ELECTRONICS COMPUTING COMMUNICATIONS BROADCASTING AUDIO AND VIDEO

# wireless world

JULY 1982 70p

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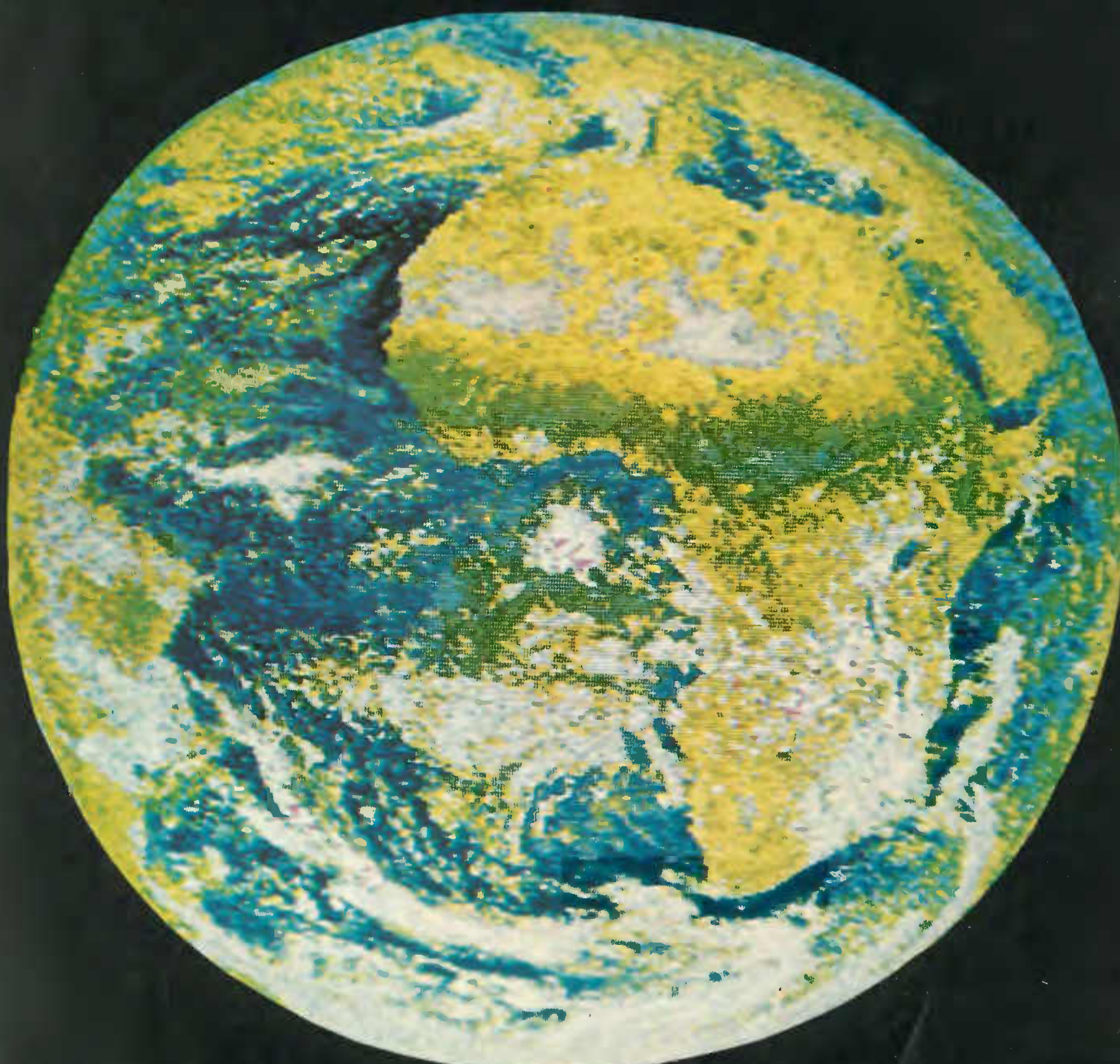
## Printer mechanism interface

## V.d.u. light pen



## G.P.I.B./serial interface

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# ORYX

## the new name in quality solder

Now there is another choice in high quality solder. The new Oryx resin cored solder. Try it and you will find it spreads easier than the solder you are using.
Specially formulated for fast precision solder work, it is 60% tin, 40% lead alloy with quality flux construction and melts at 183°C.
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Oryx is competitively priced – write now for details and technical information.

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Greenwood Electronics Limited, Portman Road, Reading, Berkshire RG3 1NE. Telephone: (0734) 595844. Telex: 848659

## The TC82 - a significant development in temperature controlled soldering

The new Oryx TC 82 has features unique to any temperature controlled precision soldering iron.
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**This eliminates the need for temperature measuring equipment.** You get **faster** and **better** soldering.
For 24 V models a special Oryx power unit connects directly to the iron and contains fully isolated transformer to BS3535, a safety stand, tip clean facility and illuminated mains socket switch.
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Other TC 82 features include: Power-on Neon indicator in handle; burn proof cable; choice of 13 tip styles.

**And more good news**

The Oryx TC 82 iron costs only £13.00 (+VAT) and the power unit for 24 V operation £23.00 (+VAT).
The TC82 240 volt is also available as a 30 watt general purpose iron at only £3.95 (+VAT).

**Greenwood Electronics**

Greenwood Electronics Limited, Portman Road, Reading, Berkshire RG3 1NE. Telephone: (0734) 595844. Telex: 848659

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WIRELESS WORLD JULY 1982 VOL 88 NO 1558

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## Printer mechanism interface
## V.d.u. light pen

## G.P.I.B./serial interface

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# TRANSMITTER TEST SET, TTS520

Tests transmitters up to 100 watts rating

For testing base stations; mobile or fixed radios; pocket phones; pagers, etc

Instrument incorporates: r.f. counter • modulation meter • directional power meter • a.f. voltmeter • a.f. synthesizer • distortion analyser • a.f. counter • weighting filters • r.f. power load/attenuator

Transmitter measurements include: frequency • power • modulation (a.m. or f.m.) level, frequency, distortion, sensitivity, bandwidth, capability • call tone modulation check • aerial efficiency

Many measuring functions automatic – fewer controls, easier to understand and operate

Helps speed up test throughput

Reduces operator error and fatigue

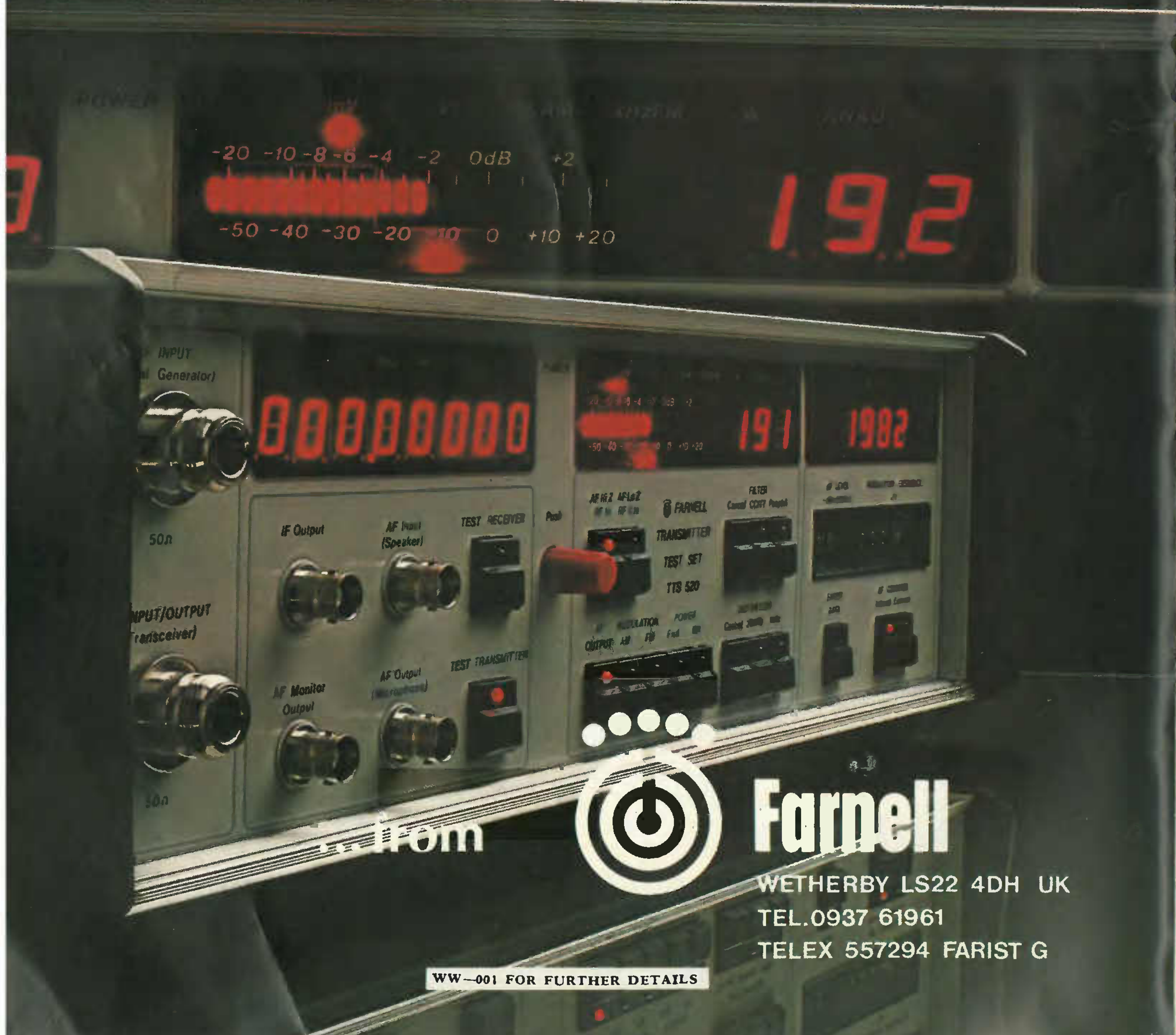
Compatible with Farnell SSG520 synthesized signal generator to provide full transceiver testing facilities

Split concept (receiver/transmitter testing) offers distinct advantages over dedicated test set or discrete instruments

Programmable. Also IEEE488 option available for low cost computer controlled A.T.E.

Releases skilled engineers from routine tests. More time for repairs and other tasks

Pre-service diagnostic tool. Use printer to record condition of radio as received and to verify performance to specification after repair or recalibration



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BROADCASTING
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COMMUNICATIONS
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VIDEO

JULY 1982 Vol 88 No 1558



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*Front cover shows one of the more familiar parts of the universe, scanned by Meteosat and received and photographed by Mike Christieson.*

## NEXT MONTH

**100W mosfet amplifier – John Linsley Hood concludes his three-part series with a description and full circuit and layout details of the final power amplifier design.**

**Meteosat high-resolution images – Mike Christieson presents expansions for the weather-satellite picture receiver to cover Meteosat-II's primary data.**

**Circuit modelling by microcomputer – the use of programming techniques to reduce computing time in circuit modelling.**


Current issue price 70p, back issues (if available) £1, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.

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# EP4000 *EPROM EMULATOR PROGRAMMER*

The microprocessor controlled EP4000 will emulate and program all the popular EPROMs including the 2704, 2708, 2716(3), 2508, 2758, 2516, 2716, 2532 and 2732 devices. Personality cards and hardware changes are not required as the machine configures itself for the different devices. Other devices such as bipolar PROMs and 2764 and 2564 EPROMs are programmed with external modules.

The editing and emulation facilities, video output and serial/parallel input/output provided as standard make the EP4000 very flexible to allow its use in three main modes:

– As a stand alone unit for editing and duplicating EPROMs.
– As a slave programmer used in conjunction with a software development system or microcomputer.
– As a real time EPROM emulator for program debugging and development (standard access time of the emulator is 300ns).

Data can be loaded into the 4k x 8 static RAM from a pre-programmed EPROM, the keypad, the serial or parallel ports and an audio cassette. Keypad editing allows for data entry, shift, move, delete, store, match and scroll, and a 1k x 8 RAM allows temporary block storage. A video output for memory map display, as well as the built-in 8 digit hex display allows full use of the editing facilities to be made.

Items pictured are: ● EP4000 Emulator Programmer – £545 + £12 delivery; ● BSC buffered simulator cable – £39; ● MESA 4 multi EPROM simulator cable – £98; ● 2732A Programming adaptor – £39; ● 2764 Programming adaptor – £64; ● 2564 Programming adaptor – £64; ● BP4 (TEXAS) Bipolar PROM Programming module – £190

Also available (not shown): ● VM10 Video monitor – £99; ● UV141 EPROM Eraser with timer – £78; ● GP100A 80 column Printer – £225; ● PI100 interface for EP4000 to GP100A – £65.

*VAT should be added to all prices*

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**Rohde & Schwarz.**
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S1 Sampling Head. As New ........ **£450.00**
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434 Option 01 Storage Oscilloscope 25MHz ........ **£2250.00**
1502 TDR ........ **£3500.00**
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1481C PAL TV Waveform Monitor . **£2375.00**
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106 Square Wave Generator 1nS risetime 10Hz-1MHz without accessories .... **£175.00**
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**With Home Office Type approval**

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# *Wireless World* Dolby noise reducer

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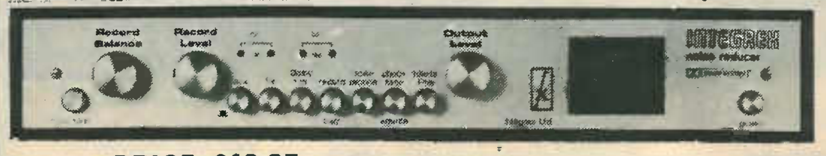

**Typical performance**
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)
Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%
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ACCESS and VISA welcome

*Please send SAE for complete lists and specifications*

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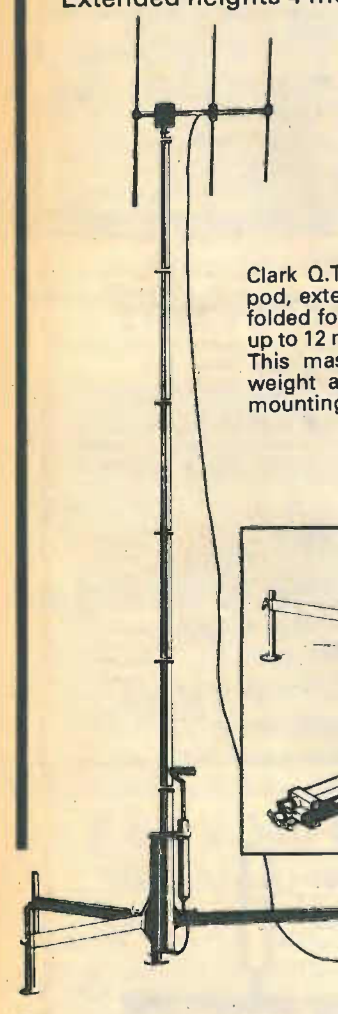
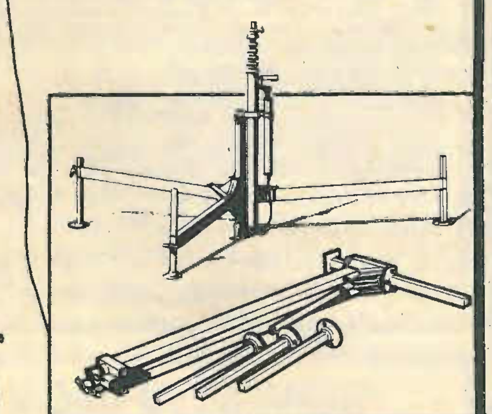


Clark Q.T.4M/HP mast shown on tripod, extended to 4 metres and tripod folded for transit. Available in heights up to 12 metres.
This mast is ideal for raising lightweight antennas for field or vehicle mounting.



**CLARK MASTS LTD.**
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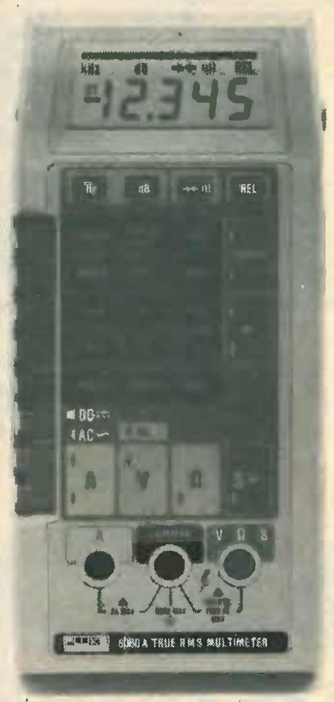
# New Fluke 4½ Digit Hand-held D.M.M.s

**Now in Stock**



Basic dc accuracy 0.04%; 10 µV, 10 nA and 10 mΩ sensitivity.
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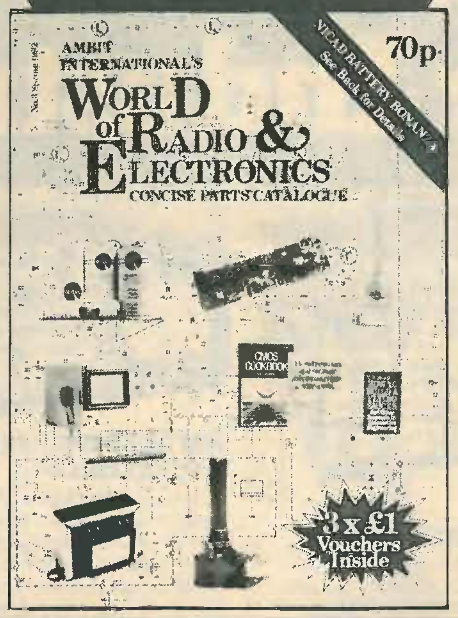


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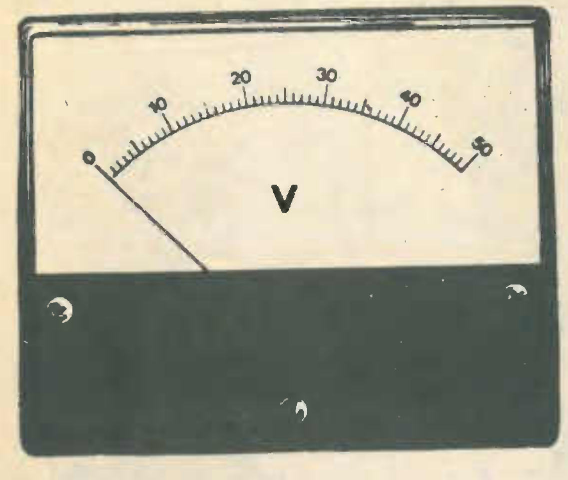


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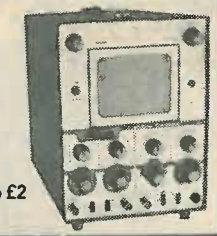

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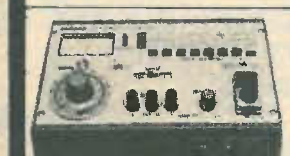

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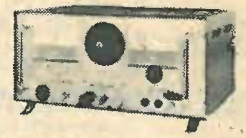

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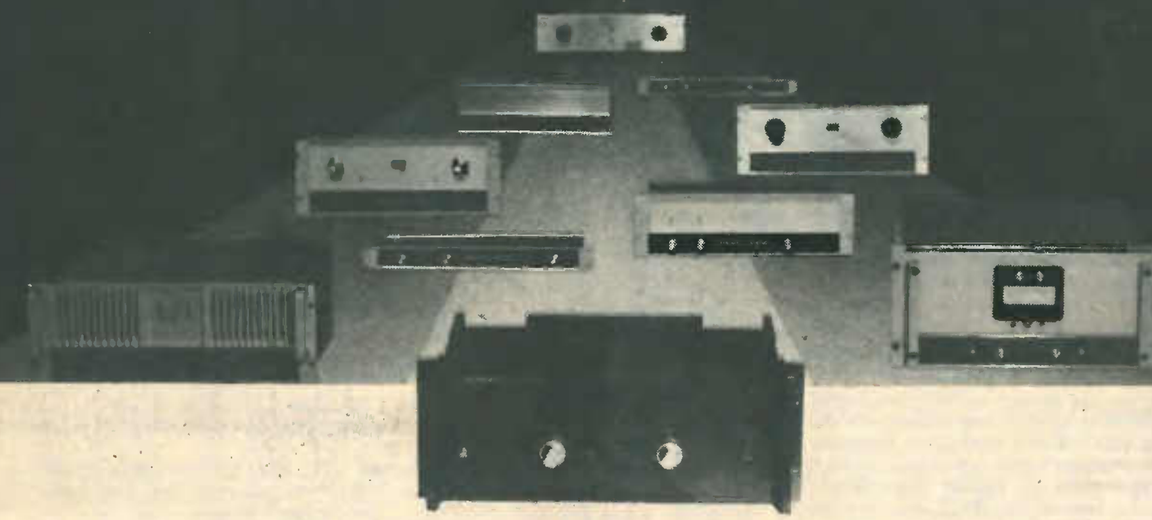

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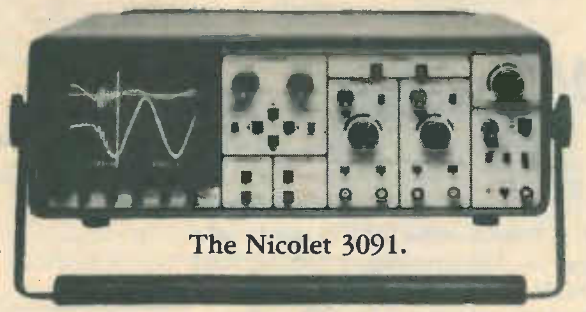
To celebrate the launch of this new digital oscilloscope, we are offering you the opportunity to visit the manufacturing plant of this product in Madison, U.S.A. Bonafide enquirer's names will go into the hat for a straight draw to determine the winner who will receive a round trip flight and accomodation for 3 days by courtesy of Nicolet



The Nicolet 3091.

A small, lightweight, high precision instrument.

- £2,750
- Dual differential inputs with 12 bit resolution.
- 4K words memory per channel.
- "Roll" mode for monitoring continuous signals.
- Full alphanumeric display & electronic grid.
- × 64 Expansion on both axes.
- Digital Interface as standard.

Plus Unique option of permanent Data Storage on magnetic bubble cassette.

## Nicolet Instruments

Nicolet Instruments Limited. (A Nicolet Instrument Subsidiary). Budbrooke Road, Warwick, England. CV34 5XH. Telephone (0926) 494111 Telex 311135

WW – 028 FOR FURTHER DETAILS

TECHNOMATIC TECHNOMATIC TECHNOMATIC

# SPECIAL OFFER

| | 1–24 | 25–99 |
|---|---|---|
| 2114L-200nS | 100p | 90p |
| 2114L-450nS | 90p | 85p |
| 2716 (+5v) | 250p | 225p |
| 2532 | 400p | 375p |
| 2732 | 400p | 375p |
| 6116P-3 | 500p | 475p |

## CONNECTOR SYSTEMS

### I.D. CONNECTORS (Speedblock Type)

| No. of Ways | Header Plug | Receptacle | Edge Conn. |
|---|---|---|---|
| 10 | 90p | 90p | 200p |
| 20 | 145p | 125p | 240p |
| 26 | 175p | 150p | 300p |
| 34 | 200p | 160p | 380p |
| 40 | 220p | 190p | 550p |
| 50 | 235p | 200p | 600p |

### D CONNECTORS

| | 9 way | 15way | 25way | 37way |
|---|---|---|---|---|
| MALE | | | | |
| Solder | 90p | 130p | 160p | 250p |
| Angled | 160p | 230p | 265p | 425p |
| FEMALE | | | | |
| Solder | 110p | 160p | 210p | 350p |
| Angled | 175p | 240p | 310p | 500p |
| Hood | 95p | 95p | 95p | 125p |

IDC Type 25 way M £4.50. P £5.00

### DIP PLUGS

| | Solder Type | IDC Type |
|---|---|---|
| 14 pin | 40p | 90p |
| 16 pin | 50p | 100p |
| 24 pin | 100p | 175p |
| 40 pin | 200p | 225p |

### FLAT CABLE (Grey)

| | |
|---|---|
| 10 way | 60p |
| 14 way | 80p |
| 18 way | 90p |
| 20 way | 105p |
| 26 way | 140p |
| 34 way | 220p |
| 40 way | 265p |
| 50 way | 300p |
| 64 way | 370p |

### JUMPER LEADS

24" Cable with DIP Headers

| | 14 pin | 16 pin | 24 pin | 40 pin |
|---|---|---|---|---|
| 1 End | 145p | 165p | 240p | 380p |
| 2 Ends | 210p | 230p | 345p | 540p |

Cable with Sockets

| No. of Ways | 20 | 26 | 34 | 40 |
|---|---|---|---|---|
| 1 End | 160p | 210p | 270p | 300p |

Cable with D Connectors

24" Single End Male £5.50 Female £6

36" Double End Male £11 Female £11.50

36" Male/Female £11.00

### EDGE CONNECTORS

| | 0.1" | 0.156" |
|---|---|---|
| 2 × 18 way | – | 140p |
| 2 × 22 way | 200p | 170p |
| 2 × 23 way | 210p | – |
| 2 × 25 way | 225p | 220p |
| 1 × 43 way | 260p | – |
| 2 × 43 way | 395p | – |
| 1 × 77 way | 700p | – |

S-100 £6.00

### EURO CONNECTORS

| | Plug | Skt |
|---|---|---|
| DIN41612 2 × 32 | 220p | 290p |
| 2 × 32 Angled Pins | 230p | 330p |
| (pse specify a+b/a+c) | | |
| 3 × 32 way | 250p | 380p |
| IDC 2 × 32 way | | 475p |
| DIN 41617 31 way | 180p | 180p |
| 21 way | 170p | 170p |

# ACORN ATOM

Built 8K + 2K **£135** 5K + Coloured Card **£175** 12K + 12K **£180** (p & p £3/unit)

Atom PSU **£7** (p & p 70p) 3A 5V Regulated PSU **£24** (p & p £1.50)
F.P. ROM **£20** 1K RAM (2 × 2114L) **£2** Tool Box Room **£25**
NEW COLOUR ENCODER CARD **£39.00**

ATOM SOUND BOARD: Kit comprises of a PSG, VIA and a 2K ROM with resident demo program. The board plugs onto ATOM BUS to parallel and serial output ports and audio output mini speaker or hi fi amplifier. Complete kit **£35.00**

ATOM VISION: An ultrasonic transducer is rotated by a software controlled stepper motor. Data collected by the sensor is processed as displayed on the screen either as a radar type plot or as distance. Complete kit **£46.00**

ATOM DISC Module with: PSU for both drive & 12K + 12K ATOM, Controller card, Connector cable, instruction manual **£299** + £6 carr.

# PRINTERS

SEIKOSHA GP100A dot matrix printer, full graphics double width characters, up to 10" wide paper, self testing parallel interface **£199** + Carriage £6

EPSON MX80 Friction and Tractor, 9 × 9 matrix 80 CPS bi-directional with logic seeking, variety of charac.

MX80 F/T 1 **£350** + £6 carr. MX 80 F/T 2 with High Res Graphics **£360** + £6

BMC 12" Green Screen Monitor £100 + £6 carr.

# BBC COMPUTER UPGRADE

**MEMORY**

IC61-68 16K RAM 100nS AP3 **£25.60**

**PRINTER & USER PORTS**

IC69, 70, PL9, 10 **£8.50** SK10 with 36" Cable **£2.20**

36" Printer Connector Lead Complete **£13.50**

SK9 with 36" Cable **£3.30**

**ANALOGUE PORT**

IC73, SK6 **£6.80** PL6 **£1.60** PL6 + Hood with 36" Cable **£5.00**

**F.D. PORT**

IC77-87 + PL8 **£44** SK8 with 36" Cable **£3.50**

**BUS PORT**

IC71-72 + PL11 **£3.30** SK11 with 36" Cable **£3.50**

**TUBE PORT**

PL12 **£3.00** SK12 with 36" Cable **£3.90**

# SOFTY II

The complete microprocessor development system for both Engineers and Hobbyists. You can develop programs, debug, verify and commit them to EPROMs. Will accept most +5V EPROMs. Can also be used as a ROMULATOR. Full review in September '81 P.E. Built unit complete with PSU and TV lead **£169**

TECHNOMATIC TECHNOMATIC TECHNOMATIC



### 74 SERIES

| | |
|---|---|
| 7400 | 11p |
| 7401 | 11p |
| 7402 | 12p |
| 7403 | 12p |
| 7404 | 12p |
| 7405 | 15p |
| 7406 | 20p |
| 7407 | 20p |
| 7408 | 14p |
| 7409 | 14p |
| 7410 | 14p |
| 7411 | 18p |
| 7412 | 18p |
| 7413 | 18p |
| 7414 | 28p |
| 7416 | 20p |
| 7417 | 20p |
| 7420 | 15p |
| 7421 | 20p |
| 7422 | 20p |
| 7423 | 20p |
| 7425 | 24p |
| 7426 | 28p |
| 7427 | 22p |
| 7428 | 26p |
| 7430 | 14p |
| 7432 | 22p |
| 7433 | 22p |
| 7437 | 25p |
| 7438 | 25p |
| 7440 | 15p |
| 7441 | 70p |
| 7442A | 32p |
| 7443 | 90p |
| 7445 | 50p |
| 7446A | 60p |
| 7447A | 40p |
| 7448 | 45p |
| 7450 | 15p |
| 7451 | 15p |
| 7453 | 15p |
| 7454 | 15p |
| 7460 | 15p |
| 7470 | 36p |
| 7472 | 25p |
| 7473 | 25p |
| 7474 | 20p |
| 7475 | 25p |
| 7476 | 30p |
| 7480 | 50p |
| 7482 | 70p |
| 7483A | 38p |
| 7484 | 65p |
| 7485 | 60p |
| 7486 | 20p |
| 7489 | 210p |
| 7490A | 20p |
| 7491 | 35p |
| 7492A | 25p |
| 7493A | 24p |
| 7494 | 35p |
| 7495A | 35p |
| 7496 | 40p |
| 7497 | 90p |
| 74100 | 80p |
| 74107 | 22p |
| 74109 | 25p |
| 74116 | 50p |
| 74118 | 60p |
| 74119 | 80p |
| 74120 | 60p |
| 74121 | 25p |
| 74122 | 40p |
| 74123 | 40p |
| 74125 | 40p |
| 74126 | 34p |
| 74128 | 35p |
| 74132 | 30p |
| 74136 | 30p |
| 74141 | 55p |
| 74142 | 200p |
| 74145 | 60p |
| 74147 | 90p |
| 74148 | 70p |
| 74150 | 50p |
| 74151A | 40p |
| 74153 | 40p |
| 74154 | 50p |
| 74155 | 40p |
| 74156 | 40p |
| 74157 | 30p |
| 74159 | 75p |
| 74160 | 60p |
| 74161 | 48p |
| 74162 | 48p |
| 74163 | 48p |
| 74164 | 48p |
| 74165 | 48p |
| 74166 | 48p |
| 74170 | 120p |
| 74172 | 275p |
| 74173 | 70p |
| 74174 | 60p |
| 74175 | 50p |
| 74176 | 40p |
| 74177 | 45p |
| 74178 | 80p |
| 74180 | 40p |
| 74181 | 115p |
| 74182 | 40p |
| 74184A | 90p |
| 74185 | 90p |
| 74186 | 500p |
| 74188 | 250p |
| 74190 | 48p |
| 74191 | 48p |
| 74192 | 48p |
| 74193 | 48p |
| 74194 | 48p |
| 74195 | 48p |
| 74196 | 48p |
| 74197 | 48p |
| 74198 | 85p |
| 74199 | 85p |
| 74221 | 55p |
| 74251 | 70p |
| 74259 | 150p |
| 74273 | 140p |
| 74276 | 110p |
| 74278 | 100p |
| 74279 | 50p |
| 74283 | 55p |
| 74284 | 175p |
| 74285 | 175p |
| 74290 | 100p |
| 74293 | 100p |
| 74298 | 100p |
| 74365 | 50p |
| 74366 | 50p |
| 74367 | 50p |
| 74368 | 50p |
| 74390 | 75p |
| 74393 | 100p |
| 74490 | 95p |

### 74LS SERIES

| | |
|---|---|
| 74LS00 | 11p |
| 74LS01 | 12p |
| 74LS02 | 12p |
| 74LS03 | 12p |
| 74LS04 | 12p |
| 74LS05 | 12p |
| 74LS08 | 12p |
| 74LS09 | 15p |
| 74LS10 | 13p |
| 74LS11 | 13p |
| 74LS12 | 15p |
| 74LS13 | 20p |
| 74LS14 | 36p |
| 74LS15 | 30p |
| 74LS20 | 12p |
| 74LS21 | 15p |
| 74LS22 | 12p |
| 74LS26 | 14p |
| 74LS27 | 16p |
| 74LS28 | 18p |
| 74LS30 | 15p |
| 74LS32 | 15p |
| 74LS33 | 16p |
| 74LS37 | 16p |
| 74LS38 | 15p |
| 74LS42 | 30p |
| 74LS47 | 36p |
| 74LS48 | 45p |
| 74LS51 | 15p |
| 74LS55 | 15p |
| 74LS73 | 20p |
| 74LS74 | 16p |
| 74LS75 | 20p |
| 74LS76 | 20p |
| 74LS83 | 38p |
| 74LS85 | 65p |
| 74LS86 | 18p |
| 74LS90 | 27p |
| 74LS92 | 32p |
| 74LS93 | 27p |
| 74LS95 | 40p |
| 74LS96 | 90p |
| 74LS107 | 40p |
| 74LS109 | 30p |
| 74LS112 | 25p |
| 74LS113 | 25p |
| 74LS114 | 25p |
| 74LS122 | 36p |
| 74LS123 | 40p |
| 74LS124 | 90p |
| 74LS125 | 24p |
| 74LS126 | 25p |
| 74LS132 | 40p |
| 74LS133 | 30p |
| 74LS136 | 25p |
| 74LS138 | 32p |
| 74LS139 | 32p |
| 74LS145 | 70p |
| 74LS147 | 160p |
| 74LS148 | 75p |
| 74LS151 | 40p |
| 74LS153 | 40p |
| 74LS154 | 90p |
| 74LS155 | 40p |
| 74LS156 | 40p |
| 74LS157 | 27p |
| 74LS158 | 30p |
| 74LS160 | 40p |
| 74LS161 | 36p |
| 74LS162 | 50p |
| 74LS163 | 36p |
| 74LS164 | 40p |
| 74LS165 | 60p |
| 74LS166 | 65p |
| 74LS170 | 75p |
| 74LS173 | 70p |
| 74LS174 | 40p |
| 74LS175 | 45p |
| 74LS181 | 100p |
| 74LS183 | 180p |
| 74LS190 | 45p |
| 74LS191 | 45p |
| 74LS192 | 45p |
| 74LS193 | 45p |
| 74LS194 | 45p |
| 74LS195 | 35p |
| 74LS196 | 48p |
| 74LS197 | 60p |
| 74LS221 | 50p |
| 74LS240 | 65p |
| 74LS241 | 65p |
| 74LS242 | 65p |
| 74LS243 | 65p |
| 74LS244 | 60p |
| 74LS245 | 70p |
| 74LS251 | 35p |
| 74LS253 | 35p |
| 74LS257 | 35p |
| 74LS258 | 35p |
| 74LS259 | 75p |
| 74LS260 | 22p |
| 74LS266 | 20p |
| 74LS273 | 65p |
| 74LS279 | 35p |
| 74LS280 | 180p |
| 74LS283 | 40p |
| 74LS290 | 40p |
| 74LS293 | 40p |
| 74LS295 | 90p |
| 74LS298 | 90p |
| 74LS299 | 270p |
| 74LS323 | 175p |
| 74LS324 | 150p |
| 74LS348 | 120p |
| 74LS352 | 80p |
| 74LS353 | 80p |
| 74LS356 | 450p |
| 74LS363 | 140p |
| 74LS364 | 140p |
| 74LS365 | 30p |
| 74LS366 | 30p |
| 74LS367 | 30p |
| 74LS368 | 30p |
| 74LS373 | 60p |
| 74LS374 | 60p |
| 74LS375 | 45p |
| 74LS377 | 60p |
| 74LS378 | 80p |
| 74LS390 | 50p |
| 74LS393 | 45p |
| 74LS395 | 90p |
| 74LS399 | 160p |
| 74LS445 | 100p |
| 74LS540 | 75p |
| 74LS541 | 100p |
| 74LS640 | 160p |
| 74LS641 | 170p |
| 74LS642 | 200p |
| 74LS643 | 34p |
| 74LS644 | 250p |
| 74LS645 | 160p |
| 74LS668 | 120p |
| 74LS669 | 120p |
| 74LS670 | 140p |
| 74LS682 | 400p |
| 74LS684 | 400p |

### 74S SERIES

| | |
|---|---|
| 74S00 | 60p |
| 74S02 | 60p |
| 74S04 | 60p |
| 74S05 | 75p |
| 74S08 | 75p |
| 74S10 | 60p |
| 74S11 | 60p |
| 74S20 | 60p |
| 74S30 | 60p |
| 74S32 | 90p |
| 74S37 | 60p |
| 74S74 | 90p |
| 74S85 | 300p |
| 74S86 | 180p |
| 74S112 | 90p |
| 74S113 | 90p |
| 74S114 | 90p |
| 74S124 | 300p |
| 74S132 | 160p |
| 74S133 | 75p |
| 74S138 | 225p |
| 74S139 | 225p |
| 74S157 | 250p |
| 74S163 | 300p |
| 74S174 | 250p |
| 74S175 | 320p |
| 74S188 | 350p |
| 74S189 | 350p |
| 74S194 | 350p |
| 74S195 | 350p |
| 74S196 | 400p |
| 74S197 | 400p |
| 74S200 | 450p |
| 74S201 | 400p |
| 74S225 | 550p |
| 74S241 | 400p |
| 74S260 | 70p |
| 74S261 | 300p |
| 74S262 | £10 |
| 74S287 | 350p |
| 74S288 | 300p |
| 74S373 | 400p |
| 74S374 | 400p |
| 74S471 | 650p |
| 74S474 | 400p |
| 74S571 | 900p |
| 74S573 | 900p |

### 4000 CMOS

| | |
|---|---|
| 4000 | 12p |
| 4001 | 12p |
| 4002 | 12p |
| 4006 | 50p |
| 4007 | 18p |
| 4008 | 48p |
| 4009 | 24p |
| 4010 | 24p |
| 4011 | 14p |
| 4012 | 16p |
| 4013 | 20p |
| 4014 | 50p |
| 4015 | 50p |
| 4016 | 20p |
| 4017 | 38p |
| 4018 | 45p |
| 4019 | 20p |
| 4020 | 50p |
| 4021 | 50p |
| 4022 | 50p |
| 4023 | 16p |
| 4024 | 32p |
| 4025 | 16p |
| 4026 | 80p |
| 4027 | 24p |
| 4028 | 40p |
| 4029 | 50p |
| 4030 | 30p |
| 4031 | 125p |
| 4032 | 80p |
| 4033 | 125p |
| 4034 | 140p |
| 4035 | 65p |
| 4036 | 275p |
| 4038 | 110p |
| 4040 | 50p |
| 4041 | 60p |
| 4042 | 45p |
| 4043 | 45p |
| 4044 | 50p |
| 4045 | 105p |
| 4046 | 55p |
| 4047 | 50p |
| 4048 | 24p |
| 4049 | 24p |
| 4051 | 45p |
| 4052 | 60p |
| 4053 | 45p |
| 4054 | 90p |
| 4055 | 90p |
| 4056 | 90p |
| 4059 | 500p |
| 4060 | 90p |
| 4063 | 100p |
| 4066 | 25p |
| 4067 | 250p |
| 4068 | 16p |
| 4069 | 16p |
| 4070 | 16p |
| 4071 | 16p |
| 4072 | 16p |
| 4073 | 16p |
| 4075 | 16p |
| 4076 | 48p |
| 4077 | 18p |
| 4078 | 18p |
| 4081 | 16p |
| 4082 | 16p |
| 4086 | 55p |
| 4089 | 150p |
| 4093 | 28p |
| 4094 | 100p |
| 4095 | 75p |
| 4096 | 70p |
| 4097 | 340p |
| 4098 | 90p |
| 4099 | 100p |
| 4501 | 28p |
| 4502 | 60p |
| 4503 | 50p |
| 4504 | 75p |
| 4506 | 35p |
| 4507 | 35p |
| 4508 | 140p |
| 4510 | 30p |
| 4511 | 48p |
| 4512 | 50p |
| 4514 | 120p |
| 4515 | 120p |
| 4516 | 60p |
| 4518 | 40p |
| 4520 | 80p |
| 4521 | 120p |
| 4526 | 65p |
| 4527 | 75p |
| 4528 | 60p |
| 4532 | 80p |
| 4534 | 470p |
| 4536 | 300p |
| 4538 | 100p |
| 4539 | 110p |
| 4543 | 90p |
| 4553 | 270p |
| 4555 | 35p |
| 4556 | 35p |
| 4560 | 170p |
| 4566 | 170p |
| 4568 | 300p |
| 4569 | 180p |
| 4572 | 30p |
| 4583 | 90p |
| 4584 | 50p |
| 4585 | 100p |
| 40014 | 90p |
| 40085 | 30p |
| 40097 | 50p |
| 40102 | 150p |
| 40103 | 180p |
| 40105 | 120p |
| 40106 | 50p |
| 40109 | 100p |
| 40110 | 280p |
| 40163 | 75p |
| 40174 | 75p |
| 40175 | 75p |
| 40193 | 75p |
| 14495 | 300p |
| 14500 | 700p |
| 14568 | 200p |
| 14569 | 250p |
| 14599 | 290p |

### 74S SERIES

| | |
|---|---|
| 74S00 | 60p |
| 74S04 | 60p |
| 74S08 | 75p |
| 74S32 | 90p |
| 74S74 | 90p |
| 74S85 | 300p |
| 74S86 | 180p |
| 74S124 | 300p |
| 74S132 | 160p |
| 74S133 | 75p |
| 74S138 | 225p |
| 74S139 | 225p |
| 74S157 | 250p |
| 74S163 | 300p |
| 74S174 | 250p |
| 74S175 | 320p |
| 74S194 | 350p |
| 74S241 | 400p |

### ECLs

| | |
|---|---|
| MC4024 | 325p |
| MC4044 | 325p |
| MC10116 | 70p |
| MC10231 | 350p |
| COUNTERS | |
| 74C925 | £4 |
| 74C928 | £5 |
| 72168 | £16 |
| ZN1040 | 670p |

## LINEAR ICs

| | |
|---|---|
| AN103 | 200p |
| AY1-0212 | 600p |
| AY1-1313 | 668p |
| AY1-1320 | 320p |
| AY1-5050 | 140p |
| AY3-1270 | 825p |
| AY3-1350 | £4 |
| AY3-8910 | 550p |
| AY3-8912 | 650p |
| AY5-4007D | 520p |
| CA3028 | 120p |
| CA3019 | 80p |
| CA3046 | 70p |
| CA3048 | 225p |
| CA3059 | 300p |
| CA3060 | 350p |
| CA3080E | 72p |
| CA3086 | 48p |
| CA3089E | 200p |
| CA3090AQ | 375p |
| CA3130E | 90p |
| CA3130T | 130p |
| CA3140E | 50p |
| CA3160E | 100p |
| CA3161E | 175p |
| CA3162E | 450p |
| CA3189E | 300p |
| CA3240E | 120p |
| CA3280G | 200p |
| DAC1408-8 | 200p |
| HA1366 | 195p |
| HA1388 | 270p |
| ICL7106 | 850p |
| ICL7660 | £2 |
| ICL8038 | 300p |
| ICM7216B | £16 |
| ICM7217 | 750p |
| ICM7555 | 80p |
| ICM7611 | 130p |
| LC7120 | 325p |
| LC7130 | 325p |
| LF347 | 160p |
| LF351 | 48p |
| LF353 | 100p |
| LF356P | 95p |
| LF357 | 120p |
| LM10C | 425p |
| LM301A | 27p |
| LM310 | 120p |
| LM311 | 75p |
| LM318 | 150p |
| LM319 | 225p |
| LM324 | 30p |
| LM334Z | 100p |
| LM335Z | 140p |
| LM339 | 50p |
| LM348 | 75p |
| LM358P | 60p |
| LM377 | 175p |
| LM380 | 75p |
| LM381AN | 180p |
| LM382 | 120p |
| LM386 | 90p |
| LM387 | 120p |
| LM389 | 95p |
| LM391 | 150p |
| LM393 | 100p |
| LM394CH | 300p |
| LM709 | 36p |
| LM710 | 50p |
| LM711 | 70p |
| LM725 | £4 |
| LM733 | 70p |
| LM741 | 18p |
| LM747 | 70p |
| LM748 | 35p |
| LM1871 | 450p |
| LM1872 | 450p |
| LM1886 | 700p |
| LM1889 | 350p |
| LM2917 | 200p |
| LM3302 | 90p |
| LM3900 | 50p |
| LM3909 | 95p |
| LM3911 | 130p |
| LM3914 | 210p |
| LM3915 | 225p |
| LM3916 | 225p |
| LM13600 | 110p |
| M51513L | 300p |
| M51516L | 500p |
| MB3712 | 200p |
| M83730 | £4 |
| MC1310P | 150p |
| MC1445 | |
| MC1458 | 40p |
| MC1495L | 350p |
| MC1496 | 70p |
| MC3340P | 120p |
| MC3401 | 90p |
| MC3403 | 75p |
| MC3480 | 600p |
| MK50938 | 750p |
| ML920 | 800p |
| MM57160 | 620p |
| MN6221A | 600p |
| NE531 | 150p |
| NE555 | 18p |
| NE556 | 50p |
| NE564 | 420p |
| NE565 | 130p |
| NE566 | 155p |
| NE567 | 140p |
| NE570 | 375p |
| NE571 | 375p |
| NE5534A | 150p |
| PLL02A | 500p |
| RC4136 | 60p |
| RC4151 | 200p |
| S566B | 260p |
| SAA1900 | 1600p |
| SAD1024A | 850p |
| SFF96364 | 800p |
| SL490 | 350p |
| SN76477 | 480p |
| SN76478 | 480p |
| SP8515 | 750p |
| TA7120 | 160p |
| TA7204 | 200p |
| TA7205 | 90p |
| TA7222 | 160p |
| TA7310 | 160p |
| TBA641AX1 | 275p |
| TBA641BX1 | 300p |
| TBA651 | 200p |
| TBA800 | 90p |
| TBA810 | 100p |
| TBA820 | 90p |
| TBA920 | 200p |
| TBA950 | 225p |
| TC9109 | 900p |
| TCA210 | 350p |
| TCA220 | 350p |
| TCA940 | 175p |
| TDA1004A | 300p |
| TDA1008 | 320p |
| TDA1010 | 225p |
| TDA1022 | 520p |
| TDA1024 | 120p |
| TDA1034B | 250p |
| TDA1170 | 300p |
| TDA2002V | 325p |
| TDA2006 | 350p |
| TDA2020 | 320p |
| TL064 | 100p |
| TL071/81 | 25p |
| TL072/82 | 45p |
| TL074 | 100p |
| TL083 | 75p |
| TL084 | 90p |
| TL094 | 200p |
| TL170 | 50p |
| TL430C | 70p |
| UA2240 | 300p |
| UAA170 | 170p |
| ULN2003 | 100p |
| ULN2004 | 75p |
| UPC575 | 275p |
| UPC592H | 200p |
| UPC1156H | 275p |
| XR2206 | 300p |
| XR2207 | 400p |
| XR2211 | 600p |
| XR2216 | 675p |
| ZN414 | 90p |
| ZN419C | 225p |
| ZN423E | 160p |
| ZN424E | 135p |
| ZN425E | 350p |
| ZN426E | 300p |
| ZN427E | 600p |
| ZN428E | 500p |
| ZN1034E | 200p |
| ZN1040E | 670p |
| ZNA234 | 850p |

FOR FAST DELIVERY PHONE 01 452 1500 WITH VISA/ACCESS No. MINIMUM ORDER £5

## COMPUTER COMPONENTS

### CPUs

| | |
|---|---|
| 1802CE | 700p |
| 2650A | £12 |
| 6502 | 400p |
| 6502A | 500p |
| 6800 | £3 |
| 6802 | 350p |
| 68802 | 790p |
| 6809 | 850p |
| 68809 | £14 |
| 6809E | £15 |
| 8035 | 350p |
| 8039 | £4 |
| 8080A | 280p |
| 8085A | 450p |
| INS8060 | £11 |
| TMS9980 | £20 |
| Z8 | £24 |
| Z80 | 320p |
| Z80A | 360p |
| Z80B | £15 |
| 8088 | £18 |

### SUPPORT DEVICES

| | |
|---|---|
| 3242 | 800p |
| 3245 | 450p |
| 6520 | 280p |
| 6522 | 450p |
| 6532 | 600p |
| 6551 | 650p |
| 6821 | 120p |
| 68B21 | 220p |
| 6840 | £4 |
| 68B40 | £6 |
| 6850 | 140p |
| 68B50 | 220p |
| 6852 | 370p |
| 6854 | £7 |
| 6875 | 600p |
| 8154 | 950p |
| 8155 | 450p |
| 8156 | £5 |
| 8205 | 225p |
| 8212 | 160p |
| 8216 | 100p |
| 8224 | 200p |
| 8226 | 250p |
| 8228 | 250p |
| 8243 | 250p |
| 8250 | 850p |
| 8251 | 320p |
| 8253 | 400p |
| 8255 | 300p |
| 8256 | £36 |
| 8257 | 500p |
| 8259 | 550p |
| 8279 | 550p |
| 8284 | 350p |
| 8288 | £11 |
| TMS9918 | £60 |
| Z80PIO | 280p |
| Z80APIO | 300p |
| Z80CTC | 280p |
| Z80ACTC | 300p |
| Z80ADART | £8 |
| Z80ADMA | £12 |
| Z80SIO-0/1/2 | £9 |
| Z80SIO-1 | £9 |
| Z80SIO-2 | £9 |

### MEMORIES

| | |
|---|---|
| 2101A | 400p |
| 2102-3L | 120p |
| 2107B | 500p |
| 2111A | 300p |
| 2112-A | 300p |
| 2114-2L | 100p |
| 2147 | 450p |
| 4027-3 | 300p |
| 4044-45 | 450p |
| 4116-15 | 100p |
| 4116-20 | 90p |
| 4118-3 | 500p |
| 4164-2 | £6 |
| 4816AP-3 | 320p |
| 5101 | 300p |
| 5516 | £9.50 |
| 6116P-3 | £5 |
| 6116LP | 750p |
| 6514-45 | £3 |
| 6810 | 120p |
| 7489 | 210p |
| 74S189 | 325p |
| 74S201 | 350p |
| 74S289 | 325p |
| 93415 | 600p |
| 93425 | 600p |

### ROMs/PROMs

| | |
|---|---|
| 74S188 | 325p |
| 74S287 | 308p |
| 74S288 | 226p |
| 74S387 | 325p |
| 74S471 | 650p |
| 74S473 | 850p |
| 74S474 | 650p |
| 74S570 | 650p |
| 74S571 | 650p |
| 74S573 | 950p |

### EPROMs

| | |
|---|---|
| 1702A | £5 |
| 2516(+5v) | 250p |
| 2532 | 450p |
| 2564 | £25 |
| 2708 | 250p |
| 2716(+5v) | 250p |
| 2732 | 450p |
| 2716(3 rails) | 500p |
| 2732(300ns) | 500p |
| TMS2716 | 750p |

### CRT CONTROLLER

| | |
|---|---|
| CRT6545 | 950p |
| CRT5027 | £18 |
| CRT5037 | £18 |

| | |
|---|---|
| EF9365 | £60 |
| MC6845 | 700p |
| MC6847 | 825p |
| SFF96364 | £8 |
| TMS9918 | £60 |
| TMS9927 | £18 |

### INTERFACE ICs

| | |
|---|---|
| AD558CJ | 775p |
| AD561J | £14 |
| AM25S10 | 350p |
| AM25LS2521 | £2 |
| AM26LS31 | 125p |
| AM26LS32 | 125p |
| CDM8116 | 800p |
| DAC80 | £20 |
| DM8131 | 375p |
| DP8304 | 450p |
| DS8830 | 140p |
| DS8831 | 140p |
| DS8832 | 250p |
| DS8833 | 225p |
| DS8836 | 150p |
| DS8838 | 225p |
| LF13201 | 450p |
| MC1488 | 55p |
| MC1489 | 55p |
| MC3418 | 950p |
| MC3446 | 300p |
| MC3480 | 850p |
| MC3486 | 500p |
| MC3487 | 300p |
| MC4024 | 325p |
| MC4044 | 325p |
| MC14412 | 900p |
| ULN2003A | 100p |
| ULN2004A | 100p |
| 75107 | 160p |
| 75110/12 | 160p |
| 75114/15 | 160p |
| 75121/22 | 140p |
| 75150P | 140p |
| 75154 | 140p |
| 75182 | 230p |
| 75324 | 375p |
| 75361 | 150p |
| 75363 | 150p |
| 75365 | 150p |
| 75451/2 | 72p |
| 75453/4 | 72p |
| 75491/2 | 70p |
| 8T26 | 120p |
| 8T28 | 120p |
| 8T95/96 | 90p |
| 8T97/98 | 90p |
| 81LS95 | 90p |
| 81LS96 | 90p |
| 81LS97 | 90p |
| 81LS98 | 90p |
| 9602 | 220p |
| 9637AP | 160p |
| ZN425E-8 | 350p |
| ZN426E-8 | 350p |
| ZN427E-8 | 650p |
| ZN428E-8 | 500p |

### TELETEXT DECODER

| | |
|---|---|
| SAA 5020 | £6.00 |
| SAA 5030 | £9.00 |
| SAA 5041 | £16.00 |
| SAA 5050 | £9.00 |

### DISC CONTROL ICs

| | |
|---|---|
| FD1771 | £20 |
| FD1791 | £30 |
| FD1793 | £32 |
| FD1795 | £35 |
| FD1797 | £37 |
| WD1691 | £15 |
| WD2143 | 550p |

### CHARACTER GENERATORS

| | |
|---|---|
| RD-3-2513UC | 750p |
| RO-3-2513LC | 700p |
| SN74S262AN | £10 |

### KEYBOARD ENCODER

| | |
|---|---|
| AY-6-2376 | 700p |
| 74C922 | 500p |

### MODULATORS

| | |
|---|---|
| 6MHz UHF | 375p |
| 8MHz UHF | 450p |

### BAUD RATE GENERATORS

| | |
|---|---|
| MC14411 | 700p |
| COM8116 | 800p |
| 4702A | 750p |

### UARTs

| | |
|---|---|
| AY-3-1015P | 300p |
| AY-5-1013P | 300p |
| COM8017 | 300p |
| IM6402 | 300p |
| TR1602 | 300p |

### ZIF SKTS (TEX TOOL)

| | |
|---|---|
| 24 pin | £6 |
| 28 pin | £8 |
| 40 pin | £10 |

### CRYSTALS

| | |
|---|---|
| 32·768KHz | 100p |
| 100KHz | 250p |
| 200KHz | 280p |
| 1.0MHz | 290p |
| 1.008MHz | 275p |
| 1.5MHz | 450p |
| 1.8432MHz | 210p |
| 2.00MHz | 225p |
| 2.45760MHz | 210p |
| 2.5MHz | 250p |
| 2.662MHz | 250p |
| 3.276MHz | 150p |
| 3.595MHz | 100p |
| 3.686MHz | 300p |
| 4.00MHz | 150p |
| 4.194MHz | 200p |
| 4.43MHz | 110p |
| 4.608MHz | 250p |
| 4.9152MHz | 250p |
| 5.00MHz | 175p |
| 6.0MHz | 150p |
| 6.144MHz | 150p |
| 7.0MHz | 150p |
| 7.168MHz | 175p |
| 8.00MHz | 175p |
| 8.86MHz | 175p |
| 10.00MHz | 175p |
| 10.5MHz | 250p |
| 10.7MHz | 150p |
| 12.00MHz | 150p |
| 14.318MHz | 175p |
| 14.756MHz | 250p |
| 15.000MHz | 200p |
| 16.00MHz | 200p |
| 18.00MHz | 200p |
| 18.432MHz | 150p |
| 19.968MHz | 150p |
| 20.000MHz | 200p |
| 26.690MHz | 150p |
| 27.145MHz | 200p |
| 38.6667MHz | 175p |
| 48.0MHz | 175p |
| 55.5MHz | 400p |
| 116MHz | 300p |
| 145.80MHz | 250p |

### DIL SWITCHES

| | |
|---|---|
| 4 way | 70p |
| 6 way | 85p |
| 8 way | 90p |
| 10 way | 145p |

## VOLTAGE REGULATORS

FIXED PLASTIC

| | | +ve | | -ve | |
|---|---|---|---|---|---|
| 1A | 5V | 7805 | 45p | 7905 | 50p |
| | 6V | 7806 | 50p | 7906 | 60p |
| | 8V | 7808 | 50p | 7908 | 60p |
| | 12V | 7812 | 50p | 7912 | 50p |
| | 15V | 7815 | 50p | 7915 | 50p |
| | 18V | 7818 | 50p | 7918 | 60p |
| | 24V | 7824 | 50p | 7924 | 60p |
| 5V | 100mA | 78L05 | 30p | 79L05 | 60p |
| 6V | 100mA | 78L06 | 30p | | |
| 8V | 100mA | 78L08 | 30p | | |
| 12V | 100mA | 78L12 | 30p | 79L12 | 60p |
| 15V | 100mA | 78L15 | 30p | 79L15 | 60p |

OTHER REGULATORS

| | | | |
|---|---|---|---|
| LM309H | 100p | 78HGKC | 600p |
| LM309K | 140p | 78H05KC | 550p |
| LM317K | 325p | 78MGT2C | 140p |
| LM317T | 200p | 78GUIC | 200p |
| LM337T | 225p | 79GUIC | 225p |
| LM323K | 500p | 79HGKC | 700p |
| LM723 | 37p | ICL7660 | 200p |
| TL494 | 400p | TL497 | 300p |
| 78S40 | 225p | LM305AH | 250p |
| 78P05 | 600p | 78H12 | 600p |

### OPTO-ELECTRONICS

| | | | |
|---|---|---|---|
| 2N5777 | 45p | ORP60 | 120p |
| OCP71 | 180p | ORP61 | 120p |
| ORP12 | 120p | TIL78 | 55p |

OPTO-ISOLATORS

| | | | |
|---|---|---|---|
| ILD74 | 130p | TIL111 | 90p |
| MCT26 | 100p | TIL112 | 90p |
| MCS2400 | 190p | TIL113 | 90p |
| ILQ74 | 240p | TIL116 | 90p |

LEDS

| | | | |
|---|---|---|---|
| 0.125" | | 0.2" | |
| TIL32 | 55p | TIL220 Red | 12p |
| TIL209 Red | 11p | TIL222 Gr | 15p |
| TIL211 Gr | 18p | TIL228 Yel | 22p |
| TIL212 Ye | 18p | Rectangular LEDs(R,G,Y) | 30p |
| TIL216 Red | 18p | NSB5881 | 570p |

DISPLAYS

| | | | |
|---|---|---|---|
| | | TIL311 | 600p |
| | | TIL312/3 | 110p |
| | | TIL321/3 | 130p |
| DL704 | 140p | TIL330 | 140p |
| DL707 Red | 140p | 7750 60 | 200p |
| FND357 | 120p | DRIVERS | |
| FND500 | 90p | 9368 | 250p |
| FND507 | 90p | 9370 | 300p |
| MAN3640 | | UDN6118 | 320p |
| MAN4640 | 200p | UDN6184 | 320p |

## TRANSISTORS

| | |
|---|---|
| AD161/2 | 45p |
| BC107/8 | 13p |
| BC109C | 14p |
| BC117 | 20p |
| BC147/8 | 9p |
| BC149 | 10p |
| BC157/8 | 10p |
| BC159 | 11p |
| BC169C | 12p |
| BC172 | 12p |
| BC177/8 | 17p |
| BC179 | 18p |
| BC182/3 | 10p |
| BC184 | 11p |
| BC187 | 30p |
| BC212/3 | 11p |
| BC214 | 12p |
| BC237 | 15p |
| BC327 | 16p |
| BC337 | 16p |
| BC338 | 16p |
| BC461 | 25p |
| BC477/8 | 30p |
| BC516/7 | 40p |
| BC547B | 14p |
| BC548C | 12p |
| BC549C | 16p |
| BC557KB | 14p |
| BC559C | 16p |
| BCY70 | 18p |
| BCY71 | 22p |
| BD131 | 75p |
| BD135/6 | 40p |
| BD139 | 40p |
| BD140 | 40p |
| BD189 | 60p |
| BD232 | 60p |
| BD233 | 75p |
| BD235 | 85p |
| BD241 | 60p |
| BD242 | 60p |
| BD379 | 60p |
| BD380 | 60p |
| BD677 | 40p |
| BF244B | 35p |
| BF256B | 50p |
| BF257/8 | 32p |
| BF337 | 30p |
| BF339 | 25p |
| BFR40/1 | 25p |
| BFR79 | 25p |
| BFR80/1 | 25p |
| BFR96 | 180p |
| BFX29 | 40p |
| BFX30 | 27p |
| BFX84/5 | 40p |
| BFX86/7 | 27p |
| BFX88 | 27p |
| BFX89 | 180p |
| BFY50 | 24p |
| BFY51/2 | 24p |
| BFY56 | 33p |
| BFY90 | 80p |
| BRY39 | 45p |
| BSX19/20 | 24p |
| BU104 | 225p |
| BU105 | 190p |
| BU108 | 250p |
| BU109 | 225p |
| BU126 | 150p |
| BU180A | 120p |
| BU205 | 200p |
| BU208 | 200p |
| BU406 | 145p |
| BUX80 | £6 |
| BUY69C | 350p |
| E310 | 50p |
| MJ802 | £4 |
| MJ2501 | 225p |
| MJ2955 | 90p |
| MJ3001 | 225p |
| MJ4502 | £4 |
| MJE340 | 60p |
| MJE2955 | 100p |
| MJE3055 | 70p |
| MPF102 | 40p |
| MPF103/4 | 30p |
| MPF105 | 30p |
| MPSA06 | 30p |
| MPSA12 | 50p |
| MPSA13 | 50p |
| MPSA20 | 50p |
| MPSA42 | 50p |
| MPSA43 | 50p |
| MPSA56 | 32p |
| MPSA70 | 50p |
| MPSA93 | 40p |
| MPSU06 | 63p |
| MPSU07 | 60p |
| MPSU45 | 90p |
| MPSU65 | 78p |
| TIP29A | 35p |
| TIP29C | 40p |
| TIP30A | 35p |
| TIP30C | 40p |
| TIP31A | 40p |
| TIP31C | 45p |
| TIP32A | 45p |
| TIP32C | 40p |
| TIP33A | 70p |
| TIP33C | 80p |
| TIP34A | 90p |
| TIP34C | 120p |
| TIP35A | 120p |
| TIP35C | 140p |
| TIP36A | 140p |
| TIP36C | 150p |
| TIP41A | 50p |
| TIP41C | 55p |
| TIP42A | 60p |
| TIP42C | 65p |
| TIP54 | 160p |
| TIP120 | 75p |
| TIP121 | 75p |
| TIP122 | 80p |
| TIP142 | 120p |
| TIP147 | 120p |
| TIP2955 | 78p |
| TIP4055 | 70p |
| TIS93 | 30p |
| ZTX108 | 12p |
| ZTX300 | 13p |
| ZTX452 | 45p |
| ZTX500 | 15p |
| ZTX502 | 16p |
| ZTX504 | 18p |
| ZTX552 | 55p |
| ZTX652 | 60p |
| ZTX752 | 70p |
| VN66AF | 72p |
| VN10KM | 60p |
| VN66 | 80p |
| 2N697 | 25p |
| 2N698 | 45p |
| 2N706A | 30p |
| 2N708 | 30p |
| 2N918 | 45p |
| 2N930 | 18p |
| 2N1131/2 | 36p |
| 2N1613 | 25p |
| 2N1711 | 25p |
| 2N2102 | 70p |
| 2N2160 | 350p |
| 2N2219A | 25p |
| 2N2222A | 25p |
| 2N2369A | 25p |
| 2N2484 | 30p |
| 2N2646 | 45p |
| 2N2904/5 | 25p |
| 2N2906A | 25p |
| 2N2907A | 25p |
| 2N2926 | 9p |
| 2N3053 | 30p |
| 2N3054 | 65p |
| 2N3055 | 48p |
| 2N3442 | 140p |
| 2N3553 | 240p |
| 2N3584 | 250p |
| 2N3643/4 | 48p |
| 2N3702/3 | 12p |
| 2N3794/5 | 12p |
| 2N3796/7 | 14p |
| 2N3708/9 | 12p |
| 2N3773 | 300p |
| 2N3819 | 25p |
| 2N3820 | 40p |
| 2N3823 | 50p |
| 2N3866 | 90p |
| 2N3902 | 700p |
| 2N3903/4 | 16p |
| 2N3905/6 | 16p |
| 2N4037 | 65p |
| 2N4123/4 | 27p |
| 2N4125/6 | 27p |
| 2N4401/3 | 27p |
| 2N4427 | 90p |
| 2N4871 | 60p |
| 2N5087 | 27p |
| 2N5089 | 27p |
| 2N5172 | 27p |
| 2N5191 | 90p |
| 2N5194 | 90p |
| 2N5245 | 40p |
| 2N5298 | 65p |
| 2N5401 | 60p |
| 2N5457/8 | 40p |
| 2N5459 | 40p |
| 2N5460 | 60p |
| 2N5485 | 44p |
| 2N5875 | 250p |
| 2N6027 | 48p |
| 2N6052 | 300p |
| 2N6059 | 325p |
| 2N6107 | 65p |
| 2N6247 | 190p |
| 2N6254 | 130p |
| 2N6290 | 65p |
| 2SC1172 | 150p |
| 2SC1306 | 100p |
| 2SC1307 | 150p |
| 2SC1957 | 90p |
| 2SC1969 | 150p |
| 2SC2028 | 95p |
| 2SC2029 | 250p |
| 2SC2078 | 200p |
| 2SC2335 | 250p |
| 2SC2612 | 250p |
| 3N128 | 120p |
| 3N140 | 120p |
| 3N141 | 110p |
| 3N201 | 110p |
| 3N204 | 120p |
| 40290 | 260p |
| 40361/2 | 75p |
| 40408 | 90p |
| 40409 | 100p |
| 40410 | 100p |
| 40411 | 300p |
| 40594 | 120p |
| 40595 | 120p |
| 40673 | 75p |
| 40871/2 | 100p |

### LOW PROFILE SOCKETS BY TI

| | | | | | |
|---|---|---|---|---|---|
| 8 pin | 9p | 18 pin | 16p | 24 pin | 24p |
| 14 pin | 10p | 20 pin | 18p | 28 pin | 26p |
| 16 pin | 11p | 22 pin | 22p | 40 pin | 30p |

### WIRE WRAP SOCKETS BY TEXAS

| | | | | | |
|---|---|---|---|---|---|
| 8 pin | 25p | 18 pin | 50p | 24 pin | 70p |
| 14 pin | 35p | 20 pin | 60p | 28 pin | 80p |
| 16 pin | 40p | 22 pin | 65p | 40 pin | £1 |

### DIODES

| | |
|---|---|
| BY127 | 12p |
| BYX36.300 | 20p |
| OA47 | 8p |
| OA90/91 | 9p |
| OA95 | 9p |
| OA200 | 9p |
| OA202 | 10p |
| 1N914 | 4p |
| 1N916 | 7p |
| 1N4148 | 4p |
| 1N4001/2 | 5p |
| 1N4003/4 | 6p |
| 1N4005 | 6p |
| 1N4006/7 | 7p |
| 1N5401/3 | 14p |
| 1N5404/7 | 19p |
| 1S920 | 9p |

### BRIDGE RECTIFIERS

| | |
|---|---|
| 1A 50V | 19p |
| 1A 100V | 20p |
| 1A 400V | 25p |
| 1A 600V | 30p |
| 2A 50V | 30p |
| 2A 100V | 35p |
| 2A 400V | 45p |
| 3A 200V | 60p |
| 3A 600V | 72p |
| 4A 100V | 95p |
| 4A 400V | 100p |
| 6A 50V | 80p |
| 6A 100V | 100p |
| 6A 400V | 120p |
| 10A 400V | 200p |
| 25A 400V | 400p |

### ZENERS

| | |
|---|---|
| 2.7V-33V | |
| 400mW | 9p |
| 1W | 15p |

### TRIACS PLASTIC

| | |
|---|---|
| 3A 400V | 60p |
| 6A 400V | 70p |
| 6A 500V | 88p |
| 8A 400V | 75p |
| 8A 500V | 95p |
| 12A 400V | 85p |
| 12A 500V | 105p |
| 16A 400V | 110p |
| 16A 500V | 130p |
| T2800D | 130p |

### THYRISTORS

| | |
|---|---|
| 3A 400V | 100p |
| 8A 600V | 140p |
| 12A 400V | 160p |
| 16A 100V | 180p |
| 16A 400V | 180p |
| C106D | 45p |
| MCR101 | 36p |
| TIC44 | 27p |
| 2N3525 | 130p |
| 2N4444 | 180p |
| 2N5060 | 30p |
| 2N5064 | 35p |

### PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24V DC 160p

6 or 12V DC Coil DPDT 5A 24V DC 240V AC 200p

6 or 12V DC Coil SPDT 10A 24V DC 240V AC 225p

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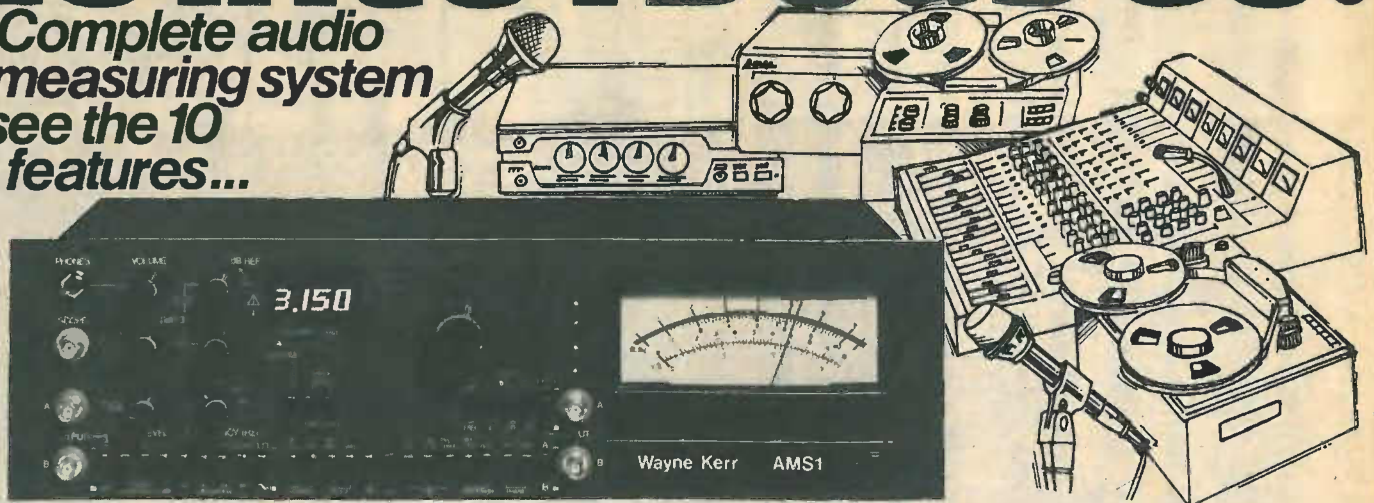
# 10 into 1 Does Go.

*Complete audio measuring system see the 10 features...*

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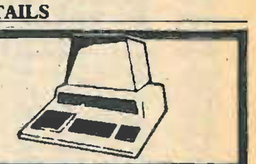

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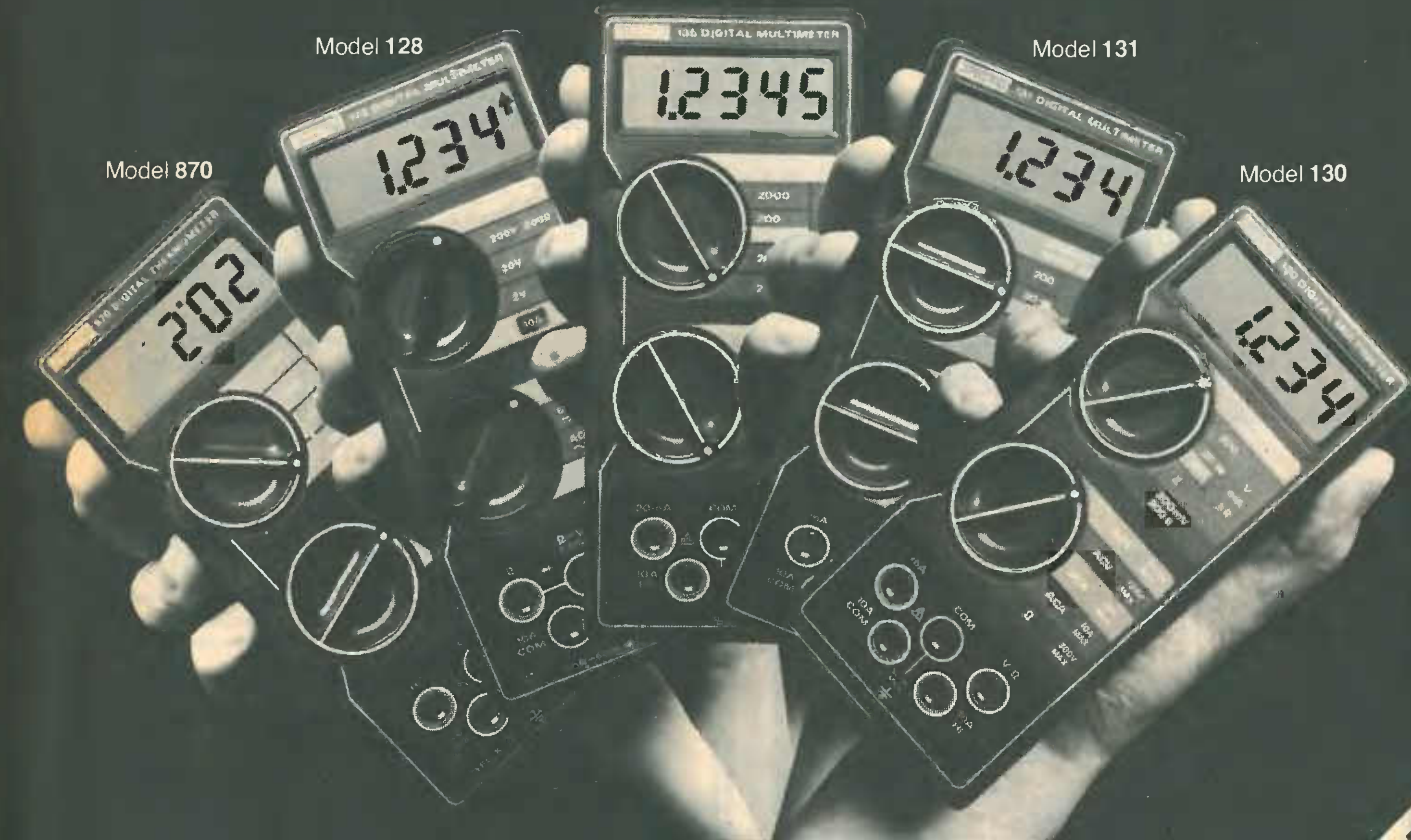


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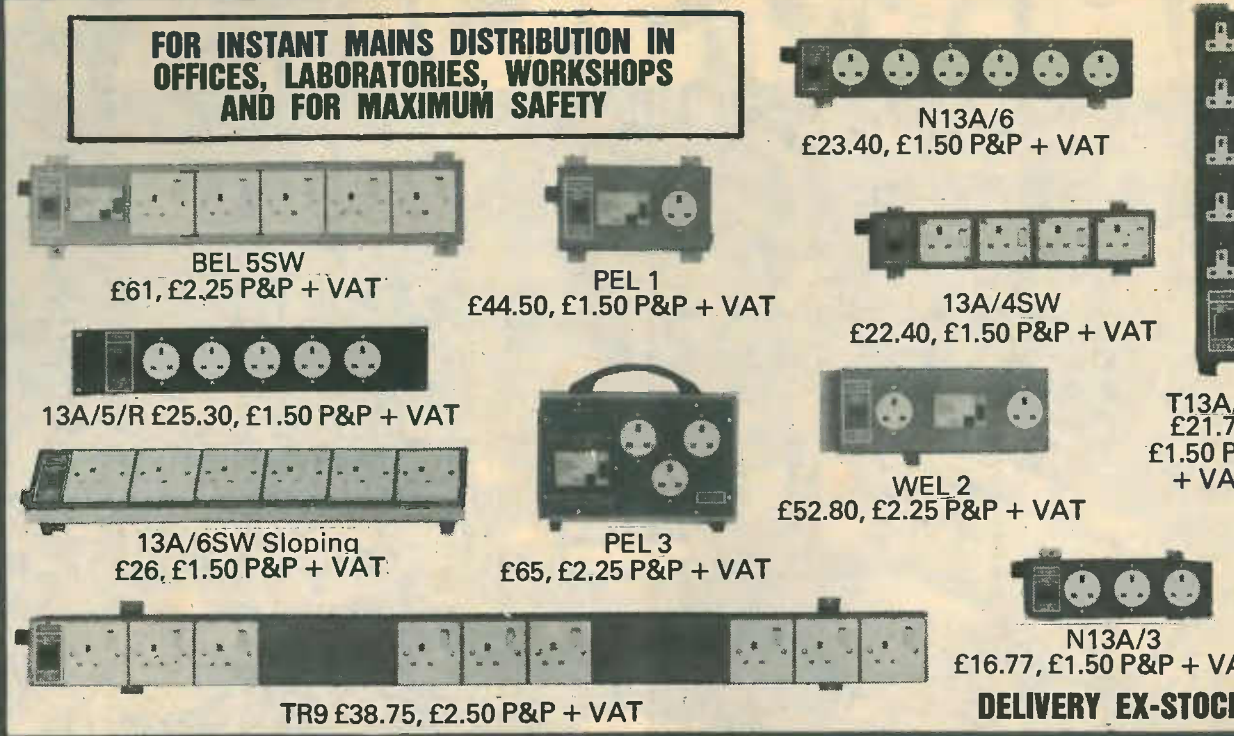

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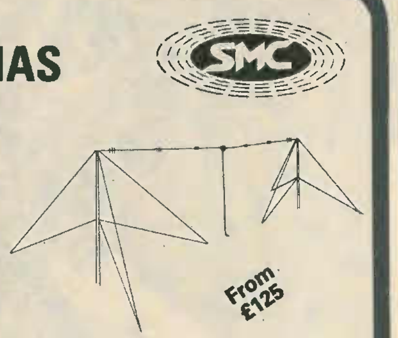
# HF ANTENNAS

SMC




★ MODE; Full half wave operation.

★ BANDS; Up to 4 spot frequencies.

★ POWER; Receive to 800W (PEP).

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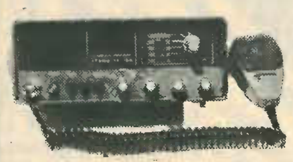

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**The Digitel D4060 Noise Measurement System offers an accurate and economical method of measuring video signal to noise ratio on broadcast or industrial TV systems.**

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**Accurate to ± 1.5dBs from 20dBs to 60dBs**

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# SAFGAN DT-400 Series BRITISH MAKE DUAL TRACE 'SCOPES


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

★ CH1, CH2: 5mv/div – 20v/div.
★ Time Base: 1 sec/div – 100ns/div.
★ XY Facility: Matched XY inputs.
★ 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) £11.50**

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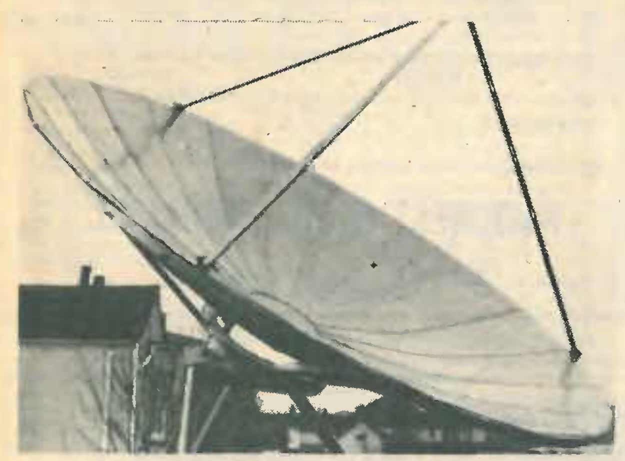

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|---|---|
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| 2708 450ns | 2.93 |
| 2716 450ns (+5v) | 2.49 |
| 2716 350ns (+5v) | 3.59 |
| 2716 (3 rail) 450ns | 5.95 |
| 2732 450ns | 3.90 |
| 2732 350ns | 4.40 |
| 2532 450ns | 3.90 |
| 4116 200ns | 0.70 |
| 4116 150ns | 0.84 |
| 4118 200ns | 3.38 |
| 4164 200ns | 4.65 |
| 4516/4816 100ns | 3.25 |
| 5516 200ns | 9.38 |
| 6116 200ns | 5.10 |
| 6116LP 200/150ns | 7.61 |
| **CRT CONTROLLERS** | |
| EF6845P | 9.50 |
| EF9364P | 5.94 |
| **BUFFERS** | |
| 81LS95 | 0.90 |
| 81LS96 | 0.90 |
| 81LS97 | 0.90 |
| 81LS98 | 0.90 |
| 8T26A | 1.20 |
| 8T28A | 1.20 |
| 8T95 | 1.35 |
| 8T97A | 1.35 |
| 8T98 | 1.45 |
| **DATA CONVERTERS** | |
| ZN425E-8 | 3.45 |
| ZN426E-8 | 3.00 |
| ZN427E-8 | 5.99 |
| ZN428E-8 | 4.75 |
| ZN429E-8 | 2.10 |
| ZN432CJ-10 | 28.09 |
| ZN433CJ-10 | 2.59 |
| ZN440 | 56.63 |
| ZN432E-10 | 13.00 |
| ZN447 | 9.14 |
| ZN448 | 6.95 |
| ZN449 | 3.20 |
| **FLOPPY DISC CONTROLLERS** | |
| FD1771 | 17.12 |
| FD1791 | 32.61 |
| FD1793 | 32.61 |
| FD1795 | 35.33 |
| WD1391 | 45.50 |
| WD1393 | 45.50 |
| WD1395 | 45.50 |
| WD1397 | 45.50 |
| WD2143-01 | 5.45 |
| WD1691 | 10.87 |
| **MISCELLANEOUS SUPPORT CHIPS** | |
| AY-3-1015 | 2.99 |
| AY-3-1270 | 7.95 |
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| AY-5-1013 | 2.99 |
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| DP8304 | 4.50 |
| MC1488 | 0.55 |
| MC1489 | 0.55 |
| MC3446 | 2.95 |
| MC3448A | 4.25 |
| MC3480 | 7.95 |
| MC3487 | 2.95 |
| MC14411 | 8.94 |
| MC14412 | 7.99 |
| RO-3-2513L | 6.99 |
| RO-3-2513U | 5.99 |
| ULN2803A(L203) | 0.84 |
| **DVM CHIPS** | |
| ZN450e | 7.61 |
| ZN450E DVM KIT | 17.35 |
| **LINEARS** | |
| LM301AN | 0.25 |
| LM308N | 0.89 |
| LM311N | 0.90 |
| LM319N | 2.14 |
| LM324N | 0.30 |
| LM348N | 0.50 |
| LM555CN | 0.18 |
| LM556CN | 0.45 |
| LM725CN | 3.20 |
| LM741CN | 0.14 |
| LM747CN | 0.64 |
| LM748CN | 0.34 |
| **REGULATORS** | |
| 7805 | 0.39 |
| 7812 | 0.39 |
| 7815 | 0.39 |
| 78L05 | 0.29 |
| 78L12 | 0.29 |

| Device | Price |
|---|---|
| 78L15 | 0.29 |
| 7905 | 0.55 |
| 7912 | 0.55 |
| 7915 | 0.55 |
| 79L05 | 0.59 |
| 79L12 | 0.59 |
| 79L15 | 0.59 |
| LM309K | 0.99 |
| LM317K | 3.20 |
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| Z80A DART | 5.70 |
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| Z80A PIO | 3.15 |
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| Z80A SIO-0 | 11.99 |
| Z80 SIO-1 | 10.99 |
| Z80A SIO-1 | 11.99 |
| Z80 SIO-2 | 10.99 |
| Z80A SIO-2 | 11.99 |
| MK 3886 | 11.00 |
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| **6800 FAMILY** | |
| 6800 | 2.99 |
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| 6810 | 1.12 |
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| 6880 | 1.07 |
| 6887 | 0.80 |
| 68488 | 9.11 |
| 6875 | 5.62 |
| 6843 | 13.99 |
| 68B00 | 6.30 |
| 68B02 | 19.11 |
| 68B21 | 2.29 |
| 68B10 | 2.00 |
| 68B40 | 4.70 |
| 68B50 | 2.86 |
| **6500 FAMILY** | |
| 6502 | 3.45 |
| 6520 | 2.99 |
| 6522 | 4.75 |
| 6532 | 6.65 |
| **8080 FAMILY** | |
| 8085A | 5.20 |
| 8212 | 1.70 |
| 8216 | 0.80 |
| 8224 | 1.80 |
| 8228 | 3.95 |
| 8251 | 3.19 |
| 8253 | 7.95 |
| 8255 | 3.90 |
| **CMOS 4000 'B' SERIES** | |
| 4000 | 0.11 |
| 4001 | 0.11 |
| 4002 | 0.13 |
| 4006 | 0.80 |
| 4007 | 0.15 |
| 4008 | 0.55 |
| 4009 | 0.28 |
| 4010 | 0.35 |
| 4011 | 0.12 |
| 4012 | 0.15 |
| 4013 | 0.29 |
| 4014 | 0.58 |
| 4015 | 0.58 |
| 4016 | 0.25 |

| Device | Price |
|---|---|
| 4017 | 0.45 |
| 4018 | 0.58 |
| 4019 | 0.29 |
| 4020 | 0.58 |
| 4021 | 0.80 |
| 4022 | 0.62 |
| 4023 | 0.17 |
| 4024 | 0.35 |
| 4025 | 0.16 |
| 4026 | 0.99 |
| 4027 | 0.30 |
| 4028 | 0.55 |
| 4031 | 1.85 |
| 4033 | 1.80 |
| 4034 | 1.55 |
| 4035 | 0.72 |
| 4040 | 0.54 |
| 4041 | 0.69 |
| 4042 | 0.54 |
| 4043 | 0.59 |
| 4044 | 0.84 |
| 4045 | 1.85 |
| 4046 | 0.88 |
| 4047 | 0.88 |
| 4048 | 0.54 |
| 4049 | 0.28 |
| 4050 | 0.28 |
| 4051 | 0.59 |
| 4052 | 0.68 |
| 4053 | 0.59 |
| 4054 | 1.20 |
| 4055 | 1.20 |
| 4060 | 0.79 |
| 4063 | 0.95 |
| 4066 | 0.34 |
| 4068 | 0.17 |
| 4069 | 0.17 |
| 4070 | 0.17 |
| 4071 | 0.17 |
| 4072 | 0.17 |
| 4073 | 0.19 |
| 4075 | 0.17 |
| 4076 | 0.62 |
| 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 | 0.69 |
| 4518 | 0.40 |
| 4519 | 0.28 |
| 4520 | 0.69 |
| 4521 | 1.49 |
| 4522 | 1.20 |
| 4526 | 0.70 |
| 4527 | 0.99 |
| 4528 | 0.70 |
| 4532 | 0.85 |
| 4541 | 0.99 |
| 4543 | 0.99 |
| 4553 | 2.90 |
| 4555 | 0.39 |
| 4556 | 0.44 |
| 4585 | 0.62 |
| **74LS SERIES** | |
| 74LS00 | 0.10 |
| 74LS01 | 0.11 |
| 74LS02 | 0.12 |
| 74LS03 | 0.12 |
| 74LS04 | 0.12 |
| 74LS05 | 0.13 |
| 74LS08 | 0.12 |
| 74LS09 | 0.12 |
| 74LS10 | 0.12 |
| 74LS11 | 0.12 |
| 74LS12 | 0.12 |

| Device | Price |
|---|---|
| 74LS13 | 0.22 |
| 74LS14 | 0.37 |
| 74LS15 | 0.12 |
| 74LS20 | 0.12 |
| 74LS21 | 0.12 |
| 74LS22 | 0.12 |
| 74LS26 | 0.15 |
| 74LS27 | 0.12 |
| 74LS28 | 0.15 |
| 74LS30 | 0.12 |
| 74LS32 | 0.12 |
| 74LS33 | 0.16 |
| 74LS37 | 0.15 |
| 74LS38 | 0.15 |
| 74LS40 | 0.12 |
| 74LS42 | 0.33 |
| 74LS47 | 0.39 |
| 74LS48 | 0.59 |
| 74LS49 | 0.59 |
| 74LS51 | 0.14 |
| 74LS54 | 0.15 |
| 74LS55 | 0.15 |
| 74LS73 | 0.19 |
| 74LS74 | 0.16 |
| 74LS75 | 0.24 |
| 74LS76 | 0.20 |
| 74LS78 | 0.19 |
| 74LS83 | 0.44 |
| 74LS85 | 0.60 |
| 74LS86 | 0.15 |
| 74LS90 | 0.28 |
| 74LS91 | 0.74 |
| 74LS92 | 0.33 |
| 74LS93 | 0.33 |
| 74LS95 | 0.42 |
| 74LS109 | 0.21 |
| 74LS112 | 0.21 |
| 74LS113 | 0.23 |
| 74LS114 | 0.30 |
| 74LS122 | 0.39 |
| 74LS123 | 0.39 |
| 74LS124 | 1.20 |
| 74LS125 | 0.24 |
| 74LS126 | 0.25 |
| 74LS132 | 0.28 |
| 74LS136 | 0.28 |
| 74LS138 | 0.33 |
| 74LS139 | 0.35 |
| 74LS145 | 0.74 |
| 74LS148 | 0.80 |
| 74LS151 | 0.39 |
| 74LS153 | 0.28 |
| 74LS155 | 0.38 |
| 74LS156 | 0.38 |
| 74LS157 | 0.29 |
| 74LS158 | 0.31 |
| 74LS160 | 0.39 |
| 74LS161 | 0.37 |
| 74LS162 | 0.39 |
| 74LS163 | 0.36 |
| 74LS164 | 0.45 |
| 74LS165 | 0.75 |
| 74LS166 | 0.84 |
| 74LS173 | 0.69 |
| 74LS174 | 0.45 |
| 74LS175 | 0.45 |
| 74LS181 | 1.28 |
| 74LS190 | 0.49 |
| 74LS191 | 0.49 |
| 74LS192 | 0.49 |
| 74LS193 | 0.45 |
| 74LS194 | 0.39 |
| 74LS195 | 0.39 |
| 74LS196 | 0.57 |
| 74LS197 | 0.59 |
| 74LS221 | 0.54 |
| 74LS240 | 0.69 |
| 74LS241 | 0.69 |
| 74LS242 | 0.78 |
| 74LS243 | 0.79 |
| 74LS244 | 0.60 |
| 74LS245 | 0.80 |
| 74LS247 | 0.60 |
| 74LS248 | 0.80 |
| 74LS249 | 0.63 |
| 74LS251 | 0.40 |
| 74LS253 | 0.39 |

| Device | Price |
|---|---|
| 74LS257 | 0.43 |
| 74LS258 | 0.39 |
| 74LS259 | 0.78 |
| 74LS261 | 1.95 |
| 74LS266 | 0.22 |
| 74LS273 | 0.70 |
| 74LS279 | 0.39 |
| 74LS283 | 0.44 |
| 74LS290 | 0.54 |
| 74LS293 | 0.45 |
| 74LS365 | 0.34 |
| 74LS366 | 0.36 |
| 74LS367 | 0.34 |
| 74LS368 | 0.35 |
| 74LS373 | 0.70 |
| 74LS374 | 0.70 |
| 74LS375 | 0.47 |
| 74LS377 | 0.70 |
| 74LS378 | 0.80 |
| 74LS379 | 0.84 |
| 74LS386 | 0.28 |
| 74LS390 | 0.54 |
| 74LS393 | 0.59 |
| **DIL SOCKETS LOW PROFILE - TIN** | |
| 8 pin | 0.07 |
| 14 pin | 0.09 |
| 16 pin | 0.09 |
| 18 pin | 0.13 |
| 20 pin | 0.14 |
| 22 pin | 0.17 |
| 24 pin | 0.19 |
| 28 pin | 0.25 |
| 40 pin | 0.29 |
| **LOW PROFILE - GOLD** | |
| 8 pin | 0.22 |
| 14 pin | 0.29 |
| 16 pin | 0.31 |
| 18 pin | 0.33 |
| 20 pin | 0.35 |
| 22 pin | 0.40 |
| 24 pin | 0.42 |
| 28 pin | 0.54 |
| 40 pin | 0.81 |
| **ZERO - INSERTION FORCE DIL** | |
| 24 pin | 6.30 |
| 28 pin | 7.40 |
| 40 pin | 8.80 |
| **CRYSTALS** | |
| 1 MHz | 2.90 |
| 1.008 MHz | 2.90 |
| 1.8432 MHz | 2.20 |
| 3.6864 MHz | 2.95 |
| 4 MHz | 1.85 |
| 6 MHz | 1.90 |
| 8 MHz | 1.95 |
| **UHF MODULATORS** | |
| 6 MHz | 3.70 |
| 8 MHz | 4.40 |
| **BBC MICRO-COMPUTER UPGRADES** | |
| BBC 1 RAM Upgrade Kit | 26.00 |
| BBC 2 Printer User I/O Kit | 9.50 |
| BBC 4 Analogue I/P Kit | 9.50 |
| BBC 5 Serial I/O and RGB Kit | 11.45 |
| BBC 6 Expansion BUS Kit | 7.95 |
| Connectors for BBC 4 | 2.25 |
| Connectors for BBC 5 | 0.80 |
| The above kits make up the full Model 'A' to Model 'B' Upgrade for the BBC Microcomputer Special Price when bought complete | 62.00 |
| **NEW NEC 12" MONITOR** Custom made computer display inc built in speaker and amp. Green phosphor display | 149.00 |
| (£10 carriage & VAT) | |
| **EPROM Erasers** UV141-14 eprom capacity-built in timer | 78.00 |
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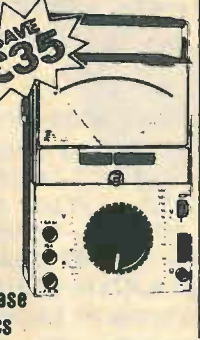

## LCD LOW COST MULTIMETERS

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HC703 0.1% version of above £54.00
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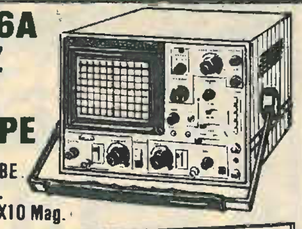

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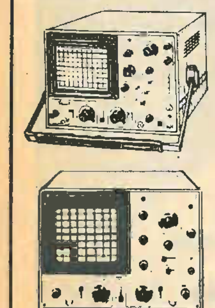

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Range of mains operated Scopes with 5" displays, triggered sweep (UK c/p £3.50)

**DUAL TRACE**

| | |
|---|---|
| CS1562A 10 MHZ; 10 MV; 1 micro sec. | £267.95 |
| CS1560A II 15 MHZ; 10mV; 0.5 micro sec. | £341.55 |
| CS1566A 20 MHZ; 5mV; 0.5 micro sec. | £320.00 |
| CS1577A 35 MHZ; 2mV; 0.1 micro sec. | £523.25 |
| CS1820 20 MHZ; 2-5mV 1 micro delay sweep | £483.00 |
| CS1830 Mk II 300 MHZ, 2mV, 0.2 micro sec (fitted delay line) | £626.75 |
| CS1575 5 MHZ, 1mV, 0.5 micro sec. Multi display Audio scope. | £312.80 |

**SINGLE TRACE**

CO1303D 5 MHZ, 10mV, low sweep for observation below 1 HZ and up to 450 MHZ. 75mm display (UK c/p £2.00) £124.20

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| | |
|---|---|
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| 3131 Dual trace 15 MHZ, trg to 35 MHZ, 5mV, 0.5 micro sec, 130mm tube, plus component tester. | £276.00 |
| 3034 Battery-mains dual trace 15 MHZ, trig to 20 MHZ built in Nicads, 5mV, 0.5 micro secs. (Eliminator charger optional £28.75) | £356.50 |
| Also Available 3033, single trace 3034 | £322.00 |
| 3337, dual MHZ, 130mm | £454.00 |

STOP PRESS
Model 3035 was £189.75 – Special Offer £168.50

## DIRECT READ HV PROBE (UK c/p 65p)

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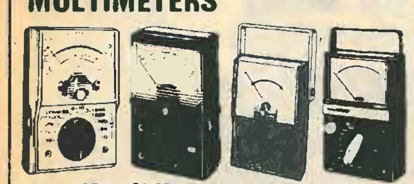
## MULTIMETERS



(UK c/p 65p or £1.00 for two)
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|---|---|
| KRT101 10 range pocket 1K/Volt | £4.95 |
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| NH55 10 range pocket 2K/Volt | £6.50 |
| ST5 11 range pocket 4K/Volt | £7.50 |
| AT1 12 range pocket Deluxe 2K/Volt | £8.95 |
| NH56R 22 range pocket 20K/Volt | £11.50 |
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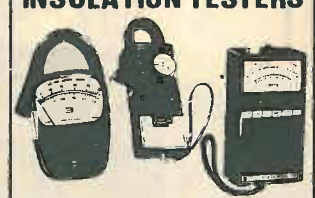
| KRT6001 16 range 10 amp DC range double 50K/Volt | £17.95 |
| ST303TR 21 range plus Hfe Test 20K/Volt | £18.95 |
| AT1020 19 range Deluxe plus Hfe Test 20K/Volt | £18.95 |
| ECT5000 As KRT5001 plus colour scales 50K/Volt | £18.95 |
| 7081 18 range double 10A DC 50K/Volt | £23.75 |
| TMK500 23 range plus 12A DC plus cont. buzzer 30K/Volt | £24.50 |
| 168m 36 range large scale 10A AC/DC 50 K/Volt | £28.50 |
| AT2050 17 range Deluxe plus Hfe tester 50 K/Volt | £29.95 |
| AT210 23 range Deluxe 12A AC/DC 100K/Volt | £32.50 |
| 360TR 23 range large scale 10A AC/DC Hfe test 50 meg ohm. 1KV AC/DC 100 K/Volt | £39.95 |

## SCOPE ADD ON UNITS

SUITABLE FOR ALL SCOPES

LTC905 Semiconductor Curve tracer £95.45 (post 85p)
HZ65 Component Tester £29.95 (Post 55p)

## CLAMP-ON-METERS INSULATION TESTERS



Multi-range clamps all with resistance range, carry case & leads. Also digital and DC clamp in stock (UK c/p 75p)

| | |
|---|---|
| ST300 300A 600V 9 ranges | £25.95 |
| ST310 300A 600V 9 ranges | £28.95 |
| K2602 150A, 600V, AC 7 ranges | £35.95 |
| *K2606 300A, 600V, AC 8 ranges | £49.50 |
| K2803 300A, 600V, AC 9 ranges | £59.95 |
| K2903 900A, 750V, AC 9 ranges | £77.50 |
| K2103 1000A, 750V, AC 9 ranges | £95.00 |
| *Optional temperature probe | £13.80 |

**ELECTRONIC INSULATION TESTERS**
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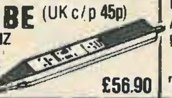
| | |
|---|---|
| YF500L 500V/100Meg. Plus 0-100 ohm | £65.00 |
| K3103 600V/100Meg. Plus 0-2.6K ohm | £109.00 |
| K3106 500V & 1000V, 1000 & 2000Meg. | £119.00 |
| K4101 Earth resistance tester | £149.00 |
| M500 Hand cranked insulation tester 500V/100Meg. | £79.50 |

## LOGIC PROBE (UK c/p 45p)

Leader LDP076 50 MHZ 10MEG ohm. 10n Sec with carry case. LP10 10Mhz probe £28.50 £56.90



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| TM352 Hand held, DC 10A, Hfe test. Continuity test | £57.44 |
| TM353 Bench 2A AC/DC 1000V AC/DC 20M ohm. Typical 0.25% NEW LOW PRICE | £86.25 |
| TM351 Bench, 10A AC/DC, 1000V AC/DC, 20M ohm Typical 0.1% | £113.85 |

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| PFM200A Hand held LED 200 MHZ 10mV (600 MHZ with TP600). New Model fitted BNC sockets. | £67.50 |
| TF040 Bench LCD. 40 MHZ. 40mV (400 MHZ with TP600) | £126.50 |
| TF200 Bench LCD. 200 MHZ. 10-30mV (600 MHZ with (TP600)) | £166.75 |
| TP600 600MHZ + 10 Prescaler 10 mV | £43.13 |

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| | |
|---|---|
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| TG102 Function 0.2 HZ-2 MHZ Sine/SQ/Triangle/TTL | £166.75 |
| TG105 Pulse. 5 MHZ-5HZ (200nS-200mS) various outputs | £97.75 |

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Model 130, 25 range. Easy to hold and use LCD DMM. Size 7 x 3.1 x 1.5
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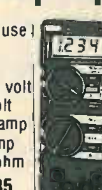
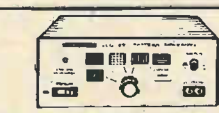
AC current 2mA-10AMP 2% 1 micro amp
Resistance 200 ohm-20 Meg 0.5% 0.1 ohm
£102.35
Model 129 as above £79.35





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| LCG393 VHF 6 pattern | £143.75 |
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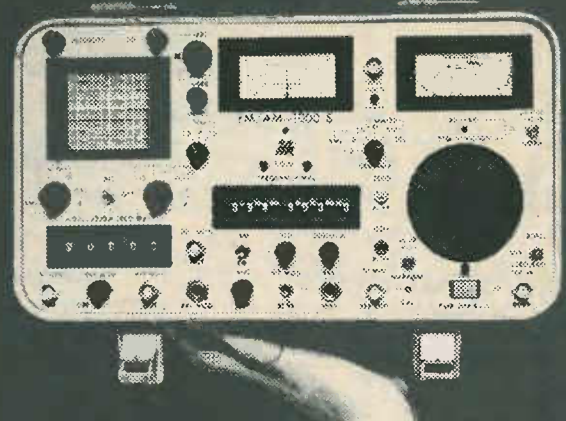

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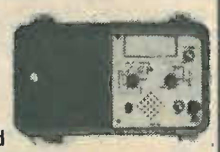
### MM-100 MULTI-METER

Simply replaces the protective lid of the FM/AM 1000s. It includes a modified probe, PB-114, and a built in speaker unit with independent volume control for audible response to signal measurement. This practical 'top up' will perform the following functions.



**Sinad**: Measurements for 1 kHz tone (± 20 Hz)
**Distortion**: To 30%
**DC Volts**: Up to 300 volts and up to 800 volts when the X10 probe is used
**AC Volts**: 600 VRMS maximum for frequencies between 25 Hz and 25 kHz
**Ohms**: Using the modified probe, part number PB-114, Ohms can be measured on scales X1 to X10 K
**% AM** Measured on the RF signal applied to the FM/AM-1000 unit

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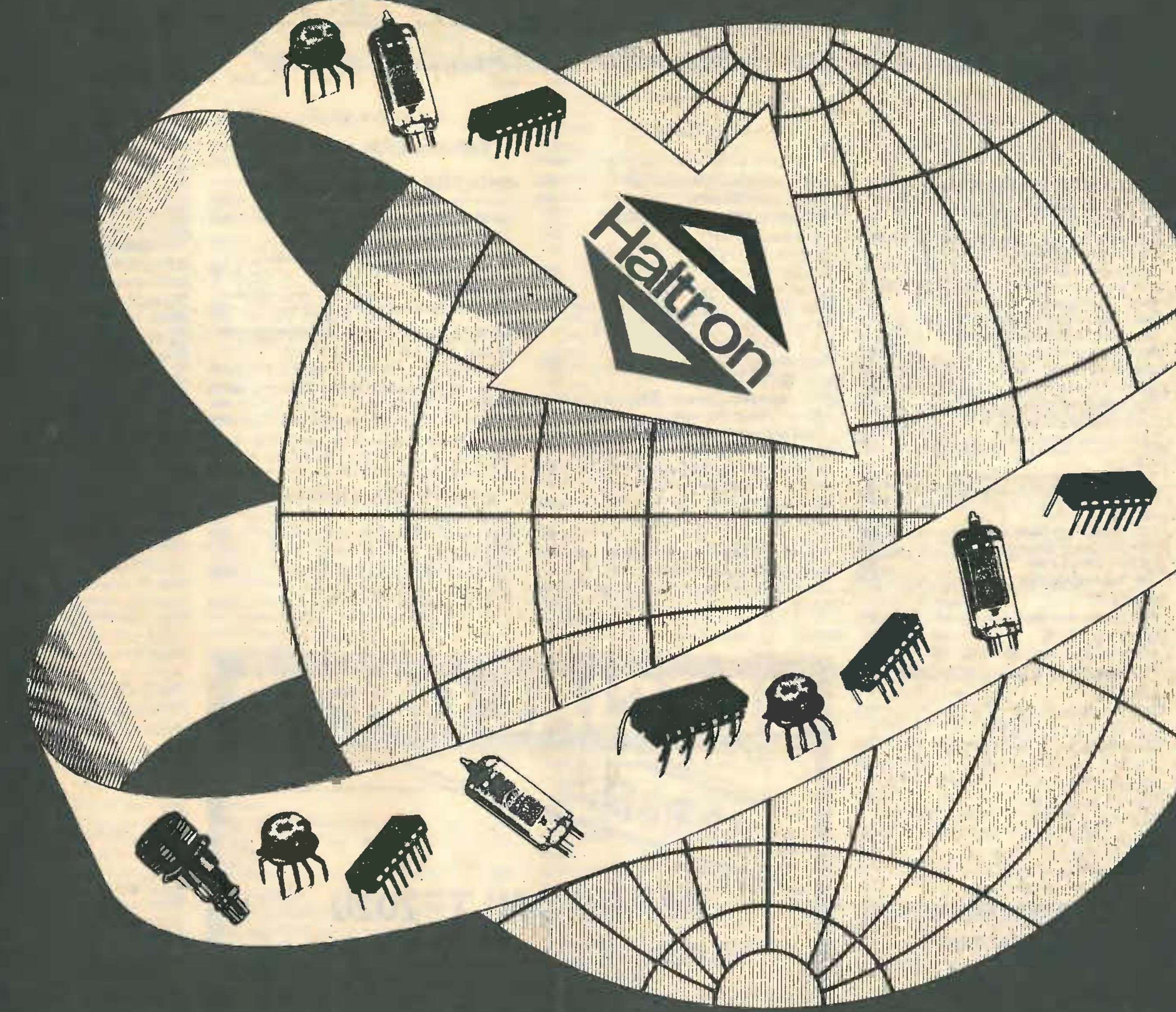


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| 2215 Sound Level Meter inc. Oct. Filter | 1050 |
| 2218 Sound Level Meter inc. Leq. | 1475 |
| 2305B Level Recorder inc. 50 dB pot. | 1350 |
| 2625 Vibration pick-up amplifier | 350 |
| 2808 Power Supply/Mains Adapter | 90 |
| 2972 Tape Signal Gate | 200 |
| 4230 Sound Level Calibrator | 120 |
| 4423 Noise Dosemeter | 350 |
| 4424 Noise Dosemeter | 375 |
| **CASTLE ACOUSTICS** | |
| CS181 Sound Level Meter & Calibrator | 295 |
| **C.E.L.** | |
| 112 Environmental Noise Analyser | 300 |
| 144 Environmental Noise Analyser | 500 |
| **DAWE** | |
| 419C Audio White Noise Generator | 190 |
| 1461CV Vibration Analyser | 350 |
| 1463B ⅓ Octave Filter | 200 |
| 1465 Octave Band Filter | 150 |
| **KISTLER** | |
| 504A Charge Amplifier | 200 |
| **WAYNE KERR** | |
| B731B Vibration Meter inc. probe | 270 |

## BRIDGES & V and I STANDARDS

| Item | Prices from £ |
|---|---|
| **CINTEL** | |
| 2773 Inductance Bridge | 160 |
| **HEWLETT PACKARD** | |
| 4261A Digital Automatic LCR Bridge | 975 |
| 4342 QLC Meter 22 KHz-70 MHz | 2600 |
| **MUIRHEAD** | |
| D30A DC Bridge 0.15% | 180 |
| **WAYNE KERR** | |
| B224 RCL Bridge 0.1% | 500 |
| B521 LCR Bridge | 115 |
| B801/CU681/Q801/SR268 VHF Admittance Bridge with source and detector transistor adapter & D.C. Control Unit for transistor measurements | 750 |

## COMMS & CABLE TEST EQUIPMENT

| Item | Prices from £ |
|---|---|
| **DYMAR** | |
| BC282 Battery charger for 883 Radio Telephone | 80 |
| 883 Radio Telephone — VHF band — hand held | 245 |
| **MARCONI** | |
| TF2091 White Noise Generator (exc. filters) | 1000 |
| TF2092 White Noise Receiver (exc. filters) | 1000 |
| TF2809 Data Line Analyser | 600 |
| **NORTHEAST ELECTRONICS** | |
| TT537B Psophometer/VU Meter | 200 |
| **SEIMENS** | |
| U2033 Psophmeter | 475 |
| **S.T.C.** | |
| 74106 Bridge Unit | 135 |
| 74184B Selective Level Measuring Set | 600 |
| 74216A Noise Generator | 300 |
| 74261A Psophometer | 300 |
| 74262B White Noise Generator & Receiver | 2000 |
| 74307C Level Measuring Set | 175 |
| 74834C Distortion Measuring Set | 500 |
| 96016 Selective Null Detector | 200 |
| GTA-2 Quantization Distortion Tester | 800 |
| GTA4B Pattern Generator | 900 |

## COMPUTER EQUIPMENT

(90 day guarantee)

| Item | Prices from £ |
|---|---|
| **CENTRONICS** | |
| 702 matrix printer | 500 |
| **HEWLETT PACKARD** | |
| 9835A Desktop Computer 64K + expanded I/O ROM + HP — IB interface. Includes C.R.T. Cartridge Tape Drive — Full documentation test tapes etc. | 5900 |
| **TEKTRONIX** | |
| 4610-1 Hard copy printer for 4010 series computer display terminals | 1500 |

## COUNTERS & TIMERS

| Item | Prices from £ |
|---|---|
| **FLUKE** | |
| 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/5305B 1300 MHz 6 Digit Counter | 425 |
| 5345 500 MHz 11 Digit Counter Timer | 2000 |
| **SYSTRON DONNER** | |
| 6053 3 GHz 9 digit Counter BCD O/P | 790 |
| 5103B Strip Printer for 6053/6054 | 375 |
| **TEKTRONIX** | |
| DC501 7 Digit 100 MHz Counter — TM500 Plug-in | 180 |
| **VENNER** | |
| 1000F 32 MHz 7 digit counter/timer | 190 |
| **MARCONI** | |
| TF 2432 560 MHz 8 Digit Counter | 350 |
| **PHILIPS** | |
| PM6614/02 520 MHz 9 Digit Counter TCXO | 480 |
| PM6624/02 520 MHz 9 Digit Counter Timer TCXO | 750 |
| PM6661 80 MHz 8 Digit Counter | 180 |
| **RACAL-DANA (E.I.P.)** | |
| 371 18 GHz 11 Digit Counter with Source Locking facility | 4950 |
| 371 18 GHz 11 Digit Counter with high stab xtel option. Source Locking facility, HP-IB opt | 5500 |
| 8110 50 MHz 8 Digit Counter Timer | 320 |
| 9025 1 GHz 8 Digit Counter | 450 |
| 9903 50 MHz 7 Digit Counter Timer | 350 |
| 9905 200 MHz 8 digit Counter Timer | 360 |

## DIGITAL TESTING EQUIPMENT

| Item | Prices from £ |
|---|---|
| **HEWLETT PACKARD** | |
| 1600A Logic Analyser 16 ch 20 MHz | 1150 |
| 1600S Logic Analyser 32 ch 20 MHz | 2250 |
| 1602A Logic Analyser 16 ch 10 MHz | 900 |
| 1615A Logic Analyser 24 ch 20 MHz | 4850 |
| **TEKTRONIX** | |
| 832 Datacom Tester R5232/V24 | 1150 |
| 833 As 832 plus BERT/BLERT feature | 1300 |

## MAINS TEST EQUIPMENT

| Item | Prices from £ |
|---|---|
| **DATALAB** | |
| DL019 Mains Interface for DL905 | 300 |
| **DRANETZ** | |
| 606 3ch Volts Av/Spike/Time/Printer | 2950 |
| 616 2ch AC 1ch DC Volts/Av/Spike/Time/Printer | 3300 |
| **GAY** | |
| LDM AC/DC/Spike/Time inc. Printer | 900 |

## SPECIAL OFFER

### STOP PRESS

## MARCONI TF2020

**50 KHz - 520 MHz Synthesised Signal Generator**

High Accuracy — High Stability
High Performance — Full AM/FM Facilities

***LOW PRICE!***

**Two units only available at this price**

## £5500

## MISCELLANEOUS

| Item | Prices from £ |
|---|---|
| **A.I. INDUSTRIES** | |
| TCS General Purpose Gas Leak Detector — intrinsically safe | 290 |
| **BRADLEY** | |
| 192 Oscilloscope Calibrator | 825 |
| **COMARK** | |
| 1601BLS Thermom 10ch 87 + 1000°C type K *N.B. Thermocouples not included* | 50 |
| **CROWCON** | |
| 71P Inflammable Gas Detector/Alarm | 125 |
| **DATALAB** | |
| DL905 Digital Transient Recorder/Display Storage | 1050 |
| **FLANN** | |
| 16/11 Rotary Vane Attenuator WG16 | 25 |
| **HEWLETT PACKARD** | |
| 342A Noise Figure Meter | 50 |
| X382A Rotary Vane Attenuator WG16 | 17 |
| 536A 0.96-4.2 GHz Cavity Frequency Meter | 30 |
| **MEGGER** | |
| BM6 500V 0 – 200 mΩ tester. Batt op. | 7 |
| MJ4 1 kV 0 – 200 mΩ tester. Hand Drive | 16 |
| **MULTIMETRICS** | |
| AF120 Dual H/Pass L/Pass active filter 20 Hz – 2 MHz | 60 |
| **PHILIPS** | |
| PM 5501 Colour TV Pattern Generator | 19 |
| PM 5519 Colour TV Pattern Generator | 63 |
| PM 6456 Stereo FM Generator | 29 |
| **RADIOMETER** | |
| SMG1 Stereo FM Generator | 42 |
| **ROHDE & SCHWARZ** | |
| BN252 Transistor Y Parameter Test Set | 150 |
| **SCHLUMBERGER** | |
| 4010A VHF/UHF Radio Telephone Test Set | 650 |
| **S.T.C.** | |
| 74600J Attenuator 0-9 dB 50Ω in 1 dB steps | 12 |
| 74616A Attenuator 0-100 dB 600Ω in 0.1 dB steps — | 18 |
| **TEKTRONIX** | |
| 184 Time Mark Generator | 29 |
| 521PAL Vectorscope | 276 |
| 528 TV Waveform Monitor | 75 |
| 575 Semiconductor Curve Tracer | 42 |
| 1485C TV Waveform Monitor PAL/NTSC | 310 |
| **TELONIC** | |
| 6001 RF Detector with Log Amplifier — Analogue display & recorder O/P. 0.4-130 MHz — 80 dB range | 27 |
| **YELLOW SPRINGS** | |
| YS157 Water Pollution Measurement System | 30 |

## NETWORK ANALYSERS/ PHASEMETERS

| Item | Prices from £ |
|---|---|
| **DRANETZ** | |
| 301A Analogue Phasemeter 5 Hz-500 KHz | 7 |
| **GENERAL RADIO** | |
| 1710/11/12/14 0.4-500 MHz 115 dB range | 370 |
| **HEWLETT PACKARD** | |
| 8405A Vector Voltmeter 1–1000 MHz | 310 |
| 8407A/8412A/8601A 100 KHz-110 MHz complete Network Analyser system comprising Analyser, Phase/Magnitude display and Sweep Generator. 50Ω or 75Ω system available. 80 dB dynamic range | 650 |
| 8745A S Parameter Test Set 0.1-2 GHz | 310 |
| 11570A Accessory Kit for 8405A | 17 |
| 11600A Transistor Test Fixtures TO18/TO-72 | 12 |
| 11602A Transistor Test Fixtures TO5/TO-12 | 12 |
| 11604A Universal extension arm for 8745A | 25 |
| 11605A Flexible arm for 8743A | 25 |

## OSCILLOSCOPES & ACCESSORIES

### CROTECH Oscilloscopes

***These are brand-new instruments***

| Item | Prices from £ |
|---|---|
| 3030 15 MHz 1 Trace 5mV built-in component tester | 150 |
| 3033 15 MHz 1 Trace 5mV battery operation | 280 |
| 3034 15 MHz 2 Trace 5mV battery operation | 360 |
| 3131 15 MHz 2 Trace 5mV built-in component tester | 240 |
| 3337 30 MHz 2 Trace 5mV with signal delay | 395 |

| Item | Prices from £ |
|---|---|
| **BIOMATION** | |
| 350 Compact XYZ Display | 41 |
| **GOULD ADVANCE** | |
| OS1000B 20 MHz 5mV 2 Trace | 45 |
| **HEWLETT PACKARD** | |
| 1740A 100 MHz 5mV 2 Trace 2TB | 14 |
| 182C 100 MHz Mainframe | 13 |
| 182T 100 MHz Mainframe with digital normaliser interface | 15 |
| 1804A 50 MHz 20mV 4 Trace Plug-in | 62 |
| 1825A Dual Timebase Plug-in | 50 |
| 1805A 100 MHz 5mV 2 Trace Plug-in | 62 |
| **PHILIPS** | |
| PM3207 15 MHz 5mV 2 Trace TV trig | 270 |
| PM3211 15 MHz 2mV 2 Trace TV trig | 299 |
| PM3212 25 MHz 2mV 2 Trace TV trig | 499 |
| PM3233 10 MHz 2mV 2Ch fixed delay Dual Beam | 250 |
| PM3244 50 MHz 5mV 4 Trace 2T base | 1250 |
| 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 2TB | 1600 |
| 465B 100 MHz 5mV 2 Trace 2TB | 1685 |
| 475 200 MHz 2mV 2 Trace 2T base | 1750 |
| 475A 250 MHz 2mV 2 Trace 2T base | 2200 |
| 485 350 MHz 5mV 2 Trace 2T base | 3600 |
| 5B42 2 T/base plug-in 50 MHz Trig for 5000 series Mainframe | 325 |
| 661/4S3/5T1A 1 GHz Sampling scope | 595 |
| 7A18 75 MHz 5mV 2 Trace Plug-in | 420 |
| 7A22 1 MHz 10μV Differential Plug-in | 595 |
| 7A26 200 MHz 5mV 2 Trace Plug-in | 655 |
| 7B53A 2 Timebase Plug-in 100 MHz Trig | 350 |
| 7403N 75 MHz 3 slot M/Frame | 990 |
| 7603 100 MHz CRT r/out 3 slot M/Frame | 1350 |
| **TELEQUIPMENT** | |
| D63/V1/V1 15 MHz 2 Trace 1mV | 370 |
| D63/V5/V5 15 MHz 5mV 2 Trace & fixed delay | 390 |
| S61 5 MHz 5mV 1 Trace | 135 |
| **TEXSCAN** | |
| DU120 Large CRT XY Display with z modulation | 280 |
| *Note: we hold a range of cameras* | P.O.A. |

## OSCILLOSCOPES (STORAGE)

| Item | Prices from £ |
|---|---|
| **HEWLETT PACKARD** | |
| 181A 100 MHz Mainframe 5cm/μs | 2500 |
| 1703A 35 MHz 10mV 2 Tr 2TB 1000 Div/ms | 1400 |
| **TEKTRONIX** | |
| 466 100 MHz 5mV 2 Tr 2TB 1350cm/μs | 2950 |
| 7313 25 MHz 3 slot M/frame split screen 5cm/μs | 1700 |
| 7613 100 MHz 3 slot M/frame 4.5cm/μs | 2700 |

## POWER MEASUREMENT

| Item | Prices from £ |
|---|---|
| **HEWLETT PACKARD** | |
| 432A RF-Microwave Powermeter for use with 470 series sensors | 430 |
| 478A Co-ax sensor for 432 meter 10 MHz-10 GHz | 160 |
| X486A Power sensor for 432 meter W.G. 16 | 160 |
| 432A/478A combined price | 550 |
| 432A/X486A combined price | 550 |
| 8482H Co-ax sensor for 435/436 100 KHz-4.2 GHz | 220 |
| **MARCONI** | |
| 2502 R.F. Powermeter DC-1 GHz 10W max | 475 |
| 2503 R.F. Powermeter DC-1 GHz 100W max | 800 |
| 6460/6421 Microwave Powermeter & sensor 0.01-12.4 GHz | 500 |

## POWER SUPPLIES etc

| Item | Prices from £ |
|---|---|
| **ADVANCE** | |
| MG5-20 Switching PSU module 5V-20A fixed | 90 |
| **BRANDENBURG** | |
| 800 EHT Power supply 3-30 KV-1mA | 450 |
| **FARNELL** | |
| B30/5 0-30V-5A variable | 110 |
| B30/20 0-30V-20A variable | 225 |
| FFSL 5V – 20A PSU module | 80 |
| S830/10 0-30V-10A variable | 190 |
| **HEWLETT PACKARD** | |
| 6268B 0-40 V variable 30 A Metered V + I | 575 |

## PULSE GENERATORS

| Item | Prices from £ |
|---|---|
| **ADVANCE** | |
| PG 52A Modular pulse generator system — wide range of configurations — cost dependent on modules — typical | 650 |
| PG5002D 0.1 Hz-1 MHz 50V 100Ω Double pulse R.T. 15ns | 290 |
| **HEWLETT PACKARD** | |
| 8011A 0.1 Hz-20 MHz 16V 50Ω RT 10ns inc Burst mode | 475 |
| 8016A Digital word generator to 50 MHz 9 x 32 bit | 3400 |
| **LYONS** | |
| PG73N 20 MHz 10V 50Ω R.T. 5ns | 390 |

## RECORDERS & ACCESSORIES

| Item | Prices from £ |
|---|---|
| **BRYANS SOUTHERN** | |
| BS314 Chart 10" 4 Pen 16 speed | 1900 |
| **DCM** | |
| 8100W Wow & Flutter Analyser | 800 |
| **EM** | |
| LVDT Linear Displacement & Transducer | 50 |
| **FYLDE** | |
| 154 Bridge supply and Amplifier | 110 |
| **HEWLETT PACKARD** | |
| 680M Chart 5" 1 pen 8 speed | 750 |
| 7015A XY 1 pen A4 size | 700 |
| **HONEYWELL** | |
| 5600B Instrumentation tape recorder 14 ch FM/DR | 9000 |
| **MICRO-MOVEMENTS** | |
| M10-120/A Compact UV 10 ch 7 speed recorder (inc. galvos) | 1900 |
| **PHILIPS** | |
| 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 | 1275 |
| **SEIMENS** | |
| M936 Chart 5" 1 pen 0-20 mA F.S.D. but can readily be adapted by internal links to a wide range of volt and current measurements | 150 |
| **SOLARTRON** | |
| 3240 Modular Data Logger system | P.O.A. |
| *Note: UV recorders are priced less galvos* | |

## SIGNAL ANALYSIS EQUIPMENT

| Item | Prices from £ |
|---|---|
| **AIRMEC** | |
| 210 AM/FM Mod Meter 2.25 MHz-300 MHz | 235 |
| 248A Wave Analyser 5-300 MHz | 200 |
| 853 Wave Analyser 30 KHz-30 MHz | 200 |
| **MARCONI** | |
| TF2330A Wave Analyser 20 Hz-76KHz | 900 |
| **RADFORD** | |
| DM52 Distortion meter 20 Hz-20 KHz | 200 |
| **SOUND TECHNOLOGY** | |
| 1700A Distortion Meter 10 Hz-100 KHz inc. oscillator | 800 |
| **WAYNE KERR** | |
| A321 Wave Analyser 20 Hz-20 KHz | 180 |
| *Note: see also "Spectrum Analysers"* | |

## SIGNAL/FUNCTION/ + SWEEP GENERATORS

| Item | Prices from £ |
|---|---|
| **FARNELL** | |
| SSG520 10 MHz-520 MHz Generator — Auto Phaselock. AM/FM and SINAD feature. Reverse power protection | 2000 |
| **GENERAL RADIO** | |
| 1362 Generator 220-920 MHz | 375 |
| **GOULD** | |
| J3B Generator 10 Hz-10 MHz O/P level meter & Attn. | 350 |
| J4 Generator as J3 but no output level meter | 220 |
| SG21 Generator — Square Wave only 0.3-100 MHz | 80 |
| **HEWLETT PACKARD** | |
| 204C Oscillator 5 Hz-1.2 MHz | 230 |
| 204D Oscillator 5 Hz-1.2 MHz inc. 80dB attenuator | 280 |
| 608E Generator 10-480 MHz AM/Pulse | 400 |
| 8614A Generator 800-2400 MHz AM/FM/Pulse | 2800 |
| 8620C/11 Sweep Generator Mainframe with HP-IB | 2350 |
| 86222A 10 MHz – 2.4 GHz Plug-in for 8620 system | 2950 |
| 86230B/1 1.8 – 4.2 GHz Plug-in for 8620 system | 1600 |
| 8660C/86632A/86603A Synthesised Signal Generator 1-2600 MHz AM/FM digital readout, push button controls, BCD programmable | 14000 |
| **IEC** | |
| F51A Function 1 mHz-10 MHz Sin/Sq/Tri/Pulse/Ramp | 375 |
| **MARCONI** | |
| TF144H/4S Generator 10 KHz-72 MHz AM | 550 |
| TF955/2 Generator 0.2-220 MHz AM/FM | 670 |
| TF2000 Generator 20 Hz-20 KHz-111 dB attenuator | 750 |
| TF2002/3MI Generator 10 KHz-72 MHz AM only | 550 |
| TF2011/S Generator 96-140 MHz FM only | 550 |
| TF2012 Generator 400-520 MHz FM | 550 |
| TF2015/1 Generator as 2015 with narrow FM deviation | 1350 |
| TF2020 Synthesised AM/FM Generator 50 KHz-520 MHz. Built-in modulation oscillator. State of the art performance. Can use on GP-IB with optional adapter | 6900 |
| **PHILIPS** | |
| PM5108L Function 0.1 Hz-1 MHz Sin/Sq/Tri O/P meter — 50 and 600Ω | 425 |
| 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 |
| **RADIOMETER** | |
| MS27G Generator 0.3-240 MHz AM/FM | 585 |
| **TEXSCAN** | |
| 9900 Sweeper 10-300 MHz 6/in CRT disp | 525 |
| VS60 Sweeper 5-1000 MHz | 890 |
| **WAVETEK** | |
| 157D Waveform Synthesiser 100 μHz – 1 MHz BCD Prog. | 1500 |

## SPECTRUM ANALYSERS

| Item | Prices from £ |
|---|---|
| **HEWLETT PACKARD** | |
| 141T/8552B/8555A 10 MHz-18 GHz system | 10250 |
| 3582A 0.02 Hz – 25.5 KHz 2 channel Real Time Spec. Analyser using F.F.T. inc. Phase measurements | 5750 |
| **MARCONI** | |
| TF2370 30 Hz-110 MHz Digi-store display built-in counter and tracking gen | 7500 |
| **TEKTRONIX** | |
| 7L5/L3 20 Hz-5 MHz Plug-in for 7000 series M/Frame 10 Hz resolution. Sensitivity −148 dBV. Impedance 50Ω, 600Ω and 1MΩ. C.R.T. readout. Digi-store display | 6750 |
| 7L13 1 KHz-1800 MHz Plug-in for 7000 series M/Frame | 7700 |
| 7L18 1.5-18 GHz Plug-in for 7000 series. High resolution. Digital storage display. Built-in pre-selector | 8500 |
| 7603/7L5/L3 System with display 20 Hz-5 MHz | 7750 |
| 7603/7L13 System with display 0.1-1800 MHz | 8900 |
| 7613/7L13 System with storage/var. persist. display | 9900 |
| 7603/7L18 System with display 1.5-18 GHz (60 GHz with external mixers) | 9600 |

## VOLT/MULTI-METER (ANALOGUE)

| Item | Prices from £ |
|---|---|
| **BOONTON** | |
| 92C AC/RF 10 KHz-1.2 GHZ ½ mV-3V | 250 |
| **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 |
| **LEVELL** | |
| TM11 Analogue Multimeter AC/DC/V/I/Ω | 115 |
| **M.L. ENGINEERING** | |
| NAMV — DC sensitive μ Volt/nAmp meter centre zero | 45 |
| **MARCONI** | |
| TF2600 10 Hz-10 MHz 1mV-300V AC + DC O/P | 230 |
| TF2604 20 Hz-1.5 GHz 300mV-300V | 425 |
| **PHILIPS** | |
| PM2404 Analogue Multimeter AC/DC/V/I/Ω | 100 |
| PM2504 Multimeter AC/DC/V/I/Ω | 120 |
| **RACAL-DANA (E.I.P.)** | |
| 9301 RMS 10 KHz-1.5 GHz 100μV-300V | 550 |
| **VIBRON/E.I.L.** | |
| 33B-2 1mV-1V Electrometer | 200 |

## VOLT/MULTI-METER (DIGITAL)

| Item | Prices from £ |
|---|---|
| **BOONTON** | |
| 92AD 3½ Digit 10 KHz-1.2 GHz 10μV res. | 525 |
| **FLUKE** | |
| 8010A 3½ Digit AC/DC/V/I/ΩTRMS | 140 |
| 8010A01 3½ Digit as 8010 + int. re-chg. batts. | 159 |
| 8050A 4½ Digit AC/DC/V/I/Ω/dB TRMS | 215 |
| 8050A01 4½ Digit as 8050 + int. re-chg. batts. | 245 |
| 8200A 4½ Digit DC only. Fast reading systems V. meter | 850 |
| 8300A 5½ Digit DC only. Fast reading systems V. meter | 1100 |
| 8800A 5½ Digit AC/DC/V/Ω Auto Range TRMS | 430 |
| **GOULD** | |
| DMM7 3½ Digit AC/DC/V/I/Ω | 75 |
| **HEWLETT PACKARD** | |
| 3490A 5½ Digit AC/DC/V/Ω Auto Range | 750 |
| **PHILIPS** | |
| PM2517 4 Digit AC/DC/V/I/Ω Auto Range TRMS | 110 |
| PM2522G 3½ Digit AC/DC/V/I/Ω | 145 |
| PM2524 4½ Digit AC/DC/V/I/Ω Auto Range | 299 |
| PM2527 4½ Digit AC/DC/V/I/Ω TRMS Auto Range | 625 |

### LOW COST CORNER

**Items in this box have 30 day guarantee only.**

| Item | Prices from £ |
|---|---|
| **AIRMEC** | |
| 210 AM/FM Modulation meter from 2.25-300 MHz | 150 |
| **HEWLETT PACKARD** | |
| 1600A Logic Analyser 16 channels 20 MHz Clock rate | 990 |
| **HEWLETT PACKARD** | |
| 608E 10-480 MHz AM/Pulse Signal Generator | 220 |
| **M.L. ENGINEERING NAMV** | |
| D.C. Sensitive nAmp/μVolt meter — centre zero | 30 |
| **TEKTRONIX** | |
| 575 Transistor Curve Tracer | 200 |
| **TAYLOR** | |
| 62A AM/FM Signal Generator 4-120 MHz | 85 |

All items have a 12 month guarantee unless otherwise stated.

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 9.30 am -5.00 pm (lunch, 1-2 pm). **Prices exclude delivery and VAT.**
We take Access or Visa. WW – 052 FOR FURTHER DETAILS


**Carston Electronics Ltd**
**01-267 5311**
**Shirley House, 27 Camden Road, London NW1 9NR. Telex: 23920.**



**Carston Electronics Ltd**
**01-267 5311**
**Shirley House, 27 Camden Rd, London NW1 9NR. Telex: 23920**


# Carstonbuy

**Contact us for a cash quote on your under utilised test equipment**

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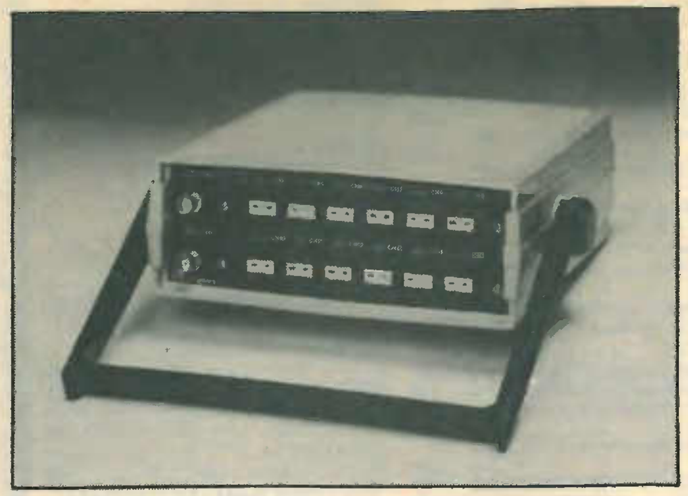
# PCI 1002 IEEE THERMOCOUPLE CONVERTER



The PCI 1002 is a 12 Channel IEEE compatible thermocouple converter having two input ranges of ± 10mV or ±100mV F.S.D. selected by an internal switch. It has 12 Bit resolution of the A to D converter giving a resolution of 0.06 deg.C on 10mV range and covers all common thermocouple types.

Cold Junction Compensation is provided giving a resolution of 0.2°C on 100mV range and 0.02°C on 10mV range.

Linearising software in Basic using optimised coefficients for ranges and thermocouple types.

Two other channels are provided via BNC input sockets on the front panel. Input ranges are I/V for 10 mV range and ±10V for 100mV range.

CIL MICROSYSTEMS LTD

**CIL MICROSYSTEMS LTD**
DECOY ROAD, WORTHING, SUSSEX.
TEL: 210474.

WW – 055 FOR FURTHER DETAILS

# PRINTED CIRCUITS
## FOR WIRELESS WORLD PROJECTS

| | |
|---|---|
| Audio compressor/limiter—Dec. 1975—1 s.s. (stereo) | £4.25 |
| Cassette recorder—May 1976—1 s.s. | £5.00 |
| Audio compander—July 1976—1 s.s. | £4.25 |
| Audio preamplifier—November 1976—2 s.s. | £8.50 |
| Additional circuits—October 1977—1 s.s. | £4.00 |
| Stereo coder—April 1977—1 d.s. 2 s.s. | £8.50 |
| Low distortion disc amplifier (stereo)—September 1977—1 s.s. | £2.00 |
| Low distortion audio oscillator—September 1977—1 s.s. | £3.50 |
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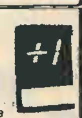
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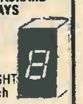
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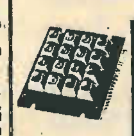
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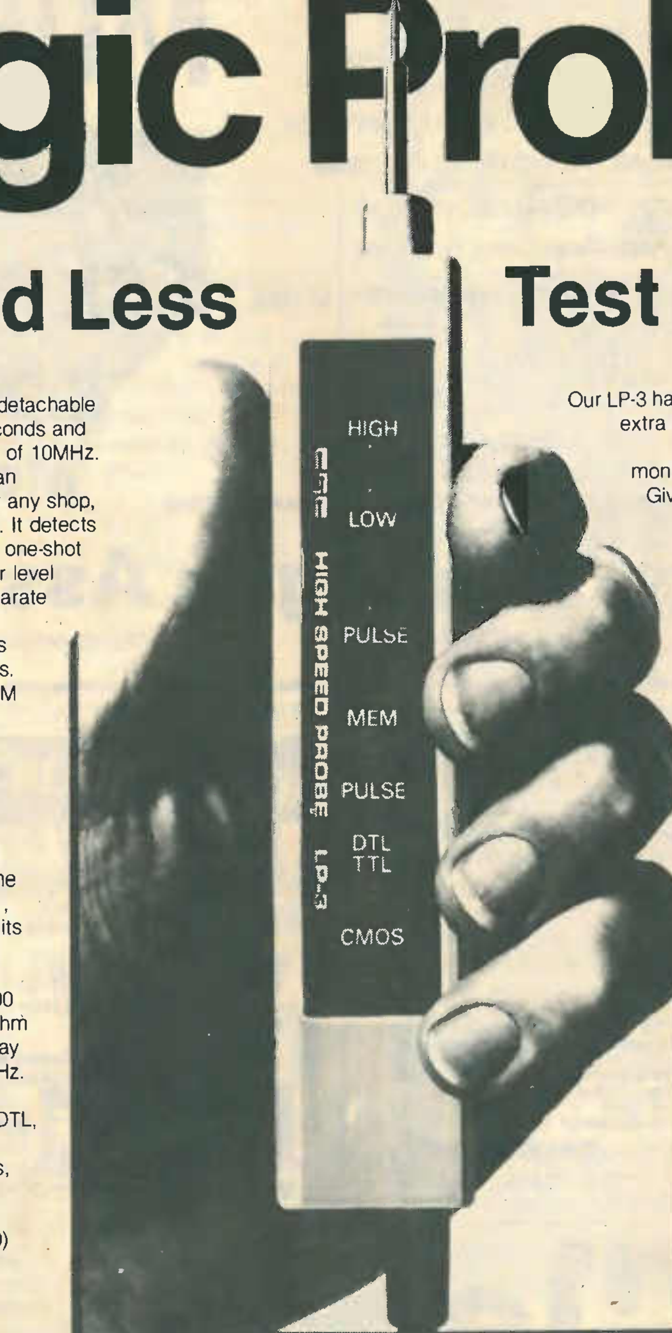


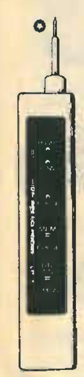

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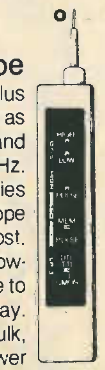

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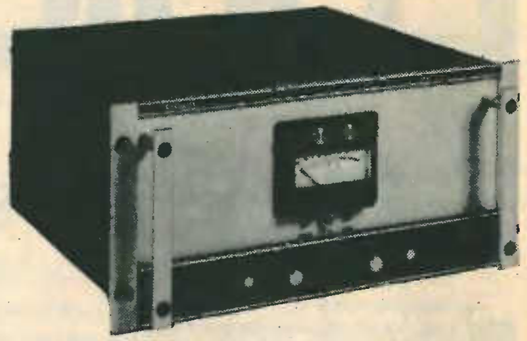

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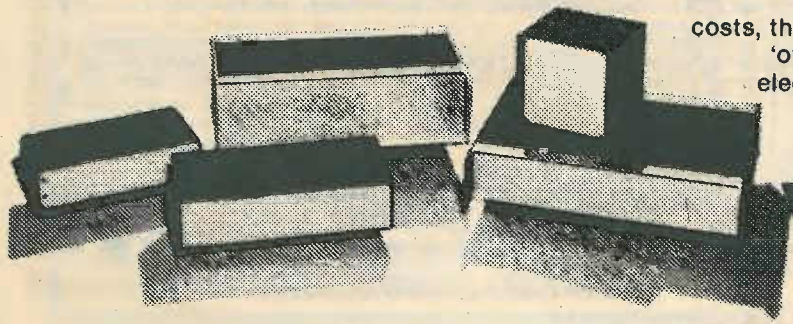

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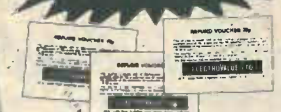

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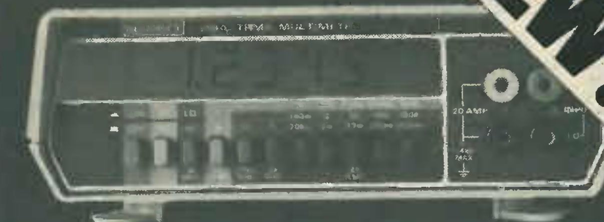

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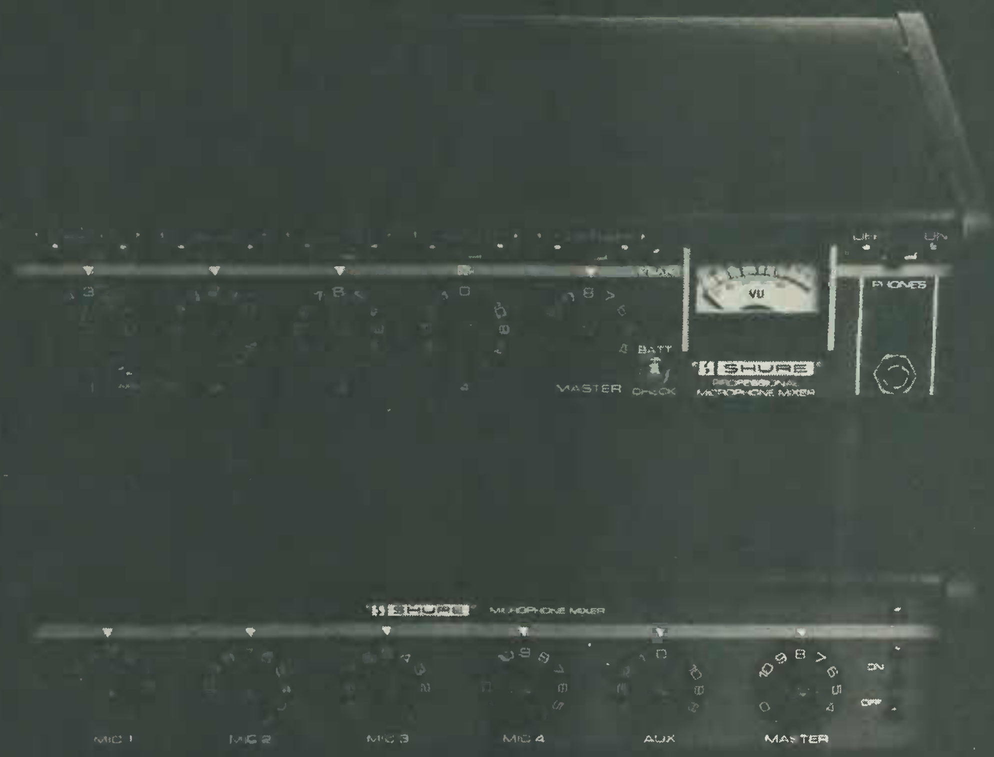


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# A job to be done

At a press conference on mobile radio held by the UK's Electronic Engineering Association earlier this year there was much discussion on the small amount of frequency spectrum allocated to private mobile radio (p.m.r.) relative to that given to broadcasting, military communications and other services. At least, the EEA officials *claimed* that it was too small for the needs of the p.m.r. service and emphasized their argument with a diagram showing the p.m.r. bands as thin slices sandwiched between large chunks of other bands. One must remember, of course, that the EEA represents the mobile radio manufacturers, who have a vested interest in the frequency space available to p.m.r. But this doesn't alter the fact that nobody is in a position to refute the EEA's assertion – only to rebut it. The whole question of what is an appropriate allocation of spectrum for a given service is entirely a matter of claim and counter claim. And the actual decisions on allocations are made on this same basis by the activities of pressure groups in international conferences, with the ITU acting as umpire and simply confirming the results of the contests.

Of course, other methods of allocating frequencies have been proposed. One is that spectrum space should be sold to the highest bidder. The thinking behind this is that the more you have to pay for your piece of territory the more economic pressure there will be on you to use it efficiently. Another suggestion is to allow a free-for-all in certain bands (as in citizens' bands at present) on the principle that some kind of adjustment will occur naturally and make formal regulation unnecessary. Thankfully, neither of these uncivilized methods has been considered too seriously.

The central problem, as pointed out by the chairman of the EEA's mobile radio committee, Mr J. W. Carlton, is the lack of some kind of "value analysis". In other words, frequency space would be allocated more fairly if it were done on the basis of relative social needs. But there is no objective data from which these relative needs can be calculated straightforwardly. They can only be derived from the value systems prevailing in a society. We therefore have to analyse these values in such a way that would allow us to attach numerical indices to the various needs for frequency space. To be accepted the analysis would have to be demonstrably rational and so obviously right that no reasonable person could disagree with it.

Who is capable of such an analysis? At first sight the politicians and their permanent bureaucrats seem to have the necessary experience in attaching measurable quantities to social needs; but their decisions are too often a facile response to popular opinion and swayed by party dogmas. Perhaps the nearest type of analysis we have already is the mathematical model of the economy – sets of equations into which changing data are fed to obtain forecasts – because this type of model does have to take human behaviour into account. There are, however, several research organizations with particular interests in studying the interaction of technology with society. In the UK, for example, we have the Social Science Research Council and two new bodies both of which already have some experience with telecommunications and electronics – the Technical Change Centre in London and the New Technology Research Group at Southampton University. In the USA the National Academy of Engineering has looked at the problem and at least recognized the importance of social and economic factors in spectrum management. It should not be beyond the abilities of such organizations to find a method of analysis which, if not completely rigorous, would be greatly superior as a rational basis for allocation to the empirical procedures using political and commercial pressures that we rely on at present.

Fastidious people may well reject instinctively any attempt to equate quantities with qualities. This is understandable in so far as social values are subjective and rooted in the ethical or religious beliefs of individuals. But ethics are a guide to conduct: if there is no conduct resulting from them they are worthless. There is a good case for testing our values in the worldly business of sharing out a natural resource.




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# A LIGHT PEN FOR MICROCOMPUTERS

*Light pens provide an alternative means of interactive communication with a computer via the visual display, and are often used with mainframe computers in graphics oriented applications. They are less common with microcomputers, but this article describes a simple, inexpensive light pen which can be easily adapted for use with most microcomputers which use a memory-mapped video display.*

The light pen can detect individual characters on the screen and return, via two parallel 8-bit ports of the microcomputer, the address of that character. Through the use of appropriate software, individual characters may be changed or deleted or specific actions can be initiated when certain characters are detected. This capability may be used in a number of ways such as in 'menu' applications, where a large number of choices are available, in interactive games, etc.

## Video displays

A memory-mapped video display system is shown schematically in Fig. 1. Essentially this comprises a video ram, a character generator (usually a mask-programmed rom), a shift register and associated timing circuitry. The address and data lines of the video ram are multiplexed so that the memory can be accessed either by the c.p.u., to update or read data, or by the dedicated video circuitry which produces the display. The video ram usually occupies a 1K block of memory in the memory map of the microcomputer and stores the m lines of n characters which make up the display. Each position on the screen, p(row,column), corresponds to a unique location in the video ram. The characters are displayed as a dot matrix pattern (Fig. 2). Unless locked out by the c.p.u., the video divider chain continuously addresses the video ram in a predetermined order and, in turn, the video ram output word addresses the character generator. In addition, the divider chain sequences the row address lines of the character generator so that the output word of the generator corresponds to a particular row i of the relevant character at position p(row,column). This word is then loaded into the shift register from which the appropiate series of dots and blanks are clocked out to form part of the video signal. The shift register is typically clocked at around 8 MHz, giving a time separation between adjacent dots of, say, 125 ns. The video display of most microcomputers in the UK uses a 50 Hz frame rate scanning 312 lines without interlace.

## Sensor

The light pen and its associated circuitry must detect the rising edge of phosphor emission when a dot is drawn on the screen and simultaneously latch the current address on the video ram. From this

**by M. Shepherd.**

address, one can deduce the memory location corresponding to the character containing the dot and hence the actual position of the light pen. Since we are only concerned with locating characters, rather than individual pixels, the particular dot detected within the character is not important. The optical sensor must have a fast risetime preferably much less than the interval between adjacent dots, say, much less than << 100 ns. Another requirement for a successful sensor is that it should have a field of view which is comparable to or preferably smaller than a single character when it is held on the surface of the screen. With a 9 in monitor, a character is likely to be of the order of 5 mm square; the exact size depends on the format of the character generator, the number of characters per line, etc. Both of these requirements can be adequately met using a polymer-fibre light guide and an associated planar silicon p-i-n photodiode.

The polymer-based light guide has an overall diameter of 2.2 mm and a core diameter of 1 mm: it is considerably cheaper and physically much more flexible than equivalent glass light guides. Although its attenuation is markedly greater

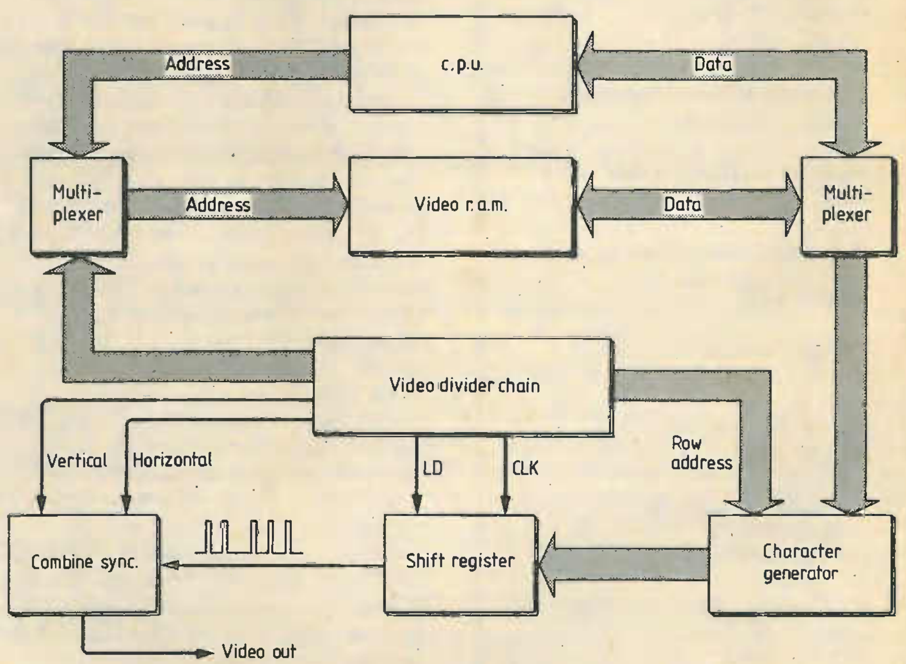


*Fig. 1. Block diagram of memory-mapped visual display circuitry in typical microcomputer.*

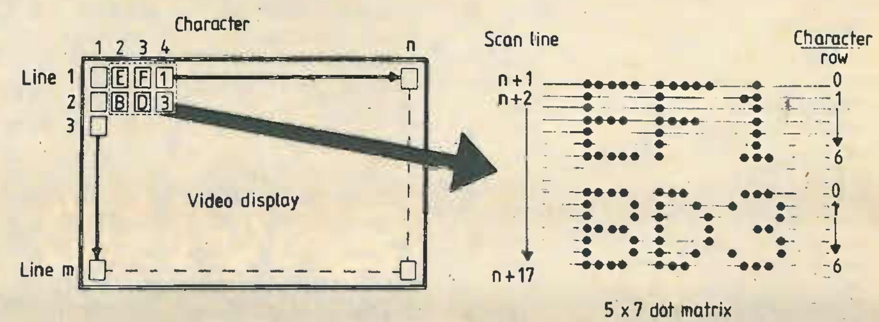


*Fig. 2. Dot-matrix representation of characters on screen for 5x7 matrix format.*



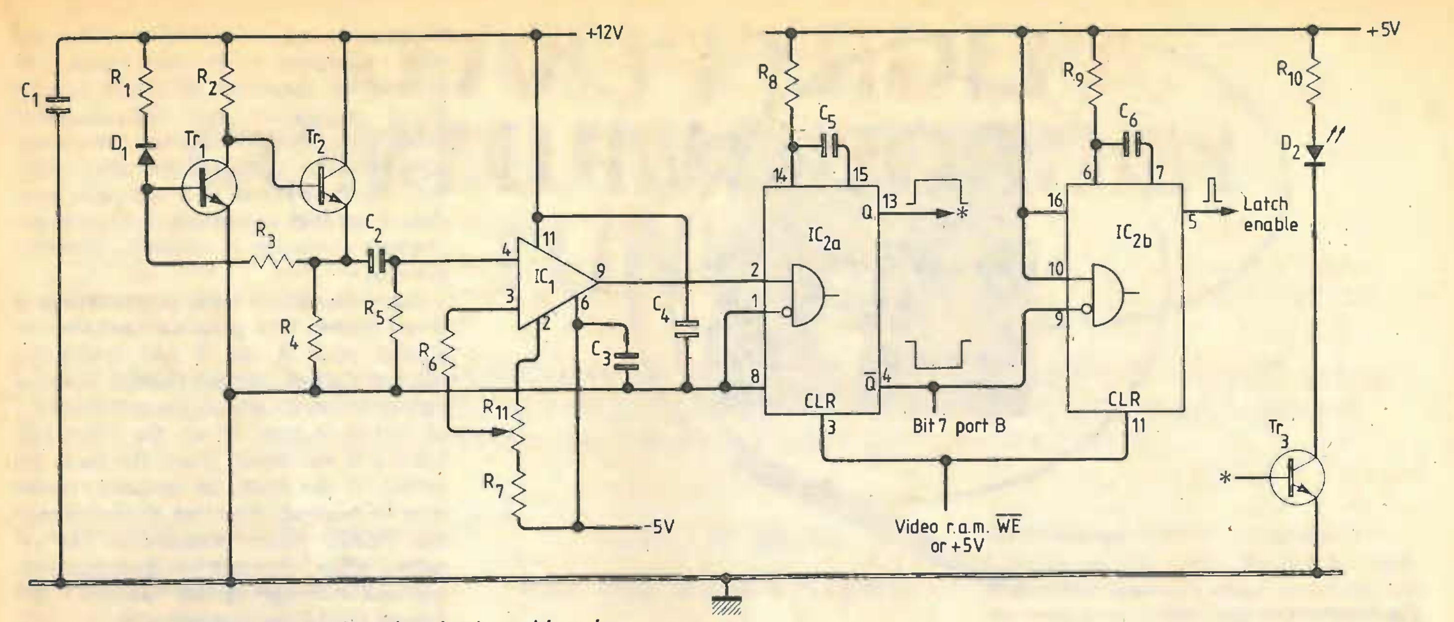


*Fig. 3. Circuitry to detect dots and produce latch-enable pulses.*

than its glass equivalent this is not a serious problem over the length of about one metre required for this application. The photodiode has a risetime of < 5 ns and can be coupled directly onto the polymer optic using the special termination. This does not require the use of special tools.

The use of a light guide has the advantages that (a) it has inherently a sufficiently narrow field of view to preclude the need for further optics and (b) it isolates the photodiode and related circuitry from the appreciable radiation fields found near the surface of a display tube.

With most opto sensors the sensitivity decreases with increasing speed of response. However the instantaneous brightness of spots on a video screen can be very high and sufficient to give a satisfactory signal-to-noise ratio even with this otherwise relatively insensitive detector. It is, however, worth noting that the maximum instantaneous brightness is a function of the phosphor 'lifetime' and for these purposes screen with short-lived phosphors are preferable. Their distinction is not visually obvious since the eye is integrating the total light output and, at least to a good approximation, is oblivious of instantaneous brightness levels.

## Circuitry

Figure 3 shows the circuitry which detects the phosphor emission, as the electron beam draws a dot, and produces the t.t.l. pulse which latches the video ram address. An increase in incident light intensity on the diode produces an increased base current for $Tr_1$. $Tr_2$ acts as an emitter follower, with $R_3$ providing some d.c. stabilization for the base of $Tr_1$. Negative-going pulses at the inverting input of the 710 are compared with the preset negative threshold voltage on the non-inverting input. The potentiometer $R_{11}$ acts as a sensitivity control for the light pen and typically the negative threshold is set at about -50mV.

The first half of the 74123 retriggerable monostable responds to a positive going 'spot detected' pulse from the comparator

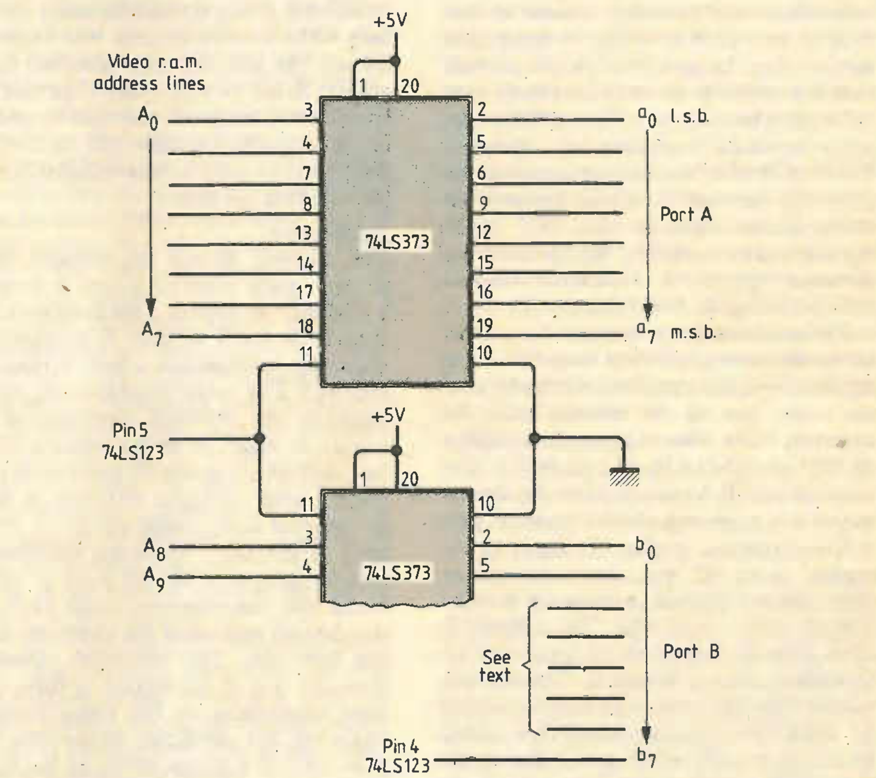


*Fig. 4. Latching of video ram address lines.*

by ignoring any further pulses for about 18ms, i.e. effectively until the next frame. This prevents multiple triggering of the 74123 by different dots within the same character. For example, two vertically coincident dots would produce pulses separated by 64 microseconds. To ensure that a spot is never detected while the c.p.u. is addressing the video ram, the write enable, WE, of the video ram is shown connected to pins 3 and 11 of the 74123; if this is not required, these pins should be tied high. The Q output of the 74123(a) is used via a transistor switch to light a led, which indicates that a spot has been detected during the current frame. The $\overline{Q}$ output is used by software and is discussed below. The second half of the 74123 produces a nominal 100 ns pulse used to latch the video ram address.

This section of the light pen can be checked using the led and without any connexion to the microcomputer. With the screen brilliance set to a normal working level the sensitivity should be set using $R_{11}$ so that the led emits when the probe is placed on a character on the screen. It will be found that some characters are more easily detected than others, notably those with several contiguous horizontal dots such as E, F or T. Increasing the sensitivity too far will allow the comparator to trigger continuously on noise and a compromise setting may be necessary. Further adjustments can then be made using the brightness control of the video display.

The circuitry to latch the video ram address is shown schematically in Fig. 4. It is assumed, for simplicity, that a 1K video ram is used and therefore that ten address lines A0 – A9 must be latched. De-



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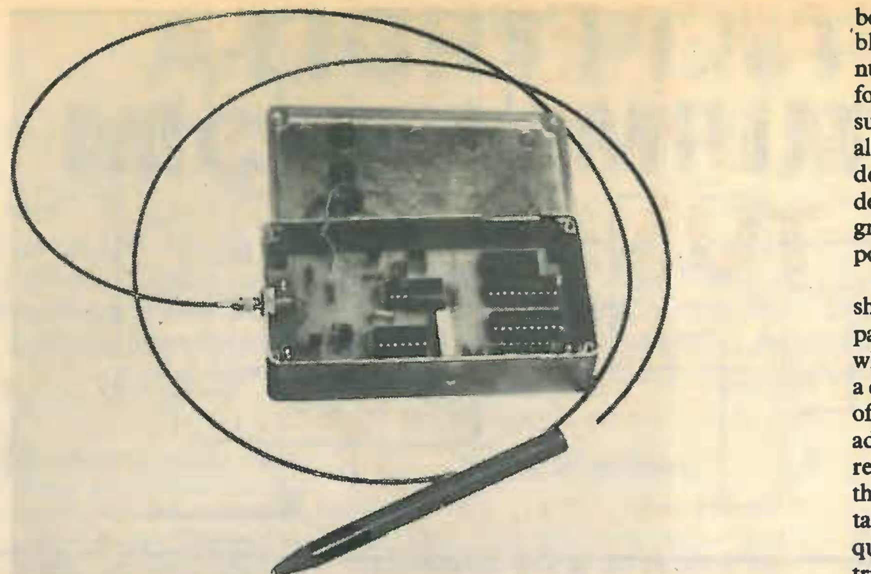

*Fig. 5. Prototype light pen.*

pending on the actual microcomputer, the video ram will probably consist of one 4118 or two 2114 or seven or eight 2112 memory i.cs. In each case the ten address lines are available at the i.c. socket(s) and these must be accessed; They will not normally be taken to an external connector. Two 74373 octal latches were used in the prototype (leaving 6 unused latches) but other latches such as the 7575 could equally well be used. The ten latch outputs corresponding to A0 -A9 are fed into two 8-bit parallel ports of the computer.

The actual memory address of a character on the screen is 16 bits long. The most significant six bits indicate the location of the video ram in the memory map for example, if the video ram occupies 0800 – 0BFFF, then bits A16-A11 are 00010. The relevant port B inputs could be hardwired in this way to provide the full address. One problem remains in that the input to the parallel ports will now always be a video ram address but not necessarily a valid address. To ensure that the address is valid, the $\overline{Q}$ output of 74123(a) can be input to the m.s.b. of port B. The software can then decide whether an address is valid by checking the state of this bit; if it is zero then a spot has been detected during the current or the previous frame. In some applications, one may only wish to accept an address as valid if a button is also pressed in addition to the condition noted above; this can be done by by allowing the button to ground, for example, bit 6 of port B. The state of this bit can then also be checked by software.

## Construction

The entire light pen circuitry and photodiode can be built into a small diecast box (Fig. 5). In the prototype, the video address lines and the power supplies were accessed on the main c.p.u. and video board and taken via ribbon cable to d.i.l. sockets in the box. The sixteen lines from the box taking the video address to the ports also used a ribbon cable. The layout was not found to be particularly critical, but some care should be taken with the front end to avoid spurious responses. The casing of the photodiode was grounded through the box. Two leds were used, one to indicate power on and the other to indicate when a valid address was being received. The polymer optic fibre had terminations fitted to both ends. One end was fitted into a ballpoint pen case to make it easier to handle; the other end, as shown in Fig 5, screws onto the photodiode through the standard connexion.

## Software

The essential part of the software which recovers valid video addresses is shown as a flowchart in Fig. 6. This flowchart does not check bit 6 of port B as suggested above for applications where a button is required. The actual programming may be done in the machine language of the c.p.u., in Basic, or in any other available language which allows the ports to be read. Since a valid character can only, at most, be detected every frame i.e. every 20 ms, there is not likely to be any problems in processing speed. At this stage it will be found that the recovered video address is not the real address of the character under the light pen. The recovered address is probably that of the second or third character (depending on the video circuitry) following the character under the light pen. This is a consequence of the delays between a particular video ram location

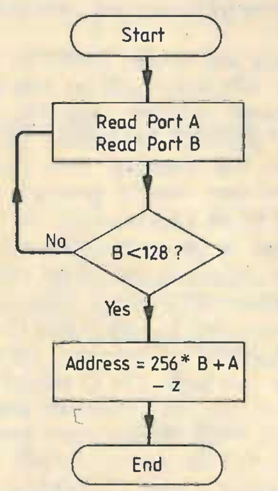


*Fig. 6. Flowchart for recovery of valid video ram address.*

being addressed and the relevant dots and blanks appearing in the video signal. The number of characters difference can be found empirically and the necessary subtraction made by software. Since some alphanumeric characters are more easily detected than others it is obviously prudent to use such characters, or appropriate graphics characters if available, wherever possible.

Some illustrative basic programming is shown below. This program reads the two parallel ports A and B and determines whether the light pen has recently detected a character on the screen, i.e. whether bit 7 of port B is zero. If so, the video ram address is calculated; if not the ports are reread. If the ports are memory, rather than i/o mapped, then line 20 should contain PEEKs rather than INPs. The required offset, Z, must be determined by trial and error; appropriate values of A and B must also be inserted in line 10.

```
10 A= :B= :Z=
20 X=INP(A):Y=INP(B)
30 IF Y>127 THEN GOTO 20
40 VA=Z+X+Y*256
```

That particular character can now be 'deleted' by writing an ASCII space (decimal 32) to its video ram address, VA.

```
50 POKE VA,32
60 END
```

Alternatively, by using

```
50 IF VA=POSITION THEN GO-
   SUB 100
60 GOTO 20
```

the program will jump to a given subroutine only when the light pen is held on the character with video ram address, POSITION.

These simple examples illustrate the types of programming techniques which can be used with the light pen.

## Components

| | |
|---|---|
| **Capacitors** | |
| 1,3,4 | 10n |
| 2 | 100n |
| 5 | 470n polyester |
| 6 | 10p silvered mica |
| **Resistors** | |
| 1 | 100p |
| 2,3 | 100k |
| 4 | 330 |
| 5,6 | 81 All 0.25W, ±5% |
| 7 | 10k |
| 8 | 120k |
| 9 | 4.7k |
| 10 | 270 |
| 11 | 500 multiturn trimmer |
| **Semiconductors** | |
| $D_1$ | Silicon p-i-n photodiode. |
| $D_2$ | led |
| $IC_1$ | 710 |
| $IC_2$ | 74123 |
| $Tr_{1,2}$ | Any general-purpose Si n-p-n with $f_t$>100MHz should be suitable, e.g. BC182L |
| $Tr_3$ | General-purpose Si n-p-n. |

Polymer optic cable (367-791)
Photodiode (309-307)
Terminations (456-396)
All from RS Components. □



# LEAKY FEEDER COMMUNICATION IN TUNNELS

*For short ranges, a simple installation using the techniques outlined in the first part of this article is effective. Outside the limits of the basic system, more elaborate equipment is needed, the remainder of the discussion being centred on this.*

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It was shown in Part 1 that the reliable radiocommunication range obtainable in a tunnel or mine can usually be dramatically improved by running a 'leaky feeder' through the tunnel or region where communication is required, and connecting one end to a conventional v.h.f. base station. Communication is then through the leakage fields of the feeder, and the total system loss – which in conjunction with the transmitter power and receiver sensitivity will determine the actual range available – is made up of the 'coupling loss', between a mobile set and the feeder, and the feeder loss between that region and the base station.

A typical reliable range from such a simple system, using conventional mobile radio equipment and a practical type of leaky feeder, would be 2 km – equal perhaps to ten times the unassisted or 'natural' range obtainable in the tunnel without a feeder. If such a range is adequate for the purpose, then little more in the way of systems engineering is required. The major factors to be determined will be the type of leaky cable to use and the nature of its mounting or suspension in the tunnel. These decisions will be based largely on the considerations detailed in Part 1, together with a discerning study of cable manufacturers' data, experience gained in similar situations, specialist advice or even a pilot experiment in the tunnel concerned.

From the standpoint of systems performance it is not even necessary to terminate the free end of the feeder in its characteristic impedance; the short-standing-wave effect caused by a mistermination will normally be masked by the general multipath effects in the tunnel, and it can be argued that residual energy is more usefully reflected back down the feeder than dissipated in a termination. However, if the feeder is not carrying additionally any d.c. or a.f. signals, a resistive termination can be of value in facilitating d.c. continuity and short-circuit checks in case of trouble.

The range of the simple system may be effectively doubled by connecting the base station at the middle of the total span rather than at one end; the few decibels lost from each limb in such a two-way split represents only about 5% of the range. However, this option may not always be convenient, involving perhaps the extension of control lines and the provision of a power supply in an awkward place. The same splitting principle, it may be noted, can be used at any point in the line to serve a branch tunnel; again, strict impedance matching at such junctions is unimportant.

A few other expedients may be available if the predicted range falls slightly short of requirements. Use of a lower frequency band – say v.h.f. low band instead of v.h.f. high band – will often give a worthwhile advantage (radio regulatory considerations are not normally a restriction if the system is wholly underground); or the expensive decision could be taken to specify a heavier grade of leaky cable and so reduce line loss. It is also possible to 'grade' the feeder, by using a more leaky type towards the extremities of the system in an attempt to preserve the diminishing field. But generally in such circumstances one is better looking towards the active techniques to be described.

On the other hand, if the absolute maximum range is being sought for the very minimum of active equipment then the INIEX systems should be considered, especially if a rather lower frequency – say, in the h.f. range, can be used.

## Multiple base stations

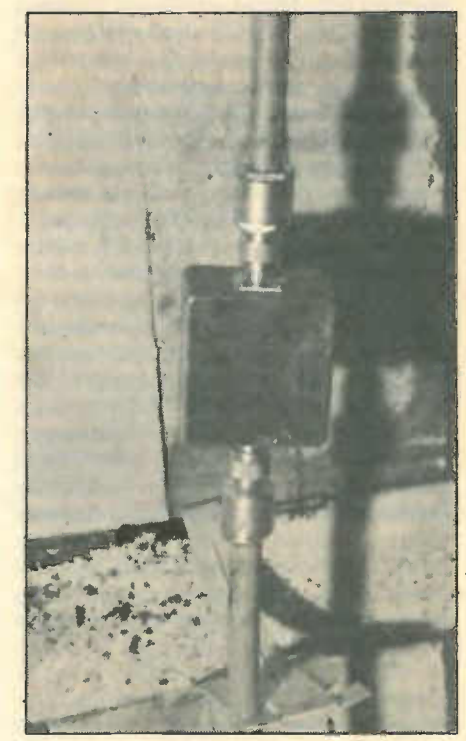
When the economic limit of range from a single base station has been reached, one obvious course left is to borrow a technique from land-mobile and aeronautical schemes and deploy further base stations as necessary to achieve the desired cover. This was the solution adopted in the early railway systems such as that for the New York Subway. It was also used in the first coalmine system, commissioned at Longannet, Scotland, in 1970.

The leaky coaxial cable serving the 9 km tunnel there is divided into three sections, with a base station serving each near its centre, as shown in Fig. 4. The base stations are operated under a common control from the surface over telephone lines. Operating frequencies are in the v.h.f. low band (70-90 MHz) as with all subsequent National Coal Board systems, and the cable is a braided coaxial type with a rather lower leakage than is usual nowadays.

Such systems suffer the familiar land-mobile problem of 'overlap' interference in the regions receiving signals from two base transmitters, resulting from lack of synchronization. At Longannet, the line was simply gapped for a metre or so midway between base stations; by the use of frequency modulation (25 kHz channelling), and relying on tunnel attenuation (about 0.5 dB/m) and capture effect, the extent of confused signals was restricted to a few metres. Nowadays, the land-mobile technique of quasi-synchronous operation would probably be used in a multi-base system; but it would also be quite feasible to use the leaky feeder itself as a synchronization link, passing a ready-modulated pilot signal to outlying transmitters at a frequency of one or two megahertz, where line losses are low.

## Line repeaters

Since leaky-feeder communication is basically a hybrid technology, borrowing from both radio and line transmission, it is logical to look also to the latter field for pos-



*Line-powered repeater in a coal mine. This example has a consumption of 2.5 mA at 12 V, and is installed at 500 m intervals.*



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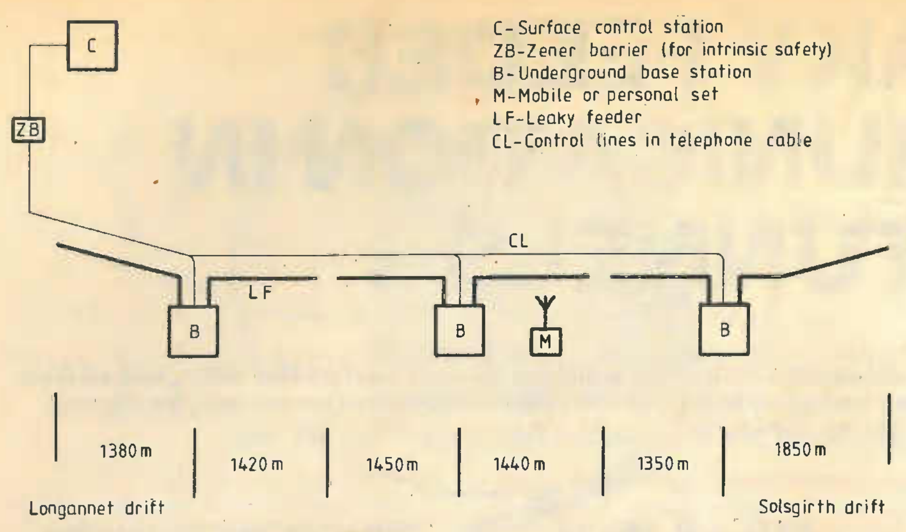


**Fig. 4.** *Multiple-base-station system operating at Longannet Mine, Scotland, since 1970. The 9-km tunnel rises to the surface at each end, at Longannet and Solsgirth. The leaky feeder is divided into three roughly-equal sections, each served by a base station near its centre.*

sible means of extending the range of a single base station. The obvious technique which line technology offers is the use of in-line repeaters or 'signal boosters' to amplify signals and so compensate for line losses periodically.

An immediate attraction of the idea is that a repeater can easily be made to handle a band of frequencies and so allow multichannel operation for little additional complexity. But the overwhelming advantage is that by spacing the repeaters comparatively closely, with correspondingly lower gain and line loss between repeaters, one can provide a consistency and reliability of signal level undreamed-of in conventional radio systems. In the same process the output power requirement of each repeater is dramatically reduced, typically to a few milliwatts compared with a base station of several watts. It then becomes possible and logical to power all such repeaters by d.c. over the leaky feeder itself, giving a remarkable saving in cost of a system over one using multiple base stations.

All this assumes that the repeater design itself can be made cheap and simple. But in fact there is a complication in the apparent need for such a device to amplify in both directions. If simplex operation is adequate, then it is not too difficult to arrange that the repeater reverses its direction of operation in sympathy with the base-station switching, perhaps through the polarity of the line-fed supply. But if there is a system requirement for talk-through operation, where the base station simultaneously retransmits everything it receives, then a two-way repeater would need to amplify in both directions simultaneously. The design thereupon becomes complex, with the involvement of elaborate filters and perhaps hybrids to ensure stability. This prospect discouraged the development of repeatered leaky-feeder systems for several years.

## Daisy-chain systems

The innovation that opened the way for the development of practical repeatered systems was the 'daisy chain' principle[17]. In the basic form of this arrangement, shown in Fig. 5, the base station is split into its constituent transmitter and receiver, which are then sited at the opposite extremities of the system. All signals, whether from base to mobile or from mobile to base, now travel in the same direction in the feeder and so simple one-way wide-band repeaters serve to amplify them all, simultaneously if necessary, to provide duplex or talk-through operation. A disadvantage shared with the multiple-base-station system is the need for a parallel audio-frequency link, though for a single channel the leaky feeder can be made to double for that purpose. Excessive branching of the system can also be uneconomic, since every extremity has to be terminated in either a transmitter or a receiver (again with its attendant a.f. link), but the system adapts admirably to twin-tunnel situations where the daisy chain can loop back down the second tunnel and allow the transmitter and receiver to be co-sited.

Following its successful introduction at Cadley Hill colliery in 1973, the daisy-chain system rapidly became the standard leaky-feeder arrangement for British coal mines. A typical repeater now in widespread use has a gain of about 16 dB over the range 70 to 90 MHz. Drawing only 2.5 mA from the line-fed 12 V supply, it delivers a power of 12.5 mW for the base-transmit signal. With the cable normally used, such repeaters are installed at 500 m intervals. A simple calculation based on these figures shows the minimum performance to be equal to that of a 20 W base station feeding 1500 m of feeder.

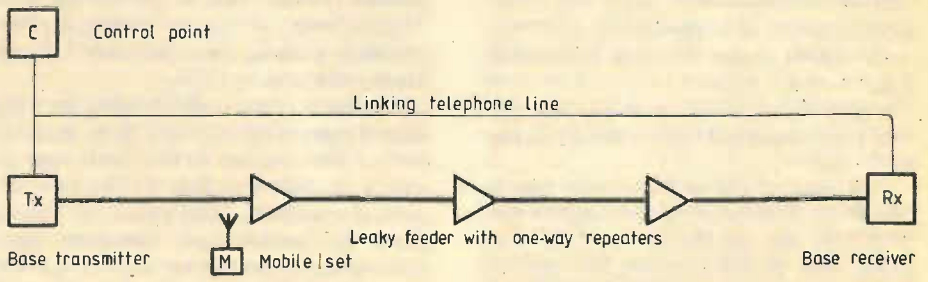


**Fig. 5.** *Simple 'daisy-chain' system, using a split base station and simple one-way repeater-amplifiers to allow two-way communication (including duplex or talk-through operation) over long ranges.*

In the more recent coal-mine installations the improved arrangements shown in Figs. 6 and 7 are used. Both replace the telephone line by a medium-frequency link over the feeder itself, the signals passing through the repeaters in the 'wrong' direction without being affected. In the 'i.f. return' version, shown in Fig. 6, it will be seen that the frequency-changer portion only of the base receiver is located at the tail end, and all signals originating at a mobile transmitter are returned to the main base station in intermediate-frequency form, conveniently at 455 kHz. In-line amplification at this frequency is unnecessary, and the v.h.f. repeaters used will pass the i.f. signals in the reverse direction with negligible attenuation.

As indicated in the diagram, the arrangement also adapts easily to the provision of spurs, since the frequency changers can be line-powered and are inexpensive enough to be used at every extremity without significantly increasing the total system costs. The line filters shown serve to prevent signals from a mobile reaching more than one frequency changer and so giving rise to heterodyne interference resulting from lack of synchronism between the frequency changers, and also eliminate undesirable recombination effects (and perhaps phase cancellation) of any base-station signals having taken more than one path through the system. Any residual interference effects are confined to the immediate vicinity of the filters.

The i.f.-return system lends itself neatly to multichannel operation. If the carrier frequencies used are reasonably closely spaced – say, grouped within a 500 kHz range – the frequency changers can be common to all channels; a corresponding group of i.fs is produced having the same spacing and lying, for example, in the range 1.5 to 2.0 MHz. It may then be convenient to introduce a further common frequency-changer at the base-station end of the feeder, to restore all the i.fs to their original carrier frequencies for processing by conventional v.h.f. receivers.

Figure 7 illustrates the converse arrangement, known as 'forward drive'. Here, the repeaters are polarized in the reverse direction and the frequency conversion is now applied in the base-transmit path. The output from a normal frequency-modulated transmitter is divided in frequency, using digital techniques, by a factor of (say) 48 or 64. The resulting signal in the region of 1-2 MHz is passed along the line and through the repeaters the 'wrong' way, again with low loss, to each extremity, where they are multiplied back to the original frequency for transmission through the system the 'right' way and out to the mobiles. Again, a moderate degree of filtering is included at each junction to prevent, in this case, the possibility of phase cancellation between signals from two or more remote converters.

The forward-drive technique is best suited to single-channel systems. It has proved particularly successful in coalmining applications for ranges up to about 4km; beyond that distance it becomes necessary to introduce some intermediate amplification of the forward-drive signal. The i.f.-return system using a single 455 kHz i.f. is generally capable of a greater range – say, up to 10 km – without intermediate amplification.

Repeaters, frequency converters and filters are available commercially for both these 'medium-frequency link' systems.

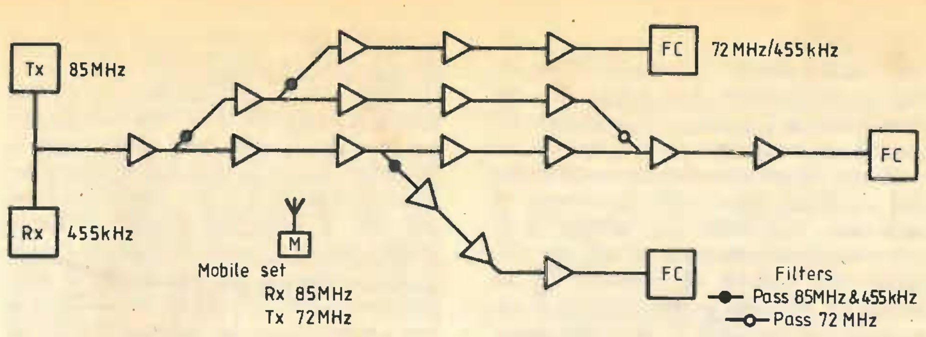


**Fig. 6.** *Daisy-chain system using 'IF return' principle, allowing the base transmitter and main receiver to be re-united and avoiding the need for a parallel telephone line. Every remote extremity is terminated in a small line-powered frequency changer which returns any received mobile signals to the main receiver at (typically) 455 kHz.*

## Other configurations

The main alternative to these daisy-chain configurations is the 'conventional' approach using some form of two-way repeater. In the v.h.f. low and middle bands in particular, the standard transmit-receive frequency spacing is sufficient to allow a practical two-way device to be engineered, though at the cost of some complexity. Generally, such a solution is unattractive except for short systems where only one or two repeaters would be required, or perhaps to accommodate short repeatered spurs in an otherwise daisy-chain system.

A consideration which becomes important in large repeatered systems is the cumulative noise introduced into the base-receive path by the repeaters. If the repeaters themselves were noiseless, and there were no external interference to the system, then the power of a mobile transmitter need only match that of a single repeater for equal performance to that of the base-transmit direction – perhaps only a few milliwatts. But in practice the signal in the base-receive path is inevitably degraded by repeater noise. If the noise introduced by one repeater is equal to that of the final receiver itself – a realistic assumption – then the mobile power needs to be greater than the repeater power by a factor equal to the number of repeaters in the system (strictly, plus one). This does not threaten to be an embarrassment except in the very largest of systems, and even there it will still leave a substantial advantage over the corresponding multiple-base-station solution. It does become important, however, in coalmining applications, where the need for intrinsic safety* and the absolute minimum of battery weight can restrict practical powers to about 50 mW.

In this connexion, the two-way repeater is at a disadvantage, since the inevitable losses introduced by hybrids and filtering increase the noise figure, typically by about 5 dB in practice. This is reflected directly as a required increase of mobile transmitter power for a given performance.

On the other hand, the i.f.-return system of Fig. 6 lends itself to a method of substantially reducing the overall noise figure of a daisy-chain system. For by suitable design the terminal frequency converters can be made 'squelching', so that only the particular converter receiving a signal passes on any noise. The system effectively becomes sectionalized for noise, and if necessary even an unbranched system may be treated in this way by introducing intermediate converters and filters.

Despite the consequent increase in total repeater noise, increasing the number of repeaters in a system by reducing their space will normally improve the overall signal/noise ratio in the base-receive path because of the overriding improvement to the minimum signal level from the reduction in span loss. The break-even point – unlikely to be reached in practice – comes when the span loss (or repeater gain) is only 3dB; beyond that point, the signal/noise ratio would suffer with further reduction in spacing. The base-transmit path also benefits, of course, from any reduction in repeater spacing, and in this case there is no offsetting noise factor.

In large systems particularly it is important to maintain a good overall balance between line loss and repeater gain; the effect of any substantial discrepancy shows up as a variability in signal/noise ratio of the received signal through the system, over and above that normally expected over the extent of a single span. It may be advisable to design the system for excess gain and then pad with additional attenuation as shown necessary during commissioning tests using an injected pilot signal.

Techniques exist for adjusting repeater gain to line conditions, including control through the line-fed supply. Daisy chain repeaters may also be designed so that the small-signal (base-receive) gain follows that for the high-level base transmission, itself largely self-compensating by virtue of a non-linear static characteristic of the repeater. This assumes that the base carrier is permanently present; it may be necessary to shift it off-channel when not in use to avoid keeping the mobile receiver mutes open and possibly wasting battery energy, or else to use tone squelch.

For a multichannel system, any choice or design of repeater may need to take into account intermodulation performance, which is governed by the linearity of the dynamic characteristic. Repeater linearity is also important in single-channel systems using any form of amplitude modulation. Multichannel a.m. systems suffer the additional risk of cross-modulation, and here the highest linearity is essential.

To some extent, it may be possible to avoid the effects of intermodulation by careful choice of carrier frequencies, allowing the repeaters to be designed for high efficiency rather than linearity. This can be especially important in coalmining applications, where d.c. power is limited by intrinsic-safety considerations.

The most difficult effects to counter are often the high-order products of two or more base transmissions falling within the base-receive band. The safest course then is to separate the base-transmit carriers as widely as possible – perhaps by several megahertz – to guard against the multiplicative effect on any frequency drift. Preferably, the use of discrete base-station carriers should be minimized by recourse to multiplexing (even though this will not be possible in the return direction). Where power supply permits, the use of linear repeaters is recommended, but such devices are complicated by the need for some form of automatic level control to prevent overload (non-linear repeaters are to some extent self-compensating for variations in line loss).

At first sight, a two-way repeater using separate amplifiers for the send and receive paths should be capable of a better 'cross function' intermodulation performance, but in practice the 'retro-gain' of the receive amplifier destroys or even reverses any such advantage unless very good filtering is incorporated. A better solution is to use wide-band daisy-chain repeaters and group the channel frequencies over a broad spectrum.

A radically different method of avoiding cross-function intermodulation is by using a double-daisy-chain configuration, shown in Fig. 8. In a multichannel system, such use of a double feeder can sometimes be justified by the simplicity it retains in the repeaters. The separate transmit and receive feeders can be combined in a single cable without cross-talk becoming a problem.

*Intrinsic safety is a concept applied to apparatus used in potentially explosive atmospheres, and demands that the apparatus is not capable of causing an incendive spark in either normal or faulty operation. Its practical effect is a severe limitation on power levels, though circuit techniques can mitigate this disadvantage to some extent.



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The addition of yet a third feeder may then be worthwhile. As shown in Fig. 9, this is sectionalized and serves the two directions alternately. The additional lengths are connected as 'tailbacks' to the repeaters, in parallel with the main feeder and extending back as far as midspan in each case. The effect of a tailback is to halve the span variation of signal; this allows the number of repeaters to be halved for the same performance, and advantage felt primarily in increased range from a single power-feed point.

The tailback principle may also be applied to single-daisy-chain systems, in which case each repeater has two tailbacks, one from each side, and the total requirement is for a double feeder. The further addition of filters linking the juxtaposed free tailback ends and in the main feeder gives the 'bi-directional routing' (BDR) system, which allows the base transmitter and receiver to be sited at the same end of the system[18].

## Operational systems

The world's largest user of leaky-feeder systems is probably still the UK National Coal Board, with over 100 mines at least partially equipped. Most of these employ one or other of the daisy-chain variants, the forward-drive arrangement having proved particularly convenient and economic for single-channel applications. A BDR system has been in very satisfactory service at Maltby colliery for several years, and a practical design of two-way repeater is also being evaluated for systems of modest extent.

All such techniques, including i.f. return for multichannel use, are brought together in a very flexible new system for coal mines known as Ariadne[19]. This is intended to cover a network of mine tunnels up to 100 km in total extent, with the total power requirement kept within intrinsic-safety limits. A key feature of the Ariadne concept is the division of the base-station carriers into two groups, according to function, spaced 6 MHz apart to ease intermodulation problems and allow selective propagation by the insertion of bandpass filters into the feeder runs. The corresponding base-receive signals are segregated where necessary at intermediate frequency after conversion by the line-powered frequency changers.

Principal among other UK users, London Transport have adopted the simple daisy-chain configuration, with linking telephone line, for the tunnel sections of the London Underground[20]; this follows the abandonment of an earlier pilot scheme employing multiple 25 W base stations and a bifilar feeder. The new arrangement is probably unique in that the repeaters are powered through d.c.-d.c. converters from the 110 V signalling supply. Initially, single-channel operation (in the v.h.f. high band) is allowing the use of simple non-linear repeaters, but the future addition of two further channels (unhappily, at equal spacing) will require a change to a linear type.

British Rail, while relying primarily on natural propagation in the u.h.f. band for train communication, has engineered a daisy-chain system for a tunnel section of the Great Northern line, recently taken over from London Transport[21].

Isberg[22,23] has made a particular study of such European leaky-feeder practice, and has himself led the recent trend towards repeater techniques in the USA (where repeaters, to avoid confusion in terminology, are often referred to as 'signal boosters'). His papers collect together useful technical information, some of it not published elsewhere.

In Vienna[22], the single-channel high-band v.h.f. system in the new U-Bahn (subway) uses a simple daisy-chain configuration with a linking telephone line; 19 repeaters serve a total tunnel length of 9 km. The leaky feeder in this case is of the type having small holes or slots in a solid outer conductor.

Delogne[22,24] has engineered a particularly ambitious scheme for extending broadcast and selected two-way radio channels into road tunnels in Brussels, using off-air relaying techniques. The INIEX-Delogne system serves a.m. (150 kHz-1.5 MHz) and f.m. (88-108 MHz) broadcasting and the v.h.f. low (c.70 MHz) and high (c.170 MHz) mobile radio bands. The tunnels are relatively short (maximum length 395 m) and so the only repeaters required are in the elaborate interfacing arrangements between the tunnel cable and the special wide-band aerial system. Unique problems of system stability had to be solved in this pioneering project.

For the far longer road tunnels in Switzerland, the PTT authority there has developed a system having a broadly similar function but using land-line links to remote control centres and other outside sources rather than off-air feeds[25]. In a

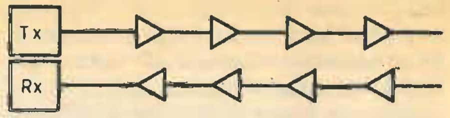


**Fig. 8.** *Double daisy chain, in which signals in the two directions of communication are kept separate to minimize intermodulation effects.*

typical installation[26] two separate daisy chains are used: one serves the police, highway maintenance and driver-information (f.m. broadcast) channels, while the other carries the public radiotelephone service. In the event of failure in the first system, the public radiotelephone service gives up its chain to the essential channels. Furthermore, the chains are oppositely polarized, so can operate together as a double-daisy-chain system if necessary to cope with a variety of fault conditions.

All services are contained within the repeater range of 63.5-180 MHz. The Gotthard tunnel, in particular, is about 16 km long and employs 24 repeaters in each chain. Over such a distance, careful attention has to be paid to gain balance through the system. The repeaters, in fact, are rather complicated assemblies. Every third one incorporates automatic gain-adjustment and equalization circuits responding to two pilot carriers permanently transmitted, one at each end of the frequency range.

On the continent of America, as in remaining parts of the world, most operational systems still apply the original multiple-base-station concept. Some recent installations (such as at Sesser Mine, Illinois, and Black River Mine, Kentucky) employ a successful but somewhat elaborate and expensive form of two-way repeater, while in Washington, DC, a particularly awkward requirement in the under-river section of the Metro system is being met by installing a daisy-chain arrangement using i.f. return, probably the first embodiment of such principles in that continent. A similar trend is evident in new systems being engineered for Canadian mines.

The principle and techniques that have been described in the two parts of this article represent established theory and practice in leaky-feeder communication. But the subject also gives particular scope for 'armchair innovation', with frustratingly too few opportunities or facilities for demonstrating such ideas in practical systems.

For example, leaky-feeder systems generally would stand to benefit from the application of diversity to overcome or mitigate the local variations in signal strength which are so characteristic of all v.h.f. communication in enclosed or urban environments. Most of the standard techniques used or proposed for conventional mobile radio could be applied with advantage, but leaky-feeder systems that include tailbacks lend themselves peculiarly to a principle known as 'direction diversity'[18,27]. Treen[28] has described an ingenious combination of space and frequency diversity particularly

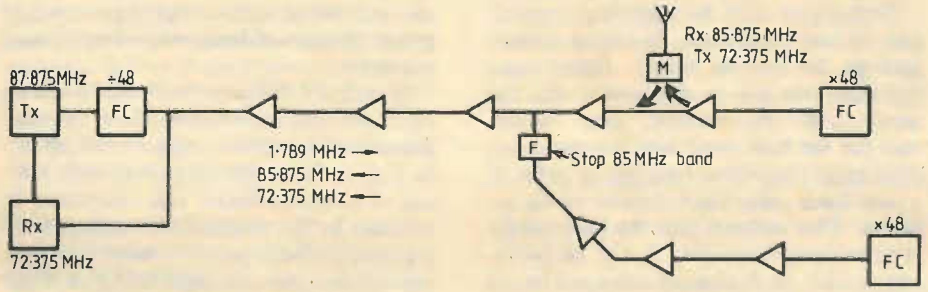


**Fig. 7.** *Daisy-chain system using 'forward drive', achieving the same advantages as IF return but using frequency-conversion in the base-transmit path.*





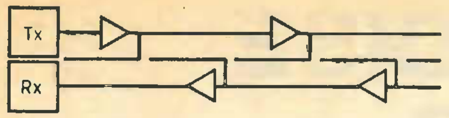


**Fig. 9.** *Double daisy chain to which 'tailback' feeders have been added to halve the variation in signal level between repeaters.*

well suited to leaky-feeder operation. The increased demands on bandwith or spectrum made by all these proposals would not be serious in enclosed environments.

It could similarly be speculated that a development of line-powered 'mini-base-stations' of extremely low power might challenge the now-established repeater technology, exploiting the frequency-conversion devices developed for the i.f.-return and forward-drive systems. A striking property of such systems would be their ability to operate over wide ranges with 'flea powered' mobiles of a milliwatt or so, perhaps in conjunction with a revived form of superregenerative receiver.

For the present, however, there is a wealth of proved and established technology in repeatered leaky-feeder systems, capable of meeting the most demanding requirements for radio communication in mines, tunnels and other enclosed environments.

The author is grateful to the National Coal Board for permission to reproduce the photographs accompanying this article. It is stressed that the author alone is responsible for any statements or opinions expressed about equipment or systems depicted.

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# LITERATURE RECEIVED

**Power Transistor Selection Guide** from Marconi Electronic Devices Ltd has three pages of data and a selection table for their Powerline range, which are intended for high power switching circuits, choppers, inverters, motor-drive circuits and l.f. transmitters. MEDL, Doddington Road, Lincoln LN6 0LF. WW400

**Thick-film microcircuits** are the subject of a brochure from Newmarket Microsystems Ltd, Exning Road, Newmarket, Suffolk CB8 0AU. They offer a custom service for hybrid microcircuits and the brochure details their standards and facilities. WW401

**Technical handbooks and manuals,** along with data sheets for Advance, Alpha, Intersil, Motorola and Texas instruments' products are available from Hawke Electronics, 45 Hanworth Road, Sunbury-on-Thames, Middlesex. They are listed in a Data Library Services brochure. WW402

Spectrol Reliance are manufacturers of **precision trimmer potentiometers,** subminiature switches and multidials. They have detailed their products in a shortform catalogue which also includes technical data and information on their facilities for manufacturing special potentiometers. Copies are available from Spectrol Reliance Ltd, Drakes Way, Swindon, Wilts SN3 3HY. WW403

Thousands of **gears, pulleys and drive couplings,** especially all those hard-to-find mechanical bits are listed in a American publication. The Handbook of Small Standardised Components, some 750 pages long, is published by Stock Drive Produces, 55 South Denton Avenue, New Hyde Park, New York 11040. WW404

**Inductive Transducers** is the self-explanatory title of a catalogue from R.D.P. Electronics Ltd, Grove Street, Heath Town, Wolverhampton. Specification details are given for the range of precision gauging, waterproof, long stroke and miniature displacement transducers and devices for measuring pressure, velocity and angular tilt using inductive and l.v.d.t. sensors. WW405

Portastudio is the brandname for a Tascam 244 **portable recording and mixing system** which can record four tracks onto a standard microcassette which is incorporated into it. It includes dbx noise reduction and is described in a brochure, copies of which are available from Harman U.K., St Johns Road, Tylers Green, High Wycombe, Bucks. WW406

Thomson-CSF has published a new issue of its catalogue on **active components for 0.84μm optical applications.** Twenty-five data sheets devoted to l.e.d.s, p.i.n. diodes and laser diode transmitters are included in the 108-page publication. Thomson-CSF, 101 Boulevard Murat, 75781 Paris Cedex 16, France. WW407

Burndy Ltd are a new company producing **connectors for shielded or coaxial cables.** Their catalogue shows the full range, most of which is available from stock. Burndy Ltd, Colney Street, St Albans, Herts AL2 2ED. WW408

**Standards from the International Electrotechnical Commission** seem to be published at a phenomenal rate. A selection of those received include Publication 679-2, Quartz crystal controlled oscillators; 147-ID, Essential ratings and characteristics for semiconductor devices, Part 1, Chapter √I, Integrated circuits; Publication 705, Measuring performance in microwave ovens; Publication 717, Method for the determination of the space required by capacitors and resistors with unidirectional terminations. Publication 698, Measuring methods for television tape machines. There are a number of additions to Publication 487, dealing with standards for equipment in radio-relay systems; and to Publication 708, cable standard. I.E.C. 1 Rue de Varembé, 1211 Geneva 20 Switzerland. WW409

An application reference book has been published by Zilog which is of use to all employers of **Zilog processors and peripherals.** Chapters are devoted to the Z8 family, Z80 and Z8000 together with their appropriate peripheral devices. Other chapters are on the Z6132 quasi-static r.a.m., the Z-bus and on the applications of the devices and the Unix operating system. Copies cost £8.50 and are available from Zilog distributors and from Zilog (UK) Ltd, King Street, Maidenhead, Berks SL6 1DU. WW410

**Integra Microwave Catalog** (1982) gives general descriptions and specifications for microwave test equipment operating to 40GHz. Equipment consists of sweep generators, frequency and power meters, spectrum analysers, mixer test sets, v.c.o. test sets, sweeping voltage and current supplies. All equipment is compatible with IEEE-488. Copies may be obtained from Farnell International Instruments Ltd, Wetherby, W. Yorkshire LS22 4DH. WW411

A very wide range of **loudspeaker kits** to their own designs are detailed in a catalogue from Badger Sound Services Ltd, 46 Wood Street, Lytham St Annes, Lancs FY8 1QG. In the catalogue they point out that although loudspeaker designs are highly sophisticated, they are often easy to build and it is the building which is the most expensive factor when purchasing commercial speakers. By constructing them oneself, often only requiring a screwdriver it is possible to save greatly on the cost. WW412

**Becoming Comfortable with Computer Graphics** is the title of a booklet from Hewlett Packard. It is a useful introduction to graphics and the methods for generating them, with some fine colour illustrations. Hewlett-Packard Ltd, Winnersh, Wokingham, Berks RG11 5AR. WW413





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# WIDE-RANGE NOISE GENERATOR

*Although intended to form part of an electronic organ, in which the noise simulated the sound of a pipe 'chiff', the circuit is useful in synthesizer systems. The circuit was designed some time ago and uses 74-series i.cs, but nevertheless illustrates valid techniques.*

**by Ian Hickman**

Like many others, the author has been experimenting for years, on and off, with tone generators and keying circuits designed to simulate to a greater or lesser degree the sound of a pipe organ. Efforts have been centred on devising an economical system using an independent free running oscillator for each note. Keying circuits were also considered necessary, as it has not proved possible to key an RC oscillator (and LC types work out more expensive and bulky, though they have other advantages) without "chirp". Attempts have also been made to key noise along with the tone, to simulate the characteristic "chiff" or starting transient of a flue pipe. The noise was obtained from a very simple noise generator knocked up hurriedly and very promising results were obtained, which indicated that band-pass-filtered rather than white noise was appropriate to the chiff circuit. Further experiments in this direction were therefore postponed whilst a versatile a.f. noise generator was produced. In addition to a maximal-length-feedback shift-register-type noise generator, a universal filter of the Sallen and Key variety was incorporated, providing low-pass, high-pass and band-pass filtering facilities.

## Noise generator

The noise is generated by an n-stage feedback shift register (see Fig. 1(a)). This is a shift register clocked in the normal way and having for its input the output of an exclusive-Or gate. The two inputs to the exclusive-Or gate are taken from the last stage of the shift register and an earlier stage. Under these conditions, the output from the shift register is an apparently random string of 0s and 1s and the longest pseudo-random pattern results if the input is taken from the correct earlier stage. Under these conditions, the output pattern will repeat after $2^n-1$ clock pulses. When the generator is switched on, some other sequence may appear briefly, but provided at least one of the shift register stages comes on with a 1 output the maximal length pattern of $2^n-1$ digits will establish itself. (The all 0s condition would circulate indefinitely also, but is of no use to us and is avoided.) During one cycle of the complete sequence, the shift register will hold during one clock period or another every possible combination of n 0s and 1s, so that the longest string of 1s which occurs is n in a row and the longest string of 0s is (n−1). It can be shown mathematically that the output sequence has a frequency spectrum consisting of all harmonics of (clock frequency)/($2^n-1$). Thus a 10-stage register clocked at 1023 Hz would have an output spectrum consisting of all harmonics of 1023/($2^n-1$), i.e. of 1 Hz. These harmonics are all of equal amplitude up to about one sixth of the clock frequency, so up to this frequency the maximal length pattern is quite a good approximation to a source of 'white' noise.

Naturally occurring noise may or may not be 'white', but it usually has a "Gaussian" or 'normal' amplitude distribution. This can be very closely approximated by low-pass filtering the maximal length pattern with a cut-off frequency lower than (clock frequency)/n. This is shown in Fig. 2 where it is obvious that the occasional large positive and negative peaks found in random Gaussian noise correspond with the occasional longish strings of 1s and 0s in the pseudo-random pattern respectively.

In the full circuit of the pseudo-random feedback shift register (Fig. 3) an additional exclusive-Or gate used as an inverter has been included in the feedback path. The effect of this is that the combination of shift register states which does not occur is all 1s rather than all 0s. Owing to the internal architecture of the 7495 i.cs (which each contain four shift-register stages plus various control gates) on switch-on, all outputs usually come up in the 0 state. Thus the maximal length pattern is self-starting. With seven 7495s, the length of the pseudo-random pattern is $2^{28}-1$ or 268,435,455 clock pulses. Clock generator $IC_9$ runs at approximately 6MHz and so Gaussian white noise is available up to somewhat less than 6 MHz/28 or approximately 200 kHz. The 3 dB attenuation frequency of $R_2$, $C_6$ is accordingly set at 100 kHz.

At the other end of the scale, the pattern will repeat at a frequency of $6\times10^6/(2^{28}-1)$ or about once every 43 seconds. So with a spectrum consisting of harmonics spaced 1/43 Hz apart, the output is a very good approximation to the continuous frequency distribution of true white noise, even when the filter is set to 10 Hz low pass. The wide band noise is not low-pass filtered at all. Its level can be set by 'wide-band noise level' control $R_{38}$ and it is made available via an emitter-follower at Belling Lee socket $SK_1$, as in Fig. 4. It is not Gaussian (but may be externally filtered, if desired, to make it so) but is

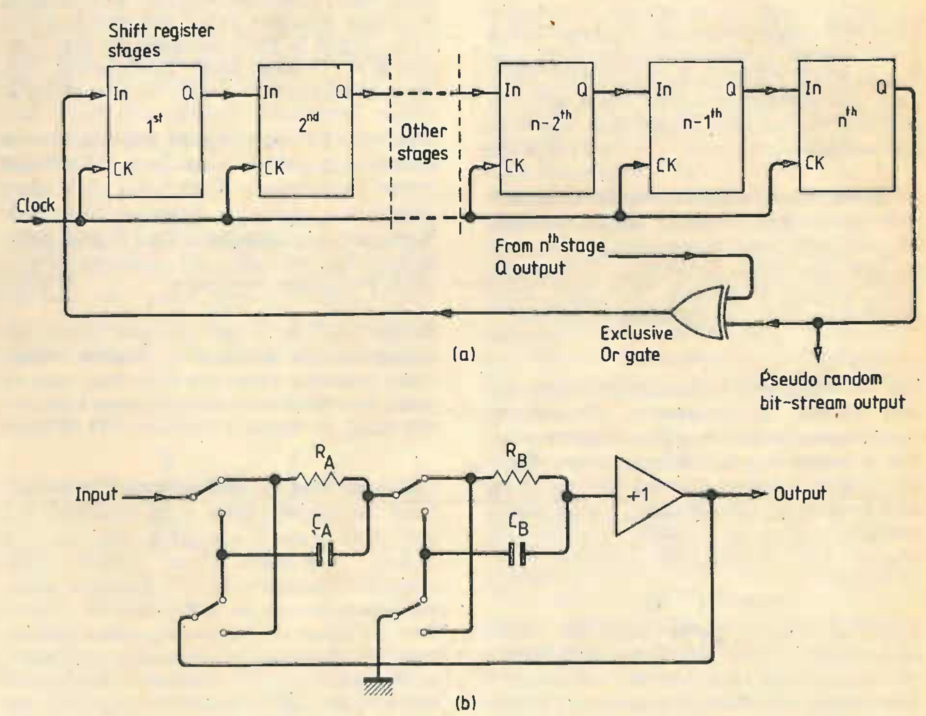


*Fig. 1. Block diagram of n-stage shift register (a). Length of sequence is determined by stage from which second ex-Or input is taken. Sallen/Key filter at (b) can be of high-pass or low-pass configuration*



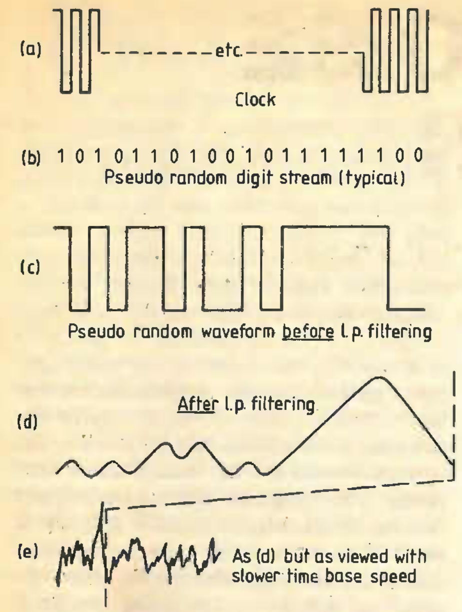


*Fig. 2. Waveforms in the pseudo-random sequence generator. Waveform at (c) shows output before filtering. Filtered output shown at (d) and (e), which is gaussian white noise.*

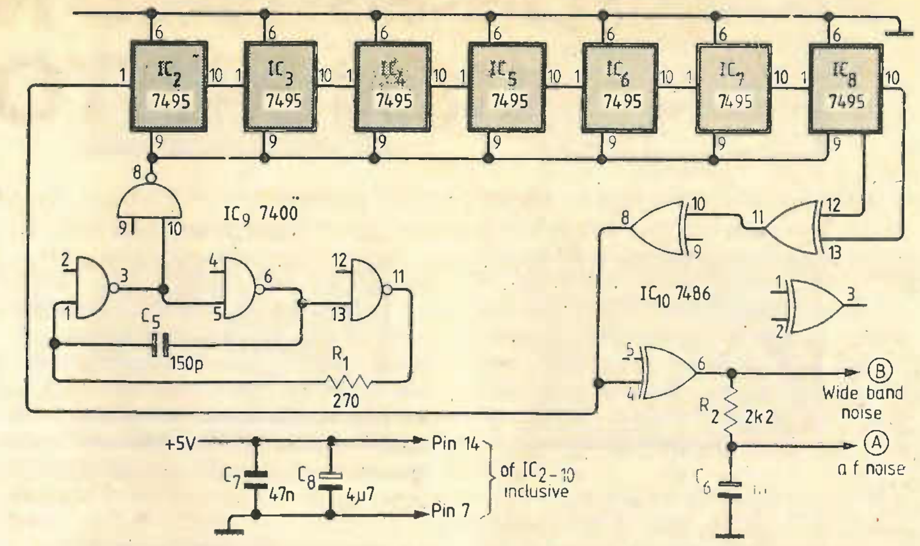


*Fig. 3. Practical maximal-length shift register*

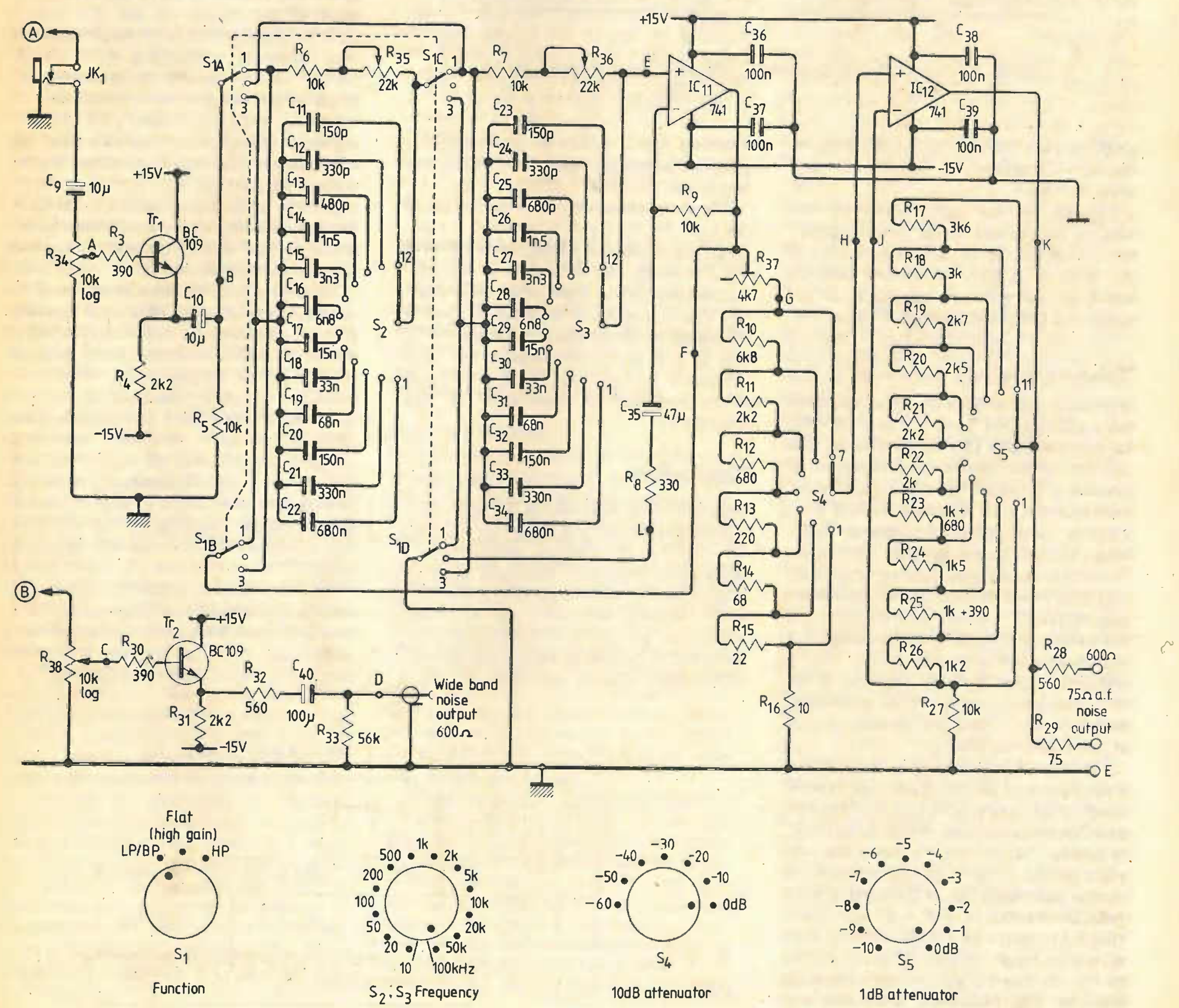


*Fig. 4. Filter, attenuator and output circuits*



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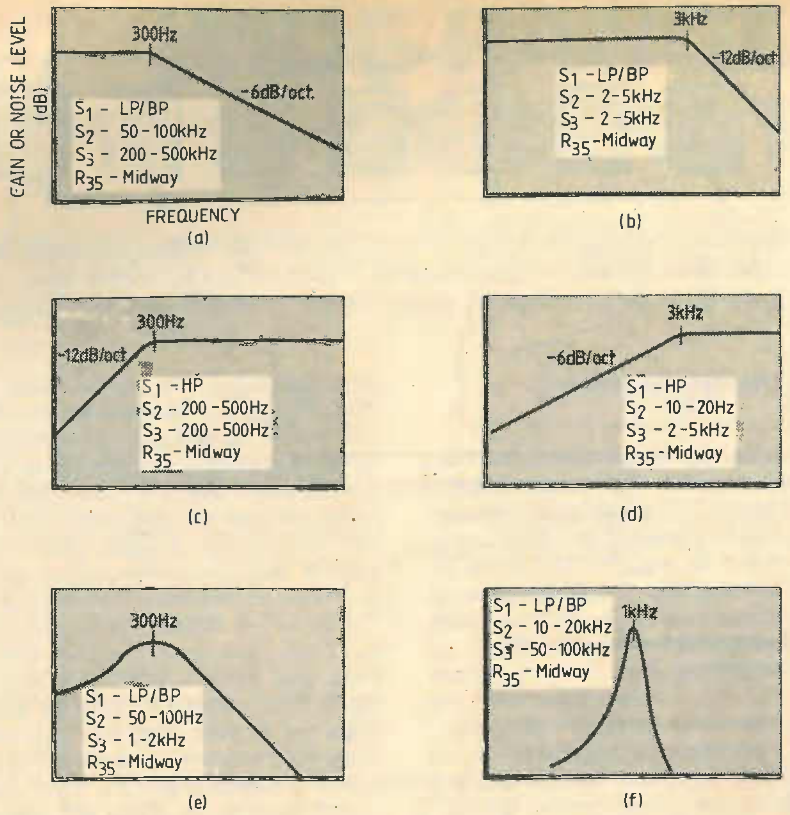



***Fig. 5.*** *Typical responses obtained at various settings of filter controls*

approximately white from 1 MHz down to the cut off frequency of $C_{40}$, $R_{33}$, i.e. approx. 1/30 Hz.

The a.f. noise is band limited to 100 kHz by $R_2$, $C_6$ and at the low frequency end, to 1.6 Hz, by $C_9$, $R_{34}$ and $C_{10}$, $R_5$. It can also, of course, be further limited, high-pass, low-pass or band-pass as required by the filter section. Typical responses and the control settings producing them are shown in Fig. 5. The a.f. noise is available at either 600 Ω or 75 Ω output impedance and its level can be set in 10 dB and 1 dB steps by $S_4$ and $S_5$ respectively. An external input $JK_1$ is provided so that the filter section can be used to shape the frequency response of any audio signal. Alternatively, with 'function' switch $S_1$ at position 2, the frequency response is flat, but up to 40 dB of voltage gain is available. This position may also be used to produce high-level white noise, but the occasional large-amplitude spikes characteristic of white noise will be somewhat reduced due to slew rate limitations in $IC_{11,12}$. $R_{37}$ is provided to permit the adjustment of the maximum noise output level to a predetermined value. It may be omitted if this facility is not required.

For either a high-pass or a low-pass response with a 12 dB per octave fall beyond the cut off frequency, $S_2$ and $S_3$ should be set to the same position. When using h.-p., increasing the l.f. cut-off frequency will progressively remove the low-frequency noise components, but as these represent a small percentage of the total a.f. bandwidth, the effect of overall volume does not appear large, except of course for the last few positions. This is because the noise power per unit bandwidth is constant and therefore when, in the l.-p. mode, the cut-off frequency is reduced, so is the output amplitude.

The b.-p. response is a modification of the l.-p. response and is obtained by setting $S_3$ to a more clockwise position than $S_2$. The larger the difference in settings, the narrower is the 'band-pass' characteristic. The frequency of the peak is equal to the mean of the frequency settings of $S_2$ and $S_3$ and fine adjustment to the peak frequency, without affecting the sharpness of the peak, can be made with $R_{36}$ 'fine frequency'.

## Application

Before dealing with uses of the generator, it is worth emphasizing again that although the circuit is self-starting, there will be a delay after switch on before the maximal length pseudo-random pattern establishes itself. During this start up sequence, which may last up to 40 seconds or more, there will be periods of silence interspersed with sundry whistles and hisses. So if you switch on and apparently nothing happens, fear not! Thirty to forty seconds can seem an awful long time!

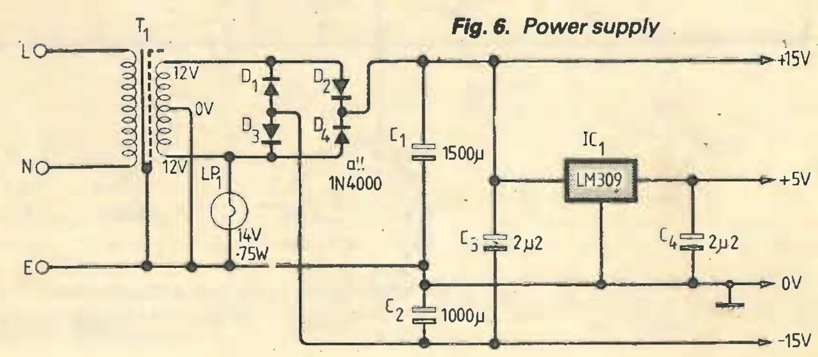
In addition to the use for which it was originally required, i.e. experiments in producing a realistic electronic simulation of the sound of a pipe organ, the completed noise generator can be used for a wide variety of purposes. It is a very useful adjunct to a synthesizer and can contribute to a whole range of novel effects. For instance, with 'Function' switch $S_1$ set to l.-p. and $S_2$, $S_3$ set to posotion 11 (20 to 50 kHz cut-off), the output of the noise generator passed through a synthesizer envelope circuit set for rapid attack and decay will sound like a pistol shot in the open air. A slightly longer decay sounds like a shot inside a building and repeated envelopes like an automatic or machine gun. Even without a synthesizer, a wide range of effects can be demonstrated. For example, with the output of the noise generator feeding an amplifier and speaker, set 'function' switch $S_1$ to l.-p. $R_{34}$ to maximum and $S_2$, $S_3$ to position 5, 200-500 Hz cut off. With the volume set rather loud, the sound is very like that experienced in a tube train, apart of course from the regular noise of the wheels on the rail joints. Slowly reducing the cut off frequency with 'fine frequency' control $R_{36}$ whilst reducing the 'volume' ($R_{34}$) gives the impression of the train slowing down for a station.

Setting $S_2$, $S_3$ to position 7, 1-2 kHz cut off and $S_1$ (function) to high-pass gives the sound of waves hissing on a shingle beach. Again, adjustment of 'fine frequency' control in conjunction with $R_{34}$ can give the deeper sound of a wave breaking, followed by the hiss of the water receding through the shingle.

Band-pass-filtered noise lends itself to some dramatic effects. Thus with $S_2$ set to 200-500 and $S_3$ set to 2-5kHz, ('function' switch at LP/BP) the sound can be made to sound like the sighing of the wind in a woodland setting by manipulating $R_{36}$. Set $S_2$ to 100-200 and $S_3$ to 20-50kHz and we have the sound of the wind screaming round a climber belayed on an exposed ledge. Set $S_2$ to 10-20 Hz and $S_3$ to 50-100 kHz (again tweaking $R_{34}$) and it sounds like the blizzard howling through the gaping windows of the ruins of Dracula's castle!

The ear will recognise the centre frequency of the band-pass response as a musical pitch even with a very modest amount of peaking, e.g. Fig. 5(e) and it is quite easy to play tunes simply by adjusting $R_{34}$ □

***Fig. 6.*** *Power supply*






# PATENTING AN INVENTION

***Protecting your invention is neither as simple nor as cheap as it is sometimes imagined, and the protection it affords is often illusory. Barry Fox explains the pitfalls and shows the way round them.***

**by Barry Fox**

Everyone has, at some time in their life, had an idea which they felt was important. "You should patent it", says a friend, "and earn some money from it". If only it were that simple!

Some good ideas aren't patentable. Others ideas are patentable, but not worth patenting. And the whole business of patenting is much more complicated and expensive than most people realise. Patenting an invention can sometimes bring very considerable financial rewards, not to mention fame. But more often, patenting an invention brings only disappointment and financial loss.

### What is a patent?

Although everyone has heard of patents, few people can even pronounce the name correctly. It's patent as in cat, not patent as in latent. Even fewer people understand what patenting is all about.

A patent is, in effect, a bargain struck between the Government and an inventor. The inventor discloses full details of a new idea to the public through the government-controlled Patent Office and in return is rewarded with a legal monopoly on that idea for a limited period of time. The public gains because the inventor's idea is published and adds to the sum of human knowledge. The inventor gains because a patent monopoly can be potentially very valuable. For instance a patent which is legally strong enables the inventor, or anyone who has legitimately taken over the patent rights, to control the manufacture, sale and use of an invention. But patents, unlike trademark registrations, are not permanent. Whereas the first British trademark, Bass for beer, is still in force after over 100 years, patents can only last for up to twenty years. Before a major change in British patent law took place, in June 1978, the life of a British patent was sixteen years. It's also part of the bargain that once the patent monopoly period has expired, the patented idea becomes public property – or passes into the "common domain".

It is expensive to obtain a patent and in most countries of the world (including Britain) it is also expensive to keep a patent in force. Annual renewal fees must be paid. There are also many pitfalls for the unwary inventor, and the grant of a patent is certainly no guarantee of financial reward. There is, for instance, no point in having a legally strong patent on a commercially valueless idea. The whole point of a patent is that it gives the owner a temporary right to prevent plagiarism. If the patented idea isn't worth plagiarising, there is no value in holding a patent on it. Likewise if a patent is not legally strong, for instance if it has been inexpertly drafted or is anticipated by earlier knowledge, it will be of no real value.

As a rule of thumb, it is usually easier to secure a patent on a worthless idea because the chances are that no-one has previously wasted time and money on patenting it. As another rule of thumb, the more valuable the idea protected, the stronger the patent

will have to be if it is to withstand the legal attacks which will be brought against it by competitors who want to use the same idea. Incidentally, although "idea" is a convenient term to use in the context of patenting, it is not strictly correct. You can't patent a bright idea as such, only some way of putting it into action.

### Success stories

Perhaps the most famous example of a commercially successful patent is that which was filed by Percy Shaw of Halifax, shortly before World War II. Shaw's invention was what we now know as "cat's eyes". In fact the idea of marking a road with glass reflectors wasn't new, but the idea had never caught on because the reflectors soon became dirty. Shaw's brainwave was to mount the glass eyes under rubber lids which, in the manner of a blink, closed and cleaned the glass every time a car ran over them. When war broke out, and car headlights had to be shielded for the black-out, Shaw's invention came into its own.

When Percy Shaw died, forty years and 15 million cat's eyes later, he was still paying around £37,000 a year in income tax on the profits from his original invention. His patents had of course long since run out. But Shaw continued to manufacture cat's eyes himself and thereby capitalized from a commercial monopoly long after his legal monopoly had expired.

Of course, the fact that Shaw's patents have run out does not mean that anyone else can re-patent the same idea. It is now in the public domain. But there is no reason why a modern inventor should not come up with a new idea relating to cat's eyes. Indeed I noticed recently that an inventor is currently trying to patent a new type of cat's eye which is temperature sensitive and so gives drivers a signal of road conditions.

It's important to understand that every country has its own patent laws which apply only to that particular country. A British patent, for instance, cannot be used to control the manufacture of a patented invention abroad. But it can be used to control the sale here of foreign-made goods. So a British inventor can block the import of foreign copies or "infringements"

Consider the case of a now-famous invention by German engineer Walter Bruch of AEG Telefunken. This has not only rewarded the German company but helped shield the entire European tv industry from cut price competition from the Far East. In the early 60's Bruch developed a colour tv system which was an improvement on the NTSC system then being used in the USA. The new system, which became known as PAL, is of course used in most European countries and thus in most colour tv sets suitable for use in Europe. Because the patents on PAL were legally strong, Telefunken, (with the help of EMI, and now Thorn-EMI, as the company's British agent) was able to insist that any firm making or selling PAL colour tv sets did so under a patent licence. The licence not only earned money for Telefunken on every PAL set but also put very strict limits on the number and type of PAL sets imported into Europe from the Far East.

Now the PAL patents are expiring. But thanks to the different laws in different countries the expiry dates are confused. Also because new patents on PAL improvements have been granted over the years to create the illusion of an everlasting patent folio, electronics companies are still unwilling to dispute the illusion in court. The Taiwanese firm Tatung recently bought the old Decca tv factory at Bridgnorth to secure a PAL licence. No licence has ever been given to a company operating out of Taiwan or Korea, or for that matter Portugal. This has been deliberate policy on the part of Telefunken and Thorn-EMI to protect Europe from a flood of cheap sets made in countries where production worker wages are still much lower than in European factories.

Another invention in the electronic field which has proved financially rewarding is that made in the late 1960s by the US firm



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Sanders Associates. The company filed a patent application for a "television gaming and training apparatus and method". This, and a series of follow-up patents, covered the broad concept of generating blips on a tv screen and offering the viewer the opportunity to control them. Sanders eventually sold the patent rights to Magnavox, Philips US subsidiary. Virtually every tv game sold today is now made under licence to these patents, with a royalty paid to Magnavox. The Sanders patents could well prove to be the most valuable electronics folio of all time.

Because every country has its own patent laws, and a patent in one country only protects an invention in that country, it clearly makes sense for an inventor to file patents on a new idea in as many countries as possible around the world. But to patent an invention on a worldwide scale is prohibitively expensive. So all the largest firms, with the most important inventions, must take a value judgement on which countries warrant the cost of patent protection. Phrases like "world patented" or "world patent pending" are almost always bluff.

## Disputes and delays

Bluff is an important part in patent procedures. Suing on a patent in court is even more expensive than obtaining one. Once a patent dispute reaches court, only the lawyers will win. A classic example and a warning to anyone involved in a patent dispute, is the case between British Celanese and Courtaulds in the early 30's. For four years the two textile companies fought a patent dispute in court which, even then, cost them around £100,000. Even the Celanese-Courtaulds battle was short and cheap compared to that between the Glacier Metal Company of Britain and the Cleveland Graphite Bronze Company of the United States. In 1934 CGB was granted a patent on the method of making main bearings for car engines. In 1937 the two companies started a legal battle over the intertwined issues of whether the CGB patent was valid and whether Glacier was infringing it. Thanks to delays caused by the outbreak of war, and a series of appeals, it took until the early 1950's before the House of Lords finally reached a decision. The protagonists agreed to settle their costs out of court because by then the patent had died of old age!

Patent disputes can be so wearing to all parties concerned that they will quite literally drive the litigants to suicide. This is exactly what happened in the case of Major Edwin Howard Armstrong, inventor of f.m. radio. While still a young man Armstrong patented regenerative feedback, and the super-heterodyne principle. In 1920 he signed over these patents to Westinghouse for half a million dollars. He needed the money to help pay his legal fees arising from a bitter patent dispute with Lee de Forest over the patents on feedback. Armstrong and de Forest fought each other through twelve separate court hearings, winning six each. Then in 1934 the Supreme Court in Washington handed down a final judgement. It was against Armstrong, leaving him no longer the true inventor of feedback. Although the decision soon achieved legendary status as classic proof that the law is sometimes an ass, Armstrong was terribly disillusioned with patents. Nevertheless he still found the time and enthusiasm to work on super regeneration and then f.m. communication, which he patented in early 1933.

In the late 1930's the major US radio manufacturers, including Westinghouse, GE and Zenith, took licences to manufacture f.m. receivers under the Armstrong patents. But RCA refused. The outbreak of war postponed a legal confrontation between Armstrong and RCA. But in 1948 Armstrong sued. The pre-trial work necessary just to prepare the case for court took five years. The patents expired on Boxing Day 1950 but the court case continued. On the evening of 31st January 1954, Major Armstrong, exhausted by it all, just walked out of his 13th storey apartment window in New York to instant death.

Armstrong's widow, Marian, continued the case in Armstrong's name. Shortly before his death he had filed twenty fresh court actions against a string of smaller f.m. set manufacturers. To pay for these cases, Marian Armstrong made an out of court settlement with RCA for one million dollars. It was not until 1967, seventeen years after the Armstrong f.m. patents had expired and thirteen years after the inventor's death that the most crucial Armstrong case – against Motorola – was decided in Armstrong's favour. The inventor was posthumously vindicated on all 13 points in dispute and 10 million dollars of back royalty payments were collected from Motorola and the others. This payment was for just three years of activity on f.m. in the United States between the end of the war and expiry of the patents.

Our own Alan Blumlein was less lucky. He died, in 1942, ten years after his invention of stereo and long before there were any commercial rewards. It is often said that inventions are ahead of their time and Blumlein is a classic example of an inventor ahead of his day. His master patent on stereo, BP 394 325, was filed between 1931 and 1932. It was hopefully kept in force by his employer EMI for the whole of its sixteen years natural life, despite the fact that there was no commercial call for what it protected. As Arthur Keller of Bell Labs in America, who was working on stereo at exactly the same time as Blumlein (unbeknown to each other) told me in America last year: "It was the recession and people couldn't afford one loudspeaker, let alone two".

The EMI-Blumlein patent routinely expired in 1947, but EMI made an application to have its life extended because of the hiatus created by the war years. Under special provisions a new patent on stereo was sealed in 1949 and had a five year life. So Blumlein's original patent did not finally expire until the 13th December 1952. This was just a couple of years before the first stereo tape recordings were issued. Discs came at the end of the fifties. So neither Blumlein, who was dead, nor EMI, whose patents were dead, reaped any financial reward from the invention.

## Ideas exposed

To patent an invention, then, can be as demoralizing as it can be rewarding. But it is fortunate for the general public that inventors do still continue to file patents. The reason is in the word "patent", which means to lay open. As previously explained, a patent is a bargain struck between the Government and an inventor, with the inventor disclosing full details of the new idea in return for that elusive and limited period of legal monopoly. The resultant value of patents as a source of information is widely misunderstood and grossly underestimated. Patents are probably the only technical publications which remain permanently published "in print". It is possible today for anyone to read a copy of British patent Number One of 1617, simply by visiting any patent library which houses a full collection of British patents. A full xero-copy can be bought for the same price and as easily as a copy of any other British patent. Of course, BP No. 1 is now only of value as a curiosity. Although it ostensibly describes a new process for printing "mappes", the five pages of text are filled mainly with prosaic "know ye's", "whereas we's", and "uttermost peril" threats. But some of the millions of more recent patents are much more informative.

An inventor is legally obliged to give a full working description of his idea, and a method or means of putting it into practice. Even if only a small aspect of the idea is new, and patentable, the description must still be full. It must put the new idea into perspective and enable someone who understands the general field of technology to put it into working practice. So a patent can tell all, or almost all, about a company's research project. Quite often a company with a supposedly secret idea will already (and unrecognised by most of the staff) have published that idea to the public in the form of a patent! This is particularly likely now because under the new patent laws *pending* patent applications are published. (Under the previous British laws only granted patents were published). For instance while the technology of the new Sinclair flat-screen tv tube was supposedly still under wraps, full details had already been published in pending patent applications. The press was thus quite free to publish information which the company and its PR people regarded as secret. And a search through Kodak's patents tells much more than the company tells. Its important to understand that you don't infringe a patent simply by reading it. You can also talk and write about what it describes. It's only when you start to use the invention that the legal problems arise. Even so, the effective scope of a patent is defined by a set of claims at the end, *not* the detailed description and drawings that precede them. These claims may be very limited in scope, even though the preceding description is lengthy and detailed. USA patents number 3,852,787 on the Nimslo 3-D process is a good example of this. The text and drawings describes in fine details of the process but the patent claims are much more limited.





## What to patent – and when

Patent claims must be very carefully drafted. If they are too broad, or greedy in scope, they will raise official objections from the Patent Office examiners, whose job it is to process every application before granting a patent. And even if the Patent Office can be persuaded to grant excessively broad claims, the resulting patent may be open to legal attack because its claims also cover well known devices. When a patent describes a broad field of technology in detail, but claims only a specific fine point of detail, this is usually a sure sign that most of the field is already covered by other patents or is no longer patentable because almost everything is well known and in the public domain.

This point underlines a basic canon of patent law. To be legally valid a patent must claim an invention that is truly new when the application is filed. If anyone, including the inventor, has previously disclosed the idea, then any patent granted on it will be open to legal attack and probably worth no more than the paper on which it is printed.

There was a good example of this in the field of quadraphonics. American inventor David Hafler had a clever idea of deriving surround-sound from stereo. This was the so-called "Hafler system". Different information is extracted from the stereo pair of outputs from an amplifier and fed to extra speakers. Hafler patented the system but only *after* he had published an article describing it. So at least part of his patent monopoly was automatically invalidated. The inventors of the Aerostat anti-static pistol have faced a similar problem. Their pistol was shown on the tv programme *Tomorrow's World* before a patent application was filed.

Under the new British laws (but not under the old laws) an invention must be truly inventive as well as new. Suppose you came up with the idea of soldering a joint by clamping a soldering iron in a vice, and moving the joint and solder over the fixed iron. Strictly speaking this could be new, because it's unlikely that anyone has ever patented the idea before or suggested it in print. Everyone has previously clamped the joint and moved the iron across it. But the new idea is plainly obvious, not inventive, and thus not now patentable.

Although a narrow patent claim, which seeks monopoly on just one specific technical advance, may be legally valid, it may also be of little commercial value. It is too easy for a would-be infringer to avoid. In the mid-1960s the National Research Development Corporation filed a patent application on the use of carbon fibre as a material strengthener. But the claims in this patent were drafted in narrow terms to cover only carbon fibres made from a particular raw material (polyacrylonitrile). After the NRDC patent was granted other firms devised and patented other ways of making carbon fibres from other materials e.g. pitch and rayon. So the NRDC patent was enforceable only against carbon fibres made from the particular raw material specified in its claims.

By now it should be clear that securing a patent is a tricky legal business. In fact it's even more tricky than you would think. Some people would say it's as easy and safe as taking out your own appendix. So inventors should seek professional advice from a patent agent. And of course they should do so *before* saying anything to anyone about their invention. Remember always that the grant of a patent is no guarantee of legal validity. The Patent Office examiners cannot possibly be expected to know of every prior sale, publication or disclosure which can undermine the legal strength of a patent. But you can be sure that if you are granted a patent on a commercially valuable idea, if you have disclosed that idea before the filing date, someone will subsequently use that disclosure to attack your patent if it is to their commercial advantage.

## Taking advice

The Chartered Institute of Patent Agents (Staple Inn Buildings, London WC1V 7PZ) publishes a list of qualified or chartered agents. But be warned that patents agents are, like solicitors, expensive. They can charge you at least £30 or £40 an hour for advice and patent aid. This is of course on top of all the official legal fees (like stamp duty) involved in securing a patent. And then there are those renewal fees which in Britain must be paid annually from the fifth year of life of any patent you are granted. These fees are heavy and run on a sliding scale of several hundred pounds a year.

Unlike the Government Patent Office, patent agents don't operate on a fixed charge of fees so ask for a rough estimate of costs when you talk to a patent agent about your invention, or you may find yourself faced with a surprisingly heavy bill. Also, although in theory any patent agent should be able to handle any case, in practice of course some specialise in chemical matters, others in mechanical matters and others in electronics. Some patent agency firms employ several qualified agents to cover a wide spectrum of science and technology. Inevitably word of mouth recommendations can be very valuable.

A patent agent's advice is needed not just when you have invented something and want to patent it; you should also take a patent agent's advice when you are planning to manufacture something, perhaps in the face of a prior patent. If you know of a patent's existence it's easy to establish whether it is still in force, has expired through natural old age or been allowed to lapse through non payment of renewal fees. But it is much more difficult to establish whether what you are doing does or does not infringe the claims of some unknown patent.

There is also now some confusion under British law over the relevance of artistic copyright to inventions. Artistic works in the UK are automatically afforded copyright protection and as a result of various legal precedents created over the last decade, a court may decide that the artistic copyright in a set of engineering drawings or blueprints is infringed by someone who produces a closely similar item. There is even some legal doubt over whether or not an inventor forfeits artistic copyright when a patent has been granted on the idea. So it is possible that a design not covered by a live patent may be covered by artistic copyright and drawings. There is also of course the possibility that a recent improvement on an old unprotected idea may be covered by a new patent. Frankly anyone who relies on their own judgement to decide whether or not they are infringing someone else's patents is asking for trouble. There really is no useful advice to give, other than take legal advice from a patent agent.

It's here worth pointing out that under a quirk of British law a solicitor is entitled to act as a patent agent, even though solicitors are not required to take the same very tough examinations faced by trainee patent agents. There are some solicitors who specialise in patent matters and are every bit as competent in this areas as a qualified patent agent. But there are other solicitors who know little of patents. Some know enough to recognise their limitations and sub-contract patent work to a patent agent. This can put up the end price to the inventor and make the chain of communication confused. Worst of all, some solicitors know so little about patent matters that they don't recognise how little they know, and thus feel confident to advise on patent affairs.

Even if you take advice from a patent agent, it can help to have some background knowledge of the law. Apart from anything else it can cut down the time, and thus the cost, of initial consultation. What follows therefore is not, repeat not, intended as a do-it-yourself guide to patenting. It's simply a briefing on patents which is intended to make any subsequent consultation with a patent agent more efficient, more effective and more economical.

Because patent law in every country is different, what follows applies only to the United Kingdom. British patent agents have associates in foreign countries through whom they file foreign applications. If this is done within one year of the British filing date, the original British filing date can be claimed for the foreign applications. There is also now a European scheme, which makes it easier (and under some circumstances cheaper) to file in a number of European countries. One day, but not yet, inventors will be able to obtain a single patent covering the whole Common Market. There also exists a Patent Cooperation Treaty which takes in countries all round the world. This, rather like the European scheme, makes it easier, and sometimes cheaper to file in several countries at once. But the over-riding consideration is that foreign filing is extremely expensive. Unless you have good reason to believe that your invention is a potential worldwide money spinner, then a British application is the best compromise between doing nothing, with the risk of seeing someone else reap the rewards from your idea, and patenting in a string of foreign countries and going bankrupt in the process.

This prompts one further point. If you





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are hoping to sell an idea, rather than exploit it yourself, then you must first file a patent application. The very act of offering an idea to a third party may well spoil your chances of subsequently securing a legally valid patent on it. This is because most firms will refuse to consider an idea in confidence. They are scared that the inventor may disclose in confidence what they already have on their own secret drawing board. Such a clash can create the most awful legal tangles. So usually a firm will insist that before looking at any invention it must be covered by a pending patent application and disclosed without any seal of confidence.

### The basics of British patent procedure

For the sake of this section let's assume that an inventor dreams up a new idea for noise reduction which is different from Dolby and dbx. It's not strictly necessary for him to build a working system before filing a patent application. But obviously there's little point in filing a patent application on something that won't work. Some experimental testing is thus usually worthwhile. But the inventor shouldn't experiment for too long or in the meantime someone else may come up with the same idea and file their own patent application first. Also the inventor should not talk about the circuit, except to friends and colleagues in confidence. Certainly he should not try and sell it to anyone or publish it, for instance in a magazine article.

Let's assume that the idea seems to work. The next stage is to stop and think hard about whether it's commercially viable. Is there really room in the world for another noise reduction system as well as Dolby and dbx? What does it offer that Dolby and dbx can't offer? Is it cheaper, better, or what? In other words, is it a better mousetrap, or just another mousetrap?

Let's now suppose that the inventor has good reason to believe that the new noise reduction system not only works, but will sell in competition with Dolby and dbx. Some people would say that the next step is to carry out a patent search and see whether the idea is new. But in practice this may not be the best course of action. Searching for prior patents in a field of subject matter (in this case noise reduction systems) is a lengthy, complicated, expensive and not always very conclusive business. It takes years of practical experience to become an efficient patent searcher. There are professional firms which specialise in patent searching, and these are often employed on a sub-contract basis by patent agents. Other patent agents have "tame" searchers on the payroll. Some very large manufacturers employ their own searchers. But whoever does the work, it's never easy and it's never cheap. A search will cost hundreds even thousands of pounds. Also the fact that no relevant patents are found in a search isn't proof positive that no relevant patents exist. The British Patent Office has been heavily criticised over recent years for mis-filing some patents, so even the most diligent searcher couldn't be expected to find them.

Of course it makes sense to pay for a patent search before embarking on an expensive development project, for instance to produce chips and market equipment incorporating the new noise reduction system. But first priority, assuming the idea works and the inventor thinks it has a commercial future, is to get a patent application on file and so establish a priority date.

Under the old British patent laws (prior to 1978) the inventor could cheaply file a provisional specification which gave a rough outline of an invention. Then, a year later, a complete specification told the whole story and claimed monopoly. Today an application can still be filed cheaply without claims and lie dormant at the Patent Office for twelve months. During this period the inventor can continue to work on the project, perhaps trying to sell it to a manufacturer. The application has established a priority date and generated the freedom to talk and write. If the idea proves to be less exciting than at first seemed likely, then the application can simply be abandoned. If the idea looks hopeful, then within twelve months the inventor must pay extra fees and file a set of claims to define the scope of the legal monopoly sought. These claims would for instance distinguish the new noise reduction system from whatever the inventor knows about all the many noise reduction systems which have been described and patented over the last half century. The further fees pay for an official search by the Patent Office. (This is another good reason for not bothering too much about an earlier, privately-financed, search). After that more fees buy a thorough examination. If all goes well the application is accepted and granted. But it can take up to 4½ years. An important point to remember is that after eighteen months from the filing date, the application and the results of the search report will be published for anyone to read. So any secrecy is then forfeited for ever. Objections by the Patent Office examiners, for instance that the idea isn't new, or is obvious and without any inventive step, or that the application is unclear, have to be dealt with in correspondence, logged phone calls or meetings. Although there is nothing to stop an inventor drafting his own application documents and handling or "prosecuting" the case through the Patent Office, it's a daunting procedure. Also most patents which are obtained by inventors, acting on their own behalf, are legally very unsound.

By far the best course of action is for the inventor to have a patent agent draft the original description, follow through after a year with the claims and then argue all the matters that arise with the Patent Office examiners. The pitfalls for d.i.y. patenters are too numerous to mention. If, for instance, vital information is left out of the original case papers, it can't later be included. A new application will have to be filed. This can cause terrible problems for the inventor. Suppose, for instance, that the Patent Office searcher finds a previous disclosure of a similar noise reduction circuit, but the new circuit has a quite different attack and release time which provides immunity from undesirable breathing noises. This small difference might be enough to secure the grant of a patent on the new circuit, with the claims limited to circuits for generating the particular beneficial range of new attack and release time constants. This feature might turn out to be the vital selling point of the system. But if it wasn't adequately described in the original application documents, then the inventor won't be able to claim it and the application will fail. This holds good even if the inventor had worked on and solved the problem of attack and release time constants before filing the application. If a description of that work isn't in the patent it's legally valueless. A second application might come after someone else's work on the same invention. There's also a risk from over-specific description. Suppose, that the time constants have been too closely defined in the original document, with only a very limited range of constants listed. If it subsequently turns out that time constants outside that range are ideal, then the inventor may end up with a patent but one that only protects a circuit that isn't of commercial value.

Patent fees are continually rising and so are patent agent fees. It can easily cost several hundred pounds to secure a patent on even a very simple idea that runs into no prosecution difficulties. But most ideas that are worth patenting aren't simple and they don't sail through the Patent Office without problems. Although the Patent Office official fees are fixed, for the most part irrespective of the invention and problems of prosecution, patent agents charge by the hour. So the more complicated the case the more it costs to secure a patent. And of course there's no guarantee that the inventor will be granted a patent in the end, however much he spends, if the Patent Office doesn't agree that the idea is new and inventive.

The Patent Office, 25 Southampton Buildings, London WC2A 1AY provides free official pamphlets on applying for a patent. The current scale for official fees is also available from the same address. Copies of all British patents and the list of patent agents who are registered to practise in Britain are available for free reading in the Science Reference Library (once the Patent Office Library) which is housed in the same building as the Patent Office. □





# CRISIS CONTROL

*In the first part of this article, R. E. Young dealt with the problems faced by control engineers in moments of crisis. The second part is a description of methods of data presentation and operator training.*

**by R. E. Young,**
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As has already been implied, once it has been accepted that ultimate-emergency crisis-control facilities must be incorporated in an installation, then an entirely new form of control working – a new 'safety regime' – is needed. This is real-time operation, in contrast to the routine control methods which can be used with the 'slow-to-change' parameters of most established public utility and like systems.

There is consequently a demand for special equipment and techniques to deal with rapidly changing and unexpected situations. Examples are the 'at-a-glance' and comparable reading techniques, all aimed at producing an operator response which is in effect instantaneous and, as far as possible, error-free. Also, because of the special nature of these displays, e.g. for independent-check applications, design provision should include observer-assistance to enable accurate transfers to be made between alternative types of display.

### Independent-check principle

Independent-check methods, which originated in aerospace and similar instrumentation, use the principle of a specific measurement covered by two completely separate instrumentation chains, each working on an entirely different physical basis from the other.

In many of the applications proposed for emergency working – and as used for aerospace development – closed-circuit television provides the second chain, with conventional transducers used for the first. There are several advantages in adopting such a system, not least the facility it gives to make calibration checks on remote transducers which are virtually inaccessible under working conditions, and which cannot even be approached in a hostile local environment.

The main argument for independent check – again backed by aerospace experience – lies in its relative invulnerability, when compared with straightforward duplication, an obvious alternative. Taking a severe break-down condition in a duplicated system, failure of one component due to, for example, abnormal mechanical shock, will almost certainly be accompanied by the corresponding component in the other (parallel) set failing in the same way. Even the suggestion of triplication can be countered by the same reasoning, particularly if only one system element fails completely and the other two are on the 'break-point', i.e. are in a 'false indication' type of fault condition. Furthermore, it must be pointed out that the 'voting' equipment generally used in these case is, by the same token, open to doubt in itself, and especially under far-reaching crisis conditions. Incidentally, this classic voting problem, whether it is carried out by human assessment or by some form of comparator equipment, demands for its final solution comparison with some form of external reference.

Besides the use of c.c.t.v., alternative types of transducer can be used in the second (checking) chain; but as part of the overall philosophy of independent check, the minimum amount of equipment

*Fig. 4. Closed-circuit television monitoring can form one of the chains in an independent-check system. System at (a) uses a conventional camera, while that at (b) has a flying-spot scanner and detector.*

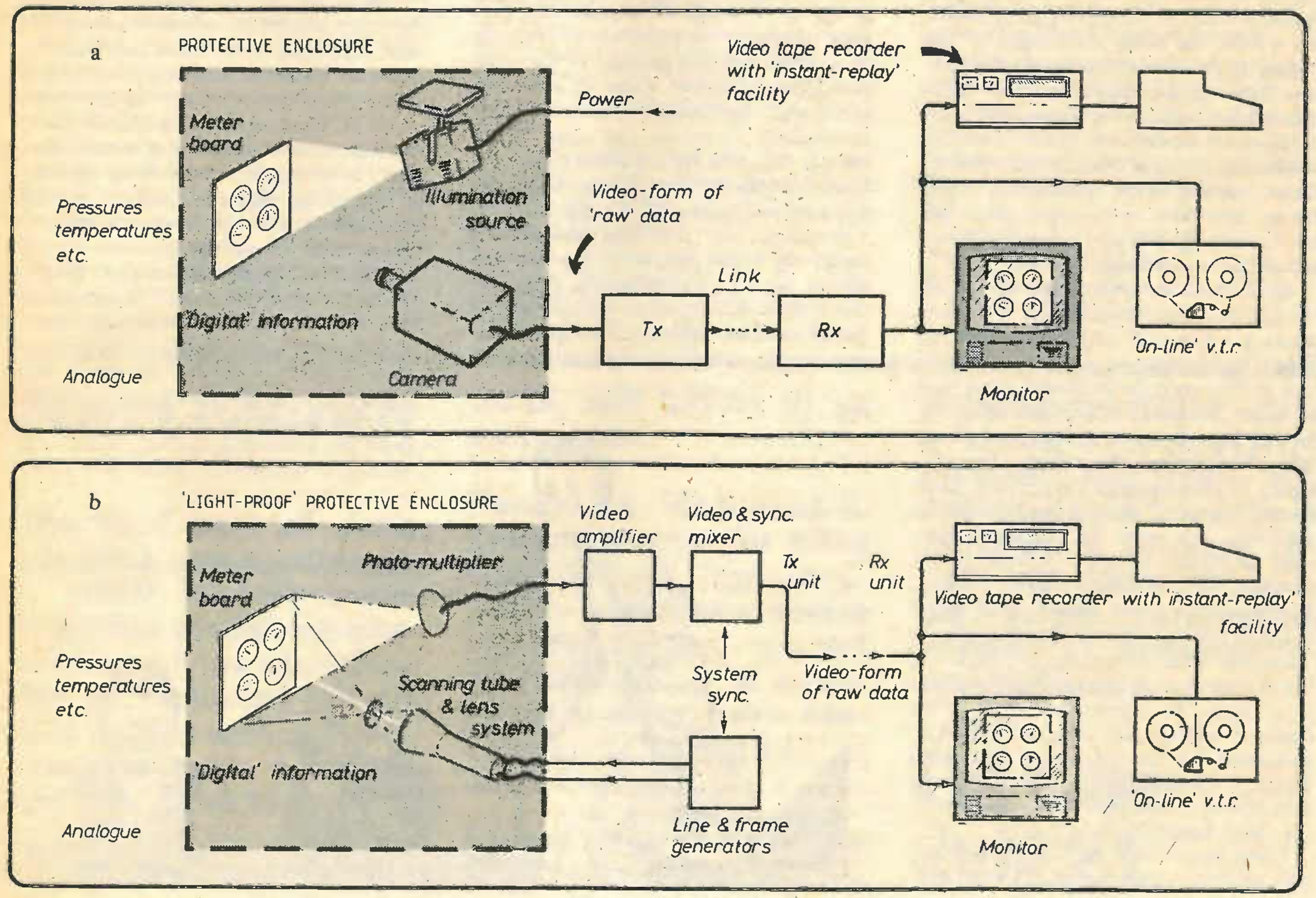

*Fig. 5. Sine-wave raw-data trace of balanced-oscillator type of transducer, aided by digital frequency display, discriminates between required reading and interfering pulses. Photo by Manchester Polytechnic.*

should be interposed between the instrument output and the data presentation points. In other words, ideally no equipment (liable to cause unreliability or error by its very presence) should come between the measuring instrument and the display.

The considerations lead to the concept of working at 'raw-data' level where the transducer feeds a v.d.u. and, with the balanced-oscillator or other frequency output transducer, presents a sine-wave-type trace. As shown in the photograph (Fig. 5) the c.r.t. trace can be backed up by a digital counter or other frequency meter, but one of the main advantages of this display is that the operator can discriminate between the required 'value' signal and spurious interfering signals which can be expected during the totally abnormal conditions of crisis breakdown. For instance, under such conditions, high-energy impulsive interference alone can reach such proportions as to obliterate completely a coded signal pattern.

Similar considerations apply to the use of c.c.t.v. for independent checking, where it works as a telemetering medium. It has, in addition, an outstanding advantage in that once the intelligence has been in effect 'encoded' in pictorial form, no further degradation in its data content can take place through the system. Also, the ability to read through interference given by the 'frequency' signal is enhanced in the television case since the operator knows what the picture should be and can read it through near-saturation interference. Furthermore – and this is vital for a multiple breakdown due, for example, to 'knock-on' fault development – failure of the tv system as an instrumentation chain is obvious. In comparison with other chains it is effectively 'fail-safe' in that no indication by an individual instrument within a televised group means that the instrument, rather than the remainder of the chain, has developed a fault.

Using these visual methods, which can only be surveyed here in broad terms, does put a significant load on the observers/operators; but means for reducing this load form part of the treatment in 'Control in Hazardous Environments'[2] of control room organization which includes a 'two-tier' control structure. The picture of Fig. 6 is a representation of a small, highly-trained crisis management team of engineers working under full emergency conditions at their special positions on the master consoles. The team is operating in a two-tier grouping with the senior engineer at the back in control overall, having access to all levels of information, with their selection determined by him in accordance with his 'reading' of the situation. Communication is also on a two-tier basis with information 'filtered' (data-marshalled) to ensure that only 'mainstream' data and speech reach those concerned primarily with taking immediate decisions and crisis-control actions.

Although the preceding descriptions cover only visual analysis of raw data and similar displays, the writer has suggested that future development should include 'super-software' techniques to replace routine human observation by computer interpretation of a number of raw-data television pictures. Thus, for example, a group of (say) simple instrument dials, would be kept under computer-based observation (image analysis) to detect changes, in an anticipatory control rôle, but this would be brought into use for crisis control to take some of the load off the operators under emergency saturation conditions.

## Training

These new methods of operational working place a heavy 'thinking' demand on the engineers; and it is suggested that the corresponding levels of training and preparation which are required are such that they should be largely subliminal in nature. This means that the training mechanisms should not be obvious; a 'from-within' type of intuitive element is needed, ideally on both sides (teacher and pupil).

That conventional methods, even most types of simulator training, should be avoided, comes out of the consideration of (stress) conditions A and B and the manner in which individuals enter them. As a general rule, those in condition A had developed an absorbing technical interest in, and grasp of, the system they were operating, and had been helped to reach this position by on-the-job training. Here, they had been allowed to do specific pieces of responsible work, but at the same time were given an overall view of the system at suitably timed intervals without any of the tasks being made over-taxing, either in length of time spent or in unnecessary mental effort (e.g. in memorizing facts not directly concerned with the work).

These points may seem unimportant, but the conclusion which emerged was that, by what amounted to subliminally-induced learning, those in condition A were able to arrive at correct interpretations of situations, and to make correct decisions, *without any lengthy mental search (and 'back-comparison') time being required.*

In contrast, those in condition B were not able to achieve these near-instantaneous results in such a crisis and this appeared to be due, at least in part, to the way in which their standard (classroom) courses had to be conducted – they had to absorb a great deal of inessential material along with the essential. This meant that, under the stress of an emergency, they had to separate out the wanted information from the unwanted and this meant that because of this mental clutter, an acceptable time of response could not be achieved. In turn, the thinking fatigue generated was sufficient to cause a relapse into condition B.

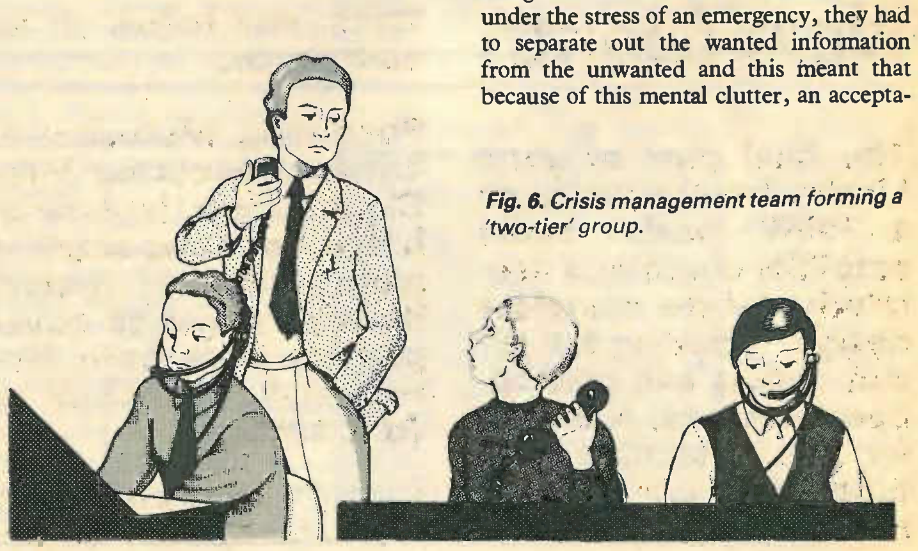

*Fig. 6. Crisis management team forming a 'two-tier' group.*

The importance of these statements needs no emphasis; but it was not until correlation was established with the results of the mental handicap research already mentioned that they were seen to be based on two very different kinds of observation and two different kinds of theoretical follow-up, both of which nevertheless gave, in effect, the same answers.

With this background, it was possible, for example, to embark on various pieces of 'system modelling'; and from them, to predict certain effects such as the delay time which can elapse between question and answer with mental handicap hyperautism, and the distortion (inversion) of words in speech, making a word completely unrecognizable, which appears to be set up as the result of imperfect mental data marshalling (selection) and checking.

Turning to the question of mental handicap itself, "this most mysterious of human complaints", the 'shell' effect not only represents the isolation of the hyperautistic state, but also throws into relief the need to help the mentally handicapped person to communicate 'from within'.

The word 'shell' – put forward by the parent of a mentally handicapped girl – is probably unequalled to describe the state reached when conditions are at their worst, with energy sapped by thinking fatigue, itself set up by, for example, attempts at conversation with no allowance made for delay time, or by unknown visitors appearing without warning. This need to avoid intrusion by strange visitors is not always recognized; but it is understood that in at least one centre in Europe, visitors are not allowed to watch the mentally handicapped students during working hours to avoid disturbing them.

The two-way mirror which permits shielded observation without causing disturbance forms an important part of the Embryo Language Laboratory shown in Fig. 6; and which in this case is being used to give the mentally handicapped the opportunity to use the telephone under controlled conditions. It can be predicted that, provided the telephone is 'accepted', this can be helpful in reducing the shell, i.e. in reducing the obstacles to communication. It does seem that side-tone and similar effects may well be clutter-reducing, while the interest engendered by using adult technical equipment can reduce the shell enormously.

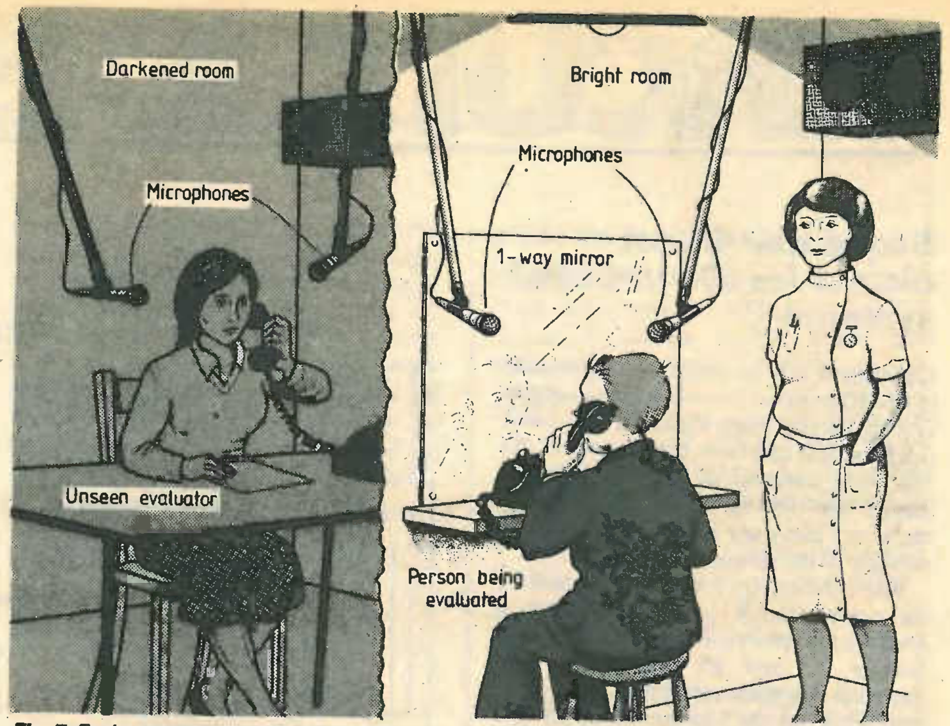


*Fig. 7. Embryo language lab. for training the mentally handicapped – in this case in using the telephone.*

In the arrangement shown, the student using the telephone, and looking into the obscured side of the mirror, is talking to the instructor on the other side. Microphone/loudspeaker monitoring is provided back to the instructor giving local assistance to the student in this particular instance.

One of the objectives here was to gain information on the degree of confidence given to the student by using the telephone, and the amount which can be attributed to side-tone anti-clutter reinforcement, and how much to the use of the telephone itself. This information is obviously of value on the mentally handicapped side, but perhaps even more to study of the B condition.

In general terms, "the mentally handicapped never look at themselves in mirrors"; and the extent to which this is true for the individual shown – looking in to the mirror – provides additional information for the assisting instructor. This is typical of the indirect methods which may be used to obtain information unobtrusively so as not to cause distress and to prevent the development of the shell.


Full acknowledgement must be made of the major contribution of Dr. Gordon Avery, when District Community Physician of the Warwickshire Area Health Authority, South District, in his interest in the research programme on mental handicap.

Corresponding recognition must also be given to Professor Harold C. A. Hankins of the University of Manchester Institute of Science and Technology for invaluable discussion of this subject.


# Next Month

**The final part of John Linsley Hood's series on a 100W mosfet audio amplifier contains a description of the complete design, including full circuit details and printed-board layouts. A design for the matching pre-amplifier, which possesses several novel features, will follow in an early issue.**

**Receiving Meteosat-II. Enhancements for Mike Christieson's high-resolution weather-satellite picture system extend its capabilities to cover primary data from Meteosat-II, launched in June 1981.**

**Circuit modelling by micro-computer. By removing repetition from a circuit modelling program and using macro-codes for certain routines, a 16-node circuit can have its gain and phase parameters plotted in minutes instead of hours.**

# On sale July 21




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# CIRCUIT IDEAS

## Sequential digital display for 8080A-based systems

Eight digits can be displayed sequentially in two steps using seven-segment displays. During the first step, segments a, b. c and d are enabled and show the contents of the first byte assigned to this digit in the display ram. During the second step, segments e, f and g are enabled and show the contents of the second byte.

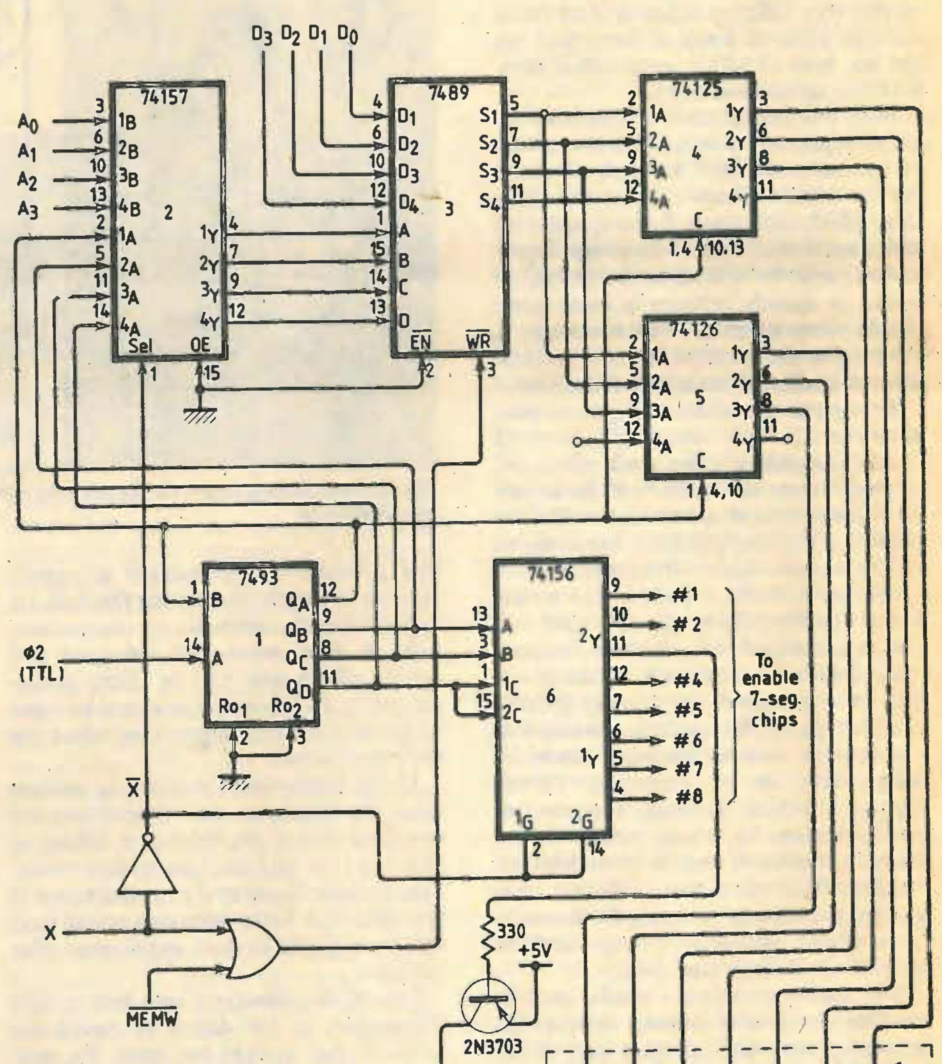
When the display r.a.m. is addressed by the c.p.u. line X (one output from a memory-mapped i/o decoder) goes low and disables $IC_4$ and all displays. In the meantime $IC_2$ selects the four lowest-order bits AO-A3 of the address bus to address the required byte in the display r.a.m. $IC_3$. With the $\overline{MEMW}$ line low (in response to a store-in-memory instruction) the lowest-order bits D0-D3 of the data bus are stored in the addressed byte of display r.a.m.

When the write operation is terminated, X goes high and the refresh circuit is enabled. Outputs of the hexadecimal counter $IC_1$ ($Q_A$, $Q_B$, $Q_C$, $Q_D$) are selected by $IC_2$ to address the 16-byte r.a.m. ($IC_3$). When $Q_A$ is high, the output of $IC_3$ is passed to segments e,f, g of the display chips. The seven-segment chip addressed and selected by $IC_6$ will be the only one to respond to the output of the display r.a.m.

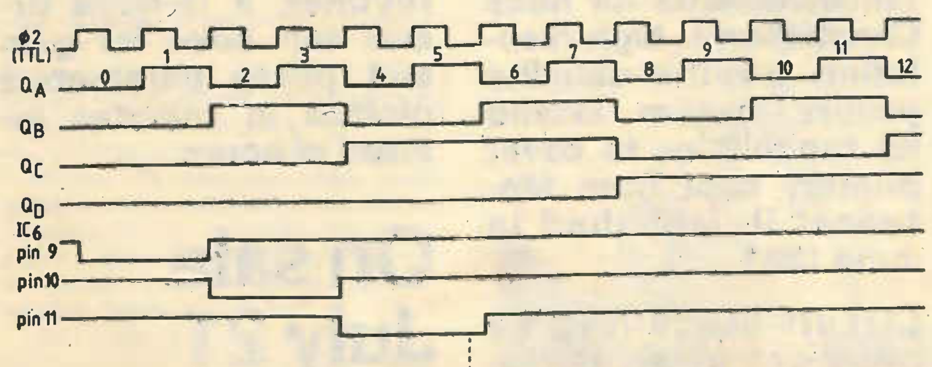
Decimal points are excluded in this design. To permit control over decimal points, connect pin 11 of $IC_3$ to pin 12 of $IC_5$ and pin 11 of $IC_5$ to the cathode of the decimal points. The circuit is expandable to display more than eight digits, but other components such as 2112-4 ram are recommended, instead of a multiple of 7489 rams, to reduce cost and size.

The word byte refers to a word of four bits in the display r.a.m.

G. A. M. Labib
Heliopolis
Cairo




φ2 (TTL) is a clock-output of the 8224 device




| | $S_1$ | $S_2$ | $S_3$ | $S_4$ |
|---|---|---|---|---|
| 1st byte | a | b | c | d |
| 2nd byte | e | f | g | Option |

Option: Decimal point

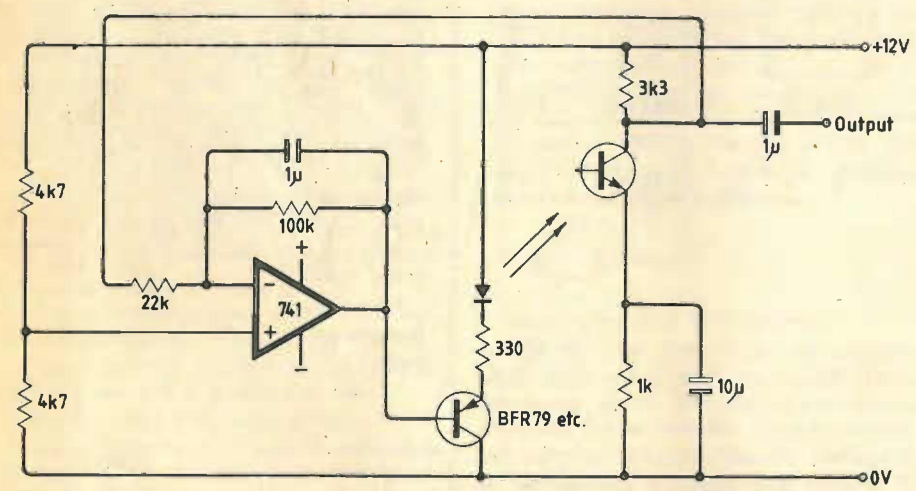
*As data sensed at the outputs of $IC_3$ is the complement of data stored, and as seven-segment chips are common anode, a logic 1.0 data-bus bits (D0, D1, D2, D3 or all) will cause the corresponding segments to light when enabled.*

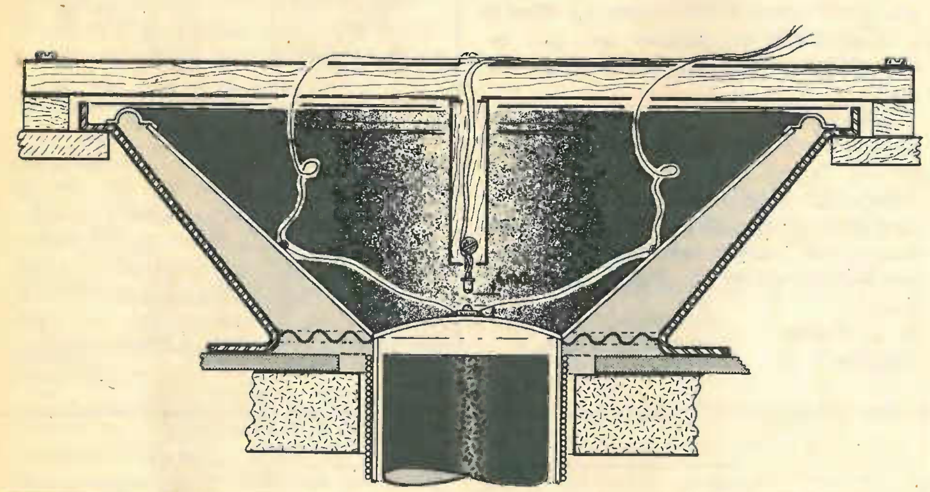


## Loudspeaker displacement detector

Used as part of a motion-feedback system, this circuit detects the dynamic displacement of a loudspeaker optically using an led and phototransistor. The small infra-red led is attached to the loudspeaker cone and the photo-transistor positioned to give between 20 and 30mA led current. Optical bias for the photo-transistor and compensation for changes in ambient lighting are provided by the op-amp. Sensitivity is high, and for practical displacements, the output is quite linear and does not require square-law conversion. Simple shielding from artificial lighting may be required to prevent 100Hz ripple on the output, and screened cable should be used for the transistor lead. Construction of the prototype is shown in the diagram. 'Blue-tak' was used to secure the led and leads to the loudspeaker. The cross-piece and transistor mountings should be as rigid as possible.

Simon Young
Cambridge



## Full-wave precision rectifier

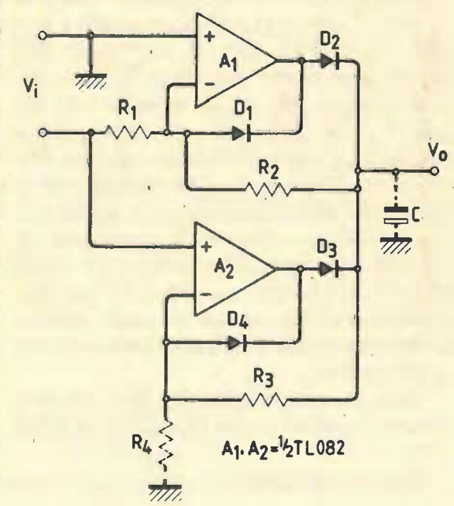
This circuit has two advantages over other forms of precision rectifier – for unity gain only two matched resistors and required, $R_1$ and $R_2$, and with capacitive loads, the circuit becomes peak reading. The peak-reading configuration decay-time constant is defined by the capacitance, C, and the parallel combination of $R_2$ and $R_3$.

If the rectifier is required to have gain, then $R_4$ may be included, in which case;

$$\text{Gain}=\frac{R_2}{R_1}=\frac{R_3+R_4}{R_4}$$

The circuit is accurate at high frequencies and responds to greater than 100kHz with TL082 amplifiers. If high-frequency response is not required, $D_1$ and $D_4$ may be eliminated and $R_3$ reduced to zero. Note that without $D_1$, there must be a d.c. path at the input.

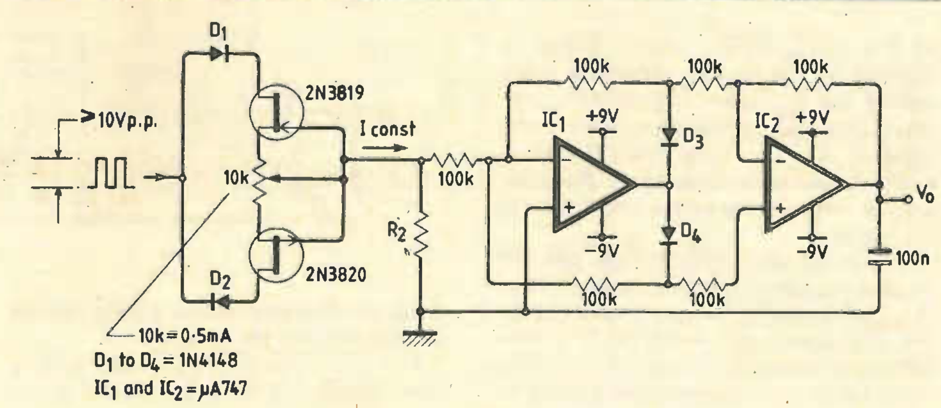
C. W. Beal
Baildon
West Yorkshire




## Non-polarizing R-to-V transducer

Circuit shows a resistance-to-voltage transducer designed for a soil-moisture measuring instrument. It uses complementary j.f.e.ts to provide positive and negative constant-current sources for $R_2$. The resulting voltage is rectified by $IC_1$ and $IC_2$ to produce $V_o=I_{const.}\times R_1$.

A. Bartram
University of Exeter
Devon



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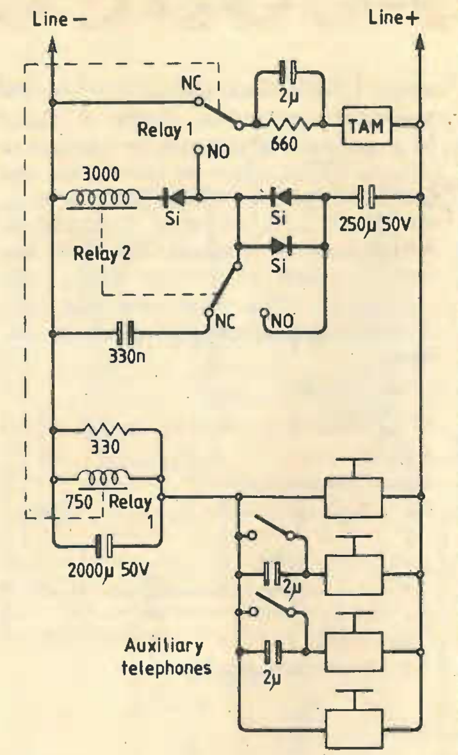
## Connecting answering machines

This circuit connects a telephone answering machine (tam) to an exchange line and includes relay switching so that all the facilities may be used automatically, without restriction.

For automatic call answering the tam senses a.c. ring current from the line via the n.c. contacts of relay 1 and, after a predetermined period set by the user (1 to 10 rings), answers the call by connecting a d.c. loop across its terminals. After exchange of outgoing and incoming audio messages, the tam opens the d.c. loop and returns to a state of readiness. This automatic process may be interrupted at any stage by picking up manually and answering any of the associated telephones, energizing relay 1. If this is done before the tam answers, relay 2 does not energize. If interruption happens after the tam has answered, the d.c. loop of the tam causes relay 2 to be energized and its n.o. contacts place the attenuator, comprising relay 2 coil and 250μF capacitor, blocking the audio path between the tam and line. Sensing the resulting silence, the tam resets and returns to readiness.

Outgoing calls may be dialled normally from any of the associated telephones; the n.o. contacts of relay 1 (whose coil is slugged by 2000μF) and the n.c. contacts of relay 2 connect to the tam network and effectively block the 50 volt 10Hz dial pulses from falsely operating the ring-current detector. The diode in series with the coil of relay 2 stops the 250μF capacitor discharging while dialling and so aids this blocking. The tam may be used to record both sides of a telephone input across the line via the n.c. contacts of relay 2 and the 0.33μF capacitor. The 250μF capacitor and silicon diodes connected in parallel-opposition limit signals to some 600mV peak-to-peak but do not affect recording of conversations.

Calls being answered by the tam may be monitored by means of its internal loud-




speaker and interrupted manually if desired. Monitoring may also be done from other rooms using one of the associated telephones if d.c. through the coil of relay 1 is blocked. This may be achieved by means of a series 2μF capacitor shunted by an n.c. press switch which is pressed when it is desired only to monitor calls and released (or not pressed) to interrupt the tam.

Normal line polarity should be observed, as shown. The 660Ω resistor and its 2μF bypass capacitor, and the 330Ω resistor across relay 1 coil adjust the d.c. level through the tam and the sensitivity of relay 1 for reliable operation when any auxiliary telephone is picked up or replaced.

H. T. Wynne
Glasgow

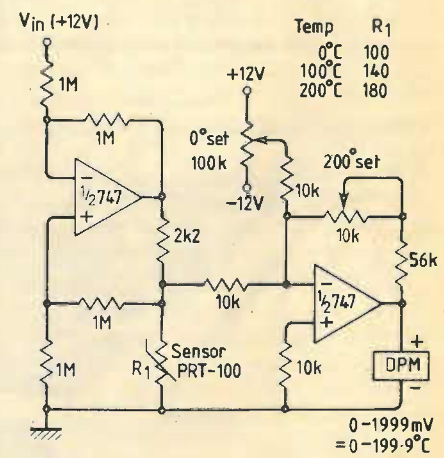
## Thermometer for d.m.m.

The circuit shown can be combined with an inexpensive digital-panel meter to form a compact, accurate digital thermometer.

A dual op-amp and a PRT-100 platinum resistance thermometer, whose resistance is is a linear function of temperature, are the main elements. The first op-amp is used as a precision constant-current source and the second as an amplifier. Any 3½-digit meter with a 1999mV range will indicate temperature directly in degrees centigrade, from 0 to 199.9 with 0.1 degree resolution.

The sensor is pre-calibrated and its resistance is linear from −40° to + 400°C, so the circuit can be calibrated by replacing the sensor with two known resistances. First, using 100Ω, zero adjustment is made with the '0° set' potentiometer ($R_T$=100Ω at 0°C). Next, the gain is adjusted for 200°C on the second potentiometer using 180Ω ($R_T$=180Ω at 200°C). This thermometer can replace thermocouples in many applications and provide better accuracy (± 1%) and linearity (2%) between 0 and + 200°C.

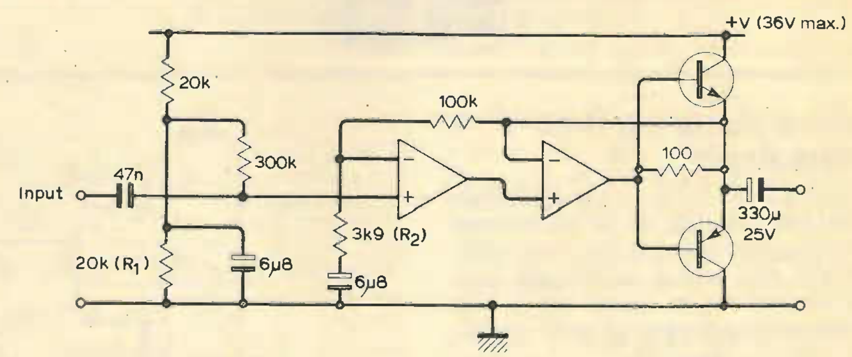
Dil Sukh Jain,
Hyderabad,
India.




## Poor man's current dumper

At low output levels, output current is supplied by the op-amp through a 100Ω resistor and at higher output levels, current is provided by the output transistors. Because of this, cross-over distortion would appear to be eliminated. Quiescent current through the output transistors is not required.

The maximum supply voltage that can be used is limited by the op-amp, and was 36V (stabilized) for the prototype using an MC3403 device. An output of 10W into 8Ω was obtained. If the supply is unstabilized, the resistor connected to ground in




the input-biasing potential divider should be replaced with a zener diode.

For the circuit shown, voltage gain is about 28dB, but this may easily be increased at the expense of h.f. response by reducing the 3.9kΩ resistor, $R_2$.

R. C. Cross,
Felixstowe.





# MICRO-CONTROLLED RADIO-CODE CLOCK

*Based on a 6502 microprocessor, this clock decodes and displays serial information from a v.l.f. receiver. Although requiring powerful and complex firmware for best possible performance in difficult areas, a system for non-critical applications can use only 2K of object code. This second article describes alignment and firmware for a basic clock which can be contained in a low-cost 2716. For future expansion, this ram can be replaced by link selection with a 2732 device.*

**by N. E. Sand**

Because most of the processing is real-time, fast and efficient assembly language must be used to decode and display the transmitted information. In the flow chart for the basic clock, shown in Fig 1, the program starts with a short initialization sequence which sets the interface adapter i/o configuration, the timer for regular 1ms interrupts, and clears part of the ram area. After initialization, the processer enters the main software loop which is followed continuously. Flags are passed by routine which mainly maintains a series of timers. The receiver output is sampled in the main loop by a routine which searches for level changes from low to high or *vice versa*. When a change is detected, one of the timers is read and reset. The low-to-high transition usually occurs at the end of a carrier break, the duration of which determines a logic 1 or 0 in the serial code.

Invalid timer values signal error conditions which reject the block of code being received. The various double pulses that occur in the code are detected and ignored. While the main program loop is operating, a continual search is made for the unique eight-bit synchronizing sequence 01111110 which indicates the end of each time frame. When this sequence is recognized, a further timer, also updated by the 1ms interrupts, is initialized. On time-out a window is set for a further short period, during which a high-to-low transition in the receiver output will synchronize the decoded seconds counter and relevent timers. A software loop is then initialized and maintained in-phase with the received second pulses.

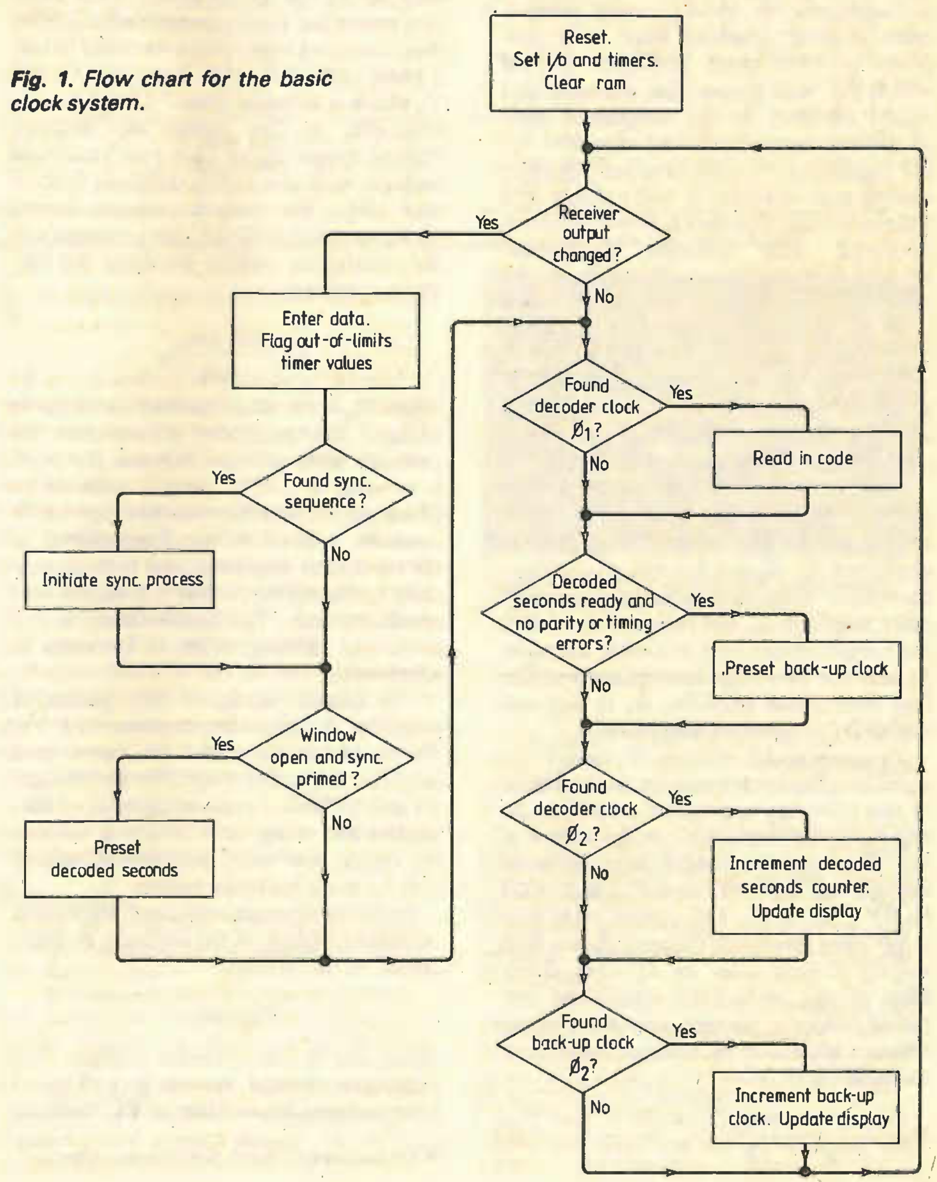
The display is updated whenever a change could have occurred in the display registers. Digit-select codes are set with the relevant data for each digit, and strobing of the display drivers is achieved by writing to these locations in sequence using the chip selects inputs. When the decoded seconds count and timer are at a certain value the error status, including a parity check, is examined and if error-free, the decoded time is transferred to the back-up clock.

This design provides better error protection than the parity bit alone can offer, and does not use too much memory space. A commercial system which offers foolproof operation requires greatly extended error detection and analysis together with optimization techniques to maintain accuracy; far more memory space would be needed to accommodate the software and this would depart from the "evaluation-system" concept. The present design provides good performance in normal operating conditions and only requires one 2K rom. A high interrupt rate provides good measurement accuracy and resolution in the timers. Overall accuracy of the clock after synchronization with the transmission is approximately 50ms.

The most important part of this clock, or any other design based on a time-coded transmission, is the receiver. Although complex logic circuits or powerful software and microprocessors can be used to detect and analyse any error or noise transient in the transmitted code, unless a carefully designed receiver is used in conjunction with this processing, practically every clock or code will be rejected and the clock will suffer from the usual crystal drift over long periods, or worse still, will not be

Continued on page 56

*Fig. 1. Flow chart for the basic clock system.*





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# FAST AMPLITUDE STABILIZATION OF AN RC OSCILLATOR

*This technique for stabilizing the output amplitude of an RC sine-wave oscillator uses a multiphase rectifier to convert the oscillator output to d.c. This voltage does not require further filtering, which results in a short amplitude settling time. An experimental circuit demonstrates the technique.*

A stable sine-wave oscillator with amplitude control usually incorporates a voltage-controlled attenuator. The d.c. input to this attenuator must have a very small ripple to avoid excessive distortion of the output waveform. If this direct voltage is derived from the usual half-wave rectifier, an extremely large filter time constant is required: the oscillator output level consequently settles very slowly. This behaviour is undesirable in low-frequency applications. Several solutions have been proposed to solve these problems, one of which has been to combine analogue and digital circuitry to use amplitude sampling[1,2] or correction to the capacitor initial conditions,[3,4]. This involves relatively complicated circuits. A more direct and simpler circuit approach is to use oscillator networks with available four-phase voltage[5] or multiphase oscillators[6] with the rectified, multiphased voltage obtained from the oscillator. The circuit proposed here also uses multiphase rectified voltages, but these voltages are obtained in a special circuit from two sinusoidal voltages shifted by 90°. The circuit consists of summing operational amplifiers.

The full circuit of the RC oscillator with the eight-phase rectifier is shown in Fig. 1. It includes an RC resonator (operational amplifiers $A_1$, $A_2$ and $A_3$) with the voltage-controlled attenuator (the transconductance amplifier $g_m$ and resistors $R_7$ to $R_8$); the control circuit with the error amplifier $A_4$ and the two-stage multiphase rectifier (the operational amplifier $A_5$ to $A_{10}$ and diodes $D_1-D_8$) mentioned above.

Two sinusoidal voltages $V_1$ and $V_7$ of equal amplitudes are applied to the inputs of two inverting operational amplifiers $A_5$ and $A_6$ in the first stage. At the output of this first stage we obtain four sinusoidal voltages shifted with respect to each other by 90° (Fig. 2(a)). The second stage produces eight sinusoidal voltages shifted with respect to each other by 45° (Fig. 2(b)). Here we use the fact that operational amplifier produces vector summation of the voltages applied to its inverting input. For example

$$\dot{V}_6=-\frac{1}{\sqrt{2}}\dot{V}_1-\frac{1}{\sqrt{2}}\dot{V}_3 \qquad (1)$$

**by I. M. Filanovsky V. A. Piskarev and K. A. Stromsmoe***

where $\dot{V}_1$, $\dot{V}_3$ and $\dot{V}_6$ are phasors corresponding to $v_1$, $v_3$ and $v_6$.

The multiplying factor $1/\sqrt{2}$ in (1) is achieved by the special choice of the resistors connected to the operational amplifier $A_{10}$. Changing their values we could obtain a phase shift of $\dot{V}_6$ with respect to $V_1$ and $\dot{V}_3$ which is different from $\pm 135°$. Thus, in principle, we can obtain any *m*-phase voltage system if we have two sinusoidal voltages with phase shift different from 0° and 180°. The output voltages appear simultaneously with the input voltages and the multiphase rectifier produces the output d.c. voltage.

$$V_R=\frac{\sin \pi/m}{\pi/m}V_m$$

where $V_m$ is the amplitude of the *m*-phase voltage. The multiplier $\sin\pi/m \div \pi/m$ approaches unity when $m$ increases (for $m=8$ it is equal to 0.975). Hence, such an *m*-phase rectifier can be used as a unit which produces a direct voltage proportional to the oscillation amplitude and without any delay (theoretically, at least), with low harmonic content. The requirement of any additional filtering when $m$ increases is eliminated.

The output voltage of the operational amplifier $A_1$ coincides in phase with $V_5$. We could use it and save one operational amplifier in the first stage. But the voltages $V_1$ and $V_7$ have the lowest amount of harmonics and using only these two voltages we obtain less total harmonic distortion (t.h.d.) at the oscillator output.

In the steady-state condition, the output voltage amplitude of the oscillator is determined by the equality

$$V_R=E_R$$

where $E_R$ is the reference voltage. The amplitude control system is a Type 1 system due to the fact that an RC oscillator acts as an integrator with respect to an amplitude change[1,7] in the amplitude control system.

* University of Alberta, Edmonton, Alberta.

During the static oscillations the condition

$$g_m\frac{R_7}{R_6+R_7}=\frac{1}{R_5}$$

is satisfied.

The tranconductance $g_m$ is determined by the d.c. control current $I_c$ in the resistor $R_8$ and, for the CA 3080 transconductance amplifier which we used in our experiments,

$$g_m\approx\frac{I_c}{2V_T}$$

where $V_T$ is threshold voltage[8] ($V_T \approx$ 26mV at 300°K). The resistors $R_6$ and $R_7$ are chosen from the condition that

$$V_7 \cdot \frac{R_7}{R_6+R_7}\leqslant V_T$$

where $V_7$ is the amplitude of $v_7$. This ensures the linear operation of the transconductance amplifier. The value of $R_8$ was chosen in such a way that the control current $I_c$ (in the steady state condition) is approximately equal to one half of the maximum control current allowable for linear operation. The control input (pin 5) d.c. potential is close to the negative of the power supply for CA 3080. In this case, the linear operation will be preserved for the whole output voltage range of the error amplifier $A_4$ and at the same time the value of $R_5$ will be low. As a result the displacement of poles from the $j\omega$-axis into the left or right half plane due to the sudden change in the $E_R$ level will be maximum and the transient response duration will be shortened.

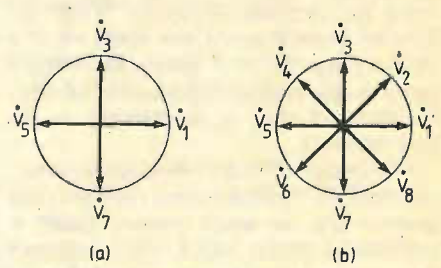


*Fig. 2. Output voltages in multiphase rectifier*
*(a) first stage*
*(b) second stage*

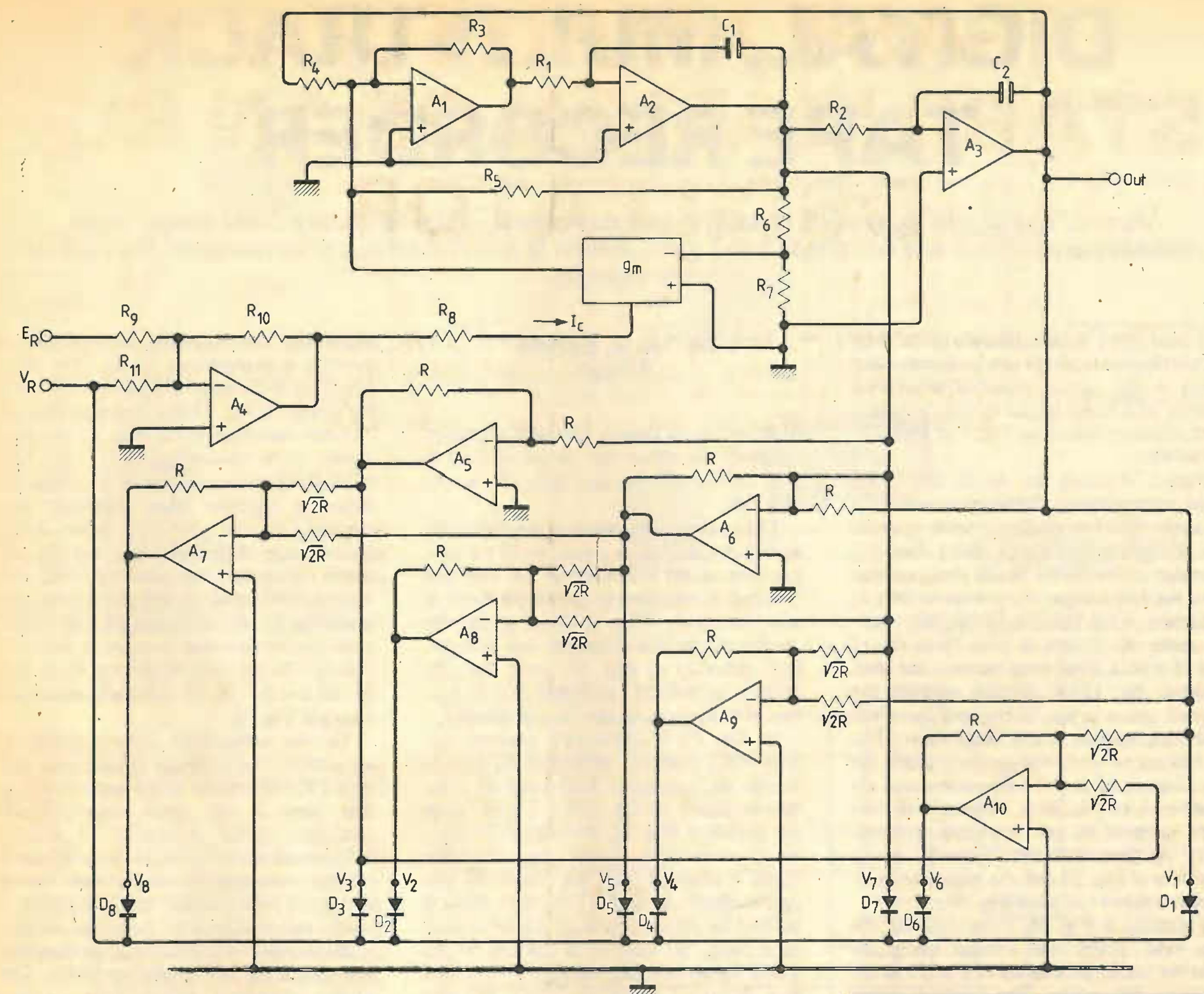


*Fig. 1. RC oscillator with multiphase rectifier*

The output voltage of the multiphase rectifier includes the small ripple voltage also. The amplitude of the *k*-th harmonic equals

$$a_k=2V_m \cdot \frac{\sin \pi/m}{\pi/m} \cdot \frac{(-1)^{k+l}}{k^2m^2-1}$$

This ripple voltage will be amplified in $A_4$ and applied to the control input modulating the transconductance $g_m$. The approach used by Vannerson and Smith[5] allows us to calculate the output distortion voltage which consists of only two significant harmonics given by

$$v_d=\frac{1}{2}\frac{R_3}{R_8}\cdot\frac{R_{10}}{R_{11}}\cdot\frac{V_m{}^2}{V_T}\frac{R_7}{(R_7+R_6)}\cdot\frac{\sin \pi/m}{\pi/m}.$$

$$\left[\frac{1}{(m^2-1)}\left(\frac{\cos(m-1)\omega_0}{(m-1)^2-1}+\frac{\cos(m+1)\omega_0}{(m+1)^2-1}\right)\right.$$

where $\omega_0$ is the oscillator frequency.

In the test oscillator,

$R_1, R_2, R_3, R_4$ 15kΩ
$R_5$ 47kΩ, $R_6$ 39kΩ
$R_7$ 100Ω, $R_8$ 33kΩ
$R_9, R_{11}$ 75kΩ
$R_{10}$ 220kΩ, R 15kΩ
$C_1, C_2$, 10nF.

For the output amplitude of $V_1$=10V, the total harmonic distortion is 0.2% approximately. Further reduction of the t.h.d. can be obtained by reducing the ratio $R_{10}/R_{11}$.

Figure 3 shows the transient response of this oscillator when the reference voltage $E_R$ is modulated by a 60Hz square wave that changes from 10 to 6.6V. The transient response duration is not more than two periods of the output voltage.

If the ratio $R_{10}/R_{11}$ is decreased to 1 (decreasing the t.h.d. to less than 0.01%) the transient response duration will increase from 2 to 5 periods which is also acceptable in many cases.

The control zone is from 0.7V (or 0.3V if we use germanium diodes) to saturation voltage of operational amplifiers.

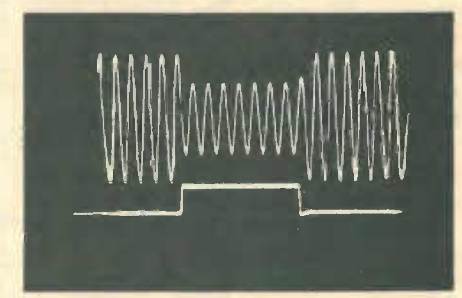

*Fig. 3. Modulation of the reference voltage and the oscillator output voltage.*

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□





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# DIGITAL, MULTI-TRACK TAPE RECORDER

*Most of the digital playback circuitry was described in the February 1982 issue – the remaining sections are covered in this part, which is published out of order with the rest of the series.*

**by *A. J. Ewins,**
B.Tech.

The final block circuit diagram of the digital 'playback' electronics to be discussed in detail is the 12-bit, serial-in/parallel-out register and 12-bit latch, sample/hold and demultiplexer shown in Fig. 9 of Part 2 of the series.

Figure 34 shows the circuit of a 12-bit serial-in/parallel-out shift register and a 12-bit latch. The i.cs used are shown in detail and no further comments about them are necessary. The NRZ serial data, output from the four temporary storage buffers in sequence, is fed into the 12-bit shift register under the control of $\overline{D/C}$. Once the 12 bits of a data word have entered the shift register, the 12-bit parallel outputs are latched across to the 12-bit latch upon the positive transition of the Latch pulse. The 12 bits output from the latches remain for the duration of twelve $\overline{D/C}$ pulses, and are numbered in the same sequence as they were entered in the recording process. They are passed to the 'Odd-bit' parity checkers of Fig. 35 and the digital-to-analogue converter circuit of Fig. 36.

Referring to Fig. 35, P1 and P2 are the two 'odd' parity bits created using the 'odd-bit' parity generators of Fig. 21 in the January 1981 article. The 'odd-bit' parity checkers produce outputs, PC1 and PC2, which are both logic 1 if the parity check is GO, but logic 0 if the parity check is NO-GO. PC1 and PC2 are passed to the circuit of Fig. 37 to control the transfer of analogue data to the appropriate analogue output channel.

Figure 36 is the circuit of the digital-to-analogue converter circuit using the Analogic 10-bit d-to-a converter i.c., AD561K. As shown, the circuit produces an analogue output in the range ± 5 V for the full range of ten digital inputs. The AD561K is the complement of the AD571K (a-to-d converter) used in the recording digital electronics and has similar tolerances of accuracy and temperature sensitivity: the circuit of the digital-to-analogue converter as shown in Fig. 36 is that recommended by Analogic for a buffered output. The fixed resistors of 10 ohms and 24 ohms can be replaced by trimmers of 20 ohms and 50 ohms, respectively, for greater accuracy: with the fixed values, scale and offset errors are typically ± 0.1%. If trimmers are used, then the 20 ohm trimmer should be adjusted for 0.000 output volts with the m.s.b. only ON, and all other bits OFF – the 50 ohm trimmer should be adjusted to give a reading of – 5.000 volts with all bits OFF. Using the fixed values, as shown, it is only necessary to adjust the offset zero of the op-amp to give 0.000 volts output with the m.s.b. only ON.

The analogue output from the digital-to-analogue converter is passed to all six sample/hold output stages of Fig. 38, only one of which is switched to its sample mode at any one time. This is done under the control of the demultiplexer and sample/-hold circuitry of Fig. 37, such that the correct, converted, analogue data is presented to the appropriate output channel.

In Fig. 37, a divide-by-8 counter, i.c. type 4022, produces sequential outputs to enable six two-input And gates in turn. Synchronized by the (D/C)/72 pulse from the circuit of Fig. 30, the counter is reset, via a monostable circuit, as each data frame is emptied from the temporary storage buffers. As each 12-bit data word is latched for conversion from digital to analogue form, the counter is clocked by the Latch pulse, enabling the appropriate And gate. Provided the parity checks, PC1 and PC2, are GO (at the logic 1 level) the appropriate control output will go to the logic 1 level when the Latch pulse goes negative, triggering the second monostable to produce a sample/hold pulse. The logic sequence of the control pulses produced by the circuit of Fig. 37 was shown in Fig. 10. The two monostables of Fig. 37 are contained in a dual-monostable i.c., type 4538. Both monostables may be either positive or negative edge triggered, that clocked by the (D/C)/72 pulse being postive-edge triggered and that by the Latch pulse, negative-edge triggered. The resistor and capacitor values of both monostables are selected to produce an output pulse whose duration is equal to five D/C pulses. The six control outputs from Fig. 37 are passed to the sample/hold output stages of Fig. 38.

The six sample/hold circuits of Fig. 38 are constructed from six sample/hold i.cs, type LF 398, which is the same device as that used in the input stages of the recording digital electronics. A sample/hold circuit is in its sample mode when its control input (pin 3) is at the logic 1 level and in the hold mode when it is at logic 0.

The value of the hold capacitor, 0.1 μF, is chosen for optimum speed of sampling and minimum droop during 'hold'. The diodes connected between the various control inputs and the 8-way pin connector are included so that the effective number of channels used may be reduced from six to three, two or one. If all six channels are used, no interconnexions are made between the eight pins of the 8-way pin connector. If three channels have been selected during the recording process then the analogue inputs to the recording electronics will have been linked such that channels 1 and 4, 2 and 5 and 3 and 6 are connected together. On playback, the corresponding control lines thus need to be Ored together, producing analogue outputs from channels 1, 2 and 3. This is achieved by connecting the following pins of the 8-way pin connector together: 3 to 6, 2 to 7 and 1 to 8.

Similarly, if two channels have been selected during the recording process, then analogue inputs to the 'recording' electronics 1, 3 and 5 and 2, 4 and 6 will have been linked together. On playback, control lines 1, 3, and 5 and 2, 4 and 6 thus need to be Ored together, producing analogue outputs from channel 1 and 2, by connecting pins 2, 4 and 6 and pins 1, 3 and 7 of the 8-way pin connector together.

If only one channel has been selected during the recording process then all six analogue inputs will have been connected in parallel – all six control lines must be Ored by connecting pins 1, 2, 3, 4, 5 and 6 of the 8-way pin connector together. The analogue output will be from channel 1. All the electronics of the demultiplexer, d-to-a converter and sample/hold circuits, etc. are constructed on the final circuit board, board 7.

This concludes the detailed description of the digital recording and playback electronics associated with one track of the tape-recorder.

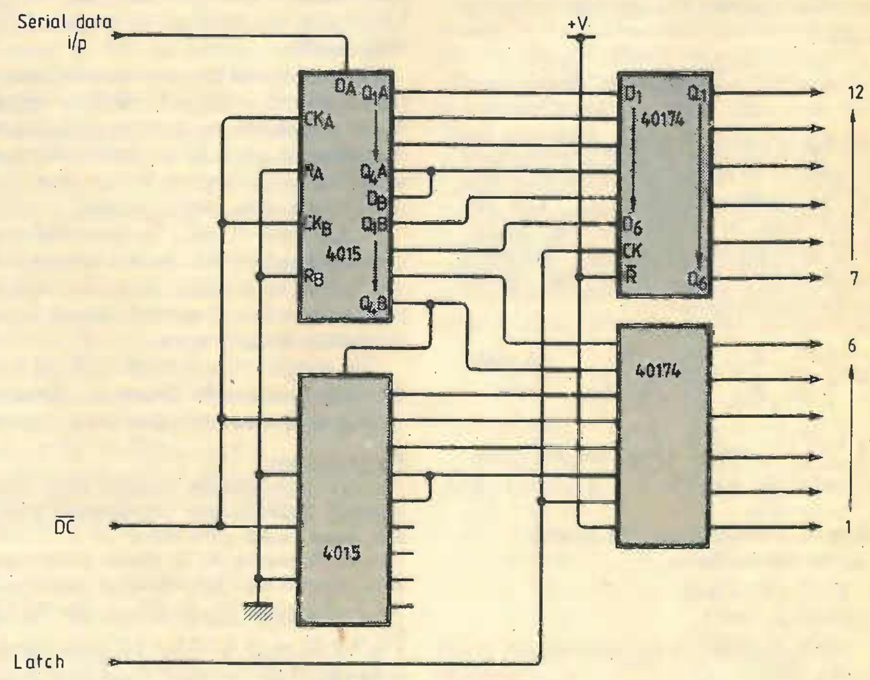


*Fig. 34. 12 bit serial-in/parallel-out shift register and 12 bit latch.*

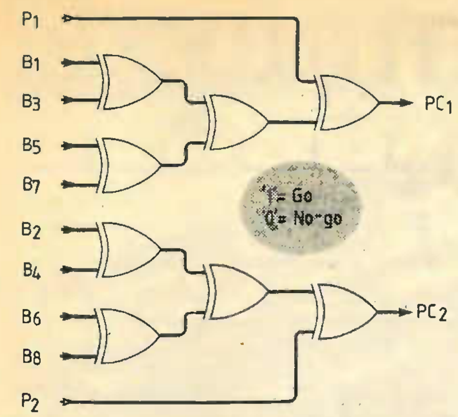


*Fig. 35. 'Odd-bit' parity checkers.*

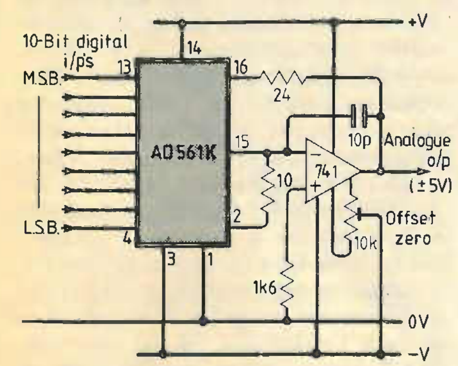


*Fig. 36. Digital-to-analogue converter, gives –5V to +5V swing when all inputs present.*

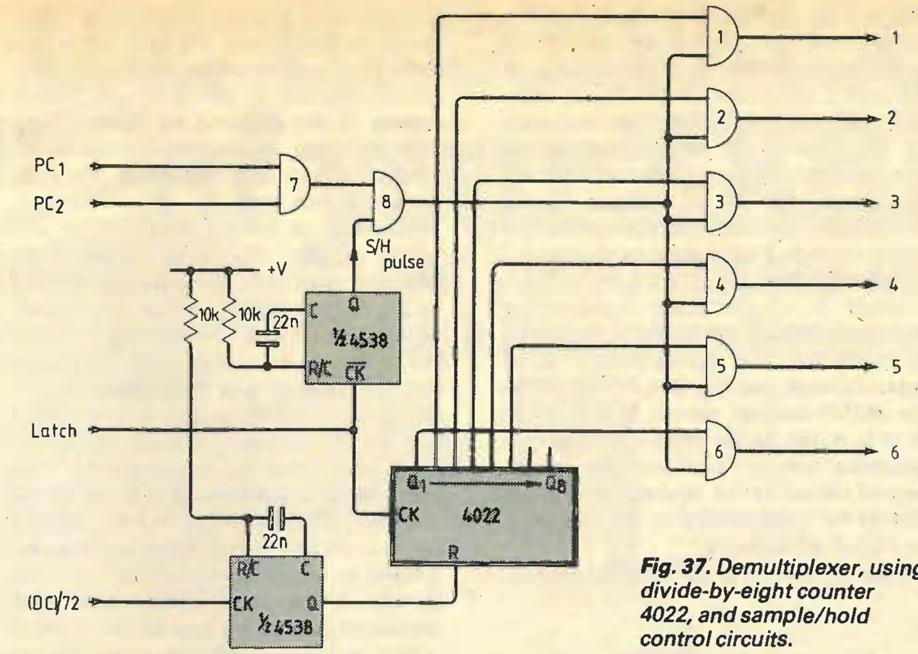


*Fig. 37. Demultiplexer, using divide-by-eight counter 4022, and sample/hold control circuits.*

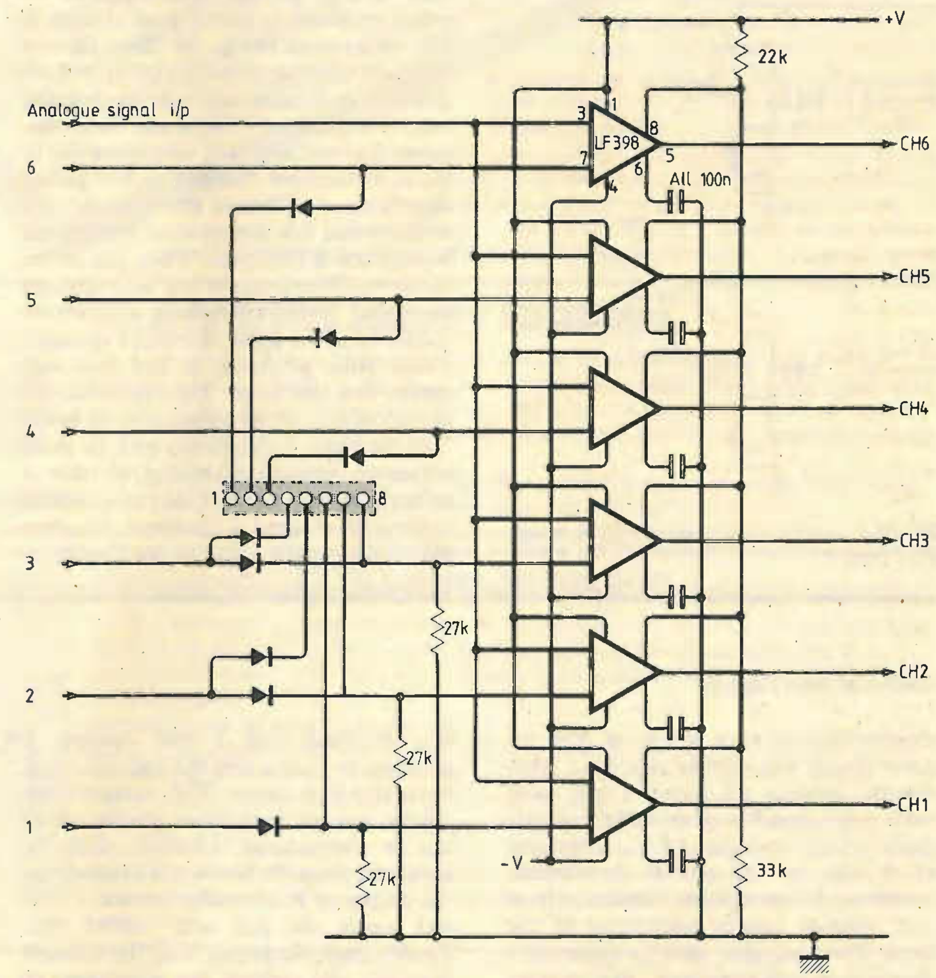


*Fig. 38. Sample/hold analogue output stages, controlled by circuit of Fig. 37.*

## Track 2 synchronizing electronics

For simplicity of construction, in modular form, most of the digital electronics of the second track of the tape-recorder is a duplicate of the first. This leads to some redundancy of circuitry, but considerably reduces the amount of labour necessary in designing new board layouts and in the problems associated with inter-board connexions.

In the recording electronics, the input stages comprising the circuits of block circuit diagram, Fig. 4 are duplicated. Similarly it is necessary to duplicate the two temporary storage buffers and Miller encoder of the block circuit diagram of Fig. 2. However it is not necessary to duplicate the control circuitry: the same control circuitry used in the recording stages of the track 1 electronics *could* be used to control the flow of serial data into and out of the temporary storage buffers of the track 2 electronics. For the reasons outlined at the beginning of this section

*Research Department, London Transport





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this was not in fact done, and the only components omitted from the detailed circuit of the control circuitry of Fig. 13 (a) in the track 2 electronics are the crystal oscillator and the D-type flip-flop producing the Reset pulse. For perfect synchronization of the track 2 electronics to the track 1 electronics, the crystal oscillator output and the Reset pulse from the control circuitry of track 1 are passed to the track 2 control circuitry.

Board 3 of the track 1 recording electronics contain the reference frequency generator for the tape-recorder's speed control system (see Fig. 23), in addition to the Miller encoder circuit. There is no need to duplicate the reference-frequency generator circuit, because the speed-control circuit of the tape-recorder needs only to be synchronized to the recovered tape-clock of one track.

Coming now to the playback electronics, it is necessary to duplicate all the circuitry associated with board 4. i.e. the peak detector, Miller decoder and clock-recovery circuit. Because of the wow and flutter content of the data and the relative tape skew between tracks, it is essential to produce a recovered tape-clock for each recording track used.

Referring to the playback control circuitry of Fig. 30, it is necessary to duplicate most of it. However, the divide-by-72 counter need not be duplicated: neither need the B divide-by-4 counter, but is done so for convenience. To ensure that the replayed data from both tracks is in perfect synchronization, it is essential that the two divide-by-4 counters, A and B, of each track are synchronized. The problem of synchronising the two A divide-by-4 counters is that they are clocked by two different recovered tape-clocks, divided by eighty, and that they must be allowed to contain the wow and flutter content of each track's tape-clock.

This problem is overcome using the circuits of Fig. 39, the logic sequence of pulses produced by one of these circuits of Fig. 39 is shown in Fig. 40. (Both circuits operate on the same principle and therefore it is necessary only to describe one.) The problem of wow and flutter between the two tracks will only cause one of the A divide-by-4 counters to be clocked slightly ahead or behind the other and it is unlikely that this timing error will extend beyond one RT/C cycle. When one of the divide-by-80 counters is half way through its cycle, both A divide-by-4 counters should be in the same state and a synchronizing pulse produced at this time will ensure that this is so. The synchronizing circuits of Fig. 39 are constructed on board 5 of the track 2 electronics and all pulse sequences referred to belong to track 2 unless otherwise stated. Using an inverting buffer (1/4 of quad 2 i/p Nand, i.c. type 4011), the negative edge of the divide-by-80 counter's output pulse produces a short-duration positive pulse via the monostable constructed of the 15 nF capacitor, 10kΩ resistor and silicon diode. This is Nanded with the A1 output from the track 1 electronics to produce a short negative synchronizing pulse as shown in Fig. 40. This is Anded (negative Ored) with the Q output from DI and fed to the reset input, R, of the A divide-by-4 counter. The B divide-by-4 counter of the track 2 electronics is synchronized in an exactly similar manner using the B′ output from the track 1 electronics. All the rest of the track 2 electronics is an exact duplicate of boards 6 and 7 of the track 1 electronics.

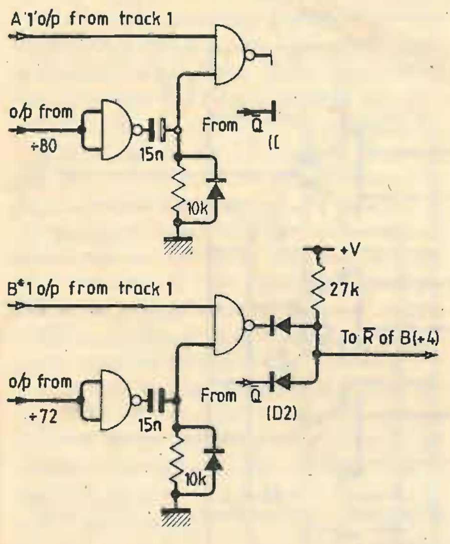


*Fig. 39. Sync. circuitry to synchronize 'track 2' to 'track 1'.*

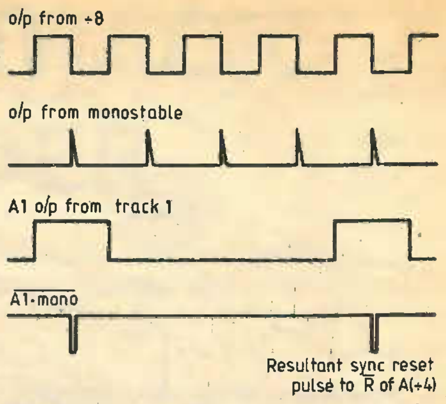


*Fig. 40. Sequence of pulses in sync. circuit of Fig. 39.*

This digital, multi-track tape-recorder was designed and developed by the A. J. Ewins in the Research Laboratories of London Transport. Inquiries into its practical application and usefulness will be welcomed by the head of the research laboratories and should be addressed to: The Scientific Adviser, L.T.E. Research Laboratories, 566 High Road, Chiswick, W4 5RR. □


Reference 1. Digital data recording without f.s.k. by Brian T. Evans, Wireless World, April 1979



*Continued from page 51*


automatically set after switch-on. This receiver design was chosen as a good compromise between the complex and more costly professional receivers and the simple phase-locked loop or r.f. i.c. designs which, due to the special interference problems, do not operate satisfactorily at v.l.f. without careful positioning of the aerial. Provided that care is taken with construction and alignment, this receiver will provide good performance in most conditions and at long range.

The 3dB bandwidth of the tuned circuit is about 300Hz, so if a signal generator is used it must be set to 60k ± 30Hz. Short the receiver input at the aerial terminals and adjust the potentiometer for 4V at the output of $IC_1$. Remove the short, set the aerial trimmer capacitor to the mid point, and position the aerial coil so that the centre is about 65mm from the centre of the ferrite rod. Adjust the tuning core of the transformer for maximum output at $IC_4$, ensuring that a true reading is achieved by tuning well through the maximum and back again. With eccentric adjusters, two or even three smaller peaks can be encountered. Carefully slide the aerial coil along the ferrite rod to maximize the output at $IC_4$ (usually around 1.35V) and secure the coil with melted wax. Finally, peak the tuning with the trimmer capacitor and recheck the adjustment of the transformer.

When correctly tuned to 60kHz the receiver produces regular inverted pulses at the output. Resistor 9 has been included to disable the a.g.c. loop and is normally left disconnected as shown. When the clock has been assembled and the receiver aligned, feed the receiver output to pin 15 of the v.i.a. and check that a 1Hz output is produced at pin 14. If no output is present, test the receiver output, check that the supply voltage is present on all i.cs and check that the oscillator is operating correctly. Connect the display board and check that the correct time is loaded into the registers. This may take two or three minutes after switch-on, depending on where in the code the processor starts to operate. When the correct time appears, select the date display by switching pin 10 of the v.i.a. to 0V. The remaining pins on the control port have been provided for future expansion to select and control other functions. If sporadic operation occurs check that the aerial is not in the signal-null position (axis pointing to the transmitter) and check for sources of local interference such as television receivers, lamp dimmers and noisy fluorescent tube fittings. □

*A kit of parts for the clock is available from Circuit Services, 6 Elmbridge Drive, Ruislip, Middx (telephone 71 76962). Copies of the object code listing are obtainable from the editorial office, in return for a stamped envelope.*




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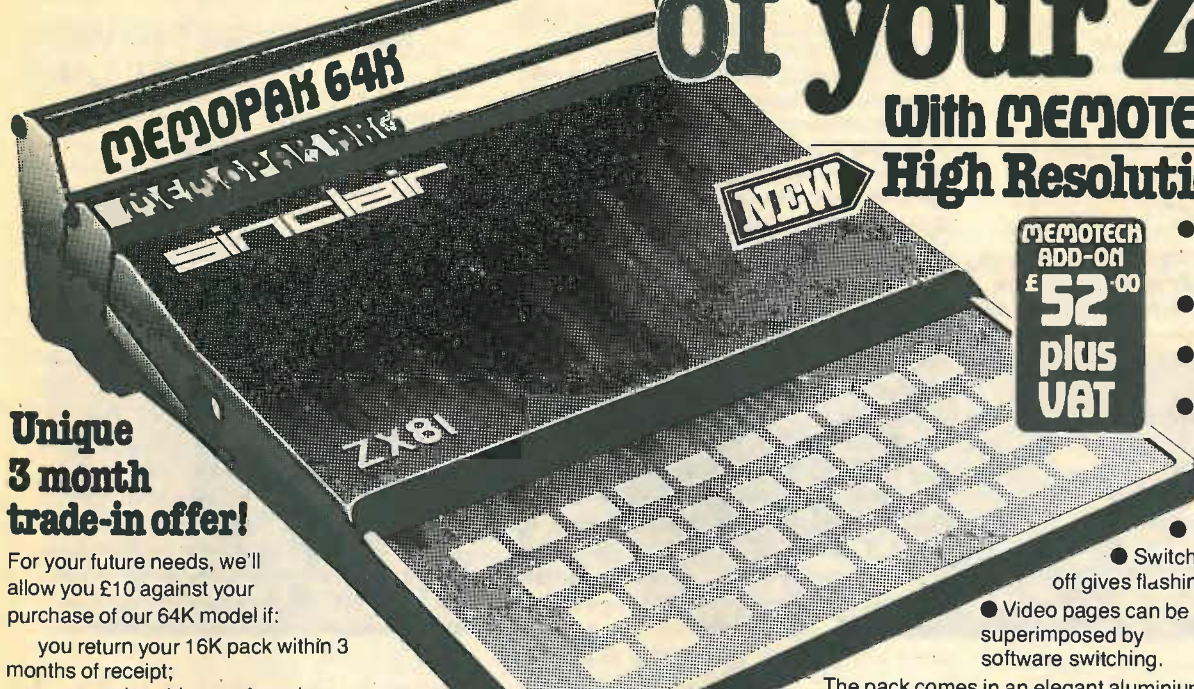


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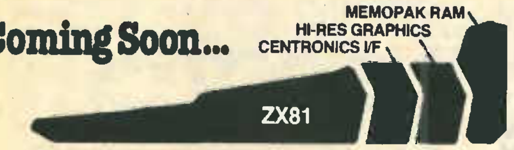


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# LETTERS

## POWER TRANSISTOR FAILURE

This is in reply to your letter about transistor failures in your power amplifier, published in *Wireless World*, May 1982, page 60.

The most likely cause of the failures you describe is secondary breakdown of the power transistors, probably during the turn-off transient, during the fall time of collector current and rise time of collector voltage. An aggravating factor might be unequal sharing of collector current between the two paralleled transistors during the turn-off transient. That would cause the already-severe stress to be increased, on whichever of the paralleled transistors has the dubious privilege of carrying the larger fraction of the unequally shared load current. (Especially onerous is the case of large difference in turn-off times. In that case, the transistor which turns off later has the privilege of carrying *all* of the load current, instead of half of it, during the most stressful part of the cycle of operation.)

See the Motorola data sheet for the 2N6547, Fig. 13. That shows the allowed instantaneous combination of voltage and current. If the transistor operation falls outside of the lower-left boxed-in area, even momentarily, the transistor might be destroyed. Typcially, the symptom is a collector-emitter short-circuit. In especially severe cases, the emitter bonding wire might be melted open, so you might have to de-lid the transistor to make contact to the emitter bonding pad. Is that the symptom you see?

Another thought: you mention rise and fall times typically being 5μs; that seems to be surprisingly slow, and such slow switching would aggravate the stress on the transistors.

Nathan O. Sokal
Design Automation, Inc.
Lexington
Massachussets

## NETWORKING SMALL COMPUTERS

I have recently read an article, very similar to that by P. G. Barker in the May issue, in the Commodore PET User Group Newsletter (CPUCN). It seems that, put simply, a couple of programs are presented which convert text files into internal format files. Programs of this type have been widely published for some time and are also known as merge programs for which they are usually used. The best known is the 'Templeton' merge – a one line set of immediate-mode instructions for pre-opened cassette files. It does not suffer from the major disadvantage of Dr Barker's program. I have written a short (121 bytes) merge program for either cassette or memory-based text data, from which cassette files must have originated, but found that the Templeton merge made it redundant. Unfortunately, a number of practical communication problems were not touched on in the article.

Stephen H. Binns, Ph.D., G8EWX
Sproatley,
Hull

*The author replies:*
I think Dr Binns has missed the point of my article which was to show (a) the feasibility of transferring programs via the public switched network, (b) the conversion problems likely to be encountered in target machines, and (c) the relative speeds of tape and disc loading. The existence of his loader, the 'Templeton' merge or any other loading technique is totally irrelevant unless they can be shown to be substantially faster than the code which I presented. Code compactness is not necessarily a question at issue in this particular case since the 3000 series PET has a 12K memory expansion area that could be used to accommodate programs such as mine which may be a little larger than 121 bytes. As your correspondent will appreciate there is likely to be a multitude of approaches to the conversion problem. I do not claim that there is any novelty involved in the logic underlying the algorithms I have employed – but again, this was not the point of the article, which was: program transfer via the PSN.

The similar article to which Dr Binns referred is one which I wrote called 'Computer Networks and Program Distribution'. It is an 'unofficial' newsletter of the PET users' group which has now ceased circulation. The article that was published in *WW* was a re-written abstracted version of the item that appeared in CPUCN.

## MICROCHIPS AND MEGADEATHS

It was interesting to read Steve Coleman's letter in April's *Wireless World*, asserting that other correspondents were "wrong to imagine that refusal to fight in wars will avert their occurrence".

The two world wars of the century were the first (and may be the last) in which it could be reasonably asserted that "we are all fighters now" soldiers, sailors, airmen (airpersons?), farmworkers, factory workers, transport workers, miners, journalists, doctors, nurses – clergymen! – even some politicians!

To refuse to fight means to refuse to design, make, provide, transport, service, organize and use materials of war. More than that, it means to reject violence itself as acceptable human behaviour (some training in semantics is necessary in order to winkle out every form of violence – possibly only two or three human beings have managed it to date, but millions have come so near that we know what it is like).

To refuse to fight in this sense (what other sense is there?) is the highest form of political action. When people really care enough about each other – and all creation – problems dissolve, appropriate action is taken in every situation (remember semantics!) and the kingdom of heaven is revealed – as it always has been and always will be, in patches, in every place, in every day. *Experto crede!*

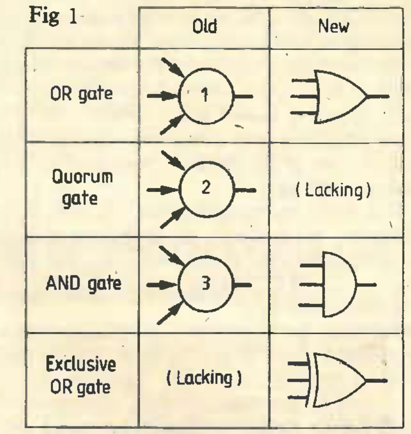
Ronald Gill
Allestree
Derby

## INTENTIONAL LOGIC SYMBOLS

The protracted and confused correspondence started by Tony Cassera's article (*WW* November 1980) goes to prove the inadequacies of the new system of logic circuit symbols which has so undeservedly supplanted the old.

Mr. J. E. Kennaugh (Letters October 1981) has even gone part of the way towards reinventing the old system of logic gate symbols. I first met that system (Fig. 1) on joining an Admiralty equipment design team in 1959. All gates were represented by circles, and bistables and counters by rectangles, whereas the D symbol now used for And gates then indicated a delay circuit, a monostable being drawn as a delay with a feedback loop. Connexions could be drawn to the gates from any direction and the inputs were distinguished by arrow-heads.

Fig 1




These older symbols had to have the greater flexibility to meet the versatility of the usually customized circuitry, most of which was derived from a famous light blue booklet on r.t.l. widely esteemed until several well-advanced design teams began to run into the same fundamental large-system snags simultaneously.

An inhibit could be introduced by adding a single resistor to the base of the second transistor in any of these gates, and this was indicated by a stroke through the symbol as in Fig. 2 which illustrated how an exclusive-Or gate might have been achieved in the old logic if anyone had ever called for such a circuit in those days – the earliest Ex-Or gate I ever saw was on page 88 of Electronic Design No. 26, dated November 22, 1966.

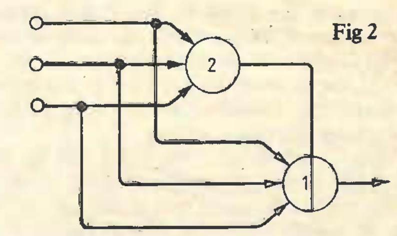



Fig 2

Why the Quorum gate has lapsed from favour has long puzzled me, especially those types in which the inputs could be weighted to give all sorts of weird truth tables; however, a lecturer in the American Institute has assured me that they are still used in some places where they are known as voting circuits.

There was but one polarity of (cheap) transistor available in those happy days so that nobody ever had cause to mix-up all the And and Or gates by turning the logic polarity upside-down.

John C. Rudge
Harlington
Middlesex

In the debate about Nand and Nor gates, and their relationship to other gates, J E Kennaugh (Letters, May 82) seems to imply that Nand and Nor gates only predominate in 'practical logic'.



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# LETTERS

In what might be termed 'theoretical logic', Pierce's 'dagger' (↓) and Sheffer's 'stroke' (|) have both been put forward as candidates for *the* basic logical connective, from which all other connectives can be derived. (The dagger is equivalent to Nand, and the stroke is equivalent to Nor.) Bertrand Russell in the second edition of 'Principia Mathematica' actually suggested the exclusive use of the Sheffer stroke (i.e. Nor) in mathematical logic.

It is worth remembering that (A Nand A) is equivalent to (A Nor A) is equivalent to (Not A), so in theory we do not even need the negator.

G. J. Boris Allan
Stockport
Cheshire

## ARMS AND THE MAN

I am writing to support your editorial 'Arms and the Man' in the May issue. The electronics industry employs about 60-70% of its engineers in the 'defence' of the developed world, whose only task is to provide large profits for the companies concerned and to make weapons of mass murder, while a large part of the developing world is struggling to find enough food to eat.

There are alternatives to working to kill people, as shown by the example of the efforts of the Lucas Aerospace Combine Shop Stewards Committee. Instead of providing the means for our own destruction, the electronics industry has the ability to provide safe and efficient tools for a caring society. If the only alternative to military work is unemployment, do as others are doing – start a cottage industry.

William Sigmund
Omega Systems
Trebullett,
Launceston,
Cornwall

## CAR IGNITION SYSTEMS

Referring to the article by Rod Cooper in the March issue of *Wireless World*, in which he described a capacitive discharge ignition system, I should like to draw the attention of readers to the problems encountered on many modern cars when using this type of system.

Vehicle manufacturers designing cars for the European market are under increasing pressure to improve fuel economy and, unlike the American and Japanese markets, they are not faced in Europe with particularly stringent exhaust emission regulations. Sophisticated air-to-fuel ratio control systems have, therefore, to be justified solely on improved fuel economy and not on the grounds of complying with emissions legislation and so it is that the low cost of the carburettor remains a compelling attraction.

Considering its relative simplicity the carburettor does a remarkably good job of controlling the air: fuel ratio, but compromises have to be made and with increasing pressure for improved economy the designers walk the tight rope of the borderline between maximum economy and flat spots. More and more the compromise is being chosen in favour of economy at the expense of flat spots and excessively lean ratios are tolerated under certain operating conditions where the effect, it is hoped, will not be too noticeable.

It is under these conditions, however, that spark energy and spark duration are critical, and substituting a capacitive discharge system for an inductive system runs the gauntlet of partial misfire, particularly on light throttle and under transient conditions or during warm up. This is not merely a theoretical consideration but a practical fact of life experienced unfortunately by all too many owners of capacitive discharge systems.

There are undoubtedly advantages in a capacitive discharge system but nowadays these can best be realised by using a "reactive" combination of inductive and capacitive systems to give you the best of both worlds.

A. P. M. Bull
Director
Eda-Sparkrite Ltd.

*The author replies:*
The observant owner of a car of recent manufacture cannot have failed to notice a relatively new addition to the carburettor – tamper-proof seals fitted to the fuel/air mixture controls.

These seals are fitted at the factory as a direct result of the Dept. of Environment's Vehicle Emission Regulations (available at H.M.S.O. at £2.50). To comply with the regulations it is necessary to use an exhaust gas analyser as the old methods of trial and error are no longer good enough.

This does not leave the engine designer much latitude for running the engine on weakened fuel/air mixtures and he no longer has the free hand that Mr Bull suggests he has in designing for economy of fuel at the expense of pollution, although as pointed out, our regulations are not as strict as America's or Japan's are . . . yet.

Now, the circuit described in my article has been tried on several cars of recent origin which are fitted with the tamper-proof carburettor and they have all worked perfectly well.

I suggest that the misfiring experienced with some types of electronic ignition is to be found on cars of the pre-tamper-proof era whose owners have "tweaked" the carburettor to give an excessively lean fuel/air mixture in the misguided belief that this is the best way to fuel economy. Also, the interference effects described in the article play a large part in such misfiring even on correctly-set fuel/air mixtures; and there is always the problem of matching the electronics to the ignition coil, which can give similar effects if there is a mismatch.

When correctly designed and used, there is nothing wrong in principle or practice with the capacitor-discharge ignition system, and it is particularly suitable for the relatively low-performance 4-cylinder family saloon which my design was intended for, because it is inexpensive, and this cannot be said for some commercial systems.

## THE RIGHT FORMULA

I have been reading with considerable fascination the various controversies about basic theory in your letters pages. 'Death of Electric Current', 'Einstein was Wrong' and 'Electromagnetic Units', to name but three.

No one seems to acknowledge the fact that all such 'theories' are purely human artifacts, designed to make predictions of the way things work! Such equations, when it comes down to it, have to obey one rule – do they give sensible answers, given the measuring techniques open to the one wishing to design a piece of apparatus.

We use ohms, volts, amps and unit of charge, not because such units would mean anything to a scientist from, say, Betelgeuse, but so that we can tell what will happen if changes are made. But any working (hands-on) engineer will tell you that even the simplest of devices can display some very odd behaviour! The trick is to use the 'right' formula! Ask any engineer if he can name a single text-book which will invariably give the correct answers to whatever he needs to know! I can't, and I doubt if any can – no matter how 'simple' his needs!

Does Mr Catt find his theories enable him to do better design work? I very much doubt it! In my experience of designers, all have 'private' data notebooks without which their jobs would collapse. So whilst arguments about units are interesting, no final formulae can or ever will exist. So far as Einstein is concerned the whole thing hinges upon whether any object with mass can move at a relative speed (to that of the universe) greater than the velocity of photons. The answer is less clearcut than physicists would have us believe. Indeed, at this very moment I am informed that certain objects have been observed by astronomers that may be moving faster than lightwaves. Information is scanty and I have no references I can quote.

Incidentally, if atomic particles moving near the speed C do get heavier, how come wires don't weigh heavier when current flows? (Yes – I know the 'peas in a drainpipe' analogy, but a moment's thought will disclose that whilst the electrons may not move very far, they have to have peak speeds approaching C when they 'bounce', for the impulse cannot move faster than the peak speed of the 'peas' – ask Steve Davis!)

Ronald G. Young
Peacehaven
East Sussex

## CITIZENS' BAND

I wish to support the views of S. Frost in the March issue about the "arrogance and lethargy of civil servants who have neglected their duty to serve the people who pay them". This criticism may be applied equally to 'our obedient servants' in both national and local governments.

Part of the problem lies in the historical conditioning which says that 'we' are only permitted to do what is not forbidden by 'them'. Fortunately for the future of freedom, young people are less inclined to accept this limitation – at least until they have themselves become part of the establishment.

The fact is, of course, that we are free to do what we like unless forbidden by law; but, if we have retained our flexible intelligence and not been deeply distressed by oppressive social conditioning, we will not regard the law as our criterion of reasonable behaviour. The law is after all, the lowest common denominator of acceptable behaviour, not the highest.

Peter Hartley, in his penetrating article "Educating Engineers" in December *WW* has neatly sewn up all the loose ends of your never-ending correspondence about responsibility, currently running under the heading "Microchips and Megadeaths". But surely his article should be called "Educating Human Beings". In the sense in which he uses the word, we are all professionals now.

R. Gill
Allestree
Derby





In my letter about CB in the March issue certain words were transposed; and this makes it very difficult to understand the sentence in question.

The second sentence of paragraph 6 should read as follows; "If the people have a legitimate demand of government, and government fails to do its duty to meet that demand, the people will take the law into their own hands . . ."

S. Frost,
Edinburgh.

As the secretary of a local c.b. club, I would like to offer my personal views on the letter from Mr Frost in Wireless World, March 1982.

His most disagreeable point is where he quoted someone as saying that c.b. was (presumably before legalization) a symbol of 'young revolt'. The long-term c.b. pirates known to myself were operating their equipment for nothing more than the enjoyment of talking to like-minded enthusiasts and forming new friends with common interests. Politics has never entered into it.

Another aspect of this view is that c.b. users are much of a sameness and young whereas in practice a good proportion of breakers were and are such as lorry drivers, company reps and radio amateurs (RSGB take note), with a few policemen and similar adults in responsible positions thrown in for good measure. There were and are also a good many youngsters about for whom c.b. is really only a toy, a passing novelty, but again there is no political motive.

Mr Frost's political comment about people reacting against improper democracy is probably quite true, witness Poland, but hardly relevant and out of place in a journal of this standing.

It was not realistic to blame officials for not granting c.b. when it was first asked for and then going on to imply that legal f.m. was a political move without any technical merit. We are to suppose then that the existing users of 27MHz allocations should have instantly re-quipped and moved to other frequencies and that this would not have counted as a problem. The Home Office *are* to be blamed for hoping that c.b. would disappear if it was ignored, probably egged on by RSGB stalwarts. They are still to be blamed for not taking a positive lead and maybe a little enthusiasm to the problems of legal c.b., like channel usage (9, 14 and 19 in particular) and official guidelines to the use and operating procedure of c.b. It is probably asking too much for the H.O. to liaise with and recognise the usefulness of c.b. clubs like ours.

As far as the legal system is concerned, breakers in my area (which is next to 'The Republic of Barnsley') have taken to it very well and are pleasantly surprised by the technical quality with very little activity remaining on the old a.m. channels. Incidently, this area is far enough away from hospital paging systems, etc., for it to ever have been troublesome in this way on a.m.

For those who think that c.b. is fading fast, I would like to point out that at the time of writing (February), membership of my club is increasing at about four new members at each 'eyeball'. That's about 120 so far in a small township.

In conclusion, I would like to say that I see Mr Frost's letter as trying to entice c.b. enthusiasts to follow his political views rather than make any serious point.

J. Briggs,
Secretary GCBC,
Penistone.

I was initially surprised that so much space was allocated in the Wireless World, (Letters, March, 1982), to the petulant, semi-political diatribe about c.b. by S. Frost of Edinburgh. Whatever the merits or otherwise of c.b. itself and of the arguments concerning channel allocations, modulation methods, etc., this kind of emotive rubbish clearly has no place in a supposedly technical journal. However, I then read the leader article in the same issue. In the penultimate paragraph the remark " . . . when the present government is but a bad memory" . . . gave the game away! When an editor allows his political prejudice to intrude into his production of a technical magazine, then I suppose we must expect an increasing contamination of its contents by half-baked political propaganda.

What a pity that *Wireless World* does not stick to its proper function, i.e., technical information; we can all get enough of the other thing from any of the vast range of politically biased media.

M. G. T. Hewlett,
Midhurst,
W. Sussex.

## WHAT HAPPENED TO THE PANADAPTER?

I have taken your magazine for about 37 years, during which time I have been a Merchant Navy Radio officer, and more recently proprietor of a small electronics shop.

Over the years I have seen a wealth of design circuitry in Wireless World, relating to Audio amplifiers, Audio pre amplifiers, power supplies, microprocessors, etc, etc.

However I would respectfully submit that designs for test equipment seem to be somewhat thin on the ground. Also designs for HF communications receiving equipment.

As an ex radio amateur (GM3GYB) I lament the fact that the vast majority of modern amateurs no longer build equipment; perhaps the shortage of modern design material is one reason?

As you will know, spectrum analysers even second hand, cost thousands of pounds. You will also remember the end of WW2 saw the release of some American surplus 'panadaptors' for connecting to the mixer stages of receivers, to display a segment of the RF band on a CRT. These I believe had inputs of 455kHz, and 30MHz is another model.

You will appreciate that there is some marked similarity between panadapters, and spectrum analysers.

Having designed and built two valve panadapters about 18 years ago, for my own use, I can vouch for their usefulness in searching a specific band for instant visual location of signals.

In view of the cost of second hand spectrum analysers, and the lack of commercial panadapters (Heathkit made one years ago) I wonder if it would not be an interesting and challenging project for one of your design contributors to come up with a modern solid state unit using varicaps etc, that could double as both a simple low cost spectrum analyser for test purposes, and also a practical Panadapter suitable for at least several I.F. inputs as used on modern HF amateur communications receivers – such as the Yaesu FRG7 FRG7700 and Trio R1000 etc.

Such a low cost design would appeal to both test engineers and communications people, as at present, the cost of such equipment is placing it completely outside anywhere but the laboratories of large companies, and government establishments, etc.

Martin S. Lebbon,
Harrogate,
Yorkshire

## DATA RECORDING ON AUDIO CASSETTE

I read with interest the article entitled "Data Recording on Audio Cassette" by P. Smith and P. I. Zorkoczy in your February issue. However, two points puzzle me. Firstly, the coder circuit as drawn is unlikely to work reliably, since the output of $IC_1$ has an undefined phase relationship with the data input to the coder. As a consequence, the coder output is likely to adopt an assymmetrical mark-space ratio, dependent on the switch-on state of the counter $IC_1$. To remedy this problem, the data should be re-synchronized to the counter output by means of a clocked flip-flop.

Secondly, the authors state that the voltage induced in the playback head is proportional to the rate of change of the recorded waveform, and yet that the associated 90° phase shift would not normally be expected with such a frequency response. Unless prolonged exposure to microprocessors has affected my understanding of circuit theory, that is precisely the phase shift one does expect to see, the head acting as an ideal differentiator in the mid-band. This phase lead should be accurately compensated by the 90° lag in the equalization circuit, to yield an overall flat response in frequency and phase.

While I am no expert on transducers, I suspect that the region in which the head phase response differs from the amplitude correction circuitry is at those frequencies where the head response ceases to match the 6dB/octave rise due to losses.

P. G. Hinch
Stockport
Cheshire

*The author replies:*
Let me first assure Mr Hinch that the coder circuit as described does work reliably and does not suffer from the asymmetry of "mark-space ratio" you describe. The coded output at Q of $IC_{2(b)}$ is symmetrical because the clock input to $IC_{2(b)}$ from $Q_3$ of $IC_1$ is a symmetrical waveform. By adding a flip-flop as you suggest we would be doing the same job twice.

The 6 dB/octave rise in playback voltage with frequency at frequencies below which losses take effect is characteristic of the ubiquitous first order highpass filter. The phase response is however not that which is associated with such a filter. Over this frequency range the amplitude equalization filter is in essence a first-order, low-pass filter, giving a fall of 6 dB/ocatave to provide an overall flat amplitude response. The phase response of any such low-pass filter depends upon frequency:

Phase = - arctan $f/f_0$ where $f$Hz is frequency, and $f_0$ Hz is corner frequency of filter.
The phase response of this filter is therefore not the constant -90° that you assume. The amplitude equalization filter does give an overall flat amplitude response but not phase linearity.





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## SYMMETRICAL OUTPUT DIVIDERS

The symmetrical output dividers described by Gerard Girolami and Philippe Bamberger are based on a very ingenious principle – inverting the clock input for half the count. It is a pity that they then use such awkward techniques to design their dividers.

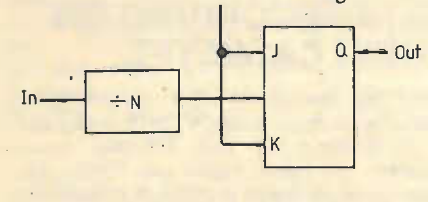


Fig 1

Figure 1, as shown above, is a ÷2n circuit with symmetrical output – this is trivial. By using the output to invert the clock input, a (2n-1) circuit is produced. Using this principle, Fig. 2 shows a programmable divider which can be extended 4 bits at a time by simply cascading 74168 counters in a standard configuration. Using decade counters produces the b.c.d. version of Fig. 3. An extra data selector is required to make the least significant 4 bit counter divide by 5 rather than 10, so that the correct weightings are achieved for the inputs.

These two circuits give a much more easily extended and general solution than the ones described in the article. They require lower device counts and only need one device rather than two – for each 4 bits added since they eliminate the need for binary comparations. In addition, the binary version gives one extra bit of binary input. Note that for a divide ratio of n, the binary (or b.c.d.) inputs must be set to n-1. For most applications this does not matter, as the input circuitry can be adjusted accordingly, e.g. by simple relabelling a switch or, in the cause of microprocessor control, by software. If absolutely necessary, 7485 adders can be used to add "all ones" to the inputs, which is equivalent to subtracting 1 in two's complement arithmetic.

Philip Nye
Edinburgh

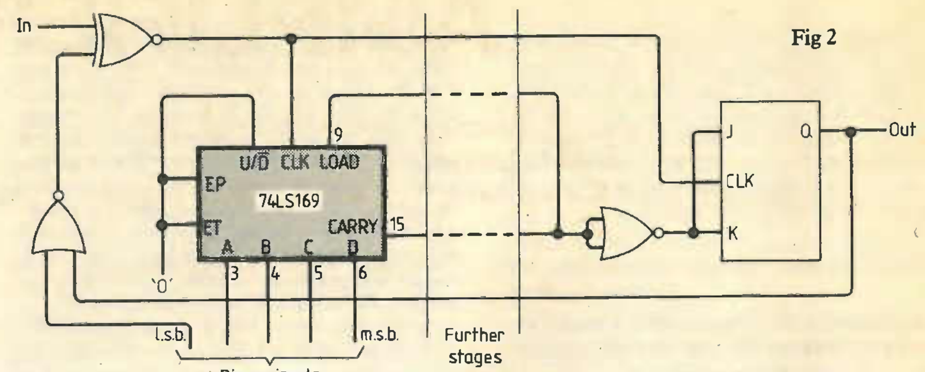


Fig 2

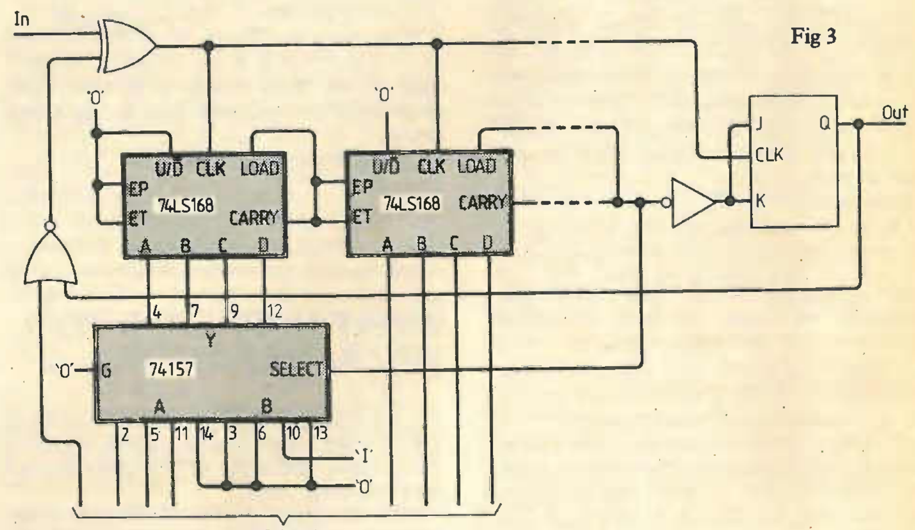


Fig 3

## LAWS OF MOTION

In his letter of November 1980 Mr Walton wondered how far back the principle of inertia goes, and he suggested that Galileo might have thought of it before Newton. In fact, since the fossil record shows that modern man is at least 100,000 years old, the laws of motion must have been thought of thousands of years ago, but the geniuses of those days had no writing with which to express themselves.

As far as modern times are concerned (and we can say that modern times began about 10,000 years ago), there are a couple of references on the subject which may be of interest.

Galileo died in 1642 and Newton's laws of motion were published in 1687, but here is what Thomas Hobbes said in 1651:

"That when a thing lies still, unless somewhat else stir it, it will lie still for ever, is a truth that no man doubts of; but that when a thing is in motion it will eternally be in motion, unless somewhat else stay it . . ."[1]

And here are the thoughts of the Roman poet Lucretius in about 50 B.C.:

". . . the light and heat of the sun . . . are composed of minute atoms which, when they are shoved off, lose no time in shooting right across the interspace of air in the direction imparted by the shove . . .

A very slight initial impetus far away to the rear sufficed to launch them, and they *continue on their course* at a velocity proportional to their lightness."[2]

All the three laws seem to be in Lucretius, even if not very well expressed. There is no doubt however that he knew that a *continuous* force is not necessary. He was aware, in other words, that a body continues in its state of rest or uniform motion in a straight line unless impressed forced act on it.

Did Newton ever read Lucretius?

S. Frost
Edinburgh

### References


1. Leviathan; chapter 2. (Fontana p.63.)
2. On the Nature of the Universe; Book 4 (Penguin pp 135, 136).

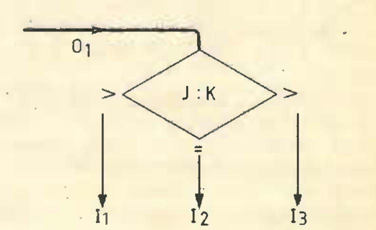

## DISC DRIVES

Following the article by J. R. Watkinson in the March issue, I wish to comment on the conceptual aspect which makes discs necessary, viz. that we must have a machine and store programs in it, either in the spatial sense (enormous memories) or in the temporal sense (disc drives but enormous programs).

Due to the difficulties we have experienced with the development of programs for the solution of engineering problems we were bold enough to make the suggestion that the flowchart must be the beginning and the end of software, e.g. will be a package to be calibrated according to the conditions set by the problem. This amounts, of course, to assembling the program before the computer. We hear sometimes from leaders in engineering that programming is a medieval remnant in our technology, but no alternative was forthcoming. I think this alternative is implicitly suggested in the *WW* editorial of January 1982 and it was as always so close and so remote to us; nature is doing programming, therefore the alternative is but *experiment*.

By the way we have speculated lately that if the concept of e-m queues is correct (my letter in the January 1982 issue of *WW*) then the initial troubles experienced in running complex programs are due to the inertia of particles or waves in forming queues, therefore this famed software problem is really a hardware phenomenon.

G. Xenoulis
Edmonton
Alberta, Canada






# 80-100W MOSFET AUDIO AMPLIFIER

*One solution to the problem of low mosfet $g_m$ – using the mosfet with bipolar small-signal devices – was described in the first part of this article. Here, John Linsley Hood presents an alternative, which is to improve the gain of the voltage-amplifier stage.*

**by J. L. Linsley Hood**

A considerable amount of development work has been done over the past decade in the design of high gain class A amplifier stages, mainly in the evolution of integrated circuit operational amplifiers, in which the design requirements in this application are high gain, good immunity from supply line breakthrough, and wide bandwidth. In addition, some attention has been paid to cost-effectiveness which, in discrete component terms, means the use of active elements to provide the best performance for the lowest number of components.

Although this work has been done, largely, by the designers of i.c. op-amps, it is profitable for those working on discrete-component circuitry to look over their shoulders to see what they are up to.

### The Class 'A' amplifier stage

It is a fundamental requirement of any feedback amplifier design that it should be absolutely and unconditionally stable, and this requirement applies with as much force to audio amplifiers of this type as to closed-loop servo-mechanisms. This consideration, coupled with the need for audio-amplifier designs to operate satisfactorily with a wide range of load reactances, leads to designs in which there is a substantial gain or phase margin at the unity-gain point on the Bode plot.

This requirement is easy to satisfy in a single-stage amplifier, of the type shown in Fig. 6, where it is unlikely that the internal phase shift, without feedback, will exceed 90° until frequencies are reached at which the gain is very much less than unity. However, the stage gain from such an amplifier will only lie in the range 50-250, with a conventional resistive collector load. It is true that gains of several thousand can be obtained from such a stage if the collector load resistor is replaced by a constant-current source, as in the 'Liniac' configuration[2] and this figure can be increased towards the hundred thousand mark if the amplifier transistor is operated in cascode with a device such as a junction fet, to increase its output resistance. Unfortunately, such high gains are only obtainable at very low collector currents, which imply very high output impedances and a relatively poor h.f. performance, which would not allow an adequate loop gain at the upper end of the audio band.

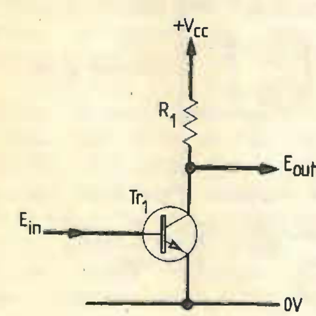


*Fig. 6. Basic single-stage amplifier. At reasonable collector currents, stage gain is modest, but phase shift is less than 90° at frequencies below $f_1$.*

The use of a two-stage voltage amplifier gives a much greater degree of design freedom, and while such an amplifier may not automatically guarantee, under all load conditions, that the internal phase shift does not approach 180° until the open-loop gain is negligible, the necessary conditions for an adequate phase margin, at unity gain, are much easier to contrive in this type of design than in circuits with more amplifying stages. For this reason, the possibilities of two-stage voltage amplifiers have attracted the attention of many designers working in the audio and operational-amplifier fields, where large amounts of negative feedback are deliberately employed to improve bandwidth, transient response, and linearity.

Because of the relatively low input impedance of $Tr_2$, a simple two-stage amplifier of the type shown in Fig. 7(a) will not give a gain which is that of a single stage, squared, but nevertheless a stage gain in the range 2000-3000 can be obtained, and this can be increased by a further factor of ten if a constant-current source is used as the load for $Tr_2$ instead of the load resistor $R_2$. Moreover, this order of stage gain can be achieved with collector currents in $Tr_2$ which are high enough to allow a relatively low output impedance at $Tr_2$ collector. In practice, the input transistor will most commonly be replaced by a long-tailed pair, as in Fig. 7(b), which reduces the odd harmonic distortion introduced by the input stage, as shown by Taylor[3,4]. This arrangement also facilitates the design of direct-coupled amplifier systems, in which the long-tailed pair input cancels the voltage offset otherwise introduced by $Tr_1$.

Circuit configurations of this type, using one or other of the arrangements of Fig. 7, with the constant-current source sometimes replaced by a bootstrapped load resistor, formed the bulk of class A gain stages used in commercial audio amplifiers up to a few years ago. In these designs, the output-impedance transformation was accomplished by a complementary, or quasi-complementary, compound emitter-follower pair, using bipolar junction transistors, and overall negative feedback would be taken from the output to the inverting input connexion. With careful design, circuits of this type give overall harmonic distortion figures of 0.01-0.02%, as measured at 1kHz, and at a few dB below clipping point. Although the t.h.d. figures will worsen somewhat at lower power output levels, the signal-to-noise ratio of such an amplifier is only some 80-90dB, which means that the residual distortion is soon swamped by circuit noise.

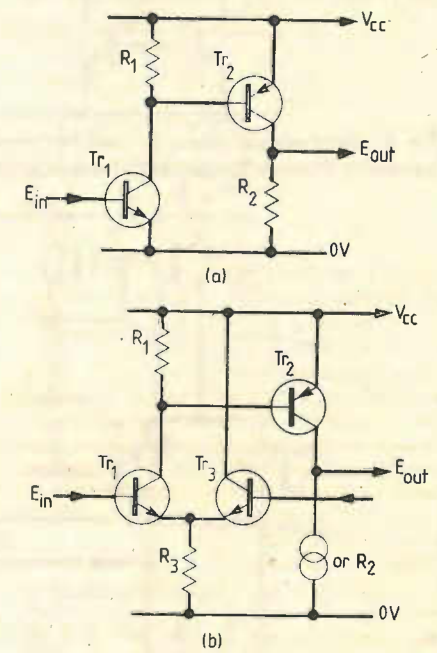


*Fig. 7. Much higher gain is obtained from two-stage circuit at relatively high $Tr_2$ collector currents. Long-tailed pair input at (b) reduces odd harmonics.*

The approach has changed somewhat in the last few years with the marketing of amplifiers, mainly of Japanese origin, having distortion levels in the 0.002-0.008% bracket, apparently in an attempt to obtain more impressive consumer reviews. In these designs, changes have been made in both the output stage biasing arrangements to minimize crossover discontinuities, and also in the number and complexity of the preceding gain stages. Where the improvement in



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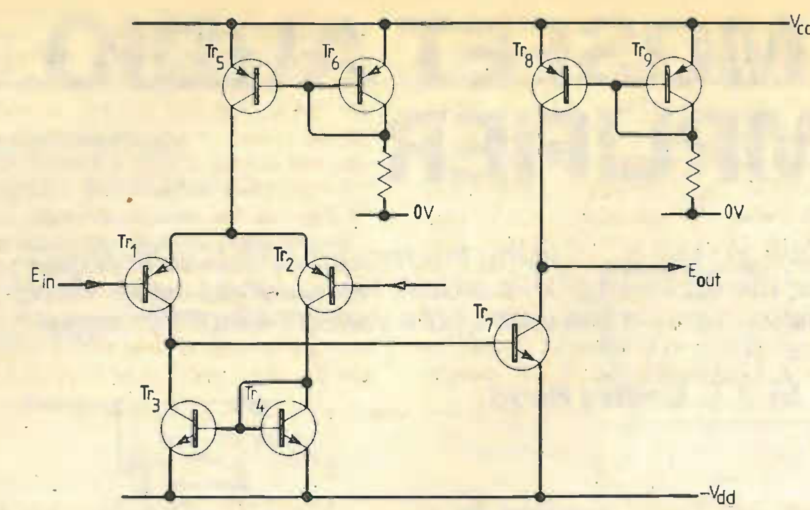



*Fig. 8. Use of current mirror as load for $Tr_1$ offsets lower gain of long-tailed pair over single transistor. Process is repeated at output stage.*

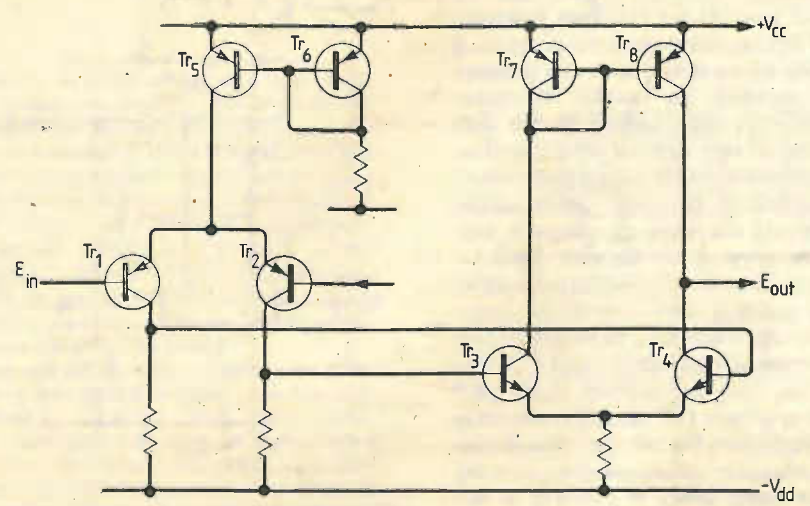



*Fig. 9. Symmetrical, push-pull version of Fig. 7(a) circuit, with current-mirror load for $Tr_4$.*

linearity has been made at the expense of stability margin, or has led to a less ideal response to a step function input, the final result may be less good in the ear of the listener. Nevertheless, there is one trend amongst those currently being explored which is of interest, particularly since it follows techniques developed earlier for operational-amplifier integrated circuits, and I propose to consider this in greater detail.

## Higher-gain configurations

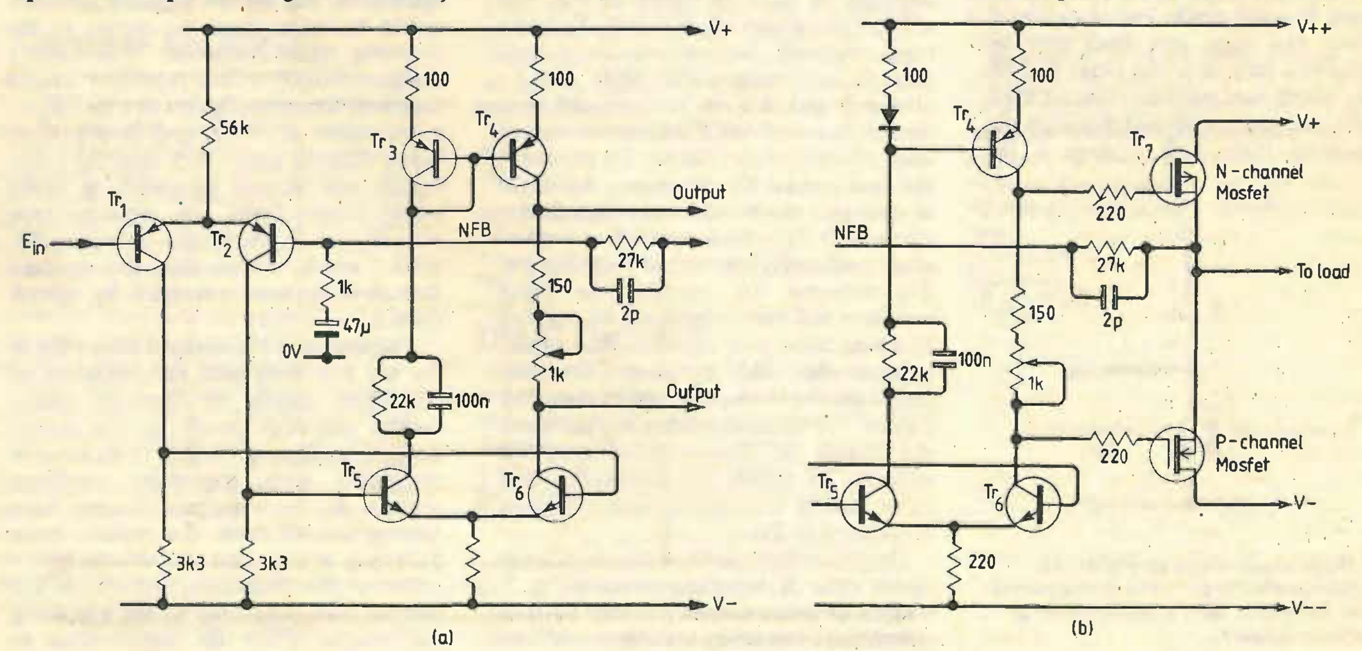
One of the penalties in the use of a symmetrical-input long-tailed pair is that the $g_m$ of the input device is halved, with a consequent reduction in the gain in comparison with a similar amplifier having only a single input resistor. This loss of gain can be minimized by the use of an asymmetrical input stage, with the feedback transistor operated at a higher current than the gain transistor, as in the earlier design of my own[5], provided that the loss of the inherent d.c. balance is within tolerable limits.

A better method of avoiding this loss of gain, and very commonly used in i.c. operational amplifiers such as the 741, is to use a current mirror as the load for the amplifying transistor, with the operating current being set by the feedback one. This type of arrangement is shown in Fig. 8, and when used with a constant current load – normally yet another current mirror – on the output of $Tr_7$, will give stage gains of the 50,000-100,000 range at low frequencies. Although this approach is easier to adopt in 'single-chip' fabrications, where the simultaneous fabrication of all the transistors will ensure identity of the base-emitter turn-on characteristics necessary for proper current-mirror operation, it has also been used in discrete-component designs.

This circuit employs nine transistors, and while the actual transistor count may be of little moment in an integrated circuit where the fabrication of active components presents no difficulty and little extra cost, it is nevertheless interesting to observe that a better stage gain can be obtained using the arrangement of Fig. 9, which uses one less transistor. In this circuit, the two-stage amplifier remains a symmetrical push-pull version of that shown in 7(a), but with the current-mirror active load moved back to the output of the second stage. This particular version of the two-stage amplifier was used first, so far as I can discover, in the National Semiconductors LH0001 low-power operational amplifier. Low-frequency small-signal voltage gains of up to 200,000 are possible using this layout.

The good gain and phase characteristics of this particular circuit arrangement have attracted the attention of Japanese designers seeking a circuit to provide enough gain to compensate for the relatively poor dynamic transfer characteristics of a simple, complementary-pair, power-mosfet source follower. The circuit design of Fig. 10(a) with emitter resistors in $Tr_{3,4}$ helping to minimize $V_{be}$ differences, is normally simplified to that in Fig. 10(b), which is recommended by Hitachi for use with their 2SJ and 2SK-series complementary devices.

*Fig. 10. Two commercial circuits using form of Fig. 9.*




Because of the low impedance presented at the collector of $Tr_5$ (Fig. 10) by the input to the current-mirror active load, this circuit provides only a 'single-ended' output. This restriction may be avoided, with a further improvement in voltage gain, if the simple current mirror of Figs 9 and 10 is replaced by the 'double-mirror' circuit shown, on its own, in Fig. 11. This permits an l.f. voltage gain in excess of 500,000, with a balanced push-pull output, which would be of advantage in circuits employing identical rather than complementary output devices.

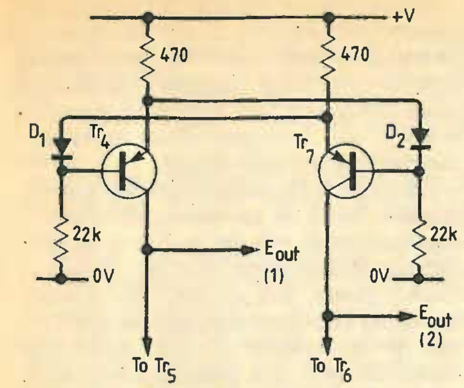



*Fig. 11. 'Double-mirror' allows high gain, but with push-pull operation.*

There is, however, a point which must be borne in mind in this usage, that in any straightforward embodiment of this circuit arrangement, the d.c. output potential at the collector of only one of the two second stage amplifier transistors can be controlled by the use of the internal d.c. negative feedback path; the output potential at the collector of the other could lie at any point between the +V and −V supply limits, which would preclude any significant undistorted output swing being obtained from the uncontrolled output. This difficulty can be removed, however, by using the output from the uncontrolled amplifier to regulate the input current supplied to the initial long-tailed pair, as shown in Fig. 12. This effectively stabilizes the output potential of this point as well, and leads to the interesting possibility of a truly symmetrical, very high-gain stage with antiphase outputs, both of which can swing within nearly the total voltage range of the supply.

Power mosfet amplifiers using the general circuit structure of Fig. 3(b) (Part 1), and any of the gain blocks of Figs. 9-12, will give very satisfactory steady-state t.h.d. and transient (step function) performance, but there is a fairly substantial snag in respect of the output stage quiescent current. This is normally controlled by some circuit arrangement such as the variable resistance in the collector circuit of $Tr_6$ in Fig. 10, which produces a suitable voltage drop to maintain an appropriate forward voltage bias on the output devices, and which may be adjusted to set the output stage quiescent current to a suitable value. This chosen value of forward bias must be stable, and maintained at the set value throughout the life of the amplifier, and affected as little as possible by changes in ambient temperature, supply line voltages or ageing of components.

Current mirrors, while providing excellent active loads to gain stages, are not, in any sense, constant-current sources, but merely circuit arrangements which reflect into the output limb the current fed into the input limb. In the circuit configuration of Fig. 10, the current through $Tr_4$ and $Tr_6$ is determined by the potential applied across the 'tail' resistor of $Tr_1$ and $Tr_2$, and the current gains and forward $V_{be}$ potentials of $Tr_5$ and $Tr_6$: in the circuit of Fig. 11, this current is determined mainly by the $V_{be}$ characteristics of $Tr_4$ and $Tr_7$ and

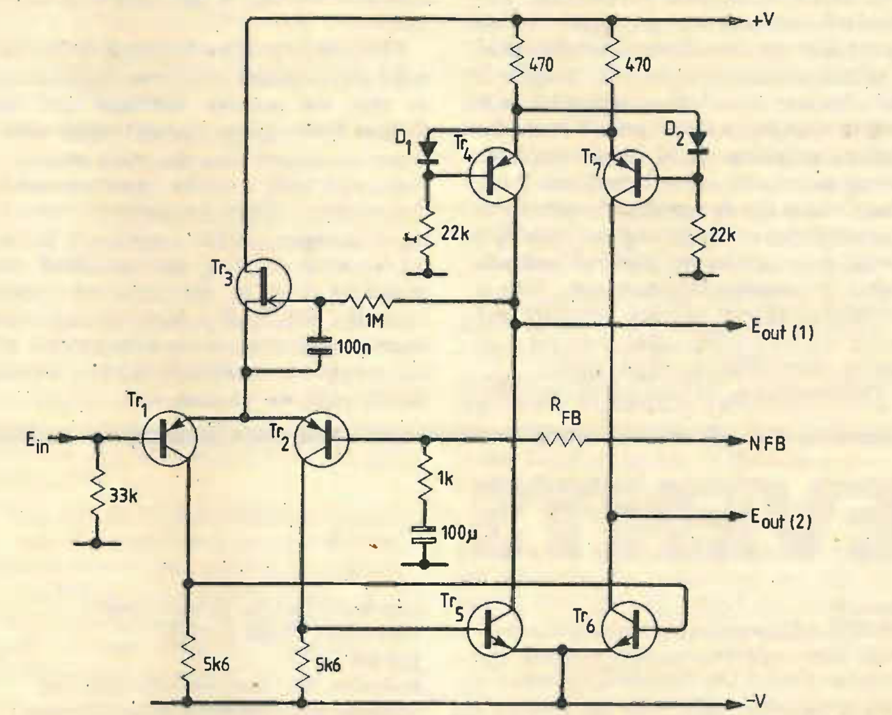



*Fig. 12. Amplifier using circuit of Fig. 11, d.c. stabilized by connexion from $Tr_5$ collector to gate of $Tr_3$. Provides symmetrical output, very high gain and large voltage swings.*

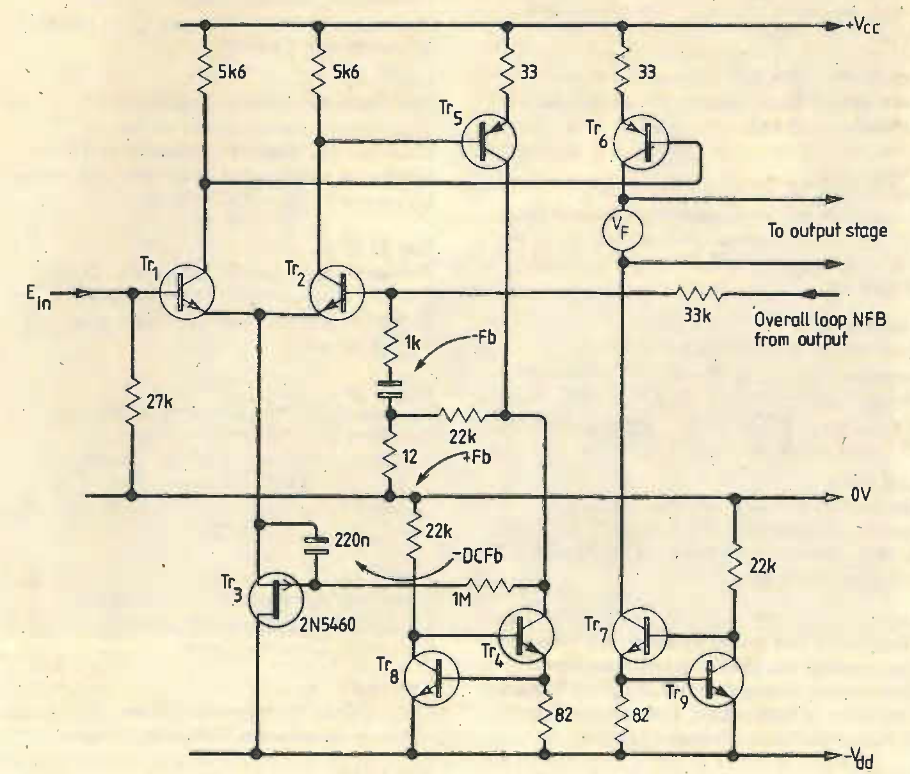



*Fig. 13. Ordinary constant-current loads used in conjunction with positive feedback give same results as current mirrors.*





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the supply potential across the 22k feed resistors.

In such circuit configurations it is difficult to achieve quiescent current stability in the output stage over the expected range of supply voltage variations and fluctuations in ambient temperature. So, with regret, I concluded that a more formal constant-current source was necessary as the load element in Fig. 12, at least for $Tr_6$, if a straightforward voltage dropper circuit in this path was to be used to generate the forward bias of the output devices.

While it is difficult to envisage any standard constant-current source which would have the same dynamic advantage as a current-mirror active load, an analysis of the behaviour of such an active load (which is that of positive feed-forward from the parallel antiphase limb) in an amplifier having an overall negative-feedback loop, shows that it is substantially identical in its characteristics to any arrangement giving a similar gain increase by 'positive feedback within the negative-feedback loop'. This is a circuit technique of some antiquity and more widely used, deliberately or inadvertently, than one might guess.

This realization, in addition to focusing attention upon the possibilities and penalties of the technique, opens the door to the use of such a symmetrical amplifier configuration, with each half operating against a standard constant-current load, and an open-loop gain equal to or greater than that of the same circuit using a current mirror as the second-stage load by the use of a suitable positive-feedback path, as shown in the circuit of Fig. 13. In this, the polarities of the transistors have been reversed to take advantage of the slightly more favourable characteristics of the p-channel junction fet constant-current source in the 'tail' of the input long-tailed pair.

This use of positive feedback meets the main requirements of such an application, in that the positive feedback path is derived from a stage operated under more linear conditions than the main amplifier loop, and with a wider gain/bandwidth characteristic. Since the positive feedback signal is applied to the same point as the n.f.b. one, it can be visualized as cancelling part of the distorted signal normally fed back, thus leaving the distortion components as a larger part of the negative-feedback input, which facilitates their reduction.

This type of circuit, as an application of positive feedback, may be contrasted with the very commonly employed output-stage 'bootstrap', in which the positive-feedback signal is derived from a stage having worse linearity, and less good phase linearity, than the overall amplifier loop.

The practical power mosfet audio amplifier based on this design of voltage-amplifier stage, will be described in the next part of this article. This circuit has an output power of up to 100 watts, depending on supply line voltage, and has very good stability of d.c. operating conditions, gain and phase margins, and offers a significant advantage in audible quality over conventional bipolar power transistor designs.

### References


2. Linsley Hood. J. L., *Wireless World*. Sept. 1971 pp 437-441.
3. Taylor. E. F., *Wireless World*. Aug. 1977 pp 28-32.
4. Taylor. E. F., *Wireless World*. Sept. 1977 pp 55-59.
5. Linsley Hood. J. L., *Hi-Fi News and Record Review*, Nov. 1972 pp 2120-2123.


*To be concluded*

# EVENTS

**June 19**
**RSGB H.f. Convention 1982** to be held at the Belfry Hotel and conference centre, Milton Common, Oxford. One day exhibition and lecture programme organised by the Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE.

**June 21-22**
**Cable-casting in Europe** – The commercial future. A conference on cable tv to be held at the International Press Centre, Shoe Lane, London EC1. Further information from International Broadcasting, 3-5, St John St. London EC1M 4AE.

**June 22-24**
**Lab design '82**, Joint Meeting of the Laboratory of Government Chemists and the IEE, at Church House, Westminster, London SW1. Details from IEE, Savoy Place, London WC2R 0BL.

**June 29-July 1**
**The influence of microelectronics on measurements, instruments and transducer design.** Conference to be held at UMIST. Details from the Conference Registrar, IERE, 99 Gower Street, London WC1E 6AZ.

**July 4-9**
**Electronics systems.** Summer school for teachers. Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.

**July 5-7**
**Distributed computing systems.** A Conference sponsored by the SERC, to be held at (and details from) Department of Computer Science, University of Strathclyde, Livingstone Tower, 26 Richmond Street, Glasgow G1 1XH.

**July 6-9**
**Man/machine systems.** IEE international conference to be held at University of Manchester Institute of Science and Technology. Details from IEE.

**July 6-8**
**Reliability '83.** Fourth national conference organised by the National Centre of Systems Reliability, and the Institute of Quality Assurance. To be held at the Metropole Hotel. National Exhibition Centre, Birmingham. Details from National Centre of Systems Reliability, UKAEA, Wigshaw Lane, Culcheth, Warrington, WA3 4NE.

**July 12-15**
**The Video Revolution.** A residential symposium organised by the Society of Electronic and Radio Technicians, 57-61 Newington Causeway, London SE1 6BL, to be held at the University of Reading.

**July 12-16**
**Electronic application for teachers.** Details from the Administrative Assistant, Room 110, Registrar's Department, University of Salford, Salford M5 4WT.

**July 12-16**
**Integrated circuit engineering.** Short course presented by the George Washington University, at Imperial College, London. Details from the UK/European office of the George Washington University, Hanover Square, London W1R 9DE.

**July 12-16**
**Spectrum Management.** Short course presented by The George Washington University. Details as above.

**July 18-23**
**Optical fibre telecommunications.** IEE Vacation school at the University of Essex.

**July 19-23**
**Optical engineering including electro-optics.** A short course presented by the George Washington University at Imperial College, London.

**July 19-23**
**Satellite systems for navigation, traffic control and surveillance.** A short course presented by the George Washington University at Imperial College, London.

**July 19-22**
**Acoustical imaging '82.** Twelfth international symposium to be held at the IEE, Savoy Place, London.

**July 21**
**IEEIE Annual General Meeting.** Savoy Hill, London WC2R 0BS.

**July 26-28**
**Electronic Image Processing.** IEE international conference at the University of York.

**July 26-30**
**Data Communications Systems and Networks.** Short course presented by the George Washington University at Imperial College, London.

**July 26-30**
**Communications satellite engineering.** Short course presented by the George Washington University at Imperial College, London.

**July 26-28**
**Electromagnetic pulse** and its effects on systems. Short course presented by the George Washington University at Imperial College, London.

**A light pen for microcomputers.**
For this project, described on p.30 of this issue, glass fibre printed circuit boards and a fibre optic cable assembly is available from M. R. Sagin, Nancarras Mill, The Level, Constantine, Falmouth, Cornwall.



# NEWS

## The re-wiring of Britain

Following the recommendations of the Cabinet Office Information Technology Advisory Panel, (ITAP), the Home Secretary asked Lord Hunt of Tanworth to chair an inquiry into the implications of cable technology and its effect on broadcasting policy. The inquiry to be complete by the end of September 1982.

Various bodies will be making representations to the Hunt inquiry and two that we have received are from British Telecom and from the Post Office Engineers' Union. For once employers and employees are in accord and their submissions are very similar.

The BT and POEU submissions both point out that broadcasting and telecommunications are converging industries. Multi-channel cables can offer both broadcast channels and 'narrow-casting', the transmission of specialised, minority programmes. There is an overlap in the screen information services with teletext and viewdata. Electronic mail services can direct information to one terminal or to many and BT believes that the borderline between broadcasting and telecom services will eventually disappear.

Both submissions discuss the two principal cable techniques; tree networks in which all channels are presented to all customers, and the switched star network where the broadband service is available to a local exchange and a narrower service may be switched to the customer according to the service selected and/or subscribed to. The switched star system is recommended as being more suitable for an interactive service and most easily realised with a mixture of fibre optic transmission for the broadband with co-axial cable for the local distribution.

The most important part of each submission is an answer to the question as to who would provide the physical cable network as opposed to the programmes. The BT report says, "There should be a clear distinction between the providers of the network and those purveyors of programme material which require franchises. This policy would permit franchises to be awarded and discontinued and for the introduction of competition between programme purveyors without replacement, disturbance or duplication of the physical network.

"The providers of the network then fill the role of carriers who provide the network for both tv and telecommunications services. Programme purveyors who need to seek franchises to offer their services should not have monopoly ownership of local broadband networks."

All this leads, of course, to the logical conclusion that BT should not only provide the cable network, but indeed have a unique ability to do so. They already provide point-to-point transmission of radio and tv signals along their landlines. There is an established force of engineers in the field and are the owners of wayleaves, ducts, poles and street furniture. They are providers of cable tv to some areas including an experimental fibre optic network in the City of Milton Keynes. Improvements to the telecommunication network will need a certain amount of re-cabling; if independent franchised programme companies were to provide the cable system, unneccessary duplication would result.

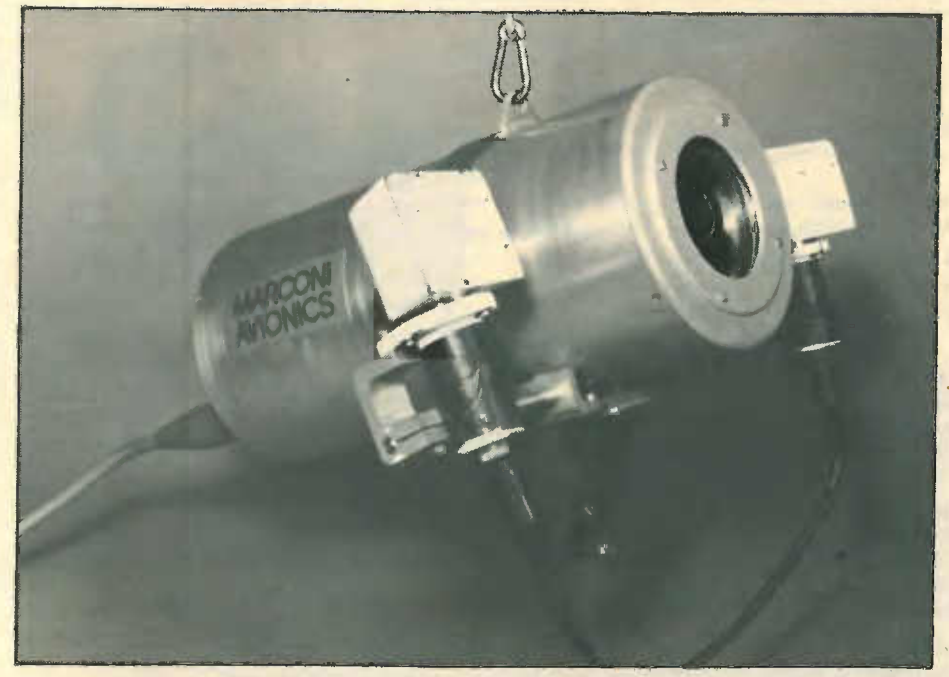
Another aspect that the Hunt inquiry has been asked to investigate is a supervisory system. ITAP suggest that programme providers should be self-regulating with a supervisory body such as the Press Council. BT suggests that there could be an extension of the IBA's franchising responsibilities.

The POEU highlights some of the political implications. The Labour party has promised that when they are next in power, they will put Project Mercury, the private telephone network, under BT's wing. Similar policies are likely to be applied to any cable service, and such political uncertainty will deter potential commercial providers of cable systems.

## 3-D tv – did it work?

When we wrote about the TVS *Real World* 3-D experiments it was before the event, so we hadn't seen it. Now we have. Frankly the results were rather disappointing. There were some close up sequences of a man blowing smoke through the screen and other people poking different things out at the viewer. These were very effective but somewhat limited in application. Other sequences of vehicles skidding on a test pad in Holland and of underwater examination of a sunken aircraft, were less successful and offered little enhancement over conventional two-dimensional tv images. One possible explanation may not be because of any failure in the system but in production techniques. We also saw recently a transmission (in two dimensions) of the Hollywood musical *Kiss Me Kate*, which was originally made in 3-D: it was noticeable how often deep perspective and out-of-focus backgrounds were used to enhance the three-dimensional effect. When the anaglyph effects were added, the original film must have been very spectacular.

The transmission of the *Real World* not




*The recent edition of TVS's* The Real World, *devoted to the development of 3-D television, included some underwater sequences taken with this Marconi camera. The camera is designed for industrial use where the depth perception can be used for the remote inspection and control of underwater work, exposing divers to fewer risks. The cameras are used to produce images on two tv screens, combined by polarizing optics and then viewed through polarized goggles. For the tv programme, the images were transformed into the red/green anaglyph system. The camera has also been used to record the wreck site of the Tudor warship* Mary Rose.

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only included the 3-D sequences but was about 3-D images and gave a history and some examples of modern use of 3-D systems. The most important use seems to be in remote control for hazardous areas, such as inspection of undersea drilling platforms or inspection at nuclear power plants. For these purposes the system is not restricted to the red/green anaglyph system as two independent channels can be processed and displayed on two displays where they may be combined optically to present one of the displays to each eye. This enables full colour displays without any of the crosstalk of the anaglyph system.

TVS tell us that they have no further plans to transmit 3-D material, although the possibility of late-night films in 3-D has been mooted.

# Computer controlled radio station

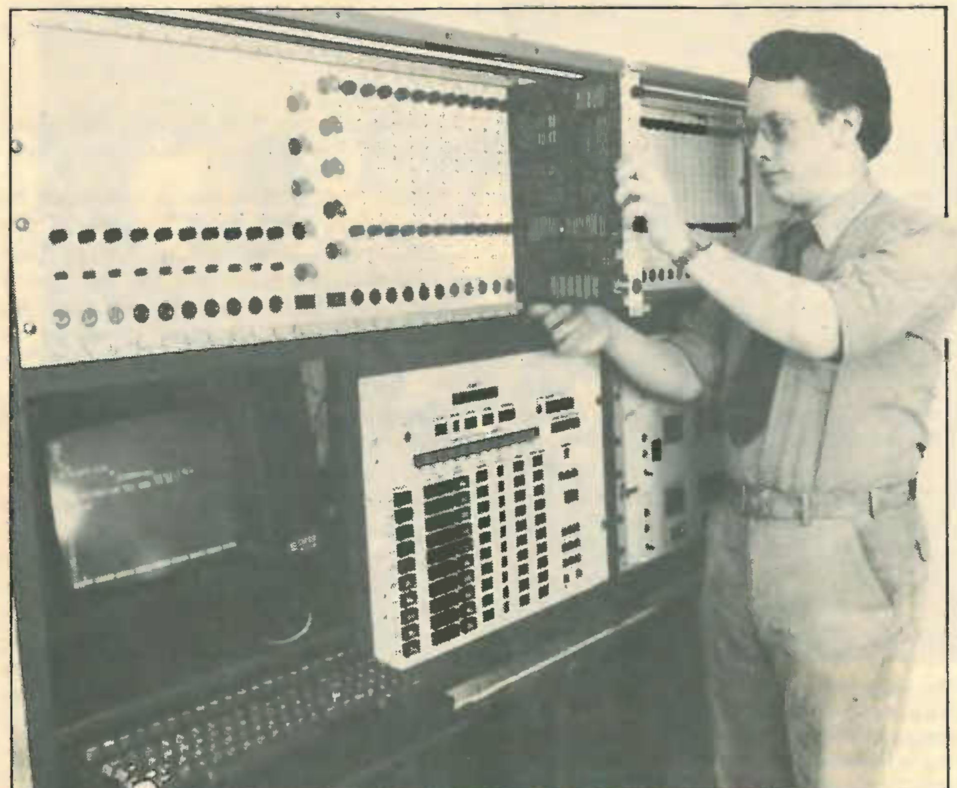
ATAC is a system for switching between transmitters and aerials. One to be used for the BBC's overseas service in Cyprus will allow any of the ten transmitters to be connected to any of 32 aerial arrays, or to artificial loads, at a preselected time, frequency and mode dictated by operational requirements. The equipment has been designed, developed and manufactured by Drallim Davis Electronics.

Switching of the r.f. power between aerials and transmitters is accomplished by 250kW r.f. switches, pneumatically actuated and controlled by solenoid valves. Up to 250 of these switches are arranged in a matrix, housed in a special building.

Routeing the signals through the matrix is achieved through a switching program module. Numbered plugs are inserted in sockets and actuate four switches corresponding to a number in b.c.d. Each group of plugs represents a code, for a transmitter mode or time switching instruction, which is stored in a computer memory. The condition of each r.f. switch is recorded by the computer which can send the appropriate signals to the actuating solenoids. An important requirement is the ability to revert to manual control if needed. There is a keyswitch system which can do this and can also disconnect an aerial or transmitter for safety during maintenance.

The computer controls all the switching automatically and also maintains a record of all operations which is stored on disc and may be retrieved to diagnose, for example, any malfunction.

Drallim have supplied switching systems to all the Independent Local Radio stations. They are quick to point out that such a system, although designed for use with a radio station, is suitable for a wide range of industrial applications where the computer switches mechanical movement in a pre-arranged sequence.



*The Drallim ATAC (aerial/transmitter automatic control) system nearing completion at Bexhill-on-Sea before its installation in the overseas service transmitter in Cyprus*

# Are you sitting comfortably?

. . . because Bruel & Kjaer have developed an environment tranducer which can measure a combination of air temperature, air velocity, and humidity to indicate the overall thermal comfort of a human being. The six-inch ellipsoidal transducer is combined with a control and display instrument which gives a numerical display to indicate the precentage of people likely to be dissatisfied with the thermal conditions if subjected to them. Such factors as the type of clothes likely to be worn, the activities to be undertaken, the prevailing vapour pressures can all be entered into the control unit and included in the calculations. Six different readouts are given and may be used as a guide to any modifications which may be necessary to provide optimum thermal comfort at a particular location. The system is battery-powered and portable and may be used wherever the maintenance of better thermal conditions is required in buildings, public vehicles and the like.

# Dolby for personal stereo

One recent explosive expansion in the audio market has been the headphone cassette player exemplified by the Sony Walkman. Good as the reproduction is on these units, Dolby Laboratories hopes to improve them by re-designing the Dolby-B noise reduction system so that it can work at the lower voltages associated with the portable players. It not only needs to work at the lower voltages, but also be physically small enough to fit into these minuscule units. According to Dolby the development work is well advanced and integrated circuit manufacturers are primed to produce devices to be available to Dolby licensees very soon.

# Plessey: a correction

In our March issue we reported that there is a six-month backlog in orders for the BBC computer used in conjunction with the current television series.

Our report stated that the cause of the backlog was the high drop-out rate in a gate array integrated circuit from Plessey.

In fact, Plessey do not supply any gate arrays for the BBC computer; nor are they in any way concerned with their design.

We apologise for any inconvenience caused by our mistaken statement that Plessey are responsible for any delays in fulfilling orders for the BBC computer.





# BBC's micro – users comment

In this, the first BBC computer user's newsletter, the editors say they, "hope to adopt a reasonably neutral and objective stance on all questions relating to the BBC machine." The words 'hope to' and 'reasonably' may imply some cover for future comment but in this issue, honesty abounds. Besides the usual presentation of programs and tips for using the computer, Beebug, who call themselves the 'registered referral centre for the BBC project', inform readers as to how they might claim interest lost between Acorn cashing their cheque and their receiving their goods, of what they might expect if the computer they eventually receive is faulty and has to be returned to the manufacturer (illustrated by a typical reader's letter), and as to how long they might have to wait to receive a computer ordered. Users and potential buyers of this computer, which, according to published specifications and prices is one of the better buys on the market, should find this newsletter interesting. A cheque for £8.90 (or £10.40 outside UK) sent to Beebug, Dept 1, 374 Wandsworth Rd, London SW8 4TE, will secure a year's membership.

*Specifically designed for currency dealers and stock brokers, the City Business System from British Telecom has a v.d.u. terminal with a touch-sensitive screen. The surface of the screen is crossed by a matrix of infra-red beams which can sense which part of the screen is being touched. Each square on the screen enables the dealer's telephone to be connected to a pre-set number and the name or number of the dealer's contact is displayed within the square. Several pages of the 'electronic telephone directory' are available to the user and can automatically connect his telephone to any number displayed. Part of the screen can also be used to 'dial' any number not programmed into the system. The computer controlling the system has access to 5,000 pages of data and can also be connected to other data bases. The first commercially operational system has been installed at the treasury of Williams and Glyn's Bank. Ginger Brooks, the bank's treasurer, said how pleased he was with the system. The dealers had become familiar with its operation within a day and were completely at home within a very few days. Tony Booth of BT London, whose engineering staff invented the system, told us that a large number of enquiries and orders were being processed and that they were obviously 'backing a winner'.*

# Banknote reader

A machine that can accept banknotes and reject forgeries is difficult to design because the ratio, between the acceptance of genuine notes and the rejection of the others, has to be finely adjusted. If it rejects too many genuine notes the customer becomes dissatisfied and will prefer to use some other facility. On the other hand if it accepts too many forgeries it becomes unprofitable. Landis & Gyr, a Swiss manufacturer settled on a 90% acceptance level as being the right compromise. Their acceptance machine, type SN25, incorporates a microprocessor which enables it to measure the bank note and to analyse the colour at pre-selected spots on the note. The m.p.u. can also be used to record the use of the machine. It monitors its own operation and adjusts its parameters on a statistical basis to give a final acceptance rate of 99% of all genuine notes. The machine may be fitted to a wide range of vending equipment and is thought to be of particular use in petrol vending.

# Radiotelephones from Neve

When E.S.E. Ltd acquired the mobile radio division of Nolton Communications, they decided to use the name of one of their subsidiaries in a related field and launched Neve Radio Telephones. They are continuing to manufacture market and service the Nolton range of mobile radios and radio telephones, but have wasted little time in getting new Neve products off the ground. One is a frequency-synthesised a.m./f.m. mobile radio telephone which is the subject of an order from the North West Gas authority and, claims Neve RT, is especially suitable for similar fuel and power customers who may have a large number of service vehicles. The mid-band model will shortly become available and is to be followed by low and high-band models. The set has 80 channel capability which can be extended to 160 channels.

# In brief

In order to make communications between combat aircraft more secure, Lockheed are working on an **optical communication link**. The system would transmit and receive laser and non-coherent light in the infra-red range of the spectrum. Sets on each aircraft would be directed automatically and would be carried in addition to conventional radio. Experiments are being carried out on both intensity-modulated and pulse-modulated systems.

**The National Wireless Museum** has recently been given a vast collection of very old service sheets, wiring diagrams and workshop manuals dealing with early radios, television receivers and even tape recorders. The Museum is willing to supply data and technical information free of charge to owners of very old equipment. The honorary curator is Douglas Byrne, 34 Pellhurst Road, Ryde, Isle of Wight.

**Enamelled steel substrates** are likely to replace conventional p.c.bs in electronic equipment of advanced design, according to a report following a nine-month evaluation by ERA Technology. The princical reason is the thermal conductivity of the metal substrate combined with the ability of the enamelled surface to withstand high temperatures. This will allow high density packing of integrated circuits with high-speed switching. Fine-line metallization suitable for solder attachment of surface mounted devices is available; flow soldering techniques are being investigated.





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INTRODUCTION
This Digital Multitester is a portable 3½-digit, compact sized multitester, ideally suited for field, lab, shop, bench and home applications. Here's a review of some of the features that quality your new Digital Multitester as a real 'pro'. The latest IC and display technology is used to achieve the lowest possible component count. This, in turn, ensures reliability, accuracy, stability and a really rugged, easy-to-handle instrument.
Low battery voltage automatically detected and displayed.
No needles to bend. No parallax and no zero adjust. Just a high contrast, easy-to-read, 3½ digit LCD.
Effective overload and transient protection on all ranges.
Over-range indication on each range.
Full auto-polarity operation.
Dual-slope integration to ensure fast, accurate, noise-free measurements.

GENERAL SPECIFICATION
Operating Temperature: 0°C to 50°C
Storage Temperature: −10°C to 50°C
Input Impedance: 10 megohms (DC/AC VOLTAGE)
Polarity: Autopolarity, (−) sign when minus
Over Range Indication: The number of "1" only display
Power Source: 9 Volt rectangular battery
Low Battery Indication: "BT" on left side of display
Zero Adjust: Auto Zero-Adjustment
Weight: 580g (Battery and Test Lead Included)
Dimension: 165 x 95 x 41 (H.W.D.)
Accessories: ★ Complete with 9V Battery, Test Lead, Spare Fuse and Optional Carrying Case

| ITEM NO. | NAME | FUNCTION |
|---|---|---|
| 1. | Display | A 3½ digit display (1999 max.) with decimal point and minus polarity indication. Indicates measured input values plus over-range and low battery condition. |
| 2. | POWER switch | Turns the instrument ON and OFF. |
| 3. | Input + jack | Connect + red lead for all voltage, current and resistance measurements. |
| 4. | Input − jack | Connect − black lead for all measurement. |
| 5. | Input 10A jack | Connect + red lead for over 1 to 10A (KD-55C only). |
| 6 | Mode switch | For selecting modes: DC Volts, AC Volts, Kohms, DCA, ACA. |
| 7. | Range switch | For selecting ranges: Voltage: 200mV, 2V, 20V, 200V, 1000V/DC, 700V/AC. Current: 200µA, 2mA, 20mA, 200mA, 1000mA(1A), 10A/KD-55C. Resistance: 200Ω, 2k, 20k, 200k, 2000k, 20MΩ. |
| 8 | Compartment | Battery and Fuse. |
| 9. | Lamp | Over load indication. (Resistance Range only) |

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# GPIB-TO-SERIAL INTERFACE

*Economical and practical design has 'talker/listener' capability*

**by Chris Jay**

There are a number of large-scale integrated circuits designed to make an instrument GPIB-compatible, so it is possible to develop an instrument interface without detailed knowledge of the protocols. Most of these are register oriented, implying the need for host processor, ram and rom circuitry. But a costly handicap will be the time required for software development. The Fairchild 96LS488 i.c. has the ability to perform a logic interface as a stand-alone unit independent of any host processor, so an interface may be quickly realised with a few logic chips, no host processor and no software development. Total chip count for the entire talker/listener unit was 14 i.cs, including a 6402 uart for parallel/serial and serial/parallel data conversion and generator chip, MC14411. (The serial interface used RS232C signal levels synchronized to a predetermined speed, link selectable to 1200, 600, 300 or 150 baud.) It is possible to depopulate the circuit board if fewer functions are required, for example a single keyboard might require only the talker capability. All the circuit components necessary for the complete interface were assembled with ease onto a single Eurocard prototyping board. The interface function subset incorporated in the GPIB/RS232C circuit are listed as

SH1 source handshake
AH1 acceptor handshake
T6 talker
TE0 no extended talker addressing
L4 listener
LE0 no extended listener addressing
SR1 service request
RL0 remote/local
C0 no controller capability.

Connections of the 96LS488 to the signal lines, address and mode switches, and the clock and master reset circuitry are shown in Fig. 1. This configuration will be standard for most interface designs. The clock pulse is generated on-chip, but requires an external RC network to provide the necessary time constant for oscillation; 220Ω and 220pF yield a clock of about 7MHz. The master reset pin is connected to a "power up" reset circuit using a 10kΩ resistor pull-up and 10µF capacitor to ground. The diode can be any medium current signal diode to provide a rapid discharge path for the capacitor when power is removed from the circuit.

The talk and listen address assignment of the instrument is programmed on the five-way switch pack. The A1-A5 inputs to the 96LS488 will be individually set to either a logic high or low; Table 1 lists the range of addresses available. This switch pack should be located at the rear panel of the instrument chassis to make it easy to reprogram the address assignment. Table 2 shows the range of operating modes: M0-M3 inputs may be set high or low by the

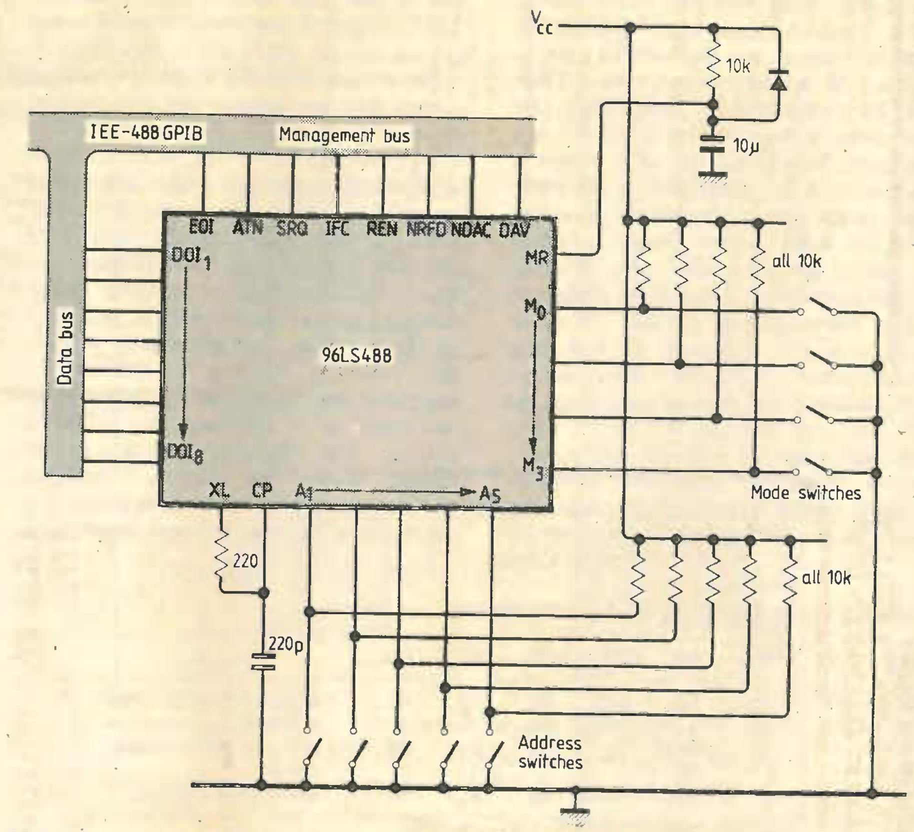



*Fig. 1. Connections of the 96LS488 to bus signal lines, address and mode switches, and the clock and master reset circuitry. This configuration will be standard for most interface designs. The clock pulse is generated on-chip, but requires an external RC network.*

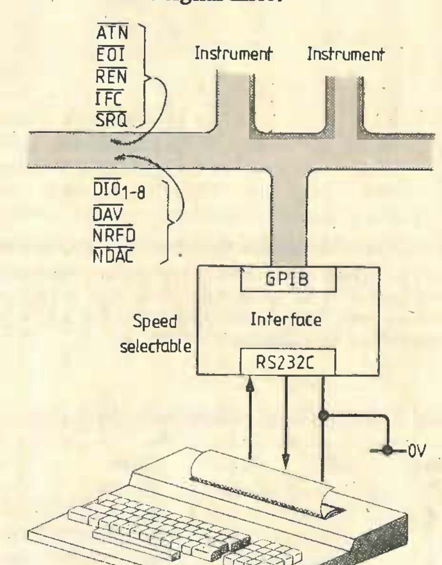
## What is GPIB?

The general-purpose instrument bus, originally defined in the Standard Digital Interface for Programmable Instrumentation ANSI/IEEE Std 488-1975, and revised in 1978 and 1980 as "Standard 488A", is now a standard instrument interface offering a universal approach to automatic operating, testing and measurement, and defines mechanical, electrical and functional specifications. It is a byte-serial, bit-parallel party line structure organised to provide asynchronous communication of digital data between a maximum of 15 devices called instruments, including at least one controller. The devices are classified into four categories

talker – capable of sending data
listener – capable of receiving data
talker/listener – capable of either sending or receiving data
controller – capable of controlling the overall interface functions, talking and listening.

All instruments configured to the bus will fall into one of these categories. Electrical interconnection comprises a 16-wire structure where all the devices are connected in parallel, these lines subdivided into three groups

data – eight signal lines
byte transfer handshake – three signal lines
general interface and management – five signal lines.



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four-way switch pack shown in Fig. 1 or alternatively, by jumper links. The talker low or high-speed mode depends on whether the bus is configured around open-collector or three-state drivers. Table 3 shows the range of logic signals that reflect the state of the interface. The TAD, LAD, and D/S/E outputs may be used as inputs to combinational logic or to drive leds to give visual indication of instrument status. Two additional logic outputs, not listed in Table 3, are also used to provide interface state information. The DRB output goes active low when the instrument is required to drive the bus data lines. When this output goes low it indicates that the instrument interface is either in the talker active state or in the serial poll active state. The R/L output provides remote or local status indication, but this feature is not used in the design.

The talker/listener interface circuit is shown in Fig. 2. Although the data lines are connected to the 96LS488 interface chip (necessary for message decoding) no data will pass through the device. The 6402 uart eight-bit transmit and receive register lines are connected through inverting buffer drivers to the bus data lines. The 96LS488 provides the necessary handshake signals to ensure asynchronous transfer of data to the 6402 transmit buffer register when the interface is in the listener active state, and from the 6402 receiver buffer register when the interface is in the talker active state.

When power is applied to the interface the master reset circuit resets the 96LS488 chip and 6402 uart through the inverter and or-gate. The 74LS74 latch is cleared. The Q output of this device is wired to the request service input of the 96LS488. In response the 96LS488 pulls the service request line low inviting the controller to conduct a serial poll; the line is used as wired-or function for instruments configured to the bus. Any instrument requiring attention will assert this line by taking it low. The controller may then conduct a serial poll to determine the source of the service request. When initially powered the instrument will be in an off-line state, but requesting service, see Table 3. This is to inform the controller that the interface is powered up and ready to be addressed as a talker or listener. The controller responds to the service request as follows. First the unlisten message is sent to all instruments, necessary to prevent listeners responding to status bytes as though they were data bytes, then the serial poll enable message is issued over the bus. The controller then issues the talk address of each instrument, and sets the attention line inactive to take the status byte of the instrument currently in serial poll active state.

When the serial interface receives its talk address the instrument enters the serial poll mode. The controller may listen to read the active low assertion of the request service output from the 96LS488 on data line seven (the other data lines float passive high). When the controller accepts this status byte, STST will pulse high, driving STRDY low through the inverter. This illustrates the automatic response of the STST/STRDY handshake. The controller's command program may now recognize that power has been applied to the serial interface and it may be addressed as a talker or listener. The rising edge of STST will clock a high onto the Q output of the 74LS74 removing the request for service.

## Listener Interface

For a printer interface the instrument will be addressed as a listener. The LAD output goes low to illuminate the green led when the listen address is received. More than one listener may be active on the bus at any one time but only one talker is permitted.

During the listener active state valid data on the data lines will be present at the TBR inputs of the 6402 from the outputs of the 74LS240 inverters. The 96LS488 will decode the three-bus handshake lines to assert RXST high when data has settled. The rising edge of RXST triggers the 121 monostable to its quasi-stable state. Its Q output will be low for a time constant of 0.7CR, then go high, the rising edge transfering data in the 6402 transmit buffer register to the internal transmitter register (delayed if the transmitter register is not empty). The 6402 serially transmits this data byte and automatically inserts the appropriate stop, start and parity bits. The format is pre-programmed by a binary data pattern set on the switch pack and resistor combination wired to the PI, EPE, SBS, CLS inputs, see Table 4. These control register inputs require that CRL be high during control register load. Data speed at the TR0 output is determined by the clock rate at the TRC input, 16 times the rate of the serialized data. The RXST/RXRDY handshake is completed when the transmit buffer register is empty. TBRE goes high informing the 96LS488 i.c. that the uart is ready to accept the next data byte for serial transmission. The local handshake is therefore achieved by RXST/TBRL and TBRE/RXRDY signals, decoded from the handshake signals. The actual speed of data byte transfer over the bus depends on the slowest active listener. If the printer interface is the only active listener, then the data lines will be ready for the talker to transmit the next data byte.

The signal conditioning and inversion required to drive the RS232C input from the 6402 output is achieved by the μA1488 line driver circuit (pin 3).

**Table 1. Talk and listen address assignment**

| $DIO_8$ | $DIO_7$ | $DIO_6$ | $DIO_5$ | $DIO_4$ | $DIO_3$ | $DIO_2$ | $DIO_1$ | |
|---|---|---|---|---|---|---|---|---|
| X | H | L | $A_5$ | $A_4$ | $A_3$ | $A_2$ | $A_1$ | primary listen address |
| X | H | L | L | L | L | L | L | unlisten |
| X | L | H | $A_5$ | $A_4$ | $A_3$ | $A_2$ | $A_1$ | primary talk address |
| X | L | H | L | L | L | L | L | untalk |
| X | L | L | $S_5$ | $S_4$ | $S_3$ | $S_2$ | $S_1$ | secondary address |

**Table 2. Operating modes set by four-way switch pack**

| Mode inputs $M_0$ | $M_1$ | $M_2$ | $M_3$ | Operating mode | Function |
|---|---|---|---|---|---|
| L | L | L | L | off line | device cannot take part in bus operations |
| L | L | L | H | T on low speed | device goes directly to talk addressed state and can source data to bus |
| L | L | H | L | L on | device goes directly to listen addressed state and can receive data from bus |
| L | L | H | H | T on high speed | as for T on (low speed) |
| L | H | L | L | T low speed | talker only, single address mode |
| L | H | L | H | TE low speed | talker only, extended address mode |
| L | H | H | L | T high speed | talker only, single address mode |
| L | H | H | H | TE high speed | talker only, extended address mode |
| H | L | L | L | L | listener only, single address mode |
| H | L | L | H | LE | listener only, extended address mode |
| H | H | L | L | T/L low speed* | talker/listener, dual address mode |
| H | H | L | H | TE/LE low speed | talker/listener, extended address mode |
| H | H | H | L | T/L high speed* | talker/listener, dual address mode |
| H | H | H | H | TE/LE high speed | talker/listener, extended address mode |

* For dual-address talker/listener modes the talk and listen addresses can be different.

**Note:** Low speed talker option is selected where open-collector data drivers are used. Delay from putting valid data on bus to DAV going true is 2.0μs. High speed option is selected where three-state drivers are used. Settling delay (data to DAV) is 1.1μs for first byte sent after a low-to-high transition of ATN and 500ns for subsequent bytes.

**Table 3. Codes that reflect interface state**

| TAD | LAD | D/S/E | State |
|---|---|---|---|
| H | H | L | off line |
| H | L | L | addressed to listen (LADS) |
| L | H | L | addressed to talk (TADS) |
| L | H | H | serial poll mode (SPM) |
| H | L | H | receiving end message (LACS) |





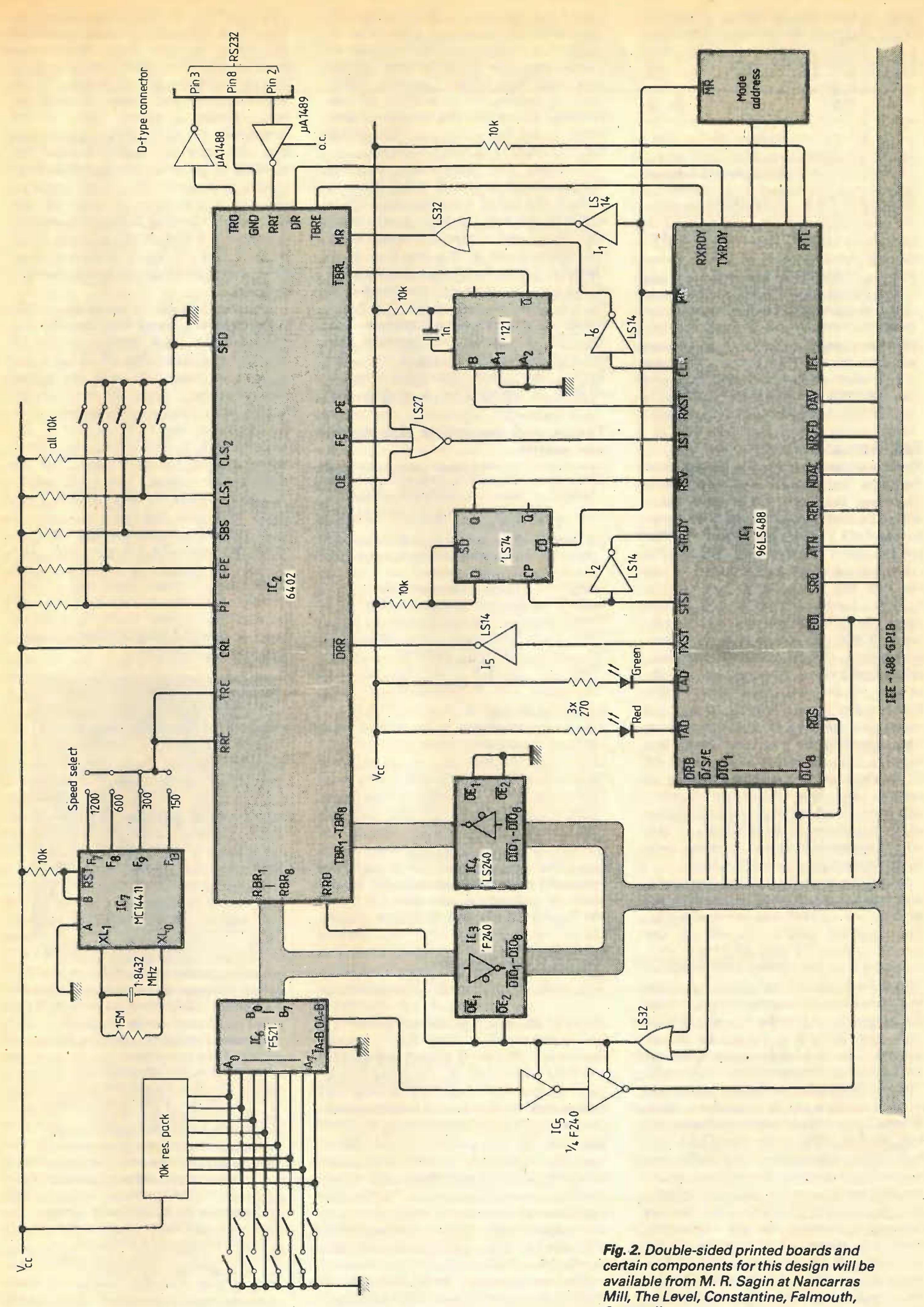


*Fig. 2. Double-sided printed boards and certain components for this design will be available from M. R. Sagin at Nancarras Mill, The Level, Constantine, Falmouth, Cornwall.*





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**Table 4. Codes required for character length and stop bit format in 6402.**

| Character length (bits) | 5 | 6 | 7 | 8 |
|---|---|---|---|---|
| CLS1 | L | H | L | H |
| CLS2 | L | L | H | H |

| | Character length selected | | |
|---|---|---|---|
| SBS input | 5 bits | 6, 7 or 8 bits | |
| L | 1 | 1 | Stop bits |
| H | 1½ | 2 | Stop bits |

PI– Parity inhibit – A high level on this input inhibits the generation of a parity bit. A low level enables the generation of a parity bit.

EPE– Even parity enable – When PI is set low, a high level on the EPE input enables even parity checking and generation. A low enables odd parity checking and generation.

### Talker interface

Keyboard data may be transmitted over the data lines when the interface is addressed into the talker-active state. When the interface receives its talk address the 96LS488 TAD output goes low and the red led lights. When the controller drives ATN high it relinquishes control of the bus data and management lines and the keyboard interface enters the talker active state. The D/S/E output would already be low in TADS, and on entry to the talker-active state, the DRB output goes low, relieving the three-state condition via the or-gate at the output of the 74F240 inverting bus driver. Note that during the serial poll active state D/S/E would be high, disabling the bus driver device and allowing data line seven to be driven by RQS. The 74F240 was chosen because its outputs can sink 64mA and therefore satisfy the 48mA current sink requirement of the bus electrical specifications. It also offers considerable power economy over the functionally equivalent 74S240.

Serial data from the RS232C interface is inverted and conditioned to a t.t.l. signal level by the μA1489 line receiver circuit. The serialized data is clocked into the receive register of the 6402 and then transferred to the receive buffer register with the appropriate start, stop and parity bits automatically inserted, according to the program set on the five-way switch pack (see Table 4 for character format details). The data-ready output from the 6402 drives the transmit-ready input high. The 96LS488 informs the listeners active on the bus that a data byte present is valid. When all active listeners have accepted this byte the 96LS488 asserts the TXST line high. The inverted output drives the data received reset input to the 6402 low, clears the data-ready output permitting the next byte to be received without an overrun error. It is assumed that the rate of the serial data generated by a typist at the keyboard will be slower than the of data reception by the active listeners on the bus, therefore no overrun error will occur. It is up to the instrument designer to ensure a speed compatability of instruments on the bus. If a fast talker is required to transmit data to one or more slow listeners then the listeners should have some kind of fast front-end buffer store, to reduce the probability of data overrun. The talker will transfer a data string to the bus using the TXST/DRR and DR/TXRDY as local handshake.

Provision has been made for the transmission of an end-of-string character to mark the end of a transmission. When an instrument is in the talker-active state it may use the end-or-identify line to signify the transmission of the last byte in a character string. A low signal transmitted on the line concurrent with transmission of the final data byte may be decoded by the listeners as receiving the end message. The 96LS488 is capable of decoding this message in the listener-active state, see Table 3 status codes. This talker design is capable of recognizing a unique end character and asserting the end-or-identify line automatically. The 74F521 octal comparator chip A=B output will go low when the code set on the eight-way switch pack matches the data byte waiting for transmission in the receiver buffer register output. A 74F240 inverting buffer provides the necessary current drive capability to the line. This device will only be enabled during the talker-active state, so other instruments may use the line for end message generation when they are addressed as active talkers. The controller may also use this as the identify line to invoke a parallel poll.

The interface has been designed to respond to a parallel poll. The individual status input to the 96LS488 will remain high if no error occurs during transmission but will go low if either a parity, framing or overrun error occurs during transmission. The 6402 status bits are latched internally, so the output of the three-input nor gate stays low until the 6402 receives a master reset. If the comparison bit of the PPE message was low, the interface would respond by asserting its assigned data line during the parallel poll active state. The controller will read this as an error condition, the error having occurred during transmission or reception of data. A non-assertion of the assigned data bit would indicate that no error had occurred during transmission or reception.

A master reset may be issued to the 6402 in the form of a device clear message or a selected device clear message. It will be necessary to clear the PE, FE or OE if one or more of these flags were set during transmission. When the instrument receives such a master reset message from the controller the CLR output of the 96LS488 will go low setting the master reset input to the 6402 high, via the inverter and or-gate. The CLR output remains low while the instrument is in the accept data state and ATN is active. If ATN goes false or the interface exits the accept data state the line goes high. The interface will be reset, and the ist line will return high. Normal talker and listener activities may be resumed after the uart has received a master reset, via a device clear or selected device clear message issued by the controller. □

### Terms and acronyms describing bus events

| | |
|---|---|
| GPIB | General purpose interface bus |
| TALKER | Device forming part of bus interface which can send data to DIO lines |
| LISTENER | Device forming part of bus interface which can receive data from DIO lines |
| TADS | Talker addressed state |
| LADS | Listener addressed state |
| SPAS | Serial poll active state |
| PPAS | Parallel poll active state |
| CIC | Controller in charge |
| TACS | Talker active state |
| LACS | Listener active state |

**Remote Messages**

| | |
|---|---|
| ATN | Attention |
| UNT | Untalk |
| UNL | Unlisten |
| MLA | My listen address |
| MTA | My talk address |
| SRQ | Service request |
| RQS | Request service |
| SPE | Serial poll enable |
| SPD | Serial poll disable |
| STB | Status byte |
| PPE | Parallel poll enable |
| PPD | Parallel poll disable |
| PPC | Parallel poll configure |

**Local Messages**

| | |
|---|---|
| rsv | Request service |
| ist | Instrument status |

*Chris Jay is applications engineering manager for digital bipolar and l.s.i. products at Fairchild's Bristol design centre, providing technical support for customers and marketing. Joining GCHQ in Cheltenham as a trainee technician straight from school, he obtained City and Guilds (Telecommunications) and HNC qualifications at day release and evening classes. These qualifications helped him qualify as a mature student for a full-time degree course at Essex University. On graduation in 1977 he joined Texas Instruments as part of the engineering design effort on the 9911 DMA controller chip. Preferring to be involved with device applications he joined Linotype Paul in Cheltenham where he designed computerized file storage equipment for the newspaper and printing industries. He left to take up his present job two years ago.*



# COMMUNICATIONS

## The expanding spectrum

It is now 70 years since American engineers decided that radio waves of "200 metres and down" were of little or no practical value and could safely be given to experimenters and radio amateurs who, they confidently predicted, would find it difficult to radiate far beyond their own back yards! By the 1930s not only had h.f. been opened but "microrays" were spanning the English Channel and frequencies up to about 100 MHz were coming into general use. The development of the magnetron, the klystron and (later) the travelling-wave-tube opened up an extensive microwave spectrum, and the process of expanding the useful frequencies continues. Japan now has some local urban broadband links on 40 GHz, possibly the highest frequency to be used for commercial telecommunications, and one notes that the Rutherford and Appleton Laboratories have developed methods of measuring molecular absorption by atmospheric gases in the 100 to 1000 GHz region.

## Conferences galore

Over the past couple of decades, large engineering conferences, seminars and associated trade exhibitions seem to have become ever more frequent and more specialised. This is certainly true of the telecommunications, radio communications and broadcasting scene. For example in the space of the one month of April there was the enormous annual NAB (National Association of Broadcasting) event at Dallas, Texas involving some 30,000 people and 400-plus trade stands in what has become an increasing international exhibition; Communications '82 at NEC Birmingham; the IEE's second "International Conference on Antennas and Propagation" at York University; and the IERE's fourth "International Conference on Video and Data Recording" at Southampton University – and possibly others that I have remained blissfully unaware of. And once again those concerned with broadcasting face the prospect of the International Broadcasting Convention at Brighton in September, another NAB at Las Vegas next April and the Montreux Technical Symposium a few weeks later.

NAB succeeds in keeping it all down to 3½ days (engineering papers 2½ days) and the papers tend to be of a much more practical and operational nature than those delivered, for example, at IBC. As someone who has attended every IBC since its start in 1967, some five Montreux and three NAB events I have little doubt that NAB comes nearest to meeting the real needs of the broadcaster – its size alone ensures that firms concentrate on introducing new ideas and new equipment at that event. The papers at IBC, admittedly, are usually of a higher technical level, but the "workshops" and panel discussions at NAB often mean more to those who attend – and can sometimes be in advance of even the R and D conferences. NAB 1982, for example, provided much more information about the latest non-composite analogue video recording techniques, such as the ½-inch Chroma Trak format used in the one-piece RCA "Hawkeye" camera/recorder (and also ¼-inch and 1-inch component formats) than the specialized recording conference at Southampton – though this has more to say about the ultimate all-digital component recording systems that have not yet reached the market place.

## Antennas and propagation

Browsing through the formidable 839 pages of IEE Conference Publication No 195 "Antennas and Propagation" one cannot but sense the gap that separates R and D people and the communications practitioners. For example, a number of the papers reflect the intensive study of s.h.f. transionospheric propagation, including the effects of heavy rain and ice crystals on 12 to 20 GHz satellite circuits, including the extent of attenuation and depolarization in different parts of the world. Clearly these studies are of practical importance both for communications and satellite broadcasting – and indeed show that these effects are rather more severe than originally thought. But, at least for European DBS systems, the main technical parameters were determined in 1977 and one suspects that the R and D results, important though they are, will have only limited influence on the systems planning for 12 GHz despite the additional fade margins etc. that theoretically should be provided in those parts of the world subject to monsoons, tropical rainfall or where ice crystals can reduce the co-channel interference protection provided by polarization discrimination.

## Modelling h.f. propagation

The conference also underlined the continued search for accurate "modelling" of h.f. propagation. Despite some 60 years of study, it is clear that nobody can yet predict with confidence either tomorrow's optimum working frequencies or those for ten years ahead. Neither the short-term daily variations of up to 10 or 15 per cent, or the maxima or minima of future sunspot cycles can yet be delivered with confidence by even the most complex, computer-based models. This does not stop R and D from trying – and the scientific journals as well as the conferences are full of attempts. But such predictions remain as uncertain as long-range weather forecasting, though one notes that one of the leading experts in this field, C. M. Rush of the Institute of Telecommunication Sciences, is convinced that "the limitations imposed upon h.f. propagation systems by the ionosphere must be assessible, quantifiable, and predictable". That will be the day! In the world of antennas, the keyword still seems to be "adaptive" and the mathematicians reign supreme; and one notes that most of the more practical innovations described at York had already appeared in the journals or around the conference circuit. This is not to criticize the R and D work but only to wonder what impression some of it will make outside the laboratories. Yesterday's R and D is often a closed chapter.

## Above the m.u.f.

At York University, H. P. Williams noted the way in which, at h.f., it is possible to use frequencies above the m.u.f. though surprisingly he made no mention of the regular "long-path" type of chordal hop propagation now well established. But he does make the interesting suggestion of using frequencies as low as 14 MHz for commercial or military "meteor-scatter" communications links (usually operated at v.h.f.). Some of the original investigations by Professor O. G. Villard of Stanford University in 1947-53 showed that reflections from meteor trails can be detected as an almost continuous weak-signal background on frequencies down to about 10 MHz. H. P. Williams believes that meteor-burst communications at h.f. could be of practical value for medium-distance paths of about 1000 km, at times when the path is otherwise closed to ionospheric reflections.

## Noted at NAB

American medium-wave (a.m.) broadcasters are worried at the prospect of reduced night-time "clear channel" coverage following the walk-out of Cuba from the Region 2 planning conference after filing a plan for 187 m.f. stations (without directional aerials) including two 500 kW installations . . . another problem is the FCC's decision to leave the choice of an a.m. stereo system to the market place while there are still four aggressively competing and non-compatible systems: Magnavox AM-OM; Motorola C-QUAM; Harris V-CPM; and Kahn/Hazeltine Independent Sideband . . . FCC is to authorize a whole new category of tv broadcasting as a "Low power television service" with a minimum of regulations. . . . Three competing systems are being investigated for multichannel sound on tv; a Japanese



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system proposed by EIAJ and two American systems by Zenith and Telesonics. . . . Network radio is back in fashion using a great deal of satellite distribution. . . . Japanese firms are making ever deeper inroads into the American broadcast-equipment market including growing use of small Saticon pick-up tubes in the increasingly fashionable compact colour cameras. For 25 or 30mm sizes the lead-oxide vidicon remains the first choice.

# AMATEUR RADIO

## First moonbouncer

The ability to make world-wide contacts on v.h.f. and u.h.f. by utilizing the earth-moon-earth path continues to attract more enthusiasts into this branch of the hobby, despite the demanding requirements in terms of aerials, transmitter powers and low-noise receivers. Stuart Jones, GW3XYW, near Swansea recently became the first amateur in Wales to "work all continents" on 432 MHz moonbounce. G3WDG and G4KGC of Towcester have successfully used a 4-metre dish aerial designed for 1296 MHz on 432 MHz, and this is believed to be one of the smallest dishes yet used on this band.

During the now well-established annual amateur radio reception at NAB a plaque was presented to John De Witt, N4CBC (formerly W4ER1 and W4FU) who as a lieutenant colonel in the U.S. Army Signal Corps at the end of the war was officer in charge of the project at the Evans Signal Laboratory that led to the first successful "moonbounce". This was realised on January 10, 1946 when a quarter-second pulse was transmitted on 111.5 MHz, and 2½ seconds later a faint returning 'beep' was heard. Earlier, in May 1940 while chief engineer of WSM, Nashville, Tennessee "Jack" De Witt had attempted to achieve moonbounce and shortly after V-J day he again turned his attention to the question, this time based on modified radar equipment with a 64-dipole aerial array and narrow-band quadruple-superhet receiver tuned to take account of doppler frequency shift. The first engineer actually to hear the moon-echoes was Herbert Kauffman, W2OQU. The idea of hearing radio signals from the moon was even then not new. As early as September 1921, *QST* had warned:

"A whimsical lad called Maloney,
A ham in the art of Marconi,
Once essayed to tune
A spark from the moon.
With suspicion regarded
He's now always guarded
Beware lest you follow Maloney!

Fortunately many amateurs have been able to follow in the steps of Maloney, De Witt and Kauffman without incurring excessive suspicion as to their sanity. Indeed nature's passive satellite system e-m-e is now well established.

## Amateur tv

In *CQ-TV*, D. J. Long, G3PTU suggests that for amateur television transmissions on bands above 432 MHz consideration should be given to frequency-modulation of the vision channel. With the approach of direct broadcasting from satellite, components for f.m.-type tv receivers will become more readily available. Problem may be to find 27 MHz or so of available radio spectrum. Grant Dixon, G8CGK draws attention to the availability of one-chip analogue/digital converters (at around £66) that provides 6-bit (64 level) coding, sufficient for experimental digital-video systems. The British Amateur Television Club will hold its 1982 convention at the Post House Hotel, Leicester on September 4-5. John Wood, G3YQC, editor of *CQ-TV*, has started trying to compile a history of amateur television from the earliest pre-broadcast days. Amateur tv enthusiasts in the Bath and Leicester areas are seeking to establish atv repeaters.

It was just 30 years ago, in May, 1952 that what is believed to have been the first amateur two-way high-definition tv contact was made on 432 MHz by Harold Jones, G5ZT/T of Plymouth and Fred Rose, G3BLV/T who lived in Sunderland but brought his equipment by car down to the Plymouth area. The a.t.v. stations had taken some three years to build.

## Here and there

Just after World War II, when many amateurs were eagerly buying up surplus military equipment, there were frequent warnings that some airborne equipment contained explosive devices intended to prevent the equipment falling intact into enemy hands. However, R. C. Field, G3IPM, recently had an unpleasant surprise when an old IFF (Identification Friend or Foe) unit which had been in his possession for 36 years exploded without warning, wrecking his garden shed but fortunately resulting in no human casualties.

British amateurs are participating in a study being carried out for CCIR into the extend of v.h.f. sporadic-E propagation on the v.h.f. bands. On 144MHz this has been found to exceed greatly that predicted by methods currently recommended by CCIR. Of particular importance will be the observation of the duration of such events as established by the large network of European v.h.f. enthusiasts.

At the recent IEE Conference at York University, R. G. Flavell, G3LTP described the work of European amateurs in determining the limits of long-range tropospheric propagation on 144MHz and 432MHz in anticyclonic weather conditions. He pointed out that although doubts had sometimes been raised on some quarters about the genuiness of the long distance claimed by amateurs, there was good independent evidence relating to the long oversea path of 2635km (a European record) achieved in a two-way contact on 144MHz between Devon and the Canary Islands on August 6, 1980.

The revised schedule for the British amateur radio licences finally appeared in the London, Belfast and Edinburgh Gazettes on April 16 and the Home Office has resumed the issue of new licences.

The ARRL has formally asked the FCC to ban the use of amateur frequencies by American cable television operators claiming "amateur radio operators in many states have suffered severe interference caused by operation of cable systems which 'leak' radio frequency energy on amateur frequencies . . . worse, consumers of cable television are subjected to interference from amateur v.h.f. stations". It is noted that problems arise from inadequate shielding of the cable systems, the use of poor quality components, inferior installation procedures and that the problem cannot be resolved in the context of the present rules due to the proximity of the two services in residential areas . . . even hand-held 144MHz transmitters can destroy a cable channel for several city blocks". ARRL have also formally opposed the relaxation of cable leakage regulations which currently limit radiation to 20μV/m at 10ft between 54 and 216MHz but which may be relaxed to 100μV/m.

## In brief

ZD9GI a 28.212MHz beacon station on Gough Island in the South Atlantic is now operational, tended by members of the weather station . . . Some Swedish amateurs are active on 1.8MHz c.w. and more and more countries are now permitting operation on this band. . . . The ARRL DX countries list currently totals 318 different "countries". . . . The GB3ANG 70.06MHz beacon station has a two-speed keyer in order to provide high-speed (100 w.p.m.) identification during meteor-scatter bursts. . . . Hans Meurer, W2TO has achieved 100 countries confirmed using a 2-watt Heathkit HW8 transceiver among the high-power stations in New Jersey. 60 per cent of his contacts were on 21MHz, 35 per cent on 14MHz and 5 per cent on 7MHz. . . . The Americans are shortly to begin operating an over-the-horizon radar between 5 and 35MHz located near Moscow, Maine. It will have an effective radiated power of the order of 1.2MW. The American military users have promised to co-operate with h.f. users to minimize interference which should prove less than that suffered from the Russian "woodpecker" system. . . . The FCC have suspended licences of two American amateurs who have deliberately jammed an amateur net on 14MHz.

**PAT HAWKER, G3VA**





# MICROCOMPUTER LINE PRINTER

*Requiring 'hard copy' from a Z80-based microcomputer to aid program compilation, the author obtained a 40-column dot-matrix printer mechanism with a dedicated controller i.c. and designed an interface around them. The result – a cost-effective line printer with few components – lends itself to modification and to other applications.*

**by P. L. Woods**

Generally, and excluding the cassette recorder, a printer is the most useful peripheral for a small computer. Hard copy of program listings or computed results for documentation and dissemination purposes are the first applications that spring to mind, but probably the most interesting aspect of a printer as far as serious microcomputer users are concerned is its value as an aid to program debugging and compilation. It is far easier to find an error in a complete listing on paper than it is from a partial listing on a c.r.t. screen.

Given these merits, it is surprising to find that for some small computers, directly compatible printers are not readily available. Many complete units requiring only a standard serial or parallel interface are available, but for my purposes, they were found too expensive, too large and too heavy. For these reasons I decided to choose one of several bare printer mechanisms now on the market, and design an interface around it.

Of the mechanisms available, many have only between 16 and 20 printing positions, since they are intended for use in cash registers and similar equipment. For practical listings in Basic or assembly language, more columns are needed. Another variable to take into account when choosing a mechanism is that of paper type. Many drives using thermal or electrosensitive paper are inexpensive, but then again, the paper they use is relatively expensive. The final choice was a plain-paper dot-matrix printer.

### Mechanism

The DP-824F-24 is a 24 volt d.c. mechanism capable of printing 40 characters per line on a roll of plain paper 114cm (4.5 inches) wide. This gives a character density of about 12 characters per inch, which is the same as that given by many typewriters. The printer prints 6 lines per inch at about 1.2 lines per second, the actual rate depending on the microcomputer software. Some idea of the quality of printing provided by this unit can be obtained from the listings shown.

In this, and most dot-matrix printers, a vertical row of seven solenoid-operated needles are drawn across the surface of the paper and carefully timed pulses are sent to the solenoids to leave a pattern of dots on the paper, forming the selected character. A standard (group 24) typewriter ribbon is used in this case. The print head is driven along the line by a motor driven lead screw, while a timing signal derived from a pickup coil driven by this motor ensures a correctly proportioned character. The motor also drives the paper advance mechanism through a series of gears.

The mechanism is quite small, measuring 5.7cm high by 15.8cm wide by 14.7cm long, and can easily be mounted in a small container. My container measures 12.5cm high by 17.5cm wide by 21.5cm long, the extra height being needed to house the solenoid driver circuits in the bottom of the box.

Dot-matrix printers need a character generator to form the pattern of dots for the desired character set. For this mechan-

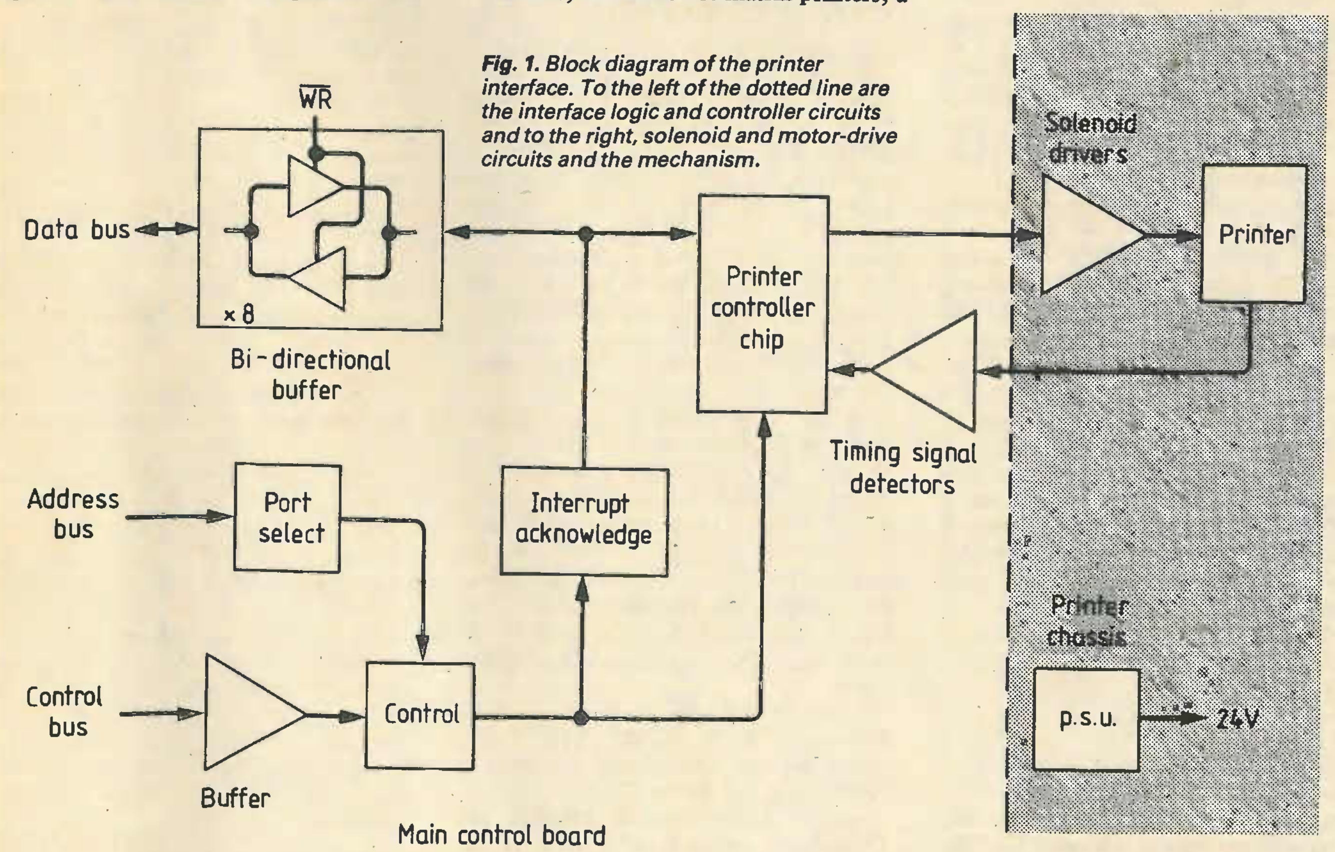


*Fig. 1. Block diagram of the printer interface. To the left of the dotted line are the interface logic and controller circuits and to the right, solenoid and motor-drive circuits and the mechanism.*





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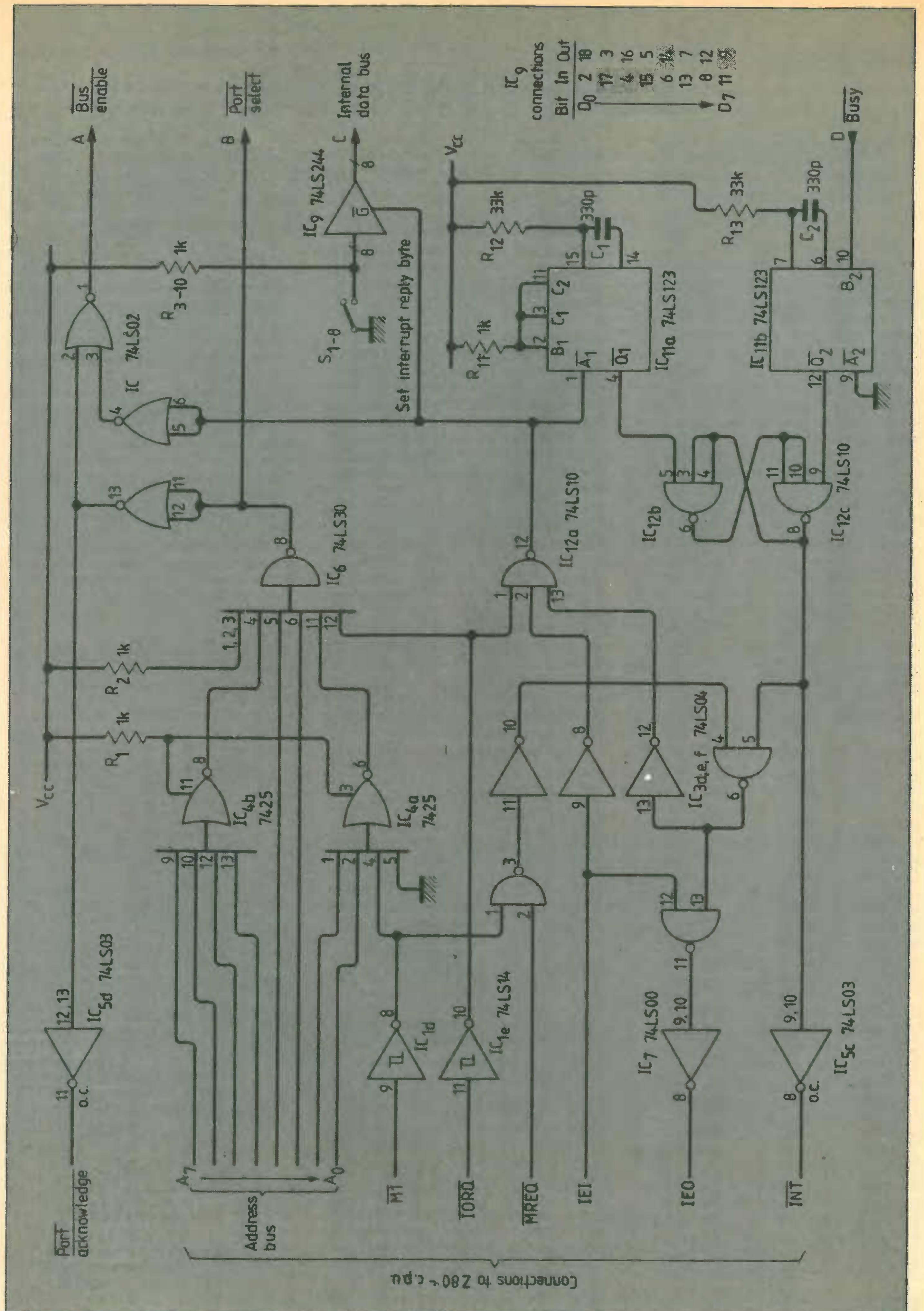
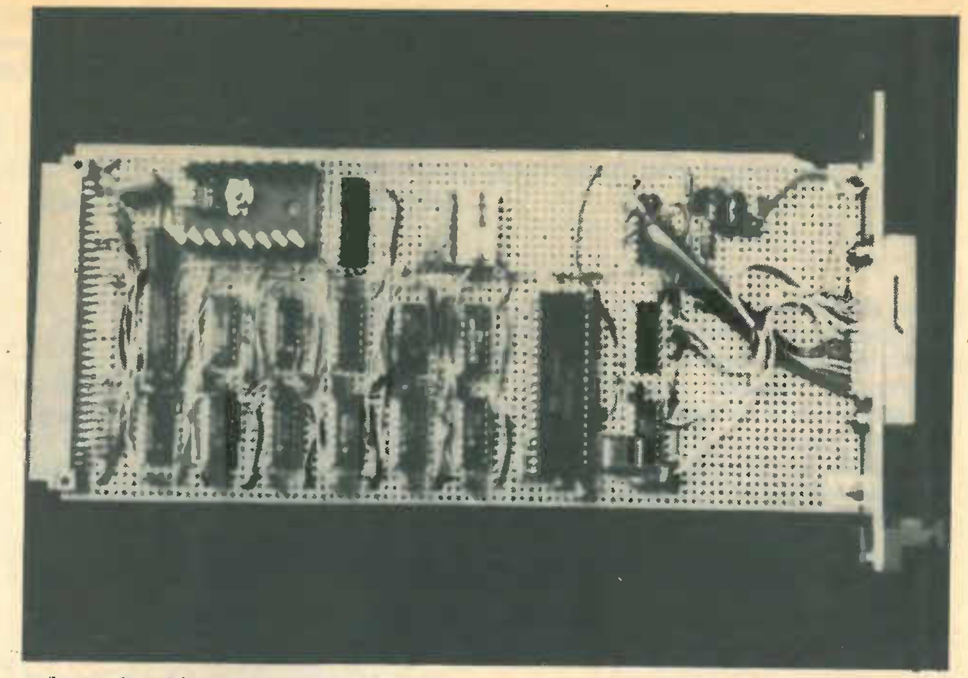


◀ *Fig. 2. Port select and interrupt circuits. Address decoding may be varied (see text) and in most situations, the interrupt circuits may be ignored and pin 3 of $IC_8$ connected to ground.*



*Interface board. This circuit serves to connect the printer to the microprocessor. The DIN41612 connector on the left plugs into the back plane of the author's computer system and the signals to and from the printer are conveyed via the 'D' connector at the right. The large integrated circuit in the centre is the printer controller chip.* ▶

ism, a matching controller i.c. is available from the same manufacturer. This i.c. also takes care of all the timing, paper feed and character buffering problems associated with driving a printer of this type. A self test facility is also built into the controller.

So, given the controller and mechanism, designing the interface is a simple matter of adapting the microcomputer's bus to suit the requirements of the controller, and providing drive circuits for the motor and solenoids. Here, the interface is designed to accept Z80-bus signals but modifying the circuit to suit other microprocessor buses should not be a difficult task.

## Circuit description

Figure 1 shows a block diagram of the interface, separated into two parts by a dotted line. Circuits to the left of the line form the controller and carry low-level t.t.l. signals, while those on the right are for driving the motor and solenoids and thus carry high-voltage/high-current signals. These two sections are kept separate as the current surge caused when all the solenoids are switched at once is around 30A. The driver circuits are mounted in the container with the printer mechanism and connected by a ribbon cable to the controller section, which is kept close to the computer.

## Port-select and control logic

A detailed circuit diagram of the controller is shown in Figs 2 and 3. First consider Fig. 2. This is the printer port-select logic, and general and interrupt-control logic. Although designed into the circuit, the interrupt function is not needed to successfully operate the circuit and may thus be omitted.

Z80 (and 8080) devices have input/output instructions to activate their peripherals. Thus the first step in the interface design is to establish whether an i/o instruction is occurring, and whether it is addressing the printer board.

$IC_4$ and $IC_6$ perform the address-decoding and port-select functions. Depending on the precise address required for the printer, the address lines are fed either into one of the two NOR gates, $IC_{4a}$, $IC_{4b}$, or into the NAND gate, $IC_6$. The $\overline{IORQ}$ signal is active when the current instruction is an i/o instruction, and the $\overline{M1}$ signal is used for synchronisation purposes.

The controller, as shown, is set to respond to port 0C (hexadecimal), but any other address could be used if needed. Only the least significant lines of the address bus (A0 to A7) are used by i/o instructions. Connect any line of the address bus which must be high when the printer is to be active to an input on the NAND gate, $IC_6$, and all of the other address lines (A0 to A7) to an input on the NOR gate, $IC_4$. The circuit is designed such that when the port is selected, the output of $IC_6$ (pin 8) goes low. This is the $\overline{\text{Port select}}$ signal.

$IC_{5d}$ buffers the $\overline{\text{Port acknowledge}}$ signal on its way back to the microprocessor. My computer's hardware needs this signal but in most cases it will either remain unused or, in systems with a fast microprocessor such as the Z80A or Z80B, used to generate a processor wait signal.

## Interrupt logic

The remainder of Fig. 2 is the interrupt handling circuit and comprises $IC_{5c}$, $IC_7$, $IC_9$, $IC_{11}$, $IC_{12}$ and $S_1$-$S_8$. If unwanted, this section may be omitted, in which case pin 3 of $IC_8$ is connected to ground.

When the printer controller chip, $IC_{14}$, becomes idle, a 4µs pulse is generated by $IC_{11b}$ which sets an interrupt request latch formed by $IC_{12b}$ and $IC_{12c}$. This signal is buffered on its way to the microprocessor by $IC_{5c}$. When the Z80 microprocessor generates an interrupt acknowledge cycle, $IC_{7b}$ and $IC_{7c}$ will establish the priority of the board concerned in the interrupt priority chain, and, if selected, will send the output of $IC_{12a}$ (pin 12) low. This enables $IC_9$ to connect switches $S_1$ to $S_8$ onto the internal data bus, and then through $IC_2$ to the system data bus. Further, $IC_{11a}$ automatically clears the interrupt request latch.

Switches $S_1$ to $S_8$ are used to set up the interrupt reply byte to the microprocessor and serve to tell the software that it is the printer that needs attention. The value set on the switches will depend on the system software written, and so is outside the scope of this article. □

*To be continued*

### Componets

**Integrated circuits**

| | |
|---|---|
| 1 | 74LS14 |
| 2 | 74LS245 |
| 3 | 74LS04 |
| 4 | 7425 |
| 5 | 74LS03 |
| 6 | 74LS30 |
| 7 | 74LS00 |
| 8 | 74LS02 |
| 9 | 74LS244 |
| 11 | 74LS123 |
| 12 | 74LS10 |
| 13 | 74LS367 |
| 14 | DPC-2 |
| 15 | 74LS14 |
| 16 | 7406 |
| 17 | 7406 |
| 301 | 7805 |
| 302 | 741 |

**Diodes**

| | |
|---|---|
| 101 | 1N4001 (8 off rqd.) |
| 102 | 6.2 V, 1 w Zener diode. (8 off rqd.) |
| 301-304 | 1N4001 |
| 305, 306 | 1N5402 |
| 307 | 24 V, 1 W Zener diode. |

**Transistors**

| | |
|---|---|
| 1 | BC109 |
| 101 | TIP120 (8 off) |
| 201, 202 | 2N3702 |
| 203 | TIP120 |
| 204 | TIP42A |
| 301 | BC109 |
| 302 | TIP120 |

**Resistors**

| | |
|---|---|
| 1-11 | 1k |
| 12,13 | 33k |
| 14,15 | 1k |
| 16 | 10k |
| 17 | 120k |
| 18 | 22k |
| 19,20 | 4.7k |
| 21 | 120k |
| 101 | 3.3k (8 off) |
| 201 | 10k |
| 202,203 | 4.7k |
| 204 | 10k |
| 205 | 150 |
| 301 | 100k |
| 302 | 390 |
| 303,304 | 1k |

**Capacitors**

| | |
|---|---|
| 1,2 | 330p |
| 3,4 | 22p |
| 5 | 1n |
| 6 | 100n |
| 7,8 | 10n |
| 301 | 2500µ 25V |
| 302 | 300n |
| 303 | 100n |
| 304,305 | 6800µ 25V |
| 306 | 500µ 30V |

**Others**

$XL_1$ 6.0 MHz (HC25/U)

**Transformer**

9V, 1A and 12V, 2A.







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# DISC DRIVES

*Turning first to how discs are driven, John Watkinson briefly discusses motors, mountings and bearings, and rotation sensing. How and why cooling and filtration techniques are used follows.*

**by J. R. Watkinson***

Now, after having covered head selection and positioning, we move onto the third dimension of disc access – rotation.

Alignment between read/write heads and data tracks is not only determined by the head positioning system's accuracy. Play in the drive spindle can also cause problems in this area. 'Runout', the term used to describe this phenomenon, becomes more critical as the disc's track spacing decreases, and is usually minimized by the use of axially-preloaded tapered roller bearings on the drive spindle as shown in Fig. 1.

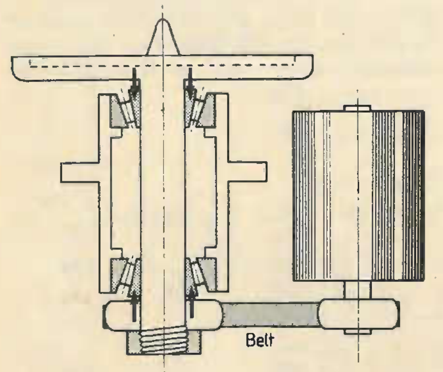



*Fig. 1. Axial preload applied to tapered roller bearings takes up all play in the spindle. The motor's speed is frequency dependent, therefore, the domed pulleys on which the flat belt runs are interchangeable for either 50 or 60Hz mains frequencies.*

Squirrel-cage type induction motors are most commonly used to drive the spindle. Electrical interference, mechanical noise and physical wear from brush type motors make them unacceptable for this application, and the power required to turn a relatively heavy disc pack at speeds of up to 3600 r.p.m. discounts shaded-pole motors. Two types of spindle motor are often encountered; one, the so called two-phase or capacitor-run motor, has a second winding fed by a phase-advance capacitor to achieve field rotation and the other has an auxiliary starting winding switched in and out by a centrifugal switch.

Larger drives use three-phase motors with windings designed to work at between 200 and 240V, and the windings may easily be configured to suit either 110 or 240V mains supplies.

Almost every spindle is coupled to its motor by a textile-belt and pulley arrangement, the pulleys of which may be changed to suit either 50 or 60Hz mains frequencies and thus compensate for the motor's speed change. A conductive drive belt may be used to provide a discharge path for static electricity on the motor rotor and for the same reason, a carbon brush is fitted at the end of the spindle.

For several seconds during start up, a motor driving a large multi-platter disc pack may draw 10A from each phase, after which the normal running current is around 1A. Where a number of drives are being used together, an automatic mains switching circuit allows only one drive to be started up at once to avoid mains overload.

A disc pack without some form of braking would turn for several minutes after its motor had been switched off. Often the spindle motor is used as a brake by applying around 50V direct to its windings, Fig. 2, but this can lead to overheating when the motor is frequently stopped and started since the windings heat up on both occasions. Therefore, a thermal switch is often included in the drive circuit.

## Rotational position sensing

To position the head for reading or writing, the drive's circuits need to know which cylinder the head is at, as was discussed in the previous article, and which sector is currently under the head. Sector information is usually obtained from a sensor detecting slots cut in either the hub or lower protection platter of the disc pack. There are three main types of sector transducer – one uses light emitting and detecting devices, with the advantage that precise physical tolerances are not required, one relies on varying reluctance, and the last is an eddy-current detector working on the same principle as some metal detectors.

Timing of the sector pulse occurring between data blocks is critical because this signal is used to initialize logic circuits for reading a header. There are two ways in which the timing of the pulse may be adjusted, depending on the type of drive. Sometimes a fixed transducer is used and the pulse is varied by altering the setting of a monostable circuit; in other cases, the pulse is varied by moving the transducer tangentially in relation to the disc. Whatever method is used, the adjustment is made using a reference disc pack to ensure that all the drives concerned have exactly the same setting.

Pulses from the transducer increment the sector counter. In Fig. 3, it can be seen that the sector detection disc has a double slot at one point on its circumference. When these slots pass the detector, the timing logic circuit generates a separate pulse to reset the sector counter.

The desired-sector register is loaded from the host c.p.u. as part of the disc address. This register is compared with the sector counter by the disc-control logic. When the two match, the desired sector is located. This process is referred to as a search, and usually takes place after a seek to the desired cylinder. Having found the correct physical block on the disc, the next step is to read the header of that block to confirm that the disc address it contains is the same as the desired address. Following this confirmation the data transfer proceeds. This process will be detailed in the section on disc-control logic.

The sector counter is often accessible by the host c.p.u. as the current-sector register. In a multi-drive system, part of the operating system has to decide in what order to carry out the many data transfers requested. In Fig. 4, two drives are on the correct cylinder, waiting for the desired block to come under the heads. By reference to the current-sector register in the two drives, the system can decide which data transfer to make first for maximum efficiency. For this reason the current sector register is often called the look-ahead register.

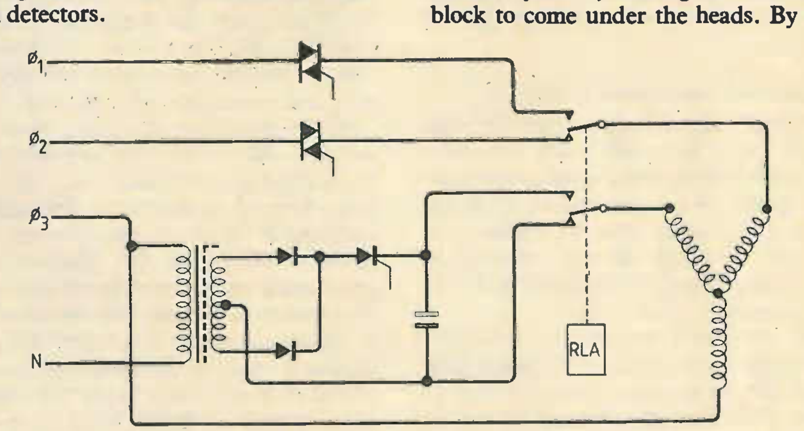



*Fig. 2. Three-phase motor control with dynamic braking. Drive power to the motor is controlled by the two triacs, and d.c. braking by the thyristor. The relay only switches when both braking and drive control devices are off. During braking, the d.c. supply floats at the phase voltage since only two phases are triac controlled. The thyristor gate is driven by a reed relay or optical isolator.*

*B.Sc., M.Sc., Digital Equipment Co.



## Cooling and filtration

It has been stated that the 'flying height' of the head is very low indeed. Figure 5 shows the relationship between flying height and common contaminants. Air in the vicinity of the disc and head must be totally free from contaminants or serious problems may result. Any particle carried under the head is likely to weld itself in place owing to the high relative speed, then acting as a nucleus for the collection of further debris. In the absence of a regular inspection programme, the build up of debris continues until the flying characteristics of the head are so impaired that contact is made with the disc surface. A regenerative process now begins as the oxide torn from the pack, welded to the head by the heat generated, makes a more effective tool to remove more oxide. This rare occurrence, resulting from neglect, is called a head crash and usually destroys both head and disc.

Most of the heat from the spindle motor, which may be up to 500W, is dissipated in the air surrounding the disc, so some form of cooling is required. Cooling and filtration systems are usually combined as, for example, in the full-flow air system, in which room air is drawn in through a pre-filter to remove large contaminants, such as hair and fluff, and then forced through an absolute filter by the blower. The pores of the absolute filter are so small that nothing much larger than a gas molecule can pass through them.

The filter is made of a special grade of paper, which is corrugated and folded to present a large surface area. Some filters may have a working area of over 20 square feet, and yet are no larger than a cereal packet. The condition of the filter is monitored by measuring the pressure drop across it, typically half an inch of water. Air from the filter passes into the shroud surrounding the disc, from which the only exit is through the e.m.a. As a result the head area is kept clean and heat generated by the disc and the e.m.a. coil carried away.

On some units the blower motor also drives a fan to cool the logic circuits, power supply and servo-amplifier modules. On others the blower motor is dispensed with, and the rotation of the disc itself draws air through the system. In this case, the circuits require separate cooling. In a full-flow system, the environment must be clean if the absolute filter is to have a reasonable service life.

Where a drive is expected to operate in an office environment, a closed-circuit clean air system can be used, in which clean air recirculates through the disc, the positioner and the absolute filter, and through the 'clean side' of a heat exchanger. Room air is blown through the 'dirty side' of the heat exchanger to cool the disc and positioner. Mechanical noise from a closed-circuit system is lower than with a full-flow system, a further asset in an office environment. Noise from conventional disc-drive blowers is appreciable, but seldom adds to the existing noise level in a computer room.

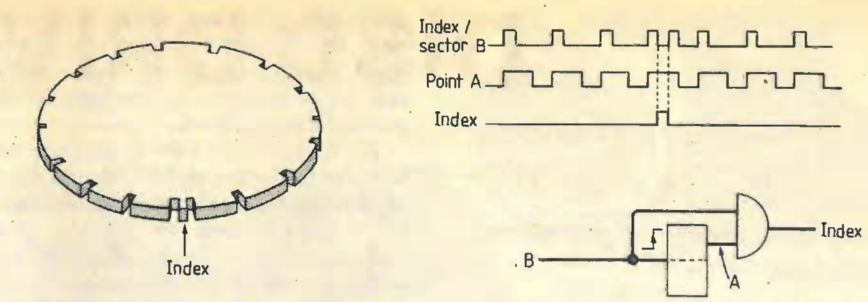



*Fig. 3. Pulses indicating sector positions on a disc are derived from slots cut in the edge of the protection platter or in the disc hub. A double slot, detected by the circuit shown, is used to derive a separate pulse for resetting the sector counter.*

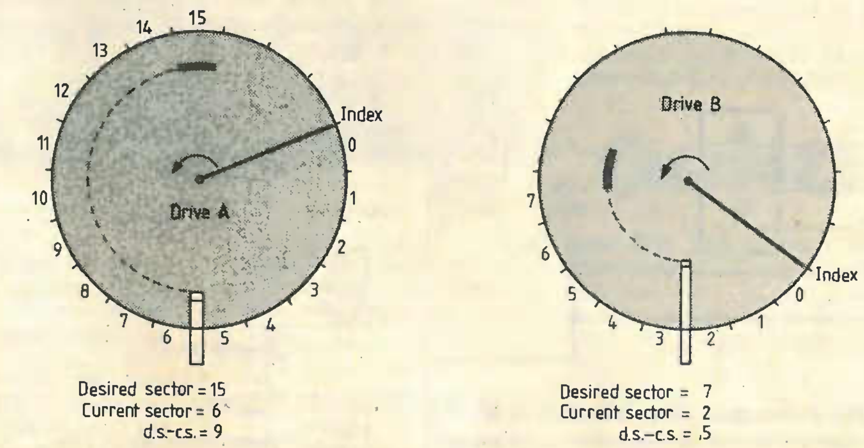


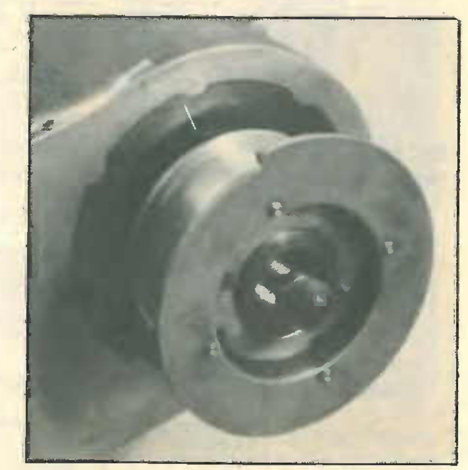

*Fig. 4. A comparison between the desired-sector register and the current-sector register tells the logic circuits when the required transfer will take place. Using this information, the system can schedule data transfers from different discs for greater efficiency. In the example shown, it is clear that the data block on the right-hand disc should be read first. Because of this function, the current-sector register is often referred to as the look-ahead register.*

Air conditioning is often necessary in computer installations, to carry away the heat dissipated by the equipment and to filter the air. Humidity control is also needed because a low moisture content causes static electricity problems, whereas high moisture content causes dimensional changes to most papers and plastics. The readability of punched cards, paper tape and magnetic tape may be affected.

Dimensions of the disc and the components of the positioner are affected by thermal expansion, and temperature control may be necessary to prevent head/track misalignment. As the drive may take some time to reach thermal equilibrium with its surroundings, manufacturers often specify a maximum temperature gradient for a particular unit. Many air conditioners control temperature by turning on and off the compressor, resulting in temperature steps in the air supply. For this reason disc drives should not be situated close to air conditioner outlets, but should be allowed to take in air which has had the opportunity to mix. When installing a disc-cooling system, thought has also to be given to the airflow requirements of adjacent equipment. Many disc drives take in air at the bottom and exhaust leaves at the top, whereas many processors take in air at the top and exhaust at the bottom. If the units are badly positioned, used air will recirculate, rather than flow back to the air conditioner.

## Power supplies and grounding

A typical disc drive will contain circuits of many different kinds, both analogue and logical, from low-noise linear amplifiers at



*Spindle speed and direction of rotation information is provided by a snail cam, shown here, in conjunction with a transducer. At the end of the spindle, a small carbon ground button makes contact with its mating part when assembled to provide a discharge path for static electricity.*

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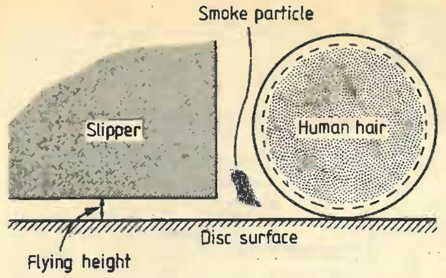



*Fig. 5. Common contaminants dwarf the flying height of a typical disc head, illustrating the need for air filtration, clean surroundings and careful handling.*

the heads, to high-power e.m.a. drivers; from slow transistor logic to e.c.l. in the serial-binary data channel. Many supply rails are necessary to feed the various component families, Fig. 6.

The signal from a reading head may only be a few millivolts, and in order to ensure reliable operation, the read channel has to be as noise immune as possible. In an earlier article it was explained that the read amplifiers are differential for noise rejection, and the read-write matrix is usually entirely screened for the same reason. The remaining circuits must be designed to cause as little interference as possible.

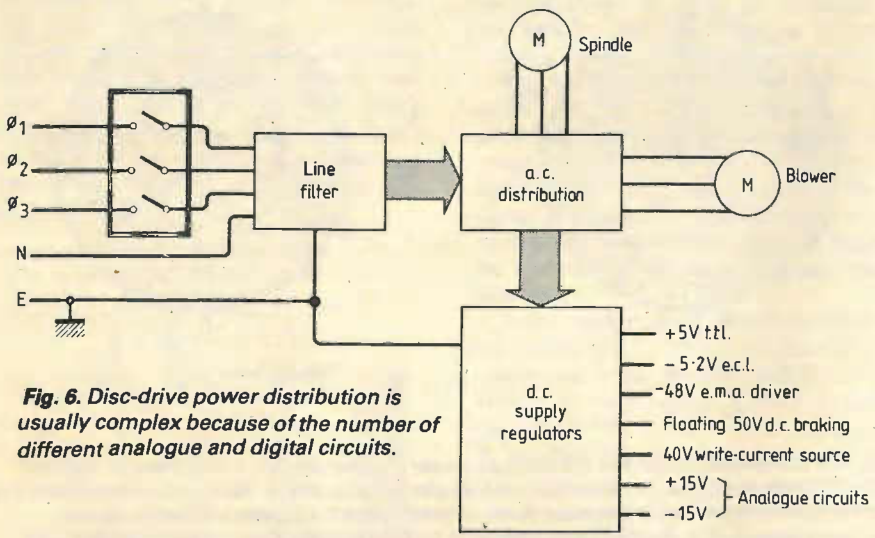



*Fig. 6. Disc-drive power distribution is usually complex because of the number of different analogue and digital circuits.*

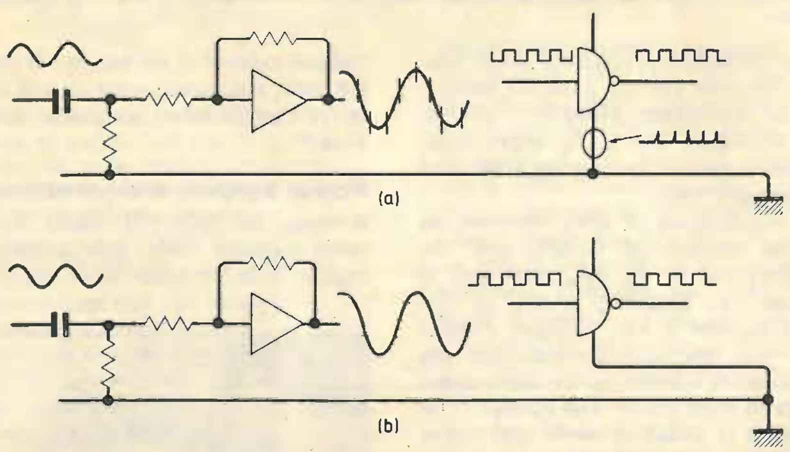



*Fig. 7. Incorrect grounding at (a) results in current spikes from the t.t.l. circuit appearing on the analogue output. Separate grounding, as shown in (b), eliminates this problem.*

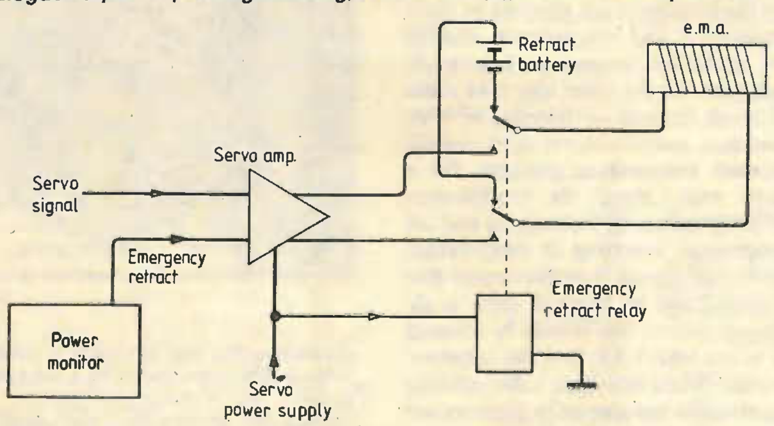



*Fig. 8. An emergency retract circuit. In the event of a logic circuit or low-level signal power failure, the positioner retracts by the normal means. Should the power supply to the servo amplifier fail, power is supplied to the retract mechanism by an NiCd battery or, in the case of larger drives, by an electrolytic capacitor.*

Switched-mode power supplies are excluded from the disc drives, but pulse-width modulated e.m.a. drivers are acceptable since no data transfer takes place during a seek, and the servo reverts to linear operation during track following.

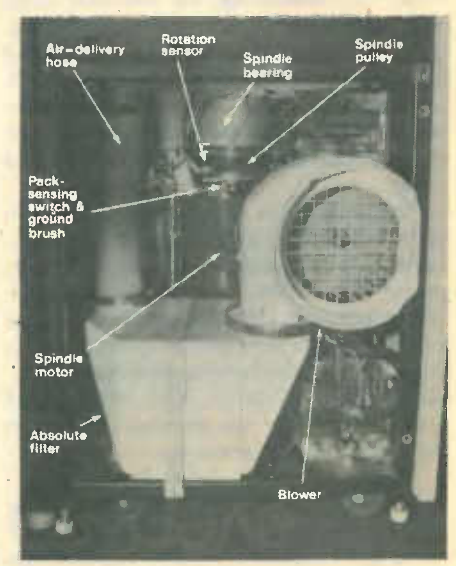
Linear-circuit supplies usually have current foldback protection, and the circuit can usually withstand the raw supply should the regulator fail. The logic supply, will, however, have an over-voltage crowbar. Some circuit breakers used have a trip coil whereby the drive can turn off its own power in the case of an over-temperature condition or insufficient airflow.

As with all mixed circuitry, the problem of ground return currents must be eliminated by careful design. Figure 7(a) shows analogue and logic signals sharing the same return. Currents from the logic inject noise into the analogue signal owing to the poor layout; Figure 7(b) shows a better layout. Many mixed circuit modules have separate connections for logic ground and analogue ground, which may find their way to the frame through quite different back-plane routes. The usual precautions must be taken with the analogue circuitry to ensure stability, which means, for example, that e.m.a. driver currents must not cause ground potentials in the analogue servo circuit.

In some drives, the grounding is split, the disc, positioner and circuitry being grounded to the host processor, and the frame and spindle motor being grounded to the a.c. supply lead.

Figure 8 shows an emergency-retract circuit used to protect the disc and heads in the event of a supply failure.

Drastic reductions in track spacings, and hence increases in storage capacity, may be made if the read/write head's position is determined by information on the disc surface. Servo systems using these techniques are described in the next article. □




*An interior view of a multi-platter disc drive showing major rotation and cooling components.*





# NEW PRODUCTS

## DATA ACQUISITION UNITS

These small data-acquisition units are designed for use by engineers and scientists who are not necessarily familiar with computers. Analogue inputs are converted to 12-bit digital information, linearized, and sent to a computer, v.d.u. or printer in serial form as ASCII characters. The linearization process, which may be bypassed, is selectable for J, K, T, S and R type thermocouples, platinum resistance thermometers and square-law sensors; cold-junction compensation is internal but may also be bypassed. Single character commands, in ASCII form may be used to control the data flow through a 20mA loop (RS232 is optional) to the computer. Alternatively, for applications such as data logging, data may be transmitted automatically. Up to 256 units, each with its own address may be connected to a single loop. Field Electronics Ltd, Gill House, Conway Street, Hove, East Sussex BN3 3LW.
**WW301**

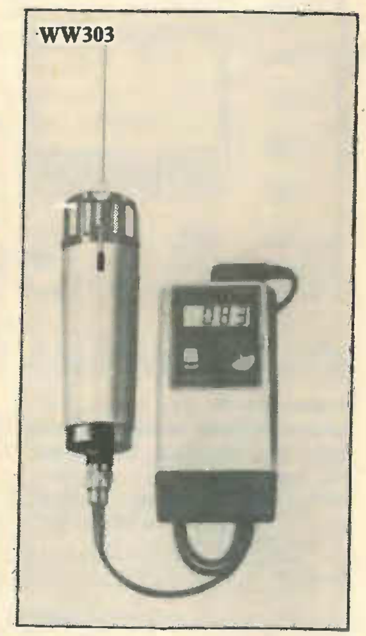

WW301

## PRINTER BUFFER/INTERFACE

Most microcomputers may not be used while they are sending information to a printer. If the printer is slow, or the amount of hard copy required large, a buffer memory may be used to take information from the computer quickly and send it out to the printer slowly, leaving the computer free. Spriinter, from Mutek, is such a buffer with RS232, Centronics and IEEE inputs and outputs that may be used in any combination. Protocol conversion, from say ASCII to Telex or TTS photo-typesetting code, is possible and the unit may be used as an interface-standard converter. With 32K of buffer memory, the Spriinter costs £255 excluding v.a.t., or with 16K, £185. A 6502 microprocessor running at 2.4MHz is used in the unit. Mutek, Quarry Hill, Box, Wilts.
**WW302**

## INFRA-RED THEMOMETER

A none-contact thermometer with an infra-red sensing device, from Prolab instruments, can be used to measure temperatures from 50 to 750°C, with a resolution of 1°C. The meter has a thermocouple input so adjustments may be made to suit the emissivity of the material being measured; the thermocouple range is 0 to 700°C. A 1mV/digit analogue output is provided and a peak hold facility may be used to store maximum readings. Up to 200°C, the meter's readings are within 2° of the actual temperature and above 200°, ±1.5%, ±1 digit. Complete with sensor, the thermometer costs £445. Prolab Instruments Co., Greenside House, Lisle Way, Emsworth, Hants P010 7XN.
**WW303**



WW303

## GRAPH SOFTWARE

As a follow up to their recently introduced software for solving mathematical problems, ISM have brought out Graphmagic, a program which turns mathematical data into graphs or diagrams. Pie charts, line graphs and bar graphs are among the examples given. At the moment, the graph software can only be run on the Apple computer but there are plans to adapt the program to run on the IBM personal computer and with CP/M. Mathemagic, however, is available for Apple, TRS80, and IBM personal computers and for use with any Z80-based microcomputer running CP/M. International Software Marketing, Hayden House, 5-6 Millmead, Guildford, Surrey GU2 5BZ.
**WW304**

## 64K DYNAMIC R.A.M.

Plastic-packaged 64K r.a.ms for industrial use are available from Hitachi in 150 or 200ns access time versions. The HM4864P may be used as a direct replacement for conventional ceramic-packaged types and costs £6.89 or £6.47 in 10-off quantities for the 150ns and 200ns types respectively. Hitachi (UK) Ltd, Hitec House, 221-225 Station Rd, Harrow, Middx.
**WW305**

## WIDEBAND ANTENNA

A relatively small 50W wideband antenna with a frequency range of 150 to 2000MHz is produced by Applied Communications. With a gain approximately equal to a half-wave dipole, the 9014 has circular polarization and is suitable for both, receiving and transmitting. The manufacturers claim that the antenna may be used with frequencies from 70 to beyond 3000MHz. With its fibre-glass housing, the 9014 measures 650 by 600 by 40mm and weighs 5.5kg. Applications include wideband laboratory measurements and general surveillance. Applied Communications (UK), Tower Street, Coventry CV1 1JP.
**WW306**

## TO-3 INSULATING PLATE

Usually, four plastic washers are required to keep a TO-3-packaged transistor's leads and mounting screws electrically isolated from its heat sink. Richco International have introduced a glass-filled nylon plate that will replace these four shoulder washers. Richco International, West Street, Erith, Kent DA8 1AA.
**WW307**

## P.C.B. PROTOTYPING AID

Boards fitted with numerous pillars are the heart of BICC-Vero's Speedwire system. On the component side of the board, these pillars form selectively gold-plated contacts into which the leads of i.cs or discrete components may be inserted. Each pillar is terminated by an insulation displacing tine for point-to-point wiring on the underside of the board; the tines are reusable and can accept two wires.

Initially, two kits are being offered. One kit contains a 100 by 160mm Eurocard board, a wiring pen and wire, and contacts with a manual insertion tool. A more comprehensive kit comprises a plated-through-hole Eurocard fitted with contacts, wiring pen and wire. BICC-Vero Packaging, Industrial Estate, Chandlers Ford, Eastleigh, Hants SO5 3ZR.
**WW308**





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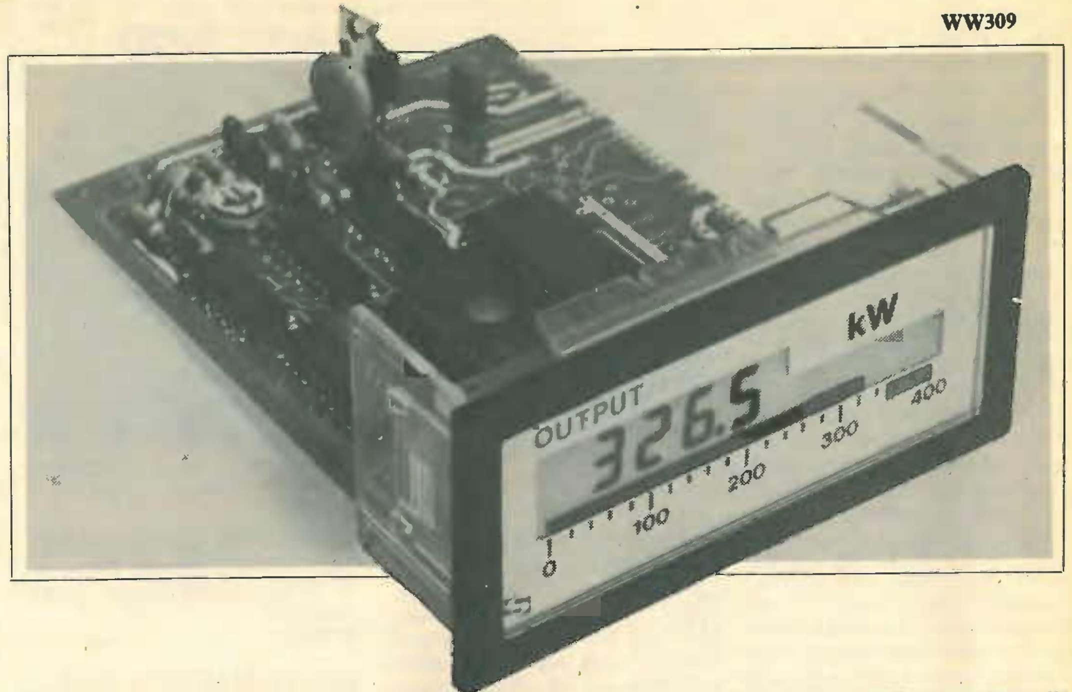
# NEW PRODUCTS

WW309




## HARMONIC SCALES

Digital displays are accurately readable, can contain as many digits as the associated electronics can support and give the impression (though not always the reality) of authority. For many purposes they are ideal: for others they cannot be used at all. If the reading changes, the display can be confusing and gives a poor indication of the direction of change, its speed or of what proportion of full scale the reading occupies. In these circumstances, an analogue indicator of some kind is a great deal more informative, so that the use of two meters is the ideal.

In a development claimed by Sifam to be unique, both kinds of indicator are used in one instrument. The Harmony is a multi-purpose meter which possesses the usual kind of liquid-crystal, numerical display (albeit in several colours), but with an associated bar indicator on the same panel. Measurement accuracy is the province of the digital readout, the function of the bar being to indicate the reading fairly coarsely, following changes to show the direction and rate of change and the position of the digital reading against a background of full scale. The bar can be left, right, centre or offset zero, and both displays may be of the suppressed-zero type.

By means of a built-in microprocessor and e.p.r.o.m., the meter can be used for a variety of functions, can display any desired unit, and can cope with non-linear characteristics. Relevant information on range, units in use, decimal-point position and function selected appears on the display.

Harmony is made by Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY and costs £35 in small quantities.

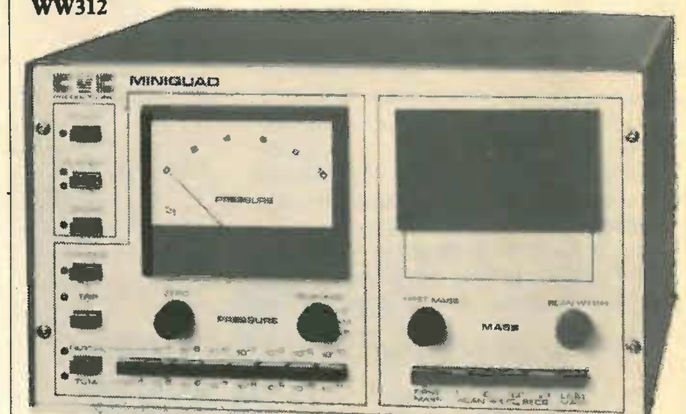
**WW309**

## BRIGHT LEDS

Seven-segment l.e.d. displays giving light outputs in excess of 5mcd at 10mA/2V are available through IMO Electronics. Both common-anode and common-cathode types are available in heights of 8, 10, 12.5 and 15mm. Pin spacings of the 6000 series displays conform to the standard 0.1in matrix. These displays are "ten times brighter than other manufacturers' equivalents", and "have an unsurpassed uniformity of brilliance", claims the distributor. IMO will not say who manufactures these leds, but they assure us that they are made in Japan. We encountered exactly the same response when we approached the blue led's distributors (*WW*, May) but we are almost certain that there are only two major Japanese manufacturers making blue leds – Matsushita and Sanyo (neither UK subsidiary has these blue leds or any knowledge of a deal). Finding out who might manufacture these seven-segment displays is going to be a harder task. IMO Electronics Ltd, 1000 North Circular Road, Staples Corner, London NW2 7JP.

**WW310**

WW312

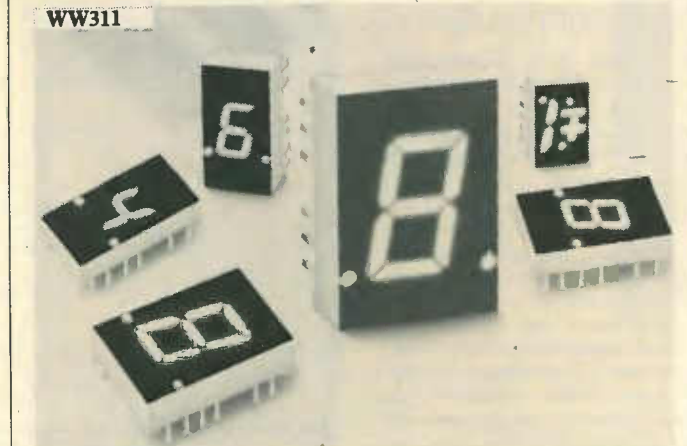



## 16K STATIC R.A.M.

A second-source device, the MV5516 c.m.o.s. static r.a.m., is the first large-scale integration memory to appear from Plessey Semiconductors. The manufacturers say that their 2K by 8-bit word memory will be attractive to UK buyers requiring large quantities and reliable after-sales back up. Two chip-enable inputs are used, one for memory access in 250ns and the second, for 0.25μW power consumption in standby mode. While operating, the device consumes around 200mW. The 24-pin package has the same configuration as the 2716 e.p.r.o.m., and its outputs and inputs are t.t.l. compatible. Plessey Semiconductors Ltd, Cheyney Manor, Swindon, Wilts SN2 2QW.

**WW311**

WW311



## RESIDUAL-GAS ANALYSER

Sputtering-vacuum impurities cause problems in semiconductor manufacturing processes. According to CVC, manufacturers of the Miniquad gas analyser, total-pressure gauges often used to judge impurities in this application have limitations in that they are not capable of measuring individual residual gases accurately. Their instrument will detect partial pressures of all gases of interest and can be used to initiate a sputtering process automatically once a desired partial pressure has been reached. Besides gas analysis, the apparatus aids detection of leaks, vacuum fingerprinting and impurities. Detector heads are interchangeable so the unit may be used for monitoring in different types of system. CVC Scientific Products Ltd, Eastheath Avenue, Wokingham, Berks RG11 2PW.

**WW312**





**DP-824-24 PRINTER KIT SPECIAL OFFER**

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1pc DP-824F-24 Printer Mechanism
1pc DPC-4A Controller Chip
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WW – 069 FOR FURTHER DETAILS

RUSH

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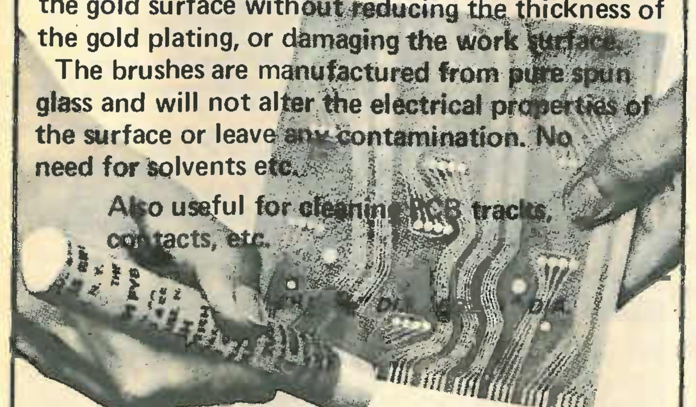
The brushes are manufactured from pure spun glass and will not alter the electrical properties of the surface or leave any contamination. No need for solvents etc.
Also useful for cleaning PCB tracks, contacts, etc.



Eraser International Ltd.,
Unit M, Portway Industrial Estate,
Andover, Hants SP10 3LU.
Tel: Andover (0264) 51347/8 Telex: 477291

WW – 067 FOR FURTHER DETAILS

**LION TELETEXT PRESTEL ADAPTOR**

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★ 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:
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**LONDON SW10. 01-373 5218**

WW – 072 FOR FURTHER DETAILS





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**74LS TTL**

| | |
|---|---|
| LS00 | 12p |
| LS01 | 12p |
| LS02 | 14p |
| LS03 | 15p |
| LS04 | 15p |
| LS05 | 15p |
| LS08 | 15p |
| LS09 | 15p |
| LS10 | 15p |
| LS11 | 15p |
| LS12 | 15p |
| LS13 | 29p |
| LS14 | 45p |
| LS15 | 15p |
| LS20 | 15p |
| LS21 | 15p |
| LS22 | 15p |
| LS26 | 20p |
| LS27 | 18p |
| LS28 | 20p |
| LS30 | 16p |
| LS32 | 15p |
| LS33 | 16p |
| LS37 | 16p |
| LS38 | 16p |
| LS40 | 16p |
| LS42 | 38p |
| LS47 | 50p |
| LS48 | 72p |
| LS49 | 65p |
| LS51 | 15p |
| LS54 | 16p |
| LS55 | 25p |
| LS73A | 28p |
| LS74A | 24p |
| LS75 | 30p |
| LS76A | 30p |
| LS77 | 32p |
| LS78A | 32p |
| LS83A | 48p |
| LS85 | 65p |
| LS86 | 30p |
| LS90 | 38p |
| LS91 | 75p |
| LS92 | 38p |
| LS93 | 38p |
| LS95B | 45p |
| LS107A | 45p |
| LS109A | 30p |
| LS112A | 30p |
| LS113A | 35p |
| LS114A | 35p |
| LS122 | 42p |
| LS123 | 50p |
| LS125A | 35p |
| LS126A | 35p |
| LS132 | 42p |
| LS133 | 36p |
| LS136 | 30p |
| LS137 | 45p |

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|---|---|
| LS138 | 35p |
| LS139 | 37p |
| LS145 | 85p |
| LS151 | 40p |
| LS153 | 40p |
| LS155 | 40p |
| LS156 | 40p |
| LS157 | 35p |
| LS158 | 35p |
| LS160A | 42p |
| LS161A | 42p |
| LS162A | 42p |
| LS163A | 42p |
| LS164 | 48p |
| LS165 | 70p |
| LS166 | 80p |
| LS168 | 120p |
| LS169 | 120p |
| LS170 | 95p |
| LS173 | 70p |
| LS174 | 63p |
| LS175 | 55p |
| LS181 | 125p |
| LS182 | 120p |
| LS183 | 120p |
| LS190 | 60p |
| LS191 | 60p |
| LS192 | 60p |
| LS193 | 60p |
| LS194A | 45p |
| LS195A | 45p |
| LS196 | 65p |
| LS197 | 65p |
| LS221 | 55p |
| LS240 | 80p |
| LS241 | 80p |
| LS242 | 80p |
| LS243 | 80p |
| LS244 | 80p |
| LS245 | 95p |
| LS251 | 40p |
| LS253 | 40p |
| LS256 | 96p |
| LS257A | 42p |
| LS258A | 42p |
| LS259 | 80p |
| LS260 | 22p |
| LS266 | 22p |
| LS273 | 80p |
| LS279 | 80p |
| LS283 | 45p |
| LS290 | 45p |
| LS293 | 45p |
| LS295A | 96p |
| LS298 | 90p |
| LS352 | 96p |
| LS353 | 96p |
| LS365A | 40p |
| LS366A | 40p |
| LS367A | 40p |
| LS368A | 55p |

| | |
|---|---|
| LS373 | 75p |
| LS374 | 75p |
| LS375 | 45p |
| LS377 | 75p |
| LS378 | 75p |
| LS379 | 65p |
| LS385 | 260p |
| LS386 | 45p |
| LS390 | 85p |
| LS393 | 58p |
| LS395 | 150p |
| LS398 | 130p |
| LS399 | 120p |
| LS490 | 120p |
| LS540 | 105p |
| LS541 | 140p |
| LS568 | 345p |
| LS569 | 345p |
| LS640 | 190p |
| LS641 | 190p |
| LS642 | 190p |
| LS643 | 190p |
| LS644 | 200p |
| LS645 | 190p |
| LS670 | 135p |
| LS796 | 210p |
| LS797 | 210p |
| LS798 | 210p |

**CMOS 4000B**

| | |
|---|---|
| 4000 | 14p |
| 4001 | 14p |
| 4001U | 14p |
| 4002 | 14p |
| 4002U | 14p |
| 4006 | 65p |
| 4007 | 16p |
| 4008 | 65p |
| 4011 | 14p |
| 4011U | 14p |
| 4012 | 16p |
| 4012U | 16p |
| 4013 | 33p |
| 4014 | 70p |
| 4015 | 85p |
| 4016 | 35p |
| 4017 | 48p |
| 4018 | 65p |
| 4020 | 65p |
| 4021 | 72p |
| 4022 | 70p |
| 4023 | 16p |
| 4023U | 16p |
| 4024 | 55p |
| 4025 | 18p |
| 4025U | 18p |
| 4027 | 37p |
| 4028 | 48p |
| 4029 | 60p |
| 4032 | 120p |
| 4034 | 165p |

| | |
|---|---|
| 4035 | 90p |
| 4038 | 120p |
| 4040 | 58p |
| 4042 | 62p |
| 4043 | 70p |
| 4044 | 70p |
| 4046 | 65p |
| 4049U | 28p |
| 4050 | 28p |
| 4051 | 72p |
| 4052 | 72p |
| 4053 | 72p |
| 4060 | 90p |
| 4066 | 35p |
| 4068 | 18p |
| 4069U | 18p |
| 4070 | 20p |
| 4071 | 20p |
| 4072 | 20p |
| 4073 | 20p |
| 4075 | 20p |
| 4076 | 85p |
| 4077 | 20p |
| 4078 | 20p |
| 4081 | 20p |
| 4082 | 20p |
| 4093 | 40p |
| 4094 | 120p |
| 4099 | 110p |
| 4160 | 80p |
| 4161 | 80p |
| 4162 | 80p |
| 4163 | 80p |
| 4174 | 80p |
| 4175 | 100p |
| 4194 | 100p |
| 4433 | 820p |
| 4443 | 390p |
| 4447 | 390p |
| 4493 | 320p |
| 4494 | 320p |
| 4495 | 320p |
| 4499 | 330p |
| 4501U | 25p |
| 4502 | 89p |
| 4503 | 60p |
| 4504 | 100p |
| 4506 | 68p |
| 4508 | 240p |
| 4510 | 75p |
| 4511 | 75p |
| 4512 | 75p |
| 4513 | 160p |
| 4514 | 180p |
| 4515 | 180p |
| 4516 | 90p |
| 4517 | 290p |
| 4518 | 56p |
| 4519 | 36p |
| 4520 | 80p |
| 4521 | 195p |

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|---|---|
| 4522 | 110p |
| 4526 | 110p |
| 4527 | 110p |
| 4528 | 90p |
| 4529 | 120p |
| 4530 | 90p |
| 4531 | 95p |
| 4532 | 120p |
| 4534 | 480p |
| 4536 | 290p |
| 4538 | 105p |
| 4539 | 105p |
| 4541 | 110p |
| 4543 | 170p |
| 4544 | 120p |
| 4547 | 130p |
| 4549 | 380p |
| 4551 | 105p |
| 4553 | 295p |
| 4554 | 165p |
| 4555 | 70p |
| 4556 | 75p |
| 4557 | 280p |
| 4558 | 125p |
| 4559 | 410p |
| 4560 | 180p |
| 4561 | 100p |
| 4562 | 395p |
| 4566 | 165p |
| 4568 | 280p |
| 4569 | 170p |
| 4572U | 38p |
| 4580 | 395p |
| 4581 | 240p |
| 4582 | 65p |
| 4583 | 105p |
| 4584 | 50p |
| 4585 | 95p |
| 4597 | 295p |
| 4598 | 295p |
| 4599 | 290p |
| 44100 | 625p |
| 44110 | 498p |
| 44111 | 450p |
| 44115 | 426p |

**LINEAR**

| | |
|---|---|
| 709 | 35p |
| 741 | 16p |
| 741S | 55p |
| 747 | 65p |
| 748 | 35p |
| LF355 | 80p |
| LF356 | 90p |
| LF357 | 100p |
| LM301A | 30p |
| LM307 | 50p |
| LM308A | 95p |
| LM311N | 80p |
| LM324 | 45p |

| | |
|---|---|
| LM339 | 55p |
| LM348 | 80p |
| LM358 | 60p |
| MC1455 | 66p |
| MC1456 | 135p |
| MC1458 | 45p |
| MC3302 | 95p |
| MC3401 | 65p |
| MC3403 | 70p |
| MC3456 | 107p |
| MC34001 | 58p |
| NE555 | 16p |
| NE556 | 45p |
| NE565 | 165p |
| NE567 | 140p |
| SN76477 | 175p |
| TL061 | 40p |
| TL062 | 60p |
| TL064 | 98p |
| TL071 | 30p |
| TL072 | 50p |
| TL074 | 100p |
| TL081 | 25p |
| TL082 | 45p |
| TL084 | 95p |

**TRANSISTORS**

| | |
|---|---|
| BC107 | 12p |
| BC107B | 15p |
| BC108 | 12p |
| BC108B | 15p |
| BC109 | 12p |
| BC109B | 15p |
| BC109C | 15p |
| BC177 | 25p |
| BC178 | 25p |
| BC179 | 25p |
| BC182 | 10p |
| BC182A | 10p |
| BC182B | 10p |
| BC183A | 10p |
| BC183C | 10p |
| BC184 | 10p |
| BC184C | 10p |
| BC212 | 10p |
| BC212A | 10p |
| BC212B | 10p |
| BC213A | 10p |
| BC213C | 10p |
| BC214 | 10p |
| BC214C | 10p |
| BC237A | 12p |
| BC237C | 12p |
| BC238 | 12p |
| BC238A | 12p |
| BC238B | 12p |
| BC238C | 12p |
| BC239 | 12p |
| BC307A | 12p |

| | |
|---|---|
| BC307C | 15p |
| BC308 | 15p |
| BC308A | 15p |
| BC308B | 15p |
| BC308C | 15p |
| BC309 | 15p |
| BC309C | 15p |
| BC327 | 15p |
| BC328 | 15p |
| BC337 | 15p |
| BC338 | 15p |
| BCY70 | 20p |
| BCY71 | 20p |
| BCY72 | 20p |
| BD135 | 40p |
| BD136 | 48p |
| BD139 | 45p |
| BD140 | 45p |
| BD165 | 45p |
| BD166 | 45p |
| BD169 | 45p |
| BD170 | 45p |
| BD677 | 60p |
| BD678 | 80p |
| BD679A | 60p |
| BD680A | 60p |
| BFY50 | 25p |
| BFY51 | 25p |
| BF244A | 30p |
| MJE241 | 80p |
| MJE251 | 80p |
| MJE340 | 80p |
| MJE350 | 80p |
| MJE370 | 95p |
| MJE520 | 95p |
| MJE2955 | 90p |
| MJE3055 | 65p |
| MPF102 | 45p |
| MPS2369 | 30p |
| MPS3640 | 30p |
| MPS3646 | 30p |
| MPSA06 | 20p |
| MPSA13 | 20p |
| MPSA14 | 20p |
| MPSA18 | 20p |
| MPSA27 | 20p |
| MPSA42 | 25p |
| MPSA56 | 25p |
| MPSA63 | 30p |
| MPSA64 | 30p |
| MPSA77 | 45p |
| MPSA92 | 30p |
| TIP29 | 35p |
| TIP29A | 35p |
| TIP29B | 55p |
| TIP29C | 60p |
| TIP30 | 50p |
| TIP30A | 50p |
| TIP30B | 50p |
| TIP30C | 50p |
| TIP31A | 45p |

| | |
|---|---|
| TIP31B | 48p |
| TIP31C | 55p |
| TIP32 | 50p |
| TIP32A | 50p |
| TIP32B | 60p |
| TIP32C | 65p |
| TIP33 | 65p |
| TIP33A | 65p |
| TIP33B | 70p |
| TIP33C | 75p |
| TIP34 | 75p |
| TIP34A | 75p |
| TIP34B | 99p |
| TIP34C | 90p |
| TIP35 | 180p |
| TIP35A | 165p |
| TIP35B | 170p |
| TIP35C | 185p |
| TIP36 | 170p |
| TIP36A | 175p |
| TIP36B | 185p |
| TIP36C | 199p |
| TIP41 | 50p |
| TIP41A | 55p |
| TIP41B | 60p |
| TIP41C | 60p |
| TIP42 | 58p |
| TIP42A | 60p |
| TIP42B | 75p |
| TIP42C | 75p |
| TIP47 | 50p |
| TIP48 | 50p |
| TIP49 | 50p |
| TIP50 | 48p |
| TIP110 | 30p |
| TIP111 | 75p |
| TIP112 | 50p |
| TIP115 | 40p |
| TIP116 | 73p |
| TIP117 | 45p |
| TIP120 | 39p |
| TIP121 | 100p |
| TIP122 | 99p |
| TIP125 | 45p |
| TIP126 | 80p |
| TIP127 | 45p |
| TIP140 | 130p |
| TIP141 | 140p |
| TIP142 | 180p |
| TIP145 | 140p |
| TIP146 | 180p |
| TIP147 | 170p |
| TIP2955 | 60p |
| TIP3055 | 75p |
| 2N1613 | 30p |
| 2N1711 | 35p |
| 2N1893 | 35p |
| 2N2218A | 45p |
| 2N2219 | 30p |
| 2N2221/A | 30p |
| 2N2222/A | 25p |

| | |
|---|---|
| 2N2904A | 30p |
| 2N2905 | 30p |
| SN2905A | 30p |
| 2N2906A | 30p |
| 2N2907A | 25p |
| 2N3053 | 30p |
| 2N3054 | 70p |
| 2N3055 | 50p |
| 2N3439 | 80p |
| 2N3440 | 80p |
| 2N3771 | 180p |
| 2N3772 | 180p |
| 2N3773 | 250p |
| 2N3821 | 120p |
| 2N3822 | 120p |
| 2N3823 | 95p |
| 2N3824 | 95p |
| 2N3903 | 15p |
| 2N3904 | 15p |
| 2N3905 | 15p |
| 2N3906 | 15p |
| 2N4391 | 70p |
| 2N4392 | 70p |
| 2N4400 | 20p |
| 2N4401 | 25p |
| 2N4402 | 25p |
| 2N4403 | 25p |
| 2N4410 | 45p |
| 2N4416 | 95p |
| 2N4856 | 80p |
| 2N4857 | 60p |
| 2N4858 | 80p |
| 2N4918 | 95p |
| 2N4919 | 120p |
| 2N4920 | 130p |
| 2N4921 | 105p |
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| 2N5192 | 75p |
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| 68B00 | 450p |
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| 68B09 | 1495p |
| 6809E | 1295p |
| 6810 | 150p |
| 6821 | 180p |
| 68B21 | 250p |
| 6829 | 1335p |
| 6840 | 410p |

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| 68B40 | 620p |
| 6844 | 1295p |
| 6845 | 795p |
| 6850 | 165p |
| 6852 | 250p |
| 6854 | 795p |
| 6875 | 495p |
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| 8T95 | 105p |
| 8T96 | 105p |
| 8T97 | 105p |
| 8T98 | 105p |
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| 8085A | 595p |
| 8155 | 880p |
| 8212 | 170p |
| 8216 | 170p |
| 8224 | 200p |
| 8226 | 275p |
| 8228 | 280p |
| 8251 | 320p |
| 8253 | 800p |
| 8255 | 300p |
| 8257 | 800p |
| 8259 | 880p |
| 8279 | 950p |
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| MC1488 | 60p |
| MC1489 | 60p |
| MC3459 | 265p |
| 75491 | 80p |
| 75492 | 80p |

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| 78M06 | 55p |
| 78M08 | 55p |
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| 78M24 | 55p |

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| 7806 | 65p |
| 7808 | 65p |
| 7812 | 60p |
| 7815 | 60p |
| 7818 | 65p |
| 7824 | 65p |

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|---|---|
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| 79L12 | 35p |
| 79L15 | 35p |

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|---|---|
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| 7906 | 70p |
| 7908 | 70p |
| 7912 | 60p |
| 7915 | 60p |
| 7918 | 70p |
| 7924 | 65p |

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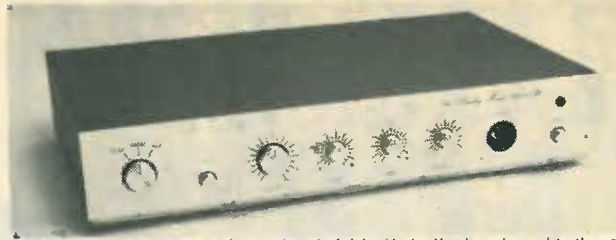

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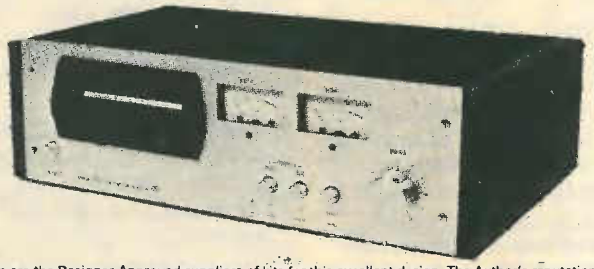

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| AAZ17 | 0.17 |
| AC107 | 0.63 |
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| AC126 | 0.29 |
| AC127 | 0.29 |
| AC128 | 0.35 |
| AC141 | 0.32 |
| AC141K | 0.40 |
| AC142 | 0.32 |
| AC142K | 0.40 |
| AC176 | 0.35 |
| AC187 | 0.32 |
| AC188 | 0.32 |
| ACY17 | 1.50 |
| ACY18 | 1.32 |
| ACY19 | 1.27 |
| ACY20 | 1.27 |
| ACY21 | 1.32 |
| ACY39 | 2.88 |
| AD149 | 0.86 |
| AD161 | 0.40 |
| AD162 | 0.40 |
| AF106 | 0.40 |
| AF114 | 0.86 |
| AF115 | 0.86 |
| AF116 | 0.86 |
| AF117 | 0.86 |
| AF139 | 0.38 |
| AF186 | 1.15 |
| AF239 | 0.45 |
| AFZ11 | 4.60 |
| AFZ12 | 4.60 |
| ASY26 | 1.61 |
| ASY27 | 1.04 |
| ASZ15 | 1.38 |
| ASZ16 | 1.27 |
| ASZ17 | 1.15 |
| ASZ20 | 2.64 |
| ASZ21 | 2.88 |
| AU113 | 2.88 |
| AUY10 | 3.45 |
| AU110 | 2.88 |
| BA145 | 0.15 |
| BA148 | 0.17 |
| BA154 | 0.12 |
| BA155 | 0.13 |
| BA156 | 0.12 |
| BAW62 | 0.06 |
| BAX13 | 0.07 |
| 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 | 0.21 |
| 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 | 0.12 |
| BC172 | 0.13 |
| BC173 | 0.13 |
| BC177 | 0.32 |
| BC178 | 0.16 |
| BC179 | 0.32 |
| BC182 | 0.13 |
| BC183 | 0.13 |
| BC184 | 0.13 |
| BC212 | 0.13 |
| BC213 | 0.13 |
| BC214 | 0.13 |
| 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 |
| BD182 | 1.36 |
| BD237 | 0.62 |
| BD238 | 0.62 |
| BDX10 | 1.05 |
| BDX32 | 2.30 |
| BDY20 | 1.73 |
| BDY60 | 3.16 |
| 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 |
| BU205 | 1.50 |
| BU206 | 1.73 |
| BU208 | 2.30 |
| BY100 | 0.46 |
| BY126 | 0.15 |
| BY127 | 0.16 |
| BZX61 Series | 0.20 |
| BZY88 Series | 0.12 |
| CRS1/40 | 0.69 |
| 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 |
| MJE3055 | 1.27 |
| 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 |
| T1C44 | 0.31 |
| T1C226D | 1.38 |
| T1L209 | 0.18 |
| T1P29A | 0.49 |
| T1P30A | 0.52 |
| T1P31A | 0.38 |
| T1P32A | 0.41 |
| T1P33A | 0.62 |
| T1P34A | 0.77 |
| T1P41A | 0.51 |
| T1P42A | 0.48 |
| T1P2955 | 0.81 |
| T1P3055 | 0.64 |
| T1S43 | 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 | 5.75 |
| 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 |
| 2S322 | 4.03 |
| 2S324 | 4.03 |
| 2S701 | 2.30 |
| 2S745A | 1.09 |
| 2S746A | 1.09 |

## VALVES

| Type | Price |
|---|---|
| A1834 | 10.35 |
| A2087 | 13.58 |
| A2134 | 20.13 |
| A2293 | 8.62 |
| A2426 | 17.63 |
| A2521 | 24.38 |
| A2900 | 14.43 |
| 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 |
| BT69 | 327.69 |
| BT79 | 333.50 |
| BT75 | 102.46 |
| BT95 | 127.02 |
| CBL31 | 2.30 |
| CL33 | 2.30 |
| CY31 | 13.58 |
| C1K | 21.30 |
| C3A | 11.50 |
| C3JA | 23.23 |
| DA41 | 28.75 |
| 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 | 5.75 |
| 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 | 2.02 |
| ECC808 | 2.59 |
| ECF80 | 1.24 |
| ECF82 | 1.38 |
| ECF86 | 1.73 |
| ECH35 | 2.30 |
| ECH42 | 1.32 |
| 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 | 0.92 |
| EF804S | 12.65 |
| EF805S | 12.65 |
| EH90 | 1.61 |
| EK90 | 1.24 |
| EL32 | 1.73 |
| EL33 | 4.02 |
| EL34TH | 2.53 |
| EL34MUL | 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 | 1.73 |
| 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 | 2.30 |
| GZ37 | 4.60 |
| KT61 | 4.02 |
| KT66 | 5.75 |
| 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 | 8.51 |
| M8091 | 11.99 |
| M8096 | 4.31 |
| M8097 | 5.50 |
| M8098 | 5.50 |
| M8099 | 5.86 |
| 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 | 1.56 |
| PCC189 | 1.61 |
| PCC805 | 1.51 |
| PCC806 | 2.07 |
| PCF80 | 1.38 |
| 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 | 37.54 |
| RR3-1250 | 94.83 |
| S11E12 | 55.20 |
| S130 | 3.45 |
| S130P | 4.03 |
| ST280-40 | 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 | 155.42 |
| XG5-500 | 28.23 |
| 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 | 40.25 |
| 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 |
| 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 | 2.30 |
| 6F23 | 1.84 |
| 6F28 | 1.33 |
| 6H1 | 34.50 |
| 6H6 | 14.38 |
| 6H2N | 1.21 |
| 6H3N | 1.21 |
| 6J4 | 6.10 |
| 6J5 | 1.61 |
| 6J6 | 2.88 |
| 6J7 | 1.88 |
| 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 |
| 12E11TT | 19.26 |
| 12E14 | 34.50 |
| 13E1 | 123.05 |
| 19H5 | 28.75 |
| 19H4 | 40.25 |
| 24B9 | 55.20 |
| 30C15 | 1.84 |
| 30C17 | 1.84 |
| 30C18 | 1.84 |
| 30F5 | 1.93 |
| 30FL1/2 | 1.88 |
| 30FL12 | 2.07 |
| 30FL14 | 1.84 |
| 30L1 | 1.15 |
| 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 | 3.35 |
| 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 | 5.75 |
| 5814A | 2.28 |
| 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

| Type | Price |
|---|---|
| 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

| Type | Price |
|---|---|
| 2AP1 | 9.78 |
| 2BP1 | 10.35 |
| 3BP1 | 11.50 |
| 3DP1 | 5.75 |
| 3EG1 | 11.50 |
| 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

| Type | Price |
|---|---|
| 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 |
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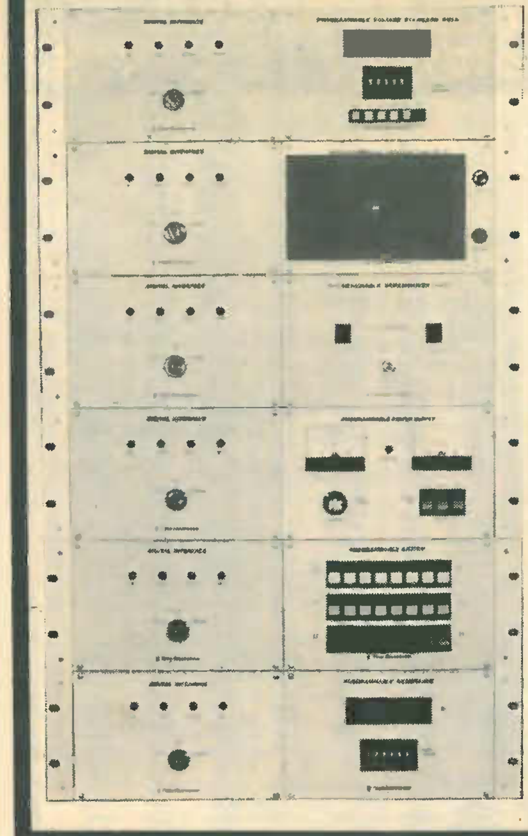

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| E88CC/01 | 3.10 | | 9.20* | UBL21 | 1.75 | 6BW7 | 0.90 | 12SQ7GT | 0.85 | | 41.80 |
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| ECC85 | 0.60 | PCF84 | 0.75 | | 82.90 | 6GA8 | 1.95 | 30C17 | 0.50 | YL 1440 | |
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| ECC88 | 0.80 | PCF87 | 0.50 | Z749 | 0.75 | 6H6 | 1.80 | 30F5 | 1.15 | CV1597 | |
| ECC189 | 0.95 | PCF200 | 1.45 | Z800U | 3.45 | 6J4 | 1.35 | 30FL2 | 1.40 | CV2116 | |
| ECC804 | 0.90 | PCF201 | 1.65 | Z801U | 3.75 | 6J4WA | 2.00 | 30FL12 | 1.25 | BR 189 | |
| ECF80 | 0.85 | PCF800 | 0.50 | Z803U | 16.00 | 6J5 | 2.30 | 30FL14 | 2.15 | BR 179 | |
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| ECF801 | 1.05 | PCF802 | 0.70 | 1A3 | 0.85 | 6J6 | 0.65 | 30L17 | 1.10 | GMU 2 | |
| ECH34 | 2.25 | PCF806 | 1.20 | 1L4 | 0.50 | 6J6W | 0.90 | 30P12 | 1.15 | TY4-500 | |
| ECH35 | 1.70 | PCF808 | 1.45 | 1R5 | 0.60 | 6JE6C | 2.95 | 30PL13 | 1.25 | BK485/5552A | |
| | 2.10* | PCH200 | 1.35 | 1S4 | 0.45 | 6JS6C | 2.95 | 30PL14 | 2.45 | MIL 5948/1754 | |
| ECH42 | 1.20 | PCL81 | 0.75 | 1S5 | 0.45 | 6K7 | 0.80 | 35L6GT | 1.40 | | |
| ECH81 | 0.70 | PCL82 | 0.95 | 1T4 | 0.45 | 6KD6 | 3.35 | 35W4 | 0.80 | | |
| ECH84 | 0.80 | PCL84 | 0.90 | 1U4 | 0.60 | 6L6M | 2.80 | 35Z4GT | 0.80 | | |
| ECL80 | 0.70 | PCL86 | 0.75 | 1X2B | 1.40 | 6L6G | 2.50 | 50C5 | 1.15 | IC | |
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| EF83 | 1.75 | PL83 | 0.60 | 3D6 | 0.50 | 6Q7G | 1.30 | | 2.55* | SN74453P | 1.10 |
| EF85 | 0.60 | PL84 | 0.95 | 3D22 | 23.00 | 6SA7 | 1.00 | 807 | 1.25 | SN7453N | 0.18 |
| EF86 | 0.75 | PL504 | 1.00 | 3E29 | 19.00 | 6SG7 | 1.15 | | 1.90* | SN74L73N | 0.38 |
| EF89 | 1.05 | PL508 | 1.95 | 3S4 | 0.60 | 6SJ7 | 1.05 | 813 | 19.32 | SN7474N | 0.30 |
| EF91 | 1.50 | PL509 | 3.20 | 4B32 | 18.25 | 6SK7 | 0.95 | | 88.50* | SN7485N | 0.95 |
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| EF96 | 0.80 | | 6.10* | 5B/258M | 12.50 | 6SR7 | 1.10 | 866A | 3.80 | SN74123N | 0.42 |
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| EF184 | 0.80 | PY33 | 0.70 | 5R4GY | 1.80 | 6V6G | 1.50 | 931A | 13.80 | SN15836N | 0.26 |
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| EFL200 | 1.85 | PY81/800 | 0.85 | 5V4G | 0.75 | 6X4 | 0.95 | 955 | 1.20 | SN76013N | 1.80 |
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| EL32 | 1.10 | PY83 | 0.80 | 5Z3 | 1.50 | 6X5GT | 0.65 | 957 | 1.05 | SN76033N | 1.35 |
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| EL86 | 0.95 | QQV03-20A | | 6AG5 | 0.60 | 9D6 | 2.90 | 5881 | 3.40 | B1702AL | 3.30 |
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| EL509 | 3.95 | QV03-12 | 4.20 | 6AM5 | 4.20 | 12AT6 | 0.70 | 6067 | 2.30 | MIC945-5D | 0.28 |
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| | 1x011 | 9+9 | 1.66 | |
| | 1x012 | 12+12 | 1.25 | |
| | 1x013 | 15+15 | 1.00 | |
| | 1x014 | 18+18 | 0.83 | |
| | 1x015 | 22+22 | 0.68 | |
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| | 1x017 | 30+30 | 0.50 | |
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| | 2x014 | 18+18 | 1.38 | |
| | 2x015 | 22+22 | 1.13 | |
| | 2x016 | 25+25 | 1.00 | |
| | 2x017 | 30+30 | 0.83 | |
| | 2x028 | 110 | 0.45 | |
| | 2x029 | 220 | 0.22 | |
| | 2x030 | 240 | 0.20 | |
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| | 3x015 | 22+22 | 1.81 | |
| | 3x016 | 25+25 | 1.60 | |
| | 3x017 | 30+30 | 1.33 | |
| | 3x028 | 110 | 0.72 | |
| | 3x029 | 220 | 0.36 | |
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| | 5x016 | 25+25 | 3.20 | |
| | 5x017 | 30+30 | 2.66 | |
| | 5x018 | 35+35 | 2.28 | |
| | 5x026 | 40+40 | 2.00 | |
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| | 6x016 | 25+25 | 4.50 | |
| | 6x017 | 30+30 | 3 75 | |
| | 6x018 | 35+35 | 3.21 | |
| | 6x026 | 40+40 | 2.81 | |
| | 6x025 | 45+45 | 2.50 | |
| | 6x033 | 50+50 | 2.25 | |
| | 6x028 | 110 | 2.04 | |
| | 6x029 | 220 | 1.02 | |
| | 6x030 | 240 | 0.93 | |
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| | 7x017 | 30+30 | 5.00 | |
| | 7x018 | 35+35 | 4.26 | |
| | 7x026 | 40+40 | 3.75 | |
| | 7x025 | 45+45 | 3.33 | |
| | 7x033 | 50+50 | 3 00 | |
| | 7x028 | 110 | 2.72 | |
| | 7x029 | 220 | 1.36 | |
| | 7x030 | 240 | 1 25 | |
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| | 8x026 | 40+40 | 6.25 | |
| | 8x025 | 45+45 | 5.55 | |
| | 8x033 | 50+50 | 5.00 | |
| | 8x042 | 55+55 | 4.54 | |
| | 8x028 | 110 | 4.54 | |
| | 8x029 | 220 | 2.27 | |
| | 8x030 | 240 | 2.08 | |
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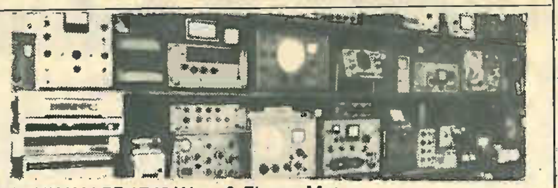

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| 17 | 16 | 8.0 | 12.97 | 2.12 |
| 115 | 20 | 10.0 | 17.46 | 2.44 |
| 187 | 30 | 15.0 | 21.69 | 2.64 |
| 226 | 60 | 30.0 | 44.45 | OA |

### 50 VOLT RANGE

2×25V tapped sec's. Volts 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 | 0.5 | 1 | 4.13 | 1.40 |
| 103 | 1 | 2 | 5.03 | 1.40 |
| 104 | 2 | 4 | 8.69 | 1.84 |
| 105 | 3 | 6 | 10.36 | 1.90 |
| 106 | 4 | 8 | 14.10 | 2.12 |
| 107 | 6 | 12 | 16.37 | 1.84 |
| 118 | 8 | 16 | 24.52 | 2.70 |
| 119 | 10 | 20 | 30.23 | OA |
| 109 | 12 | 24 | 36.18 | OA |

### 30 VOLT RANGE

Sec. Volts available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V or 15V-0-15V

| Ref. | Amps 30v | 15v | £ | P&P |
|---|---|---|---|---|
| 112 | 0.5 | 1 | 3.19 | 1.20 |
| 79 | 1 | 2 | 4.32 | 1.40 |
| 3 | 2 | 4 | 6.99 | 1.60 |
| 20 | 3 | 6 | 8.10 | 1.85 |
| 21 | 4 | 8 | 9.67 | 1.90 |
| 51 | 5 | 10 | 11.95 | 2.00 |
| 117 | 6 | 12 | 13.52 | 2.02 |
| 88 | 8 | 16 | 18.10 | 2.26 |
| 89 | 10 | 20 | 20.88 | 2.24 |
| 90 | 12 | 24 | 23.20 | OA |
| 91 | 15 | 30 | 26.60 | 3.00 |
| 92 | 20 | 40 | 35.64 | 4.83 |

### 60 VOLT RANGE

Pri 0-120V×2
2×30V tapped secs volts 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 | 0.5 | 1 | 4.70 | 1.50 |
| 126 | 1 | 2 | 7.15 | 1.50 |
| 127 | 2 | 4 | 9.20 | 1.90 |
| 125 | 3 | 6 | 13.31 | 2.02 |
| 123 | 4 | 8 | 15.15 | 2.26 |
| 40 | 5 | 10 | 19.16 | 2.24 |
| 120 | 6 | 12 | 21.86 | 2.64 |
| 121 | 8 | 16 | 30.72 | OA |
| 122 | 10 | 20 | 35.76 | OA |
| 189 | 12 | 24 | 41.22 | OA |

### SCREENED MINIATURES Pri 240V

| Ref. | mA | Sec Volts | £ | P&P |
|---|---|---|---|---|
| 238 | 200 | 3-0-3 | 3.11 | .90 |
| 212 | 1A, 1A | 0-6, 0-6 | 3.45 | 1.20 |
| 13 | 100 | 9-0-9 | 2.59 | .80 |
| 235 | 330, 330 | 0-9, 0-9 | 2.41 | .90 |
| 207 | 500, 500 | 0-8-9, 0-8-9 | 3.36 | 1.20 |
| 208 | 1A, 1A | 0-8-9, 0-8-9 | 4.27 | 1.40 |
| 236 | 200, 200 | 0-15, 0-15 | 2.41 | .90 |
| 239 | 50MA | 12-0-12 | 3.11 | .90 |
| 214 | 300, 300 | 0-20, 0-20 | 3.39 | 1.20 |
| 221 | 700 (DC) | 20-12-0-12-20 | 4.13 | 1.20 |
| 206 | 1A, 1A | 0-15-20, 0-15-20 | 5.60 | 1.60 |
| 203 | 500, 500 | 0-15-27, 0-15-27 | 4.83 | 1.50 |
| 204 | 1A, 1A | 0-15-27, 0-15-27 | 7.30 | 1.60 |

### 400/440V ISOLATORS

400/440 to 200/240V

| VA | Ref. | £ | P&P |
|---|---|---|---|
| 60 | 243 | 8.11 | 1.50 |
| 250 | 246 | 16.07 | OA |
| 350 | 247 | 19.88 | OA |
| 500 | 248 | 24.77 | OA |
| 1000 | 250 | 50.53 | OA |
| 2000 | 252 | 74.79 | OA |
| 3000 | 253 | 104.86 | OA |
| 6000 | 254 | 207.92 | OA |

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| Ref. | VA (Watts) | TAPS | £ | P&P |
|---|---|---|---|---|
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| 64 | 80 | 0-10-115-210-240V | 4.84 | 1.40 |
| 4 | 150 | 0-10-115-200-220-240V | 6.48 | 1.60 |
| 67 | 500 | 0-10-115-200-220-240V | 13.30 | 2.24 |
| 84 | 1000 | 0-10-115-200-220-240V | 22.70 | 2.80 |
| 93 | 1500 | 0-10-115-200-220-240V | 28.17 | OA |
| 95 | 2000 | 0-10-115-200-220-240V | 42.14 | OA |
| 73 | 3000 | 0-10-115-200-220-240V | 71.64 | OA |
| 80s | 4000 | 0-10-115-200-220-240V | 93.01 | OA |
| 57s | 5000 | 0-10-115-200-220-240V | 108.30 | OA |

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| VA | Price | P&P | Ref |
|---|---|---|---|
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| 80 | £9.35 | 1.50 | 64W |
| 150 | £12.10 | 1.84 | 4W |
| 200 | £12.02 | 1.44 | 65W |
| 250 | £14.73 | 1.60 | 69W |
| 500 | £22.14 | 2.24 | 67W |
| 1000 | £33.74 | 2.80 | 84W |
| 2000 | £80.47 | OA | 95W |

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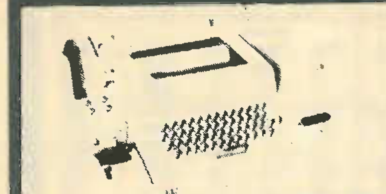

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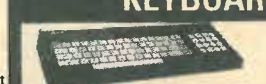

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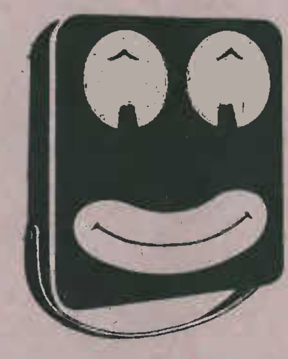

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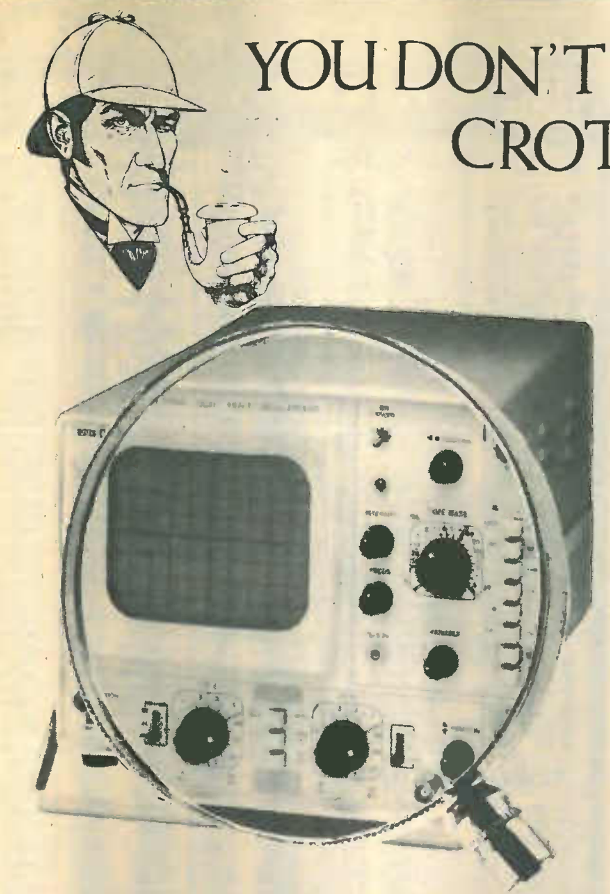

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|---|---|---|---|---|---|---|---|---|---|---|
| CE 608 | 38 | — | CPS 80 | H550 | 30Vu5 | 110dB | 775mV | 0.0035% | 1.5Hz—50KHz | 80—120—25 |
| CE1004 | 44 | 70 | CP5150 | H550/100 | 30Vu5 | 110dB | 775mV | 0.0035% | 1.5Hz—50KHz | 80—120—25 |
| CE1008 | 65 | — | CP5150 | H550/100 | 30Vu5 | 110dB | 775mV | 0.0035% | 1.5Hz—50KHz | 80—120—25 |
| CE1704 | 85 | 121 | CP5250 | H5100/150/FM1 | 30Vu5 | 110dB | 775mV | 0.0035% | 1.5Hz—50KHz | 80—120—25 |
| CE1708 | 125 | — | CP5250 | H5100/150/FM1 | 30Vu5 | 110dB | 775mV | 0.0035% | 1.5Hz—50KHz | 80—120—25 |
| CE3004 | 170 | 250 | CP5250 | H5150/FM2 | 30Vu5 | 110dB | 775mV | 0.008 % | 1.5Hz—50KHz | 161—102—35 |
| CPR1X | output | 775mV | REG1 | — | 3Vu5 | 70dB | 2.8mV | 0.008 % | 10Hz —50KHz | 138— 80—35 |
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| XO2/3 | output | 775-2500mV | REG1 | — | 9Vu5 | 90dB | 775mV | 0.01 % | Preset | 150— 50—20 |

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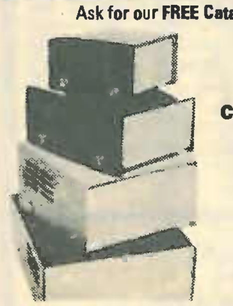

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| | 0-15V, 0.15V | |
| | 0-20V, 0-20V | |
| 20VA | 0-4V5, 0-4V5 | |
| | 0-6V, 0-6V | |
| | 0-9V, 0-9V | |
| | 0-12V, 0-12V | 3.80 |
| | 0-15V, 0-15V | |
| | 0-20V, 0-20V | |
| 50VA | 0-6V, 0-6V | |
| | 0-9V, 0-9V | |
| | 0-12V, 0-12V | 4.75 |
| | 0-15V, 0-15V | |
| | 0-20V, 0-20V | |
| 120VA | 0-30V, 0-30V | |
| | 0-40V, 0-40V | 8.90 |

**CASED AUTO TRANSFORMERS**
240V Cable input. American outlet socket.

| Rating | Price | | |
|---|---|---|---|
| 300VA | £13.00 | 750VA | £23.50 |
| 500VA | £18.00 | 1000VA | £27.00 |
| | | 1500VA | £36.00 |

**Other Transformers**

| | | | |
|---|---|---|---|
| 1.2VA. 6-0-6, 9-0-9, 12-0-12 | all 1.14 | 12VA | |
| 1.5VA | | 0-12, 0-12 | 2.96p |
| 12V | 80p | 18VA | |
| 15V | 1.00p | 9-0-9 | 2.64p |
| 2.4VA | | 24VA | |
| 12-0-12 | 1.48p | 12-0-12 | 3.36p |
| 24V(pcb) | 1.00p | 12V | 4.84p |
| 4VA | | 30VA | |
| 5-0-5 | 1.25 | 15-0-15 | 3.62p |
| 6VA | | 36VA | |
| 24V | 1.50 | 9-0-9 | 4.70p |
| | | 50VA | |
| | | 0-2-4-6-8-10 | 6.00p |

**ALUMINIUM BOXES**

| | |
|---|---|
| AB7 2.75x5.25x1.5in. | £1.06 |
| AB8 4x4x1.5in. | £1.06 |
| AB9 4x2.75x1.5in. | £1.06 |
| AB10 4x5.25x1.5in. | £1.23 |
| AB11 4x2.5x2in. | £1.06 |
| AB12 3x2x1in. | 77p |
| AB13 6x4x2in. | £1.43 |
| AB14 7x5x2.5in. | £1.80 |
| AB15 8x6x3in. | £2.18 |
| AB16 10x7x3in. | £3.06 |
| AB17 10x4.5x3in. | £2.52 |
| AB18 12x5x3in. | £2.77 |
| AB19 12x8x3in. | £3.34 |

**PLASTIC BOXES**

| | |
|---|---|
| 75x50x25mm black or white | 65p |
| 180x110x55mm black | £1.65 |
| 80x60x40mm black | 92p |
| 215x130x85mm black or white | £3 |
| 120x100x45mm black | £1.18 |
| 100x75x40mm black | 99p |
| 150x100x60mm black | £1.35 |

**BLUE REXINE COVERED ALUMINIUM BOXES**

| | |
|---|---|
| RB1 6x4.5x2.5in. | £2.15 |
| RB2 8x5x3in. | £2.77 |
| RB3 9x5x3.5in. | £2.99 |
| RB4 11x8x4in. | £3.45 |
| RB5 11x7.5x4.5in. | £4.29 |

**MAIL ORDER:** Gds. + 15% VAT, **plus** VAT-INCLUSIVE Adm/Pkg./Post:

| | | | | | |
|---|---|---|---|---|---|
| ¼Kg | £1.30 | 2Kg | £3.00 | 6Kg | £4.40 |
| ½Kg | £1.70 | 3Kg | £3.45 | 6-10 | £5.00 |
| ¾Kg | £2.20 | 4Kg | £3.90 | Over 10Kg: | |
| 1Kg | £2.55 | 5Kg | £4.20 | | Quote |

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**Speakers:** 2in. 16 ohm 200mW **60p**; 7x4in. dual-cone 8ohm high quality 5W LS **£1.60.** Brand new and boxed
**Multiturn Pots.** We have large stocks, all makes, multiturn pots, cermet, etc.
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Bourns type 3386P 5K/trimpot ........ **30p each**
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**Cassette Decks:** With stereo heads, mechanically complete, but with no electronics. Brand new, smart black modern finish ........ **£7.45** inc. VAT + P&P
**VU Meters:** 40x30x23mm deep. White/red scale on black background. Brand new ........ **60p**
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3.3µF at 100v radial block ........ **25p each**
4.7µF at 100v radial block ........ **30p each**
10µF at 63v radial block ........ **40p each**
**Mains Filters** by Erie/Corcom from 3A to 15A, 250v AC rated .... **£3 each**

**SPRAGUE:** Series 36D Computer grade electrolytics 3,300 at 40V. Brand new and boxed ........ **35p ea.**
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Quantity available

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**FIELD GOAL VIDEO GAME, BY TAITO.** A top quality board complete with 6800 CPU system with 2716 eproms with circuit diagram, plus all connections for either colour or black and white monitors (TV sets). **Price £20 + VAT £3. P/P £2.55.**

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**Price £15 + VAT £2.25. P/P £3.45.**

**2 x 22-WAY GOLDPLATED DOUBLE-SIDED 0.156" EDGE CONNECTORS** to suit videoboards.
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|---|---|---|---|
| 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 |
| 17×12⅞×3½in. | £6 | 17¼×13¾×4⅛in. | £6 |

Callers Only (not suitable for post)

| | | | |
|---|---|---|---|
| 21½×14¼×2½in. | £6 | 21×13⅞×4⅛in. | £6 |
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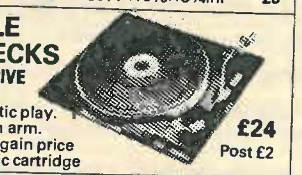
## BSR SINGLE PLAYER DECKS



**BSR P232 BELT DRIVE QUALITY DECK**
Manual or automatic play. Precision ultra slim arm. Cueing device. Bargain price With stereo ceramic cartridge **£24** Post £2

**BSR P204 SINGLE PLAYERS SPECIAL OFFERS**
Two speed 33/45 r.p.m. hi-fi decks with stereo cartridges, cueing device and snake arm.
Ceramic – 240V AC **£15** or 9V DC **£19**
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Brushed Aluminium Arm with stereo ceramic cartridge and Diamond Stylus, 3-speeds. Manual and Auto Stop/Start. Large Metal Turntable. Cueing Device. Ready cut mounting board £1 extra.
**GARRARD 730SP.** 240V. **£27.50.** Magnetic Cartridge Snake arm, 3-speed single player, p.p. £2

**BATTERY ELIMINATOR MAINS to 9 VOLT D.C.**
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Model 450, 10 watss R.M.S. with moving coil tweeter and two-way crossover; 3 ohm or 8 ohm.
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**ANGLE ALI.** 6×¾×¾in. 18 swg. **30p.**
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**RESISTORS.** 10Ω to 10M. ¼W, ½W, 1W, **2p**: 2W **10p.**
**HIGH STABILITY.** ½w 2% 10 ohms to 1 meg. **10p.**
Ditto 5%. Preferred values, 10 ohms to 10 meg. **3p.**
**WIRE-WOUND RESISTORS** 5 watt, 10 watt, 15 watt **20p.**
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**LOCKTITE SEALING KIT DECCA 118.** Complete **£1.**
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**JACK PLUGS** Stereo Plastic **30p**; Metal **35p.**
**JACK SOCKETS** Mono Open **20p**; Closed **25p.**
**JACK SOCKETS** Stereo Open **25p**; Closed **30p.**
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2.5mm and 3.5mm **JACK SOCKETS 20p. Plugs 20p.**
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Sockets 3-pin, 5-pin **10p.** Free Sockets 3-pin, 5-pin **25p.** Plugs 3-pin **20p**; 5-pin **25p**; Speaker plugs **20p**; Sockets **15p.**
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De luxe pocket size precision moving coil instrument. Impedance + Capacity – 4000 o.p.v. Battery included.
11 instant ranges measure:
DC volts 5.25, 250, 500.
AC volts 10, 50, 500, 1000.
DC amps 0-250µa, 0-250mA.
Continuity and resistance 0 to 600K ohms
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50µa 100µa, 500µa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp 25 volt, 50 volt, VU Meter. 2¼x2x1¼in. 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. Operates from 200MV to 100W.
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4**, or 12 for **£7.50.** Post 65p. Suitable panel mounting holders **85p.**

**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.** Specification 10W per channel; size 9½×3×2in. SAE details. Full instructions supplied. 240V AC mains. Post £1.

**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**

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|---|---|---|
| 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 | £12.00 | £2 |
| 220V 45mA, 6.3V 2A | £2.50 | £1 |

STEP UP 115V to 240V 150W **£9.** 250W **£10.** 400W **£11.** 500W **£12.** £2

**GENERAL PURPOSE LOW VOLTAGE**
Tapped outputs available

| | Price | Post |
|---|---|---|
| 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V | £8.00 | £2 |
| 1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 | £8.00 | £2 |
| 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 | £10.50 | £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 | 20V 1 amp | £3.00 | £1 |
| 6-0-6V. 1½ amp. | £3.50 | £1 | 20-0-20V 1 amp | £3.50 | £1 |
| 9V. 250ma. | £1.50 | 80p | 20-40-60V 1 amp | £4.00 | £2 |
| 9V. 3 amp | £3.50 | £1 | 25-0-25V 2 amps | £4.50 | £1 |
| 9-0-9V. 50ma | £1.50 | 80p | 28V 1 amp Twice | £5.00 | £2 |
| 10-0-10V. 2 amps | £3.00 | £1 | 30V 1½ amp | £3.50 | £1 |
| 10-30-40V. 2 amps | £3.50 | £1 | 30V 5 amp and 17-0-17 2a | £4.50 | £2 |
| 12V. 100ma | £1.50 | 80p | 35V 2 amps | £4.00 | £1 |
| 12V. 750 ma | £2.00 | 80p | TOROIDAL30-0-30V 4a and 20-0-20V ½a | £10.00 | £2 |
| 12V 3 amps | £3.50 | £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 | 8-12 volt 4a | £2.00+80p |

## OPUS COMPACT SPEAKERS £22 pair Post £2

**TEAK VENEERED CABINET**
11×8½×7in, 15 watts
50 to 14,000 cps. 4 ohm or 8 ohm
**OPUS TWO** 15×10½×7¾in 25 watt 2-way system **£39 pair.** Post £3.

**LOW VOLTAGE ELECTROLYTICS** 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.
500mF 12V **15p**; 25V **20p**; 50V **30p.** 1200mF 76V **86p.**
1000mF 12V **20p**; 25V **35p**; 50V **50p**; 100V **70p.**
2000mF 6V **25p**; 25V **42p**; 40V **60p**; 1200mF 76V **80p.**
2200mF 63V **90p.** 2500mF 50V **70p**; 3000mF 50V **65p**;
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**

**HIGH VOLTAGE ELECTROLYTICS**

| | | | | | |
|---|---|---|---|---|---|
| 2/500V | 45p | 8+8/450V | 75p | 32+32+16/350V | 90p |
| 8/450V | 45p | 8+8/500V | £1 | 100+100/275V | 65p |
| 16/350V | 45p | 8+16/450V | 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 |
| 50/450V | 95p | 50+50/300V | 50p | 50+50+50/350V | 95p |

**CAPACITORS WIRE END High Voltage**
.001, .002, .003, .005, .01, .02, .03, .05 mfd 400V **5p.**
.1MF 200V **5p.** 400V **10p.** 600V **15p.** 1000V **25p.**
.22MF 350V **12p.** 600V **20p.** 1000V **30p.** 1750V **50p.**
.47MF 1500V **10p.** 400V **20p.** 630V **30p.** 1000V **60p.**
**VALVE OUTPUT** Transformers (small) **90p.**
**TRIMMERS** 30pF, 50pF, **10p.** 100pF, 150pF, 500pF **30p.**
**MICROSWITCH SINGLE POLE CHANGEOVER 40p.**
**SUB-MIN MICROSWITCH, 50p,** Single pole changeover.
**TWIN GANG,** 120pF **50p.** 500 plus 200pF **£1.**
**GEARED TWIN GANGS** 25pF **95p.**
**GEARED** 365+365+25+25pF **£1.**
**TRANSISTOR TWIN GANG.** Japanese Replacement **£1**
**SOLID DIELECTRIC** 100pf **£1.50,** 500pf **£1.50.**

**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 or ceramic, etc.
ONLY **60p** EACH (FOUR FOR £2) ALL POST PAID.

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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.

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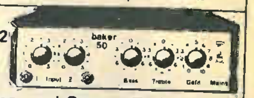
|---|---|---|---|---|---|---|
| MAJOR | 12 | 4-8-16 | 30 | HI-FI | £14 | £2 |
| DELUXE MK II | 12 | 8 | 15 | HI-FI | £14 | £2 |
| SUPERB | 12 | 8-16 | 30 | HI-FI | £24 | £2 |
| AUDITORIUM | 12 | 8-16 | 45 | HI-FI | £22 | £2 |
| AUDITORIUM | 15 | 8-16 | 60 | HI-FI | £34 | £2 |
| GROUP 45 | 12 | 4-8-16 | 45 | PA | £14 | £2 |
| GROUP 75 | 12 | 4-8-16 | 75 | PA | £18 | £2 |
| GROUP 100 | 12 | 8-16 | 100 | Guitar | £24 | £2 |
| DISCO 100 | 12 | 8-16 | 100 | Disco | £24 | £2 |
| GROUP 100 | 15 | 8-16 | 100 | Guitar | £32 | £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.
**New Stereo Slave Model 150 + 150 watt £125.** Post £4.
**BAKER'S NEW PA150 MICROPHONE PA AMPLIFIER £129.** PP £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 £69 Post £2 50 WATT AMPLIFIER



Ideal for PA systems, Discos and Groups. Two inputs, Mixer, Volume, Controls, Master Bass, Treble Gain.

**RCS offers MOBILE PA AMPLIFIERS. Outputs 4-8-16 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**
**60-watt** RMS, Mobile 24 volt DC & 240-volt AC mains. inputs 50K. 3 mics + 1 music. Outputs 4-8-16 ohm + 100 volts line **£95 PP £2**

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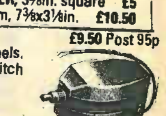

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* Most UK locations and some Overseas.
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(1471)



## DISTRICT WORKS DEPARTMENT MEDICAL ENGINEERING SECTION

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Salary dependent on qualifications and previous experience.

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**Application forms and job descriptions from District Engineer, Dudley Road Hospital, P.O. Box 293, Dudley Road, Birmingham B18 7QH. For further information telephone Mr. D. L. Hall, District Engineer – 021-554 3801 Ext. 4838.**

**WEST BIRMINGHAM** Health Authority

(1684)



## VACANCY FOR TELEVISION ENGINEER

We have a vacancy for a Television Engineer in the British Forces Broadcasting Service at Rheindalen, West Germany. The selected candidate must have experience of 1in. and 2in. VTRs, TV Studio equipment and, preferably, ENG equipment.

Applicants qualified to degree or H.N.C. or equivalent standard preferred and a key requirement is a sound up-to-date knowledge of electronics.

Good salary paid and an overseas allowance. Single or married accommodation available. Air passage paid. Good pension scheme. Career prospects.

*Please apply in writing, giving details of previous experience, to Mrs Diane Trigg, Services Sound and Vision Corporation, Chalfont Grove, Gerrards Cross, Bucks, SL9 8TN.*

(1664)



## ELECTRONIC ENGINEER

Required by leading AV and Video Company to work a wide range of video equipment, including receiver/monitors, cameras and video recorders, etc.
Candidates should have City and Guilds full certificate and experience working with colour TV and video equipment.

For further details please contact:
Gary Davis
**SAMUELSON SIGHT AND SOUND LTD.**
**303-315 Cricklewood Broadway**
**Edgware Road**
**London NW2 6PQ**

(1666)





www.americanradiohistory.com

# Space and Microwave
# INSTALLATION ENGINEERS

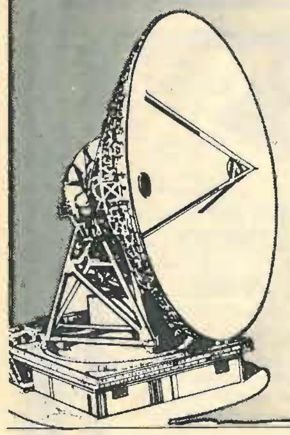
Marconi Communication Systems has an international reputation for the design, development and manufacture of high technology communications equipment and systems.

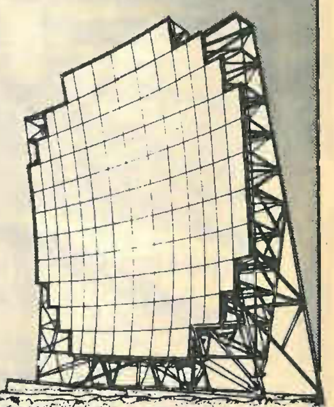
Right now we need adventurous Engineers, keen to use their engineering and technical skills to the full, to join our installation teams operating throughout the world. We can offer challenging and exciting opportunities in both the U.K. and overseas. Some appointments will be on a fixed term contract.

We are seeking men or women with an electronics qualification or HM Forces experience who have a minimum of three years' practical background of installing and commissioning satellite earth stations, line of sight or tropospheric scatter systems. A current U.K. driving licence is also required.

Excellent salaries, and overseas benefits where applicable, are offered with these posts.

If you are interested send a full c/v or telephone for an application form to **Gordon Short, Marconi Communication Systems Limited, New Street, Chelmsford, Essex, CM1 1PL. Telephone Chelmsford (0245) 353221, extension 592.** (1672)





**Marconi**
Communication Systems

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## ELECTRONICS TECHNICIANS

The incumbents will be based onshore and will be working within our Aberdeen facility.

Ideally, the successful candidates will possess practical experience of digital and analogue systems as well as having formal qualifications such as O.N.C. or equivalent C. and G. qualifications in Electronic Engineering.

Attractive salaries for the above positions are enhanced by a comprehensive benefit package including contributory pension scheme, AVC scheme, free life assurance, good working conditions and the excellent prospects offered by an international service company with expanding interests worldwide.

Applicants should send a c.v. stating salary required in confidence to:

The Personnel and Administration Manager
TELECO OILFIELD SERVICES LIMITED
Hareness Circle, Altens Industrial Estate, Aberdeen

Agency enquiries are not requested

(1660)

**TELECO**

## RED ROSE RADIO

The new ILR station for Lancashire due on the air in the autumn requires the following staff:

**SENIOR ENGINEER (ILR1)**
**ENGINEER (ILR2)**

Applicants for both positions should have considerable broadcasting experience, technically and operationally. A clean driving licence is preferred.
For the senior position, an HND or equivalent qualification in Electronics is essential, and a knowledge of digital techniques would be an advantage.
Applications including C.V. with full career details should be sent to:
**David Cockram, Chief Engineer**
**Red Rose Radio PLC**
**49a Fishergate, Preston PR1 8BH**
quoting reference WW. (1675)

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*Enthusiastic*

## AUDIO SYSTEMS ENGINEER

required by international consultancy practice specialising in installations in theatre, television and conference buildings. Candidates should have a background in the electrical and electronics business, an understanding of technical drawings and an interest in the performing arts. Selected person will work with small team in Covent Garden area and will be trained to use computer-aided design system.
Salary will depend on experience and contribution made to this leading practice of theatre consultants.

*Apply with c.v. to:*
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**Theatre Projects Consultants Ltd.**
**14 Langley Street, London WC2H 9JG**
**Telephone: 01-836 0386** (1663)

APEX VIDEO LTD

## APEX VIDEO LTD.
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Are you a travel hassle hater and a competent video engineer? We have broadcast TV facilities and need an additional **ENGINEER.** Excellent salary with even more money for the right experience.
Please send CV or telephone for more information on **SLOUGH 25142 and speak to Barry Blight or Ian Browning.**

(1679)





Appointments

# NO CONCESSION TO RECESSION!

In communications, the industry of the 21st Century, the BBC is forging ahead with its programme of expansion. This year we are seeking 150 young, enthusiastic Engineers both in London and throughout the United Kingdom to work in the expanding field of Television.

The ability to handle new technology long before it appears in other industries, a thorough understanding of traditional electronics and the motivation to have found out about Broadcasting technology, together with the right personality are just some of the qualities we are seeking.

Many have already accepted the challenge and joined us, but there are vacancies in the Television Service, London for those men and women with the right qualities. If you are qualified, or soon to be qualified, with a Degree in Electrical and Electronic Engineering, Applied Physics or equivalent and have both normal hearing and colour vision why not fill in the coupon for further details, quoting reference number 82.E.4029/W.W.

Starting salary in the Television Service, London is in the range £7314 to £7892 plus shift working allowance of between £800 and £1000pa.

**We are an equal opportunities employer.**

To: The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA. Reference No. 82.E.4029/W.W.

Name: ____________
Address: ____________

Tel. No: ____________
Qualification/Date obtained: ____________

BBC

# 150
# TELEVISION ENGINEERS

(1616)

# Engineers & Scientists
## £8,589
### Communications R & D... ...the leading edge

At HM Government Communications Centre, we're applying the very latest ideas on electronics and other technologies to the problems of sophisticated communications systems, designed to enable and protect the flow of essential information.

The work is of the highest technical challenge, offering full and worthwhile careers to men and women of high ability, on projects covering the following areas of interest:—

RADIO - from HF to microwave, including advanced modulation systems, propagation studies, applications of Microcircuitry.

ACOUSTICS SIGNAL ANALYSIS
MAGNETICS SYSTEMS ENGINEERING

Applicants, under 30 years of age, should have a good honours degree or equivalent qualification in a relevant subject, but candidates about to graduate may also apply.

Appointments are as Higher Scientific Officer (£6,530-£8,589) or Scientific Officer (£5,176-£6,964) according to qualifications and experience. Promotion prospects.

For an application form, please write to the **Recruitment Officer (Dept. WW7), HM Government** Communications Centre, Hanslope Park, Milton Keynes, MK19 7BH.

(1589)

## £25,000?

**1. PROJECT LEADER**
VHF/UHF equipment. Some microwave involvement. **£14,000 – Herts.**

**2. SENIOR DESIGN ENGINEER**
Working on transmission systems or for digital beam forming equipment. **To £11,000 – Essex.**

**3. DESIGN ENGINEER**
For power amplifier design on satellite communications equipment. **To £10,000 – Hants.**

**4. DEVELOPMENT MANAGER**
Lead team of 4 on RF surveillance equipment development. **To £16,000 – Berks.**

**5. ANALOGUE DESIGNER**
VHF/UHF commercial equipment. **£9,000 – Bucks.**

**6. DEVELOPMENT ENGINEER**
Command and control systems for MOD vehicles. **To £10,000 – Surrey.**
100s of other electronics and computer vacancies. **To £25,000.**

Phone or write: Roger Howard
C.Eng, M.I.E., R.E., M.I.E.E.

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GLOUCESTERSHIRE GL5 2PW
TEL. 0453 883264, 01-290 0267 (321)

## Telecommunications Officers
### Up to £9270

The posts available are varied, but broadly they fall into 2 groups at 5 different locations.

**Hanslope Park (Milton Keynes), North Bucks and Central London**

Work associated with HF communications equipment, VHF, UHF and microwave links and associated test equipment; teleprinters, telephone subscribers' apparatus, PMBXs, PAXs, PABXs and ancillary equipment including that using analogue and digital techniques and voice frequency telegraph.

**Crowborough, Sussex and Orfordness, Suffolk**

The maintenance and operation of high power, medium and short wave broadcasting transmitters and associated equipments.

Candidates must have had appropriate training. They should normally have 4 years' relevant experience, and hold **either** ONC in Engineering (with pass in Electrical Engineering 'A') **or** ONC in Applied Physics **or** TEC/SCOTEC certificate **or** City & Guilds Telecommunications Technicians Certificate Part II (Course No. 271), **or** Part I plus 3 'B' subjects **or** a pass in the Council of Engineering Institutions Part I examination **or** an equivalent or higher relevant qualification. **Ex-Service personnel** who have had suitable training and at least 3 years' appropriate service (as Staff Sergeant or equivalent) will also be considered.

Salary: £5980-£8180; London £1087 more. Starting salary may be above minimum for those with additional relevant experience. Promotion prospects.

**Relocation assistance may be available.**

For further information and an application form (to be returned by 8 July, 1982), write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote ref: T/5782.**

**Foreign and Commonwealth Office** (1685)

## APPOINTMENTS IN ELECTRONICS to £15,000

**MICROPROCESSORS**
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Design, test, field and support engineers – for immediate action on salary and career advancement, please contact

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11, Westbourne Grove
London W2. 01-229 9239 (9257)

**UNIVERSITY OF LONDON**
**INSTITUTE OF NEUROLOGY**

**DEPARTMENT OF NEUROLOGICAL SURGERY**

## UNIVERSITY TECHNICIAN GRADE 3

is required to join an established research group working on laboratory projects with a strong neurological orientation. The post calls for someone with an aptitude for electronics and instrumentation and an interest in physiology. Initial salary will be in the range £4,672-£5,473 plus £1,087 London Allowance. Applications in writing, with names of two referees, to the Secretary, Institute of Neurology, Queen Square, London WC1N 3BG.

(1668)







# CHANNEL FOUR will be transmitting nationally from November 1982 and applications are invited for the following posts:

## TECHNICAL SUPERVISOR
£16,267 p.a.

## SENIOR ENGINEERS
£12,495 p.a.

## SUBSTANTIVE ENGINEERS
£8,284 – £11,167 p.a.

## VIDEOTAPE EDITOR
£15,612 p.a.

Applicants should have had some previous experience of television operation and a formal qualification such as an HNC or degree would be an advantage.

Please write enclosing a C.V. to Ellis Griffiths, Channel Four Television Company Ltd., 60 Charlotte St., London W1P 2AX, or telephone 01-631 4444 for an application form.

**Channel Four is an equal opportunity employer: applications are welcome from candidates regardless of marital status, race, nationality, ethnic or national origins or sex and from registered disabled persons.**

**CHANNEL FOUR TELEVISION** (1671)

As the old song says 'A good man nowadays is hard to find'.

1) Design Development Engineers for a thermal imaging system that will hopefully develop into a family of systems. Analog engineers for power supplies, processing low-noise signals for display. Digital Engineer for control of same. Essex, to £11,000.
2) Programmer capable of writing innovative software for microprocessor based data recorders and display products using the new Motorola range of microprocessors. Must be experienced graduate who can write programs that work. Sussex, up to £15,000 for the man who's worth it!
3) Customer Liaison Engineer who besides providing technical and applications support for an extensive range of printers can organise and provide technical training for customers and engineers. Must have strong technical and hands-on background, if possible with experience of printers and be qualified at HNL or equivalent level. Berks, up to £10,000 with car provided.
4) Software Engineer capable of writing good software and also de-bugging existing programs, trouble-shooting clients' software as required. Most is on PDP11/LS1, 11 or 8080/8086. Main operating system is RSX-11M, but macro-11, Coral and Intel operating system and assembler knowledge will come in useful. South London, salary starting at up to £10,500.
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**Charles Airey Associates**
**Tempo House, 15 Falcon Road, Battersea London SW11 2PJ**
**Tel: 01-223 7662 or 228 6294** (1357)

**CELESTION INTERNATIONAL LIMITED**
require

## DESIGN ENGINEER

A chance has arisen for a suitably qualified person to join Celestion's High Fidelity loudspeaker design team. These designs range from conventional loudspeaker systems up to state of the art transducer technology.
The successful candidate should have an Honours Degree in Physics, Electrical Engineering or related discipline and have some experience in either loudspeaker design or vibration analysis. Such a person is likely to be in the age group 24-30 years old, and should be capable of contributing to the theoretical aspects of transducer technology.

## ELECTRONICS ENGINEER

A vacancy exists for an Electronics Engineer to join the Celestion Development team. The successful candidate will be initially responsible for the development and maintenance of both Development and Factory test equipment.
The candidate should have experience in both analogue and digital test equipment, including a working knowledge of microprocessor systems as well as experience in audio amplification.
Graduates seeking First Appointments will be considered for both appointments.
Candidates should apply in writing, giving details of their experiences in the above fields to the Personnel Manager, Celestion International Limited, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP. (1676)

## TRAINEE RADIO OFFICERS

First-class, secure career opportunities.

A number of vacancies will be available in 1982/83 for suitable qualified candidates to be appointed as Trainee Radio Officers.

If your trade or training involves Radio Operating, you qualify to be considered for a Radio Officer post with the Composite Signals Organisation.

Candidates must have had at least 2 years' radio operating experience or hold a PMG, MPT or MRGC certificate, or expect to obtain this shortly.

On successful completion of between 36 and 42 weeks specialist training, promotion will occur to the Radio Officer grade.

Registered disabled people may be considered.

SALARY & PROSPECTS

**TRAINEE RADIO OFFICER**: £4159 at 19 to £4897 at 25 and over. On promotion to RADIO OFFICER: £5698 at 19 to £6884 at 25 and over. Then by 4 annual increments to £10,034 inclusive of shift working and Saturday and Sunday elements. Salaries reviewed annually.

For full details please contact our Recruitment Officer on Cheltenham (0242) 21491 Ext. 2269 or write to her at:

Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, Cheltenham, Gloucestershire GL52 5AJ

(1531) **GCHQ**





www.americanradiohistory.com

SULTANATE OF OMAN
ROYAL OMAN POLICE

## TELECOMMUNICATION TECHNICIAN

The Royal Oman Police are seeking persons for appointment as Telecommunication Technician, applicants should be suitably qualified with at least 12 months' experience in the following subjects:
(A) HF, VHF, UHF Fixed/Mobile Equipment
(B) Teleprinters (Electronic)
(C) Microwave/Multiplex Equipment
(D) Marine Radar
Applicants should possess at least City & Guilds intermediate or equivalent. Previous Police/Military experience and a knowledge of Arabic would be an advantage, but is not essential.

## GENERAL

This appointment is offered on contract terms of service for an initial period of two years. Conditions of service include annual emoluments of the equivalent of R.O.6624.000 (£10,700 at current rate of exchange) and normal benefits which are associated with working overseas including furnished air conditioned accommodation, medical treatment, 60 days' leave per annum with paid passages, plus an end of contract benefit equal to 25% of basic salary.

Applications with detailed curriculum vitae attached to be forwarded to:
**Inspector General of Police and Customs**
**Attn.: Assistant Commissioner of Police**
**(Personnel & Training)**
**Royal Oman Police**
**P.O. Box 2, Muscat**
**Sultanate of Oman**

(1669)

## SYSTEMS PROPOSAL ENGINEER

Ampex requires a self-motivated Engineer capable of applying systems knowledge, to the design of **television studio and outside broadcast vehicles.**

Key requirements are:

★ Thorough knowledge of video and audio principles – HNC or equivalent.
★ At least three years' practical experience in the broadcast industry.
★ Ability to originate technical write-ups to price and present proposals to customer requirements.

Excellent salary, pension, life assurance and permanent health insurance schemes. Relocation expenses as appropriate.

AMPEX

**Send cv, write to, or phone Maureen Brake at:**
**Ampex Great Britain Ltd**
**Acre Road, Reading RG2 0QR**
**Berkshire, England**
**Tel. Reading (0734) 875200**

(1670)

## T.V. Technicians

**Salary: £11,619 per annum tax free***

**for the**
**King Faisal Specialist Hospital and Research Centre**
**Riyadh, Saudi Arabia**

If you have at least 5 years preventive maintenance experience working on a range of T.V. systems, here is a unique opportunity to work in the T.V. studio attached to a modern hospital in the capital city of Saudi Arabia. You should have had some formal training or possess a qualification in electronics.

Your duties will include maintenance on a wide range of video and audio equipment including patient monitoring systems, video and audio tape recorders, T.V. cameras (colour and black and white), T.V. monitors, film and slide projectors.

Benefits will include:
- **2 year single status contracts, extendible by mutual agreement.**
- **Air passages.**
- **Air conditioned, furnished accommodation.**
- **Medical and dental facilities.**
- **50 days leave per year.**
- **End of contract bonuses.**
- **Excellent facilities for sport and recreation.**

*Salary is paid in Saudi Riyals — 6,100 Riyals per month. Sterling exchange rate at the time of going to press: 6.3 Riyals to the £.

Please apply in writing with brief career details, or telephone for application form to:
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**HCA United Kingdom Ltd**
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**London W1H 9LE**
**Tel 01-935 7185**

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DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

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Appropriate industrial experience with a keen interest in development of practical and project work will be an advantage.
Minimum qualification is a City and Guilds Full Technological Certificate or equivalent.
Salary (under review): £5,034-£8,658 plus £759 p.a. London Allowance.
Application form and further details may be obtained by writing to the Vice-Principal enclosing a self-addressed envelope. Completed forms should be returned within 14 days of the appearance of this advertisement.

LONDON BOROUGH OF NEWHAM

(1688)







SITUATIONS VACANT

Metropolitan Police Office

## Telecommunications Officers

. . . in Central London to maintain on a shift basis the data and radio networks associated with the New Scotland Yard Command and Control function and other operational systems.

The successful candidate will implement maintenance policy; maintain systems within agreed parameters; liaise with Operations (Technical) Support Group on system failure and the duty Police Officer; take responsibility for calling out additional staff and contractors in emergencies; ensure that faults are documented for subsequent investigation and supervise the Telecommunications Technical Officers Grade II.

Candidates must have TEC/SCOTEC certificate in Electronics, Telecommunications or similar discipline; **or** City & Guilds Telecommunications Technicians Certificate Part II, or Part I plus Mathematics B, Telecommunications Principles B and, either Radio Line Transmission B or Computers B; **or** ONC in electrical, Electronic or Telecommunications Engineering or similar discipline; **or** a pass in the Council of Engineering Institutions Part I examination; **or** an equivalent or higher qualification. All candidates must have had appropriate training and should normally have four years' experience in a related field of work. Senior exservice personnel with TEC/C&G recognised exemptions will also be considered.

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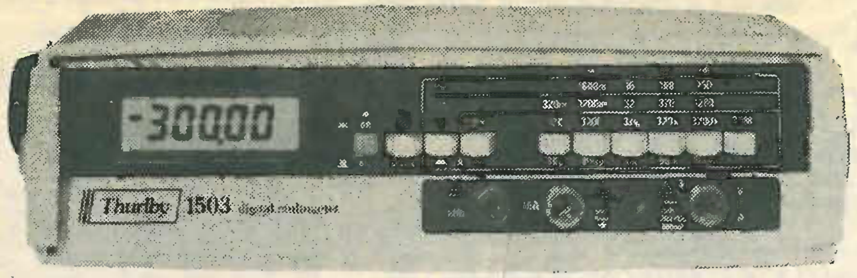


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* Prices subject to change without notice.

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