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MARCH 1983 80p



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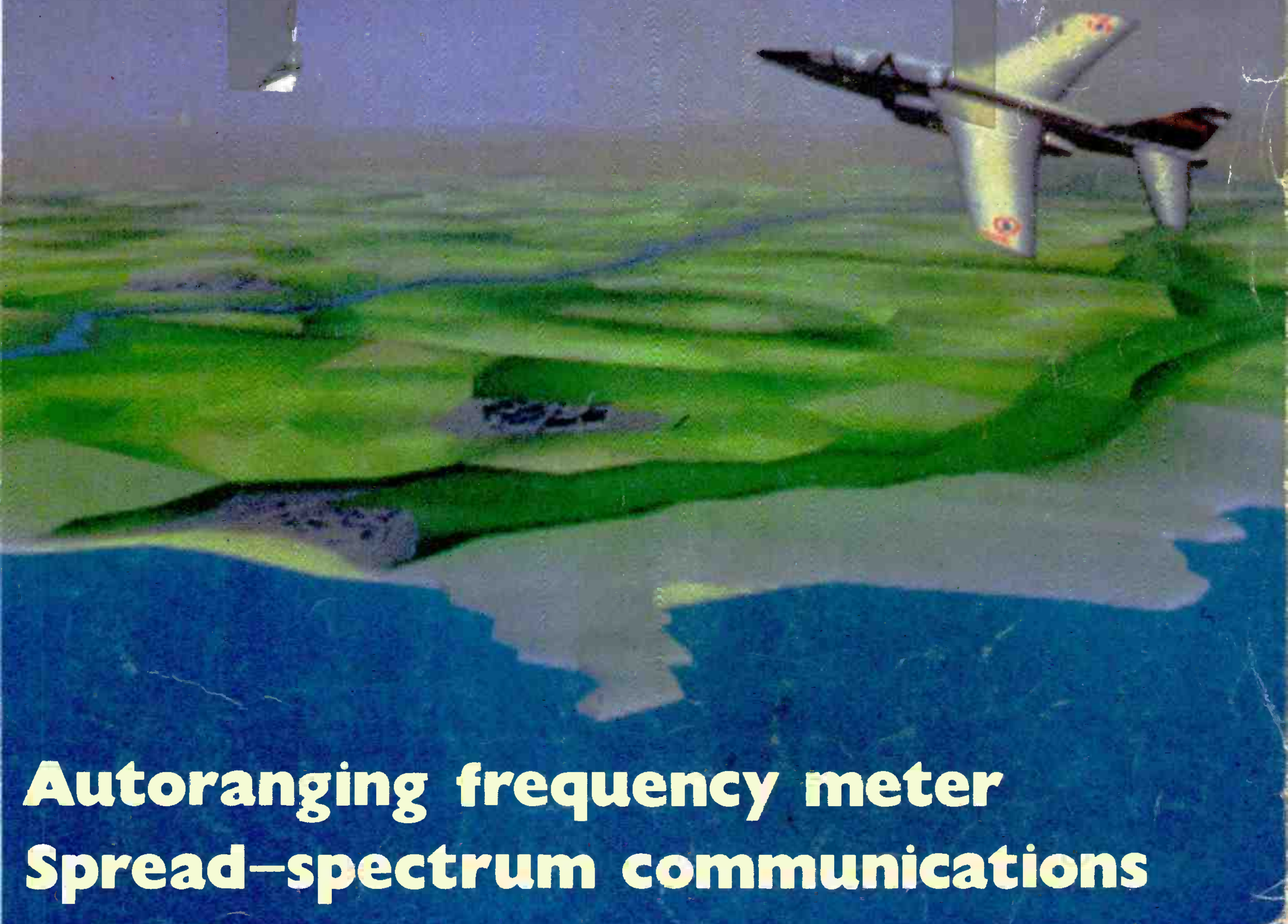

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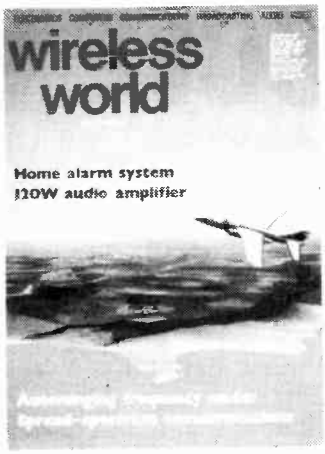


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**Subscriptions**: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 0444 59188. Please notify a change of address.
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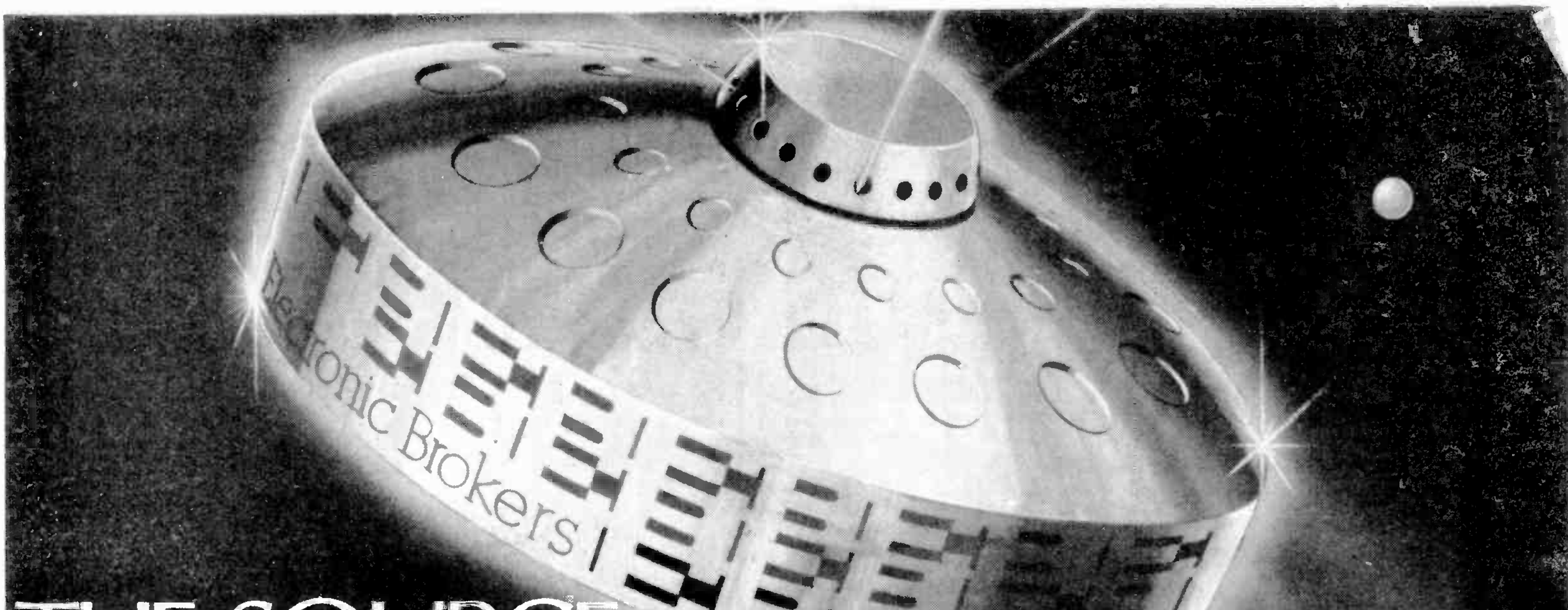
 ISSN 0043 6062.

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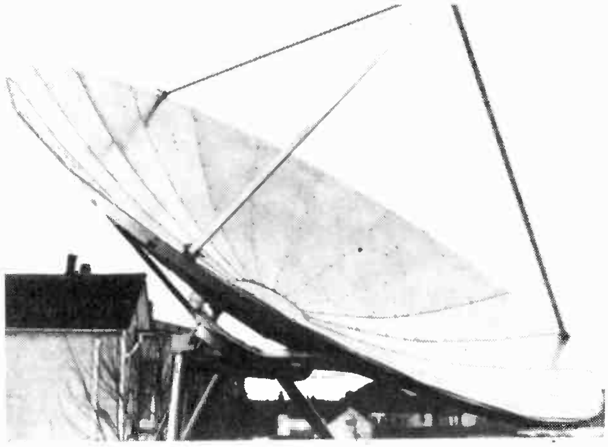

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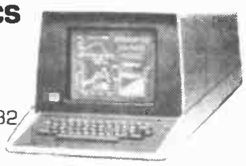

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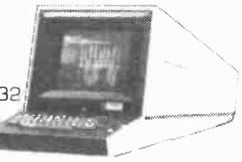

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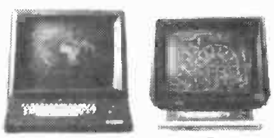

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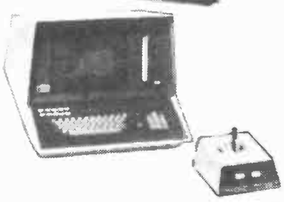

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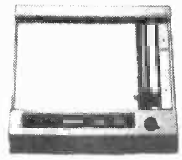

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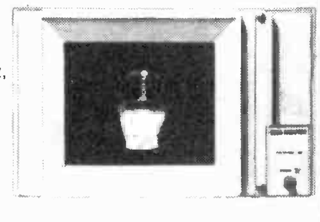

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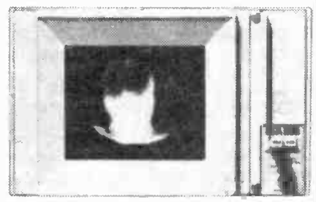

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11/23 CPU, 128KB MOS, Dual RL02 & Control, DLV11J 4-line Interface, Cabinet, VT100 Console, NEW
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**PDP11/24 SYSTEM**
11/24 CPU, 256KB MOS, Dual RL02 & Control, Cabinet, VT100 Console, NEW
**£15,750**

**PDP11/34 SYSTEM**
11/34 CPU, 256KB MOS, Dual RK07 & Control, Cabinet, LA36 Console
**£13,725**

**PDP11/70 SYSTEM**
11/70 CPU 1MB CORE Dual Data System Cabinet RM03 & Control, LA120 Console
**£38,500**

**WS78 WORD PROCESSOR**
WT78 Word Terminal and Processor RX01 Dual Floppy Disk Drive Diablo Letter Quality Printer. Complete with cabinets and full documentation
**£2950**

### DEC CONTROLLERS

| | |
|---|---|
| RH11 [NEW] | £3,000 |
| RK11D [NEW] | £895 |
| RK711 | £1,750 |
| RKV11 | £525 |
| RX211 | £195 |
| TMB11 [NEW] | £1,250 |

### DEC 11/70 MEMORY
MJ11BY Memory box including Controller and 64KW Core [excluding cables]
**£2250**
MJ11BM 32KW Core Stack
**£600**

### DEC PRINTERS AND TERMINALS

| | |
|---|---|
| LA36 DECwriter II 20mA | £295 |
| LA36 DECwriter II RS232 | £325 |
| LA180-PD DECprinter I [NEW] | £495 |
| VT50 DECscope 20mA | £199 |
| VT50 DECscope RS232 | £225 |
| VT105 Graphics Terminal | £950 |

### NEW HAZELTINE VDUS

| | |
|---|---|
| Hazeltine 1420 | £350 |
| Hazeltine 1510 | £550 |
| Hazeltine 1520 | £625 |

## VT100 – PLUS
**SPECIAL PURCHASE BRAND NEW SURPLUS**

**DEC PDT11/130 PROGRAMMABLE DATA TERMINAL COMPRISING:**
* VT100 with Advanced Video Option & Printer Port
* Integral LSI Processor with 32K RAM
* Integral dual TU58 mini cartridge

Fantastic value whether for use as VT100 only or as full PDT

**£995** including comprehensive manual

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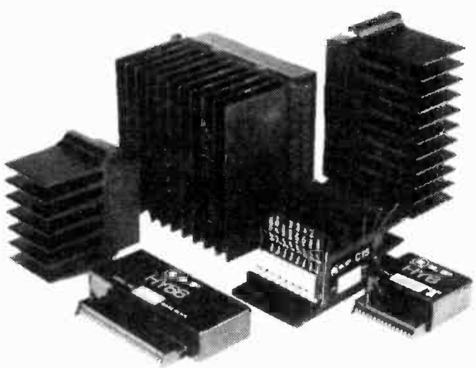
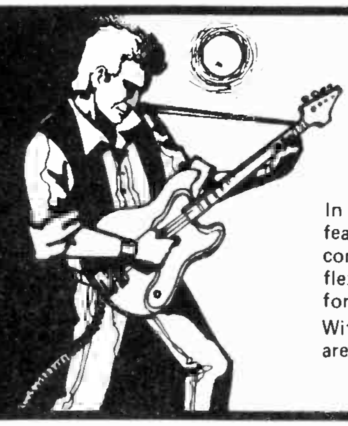
Electronic Brokers

# GET BIG POWER




# ILP Modular Amplifiers
## the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.



## WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.


### BIPOLAR MODULES

| Module Number | Output Power Watts rms | Load Impedance Ω | DISTORTION T.H.D. Typ at 1KHz | I.M.D. 60Hz/7KHz 4:1 | Supply Voltage Typ | Size mm | WT gms | Price inc. VAT |
|---|---|---|---|---|---|---|---|---|
| HY30 | 15 | 4-8 | 0.015% | <0.006% | ± 18 | 76 x 68 x 40 | 240 | £8.40 |
| HY60 | 30 | 4-8 | 0.015% | <0.006% | ± 25 | 76 x 68 x 40 | 240 | £9.55 |
| HY6060 | 30 + 30 | 4-8 | 0.015% | <0.006% | ± 25 | 120 x 78 x 40 | 420 | £18.69 |
| HY124 | 60 | 4 | 0.01% | <0.006% | ± 26 | 120 x 78 x 40 | 410 | £20.75 |
| HY128 | 60 | 8 | 0.01% | <0.006% | ± 35 | 120 x 78 x 40 | 410 | £20.75 |
| HY244 | 120 | 4 | 0.01% | <0.006% | ± 35 | 120 x 78 x 50 | 520 | £25.47 |
| HY248 | 120 | 8 | 0.01% | <0.006% | ± 50 | 120 x 78 x 50 | 520 | £25.47 |
| HY364 | 180 | 4 | 0.01% | <0.006% | ± 45 | 120 x 78 x 100 | 1030 | £38.41 |
| HY368 | 180 | 8 | 0.01% | <0.006% | ± 60 | 120 x 78 x 100 | 1030 | £38.41 |

Protection Full load line. Slew Rate 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz – 50KHz. Input sensitivity 500mV rms.
Input Impedance 100K Ω . Damping factor 100Hz >400.

### PRE-AMP SYSTEMS

| Module Number | Module | Functions | Current Required | Price inc. VAT |
|---|---|---|---|---|
| HY6 | Mono pre amp | Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble | 10mA | £7.60 |
| HY66 | Stereo pre amp | Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance | 20mA | £14.32 |
| HY73 | Guitar pre amp | Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix | 20mA | £15.36 |
| HY78 | Stereo pre amp | As HY66 less tone controls | 20mA | £14.20 |

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

**Mounting Boards**
For ease of construction we recommend the **B6** for modules HY6–HY13 £1.05 (inc. VAT) and the **B66** for modules HY66–HY78 £1.29 (inc. VAT).

### MOSFET MODULES

| Module Number | Output Power Watts rms | Load Impedance Ω | DISTORTION T.H.D. Typ at 1KHz | I.M.D. 60Hz/7KHz 4:1 | Supply Voltage Typ | Size mm | WT gms | Price inc. VAT |
|---|---|---|---|---|---|---|---|---|
| MOS 128 | 60 | 4-8 | <0.005% | <0.006% | ± 45 | 120 x 78 x 40 | [illegible] | [illegible] |
| MOS 248 | 120 | 4-8 | <0.005% | <0.006% | ± 55 | 120 x 78 x 80 | 850 | £39.86 |
| MOS 364 | 180 | 4 | <0.005% | <0.006% | ± 55 | 120 x 78 x 100 | 1025 | £45.54 |

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time. 3μs. S/N ratio. 100db
Frequency response (−3dB): 15Hz – 100KHz. Input sensitivity 500mV rms
Input impedance: 100K Ω. Damping factor. 100Hz > 400.

## 'NEW to ILP' In Car Entertainments

**C15**
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.
Very easy to use.
Robust construction. £9.14 (inc. VAT)
Mounts anywhere in car.
Automatic switch on.
Output power maximum 22w peak into 4Ω.
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω.
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω.
Size 95 x 48 x 50mm. Weight 256 gms.

**C1515**
Stereo version of C15. £17.19 (inc. VAT)
Size 95 x 40 x 80. Weight 410 gms.

### POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

| Model Number | For Use With | Price inc. VAT |
|---|---|---|
| PSU 21X | 1 or 2 HY30 | £11.93 |
| PSU 41X | 1 or 2 HY60, 1 x HY6060, 1 x HY124 | £13.83 |
| PSU 42X | 1 x HY128 | £15.90 |
| PSU 43X | 1 x MOS128 | £16.70 |
| PSU 51X | 2 x HY128, 1 x HY244 | £17.07 |

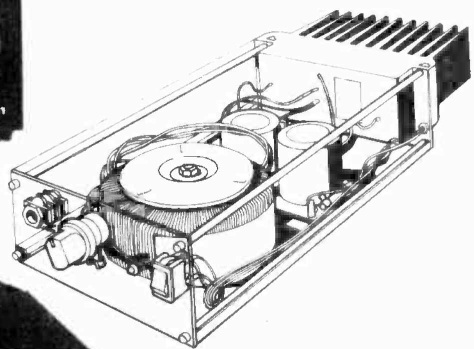
| Model Number | For Use With | Price inc. VAT |
|---|---|---|
| PSU 52X | 2 x HY124 | £17.07 |
| PSU 53X | 2 x MOS128 | £17.86 |
| PSU 54X | 1 x HY248 | £17.86 |
| PSU 55X | 1 x MOS248 | £19.52 |
| PSU 71X | 2 x HY244 | £21.75 |

| Model Number | For Use With | Price inc. VAT |
|---|---|---|
| PSU 72X | 2 x HY248 | £22.54 |
| PSU 73X | 1 x HY364 | £22.54 |
| PSU 74X | 1 x HY368 | £24.20 |
| PSU 75X | 2 x MOS248 1 x MOS368 | £24.20 |

**Please note:** X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

# WITH A LOT OF HELP FROM ILP ELECTRONICS LTD

# PROFESSIONAL HI-FI THAT EVERY ENTHUSIAST CAN HANDLE...

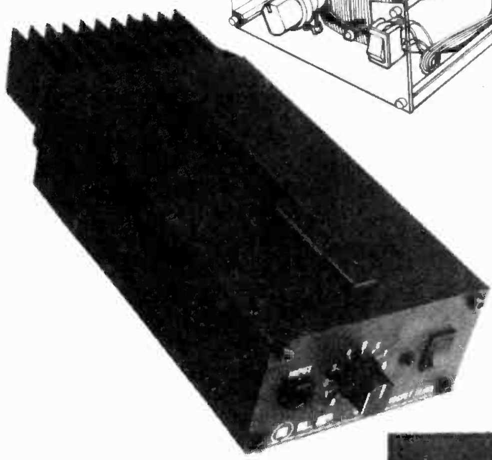



## Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.



## Hi Fi Separates

**UC1 PRE AMP UNIT:** Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

**POWER AMPS:** The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.


## Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

**UNICASES**

| **HIFI Separates** | | | | | **Price inc. VAT** |
|---|---|---|---|---|---|
| UC1 | Preamp | | | | £29.95 |
| UP1X | 30 + 30W/4–8Ω | Bipolar | Stereo | HiFi | £54.95 |
| UP2X | 60W/4Ω | Bipolar | Mono | HiFi | £54.95 |
| UP3X | 60W/8Ω | Bipolar | Mono | HiFi | £54.95 |
| UP4X | 120W/4Ω | Bipolar | Mono | HiFi | £74.95 |
| UP5X | 120W/8Ω | Bipolar | Mono | HiFi | £74.95 |
| UP6X | 60W/4–8Ω | MOS | Mono | HiFi | £64.95 |
| UP7X | 120W/4–8Ω | MOS | Mono | HiFi | £84.95 |
| **Power Slaves** | | | | | |
| US1X | 60W/4Ω | Bipolar | Power | Slave | £59.95 |
| US2X | 120W/4Ω | Bipolar | Power | Slave | £79.95 |
| US3X | 60W/4–8Ω | MOS | Power | Slave | £69.96 |
| US4X | 120W/4–8Ω | MOS | Power | Slave | £89.95 |

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

**TO ORDER USING OUR FREEPOST FACILITY**
Fill in the coupon as shown, or write details on a separate sheet of paper, quoting the name and date of this journal. By sending your order to our address as shown at the bottom of the page opposite, with FREEPOST clearly shown on the envelope, you need not stamp it. We pay postage for you. Cheques and money orders must be crossed and made payable to I.L.P. Electronics Ltd. if sending cash, it must be by registered post. To pay C.O.D. please add £1 to TOTAL value of order.

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Please debit my Access/Barclaycard No. ____________________

Name ____________________

Address ____________________

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Signature ____________________

WW – 013 FOR FURTHER DETAILS

## SWITCHES

TOGGLE 2A 250V
- SPST 33p
- DPDT 44p

SUB-MIN TOGGLE
- SPST on/off 54p
- SPDT c/over 60p
- SPDT centre off 85p
- SPDT biased both ways 105p
- DPDT 6 tags 75p
- DPDT centre off 88p
- DPDT biased both ways 145p
- DPDT 3 positions on/on/on 185p
- 3-pole 2 way 205p

SLIDE 250V
- DPDT 1A 14p
- DPDT 1A c/off 15p
- DPDT 1/2A 13p

PUSHBUTTON 6A with 10mm Button
- SPDT latching 99p
- DPDT latching 145p
- SPDT moment 99p
- DPDT moment 145p

Mini Non Locking
- Push to Make 15p
- Push to Break 25p

**DIL SWITCHES** (SPST) 4-way 70p; 6-way 85p; 8-way 90p; 10-way 145p. (SPDT) 4-way 190p.

**ROTARY SWITCHES** (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way 45p

**ROTARY:** Mains DP 250V 4 Amp on/off 58p

**ROTARY:** (Mak-a-switch) Make a multi-way switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers. (max 6 pole/12 way – DP switch) Mechanism only 90p

**WAFERS:** (make before break) to fit the above switch mechanism 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 way 65p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 8p.

- ROCKER: 5A/250V SPST 28p
- ROCKER: 10A/250V SPDT 38p
- ROCKER: 10A/250V DPDT c/off 95p
- ROCKER: 10A/250V DPST with neon 85p

**THUMBWHEEL:** Mini front mounting
- Decade Switch Module 220p
- B.C.D. Switch Module 275p
- Mounting Cheeks (per pair) 75p

**ETI PROJECTS** We stock most of the parts

**JUMPER LEADS** (Ribbon Cable Assembly)

| Length | 14 pin | 16 pin | 24 pin | 40 pin |
|---|---|---|---|---|
| Single ended DIP (Header Plug) Jumper | | | | |
| 24 inches | 145p | 165p | 240p | 380p |
| Double ended DIP (Header Plug) Jumper | | | | |
| 6 inches | 185p | 205p | 300p | 465p |
| 12 inches | 198p | 215p | 315p | 490p |
| 24 inches | 210p | 235p | 345p | 540p |
| 36 inches | 230p | 250p | 375p | 595p |

IDC Female Header Socket Jumper Leads 24''

| | 20 pin | 26 pin | 34 pin | 40 pin |
|---|---|---|---|---|
| Single ended | 160p | 200p | 260p | 300p |
| Double ended | 290p | 370p | 480p | 525p |

## VEROBOARD 0.1in

| | clad | plain |
|---|---|---|
| 2½-3¼'' | 80p | – |
| 2½-5'' | 91p | – |
| 3¾-3¾'' | 91p | – |
| 3¾-5'' | 105p | 87p |
| 3¾-17'' | 380p | 232p |
| 4¾-17'' | 470p | – |
| Pkt of 100 pins | 50p | |
| Spot face cutter | 135p | |
| Pin insertion tool | 178p | |

- VQ Board 180p
- DIP Board 350p
- Vero Strip 95p

**PROTO DECs**
- Veroblock 405p
- S-Dec 350p
- Eurobreadboard 520p
- Bimboard 1 575p
- Superstrip SS2 1350p

**VERO WIRING**
- PEN + Spool 340p
- Spare Spool 75p
- Combs 6p

**DALO ETCH RESIST PEN** Plus Spare Tip 90p

**FERRIC CHLORIDE** 1 lb bag Anhydrous 195p + 50p P&P

**ULTRASONIC TRANSDUCER** 40kHz 325 pr

## COPPER CLAD BOARDS

| Fibre glass | Single sided | Double sided | S.R.B.P. 9.5''x8.5'' |
|---|---|---|---|
| 6''x6'' | 90p | 110p | 95p |
| 6''x12'' | 150p | 195p | |

**DIL SOCKETS**

| | Low Prof | Wire Wrap |
|---|---|---|
| 8 pin | 8p | 25p |
| 14 pin | 10p | 35p |
| 16 pin | 10p | 42p |
| 18 pin | 16p | 52p |
| 20 pin | 20p | 60p |
| 22 pin | 22p | 65p |
| 24 pin | 25p | 70p |
| 28 pin | 28p | 80p |
| 40 pin | 30p | 99p |

**EDGE CONNECTORS**

| | .1 | .156 |
|---|---|---|
| 2×15 way | – | 140p |
| 2×18 way | 180p | 145p |
| 2×22 way | 199p | 200p |
| 2×23 way | 175p | – |
| 2×25 way | 225p | 220p |
| 2×28 way | 190p | – |
| 2×30 way | 245p | – |
| 2×36 way | 295p | – |
| 2×40 way | 315p | – |
| 2×43 way | 395p | – |
| 2×75 way | 550p | – |

**ANTEX SOLDERING IRON**
- C-15W 455p  CX17W 475p
- CCN-15W 495p  CX25W 510p
- Spare tips, assorted sizes 65p
- Spare Elements 210p
- Iron stand with sponge 165p

**SIL Socket** 0.1'' pitch 20 way 65p

## IDC CONNECTORS

| | PCB Plugs with latch Strt Pins | PCB Plugs with latch Angle Pins | Female Hdr. Plug | Female Card Edge Conn. |
|---|---|---|---|---|
| 10 way | 90p | 99p | 85p | 120p |
| 16 way | 130p | 150p | 110p | – |
| 20 way | 145p | 166p | 125p | 195p |
| 26 way | 175p | 200p | 150p | 240p |
| 34 way | 205p | 236p | 160p | 320p |
| 40 way | 220p | 250p | 190p | 340p |
| 50 way | 235p | 270p | 200p | 395p |
| 60 way | – | – | 230p | 495p |

## EURO CONNECTORS

| | Female Socket Strt Pins | Female Socket Angle Pins | Male Plug Strt Pins | Male Plug Angle Pins |
|---|---|---|---|---|
| DIN41617 31 way | 170p | – | – | 175p |
| DIN41612 2×32 A+B | 275p | 320p | 220p | 285p |
| DIN41612 2×32 A+C | 295p | 340p | 240p | 300p |
| DIN41612 3×32 A+B+C | 380p | 380p | 380p | 380p |

**DIL PLUG** (Header)

| | Solder | IDC |
|---|---|---|
| 14 pin | 40p | 99p |
| 16 pin | 49p | 105p |
| 24 pin | 88p | 178p |
| 40 pin | 250p | 255p |

**ZIF DIL SOCKETS**
- 24 pin 575p
- 28 pin 820p
- 40 pin 975p

**RIBBON CABLE** price per foot

| | Grey | Colour |
|---|---|---|
| 10 way | 12p | 22p |
| 16 way | 18p | 32p |
| 20 way | 25p | 40p |
| 24 way | 35p | 50p |
| 34 way | 48p | 60p |
| 40 way | 55p | 75p |
| 50 way | 65p | 90p |
| 64 way | 85p | 110p |

## PANEL METERS

FSD 60×46×35mm
0.50µA, 0.100µA, 0.500µA, 0.1mA, 0.5mA, 0.10mA, 0.50mA, 0.100mA, 0.500mA, 0.1A, 0.2A, 0.25V, 0.50V AC, 0.300V AC, "S", "VU" 425p each

## CRYSTALS

| | |
|---|---|
| 32.768kHz | 100 |
| 100kHz | 235 |
| 200kHz | 268 |
| 455kH | 370 |
| 1MHz | 275 |
| 1.008M | 275 |
| 1.28MHz | 392 |
| 1.6MHz | 395 |
| 1.8MHz | 395 |
| 1.8432M | 200 |
| 2.0MHz | 225 |
| 2.4576M | 200 |
| 3.278M | 150 |
| 3.5794M | 98 |
| 3.6864M | 300 |
| 4.0MHz | 150 |
| 4.032MHz | 290 |
| 4.19430M | 200 |
| 4.433619M | 100 |
| 4.80MHz | 200 |
| 5.0MHz | 160 |
| 5.185MHz | 300 |
| 5.24288M | 390 |
| 6.0MHz | 140 |
| 6.144MHz | 150 |
| 6.5536MHz | 200 |
| 7.0MHz | 150 |
| 7.168MHz | 250 |
| 7.68MHz | 200 |
| 8.0MHz | 150 |
| 8.08333M | 395 |
| 8.86723M | 175 |
| 9.00MHz | 150 |
| 10.0MHz | 175 |
| 10.24MHz | 200 |
| 10.7MHz | 150 |
| 12.0MHz | 175 |
| 12.528M | 300 |
| 14.31814M | 170 |
| 16.0MHz | 200 |
| 18.0MHz | 180 |
| 18.432M | 150 |
| 20.0MHz | 200 |
| 19.968MHz | 150 |
| 24.0MHz | 170 |
| 24.930MHz | 325 |
| 26.69M | 150 |
| 27.648M | 170 |
| 27.145M | 190 |
| 38.66667M | 175 |
| 48.0MHz | 170 |
| 100.0MHz | 295 |
| 116.0MHz | 250 |

## RELAYS

Miniature enclosed PCB mount
SINGLE POLE Changeover
RL6-91 205Ω Coil; 12V DC, 10V5 to 19.5V). 10A at 30V DC or 250V AC 185p
DOUBLE POLE Changeover. 6A 30V DC or 250V AC.
RL6-100 53Ω Coil, 6V DC (5V4 to 9V9) 190p
RL6-111 205Ω Coil, 12V DC (10V7 to 19V5) 195
RL6-114 740Ω Coil, 24V DC (22V to 37V) 200p

**AMPHENOL PLUGS**
- IEEE 24 way 550p
- Centronics Parallel 36 way solder 530p
- Centronic Parallel 36 way IDC 495p

**BUZZERS:** miniature, solid-state 6V, 9V & 12V 70p

**PIEZO TRANSDUCERS** PB2720 55p

**LOUDSPEAKERS**
Miniature 0.3W 8Ω
- 2in, 3¼in, 2½in, 3in 80p
- 2½in 40Ω, 64Ω or 80Ω 80p

**ASTEC UHF MODULATORS**
- Standard 6MHz 280p
- Wideband 8MHz 480p

## 'WEMON' New Version WATFORD'S Ultimate Monitor IC

A 4K Monitor chip specially designed to produce the best from your Super board Series I & II. Enhanced Super board & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
**Only £10**

## TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA 98p

pcb mounting Miniature Split Bobbin
**3VA:** 2×6V-0.25A; 2×9V-0.15A; 2×12V-0.12A; 2×15V-0.1A 200p
**6VA:** 2×6V-0.5A; 2×9V-0.3A; 2×12V-0.25A; 2×15V-0.2A 270p

Standard Split Bobbin type
**6VA:** 2×6V-0.5A; 2×9V-0.4A; 2×12V-0.3A; 2×15V-0.25A 220p
**12VA:** 2×4.5V-1.3A; 2×6V-1A; 2×9V-0.6A; 2×12V-0.5A; 2×15V-0.4A; 2×20V-0.3A 295p (35p p&p)
**24VA:** 2×6V-1.5A; 2×9V-1.2A; 2×12V-1A; 2×15V-0.8A; 2×20V-0.6A 330p (60p p&p)
**50VA:** 2×6V-4A; 2×9V-2.5A; 2×12V-2A; 2×15V-1.5A; 2×20V-1.2A; 2×30V-0.8A 465p (60p p&p)
Specially wound for Multirail Computer PSUs 50VA: Outputs: +5V/5A; +12V; +25V; −5V, −12V×1A 575p (60p p&p)
**100VA:** 2×12V-4A; 2×15V-3A; 2×20V-2.5A; 2×25V-2A; 2×30V-1.5A; 2×50V-1A 920p
(75p p&p charge to be added over and above our normal postal charge).

## VOLTAGE REGULATORS

1A T0220 Plastic casing

| | +ve | | −ve | |
|---|---|---|---|---|
| 5V | 7805 | 40p | 7905 | 45p |
| 12V | 7812 | 40p | 7908 | 60p |
| 15V | 7815 | 40p | 7912 | 45p |
| 18V | 7818 | 40p | 7915 | 45p |
| 24V | 7824 | 40p | 7918 | 45p |
| | | | 7924 | 45p |

100mA T092 Plastic package

| | +ve | | −ve | |
|---|---|---|---|---|
| 5V | 78L05 | 30p | 79L05 | 60p |
| 6V | 78L06 | 30p | | – |
| 8V | 78L08 | 30p | | – |
| 12V | 78L12 | 30p | 79L12 | 60p |
| 15V | 78L15 | 30p | 79L15 | 60p |

- LM300H 170p
- LM304H 170p
- LM305H 140p
- LM309K 135p
- LM317K 320p
- LM317KP 99p
- LM323K 450p
- LM337 175p
- LM723 Var. 36p
- TAA550 50p
- TDA1412 150p
- 78HO5 +5V/5A 550p
- 78H12 +12V/5A 580p
- 78HG +5V to +25V/5A 599p
- 79HG +2.25V to 24V5A 685p

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| | |
|---|---|
| 3x2x1'' | 65p |
| 4x2½x2'' | 85p |
| 4x2¾x2½'' | 103p |
| 4x4x2'' | 105p |
| 4x4x2½'' | 120p |
| 5x4x1½'' | 99p |
| 5x4x2½'' | 120p |
| 5x2¾x1½'' | 90p |
| 5x2¾x2½'' | 130p |
| 6x4x2'' | 120p |
| 6x4x3'' | 150p |
| 7x5x3'' | 180p |
| 8x6x3'' | 210p |
| 10x4x3'' | 240p |
| 10x7x3'' | 275p |
| 12x5x3'' | 260p |
| 24x8x3'' | 295p |

**D CONNECTORS: Miniature**

| | 9 way | 15 way | 25 way | 37 way |
|---|---|---|---|---|
| MALE | | | | |
| Solder lugs | 80p | 105p | 160p | 250p |
| Angle pins | 150p | 210p | 250p | 385p |
| PCB pins | 120p | 130p | 195p | 295p |
| FEMALE | | | | |
| Solder lugs | 105p | 160p | 200p | 335p |
| Angle pins | 165p | 215p | 290p | 440p |
| PCB pins | 150p | 180p | 240p | 420p |
| COVERS | 90p | 85p | 90p | 100p |

IDC 25 way D Plug 385p
Skt. 450p

**25 way 'D' CONNECTOR Jumper Lead Cable Assembly**
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- 18'' long, Single end, Female 525p
- 36'' long, Double ended, M/M 1025p
- 36'' long, Double ended, F/F 1050p
- 36'' long, Double ended, M/F 995p

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## CMOS

| | | | | | |
|---|---|---|---|---|---|
| | | 4075 | 13 | 4543 | 70 |
| | | 4076 | 50 | 4544 | 150 |
| 4000 | 10 | 4077 | 13 | 4548 | 40 |
| 4001 | 10 | 4078 | 15 | 4549 | 375 |
| 4002 | 12 | 4081 | 13 | 4553 | 245 |
| 4006 | 50 | 4082 | 13 | 4554 | 190 |
| 4007 | 14 | 4085 | 50 | 4555 | 35 |
| 4008 | 32 | 4086 | 60 | 4556 | 35 |
| 4009 | 24 | 4089 | 125 | 4557 | 320 |
| 4010 | 24 | 4093 | 20 | 4558 | 120 |
| 4011 | 10 | 4094 | 70 | 4559 | 395 |
| 4012 | 16 | 4095 | 95 | 4560 | 160 |
| 4013 | 20 | 4096 | 70 | 4561 | 104 |
| 4014 | 46 | 4097 | 290 | 4562 | 495 |
| 4015 | 40 | 4098 | 75 | 4566 | 165 |
| 4016 | 20 | 4099 | 110 | 4568 | 250 |
| 4017 | 32 | 4160 | 95 | 4569 | 175 |
| 4018 | 45 | 4161 | 99 | 4572 | 36 |
| 4019 | 25 | 4162 | 99 | 4580 | 460 |
| 4020 | 42 | 4163 | 99 | 4581 | 250 |
| 4021 | 40 | 4174 | 99 | 4582 | 99 |
| 4022 | 40 | 4175 | 105 | 4583 | 90 |
| 4023 | 13 | 4194 | 105 | 4584 | 40 |
| 4024 | 32 | 4408 | 790 | 4585 | 60 |
| 4025 | 13 | 4409 | 790 | 4597 | 330 |
| 4026 | 80 | 4410 | 725 | 4599 | 290 |
| 4027 | 20 | 4411 | 675 | 40085 | 90 |
| 4028 | 39 | 4412 | 775 | 40097 | 45 |
| 4029 | 45 | 4415 | 480 | 40098 | 42 |
| 4030 | 15 | 4419 | 280 | 40100 | 215 |
| 4031 | 125 | 4422 | 770 | 40101 | 130 |
| 4032 | 80 | 4435 | 850 | 40102 | 140 |
| 4033 | 125 | 4440 | 999 | 40103 | 175 |
| 4034 | 140 | 4450 | 350 | 40104 | 95 |
| 4035 | 45 | 4451 | 350 | 40105 | 105 |
| 4036 | 275 | 4490 | 350 | 40106 | 35 |
| 4037 | 115 | 4500 | 675 | 40107 | 60 |
| 4038 | 110 | 4501 | 28 | 40108 | 198 |
| 4039 | 250 | 4502 | 60 | 40109 | 80 |
| 4040 | 40 | 4503 | 40 | 40110 | 198 |
| 4041 | 40 | 4504 | 75 | 40114 | 240 |
| 4042 | 40 | 4505 | 185 | 40161 | 194 |
| 4043 | 40 | 4506 | 35 | 40163 | 50 |
| 4044 | 40 | 4507 | 35 | 40174 | 45 |
| 4045 | 105 | 4508 | 130 | 40175 | 50 |
| 4046 | 46 | 4510 | 46 | 40181 | 220 |
| 4047 | 40 | 4511 | 45 | 40182 | 90 |
| 4048 | 40 | 4512 | 50 | 40192 | 75 |
| 4049 | 25 | 4513 | 199 | 40193 | 70 |
| 4050 | 25 | 4514 | 115 | 40194 | 70 |
| 4051 | 45 | 4515 | 115 | 40195 | 75 |
| 4052 | 60 | 4516 | 55 | 40244 | 195 |
| 4053 | 50 | 4517 | 275 | 40245 | 195 |
| 4054 | 85 | 4518 | 40 | 40257 | 195 |
| 4055 | 85 | 4519 | 30 | 40373 | 160 |
| 4056 | 85 | 4520 | 50 | 40374 | 160 |
| 4057 | 1915 | 4521 | 90 | 45106 | 598 |
| 4059 | 435 | 4522 | 125 | | |
| 4060 | 45 | 4526 | 70 | | |
| 4061 | 1195 | 4527 | 65 | | |
| 4062 | 995 | 4528 | 70 | OPTO | |
| 4063 | 85 | 4529 | 150 | LS400C | 286 |
| 4066 | 24 | 4530 | 90 | OCP71 | 120 |
| 4067 | 245 | 4531 | 130 | ORP12 | 88 |
| 4068 | 14 | 4532 | 70 | ORP61 | 85 |
| 4069 | 16 | 4534 | 400 | 2N5777 | 45 |
| 4070 | 13 | 4536 | 275 | BPX25 | 195 |
| 4071 | 13 | 4538 | 80 | BPW21 | 295 |
| 4072 | 13 | 4539 | 90 | BPX65 | 270 |
| 4073 | 15 | 4541 | 140 | | |

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| 4557 | 23-04557 | 2.30 |
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| 4560 | 23-04560 | 2.50 |
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| 4562 | 23-04562 | 2.50 |
| 4566 | 23-04566 | 1.20 |
| 4568 | 23-04568 | 1.45 |
| 4569 | 23-04569 | 1.70 |
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| 4580 | 23-04580 | 3.25 |
| 4581 | 23-04581 | 1.40 |
| 4582 | 23-04582 | 0.70 |
| 4583 | 23-04583 | 0.80 |
| 4584 | 23-04584 | 0.27 |
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| 4702 | 23-04702 | 4.50 |
| 4703 | 23-04703 | 4.48 |
| 4704 | 23-04704 | 4.24 |
| 4705 | 23-04705 | 4.24 |
| 4706 | 23-04706 | 4.50 |
| 4720 | 23-04720 | 4.00 |
| 4723 | 23-04723 | 0.95 |
| 4724 | 23-04724 | 0.95 |
| 4725 | 23-04725 | 2.24 |
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| 40085 | 23-40085 | 0.89 |
| 40098 | 23-40098 | 0.54 |
| 40106 | 23-40106 | 0.89 |
| 40160 | 23-40160 | 1.05 |
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| 74LS32 | 31-07432 | 0.14 |
| 74LS33 | 31-07433 | 0.14 |
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| 74LS93 | 31-07493 | 0.24 |
| 74LS95 | 31-07495 | 0.38 |
| 74LS107 | 31-74107 | 0.31 |
| 74LS109 | 31-74109 | 0.25 |
| 74LS112 | 31-74112 | 0.21 |
| 74LS113 | 31-74113 | 0.21 |
| 74LS114 | 31-74114 | 0.21 |
| 74LS122 | 31-74122 | 0.27 |
| 74LS123 | 31-74123 | 0.38 |
| 74LS125 | 31-74125 | 0.27 |
| 74LS126 | 31-74126 | 0.27 |
| 74LS132 | 31-74132 | 0.27 |
| 74LS133 | 31-74133 | 0.24 |
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| 74LS138 | 31-74138 | 0.30 |
| 74LS139 | 31-74139 | 0.30 |
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| 74LS155 | 31-74155 | 0.30 |
| 74LS156 | 31-74156 | 0.33 |
| 74LS157 | 31-74157 | 0.27 |
| 74LS158 | 31-74158 | 0.27 |
| 74LS160 | 31-74160 | 0.34 |
| 74LS161 | 31-74161 | 0.36 |
| 74LS162 | 31-74162 | 0.36 |
| 74LS163 | 31-74163 | 0.36 |
| 74LS164 | 31-74164 | 0.40 |
| 74LS165 | 31-74165 | 0.80 |
| 74LS166 | 31-74166 | 0.58 |
| 74LS168 | 31-74168 | 0.69 |
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| 74LS175 | 31-74175 | 0.40 |
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| 74LS183 | 31-74183 | 1.05 |
| 74LS190 | 31-74190 | 0.39 |
| 74LS191 | 31-74191 | 0.39 |
| 74LS192 | 31-74192 | 0.39 |
| 74LS193 | 31-74193 | 0.39 |
| 74LS194 | 31-74194 | 0.39 |
| 74LS195 | 31-74196 | 0.39 |
| 74LS196 | 31-74196 | 0.39 |
| 74LS197 | 31-74197 | 0.47 |
| 74LS221 | 31-74221 | 0.50 |
| 74LS240 | 31-74240 | 0.80 |
| 74LS241 | 31-74241 | 0.80 |
| 74LS242 | 31-74242 | 0.55 |
| 74LS243 | 31-74243 | 0.55 |
| 74LS244 | 31-74244 | 0.80 |
| 74LS245 | 31-74245 | 1.00 |
| 74LS251 | 31-74251 | 0.38 |
| 74LS253 | 31-74253 | 0.38 |
| 74LS257 | 31-74257 | 0.38 |
| 74LS258 | 31-74258 | 0.38 |
| 74LS259 | 31-74259 | 0.51 |
| 74LS260 | 31-74260 | 0.28 |
| 74LS266 | 31-74266 | 0.20 |
| 74LS273 | 31-74273 | 0.70 |
| 74LS279 | 31-74279 | 0.35 |
| 74LS283 | 31-74283 | 0.40 |
| 74LS290 | 31-74290 | 0.40 |
| 74LS293 | 31-74293 | 0.40 |
| 74LS298 | 31-74298 | 0.54 |
| 74LS365 | 31-74365 | 0.34 |
| 74LS366 | 31-74366 | 0.40 |
| 74LS367 | 31-74367 | 0.30 |
| 74LS368 | 31-74368 | 0.30 |
| 74LS373 | 31-74373 | 0.72 |
| 74LS374 | 31-74374 | 0.72 |
| 74LS375 | 31-74375 | 0.31 |
| 74LS377 | 31-74377 | 0.80 |
| 74LS378 | 31-74378 | 0.44 |
| 74LS379 | 31-74379 | 0.44 |
| 74LS385 | 31-74385 | 1.30 |
| 74LS386 | 31-74386 | 0.27 |
| 74LS390 | 31-74390 | 0.51 |
| 74LS393 | 31-74393 | 0.48 |
| 74LS398 | 31-74398 | 0.80 |
| 74LS399 | 31-74399 | 0.85 |
| 74LS490 | 31-74490 | 0.80 |
| 74LS670 | 31-74670 | 1.15 |

## 74HCXX

| Type | Stock No. | Price |
|---|---|---|
| 74HC00 | 30-07400 | 0.56 |
| 74HC02 | 30-07402 | 0.56 |
| 74HC04 | 30-07404 | 0.68 |
| 74HC10 | 30-07410 | 0.56 |
| 74HC20 | 30-07420 | 0.56 |
| 74HC86 | 30-07486 | 0.74 |
| 74HC132 | 30-74132 | 1.26 |
| 74HC266 | 30-74266 | 0.81 |
| 74HC4002 | 30-04002 | 0.56 |
| 74HC4075 | 30-04075 | 0.56 |
| 74HC242 | 30-74242 | 2.00 |
| 74HC243 | 30-74243 | 2.00 |
| 74HC74 | 30-07474 | 0.74 |
| 74HC109 | 30-74109 | 0.88 |
| 74HC175 | 30-74175 | 1.08 |
| 74HC373 | 30-74373 | 2.40 |
| 74HC374 | 30-74374 | 2.40 |
| 74HC533 | 30-74533 | 2.40 |
| 74HC534 | 30-74534 | 2.40 |
| 74HC165 | 30-74165 | 1.98 |
| 74HC173 | 30-74173 | 1.20 |
| 74HC160 | 30-74160 | 1.33 |
| 74HC161 | 30-74161 | 1.33 |
| 74HC162 | 30-74162 | 1.33 |
| 74HC163 | 30-74163 | 1.33 |
| 74HC4538 | 30-74538 | 2.10 |
| 74HC85 | 30-74280 | 2.95 |
| 74HC280 | 30-74280 | 2.95 |
| 74HC42 | 30-07442 | 1.00 |
| 74HC138 | 30-74138 | 1.08 |
| 74HC139 | 30-74139 | 1.08 |
| 74HC4514 | 30-04514 | 3.40 |
| 74HC4543 | 30-04543 | 2.75 |
| 74HC157 | 30-74157 | 0.92 |
| 74HC158 | 30-74158 | 0.90 |
| 74HC257 | 30-74257 | 0.90 |

## LINEAR ICs

| Type | Stock No. | Price |
|---|---|---|
| LM10CN | 61-00010 | 3.88 |
| MF10 | 61-00011 | 5.05 |
| L149 | 61-00149 | 1.86 |
| ZNA234 | 61-02340 | 8.50 |
| U237B | 61-00237 | 1.28 |
| U247B | 61-00247 | 1.28 |
| U257B | 61-00257 | 1.28 |
| U267B | 61-00267 | 1.28 |
| LM301AH | 61-03010 | 0.67 |
| LM301AN | 61-03011 | 0.27 |
| LM308H | 61-03080 | 0.70 |
| LM308CN | 61-03081 | 0.85 |
| LM324 | 61-03240 | 0.45 |
| LM339N | 61-03390 | 0.68 |
| LF347 | 61-00347 | 1.80 |
| LM348 | 61-03480 | 0.90 |
| LF351 | 61-03510 | 0.49 |
| LF353 | 61-03530 | 0.76 |
| LM380N | 61-00380 | 1.00 |
| LM381 | 61-00381 | 1.81 |
| LM382 | 61-00382 | 1.81 |
| ZN419CE | 61-00419 | 1.88 |
| ZNA423 | 61-04230 | 1.00 |
| ZN425E/8 | 61-04250 | 3.50 |
| ZN426E/8 | 61-04260 | 3.00 |
| ZN427E/8 | 61-04270 | 6.28 |
| ZN428E/8 | 61-04280 | 4.78 |
| ZN429E/8 | 61-04290 | 2.10 |
| ZN432CJ10 | 61-04320 | 28.09 |
| ZN433CJ10 | 61-04330 | 22.59 |
| ZN440J | 61-04400 | 0.80 |
| ZN450E | 61-04500 | 7.81 |
| NE542 | 61-05420 | 1.20 |
| NE544 | 61-00544 | 1.80 |
| NE555N | 61-05550 | 0.20 |
| NE556N | 61-05560 | 0.50 |
| SL560C | 61-05600 | 1.98 |
| NE562 | 61-00562 | 4.05 |
| NE564 | 61-00564 | 4.29 |
| NE565 | 61-00565 | 1.00 |
| NE566 | 61-00568 | 1.30 |
| NE567 | 61-00567 | 1.30 |
| NE570N | 61-00570 | 3.85 |
| SL624 | 61-00624 | 3.28 |
| uA709HC | 61-07090 | 0.64 |
| uA709PC | 61-07091 | 0.38 |
| uA710HC | 61-07100 | 0.64 |
| uA710PC | 61-07101 | 0.58 |
| uA711CN | 61-07110 | 0.95 |
| uA733CN | 61-07330 | 0.89 |
| uA741CH | 61-07410 | 0.66 |
| uA741CN | 61-07411 | 0.20 |
| uA747CN | 61-07470 | 0.78 |
| uA748CN | 61-04780 | 0.30 |
| uA758 | 61-00758 | 2.35 |
| TBA820M | 61-00820 | 0.78 |
| TDA1028 | 61-01028 | 2.11 |
| TDA1029 | 61-01029 | 2.11 |
| ZNA1034 | 61-01034 | 2.10 |
| LM1035 | 61-01034 | 2.10 |
| TDA1054M | 61-01054 | 1.45 |
| TDA1062 | 61-01062 | 1.95 |
| TDA1072 | 61-01072 | 2.00 |
| TDA1074A | 61-01074 | 5.04 |
| TDA1083 | 61-01083 | 1.95 |
| TDA1090 | 61-01090 | 3.05 |
| HA1137 | 61-12411 | 1.20 |
| HA1196 | 61-01196 | 2.00 |
| HA1197 | 61-01197 | 1.00 |
| TDA1220 | 61-01220 | 1.40 |
| LM1303 | 61-01303 | 0.99 |
| LM1307 | 61-01307 | 1.55 |
| MC1310P | 61-01310 | 1.90 |
| MC1330 | 61-01330 | 1.20 |
| MC1350 | 61-01350 | 1.20 |
| HA1370 | 61-11370 | 1.80 |
| HA1388 | 61-01388 | 2.75 |
| LM1458N | 61-14580 | 0.45 |
| MC1496P | 61-01496 | 1.25 |
| SL1610 | 61-01610 | 1.92 |
| SL1611 | 61-01611 | 1.80 |
| SL1612 | 61-01612 | 1.80 |
| SL1613 | 61-01613 | 2.08 |
| SL1620 | 61-01620 | 2.50 |
| SL1621 | 61-01621 | 2.50 |
| SL1623 | 61-01623 | 2.44 |
| SL1625 | 61-01625 | 2.50 |
| SL1626 | (SL6270) | |
| SL1630 | 61-01630 | 1.62 |
| SL1640 | 61-01640 | 2.25 |
| SL1641 | 61-01641 | 2.25 |
| MC1648 | 61-01648 | 3.25 |
| TDA2002 | 61-02002 | 1.25 |
| ULN2240 | 61-02240 | 3.25 |
| ULN2242 | 61-01090 | 3.05 |
| ULN2283 | 61-02283 | 1.00 |
| CA3080 | 61-03080 | 0.70 |
| CA3089 | 61-03089 | 1.84 |
| CA3123 | 61-03123 | 1.40 |
| CA3130E | 61-31300 | 0.80 |
| CA3130T | 61-31301 | 0.90 |
| CA3140E | 61-31400 | 0.46 |
| CA3189E | 61-03189 | 2.20 |
| CA3240E | 61-32400 | 1.27 |
| MC3357 | 61-03357 | 2.85 |
| MC3359 (see ULN3859) | | |
| ULN3859 | 61-03859 | 2.85 |
| KM3701 | 61-03701 | 85.53 |
| KM3702 | 61-03702 | 74.84 |
| LM3900 | 61-39000 | 0.80 |
| LM3909N | 61-39090 | 0.68 |
| LM3914N | 61-03914 | 2.80 |
| LM3915N | 61-03915 | 2.80 |
| KB4400 | 61-04400 | 0.80 |
| KB4412 | 61-04412 | 1.95 |
| KB4413 | 61-04413 | 1.95 |
| KB4417 | 61-04417 | 1.80 |
| KB4420B | 61-04420 | 1.09 |
| TDA4420 | 61-14420 | 2.85 |
| TDA4421 | 61-14421 | 2.85 |
| KB4423 | 61-04423 | 2.30 |
| KB4424 | 61-04424 | 1.65 |
| KB4430 | 61-04430 | 2.30 |
| KB4431 | 61-04431 | 1.95 |
| KB4432 | 61-04432 | 1.95 |
| KB4433 | 61-04433 | 1.52 |
| KB4436 | 61-04436 | 2.53 |
| KB4437 | 61-04437 | 1.75 |
| KB4438 | 61-04438 | 2.22 |
| KB4441 | 61-04441 | 1.35 |
| KB4445 | 61-04445 | 1.29 |
| KB4446 | 61-04446 | 2.75 |
| KB4448 | 61-04448 | 1.65 |
| NE5044 | 61-05044 | 2.26 |
| MC5229 | 61-05229 | 9.80 |
| NE5532 | 61-55320 | 1.95 |
| KM5624 | 61-05624 | 4.35 |
| SD6000 | 61-06000 | 3.75 |
| SL6270 | 61-06270 | 2.03 |
| SL6310 | 61-06310 | 2.45 |
| SL6440 | 61-06440 | 3.38 |
| SL6600 | 61-06600 | 3.75 |
| SAS6610 | 61-06610 | 1.48 |
| SL6640 | 61-06640 | 2.75 |

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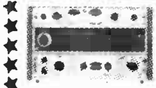

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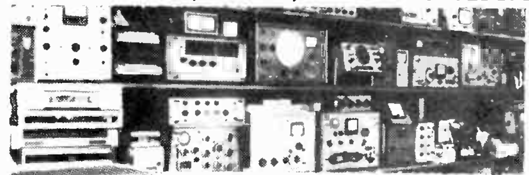

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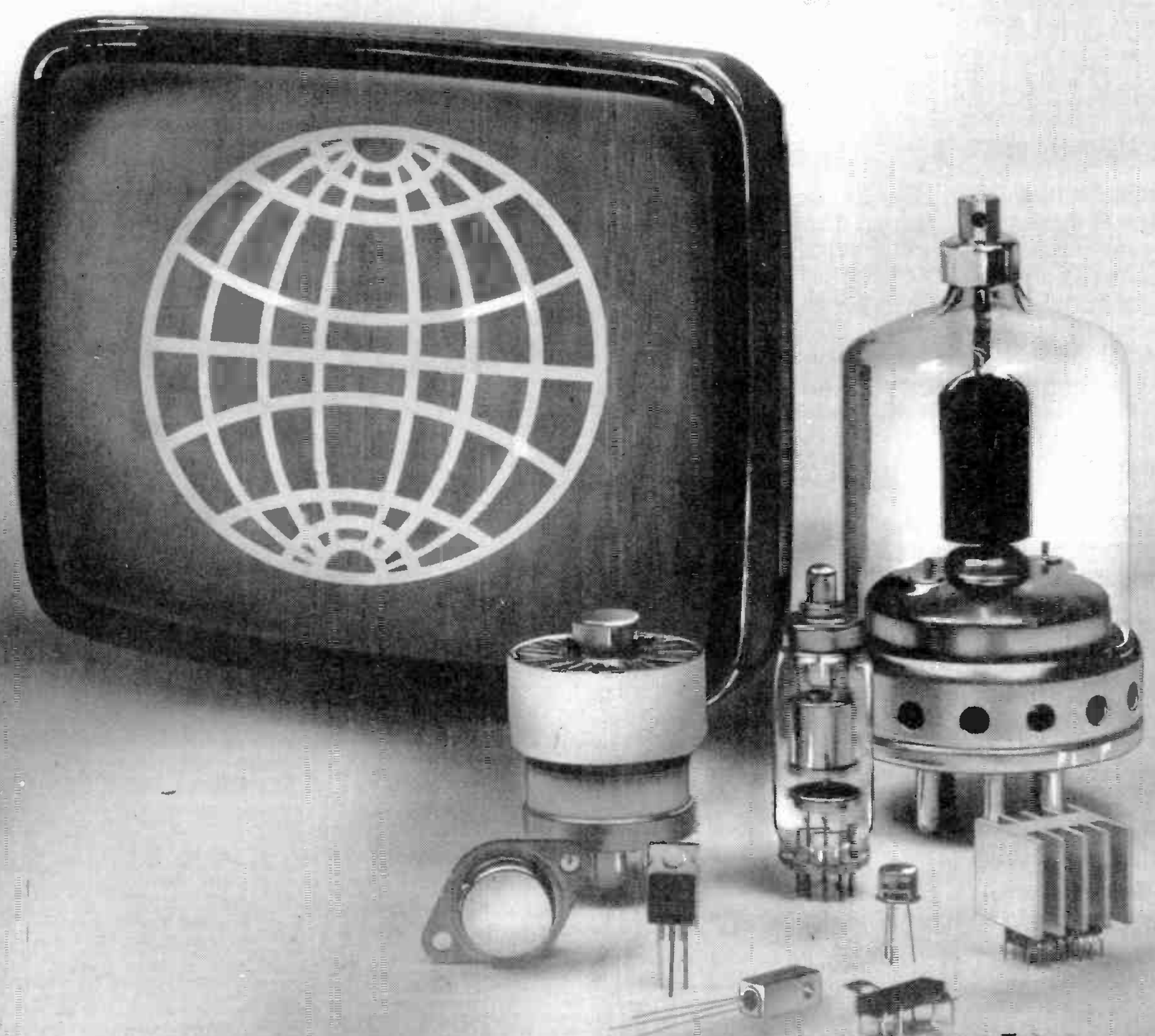

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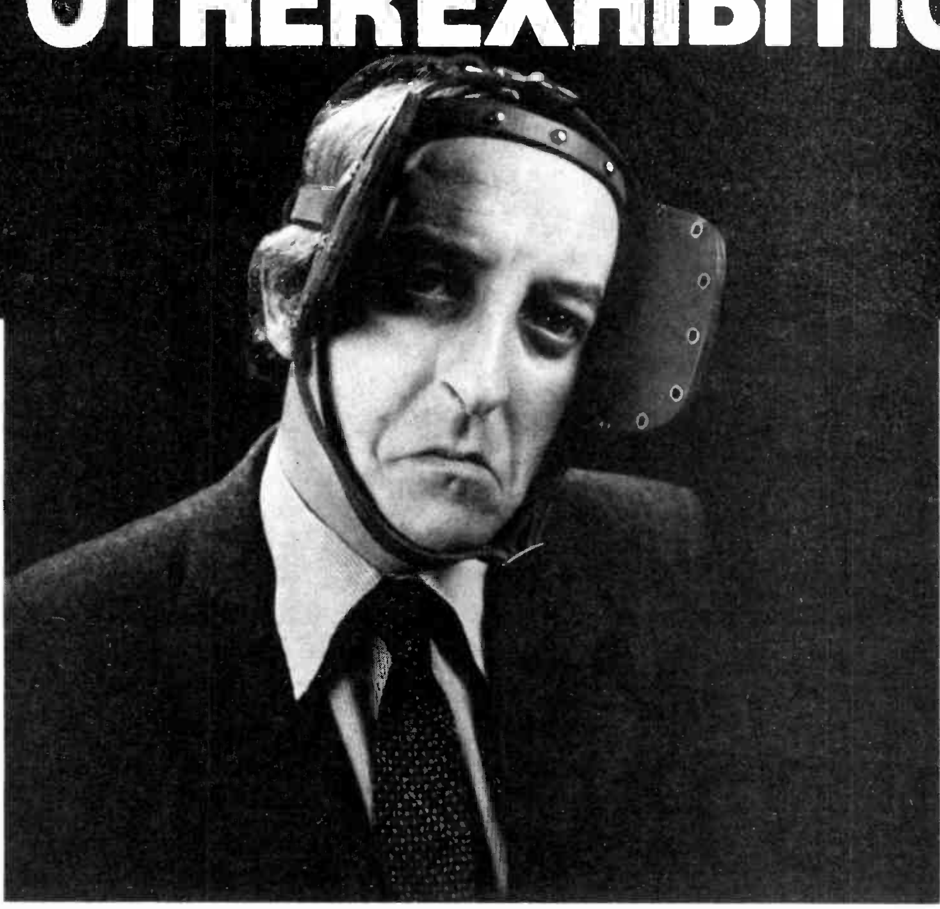

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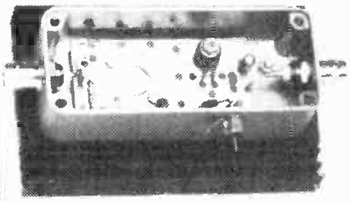

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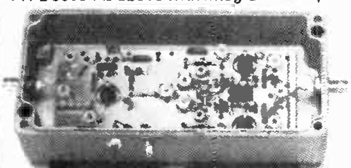

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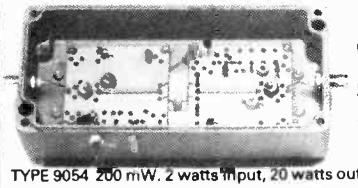

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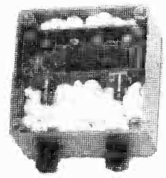

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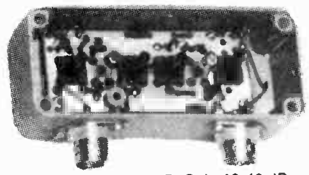

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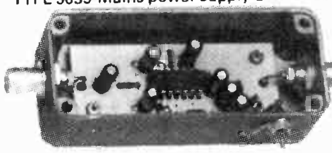

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# Design for living

Military needs are a powerful stimulus to invention. Large companies fall over themselves to tender for the latest 'defence' requirement for a communications system or missile guidance, and many rely on military procurement for their existence. No expense is too high and the concept of deterrence, which implies that none of the equipment will ever be used for its designed purpose is, apparently, irrelevant.

Domestic equipment is the other major sink for materials and inventive talent. The pace of development in passive home entertainment shows no sign of slackening, even though the performance of, for example, audio systems is at the stage where it takes a collection of instruments to measure the difference between the original and the reproduction. Video recorders are a latter-day "opium of the people".

All this is not to say that the design effort expended on offensive or brain-paralysing electronics is wasted: very little ingenuity is ever a total loss, since engineering is engineering, in whatever walk of life it is applied, and 'spin-off' is always a benefit.

It seems to us that the truly gigantic body of knowledge in electronics should be applied in an immediately useful, peaceful and thrifty manner to enrich human life. Since most of us in the developed countries already enjoy an existence which is far above the tolerable, it makes sense to assist those whose lives are made more difficult than they need be through physical handicap.

With this in mind, our publishers announce this month a design competition, very open in its aims, to stimulate invention of aids to the handicapped. Anyone can enter – individuals or organizations – but perhaps the most rewarding form of entry would be by a small group, with the implied teamwork behind it. Such a competition offers two challenges: firstly, to decide what is needed, to stick to the decision when the going becomes difficult and not to change horses; and secondly, to carry out the design work itself – perhaps the easier of the two.

The constraints to be applied, both in selection of goal and its realisation, are few, and are practical. For example, it serves no purpose to design a brilliant device to enable the deaf to hear if no-one can afford to buy it: similarly, a blind pedestrian will not thank the designer of his 'hazard detector' if it breaks down every time he goes out, leaving him exposed in the middle of the High Street race-track.

It must be feasible to manufacture the equipment, and it must be usable by the type of person for whom it is intended: aids have been produced in the past for which a commercial pilot's licence would have been a distinct advantage.

Maintenance – replacement of batteries, mechanical attention and the renewal of components such as tungsten bulbs should be kept to a minimum and, above all, the device must be safe: to be savaged by a deranged robot would not contribute greatly to one's peace of mind.

The rules stipulate that designs should be electronics-based, for the obvious reason that our readers are electronic engineers: this does not mean that designs for equipment which would be better without electronics will be welcomed – a sense of proportion is necessary. And solutions which are simply software written for existing hardware are not acceptable: this is an engineering competition, for which engineering design skills are needed.

Schools, university departments, company design teams and individuals are all eligible to enter: the prizes are worthwhile and the highest reward of all is that of having assisted someone to live a more active life.

# Domestic alarm system

*A low-cost unit which possesses a number of features designed to cause the maximum confusion and frustration for a house-breaker*

**By Paul E. Bruin**

Of the many low-cost domestic alarm systems on the market today, most combine their arm, disarm and other circuitry in a single box, sometimes including a built-in intruder sensor and a noisemaker. Although convenient to use and install, such devices can be self-defeating: if spotted by an intruder, they may be quickly disabled or destroyed. This relatively economical project is designed to be less vulnerable. A remote arm/disarm facility and remote sensors allow its main unit to be safely hidden and locked away. Once the system fires, clocked logic sequentially sets off three individually placed noisemakers to distract and confuse the intruder. These later shut down to save neighbours' nerves, but an outdoor lamp flashes for an additional 20 minutes to persuade them that a true break-in has occurred. The lamp also helps police localize the endangered premises. Finally, the system rests and awaits a new trigger. An external storage battery provides the relatively high current consumed by the noisemakers and the lamp, and supplies over-all circuit power in case mains power fails.

## Main unit

Figure 1 shows the system's main circuit, controlled via input terminals DISARM and $\overline{\text{FIRE}}$. The $\overline{\text{FIRE}}$ input goes low only when a normally closed alarm loop, routed through perimeter sensor switches to $V^+$, is broken. If DISARM is made high, the output of $IC_2$ goes low, forcing the $\overline{Q}$ output of master latch $IC_{3b}$ and $IC_{3c}$ high. This clears or resets all subsequent circuitry and prevents further circuit operation. The DISARM high level is 9 V. Should external tampering short-circuit DISARM to $V^+$ (13.8 V), $Tr_8$, acting as a

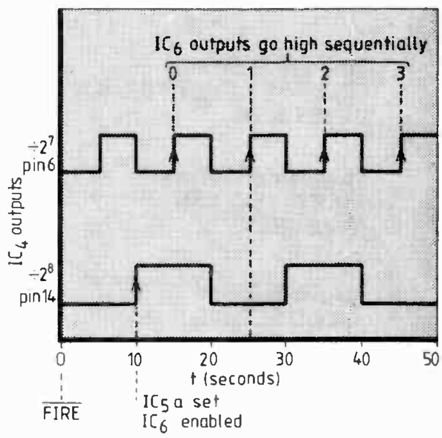
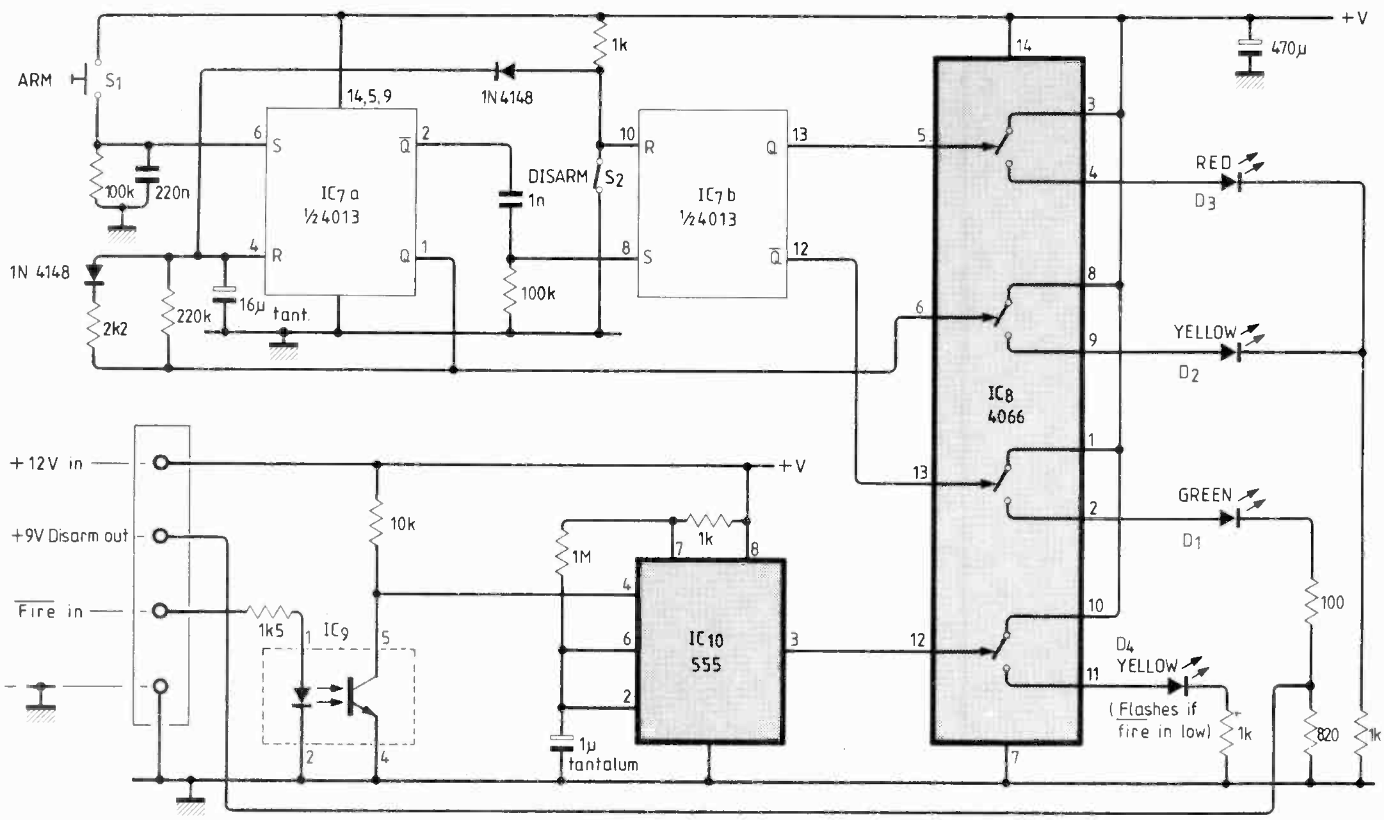
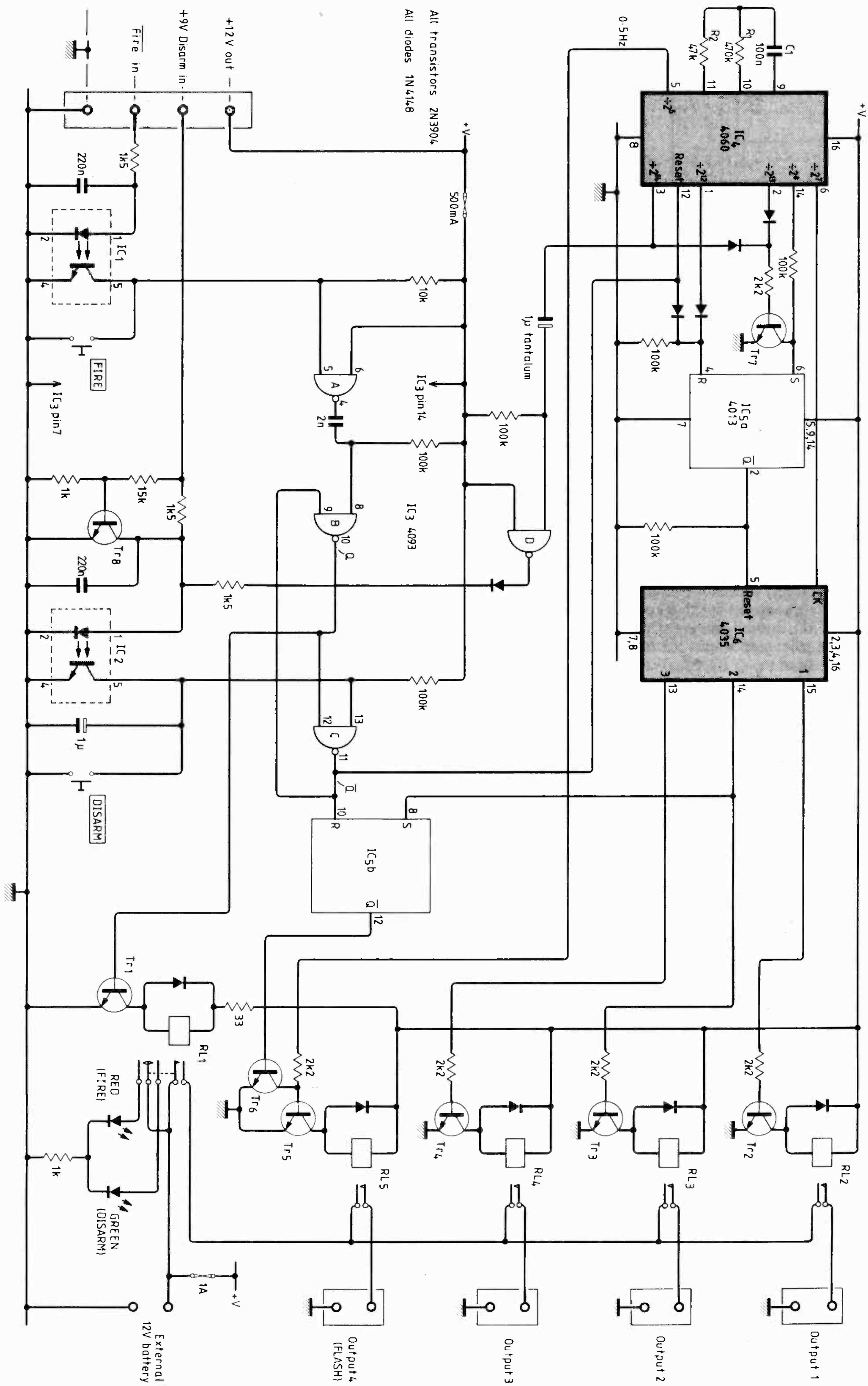



*Fig. 2. Counter $IC_4$ timing diagram, showing 20s delay after $\overline{\text{FIRE}}$ input.*

*Fig. 3. Remote-control unit.*

*Fig. 1. Main control circuit diagram – inputs are DISARM and $\overline{\text{FIRE}}$.*




All transistors 2N3904
All diodes 1N4148
+12V out
+9V Disarm in
Fire in
FIRE
DISARM
IC1
IC2
IC3 4093
IC3 pin 14
IC3 pin 7
IC4 4060
IC5a 4013
IC5b
IC6 4035
0.5Hz
1μ tantalum
500mA
1A
RL1
RL2
RL3
RL4
RL5
RED (FIRE)
GREEN (DISARM)
Output 1
Output 2
Output 3
Output 4 (FLASH)
External 12V battery

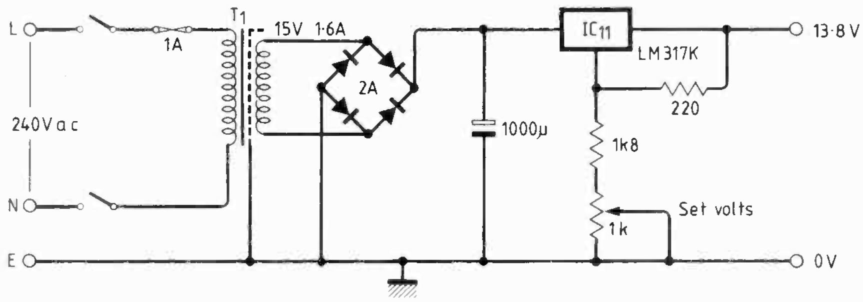



*Fig. 4. Power supply, which also charges external battery.*

level detector, inhibits false disarming by clamping the $IC_1$ input to ground.

If DISARM goes low, all remains passive until the alarm loop is broken. Then, $IC_1$ output goes high, producing a fast, negative-going voltage at pin 4 of Schmitt trigger $IC_{3a}$ as it inverts the change. This edge triggers the master latch, bringing its $\overline{Q}$ output low and further enabling the system. Safety relay $RL_1$, is activated by driver transistor $Tr_1$, providing current for the other relay contacts while switching on a red led to indicate the $\overline{FIRE}$ condition. The system can be placed in the $\overline{FIRE}$ or DISARM states manually by depressing $S_1$ or $S_2$ respectively.

Ripple counter $IC_4$ is the system clock. It divides its internal oscillator frequency (set at 12Hz by $R_1$ and $C_1$) by $2^n$, where n can be one of several integer values depending on the output pin selected. Thus, the $2^8$ output pin of $IC_4$ completes a timing cycle $\tau = (2^8 \times 1/12)$ about 20 seconds after the clock is enabled by a $\overline{FIRE}$ input. For the first half of this period, the $2^8$ output stays low; it then sets latch $IC_{5a}$ at its 10-second positive-going transition. This enables $IC_6$, a parallel-output shift register, which serially loads a 'one' every time a 10-second signal clocks it from the $2^7$ output of $IC_4$. In this way, the $IC_6$ outputs, which drive transistors $Tr_2$, $Tr_3$ and $Tr_4$ to close noisemaker relays $RL_2$, $RL_3$ and $RL_4$ go high

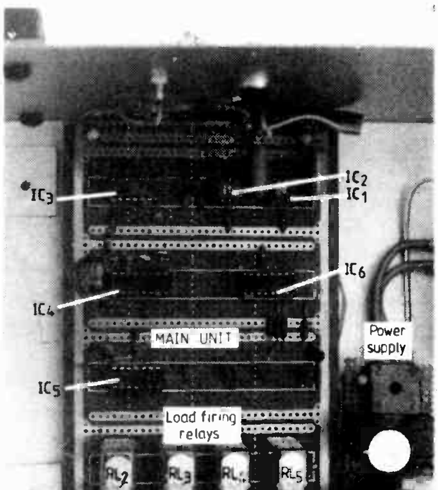



*Fig. 5. Main unit construction, on Veroboard. $IC_1$ and $IC_2$ are opto-isolators.*

sequentially from 25 seconds after $\overline{FIRE}$ occurs, at 10-second intervals (as in Fig. 2). They stay high until the shift register is later cleared. As $IC_6$ pin 14 clocks high, latch $IC_{5b}$ is set, removing drive from $Tr_6$. This allows $Tr_5$ to be turned on and off with a 0.5Hz signal, derived from the clock, and can flash an exterior warning lamp through relay $RL_5$. Approximately three minutes after the FIRE input goes low, $IC_4$ pin 1 goes high, shutting off the noisemakers. Transistor $Tr_7$ prevents $IC_5$ from re-starting them during repetitive clock progressions before final system reset. Some 20 minutes later, $IC_{3d}$ triggers on the falling edge of the clock's slowest output count, resetting the master latch and $IC_{5b}$. The external lamp stops flashing, and the system's timing cycle is complete.

## Control unit

The heart of the remote control unit in Fig. 3 is latch $IC_{7b}$, whose $\overline{Q}$ output determines the state of the DISARM line routed to the main control unit. When the latch's $\overline{Q}$ output is high, analogue switch $IC_{8a}$ is closed, illuminating green led $D_1$ to indicate the system is disarmed. The 100Ω and 820Ω resistors form a voltage divider which sources the 9 V DISARM signal when the green led is on.

Pushing $S_3$ brings monostable $IC_{7a}$ Q output high, lighting yellow led $D_2$ – an intermediate condition. About 20 seconds later, the monostable times out, positive-edge setting the latch and lighting red led $D_3$. Now the system is armed, for with $IC_{7b}$ $\overline{Q}$ low, the DISARM signal is also low and the main control unit is free to respond to a break in its perimeter d.c. alarm loop. Optoisolator $IC_9$ monitors that loop. If there is a break, its output goes high, enabling $IC_{10}$ to flash led $D_4$. This warns the user against activated sensors (e.g., forgotten open doors, windows, etc.) before he sets the alarm. To disarm the system, $S_4$ must be briefly opened. This is a normally closed reed switch, hidden either inside the control unit itself or elsewhere, and is activated by brushing a magnet nearby.

## Power supply

The power supply combines a full-wave rectifier bridge, a smoothing capacitor and an LM317K adjustable regulator to provide a d.c. source from its a.c. line-power transformer. The power supply output voltage, which is also used to

*Mr Bruin was born in Amsterdam, Holland, was raised in Lebanon and attended British and American schools there. After graduating from the American University of Beirut with a B.Sc. in 1976, he found work with CBS News as a television sound recordist covering the Lebanese civil war. The job later took him to Africa for 18 months, travelling around the continent with a cameraman and correspondent. By 1978, photographic film had given way to fully electronic video news coverage, and he was moved to Europe to give technical support to news operations and set up a video maintenance facility in London. As a field engineer, Mr Bruin now travels abroad to install and operate television systems at remote news events, and supervise electronic maintenance.*

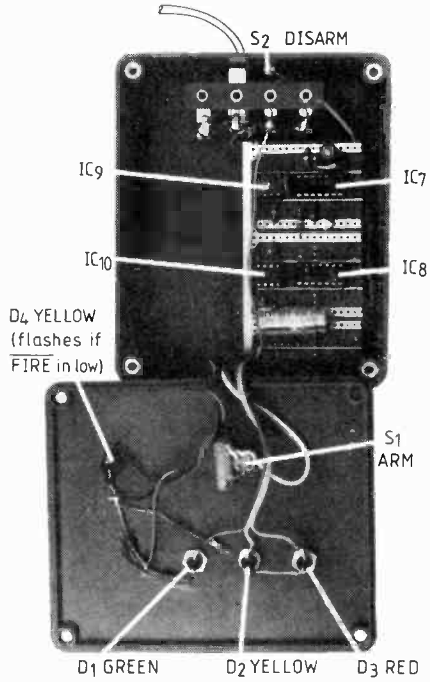



*Fig. 6. Remote unit in its metal box.*

charge the external battery, is set by the 1k potentiometer.

## Construction

The prototype's main circuit board (that is, Fig. 1) was built on 10 × 15 cm Veroboard in a metal case. The power supply regulator, $IC_{11}$, should be mounted separately on a heat sink that will dissipate 15 W comfortably.

Normal c.m.o.s. handling precautions should be observed, and i.c. sockets should be used so that the integrated circuits can be inserted after soldering is complete.

Wiring is not critical, but the lead to $C_2$ should be kept as short as possible, and the wires carrying high current via the relays to the noisemaker and lamp outputs should be as thick and short as practical to reduce IR losses.

On the rear of the main unit, insulated binding posts or 'speaker type' spring-action terminals can be used to connect the output loads and the external battery. A four-terminal barrier strip allows

*continued on page 35*

# High-impedance electronics

*A discussion of voltage-follower circuitry for measurements from high-impedance sources. A subsequent article will describe the precise generation and measurement of currents in the nanoamperè range*

**by R. D. Purves,** Ph.D.

A common experimental procedure in neurophysiology and biophysics is the recording of voltage signals from single nerve or mucle cells[1]. The most accurate measurements are usually made via a fine-tipped hollow glass tube (micropipette) filled with concentrated salt solution and inserted into the interior of the cell (Fig. 1). To minimize damage to the cell's membrane, the diameter of the micropipette at its tip is only 0.05 − 0.5 μm and the resistance of the tapered column of salt solution is therefore high, typically 5 − 50 MΩ or more. The biological signals of interest are 0.1 − 100 mV in amplitude, occupying a bandwidth extending from zero to perhaps 5 or 10 kHz.

The principal tasks of the electronics are to offer an input resistance at least two orders of magnitude greater than the equivalent source resistance, and to generate a bias current sufficiently small not to disturb the impaled cell or produce a significant offset potential. Some nerve cells may be excited by currents less than 1 nA and so the bias current needs to be below 10 pA. Other aspects of performance that may be important in certain applications include bandwidth, noise, drift, gain accuracy and dynamic range. Voltage gain *per se* is not usually a consideration since it can be provided without difficulty once the signal is made available at low impedance.

These design constraints were formerly met, not very conveniently, by the use of electrometer valves such as the Mullard ME1400 (actually a "domestic" pentode with top grid-cap, selected for small grid current) connected in pairs as differential cathode followers, and run with reduced anode voltage and heater current. When fets were introduced, attempts were made to use them because of their small size and easily met power-supply needs. However, the rather large temperature coefficient of $V_{GS}$ (about 2 mV/°C) posed problems, subsequently solved by the appearance of monolithic dual fets. In the circuit of Fig. 2 both fets operate at the same drain current ($I_{DSS}$ of $Tr_2$). Since the fets are matched and at the same temperature, $V_{GS1}=V_{GS2}=0$. The output buffer prevents loading and disturbance of the match of drain currents.

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In recent years, fet operational amplifiers with extremely good specifications have become widely available. The RCA CA3130 and its internally compensated version the CA3160 are priced at less than £1 and offer an input resistance of more than 1 TΩ with a typical bias current of 5 pA at room temperature. The CA3140 has only slightly worse specifications and allows operation from ±15 V supplies, whereas the CA3160 is restricted by its c.m.o.s. output stage to a total supply of 16 V and gets very hot indeed if inadvertently connected to ±15 V. The LF356 is another low-cost device with good noise performance. More expensive devices include the Teledyne-Philbrick 1425 and 1439, and the Burr-Brown 3523, the last-named giving − at a price − spectacularly low noise.

## Bootstrapping

Bootstrapping (Fig. 3) provides a simple means of increasing apparent impedances (or equivalently of reducing apparent admittances). The principle is that when a signal voltage is applied simultaneously to the two ends of a resistor or capacitor, no signal current flows. In Fig. 3(b), if the gain of the feedback amplifier is A, the apparent value of the admittance element is Y (1 − A). Since for a voltage follower A ≈ 1.0, the unwanted admittance can be reduced to virtual non-existence.

The input admittance of an operational voltage follower, whatever its internal construction may be, is chiefly an admittance to the power supply terminals, because the other relevant terminals (output and inverting input) already have the unity-gain signal impressed on them. Bootstrapping the supply lines is readily accomplished by circuits like that of Fig 4. Readers unacquainted with the concept may feel uneasy about bootstrapping an entire

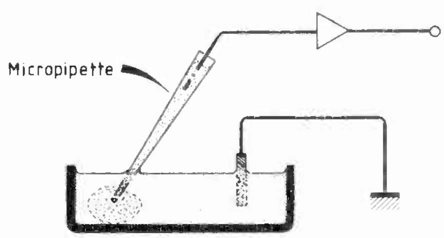


**Fig. 1.** *Intracellular recording of potentials from a nerve or muscle cell. The tip of the micropipette is inserted through the cell's membrane. A reference potential is established by an earthed electrode contacting the extracellular electrolyte.*

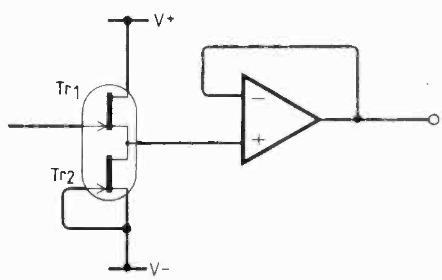


**Fig. 2.** *Voltage follower using matched junction fets as input stage.*

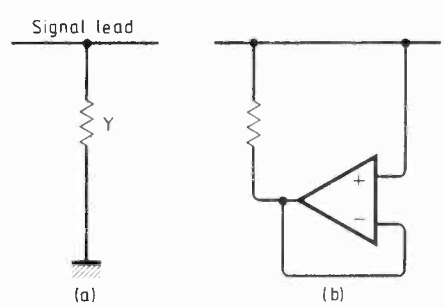


**Fig. 3.** *The bootstrap. (a) An unwanted admittance Y shunts the signal lead. (b) The earthy end of Y is driven by the signal at unity gain. Y is still physically present, but no signal current flows through it.*

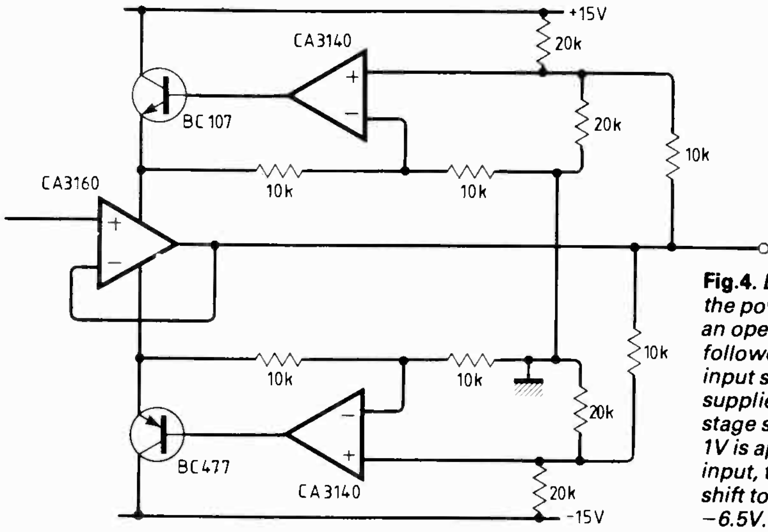


**Fig.4.** *Bootstrapping the power supplies to an operational voltage follower. With no input signal, the suppliers to the input stage sit at ±7.5V. If 1V is applied to the input, the supplies shift to +8.5V and −6.5V.*

amplifier (surely one only bootstraps passive components?), but the circuit does work as advertised. Indeed, some operational amplifiers have *internal* bootstrapping of the input stage. If the signal gain from input to supply leads in Fig. 4 is adjusted to be very close to unity, improvements of several orders of magnitude in the input impedance can be obtained. Even ordinary bipolar amplifiers such as the 741 can be given an effective input resistance of many GΩ.

The bootstrapped configuration, unfortunately, does not lead to similar improvements in the bias current. The 741 with its 80 nA bias remains grossly unsuitable for signal sources of high resistance. Some fet devices have bias currents in the sub-picoamp range (Analog Devices AD41, AD42 and AD515, and Teledyne-Philbrick 1035), but for the ultimate in low bias current, parametric (varactor bridge) amplifiers can be used. The Teledyne-Philbrick 1702 and Analog Devices AD322 feature bias currents of 2 fA and 10 fA respectively. Parametric operational amplifiers have extremely limited bandwidths, but signals from ultra-high-resistance sources rarely have rise times of less than a few tens or hundreds of milliseconds.

The physical design of the input circuit needs careful treatment if source resistances in excess of 100 MΩ are contemplated. To mount one of these high quality amplifiers on an ordinary printed circuit board is to destroy its performance utterly. The pin connexions of the T05 and 8-pin d.i.l. packages are not ideal, since $V^-$ is adjacent to the non-inverting input. A fingerprint or other contaminant at this position can easily increase the leakage current to the nanoamp range. The more exotic amplifiers are sometimes packaged in a physically large form giving better isolation to the input. The most reliable insulator for high-impedance work is air; the input lead should pass directly to the amplifier's input terminal, any intervening mechanical connexions being made on p.t.f.e. stand-off insulators. After construction, the input stage should be degreased with fluorocarbon solvent and rinsed several times in deionised distilled water before careful drying.

## Response speed

The principal enemy of response speed is the total shunt capacitance at the input which, together with the source resistance, forms a low-pass filter. The input capacitance of the amplifier by itself is typically 4 pF; when combined with a source resistance of 50 MΩ this contribution alone gives a rise time of 2.2RC=440μs, considerably too slow for some neurophysiological applications. Fortunately the bootstrap technique of Fig. 4 reduces the amplifier's input capacitance to an effective low frequency value of a fraction of a picofarad[2].

The stray capacitance of the connecting lead depends on physical layout and is minimized by construction of the input circuitry as a small probe placed as close to the source as possible. Alternatively, the input lead can be screened and the core-to-screen capacitance bootstrapped from the voltage follower's output. This approach tends to degrade noise performance since the necessarily large capacitance from core to screen couples noise at the output back into the input.

The remaining capacitance is that of the signal source itself. The neutralizing or "negative capacitance" arrangement of Fig. 5 is commonly used to overcome this last limitation on response speed. A textbook account of this circuit would describe it as a negative immittance converter, in which the shunt value of $C_f$ as seen from the input is $C_f$ (1 − A), where A is the signal gain at point Y. If A > 1, the effective value of $C_f$ is negative. More concretely, we can analyse the circuit by recognising that whenever the input signal (and hence the potential at point X) is changing, some current is shunted to earth via C. In the absence of the feedback circuit this current must be drawn from the input and causes an ohmic potential drop across R. Under these conditions the potential at X cannot be a faithful replica of the input. The purpose of the feedback components is to supply most of the "error" current through $C_f$, so that it does not have to be drawn from the input.

Ideally A would be adjusted to the value $(1+C/C_f)$ so that the negative effective value of $C_f$ exactly cancels the positive value of C. In practice, perfect neutralization is prevented by phase shift in the amplifiers. The rise time with optimum neutralization is roughly the geometric mean of the amplifier's rise time and the original (unneutralized) input circuit's rise time (see appendix). The feedback amplifier should be compensated for fastest response at the gain used, not for stability at unity gain. A 357 operational amplifier is shown in Fig. 5; this is a version of the 356 internally compensated for a gain of 5.

There is an advantage both for low noise and short rise time if the total capacitance seen by the input lead is made as small as possible. In an ingenious design by Thomas[3] the feedback capacitor is not present at all, negative capacitance being applied via the amplifier's own input capacitance. The supply lines to the follower are driven by the signal, as in Fig. 4, but with a gain adjustable from 1 to 3.2. Thomas illustrates step responses with rise times less than 10 μs from a 10 MΩ source.

## Appendix

**Rise time of capacitance neutralized input stage**

In Fig. 5 the high-frequency behaviour of the voltage follower may be represented by a single pole with time constant τ (typically 0.04-0.15 μs); its transfer function $E_{out}/E_x$ is therefore $1/(1+s\tau)$. For simplicity the feedback amplifier will be assumed infinitely fast. Kirchoff's current law applied to the input (point x) gives:

$$C\frac{dE_x}{dt}=\frac{E_{in}-E_x}{R}+C_f\frac{d(AE_{out}-E_x)}{dt}$$

In the Laplace transform domain the output signal following an input step of magnitude E is found, after some rearrangement, to be

$$\bar{E}_{out}=\frac{E}{s\{s^2\tau R(C+C_f)+s(RC+\tau+RC_f[1-A])+1}$$

where s is the transform variable and $\bar{E}_x$ has been eliminated by the relation $\bar{E}_x$

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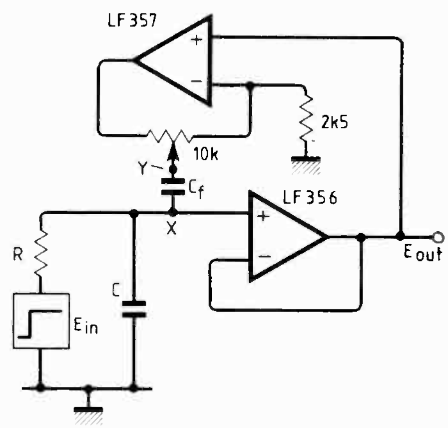


**Fig. 5.** *Capacitance-neutralised voltage follower. R and C are the series resistance and shunt capacitance of the signal source. Signal gain at point Y is adjustable from 1 to 5. The follower stage, here shown as a 356 operational amplifier, is often constructed with bootstrapped supplies as in Fig. 4.*

# Assembly language programming

*The main hurdle to overcome with assembly language programming is getting started, and the object of this series is to guide beginners to the subject through the fundamentals to a stage where you are able to continue with the processor of your own choice.*

by R. F. Coates

Many people are becoming acquainted today with programming microcomputers, usually in a high-level language such as Basic. High-level languages provide an easy means of programming and take all the hard work out of data processing and "number crunching" tasks. However, not all programming of microprocessors is done at a high level.

In many applications, programming at a low level, or assembly language, is preferred for several reasons. High-level languages have the disadvantages that they use a great deal of memory for program storage compared with programming in the processor's native code, are slow in operation and are usually not well suited to control applications.

For high-volume production applications, the higher initial costs of program development in assembler will be more than offset by the lower memory costs per unit. For smaller applications there is a simple rule-of-thumb guide for the best approach; if the task is mainly maths or data processing, use a high-level language; if it is mainly process control, use assembler.

## Architecture

When programming a computer in a high-level language, the architecture of the particular central processing unit, or microprocessor, in use is not a matter of great interest to the programmer, but when programming in Assembler it is essential to fully understand the workings of the processor in use.

Figure 1 shows the programming models of the various microprocessors which will be referred to in this series. These models consist of a list of the registers in the central processing element available. The various registers have different and specialized functions, but generally speaking, registers are stores of bits of information which the c.p.u. can use or manipulate.

Data can be passed in both directions between the registers and memory or peripheral devices along the data bus in groups of eight bits (the processors discussed are eight-bit devices). In the registers the data can be manipulated by arithmetic and logic functions, the functions performed depending on the instructions given to the c.p.u. by the program.

## Five registers

**Accumulator.** Let's have a look first at the five registers available on the 6805. The first is the accumulator, an eight-bit register with the individual bits numbered 0 to 7. This is designed to hold the data for manipulation. All the processors have at least one accumulator.

Operations that can be performed on the data in the accumulator include adding a binary number to the contents of the accumulator, the result replacing the first number in the accumulator; subtracting a number from it; shifting the bits by one, either left or right. Shifting is useful when multiplying. Only the 6809 has a specific instruction for multiplying two numbers together, and so with the others it's down to basics if you wish to multiply, by shifting and adding. How this is done is described later in the series.

**Index register.** The index register (X) is generally used as an index or pointer to data. For instance, there is an instruction to enable the accumulator to be loaded with data from a specified location in memory. It is also possible to do this without specifying the address of the memory, but specifying that the address is contained in the index register, or 'pointed' to it by the index, having been previously loaded with the address.

**Program counter.** The program counter is also used as a pointer, not to data, but to the program in memory.

Microprocessors operate by fetching and executing instructions stored in memory as sequential binary codes. The program counter itself contains an 11bit binary number which gives the address of the next instruction to be executed. The c.p.u. places this 11bit binary number onto the address bus, which selects the memory location containing the next instruction. The memory then places the eight-bit binary instruction code it contains on the data bus, to be read by the c.p.u. and acted on. The program counter is then automatically incremented to point at the next instruction, which is fetched from the memory when the current instruction has been completed.

The 11bit program counter means that there are $2^{11}$ possible binary combinations it can provide, so that it can address 2048 different memory locations. In fact, there are 1796 locations in the program memory (eprom) of the 68705 used in the Picotutor; the rest contain ram and i/o ports and a few are unused. The other processors have a 16bit program counter.

**Stack pointer.** This is also an 11bit register, but bits 5 to 10 are permanently fixed at a certain binary value and only bits 0 to 4 can be altered. Only one instruction allows the user to alter this register, and that sets bits 0 to 4 to a logical 1. The stack pointer then just happens to contain an 11bit address which corresponds to the address of the last location of ram in the 6805.

But what is the stack pointer for? Though the c.p.u. fetches instructions in numerical sequence from the program memory, life isn't always that simple. Sometimes it is necessary to jump to somewhere else in memory to execute a collection of instructions there. It is common to have a particular sequence of instructions which may occur several times in a program, and rather than repeat them, it saves memory space if it is inserted once, and when required, the numerical sequence of instructions is broken and control jumps to this separate section, or subroutine, and returns back to the main program when finished.

This is exactly the same as the GOSUB function in Basic. When a program encounters a 'jump to subroutine' instruction it has to provide some means of recording where it has to return to after executing it. A device called stack, an area of ram is used for this and the 'jump to subroutine' instruction causes the address of the next instruction in the sequence (obtained by advancing the program counter) to be placed in that ram.

The stack pointer indicates the next free space available on the stack. The return

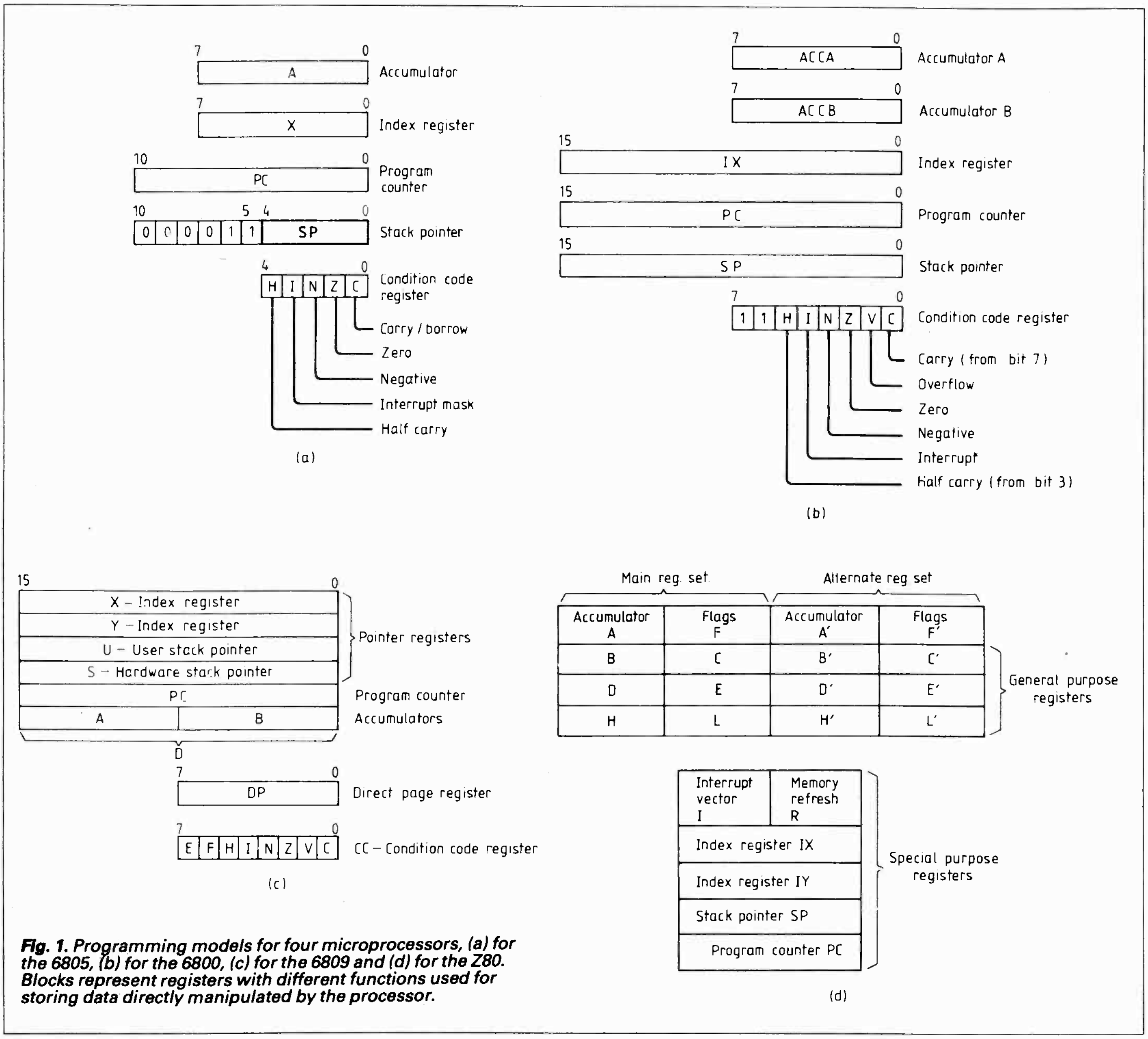


***Fig. 1.*** *Programming models for four microprocessors, (a) for the 6805, (b) for the 6800, (c) for the 6809 and (d) for the Z80. Blocks represent registers with different functions used for storing data directly manipulated by the processor.*

**Picotutor calibration**

**Resistor $R_1$ on the analogue interface board should be reduced to 8.2k if calibration cannot be achieved. Some of the first kits from Magenta have a 12kΩ resistor in this position so a replacement will almost certainly be needed. Display type numbers omitted from the main Picotutor parts list are either NSA1588A (8-digit, 0.14in) or NSA1198 (9-digit, 0.1in); both are National Semiconductor devices.**

address is pushed onto the stack, and the pointer automatically moves down one.

Each ram location though is only eight bits wide and the program counter contains 11bits, so two ram locations are required. Bits 0 to 7 are pushed to the stack first, and SP decremented. The remaining three bits, 8 to 10, are now pushed on leaving five bits in that ram location unused. SP is decremented again, and now points to the next free stack location, in case our subroutine happens to call another subroutine itself. This is nesting.

At the end of the subroutine, a 'return from subroutine' instruction is executed which causes the return address to be pulled from the stack, incrementing the SP as it does so. The return address is now forced into the program counter, and execution continues from that point.

With all the other processors, the stack pointer is a 16bit register and can be pointed anywhere in memory for greater flexibility. Also, other registers may be pushed onto the stack to temporarily save them.

**Condition code register.** The condition code register (flag register on the Z80) is a collection of individual bits or flags which are used to indicate certain conditions that prevail following execution of the last instruction. There are five flags in the 6805 condition code register. The H and I flags are discussed later.

The N bit indicates if the result of the last operation was negative, the Z bit if the result was zero, and the C bit if a carry was generated, say from adding two eight-bit numbers which save a nine-bit result. These flags can then be used by instructions following the one that set them to make decisions as to how to proceed. Their use will be clearer when we come to the programming examples.

**Other registers.** Finally a word on some of the other registers available on the other processors. The 6809 has two index registers X and Y and a second stack pointer, U, can also function as another index register if required. A "direct page" register on the 6809 will be explained when we come to addressing modes.

Besides the registers already mentioned the Z80 has a number of general-purpose registers not available on the Motorola processors. These can be used for manipulating data within the c.p.u. Transfering data from memory to c.p.u. takes a considerable amount of time and having a number of general-purpose registers within the c.p.u. can speed up the operation, particularly in 'number-crunching' applications. However, there are situations in real-time applications where multiple c.p.u. registers can actually slow things down. This has led to processors such as the Texas 9900 which implements all required registers in ram rather than in the processor. Consequently there are arguments for and against multiple general-purpose registers and Motorola chose a compromise of essential registers on the c.p.u. and the ability to implement registers in ram, which offers greater flexibility and is not possible with the Z80.

Probably the most important factor for the beginner is the fact that the fewer the registers the easier it is to learn to program, and this was a major factor in using the 6805 as our basis.

The numbering system almost universally used in microprocessor programming is hexadecimal notation, and in counting to the base 16, the characters A to F represent the decimal values from 10 to 15 in hexadecimal.

A group of four binary digits gives a possible $2^4$ or 16 combinations, and these could be represented by one of the 16 hexadecimal characters shown in the following table

| Binary value | Hex character |
|---|---|
| 0000 | 0 |
| 0001 | 1 |
| 0010 | 2 |
| 0011 | 3 |
| 0100 | 4 |
| 0101 | 5 |
| 0110 | 6 |
| 0111 | 7 |
| 1000 | 8 |
| 1001 | 9 |
| 1010 | A |
| 1011 | B |
| 1100 | C |
| 1101 | D |
| 1110 | E |
| 1111 | F |

If we take a binary number and divide it up into groups of four digits each group can be assigned its hexadecimal equivalent, which reduces the number of characters required by four. The 16bit value

1011010000001111

becomes B40F, which is much easier to write and remember.

To avoid confusion when working with hex numbers a suffix or prefix is normally added to a hex number to distinguish it from decimal. Motorola use the prefix '$' whilst Zilog use the suffix 'H' for this purpose. In these articles the '$' prefix will denote a hex number where necessary.

So much for the boring fundamentals of assembly language programming; next we shall be looking at some of the instructions of the 6805 and trying out some simple programs and the equivalents for the other processors.

*To be continued*

*continued from page 30*

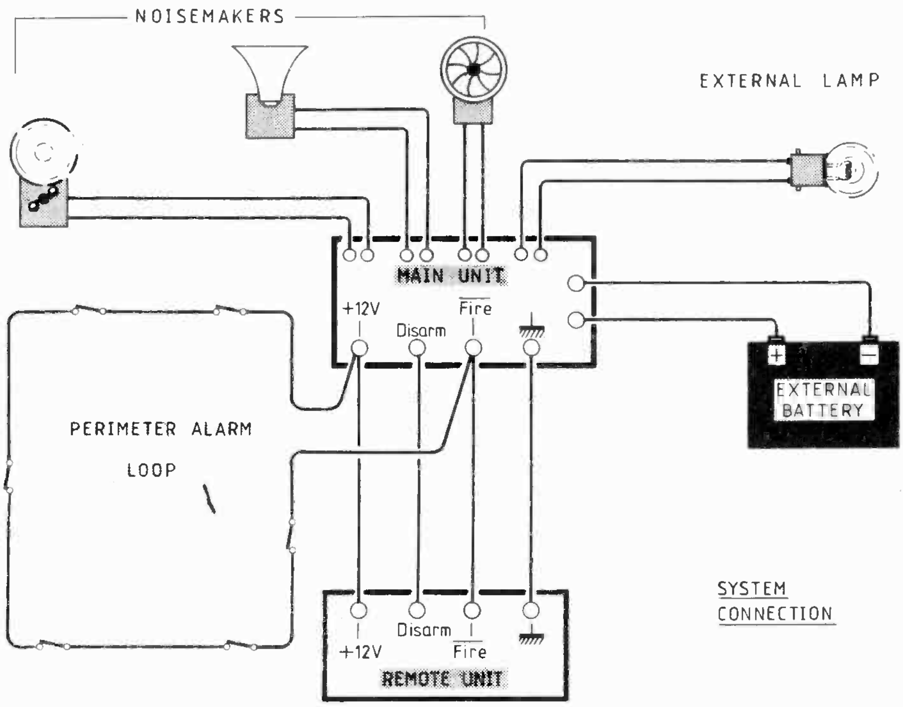


***Fig. 7.** Connexion of units to form complete system.*

connection of the DISARM, FIRE, +12V and ground lines to the remote control unit.

The remote circuit can also be wired on veroboard. Leads to $C_x$ should be kept short. The board can be fitted inside a small plastic box. Holes drilled in the back (or a strip of Velcro stuck to it) will allow wall mounting.

## Peripherals

All perimeter alarm loop switches must be of the 'normally closed' variety (these open when triggered). They can be anything from simple magnetic reed or pressure mat switches to the output contacts of a motion detector or light beam device. All switches must be wired in series.

Any 12 volt d.c. bells, horns or sirens with a current drain of less than 2A can be used with this project, and a wide selection are readily available. An accessory red, 12V rear light for a caravan or trailer makes a good external lamp for the alarm, and can be bolted to an outside pipe, railing or wall. Wires running to these loads should be at least 16A.w.g., or 1mm in copper core diameter, and each run *must* be fused at the control unit end with a 2A fuse. Automotive in-line fuse holders are convenient and cheap for this purpose.

For the external battery, an ordinary lead/acid car or motorcycle type is recommended. It should be placed in a reasonably ventilated location, to prevent small amounts of gas released during charging from collecting to become a possible explosion hazard.

# Autoranging frequency meter

*This meter measures frequencies in four ranges up to 10MHz (9,999kHz) with automatic switching between the ranges. It displays the four most significant digits.*

by F. P. Caracausi

The meter consists of four principal parts: input, timing, scaling and counter/display sections. Each is described separately but it must be noted that they are not necessarily separate modules, for example $IC_{10}$ and $IC_{11}$ are shared between the timing and scaling sections.

### Counting and display

The main counter, Fig. 1, is built around a 74C926 i.c. which has four binary-coded decimal counters with multiplexed outputs to common-cathode led seven-segment displays. The counter module receives the signal to be counted through MCP. A positive signal (see note) on the MCP line, labelled 'store', will latch the counter value into the internal output latches and this value is displayed permanently as the display select input to the 74C926 is held low. The counter is cleared by a positive pulse on the MCL line and the 'carry out' signal is used to indicate an overflow, occurring whenever the count advances from 9999 to 0000. This negative-going transition is switched back to positive between 5999 and 6000. The underflow signal at MUF is a 1kHz (multiplexer frequency) pulse train which occurs as long as the most significant digit is zero; when the m.s.d. is not zero, there is no output.

### Scaling

The signal to be measured is fed to three cascaded decimal dividers, $IC_{6,7,8}$ (Figure

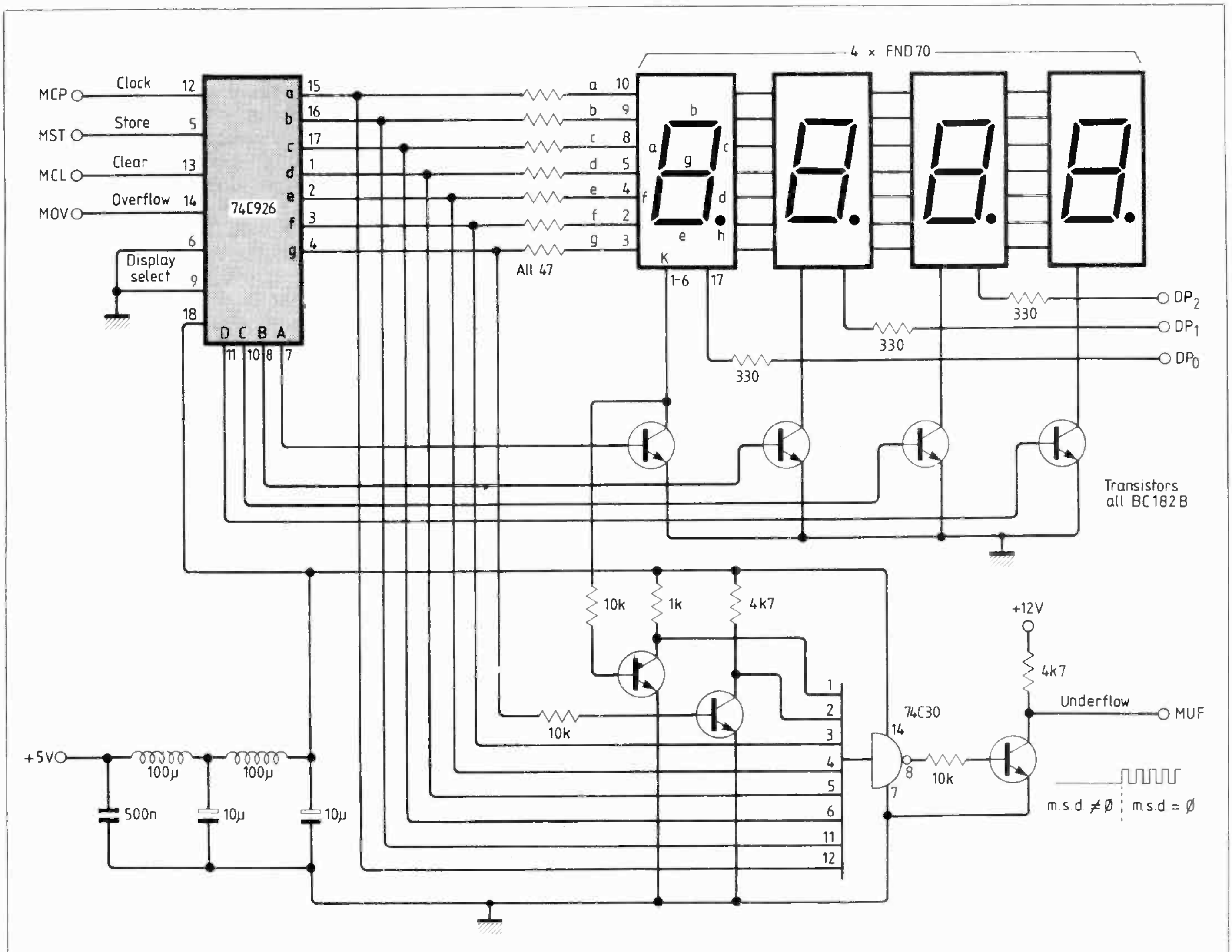


**Fig. 1.** *The counter and display module built around a 74C926 i.c.*

**Fig 2.** *The scaling circuit automatically selects the range to be displayed.* ▶

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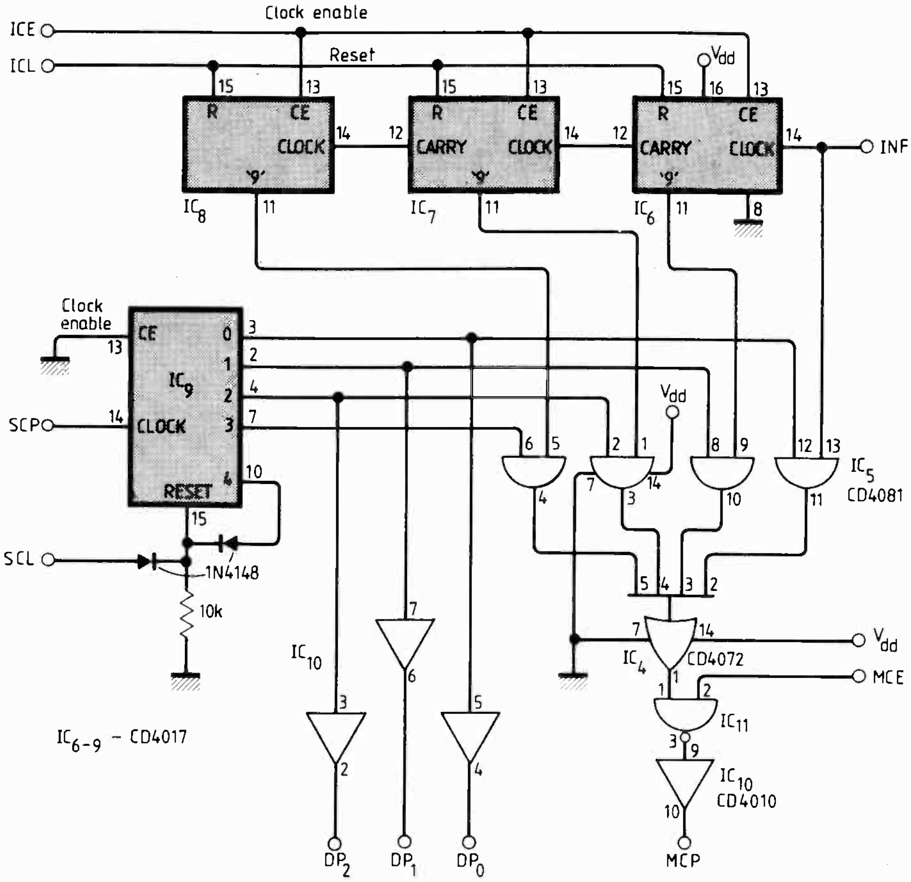



2). Depending on the value of the scale counter $IC_9$, the input frequency is divided by 1, 10, 100 or 1000. Provided that the MCE line is 'high', the signal is fed to the counter section through MCP, while the appropriate decimal point signal is sent through DP 0, 1 or 2. The displayed number is read as kHz.

Counter $IC_9$ is advanced by a positive clock pulse, SCP, and is cleared whenever it reaches a count of four or when the SCL signal is high. SCL and SCP both come from the counter module where SCP is generated when there is a overflow signal from the counter and SCL is derived from the underflow signal.

The counters $IC_{6,7,8}$ are enabled by a low signal on ICE and cleared by ICL going high. ICE and ICL are generated in the timing circuit when overflow or underflow signals occur.

## Timing

The decimal counters $IC_1$ and $IC_2$ (figure 3), fed with a 50Hz pulse train, give a positive signal once a second. On the signal, MCE goes high which enables counter $IC_3$, disables $IC_{2,6,7,8}$, and stops the clock going to the main counter (signals MCE and MCP on the scaling circuit). MCE goes low if an overflow occurs on the main counter (MOV is low) and this makes Q on

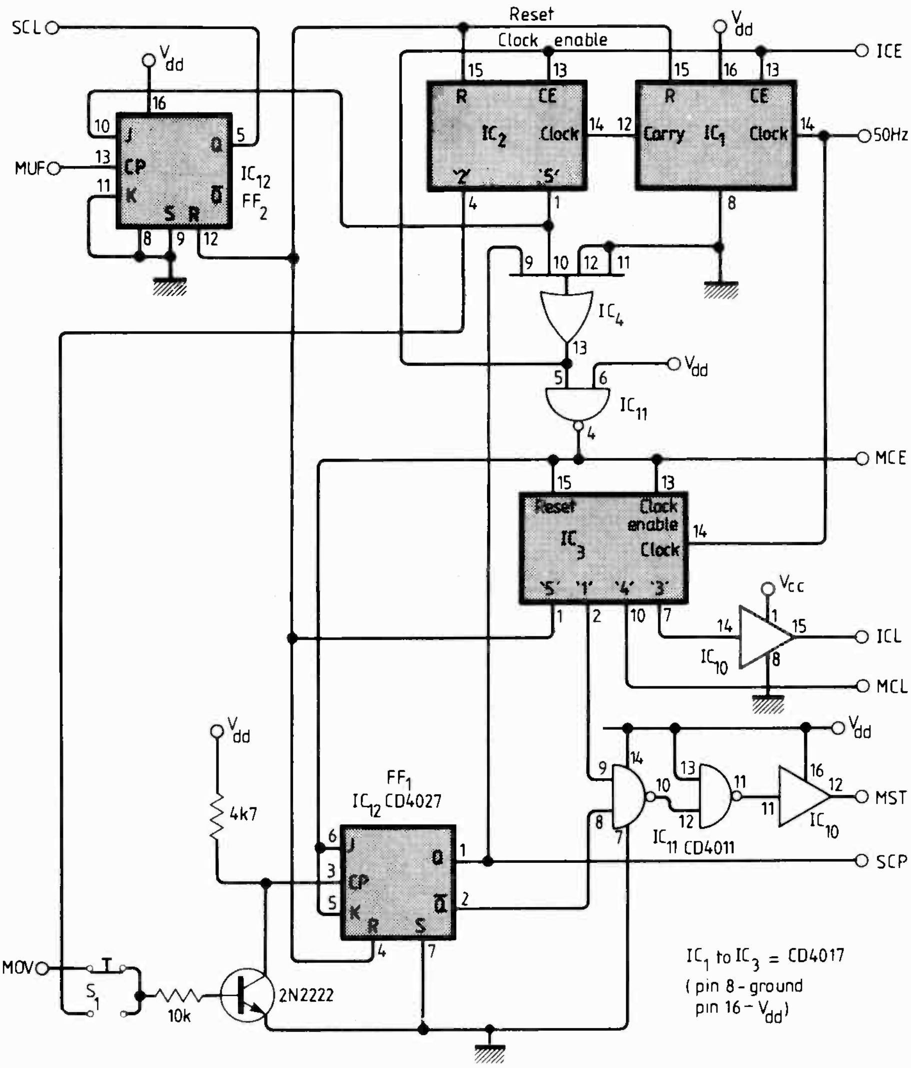



**Fig 3.** *The timing module generates control signals for the scaling and counting circuits.* ▶

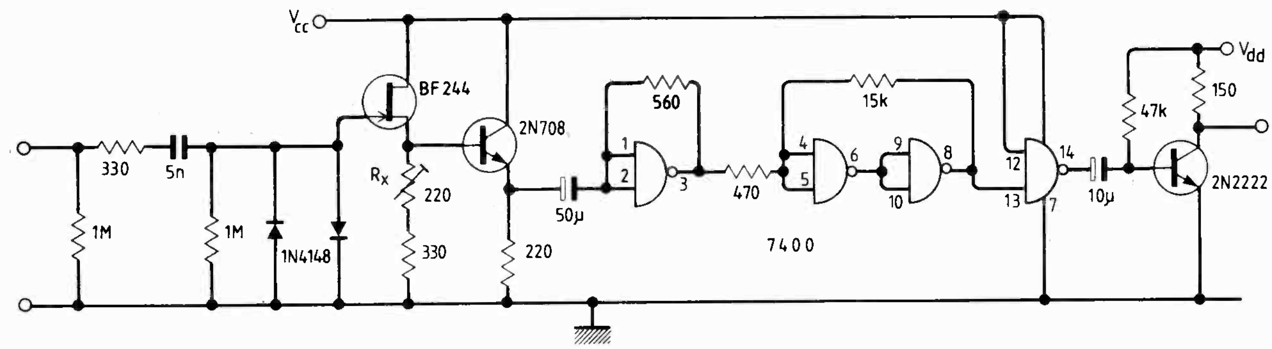



**Fig. 4.** *Input module.*

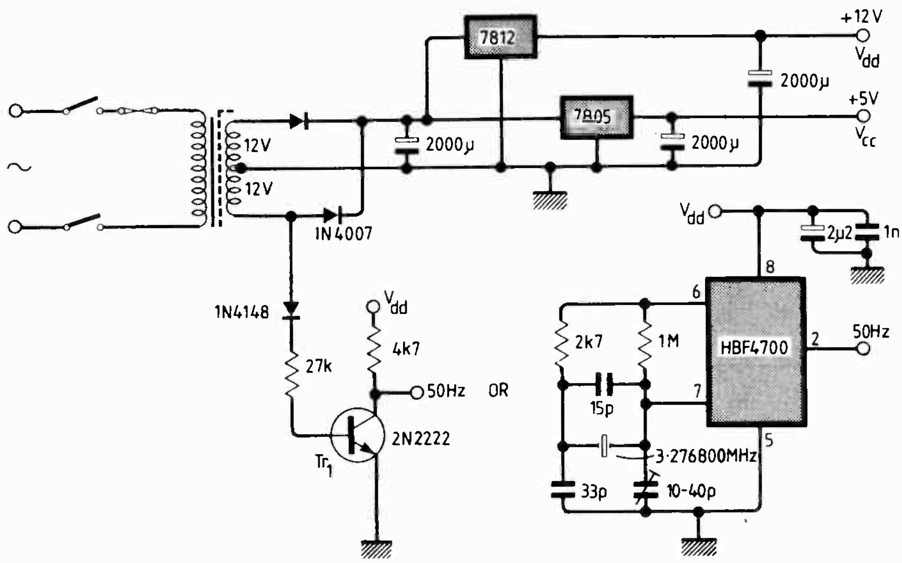



**Fig. 5.** *Power supply. Two versions of a 50Hz clock generator are given, one derived from the mains frequency, the other gives quartz crystal precision.*

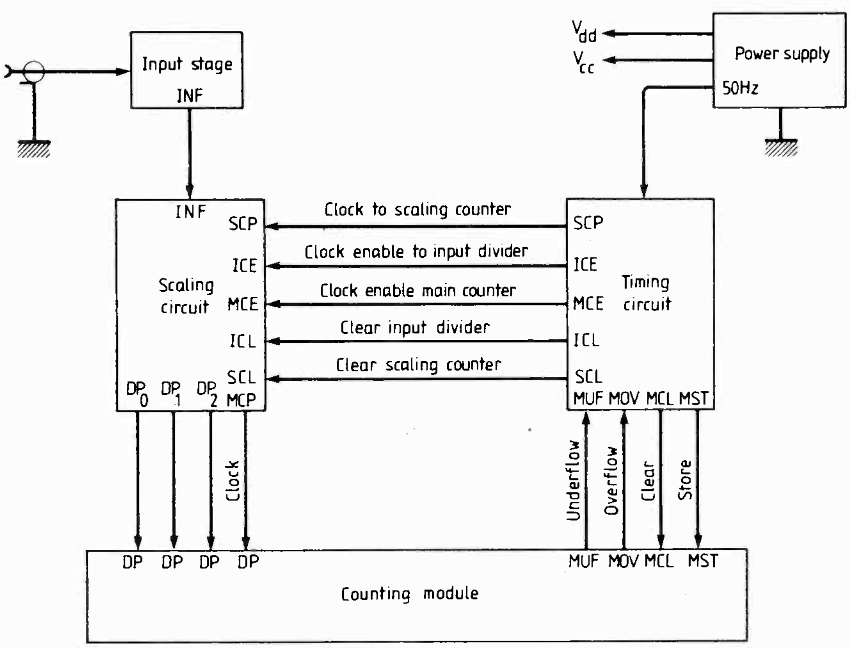



**Fig. 6.** *Interconnections between the sections.*

$FF_1$ go high and advances counter $IC_9$ by one to change the range. As $IC_3$ is enabled, it can generate the store signal, MST, and the clear signal, MCL. At the same time, through ICL, $IC_{6,7,8}$, both flip-flops and $IC_{1,2}$ are all reset and the next count period starts.

In an underflow condition $FF_2$ is set at the end of the count period as J on $FF_2$ is connected to output 5 of $IC_2$ which only goes high on a count of 50. When $FF_2$ is set, $IC_9$ is cleared through SCL and the next count starts at the lowest range (X.XXXkHz). An overflow condition may be simulated by pushing $S_1$. This may be necessary if the main counter locks, which can happen because the 74C926 can operate at frequencies up to 3 or 4MHz.

## Input circuit

Figure 4 represents a classical circuit which requires no comment. $R_x$ is set to give the best results.

## Power supply and 50Hz generator

The power supply is a standard circuit to give $V_{dd}$ (12V) and $V_{cc}$ (5V). In Figure 5 there are two circuits for clock generators for the timing circuit. The first derives a signal from clipping the a.c. input, theoretically 50Hz. The second is built around an HBF4700 to give 50Hz with quartz precision.

**Note.** According to the 74C926 data sheet: "A low signal on the latch enable input will latch the number in the counters into the internal output latch". I found that it needed a high signal but if some versions of the i.c. work as described, it would be necessary to invert the signal by disconnecting the link between pin 11 of $IC_{10}$ and pin 11 of $IC_{11}$ and then connecting pin 11 of $IC_{10}$ to pin 10 of $IC_{11}$ (Figures 2 and 3).

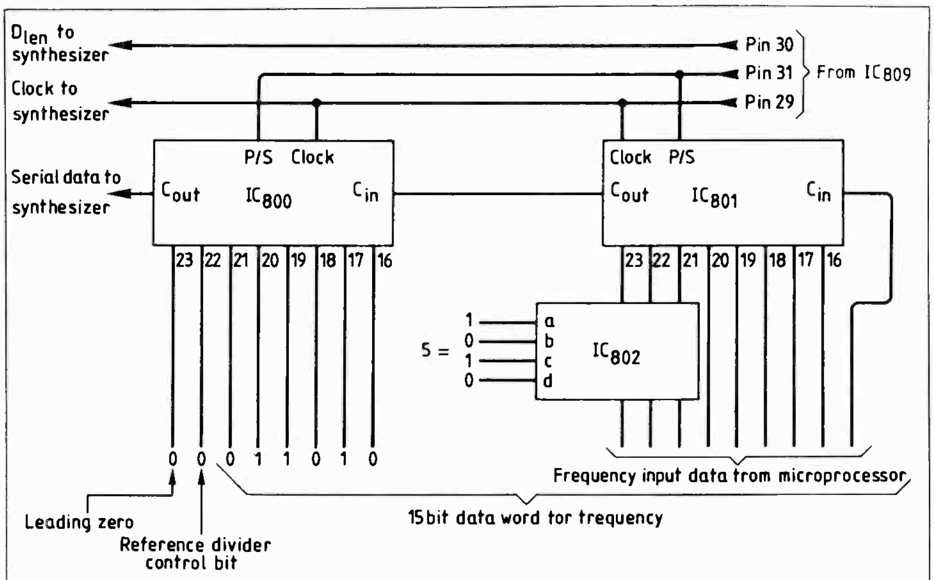
## Bibliography

A. Fantini, Note sui frequenzimetri digitali. *CQ Elettronica*, July, 1974.
F. P. Caracausi, Frequenzimetro digitale automatico. CQ *Elettronica*, Sept. 1976
F. Bonadio, 50Hz con lo HBF4700A, *CQ Elettronica*, April, 1980.

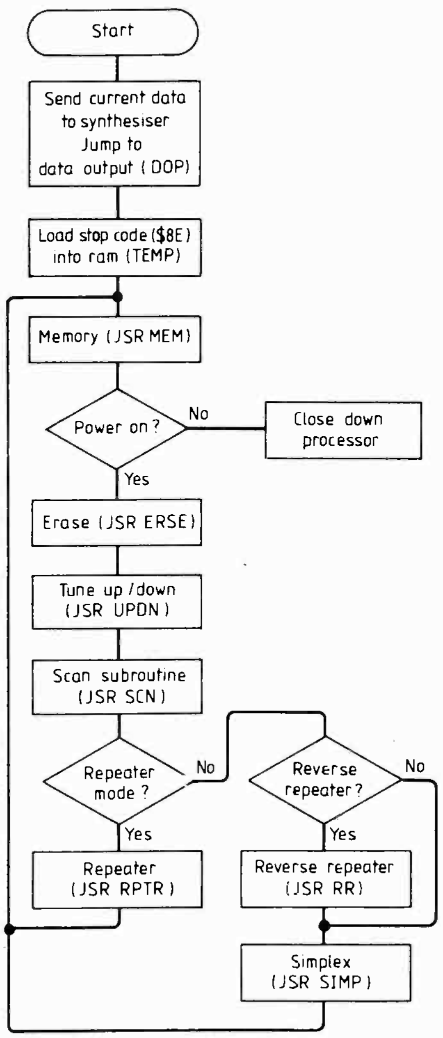
# Two-metre transceiver

*Coordination and frequency indication are functions carried out by these two modules of Forrester's multi-mode transceiver. At the heart of module 8 – the processor/interface board – is a 6805 microprocessor with built-in p.i.a. This section interprets front-panel settings and controls mode, frequency, and memory operations while module 9 converts port signals into an l.e.d. readout.*

Module eight uses a c.m.o.s. MC146805 microprocessor (Motorola) which was chosen from the many now available for several reasons. Most modern processors have built-in ram and clock-generator circuits but the 6805 also has its own peripheral-interface adapter, or p.i.a., which provides a means of getting data in and out of the processor. This factor, combined with the device's low power consumption of 20mW and its potential for single-stepping through a program to aid debugging make it ideal for this application. Memory in the form of a 2716 eprom and five other i.cs




*Bits for the synthesizer-control word are set on $IC_{800,801}$ as shown. Nine least-significant bits are required for the range 135-137MHz, the remaining six are hard wired. Full adder $IC_{802}$ produces offset required to provide nine control bits from an eight-bit processor port.*




*Transceiver software breaks down into these main routines. Mnenonics shown are used in the assembly-language program.*

are all that is required to interface the microprocessor to the transceiver, as the circuit diagram shows.

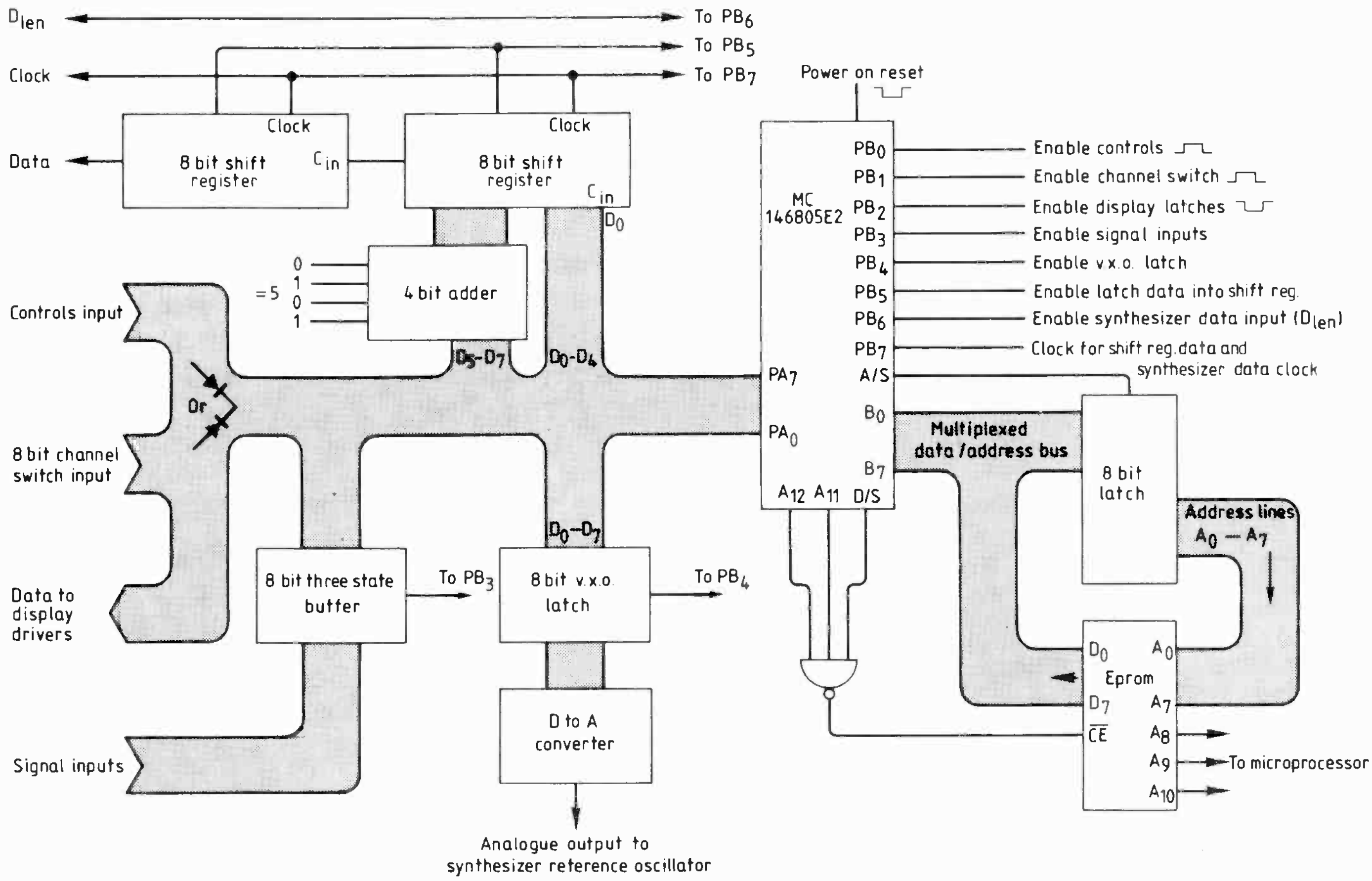
First described is the operation of the microprocessor as this will lead to a better understanding of the hardware around it and how the software functions. In the software, a master-control program calls various subroutines depending on control settings and these subroutines may call further subroutines; at times there may be eight levels of subroutine in use.

Before the microprocessor can act, it has to contain data relating to the front-panel control settings and it acquires this information by setting one of its p.i.a. B-port lines high. Pin 36 of the processor is one line used for this purpose. This line, called controls enable, is connected to the common of switches for mode, scan, memory, memory write and skip control. These switches are sensed by p.i.a. A-port lines through diodes when pin 36 is high; any switch closed while the controls enable line is high shows a logic 1 on its A-port line. This port is examined by the software and a decision made as to which subroutine is to be called for the mode concerned.

Port A of the 6805 p.i.a. is also used for sensing the channel-switch condition. When memory mode is entered the channel-enable line at pin 35 of the 6805 goes high and the channel switch is represented on the A port through diodes. Interaction between channels is prevented by these diodes.

In this situation, port A is bidirectional and each device driven by the processor through it is selected independently by control lines from port B. For example, when frequency is to be displayed, display latches are enabled by taking the enable-display line low. The five l.e.d. drivers are selected sequentially by lines $PA_{4-6}$ and presented with four-bit words representing their digit value on lines $PA_{0-4}$. Likewise for transmitting data to the synthesizer the 4034 shift registers are enabled and the appropriate data loaded then clocked out sequentially.

Appropriate control bits for the synthesizer are set on $IC_{800,801}$ as shown in the diagram. As mentioned in the description of the synthesizer control logic in module 5 (see January 1983 issue), only the nine least significant bits are required to change to cover 135 to 137MHz, so the other six bits of frequency-data word are hard wired




*Module 8 block diagram showing the microprocessor and its interfaces. The 6805 has multiplexed address/data buses and two 8-bit peripheral-interface adapter ports. Port A is used as a bidirectional bus while port B is used to select individual peripheral input/output elements. NiCd batteries hold the processor's ram contents when the transceiver is switched off.*

to the appropriate level. A problem arises in that nine bits are required to cover the range and the processor only has eight bits.

This problem is overcome by using a four-bit full adder, $IC_{802}$, to add the offset needed by the three most significant bits on the microprocessor A-port to produce 135MHz. These three m.s.bs are normally weighted 32, 64 and 128 and for 135MHz their bit pattern is 101. But this pattern after being subjected to the adder appears as 5, enabling the processor to start at zero and count up to 255 in 10kHz steps. When the processor counts to 32 and above, its output is summed by $IC_{802}$ and sent to a shift register, $IC_{801}$. Software converts binary data resulting from the hard-wired offset to b.c.d. for driving the displays.

Data feed into $IC_{800,801}$ is controlled by the processor through clock and serial/parallel inputs of these i.cs. The data-length line to the synthesizer, also controlled by the processor, only goes high when data for the synthesizer is valid. Besides driving the synthesizer in 10kHz steps, the processor also has to pull the synthesizer reference by up to 9.9kHz to give continuous coverage and it does this through eight-bit latch, $IC_{804}$, which accepts its data word on receipt of a signal called vxo from pin 32 of the processor, $IC_{809}$. Data for controlling the reference are in the form of two b.c.d. words which give a maximum count of 99, representing 9.9kHz.

Nine resistors on the output of $IC_{804}$ ($R_{810-818}$) form a digital-to-analogue

## Components

**Resistors**

| | |
|---|---|
| 800,819,825--828,935-940 | 1k |
| 801 | 10k |
| 802,803 | 56k |
| 804 | 22 |
| 805 | 390k |
| 806 | 200k s.o.t. |
| 807,829,830 | 100k |
| 808,833 | not used |
| 809 | 33k |
| 810 | 470k, 1% |
| 811,815 | 100k, 1% |
| 812,816 | 200k, 1% |
| 813,817 | 400k, 1% |
| 814,818 | 800k, 1% |
| 820 | 15k |
| 821 | 2.2k |
| 822 | 1.5k |
| 823,824 | 100 |
| 831 | 22k |
| 832 | 10M |
| 834 | 22k sub-min preset |
| 835-842 | 3.9k |
| 900-934 | 390 |

all 1/4W, unspecified resistors are 10%

**Capacitors**

| | |
|---|---|
| 800 | 10n disc |
| 801 | 470μ electrolytic, 16V |
| 802,804,805 | 47μ electrolytic, 35V |
| 803 | 47n disc |
| 806,807 | 100n disc |
| 808,809 | 22p disc |
| 900,901 | 2.2μ tantalum, 16V |

**Transistors**

| | |
|---|---|
| 800,801 | BC107 |
| 802 | BCY71 |
| 803,806 | 2N3819 |
| 804,805 | BC109 |
| 807 | 2N3707 |

**Diodes**

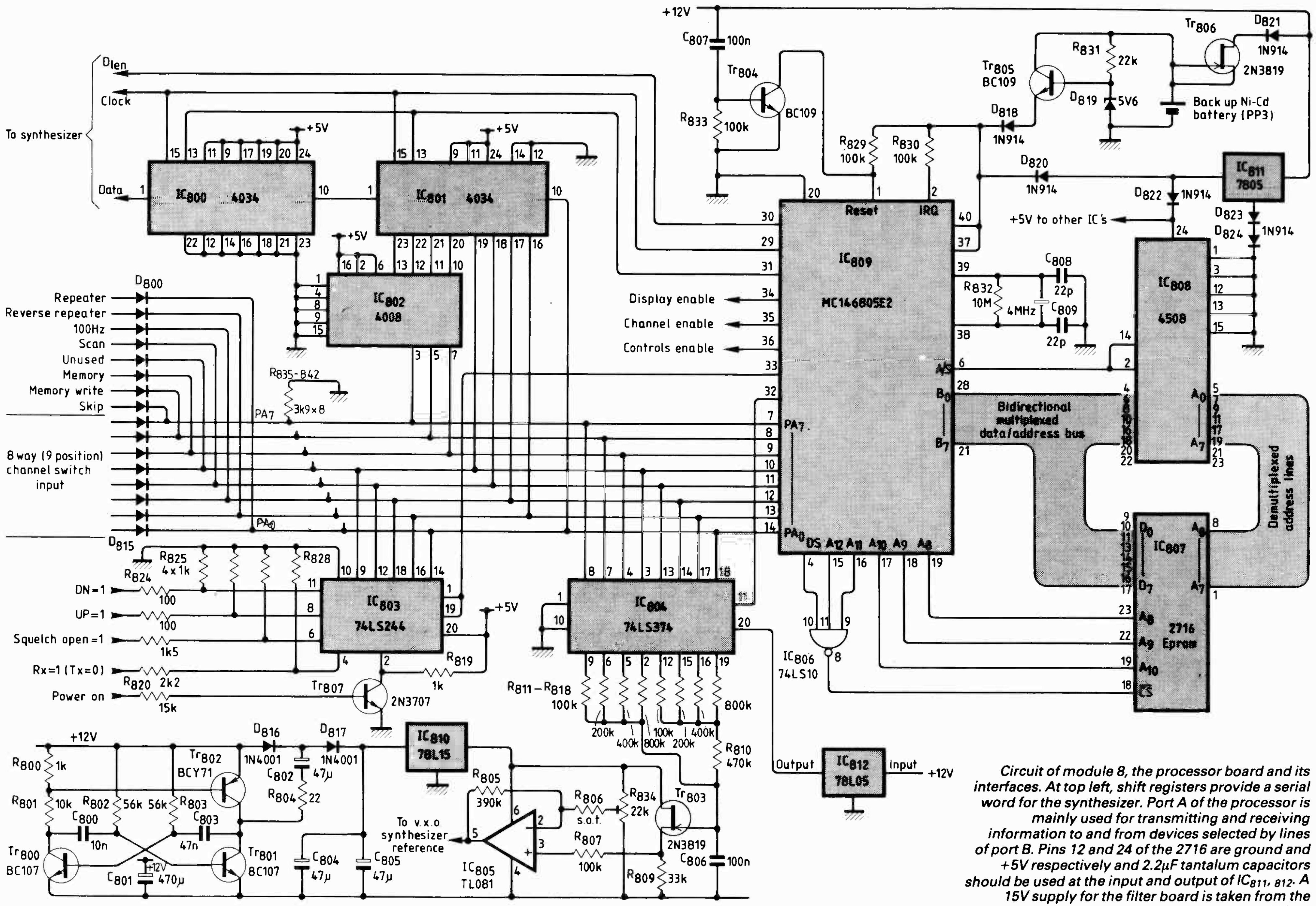
| | |
|---|---|
| 800-815,818 | |
| 820-824 | 1N914 |
| 816,817 | 1N4001 |
| 819 | 5.6V zener, 400mW |
| 900-906 | GL9R03 |

**Integrated circuits**

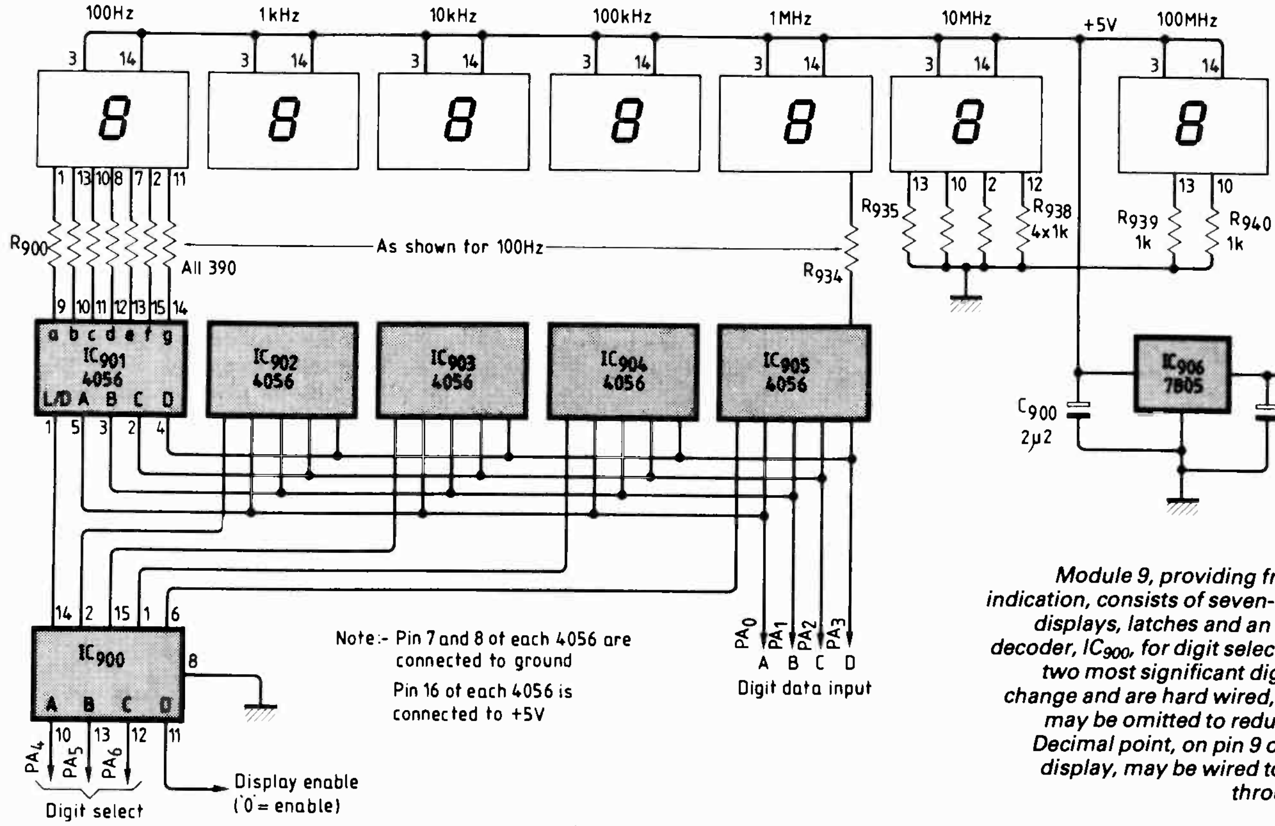
| | |
|---|---|
| 800,801 | 4034 |
| 802 | 4008 |
| 803 | 74LS244 |
| 804 | 74LS374 |
| 805 | TL081 |
| 806 | 74LS10 |
| 807 | 2716 (eprom) |
| 808 | 4508 |
| 809 | MC146805E2 |
| 810 | 78L15 |
| 811,812 | 78L05 |
| 900 | 4028 |
| 901-905 | 4056 |
| 906 | 7805 |

**Crystals**

| | |
|---|---|
| 800 | 4MHz HC18U |




Circuit of module 8, the processor board and its interfaces. At top left, shift registers provide a serial word for the synthesizer. Port A of the processor is mainly used for transmitting and receiving information to and from devices selected by lines of port B. Pins 12 and 24 of the 2716 are ground and +5V respectively and 2.2µF tantalum capacitors should be used at the input and output of $IC_{811, 812}$. A 15V supply for the filter board is taken from the output of $IC_{810}$.




*Module 9, providing frequency indication, consists of seven-segment displays, latches and an address-decoder, $IC_{900}$, for digit selection. The two most significant digits don't change and are hard wired, but they may be omitted to reduce costs. Decimal point, on pin 9 of 100kHz display, may be wired to ground through 1kΩ.*

converter and the d.c. level at $C_{806}$ is buffered and modified by $Tr_{803}$ and $IC_{805}$ respectively. A starting frequency of 135.0000MHz is set using $R_{834}$ and the synthesizer-reference pulling range is set by $R_{806}$, which is nominally 200 kilohm. To ensure a stable supply voltage, $IC_{804}$ has its own 5V supply. Transistors 800-802 and $IC_{810}$ form a d.c.-to-d.c. converter supplying a stabilized 15V rail for $IC_{805}$; this rail is also used to power $IC_{503}$ of module 5.

Five status signals are switched onto the A port through $IC_{803}$ by the enable line from pin 33 of $IC_{809}$. These active-high status signals are

- up button pressed
- down button pressed
- squelch open
- receive/transmit
- power on.

The first four indications act straightforwardly on the microprocessor but the fifth, power on, it a little more involved. When the transeiver is turned off, $Tr_{807}$ conducts momentarily using charge stored in the set's capacitors and pulls pin 2 of $IC_{803}$ low, forcing the processor to revert to its low-power standby mode. Resistor 820 is wired to the off contact of the mode switch, the common of which normally distributes a 12V supply to the appropriate modules.

In standby mode, the processor ram contents are held intact by an NiCd battery through $D_{818}$. A 2N3819 fet, $Tr_{808}$, forms a constant-current charger for the back up battery while $Tr_{805}$ and $D_{819}$ regulate the voltage. Under normal conditions, $IC_{809}$ is powered from $IC_{811}$ through $D_{820,818}$ to allow charging of the battery. Diode 820 isolates the battery supply from logic power lines when the transceiver is turned off. When the transeiver is switched on, $Tr_{804}$ is momentarily turned on through $C_{807}$, causing the microprocessor to reset.

As the processor's data and address buses are multiplexed, a latch, $IC_{808}$, is required to separate the two. This latch is controlled by the address strobe line, pin 6 of $IC_{809}$. Demultiplexed addresses are then fed to $IC_{807}$, a 2716 eprom; this memory is enabled when its chip-select input is low, and this only occurs when address lines A11 and A12 combined with the data strobe line in NAND gate $IC_{806}$ go high. Prospective builders of this transceiver should not be deterred by the need for eprom-based software as these devices are available ready programmed from me.

Channel switch, skip, memory-write, memory, scan, 100Hz-step, repeater and reverse repeater controls are all connected to the p.i.a. A port through 1N914 diodes forming OR gates. Sixteen diodes are used in all, including a spare one for future expansion. Eight 3.9kΩ pull-down resistors, $R_{835\text{-}842}$, are connected to A-port lines $PA_{0\text{-}7}$. $IC_{812}$ should be mounted on the metal enclosure to keep it cool.

The only adjustments needed on this board are to $R_{806}$ and $R_{834}$. Initially, $R_{806}$ should be set at around 200kΩ with the transceiver set to 144MHz and $R_{834}$ adjusted so that the synthesizer produces exactly 135MHz. Now the frequency is changed to 144.0099MHz, i.e. 9.9kHz higher, and $R_{806}$ adjusted so that the synthesizer frequency increases by 9.9kHz. This process should be repeated.

This module is mounted directly to the chassis of the transceiver without screening. R.f. radiation is emitted by devices in this circuit but screening and filtering on the other modules is sufficient to prevent interference. On the current transceiver, the interrupt-request input (IRQ) is not used but I plan to incorporate an infra-red remote control unit using this line.

# Frequency display – module 9

Microprocessor control makes driving of the frequency display relatively easy. Seven-segment l.e.ds were used for the display in preference to l.c.ds because they were cheaper, but by now the situation may have changed. Display latching is used to ensure that the maximum brightness is obtained for viewing in sunlight; many transceivers using strobed displays suffer from lack of brightness.

Display-drive data are taken from the processor p.i.a. A port, the digit being represented by $PA_{0\text{-}3}$ and the digit address represented on lines $PA_{4\text{-}6}$. Digit-address decoding is performed by $IC_{900}$ which enables the appropriate latch. The display latches can only be enabled if the D input of $IC_{900}$ is taken low by the processor. Resistors 900-934 limit the display current for the active digits and $R_{934\text{-}940}$ hold the two most significant digits permanently at 14. Here, the five-volt regulator, $IC_{906}$ is mounted to the chassis to keep it cool.

Programmed eproms at £8 and software listing at £1.50 including UK postage and vat are available from T. Forrester, 125 Seven Way, Bletchley, Bucks.

# Waves in space

*In an open circuit, only an electric field is detectable. Is this because there is no magnetic field present?*

**by Ivor Catt**

Prior to Maxwell, a great deal of theory had been developed around electric and magnetic fields. This theory included Kirchhoff's Laws, the Biot-Savart Law and Ampère's Rule. Electrical circuits were generally steady state, or at worst slowly varying, and the problem of whether electrical and magnetic effects traversed distance instantaneously or took time to propagate did not arise.

Because fields were steady or slowly varying, experiments were generally limited to the study of closed circuits of conductors (and resistors). However, capacitors (electrolytics) were also used, and these created an anomaly in a theoretical structure which included Ampère's circuital law ($\oint H dl = i$) and Kirchhoff's second law ($\Sigma i = 0$). When the switches were closed, electric current flowed in the loop and (following Ampère's circuital law, also called Ampère's Rule,) magnetic flux appeared in the space around the wires.

Ampère's Rule says that if we describe a closed loop, the line integral of the magnetic field strength along the edge of the loop is related to the electric current through any surface bounded by the loop.

The capacitor created an anomaly, because a closed loop could be described where i had more than one value, depending on whether the surface ($S_1$) cut the conductor or $S_2$ passed between the plates of the capacitor. Consequently the absurd situation arose that $\oint H dl$ had to have two values at the same time.

Maxwell 'cut the Gordian Knot' by asserting that the rate of change of electric field between the capacitor plates behaved just like a real current i. So Ampère's rule became

$$\oint H dl = i + \int_s \frac{dD}{dt} ds$$

It is important to remember that the *premise* which preceded the problem of the capacitor was that electric currents and fields were steady or slowly varying. It was accepted that, at the moment the switches closed, the current i appeared at all points in the circuit. The time for the effect of the switch closure to travel across the distance from switches to capacitor was zero.

The current-like field dD/dt between the capacitor plates led Maxwell to conjecture that there could be electromagnetic 'waves in space'. It was already known that a changing magnetic field produced electric current (Faraday's Law $v = d\phi/dt$) and that electric current produced a magnetic field (Biot-Savart Law $H = i\, dl \sin\theta / 4\pi r^2$.) The changing electric field dD/dt seemed to be an electric current in space. With both changing magnetic fields and changing electric currents in space, we seemed to have the possibility of wire-less propagation of electromagnetic signals using a crabwise progression of cause and effect; electric current → magnetic field → electric current

The error in this whole business occurred right at the start. Let us assume that the conductors linking battery to capacitor are one light year long. When the switches are closed, it is obvious that current will not immediately flow in the capacitor. A wave front must travel from switches to capacitor, and behind that front will be electric field and magnetic field – we have a transmission line. Also, should the distance between the two conductors or their shape change, some of the wave front will continue to the right and some will reflect to the left, carrying back the message about the change.

The front end of the capacitor is merely one such change in the cross section of the transmission line. The far (open circuit) end of the capacitor is another such change.

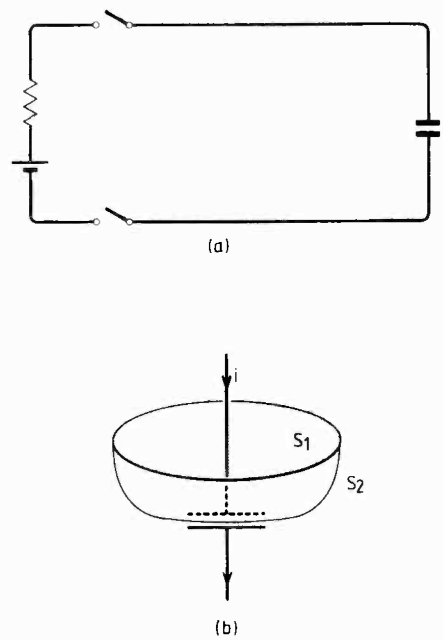



**Fig 1**. *The elemental closed loop (a), in which the capacitor creates the difficulty that the current must have two values, depending on whether the surface (b) cuts the conductor or bisects the capacitor.*

The problem Maxwell should have been concerned about was how the electromagnetic field developed between the wires when the switches were closed, not what happened in a capacitor. The transmission line problem (AB) *precedes* the capacitor problem (CD), and the capacitor problem would be solved automatically with the solution of the transmission line problem.

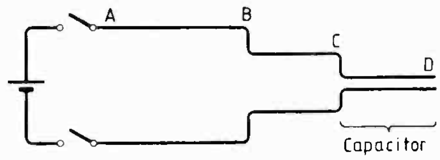



**Fig 2.** *A changing separation between conductors reflects energy. The capacitor is simply another change.*

Before the switches are closed, we can measure a voltage and electric field but find no trace of a magnetic field. When the switches are closed, an electric current starts off down the wires and a magnetic field begins to appear between the wires. The conclusion that the voltage (or pressure) causes the electric current which in turn causes the magnetic field is compelling, and it is not surprising that this mistaken view has lasted for a century. It is then a short step to say that the changing magnetic field in its turn (by Faraday's Law) generates an electric field and thence a (displacement) current, and the sequence can start again.

But was there *really* no magnetic field before the switches were closed?

Let us consider a steady charged capacitor. Does it have no magnetic field, only an electric field? In order to understand the situation in the battery and wires up to the switches before they are closed, it is useful to study the reed-relay pulse generator.

The reed relay pulse generator was a means of generating a fast pulse using rather primitive methods. A one metre section of 50 ohm coax. AB was charged up to a steady 10 volts (say) via a one megohm resistor, and then suddenly discharged into a long piece of coax. BC by the closure of two switches.

A five volt pulse two metres wide was found to travel off to the right at the speed of light for the dielectric on closure of the switches, leaving the section AB completely discharged.

(The practical device lacked the second, lower switch at B, which is added in the diagram below to simplify the argument.)

The curious point is that the width of the pulse travelling off down BC is twice as much as the time delay for a signal between A and B. Also, the voltage is half of

*continued on page 66*

# The limitation of indeterminacy

*Knowing the difference between physics and metaphysics, likewise between "matter-waves" and probability theory, one can begin to understand where modern physics went wrong. Two well-known Copenhagen doctrines can then be taken apart: in consequence the law of causation can be restored to its rightful, paramount place in natural philosophy.*

I have drawn attention to the two principal confusions of thought which were allowed, or perhaps even encouraged, to enter physical science during the decade 1925 to 1935 and which have caused untold philosophical chaos ever since. These were: the indiscriminate juxtaposition or equation of physical entities, such as electrons and mechanical momentum, together with metaphysical entities such as probability and knowledge; and the failure to reject the wave theory of matter when it had been disproved (on both experimental and logical grounds), and to distinguish between its concepts and those of the legitimate statistical quantum mechanics. Even the popular name for the last-mentioned, "wave-mechanics", which derives from its conceptual origin under Schrödinger but is no longer relavant, contributes to the perpetuation of the muddle; a first-rate example of confusion is to be found in the frequently-used expression "probability waves".

Lest it should be thought that these confusions have been innocuous in their effects I will instance a famous statement by a member of the Copenhagen School which provides a vignette of both of them. The date of presentation was 1933, the place Chicago, the reporter Alfred Landé, and the speaker on this occasion Werner Heisenberg. He was referring to the partial reflection of light by a half-silvered mirror, in a thought-experiment that we have already considered in the contexts of quantisation and determinacy. His words were as follows:

> "There is, then, a definite probability of finding the photon either in the one or the other part of the divided ψ-wave packet. Now, if an experiment finds the photon in the reflected part, say, then the probability of finding it in the other part immediately becomes zero. The experiment at the position of the reflected part thus exerts a kind of action, a 'reduction of the wave packet', at the distant point occupied by the transmitted part. And one sees that this action is propagated with a velocity greater than that of light".

Feeling the draught, perhaps, he then went on to say,

> ". . . This 'action' can never be used for the transmission of signals".

**by W. A. Scott Murray,**
B.Sc., Ph.D.

By all accounts Heisenberg made this statement with a completely straight face and believed in what he was saying. It is manifestly nonsense, but for that very reason it may be difficult to make a rational reply to it. The argument that light waves are electromagnetic waves which carry energy and therefore cannot collapse faster than the velocity of light is not quite sufficient because Heisenberg has dodged it by referring to "ψ-waves". He is, however, proposing that *something* associated with the photon must collapse in this way; as Professor Frisch said in a passage that I quoted earlier,

> ". . . It would seem that something does travel along both paths in the interferometer even when only one photon is admitted; but what is it?"

Clearly we are right at the centre of the duality paradox.

The understanding that we have been able to build up of the dualistic machinations of Copenhagen will now stand us in very good stead for dealing with Professor Heisenberg's curious proposal. The ψ-waves that he is playing with are not real waves but metaphysical waves. They do not have to comply with the laws of physics. Like Castles in Spain, he can give them any properties he wishes. If those properties should make his equally metaphysical ψ-function provide a reasonably accurate statistical analogue of how real photons behave, that is all to the good, but his ψ-waves need not otherwise relate to the physical world and indeed for reasons that we have discussed it is clear that they must remain always "unobservable". They are subjective, mathematical abstractions. The photon, on the other hand, is a physical entity which is indivisible and which travels strictly at the speed of light. It goes one way or the other at the mirror surface, but not both; there is no question of a transmitted part of the photon collapsing when a reflected part is detected. The photon's existence is objectively real. So where is the paradox?

The rationale for Heisenberg's statement is that the intensity of his ψ-waves represents *the precision of his knowledge* of the past, present, and future location of this particular photon. (You will note that both "precision" and "knowledge" are metaphysical quantities, appropriately described by ψ-waves). When his knowledge becomes sure – 100% certain because he has detected the photon – the probability that it may be elsewhere instantly becomes zero, as he says. This has nothing to do with the photon, but only with his knowledge; it would be quite wrong to assume, as the Copenhagen School assumed and declared as doctrine on the basis of extensions of this argument and others, that the observer's knowledge or even the observer himself had any influence on the physical, mechanical process of detecting the photon. Indeed, neither the photon nor the rest of the apparatus cares two pence whether an observer is present or not. We now see that the metaphysical doctrine of the relevance of the observer was just another Copenhagen fallacy.

Before leaving this topic let me mention a point which was first picked up by Sir Karl Popper, who has tended to specialise in this sort of thing. Even his ψ-wave packet does not in fact collapse as Heisenberg says it does. The distribution of ψ-wave intensity as a probability density – the probability of finding a photon here or there – does not change when any one photon is detected. It is to be identified as a prediction, the probability of detecting "any" photon as estimated before the event; for after the event the probability of a contrary result is a meaningless concept. And however many times you may have tossed a coin, the probability of obtaining heads or tails on the next toss remains always the same, 50/50 . . .

Thus Heisenberg's celebrated puzzle of the "reduction of a wave-packet" turns out not to have been a puzzle after all. It was a man-made nonsense consisting of one false concept and two logical errors held together by two major confusions concerning, respectively, the mixing of matter-waves with probability theory and the mixing of metaphysics with physics. It was also unnecessary. We can see how it came about, but as physicists we have no cause to be proud of it.

★ ★ ★

I am going to conclude my exposition by analysing one more example of twentieth-century mysticism in the same way. The great Principle of Indeterminacy was enunciated by Heisenberg in 1927, and its profound philosophical message has dominated human thinking ever since. Like so many concepts of modern physics it is partly true. My purpose now is to examine the limits of its applicability and truth.

In its legitimate form the Principle of Indeterminacy (or Uncertainty) has to do with making measurements. For a host of reasons, all of which in the end boil down to the desire to make predictions in order to better manage our surroundings, we are interested in the positions and motions of things. We measure the position and motion of an oncoming motor-car by eye when we are deciding whether or not to cross the road; for more precise measurements we make use of various instruments such as rulers, gauges and graticules. In the ultimate of fineness of measurement our measuring instrument may consist of one photon or one electron which we aim carefully toward the target object whose location we wish to know; the electron or photon will be reflected (or bounce) on contact, and its reflection will tell us where the object was. Microphysical Nature being granular or "quantized", this represents the most delicate measurement that we can ever hope to make.

It was Heisenberg who pointed out, correctly, that this process doesn't provide a measurement of where the object is, but of where it *was* at the instant of making the measurement. The measuring process itself must disturb the object being measured, to an extent that depends on how massive the object is. Projecting one photon of visible light at an elephant, for example, wouldn't shift the elephant very far, but if that same photon were to hit an isolated electron it would set it in motion at a speed of several hundred miles per second. (This is the Compton effect discussed earlier). If you were to use a less massive photon – that is to say, conventionally, a quantum of light of lower "frequency" or longer "wavelength" – you wouldn't disturb the target electron so much but you wouldn't get such a precisely-defined reflection from it either. You can't have it both ways.

Heisenberg condensed these ideas into what was to become one of the most famous Principles of physics. (For those who don't mind equations, I am referring now to $\Delta p \, . \, \Delta x \approx h$). Stated in words, it says that there is a natural limit to the accuracy ($\Delta$) with which physical quantities can be *measured*. The position and momentum of any particle as measured are in a sense complementary. We can in principle devise an experiment to measure either position (x) or momentum (p) as accurately as we wish, but if we try to measure both simultaneously we come up against this natural limit. We cannot measure, and therefore cannot know, both the location and the subsequent velocity of an individual electron with greater accuracy than is indicated by Heisenberg's formula. No evidence has yet been found to suggest that his formula when interpreted in this way is not always and exactly true.

Now it must follow as the night the day that *if* we cannot measure the position and velocity of an electron precisely at the beginning of an experiment or during it, *then* we cannot predict with precision where that electron will be at the end of the experiment. The Principle of the indeterminacy of measurement must therefore lead directly to a corollary Principle of the limitation of prediction. This realisation came as an unwelcome shock to the physics of the 1930s and also, when news of it leaked out, to philosophy in general; for physical science had come to extol its ability to make precise predictions above all other virtues, while human vanity was unwilling to accept that there was anything that human technology ultimately could not do. Faced with this crisis of confidence it was perhaps inevitable that certain spirits should cast about in the hope of finding an escape clause.

We shall examine the defensive antics and flights of fancy of those folk in the next article, but before doing so it will be well to establish how far the *experimentally-verified* aspects of the indeterminacy principle can carry us. Suppose that a fundamental particle (an electron, say) is initially at point A at time zero and travelling at velocity v. According to our best possible measurements we know only that it is within, say, one micrometre of A at that instant and travelling subsequently at a velocity within, say, 100 metres per second of v. From this knowledge we can predict that the electron will in due course pass within one centimetre of a second point, B. The quantum mechanics as a mathematical tool will perform that prediction for us beautifully – there is nothing mystical about it or its calculations, which rely on the conservation laws. But we should note that it is not the position of the electron which is uncertain; it is *we* who are uncertain about its position. The electron itself travels from point A (exactly) to point B (exactly) along a track AB which is precisely determined. It is *our knowledge* of that track, not the track itself, that is imprecise; and it is *the imprecision of our knowledge,* not the physical body itself, that is transferred from the vicinity of point A to the vicinity of point B by the so-called "operators" – metaphysical operators – of the statistical quantum mechanics.

Now what I have just said constitutes a new interpretation of the function of the quantum mechanics or "wave mechanics", and it is controversial. It is also very dangerously heretical, because anyone who accepts it must eventually refute the Copenhagen dogma. I should therefore amplify it a little. Even Heisenberg, under pressure, admitted that his indeterminacy principle did not apply to retrospective measurements. By observing the same electron on two occasions very far apart in time and space, we can determine where that electron was at the time of the first measurement and how fast it was then moving, and we can in principle determine *both* those quantities after the event *to any accuracy we please.* I believe that to be the most important single point I have to make in all these discourses; for Heisenberg, hedging hard, claimed vehemently that such retrospective determinations, although valid, were irrelevant to science

**Catastrophic misconceptions**

A fine example of the effect on physics of man-made confusions is afforded by Heisenberg's famous proposal of the "reduction of a wave-packet". On the basis of physical arguments already generated it is possible to refute this proposal on three counts and to resolve it as a paradox. Similar treatment may be extended to the great Principle of Indeterminacy. It is readily argued that as applied to current measurements and forward predictions the Principle is almost certainly true. However, it is not true in the case of retrospective determinations, and it follows that, contrary to the generally-accepted Copenhagen doctrine, the behaviour of every microphysical entity is determinate and complies with the conservation laws. This is equivalent to the statement that the law of causality is obeyed universally in inanimate Nature, not only statistically but by individual micro-objects. Such a view is philosophically consistent with the laws of conservation. It is likely that the opposing (Copenhagen) doctrine, now widely held, arose from the 1930s confusion of inanimate physics, always determinate, with animate metaphysics, not necessarily determinate or rational.

(which he declared should be concerned only with prediction), whereas you and I will discern instead that they are highly relevant. We will recognise that our ability to calculate precisely the earlier position and momentum of an electron on the basis of later knowledge constitutes philosophical proof that the electron's behaviour during the interval was determinate. During that particular but arbitrary interval it must have obeyed the law of causality: and if then, always. The reason why this new argument is especially important, although one might have thought it obvious, is that the most celebrated doctrine of Copenhagen physics categorically asserts the opposite – that microphysical particles do *not* obey the causality law as individuals, but only "on average", in a statistical manner.

Thus the vital limitation or restriction which I now suggest must attach to the great Principle of Indeterminacy is that it may deal legitimately with the indeterminacy of measurement and prediction but may not, *repeat* not, express or imply any mystical indeterminacy of Nature. Despite general belief and conventional doctrine there is not, and never has been, any experimental evidence in support of the established idea that its operations are not bearings" and that its operations are not precisely determined. How that gross error came to be made will be reviewed in the next article, together with some examples of its catastrophic effects; in the meantime I shall ask the printer to set this statement out by itself, so that there can be no mistake about what I am saying: –

*The law of causality is obeyed throughout inanimate nature*

I cannot prove that statement. No scientific law can be proved, but its strength lies in the fact that no record exists of its ever having been broken. Specious Copenhagen "quantum" arguments notwithstanding, I can only re-assert that there is no experimental evidence against causality. Evidence in its favour surrounds us at every turn, because the law is itself a paraphrase of the great conservation laws of energy and momentum whose universal applicability is generally accepted. Therefore one cannot in logic acknowlege conservation while at the same time denying causality; that is what was so very odd about the 1930s doctrine that nature is indeterminate.

Almost certainly the confusion arose out of the failure to distinguish between physics and metaphysics, the science of the mind. There is plenty of evidence that *decisions* (made by living creatures)* are not always necessarily rational. That fact alone is sufficient to prevent a "Laplacian being" – or anyone else – from making an ultimately precise prediction of the future of the universe. Free will does, indirectly, modify the course of events, as human beings are fully aware; determinism applies only to inanimate, physical interactions. There is room in God's world for both vitalists and mechanists! But here for our sins we must stick with inanimate nature.

I said earlier, in connection with the reflection of photons by the half-silvered mirror, that the word determinate is not synonymous with "predictable by mankind", and went on to say that the arrogant assumption that it was had led to much philosophical trouble in physics. It has also been exported, and caused much trouble elsewhere. It was the basis of the twentieth-century denial of causality, in which the whole of philosophy followed the physicists' misguided lead.

If I were to give you three guesses as to where that assumption came from I'm sure you would be right first time – and not by guessing. It came from the already-disproved but still unrejected wave theory of matter. Let us next explore how.

* Automatic electronic computers do not make decisions. They are inanimate machines, physical structures driven by energy, which obey a set of instructions or program in a strictly causal, pre-determined way. A program, however, is a metaphysical structure – an expression of a human programmer's will. It is not a tape or a disc, but the information which is stored on tape or disc (it is equally valid in typescript or in the form of a flow diagram). It consumes no energy itself, and it can influence physical events only when it is able to control the operation of a physical computer as intermediary. The analogy with mind and brain is self-evident.

# LITERATURE RECEIVED

PCB assembly can be made easier using a Royonic semi-automatic assembly table, according to a brochure describing the system. Components are presented to the assembler in order from a dispenser and their position is indicated by a light spot projected on to the p.c.b. which can draw an outline round the position of an integrated circuit or flash to indicate that polarity needs to be checked for a diode or an electrolytic capacitor. The machine may be programmed by using a joystick or a touch-sensitive pad and the program stored on a floppy disc. Fast assembly of boards with fewer faults is claimed for the system. The brochure is available from W. J. Stickland (Electronics) Ltd, 60 Tower Hill, Chipperfield, Kings Langley, Herts WD4 9LH. WW 400

Recent additions to the Online Conferences 1983 catalogue of conference proceedings. Viewdata 82, Videotex, Local Area Networks and distributed office systems and the Computer Graphics 1982 conferences. Online act as distributors for other publishers including QED Information Sciences and list their publications on data processing and information management. Online Publications Ltd, Argyle House, Northwood Hills, Middlesex HA6 ITS. WW 401

Tools, cases, breadboards, circuit boards and p.c.b. etching patterns are included in the *Hobby Herald*, a catalogue for the "hobby engineer", presented in a newspaper format by BICC-Vero Electronics, Parr, St Helens, Merseyside. WW 402

Specifications, standards and technical documents from the world over are available through a service described in a brochure from London Information (Rowse Muir) Ltd, Index House, Ascot, Berks SL5 7EU. WW 403

Line conditioners to protect computers and other digital systems against noise and voltage variations on a.c. power lines are featured in a leaflet. It includes a selection guide to range of units in the GT series, with detailed information on the electrical parameters which affect the choice of unit. Gould Electronic power conversion Division, Rhosymedre, Wrexham, Clwyd, LL14 4YR. WW 404

Two volumes and over 1,500 pages describe data aquisition products of Analog Devices. The Data Acquisition Databook includes 500 standard products and includes both data sheets and tutorial sections, Products include converters, op amps, conditioners, computing circuits, power supplies, panel instruments, systems and subsystems for measurement and control, and component test systems. Key specifications and applications are given for all the products and a price list is included. Analog Devices Ltd, Central Avenue, East Molesey, Surrey KT8 0SN. WW 405

A glossary of filter terminology and design examples with information on the use of filters in diplexers and multiplexers are included in the Lark Engineering catalogue. Product information includes performance characteristics of bandpass, band reject, tuneable, high and lowpass filters and switchable filter banks. The company uses c.a.d. to produce filters to specified requirements in the frequency range from 12Hz to 18GHz. March Microwave Ltd, 112 South Street, Braintree, Essex. WW 406

Measurement of the suppression characteristics of passive radio interference filters and suppression components is subject to a new Standard, BS6299. The standard specifies methods for measuring insertion loss of passive r.f. filters which may consist of single elements, singly or in combination and either lumped or distributed types. Methods include those for laboratory testing or on a production line tests using fixed impedance terminations. The standard costs £19.50 from BSI sales department, 101 Pentonville Road, London N1 9ND. WW 407

# Ultra high density data recording

Since the disc-drive series was written a great deal of significance has happened in the field – the next few years will see progress that will make $10^7$ bit per square inch seem pedestrian.

by J. R. Watkinson, M.Sc.

The first disc drives appeared around 1956, when computers were exotic vacuum tube monsters, and these early drives offered densities of about 2000 bit/in$^2$. Currently available machines offer around $10^7$ bit/in$^2$ – a staggering increase in such a short time, but the next few years will see progress that will make these figures seem very pedestrian. Current research is concentrated in three areas, the medium, thin-film heads and vertical recording.

The great majority of today's discs are coated with the gamma form of ferric oxide, the familiar brown material. If tracks are to be made narrower to pack more of them on to a surface, there will be a pro-rata reduction in signal output, and it is necessary to adopt a medium which has greater magnetization to maintain s/n ratio at a level which gives acceptable data error rates. Cobalt has been found to have this desirable property. Given the greater magnetization of cobalt, the coating can be made thinner as well as the tracks narrower. With conventional longitudinal recording, the smaller the cross-section of the recorded magnets (track width × coating thickness) the shorter they can be before self-demagnetization makes them unreadable.

John Watkinson is now with Sony Broadcast Ltd

Although thin cobalt coatings are more sensitive to substrate irregularities, this has not been the main reason for the slowness of the industry to adopt the medium. The main cause is that the process required to make cobalt-coated discs is totally different from that required for conventional oxide coating. Oxide is applied in the form of a slurry, which then dries out; cobalt cannot be applied by this old technique and requires either ion bombardment or spluttering. As the industry cannot tolerate instantaneous obsolescence of current media plant, the move to the metal-coated discs will be gradual.

Conventional heads are made of ferrite with a glass gap. The performance limits set by this form of construction have now been reached; losses in ferrite mean that it cannot follow more than about $10^7$ transitions per second. Width of the recorded track is determined by the thickness of the magnetic circuit in the head and the brittle nature of ferrite sets a limit of about 1000 tracks per inch, beyond which the head would lack durability.

A solution to the problem is the thin-film head. Unlike a conventional head, which is assembled from a variety of components, the new thin-film head is fabricated by plating in the same way as thin-film microcircuits. The magnetic circuit is a nickel-iron alloy, permalloy, plated onto a silicon substrate along with a single-plane copper coil in the form of a spiral. The permalloy can be plated to write a track of any desirable width, because it is evenly supported by the silicon substrate which then subsequently becomes the aerodynamic head slider, as shown in Fig. 1.

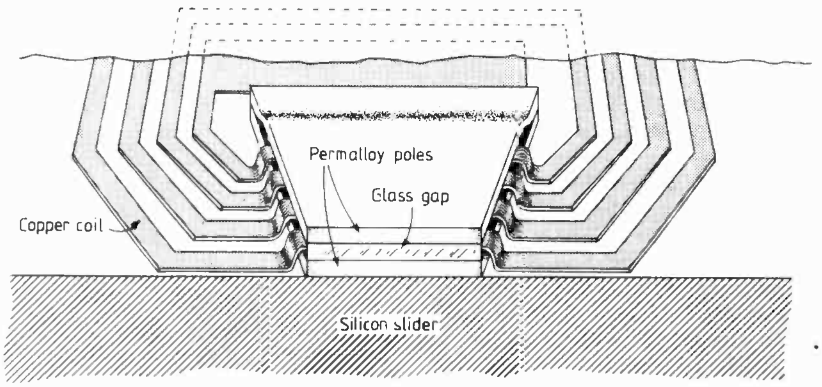



*Fig. 1. Thin-film head made using microcircuit technology on a silicon substrate which becomes the slider.*

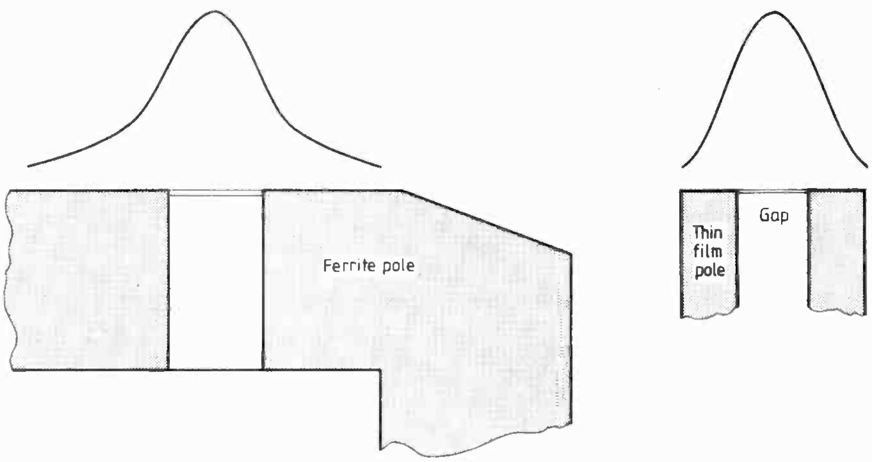



*Fig. 2. Comparison of fields of ferrite (left) and thin-film heads (right). Curves show longitudinal field strength at typical working distance from poles. Sharper curve of thin-film head allows shorter wavelength recording.*

This arrangement has a number of advantages. Firstly, permalloy has a frequency response an order of magnitude better than ferrite. Secondly, the thin-film construction and the characteristics of permalloy cause a very sharp fall in flux density away from the gap along the longitudinal axis. The final magnetization of the medium is determined by the trailing edge of the head field. This effect restricts ferrite heads to about 10,000 transitions per inch, whereas the thin film head can give a 50% improvement on oxide media, and may give as much as 25,000 transitions per inch with metal media, Fig. 2.

Very short magnetic domains tend to demagnetize themselves. The effect is governed by the ratio of the length to the width; the longer and thinner a magnet, the less likely it is for the opposing poles to neutralize each other. As Fig. 3 shows, it is an unfortunate fact of life in longitudinal recording that the higher the density, the shorter the domains.

Now vertical recording organises the domains at right angles to the substrate such that the higher the density, the narrower the domains. Domain length is now controlled by the coating thickness. Claims have been made that $10^5$ bits per inch will soon be available in production equipment, with ultimate density perhaps an order of magnitude greater. The problem is one of designing a compatible head and medium; chromium cobalt is sputtered onto a substrate.

The head must consist of a pole at right angles to the disc which throws the field into, rather than along, the medium. As the trailing edge of the field determines the final state of the medium, the pole used for writing only could have a relatively large dimension along the track, but a head used for reading would need a very small pole indeed. The minute signals induced at such high densities might require an amplifier to be integrated into the slider. Thin film technology might enable the magnetic circuit and the amplifier to be fabricated in one process.

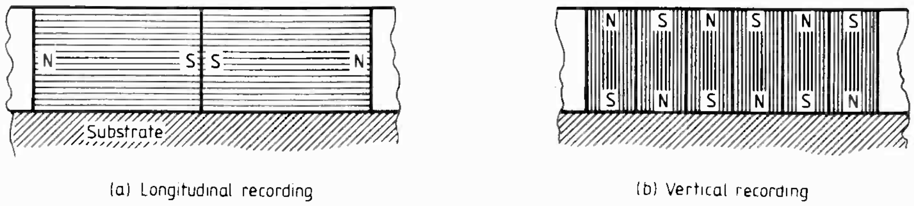



*Fig. 3. With conventional longitudinal recording, an increase in density reduces the aspect ratio of the media domains (a) aggravating self-demagnetization. With vertical recording increased density actually improves the situation (b).*

## Optical recording

Optical recording is as old as talking pictures, when recording was by modulating the width or density of a track alongside the picture frames, which could be read with a lamp and a photocell. Such techniques were studied in the 1940s when the first digital computer emerged. These optical storage projects were quietly forgotten when the first magnetic drums and subsequently discs started to show their paces. Film needed to be processed before it could be read back, whereas magnetic storage offered immediate read back. But optical recording never died, and the invention of the laser with the consequent study of its applications gave it new potential.

The essence of modern optical storage is that laser light is used to melt or otherwise affect the medium in such a way that the changing reflecting power of the surface can be used in the read process. There are a number of different approaches to the basic principle, but the optical assembly required is similar in construction in all of them, Fig. 4. There are two lasers, the write laser being the more powerful; a half-silvered mirror allows light from either into the system. For reading, the low power read laser is activated. Unlike magnetic reading, where the read head acts as a generator, optical reading requires an external source of energy that is modulated by the medium, permiting large signals to be generated.

The most interesting aspect of the read process is the separation of incident and reflected light. The polarizing beam splitter acts as a plain block for light polarized in one direction, but as a prism for light polarized at right angles. The quarter-wave plate rotates the plane of polarization by 45°.

It consists of a crystal whose refractive index is anisotropic; the principle is similar to that used in structural analysis, where models of engineering components made in clear acrylic are placed under stress and studied with polarized light. Rotation of the plane of polarization is a function of the wavelength, so the monochromatic output of the laser is essential. Light from the laser travels once through the quarter-wave plate on its way to the medium, and once again following reflection from it. Reflected light entering the beam splitter is thus polarized at right angles to the incident light, and the splitter acts as a prism, reflecting the light onto the read sensor assembly.

For writing, the output of the write laser passes straight through the system, and is focused on the medium. What takes place on the medium can be one of several mechanisms shown in Fig. 5. In the ablative process, the laser beam is focused on a thin metal film supported on a substrate. This melts right through the film, and surface tension causes a hole to appear before the metal re-freezes. The most common material proposed for this is tellurium because it offers high density, but if suffers from a number of drawbacks. It is difficult to deposit permanently onto a substrate, and is subject to deterioration caused by oxidation and humidity.

In a different technique the laser beam passes through a very thin film into a plastics substrate where the intense heat causes decomposition to gas, forming a blister in the metal film. Although these

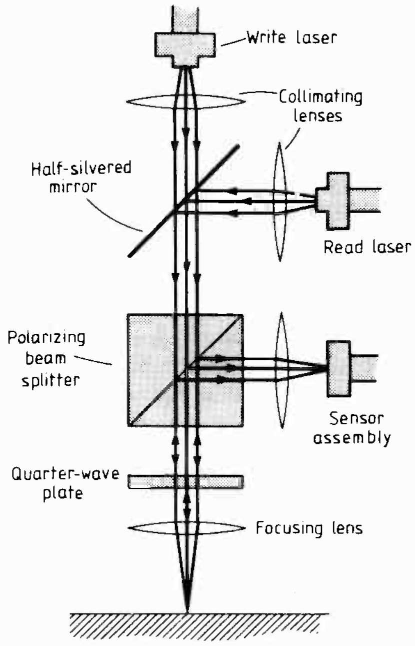



*Fig. 4. Components of an optical read/write head, see text for details.*

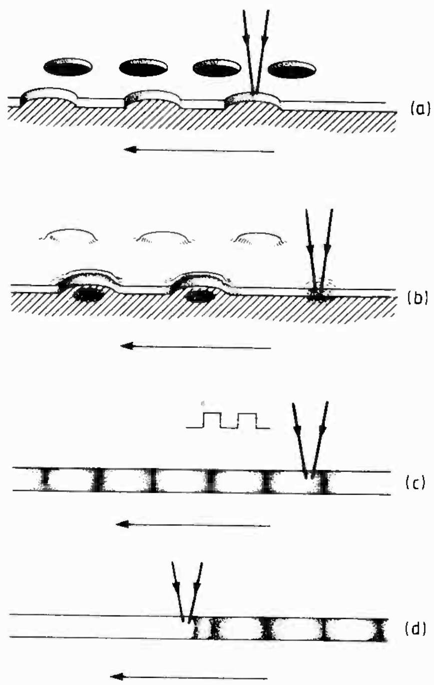



*Fig. 5. Three optical writing techniques. In the ablative technique (a) the laser melts holes in a tellurium film. At (b) laser beam decomposes plastics substrate, causing gas pressure which raises thin coating film in a blister. In (c), a possible eraseable recording, surface ripples are left where the medium has been partly melted. In the erase process a steady beam melts the track continuously; surface tension smooths out the tracks.*

two new techniques permit reading and writing, the last-mentioned process is once and for all. There is no parallel with the ability of the magnetic head to erase and re-write.

Eraseable optical storage exists at the laboratory stage, but it remains to be seen whether it will be marketed. The essentials of the process are to melt part way through the medium only, to prevent evaporation and the formation of holes. A steady erase beam could melt the entire surface of a track, allowing surface tension to smooth out the surface, but it is not inconcievable that a beam switching between two levels might erase and write at the same time. Inherent in the process is a very small displacement of the medium, so that erasure is possible. This will inevitably cause the read-back signals to be small – another problem to be overcome.

An optical disc drive requires many of the same components as a magnetic drive; spindle drive, read/write encoding logic, and some form of positioner are common to both. However, magnetic heads need to fly close to the medium to read short-wavelength signals, and they are designed to follow disc warps. As light can be focused, the optical head can be a short distance from the medium. This eliminates the possibility of head crashes caused by contamination, but it also prevents the head following warps and an active focus system is necessary.

This is commonly provided by using the principle of astigmatism. If a cylindrical lens is interposed between the prism and the sensor, the image of the round read-laser spot on the sensor will only be circular at the point of correct focus. Fig. 6 shows that the shape of the image becomes an ellipse on leaving the focal plane, with the angle of the major axis being determined by the direction of movement. If the image falls on a four-quadrant sensor, the four outputs can be summed and differenced to produce a focus error signal, used to drive an actuator on the focus lens.

For high-density magnetic recording, the track-following signals come from the disc itself (part 5) and this remains true for optical discs. Whereas in a magnetic drive the positioner and head have to move precisely to follow the track, the laser head performs fine tracking by steering the beam and the positioner is only used for coarse positioning. Fig. 7 shows the two major approaches to fine tracking. Where only a single platter is used fine tracking can be done by shifting the lens laterally, Fig. 7(a), which must be fast enough to follow disc run out; a moving coil actuator is one solution. At Fig. 7(b), fine tracking is done by rotating a mirror to reduce the height of the assembly. (The assembly can scan two surfaces by turning the mirror 90°.) In both cases focus is by moving a lens along the axis of the beam. In case (a) it can be the same lens as the tracking lens, in which case it will need to be driven in two axes. Control signals for fine tracking are derived from disc patterns and are, in the broadest sense, optical analogues of magnetic servo-head techniques.

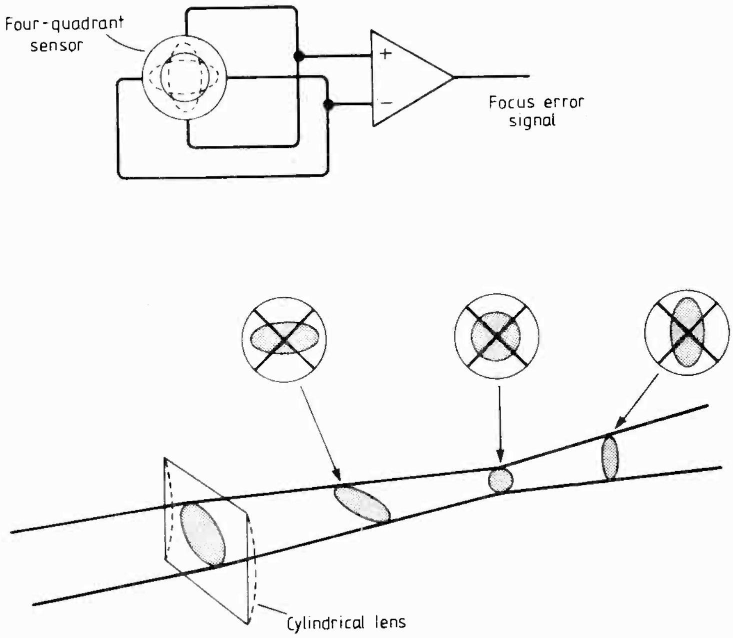



*Fig. 6. Use of a cylindrical lens prevents a point focus and results in an elliptical image, circular at one point only. Horizontal ellipse causes more light to fall on left and right sensor quadrants, vertical ellipse favours upper and lower quadrants, and a differential amplifier provides focus error signal. Four quadrants are summed for read signal output.*

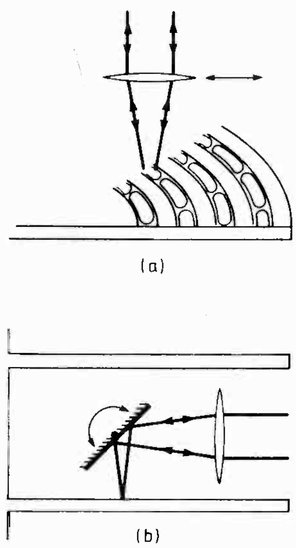



*Fig. 7. Where space is no problem, fine track-following can be done by lateral lens shift (a). More compact arrangement uses a rocking mirror as shown at (b).*

A simple arrangement is shown in Fig. 8 – here a diffraction grating creates two side beams which follow different paths through the system to fall on different sensors. Modulation of the side beams changes differentially with tracking error, allowing the generation of a feedback signal. A disadvantage of this method is that a space has to be left between tracks that is slightly greater than the track width, which wastes space on the medium. A more complex approach is shown in Fig. 9.

A great drawback of magnetic recording from the point of view of duplication is that every copy has to be individually recorded. One of the reasons why vinyl discs have survived the coming of the compact cassette is that they can be duplicated by stamping. Both video and audio optical discs are now available where the read mechanism is by laser, as described. In the case of video discs, the length of the holes or pits in the disc is modulated directly by the programme waveform, whereas in audio discs, the sound waveform is digitized and encoded using similar techniques to those on the latest magnetic discs. None of these laser players can record – they are intended solely for playing recorded discs.

The optical discs are duplicated by electroplating a master to form a die. The master can be made by writing on photoresist with a low-power laser and developing to leave areas of hardened resist in relief, or by direct writing with a high-power laser. The resulting dies are used to stamp plastic discs which then receive a thick electroplated metal coat and a transparent protective layer. The medium is thus sandwiched between plastics and is very resistant to damage.

## Magnetic and optical recording compared

It is too early to be able to write definitively on this subject as so much research remains to be done. Proponents of optical recording claim that magnetic discs are further along their learning curve than optical ones, and that future research in the field will follow the law of diminishing returns. The fact that the magnetic head has to be very close to the medium is also held to be a drawback, as great cleanliness is required.

Proponents of magnetic recording claim that combinations of metal media, thin-film heads and vertical recording will enable them to match the densities claimed for optical recording. It has been suggested that diffraction may set a limit to the density of optical discs from which magnetic discs will not suffer. Criticism can also be directed at the high raw error rates of current optical devices, and the inability to erase in most of them.

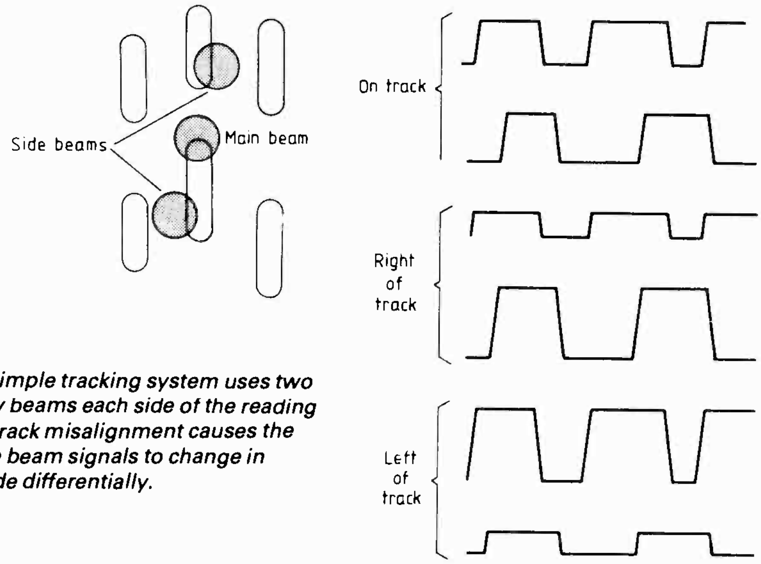
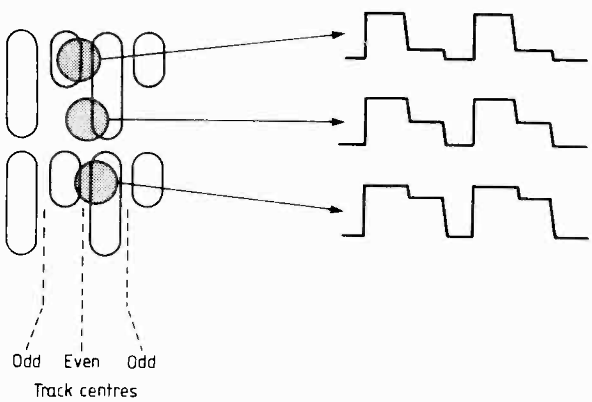



*Fig. 8. Simple tracking system uses two auxiliary beams each side of the reading beam. Track misalignment causes the two side beam signals to change in amplitude differentially.*

*Fig. 9. A possible embedded servo technique for optical discs uses one beam for track following. Two beams spaced at ½ track apart could generate two-phase signal to count track crossings. In the three examples shown, notice the effect of position error on the second part of the pulse waveform. (Compare with article on servo surface drives, August 1982 issue.)*




The truth lies somewhere between the extremes of this clamour. In my view, the optical and magnetic data discs are complementary rather than competitive. In large-scale data processing, there will be no significant departure from the well-proven combination of multiprogramming processor and swapping disc, as the emerging magnetic technologies will produce hard-disc drives offering low cost per bit and retaining the ability to erase. For backup and archival purposes, the write-once characteristic of optical discs is not a problem, and their resistance to contamination makes them ideal where the medium is to be removed from the drive. This may well have an impact on magnetic tape storage.

Possibly the greatest potential for optical discs lies not in the existing data processing fields, but in new applications for which their characteristics are better suited. These include electronic filing cabinets, where images of documents are stored as disc data. In these applications, non-eraseability is an asset rather than a drawback.

One far reaching consequence of the latest generation of computer equipment is its impact on maintenance philosophy. Most of the current units incorporate microdiagnostic hardware and firmware in such a way that in the event of a hardware malfunction a code is displayed that specifies the faulty assembly to be replaced. It is no longer necessary to know how these units work in order to repair them. In normal disc drive operation, microprocessors eliminate the need to make manual adjustments. In some current disc drives, the critical access time adjustment is performed automatically every "power-up". Hard-disc technology eliminated head alignment problems for non-exchangeable drives, but now a combination of embedded servo drives and intelligent controller eliminates head alignment in exchangeable pack drives, and in fact enhances compatibility between drives.

This is, of course, good news for the computer user, as reliability will be increased and repair costs will be reduced in line with falling hardware cost. What is also implied is that the requirement for engineers who have both the mechanical and electronic skills necessary to repair hardware of the last generation has simply gone away, along with the requirement to provide in-depth training. A process of de-skilling is well under way in computer maintenance. The next generation of computer technicians is already being recruited from television and domestic appliance repairers – a sobering thought when it is remembered that the first stored-program computer ran as recently as 1949.

WW

# Next month

Viewdata display module, linked to a home computer, allows a colour tv to receive and display Prestel and teletext. Full design and construction information, including a printed-board design, is presented.

Digital tape timer is a replacement for the mechanical counter used in tape recorders. Accuracy is around one part per thousand on a 10½ in. reel. The tape itself drives optical sensors, which also ensure that the reading is maintained in both forward and reverse directions.

Amateur satellite tracking system, controlled by a Pet micro, will continuously adjust aerial altitude and azimuth to track Oscar 7, Oscar 8, Tiros-N or NOAA-6 by means of rotators.

Single-chip microcontrollers with program in eprom are now available cheaply. Program development can therefore be carried out using an eprom emulator; this article describes a circuit to enable this to be done.

**On sale March 16**

# LETTERS

## AMATEURS AND CABLE

As Pat Hawker (G3VA) has mentioned on more than one occasion the question of cable tv being installed for tv links and its possible interference to the amateur bands between 5MHz and above is looming.

With the ratification of the R.F.I. Bill S.929 last September it would appear that 'we' as the amateur population are dragging our feet somewhat.

Hopefully, as I ask you to publish these few words, someone somewhere, both in industry and the amateur world, here in the UK at least, will take note and realise that if cable tv is to progress without (?) problems then parties must get together quickly. It not only affects the amateur and industry at large but in some cases the short-wave and domestic listener/viewer.

Bearing in mind the radio amateurs throughout the world form a substantial part of this balance of payments of varying countries and after all not every firm depends on MoD contracts.

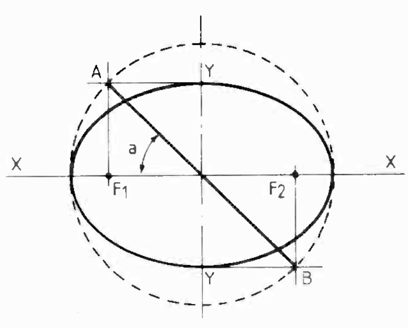
The naive idea that amateurs do not count according to some professional engineers must be looked at in the light of future and past developments in both radio and tv. In short, what works in theory doesn't always work in practice so consequently the need for liaison between interested parties, notably the RSGB on the one hand and industry and the Home office on the other. The RSGB and others are aware of this problem regarding cable tv and it should not be allowed to drift. I thank you in anticipation of publication as the subject does affect all radio amateurs and listeners alike.

J.A. Holmes
London E4

## CONSTRUCTING AN ELLIPSE

I required a simple method that would give a visual picture of the specified ellipse; the distance between its foci, $F_1$ and $F_2$; and the area of the ellipse.

Imagine the ellipse's auxiliary circle, shown dotted, (see diagram), to rotate about diameter $\times-\times$. It would project an infinity of ellipses each having a common major axis, with corresponding minor axes diminishing to 0, as it resolves into a straight line on $\times-\times$. The relative foci, $F_1$, $F_2$; diverge from the centre, finally reaching the extremities of the major axis $\times-\times$. The sine of the angle of inclination a to project a specified ellipse = minor axis/major axis=angle a, and, if this angle is projected on to the auxiliary circle, passing through its centre, similar to a side projection to itself, A–B, then perpendiculars are erected from A and B to meet z–z, these points will meet it at $F_1$ and $F_2$, their accurate distance apart=major axis × cos "a". To find the area of the ellipse I multiply the area of the auxiliary circle by sin a.




L.G. Miller
Lydney
Glos.

## THE NEW BUREAUCRACY

When Dr Catt produced the first of his series of articles attacking me and my colleagues, I tended to dismiss them as the ravings of a confused mind, even when they were printed as leading articles in a journal which I respect. Could this outpouring be from the same office which produced "Microchips and megadeaths," I wondered? Now, after the third attack, it is time to speak.

Like Dr Catt, I have worked for computer manufacturers and computer users for the past twenty years, but in software. Like him, I have been confounded by bureaucratic interference and bloody-mindedness, but the strength of his feeling is truly amazing. What a pity he turns his feeling against his colleagues.

In short, it is facile in the extreme to argue that programmers, whose job it is to convert a statement of requirements to a working system on a given set of hardware, can be blamed for the adoption, retention or, indeed for any influential action at all when it comes to computer hardware. We use what is available, that is all.

To those of us in the real world – implementing working systems – the idea of us "infiltrating and subverting" the process of hardware design, while attractive, is unreal. None of us likes the von Neumann architecture – we spend our lives trying to circumvent it. Indeed, when I showed his article on Wafer-Scale Integration to some of my colleagues, there was universal interest. As an aside, our Systems Manager would like to find these systems programmers who are politically adept, for they would be rare beasts indeed.

It seems that we have given offence because we have neither science nor technology. I must confess that is some months since I integrated my last expression (compound interest calculation, as it happens), and I agreed that university courses are of little relevance to the practising programmer. But my craft is not to blame for that, and the universal requirement for experience is a good illustration that the industry is being condemned by the action of a few. My Oxford dictionary, incidentally, relates the word "technology" to grammar and a study of the techniques of art, or the arts. Our use of the expression "Software Engineering" was devised as a tribute to our hardware colleagues, and a good pointer to the way we had to go. It is churlish to refute such a tribute because, we have not yet completed the journey.

Finally, if Dr Catt has difficulty in finding software people to design and develop his software (should he concede that he needs it), then he need look no further. I am a consultant with a background similar to his, with experience in the fields he requires. My only qualms in volunteering to work with him is that, although I understand him, will he understand me?

D. W. Scott
Nettlestead Green
Kent

## NO SUCH THING AS A MAGNETIC FIELD

I have always been pleased and surprised by *Wireless World*'s editorial policy which seems to take a far wider view of the world than the purely technical, electronic one.

Over the years we have frequently seen letters, articles and editorials which enrich the subject matter of *Wirless World* on such topics as relativity, fundamental electronic philosophy and the morality of contributing to warfare. A very healthy and refreshing state of affairs.

May I be permitted to make a small contribution. When learning about electricity at school, it suddenly struck me rather forcibly that there can be no such thing as a magnetic field. Some readers will no doubt find this assertion very curious as we measure, use and describe magnetic fields mathematically. We can even feel them if we take hold of a couple of magnets, and by using rather specialised techniques we can make them visible.

The simple fact about the magnetic field however, is that it has no separate existence; all the techniques for measurement or detection of the magnetic field have common features and none can demonstrate or identify the separate existence of the thing we call a magnetic field.

When, for example, we "detect" a "magnetic field" between wires in which a current flows, the only factor we can be reasonably certain of is that we are bringing into proximity moving electric charges. There is no proof of a "field" and nothing to be dignified by a special name "magnetic". We simply have a force between moving electrons.

When we bring two magnets together, the force between them is not due to any invisible etherial field, but is due to the proximity of moving electric charges, the electrons confined to orbits (or orbitals of the Schrödinger wave equation). All the force effects between magnetic (ferro, para or diamagnetic) materials can be explained in terms of moving electrons.

What other "proofs" or "measurements" of "magnetic fields" exist? The Hall effect springs to mind. Here again, we are simply looking at a force between moving electrons, which is either allowed to set up a transverse potential gradient, or a small transverse current in a conducting medium when another medium containing moving electrons is brought nearby. Once again, all we have is a force between moving sets of electrons.

These common features are found in any test or experiment concerning the "magnetic field", whether we consider electron beam deflection in a c.r.t., electro-magnetic induction, compass needles or whatever.

The history of science is littered with examples of concepts which at best summarize the truth, and at worst hinder the understanding of the true state of affairs, and as Bertrand Russell said, once people believe a thing really must be so, it takes a tremendous weight of evidence to change their minds. Examples are "phlogiston", a gas once supposed by chemists to be given our during any combustion, "caloric", the fluid responsible for heat, and the ether, once supposed essential to the transmission of electromagnetic waves. The trouble with the foregoing concepts is a natural tendency to believe that if a special name exists for a concept we know all about it. In fact we know next to nothing about this force between moving electrons, just its size and existence are known.

How it arises and why are a mystery which the mere name "magnetism" does nothing to explain.

It would be rather perverse to attempt to tear down a cornerstone of electromagnetic beliefs without attempting to make some progress. Perhaps it would be useful to clarify the situation by discarding all the terms containing the "magnetic" root and use the following.

Electrokinetic force – the force between moving electrons (formerly known as magnetism).

Electrostatic force – as before, the force between stationary charges.

We could manage very nicely with just these two. It would be useful to dispense with the antiquated term "field" (does it originate somewhere in our agrarian past?) and write all the equations in terms of forces instead of invoking this roundabout complication.

It is to be hoped that by clarifying the situation in these ways, more would call into question the fundamental nature of the forces between electrons at rest and in movement and some real progress could be made.

I hope there may be something of originality and controversy in this, I have not seen such ideas expressed in your columns before (equally, I have not read every issue of *Wireless World*). If you would like to publish any of this letter I would be very pleased and grateful. In the meantime, I shall continue to look forward to the "questioning" letters and articles I have come to expect as a part of your excellent publication.

A. R. Churchley
SARA Krd
Warrington

## ELECTROMAGNETIC DOPPLER

I have been unable to find the answer to what is superficially a straightforward question. What is the mechanism by which Doppler shift is produced in the case of electromagnetic waves?

In acoustics, when two observers in relative motion observe the same sound wave they measure different frequencies due to the simple fact that the wave is passing each at a different relative velocity. If $V_{R1}$ and $V_{R2}$ represent the velocities of observers 1 and 2 relative to the wave then

$$\frac{f_1\lambda}{V_{R1}}=\frac{f_2\lambda}{V_{R2}} \qquad (1)$$

$$\text{or} \quad f_1/f_2=V_{R1}/V_{R2}=(V-V_1)/(V-V_2) \qquad (2)$$

Equation (2) is the derivation of the more familiar form of the equation where the relative velocity of wave and observer is expressed in terms of the velocity of propagation in the medium V, and the velocity of the observers relative to the medium $v_1$ and $v_2$.

The e.m. Doppler shift equation (3) can be verified experimentally to a high degree of accuracy.

$$\frac{f_o}{f_s}=\frac{C-V}{C} \qquad (3)$$

Now if, as I have seen stated, "similar principles apply" one can deduce two things: that the velocity of light relative to the observer is c-v which is in direct opposition to the postulate of relativity which insists that the velocity of light is always c independent of relative motion between source and observer; that the velocity of light is constant relative to the source which would provide an adequate explanation of the null result of the Michelson Morley experiment and would support the corpuscular/photon model of light, photons being "shot" out of matter at constant "muzzle" velocity.

A further piece of evidence supporting (2) is that of star aberration. In 1729 Bradley showed that the apparent direction of a star is actually the vector sum of the velocity of the light from the star and that of the earth.

It would seem that there is at least some evidence to support the view that the velocity of light is constant with respect to the source and that this would resolve the dilemma presented to physics by the Michelson Morley experiment. As physics has not accepted this path one can logically assume that there must be overwhelming evidence to the contrary which supports the postulate that the velocity of light is always constant independent of the velocity of the source. I have looked in vain for such evidence, most books seem to manage without any: the only evidence which I have found is de Sitters observation of double stars. If the whole of modern physics is based only on that I think we should all be worried.

The standard technique seems to be to ignore Doppler and aberration, to fudge the evidence in respect of the postulate and dive straight into the mathematics of relativity. From this appear the relativistic Doppler shift equation and aberration equation. Thus having shown that both are embraced by relativity one never has to ask the questions I have raised. Now the relativistic Doppler equation may be written.

$$\frac{f_o}{f_s}=\left(\frac{C-V}{C}\right)\left(\frac{1}{\sqrt{1-V^2/C^2}}\right)$$

The second term is time dilation which for modest values of v is equal to unity. My question is what is the physical mechanism which produces the first term which appears to be the ratio of two velocities. If the velocity of the wave is the same to both observers there is effectively only one other possible variable and that is time (note distance can be defined as the distance travelled by a light beam in unit time) so that if the first term is not due to a difference in velocity of the wave it must be due to a time difference or time dilation. Both observers observe the same wave. They both observe that it is travelling at the same velocity yet they disagree as to its frequency because their clocks are ticking at a different rate. But whose clock is ticking faster than whose. It depends on which observer is sourcing the beam of light. If both send a beam to the other simultaneously then we get the mathematical absurdity

$$T_A>T_B \text{ and } T_A<T_B$$

This type of "paradox" has been mentioned in *WW* before, but surely either the result must be rejected because it doesn't conform to the laws of mathematics, or the laws of mathematics are wrong, in which case the derivation of the result must be rejected as being based on faulty mathematical laws.

I would welcome any suggestions as to where I am going wrong.

I have followed Dr Murray's articles with interest but he has lost me on one point. If, as he suggests, light waves are periodic variations in photon density then presumably destructive interference occurs when the peaks in density of one wave 'fill in' the troughs of the other so that the *variation* in density is zero but the *actual* density is the combined averate density of the two waves. Surely this could be easily checked experimentally as the photo-electric current produced by a dark fringe of an interference pattern should be the same as that of a light fringe. I cannot see either how his model can explain polarization.

**Appendix**

*Double stars*

For those unfamiliar with this piece of evidence the idea is that if the velocity of light were constant with respect to the source, then the light from a star in a binary system which is travelling towards us would tend to overtake that from the star going away from us with the result that their observed orbits would seem irregular. De Sitter observed double stars and no orbital irregularity. I have yet to find out when or where these observations took place, the magnitude of the expected irregularity, de Sitter's measurement accuracy, and why he didn't get a Nobel prize for this obviously vital work.

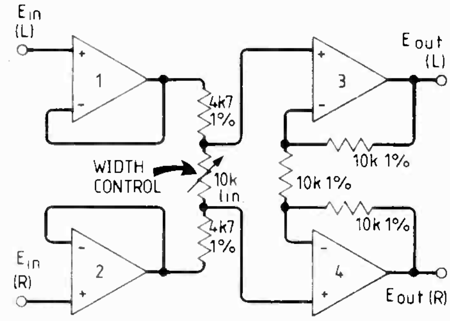
J Kennaugh
Callington
Cornwall

## STEREO WIDTH CONTROL

In the article Modular preamplifier' Mr J. L. Linsley Hood describes a circuit to blend or separate 2 stereo channels (*WW* Jan, 83 page 47/48, Figs. 20, 21). Although there can be no doubt that these circuits can work satisfactorily, with some minor modifications a combined separate blend circuit is possible – see Fig. 1. As you can see, by adding four extra resistors, just a one-section potentiometer is required, and width control can be turned completely back to mono.

I like to use this opportunity to warn experimenters, who for some reason use bipolar op-amps of the 741 type for audio purposes, that a negative d.c. bias at the output of such op-amps (e.g. a 3k9 resistor from output to minus supply) can reduce crossover distortion at higher frequencies remarkably.

P. C. W. Demmer
Amsterdam-Osdorp
Netherlands



## ELECTRONIC IGNITION

Users of the electronic ignition published in the March 1982 edition may be interested in an important secondary use for the change-over switch recommended in the article for all electronic systems, in the event of failure.

It is a well-known effect that the contact breaker tends to get dirtier soon with electronic ignition, an effect which is made worse if the distributor capacitor is removed. This results in misfiring and eventual stoppage. However a few minutes running with the change-over switch in the conventional mode every now and then will prevent an accumulation of dirt, which is presumably burnt off by the arcing and sparking that is a normal feature of conventional ignition.

Contamination of the contact breaker can be surprisingly difficult to diagnose unless you know of its effects, and can lead to time wasted in a search for component failure in the electronic ignition.

Rod Cooper
Lichfield
Staffs

## FAILURE OF DISTRESS SIGNALS AT SEA

I would like to make a few comments on the letters from Mr Hans P. Faye-Thilesen (*WW* February, 1983).

Whatever the losses in the insulators and wires of an aerial caused by dielectric and induction heating, these are (for a particular frequency) constant and predictable losses, which, as for any electrical machine, are taken into account in any calculation of efficiency, and which *ought* to very much increase with frequency. Losses due to inductive heating of parts of a ship's superstructure, caused by poor siting of aerials, are probably worse, but not readily measurable.

Some of the "top loaded unipole" aerials mentioned by Mr Faye-Thilesen are only 10 per cent efficient at 500kHz, according to their manufacturers ' data. Even this we are grateful for (and it isn't very good), *when* it is available, but it is not the theoretical aerial efficiency under ideal theoritical conditions that people at sea have been criticizing; it is the total collapse of any efficiency *at all* in bad weather conditions, and there is no denying that it is related to two main factors, namely aerial capacity and insulator leakage. This is experimentally demonstrable by the instant improvement in performance obtainable by parallel connecting several aerials and washing, shielding and/or reducing numbers of insulators. I could speculate that dielectric heating of water droplets in moist air contributes to the problem, but then it *ought* to be evident at h.f. as well as 500kHz, and it is not. We have no problems with these aerials at h.f.

For information about the performance of low-powered 500kHz life-boat transmitters, I would refer readers to my letter in *WW* June, 1981, in which I quoted from actual experience. I have, as a matter of routine, regularly tested life-boat radio equipment on board ship. With a 5W transmitter on 500kHz, and 30 feet of wire, six feet above the deck, 40 feet above the water, it is not very difficult to obtain a good signal report from a coast station 25 miles away in daylight hours. I would not agree that this equipment is "useless". I don't know how to keep 60 feet of wire supported from a kite or balloon in a storm either, but I still wish to have the kite or balloon available for possible use in the calm that follows the storm.

I certainly support Mr Faye-Thilesen's contention that only 500kHz is reliable for DF purposes and that 2182khz is *absolutely useless*. This was borne out a few years ago in the loss of the German ship Munchen. DF bearings taken on a 2182kHz EPIRB beacon later proved to be wildly inaccurate. No trace of either ship or crew was ever found.

Finally, SOLAS means Safety Of Life At Sea.

John Wiseman
London, E3

## THE RIGHT FORMULA

Referring to R. G. Young's letter in the November issue, when Max Bohr was discussing the existence and reality of purely theoretical (abstract) entities, the conclusion reached was that their existence and reality were both unnecessary attributes. From this conclusion one may safely say that materiality diminished to its ultimate stops at Newtonian physics and the molecule. Anything smaller such as concepts of atoms, electrons and nuclear particles reside only in the mind and are devolutions of the physicists' credo and not science. The theories evolved from such conceptual devolutions comprise metaphysics. It is for this reason that $1.1 \times 10^{-14}$ grams increased mass ($1.1 \times 10^{14}$ was a slip of the pen as was the use of 'velocity' rather than 'motion' in the definition of mass) does not exist.

If there ever was a 'big bang' start to the universe then there must be an absolute still from which the increases in mass may be measured. Einstein denies this absolute still point, hence some absurdities result from his theory, which only partially accounts for phenomena. Hence perhaps one may say that $1.1 \times 10^{-14}$ grams is a mathematical figment of the imagination and also that it is neither real nor existent.

The mathematics used in science must follow the same laws as the physical phenomena being investigated so that it may be regarded as valid. It is, for example, mathematics which rules that light must be a wave or a particulate phenomenon but not both. It is the physical phenomenon of light which rules that it is both a wave and a particle and therefore scientists ought to get used to thinking this way and cast out some of the imprinted ideas of their earlier days of what exists, what is real, and what can or cannot happen, if they wish to advance in knowledge rather than speculation.

O. Balean
Chatham
Kent

## SEEING RED

I have had recently to up-date my rented colour television receiver because of problems as regards replacement spares for the old one which was still performing satisfactorily.

I was immensely impressed with the technological progress which has been made not only as regards the facilities provided but the way in which they can be controlled. No longer does it feel as if I am operating an oil circuit-breaker when I change channels and I am given access to a vast amount of information by courtesy of Teletext. I am moreover given remote control of all this by the choice of something like 30 different commands over an infra-red link.

Being so impressed, I was perhaps somewhat slow in giving a critical eye to the receiver's main purpose, namely to produce a picture of at least as good quality as that available from the old receiver.

What I found was, that while the pictures were sharp and bright, the colour rendering was not what I might have expected.

It is in the red part of the colour range where I feel most dissatisfaction because what I am shown is a red which is more of an orange hue though some might refer to it as flame colour.

Some well-known objects have a particular colour association and errors in colour rendition in such instances, can be quite disturbing. Grass can be more or less green and sky can vary in its blueness but the colour of a London omnibus and that of a guardsman's uniform is well-remembered in the mind's eye and it is here that errors will be immediately apparent.

Switching to Teletext on the new receiver showed that red was the same hue as obtained in the tv picture and this would seem to show that the modern "red" phosphor has a characteristic rather different from the primary red phosphors of a few years ago. Manufacturers may have seen fit to do this in order to give increased brightness when viewing under conditions of high ambient lighting but if this is the case, a regrettable error is being built in to the modern receiver.

For instance, where a floral display is involved, the inability to portray a pure or primary red could result in flowers being seen with hues quite inappropriate to their species.

Finally, I can admire my receiver as a product of high technology and it produces some very pretty pictures but in the cirumstances I have described, I find them unsatisfactory if only because I am no longer allowed to see red.

Gwilym Dann
Chipstead
Surrey

## DESIGNING WITH MICROPROCESSORS

It is unfortunate that several errors appear in the 8080 PRINT program in the article by Zissos and Valan (December 1980 issue).

The MVI instruction at location 1003 does not set the zero flag, so a zero length block will not be trapped.

The JNZ instruction at location 1005 should be a JZ.

The JMP instruction at location 1013 jumps to the wrong place, causing an endless loop.

A possible revised program, in Assembler format, appears below:

```
     ORG  1000H     ; program start address
     LXI  H,2040H   ; address of first byte to be printed
     MVI  A,n       ; A=ngth of block
     MOV  C,A       ; C=length of block
     ORA  A         ; set flags
L3:  JZ   L1        ; jump to L1 if count=0
L2:  IN   60H       ;
     RLC
     JC   L2        ; loop if printer not ready
     MOV  A,M       ; next byte to be printed
```

# LETTERS

```
      OUT  61H        ; print
      INX  H          ; point to next byte
                        to be printed
      DCR  C          ; decrement count
      JMP  L3
L1: HLT
```

Neil Roberts
Leasco Software Limited
Maidenhead
Berkshire

## NON-BINARY LOGIC CIRCUITS

I was saddened to see the article by C. W. Ross in the December 1982 issue, page 68. The idea of something other than straight binary surfaces every few years, and then sinks out of sight. The reality is that in around 1960 there was an historic shift from the supremacy of analogue to the supremacy of digital. The full power of binary has been missed during the last 20 years due to the worldwide fixation on the expensive, fully parallel binary. This is very limiting, and makes more plausible the partial resurgence of analogue in the form of Ross's ideas, ternary logic, majority logic, etc., etc.

In 1964 at Motorola (see "A high-speed integrated circuit scratchpad memory," Fall Joint Computer Conference, November 1966), my team delivered a system in which logic pulses 4ns wide (2ns rise time, 2ns flat, 2ns fall time) were used as a matter of course. At that time, an eight-bit byte could be delivered as a routine matter in serial form down one single wire (plus 0V return) in 32ns, a 16-bit word in 64ns. Today, 20 years later, we could probably go 10 times faster if we tried, delivering a 16-bit word in serial form down one wire (plus 0V return) in 6.4ns. (In fact, for all the ballyhoo about increasing speed, we have not tried at all to increase speed during the last 20 years!)

Serial working would reduce the cost and increase the reliability of present-day microprocessors and rams, drastically reducing the number of legs on on the chip, the number of interconnecting leads, and the chip d.i.p. size. It would also drastically reduce the cost of standard buses. [In 1964, signals starting on one board, transferring to a mother board, and then transferring back to another daughter board, retained their fast (2ns) rise and fall times.]

Fixation on fully parallel working shows how this crazy industry can ignore the strongest financial imperatives. This is because of the extreme youth of the people in the industry. They learn about what should be temporary phases in the industry and assume that it was always thus and will always be thus. In fact, serial working was the norm until around 1960. Today, you are not allowed to design serial working into a digital system. (This includes a ban on serial memory.) How this fixation can hold out against the present alleged trend of computer linking up with a fully serial industry, telecom, I do not understand. It proves the strength of a fixation, how it can stand firm against all odds, including strong financial pressures.

Fully parallel working, with its concomitant complex failure (breakdown) modes, has spawned the growth of the very complex, expensive logic analyser industry, and massively forced up the complexity and rate per hour of system repair. By contrast, a serial system can be analysed using a normal oscilloscope. The bits lay themselves out along the trace, and failures are easy to find because they are catastrophic – the whole word disappears.

Ivor Catt
St Alans
Herts

## MODERN PHYSICS

Congratulations to Wireless World for providing publication for Dr Murray's series. To find such an open-minded and intelligent discussion in a respected journal is today exceedingly rare.

Modern thinkers have become so entrapped in preconceived notions that their power of detached observation has almost entirely disappeared. To illustrate, it has never been explained *why* an electron should orbit the nucleus of an atom. Surely, if an electron and a proton experience a mutual attraction they should simply move together and unite; there is nothing to suggest that any sort of rotational motion is either necessary or possible. The fact of the matter, and one that is becoming increasingly obvious to many thoughtful persons, is that Nature does not consist of the attraction or repulsion of *two* opposing principles, but is formed by the interplay of *three* mutually interdependent principles.

Neither the electric, nor the magnetic, nor the gravitional forces exist in reality; they are merely concepts used to explain observed phenomena. An electron possesses the single property of ever-increasing motion; a proton possesses the tendency to absolute stillness; the third principle that seeks to unite the other two is as yet un-named, but determines the phenomena which our theories clumsily attempt to explain. And this view is not without historic precedent.

Although it is reassuring to assume that men of antiquity were less intelligent than we are today, this assumption is not supported by investigation. The Bhagavad Gita, an ancient text, states that Nature is formed from three 'Gunas' or principles, referred to as inertia, motion, and harmony; even Christianity insists that God is a trinity. When scientists learn to interpret their observations as being the interplay of three principles and not two, they will not only have re-established a teaching that is thousands of years old, but will be well on the way to a truly scientific understanding of the Universe, instead of a merely mechanistic one. Einstein's famous equation, $E=mc^2$, is a relationship between three concepts; mass, space, and time, and simply states that the tendency to infinite motion reaches an upper limit established by the balance between the principles. It does *not* state, as so many suppose, that "Nothing can travel faster than light". If it be re-written in the form $c^2=E/m$, then it is obvious that the limiting vela relationship between three concepts; mass, space, and time, and simply states that the tendancy to infinite motion reaches an upper limit established by the balance between the principles. It does *not* state, as so many suppose, that "Nothing can travel faster than light". If it be re-written in the form $c^2=E/m$, then it is obvious that the limiting velocity is determined by the ratio between 'energy' and 'matter', and that where this ratio is low, as in a piece of glass, the limiting velocity is lower than the 'speed of light', and where the ratio is high, as in interstellar space, the limiting velocity is higher.

I hope that this letter, the first I have been encouraged to write to any journal, serves to stimulate vital discussion on ideas that are very much in need of a thorough research and restatement.

P. Craig
Wellington
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# NEWS

# Seeing the light?

Around 30 000 homes in a San Francisco suburb are to be wired with a 50:50 coaxial/optical cable tv network costing only 3% more than an entirely coaxial system by Commco Cable TV of Texas who have recently formed an Anglo-American partnership. Using both aerial and underground cable routes, this $10m switched star system has optical fibre trunk-to-house links carrying only one signal at a time so tv-converter costs are possibly 10 times lower than they would be with a tree and branch network and switching circuits, being outside the home are said to be cheaper to maintain. Labour-intensive hole digging is avoided as the optical-fibre cables are thin enough to pass through existing ducts.

Commco's partnership with Cable and Wireless and Charterhouse Group plc, called Cable TV Construction, will start its life in the Birmingham area involved with planning and consultancy contracts. As the name implies, the company also plans to install networks in the future.

A second recent Anglo-American partnership, Cabletime, plans to offer a cheap cable tv system in the UK by the end of the year. Their system, a star network combining typically 85% optical-fibre cable with 15% coaxial, is based on one designed in America mainly for use with blocks of flats, each with their own distribution unit. But David Mann, managing director of Cabletime, emphasises "the system that we plan to offer in the UK is not the same as its US counterpart. Modifications make the switching units and cable more suitable for outdoor use and we are uprating the system to comply with PAL requirements, probable UK standards on the number of channels for each home, and satellite broadcast interfaces. The network's final form will depend on the requirements yet to be decided upon. All our equipment is to be made in the UK." One arm of the company, Cabletime Installations, will manufacture robots for laying cables in sewers. Times Fiber Communications of America who formed Cabletime together Britain's UEI group provided the system for Commco's San Francisco installation.

"If cable tv is to start soon, a system such as ours is the answer – if a wholly wideband optical-fibre system has to be used, Britain will have to wait another 10 years," adds Mr Mann. Many network-cost estimates for the UK are high, since they are based on prices for communications systems using high-grade optical-fibre cables carrying fast signals over long distances. A star-switched system such as the one proposed by Cabletime would be far cheaper than one using only optical fibres and meet requirements so far outlined by the government for an initial 20-year licence (tree and branch systems will probably receive 12-year licences). The government is likely to insist that cables be laid in ducts, paving the way for future improvements.

In January, an agreement providing for the formation of a joint venture company in the UK – Plessey Scientific-Atlanta Ltd – was announced by Plessey's chief executive, Sir John Clark. The new company is to "exploit developing business opportunities for satellite and cable communications in Western Europe". In Sir John's words, "With the joint resources of our two companies, we shall be addressing the European satellite communications market which is set to take off with the launch of the ECS1 satellite during 1983. Furthermore, it is clear that many governments in Europe, including in particular our own, are seeking to provide as rapidly as possible a national wide-band network financed from the public's appetite for tv entertainment." A second agreement between the two companies gives Scientific Atlanta Inc. access to Plessey's v.l.s.i., microwave device and optical-fibre technologies.

Scientific Atlanta of Georgia in the US opened up a catalogue service called Cablemart in November of 1982 that illustrates the type of business that cable tv has become in America. "Cablemart promises 24-hour order processing of hundreds of cable tv products listed in its catalogue . . . customers can call in orders using a toll-free telephone number . . . to hasten delivery, in-stock items will be shipped within 24 hours," reads the description.

Among other companies involved with cable tv are GEC, who are to manufacture hardware; Racal, who have combined with Oak Industries of America to make both equipment and programmes (see News, October 1982), and Thorn, who have set

## Wideband cable systems

Terms of reference used by the DoI technical working group chaired by Dr E. N. Eden to provide draft British Standards for wideband cable systems read as follows:

"To consider the specifications necessary for the design and operation of wideband cable systems, in particular as respects the needs for cable systems

- to be compatible with appropriate technical and service features of the networks operated by BT and Mercury
- to have the capacity to provide interactive services
- to comply with the requirements for the prevention of electro-magnetic interference laid down by the UK, the EC and the international specifications of the International Special Committee on Radio Interference (CISPR)
- to have some reserve capacity for which standards will be specified in the future (the level of spurious signals for other services that may appear should be specified)

and for existing tv receivers used for uhf reception to be capable of being linked to the system (the properties of receivers with other interface ports and of receivers equipped to take adaptors for the reception of transmissions from satellites of direct broadcasting will also need to be taken into account).

In considering these specifications the working group should take into account all the various types of services, including switched interactive services, that it can envisage as being provided in due course by wideband cable systems, with the exception of voice telephony, and where appropriate British Standards do not exist it is asked to draft them. These standards should encompass the principal alternative configurations and technologies and the working group may therefore find it necessary to produce alternative standards for particular services.

The principal services that the Department can anticipate as being among the potential capability of wideband cable systems are

- downstream video channels, where the Department wishes the working group to look towards 30 channels each with its associated sound and teletext data signals (a proportion of these should be capable of handling the features included in the standards for direct broadcasting by satellite, where appropriate with any necessary transcoding)
- audio channels
- at least one return video channel, with an associated sound capability, which may be used for a range of services
- two-way data channels, some of which should have a signalling rate of 80kbit/s.

In the case of the latter two services the Department would wish the working group to produce standards that allow for a number of subscribers to have simultaneous access to those two-way services including viewphone.

The working group is asked to produce drafts of the appropriate standards on or about 1 March 1983 in such a form, using the guidance of BS0:1981 wherever possible, that the British Standards Institution may issue them for public consultation. An interim progress report should be submitted by 1 October, 1982" up a new company called Thorn EMI Cable Television Services to coordinate their various interests in c.tv. These interests include receiver and decoder design, the preparation of programme material and studio equipment. Operating experience from Radio Rentals Cable Television, who are currently managing services in Swindon and Medway, will also be used by CTS.

BT and its unions are opposed to the fast turnover, low-bandwidth approach and would rather that the UK embarked on a long-term project to provide a high-bandwidth national network with the potential to supply demands well into the future. There is a chance that independent and incompatible services could be dotted about the country if a free-for-all is allowed. BT has the experience and resources to lay such a network but their role in cable tv is not yet clear.

Whether cheap hybrid systems may be applied in the UK hangs on requirements yet to be decided. A pending government White Paper discussing legislation to enable cable tv authorities to be set up, franchises, etc., in response to the Hunt report and results of the Eden inquiry due early in March are important factors. The Eden inquiry, which will be presented to BSI, will include draft technical specifications for the type of service to be provided (see Wideband cable systems).

An attractive system is only the first hurdle – given the organ, providers must offer a viable service. UK trials have shown that American material can be very expensive and feature-film channels could run into difficulties as under 150 English-language films are produced each year (excluding Indian films). Rediffusion's Starview film-channel service (see News, November 1981) covers a potential 56 000 viewers in five towns but according to recent figures only 9 000 of these have subscribed. In Hull, 22% of the potential audience use Starview whereas in Reading, only 6% have taken the service (these figures represent the highest and lowest percentages for the five towns).

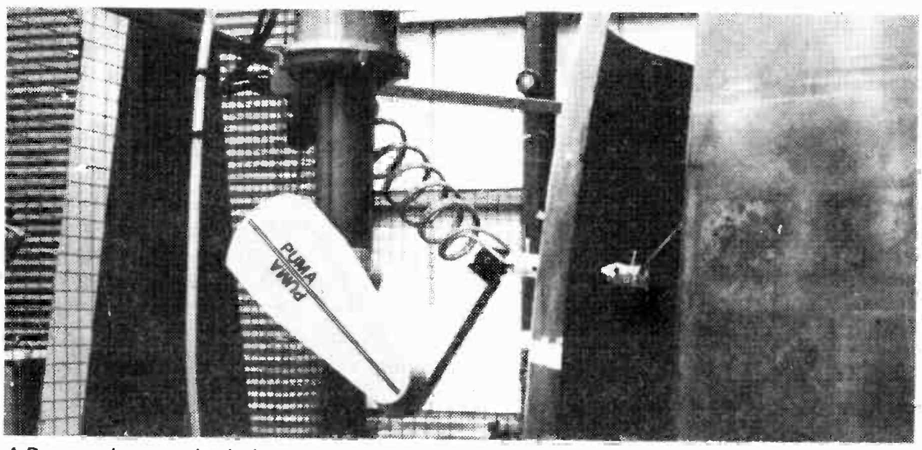
# UK robot plant expands

A UK company is to develop a new robot and supply western Europe with its parent company's existing range as a result of a jointly funded £10m investment plan. Creating more than 250 jobs, Kenneth Baker, Minister for Information Technology, said that the project "clearly gives the lie to any belief that robots simply take away jobs". The company concerned, Unimation Ltd, and its US parent are to provide £6.5m towards the investment and financial support from the British Technology Group and the DoI yet to be finalised is expected to provide the remainder.

Announcing the plans, Mr Baker said: "The Unimation project is a major step forward in the government's policy of encouraging the establishment of Britain as a major robot supplier . . . the adoption of robots and other advanced manufacturing technology is not only vital to maintain our competitiveness in world markets and hence safeguard existing jobs, it can create new ones as well." Unimation's European base in Telford currently employs around 120 people.

Part of the investment will be used to set up a systems engineering division to tailor robots for use in applications other than assembly tasks in the automotive industry which are currently their mainstay.

● Thorn EMI are to manufacture a range of large-screen colour tv sets for JVC at their Enfield and Gosport plants but as the sets are constructed by robots, new jobs are not likely to be created by the planned deal in the near future. Five Thorn sets from 20 to 26in will extend JVC's colour tv range to ten sizes, starting at 6in. Production is expected to start in mid-1983.




*A Puma robot manipulating transmitting and receiving probes for ultrasonic inspection of carbon-fibre aircraft components.*

# Charity buys school micros

A comprehensive school with 1 500 pupils has been given a £16 000 microcomputer grant as a result of a report submitted to a local charity. The report, written by the school's computer development advisory committee, recommended a computer classroom with at least one computer between two pupils. Parents and teachers of the school formed the committee which includes members from Lanchester Polytechnic and Warwick University.

As a result of the committee's concerted efforts and the Edwards Kenilworth School Charity's awareness of the problems facing pupils and teachers, the school now has 27 computers. This is the first donation of its kind made by the charity, which covers all schools in the area.

The grant has funded a 14-unit Nascom computer network, but the school also has 380Z, BBC and ZX80 computers. When asked why such a variety of machines were bought, computer studies teacher Bill Nash replied, "To give the pupils a truer picture of the world of microcomputers." Between one and three pupils in each class have their own microcomputer.

Mr Nash said that during the school's evaluation of computers for use in the network, Acorn Computers were not very helpful. He added that contrary to claims made for them, some of the computers looked at didn't have a true networking facility. Lucas Logic, manufacturers of the Nascom, are based in the area.

"To be fully equipped," concludes Mr Nash, "we need another 15 computers to construct a computer-aided learning laboratory" – and they have been lucky.

# More money for fibre development

Under a joint opto-electronic research scheme set up by the DoI and Science and Engineering Research Council, £15m will be available to support collaborative research projects between industry and universities. Project work will be shared equally between the partners, companies receiving up to 50% grants from the DoI and universities receiving up to 100% SERC awards. The joint opto-electronics research scheme is expected to run for five years.

The DoI also announce a £15m boost to the £25m set aside in 1981 under the fibre-optic scheme, £20m of which has already been used for grants covering up to a third of the costs involved in designing, developing and launching new fibre-optic products, including equipment and new building expenses.

## Satellite to observe Halley

European Space Agency and British Aerospace have designed a £34m contract for the Giotto spacecraft, Europe's first deep space probe, which is to intercept Halley's comet eight months after its launch scheduled for July 1985. Russian and Japanese satellites will also observe Halley but Giotto will carry the most advanced instrumentation and pass closest to the comet. Instruments will investigate the chemical composition of the comet's coma region, take colour photographs of the nucleus and measure magnetic fields.


One of the earliest known illustrations of Halley's comet is from the Bayeux tapestry depicting events leading up to the Battle of Hastings, and the battle itself. This section of the tapestry was sent to us by Rainford Racks who are to supply ground-station equipment for the Giotto project.

## Mac overseas

On January 24-25, tv pictures with multichannel sound were sent via OTS to Stockholm in the first demonstration outside the UK of the IBA's Mac system for satellite-tv broadcasting. C-Mac's ability to provide eight sound channels will be of particular interest in Scandinavia due to the number of different languages spoken in countries likely to be covered by a Nordic direct-broadcast satellite service.

Apart from its acceptance by the BBC, Mac has had another recent boost in that it is to be used by a third US company. This latest patent-licensing agreement with the United States Satellite Broadcasting Corporation is the first to be concluded since the Part report.

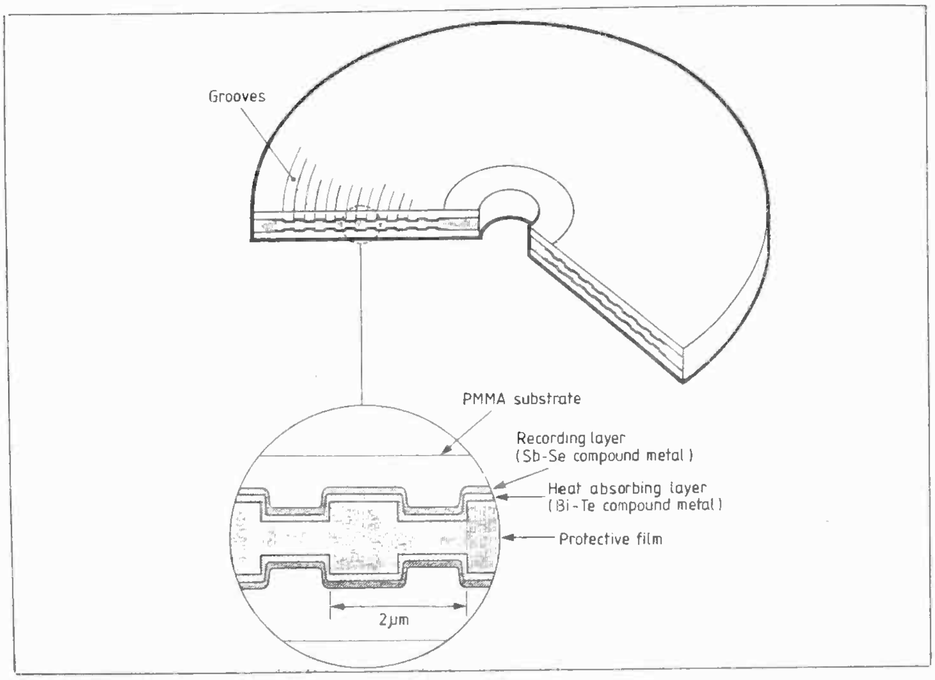
## Optical fibres sink

Britain's first undersea optical-fibre cable carrying telephone calls 25km across the Solent linking Portsmouth and Ryde is to be installed by 1985. BT say that the 140Mbit/s cable, supplied by STC, costs £600 000 and will carry "a variety of information technology services" as well as speech.

Negotiations between telecommunications authorities in the UK, Holland, Germany and Belgium for a European optical-fibre link are underway. An agreement is expected this year.

# 15Gbit recordable laser disc

Laser discs that can be used to record both analogue and digital signals at high densities have been developed by Sony. Densities of $15\times10^9$ bits per side on a 300mm-diameter disc are claimed for the prototype system and although this achievement represents a significant step towards the optical equivalent of magnetic media, the last hurdle – that of disc erasure – is yet to be crossed. But because of its high recording density Sony's disc is likely to be attractive, especially in archiving applications.




Each disc surface has two layers evaporated onto it. When recording, a modulated laser beam of less than 7mW changes 'bits' of the upper recording surface from an amorphous to a crystalline state. Areas heated to 170° by the beam have three times the reflectivity of the untouched amorphous areas, and information on the disc represented by the reflectivity of crystalline and amorphous areas is read in the same way as a conventional optical video disc. The recording layer is a film of antimony-selenide.

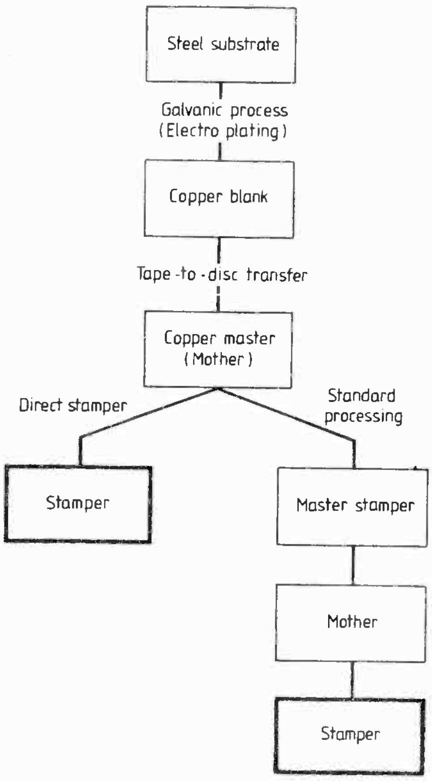
A second layer of bismuth-telluride underneath the recording layer provides a reflective surface behind crystalline areas to increase the difference between reflective and non-reflective areas, but more important it absorbs heat from the laser during recording to increase the definition of transitions between amorphous and crystalline areas. This means that the lengths of reflective and non-reflective areas can be accurately defined, facilitating analogue recording.

# Mastering metals for mothers

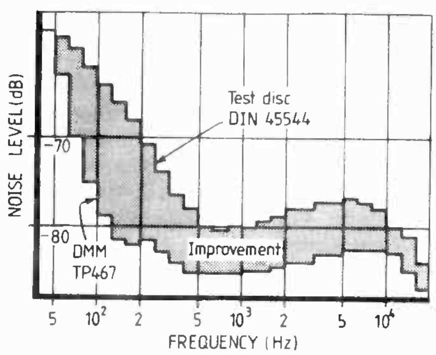
A licensing agreement to manufacture records using a metal mastering process has been signed by EMI Music, holding company for EMIs international record interests. The new process eliminates several steps in the record-making chain, allowing a record master to be cut directly into copper thus producing a positive-image "mother". Direct metal-mastered records, which will carry a DMM logo, cost no more than normal pressings but can be made in about two hours as opposed to about a day with conventional discs. Audibly, the new discs claim to virtually eliminate surface clicks and pops, increase signal-to-noise ratio by up to 10dB, allow up to 15% more playing time per side, and eliminate the pre and post-echo associated with lacquer springback.

There are well-known difficulties with traditional nitro-cellulose lacquer blanks. Though it is ideal for cutting it is an unstable material in that it changes with both climatic conditions and time. It is also adversly affected by stylus heat and by burnishing facets, both of which are important for good groove-wall structure. There are problems of groove tearing, horn formation and of plastic deformation in the lacquer material, which results in the well-known phenomenon of springback of the engraved groove (both time and temperature dependant). Then there are severe demands placed on the next step – nickel pre-plating onto a silver conductive coating. It must be extremely thin, its metallurgical structure fine-grained, and it must not contain impurities. The cleaning process should not attack the lacquer surface and the activation or sensitizing process must produce even deposition of silver atoms.

According to its developers, Teldec in Berlin, the new process eliminates all three problems by circumventing those steps.




*In contrast to lacquer masters, numerous matrices can be produced from a direct metal master, permitting easy correction of defects which may appear in the plating steps en route to the stamper. Process gives a significant time economy in the plating process, especially when making a stamper directly.*




*Teldec curves show that new direct metal mastering audibly reduces background noise (measured by third-octave filter). Reference level measurement corresponded to a recorded velocity of 10cm/s for one groove wall. Curve A shows the background noise of rumble test record DIN 45544, and B shows the same measurement with the DMM record TP467.*

First proposed over 90 years ago and recently revived by RCA for capacitance video discs (see page 39, September 1981), the direct cutting into metal means that the cutting lathe produces the mother (metal positive) for the plating process. But the demands on the video disc manufacturing process were small by comparison, as indeed are the groove dimensions: depth is 1μm and width 2μm (not 2mm as misprinted in that article), with a modulation depth of only tens of nanometres.

But the electrolytically-produced copper coating is not readily applicable to conventional records. As the cross-section of the groove is 100 times larger than that cut from videodiscs its ductility and elasticity must be right; the copper coating needs an amorphous rather than the crystalline structure of pure electrolytic copper. Equipment for producing the copper blank developed in conjuction with Europafilm of Sweden deposits the copper onto the 0.8mm-thick stainless steel substrate, and may be immediately used when cut as the mother in the plating process.

This metal cutting blank provides a higher resistance to the cutting stylus than does the traditional lacquer blank. To reduce cutting resistance three measures have been applied. Unusually, the diamond cutting stylus has no burnishing facets. This means that the innermost turns of the groove show no amplitude losses, even when cutting at the highest frequencies. Secondly, the face angle of the diamond stylus is greater than 90°. The sum of the face and stylus angles is chosen so that for the maximum groove excursion there still remains sufficient space between the groove walls and the back of the stylus. And thirdly, the cutting stylus is excited at an ultrasonic frequency whose amplitude increases with increasing groove depth, where cutting resistance is greater. This results in an extremely smooth groove wall and keeps the mechanical loading of the cutterhead – a Neumann SX80CM – and the resulting electrical power demand within reason.

Experience up till now has shown that the stampers from the new masters are "entirely free" of ticks and pops and the surface noise is diminished more than 10 dB, against a mother made from lacquer blank. For carefully pressed records, this can extend all the way to the final product. Background noise of the final disc shows fewer impulse-type disturbances compared to traditionally produced l.ps, and Teldec say unwanted high frequency components are significantly reduced.

The elimination of lacquer springback eliminates pre and post-groove echo. It is therefore possible to reduce the groove-to-groove spacing and to fully utilize pitch control methods. With the Neumann VMS80 tape-to-disc transfer system the result is 10 to 15% more playing time per record side. Elimination of groove deformation during or after the cutting process has provided A/B comparisons between discs cut in lacquer and the new masters which show improved transient behaviour, and Teldec say that instruments rich in upper harmonics and sibilant voices are particularly free of coloration.

Initial manufacturing experience has confirmed Teldec's original assumption – that manufacturing reliability will be much higher than through the use of traditional technology. After conversion to the new process the number of recuts necessitated either in the cutting or plating process were reduced "drastically."

But despite this, and significant savings in the plating process particularly for short-run classical recordings, the price of DMM records will not be lower, though an EMI spokesman did concede that some increases may be circumvented. According to the BPI, manufacturing costs are but a small fraction of the selling price of records, typically 38 pence in £4.39, and the new process will only bring about small savings in that fraction. EMI say they will introduce the process in its Köln pressing plant in about six months time, and in its other main plants by early 1984. Until then EMI's initial releases will be pressed by Teldec in Germany.

# CIRCUIT IDEAS

## Floppy-disc drive tester

All major functions on a standard 5¼in mini-floppy disc drive are tested by this circuit without the aid of a computer. Using the box with an alignment disc allows the read/write head to be accurately aligned with the disc. As the connections on the drives shown are standard, logic signals and power come out on two plugs. There are four inputs to the box from the drive,

- write protect (WP)
- track 0 (TR00)
- index, signal showing each revolution of drive
- read data, data output from disc.

Inputs simply light leds through cmos buffers to show conditions of the various signals. Outputs from the test unit to the drive are almost all switch closures,

- drive selects, $DS_1$, $DS_2$ and $DS_3$, set up code to select drive unit
- motor, switches on drive motor
- direction, selects step in or step out of read/write head
- step, pulse that steps head in our out (depending upon condition of direction signal)
- write gate, low for write enable, high for read enable
- write data, does not write any useful data to the drive but produces a digital pulse train used for tracing through disc circuitry.

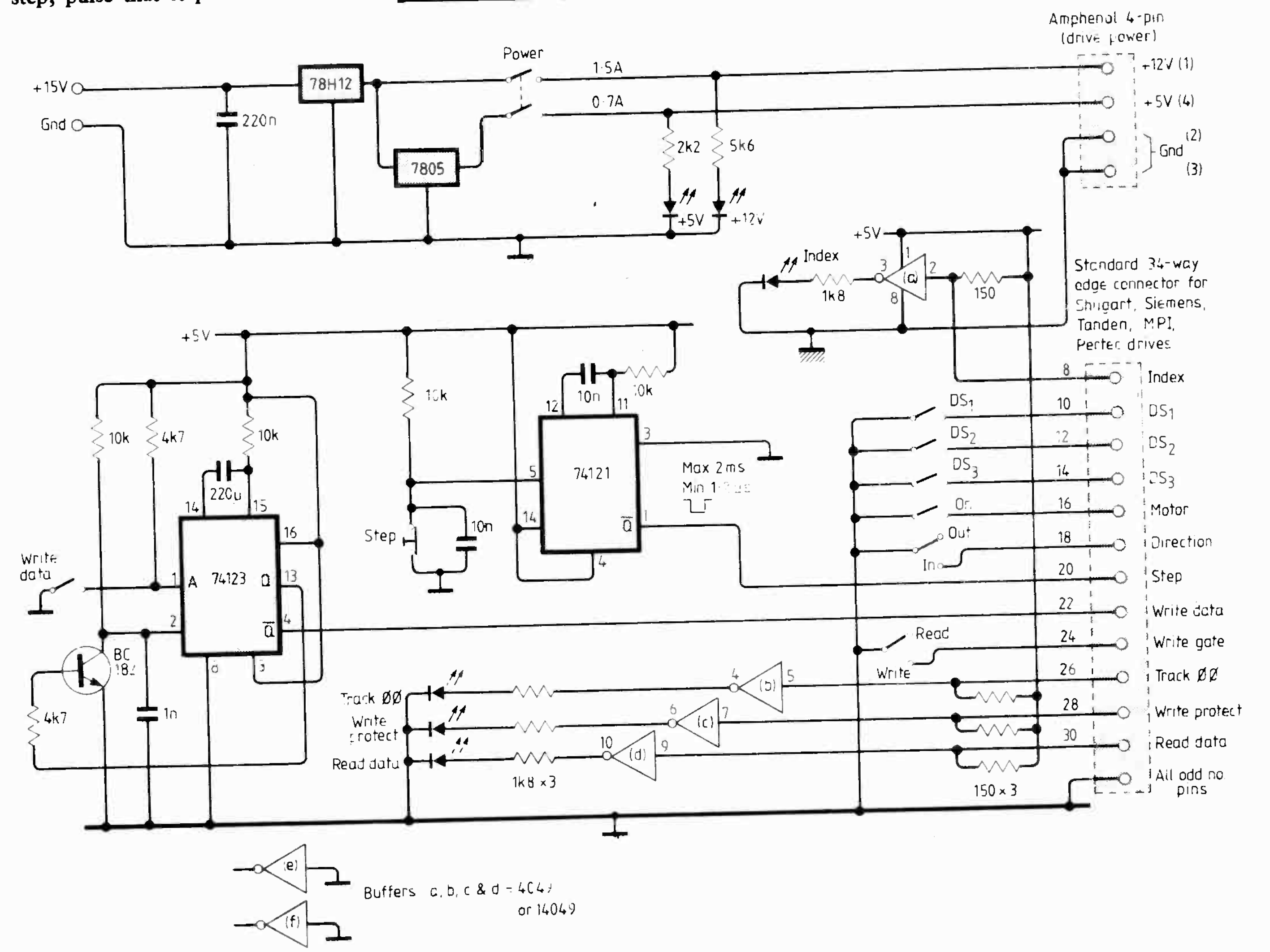
S. J. Evans
Cradley Heath
West Midlands

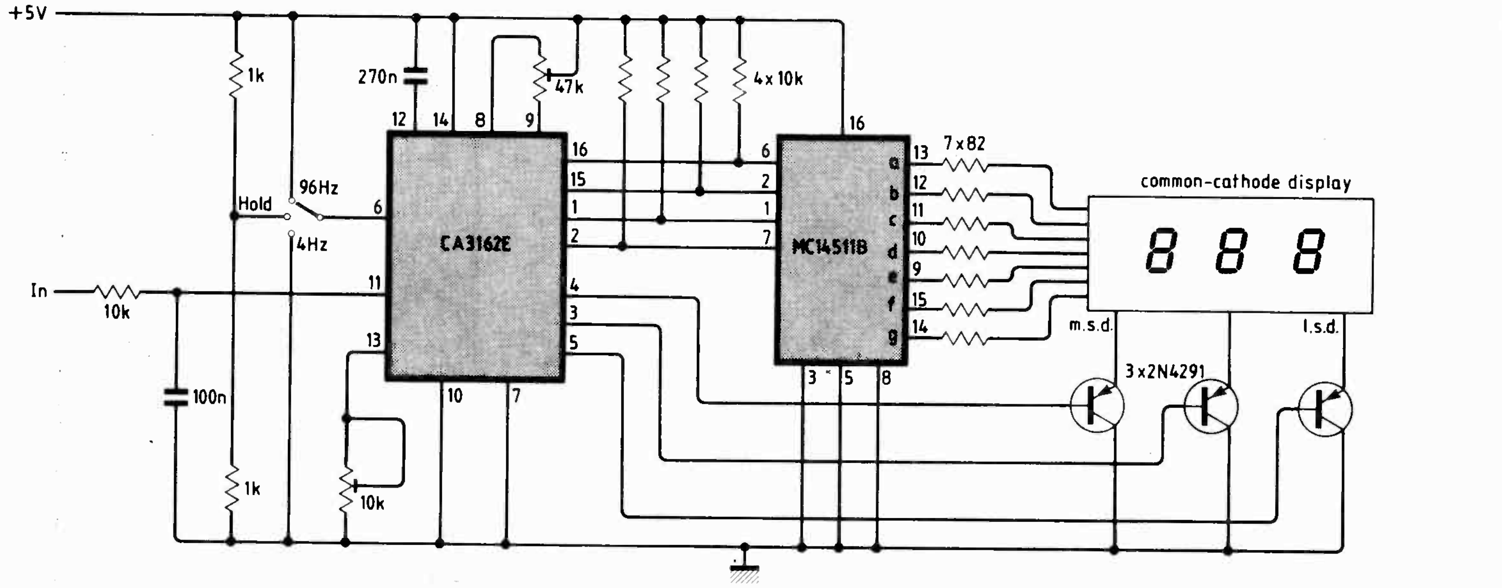
## Low-cost 3-digit common-cathode d.v.m.

The three-digit common-anode d.v.m. based on CA3162E & CA3161E integrated circuits from RCA is well known; the CA3162E is a multiplexed a-d converter, and the CA3161E is a simple b.c.d.-to-seven-segment common-anode display decoder/driver, with integral segment-current limiters. For a d.v.m. with common-cathode display (like most of pocket calculator led displays), you can't use the CA3161E; it must be substituted by another display decoder/driver i.c. The MC14511B is a cmos b.c.d.-to-seven-segment common-cathode display decoder/driver, but without segment-current limiters that must be added externally. A 10kΩ pull-up resistor must be added to each 14511 b.c.d. input to operate correctly with the CA3162E.

The switch selects the sample rate. In the 4Hz position (pin 6 to ground) a sample is taken every 0.25 second; in the 96Hz position (pin 6 to +5 V) a sample is taken every 0.01 second (approximately); and in the hold position (pin 6 to +2.5 V) the display is frozen.

Calibration should be as follows. Firstly, connect the input to ground. The 47kΩ preset potentiometer is then adjusted so that the display reads 000. Now, an accurate known voltage of, for example, 800 mV is connected to the input, after which the 10kΩ preset potentiometer is adjusted to give the correct display of 800. The range is −99 to +999 mV. However, the





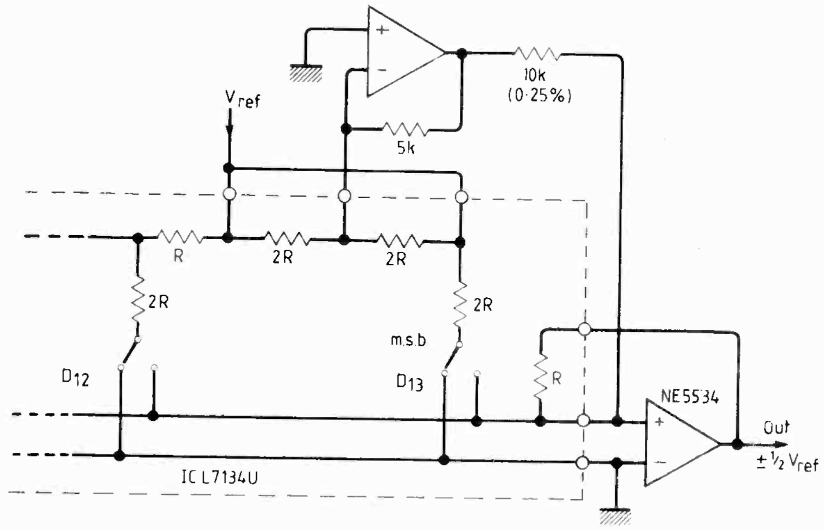

MC14511B is not able to display the "–" (minus) and the "E" (overload) characters. With negative input signals the most significant digit will be blanked, and with overrange input signals all digits will be blanked.

Francisco J. Herrero
Soria
Spain

## Improving the 7134 d-to-a for audio use

The Intersil 7134 14-bit d-to-a converter is designed for a unipolar, +10V, or bipolar, ±10V, output range depending on whether the m.s.b. of its R-2R ladder is fed from $V_{ref}$ directly or through an inverter. It provides two resistors for use with an external inverter and the 7134B is programmed to correct for any error in the resistor ratio. Unfortunately an offset voltage at either of the op-amps causes an abrupt step at zero crossover, just where it matters most for many digital audio applications, and maintaining 14-bit linearity requires offsets below 100μV. A more satisfactory way of obtaining bipolar operation is to use the 7134U and offset the output by $-\frac{1}{2}V_{ref}$. Normally this would require a second op-amp in the signal path, but the internal resistor values turn out to be exactly 2R. Used with an op-amp as shown they provide an offset current which accurately matches the internal feedback resistor in value and temperature coefficient. Offset voltages on either op-amp now result in only d.c. shift, with no effect on linearity.

P. J. Skirrow
Lindos Electronics
Woodbridge
Suffolk

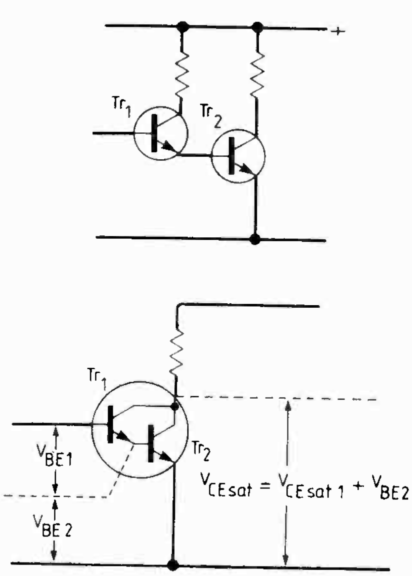


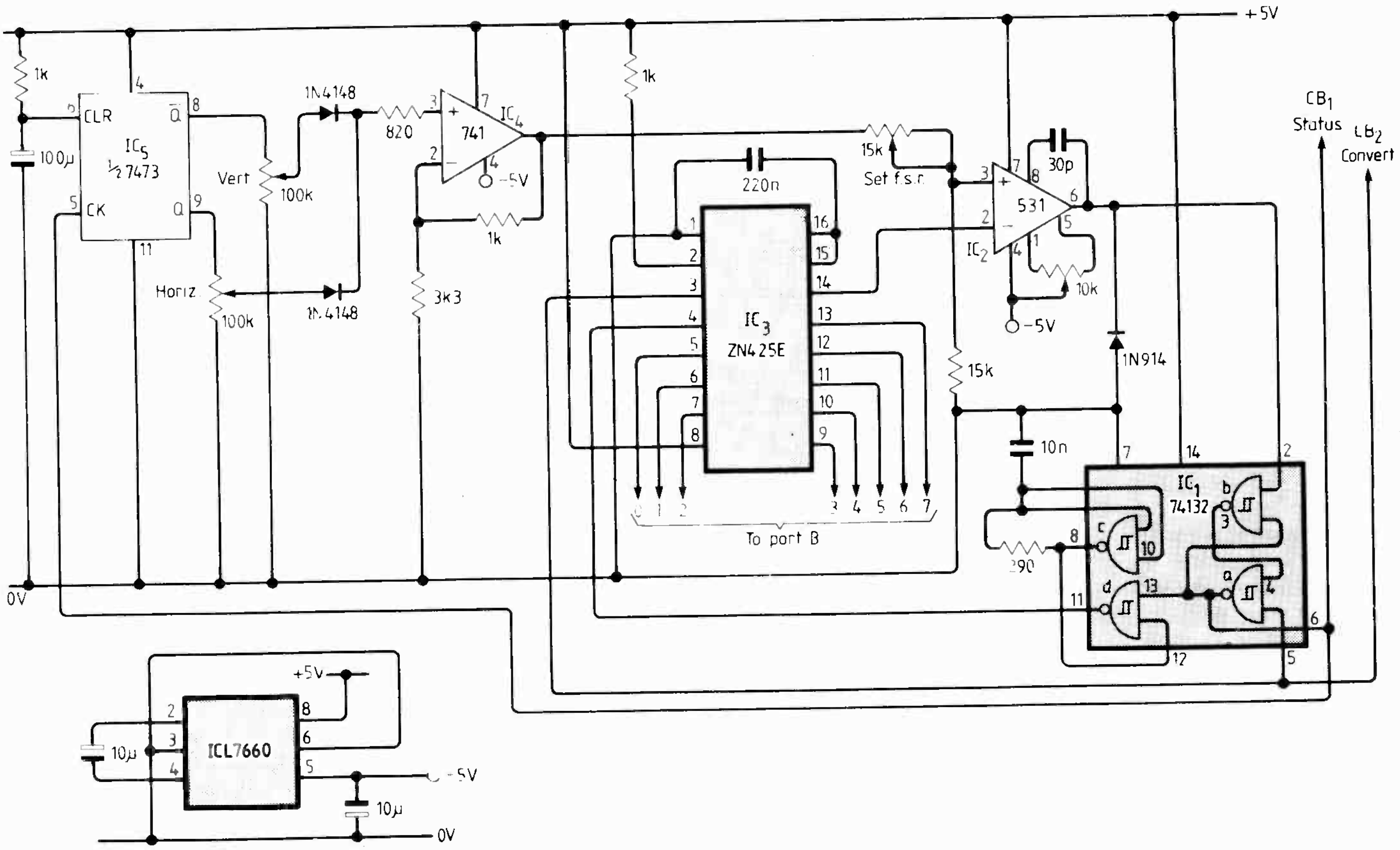

## Darlington difficulty

The Darlington transistor configuration has proved its worth in many designs but budding engineers can be caught out by overlooking one of its basic parameters – no matter how hard the first transistor of the pair is driven, $V_{CEsat}$ will never be less than 0.7 volt ($V_{CEsat1}+V_{BE2}$), important when the Darlington is used to turn off transistors in logic circuits or as a power switch.

Extra power consumed by the device because of the voltage drop is also often overlooked. For example, a 600mW device would be working close to its maximum dissipation rating with a collector current of only 800mA. Both problems are overcome by using separate transistors.

D. Gray
Todley
Hants






# Joystick interface

Conventional joysticks use either two expensive a-to-d converters with three-state outputs and good resolution in microseconds or include cheaper, slower converters with limited resolution. This interface offers the best of both designs with 500µs conversion time: if speed is important, a ZN427E a-to-d converter may be used. The circuit shown uses port B of a 6522 v.i.a. with $CB_1$ and $CB_2$ acting as input and output lines respectively. But any p.i.a. or v.i.a. with more than nine inputs and one output may be used.

On power up the clear input of $IC_5$ is held low for around 100ms to give Q=0 and $\bar{Q}=1$ so there is no potential drop across the horizontal-axis potentiometer and the non-inverting input of $IC_4$ represents the vertical potentiometer position. Diodes connected in series with the potentiometer wipers block the ground path.

To start conversion, $CB_2$ is pulsed to 0V. The falling edge of this pulse sets the counter of $IC_3$ to zero and sets the status line ($CB_1$) and the output of $IC_2$ high while the rising edge starts the clock, $IC_{1c}$, which runs at around 200kHz. When the output of $IC_3$ exceeds the output of 1.3-gain buffer, $IC_4$, the output of $IC_2$ returns to zero and through gating by $IC_{1a,b,d}$, clock pulses to $IC_3$ are inhibited and the status line returns to zero. The digital output of $IC_3$ now represents the vertical-potentiometer position.

When the clock input of $IC_5$ receives a falling edge from the status line, the i.c. outputs change to Q=1 and $\bar{Q}=0$. Now, triggering the a-to-d will result in conversion of the horizontal potentiometer representation at the output of $IC_4$ to digital form and $IC_5$ reverting to its original state. Thus the same routine used twice gives x and y coordinates of the joystick.

The Atom-Basic list shown reads and displays the control settings but machine code will probably be required in practice. For other computers, v.i.a. base address B800 will need changing. Query operator, ?, achieves peek or poke depending on its context. Program actions are

| Line | Action |
|---|---|
| 5 | set B port as 8 input lines |
| 10-40 | control loop |
| 150 | set and reset converter (B80C is PCR controlling $CB_2$ through bit 5; set=224, reset=192) |
| 160 | loop until $CB_1$ is low (B80D is interrupt flag register; bit 4 indicates negative transition on $CB_1$; other bits are zero and bit 4 set to zero when B port is read. |
| 170 | return to control loop |

If the microcomputer only has a positive supply, the 7660 circuit may be added to provide −5V for $IC_{2,4}$.

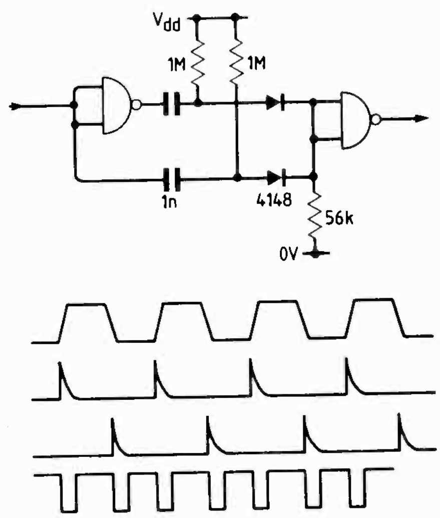
D. C. Grindrod
Sutton Coldfield
West Midlands

```
  5 ?#B802=0
 10 DO
 20 GOS.150;X=?#B800;
    GOS.150;X=?#B800
 30 PRINT X,Y
 40 UNTIL 0
150 ?#B80C=192; ?#B80C=224
160 DO; UNTIL?#B80D>0
170 RETURN
```

# Simple clock doubler

I have used this frequency doubler on numerous occasions to generate high rate clock pulses around spare gates/inverters left on circuits.

D. J. Greenland
Bar Hill
Cambridge



# Some problems of aerials at sea

*Many marine radio installations are far from competently carried out. More photographic evidence is presented*

**by J. J. Wiseman**

In the September 1982 issue of *WW* I discussed the merits of a variety of merchant ship transmitting aerials from a theoretical point of view. In this article, I propose to show some of the problems which have been experienced with a fairly typical aerial installation and the transmitters which it serves, adding a word, wherever possible, on what might be done to bring about improvement. Most of the equipment depicted dates from the late 1960s – early 1970s, but this is what hundreds of ships at sea still depend on. There is no reason to believe that more recently manufactured installations, with all their ics and digital readouts, work any better.

The two aerials in question are shown in Fig 1. The 'main' aerial is a popular mast or cage type, widely used on ships of many nationalities. Height from base to tip of the whip is 16.2 metres; height from base to top of the cage is 10.5 metres; and nominal capacity is 400 pF. The central support is a hollow, tapered, tube of glass fibre, which deteriorates with age, especially out-of-doors, the surface becoming crazed as water seeps in. The other aerial (reserve) is a rather short piece wire of the "It'll be all right if it ends in a whip" school. Its capacity I estimate as less than 100 pF, and its usefulness as 'emergency' aerial as doubtful – it is *far too short* and the two aerials are so close together that any catastrophe befalling one of them is likely to damage the other as well. Note how both these aerials are raked, indicative of shipbuilders' obsession with style over function. Figures 2 and 3 show the feedthrough arrangements for mast and wire aerials respectively.

**First problem:**
The main transmitter, (Fig 4), delivers 400 watts on 500 kHz and 6 other frequencies in the band 410/512 kHz. It has ample tank-circuit loading/tuning adjustment and can put 10A up the mast aerial, still delivering 2 to 5A in wet and humid weather. Radiated power under these conditions may be down to 50 watts, still quite useful and not unusual. However, in hot dry climates, less than half maximum power can be realised due to severe arcing to ground in the aerial switching unit, in Fig 5. This indicates insufficient aerial capacity: if that cannot be increased, then it is still possible to distribute tank-circuit inductance between transmitter and aerial by means of loading coils in the aerial,

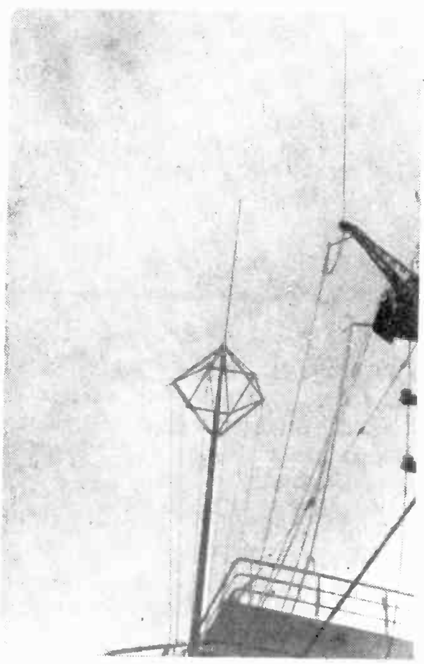


*Fig. 1. Popular mast or cage aerial.*

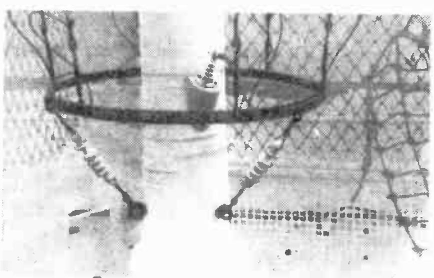


*Fig. 2. The base of the fibre-glass supporting pole of the mast aerial is also the feed-through insulator. The ring at the bottom is a rain-cone.*

*Fig. 3. Feed through insulator of emergency aerial.*

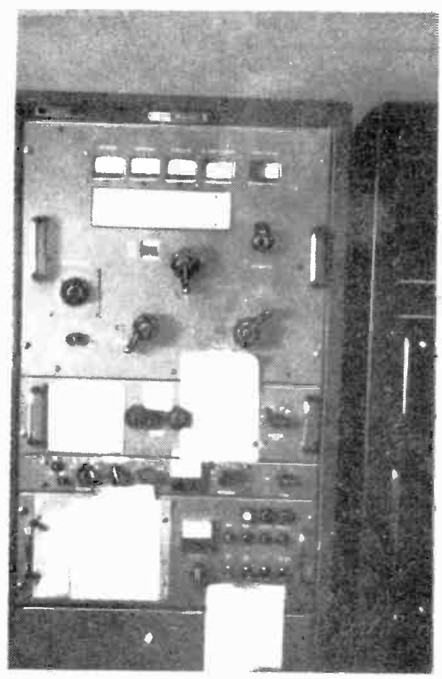


*Fig. 4. The main transmitter.*

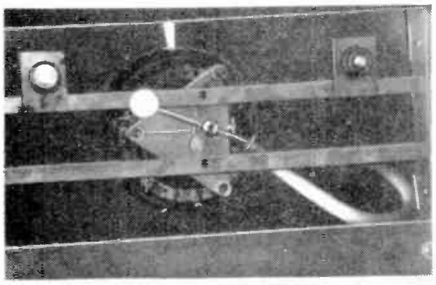


*Fig. 5. Arcing from frame to switch interconnecting wire, top centre. The round objects, left and right hand sides, are neon bulbs.*

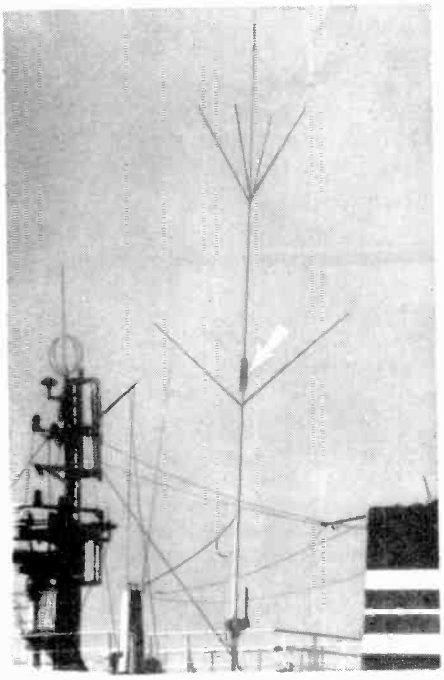


*Fig. 6. German mast aerial with loading coil.*

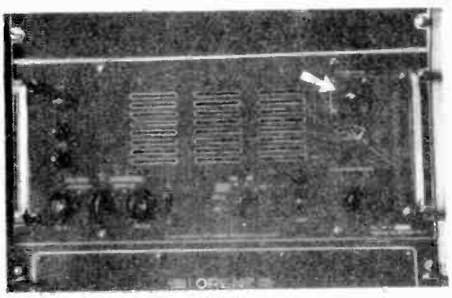


*Fig. 7. 70 Watt emergency transmitter.*

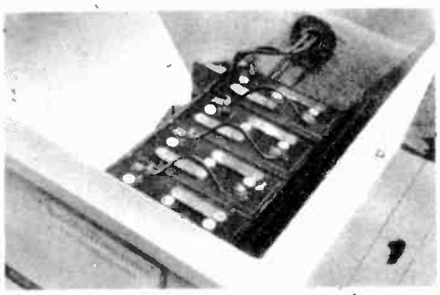


*Fig. 8. The emergency radio batteries.*

*Fig. 9. (1) P.a. valve (2) Coupling adjustment (3) Neon tuning indicator.*

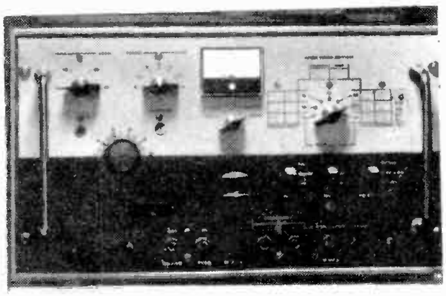


*Fig. 10. Emergency transmitter with much better facilities.*

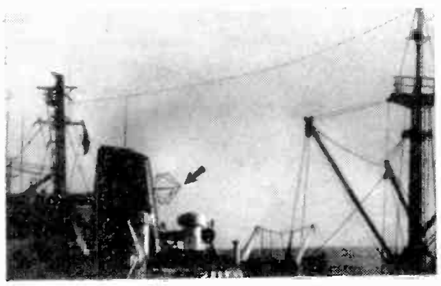


*Fig. 11. British Flag, 6925 g.r.t, Built 1974. Photographed in Gulf of Aqaba, October 1982. Mast aerial struck by lightning.*

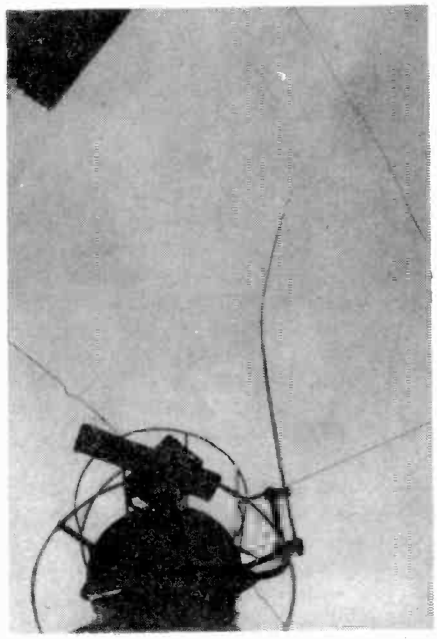


*Fig. 12. British Flag. B.1974. Short receiving whip, long co-ax., no impedance matching transformer.*

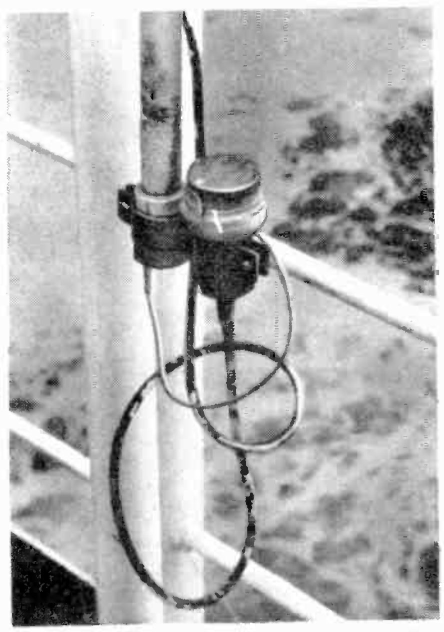


*Fig. 13. Matching transformer on receiving whip greatly improves 500 khz reception.*

shown in Fig 6. (Some old ships actually *had* large loading coils built into the rack – never seen these days.) The same transmitter delivers up to 1400 watts h.f., but no arcing problems occur; aerial capacity is always very large by the requirements of h.f. tuned circuits, or the aerial is operating in other modes, near 0.25 wavelength or multiples thereof. This is exclusively a 500 kHz problem – power radiated is critically dependent on the weather. Is it an aerial or a barometer?

## Second problem

The reserve or 'emergency' transmitter in Fig. 7 delivers a nominal 70 watts, at 500 kHz and six other frequencies in the band 410/512 kHz only. It is powered, via a rotary converter, from the bank of batteries giving 24V, 180A seen in Fig. 8, and is all one has to depend on if the main transmitter or the power mains fail. It lacks: external coupling adjustment; overload trip; power reduction switch; metering of any kind; external h.t. fuse. The panel has a meter-shaped hole cut in it (arrowed), but this is occupied by a neon bulb capacitively coupled to the tank coil by means of a piece of stiff wire close to the coil. This is the only tuning indicator provided. Internal adjustment of coupling is available (Fig. 9). The 70 watts is squeezed out of a very small valve seen at the bottom l.h. corner of the photograph. If the weather is even slightly humid, the neon bulb *fails to light*. Then the only means of tuning available is to listen for an increase of signal strength in the receiver. Since only a vague and shallow dip is obtained, and there is no overload trip or power reduction, the anode of the very small valve glows red-hot, threatening self destruction. When the ship is pitching, listing, sinking, or on fire, that is *not* a good time to be pulling the transmitter out of the rack, screw-driver in hand, fiddling with the internal coupling, which in any case proves quite inadequate when the Q of the tank circuit is at the mercy of the vagaries of the weather.

This equipment has been Post Office approved in its country of origin, and surveyed and passed, year after year. This being 'Holy Writ', it is useless to com-plain, because, "It passed survey". To those who claim that you can 'burn off' moisture on aerial insulators by holding the key down, I would point out that: there has to be enough energy available to vaporise a lot of water, and there isn't; if the key is held down, the p.a. valve will melt! (just as well the p.a. isn't transistorized!); the dielectric properties of humid air seem to play a part. No output or dip whatsoever can be obtained with the "reserve" aerial connected during wet or humid weather.

A far better emergency transmitter is shown in Fig 10. It has: ample tank tuning/coupling adjustment; metering of five functions, including aerial current and p.a. cathode current; overload trip; four very robust valves in parallel in the p.a. stage, the drive and power supply being all transistorized; power reduction switch; numbered controls, which, in conjunction with the instruction card enable the transmitter to be put into operation by unskilled personnel in an emergency, and automatically to key an alarm signal and distress call. But still, a too-short, low-capacity, high-leakage aerial and severe weather, *even this* has been known to fail. The aerial is all important. An h.f. capability for emergency transmitters would be very useful.

### Third problem

This is the ultimate problem. The mast aerial of this British ship has been struck by lightning, and it is laying on deck with its whip tip burned right off. A traditional long wire aerial has had to be rigged. The aerial switching unit was also destroyed. Benjamin Franklin would not have been surprised.

### Fourth problem

This concerns receiving aerials. The whip aerial (Fig. 12) is quite short and is mounted next to the radar scanner, where it is likely to pick up noise from the modulator pulses and scanner motor commutator. It has a very long run of coax. and no impedance matching is attempted, so that signals at 500 kHz are very much attenuated. (There is a naive belief in shipyards that coax. is a magical electrical 'water pipe'.) If the aerial is mounted near the bow to isolate it from the transmitting aerials, then a short receiving whip may have an unmatched coax. run exceeding 100 metres. Inefficient transmitting aerials *plus* inefficient receiving aerials makes for poor communication at 500 kHz. Figure 3 shows a simple matching transformer on a 500 kHz Auto-Alarm receiving whip. Broad-band transformers are available, but seldom seen.

A more professional approach to design of ships' radio installations will be needed if the unique properties of 500 kHz as a marine distress frequency are to be realised fully. WW

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*continued from page 32*

$=(1+s\tau)\bar{E}_{out}$. In use, the gain A is adjusted to give the fastest response without overshoot, i.e. the circuit is critically damped. Hence the denominator of the above expression can be factored to give a squared term:

$$\bar{E}_{out}=\frac{E}{s(\alpha s+1)^2}$$

where $\alpha=\tau R(C+C_f)$. The inverse transform from standard tables is

$$E_{out}=E\{1-(1+t/\alpha)\exp(-t/\alpha)\}$$

The rise time of this function is governed by the value of $\alpha$(it can be found graphic ally to be approximately $3.4\alpha$). The rise time of the original input circuit is 2.2RC. Comparison of the two values shows that for the greatest improvement by neutralization $C_f$ should not be unduly large, and the amplifier time constant $\tau$ should be as small as possible. WW

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3. Thomas, M. V. Microelectrode amplifier with improved method of input-capitance neutralisation. *Med. & Biol. Eng. & Comput.*, vol. 15, pp. 450-454, 1977.


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what one would expect.

It appears that after the switch was closed, some electromagnetic energy must have started off to the *left*, *away* from the now closed switch; bounced off the open circuit at A, and then returned all the way back to the switch B and beyond.

This paradox, that when the switches are closed, electromagnetic energy promptly rushes *away* from the path suddenly made available, is understandable if one postulates that a steady charged capacitor AB is not steady at all; it contains electromagnetic energy, half of it travelling to the right at the speed of light, and the other half travelling to the left at the speed of light.

Now it becomes obvious that when the switches are closed, the rightwards travelling electromagnetic energy will exit down BC first, immediately followed by the leftwards travelling electromagnetic energy after it has bounced off the open circuit at A. Even before the switches were closed, every segment of electric field had coexisting with it a segment of magnetic field at right angles, and both were travelling together at the speed of light.

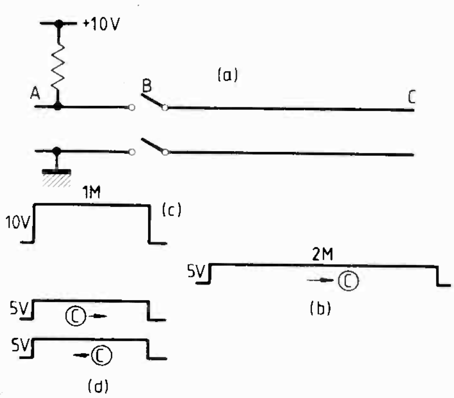



**Fig 3.** *Pulse generator (a). Changing AB to 10V and closing switches produces 5V pulse twice as long as AB (c) and (d), caused by left and right travelling pulses following down line BC.*

What is true of a 'steady' charged capacitor or coax. cable is also true of a pair of wires connected to the battery. Before closure of the switches, electromagnetic (not electric) energy was oscillating to and fro between battery and switches. Since the same amount travelled in both directions, the magnetic fields being equal and opposite cancelled, and only an electric field could be detected. 'Waves in space' existed between these two wires long before the switches were closed and before the capacitor came into the picture. WW

**The author**

*In 1953, at the age of 17, Ivor Catt won a State Scholarship in mathematics. In 1959 he gained a B.A. in engineering at Trinity College, Cambridge. He is married with four children ranging in age from 22 down to 1.*

*Ivor Catt's 25 year career has been mostly in R&D in industry but partly in teaching. His field of experience is centred on computer hardware design, for instance at Ferranti (now I.C.L.) Manchester, and on microelectronics, for instance at Motorola, Phoenix, Arizona.*

*Catt's second field of research, which resulted from his experience spanning both microelectronics and computer hardware, led to his patented inventions in Wafer Scale Integration and computer architecture, described in the July 1981* Wireless World.

# COMMUNICATIONS

## A.m. stereo standards

The difficulties of obtaining international or European agreement on broadcast transmission standards are well-known, but they begin to pale into insignificance beside the dog-fight in the USA over which system to use for a.m. stereo broadcasting on the medium-wave band. Following several years of technical investigations and field trials, the FCC decided early in 1982 that the choice between six competing systems – Motorola "C-QUAM"; Magnavox AM-PM; Harris V-CPM; the Kahn/Hazeltine independent-sideband system; the Belar a.m.-f.m. system; and the Fisher DPC system – would have to be left to "the market place." This process is made infinitely more difficult by American anti-trust legislation which makes it impossible for any organization, or group of broadcasters or manufacturers to take responsibility for agreeing with others to adopt a particular system. Even in a city having half-a-dozen a.m. broadcast stations, each is expected to make up its own mind regardless of what the others intend to do. Since the systems are, at least to a considerable degree, non-compatible, this would create a situation where a listener might receive stereo from only one station.

The FCC technical assessment of the four systems, issued on March 18, 1982, generally appeared to favour the Harris system, particularly in view of the future use of synchronous-detector technology, stating: "Of the five proposed systems, the Harris is the only one which can make full use of this technology . . . and has the potential to evolve into an even better system."

Nevertheless in the FCC evaluation, the Magnavox system scored 76 points; Harris 72; Motorola 71; Kahn 65; and Belar 58, taking into account monophonic compatibility, interference characteristics, coverage, transmitter stereo performance and receiver stereo performance.

Since March 1982 there has been virtually a stalemate, with most broadcasters waiting for others to see which way the wind will blow. However, in December 1982 the Delco Electronics division of General Motors announced that it was recommending for GM cars the Motorola system. This system amplitude modulates two r.f. carriers that are separated in phase by 90°, but uses non-linear hard limiting to achieve a better degree of compatibility.

The Delco recommendation, because of the firm's prominence in the car radio industry, is seen as a major boost for the Motorola system. It followed bench and field tests carried at station WIRE, Indianapolis, on three of the four still contending systems: Motorola, Harris and Magnavox. Leonard Kahn, originator of the i.s.b. system, declined to participate. At NAB1982 he made it clear that he would be prepared to challenge in the courts any possible breach of the anti-trust legislation. It remains to be seen whether other radio manufacturers and broadcasters will jump on the Motorola bandwagon or whether the struggle between linear and non-linear systems will continue.

A "market place" choice may seem a good idea in theory. The buyer pays his money and takes his choice. But in a matter as complex as a stereo transmission system, where consumers are not even interested in such questions as coverage and interference, provided that they can hear the stations they want to hear with some sort of stereo effect, this is surely a curious way of choosing a system that may have to last the American public for many years to come.

## Places at risk

Communications and broadcasting installations have always been regarded as places at risk in the event of civil disobedience, revolutionary coups and the like. The first news of such happenings often emerges when a takeover brings strange new voices to the microphones. World War I was started by an assassination in Sarajevo but the first shots in World War 2 were fired when the Germans, using concentration camp prisoners dressed in Polish uniforms, staged a mock coup on one of their own radio stations close to the Polish frontier.

A story which is virtually unknown in the UK comes from a book published some years ago to mark 50 years of Japanese broadcasting, produced by the "History Compilation Room" of NHK's Radio and TV Culture Research Institute. In the period immediately following the Japanese surrender in August 1945 there were several attacks on broadcasting stations. For instance, on the morning of August 24, a group of former Japanese soldiers, under the cover of a severe rainstorm, attacked the Kawaguchi site of the main Tokyo transmitting station "trying to force the station officials to broadcast a message urging continuation of the war" (which had cost over three million Japanese lives). They interrupted the regular programmes for nine hours.

Two days later, a group of 40 former soldiers and what the book calls "rightists" attacked the Matsue station in western Japan but "they also failed in trying to rouse support for a continuation of the war." It could thus be argued, I suppose, that World War 2 both started and ended with attacks on radio stations!

Centralized broadcast and telecommunications facilities are still clearly recognized as being at risk – as witness the closing for so many years of what was planned as a major London tourist attraction: the public observation galleries of the Post Office Tower.

## Radiation hazards

The possible effects of a different type of hazard occurred to me last year when I made the ritual trip to the very top of the Empire State Building in New York. Looking out of the glass windows one seemed very close to some of the many broadcasting aerials that adorn the building. I began to wonder just what levels a field strength meter might have revealed, particularly when compared to the guidelines in the new American "ANSI C95.1–1982 American National Standard Safety Levels with respect to human exposure to radio frequency electromagnetic fields." This recognises that it is prudent to restrict exposure, on frequencies between 30 and 300MHz, to power densities of less than $1mW/cm^2$ rather than the older limit of $10mW/cm^2$ (the current British figure). ANSI now recognises that non-ionizing radiation at some frequencies is potentially more hazardous than at others. Below 3MHz the guide limit increases to $100mW/cm^2$ and above 1500MHz to $5mW/cm^2$; between 300 and 1500MHz it is f/300 and between 300 and 1500MHz f/300 where f is in MHz. The ANSI standard, however, admits some important exclusions to these figures: for example for hand-held, mobile and marine transmitters which can produce strong localized fields but tend to result in lower overall body absorption the guide figures do not apply below 1 GHz for transmitters with less than 7 watts r.f. output. The ANSI standard is quite a complex document but clearly deserves careful study in the U.K.

## Consumers and EMC

A few years ago the susceptibility of so much consumer electronics equipment in homes and cars to strong out-of-band r.f. fields was of concern mainly to the 30,000 or so UK radio amateurs. Today there are not only the 350,000-plus CB transmitters to take into account but also the many consumer digital-type systems and electronic devices such as semiconductor lamp dimmers that can affect television, radio and audio. In addition many high-gain audio systems, including tape recorders and record reproducers, are vulnerable to the sync pulses of strong television signals. Home Office statistics normally cover only complaints of interference to the off-air reception of local television and radio broadcasts, today only part of the problem.

In North America leakage into and out of wideband cable tv systems is proving a difficult problem and represents an argument in favour of fibre-optics systems which should be far less susceptible to r.f.i. and not give rise to outward leakage problems.

In the UK a more immediate problem is the added susceptibility of domestic tv where a video cassette tape recorder is in use. This vulnerability extends to off-air reception where the signals pass through the wideband v.h.f./u.h.f. amplifiers in the recorders. These amplifiers often exhibit gain from about 12 MHz up to 900 MHz and can be overloaded by a strong signal anywhere in this range. For the UK market, the v.h.f. capability of the recorder amplifiers is unnecessary, and it would reduce susceptibility to local transmitter interference if u.h.f.-only recorders were marketed in the UK.

A further problem, affecting primarily amateurs using the 3.5 MHz band, is the high-gain head amplifier with a frequency range extending up to about 5 MHz. In some recorders this is comparatively well screened, but this is not always the case; the general use of plastics enclosures for recorders does not help.

A problem common in the USA that has not yet arisen in the UK is that of interference to the receivers used for opening garage doors by radio control. Apparently it is by no means unusual to see a succession of garage doors swing open when a mobile transmitter passes by. Yet in many cases the manufacturers of the radio control equipment are well aware that the problem can often be solved by fitting just one or two r.f. bypass capacitors at suitable points.

It can be argued that the Home Office accepts that susceptibility of consumer equipment to out-of-band signals cannot be blamed on the transmitter. Nevertheless, it was precisely this susceptibility that led the Home Office to restrict legal c.b. to the f.m. mode. For both radio amateurs and c.b. operators there are the difficult social problems that arise with neighbours. It is near impossible to convince somebody who has just spent £450 on a video recorder that the interference is due to its deficiencies! The owner always blames the transmitter.

Two California cable tv operators were recently ordered to stop using their 151.25 MHz channels in wideband cable systems because leaking signals interfered with Department of Forestry firefighting communications. The FCC Field Office told cable operators to ensure their systems comply with FCC rules, and added that even if a system complies fully with the rules but still causes harmful interference, it is up to cable operator to remedy the problem.

# AMATEUR RADIO

## Natural energy

For portable and transportable two-way radio, the power source remains the key factor. Even for the popular 144MHz hand-held transceivers the most frequent complaint is that power consumption is such that it gives rise to too-short battery life, even though this may be rechargeable. Many units incorporate a "high/low" power-output switch and, particularly when used with repeaters, the low-power mode often provides adequate range. Power consumption, however, is not helped by some of the recent digital techniques that provide additional operator convenience but shorten battery life.

The use of solar generators is thus of increasing interest although currently not economically viable in many cases. However a relatively powerful solar generator using 20 solar modules each with an array of photovoltaic silicon solar cells and used in conjunction with a 500Ah lead-acid battery has been used at the Jet Propulsion Laboratory in California to power a combined h.f. and v.h.f. "emergency" station based on standard amateur-radio transceivers. In sunlight the solar generator provides about 200 watts of electrical power to charge the battery. This is capable of keeping the equipment running with a low transmit/receive duty cycle for several days. However such installations are costly and not readily transportable so that their application to amateur radio is likely to be limited: possibly in future the development of large area amorphous silicon solar cells may widen the scope.

## Pedal-to-talk

A man-wife team of British amateurs – J. R. G. Corbett, G3TWS and Mrs M. G. Corbett, G8TWS – have recently assembled a pedal-powered generator for use in Zaire to power an h.f. network linking Mission hospitals – bicycle minus a front wheel and with a generator driven by the back wheel held in a cradle. Pedal generators of a similar type have been widely used in the past and can deliver well over 100 watts of power when an energetic cyclist is available – considerably more than can be readily obtained with a hand generator.

An energetic American college professor, Elliot Kleinman, WA4YDK, in a variation on this theme, has recently accomplished the feat of working all 50 American states while operating "bicycle mobile" and is reported to be well on his way to making it 100 different countries. In his case, however, the power source is a 9Ah motorcycle battery which powers a compact h.f. Atlas transceiver for rather over an hour per charge, although liable to die suddenly as it finally discharges. His aerial is a 66-in whip. He uses the 21MHz band.

Not surprisingly, in view of the unstable nature of his loaded vehicle, he reports that the reaction of the people on the streets varies from interested to dumbfounded.

## In brief

The Norwegian N.R.R.L. society has awarded its 1982 Golden Key Award to Noel B. Eaton, VE3CJ, former president of IARU. He becomes only the third non-Norwegian amateur to receive this award . . . Father Maksymilian Kolbe, SP3RN, who gave his life to save that of a fellow concentration-camp prisoner in World War 2, has been canonized. In 1938 he set up an amateur station to communicate with missionary stations worldwide . . . A new Russian amateur radio satellite, ISKRA-3 was launched by hand from the Salyut spacecraft during November . . . The RSGB national amateur radio convention at the National Exhibition Centre on March 5 and 6 is to include both lectures and convention features as well as a large trade exhibition . . . The Society's VHF Convention is at Sandown Park Racecourse, Esher, Surrey, on March 26.

**–PAT HAWKER, G3VA**

# High power high quality amplifier using mosfets

*Though power mosfets are superior to bipolars because of wide frequency response, high switching speed and absence of secondary breakdown, input capacitance can cause non-linearity problems at high frequencies if you don't have enough drive current. This is especially important when paralleling mosfets for higher output power.*

**by Erno Borbely**
Dipl. Eng., M.I.E.E.E.

The amplification of very low level signals delivered by a pickup to the high power level needed to drive inefficient loud-speakers presents unique problems which have attracted the attention of many engineers, as witnessed by the many articles in WW. Some of these are closely related to the devices used: bipolar transistors. The relatively new power devices in m.o.s. technology, power mosfets, are capable of solving most of these problems.

Audio power amplifiers using bipolar devices tend to be overload protection. The first one is needed because of the positive temperature coefficient of the collector current versus base-emitter voltage. With increasing power dissipation we get an increasing junction temperature, which increases with the collector current and therefore power dissipation. Eventually, this will lead to thermal runaway, causing destruction of the device. To avoid it a sophisticated circuit is needed to sense the temperature on the output devices and regulate the quiescent current through them accordingly.

Bipolar power transistors are also well known for current concentration under high current conditions. This causes local hot-spots which can eventually lead to secondary breakdown. This is especially dangerous at combinations of high voltage and high current. Consequently bipolar power amplifiers use sophisticated volt-amp limiting to get the maximum from the devices without damaging them.

The Hitachi 2SK134/2SJ49 power mosfets used in this design do not have such problems. Their most important advantage is the negative temperature coefficient of the drain current versus gate-source voltage. As Fig. 1 shows, the drain current is decreasing with increasing temperature above approximately 100mA. This means that thermal runaway cannot occur and complicated temperature-tracking circuits are therefore not required.

Another advantage is the uniform current distribution across the whole silicon die, which does not deteriorate in the high current, high voltage area. The result is that there are no hot spots and no second breakdown. Sophisticated V-A limiters are

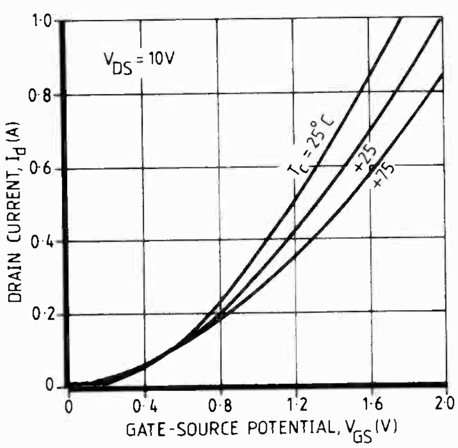



***Fig. 1.*** *Negative temperature coefficient of the drain current above 100mA prevents thermal runaway with Hitachi 2SK134/2SJ48 type mosfets and avoids use of temperature-tracking circuits.*

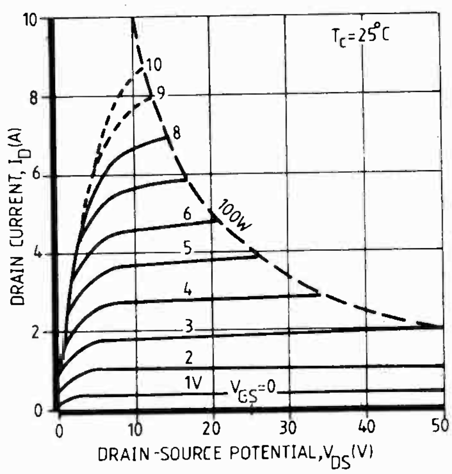



***Fig. 3.*** *Typical $I_D$-$V_{DS}$ curves for 2SK134 show that maximum drain current is limited to seven amps.*

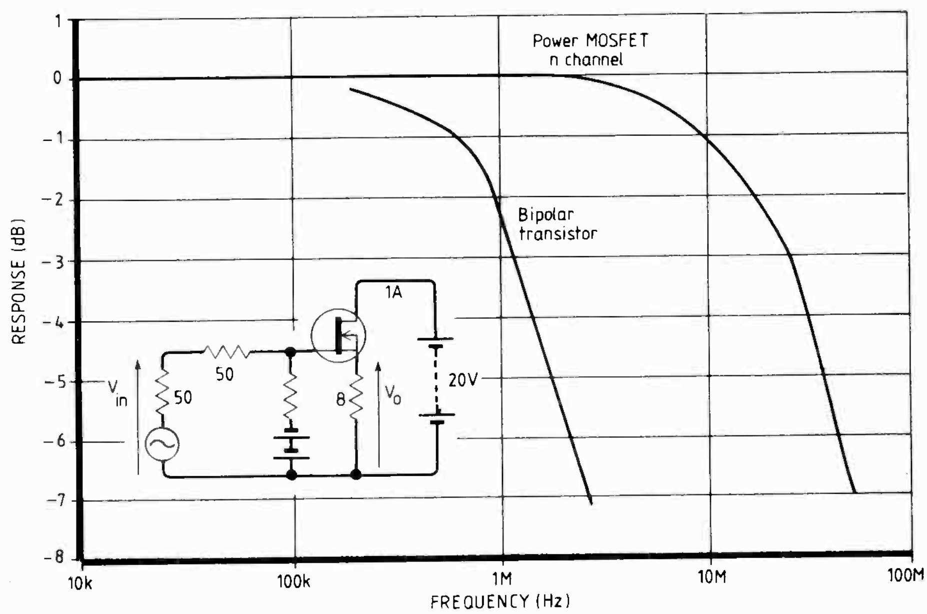



***Fig. 2.*** *This n-channel mos source follower has ten times the bandwidth of an emitter follower.*

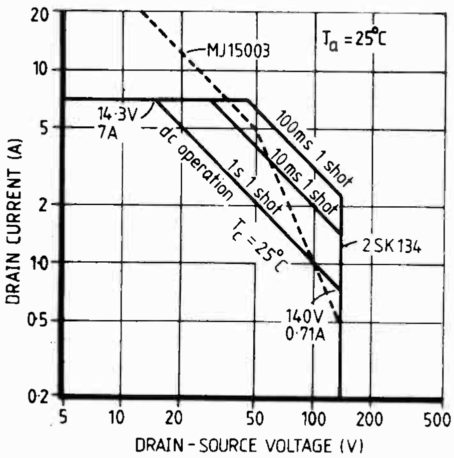
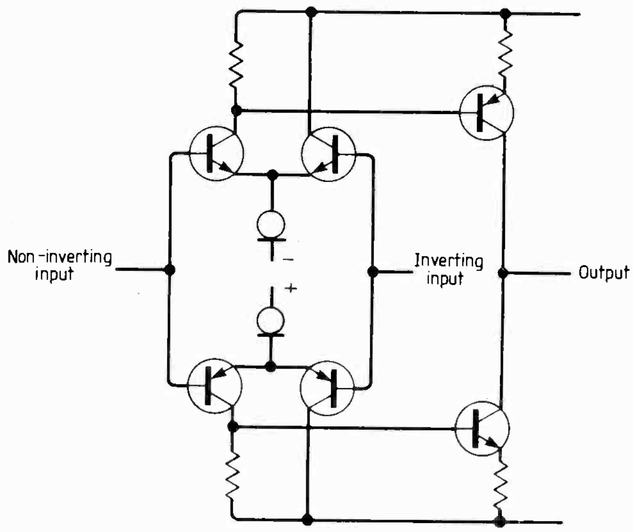



*Fig. 4. Compared to a giant bipolar transistor, the mosfet has limited current capability at low voltages, but outperforms the bipolar at combinations of high current and high voltage.*

*Fig. 5. Many top-quality amplifiers have used a fully balanced, complementary, dual-differential topology, known for very low static distortion at low levels and for good power supply ripple rejection, but it's difficult to get good linearity at high levels, because the second-stage transistors are working with extreme $V_{CE}$-excursions, causing large gain variations.*




therefore not required for protection. In fact most amplifiers do not need any protection at all.

There are several more advantages with mosfets that are important in audio applications. One is that they are majority carrier devices. Because the charge carriers are controlled by electric fields and not by injection of minority carriers in the active region, there is no stored charge in the gate region. The result is wide frequency response and fast switching, even when coming out of clipping.

Like bipolar transistors, mosfets are usually used in the follower configuration in audio amplifiers. Fig. 2 shows the frequency response of an n-channel mosfet in source-follower configuration. For comparision, the response of an emitter follower is also shown: bandwidth of the source follower is ten times wider than that of a bipolar device.

Another important advantage is their high input impedance. Together with the uniform current distribution, this allows paralleling of mosfets without undue problems. However the spread in the gate-source turn-on voltage has to be considered when doing this, as we will see later. Although the statement "high impedance" is correct at very low frequencies, it is by no means applicable for the whole audio frequency range. The input looks like a pure capacitor with a value of about 1nF. This can cause non-linearities at high frequencies if you don't have enough drive current available. The input capacitance therefore becomes the most important factor in selecting the driver circuit.

## Disadvantages of power mosfets

Although having a number of advantages compared to bipolars, mosfets are by no means ideal. The most important disadvantage with the 2SK134/2SJ49s is the high on-resistance. Worst-case calculations show that it can go up to 1.7ohm; a current of 5 amps through the device gives a voltage drop of 8.5 volt across it. Clearly this would increase power dissipation and decrease efficiency. Power supply design has to be based on this worst-case on-resistance. Typical on-resistance is around one ohm, so there is some margin built-in if we calculate with the worst-case value. Other manufacturers are offering devices with much lower on-resistance but they are limited in other parameters such as breakdown voltage and/or in offering complementary devices. A wider selection of mosfets is expected to be available on the market in the next few years.

When looking at the $I_d$-$V_{ds}$ characteristics of the Hitachi mosfets, Fig. 3, notice that the curve is not shown at higher drain currents than about 7A – the maximum rated drain current. Compared to some of the bipolar transistors rated at 20-30A this might look meagre. But taking into consideration the device's complete freedom from secondary breakdown, one can usually use more of the available current capability of the mosfets than of the bipolars. Fig. 4 shows the safe operating areas for the Hitachi 2SK134 and, for comparison, of a representative bipolar power device, the MJ15003, being a 20A device and superior at low voltages. At high voltages the mosfet is equal to, or in one area it is even better than, the bipolar device.

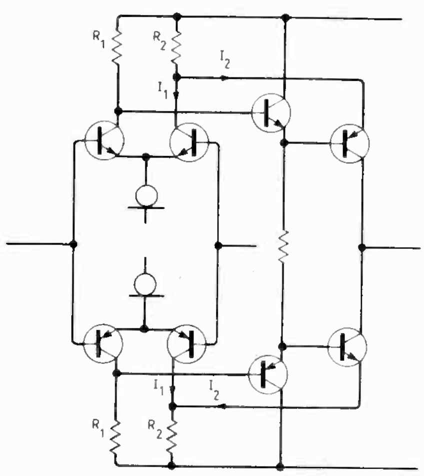



*Fig. 6. This offers very good linearity and easy control of the second stage current, $I_2$.*

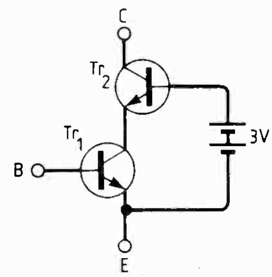



*Fig. 7. The cascode configuration is one of the best for large signal handling capability.*

The maximum output power one can get with power mosfets is limited only by the thermal capability of the die/package combination. A 2SK134/2SJ49 pair can easily deliver 60W into 8Ω and more than 75W into 4Ω. Two pairs in parallel make a 120W/8Ω or a 150W/4Ω amplifier, as in this design.

## Driver design

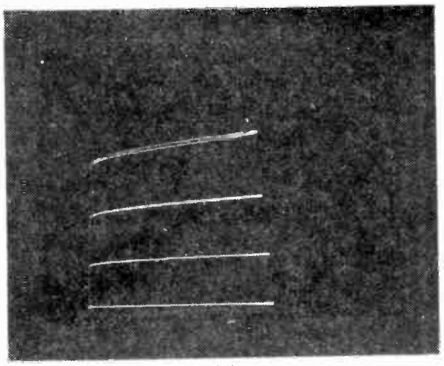
The most important considerations when selecting the topology for the driver circuit are

- linearity
- open-loop bandwidth
- drive capability.

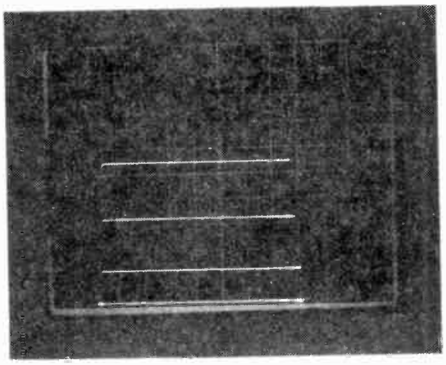
Although there are some three-stage driver circuits in commercial amplifiers of Japanese origin, most European and American designers prefer the two-stage design which can achieve both good linearity and wide bandwidth.

The differential input is universally accepted as the input stage. The second stage, which has to supply all of the drive to the output stage, is either a common-emitter stage with a current source as a load, or a differential amplifier using a current mirror for differential to single-ended conversion.

Many top-quality amplifiers have been using a fully-balanced complementary dual-differential topology in recent years, known for very low static distortion at low levels and for good power supply ripple rejection, Fig. 5.



(a)



(b)

*Fig. 8(a) shows the $I_C$-$V_{CE}$ characteristics of a typical high-voltage transistor, the MJE340. Allthough limited in terms of voltage and current, the curves clearly indicate gain variations with changing collector-emitter voltage. (b) shows the characteristics of cascode circuit where $Tr_2$ is a MJE340, and $Tr_1$ is MPSA55. The composite characteristics of this circuit are extremely linear, approaching that of an ideal transistor. Voltage variations across the transistors do not cause significant gain variations, consequently these can handle large voltage swings with very little distortion.*

It is more difficult to get good linearity at high levels because the second-stage transistors are working with extreme $V_{ce}$ excursions, causing large gain variations. There are a number of ways to improve large-signal handling capability; I have found the circuit shown in Fig. 6 excellent in this respect. This fully symmetrical circuit also allows easy control of the current in the second stage; it is fixed by the ratio of the two collector resistors in the input stages:

$$R_1/R_2=(I_2+I_1)/I_1$$

I have found that this current transformation from first stage to second stage works well up to a ratio of about 30 and, with the particular transistors used, up to a second stage current of 30mA. This current was used to drive a pair of 2SK134/2SJ49s in a 60W amplifier with good linearity and slew rate. However, if we want to drive two pairs of devices to increase the output power to over 100W, this current is not sufficient any more (see calculations below). To be able to use higher current in the second stage with good linearity, I redesigned it using a cascode configuration.

Fig. 7 shows the basic cascode connection of two transistors. Used alone, a high-voltage transistor such as the MJE340 clearly suffers from gain variations with changing collector-emitter voltage; see the $I_c$-$V_{ce}$ characteristics in Fig. 8(a). The composite characteristics of a cascode circuit (MPSA55, MJE340) are extremely linear, approaching that of an ideal transistor, Fig. 8(b). Voltage variations across the transistors do not cause significant gain variations, consequently these can handle large voltage swings with very little distortion.

An additional advantage of the cascode circuit is its wide bandwidth. It was established many years ago[1] that we need an open-loop frequency response up to 20kHz to avoid transient overload inside the feedback loop. Using the cascode configuration in the second stage, we can easily satisfy this requirement.

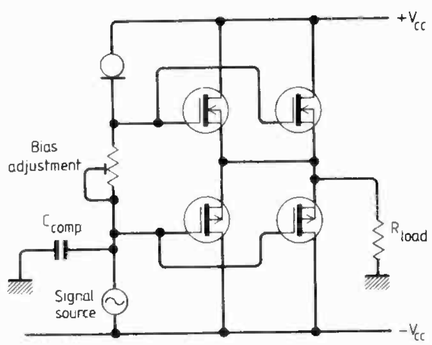



*Fig. 9. Paralleling mosfets is easy, thanks to the high-input impedance and the uniform current distribution across the die.*

As the collector-base voltage of $Tr_1$ is held constant in this circuit there is minimum charging of its collector-base capacitance, effectively eliminating the influence of this capacitor on the frequency response. Transistor $Tr_2$ is operating in common-base mode, which is inherently a wideband configuration. Together, they offer a very linear operation over a wide frequency range. A slight disadvantage is the increased voltage loss across the two devices. This is not a problem in our application because the voltage loss across the output devices due to the on-resistance will dominate. Alternatively the driver circuit could be supplied from a higher voltage.

Finally, look at the drive requirements. Fig. 9 shows the output stage, consisting of two pairs of n and p-channel devices operating in source-follower mode. The input capacitance of the p-channel fets is around 900pF, the n-channel around 500pF. Used in the source-follower mode, the input capacitance is reduced by the local feedback. As the transconductance of the devices is fairly low ($g_m$=0.7 to 1.4S), this reduction is moderate. Calculations based on the published figures in the Hitachi data sheets show that we will end up with 100 to 200 pF input capacitance for each of the devices using an 8Ω load.

The input of the output stage is normally used as the main roll-off point for the amplifier. Because input capacitance varies with operating conditions, it is necessary to add a real capacitor here ($C_{comp}$ in Fig. 9), to come up with the total value needed to stabilize the amplifier. Assuming $C_{comp}$ 400pF, and 150pF each

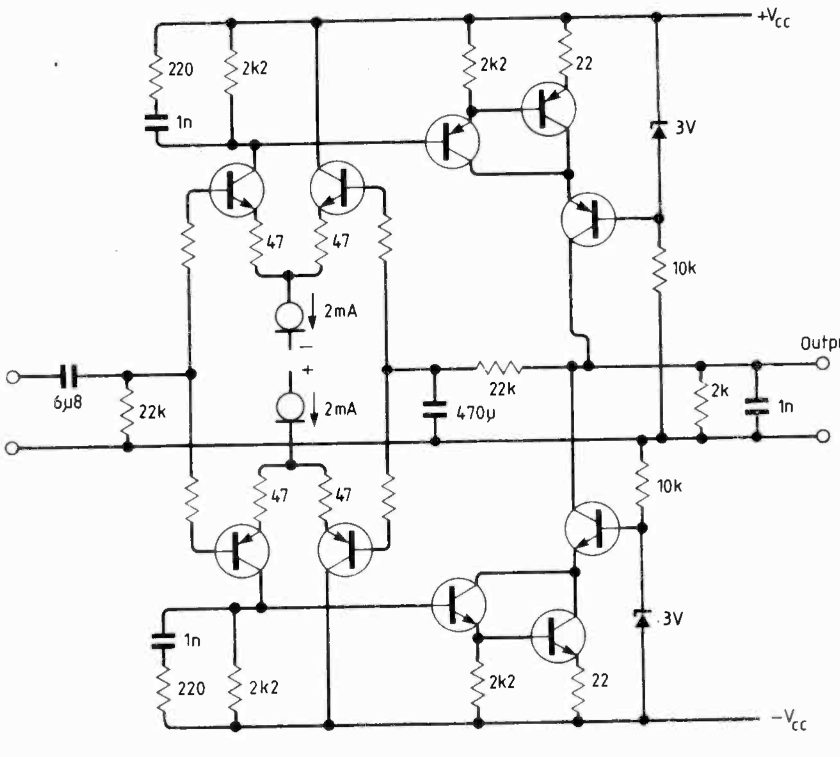



*Fig. 10. Driver circuit chosen is as it was for open-loop measurements: gain without the load was too high: the 2kΩ load reduced it to about 66dB. In parallel with 1nF the distortion was 0.1%, both at 1 and 10kHz. Response was down 1dB at 20kHz, 2dB at 30kHz.*

for the mosfets, the total load capacitance seen by the driver circuit is around 1nF.

To avoid non-linearities caused by this input capacitance, we have to have enough current available in the driver stage to charge and discharge it under all conditions. I was especially interested in very low distortion across the whole audio band with a reasonably high internal slew rate as a secondary requirement. This was to be higher than the slew rate of any signal capable of entering the amplifier, through the low-pass filter used at the input. Using the well-known formula for the slew rate

$$dV/dt = i/C$$

calculate the necessary current to charge and discharge the input capacitance at the rate required. For a slew rate of 100V/μs, and assuming an input capacitance of 1nF, 100mA is needed in the driver stage.

The final driver circuit selected consists of a balanced complementary differential input stage and complementary cascode second stage, Fig. 10. The differential input stages are working with 2mA each (1mA per transistor) while the second stage, for reasons of linearity and power dissipation, ended up with approximately 50mA.

Open-loop distortion for the whole amplifier is approximately 0.5% measured at 1kHz and 100W into 8Ω. If all of the feedback (40dB in this case) reduced the distortion effectively, we would end up having 0.005% in the final amplifier. This is more than adequate for any high quality amplifier. However, the 2kΩ resistor is shunting too much of the available current away from the load capacitor (corresponding to the input capacitor of the output stage), resulting in a little higher distortion at high frequencies than I was looking for. To avoid this, I removed the 2kΩ load and replaced it with 10kΩ (actually 2×22k, see final circuit). This increased the open-loop gain and the feedback, and the final amplifier shows very low distortion across the whole audio range.

It has been said that due to the low $g_m$ of the mosfets, special circuit configurations like the composite source-follower or extrememly high open-loop gain in the driver stage are necessary to get an acceptable linearity[2]. It is my experience that the only precaution necessary is to have enough current available to charge and discharge the mosfet input capacitances. The design described shows that very good linearity can be achieved with a moderate amount of feedback (30 and 40dB, respectively) and normal source-follower configuration.

## Circuit discussion

In the complete circuit diagram, p.73, the blocking capacitor $C_1$ together with $R_1$-$R_2$ and the output impedance of the preamplifier determines one of the low-frequency roll-offs of the amplifier. Assuming that the impedance feeding the amplifier is low, the −3dB point will be about 1Hz. The non-polar capacitor $C_1$, should be polypropylene, polycarbonate or, if these are not available, a polyester capacitor. Worst case, a non-polar electrolytic or two nor-

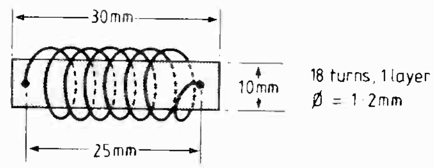



*Fig. 11. A suitable output coil can be made on a plastics spacer with parallel resistor to dampen ringing caused by capacitative load.*

mal electrolytics connected to form a non-polar capacitor can also be used. The layout gives a number of possibilities as far as type and size of the capacitor(s) are concerned.

Components $R_1$ and $C_2$ form a low-pass network to prevent high frequency signals with slew rates higher than the internal slew rate of the amplifier from reaching the input. As the output impedance of the preamplifier forms part of this filter, the value of $C_2$ should be adjusted for the particular system it is used in. Assuming that the output impedance is very low, the values shown give a −3dB point of over 200kHz, so $C_1$ should be changed to 1 to 1.2nF, bringing the −3dB point down to about 60kHz. The value shown can be used with preamplifiers with output impedance up to about 10kΩ. $C_2$ should be a polystyrene or polypropylene capacitor. The d.c. path for the input transistors goes through $R_2$ which for minimum d.c. offset at the output of the amplifier should be equal to $R_{22}$.

For minimum d.c. offset we also need high-gain transistors in the input stages but it is difficult to find them with high breakdown voltage. The best compromise I have found is the BC546B and BC556B complementary pair; $h_{FE}$ is specified as 180-450 at 2mA collector current and breakdown voltage 65V. A better choice as far as breakdown voltage is concerned is the MPS8099 and MPS8599 pair (80V) which gives the possibility of higher supply voltages; $h_{FE}$ is 100-300 at 1mA, but does not create any problems with the relatively low-impedance d.c. path used.

The current sources, which supply 2mA to the differential stages, require a stable voltage reference. This is normally obtained from low-voltage zener diodes or a string of small-signal silicon diodes. 1N4148 can be used in this circuit: they show a good repeatability and are very inexpensive. Operating the 1N4148s at around 1mA, the voltage drop is very close to 0.6V: two in series with 2mA through them give an acceptable performance ($R_{11}$, $R_{13}$=22k, $R_{10}$, $R_{12}$=300Ω).

A zener diode solution, shown on p73, needs zener diodes operated at a higher current than the 1N4148s, hence the change of $R_{11}$, $R_{13}$ to 10kΩ. Although not shown in the schematic, a good temperature compensation can be achieved by connecting a silicon diode in series with the 4.7V zener, which follows the $V_{BE}$ variations of the current-source transistor. This is recommended when operating the amplifier at very high ambient temperatures.

The proposed layout accepts all three solutions: two silicon diodes in series, a single zener diode or a zener diode and a silicon diode in series.

The 3V reference for the cascode circuit (formed from $Tr_7$, $Tr_8$ & $Tr_9$ as the p-n-p part, and $Tr_{11}$, $Tr_{12}$ and $Tr_{13}$ as the n-p-n part) is derived from a string of 1N4148s. This might seem extravagant, but the only alternative, a 3V zener diode, required a much higher operating current. Operating at 5mA, the average forward drop is 0.64V, five of them in series supply 3.2V for the cascode circuit.

Transistor 10 and associated circuitry is for bias adjustment. Hitachi recommend a regular potentiometer for this but as the relatively high current in the second stage is 50mA I didn't find it satisfactory to pass all of this through the wiper of a small trimpot. Instead, I use a normal bias adjustment circuit ($V_{BE}$-multiplier) found in practically all bipolar amplifiers. The difference is that this circuit is not supposed to have any temperature compensation: $Tr_{10}$ should therefore not be mounted on or near the output heatsink.

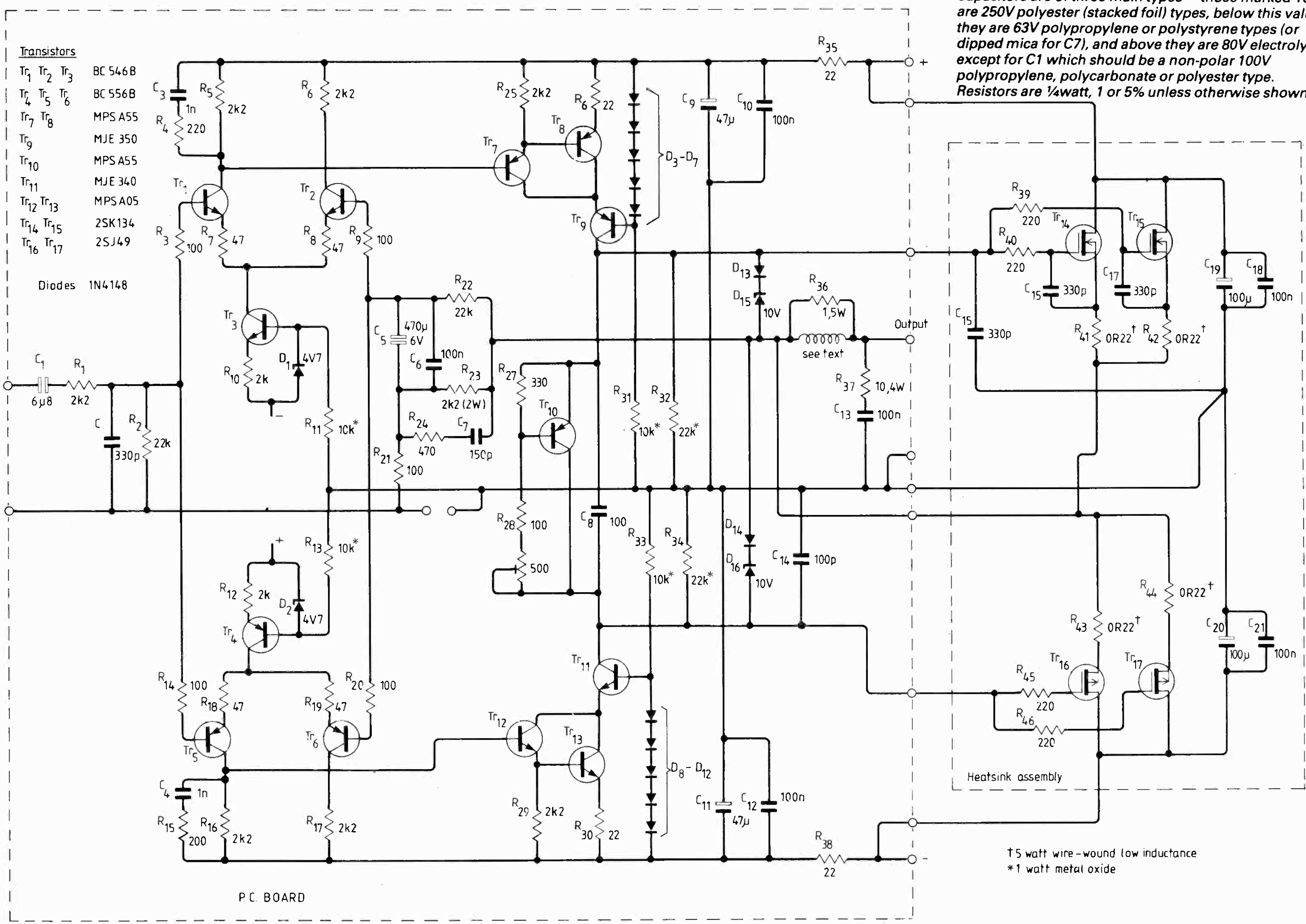
When switching the amplifier on the first time, the potentiometer should be set to its anti-clockwise position. While monitoring the current through the whole amplifier (for example by removing one of the fuses and connecting an ammeter across its terminals), the quiescent current should be adjusted to 260mA (100mA in each of the output devices, plus driver). This ensures an optimum operation from the point of view of temperature stability, and low-level distortion.

The mosfets are guaranteed for a minimum gate-source breakdown of ±14V. The devices have built-in protection diodes, so it should not be necessary to use external protection unless the amplifier is overloaded at very high frequencies. For testing I usually drive the amplifier to maximum output in the frequency range 30 to 50kHz with an 8Ω load and then connect a large capacitor (around 4μF) across the output. The amplifier should work either normally if current handling capability permits or should automatically limit the output.

I have seen the Hitachi devices act a number of ways, depending on the circuit configuration. They might latch, conducting a very high current; they might break up, delivering a very distorted wave form; or they might go into oscillation. Although none of these conditions ever produced a destruction, the devices should not operate under such conditions for an extended period of time. Diodes $D_{13}$-$D_{16}$ serve that purpose; no matter what current is demanded from the output stage, the diodes prevent the driver stage from delivering more than ±10.6V peak gate-to-source voltage. This protects the output from out-of-audioband overstress and just about any sort of abuse is tolerated, until we reach the thermal limitation of the die/package combination.

There are three more blocks of components on the p.c.-board. One is the feedback network, in which d.c.-feedback is applied through $R_{22}$; for minimum offset this is equal to $R_2$ and a.c.-feedback, given by $R_{23}$ and $R_{21}$, isolated from the d.c.

*Capacitors are of three main types – those marked 100nF are 250V polyester (stacked foil) types, below this value they are 63V polypropylene or polystyrene types (or dipped mica for C7), and above they are 80V electrolytics, except for C1 which should be a non-polar 100V polypropylene, polycarbonate or polyester type. Resistors are ¼watt, 1 or 5% unless otherwise shown.*




†5 watt wire-wound low inductance
*1 watt metal oxide

feedback by $C_5$ and $C_6$. The d.c. gain is unity, and a.c. gain is approximately

$$(R_{23}||R_{22}+R_{21})/R_{21}$$

which is close to 20 times or 26dB. Capacitor 5 is a non-polar electrolytic and since electrolytics have an increasing impedance at higher frequencies, I connected a 0.1μF capacitor in parallel with it.

Components $C_7$ and $R_{24}$ provide lead compensation and optimize square-wave response; $C_7$ should be polystyrene, polypropylene or a dipped-mica type.

The next block is the output network, consisting of L in parallel with $R_{36}$, and the RC network $R_{37}$-$C_{13}$. To prevent short circuit of the output with capacitative load and high frequencies, an inductance is in series with the output. This has an increasing impedance with frequency, thus preventing the short circuit. This can cause sustained ringing with a capacitive load, so we dampen the inductance with $R_{36}$. A suitable coil is shown in Fig. 11 (I used a plastics spacer as a coil former).

Components $R_{37}$-$C_{13}$ terminate the amplifier resistively at very high frequencies, necessary because loudspeakers represent a very high or uncontrolled impedance at h.f., causing oscillation that can destroy tweeters.

Finally, there are RC networks in each of the supply connections. Although the amplifier has a good inherent ripple rejection, additional filtering is an advantage from the point of view of isolating the two channels. This is especially important at high frequencies, hence the paralleling of the electrolytic with a 0.1μF polyester capacitor.

## Heatsink assembly

The rest of the components are mounted directly with the output devices on the heatsink assembly.

The power mosfets are high speed devices, and require special mounting and wiring precautions. The first one is a proper decoupling of the power supply connections directly at the device packages. Again, a combination of electrolytic and polyester capacitors is used for this. The second one is the usual source follower problem of parasitic oscillation with capacitative load: a resistor in series with the gates to prevent this. Resistors $R_{39}$, $R_{40}$, $R_{45}$ and $R_{46}$ should be wired directly to the gate pins of the devices.

The uniform current distribution across the die means hot-spots cannot occur and together with the fact that they have a high input impedance enables operation in parallel mode without too much trouble. However, some precautions have to be taken because of the $V_{GS}$ spread. We want to operate them at a quiescent current of 100mA. Unfortunately, the $V_{GS}$ voltage necessary to turn on the mosfet to this drain current varies from device to device.

Ideally, the devices should be matched to within ±10mA at 100mA drain current. But unfortunately, this requires a large number of devices to select from and can only be done in large-scale production. Happily, devices coming from the same production batch (bought at the same time from a distributor and marked with the same date code), seem to be close enough to work satisfactorily in the amplifier. Resistors $R_{41}$, $R_{42}$, $R_{43}$ and $R_{44}$ are also helping in equalizing the current at the same time, as they help linearize the characteristics of the mosfets. These resistors should be non-inductive types.

Although the n and p-channel devices are said to be complementary, some parameters are different. One is input capacitance, specified as 900pF for the p-channel and 500pF for the n-channel ones. This difference can influence rise and fall times in the amplifier, make square-wave response a symmetrical, and made stabilizing more difficult.

As we usually do not know the exact value of the input capacitances, we can only make an approximate balancing of these by adding extra capacitance to the n-channel devices, the optimum value found by experiment. Capacitors $C_{16}$ and $C_{17}$, should be polystyrene or dipped mica, and soldered directly to the gate-source pins of the n-channel fets.

Capacitor $C_{15}$, together with $C_{14}$ on the p.c. board, make up the compensation shown in Fig. 9. The reason for dividing it into two is to accommodate a wide variety of wiring schemes. A minimum value of around 100pF is needed on the board, the rest does a better job when connected directly at the input of the mosfets. Make them polystyrene types, polypropylene or dipped-mica.

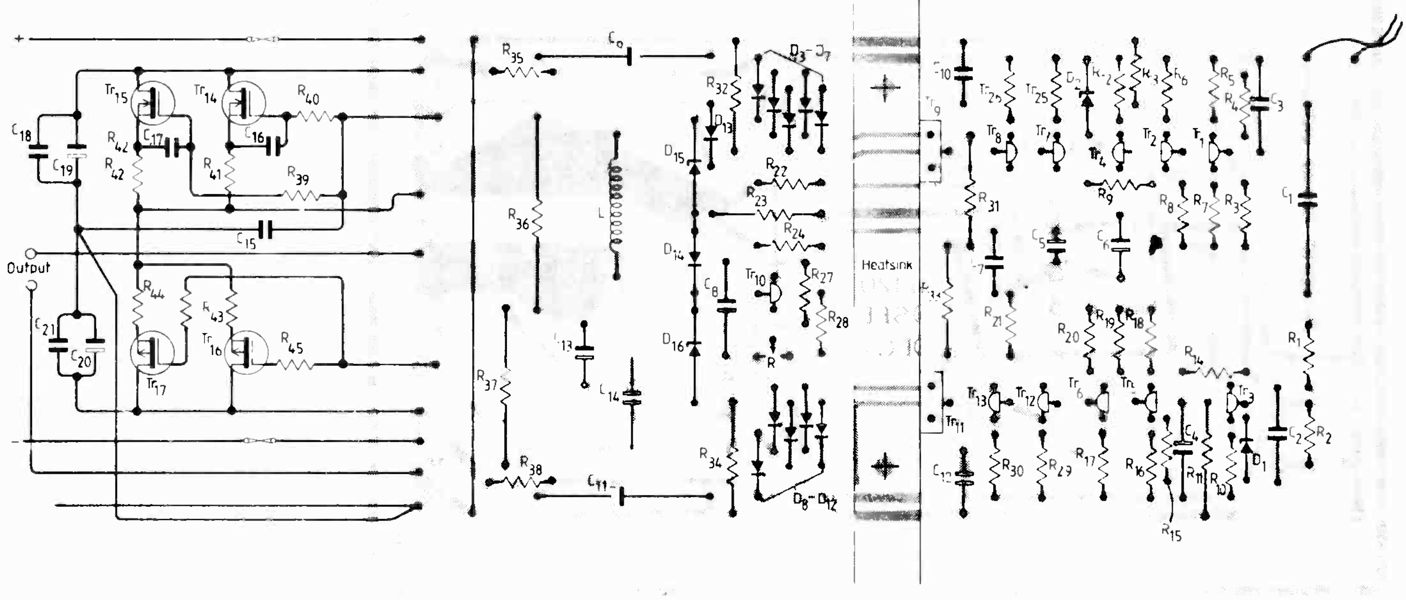
Although not intended primarily for plug-in systems, the p.c. board is made in a standard-size Eurocard format (100×160mm), including a 31pin connector. For simplicity, the input is available at the other end of the board. This makes the layout very straightforward; except for the ground path, the layout follows the circuit diagram very closely. There are two jumpers on the board, both indicated on the component layout.

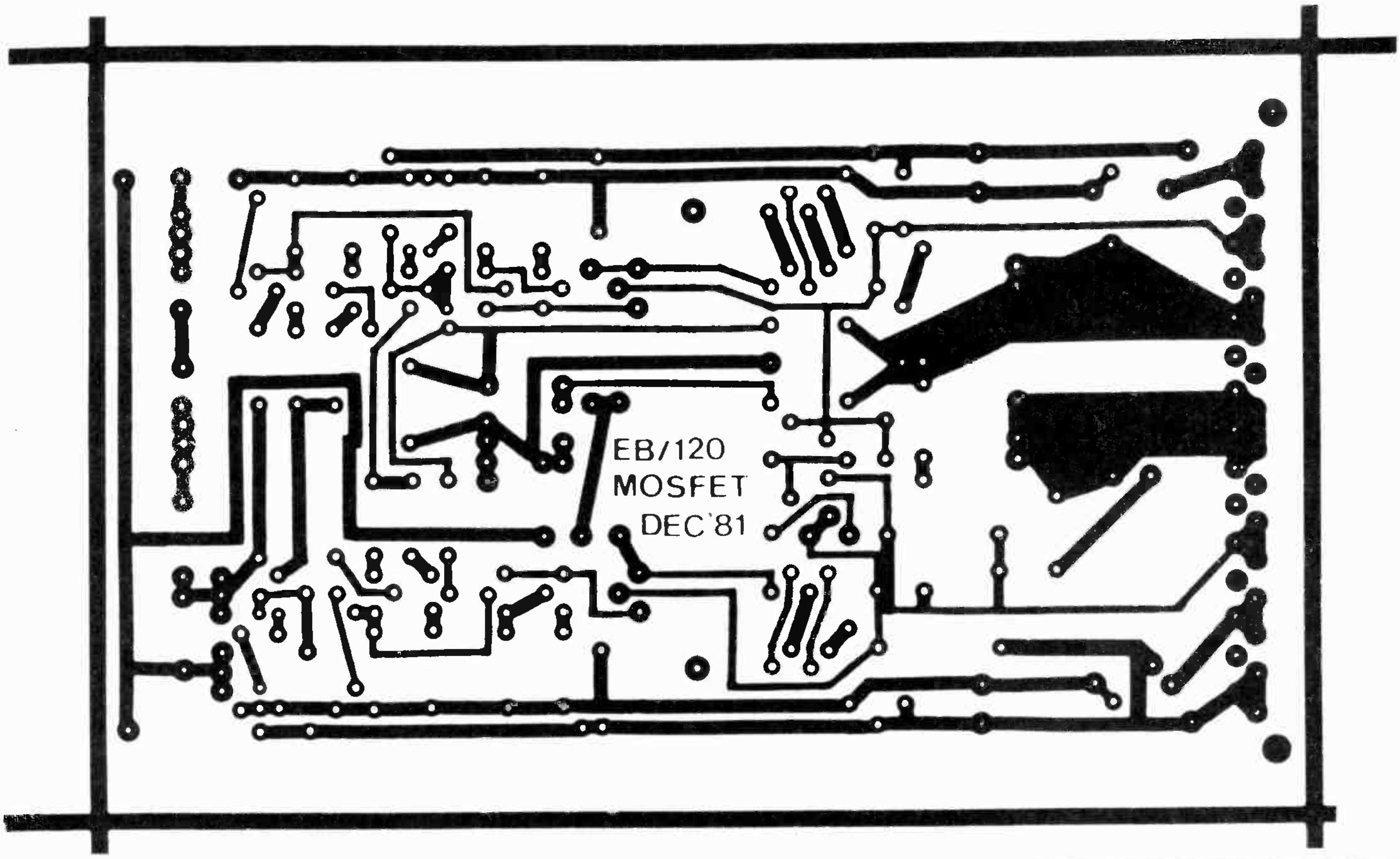
Thermal resistance should be around 0.5deg C/W per channel, which allows the amplifier to operate at a very high average output power continuously. A 150mm piece of a standard SK47 extrusion, with a T or L-bracket to mount the mosfets on, works fine. If the possibility for continuous operation with very low impedance loads exists (less than four ohms), it is a

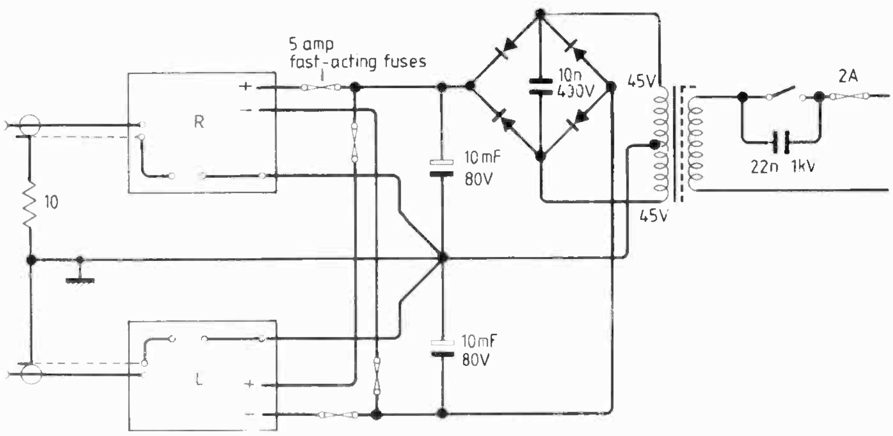
### Measurements on practical amplifier

| | | |
|---|---|---|
| Gain | | 26dB |
| Input impedance | | 24kΩ |
| Output power | | 120W into 8Ω<br>150W into 4Ω |
| Harmonic distortion | 1kHz | 0.002% at 120W into 8Ω |
| | 10kHz | 0.0065% at 120W into 8Ω |
| Slew rate | | 60V/μs without input filter |
| Rise time | | 1.2μs without input filter<br>2μs with input filter |

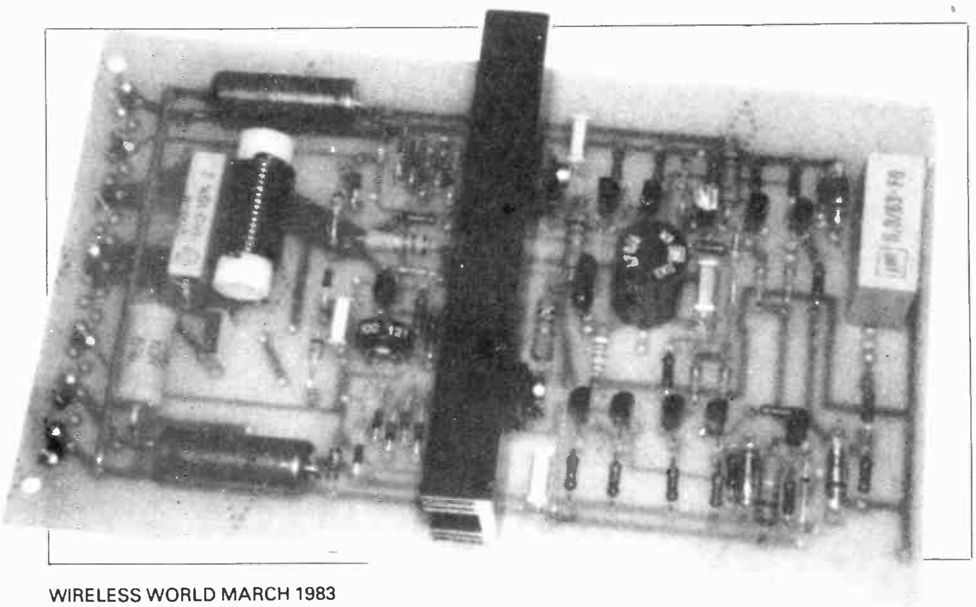
*Transistors 9 & 11 need heat dissipators – either a standard extrusion (SK09) or an L-bracket can be used.*






*The grounding scheme is flexible in that output ground and input ground are not connected together on the board. This makes it very simple to adopt a number of wiring schemes: a proposed wiring diagram for a stereo amplifier using a common power supply is shown. Using the boards with separate supplies, output and input ground can be connected together, which gives the best signal/hum ratio in a system.*



**The author**

*In 1973, Erno Borbely joined Motorola in Geneva as a senior applications engineer, responsible for audio and radio. He worked mostly on low-noise circuit design and on power amplifier circuits, and some of the ideas formulated there later found their way into the products of the David Hafler Co., which he joined in 1978 and where he designed the DH-200 mosfet power amplifier.*

*He'd previously got a degree in electronic engineering from the Technical University of Norway in 1961 and for seven years worked for the Norwegian Broadcasting Corporation designing professional audio equipment. In 1969 he moved to the U.S. to work for David Hafler at Dynaco.*

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good idea to put thermal breakers on the heatsinks with a cut-out temperature of about 75°C.

Plus and minus 57V supplies are needed for 120W into an eight ohm load. Assuming a 10% transformer regulation, the no-load voltage should be ±63V. This translates into a transformer with a 2×45V secondary, and rated at 500VA, toroidal for minimum hum. The filter capacitors must be at least 10mF each, rated at 80V. The bridge has a rating of 30A with a surge rating of 300A. WW

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# Spread spectrum communication system for civil use

*Considering the present congestion in civilian communication bands more efficient use by exploiting the multiplexing capabilities of spread spectrum systems should be welcomed. High complexity – not a problem for space and military systems – can be avoided by reducing the number of electrodes in the surface wave devices.*

**by Noman Mahmood** M.Sc.

The h.f. band is one of the most congested parts of the spectrum, and also suffers from multipath and flat fading. Spread spectrum systems would be particularly useful in this field. The spread-spectrum technique is a modulation method in which the bandwidth used is much greater than that required by the message. To be classified as spread spectrum, the modulated signal bandwidth is at least 10 to 100 times the information rate, and the information itself should not be a factor in setting the modulated signal bandwidth. The result is very low signal-to-noise ratio which makes reception of the signal complicated. This is the major problem to be encountered. Various methods of synchronization and demodulation have been suggested and tested without really solving the problems of high synchronization delay and the difficulties of maintaining synchronization.

Considering its potential advantages and the wide coverage of h.f. the research being carried out in this field is very limited, and deserves more investigation. Though spread-spectrum has its own characteristic problems, it offers the kind of promise which could revolutionize communication technology, by offering channel multiplexing for more efficient use of the spectrum; antijam capability; low detectability by an unwanted receiver; accurate ranging; and inherent multipath rejection.

**Antijam capability** can be proved directly from Shannon's equation of channel capacity $C=W\log_2(1+S/N)$, where W is bandwidth and S/N is signal-to-noise ratio

$$C=W\log_e(1+S/N)\log_2 e.$$

When $s/n << 1$, that is for low signal-to-noise ratio as is always the case with spread-spectrum,

$$\log_e(1+S/N)=S/N-(S/N)^2 1/2+(S/N)^3 1/3$$

$$\ldots \approx S/N, \text{ and } C=1.45W(S/N).$$

As the bandwidth is increased more jamming power N will be required to effectively jam the signal.

**Multiplexing capability.** Each channel user has a unique pseudo-random sequence code assigned which has very low cross-correlation with pseudo-random sequence codes assigned to others using the same channel. Receivers are designed to use a local code generated to produce an identical psuedo-random binary code as transmitted by a particular user to correlate the received sequence. When properly synchronized the result is an autocorrelation of the particular code as the output of the correlator. Interference produced by other user's codes is spread out by the action of the multiplier in the correlator.

The problem of the multiplexing is to find a sufficient number of orthogonal codes of the same length. There is no rule available for predicting the mutual cross-correlation performance of sets of psuedo-random sequences. One rule of thumb that can be used in the choice of sets of sequences is to examine the factors of the length of the sequence. Sequence lengths that have small factors are almost certain to exhibit large values of cross-correlation between some pairs of the possible sequences. Sequence lengths that do not have small factors are relatively free from high values of cross-correlation.

The importance of orthogonality between codes in the same channel is made clear by the following example. Suppose $f_1(t), f_2(t), \ldots f_n(t)$ are the several spreading sequences used by different users of the channel. Each user is using the different signals $s_1(t), s_2(t) \ldots s_n(t)$ to modulate their respective data. The modulation is done by multiplying the signal with the spreading sequence e.g. $s(t)*f(t)$. When these are sent over a channel the resulting overall channel signal is

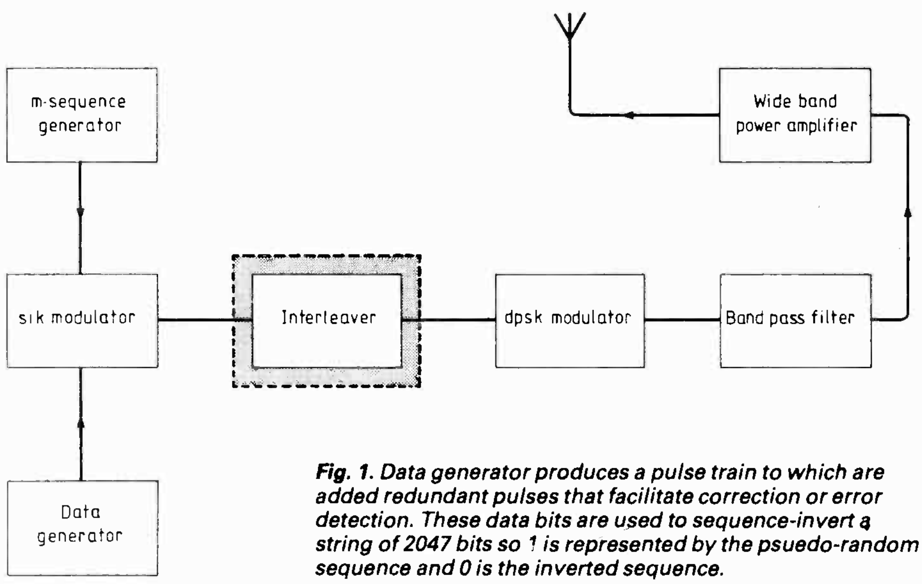



*Fig. 1. Data generator produces a pulse train to which are added redundant pulses that facilitate correction or error detection. These data bits are used to sequence-invert a string of 2047 bits so 1 is represented by the psuedo-random sequence and 0 is the inverted sequence.*

## Properties of pseudo-random sequence

In any spread-spectrum system, the base-band signal is spread over the channel with the help of a pseudo-random sequence, even though the actual system may differ according to what method is used. A pseudo-random (pn) sequence is chosen because of its excellent two-valued autocorrelation function which aids in correlation detection, its noise-like properties, as well as certain other characteristics.

- Any cyclic shift of a pseudo-random sequence is also a psuedo-random sequence.
- Any sequence may be generated by a maximal sequence (m-sequence) generator polynomial, provided the polynomial is irreducible and prime. The polynomial can be represented by

$$C(x)=\sum_{i=0}^{n} bx^i, \text{ where } b_i=0,1.$$

- If a sequence is generated by a polynomial of degree n and a window of width n is slid along a sequence, each of the $2^n-1$ non-zero binary n-tuples is seen exactly once.
- Any sequence contains $2^{m-1}$ ones and $2^{m-1}$ zeros, that is the number of ones and zeros differ by one in a sequence.
- The modulo-2 sum of two sequences is another sequence.
- The modulo-2 sum of a sequence and a cyclic shift of itself is another sequence.
- The autocorrelation function of a sequence of length $2^n-1$ is given by $P(0)=1$, $P(1)=-1/n$ for $1\leq i\leq 2^m-2$, where n is an integer and P(1) is normalized autocorrelation. The normalized cross-correlation of two such sequences is measured by $(A-D)/(A+D)$, where A is the number of agreements between bits, and D is the number of disagreements between bits. If we modulo-2 add two sequences the number of zeros would be the bits that agree and the number of ones are the bits that disagree. The distance between two codes is defined by the total number of bits that disagree. If p is the number of bits that agrees and d is the distance between two sequences, then it is possible to find an expression for the normalized correlation in terms of distance between the codes as follows. From the last expression, normalized correlation is thus $(p-d)/(p+d)$. If the total number of bits in a sequence is N then the normalized correlation is

$$((N-d)-d))/N=(N-2d)/N=1-2d/N,$$

where d the distance between codes. The distance between two codes always remains the same and constant even after cyclic shift.

$s_1(t)f_1(t)+s_2(t)f_2(t)+ \ . \ . \ . \ s_n(t)f_n(t)$. If a receiver is to retrieve $s_1(t)$ the signal would be multiplied by $f_1(t)$ giving an output

$$s_1(t)f_1^2(t)+s_2(t)f_2(t)f_1(t)\ldots s_n(t)f_n(t)f_1(t).$$

If $f_i(t)$ are chosen so that they are orthogonal, then

$$f_i^2(t)=1 \text{ for } i=j,\ f_1(t)f_i(t)f_j(t)=0 \text{ for } i=j$$

so that s(t) will be the output of the coherent detector. Hence each receiver can retrieve its particular signal with the knowledge of the particular transmitter signature or pn sequence.

**Low detectability.** The processing gain in a spread spectrum is defined as the ratio of the r.f. spread bandwidth $W_{rf}$ to the message bandwidth $W_b$ or $PG= W_{rf}/W_b$. Expressed as a time bandwidth product substituting $T_b=1/W_b$ gives $PG=T_bW_{rf}$. If $(S/N)_b$ is the bandwidth needed by a conventional receiver then the signal-to-noise ratio that a spread-spectrum system can operate on is $(S/N)_{rf}=1/PG*(S/N)_b$ on account of the processing gain. So the detectability is reduced by 1/PG, which is enormous.

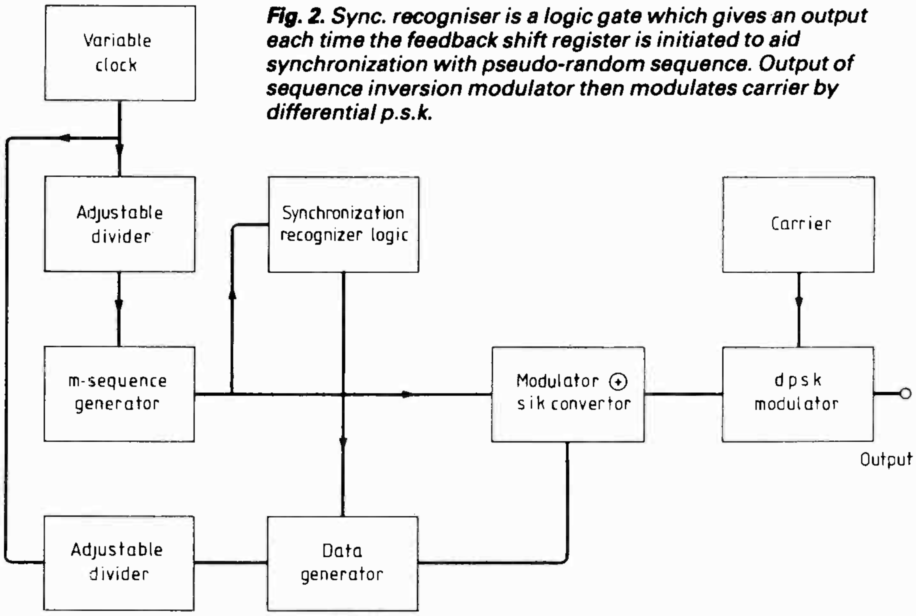



***Fig. 2.*** *Sync. recogniser is a logic gate which gives an output each time the feedback shift register is initiated to aid synchronization with pseudo-random sequence. Output of sequence inversion modulator then modulates carrier by differential p.s.k.*

**Multipath rejection** comes about due to the method of detection used and the autocorrelation property of the sequence. The pn sequence has only two values for its autocorrelation in different phase shifts of the sequence. Now a delayed version of the pn sequence reaching the correlator would be out of phase with the locally generated pn sequences used in the correlator. This would not be detected as the output would remain low due to the low autocorrelation.

### Engineering details

The h.f. band is one of the most congested of all; it also suffers from the multipath effect and flat fading. Spread spectrum systems would be particularly useful here.

An h.f. radio link is a time-varying channel in which the attenuation and delay characteristic vary with time. This is called frequency-selective fading, and can be a serious source of error. The main cause of additive noise is atmospheric noise caused by lightning discharges, occupying a frequency from v.l.f. to around 30MHz at the input to the radio receiver.

Fading rates for both flat and frequency selective fading are normally in the range of 4 to 15 fades per minute. The flat fading may vary from 0 to 70dB, so a.m. is not suitable. Suppressed-carrier a.m. when binary coded is equivalent to p.m. Both f.m. and p.m. may be used at h.f. satisfactorically, with p.m. requiring less bandwidth than f.m. To overcome the phase ambiguity inherent in a p.m. system, data is differentially encoded before phase shift keying is used, which is actually binary p.m. A phase ambiguity occurs in the receiver as absolute phase reference is not available. This is called differential phase shift keying and uses 180° phase shift of the carrier to represent a 1 and zero phase shift for 0.

A problem that is faced in any kind of modulation scheme is pattern noise. This is due to the fluctuating sidebands caused by the data modulation and becomes especially important when extracting the carrier from the signal. The fluctuating amplitude of the sidebands is attenuated by the carrier filter but the remaining phase fluctuations are irremovable. It exists even if the incoming signal is perfectly free of noise.

A major drawback with multi-user spread spectrum systems is their proneness to self-jamming. If all the received signal amplitudes are approximately the same at all user locations, then the correlation processing gain of the receiver is sufficient to clearly detect each signal separately. In practice however the distances between various users in a multi-user system vary widely and correspondingly the signal strengths vary widely, resulting in jamming of the weaker ones. This situation is commonly referred to as the "near and far problem".

The problem can be reduced by the use of a modulation format that includes a modest amount of signal spreading with signal encoding, while the remainder of the spectrum spreading is accomplished by rapid frequency hopping of the signal in a predetermined sequence over the total band of interest.

### Transmitters

The most popular type of spread spectrum system is the direct sequence system where a pseudo-random sequence is used to spread data. Other methods are frequency hopping, time hopping, or a hybrid between these two. In frequency hopping a sequence switches a frequency synthesizer to hop to different frequencies it switches onto.

The method studied here is the use of direct sequence spreading using sequence inversion-keying modulation at baseband, with differential phase-shift keying for transmission. The sequence inversion keying of the pseudo-random sequence by the data is achieved by modulo-2 addition of the data with the sequence at a rate 1/T, where T is the stretch of one sequence. Sequence inversion keying gives optimum protection against inter-symbol interference and bit error because the detection of half of the sequence provides the decision on the data received. The d.p.s.k.-modulated signal is then passed through a band-pass filter to conserve power, and amplified before radiation in the electromagnetic field.

A "data generator" produces a train of pulses carrying the information, to which are added a fixed number of redundant pulses to facilitate the correlation or detection of errors by the receiver. These data bits are used to sequence-invert a string of 2047 bits, so the 1 is represented by the pseudo-random sequence and 0 is the inverted sequence.

The m-sequence generator is a well-known technique. For a feedback shift register of N bits the sequence produced is of length $2^N-1$. The taps of an eleven-bit feedback shift register was modulo-2 added in a feedback loop to produce the 2047 pseudo-random sequence. The polynomials that would generate the sequence of this length are

$1+x^4+x^{11}$.

$1+x^2+x^5+x^8+x^{11}$

$1+x^2+x^3+x^7+x^{11}$

$1+x+x^4+x^9+x^{11}$

$1+x^9+x^{11}$

The last polynomial offers least complexity in hardware terms.

The sync recognizer in Fig. 2 is a logic gate which gives a pulse each time the intitial state of the feedback shift register is reached. The data are synchronized with the pseudo-random sequence with the help of these pulses. The output of the sik modulator is then used to modulate a carrier by differential phase-shift keying. The clock pulses for all these sequential logic circuits are derived from a stable crystal clock by passing the output through a Schmitt trigger and then dividing down to the required frequencies. The output of the d.p.s.k. modulator is applied to a band-pass filter to restrict power requirements for transmission as well as spill-over into adjacent channels.

Other methods of encoding using pseudo-random sequences include modulating a long sequence with a shorter one to enable use of a short surface-wave matched filter, use of a recirculation loop or charge-coupled devices to reduce synchronization time at the receiver, and the use of a shorter section of the sequence that is a multiple of the number of bits in the f.s.r. used to generate the sequence along with a recirculation loop to enhance the output.

## Receivers

The most complicated part of a spread spectrum communication system is the receiver. It has to perform under the difficult conditions of

- very low signal-to-noise ratio, as low as 30dB
- time uncertainty of receiver sequence-complicated synchronization circuits required
- maintaining synchronization after it is achieved is difficult so code-tracking circuits are required.

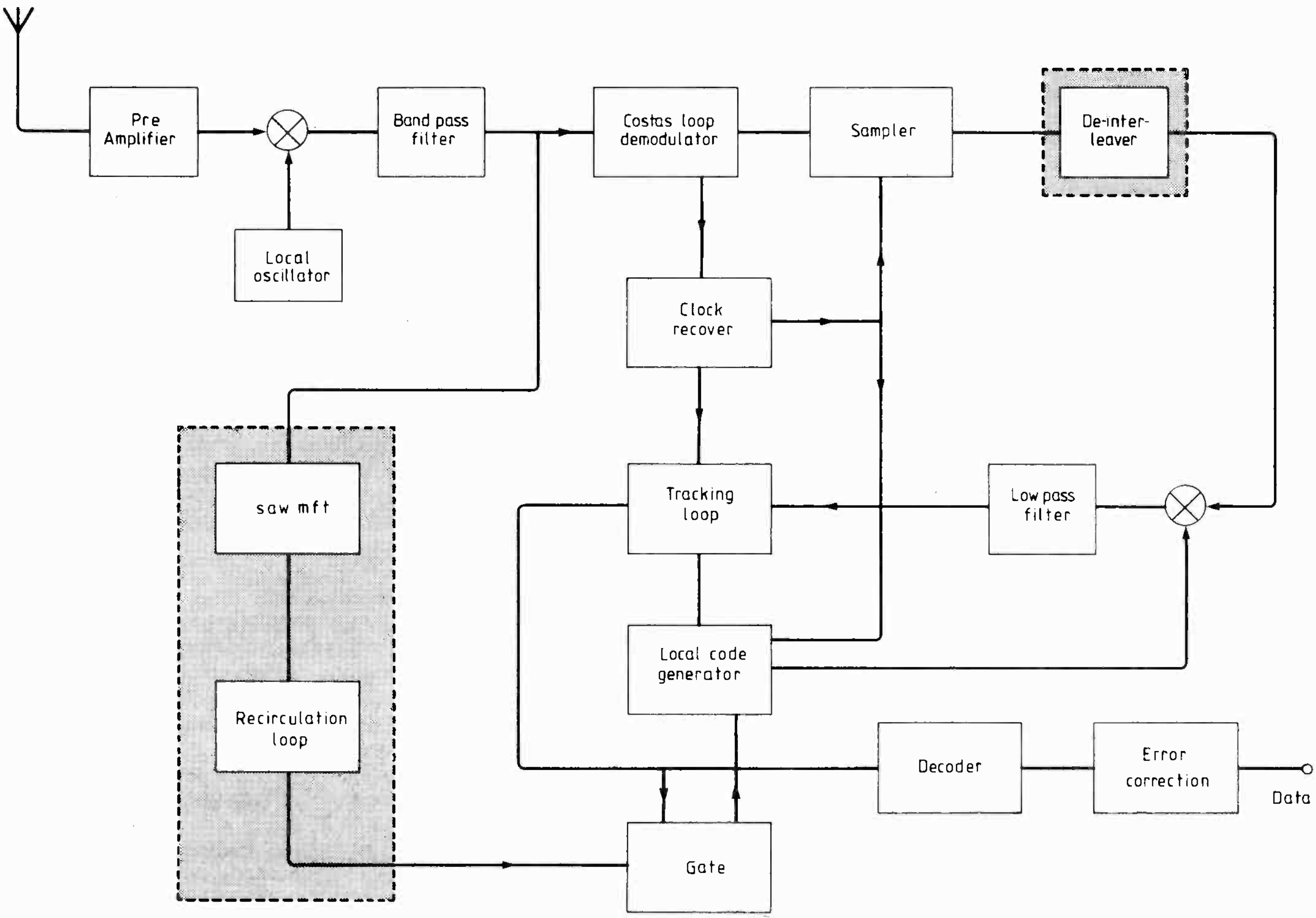
So the design of carrier extraction, clock recovery and demodulation must be such that it can operate at the very low signal-to-noise ratio that is available. The block diagram in Fig. 3 gives a simplified version of the receiver. The operation of each box on the signal input is described below, headed by the labels in the diagram.

**Band-pass filter** following the down-converter has a bandwidth centred at $W_{if}$ and just wide enough to let the data components pass through. This slices off the unnecessary interference and allows the i.f. amplifier to operate effeciently.

**Demodulator.** In search of a d.p.s.k. demodulator which can operate under low signal-to-noise ratio, two sorts of demodulators are favourable – Costa's loop and the squaring loop. They have similar performance, but Costa's loop has some implementation advantage even though tuning is a little more difficult as the two arms (Fig. 4) have to be accurately balanced for satisfactory performance. Once acquired a signal should be introduced to hold the input to the voltage-controlled oscillator steady.

**Surface wave filter and recirculation loop.** The main purpose of using a surface matched filter and recirculation loop is to

*Fig. 3. Design of carrier extraction, clock recovery and demodulation must allow operation of very low s/n route. See text for box descriptions.*



achieve code synchronization so that the local code generator can be synchronized with the received code. As soon as code synchronization is obtained, the tracking loop is switched on and decoding by correlation begins. Further description of acoustic surface-wave matched filters is given later.

**A tracking loop** is needed to stay in lock with the signal. There are two main methods: a tau-dithering loop, and a delay lock loop; the first time-shares a signal correlator, whereas the other uses two separate correlators. They have been found to have almost similar performances: assuming ideal bandpass arm filter the tau-dither loop requires approximately 1dB more S/N than the delay-locked loop, for equal r.m.s. tracking jitters. In a delay-lock loop two local reference signals are generated differing only by a time delay and may be extracted by tapping two adjacent bits in the feedback shift register generating the local sequence. This is used to correlate with the incoming signal. The correlation between output of each correlator is a triangular function two bits wide. Once the system is synchronized and tracked the rest of the operation uses more-or-less conventional circuits.

The received signal is digitally correlated with a locally generated signal and the output filtered. If more than half of the received bits are in error then it is considered to represent the inverted sequence and if they are correct it is a true sequence. The composite correlation function for a delay-lock loop has a double-peaked triangular shape before summing in which one half of the double triangle is inverted so that the composite correlation has a linear region centred around the point half way between the two correlation maxima. When the summed output is filtered and used to control the receiver's voltage controlled oscillator, the receiver's code will track the incoming code at a point half way between the maximum and minimum of the composite correlator output (Fig. 5).

A serious consequence of spectrum spreading is the complexity of the signal processing required to extract the useful information.

With a direct sequence method, the longer the sequence used to spread the data energy, the greater is the security of the system as it resembles noise more closely. But this increases the synchronization problem enormously; with a conventional digital correlator it would take from seconds to half an hour before synchronization is achieved.

Other methods, such as the use of a combination of shorter sequences to form a long one called Gold's code, can be used. The system would then have to look for one of these short codes which would shorten the sync time to some extent; it would also be easy for intruders to synchronize their systems too.

One possible way out is to use a long code, then a matched filter to match a section of the long code. A matched filter requires an accurately synchronized clock to clock the bits in. A small Doppler shift may result in part of the signal being matched at one shift and the remainder at the next shift, so that instead of one high peak one obtains two smaller peaks. To avoid this difficulty the shift register may have 2N stages and be clocked at a rate of twice the frequency of the encoder. The match in this case will not be spoiled for fractional Doppler shift in frequency as large as $D=\pm 1/4N$, where $D=2v/C$.

Acoustic surface wave matched filters have the potential to revolutionise spread spectrum systems. They can be used for analogue matched filters which require no clocking. But the problem is that the longer the code to be matched the greater the cost of fabrication.

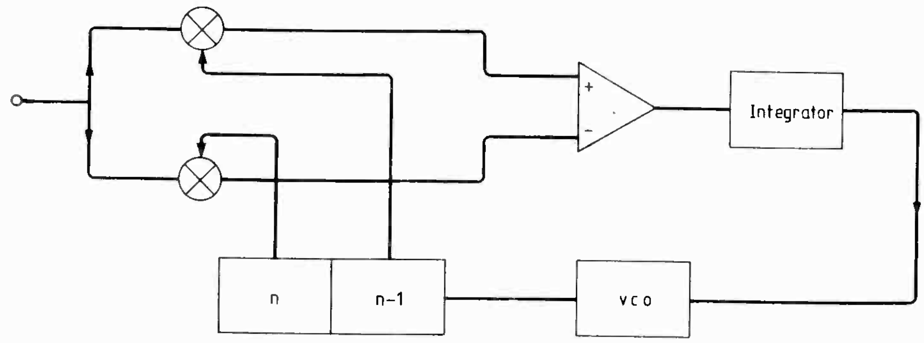



*Fig. 4. A d.p.s.k. demodulator that can operate under low s/n ratio is the Costas loop, which requires accurate balancing of the two arms. Loop filter is similar to that used in phase-locked loops.*

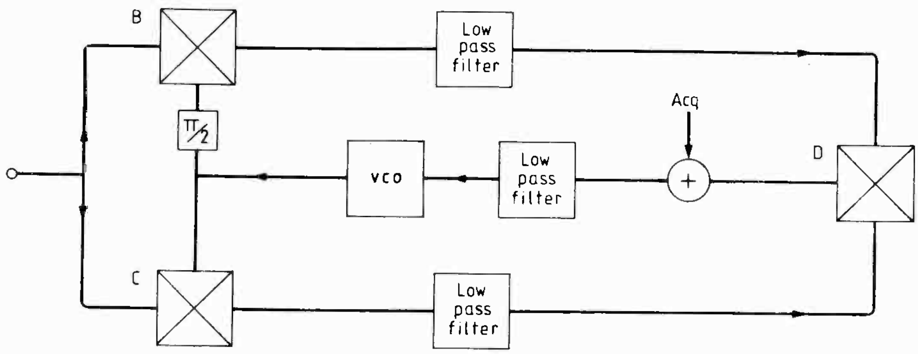



*Fig. 5. Received signal is digitally correlated with local signal and filtered. If more than half of the bits are in error it is taken to represent the inverted sequence, and if correct it is a true sequence. The composite correlation function for a delay-lock loop has a double-peaked triangular shape before summing in which one half of the double triangle is inverted so that the composite correlation has a linear region centred around the point half way between the two correlation maxima. When the summed output is filtered and used to control the receivers voltage controlled oscillator, the receivers code will track the incoming code at a point half way between the maximum and minimum of the composite correlator output.*

**Comparison between surface wave and charge transfer filters.**

| | Surface wave | Charge transfer |
|---|---|---|
| Centre frequency | 10M to IGHz | 20MHz max |
| Insertion loss | 6dB min | nil |
| Storage time | depends on length | 1s |
| Length limited by | losses | c.t.eff.(<2) |
| Signal bandwidth | 50kHz to 0.4f. | <½ clock |

Another sort of long-transversal-type matched filtering may be possible with the help of charge-transfer devices. The principle advantages of c.t.d. transversal filters are tunability and flexibility in spectral characteristic. Filter length is limited by tap-weight inaccuracy and weighting-coefficient error poses a severe limitation on many applications.

If the sequence is of length 2047 bits then the surface-ware matched filter must have pre-programmed or programmable 2047 electrodes plus the launcher electrodes. This increases the fabrication problems, though when used this would give execellent two-valued autocorrelation. So a study was made to reduce the number of electrodes in the matched filter.

In a sequence of length $2^m-1$ bits any section of m bits will appear only once. Called the "window effect", this property is true because the polynomial is primitive, which also implies that if n is an integral number then any consecutive length of mn bits would occur only once. With the help of a computer program, a sequence of length 2047 was generated. Out of these 2047 bits generated by an 11 bit shift register for the length $N=2^m-1$, a set of 11 bits were picked up at random. This set was then slid along the sequence of 2047 bits and the normalized correlation function at all positions calculated. This was tabulated along with the number of times certain values occurred

*agreements − disagreements* / *total number of bits*.

**Sliding correlation for m=11 bits with $2^{11}-1=2047$ in sequence.**

| Normalized correlation of random 11 bit window | Number of times value occurs |
|---|---|
| 1.00 | 1 |
| 0.81 | 10 |
| 0.63 | 55 |
| 0.45 | 165 |
| 0.27 | 330 |
| 0.09 | 461 |
| −1.00 | 1 |
| −0.81 | 10 |
| −0.63 | 54 |
| −0.45 | 160 |
| −0.27 | 329 |
| −0.09 | 460 |

The correlation values are pretty well balanced due to the random characteristic of the occurrence of 0s and 1s. If an eleven-bit matched filter correlates the 2047 bit sequence, the outputs would appear proportional to the correlation values. As the maximum value of 1.00 occurs only once (the autocorrelation function of the 11 bits) and if this can be detected in the output it would drastically reduce the synchronization delay, at much reduced hardware complexity. Unfortunately the next lower value is 0.81, and this occurs ten times in the sequence and would give high sidelobes. In the case of high Gaussian noise it would result in many false alarms.

A second study was made with a randomly picked window of length nm where n=2 i.e. of length 22 bits. The table shows the highest correlation achieved:

| Normalized correlation of random 22 bit window | Number of times value occurs |
|---|---|
| 1.00 | 1 |
| 0.72 | 1 |
| 0.63 | 2 |
| 0.54 | 8 |
| 0.45 | 31 |

So this tends to give slightly improved sidelobe-to-signal characteristic, as expected.

A third program attempted to reduce the sidelobes. This picks up two 11 bits adjacent to each other. If R1 is the value of the correlation of the first 11 bits with the section of the main sequence and R2 for the next 11 bits, then R=R1*R2 is the output of the simulated correlator. This gave some interesting results. The sidelobes were drastically reduced. Also the number of occurrences of the sidelobes or high correlation is much reduced. So most of the time the output remains pretty low, as tabulated below:

| Normalized correlation of random 11 bit window | Number of times value occurs |
|---|---|
| 1.00 | 1 |
| 0.52 | 2 |
| 0.40 | 2 |
| 0.37 | 2 |
| Remainder ≤0.28. | |

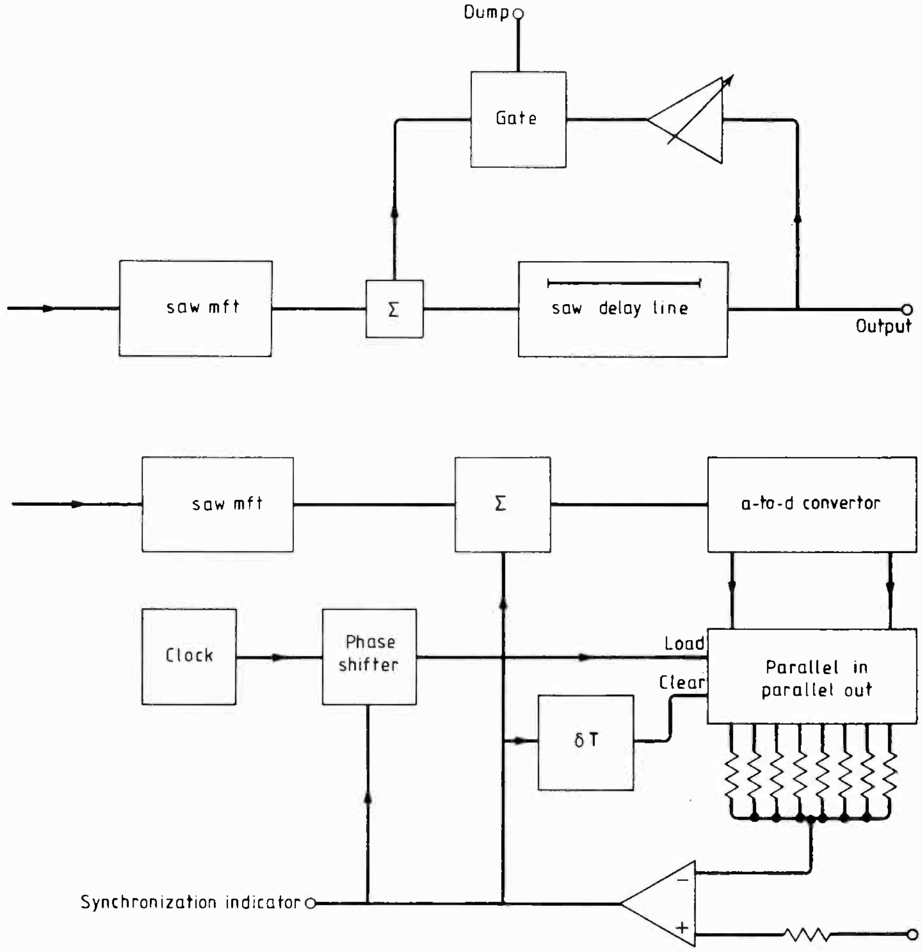



*Fig. 6. Recirculation loop enhances otherwise noisy output. As data rate is fixed, section of the sequence appears after a fixed time T. The first output is delayed by T so that it reaches the input of the summer at the same time as the next output of the filter arrives. The output of the summer would go on increasing until a threshold is reached, when the gate would open and sync achieved. A t.t.l. version of the recirculation loop is shown at bottom.*

*After obtaining an M.Sc. in electronics from the University of Kent at Canterbury, Noman Mahmood worked at the same place as an Experimental Officer for three years. He is presently working as Development Engineer with Chalwest Ltd, subsidiary of the Ladbroke Group, dealing with microprocessor control systems.*

It may therefore be possible to reduce the number of electrodes required in a surface ware device by using two 11-bit matched filters and multiplying the outputs, thus drastically cutting down on the cost of having a long matched filter. In practice the effect of noise would reduce performance of such a device. The output may be amplified using a conventional amplifier, but this would also amplify the noise and sidelobes.

A method using a recirculation loop as in Fig. 6 may be used to enhance the output. As the data rate is fixed our section of the sequence appears after a fixed time T. The first output is delayed by T so that it reaches the input of the summer at the same time as the next output of the filter arrives. The output of the summer would go on increasing until a threshold is reached, when the gate would open and sync would be achieved. False sync cannot occur as it will have to be caused by random errors which do not always occur at the same time. A t.t.l. version of the recirculation loop also shown. WW

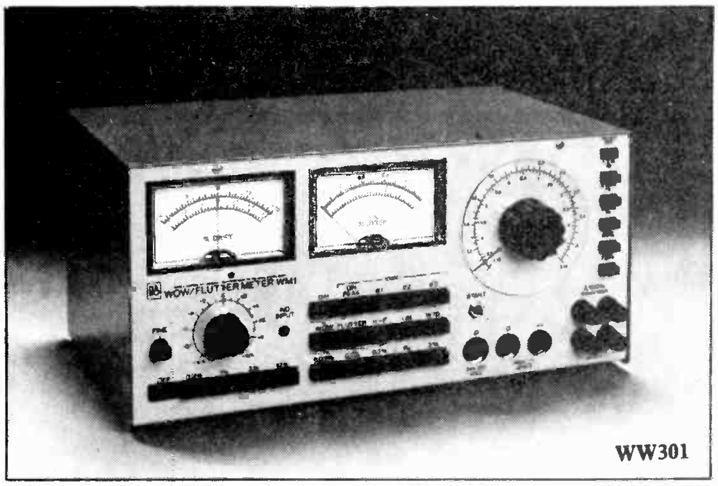
# NEW PRODUCTS

## MEASURING WOW AND FLUTTER

For use in the servicing and testing of recording and sound studio equipment, the Bang & Olufsen wow-and-flutter meter has been improved by the inclusion of a high-stability, crystal-controlled 3.15kHz oscillator for very accurate measurements. Wow from 0.2 to 10Hz, flutter from 10 to 300Hz or wow and flutter combined can be measured linearly or weighted to an accuracy of 0.003%. Drift in speed may be measured from 0.03% to 20% relative to the oscillator frequency.

The WM 1A meter includes a frequency spectrum analyser which can determine which wow or flutter frequencies are dominant and thus help to point to any faulty rotating component, be it idler, belt drive, motor or bearings, etc. The meter costs £682 from David Bisset Ltd, 52 Luton Lane, Redbourn, Herts AL3 7PY.

**WW301**




WW301

## SOLID-STATE RELAYS

The Sigma range of relays are capable of switching 10A a.c. loads and remain unharmed by surges of up to 60A. The design guarantees leakage to be less than 1mA and meets standard requirements for isolation when used in 120 or 240V line applications. The relay is mounted on a heat-sink base which is isolated and has TO-3 spacing for mounting on external heat sink or chassis. Input control voltages range from 3 to 24V with a drive current of 6mA. This, combined with zero-crossing switching eliminates interference and enables the relays to be operated by microprocessor or t.t.l. logic circuits. Zero-crossing switching makes the relays useful in filament lighting applications, providing them with high-speed starting. Unimatic Engineers Ltd, 122 Granville Road, London NW2 2LN.

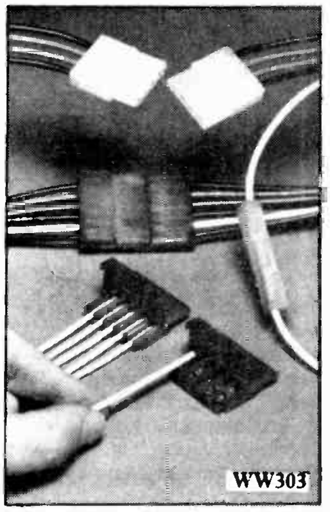
**WW302**


WW302

## UNISEX CONNECTORS

It is no longer necessary to specify male or female when the Jaguar power connectors are used. The manufacturers describe them as hermaphrodite and the contacts are the same for both halves of a connected pair. Wires do not need to be stripped of insulation, as the contacts pierce the insulation when the wires are installed. Various wire gauges may be used in the same connector which is rated at 12A. Various colours are available to indicate which pairs are connected. Different connectors can accommodate one to six wires and various colours are available to identify which pairs are connected. The nylon connectors slide together and are provided with a keyway to hold them. Methode International Inc, PO Box 98, Berkhamsted, Herts HP4 2AT.

**WW303**



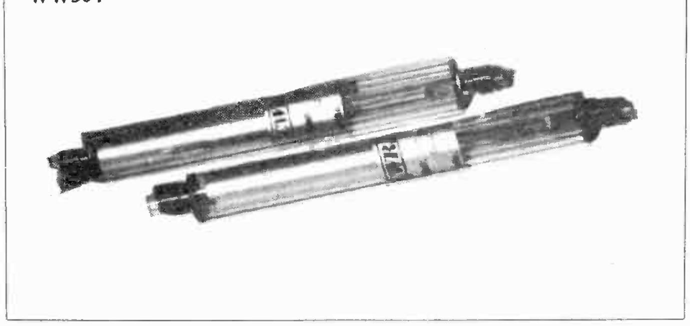
WW303

## MINI LASER TUBES

Intended for use in compact alignment and aiming systems the CWR LT1RG is a miniature HeNe laser tube with an output power of greater than 1mW t.e.m. It gives a 0.64mm diameter output beam with divergence of 1.27mrads. It requires 1150V at 3.5mA to operate and a suitable battery power supply is available. Because of its sturdy construction, the tube may be used in conditions where it may be subject to extreme shock. Laser Lines Ltd, 19 West Bar, Banbury, Oxon OX16 9SA.

**WW304**

WW304



## COMPUTING METER

Based around a 6502 microprocessor, the Thurlby DM 1905a is a 5½-digit bench multimeter with extensive calculating and data-storage facilities. There is 8K of rom which is used to control the a-to-d converter, the display and keyboard, and all the calculating functions.

A full range of measuring functions is available: direct voltage from 1μV to 1,100V; alternating voltage from 10μV to 750V; resistance from 1mΩ to 21MΩ; d.c. from 1nA to 5A and a.c. from 10nA to 5A. Accuracy over a year is 0.015%.

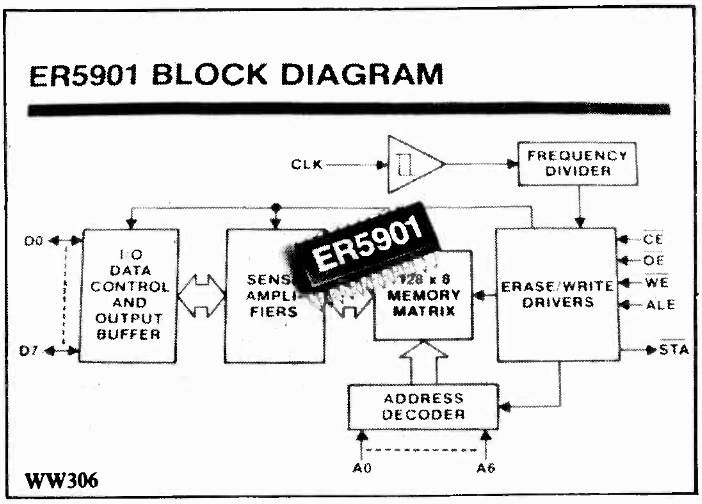
Twenty keys are built in to give access to the computing functions, which include linear scaling with offset, percentage deviation, limits comparison, offset zero, dB and general logarithmic calculations. Automatic data logging is available and up to 100 readings can be stored in memory at programmed intervals. The meter can keep a running average and the highest and lowest of a set of readings. Priced at £298 (+ v.a.t.), Thurlby claim that the meter is in the same bracket as many general purpose d.m.ms that don't have the computing facility. Thurlby Electronics Ltd, Coach Mews, St Ives, Huntingdon, Cambs PE17 4BN.

**WW305**


WW305

# EEPROM CHANGES A WORD AT A TIME

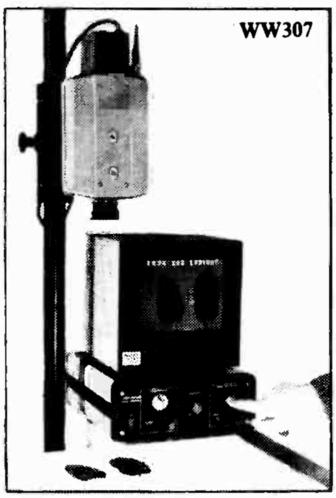
Designed as a replacement for circuit board d.i.p. switches, as may be used in computer terminals, present calibration references in instruments, and intelligent control applications, the ER5901 is a 1k-bit word-alterable electronically erasable prom. It operates at 5V in all modes and has an automatic erase/write cycle, data and address latches are on the chip. Access time is less than 250ns and the minimum data retention capability (how long it remembers) is 10 years. General Instruments Microelectronics Ltd, Times House, Ruislip, Middlesex HA4 8LE.
**WW306**



WW306

# AREA METER

A standard c.c.t.v. camera can be used to measure the area of an object or any image that can be seen in high contrast. The Delta-T area meter displays the area in view, a cumulative total of the areas measured and the number of measurements. Objects moving past the camera can be automatically measured and counted. The readings can be transferred by a digital interface to


WW307

an alarm system for use with process control.

Applications for the meter include industrial control, the measurement of photographs, for example X-rays, the counting and sizing of many things including fish (!), the lengths of roots, studies of diseased leaves, etc.

For those with tv equipment the meter costs £440. It is available as a complete system including tv camera and monitor, camera stand and light box for £990. Prices exclude v.a.t. and freight. The company that manufactures the meter is a workers' co-operative wholly owned and controlled by its nine members. It has expanded in 12 years from its one founder member. Delta-T Devices Ltd, 128 Low Road, Burwell, Cambridge CB5 OEJ.
**WW307**

# TV SOUND RECEIVER

Assuming that a large number of viewers also have hi-fi equipment, Kingsbrook Marketing have designed and developed a tv sound tuner to take full advantage of the transmitted sound by feeding sound to the hi-fi amplifier with a re-modulated r.f. signal to the tv. They claim to use a very high quality tuner which includes a surface acoustic-wave filter. There are six preset channels, of which one may be used for a video recorder. The audio frequency response is 30Hz to 12kHz ±1dB with a total harmonic distortion less than 1%. The tuner incorporates the National Semiconductor dynamic noise reduction (DNR) integrated circuit, and also Viosound, a method of spreading the output between two speakers to give a spacious sound quality.

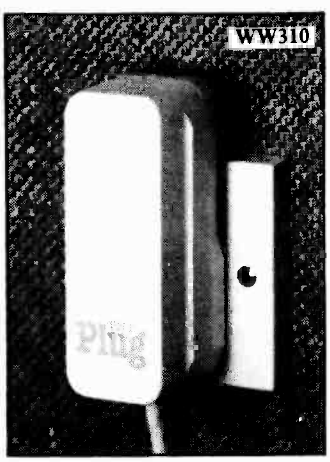
The r.f. output to the tv set is at a fixed frequency (channel 36) so channel switching is transferred to the new tuner. This eliminates the sound distortion of the picture in high signal areas. Its full title is the VT1000 Tele Video Tuner and is available from a number of audio dealers at £99.50. Kingsbrook Marketing Co Ltd, 29 Heathfield, Stacey Bushes, Milton Keynes MK12 6HR.
**WW308**

# VIDEO COLOUR BALANCE METER

In our item on the Invotron Meter (January) it was stated that the meter is used *with* an oscilloscope. In fact it is designed to be used *instead* of a 'scope and, being hand-held, is useful where it is not convenient to use an oscilloscope to check the illumination level for tv studios or outside locations. Invotron, of Dublin, have informed us that the meter is now available in the UK through Shipping Services Ltd, 9/15 Grundy Street, Liverpool L5 9YH.
**WW309**

# MAINS FILTER FOR MICROCOMPUTERS

Spikes and holes in the power supply can cause havoc in a microcomputer. Programs or data can be lost or corrupted. A solution is provided in a mains filter from Power International; fitting into an enlarged 13A plug it is called 'The Plug'. It provides mains voltage, up to 4A current and as well as transient supression it also protects against radio-frequency interference. The Plug may be used on any portable electronic equipment which may need such protection. It costs £15.50 inclusive from Power International Ltd, 2A Isambard Brunel Road, Portsmouth, Hants PO1 2DU.
**WW310**



WW310

# HYBRID ASSEMBLIES

A prototypying service of hybrid circuits using leadless passive components and semiconductors directly mounted on to printed wiring boards, is offered by AB Microelectronics. The process has been developed to provide low power circuitry where miniaturization is essential at low cost. This is possible because of the mechanized assembly methods used.

The degree of miniaturization is comparable to that of thick-film circuits, though the temperature range is restricted to 0 to 85°C for the FR4 circuits. Polyimide circuits have a greater range. The packages have leads at 0.1 in. pitch for both single and dual in-line styles. AB Microelectronics, Dinas, Rhondda, Mid Glamorgan.
**WW311**

# C.R.T. POWER

A power supply specifically for use with high-definition cathode-ray tubes has been developed by Wallis Electronics. The three outputs are for the main anode (10 to 12kV at 25μA beam current), the focus anode (2.4 to 4kV at 250μA) and the third anode (300 to 600V). The focus voltage can be switched to 200V in 100μs to correct for defocusing at the edge of the c.r.t. The unit is intended for c.r.ts with fibre-optic face plates which are used in phototypesetting, computer microfilm storage and other precision applications. It has high stability against changes in supply voltage and is guaranteed a drift of better than 500p.p.m. over eight hours. Wallis Electronics Ltd, Decoy Road, Worthing, Sussex BN14 8ND.
**WW312**

*If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card.*

# LANGREX SUPPLIES LTD

**Climax House, Fallsbrook Rd., Streatham, London SW16 6ED**

**RST** **Tel: 01-677 2424 Telex: 946708** **RST**

## SEMICONDUCTORS

| | |
|---|---|
| AA119 | 0.10 |
| AAY30 | 0.17 |
| AAY30 | 0.17 |
| AAZ13 | 0.15 |
| AAZ15 | 0.15 |
| AAZ17 | 0.15 |
| AC107 | 0.55 |
| AC125 | 0.25 |
| AC126 | 0.25 |
| AC127 | 0.25 |
| AC128 | 0.30 |
| AC141 | 0.28 |
| AC141K | 0.35 |
| AC142 | 0.28 |
| AC142K | 0.35 |
| AC176 | 0.30 |
| AC187 | 0.28 |
| AC188 | 0.28 |
| ACY17 | 1.30 |
| ACY18 | 1.15 |
| ACY19 | 1.10 |
| ACY20 | 1.10 |
| ACY21 | 1.15 |
| ACY39 | 2.50 |
| AD149 | 0.75 |
| AD161 | 0.35 |
| AD162 | 0.35 |
| AF106 | 0.35 |
| AF114 | 0.75 |
| AF115 | 0.75 |
| AF116 | 0.75 |
| AF117 | 0.75 |
| AF139 | 0.33 |
| AF186 | 1.00 |
| AF239 | 0.39 |
| AFZ11 | 4.00 |
| AFZ12 | 4.00 |
| ASY26 | 1.40 |
| ASY27 | 0.90 |

| | |
|---|---|
| ASZ15 | 1.20 |
| ASZ16 | 1.10 |
| ASZ17 | 1.00 |
| ASZ20 | 2.30 |
| ASZ21 | 2.50 |
| AU113 | 2.50 |
| AUY10 | 3.00 |
| AUY10 | 3.00 |
| BA145 | 0.13 |
| BA148 | 0.15 |
| BA154 | 0.10 |
| BA155 | 0.11 |
| BA156 | 0.10 |
| BAW62 | 0.05 |
| BAX13 | 0.06 |
| BAX16 | 0.06 |
| BC107 | 0.16 |
| BC108 | 0.16 |
| BC109 | 0.16 |
| BC113 | 0.15 |
| BC114 | 0.15 |
| BC115 | 0.18 |
| BC116 | 0.19 |
| BC117 | 0.23 |
| BC118 | 0.18 |
| BC125 | 0.18 |
| BC126 | 0.18 |
| BC135 | 0.15 |
| BC136 | 0.19 |
| BC137 | 0.19 |
| BC147 | 0.12 |
| BC148 | 0.12 |
| BC149 | 0.13 |
| BC157 | 0.13 |
| BC158 | 0.13 |
| BC159 | 0.13 |
| BC167 | 0.11 |
| BC170 | 0.11 |
| BC171 | 0.11 |

| | |
|---|---|
| BC172 | 0.11 |
| BC173 | 0.11 |
| BC177 | 0.28 |
| BC178 | 0.28 |
| BC179 | 0.28 |
| BC182 | 0.11 |
| BC183 | 0.11 |
| BC184 | 0.11 |
| BC212 | 0.11 |
| BC213 | 0.11 |
| BC214 | 0.11 |
| BC237 | 0.11 |
| BC238 | 0.11 |
| BC301 | 0.33 |
| BC303 | 0.34 |
| BC307 | 0.11 |
| BC308 | 0.11 |
| BC327 | 0.12 |
| BC328 | 0.12 |
| BC337 | 0.12 |
| BC338 | 0.12 |
| BCY30 | 1.25 |
| BCY31 | 1.50 |
| BCY32 | 1.50 |
| BCY33 | 1.10 |
| BCY34 | 1.00 |
| BCY39 | 3.40 |
| BCY40 | 2.80 |
| BCY42 | 0.30 |
| BCY43 | 0.30 |
| BCY58 | 0.19 |
| BCY70 | 0.17 |
| BCY71 | 0.18 |
| BCY72 | 0.17 |
| BCZ11 | 1.75 |
| BD115 | 0.42 |
| BD121 | 1.70 |
| BD123 | 2.80 |
| BD124 | 2.00 |

| | |
|---|---|
| BD131 | 0.44 |
| BD132 | 0.48 |
| BD135 | 0.40 |
| BD136 | 0.40 |
| BD137 | 0.40 |
| BD138 | 0.48 |
| BD139 | 0.48 |
| BD140 | 0.50 |
| BD144 | 2.00 |
| BD181 | 1.20 |
| BD183 | 0.80 |
| BD2137 | 0.54 |
| BD238 | 0.54 |
| BDX10 | 0.91 |
| BDX32 | 2.00 |
| BDY20 | 1.50 |
| BDY60 | 2.75 |
| BF115 | 0.35 |
| BF152 | 0.16 |
| BF153 | 0.16 |
| BF154 | 0.17 |
| BF159 | 0.17 |
| BF160 | 0.17 |
| BF167 | 0.24 |
| BF173 | 0.30 |
| BF177 | 0.35 |
| BF178 | 0.35 |
| BF179 | 0.35 |
| BF180 | 0.28 |
| BF181 | 0.28 |
| BF182 | 0.30 |
| BF183 | 0.28 |
| BF184 | 0.28 |
| BF185 | 0.30 |
| BF194 | 0.14 |
| BF195 | 0.12 |
| BF196 | 0.13 |
| BF197 | 0.14 |
| BF200 | 0.40 |
| BF224 | 0.25 |
| BF244 | 0.28 |

| | |
|---|---|
| BF257 | 0.27 |
| BF258 | 0.27 |
| BF259 | 0.28 |
| BF336 | 0.34 |
| BF337 | 0.33 |
| BF338 | 0.36 |
| BFS21 | 4.00 |
| BFS28 | 2.25 |
| BFS61 | 0.20 |
| BFS98 | 0.20 |
| BFW10 | 0.97 |
| BFW11 | 0.96 |
| BFX84 | 0.30 |
| BFX85 | 0.30 |
| BFX87 | 0.30 |
| BFX88 | 0.30 |
| BFY50 | 0.25 |
| BFY51 | 0.25 |
| BFY52 | 0.25 |
| BFY64 | 0.30 |
| BFY90 | 0.95 |
| BSX19 | 0.27 |
| BSX20 | 0.27 |
| BSX21 | 0.29 |
| BT106 | 1.20 |
| BTY79/400R | 2.00 |
| BU205 | 1.30 |
| BU206 | 1.50 |
| BU208 | 2.00 |
| BY100 | 0.40 |
| BY126 | 0.13 |
| BY127 | 0.14 |
| BZX61 Series | 0.17 |
| BZY88 Series | 0.10 |
| CRS1/40 | 0.60 |
| CRS3/40 | 0.75 |
| CRS3/60 | 0.90 |
| GEX66 | 3.00 |

| | |
|---|---|
| GEX541 | 5.00 |
| GJ3M | 1.50 |
| GM0378A | 1.75 |
| KS100A | 0.45 |
| MJE340 | 0.60 |
| MJE370 | 0.73 |
| MJE371 | 0.71 |
| MJE520 | 0.47 |
| MJE521 | 0.73 |
| MJE2955 | 1.30 |
| MJE3055 | 1.10 |
| MPF102 | 0.35 |
| MPF103 | 0.35 |
| MPF104 | 0.35 |
| MPF105 | 0.35 |
| MPSA06 | 0.26 |
| MPSA56 | 0.28 |
| MPSU01 | 0.53 |
| MPSU06 | 0.65 |
| MPSU56 | 0.69 |
| NE555 | 0.45 |
| NKT401 | 3.50 |
| NKT403 | 2.50 |
| NKT404 | 2.20 |
| OA5 | 1.20 |
| OA7 | 0.60 |
| OA10 | 0.55 |
| OA47 | 0.12 |
| OA70 | 0.25 |
| OA79 | 0.12 |
| OA81 | 0.17 |
| OA85 | 0.17 |
| OA90 | 0.08 |
| OA91 | 0.08 |
| OA95 | 0.08 |
| OA200 | 0.15 |
| OA202 | 0.15 |
| OA211 | 1.50 |
| OAZ200 | 1.50 |
| OAZ201 | 1.50 |
| OAZ206 | 1.50 |

| | |
|---|---|
| OAZ207 | 1.50 |
| OC16 | 2.50 |
| OC20 | 2.50 |
| OC22 | 2.50 |
| OC23 | 4.00 |
| OC24 | 3.00 |
| OC25 | 1.00 |
| OC26 | 1.50 |
| OC28 | 2.00 |
| OC29 | 2.00 |
| OC35 | 1.50 |
| OC36 | 1.50 |
| OC41 | 0.90 |
| OC42 | 0.90 |
| OC43 | 1.50 |
| OC44 | 0.85 |
| OC45 | 0.65 |
| OC71 | 0.55 |
| OC72 | 1.00 |
| OC73 | 1.00 |
| OC74 | 0.70 |
| OC75 | 0.65 |
| OC76 | 1.00 |
| OC77 | 1.00 |
| OC81 | 0.65 |
| OC81Z | 1.20 |
| OC82 | 0.90 |
| OC83 | 0.80 |
| OC84 | 0.80 |
| OC122 | 2.75 |
| OC123 | 2.00 |
| OC139 | 3.00 |
| OC140 | 4.00 |
| OC141 | 4.25 |
| OC170 | 1.25 |
| OC171 | 1.25 |
| OC200 | 1.50 |
| OC201 | 2.50 |
| OC202 | 2.75 |
| OC203 | 3.00 |
| OC204 | 3.00 |

| | |
|---|---|
| OC205 | 2.75 |
| OC206 | 2.75 |
| OC207 | 2.50 |
| OCP71 | 2.00 |
| ORP12 | 1.00 |
| R2008B | 2.00 |
| R2009 | 2.25 |
| R2010B | 2.00 |
| T1C44 | 0.27 |
| T1C226D | 1.20 |
| T1L209 | 0.16 |
| T1P29A | 0.43 |
| T1P30A | 0.45 |
| T1P31A | 0.33 |
| T1P32A | 0.36 |
| T1P33A | 0.54 |
| T1P34A | 0.67 |
| T1P41A | 0.44 |
| T1P42A | 0.42 |
| T1P2955 | 0.70 |
| T1P3055 | 0.56 |
| T1S43 | 0.43 |
| ZS140 | 0.25 |
| ZS170 | 0.21 |
| ZS178 | 0.54 |
| ZS271 | 0.23 |
| ZS278 | 0.57 |
| ZTX107 | 0.12 |
| ZTX108 | 0.12 |
| ZTX109 | 0.12 |
| ZTX300 | 0.13 |
| ZTX301 | 0.14 |
| ZTX302 | 0.18 |
| ZTX303 | 0.18 |
| ZTX304 | 0.20 |
| ZTX311 | 0.13 |
| ZTX314 | 0.25 |
| ZTX500 | 0.14 |
| ZTX501 | 0.14 |
| ZTX502 | 0.18 |
| ZTX503 | 0.19 |

| | |
|---|---|
| ZTX504 | 0.21 |
| ZTX531 | 0.24 |
| ZTX550 | 0.25 |
| 1N914 | 0.05 |
| 1N916 | 0.09 |
| 1N4001 | 0.06 |
| 1N4002 | 0.06 |
| 1N4003 | 0.06 |
| 1N4004 | 0.07 |
| 1N4005 | 0.09 |
| 1N4006 | 0.11 |
| 1N4007 | 0.12 |
| 1N4009 | 0.07 |
| 1N4148 | 0.04 |
| 1N5400 | 0.13 |
| 1N5401 | 0.13 |
| 1S44 | 0.04 |
| 1S920 | 0.08 |
| 1S921 | 0.09 |
| 2G301 | 1.00 |
| 2G302 | 1.00 |
| 2G306 | 1.00 |
| 2N404 | 1.30 |
| 2N696 | 0.32 |
| 2N697 | 0.32 |
| 2N698 | 0.32 |
| 2N705 | 1.25 |
| 2N706 | 0.25 |
| 2N708 | 0.25 |
| 2N930 | 0.25 |
| 2N1131 | 0.30 |
| 2N1132 | 0.30 |
| 2N1302 | 1.20 |
| 2N1303 | 0.80 |
| 2N1304 | 1.20 |
| 2N1305 | 1.00 |
| 2N1306 | 1.50 |
| 2N1307 | 1.10 |
| 2N1308 | 1.75 |
| 2N1309 | 1.20 |
| 2N1613 | 0.32 |

| | |
|---|---|
| 2N1671 | 5.00 |
| 2N1893 | 0.32 |
| 2N2147 | 4.00 |
| 2N2148 | 3.75 |
| 2N2218 | 0.32 |
| 2N2219 | 0.32 |
| 2N2220 | 0.20 |
| 2N2221 | 0.20 |
| 2N2222 | 0.20 |
| 2N2223 | 4.25 |
| 2N2368 | 0.25 |
| 2N2369A | 0.25 |
| 2N2484 | 0.25 |
| 2N2646 | 0.50 |
| 2N2904 | 0.32 |
| 2N2905 | 0.32 |
| 2N2906 | 0.21 |
| 2N2907 | 0.21 |
| 2N2924 | 0.26 |
| 2N2925 | 0.22 |
| 2N2926 | 0.15 |
| 2N3053 | 0.26 |
| 2N3054 | 0.55 |
| 2N3055 | 0.65 |
| 2N3440 | 0.70 |
| 2N3441 | 0.85 |
| 2N3442 | 1.25 |
| 2N3614 | 2.20 |
| 2N3702 | 0.11 |
| 2N3703 | 0.11 |
| 2N3704 | 0.11 |
| 2N3705 | 0.11 |
| 2N3706 | 0.11 |
| 2N3707 | 0.11 |
| 2N3708 | 0.10 |
| 2N3709 | 0.11 |
| 2N3710 | 0.10 |
| 2N3711 | 0.10 |
| 2N3771 | 1.40 |
| 2N3772 | 1.60 |
| 2N3773 | 1.80 |

| | |
|---|---|
| 2N3819 | 0.30 |
| 2N3820 | 0.39 |
| 2N3823 | 0.60 |
| 2N3866 | 1.00 |
| 2N3904 | 0.17 |
| 2N3905 | 0.17 |
| 2N3906 | 0.17 |
| 2N4058 | 0.20 |
| 2N4059 | 0.20 |
| 2N4060 | 0.16 |
| 2N4061 | 0.16 |
| 2N4062 | 0.16 |
| 2N4124 | 0.16 |
| 2N4126 | 0.16 |
| 2N4286 | 0.15 |
| 2N4288 | 0.18 |
| 2N4289 | 0.18 |
| 2N5457 | 0.32 |
| 2N5458 | 0.32 |
| 2N5459 | 0.32 |
| 2S017 | 10.00 |
| 2S019 | 12.00 |
| 2S026 | 25.00 |
| 2S103 | 1.50 |
| 2S302 | 2.00 |
| 2S303 | 1.50 |
| 2S322 | 3.50 |
| 2S324 | 3.50 |
| 2S701 | 2.00 |
| 2S745A | 0.95 |
| 2S746A | 0.95 |

## VALVES

| | |
|---|---|
| A1834 | 9.00 |
| A2087 | 13.50 |
| A2134 | 17.50 |
| A2293 | 16.00 |
| A2426 | 18.75 |
| A2521 | 22.50 |
| A2900 | 22.50 |
| A3343 | 45.00 |
| AZ31 | 2.75 |
| AZ41 | 2.60 |
| BK448 | 114.90 |
| BK484 | 155.35 |
| BS90 | 58.00 |
| BS452 | 60.00 |
| BS810 | 60.00 |
| BT5 | 58.95 |
| BT17 | 151.00 |
| BT19 | 44.05 |
| BT29 | 349.15 |
| BT69 | 354.80 |
| BT95 | 129.00 |
| CBL31 | 4.00 |
| CL33 | 4.00 |
| CY31 | 3.00 |
| C1K | 20.00 |
| C3A | 22.00 |
| C3JA | 22.00 |
| DA41 | 25.00 |
| DA42 | 18.70 |
| DAF91 | 1.75 |
| DAF96 | 1.75 |
| DET22 | 35.00 |
| DET24 | 49.00 |
| DF91 | 1.75 |
| DF96 | 1.75 |
| DK91 | 1.75 |
| DK92 | 2.00 |
| DK96 | 1.75 |
| DL92 | 2.00 |
| DL94 | 1.75 |
| DL96 | 1.75 |
| DLS10 | 14.00 |
| DLS15 | 12.50 |
| DLS16 | 12.50 |
| DLS19 | 12.50 |
| DM70 | 2.00 |
| DM71 | 2.00 |
| DM160 | 4.75 |
| DY87 | 1.50 |
| DY802 | 1.50 |
| E55L | 22.00 |
| E80CC | 8.81 |
| E80CF | 11.27 |
| E80F | 13.58 |
| E80L | 13.37 |
| E81CC | 8.00 |
| E81L | 12.57 |
| E82CC | 8.10 |
| E83CC | 8.40 |
| E86C | 8.25 |
| E88C | 8.25 |
| E88CC | 8.00 |
| E90CC | 8.61 |
| E90F | 9.90 |
| E91H | 6.25 |
| E92CC | 8.75 |
| E99F | 9.10 |

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|---|---|
| E130L | 18.50 |
| E180CC | 10.50 |
| E180F | 9.90 |
| E182CC | 13.25 |
| E186F | 11.50 |
| E188CC | 8.25 |
| E280F | 22.51 |
| E283CC | 12.00 |
| E288CC | 17.50 |
| EA52 | 32.25 |
| EA76 | 2.50 |
| EABC80 | 1.25 |
| EAC91 | 3.50 |
| EAF42 | 2.50 |
| EAF801 | 2.00 |
| EB41 | 4.00 |
| EB91 | 1.50 |
| EBC33 | 2.50 |
| EBC41 | 2.50 |
| EBC81 | 1.50 |
| EBC90 | 1.25 |
| EBF80 | 1.50 |
| EBF83 | 1.75 |
| EBF89 | 1.50 |
| EBL31 | 6.00 |
| EC90 | 1.25 |
| EC91 | 8.00 |
| EC92 | 1.75 |
| EC157 | 325.40 |
| ECC33 | 4.50 |
| ECC35 | 4.50 |
| ECC40 | 4.50 |
| ECC81 | 1.75 |
| ECC82 | 1.75 |
| ECC83 | 1.75 |
| ECC84 | 1.75 |
| ECC85 | 1.75 |
| ECC86 | 2.50 |
| ECC88 | 2.10 |
| ECC89 | 2.00 |
| ECC91 | 8.93 |
| ECC189 | 2.10 |
| ECC807 | 1.75 |
| ECC808 | 3.50 |
| ECF80 | 1.55 |
| ECF82 | 1.50 |
| ECF86 | 2.50 |
| ECH35 | 3.00 |
| ECH42 | 3.50 |
| ECH81 | 3.00 |
| ECH83 | 2.50 |
| ECH84 | 2.50 |
| ECL80 | 1.50 |
| ECL81 | 1.75 |
| ECL82 | 1.50 |
| ECL83 | 3.00 |
| ECL84 | 1.50 |
| ECL85 | 1.50 |
| ECL86 | 1.75 |
| EF37A | 5.00 |
| EF39 | 2.75 |
| EF40 | 5.00 |
| EF41 | 3.50 |
| EF42 | 4.50 |
| EF50 | 2.50 |
| EF54 | 5.00 |
| EF55 | 3.50 |
| EF80 | 1.75 |
| EF83 | 4.00 |

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|---|---|
| EF85 | 1.75 |
| EF86 | 1.75 |
| EF89 | 2.50 |
| EF91 | 2.95 |
| EF92 | 6.37 |
| EF93 | 1.50 |
| EF94 | 2.50 |
| EF95 | 5.99 |
| EF98 | 2.00 |
| EF183 | 2.00 |
| EF184 | 2.00 |
| EF804S | 12.00 |
| EF805S | 9.80 |
| EH90 | 1.75 |
| EK90 | 1.50 |
| EL32 | 2.50 |
| EL33 | 4.00 |
| EL34MUL | 3.00 |
| EL36 | 2.50 |
| EL41 | 2.80 |
| EL42 | 2.50 |
| EL81 | 5.25 |
| EL83 | 6.00 |
| EL84 | 2.25 |
| EL86 | 2.75 |
| EL90 | 2.25 |
| EL91 | 9.69 |
| EL95 | 2.00 |
| EL156 | 25.00 |
| EL360 | 8.50 |
| EL500/504 | 3.00 |
| EL509 | 7.00 |
| EL821 | 13.00 |
| EL822 | 13.97 |
| EM34 | 5.00 |
| EM80 | 2.50 |
| EM81 | 2.50 |
| EM84 | 2.00 |
| EM85 | 2.75 |
| EM87 | 2.50 |
| EN32 | 17.46 |
| EN91 | 7.50 |
| EN92 | 6.96 |
| EY51 | 2.75 |
| EY81 | 2.50 |
| EY83 | 2.50 |
| EY84 | 9.24 |
| EY86 | 1.75 |
| EY88 | 1.75 |
| EY500A | 3.00 |
| EY802 | 1.75 |
| EZ35 | 1.75 |
| EZ40 | 2.50 |
| EZ41 | 2.50 |
| EZ80 | 1.50 |
| EZ81 | 1.50 |
| EZ90 | 2.00 |
| FW4-500 | 3.50 |
| FW4-800 | 3.50 |
| G1.371K | 35.00 |
| G551K | 12.00 |
| G180.2M | 17.50 |
| G240.2D | 12.00 |
| G400.1K | 17.50 |
| GN4 | 9.00 |
| GN4A | 9.00 |
| GS16 | 16.00 |
| GT1C | 15.00 |
| GU50 | 20.00 |

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|---|---|
| GU51 | 20.00 |
| GXU1 | 15.35 |
| GXU2 | 30.00 |
| GXU3 | 25.00 |
| GXU4 | 44.50 |
| GXU50 | 20.00 |
| GY501 | 3.00 |
| GZ32 | 2.50 |
| GZ33 | 4.75 |
| GZ34 | 3.00 |
| GZ37 | 4.75 |
| KT61 | 5.00 |
| KT66 | 8.00 |
| KT88 | 11.00 |
| KTW61 | 2.50 |
| KTW62 | 2.50 |
| KTW63 | 2.50 |
| M8079 | 12.34 |
| M8080 | 8.25 |
| M8081 | 9.82 |
| M8082 | 9.69 |
| M8083 | 8.58 |
| M8091 | 10.43 |
| M8096 | 6.80 |
| M8097 | 8.10 |
| M8098 | 6.15 |
| M8099 | 8.00 |
| M8100 | 9.52 |
| M8136 | 10.23 |
| M8137 | 10.23 |
| M8140 | 6.00 |
| M8141 | 6.50 |
| M8142 | 8.75 |
| M8144 | 7.50 |
| M8149 | 6.50 |
| M8161 | 9.35 |
| M8162 | 10.40 |
| M8163 | 8.25 |
| M8190 | 5.00 |
| M8195 | 10.85 |
| M8196 | 7.50 |
| M8204 | 7.05 |
| M8212 | 11.37 |
| M8223 | 6.00 |
| M8224 | 6.30 |
| M8225 | 4.50 |
| M8248 | 14.03 |
| MD2901 | 60.00 |
| MU14 | 2.50 |
| MX119 | 55.00 |
| MX123 | 72.00 |
| MX145 | 56.70 |
| MX151 | 17.25 |
| MX152 | 131.25 |
| MX161 | 152.25 |
| MX163 | 20.25 |
| MX164 | 25.52 |
| MX166 | 147.00 |
| MX168 | 48.00 |
| N78 | 15.00 |
| OA2 | 3.25 |
| OA3 | 2.50 |
| OA4 | 6.00 |
| OB2 | 4.35 |
| OB3 | 2.50 |
| OC2 | 4.35 |
| OC3 | 2.50 |
| OD3 | 2.50 |
| OZ4 | 3.50 |

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|---|---|
| PC86 | 2.50 |
| PC88 | 2.50 |
| PC95 | 1.75 |
| PC97 | 1.75 |
| PC900 | 1.75 |
| PCC84 | 1.50 |
| PCC85 | 1.50 |
| PCC88 | 2.00 |
| PCC89 | 1.75 |
| PCC189 | 2.50 |
| PCC805 | 1.60 |
| PCC806 | 1.60 |
| PCE82 | 2.00 |
| PCF80 | 2.00 |
| PCF82 | 1.50 |
| PCF86 | 2.50 |
| PCF87 | 2.00 |
| PCF200 | 3.25 |
| PCF201 | 3.25 |
| PCF801 | 2.50 |
| PCF802 | 2.50 |
| PCF805 | 1.70 |
| PCF806 | 1.70 |
| PCF808 | 1.70 |
| PCL82 | 2.00 |
| PCL83 | 3.00 |
| PCL84 | 2.00 |
| PCL85 | 2.50 |
| PCL86 | 2.50 |
| PCL805/85 | 2.50 |
| PD500 | 6.00 |
| PE06-40N | 30.00 |
| PFL200 | 2.50 |
| PL36 | 2.50 |
| PL81 | 1.75 |
| PL81A | 2.00 |
| PL82 | 1.50 |
| PL83 | 2.50 |
| PL84 | 2.00 |
| PL504/5 | 2.50 |
| PL508 | 2.50 |
| PL509 | 6.00 |
| PL519 | 6.00 |
| PL801 | 1.50 |
| PL802 | 6.00 |
| PPV03-10 | 14.00 |
| PY33 | 2.50 |
| PY81 | 1.75 |
| PY82 | 1.50 |
| PY83 | 2.50 |
| PY88 | 2.00 |
| PY500A | 3.00 |
| PY800 | 1.50 |
| PY801 | 1.50 |
| QQV02-6 | 16.50 |
| QQV03-20A | 48.38 |
| QQV06-40A | 48.38 |
| QQV07-50 | 66.90 |
| QQZ06-40A | 62.20 |
| QU37 | 12.50 |
| QV03-12 | 6.80 |
| QV04-7 | 3.50 |
| QV08-100 | 136.85 |
| QY3-65 | 54.26 |
| QY3-125 | 60.40 |

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|---|---|
| QY4-250 | 73.15 |
| QY4-400 | 76.80 |
| QY5-500 | 175.00 |
| QY5-3000A | 335.00 |
| QZ06-20 | 32.70 |
| R10 | 6.00 |
| R17 | 3.00 |
| R18 | 3.00 |
| R19 | 9.24 |
| R20 | 2.50 |
| RG3-250 | 32.68 |
| RG3-250A | 32.68 |
| RG3-1250 | 59.50 |
| RG4-1250 | 61.60 |
| RG4-3000 | 99.45 |
| RR3-250 | 40.00 |
| RR3-1250 | 45.75 |
| S11E12 | 65.00 |
| S130 | 6.00 |
| S130P | 6.00 |
| STV280-40 | 14.00 |
| STV280-80 | 21.00 |
| SU41 | 5.00 |
| SU42 | 10.00 |
| TD03-10 | 35.00 |
| TD03-10F | 35.00 |
| TT15 | 35.00 |
| TT21 | 23.00 |
| TT22 | 23.00 |
| TT100 | 60.00 |
| TY2-125 | 60.00 |
| TW4-400 | 71.40 |
| TY4-500 | 98.35 |
| TY5-500 | 175.00 |
| TY6-800 | 188.00 |
| TY6-5000A | 375.00 |
| TY6-5000B | 395.00 |
| TY6-5000W | 325.00 |
| TY7-6000A | 374.00 |
| TY7-6000W | 303.60 |
| TZ40 | 25.00 |
| U18-20 | 3.50 |
| U19 | 13.75 |
| U25 | 2.50 |
| U26 | 2.50 |
| U37 | 12.00 |
| UABC80 | 1.25 |
| UAF42 | 2.50 |
| UB41 | 3.00 |
| UBC41 | 2.25 |
| UBF89 | 1.50 |
| UCC84 | 1.75 |
| UCC85 | 1.85 |
| UCF80 | 2.00 |
| UCH42 | 2.50 |
| UCH81 | 2.50 |
| UCL82 | 1.75 |
| UCL83 | 2.75 |
| UF41 | 2.00 |
| UF42 | 2.10 |
| UF80 | 1.75 |

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|---|---|
| UF85 | 1.75 |
| UF89 | 2.00 |
| UL41 | 3.50 |
| UL84 | 1.75 |
| UM80 | 2.00 |
| UY41 | 2.25 |
| UY85 | 2.25 |
| VLS631 | 15.00 |
| XG1-2500 | 45.80 |
| XG2-6400 | 141.90 |
| XG5-500 | 26.60 |
| XG2-6400 | 162.00 |
| XR1-1600A | 53.75 |
| XR1-3200 | 81.97 |
| XR1-3200A | |
| XR1-6400 | 102.00 |
| YD1120 | 395.00 |
| YD1240 | 351.00 |
| Z759 | 25.00 |
| ZM1000 | 8.00 |
| ZM1001 | 8.00 |
| ZM1020 | 9.00 |
| ZM1021 | 9.00 |
| ZM1022 | 9.00 |
| ZM1023 | 9.00 |
| ZM1040 | 19.36 |
| ZM1041 | 16.66 |
| ZM1042 | 17.77 |
| 1B3GT | 3.00 |
| 1B24 | 25.00 |
| 1B35A | 48.00 |
| 1B63 | 64.00 |
| 1R5 | 1.75 |
| 1S5 | 1.75 |
| 1T4 | 1.75 |
| 2AS15 | 11.50 |
| 2C39A | 60.00 |
| 2C43 | 70.00 |
| 2D21 | 3.25 |
| 2E26 | 8.25 |
| 2J42 | 98.00 |
| 2J55 | 175.00 |
| 2J70A | 383.00 |
| 2J70B | 336.00 |
| 2K25 | 125.00 |
| 3-400Z | 85.00 |
| 3-500Z | 85.00 |
| 3A5 | 3.00 |
| 3B24 | 11.00 |
| 3B28 | 15.35 |
| 3B29 | 20.00 |
| 3B240M | 17.50 |
| 3B241M | 17.50 |
| 3C23 | 25.00 |
| 3C45 | 24.50 |
| 3CX100A5 | 47.00 |
| 3E29 | 45.00 |
| 3S4 | 2.00 |
| 3V4 | 1.75 |
| 465A | 60.00 |
| 4-125A | 60.00 |
| 4-250A | 80.00 |
| 4-400A | 87.00 |
| 4B32 | 20.00 |

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|---|---|
| 4C35 | 78.00 |
| 4CX250B | 40.00 |
| 4CX350A | 73.00 |
| 4X150A | 60.00 |
| 4X150D | 56.00 |
| 5B254M | 35.00 |
| 5B255M | 35.00 |
| 5C22 | 160.00 |
| 5J180E | 1650.00 |
| 5R4GY | 3.50 |
| 5U4G | 3.00 |
| 5U4GB | 2.50 |
| 5V4G | 2.50 |
| 5Y3GT | 2.50 |
| 5Z3 | 4.00 |
| 5Z4G | 2.50 |
| 5Z4GT | 2.50 |
| 6-30L2 | 1.75 |
| 6AB4 | 1.75 |
| 6AB7 | 3.00 |
| 6AC7 | 3.00 |
| 6AF4A | 4.25 |
| 6AG7 | 3.00 |
| 6AH6 | 5.00 |
| 6AK5 | 7.10 |
| 6AK6 | 2.50 |
| 6AL5 | 1.50 |
| 6AM4 | 4.00 |
| 6AM5 | 9.69 |
| 6AM6 | 6.00 |
| 6AN5 | 4.75 |
| 6AN8A | 3.50 |
| 6AQ5 | 2.25 |
| 6AS6 | 8.66 |
| 6AS7G | 8.75 |
| 6AT6 | 1.25 |
| 6AU5GT | 5.00 |
| 6AU6 | 2.50 |
| 6AV5GA | 4.50 |
| 6AV6 | 1.50 |
| 6AX5GT | 3.00 |
| 6B7 | 3.25 |
| 6B8 | 3.25 |
| 6BA6 | 1.50 |
| 6BA7 | 5.00 |
| 6BA8A | 4.00 |
| 6BC4 | 4.00 |
| 6BE6 | 1.50 |
| 6BH6 | 2.50 |
| 6BJ6 | 2.25 |
| 6BK4 | 4.50 |
| 6BL6 | 85.00 |
| 6BL7GT | 4.50 |
| 6BM6 | 115.00 |
| 6BN6 | 2.00 |
| 6BQ7A | 3.50 |
| 6BR7 | 6.00 |
| 6BR8A | 3.50 |
| 6BS7 | 6.00 |
| 6BW6 | 6.00 |
| 6BW7 | 1.50 |
| 6BX7GT | 5.00 |
| 6BZ6 | 2.75 |
| 6C4 | 1.25 |
| 6CB6A | 2.50 |
| 6CD6GA | 5.00 |
| 6CG7 | 2.50 |
| 6CH6 | 13.00 |
| 6CL6 | 3.75 |

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|---|---|
| 6CW4 | 8.00 |
| 6D2 | 1.50 |
| 6DK6 | 3.00 |
| 6DQ6B | 4.75 |
| 6EA8 | 3.00 |
| 6EB8 | 2.50 |
| 6EW6 | 2.25 |
| 6F6 | 3.00 |
| 6F23 | 1.60 |
| 6F28 | 1.60 |
| 6F33 | 33.50 |
| 6H1 | 14.00 |
| 6H2N | 2.75 |
| 6H3N | 2.75 |
| 6H6 | 3.00 |
| 6J4 | 5.50 |
| 6J6 | 8.93 |
| 6J7 | 4.75 |
| 6K4N | 2.50 |
| 6K6GT | 2.75 |
| 6K7 | 3.00 |
| 6K8 | 3.00 |
| 6KD6 | 7.00 |
| 6L6G | 3.00 |
| 6L6GA | 2.25 |
| 6L6GT | 2.25 |
| 6L6GC | 2.25 |
| 6L7 | 2.50 |
| 6N2P | 2.50 |
| 6N3P | 2.50 |
| 6N7 | 3.00 |
| 6P25 | 4.00 |
| 6Q7 | 3.75 |
| 6R7 | 3.25 |
| 6SA7 | 3.00 |
| 6SC7 | 2.75 |
| 6SF7 | 2.50 |
| 6SH7 | 3.00 |
| 6SJ7 | 3.25 |
| 6SK7 | 3.50 |
| 6SK7GT | 3.00 |
| 6SN7GT | 3.00 |
| 6SQ7 | 3.40 |
| 6SR7 | 4.00 |
| 6SS7 | 2.75 |
| 6U5G | 3.50 |
| 6U8A | 2.25 |
| 6V6GT | 2.25 |
| 6X4 | 2.00 |
| 6X5GT | 1.75 |
| 7B7 | 2.50 |
| 7C5 | 4.00 |
| 7C6 | 2.50 |
| 7H7 | 4.00 |
| 7R7 | 4.25 |
| 7S7 | 3.50 |
| 7Y4 | 2.25 |
| 7Z4 | 2.00 |
| 11E3 | 55.00 |
| 12AH8 | 5.00 |
| 12AT6 | 1.50 |
| 12AT7 | 1.75 |
| 12AU6 | 2.50 |
| 12AU7 | 1.75 |
| 12AV6 | 2.50 |
| 12AV7 | 3.50 |
| 12AX7 | 1.75 |
| 12AY7A | 4.00 |
| 12B4A | 3.50 |

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|---|---|
| 12BA6 | 2.50 |
| 12BE6 | 2.50 |
| 12BH7 | 1.50 |
| 12BY7 | 3.00 |
| 12E1 | 20.00 |
| 12E11TT | 170.00 |
| 12E14 | 35.00 |
| 13E1 | 20.00 |
| 19H4 | 27.50 |
| 19H5 | 47.50 |
| 24B9 | 67.25 |
| 30C15 | 2.00 |
| 30C17 | 2.00 |
| 30C18 | 2.00 |
| 30F5 | 1.60 |
| 30FL1/2 | 1.38 |
| 30FL12 | 1.80 |
| 30FL14 | 2.00 |
| 30L1 | 1.50 |
| 30L15 | 2.00 |
| 30L17 | 2.00 |
| 30P4 | 2.50 |
| 30P19 | 2.50 |
| 30PL1 | 3.00 |
| 30PL14 | 1.80 |
| 30PL15 | 1.80 |
| 35W4 | 1.00 |
| 50C5 | 1.50 |
| 75B1 | 6.05 |
| 75C1 | 3.50 |
| 85A1 | 7.50 |
| 85A2 | 4.45 |
| 90AG | 12.96 |
| 90AV | 12.96 |
| 90C1 | 6.00 |
| 90CG | 14.54 |
| 90CV | 15.45 |
| 92AG | 12.96 |
| 92AV | 12.96 |
| 95A1 | 8.45 |
| 150B2 | 6.50 |
| 150B3 | 8.35 |
| 150C2 | 3.25 |
| 150C4 | 6.00 |
| 211 | 35.00 |
| 723AB | 125.00 |
| 803 | 25.00 |
| 805 | 45.00 |
| 807 | 3.75 |
| 811A | 18.33 |
| 812A | 18.33 |
| 813 | 125.86 |
| 833A | 193.16 |
| 866A | 20.03 |
| 872A | 20.00 |
| 922 | 6.00 |
| 931A | 18.52 |
| 1624 | 4.00 |
| 1625 | 3.50 |
| 2050 | 17.46 |
| 4212E | 3.00 |
| 4212H | 300.00 |
| 5544 | 81.97 |
| 5545 | 102.00 |
| 5551A | 114.90 |
| 5552A | 155.35 |
| 5642 | 9.00 |
| 5654 | 3.00 |
| 5651 | 4.45 |

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|---|---|
| 5670 | 4.50 |
| 5675 | 28.00 |
| 5687 | 6.00 |
| 5696 | 4.50 |
| 5718 | 7.50 |
| 5725 | 5.50 |
| 5726 | 11.37 |
| 5727 | 7.05 |
| 5749 | 2.50 |
| 5751 | 4.00 |
| 5763 | 4.50 |
| 5814A | 4.00 |
| 5840 | 4.00 |
| 5842 | 12.00 |
| 5876A | 31.50 |
| 5879 | 5.00 |
| 5886 | 12.50 |
| 5963 | 2.50 |
| 5965 | 3.50 |
| 6005 | 2.25 |
| 6021 | 4.50 |
| 6057 | 10.23 |
| 6058 | 12.34 |
| 6059 | 6.00 |
| 6061 | 6.00 |
| 6063 | 3.75 |
| 6064 | 8.58 |
| 6067 | 10.23 |
| 6072 | 6.00 |
| 6080 | 14.00 |
| 6097A | 235.00 |
| 6097B | 200.00 |
| 6146A | 8.25 |
| 6146B | 8.25 |
| 6159B | 19.00 |
| 6189 | 9.55 |
| 6201 | 11.40 |
| 6442 | 20.00 |
| 6883B | 17.54 |
| 6973 | 4.00 |
| 7025 | 3.00 |
| 7551 | 6.25 |
| 7586 | 12.00 |
| 7587 | 18.50 |
| 7609 | 56.00 |
| 7868 | 6.00 |
| 7895 | 12.00 |
| 8005 | 110.49 |
| 8068 | 14.00 |
| 8122 | 90.00 |
| 8136 | 2.50 |
| 8417 | 6.00 |
| 18042 | 11.53 |
| 18045 | 10.49 |

Tested Ex-Equipment
4CX250B 6.50

## BASES

| | |
|---|---|
| B7G unskirted | 0.22 |
| B7G skirted | 0.30 |
| B9A unskirted | 0.22 |
| B9A skirted | 0.30 |
| Int Octal | 0.35 |
| Loctal | 0.55 |
| Nuvistor base | 0.75 |
| 8 pin DIL | 0.15 |
| 14 pin DIL | 0.15 |
| 16 pin DIL | 0.17 |
| Valve screening cans all sizes | 0.30 |

## CRTs

| | |
|---|---|
| 2AP1 | 8.50 |
| 2BP1 | 9.00 |
| 3BP1 | 20.00 |
| 3DP1 | 5.00 |
| 3EG1 | 10.00 |
| 3FP7 | 6.00 |
| 3GP1 | 6.00 |
| 3JP1 | 8.00 |
| 3JP2 | 8.00 |
| 3JP7 | 10.00 |
| 3KP1 | 15.00 |
| 3RP1 | 35.00 |
| 3WP1 | 20.00 |

| | |
|---|---|
| 5ADP1 | 35.00 |
| 5BP1 | 10.00 |
| 5CP1 | 10.00 |
| 5CP1A | 40.00 |
| 5FP15A | 15.00 |
| 5UP7 | 25.00 |
| DG7-5 | 63.32 |
| DG7-31 | 58.07 |
| DG7-32 | 58.07 |
| DH3-91 | 56.83 |
| DH7-11 | 113.12 |
| VCR97 | 12.00 |
| VCR138 | 12.00 |
| VCR138A | 12.50 |
| VCR139A | 8.00 |

| | |
|---|---|
| VCR517A | 10.00 |
| VCR517B | 10.00 |
| VCR517C | 10.00 |

Tube Bases Prices on application

## INTEGRATED CIRCUITS

| | |
|---|---|
| 7400 | 0.16 |
| 7401 | 0.17 |
| 7402 | 0.17 |
| 7403 | 0.17 |
| 7404 | 0.18 |
| 7405 | 0.18 |
| 7406 | 0.43 |
| 7407 | 0.43 |
| 7408 | 0.20 |
| 7409 | 0.20 |
| 7410 | 0.17 |
| 7412 | 0.29 |
| 7413 | 0.32 |
| 7416 | 0.32 |
| 7417 | 0.32 |
| 7420 | 0.18 |
| 7422 | 0.20 |

| | |
|---|---|
| 7423 | 0.33 |
| 7425 | 0.30 |
| 7427 | 0.30 |
| 7428 | 0.43 |
| 7430 | 0.17 |
| 7432 | 0.30 |
| 7433 | 0.40 |
| 7437 | 0.32 |
| 7438 | 0.32 |
| 7440 | 0.32 |
| 7441 | 0.90 |
| 7442 | 0.72 |
| 7447AN | 1.17 |
| 7450 | 0.18 |
| 7451 | 0.18 |
| 7453 | 0.18 |
| 7454 | 0.18 |

| | |
|---|---|
| 7460 | 0.18 |
| 7470 | 0.38 |
| 7472 | 0.33 |
| 7473 | 0.38 |
| 7474 | 0.38 |
| 7475 | 0.54 |
| 7476 | 0.42 |
| 7480 | 0.56 |
| 7482 | 0.75 |
| 7483 | 1.00 |
| 7484 | 1.05 |
| 7486 | 0.39 |
| 7490 | 0.60 |
| 7491 | 0.82 |
| 7492 | 0.60 |
| 7493 | 0.60 |
| 7494 | 0.82 |

| | |
|---|---|
| 7495 | 0.73 |
| 7496 | 0.82 |
| 7497 | 3.15 |
| 74100 | 1.54 |
| 74107 | 0.45 |
| 74109 | 0.73 |
| 74110 | 0.51 |
| 74111 | 0.71 |
| 74116 | 1.85 |
| 74118 | 1.00 |
| 74119 | 1.54 |
| 74120 | 0.83 |
| 74121 | 0.43 |
| 74122 | 0.62 |
| 74123 | 1.18 |
| 74125 | 0.58 |
| 74126 | 0.58 |
| 74128 | 0.63 |
| 74132 | 0.72 |

| | |
|---|---|
| 74136 | 0.51 |
| 74141 | 0.89 |
| 74142 | 2.30 |
| 74143 | 2.60 |
| 74144 | 2.60 |
| 74145 | 1.00 |
| 74147 | 2.00 |
| 74148 | 1.76 |
| 74150 | 1.80 |
| 74151 | 0.94 |
| 74154 | 1.80 |
| 74155 | 0.90 |
| 74156 | 0.90 |
| 74157 | 0.75 |
| 74159 | 2.20 |
| 74170 | 2.40 |
| 74172 | 4.40 |
| 74173 | 1.42 |
| 74174 | 1.60 |

| | |
|---|---|
| 74175 | 1.02 |
| 74176 | 1.16 |
| 74178 | 1.36 |
| 74179 | 1.36 |
| 74180 | 1.20 |
| 74190 | 1.90 |
| 74191 | 1.90 |
| 74192 | 1.90 |
| 74193 | 1.90 |
| 74194 | 1.25 |
| 74195 | 1.20 |
| 74196 | 1.35 |
| 74197 | 1.35 |
| 74198 | 2.70 |
| 74199 | 2.30 |
| 76013N | 1.76 |
| TAA570 | 2.30 |
| TAA630S | 3.50 |
| TAA700 | 3.90 |

| | |
|---|---|
| TBA480Q | 1.84 |
| TBA520Q | 2.30 |
| TBA530 | 1.98 |
| TBA540Q | 2.30 |
| TBA550Q | 3.22 |
| TBA560CQ | 3.22 |
| TBA673 | 2.20 |
| TBA700 | 1.52 |
| TBA720Q | 2.30 |
| TBA750Q | 2.07 |
| TBA800 | 1.20 |
| TBA920 | 2.90 |
| TBA920Q | 2.90 |
| TBA990Q | 2.90 |
| TCA270Q | 2.90 |
| TCA760A | 1.38 |

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WW-11



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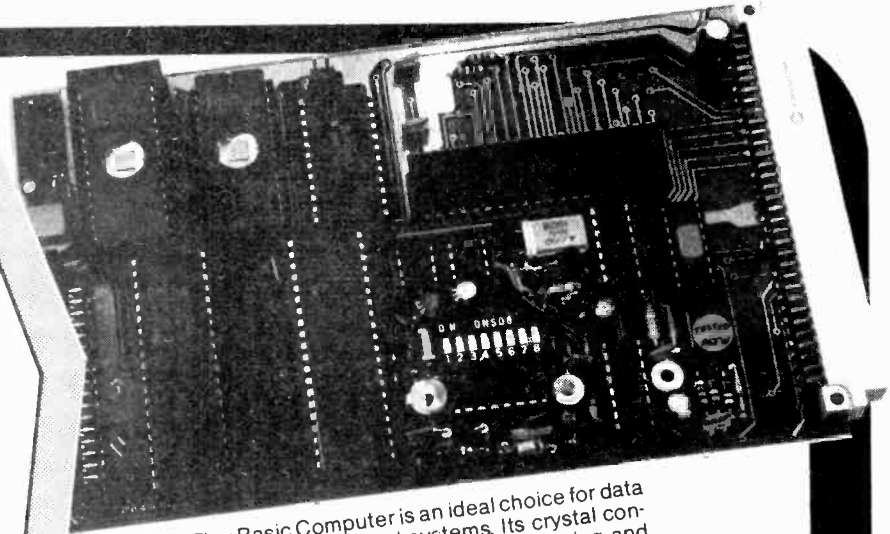
# Essex Tiny Basic System



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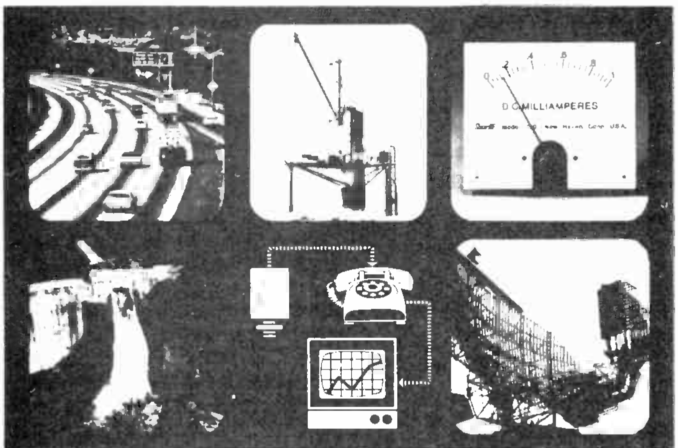


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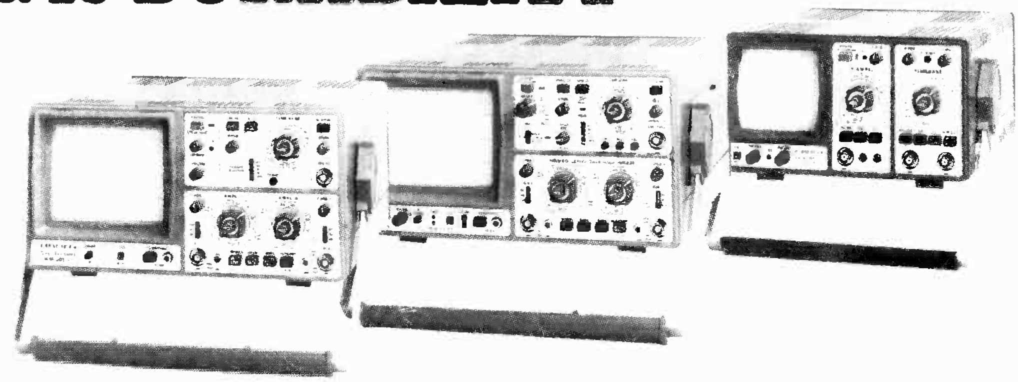

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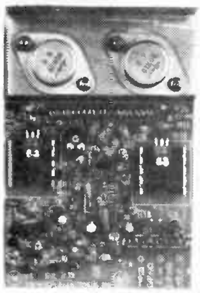
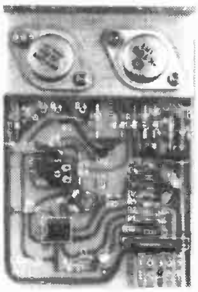
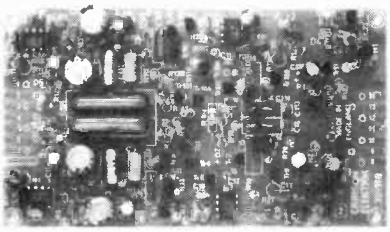


POWER AMPLIFIERS



POWER AMPLIFIERS



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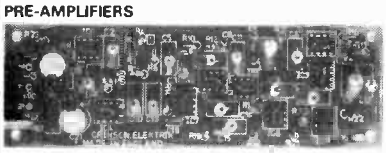
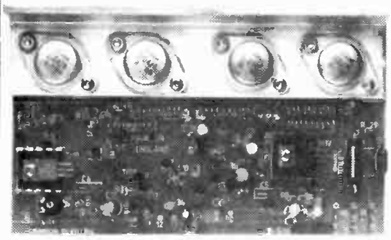


ACTIVE CROSSOVERS



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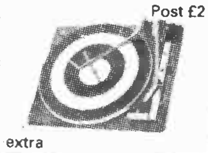

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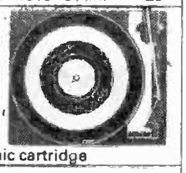

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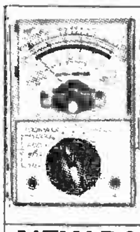
**NEON INDICATORS 250V,** round **40p.** Rectangular **45p.**

## POTENTIOMETERS Carbon Track

5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.**

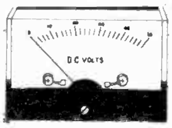
## MINI-MULTI TESTER NEW



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. **£6.50**
DC amps 0-250µA, 0-250mA. Post 50p
Resistance 0 to 600K ohms.

**De Luxe Range Doubler Model, 50,000 o.p.v. £18.50.** 7×5×2in. Post £1

## NEW PANEL METERS £4.50



50µa, 100µa, 500µa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp 25 volt, VU Meter. 2¼×2×1¼ Post 50p
Stereo VU meter 3¼×1⅝×1in. **£3**

## RCS SOUND TO LIGHT CONTROL BOX

Complete ready to use with cabinet size 9×3×5in. 3 channel, 1000 watt each. For home or disco Input 200mV to 100 watt. AC 200/250V. Post £1. **£27**
**OR KIT OF PARTS £19.50, LESS CABINET £15**
Disco bulbs 100 watt, blue, green, yellow, red, amber, screw or bayonet **£1.85** each. Post £1.50 per six.
Rope lights, 4 channel, 11ft with controller **£33.** PP £1.
**"FUZZ"** lights, red, blue, green, amber, 240V AC. **£23.**
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post £1.50. 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 **£3.50** Post 65p

## MAINS TRANSFORMERS

| | Price | Post |
|---|---|---|
| 250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A | £6.00 | £2 |
| 350-0-350V 250mA, 6.3V 6A CT | £12.00 | £2 |
| 220V 25ma 6V lamp £2.50. 220V 45ma 6V 2 Amp | £4.00 | £1 |
| 250V 60mA, 6V 2A | £4.75 | £1 |

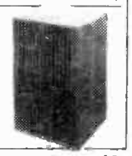
**AUTO** 115V to 240V 150W **£9.** 250W **£10.** 400W **£11.** 500W **£12.00** £2

## GENERAL PURPOSE LOW VOLTAGE

| Tapped outputs available | Price | Post |
|---|---|---|
| 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V | £6.00 | £2 |
| 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 | £6.00 | £2 |
| 2 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 | £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 | £1 | 15-0-15V 2 amps | £4.50 | £1 |
| 6V ½ amp | £2.00 | £1 | 20V 1 amp | £4.00 | £1 |
| 6-0-6V 1½ amp | £3.50 | £1 | 20-0-20V 1 amp | £4.50 | £1 |
| 9V 250ma | £1.50 | £1 | 20-40-60V 1 amp | £4.50 | £2 |
| 9V 3 amp | £3.50 | £1 | 25-0-25V 2 amps | £4.50 | £1 |
| 9-0-9V 50ma | £1.50 | £1 | 28V 1 amp Twice | £6.00 | £2 |
| 10-0-10V 2 amps | £4.00 | £1 | 30V 1½ amp | £4.50 | £1 |
| 10-30-40V 2 amps | £4.50 | £1 | 30V 5 amp and | | |
| 12V 100ma | £1.50 | £1 | 17-0-17 2a | £5.50 | £2 |
| 12V 750 ma | £2.50 | £1 | 35V 2 amps | £4.50 | £1 |
| 12V 3 amps | £4.50 | £1 | TOROIDAL 30-0-30V 4a | | |
| 12-0-12V 2 amps | £4.50 | £1 | and 20-0 20V ½a | £10.00 | £2 |
| **CHARGER TRANS** | | Post | **RECTIFIERS** | | Post |
| 6-12 volt 3a | | £4.00+£2 | 6-12 volt 2a | | £1.10+80p |
| 6-12 volt 4a | | £6.50+£2 | 6-12 volt 4a | | £2.00+80p |

## OPUS COMPACT SPEAKERS £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** Wire ends 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; 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 **80p.**
1000mF 12V **20p**; 25V **35p**; 50V **50p**; 100V **70p.**
2000mF 6V **25p**; 30V **42p**; 40V **60p**; 1500mF 100V **£1.20.**
2200mF 63V **90p.** 2500mF 50V **70p**; 3000mF 50V **65p**;
4500mF 64V **£2.** 4700mF 63V **£1.20.** 4700mF/30V **75p.**

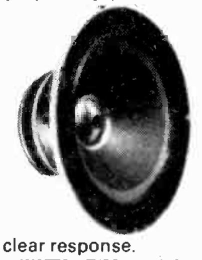
**HIGH VOLTAGE ELECTROLYTICS**

| | | | | | |
|---|---|---|---|---|---|
| 2/500V | 45p | 32+32+16/350V | 90p | 8+8/500V | £1 |
| 8/450V | 45p | 100+100/275V | 65p | 8+16/450V | 75p |
| 16/350V | 45p | 150+200/275V | 70p | 16+16/350V | 80p |
| 32/500V | 95p | 220/450V | 95p | 32+32/350V | 85p |
| 32/350V | 50p | 32+32+32/325V | 75p | 32+32/500V | £1.80 |
| 50/450V | 95p | 50+50+50/350V | 95p | 50+50/300V | 50p |

**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 150V **10p.** 400V **20p.** 630V **30p.** 1000V **60p.**
**TRIMMERS** 30pF, 50pF, **10p.** 100pF, 150pF **20p.** 500pF **30p.**
**MICROSWITCH SINGLE POLE CHANGEOVER 40p.**
**TWIN GANG,** 120pF **£1.** 500+200pF **£1. GEARED TWIN GANGS** 25pF **95p.** 365+365+25+25pF **£1.**
**BRASS SPINDLE EXTENDERS 85p.** Couplers **65p.** Vernier drive dials, 36mm **£2.25,** 50mm **£2.75.**
**TRANSISTOR TWIN GANG.** Japanese Replacement **£1**
**SOLID DIELECTRIC 100pf £1.50, 500pf £1.50**

**HEATING ELEMENTS, WAFER THIN (Semi Flexible)**
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.

## NEW baker Star sound



high power full range quality loudspeakers British made exceptional reproduction. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling is required with quality results. The high flux ceramic magnet ensures clear response.

| MODEL | INCHES | OHMS | WATTS | TYPE | PRICE | POST |
|---|---|---|---|---|---|---|
| MAJOR | 12 | 4-8-16 | 30 | HI-FI | £16 | £2 |
| DELUXE MK II | 12 | 8 | 15 | HI-FI | £16 | £2 |
| SUPERB | 12 | 8-16 | 30 | HI-FI | £26 | £2 |
| AUDITORIUM | 12 | 8-16 | 45 | HI-FI | £24 | £2 |
| AUDITORIUM | 15 | 8-16 | 60 | HI-FI | £37 | £2 |
| GROUP 45 | 12 | 4-8-16 | 45 | PA | £16 | £2 |
| GROUP 75 | 12 | 4-8-16 | 75 | PA | £20 | £2 |
| GROUP 100 | 12 | 8-16 | 100 | Guitar | £26 | £2 |
| DISCO 100 | 12 | 8-16 | 100 | Disco | £26 | £2 |
| GROUP 100 | 15 | 8-16 | 100 | Guitar | £35 | £2 |
| DISCO 100 | 15 | 8-16 | 100 | Disco | £35 | £2 |

## BAKER AMPLIFIERS BRITISH MADE



**NEW PA150 MICROPHONE PA AMPLIFIER £129**
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 sockets. Post £3.

**BAKER 150 Watt AMPLIFIER 4 Inputs £99**
For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state. Post £2.
**MONO SLAVE VERSION £80. 100 Volt Line Model £104.** Post £2.
**New Stereo Slave Model 150 + 150 watt £125.** Post £4.

**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.
**40-watt** RMS 12v DC, AC 240v, 4 inputs. 50K **£75** PP £2
**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

**Battery only Portable PA Amplifier** 10w max. Includes mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, parties, etc. Batteries included (6 of U2) **£27.50** post £2.

**R.C.S. 100 watt Robust VALVE AMPLIFIER**

4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm. Disco group. **£125.** Carr. & ins. £15.

## FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

| MAKE | MODEL | SIZE | WATTS | OHMS | PRICE | POST |
|---|---|---|---|---|---|---|
| SEAS | TWEETER | 4in | 50 | 8 | £9.50 | £1 |
| GOODMANS | TWEETER | 3½in | 25 | 8 | £4 | £1 |
| AUDAX | TWEETER | 4in | 30 | 8 | £6.50 | £1 |
| SEAS | MID-RANGE | 4in | 50 | 8 | £7.50 | £1 |
| SEAS | MID-RANGE | 4½in | 100 | 8 | £12.50 | £1 |
| AUDAX | WOOFER | 5½ | 25 | 8 | £10 | £1 |
| GOODMANS | HIFAX | 7½×4¼ | 100 | 4/8/16 | £27 | £2 |
| GOODMANS | WOOFER | 8in | 25 | 4/8 | £6.50 | £1 |
| GOODMANS | HB | 8in | 60 | 8 | £12.50 | £1 |
| WHARFEDALE | WOOFER | 8in | 30 | 8 | £9.50 | £2 |
| AUDAX | WOOFER | 10in | 50 | 8 | £16 | £2 |
| GOODMANS | HPG | 12in | 120 | 8/15 | £29.50 | £2 |
| GOODMANS | GR12 | 12in | 90 | 8/15 | £27.50 | £2 |
| GOODMANS | HPD | 12in | 120 | 8/15 | £29.50 | £2 |
| GOODMANS | HPD | 18in | 230 | 8 | £80 | £4 |

**SPEAKER COVERING MATERIALS.** Samples Large S.A.E.
**B.A.F. LOUDSPEAKER CABINET WADDING** 18in wide **35p** ft.

**MOTOROLA PIEZO ELECTRIC HORN TWEETER,** 3⅜in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7⅜x3⅛in. **£10**

**CROSSOVERS. TWO-WAY** 3000 c/s 30 watt 8 **£3.** 100W **£4.**
3-way 950 cps/3000 cps. 40 watt rating. **£4.** 3 way 60 watt **£6.** 100W **£8.**
**LOUDSPEAKER BARGAINS.** Please enquire, many others.
**3 ohm,** 5in, 7×4in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£3.50.** 10in, **£5.**
**8 ohm,** 2⅝in, 3in, **£2**; 5×3in, 6×4in, 7×4in, 5in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£4.50**; 10in, **£5**; 12in, **£6.**
**15 ohm,** 2¼in, 3½in, 5×3in, 6×4in, **£2.50.** 6½in 10W **£5.** 8in **£4.**
**25 ohm,** 3in, **£2**; 5×3in, 6×4in, 7×4in, **£2.50. 120 ohm,** 3¼in dia. **£1.**
**CAR CASSETTE MECHANISM.** 12V Controlled Motor Stereo Head **£5**

## R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

**£3.95.** Post 65p
All parts and instructions with Zener diode printed circuit, mains transformer 240V a.c. Output 6 or 7½ or 9 or 12V d.c. up to 100mA or less. Please state voltage required.

# RADIO COMPONENT SPECIALISTS

**Dept 1, 337 WHITEHORSE ROAD, CROYDON**
Open 9-6. Closed all day Wed. Open Sat. 9-5.

Radio Books and Components Lists 25p stamps. (Minimum post/packing charge 50p.) Access or Barclaycard Visa. Tel: 01-684 1665 for SAME DAY DESPATCH. Cash prices include VAT.

# HEMMINGS ELECTRONICS AND MICROCOMPUTERS

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*Shop open Mon.-Sat. 9 a.m.-5.30 p.m.*
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**Professional quality electronic components, brand new and fully guaranteed. Mail order by return of post. Cash/Cheque/POs or Banker's Draft with order, payable to Hemmings Electronics Ltd. Official orders from schools, colleges and universities welcome. Trade and export enquiry welcome. P.&P. add 45p to all orders under £10. Telephone your Access orders, using our 24-hr. Ansaphone service. Please send SAE for full price list.**
**VAT – All prices exclusive of VAT – Please add 15% to total cost including P.&P.**
**No VAT on export orders or books.**

## COMPUTER ICs

| | |
|---|---|
| 6502 | 350p |
| 6522 | 340p |
| 6800 | 290p |
| 68B00 | 450p |
| 6802 | 345p |
| 6809 | 845p |
| 68B09 | 1350p |
| 6809E | 1295p |
| 6810 | 120p |
| 6821 | 160p |
| 68B21 | 215p |
| 6840 | 390p |
| 68B40 | 580p |
| 6844 | 1295p |
| 6845 | 795p |
| 6850 | 140p |
| 6852 | 250p |
| 6854 | 680p |
| 6875 | 490p |
| 8T26A | 120p |
| 8T28 | 120p |
| 8T95 | 90p |
| 8T96 | 90p |
| 8T97 | 90p |
| 8T98 | 90p |
| 8035L | 340p |
| 8039L | 290p |
| 8080A | 360p |
| 8085A | 450p |
| 8155 | 450p |
| 8212 | 155p |
| 8216 | 100p |
| 8224 | 160p |
| 8226 | 195p |
| 8228 | 250p |
| 8243 | 210p |
| 8251 | 300p |
| 8253 | 450p |
| 8255 | 280p |
| 8257 | 450p |
| 8259 | 450p |
| 8279 | 460p |
| 75451 | 65p |
| 75452 | 65p |
| 75491 | 70p |
| 75492 | 70p |
| AY-3-1015D | 300p |
| AY-5-1013A | 300p |
| MC1408 | 295p |
| MC1488 | 55p |
| MC1489 | 55p |
| MC3459 | 265p |
| Z80ACPU | 350p |
| Z80APIO | 300p |
| Z80ACTC | 300p |
| Z80ADART | 750p |

## MEMORIES

| | |
|---|---|
| 2114L | 90p |
| 2708 | 220p |
| 2716 | 210p |
| 2532 | 380p |
| 2732 | 380p |
| 4116 | 85p |
| 4164 | 500p |
| 6116 | 390p |
| 6116L | 480p |

## LINEAR ICs

| | |
|---|---|
| AY-3-1270 | 725p |
| AY-3-1350 | 360p |
| AY-3-8910 | 435p |
| AY-3-8912 | 620p |
| AY-5-1230 | 450p |
| 709 | 35p |
| 741 8 pin | 25p |
| 741 14 pin | 25p |
| 741S | 55p |
| 747 | 65p |
| 748 | 35p |
| CA3080E | 70p |
| CA3130E | 75p |
| LA4422 | 295p |
| LF355 | 80p |
| LF356 | 90p |
| LF357 | 100p |
| LM301A | 26p |
| LM307 | 50p |
| LM308A | 95p |
| LM311N | 66p |
| LM324 | 35p |
| LM339 | 50p |
| LM348 | 75p |
| LM358 | 60p |
| LM380 | 95p |
| LM381 | 150p |
| LM393 | 90p |
| LM3909 | 85p |
| MC1310P | 210p |
| MC1455 | 66p |
| MC1456 | 135p |
| MC1458 | 35p |
| MC3242A | 630p |
| MC3302 | 95p |
| MC3340 | 120p |
| MC3401 | 65p |
| MC3403 | 70p |
| MC3456 | 107p |
| MC3480 | 580p |
| MC34001 | 58p |
| NE555 | 16p |
| 555CMOS | 90p |
| NE556 | 55p |
| NE565 | 155p |
| NE567 | 140p |
| TA7205A | 125p |
| TBA480Q | 175p |
| TBA530Q | 140p |
| TBA540Q | 130p |
| TBA550Q | 280p |
| TBA560CQ | 160p |
| TBA750 | 280p |
| TBA800 | 90p |
| TBA820 | 95p |
| TBA820M | 85p |
| TBA920 | 190p |
| TBA990Q | 190p |
| TCA650 | 390p |
| TCA910 | 180p |
| TDA1004 | 290p |
| TL061 | 40p |
| TL062 | 60p |
| TL064 | 98p |
| TL071 | 30p |
| TL072 | 50p |
| TL074 | 100p |
| TL081 | 25p |
| TL082 | 45p |
| TL084 | 95p |
| UPC575 | 149p |
| UPC1167 | 158p |
| UPC2002V | 285p |
| UPD7002 | 450p |
| ZN414 | 100p |

## LIQUID CRYSTAL DISPLAY MODULES

PCIM177 Frequency Counter
5 Digits, 0.35" FM, SW, MW, MHz, KHz Annunciators
Sample and Hold Capability
Reset Capability
25 Selectable IF Offsets
Prescaler Available
Incandescent Backlighting
Supply Voltage 5v
Operating Current 4mA
**£17.15**

PCIM 176 Digital Meter Module
3 1/2 digits, 0.5"
+, – and Decimal Point
200mV Full Scale Input
True Differential Input
Guaranteed 'O' Reading
Single 9v Operation
Power Consumption 20mW
Accuracy 0.15%, +/– 1 Count
Temperature drift 80ppm/C
Low Battery Indicator
Incandescent Backlighting
**£22.50**

All modules are supplied with Data Sheet.

## FIBRE OPTIC POLYMER CABLE

A 10m coil of 1mm core optical fibre cable sheathed in black polyethylene for protection £4.95

## 8" FLOPPY DISK DRIVES

Secondhand, manufactured by CDC – 400KByte. SSSD – perfect condition with data.
**Only £90 Inc. VAT**
Carriage £3

WW-3

## CONNECTORS

### BNC SERIES

| | |
|---|---|
| Free Plug 50 ohm | 83p |
| Chassis Socket 50 ohm "D" fixing hole | 74p |

### "D" TYPE

| | Male | Female | Hoods Top Entry |
|---|---|---|---|
| 9 way | 90p | 110p | 60p |
| 15 way | 130p | 155p | 64p |
| 25 way | 160p | 210p | 67p |
| 37 way | 220p | 270p | 75p |

(Wire Wrap)

| | |
|---|---|
| 37 way Female | 270p |

(IDC Type)

| | |
|---|---|
| 25 way Male | 450p |
| 25 way Female | 500p |

### DC CONNECTORS

| | |
|---|---|
| Plug 2.1mm, 2.5mm or 3mm, Short or Long Reach | 20p |
| Socket 2.1mm or 2.5mm | 20p |

### DIN SERIES

| | Line Plug | Line Socket | Chassis Socket |
|---|---|---|---|
| 2 pin | 10p | 10p | 9p |
| 3 pin | 15p | 21p | 21p |
| 4 pin | 18p | 21p | 21p |
| 5 pin 180 | 20p | 21p | 21p |
| 5 pin 240 | 20p | 21p | 21p |
| 5 pin 360 | 20p | – | – |
| 6 pin | 20p | 22p | 22p |
| 7 pin | 22p | 22p | 24p |

### EUROCARD DIN 41612 2x32 WAY

| | 2 Row | 3 Row a+c |
|---|---|---|
| Socket | 290p | 290p |
| Socket (IDC) | 450p | 500p |
| Plug (Solder) | 195p | 195p |
| Plug (W/wrap) | | 320p |

### IC SOCKETS

| | Low Profile | Wire Wrap | Turned Pin |
|---|---|---|---|
| 8 pin | 9p | 30p | 26p |
| 14 pin | 10p | 38p | 35p |
| 16 pin | 11p | 45p | 38p |
| 18 pin | 16p | – | – |
| 20 pin | 18p | 60p | 70p |
| 22 pin | 24p | – | – |
| 24 pin | 24p | 70p | 53p |
| 28 pin | 28p | 95p | 67p |
| 40 pin | 30p | 120p | 102p |

| | | |
|---|---|---|
| Zero Insertion Force Socket | 24 pin | 550p |
| | 40 pin | 750p |

### IDC (SPEEDBLOCK TYPE)

| | Header Plug | Socket with Strain Relief |
|---|---|---|
| 10 way | 90p | 90p |
| 20 way | 140p | 125p |
| 26 way | 175p | 150p |
| 34 way | 200p | 175p |
| 40 way | 220p | 200p |
| 50 way | 240p | 240p |

## ALFAC ETCH RESIST TRANSFERS

Make your own Printed Circuit Boards with our PCB transfers
★ Draw your artwork on 0.1" grid
★ Transfer to copper board using carbon paper
★ Burnish the Alfac transfers to the board using a spatula using carbon marks to assist in accurate alignment
★ Use Alfac chemical eraser to correct mistakes
★ Etch in Ferric Chloride

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EC902/1 0.156" Edge Connector
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EC944 0.061" Lines
EC945 0.079" Lines
EC946 0.100" Lines
EC947 0.124" Lines
EC950/1 0.031" 90° Bends
EC950/2 0.061" 90° Bends
EC952/1 0.031" 30°, 45°, 60° Bends
EC952/2 0.061" 30°, 45°, 60° Bends
EC908 0.063" Pads
EC910 0.094" Pads
EC911 0.189" Pads
EC960/1 TO-5 Transistor Pads
EC993/1 IC Pads
EC997/1 IC Pads with tracks between pads
5 identical sheets in sealed pack 195p

| | |
|---|---|
| Individual sheets | 45p |
| Spatula AR4 for burnishing | 45p |
| Alfac knife | 180p |
| Spare Blades (pack of 10) | 280p |
| Alfac Eraser | 40p |

Alfac Precision Grids: Polyester film, matt finish 0.14mm thickness, 20 lines/in
A3 199p A4 100p
Double Sided Fibreglass Board 1/16" thickness, 1oz Copper
5"×4" 25p; 5"×8" 45p

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| Bulgin P551 8 Pin Plug | 220p |
| Bulgin P552 8 Pin Socket | 75p |
| Cassette Mains Lead 2m Reversible Connector | 70p |
| Cassette Mains Plug Non-reversible | 28p |
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| 22-01-2065 | 6 Pole | 8p |
| 22-01-2075 | 7 Pole | 8p |
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| 22-01-2095 | 9 Pole | 10p |
| 22-01-2105 | 10 Pole | 11p |
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| 22-01-2155 | 15 Pole | 14p |

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|---|---|
| Crimp Contacts for Housings 08-50-0136 | 3p |
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| PCB Wafer Straight Square Pin 22-03-2151 15 Pole | 38p |
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| Plug Blue, Yellow, Red, Black | 15p |
| Plug Screened | 22p |
| Line Socket Blue, Yellow Red, Black, White, Green | 15p |
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| 4 Way In-line Socket | 30p |
| Socket/Socket Adaptor | 25p |

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| Standard | 10p |
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| TV Coax Plug | 20p |
| TV Coax Line Socket | 45p |

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| 3mm Green LD37C | 15p |
| Panel Clip | 4p |
| 3mm Chrome Bezel | 35p |
| 5mm Red CQY40L | 10p |
| 5mm Green, Yellow | 15p |
| Panel Clip | 4p |
| 5mm Chrome Bezel | 42p |
| 5mm Square Red | 25p |
| Green, Yellow | 30p |
| Tri-colour V518P | 70p |
| Red Flashing CQX21 3Hz at 5V | 45p |

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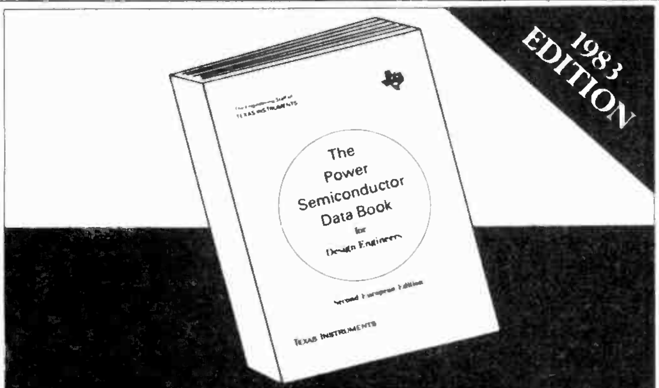


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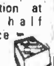

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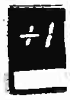

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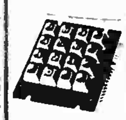

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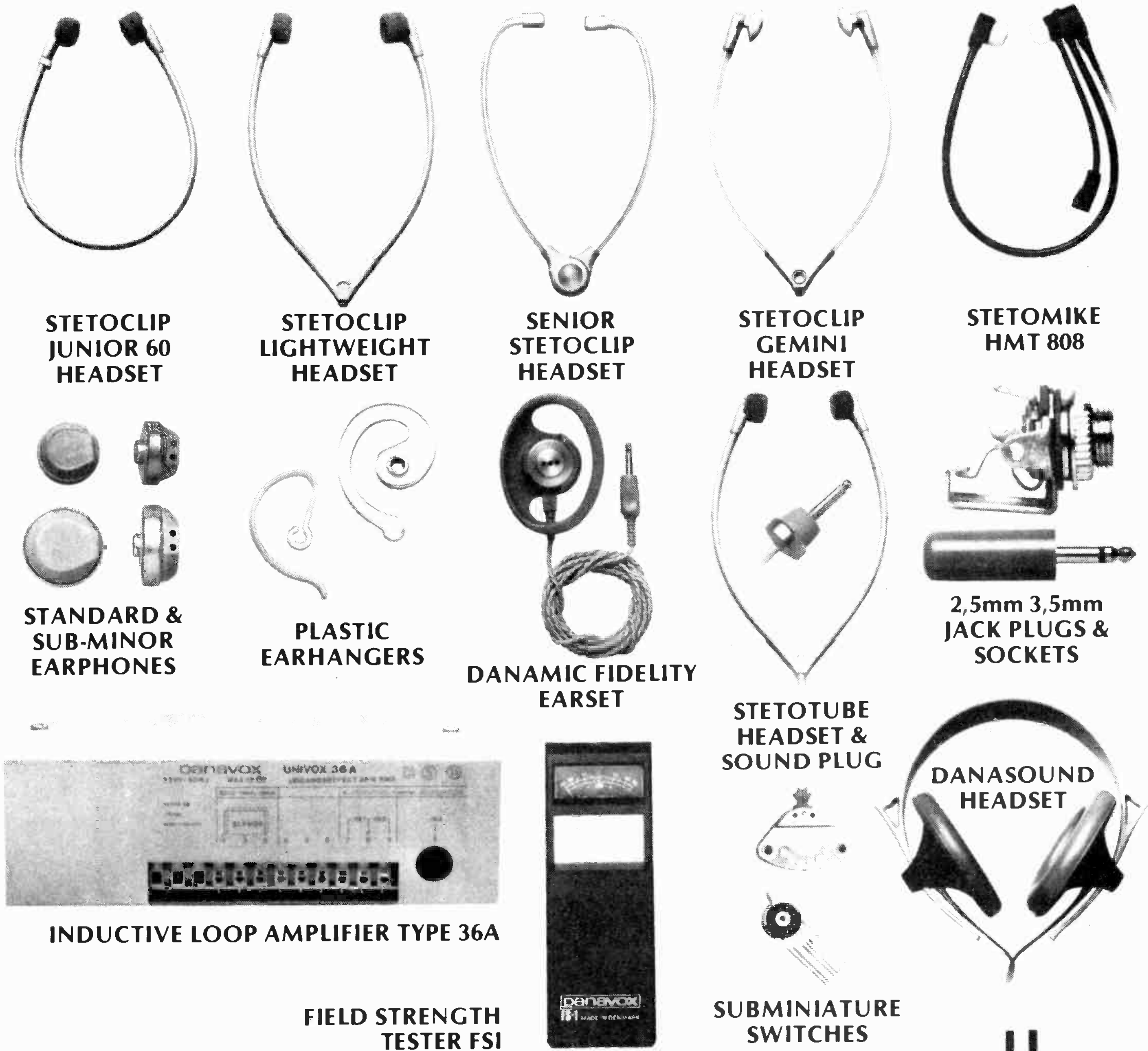


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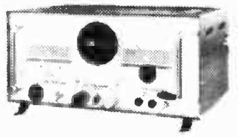

Type 250VRU/30/25

OUTPUT 1 0-30v, 25A DC

OUTPUT 2 0-70v, 10A AC

OUTPUT 3 0-250v, 4A AC

ALL Continuously Variable

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|---|---|
| AN124 | 2.50 |
| AN214Q | 2.50 |
| AN240P | 2.80 |
| AN612 | 2.15 |
| AN7150 | 2.95 |
| BA521 | 3.35 |
| ETT6016 | 1.75 |
| HA1366W | 1.95 |
| LA1230 | 1.15 |
| LA4031P | 2.70 |
| LA4102 | 2.95 |
| LA4400 | 4.15 |
| LA4422 | 2.50 |
| LC7120 | 3.25 |
| LC7130 | 3.50 |
| LC7131 | 5.50 |
| LC7137 | 5.50 |
| LM324N | 0.45 |
| LM380N | 0.95 |
| LM383T | 2.95 |
| LM390N | 1.95 |
| M51513L | 2.30 |
| M51515L | 2.95 |
| MB3712 | 2.00 |
| MC1307P | 1.00 |
| MC1310P | 1.50 |
| MC1327 | 0.95 |
| MC1327Q | 0.95 |
| MC1330P | 0.95 |
| MC1349P | 1.20 |
| MC1350P | 0.76 |
| MC1351P | 1.50 |
| MC1352P | 1.25 |
| MC1357 | 2.35 |
| MC1358 | 1.58 |
| MC1495 | 3.00 |
| MC1496 | 1.25 |

| | |
|---|---|
| MC14011BCP | 0.32 |
| MC1723 | 0.50 |
| MC3357 | 2.25 |
| ML231B | 1.75 |
| ML232B | 1.75 |
| ML237B | 1.95 |
| ML238B | 4.20 |
| ML920 | 4.12 |
| MSM5807 | 6.75 |
| PLL02A | 5.75 |
| SAA1025 | 7.25 |
| SAA5000A | 3.05 |
| SAA5010 | 6.35 |
| SAS560S | 1.75 |
| SAS570S | 1.75 |
| SAS580 | 2.85 |
| SL901B | 4.85 |
| SL917B | 6.65 |
| SL1310 | 1.80 |
| SL1327 | 1.10 |
| SL1327Q | 1.10 |
| SN76003N | 1.95 |
| SN76013N | 1.95 |
| SN76013ND | 1.95 |
| SN76023N | 1.65 |
| SN76033N | 1.65 |
| SN76110N | 0.89 |
| SN76131N | 1.30 |
| SN76226DN | 1.55 |
| SN76227N | 1.05 |
| SN76532N | 1.40 |
| SN76533N | 1.65 |
| SN76544N | 1.65 |
| SN76650N | 1.15 |
| SN76660N | 0.80 |

| | |
|---|---|
| SN76666N | 0.70 |
| TA7061AP | 3.95 |
| TA7108P | 1.00 |
| TA7120P | 1.65 |
| TA7130P | 1.50 |
| TA7146 | 2.95 |
| TA7203 | 2.95 |
| TA7204P | 2.15 |
| TA7205AP | 1.50 |
| TA7222AP | 1.80 |
| TA7227P | 4.25 |
| TA7310P | 1.80 |
| TA7313AP | 2.95 |
| TA7611AP | 2.95 |
| TAA550 | 0.25 |
| TAA570 | 1.95 |
| TAA661B | 1.20 |
| TAA700 | 1.70 |
| TAA6305 | 3.50 |
| TBA120B | 0.95 |
| TBA120S | 0.70 |
| TBA120SA | 0.70 |
| TBA120SQ | 0.70 |
| TBA120T | 1.05 |
| TBA120U | 1.00 |
| TBA231 | 1.25 |
| TBA395 | 1.50 |
| TBA396 | 0.75 |
| TBA440N | 2.55 |
| TBA480Q | 1.25 |
| TBA510 | 2.50 |
| TBA510Q | 2.50 |
| TBA520 | 1.10 |
| TBA520Q | 1.10 |
| TBA530 | 1.10 |
| TBA530Q | 1.10 |
| TBA540 | 1.25 |
| TBA540Q | 1.35 |
| TBA550Q | 1.45 |
| TBA560C | 1.45 |
| TBA560CQ | 1.45 |
| TBA570 | 1.00 |

| | |
|---|---|
| TBA641A12 | 2.50 |
| TBA641BX1 | 3.00 |
| TBA641-B11 | 3.00 |
| TBA651 | 1.75 |
| TBA720A | 2.45 |
| TBA750Q | 2.65 |
| TBA800 | 0.89 |
| TBA810AS | 1.35 |
| TBA820Q | 1.45 |
| TBA890 | 2.50 |
| TBA920 | 1.65 |
| TBA920Q | 1.65 |
| TBA950 | 2.35 |
| TBA950/2X | 2.35 |
| TBA990 | 1.49 |
| TBA990Q | 1.49 |
| TBA1441 | 2.15 |
| TCA270 | 1.10 |
| TCA270SQ | 1.10 |
| TCA650 | 2.50 |
| TCA800 | 2.15 |
| TCA830S | 1.40 |
| TCA940 | 1.65 |
| TDA440 | 2.20 |
| TDA1004A | 2.20 |
| TDA1006A | 2.50 |
| TDA1010 | 2.15 |
| TDA1035 | 2.50 |
| TDA1037 | 1.95 |
| TDA1170 | 1.95 |
| TDA1170S | 1.95 |
| TDA1190 | 2.15 |
| TDA1270Q | 3.95 |
| TDA1327 | 1.70 |
| TDA1352B | 1.43 |
| TDA1412 | 0.85 |
| TDA2002 | 1.95 |
| TDA2020 | 2.45 |
| TDA2030 | 2.80 |

| | |
|---|---|
| TDA2522 | 1.95 |
| TDA2523 | 1.95 |
| TDA2524 | 1.95 |
| TDA2530 | 1.95 |
| TDA2532 | 1.95 |
| TDA2540 | 1.25 |
| TDA2541 | 2.15 |
| TDA2560 | 2.15 |
| TDA2581 | 2.25 |
| TDA2590 | 2.95 |
| TDA2591 | 2.95 |
| TDA2593 | 2.95 |
| TDA2600 | 3.50 |
| TDA2610 | 2.50 |
| TDA2611A | 1.95 |
| TDA2640 | 2.80 |
| TDA2690 | 1.35 |
| TDA3560 | 3.95 |
| TDA3950 | 1.95 |
| UPC566H | 2.95 |
| UPC575C2 | 2.75 |
| UPC1001H | 2.50 |
| UPC1025H | 2.50 |
| UPC1028H | 1.95 |
| UPC1156H | 2.75 |
| UPC1167C2 | 1.15 |
| UPC1181H | 1.25 |
| UPC1182H | 2.95 |
| UPC1185H | 3.95 |
| UPC1350C | 2.95 |
| UPC2002H | 1.95 |
| ZTK33B | 0.50 |
| 555 | 0.35 |
| 556 | 0.42 |
| 723 | 0.50 |
| 741 | 0.35 |
| 747 | 0.50 |
| 748 | 0.35 |
| 4042 | 0.50 |
| 7805 | 0.80 |

## SEMICONDUCTORS

| | |
|---|---|
| AAY12 | 0.25 |
| AC126 | 0.22 |
| AC127 | 0.20 |
| AC128 | 0.20 |
| AC128K | 0.32 |
| AC141 | 0.28 |
| AC141K | 0.34 |
| AC142K | 0.30 |
| AC176 | 0.22 |
| AC176K | 0.31 |
| AC187 | 0.25 |
| AC187K | 0.28 |
| AC188 | 0.25 |
| AC188K | 0.37 |
| AD142 | 0.90 |
| AD143 | 0.82 |
| AD149 | 0.70 |
| AD161 | 0.39 |
| AD162 | 0.39 |
| AD161/2 | 0.90 |
| AF115 | 0.75 |
| AF124 | 0.34 |
| AF125 | 0.35 |
| AF126 | 0.32 |
| AF127 | 0.32 |
| AF139 | 0.40 |
| AF150 | 0.42 |
| AF239 | 0.42 |
| AU106 | 2.00 |
| AU107 | 1.75 |
| AU110 | 2.00 |
| AU113 | 2.95 |
| BC107 | 0.10 |
| BC107A | 0.11 |
| BC107B | 0.11 |
| BC108 | 0.10 |
| BC108A | 0.11 |
| BC108B | 0.12 |
| BC109 | 0.10 |
| BC109B | 0.12 |
| BC109C | 0.12 |
| BC114 | 0.11 |
| BC116A | 0.15 |
| BC117 | 0.19 |
| BC119 | 0.24 |
| BC125 | 0.25 |
| BC140 | 0.31 |
| BC141 | 0.25 |
| BC142 | 0.21 |
| BC143 | 0.24 |
| BC147 | 0.09 |
| BC147B | 0.09 |
| BC148A | 0.09 |
| BC148B | 0.09 |
| BC149 | 0.09 |
| BC157 | 0.12 |
| BC158 | 0.09 |
| BC159 | 0.09 |
| BC160 | 0.28 |
| BC161 | 0.28 |
| BC170B | 0.15 |
| BC171 | 0.09 |
| BC171A | 0.10 |
| BC171B | 0.10 |
| BC172 | 0.10 |
| BC172B | 0.10 |
| BC172C | 0.10 |

| | |
|---|---|
| BC173B | 0.10 |
| BC174 | 0.09 |
| BC174A | 0.09 |
| BC177 | 0.15 |
| BC178 | 0.15 |
| BC182 | 0.10 |
| BC182LB | 0.10 |
| BC183 | 0.10 |
| BC183L | 0.09 |
| BC184LB | 0.09 |
| BC204 | 0.10 |
| BC207B | 0.13 |
| BC208B | 0.13 |
| BC212 | 0.09 |
| BC212L | 0.09 |
| BC212LA | 0.09 |
| BC213 | 0.09 |
| BC213L | 0.09 |
| BC214 | 0.09 |
| BC214C | 0.09 |
| BC214L | 0.09 |
| BC237 | 0.10 |
| BC237A | 0.09 |
| BC237B | 0.09 |
| BC238 | 0.09 |
| BC239 | 0.12 |
| BC251A | 0.12 |
| BC252A | 0.15 |
| BC258 | 0.25 |
| BC258A | 0.39 |
| BC284 | 0.30 |
| BC300 | 0.30 |
| BC301 | 0.30 |
| BC303 | 0.26 |
| BC307 | 0.09 |
| BC307A | 0.09 |
| BC307B | 0.09 |
| BC327 | 0.10 |
| BC328 | 0.10 |
| BC337 | 0.10 |
| BC338 | 0.09 |
| BC347A | 0.13 |
| BC461 | 0.35 |
| BC478 | 0.20 |
| BC527 | 0.20 |
| BC547 | 0.10 |
| BC548 | 0.10 |
| BC549A | 0.08 |
| BC550 | 0.08 |
| BC557 | 0.08 |
| BC557A | 0.08 |
| BC557B | 0.08 |
| BC558 | 0.10 |
| BCY33A | 1.60 |
| BD115 | 0.30 |
| BD116 | 0.60 |
| BD124P | 0.59 |
| BD131 | 0.32 |
| BD132 | 0.35 |
| BD133 | 0.40 |
| BD135 | 0.30 |
| BD136 | 0.30 |
| BD137 | 0.32 |
| BD138 | 0.30 |
| BD139 | 0.32 |
| BD140 | 0.30 |
| BD144 | 1.10 |

| | |
|---|---|
| BD159 | 0.65 |
| BD166 | 0.55 |
| BD179 | 0.72 |
| BD182 | 0.70 |
| BD201 | 0.83 |
| BD202 | 0.65 |
| BD203 | 0.78 |
| BD204 | 0.70 |
| BD222 | 0.48 |
| BD223 | 0.48 |
| BD225 | 0.48 |
| BC232 | 0.35 |
| BD233 | 0.35 |
| BD234 | 0.35 |
| BD236 | 0.45 |
| BD237 | 0.40 |
| BD238 | 0.40 |
| BD241 | 0.40 |
| BD242 | 0.50 |
| BD246 | 0.60 |
| BD376 | 0.32 |
| BD410 | 0.55 |
| BD434 | 0.55 |
| BD437 | 0.50 |
| BD438 | 0.60 |
| BD506 | 0.50 |
| BD508 | 0.40 |
| BD520 | 0.65 |
| BD538 | 0.65 |
| BD597 | 0.75 |
| BD697 | 1.10 |
| BD698 | 1.10 |
| BD707 | 0.80 |
| BDX32 | 1.50 |
| BF115 | 0.35 |
| BF127 | 0.24 |
| BF154 | 0.12 |
| BF158 | 0.22 |
| BF160 | 0.27 |
| BF167 | 0.24 |
| BF173 | 0.22 |
| BF177 | 0.38 |
| BF178 | 0.26 |
| BF179 | 0.34 |
| BF180 | 0.29 |
| BF181 | 0.29 |
| BF182 | 0.29 |
| BF183 | 0.29 |
| BF184 | 0.28 |
| BF185 | 0.28 |
| BF194 | 0.11 |
| BF195 | 0.11 |
| BF196 | 0.11 |
| BF197 | 0.11 |
| BF198 | 0.16 |
| BF199 | 0.14 |
| BF200 | 0.40 |
| BF241 | 0.15 |
| BF245 | 0.30 |
| BF246 | 0.28 |
| BF256/LC | 0.28 |
| BF257 | 0.28 |
| BF258 | 0.28 |
| BF259 | 0.28 |
| BF271 | 0.26 |
| BF273 | 0.13 |
| BF336 | 0.34 |
| BF337 | 0.29 |
| BF338 | 0.32 |
| BF355 | 0.37 |

| | |
|---|---|
| BF362 | 0.38 |
| BF363 | 0.38 |
| BF371 | 0.20 |
| BF394 | 0.19 |
| BF422 | 0.32 |
| BF457 | 0.32 |
| BF458 | 0.28 |
| BF459 | 0.36 |
| BF595 | 0.23 |
| BF597 | 0.25 |
| BFR39 | 0.23 |
| BFR40 | 0.23 |
| BFR41 | 0.28 |
| BFR88 | 0.30 |
| BFR90 | 1.50 |
| BFR91 | 1.75 |
| BFT42 | 0.28 |
| BFT43 | 0.28 |
| BFW92 | 0.85 |
| BFX29 | 0.30 |
| BFX84 | 0.26 |
| BFX85 | 0.32 |
| BFX86 | 0.30 |
| BFX88 | 0.25 |
| BFY50 | 0.21 |
| BFY51 | 0.21 |
| BFY52 | 0.25 |
| BFY90 | 0.77 |
| BR100 | 0.26 |
| BR101 | 0.30 |
| BRC4443 | 0.85 |
| BT106 | 1.22 |
| BT108 | 1.22 |
| BT116 | 1.20 |
| BT119 | 1.85 |
| BT120 | 1.65 |
| BU105 | 1.22 |
| BU108 | 1.69 |
| BU124 | 1.25 |
| BU125 | £1.25 |
| BU126 | 1.60 |
| BU204 | 1.55 |
| BU205 | 1.30 |
| BU208 | 1.39 |
| BU208A | 1.52 |
| BU326 | 1.20 |
| BU326A | 1.42 |
| BU326S | 1.90 |
| BU407 | 1.24 |
| BU500 | 2.25 |
| BU526 | 1.90 |
| BUY69B | 1.70 |
| MJ3000 | 1.98 |
| MJE340 | 0.40 |
| MJE520 | 0.48 |
| MPSA12 | 0.20 |
| MPSA13 | 0.20 |
| MPSA92 | 0.30 |
| MRF450A | 11.50 |
| MRF453 | 13.50 |
| MRF454 | 17.50 |
| MRF475 | 2.50 |
| MRF477 | 10.00 |
| OC23 | 1.50 |
| OC42 | 0.55 |
| OC44 | 0.55 |
| OC45 | 0.55 |
| OC70 | 0.45 |
| OC71 | 0.40 |
| OC81 | 0.50 |

| | |
|---|---|
| R2008B | 1.70 |
| R2010B | 1.70 |
| R2322 | 0.58 |
| R2323 | 0.66 |
| R2540 | 2.48 |
| RCA16334 | 0.90 |
| RCA16335 | 0.80 |
| SKE5F | 1.45 |
| TIP29 | 0.40 |
| TIP29C | 0.42 |
| TIP30C | 0.43 |
| TIP31C | 0.42 |
| TIP32C | 0.42 |
| TIP33B | 0.75 |
| TIP34B | 0.75 |
| TIP41A | 0.45 |
| TIP41C | 0.45 |
| TIP42C | 0.47 |
| TIP47 | 0.65 |
| TIP120 | 0.60 |
| TIP125 | 0.65 |
| TIP142 | 1.75 |
| TIP146 | 1.75 |
| TIP161 | 2.95 |
| TIP2955 | 0.80 |
| TIP3055 | 0.55 |
| TIS91 | 0.20 |
| TV106/2 | 1.50 |
| 2N2219 | 0.28 |
| 2N2905 | 0.40 |
| 2N3053 | 0.40 |
| 2N3054 | 0.59 |
| 2N3055 | 0.52 |
| 2N3702 | 0.12 |
| 2N3703 | 0.12 |
| 2N3704 | 0.12 |
| 2N3705 | 0.12 |
| 2N3706 | 0.12 |
| 2N3708 | 0.12 |
| 2N3773 | 1.75 |
| 2N3792 | 1.35 |
| 2N4427 | 1.50 |
| 2N4444 | 1.15 |
| 2N5294 | 0.42 |
| 2N5296 | 0.48 |
| 2N5298 | 0.80 |
| 2N5496 | 0.85 |
| 2SA715 | 0.60 |
| 2SC495 | 0.80 |
| 2SC496 | 0.80 |
| 2SC1096 | 0.80 |
| 2SC1172Y | 2.20 |
| 2SC1173 | 1.15 |
| 2SC1306 | 1.00 |
| 2SC1307 | 1.50 |
| 2SC1449 | 0.80 |
| 2SC1678 | 1.25 |
| 2SC1945 | 2.10 |
| 2SC1953 | 0.95 |
| 2SC1957 | 0.80 |
| 2SC1969 | 1.95 |
| 2SC2028 | 1.15 |
| 2SC2029 | 1.95 |
| 2SC2078 | 1.45 |
| 2SC2091 | 0.85 |
| 2SC2166 | 1.95 |
| 2SC2314 | 0.80 |
| 2SD234 | 0.50 |
| 3N211 | 1.50 |

## DIODES

| | |
|---|---|
| AA119 | 0.08 |
| BA102 | 0.17 |
| BA115 | 0.13 |
| BA145 | 0.16 |
| BA148 | 0.17 |
| BA154 | 0.06 |
| BA155 | 0.13 |
| BA156 | 0.15 |
| BA157 | 0.30 |
| BAX13 | 0.04 |
| BAX16 | 0.06 |
| BB105B | 0.30 |
| BT151 | 0.79 |
| BY126 | 0.10 |
| BY127 | 0.11 |
| BY133 | 0.15 |
| BY164 | 0.45 |
| BY176 | 1.20 |
| BY179 | 0.63 |
| BY184 | 0.35 |

| | |
|---|---|
| BY199 | 0.40 |
| BY206 | 0.14 |
| BY208-800 | 0.33 |
| BY210-800 | 0.33 |
| BY223 | 0.90 |
| BY298-400 | 0.22 |
| BY299-800 | 0.22 |
| BYX10 | 0.20 |
| BYX36-150R | 0.20 |
| BYX38-600R | 0.60 |
| BYX55-600 | 0.30 |
| BYX71-600 | 0.60 |
| BZY95C30 | 0.35 |
| OA47 | 0.09 |
| OA90 | 0.05 |
| OA91 | 0.06 |
| OA95 | 0.06 |
| OA202 | 0.10 |
| IN914 | 0.04 |
| IN4001 | 0.04 |
| IN4002 | 0.04 |

| | |
|---|---|
| IN4003 | 0.04 |
| IN4004 | 0.05 |
| IN4005 | 0.05 |
| IN4006 | 0.06 |
| IN4007 | 0.06 |
| IN4148 | 0.02 |
| IN4448 | 0.10 |
| IN5401 | 0.12 |
| IN5402 | 0.14 |
| IN5403 | 0.12 |
| IN5404 | 0.12 |
| IN5405 | 0.13 |
| IN5406 | 0.13 |
| IN5407 | 0.16 |
| IN5408 | 0.16 |
| ITT44 | 0.04 |
| ITT923 | 0.15 |
| ITT2002 | 0.10 |

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Entries, which will be judged by a group of eminent engineers and doctors, must consist of the following:- a statement of the design objectives; an overall description of the device; detailed circuit descriptions and diagrams; a model of the device or a model of a unique aspect of the design sufficient to demonstrate its feasibility.

The finalists will be invited to London to talk over their entries with the judges and be awarded their prizes. The prizes are:

**1st prize £2,500**
**2nd prize £1,500**

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**To make sure you have the maximum time to undertake your design, return your entry form now!**

### "DESIGN AN ELECTRONIC DEVICE TO HELP THE DISABLED" LIST OF RULES

1. The competition is open to U.K. residents only.
2. Entrants can be individuals or groups.
3. All participants must register their interest in entering the competition on the form provided which must be returned to the Wireless World Editorial Department by the 30th June 1983.
4. All entrants agree to give Wireless World first serial publication rights to an article describing the entry.
5. All entrants indemnify Wireless World from any liability in respect of injury to people or damage to property arising from the use of the design.
6. All submitted designs must be the original work of the entrant or entrants and must not infringe the rights of third parties in anyway.
7. All submissions should consist of:
   a) **A statement of design objectives**
   b) **An overall description of the device**
   c) **Detailed circuit descriptions and diagrams**
   d) **A model of the device or the unique aspect of the design sufficient to demonstrate its feasibility.**
8. The design will be judged on:
   a) **Originality and benefit to the handicapped**
   b) **Potential for production**
   c) **Elegance of engineering design**
   d) **Electronics content**
   e) **Design reliability**
   f) **Simplicity of operation**
   g) **Freedom from excessive maintenance**
   h) **Safety.**
9. Software only solutions are not accepted.
10. The judges' decision is final.
11. All designs must be submitted to the Wireless World Editor by the 1st October 1983.
12. Shortlisted entrants must be prepared to travel to a venue in London sometime during November and December 1983 to demonstrate their design. All costs will be paid by the journal.
13. Employees of Business Press International are not allowed to enter this competition.

**wireless world**

**COMPETITION ENTRY FORM**

**"Design an electronic device to help the disabled"**

Name of competitor__________

Address__________

Telephone (home)__________

(business)__________

I intend to enter the competition and to abide by the rules as laid down in the March 1983 issue of Wireless World.

I understand that, in order to quaify, my entry must in the hand of the judges by 1st October 1983.

Signature__________

Date__________

*Please send this form, as soon as possible, to:*

**The Editor, WIRELESS WORLD**
**Room L302, Quadrant House, The Quadrant**
**Sutton, Surrey SM2 5AS.**

*Receipt of the form will be acknowledged.*

# COMPUTER WAREHOUSE

## THE 'ALADDIN'S' CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

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DRE 44A/4000A/B 10 mb 5+5 all configurations from £995.00. Call sales office for details.

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Cure those unnerving hang ups and data glitches caused by mains interference. Matchbox size – Up to 5 amp 240 v load. As recommended by the ZX81 newsletter. Suppression Devices SD5A £5.95.

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The UK's **FIRST** free of charge, 24 hr. public access data base. Get information on **1000's** of stock items and order via your computer and credit card. On line now, 300 baud. CCITT tones, full duplex, fully interactive.

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### COMPUTER 'CAB'

All in one quality computer cabinet with integral switched mode PSU, Mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the PSU is fully screened and will deliver a massive +5v DC at 17 amps, +15v DC at 1 amp and −15v DC at 5 amps. The complete unit is fully enclosed with removable top lid, filtering, trip switch, 'Power' and 'Run' LEDs mounted on Ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. **Give your system that professional finish** for only £49.95 + Carr. Dim. 19" wide 16" deep 10.5" high. Useable area 16"w 10.5"h 11.5"d. Also available **LESS PSU** with internal dim. 19"w, 16"d, 10.5"h, £19.95". Carriage & insurance £9.50.

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Keep your hot parts COOL and RELIABLE with our range of **BRAND NEW** professional cooling fans.
**ETRI 99XUOI** Dim. 92 x 92 x 25 mm. Miniature 240 v equipment fan complete with finger guard. **£9.95.**
**GOULD JB-3AR** Dim. 3" x 3" x 2.5" compact very quiet running 240 v operation. **NEW £6.95**
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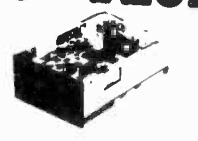
**MUFFIN-CENTAUR** standard 4" x 4" x 1.25" fan supplied tested EX EQUIPMENT 240 v at £6.25 or 110 v at £4.95 or BRAND NEW 240v at £10.50. 1000's of other fans Ex Stock. Call for Details. Post & Packing on all fans £1.60

### 8" FLOPPY DISK DRIVES



Unbelievable value the DRE 7100 8" floppy disk drives utilise the finest technology to give you 100% bus compatibility with most drives available today. The only difference being our **PRICE** and the superb manufacturing quality!! The 7100 single sided and 7200 double sided drive accept hard or soft sectoring IBM or ANSI standard formats giving a massive 0.8 MB (7100) 1.6 MB (7200) of storage. Absolutely SHUGART, BASF, SIEMANS etc. compatible. Supplied BRAND NEW with user manual and full 90 day warranty. Carriage and insurance £9.75.
**7100 Single sided £225.00** + Carr. **7200 Double sided £295.00** + Carr.
Optional accessories: Full technical manual £20.00 alone. £10.50 with drive. Refund of difference on drive purchase. DC and AC power connector and cable kit £8.45. 50 way IDC connector £5.50. 50 way ribbon cable £3.20 per metre.

### VIDEO MONITORS

**MOTOROLA 9"** open chassis monitor. Standard 240 v AC with composite 75 ohm video input, bandwidth in excess of 18 mhz. Monitors are ex equipment and although unguaranteed they are all tested prior to despatch, and have no visible burns on the screens. Dim approx. 9" x 9" x 9". Supplied complete with mains and input lead. Ideal ZX81 etc. or giving the tele back to the family!! Black and white phosphor. **£35.00** + £9.00 Carr.

**12" CASED.** Made by the British KGM Co. Designed for continuous use as a data display station, unit is totally housed in an attractive brushed aluminium case with ON-OFF, BRIGHTNESS and CONTRAST controls mounted to one side. Much attention was given to construction and reliability of this unit with features such as, internal transformer isolated regulated DC supply, all components mounted on two fibre glass PCB boards – which hinge out for ease of service, many internal controls for linearity etc. The monitor accepts standard 75 ohm composite video signal via SO239 socket on rear panel. Bandwidth of the unit is estimated around 20 Mhz and will display most high def graphics and 132 x 24 lines. Units are secondhand and may have screen burns. However where burns exist they are only apparent when monitor is switched off. Although unguaranteed all monitors are tested prior to despatch. Dimensions approx. 14" high x 14" wide by 11" deep. Supplied complete with circuit. 240 volt AC operation. ***ONLY £45.00 PLUS £9.50 CARR.***

**14" COLOUR** superb chassis monitor made by a subsidiary of the HITACHI Co. Inputs are TTL RGB with separate sync. and will plug direct into the BBC micro etc. Exceptional bandwidth with good 80 col. definition. Brand new and guaranteed. Complete with full data & circuit. 240 v AC working. Dim. 14" x 13" x 13". ***ONLY £199.00 PLUS £9.50 CARR.***

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Made to the very highest spec. the **TEC Starwriter FP1500-25** features a heavy duty die cast chassis and DIABLO type print mechanism giving superb registration and print quality. Micro-processor electronics offer full DIABLE/QUME compatibility plus Bi directional printing, 10 or 12 pitch, 136 or 163 chars per line, full width 381 mm friction or single sheet paper, – order now or call sales office for more information and print sample. Please specify RS232 or CENTRONICS interface. Supplied complete with **FREE** dust cover and daisy wheel. Optional extras: RS232 data cable **£10.00** – Tech. manual **£7.50.** Carriage & Ins. (UK) **£12.50.** – Tractor feed option **£120.00**

### TELETYPE ASR33 I/O TERMINALS

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Fully fledged industry standard ASR33 data terminal. Many features including ASCII keyboard and printer for data I/O auto data detect circuitry. RS232 serial interface. 110 baud, 8 bit paper tape punch and reader for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order.
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### RECHARGEABLE BATTERIES

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### D.C. POWER SUPPLY SPECIALS

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**CUSTOM POWER CO55** 5v @ 3 amp. Very compact unit dim. approx 60 x 90 x 190 mm. Semi open chassis, full crowbar overvoltage protection. Tested Ex Equipment. ***£11.95*** + pp £1.25
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**PERIPHERAL SYSTEM SUPPLY.** Fully cased unit supplied in a Brand new or little used condition. Outputs give 5v @ 11 amps, "+" 15-17v @ 8 amps "−" 15-17v @ 8 amps and "+" 24v @ 4 amps. All outputs are crowbar protected and the 5 volt output is fully regulated. Fan cooled. Supplied tested, with circuit ***£55.00*** + £8.50 carr.
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Join the communications revolution with our range of EX TELECOM data modems. Made to most stringent spec and designed to operate for 24 hrs per day. Units are made to the CCITT tone spec. With RS232 i/o levels via a 25 way 'D' skt. Units are sold in a tested and working condition with data. Permission may be required for connection to PO lines.
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**MODEM 20-1** Compact unit for use with PRESTEL or full duplex 2 wire link. 75 baud transmit – 1200 baud receive. Auto answer. **£130.00**
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**MODEM 20-3** Made for data rates up to 1200 baud in full duplex mode over 4 wire circuit or half duplex mode over 2 wires. **£130.00**
Carriage. 13A £4.50. 2B/C & 20 £9.50.
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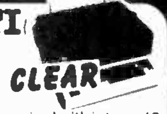
**ALL PRICES PLUS VAT**

### OLIVETTI TE300



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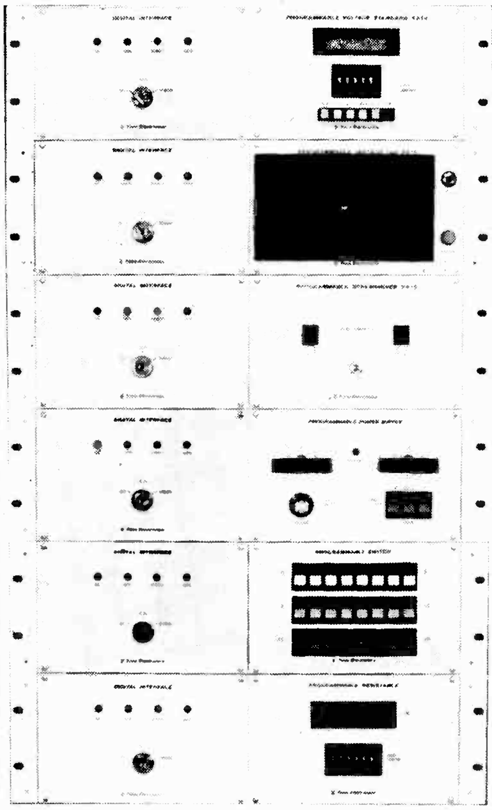

# IEEE PROGRAMMABLES from TIME

**9814 IEEE PROGRAMMABLE VOLTAGE STANDARD**

A higher performance voltage standard with 4 ranges from 0.1 volt to 10 volt output. Accuracy is 0.01% and the resolution of setting is 1 in 200,000. Output resistance is less than 0.01 ohms, and output current adjustable 20mA-200mA. Temperature coeff is less than 20ppm/°C and long term stability better than 50ppm per year. Full manual control is available via front panel controls. Available for benchtop use or 19" rack mounting.

**9816 IEEE PROGRAMMABLE VOICE**

A high quality speech synthesizer which has a 280 word vocabulary. By suitable programming via the IEEE bus it is possible to output single words, phrases and sentences. The vocabulary has been chosen to be applicable to many ATE applications.

**9815 IEEE PROGRAMMABLE SCREWDRIVER**

The unit has been designed to overcome the problems of adjusting large numbers of multi-turn trimmers in ATE systems. The screwdriver is fully programmable via the IEEE bus with 3 speeds of rotation and 2 selectable torque values available. The unit is supplied complete with a flexible drive shaft and drill chuck into which various adjusting tools can be located.

**9810 IEEE/PROGRAMMABLE POWER SUPPLY**

0-33V in 0.1V steps. Local or remote (IEEE) operation. Fully programmable on the IEEE bus with 3 settable current limits 1mA, 10mA and 1.1A. A dual version of the 9810 is also available. The unit is 3 Euro units high and standard 19" rack mounting width.

**9812 IEEE PROGRAMMABLE SWITCH**

24 double pole changeover switches are available with full IEEE control. Each switch is rated at 1 Amp, 30V dc or 100V ac. Thermal emfs have been minimised to less than 1µV per switch. All outputs are on the rear panel along with the IEEE address selector switch and bus connector. Manual control of the switches is also provided via a set of front panel switches which also incorporate LED indicators.

**9811 IEEE PROGRAMMABLE RESISTANCE**

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**TIME ELECTRONICS LTD, Botany Industrial Est., Tonbridge, Kent, England TN9 1RS. Tel: (0732) 355993. Telex: 95481**

**WW – 079 FOR FURTHER DETAILS**

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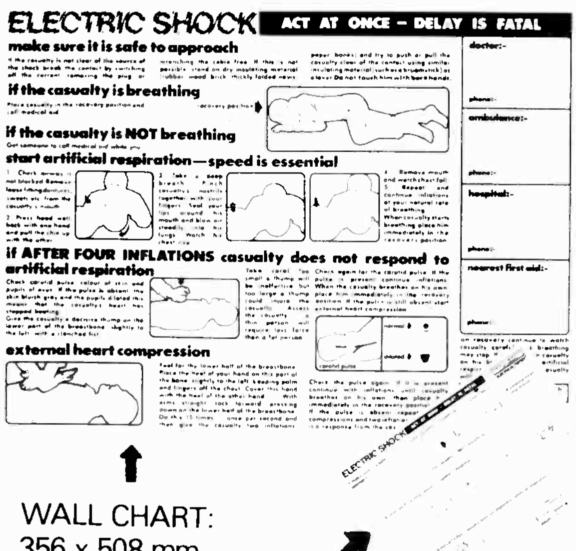


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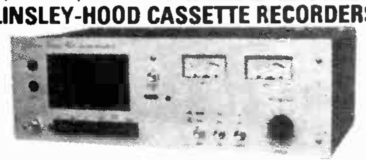
## LINSLEY-HOOD 300 SERIES AMPLIFIERS

These latest designs from the drawing board of John Linsley-Hood, engineered to the very highest standard, represent the very best that is available on the kit market today. The delicacy and transparency of the tone quality enable these amplifiers to outperform on a side-by-side comparison, the bulk of amplifiers in the commercial market-place and even exceed the high standard set by his earlier 75-watt design.
Three versions are offered, a 30-watt with Darlington output transistors, and a 35- and 45-watt, both with Mosfet output devices. All are of identical outside appearance which is designed to match and stack with our Linsley-Hood cassette recorder 2.
As with all Hart kits the constructor's interests have been looked after in a unique way by reducing the conventional (and boring) wiring almost to the point of extinction.
Any of these kits represents a most cost-effective route to the very highest sound quality with the extra bonus of the enjoyment of building a sophisticated piece of equipment.
30-watt Darlington amplifier, fully integrated with tone controls and magnetic pick-up facility. Total cost of all parts is £81.12. Special offer price for complete kits is **£72.**
35-watt Mosfet amplifier. Total cost of parts **£98.41.** Special offer for complete kits **£87.40.**
45-watt Mosfet amplifier. Total cost of parts **£104.95.** Special offer price for complete kits **£94.80.**
(Reprints of original Articles from Hi-Fi News 50p. Post free. No VAT.
Reprints of MOSFET article 25p. No V.A.T. Post free.

## 'P.W. WINTON' TUNER AND AMPLIFIER

Snazzy matching slimline tuner and amplifier in beautiful wooden cabinets. These Ted Rule designs are for the enthusiast. Tuner covers LW, MW, SW, FM and TV sound! Digital frequency readout with clock and timer features. FM has 6 section front end and switchable bandwidth for exceptional fringe area performance. Amplifier has Toroidal transformer. Mosfet output stages, 50 watts per channel and got a cracking review in Practical Wireless.
**Tuner. Complete Kit** .......... **£123**
**Amplifier. Complete Kit** .......... **£98**

## LINSLEY-HOOD CASSETTE RECORDERS



We have done two kits to this design, one using the original car cassette mechanism and the newer version using a very high quality front loading deck. This new deck has an excellent W & F performance and fitted with our latest Sendust Alloy Super Head gives an incredible frequency range (with good tape you can see 23KHz on ours!).
**Linsley-Hood Cassette Recorder 1** .......... **£75.00**
**Linsley-Hood Cassette Recorder 2** .......... **£94.90**
**Reprints of "WW" Articles** .......... **70p. No VAT**

# THIS MONTH'S SPECIAL OFFER

## LINSLEY-HOOD 300 Series Amplifiers reduced in price

**30 Watt Darlington Output £65**

**35 Watt MosFet Output £79.50**

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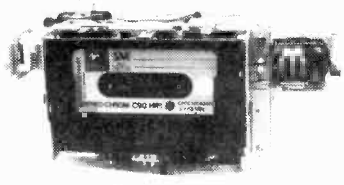
## FEED YOUR MICRO BYTES WITH OUR SOLENOID CONTROLLED CASSETTE DECK



Front loading deck with full solenoid control of all functions including optional read in fast wind modes. 12 volt operation. Fitted 3-digit memory counter and Hall IC Motion Sensor. Standard erase and stereo R/P Heads. Cheapest price ever for all these features. Only **£38.90** plus VAT. Full technical specification included.

## LINSLEY-HOOD 100 WATT POWER AMPLIFIER

Our complete kit for this brilliant new design is the same size as our Linsley-Hood Cassette Recorder 2. Kit includes all parts for two power amplifiers with large heatsink area, huge power supply and speaker protection circuit. Total cost of all parts is **£114.46** but our special introductory price for all parts bought together is only **£105.50.**

## HIGH QUALITY REPLACEMENT CASSETTE HEADS

Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard mountings make fitting easy and our TC1 Test Cassette helps you set the azimuth spot-on. We are the actual importers which means you get the benefit of lower prices for prime parts. Compare us with other suppliers and see! The following is a list of our most popular heads, all are suitable for use on Dolby machines and are ex-stock.
**HC20 Permalloy Stereo Head.** This is the standard head fitted as original equipment on most decks .......... **£4.25**
**HM90 High Beta Permalloy Head.** A hard-wearing, higher performance head with metal capability .......... **£6.20**
**HS16 Sendust Alloy Super Head.** The best head we can find. Longer life than Permalloy, higher output than Ferrite, fantastic frequency response .......... **£8.20**
**HQ551 4-Track Head** for auto-reverse or quadrophonic use. Full specification record and playback head .......... **£7.40**
Please consult our list for technical data on these and other Special Purpose Heads.

### STUART TAPE CIRCUITS
(For reel-to-reel decks)

These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not have the detailed instructions that we give with our more recent designs. We would not therefore recommend it to beginners. Reprints of the original three articles 45p. Post free. No VAT.

## HART TRIPLE-PURPOSE TEST CASSETTE TC1

One inexpensive test cassette enables you to set up VU level, head azimuth and tape speed. Invaluable when fitting new heads. Only **£3.80** plus VAT and 50p postage.

**Tape Head De-magnetiser.** Handy cassette size mains operated unit prevents build up of residual head magnetisation causing noise on playback .......... **£3.68**

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**Brand New Governed 12v DC Tape Drive Motor Type MMI-6A2LK.**
As used in SF925 and many other decks. 40mm Dia x 35mm Long, Shaft 10.5mm long x 2mm Dia. 6 x 2.5mm Mounting Holes on 26mm PCD on shaft end face. Anti-clockwise rotation at rated speed of 2200 RPM. Free run current 25mA. **£4.85 each.**
**Lenco CRV/FFR.**
We have a small quantity of spare motors for these decks at £6 each complete with drive pulley. Spare belts for FFR or CRV **90p (Large), 30p (Small).**

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**Personal callers are always very welcome but please note that we are closed all day Saturday**

**HART ELECTRONIC KITS LTD.**
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## Northern Amateur Radio Societies Association

The Society is holding its **21st Exhibition at Pontins Holiday Village, Southport, on Saturday, 19th March and Sunday, 20th March, 1983.** This was formerly the Belle Vue exhibition. The Exhibition will open at 11 a.m. each day.
It will include an inter club quiz, construction contest, grand raffle, R.S.G.B. bookstall, amateur computers, N.A.R.S.A. stands and trophy. Trade stands, featuring all types of Radio/Electronic equipment; Demonstration station.
The following traders will be present J. Birkett; Radiotronics; Amateur Radio Exchange; John's Radio; New Cross Radio; Wilson Valves; C.B. Electronics; S.O.T.A.; The Computer Junk Shop; W. H. Westlake; D. S. Electronics; Arrow Electronics Ltd; Green's Telecom; Royd Electronics; Newton Engravers; Leeds Amateur Radio; Macro Trading; R.A.I.B.C.; Micro Print Ltd; 2 J Sound; Gemini Communications; Radio Surplus; B.N.O.S. Electronics; D. Currie (Printer); G. Jackson; W. E. Griffiths; Waters & Stanton; Ham Radio Today; Garex Electronics; P.L.M. Communication Supplies; Tricon Supply Co.; Electro-Supplies.
Admission to the Exhibition will be 60p per day or £1 for two days.
Lots of 20 tickets or more booked in advance from Mike Bainbridge GAGS7, 7 Rothburg Close, Bury BL8 2TT, Lancs can be obtained at a 20% discount by sending the appropriate cash and s.a.e.
Chalets are available if booked direct from Pontins. Tel: 0704 77165 and can be equipped for self catering if you so wish. Charges vary from £10 + VAT (for 2 person chalet) to £26 + VAT (for a six person chalet). Larger family chalets are available.
Family entertainment will be available during the day while 'Residents' will be able to enjoy evening entertainment.
Talk in will be on S22 and other available simpler channels.
Car parking is free but please follow the parking attendants instructions and the notices to prevent congestion.
Enjoy yourself at this family Week End Exhibition.

IN VIEW OF THE EXTREMELY RAPID CHANGE TAKING PLACE IN THE ELECTRONICS INDUSTRY, LARGE QUANTITIES OF COMPONENTS BECOME REDUNDANT. WE ARE CASH PURCHASERS OF SUCH MATERIALS AND WOULD APPRECIATE A TELEPHONE CALL OR A LIST IF AVAILABLE. WE PAY TOP PRICES AND COLLECT.

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**Advertisements accepted up to 12 noon Thursday, March 1st, for April issue, subject to space available.**

**DISPLAYED APPOINTMENTS VACANT:** £15.50 per single col. centimetre (min. 3cm).
**LINE advertisements (run on):** £3 per line, minimum £20 (prepayable).
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★ **First call:** MIKE GERNAT or JOHN SANDERS on 076 384 676/7.

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(1926

## POTENTIAL LEADER for SUNNY CALIFORNIA

An organisation in the San Francisco area is seeking a person fully competent in all aspects of software design and production, capable of leading others in this field and integrating with the hardware development and production groups.

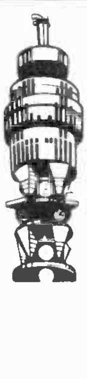
The organisation and its environment offers advantages for advancement and living and disposes of adequate funds to ensure that any of its projects can be implemented and profitable.

The self-motivating person we seek needs to be capable of inspiring others and to possess the determination to bring projects to the market place.

Experience in communications and in navigation will be an advantage.

The organisation will ensure that the successful candidate is satisfactorily relocated and rewarded.

**Replies to Box No. 1989**



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Design, Development and Test to £14,000
Ask for Brian Cornwell

SALES to £15,000 plus car
Ask for Maurice Wayne

FIELD SERVICE to £12,000 plus car
Ask for Paul Wallis

**We have vacancies in ALL AREAS of the U.K.**

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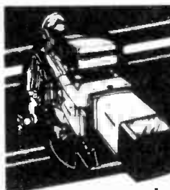

## Join the Worldbeaters at Pye TVT

**Senior Projects Engineer — Service**

We are looking for someone who can supervise our Service workshops and undertake in depth investigations into our Customers' service problems. We also need someone who can present and demonstrate our company's products. Do you think you are the one for the job? Then read on.

Firstly, you will need formal qualifications to degree standard.

You will also need to have a good few years experience in TV broadcast engineering tucked under your belt in installation, operation and maintenance, and a specialist knowledge of cameras, vision mixers, video recorders or assignment systems is essential.

All this, plus a current driving licence and the ability to work on your own initiative at home or abroad? Yes? We can't wait to hear from you.

Write to me enclosing a C.V. and tell me why you think you should be offered this important post. In return I can give you further details about our modern facilities, the advantages of working for a member of the Philips organisation and the opportunity of living in a beautiful city like Cambridge.

I'm Lynn Osborne, Personnel Officer, at Pye TVT Limited, Coldhams Lane, Cambridge.

PHILIPS

**Pye TVT Limited**
The Broadcast Company of Philips
(1993)

## Electro-Acoustic
# Product Development Engineer

**c. £11,000** — **North London**

The advent of digital switching systems allied to the rapid development in microprocessor technology means that tomorrow's telephone will provide a highly versatile communications medium. "New Generation" telephones will incorporate such aspects as large scale data memory, automatic call and recall options, visual displays, loud speaking facilities etc.

Our client, an international market leader in the field of telephone design and manufacture, is committed to an exciting product development programme and now needs to strengthen its engineering team through the appointment of an experienced Electro-Acoustic Engineer.

This position will be of interest to qualified engineers, degree level or equivalent, with several years' revelant experience in the design and development of electro-acoustic products. Successful applicants will be expected to demonstrate a high degree of design innovation to meet the critical low cost requirement associated with the high volume production of moulded components and small electro-mechanical assemblies while ensuring optimum acoustic performance.

This represents an exceptional opportunity to join a small, multi-disciplined team of professional engineers working within the framework of a large organisation situated in the North London area. In addition to an attractive salary, the company offers relocation expenses where appropriate.

## RF Development Engineers

Our client would also like to meet RF Development Engineers to work on a future range of Personal Communications products incorporating state-of-the-art technology up to 1GHz.

Whatever your level of experience, if you are qualified to degree level or equivalent and have a sound knowledge of analogue r.f. circuit design, our client would be interested in hearing from you.

In the first instance please telephone for an application form or write with full c.v. stating in a covering letter any companies to whom you do not wish your application forwarded, to: B. Kelly, Moxon Dolphin & Kerby Ltd., 178-202 Great Portland Street, London W1N 5TB. Tel 01-631-4411 quoting ref: BK/955/W.

MOXON DOLPHIN & KERBY LTD

(2000)

# SENIOR SERVICE ENGINEERS
## (Consumer Electronics)

Mitsubishi Electric (UK) Limited is a rapidly expanding and very successful division of the multi-national Mitsubishi Corporation.

In order to maintain and increase our present rate of growth we need to appoint additional Service Engineers to work on our wide range of consumer goods, including audio, T.V. and VHS video products. The appointments will be based at our modern Service Depot in Watford and offer excellent career opportunities.

The positions require at least five years experience of servicing the relevant equipment but offer opportunities for the successful applicant to expand his/her experience as the Company grows. Applicants should have a good technical qualification, ideally HND/HNC or HTEC Diploma (Electronics) and preferably some previous supervisory experience as well as a high level of self motivation.

A first class salary package is available including free BUPA cover and a twice yearly bonus scheme. Please telephone for an application form or send c.v. to:

**Alan Freemantle,**
**Personnel and Administration Manager,**
**Mitsubishi Electric (UK) Limited,**
**Otterspool Way, Watford, Herts, WD2 8LD.**
**Tel: Watford 34618.**

**MITSUBISHI ELECTRIC**

(2002)

## "HI-FLIERS" WANTED READY FOR "TAKE-OFF"

Senior Development Engineer to take design of real time microprocessor systems for video picture processing all the way from specification through to de-bugged delivery to client covering hardware (P.C.B. layout and prototype construction included) and software (high level and Assembler). Must be highly qualified with experience of microprocessors, vast memories, and L-S-I techniques, while knowledge of broadcasting video and display techniques would be useful.
**Surrey** — **To £12,000**

Computer Hardware Engineers to design digital and analogue interfaces for peripherals to mini and micro computers. Must be graduates with at least four years' experience of microcoding signal processing and embedded software, and simulator or trainer knowledge much appreciated.
**Central Berks** — **Salary up to £12,000 p.a.**

Commissioning and Test Engineers for a wide range of signal processing and digital video standards converters. Must have video and digital test experience and at least O.N.C.
**London** — **To £10,000 p.a.**

Senior Design Engineers to work on industrial data acquisition monitoring and control systems with associated test equipment with an emphasis on hardware with at least two years' experience of real time microprocessors and knowledge of assembler and high level structured languages. Must have H.N.C. at least and R.C.A. 1802 background would help.
**Northants** — **And the salary? GOOD**

# Charles Airey Associates

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(1357)

## ELECTRONICS APPOINTMENTS
## £6,000 - £16,000

**ANALOGUE, RADIO, MICROWAVE**
**DIGITAL, MICROPROCESSOR, COMPUTER**
**DATA COMMS, MEDICAL**

Design, Test, Sales and Field Service Engineers — to use our free, confidential service and improve your salary and career prospects. UK and overseas, contact:

**Technomark**
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(1935)

## BORED ?

### Then change your job!

**1) Test Equipment Controller**
Plan and procure test equipment and control a team of test equipment engineers. To £12,670 — Hants.

**2) Maintenance Engineer**
Start an in-house test of communications equipment — then move to field service when fully conversant. To £8,000 + car — London.

**3) Service Engineer**
Analogue and digital detection and alarm systems. Middx-Essex — to £8,000.

**4) Test Engineer**
In-house work on modems and data communications systems. To £7,500 — Bucks.

**5) Service Personnel**
**(RAF, RN, Army)**
We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details.

**6) £500 per week**
We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

***Hundreds of other Electronic and Computer Vacancies to £12,500***

**Phone or write:**
**Roger Howard, C.Eng.M.I.E.E., M.I.E.R.E.**
**CLIVEDEN CONSULTANTS**
**87 St. Leonard's Road, Windsor, Berks.**
**Windsor (07535) 58022 (5 lines)**
(1646)

**CLIVEDEN**

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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Applications are invited from suitably qualified persons regardless of sex, race, colour or national origin for appointment to the following immediately available post:

### TELEVISION ENGINEER

R12 252-R17 880 p.a.
(£1 = R173 approx.)

A vacancy exists in the Central Television Service for a suitably qualified Studio Engineer. The University operates two full-colour television studios and a campus distribution system.

The main activities are making educational training programmes for the University and commerce and industry. Duties include the maintenance of television studio equipment, campus distribution system and associated equipment. Also studio operation duties as and when required.

Applicants should have a number of years' relevant experience in Television Engineering.

The University offers salary commensurate with qualifications and experience plus 13th cheque, pension, medical aid and housing subsidy for eligible applicants, congenial and dynamic environment, continuous opportunities for education and training, generous leave. There is a possibility of a salary supplementation.

Applicants should write to the **Deputy Registrar (Non-Academic Staffing) University of the Witwatersrand, 1 Jan Smuts Avenue, Johannesburg 2001** giving full personal and career details, as well as the names and addresses of at least two referees.

Applications should be lodged by **15 March, 1983.** (1984)

---

## LOGEX ELECTRONICS RECRUITMENT

Specialists in Field & Customer Engineering appointments, all locations and disciplines

**Logex House, Burleigh, Stroud**
**Gloucestershire GL5 2PW**
**0453 883264 & 01-290 0267**
*(24 hours)*

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### EXPERIENCED SERVICE ENGINEER

wanted to repair and service Amateur, Private, Mobile and Marine equipment. Previous experience is necessary. Salary approximately £7,500/negotiable per year, plus car for personal use.

**Apply to:**
**Communique, Communications House**
**Purley Avenue, London NW2**
**Tel: 01-450 9755**
(2001)

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**CHANCE FOR YOUNG ENTHUSIAST WITH TOP BRITISH MICRO MAKER**

# TECHNICAL SUPPORT (SALES)

**UP TO £5-7.6K, OXFORD-BASED**

Research Machines is one of the leading British manufacturers of microcomputers. Thousands of users of our 380Z, ranging from school teachers and scientists to technicians and DP professionals, regard it as an essential tool of their trade. Satisfying their hardware and software information needs and solving their problems — by telephone and letter — is the first job of Technical Support.

*But there's a lot more to this interesting and challenging vacancy than that. In addition to sales and technical support to customers, you will also give technical support to the sales team; support the Sales team at exhibitions and demonstrations; provide feedback to relevant departments on technical matters and sales trends; and liaise between customers and maintenance engineers. In the process you will get plenty of opportunity for hands-on experience of our range of hardware and software.*

We are looking for a computer enthusiast to join this young, small team in our Sales Department. The successful candidate will probably:

- ☐ **be capable of programming in a high-level language — preferably BASIC;**
- ☐ **have a real interest in microcomputing and some knowledge of electronics;**
- ☐ **be educated to at least 'A' level;**
- ☐ **have some admin or sales office experience.**

Starting salary is between £5,000 and £7,600 depending on age and experience, and we also offer a number of valuable benefits such as free BUPA, life and disability insurance, and a pension scheme.

**If you are interested in this vacancy please contact *Polly Keane*, by phone or letter, for an application form, quoting TS/WW**

**RESEARCH MACHINES**
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**RESEARCH MACHINES LTD** Mill Street, Oxford OX2 0BW, Tel: (0865) 726136 (1999)

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# SENIOR RF ENGINEER

**Western Home Counties** **c £12-£14,000**

Our client is a remarkable company with an enviable record of success and development.

Although they recruit infrequently they have identified a need for one Senior RF Engineer.

Ideally you will have attained Project Leader status and be able to work within a highly innovative environment.

You will have exacting, technical and commercial deadlines to meet and will therefore frequently work under pressure within a small department of very highly skilled and qualified people.

The prospects for promotion and career development are excellent as the company is commercially aggressive and has a number of unique qualities.

They are part of a successful multinational group covering a range of communications equipment.

To discuss this position contact PAUL HECQUET on Lewes (07916) 71271 or write with brief C.V. to the address given below.

(1990)

The Electronics Recruitment Company
Temple House
25/26 High Street, Lewes
East Sussex BN7 2LU
Tel: Lewes (07916) 71271

# Appointments

Premier international electronics companies – very secure and expanding in North, South, East and West of London and Home Counties – require professional senior staff (including departmental heads). Re-location allowance up to £3,000.

## ELECTRONIC ENGINEERS

Electronic engineers required with degree – H.N.C. – tech. cert. – O.N.C. Almost any background required but software and hardware experience will bring salary of absolute minimum of £6,500 p.a. and could be up to £11,000 p.a.

## ELECTRONIC DESIGN/DEVELOPMENT

Engineers required with experience of circuit or component design or development for microwave equipment or digital logic or computer peripherals or electronic packaging or film technology or telecommunications. Also above for up-dating in modern techniques. Salaries up to £11,000.

## SOFTWARE PROGRAMMERS & ENGINEERS

Engineers or mathematicians required for development of commissioning and design proving programmes from assistant to team leader level. Salaries up to £12,000 p.a.

Please contact by telephone, or letter, to discuss companies and possibilities. Rickmansworth 770431 (Ansafone after 5 p.m.) or telephone Watford 49456 any time.

**GORE MANAGEMENT SERVICES LTD**

**SELECTION & TRAINING CONSULTANTS**
**111 High Street, Rickmansworth, Herts**
**Rickmansworth 770431**

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Applications are invited from suitably qualified persons regardless of sex, race, colour or national origin for appointment to the following immediately available post:

## TELEVISION ENGINEER

### R12 252 - R17 880 p.a.

A vacancy exists in the Central Television Service for a suitably qualified Studio Engineer. The University operates two full-colour television studios and a campus distribution system.
The main activities are making educational training programmes for the University and commerce and industry. Duties include the maintenance of television studio equipment, campus distribution system and associated equipment. Also studio operation duties as and when required.
Applicants should have a number of years' relevant experience in Television Engineering.
The University offers salary commensurate with qualifications and experience plus 13th cheque, pension, medical aid and housing subsidy for eligible applicants, congenial and dynamic environment, continuous opportunities for education and training, generous leave.
There is a possibility of a salary supplementation.

**Applicants should write to the Deputy Registrar (Non-Academic Staffing), University of the Witwatersrand, 1 Jan Smuts Avenue, Johannesburg, 2001, South Africa, giving full personal and career details as well as the names and addresses of at least two referees.**
Applications should be lodged by 15th April, 1983.

**UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG**

(1987)

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## TECHNICAL VIDEO SALES

Rapidly growing video division need sales person to sell sophisticated military airborne video and image processors to U.K. Aerospace and Government research laboratories and with our agents in Europe.

Applicants should be qualified to HNC and should have experience in Aerospace or video background. Preference will be given to applicants in their early or mid twenties. Salary £9,000 plus car and other benefits.

Write for full description and application form to:

JHPI

**Mrs M. Berrow**
**Personnel & Training Manager**
**John Hadland (PI) Ltd.**
**Newhouse Road**
**Bovingdon**
**Hemel Hempstead**
**Herts HP3 0EL**

(1988)

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WESSEX ELECTRONICS LIMITED

**SALES ENGINEER**

We require a first class sales engineer with experience in test and measuring instruments or microwave components to cover the South East and South of England – that is Essex to Hampshire, south of the Thames. If you know you would meet our needs – or think you would – we would like to hear from you.
We offer an interesting range of products – life will never be dull – a small company atmosphere, a basic salary of £8,500 per annum plus bonus and more if you are worth it, together with company car and free BUPA membership for you and your family.

**Applications to: Philip Westwood, Managing Director**
**WESSEX ELECTRONICS LIMITED**
**114-116 NORTH STREET, DOWNEND, BRISTOL BS16 5SE**
***Telephone: (0272) 571404***

(2014)

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## ELECTRONIC DESIGN ENGINEERS

We are a small highly successful manufacturing company specialising in RF communications, digital and low frequency analogue equipment.

We require young highly motivated engineers wishing to develop their experience. The ideal candidate must have complete confidence in his ability.

- Starting salary £10K + (neg).
- 37½-hour week. Overtime available.
- Pay reviews every 6 months.
- Pleasant working environment.
- Location near City of London.

**Contact Keith Penny on (01) 250 0894**

(1983)

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# DEVELOPMENT ENGINEER - ACOUSTICS

**c £9500 + BONUS**

Senior Engineer required by leading manufacturers situated in pleasant South Coast area. To be responsible for design and development of electro-acoustic devices/products for volume production in telecommunications or related industry.

Ideally, applicants (M/F) should be of degree standard (with acoustics endorsement) with experience of design of transducers for electro-acoustic applications. However, good experience may offset lower academic qualifications. Age range 25-40 years.

Write in first instance to:

FENTON EXECUTIVE

**21 CHURCH ROAD**
**HOVE**
**SUSSEX BN3 2FA**
**BRIGHTON 779574**

(1994)

*Brompton Hospital*

# Trainee Medical Electronics/ Physics Technician

We require a Trainee Technician with an interest in medical electronics. Training and day release to study for O and H TEC will be provided. During the first year the technician appointed will be expected to spend at least half his/her time working in the Intensive Care Units where they will gain experience of the clinical environment. The work will be of a varied but routine nature. The remaining time will be spent in the Department of Medical Electronics.

The post is likely to suit those with science 'A' levels who have a desire to make a career in medical electronics/ physics.

The post is for one year in the first instance. Salary will be according to age and qualifications.

Further information and application form available from **Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP. Telephone: 01-352 8121 Ext. 4357.** Completed application forms to be returned as soon as possible. (1985)

WTI

APPLICATIONS ARE INVITED FOR THE POST OF

## SERVICE TECHNICIAN

AT OUR HEAD OFFICE IN LONDON

The principal responsibility will be for maintenance of multi-standard television receivers and video cassette recorders.

The successful applicant will have considerable experience of colour television receiver and video cassette recorder servicing probably with a major television rental company in the industrial or domestic sectors. Knowledge of the V.H.S. format would be an advantage.

Candidates should be prepared to work with the minimum of supervision and be capable of using their own initiative.

Qualifications are less important than practical ability but we would expect City and Guilds Full Technological Certificate to have been gained.

The salary will depend upon qualifications and experience. Conditions of employment include a 35-hour week, 20 days' holiday per annum, and a contributory pension scheme.

**Application forms may be obtained from: Mr. G. J. Atkins, Technical Services Manager, Walport Telmar International Ltd., Walpot House, 62/66 Whitfield Street, London, W1P 6JH. Telephone: 01-631 4373.** (2010)

# FIELD SERVICE ENGINEERS

**(Based in Italy)**

Exciting opportunities for qualified Electronics Engineers to work on the installation and maintenance of Television Studio Equipment at customer sites throughout Italy and Africa.

Key requirements are:

- ★ A sound knowledge of Electronic Engineering – Degree/HNC or equivalent
- ★ At least 3 years' experience in a Television Studio/Production environment, with specific experience of both Quad and Helical Scan, VTR, TV Camera and Switcher Engineering
- ★ Availability to travel extensively throughout Italy and Africa and ability to work on own initiative while away from base

Attractive salary package and other benefits to include overseas allowances and relocation expenses.

AMPEX

**Please write or 'phone Maureen Brake at:**
**Ampex Great Britain Limited**
**Acre Road, Reading RG2 0QR**
**Berkshire, England**
**Tel: Reading (0734) 875200**

(1995)

# Satellite Operations Coordinator

The International Telecommunications Satellite Organization is a rapidly growing organization offering challenging career opportunities and comprehensive salary and benefits packages which include five weeks' paid vacation and free medical and dental coverage.

Position available as Operations Centre Coordinator to assist in providing real time guidance to earth stations operating in an international satellite communications system. Duties include network control, system performance monitoring and implementation of telecommunications services through coordination with domestic and international earth stations and telecommunications entities.

Applicants should have 3-5 years of experience in satellite earth station operations or international communications network control facilities at a supervisory or senior technician level. A strong background in satellite system operations with recent maintenance experience and technical training are required. The ability to engage in effective liaison with international telecommunications entities and acceptance of shift work assignments are required.

Position is based in Washington D.C. For more information about this exciting opportunity please forward your resume including salary history to:

intelsat

**INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION**
*ATT: Personnel Department Box C*
490 L'Enfant Plaza S.W. Washington D.C. 20024

(2004)

# Classified

SITUATIONS VACANT

# Medical Physics Technical Officers

## Saudi Arabia

### c.£13,500-£18,000 p.a. inc. tax free

Allied Medical Group are the British consultants to the prestigious Riyadh Al-Kharj Hospital Programme in Saudi Arabia which provides the best of health care to the armed forces of Saudi Arabia and their families. The two hospitals which comprise the Programme – totalling approximately 660 beds – are new, superbly equipped, mainly U.K. staffed and enjoy a full range of paramedical and other support services. Within the next three years the Programme will expand to 1,000 beds and will become a principal referral centre in the Kingdom.

The Bio-Engineering Division, within the Medical Physics Department, is responsible for servicing a wide range of bio-medical equipment. We are now seeking Medical Physics Technical Officers to specialise in the maintenance of an extensive range of laboratory equipment covering clinical chemistry, haematology, microbiology and histo-pathology. Most of the equipment is maintained within the well-equipped workshop with sophisticated items being handled in conjunction with service agents.

Applicants should possess an HNC or equivalent qualification in electronics or another appropriate subject with at least 2-3 years' experience of maintaining hospital laboratory equipment. Three years' post-qualification experience would be an advantage.

Quote Ref: RKH 462

*Junior and senior posts have also arisen within other areas of the mechanical workshop and more general applications are invited.*
*Quote Ref: RKH 463*

Posts are offered on a two year renewable contract basis and attract one of the best benefits packages in the Middle East.

For further details please write, quoting the appropriate reference number to: Theresa Sutherland, Senior Personnel Officer, Allied Medical Group, 18 Grosvenor Gardens, London, SW1W 0DZ. Alternatively, call our 24-hour answering service on 01-730 5339, quoting appropriate reference number.

All applications will be dealt with in the strictest confidence.

**INFORMAL OPEN DAYS – SCOTLAND**

Please come along and see us. We'll be able to answer all your questions about living and working in Saudi Arabia.

| Date | Location | Time |
|---|---|---|
| Wednesday, 16th March | North British Hotel George Square, Glasgow | 2-8pm |
| Thursday, 17th March | North British Hotel Princess Street, Edinburgh | 2-8pm |

AM

*Allied Medical Group*

The best of British Health Care in the Middle East

Guys Hospital
**DEPARTMENT OF CLINICAL PHYSICS AND BIOENGINEERING**

This active, well established and well-equipped Department provides a physical sciences service for a number of clinical departments in the Hospital. We require a technician to join our electronics servicing group. This work includes the maintenance and servicing of a varied range of medical electronic equipment and covers all aspects of patient orientated equipment from fixed installations to small portable instruments.

Experience in this type of work would be an advantage but candidates with HM Forces' experience or having a good background of TV servicing are encouraged to apply.

An ONC/HNC or equivalent qualification, followed by at least three years' technical experience, are required. The appointment will be on the Medical Physics Technician Grade 3 Scale.

Salary: £6,468 p.a.-£8,087 p.a. inclusive.

**Application forms may be obtained from the Personnel Department, Mary Sheridan House, Guy's Hospital, St Thomas' Street, London SE1 9RT. Telephone: 01-407 7600 Extn 3471 quoting Ref. P/2.**

*Closing date for completed applications: 4th March, 1983.*

**PRESTON POLYTECHNIC SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING.** Applications are invited for the post of Senior Laboratory/Workshop Technician. Salary Scale: T3/4 (DLW) £5973 to £7545 plus up to £114 per annum for possession of appropriate qualifications. Applicants must possess a recognised electrical/electronic technician qualification and have experience in electronic design and construction. Application forms and further details obtainable from the Personnel Officer, Preston Polytechnic, Corporation Street, Preston PR1 2TQ. Tel: Preston 262027. Reference No: NT/82/83/19. Closing date: 3rd March 1983. (1981)

**R & D OPPORTUNITIES.** Senior level vacancies for Communications Hardware and Software Engineers, based in West Sussex. Competitive salaries offered. Please ring David Bird at Rediffusion Radio Systems on 01-874 7281. (1162

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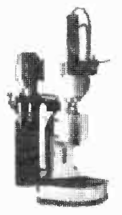
**HYDROKIT**
**Hydraulic Flypress Conversion**



Complete Hydraulic Kits comprising: Power Pack, Control Valve, Ram, Hoses and Fittings. Suitable for many applications including Flypress Conversions. Working pressure 2,000 p.s.i. 2-10 tons. Stroke 4in. Adjustable relief valve. Power pressure and return.

**PRICE FROM £428**

**"HYDROKITS" ARE COMPLETE**
Just remove arm of press and operate screw shaft, fit hydraulic ram assembly with manual valve (all supplied), fill with hydraulic oil and connect to power source, 13 amp or 3-phase. Send details of press or ask for questionnaire.

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**SULLIVAN** Thermistor Bridge £59. Heterodyne Bridge Detector £39. EMI Disc Recording blanks 100 – £150. Laboratory oven £49. Labgear TV Pattern Generator £45. Small compressor pump £20. 500lbs/sq.in. receiver £25. Watson lab microscope £89. Centrifuge £49. Brinell Hardness Tester £98. Ultrasonic Leak Detector £59. 4KW Diesel Generator £195. Water pumps £12-£98. Sullivan Mirror Galvanomoter £39. Audio Analyser £65. 220MHz Sweep Generator £79. EMI Audio Sweep Generator £65. Record Clip-on Ammeter/voltmeter/Recorder £79. Marconi TF 1225A Noise Receiver £59. Plug-ins Cossor 1078 £15 ea. Pye 200,000 M/ohm meter, EIL twenty-million M/ohm meter £35 ea. A few oscilloscopes and other RF, AF, sweep generators
**040-376236** (2000)

ARTICLES FOR SALE


*Private enquiries send 13p in stamps for brochure*

**THE QUARTZ CRYSTAL CO. LTD.**
Q.C.C. WORKS, WELLINGTON CRESCENT
NEW MALDEN, SURREY 01-942 0334 & 2988
(8493)

**ENCAPSULATING EQUIPMENT FOR** coils, transformers, components, degassing silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment, low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon CR0 2QP. 01-684 9917. (9678)

**VALVES, PROJECTOR** Lamps, 6000 types, list £75, world wide export. Cox Radio (Sussex) Ltd., The Parade, East Wittering, Sussex. Phone (024 366) 2023. (1991)

**LAMPS AND CABLE.** Large amount of lamps and cable for sale – all types and sizes, domestic and industrial. Telephone MIRAGE LIGHTING on HITCHIN (0462) 733388 between 10am-7pm. (1809)

**BRIDGES,** waveform/transistor analysers. Calibrators, Standards. Millivoltmeters. Dynamometers. KW meters. Oscilloscopes. Recorders. Signal generators – sweep, low distortion, true RMS, audio, FM, deviation. Tel. 040 376236. (1627

**TV TUBE** Rebuilding Plant. Due to frustrated export order many items of latest plant and equipment available at half price. Western-Whybrow Engineering, The Square, Marazion, Cornwall. Telephone (0736) 710456. (1986)

**WIRELESS WORLD 1968-81.** (Few missing). Excellent condition. £40 + carriage. 15 copies 1930's, 40's including 2 RF straight set, Williamson Amplifier, Golden Jubilee issue £10. Phone Bristol (0272) 733 837. (1982)

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(1978)

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(1997)

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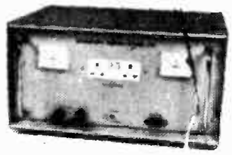

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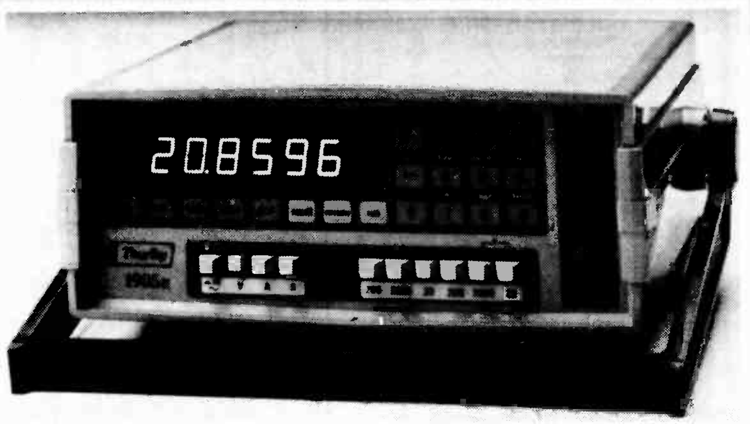


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## Appointments Vacant Advertisements appear on pages 110-119



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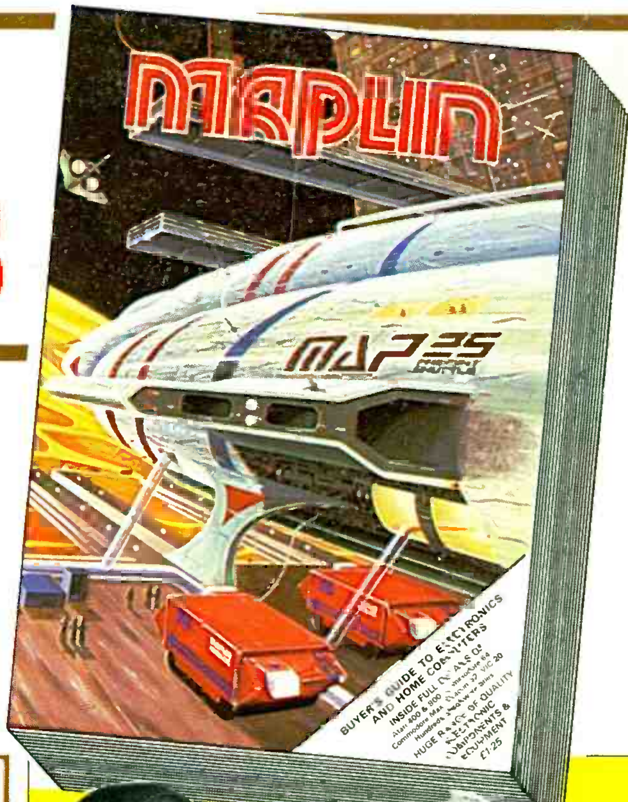


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| YG00A | Ni-Cad AA 500mAh | 26 | £1.25 | 50 | 75p |
| FB15R | Electrolytic 2.2uF 63V | 90 | 10p | 500 | 4.5p |
| FB22Y | Electrolytic 10uF 25V | 90 | 9p | 1000 | 3.5p |
| FB49D | Electrolytic 100uF 25V | 90 | 14p | 500 | 6.5p |
| FB73Q | Electrolytic 470uF 25V | 90 | 30p | 250 | 12p |
| FB83E | Electrolytic 1000uF 25V | 90 | 40p | 250 | 17p |
| FB96E | Electrolytic 4700uF 25V | 90 | £1.25 | 50 | 58p |
| YG41U | 27MHz Rubber Duck | 99 | £4.75 | 25 | £2.95 |
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| WL28F | LED 0.2in. Green | 182 | 19p | 500 | 10p |
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| RK07H | Panel Meter 100uA | 197 | £2.95 | 25 | £1.95 |
| RK09K | Panel Meter 1mA | 197 | £2.95 | 25 | £1.95 |
| RK19V | Panel Meter VU | 197 | £2.95 | 25 | £1.95 |
| YQ47B | Dual VU Meter | 197 | £3.90 | 25 | £2.30 |
| YR84F | Professional Plugblock | 201 | £6.95 | 10 | £4.95 |
| RX96E | 20mm Fuse Holder | 250 | 45p | 250 | 24p |
| M10R-M1M | Metal Film 0.4W 1% Resistor | 262 | 2p | 1000 | 1p |
| FW00A-FW09K | Rotary Potentiometers linear | 265 | 45p | 250 | 32p |
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| QL80B | 1N4148 | 270 | 4p | 1000 | 2p |
| QL22Y | 741C 8-pin DIL | 270 | 23p | 500 | 12p |
| QH66W | NE555 | 270 | 21p | 500 | 12p |
| QQ06G | 4164 64K dynamic RAM | 271 | £5.99 | 100 | £3.84 |
| BL18U | DIL Socket 14-pin | 336 | 11p | 500 | 7.5p |
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| FH42V-FH45Y | Rotary Switch make before break | 348 | 70p | 100 | 42p |
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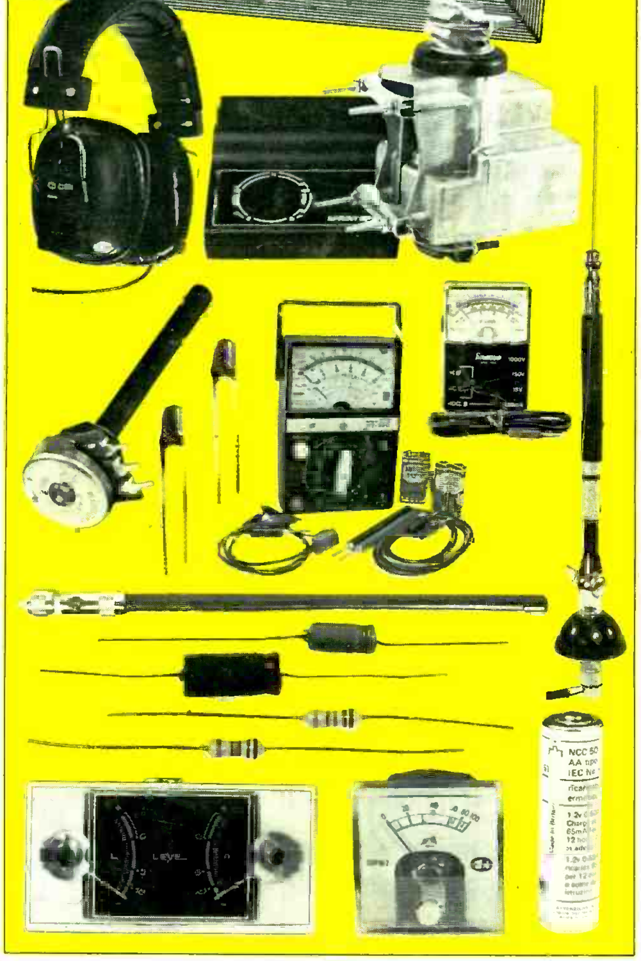

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