 54) is "a lottery conducted in secret". Nothing could be further from the truth. The papers are compiled, by a group of subject experts with extensive knowledge of the theory and practice of the subject and similar extensive experience in teaching courses leading to the examination, from banked items which have been written by highly competent subject experts.

The papers are compiled in accordance with the examination specification published by the Institute in the syllabus pamphlet, 765 – Radio Amateurs Examination, and with the set of sample items from the question bank. Both of these may be purchased from the Institute's Sales Section by anyone wishing to establish the facts. Furthermore, permission to include the specification and sample items in textbooks is freely granted to authors and publishers, as well as to the correspondence colleges who prepare so many of the students for examination.

All the items appearing in the RAE question papers have previously appeared in public because they are pretested on a sample of at least 300 candidates as part of the item validation process. These pretests take place shortly before the date of the May examination, and when pretest papers are despatched to centres the course tutors are specifically asked for comments: a special form for these is enclosed in order to encourage a response.

Mr Hawker also suggested that the marking may be 'suspect' – a most serious charge which I refute absolutely. The candidates' answer sheets are optically scanned and, before the scores are output to the results determination part of the computer system, a preliminary item analysis is produced. This allows the statistics for each item to be checked. Any items which have been commented upon by examination centres are given special scrutiny and if a suspect item is discovered it is possible to instruct the computer to ignore it, thus effectively deleting it from the question paper.

This procedure was in fact activated in respect of two items in the December 1980 second paper, which had been made nonsensical as a result of printing errors. Whilst I accept that it is inexcusable for an examining body to have allowed such errors to slip through the checking procedures, nonetheless the question invalidation facility that I have described above, which was written into the multiple choice marking system for just such an eventuality, prevented any distortion of the results.

The other specific criticism of a question related to the following: "A standing wave meter is used to check the (a) stability of the oscillator (b) efficiency of the transmitter (c) resonant frequency of the aerial (d) operation of the aerial feeder." A subsequent check with members of the examination team indicated that recent technical developments might have made this item suspect.

In general, if an item is technically incorrect it becomes totally unacceptable. However, it is occasionally permissible, when framing items at a fairly low technical level, to make simplifications which, to the expert, would be unjustifiable. The statistics for this item gave no indication that the question was confusing to candidates:

Facility Value = 48.7 Discrimination Index = .470

	No.	(%)	LG%	UG%
A	99	(4)	8.7	0
B	327	(12)	18.3	4.9
C	986	(36)	52.6	16.3
D	1350	(49)	19.2	78.6

(The correct answer is D).

Note: UG and LG stand for upper group and lower group, corresponding to the top and bottom 27% of the candidates on the paper as a whole. The analysis indicates the response preferences of each of these groups in percentage terms.

This analysis clearly shows that the students who got this question right belonged mainly to the upper group, i.e. those who tended to get a high score on the paper, which would indicate a better knowledge of the Radio Amateurs syllabus.

The other major criticism which I should like to refute for the benefit of your readers is the suggestion by Mr Osborne in your August 1981 issue (page 34) that "there are doubts about the validity of the examination". Doubts there may be in Mr Osborne's mind but they are unjustified. The Radio Amateurs Examination is a high quality examination of proven reliability which is designed, constructed and validated in accordance with the principles of modern achievement testing. The two basic criteria used to judge the quality of any system of educational measurement are *accuracy* and *validity*.

The RAE is *valid* if it measures an appropriately balanced selection of the objectives of the scheme. This balance is determined by a panel of subject experts devising a precise test plan which determines the proportion of the rest related to each objective. Having an explicit plan means that the content balance of the tests can be kept constant from one examination series to another.

The *accuracy* of the RAE is checked by estimating the reliability coefficient for the test, i.e. an index of the proportion of the variation in test scores which is due to true measurements as opposed to errors of measurement. A set of test scores with a reliability of 1 would be completely free of error; a set of test scores with a reliability of 0 would consist entirely of error variation. The reliabilities of the last five Radio Amateur Examinations are given below:

	Licensing Conditions	Operating Practices
May 1981	.81	.90
December 1980	.76	.90
May 1980	.79	.89
December 1979	.77	.89
May 1979	.82	.89

Note: the Operating Practices reliabilities are higher than those for Licensing Conditions because of the greater length of the paper.

These values are at the upper end of the range of reliabilities achieved by British public examinations, and they indicate that the examination is capable of distinguishing between candidates according to their knowledge of the Radio Amateurs syllabus with a high degree of consistency and a minimum of error.

With regard to random guessing, application of the binomial theorem will inform anybody with access to a pocket calculator that the chance of achieving a high score by this means is very small indeed. For example, the probability of obtaining a score of 35 on a 60 item test is 3.30924×10^{-8}. (To calculate the probability of achieving a score of 35 or above it is necessary to sum the probabilities of achieving all the individual scores above 35.) What evidence there is suggests that random guessing is not a frequent or significant strategy used by candidates in the Radio Amateurs Examinations. Many well constructed but difficult multiple choice items have facility values (i.e. percentage of correct responses) of less than 25%. If random guessing were a significant factor, facility values would be unlikely to fall below 25%.

I apologise for having written at such length but I felt it to be necessary to reassure your readers about the high quality of the Radio Amateurs Examinations conducted by City and Guilds. Prospective candidates should know that all the items are pre-tested, that they are checked before responses are finally marked, and that comments from examination centres are considered very carefully and acted upon if appropriate.

B. H. Henson
Controller, Education and Training Services
City and Guilds of London Institute
London WC1

C.b. frequency synthesis

The article on c.b. frequency synthesis in your November 1981 issue, in common with many advertisements for quartz crystals, fails to give full specifications of the quartz crystals mentioned; also the published circuit for the mixing synthesiser makes no provision for adjustment of the frequency of the crystal oscillator, f_c. As one input to the phase-locked loop is the frequency difference between the v.c.o. output and f_c, the performance of the synthesiser is directly affected by the accuracy and stability of f_c.

The article *does* quote a frequency tolerance of 1.5kHz for the British c.b. system, but no further mention of tolerance or stability is made; there is no analysis of the factors affecting tolerance and stability, and, lastly, the frequency spectrum plot (Fig. 5) gives no scale information (amplitude change per Y-axis step, frequency change per X-axis step).

± 1.5kHz in 27MHz is $\pm 0.005\%$ or 50 p.p.m. To achieve this stability over a temperature range of, say, $-5°C$ to $+45°C$ in the published circuit is no mean feat.

The above omissions suggest your vetting process for articles to be somewhat lacking; an early remedy in this case seems necessary in order to remove some tarnish from your reputation, the more so because the footnote to the news item "S.s.b mobile radio still promising" (p.67) indicates that someone on your staff is aware of the problem.

P. W. Tomlinson
Data-Type Terminals Ltd
Cwmbran
Gwent

Linear power amplifier

As can happen even to Mr Linsley Hood (Letters, September 1981), your correspondent Mr Rice (Circuit Ideas, October 1981) has submitted circuits which are not new. The earliest reference which I know of is in a text book from 1964[1] and the next is from an article by Motorola in 1976[2]. The text does not claim originality, perhaps because of some valve equivalent known to the authors, but Motorola did. Motorola actually announced a set of power transistors adapted to the arrangement of Mr Rice's Fig. 1 (BD364 to BD369, 25 amps, 50 to 80 volts V_{CE}) and considered using six of them per amplifier!

However, the main reason for my writing is to emphasise the virtues of the arrangement shown in Mr Rice's Fig. 2. Some years ago I used such an output stage in a circuit as indicated here (Fig. 1) and, subject to my poor experimental technique and equipment, found it to be flat to about 1MHz at 20 volts r.m.s. into 6.8 ohms.

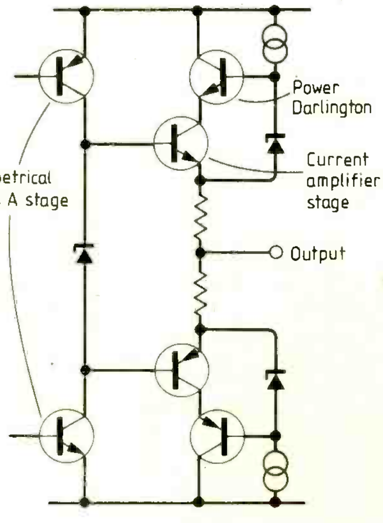


Fig.1

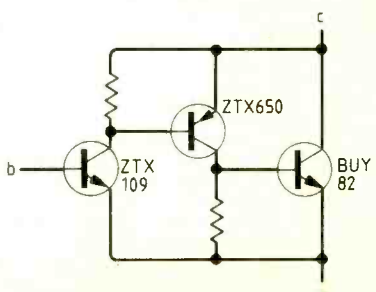


Fig. 2

The Darlington is in common-base mode, so it is free of thermal runaway problems, is limited in voltage by its V_{CB} rather than its V_{CE} giving an advantage with some types and is limited in frequency by its f_α rather than its f_β. I suspect that it could be operated beyond its f_α (possibly with due regard to safe operating area) because the phases of the currents and voltages related to the Darlington do not much matter to the current amplifier.

The current amplifier is operated at an almost low voltage, so is free of Miller effect problems and dissipates very little power. High frequency switches, such as BUY82/92 (8-10 amps, 20 watts, 50MHz) can be used, with cheap plastic drivers (ZTX650/750, 2 amps, 1 watt, 75MHz), in a triplet as in Fig. 2, giving input impedance and current gain approaching f.e.t. values but without the enormous voltage drop of a power f.e.t. Such a current amplifier can operate at about 2 volts and dissipates about 7 watts delivering 100 watts into 8 ohms.

D. Rawson-Harris
Ferranti Ltd
Stockport
Cheshire

References
1. "Transistors, Theory and Circuitry", K. J. Dean, McGraw-Hill, 1964.
2. *Electron*, 6th May, 1976.

Cartridge alignment

In his article about the cartridge alignment problems in the October issue, Mr Gilson gives the impression that the offset angle must always be a compromise. This is true if the cartridge is fixed rigidly to the arm, but why must it be fixed rigidly to the arm? Why can't it be pivoted to make it self-adjusting like the bogies of a railway carriage? If this was done the offset angle would always be at the optimum at every point of the arc.

If the pivot was directly above the needle the cartridge might have a tendency to spin, and if this was so it could be contained by vertical fins hanging down from either side of the arm. If however the needle was forward of the pivot no fins would be necessary, although there would then be uneven friction at the pivot.

Has anyone ever tried this?

S. Frost
Edinburgh 2

James Clerk Maxwell

To begin with I would like to congratulate you on *Wireless World's* presentation of theoretical and practical material. But what is more practical than a good or a lucky theory! In this respect I am in agreement with Mr Wellard's implicit or explicit opinion (March and May issues) that Maxwell's view of the world was and remains still one of the greatest human achievements. The e-m means of communication maintained between Earth and the Voyager spaceship, billions of miles away, was another vindication (if one more was needed) of Maxwell's theory. His theory of the Saturn rings does not prove equally successful, and to add insult to injury his statistics and the quantized statistics may be abandoned soon.

I wish to bring to your readers' attention some unexpected results we obtained three years ago at the Electrical Test and Research Laboratories of the SA Railways. The problem concerned flashovers and burn-ups of (3kV d.c.

operated) electric locomotives. Tests and investigations went on for more than a decade. At last in 1978, and during the course of what may be called data processing and data reliability testing, I struck upon the idea of manipulating the recorded surges as e-m occurrences, using the Maxwell equations. One thing leading to another, we found that the data could be modelled as a stochastic queue and subsequently that the cause of locomotive failure was the frequency, not the expected amplitude, of surges.

It appears that Maxwell's point of view will always present the same sort of questions to successful explanations. People asked then "but what is vibrating to produce the e-m waves?" and they ask now "but what is queueing?". The mathematical method is very difficult now, as it was then.

G. Xenoulis
Montreal
Quebec, Canada

Invention of stereo recording

I am afraid that both Bell Telephone Labs and Blumlein were pre-empted by about a decade! (June, August, September Letters). US Patent No. 1520378, application date 3rd July 1920, granted 23rd December 1924 to Samuel S. Waters of Washington DC, describes a mechanico/acoustic transducer for independent operation from each groove wall. Extract from Patent, lines 16 to 25:

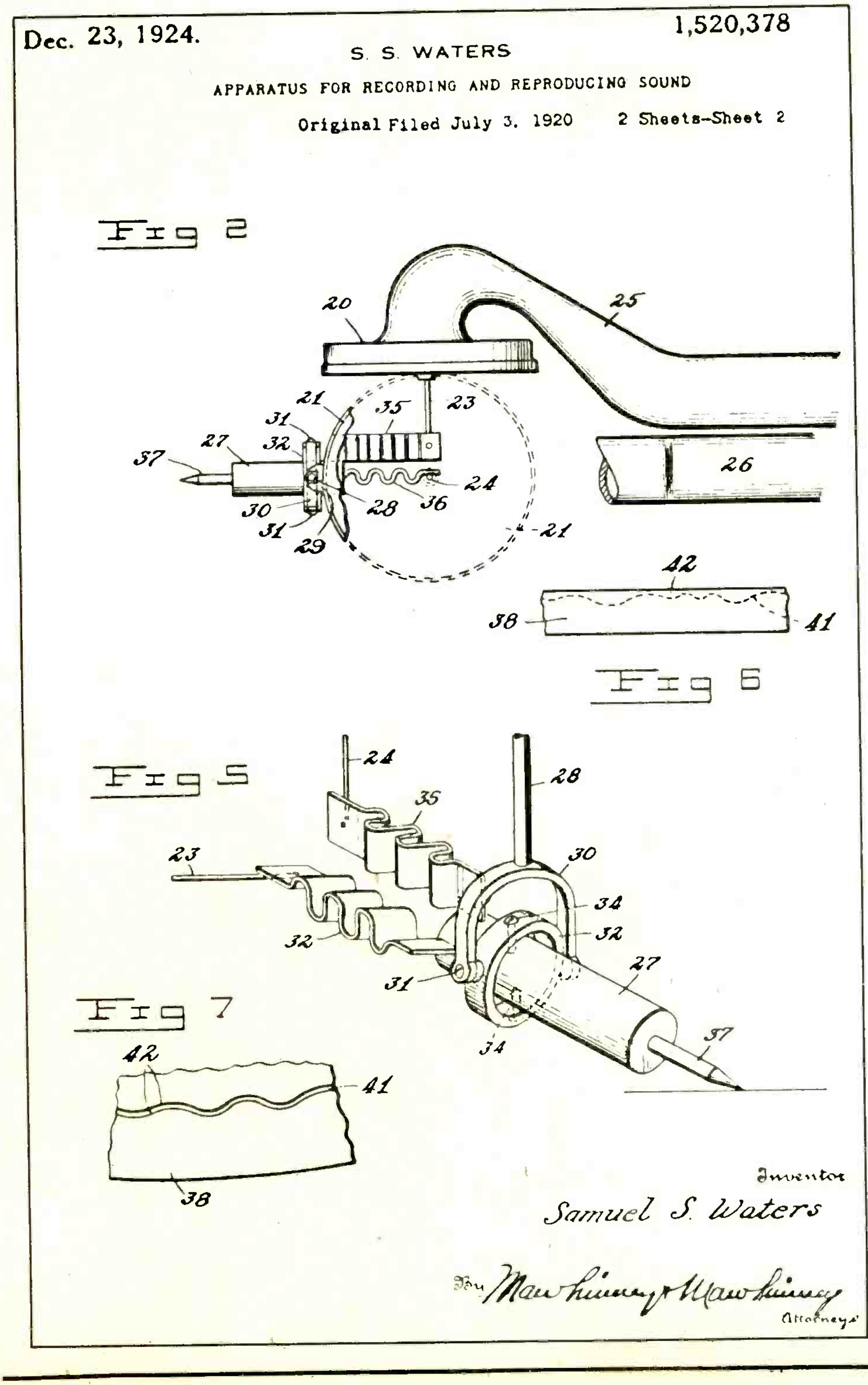
"the synchronous and independent transmission of the various component parts of compound sound reproductions for natural blending in the ears of the hearer to more nearly approach the native and direct sounds, such as: transmission of the voice in song with an instrumental accompaniment, two voices, and various other combinations of sounds which it is desired to reproduce."

Claim 5 antedated by 30 years the couplers between stylus and crystal used in stereo crystal pickups. Extract from Patent, lines 45 to 60:

"5. In a graphophone, a pair of sound boxes arranged at right angles to each other, a stylus holder, means for supporting the stylus holder for universal pivotal movement, and one way flexible and opposite way rigid connecting members between the stylus holder and the sound boxes, said connecting members being arranged to operate at right angles to each other for operating the selected sound box when the stylus is vibrated in the other direction, said flexible connecting members being adapted to absorb the vibrations between the stylus holder and the unselected sound boxes to prevent operation thereof."

Alii sementem faciunt, alii metentem.

Stanley Kelly
Westgate-on-Sea
Kent



Dangers of low a.f. sound?

Mr Holliman must be careful. He tells us in October letters that he has developed a loudspeaker which is flat to 4Hz. He would be well advised to remember that the infrasound which his speaker is generating can cause side-effects in some people in some conditions. The details can be found in chapter 3 of "Supernature" by Dr Lyall Watson (p. 92 in the 1974 paperback). The side-effects include recklessness, euphoria, lower efficiency, dizziness, and nausea.

S. Frost
Edinburgh 2

Performance of dry batteries

My medium-wave dx receiver is powered by dry batteries to ensure portability and isolation from mains-borne interference. Frequent replacement of the six R20 (U2) cells is a result of 2 to 12 hours daily listening at 50mA average consumption.

Battery life comparisons were made of Standard Leakproof (SP), High Power (HP), Power Plus (PP) and Alkaline (Alk) cells to establish which would be the most economical. Different characteristics for each type became apparent though there was little to choose between similar cells from various manufacturers, where available.

The PP batteries are a recent product, useful for situations requiring high cell voltage. My measurements indicated that they gave up about 95% of their energy before terminal voltage dropped below 1.1V under load. Similar discharge voltages for the others were SP 0.7V, HP 0.9V and Alk 0.7V. An observation of the PP cell not noted in other types is the sudden drop in output once voltage falls below 1.1V, and when almost fully discharged they become unusually noisy.

All four types produced a total energy output closely proportional to normal retail price but only when conditions of use allowed the cell to become fully discharged.

Also of note is the fact that, independent of type, one cell will fail before others in a series chain. However, rather than replace the entire set it is prudent to check each with a voltmeter and exchange the weakest only, so that all cells can be fully discharged in rotation.

Taking my own case of six R20 cells (9V nominal) at 50mA average drain and domestic usage, when compared to full set replacement at 6V, single cell rotation extended useful lifetime by the following amounts: SP 50%, HP 20%, PP 5%, and Alk 45% at average supply potentials of 6.6V, 7.4V, 7.8V and 6.9V respectively. All voltages were measured under load.

A study of manufacturers' discharge

characteristics should verify the possibility of these findings.

I have concluded: Individual replacement always saves money and produces a more consistent voltage supply. PP types offer sustained voltage to end of life but fail suddenly. Alk types give a long reliable life but at lower average voltage. HP types are excellent all rounders for most applications but SP types, having low average voltage and a requirement for long periods of rest, seem outdated.

On balance one gets exactly what one pays for!

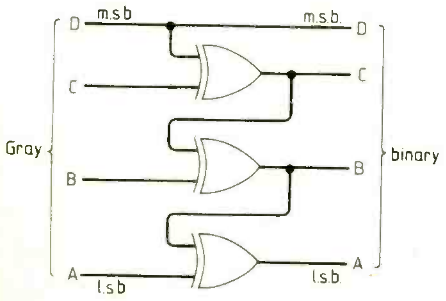
G. S. Maynard
Newtownabbey
Northern Ireland

Gray to binary converter

I fear that J. J. Mouton (Circuit Ideas, October) has rather 'over-killed' the design of a Gray code to binary converter. The circuit given will work, but is based on the rather simplistic description of the code structure in his accompanying text, without any simplification of the combinational logic having been effected.

Four bit binary and Gray codes are shown in full below, and careful examination of them will demonstrate that only three Exclusive-Or gates are needed for conversion, as in the circuit shown. Expansion of this principle is possible to any number of ways; in each case the m.s.b. is common between the codes and all other digits are connected in the manner shown. This conversion requires only four gates for a five bit code, as opposed to J. J. Mouton's ten.

Tom Gaskell
Haverhill
Suffolk



DECIMAL No.	GRAY D C B A	BINARY D C B A
0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1
2	0 0 1 1	0 0 1 0
3	0 0 1 0	0 0 1 1
4	0 1 1 0	0 1 0 0
5	0 1 1 1	0 1 0 1
6	0 1 0 1	0 1 1 0
7	0 1 0 0	0 1 1 1
8	1 1 0 0	1 0 0 0
9	1 1 0 1	1 0 0 1
10	1 1 1 1	1 0 1 0
11	1 1 1 0	1 0 1 1
12	1 0 1 0	1 1 0 0
13	1 0 1 1	1 1 0 1
14	1 0 0 1	1 1 1 0
15	1 0 0 0	1 1 1 1

Three other readers have written to make the same point: Dr P. J. Best of University of Aston Computer Centre, John R. C. Crabtree of Cambridge University Engineering Department, and Geraint Jones of Oxford University Computing Laboratory. We thank them for their letters. Mr Crabtree says that the simpler version is also easier to expand for more bits and Mr Jones that it suffers only slightly reduced fanout. – Ed.

Radio amateurs' licence

While I am in sympathy with at least some of the amendments to the amateur radio licence proposed by G8EOP *et. al.* (October letters), I would suggest that to use the introduction of a citizens' band service as reason for such changes is to be in danger of falling into the trap of confusing c.b. with amateur radio. Taxi drivers use v.h.f. f.m., and Merchant Navy personnel make dx "contacts" (telephone calls) using s.s.b. on h.f. Neither of these groups need to pass examinations, either technical or Morse code, but few amateurs would seriously suggest that this is a reason to change the amateur radio licence.

Surely the (legal) citizens' band service should be regarded in a similar way; with its type approved equipment and strictly limited power providing a personal communication *service*, rather than being a communications hobby. The present a.m. operation is rather different, but whatever the prosecution rate, let us not forget that it is illegal. Of course there will be nothing to prevent any licensed amateur from taking out a citizens' band licence as well – if nothing else it should prove useful for inter-tent communication during multi-station contests!

John Morris, G4ANB
Wantage
Oxon

Microchips and megadeaths

Tim Bierman writes in October Letters that he will not fight any wars, and asks "who will stand beside me?" I suggest that *Wireless World* publishes a monthly Bierman list, and although I am past fighting age I would like my name to appear on it.

History shows that as long as people are prepared to manufacture armaments and to enlist in armed forces, so long will incompetent and corrupt combinations of governments, arms manufacturers and militarists generate wars for the populace to fight.

What is the process by which people have been so hood-winked? It is subtle brain-washing from the cradle upwards. The populace is fed with a stream of stories and military "glamour", royal weddings with street parties for the children, funerals, the Red Arrows displays, military tattoos, changing the guard, all intended to pull the wool over the eyes of the public regarding the real significance of these death-dealing organisations and to seduce the population to sacrifice their own and other people's lives.

The excuses given for these wars have been dynastic, religious, territorial and ideological. Ask the Russians and the Germans who "won" the last war. Who is "winning" in Lebanon, Israel, Iraq and Iran?

Our recent governments, of both left and right wings, have tied to us the USA against the Soviets in a "fight to preserve democracy", but the post-war records of *both* super-powers are appalling. Our first step should be to terminate the occupation of our country by foreign troops, then to examine our own "democracy" where nearly all power is inherited. We cannot have a law to enforce the compulsory wearing of seat-belts because it would be a "restriction of personal freedom", but what choice have we over whether our social services are cut to the bone in order to feed a machine which is most likely to render all social services redundant from some time in the near future.

What is the British government's real intention and confidence regarding multi-lateral disarmament? The defence (?) minister, Mr John Nott, has stated (BBC News, 1 p.m. 4th October 1981) that his plans for nuclear ballistic missiles cover the period up to year 2020!, so that he proposes to burden not only a generation yet unborn, but their children also.

The "experts" will retort that they know better, and that views such as these are hollow, but let us remember the pronouncements and results of previous experts. Remember the fiascos of the Boer War, the Battle of the Somme, the unsinkable Titanic, and in our own profession many expert opinions, acted upon by experts which have turned out to be wrong, but unfortunately not fatal. Following our "defence" experts may not be so innocuous.

Roy C. Whitehead
Sutton
Surrey

Frequency hopping

The recent news item and letter on frequency hopping (November Letters) have intrigued me. Yet how can we know when these concepts were being used, behind closed doors? My group at Packard Bell, Culver City, Los Angeles, in 1963 was heavily involved with frequency hopping, especially relative to tiny parametric amplifiers. In fact I still have one or two of the advanced company reports. But I'm sure the subject was being studied for years before I arrived on the scene.

At that time many other very "modern" concepts were being studied – l.s.i., nuclear particle communications, optical computers, etc.

Patrick F. Howden
Truro, Cornwall

On tow

Is it coincidence that, in the issue of *Wireless World* containing a reprint of Arthur C. Clarke's 1945 article on satellite broadcasting (October 1981), you include an item about a low orbit satellite being towed on a very, very long length of cord by the NASA space-shuttle?

Could this perhaps be the first small step towards a geosynchronous satellite being connected by cables to the surface of the earth? (See Arthur C. Clarke's *Fountains of Paradise*). Impossible?

A. L. S. Harris, E17APB/G8ZNB
Ballynerrin
Co. Wicklow
Republic of Ireland

Back garden Earth station

The article "Development of a satellite terminal" by Mr S. J. Birkhill in your September 1980 issue prompted me to search for constructional articles on this subject. I have found a series which may interest other readers. The series describes an aerial and receiver for the 4GHz band and includes details of a 4GHz low noise amplifier developed by Mr Birkill.

The title is "Low cost backyard satellite tv earth station" by Robert B. Cooper Jnr and the series was published in the USA in *Radio Electronics* magazine January to April 1980 inclusive. A booklet of reprints is available from *Radio Electronics*, Room 1101, 200 Park Ave South, New York, NY 10003, USA. The price is 10 US dollars including postage overseas.

D. M. Lauder
Barnet, Herts.

World of Amateur Radio

RFI

With a tally of 5800 complaints of 27MHz a.m. interference from "premature" c.b. operation in September, it seems likely that the whole subject of radio frequency interference (r.f.i.) and electromagnetic compatibility (e.m.c.) will receive more attention in the UK as it has in the USA, though with some disturbing overtones for radio amateurs.

For many years, with transmitter interference cases far less widespread, it has become standard practice in many countries to put the blame squarely on the transmitter where the interference is due to harmonics or other spurious out-of-band radiation, but to consider the receiver (or audio equipment) at fault where the trouble is due to breakthrough, overloading, intermodulation in the receiver, etc.

But the FCC, in looking at possible new "standards", appears to be ready to depart from this pragmatic but logical system. David Sumner, K1ZZ, of ARRL has warned: "The FCC's three-year-old inquiry into r.f.i. is heading in what could be a very dangerous direction for Amateur Radio and other long-time users of radio spectrum . . . some of the options apparently under consideration would place burdens on the operators of radio transmitters that are simply indefensible on technical grounds, and the choice of options apparently is to be based on economic, not engineering considerations". In brief, ARRL are worried that responsibility for resolving interference problems in the USA, regardless of technical fault, would be shifted to the transmitter operators. There have already been several FCC decisions (not relating to amateur radio) where authorizations to use specific frequencies are being withheld solely because of possible interference to domestic equipment of which the design is thought to be inadequate from an e.m.c. viewpoint.

Microwaves

WoAR (May 1981) described the pioneer experiments of Clive Elliott, G8ADP (now G4MBS) in using rain scatter to receive 10GHz amateur signals over non-optical paths. The very heavy rainstorms in September encouraged a number of enthusiasts to listen from home locations, with interesting results. For example 1mW transmissions from G4KNZ in Slough were heard by G3YGF, Oxford. G4KNZ received the higher power tranmissions from G3JVL near Southampton. G3FYX, near Bristol, heard G4MBS near Alton, Hampshire. Such results seem bound to encourage further rain scatter trials on 10GHz, though these were unusually heavy rainstorms, from sites far less favourable than the more usual portable hill-top operations.

The Home Office has authorised the RSGB, on behalf of local groups, to establish 10 f.m. repeaters in the 1.3GHz band. These will have a 6MHz separation between incoming and outgoing transmissions with a 1750Hz access tone and horizontal polarization. Unlike existing 144 and 432 MHz UK repeaters, they will radiate continuous carrier when not being used, providing a beacon to show mobile operators when they are within range. Initially, channel spacing will be 75kHz (with a.f.c. in the repeater receiver) but this will be reduced later to 25kHz (RMO 1297.00MHz out, 1291.00MHz in; RM3 1297.075MHz out, etc). Repeaters will be located at: GB3AA Alveston, Avon; GB3BH Watford, Herts; GB3BW Brentwood, Essex; GB3CP Crawley, West Sussex; GB3LN Greenwich, London; GB3MC Horwich, Lancs; GB3PS Barkway, Herts; GB3RU Reading, Berks; GB3MM Bloxwich, West Midlands; and GB3WX Brighton, Sussex.

A 10.4GHz beacon transmitter, GB3MLE, has been installed at the 900ft level of the IBA's concrete television tower at Emley Moor, near Huddersfield, West Yorkshire, using a 40mW Gunn oscillator.

Future outlook?

The American FCC has released a 69-page document described as a "working paper" reflecting its author's opinions only but including radical suggestions for "Deregulating personal and amateur radio". Proposals include: (1) code-free v.h.f. licences for technically qualified people (i.e. comparable with British Class B licence); (2) amateur operation to be permitted on some c.b. frequencies (including 27MHz and proposed 900MHz band); (3) expansion of h.f. operating privileges for "technician" class licences; (4) systematic study to encourage a more technically-innovative amateur radio service; (5) elimination of some repeater and third-party restrictions.

If one had to draw up a New Year list of problems that need to be tackled in the UK, the following might well be included: (1) The need to come to terms with a c.b. movement that may vastly outnumber licensed amateurs; (2) The urgent need for a fresh look at the Radio Amateurs' Examination – its scope, its aims, its conduct – and whether these are in practice meeting modern requirements; (3) Encouragement of British manufacture to reduce the virtual dependence of the hobby on Japanese industry – and to encourage more home-construction; (4) To look afresh at frequencies available to Class B licensees and to introduce a "novice" licence to revitalise interest in h.f. c.w.; and (5) to make further concerted efforts to overcome the "repeater abuse" that has done so much to lower the reputation of amateur radio.

Jack Anthony, G3KQF, who is chairman of the RSGB's education committee, is to be installed as the Society's 1982 president at Derby on January 9, so it seems likely that rather more priority will be given by RSGB to questions relating to the RAE – several people have commented that the Society's journal was one of the very few British publications concerned with amateur radio that carried no adverse comment on the December 1980 examination.

In the USA, the ARRL appear to be encouraging amateurs to experiment with "advanced" modes such as spread spectrum and data packet switching. Contacts have already been made using these modes, though it remains to be seen whether such techniques are really suitable for amateur operation. An attempt a few years ago by ARRL to promote a complex narrow-band-voice-modulation technique was not a success.

In Brief

The new booklet "A newcomer's guide to f.m. simplex and repeater operation on two metres" (WoAR November 1981) is available from Mrs P. A. Spenceley, G8LZA, 67 Downswood, Tattenham Corner, Epsom Downs, Surrey, KT18 5UJ, price 75p including postage; cheques etc. payable to UK FM Group (London). It is a non-profit making venture in support of club funds . . . Signs of a relaxation of attitudes towards amateur radio in China include recent limited permission for the American Boeing Employees society to operate a demonstration station in Beijing (Peking) including contacts with former Chinese amateurs in Shanghai . . . Although French repeaters are subject to considerable abuse REF has warned its members not to attempt themselves to track down the offending stations . . . Band Plan recommended by IARU Region 1 Division for the new 10, 18 and 24 MHz bands: 10,100 to 10,140 kHz c.w. only; 10,140 to 10,150 kHz c.w./r.t.t.y. (s.s.b. on 10MHz only for emergency traffic); 18,068 to 18,100 kHz c.w. only; 18,100-18,110 kHz c.w./r.t.t.y.; 18,110 to 18,168 kHz phone/c.w.; 24,890 to 24,920 kHz c.w. only; 24,920 to 24,930 kHz c.w./r.t.t.y.; 24,930 to 24,990 kHz phone/c.w. . . . From about 15 to 20 firms manufacturing c.b. equipment in Australia in the mid-1970s there are now only five.

PAT HAWKER, G3VA

Digital storage and analysis of speech

"Pitch extraction is undoubtedly one of the messiest areas of speech analysis"

by Ian H. Witten, M.Sc., Ph.D., M.I.E.E., University of Calgary, Canada

This final article discusses two ways of avoiding the substantial computation involved in the cepstral method of pitch extraction. Autocorrelation analysis – the standard way of finding fundamental frequency in non-speechlike sounds – causes difficulty with speech because of the proximity of the lower formants to the pitch region. Though also computation-intensive, its calculations are more amenable to simple special-purpose hardware than the cepstral ones and can be speeded up. Time-domain feature-extraction methods are the most economical way of detecting pitch periods; they can be tuned to give good results though the process can be difficult and unreliable.

In many ways pitch extraction is more important from a practical point of view than formant estimation. In a voice-output system formant estimation is only necessary if speech is to be stored in formant-coded form. For speech synthesis from phonetics or text formant extraction is unnecessary, although general information about formant frequencies and formant tracks in natural speech is needed before a synthesis-from-phonetics system can be built. But knowledge of the pitch contour is needed for many different purposes. For example certain methods of compact speech coding rely on the pitch being estimated and stored as a parameter separate from the articulation. Significant improvements in frequency analysis can be made by performing pitch-synchronous Fourier transformations because the need to window is eliminated. Many synthesis-from-phonetics systems require the pitch contour for utterances to be stored rather than computed from markers in the phonetic text.

Another issue closely bound up with pitch extraction is the voiced/unvoiced distinction. A good pitch estimator ought to fail when presented with aperiodic input such as an unvoiced sound and so give a reliable indication of whether the frame of speech is voiced or not.

The method of pitch estimation using the cepstrum (part 4) involves a substantial computation and has a high degree of complexity, though implemented properly it gives excellent results because the source-filter structure of the speech is fully utilized.

Autocorrelation methods

The most reliable way of estimating the pitch of a periodic signal corrupted by noise is to examine its short-time autocorrelation function. The autocorrelation of a signal $x(n)$with lag k is defined as

$$\phi(k)=\sum_{n=-\infty}^{\infty}x(n)x(n+k).$$

If the signal is quasi-periodic with slowly varying period, a finite stretch of it can be isolated with a window $w(i)$, which is zero when i is outside the range $(0,n)$. Beginning this window at sample m gives the windowed signal $x(n)w(n-m)$, whose autocorrelation, the short-time autocorrelation of the signal x at point m, is

$$\phi_m(k)=\sum_{n}x(n)w(n-m)x(n+k)w(n-m+k).$$

The function exhibits peaks at lags which correspond to the pitch periods and multiples of it. At such lags the signal is in phase with a delayed version of itself, giving high correlation. The pitch of natural speech ranges about three octaves, from 50Hz in low-pitched men to around 400Hz in children. To ensure that at least two pitch cycles are seen, even at the low end, the window needs to be at least 40ms long, and the autocorrelation function calculated for lags up to 20ms. The peaks which occur at lags corresponding to multiples of the pitch become smaller as the multiple increases because the speech waveform will change slightly and the pitch period is not perfectly constant. If signals at the high end of the pitch range, 400Hz, are viewed through a 40ms autocorrelation window, considerable smearing of pitch resolution in the time domain is to be expected. Finally, for unvoiced speech, no substantial peaks of autocorrelation will occur.

If all deviations from perfect periodicity can be attributed to additive white Gaussian noise then it can be shown from standard detection theory that autocorrelation methods are appropriate for pitch identification. Unfortunately this is certainly not the case for speech signals. Although the short-time autocorrelation of voiced speech exhibits peaks at multiples of the pitch period, it is not clear that it is any easier to detect these peaks in the autocorrelation function than it is in the original time waveform! To take a simple example, if a signal contains a fundamental and in-phase first and second harmonics,

$$x(n)=a\sin 2\pi fnT+b\sin 4\pi fnT+c\sin 6\pi fnT,$$

then its autocorrelation function is

$$\phi(k)=\frac{a^2\cos 2\pi fkT + b^2\cos 2\pi fkT + c^2\cos 2\pi fkT.}{2}$$

There is no reason to believe that detection of the fundamental period of this signal will be any easier in the autocorrelation domain than in the time domain.

The most common error of pitch detection by autocorrelation analysis is that the periodicities of the formants are confused with the pitch. This typically leads to the repetition time being identified as $T_{\text{pitch}} \pm T_{\text{format 1}}$. Fortunately there are simple ways of processing the signal non-linearly to reduce the effect of formants on pitch estimation using autocorrelation.

One way is to low-pass filter the signal with a cut-off above the maximum pitch period, say 600Hz. However formant 1 is often below this value. A different technique which may be used in conjunction with filtering is to "centre-clip" the signal, as shown in Fig. 22. This removes many of the ripples associated with formants, but it entails the use of an adjustable clipping threshold to cater for speech of varying amplitudes. An alternative which achieves much the same effect without the need to fiddle with thresholds, is to cube the signal or raise it to some other high (odd!) power before taking the autocorrelation. This highlights the peaks and suppresses the effect of low-amplitude parts.

Speeding up autocorrelation

Calculating the autocorrelation function is an arithmetic-intensive procedure. For large lags it can best be done using fast Fourier transform methods, although there are simpler arithmetic tricks which speed it up without going to such complexity. And with the availability of analogue delay lines using charge-coupled devices autocorrelation can now be done effectively and cheaply by analogue sampled-data hardware.

Nevertheless some techniques to speed digital calculation of short-time autocorrelations are in wide use. It is tempting to hard-limit the signal so that it becomes binary, Fig. 23(a), thus eliminating multiplication. This can be disastrous because hard-limited speech is known to retain considerable intelligibility and therefore the formant structure is still there. A better plan is to take centre-clipped speech and hard-limit that to a ternary signal, Fig. 23(b), to simplify computation.

A different approach to reducing the amount of calculation is to perform a kind of autocorrelation which does not use multiplications. The "average magnitude difference function", defined by

$$\phi(k)=\sum_{n=-\infty}^{\infty}|x(n)-x(n+k)|,$$

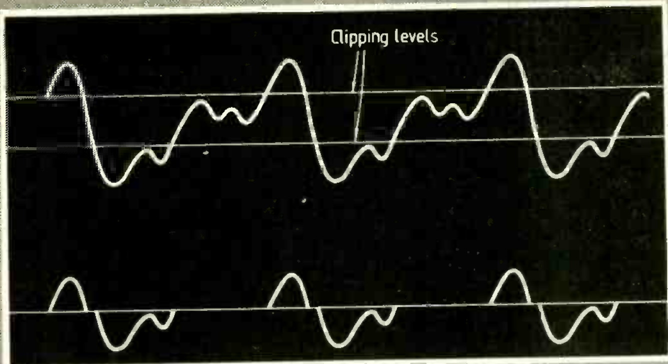


Fig 22

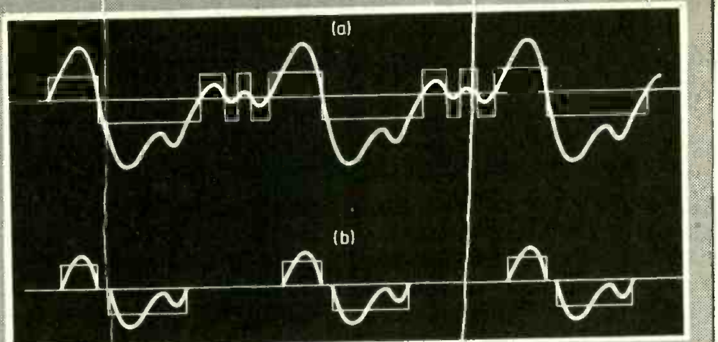


Fig 23

has been used for this purpose. It exhibits dips at pitch periods instead of the peaks of the autocorrelation function.

Feature-extraction methods

Another possible way of extracting pitch in the time domain is to try to integrate information from different sources to give reliable pitch estimates. Several features of the time waveform can be defined, each of which provides an estimate of the pitch period and an overall estimate can be obtained by majority vote. For example, suppose that the only feature of the speech waveform which is retained is the height and position of the peaks, where a "peak" is defined by the simplistic criterion

$$x(n-1)<x(n) \text{ and } x(n)>x(n+1).$$

Having found a peak which is thought to represent a pitch pulse, one could define a "blanking period" based on the current pitch estimate within which the next pitch pulse could not occur. When this period has expired the next pitch pulse is sought. A stringent criterion should be used at first for identifying the next peak as a pitch pulse, but it can be gradually relaxed if time goes on without a suitable pulse being located. Figure 24 shows a convenient way of doing this: a decaying exponential is begun at the end of the blanking period and when a peak shows above, it is identified as a pitch pulse. One big advantage of this type of algorithm is that data are greatly reduced by considering peaks only – easily detected by simple hardware. Thus it can permit real-time operation on a small processor with minimal special-purpose hardware.

Such a pitch pulse is exceedingly simplistic and will often identify the pitch incorrectly. However it can be used in conjunction with other features to produce good pitch estimates. Examples of such features are

- peak height
- valley depth
- valley-to-peak height
- peak-to-valley depth
- peak-to-peak height if greater than zero
- valley-to-valley depth if greater than zero.

The features are symmetric with regard to peaks and valleys. The first feature is the one described above and the second works in exactly the same way. The third feature records the height between each valley and the succeeding peak while the fourth uses the depth between each peak and the succeeding valley. The purpose of the final two detectors is to eliminate secondary though large peaks from consideration. Figure 25 shows the kind of waveform on which the other features might incorrectly double the pitch but that the last two features would identify correctly.

Fig 24

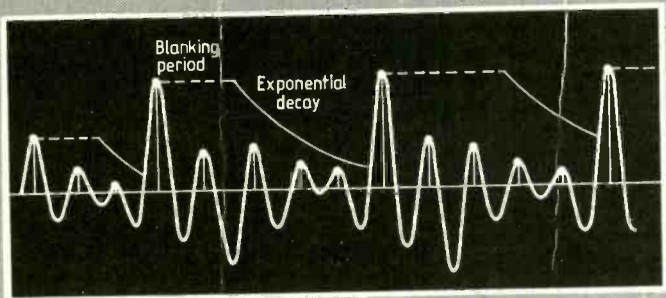


Fig 25

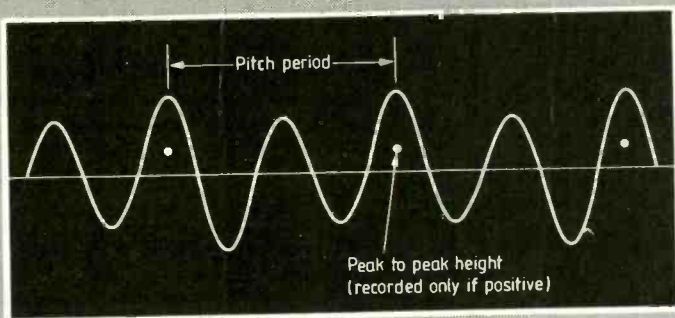
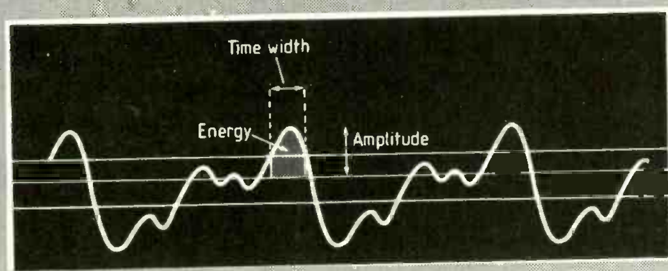


Fig 26



In one implementation of this scheme the last two pitch estimates from each feature detector were included as well. For each feature the present estimate was added to the previous one to make a fourth and the previous one to the one before that to make a fifth. All three were added together to make a sixth, so that for each feature there were six separate estimates of pitch. The reason for this is that if three consecutive estimates of the fundamental period are T_0, T_1 and T_2, and if some peaks are being falsely identified, the actual period could be any of

$$T_0+T_1 \quad T_1+T_2 \quad T_0+T_1+T_2.$$

It is essential to do this because a certain feature can occur more than once in a pitch period – secondary peaks usually exist.

Six features each contributing six separate estimates make 36 estimates of pitch in all. An overall figure can be obtained from this set by selecting the most popular estimate within some specified tolerance. The complete scheme has been evaluated extensively and compares favourably with other methods. But the procedure seems to be *ad hoc*, as are many other successful speech parameter estimation algorithms! It is not easy to predict what kinds of waveforms it will fail on and evaluation of it can only be pragmatic.

When used to estimate the pitch of musical instruments and singers over a six-octave range (40Hz to 2.5kHz), instances were found where it failed dramatically. This is of course a much more difficult

Continued on page 49

The new electronics

by Hugh Jaques

For many years I have earned a modest income designing electronic equipment. Recently it has become apparent that the fundamental basis of the theory of electronic circuitry has changed during the last decade, and that my techniques are not only out of date but in some respects totally wrong.

This shattering discovery is the result of interviewing numerous applicants for jobs in the fields of design, development and testing on behalf of an organisation whose interests lie in the application of analogue and digital electronics to a wide range of physical problems. The applicants have all obtained 1st, 2nd or 3rd class Honours degrees in electronic engineering during the last six years, and the majority have been employed in industry for at least one year. The jobs offered demand a reasonably sound knowledge of electronic circuitry at various levels.

During the interviews certain standard questions were asked, and it was the consistency of the answers to these which first made me realise that a New Electronics has arisen, and has obviously been taught for some years at many seats of learning. As yet no text books have appeared; I am striving to remedy this deficiency, but the problems are formidable and in view of the long time it takes to get a book into publication I thought that *Wireless World* in its 70th year of publication should have the honour of being the first to publish a few of the laws of the New Electronics.

First Law: The V_{BE} of a conducting silicon transistor is always either 0.6 or 0.7 volts. It does not vary with temperature or collector current.

Second Law: The V_{BE} of a conducting germanium transistor is 10 volts, or is unknown.

Third Law: In the circuit of Fig. 1, the ripple voltage is either about 10mV or can-

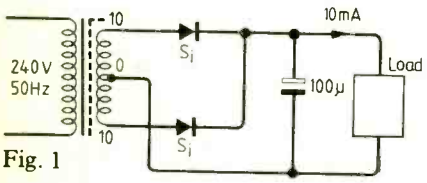


Fig. 1

not be calculated, even approximately. The ripple frequency may be 25, 50 or 100Hz.

Fourth Law: The impedance looking into the emitter of a transistor connected in grounded-base and passing 1 mA of collector current is either 'very low' or 'very high' or somewhere in between, depending on the current gain.

Fifth Law: Transistors do not possess a mutual conductance; in fact the term is unknown in the New Electronics.

Sixth Law: R-S and D type flip-flops are the only ones known in the New Electronics, the J-K variety is apparently of no importance.

Seventh Law: This, the most important of the laws, is best described as the ultimate dèvelopment of Heisenberg's Uncertainty Principle.

Eighth Law: All electronic circuit problems can be solved by a phase-locked loop and a sprinkling of monostables.

It will be seen that the New Electronics has made life much easier for the designer. For example, the First Law implies that the design of drift-free amplifiers is now a trivial matter, since V_{BE} does not vary with temperature. Thanks to the Third Law we may reduce the size of our reservoir capacitors by a considerable factor. If the resulting circuits do not work, we can always blame the Seventh Law.

The following electronic pantomime sketch has been repeated five times in the last twelve interviews with only minor variations (refer to Fig. 2):

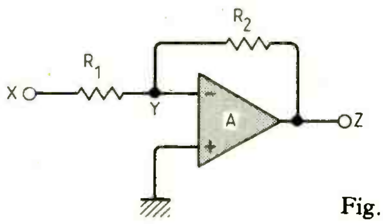


Fig. 2

H.J.: "Given that the op-amp has a very high gain and that its input impedance is infinite, what is the voltage gain between X and Z?

Interviewee: "R_1/R_2"

H.J.: "So if R_1 goes o/c the gain becomes infinite?"

Int. (after a pause): "R_2/R_1"

H.J.: "Nearly, but not quite right."

Int.: "I think it's all right."

H.J.: "If the input is made more positive, what happens to the output?"

Int.: "It goes negative."

H.J.: "So?"

Int.: "$-R_2/R_1$. I always forget the minus sign!"

H.J.: "What is the input impedance at X?"

Int.: "R_1"

H.J.: "Why?"

Int.: "Because Y is a VIRTUAL EARTH."

H.J.: "What is the input impedance at Y?"

Int.: "Very high."

H.J.: "But you just said it was a virtual earth."

Int.: "Oh, very low."

H.J.: "How low?"

Int.: "About 0.1 ohm."

H.J.: "Why 0.1 ohm? Are all op-amps identical?"

Int.: "I think that's what the book said."

H.J.: "Come now, what governs the impedance at Y?"

Int.(after a long pause): "The gain and R_2".

H.J.: "Right; now, how do you calculate the impedance at Y?"

Int. (after a very long pause): "I can't remember the formula."

H.J.: "How about Ohm's Law?"

Int.: ???????

H.J.: "Apply a small voltage V to the point Y and see what current it produces."

Int.: No reply.

H.J.: "Well, where does the current flow?"

Int.: "Into the op-amp and out at the positive input."

H.J.: "Suppose that the op-amp has an infinite input impedance?"

Int. (after a titanic struggle): "Through R_2."

H.J.: "Right; what is the voltage at Z?"

Int.: "AV."

H.J.: "Don't forget the minus sign! Now, what is the voltage across R_2?"

Int.: "$V + AV$."

H.J.: "So the current produced by V is . . . ?"

Int.: "$(V + AV)/R_2$"

H.J.: "And the input impedance is . . . ?"

Int. (triumphantly, having at last seen the light): "$R_2/(1 + A)$"

H.J.: "Yes."

The writer sometimes feels like one of the original members of the cast of a long-running farce; he himself is word-perfect and can almost, but not quite, predict what the newcomers are about to say.

The answers to another question follow a fairly standard pattern:

H.J.: "What practical project did you do for your Final year?"

Int. (with much flapping of hands): "Rhubarb rhubarb . . . . PHASE-LOCKED LOOP . . . . rhubarb rhubarb . . . . D/A CONVERTER . . . . rhubarb rhubarb . . . . ACTIVE FILTER . . . . rhubarb rhubarb . . . . RAM . . . . rhubarb rhubarb . . . . PHASE-LOCKED LOOP . . . . A/D CONVERTER . . . . rhubarb rhubarb . . . . ROM . . . . SHIFT REGISTER . . . . rhubarb rhubarb rhubarb . . ."

H.J. (feeling slightly dizzy and proffering a sheet of foolscap): "Can you draw a block diagram?"

This usually results in a spidery postage-stamp sized drawing in the middle of the paper.

H.J.: "What was the purpose of the device?"

Int. (after a long pause): "I'm not quite sure."

H.J.: "Did it work?"

Int.: "No, I never managed to finish it/No not very well/It worked all right on paper."

From these and other answers to questions one suspects that much of the teaching of the New Electronics is done by the Victorian method of the standard question and the standard word-for-word answer, which occasionally gave rise to such delights as:

Q. What organs are contained in the abdomen?

A. The abdomen contains the stomach and the bowels, which are a, e, i, o, and u.

E finita la commedia. What in the Name of Blumlein are the universities and colleges doing awarding degrees to people like this? They have no understanding of electronics, or, for that matter, elementary electrical theory. Kirchhoff, Thévenin and Norton are merely names which, if remembered at all, were 'done in the First Year'! Not one of the last twelve interviewees recognised the simple symmetrical voltage doubler of Fig. 3, or could even

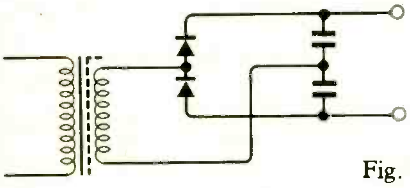


Fig. 3

hazard a guess as to its mode of operation. In Fig. 1 more than half gave the ripple frequency as 50Hz, and the capacitor voltage as 10V when the load current was zero. When asked to draw the general shape of the frequency response of the

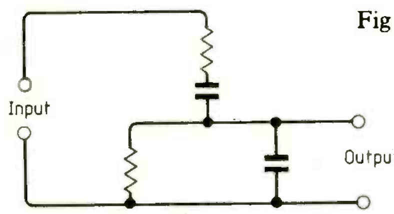


Fig. 4

network of Fig. 4, none succeeded without a considerable amount of coaxing or goading, or recognised it as a Wien bridge network. Does this suggest a lack of interest in technical magazines?

Lest it should be thought that the interviewees were overawed by the company's products, or the interviewer, or were suffering from 'interview nerves', or were uniformly unintelligent, it must be stated that (a) hardly any had taken the trouble to find out the nature of the company's products, (b) the interviewer is a kindly soul who bends over backwards to find just one topic with which the interviewee is familiar, (c) all, without exception, were extremely self confident, although they ranged in appearance and manner from the bright-eyed and bushy-tailed to the near-moronic and bushy-faced, with almost all possible gradations and variations. Few of them took the trouble to fill in the application form completely or legibly, and more than half came to the interview without pen or pencil. Yet many of these people are supposed to be anxiously seeking jobs, having been made redundant, or are looking for their first job.

The last member of this pathetic group, when asked what his ambitions were, said "Oh, to do a couple of years' design work and then move on into Management".

Not in this company, laddie!

Walsh functions

Generation and application

by Thomas Roddam

The first part of this article, under the title "The function of functions" was an introduction to the nature of Walsh functions through telecommunications history (December issue). In this concluding part the author shows how Walsh functions may be produced electronically and discusses some of their uses.

Before we consider how we can use the Walsh functions we need to be able to produce them. Sine waves were easy, though not as easy as they looked, because a spring and a weight, an inductance and a capacitance (-ance, because the inductance could be a gyrator and a capacitor, for example), with some energy top-up, were all that we needed. We will be making Walsh functions with logic circuits, so we first need to agree to use the values 1,0 instead of 1,−1. If you like, we always add wal(0,θ), and divide by 2 in amplitude.

A general way of making Walsh functions is to begin with the Rademacher functions. These are the 2^n harmonics of a sine wave, squared right off, and are shown in Fig. 4. Combining these together by means of Exclusive-Or circuits, in the way shown in Fig. 5, we shall get a family of Walsh functions. Obviously, once the need is there, we shall be able to buy a chip to do the whole job. An alternative method, if you want one Walsh function at a time, a kind of Walsh tone generator, is to use a 74150 16-line to 1-line multiplexer with a 7493 four-bit binary counter and a clock drive, Fig. 6. The 16 lines can be taken to switches, and the counter steps the system round the inputs and gives an output to line which is just the inverted input. Any pattern can be set up on the switches, any sequency can be chosen by choosing the clock frequency. This type of generator seems to be more attractive for getting a feel of the Walsh functions, because you do set the thing up yourself.

Having now particularly described and ascertained the nature of the Walsh functions and the manner in which they are to be produced, what we want to know is, what good are they? "What is the use of a new-born baby, Sir?" The Walshites react to the sight of a sine wave by singing Anything you can do, we can do better! But what do we use sine waves for?

The first use is analysis and classification. An obvious application for Fourier analysis is determining what makes the note of a flute sound different from the same pitch on a clarinet. From this we go

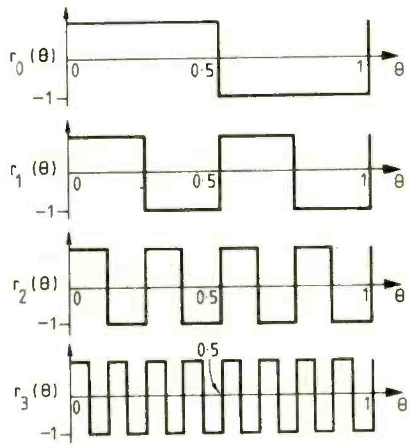


Fig. 4. Rademacher functions $r_n(\theta)$.

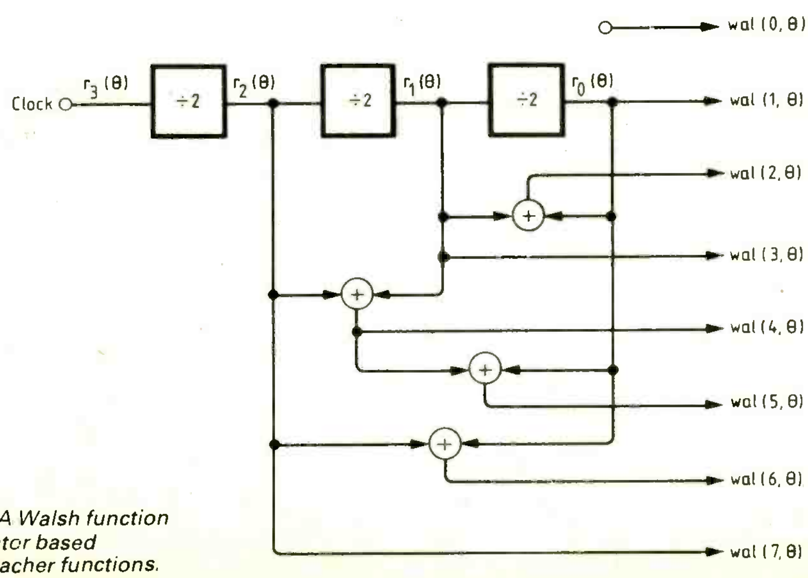


Fig. 5. A Walsh function generator based Rademacher functions.

on to synthesize these sounds using a bank of oscillators. The use of Fourier analysis in directional aerial design may be less familiar to many readers, though it can play an important part in side-lobe control. Even less familiar will be the application to crystallography. The reflection patterns produced by a beam of x-rays echoing off the surface of a crystal were first analysed by long and tedious calculations of Fourier transforms, with hours, days of arithmetic to each photograph.

Walsh funtions are orthogonal. We can produce the Walsh-Fourier transform of some functions f(θ), in the form $f(\theta) - a_0\,\mathrm{wal}(0,\theta) + a_1\mathrm{wal}(1,\theta) + a_2\mathrm{wal}(2,\theta)\ldots$ by using the fact that

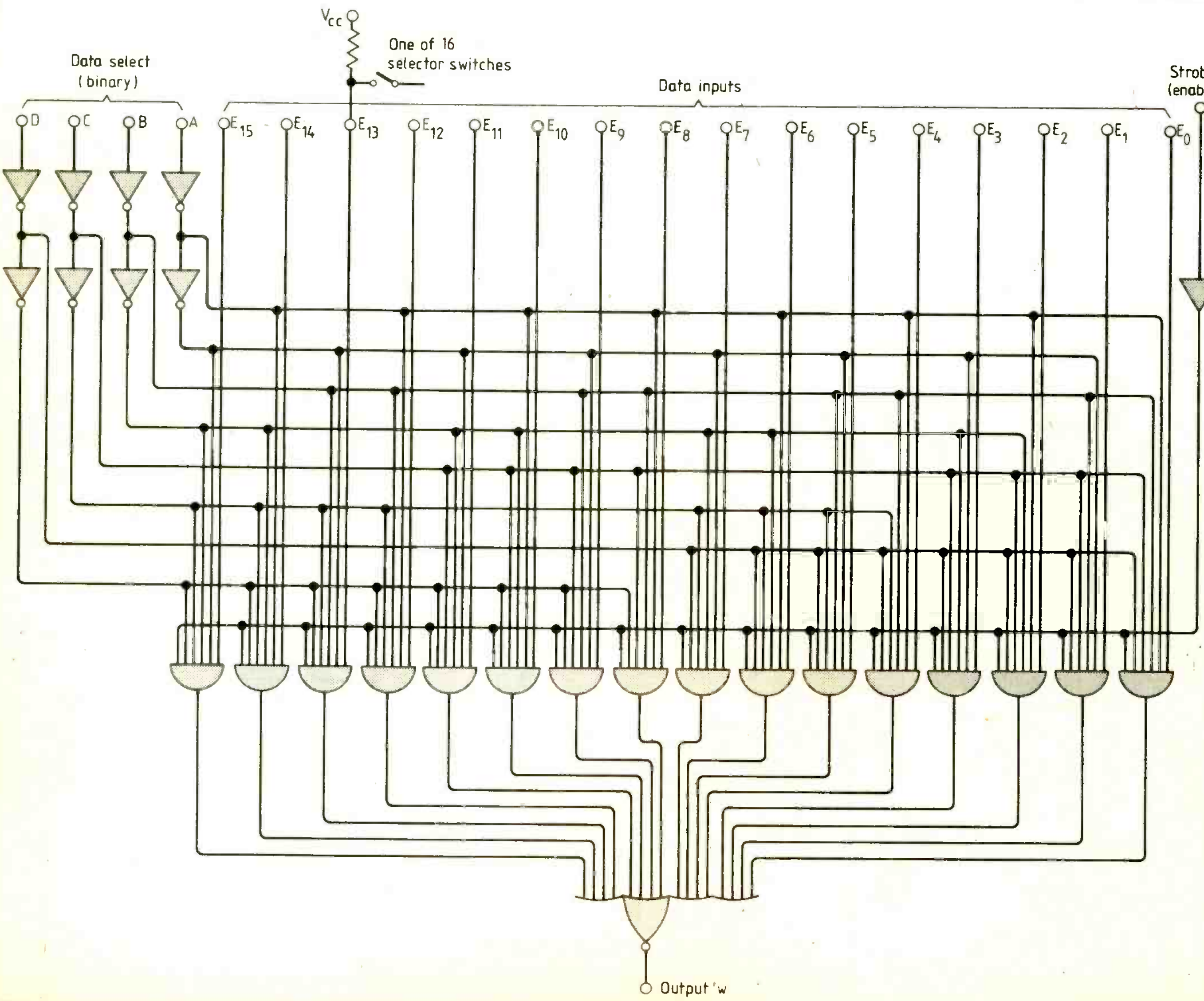
$$\int_{-\frac{1}{2}}^{\frac{1}{2}} f(\theta)\mathrm{wal}(i,\theta)d\theta$$

$$= a_0 \int_{-\frac{1}{2}}^{\frac{1}{2}} \mathrm{wal}(0,\theta)\mathrm{wal}(i,\theta)d\theta +$$

Truth table

INPUTS																					OUTPUT
D	C	B	A	STROBE	E_0	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}	E_{12}	E_{13}	E_{14}	E_{15}	W
X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
O	O	O	O	O	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O
O	O	O	1	O	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1
O	O	O	1	O	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O
O	O	1	O	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	1
O	O	1	O	O	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	X	O
O	O	1	1	O	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	1
O	O	1	1	O	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	X	O
O	1	O	O	O	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	1
O	1	O	O	O	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	X	O
O	1	O	1	O	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	1
O	1	O	1	O	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	X	O
O	1	1	O	O	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	1
O	1	1	O	O	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	X	O
O	1	1	1	O	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	1
O	1	1	1	O	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	O
1	O	O	O	O	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	1
1	O	O	O	O	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	X	O
1	O	O	1	O	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	1
1	O	O	1	O	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	X	O
1	O	1	O	O	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	1
1	O	1	O	O	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X	O
1	O	1	1	O	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	1
1	O	1	1	O	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	O
1	1	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	1
1	1	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	O
1	1	O	1	O	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	1
1	1	O	1	O	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	X	O
1	1	1	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	1
1	1	1	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	X	O
1	1	1	1	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	1
1	1	1	1	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1	O

Fig. 6. Circuit and truth table of the 74150 integrated circuit, a one-of-sixteen data selector performing parallel-to-serial data conversion. As shown at the top, the 16 lines can be taken externally to switches, on which any pattern may be set up.



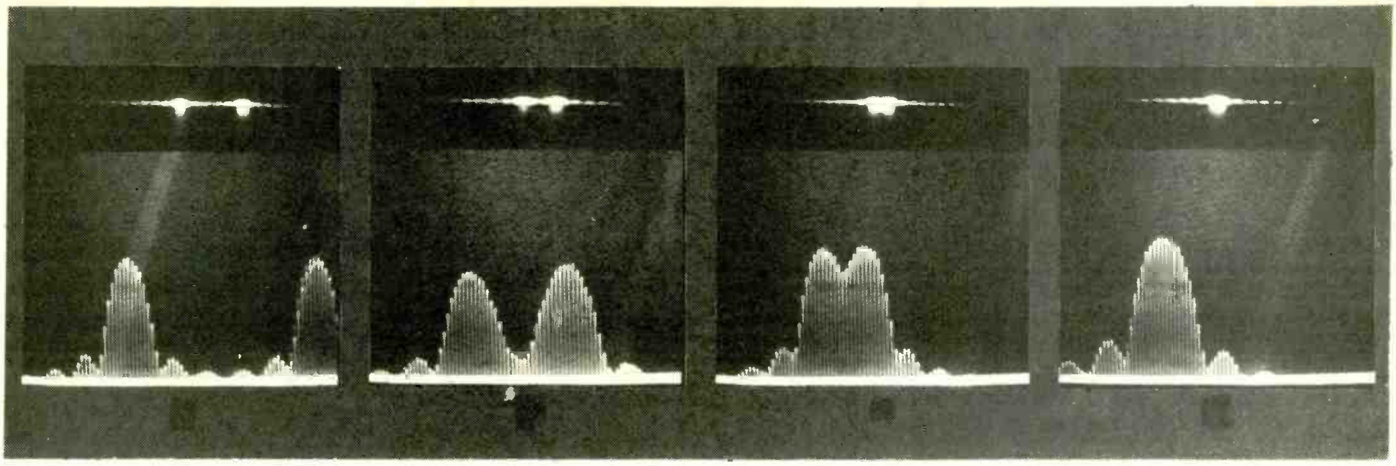


Fig. 7. *This display shows a diffraction pattern (taken from Fig. 4, page 43, of Wireless World June 1981), but looks just like the display of a frequency analyser.*

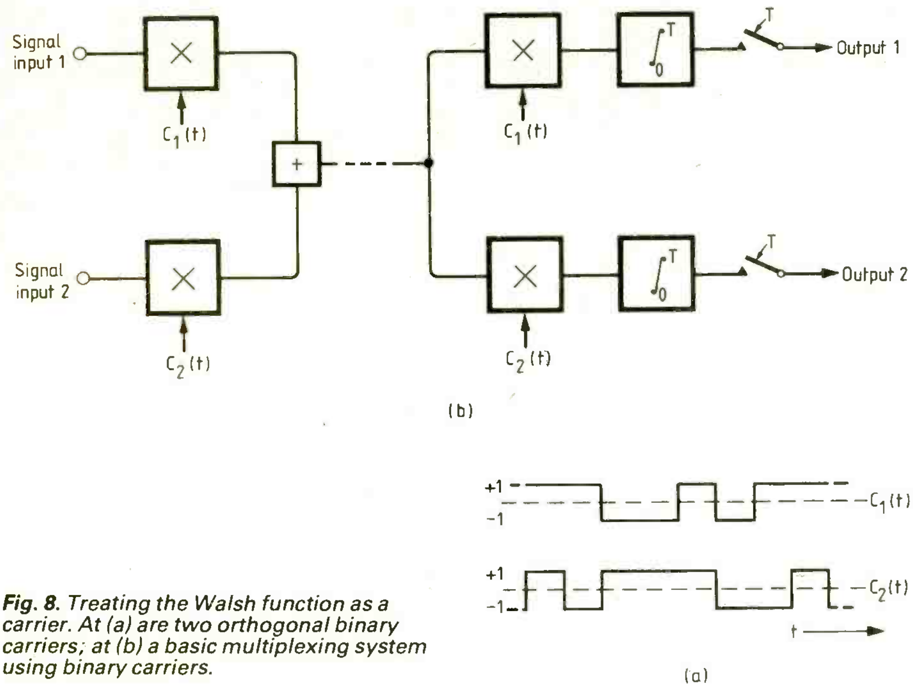


Fig. 8. *Treating the Walsh function as a carrier. At (a) are two orthogonal binary carriers; at (b) a basic multiplexing system using binary carriers.*

$$a_1\int_{-1/2}^{1/2} \mathrm{wal}(1,\theta)\mathrm{wal}(i,\theta)d\theta \ldots$$

$$a_i\int_{-1/2}^{1/2} \mathrm{wal}(i,\theta)\mathrm{wal}(i,\theta)d\theta \ldots$$

and, as the Walsh function is orthogonal, all the terms vanish except

$$\int_{-1/2}^{1/2} \mathrm{wal}(i,\theta)\mathrm{wal}(i,\theta)d\theta=1$$

so

$$a_i=\int_{-1/2}^{1/2} f(\theta)\mathrm{wal}(i,\theta)\, d\theta$$

At any instant wal(i,θ) is either 1 or −1. If we integrate using either f(θ) or −f(θ) at any instant, the integral is a_i and we have a great supply of circuits – single-ended to push-pull conversion – to produce −f(θ). So it becomes switch and integrate.

Now multiply a_i and wal(i,θ). This sequency filtering has filtered out one component of the waveform f(θ). In many communication systems we work with sampled waveforms. The clock frequency used in sampling forms an upper limit to the Walsh functions needed. A sequency low-pass filter can have a sharp dead-end characteristic.

Speech signals, according to some sources, can be converted first into Walsh-Fourier transforms and then digitized to give the same signal quality with only about one-half the number of digital characters. Another transmission possibility is to treat the Walsh function as a carrier. At the receiving end the same Walsh function is fed into the demodulator, to pick out my message on wal(13,θ) from yours on wal(16,θ). Each Walsh function, like a key, opens only its own lock. The sort of circuit used is shown in Fig. 8.

There is already a vast literature on Walsh functions and their applications but much of it is highly formalized, with expressions like dyadic convolution and the Wiener-Kinchin theorem thick on the page. There has been at least one article in *Wireless World* so far, and I am sure that it will not be too long before we see circuits to enable us to Walsh code our holiday snaps on an audio cassette recorder. As we come to this stage we shall, I hope, come to get some sort of feeling for the Walsh approach. We know from a Fourier spectrum if the sound analysed was an ocarina or a violin; we know roughly what sound the spectrum represents. The Walsh spectrum of an image waveform has some subjective characteristics. The wal(0,θ) term is the average level, the greyness; the wal(1,θ)is an indicator of symmetry about the centre line, or lack of it, and, some large positive values of wal(2,θ) and wal(6,θ), with a negative value for wal(4,θ), would indicate a strong central element, black or white according to the coding.

In the kingdom of the blind, the one-eyed man is king. This short summary of Walsh functions has offered you one bleary eye. But remember that Erewhon was a kingdom of the blind, and vision, however poor, is not necessarily popular.

The material on Walsh functions relies very heavily on two volumes of transactions produced by Hatfield Polytechnic which have told me far more than I want to know about the theory and applications of Walsh functions.

Digital storage and analysis of speech

continued from p45

problem than pitch estimation for speech where the range is typically three octaves. In fact for speech the feature detectors are usually preceded by a low-pass filter to attenuate the myriad of peaks caused by higher formants, and this is inappropriate for musical applications.

Additional features can assist with pitch identification. The above features are all based on signal amplitude and could be described as secondary features derived from a single primary feature. Other primary features can easily be defined, for example one can use a centre-clipped waveform and consider only the peaks rising above the central region. Further primary features that have been used are the time width of a peak – the period for which it is outside the clipping level – and its energy outside the clipping level. The primary features are shown in Fig. 26. Secondary features can be defined based on these three primary ones and pitch estimates made for each one.

Display aid for microprocessors

Eight line operation with a 2716 character generator

by K. Padmanabhan, Ph.d.,M.I.E.E., and A.P. Senthilnathan

Part one described a display aid which enabled 4 lines of sixteen characters to be shown on a conventional 5MHz oscilloscope. The design uses a 6810 1K display memory which can store 128 words, i.e. 8 lines of 16 characters. The modifications necessary to display eight lines are shown in Fig. 1 and listed in Table 1.

Further expansion is possible if the display memory is increased and a faster character generator is used to avoid flickering on the c.r.t. The original design used a surplus MK2002 character generator to reduce the cost, however, a single rail 2716 e.p.r.o.m. can be used instead and the interfacing components omitted, see Fig. 1. Table 2 gives a hex list for programming the first 512 bytes of the 2716 to provide upper case characters.

Table 1

1. Connect pin 10 (B3) 74157 to A6 instead of pin 15/7475.
2. Disconnect pin 11 (A3) from pin 10 (B3) and connect to pin 13/4518.
3. Disconnect pin 15 (Reset) from pin 13/4518 and connect to pin 14 (Q4).
4. Add 75k summing resistor and connect pin 13/4518.
5. Reduce 47k summing resistor to 22k.
6. Reduce 10k feedback resistor on CA3130 to 5k.
7. Change three series capacitors pin 2 or 555 to two 3nF and one 10nF in series.
8. Disconnect 1nF capacitor pin 2/555 and connect to pin 5.
9. Reduce capacitor across pins 2 and 3/4011 to 5nF.
10. Adjust potentiometer pin 10/4011 so that 16 characters fit across the c.r.t.

Table 2

0	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	7C	7E	FE	7C	FE	FE	FE	7C	FE	00	0C	FE	FE	FE	FE	7C
1	FE	7C	FE	62	80	FC	E0	FE	C6	E0	86	FE	C0	00	40	02
2	00	00	00	28	24	C6	0C	20	00	00	28	10	02	10	02	60
3	7C	22	46	82	18	E4	3C	80	6C	62	00	02	10	28	82	40
4	82	90	92	82	82	92	90	82	10	82	02	10	02	40	60	82
5	90	82	90	92	80	02	18	04	28	10	84	82	20	00	80	02
6	00	00	E0	FE	54	C8	72	40	38	82	10	10	2C	10	00	08
7	8A	42	8A	82	28	A2	52	8E	92	92	00	2C	28	28	82	80
8	3A	90	92	82	82	92	90	82	10	FE	82	28	02	30	10	82
9	90	8A	98	92	FE	02	06	18	10	1E	92	82	10	82	80	02
A	00	F2	00	28	FE	10	9A	40	44	44	7C	7C	00	10	00	10
B	92	FE	8A	92	48	A2	92	90	92	92	22	00	44	28	44	86
C	AA	90	92	82	44	92	90	92	10	82	FC	44	02	40	0C	82
D	90	84	94	92	10	02	18	04	28	10	A2	00	08	82	80	02
E	00	00	E0	FE	54	26	64	00	82	38	10	10	00	10	00	20
F	A2	02	92	AA	FE	A2	92	A0	92	94	00	00	82	28	28	90
1																
0	78	75	6C	44	38	92	80	5E	FE	00	80	82	02	FE	FE	7C
1	60	72	62	8E	10	FC	E0	FE	C6	E0	C2	00	06	FE	40	02
2	00	00	00	28	48	C6	0A	00	00	00	28	10	00	10	00	C0
3	7C	02	62	44	08	9C	8C	C0	6C	78	00	00	82	28	10	60
4	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
5	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
6	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
7	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
8	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
A	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
B	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
C	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
D	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
E	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
F	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Literature Received

A detailed description of the techniques employed in the manufacture of thick-film hybrid circuits is provided by a handbook, now available at £1.25 from Neohm (UK) Ltd, Italia House, 99 Windsor Road, Oldham, Greater Manchester.

Two brochures from GenRad deal with the 1795-B logic test system and the 1796 and 1799 digital analogue test systems, and the 2270 in-circuit test equipment. Copies can be had from GenRad Ltd, Norreys Drive, Maidenhead, Berkshire. WW401

Components for optical communications (l.e.ds, p-i-n diodes, laser diodes and complete transmitter/receivers) are descibed in a new bilingual catalogue from Thomson-CSF, Division Microonde, 101 Boulevard Murat, 75781 Paris, Cedex 16 France. WW402

Power supplies producing up to 1kW, including IEEE 488 types, are characterized in the new Kepco catalogue, which deals with o.e.m. models using switching and ferroresonant stabilizers. There is also a handbook section which presents 40 pages of the theory of design and application of this equipment. The book is obtainable from Techmation Ltd, 58 Edgware Way, Edgware, Middx. HA8 8JP. WW403

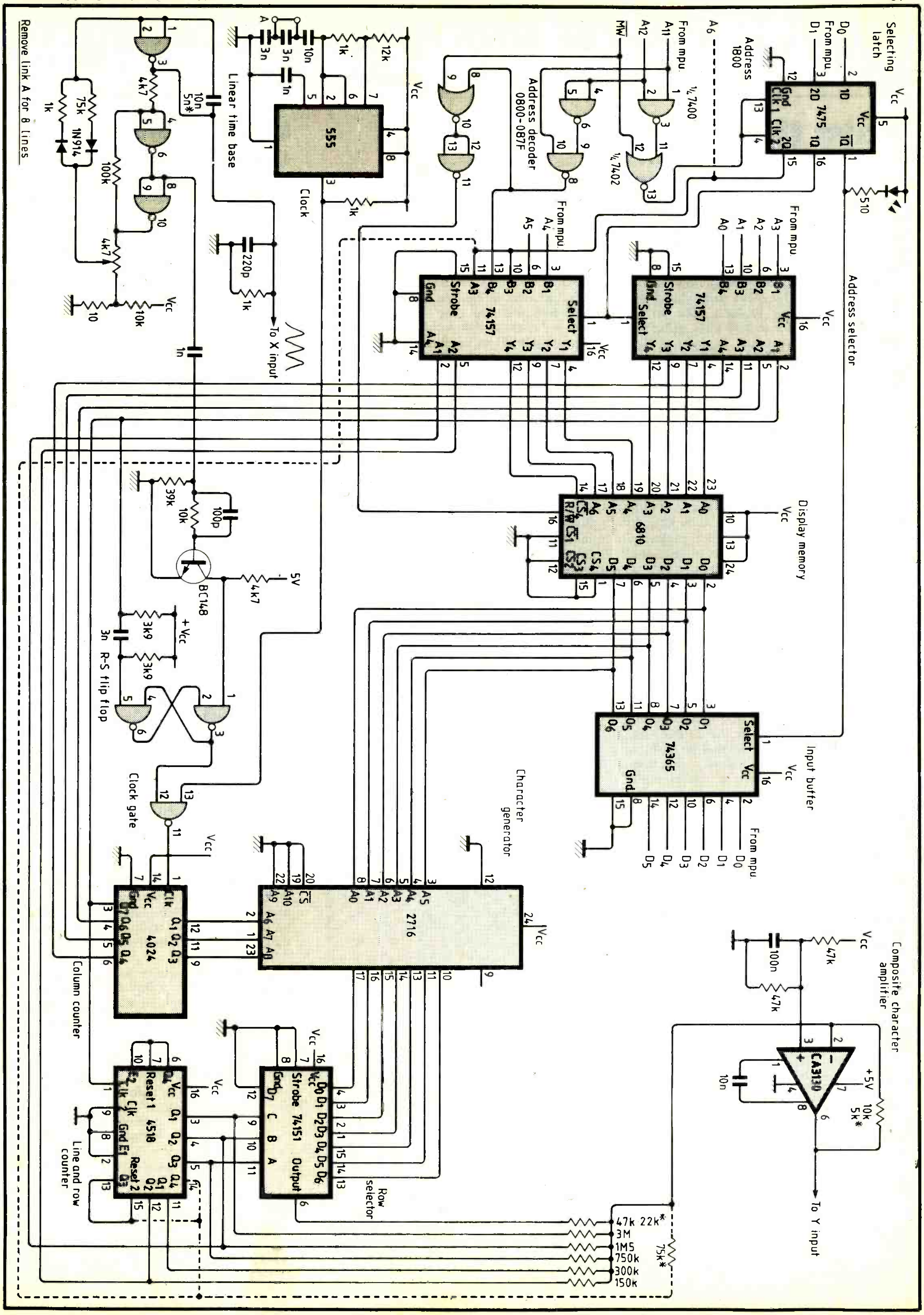
Leaflet from Pascall Electronics Systems Ltd details the company's activities in the production of i.f. amplifiers, filters, phase-sensitive detectors and data acquisition for communications and navigation. It can be had from Pascall at Hawke House, Green Street, Sunbury-on-Thames, Middx. TW16 6RA. WW404

Dial Search is a list of broadcasting stations in Europe, in the long, medium and short (v.h.f. f.m.) bands. It assumes the use of an ordinary domestic radio with a built-in aerial, and provides lists of frequency, wavelength and direction from a spot near Eastbourne for each station (there is a map of the stations listed, which carries bearings and explains a method of adapting it to a different location). The book costs £1.00 by post from George Wilcox, 9 Thurrock Close, Eastbourne, East Sussex BN20 9NF. WW405

The instrument division of the American Gould company (used to be Advance) has a catalogue of test and measuring gear, including oscilloscopes (real-time and storage), logic analysers, signal sources, counters, meters, etc. The address of the company is Gould Instruments Division, Roebuck Road, Hainault, Essex, 1G6 3UE. WW406

Semiconductors, microprocessors and computer boards, connectors and a range of measuring instruments are among the 3000 or so products listed in the new catalogue from Abacus Electronics PLC, Kennet House, Pembroke Road, Newbury, Berks RG13 1BX. WW407

Operational and electrometer amplifiers, instrumentation modules, power supplies, panel-mounting instruments and other products for temperature measurement and control are the province of Ancom, who can supply a catalogue from Devonshire Street, Cheltenham, GL50 3LT. WW408



Remove link A for 8 lines
Linear time base
Clock
To X input
Address decoder 0800-087F
From mpu
Selecting latch
Address 1800
Address selector
Display memory
Input buffer
Character generator
Clock gate
R-S flip flop
Column counter
Line and row counter
Row selector
Composite character amplifier
To Y input

News of the Month

Very thin films

You may remember having seen 'marbled' paper. Colours are floated on the surface of water and when a sheet of paper is passed through the surface, the colours cling to the paper to make patterns rather like the veins in marble, hence their title. Between the world wars, Langmuir and Blodgett used a similar technique to deposit thin films, one molecule thick, onto solids. The films so produced are now called Langmuir Blodgett films and a group of academics and industrialists, under the auspices of the Science and Engineering Research Council, led by Professor Gareth Roberts of Durham University, are investigating the electrical properties of such films.

In order to get uniform films one molecule thick it is necessary to use special techniques: The material used to form the film needs to be 'amphipathic' – each molecule has one end attracted to water and the other end is 'fatty' and is repelled by water. When they are floated, such molecules 'stand' on the water surface and a solid dipped into the water can be coated with a monomolecular, oriented layer of the film. It is necessary to achieve a perfect film, unlike the marbled paper, without any holes or gaps, and this may be done by replenishing the supply of the molecules as they are used with a 'feedback' mechanism. Multi-layers can be built up, and the materials for the layers can be varied.

Applications for the films are many. For example, the success of silicon-based microcircuits is due largely to the fact that the silicon oxidizes rapidly and forms an insulating coat. Such a coat may be applied to other semiconductors by the film technique and Langmuir Blodgett films may also be used to insulate between layers in microcircuits. As the films are composed of organic molecules they are likely to respond more positively to external stimuli than inorganic materials and may be incorporated into transducers to measure changes in temperature, pressure or to sense the presence of gases. Organized layers may be built up using the Langmuir Blodgett technique which would be difficult or impossible by any other means. This ability is likely to be exploited in future investigations of high temperature superconductors, organic semiconductors, conducting polymers and magnetic storage devices. Other potential applications are in the areas of integrated optics, where the ability to define accurately the thickness and refractive index of a material is important, and in electron beam lithography. Lipid molecules with their fatty and polar regions are suited to the technique and it is possible to build bilayer structures of lipids similar to those found in life. This incorporation of proteins and other constituents of living cells into the lipid layers allows accurate modelling of biological systems. There are further implications in the transducer field. If biological molecules such as antibodies and enzymes are incorporated within insulating films, it is then possible, for example, to propose field-effect devices for monitoring immunological response.

A large number of meetings and symposia are being organized for the researchers and interested bodies in this field and a large international conference on Langmuir Blodgett films is to be held at the University of Durham in September 1982.

Digital audio cassette player

JVC has announced the successful development of a p.c.m. cassette deck, which they claim is the world's first. The deck is designed for audio recording and playback and for the playing of pre-recorded cassettes. The deck offers the advantages of a cassette deck, such as convenient operation, portability and low cost with low distortion and high dynamic range. JVC have achieved a linear recording density of 46.3K b.p.i. with a two-way, four tracks per channel recording system with service tracks for random access, programme indication and other functions. The p.c.m. deck uses metal tape with a high coercive force. The tape transport has a direct drive capstan motor combined with a newly developed tape-tension servo system; it operates at a tape speed of 7.1cm/s with a playing time of 60 minutes. Despite the high recording density and the sampling rate of 33.6kHz, the 14-bit system uses a bi-parity error correction to ensure high stability.

A JVC spokesman told us that they have no immediate plans to launch the deck as they are hoping to establish standards and avoid some of the multiplicity of methods used for some other equipment, for example video discs.

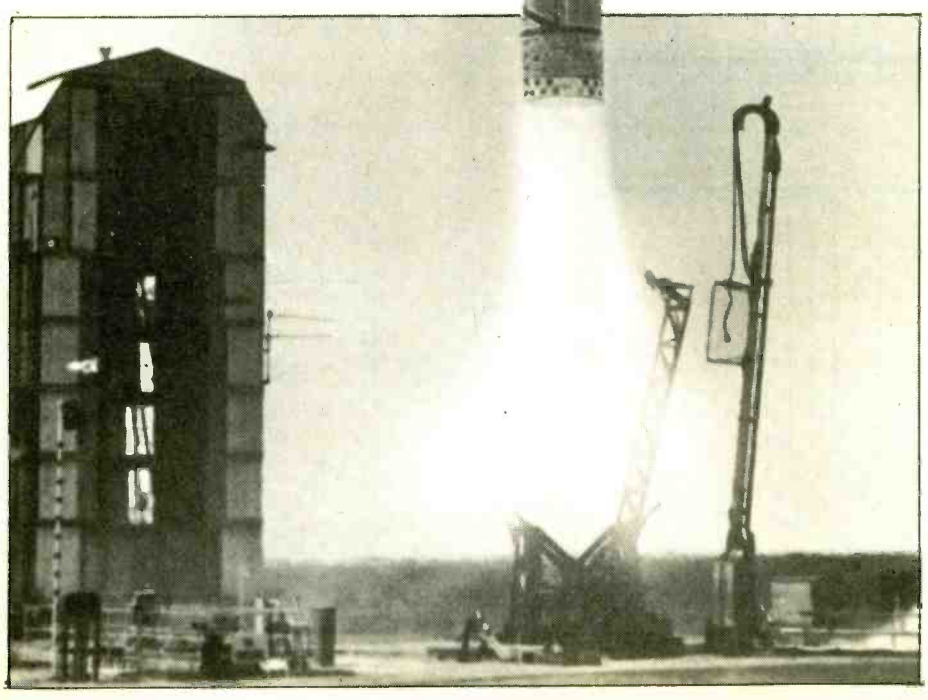
Prospero continues to prosper

Engineers and scientists of the Royal Aircraft Establishment, Farnborough, met late last October at the Lasham, Hants, tracking station, to celebrate the 10th year in orbit of the only experimental/communications satellite to have been built and launched entirely by British technologists. Prospero was launched by a Black Arrow rocket from the Woomera range in South Australia on October 28, 1971, and although intended to last for a year it is now expected to remain in orbit for another 140 years. This is due to its high elliptical orbit, which varies between 983 miles (1582km) and 340 miles (547km) above the earth.

The satellite's purpose was to carry out experimental work needed for the development of common services such as telemetry, data handling, telecommand and power switching, as well as the testing of ultra-lightweight solar cell arrays, optical and thermal surface finishes and hybrid circuit techniques. An additional role was that of micrometeoroid detector – this was sponsored by the University of Birmingham.

Modules designed for Prospero have been used in the technological satellite Miranda (X4), the X-ray astronomy satellite Ariel 5 (UK5) and the gamma and X-ray astronomy satellite Ariel 6 (UK6).

Several British companies contributed to the Prospero project, with British Aerospace (then British Aircraft Corporation) being responsible for the main structure and Marconi Space and Defence Systems for electronic aspects. The Solartron Electronic Group designed and assembled the automatic checking and control centre equipment, while Spembly Ltd provided operational support for the control and ground station, which, although of "dated" appearance, continues to receive meteorological data from the Tiros "N" series and two weather satellites in geostationary orbit – Meteosat 2 and Goes East. This data is transmitted to the BBC television weather service by way of telephone line and the Meteorological Office at Bracknell, Berks.



Black Arrow rocket launching the Prospero satellite in Australia.

Towards a cashless society – part 2

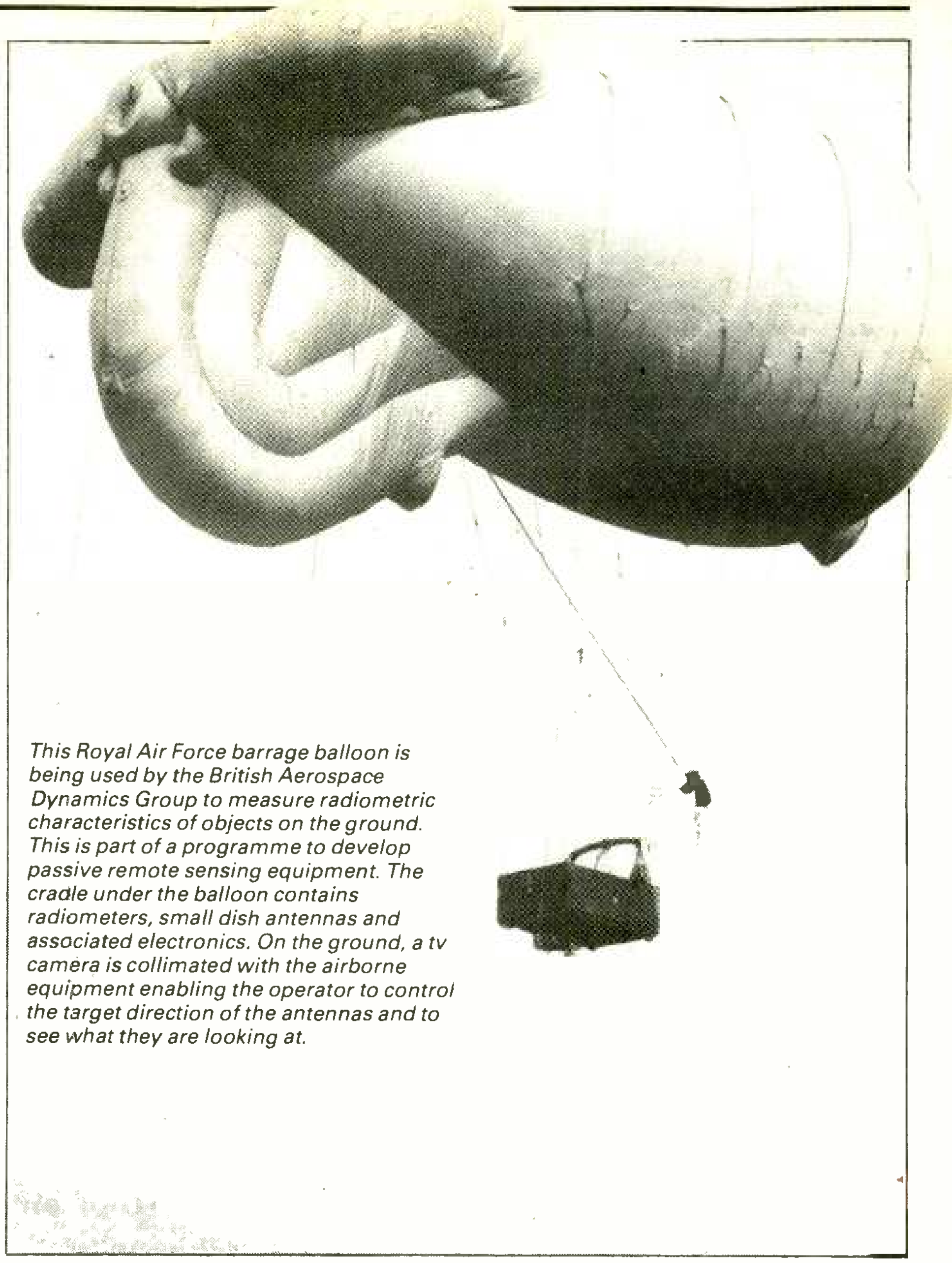
We used the above heading in October 1981 when we reported the use of a telephone pay card. We have heard now of two further examples of 'plastic money'. STC is to supply 400 electronic card authorisation terminals for use with American Express cards. When presented with a card the terminal can check instantly whether the card is on the lost or stolen list; it can read the customer's account number from the magnetically encoded stripe on the back of the card and can transmit the details of the transaction direct to the American Express computer via the public telephone network, which is connected automatically. The whole process takes seconds. The success of a similar system in the United States where over 5,000 terminals have been installed, has led to the introduction of the system into Europe.

A very ambitious scheme comes from France where the Laboratoires d'Electronique et de Physique appliquée (LEP), with Philips Research, Radiotechnique-Compélec and Philips Data systems, is designing an electronic payment card for making purchases. Within the confines of the international credit card dimensions, including a thickness of only 0.76mm, they have fitted a microprocessor and an e.p.r.o.m. It also has magnetic strips for identification and registration so that it can be used for drawing cash automatically from a bank. The card may also carry information about the user and incorporate a passport photograph if required.

The payment card serves as a chequebook and has been designed for an experimental project in which the French banks and postal and telecommunications authorities are cooperating. The user can periodically arrange for his bank to enter an amount into the card's memory; this money is then available for making payments. A shop would have a terminal which could show the customer how much money is left on his card, the shop assistant could key in the amount of the transaction which is deducted from the card. The memory on the card can supply the details of the account number and bank so that the money can be paid directly to the shop.

In order to get the microcircuits into the thickness of a credit card that is also pliable, it was necessary to mount them on polyimide film by a method developed at LEP. The film contains all the interconnexions, and the microcircuits on the film are sandwiched between the top and bottom p.v.c. layers of the card. Cut-outs in the upper surface of the card permit connection to the contact areas on the polyimide film to permit write-in and read-out. This work refers only to laboratory experiments at the moment and does not imply production or marketing of the system in the near future.

The electronic chequebook, the same size as a credit card contains a microprocessor and an e.p.r.o.m. The customer inserts it into a terminal while the assistant enters the transaction. The price is deducted automatically from the card (and from the customer's bank account!).



This Royal Air Force barrage balloon is being used by the British Aerospace Dynamics Group to measure radiometric characteristics of objects on the ground. This is part of a programme to develop passive remote sensing equipment. The cradle under the balloon contains radiometers, small dish antennas and associated electronics. On the ground, a tv camera is collimated with the airborne equipment enabling the operator to control the target direction of the antennas and to see what they are looking at.

Bus pact

Four major electronics companies; Philips/Signetics, Mostek, Motorola and Thomson EFCIS, have announced their support of a microcomputer interconnect structure, the VME bus. The companies have agreed on a detailed specification for the bus, which is to be implemented on p.c.bs and backplanes meeting the DIN41612 and 41494 mechanical standards. This board form, popularly known as Eurocard, is an accepted standard in Europe and features industrial quality pin and plug style connectors as well as a highly modular format.

The VME system is based on Motorola's Versabus structure that has been employed in MC68000-based microcomputer system products. The other firms are all alternative sources for the 16-bit 68000 microprocessor unit. The VME bus is not limited in application to the 68000-based systems but has been designed with this microprocessor in mind.

The features of the VME bus include the ability to support both single and multiprocessor systems; supports 32-bit architecture; allows data transfers up to 20Mbytes/s; incorporates non-multiplexed asynchronous data transfer protocol; permits bus transfer requests via four lines with different priority levels; supports centralized or distributed system interrupt handling with seven interrupt priority levels; supports block mode transfers; supports read-modify-write cycle, as required for safe semaphore usage; provides reliability features including bus error, system fail and a.c. fail indicators.

The VME bus is deemed to be particularly suitable for industrial process control, intelligent terminals and digital network communications.

Video centre proposed

If the architects, Avery Associates, have their own way, they could be building a temple to the great god 'Video', in the heart of London, on the vacant site next to the National Gallery, Trafalgar Square. The building would have the title of National Video Archive and Visual Communication Centre – Video Viscom for short. It is planned to use the electronic technologies to bring together the electronics industry and the public in "a unique synthesis of scientific, cultural and entertainment facilities".

To give Avery their due, they have paid particular attention to the design of the building so that it will complement the surrounding buildings. It would be set back to create a new public plaza, dominated by a monument to the British television pioneer J. Logie Baird. It is planned that there would be monitor screens high up on the front of the building to attract the public.

Inside the entrance foyer (No. 3 in the picture) a visitor is loaned a pair of headphones with a miniature remote control and receiver unit. With this he can select the sound track of the programme showing on any of the large video screens around the hall (4). Some of the screens can provide information such as catalogues of the contents of the centre and it would be possible for the visitor to select programmes. A two-way transmitter in the hand-held control unit would allow him to contact a control centre or advice bureau. It is also planned that there would be a wide variety of video games to play.

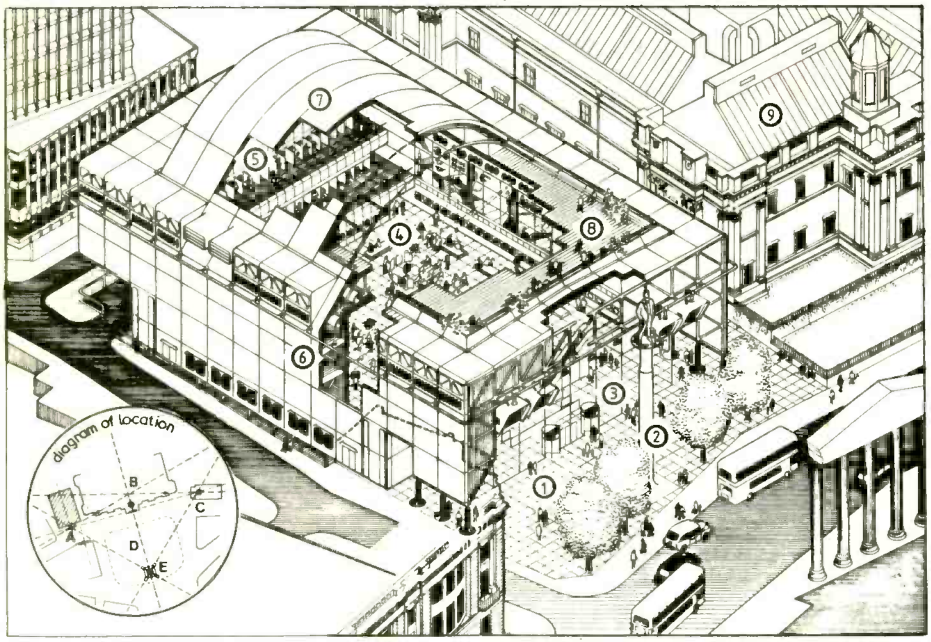
The centre would be a meeting place for the video industry; conference halls and meeting rooms would be available. It would also be their showroom, and they woud be able to display and demonstrate their wares. The building is designed to be flexible so that the displays may be changed or new techniques demonstrated without disrupting the running of the centre.

At the far end of the hall (5) there would be galleries of study carrels, provided for users of the National Video Archives. They would have access to a very large data base of films or video programmes. It is envisaged that the material would all be stored on video discs in some remote warehouse linked to the Viscom Centre by a fibre optic land line with an automatic storage and retrieval system.

Meanwhile, in the main hall, there would be a large number of small screens which could display programmes received direct by satellite from around the world. Information as to the source would be displayed and it is thought that foreign governments or tourist boards would finance such a service to promote their countries.

The rooftop restaurant (7) and terrace (8) overlooking the square, offer rest and relaxation from all that viewing.

A cut-away view of the proposed Video Viscom; a video archive and video trade centre with many other uses. The inset shows its position in Trafalgar Square, London, next to the National Gallery (B) with views of St Martins-in-the-Fields (C) and Nelson's Column (E).



Trans-Pacific cable

An undersea telecommunications cable, eight thousand nautical miles long, will link Australia and New Zealand to Canada, by way of Norfolk Island, Fiji and Hawaii. It will provide 1380 simultaneous telephone circuits. Called Anzcan the system is scheduled to be designed, manufactured and installed by August 1984.

The whole Anzcan project will cost £160 million and the major part of the order has been won by Standard Telephones and Cables (STC) London, against international competition. It is thought to be the largest single export order ever received by the British telecommunications industry. STC Sydney are to manufacture almost half the 1,000 electronic repeaters which will be spaced at regular intervals along the cable, and with this project and a new factory at Liverpool, New South Wales, Australia joins the league of those few nations able to manufacture these complex devices.

The Nippon Electric Company will be responsible for the link from New Zealand to Norfolk Island.

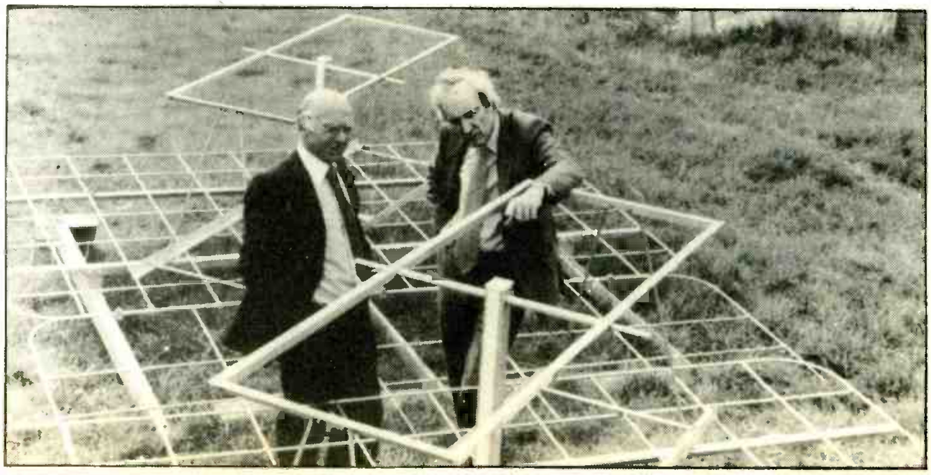
Emmy for Marconi

At their annual awards ceremony, the National Academy of Television Arts and Sciences, in the USA, recognised the pioneering work done by Marconi in tv cameras. The award was given for "Engineering innovation in the design and development of a system for the automatic alignment of colour television studio cameras". This refers to the development of the Marconi Mark VIII colour tv camera, introduced in 1970, which was the first to include the automatic registration of the three camera images, which need to coincide to an accuracy of less than one part in a thousand. The adjustment of colour balance is very easy; the camera is exposed to a reference white in the scene immediately prior to the actual transmission since this setting is a function of the lighting and may vary with the time of day on outside broadcasts.

Radio London gets slanted

A new antenna has been supplied to the BBC by CSA (C&S Antennas Ltd) as part of the equipment to be installed at Crystal Palace when the Radio London transmitter moves there from Wrotham. Each of the 16 elements has a slot radiator at a fixed angle 45° to the reflector screen. This gives a slant polarised transmission, adding a vertical component to the usual horizontal transmission. The vertical component will make it easier for car and portable radios to receive the station and the Crystal Palace transmitter is the first to offer slant polarisation from the BBC who intend to extend the system to all their v.h.f./f.m. transmitters, as part of their modernisation plans. There has been some criticism of slant polarisation as the vertically polarised part of the signal may be more prone to multipath distortion (see Pat Hawker, *Wireless World* April 1981, pp. 83-85 and the letter from D. P. Leggatt in June 1981, p. 45).

Derek East, head of transmitter capital projects department at the BBC discussing the aerials to be installed at the Radio London transmitter at Crystal Palace with Cyril Whitebread, managing director of CSA, who supplied them.



Automated direction finder

Offshore navigation aid samples radio and compass signals to give averaged magnetic bearing

by John Barratt, Sysmaster Ltd

Over the last 25 years a multitude of r.d.f. sets have been introduced as the number of marine beacons expanded, ranging in price from £50 to nearly £2000. At the lower end of the market, manual sets predominate with aerial, compass and radio in a single hand-held pack. More recent designs use digitally synthesized tuning, giving a much simplified keyboard entry of frequency. But the problem remains that on a heavily pitching boat keeping the unit stable and homed to a beacon was extremely difficult. At best, under reasonably stable conditions, accuracies of ±5° could be attained; in bad weather it is more likely to be ±20° or worse. At the upper end of the market are the so-called automatic d.f. sets that use two matched orthogonal loops and display a ship's head relative bearing on a circular dial. Whilst they perform well in a calm environment, in heavy seas where the heading of the vessel can vary dramatically the operator has to monitor simultaneously the r.d.f. bearing and the current heading of the vessel. Plainly a difficult task prone to error.

What was needed was a truly automatic radio direction finder which would provide a magnetic bearing to the beacon automatically and unambiguously. Assigning the difficult task of determining the null position of the signal to a machine, the navigator was freed to concentrate on the specific skills of navigation. The machine should operate consistently regardless of sea state or weather conditions and providing a much higher level of navigational accuracy. Fortunately technology has enabled sufficient "intelligence" to be incorporated in the form of a microprocessor to produce a significantly improved d.f. system at a price comparable to existing a.d.f. receivers.

The dominating factor in considering implementation options was the microprocessor. With flexibility limited simply to program store size and machine run time, the possible levels of integration of radio functions to computer functions was enormous. In addition, sensor design could be re-assessed as the processor would be used to enhance data from a low grade (cheaper) source. The criteria for deciding on an implementation path were low cost of material, minimum assembly and test time, maximum interchangeability of assemblies, and performance equal to or better than conventional d.f. receivers. Some of these decisions had to be made at an early stage and looking at the design in retrospect we can see that some of our assumptions were wrong. In particular, our concern about cost of electronic components was probably over-emphasized – prices have dropped dramatically. One particular microprocessor component for which we originally paid £40 and budgeted at £15 is now costing £4.

To simplify interchangeability and testing we decided on a conservative approach to integrating the receiver with the processor keeping the interface simple (seven wires plus power). This reduced the number of microprocessor interface components and made the design of the receiver relatively independent of the microprocessor.

The two primary sensors are the compass and the aerial. For the aerial, a rotating ferrite rod offered the processor a potentially large amount of data. Current aerial position could be simply a single index pulse to indicate the aerial passing through 000°, as the processor could calculate aerial speed and therefore instantaneous position. Alternative approaches for the compass included low sensitivity flux gates for indirectly sensing the earth's field using an existing compass; high sensitivity gimbled flux gate for direct sensing and a strapped-down three-axis flux gate with axis transformation. The later system is an extremely elegant approach; but to maintain long-term stability some kind of attitude sensor would be required whose cost would largely offset any savings in static sensor array. The solution chosen uses a direct-sensing gimbled system with excitation circuits which produce two outputs proportional to the sine and the cosine of the impinging horizontal field.

On the digital side the design was dictated essentially by the requirements of the other sections of the system, e.g. number of input/output lines, analogue input/output requirements, processor speed and capacity. These factors were matched against the available microprocessor systems and a short list produced.

Principal units are the navigation unit which houses the microprocessor system radio receiver and displays and controls, an aerial unit which comprises two aerials and associated amplifiers and a compass sensor unit. The primary sensor elements of the direction finder comprise a rotating ferrite rod antenna and a short whip aerial to provide omnidirectional reception for station identification. In combination the aerials are used to resolve the 180° ambiguity inherent in the ferrite rod aerial. The microprocessor samples the output from the radio and calulates the azimuth of the transmitter. An input from a remote flux-gate compass is used to convert the azimuth to a magnetic bearing which is then displayed on the front panel of the navigation unit. Successive samples are averaged to give a best estimate of angle.

In addition to digital operation at the man-machine interface there were fairly complex signal processing functions to be performed together with a diversity of other tasks such as time keeping, mode and data memory functions, frequency division, display refresh and system control. Taken together these tasks added up to a potentially complex piece of equipment. While each of these functions could have been implemented with discrete special-purpose circuits, the amount of hardware required to provide all the facilities would have been prohibitive both in terms of price and of the size of the equipment. In addition, further changes to functions beyond the original specification would involve modifications to the hardware and hence component and p.c.b. changes with the inevitable impact on production.

The essential difference when adopting a microprocessor solution is the inherent flexibility of the hardware and its ability to perform a multitude of different tasks defined simply by the contents of the operational program. The limitations to this flexibility are principally confined to the speed of the processor, the size of the program and data store and the number of interfaces provisioned.

A further and important feature of a microprocessor system, particularly when applied to a commercial/consumer system, is the potential for value-added features which can be provided by additional programs. This can both extend the life of the product and broaden the product range whilst maintaining the same production line for product variants. It is not unreasonable to envisage two or three products identical in production terms offering quite different facilities and covering perhaps two-to-one selling price range.

Method of operation

A chain-dot line broadly depicts the interface between hardware and software functions in the large diagram, but software is an integral part of the engineering of the unit. System performance depends initially on the quality of the data available which relates to the performance of the primary sensors: aerial-radio combination and the compass. The way information is used by the processor also contributes to the final performance of the system, particularly under noisy and/or high dynamic conditions.

Output from each aerial enters a broadly tuned circuit followed by a single stage of amplification on each channel. Tuning is achieved by variable-capacitance diodes with a control from the phase-locked loop local oscillator. The gain of the whip aerial amplifier is variable to enable the gains of the rod and whip aerials to be balanced when summing. The output from either or both channels is switched into the r.f. feeder under control from the microprocessor. Mechanical rotation is effected by a small d.c. motor and gearbox. Coupled to the output drive shaft is a magnet which triggers a Hall-effect device every revolution of the shaft.

The front end of the receiver is tuned by a three-stage passive filter giving a bandwidth of approximately 10kHz and after impedance conversion matched into a 455kHz notch filter and f.e.t. mixer. Ceramic filters are used before the first i.f. gain stage and before the final gain stage giving a narrow bandpass of 3kHz. Output from is produced to both an a.m. dector for a.g.c. and audio output and to a product detector driven from a b.f.o. This output is filtered by an LC filter to give an effective bandwidth of 300Hz for the signal strength output.

Oscillator frequency is synthesized by a phase-locked loop whose reference frequency is 100Hz. The microprocessor divides the local oscillator output by the desired frequency ratio (455kHz above required signal frequency). The 100Hz is also used by the microprocessor for its primary timing functions.

Basic directional information is presented to the processor as a continuously varying signal proportional to signal strength over 360° of aerial rotation. A single pulse is also generated each time the aerial passes through the vessel's head. Fig. 1 shows a typical waveform of the rod alone and the combined whip aerial. With marine beacons the microprocessor has 25 seconds to establish a solid bearing after which the beacon returns to its ident code before switching off (see Fig. 2) – about 60 revolutions of the aerial. To obtain a statistically useful number of measurements the acquisition time of the bearing calculation must be limited. This requirement and the limited data store available, meant a fresh look at the method of data extraction; most data correlation techniques require many input cycles and long data strings. What is needed is a quick initial result, with minimum data store and a manageable processor time load. The method chosen can establish a bearing in about eight cycles of the aerial including establishing the polarity of the bearing.

Under good listening conditions the d.f. waveform (rod only) looks like a rectified sine wave, Fig. 1. In practice

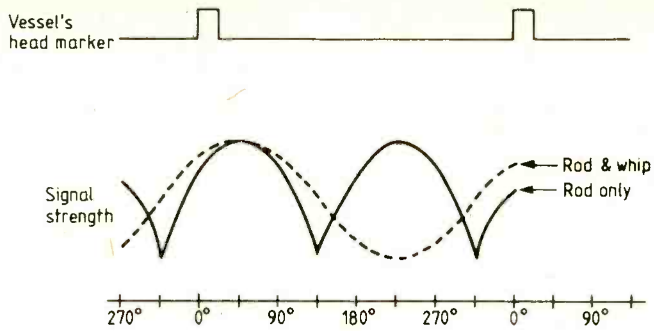


Fig. 1. Directional information is presented to the processor as a varying signal proportional to signal strength over 360° of aerial rotation. A single pulse is also generated each time the aerial passes through the vessel's head.

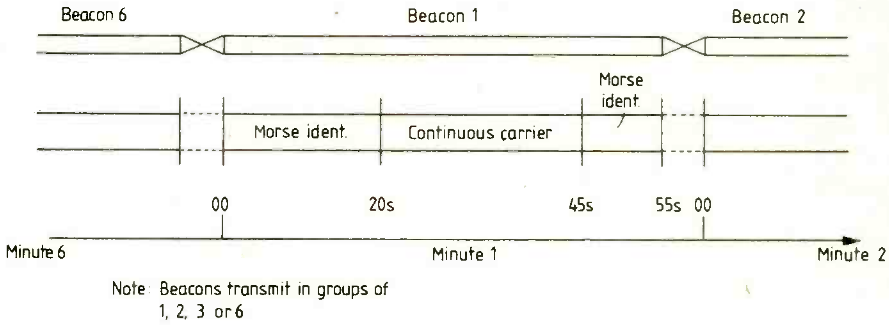
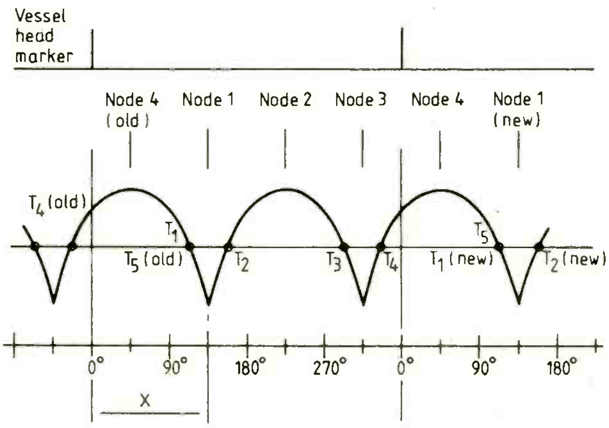


Fig. 2. Marine d.f. beacons, normally synchronized to g.m.t., give 25 seconds in which to establish a bearing – about 60 revolutions of the aerial.



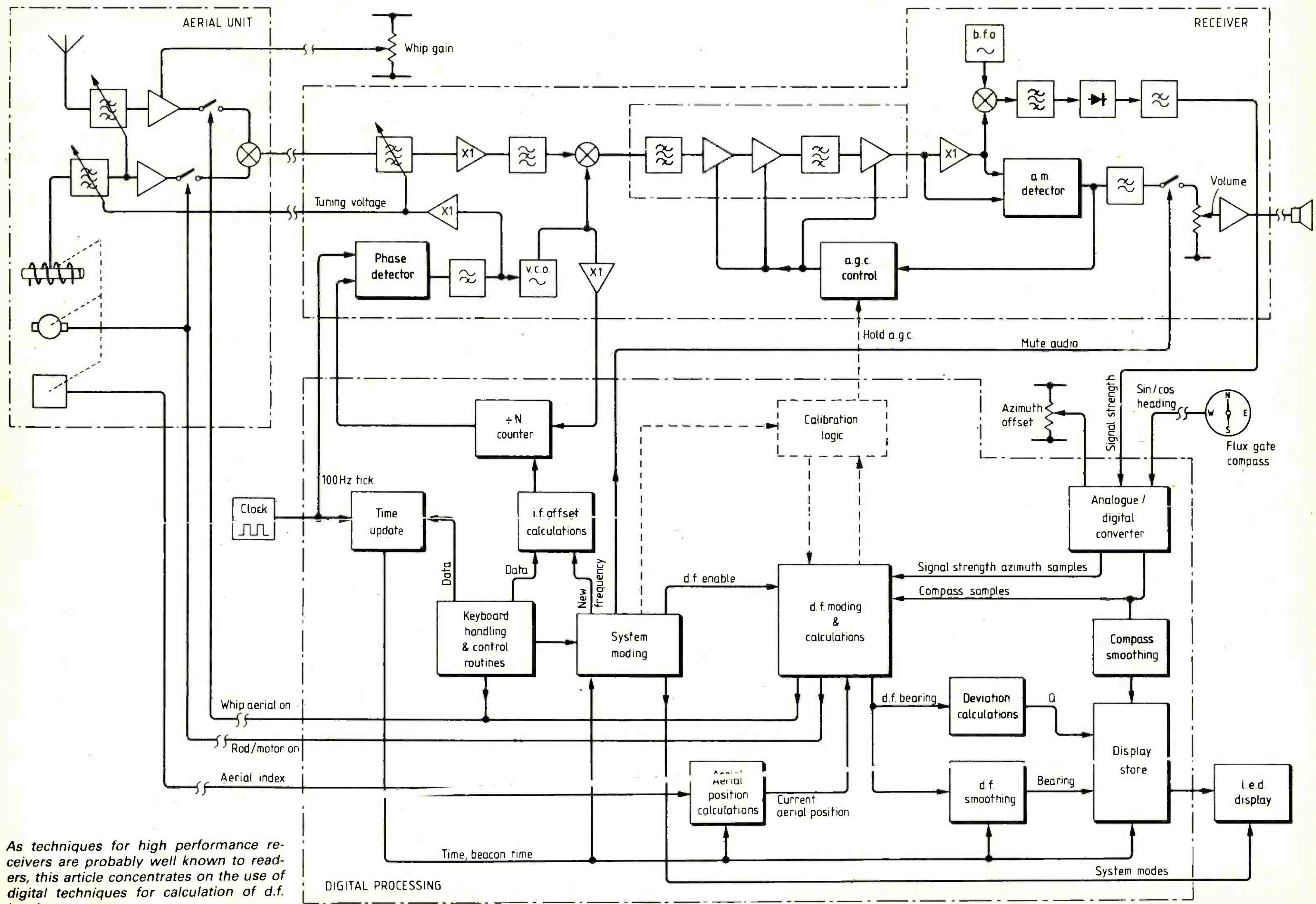
Node calculations

Node 1 $\frac{T_1 + T_2}{2} = X°$ Node 3 $\frac{T_3 + T_4}{2} = X + 180°$ Node 2 $\frac{T_2 + T_3}{2} = X + 90°$ Node 4 $\frac{T_4 + T_5}{2} = X + 270°$	$X = \dfrac{\left(\left(\frac{T_1 + T_5}{2}\right) + T_2 + T_3 + T_4\right) + 540°}{4}$

Fig. 3. Algorithm samples points at which waveform crosses mean value, calculated from previous cycle, to give four node values. Bearing relative to vessel's head is then converted to a magnetic bearing.

however the instantaneous position of the peak tends to move due to noise on the waveform. Similarly, with weak signals the null becomes very rounded as it approaches the noise floor. An algorithm samples the point at which the waveform crosses the mean value of the waveform calculated from the previous cycle. This significantly reduces the amount of data required to be stored and processed, whilst sampling the waveform at the point least susceptible to noise. By taking the centre between these crossover points the four-node points of the waveform can be established. And by summing the nodes it is possible to extract an average position X to the first node, Fig. 3. This calculated position is then compared against the approximate positions of the measured maximum and minimum to establish whether it measures a peak or a null. If it coincides with a null the angle is offset by 90° to bring it in line with one of these peaks. At this stage the routine has calculated the bearing relative to the vessel's head (azimuth) in a range 0 to 180°. It is now necessary to correct it for ambiguity and convert it to a magnetic bearing.

At the beginning of a d.f. cycle during acquisition, the sense of the bearing is eatablished by summing the d.f. and



As techniques for high performance receivers are probably well known to readers, this article concentrates on the use of digital techniques for calculation of d.f. bearing.

whip aerial signals. The phasing of the two aerials is such that when the rod aerial is facing the transmitter the signals are in phase and add. Conversely, when the rod is facing away from the transmitter the signal phases are in opposition and therefore subtract. The approximate position of the maximum of the signal under these conditions is measured by the processor, corrected for vessel's heading and stored. To correct the current azimuth, the stored sense value is converted back to the azimuth by subtracting the current heading. This value is then compared with the current azimuth and if it coincides within a predefined window the angle is accepted as correct. If it does not, 180° is added to the value and the test repeated. The vessel's compass heading is then added to the corrected azimuth to obtain the bearing to the station.

To maintain a stable display and to improve accuracy successive bearing samples are accumulated in a filter and averaged over the measurement period. In addition, the variance of the bearing from the mean is monitored and a quality factor of 0 to 7 calculated. This value is displayed together with the bearing after the measurement and assists the operator in selecting the best set of bearings to plot his position. The algorithm described has assumed a clear noise-free input signal. Inevitably, this is not the case when working in the 200 to 500kHz frequency band and it is necessary to overlay the process with a series of data checks to ensure that valid data is being processed. At each stage of the processing checks are made to ensure that data corrupted by noise are rejected if it affects the values being calculated.

- Checks on the crossover data cover number of crossovers per revolution and consistency in their spacing
- Checks on the node calculations establish that the nodes add up to 360° and there is approximately 90° between nodes.
- Checks on correlation against the sense measurements are made and the entire cycle rejected if correlation is not present.

The algorithm has been organized to run on the processor in a sequential manner, each revolution of the aerial incrementing the sequence by one step, an approach that ensured predictable and controllable sequencing. Fig. 4 shows the order of sequencing from initiating d.f. mode through to continuous d.f. measurement revolutions. The sequence is the minimum sequence and could take longer if any of the data checks failed.

Between each aerial mode change (i.e. whip only, to whip summed with rod, to rod only) a settling revolution is initiated to allow the a.g.c. of the receiver to stabilize after the transients generated by switching the aerials.

The d.f. cycle commences with a settling revolution with the aerials switched in the sense mode (i.e. with both whip and rod aerials active). The sequence then increments to sense measurement where the approximate position of the signal peak is established for later use in ambiguity correction. A minimum of three revolutions are required for this and the position of the peak must correlate over three successive revolutions before the next phase can be entered.

When correlation has been satisfactorily achieved, the whip aerial is switched off and a settling revolution initiated. The next revolution is used by the processor to calculate the first mean value of the d.f. waveform. Subsequent revolutions of this aerial are used for d.f. measurements provided that correlation is achieved with the sense measurements. If correlation cannot be achieved, the system returns to the beginning of the sense sequence and the sequence is repeated.

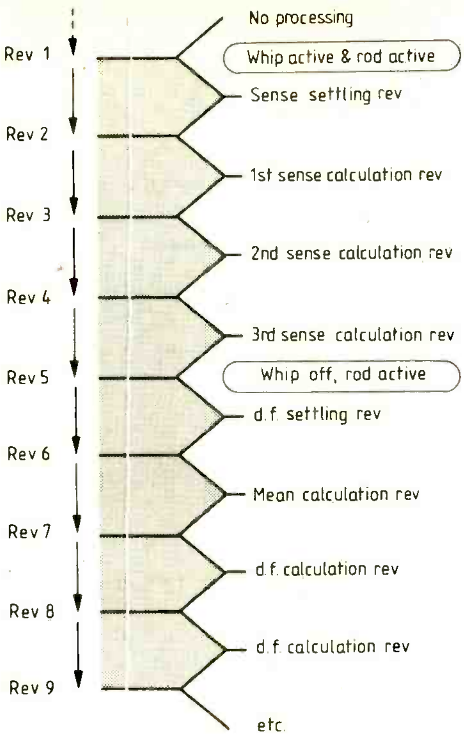


Fig. 4. Algorithm sequences once per aerial revolution. Correlation between three sense-mode measurements is needed before d.f. measurements are made.

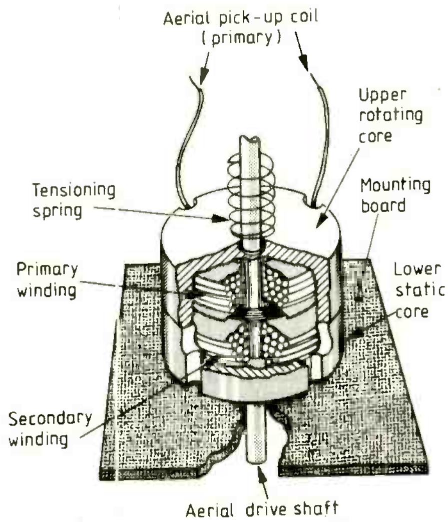


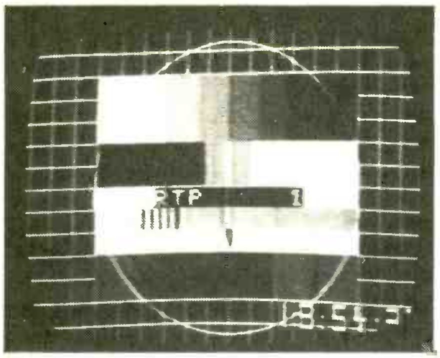
Fig. 5. Light loading of surfaces in Vinkor-style rotary transformer makes lubrication unnecessary.

For coupling the aerial signal to the head amplifier a brush and slip-ring arrangement with such low signal levels would be intolerably noisy. As it was not practical to rotate the electronics with the aerial we chose a rotary transformer formed from the two halves of a ferrite Vinkor-type transformer, as shown in Fig. 5. The upper half of the core together with the primary bobbin, is attached to the rotating rod aerial and the lower sections with secondary bobbin to the static base of the unit. To maintain sufficient coupling the mating surfaces of the two cores had to be held in intimate contact by light pressure from a spring. Provided that the surfaces were spotlessly clean during assembly the coupling generated virtually no noise.

A number of factors had to be considered when choosing the microprocessor. The first criterion was that it had to be a single power rail device running on less than 12V as the unit was to operate from a 12V battery supply. This ruled out some of the early microprocessors such as the Intel 8080 which required three voltage rails. The processor would have to be an eight-bit machine (only one 16-bit processor was available at the time and was too expensive) and would have to have at least minimal arithmetic functions since the task was not simply for a logic sequencer. Suitable processors were Zilog Z80, Motorola 6800 and the Intel 8085.

Relatively high-priced l.s.i. programmable components were chosen for interfacing; we thought these would be likely to reduce in cost more rapidly than the established m.s.i. products, an assumption which proved correct. Reviewing the chip sets available from each manufacturer, they were found to be nominally equivalent. However, Intel had a set of interface super-chips specifically designed for their 8085 processor, one of which included memory, timing functions and input/output ports. Looking more closely at the timer function, we discovered that one of the timer's counting modes would make it suitable as the $\div N$ counter for the frequency synthesizer. This would simplify the interface to the synthesizer to two lines.

A further factor encouraged the use of the 8085 microprocessor: our previous products were based on the 8080 microprocessor and we consequently had development equipment for it. The investment of approaching £15k on a different set of development equipment was not attractive particularly when a suitable software-compatible microprocessor was available. The final configuration was an Intel 8085 processor alongside an 8155 combined r.a.m., i/o and timer chip and an 8255 i/o chip. Program memory was three 2716 e.p.r.o.m.s and an additional 256 bytes of c.m.o.s. r.a.m. were added for data retention in a power-down standby mode.



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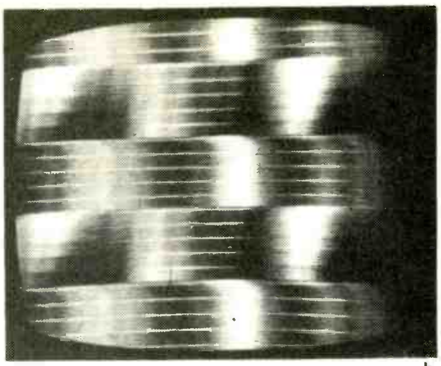
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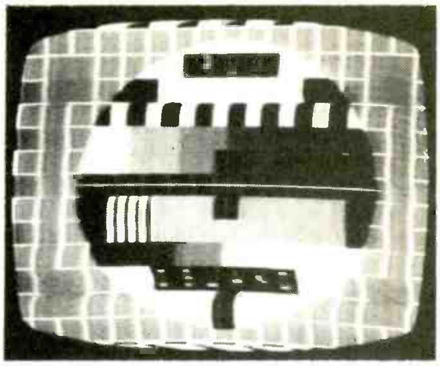
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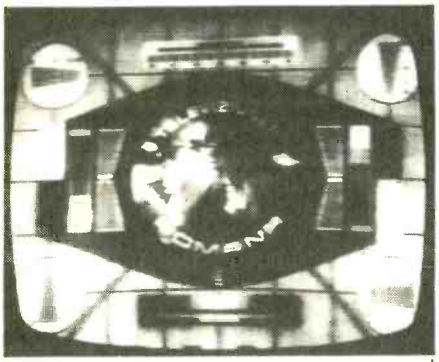
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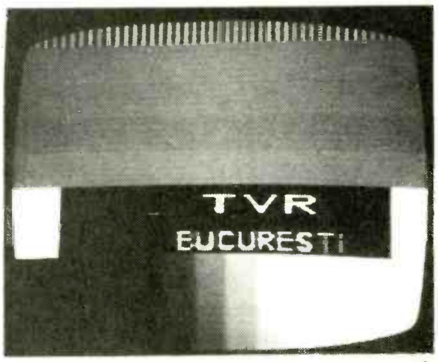

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World television standards

Long-distance television reception; system descriptions and v.h.f. channel allocations

by Keith Hamer and Garry Smith

Continuing the discussion on long-distance television reception, this third article covers international television standards, various v.h.f. tv-channel allocations and colour systems. A review of the 1981 'sporadic-E season', transmitter news and reports from overseas enthusiasts are included.

The surge in the number of television services appearing throughout the world after 1945 brought with it various different standards for sending tv picture and sound information. In the UK, transmissions using the 405-line system adopted in 1936 were resumed. This 405-line standard, system A, used positive-going vision modulation and had a video bandwidth of 3MHz. The sound channel was a.m. and the sound carrier frequency 3.5MHz below the vision carrier.

Most Western European countries chose a 625-line system with negative-going vision modulation and f.m. inter-carrier sound. This is generally referred to as the CCIR system (system B, v.h.f. or system G or H, u.h.f.), in which the video bandwidth is 5MHz and the sound is 5.5MHz above the vision carrier. Many African and Middle East countries and parts of Asia and Australasia have also adopted the CCIR system.

Eastern-bloc countries, including the USSR, chose a similar standard but with 6.5MHz sound and vision separation, known as OIRT (system D, v.h.f. and K, u.h.f.). China also uses the OIRT standard. Systems D and K are used in parts of Africa, and several French Territorial countries use system K1, which is very similar to K, for their v.h.f. transmissions.

During the early sixties, the UK finally chose a 625-line standard for their intended u.h.f. transmissions. This standard, system I, was very similar to those of the CCIR and OIRT but with a vision bandwidth of 5.5MHz and an inter-carrier sound channel separation of 6.0MHz. This system was also adopted by the Irish for their 625-line v.h.f. transmissions. More recently, Hong Kong, South Africa and a few Central African countries have selected system I for their television services.

The French were experimenting with two different standards, one a 441-line system and the other using 819 lines (system E). The latter is still in use for v.h.f. transmissions. Both systems employed positive-going vision modulation and, as in the UK 405-line system, a.m. sound. The 819-line system had a vision bandwidth of 10MHz while the experimental 441-line system, which ceased operation in the fifties, had a much narrower bandwidth. The overall channel bandwidth of the 819-line systen was almost three times that of the 405-line

*OIRT (International Radio and Television Organization) is an association of Eastern European broadcasters, similar to the EBU in Western Europe.

(a) *The FuBK electronically generated test card received from Portugal on 3 July at 1854 CET on ch. E3. Note that RTP-1 sometimes inserts a digital clock with the test card.*
(b) *The Philips Chequerboard or Chessboard pattern received from ZTV-Zimbabwe on 5 October during the early afternoon on ch. E2 from the Gwelo transmitter. Signals propagated via F2 and Trans-Equatorial (TE) modes usually display some form of video distortion.*
(c) *The Icelandic television network (Ríkisútvarpid-Sjónvarp) often transmits the Philips PM5544 electronic test card for long periods, occasionally at 0300 CET. This particular reception via sp.E was logged on June 11th on ch. E4 in good colour. The identification used with the PM5544 is "RUV ISLAND".*
(d) *One of the very few remaining individual monoscopic test cards as used by Radiodifuziunea Televiziunea Românâ (TVR-Rumania). This was received on ch. R2 at 0835 CET on 12 August.*
(e) *The "EBU Bar" which is still used in Rumania. This monochrome signal incorporates the date to the left of the "TVR" identification.*
(f) *An electronically-generated test pattern recently introduced by Radiotelevision Española (RTVE-Spain). The photograph shows reception logged on July 15 of a transmission from the Navacerrada outlet near Madrid on channel E2. A slightly modified version of this pattern (which includes a white central bar beneath the "rtve" identification) is used by several other Spanish transmitters with appropriate identification.*

system, i.e. 14MHz as opposed to 5MHz. Consequently, the number of channels possible in a given band of frequencies was greatly reduced. To overcome this problem the French devised a method of channel interleaving in which the sound channel would be 11.15MHz above the vision carrier on certain channels and 11.15MHz below on others. This method eventually allowed a total of nine channels on Band III, although only two Band I channels were used.

Several French territories adopted the 819-line system under the influence of the French. Luxembourg also used the system on v.h.f., but with a reduced video bandwidth of 5MHz (system F), until the late sixties when the number of scanning lines was reduced to 625. The 5MHz video bandwidth, positive video modulation and a.m. sound characteristics were retained and the resulting system became standard C. Belgium had system C on v.h.f. up until 1977 when it switched to CCIR. Monaco still uses system E on v.h.f. but with 625-line scanning.

For u.h.f. transmissions in Bands IV and V, the French introduced a 625-line standard, system L. This has a vision bandwidth of 6MHz, an a.m. sound channel 6.5MHz above the vision frequency and uses positive-going video modulation. Luxembourg uses system L for its channel 21 transmissions but within the next year or so a variant system L1, will replace the present 819-line transmission in Bands I and III.

In the USA, the position was much simpler. The Americans agreed on a 525-line standard, system M, using negative-going vision modulation, 4.2MHz video bandwidth and an f.m. inter-carrier sound channel at 4.5MHz above the vision frequency. This system was also chosen by Canada and eventually spread throughout Central and Southern America, Alaska, parts of the Caribbean, Japan, Korea and parts of Asia. At American Forces bases throughout the world system M is usually the norm. Until recently, the ARAMCO transmitter at Dhahran in Saudi Arabia employed the 525-line system M standard, but the station now uses the CCIR system B.

In certain South American countries and parts of the Caribbean where a 50Hz mains supply is available another standard, system N, is used. This is a 625-line standard with vision bandwidth and sound separation the same as in system M, but the field frequency is 60Hz whereas system M has a field frequency of 50Hz. Countries using system N include Argentina, Uruguay, Bolivia and Barbados. Venezuela has a mixture of 50 and 60Hz domestic mains supplies and consequently television transmissions may use either system M or N depending on the location of the transmitter. In areas where a choice of standards is available, controls for adjusting frame hold and frame amplitude are necessary. Little, if any, adjustment is required to the line control as the line-oscillator frequency on both systems is similar i.e. 15.750kHz for 525-line and 15.625kHz for 625-lines.

So far, colour television systems have not been mentioned. This is because the choice of colour system is not directly dependent on the characteristics of the television standard adopted. There are three colour systems in use at present, namely NTSC, PAL and SECAM.

During the fifties, colour television was introduced in the USA using the NTSC colour encoding system. NTSC was then adopted by most countries already using the 525-line system M. This colour system was field tested in Europe but was found to be unsuitable. PAL and SECAM were developed in Europe and towards the end of the sixties several Western European countries (excluding France) introduced a regular colour-tv service using PAL. Eastern-bloc countries and France were considering SECAM for their colour transmissions.

The last decade has witnessed the introduction of colour television to virtually every European country. The PAL system has been adopted by most countries using the CCIR norm (systems B, G, H and I) except for East Germany which, for political reasons, chose SECAM. Although CCIR is used extensively in North Africa and countries in the Middle East we find a mixture of PAL and SECAM transmissions due mainly to previous political decisions. Most West and South African countries with CCIR are adopting the PAL system. Regular PAL transmissions commenced in Australia and New Zealand during the last decade. More recently, China has decided to use PAL although standards D and K are in use there.

PAL has unexpectedly been favoured by at least two South American countries, namely Brazil with system M and Argentina with system N. Normally the PAL (and SECAM) subcarrier frequency is 4.43MHz but for compatibility with systems M and N, where the video bandwidth is only 4.2MHz, a lower subcarrier frequency is used.

SECAM is used by the French for their 625-line system-L transmissions on u.h.f. Colour is not used on the 819-line v.h.f. transmissions. In Luxembourg, the situation is complicated as three standards, namely C, L and G, are used. The channel 21 transmitter radiates a system L SECAM signal to serve the French-speaking population and parts of France while the E7 channel outlet provides a system-C PAL signal. Colour-standard conversion takes place at the transmitter. Channel-27 system G transmissions are also PAL and serve viewers in the Low Countries and West Germany.

Tele-Monte-Carlo in Monaco transmits both SECAM and PAL colour on u.h.f. System-L SECAM transmissions are intended for neighbouring France while the system-G PAL service on channel 35 is intended for viewers on the western coast of Italy and across the Lombardy Plains as far as Venice in the North. In general, French overseas territories and countries influenced by the French use SECAM.

Channel allocations

V.h.f. channel allocations are shown in Table 1. U h.f. channels are not included in the table because channel numbering and corresponding vision frequencies are identical for all u.h.f. systems except M and N. The 625-line u.h.f. channels are numbered from 21 to 69. Owing to the narrower channel bandwidth of systems M and N, the u.h.f. spectrum can accommodate a greater number of channels; these are numbered 14 to 83. Japan uses system M but has a restricted number of u.h.f. channels.

Newcomers to DX-tv may find it easier to consider the chart layout of Table 1 as a tuning scale on a radio receiver. If several UK 405-line channels can be received (hopefully weakly), they may be used as markers to enable a Continental channel to be identified.

UK 405-line channels are referred to as 'B' channels and subdivisions are made by adding a numerical suffix, i.e. B1, B2, etc. Generally, CCIR channels in Bands I and III have a letter prefix, E, also followed by a number. Prefix M is used for Moroccan channels and for French channels carrying 819-line system E transmissions, prefix F is used; again, both are subdivided using a numerical suffix. Italy, one of the few exceptions, uses a letter suffix after its designation, I, to give channels IA, IB, etc. Similar letter suffixes are used by the Irish Republic and confusion can result, especially in reception logs, as their prefix is also I. To add to the confusion, the Irish Republic's channel-IB vision frequency is identical to the Italian IA vision frequency.

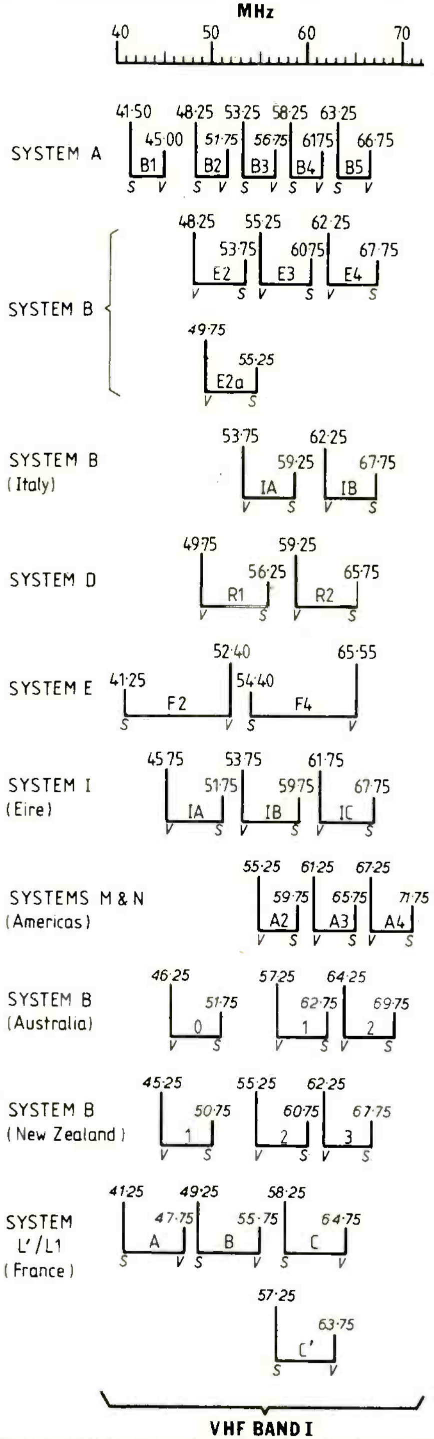
In the Americas where systems M and N are used, channels carry the prefix A followed by a number.

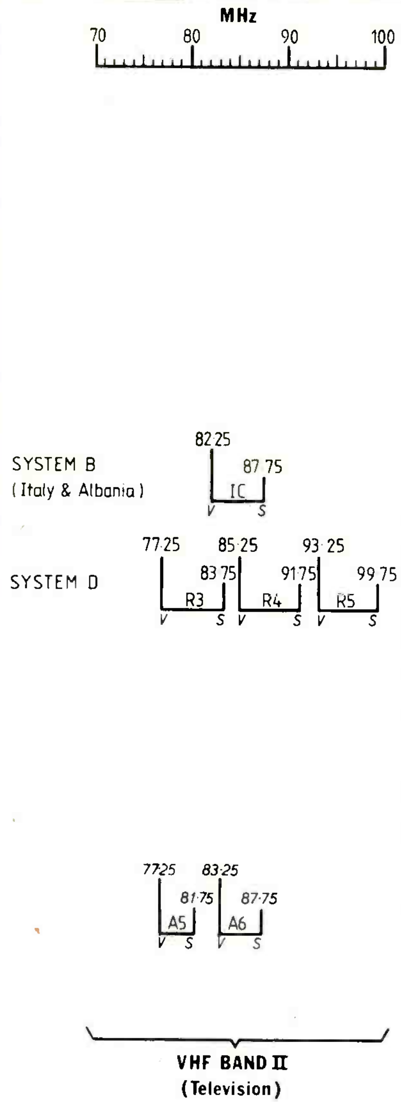
1981 sp. E review

The first signs of the 1981 sporadic E season occurred on 29 April with strong southerly signals from the Spanish television service RTVE on channel E3 in the late-afternoon/early-evening period. A new test pattern carrying the transmitter location was seen followed by the electronically generated test card (see the October issue of *Wireless World*, p69) prior to the normal programmes.

There were several weak and short-duration 'openings' during May with signals from the south-east predominating. Good quality colour signals were obtained from RTVE on channels E2 and E3 during the evening of the 19th. Other countries received on Band I during May include Italy (RAI), West Germany (ARD), Portugal (RTP), Yugoslavia (JRT), Sweden (SR), Norway (NRK), East Germany (DDR: F/DFF), Czechoslovakia (CST) and Switzerland (and PTT, SRG, SSR, TSI, DRS).

Signals from most European countries were seen during June with sporadic E signals around on most days. On the 7th, towards late afternoon, several enthusiasts reported exceptional reception conditions with television signals well into the Band II spectrum. Long range f.m. radio was also very much in evidence and a few lucky television DX enthusiasts who tried the lower Band-III channels were rewarded with signals from the USSR (TSS). A DX enthusiast in the Netherlands received Russian programmes on all Band III chan-





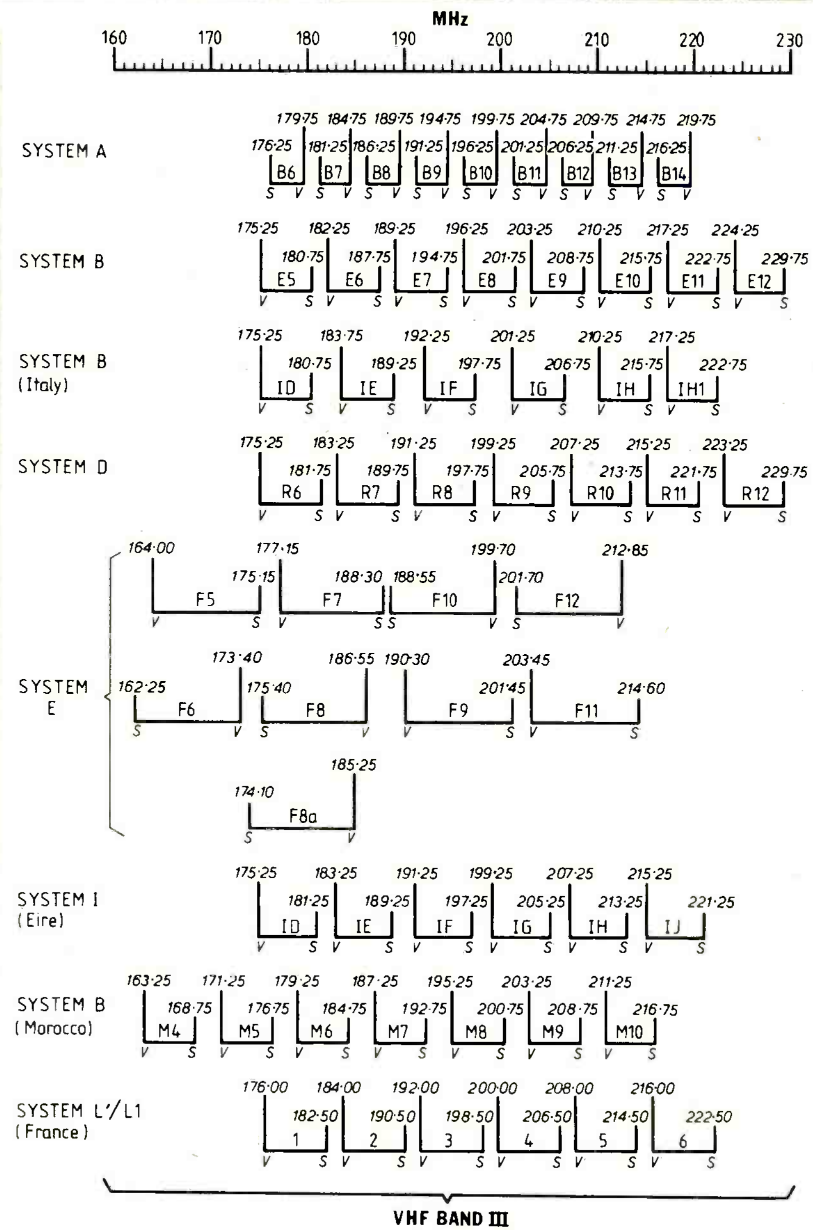


Table 1: v.h.f.-tv channel allocations
Different systems for transmitting picture and sound information are used by different countries. Within each Band, channel frequency allocations can vary depending on the system. Channels within a system usually have a fixed letter prefix followed by a variable number to indicate their position in the Band; hence the first channel in system A (Band I), is called B1. V and S under the channel allocation refer to vision and sound frequencies. U.h.f. channels are not shown because channel numbering and corresponding vision frequencies are identical for all u.h.f. systems except M and N.

nels due to the exceptionally high maximum-usable frequency m.u.f. enhanced by sp.E conditions.

Another notable day in June was the 11th with signals from all points of the compass received within the space of an hour. Fortunately most were transmitting the test card so identification was relatively easy.

Several times during June a colour-bar or grey-scale pattern was seen between channels IA and E3, sometimes as late as 2030 CET. This was finally identified as an Italian "pirate" transmission from Nord Center Television (NCT) which operates from Udine. On the 29th at 1836 CET, signals from the Albanian (RTS) channel IC transmitter (82.25MHz vision) were received. Practically every European country was received during June.

July will be remembered for multiple-hop sporadic E signals and the appearance of a new Band I country. On 10 July there was an intense sporadic-E opening for most of the day with signals from the south-east. A tv-DX enthusiast in the north of England received signals from the Canary Islands (RTVE) on channel E3. Sporadic-E signals on the 2-metre band prompted him to check Band III and during the late afternoon he saw RTVE (Spain) on E6 and E7 and some amazing reception of Morocco (RTM) on channel M5. Later that evening after Portugal (RTP) and Spain had closed down around 2300 CET, many enthusiasts saw a system-B signal remaining on E3 from the south. The signal (a feature film) was slow-fading and later identified as coming from the Canary Islands.

A mystery signal appeared on E4 from the south at 2326 CET which consisted of an announcer or newsreader speaking in a language thought to have been Arabic. This was later identified as a new Moroccan transmitter operating in Band I. This transmitter was received on an almost daily basis in France during the summer.

Towards the end of July reception of trans-Atlantic System M signals on channels A2, A3 and A4 was experienced in the south of England. Trans-equatorial (te) signals were resolved from the Zimbabwe E2 transmitter at Gwelo several times during the month. Reception usually occurred between 1700 and 1830 CET. Signals tended to take on a sporadic E appearance and it is generally felt that the signals arrived in the Mediterranean area via F2 or te mode, and sporadic E assisted the signals for the distance. Italian (RAI) channel IA signals were often present during reception from Gwelo. If sp.E conditions prevail during the late evening it is always wise to monitor the conditions until as late as possible in case rare signals are present which may normally be masked by stronger, more commonly received, stations.

A strange signal was detected at 4030 CET on 13 July which consisted of fairly weak horizontal bands, not unlike those caused by a signal generator, on the vision frequencies of R2 and E4. The R2 signal finally disappeared but the E4 signal faded in and out slowly over a period of time in a similar manner to tropospheric signals. Both signals came from an easterly direction. All in all, July was an interesting and busy month for DX television.

During the first few days of August, OIRT signals prevailed with test patterns from the USSR, Czechoslovakia (CST) and Hungary on the 6th. The 9th was hectic with signals from no fewer than 12 countries being received during a continuous opening lasting all day. 819-line pictures from France (TF1) on channels F2 and F4 and 625-line signals below the E2 vision frequency (a signal thought to be the new French System L1 on test) were resolved during the morning. At 1242 CET the Hungarian television service (MTV) was radiating a frequency-grating pattern on R1 and R2 prior to the PM5544 test pattern. At 1331 the Yugoslavian FuBK test pattern appeared with good quality colour signals accompanied by music. The Russian test card appeared on the 12th at 0830 CET on channel R2 from the Bucuresti transmitter. At 1742 a feature film with Arabic subtitles was noted on channel E3 from the Suwaileh transmitter in Jordan. Mainly OIRT signals were logged on the 13th with test patterns from Poland (TVP) and Czechoslovakia as well as the USSR news program "ВРЕМЯ" on R3 at 1800 CET. Signals from Eastern European stations prevailed on the 16th with programmes on channel R1, R2, R3, and at times on R4. Again, most countries were received during August with exceptionally strong signals from Gwelo (ZTV) on the 14th and 15th.

Sp.E activity diminished during early September with mainly weak, short duration, signals being present. However, a late afternoon opening on the 23rd from the south revealed at least two exotic signals. In East Anglia a PM5544 test card was seen with what appeared to be Arabic identification in the lower black rectangle. This was on channel E4 and may have been the new Moroccan Band I transmitter. Later, a strong F2/te signal on channel E2 was noted consisting of a grey-scale pattern but the line hold of the receiver had to be adjusted to lock the picture. This was obviously not a standard 625-line CCIR signal. The pattern probably originated in Ghana or Nigeria.

October is usually a very quiet month with long-range reception normally due only to meteor showers and, perhaps, tropospheric ducting. However, on 5 October during the early afternoon very strong signals were logged on channel E2 from Zimbabwe. Reception lasted for some time and consisted of the Philips 'chequerboard' pattern. The PM5544 is also used by ZTV.

Transmission information

In this section, recent news concerning tv transmissions from various countries is given.

Argentina. Despite raging inflation, most of the television networks have now commenced PAL-N colour transmissions. The latest service operates from Buenos Aires on channel 11.

France. Test transmissions are being carried out on the first network, TF1, using the recently developed 625-line system L' on v.h.f. Channel C' shown in Table 1 is used only by the Besançon-Lomont transmitter.

Luxembourg. Some DX-tv enthusiasts may be wondering why they experienced difficulties in receiving transmissions on E7 or E21 from the Dudelange transmitter from the end of July. An aircraft of the Belgian Air Force collided with the 300-metre high mast causing severe damage. Until a temporary antenna can be installed at Dudelange, programmes from Radio-Télé-Luxembourg (RTL) will be distributed only to viewers subscribing to cable-television networks. RTL will be the only national broadcasting authority in Europe to distribute programmes in this manner. Further information is given in the *EBU Review* 188, published last August.

Spain. Strong signals from RTVE have always been a regular feature of 'sporadic E seasons' so many DX-tv enthusiasts should know that several new test cards have been introduced similar to the one shown in the photo. Transmitter identification is included on most test transmissions.

There are plans to introduce private television stations but details are not yet available. We understand that there have been several applications for permission to transmit. Many non-technical magazines are giving extensive coverage to the idea of private television in a similar manner as c.b. radio has been covered here in the UK.

Uruguay. Colour television commenced last August using PAL-N.

West Germany. Hessicher Rundfunk's third network, HR3, has a new transmitter located at Rhön on channel E37. The transmitter's e.r.p. is 364kW.

There are also two new transmitters at Opherten for the Belgian Army stationed there. One is BRT/D (Flemish language) operating on channel E12 with an e.r.p. of 32W and the other RTBF/D (French language) on channel E39 with 625W e.r.p.

Test transmissions have commenced using stereo sound channels for tv.

Reports

The following reports received from overseas DX-tv enthusiasts provide background information for the newcomer to the hobby. No doubt experienced enthusiasts will also find them interesting.

Ernesto Villeyra and Salvador Espín have written from the Balearic Islands with details of their reception. They both have regular u.h.f. reception during the summer from Italy, Sardinia and France. They are using a wideband aerial, which gives gain of 13dB, feeding a low-noise pre-amplifier which in turn feeds a medium-power amplifier at about 1 metre away from the pre-amp. They have identified about 25 stations so far, many of which

continued on page 68

Digital, multi-track tape recorder

Circuitry of input stages and speed-control frequency generator

by A. J. Ewins, B.Tech., Research department, London Transport

This third part of a series describing the design and construction of a very low cost, professional instrumentation recorder presents the circuitry of the input stages, including the multiplexer and analogue-to-digital converter, and discusses the reference-frequency generator used for motor speed control.

The input stages, shown in block form in Fig. 4 of part 1 of the article, are illustrated in detail in Figs 19 to 22.

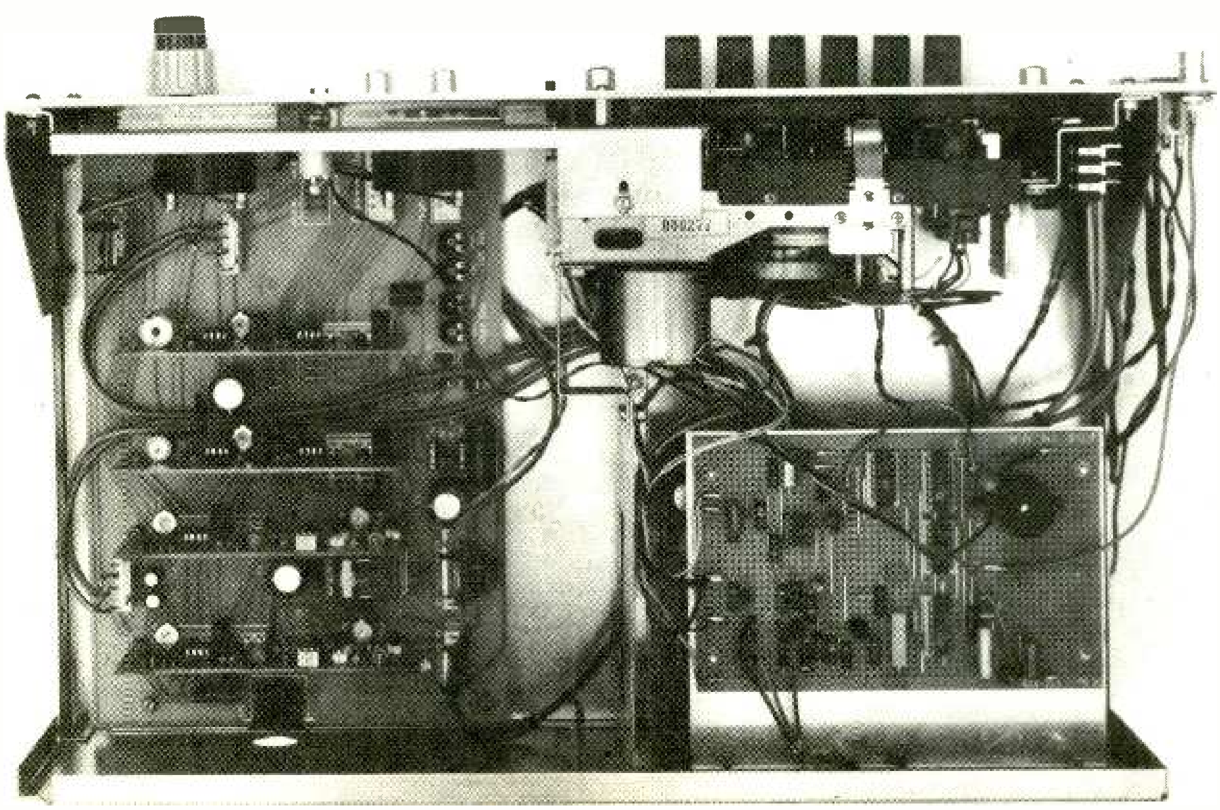
Analogue multiplexer. Firstly, Fig. 19 shows the circuit diagram of the analogue multiplexer and differential, times-five amplifier, which was needed because the a-to-d converter has a full-scale input range of ±5V and the normal range of the input signals is ±1V. A differential input stage was required to give greater flexibility to the input signals.

The i.cs used in the analogue multiplexer are 8-way analogue switches, type DG508, addressed by a divide-by-2^7 counter, i.c. type 4024. The analogue switches are powered by plus and minus 15V supplies and also have connexions to the 0V line, accepting logic inputs between 0 and 15V and handling analogue signals within the range ±15V. The six analogue input channels are connected to seven of the eight switch inputs as shown in Fig. 19 (the reason for the order in which the channels are connected to the switch inputs was explained in Part 1). Channel 2 is connected to both S1 and S7 inputs, because a sixth clock pulse is received by the 4024 counter ahead of the reset pulse, as shown in Fig. 5 of Part 1. Resistors, of any value up to around 1MΩ, are connected between ground and the six switch inputs of the DG 508 i.cs to prevent them from 'floating' in the absence of an analogue signal input. They may not be strictly necessary but are, in the author's opinion, thought advisable. The differential amplifier with a gain of five to differential signals and unity gain to common mode signals is of standard op amp design.

Sample/hold. Figure 20 is a detailed circuit diagram of the sample/hold circuit and analogue-to-digital converter. The sample/hold circuit is an i.c. type LF 398 and, like the analogue switches, is powered by the ±15V lines, accepting logic control pulses between 0 and 15V and analogue signals between ±15V. The 4700p sample/hold capacitor was chosen for optimum sample speed and hold retention when operating at a speed of 284.4 samples/s. As connected, the sample/hold circuit is in its 'sample' mode with a logic 0 signal on pin 7 and in its 'hold' mode with a logic 1 signal on pin 7. The two diodes, D_1 and D_2, and the 100kΩ resistor form a 2-input OR gate to the two sample/hold control pulses, B4 and DR.

A-to-d converter. The i.c. used for the analogue-to-digital converter is an Analogic device, the AD571K. It will convert unipolar signals in the range 0 to 10V, or bipolar signals in the ±5V range, to a 10-bit digital word. It has a typical conversion time of 25μs, and is therefore operated well within its capabilities in this particular application. The type used is designed to operate from ±15V supplies, indicated by K in the device number, and accepts control pulses in the range of 0 to 15V. The voltage input on pin 15 of the device defines its operation in the unipolar or bipolar modes. For unipolar operation, pin 15 is shorted to ground via pin 16, but for bipolar working is left unconnected and is therefore not shown in Fig. 20. Upon

View of Hart Electronics audio cassette deck, with new speed control circuit at bottom right.



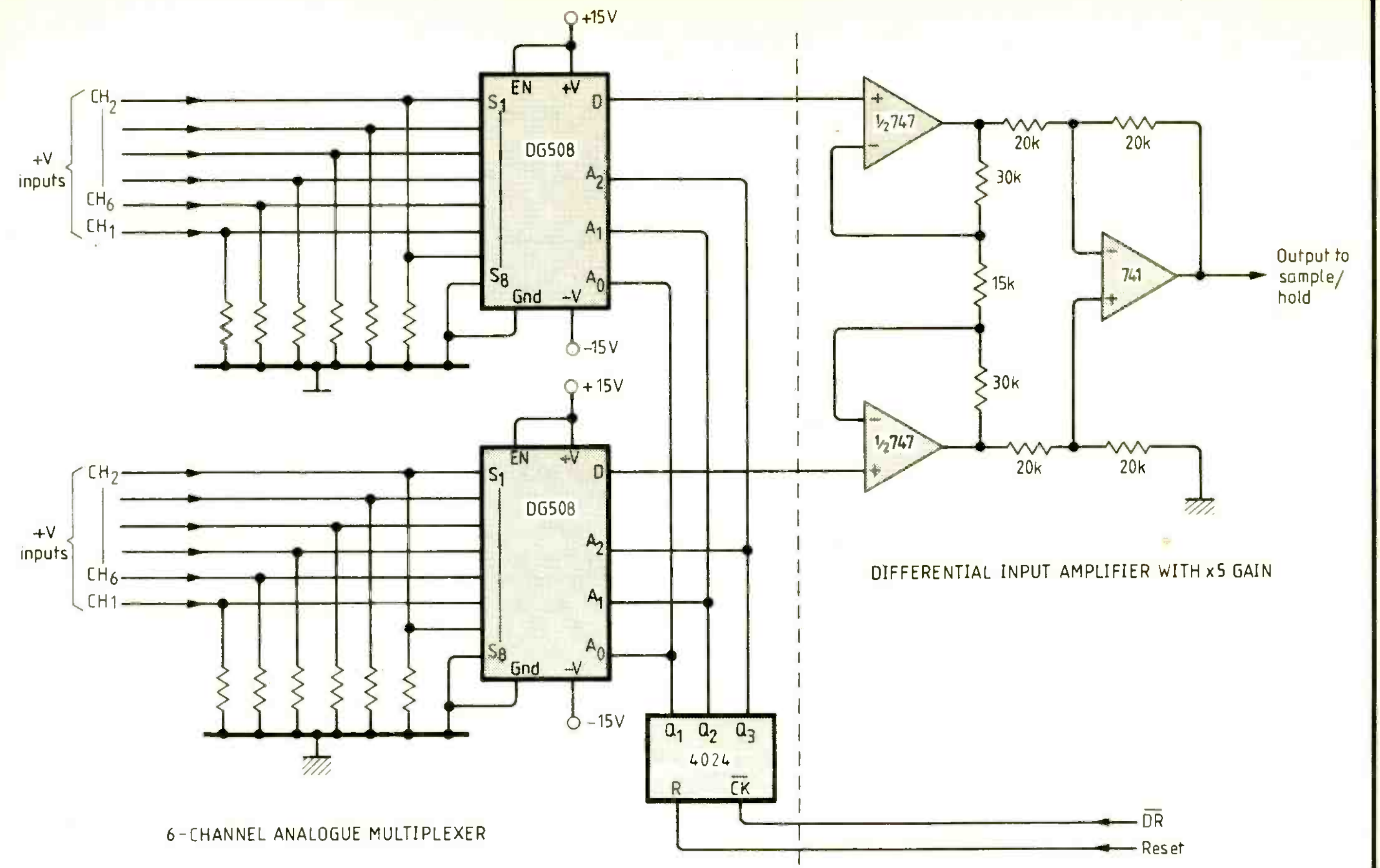


Fig. 19. Six-channel analogue multiplexer and differential amplifier. Resistors on inputs can be chosen to suit source requirements.

receipt of a logic 1 pulse at pin 11 of the a-to-d converter (when B4 goes high) the 10 digital outputs are blanked (i.e. the ten digital outputs go into an open-circuit condition). Simultaneously, the sample/hold circuit is put into its hold mode via the 2-input OR gate. As the outputs are blanked, the a-to-d converter generates a logic 1 pulse at its data ready, DR, output on pin 17, which is used to maintain the sample/hold circuit in its hold mode (via the 2-input OR gate) until the conversion process is completed; i.e., until the data is ready and DR goes low. The a-to-d converter begins its actual conversion of the analogue data when the control pulse B4 goes low. When the conversion is complete the 10-bit digital word is presented to the ten digital outputs, the DR output goes low, and sample/hold circuit returns to its sample mode: the negative transition of DR is used to clock the multiplexer to sample the next analogue input channel in sequence.

Parity generators. The circuit of the two odd-bit parity generators are shown in Fig. 21. Outputs P1 and P2 will be at logic 0 if, and only if, an odd number of their four respective input bits are at the logic 1 level. When P1 and P2 are added to their respective input bits to make five-bit words there will always be an odd number of bits at the logic 1 level in each of the two 5-bit words. Only eight of the ten bits from the 10-bit digital word are used to generate the two parity bits, the two least significant bits, B9 and B10, being ignored.

Obviously, there are many ways in which parity bits may be generated and the author thought long and hard about the most appropriate method to use. In the end, the technique selected was chosen mainly because of its simplicity and economic use of i.cs. Although, at the time of its inception, its success in operation could not be accurately foreseen, it has subsequently performed satisfactorily. The author can therefore see no reason to use an alternative design.

12-bit shift register. Figure 22 is the detailed circuit of the 12-bit parallel-in/serial-out shift register used to insert the 12-bit data words into the serial data stream. One and a half 8-stage shift registers, i.c. type 4014, are used, the four unused parallel inputs of one i.c. being connected to ground. The twelve parallel inputs are numbered in the order in which the bits are serially shifted out. There may be some virtue in 'randomizing' the sequence of the bits of the 12-bit data words, rather than entering them in a logical order. Having used two different sequences for each of the two halves of the electronics (one per track of the tape-recorder), the author found no significant difference between them in the generation or concealment of errors. One sequence used was B1, B4, B7, B10, B2, B5, B8, P1, B3, B6, B9 and P2. All the circuits of the input stages are constructed on one board, together with the sync. register which was

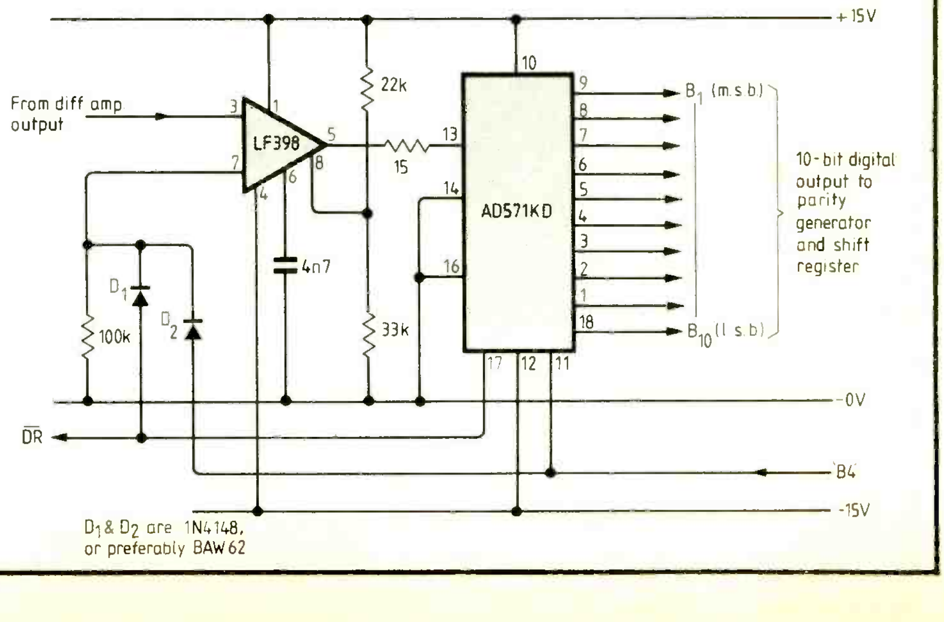


Fig. 20. Sample/hold and a-to-d converter. Only AD571K should be used, since other variants need different supply voltages.

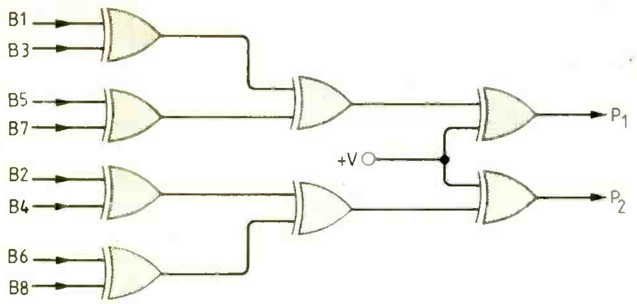


Fig. 21. 'Odd-bit' parity generators.

shown in detail in Fig 12.

As mentioned in part 1, it is a simple matter to reduce the number of analogue channels that may be recorded onto one track of the tape-recorder, from six to three, two or one. In the recording stages this is simply achieved by paralleling the input channels together and may be done using plug-in connectors on board 1, or externally. For three channels, input 1 is paralleled with input 4, input 2 with input 5 and input 3 with input 6. For two channels inputs 1, 3 and 5 are paralleled together and inputs 2, 4 and 6. For one channel all six inputs are connected together. It is also possible to have a number of channels of different bandwidths by combining the inputs in a number of other ways. For example, if inputs 1, 3 and 5 are connected together a channel with a bandwidth of 210 Hz is created. The other three channels may be used individually with bandwidths of 70 Hz each. Other combinations are possible and what may, or may not, be achieved can be determined according to requirements.

Speed control

To complete the detailed description of the circuitry constructed on the first three circuit boards,* the final circuit to be discussed is that of the reference frequency generator for the tape-deck motor-speed control. Speed control for the tape drive motor is achieved by comparing the frequency produced by the tachogenerator (which is built into the drive motor) with a reference frequency in a phase-locked loop. The principle of operation of the speed-control system was described in part 1 and details of the circuit will be given later. The reference frequency generator is constructed, together with the Miller encoder, on board 3 and it is this circuitry that will now be described.

During the recording process, the reference frequency is derived from the tape-clock frequency by dividing it by 50 to produce a crystal-stable frequency of 455Hz. During playback, the reference frequency is derived by comparing this 455 Hz with that of the recovered tape-clock divided by 50, in a phase-locked loop, the resulting frequency output of the v.c.o. of the p.l.l. providing the reference frequency. The reason for using this particular technique for producing long-term tape-speed stability was given in Part 1.

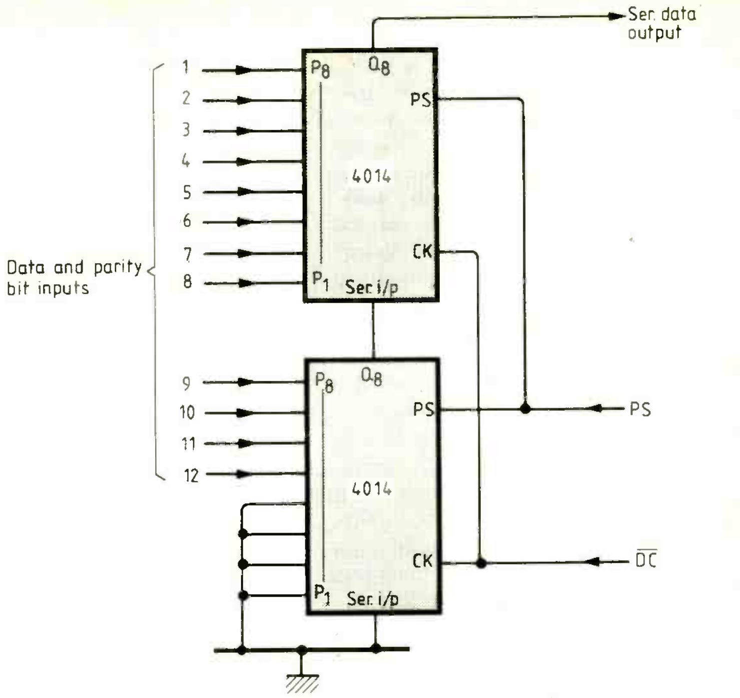
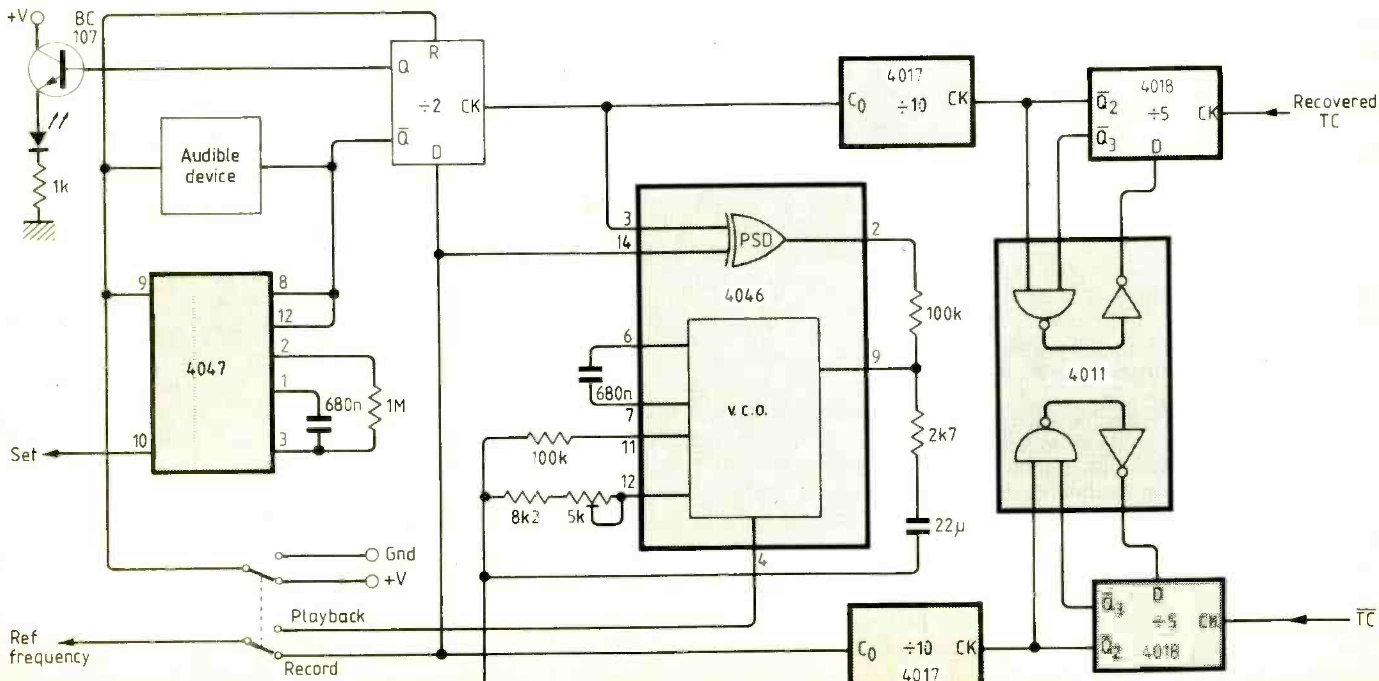


Fig. 22. 12-bit p.i.s.o. shift register.

Reference frequency generator. Figure 23 shows the circuit diagram. The production of the reference frequency for the recording process is straightforward and consists simply of two counters which divide the tape-clock by 50. One counter is an i.c. type 4018 which, together with half a quad 2-input NAND, divides by 5. The other is a divide-by-10 counter using an

Fig. 23. Reference-frequency generator for speed control.



i.c. type 4017. On playback, the recovered tape-clock is similarly divided by 50 using identical counter i.cs. The two resulting frequencies are compared using the EX-OR phase-sensitive detector of a p.l.l. i.c., type 4046, the output of which is filtered and used to control the frequency output of the v.c.o. contained within the 4046. Frequency selective components of the v.c.o. were chosen so that the desired output frequency of 455 Hz is obtained when the input voltage to the v.c.o. on pin 9 is half the supply voltage, i.e., 7.5V. The 5kΩ variable resistor in series with the 8.2kΩ resistor is adjusted to produce this desired result. A ±5% variation in frequency is obtained as the input voltage on pin 9 varies from 0 to +15v. Filter components between the output of the p.s.d. and the input to the v.c.o. were selected by trial and error to produce a stable phase-locked loop when operating with the chosen cassette tape-recorder.

It is important to know when the p.l.l. of the playback reference-frequency generator is in lock; or more importantly, when it is out of lock: for this purpose an in-lock indication is provided. When the recovered tape-clock frequency divided by 50 is in lock with the tape-clock frequency divided by 50, it lags it in phase by 90° (± any wow and flutter content). As a result of this, the D input to the D-type flip-flop goes high ahead of a positive transition on the clock input. Thus, so long as the two frequencies remain in lock, a logical 1 will be continually clocked to the Q output of the D-type flip-flop.

Via an emitter follower circuit, the logical 1 on the Q output illuminates an l.e.d., giving the required lock indication. Should the two frequencies slip out of lock, alternate logic zeros and ones will be clocked across to the Q output of the D-type flip-flop and the l.e.d. will flash on and off. As it is important to know of a loss of lock, an audible indication is also provided. The audible device referred to in Fig. 23 is a piezo-electric type sold by RS Components and will operate from voltages of 3 – 16V, with a current consumption of about 8mA at 12 volts. It is thus easily powered by outputs of B type c.m.o.s logic circuits. When in lock the $\overline{Q}$ output of the D-type flip-flop is low and the audible device is thus silent. When out of lock the $\overline{Q}$ output will go alternately high and low, powering the device to give an audible indication of the loss of lock. When the record reference frequency is selected by the d.p.d.t. switch, the audible device is automatically silenced by holding the $\overline{Q}$ output of the D-type flip-flop reset high and by connecting its other terminal to +V.

When, on playback, the recovered tape-clock is not synchronized to the tape-clock, it is desirable to inhibit the flow of data out of the data storage buffers of the playback digital circuitry. This is achieved by the monostable circuit, i.c. type 4047, which is triggered by the $\overline{Q}$ output of the D-type flip-flop. Connected in its retriggerable mode, the monostable is continually triggered by the pulsing output of $\overline{Q}$ when the p.l.l. is out of lock. The 'set' output from the monostable is thus maintained high. This high 'set' output is fed to the playback circuitry (to be discussed in a later article) where it is used to inhibit the flow of data. The time-period of the monostable is set large enough to maintain the 'set' output high whilst the $\overline{Q}$ output slowly pulses. Once the p.l.l. is in lock, $\overline{Q}$ goes low and so, eventually, does the 'set' output, releasing the flow of output data.

To be continued

*A set of Veroboard layouts will be made available when this series is finished.

Books

New Systems and Services in Telecommunications

Ed: G. Cantraine and J. Destine. 375 pp., hardback. North Holland Publishing Company, 56 US dollars, Dfl.115.00.

Papers presented at the 1980 international Liege conference on videotex, data broadcasting and satellite broadcasting are collected here in book form. The intention of the conference was to look at these new types of communication from the engineering standpoint, so that anyone reading the papers will find opinion, description and suggestion from the world's leaders in the field, free of the unhelpful crystal-gazing that so many 'experts' in communications are apt to indulge in. Papers are printed in the original language – either French or English. Copies of the book can be obtained either from bookshops or from Elsevier Science Publishers, PO Box 211, 1000AE Amsterdam. The Netherlands.

Practical Handbook of Solid-state Troubleshooting

by R. C. Genn, Jr. 239 pp., hardback. Prentice-Hall International, £10.45.

The servicing of most kinds of radio, audio and general electronic devices, in varying depth and quality of detail (at one point one is informed that a voltage can vary from "a few millivolts to quite a few millivolts"). Both analogue and digital equipment is described from the fault-finding point of view and there is some information on test instruments. The book is implicitly written for technicians in radio and television repair shops and, although there are misleading statements and some drawing errors, it may be useful as a guide to methods of fault-finding.

Introducing Microprocessors

by I. R. Sinclair. 121 pp., paperback. Keith Dickson Publishing Ltd, £4.50.

Among the welter of pretentious little books which claim to explain the mysteries of microprocessors and their uses, this is one that stands out, in that it does go some way towards fulfilling the promise of its title. By way of a little gentle instruction in logical processes and a short description of digital circuits, the author goes on to explain how microprocessors use these devices on a large scale. Various types of memory and register and types of instruction are considered before attention is paid to loading the memory and some simple program operations. A final chapter is on the approach to programming. This book is, as is explicit in its title, an introduction: as such, it is to be recommended. Keith Dickson are at 17 Hendon Lane, London N3 1RT.

World television standards

continued from page 64

were Italian pirate/private networks. Most of the signals suffered from severe fading and co-channel interference. Ernesto and Salvador are now attempting to improve reception quality. They have had the attenuation of the sea path evaluated at about 240dB.

Anselmo Roccaforte (Buenos Aires) is having some success with DX-tv using a 14-inch Sony KV-1400 AN receiver and a JVC v.h.f./u.h.f. CX-610 ME colour monitor. The latter is multi-standard in that it is PAL/SECAM with sound facilities for 5.5MHz, 6.0MHz and 6.5MHz but Anselmo's receiver is modified to accept PAL-N transmissions with 4.5MHz sound/vision spacing. We will be reviewing the JVC CX-610 GB version in the near future.

Hugh Lloyd-Bennett (Dhahran, Saudi Arabia) appears to have an ideal DX location being only a mile from the coast with a surrounding terrain of desert, hence few obstructions. Weather conditions in the Gulf greatly enhance tropospheric propagation and he reports daily television reception from Doha (Qatar, chs. 9 and 11), Abu Dhabi (United Arab Emirates, ch. 5) Dubai (also U.A.E., chs 2, 10, 33 and 41), Muscat (Sultanate of Oman, ch. 8 in Buraimi), Manama (Bahrain, chs. 4 and 55) and Kuwait (chs. 8 and 10). Reasonable reception has also been achieved from West Germany (NDR, ch. E4), Italy (RAI), Spain (RTVE), Hungary (MTV), Czechoslovakia (CST), Poland (TVP), Jordon (JTV) and even South Africa (SABC/-SAUK). Reception from the USSR (TSS) is logged on most days.

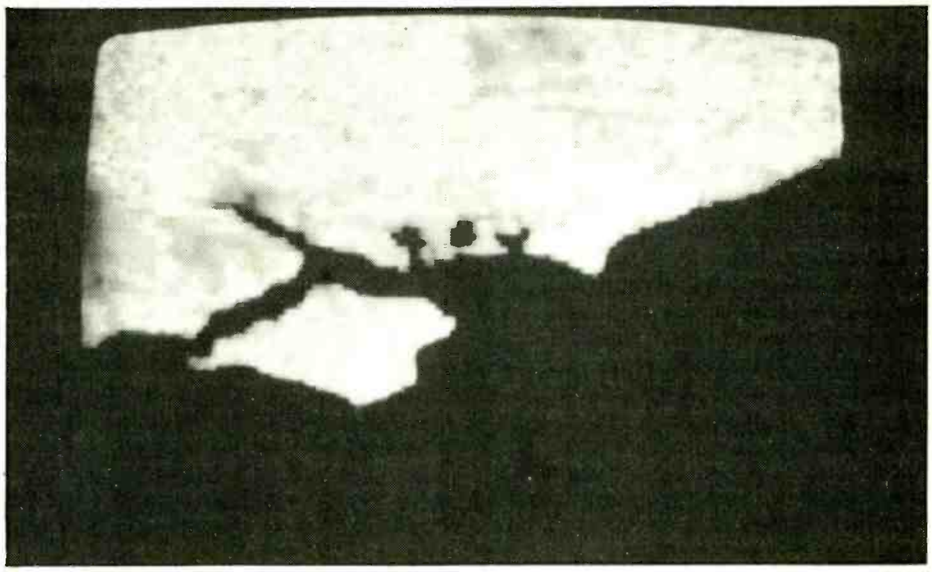
Finally, John Combs (Florida, USA) comments that on the morning of the Royal Wedding last July he managed to obtain clear off-screen photographs of the BBC-1 clock caption. This was due to a switching error by the Cable News Network in America which distributes news material to cable television systems via satellite. This is definitely a case of trans-Atlantic DX-tv the easy way.

High-resolution weather satellite pictures

Image display, testing and alignment

by M. L. Christieson

Concluding these articles describing the design philosophy for a station receiving high-resolution weather pictures from a satellite, the author discusses methods of displaying image information received using the circuits described in previous articles. The remainder of the article is devoted to system testing and alignment and includes designs for a test transmitter and digital-data simulator. The author's system was designed using high-resolution weather picture transmissions from NOAA-6.



A scan of the Isle of Wight and surrounding area received from NOAA 6 using the system described.

Whatever method of processing and display is used, it must be capable of dealing, at least initially, with the incoming data in real time. Usually this means that some form of magnetic storage medium will be required, such as tape or disk. The following combinations are possible:

- A digital tape recorder storing raw data for later handling by a dedicated logic system.
- A computer programmed to store raw data on magnetic tape or disk for later decoding by the same computer.
- A computer operating a real-time data stripping program and recording only part of the data on tape or disk in order to minimize storage requirements.

There are three main display methods which may be fed from any of the previous handling options.

- A high-quality photographic facsimile recorder.
- A c.r.t. based visual-display unit.
- Direct numerical analysis.

Data processing

The first problem in data processing is the data rate and the real-time constraints that it places on the system. There are many ways of solving this problem, but the easiest is to use a computer. The time available to deal with each word is 15μs so a mini-computer or mainframe will probably be required as the average microcomputer is too slow. The tape or disk drive should be capable of transferring the data in the available time which might be, for example, 2048, 10-bit words in 166.6ms for a single image channel.

This system uses a PDP-9 mainframe which was available, and fast enough to do the job. The magnetic-tape facility (a 'DECtape' drive) is however, not so satisfactory as the maximum data rate is not obtainable because the transport must be started and stopped depending on the state of the data buffer in the main memory.

As an initial experiment only the centre 1024 pixels of one channel are stored and using four bits from the ten-bit word. These are packed, four at a time, into 16-bits for transfer via the 18-bit input-output bus to the computer.

The two spare bits are used to carry the data valid and line-sync. signals. A routine written in assembly language separates one image channel, selects the required pixels and repacks them into a 6K (×18) buffer in core. This buffer is read out into a DECtape drive using an interrupt service routine. The PDP-9 data-channel transfer facility connected to the tape drives is convenient because it means the transfer, once initiated in the main program, continues without program intervention. This is vital where time is at a premium.

One DECtape, which stores 576 blocks each of 256 words, i.e. 1.4M-bytes, fills up in 96 seconds so some decision about the approximate image area must be made prior to reception. These sacrifices are unsatisfactory and if a better tape or disk drive were available would not have to be made.

It has been found that for simple pictures it is better to ignore the two most significant bits and take the next four. This means that all the available dynamic-storage range is used.

In any system of this type the constraints on the software are severe and some outline of the program may be of interest. When first loaded by means of the linking loader, the program requests which channel is required. On receiving this information via a v.d.u., it calculates the number of words between the end of the sync. word (coincident with the line-sync. bit being high for one input cycle) and the word containing the first required image-data pixel (sample 512 in this case). This number is stored. The appropriate interrupt skip chain for the tape is set up and the tape rewound to the beginning.

The availability of a new data word is indicated by the word clock setting a device flag high. This is sensed by the computer by means of a flag check loop and the word is read into the accumulator, resetting the device flag. The word is examined for the state of the valid bit, and if it is not set, returns to the flag-check loop. If the valid bit is set, the program checks for the line-sync. bit, and again if not set returns to the flag-check loop. When line sync. is found the program counts the words that follow, rejecting them until the line delay runs out. 1024 words are then read (packed as 256 × 18-bit words) and one image separated by counting each block of five words.

Each time a new 18-bit word is assembled it is stored in a 6K buffer in core using auto-indexing. The two spare bits are unused. A constant check is kept on the state of the buffer input pointer and when it reaches 3K the tape drive searches for the first available block and starts to empty the buffer by means of the data channel. When 3K words have been transferred out, an interrupt stops the tape and winds it back to clear the overshoot. Because tape transfers data out faster than it comes in, by this time the input pointer has only just reached 6K.

The input pointer is reset to commence refilling the lower 3K of the buffer while the tape restarts and reads out the upper 3K. This cycle, where the tape-output pointer is in constant pursuit of the data-input pointer but never catching it, will continue until the tape is full, causing another interrupt. This stops further data input. At the end of 1024 pixels read from each line, the program returns to search for the sync. in the next line.

A particular problem involved the length of the interrupt service routine which effectively blocks input data transfers during its execution. This was solved by including an input flag and data check within the interrupt routine, depositing any input word in a temporary buffer to be dealt with on return to the program. It was not possible to use the tape handler within the PDP-9 operating system because of its complexity, incurring a heavy penalty in both memory space and time. A special handler was written and included as part of the program.

Display system

The display consists of a colour v.d.u. connected to a small frame store operating as a peripheral to the computer. The store uses static ram and is arranged as 12K by 4. This gives a basic picture of 96 lines, each of 128 pixels. This was chosen to fit in with the aspect ratio of the display. Data is loaded into the store by another program during which the display is not available. For display, the store is read out as 630 lines by repeating data, and converted to three analogue signals which operate the three colour guns of a standard colour shadow-mask c.r.t. Because the number of levels is restricted it is possible to have presets for each level on each gun, the adjustment of which sets the false colour enhancement. 630 lines are used to remove the interlace on the 25 frames-per-second picture which causes a vertical jitter as frames are repeated. The frame store can also be read slowly at four lines per-second and the result printed in monochrome on a wet-paper facsimile machine.

One problem surrounds the rather restricted display area which could be increased at reasonable cost using dymamic r.a.m. But with the present memory size it is possible to fit into the computer core a keyboard monitor, a v.d.u. handler, the operating program and two complete frames.

One tape of recorded data consists of 576 lines each of 1024 pixels, so only selected pixels can be displayed at one time. The present software requests the coordinates of the top left-hand corner of the required image and the required resolution; for example, giving the corner as 1:1 and skipping 5 lines and 7 pixels each time, a low-resolution overview is produced. This permits the identification of surface features. After a particular area of interest is identified, it can be enlarged to full resolution. This also means that adjacent squares in full resolution may be printed out and joined together as a mosaic.

Software image processing

Several improvements may be made to the quality of each frame using software enhancement. It is probable that there will be a certain number of noise pixels; these may be cleared by taking each pixel and comparing it with the average value of the four that surround it. If the difference is great, the pixel can be replaced by the average. With the correct limits, the improvement in quality is considerable.

As the digital-to-analogue converter is preset, the pseudo colour can be wrong, depending on the illumination, so some method of adjusting the 'black level' by adding or subtracting a constant is useful.

A third facility is only required if a facsimile print out is wanted. To make maximum use of the very poor dynamic range on the paper, an image stretching routine should be used. This expands the lower light values and avoids dull pictures.

Fig. 16. Circuit diagram of a low-power transmitter that can be used for antenna and receiver alignment and testing if a microwave signal generator is not available.

Testing and adjustment

Adjustment and troubleshooting in a system of this complexity are a considerable problem, compounded by the fact that the satellite only passes over occasionally. The best way to tackle the problem is to set each section up independently. This may be done before all the sections are built.

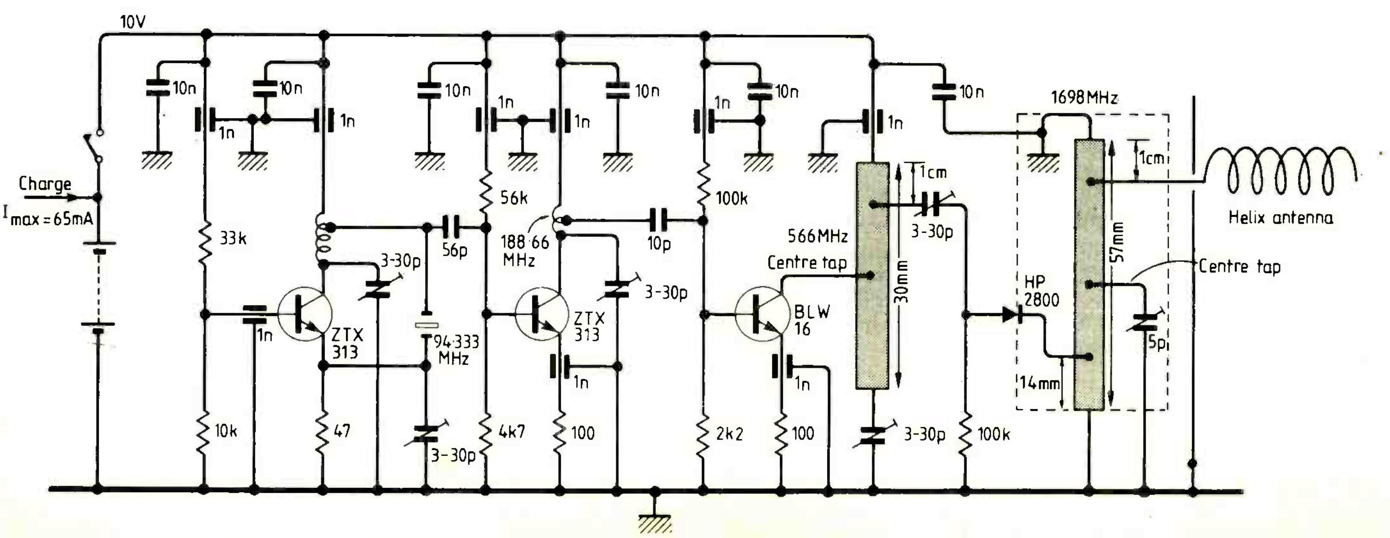
The easiest way to start is to adjust the antenna and receiver using an unmodulated S-band signal source. This source can be a microwave-signal generator connected to a small antenna, but if this equipment is not available a very low-power transmitter is easy to make. It can be battery operated and should produce r.h.c. polarization. By placing this transmitter some distance from the antenna and using the signal-level meter, the whole receiver may be checked out. Figure 16 shows the circuit diagram of such a transmitter. The antenna is a 10-turn helix wound with 16 s.w.g. wire on a 350mm length of 53mm diameter plastic drainpipe. This is mounted together with a plane reflector on the front of the transmitter's diecast box. The prototype was powered by 8AA NiCd cells.

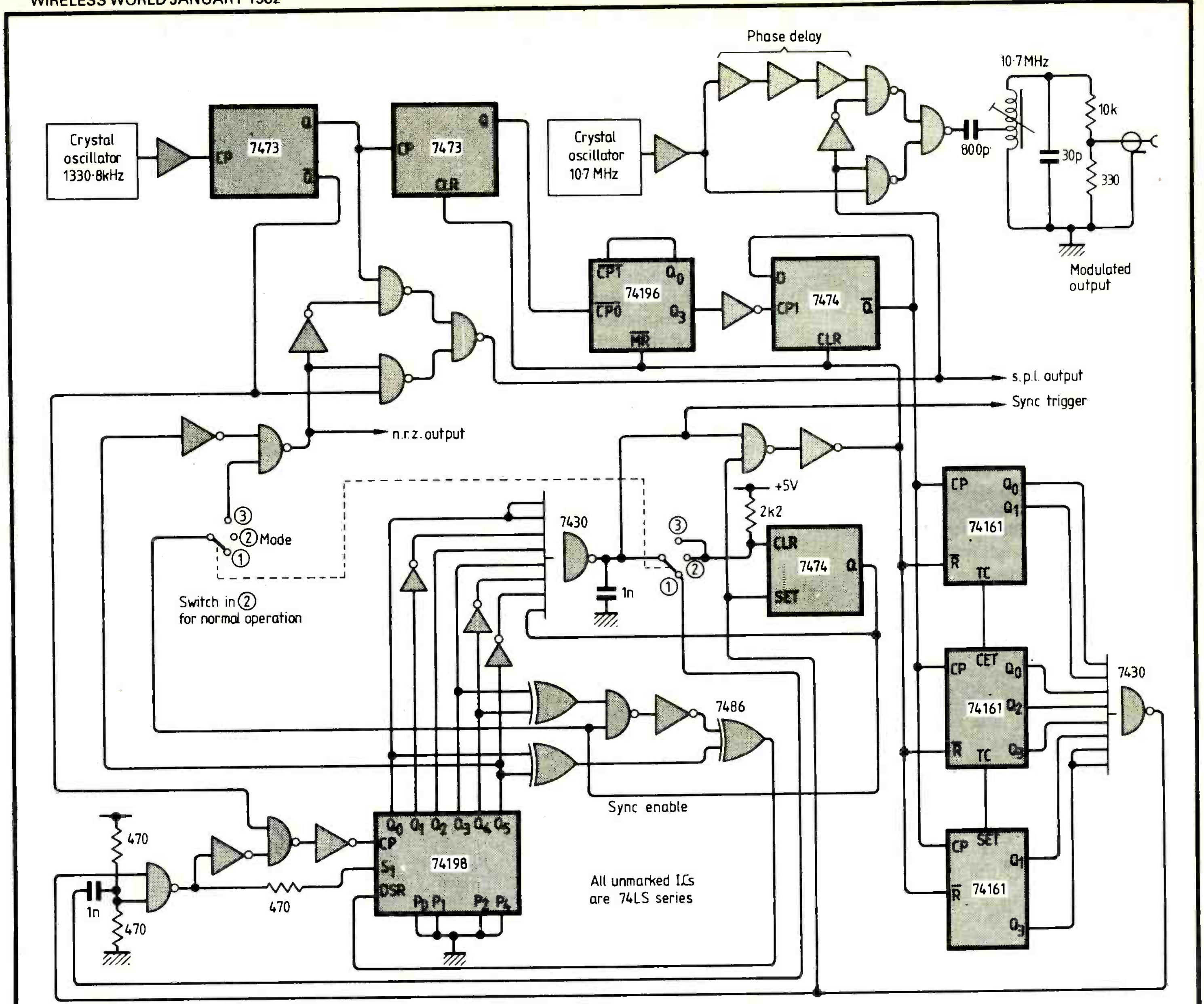
To confirm that the correct harmonics have been selected in both receiver and transmitter, a narrow-band communications receiver should be loosely coupled to the 10.7MHz output. Only the correct combination of harmonics will result in a signal at 10.7MHz. When the whole receiver chain has been adjusted, the i.f. should be examined with a 50MHz oscilloscope to check for parasitics. A further check should be made by loosely coupling a v.h.f. signal generator to the 137MHz input and measuring the bandwidth. The 3dB bandwidth should be about 3MHz.

A general sensitivity test may be made by pointing the receiver antenna at the sun, when at least 1dB of sun noise should be observed*. It is difficult to specify an exact level value here because of variations in solar flux.

Direct observation of the satellite may now be made. A communications receiver should again be used to listen for the

*The gain of the receiving antenna used with the prototype system was 22dB.





residual carrier, which is recognizable by a large doppler shift. A peak signal-to-noise ratio of about 8.5dB should be attained as measured on the signal-level meter.

The next step is adjustment of the p.l.l. in the demodulator. This should be done with a v.h.f. signal generator at 137MHz, coupled so that only a very weak signal is observed together with a large amount of noise. The v.c.o. should be tuned to lock onto the signal for about 100kHz around 10.7MHz as observed on the communications receiver. An oscilloscope attached to the v.c.o. control line will show whether or not the loop is locked. It should be possible to lock the loop over a small range with almost inaudible signal levels. A test with the satellite should now reveal recognisable data at the output of the post-detection filter.

Adjustment of the remaining circuits requires a continuous source of phase-modulated s.p.l. data. As the satellite does not provide this, a satellite simulator must be used. The signal is most easily injected at 10.7MHz and should consist of random data with the sync. sequence inserted at the correct rate. The most straightforward means of generating the sync. sequence makes use of the fact that the sync. pattern

Fig. 17. This circuit is used to simulate the data content of the satellite transmission to aid testing and setting up of the system.

is part of a maximum length pseudo-random sequence generated by a shift register with some of its outputs fed back. It is, in fact, the first 60 bits of a 63-bit generator started in 'all-ones' state. The polynomial for the sequence is

$$x^6+x^5+x^2+x+1$$

Analysis of these sequences is rather involved but nethertheless well documented[14]. The correct sequence is generated by a six-bit shift register with outputs 0,3,4 and 5 fed back. Figure 17 shows the complete circuit of the simulator.

Two crystal oscillators are used to produce the bit rate and carrier signals. A six-bit presettable shift register, clocked at the bit rate, generates the data stream. If the cycle starts with the sync. enable high, the register generates the sync.-sequence because all the required outputs are fed back. As the last bit of the sequence is sent, the 8-input NAND gate resets a flip-flop and counter. This makes the sync.-enable line go low, disabling two of the feedback outputs.

A different repetitive sequence representing picture data is now generated by the register. The counter counts the number of bits between the end of one sync. sequence and the beginning of the next. When the count runs out, the flip-flop is set and the shift-register is loaded with the pattern to start the sync. sequence. Now the sync.-enable line is high again, the sync. sequence is restarted and the cycle repeats.

If the mode switch is in position 1, the sync. sequence is sent continuously. This is used for examining the performance of the bit conditioner with an oscilloscope, when a recognizable short sequence is useful. The sync.-trigger o.p. gives a short pulse at the end of each sync. sequence to trigger the oscilloscope.

Position 3 of the switch sends sync. and all ones for error checking. The n.r.z. data, which can be monitored for correlation with the recovered output, is also available. After conversion to s.p.l., the n.r.z. signal phase modulates the 10.7MHz carrier. The phase modulator is rather crude but appears to suffice.

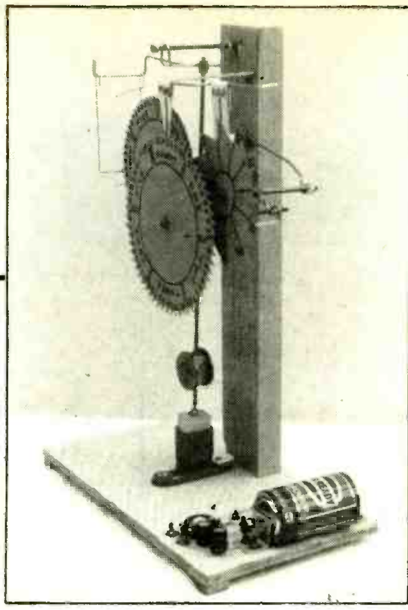
Use of this simulator enables the entire data recovery chain including clock

Continued on page 78

Cardboard clock

An outrageous project with educational uses

by **Michael McLoughlin** Haberdashers' Aske's School, Elstree



This clock keeps time to a few seconds a day and can be readily constructed with home tools. It can be made by one individual, or will serve as a holiday project for a small group. It illustrates much of electricity and mechanics, and has been found of interest at a variety of educational levels. The clock runs for about a year on an HP2 battery and has all the fascination of a little engine. The larger moving parts are cut from cardboard and this gives the device a slightly outrageous character, guaranteeing interest from anyone who sees it working.

To maximize fascination the working of the clock should be very visible, and this suggests the use of a pendulum. The latter carries a magnet, which receives drive from a stationary coil. Thus the gear train transmits no power, and the wheels only need to turn each other to record the time. This is such a light duty that the wheels can be cut from cardboard. To help overcome errors in construction these wheels are large, and many adjustments can be made to the clock after assembly. Fig. 1 is a drawing of the general arrangement.

Magnetic drive to the pendulum is quite an old idea, with the pendulum operating a mechanical switch to control the coil. When transistors became available a simpler system was devised, whereby the pulse induced by the magnet as it passes the coil is itself used to switch a short power pulse. An early system had two magnets on a balance wheel, with a stationary coil for each. One coil picked up a signal pulse, which was amplified and then fed to the other coil as a power pulse, and each winding had perhaps a thousand turns. More recently the two coils have been placed together and operated by a single magnet assembly, as in the widely used German movement shown in Fig. 2. By comparing coil resistance with coil volume in that movement, it may be estimated that the two coils contain together some 4,500 turns.

Such a figure completely excludes amateur construction. The difficulty was tackled head on by combining the two coils into a single coil of 100 turns, although this only yields some 20mV as the magnet passes over it. So the sensitive trigger circuit of Fig. 3 was developed to fire on this small pulse. The increased sensitivity found in that circuit is largely due to the relatively low value of the 10 kΩ resistor. This ensures that the first transistor is not saturated in the stable state of the circuit, and thus it is able to amplify even small input signals.

We leave further explanation of this circuit to the reader, and offer now some constructional suggestions. The reader who wishes primarily to evaluate the ideas involved is invited to proceed at once to the heading "Practical Points".

The construction will be described in its simplest form, leaving the reader to make such adaptations as he wishes. Caution is advised, however, in making changes on the mechanical side, as these tend to have knock-on effects.

The baseboard

The materials listed in Table 1 should first be assembled. To make the baseboard, cut out a rectangle of centimetric graph paper 23 × 13 cm, and copy on to it the points on Fig. 4. (Alternatively, use a tracing of Fig. 4 itself.) Stick the graph paper on to the chipboard base. The 10 mm cube blocks are feet for the baseboard: stick one under the front edge at the centre and one at each end under the rear edge. Then make, drill and bend the aluminium brackets shown in Fig. 4. Finally, drill the board as there suggested.

To mount components use 6 BA screws of about 13 mm thread length, inserting them from under the board. But do not wrap component leads round the screws. Instead, fix as suggested in the next paragraph.

To fix a lead, first load the relevant screw with a 4 BA washer. Then pass the lead close to the screw and tighten, so that the lead is trapped between washer and baseboard.

Two components can readily be trapped in this manner under a single washer, provided that their leads pass on opposite sides of the screw. On the two occasions where a second nut is recommended, the lead may be fixed by bending it. Where two washers are suggested, this is to deal with several connections, or to protect the thin coil winding wire.

Two BC108 transistors (or similar) are fitted into the 5mm diameter holes from beneath. But first bend the leads on each transistor radially outwards from the centre of its underside, taking care not to short to the can. Trap both emitter leads at e_1, e_2, and the remaining leads will point to their correct fixtures. Before fixing the 1 kΩ potentiometer, bend outwards at right angles the thin extremities of its three legs.

Acquire if possible two of the small T-style caps that close containers of detergent or washing-up liquid, as shown in Fig. 1. If the vertical height is excessive, shave small pieces off the base very carefully, to arrive at the dimensions shown. The 4mm dimension is the critical one, as it affects pendulum length. These T pieces are the coil formers, and after drilling should be fitted (T upright) as shown under washers. The 100 turn coil can now be wound tightly anticlockwise as shown, using wire of diameter about ¼mm (33 s.w.g.).

Pendulum post

This is prepared from softwood as in Fig. 1. The sawcut which defines the bottom of this post must be made with maximum care. The bottom face must be at right angles to the length of the post, and must tilt neither front-to-back nor left-to-right. Now cut from one of the lengths of studding sections of 70mm, 80mm, 90mm, using pliers or junior hacksaw. Clean the ends so that nuts will run on and off, by filing briskly at right angles to the rod. This task is made easier if a nut is already on each section when it is cut off. Bolt the 80mm length into the top of the pendulum post to give the pendulum bearing. The pendulum rolls on this rod, abolishing bearing friction.

Then screw two nuts against each other on the free forward end of this rod. Finally, screw the completed post to the baseboard as in Fig. 4. The only critical dimension in Fig. 1 is marked 284mm, and it affects pendulum length.

The pendulum

Form the bracket No. 2 (Fig. 1) from 16 s.w.g. copper wire or similar. A regular half circle loop may be obtained by bending with the fingers round a 7mm diameter screwdriver, for example. When a right angle bend is required, grip the wire in pliers so that the desired point of bending lies 2mm clear. Then push the wire round firmly with the fingers against the side of the pliers. The third loop is formed round pliers to embrace 6 BA rod. The first attempt at this bracket can be treated as a training run and discarded. The second attempt will be almost perfect!

The pendulum can now be assembled from Fig. 1. The largest faces of the ferrites will be the magnetically active surfaces, and the North seeking face can read-

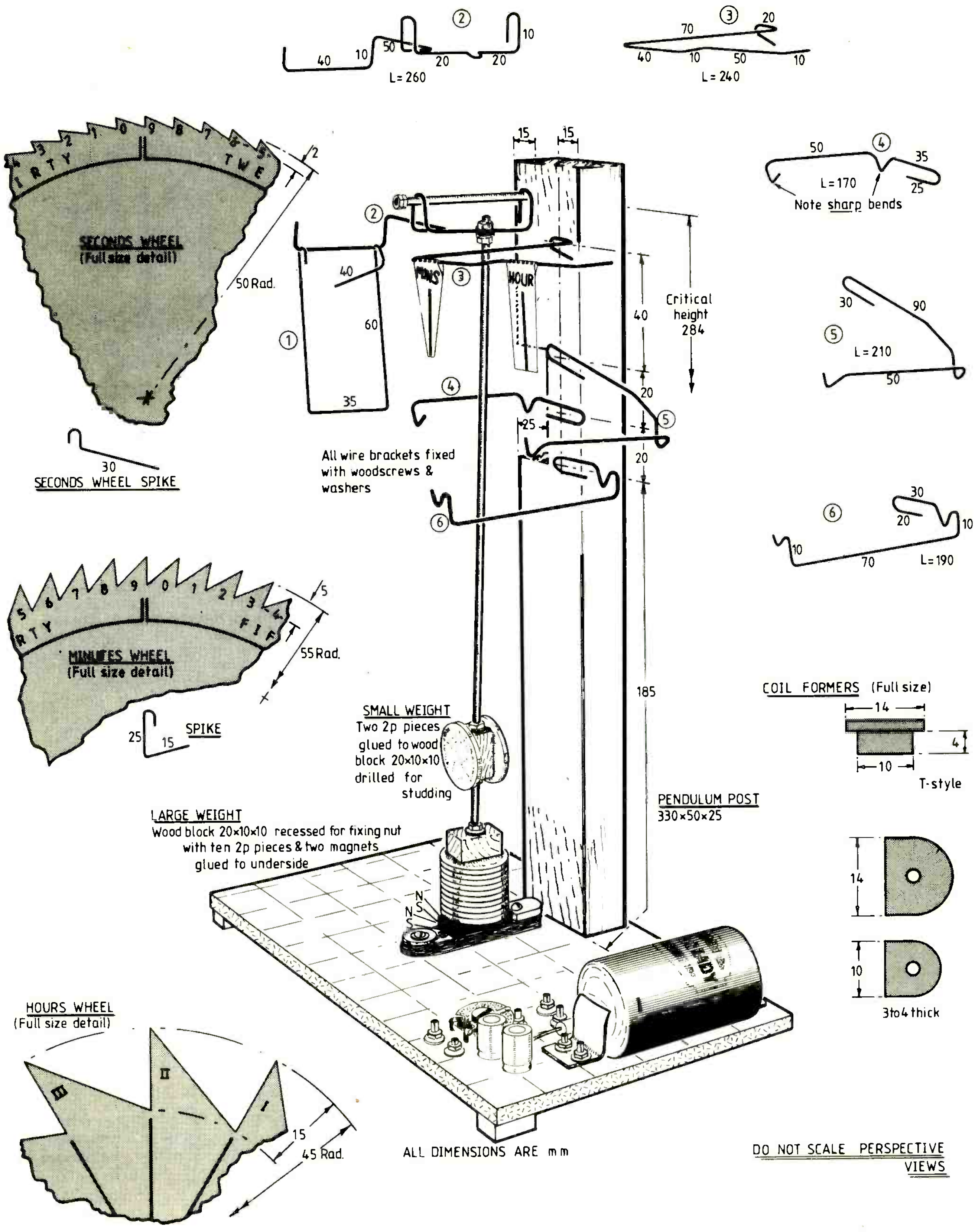


Fig. 1. Essential mechanism of the cardboard clock, showing parts of the three wheels and the axle support system. The pendulum has a period of 1Hz and so it cranks the seconds wheel directly. The offset spike at the centre of the seconds wheel drives the minutes wheel. Wire brackets are also shown. For the coil formers, if T-style caps from detergent containers are not available, use two pieces of material 3-4mm thick as shown.

ily be identified by hanging a ferrite from thread. Fine adjustment of timekeeping is made by varying the position of the small weight indicated. It should be trapped on the rod between nuts and washers, and set initially some 40mm clear of the coin stack. All the coins can be recovered undamaged at any time by shearing the stack in a vice, to break the bonds of the glue.

Adjust the position of the upper bracket on the rod so that the semicircles made in it roll on the pendulum bearing, while the magnets at the bottom clear the coil by 1mm. This task is slightly easier if the washer below the bracket is of the non-slip variety. Install the battery, adjust the pot to about mid range, and set the bob swinging with a travel of 50mm or so. It should continue to swing indefinitely, with the amplitude adjustable on the pot. This success will encourage completion of the count wheel system.

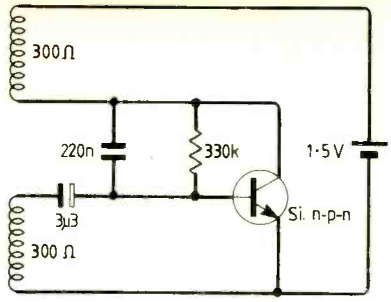
Seconds wheel

Bend the bracket No. 4 as shown in Fig. 1. The V bends as indicated must be tight, and just over a right angle. For these V bearings, the important point is to provide a gap beneath the 6 BA rod. Even the smallest gap is perfectly satisfactory. This feature removes any tendency for a wheel to roll back after being moved. The same care must also be used in constructing the V bearings on the later brackets.

Using an 18mm No. 6 woodscrew with a washer under the head, clamp the bracket to the pendulum post at the hole in Fig. 1. The woodscrew should pass through the loop of the bracket, half way along the 25mm part of it.

To cut the teeth on the wheel it is worth preparing a 6° template. Draw a circle of 60mm radius on a sheet of paper, using a sharp pencil. Prick accurately through the centre. Draw any one diameter of this circle. Using a protractor draw the other diameters that make angles of 6°, 12°, 18° with the first, and so on at 6° intervals. When drawing these diameters it is more accurate not to rely on the centre.

Now the seconds wheel can be made. Take the back of a school exercise book or other similar card, and check that when cut with scissors a clean edge is left, free from granulation. Draw on the card a circle of 48mm radius. Mark the centre with a cross of arms 10mm, and prick through. With the same centre draw a circle of 50mm radius, and carefully cut it out.



◀ *Fig. 2. Circuit of Kienzle clock movement. Five times a second a semi-sinusoidal induced voltage of 500mV peak tends to raise the upper ends of both coils. Then a current pulse of 3mA lasting 10ms does work against the induced voltage in the upper coil. Thus each pulse transmits some 15μJ of energy to the movement. Tuning fork oscillators are powered in a rather similar way.*

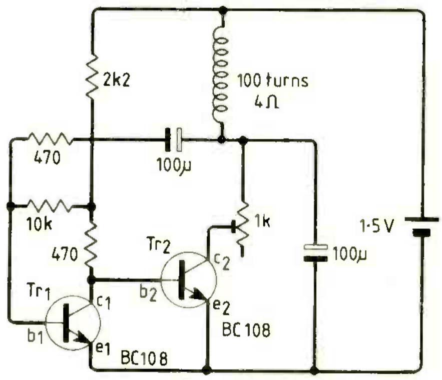


Fig. 3. The "millivolt monostable". The single coil is connected to this very sensitive form of the monostable circuit. When the hot end of the coil produces a 5mV negative trigger, a 100ms current pulse of about 3mA is provided.

Fig. 4. Full size plan of baseboard. But note the broken baseline: total length is 230mm. Do not drill the baseboard until the upper bracket is fixed. Prepare the lower bracket and position it with the aid of the battery. Then mark hole positions on the baseboard, and drill.

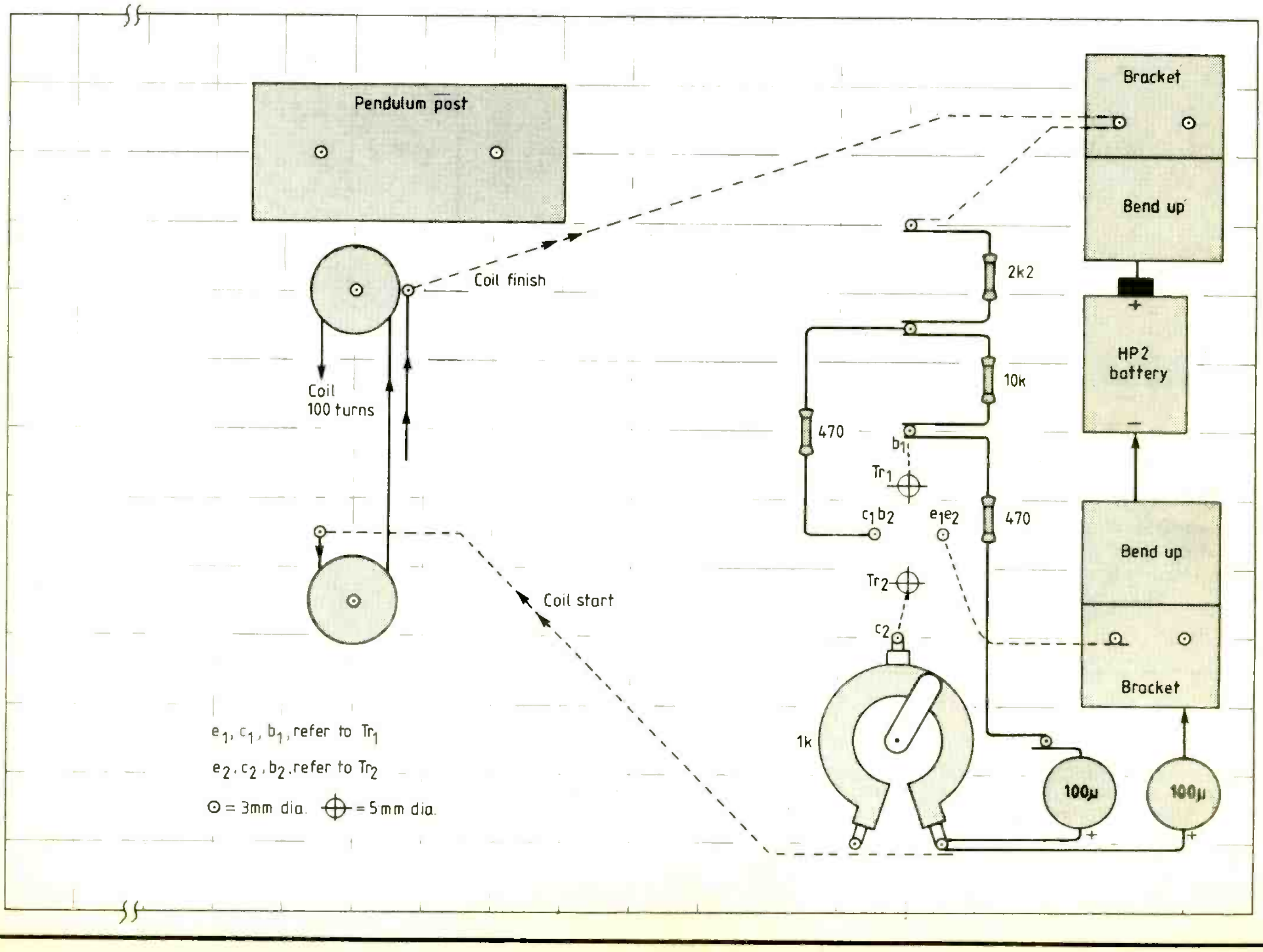


Table 1: parts for the clock

MECHANICAL MATERIALS (dimensions in mm)
2 aluminium pieces 38 × 19 of 16 s.w.g.
2 No. 10 screws 38 mm; 4 No. 6 screws 19mm
Chipboard 230 × 130 × 6, with centimetric graph paper to cover
Softwood 330 × 50 × 25
3 wood blocks 10 mm cube; 2 wood blocks 20 × 10 × 10
2 off 300 mm length 6 BA studding (threaded rod) from model/tool/hardware shop
15 screws 6 BA of 13 mm thread length or so, with 37 nuts
39 washers 4 BA (not 6 BA), ideally with one non-slip
2 detergent container caps T-style
12 coins 2p
Cover from one school exercise book, or similar card
ELECTRICAL PARTS
2 ferrite magnets 25.0 × 7.7 × 6 or so (Magnet Applications Ltd, 323 City Rd EC1V have waived their small order charge in favour of WW readers, and for 24p in stamps will supply both ferrites, if a 26p s.a.e. is also enclosed.)
1 foot connecting wire, say 24 s.w.g.
1½ metre 16 s.w.g. bare/tinned copper wire (or strip 1 metre 13A cable, and use the thicker wire)
12½ metres enamelled copper wire about ¼mm diameter = 33 s.w.g.
1 horizontal p.c.b. preset 1k (larger size: 20 mm diameter)
2 resistors 470Ω, one 2.2k and one 10k, all ½W
2 capacitors p.c.b. type 100 μF (not to be varied!)
1 HP2 battery

Place this disc centrally over the template, and mark off two points 180° apart. Then make the intermediary marks. Using the inner circle as a guide, make by eye 2mm radial cuts inwards from the points just marked on the circumference. Choose which side is to be the front of the wheel, and complete the teeth with slanting cuts, as shown in Fig. 1, top diagram. Do not use a mirror image, but follow the slants as shown. Keep the slant angle constant, and this will compensate for errors in the radial cut. The precise length and direction of these cuts is not too critical, but the radial cuts must start at the correct point.

Number the teeth in the direction shown, using a felt-tip pen. Teeth 25-34 are illustrated. To control warp, cut a second disc of half the radius, and glue it to the back of the first. Form the spike, using the thin connecting wire. Now trap the seconds wheels between washers at the front end of the 70mm length of studding. Then slip on an extra washer to trap the spike. This must point out ahead of the wheel, parallel to its axle, but 4mm off centre in the direction of tooth 15. This spike will then provide the correct drive for the minute wheel.

Place the completed seconds wheel in its bearing. Make the claw No. 1 in Fig. 1, but again using the finer connecting wire. The 40mm tail is an adjustable counterweight, which varies the pressure exerted by this claw on the seconds wheel. The diameter of the curves of the claw should be 4mm or more, to ensure that rolling takes place on 2. Hang the claw there, and loosen the screw holding bracket No. 4. This bracket can now be moved horizontally, to allow the claw to hang vertical, touching the wheel at about the level of its axle. The pendulum should now drive the seconds wheel. If at any time this wheel starts to squeak, place a little lard on the front bearing.

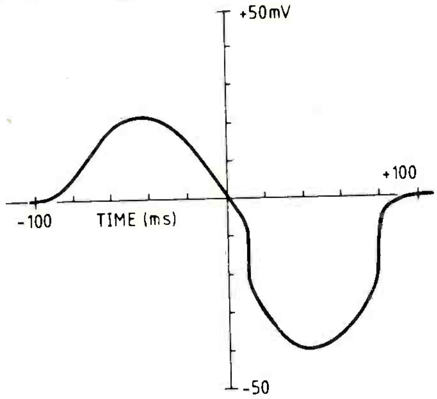


Fig. 5. Trace of the potential of the hot end of the coil in Fig. 3 as the magnet passes in either direction. Triggering occurs when the induced volts reach some 5mV negative. The negative pulse should occur as the magnet is leaving the coil, so that a long pulse has no ill effects.

Minute and hour wheels

Make the minute wheel bearing 6 in Fig. 1, constructing the V bends once more as explained above. Clamp the bearing to the pendulum post as shown. Now draw on card a circle of 50mm radius, and mark the centre with a cross. Prick it through. Draw a concentric circle of 55mm radius, and cut it out carefully. Mark the periphery from the template as before, and make 5mm radial cuts as in Fig. 1, middle diagram. Choose which side is to be the front, and complete the teeth and numbering as shown, noting that slanting cuts and numbers now proceed in the other direction. Back the new wheel with a 25mm radius disc, and mount it at the front end of the 90mm length of studding. Make the spike shown and trap it behind an extra washer, but this time at the rear of the wheel below tooth 07. This spike will then drive the hour wheel correctly. Now mount the minute wheel in its bearing, and terminate the axle at the rear with two nuts screwed together, so that the axle has little freedom of movement backwards and forwards. Ultimately both other axles may be so terminated.

Imagine the seconds wheel axle to extend forward indefinitely. Now adjust horizontally the bearing of the minute wheel, so that its teeth would just scrape the extended axle. As the seconds wheel rotates, its spike will now mesh with the minute wheel teeth, but it should only penetrate some two thirds of the available distance. Also when the seconds spike leaves the minute wheel it should next enter it near the centre of the next tooth. If the spike does not meet these two requirements, its radius can be adjusted.

Make the hour wheel bearing 5 in Fig. 1 without bends, and fix at the hole 2 on the post. Draw on card a 30mm radius circle, marking the cross at the centre and pricking through. Draw a concentric circle of 45mm radius, and cut it out. Mark the perimeter from the template, but only every 30°. Make 15mm radial cuts and choose the front. The slanting cuts are large, and they and the numbering follow the direction of the seconds wheel. Number the teeth I-XII. Mount the wheel at the front end of the 65mm or so length of studding remaining. Adjust the position of the bearing so that the hour wheel is correctly driven. This will include making two bends to bring the wheel forward somewhat. When the hour wheel is correctly driven each operation by the minute wheel leaves a radial side of an hour tooth vertical.

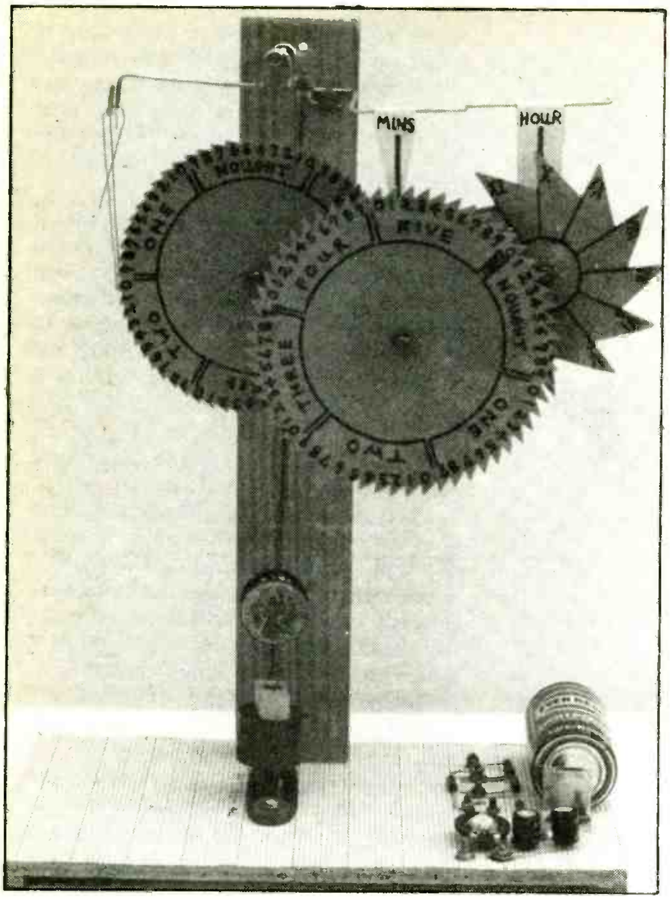
Finally the bracket 3 is constructed, and fixed at a hole on the post. Before making the bends shown at the top of 3 compare with the actual clock, to ensure that 3 will do its job. On its 40mm and 50mm sections it has to carry a card which can slide horizontally. One card indicates which tooth of the minute wheel is to be read, and the other does the same thing for the hour wheel. The time can be read more easily if these cards hang just behind the wheels, and extend just below them.

Practical points

A warning: the pendulum bearing can absorb some energy if the semicircles on No. 2 do not line up with the threads at the point of contact. If the pendulum bob describes a curved path that takes it out of the vertical plane, this is because the semicircles just mentioned differ markedly in radius. If a tooth is ruined while constructing any wheel, another can be stuck behind it. But keep glue off the active surface of the new tooth. If this addition unbalances the wheel, it may be brought back into balance again by glueing a 1cm square piece of card on the back in an appropriate position. If desired the wheels may be tested for balance by tapping the baseboard, and then corrected as above.

Lowering the adjusting weight by one turn of its fixing nuts slows the clock by about ten seconds a day, and conversely. Thus good timekeeping may rapidly be achieved. The clock malfunctions in strong draughts or vibration, but the time shown can be readily adjusted. Seconds should be read where the claw touches the seconds wheel. Enthusiasts may add a moon wheel, which will keep quite good time if two spikes on the hour wheel address a 59 tooth moon wheel.

Two patents are held on the clock, but that only stops it being made if some sort of financial gain accrues, and indeed full constructional details have been given here. A kit might be preferred, but no



The completed cardboard clock, which runs for about a year on an HP2 battery.

large manufacturer has been found to produce one. However Webbonware, 398 Hatfield Rd, St Albans, Herts, will supply a complete and engineered kit (less battery) for £17, which includes postage and packing. The teeth on the wheels are marked for cutting out, and all drilling is done. Baseboard and backboard are elegantly shaped in hard wood, but to look their best they need some finishing. Stripboard is provided to connect the electrical parts, which are then concealed. In this form the clock becomes a permanent piece of furniture.

Energy balance

A pendulum is a device which lends itself to measurement. By observing the decay in oscillation when there is no drive, it is possible to study the energy absorption of the various parts. When the amplitude is at its maximum permissible value the claw is almost drawing forward two teeth at a time on the seconds wheel. At this amplitude some 5 μJ of energy are absorbed per cycle in overcoming the air resistance met by the bob, while a further 3μJ is needed to handle friction at the axle of the seconds wheel. But the amplitude also has a minimum permissible value of about half the above, when the claw only just succeeds in moving one tooth of the seconds wheel. Here the friction requirement remains unaltered, but the air resistance element falls as the 2.5th power of the amplitude, and so reduces to about 1 μJ.

Thus the air resistance of the bob provides an energetic buffer against amplitude variation, and it must not be reduced. If the pot is adjusted for maximum permissible amplitude when the battery is new and delivering 1.6V, it will be found that when the battery is old and delivering only 1.1V there is still more than sufficient amplitude to drive the clock. With this endpoint voltage the battery specified yields nearly 10A h, and so at about 1mA consumption the clock should run for over a year.

Electrical measurements complement these mechanical observations. Arrange for the pendulum to swing with amplitude near the maximum permissible, while driving the seconds wheel as usual. Monitor meanwhile the voltage across the coil on an oscilloscope. As shown in Fig. 5 something like a single sine wave cycle is induced as the magnet passes over the coil, with amplitude some 25mV. Superimposed on this is a clearly distinguishable 16mV power pulse which switches rapidly and lasts 100ms. The coil is 4Ω so the power current was 4mA, flowing for 100ms against an induced e.m.f. of average value some 12mV meanwhile. All this happens twice in the pendulum cycle, and multiplication shows that during that time some 10μJ of kinetic energy are transferred to the pendulum. This is very close to the 8μJ suggested above from mechanical studies.

As with the electric motor, energy is transferred when current flows against back e.m.f. But the battery has to overcome not only the 12mV just mentioned, but also the 1500mV found at the pot. So the circuit is less than 1% efficient, compared with the 30% that may be deduced from Fig. 2 for the Kienzle movement. This is the price paid for a simple coil and magnetic circuit. Nevertheless, the battery lasts a year, and this might be regarded as sufficient.

Weather-satellite images

Continued from page 73

regenerator, demodulator and sync. detector, to be adjusted. The input level should be progressively reduced and each part 'retweaked'. The whole system should be adjusted by monitoring the noncoincidence pulses at the error monitor point in the bit conditioner. Final adjustment is a significant problem and can only be achieved after much trial and error.

Results and conclusion

A number of images have been recorded using this system and the ground resolution obtained is close to that specified in the spacecraft parameters list of 1.1km. It is likely that many improvements could be made by other experimenters but it is the intention that this article should be a basis for further work rather than a complete discription of a finished project.

Although the system was designed for h.r.p.t., facilities for Meteosat p.d.u.s. will be added since the Meteosat system is fully operational again: the basic philosophy is similar. Further design information about both systems is readily obtainable[16,17].

Many people offered advice and help during the development of the equipment. I would particularly like to thank all my colleagues at Feedback Instruments Limited, Miss C. Thoburn (Royal Greenwich Observatory, Herstmonceaux) and Mr W. S. Steer (Imperial College, London) without whose encouragement the project might never have been completed.

References

14. Generation and Properties of Maximum Length Sequences, W. D. F. Davies, 'Control' Vol. 10 numbers 96 and 97.
15. Antenna and Receiving-System Noise-Temperature Calculation, L. V. Blake, US Naval Research Laboratory, September, 1961.
16. Guide for Designing RF Ground Receiving Stations for TIROS-N, NOAA technical report NESS 75. Obtained from US Department of Commerce, NOAA (National Oceanic Atmospheric Administration), NESS (National Environmental Satellite Service), Washington DC 20233, USA.
17. Meteosat High-Resolution Image Dissemination, European Space Agency.

The NEC semiconductors mentioned in the article can be obtained through California Eastern Laboratories, 2 Clarence Rd, Windsor SL4 5AD (telephone Windsor 56891) and the address of the p.t.f.e. board manufacturers is 3M (UK) Ltd, PO Box 38, Yeoman House, 57-63 Croydon Rd, Penge, London SE20.

The chip capacitors mentioned in the first article have a value of 100pF and not 1nF as shown in Fig. 1. The manufacturer's type number given is correct.

The circuit shown in Fig. 15 of last month's article needs a slight modification. A series capacitor of 100pF is required in the g sync line to the 4017IC reset input. The capacitor is followed by a 10k-ohm resistor to ground so that the R and C form a high-pass filter. Without these components some resetting problems may occur.

Britain backs L-Sat

The UK government is to provide £77 million of the £230m cost of developing and building a large European Space Agency satellite for telecommunications and broadcasting. This is the L-Sat, which has been under discussion for a good many years (see, for example, November 1980 issue, p.65). The other major partner in the consortium for building it is Italy, and participants include Canada, Netherlands, Switzerland, Austria, Belgium, Spain and Denmark. Originally France and Germany were to have been major partners in the project, but in 1979 they withdrew and started a collaboration to build their own satellites (one for each country).

L-Sat, for which British Aerospace is the prime contractor, will be a new design of geostationary satellite platform, suitable for carrying a wide range of payloads. Two of these will be 12GHz transponders for pre-operational use in satellite broadcasting, and their aerial beams will be steerable to cover any European country. Other transponders will allow trials on business communication systems, with uplinks in the 14-14.5GHz band and downlinks in the 12-12.75GHz band. The first flight, planned for 1986, will provide demonstrations and experiments in advanced digital communications and direct television broadcasting.

The spacecraft will be placed at 19° West in its geostationary orbit and will carry fuel for five years of operations. Designed to be launched either by the Ariane rocket or the US Space Shuttle, it has been matched to the predicted satellite market up to the end of the century. British Aerospace estimate the total market to include at least 120 large satellites. The L-Sat contract is worth about £150m to them.

Marconi Space and Defence Systems will provide the business communications payload, which will be the first in the world to use on-board switching between multiple-spot aerial beams – a technique that increases the communications capacity obtainable for a given size of satellite and a given frequency allocation. This technique is expected to be used in most future communications systems.

● British Aerospace are also prime contractors for the series of European Communications Satellites, ECS (for which the first launch is due in 1982) and for the Maritime Communications Satellites, MARECS (first launch due soon).

More letters

Horn loudspeaker design

In 1974 you published Dinsdale's three-part article[1] on horn speaker enclosures for domestic use with numerous theoretical aspects outlined. These include the beautiful ideas of Voigt who showed that a tractrix profile for a round horn would allow a wave front always perpendicular to the horn edges to travel up the horn, meeting the condition of travel with constant velocity for every part of the wave. The wave front is spherical with a constant radius equal to the length of the straight line which generates the tractrix. At the mouth the direction of the horn profile is perpendicular to the axis and the wave front stands on it, a perfect hemisphere, before setting off to meet some diffraction problems as its introduction to the big world outside. Whether it has the same intensity all over the hemisphere, I wish I knew.

In later correspondence one reader mentioned the failure of the familiar flattened tweeter horn to spread out the treble as widely as was hoped (in a design independent of Dinsdale). Dinsdale's Fig. 13 shows clearly how for a treble horn he elongates the horizontal cross-section and compresses the vertical cross-section, using an exponential horn, I think, though there is something worrying about the way his profiles in Fig. 13 both fall initially *inside* the circular-horn profile they derive from. But a proper consideration for the spherical wave emerging tangential to the end of the horizontal profile would apparently entail enclosing it all round at this stage in its journey, by bringing the top and bottom out in a curve for some 5in extra to a horn 5in long! Small tweeter horns are becoming almost a logo on transistor radios but in so far as they are generally flat-fronted and elongated sideways they presumably all suffer from this fault.

Further, my reference to diffraction problems was triggered by coming across a design for a narrow horn expanding between vertical planes to become elongated vertically – which spread the treble sideways by diffraction. All this tends to show why a pair of tweeters tilted left and right is sometimes used without horn loading, while others find it necessary to subdivide the horn longitudinally so their partitions can curve outwards and take the sound with them to get wide dispersion. Dinsdale's horn works into a baffle (hemisphere loading) but I suspect anyone using a flat-fronted horn without a baffle is going to get disappointing results as their spherical wave will be in poor condition when its edges reach the lateral limits of the horn. In practice wavefronts are pretty thick compared with horn size if they fall within the passband, but it is useful to compare them to a rather durable soap film being blown towards the mouth, which can be imagined standing neatly at the outline of a laterally elongated tweeter horn with a bowed front.

Bernard Jones
London W1

Reference

1. "Horn loudspeaker design", J. Dinsdale, *Wireless World* March 1974, p. 19, May 1974, p. 133, June 1974, p. 156.

Concepts in physics

I have mixed feeling about J. L. Linsley Hood's letter in the November 1981 issue discussing the prevalent censorship of any ideas which have tended to cast doubt on the validity of orthodox theories.

The self-appointed guardians of the faith, who have arrogated to themselves the right to stop me from publishing in any learned journal in Britain and the USA by means of the refereeing system, are today an extremely ignorant, arrogant bunch in the fields of relativity and electromagnetic theory. On the other hand, the fact that one is a dissident does not necessarily mean that one is competent, and unfortunately one at least of the suppressed dissidents has failed completely to understand his subject. I only wish the lines were more clearly drawn beteeen the goodies and the baddies.

Ivor Catt
St Albans
Herts

Selective calling on c.b.

I note that condition 6 printed on my Citizens' Band licence application form permits the use of selective calling and transmitter identification signals. In view of the enormous benefits which would derive from standardisation now, may I offer the following suggestions.

1. Each station to be identified by a ten-digit number made up of the eight digits of the licence number and two digits selected by the licensee differently for each transceiver owned.
2. The selective calling signal to consist of the called station identity, calling station identity, a channel number and an error detection code. The called station identity would either be input on a calculator type keyboard on the unit or called up from a store of frequently used numbers.
3. The called station to display or change automatically to the channel number in the received signal, thus enabling selective calling signals to be segregated from voice signals on different channels if required.
4. The called station to display the calling station identity and give an audible and/or visual indication to attract the operator's attention.
5. The called station to reply by sending its identity, and positive confirmation that this has been received to be given to the operator of the calling station.

The use of some form of tone coding would be desirable as this would allow add-on selective calling units to be plugged in to the microphone and loudspeaker sockets of existing transceivers. For example two tones could be used, 2.4kHz marking and 1.2kHz spacing, and the data transmitted as a bit stream after a short burst of marking tone. A data rate of about 50 bits per second possibly would be appropriate in this case. The two station identities sent as 34-bit binary numbers, the channel number as six bits and about another six bits of error detection code would give a total of eighty bits and a transmission time of 1.6 seconds with the rates and frequencies given above. It should be noted that these frequencies are intelligent guesses only, chosen for convenience of derivation from a standard 2.4576MHz microprocessor crystal, as before 2nd November 1981 I could perform no actual tests.

R. Billing
Farnborough
Hants

Direct digital frequency synthesizer

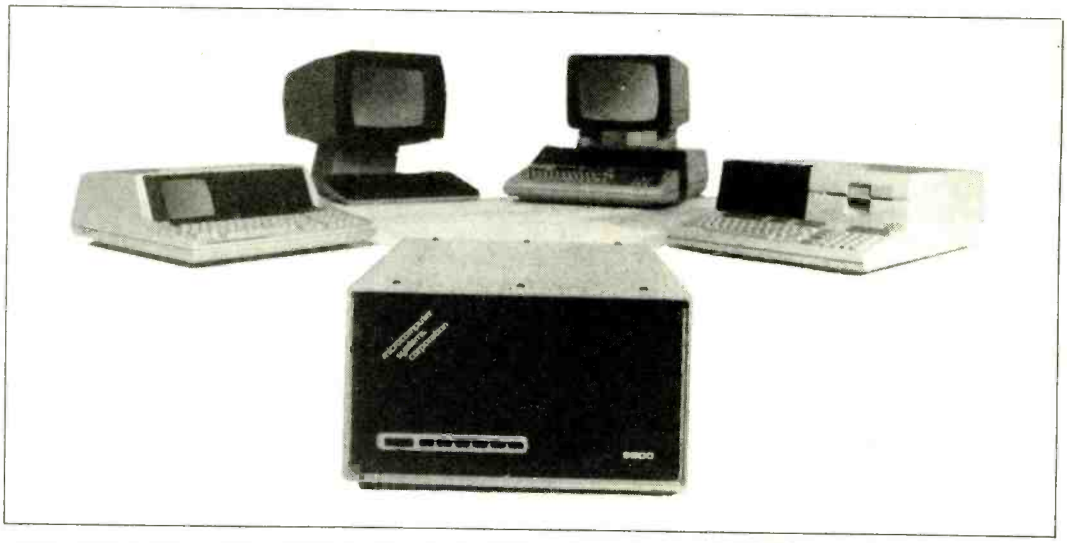
Dr J. H. J. Dawson, author of "Direct digital frequency synthesizer" in the December 1981 issue, asks us to print the following acknowledgement, which was not included in the published article: "Thanks to André Noest, for many helpful discussions during the design of the synthesizer, and to Professor Nibbering, Laboratory for Organic Chemistry at the University of Amsterdam, and the Netherlands Organisation for Pure Research for commissioning and financing the project".

New Products

Hard-disc for HP's

A new company specializing in hardware and software for Hewlett-Packard systems, Protek, have made available in the UK a 5M-byte hard-disc drive for Series 80, 9825, 9826, 9845, 250 and 125 desktop computers. The MSC9800, from the Microcomputer Systems Corp., is fully compatible with the aforementioned computers, even down to the paintwork, and incorporates a 5 1/4in Seagate Technology Winchester drive. A single-board controller is used. The controller provides 22-bit error detection, 11-bit error correction, a 256-bit data buffer, single-command disc initialization and a switch selectable bus address. The unit measures 159 by 254 by 305mm. Protek Electronics, 115 Alderney Street, London SW1V 4HE.

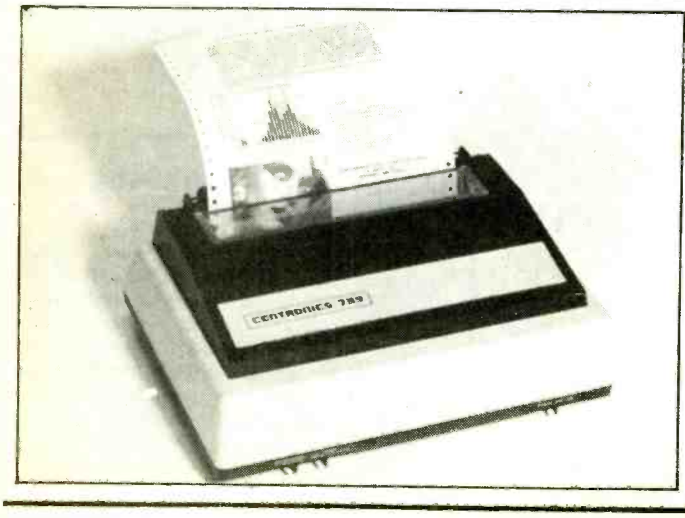
WW301



Dot-matrix printers

Additions to Centronics' range of matrix printers for microcomputer users have been made. First is the 132-column model 152 with a print speed of 150chars/s. This is a bi-directional printer with a variable-width tractor feeder for both fan-fold and single-sheet paper and produces from 5 to 16.4 characters per inch in both expanded and compressed modes. Self-test is incorporated. The model 150 is an 80-column version of the 152 but with a removable tractor. Lastly, an improved version of the existing 737 printer, the 739, has been produced. Among the improvements are increased speed (100 chars/s), full pin-addressable graphics, a 'top-of-the-form' (i.e. printer automatically runs to top of next page) capability and self-test. A cover, claimed to reduce noise to 60dBA, is standard on this model. Approximate prices are, under £700 (starting price) for the 152, under £500 for the 150 and around £500 for the 739. RS232 or Centronics-parallel interfaces are available for all models and the 739 also has a 20mA-loop option. Centronics Data Computer, Petersham House, Harrington Rd, London SW7.

WW302



Power op-amps

High-voltage power op-amps from Apex Microtechnology are available through Pascall. The PA83A has the highest output-voltage swing of this range of hybrid-TO3 devices at ±145V max. Its minimum output current and slew ratings are 75mA peak and 30V/μs respectively. At present, the device with the highest current output is the PA07A, rated at 5A minimum (peak). Maximum output-voltage swing and slew ratings of the 07A are ±47V and 4.5V/μs respectively. Both the 83A and 07A have a typical d.c. input impedance of $10^{11}\Omega$ and the slew rates given here are for maximum load. There are 11 devices in the present range and another four planned, one of which will deliver a minimum peak-output current of 15A. Pascall Electronics Ltd, Hawke House, Green Street, Sunbury-on-Thames, Middx TW16 6RA.

WW303

C.v. transmission controller

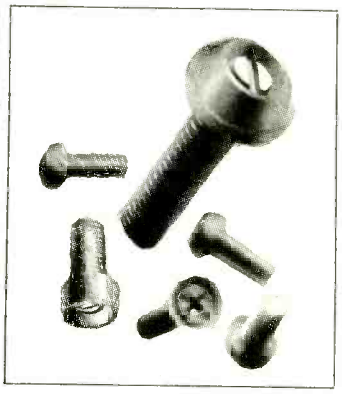
A reduction in fuel consumption of between 10 and 15% is claimed for the Tecton Motronics digital continuously-variable transmission controller. The system, designed to operate with any c.v.t./engine combination, is programmed to monitor load speed, load torque, engine speed and load-speed demand and adjust the throttle and transmission accordingly. The best possible overall efficiency under any load conditions and at the demanded load speed is claimed. Tecton Motronics Ltd, 12 St George's Rd, Leamington Spa, Warwickshire CV31 3AY.

WW304

Plastic screws

Nylon screws with metal cores are manufactured by Plastic Screws Ltd. These screws are claimed to combine the advantages of their all-plastic equivalents with much increased mechanical strength. The heads, forming part of the metal core, can be round, countersunk, fillister or round-with-washer types. Plastic Screws Ltd, Uddens Trading Estate, Nr Wimborne, Dorset BH21 7NL.

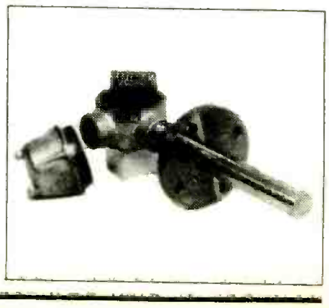
WW305



Liquid-level sensors

Fluid-level monitoring units operating on the diaphragm/strain-gauge principle are available from RDP. LL-series 'liquid-level transmitters', as RDP call them, may be obtained with an attached output circuit providing either 0 to 5V d.c. or 4 to 20mA. Sensing heads can have a circular mounting flange or they can be delivered for plumbing directly into a tank's outlet. RDP Electronics Ltd, Grove Street, Heath Town, Wolverhampton WV10 0PY.

WW306



Data logger

Up to 128 analogue and 240 16-bit digital inputs can be handled by the mDAS/SP software-programmable data logger from Base Ten Systems. This unit, with built-in c.r.t. display, 'qwerty' keyboard and cartridge recorder has 76 Basic commands and 64 graphics characters. Data acquisition, recording and control instructions, analysing routines and compensation/linearization for sensors can be programmed. Both programmes and acquired data can be stored in the logger's cartridge recorder. Software for the unit includes scan, alarm, linearization, control, graphics and file-handling routines. An option with internal printer is available; remote printers and v.d.us can be driven through a serial link. Other options include RS232 and IEEE488 compatibility and CCIR composite-video output. Base Ten Systems Ltd, 12 Eelmoor Rd, Farnborough, Hants GU14 7QN.
WW307

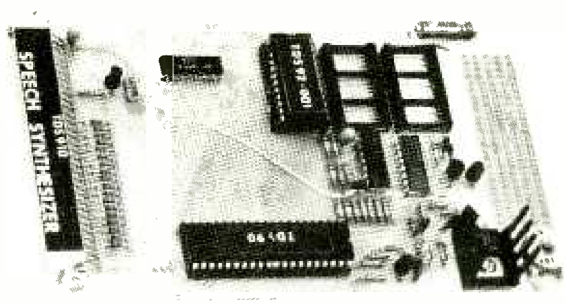
Speech synthesizer

Integrated-circuit sets for Triangle's Instant Speech system, previously only available as part of an assembled unit, can now be obtained separately for around £39. The TDS934 set consists of a speech synthesizer, a speech memory and four standard ics for voltage regulation and filtering. Up to eight memories can be used with the system; the one supplied contains data for the words 'oh', point, gram, kilo, ohms, volts, amps and numbers one to nine. Extra memories can be programmed to customers' requirements at 48 hours notice. Microprocessor control is not essential but serial and parallel interfaces can be used. Using a few extra c.m.o.s. i.cs, the vocabulary can be expanded to almost any size, claim Triangle. An assembled system on Eurocard (see photo) costs £97.06. Triangle Digital Services Ltd, 23 Campus Rd, London E17 8PG.
WW308

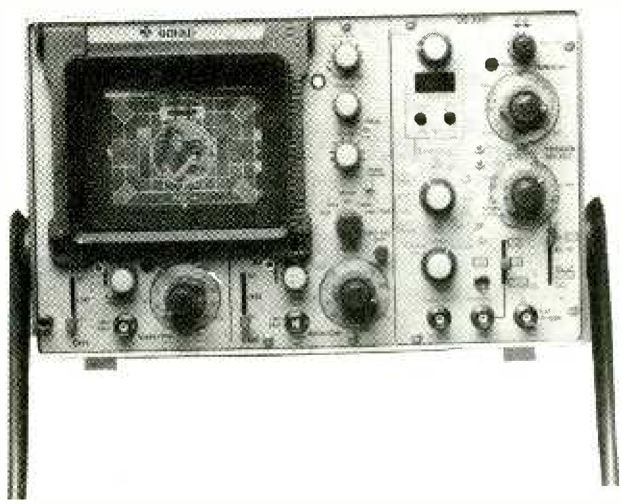
Tv monitor oscilloscope

Incorporated in the Gould OS3351 oscilloscope is a BBC-designed time-base for monitoring and measuring broadcast signals. This 30MHz dual-trace instrument accepts composite-video signals, with or without 'sound-in-sync', which can be examined in one of six triggering modes. Any line, or line-pairs in the range 16/329 to 22/335, can be selected and displayed. Triggering can be delayed continuously by up to 90μs for studying parts of a line. Line selection is by push-buttons, the displayed line number being indicated on a 3-digit display. The triggering point of a tv frame may be displayed as a 'bright-up' line on the picture to establish the relationship between waveform and picture. A single switch is used to change between picture and waveform display modes. The OS3351 can also be used as a conventional 30MHz oscilloscope. At 1mV/cm the bandwidth is 0 to 10MHz. Gould Instruments Division, Roebuck Rd, Hainault, Essex 1G6 3UE.
WW309

WW307



WW308



WW309

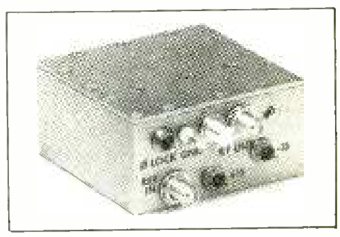
WW310

Tunable filter

An automatic variable-bandpass filter covering the range 1Hz to 1kHz has been introduced to the market by Bang & Olufsen. Primarily intended for audio equipment assessment, the TF2 has a filter width of around 10% with 40dB/octave skirt selectivity and a gain of approximately one (in the pass-band). Manual and automatic-sweep modes and sweep range are selectable. Applications include wow-and-flutter and resonance measurements. An output for an X,Y recorder is provided and an option for remote control is available. Danbridge (UK) Ltd, Sherwood House, High Street, Crowthorne, Berks.
WW310

Phase-locked oscillators

A series of phase-locked oscillators from RFD covers the range 0.4 to 5.2GHz. Stability error of the internal reference is ±3 parts in 10^5 over the operating temperature range of 0 to 50°C. R.f. output levels are +20dBm for types in the range 0.4 to 2GHz and +13dBm for 2 to 5GHz types; units with higher output levels can be supplied. Harmonics and spurii are −20dBc and −80dBc respectively and power re-



quirements are 12V to 28V d.c. at around 150mA. Units can be supplied to operate on either an internal or external reference with automatic switch-over between the two. Other options include lock-limit alarm, mountings to customers' specifications and extended temperature range. Dimensions of the units are 32 by 57 by 57mm excluding terminals. March Microwave Ltd, 112 South Street, Braintree, Essex.
WW311

SIDEBANDS

By Mixer

Lost for words

However ingenious and hardworking electronic engineers are, you'll always find someone ready to sneer at their work. I used to find that sort of thing very depressing myself when I was employed to design things. Come up with any kind of device you like to mention and I guarantee there'll be some character around who will ask, with ready wit, whether it will play 'God Save the Queen', or remark that if only you'd made it a bit heavier it would have performed with credit as a doorstop.

I've even been guilty of that sort of thing myself, but the time, as I now recognize, has come to stop it. I've always prided myself on knowing my limitations, and when something truly stupendous is announced I feel I have to bow to a superior intelligence and simply report the fact. This is that Olympus Optical make a little dictation machine which has recently undergone 'an interesting development'. Pearlcorder X-R1 – I hardly know how to say this – is a dictation machine 'with additional yodelling facility'. It can be connected to a timer which will not only wake you in the morning but send you off to sleep at night to the sound of yodelling. This intelligence, I must point out, comes not from the Olympian heights direct, but from the p.r. organization at the Berlin show, so the Japanese-German-English translation may have introduced an element of whimsy.

There is, as they say, no answer to that. Never again will I look forward to each day's post, hoping to see something to brighten my humdrum existence. When you've reached the peak, what then? From here on, it's downhill all the way.

Just one point, though, before I find a wall to bang my head against: if this is 'an additional yodelling facility' does it mean that all dictation machines already have a built-in, basic yodelling facility? Perhaps I'm not exploiting the full potential of mine.

Small talk

When I was being persuaded to part with my wind-up gramophone in favour of 'hi-fi' equipment, a few years ago, one of my colleagues who had placed himself in charge of my sonic education used to drag me all over South-East England to listen to loudspeakers. After the first two or three of these lecture tours my hearing began to fail under the assault: it must have been that, I suppose, but anyway I found that I couldn't swear to any audible difference between any of the gigantic boxes he showed me. It seemed to me that so long as the speakers occupied not less than a quarter of the volume of a good-sized sitting room they could be called high-fidelity units.

Maybe it all got to be a bit too much, or perhaps the application of science instead of guesstimation began to tell, but whatever the cause there is now a great number of tiny boxes, all labelled 'high fidelity'. Until quite recently, I'd thought that this description was a bit optimistic, but I've had a pair of microscopic Koss speakers on loan for several weeks and they've brought a new element into our lives – space: we have rediscovered carpet we haven't seen for years. No longer does the cat cringe in terror at the sound of Val Doonican – I do, but the cat's all right because the speakers are up on bookshelves, being only the size of a couple of atlases. And all this has been achieved without any significant loss in sound quality, to my ears at least.

There's a problem, though, because we've lost a talking point. The ones I had before were pyramidal, omnidirectional speakers and people who had never been before couldn't resist asking what in the world they were, which usually started a conversation along the lines of "Vivaldi wrote one concerto 400 times" or "Did you know Mozart was a drunken slob?". Riveting stuff, and it's gone forever. I expect we'll have to talk about Wedgwood Benn, now.

Record – of a sort

I think I can claim a record, or maybe the Post Office can. I've heard before of the sorting-office people dealing with impossibly addressed mail, but this time they've really pulled one off.

It was a letter from Belgium, posted in September and reaching me about a week later, that put them on their mettle. The address was "Mixer, Stamford Street, GB": not only an incomplete address, but the wrong area, because we've been here in Sutton since last November. It didn't stump the PO, though – they got it in one. They delivered to Dorset House, reasoning that only someone employed by IPC would assume a daft name like that, I suppose, and it was collected from there by the forwarding service.

Although I don't expect it will stop me grumbling when I arrive home from holiday before my "Wish you were here" communications, I feel like standing the relevant sorter a drink. I'd send the money off, except that it would most likely get lost in the post.

Plan-view

I don't know whether the motor car will survive the next twenty years, in view of the drying up of oil wells, but if it does – perhaps with some other method of propulsion – the inside isn't going to look much like the kind we're used to. The seats will still, I expect, be people-shaped, but the instrument panel is going to look even more like the cockpit of a Tornado than I had previously supposed. C.r.ts will, as I have mentioned before, probably replace 'clocks' as they are already doing in aircraft, and now Honda has developed a 'moving map' navigational display, too. You know the sort of thing – either a spot of light moves over a map of the area or the map moves relative to fixed point on the display to show you where you are.

Sounds great, but I'm not sure that all this entertaining gadgetry on the dashboard is such a good idea. They're all coming up with it now: Zenith with their computer that plays games, countless variations on the standard instruments – many of which don't seem at all easy to read – and now Honda wants us to do map reading. Admittedly, the machine only comes alive when the car stops, but that in itself could very well be a bit tricky. Anyone trying to thread his way through London in the rush hour might find doubts being cast on his ancestry and future prospects if he has to stop every hundred yards or so to see where he is. Too much reliance placed on this sort of thing could be a mistake, too. It will not be an acceptable excuse, when picked up for driving the wrong way down the fast lane of a motorway, to say that the machine made you do it, being ten yards out.

Bits and peace

Scotland Yard's delighted leap on to the computer bandwaggon has caused a slight disturbance of equilibrium, according to a report in the *Observer*. It seems that if you know "one of three childishly simple methods", you can get into the Police National Computer and find out which terrorist gang your mother-in-law belongs to, should the need arise.

The police say that the computer bureau 'phone number has now been taken out of service and that requests for information must be sent by teleprinter until they come up with a more tight-lipped way of going about it than the telephone. They also imply that they don't know how many Toms, Dicks or even Harrys have been furnished with info. that ought to have been clasped tightly to the collective police bosom, and can only hope that dumping their computer store hasn't begun to rival Space Invaders as a pastime.

There doesn't seem to be any real answer to this kind of thing. However clever the police become at specifying and using electronic aids to investigation and communication, there's always going to be a way for individuals to use them illegally. The rising generation is going to be a lot brighter about computers, too, so anyone placing excessive faith in electronics had better be very careful.

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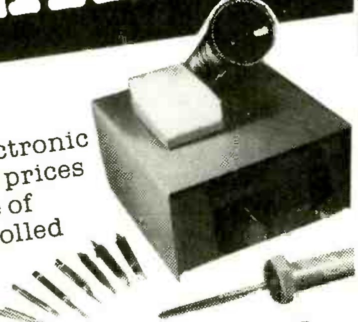

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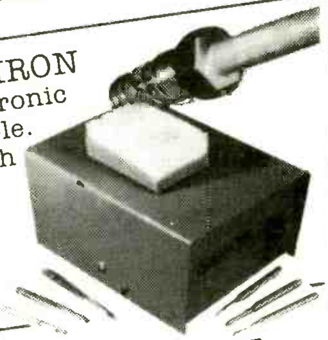

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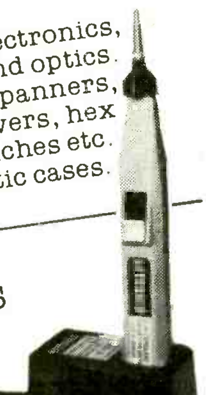

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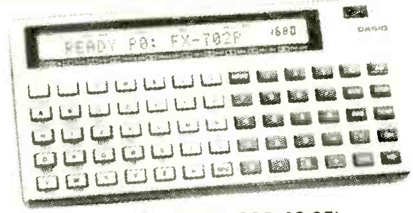

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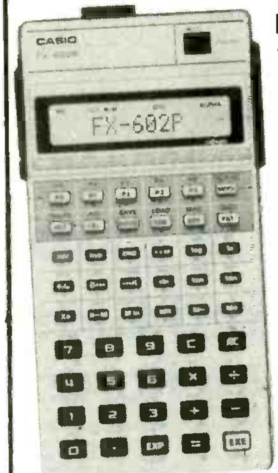

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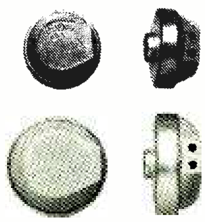

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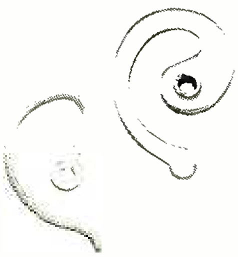

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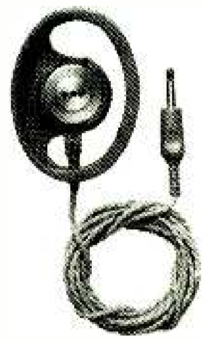

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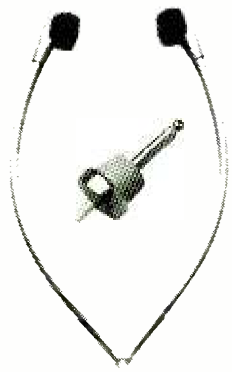

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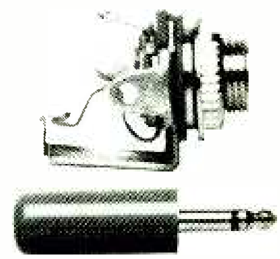

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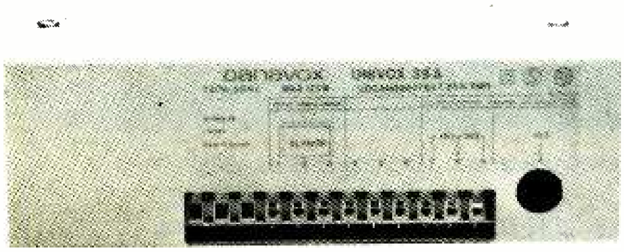

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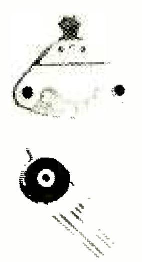

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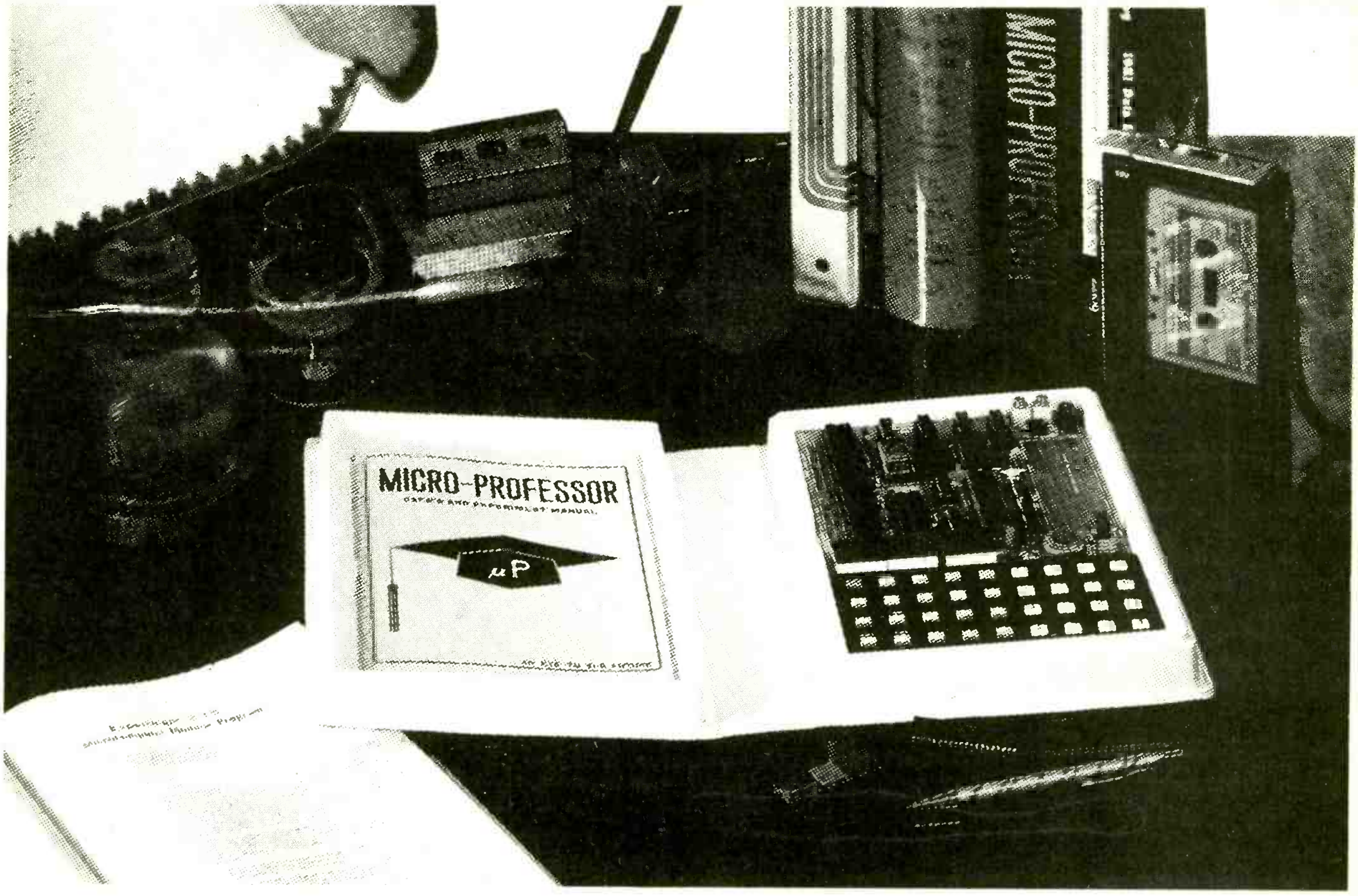

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EM87	1.30
EY51	0.95
EY81	0.65
EY86/87	0.60
EY88	0.65
EZ80	0.70
EZ81	0.70
GM4	5.90
GY501	1.30
GZ32	1.05
GZ33	4.20
GZ34	2.75
GZ37	3.95
KT66	6.30
	9.20*
KT88	8.95
	13.80*
MH4	2.50
ML6	2.50
MX10/01	21.50
N78	9.90
OA2	0.70
OB2	0.80
PABC80	0.60
PC85	0.75
PC86	0.95
PC88	0.95
PC97	1.50
PC900	1.15
PCC84	0.50
PCC89	0.85
PCC189	1.05
PCF80	0.80
PCF82	0.70
PCF84	0.75
PCF86	1.50
PCF87	0.50
PCF200	1.60
PCF201	1.65
PCF800	0.50
PCF801	1.75
PCF802	0.85
PCF805	2.45
PCF806	1.20
PCF808	2.75
PCH200	1.35
PCL81	0.75
PCL82	0.95
PCL84	0.90
PCL86	1.05
PCL805/85	1.25
PO500/510	4.30
PFL200	1.10
	2.80
PL36	1.25
PL81	0.85
PL82	0.70
PL83	0.60
PL84	0.95
PL504	1.45
PL508	1.95
PL509	2.90
PL519	3.20
PL802	3.20
PY33	0.70
PY80	0.70
PY81/800	0.85
PY82	0.65
PY83	0.80
PY88	0.85
PY500	1.70
PY809	6.45
PY801	0.80
QQV03/10	2.85
QQV03 20A	14.40
QQV03-25A	21.20
QQV06/40A	16.10

QV03-12	4.20
SC1/400	4.50
SC1/600	4.50
SP61	1.80
TT21	16.50
U25	1.15
U26	1.15
U27	1.15
U191	0.85
U281	0.70
U301	0.65
U600	11.50
U801	0.90
UBC41	1.20
UABC80	0.75
UAF42	1.20
UBF80	0.70
UBF89	0.70
UBL21	1.75
UCC84	0.85
UCC85	0.70
UCF80	1.30
UCH42	1.65
UCH81	0.75
UCL82	0.95
UF41	1.35
UF80	0.95
UF85	0.95
UL84	0.95
UM80	0.90
UM84	0.70
UY82	0.70
UY85	0.85
VR105/30	1.25
VR150/30	1.35
X66	0.95
X61M	1.70
XR1 6400A	82.90
Z759	19.00
Z749	0.75
Z800U	3.45
Z801U	3.75
Z803U	16.00
Z900T	2.45
1A3	0.85
1L4	0.50
1R5	0.60
1S4	0.45
1S5	0.45
1T4	0.45
1U4	0.80
1X2B	1.40
2D21	1.10
	1.85*
2K25	11.90
2X2	1.15
3A4	0.70
3AT2	2.40
3D6	0.50
3D22	23.00
3E29	19.00*
3S4	0.60
4B32	18.25
5B/254M	16.90
5B/255M	14.50
5B/258M	12.50
5C22	29.90
5R4GY	1.80
5U4G	0.75
5V4G	0.75
5Y3GT	0.80
5Z3	1.50
5Z4G	0.75
5Z4GT	1.05
6/30L2	0.90
6AB7	0.70
6AC7	1.15
6AG5	0.60
6AH6	1.15
6AK5	0.65
6AK8	0.60
6AL5	0.60
6AL5W	0.85
6AM5	4.20

6AM6	1.50
6AN8A	2.50
6AQ4	3.40
6AQ5	1.00
6AQ5W	1.80
6AS6	1.15
6AT6	0.90
6AU6	0.60
6AV6	0.85
6AX4GT	1.30
6AX5GT	1.30
6BA6	0.55
6BE6	0.60
6BG6G	1.60
6BJ6	1.30
6BQ7A	0.85
6BR7	4.80
6BW6	6.20
6BW7	0.90
6C4	0.50
6C6	0.55
6CH6	8.20
6CL6	1.70
6CX8	3.80
6CY5	1.15
6D6	0.70
6EA8	3.20
6F6	1.60
6F6GB	1.10
6F7	2.80
6F8G	0.85
6F12	1.50
6F14	1.15
6F15	1.30
6F17	1.15
6F23	0.75
6F24	1.75
6F33	10.50
6FH8	4.20
6GA8	0.90
6GH8A	0.95
6H6	1.60
6J4	1.35
6J4WA	2.00
6J5	2.30
6J5GT	0.90
6J6	0.65
6J6W	0.90
6JE6C	2.95
6JS6C	2.95
6K7	0.80
6L6M	2.80
6L6G	2.50
6L6GC	2.10
6L6GT	1.25
6L7G	0.65
6L18	0.70
6LQ6	2.95
6LD20	0.70
6KG6A	2.70
6Q7G	1.30
6SA7	1.00
6SG7	1.15
6SJ7	1.05
6SK7	0.95
6SL7GT	0.85
6SN7GT	0.80
6SR7	1.10
6SQ7	0.95
6V6G	1.50
6V6GT	0.95
6X4	0.75
6X4WA	2.10
6X5GT	0.65
6Y6G	0.90
6Z4	0.70
7B7	1.75
7Y4	1.25
9D2	0.70
9D6	2.90
10C2	0.85
10F18	0.70
10P13	1.50
11E2	19.50
12A6	0.70
12AT6	0.70

12AT7	0.65
12AU7	0.60
12AV6	0.95
12AX7	0.65
12BA6	0.90
12BE6	1.25
12BH7	1.10
12C8	0.65
12E1	18.95
12J5GT	0.55
12K7GT	0.70
12K8GT	0.80
12Q7GT	0.60
12SC7	0.65
12SH7	0.65
12SJ7	0.70
12SQ7	1.45
12SQ7GT	0.85
12Y4	0.70
13D3	0.70
13D5	0.90
13D6	0.80
14S7	1.15
19AQ5	0.85
19G3	11.50
19G6	8.50
19H5	39.55
20D1	0.80
20F2	0.85
20E1	1.30
20P1	0.65
20P3	0.75
20P4	1.25
20P5	1.35
25L6GT	0.95
25Z4G	0.75
30C15	0.50
30C17	0.50
30C18	2.45
30F5	1.15
30FL2	1.40
30FL12	1.25
30FL14	2.15
30L15	1.10
30L17	1.10
30P12	1.15
30PL13	1.25
30PL14	2.45
35L6GT	1.40
35W4	0.80
35Z4GT	0.80
40KD6	3.15
50C5	1.15
50CD6G	1.35
75B1	1.25
75C1	1.70
76	0.95
78	0.95
80	1.70
85A2	1.40
	2.55*
723A/B	11.90
807	1.95
	2.95*
813	19.32
	68.50*
829B	14.00
832A	8.90
866A	3.80
866E	6.25
931A	13.80
954	0.60
955	0.70
956	0.60
957	1.05
1625	1.80
1629	1.85
2051	2.90
5763	4.20
5842	7.50
5881	3.40
5933	6.90
6057	2.20
6060	1.95
6064	2.30
6065	3.20

6067	2.30
6080	5.30
6146	4.95
6146B	5.20
6360	2.85
6550	6.60
6870	14.00
8552	8.20
6973	3.30
7199	2.85
3BP1	11.00
5FP7	18.00
4EP1	32.00
88J	14.00
88L	14.00
CV1526	16.00
DG7-32	34.80
DG7-36	36.00
DPM9-11	38.40
D13-33GM	41.80

* spec. Q

PLUMBICON

P800 3LF
P800 IR
P800 IB
XQ1020R
XQ1020B

SPECIAL V.

4CX 1000A
4CX 5000A
BM 25L
BW 153
DM 25LB
YL 1420
YL1430
YL 1440
GXU 6
CV1597
CV2116
BR 189
BR 179
CV 6131
GMU 2
TY4-500
BK485/5552A
MIL 5948/1754

IC

SN5402N	0.28
SN5410F	0.32
SN5470F	0.48
SN54196J	1.20
SN7407N	0.29
SN7408N	0.18
SN7445P	0.85
SN74453P	1.10
SN7453N	0.18
SN74L73N	0.38
SN7474N	0.30
SN7485N	0.95
SN74L85N	1.10
SN7491AN	0.32
SN74123N	0.42
DM74123N	0.38
SN15836N	0.26
SN76013N	1.80
SN76003N	1.60
SN76033N	1.95
MC6800P	5.80
MC68B00P	6.40
MC14511BA1	2.20
B1702AL	3.30
MM6300-1J	3.80
MCM6810AP	3.40
6340-1J	3.60
MIC945-5D	0.28
MIC936-5D	0.22

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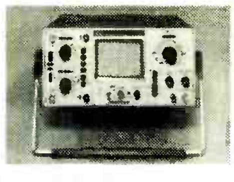

WIDE BAND DUAL TRACE OSCILLOSCOPE
LB0-508A £316

SINGLE TRACE TRIGGERED OSCILLOSCOPE
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LSG-16 £55

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Type	VA	Secondary Volts RMS	Secondary Current RMS	Dimensions Dia.	Dimensions Height	Weight Kg	Price
C1000	30	6+6	2.50	70mm	30mm	0.45	£6.38 (+£1.10 p.p.)
C1001	30	9+9	1.67	70mm	30mm	0.45	
C1002	30	12+12	1.25	70mm	30mm	0.45	
C1003	30	15+15	1.00	70mm	30mm	0.45	
C1004	30	18+18	0.83	70mm	30mm	0.45	
C1005	30	22+22	0.68	70mm	30mm	0.45	
C1006	30	25+25	0.60	70mm	30mm	0.45	
C1007	30	30+30	0.50	70mm	30mm	0.45	
C1010	60	9+9	3.33	87mm	33mm	0.75	£7.31 (+£1.43 p.p.)
C1011	60	12+12	2.50	87mm	33mm	0.75	
C1012	60	15+15	2.00	87mm	33mm	0.75	
C1013	60	18+18	1.67	87mm	33mm	0.75	
C1014	60	22+22	1.36	87mm	33mm	0.75	
C1015	60	25+25	1.20	87mm	33mm	0.75	
C1016	60	30+30	1.00	87mm	33mm	0.75	
C1017	60	110	0.55	87mm	33mm	0.75	
C1018	60	220	0.27	87mm	33mm	0.75	
C1019	60	240	0.25	87mm	33mm	0.75	
C1020	100	12+12	4.17	88mm	40mm	1.00	£8.15 (+£1.43 p.p.)
C1021	100	15+15	3.33	88mm	40mm	1.00	
C1022	100	18+18	2.78	88mm	40mm	1.00	
C1023	100	22+22	2.27	88mm	40mm	1.00	
C1024	100	25+25	2.00	88mm	40mm	1.00	
C1025	100	30+30	1.67	88mm	40mm	1.00	
C1026	100	110	0.91	88mm	40mm	1.00	
C1027	100	220	0.45	88mm	40mm	1.00	
C1028	100	240	0.42	88mm	40mm	1.00	
C1030	160	18+18	4.44	108mm	42mm	1.5	£12.26 (+£1.73 p.p.)
C1031	160	22+22	3.64	108mm	42mm	1.5	
C1032	160	25+25	3.20	108mm	42mm	1.5	
C1033	160	30+30	2.67	108mm	42mm	1.5	
C1034	160	35+35	2.29	108mm	42mm	1.5	
C1035	160	110	1.46	108mm	42mm	1.5	
C1036	160	220	0.73	108mm	42mm	1.5	
C1037	160	240	0.67	108mm	42mm	1.5	
C1040	230	25+25	4.60	115mm	50mm	2.2	£14.87 (+£1.73 p.p.)
C1041	230	30+30	3.83	115mm	50mm	2.2	
C1042	230	35+35	3.29	115mm	50mm	2.2	
C1043	230	40+40	2.88	115mm	50mm	2.2	
C1044	230	110	2.09	115mm	50mm	2.2	
C1045	230	220	1.05	115mm	50mm	2.2	
C1046	230	240	0.96	115mm	50mm	2.2	
C1050	330	25+25	6.60	130mm	52mm	2.8	£17.36 (+£1.90 p.p.)
C1051	330	30+30	5.50	130mm	52mm	2.8	
C1052	330	35+35	4.71	130mm	52mm	2.8	
C1053	330	40+40	4.13	130mm	52mm	2.8	
C1054	330	45+45	3.67	130mm	52mm	2.8	
C1055	330	110	3.00	130mm	52mm	2.8	
C1056	330	220	1.50	130mm	52mm	2.8	
C1057	330	240	1.38	130mm	52mm	2.8	
C1060	530	30+30	8.83	145mm	60mm	3.8	£22.57 (+£2.05 p.p.)
C1061	530	35+35	7.57	145mm	60mm	3.8	
C1062	530	40+40	6.63	145mm	60mm	3.8	
C1063	530	45+45	5.89	145mm	60mm	3.8	
C1064	530	50+50	5.30	145mm	60mm	3.8	
C1065	530	110	4.82	145mm	60mm	3.8	
C1066	530	220	2.41	145mm	60mm	3.8	
C1067	530	240	2.21	145mm	60mm	3.8	

NOTE: All types normally supplied with 240 V primary 110 V, 220 V or other voltage supplied on request.

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12 or 24-VOLT RANGE

Separate 12V windings Pri 220-240V

Ref.	12v Amps	24v	£	P & P
111	0.5	0.25	2.42	95
213	1.0	0.5	2.90	1.00
71	2.0	1.0	3.86	1.00
18	4.0	2.0	4.46	1.20
85	5.0	2.5	6.16	1.20
70	6.0	3.0	6.99	1.20
108	8.0	4.0	8.16	1.44
72	10.0	5.0	8.93	1.60
116	12.0	6.0	9.89	1.60
17	16.0	8.0	11.79	1.72
115	20.0	10.0	15.87	1.84
187	30.0	15.0	19.72	2.04
226	60.0	30.0	40.41	OA

30 VOLT RANGE (Split Sec)

Pri 220-240V. Volt available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-O-12V or 15V-O-15V

Ref.	Amps 30v	15v	£	P & P
112	0.5	1	2.90	1.00
79	1	2	3.93	1.00
3	2	4	6.35	1.20
20	3	6	7.39	1.44
21	4	8	8.79	1.60
51	5	10	10.86	1.60
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.98	1.84
90	12	24	21.09	OA
91	15	30	24.18	OA
92	20	40	32.40	OA

SCREENED MINIATURES Pri 240V

Ref.	mA	Sec Volts	£	P&P
238	200	3-0-3	2.83	50
212	1A, 1A	0-6, 0-6	3.14	1.00
13	100	9-0-9	2.35	50
235	330, 330	0-9, 0-9	2.19	60
207	500, 500	0-8-9, 0-8-9	3.05	95
208	1A, 1A	0-8-9, 0-8-9	3.88	1.20
236	200, 200	0-15, 0-15	2.19	60
239	50MA	12-0-12	2.88	50
214	300, 300	0-20, 0-20	3.08	1.00
221	700 (DC)	20-12-0-12-20	3.75	1.00
206	1A, 1A	0-15-20,0-15-20	5.09	1.20
203	500, 500	0-15-27,0-15-27	4.39	1.20
204	1A, 1A	0-15-27,0-15-27	6.64	1.20

AUTO TRANSFORMERS

Voltages available 105, 115, 190, 200, 210, 220, 230, 240. For step up or step down.

Ref.	VA (Watts)	TAPS	£	P&P
113*	15	0-10-115-210-240V	2.77	1.00
64	80	0-10-115-210-240V	4.41	1.20
4	150	0-10-115-200-220-240V	5.89	1.20
67	500	0-10-115-200-220-240V	12.09	1.84
84	1000	0-10-115-200-220-240V	20.64	2.20
93	1500	0-10-115-200-220-240V	25.61	OA
95	2000	0-10-115-200-220-240V	38.31	OA
73	3000	0-10-115-200-220-240V	65.13	OA
80	4000	0-10-115-200-220-240V	84.55	OA
57	5000	0-10-115-200-220-240V	98.45	OA

MAINS ISOLATORS (screened)

Pri 0-120; 0-100-120V (120, 220, 240V) Sec

Ref.	VA (Watts)	£	P&P
07*	20	4.84	1.20
149	60	7.37	1.20
150	100	8.38	1.44
151	200	12.28	1.72
152	250	14.61	2.04
153	350	18.07	2.12
154	500	22.52	2.20
155	750	32.03	OA
156	1000	40.92	OA
157	1500	56.52	OA
158	2000	67.99	OA
159	3000	95.33	OA
161	6000	203.65	OA

★115 or 240v sec only. State volts required. Pri 0-220-240V

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50 VOLT RANGE (Split Sec)

Pri 220-240V. Volt available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V or 25V-0-25V

Ref	Amps 50v	25v	£	P&P
102	·5	1	3.75	1.20
103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
119	10	20	27.48	OA
109	12	24	32.89	OA

TELEPHONES

746 Grey £11.50 P & P £1.20 V.A.T. Other types available

400/440V ISOLATORS

400/440 to 200/240 (screens)

VA	Ref.	£	P&P
60	243	7.37	1.20
250	246	4.61	2.04
350	247	18.07	2.04
500	248	22.52	OA
1000	250	45.94	OA
2000	252	67.99	OA
3000	253	95.32	OA
6000	254	189.02	OA

60 VOLT RANGE

(Split Sec) Pri 220-240V.

Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48 60V or 24V-0-24V or 30V-0-30V

Ref.	Amps 60v	30v	£	P&P
124	·5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	OA
122	10	20	32.51	OA
189	12	24	37.47	OA

CASED AUTOS

240V cable input USA 115V outlets

VA	Price	P&P	Ref
20	£6.55	.95	56W
75	£8.50	1.20	64W
150	£11.00	1.44	4W
200	£12.02	1.44	65W
250	£13.38	1.44	69W
500	£20.13	2.04	67W
1000	£30.67	2.20	84W
2000	£54.97	OA	95W

0-15 V CT (7.5-0-7.5V)

Ref	Amp	Price	P&P
171	500MA	2.30	.52
172	1A	3.26	.90
173	2A	3.95	.90
174	3A	4.13	.99
175	4A	6.30	1.10

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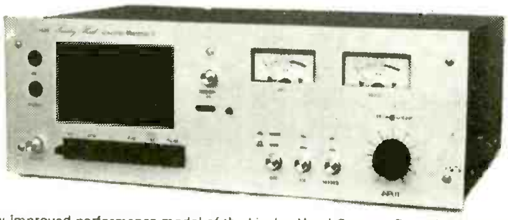
HART

LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother-and-daughter arrangement used on our Linsley-Hood Cassette Recorder 1.
This latest version has the following extra features: Ultra low wow-and-flutter of .09% – easily meets DIN Hi-Fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto-stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents rerecording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest, **£94.90** + V.A.T. we ask for the complete kit.

LINSLEY-HOOD CASSETTE RECORDER 1

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High-quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily-built and tested layout. All these features added to the high-quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our latest HS 16 Sendus Alloy super head, available separately at **£8.20** but included free with the complete kit at **£75** plus VAT.
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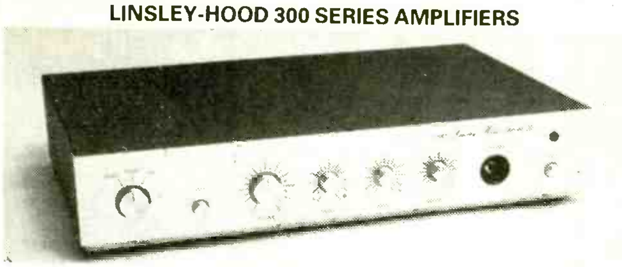

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71	2	1	2.77	1.10
18	4	2	3.98	1.43
68	3	1.5	3.46	1.43
85	5	2.5	6.06	1.43
70	6	3	6.67	1.43
108	8	4	8.03	1.43
72			8.66	1.73
116	12	6	9.31	1.90
17	16	8	11.46	2.05
115	20.10		13.69	2.05
187	30.15		19.23	2.35
232	40	20	27.61	4.50
226	60	30	35.35	4.00

15/30V RANGE PRI 220/240V
SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 ⇒ 15 — 0 — 15

TYPE	AMPS 15v	AMPS 30v	PRICE £	P/P £
112	1	0.50	2.84	1.10
79	2	1.0	3.29	1.10
3	4	2	6.18	1.43
20	6	3	7.19	1.73
21	8	4	8.52	1.73
51	10	5	10.57	1.90
117	12	6	11.94	2.05
88	16	8	16.14	2.20
89	20	10	18.54	2.35
90	24	12	20.57	2.55
91	30	15	23.63	2.65
92	40	20	33.21	4.50

25/50V RANGE PRI 120/220/240V
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 ⇒ 25 — 0 — 25

TYPE	AMPS 25v	AMPS 50v	PRICE £	P/P £
102	1	0.50	3.29	1.43
103	2	1.0	4.09	1.43
104	4	2	7.65	1.73
105	6	3	9.09	1.90
106	8	4	12.24	1.90
107	12	6	16.15	2.20
118	16	8	22.46	2.55
119	20	10	27.05	2.55
109	24	12	32.44	4.50

30/60V RANGE PRI 120/220/240V
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 ⇒ 30 — 0 — 30

TYPE	AMPS 30v	AMPS 60v	PRICE £	P/P £
124	1	0.5	3.30	1.43
126	2	1	6.36	1.43
127	4	2	7.86	1.73
125	6	3	11.78	1.90
123	8	4	14.72	2.20
40	10	5	17.10	2.20
120	12	6	19.44	2.35
121	16	8	27.70	2.65
122	20	10	32.05	4.00
189	24	12	37.02	5.00

48/96V RANGE PRI 120/220/240V
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 ⇒ 48 — 0 — 48

TYPE	AMPS 48v	AMPS 96v	PRICE £	P/P £
430	1	0.5	4.69	1.43
431	2	1	7.84	1.43
432	4	2	12.94	2.05
433	6	3	14.62	2.20
434	8	4	20.04	2.45
435	10	5	28.75	2.65
436	12	6	36.16	4.00
437	16	8	39.47	5.00

AUTOTRANSFORMERS 240/220 115V 65VA — 10KVA
0v 115V 220V 240V

TYPE	VA	PRICE £	P/P £
25	65	3.90	1.10
64	80	4.82	1.10
4	150	6.21	1.43
69	250	7.54	1.43
53	350	9.73	1.90
67	500	11.70	2.20
83	750	13.51	2.05
84	1000	18.31	2.35
95	2KVA	34.36	5.00
73	3	64.74	5.00
57	5	97.85	6.50
101	10	179.05	10.00

CASED AUTOTRANSFORMERS
240V LEAD IN: 115V 2 PIN SOCKET OUT

TYPE	VA	PRICE £	P/P £
56W	20	6.60	0.87
64W	80	8.43	1.43
4W	150	10.86	1.73
69W	250	13.17	1.90
67W	500	20.46	2.20
84W	1000	30.24	2.55
95W	2000	54.83	5.00
73W	3000	78.67	6.50

LINE ADJUSTMENT AUTOTRANSFORMERS
0 200 210 220 230 240 250

TYPE	VA	PRICE £	P/P £
415C	50	2.31	0.87
416C	100	3.46	0.87
417C	200	4.00	1.10
418F	350	6.26	1.43
419F	500	6.74	1.73
420E	750	8.33	1.90
421F	1000	11.64	2.05

MAINS ISOLATORS (SAFETY SCREEN)

TYPE	VA	PRICE £	P/P £
149F	60	8.40	1.73
150F	100	9.71	1.73
151F	200	13.84	2.05
152F	250	16.69	2.20
153F	350	20.77	2.55
154F	500	26.03	2.65
155F	750	36.75	5.00
156F	1000	47.42	6.00

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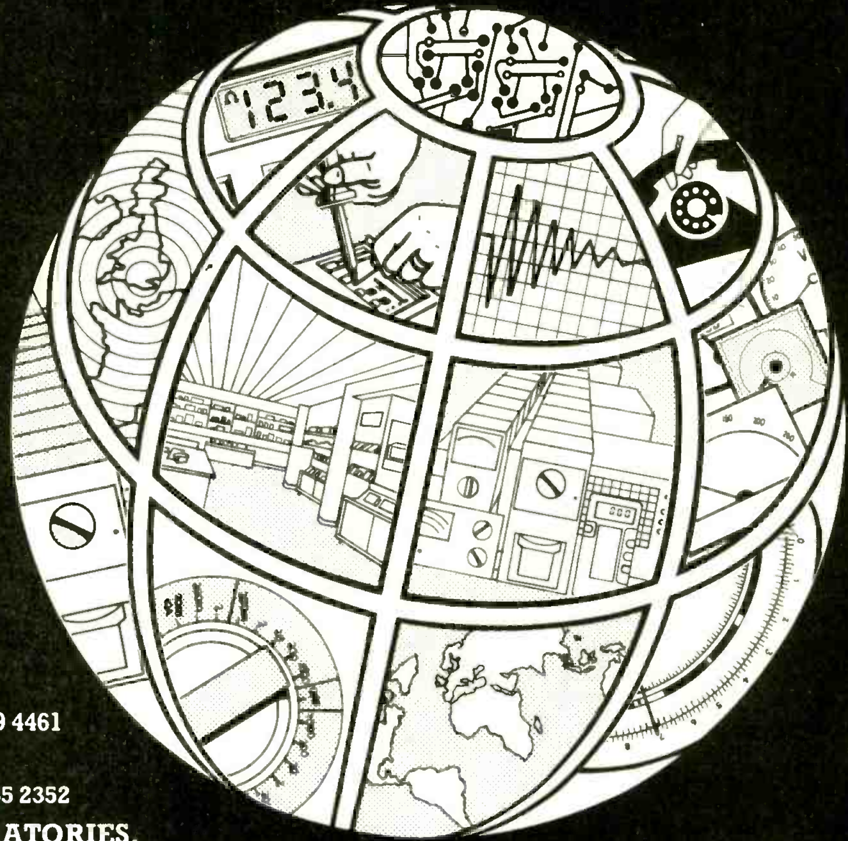

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BA156	0.12
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BAX16	0.07
BC107	0.18
BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.21
BC116	0.22
BC117	0.26
BC118	0.21
BC125	0.21
BC126	0.22
BC135	0.17
BC136	0.22
BC137	0.22
BC147	0.14
BC148	0.14
BC149	0.15
BC157	0.15
BC158	0.15
BC159	0.15
BC167	0.13
BC170	0.13
BC171	0.13

BC172	0.13
BC173	0.13
BC177	0.32
BC178	0.16
BC179	0.32
BC182	0.35
BC183	0.13
BC184	0.13
BC212	0.13
BC213	0.13
BC214	0.12
BC237	0.13
BC238	0.13
BC301	0.38
BC303	0.39
BC307	0.13
BC308	0.13
BC327	0.14
BC328	0.14
BC337	0.14
BC338	0.14
BCY30	1.44
BCY31	1.73
BCY32	1.73
BCY33	1.27
BCY34	1.15
BCY39	3.91
BCY40	3.22
BCY42	0.35
BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
BCZ11	2.01
BD115	0.48
BD121	1.96
BD123	3.22
BD124	2.30

BD131	0.51
BD132	0.55
BD135	0.46
BD136	0.46
BD137	0.46
BD138	0.55
BD139	0.55
BD140	0.58
BD144	2.30
BD181	1.38
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BD237	0.62
BD238	0.62
BDX10	1.05
BDX32	2.30
BDY20	1.73
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BF115	0.40
BF152	0.18
BF153	0.18
BF154	0.20
BF159	0.20
BF160	0.20
BF167	0.28
BF173	0.35
BF177	0.40
BF178	0.40
BF179	0.40
BF180	0.32
BF181	0.32
BF182	0.35
BF183	0.32
BF184	0.32
BF185	0.35
BF194	0.16
BF195	0.14
BF196	0.15
BF197	0.16
BF200	0.46
BF224	0.29
BF244	0.32

BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.39
BF337	0.38
BF338	0.41
BFS21	4.60
BFS28	2.58
BFS61	0.23
BFS98	0.23
BFW10	1.12
BFW11	1.10
BFX84	0.35
BFX85	0.35
BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
BFY64	0.35
BFY90	1.09
BSX19	0.31
BSX20	0.31
BSX21	0.33
BT106	1.38
BTY79/400R	2.30
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BY100	0.46
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BZX61 Series	0.20
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CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86

CRS3/60	1.04
GEX66	3.45
GEX541	5.75
GJ3M	1.73
GM0378A	2.02
KS100A	0.52
MJE340	0.69
MJE370	0.84
MJE371	0.82
MJE520	0.54
MJE521	0.84
MJE2955	1.50
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MPF102	0.40
MPF103	0.40
MPF104	0.40
MPF105	0.40
MPSA06	0.30
MPSA56	0.32
MPSU01	0.61
MPSU06	0.75
MPSU56	0.79
NE555	0.52
NKT401	4.03
NKT403	2.88
NKT404	2.53
OA5	1.38
OA7	0.69
OA10	0.63
OA47	0.14
OA70	0.29
OA79	0.14
OA81	0.20
OA85	0.20
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.17
OA202	0.17
OA211	1.73
OAZ200	1.73

OAZ201	1.73
OAZ206	1.73
OAZ207	1.73
OC16	2.88
OC20	2.88
OC22	2.88
OC23	4.60
OC24	3.45
OC25	1.15
OC26	1.73
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	1.04
OC42	1.04
OC43	1.73
OC44	0.98
OC45	0.75
OC71	0.63
OC72	1.15
OC73	1.15
OC74	0.81
OC75	0.75
OC76	1.15
OC77	1.15
OC81	0.75
OC81Z	1.38
OC82	1.04
OC83	0.92
OC84	0.92
OC122	3.16
OC123	2.30
OC139	3.45
OC140	4.60
OC141	4.93
OC170	1.44
OC171	1.44
OC200	1.73
OC201	2.88
OC202	3.16

OC203	3.45
OC204	3.45
OC205	3.16
OC206	3.16
OC207	2.88
OCP71	2.30
ORP12	1.15
R2008B	2.30
R2009	2.59
R2010B	2.30
TIC44	0.31
TIC226D	1.38
TIL209	0.18
TIP29A	0.49
TIP30A	0.52
TIP31A	0.38
TIP32A	0.41
TIP33A	0.62
TIP34A	0.77
TIP41A	0.51
TIP42A	0.48
TIP2955	0.81
TIP3055	0.64
TIS43	0.49
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.26
ZS278	0.65
ZTX107	0.14
ZTX108	0.14
ZTX109	0.14
ZTX300	0.15
ZTX301	0.16
ZTX302	0.21
ZTX303	0.21
ZTX304	0.23
ZTX311	0.15
ZTX314	0.29
ZTX500	0.16
ZTX501	0.16

ZTX502	0.21
ZTX503	0.22
ZTX504	0.24
ZTX531	0.28
ZTX550	0.29
1N914	0.06
1N916	0.10
1N4001	0.07
1N4002	0.07
1N4003	0.07
1N4004	0.08
1N4005	0.10
1N4006	0.13
1N4007	0.14
1N4009	0.08
1N4148	0.05
1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.09
1S921	0.10
2G301	1.15
2G302	1.15
2G306	1.15
2N404	1.50
2N696	0.37
2N697	0.37
2N698	0.37
2N705	1.44
2N706	0.29
2N708	0.29
2N930	0.29
2N1131	0.35
2N1132	0.35
2N1302	1.38
2N1303	0.92
2N1304	1.38
2N1305	1.15
2N1306	1.73
2N1307	1.27
2N1308	2.01

2N1309	1.38
2N1613	0.37
2N1671	1.73
2N1893	0.37
2N2147	4.60
2N2148	4.31
2N2218	0.37
2N2219	0.37
2N2220	0.23
2N2221	0.23
2N2222	0.23
2N2223	4.89
2N2368	0.29
2N2369A	0.29
2N2484	0.29
2N2646	0.58
2N2904	0.37
2N2905	0.37
2N2906	0.24
2N2907	0.24
2N2924	0.30
2N2925	0.25
2N2926	0.17
2N3053	0.30
2N3054	0.63
2N3055	0.75
2N3440	0.81
2N3441	0.98
2N3442	1.44
2N3614	2.53
2N3702	0.13
2N3703	0.13
2N3704	0.13
2N3705	0.13
2N3706	0.13
2N3707	0.13
2N3708	0.12
2N3709	0.13
2N3710	0.12
2N3711	0.12

2N3771	1.61
2N3772	1.84
2N3773	2.07
2N3819	0.35
2N3820	0.45
2N3823	0.69
2N3866	1.15
2N3904	0.20
2N3905	0.20
2N3906	0.20
2N4058	0.23
2N4059	0.23
2N4060	0.18
2N4061	0.18
2N4062	0.18
2N4124	0.18
2N4126	0.18
2N4286	0.17
2N4288	0.21
2N4289	0.21
2N5457	0.37
2N5458	0.37
2N5459	0.37
2S017	11.50
2S019	13.80
2S026	28.75
2S103	1.73
2S302	2.30
2S303	4.03
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A2134	20.13
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A2521	24.38
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A3343	51.75
AZ31	1.26
AZ41	1.32
BK448	110.27
BK484	149.09
BS90	52.27
BS810	86.25
BT5	58.13
BT17	106.89
BT19	36.17
BT29	327.69
BT69	333.50
BT75	102.46
BT95	127.02
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CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.50
C3JA	23.23
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DA42	21.51
DA100	97.93
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY87	0.74
DY802	0.96
E55L	25.17
E80CC	11.27
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	13.23
E88C	7.12
E88CC	3.86
E90CC	9.94
E90F	11.39
E91H	5.34
E92CC	9.40
E99F	10.16

E130L	19.39
E180CC	11.39
E180F	7.83
E182CC	13.80
E186F	12.58
E188CC	9.40
E280F	25.88
E283CC	9.02
E288CC	18.54
EA52	28.18
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
EC90	1.28
EC91	9.33
EC92	1.44
EC157	349.26
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.20
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.38
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	3.45
EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	4.03
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.68
EF93	1.15
EF94	1.24
EF95	6.27
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	12.65
EF805S	12.65
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	4.03
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.96
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	13.66
EN91	2.94
EN92	5.23
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.50
M8099	5.98
M8100	9.49
M8136	9.98
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	62.10
MX151	17.25
MX152	143.75
MX161	166.75
MX163	23.11
MX164	27.95
MX166	161.00
MX168	48.30
N78	20.13
OA2	2.30
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

PC97	1.38
PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.84
PCC189	1.61
PCC805	1.51
PCC806	2.07
PCE82	2.07
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	3.74
PCF201	2.45
PCF801	1.84
PCF802	2.19
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL82	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	3.73
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	16.17
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	63.37
QU37	14.38
QV03-12	5.62
QV04-7	2.88
QV08-100	137.08
QY3-65	57.06
QY3-125	62.40
QY4-250	77.05
QY4-400	80.44
QY5-500	168.83

QY5-3000A	356.66
QZ06-20	34.16
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	35.77
RG3-250A	37.49
RG3-1250	63.94
RG4-1250	43.13
RG4-3000	90.36
RR3-250	53.54
RR3-1250	94.83
S11E12	55.20
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	16.98
TT22	16.98
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	105.97
TY5-500	187.45
TY6-800	193.20
TY6-5000A	356.50
TY6-5000B	264.50
TY6-5000W	316.25
TY7-6000A	368.80
TY7-6000W	322.00
TZ40	28.75
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88

UL84	1.38
UM80	1.15
UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	58.02
XG2-6400	113.50
XG5-500	28.23
XG2-6400	155.42
XR1-1600A	58.88
XR1-3200	87.15
XR1-3200A	93.15
XR1-6400	108.30
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	17.86
2J42	109.25
2J55	239.97
2J70A	442.75
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	16.50
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	26.83
3C45	28.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05

4B32	29.16
4C35	74.75
4CX250B	51.75
4CX350A	80.50
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	4.03
5U4G	1.75
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4GT	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	11.96
6CL6	4.12

6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	34.50
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	2.88
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52

12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E1ITT	19.26
12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	55.20
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30PL1	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.75
90AG	14.90
90AV	14.90
90C1	2.81
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.48
150B2	3.47
150B3	6.39
150C2	2.21
150C4	2.75
211	21.85
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	21.08
812A	21.08
813	91.15
833A	153.57
866A	17.56
872A	24.69
922	5.01
931A	18.15
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	123.51
5552A	166.98
5553A	259.10
5642	6.45
5654	3.93
5651	4.66

5670	5.18
5675	21.47
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	6.47
5749	5.14
5751	4.80
5763	4.66
5814A	4.28
5840	5.06
5842	13.90
5876A	19.55
5879	5.38
5886	12.08
5963	3.38
5965	4.00
6005	5.62
6021	5.13
6057	4.02
6058	12.47
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	8.54
6067	4.02
6072	5.80
6080	7.88
6097AxBxC	166.75
6146A	12.24
6146B	9.34
6159B	19.91
6189	10.03
6201	10.92
6442	17.25
6883B	14.64
6973	4.38
7025	2.73
7551	6.45
7586	11.66
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	86.40
8068	6.33
8122	60.11
8136	2.48
8417	6.76
18042	8.63
18045	12.06

Tested Ex-Equipment

4CX250B	5.75

BASES

B7G unskirted	0.25
B7G skirted	0.35
B9A unskirted	0.25
B9A skirted	0.35
Int Octal	0.40
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

2AP1	9.78
2BP1	10.35
3BP1	11.50
3DP1	5.75
3EG1	8.05
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	28.75
DG7-5	72.82
DG7-31	66.78
DG7-32	66.78
DH3-91	67.65
DH7-11	130.09
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.20
7402	0.20
7403	0.20
7404	0.21
7405	0.21
7406	0.49
7407	0.49
7408	0.23
7409	0.23
7410	0.20
7412	0.33
7413	0.37
7416	0.37
7417	0.37
7420	0.21
7422	0.23

7423	0.38
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.35
7433	0.46
7437	0.37
7438	0.37
7440	0.37
7441	1.04
7442	0.83
7447AN	1.35
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.44
7472	0.38
7473	0.44
7474	0.44
7475	0.62
7476	0.48
7480	0.64
7482	0.86
7483	1.15
7484	1.21
7486	0.45
7490	0.69
7491	0.94
7492	0.69
7493	0.69
7494	0.94

7495	0.84
7496	0.94
7497	3.62
74100	1.77
74107	0.52
74109	0.84
74110	0.59
74111	0.82
74116	2.13
74118	1.15
74119	1.77
74120	0.95
74121	0.49
74122	0.71
74123	1.36
74125	0.67
74126	0.67
74128	0.72
74132	0.83

74136	0.59
74141	1.02
74142	2.64
74143	2.99
74144	2.99
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.07
74155	1.04
74156	1.04
74157	0.86
74159	2.53
74170	2.76
74172	5.06
74173	1.63
74174	1.84

74175	1.17
74176	1.33
74178	1.56
74179	1.56
74180	1.38
74190	2.19
74191	2.19
74192	2.19
74193	2.19
74194	1.44
74195	1.38
74196	1.55
74197	1.55
74198	3.11
74199	2.64
76013N	2.02
TAA570	2.65
TAA630S	4.02
TAA700	4.50

TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

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		SN76570N	1.00	TBA480Q	1.25	TDA1004A	2.20	ZTK33B	0.37
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AC141K	0.34	BC161	0.28	BD139	0.32	BF273	0.13	R2322	0.58
AC142K	0.30	BC170B	0.10	BD140	0.30	BF336	0.34	R2323	0.66
AC176	0.22	BC171	0.08	BD159	0.65	BF337	0.29	R2540	2.48
AC176K	0.31	BC171A	0.10	BD166	0.46	BF338	0.32	RCA16334	0.90
AC187	0.25	BC171B	0.10	BD179	0.72	BF355	0.37	RCA16335	0.80
AC187K	0.28	BC172	0.09	BD182	0.70	BF362	0.38	TIP29	0.40
AC188	0.22	BC172B	0.10	BD201	0.83	BF363	0.31	TIP29C	0.42
AC188K	0.37	BC172C	0.10	BD202	0.65	BF371	0.20	TIP30C	0.43
AD142	0.90	BC173B	0.10	BD203	0.78	BF394	0.19	TIP31C	0.42
AD143	0.82	BC174	0.09	BD204	0.70	BF457	0.23	TIP32C	0.42
AD149	0.70	BC182	0.09	BD222	0.46	BF458	0.23	TIP33B	0.75
AD161	0.39	BC182LB	0.10	BD223	0.48	BF459	0.36	TIP41C	0.45
AD162	0.39	BC183	0.12	BD225	0.46	BF595	0.23	TIP42C	0.47
AD161/2	0.90	BC183L	0.09	BD233	0.35	BF597	0.25	TIP47	0.65
AF124	0.34	BC184LB	0.09	BD234	0.35	BFR39	0.23	TIP2955	0.84
AF125	0.32	BC204	0.10	BD236	0.45	BFR41	0.28	TIP3055	0.66
AF126	0.32	BC208B	0.13	BD237	0.30	BFT42	0.28	TIS91	0.20
AF127	0.32	BC212	0.09	BD238	0.33	BFW92	0.85	2N2219	0.28
AF139	0.42	BC212L	0.09	BD410	0.55	BFX29	0.30	2N2905	0.40
AF150	0.42	BC213	0.09	BD434	0.55	BFX84	0.26	2N3054	0.59
AF239	0.42	BC213L	0.09	BD437	0.50	BFX85	0.28	2N3055	0.52
AU106	2.06	BC237	0.09	BD517	0.60	BFX86	0.30	2N3702	0.12
AU107	1.75	BC238	0.09	BD520	0.65	BFX88	0.25	2N3703	0.12
AU110	2.00	BC251a	0.12	BDX32	1.50	BFY50	0.21	2N3704	0.12
AU113	1.48	BC252A	0.15	BF115	0.35	BFY51	0.21	2N3705	0.12
BC107	0.10	BC258A	0.39	BF127	0.24	BFY52	0.25	2N3706	0.12
BC107A	0.10	BC300	0.30	BF158	0.18	BFY90	0.77	2N3708	0.12
BC107B	0.10	BC301	0.30	BF160	0.27	BR100	0.19	2N5294	0.38
BC108	0.10	BC303	0.26	BF167	0.24	BR101	0.30	2N5296	0.48
BC108A	0.10	BC307	0.09	BF173	0.22	BRC4443	0.85	2N5298	0.52
BC108B	0.10	BC327	0.10	BF177	0.38	BT106	1.00	2N5496	0.66
BC108C	0.10	BC337	0.10	BF178	0.26	BT108	1.22	2SA715	0.95
BC109	0.10	BC338	0.09	BF179	0.34	BT116	1.20	2SC495	0.80
BC109B	0.10	BC461	0.30	BF180	0.29	BU105	1.22	2SC496	0.80
BC114	0.11	BC478	0.20	BF181	0.29	BU108	1.69	2SC1096	0.80
BC116A	0.12	BC547	0.10	BF182	0.29	BU124	1.00	2SC1172Y	2.20
BC117	0.19	BC548	0.10	BF183	0.29	BU126	1.22	2SC1173	1.15
BC119	0.24	BC549A	0.08	BF184	0.28	BU204	1.55	2SC1306	1.25
BC125	0.12	BC550	0.07	BF185	0.28	BU205	1.30	2SC1307	1.85
BC140	0.31	BC557	0.07	BF194	0.11	BU208	1.39	2SC1449	0.80
BC141	0.25	BC557B	0.07	BF195	0.11	BU208A	1.52	2SC1678	1.25
BC142	0.21	BC558	0.07	BF196	0.11	BU208/02	1.89	2SC1945	2.10
BC143	0.24	BD115	0.30	BF197	0.11	BU326A	1.42	2SC1953	0.95
BC147	0.09	BD116	0.52	BF198	0.10	BU407	1.24	2SC1957	0.80
BC148A	0.09	BD131	0.32	BF199	0.14	BU500	1.75	2SC1969	1.95
BC148B	0.09	BD132	0.35	BF200	0.30	MJ3000	1.98	2SC2028	1.15
BC149	0.09	BD133	0.40	BF241	0.15	MJE340	0.40	2SC2029	1.60
				BF256	0.28	MJE520	0.48	2SC2078	1.45
				BF256/LC	0.28	MRF450A	11.50	2SC2091	0.85

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AA119	0.08	BY126	0.10	BYX36-150R	0.20	IN4001	0.04	IN5405	0.13
BA102	0.17	BY127	0.11	BYX38-600R	0.60	IN4002	0.04	IN5406	0.13
BA115	0.13	BY133	0.15	BYX55-600	0.30	IN4003	0.04	IN5407	0.16
BA145	0.16	BY164	0.45	BYX71-600	0.60	IN4004	0.05	IN5408	0.16
BA148	0.17	BY176	1.20	OA47	0.09	IN4005	0.05	ITT44	0.04
BA154	0.06	BY179	0.63	OA90	0.05	IN4006	0.05	ITT827	0.48
BA155	0.13	BY206	0.14	OA91	0.06	IN4007	0.06	ITT921	0.09
BA156	0.15	BY208-800	0.33	OA95	0.06	IN4148	0.02	ITT923	0.15
BAX13	0.04	BY210-800	0.33	OA202	0.10	IN4448	0.10	ITT2002	0.11
BAX16	0.06	BY223	0.90	IN60	0.06	IN5401	0.12		
BB105B	0.30	BY298-400	0.22	IN914	0.04	IN5402	0.14		
		BY299-800	0.22			IN5403	0.12		
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B13B	0.50
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CANS	0.27

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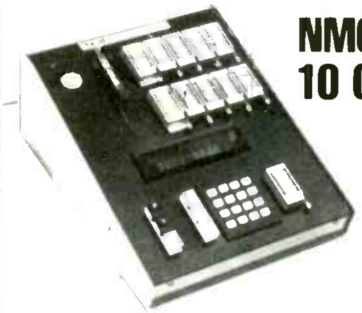

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Bullet

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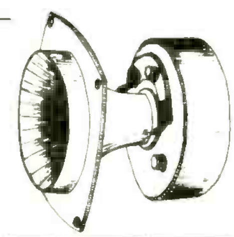
K-3050 SUPER TWEETER



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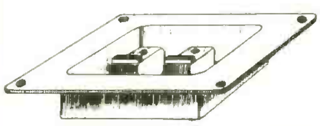

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POWER RELAYS. Plug in octal and 11-Pin 2 and 3 PCO types with 7½ Amp contact ratings. By Schrack, B&R Omron, etc. **Only 2.00p ea.**

ZETTER LOW PROFILE (Type AZ5 and 6)
Just in, a large quantity of 'flat pack' relays in standard, heavy duty and latching types. We can offer these at a fraction of list price in many coil voltages and contact arrangements. Full data supplied on request. Send SAE or ring for list.

DIL Relays
Form A .... **Only 1.00p ea.**

SWITCHES

Special offers include:

ILLUMINATED
Licon 01-800 push fit 2PCO switches. Separate bulb contacts (T¼ flange) 5A rated contacts, lenses included. Latching or momentary action .... **Only 1.50p**
MATCHING INDICATORS .... **60p ea.**
Attention: Licon stocks rapidly diminishing – BUY NOW and SAVE.

ROCKER
Illuminated mains rocker switches, 16A contacts
DPST. Red, push fit, 26x30mm standard type **75p**
SPST. Amber, push fit, 14x30mm standard type **30p**

ROTARY
1P12W, 2P6W, 3P4W Lortin type .... **50p ea.**
2P11W Elma gold plated adjustable. High quality .... **£1 ea.**

MICRO
V3 roller, arm or standard .... **40p ea.**
V4 roller, arm or standard .... **50p ea.**

DIL
4xDPDT; 5xDPDT, gold contacts, by ERG & CTS, only **80p**

Industrial type
2 Pole 12A/600VAC **£1.50**
8 Pole 10A/380VAC **3.00**
10 Pole 12A/600VAC **3.00**

CABLE

Our cable stock must be seen to be believed, so it is impossible to list it all. ELECTRICIANS . . . buy our 2.5mm² for only **£6**/100 and 1.5mm² only **£5**/100. VIDEO CABLE. UR75 75Ω Coax Mil spec. only **£20**/100. BELDEN CABLE. Hook up wire in 24, 20 and 18 AWG. Super prices. MAINS CABLE in 0.5mm², 0.75mm² 1mm², 1.5mm². T.V. DOWNLEAD, excellent rates for 100m. MULTICOES of all types. RIBBON CABLE. We've got it. Why not see for yourself.

SEMICONDUCTORS

We of course carry a full range of transistors, diodes, CMOS, TTL, Linears, Triacs, Thyristors and other devices but lack space to print long boring lists. Suffice to say we will beat most of our competitors on price, availability and quality of product.

The following are available in enormous quantity, generous trade discounts are offered:
BC184L – BUY69C – BFR87 – ZTX342(npn) – ZTX542(pnp)
BY208. Our price **2.00p** – 2N3373. Our price **1.80p**

74LS Series TTL
The following numbers are held in quantity. Maximum savings.
LS01 . . . 02 . . . 10 . . . 11 . . . 30 . . . 73 . . . 75 . . . 76 . . . 138 . . . 175 . . .192 . . . 193 . . . 221 . . . 251 . . . 273 . . . 290 . . . 293
Standard TTL
7401 . . . 02 . . . 04 . . . 05 . . . 15 . . . 20 . . . 25 . . . 75 . . . 86 . . . 123 . . . 452.

Heatsinks
Redpoint TV4 (for TO-220 package .... **15p ea. discount on qty.**
TO5 tpe (50°C/W) .... **8p ea. discount on qty.**

CONNECTORS

RF CONNECTORS
BNC Plug (50R or 75R) **50p**
BNC Line socket **50p**
BNC Chassis socket
Flange **45p**
SHF **45p**
PL259 Plug **40p**
Reducer **14p**
SO239 Flange Chassis socket **40p**
PL258 Double socket **50p**
PL259 to BNC (male) adaptor **1.20p**
PET100 plugs **50p**
PET100 Chassis socket **50p**
N-Type Plugs (Amphenol) ... **75p**
N-Type Chassis sockets (SHF Amphenol) **75p**

MULTIWAY CONNECTORS
We carry good stocks of new and bargain priced used D-Series rectangular connectors from 9 to 50 way.
Example:
New D15 socket **60p**
New D9 plug **60p**

MAINS CONNECTORS
US pattern 2 pin flat plugs, sockets, line sockets **all 20p ea.**
IEC Europlugs .... **Our price only 50p**
Bulgin 3 pin 6 Amp plug and free socket .... **80p pr.**
Cannon LNE latching mains free socket **1.75p**
Chassis mounting plugs... **1.50p**

EDGE CONNECTORS (ALL GOLD PLATED)
0.15 pitch
18 way **80p**
22 way **1.00**
2x22 way **1.50**
0.1 pitch
24 way **1.00**
37 way **1.50**
40 way **1.75**
2x40 way **£2.00.** 78 way **2.50.** 2x78 way **4.50**

AUDIO CONNECTORS
We stock all types of jack, phone and DIN plugs too numerous to list, phone for details. In professional types we have:
CBC Type ring locking multiway connectors fashioned in heavy duty nickel plated steel with cable clamp. In 2, 3, 4, 5 and 6 way .... **Only £1.00 per pr.**
Switchcraft XLR Series, the professionals choice:
A34M 3 pin free plug **1.20p**
A3F 3 pin free skt **1.32p**
D3M 3 pin chassis plug **1.10p**
D3F 3 pin chassis skt. **1.60p**

FUSES: 20mm QB **7p.** AS **10p.** 1¼ inch QB **7p.** A/S **12p.** ⅝ inch **6p each.**
HOLDERS: 20mm P/M **35p.** Chassis mounting **10p.** 1¼ inch Panel mounting **40p.** C/M **10p.** ⅝ inch P/M **25p.**
MAINS FILTERS: Computer grade but ideal for HiFi, etc. 8 or 15 Amp .... **£4 ea.**
SLOW MOTORS: Mains or 115V operation, great for timing purposes or discos .... **£1.50 ea.**
NEON BULBS: We have very large quantities in stock.
QI BULBS: 50W 12V projector type, to clear .... **50p ea.**
LOCTITE: Penetrating adhesive. It really sticks. 50ML for only **£3**
DIGITAL MULTIMETERS: Superb value, copy of professional model. Full ranges and specs. .... **OUR PRICE £40**
TMK500 METERS: Tough dependable Multimeter 20K/V sens. Full ranges in V, A & R. .... **OUR PRICE £24**
CAR SPEAKERS: 3 way 20 watt shelf mounting. 4" Bass driver, 2½" Midrange, 1" Tweeter. Internal passive crossover. Great sound **£32**/pr. **PLUS** 4" driver BALL SPEAKERS, real 20W output, crisp, clean sound, a genuine bargain at .... **£12 pr.**
SOLDER: 60/40 18SWG, 500gm **£6.50.** 250gm **£3.50.**
IRONS: Antex X25 **£4.50.** Antex C15 **£4.50.** 12V 25W Irons **£6.**

This advertisement is mainly of our excess stockholding. We also have excellent stocks of semiconductors, hardware, cables, etc, etc. For further details send for our lists and retail price catalogue, phone or visit our shop. All prices are exclusive of VAT (and P&P). Minimum Mail Order £5 + P&P + VAT. Government departments, schools, colleges, trade and export welcome.

WW – 091 FOR FURTHER DETAILS

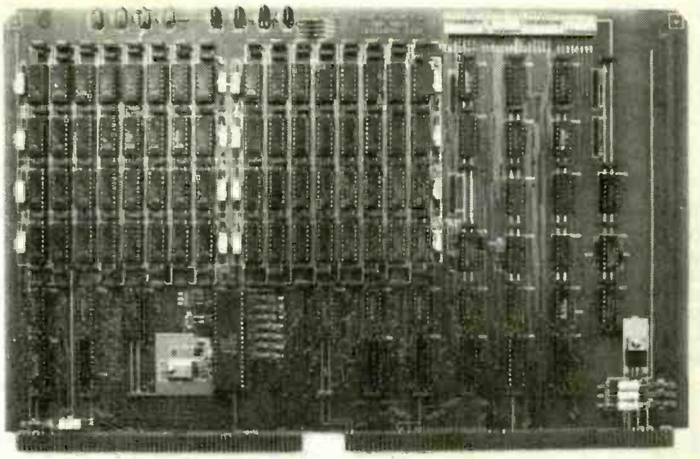
TWO NEW MEMORY PRODUCTS FROM SEED

1) 128K BYTE DYNAMIC RAM

Card for Versabus Systems

Organised as 2 x 64K BYTE Blocks. SWITCHABLE to any 64K boundary, and any combination of supervisor Prog. or data and USER Prog. or data space. On board parity generator/checker.

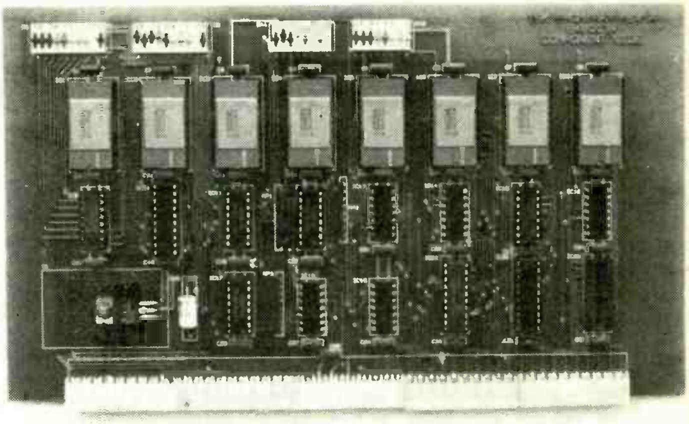
£1403



2) 16K BYTE STATIC BYTEWIDE PROM/RAM CARD

Using the latest bytewide technology this card allows any 2K space to contain static RAM or single rail 2716 EPROM. Two methods of paging are allowed, either software register or 6809 extended address for larger systems.

£245



seed

STRUMECH

PORTLAND HOUSE, COPPICE SIDE, BROWNHILLS, WEST MIDLANDS.

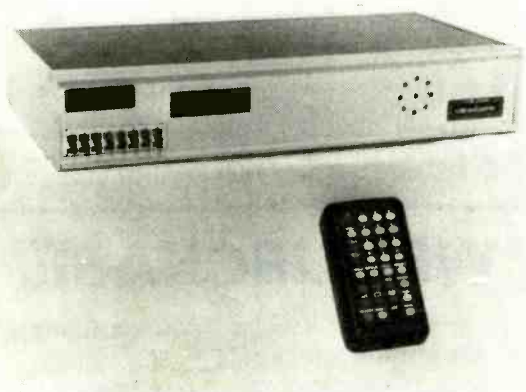
TELEPHONE: BROWNHILLS 78151

WW – 090 FOR FURTHER DETAILS

LION TELETEXT PRESTEL ADAPTOR

why buy two separate adaptors when one will do?

★ PRESTEL



★ TELETEXT

Our adaptor has the plug-in Lion Teletext or Prestel and Teletext board which is used in our Television TXV 56 and our Ferguson Colourstar adaptor. Features include: full infra-red remote control, printer facility, full alphanumeric keyboard or microcomputer input, cassette recording output, autodial of Viewdata numbers, eight-page memory option, local editing facility and many other features.

Realistic Prices:

AXV03 £250 AXV04 £199 (Teletext only)

LION TV, 18 HARCOURT TERRACE LONDON SW10. 01-373 5218

WW – 085 FOR FURTHER DETAILS

FROM A NEW COMPANY WITH NEW IDEAS

SOMETHING SPECIAL

BATTERIES
BOXES
BOARDS
CAPACITORS
RESISTORS
CONNECTORS
CABLES
COAX
FLAT RIBBON
POTS
SWITCHES
RELAYS
CMOS
TTL LS
TTL
MEMORIES
SUPPORT CHIPS
LINEAR
OP. AMPS
COMPARATORS
A-D D-A
OPTO
LEDS
DISPLAYS
LCDs
TRANSISTORS
THYRISTORS
TRIACS
DIODES
BRIDGES
METERS
ZENERS
SOLDERING IRONS
IC SOCKETS

AIRWAVES ELECTRONICS INVITE YOU TO OPEN YOUR OWN PERSONAL ACCOUNT.

THERE COULDN'T BE AN EASIER WAY TO BUY COMPONENTS, ONCE YOU HAVE OPENED YOUR ACCOUNT. JUST PHONE OR WRITE YOUR ORDER THROUGH, STATING YOUR ACCOUNT NUMBER TOGETHER WITH YOUR OWN SECURITY CODE NUMBER AND GOODS WILL BE DESPATCHED SAME DAY AND YOUR ACCOUNT DEBITED WITH THE COSTS.

MAYBE YOU'RE THINKING – YOU'LL HAVE TO PAY OVER THE ODDS FOR THIS, BUT YOU WILL BE WRONG. ACCOUNT CUSTOMERS WILL RECEIVE OUR PRODUCT-PACKED CATALOGUE SHOWING V.A.T. INCLUSIVE PRICES, WHICH WE BELIEVE TO BE VERY COMPETITIVE. AFTER ALL YOU'RE THE BEST JUDGE AND WE DO OFFER SOMETHING SPECIAL.

IF YOU WOULD LIKE TO OPEN YOUR ACCOUNT, THEN PLEASE CONTACT US FOR APPLICATION DETAILS ENCLOSING JUST A STAMP TO COVER POSTAGE.

AND, OF COURSE, CALLERS ARE ALWAYS WELCOME AT OUR CAMBERLEY ADDRESS.

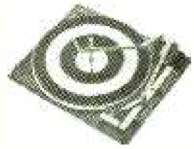
AIRWAVES ELECTRONICS

151 LONDON ROAD, CAMBERLEY, SURREY GU15 3JY
TELEPHONE: (0276) 62949

WW – 099 FOR FURTHER DETAILS

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

BSR DE LUXE AUTOCHANGER £20



Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½×11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in.
Post £2 Board £1 extra

HEAVY METAL PLINTHS Post £2

Cut out for most BSR or Garrard decks. Silver grey finish. Size 16x13¾in. **£4**

DECCA TEAK VENEERED PLINTH. Post £1.50
Superior finish with space and panel for small amplifier. Board is cut for B.S.R. 18¾in.×14¼in×4in. Black/silver facia trim. Also with boards cut out for Garrard only £3. **Plastic cover £6** **£5**

TINTED PLASTIC COVERS Post £2

17⅞×13⅛×3¼in.	£6		18¼×12½×3in.	£6	
17¼×9⅜×3½in.	£3		14⅜×12½×2⅞in.	£5	
13¾×12×2¼in.	£5		16⅝×13×4in.	£6	
15¼×13½×4in.	£6		14½×13⅛×2¾in.	£5	
17¼×13⅛×3⅛in.	£6		17¼×13¾×4⅛in.	£6	
21½×14¼×2½in.	£6		21×13⅞×4⅛in.	£6	
23¾×14×3⅞in.	£6		30¾×13⅝×3¼in.	£6	

BSR SINGLE PLAYER DECKS

BSR P172 RIM DRIVE QUALITY DECK
Manual or automatic play
Precision ultra slim arm.
Cueing device. Bargain price
With stereo ceramic cartridge **£20** Post £2

BSR P207 BUDGET SINGLE PLAYER ideal for disco or small two-speed Hi-Fi system with stereo cartridge and cueing device. **£15** Post £2

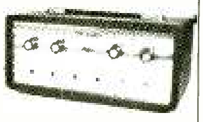
BSR ready cut mounting board. Only £1 extra.

GARRARD 6-200 SINGLE PLAYER DECK
Brushed Aluminium Arm with stereo ceramic cartridge and Diamond Stylus, 3-speeds. Manual and Auto Stop/Start. Large Metal Turntable. Cueing Device and Pause Control. Ready cut mounting board £1 extra. **£20** Post £2

BATTERY ELIMINATOR MAINS to 9 VOLT D.C.
Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5 x 3¼ x 2½in. Transformer Rectifier Unit. Suitable Radios, Cassettes, models, £4.50. Post 65p.
DELUXE SWITCHED MODEL STABILISED VOLTAGES 3-6-7½-9 volt 400ma DC max. Universal output plug and lead. Pilot light, mains switch, polarity switch, **£7.50.** Post 65p.

DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy to build kit. Controls up to 480 watts AC mains, £3. Post 65p.
DE LUXE MODEL READY-BUILT 800 watts. Front plate fits standard box, £5.

ECHO CHAMBER £68. Post £2



Good quality unit with endless play tape cartridge. Stationary play heads ensure good reproduction and echo variance is achieved by changing tape speed. Input imp: 50k and 600 ohms. Power: 240 volts A.C.

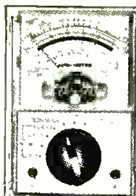
RELAYS. 12V DC **£1.25.** 6V DC **95p.** 18V **£1.25.**
BLANK ALUMINIUM CHASSIS. 6×4–**£1.45**; 8×6–**£1.80**; 10×7–**£2.30**; 12×8–**£2.60**; 14×9–**£3.00**; 16×6–**£2.90**; 16×10–**£3.20.** All 2½in. deep. 18 swg
ANGLE ALI. 6×¾×¾in. 18 swg. **25p.**
ALUMINIUM PANELS, 18swg. 6×4–**45p**; 8×6–**75p**; 14×3–**75p**; 10×7–**95p**; 12×8–**£1.10**; 12×5–**75p**; 16×6–**£1.10**; 14×9–**£1.45**; 12×12–**£1.50**; 16×10–**£1.75.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
ALUMINIUM BOXES. 4×4×1½ **£1.** 4×2½×2 **£1.** 3×2×1 **£1.** 6×4×2 **£1.60.** 7×5×3 **£2.40.** 8×6×3 **£2.50.** 10×7×3 **£3.** 12×5×3 **£2.75.** 12×8×3 **£3.60.** All with lids.
BRIDGE RECTIFIER 200V PIV 2a **£1.** 4a **£1.50.** 8a **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **1p**: 2W **10p.**
HIGH STABILITY. ½w 2% 10 ohms to 1 meg. **8p.**
Ditto 5%. Preferred values, 10 ohms to 10 meg, **3p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **20p**
PICK-UP CARTRIDGES SONATONE 9TA **£2.50.** 9TAC **£3.80**
BSR Stereo Ceramic SC7 Medium Output **£2.** SC12 **£3.**
PHILIPS PLUG-IN HEAD. Stereo Ceramic. AU1020 (G306 - GP310 - GP233 -AG3306 - AG3310) **£2.**
LOCKTITE SEALING KIT DECCA 118. Complete **£1.**
ANTEX SOLDERING IRON 240V 15W. 3mm bit **£4.75.**
JACK PLUGS Mono Plastic **25p**; Metal **30p.**
JACK PLUGS Stereo Plastic **30p**; Metal **35p.**
JACK SOCKETS Mono Open **20p**; Closed **25p.**
JACK SOCKETS Stereo Open **25p**; Closed **30p.**
FREE SOCKETS – Cable end **30p.** Metal **45p.**
2.5mm and 3.5mm **JACK SOCKETS 20p. Plugs 20p.**
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin **10p.** Free Sockets 3-pin, 5-pin **25p.**
Plugs 3-pin **20p**; 5-pin **25p.**
PHONO PLUGS and SOCKETS ea **15p.**
Free Socket for cable end **20p.** Screened Phono Plugs **25p.**

U.H.F. COAXIAL CABLE SUPER LOW LOSS, 25p yd.
COAX PLUGS 20p. COAX SOCKETS 20p.
NEON PANEL INDICATORS 250V 30p.
ILLUMINATED ROCKER SWITCH. Single pole. Red **65p.**

POTENTIOMETERS Carbon Track

5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.**

MINI-MULTI TESTER



Deluxe pocket size precision moving coil instrument. Impedance + Capacity – 2000 o.p.v. Battery included.
11 instant ranges measure:
DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0-100mA.
Continuity and resistance to 1 meg ohms in two ranges.

£6.50 Post 65p

De-Luxe Range Doubler Model, 50,000 o.p.v. £18.50. 7 × 5 × 2in. Post £1

NEW PANEL METERS £6

50μa 100μa, 500μa, 1ma, 5ma, 50ma, 100ma, 25 volt, 50 volt, VU Meter. 500ma, 1 amp, 2 amp
Facia 2⅜×1¾×1½in.

Post 65p

RCS SOUND TO LIGHT CONTROL KIT

Kit of parts to build a 3 channel sound to light unit. 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. **£15** Post 95p
Cabinet £4.50 extra. Will operate from 200MV to 100 watt signal.
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4**, or 12 for **£7.50.** Post 65p.

RCS "MINOR" 10 watt AMPLIFIER KIT £14

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14**; Stereo, **£20.** Post £1. Specification 10W per channel; input 100mV; size 9½ × 3 × 2in. approx. SAE details. Full instructions supplied. AC mains powered.
Input can be modified to suit guitar.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board. Can be ganged to make multi-way stereo mixers **£2.95** Post 65p

MAINS TRANSFORMERS

		Post
250-0-250V 70mA, 6.5V, 2A	**£4.50**	£2
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	**£5.00**	£2
350-0-350V 250mA, 6.3V 6A CT	**£12.00**	£2
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	**£10.00**	£2
220V 45mA, 6.3V 2A	**£2.50**	£1

STEP DOWN 115V to 240V 150W **£9.** 250W **£10.** 400W **£11.** 500W **£12.** £2.

GENERAL PURPOSE LOW VOLTAGE

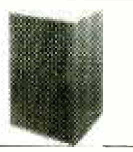
Tapped outputs available

2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	**£6.00**	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£6.00**	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£9.50**	£2
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£12.50**	£2
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£16.00**	£2

5-8-10-16V. ½ amp.	**£2.50**	80p	15-0-15V. 2 amps	**£3.75**	£1
6V. ½ amp.	**£2.00**	£1	17-0-17V. 2 amps	**£4.50**	£2
6-0-6V. ½ amp.	**£3.50**	£1	18V 6a Twice	**£11.00**	£2
9V. 250ma.	**£1.50**	80p	20V 1 amp	**£3.00**	£1
9V. 3 amp	**£3.50**	£1	20-0-20V 1 amp	**£3.50**	£1
9-0-9V. 50ma	**£1.50**	80p	20-40-60V 1 amp	**£4.00**	£2
10-0-10V. 2 amps	**£3.00**	£1	25-0-25V 2 amps	**£4.50**	£1
10-30-40V. 2 amps	**£3.50**	£1	28V 1 amp Twice	**£5.00**	£2
12V. 100ma	**£1.50**	80p	30V 1½ amp	**£3.50**	£1
12V. 750 ma	**£2.00**	80p	30V 5 amp and 17-0-17 2a	**£4.50**	£2
12V 3 amps	**£3.50**	£1	35V 2 amps	**£4.00**	£1
12-0-12V. 2 amps	**£3.50**	£1			

CHARGER TRANS	Post	RECTIFIERS	Post
6-12 volt 3a	**£4.00**+£2	6-12 volt 2a	**£1.10**+80p
6-12 volt 4a	**£6.50**+£2	6-12 volt 4a	**£2.00**+80p

OPUS COMPACT SPEAKERS



FLUTED WOOD FRONTS
TEAK VENEERED CABINET
11×8½×7in, 15 watts
50 to 14,000 cps. 4 ohm or 8 ohm
£20 pair Post £2

LOW VOLTAGE ELECTROLYTICS **ALL 10p**
1 mf, 2 mf, 4 mf, 8 mf, 10 mf, 16 mf, 25 mf, 30 mf, 50 mf, 100 mf, 250 mf. All 15 volts. 22 mf/6v/10v; 25 mf/6v/10v; 47 mf/10v; 50 mf/6v; 68 mf/6v/10v/16v/25v; 100 mf/10v; 150 mf/6v/10v; 200 mf/10v/16v; 220 mf/4v/10v/16v; 330 mf/4v/10v; 500 mf/6v; 680 mf/6v/10v/16v; 1000 mf/2.5v/4v/10v; 1500 mf/6v/10v/16v; 2200 mf/6v/10v; 3300 mf/6v;
4700 mf/4v. **ALL 10p.**
500mF 12V **15p**; 25V **20p**; 50V **30p.**
1000mF 12V **20p**; 25V **35p**; 50V **50p**; 100V **70p.**
2000mF 6V **25p**; 25V **42p**; 40V **60p**; 1200mF 76V **80p.**
2500mF 50V **70p**; 3000mF 50V **65p**; 2000mF 100V **£1.20.**
4500mF 64V £2. 4700mF 63V **£1.20.** 2700mF/76V **£1.**

HIGH VOLTAGE ELECTROLYTICS

8/450V	**45p**	8+8/450V	**75p**	32+32+16/350V	**90p**
8/800V	**£1.20**	8+16/450V	**75p**	100+100/275V	**65p**
16/350V	**45p**	20+20/450V	**75p**	150+200/275V	**70p**
32/500V	**75p**	32+32/350V	**50p**	220/450V	**95p**
32/350V	**50p**	32+32/500V	**£1.80**	32+32+32/325V	**75p**
50/500V	**£1.20**	50+50/300V	**50p**	50+50+50/350V	**95p**

VALVE OUTPUT Transformers (small) **90p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CAPACITORS Various 10pf to 100,000pf **5p.**
PAPER 350V-0.1 **7p**; 0.5 **13p**; 1mF 150V **20p**; 2mF 150V **20p**; 500V-0.001 to 0.05 **12p**; 0.1 **15p**; 0.25 **25p**; 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 30p.
SUB-MIN MICRO SWITCH, 30p. Single pole changeover.
TWIN GANG, 120pF **50p.**
GEARED TWIN GANGS 25pF **95p.** 365pF **£1.**
GEARED 365+365+25+25pF **£1.**
TRANSISTOR TWIN GANG. Japanese Replacement **50p.**

HEATING ELEMENTS, WAFER THIN
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal, etc.
ONLY **60p** EACH (FOUR FOR **£2**) ALL POST PAID.

NEW baker Star sound

high power full range quality loudspeakers produced to give exceptional reproduction. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling is required with quality results. The high flux ceramic magnet ensures clear response.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
MAJOR	12	4-8-16	30	HI-FI	£14	£2
DELUXE MK II	12	8	15	HI-FI	£14	£2
SUPERB	12	8-16	30	HI-FI	£24	£2
AUDITORIUM	12	8-16	45	HI-FI	£22	£2
AUDITORIUM	15	8-16	80	HI-FI	£34	£2
GROUP 45	12	4-8-16	45	PA	£14	£2
GROUP 75	12	4-8-16	75	PA	£22	£2
GROUP 100	12	8-16	100	PA	£24	£2
GROUP 100	15	8-16	100	PA	£32	£2
DISCO 100	12	8-16	100	DISCO	£24	£2
DISCO 100	15	8-16	100	DISCO	£32	£2

BAKER 150 WATT MIXER/POWER AMPLIFIER £89 Post £2 SLAVE VERSION £75

For Organs, Discotheque, Vocal, Public Address. Three loudspeaker outlets for 4, 8 or 16 ohms. Four high gain inputs, each 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts into 8 ohms R.M.S. Music Power. Distortion less than 1%. Slave output 500 M.V. 25K.ohm. Frequency Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Compact – 16" x 8" x 5½". Lightweight – 14lb: Master volume control. Made in England. 12 months' guarantee. 200/250v A.C. mains or 120V to order. All transistor and solid state devices. 100 Volt Line £15 extra.
BAKERS NEW PA150 MICROPHONE PA AMPLIFIER £129. Post £3
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo/send/return socket. Slave input/output sockets.

BAKER 50 WATT AMPLIFIER

£69 Post £2
Ideal for Halls/PA systems, Discos and Groups. Two inputs. Mixer, Volume Controls, Master Bass, Treble and Gain.

RCS offers MOBILE PA AMPLIFIERS. Outputs 4-18-16 ohms
20-watt RMS 12v DC, AC 240v, 3 inputs. 50K £46 (PP £2).
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Mic 1; Mic 2; Phono; aux. outputs 4 or 8 or 16 and 100v line
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FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
SEAS	TWEETER	4in	50	8	£9.50	£1
GOODMANS	TWEETER	3½in	25	8	£4.00	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
GOODMANS	HIFAX	7½x4¼	100	4/8/16	£22	£2
SEAS	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	5in	80	8	£12.00	£1
SEAS	MID-RANGE	4½in	100	8	£12.50	£1
AUDAX	WOOFER	8in	40	8	£14.00	£2
CELESTION	DISCO	10in	20	8/16	£11.50	£2
CELESTION	DISCO	10in	60	8/16	£21.50	£2
RIGONDA	GENERAL	10in	15	8	£5.50	£2
AUDAX	WOOFER	10in	50	8	£16.00	£2
GOODMANS	AUDIOM PG	12in	60	8	£20.00	£2
GOODMANS	PP12	12in	75	8/15	£24.50	£2
GOODMANS	AUDIOM P	12in	50	8/15	£20.00	£2
GOODMANS	GR12	12in	90	8/15	£27.50	£2
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CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. 20 watt rating **£2.20.** 3 way 60 watt **£6.**
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3 ohm, 4in, 5in, 7×4in, **£1.50**; 6½in, 8×5in, **£3**; 8in, **£3.50.**
8 ohm, 2⅝in, 3in, 5in, **£1.50**; 6½in, **£3**; 8in, **£4.50**; 12in, **£6.**
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25 ohm, 3in, 5×3in, 7×4in, **£1.50.** **120 ohm,** 3¼in dia. **£1.**

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3⅜ square **£5**
100 watts. No crossover required 4-8-16 ohm, 7⅜x3⅛ **£10.50**

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South Africa: Central News Agency Ltd, P.O. Box 1033, Johannesburg

Spain: Comercial Atheneum s.a. Consejo de Ciento, 130-136 Barcelona 15

Sweden: Wennegren, Williams A B. Fack S-104, 25 Stockholm 30

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Reader Enquiry Service
429 Brighton Road
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WIRELESS WORLD Wireless World, January 1982 WW 261

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To become a subscriber to Wireless World please complete the reverse side of this form and return it with your remittance to:

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WIRELESS WORLD Wireless World, January 1982 WW 261

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Advertisements accepted up to 12 noon Monday January 4th, for February issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £13.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £2.50 per line, minimum 5 lines. (Prepayable).
BOX NUMBERS: £1.50 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.)
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ELECTRONIC COMPUTER AND MANAGEMENT APPOINTMENTS LIMITED
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(1458)

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to take day-to-day responsibility for Medical Electronics Section of the Medical Physics Department providing a full range of electronic support to Hospitals and Units.

Extensive experience of Medical Electronics essential, with a minimum qualification of O.N.C. Preference given to applicants holding H.N.C. or equivalent.

Further details from Mr. P. E. Ward, Principal Physics Technician, Telephone: (0223) 245151, Extension 471.

Application form and job description from the Personnel Department, Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ, Ext. 7350.

Closing date for completed applications: January 18, 1982.

(1439)

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need an

ENGINEER

for varied and interesting work in a thriving research and development department.

If you are self-motivated, energetic and have practical experience in Audio/Digital electronics, contact–

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Chaul End Lane
Leagrave, Luton, Bedfordshire

(1457)

TELEVISION BROADCASTING

In spite of the recession LINK ELECTRONICS still continues to grow rapidly, and needs to recruit engineers for the expansion of existing departments and for entirely new fields.
We are one of the larger manufacturers of television studio products in Europe. Our range includes broadcast colour cameras together with the design and construction of Television Studios and Outside Broadcast Vehicles.

T.V. STUDIO PROJECT ENGINEER

An experienced engineer is needed to work on design and project management of O.B. vehicles and T.V. studios. Our custom-built systems require a high degree of customer contact from initial design concept through manufacturing to delivery, installation and commissioning.
You should have a knowledge of T.V. studio engineering gained from experience in this type of work or from the operational side of television.

T.V. SYSTEMS PROPOSALS ENGINEER

In addition to a good working knowledge of the requirements of T.V. studio engineering, you should have a degree of commercial experience enabling you to deal with the preparation of quotations for home and overseas projects, this will enable you to progress into negotiating contracts with customers after a suitable settling in period.

VIDEO MONITOR AND V.D.U. SALES ENGINEER

This new position is an opportunity for a sales-minded engineer to join our sales team to develop the market for our range of video monitors and computer terminals. Under the guidance of our Sales Director you will be able to formulate your strategy within the expanding data displays market.
A knowledge of computer peripheral users, especially O.E.M.s, is essential. You should be aged between 25 to 35 and be prepared to travel extensively throughout the U.K. for which a company car will be provided.

SALES SUPPORT ENGINEER (Vision mixers)

An electronic engineer with a background in T.V. studio engineering is required to join our sales support team to work on commissioning, demonstration and after-sales activities of the GRASS VALLEY range of studio vision mixers and video switching systems.
You should have a working knowledge of modern analogue and digital circuitry and be prepared to travel as necessary.

TEST ENGINEERS – STUDIO PRODUCTS

Qualified engineers are required for test and quality assurance duties on our exciting range of broadcast T.V. studio products. You will be involved in testing and checking to spec. products ranging from simple amplifiers to complete studio colour cameras and digital test equipment.
You should be qualified to at least H.N.D./H.N.C. Level and be familiar with modern digital and analogue circuitry. At least three years' experience since qualifying is considered essential for the present level of vacancies.

MICROWAVE SYSTEMS ENGINEER

This is a senior appointment. You will be required to head up a new engineering department and create a product range of new microwave communications equipment for sale throughout the world.
You should be qualified to degree level, have experience of microwave engineering, and of running a small engineering department.

Competitive salaries, backed by free life and health insurance plus contributory pension scheme.
Generous financial assistance with relocation where appropriate to help successful candidates move to Andover, located in a pleasant part of rural Hampshire within easy reach of London and the South Coast.

Please write or telephone our Personnel Department on Andover (0264) 61345 for an application form or alternatively let us have full details of your background and experience.

PLEASE NOTE OUR OFFICE IS CLOSED FROM THE 24th DECEMBER, 1981, TO THE 3rd JANUARY, 1982, INCLUSIVE.

LINK ELECTRONICS

Walworth Industrial Estate,
Andover, Hampshire, England

Telephone: Andover (0264) 61345

(1447)

METROPOLITAN POLICE

Telecommunications Technical Officers

Vacancies for Telecommunications Technical Officers Grades II and III exist in the Operations (Technical) Support Group of the Chief Engineer's Department.

Duties vary according to post but include the planning, installation, modification and maintenance of a wide range of advanced telecommunications equipment. Such equipment includes mobile and hand held radios, transmitter/receiver sites and base stations, C.C.T.V. and Video/Audio recorders, computer terminals (V.D.U. and printers), microprocessor control, alarm systems and a central systems complex.

Candidates should possess an ONC in Engineering or an equivalent City & Guilds/TEC qualification. Candidates for Grade III posts should have a total of 4 years training and experience with a further 3 years experience for Grade II posts.

Posts are in Central London, Hendon and Thornton Heath.

Salary: (National) Grade III Posts £5,712 to £7,702.
Grade II Posts £7,702 on entry rising to £8,553.

In addition to the above a London Weighting allowance of £1,087 p.a. is payable in inner London and £454 p.a. at Hendon and Thornton Heath.

Annual Leave: 4 weeks 2 days rising to 6 weeks with an additional 10½ days public and privilege holidays.

Non-contributory pension scheme.

There are good prospects for promotion and assistance is given for further educational studies where appropriate.

For further details and an application form apply to:
The Establishment Officer,
Room 213 (/TTO),
105, Regency Street,
LONDON SW1P 4AN.

Telephone: 01-230 3122 (24 hour answering service).

Closing date for return of application forms is 15th January 1982.

(1440)

SENIOR PROJECT LEADER
to carry out support work on Electronic Telephone Exchange; to **£14,000 – Berks.**

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to work on Hardware and Software for military projects; to **£10,000 – Hants.**

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to teach Hardware and Software aspects of office equipment; to **£11,300 – Berks.**

FIELD SALES ENGINEER
to sell Microcomputer Systems; to **£16,000 – Herts.**

RF DEVELOPMENT ENGINEERS
to work on Radio Paging Systems; to **£14,000 – London**

Phone or write: Anthony Giles, M.Sc.Eng., M.I.E.E.

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24-hour service

(1119)

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Colin Arnold
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London W3 9BR
Or phone 01-992 8647
(24-hour service)

(1453)

ATE TEST PROGRAMMERS

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TESTECH is seeking experienced digital and analog engineers to join its team developing and commissioning ATE test programs for its international customer base.

Engineers new to ATE will be trained but must be well grounded in the use of modern LSI components.

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Tel: (0202) 735252, or write to:
TESTECH LIMITED, 129 Commercial Road
Parkstone, Poole, Dorset BH14 0JD.

(1420)

MANCHESTER POLYTECHNIC
Educational Services Unit

Senior Technician (Electronics Egineer)

Reliable, experienced person required with responsibility for maintaining, through a qualified team of technicians, the functions provided by the unit, particularly on the Didsbury site. Briefly, these services include Television, Audio-Visual and Workshop facilities throughout the campus. The person appointed will have special responsibility for the Television Studio engineering, electronics servicing and development and will, therefore, be expected to have appropriate qualifications to deal with the range of television, projection and sound equipment used in the Polytechnic.

A union membership agreement is in operation under which new employees are required to join a recognised union.

Salary scale (T5), £7,371-£7,875.

For further particulars and application form (returnable by January 8, 1981) send a self-addressed envelope marked "T/585" to the Secretary, Manchester Polytechnic, All Saints, Manchester, M15 6BH.

(1423)

ITN

SENIOR MAINTENANCE ENGINEERS

Salary £12,877 p.a.

Independent Television News Ltd. has vacancies for Senior Engineers in the following Maintenance sections at ITN House, London W1.

Senior Engineer VTR & Telecine Maintenance

(Ref. 303010)

The successful candidate will join the expanding Facilities Maintenance team responsible for the maintenance of VTR and Telecine equipment including ACR25B, VPR2B, VR1200C, BVU and standard U-Matics, Cintel Mk III and associated control and editing systems.

Previous maintenance experience with at least some of this range of equipment is essential.

Senior Engineer Radio Links Maintenance

(Ref. 303002)

The successful candidate will be a member of the small team responsible for the maintenance of our Radio Link equipment and extensive R/T network. This is a rapidly expanding field following the successful introduction of Electronic News Gathering to ITN.

Previous maintenance experience with RF systems is essential.

Senior Engineer Vision Equipment Maintenance

(Ref. 302004)

ITN is seeking a senior engineer to work in the Central Maintenance section. This section is responsible for maintaining not only all our Studio equipment, including Marconi Mk 9 cameras, CD480 mixers, Quantel DPE5001, Aston Character Generators and the usual ancillaries, but also such equipments as DICE and ACE digital converters, Oracle and Graphics computer systems.

Previous maintenance experience with Broadcast studio equipment is essential. It would be of considerable advantage to have some practical experience with computer or microprocessor systems.

Good prospects exist, in all the above posts, for promotion with experience to Supervisory Engineer.

Generous pension scheme, free life insurance.

Please telephone the Personnel Office on 01-637 3144 for an application form, quoting the relevant reference number.

(1426)

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01-290 0267

LOGEX

ELECTRONICS RECRUITMENT SERVICE
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GLOUCESTERSHIRE GL5 2PW
TEL. 0453 883264, 01-290 0267

(321)

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Small and progressive company servicing educational audio and AV systems, requires versatile and self-motivated engineer for field maintenance and refurbishment work in S.E. England. Microprocessor or video experience advantageous, as there is scope for further responsibilities contributing to the growth of the operation. Salary negotiable to £8,000 with car. Please write with detals of experience and qualifications to:

Bellnorgis Limited
9/11 Kensington High Street
London W8 5NP

(1455)

FIELD SERVICE ENGINEERS

C£7,000 plus car, expanding dynamic group, computer peripherals. Various UK opportunities HNC (or ex-service) standard product training given.
For further information please phone:
03843-4436
Jonathon Lee Technical Recruitment
62 Hagley Road
Stourbridge

(1419)

Trainee Broadcast Engineers

One of our main functions is to build, operate and maintain a network of Transmitting Stations which broadcast the programmes of Independent Television and Independent Local Radio.

With the introduction of the Fourth Television Channel and the expansion of independent local radio services, the network of transmitting stations is steadily growing to the extent of over 686 transmitting stations nationwide; providing a challenging and secure working environment.

Broadcast Engineers are responsible for the operation and maintenance of our transmitting stations and applications are now invited from people who wish to train as Broadcast Engineers and embark on our next training programme which commences this summer.

Applicants (male or female) should be qualified, or about to qualify to HNC/HTC level, in Electrical or Electronic Engineering.

Consideration will also be given to applicants at the City and Guilds Full Tech. and the CNAA pass degree level who have also gained their qualification in the same engineering disciplines.

The residential training course will commence in June 1982 and will occupy 18 months. It will be conducted at the Authority's Harman Engineering Training College, Seaton in Devon and also at a leading Polytechnic. The course is designed to give you a grounding in broadcast engineering that is second to none.

During the course we will pay your fees, accommodation, meals and assistance will be given if you do not already possess a full driving licence.

Your salary on satisfactory completion of the training, will be £7,425 and will then rise annually to £9,205 per annum, with further progression possible to £11,410 per annum. Your initial salary while training will be in the range of £5,333-£5,973 per annum.

Additionally we offer you a generous range of benefits including a free life assurance and personal accident scheme, a contributory pension scheme, generous relocation expenses and subsidised mortgage facilities.

For a fully illustrated information package and application form, please write to Mike Wright, Personnel Officer - Engineering Regions at IBA, Crawley Court, Winchester, Hants, SO21 2QA. Or telephone the Personnel Office between the hours 9 a.m. and 4 p.m. on Winchester 822574 or 822273.

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(1427)

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SENIOR ELECTRONICS TECHNICIAN

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Application form and job description from Sector Personnel Officer by January 8, 1982.

(1444)

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(1425)

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Capital Radio has a vacancy for a Maintenance Engineer within its Engineering Department. Candidates should be qualified to H.N.C. or degree level in a relevant subject and be experienced in maintaining modern studio and radio broadcasting equipment to the highest engineering standards. The successful applicant may be required to work on a shift rota – which includes weekends – and on operational duties such as outside broadcasts. He/she would normally be working on the instructions of the Maintenance Supervisor but would also be expected to work for periods unsupervised. The opportunity may arise for some development work.

Starting salary will be dependent upon qualifications and experience and will be on an incremental scale rising to £11,169 per annum, including shift enhancement.

Applications should be in writing and addressed to Peggy Davidson, Head of Administration, Capital Radio Ltd., P.O. Box 194, London, NW1 3DR – to be received no later than December 24, 1981.

(1449)

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NORTH DISTRICT

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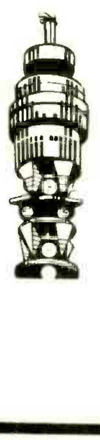

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IR. £12,500

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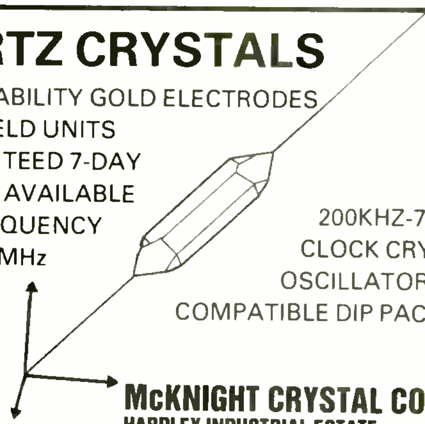

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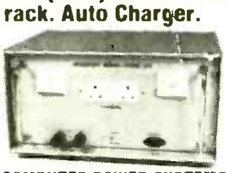

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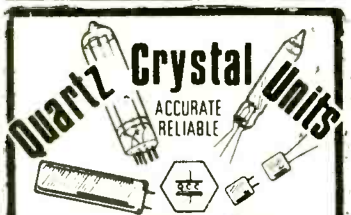

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United States of America: Ray Barnes, IPC Business Press, 205 East 42nd Street, *New York*, NY 10017 – Telephone: (212) 867-2080. Telex: 238327.
Mr Jack Farley Jnr., The Farley Co., Suite 1584, 35 East Walker Drive, *Chicago*, Illinois 60601 – Telephone: (312) 63074.
Mr Victor A. Jauch, Elmatex International, P.O. Box 34607, *Los Angeles*, Calif. 90034, USA – Telephone (213) 821-8581 – Telex: 18-1059.
Mr Jack Mentel, The Farley Co., Suite 650, Ranna Building, *Cleveland*, Ohio 4415 – Telephone: (216) 621 1919.
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Mike Loughlin, IPC Business Press, 15055, Memorial Ste 119, *Houston*, Texas 77079 – Telephone (713) 783 8673.

Canada: Mr Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269.
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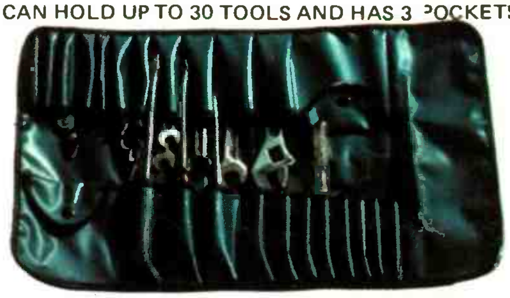

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